

*Review of Surgery for*  
**ABSITE AND BOARDS**

SECOND EDITION



**EDITOR Christian de Virgilio**

**ASSOCIATE EDITOR Areg Grigorian**

**ASSISTANT EDITORS Patrick T. Delaplain | Michael D. Sgroi**

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# Table of Contents



Cover image

Title page

Copyright

Dedication

Contributors

Foreword

Preface

Acknowledgments

**Part I. Patient Care**

1. Abdomen—General

2. Abdomen—Hernia

3. Abdomen—Biliary

4. Abdomen—Liver

5. Abdomen—Pancreas

6. Abdomen—Spleen

7. Alimentary Tract—Esophagus

8. Alimentary Tract—Stomach

9. Alimentary Tract—Small Bowel



10. Alimentary Tract—Large Intestine

11. Alimentary Tract—Anorectal

12. Breast

13. Endocrine

14. Skin and Soft Tissue

15. Surgical Critical Care

16. Trauma

17. Vascular—Arterial

18. Vascular—Venous

19. Vascular—Access

20. Transplant

21. Thoracic Surgery

22. Pediatric Surgery

23. Plastic Surgery

24. Genitourinary

25. Gynecology

26. Head and Neck

27. Nervous System

## **Part II. Medical Knowledge**

28. Anesthesia

29. Fluids, Electrolytes, and Acid-Base Balance

30. Immunology

31. Infection and Antimicrobial Therapy

32. Nutrition and Metabolism

33. Oncology and Tumor Biology

34. Pharmacology

35. Preoperative Evaluation and Perioperative Care

36. Transfusion and Disorders of Coagulation

37. Wound Healing

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# Dedication

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*To my parents Miguel and Kerstin, both in their 80s and still working, who have always inspired me to aim high, and to surgical residents everywhere who motivate me to always keep learning.*

Christian de Virgilio

*To Dr. de Virgilio and my surgical mentors, thank you for teaching me. And to my physician wife, Rebecca, thank you for always supporting me.*

Areg Grigorian



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# Foreword

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Dr. Christian de Virgilio and his collaborators have successfully produced the second edition of their now famous book, *Review of Surgery for ABSITE and Boards*. This publication provides a unique resource for residents taking the ABSITE and the American Board of Surgery qualifying examination and for practicing physicians who are facing the challenge of recertification. The book, originally the product of a Harbor- UCLA Medical Center educational effort conceived and developed by the senior author, is a great resource for younger and older physicians who embrace the art and science of surgery. In this era of constant change, lifelong learning has become one of the most important components of continued professional development. The nearly 1000 carefully edited questions are arranged in logical sections and provide an introduction to the realistic problems surgeons face. The well-constructed answers and accompanying references deliver a natural follow-up to the introductory questions and establish the basis for learning that moves the needle of knowledge in the right direction. Thus this text both prepares the reader to take an examination and provides a great learning experience. In this sense, residents preparing for the exam and practicing surgeons preparing for re-examination not only dramatically increase their chances of successfully passing the exam but also actually learn about the topics in question. This book was made possible by the work and dedication of many faculty members at Harbor-UCLA who should be congratulated. To me, their efforts reflect both the pursuit of excellence, one of the tenets of the American College of Surgeons, and the overall dedication of surgeons to this sacred profession.

*Carlos A. Pellegrini, MD, FACS, FRCS(I)(Hon),*    *President American College of Surgeons 2013–2014, Chief Medical Officer, UW Medicine, Seattle, Washington*

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# Preface

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We are most excited about the second edition of *Review of Surgery for ABSITE and Boards* designed to help students of surgery prepare for the American Board of Surgery In-Training (ABSITE), the American Board of Surgery (ABS) Qualifying (written) Examinations (QE), and for ABS recertification. The original inspiration for the book stemmed from a surgery review program we developed at Harbor-UCLA Medical Center. The intention of the review was to stimulate the residents to read, improve performance on the ABSITE, and enhance their likelihood of passing the ABS examinations on the first try. Based on the feedback we received from the first edition, we were pleased to hear that the book proved to be a valuable resource for all three of these examinations. With that in mind, we have strived to maintain a strong clinical focus for this second edition.

In this second edition, there are some exciting updates and changes. We have added three new members to our editorial team, Drs. Areg Grigorian, Patrick Delaplain, and Michael Sgroi. All three are surgical residents at UC Irvine and were handpicked because of their outstanding track record in test-taking and question writing and their demonstrated strong interest in surgical education. We have also added numerous surgical educators from Harbor-UCLA Medical Center, so as to broaden our expertise. Our editorial team reviewed each question for both accuracy and for clinical relevance. We attempted to eliminate questions with “all of the following are true except,” given that such questions rarely appear on examinations. We have aligned the chapters in such a way that they are now even more in sync with the topics covered by the ABSITE and the ABS QE. We have added new chapters and significantly updated each section, so as to provide the reader with the most updated literature and evidence-based, clinical information. As with the original version, we believe that the greatest value of this book lies in the robust explanations provided for why the correct answer is right and why the incorrect answers are wrong. We hope that this helps the reader in developing his or her test-taking skills and expands his or her knowledge beyond one simple fact.

As with any review book (this one included), it is important to emphasize that studying surgery by simply reviewing a series of practice questions is not sufficient. No amount of review can or should replace the importance of regular reading of a major surgical textbook. A recent multi-institutional study lends support to this. Daily reading, reading geared toward both patient care and ABSITE, and reading from a textbook are associated with better ABSITE performance.\*

As with the first edition, we believe that the ideal way to prepare for the ABSITE and ABS QE is to create a year-round reading program. Read a chapter in a major surgical textbook (such as by Cameron, Sabiston, Schwartz, or Greenfield), and then answer the questions in our review book. Pay special attention to the robust responses provided in the back of each section. Then go to the selected references and read further on the topic. As we have cautioned before, the reader must be cognizant of the fact that no textbook or review book has all the answers. Some answers may be controversial. If you disagree with a question, or think you found an error, we’d love to hear back from you. My email is [cdevirgilio@labiomed.org](mailto:cdevirgilio@labiomed.org).

As a former residency program director in surgery at Harbor-UCLA, and now as Department Chair, I have always advocated that knowledge provides an invaluable tool to the surgeon. Good luck in your pursuit of knowledge. On behalf of my coeditors, I hope you find this review book useful.

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\* Kim, J., Kim, D., & Kaji, A., et al. (2015). Reading habits of general surgery residents and association with American board of surgery in-training examination performance. *JAMA Surg*, 150(9), 882-889.

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## PART I

# Patient Care

### OUTLINE

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1. Abdomen—General
2. Abdomen—Hernia
3. Abdomen—Biliary
4. Abdomen—Liver
5. Abdomen—Pancreas
6. Abdomen—Spleen
7. Alimentary Tract—Esophagus
8. Alimentary Tract—Stomach
9. Alimentary Tract—Small Bowel
10. Alimentary Tract—Large Intestine
11. Alimentary Tract—Anorectal
12. Breast
13. Endocrine
14. Skin and Soft Tissue
15. Surgical Critical Care
16. Trauma
17. Vascular—Arterial
18. Vascular—Venous
19. Vascular—Access
20. Transplant
21. Thoracic Surgery
22. Pediatric Surgery
23. Plastic Surgery
24. Genitourinary
25. Gynecology
26. Head and Neck
27. Nervous System



# Abdomen – General

*Michael D. Sgroi, Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 74-year-old male presents to your clinic hoping to have his reducible umbilical hernia repaired secondary to increasing but intermittent pain and discomfort. Two days before his clinic visit, he had been discharged from the hospital for unstable angina for which he underwent balloon angioplasty with placement of a bare metal coronary artery stent (BMS). When should his surgery be scheduled?
  - A. 2 weeks
  - B. 1 month
  - C. 2 months
  - D. 6 months
  - E. 1 year
2. Which of the following is true regarding abdominal incisions and the prevention of incisional hernias?
  - A. A 3:1 suture:wound length is the current recommended closure length.
  - B. There is no difference in hernia occurrence between a running closure and an interrupted closure.
  - C. A slowly absorbable monofilament suture is preferred in the closure of the fascia in a running fashion.
  - D. Prophylactic use of mesh after open aortic aneurysm surgery is not efficacious.
  - E. A 1-cm bite between each stitch is the recommended distance during abdominal closure.
3. A 55-year-old obese male presents to the hospital for his bariatric sleeve gastrectomy procedure. His comorbidities include diabetes and hypertension, and he states he was diagnosed with “walking pneumonia” 2 weeks ago and placed on antibiotics, which he has finished. Which of the following would not be of benefit if the SCIP measures for preoperative and postoperative care are followed?
  - A. Placing the patient on an insulin sliding scale in an effort to keep glucose levels between 80 to 120 mg/dL
  - B. Clipping the patient’s abdominal hair with an electric shaver before operating
  - C. Administering anticoagulation on postoperative day 1
  - D. Administering antibiotics within 1 hour of surgery
  - E. Discontinuing antibiotics by postoperative day 1
4. A 32-year-old female who is 24 weeks pregnant presents to the emergency department with an acute onset of abdominal pain, fever, and vomiting. She states the pain woke her up in the middle of the night with sudden onset of epigastric pain that is now diffuse. She has no vaginal bleeding and fetal monitoring demonstrates normal vitals for the fetus. Upon physical exam, the patient has diffuse tenderness with guarding throughout the abdomen, worse in the epigastric region. Pelvic examination is normal. She has a leukocytosis of 15,000 cells/L. Abdominal x-ray series shows some dilated bowel loops but no other findings. What is your next step in management of this patient?
  - A. Abdominal ultrasound
  - B. CT scan of the abdomen/pelvis with contrast
  - C. Admit and observe with serial abdominal exams

- D. Exploratory laparotomy
  - E. Diagnostic laparoscopy
5. Which of the following is true regarding omental torsion?
    - A. Secondary torsion is more common than primary.
    - B. Treatment is usually observation and pain control.
    - C. If surgery is necessary, management consists of detorsion and omentopexy.
    - D. The pain is usually in the left lower quadrant of the abdomen.
    - E. It typically produces purulent-appearing peritoneal fluid.
  6. The intrinsic hemostatic characteristics of the omentum are due to its:
    - A. Ability to recruit platelets
    - B. Greater concentration of von Willebrand factor
    - C. Greater concentration of tissue factor
    - D. Ability to induce local vasoconstriction
    - E. Ability to activate the intrinsic coagulation pathway
  7. The most common organism isolated from the infected peritoneal fluid of a patient with a peritoneal dialysis catheter is:
    - A. Beta-hemolytic streptococcus
    - B. *Enterococcus*
    - C. *Escherichia coli*
    - D. Coagulase-negative staphylococcus
    - E. Coagulase-positive staphylococcus
  8. A 70-year-old woman presents with progressive abdominal pain and abdominal distention with nonshifting dullness. A CT scan demonstrates loculated collections of fluid and scalloping of the intra-abdominal organs. At surgery, several liters of yellowish gray mucoid material are present on the omentum and peritoneal surfaces. Which of the following is true about this condition?
    - A. There is no role for surgical resection.
    - B. It is unlikely to involve the appendix.
    - C. This most likely represents a primary peritoneal malignancy.
    - D. It is more common in males.
    - E. Cytoreductive surgery is indicated.
  9. The most common cause of a retroperitoneal abscess is:
    - A. Diverticulitis
    - B. Appendicitis
    - C. Renal disease
    - D. Tuberculosis of the spine
    - E. Hematogenous spread from a remote location
  10. A 50-year-old male with cirrhotic ascites secondary to hepatitis C presents with fever, elevated white blood cell count, and abdominal pain. He has a history of esophageal varices. He has been on the liver transplant list for 6 months. Paracentesis was performed and cultures were sent. A single organism grows from the culture. Which of the following is true regarding this condition?
    - A. He is currently eligible for a liver transplant.
    - B. Prophylactic use of fluoroquinolone can be used to prevent this condition.
    - C. In adults, nephrotic syndrome is the most common risk factor.
    - D. In children, *E. coli* is the most common isolate.
    - E. He will likely need an exploratory laparotomy.
  11. Which of the following is true regarding a rectus sheath hematoma?
    - A. If located above the umbilicus, it is more likely to resemble an acute intra-abdominal process.
    - B. If located below the umbilicus, it is more likely to cause severe bleeding.

- C. The majority are associated with a history of trauma.
  - D. Operative drainage is the treatment of choice in most cases.
  - E. Angiographic embolization is not useful.
12. A 35-year-old female presents with an enlarging mass in her right arm. After appropriate workup, she is diagnosed with a desmoid tumor. Which of the following is true about this condition?
- A. They have a high rate of metastasis without proper treatment.
  - B. The chance of local recurrence is low after appropriate intervention.
  - C. Oral contraceptive pills (OCP) have been shown to reduce their size and make them more resectable.
  - D. Colonoscopy is indicated.
  - E. These tumors arise from proliferative chondroblastic cells.
13. Which of the following is true regarding retroperitoneal fibrosis?
- A. The mainstay of treatment involves radiation therapy.
  - B. It occurs more commonly in women.
  - C. The erythrocyte sedimentation rate (ESR) is typically normal.
  - D. Intravenous pyelography (IVP) is the diagnostic study of choice.
  - E. Medial deviation of the ureters is characteristic.
14. Which of the following is true regarding retroperitoneal sarcomas?
- A. They are best managed by enucleation.
  - B. Prognosis is best determined by histologic grade.
  - C. Lymph node metastasis is common.
  - D. Fibrosarcomas are the most common type.
  - E. Radiation therapy is often curative for small sarcomas.
15. A 75-year-old female with recently diagnosed atrial fibrillation, for which she was given an anticoagulant, presents with sudden onset abdominal pain. It is not related to oral intake. Surgical history is remarkable for a total hip arthroplasty 3 years ago. Her physical exam is significant for a tender, palpable abdominal wall mass above the umbilicus that persists during flexion of abdominal wall muscles. The mass is most likely related to which of the following?
- A. Thrombocytopenia
  - B. Bleeding from the superior epigastric artery
  - C. Occult trauma
  - D. An intra-abdominal abscess
  - E. Bleeding from the inferior epigastric artery

## Answers

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1. **B.** Good communication between the cardiologist and surgeon is essential before performing coronary interventions in a patient who requires surgery. Coronary revascularization before elective surgery is not recommended if the patient has asymptomatic coronary artery disease (CAD). However, in the setting of an acute coronary syndrome (acute myocardial infarction [MI], unstable angina), a percutaneous coronary intervention (PCI) is recommended before surgery. The options are to perform balloon angioplasty alone or add a bare metal stent (BMS) or a drug-eluting stent (DES). The DES is the best long-term option, but it requires a longer delay to surgery. Thus the decision of which to use depends on the urgency of the subsequent operation (urgent, time sensitive, or elective) and the feasibility of operating with antiplatelet agents on board. If the operation is urgent (within 2 weeks), a PCI with balloon angioplasty may be best because the waiting period for surgery is 2 weeks (A). If the operation is time sensitive (2–6 weeks), a BMS is a better option because it is less likely to suddenly occlude as compared with angioplasty alone. However, one should wait 1 month before performing surgery (C). Because this patient has a relatively symptomatic hernia, the operation is time sensitive. Finally, if a DES is placed, the recommendation is to wait 6 months before performing surgery (D, E).

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2. **C.** The material and the surgical technique used to close an open abdomen are important determinants of the risk of developing an incisional hernia. The European Hernia Society has recently come out with guidelines recommending that small bite closure be performed using at least a 4:1 suture:wound length during closure (A). It has also been shown that running closure is superior to an interrupted closure (B). Prophylactic use of mesh during closure has been shown to be efficacious after open aortic aneurysm surgery because of the high rate of incisional hernia (D). A randomized control trial looking at small bites compared to large bites has recently been performed looking at 560 patients who received either small, 5-mm bites 5 mm apart or large, 1-cm bites 1 cm apart. They found a statistically significant reduced rate of hernia occurrence in the small bite group, which is now the recommended bite size and length (E). A slowly absorbable monofilament suture (polydioxanone suture [PDS]) has been shown to also be the recommended suture in abdominal closure.

**References:** Deerenberg, E. B., Harlaar, J. J., Steyerberg, E. W., et al. (2015). Small bites versus large bites for closure of abdominal midline incisions (STITCH): a double-blind, multicentre, randomised controlled trial. *Lancet*, 386(10000), 1254–1260.

Muysoms, F. E., Antoniou, S. A., Bury, K., et al. (2015). European Hernia Society guidelines on the closure of abdominal wall incisions. *Hernia*, 19(1), 1–24.

3. **A.** The Surgical Care Improvement Project (SCIP) is a national quality partnership of organizations interested in improving surgical outcomes that began in 2006. Care is taken by all institutions to follow the recommendations by the Joint Commission because all these outcomes are documented and measured quarterly. The core measures include giving antibiotics within 1 hour of surgery (D) and discontinuing within 24 hours (E), Foley catheter removal by postoperative day 2, and hair removal by clipping on the day of surgery. Shaving the hair off has been shown to increase the risk of infection (B). Other beneficial measures include being on appropriate venous thromboembolism (VTE) prophylaxis within 24 hours after surgery and glucose control. The importance of glucose control and surgical outcomes has been well established; however, in 2009 the NICE-SUGAR trial demonstrated that strict glucose control was actually associated with worse outcomes. It is now widely accepted that the goal should be to keep glucose levels below 180 mg/dL (C).

**Reference:** NICE-SUGAR Study Investigators, Finfer, S., Chittock, D. R., et al. (2009). Intensive versus conventional glucose control in critically ill patients. *The New England Journal of Medicine*, 360(13), 1283–1297.

4. **B.** Fear of radiation exposure during pregnancy should not take precedence over quickly establishing the correct diagnosis and initiating treatment. Based on the patient's acute onset of symptoms and location, the presentation is concerning for peritonitis, potentially due to a perforated viscus, such as a peptic ulcer, or a closed loop bowel obstruction. In this situation, the best next step would be to perform a computed tomography (CT) scan of the abdomen (A, C–E). As a general rule, the care of the patient, not the fetus, should take first priority. Based on the National Guideline Clearinghouse, expeditious and accurate diagnosing should take precedent over risk of ionizing radiation. The effects of radiation exposure on the fetus depend on the gestational age and the amount of radiation. In general, the earlier the gestational age, the greater the risk is. High dose (>10 rads) exposure early in pregnancy (within the first 4 weeks) can lead to fetal demise. However, such a high exposure exceeds the dose of typical imaging (abdominal x-ray is 200 mrad while abdominal and pelvic CT is about 3–4 rads). Between 8 to 15 weeks' gestation, high-dose (>10 rads) radiation can lead to intrauterine growth retardation and central nervous defects. Beyond 15 weeks (as in the present case), there do not appear to be any deterministic effects (dose-dependent events such as fetal loss, congenital defects) on the fetus. Stochastic effects (those that are not dose

dependent), such as the subsequent risk of cancer or leukemia, are increased with exposure of 1 rad or more. The risk is about 1 cancer for every 500 exposures. Conversely, if the pregnant patient with an acute abdomen progresses to peritonitis and bowel perforation, the risk of fetal demise is very high. Thus the risk of fetal miscarriage is higher with visceral perforation than with radiation exposure, and therefore all measures should be taken for an accurate diagnosis. Magnetic resonance imaging (MRI) is considered a good imaging option in pregnancy; however, its use in the emergent setting may be limited by its availability. Ultrasound is also useful, but would be more useful if the patient presented with right upper quadrant pain (suspected biliary disease) or right lower quadrant pain (suspected appendicitis).

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Khandelwal, A., Fasih, N., Kielar, A., et al. (2013). Imaging of acute abdomen in pregnancy. *Radiologic Clinics of North America*, 51(6), 1005–1022.

5. **A.** It is important to be aware of omental torsion because it readily mimics an intra-abdominal perforation. Because it is typically very difficult to diagnose preoperatively, the diagnosis is most often made at surgery. Torsion of the omentum describes a twisting of the omentum around its vascular pedicle along the long axis. Primary torsion, in which case there is no underlying pathology, is extremely rare. Secondary torsion is much more common, and the torsion is usually precipitated by a fixed point such as a tumor, an adhesion, a hernia sac, or an area of intra-abdominal inflammation. Omental torsion is much more common in adults in their fourth or fifth decade of life. Children with torsion are typically obese, likely contributing to a fatty omentum that predisposes to twisting. Other factors that predispose a patient to torsion include a bifid omentum and a narrowed omental pedicle. In primary omental torsion, the twisted omentum tends to be localized to the right side; thus it is most commonly confused with acute appendicitis, acute cholecystitis, and pelvic inflammatory disease (D). Complicating the diagnosis is the fact that the omentum itself tends to migrate and envelop areas of inflammation. Laparoscopy is ideal for establishing the diagnosis and to exclude other etiologies. Treatment is to resect the twisted omentum, which can often be infarcted at the time of surgery, and to correct any other related condition that may be identified (B, C). The finding of purulent fluid would suggest another diagnosis because it is not consistent with omental torsion. The fluid usually seen is serosanguinous (E).

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6. **C.** Rutherford Morison originally described the omentum as the abdominal “policeman” as it walls off infections and prevents further peritoneal contamination. In fact, omental wrapping is still used by trauma surgeons to control bleeding around the liver and spleen. In an attempt to explain the omentum’s hemostatic properties, a 1996 study demonstrated that the concentration of tissue factor in omentum is more than twice the amount per gram of that found in muscle. This property facilitates the activation of the extrinsic pathway of coagulation in the settings of trauma, infection, or ischemia. This leads to the production of fibrin, which facilitates the adherence of the omentum to these areas. The remaining choices do not contribute to the omentum’s intrinsic hemostatic capability (A, B, D, E).

**References:** Logmans, A., Schoenmakers, C., Haensel, S., et al. (1996). High tissue factor concentration in the omentum, a possible cause of its hemostatic properties. *European Journal of Clinical Investigation*, 26(1):82–83.

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New York, NY: McGraw-Hill.

7. **D.** Coagulase-negative staphylococci (*Staphylococcus epidermidis*) is by far the most common cause of peritoneal catheter-related infections (A–C). *Staphylococcus aureus* is coagulase positive (E). Another defining feature of *S. aureus* is that it is catalase positive. The diagnosis is made by a combination of abdominal pain, development of cloudy peritoneal fluid, and an elevated peritoneal fluid white blood cell count greater than 100/mm<sup>3</sup>. Initial treatment consists of intraperitoneal antibiotics, which seem to be more effective than intravenous (IV) antibiotics for a total of 2 weeks. If the infection fails to clear, based on abdominal examination, clinical picture, or persistent peritoneal fluid leukocytosis, then the catheter needs to be removed and a temporary hemodialysis catheter will need to be inserted. *S. aureus* and gram-negative organism infections are less likely to respond to antibiotic management alone.
8. **E.** Pseudomyxoma peritonei is a rare process in which the peritoneum becomes covered with semisolid mucus and large loculated cystic masses. It is unclear whether it represents a true malignant process (C). A useful classification derived from a large series uses two categories: disseminated peritoneal adenomucinosis (DPAM) and peritoneal mucinous carcinomatosis (PMCA). DPAM is histologically a benign process and most often due to a ruptured appendix. In one large series, appendiceal mucinous adenoma was associated with approximately 60% of patients with DPAM. In patients classified as PMCA, the origin was either a well-differentiated appendiceal or intestinal mucinous adenocarcinoma (B). Pseudomyxoma peritonei is most common in women aged 50 to 70 years (D). It is often asymptomatic until late in its course. Symptoms are often nonspecific, but the most common symptom is increased abdominal girth. Physical examination may demonstrate a distended abdomen with nonshifting dullness. Management is surgical, with cytoreduction of the primary and secondary implants, including peritonectomy and omentectomy (A). If there is a clear origin at the appendix, a right colectomy should also be performed. If the origin appears to be the ovary, total abdominal hysterectomy with bilateral salpingo-oophorectomy is recommended. The recurrence rate is very high (76% in one series).

**References:** Gough, D., Donohue, J., Schutt, A. J., et al. (1994). Pseudomyxoma peritonei: long-term patient survival with an aggressive regional approach. *Annals of Surgery*, 219(2), 112–119.

Hinson, F., & Ambrose, N. (1998). Pseudomyxoma peritonei. *The British Journal of Surgery*, 85(10), 1332–1339.

Ronnett B., Zahn, C., Kurman, R., et al. (1995). Disseminated peritoneal adenomucinosis and peritoneal mucinous carcinomatosis: a clinicopathologic analysis of 109 cases with emphasis on distinguishing pathologic features, site of origin, prognosis, and relationship to “pseudomyxoma peritonei.” *The American Journal of Surgical Pathology*, 19(12), 1390–1408.

9. **C.** Primary retroperitoneal abscesses are secondary to hematogenous spread while secondary retroperitoneal abscesses are related to an infection in an adjacent organ. The most common source of retroperitoneal abscesses are secondary with renal infections accounting for nearly 50% of all cases. Hematogenous spread is not a significant contributing factor for secondary retroperitoneal abscesses (E). Other common causes include retrocecal appendicitis (B), perforated duodenal ulcers, pancreatitis, and diverticulitis (A). In rare cases, patients may have Pott’s disease, which is a disseminated form related to tuberculosis (D). Patients typically present with back, pelvic, flank, or thigh pain with associated fever and leukocytosis. Flank erythema may be present. Kidney infections often have gram-negative rods such as *Proteus* and *E. coli*. Treatment consists of broad-spectrum antibiotics and drainage, as well as identification of the source. If the abscess is simple and unilocular then CT-guided drainage is the treatment of choice. Operative drainage may be required for complex abscesses.
10. **B.** Spontaneous (primary) bacterial peritonitis (SBP) is defined as bacterial infection of ascitic fluid in the absence of any surgically treatable intra-abdominal infection. Patients usually present with fever, diarrhea, and abdominal pain but if severe enough, will also have altered mental status, hypotension, hypothermia, and a paralytic ileus. However, 13% of patients will be completely asymptomatic. Treatment is with antibiotics alone. Prophylactic antibiotics (with fluoroquinolones) to prevent SBP should be considered in high-risk patients with cirrhosis, ascites, and history of gastrointestinal bleeding (as in the present case). Patients with cirrhosis who have low ascitic fluid protein (<1.0 g/dL) and those with a serum bilirubin greater than 2.5 mg/dL should also be started on prophylactic antibiotics. Opsonic or bactericidal activity of ascitic fluid is related to protein

concentration. One of the key features of primary peritonitis is that the isolate is usually a single organism and that organism usually is not an anaerobe. Secondary peritonitis refers to peritonitis in the setting of a bowel perforation. Thus, polymicrobial or anaerobic cultures should raise suspicion for bowel perforation and secondary peritonitis (E). In adults, the most common pathogens in spontaneous bacterial peritonitis are the aerobic enteric flora *E. coli* and *Klebsiella* (C). In children with nephrogenic or hepatogenic ascites, group A *Streptococcus*, *S. aureus*, and *Streptococcus pneumoniae* are common isolates (D). The diagnosis is made by paracentesis demonstrating more than 250 neutrophils/mm<sup>3</sup> of ascitic fluid in the presence of a correlating clinical presentation. This should be evaluated before initiating antibiotics because cultures will return falsely negative. An active infection is considered a contraindication for liver transplantation (A).

**References:** Bell, R. B., & Seymour, N. E. (2005). Abdominal wall, omentum, mesentery, and retroperitoneum. In F. C. Brunickardi, D. K. Andersen, T. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp. 1317–1328) (8th ed.). New York, NY: McGraw-Hill.

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Turnage, R. H., Li, B., & McDonald, J. C. (2004). Abdominal wall, umbilicus, peritoneum, mesenteries, omentum and retroperitoneum. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1171–1198) (17th ed.). Philadelphia, PA: W. B. Saunders.

11. **B.** Rectus sheath hematomas are clinically significant because of the fact that they can easily be mistaken for an intra-abdominal inflammatory process. The etiology is an injury to an epigastric artery within the rectus sheath. In most cases, there is no clear history of trauma (C). Particularly in the elderly who are taking oral anticoagulants, they typically occur spontaneously. Patients frequently describe a sudden onset of unilateral abdominal pain, sometimes preceded by a coughing fit. In one series, 11 of 12 patients were women, and in another series, all 8 were women, with an average age in the sixth decade. Below the arcuate line, there is no aponeurotic posterior covering to the rectus muscle. Therefore, hematomas below this line can cross the midline, causing a larger hematoma to form, and cause bilateral lower quadrant pain resembling a perforated viscus. On physical examination, a mass is often palpable. The Fothergill sign is the finding of a palpable abdominal mass that remains unchanged with contraction of the rectus muscles. This helps distinguish it from an intra-abdominal abscess, which would not be palpable with rectus contraction. The diagnosis is best established with a CT scan, which will demonstrate a fluid collection in the rectus muscle. The hematocrit should be closely monitored. Once the diagnosis is established, management is primarily nonoperative and consists of resuscitation, monitoring of serial hemoglobin/hematocrit levels, and reversal of anticoagulation (D). However, one should be cautious with reversal of anticoagulation, as stable patients may benefit from continued anticoagulation (e.g., recent mechanical valve). On rare occasions, angiographic embolization may be necessary (E). Surgical management, while rarely necessary, would involve ligation of the bleeding vessel and evacuation of the hematoma.

**References:** Berná, J., Zuazu, I., Madrigal, M., et al. (2000). Conservative treatment of large rectus sheath hematoma in patients undergoing anticoagulant therapy. *Abdominal Imaging*, 25(3), 230–234.

Zainea, G., & Jordan, F. (1988). Rectus sheath hematomas: their pathogenesis, diagnosis, and management. *The American Surgeon*, 54(10), 630–633.

12. **D.** Desmoid tumors are unusual soft-tissue neoplasms that arise from fascial or fibro-aponeurotic tissue. They are proliferations of benign-appearing fibroblastic cells with abundant collagen and few mitoses (E). Desmoid tumors do not metastasize (A); however, they are locally aggressive and have a very high local recurrence rate reaching almost 50% (B). They have been associated with Gardner syndrome (intestinal polyposis, osteomas, fibromas, and epidermal or sebaceous cysts) and familial adenomatous polyposis (FAP), which is why patients should be scheduled for a colonoscopy soon after diagnosis. In sporadic cases, surgical trauma appears to be an important cause. Desmoid tumors may develop within or adjacent to surgical scars. Patients with FAP have a 1000-fold increased risk of the development of desmoid tumors. Desmoids are more common in women of childbearing age and may be linked to estrogen. OCPs have also been found to be associated with the occurrence of these tumors (C). Patients are typically in their third or fourth decade of life and present with pain, a mass, or both. They are classified as either extra-abdominal

(extremities, shoulder), abdominal wall, or intra-abdominal (mesenteric and pelvic). There are no typical radiographic findings, but MRI may delineate muscle or soft-tissue infiltration and is required in larger tumors to delineate anatomic relations before surgical intervention. Core needle biopsy often reveals collagen with diffuse spindle cells and abundant fibrous stroma, which may suggest a low-grade fibrosarcoma; however, the cells lack mitotic activity. An open incisional biopsy of lesions larger than 3 to 4 cm is often necessary. Wide local excision with negative margins is indicated for symptomatic desmoid tumors. Nonresectable or incidentally found, asymptomatic, intra-abdominal desmoid tumors (even if resectable) should be treated with nonsteroidal antiinflammatory agents (e.g., sulindac) and antiestrogens, which have met with objective response rates of 50%. In regards to adjuvant therapy, recent retrospective reviews have seen significant reductions in recurrence with radiation combined with surgery and even with radiation alone. More research is necessary for the use of chemotherapy agents, but it has been seen that when cytotoxic chemotherapy agents are used in inoperable desmoid tumors, there is a 20% to 40% positive response. The aggressive nature of these tumors and high rate of occurrence make desmoid tumors the second most common cause of death in patients with FAP, after colorectal carcinoma.

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Nuyttens, J. J., Rust, P. F., Thomas, C. R., Jr., et al. (2000). Surgery versus radiation therapy for patients with aggressive fibromatosis or desmoid tumors: a comparative review of 22 articles. *Cancer*, 88(7), 1517–1523.

13. E. Retroperitoneal fibrosis is characterized by a periaortic and retroperitoneal proliferation of fibrous tissue and chronic inflammation that extends laterally and often surrounds the ureters and leads to ureteral obstruction, flank pain, and, in some cases, acute renal failure. The disorder is idiopathic (also known as Ormond disease) in 70% of cases, with the other 30% being a secondary reaction to an inciting inflammatory process, malignancy, or medication (e.g., methysergide use). It occurs twice as often in men as women, with a mean age at presentation of 50 to 60 years (B). One theory is that it is related to an autoimmune response, having a similar allele (*HLA-DRB1\*03*), to type I diabetes, myasthenia gravis, and systemic lupus erythematosus (SLE). There does not seem to be any support for an infectious etiology. The fibrotic process can eventually encase the ureters, inferior vena cava, aorta, mesenteric vessels, and/or sympathetic nerves. On physical examination, patients are often hypertensive and an abdominal or flank mass may be palpated. Compression of pelvic veins may lead to lower extremity edema and pelvic congestion. Laboratory evaluation often demonstrates elevated blood urea nitrogen and creatinine levels as the majority of these patients will have azotemia. Additionally, an elevation in ESR is a common finding (C). Ultrasound is often used as the initial study to evaluate extent of ureter involvement and hydronephrosis. IVP will also show hydronephrosis, as well as the extrinsic compression of the ureters. A noncontrast CT scan, though, is the most reliable study used for diagnosis, demonstrating a homogenous fibrous plaque surrounding the lower aorta and iliac arteries (D). Medial deviation of the ureters is characteristic for idiopathic retroperitoneal fibrosis but not pathognomonic. It tends to have a symmetric distribution. Malignant tumors conversely tend to deviate the ureters laterally (E). It is important to note that malignant tumors can induce retroperitoneal fibrosis. As such, CT-guided needle biopsy is essential. The mainstay of treatment is use of corticosteroids. Immunosuppressants have also been used in those refractory to steroid treatment.

**References:** Cronin, C., Lohan, D., Blake, M., et al. (2008). Retroperitoneal fibrosis: a review of clinical features and imaging findings. *American Journal of Roentgenol*, 191(2), 423–431.

Gilkeson, G., & Allen, N. (1996). Retroperitoneal fibrosis: a true connective tissue disease. *Rheumatic Diseases Clinics of North America*, 22(1), 23–38.

Martorana, D., Vaglio, A., Greco, P., et al. (2006). Chronic periaortitis and HLA-DRB1\*03: another clue to an autoimmune origin. *Arthritis and Rheumatism*, 55(1), 126–130.

14. **B.** Most retroperitoneal tumors are malignant and comprise approximately half of all soft-tissue sarcomas. The most common sarcomas occurring in the retroperitoneum are liposarcomas, malignant fibrous histiocytomas, and leiomyosarcomas (D). Approximately 50% of patients will have a local recurrence and 20% to 30% will end up having distant metastases. Lymph node metastases are rare (C). Retroperitoneal sarcomas present as large masses because they do not typically produce symptoms until their mass effect creates compression or invasion of adjacent structures. Symptoms may include gastrointestinal hemorrhage, early satiety, nausea, vomiting, and lower extremity swelling. Retroperitoneal sarcomas have a worse prognosis than nonretroperitoneal sarcomas. The best chance for long-term survival is achieved with an en bloc, margin-negative resection. Tumor stage at presentation, high histologic grade, unresectability, and grossly positive resection margins are strongly associated with increased mortality rates. Tumor grade is the most significant predictor of outcome. Complete surgical resection is the most effective treatment for primary or recurrent retroperitoneal sarcomas (A, E). Surgical cure can be limited because the margins are often compromised by anatomic constraints. There is no difference in survival between those who had a resection with a grossly positive margin and those with inoperable tumors. Unlike extremity sarcomas, external beam radiation therapy is limited for retroperitoneal malignancies because there is a low tolerance for radiation to surrounding structures. Postoperative and intraoperative radiation therapy have been shown to reduce local recurrence, but further studies are needed to determine if this leads to improved survival.

**Reference:** Lewis, J. J., Leung, D., Woodruff, J. M., et al. (1998). Retroperitoneal soft-tissue sarcoma: analysis of 500 patients treated and followed at a single institution. *Annals of Surgery*, 228(3), 355–365.

15. **B.** This patient was recently diagnosed with atrial fibrillation and started on oral anticoagulants. One should suspect a rectus sheath hematoma in older patients taking anticoagulants who present with the clinical triad of acute abdominal pain, an abdominal wall mass, and anemia. The mass is palpable even during flexion of abdominal wall muscles helping differentiate this from an intraperitoneal process (Fothergill sign) (D). In a review of 126 patients by Mayo Clinic, anticoagulation was associated with 70%. Above the arcuate line, the etiology is often related to a lesion to the superior epigastric artery within the rectus sheath (E). In most cases, there is no clear history of trauma (C). In particular, in the elderly who are taking oral anticoagulants, they typically occur spontaneously. The most common treatment for patients with rectus sheath hematomas is rest, analgesics, and blood transfusions as necessary. In general, coagulopathies are corrected; however, continuing anticoagulation may be prudent in select patients (e.g., biomechanical valve, recent saddle embolus) (A). In extreme cases, angioembolization may be required.

**References:** Alla, V. M., Karnam, S. M., Jaushik, M., et al. (2010). Spontaneous rectus sheath hematoma. *Western Journal of Emergency Medicine*, 11(1), 76–79.

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# Abdomen—Hernia

*Patrick T. Delaplain, Areg Grigorian, and Christian de Virgilio*

## Questions

1. One hour after laparoscopic repair of a left inguinal hernia, the patient complains of severe burning groin pain. Which of the following is the most appropriate recommendation?
  - A. Immediate return to the operating room for laparoscopy
  - B. Nonsteroidal antiinflammatory drugs
  - C. Neurontin
  - D. Opioid analgesia
  - E. Inject groin region with local anesthetic
2. The most important component of surgical repair in an infant with ultrasound-confirmed unilateral inguinal hernia is:
  - A. A high ligation of the hernia sac
  - B. Obliterating the deep ring
  - C. Creating a tension-free repair with mesh
  - D. Releasing the anterior rectus sheath to allow a tension-free connection between the conjoint tendon and Cooper ligament
  - E. Identification of all nerves
3. Which of the following is true regarding femoral hernias?
  - A. They are the most common hernia in females.
  - B. Cooper's ligament is considered the anterior border of the femoral canal.
  - C. They are lateral to the femoral vein.
  - D. Repair involves approximating the iliopubic tract to Cooper's ligament.
  - E. Bassini operation is considered an appropriate surgical option.
4. A 42-year-old male presents to the emergency department (ED) with vague abdominal pain for the past month that has suddenly worsened over the past several hours. Computed tomography (CT) of the abdomen is performed and demonstrates mesenteric fat stranding between the rectus abdominis muscle and semilunar line. Which of the following is true regarding this condition?
  - A. Typically patients present with a palpable mass.
  - B. It mandates an open repair with incision directly over the affected area.
  - C. Patients with this condition are typically on anticoagulation.
  - D. There is a high risk of sepsis.
  - E. It is considered a clinical diagnosis and imaging is not typically needed.
5. Which of the following best describes umbilical hernias in children?
  - A. They are more common in white children than black children.
  - B. Repair is indicated once an umbilical hernia is diagnosed.
  - C. Repair should be performed if the hernia persists beyond 6 months of age.
  - D. Most close spontaneously.



- E. Repair should be performed only if the child is symptomatic.
6. Which of the following is true regarding umbilical hernias in adults?
- A. Most are congenital.
  - B. Repair is contraindicated in patients with cirrhosis.
  - C. Strangulation is less common than in children.
  - D. Small, asymptomatic hernias can be clinically observed.
  - E. Primary closure has recurrence rates similar to those of mesh repair.
7. The hernia bounded by the latissimus dorsi muscle, iliac crest, and external oblique muscle is known as:
- A. Grynfeltt hernia
  - B. Richter hernia
  - C. Petit hernia
  - D. Littre hernia
  - E. Obturator hernia
8. Ischemic orchitis after inguinal hernia repair is most often due to:
- A. Too tight a reconstruction of the inguinal ring
  - B. Preexisting testicular pathology
  - C. Inadvertent ligation of the testicular artery
  - D. Completely excising a large scrotal hernia sac
  - E. Anomalous blood supply to the testicle
9. The genital branch of the genitofemoral nerve:
- A. Is typically found anteriorly on top of the spermatic cord
  - B. Provides sensation to the base of the penis and inner thigh
  - C. Typically lies on the anterior surface of the internal oblique muscle
  - D. Provides sensation to the side of the scrotum and motor innervation to the cremaster muscle
  - E. Often intermingles with the iliohypogastric nerve
10. Four months after open inguinal hernia repair with mesh, a patient reports persistent burning pain at the incision site that radiates to the groin. On examination, there is no evidence of recurrent hernia. The patient experienced moderate improvement after ultrasound-guided nerve block immediately lateral to the spermatic cord near the pubic tubercle. Which of the following is true about this condition?
- A. Careful identification of all three sensory nerves will prevent this complication.
  - B. Initial management involves reexploring the wound.
  - C. Reoperation for failure of conservative therapy is best accomplished via a laparoscopic retroperitoneal approach.
  - D. Chronic pain after hernia repair is uncommon.
  - E. Intentional division of sensory nerves in the groin during the index operation would have effectively prevented this complication from occurring.
11. A 5-month-old previously full-term male infant presents with a tender left groin mass that has been present for the past several hours. There is slight erythema over the skin. He is afebrile and his labs are normal. Which of the following is the best next step?
- A. Attempt manual reduction, and if successful, schedule surgical repair when infant reaches 1 year of age.
  - B. Attempt manual reduction, and if successful, immediately take to the operating room for surgical repair.
  - C. Attempt manual reduction, and if successful, schedule repair in 2 days.
  - D. Attempt manual reduction, and if successful, schedule left-sided surgical repair with contralateral groin exploration in 2 days.
  - E. Take immediately to the operating room for operative repair.

12. Which of the following is true regarding hernia anatomy?
- A. Poupart ligament is formed from the anteroinferior portion of the external oblique aponeurosis.
  - B. The cremaster muscle arises from the transversus abdominis muscle.
  - C. The genital branch of the genitofemoral nerve passes through the superficial ring.
  - D. The femoral branch of the genitofemoral nerve innervates the cremasteric muscle.
  - E. Indirect hernias most often arise within the borders of the rectus muscle, inferior inguinal ligament, and inferior epigastric artery
13. Which of the following is true regarding the arcuate line?
- A. It is usually located a few centimeters above the umbilicus.
  - B. Below this line, the internal oblique aponeurosis splits.
  - C. Below this line, the rectus muscle lies on the transversalis fascia.
  - D. Below this line, the posterior rectus sheath is thinner.
  - E. Below this line, the external oblique muscle does not contribute to the anterior rectus sheath.
14. A 45-year-old man presents with an asymptomatic right inguinal hernia. It is easily reduced with gentle pressure. Which of the following is true about this condition?
- A. The likelihood of strangulation developing is high without surgery.
  - B. Without surgery, intractable pain will most likely develop.
  - C. Waiting until symptoms develop is a reasonable alternative to surgery.
  - D. Laparoscopic repair is the best option.
  - E. If the hernia is small, there is a lower chance of incarceration.
15. A 55-year-old male presents with a painful bulge in the left groin that first appeared several months ago. His surgical history includes a right-sided open inguinal hernia repair. Upon examination you also note a bulge in the right groin over his previous incision. Both masses are reducible. Which of the following is true regarding this patient's condition?
- A. Open repair is preferred.
  - B. In laparoscopic repair, failure to tack the mesh lateral to the inferior epigastric vessels can lead to recurrence through the internal ring.
  - C. Violation of the peritoneum during a totally extraperitoneal (TEP) repair requires conversion to an open or transabdominal preperitoneal (TAPP) approach.
  - D. Persistent numbness or pain of the lateral thigh is more common with open versus laparoscopic repair.
  - E. Laparoscopic repair will prevent him from developing a femoral hernia in the future.
16. A 28-year-old male patient is asking for advice on whether to pursue open mesh repair or TEP repair of a newly diagnosed, reducible right-sided inguinal hernia. What can you tell the patient about these two methods of repair?
- A. Chronic pain is reduced with an open mesh repair.
  - B. Operative time is not significantly different between the two.
  - C. TEP repair is associated with a quicker return to work and normal activities.
  - D. Open mesh repair is associated with a higher number of intraoperative complications.
  - E. Recurrence is relatively common (>25%) no matter which method is chosen.
17. A 45-year-old male presents with a reducible but intermittently painful incisional hernia about 5 cm above his umbilicus. He had a prior laparotomy for a gunshot wound about 10 years ago that was complicated by a surgical site infection. Physical exam reveals a defect that is approximately 6 cm in size. Which of the following is true regarding his condition?
- A. Incisional hernia occurs in about 1% of all laparotomies.
  - B. The total cost of a patient undergoing laparoscopic repair is more costly than open repair.
  - C. Repair of defects larger than 10 cm should not be attempted laparoscopically.
  - D. Surgical site infection likely contributed to this complication.
  - E. Use of an interposition mesh reduces recurrence rates compared with other methods of repair.

18. A 78-year-old female presents with a 6-hour history of bilious vomiting. On exam, she has a firm tender mass just inferior to the inguinal ligament on the left. Which of the following is true regarding the most likely condition?
- A. The lacunar ligament is lateral to the mass.
  - B. If discovered in an asymptomatic patient, it should still be repaired.
  - C. The adductor longus muscle often marks the lateral border of the mass.
  - D. Repair via an infrainguinal incision directly over the mass is not recommended.
  - E. The risk of this condition is similar in multiparous and nulliparous women.
19. A 55-year-old woman presents with a painless abdominal wall bulge. She reports a successful diet and exercise program and has lost almost 40 kg over the past 2 years. However, she is worried because yesterday when she was sitting up in bed, she noticed a bulge that looks like a large ridge between her rib cage and belly button. On physical exam the bulge becomes visible when she lifts her head off the bed. Which of the following is true regarding her condition?
- A. Surgical repair should be done immediately before signs of incarceration develop.
  - B. There are both congenital and acquired etiologies.
  - C. A strict regimen of abdominal wall exercises usually results in complete resolution.
  - D. The defect is limited to the transversalis fascia.
  - E. Typically these defects contain only preperitoneal fat.
20. A 20-year-old female presents to the ED with a 4-hour history of severe left lower quadrant pain one week after an uneventful laparoscopic appendectomy. She reports nausea and anorexia but denies vomiting or difficulty with bowel movements. She is tender to palpation at the location of a previous 12-mm trocar with some overlying erythema and fullness, but the incision is intact with no drainage. CT scan shows close association of the ileum with the abdominal wall in this location and an air-fluid collection within the abdominal wall that appears to be in continuity with the ileum. The small bowel appears to be moderately dilated without a transition point. Which of the following is true of this condition?
- A. An attempt should be made to gently compress the trocar site under conscious sedation.
  - B. The trocar site should be incised and drained in the operating room.
  - C. The trocar site should be opened in the ED.
  - D. The condition can be treated laparoscopically.
  - E. There is little risk of developing necrotic bowel.
21. A 45-year-old male presents to the ED with a 4-hour history of abdominal pain and nausea. He states that he has had a small right inguinal bulge for several years that intermittently pops out and becomes painful but he has always been able to manually reduce it. The same thing occurred earlier today, but he now has constant abdominal pain. On exam, his abdomen is nontender and soft. He does not have leukocytosis. Inguinal exam reveals no evidence of a hernia on either side, and he has no testicular or epididymal tenderness. There is no tenderness to palpation of his inguinal canal. However, his nausea persists. Which of the following is the most appropriate next step?
- A. Urgent right inguinal hernia repair
  - B. Repair of right inguinal hernia within the next 2 days
  - C. CT scan of the abdomen and pelvis
  - D. Ultrasound of the scrotum
  - E. Admission for observation
22. Which of the following hernia repairs is INCORRECTLY matched with a key step in its completion?
- A. Bassini repair: incising the transversalis fascia to enter the preperitoneal space
  - B. McVay repair: incising the anterior rectus sheath
  - C. Shouldice repair: suturing the transversalis fascia to Cooper's ligament
  - D. Lichtenstein repair: recreation of the internal ring with prosthetic mesh
  - E. Laroque repair: delivery of hernia contents through an incision superior to the internal ring
23. Which of the following is true regarding component separation?

- A. Release of the internal oblique muscle is advised if one is unable to close after incision of the external oblique aponeurosis.
- B. Ligation of abdominal wall perforators is essential when raising the lateral flaps.
- C. Recurrence rates are much higher when compared with prosthetic mesh placement.
- D. Incising the posterior rectus sheath above the level of the arcuate line can increase the length available for repair.
- E. When releasing the external oblique, the incision extends from the costal margin to the arcuate line.

## Answers

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1. **A.** Severe groin pain developing in the recovery room following laparoscopic hernia repair is most likely due to a stapling/tacking injury to a nerve. If this complication is suspected, the patient should return to the operating room to remove the offending tack. The most commonly injured nerve during laparoscopic hernia repair is the lateral femoral cutaneous nerve (provides sensation to the lateral thigh). However, tacks applied too deep in the anterior abdominal wall can injure the ilioinguinal nerve (as in the above case). Injecting the groin with local anesthetic may not relieve the pain and if it works, it will only be a temporary measure (E). Medical therapy is not appropriate if the suspected etiology is irritation of the nerve secondary to stapling/tacking (B–D).
2. **A.** The etiology of inguinal hernias in infants is a patent processus vaginalis. Typically, there is no weakness in the floor of the inguinal canal. As such, high ligation of the sac is generally all that is required (B–E). On rare occasions when the hernia is very large, tightening of the internal inguinal ring or even formal repair of the inguinal floor may be necessary. Several recent studies comparing laparoscopic versus open hernia repair in the pediatric population demonstrate superiority of the former, particularly in patients with bilateral hernia and in those undergoing an extraperitoneal approach. However the most important component of either procedure is a high ligation of the sac.

**Reference:** Yang, C., Zhang, H., Pu, J., et al. (2011). Laparoscopic vs open herniorrhaphy in the management of pediatric inguinal hernia: a systemic review and meta-analysis. *Journal of Pediatric Surgery*, 46(9), 1824–1834.

3. **D.** Femoral hernias occur more commonly in females and have a high risk of incarceration. However, the most common overall hernia in females is an indirect inguinal hernia (A). Bowel entering a femoral hernia passes down a narrow femoral canal. This is because the femoral ring, which serves as the entrance for the femoral canal, is very rigid and unyielding. Thus the fixed neck of a femoral hernia is prone to pinching off the bowel, putting the patient at risk for incarceration. The borders of the femoral canal are as follows: inguinal ligament (anterior) (B), Cooper ligament (posterior), femoral vein (lateral), and Lacunar ligament (medial). Femoral hernias occur most commonly lateral to the lymphatics and medial to the femoral vein, within the empty space (C). It is important to recognize that femoral hernias pass deep (posterior) to the inguinal ligament. As such, repairs to the inguinal ligament (such as a Bassini operation and standard mesh repair) will not obliterate the defect (E). The femoral hernia can be fixed either through a standard inguinal approach or directly over the bulge using an infrainguinal incision. The essential elements of femoral hernia repair include dissection and removal of the hernia sac and obliteration of the defect in the femoral canal. This can be accomplished by either approximation of the iliopubic tract to the Cooper ligament or by placement of prosthetic mesh.

**Reference:** De Virgilio, C., Grigorian, A., & Frank, P. N. (Eds.). (2015). *Surgery: A case based clinical review*. New York, NY: Springer.

4. **D.** This patient has a spigelian hernia, which is notoriously difficult to diagnose because patients often present with abdominal wall pain without an evident bulge on examination (A). Imaging, typically with CT scan, is often required to make the diagnosis (E). They occur anywhere along the spigelian line, an aponeurotic band at the lateral border of the rectus abdominis muscle. Patients at risk may have weakness in the spigelian fascia secondary to perforating vessels leading to a small lipoma to enter the defect. The hernia is considered intraperitoneal and occurs through a defect of the transversus and internal oblique aponeuroses forming a space behind the intact external oblique. Occasionally, they even enter the rectus sheath and can be confused with a rectus sheath hematoma (C). They tend to be small with a narrow neck and as such are at risk of

incarceration or strangulation. Due to a delay in diagnosis, patients are at high risk for subsequent sepsis. They should always be repaired once diagnosed and either an open or laparoscopic repair is appropriate (B).

**References:** Bell, R. L., & Seymour, N. E. (2005). Abdominal wall, omentum, mesentery, and retroperitoneum. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp. 1317–1328) (8th ed.). New York, NY: McGraw-Hill.

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Malangoni, M. A. & Gagliardi, R. J. (2004). Hernias. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1199–1218) (17th ed.). Philadelphia, PA: W. B. Saunders.

Mittal, T., Kumar, V., Khullar, R., et al. (2008). Diagnosis and management of spigelian hernia: a review of literature and our experience. *Journal of Minimal Access Surgery*, 4(4), 95–98.

Turnage, R. H., Li, B. D., & McDonald, J. C. (2004). Abdominal wall, umbilicus, peritoneum, mesenteries, omentum, and retroperitoneum. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1171–1198) (17th ed.). Philadelphia, PA: 2004, W. B. Saunders.

5. **D.** In children, umbilical hernias are congenital. They are formed by a failure of the umbilical ring to close, causing a central defect in the linea alba. Most umbilical hernias in children are small and will close by 2 years of age, particularly if the defect is less than 1 cm in size. As such, repair is not always indicated at the time of diagnosis (B). Additionally, the decision to perform an elective repair is not solely determined by the presence of symptoms (E). If closure does not occur by age 4 or 5 years, elective repair is then considered a reasonable option (C), even if the patient is asymptomatic. If the hernia defect is large (>2 cm) or the family is bothered by the cosmetic appearance, repair should be considered. They are eight times more common in black children (A). Although it is rare, umbilical hernias in children can incarcerate. If the child presents with abdominal pain, bilious emesis, and a tender, hard mass protruding from the umbilicus, immediate exploration and hernia repair are indicated.
6. **D.** Unlike in children, umbilical hernias in adults are usually acquired (A). Risk factors are any conditions that increase intra-abdominal pressure, such as pregnancy, obesity, and ascites. Overall strangulation of umbilical hernias in adults is uncommon, but it occurs more often than in children (C). Small barely palpable and asymptomatic hernias can be followed clinically. Larger or symptomatic hernias should be repaired. In patients with cirrhosis and ascites, the markedly increased pressure causes the skin overlying the hernia to become thin and eventually ischemic. One of the most catastrophic complications in this setting is rupture of the hernia through the ischemic skin, leading to peritonitis and death. Thus, patients with cirrhosis and ascites should undergo repair if there is evidence that the skin overlying the hernia is thinning or becoming ischemic (B). However, repair should be delayed until after medical management of the ascites. If medical management fails and the skin over the hernia is thinned and tense, then a transjugular portosystemic shunt should be considered before repair. Alternatively, if the patient is a candidate for liver transplant, the hernia can be repaired during the transplantation. Umbilical hernias have historically all been repaired by primary closure. Borrowing from the low recurrence rates using mesh for inguinal hernias, umbilical hernias are now more frequently being repaired using mesh, particularly those with large defects. A recent prospective, randomized study compared primary closure with mesh repair. The early complication rates such as seroma, hematoma, and wound infection were similar in the two groups. However, the hernia recurrence rate was significantly higher after primary suture repair (11%) than after mesh repair (1%) (E). Some authors are now advocating for the routine use of mesh for all adult umbilical hernias in the absence of bowel strangulation.

**References:** Arroyo, A., García, P., Pérez, F., et al. (2001). Randomized clinical trial comparing suture and mesh repair of umbilical hernia in adults. *The British Journal of Surgery*, 88(10), 1321–1323.

Belghiti, J., & Durand, F. (1997). Abdominal wall hernias in the setting of cirrhosis. *Seminars in Liver Disease*, 17(3), 219–226.

7. **C.** A Petit hernia is bound by the latissimus dorsi muscle, the iliac crest, and the external oblique muscle (inferior lumbar triangle). A Grynfeltt hernia is a hernia bounded by the quadratus



lumborum muscle, the internal oblique muscle, and the 12th rib (superior lumbar triangle) (A). A Richter hernia involves one wall of the bowel entering the hernia sac and then becoming incarcerated (B). It is particularly dangerous because the patient does not exhibit signs of bowel obstruction, yet there is a high risk of ischemia and gangrene of the wall that is within the hernia. A hernia containing a Meckel diverticulum is known as a Littre hernia (D). Obturator hernias occur more commonly in elderly, multiparous women, and almost 50% of patients present with small bowel obstruction (E).

**Reference:** Townsend, C. M., Beauchamp, R. D., Evers, B. M., & Mattox, K. L. (Eds.). (2004). *Sabiston textbook of surgery: The biological basis of modern surgical practice* (17th ed.). Philadelphia, PA: W. B. Saunders.

8. **D.** The precise etiology of ischemic orchitis is unclear. The most commonly identified risk factor is extensive dissection of the spermatic cord. This occurs particularly when a patient has a large hernia sac, and the entire distal sac is dissected and excised. As such, it is recommended that the sac instead is divided and the distal sac left in situ. In addition, the cord should never be dissected past the pubic tubercle. Ischemic orchitis is thought to develop as a result of thrombosis of veins of the pampiniform plexus, leading to testicular venous congestion. It has thus been termed *congestive orchitis*. The presentation is that of a swollen, tender testicle, usually 2 to 5 days after surgery. The testicle is often high riding. This may eventually progress to testicular atrophy. Scrotal duplex ultrasonography has been shown to be useful in evaluating the perfusion of the testicle after hernia repair. However, it does not change the management of ischemic orchitis. Management is expectant. In the past, attempts to reexplore the groin were undertaken to try to loosen the inguinal ring, but this was not successful (A). The blood supply to the testicle is via the testicular artery, but there are rich collaterals including the external spermatic artery and the artery to the vas. Thus, inadvertent ligation of the testicular artery does not typically lead to this complication (C). Preexisting testicular pathology (B) or anomalous blood supply (E) to the testicle is not thought to contribute to ischemic orchitis following inguinal hernia repair. However, ischemic orchitis can occur more frequently in recurrent inguinal hernia surgery using the anterior approach. Thus, the laparoscopic approach should be considered for recurrent hernias.

**References:** Holloway, B., Belcher, H., Letourneau, J., et al. (1998). Scrotal sonography: a valuable tool in the evaluation of complications following inguinal hernia repair. *Journal of Clinical Ultrasound*, 26(7), 341–344.

Wantz, G. E. (1993). Testicular atrophy and chronic residual neuralgia as risks of inguinal hernioplasty. *The Surgical Clinics of North America*, 73(3), 571–581.

9. **D.** The genitofemoral nerve arises from the L1-L2 level. The genital branch innervates the cremaster muscle and sensation to the side of the scrotum and the labia. It is responsible for the cremasteric reflex. In women, it accompanies the round ligament of the uterus. The genital branch of the genitofemoral nerve is part of the cord structures. It lies on the iliopubic tract and accompanies the cremaster vessels (B). The ilioinguinal nerve lies on top of the spermatic cord (A). It innervates the internal oblique muscle and is sensory to the upper medial thigh adjacent to the genitalia. The nerve can sometimes splay out over the cord, making dissection difficult. The iliohypogastric and ilioinguinal nerves arise from the T12-L1 level and intermingle. They provide sensation to the skin of the groin, the base of the penis, and the upper medial thigh. The iliohypogastric nerve lies on the internal oblique muscle (C), provides sensory innervation from the skin overlying the pubis and does not intermingle with the genitofemoral nerve because they cross different paths (E).

**Reference:** Wantz, G. E. (1993). Testicular atrophy and chronic residual neuralgia as risks of inguinal hernioplasty. *The Surgical Clinics of North America*, 73(3), 571–581.

10. **C.** Since the advent of tension-free inguinal hernia repair, chronic pain has become the most common long-term complication far surpassing hernia recurrence. Chronic pain is present in as many as 10% to 25% of patients at 1 year after surgery (D). As such, it is imperative that this be discussed in the preoperative consent. The majority of neuralgias are self-limited, resolving within a few weeks of the operation. The etiology is thought to be entrapment of the nerve during surgery or postoperative scarring. Thus, careful identification and preservation of the nerves will not necessarily prevent this complication (A). In an effort to prevent this complication, some authors have recommended intentional division of the nerves. There has not been any conclusive evidence in the literature demonstrating that the inadvertent division of the nerves will reduce the incidence

of chronic pain (E). Initial management of neuralgias after open hernia repair should be conservative (B). Nerve blocks can help identify which nerve is the source of the problem. If conservative management does not resolve the pain, operative exploration and division of the nerve(s) have met with success. An open approach would be ill-advised in this patient, particularly in the setting of mesh, as the tissue planes are altered making it challenging to access the nerves. The ideal approach for this patient (and in the setting of hernia recurrence) is to enter a space in which the tissue planes have not been violated. If the first surgery was an open repair, the next should be a laparoscopic repair. Similarly, if a laparoscopic repair was initially performed, the subsequent surgery should be an open approach. Additionally, an open approach for the above patient will compromise the hernia repair and risk injuring the spermatic cord and testicle. The preferred management is a laparoscopic retroperitoneal triple neurectomy, which allows a single staged approach to access the ilioinguinal, iliohypogastric, and genitofemoral nerves.

**References:** Alfieri, S., Rotondi, F., Di Giorgio, A., et al. (2006). Influence of preservation versus division of ilioinguinal, iliohypogastric, and genital nerves during open mesh herniorrhaphy: prospective multicentric study of chronic pain. *Annals of Surgery*, 243(4), 553–558.

Fitzgibbons, R. J., Filipi, C. J., & Quinn, T. H. (2005). Inguinal hernias. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp. 1353–1394) (8th ed.). New York, NY: McGraw-Hill.

Chen, D. C., Hiatt, J. R., Amid, P. K. (2013). Operative management of refractory neuropathic inguinodynia by a laparoscopic retroperitoneal approach. *JAMA Surgery*, 148(10), 962–967.

Mui, W., Ng, C., Fung, T. M., et al. (2006). Prophylactic ilioinguinal neurectomy in open inguinal hernia repair: a double-blind randomized controlled trial. *Annals of Surgery*, 244(1), 27–33.

Picchio, M., Palimento, D., Attanasio, U., et al. (2004). Randomized controlled trial of preservation or elective division of ilioinguinal nerve on open inguinal hernia repair with polypropylene mesh. *Archives of Surgery*, 139(7), 755–758.

Wijsmuller, A., van Veen, R., Bosch, J., et al. (2007). Nerve management during open hernia repair. *The British journal of Surgery*, 94(1), 17–22.

11. C. The vast majority of inguinal hernias in children are the indirect type due to a persistent patent processus vaginalis. Approximately 1% to 5% of children can develop an inguinal hernia. However, the incidence increases in preterm infants and those with a low birth weight. Right-sided hernias are more common, and 10% of hernias diagnosed at birth are bilateral. Incarceration is a more serious problem in pediatric patients than in adults. Emergent operation on an infant with an incarcerated hernia can be very challenging. Thus it is preferable to try to reduce the hernia, which is successful in 75% to 80% of cases, allow the inflammation to subside over several days, and then perform the repair semi-electively. The routine use of contralateral groin exploration is not widely supported (D). However, one option is to perform laparoscopy via the hernia sac to look for a contralateral hernia, and if found proceed to repair. If there are any signs of strangulation (e.g., leukocytosis, fever, elevated lactate) then manual reduction should be avoided and the patient should be taken immediately to the operating room for surgical intervention (E). In the patient described, though the skin is erythematous, there are no signs of systemic toxicity. Methods to achieve reduction include the use of intravenous (IV) sedation, Trendelenburg positioning, ice packs, and gentle direct pressure. Reduction without subsequent surgery is not appropriate. That being said, infants with anemia and history of prematurity are at significantly increased risk of postoperative apnea and would require overnight monitoring.

**Reference:** Özdemir, T., & Arıkan, A. (2013). Postoperative apnea after inguinal hernia repair in formerly premature infants: impacts of gestational age, postconceptional age and comorbidities. *Pediatric Surgery International*, 29(8), 801–804.

12. A. Poupart ligament is another name for the inguinal ligament. The inguinal ligament is formed from the anteroinferior portion of the external oblique aponeurosis folding back on itself. It extends from the anterosuperior iliac spine to the pubic tubercle, turning posteriorly to form a shelving edge. The cremaster muscle fibers arise from the internal oblique muscle and surround the spermatic cord (B). The genital branch of the genitofemoral nerve passes through the deep ring (C), whereas the ilioinguinal nerve passes through the superficial ring. The genital branch innervates the cremaster muscle, whereas the femoral branch controls sensation to the upper lateral thigh (D). Indirect hernias arise lateral to the inferior epigastric vessels, whereas direct hernias arise medial to the inferior epigastric vessels. The lateral border of the rectus muscle,

inferior inguinal ligament, and inferior epigastric artery define the borders of Hesselbach triangle and define the location of a direct hernia (E).

13. **C.** The arcuate line is located below the umbilicus, typically one-third the distance to the pubic crest (A). Between the costal margin and the arcuate line, the anterior rectus sheath is made up of a combination of the aponeurosis of the external and internal oblique muscles. The posterior sheath is made up of a combination of the aponeuroses of the internal oblique and transverse abdominal muscles. Below the arcuate line, the anterior sheath is made up of the aponeuroses of all three abdominal muscles (E). The internal oblique aponeurosis splits above the arcuate line to envelop the rectus abdominis muscle (B). There is no posterior sheath below the arcuate line (D), and the transversalis fascia therefore makes up the posterior aspect of the rectus abdominis muscle.

14. **C.** A recent large prospective, randomized study in men demonstrated that watchful waiting for patients with asymptomatic or minimally symptomatic inguinal hernias is an acceptable option to surgery (D). The patients were followed for as long as 9 years. Acute hernia incarceration without strangulation developed in only one (0.3%) patient, and acute incarceration with bowel obstruction developed in only one (A). Approximately one-fourth of the watchful waiting group eventually crossed over to receive surgical repair due to increased hernia-related pain (B). Smaller hernias tend to have a smaller neck, placing them at higher risk for developing incarceration (E).

**Reference:** Fitzgibbons, R., Giobbie-Hurder, A., Gibbs, J., et al. (2006). Watchful waiting vs repair of inguinal hernia in minimally symptomatic men: a randomized clinical trial. *JAMA*, 295(3), 285–292.

15. **E.** This patient has bilateral inguinal hernias, one of which is recurrent and should be offered a laparoscopic repair. The advantages of this include the ability to visualize both sides through a single incision and a potentially easier surgery in the setting of recurrence. It also protects the patient from developing a femoral hernia since the femoral canal is covered by the mesh. Of note, femoral hernias are known to develop after open inguinal hernia repair. They develop on average sooner than a typical recurrence, suggesting that the original hernia was in fact a femoral one and was missed at the original surgery. The two laparoscopic approaches include TEP and TAPP. TEP involves dissecting a plane in the preperitoneal space, which may actually be advantageous when compared to TAPP because intra-abdominal adhesions are avoided (A). This does not hold true for prior pelvic surgery as the preperitoneal space may be obliterated in these patients, necessitating a TAPP. If the peritoneum is violated during TEP, it is important to repair the defect to prevent adhesion formation postoperatively, but it is not mandatory to convert to a different technique (C). Though there are few absolute contraindications to laparoscopic hernia surgery, bowel ischemia with perforation or sepsis precludes the use of mesh, which is required in both TEP and TAPP. Tacking of the mesh in either laparoscopic approach can reduce mesh migration but should be avoided lateral to the epigastric vessels and inferior to the iliopubic tract to avoid placement in the “triangle of doom” or the “triangle of pain,” which contain the external iliac vessels and several nerves (lateral femoral cutaneous and femoral branch of genitofemoral, respectively) (B). Injury to these nerves is relatively specific to laparoscopic repairs (D).

**Reference:** Fischer, J. E. (2012). *Fischer’s mastery of surgery*. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins.

16. **C.** The preferred initial approach for an uncomplicated inguinal hernia is still actively debated within the surgical community. The LEVEL-trial specifically compared TEP repair versus open mesh repair and demonstrated reduced pain in the immediate postoperative period and earlier return to work. However, this came at the expense of longer operating room times and higher intraoperative complication rates (B, D). This seems to be consistent with the results of a *New England Journal of Medicine* study from 2004 comparing open mesh repair to all methods of laparoscopic mesh repair. However, they diverge on reported recurrence rates with the *NEJM* study favoring open repair (recurrence of 4% versus 10.1%) while the LEVEL-Trial showed equivalent recurrence rates (3.0% for open and 3.8% for TEP) (E). The LEVEL-Trial also indicated an equivalent prevalence of chronic pain, which was not one of the outcomes in the *NEJM* article (A).

**References:** Langeveld, H. R., van’t Riet, M., Weidema, W. F., et al. (2010). Total extraperitoneal inguinal hernia repair compared with Lichtenstein (the LEVEL-Trial): a randomized controlled trial. *Annals of Surgery*, 251(5), 819–824.

Neumayer, L., Giobbie-Hurder, A., Jonasson, O., et al. (2004). Open mesh versus laparoscopic mesh repair of inguinal hernia. *The New England Journal of Medicine*, 350(18), 1819–1827.

17. **D.** Incisional hernias are a relatively common complication and occur in approximately 10% of

midline laparotomies (A). Surgical site infection is probably the strongest predictor for development of an incisional hernia, but obesity, chronic obstructive pulmonary disease, and diabetes have all been identified as risk factors. No data exist to implicate early return to activity as a significant risk factor at this point in time. Primary repair is a reasonable approach if the defect is small (<3 cm) and viable, robust, and healthy tissue is available for repair, but placement of mesh reduces recurrence by almost 50% in larger hernias. Several methods exist for placement of mesh during open and laparoscopic repair, and current data seem to support the use of underlay mesh when possible and to have at least 4 cm of overlap to reduce recurrence. Interposition mesh has a predictably higher rate of recurrence when compared with mesh that overlaps with normal fascia (E). Though larger defects with loss of abdominal domain may be more difficult or impossible with laparoscopic repair, there is no definitive size cutoff (C). Relative contraindications to laparoscopic repair also include need for prior mesh removal, presence of an enterocutaneous fistula, and large defects with loss of abdominal wall domain. Recurrence rates and postoperative pain following open or laparoscopic repair seem to be similar, but laparoscopic repair shows lower rates of postoperative wound infections. The intraoperative cost of laparoscopic repair is higher compared to open repair but patients have a shorter hospital stay and thus total costs are similar (B).

**References:** Fischer, J. E. (2012). *Fischer's mastery of surgery*. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins.

Townsend, C. M., Beauchamp, R. D., Evers, B. M., & Mattox, K. L. (Eds.). (2004). *Sabiston textbook of surgery: The biological basis of modern surgical practice* (17th ed.). Philadelphia, PA: W. B. Saunders.

18. **B.** The most common presentation of a femoral hernia is a painful bulge just inferior to the inguinal ligament, and it is commonly associated with bowel obstruction as well. The hernia passes through the femoral canal, which is bounded by the inguinal ligament anteriorly, the femoral vein laterally, Cooper's ligament inferiorly, and the lacunar ligament medially (A). Though they always enter the groin inferior to the inguinal ligament, it is possible for a part of the hernia to be located above it. Watchful waiting is never indicated, as these hernias are associated with a high incidence of strangulation (15–20%) and subsequent bowel ischemia. Open repair can be achieved via a standard suprainguinal incision with a Cooper ligament repair or via an infrainguinal incision directly over the hernia. With this latter approach, a plug of mesh can be rolled into a cigarette shape and used to plug the femoral canal (D). Multiparous women are at increased risk of development of a femoral hernia. Though the pathophysiology is not completely understood, it is likely from a combination of increased abdominal pressure during pregnancy and subsequent femoral vein, leading to stretching of the femoral canal (E). The femoral triangle is a subfascial space that is defined superiorly by the inguinal ligament, medially by the adductor longus, and laterally by the sartorius muscle (C). The femoral artery, vein, nerve, and canal can all be found within these borders.
19. **B.** It is important to understand the difference between epigastric hernias and diastasis recti because the former is a true hernia, which should be repaired, and the latter is a benign condition. Diastasis recti is caused by increased separation of the rectus abdominis muscles and a relative thinning of the linea alba, which can mimic a hernia. The condition can be acquired, such as in multiparous women where the repeated stretching of the abdominal wall causes the rectus muscles to separate, or congenital, secondary to more lateral attachment of the rectus muscles at birth. Classically, patients present after recent weight loss because this allows for the lesion to be visible. There is no risk for strangulation in diastasis recti because all of the fascial layers are intact (A, D). Though several methods of surgical repair have been described, these are mainly cosmetic. In general, all that is required is reassurance and abdominal wall exercises to help strengthen the musculature—though complete resolution in adults is unlikely (C). In contrast, epigastric hernias are true hernias and represent a true defect in the linea alba. They are generally small and contain either preperitoneal fat or part of the falciform ligament (E). They arise from defects in the fascia in locations where neurovascular bundles perforate through. Though small, they can cause significant pain because of compression of the nerves traveling through the defect. There is some evidence to suggest that diastasis rectus may increase the risk for development of an epigastric hernia and will make primary repair of epigastric hernias more challenging. Of note, patients with diastasis recti are at increased risk of abdominal aortic aneurysms.

**References:** Brunicki, F. C., Andersen, D. K., & Schwartz, S. I. (2015). *Schwartz's principles of surgery*. New York, NY: McGraw-Hill Education.

Köhler, G., Luketina, R. R., Emmanuel, K. et al. (2014). Sutured repair of primary small umbilical and epigastric hernias: concomitant rectus diastasis is a significant risk factor for recurrence. *World Journal of Surgery*, 39(1), 121–126.

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20. **D.** The presentation is consistent with a port site hernia, and more specifically a Richter hernia. It is an uncommon complication, but delayed diagnosis can quickly lead to bowel perforation and sepsis. In order for this to develop, there has to be a fascial defect to allow for part of the antimesenteric bowel wall to herniate through but not large enough to accommodate an entire loop of bowel. The antimesenteric bowel wall is furthest from the blood supply, and a Richter hernia can quickly progress to venous congestion, gangrene, and eventual perforation (E). Since an entire loop of bowel is not involved and the lumen is open, obstruction may be a late or completely absent finding. Reduction should not be attempted outside of the operating room because of the high risk of returning ischemic bowel to the abdomen (A). Swelling and pain at the incision site due to a hernia may be hard to differentiate from a hematoma or wound infection. Treatment is surgical with reduction of the hernia and closure of the defect. This can be achieved laparoscopically or via open exploration of the trocar site with direct visualization of the incarcerated bowel. If the bowel is necrotic, a small bowel resection may be needed. If an infection is suspected with an overlying abscess, then the trocar site can be opened in the ED and subsequently drained (B, C).

**Reference:** Skandalakis, P. N., Zoras, O., Skandalakis J. E., et al. (2006). Richter hernia: surgical anatomy and technique of repair. *The American Surgeon*, 72(2), 180–185.

21. **C.** Patients with chronic hernias that are repeatedly reduced have an increased risk of developing “reduction en masse of inguinal hernia” in which the hernia sac is pushed into the preperitoneal space with the incarcerated bowel still trapped within the sac. This rare condition occurs as a result of fibrosis of the hernial sac and should be suspected anytime a hernia has been successfully reduced but signs of bowel obstruction persist. This condition requires prompt surgical intervention. However, diagnosis is difficult without a CT scan demonstrating the “preperitoneal hernia sac sign.” Observation is not appropriate because this condition can quickly progress to sepsis in the setting of bowel ischemia and/or perforation (E). Repair of the right inguinal hernia alone is not appropriate since the patient has findings concerning for bowel ischemia (A, B). Ultrasound of the scrotum can be considered if he had testicular or epididymal pain or swelling (D).

**Reference:** Ravikumar, H., Babu, S., Govindrajan, M., et al. (2009). Reduction en-masse of inguinal hernia with strangulated obstruction. *Biomedical Imaging and Intervention Journal*, 5(4), e14.

22. **C.** Though primary tissue repairs have largely been replaced with tension-free mesh repairs in the treatment of inguinal hernia, they represented a large advancement in reducing recurrence rates of inguinal hernias. All of the described techniques start with identification of the hernia sac, blunt dissection, and reduction or ligation of the sac back into the abdomen. The Bassini repair involves opening the transversalis fascia from the internal ring to the pubic tubercle. The internal oblique, transversus abdominis, and transversalis fascia are then incorporated into a “triple layer,” which is sewn directly to the inguinal ligament (A). The Bassini repair has the highest recurrence rate. Working off these same principles, the Shouldice repair reconstructs the floor of the inguinal canal via a running continuous suture that incorporates four separate layers. After incising the transversalis fascia, the repair begins by suturing the iliopubic tract to the lateral border of the rectus sheath. The inferior flap of the transversalis (which includes the iliopubic tract) is then sewn to a posterior portion of the superior transversalis flap progressing laterally. The suture is then reversed, and the second layer begins by re-approximating the superior and inferior transversalis flaps, recreating the inguinal ring and progressing medially. The suture is then tied to its own tail once the suture reaches the pubic tubercle again. A new suture line is then started near the recreated inguinal ring, which approximates the internal oblique and transversus abdominis aponeurosis with the external oblique aponeurosis just superficial to the inguinal ligament. This is run medially to the pubic tubercle and then reverses and creates a fourth and final layer incorporating the same muscle layers but slightly more superior. In a McVay repair, an additional step is taken after reconstruction of the inguinal floor. The upper margin of the transversalis fascia is sewn to Cooper ligament medially until the femoral canal is passed, at which point a transition

stitch connects the transversalis fascia to the inguinal ligament and it is run laterally until it ends at the internal ring. The advantage of this repair is the obliteration of the femoral canal. However, because of the high tension on this type of repair, McVay incised the anterior rectus sheath, which reduced the tension on the repair (relaxing incision) (B). The Lichtenstein tension-free repair uses prosthetic mesh to reconstruct the deep ring and inguinal floor instead of incising the transversalis fascia (C). Finally, the Laroque repair involves an intra-abdominal, muscle-splitting incision just superior to the deep inguinal ring to facilitate reduction of sliding hernias followed by reconstruction of the inguinal floor using any of the previous techniques (E).

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23. **D.** Component separation is a technique to facilitate primary repair of a large ventral hernia. First, subcutaneous flaps are raised a minimum of 5 cm from the edge of the fascia. Attention should be paid to preserve perforating vessels to avoid ischemic necrosis of the skin (B). The external oblique aponeurosis is then identified and a relaxing incision is made 2 cm lateral to the linea semilunaris that extends from just above the costal margin to the pubis (E). The external oblique is then freed from its attachments with the underlying internal oblique. If more length is necessary to facilitate primary closure, the posterior rectus sheath can be incised above the level of the arcuate line. Techniques have been described for release of the internal oblique and transversus abdominis, but there is a high rate of lateral bulging of the abdominal wall if these methods are utilized. They should generally be avoided (A). Though several studies have shown reduced recurrence rates of smaller incisional hernias with the placement of mesh, a study comparing component separation to underlay mesh indicated relatively similar recurrence rates at 36 months and much higher infection rates in the mesh group (C).

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# Abdomen—Biliary

*Areg Grigorian, and Christian de Virgilio*

## Questions

1. Hemobilia is most frequently accompanied by what other finding?
  - A. Arterioportal vein fistula
  - B. Arteriohepatic vein fistula
  - C. Arterial pseudoaneurysm
  - D. Portal venous pseudoaneurysm
  - E. Cavernous hemangioma
2. Choledochal cyst disease is thought to be caused by an abnormality of the:
  - A. Bile duct smooth muscle
  - B. Bile composition
  - C. Bile duct adventitia
  - D. Pancreaticobiliary duct junction
  - E. Bile duct mucosa
3. Which of the following statements is true regarding the use of intraoperative cholangiography (IOC) during laparoscopic cholecystectomy?
  - A. It helps prevent inadvertent incision of the common bile duct (CBD).
  - B. It is the best way to identify clinically significant unsuspected common duct stones.
  - C. Routine use is justified because of its ability to identify anatomic anomalies of the hepatic ducts.
  - D. Routine use is helpful to ensure complete removal of the gallbladder and cystic duct.
  - E. Routine use is unnecessary.
4. During a laparoscopic cholecystectomy for symptomatic cholelithiasis, the surgical resident inadvertently transects the CBD. The best choice for operative repair is:
  - A. End-to-end CBD anastomosis
  - B. Choledochoduodenostomy
  - C. Choledochojejunostomy
  - D. Hepaticoduodenostomy
  - E. Hepaticojejunostomy
5. Which of the following is true regarding the gallbladder?
  - A. It passively absorbs sodium and chloride.
  - B. In the setting of cholelithiasis, cholecystokinin (CCK) can cause gallbladder pain that waxes and wanes.
  - C. It harbors an alkaline environment.
  - D. Glucagon can help empty the gallbladder.
  - E. Its contraction is inhibited by vagal stimulation.
6. A 65-year-old woman presents with symptoms and signs of acute cholecystitis and undergoes an uneventful laparoscopic cholecystectomy. On postoperative day 7, the pathology report indicates a

- superficial gallbladder carcinoma that invades the perimuscular connective tissue. There is no evidence of distant metastasis on subsequent imaging. Which of the following would be the best management?
- Radiation and chemotherapy
  - Observation
  - Reoperation with resection of liver segments IVB and V
  - Reoperation with resection of liver segments IVB and V and regional lymph node dissection
  - Reoperation with resection of liver segments IVB and V, regional lymph node dissection, and resection of all port sites
7. A 24-year-old male presents with acholic stools and cola-colored urine. Alkaline phosphatase is 2000 IU/L, AST is 78 IU/L, ALT is 88 IU/L, and total bilirubin is 2.1 mg/dL. Liver biopsy demonstrates periductal concentric fibrosis around macroscopic bile ducts. He is positive for perinuclear antineutrophil cytoplasmic antibody (p-ANCA). Which of the following is true about this condition?
- It is more commonly associated with Crohn disease than it is with ulcerative colitis.
  - Cancer antigen (CA) 19-9 levels should be determined.
  - Endoscopic retrograde cholangiopancreatography (ERCP) will predominantly demonstrate irregular narrowing of the intrahepatic biliary tree.
  - Symptoms are often well controlled with medical management.
  - It is more common in females.
8. Which of the following is the best management of a localized Klatskin tumor?
- Pancreaticoduodenectomy (Whipple procedure)
  - Resection of the entire extrahepatic biliary tree with hepatic resection if necessary
  - Resection of the middle third of the biliary tree with hepaticojejunostomy
  - Chemotherapy
  - Radiation followed by chemotherapy
9. An 80-year-old patient presents with nausea, fever, and right upper quadrant pain and tenderness. Ultrasonography reveals gallstones as well as air in the wall of the gallbladder. His temperature is 103.5°F and blood pressure is 70/40 mm Hg. Medical therapy is initiated, and pressors are needed to maintain blood pressure. Which of the following is true regarding this condition?
- Metronidazole is an important antibiotic choice.
  - Emergent cholecystectomy is indicated.
  - Urgent percutaneous drainage is preferred over cholecystectomy.
  - The most common organism is an anaerobic gram-negative rod.
  - Perforation of the gallbladder is rare.
10. Which of the following is true regarding bile and gallstones?
- The primary bile acids are deoxycholic and lithocholic acid.
  - The primary phospholipid in bile is lecithin.
  - Cholecystectomy decreases bile salt secretion.
  - Brown pigmented gallstones are more likely to be found in the gallbladder versus the CBD.
  - Bile consists of an equal part bile salts, phospholipids, and cholesterol.
11. A 75-year-old woman presents to the emergency department with a 2-day history of nausea, feculent vomiting, and obstipation. Her blood pressure on admission is 80/60 mm Hg, and her heart rate is 120 beats per minute. Plain films reveal distended loops of small bowel with air–fluid levels, as well as air in the biliary tree. After resuscitation, which of the following is the best management option?
- Small bowel enterotomy with removal of the gallstone plus cholecystectomy and takedown of the fistula
  - Small bowel enterotomy with removal of the gallstone alone
  - Cholecystectomy with CBD exploration
  - Prolonged nasogastric tube decompression and intravenous (IV) antibiotics

- E. Lysis of adhesions plus resection of the small bowel
12. Rokitansky-Aschoff sinuses are seen with:
- A. Acute cholecystitis
  - B. Chronic cholecystitis
  - C. Oriental cholangiohepatitis
  - D. Sclerosing cholangitis
  - E. Acalculous cholecystitis
13. Which of the following is the correct pairing of anatomic structure and direction for retraction during a laparoscopic cholecystectomy?
- A. Gallbladder fundus laterally
  - B. Gallbladder infundibulum laterally
  - C. Gallbladder body laterally
  - D. Gallbladder infundibulum cephalad
  - E. Gallbladder fundus medially
14. Which of the following best describes the role of early (within 24 hours of admission) laparoscopic cholecystectomy for acute cholecystitis?
- A. It results in a shortened hospital stay.
  - B. It increases the rate of conversion to open cholecystectomy.
  - C. It should not be performed because the patient should be “cooled off” for 2 to 3 days with antibiotics.
  - D. It is associated with a higher overall complication rate.
  - E. It is associated with a higher mortality rate.
15. Which of the following is a feature of gallbladder cancer?
- A. Speckled cholesterol deposits are found on the gallbladder wall.
  - B. There are thickened nodules of mucosa and muscle.
  - C. Gallbladder cancer is more common in males.
  - D. It is more likely to be accompanied by large gallstones compared with smaller ones.
  - E. Porcelain gallbladders have a higher risk of harboring malignancy and should be prophylactically removed.
16. The most common cause of benign bile duct stricture is:
- A. Ischemia from operative injury
  - B. Chronic pancreatitis
  - C. Common duct stones
  - D. Acute cholangitis
  - E. Sclerosing cholangitis
17. On CT scan a type I choledochal cyst appears to be adherent to the posterior wall of the portal vein. Management consists of:
- A. Partial excision of the cyst, leaving posterior wall behind, and cholecystectomy with Roux-en-Y hepaticojejunostomy
  - B. Complete excision of the cyst, cholecystectomy, and hepaticojejunostomy
  - C. Partial excision of the cyst, fulguration of posterior cyst mucosa, and cholecystectomy with Roux-en-Y hepaticojejunostomy
  - D. Observation
  - E. Roux-en-Y cyst jejunostomy
18. Strawberry gallbladder is a gross description given to:
- A. Cholesterosis
  - B. Adenomyomatosis
  - C. Porcelain gallbladder

- D. Acalculous cholecystitis
  - E. Gangrenous cholecystitis
19. Jaundice with absent urine urobilinogen is most consistent with:
- A. Hepatitis
  - B. Cirrhosis
  - C. Hemolysis
  - D. Biliary obstruction
  - E. Sepsis
20. Which of the following best describes the role of preoperative biliary drainage before a Whipple procedure in a patient with obstructive jaundice?
- A. It has been shown to decrease the rate of cholangitis.
  - B. It has been shown to increase the rate of wound infections.
  - C. It should be performed routinely if the bilirubin level is greater than 8 mg/dL.
  - D. It has been shown to shorten the hospital stay.
  - E. It has been shown to decrease the mortality rate.
21. Ultrasonography of the gallbladder reveals a polypoid lesion. This most likely represents:
- A. A cholesterol polyp
  - B. Adenomyomatosis
  - C. A benign adenoma
  - D. Adenocarcinoma
  - E. An inflammatory polyp
22. A 45-year-old man has a 50% total body surface area third-degree burn. On hospital day 7, fever, marked leukocytosis, and right upper quadrant pain develop. His blood pressure is 130/80 mm Hg and his heart rate is 110 beats per minute. Ultrasonography shows a distended gallbladder, with gallbladder wall thickening and sludge. However, it is negative for gallstones. Antibiotics are initiated. The next step in management would consist of:
- A. Laparoscopic cholecystectomy
  - B. Computed tomography
  - C. Hepatobiliary iminodiacetic acid (HIDA) scan
  - D. Percutaneous cholecystostomy
  - E. Upper endoscopy
23. A 35-year-old Chinese man presents with a fever of 103.5°F, right upper quadrant pain, and jaundice. Laboratory values are significant for a white blood cell count of 15,000 cells/L, an alkaline phosphatase level of 400 U/L, and a serum bilirubin level of 3.8 mg/dL. Magnetic resonance cholangiopancreatography (MRCP) demonstrates a markedly dilated CBD, markedly dilated intrahepatic ducts with several intrahepatic ductal strictures, and multiple stones throughout the ductal system. Which of the following is true regarding this condition?
- A. It is associated with close contact with dogs and sheep.
  - B. It is more commonly associated with black pigment stones versus brown pigment stones.
  - C. It more commonly affects males.
  - D. Metronidazole is able to resolve the majority of cases.
  - E. Initial treatment is with endoscopic retrograde cholangiopancreatography and transhepatic cholangiography.
24. Which of the following is true regarding biliary anatomy?
- A. The right hepatic duct tends to be longer than the left and more prone to dilation.
  - B. Venous return from the gallbladder is most often via a cystic vein to the portal vein.
  - C. Heister valves have an important role in the gallbladder's function as a bile reservoir.
  - D. The CBD and pancreatic duct typically unite outside the duodenal wall.
  - E. The arterial supply to the CBD derives primarily from the left hepatic and right gastric arteries.

25. During laparoscopic cholecystectomy, bile appears to be emanating near the junction of the CBD and cystic duct. Upon conversion to open cholecystectomy, the injury is noted to be a 3-mm longitudinal tear in the anterolateral distal common hepatic duct. The duct itself measures 7 mm in diameter. Management consists of:
- Primary repair of the injury without a T tube
  - Primary repair of the injury over a T tube
  - Primary repair of the injury with a T tube placed through a separate choledochotomy
  - Hepaticojejunostomy
  - Choledochoduodenostomy
26. Hydrops of the gallbladder:
- Poses a significantly increased risk of malignancy
  - Is due to a stone impacted in the cystic duct
  - Typically starts with an enteric bacterial infection
  - Is associated with marked right upper quadrant tenderness
  - Results in the gallbladder getting filled with bile-stained fluid
27. Which of the following patients has the best indication for a laparoscopic cholecystectomy?
- A 45-year-old asymptomatic male with type 2 diabetes mellitus incidentally discovered to have gallstones
  - 25-year-old male trauma, who is now quadriplegic, incidentally discovered to have gallstones
  - A 22-year-old female who is 11 weeks pregnant with symptomatic cholelithiasis
  - A 4-year-old male with asymptomatic incidentally discovered gallstones
  - A 38-year-old asymptomatic female with a 3-mm gallbladder polyp
28. Which of the following is true regarding cholangiocarcinoma?
- The majority are intrahepatic.
  - Bismuth-Corlette type I cholangiocarcinoma occurs above the confluence of the right and left hepatic ducts.
  - Most patients benefit from adjuvant chemoradiation after surgical intervention.
  - It arises from malignant transformation in hepatocytes.
  - Resection with biliary-enteric bypass is considered appropriate management in patients with early disease.
29. Which of the following is true regarding bile and gallbladder disease?
- Primary bile acids are formed by deconjugation.
  - Bile acids are passively absorbed in the terminal ileum.
  - Bile acids are responsible for the yellow color of bile.
  - Bile duct stones occurring 1 year after cholecystectomy are considered primary common duct stones.
  - In between meals, gallbladder emptying is stimulated by motilin.
30. A 42-year-old female underwent an uneventful laparoscopic cholecystectomy. Two weeks later she presents to the emergency department with vague abdominal pain. Her vitals are normal and stable. Total bilirubin is 1.1 mg/dL. CT scan demonstrates a large biloma. Which of the following is the best choice for definitive intervention?
- CT-guided drainage
  - ERCP with biliary stent placement
  - Operative drainage
  - Hepaticojejunostomy
  - Choledochojejunostomy

## Answers

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1. **C.** Hemobilia is a rare condition and presents with a classic (Quinke's) triad of upper gastrointestinal bleeding (hematemesis), combined with jaundice and right-sided upper abdominal pain. It is most often a result of iatrogenic injury of the right hepatic artery (more common if there is an aberrant right hepatic artery off the superior mesenteric artery) during laparoscopic cholecystectomy but may also occur following blunt and penetrating traumatic injuries. The underlying lesion is typically an arterial pseudoaneurysm that has a connection with the biliary tree (hence the jaundice). It can also occur in association with gallstones, tumors, inflammatory disorders, and vascular disorders. Treatment in most instances involves angiographic embolization of the artery (thus angiography is most likely to be the therapeutic study of choice). Endoscopy may show blood coming from the ampulla of Vater but will not typically be therapeutic (because the bleeding is coming from a hepatic artery pseudoaneurysm). The remaining answer choices are not thought to play a role in hemobilia (A, B, D, E).

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2. **D.** The exact etiology of choledochal cysts is unclear. The most likely explanation is that there is an anomalous pancreaticobiliary duct junction. Specifically, the pancreatic duct joins the common bile duct more than 1 cm proximal to the ampulla, resulting in a long common channel. The long channel leads to free reflux of pancreatic secretions into the biliary tract, resulting in increased biliary pressures and inflammatory changes in the biliary epithelium, which eventually lead to dilation and cyst formation. Although an abnormal pancreaticobiliary junction is present in the majority of patients with choledochal cysts, it is not uniformly seen in all. Choledochal cysts are more common in females and Asians. It classically presents in childhood with jaundice and an abdominal mass accompanied by abdominal pain. In infants, it may be confused with biliary atresia. However, less than 50% of patients present with all three features, and thus the diagnosis is often delayed. The most common presentation is nonspecific abdominal pain. The diagnosis is made by ultrasonography, which can sometimes detect the cyst antenatally. There are five types. Type I is the most common (90%) and consists of fusiform dilation of the bile duct. Type V, also known as Caroli disease, is characterized by multiple intrahepatic dilations. Because of the risk of malignant degeneration, treatment involves excising the cyst with a biliary enteric bypass (typically hepaticojejunostomy). The risk of malignancy increases with the more advanced age at which the cyst is detected. Type V (Caroli) will need a partial liver resection or liver transplant. Biliary smooth muscle (A), mucosa (E), ductal adventitia (C), and bile (B) are not thought to play a role in choledochal cyst disease.

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3. **E.** The routine use of IOC to prevent bile duct injury is controversial, but most surgeons would say that routine use is unnecessary. Because the overall risk of bile duct injury is so small, to date there are no sufficiently large-scale randomized studies to answer this question. Most likely the use of IOC will not prevent an injury to the CBD (A). However, IOC seems to allow earlier recognition of a CBD injury and prevent complete transection of the CBD. Although routine IOC will identify unsuspected CBD stones, in most instances, CBD stones are suspected preoperatively by abnormal liver function tests, a dilated CBD, or a history of gallstone pancreatitis. In a nationwide retrospective analysis, CBD injury was found in 0.39% of patients undergoing cholecystectomy with IOC and in 0.58% of patients without IOC (unadjusted relative risk, 1.49). After controlling for patient-level factors and surgeon-level factors, the risk of injury was increased when IOC was not



used (adjusted relative risk, 1.71). Some surgeons prefer selective use of IOC and obtain what is known as the “critical view” whereby the cystic duct and artery are carefully identified and not clipped or cut until conclusive identification has been made. This is done by completely dissecting the Calot triangle free of all fat and fibrous tissue and dissecting the lower part of the gallbladder off the liver bed, such that only two skeletonized structures (the cystic duct and artery) are seen to be entering the gallbladder.

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4. **E.** The majority of common bile duct injuries occur iatrogenically during laparoscopic cholecystectomy in patients with relatively benign gallbladder disease (e.g., symptomatic cholelithiasis, acute cholecystitis). The management of an intraoperative bile duct injury depends on the type of injury and the clinical setting. If a small lateral injury is created in the CBD, this can be repaired by closing the ductotomy over a T tube and leaving a drain. Conversely, if the common bile duct is transected, this results in an interruption in the blood supply to the duct, and attempts at primary repair will inevitably lead to stricture formation and recurrent episodes of cholangitis (A). Thus, if a transection is recognized intraoperatively, it is best to repair it immediately and to do so with a biliary enteric bypass. Because most of these injuries will be in the common bile duct, the best option is to perform a hepaticoenterostomy (B, C). A critical element of the repair is to perform a tension-free, mucosa-to-mucosa duct enteric anastomosis. Hepaticoduodenostomy has largely been abandoned for benign liver disease due to ongoing enteric reflux (D). It is also more technically challenging to perform because it is difficult to reach the duodenum to the hepatic duct; thus most surgeons prefer a hepaticojejunostomy. This also depends on whether a surgeon is available with experience in treating complex biliary problems. If one is not available, the best option is to drain the area, place transhepatic catheters, and refer the patient. If the injury is discovered postoperatively and there has been a long delay, the best option is to perform transhepatic drainage and delay primary repair for 6 to 8 weeks to allow the inflammation to subside.

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5. **D.** The gallbladder concentrates and stores bile. It does this by rapidly absorbing sodium and chloride against a concentration gradient by active transport and passive water absorption (A). The epithelial cells of the gallbladder secrete mucous glycoproteins and hydrogen ions into the gallbladder lumen. The secretion of hydrogen ions acidifies the bile, increasing calcium solubility, and thus preventing its precipitation as calcium salts (C). Inflammation of the gallbladder mucosa seems to affect the ability to secrete hydrogen ions, making the bile more lithogenic. Vagal innervation stimulates contraction of the gallbladder (E). CCK causes steady and tonic contraction. The term *biliary colic* is a misnomer because postprandial gallbladder pain secondary to cholelithiasis does not wax and wane but rather stays constant for up to several hours (B). The more appropriate term is *symptomatic cholelithiasis*. The gallbladder normally fills by contraction at the sphincter of Oddi at the ampulla of Vater. In contrast, glucagon relaxes the sphincter of Oddi and creates the path of least resistance allowing the gallbladder to empty into the duodenum.

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6. **D.** Cancer of the gallbladder is predominantly adenocarcinoma. The majority of cases are discovered in an advanced state with distant metastases. Thus, the overall prognosis is very poor, with a 5-year survival rate of only 5%. The best chance of cure is if it is discovered incidentally at the time of cholecystectomy. It is 17 times more likely to be discovered in patients following open cholecystectomy as compared with laparoscopic cholecystectomy. Gallbladder cancer metastasizes first to the celiac axis lymph nodes. Recent studies indicate that those that are discovered incidentally and are superficial, such as carcinoma in situ and T1 lesions (do not extend into perimuscular connective tissue), and have negative margins that can be managed by cholecystectomy alone (B). This has a 100% 5-year survival. Those that are more locally advanced such as T2 through T4 lesions (those that invade the perimuscular connective tissue or directly invade the liver) are treated with a radical cholecystectomy, which includes subsegmental resection of segments IVb and V, plus hepatoduodenal ligament lymphadenectomy, which results in prolonged survival (C). The caveat is that there must be no evidence of distant metastases. In one series of 48 patients, the overall 5-year survival rate was 13%, but it was 60% for patients who underwent radical cholecystectomy. The radical cholecystectomy group had significantly longer survival than the simple cholecystectomy group for all stages except stage I (T1N0). Although port sites are associated with peritoneal disease and decreased survival, removing them does not improve survival and should not be done routinely in all patients with incidentally discovered gallbladder cancer (E). Radiation therapy with fluorouracil radiosensitization is the most commonly used postoperative treatment.

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7. **B.** Sclerosing cholangitis is characterized by the presence of multiple inflammatory fibrous thickenings resulting in irregular narrowing of the entire biliary tree (C). It is progressive and as such leads eventually to biliary obstruction, recurrent biliary infection, cirrhosis, and liver failure, as well as a significantly increased risk of cholangiocarcinoma (in 10–20% of patients). All patients should be checked for an elevated level of CA 19-9. It is twice as common in men, and they tend to be young (E). Risk factors for sclerosing cholangitis include inflammatory bowel disease, pancreatitis, and diabetes. The strongest association is with ulcerative colitis (A). Approximately two-thirds of patients have ulcerative colitis. In fact, it is usually discovered in these patients when an abnormal liver function test result is noted. Alkaline phosphatase is characteristically elevated out of proportion to an elevated bilirubin level. Patients may test positive for p-ANCA antibodies (in contrast to antimitochondrial antibodies for primary biliary cirrhosis). It is less commonly associated with Crohn disease. Other diseases associated with sclerosing cholangitis include Riedel thyroiditis and retroperitoneal fibrosis. Removing the colon in patients with ulcerative colitis does not affect the course of the sclerosing cholangitis. In addition, the severity of inflammation does not predict the onset of malignancy. All newly diagnosed patients with sclerosing cholangitis with or without an inflammatory bowel disease diagnosis should be scheduled for a screening colonoscopy. Patients can be managed initially with steroids, methotrexate, and cyclosporine, but

the majority will ultimately require more invasive treatment including biliary stenting (D). Currently, the best option is liver transplantation in patients who progress to liver failure.

**Reference:** Oddsdottir, M., & Hunter, J. G. (2005). Gallbladder. In F. C. Brunicaudi, D. K. Andersen, T. R. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp. 1187–1200) (8th ed.). New York, NY: McGraw-Hill.

8. **B.** Perihilar cholangiocarcinomas are also known as Klatskin tumors. They are classified into four types based on whether they are limited to the common hepatic duct (type I), involve the bifurcation of the right and left hepatic ducts (type II), or enter into the secondary right (type IIIa) or left (type IIIb) intrahepatic ducts. Surgery is the only treatment that has shown potential for long-term survival, provided the tumor has no evidence of distant spread (D, E). Type I and II tumors involve resection of the entire extrahepatic biliary tree with portal lymphadenectomy and bilateral Roux-en-Y hepaticojejunostomies (C). More recently, an even more aggressive approach has been taken for type I and II tumors to include a hemihepatectomy to achieve negative margins. Using this approach, several authors have shown improved survival. For type III lesions, a similar aggressive approach using lobectomy is advocated. Adjuvant radiation therapy has also not been shown to improve either quality of life or survival in resected patients. Patients with unresectable disease are often offered treatment with 5-fluorouracil alone or in combination with mitomycin C and doxorubicin, but the response rates are low. A Whipple procedure would be appropriate for a distal CBD tumor (A).

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9. **C.** Emphysematous cholecystitis occurs in less than 1% of acute cholecystitis cases. It is a disease that occurs predominantly in elderly diabetic men. The hallmark feature is characterized by gas within the gallbladder wall or lumen. This can be seen on plain radiograph, ultrasound, or computed tomography (CT) scan. Gangrene of the gallbladder is present in three-fourths of all cases, and perforation of the gallbladder occurs in more than 20% of cases (E). In one large series, the mortality rate was 25% and the morbidity rate was 50% despite aggressive treatment with broad-spectrum antibiotics and emergent surgery. In patients that are unstable, and not deemed suitable for general anesthesia (such as a patient on pressors or multiple medical problems), percutaneous drainage with cholecystostomy should be performed first. If the patient is more stable, cholecystectomy is preferred (B). Although prior studies suggested open cholecystectomy was preferred, laparoscopic cholecystectomy is an acceptable approach, provided a low threshold for conversion and standard principles are used. Antimicrobial coverage should include *Clostridia perfringens*, which is an anaerobic gram-positive rod and considered the most common cause of emphysematous cholecystitis (D). High-dose penicillin should be started immediately (A). Other common biliary pathogens associated with emphysematous cholecystitis include *Clostridia welchii*, *Escherichia coli*, *Enterococcus*, and *Klebsiella*.

**References:** Ahrendt, S. A., & Pitt, H. A. (2004). Biliary tract. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1597–1642) (17th ed.). Philadelphia, PA: W. B. Saunders.

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10. **B.** Bile consists of bile salts, phospholipids, and cholesterol in the following concentrations: 80%, 15%, and 5%, respectively (E). Normally, more than 95% of bile salts are reabsorbed by the enterohepatic circulation and negative feedback accounts for replacement of the 0.5 g loss of bile salts in the stool. The primary bile acids are cholic acid and chenodeoxycholic acid. The secondary bile acids are lithocholate and deoxycholate acids (A). Cholecystectomy has minimal effect on bile acid secretion but does increase enterohepatic circulation of bile salts (C). Pigment stones get their

characteristic color from calcium bilirubinate. Brown pigment gallstones occur more commonly in the setting of biliary stasis such as cholangitis and tend to form in the CBD. Black pigment stones are associated with hemolytic disorders and are more likely to be found within the gallbladder (D).

**Reference:** Oddsdottir, M., & Hunter, J. G. (2005). Gallbladder. In F. C. Brunicaudi, D. K. Andersen, T. R. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp. 1187–1200) (8th ed.). New York, NY: McGraw-Hill.

11. **B.** The presentation is consistent with gallstone ileus. *Gallstone ileus* is a misnomer because it is actually a type of mechanical small bowel obstruction. It occurs more commonly in elderly females (>70 years). The most specific study to help confirm diagnosis is a CT scan showing air in the biliary tree. It usually results from a large gallstone (>2.5 cm) that has eroded through the gallbladder into the adjacent duodenum and causing air in the biliary tree, creating a cholecystoduodenal fistula (the most common type of biliary fistula). Less commonly, the fistula can be between the gallbladder and the colon (hepatic flexure) or the stomach. The stone typically lodges in the narrowest portion of the gastrointestinal tract - the distal ileum, near the ileocecal valve. The diagnosis of gallstone ileus is made preoperatively in only approximately half of cases because a history of biliary disease may be absent, pneumobilia may not be seen, the gallstone may not be visualized, or the abdominal radiographic findings may be nonspecific. Because many of these patients are elderly, have other major comorbidities, and are often markedly dehydrated, initial surgical management should focus on relieving the obstruction. This is best accomplished by a transverse enterotomy proximal to the palpable stone and stone removal (C–E). It is also important to run the small bowel because a significant portion of patients will have more than one gallstone. Cholecystectomy with closure of the fistula should be reserved for young, low-risk, stable patients (A). In one study, leaving the fistula did not seem to lead to significant morbidity on long-term follow-up. Although most surgeons would recommend taking the patient back at a later time for fistula takedown, this decision needs to be individualized.

**References:** Ahrendt, S.A., & Pitt, H.A. (2004). Biliary tract. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1597–1642) (17th ed.). Philadelphia, PA: W. B. Saunders.

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12. **B.** Rokitansky-Aschoff sinuses are associated with chronic cholecystitis (A, D, E). Chronic cholecystitis is the histopathologic result of multiple bouts of symptomatic cholelithiasis or biliary colic. On pathologic examination, Rokitansky-Aschoff sinuses develop as a result of atrophy of the mucosa. As the mucosa atrophies, the epithelium protrudes into the muscle coat, leading to the formation of these sinuses. It is not considered a premalignant lesion. A hepatobiliary iminodiacetic acid scan that results in visualization of the gallbladder after 2 to 3 hours is suggestive of chronic cholecystitis, whereas acute cholecystitis will not result in visualization even after 4 hours.

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13. **B.** A total of four trocar sites is typically placed during laparoscopic cholecystectomy: (1) a 5-mm umbilical port for the laparoscope, (2) a 12-mm epigastric port for dissection and retrieval of the specimen, (3) a 5-mm right sided subcostal port, and (4) an additional 5-mm port inferior and lateral to the subcostal port. The 5-mm ports allow graspers to retract the gallbladder fundus superiorly (A, E) and infundibulum, or the neck, laterally. This is the ideal positioning to achieve the “critical view” and prevent CBD injury because it allows the cystic duct to remain perpendicular to the CBD. Excess cephalad retraction of the gallbladder infundibulum shifts the cystic duct in line with the CBD and is considered the most common cause of CBD injury (D). The gallbladder body should not be used as a retraction site (C).

14. **A.** Several prospective, randomized trials, although individually underpowered, have shown that early laparoscopic cholecystectomy (within 24 hours of admission) is safe for acute cholecystitis.

The overall complication rate, conversion to open cholecystectomy, bile duct injury rate, and mortality rate are the same as those with delayed cholecystectomy (B–E). However, early cholecystectomy shortens the hospital stay.

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15. **D.** Gallbladder cancer is two to three times more common in females (C). It is also more common in Native Americans in both North and South America. Approximately 90% of patients with carcinoma have gallstones. Large single stones have a much higher risk of cancer than multiple small stones, likely the result of creating more mucosal inflammation; large stones also are more likely to lead to cholecystoenteric fistulas. Other risk factors include choledochal cysts (which may be due to an abnormal pancreaticobiliary junction), sclerosing cholangitis, gallbladder polyps, and exposure to carcinogens (nitrosamines, azotoluene). Obesity has recently been shown to be a risk factor for a wide range of cancers, including the gallbladder (E). The risk of gallbladder cancer in porcelain or calcified gallbladders has recently been re-examined. There has not been a consistent association of gallbladder carcinoma with porcelain gallbladder demonstrated in the literature and the prophylactic removal is no longer supported for asymptomatic patients. Speckled cholesterol deposits on the gallbladder wall are a feature of cholesterosis (A). Thickened nodules of mucosa and muscle in the gallbladder are a feature of adenomyomatosis (B).

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16. **A.** Most benign bile duct strictures are iatrogenic and are due to a technical error during cholecystectomy, such as excessive use of cautery, incorrect placement of a surgical clip, and overly aggressive dissection near the CBD, all of which may be the result of unclear anatomy (B–E). Regardless of the cause, the eventual response is fibrosis and stricture formation. As many as three-fourths of injuries that lead to strictures are not recognized at surgery, and as many as one-third occur 5 years or more after the operation. The majority of iatrogenic strictures are short and occur in the common bile duct and can present with an episode of cholangitis. The workup consists of ultrasonography, which will detect dilated ducts proximal to the stricture, a computed tomography scan to look for masses; and endoscopic retrograde cholangiography (ERCP) with endoscopic ultrasound (EUS) which can be both diagnostic and therapeutic. EUS can be helpful in detecting a tumor within the bile duct. During ERCP, a brushing of the bile duct should be taken for cytology to rule out a malignancy. Management of focal benign strictures by a biliary enteric bypass or stenting remains debatable because of the lack of randomized trials and the lack of good long-term follow-up with stenting. The primary concern with stenting is that the strictures may become obstructed and lead to recurrent cholangitis. Given the much less invasive nature of stenting, strong consideration should be given to this approach. If recurrent obstructive symptoms subsequently develop, a biliary enteric bypass should be performed.

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17. **C.** Type I choledochal cysts are the most common type and are dilations of either the entire common hepatic duct and CBD or a segment of it. Management consists of excision of the entire cyst and a biliary enteric bypass. An exception is if the posterior wall of the cyst is stuck to the portal vein, which occasionally occurs due to ongoing inflammation. Roux-en-Y cyst jejunostomy alone would not be sufficient (E). Dissection of the posterior wall can sometimes be precarious because it may be stuck to the portal vein. In this case, the posterior wall should be left in situ and the mucosa fulgurated or curetted (Lilly procedure) because this will still theoretically remove the risk of malignancy. Type II choledochal cysts are diverticula that project from the CBD wall. Type III choledochal cysts are found in the intraduodenal portion of the CBD (also called a *choledochocoele*). Type IVa cysts are characterized by multiple dilations of the intrahepatic and extrahepatic biliary tree. Most frequently, a large solitary cyst of the extrahepatic duct is accompanied by multiple cysts of the intrahepatic ducts. Type IVb choledochal cysts consist of multiple dilations that involve only the extrahepatic bile duct. Type V choledochal cysts (Caroli disease) consist of dilations of the intrahepatic biliary tree. Partial resection may be indicated for Type V choledochal cyst (A, B). There is no role for observation (D).

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18. **A.** Cholesterolosis, or strawberry gallbladder, is caused by the accumulation of cholesterol in macrophages in the gallbladder mucosa. Cholesterol hypersecretion by the liver promotes excessive accumulation of cholesterol esters within the lamina propria of the gallbladder. The mucosal surface becomes studded with cholesterol deposits, producing the characteristic appearance of the strawberry gallbladder. It is a benign condition. Adenomyomatosis results from hypertrophic smooth muscle bundles and by the ingrowth of mucosa glands into the muscle layer (B). The cause of this overgrowth is unknown, but it is also a benign condition. Cholecystectomy is not indicated for either of these conditions. Porcelain gallbladder is suggestive of gallbladder cancer (C). Acalculous cholecystitis typically occurs in critically ill, highly stressed patients, such as those who have experienced severe trauma, sepsis, burns, or multisystem organ failure (D). The etiology is unclear but is likely related to a combination of ischemia to the gallbladder from a low-flow state and marked gallbladder distention, as well as bile stasis due to a lack of gallbladder contraction (many patients are on total parenteral nutrition). Gangrenous cholecystitis can occur in diabetics presenting with right upper quadrant pain and air within the gallbladder wall (E).

**References:** Ahrendt, S. A., & Pitt, H. A. (2004). Biliary tract. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1597–1642) (17th ed.). Philadelphia, PA: W. B. Saunders.

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19. **D.** Bilirubin is the result of the breakdown of old red blood cells into heme. Heme is broken down into biliverdin and then to bilirubin. Bilirubin is bound to albumin in the circulation, but as it reaches the liver, it is conjugated and eventually enters the gastrointestinal tract. In the gastrointestinal tract, it is deconjugated into urobilinogen by bacteria. Some urobilinogen gets reabsorbed in the gut, returns to the liver, and is excreted in the urine, where it is eventually converted to urobilin, giving urine its yellow appearance. The remaining urobilin is oxidized to stercobilin in the intestines, giving stool its brown appearance. In the presence of biliary obstruction, less bilirubin enters the gut, less urobilinogen is made, and therefore less appears in the urine. Less stercobilin is made and therefore the stools turn pale. Hemolysis would generate an



increase in bilirubin and a corresponding increase in urobilinogen in the gut and in the urine (C). The remaining answer choices do not play a significant role in bilirubin metabolism (A, B, E).

**Reference:** Ahrendt, S. A., & Pitt, H.A. (2004). Biliary tract. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1597–1642) (17th ed.). Philadelphia, PA: W. B. Saunders.

20. **B.** Several studies have analyzed the role of preoperative biliary drainage via ERCP and stenting in patients with malignant obstructive jaundice who are to undergo a Whipple procedure. Theoretically, relief of jaundice might improve the operative risk of the subsequent Whipple procedure. However, a large meta-analysis and single-center studies failed to show improved morbidity and mortality rates with preoperative biliary drainage. In fact, the routine use of preoperative biliary drainage seems to increase the risk of infectious complications including wound infection (10% with drainage vs 4% without) as well as increase the risk of pancreatic fistula (10% with drainage vs 4% without). Thus, it should only be used selectively (e.g., presence of cholangitis or severe, intractable pruritus). It has not been demonstrated to decrease the risk of cholangitis (A), shorten hospital stay (D), or decrease the mortality rate (E). Additionally, obstructive jaundice provides the surgeon a dilated pancreatic duct at the time of surgery making the pancreaticojejunostomy in a Whipple procedure easier to perform.

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21. **A.** Most polypoid lesions of the gallbladder are benign, and of these, cholesterol polyps are the most common. They are usually small (<10 mm), pedunculated, and multiple. They are usually seen in association with cholesterosis. Ultrasound imaging often demonstrates hyperechoic foci with a comet tail artifact; unlike gallstones, these foci don't produce shadowing. Adenomyomatosis polyps are the second most common (B). They appear as sessile polyps that cause focal thickening of the wall. Inflammatory polyps are the third most common (E). All three are benign and are pseudopolyps. Adenomas and adenocarcinomas of the gallbladder are generally larger than 10 mm. However, distinguishing between a benign and a malignant polyp on ultrasonography is generally not reliable (C, D). Thus, when a polyp is found on ultrasound, the general indications for cholecystectomy are (1) a symptomatic polyp, (2) a polyp in association with gallstones, (3) a polyp larger than 6 mm, and (4) age older than 50. For asymptomatic gallstone polyps that do not meet the above criteria, the recommended management is follow-up ultrasound in 6 months.

**References:** Ahrendt, S. A., & Pitt, H. A. (2004). Biliary tract. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1597–1642) (17th ed.). Philadelphia, PA: W. B. Saunders.

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22. **A.** The presentation is consistent with acalculous cholecystitis. The initial study of choice is ultrasonography, which can be performed at the bedside. Findings that would confirm the diagnosis would include thickening of the gallbladder wall, sludge (as in this patient), and pericholecystic fluid. If the ultrasound findings are negative and the patient is not critically ill, the next study would be a HIDA scan with sincalide or morphine. A positive study finding would demonstrate nonfilling of the gallbladder with visualization of the tracer in the liver and small bowel. Morphine decreases the rate of false-positive HIDA scan results because it leads to sphincter of Oddi contraction and thus increases the likelihood of filling of the gallbladder in the absence of cholecystitis. A HIDA scan is not recommended in critically ill patients in whom a delay in therapy can be potentially fatal (C). Acalculous cholecystitis requires urgent intervention, preferably cholecystectomy. The procedure can be attempted laparoscopically; however, there is a higher chance of finding gangrenous cholecystitis and needing to convert to open. If the patient is

too ill for surgery, percutaneous ultrasonography or CT-guided cholecystostomy is the treatment option of choice (B, D). Upper endoscopy is not indicated (E).

**Reference:** Ahrendt, S. A., & Pitt, H. A. (2004). Biliary tract. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, & K. L. Mattox (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1597–1642) (17th ed.). Philadelphia, PA: W. B. Saunders.

23. **E.** This patient presents with a history and findings consistent with cholangiohepatitis, also known as recurrent pyogenic cholangitis. It is endemic in Asia, although the incidence has been decreasing. Cholangiohepatitis affects both sexes equally (C). The etiology of cholangiohepatitis seems to be a combination of bacterial and parasitic (*Clonorchis sinensis*, *Opisthorchis viverrini*, and *Ascaris lumbricoides*) infections in the biliary tree. The bacteria deconjugate bilirubin, which has a greater propensity to precipitate as bile sludge. Brown pigment stones form as a consequence of the sludge and dead bacterial cells (B). In addition, the nucleus of the stone may harbor a parasite egg. The stones lead to recurrent episodes of cholangitis, liver abscesses, stricture formation, liver failure, and an increased risk of cholangiocarcinoma. Recurrence is high. Initial treatment is with ERCP and transhepatic cholangiography. Patients often require multiple interventions to clear the biliary tree. The patient may eventually require a biliary enteric bypass, but this would not be the initial procedure of choice. Metronidazole is the treatment of choice for amebic liver abscess (D). Hydatid liver disease is a liver cyst caused by *Echinococcus* and is associated with close contact with dogs and sheep (A).
24. **D.** The left hepatic duct is longer than the right and is more likely to be dilated in the presence of distal obstruction (A). The spiral Heister valves within the cystic duct do not have any true valvular function (C). In approximately three-fourths of individuals, the CBD and the main pancreatic duct unite outside the duodenal wall and traverse the duodenal wall as a single duct. The blood supply to the CBD runs along the lateral and medial walls at 3 and 9 o'clock positions and comes from the right hepatic artery and retroduodenal artery (off gastroduodenal artery) (E). Thus, a transverse hemitranssection of the duct will likely interrupt the blood supply and render a repair prone to ischemia and stricture. Venous return of the gallbladder is typically drained directly to the parenchyma of the liver (B).

**Reference:** Oddsdottir, M., & Hunter, J. G. (2005). Gallbladder. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp. 1187–1200) (8th ed.). New York, NY: McGraw-Hill.

25. **B.** All of the provided options are potential repairs for a bile duct injury. Sharp, clean, and small injuries in a large CBD or common hepatic duct are more amenable to primary repair. Repair is generally performed over a T tube (A). It is important to bear in mind that the CBD is supplied via two main arteries running at the right and left border of the duct, entering at "3 o'clock" and "9 o'clock." As such, injuries that are less than 50% in circumference are less likely to have interrupted the blood supply on both sides and are therefore less likely to develop ischemic stricture with primary repair. If the duct is transected, nearly transected (>50% circumference), or very small, a Roux-en-Y hepaticojejunostomy is recommended (D). Injuries to the proximal CBD can be treated with a hepaticojejunostomy (D), while injuries to the distal CBD can be treated with a choledochoduodenostomy (E). If the bile duct injury is the result of thermal injury, a primary repair with a T tube placed through a separate choledochotomy is the preferred approach (C).

**References:** Oddsdottir, M., & Hunter, J. G. (2005). Gallbladder. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp. 1187–1200) (8th ed.). New York, NY: McGraw-Hill.

Garden, J. O. (Ed.). (2009). *Hepatobiliary and pancreatic surgery* (p. 208) (4th ed.). New York, NY: Elsevier.

26. **B.** When a gallstone becomes impacted in the cystic duct, the typical course is that acute cholecystitis will develop in the patient. Less frequently, an acute infection does not develop in the patient even though the cystic duct remains obstructed. In this situation, bile within the gallbladder becomes absorbed, but the gallbladder epithelium continues to secrete glycoprotein (mucus). The gallbladder becomes distended with mucinous material (E). This is known as hydrops. The gallbladder may be palpable but does not create the Murphy sign (D). Hydrops of the gallbladder may result in edema of the gallbladder wall and perforation. Although hydrops may persist with few consequences, cholecystectomy is generally indicated to avoid complications. Hydrops of the gallbladder does not significantly increase the risk for malignancy (A). Although

this can subsequently become infected, enteric bacterial infection is not typically responsible for the development of hydrops (C).

**Reference:** Oddsdottir, M., & Hunter, J. G. (2005). Gallbladder. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp. 1187–1200) (8th ed.). New York, NY: McGraw-Hill.

27. **D.** Asymptomatic patients with incidentally discovered gallstones can usually be managed with observation because the lifetime risk of developing symptoms is less than 5%. This remains true even in patients with additional comorbidities including diabetes (A). Spinal cord trauma is a relative indication for cholecystectomy due to impaired pain sensation (B). Pregnant patients with symptomatic biliary disease are offered surgical intervention but only during their second trimester (weeks 13–26) because risk of injury to the fetus is the lowest during this time (C). The main indications for cholecystectomy in asymptomatic patients are the pediatric population (unreliable history and exam), adults that will not have access to medical care for a prolonged period of time (e.g., surgeon going on a medical mission trip), sickle cell disease (abdominal pain from a crisis can mimic cholecystitis), and a large (>3 cm) stone because of increased risk of malignancy. Patients with gallbladder polyps larger than 6 mm are offered surgical intervention (E).
28. **E.** Cholangiocarcinoma arises from bile duct epithelium (D). Although it can occur anywhere along the biliary tree, the majority occurs extrahepatically, while only 20% are intrahepatic (A). It is a locally aggressive cancer but can have direct spread to the liver and peritoneum. The Bismuth-Corlette classification system organizes cholangiocarcinoma by location: Type I occurs below the confluence of the left and right hepatic ducts; type II occurs at the juncture of the left and right hepatic ducts; type III involves either the left or right hepatic duct; and type IV involves secondary extensions of either the left or right hepatic ducts (B). MRCP is an appropriate initial imaging study to define the anatomy and plan for surgical intervention. ERCP is the most valuable diagnostic tool and allows for biopsy brushings. Intrahepatic disease can be managed with hepatic wedge resection while extrahepatic disease needs resection with biliary-enteric bypass. However, this is only appropriate for patients that do not have extensive local disease (involvement of the portal vein trunk or hepatic arteries), nodal involvement or distant metastases. Distal cholangiocarcinoma will need a pancreaticoduodenectomy. National Comprehensive Cancer Network recommends consideration of chemoradiation in patients with positive margins or nodal disease, but it should not be done routinely (C).
29. **E.** Cholesterol that has been conjugated with taurine or glycine is considered a primary bile (cholic and chenodeoxycholic acid). Secondary bile acids are a result of bacterial deconjugation in the gastrointestinal tract (A). Although bile acids are passively absorbed along the entirety of the small intestine, they are actively absorbed only in the terminal ileum (B). Bile acids are colorless and the yellow hue of bile is a result of the pigmented biliverdin (breakdown product of bilirubin) that is also found in bile (C). Bile duct stones occurring after 2 years are considered primary common duct stones and are often pigmented (D). During the fasting state, gallbladder emptying is stimulated by motilin.
- Reference:** Luiking, Y., Peeters, T. L., Stolk, M. F., et al. (1998). Motilin induces gall bladder emptying and antral contractions in the fasted state. *Gut*, 42(6):830–835.
30. **B.** The incidence of clinically apparent postoperative bile leaks has increased in the past three decades as we have seen a shift from performing open cholecystectomies to laparoscopic cholecystectomies. The most commonly identified culprit is a cystic duct stump leak likely secondary to an improperly placed surgical clip. In the largest audit of laparoscopic cholecystectomy complications, Deziel and others found the incidence of cystic duct stump leaks in 77,604 procedures to be 0.12%. When patients present with a biloma, they should be managed quickly because this can lead to severe morbidity and mortality secondary to biliary sepsis. The ducts of Luschka are accessory ducts in the gallbladder fossa that can sometimes have a low volume leak post-operatively; however, they do not commonly create a clinically evident biloma. Management should begin with ERCP, biliary stent placement, and sphincterotomy to promote internal biliary drainage by decreasing resistance in the biliary tree. CT-guided drainage may be considered as the first step in management in critically ill patients to gain quick control of the septic source (A), but it will not address the underlying cause. Inadvertent injury of the CBD more commonly presents with obstructive jaundice; thus a biliary enteric bypass is unlikely to be needed

(D, E). Operative drainage is not typically needed (C).

**References:** Deziel, D. J., Millikan, K. W., Economou, S. G., et al. Complications of laparoscopic cholecystectomy: a national survey of 4,292 hospitals and an analysis of 77,604 cases. *American Journal of Surgery*, 165(1), 9–14, 1993.

Eisenstein, S., Greenstein, A. J., Kim, U., et al. (2008). Cystic duct stump leaks: after learning the curve. *Archives of Surgery*, 143(12), 1178–1183.

# Abdomen—Liver

*Areg Grigorian, and Christian de virgilio*

## Questions

1. Which of the following is true regarding the portal vein?
  - A. It typically has one or two valves.
  - B. It supplies approximately one-third of the blood to the liver.
  - C. The normal pressure is 10 to 12 mm Hg.
  - D. It is formed by the confluence of the inferior mesenteric and splenic veins.
  - E. In the hepatoduodenal ligament, it is usually posterior to both the bile duct and hepatic artery.
2. Focal nodular hyperplasia (FNH):
  - A. Is typically symptomatic
  - B. Is usually centrally located in the liver
  - C. Is best confirmed with high resolution computed tomography (CT)
  - D. Poses a significant risk of rupture
  - E. Is thought to be due to an embryonic disturbance in liver blood flow
3. The best screening approach for detecting early hepatocellular carcinoma (HCC) in patients with chronic viral hepatitis is:
  - A. Alpha fetoprotein (AFP) level
  - B. AFP level and ultrasonography
  - C. Computed tomography
  - D. Carcinoembryonic antigen (CEA) level
  - E. Alkaline phosphatase level
4. A 36-year-old woman presents with right upper quadrant pain, jaundice, evidence of ascites, and an enlarged liver on physical examination. CT demonstrates marked hypertrophy of segment 1 of the liver, free fluid in the peritoneum, and inhomogeneous contrast enhancement of the remainder of the liver. This most likely indicates:
  - A. Budd-Chiari syndrome
  - B. Ruptured hepatic adenoma
  - C. Ruptured hemangioma
  - D. Acute hepatitis
  - E. Schistosomiasis
5. Which of the following is true regarding hepatic adenomas?
  - A. Acute episodes of bleeding are best managed by surgical resection.
  - B. They tend to appear “hot” on a sulfur colloid liver scan.
  - C. Rapid contrast enhancement on CT distinguishes them from FNH.
  - D. A 5.5-cm lesion should be resected even if it is asymptomatic.
  - E. They contain an abundance of nonparenchymal (Kupffer) cells.
6. Which of the following treatments of a hydatid cyst located in the mid right lobe of the liver is

- associated with the lowest recurrence rate, morbidity, and mortality?
- Long-term oral albendazole
  - Long-term oral mebendazole
  - Laparoscopic cyst excision with omentoplasty
  - Surgical total pericystectomy with pre- and postoperative albendazole
  - Percutaneous aspiration and injection of scolicidal agents
7. A 51-year-old male with liver cirrhosis presents with a moderately sized, reducible, umbilical hernia that occasionally causes pain. The skin is intact and there is no drainage. He has a significant amount of ascites. Serum bilirubin, albumin, and international normalized ratio are normal. He has no encephalopathy. He does not have any pain at the hernia site. Which of the following would be the most appropriate next step in management?
- Transjugular intrahepatic portosystemic shunt (TIPS) placement
  - Six-liter paracentesis followed by intravenous (IV) albumin replacement
  - Proceed to surgical repair of the hernia
  - Furosemide, spironolactone, and sodium restriction
  - Observation
8. The most common identifiable source of a pyogenic liver abscess is:
- Seeding from the portal vein
  - The biliary tree
  - Hematogenous from endocarditis
  - Direct extension of a nearby focus
  - Inflammatory bowel disease
9. The principal mediators of fibrosis leading to cirrhosis in the liver are:
- Kupffer cells
  - Ito (liver stellate) cells
  - Endothelial cells
  - Hepatocytes
  - Clefts of Mall
10. Which of the following is true with regard to the TNM (tumor, nodes, and metastases) system for patients with HCC?
- It includes tumor grade.
  - It includes AFP levels.
  - T2 is any solitary tumor regardless of size with vascular invasion.
  - It is considered the best classification system for long-term prognosis.
  - It does not include the number of tumors.
11. An 8-year-old girl presents with upper gastrointestinal (UGI) bleeding. The physical examination demonstrates splenomegaly. Her medical history is significant for a prolonged stay in the neonatal intensive care unit at birth due to prematurity, complicated by necrotizing enterocolitis. She has no history of travel outside the United States. Laboratory testing reveals a hematocrit of 20% and normal bilirubin, albumin, and international normalized ratio. After fluid resuscitation, an upper endoscopy is performed that reveals esophageal varices. The patient is given octreotide and undergoes sclerotherapy. Which of the following studies will most likely determine the cause of her UGI bleed?
- Duplex ultrasonography of the portal vein
  - Duplex ultrasonography of the splenic vein
  - CT scan of the abdomen
  - MRI of the abdomen
  - Liver biopsy
12. For the patient in [question 11](#), persistent UGI bleeding refractory to repeated efforts at medical management would be best managed by:



- A. TIPS placement
  - B. Superior mesenteric vein-to-left portal vein bypass at the Rex recessus
  - C. Mesocaval shunt
  - D. Splenectomy
  - E. Liver transplantation
13. A 45-year-old man with a history of alcohol abuse presents with recurrent UGI bleeding. His history is significant for alcoholic pancreatitis. On upper endoscopy, he is found to have bleeding from isolated gastric varices. The bleeding is controlled medically. On splenoportography, the portal and superior mesenteric veins are patent, but the splenic vein is not visualized. Optimal management for this patient would be:
- A. Side-to-side portacaval shunt
  - B. Mesocaval shunt
  - C. Distal splenorenal shunt
  - D. Long-term beta-blocker therapy
  - E. Splenectomy
14. A 30-year-old Hispanic man with a history of alcohol abuse presents with high fevers, right upper quadrant pain, and leukocytosis. Ultrasonography reveals a 5-cm fluid collection in the right lobe of the liver. On the CT scan, the fluid collection shows a peripheral rim of edema. The cause of the fluid collection is most likely to be determined by:
- A. Blood cultures
  - B. Stool cultures
  - C. Percutaneous aspiration of liver
  - D. Serologic tests
  - E. Liver function tests
15. Definitive management of the patient in [question 14](#) consists of:
- A. Oral metronidazole
  - B. Broad-spectrum antibiotics and open surgical drainage
  - C. Broad-spectrum antibiotics and early percutaneous aspiration of the abscess
  - D. Broad-spectrum antibiotics and CT-guided catheter insertion to drain the abscess
  - E. Broad-spectrum antibiotics and laparoscopic drainage
16. The most common benign tumor of the liver is:
- A. FNH
  - B. Hepatic adenoma
  - C. Hemangioma
  - D. Mesenchymal hamartoma
  - E. Inflammatory pseudotumor
17. Which of the following is true regarding liver cysts associated with polycystic liver disease?
- A. Laparoscopic fenestration is the preferred treatment option.
  - B. It has an autosomal recessive inheritance pattern.
  - C. They are typically symptomatic.
  - D. Oral estrogen therapy can be helpful.
  - E. Liver function tests are usually abnormal.
18. Which of the following is the best method to prevent a first bleed in a patient with known large esophageal varices?
- A. Beta-blockade
  - B. TIPS placement
  - C. Sclerotherapy
  - D. Endoscopic ligation

- E. Selective portosystemic shunt placement
19. A 45-year-old man with Child-Pugh class B cirrhosis presents with recurrent bleeding esophageal varices and refractory ascites. The patient is currently awaiting liver transplantation. Which of the following would be the best option if the bleeding is not controlled with medical management?
- TIPS placement
  - End-to-side portacaval shunt placement
  - End-to-end portacaval shunt placement
  - Distal splenorenal shunt placement
  - H-type portacaval shunt placement
20. Which of the following is true regarding bile acids?
- Deoxycholic acid and lithocholic acid are primary bile acids.
  - Cholic and chenodeoxycholic acids are secondary bile acids.
  - Secondary bile acids are formed by intestinal bacteria.
  - After ingestion of food, bile acid concentration in the portal vein increases.
  - Ingestion of food leads to an inhibition of cholesterol 7-hydroxylase.
21. Fibrolamellar carcinoma (FLC) of the liver:
- Is strongly associated with hepatitis B
  - Most often occurs in elderly men
  - Causes a marked elevation in AFP levels
  - Often contains a central scar
  - Has a worse prognosis than HCC
22. Which of the following is least likely to increase the risk of HCC?
- Toxins from *Aspergillus*
  - Hydrocarbons
  - Smoking
  - Wilson disease
  - Pesticides
23. The Model for End-stage Liver Disease (MELD) score:
- Includes an assessment of the severity of ascites
  - Includes the presence of encephalopathy
  - Is similar to Child-Pugh in that they both use INR and serum creatinine
  - Is not as useful as the Child-Pugh classification
  - Predicts 3-month mortality in patients awaiting liver transplantation
24. Which of the following is true regarding the blood supply to the liver?
- The middle hepatic vein joins the right hepatic vein as it enters the inferior vena cava.
  - Veins from the caudate lobe drain primarily into the right hepatic vein.
  - The ligamentum venosum marks the location of the intrahepatic portal vein.
  - A replaced left hepatic artery most commonly arises from a branch of the celiac axis.
  - The proper hepatic artery gives rise to the gastroduodenal artery in most instances.
25. A 72-year-old woman presents with a sigmoid colon cancer and difficulty having a bowel movement. Metastatic workup reveals a 4-cm mass in the right lobe of the liver involving segments V and VIII. Which of the following is most appropriate?
- Simultaneous sigmoid colectomy and resection of liver metastasis
  - Chemotherapy followed by sigmoid colectomy
  - Sigmoid colectomy and 8 weeks later performance of hepatic resection after reimaging
  - Sigmoid colectomy followed by chemotherapy
  - Chemotherapy only

26. Which of the following is not considered a poor predictor of survival after hepatic resection for a metastatic colorectal cancer?
- A. Hepatic metastasis measuring 4 cm
  - B. Nodes positive in colon primary
  - C. Four small hepatic metastases
  - D. Hepatic metastasis developing 6 months after primary resection
  - E. Very high CEA levels
27. The most common primary liver malignancy in children is:
- A. HCC
  - B. FLC
  - C. Intrahepatic cholangiocarcinoma
  - D. Giant cell carcinoma
  - E. Hepatoblastoma
28. A 40-year-old man presents with recurrent bleeding esophageal varices. Medical management and an attempt at TIPS placement also fails. He is still actively bleeding. He is classified as Child-Pugh B. Liver transplantation is a future possibility. Which of the following would be the best shunt option?
- A. End-to-side portacaval shunt placement
  - B. End-to-end portacaval shunt placement
  - C. Distal splenorenal shunt placement
  - D. Mesocaval shunt placement
  - E. Portocaval H graft
29. The most widely used test for assessment of hepatic reserve before major hepatic resection is:
- A. Aminopyrine breath test
  - B. Indocyanine green clearance
  - C. Bromsulphthalein retention
  - D. Sulfur colloid scan
  - E. Bile acid tolerance
30. Which of the following is true regarding Budd-Chiari syndrome?
- A. It may benefit from percutaneous angioplasty and stenting.
  - B. Diagnosis is best made by portal venography.
  - C. The jaundice is caused by presinusoidal liver failure.
  - D. TIPS placement is contraindicated.
  - E. Liver function test is often normal.
31. In patients with fulminant hepatic failure, the complication that most frequently leads to death is:
- A. Renal failure
  - B. Hypoglycemia
  - C. Pneumonia
  - D. Intracranial hypertension
  - E. Coagulopathy
32. A 30-year-old woman is found to have an incidental 3-cm mass in the liver on CT scan that intensely enhances in the arterial vascular phase. The lesion is “hot” on a technetium-99m–macroaggregated albumin liver scan. Which of the following is true about this lesion?
- A. It is usually centrally located.
  - B. It poses a significant risk of rupture.
  - C. It poses a significant risk of malignancy.
  - D. It is thought to be caused by an embryologic vascular injury.
  - E. It is composed of sheets of hepatocytes with no Kupffer cells.

33. Which of the following is true regarding preoperative portal vein embolization before hepatic resection?
- A. If liver function is normal, the threshold for portal vein embolization is a calculated future liver remnant of less than 50%.
  - B. It is contraindicated in patients with cirrhosis.
  - C. It should not be used after hepatic artery chemoembolization.
  - D. The preferred approach is the percutaneous transhepatic route.
  - E. For a planned extended right lobectomy, embolization of segment IV branches should be avoided.
34. Which of the following factors has the shortest half-life?
- A. I
  - B. II
  - C. VII
  - D. IX
  - E. X
35. Which of the following is true regarding comparisons of amebic and pyogenic liver abscesses?
- A. Amebic abscesses have a much higher female preponderance.
  - B. Mortality rates are similar.
  - C. Both are more likely to occur in the left lobe.
  - D. Percutaneous aspiration is more likely to be needed with amebic abscesses.
  - E. Pyogenic abscesses are more likely to be multiple.
36. A 30-year-old woman who is taking oral contraceptives is discovered to have a 4-cm asymptomatic solid mass in the right lobe of the liver on an ultrasound scan. CT demonstrates a central stellate scar within the mass that enhances on arterial phase. Management consists of:
- A. Observation
  - B. Discontinuing oral contraceptives, repeating the CT scan in 6 months, and resection if the mass has not decreased in size
  - C. Resection of the mass with a 1-cm margin
  - D. Radiofrequency ablation
  - E. Formal hepatic lobectomy
37. Which of the following is true regarding TIPS?
- A. It is contraindicated in patients with poorly controlled ascites.
  - B. It has a significant rate of causing encephalopathy.
  - C. It is considered to be a selective shunt.
  - D. It is best used for long-term portal decompression.
  - E. It has a low 1-year rate of shunt occlusion.
38. A 30-year-old woman with symptoms and signs of symptomatic cholelithiasis is found to have gallstones and a 4-cm mass in the left lateral lobe of the liver on an ultrasound scan. The patient takes oral contraceptives but no other medications. Contrast-enhanced MRI reveals a lesion of low signal intensity with peripheral nodular enhancement, and T2-weighted images reveal high signal intensity. Management consists of:
- A. Laparoscopic cholecystectomy with a needle biopsy of the liver mass
  - B. Laparoscopic cholecystectomy alone
  - C. A trial of contraceptive cessation
  - D. Open cholecystectomy with a wedge liver resection
  - E. Open cholecystectomy with a left lateral segmentectomy
39. The most common cause of intrahepatic presinusoidal portal hypertension is:
- A. Alcohol
  - B. Budd-Chiari syndrome

- C. Schistosomiasis
  - D. Hemochromatosis
  - E. Portal vein thrombosis (PVT)
40. During diagnostic laparoscopy preceding pancreaticoduodenectomy in a patient with pancreatic cancer, a 2-mm, firm, white lesion is noted on the periphery of the liver. Which of the following is true?
- A. The procedure should be aborted at this time.
  - B. The most likely etiology is a bile duct hamartoma.
  - C. Biopsy of the lesion should not be done at this time.
  - D. The patient likely has abnormal liver function tests (LFTs).
  - E. Wedge resection of the liver should be performed.

## Answers

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1. **E.** The portal vein has no valves (A). It supplies approximately 75% of the blood flow to the liver compared with 25% by the hepatic arteries (B). It is formed by the confluence of the superior mesenteric and splenic veins (D). The normal pressure in the portal vein is 3 to 5 mm Hg (C). The portal vein is most commonly located posterior (**Portal is Posterior**) to the common bile duct and hepatic artery in the hepatoduodenal ligament.
2. **E.** FNH is usually an incidental finding on a CT scan because most patients are asymptomatic (A), and it is not associated with a risk of rupture or subsequent malignancy (D). A hallmark feature of FNH is the presence of a hypodense central stellate scar on CT or magnetic resonance imaging (MRI) that enhances with contrast. MRI is the study of choice to confirm FNH and is often the test of choice to characterize liver lesions (C). FNH is usually located on the periphery of the liver (B). It may on occasion be difficult to distinguish from hepatic adenoma or fibrolamellar hepatocellular carcinoma. An early embryologic disturbance in liver blood flow is the postulated cause of FNH, which is supported by the findings of regenerative nodules. Resection is indicated when patients are symptomatic or if a definitive diagnosis cannot be made.

**Reference:** Gangahdar, K., Deepa, S., & Chintapalli, N. (2014). MRI evaluation of masses in the noncirrhotic liver. *Applied Radiology*, 43(12), 20–28.

Wanless, I. R., Mawdsley, C., & Adams, R. (1985). On the pathogenesis of focal nodular hyperplasia of the liver. *Hepatology*, 5(6), 1194–1200.

3. **B.** Screening for HCC is only of potential benefit in patients at high risk of developing HCC. The role and best test for screening for HCC in high-risk patients remain controversial. Studies in Asian patients with chronic viral hepatitis showed that a combination of ultrasonography and AFP is an effective screening tool. Recommendations are that AFP alone should not be used and that ultrasonography seems to be more efficient (A). The benefits of screening high-risk white patients are unclear, as is the cost-effectiveness. CT imaging can help establish the diagnosis of HCC by demonstrating a hyperintense lesion on arterial phase and rapid washout on venous phase (C). CEA can be used as a tool to measure response to treatment in patients with colorectal cancer (D). Alkaline phosphatase levels are not typically used for the diagnosis of HCC (E).

**References:** Daniele, B., Bencivenga, A., Megna, A., et al. (2004). Alpha-fetoprotein and ultrasonography screening for hepatocellular carcinoma. *Gastroenterology*, 127(5 Suppl. 1), S108–S112.

Tong, M., Blatt, L., & Kao, V. (2001). Surveillance for hepatocellular carcinoma in patients with chronic viral hepatitis in the United States of America. *Journal of Gastroenterology and Hepatology*, 16(5), 553–559.

4. **A.** The patient most likely has Budd-Chiari syndrome, a rare disorder caused by thrombosis of the hepatic inferior vena cava or the hepatic veins themselves that leads to hepatic venous outflow obstruction, postsinusoidal liver failure, and cirrhosis. The classic triad includes abdominal pain, ascites, and hepatomegaly. There are four forms: acute, chronic, asymptomatic, and fulminant. It is often associated with a hypercoagulable state that is either inherited (protein C, protein S, factor V Leiden, or antithrombin III deficiency) or acquired (myeloproliferative disorders, polycythemia vera, thrombocytosis, pregnancy). It is more common in women. The diagnosis can be made by

duplex ultrasonography, which will show the thrombosed hepatic veins or inferior vena cava. The most prominent feature on a CT scan is caudate lobe (segment I) hypertrophy and inhomogeneous contrast enhancement. The treatment depends on the acuity of the presentation. Immediate treatment is with anticoagulation followed by percutaneous angioplasty with or without stenting. There are rare reports of successful thrombolysis. Subsequent treatment depends on whether the primary indication for an intervention is portal hypertension (transjugular intrahepatic portosystemic shunt [TIPS] or nonselective shunt) or liver failure (transplantation). The remaining answer choices do not present with the aforementioned findings (B–E).

**References:** Kim, T., Chung, J., Han, J., et al. (1999). Hepatic changes in benign obstruction of the hepatic inferior vena cava: CT findings. *AJR. American Journal of Roentgenology*, 173(5), 1235–1242.

Slakey, D., Klein, A., Venbrux, A., et al. (2001). Budd-Chiari syndrome: current management options. *Annals of Surgery*, 233(4), 522–527, 2001.

Wu, T., Wang, L., Xiao, Q., et al. (2002). Percutaneous balloon angioplasty of inferior vena cava in Budd-Chiari syndrome-R1. *International Journal of Cardiology*, 83(2), 175–178, 2002.

5. **D.** Distinguishing between FNH and a hepatic adenoma is important because the management of the former is observation, whereas the treatment of hepatic adenomas often requires surgical resection because of their known risk of malignant degeneration and risk of hemorrhage and spontaneous rupture. In a recent study, 70% of hepatic adenomas were symptomatic (abdominal pain), 29% of resected hepatic adenomas had evidence of hemorrhage, and 5% had malignancy present. Hepatic adenomas present in young women and in association with oral contraceptive use. Although some authors have recommended a selective approach to the resection of hepatic adenomas (only resect if symptomatic, >5 cm, or those that do not respond to cessation of oral contraceptive use on repeat imaging), most surgeons have now shifted to a more aggressive approach and recommend the removal of all hepatic adenomas, regardless of size because there have been reports of malignant transformation even when the adenoma is shrinking. Acute episodes of bleeding should be managed by angioembolization (A). Differentiating FNH and hepatic adenoma is not always straightforward. Both may show contrast enhancement in the arterial phase of a CT scan, so this does not help to differentiate them (C). FNH characteristically demonstrates a central scar. Adenomas may demonstrate increased fat signal on MRI compared with FNH. When CT and MRI are unable to distinguish adenoma from FNH, a sulfur colloid scan may be beneficial because adenomas will appear “cold” and FNHs “hot” because of the presence of Kupffer cells (B–E). Radiofrequency ablation is another potential option in managing hepatic adenomas, especially when multiple adenomas are present, or the patient is not a candidate for a major liver resection.

**References:** Cho, S., Marsh, J., Steel, J., et al. (2008). Surgical management of hepatocellular adenoma: take it or leave it? *Annals of Surgical Oncology*, 15(10), 2795–2803.

Daniele, B., Bencivenga, A., Megna, A., et al. (2004). Alpha-fetoprotein and ultrasonography screening for hepatocellular carcinoma. *Gastroenterology*, 127(5 Suppl. 1), S108–S112.

Herman, P., Pugliese, V., Machado, M., et al. (2000). Hepatic adenoma and focal nodular hyperplasia: differential diagnosis and treatment. *World Journal of Surgery*, 24(3), 372–376, 2000.

Toso, C., Majno, P., Andres, A., et al. (2005). Management of hepatocellular adenoma: solitary-uncomplicated, multiple and ruptured tumors. *World Journal of Gastroenterology*, 11(36), 5691–5695.

6. **D.** Cystic hydatid disease of the liver is due to infection by the tapeworm *Echinococcus granulosus*. Another species, *Echinococcus multilocularis*, causes alveolar echinococcosis. Humans (and sheep) are intermediate hosts, whereas dogs are the definitive host. Diagnosis is established by an enzyme-linked immunosorbent assay test for *Echinococcus* antigen, coupled with an ultrasound or CT scan. Characteristic features have led to four types described (Gharbi types): a simple cyst (type I), a cyst with free-floating hyperechogenic material called *hydatid sand* (type II), a cyst with a rosette appearance suggesting a daughter cyst (type III), and a cyst with a diffuse hyperechoic solid pattern (type IV). Treatment options for hydatid disease include oral anthelmintic agents (albendazole, mebendazole), laparoscopic or open cyst excision with omentoplasty (C), formal liver resection, total pericystectomy, and PAIR (percutaneous aspiration, injection of a scolicidal agent, and reaspiration) (E). Drug therapy alone is curative in only a small percentage of patients (A, B). The treatment of choice is a surgical total pericystectomy with pre- and postoperative albendazole. This has been demonstrated to have the lowest rates of recurrence, morbidity, and mortality. During aspiration or surgical treatment of hydatid cysts, extreme caution must be taken to avoid



rupture of the cyst. Cyst rupture can result in release of protoscolices into the peritoneal cavity and can lead to anaphylaxis.

**References:** Etlik, O., Arslan, H., Bay, A., et al. (2004). Abdominal hydatid disease: long-term results of percutaneous treatment. *Acta Radiologica*, 45(4), 383–389.

Georgiou, G. K., Lianos, G. D., Lazaros, A., et al. (2015). Surgical management of hydatid liver disease. *International Journal of Surgical*, 20, 118–122.

Kabaalioglu, A., Ceken, K., Alimoglu, E., et al. (2006). Percutaneous imaging-guided treatment of hydatid liver cysts: do long-term results make it a first choice? *European Journal of Radiology*, 59(1), 65–73.

Khuroo, M., Wani, N., Javid, G., et al. (1997). Percutaneous drainage compared with surgery for hepatic hydatid cysts. *The New England Journal of Medicine*, 337(13), 881–887.

7. **D.** Patients with cirrhosis are at increased risk for umbilical herniation owing to the increased intra-abdominal pressure. The overlying skin can thin and eventually rupture, which is associated with high mortality. Child-Pugh A cirrhotics can proceed with elective surgery after medical optimization. Child-Pugh B cirrhotics have an increased risk during surgery, and the decision to operate should be individualized. Child-Pugh C is an absolute contraindication for elective surgery. Given that the patient above has poorly controlled ascites, he is a Child-Pugh B. Before surgical intervention in this patient, medical therapy needs to be initiated (C). Fixing the umbilical hernia without addressing the underlying ascites will increase the failure rate of the hernia repair. The initial treatment of ascites in a patient with cirrhosis includes a low-sodium diet and the use of the diuretics spironolactone and furosemide. In the majority of patients, this approach is successful. If the ascites is refractory to this management, the next step is large-volume (4–6 L) paracentesis. The paracentesis should be followed by an IV infusion of 25% salt-poor albumin (B). If the ascites is still not responsive, serial large-volume paracentesis can be used. TIPS is another option but should be reserved for patients with reasonably good liver function because those with advanced liver disease will have a high risk of the development of encephalopathy and hepatic decompensation (A). In the latter patient, the ideal option would be a liver transplantation. Peritoneovenous shunting is now rarely used because it has a high rate of shunt clotting and can induce disseminated intravascular coagulation. Observation would not be appropriate for a patient presenting with worsening ascites (E).

**Reference:** Choudhury, J., Sanyal, A. (2003). Treatment of ascites. *Current Treatment Options in Gastroenterology*, 6(6), 481–491.

8. **B.** The classic triad associated with pyogenic liver abscess is the same as Charcot triad for cholangitis. It consists of right upper quadrant pain, fever, and jaundice, although only 10% of patients have all three features. Pyogenic liver abscess remains a highly lethal disease, with mortality rates, even in more recent large series, ranging from 10% to 20%. The most common etiology of pyogenic liver abscesses is the biliary tract. It is more likely to be associated with abnormal liver function tests compared with other infectious hepatic etiologies (e.g., amebic abscess, hydatid cyst) due to its proximity to the biliary tree. In most instances, management consists of IV antibiotics with percutaneous aspiration of the abscess with or without catheter drainage. Other etiologies include seeding of the portal vein from diverticular disease, appendicitis (D), inflammatory bowel disease (E), and systemic infections such as bacterial endocarditis (C). Amebic liver abscesses more commonly involve seeding from the portal vein (A). However, in a high percentage of pyogenic liver abscesses, the source is unclear.

**Reference:** Chu, K., Fan, S., Lai, E., et al. (1996). Pyogenic liver abscess. An audit of experience over the past decade. *Archives of Surgery*, 131(2), 148–152.

9. **B.** The Ito cells are also known as the hepatic stellate cells. They are located in the space of Disse and are characterized by the presence of lipid droplets because they store vitamin A. Ito cells play an important role in the liver's response to acute liver injury as well as in chronic liver injury. In these settings, the Ito cell differentiates into a myofibroblast-like cell that has a high capacity for fibrogenesis. The remaining answer choices do not play a role in mediating fibrosis (A, D, E).

**Reference:** Hautekeete, M. L., & Geerts, A. (1997). The hepatic stellate (Ito) cell: its role in human liver disease. *Virchows Archiv*, 430(3), 195–207.

10. **C.** Numerous classification systems have been developed for HCC. None have been universally accepted as the gold standard. The primary critique of the TNM system is that it does not factor in

hepatic reserve, which is an important predictor of long-term survival in these patients. Several classification systems have been devised to try to incorporate tumor characteristics with liver function. These include the Japan Integrated Staging score, Cancer of the Liver Italian Program score, and Barcelona Clinic Liver Cancer Staging score. The Japan Integrated Staging score appears to be the most promising (D) and includes the Child-Pugh grade (based on bilirubin, albumin, prothrombin time, and presence of ascites or encephalopathy) and TNM staging. Other factors that have been shown to be important prognosticators in HCC include the AFP level (B), the alkaline phosphatase level, the presence of portal hypertension, and the presence of portal vein thrombosis. The TNM staging does include the number and size of tumor nodules and whether vascular invasion is present (E). T1 is any solitary tumor regardless of size with no vascular invasion. T2 is any solitary tumor with vascular invasion or multiple tumors with all lesions being smaller than 5 cm. T3 includes multiple lesions larger than 5 cm. T4 lesions directly invade adjacent organs. Tumor grade is not included and does not appear to be an independent predictor of outcome (A).

**References:** Cillo, U., Vitale, A., Grigoletto, F., et al. (2006). Prospective validation of the Barcelona Clinic Liver Cancer staging system. *Journal of Hepatology*, 44(4), 723–731.

Huang, Y., Chen, C., Chang, T., et al. (2005). Evaluation of predictive value of CLIP, Okuda, TNM and JIS staging systems for hepatocellular carcinoma patients undergoing surgery. *Journal of Gastroenterology & Hepatology*, 20(5), 765–771.

11. **A.** Variceal bleeding in children is rare. The combination of esophageal varices and splenomegaly, in the absence of evidence of cirrhosis (normal hepatic function), is highly suggestive of portal vein thrombosis (PVT). The diagnostic test of choice is a duplex ultrasound scan of the portal vein (B–E). PVT likely occurs because of a combination of factors that contributes to the Virchow triad (injury, stasis, and hypercoagulability). Many children with PVT have a history of neonatal umbilical vein catheterization (leading to portal venous injury), neonatal omphalitis (umbilical sepsis), or neonatal intra-abdominal sepsis (leading to infectious seeding of the portal vein). Some patients may have congenital webs in the portal vein (leading to stasis), and a smaller fraction have inherited hypercoagulable states. In one study of 100 neonates who underwent umbilical vein catheterization, portal vein ultrasonography demonstrated clinically silent PVT in 43%, and only 56% had complete or partial resolution. The etiology of PVT in adults is different. It is more likely associated with malignancy and cirrhosis. In most children, PVT is clinically silent until esophageal varices and UGI bleeding develop. Patients with PVT and without any bleeding should be started on anticoagulation. This also applies to asymptomatic patients because complete recanalization or partial resolution improves survival. Initial treatment of the bleeding varices is similar to that for adults and includes the use of sclerotherapy or banding as well as octreotide. Because PVT in children is not usually associated with cirrhosis, liver function is intact, and the overall prognosis for these children is reasonably good. Nevertheless, a portosystemic shunt should be considered in patients who are refractory to medical management.

**References:** Kim, J. H., Lee, Y. S., Kim, S. H., et al. (2001). Does umbilical vein catheterization lead to portal venous thrombosis? Prospective US evaluation in 100 neonates. *Radiology*, 219(3), 645–650.

Schettino, G. C., Fagundes, E. D., Roquete, M. L., et al. (2006). Portal vein thrombosis in children and adolescents. *Jornal de Pediatria*, 82(3), 171–178.

12. **B.** For children with PVT and recurrent refractory UGI bleeding, the superior mesenteric vein–to–left portal vein bypass at the Rex recessus (known as the Rex shunt) seems to be the most advantageous shunt because it serves the dual function of decompressing the portal system while simultaneously restoring some blood flow to the liver. The bypass is performed most often using the internal jugular vein as a conduit. This shunt seems to have the best chance to prevent long-term behavioral, growth, and personality disorders noted after the use of other portosystemic shunts in children. TIPS placement is often reserved for Child-Pugh A and some Child-Pugh B cirrhotics that have exhausted medical management but continue to have refractory UGIB bleeding from esophageal varices (A). Portocaval or mesocaval shunt may be considered in unstable patients with refractory UGI bleeding who are not candidates for liver transplantation (C, E). Splenectomy is not an appropriate treatment option for PVT (D).

**References:** Ates, O., Hakgüder, G., Olguner, M., et al. (2006). Mesenterico left portal bypass for variceal bleeding owing to extrahepatic portal hypertension caused by portal vein thrombosis. *Journal of Pediatric Surgery*, 41(7), 1259–1263.

Fuchs, J., Warmann, S., Kardorff, R., et al. (2003). Mesenterico-left portal vein bypass in children with congenital extrahepatic portal vein thrombosis: a unique curative approach. *Journal of Pediatric Gastroenterology and Nutrition*, 36(2), 213–216, 2003.

13. **E.** The finding of isolated gastric varices, without esophageal varices, is highly suggestive of splenic vein thrombosis. This condition leads to venous outflow obstruction of the spleen, resulting in massively dilated short gastric veins. The most common cause of splenic vein thrombosis is chronic pancreatitis, which leads to perivenous inflammation. It has been reported to occur in 4% to 8% of patients with chronic pancreatitis. Splenic vein thrombosis with gastric variceal formation is referred to as left-sided or sinistral portal hypertension. The mortality rate for gastric variceal bleeding exceeds 20%. Splenectomy is curative. Controversy exists as to whether prophylactic splenectomy is necessary when asymptomatic gastric varices are discovered in association with splenic vein thrombosis. A recent study suggests that gastric variceal bleeding from pancreatitis-induced splenic vein thrombosis occurs in only 4% of patients. Thus, prophylactic splenectomy is not recommended in asymptomatic patients, nor is it recommended concomitant with another planned abdominal operation. Bypass procedures carry a higher risk of morbidity and would not address the underlying problem (A–C). Long-term beta-blocker therapy is used as a prophylactic agent in patients with esophageal varices secondary to cirrhosis (D).

**References:** Agarwal, A., Raj Kumar, K., Agarwal, S., et al. (2008). Significance of splenic vein thrombosis in chronic pancreatitis. *American Journal of Surgery*, 196(2), 149–154.

Heider, T. R., Azeem, S., Galanko, J., et al. (2004). The natural history of pancreatitis-induced splenic vein thrombosis. *Annals of Surgery*, 239(6), 876–880.

Weber, S., & Rikkers, L. (2003). Splenic vein thrombosis and gastrointestinal bleeding in chronic pancreatitis. *World Journal of Surgery*, 27(11), 1271–1274.

14. **D.** The diagnosis of an amebic liver abscess is made using a combination of the clinical presentation, ultrasound and CT scan features, and serologic testing. The causative organism is *Entamoeba histolytica*. Humans ingest the cysts through a fecal-oral route. The cyst becomes a trophozoite in the colon and invades the colonic mucosa, resulting in a diarrheal illness. The organism then reaches the liver via the portal vein. It leads to a liquefaction necrosis of the liver, leading to the description of an “anchovy paste” appearance of the fluid, which is a combination of blood and liquefied hepatic tissue. The infection is much more common in endemic areas such as Central and South America, India, and Africa or in those individuals who have had recent travel to those locations. Less than one-third of patients will have a history of a diarrheal illness. Amebic liver abscesses are much more common in patients with a history of heavy alcohol consumption, suggesting that alcohol increases susceptibility. CT scanning can help distinguish amebic liver abscesses from other entities, such as a pyogenic abscess and echinococcal cysts. The classic finding on CT is that of a single fluid collection in the right lobe with a rim of peripheral edema. It is unclear why the right lobe is affected more than the left. Culturing the liver abscess or stool does not usually yield ameba (B). The best test to establish the diagnosis is serologic testing using enzyme immunoassays. The test is typically not reliable until 7–10 days after the patient is infected. Conservative medical management of amebic liver abscess is safe. Percutaneous ultrasonography-guided aspiration is indicated only in patients who fail to improve clinically after 48 to 72 hours (C). Amebic liver abscesses may lead to mildly elevated transaminase and bilirubin levels, but these findings are nonspecific (E). Blood cultures are not indicated in the workup for amebic liver abscess (A).

**References:** Blessmann, J., Binh, H., Hung, D., et al. (2003). Treatment of amoebic liver abscess with metronidazole alone or in combination with ultrasound-guided needle aspiration: a comparative, prospective and randomized study. *Tropical Medicine & International Health*, 8(11), 1030–1034.

McGarr, P. L., Madiba, T. E., Thomson, S. R., et al. (2003). Amoebic liver abscess—results of a conservative management policy. *South African Medical Journal*, 93(2), 132–136.

15. **A.** Amebic liver abscesses respond very well to oral metronidazole. Several studies have investigated whether percutaneous drainage is needed. Given the rapid response to oral metronidazole, aspiration or catheter-directed drainage is unnecessary in the majority of cases (B–E). Aspiration is only indicated if the diagnosis of amebic liver abscess is uncertain or if the patient does not respond appropriately to antibiotics within a few days. Metronidazole is administered for 7 to 10 days.

**References:** Akgun, Y., Tacyildiz, I., Celik, Y. (1999). Amebic liver abscess: changing trends over 20

years. *World Journal of Surgery*, 23(1), 102–106.

Blessmann, J., Binh, H., Hung, D., et al. (2003). Treatment of amoebic liver abscess with metronidazole alone or in combination with ultrasound-guided needle aspiration: a comparative, prospective and randomized study. *Tropical Medicine & International Health*, 8(11), 1030–1034.

McGarr, P. L., Madiba, T. E., Thomson, S. R., et al. (2003). Amoebic liver abscess – results of a conservative management policy. *South African Medical Journal*. 93(2), 132–136.

16. **C.** Hemangiomas are the most common benign tumors of the liver. They are usually discovered incidentally and are typically asymptomatic. Diagnosis is generally made by characteristic features of CT and MRI. The main issues to be aware of are that they can sometimes be difficult to distinguish from malignancy and that in children, in particular, giant hemangiomas can lead to arteriovenous shunting with congestive heart failure and thrombocytopenia secondary to consumptive coagulopathy (Kasabach-Merritt syndrome). Hemangiomas should be removed by enucleation (not by formal resection). FNH is a benign asymptomatic liver lesion located on the periphery of the liver and typically discovered incidentally on CT scan (A). Hepatic adenomas present in young women and in association with oral contraceptive use (B). Mesenchymal hamartoma of the liver typically affects young males and is considered a benign lesion that may present with intra-abdominal enlargement and respiratory distress particularly in the neonate (D). Inflammatory pseudotumor is a benign liver lesion that requires needle biopsy for correct diagnosis (E).
17. **A.** Polycystic liver disease is an autosomal dominant disorder that is seen in patients with polycystic kidney disease, or it can be seen with liver cysts alone (B). The majority of patients are asymptomatic from their liver, but on rare occasion, large cysts can produce severe abdominal pain requiring intervention (C). Various strategies have been used with varying degrees of success in symptomatic patients with liver cysts. Laparoscopic fenestration has emerged as the preferred treatment option and has a low risk of bleeding. Percutaneous aspiration, instillation of alcohol, and reaspiration (PAIR) is optimally suited for patients with single cysts but has been used in polycystic liver patients with a dominant cyst. Formal lobectomy is another option. When all other options have been exhausted, liver transplantation has been successful. To date, there is no successful medical management. However, patients are instructed to avoid factors that have been associated with increased cyst growth. Hormone replacement therapy with estrogens in particular has been linked to cyst growth and should therefore be avoided (D). Recently, octreotide has shown some preliminary promise in retarding cyst growth. Liver function tests are typically normal but can be elevated if there is gross displacement of liver parenchyma by massive liver cysts (E).

**References:** Abu-Wasel, B., Walsh, C., Keough, V., & Molinari, M. (2013). Pathophysiology, epidemiology, classification and treatment options for polycystic liver diseases. *World journal of gastroenterology*, 19(35), 5775–5786.

Que, F., Nagorney, D., Gross, J., Jr, et al. (1995). Liver resection and cyst fenestration in the treatment of severe polycystic liver disease. *Gastroenterology*, 108(2), 487–494.

Sherstha, R., McKinley, C., Russ, P., et al. (1997). Postmenopausal estrogen therapy selectively stimulates hepatic enlargement in women with autosomal dominant polycystic kidney disease. *Hepatology*, 26(5), 1282–1286.

18. **D.** Because of the high risk associated with esophageal varices, numerous studies have been undertaken to try to prevent first-time bleeds. The objective is to reduce portal venous pressure to less than 12 mm Hg without adding morbidity. Prophylaxis is important because the 1-year mortality rate is as high as 70% in cirrhotic patients. Prophylactic sclerotherapy, TIPS placement, and portosystemic shunting have not been shown to be effective (C). Conversely, both prophylactic  $\beta$ -adrenergic blockade and endoscopic ligation have been shown to be effective. Two large randomized studies demonstrated that endoscopic ligation is even more effective than beta-blockade in bleed prevention (A). The former may be more appropriate in cases of medium to large esophageal varices. The combination of beta-blockade and endoscopic ligation is not recommended as it can increase the risk for adverse effects without an added benefit. TIPS can be used as part of the acute management in patients with refractory variceal bleeding (B). Selective portosystemic shunt is reserved for patients that have failed all other management options because this carries a significant mortality rate and risk of hepatic encephalopathy (E). It is rarely performed today and only in an emergency setting.

**References:** Psilopoulos, D., Galanis, P., Goulas, S., et al. (2005). Endoscopic variceal ligation vs.

propranolol for prevention of first variceal bleeding: a randomized controlled trial. *European Journal of Gastroenterology & Hepatology*, 17(10), 1111–1117.

Sarin, S. K., Lamba, G. S., Kumar, M., et al. (1999). Comparison of endoscopic ligation and propranolol for the primary prevention of variceal bleeding. *The New England Journal of Medicine*, 340(13), 988–993.

19. **A.** In patients who are candidates for liver transplantation and have esophageal bleeding that is not controlled by medical management, TIPS is the best bridge while awaiting transplantation. Emergent portacaval shunting is rarely performed today and only in an emergency setting (B, C, E). In addition, the dissection around the portal vein makes subsequent transplantation much more challenging. Distal splenorenal shunt is a technically demanding, long operation that is not well suited for emergent indications (D). In addition, it tends to exacerbate ascites, so refractory ascites is a relative contraindication. It is best indicated in the semielective situation in patients who need long-term decompression, who are not candidates for transplantation, and who have recurrent variceal bleeding (once the bleeding has been medically controlled). A recent prospective, randomized study comparing TIPS placement with distal splenorenal shunting demonstrated equal effectiveness of both procedures for refractory bleeding but with more of a need for reintervention with TIPS.

**References:** Colombato, L. (2007). The role of transjugular intrahepatic portosystemic shunt (TIPS) in the management of portal hypertension. *Journal of Clinical Gastroenterology*, 41(Suppl. 3), S344–S351.

Henderson, J., Boyer, T., Kutner, M., et al. (2006). DIVERT Study Group: distal splenorenal shunt versus transjugular intrahepatic portal systematic shunt for variceal bleeding: a randomized trial. *Gastroenterology*, 130(6), 1643–1651.

20. **C.** Bile salts are made in the liver and then secreted to be used in the biliary tree and the intestine. Bile is composed of bile acids, pigments, phospholipids, cholesterol, proteins, and electrolytes. Bile salts are important for small intestinal absorption of fats and vitamins. Cholic acid and chenodeoxycholic acid are primary bile acids (A). They are made in the liver from cholesterol and then conjugated with glycine and taurine in the hepatocytes. The secondary bile acids are deoxycholic and lithocholic acids and are formed by intestinal bacterial modification of the primary bile acids (B). As a result of enterohepatic circulation, 95% of bile acids are returned to the liver via the portal circulation. They are reabsorbed passively in the jejunum and actively in the ileum. Bile salts are important in the absorption of dietary fats and fat-soluble vitamins. Major resection of the distal ileum results in fat malabsorption and deficiency in fat-soluble vitamins because it impairs the circulation of bile acids. It also lowers cholesterol levels because more cholesterol is used to make new bile salts. After ingestion of food, bile acid concentration in the liver decreases and the inhibition of cholesterol 7-hydroxylase decreases, resulting in an increase of bile acid secretion in the liver (D, E).

**References:** D'Angelica, M., & Fong, Y. (2004). The liver. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, K. L. Mattox, (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1513–1574) (17th ed.). Philadelphia, PA: W. B. Saunders.

Siedelaff, T. D., & Curley S. A. (2005). Liver. In F. C Brunicaardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 1139–1186) (8th ed.). New York, NY: McGraw-Hill.

21. **D.** FLC has been considered to be a variant of HCC, but recent studies suggest that it is a distinct pathologic entity. FLC generally occurs in younger patients (median age, 25 years) and HCC in older patients (median age, 55 years) (B). Unlike HCC, the majority of patients with FLC do not have cirrhosis, are not hepatitis-B positive, and do not have an elevated AFP level (A–C). The tumor is usually well demarcated and may have a central fibrotic area. This can make it hard to distinguish from FNH. In the arterial phase of a CT scan, the central scar in FNH enhances because it actually represents a vascular entity, whereas the central scar in FLC does not enhance. Likewise, the central scar in FNH is hyperintense on gadolinium MRI. The prognosis overall tends to be better than that of HCC, mostly because of the absence of cirrhosis, but it still only carries a 5-year survival rate of 45% (E). It is associated with elevated neurotensin levels. Treatment is surgical resection.

**References:** Ichikawa, T., Federle, M. P., Grazioli, L., et al. (1999). Fibrolamellar hepatocellular carcinoma: imaging and pathologic findings in 31 recent cases. *Radiology*, 213(2), 352–361.

Kakar, S., Burgart, L. J., Batts, K. P., et al. (2005). Clinicopathologic features and survival in

fibrolamellar carcinoma: comparison with conventional hepatocellular carcinoma with and without cirrhosis. *Modern Pathology*, 18(11), 1417–1423.

22. **D.** Both hepatitis B and C virus infections are factors for the development of HCC, whereas hepatitis A is not. Cirrhosis is not required for the development of HCC, and HCC is not an inevitable result of cirrhosis. Chronic alcohol abuse and smoking are also associated with an increased risk of HCC (C). Aflatoxin is linked to HCC (A). It is produced by *Aspergillus* species and can be found on contaminated peanuts and other grains. Other hepatic carcinogens include nitrites, hydrocarbons, solvents, pesticides, vinyl chloride, and Thorotrast (a contrast agent no longer used). HCC has also been linked to metabolic liver diseases such as hereditary hemochromatosis. Wilson disease and primary biliary cirrhosis have not been consistently demonstrated to increase the risk of hepatocellular carcinoma.

**Reference:** van Meer, S., de Man, R. A., van den Berg, A. P., et al. (2015). No increased risk of hepatocellular carcinoma in cirrhosis due to Wilson disease during long-term follow-up. *Journal of Gastroenterology & Hepatology*, 30(3), 535–539.

23. **E.** The MELD score is used to prioritize patients awaiting liver transplantation and includes the serum total bilirubin and serum creatinine levels and the international normalized ratio (INR). The presence of encephalopathy or ascites does not factor into this score (A, B). MELD was originally designed to predict mortality after a TIPS procedure. The score ranges from 6 to 40. It has since been modified to add the serum sodium level because low serum sodium (<126 mEq/L) has been shown to be an independent risk of mortality in liver transplant recipients. The newly modified MELD score, in combination with American Society of Anesthesiologists class and patient age, has been shown to be predictive of perioperative mortality in patients with cirrhosis undergoing a wide variety of surgical procedures. The MELD score removes the subjectivity associated with other classification systems. In patients with end-stage liver disease awaiting transplantation, the 3-month mortality rate was 1.9% for those with a MELD score less than 9, whereas patients with a MELD score of 40 or more had a mortality rate of 71.3%. A MELD score > 15 is required to be enlisted on the liver transplant list. Child-Pugh grade (based on bilirubin, albumin, INR, presence of ascites or encephalopathy) is another scoring system that can be used to measure hepatic reserve after hepatic resection (D). For each of the five criteria, a point (1–3) is assigned. Child-Pugh A includes 5 to 6 points (no mortality risk at 1 year), Child-Pugh B includes 7 to 9 points (20% 1-year mortality rate), and Child-Pugh C includes 10 to 15 points (55% 1-year mortality rate). INR and total bilirubin are the two variables the MELD and Child-Pugh score share in common (C).

**Reference:** Wiesner, R., Edwards, E., Freeman, R., et al. (2003). Model for end-stage liver disease (MELD) and allocation of donor livers, *Gastroenterology*, 124(1), 91–96.

24. **D.** The right hepatic vein drains segments V, VI, VII, and VIII and enters the vena cava. The caudate lobe, situated in the posterior right lobe, also drains directly into the inferior vena cava (B). The middle hepatic vein drains segments IVA, IVB, V, and VIII. The middle hepatic vein enters the inferior vena cava jointly with the left hepatic vein via a common orifice (A). The left hepatic vein drains segments II and III. The round ligament is a remnant of the umbilical vein and marks the location of the intrahepatic location of the left portal vein. The ligamentum venosum is a remnant of the ductus venosus and marks the border between the caudate lobe and the left lateral sector (C). In most instances, the common hepatic artery gives rise to the gastroduodenal artery and right gastric artery, after which the name changes to the proper hepatic artery (E). The proper hepatic artery becomes the right and left hepatic arteries. A replaced right hepatic artery arises from the superior mesenteric artery (most commonly) and is posterolateral to the portal vein. It is referred to as a replaced artery because it replaces the right hepatic artery coming off the proper hepatic artery. This is in contrast to an accessory right hepatic artery, which also comes off the superior mesenteric artery (most commonly), but is in *addition* to the right hepatic artery coming off the proper hepatic artery. A replaced left hepatic artery most commonly arises from the left gastric artery (branch of the celiac axis).

25. **C.** There is no evidence to demonstrate superiority of either an initial colectomy, initial liver resection, or simultaneous colon and hepatic resection in patients with metastatic colon cancer to the liver. The option needs to be individualized. In highly experienced hands and well-selected patients, the outcomes of a simultaneous approach are favorable. However, simultaneous resection is best conducted in young patients (<70 years old) with favorable operative risk who do not need a major hepatic resection but rather a segmentectomy (A). Given the patient's age and the size and



location of the hepatic tumor, the safest answer would be to perform the colonic resection first. Additionally, the patient is having difficulty with bowel movements and tumor removal will help resolve this. Repeat imaging needs to be done to ensure the liver metastasis continues to be resectable. Chemotherapy solely or as an adjunct therapy would not be appropriate (B, D, E).

**Reference:** Lykoudis, PM., O'Reilly, D., Nastos, K., & Fusai, G. (2014). Systematic review of surgical management of synchronous colorectal liver metastases. *The British journal of surgery*, 101(6), 605–612.

26. **A.** Several studies have analyzed predictors of poor long-term outcome after resection of hepatic metastasis from colorectal cancer. In one study, the factors were positive tumor margin, presence of extrahepatic disease, node-positive primary tumor, disease-free interval from primary tumor to metastases less than 12 months (D), more than one hepatic tumor, the largest hepatic tumor being larger than 5 cm, and a CEA level greater than 200 ng/mL. Using the last 5 factors, the authors recommended against hepatic resection for those with 3 or more points because the long-term outcome was poor. In another large study, the factors for adverse outcome were similar and included the number of hepatic metastases greater than three node-positive primary tumor (B), poorly differentiated primary tumor, extrahepatic disease (C), tumor diameter 5 cm or larger, CEA level greater than 60 ng/mL (E), and positive resection margin.

**References:** Fong, Y., Fortner, J., Sun, R., et al. (1999). Clinical score for predicting recurrence after hepatic resection for metastatic colorectal cancer: analysis of 1001 consecutive cases. *Annals of Surgery*, 230(3), 309–318.

Rees, M., Tekkis, P., Welsh, F., et al. (2008). Evaluation of long-term survival after hepatic resection for metastatic colorectal cancer: a multifactorial model of 929 patients. *Annals of Surgery*, 247(1), 125–135.

27. **E.** Hepatoblastoma is the most common primary liver malignancy in children. It has been associated with familial polyposis syndrome. It presents typically with an asymptomatic abdominal mass, anemia, thrombocytosis, and elevated AFP levels. Patients may also first present with precocious puberty secondary to increased beta-human chorionic gonadotropin ( $\beta$ -hCG). Fetal histology has the best prognosis. Treatment is with chemotherapy first and then resection. Chemotherapy enables the subsequent hepatic resection to be less and may make tumors resectable that initially appear to be unresectable. FLC (B) has been considered to be a variant of HCC (A), but recent studies suggest that it is a distinct pathologic entity. Focal bile duct stenosis in older male patients without any biliary instrumentation is highly suggestive of intraductal cholangiocarcinoma (C). Giant cell (osteoclast-like) carcinoma of the liver is rare (E) but is more commonly seen in bone tumors.

**Reference:** Seo, T., Ando, H., Watanabe, Y., et al. (1998). Treatment of hepatoblastoma: less extensive hepatectomy after effective preoperative chemotherapy with cisplatin and Adriamycin. *Surgery*, 123(4), 407–414.

28. **D.** Portal vein-to-systemic vein bypasses are rarely used given the success rates of medical management, TIPS placement, and liver transplantation. The few indications for shunting are when medical management and a TIPS have failed. It can then be a bridge to transplantation. However, if the patient is Child-Pugh C, the quoted operative mortality rate is exceedingly high due to further hepatic decompensation. Thus, it is ideal in patients with better hepatic reserve. The distal splenorenal shunt is too time-consuming to be used in the emergent setting (C). The mesocaval shunt is the best option of those given. It avoids dissection of the portal vein, thus avoiding the complication of a difficult reoperation for future liver transplantation (A, B, E).

**Reference:** Ezzat, F. A., Abu-Elmagd, K. M., Aly, M. A., et al. (1990). Selective shunt versus nonshunt surgery for management of both schistosomal and nonschistosomal variceal bleeders. *Annals of Surgery*, 212(1), 97–108.

29. **B.** In general, the Child-Pugh scoring system is useful in predicting hepatic reserve after hepatic resection. However, it loses its predictive value in Child-Pugh A patients. The indocyanine green clearance test is the most widely used study for measuring hepatic reserve before hepatic resection in combination with the Child-Pugh score. Indocyanine green binds to albumin and  $\alpha_1$ -lipoproteins in liver parenchymal cells and thus rapidly clears from the plasma. It is then secreted in the bile. Hepatic reserve is measured by the amount of indocyanine green retained in the plasma after 15 minutes. If more than 15% remains in the plasma at 15 minutes, this is considered abnormal (retention rate 15% = clearance rate 85%). The remaining choices are less effective

studies to assess for hepatic reserve (A, C–E).

**Reference:** Schneider, P. (2004). Preoperative assessment of liver function. *Surgery Clinics of North America*, 84(2), 355–373.

30. **A.** Budd-Chiari syndrome is due to thrombosis of the hepatic veins or intrahepatic vena cava. It is often due to an underlying hypercoagulable state. It leads to postsinusoidal portal hypertension because it is caused by hepatic venous outflow congestion (C). In contrast, presinusoidal portal hypertension develops secondary to congestion within the intrahepatic portal system. Liver function is oftentimes normal in presinusoidal portal hypertension while it is elevated in postsinusoidal portal hypertension (E). Diagnosis is made by CT scan and duplex ultrasound scan of the hepatic veins (B). Initial management is with heparinization followed by percutaneous angioplasty with or without stenting. Rare reports exist of successful thrombolysis. TIPS has also been used successfully (D). Those with decompensated liver function may require liver transplantation.

**Reference:** Slakey, D., Klein, A., Venbrux, A., et al. (2001). Budd-Chiari syndrome: current management options. *Annals of Surgery*, 233(4), 522–527.

31. **D.** Cerebral edema and intracranial hypertension (ICH) are the complications of fulminant hepatic failure, most likely to result in adverse outcome and death (A–C, E). Liver failure is accompanied by high levels of ammonia, which can be detoxified in astrocytes leading to an accumulation of astrocyte glutamine. This is associated with increased intracellular osmolality and can lead to cerebral edema and eventually ICH. Thus, it is essential to monitor intracranial hypertension as hepatic coma develops with intracranial pressure monitoring. This technology has been shown to be critical to the ongoing determination of a patient's candidacy for liver transplantation. Patients whose intracranial pressure increases to more than 20 mm Hg or whose cerebral perfusion pressure decreases to less than 60 mm Hg will have a high risk of irreversible brain injury. If the intracranial pressure is more than 50 mm Hg or the cerebral perfusion pressure is less than 40 mm Hg, transplantation is contraindicated. Coagulopathy in this patient population is not considered an absolute contraindication to invasive intracranial pressure monitoring.

**Reference:** Sass, D. A., & Shakil, A. (2005). Fulminant hepatic failure. *Liver Transplantation*, 11(6), 594–605.

32. **D.** The patient has FNH. In contrast to hepatic adenomas, FNH typically is not associated with symptoms and does not pose any risks of rupture or malignant degeneration (B, C). These lesions intensely enhance in the arterial vascular phase of axial imaging studies. Characteristically, as many as two-thirds of lesions will demonstrate a central scar that enhances in the arterial phase (versus FLC, which remains hypodense). The lesions are often peripherally located (A). On a technetium-99m-macroaggregated albumin liver scan, FNH appears “hot” because of the presence of Kupffer cells, which take up sulfur colloid (E). The etiology is thought to be the result of an early embryologic vascular injury. FNH is rarely symptomatic. In patients with symptoms related to FNH, resection is indicated. Because the lesions are often peripheral, minimally invasive (laparoscopic) approaches to resection should be advocated. Resection of the lesion with a thin margin of normal liver parenchyma is curative, but formal segmental resection should be considered because such procedures are associated with lower morbidity.
33. **D.** The primary cause of mortality after major hepatic resection in patients with underlying cirrhosis is liver failure. The premise behind preoperative portal vein embolization is to increase the safety margin of a planned hepatic resection. As such, this treatment modality is an important tool to consider for patients with cirrhosis (B). By embolizing and inducing atrophy of the planned area of resection, compensatory hypertrophy of the remaining liver ensues, reducing the likelihood that liver failure will develop. In healthy patients, a calculated future liver remnant of at least 20% is appropriate. In patients undergoing chemotherapy, 30% is needed and cirrhotic patients need 40%. There are two approaches: a transileocolic one that requires general anesthesia and a laparotomy and a percutaneous one. The percutaneous transhepatic approach under local anesthesia is generally preferred. Interestingly, hepatocytes in the embolized lobe undergo apoptosis, not necrosis. Main side effects are pain from the transhepatic access site and low-grade fever. If an extended right lobectomy is to be performed, it is important to embolize not only the main right portal vein but also the portal venous branches to segment IV (E). This approach is important to prevent accelerated growth of tumor, and it also ensures adequate hypertrophy of segments I, II, and III. Transarterial hepatic artery chemoembolization can be used before portal

vein embolization (C). This approach is particularly appealing in patients with HCC because it further helps prevent tumor growth during the waiting period after portal vein embolization. Portal vein embolization is indicated when the remnant liver volume is expected to be less than 40% with normal liver function and less than 50% when liver function is abnormal, as measured by the presence or absence of obstructive jaundice or an abnormal indocyanine green test result (normal study result is <10% retention of indocyanine green at 15 minutes) (A).

**Reference:** Kokudo, N., & Makuuchi, M. (2004). Current role of portal vein embolization/hepatic artery chemoembolization. *The Surgical Clinics of North America*, 84(2), 643–657.

34. **C.** Warfarin acts in the liver by blocking the vitamin K–dependent factors (II, VII, IX, and X). Of these, factor VII has the shortest half-life (A, B, D, E). A deficiency in factor VII manifests by a prolongation of the prothrombin time and the international normalized ratio. Vitamin K is critical in the  $\gamma$ -carboxylation of these factors that are synthesized in the liver. Patients with hepatic dysfunction would similarly display prolongation of the prothrombin time.

35. **E.** The male-to-female ratio for amebic liver abscesses is approximately 10:1 versus 1.5:1 for pyogenic abscesses (A). Three-fourths of liver abscesses involve the right lobe of the liver (C). Pyogenic abscesses are more likely to be multiple. Amebic abscesses tend to occur in younger patients and in endemic areas. Heavy alcohol consumption is commonly reported for amebic infection and is also a risk factor for pyogenic abscesses. The majority of amebic abscesses are managed with antibiotics alone, whereas pyogenic abscesses often require aspiration or catheter-based drainage (D). The mortality for patients with amebic liver abscesses is 2% to 4%; however, the mortality for patients with pyogenic abscesses ranges from 10% to 20% (B).

36. **A.** The presence of a central stellate scar is considered diagnostic of FNH when the scar enhances in the arterial phase. FNH is thought to be the result of a response to an in utero disturbance in liver blood supply with a subsequent liver regeneration. There does not seem to be any link to oral contraceptive use and no risk of rupture or malignancy, so the management is observation (B). The size of the FNH lesion does not seem to be influenced by oral contraceptive use. The only indications for surgery would be if the diagnosis cannot be made preoperatively (particularly to distinguish FNH from FLC) with certainty or if the patient has symptoms (although the presence of symptoms suggests another pathology) (C–E). Change in the size of FNH on follow-up is rare.

**Reference:** Mathieu, D., Kobeiter, H., Maison, P., et al. (2000). Oral contraceptive use and focal nodular hyperplasia of the liver. *Gastroenterology*, 118(3), 560–564.

37. **B.** TIPS has been shown to be useful in patients who do not respond to medical management of variceal bleeding. It is considered to be a nonselective shunt and is highly effective in the short term in preventing rebleeding (C, D). However, because it is nonselective, it has a significant risk of encephalopathy. Thus, it should be used with caution in patients who already have marginal hepatic reserve. TIPS is also useful in patients with refractory ascites (A). Recent studies suggest that it is also useful as a bridge to liver transplantation in patients with hepatorenal syndrome. It is not a good alternative to long-term portal decompression because the 1-year patency rate is only approximately 50% (E). Absolute contraindications to TIPS placement are polycystic liver disease and right heart failure.

**References:** Colombato, L. (2007). The role of transjugular intrahepatic portosystemic shunt (TIPS) in the management of portal hypertension. *Journal of Clinical Gastroenterology*, 41(Suppl. 3), S344–S351.

Testino, G., Ferro, C., Sumberaz, A., et al. (2003). Type-2 hepatorenal syndrome and refractory ascites: role of transjugular intrahepatic portosystemic stent-shunt in eighteen patients with advanced cirrhosis awaiting orthotopic liver transplantation. *Hepatogastroenterology*, 50(54), 1753–1755.

38. **B.** The MRI findings are characteristic of a hemangioma, given the peripheral nodular enhancement and the brightness on T2-weighted images. They have low signal intensity on T1-weighted imaging. Hemangiomas are common benign liver lesions generally discovered incidentally on imaging studies. They may on occasion be difficult to distinguish from other lesions. MRI findings tend to be more specific than CT scan for hemangiomas. Rarely, hemangiomas are difficult to differentiate on MRI or CT scan. Hemangiomas can be definitively diagnosed by a technetium-99–labeled red cell scan with single-photon emission CT. Diagnostic findings include decreased activity on early images and subsequent delayed filling from the periphery. CT criteria that are specific for hemangioma include diminished attenuation on

precontrast scan, peripheral contrast enhancement during the dynamic bolus phase of scanning, and complete isodense fill-in on delayed imaging. Given the vascular nature of hemangiomas, needle biopsy is contraindicated (A). Resection is also unnecessary (D, E). Hemangiomas are not associated with oral contraceptive use (C).

**References:** Freeny, P., & Marks, W. (1986). Hepatic hemangioma: dynamic bolus CT. *American Journal of Roentgenology*. 147(4), 711–719.

Reimer, P., Rummeny, E., Daldrup, H., et al. (1997). Enhancement characteristics of liver metastases, hepatocellular carcinomas, and hemangiomas with Gd-EOB-DTPA: preliminary results with dynamic MR imaging. *Eur Radiol*, 7(2), 275–280.

39. **C.** Portal hypertension is classified into three types: presinusoidal, sinusoidal, and postsinusoidal. Distinguishing between these causes is important because treatment may differ. Also, unlike the sinusoidal and postsinusoidal types, presinusoidal portal hypertension is more likely to be associated with a preserved liver function. Presinusoidal hypertension is further divided into intrahepatic and extrahepatic causes. Extrahepatic causes include portal and splenic vein thromboses (E). The most common intrahepatic etiology is schistosomiasis (*Schistosoma japonicum* and *Schistosoma mansoni*). The infection by a fluke leads to fibrosis and granulomatous reactions. In children, congenital hepatic fibrosis is another cause. Sinusoidal causes include alcoholism and other causes of cirrhosis (A). Other etiologies include hemochromatosis and Wilson disease (D). Postsinusoidal portal hypertension includes Budd-Chiari syndrome and congenital webs in the intrahepatic inferior vena cava (B).
40. **B.** Bile duct hamartomas are the most common lesions of the liver seen during laparotomy. They are often small (1–5 mm), firm, smooth, and white and occur in the periphery of the liver. It is important to differentiate these from metastatic lesions by taking intraoperative biopsies and sending it as a frozen specimen (C). If it is found to be a metastatic lesion, the procedure should be aborted (A). Bile duct hamartomas do not typically distort hepatic parenchyma and do not lead to elevated LFTs. They do not need to be resected (E).

# Abdomen—Pancreas

*Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 48-year-old male presents with vague abdominal pain of 2 weeks' duration. He was recently discharged for an episode of alcohol-related pancreatitis. Laboratory exam is remarkable for a mildly elevated serum amylase. A computed tomography (CT) scan demonstrates a 4-cm well-circumscribed peripancreatic fluid collection with homogeneously low attenuation. The borders of the collection appear to be ill-defined. The patient is afebrile and hemodynamically stable. What is the most appropriate next step?
  - A. Intravenous (IV) antibiotics and fluids
  - B. Admit and place the patient on nothing by mouth (NPO)
  - C. Percutaneous aspirate for carcinoembryonic antigen (CEA) level
  - D. Exploratory laparotomy
  - E. Observe
2. Which of the following is the least favorable management option for a chronic large pancreatic pseudocyst?
  - A. Endoscopic transpapillary drainage using a stent
  - B. Laparoscopic cystogastrostomy
  - C. CT-guided drainage with a pigtail catheter
  - D. Open Roux-en-Y cystojejunostomy
  - E. Endoscopic transgastric cystogastrostomy
3. A 65-year-old man presents with a persistent skin rash of the lower abdomen and perineum, accompanied by intermittent vague left upper quadrant pain and recent weight loss. A chemistry panel reveals serum glucose to be 160 mg/dL, but results are otherwise unremarkable. CT reveals a large mass in the pancreas. Which of the following is true regarding the most likely condition?
  - A. This patient is at higher risk for venous thromboembolic disease.
  - B. The mass is most commonly in the head of the pancreas.
  - C. The secretory peptide responsible for the symptoms also stimulates exocrine pancreatic flow.
  - D. Patients often have associated hypokalemia.
  - E. These are often benign lesions.
4. The most common cause of chronic pancreatitis worldwide is:
  - A. Gallstones
  - B. Alcohol abuse
  - C. Hereditary
  - D. Hypertriglyceridemia
  - E. Infectious
5. A 35-year-old cachectic woman presents with episodic severe watery diarrhea that has led to multiple hospital admissions for replacement of fluids and electrolytes over the course of several months. Stool cultures are repeatedly negative, and she has no history of travel abroad. On examination, a

mass is palpated in the epigastrium/right upper quadrant. CT reveals a large, bulky pancreatic mass with extension into the superior mesenteric vein and adjacent organs. The best palliative management option for this patient's symptoms is:

- A. Octreotide
  - B. Streptozotocin
  - C. Embolization
  - D. Chemotherapy
  - E. Radiation therapy
6. A 65-year-old male presents for evaluation of yellowing skin. Review of systems is significant for loose-fitting clothes, fatigue, and night sweats. Laboratory evaluation is remarkable for elevated total bilirubin. CT scan reveals a pancreatic mass. Which of the following is least likely to contribute to this condition?
- A. History of cholecystectomy
  - B. Diabetes
  - C. Smoking
  - D. *BRCA2*
  - E. Coffee consumption
7. A 41-year-old female presents with palpitations, trembling, diaphoresis, and confusion. Serum glucose is 48 mg/dL and C-peptide level is elevated. Her symptoms resolve with the administration of a carbohydrate load. Which of the following is true regarding the most likely condition?
- A. Elevated C-peptide and hypoglycemia rule out an exogenous source.
  - B. Patients will often have a mass in the neck of the pancreas.
  - C. The most sensitive study for localization is a high resolution CT scan.
  - D. Recurrent lesions can be managed with streptozocin and 5-FU.
  - E. It is the least common functional pancreatic endocrine neoplasm.
8. Octreotide scanning is most useful for localization of which of the following tumors?
- A. VIPoma
  - B. Glucagonoma
  - C. Pancreatic polypeptide-secreting tumor
  - D. Gastrinoma
  - E. Insulinoma
9. A 36-year-old male is admitted for management of acute alcoholic pancreatitis. Which of the following alone is considered a predictor for mortality in this patient population?
- A. BUN > 20 mg/dL
  - B. Fever
  - C. Presence of white blood cell count > 18,000 cells/L
  - D. Age > 55 years
  - E. Presence of pleural effusion
10. Which of the following is true regarding the role of endoscopic retrograde cholangiopancreatography (ERCP) and/or timing of surgery for acute biliary pancreatitis?
- A. In mild pancreatitis, laparoscopic cholecystectomy can be safely performed within 48 hours of admission.
  - B. ERCP with sphincterotomy should be used routinely before surgery.
  - C. If a common bile duct stone is suspected, ERCP with sphincterotomy should be performed preoperatively.
  - D. In severe pancreatitis, early cholecystectomy reduces morbidity and mortality.
  - E. There is minimal risk of worsening the pancreatitis with the performance of ERCP.
11. Which of the following is true regarding pancreatic cysts?
- A. Serous cystadenoma has malignant potential.



- B. Asymptomatic patients with mixed-type intraductal papillary mucinous neoplasm (IPMN) should undergo conservative management.
  - C. Weight loss in patients with IPMN is mostly attributed to an elevated level of TNF-alpha.
  - D. Mucinous cystadenoma usually occurs in women and in the body or tail of the pancreas.
  - E. Asymptomatic mucinous cystadenoma can be managed with repeat imaging in 6 months.
12. A 55-year-old man presents with a 12-hour history of epigastric pain, nausea, and vomiting. He has diffuse mild abdominal tenderness to palpation. Laboratory values are significant for serum amylase of 800 U/L, serum glucose of 130 mg/dL, chloride of 104 mEq/L, white blood cell count of 12,000 cells/ $\mu$ L, serum sodium of 125 mEq/L, and triglyceride levels of 1800 mg/dL. The most likely explanation for the hyponatremia is:
- A. Excessive fluid loss
  - B. Inappropriate antidiuretic hormone response
  - C. Excessive free water replacement
  - D. Pseudohyponatremia
  - E. Adrenal insufficiency
13. Management of pancreatic lymphoma is by:
- A. Pancreaticoduodenectomy
  - B. Chemotherapy
  - C. Pancreaticoduodenectomy with postoperative chemotherapy
  - D. Radiation therapy
  - E. Preoperative chemoradiation followed by pancreaticoduodenectomy
14. Which of the following is true regarding pancreas divisum?
- A. The duct of Santorini ends in a blind pouch.
  - B. The inferior portion of the pancreatic head drains through the duct of Santorini.
  - C. The majority of the pancreas drains through the duct of Santorini.
  - D. The duct of Wirsung drains through the minor papilla.
  - E. The ducts of Wirsung and Santorini fail to develop.
15. The preferred definitive treatment for recurrent acute pancreatitis due to pancreas divisum is:
- A. Lateral pancreaticojejunostomy (Puestow procedure)
  - B. Pancreaticoduodenectomy (Whipple procedure)
  - C. Minor papilla sphincterotomy
  - D. Major papilla sphincterotomy and pancreatic ductal septotomy
  - E. Distal pancreatectomy
16. A 50-year-old male with chronic pancreatitis has failed medical management and is being considered for more invasive treatment. Which of the following is true regarding potential interventions?
- A. Pancreaticoduodenectomy (Whipple procedure) is inappropriate for chronic pancreatitis.
  - B. Endoscopic procedures have been shown to be superior to surgical treatment.
  - C. Lateral pancreaticojejunostomy (Puestow procedure) is appropriate if the pancreatic duct is larger than 6 mm.
  - D. The most common indication for invasive intervention in chronic pancreatitis is poor exocrine and endocrine function.
  - E. Long term pain control is similar with either the Puestow, Beger, or Frey procedure.
17. Adenocarcinoma of the pancreas arises most often from which anatomic site?
- A. Main pancreatic duct
  - B. Branch pancreatic duct
  - C. Pancreatic acinus
  - D. Ampulla of Vater

E. Pancreatic islet

18. A 60-year-old man presents with obstructive jaundice, acholic stools, and weight loss. An abdominal ultrasound scan demonstrates a dilated biliary tree and no gallstones. A dynamic contrast-enhanced CT scan demonstrates a solid mass localized to the head of the pancreas without evidence of distant metastasis, or adenopathy. Vascular involvement can't be excluded. The patient is otherwise in good health. Laboratory values are normal. Which of the following is the next step in the management?
- A. Exploratory laparotomy
  - B. Diagnostic laparoscopy
  - C. MRI
  - D. Endoscopic ultrasound
  - E. Positron emission tomography (PET) scan
19. Which of the following is true regarding alcohol and its relation to the pancreas?
- A. It induces spasm of the sphincter of Oddi.
  - B. It decreases pancreatic secretion.
  - C. It decreases pancreatic duct permeability.
  - D. It transiently increases pancreatic blood flow.
  - E. It inhibits chymotrypsin.
20. Which of the following is true regarding alcohol and pancreatitis?
- A. It commonly occurs after a single binge of alcohol.
  - B. The type of alcohol consumed is an important risk determinant.
  - C. Patients consuming a high protein and fat diet are at greater risk.
  - D. There is a threshold amount of alcohol consumption below which pancreatitis does not occur.
  - E. It typically develops after a mean of 5 years of heavy drinking.
21. Which of the following is true regarding pancreatogenic (type 3) diabetes?
- A. Ketoacidosis is common.
  - B. The diabetes is easily controlled.
  - C. Peripheral insulin sensitivity is decreased.
  - D. Glucagon and pancreatic polypeptide (PP) levels are low.
  - E. Hyperglycemia is usually severe.
22. A 30-year-old nurse presents with intermittent diaphoresis, trembling, and palpitations. Her fasting blood sugar is 50 mg/dL. Her insulin-to-C peptide ratio is greater than 1. Which of the following is the next step in management?
- A. CT scan of the abdomen
  - B. Psychiatric counseling to discuss sulfonylurea abuse
  - C. Psychiatric counseling to discuss exogenous insulin abuse
  - D. Octreotide scan
  - E. Magnetic resonance imaging
23. A 60-year-old alcoholic man presents with chronic, vague abdominal pain. He denies a history of pancreatitis and is otherwise in good health. CT reveals a 6-cm multiloculated, septated cyst at the tail of the pancreas. Management consists of:
- A. Distal pancreatectomy and splenectomy
  - B. CT-guided drainage of the cyst
  - C. Endoscopic cystogastrostomy
  - D. Roux-en-Y cystojejunostomy
  - E. Repeat imaging in 6 months
24. After a motor vehicle accident, persistent ascites develops in a 55-year-old man. Other than the ascites, CT findings are unremarkable. Paracentesis reveals clear fluid with an amylase level of 5000 U/L and a protein level of 40 g/L. The patient fails an attempt at bowel rest, parenteral nutrition, and

- paracentesis. Definitive management would consist of:
- A. Distal pancreatectomy
  - B. Placement of pigtail catheter
  - C. Roux-en-Y pancreaticojejunostomy
  - D. Pancreaticoduodenectomy
  - E. Pancreatic sphincterotomy and placement of a transduodenal pancreatic stent
25. A 60-year-old man presents with chronic epigastric abdominal pain and jaundice. CT reveals diffuse swelling of the pancreas with compression of the intrapancreatic common duct. Needle biopsy of the pancreas reveals diffuse fibrosis and a plasma and lymphocytic infiltrate. Serum IgG levels are increased. Primary management consists of:
- A. Whipple procedure
  - B. Steroids
  - C. Chemotherapy
  - D. Hepaticojejunostomy
  - E. ERCP with stenting
26. A 26-year-old male is diagnosed with tropical pancreatitis. Which of the following is true regarding this condition?
- A. It is uncommon in adolescents.
  - B. It is associated with gallstones.
  - C. He likely has family members with the disease.
  - D. It is initially managed with endoscopic decompression.
  - E. It is not associated with diabetes.
27. A 61-year-old female undergoes a pancreaticoduodenectomy (Whipple) operation. On postoperative day three she becomes hypotensive, tachycardic, and has severe abdominal pain. Nasogastric tube demonstrates bilious output. She receives 2 L of fluids but remains hypotensive. The next step in her management is:
- A. Angiography with embolization
  - B. Immediate take back to the OR
  - C. IV octreotide drip
  - D. Bedside ultrasonography
  - E. Upper endoscopy
28. Which of the following is true regarding anatomy or the embryologic development of the pancreas?
- A. The most commonly injured vessel during dissection behind the neck of the pancreas is the celiac vein.
  - B. The pancreas receives its arterial supply from only the celiac artery.
  - C. The ventral pancreas constitutes the head and part of the body of the pancreas.
  - D. Venous drainage of the pancreas is to the inferior vena cava.
  - E. The uncinate process is dorsal to the portal vein and superior mesenteric artery.
29. A 35-year-old man presents with severe abdominal pain and diffuse abdominal tenderness. CT scan with IV contrast demonstrates areas of hypoattenuation in the pancreas. His vitals are stable. His temperature is 38.4°C. Which of the following is true regarding his condition?
- A. Fine-needle aspiration (FNA) for culture should be performed.
  - B. Early IV antibiotics have demonstrated improved survival.
  - C. Early necrosectomy decreases morbidity and mortality when compared with delayed intervention.
  - D. The patient should be observed with medical optimization and repeat imaging if he deteriorates clinically.
  - E. Percutaneous drainage should be performed.
30. A 60-year-old woman presents with gallstone pancreatitis. Which of the following is the best predictor of a residual gallstone persisting in the common bile duct?

- A. Persistent elevation of the total bilirubin level
  - B. A dilated common bile duct on admission
  - C. Persistent elevation of the alkaline phosphatase level
  - D. Persistent elevation of the serum amylase level
  - E. Persistent abdominal pain
31. Which of the following pancreatic cystic lesions is almost exclusively found in a young female?
- A. Serous cystic adenoma
  - B. Mucinous cystic neoplasm
  - C. Side-duct IPMN
  - D. Main-duct IPMN
  - E. Solid pseudopapillary epithelial neoplasm

## Answers

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1. **E.** The history of recent pancreatitis combined with the history of vague abdominal pain, elevated serum amylase, and CT scan demonstrating a peripancreatic fluid collection most likely represents pancreatic pseudocyst. Most patients with pseudocyst do not need admission and can continue to eat, although a low-fat diet is recommended. Admission and total parenteral nutrition (TPN) would only be recommended if they were unable to tolerate an oral diet (B). There is no reason to start IV antibiotics because he is not presenting with an infected pseudocyst (A). Initial management of pseudocysts is conservative via observation because most spontaneously resolve. Pancreatic cyst CEA level is considered the most accurate tumor marker for diagnosing a mucinous pancreatic cystic lesion. However, in the present setting, given the high suspicion for a pseudocyst, it would not be needed (C). Invasive interventions are inappropriate because most pseudocysts resolve spontaneously (D). Predictors of failure for conservative management include pancreatic pseudocysts larger than 6 cm or those that have persisted for more than 6 weeks. CT or ultrasound can be used to characterize interval changes in pancreatic pseudocysts.
2. **C.** Internal drainage is usually preferred to external drainage for a symptomatic pancreatic pseudocyst that has failed to resolve with conservative therapy. External drainage is associated with a higher rate of complications, including infection and pancreaticocutaneous fistula. The only indication for percutaneous drainage is in a patient with a documented or clinically apparent *infected* pancreatic pseudocyst that is unstable for a surgical or endoscopic procedure. Pseudocysts communicate with the pancreatic ductal system in 80% of cases. Internal drainage can be achieved endoscopically via a transmural approach or a transpapillary approach. This is gaining popularity making it the new first-line treatment for pancreatic pseudocyst. If there is portal hypertension (e.g., splenic vein thrombosis, underlying cirrhosis, esophageal or gastric varices), then surgical open internal drainage may be more appropriate. Options include a cystogastrostomy, a Roux-en-Y cystojejunostomy, and a cyst duodenostomy (A–B, D–E). Cystogastrostomy can be performed endoscopically, laparoscopically, or with a combined approach. Failure of the endoscopic approach can be predicted by the finding of major ductal disruption or stenosis on endoscopic retrograde cholangiopancreatography (ERCP) or magnetic resonance cholangiopancreatography. Regardless of the approach, biopsies of the cyst wall must be done to rule out malignancy.

**References:** Cantasdemir, M., Kara, B. Kantarci, F., et al. (2003). Percutaneous drainage for treatment of infected pancreatic pseudocysts. *Southern Medical Journal*, 96(2), 136–140.

Nealon, W., & Walser, E. (2005). Surgical management of complications associated with percutaneous and/or endoscopic management of pseudocyst of the pancreas. *Annals of Surgery*, 241(6), 948–957.

Yusuf, T., & Baron, T. (2006). Endoscopic transmural drainage of pancreatic pseudocysts: results of a national and an international survey of ASGE members. *Gastrointestinal Endoscopy*, 63(2), 223–227.

3. **A.** Glucagonoma can be remembered by the 4 D's: diabetes, dermatitis, deep vein thrombosis, and depression. The rash is termed *necrolytic migratory erythema* and tends to manifest on the lower abdomen or perineum. The mass characteristically appears in the tail of the pancreas along with VIPoma (a neuroendocrine tumor that secretes vasoactive intestinal polypeptide [VIP]). The responsible hormone, glucagon, inhibits exocrine pancreatic flow (C). The diagnosis of

glucagonoma is confirmed by measuring fasting glucagon levels. Because the tumors are in the distal pancreas, the patient does not usually present with jaundice; as such, the diagnosis is often made late when the tumor is large. Because glucagonoma is most commonly malignant, it should be removed with enucleation (if <2 cm) or by distal pancreatectomy (E). Somatostatinoma can present with diabetes, gallstones, steatorrhea, hypochlorhydria, and most commonly occurs in the head of the pancreas along with pancreatic polypeptide-secreting tumor (B). Patients with VIPoma have large-volume secretory diarrhea and can lose enormous amounts of fluids and electrolytes including potassium (D).

**References:** Vinik, A., Feliberti, E., & Perry, R. R. (2014). Glucagonoma syndrome. *Endotext*, 27(2), 89–107.

Schapiro, H., & Ludewig, R. M. (1978). The effect of glucagon on the exocrine pancreas. A review. *The American Journal of Gastroenterology*, 70(3), 274–281.

4. **B.** For acute pancreatitis, gallstones and alcohol abuse are by far the two most common etiologies, with a slightly higher incidence of biliary pancreatitis. Biliary pancreatitis, however, leads to chronic pancreatitis far less often (A). Alcohol abuse is by far the most common cause of chronic pancreatitis. Although hypertriglyceridemia, infection (often viral) and hereditary syndromes can lead to acute pancreatitis, they occur less frequently than alcohol abuse and gallstones (C, D, E).

**References:** Fisher, W. E., Andersen, D. K., Bell, R. H., et al. (2005). Pancreas. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 1221–1296) (8th ed.). New York, NY: McGraw-Hill.

Steer, M. L. (2004). Exocrine pancreas. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 1643–1678) (17th ed.). Philadelphia, PA: W. B. Saunders.

5. **A.** The patient most likely has a VIPoma. It has also been termed WDHA (watery diarrhea, hypokalemia, and achlorhydria) and Verner-Morrison syndrome. Patients have large-volume secretory diarrhea and can lose enormous amounts of fluids and electrolytes. Diagnosis is by CT scan, and most tumors have metastasized at the time of diagnosis. Another useful imaging tool is endoscopic ultrasonography. Even with distant metastasis, however, tumor debulking, hepatic artery embolization, and radiofrequency ablation of liver metastasis are useful in controlling symptoms (C, E). The best medical treatment of symptoms is achieved with octreotide, a somatostatin analogue. Chemotherapy has no role in the management of VIPoma (D). Streptozotocin is toxic to pancreatic beta cells and may be useful in the management of insulinoma (B).

**Reference:** Nguyen, H., Backes, B., Lammert, F., et al. (1999). Long-term survival after diagnosis of hepatic metastatic VIPoma: report of two cases with disparate courses and review of therapeutic options. *Digestive Diseases and Sciences*, 44(6), 1148–1155.

6. **E.** Coffee drinking has not been shown to be a risk factor for pancreatic cancer. Factors that are associated with a risk for pancreatic cancer include smoking (strongest and accounts for 25–30% of all cases) (C), obesity, diabetes (B), atypical multiple mole melanoma, hereditary pancreatitis (A), familial adenomatous polyposis, hereditary nonpolyposis colon cancer, *BRCA2* (D), and Peutz-Jeghers syndrome. The role of alcohol in pancreatic cancer is debatable. More recently, a history of cholecystectomy and/or cholelithiasis has been demonstrated to be associated with an increased risk of pancreatic cancer (A).

**References:** Fan, Y., Hu, J., Feng, B., et al. (2016). Increased risk of pancreatic cancer related to gallstones and cholecystectomy: a systemic review and meta-analysis. *Pancreas*, 45(4), 503–509.

Lowenfels, A. B., & Maisonneuve, P. (2004). Epidemiology and prevention of pancreatic cancer. *Japanese Journal of Clinical Oncology*, 34(5), 238–244.

7. **D.** Insulinoma is the most common functional pancreatic endocrine neoplasm (E). The classic feature is the Whipple triad, which includes symptomatic fasting hypoglycemia, a documented serum glucose level of less than 50 mg/dL, and relief of symptoms with the administration of glucose. Patients will often present with recurrent episodes of syncope. They may also report palpitations, trembling, diaphoresis, confusion or disorientation, and seizures. The diagnosis is confirmed by demonstrating a low fasting blood sugar (insulin to glucose ratio of > 0.3) and an elevated C peptide level. However, the advent of newer antidiabetic medications such as sulfonylureas can also present with a similar biochemical profile (A). Localization is achieved by

CT scan and endoscopic ultrasonography. On occasion, they cannot be localized preoperatively, in which case, intraoperative ultrasonography is useful and is considered the most sensitive imaging study. In contrast to the other functional endocrine pancreatic neoplasms, an octreotide scan is poor at localizing insulinoma owing to the fact that these lesions may not express sufficient somatostatin receptors (C). They are evenly distributed throughout the head, body, and tail of the pancreas. There is no pancreatic tumor that characteristically appears in the neck of the pancreas (B). The majority of insulinomas are benign (90%). They can be treated with enucleation. Diazoxide inhibits insulin release and is occasionally used for preoperative control of symptoms related to hypoglycemia symptoms. For patients with recurrent or metastatic malignant insulinoma, tumor debulking may be beneficial as is the use of streptozocin and 5-FU.

**References:** DeWitt, C. R., Heard, K., & Waksman, J. C. (2007). Insulin and C-peptide levels in sulfonylurea-induced hypoglycemia: a systemic review. *Journal of Medical Toxicology*, 3(3), 107–118.

Halfdanarson, T., Rubin, J., Farnell, M., et al. (2008). Pancreatic endocrine neoplasms: epidemiology and prognosis of pancreatic endocrine tumors. *Endocrine-Related Cancer*, 15(2), 409–427.

8. **D.** Many pancreatic endocrine tumors have high concentrations of somatostatin receptors and can therefore be imaged with a radiolabeled form of the somatostatin analogue octreotide (indium-111 pentetreotide). Octreotide scanning has the advantage of whole-body scanning, which is useful in gastrinomas because they can present in a wide area. Used in combination with endoscopic ultrasonography, it detects more than 90% of gastrinomas. It is also useful for localizing carcinoid tumors. As many as 90% of gastrinomas are found in the Passaro triangle, an area defined by the junction of the cystic duct and common bile duct, the second and third portions of the duodenum, and the neck and body of the pancreas. Although a CT scan is also useful, an octreotide scan is particularly helpful in localizing gastrinomas smaller than 1 cm. Somatostatinoma and VIPoma tend to be large bulky tumors and are thus readily seen by CT (A). Glucagonoma may present with a mass seen in the pancreatic tail (B). Octreotide scanning will miss as many as 40% of insulinomas because they may not express sufficient somatostatin receptors (E). Pancreatic polypeptide (PP) seems to have an important role in glucose metabolism. PP regulates the expression of the hepatic insulin receptor gene. PP-secreting tumor is rare and often asymptomatic but can be established by the presence of an enhancing solitary pancreatic head tumor on CT imaging with elevated fasting PP level (C).

**Reference:** de Herder, W., Kwekkeboom, D., Valkema, R., et al. (2005). Neuroendocrine tumors and somatostatin: imaging techniques. *Journal of Endocrinological Investigation*, 28(11 Suppl Int), 132–136.

9. **E.** The Bedside Index for Severity in Acute Pancreatitis (BISAP) score is a novel predictor of clinical outcome in acute pancreatitis. The parameters for BISAP include blood urea nitrogen (BUN) level greater than 25 mg/dL (A), impaired mentation, 2 or more systemic inflammatory response syndrome (SIRS) criteria (B, C), age greater than 65 years (D), and the presence of pleural effusion. It is simple to use and can be obtained on the first day of admission. The simplicity makes it attractive when compared to the Acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) scoring system and the sensitivity and specificity of BISAP has been shown to be superior. Ranson criteria have fallen out of favor because it requires 48 hours of admission to use this scoring system.

**References:** Gompertz, M., Fernandez, L., Lara, I., et al. (2012). BISAP score as predictor of clinical outcome in acute pancreatitis: retrospective review of 128 patients. *Revista Medica de Chile*, 140(8), 977–983.

Wu, B. U., Johannes, R. S., Sun, X., et al. (2008). The early prediction of mortality in acute pancreatitis: a large population-based study. *Gut*, 57(12):1698-1703.

10. **A.** The presence of gallstones is the most common cause of acute pancreatitis worldwide, which is thought to be due to a gallstone causing transient obstruction at the ampulla of Vater. In most cases, the inflammation is mild to moderate, and the stone passes into the intestine spontaneously. In patients with severe pancreatitis, early cholecystectomy is associated with an increased morbidity and mortality so that cholecystectomy should be delayed until the pancreatitis is resolved (D). In mild to moderate pancreatitis, the timing of surgery is not critical, and early cholecystectomy (within 48 hours) can be performed safely. However, long delays result in as much as a 30% recurrence of pancreatitis. Routine ERCP to detect the presence of common duct stones is unnecessary because the probability of finding residual stones is low and the risk of ERCP-induced



pancreatitis is significant (B, E). Preoperative ERCP should be reserved for patients with concomitant cholangitis or clear evidence of biliary obstruction (jaundice, persistent elevation of total bilirubin > 4 mg/dL). Otherwise, an intraoperative cholangiogram should be performed, and if a common bile duct stone is detected, either a laparoscopic common duct exploration or a postoperative ERCP should be performed (C).

**References:** Chang, L., Lo, S., Stabile, B., et al. (2000). Preoperative versus postoperative endoscopic retrograde cholangiopancreatography in mild to moderate gallstone pancreatitis: a prospective randomized trial. *Annals of Surgery*, 231(1), 82–87.

Kelly, T., & Wagner, D. (1988). Gallstone pancreatitis: a prospective randomized trial of the timing of surgery. *Surgery*, 104(4), 600–605.

Rosing, D., de Virgilio, C., Yaghoubian, A., et al. (2007). Early cholecystectomy for mild to moderate gallstone pancreatitis shortens hospital stay. *Journal of the American College of Surgeons*, 205(6), 762–766.

11. **D.** Serous cystadenoma is a benign true cyst that most commonly occurs in women and in the pancreatic head. It is often asymptomatic, but large cysts (>4 cm) may cause vague abdominal pain. They do not need to be resected unless they are symptomatic (A). Mucinous cystadenoma is considered premalignant, has a female predominance, occurs commonly in the body or tail of the pancreas, and should always undergo resection (E). IPMN is divided into three types based on pancreatic duct involvement: main-duct, side-branch, and mixed-type. Main-duct IPMN carries up to a 50% risk of harboring malignant cells and should always be resected in surgically appropriate candidates. Mixed-type IPMN also has a higher risk and should be removed (B). Side-branch IPMN has a lower risk of malignancy and can be observed unless it is symptomatic, larger than 3 cm, or associated with mural nodules. The weight loss in patients with IPMN is mostly attributed to exocrine insufficiency from duct blockage and not TNF-alpha cachexia (C).

12. **D.** Severe hypertriglyceridemia leads to a falsely low sodium level. Water is displaced in the serum by lipids, resulting in an error in measurement. The danger is that the clinician who is unaware may try to correct the hyponatremia with hypertonic saline, leading to severe hypernatremia. Similarly, a significantly elevated level of serum glucose can also result in pseudohyponatremia. Excess volume loss secondary to emesis can lead to a hypovolemic hyponatremia but is accompanied by a hypochloremic metabolic alkalosis (A). Patients with gastrointestinal (GI) losses can have hyponatremia exacerbated by excessive free water replacement (C). Adrenal insufficiency may lead to hyponatremia secondary to the loss of action of aldosterone at the distal convoluted renal tubules but is accompanied with severe refractory hypotension and marked hyperkalemia (E).

**Reference:** Howard, J., & Reed, J. (1985). Pseudohyponatremia in acute hyperlipemic pancreatitis: a potential pitfall in therapy. *Archives of Surgery*, 120(9), 1053–1055.

13. **B.** Primary pancreatic lymphoma is extremely rare. Thus, the management approach is based on case series and experience with lymphoma at other sites. Patients with pancreatic lymphoma may present with symptoms and CT findings suggestive of pancreatic adenocarcinoma, and as such, it may be difficult to diagnose preoperatively. However, suspicion of lymphoma should be raised in the presence of a large bulky pancreatic tumor or with more diffuse pancreatic involvement. This is one situation in which CT-guided needle biopsy of the mass is indicated because the majority of studies indicate that pancreatic lymphoma responds to chemotherapy as the primary modality. Surgery or radiation is not typically used in the management of pancreatic lymphoma (A, C–E).

**References:** Arcari, A., Anselmi, E., Bernuzzi, P., et al. (2005). Primary pancreatic lymphoma: a report of five cases. *Haematologica*, 90(1), ECR09.

Bouvet, M., Staerckel, G., Spitz, F., et al. (1998). Primary pancreatic lymphoma. *Surgery*, 123(4), 382–390.

Grimison, P., Chin, M., Harrison, M., et al. (2006). Primary pancreatic lymphoma—pancreatic tumors that are potentially curable without resection: a retrospective review of four cases. *BMC Cancer*, 6, 117.

14. **C.** In pancreatic divisum, the ducts of Wirsung and Santorini fail to fuse (E). The result is that the majority of the pancreas drains through the duct of Santorini and through the lesser papilla. The inferior portion of the pancreatic head and uncinate process drains through the duct of Wirsung and the major papilla (B, D). It is considered a normal anatomic variant and is seen in 10% of

individuals. It is thought to lead to an increased risk of pancreatitis because the minor papilla sometimes cannot handle the higher flow of pancreatic juices. In another more common variant, the duct of Santorini ends in a blind pouch but still fuses with the Wirsung duct (A).

15. **C.** Pancreas divisum can lead to recurrent episodes of acute pancreatitis as well as chronic pancreatitis with intractable pain. Unlike other forms of chronic pancreatitis, however, marked dilation of the dorsal duct is unusual. As such, surgical decompressive procedures are not successful (A, B). For patients with recurrent attacks of acute pancreatitis, the best option is sphincterotomy of the minor papilla because the duct of Santorini is providing the primary drainage to the pancreas. A study from Marseille found a decreased rate of acute pancreatitis in 24 patients after minor papilla sphincterotomy and dorsal duct stenting. The complication rate was lower with sphincterotomy than with stent insertion. Major papilla sphincterotomy would not likely be helpful because it drains a minority of the pancreas in pancreas divisum (D). Distal pancreatectomy is typically not needed (E).

**Reference:** Heyries, L., Barthet, M., Delvasto, C., et al. (2002). Long-term results of endoscopic management of pancreas divisum with recurrent acute pancreatitis. *Gastrointestinal Endoscopy*, 55(3), 376–381.

16. **C.** The most common indication for surgical intervention in patients with chronic pancreatitis is chronic pain (D). Surgical drainage of a dilated pancreatic duct with distal obstruction is more effective than endoscopic approaches in patients with chronic pancreatitis (B). The Puestow procedure involves cutting open the length of the main pancreatic duct and anastomosing a Roux limb of jejunum to the duct but requires a dilated duct (>6 mm). Both the Whipple procedure (for inflammation limited to the pancreatic head) and total pancreatectomy are options for the treatment of intractable chronic pancreatitis, although they are associated with greater morbidity than a drainage procedure (A). The Beger procedure is another option, which resects the pancreatic head but spares the duodenum, stomach, and bile duct, but this is a technically challenging procedure. The Frey procedure is similar to Beger but easier to perform since it avoids the transection of the pancreatic neck over the superior mesenteric vessels. The best long term pain control is achieved with longitudinal pancreaticojejunostomy with limited resection of the head of the pancreas, which Beger and Frey both satisfy, with Frey being the preferred option (E).

**References:** Cahen, D., Gouma, D., Nio, Y., et al. (2007). Endoscopic versus surgical drainage of the pancreatic duct in chronic pancreatitis. *The New England Journal of Medicine*, 356(7), 676–684.

DiMagno, M. J., & DiMagno, E. P. (2012). Chronic pancreatitis. *Current Opinion in Gastroenterology*, 28(5), 523–531.

Jawad, Z. A., Kyriakides, C., Pai, M. et al. (2016). Surgery remains the best option for the management of pain in patients with chronic pancreatitis: a systemic review and meta-analysis. *Asian Journal of Surgery*, Jan 6, Epub ahead of print.

Roch, A., Teyssedou, J., Mutter, D., et al. (2014). Chronic pancreatitis: a surgical disease? Role of the Frey procedure. *World Journal of Gastrointestinal Surgery*, 6(7), 129–135.

17. **A.** The majority of adenocarcinomas of the pancreas arise from the main pancreatic duct. Approximately 66% of pancreatic adenocarcinomas develop within the head or uncinate process of the pancreas. The remaining answer choices can lead to pancreatic adenocarcinoma, but it occurs less frequently (B, C, E). Carcinoma at the ampulla of Vater is most commonly duodenal adenocarcinoma (D).

**Reference:** Albores-Saavedra, J., Schwartz, A. M., Batich, K., et al. (2009). Cancers of the ampulla of Vater: demographics, morphology, and survival based on 5,625 cases from the SEER program. *Journal of Surgical Oncology*, 100(7), 598–605.

18. **D.** In a patient with obstructive jaundice, the first study to perform is an abdominal ultrasound scan. In the absence of abdominal pain and in the presence of weight loss, it is highly likely that the diagnosis is malignancy. A dynamic, contrast-enhanced CT scan is highly effective in determining the resectability of the mass. In cases where vascular involvement is not clear, endoscopic ultrasonography has aided in determining resectability. Pancreatic cancer is considered unresectable if the tumor is encasing or occluding the superior mesenteric vein or portal vein and causing vein contour irregularity as this is considered unreconstructable. Additionally, pancreatic cancer is considered unresectable if the tumor is abutting or encasing the superior mesenteric artery, hepatic artery, or celiac trunk by more than 180°. More frequently, endoscopic guided biopsy is being performed. The advantage of this approach is that there is no risk of tumor seeding

because the area through which the needle is passed becomes part of the Whipple specimen. That being said, in the situation in which the mass appears to be resectable, percutaneous or endoscopic ultrasonography-guided biopsy is not considered necessary. Needle biopsy is prone to sampling error; therefore, a negative biopsy finding would not alter the plan to perform a Whipple procedure (A). Likewise a positive biopsy finding would not alter the operative decision. Operative morbidity and mortality after the Whipple procedure are sufficiently low that one would accept the low likelihood (~5%) that the lesion is benign. Biopsy should be reserved for situations in which the lesion appears to be unresectable because it may guide chemotherapy. It is also indicated in situations in which the appearance of the mass suggests other less common pathologies such as pancreatic lymphoma. Diagnostic laparoscopy is often done before proceeding with a Whipple to confirm there are no obvious hepatic or peritoneal lesions (B). Suspected lesions are sent for a frozen sample. MRI may be a useful adjunct in patients with equivocal findings on CT or in cases where hepatic metastasis is suspected (C). The role of PET in cancer workup continues to develop but as of now it is unclear if PET adds any additional information beyond what is provided with CT (E).

**References:** Small, W. Jr., Hayes, J. P., Suh, W. W., et al. (2016). ACR appropriateness criteria [r] borderline and unresectable pancreas cancer. *Oncology*, 30(7), 619–619.

Tummala, P., Junaidi, O., & Agarwal, B. (2011). Imaging of pancreatic cancer: An overview. *J Gastrointest Oncol*, 2(3), 168–174.

Wang, W. L., Ye, S., Yan, S., et al. (2015). Pancreaticoduodenectomy with portal vein/superior mesenteric vein resection for patients with pancreatic cancer with venous invasion. *Hepatobiliary & Pancreatic Diseases International*, 14(4), 429–435.

19. **A.** The exact mechanism by which alcohol induces pancreatitis is unclear. Ethanol induces spasm of the sphincter of Oddi, and this may lead to an increase in ductal pressure with a simultaneous brief stimulation of pancreatic secretion (B). It also increases pancreatic duct permeability, decreases pancreatic blood flow, and inappropriately activates chymotrypsin (C–E).
20. **C.** Most patients with alcohol-related pancreatitis have a long-standing history of heavy drinking. The mean number of years of drinking at the time of presentation with pancreatitis is 18 years in men and 11 years in women (E). The type of alcohol consumed is not important but rather the quantity and duration (B). The mean amount consumed in patients in whom pancreatitis develops is 100 to 175 g/day, although it can rarely develop after just one binge (A, D). In alcoholics, the first attack of pancreatitis may represent an acute exacerbation of chronic pancreatitis, and the patient may have had repeat subclinical bouts of acute pancreatitis previously. The risk of pancreatitis seems to be higher in patients who have a diet high in protein and fat.
21. **D.** Diabetes in the setting of chronic pancreatitis or after pancreatic resection is termed *type 3 diabetes*. It differs from type 1 and 2 diabetes in that it is associated with decreased glucagon and PP levels as well as insulin due to pancreatic loss or destruction. Because all three of these hormones regulate glucose levels, the diabetes that ensues is considered to be difficult to control (B). Furthermore, peripheral insulin sensitivity is increased, whereas hepatic insulin sensitivity is decreased (C). The result is that patients are prone to the development of hypoglycemia, but ketoacidosis and marked hyperglycemia are rare (A, E). For diabetes to develop as a result of pancreatitis, extensive destruction of the pancreas must occur. In fact, resections involving up to 80% of an otherwise normal gland can be done without endocrine insufficiency. This may help explain why not all post-Whipple patients develop poor glucose control.
22. **C.** Although the patient has symptomatic hypoglycemia, seemingly consistent with an insulinoma, her insulin-to-C peptide ratio is greater than 1. This combination, particularly in a health-care worker, is highly suggestive of factitious hypoglycemia with exogenous insulin abuse. The precursor to insulin is proinsulin. Proinsulin is packaged in the pancreatic B cell where it is cleaved to insulin and C peptide, which are then released into the circulation at an equal ratio. Insulin is cleared by the liver, whereas C peptide is cleared by the kidney and is cleared more slowly than insulin, such that the normal insulin-to-C peptide ratio is less than 1 during fasting. With a true insulinoma, both insulin and C peptide levels would be elevated; however, the ratio would still be less than 1. Factitious hypoglycemia will present with an insulin-to-C peptide ratio greater than 1 only if the patient is using exogenous insulin. In contrast, sulfonylurea abuse will have a ratio less than 1 since it stimulates pro-insulin release from the pancreas (B). Factitious hypoglycemia has been reported more frequently in health-care workers and is associated with a

higher incidence of suicide, depression, and personality disorders. Thus, the patient should be referred for psychiatric counseling. Octreotide scan (D) is not useful in the workup for insulinoma but CT, MRI, or endoscopic ultrasound may demonstrate a pancreatic mass (A, E).

**References:** Lebowitz, M., & Blumenthal, S. (1993). The molar ratio of insulin to C-peptide: an aid to the diagnosis of hypoglycemia due to surreptitious (or inadvertent) insulin administration. *Archives of Internal Medicine*, 153(5), 650–655.

Waickus, C., de Bustros, A., & Shakil, A. (1999). Recognizing factitious hypoglycemia in the family practice setting. *The Journal of the American Board of Family Practice*, 12(2), 133–136.

23. **A.** It is important to be aware that not all fluid-filled pancreatic abnormalities in a patient with a history of drinking represent pseudocysts (B–E). Some of these lesions may represent cystic neoplasms of the pancreas. Suspicion of a cystic neoplasm should be particularly increased in the absence of a history of pancreatitis, as in this patient. A cystic neoplasm should also be suspected when the CT scan demonstrates a solid component (septation) in the cystic lesion. The differential diagnosis includes serous cystadenoma, mucinous cystic neoplasm, intraductal papillary-mucinous adenoma, and solid pseudopapillary neoplasm. On a CT scan, a central scar is characteristic of a serous cystadenoma (although present in only 20%), whereas the finding of peripheral eggshell calcifications, although rare, is diagnostic of mucinous cystic neoplasm and highly suggestive of cancer. In the patient presented, the procedure of choice is surgical resection with distal pancreatectomy and splenectomy. This is based on several factors: The patient is having symptoms; he is a good candidate for surgery; the lesion is readily amenable to resection; and the lesion's size, its septations, and its multiple loculations. If, conversely, a patient has an incidentally discovered pancreatic cyst without symptoms, surgery is generally recommended if the risk of surgery is low. Before surgery, further studies are recommended to attempt to determine the malignant potential. The workup may include MRI, endoscopic ultrasonography to better delineate the mass, and CT-guided aspiration of the fluid for amylase level and tumor markers (carcinoembryonic antigen, CA 19–9, CA 125, CA 72–4, CA 15–3).

24. **E.** After surgery, trauma, or bouts of pancreatitis, persistent ascites or pleural effusions can develop. These are generally caused by a disruption of the pancreatic duct, with free extravasation of pancreatic fluid, leading to the development of an internal pancreatic fistula, which is rare. More commonly, the extravasated fluid leads to the formation of a contained fluid collection known as a pseudocyst. Management of pancreatic ascites or effusion first requires establishing the diagnosis by obtaining a sample of the fluid and demonstrating a markedly elevated amylase level and a protein level greater than 25 g/L. Serum amylase may be elevated from reabsorption across the peritoneal membrane. The recommended management is a stepwise progression, first with conservative management with bowel rest, parenteral nutrition, placing the patient NPO, and paracentesis to completely drain the fluid. If this fails to resolve the internal fistula, ERCP with pancreatic stenting is recommended. If this fails, surgery is indicated and should be tailored to the location of the ductal injury (B). For distal duct disruptions, a distal pancreatectomy is recommended (A), whereas for disruption of the body, a Roux-en-Y pancreaticojejunostomy is performed (C). Whipple procedure (pancreaticoduodenectomy) is not needed (D). Conservative therapy including somatostatin is successful in only approximately 50% so that nearly one-half will require an invasive procedure.

**References:** Gómez-Cerezo, J., Barbado Cano, A., Suárez, I., et al. (2003). Pancreatic ascites: study of therapeutic options by analysis of case reports and case series between the years 1975 and 2000. *The American Journal of Gastroenterology*, 98(3), 568–577.

O'Toole, D., Vullierme, M., Ponsot, P., et al. (2007). Diagnosis and management of pancreatic fistulae resulting in pancreatic ascites or pleural effusions in the era of helical CT and magnetic resonance imaging. *Gastroenterologie Clinique et Biologique*, 31(8-9 Pt 1), 686–693.

25. **B.** Autoimmune pancreatitis is a form of chronic pancreatitis that is increasingly being recognized and can be confused with pancreatic lymphoma or pancreatic cancer. It presents most often as a diffusely enlarged hypoechoic pancreas. A CT scan often shows diffuse narrowing of the main pancreatic duct without the typical calcifications seen with chronic alcoholic pancreatitis. Pathology reveals a plasma cell and lymphocytic infiltrate. Laboratory values reveal increased levels of IgG and often diabetes. Antibodies against lactoferrin and carbonic anhydrase have been reported, but they are not a specific finding. The treatment of choice is steroid therapy, and the disease responds well to this management. Chemotherapy or invasive surgical/endoscopic

procedures are not necessary (A, C–E).

**References:** Ketikoglou, I., & Moulakakis, A. (2005). Autoimmune pancreatitis. *Digestive and Liver Disease*, 37(3), 211–215.

Okazaki, K. (2001). Autoimmune-related pancreatitis. *Current Treatment Options in Gastroenterology*, 4(5), 369–375.

26. **C.** Tropical pancreatitis is a form of chronic pancreatitis that occurs in young patients in tropical regions of the world (A). Unlike acute pancreatitis, it is not associated with gallstones (B). It is associated with a genetic mutation of the pancreatic secretory trypsinogen inhibitor or *SPINK1* gene. It is also associated with ingestion of the cassava root, which contains toxic glycosides that may lead to free radical injury to the pancreas. There is a familial pattern, and as such, some have theorized that it is simply a variant of hereditary pancreatitis. Patients present with abdominal pain, and diabetes commonly develops as the pancreatitis often becomes chronic (E). It is also associated with pancreatic duct stone formation. Treatment is with pain medication and digestive enzyme supplementation (D). Progression may require endoscopic decompression or rarely surgical decompression, although the latter has unsatisfactory results. It is associated with an increased risk of pancreatic cancer.

**Reference:** Tandon, R., & Garg, P. (2004). Tropical pancreatitis. *Digestive Diseases*, 22(3), 258–266.

27. **A.** This patient is presenting with a gastroduodenal artery stump leak following a pancreaticoduodenectomy (Whipple) procedure. It is unlikely that there is a complete blowout because those patients exsanguinate quickly and it is often fatal. The tissue planes are fragile this early after surgery making it difficult to control bleeding in the operating room (B). After resuscitation with blood products, the most appropriate next step involves performing an angiography with embolization. Upper endoscopy can be considered in the event that this patient had bloody nasogastric tube output and was suspected to have an upper gastrointestinal bleed (E). Esophagogastroduodenoscopy (EGD) needs to be selectively performed this early after surgery because the scope may compromise the freshly made gastrojejunostomy anastomosis if the afferent/efferent limbs are to be evaluated. Bedside ultrasonography is a useful adjunct but inappropriate in an unstable patient (D). Octreotide has no role in the management of gastroduodenal artery stump bleeding (C). It has been demonstrated that wrapping the gastroduodenal artery stump using the falciform ligament during surgery decreases the risk of this complication.

**Reference:** Xu, C., Yang, X., Luo, X., et al. (2014). Wrapping the gastroduodenal artery stump during pancreaticoduodenectomy reduced the stump hemorrhage incidence after operation. *The Chinese Journal of Cancer Research*, 26(3), 299–308.

28. **E.** The ventral pancreas constitutes the uncinate process and inferior portion of the head of the pancreas, leaving the remainder the embryologic remnant of the dorsal pancreas (C). The uncinate process lies ventral to the aorta but dorsal to the portal vein and superior mesenteric artery. The most commonly injured vessel during dissection behind the neck of the pancreas is the superior mesenteric vein (A). The pancreas receives blood supply from two sources: the celiac axis (superior pancreaticoduodenal artery) and superior mesenteric artery (inferior pancreaticoduodenal artery) (B). Venous drainage of the pancreas is to the portal system (D).
29. **D.** CT scan with IV contrast demonstrating areas of hypoattenuation (nonperfused) in the pancreas in a patient with this presentation is concerning for necrotizing pancreatitis. It is important to note that the necrotic pancreas is not usually infected initially. Thus initial management of necrotizing pancreatitis is conservative with the avoidance of early invasive interventions. FNA with culture might be considered later (because infected necrosis typically develops weeks later) in the course of the hospitalization if the patient were to manifest evidence of sepsis such as leukocytosis, tachycardia, refractory abdominal pain, bacteremia, and/or persistent fevers (A). Prophylactic antibiotics for severe pancreatitis are controversial, but recent studies have failed to show a consistent benefit (B). In patients with proven (via needle aspiration) infected necrosis, wide debridement with necrosectomy was the surgical procedure of choice but has been replaced by minimally invasive percutaneous or endoscopic interventions followed by video-assisted retroperitoneal debridement with the goal of postponing or obviating the need for open surgery (E). Furthermore, early necrosectomy has been shown to increase morbidity and mortality when compared with delayed intervention (C). In a patient that does not appear to have an infected necrotizing pancreatitis, it is appropriate to approach management conservatively with

medical optimization and repeat CT scan if there is a change in clinical status. It is best to allow the patient to manifest the severity of the disease before invasive interventions.

**Reference:** Bugiantella, W., Rondelli, F., Boni, M., et al. (2016). Necrotizing pancreatitis: a review of the interventions. *International Journal of Surgery*, (Suppl. 1), S163–S171.

Mier, J., Leon, E. L., Castillo, A. et al. (1997). Early versus late necrosectomy in severe necrotizing pancreatitis. *American Journal of Surgery*, 173(2), 71–75.

30. A. Although elevation of alkaline phosphatase can be seen with a residual common bile duct stone, the best predictor is a persistent elevation of the total bilirubin (C). Amylase is not typically elevated in this patient population (D). Because the pathophysiology of gallstone pancreatitis is transient obstruction of the ampulla of Vater by a gallstone, a significant number of patients will have some degree of common bile duct dilation on admission; as such, common bile duct dilation is not a specific finding (B). This differs from patients with symptomatic cholelithiasis in which ductal dilation is frequently associated with common duct stones. Persistent abdominal pain can occur as a result of multiple etiologies and should be appropriately worked up with history and physical, laboratory studies, and/or imaging, if necessary (E).

**References:** Chan, T., Yaghoubian, A., Rosing, D., et al. (2008). Total bilirubin is a useful predictor of persisting common bile duct stone in gallstone pancreatitis. *The American Surgeon*, 74(10), 977–980.

Chang, L., Lo, S., Stabile, B., et al. (1998). Gallstone pancreatitis: a prospective study on the incidence of cholangitis and clinical predictors of retained common bile duct stones. *The American Journal of Gastroenterology*, 93(4), 527–531.

31. E. Solid pseudopapillary epithelial neoplasm is a rare tumor occurring almost exclusively in young women. It has low malignant potential and for the majority of patients, the tumor can be resected with curative intent regardless of the size. Metastasis and recurrence are uncommon. Serous cystic adenoma also occurs most commonly in women, but this has no malignant potential and does not need to be resected unless it is causing mass effect (A). Mucinous cystic neoplasm is considered a premalignant lesion, has a female predominance, occurs commonly in the body or tail of the pancreas, and should always undergo resection (B). Main-duct IPMN has a high risk of harboring malignant cells and should be resected (D). Side-duct IPMN can be managed conservatively unless it is symptomatic, larger than 3 cm, or associated with mural nodules (C).

**Reference:** Frost, M., Krige, J. E., Bornman P. C., et al. (2011). Solid pseudopapillary epithelial neoplasm—a rare but curable pancreatic tumour in young women. *South African Journal of Surgery*, 49(2), 75–76, 78–81.



# Abdomen—Spleen

Areg Grigorian, and Christian de Virgilio

## Questions

1. A 50-year-old male has an incidentally discovered 8-cm nonparasitic splenic cyst. Which of the following is true about this condition?
  - A. Splenectomy should be performed.
  - B. Most are symptomatic and present with left upper quadrant tenderness.
  - C. It may secrete CA 19-9.
  - D. The patient should undergo percutaneous aspiration.
  - E. It is a common incidental finding.
2. A 7-year old-girl with hemolytic anemia that has failed conservative management is scheduled for an elective splenectomy. Which of the following is true regarding her condition?
  - A. Preoperative right upper quadrant ultrasonography should be performed.
  - B. An intraoperative search for accessory splenic tissue is not necessary.
  - C. The most common intraoperative complication is injury to the pancreas.
  - D. Open splenectomy should be performed.
  - E. Surgery should be delayed until 10 years of age.
3. A 35-year-old alcoholic male with human immunodeficiency virus (HIV) undergoes a splenectomy after being involved in a motor vehicle crash. Which of the following is true?
  - A. The primary risk of overwhelming postsplenectomy infection (OPSI) is within the first year after splenectomy.
  - B. Suspected OPSI should initially be managed with a fluoroquinolone.
  - C. The majority of OPSI cases are due to *Haemophilus influenzae*.
  - D. Daily prophylactic antibiotic is recommended.
  - E. Loss of immunoglobulin G (IgG) is what predisposes postsplenectomy patients to OPSI.
4. Which of the following indications for splenectomy poses the highest risk of postsplenectomy sepsis?
  - A. Trauma
  - B. Idiopathic thrombocytopenic purpura (ITP)
  - C. Hereditary spherocytosis (HS)
  - D. Thalassemia major
  - E. Hereditary elliptocytosis
5. After splenectomy for trauma, the optimal timing for administration of the pneumococcal vaccine is on postoperative day:
  - A. 1
  - B. 4
  - C. 7
  - D. 10
  - E. 14

6. A 32-year-old female with rheumatoid arthritis presents for evaluation of recurrent infections. Physical exam is significant for splenomegaly. Laboratory exam demonstrates marked neutropenia. Which of the following is true concerning this condition?
- A. Splenectomy is the initial treatment of choice.
  - B. There is a tendency for upper extremity ulcers to form in this patient population.
  - C. The neutrophil count does not improve with surgical intervention.
  - D. Patients have antibodies against neutrophil nuclei.
  - E. Corticosteroids are contraindicated.
7. Ectopic or “wandering” spleen:
- A. Is the presence of an accessory spleen in an unusual location
  - B. Is more common in males
  - C. Requires no surgical management even when symptomatic
  - D. May result in splenic torsion
  - E. Is best diagnosed with mesenteric angiography
8. Which of the following is true regarding hereditary spherocytosis (HS)?
- A. It is transmitted as an autosomal recessive trait.
  - B. The spleen is typically smaller than normal.
  - C. Spherocytosis on blood smear improves following splenectomy.
  - D. It is associated with leg ulcers.
  - E. A positive direct Coombs test result confirms the diagnosis.
9. A 12-year-old boy presents with ecchymosis and fever of 101.2°F. Laboratory exam is remarkable for platelet count of 30,000 cells/ $\mu$ L and hemoglobin of 8.2 mg/dL. Peripheral blood smear shows large and immature platelets. Review of systems is significant for an upper respiratory tract infection 3 weeks ago. His mother also notes that his urine has been pink. This is his second admission for this constellation of symptoms. Which of the following is true regarding this condition?
- A. If splenectomy is required, platelets should be given just before skin incision, given the low platelet count.
  - B. In children, intravenous immunoglobulin is the initial approach to management.
  - C. The spleen is typically palpable on abdominal examination.
  - D. Children with platelet counts of 50,000 or fewer cells/ $\mu$ L should be hospitalized.
  - E. In adults, this occurs more frequently in females.
10. Which of the following is the best indication for splenectomy?
- A. Sarcoidosis
  - B. Gaucher disease
  - C. Myelofibrosis
  - D. Hairy cell leukemia with neutropenia
  - E. Secondary hypersplenism in a cirrhotic patient
11. A 30-year-old woman is found to have a signet ring calcification in the left upper quadrant on a plain abdominal radiograph. A computed tomography (CT) scan confirms a 2-cm splenic artery aneurysm just beyond the take-off of the celiac axis. The pancreas appears normal. Which of the following is true regarding this condition?
- A. It is an uncommon visceral artery aneurysm.
  - B. In this patient, it is most likely a pseudoaneurysm.
  - C. It is associated with a double-rupture phenomenon.
  - D. The aneurysm typically arises in the proximal portion of the splenic artery.
  - E. Most patients require intervention.
12. Two months after a splenectomy for ITP, the patient is noted to have petechiae and a decrease in platelet count. A peripheral blood smear is noteworthy for the absence of Howell-Jolly bodies. Which of the following is the best recommendation for a workup?

- A. CT scan of the abdomen
  - B. Bone marrow biopsy
  - C. No workup needed; administer steroids
  - D. Radiolabeled RBC scan
  - E. No workup needed; administer immunoglobulin
13. Which of the following is true regarding ITP?
- A. In adults, splenectomy should be performed once the diagnosis is established.
  - B. A chronic form is more likely to develop in adults than in children.
  - C. The diagnosis is effectively established by a peripheral blood smear.
  - D. Immunoglobulin is ineffective in increasing the platelet count.
  - E. In adults, splenectomy should be delayed until after the second relapse.
14. Which of the following is true regarding thrombotic thrombocytopenic purpura (TTP)?
- A. It does not lead to hemolysis.
  - B. It is associated with liver failure.
  - C. Splenectomy is the first line of treatment in adults.
  - D. The Coombs test result is positive.
  - E. The most common cause of death is intracerebral hemorrhage.
15. Which of the following is least likely to be seen in a postsplenectomy patient?
- A. Erythrocytes containing iron deposits
  - B. Irregularly shaped and fragmented RBCs
  - C. Persistent monocytosis
  - D. Acanthocytes
  - E. Erythrocytes containing nuclear fragments
16. The most common source of splenic abscess is:
- A. Hematogenous spread
  - B. Secondary infection of a hematoma
  - C. Secondary infection of a cyst
  - D. Local extension of colonic perforation
  - E. Local extension of a pancreatic abscess
17. After splenectomy for a myeloproliferative disorder, a 40-year-old woman presents with anorexia, abdominal pain, and a low-grade fever. Her white blood cell (WBC) count is 14,000 cells/ $\mu$ L and her platelet count is 500,000 cells/ $\mu$ L. A noncontrast CT scan reveals diffuse small bowel edema and mild ascites. The most likely diagnosis is:
- A. Overwhelming postsplenectomy infection (OPSI)
  - B. Portal vein thrombosis
  - C. Primary peritonitis
  - D. Ischemic colitis
  - E. Perforated duodenal ulcer
18. Which of the following is true regarding hairy cell leukemia?
- A. Leustatin (cladribine) is hepatotoxic and should be avoided in patients with underlying cirrhosis.
  - B. Splenectomy is the first-line treatment.
  - C. It is a clonal disorder of T-lymphocytes that involves blood and bone marrow.
  - D. 5-Fluorouracil is frequently used.
  - E. It is associated with increased risk of thyroid cancer.
19. The most common cause of spontaneous splenic rupture worldwide is:
- A. Leukemia
  - B. Malaria

- C. Hemophilia
  - D. Hemolytic anemia
  - E. Hodgkin lymphoma
20. The most common indication for elective splenectomy is:
- A. Staging for Hodgkin lymphoma
  - B. Hereditary spherocytosis
  - C. Immune thrombocytopenic purpura
  - D. Thrombotic thrombocytopenic purpura
  - E. Autoimmune hemolytic anemia
21. In comparing laparoscopic with open splenectomy for hematologic disorders, which of the following is true?
- A. Open splenectomy has better long-term results with respect to response rates.
  - B. The length of hospital stay is the same.
  - C. The operative mortality rate is lower with laparoscopic splenectomy.
  - D. Laparoscopic splenectomy has emerged as the standard of care.
  - E. Laparoscopic splenectomy is frequently associated with increased cost to the patient.
22. The most common location for an accessory spleen is:
- A. Splenic hilum
  - B. Gastrocolic ligament
  - C. Greater omentum
  - D. Splenorenal ligament
  - E. Adjacent to the left testicle

## Answers

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1. **C.** Nonparasitic splenic cysts are rare (E). They are most commonly asymptomatic but when patients have symptoms they frequently complain of left upper quadrant tenderness with referred pain to the left shoulder (B). Previously, it was widely accepted that a nonparasitic splenic cyst larger than 5 cm should be surgically removed even if asymptomatic. This originated from a 1992 paper by Musy describing a case series of 8 pediatric patients. More recently it has been shown that asymptomatic cysts can safely be observed regardless of size (A). Additionally, percutaneous aspiration is met with high recurrence rates (D). Patients should be managed with observation and serial ultrasound imaging to assess for interval growth. It has been shown that splenic cysts may secrete tumor markers such as CA 19-9, but they do not have malignant potential.
- References:** Boybeyi, O., Karnak, I., Tanyel, F. C., et al. (2010). The management of primary nonparasitic splenic cysts. *The Turkish Journal of Pediatrics*, 52(5), 500–504.
- Bresadola, V., Pravisani, R., Terrosu, G., et al. (2015). Elevated serum CA 19-9 level associated with a splenic cyst: which is the actual clinical management? Review of the literature. *Annali Italiani di Chirurgia*, 86(1), 22–29.
- Musy, P. A., Roche, B., Belli, D., et al. (1992). Splenic cysts in pediatric patients—a report on 8 cases and review of the literature. *European Pediatric Surgery*, 2(3), 137–140.
- Kenney, C. D., Hoeger, Y. E., Yetasook, A. K., et al. Management of nonparasitic splenic cysts: does size really matter? *Journal of Gastrointestinal Surgery*, 18(9), 1658–1663.
2. **A.** In the pediatric population, the preoperative workup for hemolytic anemia should include a right upper quadrant ultrasound to look for cholelithiasis because these patients are susceptible to developing pigment stones, and if present, concomitant splenectomy and cholecystectomy would be considered. Laparoscopic splenectomy has emerged as the gold standard for most children (D). Intraoperatively, before removal of the spleen, there should always be a search for an accessory spleen, particularly in a patient with a hematologic indication for splenectomy (B). There is no need to delay surgery until 10 years of age (E). Most surgeons agree that the minimum accepted age is 5-years-old, but there have been reports of splenectomy in patients as young as 2-years-old.

Although the pancreatic tail is at risk of injury, the most common intraoperative complication is hemorrhage that can occur during hilar dissection (C).

**References:** Sheng, J., & Wu, Y. (2015). A report of two cases of splenectomy in children younger than two years old with hereditary spherocytosis. *Journal of Pediatric Surgery Case Rep*, 3(2), 84–86, 2015.

Vecchio, R., Intagliata, E., Marchese, S., et al. (2014). Laparoscopic splenectomy coupled with laparoscopic cholecystectomy. *JSLs: Journal of the Society of Laparoendoscopic Surgeons / Society of Laparoendoscopic Surgeons*, 18(2), 252–257.

3. **D.** OPSI is a significant concern in the asplenic patient and can occur in 0.05% to 2% of post-splenectomy patients. It is due to loss of immunoglobulin M (IgM) (E). They continue to be at an increased risk many years after splenectomy (A). Management of OPSI requires prompt identification and initiation of supportive care with a third-generation cephalosporin (B). The majority of OPSI cases are due to *Streptococcus pneumoniae* (C) followed by *H. influenzae* type B, *Neisseria meningitides*, and group A streptococcus. Daily prophylactic antibiotic use is indicated for children younger than 5 and immunocompromised patients because they may not be able to mount an appropriate response to pneumococcal vaccination. Asplenic patients may also have mild degrees of thrombocytosis and leukocytosis, Howell-Jolly bodies in red blood cells (RBCs), and an increased number of target cells. Howell-Jolly bodies are nuclear remnants in circulating erythrocytes that appear basophilic (blue). Normally, erythrocytes expel their DNA before exiting the bone marrow.

**References:** Fishman, D., & Isenberg, D. (1997). Splenic involvement in rheumatic diseases. *Seminars in Arthritis and Rheumatism*, 27(3), 141–155.

Piliero, P., & Furie, R. (1990). Functional asplenia in systemic lupus erythematosus. *Seminars in Arthritis and Rheumatism*, 20(3), 185–189, 1990.

Theilacker, C., Ludewig, K., Serr, A., et al. (2015). Overwhelming Postsplenectomy Infection: a Prospective Multicenter Cohort Study. *Clinical Infectious Diseases*, 62(7), 871–878.

4. **D.** All of the answer choices can lead to postsplenectomy sepsis (A–C, E). The incidence rate and mortality rate for postsplenectomy sepsis are highest for patients with underlying hematologic conditions, in particular, thalassemia major and sickle cell disease. Children have a higher risk than adults. In a large review, the incidence of infection after splenectomy in children (younger than 16-years-old) was 4.4% compared with 0.9% in adults. Severe infection after splenectomy for benign disease was very uncommon except in infants and children younger than the age of 5 years. Patients are also more susceptible to malaria.

**References:** Davidson R, Wall R: Prevention and management of infections in patients without a spleen, *Clinical Microbiology and Infection* 7:657–660, 2001.

Holdsworth, R., Irving, A., & Cuschieri, A. (1991). Postsplenectomy sepsis and its mortality rate: actual versus perceived risks. *The British Journal of Surgery*, 78(9), 1031–1038.

Leonard, A., Giebink, G., Baesl, T., et al. (1980). The overwhelming postsplenectomy sepsis problem. *World Journal of Surgery*, 4(4), 423–432.

5. **E.** In patients who have unanticipated splenectomy (i.e., trauma), administering the pneumococcal vaccine immediately postoperatively will result in a much higher likelihood of the need for revaccination. The optimal timing is 14 days after surgery (A–D). Furthermore, in patients undergoing planned splenectomy, those who received the vaccine less than 14 days before surgery were more likely to need revaccination. However, in the trauma population many patients are lost to follow-up and some surgeons elect to administer the appropriate vaccines before discharge. Pneumococcal vaccine needs to be repeated every 5 to 7 years. The timing of immunoprophylaxis for meningococcus and *H. influenzae* type B is less clear, so most would recommend giving it at the same time as pneumococcus. In children, antibiotic prophylaxis with penicillin or amoxicillin is also recommended for at least 2 years after splenectomy. Annual vaccination against influenza is also recommended because influenza infections predispose to secondary bacterial infection.

**References:** Shatz, D., Romero-Steiner, S., Elie, C., et al. (2002). Antibody responses in postsplenectomy trauma patients receiving the 23-valent pneumococcal polysaccharide vaccine at 14 versus 28 days postoperatively. *The Journal of Trauma*, 53(6), 1037–1042.

Shatz, D., Schinsky, M., Pais, L., et al. (1998). Immune responses of splenectomized trauma patients to the 23-valent pneumococcal polysaccharide vaccine at 1 versus 7 versus 14 days after

splenectomy. *The Journal of Trauma*, 44(5), 765–766.

6. **D.** The triad of rheumatoid arthritis, splenomegaly, and neutropenia is called Felty syndrome. It is present in 3% of patients with rheumatoid arthritis. The pathophysiology involves the coating of the white blood cell surface with immune complexes, leading to their sequestration and clearance in the spleen. An increased risk of infections due to neutropenia ensues. The size of the spleen can vary from nonpalpable to massively enlarged. Initial treatment with corticosteroids typically improves the neutrophil count, but the effects are not always permanent (A, E). Hematopoietic growth factors and methotrexate have also been used. There is a tendency for leg ulcers to form in these patients (B). Other indications for splenectomy include transfusion-dependent anemia and profound thrombocytopenia. Responses to splenectomy are excellent, with more than 80% of patients showing a durable increase in white blood cell count. The neutrophil count typically improves immediately, although the relative number of neutrophils may remain subnormal (C). However, neutrophil function improves.

7. **D.** Wandering spleen is rare. It refers to a spleen that lacks its normal peritoneal attachments, thus permitting the spleen to move freely in the peritoneal cavity (A). It has been postulated to result from failure of the dorsal mesogastrium to fuse to the posterior abdominal wall during embryonic development. The wandering spleen has an unusually long splenic pedicle. Another hypothesis is that an acquired defect in splenic attachment may occur in multiparous women secondary to hormonal changes during pregnancy and associated abdominal laxity. Wandering spleen is most commonly diagnosed in children and in women between 20 and 40 years of age (B). Most patients with a wandering spleen are asymptomatic. Symptomatic patients often present with recurrent episodes of abdominal pain. This is likely related to tension on the vascular pedicle or intermittent torsion of the splenic vessels. Acute torsion of the splenic vessels may lead to a presentation of severe abdominal pain. The diagnosis of wandering spleen is confirmed by abdominal computed tomography scan (E). Provided the spleen is not infarcted, treatment is with splenopexy (C).

**References:** Hirose, R., Kitano, S., Bando, T., et al. (1998). Laparoscopic splenopexy for pediatric wandering spleen. *Journal of Pediatric Surgery*, 33(10), 1571–1573.

Nemcek, A., Jr., Miller, F., & Fitzgerald, S. (1991). Acute torsion of a wandering spleen: diagnosis by CT and duplex Doppler and color flow sonography. *AJR American Journal of Roentgenology*, 157(2), 307–309.

8. **D.** Hereditary spherocytosis is a RBC membrane disorder that leads to hemolytic anemia. It is autosomal dominant and the most common hemolytic anemia requiring splenectomy (A). It is due to an inherited dysfunction or deficiency in one of the RBC membrane proteins (spectrin, ankyrin, band 3 protein, or protein 4.2), which causes the membrane lipid bilayers to destabilize, leading to a lack of membrane deformability. The spleen sequesters and destroys these nondeformable RBCs. Most patients are asymptomatic, although they may have mild jaundice from hemolysis as well as splenomegaly on physical examination (B). Laboratory features include a mild to moderate anemia, a low mean corpuscular volume, an elevated mean corpuscular hemoglobin concentration, and an elevated red cell distribution width. Laboratory values also reflect the hemolysis and rapid cell turnover, with an elevated reticulocyte count, lactate dehydrogenase, and unconjugated bilirubin. Unlike autoimmune hemolytic anemia, the direct Coombs test result is negative in HS (E). In HS, RBCs tend to lyse at lower concentrations of salt than normal. Splenectomy is curative for HS and serves as the sole mode of therapy but patients continue to have spherocytosis on blood smear (C). Due to ongoing red cell lysis, gallstones are common. As such, if gallstones are found, prophylactic cholecystectomy is recommended, particularly in children. Another feature of HS is leg ulceration, which is another indication for early splenectomy. These ulcers heal after splenectomy. The cause of the ulceration is unclear but may be a result of increased blood viscosity that reduce oxygen levels in the leg tissues. Alternatively, recent studies suggest that hemolysis leads to nitric oxide resistance, endothelial dysfunction, and end-organ vasculopathy, as is seen in sickle cell disease.

**Reference:** Kato, G., McGowan, V., & Machado, R. (2006). Lactate dehydrogenase as a biomarker of hemolysis-associated nitric oxide resistance, priapism, leg ulceration, pulmonary hypertension, and death in patients with sickle cell disease. *Blood*, 107(6), 2279–2285.

9. **E.** Idiopathic thrombocytopenic purpura (ITP) is an autoimmune disorder caused by the formation of antiplatelet IgG autoantibodies produced in the spleen. Platelets are opsonized by the antiplatelet antibodies and are then removed prematurely, leading to the low platelet count. In adults, it is two to three times more common in women, whereas it occurs with equal frequency in

boys and girls. Patients typically present with ecchymoses or petechiae. Others may exhibit minor bleeding from the gums or nose, excessive menstruation, or blood in the stool or urine. Life-threatening bleeding as an initial presentation is uncommon. In children, the presentation is often preceded by a viral illness. The spleen is usually not enlarged (C). The diagnosis is one of exclusion and is based on the history, physical examination, complete blood count, and examination of the peripheral smear, which should exclude other causes of thrombocytopenia. The peripheral blood smear frequently shows large, immature platelets. Bone marrow aspiration is not routinely used but is appropriate in patients older than the age of 60 and in patients considering splenectomy. The bone marrow aspirate shows normal or increased megakaryocytes. The management depends on the age of the patient, the platelet count, and the severity of symptoms. In children, the majority present with mild cases that are self-limited and do not need any medical therapy (B). In fact, children with platelet counts greater than 30,000 cells/ $\mu$ L should not be hospitalized and do not routinely require treatment if they are asymptomatic or have only minor purpura (D). In adults, that threshold is greater than 20,000 per  $\mu$ L. The first line of therapy is oral prednisone at a dose of 1 to 1.5 mg/kg/day. Another effective therapy is intravenous (IV) immunoglobulin, which is used if corticosteroids are ineffective. Splenectomy is indicated for failure of medical therapy, for prolonged use of steroids with side effects, and for most cases of a first relapse, particularly if there is preoperative bleeding. Patients with low platelets counts less than 10,000 per  $\mu$ L should have platelets available for surgery but should not receive them preoperatively because they will be consumed. Platelets should be given for those who continue to bleed after ligation of the splenic pedicle (A). The one exception is if there is preoperative bleeding; platelets can be given before or at the time of incision during splenectomy. Urgent splenectomy plays a role in severe, life-threatening bleeding, in conjunction with medical therapy in both adults and children. Splenectomy provides a permanent response in 75% to 85% of patients.

**Reference:** George, J., Woolf, S., Raskob, G., et al. (1996). Idiopathic thrombocytopenic purpura: a practice guideline developed by explicit methods for the American Society of Hematology, *Blood*, 88(1), 3–4.

10. **D.** General indications for splenectomy include symptomatic splenomegaly, hypersplenism, hemolytic anemia, thrombocytopenia or other cytopenia. Splenectomy is not indicated for sarcoidosis, Gaucher disease, or myelofibrosis unless they have hypersplenism (A–C). Splenectomy is not indicated for patients with portal hypertension (E). Hairy cell leukemia gets its name from hairlike cytoplasmic projections in lymphocytes that are seen on a peripheral smear. Treatment is with chemotherapy, but splenectomy is useful in increasing cell counts, improving pain, and early satiety. With newer chemotherapeutic agents, the role of splenectomy is decreasing.
11. **C.** Splenic artery aneurysms are the most common visceral artery aneurysms (A). Women are four times more likely to be affected than men. The aneurysm usually arises in the middle to distal portion of the splenic artery (D). The risk of rupture is very low and is likely dependent on size and hormonal influences. Once rupture occurs, the mortality rate ranges from 35% to 50%. Splenic artery aneurysm is particularly problematic in pregnancy because rupture imparts a risk of mortality to both mother and fetus. Most patients are asymptomatic and seek medical attention based on an incidental radiographic finding (a ringlike calcification on a plain abdominal radiograph located in the left upper quadrant). Indications for treatment of true aneurysms include the presence of symptoms, pregnancy, and women of childbearing age who intend to become pregnant. Pseudoaneurysms are usually associated with inflammatory processes, are inherently unstable, and as such should be treated. For asymptomatic patients, size greater than 2 cm is an indication for surgery. Most splenic artery aneurysms can be observed; however, because this woman is of childbearing age, treatment would be indicated (E). The majority of splenic artery aneurysms are true aneurysms (B). Pseudoaneurysms occur most commonly in association with an episode of severe pancreatitis with erosion into the vessel. The patient presented has no evidence of pancreatitis. Splenic artery aneurysms are associated with a double-rupture phenomenon in which there is an initial herald bleed into the lesser sac and then rupture into the peritoneal cavity.
12. **D.** When a recurrence of a platelet count decrease after splenectomy for ITP develops in a patient, one must consider the possibility of an accessory spleen that was missed. The presence of an accessory spleen is suggested by the absence of Howell-Jolly bodies on a peripheral blood smear. This patient needs to be appropriately worked up starting with radionuclide imaging to determine if an accessory spleen is present (C, E). The sensitivity of CT scan in identifying an accessory spleen is 60% (A). Bone marrow biopsy has no role (B). Identification of an accessory spleen in a patient



who remains severely thrombocytopenic warrants surgical excision of the accessory spleen. Rituximab may also be considered in this patient population.

**References:** Quah, C., Ayiomamitis, G., Shah, A., et al. (2011). Computed tomography to detect accessory spleens before laparoscopic splenectomy: is it necessary? *Surgical Endoscopy*, 25(1), 261–265.

Ghanima, W., Khelif, A., Waage, A., et al. (2015). Rituximab as second-line treatment for adult immune thrombocytopenia (the RITP trial): a multicentre, randomised, double-blind, placebo-controlled trial. *Lancet*, 385(9978), 1653–1661.

13. **B.** Adults are more likely to get a chronic, more insidious form of ITP than children. In adults, women are affected two to three times more often than men, whereas in children, it is equally common in boys and girls. The diagnosis of ITP is one of exclusion. The peripheral blood smear shows a low platelet count as well as large, immature platelets but does not establish the diagnosis (C). Intravenous immunoglobulin therapy is effective in both children and adults in increasing the platelet count (D). In adults, splenectomy is indicated for failure of medical therapy (steroids, immunoglobulin), for prolonged use of steroids beyond 3 to 6 months, and for most cases of a first relapse (A, E).
14. **E.** The first line of treatment for TTP is plasma exchange by removing the patient's plasma and exchanging it with fresh-frozen plasma (C). Splenectomy is not very effective in TTP and should be used as salvage therapy in refractory cases. Features of TTP include thrombocytopenia, microangiopathic hemolytic anemia, and neurologic complications. The pathophysiology involves abnormal platelet clumping, likely due to large multimers of von Willebrand factor, which results in thrombotic episodes in the microvascular circulation. The narrowed lumens in the microvascular circulation lead to increased shear stress on RBCs, causing them to lyse (A). Symptoms and signs include petechiae; fever; neurologic symptoms such as headaches, seizures, and even coma; and renal failure (B). The peripheral blood smear shows schistocytes, nucleated RBCs, and basophilic stippling. The most common cause of death is intracerebral hemorrhage. TTP can be distinguished from autoimmune hemolytic anemia, in that the result of the Coombs test is negative in TTP (D).  
**Reference:** Coppo, P., Froissart, A., & French Reference Center for Thrombotic Microangiopathies. (2015). Treatment of thrombotic thrombocytopenic purpura beyond therapeutic plasma exchange, *Hematology / the Education Program of the American Society of Hematology. American Society of Hematology. Education Program*, 1, 637–643.
15. **B.** After splenectomy, target cells, Howell-Jolly bodies (erythrocytes containing nuclear fragments), Heinz bodies, Pappenheimer bodies (erythrocytes containing iron deposits), and spur cells (acanthocytes) are seen (A, D–E). These inclusions (bodies) are normally pitted by the spleen. Leukocytosis, persistent monocytosis, and increased platelet counts commonly occur after splenectomy as well (C). The increase in WBC count is primarily mature neutrophils. The white blood cell count (WBC) count typically increases within 1 day after splenectomy but may remain elevated for as long as several months. Asplenic patients have been found to have subnormal IgM levels. The spleen is a major site of production for the opsonins properdin and tuftsin, and splenectomy results in decreased serum levels of these proteins. Schistocytes (irregularly shaped and fragmented RBCs) are pathologic and indicate either disseminated intravascular coagulation or traumatic hemolytic anemia (such as TTP).
16. **A.** Abscesses of the spleen are uncommon. Five distinct mechanisms of splenic abscess formation have been described: (1) hematogenous infection (70%), (2) contiguous infection, (3) hemoglobinopathy, (4) immunosuppression including human immunodeficiency virus and chemotherapy, and (5) trauma (B–E). The most common origins for hematogenous spread are infective endocarditis, typhoid fever, malaria, urinary tract infections, and osteomyelitis. Presentation is frequently delayed. Clinical manifestations include fever, left upper quadrant pain, leukocytosis, and splenomegaly. The diagnosis is confirmed by ultrasonography or CT. Upon discovery, broad-spectrum antibiotics should be started, with adjustment to more specific therapy based on culture results and continued for 14 days. If the abscess is unilocular, it can be managed with CT-guided aspiration. If it is multilocular, a splenectomy will usually be required.  
**Reference:** Smyrniotis, V., Kehagias, D., Voros, D., et al. (2000). Splenic abscess: an old disease with new interest. *Digestive Surgery*, 17(4), 354–357.
17. **B.** This patient most likely has portal vein thrombosis (PVT). It should be suspected in patients with fever and abdominal pain after splenectomy. This patient is predisposed to PVT formation

because of her hypercoagulability from a combination of thrombocytosis after splenectomy and the setting of a myeloproliferative disorder. PVT is uncommon (occurrence rate ranging from 2–8%) although not rare, and the greatest risk is in cases involving splenomegaly with a myeloproliferative disorder. Postsplenectomy PVT typically presents with anorexia, abdominal pain, leukocytosis, and thrombocytosis, as demonstrated in this patient. A high index of suspicion, early diagnosis with contrast-enhanced CT, and immediate anticoagulation are keys to successful treatment of PVT. Patients undergoing splenectomy should be treated with deep venous thrombosis prophylaxis, including pneumatic compression devices, and with subcutaneous or low-molecular-weight heparin. OPSI is an uncommon complication in postsplenectomy patients and may present with nonspecific flu-like symptoms that rapidly progress to fulminant sepsis (A). Primary peritonitis is often a monobacterial infection occurring in cirrhotic patients with ascites (C). Ischemic colitis presents with left-sided abdominal pain and bloody diarrhea in elderly patients with low-flow states, such as those with severe dehydration, heart failure, shock, and trauma (D). Perforated duodenal ulcer initially presents with epigastric pain, followed by diffuse tenderness, abdominal rigidity, and rebound tenderness (E).

**References:** van't Riet, M., Burger, J., & van Muiswinkel, J. (2000). Diagnosis and treatment of portal vein thrombosis following splenectomy. *The British Journal of Surgery*, 87(9), 1229–1233.

Winslow, E., Brunt, L., Drebin, J., et al. (2002). Portal vein thrombosis after splenectomy. *American Journal of Surgery*, 184(6), 631–636.

18. **E.** Hairy cell leukemia is a clonal disorder of B lymphocytes that involve blood and bone marrow (C). Most therapies for hairy cell leukemia begin with Leustatin (cladribine). It is known to be cardiotoxic and should be used with caution in patients with underlying coronary artery disease, but it has not been shown to be hepatotoxic (A). Nipent (pentostatin) is the next most commonly used. If these are not effective, interferon-alpha and rituximab are used. Splenectomy is used rarely to control pain or early satiety or if cell counts fail to increase (B). 5-Fluorouracil is frequently used in patients with colorectal cancer (D). Patients with hairy cell leukemia have an increased risk of thyroid cancer, Hodgkin lymphoma, non-Hodgkin lymphoma, and a decreased risk of lung cancer.

**Reference:** Hisada, M., Chen, B., Jaffe, E., et al. (2007). Second cancer incidence and cause-specific mortality among 3104 patients with hairy cell leukemia: a population-based study. *Journal of the National Cancer Institute*, 99(3), 215–222.

19. **B.** Spontaneous rupture of the spleen is an uncommon, dramatic abdominal emergency that requires immediate diagnosis and prompt treatment to ensure the patient's survival. Spontaneous rupture rarely occurs in a histologically proven normal spleen and in such cases is called a *true spontaneous rupture*. Spontaneous rupture usually occurs in a diseased spleen and is called *pathologic spontaneous rupture*. Infectious diseases have been cited in most cases involving splenic rupture but are rare in hematologic malignancies despite frequent involvement of the spleen (A, E). Malaria is the number one cause worldwide and infectious mononucleosis is the number one cause in the United States. With malaria, changes in splenic structure can result in hematoma formation, rupture, hypersplenism, torsion, or cyst formation. An abnormal immunologic response may result in massive splenic enlargement. Spontaneous rupture of the spleen is an important and life-threatening complication of *Plasmodium vivax* infection but is rarely seen in *Plasmodium falciparum* malaria. Other but less frequent causes of spontaneous splenic rupture include hemolytic anemia, hemophilia, myelodysplastic disorders, lupus, dialysis, and multiple myeloma (C, D).

**Reference:** Hamel, C., Blum, J., Harder, F., et al. (2002). Nonoperative treatment of splenic rupture in malaria tropica: review of literature and case report. *Acta Tropica*, 82(1), 1–5.

20. **C.** The most common indication for splenectomy is trauma to the spleen, whether iatrogenic or accidental. In the past, staging for Hodgkin disease was the most common indication for elective splenectomy (A). ITP is now the most frequent indication for splenectomy in the elective setting, followed by HS, autoimmune hemolytic anemia, and TTP (B, D–E).

**Reference:** Schwartz, S. L. (1996). Role of splenectomy in hematologic disorders. *World Journal of Surgery*, 20(9), 1156–1159.

21. **D.** The laparoscopic approach typically results in longer operative times, shorter hospital stays, and lower morbidity rates (B, E). It has similar blood loss and mortality rates compared with open splenectomy (A, C). Cost analysis reveals that higher operating room charges are seen with laparoscopic splenectomy. However, several studies have found that the total cost to the patient is

less with the laparoscopic procedure due to the shortened hospital stay (E). The laparoscopic approach has emerged as the standard for nontraumatic, elective splenectomy.

**References:** Beauchamp, R. D., Holzman, M. D., & Fabian, T. C. (2004). Spleen. In C. M. Townsend Jr, R. D. Beauchamp, & B. M. Evers (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp.1679–1710) (17th ed.). Philadelphia, PA: W. B. Saunders.

Parks, A. E., McKinlay, R. (2005). Spleen. F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al. (Eds.), *Schwartz's principles of surgery* (pp.1297–1318) (8th ed.). New York, NY: McGraw-Hill.

22. **A.** More than 80% of accessory spleens are found in the regions of the splenic hilum and vascular pedicle. Other locations for accessory spleens in descending order of frequency are the gastrocolic ligament (B), the tail of the pancreas, the greater omentum (C), the greater curvature of the stomach, the splenocolic ligament, splenorenal ligament (D), the small and large bowel mesenteries, the left broad ligament of the uterus in women, and the left spermatic cord in men (E). The presence of accessory spleens has clinical implications. In one large series of splenectomy for hematologic disorders, accessory spleens were found in 18%. In patients in whom recurrence of ITP developed, it was eventually found to be due to a missed accessory spleen in a significant number, and reoperation was curative.

**Reference:** Rudowski, W. (1985). Accessory spleens: clinical significance with particular reference to the recurrence of idiopathic thrombocytopenic purpura. *World Journal of Surgery*, 9(3), 422–430.

# Alimentary Tract—Esophagus

*Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 59-year-old diabetic male with chronic obstructive pulmonary disease (COPD) presents with a 2-year history of progressively greater difficulty swallowing. He has no other medical problems. Esophagram demonstrates a dilated proximal esophagus with abrupt tapering distally. Manometry shows high pressure in the lower esophageal sphincter (LES) at rest and failure of the LES to relax after swallowing. Upper endoscopy is negative. Which of the following is true regarding this patient?
  - A. The underlying condition is characterized by high amplitude, peristaltic waves of the esophagus.
  - B. Laparoscopic esophagomyotomy with complete fundoplication is the treatment of choice.
  - C. A trial of calcium channel blockers should be started.
  - D. Esophageal pneumatic dilation is the next step in management.
  - E. Peroral endoscopic myotomy (POEM) is the treatment of choice.
2. A 51-year-old male has been undergoing yearly endoscopy with biopsy for Barrett esophagus. His most recent biopsy demonstrates high-grade dysplasia without nodules. Which of the following is the best next step in management?
  - A. Esophagectomy with reconstruction
  - B. Repeat endoscopy with biopsy in 3 months
  - C. Endoscopic radiofrequency ablation
  - D. Antireflux operation
  - E. Oncology referral for consideration of neoadjuvant chemotherapy
3. Which of the following will predispose a patient to the development of esophageal disease?
  - A. LES length of 3 cm
  - B. Resting LES pressure of 8 mm Hg
  - C. Resting upper esophageal sphincter (UES) pressure of 70 mm Hg
  - D. Abdominal length less than 1 cm
  - E. Relaxation of LES with swallowing
4. A 40-year-old female has been using a proton-pump inhibitor (PPI) to control gastroesophageal reflux disease (GERD) for the past 7 years. She is otherwise healthy. She was seen in clinic and deemed a suitable candidate for definitive surgical intervention. During the operation, after the phrenoesophageal ligament is mobilized, her distal esophagus is inspected and it appears shortened. Preoperative upper gastrointestinal study did not identify a hiatal hernia. Which of the following will most likely need to be done?
  - A. Proceed with a standard Nissen fundoplication.
  - B. Proceed with a Dor fundoplication.
  - C. Perform Collis gastroplasty.
  - D. Abort the operation and initiate management with steroids.
  - E. Take several biopsies before aborting the operation.
5. A 39-year-old male presents in clinic to discuss his care before starting neoadjuvant chemoradiation

- for esophageal cancer. His albumin is 2.4 mg/dL. Which of the following is true regarding nutritional optimization for this patient?
- A. He should begin parenteral nutrition.
  - B. Percutaneous gastrostomy tube should not be offered.
  - C. Esophageal stent placement has been consistently demonstrated to improve nutritional status.
  - D. Nasogastric tube insertion has been shown to improve nutritional status.
  - E. Stent migration and chest discomfort are uncommonly reported in patients with esophageal stents.
6. A 52-year-old male with cirrhosis and known esophageal varices presents with a large amount of hematemesis. Which of the following statements is true?
- A. Beta blockade is ineffective for preventing rebleeding.
  - B. The most important next step is endoscopy for both diagnostic and therapeutic intervention.
  - C. Prophylactic antibiotics do not improve survival.
  - D. Early administration of vasoactive drugs does not improve outcomes.
  - E. Endoscopic band ligation has been demonstrated to be superior to endoscopic sclerotherapy.
7. Which of the following is true regarding the surgical approach, anatomy, or blood supply to the esophagus?
- A. Outer longitudinal muscle is an extension of the cricopharyngeus muscle.
  - B. Cervical esophagus is supplied by the inferior thyroid artery.
  - C. The narrowest point in the esophagus is at the aortic arch.
  - D. Branches off the intercostal arteries are the major blood supply to the thoracic esophagus.
  - E. The standard surgical approach to the midesophagus is a right thoracotomy because the heart is in the way during a left thoracotomy.
8. Which of the following is true regarding surgical intervention for esophageal cancer?
- A. Ivor Lewis esophagectomy involves an upper midline laparotomy and a left thoracotomy.
  - B. Transthoracic esophagectomy (TTE) is associated with a lower total hospital length of stay when compared to a transhiatal esophagectomy (THE).
  - C. There is no difference in mortality between the use of TTE or THE in the surgical treatment of esophageal cancer.
  - D. TTE is associated with fewer complications when compared with THE.
  - E. THE is performed with a right cervical incision and midline laparotomy.
9. Which one of the following is true about Mallory-Weiss syndrome?
- A. The chief pathologic finding is spontaneous perforation of the esophagus.
  - B. It typically occurs on the right side.
  - C. It is usually associated with air in the mediastinum.
  - D. Endoscopy should be performed to confirm the diagnosis.
  - E. Prompt surgical management is the treatment of choice.
10. Which of the following statements about a paraesophageal hernia is true?
- A. It is associated with anemia.
  - B. It does not pose a risk for incarceration and strangulation.
  - C. Diagnosis is not readily made with upper endoscopy.
  - D. It is usually caused by a traumatic injury.
  - E. It rarely requires operative repair.
11. Which of the following statements is true about Zenker diverticulum?
- A. It is a true diverticulum.
  - B. It is best diagnosed with esophagoscopy.
  - C. It is unlikely to cause aspiration.
  - D. It is a pulsion diverticulum.
  - E. Small diverticula (<3 cm) are best managed endoscopically.

12. Dysphagia lusoria is most likely associated with:
- A. Bovine arch
  - B. Aberrant subclavian artery
  - C. Coarctation of the aorta
  - D. Ascending aortic aneurysm
  - E. Patent ductus arteriosum
13. A 36-year-old male presents for consultation regarding an incidental esophageal mass seen on computed tomography (CT) scan. This was performed after he was involved in a motor vehicle collision (MVC). He had no serious injuries and was discharged the same day. Barium swallow demonstrates a smooth, crescent-shaped filling defect. Which of the following is true regarding this mass?
- A. Resection is the treatment of choice.
  - B. They most commonly present with satellite tumors.
  - C. They have no risk of malignant degeneration.
  - D. Esophageal ultrasonography may be useful.
  - E. A preoperative endoscopic biopsy should be performed.
14. Barrett esophagus:
- A. Is a congenital abnormality
  - B. Occurs more frequently in black patients
  - C. When diagnosed, should be treated with an antireflux procedure to prevent cancer
  - D. Diagnosis requires replacement of a 3-cm long segment of the squamous cells by columnar epithelium
  - E. Features the presence of goblet cells
15. Which of the following is true regarding Barrett esophagus?
- A. PPIs are considered a more effective treatment option than H<sub>2</sub> blockers.
  - B. Dietary restrictions such as those used for patients with GERD are not useful.
  - C. Patients with short- and long-segment Barrett esophagus have a similar risk of high-grade dysplasia.
  - D. Use of high-dose PPIs when compared with low-dose PPIs has been demonstrated to reduce the progression of carcinoma in patients with Barrett esophagus.
  - E. Photofrin is a useful treatment modality.
16. During the course of an upper endoscopy for manometry confirmed achalasia, the endoscopist thinks he may have caused an inadvertent perforation of the left lower esophagus. The patient is stable and shows no signs of sepsis. Esophagogram confirms a markedly dilated esophagus with a small distal free perforation. Management consists of:
- A. Intravenous (IV) antibiotics, placing patient NPO (nothing by mouth), and close observation
  - B. Left thoracotomy, primary repair, longitudinal myotomy on the contralateral side
  - C. Laparoscopic primary repair and longitudinal myotomy on the ipsilateral side
  - D. Esophagectomy with immediate reconstruction
  - E. Esophageal stent placement
17. A 4-year-old boy presents to the ED after an accidental ingestion of lye. The child is exhibiting stridor and hoarseness. The child is emergently intubated and resuscitated with IV fluids. An upright chest radiograph shows no evidence of perforation. The patient is admitted to the intensive care unit. The next step in the management is:
- A. Esophagoscopy
  - B. Esophagography
  - C. Chest computed tomography scan
  - D. Close observation
  - E. Immediate exploratory laparotomy

18. Over the past 2 years, a 50-year-old man repeatedly reported difficulty swallowing, which he described as a lump in his throat. He has noticed expectoration of excess saliva, dysphagia, intermittent hoarseness, and some weight loss. Which of the following is true of the most likely diagnosis?
- A. Swallowing is easiest immediately after waking up in the morning and gets increasingly difficult throughout the course of the day.
  - B. It is best managed with diverticulectomy alone through a left cervical incision.
  - C. It involves an outpouching of the muscularis propria.
  - D. Esophagectomy will improve survival.
  - E. The patient should likely be started on chemoradiation.
19. Esophageal manometry performed in a patient with a true paraesophageal hernia will demonstrate that the LES is:
- A. Above the normal position
  - B. At the normal position
  - C. Hypertensive
  - D. Hypotensive
  - E. Short

## Answers

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1. **D.** This patient has achalasia, a primary motility disorder of the esophagus, specifically of the LES. The pathogenesis is presumed to be neurogenic degeneration of ganglion cells, which can be idiopathic or infectious (i.e., Chagas disease from *Trypanosoma cruzi*). The degeneration results in a failure of the LES to relax on swallowing, leading to an increase in intraluminal esophageal pressure, marked esophageal dilation (with an air–fluid level on radiograph), and loss of progressive peristalsis in the body of the esophagus. The classic triad of symptoms is dysphagia, regurgitation, and weight loss (e.g., loose-fitting clothes). Diagnosis should include esophageal manometry (showing failure of the LES to relax with swallowing and considered the gold standard), barium esophagography (showing a “bird’s beak” appearance), and endoscopy (to rule out malignancy). There are four basic treatment options and all are considered palliative procedures in that there is no cure. According to recent American College of Gastroenterology Clinical Guidelines, initial therapy should be *either* graded pneumatic dilation or laparoscopic surgical myotomy with a *partial* fundoplication in patients fit to undergo surgery. Esophageal pneumatic dilation has reemerged as the first-line treatment recommended by most surgeons. It is safer than previously thought, but patients will often require multiple dilations over time. For patients wishing a more definitive intervention or those that have failed conservative management, a laparoscopic esophagomyotomy with an anterior fundoplication (Dor) or partial, 270-degree posterior fundoplication (Toupet) should be performed. A recent multicenter, randomized controlled trial found that although a lower percentage of patients with a Toupet fundoplication had an abnormal 24-hour pH test when compared with a Dor fundoplication, the differences were not statistically significant and that either approach would be appropriate. A complete fundoplication, or a Nissen, has a high chance of causing recurrent dysphagia in this patient population (B). Medical management with calcium channel blockers and nitroglycerin can help relax the LES, but this treatment only relieves symptoms in less than 10% of patients. These medications are only considered in patients that are not appropriate surgical candidates (C). In high-risk elderly patients, injection of the LES with botulinum toxin can provide short-term relief. Botulinum toxin should be avoided in patients that would otherwise be appropriate surgical candidates because it can ruin the anatomic planes required for surgery. Nutcracker esophagus is characterized by high amplitude, peristaltic waves of the esophagus (A). Esophageal diverticula can be associated with a hypertrophic upper esophageal sphincter. POEM is starting to be performed more commonly but requires a long learning curve, and up to 50% of patients can have acid reflux following the procedure (E).

**References:** Campos, G. M., Vittinghoff, E., Rabl, C. et al. (2009). Endoscopic and surgical treatments for achalasia: a systemic review and meta-analysis. *Annals of Surgery*, 249(1), 45–57.



Hoogerwerf W., & Pasricha, P. (2000). Achalasia: treatment options revisited. *Canadian Journal of Gastroenterology*, 14(5), 406–409.

Rawlings, A., Soper, N. J., Oelschlager, B., et al. (2012). Laparoscopic Dor versus Toupet fundoplication following Heller myotomy for achalasia: results of a multicenter, prospective, randomized-controlled trial. *Surgical Endoscopy*, 26(1), 18–26.

Vaezi, M., Richter, J., Wilcox, C., et al. (1999). Botulinum toxin versus pneumatic dilatation in the treatment of achalasia: a randomized trial. *Gut*, 44(2), 231–239.

2. **C.** The management of Barrett esophagus with carcinoma has evolved considerably in recent years. Esophagectomy with reconstruction was once considered the standard of care for high-grade dysplasia, but this has been largely replaced by minimally invasive endoscopic techniques including radiofrequency ablation (RFA) (A). A large meta-analysis published in the *New England Journal of Medicine* demonstrates that RFA is associated with a high rate of disease eradication and reduced risk of the development of carcinoma. Although no randomized control trial currently exists to support this recommendation, endoscopic therapy is now the favored approach for high-grade dysplasia in Barrett esophagus without suspicious nodules. Repeat endoscopy with biopsy in 3 to 6 months is appropriate in patients with low grade dysplasia (B). An antireflux procedure such as a Nissen procedure or medical management can be considered in patients with Barrett esophagus without high-grade dysplasia (D). Oncology referral is premature because there is not yet a cancer diagnosis established for the above patient (E).

**References:** Bennett, C., Green, S., Decaestecker, J., et al. (2012). Surgery versus radical endotherapies for early cancer and high-grade dysplasia in Barrett's oesophagus. *Cochrane Database of Systematic Reviews*, 11, CD007334.

Max Almond L., & Barr, H. (2014). Management controversies in Barrett's oesophagus. *Journal of Gastroenterology*, 49(2), 195–205.

Shaheen, N. J., Sharma, P., Overholt, B. F., et al. (2009). Radiofrequency ablation in Barrett's esophagus with dysplasia. *The New England Journal of Medicine*, 360(22), 2277–2288.

3. **D.** Manometry is an important diagnostic tool to identify predisposing conditions for esophageal disease. Characteristics of an abnormal LES include resting pressure less than 6 mm Hg (normal range is 6–26 mm Hg), overall length of less than 2 cm, and abdominal length less than 1 cm (A, B). Relaxation of LES with swallowing is a function of the normal swallowing mechanism and dysfunction will increase the risk for the development of achalasia (E). The resting UES is 60 to 80 mm Hg (C). High UES pressures will predispose patients to pulsion diverticulum and difficulty with swallowing.
4. **C.** Roughly 15% of the adult population in the United States has GERD. Most patients can initially be managed conservatively with the use of PPI. Indications for surgical intervention include failure of conservative management, patient preference for definitive intervention despite successful medical management (e.g., patient would like to avoid lifelong need for medication), and complications associated with GERD including Barrett esophagus or extra-esophageal manifestations (asthma, cough, hoarseness). The standard surgical intervention involves a Nissen fundoplication. If a shortened esophagus is encountered during surgery (abdominal length < 1 cm), then a Collis gastropasty will need to be performed to lengthen it and minimize tension during antireflux repair (A). In most patients, about 3 cm of intra-abdominal esophagus can be mobilized and thereby avoid the need to lengthen the esophagus. An anterior (Dor) fundoplication may be considered in patients with underlying esophageal dysmotility (B). Although scleroderma can present with a shortened or fibrotic esophagus, this is a diffuse process and will involve the entire esophagus. In addition, most patients will have extra-esophageal disease (D). In the above patient, a biopsy should be considered. However, the long duration of GERD and without any systemic symptoms (fevers, night sweats, weight loss) makes carcinoma unlikely, and so the surgery should proceed (E).

**Reference:** Kunio, N. R., Dolan, J. P., Hunter J. G., et al. (2015). Short esophagus. *The Surgical Clinics of North America*, 95(3), 641–652.

5. **B.** Patients with newly diagnosed esophageal cancer frequently present with poor nutritional status, which only worsens after starting neoadjuvant therapy. As such, nutritional optimization is an important component in the management of esophageal cancer. Percutaneous gastrostomy should be discouraged because it may compromise the gastric conduit needed during esophageal reconstruction and will delay chemotherapy for an additional 2 to 4 weeks. The role for parenteral

nutrition is limited because of its high cost and high rate of complications (A). Nasogastric tube insertion can lead to migration of the tube and aspiration (D). Esophageal stents are frequently offered because they can significantly improve the dysphagia associated with esophageal cancer. Unfortunately, its role in improving nutritional status has had inconsistent results in the literature (C). Stent migration and chest discomfort are common and lead to the frequent removal of the stents (E). Additional studies are needed to determine the best approach for nutritional optimization in this patient population.

**References:** Jones, C. M., & Griffiths, E. A. (2014). Should oesophageal stents be placed before neoadjuvant therapy to treat dysphagia in patients awaiting oesophagectomy? Best evidence topic (BET). *International Journal of Surgery*, 12(11), 1172–1180.

Mao-de-Ferro, S., Serrano, M., Ferreira, S., et al. (2015). Stents in patients with esophageal cancer before chemoradiotherapy: high risk of complications and no impact on the nutritional status. *European Journal of Clinical Nutrition*, 70(3), 409–410.

Naharaja, V., Cox, M. R., Eslick, G. D. et al. (2014). Safety and efficacy of esophageal stents preceding or during neoadjuvant chemotherapy for esophageal cancer: a systemic review and meta-analysis. *Journal of Gastrointestinal Oncology*, 5(2), 119–126.

6. **E.** Acute variceal bleeding (AVB) is the leading cause of upper GI bleeding in patients with cirrhosis, and the management can be challenging. Early recognition and intervention is important because the progression to sepsis and multiorgan failure confers a dismal prognosis with over 90% mortality. The most important next steps in a cirrhotic presenting with AVB involve the airway, breathing, and circulation (ABCs). Airway management should take precedence over controlling AVB (B). After the ABCs, the recommended approach involves a combination of vasoactive drugs (octreotide) and endoscopic intervention. Medical management should be initiated as soon as possible because it can reduce the rate of active bleeding and improve the yield of endoscopic intervention (D). Several randomized controlled trials have been performed comparing endoscopic band ligation versus endoscopic sclerotherapy and have demonstrated the superiority of the former in both controlling bleeding and safety profile. Infection has been demonstrated to be an important predictor of mortality in AVB. Patients that receive prophylactic fluoroquinolones have been shown to have a reduced incidence of AVB and improved survival (C). In patients with chronic esophageal varices, beta blockers can be used to prevent episodes of rebleeding (A).

**References:** Bernard, B., Grange, J. D., Khac, E. N., et al. (1999). Antibiotic prophylaxis for the prevention of bacterial infections in cirrhotic patients with gastrointestinal bleeding: a meta-analysis. *Hepatology*, 29(6), 1655–1661.

Calès P., Masliah, C., Bernard, B., et al. (2001). Early administration of vapreotide for variceal bleeding in patients with cirrhosis. *The New England Journal of Medicine*, 344(1), 23–28.

Hou, M. C., Lin, H. C., Liu, T. T., et al. (2004). Antibiotic prophylaxis after endoscopic therapy prevents rebleeding in acute variceal hemorrhage: a randomized trial. *Hepatology*, 39(3), 746–753.

Jensen, D. M., Kovacs, T., Randall, G., et al. (1994). Emergency sclerotherapy vs rubber band ligation for actively bleeding esophageal varices in a randomized prospective study. *Gastrointestinal Endoscopy*, 40, 241.

Lo, G. H., Lai, K. H., Cheng, J. S., et al. (1997). Emergency banding ligation versus sclerotherapy for the control of active bleeding from esophageal varices. *Hepatology*, 25(5), 1101–1104.

Tripodi, A., & Mannucci, P. M. (2007). Abnormalities of hemostasis in chronic liver disease: reappraisal of their clinical significance and need for clinical and laboratory research. *Journal of Hepatology*, 46(4), 727–733.

7. **B.** The esophagus is a two-layered muscular conduit connecting the oropharynx to the stomach. The outer muscular layer is longitudinal while the inner layer is circular and considered an extension of the cricopharyngeus muscle (A). Several anatomic areas of narrowing exist in the esophagus with the cricopharyngeus muscle contributing to the narrowest portion of the esophagus. Other anatomic areas of narrowing occur at the aortic arch and the diaphragm (C). The cervical esophagus is supplied by the thyrocervical trunk off the subclavian artery. The major branches of the thyrocervical trunk can be remembered by the mnemonic “STAT” (suprascapular artery, transverse cervical artery, ascending cervical artery, and inferior thyroid artery). The thoracic esophagus is primarily supplied by branches directly off the aorta. The surgical approach to the esophagus can be divided into thirds. The first and last portion of the esophagus are approached

by a left thoracotomy while the midesophagus is approached with a right thoracotomy as the aorta is in the way during a left thoracotomy (E).

8. **C.** Surgical intervention in esophageal cancer is an area of active research. The three standard approaches include TTE, THE, and a combination of the two using a three-incision esophagectomy. TTH was initially described as a two-stage procedure by Dr. Ivor Lewis in which he performed mobilization of the stomach using an upper midline laparotomy incision followed by resection of the esophagus using a right thoracotomy incision several days later (A). A large multicenter prospective study comparing THE and TTE failed to demonstrate any difference in overall mortality and morbidity between the two approaches (D). However, THE has been shown in several studies to be associated with a lower total hospital length of stay (B). THE is performed with a left cervical incision and midline laparotomy (E). It is often performed for patients with distal esophageal cancer.

**References:** D'Amico, T. A. (2007). Outcomes after surgery for esophageal cancer. *Gastrointestinal Cancer Research*, 1(5), 188–196.

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Litle, V. R., Buenaventura, P. O., & Luketich, J. D. (2002). Minimally invasive resection for esophageal cancer. *The Surgical Clinics of North America*, 82(4), 711–728.

Rentz, J., Bull, D., Harpole, D. H., et al. (2003). Transthoracic versus transhiatal esophagectomy: a prospective study of 945 patients. *The Journal of Thoracic and Cardiovascular*, 125(5), 1114–1120.

9. **D.** The mechanism of a Mallory-Weiss tear is similar to that of an esophageal perforation (Boerhaave syndrome), but differs in that the injury is not full thickness (A). It is the result of forceful vomiting or coughing, such as after an alcohol drinking binge. The classic description is retching followed by vomiting of blood. The presence of a hiatal hernia is a predisposing factor and is found in a majority of patients. This situation exposes the LES to high pressures, which results in a partial-thickness mucosal tear and bleeding most commonly 3 to 5 cm above the gastroesophageal junction on the left side (B). Boerhaave syndrome results in a full-thickness tear causing esophageal perforation (A). These patients often present in sepsis with air in the mediastinum and a pleural effusion. Severe sepsis in the setting of esophageal perforation mandates surgical intervention (C). Most bleeding from Mallory-Weiss tears stops spontaneously with nonsurgical management (E). Patients should undergo endoscopy to confirm the diagnosis. Recent studies suggest that the area of bleeding is best managed by injecting sclerosing agents or epinephrine to prevent rebleeding.

**Reference:** Llach, J., Elizalde, J., Guevara, M., et al. (2001). Endoscopic injection therapy in bleeding Mallory-Weiss syndrome: a randomized controlled trial. *Gastrointestinal Endoscopy*, 54(6), 679–681.

10. **A.** A paraesophageal hernia, or type II hiatal hernia, is also called a *rolling-type hiatal hernia*. The widened hiatus permits the fundus of the stomach to protrude into the chest, anterior and lateral to the body of the esophagus. The gastroesophageal junction remains below the diaphragm. The herniated gastric fundus rotates in a counterclockwise direction and is prone to becoming incarcerated and strangulated. This herniated portion of the stomach develops mucosal erosions (Cameron's ulcers) that can lead to chronic blood loss and anemia in up to one third of patients. Patients can also have dysphagia, heartburn and abdominal pain. Diagnosis can be made by a barium swallow. Upper endoscopy can readily make the diagnosis on a retroflex view (C). Although incarceration is rare, most surgeons recommend elective repair of paraesophageal hernias because of the potential risk of strangulation (B, E). It is not typically preceded by trauma (D).
11. **D.** A Zenker diverticulum is a false, esophageal diverticulum that does not contain all layers of the esophagus; it is also a type of pulsion diverticulum (A). A pulsion diverticulum forms at a point of weakness and is due to alterations in luminal pressure. Conversely, a traction diverticulum is from external pulling on the esophageal wall, such as from inflamed lymph nodes with tuberculosis. Zenker diverticulum is the most common type of esophageal diverticulum. It usually presents in older patients (>60 years). It characteristically arises at a point of weakness, most commonly at the Killian triangle, which is formed by the inferior fibers of the inferior constrictor muscle and the superior border of the cricopharyngeus muscle. Patients typically present with dysphagia, regurgitation of undigested food, halitosis, episodes of aspiration, and salivation (C). With the characteristic history, the first diagnostic study is a barium swallow. In the absence of other pathology (such as an irregular mucosa), endoscopy is not needed (B). Treatment is surgical by

either open or endoscopic techniques. The open technique involves cervical esophagomyotomy with stapling and amputation of the diverticulum. The endoscopic technique involves division of the common wall between the diverticulum and the esophagus. Studies have shown that results with the endoscopic technique are better with larger diverticula (E). Diverticula smaller than 3 cm are too short to accommodate one cartridge of staples and to allow complete division of the sphincter, and therefore this size is considered a contraindication to this technique.

**References:** Bonavina, L., Bona, D., Abraham, M., et al. (2007). Long-term results of endosurgical and open surgical approach for Zenker diverticulum. *World Journal of Gastroenterology*, 13(18), 2586–2589.

Collard, J. M., Otte, J. B., & Kestens, P. J. (1993). Endoscopic stapling technique of esophagodiverticulostomy for Zenker's diverticulum. *The Annals of Thoracic Surgery*, 56(3), 573–576.

Narne, S., Cutrone, C., Bonavina, L., et al. (1999). Endoscopic diverticulotomy for the treatment of Zenker's diverticulum: results in 102 patients with staple-assisted endoscopy. *The Annals of Otolaryngology, Rhinology, and Laryngology*, 108(8), 810–815.

12. **B.** Dysphagia lusoria (dysphagia by a freak of nature) refers to difficulty in swallowing due to compression of the esophagus by an aberrant right subclavian artery (C–E). The aberrant right subclavian artery arises distal to the origin of the left subclavian artery in the descending thoracic aorta, traverses the mediastinum posterior to the esophagus and trachea, and then follows the course of the normal artery into the right upper extremity. It is usually asymptomatic. The most common associated symptom is dysphagia associated with compression of the esophagus between the trachea and the artery. It is associated with a Kommerell diverticulum, which occurs as a result of abnormal regression of the fourth aortic arch and persistent patency of the right eighth dorsal aortic segments. An aortic diverticulum is found at the site of origin of the atretic arch. A Kommerell diverticulum can occur in a number of anomalies of the aortic arch system. These abnormalities can, but do not always, cause symptoms of tracheal or esophageal compression. The diverticulum is most frequently present in cases of a right aortic arch with an aberrant left subclavian artery, but it can also occur in association with an aberrant right subclavian artery. A “bovine arch” is a normal variant in which the left common carotid artery and the innominate artery share a common origin off the aortic arch (A). It is important to note that, in a trauma patient, a Kommerell diverticulum can be confused with an aortic transection on angiography.

**Reference:** Brown, D. L., Chapman, W. C., Edwards, W. H., et al. (1993). Dysphagia lusoria: aberrant right subclavian artery with a Kommerell's diverticulum. *The American Surgeon*, 59(9), 582–586.

13. **D.** Leiomyomas are the most common benign tumor in the esophagus, accounting for more than 50% of benign tumors. However, benign masses constitute only 10% of esophageal tumors. They have a small risk of malignant degeneration (C). Leiomyomas only become symptomatic when they are very large (>5 cm). Otherwise, they are incidentally discovered during the course of other studies. They have a characteristic appearance on barium swallow of a smooth, crescent-shaped filling defect that encroaches on the lumen. On endoscopy, the mucosa is usually intact, and the tumor moves up and down with swallowing. If it has the characteristic appearance, the tumor should not undergo biopsy because of an increased risk of mucosal perforation. This can and create scarring that may affect efforts at resection later (E). Esophageal ultrasonography is very useful in the diagnosis of leiomyomas because it will demonstrate a homogeneous region of hypoechogenicity. Treatment is to enucleate the mass, which can be done via a videoscopic approach with intraoperative esophagoscopy (A). The cell of origin of these tumors is mesenchymal. The average age at presentation is 38 years, and they are twice as common in males and most commonly located in the lower two-thirds of the esophagus. Leiomyomas are usually solitary, but multiple tumors are seen in as many as 10% of patients (B).

**Reference:** Aurea, P., Grazia, M., Petrella, F., et al. (2002). Giant leiomyoma of the esophagus. *European Journal of Cardio-Thoracic Surgery*, 22(6), 1008–1010.

14. **E.** Barrett esophagus occurs in 5% to 7% of patients with GERD. It is an acquired pathology (A). The hallmark feature is the presence of intestinal goblet cells, which signifies intestinal metaplasia, on endoscopic biopsy. It occurs more commonly in males with a 3:1 ratio and is uncommon in black patients (B). Once Barrett esophagus develops, the risk of adenocarcinoma is approximately 0.5% per year. In one large study, the prevalence of cancer was 4%. Management of Barrett esophagus initially is medical, provided there is no evidence of severe dysplasia. However, surveillance of patients with Barrett esophagus for dysplasia is recommended. If severe dysplasia

is present, endoscopic radioactive ablation or esophagectomy are recommended (D). Another option for high-grade dysplasia is photodynamic therapy using Photofrin (porfimer sodium), a light-sensitizing drug that is administered orally and concentrates in the area of metaplasia. A laser is then focused on the esophagus, activating the drug and destroying the cells. In patients with Barrett esophagus without dysplasia, a randomized study comparing medical management with antireflux surgery showed that there were no differences between the two treatments with regard to preventing progression to dysplasia and adenocarcinoma, although antireflux surgery was more efficient than medical treatment (C).

**References:** Drewitz, D., Sampliner, R., & Garewal, H. (1997). The incidence of adenocarcinoma in Barrett's esophagus: a prospective study of 170 patients followed 4.8 years. *The American Journal of Gastroenterology*, 92(2), 212–215.

Hameeteman, W., Tytgat, G., Houthoff, H., et al. (1989). Barrett's esophagus: development of dysplasia and adenocarcinoma. *Gastroenterology*, 96(5 Pt 1), 1249–1256.

Parrilla, P., Martínez de Haro, L. F., Ortiz, A., et al. (2003). Long-term results of a randomized prospective study comparing medical and surgical treatment of Barrett's esophagus. *Annals of Surgery*, 237(3), 291–298.

Peters, J. H., & DeMeester, T. R. Esophagus and diaphragmatic hernia. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 835–932) (8th ed.). New York, NY: McGraw-Hill.

Zwischenberger, J. B., Savage, C., & Bhutani, M. S. Esophagus. In C. M. Townsend Jr, R. D. Beauchamp, & B. M. Evers, (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice*, (pp. 1091–1150) (17th ed.). Philadelphia, PA: W. B. Saunders.

15. **A.** Although pharmacologic treatment for Barrett esophagus should be similar to that for GERD, most authorities agree that the use of PPIs is more effective in treating patients with Barrett esophagus. High-dose PPIs have not yet been demonstrated to be superior to low-dose PPIs in the progression of cancer in Barrett esophagus, but a large randomized trial from the United Kingdom (ASPECT trial) is currently investigating this along with the role of aspirin in Barrett esophagus and plans to release their results in 2018 (D). Interestingly, in vivo studies have shown that nonsteroidal antiinflammatory drugs (NSAIDs) and statins can reduce the progression of cancer in patients with Barrett esophagus. The ASPECT trial may provide more powerful evidence to suggest the use of NSAIDs in patients with Barrett esophagus for chemoprophylaxis. Long-segment Barrett esophagus has a higher risk for high-grade dysplasia (C). Photofrin has not been demonstrated to be a useful modality (E). Dietary restrictions are helpful in Barrett esophagus and include the avoidance of fatty foods, chocolate, peppermint, alcohol, coffee, ketchup, mustard, or vinegar (B).

**References:** Cameron, J. L., & Cameron, A. M. (2014). The management of Barrett's esophagus. *Current surgical therapy* (11th ed.). Philadelphia, PA: W. B. Saunders.

Shapiro, J., van Lanschot, J. J., Hulshof, M. C., et al. (2015). Neoadjuvant chemoradiotherapy plus surgery versus surgery alone for oesophageal or junctional cancer (CROSS): long-term results of a randomized controlled trial. *The Lancet Oncology*, 16(9), 1090–1098.

Tsibouris, P., Vlachou, E., & Isaacs, P. E. (2014). Role of chemoprophylaxis with either NSAIDs or statins in patients with Barrett's esophagus. *World Journal of Gastrointestinal Pharmacology and Therapeutics*, 5(1), 27–39.

16. **B.** The decision of how to proceed in an iatrogenic esophageal perforation depends on five things: whether it is a free or contained perforation, the duration of time that the perforation has been present, the underlying pathology in the esophagus, whether severe inflammation is present at surgery, and the patient's condition. As a general rule, if the perforation is contained, as shown on an esophagogram, management can be conservative (A). If it is a small free perforation, surgery is indicated with primary repair with or without an intercostal muscle flap. Resection of an injured esophagus with cervical esophagostomy (spit fistula), gastrostomy and feeding jejunostomy is reserved for situations in which there has been a long delay in diagnosis (>72 hours), severe inflammation is present, or the patient is extremely ill or disabled (B). If the underlying disease requires an esophagectomy (e.g. cancer, severe burn), immediate esophagectomy with reconstruction is recommended if it is feasible (limited inflammation and minimal delay) (D). Stenting is generally reserved for unresectable cancer (E). An iatrogenic perforation in a patient with achalasia will need to have the perforation addressed as discussed above but will also need definitive management of the underlying disease provided he or she is not extremely ill. The

treatment of choice is a left thoracotomy, primary repair, longitudinal myotomy on the contralateral side with or without fundoplication. Laparoscopic repair is increasing in popularity but will still need a myotomy on the contralateral side of the perforation (C).

**References:** Fernandez, F., Richter, A., Freudenberg, S., et al. (1999). Treatment of endoscopic esophageal perforation. *Surgical Endoscopy*, 13(10), 962–966.

Hunt, D. R., Wills, V. L., Weis, B., et al. (2000). Management of esophageal perforation after pneumatic dilation for achalasia. *Journal of Gastrointestinal Surgery*, 4(4), 411–415.

17. **A.** Caustic injuries can lead to esophageal perforation in the short term and severe esophageal strictures in the long term. Initial management should focus on the ABCs. An upright chest radiograph should be obtained to look for free air under the diaphragm. Emetics should be avoided. Further workup is needed to determine the extent of injury (E). In children, esophagoscopy may not be necessary if the patient is completely asymptomatic. In this patient who is having symptoms and in adults, esophagoscopy is recommended within 12 hours of the ingestion to assess the degree of injury (provided there is no evidence of perforation) (B). It is important to advance the endoscope only to the first area of injury, so as not to increase the risk of iatrogenic perforation. CT has lower sensitivity in demonstrating mucosal damage (C). Injury is graded as first degree (mucosal hyperemia, edema), second degree (limited hemorrhage, pseudomembrane formation), or third degree (complete obstruction of lumen by edema, charring). First-degree burns can be treated by observation (D). Second- and third-degree burns (without perforation) are treated by placing the patient NPO and administering IV antibiotics, H<sub>2</sub>-receptor antagonists, PPIs, and IV fluids. The use of steroids is controversial.

**References:** Peters, J. H., & DeMeester, T. R. Esophagus and diaphragmatic hernia. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 835–932) (8th ed.). New York, NY: McGraw-Hill.

Wilsey, M., Scheimann, A., & Gilger, M. (2001). The role of upper gastrointestinal endoscopy in the diagnosis and treatment of caustic ingestion, esophageal strictures, and achalasia in children. *Gastrointest Endoscopy Clinics of North America*, 11(4), 767–787.

Zwischenberger, J. B., Savage, C., & Bhutani, M. S. Esophagus. In C. M. Townsend Jr, R. D. Beauchamp, & B. M. Evers, (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice*, (pp. 1091–1150) (17th ed.). Philadelphia, PA: W. B. Saunders.

18. **A.** Cricopharyngeal dysfunction has multiple causes including neurogenic and myogenic etiologies, such as stroke, multiple sclerosis, peripheral neuropathy, Parkinson disease, and dermatomyositis. The exact cause is unknown, but the primary theory is that the cricopharyngeus muscle, which is normally in a state of tonic contraction, fails to relax and allow the passage of food into the cervical esophagus. This produces a Zenker diverticulum, which is considered a false diverticulum (only involves an outpouching of the mucosa and submucosa) and can be confirmed with a barium swallow (C). Endoscopic evaluation of a suspected Zenker diverticulum is discouraged as it can lead to an iatrogenic perforation. Patients describe difficulty swallowing food, which worsens throughout the day as the diverticulum increasingly gets filled with food. Another key element of the diagnosis is the classic history of an inability to handle saliva secretion, such that the patient describes expectoration of saliva. Patients also report hoarseness. Management includes a diverticulectomy through a left cervical incision. A pharyngoesophageal myotomy also needs to be performed to prevent recurrence (B). Weight loss results from a decreased caloric intake. Although one should always be suspicious of carcinoma in a patient with difficulty swallowing and weight loss, the long duration of symptoms makes carcinoma unlikely (D, E).

**References:** Cameron, J. L., & Cameron, A. M. (2014). The management of Barrett's esophagus. *Current surgical therapy* (11th ed.). Philadelphia, PA: W. B. Saunders.

Cameron, J. L., & Cameron, A. M. (2014). *The management of pharyngeal esophageal (Zenker) diverticula*. (11th ed.). Philadelphia, PA: W. B. Saunders.

19. **B.** Hiatal hernias are divided into three types. Type I, or a sliding hiatal hernia, is the most common. In this hernia, the gastroesophageal junction moves upward into the posterior mediastinum along with part of the stomach, such that the LES is above its normal position (A). The majority of these hernias are asymptomatic. Those who do have symptoms typically experience heartburn and regurgitation. In type II or paraesophageal hernias, the gastroesophageal junction and therefore the LES are in their normal positions, as is the cardia. However, the gastric fundus is

dislocated upward. The LES is neither hypertensive nor hypotensive (C, D). A type III hernia is a combination of types I and II. A hypertensive LES is characteristic of achalasia. In GERD, the LES pressure is low. GERD seems to begin from gastric distention. The distention leads to a shortening of the LES (E). As the sphincter shortens, its resting pressure decreases. The location of the LES (in the normal abdominal position or in the mediastinum) is important in GERD. Loss of abdominal length of the LES causes a decrease in LES pressure because it is no longer subjected to the positive pressure of the abdomen.



# Alimentary Tract—Stomach

*Areg Grigorian, and Christian de Virgilio*

## Questions

1. Three years after a laparoscopic Roux-en-Y gastric bypass (LRYGB), a 45-year-old male presents with symptoms and signs of a small bowel obstruction (SBO). He reports a 150-lb weight loss. Which of the following is the most likely etiology?
  - A. An internal hernia
  - B. Adhesions
  - C. Roux compression due to mesocolon scarring
  - D. Kinking of the jejunojejunostomy
  - E. Incarcerated abdominal wall hernia
2. A 79-year-old male with chronic back pain and chronic obstructive pulmonary disease (COPD) requiring supplemental oxygen presents to the emergency department (ED) with epigastric abdominal pain that started suddenly 2 days ago. His abdominal examination is significant for epigastric tenderness but is otherwise unremarkable. A computed tomography (CT) scan demonstrates a small amount of free air under the right hemidiaphragm but no contrast extravasation. An upper gastrointestinal (GI) water-soluble contrast study demonstrates a duodenal ulcer but no extravasation. Which of the following is the best management?
  - A. Nasogastric tube decompression, intravenous (IV) antibiotics, and proton pump inhibitor (PPI)
  - B. Exploratory laparotomy
  - C. Diagnostic laparoscopy
  - D. Oral antibiotics, clear liquid diet for 2 weeks, and follow-up in clinic
  - E. Serial abdominal exam in the ED for 6 to 8 hours and if improving, he may be discharged with oral antibiotics
3. Which of the following is true regarding the management of obesity?
  - A. Indications for bariatric surgery include a body mass index (BMI) greater than 30 with weight-related comorbidities or BMI greater than 35.
  - B. Sibutramine inhibits pancreatic lipase, reduces absorption of dietary fat, and leads to weight loss.
  - C. Roux-en-y gastric bypass (RYGB) does not have a restrictive component.
  - D. RYGB has a lower 30-day mortality compared with biliopancreatic diversion (BPD).
  - E. Patients with obesity-related comorbidities do not need to attempt nonoperative management before obesity surgery.
4. Which of the following is the best management for primary gastric (non-MALT [mucosa-associated lymphoid tissue]) lymphoma?
  - A. Surgical resection
  - B. Chemotherapy followed by surgical resection
  - C. Radiation therapy
  - D. Chemotherapy
  - E. Surgical resection followed by radiation therapy

5. Which of the following is the gold standard for the diagnosis of gastroparesis?
- A. Upper endoscopy
  - B. Plain abdominal x-rays
  - C. Nuclear medicine scan
  - D. CT
  - E. It is considered a clinical diagnosis.
6. Which of the following is true regarding gallstone disease after weight loss surgery?
- A. The rate of postoperative cholecystectomy is the same regardless of the type of weight loss surgery.
  - B. Prophylactic cholecystectomy should be performed at the time of surgery in most patients.
  - C. Ursodiol is recommended for 6 months after gastric bypass surgery.
  - D. Decreased secretion of calcium and mucin contributes to gallstone formation after weight loss surgery.
  - E. Acute cholecystitis after weight loss surgery is uncommon.
7. The most significant etiologic factor in peptic ulcer disease is:
- A. Duodenogastric reflux
  - B. Acid hypersecretion
  - C. Nonsteroidal antiinflammatory drug (NSAID) ingestion
  - D. Bacterial colonization
  - E. Smoking
8. Which of the following is the first manifestation of gastric leak following Roux-en-Y gastric bypass?
- A. Abdominal pain
  - B. Tachycardia
  - C. Nausea
  - D. Increased serum glucose
  - E. Tachypnea
9. A 45-year-old male with a history of laparoscopic gastric banding 5 years ago presents to the ED with complaints of pain at his port site. He first noticed it several days ago after he got his gastric band adjusted in clinic. On exam, the port site appears erythematous, warm, and is tender to palpation. He is afebrile and normotensive. Which of the following is the best next step?
- A. CT of the abdomen
  - B. Admit to the hospital, start IV antibiotics and fluid resuscitation
  - C. EGD
  - D. Incision and drainage
  - E. Discharge with oral antibiotics
10. A 60-year-old man presents with a 12-hour history of worsening epigastric pain. He has a history of duodenal ulcer, and the results of a recent biopsy 2 weeks earlier were negative for *H. pylori*. Upright chest radiograph demonstrates free air under the diaphragm. The patient is hemodynamically stable. At surgery, a perforated duodenal ulcer is found with mild peritoneal contamination. Which of the following is the best management option?
- A. Graham patch of duodenal ulcer
  - B. Graham patch of duodenal ulcer with truncal vagotomy and pyloroplasty
  - C. Truncal vagotomy and antrectomy with Billroth I reconstruction
  - D. Truncal vagotomy and antrectomy with Billroth II reconstruction
  - E. Graham patch of duodenal ulcer with a highly selective vagotomy
11. Which of the following is the most effective treatment for intractable dumping syndrome?
- A. Low-fat, lactose-free diet
  - B. Serotonin antagonists
  - C. Low-carbohydrate, high-fat diet

- D. Octreotide
  - E. Creation of a reversed jejunal segment
12. Which of the following is true regarding postvagotomy diarrhea?
- A. It is effectively treated with octreotide.
  - B. It does not improve with oral cholestyramine.
  - C. Cardiovascular manifestations are common.
  - D. Most patients require the creation of a reversed jejunal segment.
  - E. Diarrhea may improve with the administration of codeine.
13. A 45-year-old woman is undergoing an exploratory laparotomy for Zollinger-Ellison syndrome (ZES). Preoperative localization studies failed to demonstrate the location of the tumor. At surgery, no obvious tumor is seen despite an extensive Kocher maneuver and careful inspection. An intraoperative ultrasound scan is negative. The next step in the management would be:
- A. Closing the abdomen
  - B. Distal pancreatectomy and splenectomy
  - C. Proximal pancreaticoduodenectomy
  - D. Blind proximal duodenotomy
  - E. Blind distal duodenotomy
14. Which of the following is true regarding TNM (tumor, nodes, and metastases) staging for gastric adenocarcinoma?
- A. Triple-phase helical computed tomography scan is the most accurate means of determining T and N staging.
  - B. The accuracy of endoscopic ultrasound (EUS) is higher for N stage than T stage.
  - C. N staging is based on the number of positive nodes and not the anatomic distribution.
  - D. Magnetic resonance imaging (MRI) with gadolinium should be routinely performed.
  - E. T3 invades the subserosa.
15. Which of the following is associated with hypergastrinemia?
- A. Diabetes
  - B. Hypothyroidism
  - C. Hyperparathyroidism
  - D. Chronic gastritis
  - E. D-cell hyperplasia
16. A 46-year-old male undergoes a distal gastrectomy for a small tumor in the gastric antrum that is biopsy proven to be adenocarcinoma. The specimen is sent for pathology. Pathology reveals microscopic evidence of tumor at the margins. Which of the following most accurately describes this resection?
- A. D1 resection
  - B. D2 resection
  - C. R0 resection
  - D. R1 resection
  - E. R2 resection
17. Which of the following is considered to be a risk factor for gastric cancer?
- A. Pernicious anemia
  - B. Blood group O
  - C. Carbonated acidic soda
  - D. Female gender
  - E. Diabetes
18. Early gastric cancer is best defined as:
- A. Lymph node negative

- B. Limited to the mucosa
  - C. Limited to the mucosa and submucosa with negative nodes
  - D. Limited to the mucosa and submucosa regardless of nodes
  - E. In the muscularis propria but not the serosa
19. Which of the following is true regarding gastrointestinal stromal tumor (GIST)?
- A. They rarely present with GI bleeding.
  - B. They arise from smooth muscle cells.
  - C. Malignant potential is readily determined by histologic features.
  - D. They can be managed by laparoscopic wedge resection.
  - E. The extent of the tumor is best determined preoperatively by endoscopy.
20. A 56-year-old man presents with epigastric pain, diarrhea, and weight loss. Upper endoscopy reveals giant gastric folds in the proximal stomach. A biopsy specimen demonstrates diffuse foveolar hyperplasia with no evidence of malignancy. Twenty-four-hour gastric pH levels are consistent with achlorhydria. Which of the following is true regarding the most likely condition?
- A. There is no risk for the development of cancer.
  - B. It is associated with cytomegalovirus in adults.
  - C. Medical therapy is highly effective.
  - D. It is an inherited condition.
  - E. Treatment includes a high-protein diet.
21. Which of the following is true regarding postgastrectomy bile reflux?
- A. Most patients with bile reflux into the stomach will develop symptoms.
  - B. Symptoms usually correlate with the amount of bile entering the stomach.
  - C. In symptomatic patients, medical management is generally effective.
  - D. Creation of a Roux-en-Y gastrojejunostomy is an effective surgical option.
  - E. It is more likely to occur after a Billroth I than a Billroth II reconstruction.
22. The best test for localization of a gastrinoma is:
- A. MRI
  - B. CT
  - C. Abdominal ultrasound
  - D. Octreotide scan
  - E. Selective angiography
23. The best test to confirm eradication of *H. pylori* after treatment is:
- A. *H. pylori* serology
  - B. Urea breath test
  - C. Histologic biopsy
  - D. Rapid urease test
  - E. Antral mucosal biopsy with culture
24. Which of the following is true regarding a highly selective vagotomy (HSV)?
- A. The anterior and posterior vagal trunks are divided.
  - B. The nerve of Grassi is spared.
  - C. The anterior Latarjet nerve is divided.
  - D. The crow's feet to the antrum are spared.
  - E. The celiac branch is divided.
25. The most common metabolic disorder after gastric resection is a deficiency of:
- A. Iron
  - B. Vitamin B<sub>12</sub>
  - C. Folate

- D. Calcium
  - E. Vitamin D
26. Which of the following is true regarding ZES?
- A. Symptoms decrease with fasting.
  - B. Ulcers are most often located in the distal duodenum.
  - C. It is most commonly familial.
  - D. It is the most common functional neuroendocrine tumor.
  - E. Treatment with proton pump inhibitors (PPIs) can control symptoms in the majority of patients.
27. A 70-year-old man presents with an 8-hour history of acute abdominal pain. On examination, the patient is febrile to 101°F, with a blood pressure of 105/70 mm Hg and a heart rate of 130 beats per minute and has diffuse abdominal tenderness with rebound and guarding; the rectal examination is guaiac positive. Laboratory values are significant for a white blood cell count of 16,000 cells/ $\mu$ L and a hematocrit of 26%. CT demonstrates extravasation of oral contrast in the proximal duodenum. After resuscitation, management consists of:
- A. Closure of the perforation with omental patch plus an HSV
  - B. Closure of the perforation and omental patch via the open approach
  - C. Closure of the perforation with omental patch and duodenotomy with oversewing of posterior ulcer
  - D. Vagotomy and antrectomy with oversewing of the posterior ulcer and omental patch
  - E. Closure of the perforation and omental patch via laparoscopic approach
28. A 50-year-old woman presents with symptoms of early satiety, nausea, vomiting, and epigastric pain. Upper endoscopy reveals a large mass of undigested food particles in the stomach that is partially obstructing the pylorus. Which of the following is true regarding this condition?
- A. Most patients require surgery.
  - B. It can be treated with oral administration of cellulase.
  - C. Psychiatric treatment is critical in long-term management.
  - D. The patient likely has patchy areas of alopecia.
  - E. Peptic ulcer disease is a risk factor.
29. Which of the following is true regarding surgical resection for gastric adenocarcinoma?
- A. For cardia cancers, proximal gastric resection is preferable to total gastrectomy.
  - B. Splenectomy should be performed to attain adequate lymph node sampling.
  - C. Proximal and distal resection margins of 3 cm are considered adequate.
  - D. D2 resections provide improved survival with morbidity similar to that with D1 resections.
  - E. Total gastrectomy is an acceptable option for palliation in stage IV disease.
30. A 70-year-old man presents to the ED with sudden onset of severe epigastric pain associated with retching but with little vomitus. His blood pressure is 140/90 mm Hg and his heart rate is 90 beats per minute. Attempts by the ED physician to place a nasogastric tube are unsuccessful. Upright chest radiograph reveals a large gas bubble just above the left diaphragm. Which of the following is true regarding this condition?
- A. The stomach is likely twisted along the axis transecting the lesser and greater curvature.
  - B. In children it is largely due to a paraesophageal hernia.
  - C. It is associated with Bergman's triad.
  - D. It is associated with a wandering spleen.
  - E. It is initially managed conservatively for the majority of patients.
31. Which of the following describes the association between Sister Mary Joseph's nodule and gastric cancer?
- A. A metastatic left axillary lymph node
  - B. A metastatic left supraclavicular lymph node
  - C. An ovarian mass from gastric metastasis

- D. Umbilical metastasis suggesting carcinomatosis
  - E. An anterior nodule palpable on rectal examination suggesting drop metastasis
32. A 68-year-old woman presents with an upper GI hemorrhage. She has a history of ulcer disease and has recently completed a treatment for *H. pylori*. Upper endoscopy reveals brisk arterial bleeding from a duodenal ulcer located on the posterior wall. Despite numerous attempts to control the bleeding endoscopically, the ulcer continues to bleed. The patient has received 4 units of blood. Her hematocrit is 25%, her blood pressure is 110/60 mm Hg, and her heart rate is 120 beats per minute. Which of the following is the best management option?
- A. Duodenotomy, oversewing the ulcer, truncal vagotomy, and pyloroplasty
  - B. Duodenotomy and oversewing the ulcer
  - C. Truncal vagotomy and antrectomy with Billroth I reconstruction
  - D. Truncal vagotomy and antrectomy with Billroth II reconstruction
  - E. Highly selective vagotomy
33. A 42-year-old alcoholic male with recurrent episodes of pancreatitis presents to the ED with one episode of hematemesis in the morning. He does not appear to have any active bleeding currently. CT scan demonstrates splenic artery thrombosis. Lipase and liver function tests are normal. EGD demonstrates isolated gastric varices that are not currently bleeding and one 2-cm ulcer at the angularis. Which of the following endoscopic features confers the lowest risk of rebleeding?
- A. Oozing ulcer
  - B. Nonbleeding ulcer with overlying clot
  - C. Nonbleeding visible vessel
  - D. Visible ulcer base
  - E. Flat pigmented spot
34. Which of the following is true regarding gastric polyps?
- A. Fundic gastric polyps have the highest risk of harboring malignant cells.
  - B. Adenomatous gastric polyps are the most common type.
  - C. Hamartomatous polyps are associated with *H. pylori* infection.
  - D. Heterotopic polyps most commonly present with gastrointestinal bleeding.
  - E. Inflammatory polyps do not have a risk of malignancy.
35. Bleeding from a Dieulafoy gastric lesion is due to:
- A. Antral vascular ectasia
  - B. Abnormal gastric rugal folds
  - C. Ingested foreign material
  - D. An abnormal submucosal vessel
  - E. A premalignant lesion
36. Which of the following is true regarding low-grade early mucosa-associated lymphoid tissue (MALT) lymphoma?
- A. Translocation of chromosome 11 with chromosome 18 predicts poor responsiveness to antibiotics.
  - B. Regression most commonly takes 3 years to achieve.
  - C. Ampicillin is an antibiotic often used as part of triple therapy.
  - D. It is considered a clonal proliferation of T cells.
  - E. Patients with stable disease at 6 months should be referred for chemoradiation.
37. The most sensitive and specific diagnostic test for gastrinoma is:
- A. Basal and stimulated gastric acid outputs
  - B. Octreotide scan
  - C. Fasting serum gastrin
  - D. Calcium stimulation test
  - E. Secretin stimulation test

38. Which of the following is the procedure of choice for an intractable duodenal ulcer that fails to heal despite maximal medical therapy?
  - A. Truncal vagotomy and pyloroplasty
  - B. Truncal vagotomy and antrectomy with Billroth I reconstruction
  - C. Truncal vagotomy and antrectomy with Billroth II reconstruction
  - D. Highly selective vagotomy (HSV)
  - E. Distal gastrectomy
39. Which of the following is true regarding the types of gastric ulcers?
  - A. Type II ulcers are the most common.
  - B. Type IV ulcers occur near the gastroesophageal junction.
  - C. Type I ulcers usually have increased acid secretion.
  - D. Type III ulcers are associated with decreased acid secretion.
  - E. Type I gastric ulcers are prepyloric.
40. Which of the following is the procedure of choice for an intractable type I gastric ulcer that fails to heal despite maximal medical therapy?
  - A. Truncal vagotomy and antrectomy with Billroth I reconstruction
  - B. Truncal vagotomy and antrectomy with Billroth II reconstruction
  - C. HSV alone
  - D. Distal gastrectomy with Billroth I reconstruction
  - E. Distal gastrectomy with Billroth II reconstruction
41. A frail 85-year-old female presents to the ED with severe dehydration and ketoacidosis due to persistent vomiting. She is not a diabetic. She has had significant weight loss. Workup eventually demonstrates gastroparesis. After this initial hospitalization, which of the following long-term treatment strategies should be initiated?
  - A. Cisapride
  - B. Metoclopramide
  - C. Botulinum toxin injection at the pylorus
  - D. Gastric electrical stimulation device
  - E. Six low-fat, low-fiber meals per day

## Answers

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1. **A.** The most common etiology of small bowel obstruction in the United States is adhesions from previous abdominal surgery. However, this does not hold true for patients that have previously had a LRYGB. In this procedure, a potential hernia site (Petersen's space hernia) is created increasing the risk for the development of an internal hernia, which is the most common cause of SBO in this patient population with an incidence of 1% to 5%. This potential space results from herniation of intestinal loops through a defect in the mesentery and between small bowel limbs, transverse mesocolon, and the retroperitoneum. Additionally, when compared to its open counterpart, the laparoscopic approach further facilitates a Petersen's hernia because of the decreased frequency of postoperative adhesions, which seemingly have a physiologic role of preventing bowel mobility and thus, internal herniation. Risk of SBO is significantly higher with a retrocolic versus antecolic approach. Roux compression due to mesocolon scarring is the second most common etiology for SBO in patients with LRYGB followed by adhesions (B, C). Kinking of the jejunojejunostomy and incarcerated abdominal wall hernia occur less frequently (D, E).

**References:** Champion, J. K., & Williams, M. (2003). Small bowel obstruction and internal hernias after laparoscopic Roux-en-Y gastric bypass. *Obesity Surgery*, 13(4), 596–600.

Husain S, Ahmed, A. R., Johnson, J., et al. (2007). Small-bowel obstruction after laparoscopic Roux-en-Y gastric bypass: etiology, diagnosis, and management. *Archives of Surgery*, 142(10), 988–993.

2. **A.** Nonoperative management for perforated peptic ulcer disease is gaining popularity and is now accepted as an appropriate first-line management for poor surgical candidates (e.g., COPD using



home oxygen) who are stable, have no evidence of peritonitis, and have no contrast extravasation. Conservative management is also more favorable if the duration of symptoms has been present for more than 24 hours. By this time the perforation has typically been sealed. Self-sealing of the perforation is achieved by either adhesion formation to the caudate lobe, the greater omentum, the gallbladder, or the falciform ligament. In one study, only 3 out of 109 patients managed nonoperatively developed an intra-abdominal abscess (which can be managed with antibiotics and percutaneous drainage). This may speak to the intrinsic immune function of the omentum and the fact that the upper GI tract has a low bacterial load. Eighty percent of nonoperative cases respond favorably, and morbidity is not significantly increased. Patients deemed appropriate candidates for nonoperative management should be admitted, placed NPO (nothing by mouth), and given IV fluid resuscitation, IV antibiotics covering gram-negative and anaerobic organisms, and PPIs. Nasogastric tube insertion is critical to help decompress the stomach and allow the perforation to heal. CT scan may be considered for patients who fail to improve or those who deteriorate clinically. Surgery is the next step for patients who fail conservative management (B, C). Outpatient follow-up is not appropriate because nonoperative management should be performed in a monitored setting with frequent abdominal exams and follow-up esophagogastroduodenoscopy (EGD) to ensure that the perforation has sealed (D, E).

**References:** Nusree, R. (2005). Conservative management of perforated peptic ulcer. *The Thailand Journal of Surgery*, 26, 5–8.

Hanumanthappa, M. B., Gopinathan, S., Guruprasad, R., et al. (2012). A non-operative treatment of perforated peptic ulcer: a Prospective study with 50 cases. *Journal of Clinical Diagnosis Research*, 41, 4161.

3. **D.** Obesity has been linked to multiple comorbidities including hypertension and diabetes and is on the rise. As such, many clinicians have turned to medical management and/or bariatric surgery to help fight this epidemic in cases where diet and exercise fail. Two FDA-approved medications to help treat obesity include sibutramine and orlistat. Sibutramine blocks the presynaptic uptake of serotonin thereby potentiating its anorexic effects in the CNS. Orlistat inhibits pancreatic lipase, which decreases dietary fat absorption resulting in weight loss (B). A significant complication limiting its use for most patients is severe flatulence. Indications for weight loss surgery include BMI > 35 with associated obesity-related comorbidities (e.g. hypertension, diabetes) or BMI > 40 (A). Additionally, all patients will need to demonstrate that they have successfully attempted and failed non operative weight loss management such as diet and exercise programs (E). Patients will also need to be evaluated by a physiatrist and deemed suitable for the procedure. The four standard approaches in the United States include laparoscopic gastric banding, sleeve gastrectomy, BPD, and RYGB. Laparoscopic gastric banding and sleeve gastrectomy are considered restrictive procedures as they physically limit the intake of food. BPD is considered a malabsorptive procedure as it involves constructing an alimentary channel distally to the GI tract and thereby preventing the absorption of caloric intake. RYGB is considered a combined approach and involves creating a small restricted gastric remnant (restrictive component) and a roux-limb from the stomach to the distal jejunum (malabsorptive component) (C). These procedures result in up to 50% resolution of weight related co morbidities and up to 50% excess weight loss. RYGB has a lower 30-day mortality compared to BPD and is slightly favored by surgeons as it is technically easier to perform. RYGB has a slightly higher mean excess weight loss at 2 years compared to sleeve gastrectomy but sleeve gastrectomy has a higher perioperative leak rate. Both procedures are equally effective in eliminating type 2 diabetes mellitus.

**References:** Duarte, M. I., Bassitt, D. P., Azevedo, O. C., et al. (2014). Impact on quality of life, weight loss and comorbidities: a study comparing the biliopancreatic diversion with duodenal switch and the banded Roux-en-Y gastric bypass. *Argentina Gastroenterology*, 51(4), 320–327.

Santry, H. P., Gillen, D. L., & Lauderdale, D. S. (2005). Trends in bariatric surgical procedures. *JAMA: the Journal of the American Medical Association*, 294(15), 1909–1917.

O'Brien, P. (2016). Surgical treatment of obesity. *Endotext*, 19, 29–46.

Zingmond, D. S., McGory, M. L., & Ko, C. Y. (2005). Hospitalization before and after gastric bypass surgery. *JAMA: the Journal of the American Medical Association*, 294(15), 1918–1924.

4. **D.** Gastric lymphoma is a subtype of non-Hodgkin lymphoma (NHL) and considered the most common form of extranodal NHL. The vast majority are either MALT gastric lymphoma or diffuse large B-cell lymphoma (DLBCL). The current foundation for the treatment of gastric DLBCL is

chemotherapy (A, B). Depending on the response, and initial tumor size, locoregional radiation therapy may be added (C, E).

5. **C.** Gastroparesis is defined as delayed gastric emptying without a mechanical cause for obstruction. Although diabetes is the most common known cause of gastroparesis (29%), idiopathic gastroparesis occurs more frequently (36%). The most common symptoms are nausea, early satiety, and abdominal bloating. Most patients do not have abdominal pain. Although symptoms alone can be suggestive of this condition, it needs to be confirmed with imaging (E). Gastric emptying scintigraphy (delayed gastric emptying study) is the gold standard in diagnosing gastroparesis. This involves asking the patient to eat a small meal along with a radioactive tracer. The rate of emptying is measured 1, 2, 3, and 4 hours after the meal is ingested, and if more than 10% of the meal remains in the stomach after 4 hours, the study is considered consistent with gastroparesis (A, B, D).
6. **E.** Gallstone formation occurs in 30% to 52% of patients undergoing weight loss surgery, but only 7% to 15% are symptomatic. Among those 7% to 15% who do become symptomatic, acute cholecystitis is uncommon. Rapid weight loss is a known risk factor for cholelithiasis. In fact, excess weight loss greater than 25% is considered the strongest predictor of postoperative cholecystectomy and occurs more commonly in patients who have had a gastric bypass versus laparoscopic banding or sleeve gastrectomy (A). Several mechanisms have been shown to contribute to gallstone formation during weight loss including increased secretion of calcium and mucin into bile, increased concentrations of arachidonic acid derivatives, and bile stasis secondary to stringent dietary restrictions postoperatively (D). Prophylactic cholecystectomy at the time of weight loss surgery has been a point of debate in the surgical community. Proponents argue that it helps prevent the morbidity of symptomatic biliary disease and avoids the need for treatments such as endoscopic retrograde cholangiopancreatography (ERCP), which can be particularly challenging in this patient population (e.g., RYGB). However, it has been shown in several large studies that the rate of postoperative cholecystectomy remains under 15%, and so the routine removal of the gallbladder during weight loss surgery is not currently supported by the American Society of Metabolic and Bariatric Surgery (B). In contrast, symptomatic patients may undergo concomitant cholecystectomy safely. Ursodiol after gastric bypass can significantly decrease the rate of gallstone formation, but because it has not been shown to be cost effective and lead to improved outcomes, it is not routinely recommended (C).

**References:** D'Hondt, M., Sergeant, G., Deylgat, B., et al. (2011). Prophylactic cholecystectomy, a mandatory step in morbidly obese patients undergoing laparoscopic Roux-en-Y gastric bypass? *Journal of Gastrointestinal Surgery*, 15(9), 1532–1536.

Shiffman, M. L., Shamburek, R. D., Schwartz, C. C., et al. (1993). Gallbladder mucin, arachidonic acid, and bile lipids in patients who develop gallstones during weight reduction. *Gastroenterology*, 105(4), 1200–1208.

Sugerman, H. J., Brewer, W. H., Schiffman, M. L., et al. (1995). A multicenter, placebo-controlled, randomized, double-blind, prospective trial of prophylactic ursodiol for the prevention of gallstone formation following gastric-bypass-induced rapid weight loss. *American Journal of Surgery*, 169(1), 91–96.

Tucker, O. N., Fajnwaks, P., Szomestein, S., et al. (2008). Is concomitant cholecystectomy necessary in obese patients undergoing laparoscopic gastric bypass surgery? *Surgical Endoscopy*, 22(11), 2450–2454.

Villegas, L., Schneider, B., Provost, D., et al. (2004). Is routine cholecystectomy required during laparoscopic gastric bypass? *Obesity Surgery*, 14(2), 206–211.

7. **D.** *Helicobacter pylori* is considered the most significant etiologic factor in peptic ulcer disease. It is reportedly found in 80% to 90% of duodenal ulcers and more than 70% of gastric ulcers. *H. pylori* is a helix-shaped, microaerophilic gram-negative rod and is more prevalent in low and middle income countries, where as many as 70% of the population are colonized with *H. pylori*. *H. pylori* also causes acute gastritis. The exact mechanism by which it causes ulceration is unclear, but it may be by the production of local toxic products, induction of a local immune response, or an increase in gastrin levels leading to an increase in acid (B). In fact, the organism seems to be the cause of hypergastrinemia in duodenal ulcers because the infection reduces the number of antral D cells, thus reducing somatostatin levels, which then disinhibits G (gastrin) cells. *H. pylori* is a potent producer of urease, which splits urea into ammonia and bicarbonate. This allows the bacteria to

survive in a microenvironment of relative alkalinity within the stomach. It only lives in gastric epithelium (including heterotopic gastric mucosa) because it expresses specific adherence receptors recognized by the bacteria. After *H. pylori*, ingestion of NSAIDs (C) and smoking (E) are the next most important risk factors. Smoking increases gastric acid secretion and duodenogastric reflux (A) and decreases pancreaticoduodenal bicarbonate production.

**Reference:** Kurata, J. H., & Nogawa, A. N. (1997). Meta-analysis of risk factors for peptic ulcer. Nonsteroidal anti-inflammatory drugs, *Helicobacter pylori*, and smoking. *Journal of Clinical Gastroenterology*, 24(1), 2–17.

8. **B.** The rate of obesity is rising in the United States and an increasing number of patients are undergoing weight loss surgery. Gastric leak in the early postoperative period may be an indication to go back to the operating room, so early recognition of this complication is important. The first manifestations of a gastric leak are tachycardia and fever (A, C–E). This may also be accompanied by tachypnea, abdominal pain, chest pain, oliguria, and/or hypotension.

**Reference:** Bekehit, M., Katri, K., Nabil, W., et al. (2013). Earliest signs and management of leakage after bariatric surgeries: single institute experience. *Alexandria Journal of Medicine*, 49(1), 29–33.

9. **A.** Laparoscopic gastric banding involves placing an inflatable balloon around the proximal stomach at the angle of His. It was very popular when it first appeared but lost traction after subsequent studies demonstrated that it was far inferior to gastric bypass. Additionally, patients with laparoscopic bands were more likely to require revisions for complications associated with the gastric band. One such complication is band erosion (BE) into the stomach and/or adjacent organs. This may present as port site erythema (inflammation tracking down the tube), fooling the clinician into thinking the patient may only have an overlying skin infection. In fact, most patients with BE presenting with port site erythema do not have a subfascial port infection. BE can occur many years after surgery, and one proposed mechanism involves overtightening of the band (e.g., after clinic visit). With the conversion of the perigastric technique to the pars flaccid approach, the incidence of this complication has decreased from 8% to less than 1%. CT of the abdomen should be performed in patients suspected of having BE, and if found, the port site should be completely deflated and the patient should be scheduled for laparoscopic removal of the band. EGD may demonstrate BE if it has completely eroded into the gastric lumen but may miss partial BE (C). Incision and drainage are not indicated because there is no abscess (D). The patient should be monitored for the development of a subsequent port site infection, but the first step is to get a CT scan (B–E).

**References:** DiLorenzo, N., Lorenzo, M., Furbetta, F., et al. (2013). Intragastric gastric band migration and erosion: an analysis of multicenter experience on 177 patients. *Surgical Endoscopy*, 27(4), 1151–1157.

Naef, M., Naef, U., Mouton, W., et al. (2007). Outcome and complications after laparoscopic Swedish adjustable gastric banding: 5-year results of a prospective clinical trial. *Obesity Surgery*, 17(2), 195–201.

Stroh, C., Hohmann, U., Will, U., et al. (2008). Experiences of two centers of bariatric surgery in the treatment of intragastric band migration after gastric banding—the importance of the German multicenter observational study for quality assurance in obesity surgery 2005 and 2006. *International Journal of Colorectal Disease*, 23(9), 901–908.

Tice, J. A., Karliner, L., Walsh, J., et al. (2008). Gastric banding or bypass? A systematic review comparing the two most popular bariatric procedures. *The American Journal of Medicine*, 121(10), 885–893.

10. **E.** In the majority of patients with a perforated duodenal ulcer, simple closure of the ulcer with an omental (Graham) patch is all that is necessary (A). This is then followed by treatment for *H. pylori*. In addition, a Graham patch alone should be used if the patient is unstable, if there is extensive exudative peritonitis, or if the perforation is long standing (>24 hours). However, in the setting of a patient with a known ulcer diathesis who has either already been treated for *H. pylori* or is *H. pylori* negative, an ulcer surgery should be added to the operation, provided the patient is a good operative risk, is hemodynamically stable, and does not have extensive peritonitis. The options are either to perform a highly selective vagotomy (HSV) or a vagotomy and pyloroplasty (B). An HSV is the preferred approach in the good-risk patient who is stable, provided the surgeon is comfortable with the procedure. Pyloroplasty is typically performed along with a vagotomy because the widened outlet from the stomach to the duodenum helps circumvent any unwanted

effects of the decreased gastric peristalsis and overall change in gastric emptying patterns that occur following vagotomy. The entire procedure can be performed laparoscopically in select patients. Truncal vagotomy and antrectomy (C, D) is generally not recommended in the setting of perforation because of the high associated morbidity and mortality rates.

**References:** Cadiere, G. B., Bruyns, J., Himpens, J., et al. (1999). Laparoscopic highly selective vagotomy. *Hepatogastroenterology*, 46(27), 1500–1506.

Jordan, P. H., Jr, & Thornby, J. (1995). Perforated pyloroduodenal ulcers: long-term results with omental patch closure and parietal cell vagotomy. *Annals of Surgery*, 221(5), 479–486, discussion 486–488.

Siu, W. T., Leong, H. T., Law, B. K., et al. (2002). Laparoscopic repair for perforated peptic ulcer: a randomized controlled trial. *Annals of Surgery*, 235(3), 313–319.

11. **D.** Dumping syndrome can occur after any type of gastric surgery and is divided into early and late forms. Early dumping (20–30 minutes after eating) is more common and has both GI (nausea, vomiting, crampy abdominal pain, and explosive diarrhea) and cardiovascular (diaphoresis, dizziness, flushing) symptoms. The symptoms are related to the release of various substances including serotonin, neurotensin, bradykinins, and enteroglucagon. Late dumping (2–3 hours after eating) is the result of a reaction to a large amount of carbohydrates suddenly reaching the small intestine. This leads to a sudden release of large amounts of insulin with subsequent hypoglycemia with resultant diaphoresis, confusion, and tachycardia. Some patients only have early dumping, some only have late dumping, and some have both. The initial therapy for dumping syndrome is quite effective and consists of dietary modification (A–C). This includes eating frequent small meals, avoiding large amounts of carbohydrates and instead eating food high in protein and fat, and avoiding large amounts of fluids with meals. Octreotide, a long-acting somatostatin analogue, is the most effective treatment. It is effective against both the GI and cardiovascular symptoms. Long-term use of octreotide is associated with steatorrhea and cholelithiasis. Serotonin antagonists (B) have been used for dumping syndrome but have not been routinely effective. Creation of a reversed jejunal segment (E) can be considered in the management of postvagotomy diarrhea.

**References:** Geer, R. J., Richards, W. O., O'Dorisio, T. M., et al. (1990). Efficacy of octreotide acetate in treatment of severe postgastrectomy dumping syndrome. *Annals of Surgery*, 212(6), 678–687.

Gray, J. L., Debas, H. T., & Mulvihill, S. J. (1991). Control of dumping symptoms by somatostatin analogue in patients after gastric surgery. *Annals of Surgery*, 126(10), 1231–1235, discussion 1235–1236.

12. **E.** Postvagotomy syndromes include diarrhea, gastric atony, and incomplete vagotomy (leading to recurrent ulceration). Diarrhea follows truncal vagotomy and may be confused with dumping syndrome. The diarrhea associated with vagotomy occurs more frequently and is not associated with the other cardiovascular manifestations seen with dumping syndrome (C). The initial treatment is similar to that for dumping syndrome, with dietary modifications such as frequent small meals with decreased fluid intake and an increase in fiber. A proposed mechanism of the diarrhea is an increase in stool bile salts. Oral cholestyramine is often helpful because it binds bile salts (B). Loperamide and codeine have also been shown to delay intestinal transit time and improve symptoms. In the very rare patient who does not respond to medical management, reversal of a segment of jejunum is effective in slowing transit time and improving diarrhea (D). Octreotide is not effective for postvagotomy diarrhea and may make the situation worse by decreasing pancreatic secretions and thus increasing steatorrhea (A).

**References:** Duncombe, V., Bolin, T., & Davis, A. (1977). Double-blind trial of cholestyramine in post-vagotomy diarrhea. *Gut*, 18(7), 531–535.

O'Brien, J. G., Thompson, D. G., McIntyre, A., et al. (1988). Effect of codeine and loperamide on upper intestinal transit and absorption in normal subjects and patients with postvagotomy diarrhoea. *Gut*, 29(3), 312–318.

13. **D.** More than 80% of gastrinomas are localized preoperatively. For those that cannot be localized, surgical exploration is still indicated because excision of the primary tumor leads to a decreased rate of liver metastasis. When exploring, it is important to be aware that 80% of gastrinomas are found within the gastrinoma (Passaro) triangle, an area defined by the junction of the cystic duct and common bile duct, the second and third portions of the duodenum, and the neck and body of the pancreas. As many as 60% of gastrinomas are within the wall of the duodenum, primarily in the first and second portions and can be very small. Thus, the next maneuver would be to perform

a blind proximal duodenotomy to manually palpate the duodenal wall for tumors. Closing the abdomen (A) would be inappropriate. Blind distal pancreatectomy and splenectomy (these share blood supply) (B) or distal duodenotomy (E) would have very low yields. A pancreaticoduodenectomy (Whipple procedure) (C) would not be indicated in this setting. It is potentially indicated for multiple duodenal or proximal pancreatic head tumors that could not be enucleated.

14. **C.** Staging of gastric cancer involves depth of invasion (T1 invades lamina propria; T2, muscularis propria or subserosa; T3, serosa; T4, adjacent structures), nodes, and distant metastasis (E). EUS is the best modality for assessing tumor depth of invasion and nodal status. It is approximately 80% accurate in determining whether the tumor is transmural (invading serosa, T<sub>3</sub>) but only 50% accurate in assessing whether pathologically enlarged lymph nodes are present (B). EUS seems to be more accurate with advanced disease than early disease. CT scanning is the preferred method for determining distant metastases, but it is not as useful for T and N staging (A). The routine use of MRI and positron emission tomography scanning for staging of gastric cancer has not as yet been established (D). N1 disease includes 1 to 6 regional nodes; N2, 7 to 15 regional nodes; and N3, more than 15 regional nodes.

**References:** Puli, S., Batapati Krishna Reddy J., Bechtold, M. L., et al. (2008). How good is endoscopic ultrasound for TNM staging of gastric cancers? A meta-analysis and systematic review. *World Journal of Gastroenterology*, 14(25), 4011–4019.

Willis, S., Truong, S., Gribnitz, S., et al. (2000). Endoscopic ultrasonography in the preoperative staging of gastric cancer: accuracy and impact on surgical therapy. *Surgical Endoscopy*, 14(10), 951–954.

Xi, W., Zhao, C., & Ren, G. (2003). Endoscopic ultrasonography in preoperative staging of gastric cancer: determination of tumor invasion depth, nodal involvement and surgical respectability. *World Journal of Gastroenterology*, 9(2), 254–257.

15. **D.** When considering gastrinoma, it is important to be aware of the differential diagnosis of an elevated gastrin level. Causes of hypergastrinemia with increased acid production include gastrinoma, G-cell hyperplasia (not D-cell) (E), retained antrum after distal gastrectomy, renal failure, and gastric outlet obstruction. Hypergastrinemia with normal or low acid production includes pernicious anemia, postvagotomy states, use of acid-suppressive medication, and chronic gastritis. Hypothyroidism is associated with a low gastrin level, whereas hyperthyroidism increases gastrin levels (B). Diabetes (A) and hyperparathyroidism (C) do not affect gastrin levels.

**References:** Seino, Y., Matsukura, S., Inoue, Y., et al. (1978). Hypogastrinemia in hypothyroidism. *American Journal of Digestive Diseases*, 23(2), 189–191.

Korman, M. G., Laver, M. C., Hansky, J., et al. (1972). Hypergastrinemia in chronic renal failure. *British Medical Journal*, 1(5794), 209–210.

16. **D.** R0 resection is resection of all gross and microscopic tumors (C). R1 indicates removal of all macroscopic disease but microscopic margins are positive for disease. An R2 resection indicates that gross residual disease is left behind (E). A D1 resection (A) refers to removal of group 1 lymph nodes; D2 (B) refers to resection of lymph nodes in groups 1 and 2. A D3 resection is a D2 resection plus removal of para-aortic lymph nodes.

17. **A.** Risk factors for gastric cancer include dietary factors such as a large consumption of smoked meats, pickled foods, high nitrates, and high salt, whereas a diet high in fruits and vegetables may be protective (D, E). Other risk factors include smoking, low socioeconomic status, black race, *H. pylori* infection, chronic atrophic gastritis, blood type A, previous partial gastrectomy, achlorhydria, pernicious anemia, polyps (adenomatous and hyperplastic), male gender, and certain familial syndromes such as hereditary nonpolyposis colorectal cancer, Li-Fraumeni syndrome, familial adenomatous polyposis, and Peutz-Jeghers syndrome (B, D). Peutz-Jeghers syndrome is associated with a markedly increased risk of cancer in the esophagus, stomach, small bowel, colon, pancreas, breast, lung, uterus, and ovary, with a cumulative 93% risk of cancer. Carbonated acidic soda has not been shown to increase the risk for cancer (C). Gastric cancer has been categorized by Lauren into intestinal and diffuse types based on histology. The intestinal type is thought to be more related to environmental factors, is associated with chronic gastritis, and is well differentiated. The diffuse type is usually poorly differentiated and associated with signet rings and occurs in younger patients and in association with familial disorders and also with type A blood. The diffuse type has a worse prognosis.

**References:** Berndt, H., Wildner, G. P., & Klein, K. (1968). Regional and social differences in cancer incidence of the digestive tract in the German Democratic Republic. *Neoplasma*, 15(5):501–515.

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Wynder, E. L., Kmet, J., Dungal, N., et al. (1963). An epidemiological investigation of gastric cancer. *Cancer*, 16, 1461–1496.

18. **D.** Early gastric cancers are defined as adenocarcinoma limited to the mucosa and submucosa of the stomach, regardless of lymph node status (A–C, E). In Japan, because of the high prevalence of gastric cancer, aggressive screening programs are used. This has resulted in as many as one-half of gastric cancers being detected early, whereas in the United States, less than one-fourth are considered early gastric cancer. In one large series of nearly 400 patients with early gastric cancer, 11.9% had positive lymph nodes. Risk factors for lymph node metastasis included large tumor size, lymphatic vessel involvement, and invasion of the submucosa. Lymph node status was the most important determinant of survival.

**References:** Adachi, Y., Shiraishi, N., & Kitano, S. (2002). Modern treatment of early gastric cancer: review of the Japanese experience. *Digestive Surgery*, 19(5), 333–339.

Maehara, Y., Orita, H., Okuyama, T., et al. (1992). Predictors of lymph node metastasis in early gastric cancer. *The British Journal of Surgery*, 79(3), 245–247.

19. **D.** GISTs were previously called *leiomyomas* or *leiomyosarcomas* because they were thought to arise from smooth muscle cells, but they in fact originate from mesenchymal components (from Cajal cells) (B). They stain positive for CD117 (c-kit). They are most commonly found in the stomach and, although rare, it is the most common mesenchymal tumor of the intestinal tract. Because they are not epithelial tumors and grow in the wall of the stomach, they tend to be large at the time of presentation. They cause mucosal ulceration and frequently present with GI bleeding (A). Large tumors may also produce symptoms of weight loss, abdominal pain, and fullness and early satiety. An abdominal mass may be palpable. An endoscopic biopsy specimen may be negative in as many as one-half of cases due to sampling error because most of the tumor is submucosal (E). A CT scan provides a better assessment of the extent of the tumor. Determining whether a GIST is malignant is not straightforward because there are no discriminating cellular features (C). The malignant potential is determined by mitotic activity (> 5 mitoses/50 high power field) with 1 cm. Lymph node dissection is not necessary because tumors spread hematogenously and lymph node metastasis is extremely rare. Wedge resection with 1 cm margins is adequate treatment in most cases. This can be performed laparoscopically. However, microscopically positive margins have not been demonstrated to affect survival.

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Novitsky, Y., Kercher, K., Sing, R., et al. (2006). Long-term outcomes of laparoscopic resection of gastric gastrointestinal stromal tumors, *Annals of Surgery*, 243(6), 738–745.

Sexton, J., Pierce, R., Halpin, V., et al. (2008). Laparoscopic gastric resection for gastrointestinal stromal tumors. *Surgical Endoscopy*, 22(12), 2583–2587.

Malangoni M. A., et al. (2004). Stomach. In J. L. Cameron, (Ed.), *Current surgical therapy* (pp. 67–100) (8th ed.). Philadelphia, PA: Mosby.

20. **E.** The patient has Ménétrier disease. Ménétrier disease is an acquired disease with no family predisposition (D). The etiology is unknown, but it is associated with an increase in transforming growth factor alpha. Giant rugal folds, particularly in the fundus and body, and a loss of parietal cells develop. Thus, patients have hypo- or achlorhydria. Patients lose a large amount of protein in the stomach due to the hypersecretion of mucus. This results in weight loss and peripheral edema. Giant rugal folds are also seen with ZES; however, the latter can be ruled out by the demonstration of achlorhydria. Mucosal biopsy shows diffuse hyperplasia of the surface mucus-secreting cells as well as loss of parietal cells. There seems to be an increased risk of gastric cancer, although it is not high (A). It is associated with cytomegalovirus infection in children and with *H. pylori* infection in adults (B). Most patients with Ménétrier disease are middle-aged men. Symptoms include



epigastric pain, weight loss, diarrhea, and hypoproteinemia. Treatment includes a high-protein diet, anticholinergic agents, and *H. pylori* eradication if the patient tests positive. Medical treatment has not been particularly effective, although there are cases of spontaneous resolution (C). For patients who do not respond to medical therapy, gastric resection may be indicated, particularly for intractable severe hypoproteinemia or if dysplasia or malignancy develops. Recently, Erbitux (cetuximab), which blocks the action of transforming growth factor alpha, has been used as a potential new treatment.

**References:** Bayerdörffer, E., Ritter M, Hatz R, et al. (1994). Healing of protein losing hypertrophic gastropathy by eradication of *Helicobacter pylori*—is *Helicobacter pylori* a pathogenic factor in Ménétrier's disease? *Gut*, 35(5), 701–704.

Burdick, J., Chung, E., Tanner, G., et al. (2000). Treatment of Ménétrier's disease with a monoclonal antibody against the epidermal growth factor receptor. *The New England Journal of Medicine*, 343(23), 1697–1701.

Hsu, C. T., Ito, M., Kawase, Y., et al. (1991). Early gastric cancer arising from localized Ménétrier's disease. *Gastroenterol Japanese*, 26(2), 213–217.

21. **D.** Bile reflux into the stomach can occur without previous surgery, but in most instances it follows ablation of the pylorus, such as after gastric resection or pyloroplasty. After such procedures, most patients will have bile in the stomach on endoscopic examination, along with some degree of gross or microscopic gastric inflammation. However, only a small fraction of patients will have a significant degree of symptoms such as nausea, epigastric pain, and bilious vomiting consistent with alkaline (bile) reflux gastritis (A, B). Symptoms often develop months or years after the index operation. The differential diagnosis includes afferent or efferent loop obstruction, gastric stasis, and small bowel obstruction. These other diagnoses can be ruled out using a combination of abdominal radiographs, upper endoscopy, and abdominal CT scan. A hepatoiminodiacetic acid (HIDA) scan is particularly helpful for demonstrating bile reflux. Bile reflux and gastritis are more likely to occur after Billroth II reconstruction (E) than after Billroth I and least likely after vagotomy and pyloroplasty. Medical management of symptomatic patients is not particularly effective (C). The surgical procedure of choice is to convert the Billroth II into a Roux-en-Y gastrojejunostomy with a lengthened jejunal limb (at least 45 cm).

22. **D.** More than 90% of gastrinomas have receptors for somatostatin. Octreotide scanning (somatostatin receptor scintigraphy) has been shown to be the most sensitive test for localization of gastrinomas. However, successful localization depends on size and location. Somatostatin receptor scintigraphy is poor for very small (<1.1 cm) tumors and for small primary duodenal tumors. Duodenal gastrinomas are best localized by endoscopic ultrasonography. Abdominal ultrasound is not helpful (C). Failure to detect the tumor preoperatively should not preempt surgical exploration because an additional 33% will be found at surgery. CT and angiography may also be useful adjuncts in detecting gastrinoma (B–E). Aside from MRI's utility in detecting liver metastasis, it is not often employed in the workup for a presumed gastrinoma (A).

**Reference:** Alexander, H., Fraker, D., Norton, J., et al. (1998). Prospective study of somatostatin receptor scintigraphy and its effect on operative outcome in patients with Zollinger-Ellison syndrome. *Annals of Surgery*, 228(2), 228–238.

23. **B.** A urea breath test is the best way to confirm eradication of *H. pylori*. The test relies on the fact that the bacteria hydrolyze urea. The patient is given radiolabeled urea to ingest orally. If *H. pylori* is present, the urea will be converted to ammonia and radiolabeled bicarbonate, which is then exhaled as carbon dioxide. The amount of exhaled carbon dioxide is quantified. Positive *H. pylori* serology (A) provides evidence of current infection if the patient has never been treated for it but will remain positive even after successful treatment; thus, it is not useful in this setting. Antral mucosa biopsy (E) with histologic examination (C) for the organism is the gold standard test. It is useful in the initial evaluation of patients with upper GI symptoms because it permits evaluation of the stomach via endoscopy at the time of biopsy. However, given its invasive nature and increased cost, it is not routinely recommended to confirm eradication. Cultures of the gastric mucosa are not routinely available at every laboratory, and a repeat endoscopy is required. The rapid urease test, also known as the campylobacter-like organism (CLO) test (D), is ideally used if another endoscopy and biopsy are being performed. The study requires placing a sample of gastric mucosa in a urea solution and then using a pH indicator to demonstrate the production of ammonia.



24. **D.** HSV is also known as a parietal cell vagotomy or proximal gastric vagotomy. The goal of the operation is to divide the vagal nerves of the proximal two-thirds of the stomach where the parietal cells are located and preserve the distal third to maintain antral function and thus not require a drainage procedure (such as a pyloroplasty). This results in fewer complications than the classic truncal vagotomy. The operation spares the main anterior and posterior vagal trunks (A) but divides the branches of the anterior and posterior Latarjet nerves that directly innervate the proximal stomach (C). The distal 7 cm (approximately) of nerves, known as the crow's feet, are spared. Likewise, the celiac and hepatic branches are spared (E). Proximally, it is important to divide the nerve of Grassi, which is a branch off the posterior trunk of the vagus (B). It is often referred to as the criminal nerve of Grassi because failure to divide this branch leads to a higher ulcer recurrence rate. With the recognition of *H. pylori* as the main etiology of peptic ulcer, the role of surgery has greatly diminished. HSV is still indicated in certain rare situations, such as patients who do not respond to medical management, patients who are bleeding who do not respond to endoscopic management, or with perforation in patients with a long-standing ulcer diathesis.
25. **A.** Gastric resection leads to numerous disturbances in metabolism. These include deficiencies of iron, vitamin B<sub>12</sub> (B), folate (C), fat-soluble vitamins (E), and calcium (D). Of these, iron deficiency is the most common. Iron is absorbed in the duodenum and is facilitated by an acidic environment. After gastric resection, overall iron intake is decreased, and the reduced acidity impairs absorption. Reduction in the parietal cell mass from gastric resection leads to a decrease in intrinsic factor, which is necessary for the enteric absorption of vitamin B<sub>12</sub>, occurring in the terminal ileum. This leads to a megaloblastic anemia. Furthermore, an acidic environment facilitates the bioavailability of vitamin B<sub>12</sub>. Vitamin B<sub>12</sub> deficiency usually only develops when at least one-half of the stomach is resected. Fat malabsorption can occur after gastrectomy (particularly with a Billroth II reconstruction) because of inadequate mixing of food with bile and digestive enzymes. This leads to a decreased absorption of fat-soluble vitamins. Calcium is absorbed in the duodenum and small bowel and is also facilitated by an acid environment. Long-term deficiencies manifest as osteoporosis. Folate deficiency is rare.
26. **E.** ZES (gastrinoma) is caused by uncontrolled secretion of gastrin by a pancreatic or a duodenal neuroendocrine tumor. Most cases are sporadic, but 20% are inherited (C). The inherited or familial form of gastrinoma is associated with multiple endocrine neoplasia type 1. Gastrinoma is the most common functional neuroendocrine tumor in multiple endocrine neoplasia type 1 but insulinoma is the most common overall (D). The most common symptoms are epigastric pain, gastroesophageal reflux, and diarrhea. The massive acid hypersecretion leads to a secretory diarrhea that persists even with fasting (A). The majority will have demonstrable peptic ulceration that is most commonly located in the proximal duodenum (B). Unlike typical ulcers, those associated with gastrinoma on occasion will be found in the distal duodenum or jejunum. Ulcers in these locations should raise suspicion for gastrinoma, as should recurrent or refractory peptic ulcers, ulcers in association with secretory diarrhea, finding gastric rugal hypertrophy or esophagitis-related stricture on endoscopy, bleeding or perforated ulcer, family history of ulcer, and ulcers in the setting of hypercalcemia or kidney stones. PPIs are highly effective in relieving the symptoms of ZES, although definitive treatment consists of localizing and resecting the tumor.
- Reference:** Meijer, J. L., Jansen, J. B., & Lamers, C. B. (1989). Omeprazole in the treatment of Zollinger-Ellison syndrome and histamine H<sub>2</sub>-antagonist refractory ulcers. *Digestion*, 44(Suppl. 1), 31–39.
27. **C.** The presentation of oral contrast extravasation in the proximal duodenum (or free air under the diaphragm) combined with anemia and guaiac-positive stool is highly suggestive of a “kissing” duodenal ulcer. This represents a rare combination of an anterior duodenal ulcer that perforates into the peritoneum and a posterior ulcer that erodes into the gastroduodenal artery and bleeds. The majority of perforated ulcers can be managed by simple ulcer closure with an omental (Graham) patch. This can be achieved via an open or laparoscopic approach. In this patient, one must rule out a bleeding posterior ulcer. This would best be achieved via an anterior duodenotomy across the pylorus. If a posterior ulcer is identified, it should be oversewn.
- References:** Dasmahapatra, K. S., Suval, W., & Machiedo, G. W. (1988). Unsuspected perforation in bleeding duodenal ulcers. *Annals of Surgery*, 54(1), 19–21.
- Hunt, P. S., & Clarke, G. (1991). Perforation in patients with bleeding ulcer. *Australia New Zealand Journal of Surgery*, 61(3), 183–185.

Stabile, B. E., Hardy, H. J., & Passaro, E., Jr. (1979). "Kissing" duodenal ulcers. *Archives of Surgery*, 114(10), 1153–1156.

28. **B.** Bezoars are accumulations of indigestible material in the stomach. Bezoars often produce nonspecific symptoms and are usually found incidentally in patients undergoing upper gastrointestinal endoscopy or imaging. There are two types. Phytobezoars are composed of undigested vegetable matter (as in this patient). Risk factors for phytobezoars include previous gastric surgery and gastroparesis such as from diabetes. Peptic ulcer disease is not a risk factor (E). Bezoars produce obstructive symptoms but can also cause ulceration and bleeding. Diagnosis is suggested by an upper GI series and confirmed by endoscopy. Treatment generally consists of a combination of enzymatic degradation, endoscopic disruption, irrigation, and removal. Enzyme therapy can be performed with papain (present in meat tenderizers) or with cellulase. However, the use of papain has been associated with hypernatremia, gastric ulceration, and esophageal perforation so that cellulase is preferred. More recently, nasogastric Coca-Cola lavage has been successfully used. The mechanism responsible is believed to be a combination of the mucolytic effect of sodium bicarbonate ( $\text{NaHCO}_3$ ) and digestion of the bezoar by  $\text{CO}_2$  bubbles, all of which is exaggerated by the cola's acidity. Trichobezoars are composed of hair. It occurs most commonly in girls and young women who swallow their hair (trichophagia). Interestingly, most have long hair with patchy areas of alopecia (D), and many have an underlying psychiatric disorder, so psychiatric care is important in prevention (unlike phytobezoars) (C). The hair creates a cast of the stomach and strands of hair can extend into the small bowel (the so-called Rapunzel syndrome). Large trichobezoars are likely to require surgical removal because they are less likely to respond to enzymatic degradation (A).

**References:** Bonilla, F., Mirete, J., Cuesta, A., et al. (1999). Treatment of gastric phytobezoars with cellulase. *Revista Espanola de Enfermedades Digestivas*, 91(12), 809–814.

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Walker-Renard, P. (1993). Update on the medicinal management of phytobezoars. *The American Journal of Gastroenterology*, 88(10), 1663–1666.

29. **E.** Surgical resection is the mainstay of treatment for gastric adenocarcinoma. Survival does not seem to be affected by whether a total or subtotal gastrectomy is performed, provided adequate margins are obtained. However, for patients with a proximal gastric cancer, performing a proximal gastrectomy has been shown to be associated with a higher complication rate than total gastrectomy (A). Thus, total gastrectomy is preferred for proximal cancers. For distal cancers, there does not seem to be a difference in outcome between a distal gastrectomy and a total gastrectomy, provided margins are adequate. Proximal margins should be at least 6 cm because the tumor tends to spread intramurally (C). When recurrence rates were compared in one study, those without recurrence had a median proximal margin of 6 cm versus 3.5 cm for those with a recurrence. The extent of lymph node dissection remains controversial. In Japan, a D2 resection (group 1 and 2 nodes as well as splenectomy and distal pancreatectomy) has been shown to improve survival compared with D1 (group 1 nodes only) (D). In Western countries, D2 resection has not been shown to improve survival and is associated with a higher morbidity rate and perioperative mortality rate. The poorer results with D2 resection in Western countries are likely a reflection of low case volume and the associated morbidity of performing the pancreaticosplenectomy (as such, routine splenectomy is not recommended) (B). For patients with advanced stage IV gastric cancer, total gastrectomy in select patients with symptoms of bleeding or obstruction can provide good palliation with relatively low morbidity and mortality rates.

**References:** Bozzetti, F., Bonfanti, G., Bufalino, R., et al. (1982). Adequacy of margins of resection in gastrectomy for cancer. *Annals of Surgery*, 196(6), 685–690.

Degiuli, M., Sasako, M., Ponti, A., et al. (2004). Survival results of a multicentre phase II study to evaluate D2 gastrectomy for gastric cancer. *British Journal of Cancer*, 90(9), 1727–1732.

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Monson, J., Donohue, J., McIlrath, D., et al. (1991). Total gastrectomy for advanced cancer. A worthwhile palliative procedure. *Cancer*, 68(9), 1863–1868.

Nazli, O., Yaman, I., Tansug, T., et al. (2007). Palliative surgery for advanced stage (stage IV) gastric adenocarcinoma. *Hepatogastroenterology*, 54(73), 298–303.

30. **D.** Gastric volvulus is associated with Borchardt's triad (sudden onset of severe upper abdominal pain, recurrent retching without vomitus, and an inability to pass a nasogastric tube). Bergman's triad (mental status changes, petechiae, and dyspnea) is seen with fat emboli syndrome (C). The volvulus can be either organoaxial (twisting around the axis between the gastroesophageal junction and pylorus), which is twice as common, or mesenteroaxial (twisting along the axis between the lesser and greater curvature) (A). Gastric volvulus most commonly occurs in association with a diaphragmatic defect. The stomach becomes trapped in the defect and twists. In children, the defect is congenital (such as a Bochdalek hernia), whereas in adults, it is more often traumatic or secondary to paraesophageal hernias (B). Gastric volvulus can also occur in the absence of a diaphragmatic defect. In such situations, there is typically a congenital absence of intraperitoneal visceral attachments. It is seen in association with a wandering spleen, a condition in which the spleen also lacks peritoneal attachments and is prone to torsion. Gastric volvulus is a surgical emergency because there is a high risk of gastric necrosis if it is unrecognized (E). On occasion, there is a delay in diagnosis because the nasogastric tube is successfully passed and subsequent imaging is negative. Management consists of detorsion and repair of the diaphragmatic defect. If a paraesophageal hernia is present, consideration is given to performing a fundoplication. If the stomach is compromised, a gastric resection may be needed. If a volvulus is found without necrosis and without a diaphragmatic defect, then detorsion and gastropexy are performed.

**References:** Carter, R., Brewer, L., 3rd, Hinshaw, D. (1980). Acute gastric volvulus. A study of 25 cases. *American Journal of Surgery*, 140(1), 99–106.

Uc, A. Kao, S. C., Sanders, K. D., et al. (1998). Gastric volvulus and wandering spleen. *The American Journal of Gastroenterology*, 93(7), 1146–1148.

Wasselle, J. A., & Norman, J. (1993). Acute gastric volvulus: pathogenesis, diagnosis, and treatment. *The American Journal Gastroenterology*, 88(10), 1780–1784.

31. **D.** A metastatic left supraclavicular lymph node is called the *Virchow node* (Troisier sign) (B). Intra-abdominal cancers tend to metastasize to the left secondary to lymph drainage into the left subclavian vein via the thoracic duct. A metastatic left axillary lymph node from gastric cancer is called an *Irish node* (A). A Blumer shelf is a palpable nodule on rectal examination suggesting a drop metastasis (E). An ovarian mass from a gastric metastasis is also known as Krukenberg tumor. (C) An umbilical nodule (Sister Mary Joseph node) suggests carcinomatosis. Although associated with gastric cancer, it may represent any metastatic lesion, most commonly from an intra-abdominal cancer. It was named after Dr. William Mayo's surgical assistant, who made the observation while scrubbing patients for gastric surgery that those with umbilical nodules had widely metastatic and unresectable gastric cancer. Current recommendations are that if such nodules are found on physical examination, the patient should undergo fine-needle aspiration because such umbilical nodules may sometimes represent benign disease.

**References:** Fleming, M., & Oertel, Y. (1993). Eight cases of Sister Mary Joseph's nodule diagnosed by fine-needle aspiration. *Diagnostic Cytopathology*, 9(1), 32–36.

Giner Galvañ, V. (1999) [Sister Mary Joseph's nodule. Its clinical significance and management] [in Spanish]. *Anales de Medicina Interna*, 16(7), 365–370.

32. **A.** Bleeding from duodenal ulcers can be controlled endoscopically in the majority of patients; thus surgery is rarely indicated. Predictors of failure of endoscopic management include the presence of shock or a large ulcer (>2 cm). Even when bleeding recurs after having been controlled endoscopically, endoscopic treatment can again be attempted with a high rate of success, thus avoiding surgery. The bleeding is usually from a posterior ulcer that has eroded into the gastroduodenal artery (remember anterior ulcers cause a free perforation and peritonitis, posterior ulcers penetrate and bleed). Surgical management decisions should be based on the hemodynamic stability of the patient, the patient's overall medical condition, and whether the patient has a history of ulcer disease that has been treated for *H. pylori*. In the patient who is actively bleeding, the duodenum should be opened across the pylorus as is used in a pyloroplasty. The ulcer bed should be oversewn with multiple figure-of-eight sutures. If the patient has a history of ulcers that have been treated for *H. pylori* and is stable in the operating room, an ulcer operation should be

performed. The best option in this type of emergent setting is to perform a truncal vagotomy and to close the longitudinal duodenotomy in a transverse fashion as with a pyloroplasty. If the patient is a high surgical risk and unstable, another option would be to simply perform a smaller duodenotomy, oversew the ulcer, simply close the duodenotomy, and treat postoperatively for *H. pylori* (B). Although vagotomy and antrectomy are another option, they would seldom be used in the emergent setting because of the higher associated morbidity rate (D, E). An HSV (C) would not address the actively bleeding ulcer.

**References:** Brullet, E., Calvet, X., Campo, R., et al. (1996). Factors predicting failure of endoscopic injection therapy in bleeding duodenal ulcer. *Gastrointestinal Endoscopy*, 43(2 Pt 1), 111–116.

Lau, J., Sung, J., Lam, Y., et al. (1999). Endoscopic retreatment compared with surgery in patients with recurrent bleeding after initial endoscopic control of bleeding ulcers. *The New England Journal of Medicine*, 340(10), 751–756.

33. **D.** Recurrent episodes of acute pancreatitis predispose patients to developing splenic vein thrombosis, which can result in isolated gastric varices. Historically, patients were offered a splenectomy as a prophylactic measure to prevent severe upper GI bleeding. However, with improved imaging we are better able to identify splenic vein thrombosis, and we now know that only 4% of patients will have clinically significant gastric variceal bleeding, so routine splenectomy has fallen out of favor. This patient also has a concomitant ulcer, which could have been contributing to hematemesis. The Forrest classification grades peptic ulcers based on endoscopic features and allows the clinician to determine risk of rebleeding. The risk decreases in the following order: active spurting bleeding (17–100%), active oozing bleeding (17–100%), nonbleeding visible vessel (0–81%), adherent clot (14–36%), flat pigment spot (0–13%), and clean visible ulcer base (0–10%) (A–C, E). Although patients with high-risk peptic ulcers (active bleeding/oozing, nonbleeding visible vessel) may benefit from a second-look endoscopy, current guidelines recommend against routine second-look endoscopy.

**References:** Forrest, J. A., Finlayson, N. D., & Shearman, D. J. (1974). Endoscopy in gastrointestinal bleeding. *Lancet*, 2(7877), 394–397.

Heider, T. R., Azeem, S., Galanko, J. A., et al. (2004). The natural history of pancreatitis-induced splenic vein thrombosis. *Annals of Surgery*, 239(6), 876–882.

Laine, L., & Jensen, D. M. (2012). Management of patients with ulcer bleeding. *The American Journal of Gastroenterology*, 107(3), 345–360.

34. **E.** Hyperplastic polyps are by far the most common gastric polyps (70–90%) (B). Other types include adenomatous, hamartomatous, inflammatory (pseudopolyps), fundic gland, and heterotopic. Hyperplastic polyps are seen in association with chronic atrophic gastritis, which is due to *H. pylori* infection (C). Hyperplastic polyps are further classified into polypoid foveolar hyperplasia and typical hyperplastic polyps. Polypoid foveolar hyperplasia does not seem to have malignant potential, whereas the typical hyperplastic polyp has an approximately 2% chance of developing malignancy. Adenomatous polyps have the highest risk of malignancy (10–20%), and the risk of malignancy seems to be related to size and histology (greater risk for villous than tubular) (A). Fundic gastric polyps are associated with long-term PPI use, and the risk of cancer is negligible. Additionally, hamartomatous, inflammatory, and heterotopic polyps do not seem to have a risk of malignancy. Heterotopic polyps are usually the result of ectopic pancreatic tissue and are typically benign lesions without clinical significance (D). However, large heterotopic polyps can lead to obstruction and intussusception. Treatment for most polyps is simply endoscopic polypectomy. Additional surgical resection is recommended for polyps that are sessile and larger than 2 cm, those with areas of invasive tumor, and those that cause symptoms (bleeding or pain).

**References:** Orłowska, J., Jarosz, D., Pachlewski, J., et al. (1995). Malignant transformation of benign epithelial gastric polyps. *The American Journal of Gastroenterology*, 90(12), 2152–2159.

Jalving, M., Koornstra, J. J., Wesseling, J., et al. (2006). Increased risk of fundic gland polyps during long-term proton pump inhibitor therapy. *Ailment Pharmacol Therapy*, 24(9), 1341–1348.

35. **D.** A Dieulafoy lesion is a congenital malformation in the stomach (typically on the lesser curvature) characterized by a submucosal artery that is abnormally large and tortuous. As a result of its relatively superficial location, it may erode through the mucosa and become exposed to gastric secretions, leading to massive upper GI hemorrhage. On endoscopy, the mucosa of the stomach appears normal, and the only finding is a pinpoint area of mucosal defect with brisk arterial bleeding. The lesion may easily be missed if the bleeding is not active. Dieulafoy lesion is

not premalignant (E) and is not associated with the ingestion of foreign material (C). Treatment is endoscopic, via electrocautery, heater probe, or injection with a sclerosing agent. Surgery, which consists of a wedge resection, is reserved for the rare patient who is not controlled endoscopically. Antral vascular ectasia (A) is seen in a condition known as watermelon stomach and can lead to significant acute or chronic GI blood loss. Dilated mucosal blood vessels containing thrombus, mucosal fibromuscular dysplasia, and hyalinization are prominent features. It derives its name from the mucosal vessels that create parallel lines in the mucosal folds (B). The stomach is typically not enlarged. It is seen predominantly in elderly women with autoimmune disease or elderly males with cirrhosis.

**Reference:** Selinger, C. P., & Ang, Y. S. (2008). Gastric antral vascular ectasia (GAVE): an update on clinical presentation, pathophysiology, and treatment. *Digestion*, 77(2), 131–137.

36. **A.** Low-grade MALT lymphoma develops most commonly in association with *H. pylori* infection. The infection induces a lymphoid infiltrate. B cells proliferate as a result of the immunogenic stimulation (D). The infection also results in the release of toxic oxygen-free radicals by neutrophils. It is thought that these free radicals may trigger a malignant transformation of the B cells. Initial treatment of MALT lymphoma is with triple-therapy (PPI and antibiotics) targeted toward *H. pylori*. Antibiotic treatment for *H. pylori* includes a combination of one of the following: clarithromycin and amoxicillin, metronidazole and amoxicillin, or metronidazole and tetracycline (C). Remission was achieved with triple therapy in 79% in one study. Most cases take 1 year to achieve remission but rarely, it can take up to 3 years (B). Lack of response or stable disease at 1 year is usually considered an indication for radiotherapy or chemotherapy (E). The current recommendations are to proceed to standard lymphoma chemotherapy using CHOP (cyclophosphamide, doxorubicin, vincristine, and prednisone) (A). Factors that predict whether regression will occur with antibiotics include depth of invasion by endoscopic ultrasonography (beyond the mucosa), high-grade lesions, spread beyond the initial location, and the presence of nodal involvement. The overall 5-year survival rate approaches 80%. MALT lymphomas that demonstrate the (11;18) translocation are unlikely to respond to *H. pylori* eradication and will require alternative therapies including surgery (C) and/or chemoradiation (B–E).

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37. **E.** The most sensitive and specific test for gastrinoma (ZES) is the secretin stimulation test. An IV bolus of secretin is administered, and gastrin levels are checked before and after injection. An increase in serum gastrin of 120 pg/mL or greater has the highest sensitivity and specificity for gastrinoma. There are numerous other causes of hypergastrinemia. They can be divided into those associated with an increased acid production and those with a decreased acid production (A). In the latter situation, the hypergastrinemia is reactive due to hypo- or achlorhydria. In addition to ZES, G-cell hyperplasia, gastric outlet obstruction, and retained antrum after Billroth II reconstruction are associated with increased acid production. Reactive hypergastrinemia is seen with atrophic gastritis, pernicious anemia, and gastric cancer; in patients receiving H<sub>2</sub>-receptor antagonists and PPIs; and after vagotomy. Hypergastrinemia is also seen in chronic renal failure due to decreased catabolism. Given this broad differential, fasting serum gastrin levels (C) are not sufficiently specific to establish the diagnosis of ZES in the majority of patients unless gastrin levels are extremely high (>1000 pg/mL). The secretin stimulation test has higher sensitivity and specificity than the calcium stimulation test (D). The calcium stimulation test is used if the secretin test result is negative and there is a high suspicion for ZES in the presence of hypergastrinemia. Once the diagnosis of ZES is established, a nuclear octreotide scan (B) seems to be the most sensitive test to localize the tumor.

**Reference:** Berna, M., Hoffmann, K., Long, S., et al. (2006). Serum gastrin in Zollinger-Ellison syndrome: II. Prospective study of gastrin provocative testing in 293 patients from the National

Institutes of Health and comparison with 537 cases from the literature: evaluation of diagnostic criteria, proposal of new criteria, and correlations with clinical and tumoral features. *Medicine (Baltimore)*, 85(6), 331–364.

38. **D.** An HSV is the procedure of choice for intractable duodenal ulcer in which medical management fails. In the current era of *H. pylori* treatment, surgery for intractable duodenal ulceration is rare. There are three main surgical options: HSV, vagotomy and pyloroplasty (A), and vagotomy and antrectomy (B, C). The use of vagotomy and antrectomy has the overall lowest rate of ulcer recurrence (<2%). However, because it involves a gastric resection, it has the highest complication rate. The procedure also predisposes the patient to both postvagotomy syndromes and postgastrectomy syndromes. As such, it is the least favored option in this setting. The use of vagotomy and pyloroplasty has a higher ulcer recurrence rate than vagotomy and antrectomy but less morbidity. An HSV has the highest ulcer recurrence rate (≈10–15%) but the lowest morbidity rate. It requires more time and skill, so it is not an optimal choice in an emergent setting. It also has the advantage that it can be performed laparoscopically. Distal gastrectomy (E) is not an option for duodenal ulcer because it does not reduce acid secretion.
39. **B.** Gastric ulcers have been categorized into five types. The most common is the type I lesion (≈60%) (A), which is located near the angularis incisura at the border between the antrum and the fundus, usually along the lesser curve. These patients usually have normal or decreased acid secretion. Type II gastric ulcers are located in the fundus and are associated with a concomitant duodenal ulcer. Type III gastric ulcers are prepyloric. Both types II and III gastric ulcers are usually associated with increased gastric acid secretion. Type III ulcers are thought to behave like duodenal ulcers. Type IV gastric ulcers are located near the gastroesophageal junction. Like type I ulcers, type IV gastric ulcers have normal or low acid production and are associated with impaired mucosal defense. Type V gastric ulcers are considered a diffuse process and are associated with NSAID use.
40. **D.** With gastric ulcers, one must always be concerned about the risk of malignancy. As such, biopsies should be performed at the time of endoscopy. If they do not heal despite maximal medical therapy, surgical management should include excision of the ulcer. In the case of a type I gastric ulcer, this is achieved via a distal antrectomy since these ulcers are located near the angularis incisura at the border between the antrum and the fundus. The extent of resection is determined by the ulcer location. Frozen sections should be obtained to rule out malignancy. Because acid hypersecretion is not an issue with type I ulcers, vagotomy is considered unnecessary (A, B). Reconstruction can be achieved with a gastroduodenostomy (Billroth I) or a gastrojejunostomy (Billroth II). In general, a Billroth I is preferred because it is more anatomic and thus avoids the complications of a Billroth II such as a duodenal stump leak, a retained antrum, and afferent loop obstruction (E). If the duodenal remnant is severely scarred from ulcer disease, a Billroth I may not be feasible. Another option for a type I ulcer would be to excise the gastric ulcer using a wedge excision in combination with an HSV, but an HSV alone would be inadequate (C). For type II or III ulcers, vagotomy would be added because these ulcers are associated with acid hypersecretion.
41. **E.** The etiology of gastroparesis is most commonly idiopathic. Diabetes is the next most common etiology. The first step in the management of gastroparesis is fluid hydration and nutritional support. Agents to prevent nausea and vomiting are also important. Long-term management begins with dietary modification. Symptoms can be controlled with eating six small, low-fat, low-fiber meals throughout the day, which slows down gastric emptying. This may require additional nutritional supplementation with high-caloric shakes. Proton pump inhibitors such as metoclopramide or erythromycin can be helpful as well but have additional side effects restricting their widespread use; metoclopramide can lead to tardive dyskinesia and has a black box warning for this (B). Botulinum toxin injection at the pylorus has not been shown to have effective results (C). Cisapride, a cholinergic agonist, has been banned in the United States secondary to its multiple drug interactions (A). Rarely, and in severe refractory cases of gastroparesis, a gastric cardiac pacemaker can be implanted, but this needs to be done at laparoscopy under general anesthesia and lead placement must be confirmed by intraoperative endoscopy. This, however, would not be appropriate for an elderly and frail patient (D).

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Camilleri, M., Parkman, H., Shafi, M., et al. (2013). Clinical guideline: management of gastroparesis. *The American Journal of Gastroenterology*, 108(1), 18–37.



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# Alimentary Tract—Small Bowel

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## Questions

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1. A 57-year-old male with no surgical history presents with 2 days of abdominal pain, nausea, and vomiting. On exam he is distended and tympanic and is mildly tender without rebound or guarding. Computed tomography (CT) scan demonstrates multiple dilated loops of small bowel with a transition point in the distal small bowel, with some adjacent mesenteric fat stranding. He has a mild leukocytosis. His last bowel movement was 1 day ago. He has not passed flatus for over a day. He has not had any similar symptoms previously. A nasogastric tube is placed, intravenous (IV) fluids are administered, and the patient is placed NPO (nothing by mouth). Which of the following is the best management option?
  - A. Admission, observation, steroids
  - B. Diagnostic laparoscopy
  - C. Exploratory laparotomy
  - D. Admission, observation
  - E. Admission, observation, IV antibiotics
2. Which of the following has been shown to be the most efficacious means of reducing postoperative ileus in patients undergoing bowel resection?
  - A. Early ambulation
  - B. Gum chewing
  - C. Alvimopan
  - D. Ketorolac combined with reduction in opioid use
  - E. Nasogastric intubation
3. Which of the following is true regarding Crohn disease?
  - A. It is more common in individuals of high socioeconomic status.
  - B. The most common indication for surgery is perforation.
  - C. It has a unimodal distribution.
  - D. It is more prevalent in females.
  - E. The most common initial presentation is an acute onset of abdominal pain and diarrhea.
4. The earliest lesion characteristic of Crohn disease is:
  - A. Aphthous ulcer
  - B. Caseating granuloma
  - C. Noncaseating granuloma
  - D. Cobblestone mucosa
  - E. Serosal thickening
5. Which of the following is the best therapeutic option for mild active Crohn disease?
  - A. Sulfasalazine
  - B. Prednisone
  - C. Budesonide

- D. Metronidazole
  - E. Infliximab
6. Which of the following is true regarding the principles of the operative management of the small bowel in Crohn disease?
    - A. The optimal margin is at least 4 cm beyond grossly visible disease.
    - B. Frozen section should be obtained to confirm the absence of active disease in at least one margin.
    - C. A 3-cm strictured segment of duodenum is best managed by resection.
    - D. A 10-cm strictured segment of jejunum can be managed by a Heineke-Mikulicz strictureplasty rather than by resection.
    - E. Strictures longer than 10 cm are best managed by resection.
  7. Which of the following is correct with regards to Crohn disease?
    - A. Mesenteric fat wrapping is considered pathognomonic.
    - B. Symptoms of ankylosing spondylitis improve with resection of diseased bowel.
    - C. The majority of patients with an initial presentation of terminal ileitis progress to Crohn disease on long-term follow-up.
    - D. Pathergy is a common finding.
    - E. Pyoderma gangrenosum is commonly found on the initial presentation of Crohn disease.
  8. Which intestinal cells have been implicated in the formation of gastrointestinal stromal tumors (GISTs)?
    - A. Goblet cells
    - B. Cajal cells
    - C. Enteroendocrine cells
    - D. Paneth cells
    - E. Absorptive enterocytes
  9. Which of the following is true regarding duodenal diverticula?
    - A. They tend to occur on the antimesenteric side of the bowel.
    - B. Most are identified in young patients.
    - C. Treatment with endoscopic interventions is contraindicated.
    - D. Malabsorption due to bacterial overgrowth within the diverticula mandates surgery.
    - E. When discovered incidentally at surgery, they should be left alone.
  10. The etiology responsible for the most common presentation of a Meckel diverticulum in children is:
    - A. Lead point
    - B. Ectopic gastric mucosa
    - C. Ectopic pancreatic mucosa
    - D. Bacterial infection
    - E. Adhesive band to the umbilicus
  11. Two weeks after an open aortic aneurysm repair, the patient presents with marked abdominal distention without nausea or vomiting. There is no tenderness on abdominal examination. Plain films are unremarkable. CT scan reveals a large amount of ascites but is otherwise unremarkable. Paracentesis reveals turbid fluid that is culture negative. Fluid analysis reveals a triglyceride level of 400 mg/dL. The white blood cell count is 600 cells/ $\mu$ L with a predominance of lymphocytes. Which of the following is true about this condition?
    - A. The patient should be placed on total parenteral nutrition (TPN) and NPO.
    - B. Octreotide is not useful.
    - C. The patient should immediately be re-explored.
    - D. Peritoneovenous shunting is highly successful.
    - E. Most patients respond to a high-protein, low-fat diet with medium-chain triglycerides.
  12. Which of the following is true regarding short bowel syndrome in adults?

- A. The presence of an intact ileocecal valve reduces malabsorption.
  - B. It is defined as less than 300 cm of residual small bowel.
  - C. Resection of the ileum is better tolerated than resection of the jejunum.
  - D. The presence of an intact colon does not alter the severity.
  - E. It is most commonly caused by multiple operations requiring small bowel resection.
13. Which of the following is true regarding the management of short bowel syndrome?
- A. Glutamine should be avoided.
  - B. Octreotide is the cornerstone of management.
  - C. Codeine is contraindicated.
  - D. Early enteral feeding is indicated.
  - E. Patients who still require TPN after 6 months will require permanent TPN.
14. A 6-year-old boy has short bowel syndrome caused by midgut volvulus that developed during infancy and has since been dependent on TPN, which he has tolerated well. He has approximately 28 cm of small bowel remaining with an intact colon. The small bowel is markedly dilated without evidence of small bowel obstruction. Which of the following is the best option?
- A. Serial transverse enteroplasty procedure
  - B. Continue with TPN
  - C. Small bowel transplantation
  - D. Small bowel tapering procedure
  - E. Tapering and lengthening procedure (Bianchi)
15. Which of the following is true regarding small bowel neoplasms?
- A. Adenocarcinoma is the most common type.
  - B. Small bowel lymphoma most commonly occurs in the duodenum.
  - C. The incidence of primary small intestinal cancers is increasing.
  - D. Five-year survival is higher for adenocarcinoma compared with carcinoid tumors.
  - E. Small bowel lymphoma is primarily treated by chemotherapy.
16. A 68-year-old woman presents with an exacerbation of congestive heart failure and acute abdominal pain. Physical examination of the abdomen is significant for mild diffuse abdominal tenderness but no rebound or guarding. CT arteriography of the abdomen demonstrates diffuse narrowing of the superior mesenteric artery (SMA) and its branches. Which of the following is an appropriate management option?
- A. IV heparin drip
  - B. Exploratory laparotomy
  - C. Aggressive fluid resuscitation
  - D. Intra-arterial papaverine
  - E. Thrombolytic therapy
17. Which of the following is true regarding carcinoid?
- A. The majority of carcinoid syndrome is from appendiceal tumors that have metastasized.
  - B. The most common symptom of carcinoid syndrome is diarrhea.
  - C. Chromogranin A will not be elevated in nonfunctioning tumors.
  - D. Patients are at an increased risk for glossitis.
  - E. Urinary 5-hydroxyindoleacetic acid (5-HIAA) is not sensitive for detecting metastatic carcinoid.
18. Which of the following is the best test for prognosis and for monitoring treatment response in carcinoid tumors?
- A. Platelet serotonin levels
  - B. A 24-hour urinary 5-HIAA test
  - C. Serum chromogranin A levels
  - D. Serum serotonin levels

- E. Neuron-specific enolase
19. Which of the following is true regarding small bowel obstruction?
- A. The most common worldwide etiology is adhesions from prior surgery.
  - B. It is more frequent with upper intestinal than lower intestinal surgery.
  - C. In a complete closed loop obstruction, serum lactate can be normal.
  - D. Partial obstruction symptoms typically improve within 24 hours with conservative management.
  - E. Abdominal pain disproportionate to exam findings occurs early in the setting of obstruction.
20. The most common cardiac valvular lesion associated with carcinoid syndrome is:
- A. Tricuspid stenosis
  - B. Tricuspid insufficiency
  - C. Pulmonary stenosis
  - D. Pulmonary insufficiency
  - E. Mitral stenosis
21. Which of the following is the most common cause of obscure GI bleeding in adults?
- A. Small intestine angiodysplasia
  - B. Meckel diverticulum
  - C. Crohn disease
  - D. Infectious enteritis
  - E. Vasculitis
22. Which of the following is true regarding GISTs of the small bowel?
- A. Most patients are symptomatic with GI bleeding.
  - B. They stain positive for CD134.
  - C. Patients deemed candidates for chemotherapy should receive it for 1 year.
  - D. A patient with a 6-cm tumor should receive adjuvant chemotherapy.
  - E. Malignancy is primarily determined by evidence of local invasion.
23. A hernia sac containing a Meckel diverticulum is known as:
- A. Petit hernia
  - B. Littre hernia
  - C. Spigelian hernia
  - D. Richter hernia
  - E. Grynfeltt hernia
24. The SMA (Wilkie) syndrome:
- A. Involves the second portion of the duodenum
  - B. Occurs when the SMA leaves the aorta at an upward angle
  - C. Is best diagnosed with arteriography
  - D. Should initially be managed with a high caloric intake
  - E. Is best managed by gastrojejunostomy
25. A 45-year-old woman with a history of laparotomy and 5000 cGy of abdominal and pelvic irradiation for ovarian cancer 10 years ago presents with symptoms and signs of an acute bowel obstruction. CT scan shows a complete small bowel obstruction at the level of the mid jejunum with no evidence of any masses. Which of the following is true about this condition?
- A. If a stricture is present, it is best managed by strictureplasty.
  - B. Steroids should be administered.
  - C. Acute radiation enteritis is due to an obliterative arteritis.
  - D. The risk of this complication increases in the setting of diabetes.
  - E. The degree of radiation damage is not affected by whether the patient received chemotherapy.
26. A 75-year-old male with a history of chronic obstructive pulmonary disease (COPD) presents to the

- ED with a 1-day history of abdominal distention and nausea. He denies abdominal pain. Abdominal examination is benign. Laboratory values are normal. CT scan demonstrates free air under the diaphragm and thin walled, air-filled cysts within the bowel wall. Which of the following is true regarding this condition?
- A. Laparotomy is indicated.
  - B. The primary form occurs more commonly than the secondary form.
  - C. It is unlikely to be related to the patient's COPD.
  - D. It is most commonly seen in the ileum.
  - E. It is associated with steroid use.
27. Which of the following is true regarding Peutz-Jeghers syndrome?
- A. Patients should begin breast and cervical cancer screening at age 25.
  - B. It is autosomal recessive.
  - C. Small bowel obstruction is uncommon.
  - D. Prophylactic colectomy is recommended to most patients starting at age 20.
  - E. These patients are not at an increased risk for small bowel cancer.
28. A 12-year-old boy presents with a large amount of bright red blood per rectum, combined with melena. He is hemodynamically stable. Subsequent workup includes lower and upper endoscopies, both of which are negative. A technetium-99m pertechnetate nuclear scan is performed, and it lights up in the bowel in the right lower quadrant region. Further management consists of:
- A. Arteriography
  - B. Meckel diverticulectomy
  - C. Small bowel follow-through
  - D. Segmental resection of ileum to include the Meckel diverticulum
  - E. CT scan of the abdomen with oral contrast
29. A 5-year-old boy presents with symptoms and signs of acute appendicitis. He undergoes an open appendectomy. At surgery, the appendix is acutely inflamed but not perforated. A Meckel diverticulum is incidentally discovered. In addition to performing an appendectomy, further management consists of:
- A. Observation
  - B. Meckel diverticulectomy
  - C. Meckel diverticulectomy only if ectopic mucosa is palpated in the diverticulum
  - D. Meckel diverticulectomy only if an adhesive band to the umbilicus is present
  - E. Meckel diverticulectomy only if previous signs of inflammation are present
30. A 46-year-old woman is about to undergo hepatic resection for a metastatic carcinoid tumor. During anesthesia induction, her blood pressure decreases to 80 mm Hg systolic and her heart rate increases to 110 beats per minute. Her entire body appears flushed. Her temperature is normal as is end-tidal CO<sub>2</sub>. Management consists of:
- A. Corticosteroids
  - B. Antihistamine
  - C. Octreotide
  - D. Abort operation
  - E. Dantrolene
31. A 70-year-old woman presents with vague abdominal pain, diarrhea, steatorrhea, and anemia with an elevated mean corpuscular volume. Her medical and surgical history is unremarkable. A CT scan of the abdomen and pelvis is negative. An upper GI series and small bowel follow-through are significant only for a large jejunal diverticulum. Which of the following is true regarding this patient?
- A. It is typically caused by an autoimmune etiology.
  - B. A long-chain triglyceride diet may be helpful.
  - C. The diverticulum should be resected.

- D. Broad-spectrum antibiotics are indicated only if the patient presents with a fever and leukocytosis.
- E. Vitamin B<sub>12</sub> is indicated.

## Answers

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1. **C.** A small bowel obstruction (SBO), in the absence of prior surgery, most often requires surgery. The differential includes an incarcerated inguinal hernia (which is not evident in this patient), appendicitis (most likely cause), intussusception, inflammatory bowel disease, malignancy, and obstructed Meckel diverticulum. Exploratory laparotomy would be needed to gain additional information. The role for diagnostic laparoscopy in the presence of mesenteric fat stranding, leukocytosis, and possible malignancy remains controversial (B). Conservative management has a high likelihood of failing (D, E). Steroids are not indicated for SBO (A).
2. **C.** Postoperative ileus remains a major source of prolonged hospitalization in patients undergoing abdominal surgery. The use of early ambulation, early postoperative feeding protocols, and routine nasogastric intubation has not been shown to be associated with earlier resolution of postoperative ileus (A, E). Reducing opioid use in combination with the use of nonsteroidal antiinflammatory drugs such as ketorolac has been shown to reduce the duration of ileus in most studies. The mechanism may be a combination of the reduction in opioids and the antiinflammatory properties of ketorolac. However, ketorolac has been associated with an increased risk of operative site and gastrointestinal (GI) bleeding as well as fluid retention (D). Recently, ketorolac has been also shown to increase the risk of readmission and reinterventions after GI surgery. Another drug that has been investigated is erythromycin, which is useful for gastroparesis because it works by its agonistic effect on the motilin receptor. However, it does not seem to be useful for ileus and should be avoided in cases of obstruction, as would all promotility agents (B). Metoclopramide is a dopaminergic antagonist with antiemetic and prokinetic properties, but it has also not been shown to be useful for ileus. Gum chewing has had conflicting results in the literature, but a recent randomized controlled trial from New Zealand demonstrated a significant reduction in postoperative ileus in patients with colorectal cancer undergoing bowel resection (27% vs 48%). The most efficacious agent, however, is entereg (Alvimopan), which has been demonstrated in randomized studies to improve postoperative ileus in patients undergoing bowel resection. Alvimopan is an opioid receptor antagonist. It binds  $\mu$ -opioid receptors in the GI tract and selectively inhibits the opioid effects on GI function and motility while not affecting opioid analgesia. It is the first U.S. Food and Drug Administration–approved drug for postoperative ileus. It is approved for short-term (maximum 15 doses over 5 days) in-hospital use only. Patients that are on long-term narcotics (e.g., chronic pain) should not use Alvimopan because this population has an increased risk of myocardial infarction.

**References:** Ludwig, K., Enker, W., Delaney, C., et al. (2008). Gastrointestinal tract recovery in patients undergoing bowel resection: results of a randomized trial of alvimopan and placebo with a standardized accelerated postoperative care pathway. *Archives of Surgery*, 143(11), 1098–1105.

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3. **A.** Crohn disease is the most common primary surgical disease of the small bowel. Acute onset of abdominal pain and diarrhea is not the most common presentation for Crohn disease; the majority of patients first present with an insidious onset of vague abdominal discomfort (E). It has a bimodal distribution, with one large peak in the second and third decades of life and a second smaller peak in the sixth decade (C). Several risk factors for Crohn disease have been identified, including living in northern latitudes, Ashkenazi Jewish descent, smoking, and a familial inheritance. The relative risk among first-degree relatives of patients with Crohn disease is as high as 14 to 15 times greater than in the general population. It is also more common in urban areas and in patients with a high socioeconomic status. Most studies suggest that Crohn disease is

approximately of equal prevalence in females and males (D). Breastfeeding may also be protective against the development of Crohn disease. Although medical management is the first-line treatment for Crohn disease, about 75% of patients will ultimately need surgery. The most common reasons for surgery include fistula, abscess, and obstruction; perforation is quite rare (B).

**References:** Passier, J., Srivastava, N., & van Puijenbroek, E. (2006). Isotretinoin-induced inflammatory bowel disease. *The Netherlands Journal of Medicine*, 64(2), 52–54.

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4. **A.** In the early stages of Crohn disease, patients demonstrate small superficial ulcers in the mucosa known as aphthous ulcers. These superficial ulcers are often surrounded by a halo of erythema. The ulcers form as a result of submucosal lymphoid follicle expansion. As the disease progresses, the ulcers coalesce to form larger ulcers, which are stellate shaped, as well as deep linear ulcers. Further coalescence of the ulcers leads to a cobblestone appearance (D), which is a hallmark of Crohn disease. Other hallmarks of Crohn disease include noncaseating granulomas (C), transmural inflammation, serosal thickening (E), and “skip lesions,” meaning that the areas of intestinal inflammation are discontinuous. The noncaseating granulomas are found in both areas of active disease, and grossly normal-appearing intestine is seen in all layers of the bowel wall and in mesenteric lymph nodes (B). Because the inflammation is transmural, inflamed loops of bowel become adhered to one another, leading to fibrosis, stricture formation, intra-abdominal abscess, fistulas, and, rarely, free perforation.

**Reference:** Levine, M. S. (1987). Crohn's disease of the upper gastrointestinal tract. *Radiologic Clinics of North America*, 25(5), 79–91.

5. **A.** Numerous pharmacologic agents are used to treat Crohn disease. Treatment options should be divided into those used for maintenance therapy for mild active disease, those used to treat an acute exacerbation, and drugs for maintaining remission. In patients with mild active disease, the most commonly used drug is sulfasalazine, an aminosalicylate that acts as an antiinflammatory agent. This is particularly useful in patients with colitis and ileocolitis. Mesalamine is another antiinflammatory agent in the same family as sulfasalazine. It seems to have fewer side effects owing to the fact that it is activated by colonic bacteria, thus limiting its action to the colon. For acute flare-ups, the treatment of choice remains corticosteroids and, in particular, prednisone. Prednisone is highly effective in inducing remission (in approximately three-fourths of patients); however, due to the side effects of long-term use, it is not recommended for long-term prevention of remission (B). Budesonide (C), a synthetic glucocorticoid, is another option. It has an advantage over prednisone in that it has a markedly reduced systemic absorption and thus fewer long-term side effects. Nevertheless, it can also suppress the adrenal gland. If corticosteroids are ineffective in inducing remission, the next step would be to administer infliximab (E), a monoclonal antibody that targets tumor necrosis factor-alpha. Care must be used in administering infliximab. Because it targets tumor necrosis factor-alpha, a cytokine that regulates inflammatory reactions, patients who receive infliximab are at increased risk of acquiring opportunistic infections such as tuberculosis and aspergillosis. It is also associated with activation of latent multiple sclerosis, demyelinating central nervous system disorders, and worsening congestive heart failure. Infliximab has also been shown to be effective in healing complex fistulas associated with Crohn disease. Rarely, it has been associated with T-cell lymphoma and almost exclusively in young teenage males. Antibiotics have an adjunctive role in the treatment of infectious complications associated with Crohn disease (D). They are used to treat patients with perianal disease, enterocutaneous fistulas, and active colon disease and aid in situations in which bacterial overgrowth has occurred. Once remission had been achieved after an acute flare-up, it is important to maintain remission. Although corticosteroids would theoretically be useful, the side effects preclude long-term administration. Infliximab is used to maintain remission, as are azathioprine and 6-mercaptopurine. These latter drugs act by inhibiting DNA synthesis and thus suppressing the function of T cells and natural killer cells. A second-line agent for maintenance of remission is methotrexate.
6. **D.** Approximately three-fourths of patients with Crohn disease will eventually require surgery. Indications for surgery include failure of medical management, intestinal obstruction, fistula, abscess, bleeding, and perforation. In children, growth retardation is another indication. Because patients with Crohn disease will often require repeat operations, it is important to avoid unnecessary resection of small bowel because this puts the patient at risk of short bowel



syndrome. As such, several principles of surgical management should be followed. Surgical resection should be limited to the segment of bowel that is causing the complication. Other areas of active disease should be left alone provided they are not causing obvious complications. Resection margins of 2 cm beyond grossly visible disease are recommended (A). Resection margins have not been shown to affect recurrence. The presence of microscopic disease in the resection margin also does not adversely affect outcome or recurrence. Thus, frozen section is unnecessary (B). When the indication for surgery is SBO, strictureplasty has been shown to be equally effective as resection for jejunal and ileal disease while sparing bowel length. Two types of strictureplasty are recommended: the Heineke-Mikulicz pyloroplasty (for strictures <12 cm in length) and the Finney pyloroplasty (for strictures ≤25 cm in length) (E). A potential drawback of these techniques is that they may potentially leave an undetected malignancy behind. Thus, during the course of a strictureplasty, biopsy specimens of any intraluminal ulcerations should be taken. Duodenal Crohn disease is much less common, and thus guidelines are less clear. However, current recommendations are to perform a bypass of duodenal strictures, such as with a gastrojejunostomy and duodenojejunostomy, depending on the location. Duodenal resection is not recommended (C). Duodenal strictureplasty has been rarely reported. For colon disease, resection is recommended, again limiting resection to the diseased segment causing symptoms. In a meta-analysis, 90% of recurrences occurred at nonstrictureplasty sites.

**References:** Fazio, V., Marchetti, F., Church, M., et al. (1996). Effect of resection margins on the recurrence of Crohn's disease in the small bowel: a randomized controlled trial. *Annals of Surgery*, 224(4), 563–571.

Tichansky D., Cagir, B., Yoo, E., et al. (2001). Strictureplasty for Crohn's disease: meta-analysis. *Diseases of the Colon and Rectum*, 43(7), 911–919, 2001.

Yamamoto, T., Fazio, V., & Tekkis, P. (2007). Safety and efficacy of strictureplasty for Crohn's disease: a systematic review and meta-analysis. *Diseases of the Colon and Rectum*, 50(11), 1968–1986.

7. **A.** The finding of “creeping fat” or mesenteric fat wrapping is a gross feature of Crohn disease that is considered pathognomonic. It indicates the encroachment of mesenteric fat onto the serosal surface of the bowel. The presence of fat wrapping correlates well with the presence of underlying acute and chronic inflammation. A recent study suggests that adiponectin, an adipocyte-specific protein with antiinflammatory properties found in mesenteric adipose tissue, may play an important role in the inflammation seen in Crohn disease. Terminal ileitis refers to any acute inflammation of the distal ileum adjacent to the ileocecal valve and is therefore not pathognomonic. Terminal ileitis is associated with numerous infectious causes including *Yersinia enterocolitica* and pseudotuberculosis, *Mycobacterium*, cytomegalovirus (in acquired immunodeficiency syndrome), *Salmonella*, *Campylobacter*, and *Shigella*, among others. The finding of terminal ileitis does not warrant bowel resection. Overall, a minority of patients (10% in one study) who present with terminal ileitis progress to Crohn disease on long-term follow-up (C). The majority of extraintestinal manifestations in inflammatory bowel disease improve with bowel resection but ankylosing spondylitis and primary sclerosing cholangitis do not (B). Pyoderma gangrenosum is rarely the initial presentation of Crohn disease (E). These patients present with small papules often on the lower extremities that resemble a “cat's paw” appearance and can progress to larger ulcerations with necrotic centers. Rarely, patients develop pathergy, a condition in which minor trauma leads to the development of large and difficult to heal ulcers (D). Debridement of these lesions should be avoided because this worsens the lesion. Infliximab or another tumor necrosis factor-alpha inhibitor should be used.

**References:** Menachem, Y., & Gotsman, I. (2004). Clinical manifestations of pyoderma gangrenosum associated with inflammatory bowel disease. *The Israel Medical Association Journal*, 6(2), 88–90.

Yamamoto, K., Kiyohara, T., Murayama, Y., et al. (2005). Production of adiponectin, an anti-inflammatory protein, in mesenteric adipose tissue in Crohn's disease, *Gut*, 54(6), 789–796.

Hatemi, I., Hatemi, G., Celik, A. F., et al. (2008). Frequency of pathergy phenomenon and other features of Behçet's syndrome among patients with inflammatory bowel disease. *Clinical and Experimental Rheumatology*, 26(4), S91–S95.

8. **B.** There are four main cell types in the small intestine: absorptive enterocytes (E), which make up 95% of intestinal cells; goblet cells (A); Paneth cells (D); and enteroendocrine cells (C). Goblet cells secrete mucus. Paneth cells secrete several substances including lysozyme, tumor necrosis factor,

and cryptidins, which assist in host mucosal defense. There are more than 10 distinct types of enteroendocrine cells that secrete various gut hormones. The interstitial Cajal cell is a specialized cell of mesodermal origin that seems to regulate peristalsis. It is referred to as an intestinal pacemaker cell. The cells normally express KIT, a tyrosine kinase receptor. These cells have been implicated as the cells of origin of GISTs.

**References:** Miettinen, M., Majidi, M., & Lasota, J. (2002). Pathology and diagnostic criteria of gastrointestinal stromal tumors (GISTs): a review. *European Journal of Cancer*, 38(Suppl. 5), S39–S51.

Sircar, K., Hewlett, B., Huizinga, J., et al. (1999). Interstitial cells of Cajal as precursors of gastrointestinal stromal tumors. *The American Journal of Surgical Pathology*, 23(4), 377–389.

9. **E.** Acquired diverticula consist of mucosa and submucosa but lack a complete muscularis and thus are considered false diverticula. They are most commonly located in the second portion of the duodenum near the ampulla of Vater and are referred to as perampullary diverticula. They arise on the mesenteric border in areas of weakness in the bowel wall where blood vessels penetrate (A). Perampullary diverticula are associated with cholangitis, pancreatitis, and sphincter of Oddi dysfunction. Duodenal diverticula are also associated with choledocholithiasis. These latter complications are thought to be due to the location of the perampullary diverticulum, which may lead to obstruction and stasis of the common duct. The majority of patients presenting with biliary complications who are discovered to have a duodenal diverticulum can be safely treated endoscopically (C). If this is not successful, surgical diverticulectomy is recommended. Care must be taken during diverticulectomy to identify and preserve the sphincter, which may require cannulation of the common bile duct. These false diverticula are also found in the jejunum and ileum. They are distinguished from a Meckel diverticulum, which is a true diverticulum present at birth. Duodenal diverticula are most often discovered between ages 56 to 76 years during upper endoscopy, endoscopic retrograde cholangiopancreatography, or abdominal imaging in as many as 6% of patients (B). They are asymptomatic in the majority of patients, and thus surgery is not recommended if they are discovered incidentally either on imaging or intraoperatively. Complications are estimated to occur in 6% to 10% of patients. They may cause symptoms of malabsorption due to bacterial overgrowth within the diverticula. This can be treated with antibiotics (D). Less commonly, bleeding can arise within the diverticulum, or diverticulitis can develop leading to perforation, which usually occurs into the retroperitoneum. Perforation requires laparotomy, and closure of the duodenal defect can be challenging and may require placing a loop of jejunum over the defect as a serosal patch.

**References:** Kennedy, R. H., & Thompson, M. H. (1988). Are duodenal diverticula associated with choledocholithiasis? *Gut*, 29(7), 100–1006.

Tham, T. C., & Kelly, M. (2004). Association of perampullary duodenal diverticula with bile duct stones and with technical success of endoscopic retrograde cholangiopancreatography. *Endoscopy*, 36(12), 1050–1053.

Vaira, D., Dowsett, J. F., Hatfield, A. R., et al. (1989). Is duodenal diverticulum a risk factor for sphincterotomy? *Gut*, 30(7), 939–942.

10. **B.** Bleeding is the most common presentation of a Meckel diverticulum in children and is in fact the most common cause of lower GI bleeding in children. The bleeding can present as either melena or bright red blood per rectum and is due to heterotopic gastric mucosa within the Meckel diverticulum, leading to acid production and an ulcer forming in the ileum adjacent to the diverticulum. Less commonly, ectopic pancreatic mucosa can also contribute to GI bleeding (C). A Meckel diverticulum is a true diverticulum that is due to a failure of closure of the vitelline (omphalomesenteric) duct. An adhesive band may remain between the Meckel diverticulum and the umbilicus, leading to adhesive small bowel obstruction or volvulus (E). In fact, intestinal obstruction is the most common presentation in adults. Bowel obstruction can also occur due to intussusception with the Meckel diverticulum as the lead point (A) or due to incarceration of the diverticulum into a hernia sac (Littre hernia). Due to the smaller potential space of a Meckel diverticulum in a child, bacterial infection leading to diverticulitis is rarely encountered (D).
11. **E.** The patient has chylous ascites. In Western countries, chylous ascites is most often due to malignancy and cirrhosis, whereas in Eastern and developing countries, infectious etiologies predominate, such as tuberculosis and filariasis. Other causes include post-laparotomy inflammatory disorders, trauma, radiation therapy, congenital lymphatic abnormalities, and pancreatitis. The operations most associated with this complication include aortic aneurysm repair,

retroperitoneal lymph node dissection, inferior vena cava surgery, and liver transplantation because these are operations where retroperitoneal lymphatics are most likely to be interrupted. The mechanisms thought to lead to the development of chylous ascites include exudation of chyle due to obstruction of the cisterna chyli, direct leakage of chyle through a lymphoperitoneal fistula, and exudation through dilated retroperitoneal vessels. The diagnosis of chylous ascites is best established by analysis of the fluid. Chyle typically has a turbid appearance; however, it may be clear in fasting patients. Elevated triglyceride levels in the fluid are considered diagnostic, usually above 200 mg/dL, although some use a threshold above 110 mg/dL. In addition, the white blood cell count is greater than 500, with a predominance of lymphocytes. The total protein level is between 2.5 and 7.0 g/dL. Cultures are negative, except for cases of tuberculosis, in which adenosine deaminase is also positive in the fluid. The initial treatment of chylous ascites is to administer a high-protein, low-fat diet with medium-chain triglycerides. This diet minimizes chyle production and flow. Medium-chain triglycerides are absorbed by the intestinal epithelium and are transported to the liver through the portal vein and do not contribute to chylomicron formation. Conversely, long-chain triglycerides are converted to monoglycerides and free fatty acids, which are then transported to the intestinal lymph vessels as chylomicrons. If this diet regimen fails, placing the patient NPO and on TPN with octreotide has been shown to be useful in patients with postoperative chylous ascites (A, B). If these medical approaches fail, then lymphoscintigraphy is often useful to localize lymph leaks and the site of obstruction. Surgical re-exploration with localization and closure of the lymphatic leak should be performed (C). Peritoneovenous shunting has a poor success rate due to a high rate of occlusion, made worse by the viscous chyle, and a high rate of other complications including sepsis and the induction of disseminated intravascular coagulation (D). This latter complication may be due to a high plasminogen concentration in the ascitic fluid.

**Reference:** Cárdenas, A., & Chopra, S. (2002). Chylous ascites. *The American Journal of Gastroenterology*, 97(8), 1896–1900.

12. **A.** The total length of small bowel is approximately 20 feet (each foot is equal to  $\approx 30$  cm), or approximately 600 cm (6 m). Short bowel syndrome is defined as the presence of less than 180 cm of residual and functional small bowel in adult patients (B). Thus, resection of less than 50% of the small intestine is generally well tolerated. In approximately 75% of cases, short bowel syndrome results from one massive small bowel resection, as opposed to multiple sequential resections (E). In adults, the most common etiologies include acute mesenteric ischemia, malignancy, and Crohn disease. In pediatric patients, the most common etiologies include intestinal atresia, midgut volvulus, and necrotizing enterocolitis. Resection of the jejunum is better tolerated than resection of the ileum because the absorption of bile salts and vitamin B<sub>12</sub> occurs in the ileum (C). An intact ileocecal valve is thought to reduce malabsorption because it increases the residence time of the chyme in the small intestine. Likewise, an intact colon is important because it has a tremendous water-reabsorbing capacity as well as electrolytes and can also absorb fatty acids (D). With an intact colon, a shorter small bowel remnant is tolerated. The key to avoiding short bowel syndrome is avoidance of excessive small bowel resection. In Crohn patients, the use of strictureplasty as opposed to resection when possible is recommended, and in acute mesenteric ischemia, one should resect only obviously dead bowel, leaving marginal bowel in situ and performing a second-look procedure.
13. **D.** In the early phase of short bowel syndrome, treatment is directed at slowing intestinal transit; reducing GI secretions; and maintaining nutrition, fluid, and electrolyte balance. Transit time is slowed by the administration of narcotics such as codeine and diphenoxylate, as well as with the ant motility agents Lomotil (diphenoxylate and atropine) and loperamide (C). Massive small bowel resection is associated with hypergastrinemia and acid hypersecretion. The increased acidity in the small bowel results in the inhibition of digestive enzymes. This can be controlled with H<sub>2</sub>-receptor antagonists or proton pump inhibitors such as omeprazole and thus should be started in all patients with short gut syndrome (B). Nutrition is achieved with the institution of TPN. In addition, enteral feeding should be instituted as soon as postoperative ileus has resolved. Enteral feeding assists in the process of intestinal adaptation and prevents the development of villous atrophy associated with being NPO for a prolonged period of time. Glutamine is helpful because it serves as a trophic factor for the gut and is considered the principal fuel of the small intestine (A). Cholestyramine is also useful in controlling diarrhea due to unabsorbed bile salts. The role of octreotide is controversial. Short-term use leads to a reduction in diarrhea, but long-term use may

lead to steatorrhea, gallstones, and an inhibition of intestinal adaptation. More recently, a high-carbohydrate, low-fat enteral diet rich in glutamine combined with growth hormone administration has shown promise in improving intestinal absorptive capacity. Intestinal adaptation occurs over a period of 1 to 2 years in most adults. Thus, the final determination of whether permanent TPN will be necessary is not determined until after this period (E).

14. **A.** Many patients with short bowel syndrome can eventually discontinue TPN, particularly if the bowel length is more than 120 cm in adults and more than 60 cm in children. Treatment options for short bowel syndrome depend on the length of small bowel remaining, whether the remnant small bowel is markedly dilated, whether the patient remains TPN dependent, and whether multiple complications of TPN have developed such as catheter-related infections, vena cava thrombosis, and liver damage (B). A short remnant (<90 cm in adults, <30 cm in children) of small bowel poses a challenging dilemma. If the remnant of small bowel is short and markedly dilated without evidence of obstruction, the best option would be an intestinal lengthening procedure. The dilated bowel lends itself to lengthening by applying a series of transverse linear staples on the mesenteric border and then on the antimesenteric border. The procedure is known as the serial transverse enteroplasty procedure. The Bianchi procedure is another option. However, it is technically much more demanding and associated with a risk of creating ischemia and anastomotic leaks and thus has a higher complication rate and an increased need for reoperation (E). Tapering of the small bowel alone would be indicated for patients with a longer small bowel remnant (>60 cm in children) who have marked bowel distention with evidence of stasis and bacterial overgrowth (D). Tapering alone would not be appropriate in someone with such a short segment of small bowel. Small bowel transplantation is also an option but is reserved for the patient with a short segment and who is TPN dependent (such as this patient) in whom, in addition, complications have developed from the TPN, as mentioned (C). If liver failure has developed in the patient, small bowel transplantation can be combined with liver transplantation.

**References:** Kim, H., Lee, P., Garza, J., et al. (2003). Serial transverse enteroplasty for short bowel syndrome: a case report. *Journal of Pediatric Surgery*, 38(6), 881–885.

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15. **C.** Malignant tumors of the small bowel are rare. However, the incidence has nearly doubled since the 1970s. The most common tumor is carcinoid (37.4%), followed by adenocarcinoma (36.9%), lymphoma (17%), and GISTs (8%) (A). Small bowel lymphomas most commonly involve the ileum (as do carcinoids), whereas adenocarcinomas are most common in the duodenum (periampullary), and GISTs are evenly distributed throughout the small bowel (although most common in the stomach) (B). Small bowel lymphomas are predominantly the non-Hodgkin type. In children younger than age 10, they are the most common intestinal neoplasm. The propensity for involvement of the ileum is due to its high concentration of lymphoid tissue (C). The primary treatment of small bowel lymphoma (as well as all other small bowel malignancies) is surgical resection including the affected mesentery (E). There is no clear, well-defined role for radiation therapy or chemotherapy for the majority of small bowel malignancies. The exception is the use of Gleevec (imatinib mesylate) for GISTs. The 5-year survival is higher for carcinoid compared with adenocarcinoma (64.6% vs 32.5%) (D).

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16. **D.** The presentation is most consistent with nonocclusive mesenteric ischemia, which accounts for approximately 20% to 30% of cases of acute mesenteric ischemia. This condition typically affects elderly patients and presents in the setting of a decrease in cardiac output, such as after an acute myocardial infarction, exacerbation of congestive heart failure, or after cardiac surgery. There are no laboratory tests to establish the diagnosis of bowel ischemia with certainty, although the presence of lactic acidosis is considered ominous. The initial diagnostic test of choice for suspected acute mesenteric ischemia is CT angiography. It is helpful in identifying the etiology, which includes an embolus that would be visualized as an occlusion just distal to the origin of the SMA;

acute thrombosis of the SMA which would appear as an occlusion in association with diffuse calcifications within the vessel; mesenteric venous thrombosis, which would demonstrate a lack of contrast filling of either the portal or superior mesenteric vein; and nonocclusive mesenteric ischemia, which would simply show diffuse spasm. The standard treatment for SMA embolus is operative embolectomy, although there are some reports of the use of thrombolytic therapy (E). The treatment for acute thrombosis is surgical bypass from either the aorta or the iliac artery to the more distal SMA. For mesenteric venous thrombosis, the treatment is heparin alone, provided there is no suggestion of infarcted bowel (A). For nonocclusive mesenteric ischemia, the goal of treatment is to restore intestinal blood flow, which is most successfully done by correcting the underlying cause to help improve cardiac output. In addition to supportive care, selective intra-arterial infusion of a vasodilator such as papaverine hydrochloride into the SMA to reverse splanchnic vasoconstriction can be helpful. Aggressive fluid resuscitation should be used with caution as nonocclusive mesenteric ischemia often occurs in the setting of decompensated congestive heart failure (as in the above patient), which may worsen with multiple fluid boluses (C). If signs of peritonitis develop or are present, emergent laparotomy should be performed and the infarcted intestine should be resected (B). The mortality rate for nonocclusive mesenteric ischemia is approximately 50%.

**References:** Bassiouny, H. S. (1997). Nonocclusive mesenteric ischemia. *The Surgical Clinics of North America*, 77(2), 319–326.

Kozuch, P., & Brandt, L. (2005). Review article: diagnosis and management of mesenteric ischemia with an emphasis on pharmacotherapy. *Alimentary Pharmacology & Therapeutics*, 21(3), 201–215.

Trompeter, M., Brazda, T., Remy, C., et al. (2002). Non-occlusive mesenteric ischemia: etiology, diagnosis, and interventional therapy. *European Radiology*, 12(5), 1179–1187.

17. **D.** While it was long believed that the appendix was the most common source of carcinoid tumor, a large SEER database study found that the small intestine accounted for 55% of cases, followed by the rectum (20%) and then appendix (17%) (A). Carcinoid syndrome most commonly presents with flushing, followed by diarrhea and bronchospasms (B). Most gut carcinoid tumors do not cause the syndrome because vasoactive substances (serotonin, histamine, dopamine, substance P, prostaglandins) from these tumors enter the portal vein and are metabolized by the liver before reaching the systemic circulation. For carcinoid syndrome to develop, these substances need to be released directly into the systemic circulation. Thus, the syndrome develops in the setting of bronchial carcinoids (which do not drain into the liver), retroperitoneal invasion (where retroperitoneal veins drain directly into the systemic circulation), or in the presence of liver metastasis. A 24-hour urinary 5-HIAA test is highly sensitive and specific for detecting metastatic carcinoid and considered the gold standard test to establish the diagnosis (E). However, it is not as sensitive for detecting nonfunctional carcinoid tumors. Screening for a carcinoid tumor (as opposed to establishing the diagnosis of carcinoid syndrome) is probably best achieved with serum chromogranin A because it will be elevated in both functioning and nonfunctioning tumors (C). Normally, most dietary tryptophan is converted into nicotinic acid (niacin, vitamin B<sub>3</sub>). In the presence of carcinoid tumors, there is a shift toward conversion to 5-hydroxytryptophan, which is then converted to serotonin. Serotonin is then metabolized to 5-HIAA. The shift away from conversion to tryptophan to nicotinic acid can result in pellagra, which can present with diarrhea, dermatitis (rough scaly skin, glossitis, angular stomatitis), dementia, and/or hypoalbuminemia.

**References:** Swain, C. P., Tavill, A. S., Neale, G., et al. (1976). Studies of tryptophan and albumin metabolism in a patient with carcinoid syndrome, pellagra, and hypoproteinemia. *Gastroenterology*, 71(3), 484–489.

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18. **C.** Serum chromogranin A is the most sensitive marker for detecting neuroendocrine tumors in general. It has also been shown to be the most useful marker for detecting recurrence and response to treatment. Because the level of chromogranin A correlates with tumor burden, it is a

useful marker for treatment response. A high level correlates with a worse prognosis. Platelet serotonin level is also useful in detecting carcinoid tumors (A). However, platelets become rapidly saturated with serotonin; thus, it is not a useful tool for monitoring treatment response (D). 5-HIAA is also thought to be useful; however, several studies indicate that chromogranin A is more sensitive for recurrence and a better prognosticator (B). Neuron-specific enolase has a high specificity but a low sensitivity for the detection of carcinoid tumor (E).

**References:** Bajetta, E., Ferrari, L., Martinetti, A., et al. (1999). Chromogranin A, neuron specific enolase, carcinoembryonic antigen, and hydroxyindole acetic acid evaluation in patients with neuroendocrine tumors. *Cancer*, 86(5), 858–865.

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19. C. Mechanical SBO is the most frequently encountered surgical disorder of the small intestine and in the United States is most commonly due to intra-abdominal adhesions related to previous abdominal surgery. However, worldwide it is most commonly due to a hernia (A). The risk of readmission for adhesions is greatest for patients undergoing lower abdominal surgery and seems to be in the 9% range long term (B). Diagnosis of obstruction can be made with CT scan, small bowel series, or enteroclysis (fluoroscopic examination of the small bowel using liquid contrast). The majority of patients can be managed nonoperatively with nasogastric decompression and nutritional support. This is successful in 65% to 81% of patients, and resolution of symptoms most commonly occurs within 48 hours (D). However, any signs and symptoms suggestive of ischemic bowel are an indication for urgent operative intervention. The incidence of strangulation is no greater than with SBO that presents later. Features of strangulated obstruction such as abdominal pain disproportionate to abdominal findings are suggestive of intestinal ischemia and are not usually an early finding (E). Serum lactate levels are 90% sensitive and 87% specific for the presence of bowel ischemia. However, it is possible that patients with a complete closed loop obstruction (more commonly with volvulus) can have a normal lactate level. This is because obstruction of venous drainage prevents lactic acid produced by enterocytes from reaching systemic circulation. If nasogastric decompression fails to resolve the obstruction, surgery is indicated. The timing of surgery is debatable. In one large series, surgery was recommended for failure of nasogastric decompression after 6 days and in another study after 10 to 14 days. The morbidity and mortality rates of early small bowel obstruction are very low.

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20. B. Right-sided valvular disease is a significant source of morbidity and mortality in carcinoid syndrome because it can lead to right heart failure. Vasoactive substances released from liver metastasis are transported to the right heart, where endocardial damage ensues, leading to thickening, retraction, and fixation of the valves. The most common valvular disorder is tricuspid



insufficiency (A). Pulmonary valve lesions are the next most common (C, D). Left-sided heart lesions are much less common but do occur (E). The serotonin metabolites are deactivated as they travel through the lung and so are less able to exert their damaging effects when they arrive to the left heart.

**References:** Moyssakis, I., Rallidis, L., Guida, G., et al. (1997). Incidence and evolution of carcinoid syndrome in the heart. *The Journal of Heart Valve Disease*, 6(6), 625–630.

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21. **A.** The majority of lesions responsible for GI bleeding are seen with upper endoscopy or colonoscopy. Obscure GI bleeding refers to persistent or recurrent bleeding for which no source has been identified by these modalities. Obscure bleeding can be either occult (meaning not visible to the eye) or overt (such as melena and hematochezia). In most instances, the source of obscure bleeding is from the small bowel. Small intestine angiodysplasias account for 75% of cases of obscure bleeding in adults (B–E). Other causes include Crohn disease, infectious enteritis, neoplasms, and vasculitis. A Meckel diverticulum is the most common cause of obscure GI bleeding in children. Localization of small bowel lesions is difficult with standard studies. Options include push enteroscopy and small bowel barium studies, capsule endoscopy, radiolabeled red blood cell scanning and angiography (although these latter two are only useful in the setting of active bleeding).

**Reference:** Pennazio, M., Santucci, R., Rondonotti, E., et al. (2004). Outcome of patients with obscure gastrointestinal bleeding after capsule endoscopy: report of 100 consecutive cases. *Gastroenterology*, 126(3), 643–653.

22. **D.** GISTs were previously termed *leiomyomas* or *leiomyosarcomas*. It now seems that they are mesenchymal tumors. GISTs are classified into three types: spindle cell (70%), epithelioid type (20%), and mixed spindle and epithelioid cell type (10%). GISTs stain positive for CD34, the human progenitor cell antigen, as well as for CD177, the c-kit proto-oncogene protein (B). The stomach is the most common site in the GI tract. Small bowel GISTs may be incidental discoveries at surgery for other disorders. The majority of patients are asymptomatic (A). However, those that do present with symptoms tend to be very large and bulky at presentation. In one large study, the median size of a symptomatic GIST was 11 cm. They tend to present with evidence of obstruction or GI bleeding. The standard treatment is surgical resection with 1 cm margins. However, microscopically positive margins have not been demonstrated to affect survival. GISTs of the small intestine carry a high mortality rate, likely due to the late presentation. Only 28% of patients were alive at a median follow-up of 20 months in one study. Determining whether a GIST is benign or malignant is difficult because seemingly benign tumors may behave in a malignant fashion with local recurrence. The risk of malignancy can be remembered by “the rule of 5’s”: tumors > 5 cm or > 5 mitoses per 50 high-power field (E). The adjuvant treatment of GISTs includes chemotherapy with imatinib (Gleevec), a tyrosine kinase inhibitor. In one study, imatinib controlled tumor growth in as many as 85% of advanced GISTs. Currently, imatinib is recommended for unresectable, metastatic, or recurrent lesions. Adjuvant therapy should continue for a total of 3 years (C). Patients that harbor an exon 9 KIT mutation will require a higher dose of imatinib (800 mg daily vs 400 mg). The most useful indicators of survival and the risk of metastasis include the size of the tumor at presentation, the mitotic index, location within the GI tract, and the absence of tumor rupture.

**References:** Blay, J., Bonvalot, S., Casali, P., et al. (2005). GIST consensus meeting panelists: consensus meeting for the management of gastrointestinal stromal tumors: report of the GIST Consensus Conference of 20–21 March 2004, under the auspices of ESMO. *Annals of Oncology*, 16(4), 566–578.

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DeMatteo, R. P., Ballman, K. V., Antonescu, C. R., et al. (2009). Adjuvant imatinib mesylate after resection of localised, primary gastrointestinal stromal tumour: a randomised, double-blind, placebo-controlled trial. *The Lancet*, 373(9669), 1097–1104.



Joensuu, H., Eriksson, M., Sundby Hall, K., et al. (2012). One vs three years of adjuvant imatinib for operable gastrointestinal stromal tumor: a randomized trial. *The Journal of the American Medical Association*, 307(12), 1265–1272.

23. **B.** A hernia sac containing a Meckel diverticulum is called a *Littre hernia*. Lumbar hernias can be either congenital or acquired and occur in the lumbar region of the posterior abdominal wall. Hernias through the superior lumbar triangle (Grynfeltt triangle) (E) are more common than those through the inferior lumbar triangle (the Petit triangle) (A). The Petit triangle is bounded by the external oblique muscle, latissimus dorsi muscle, and iliac crest. The Grynfeltt triangle is bounded by the quadratus lumborum muscle, the 12th rib, and the internal oblique muscle. A spigelian hernia occurs through the spigelian fascia, which is composed of the aponeurotic layer between the rectus muscle medially and the semilunar line laterally (C). Nearly all spigelian hernias occur in the spigelian belt located below the umbilicus but above the epigastric vessels. The absence of posterior rectus fascia may contribute to an inherent weakness in this area. A Richter hernia occurs when only the antimesenteric border of the bowel herniates through the fascial defect (D). It involves only a portion of the circumference of the bowel. As such, incarceration and strangulation may occur in the absence of any evidence of bowel obstruction.

**Reference:** Skandalakis, P. N., Zoras, O., Skandalakis, J. E., & Mirilas, P. (2006). Spigelian hernia: surgical anatomy, embryology, and technique of repair. *The American Surgeon*, 72(1), 42-48.

24. **D.** The SMA leaves the aorta at a downward and acute angle (B). SMA syndrome or Wilkie syndrome is a rare condition characterized by compression of the third portion of the duodenum by the SMA as it passes over this portion of the duodenum (A). It occurs most often in the setting of profound weight loss. Factors that predispose to the condition include supine immobilization, scoliosis, placement of a body cast, and eating disorders. Symptoms include profound nausea and vomiting, abdominal distention, weight loss, and postprandial epigastric pain, which varies from intermittent to constant, depending on the severity of the duodenal obstruction. Weight loss usually occurs before the onset of symptoms. It is believed to occur more commonly in women likely secondary to the increased prevalence of anorexia. However, a recent study of SMA syndrome among intellectually disabled children showed that it predominantly affects males. The diagnosis can be made by a CT scan, which demonstrates a decreased aortomesenteric angle and a decreased distance between the aorta and the SMA, as well as evidence of obstruction of the duodenum (C). It can also be diagnosed by a barium upper GI series or hypotonic duodenography, demonstrating abrupt or near total cessation of flow of barium from the duodenum to the jejunum. Conservative measures are tried initially that are primarily focused on weight gain to increase the mesenteric root fat pad. The operative treatment is duodenojejunostomy (E).

**References:** Adson, D., Mitchell, J., & Trenkner, S. (1997). The superior mesenteric artery syndrome and acute gastric dilatation in eating disorders: a report of two cases and a review of the literature. *The International Journal of Eating Disorders*, 21(2), 103–114.

Agrawal G., Johnson, P., & Fishman, E. (2007). Multidetector row CT of superior mesenteric artery syndrome. *Journal of Clinical Gastroenterology*, 41(1), 62–65.

Geskey, J. M., Erdman, J. J., Bramley, H. P., et al. (2012). Superior mesenteric artery syndrome in intellectually disabled children. *Pediatric Emergency Care*, 28(4), 351–353.

25. **D.** The small-intestinal epithelium is acutely susceptible to radiation injury because radiation has its greatest impact on rapidly proliferating cells. Radiation-induced injury to the bowel can present with acute or chronic enteritis. Approximately 75% of patients undergoing radiation therapy for abdominal and pelvic cancers develop acute radiation enteritis transiently. Chronic radiation enteritis results from an obliterative arteritis in the submucosal vessels (C). This leads to progressive submucosal fibrosis and stricture formation. Not infrequently, patients with radiation-induced injury may develop a small bowel obstruction. The risk of radiation enteritis correlates with the amount of radiation received. It is uncommon if the total radiation dose is less than 4000 cGy. The risk of radiation damage increases if the patient received chemotherapy or has underlying vascular disease or diabetes (E). Early symptoms of radiation damage include diarrhea, abdominal pain, and malabsorption and are usually self-limited. The treatment of acute radiation enteritis includes antispasmodic agents, analgesic agents, and antidiarrheal agents. Steroids are not used in the management of radiation enteritis (B). Only a small group of patients with chronic radiation enteritis will require surgery for either SBO from stricture formation or fistulas. Unlike Crohn disease in which strictureplasty is used, it is not recommended for radiation enteritis because there

is a high risk of tissue breakdown (A). The extent of macroscopic radiation injury is difficult to determine on gross inspection. Extensive lysis of adhesions should be avoided because this creates a risk of an enterotomy and subsequent fistula formation as well. The two main surgical procedures are primary resection with reanastomosis or bypass. If the source of obstruction is a loop of bowel stuck in the pelvis, it is best treated with a bypass rather than an attempt to take down the adhesions and risk injury.

**References:** Galland, R., & Spencer, J. (1987). Natural history and surgical management of radiation enteritis. *The British Journal of Surgery*, 74(8), 742–747.

Tavakkoli, A., Ashley, S. W., & Zinner, M. J. (2015). Small intestine. In F. C. Brunickardi (Ed.), *Schwartz's principles of surgery* (pp. 1162–1163) (10th ed.). New York, NY: McGraw-Hill Education.

26. E. Pneumatosis intestinalis is a radiographic finding and not a disease unto itself. Its discovery on imaging is vexing because it can be a completely benign finding, or it can be associated with life-threatening bowel ischemia. It has been divided into primary and secondary pneumatosis intestinalis. The primary form is less common and is termed *pneumatosis cystoides intestinalis* (B). It consists of thin-walled, air-filled cysts within the bowel wall, usually in the colon, but it can occur anywhere in the GI tract (D). It is an incidental finding, and the diagnosis is readily made on plain radiograph or CT scan. The gas can appear as linear, curvilinear, bubbly, or cystic. There is no specific treatment (A). Secondary pneumatosis intestinalis occurs when there is an underlying disease process. The exact cause of pneumatosis intestinalis is unclear, but there seem to be several pathways that allow gas to enter the bowel wall. Immunodeficient and inflammatory bowel states lead to a loss of mucosal barrier function that may permit air to enter the bowel wall. Bowel obstruction leads to gas formation under pressure. Alterations in bacteria flora, with invasion of the bowel wall, likewise lead to gas formation. In adults, secondary pneumatosis intestinalis is most often associated with COPD (C). It is also seen with collagen vascular disease, celiac sprue, Crohn disease, and use of steroids and in immunodeficient states. More ominously, it is also associated with ischemic bowel. Thus, it is important to recognize that not all cases of pneumatosis are benign. In neonates, it is most commonly associated with necrotizing enterocolitis. The finding of pneumatosis intestinalis in association with necrotizing enterocolitis does not mandate surgical exploration. It is also seen with pyloric stenosis, Hirschsprung disease, and other causes of bowel obstruction. Pneumoperitoneum can rarely be the result of a benign case of pneumatosis intestinalis because the air-filled cysts are thin walled and can burst.

**References:** Mularski, R., Ciccolo, M., & Rappaport, W. (1999). Nonsurgical causes of pneumoperitoneum. *West Journal of Medicine*, 170(1), 41–46.

Pear, B. L. (1998). Pneumatosis intestinalis: a review. *Radiology*, 207(1), 13–19.

St. Peter, S., Abbas, M., & Kelly, K. (2003). The spectrum of pneumatosis intestinalis. *Archives of Surgery*, 138(1), 68–75.

Hsueh, K. C., Tsou, S. S., Tan, K. T., et al. (2011). Pneumatosis intestinalis and pneumoperitoneum on computed tomography: beware of non-therapeutic laparotomy. *World Journal of Gastrointestinal Surgery*, 3(6), 86.

27. A. Peutz-Jeghers syndrome features mucocutaneous melanotic pigmentation and hamartomatous polyps (not adenomatous) of the small intestine. It is an autosomal dominant inherited syndrome (B). The skin lesions are found in the circumoral region of the face, buccal mucosa, forearms, palms, soles, digits, and perianal area, whereas the hamartomas are usually in the jejunum and ileum. The most common symptom is recurrent colicky abdominal pain (C). Symptoms of a bowel obstruction develop in as many as 50% of patients, which is usually due to intussusception or obstruction by the polyp itself. Hemorrhage or chronic anemia can also occur as a result of the polyps. The polyps can also undergo adenomatous change. Patients are at significantly increased risk of the development of cancer in the GI tract (esophagus, stomach, small intestine, colon, and pancreas), as well as extraintestinal (testis, breast, uterus, ovary). Female patients should begin breast and cervical cancer screening starting at age 25. Over the long term, cancer develops in as many as 90% of patients. Compared with the general population, they are at 500 times increased risk of the development of small intestine cancer (E). Operative intervention is only indicated in the presence of symptoms (D).

**References:** Boardman, L., Pittelkow, M., & Couch, F. (2000). Association of Peutz-Jeghers-like mucocutaneous pigmentation with breast and gynecologic carcinomas in women. *Medicine (Baltimore)*, 79(5), 293–298.

Giardiello, F., Brensinger, J., & Tersmette, A. C. (2000). Very high risk of cancer in familial Peutz-Jeghers syndrome. *Gastroenterology*, 119(6), 1447–1453.

Wu, Y. K., Tsai, C. H., Yang, J. C., et al. (1994). Gastroduodenal intussusception due to Peutz-Jeghers syndrome: a case report, *Hepatogastroenterology*, 41(2), 134–136.

Van Lier, M. D., Wagner, A., Mathus-Vliegen, E. M., et al. (2010). High cancer risk in Peutz-Jeghers syndrome: a systematic review and surveillance recommendations. *The American Journal of Gastroenterology*, 105(6), 1258–1264.

28. **D.** A Meckel diverticulum is a remnant of the vitelline duct. It occurs within 2 feet of the ileocecal valve on the antimesenteric border of the bowel. It is a true diverticulum found in 2% of the population. It is twice as common in males and frequently presents in the first 2 years of life. The most common cause of lower GI bleeding in children is a Meckel diverticulum. It may contain ectopic gastric or pancreatic mucosa. The gastric mucosa secretes acid, leading to ulcer formation and bleeding, usually in the adjacent ileum, not in the Meckel diverticulum itself. Thus, surgical management consists of segmental resection of the ileum to include the Meckel diverticulum (A–C, E). At surgery, the specimen should be opened to search for the ulceration. The presence of a Meckel diverticulum can be determined with a nuclear scan, which consists of technetium-99m pertechnetate. It will light up if the Meckel diverticulum contains ectopic gastric mucosa.

29. **B.** Mesenteric diverticulum is found on the antimesenteric border approximately 60 cm (2 ft) from the ileocecal valve. It may be very small or may extend via a fibrous band up to the umbilicus. It is a remnant of the vitelline duct. Because cells from this region are pluripotent during embryologic development, heterotopic tissue may develop within a Meckel diverticulum. Intestinal obstruction is the most common presentation in adults with a Meckel diverticulum followed by intussusception and diverticulitis. Children most often present with painless GI bleeding. The management of an incidentally discovered Meckel diverticulum remains controversial. However, most surgeons would recommend removal in all children when it is discovered incidentally at surgery. Guidelines in adults for selective removal include age younger than 50 years, a narrow base, the presence of palpable heterotopic tissue, diverticulum length greater than 2 cm, the presence of a mesodiverticular band, and signs of previous diverticulitis.

**References:** Cullen, J. J., Kelly, K. A., Moir, C. R., et al. (1994). Surgical management of Meckel's diverticulum: an epidemiologic, population-based study. *Annals of Surgery*, 220(4), 564–568.

McKay, R. (2007). High incidence of symptomatic Meckel's diverticulum in patients less than fifty years of age: an indication for resection. *Annals of Surgery*, 73(3), 271–275.

Park, J. J., Wolff, B. G., Tollefson, M. K., et al. (2005). Meckel diverticulum: the Mayo Clinic experience with 1476 patients (1950–2002). *Annals of Surgery*, 241(3), 529–533.

30. **C.** The patient has a carcinoid crisis. This has been described after anesthetic induction as well as after other stressful situations such as biopsies or invasive procedures. Carcinoid crisis is characterized by hypotension, bronchospasms, flushing, and tachycardia. The primary treatment is IV octreotide administered as a bolus of 50 to 100 µg. Even more rarely, a carcinoid crisis can manifest with hypertension. Octreotide is effective for a hypertensive crisis as well. Adjunctive treatment with antihistamines may also be of benefit due to frequent histamine release from carcinoid tumors (B). If the above measures do not resolve the crisis, then aborting the procedure may be necessary (D). Dantrolene is the preferred choice of management for malignant hyperthermia (E). This diagnosis is supported by an increase in end-tidal CO<sub>2</sub>. Corticosteroids are not used in the management of carcinoid crisis (A).

**References:** Bax, N., Woods, H., Batchelor, A., et al. (1996). Octreotide therapy in carcinoid disease. *Anticancer Drugs*, 7(Suppl. 1), 17–22.

Warner, R., Mani, S., Profeta, J., et al. (1994). Octreotide treatment of carcinoid hypertensive crisis. *The Mount Sinai Journal of Medicine, New York*, 61(4), 349–355.

31. **E.** The patient has a blind loop syndrome, which is due to bacterial overgrowth (A). Symptoms include diarrhea, steatorrhea, megaloblastic anemia, weight loss, abdominal pain, and deficiencies of fat-soluble vitamins. The megaloblastic anemia is due to the utilization of vitamin B<sub>12</sub> by the bacteria. The underlying cause may be an intestinal abnormality such as a diverticulum, fistula, and intestinal stricture or it may follow a Billroth II procedure. In the patient presented, the large jejunal diverticulum is likely the etiology. The diagnosis can be confirmed by various means. A barium study is useful to define the anatomic abnormality. The D-xylose test involves ingesting

xylose, which is metabolized by the bacteria. Excessive CO<sub>2</sub> in the breath confirms the diagnosis. Cultures of the small intestine can be obtained; however, passing an intestinal tube distal enough to obtain an adequate culture can be challenging. Another useful study is the Schilling test. Oral radiolabeled vitamin B<sub>12</sub> is administered along with parenteral unlabeled vitamin B<sub>12</sub>. The unlabeled vitamin B<sub>12</sub> saturates liver receptors. Thus, if the oral radiolabeled vitamin B<sub>12</sub> is properly absorbed and liver receptors are saturated, the radiolabeled vitamin B<sub>12</sub> will be excreted in high concentrations in the urine. With pernicious anemia and blind loop syndrome, oral absorption will be low, and thus urinary excretion of radiolabeled vitamin B<sub>12</sub> will be low. When the test is repeated after the addition of intrinsic factor, vitamin B<sub>12</sub> excretion will increase, whereas with blind loop syndrome vitamin B<sub>12</sub> excretion will remain low. The initial treatment of blind loop syndrome consists of broad-spectrum antibiotics including metronidazole with tetracycline as well as vitamin B<sub>12</sub> supplementation given parenterally. This should be given to all patients presenting with blind loop syndrome (D). Prokinetic agents do not seem to help. In addition, dietary modifications are useful, such as a lactose-free diet, because patients with blind loop syndrome often become lactose intolerant. Medium-chain triglyceride diets are more readily absorbed than long-chain triglycerides because they do not require digestive enzymes (B). Resection of the diverticulum is not recommended initially (C). Surgery should be reserved for patients who fail repeated medical management attempts.

**References:** Ross, B., Richards, W., Sharp, K., et al. (1990). Diverticular disease of the jejunum and its complications. *The American Surgeon*, 56(5), 319–324.

Woods, K., Williams, E., Melvin, W., et al. (2008). Acquired jejunoileal diverticulosis and its complications: a review of the literature. *The American Surgeon*, 74(9), 849–854.

# Alimentary Tract—Large Intestine

*Beverley A. Petrie, Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 50-year-old male is undergoing a screening colonoscopy under intravenous (IV) sedation. Near the end of the procedure he briefly becomes unresponsive requiring a sternal rub to arouse him. IV anesthetics are weaned off, and the procedure is completed. In the recovery room, a chest x-ray is performed to rule out an aspiration event before discharge. There is no consolidation in the lungs, but free air is seen under the diaphragm. The patient has no complaints, the abdomen is soft, he would like to eat, and he has normal vital signs. Which of the following is the best next step?
  - A. Exploratory laparotomy
  - B. Diagnostic laparoscopy
  - C. Serial abdominal exam for 6 hours
  - D. Admit to hospital, IV antibiotics, and bowel rest
  - E. Discharge home
2. Ten years after an abdominoperineal resection for locally advanced rectal cancer, a patient presents with a hernia adjacent to his stoma that causes him discomfort and interferes with the placement of his colostomy bag. It has been increasing in size over the last several months. Which of the following is true regarding this condition?
  - A. Chronic obstructive pulmonary disease (COPD) is the strongest risk factor.
  - B. Treatment for this patient includes a support device such as a hernia belt and weight loss.
  - C. Repair is best achieved by relocating the stoma.
  - D. Prophylactic mesh placement at the initial operation decreases risk of this complication.
  - E. This complication is more common with loop ileostomy than end colostomy.
3. A 47-year-old morbidly obese male underwent emergent sigmoidectomy with end colostomy creation yesterday morning for perforated diverticulitis. Evaluation of the colostomy on morning rounds reveals diffusely dusky mucosa. On examination with a test tube and light, the dusky area appears to be superficial to the fascia. Management consists of:
  - A. Re-exploration in the operating room (OR), resection of ischemic colon and stoma relocation
  - B. Re-exploration in the OR, segmental colon resection, and placement of stoma at the same site
  - C. Re-exploration in the OR, on-table bowel prep, and primary colonic anastomosis
  - D. Observation and reevaluate the colostomy in 12 to 24 hours
  - E. IV antibiotics
4. A 75-year-old male with chronic constipation presents with severe abdominal pain and fever. CT scan shows free air and stranding in the colon. The colon and rectum appear to be dilated and filled with large masses of stool. Intraoperatively, a round perforation about 1 cm in diameter is found in the colon, with thickened balls of stool protruding out. Which of the following is true regarding this patient?
  - A. The perforation is most likely to occur at the splenic flexure.

- B. It is associated with nonsteroidal antiinflammatory (NSAID) use.
  - C. It is best managed by primary closure and washout.
  - D. Anticholinergic agents could have prevented this condition.
  - E. The perforation is usually at the mesenteric border.
5. A 71-year-old female with COPD is recovering from pneumonia in the intensive care unit (ICU). She is on a ventilator. Her abdomen is acutely distended, and she has not had a bowel movement in several days. Imaging demonstrates a cecum measuring 8 cm in diameter with gas pattern of distention extending to the rectum. There is no stool in the rectal vault. Her vital signs are stable. Her doctor would like to start neostigmine. Which of the following is true regarding the administration of neostigmine for this patient's condition?
- A. History of coronary artery disease is considered a contraindication.
  - B. History of second degree heart block is considered a contraindication.
  - C. Neostigmine should not be given as a continuous infusion.
  - D. Neostigmine is effective in 20% of patients with this condition.
  - E. If a bolus of neostigmine is not successful, repeat boluses should be avoided.
6. For the patient in [question 5](#), neostigmine fails to improve her symptoms. Her lactic acid is elevated and she is taken to the OR. Her blood pressure is 108/68 mm Hg and heart rate is 88 beats per minute. Intraoperatively, her colon appears inflamed and dilated to 10 cm, but there are no signs of ischemic bowel identified. Which of the following is the most appropriate treatment option?
- A. Total abdominal colectomy with ileoanal anastomosis
  - B. Proctocolectomy with ileal pouch anal anastomosis
  - C. Placement of cecostomy tube at one or several locations in the distended colon
  - D. Transanal retrograde colonic insertion of a long multiperforated Faucher tube
  - E. Subtotal colectomy with end ileostomy
7. A 32-year-old male diagnosed with ulcerative colitis (UC) 1 year ago presents to the emergency department (ED) with jaundiced skin. He is admitted and workup is consistent with primary sclerosing cholangitis (PSC). Which of the following is additionally recommended?
- A. Immediate screening colonoscopy
  - B. Immediate colonoscopy with random biopsies
  - C. Colonoscopy with random biopsies at 8 to 10 years after his UC diagnosis
  - D. Screening colonoscopy at age 50
  - E. Symptom-driven colonoscopy as needed
8. Which of the following is *least* likely to contribute to an anastomotic leak following colorectal surgery for cancer?
- A. Prolonged operative time
  - B. Low rectal tumors
  - C. Postoperative ketorolac use
  - D. Female gender
  - E. Multiple firings of the linear stapler
9. A 35-year-old patient with a history of UC undergoes an ileoanal anastomosis with J-pouch reconstruction. Four months later, he presents with a 3-day history of abdominal pain, diarrhea, hematochezia, and fever. Which of the following is true regarding this condition?
- A. Biopsy is typically not required in the management of this condition.
  - B. This is an uncommon complication.
  - C. Use of probiotics is not helpful.
  - D. Urgent excision of the J-pouch is often necessary.
  - E. Ciprofloxacin is more effective than metronidazole to treat this condition.
10. Which of the following is true about familial adenomatous polyposis (FAP)?
- A. Microsatellite instability is a major contributor to this disease.



- B. It is not associated with extraintestinal manifestations.
  - C. Patients with the gene mutation should begin screening with flexible sigmoidoscopy at age 20.
  - D. Patients with prophylactic proctocolectomy have a lower risk of developing periampullary carcinoma.
  - E. Upper endoscopy should be performed every 1 to 3 years.
11. A 45-year-old woman with a 15-year history of pancolitis from UC undergoes surveillance colonoscopy. No polyps are detected. Random biopsy samples are taken, and final pathology findings reveal high-grade dysplasia from the sigmoid colon region. Recommended management would be:
- A. Repeat colonoscopy in 6 months with additional random biopsies
  - B. Sigmoid colectomy
  - C. Total colectomy with ileorectal anastomosis
  - D. Total proctocolectomy with ileostomy
  - E. Restorative proctocolectomy with ileal pouch–anal anastomosis
12. The earliest manifestation of UC is:
- A. Mucosal ulcerations
  - B. Mucosal edema
  - C. Plasmacytosis
  - D. Pseudopolyps
  - E. Crypt abscesses
13. With appendicitis during pregnancy, the factor most strongly associated with fetal mortality is:
- A. Fetal gestational age
  - B. Open appendectomy instead of laparoscopy
  - C. Maternal comorbidities
  - D. Appendiceal rupture
  - E. Delay in antibiotic administration
14. A 56-year-old man presents with a 2-day history of fever, nausea, and left lower quadrant pain. His white blood cell (WBC) count is 14,000 cells/ $\mu$ L. CT shows a thickened sigmoid colon with fat stranding and a 5-cm pelvic abscess. Optimal management of this patient would be:
- A. Immediate sigmoid colectomy, end colostomy, and drainage of abscess
  - B. CT-guided drainage followed in 6 weeks by a colonoscopy and sigmoid colectomy
  - C. CT-guided drainage alone
  - D. IV antibiotics followed in 6 weeks by a colonoscopy and sigmoid colectomy
  - E. IV antibiotics alone
15. Which of the following is true regarding familial juvenile polyposis?
- A. It is autosomal recessive.
  - B. The polyps are hamartomas.
  - C. The risk of colon cancer is 100% by age 50.
  - D. Once a polyp is detected, total proctocolectomy is recommended.
  - E. There is no association with upper GI malignancy.
16. Which of the following is true regarding colonic polyps?
- A. Tubulovillous adenomas have a lower malignancy risk than tubular adenomas.
  - B. Some hyperplastic polyps are premalignant.
  - C. The polyps in Peutz-Jeghers syndrome are hyperplastic.
  - D. Pseudopolyps are commonly found in FAP.
  - E. In an adenomatous polyp, the risk of malignancy is related to its location in the GI tract.
17. A 75-year-old woman presents with mild diffuse abdominal pain and diarrhea that is positive on fecal immunochemical test. Her medical history is negative. Her WBC count is normal, as is her hematocrit. A CT scan shows mild thickening of the colonic wall at the splenic flexure with some



- associated pericolic fat stranding. Which of the following is the best next step in management?
- Diagnostic laparoscopy
  - Exploratory laparotomy
  - IV antibiotics and fluid hydration
  - Colonoscopy
  - Mesenteric angiography
18. A 69-year-old woman is treated with oral metronidazole for an uncomplicated case of pseudomembranous colitis. She develops a recurrence 2 weeks later. Which of the following is true regarding this patient?
- Oral metronidazole is the treatment of choice.
  - Oral vancomycin is the treatment of choice.
  - IV vancomycin is the treatment of choice.
  - Sigmoidoscopy is typically required before proceeding with any additional treatment.
  - This condition only develops after antibiotic use.
19. A 38-year-old woman presents with a 1-day history of nausea, vomiting, abdominal distention, and obstipation. She has no history of surgery and no medical problems. The physical examination is significant for distention with a tympanic mass in the left upper quadrant and mild abdominal tenderness. The WBC count is normal. A plain abdominal radiograph reveals a markedly dilated, kidney-shaped loop of bowel with haustral markings that project from the right lower quadrant to the left upper quadrant. Which of the following is likely to be the best treatment option?
- Cecostomy
  - Operative detorsion with cecopexy
  - Right hemicolectomy with an ileostomy and mucus fistula
  - Initial endoscopic detorsion with a subsequent right hemicolectomy
  - Right hemicolectomy with primary anastomosis.
20. Which of the following is true regarding diverticular diseases of the lower GI tract?
- They occur most commonly in the descending colon.
  - The rectum can be affected.
  - Incidentally discovered cecal diverticula require surgical management because of high risk of complications.
  - Sigmoid resection should be preceded by a mechanical bowel preparation with oral and IV perioperative antibiotics.
  - They are associated with a long, redundant colon.
21. A 30-year-old man presents with symptoms and signs of acute appendicitis. At surgery, the appendix appears red and inflamed but without perforation. Approximately 200 mL of purulent fluid is seen in the right paracolic gutter. The patient undergoes appendectomy. Final pathology reveals periappendicitis. This most likely represents:
- Acute mesenteric adenitis
  - Familial Mediterranean fever
  - Perforated duodenal ulcer
  - Tuberculosis
  - Primary peritonitis
22. A 40-year-old man presents with a 5-day history of right lower quadrant abdominal pain, anorexia, and fever. On physical examination, he is focally tender in the right lower quadrant, and a mass is palpable. A CT scan shows a small (<1 cm) abscess surrounding an inflamed appendix. After fluid resuscitation and intravenous antibiotics, which of the following is the most appropriate management?
- CT-guided drainage followed by interval appendectomy
  - Initial nonoperative management followed by interval appendectomy
  - Laparoscopic appendectomy

- D. Open appendectomy
  - E. Nonoperative management
23. A 55-year-old man is undergoing a screening colonoscopy. A benign-appearing 1-cm pedunculated polyp is removed from the sigmoid colon. Four hours later, severe left lower quadrant pain develops in the patient. A CT scan reveals free intraperitoneal air, with minimal fat stranding around the sigmoid colon. The situation is best managed by:
- A. Diverting proximal colostomy
  - B. Resection of sigmoid colon with an end colostomy and oversew of the rectum
  - C. Resection of the sigmoid colon with primary anastomosis
  - D. Primary closure of the perforation
  - E. Broad-spectrum antibiotics and nasogastric decompression
24. Five days after appendectomy, liquid stool is noted to be coming out of the right lower quadrant wound. Which of the following is true about this condition?
- A. The patient should have nothing by mouth and be placed on parenteral nutrition.
  - B. Octreotide should be started.
  - C. The patient should immediately undergo re-exploration and a cecostomy.
  - D. The patient should immediately undergo re-exploration and a right colectomy.
  - E. The condition resolves spontaneously in most instances.
25. Which of the following is true regarding chemotherapy for colon carcinoma?
- A. The combination of 5-fluorouracil and leucovorin prolongs survival in stage IV colon cancer.
  - B. Radiation therapy is commonly used in combination with chemotherapy in the management of colon cancer.
  - C. Bevacizumab (Avastin) has not been shown to prolong survival in stage IV colon cancer.
  - D. 5-Fluorouracil and leucovorin prolong survival in patients with stage III colon cancer.
  - E. Bevacizumab (Avastin) is a monoclonal antibody against epidermal growth factor receptor.
26. A 65-year-old man presents with a 2-day history of left lower quadrant abdominal pain, nausea, and low-grade fever. On physical examination, his temperature is 100.5°F and WBC count is 14,000 cells/ $\mu$ L. He has localized, moderate left lower quadrant pain without rebound. Antibiotics are administered. Which of the following is indicated as the next step in the patient's management?
- A. Plain x-rays of the abdomen
  - B. CT scan
  - C. Flexible sigmoidoscopy
  - D. Barium enema
  - E. Gastrografin enema
27. An important source of energy for colonocytes, particularly in the setting of diversion colitis, is:
- A. Ketone bodies
  - B. Glucose
  - C. Amino acids
  - D. Propionate
  - E. Glutamine
28. A 15-year-old boy presents to a colorectal clinic with a family history of familial polyposis. *APC* gene testing is performed, and the result is positive. Flexible sigmoidoscopy reveals eight polyps in the sigmoid. Colonoscopy reveals no other polyps. Polyps are consistent with adenomatous polyps without evidence of malignancy. Which of the following is the recommended management?
- A. Repeat sigmoidoscopy in 6 months
  - B. Cyclooxygenase-2 inhibitors, repeat sigmoidoscopy in 6 months
  - C. Total colectomy with ileorectal anastomosis
  - D. Total proctocolectomy with continent ileostomy
  - E. Restorative proctocolectomy with ileal pouch–anal anastomosis

29. Which of the following is the most reliable in confirming the diagnosis of acute appendicitis?
- A. Classic history of initial periumbilical pain shifting to the right lower quadrant
  - B. Localized tenderness at McBurney's point
  - C. Rebound tenderness
  - D. Presence of obturator sign
  - E. Presence of Rovsing's sign
30. The most common perianal lesion in Crohn disease is:
- A. Fissures
  - B. Skin tags
  - C. Perianal abscess
  - D. Perianal fistulas
  - E. Hemorrhoids
31. Which of the following is true regarding acute appendicitis?
- A. The luminal capacity of the appendix is 1 mL.
  - B. The initial periumbilical pain is due to stimulation of parietal afferent pain fibers.
  - C. Ruptured appendicitis can drain dependently into the rectovesical pouch.
  - D. Nausea often precedes abdominal pain.
  - E. There is no difference in perforation rates based on age.
32. The most common cause of rectovaginal fistula is:
- A. Colon carcinoma
  - B. Diverticulitis
  - C. Crohn disease
  - D. Obstetric injury
  - E. Bladder carcinoma
33. A 75-year-old woman presents to clinic for follow-up after four episodes of uncomplicated diverticulitis in the past year, each of which required a 5-day hospitalization for IV antibiotics and bowel rest. The patient is a diabetic. Previous CT scans demonstrated inflammation in the sigmoid colon with fat stranding. Subsequent colonoscopy revealed diverticula throughout the majority of the transverse, descending, and sigmoid colon but was negative for other pathology. Which of the following is the most correct surgical intervention?
- A. Total colectomy with ileoproctostomy
  - B. Sigmoid colectomy with proximal margin at an area without any hypertrophy of the muscularis propria and distal margin where the taenia splay out
  - C. Left colectomy with proximal margin where there is cessation of diverticula and distal margin where the taenia splay out
  - D. Sigmoid colectomy with proximal margin at an area without any hypertrophy of the muscularis propria and distal margin at the rectosigmoid junction
  - E. Left colectomy with proximal margin where there is cessation of diverticula and distal margin at the rectosigmoid junction
34. Which of the following is true regarding the immune function of the appendix?
- A. It secretes IgA.
  - B. It secretes IgE.
  - C. It secretes IgM.
  - D. It secretes IgG.
  - E. It has no immune function.
35. A hernia containing an appendix is known as:
- A. Petit hernia
  - B. Amyand hernia

- C. Littre hernia
  - D. Spigelian hernia
  - E. Grynfeltt hernia
36. A 35-year-old man presents with a 1-day history of anorexia, right lower quadrant pain and tenderness, and low-grade fever. At surgery, the appendix appears normal. However, both the cecum and terminal ileum appear red and inflamed. Management would consist of:
- A. Right hemicolectomy
  - B. Appendectomy
  - C. Close wound without further intervention
  - D. Biopsy of the cecal wall
  - E. Biopsy of the terminal ileum
37. A 15-year-old boy presents with a 5-day history of right lower quadrant pain and a fever of 103°F. On examination, he has right lower and right upper quadrant tenderness. Total bilirubin is 3 mg/dL and alkaline phosphatase is 250 IU/L. CT with contrast demonstrates multiple densities in the right lobe of the liver, a phlegmon in the right lower quadrant, and stranding around the superior mesenteric vein with air bubbles within the vein. The clinical picture most likely represents:
- A. Amebic liver abscess
  - B. Pylephlebitis
  - C. Carcinoid syndrome
  - D. Metastatic adenocarcinoma
  - E. Inflammatory bowel disease (IBD)
38. Which of the following is true regarding appendicitis in HIV-infected patients?
- A. Appendicitis occurs more frequently than in the general population.
  - B. HIV-infected patients usually do not manifest abdominal symptoms and signs.
  - C. Low CD4 counts are associated with a decreased risk of rupture.
  - D. Postoperative morbidity for nonperforated appendicitis is higher than in the general population.
  - E. Absolute leukocyte counts are typically elevated.
39. When comparing laparoscopic with open appendectomy, which of the following is true regarding laparoscopic appendectomy?
- A. It is at or below the cost of an open appendectomy owing to the shorter duration of surgery.
  - B. It does not affect the length of hospital stay.
  - C. It results in a decreased intra-abdominal abscess rate.
  - D. It does not affect wound infection rate.
  - E. It allows for decreased postoperative analgesic use.
40. The most common worldwide intestinal parasite causing appendicitis is:
- A. *Enterobius vermicularis*
  - B. *Strongyloides stercoralis*
  - C. *Ascaris lumbricoides*
  - D. *Echinococcus granulosus*
  - E. *Clonorchis sinensis*
41. Incidental appendectomy is BEST indicated in which of the following circumstances?
- A. During gastric bypass surgery in a 45-year-old man
  - B. During hysterectomy in a 30-year-old woman
  - C. During small bowel resection in a 30-year-old woman with Crohn disease
  - D. During laparoscopic cholecystectomy in a 25-year-old woman
  - E. During a Whipple procedure in a 50-year-old man
42. A 10-year-old boy presents with symptoms and signs of acute appendicitis. At surgery, the appendix appears normal. However, there is diffuse adenopathy within the small bowel mesentery. Which of

- the following is true about this condition?
- A. The normal appendix should be removed and a biopsy of the mesenteric lymph nodes performed.
  - B. This condition usually causes more peritoneal irritation than appendicitis.
  - C. The WBC count tends to be higher than with appendicitis.
  - D. It occurs with equal frequency in adults and children.
  - E. It is usually associated with an antecedent upper respiratory tract infection.
43. A 50-year-old woman presents with symptoms and signs of acute appendicitis. At surgery, there is a large amount of gelatinous ascites with peritoneal implants. This most likely represents:
- A. Benign ovarian tumor
  - B. Appendiceal mucinous adenoma
  - C. Tuberculous appendicitis
  - D. *Salmonella enteritidis*
  - E. *Yersinia enterocolitica*
44. The most common presentation for appendiceal adenocarcinoma is:
- A. Palpable abdominal mass
  - B. Acute appendicitis
  - C. Ascites
  - D. Incidental finding during unrelated abdominal surgery
  - E. Chronic anemia
45. A 40-year-old man undergoes an appendectomy for acute appendicitis. Final pathology reveals a 1.1-cm carcinoid at the base of the appendix. Lymph nodes are negative. Which of the following is true about this condition?
- A. No further treatment is necessary.
  - B. There is a significant chance that carcinoid syndrome will develop in the patient.
  - C. The patient should receive chemotherapy.
  - D. The patient should undergo re-exploration and a right colectomy.
  - E. Most appendiceal carcinoids are 2.5 cm or larger when discovered.
46. A 10-year-old boy with acute myelogenous leukemia presents with right lower quadrant abdominal pain and tenderness. He recently completed chemotherapy. His temperature is 102°F and WBC count is 900 cells/ $\mu$ L. A CT scan reveals inflammation and thickening of the right colon and stranding in the adjacent fat. Management consists of:
- A. IV antibiotics, bowel rest, and IV fluids
  - B. Right hemicolectomy with primary ileotransverse colostomy
  - C. Right hemicolectomy with ileostomy and mucous fistula
  - D. Cecostomy
  - E. Appendectomy
47. A 65-year-old woman presents with a massive lower GI bleed. Her initial blood pressure in the ED is 80/60 mm Hg, with a heart rate of 120 beats per minute. After volume resuscitation, the blood pressure increases to 120/80 mm Hg. A nasogastric aspirate is negative for blood. The next step in her management is:
- A. Colonoscopy
  - B. Mesenteric arteriography
  - C. Tagged red cell scan
  - D. Proctoscopy
  - E. Exploratory laparotomy
48. A 65-year-old institutionalized patient presents with a 2-day history of abdominal distention, nausea, and obstipation. Physical examination is significant for marked distention with mild diffuse abdominal tenderness, no guarding, and no rebound. The WBC count is 10,000 cells/ $\mu$ L. Plain films reveal a massively dilated, inverted U-shaped (omega sign) loop of bowel. Management should

consist of:

- A. Endoscopic detorsion
  - B. Endoscopic detorsion followed by elective sigmoid colectomy
  - C. Endoscopic detorsion followed by elective sigmoid colectomy in the case of a recurrence
  - D. Exploratory laparotomy with sigmoid colectomy, on-table lavage, and primary anastomosis
  - E. Exploratory laparotomy with sigmoid colectomy, proximal colostomy, and oversew rectal stump.
49. Which of the following is true about hereditary nonpolyposis colon cancer (HNPCC) (Lynch syndrome)?
- A. It is not associated with a higher risk of upper genitourinary tract cancer.
  - B. It is considered an autosomal recessive syndrome.
  - C. Screening colonoscopy should begin at age 12.
  - D. Colonic malignancy has the same prognosis as sporadic cancer.
  - E. Modified Amsterdam criteria requires 1 family member to be diagnosed before age 40.
50. Which of the following is true about colonic physiology?
- A. The colon absorbs the majority of water in the gastrointestinal tract.
  - B. Sodium is absorbed actively via  $\text{Na}^+, \text{K}^+$ -ATPase.
  - C. Ammonia reabsorption is unaffected by luminal pH.
  - D. Chloride is secreted.
  - E. It produces no nutrients.
51. A 55-year-old woman undergoes laparoscopy for presumed appendicitis. At surgery, she is found to have perforated appendicitis with what appears to be peritoneal studding. The patient undergoes appendectomy and biopsy of the peritoneum. Final pathology reveals appendiceal adenocarcinoma. Subsequent workup reveals no evidence of additional metastatic spread to the liver or lungs. Further treatment would consist of:
- A. No further treatment
  - B. Systemic chemotherapy
  - C. Intraperitoneal chemotherapy
  - D. Cytoreductive surgery and hyperthermic intraperitoneal chemotherapy
  - E. Cytoreductive surgery and systemic chemotherapy

## Answers

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1. **D.** Pneumoperitoneum in a symptomatic patient almost always necessitates emergency surgery and is often due to visceral perforation (A, B). However, colonoscopy (less so with diagnostic versus therapeutic) can lead to benign pneumoperitoneum and is believed to be due to microperforation and/or the transmural passage of air secondary to insufflation. Patients with benign pneumoperitoneum, no abdominal pain, and no systemic signs of sepsis (fever, leukocytosis) can be treated with IV antibiotics and bowel rest. Due to the scarcity of benign pneumoperitoneum in the literature, these recommendations are based on several case reports and one prospective study. Serial abdominal exam should also be performed but in addition to admission, antibiotics and bowel rest (C). The patient should not be discharged home if there is concern for a perforated viscus (E).
- Reference:** Pearl, J. P. (2006). Benign pneumoperitoneum after colonoscopy: a prospective pilot study. *Military Medicine*, 171(7), 648–649.
2. **D.** Parastomal hernias are a relatively common complication of stoma creation with an estimated occurrence rate as high as 50% with end colostomy having the highest risk and loop ileostomy having the lowest risk (E). Other risk factors include older age, wound infection, obesity, malnutrition, immunosuppression, inflammatory bowel disease (IBD), and COPD (A). While parastomal hernia can be asymptomatic, the estimated reoperation rate for patients with this condition is somewhere around 30%. A study published in the *World Journal of Surgery* in 2010 demonstrated a reduction of parastomal hernia rate from 55% to 7.8% with the placement of mesh

during the index operation. Another study showed reduction of clinically significant parastomal hernia but no difference in CT detectable parastomal hernias with the use of mesh. Prophylactic mesh placement is being used more commonly as more studies suggest improved outcomes. Patients with asymptomatic parastomal hernia should be managed with a support device such as a hernia belt and weight loss. However, this patient is complaining of pain and difficulty applying his colostomy bag, which are both indications for repair or relocation of the stoma (B). Prosthetic mesh repair is considered the preferred surgical approach because relocating the stoma is associated with the same high risk of hernia formation as the initial stoma (C).

**References:** Hiranyakas, A., & Ho, Y. H. (2010). Laparoscopic parastomal hernia repair. *Diseases of the Colon & Rectum*, 53(9), 1334–1336.

Kann, B. (2008). Early stomal complications. *Clinical Colon Rectal Surgery*, 21(1), 23–30.

Tam, K., Wei, P., Kuo, L., et al. (2010). Systematic review of the use of a mesh to prevent parastomal hernia. *World Journal of Surgery*, 34(11), 2723–2729.

Vierimaa, M., Klintrup, K., Biancari, F., et al. (2015). Prospective, randomized study on the use of a prosthetic mesh for prevention of parastomal hernia of permanent colostomy. *Diseases of the Colon and Rectum*, 58(10), 943–949.

3. **D.** Ischemia or necrosis of the stoma is a recognized complication of a colostomy creation. It is more likely to occur in situations in which the inferior mesenteric artery was ligated high, near the aorta, such that the stoma is relying on the marginal artery. It is important to evaluate the extent of ischemia before proceeding directly to the operating room. This is can be accomplished by placing a clear test tube into the ostomy and using a penlight to evaluate the mucosa down to the level of the fascia or via endoscopy. If the ischemia is evident down to the level of the fascia, the patient needs re-exploration and revision because otherwise it may progress to full-thickness necrosis, perforation, and stool spillage into the peritoneum. The type of operation will depend on the extent of ischemia (A–C). In contrast, if the ischemia is superficial, it can be observed, and a mucosa-cutaneous junction will form by secondary intention. This may lead to recession of the stoma or stricture, but this can be dealt with later when the patient recovers from surgery. In addition, in a morbidly obese patient, it may be technically difficult, if not impossible, to gain additional length to refashion the stoma, so a return to the OR should be avoided if it can be done safely. There is no role for IV antibiotics (E).

**Reference:** Kim, J. T., & Kumar, R. R. (2006). Reoperation for stoma-related complications. *Clinical Colon Rectal Surgery*, 19(4), 207–212.

4. **B.** This patient has a stercoral ulceration complicated by perforation. This is a rare condition occurring primarily in elderly patients suffering from chronic constipation. It is thought that a hard fecaloma leads to local ischemia, ulcer formation, and subsequent perforation. The antimesenteric border of the rectosigmoid colon is the most likely location owing to its unique characteristics including lower water content, poorer bloody supply, and higher pressure secondary to a narrowed intraluminal diameter (A–E). The diagnosis is suggested with the following four criteria: (1) a round antimesenteric colonic perforation > 1 cm in diameter; (2) colon full of stool protruding through the perforation site; (3) evidence of multiple pressure ulcers and acute inflammation around the perforation; and (4) absence of external injury, diverticulitis, or obstruction due to neoplasms or adhesions. Patients most commonly present with diffuse abdominal pain and fever. The diagnosis is seldom made before surgery. Since inflammation and ulcer formation extend beyond the immediate bowel surrounding the perforation, a simple closure or limited colonic resection should be avoided (C). Thus a formal colon resection with proximal colostomy (Hartman's procedure) is recommended. Stercoral ulcer perforation has a high mortality rate. Chronic constipation is a common problem affecting many people but stercoral ulceration is rare suggesting that there may be additional predisposing factors contributing to this entity. Several reports have shown an association of NSAID use with the development of stercoral perforation. Additionally, anticholinergic agents will worsen chronic constipation and contribute to this complication (D).

**References:** Huang, W. S., Wang, C. S., Hsieh, C. C., et al. (2006). Management of patients with stercoral perforation of the sigmoid colon: report of five cases. *World Journal of Gastroenterology*, 12(3), 500–503.

Mauer, C. A., Renzulli, P., Mazzucchelli, L., et al. (2000). Use of the accurate diagnostic criteria may increase incidence of stercoral perforation of the colon. *Diseases of the Colon and Rectum*, 43(7), 991–



998.

Patel, V. G., Kalakuntia, V., Fortson, J. K., et al. (2002). Stercoral perforation of the sigmoid colon: report of a rare case and its possible association with nonsteroidal anti-inflammatory drugs. *The American Surgeon*, 68(1), 62–64.

Serpell, J. W., & Nicholls R. J. (1990). Stercoral perforation of the colon. *The British Journal of Surgery*, 77(12), 1325–1329.

5. **B.** This patient has acute colonic pseudo-obstruction or Ogilvie's syndrome. It often occurs in critically ill patients without any signs of mechanical obstruction. The pathophysiology is not completely understood, is likely multifactorial, and is thought to occur secondary to paralysis of the bowel allowing for passive distention. Stable patients without any systemic signs of compromised bowel should initially undergo conservative management with bowel rest, nasogastric tube suction, decompressive rectal tube, and electrolyte repletion. Neostigmine is a reversible cholinesterase inhibitor that has been demonstrated in randomized controlled trials to have an improved response over placebo (reduction in cecum diameter of 5 cm compared to 2 cm). Up to 80% to 90% of patients have a favorable response to a single IV injection of 2 mg neostigmine (D). For those that do not respond, a second and third administration can be given (E). Alternatively, a continuous infusion of neostigmine at a rate of 0.4 to 0.8 mg/hour over 24 hours can be given and has been shown to have successful results (C). Contraindications to the use of neostigmine include acute urinary retention, acute coronary artery syndrome, asthma, bronchospasm, and second or third degree heart block (A). All patients being given neostigmine should be placed on cardiac monitoring and a syringe prefilled with atropine should be placed at bedside and ready for immediate use.

**References:** Harrison, M. E., Anderson, M. A., Appalaneni, V., et al. (2010). The role of endoscopy in the management of patients with known and suspected colonic obstruction and pseudo-obstruction. *Gastrointestinal Endoscopy*, 71(4), 669–679.

Ponec, R. J., Saunders, M. D., & Kimmey, M. B. (1999). Neostigmine for the treatment of acute colonic pseudo-obstruction. *The New England Journal of Medicine*, 341(3), 137–141.

Van der Spoel, J., Oudemans-van Straaten, H. M., Stoutenbeek, C. P., et al. (2001). Neostigmine resolves critical illness-related colonic ileus in intensive care patients with multiple organ failure—a prospective, double-blind, placebo-controlled trial. *Intensive Care Medicine*, 27(5), 822–827.

6. **C.** If conservative therapy fails in the management of Ogilvie's syndrome or if there is any concern for compromised bowel, surgery should be considered. The three surgical options include tube colostomy, transanal insertion of a long multiperforated drainage tube, and total or subtotal colectomy with an ostomy. If during laparotomy there is no evidence of ischemic or perforated colon, then colectomy can be avoided (E). In this scenario, a right transverse or left lower quadrant sigmoid colostomy tube is often used with a success rate of 95%. This functions as a “blow-hole” colostomy at one or several points in the bowel and is more effective than a formal colostomy at providing pressure relief. A less effective option includes the transanal insertion of a large multiperforated tube (Faucher tube) guided to the proximal edge of dilated colon by the surgeon's hands (D). Next, the surgeon performs manual compressive maneuvers to milk the colonic content toward the tube. If there is any concern of compromised bowel, a total or subtotal colectomy should be performed. Primary anastomosis should be avoided because this has a high leak rate (A, B). This is a highly morbid procedure with mortality estimated to be up to 40%.

**References:** Caves, P. K., et al. (1970). Pseudo-obstruction of the large bowel. *British Medicine Journal*, 2(5709), 583.

Vanek, V. W., et al. (1986). Acute pseudo-obstruction of the colon (Ogilvie's syndrome). *Diseases of the Colon and Rectum*, 29(3), 203–210.

7. **B.** PSC is a progressive and destructive disease of the entire biliary tree secondary to an inflammatory process. It is estimated that up to 80% of patients with PSC have IBD with UC being most common. It has been demonstrated that PSC significantly increases the risk of colorectal cancer in these patients. UC patients should typically undergo screening colonoscopy with random biopsies starting 8 years from the time of their IBD diagnosis (C). However, patients diagnosed with PSC should receive a colonoscopy with random biopsies promptly at the time of PSC diagnosis and continue every 1 to 2 years thereafter. Patients without IBD or family history of colorectal cancer should begin screening at age 50 or after presenting with worrisome symptoms (D, E). Patients with family history of colorectal cancer should begin screening 10 years before the

age of diagnosis of any first-degree relative with colorectal cancer.

**References:** Razumilava, N., Gores, G. J., & Lindor, K. D. (2011). Cancer surveillance in patients with primary sclerosing cholangitis. *Hepatology*, 54(5), 1842–1852.

Zheng, H. H., & Jiang, X. L. (2016). Increased risk of colorectal neoplasia in patients with primary sclerosing cholangitis and inflammatory bowel disease: a meta-analysis of 16 observational studies. *European Journal of Gastroenterology & Hepatology*, 28(4), 383–390.

8. **D.** Anastomotic leakage following colorectal cancer surgery can result in increased morbidity and mortality. In addition, leaks increase the risk of local recurrence and worsen cancer-specific survival. Numerous studies have analyzed risk factors for anastomotic leakage following colorectal surgery for cancer. Factors associated with an increased incidence of anastomotic leakage in patients with colorectal cancer undergoing low anterior resection include those with a lower rectal cancer (<7 cm from anal verge), tumor size larger than 5 cm, multiple firing of the linear stapler, lateral lymph node dissection, prolonged operative time (>5 hours), high ASA score, male gender, and significant operative bleeding (A, B, E). The role of perioperative NSAIDs in the development of anastomotic leaks is controversial. However, several studies have shown an association, most recently with ketorolac (C). Thus, such drugs should be avoided if possible. Routine diversion is not indicated but should be considered if there are any of the aforementioned factors present.

**References:** Kawada, K., Hasegawa, S., Hida, K., et al. (2014). Risk factors for anastomotic leakage after laparoscopic low anterior resection with DST anastomosis. *Surgical Endoscopy*, 28(10), 2988–2995.

Bakker, I. S., Grossmann, I., Henneman, D., et al. (2014). Risk factors for anastomotic leakage and leak-related mortality after colonic cancer surgery in a nationwide audit. *The British Journal of Surgery*, 101(4), 424–432.

9. **E.** Pouchitis is a nonspecific inflammation of the ileal reservoir that can occur after an ileoanal pouch creation or in a continent ileostomy reservoir. Pouchitis can be acute or can become chronic. Symptoms include increased diarrhea, hematochezia, abdominal pain, fever, and malaise. The diagnosis is established via a combination of the history, endoscopic findings, and histology from biopsy samples. Endoscopy with biopsy is important to rule out undiagnosed Crohn disease (A). It is the most common long-term complication of this procedure, with an incidence as high as 30% to 55% (B). The cause is unknown; it may be due to fecal stasis within the pouch, but emptying studies do not confirm this. A recent Cochrane study showed that ciprofloxacin is more effective than metronidazole for inducing remission of acute pouchitis. Most patients will respond rapidly to either oral preparations or enemas. Patients with chronic pouchitis may require ongoing suppressive antibiotic therapy. Salicylate and stool enemas have also been used with some success. Reintroduction of normal flora by probiotics has been shown to be useful in chronic cases (C). Rarely, the pouch requires excision, but this would not be done urgently (D).

**References:** Gionchetti, P., Amadini, C., Rizzello, F., et al. (2003). Diagnosis and treatment of pouchitis. *Best Practice & Research Clinical Gastroenterology*, 17(1), 75–87.

Holubar, S. D., Cima, R. R., Sandborn, W. J., et al. (2010). Treatment and prevention of pouchitis after ileal pouch-anal anastomosis for chronic ulcerative colitis. *Cochrane Database Systematic Reviews*, 6, CD001176.

Madiba, T., & Bartolo, D. (2001). Pouchitis following restorative proctocolectomy for ulcerative colitis: incidence and therapeutic outcome. *Journal of the Royal College of Surgeons Edinburgh*, 46(6), 334–337.

Shen, B., Achkar, J. P., Lashner, B. A., et al. (2001). A randomized clinical trial of ciprofloxacin and metronidazole to treat acute pouchitis. *Inflammatory Bowel Diseases*, 7(4), 301–305.

10. **E.** FAP is a rare autosomal dominant disease that accounts for approximately 1% of colon cancers. It is due to a mutation in the adenomatous polyposis coli (APC) tumor suppressor gene on chromosome 5q. Syndromes that are considered variants of FAP include attenuated FAP (delayed polyp growth), Turcot syndrome, and Gardner syndrome. If unrecognized or untreated, cancer can develop in all patients by age 35 to 40 years, and, in fact, polyps often begin at puberty. They eventually can develop thousands of polyps. As such, first-degree relatives of FAP patients who are APC positive should begin screening at age 10 to 12 years by flexible sigmoidoscopy (C). Relatives who are APC mutation negative can wait until age 50 for screening because they are considered to have the same risk as the normal population. Adenomas can develop throughout the

gastrointestinal (GI) tract in FAP patients, and in particular in the duodenum, and patients are at risk of the development of periampullary carcinoma. Therefore, upper endoscopy for surveillance every 1 to 3 years starting at age 25 to 30 years should be recommended. Prophylactic proctocolectomy does not decrease the risk of developing periampullary carcinoma, and it remains a common cause of morbidity in this patient population (D). Once the diagnosis of FAP has been made and polyps are developing, treatment is surgical. FAP may also be associated with extraintestinal manifestations such as congenital hypertrophy of the retinal pigment epithelium, desmoid tumors, epidermoid cysts, mandibular osteomas, and central nervous system tumors (B). In a small number of sporadic colon cancers, microsatellite instability leads to impaired DNA mismatch repair and thus, inability to ensure the fidelity of a copied DNA strand, increasing the risk for developing cancer (A).

11. **E.** The risk of the development of colon cancer in patients with UC increases with time. By 20 years, colon cancer will develop in approximately 10% of patients. Thus, surveillance colonoscopy is recommended. Colon cancer develops in UC in the absence of polyps. In addition, areas of dysplasia may not be readily apparent on standard colonoscopy. As such, once a patient has had UC for 8 years, colonoscopic surveillance is recommended annually thereafter. In addition to biopsies of areas of suspicion, random biopsies are recommended because flat dysplasia develops in these patients. The finding of even high-grade dysplasia is an indication for surgery. Repeat colonoscopy would be inappropriate (A). Some authors recommend surgery even for low-grade flat dysplasia because the risk of malignancy is also significantly increased; a recent meta-analysis demonstrated that these patients have a nine times increased risk of having colorectal cancer compared with patients that are dysplasia free. Dysplasia in a flat (nonpolypoid) lesion is concerning because it is more difficult to monitor with follow-up screening. The curative operation is a restorative proctocolectomy with an ileal pouch–anal anastomosis (B–D). In addition to dysplasia, the indications for colectomy in patients with UC include toxic megacolon, severe lower GI bleeding, and intractable disease that does not respond to medical management.

**References:** Ullman, T., Croog, V., Harpaz, N., et al. (2003). Progression of flat low-grade dysplasia to advanced neoplasia in patients with ulcerative colitis. *Gastroenterology*, 125(5), 1311–1319.

Thomas, T., Abrams, K. A., Robinson, R. J., et al. (2007). Meta-analysis: cancer risk of low-grade dysplasia in chronic ulcerative colitis. *Aliment Pharmacology and Therapeutics*, 25(6), 657–668.

12. **B.** Mucosal edema is the earliest finding on endoscopy. As the disease advances, friable mucosa and ulcerations develop (A). A “lead pipe” colon is a feature of long-standing UC seen on barium enema and is the result of a loss of haustral markings and shortening of the colon. Although crypt abscesses are almost always seen with UC, other inflammatory conditions of the colon can also present with crypt abscesses (E). Findings on gross appearance in Crohn colitis that are not characteristic of UC include a thickened mesentery, thickened bowel wall, segmental disease, and “creeping fat” or “fat wrapping.” On microscopic examination, Crohn disease is transmural, whereas UC is limited to the mucosa and submucosa. Noncaseating granulomas are a hallmark feature of Crohn disease, whereas crypt abscesses are characteristic of UC. Plasmacytosis (increase in plasma cells in lamina propria) can be found in both UC and Crohn disease (D). Pseudopolyps are seen in both UC and Crohn disease.

13. **D.** It is important to remember that appendiceal perforation is the most important variable in determining fetal mortality during pregnancy; thus, it is imperative to make the diagnosis early. Conversely, a general anesthetic increases the risk of premature labor. A recent large study was conducted comparing appendicitis in more than 3000 pregnant women with more than 94,000 nonpregnant women. The study found that the rate of negative appendectomy was higher in pregnant compared with nonpregnant women (23% vs 18%). Rates of fetal loss and early delivery were considerably higher in women with complex appendicitis (6% and 11%, respectively) compared with negative (4% and 10%, respectively) and simple (2% and 4%, respectively) appendicitis. Complex appendicitis and a negative appendectomy remained risks for fetal loss on multivariate analysis. Interestingly, laparoscopy was associated with a higher rate of fetal loss compared with open appendectomy (odds ratio of 2.31) (B). Ultrasonography has been extremely useful in helping diagnose appendicitis. If findings are equivocal, magnetic resonance imaging (MRI) should be performed. One must strive to avoid unnecessary appendectomies that place the fetus at risk; however, delays in operative care for appendicitis likewise place the fetus at risk.

**References:** McGory, M., Zingmond, D., Tillou, A., et al. (2007). Negative appendectomy in pregnant

women is associated with a substantial risk of fetal loss. *Journal of the American College of Surgeons*, 205(4), 534–540.

Lim, H. K., Bae, S. H., & Seo, G. S. (1992). Diagnosis of acute appendicitis in pregnant women: value of sonography. *American Journal of Roentgenology*, 159(3), 539–542.

14. **B.** Diverticulitis is divided into simple and complicated diverticulitis. Simple diverticulitis is limited to patients with pericolonic inflammation and/or phlegmon. Complicated cases include those associated with free perforation, abscess, fistula, obstruction or stricture. Hinchey devised the following staging system: stage I, pericolonic inflammation with pericolic abscess; stage II, retroperitoneal or pelvic abscess; stage III, purulent peritonitis; and stage IV, fecal peritonitis. Most surgeons consider Hinchey III-IV as complicated cases of diverticulitis. Stage I is treated with IV antibiotics (E). Complicated diverticulitis is treated surgically. Patients with small abscesses (<4 cm) can be treated with antibiotics alone initially, followed in several weeks by elective colectomy after colonoscopy to rule out other etiologies (D). If the abscess is larger than 4 cm, initial CT-guided drainage is recommended, followed by colonoscopy and elective sigmoid colectomy (C). Previously, patients with Hinchey III-IV received an urgent operation but it is now recommended to attempt non-operative management to provide the patient with a single stage operation. However, patients with diffuse peritonitis or overwhelming sepsis require urgent surgery without delay; Hartmann procedure (proximal colostomy and distal oversew of rectal stump) is often performed. A second stage takedown of the ostomy is performed 6–8 weeks later (A).

**References:** Feingold, D., Steele, S. R., Lee, S., Kaiser, A., Boushey, R., Buie, W. D., & Rafferty, J. F. (2014). Practice parameters for the treatment of sigmoid diverticulitis. *Diseases of the Colon & Rectum*, 57(3), 284–294.

Siewert, B., Tye, G., Kruskal, J., et al. (2006). Impact of CT-guided drainage in the treatment of diverticular abscesses: size matters. *American Journal of Roentgenology*, 186(3), 680–686.

15. **B.** Familial juvenile polyposis is an autosomal dominant (A) disorder (just like hereditary nonpolyposis colon cancer [HNPCC], FAP, and Peutz-Jeghers syndrome). It is a completely different entity from FAP. The polyps are hamartomas (also called *juvenile polyps*), not adenomas. Hamartomas are benign growths composed of histologically normal and mature cells found in abnormal locations and configurations. However, the hamartomas can degenerate into adenomas and malignancy. Thus, there is a risk of colon cancer, but not to the same degree as with FAP. The lifetime risk is approximately 10% to 38% (versus 100% for FAP) (C). Because of this risk and because many polyps occur on the right side, colonoscopic (rather than flexible sigmoidoscopic) surveillance is recommended, beginning at approximately 10 to 12 years of age. Unlike FAP, in which the presence of polyps equates with a need for a restorative proctocolectomy, if a polyp is seen, it should be snared and sent to pathology (D). In most instances, it will be a hamartoma. If adenomatous changes are seen, then a colectomy should be performed, and if the rectum is spared, an ileorectal anastomosis can be done with close surveillance. Approximately 15% to 20% of Peutz-Jeghers syndrome patients develop stomach or duodenal cancers, so upper endoscopic surveillance is recommended by age 25 (E).

**References:** Dunlop M. (2002). Guidance on gastrointestinal surveillance for hereditary non-polyposis colorectal cancer, familial adenomatous polyposis, juvenile polyposis, and Peutz-Jeghers syndrome. *Gut*, 51(Suppl. 5), v21–v27.

Howe, J., Mitros, F., & Summers, R. (1998). The risk of gastrointestinal carcinoma in familial juvenile polyposis. *Annals of Surgical Oncology*, 5(8), 751–756.

16. **B.** Isolated hyperplastic polyps are widely prevalent and not considered premalignant. About 85% of the population will develop at least one hyperplastic polyp by age 65. However, patients with hyperplastic polyposis syndrome can present with upward of 100 polyps in the colon, some of which are premalignant. Patients with this syndrome are considered to be at an increased risk for colon cancer. Adenomatous polyps are considered neoplastic and are divided into three types: tubular (<5% risk of malignancy), tubulovillous (20% risk of malignancy), and villous (40% risk of malignancy) (A). Polyp size is also an important determinant, with polyps smaller than 1 cm having an extremely low risk of malignancy versus a nearly 50% risk of malignancy in polyps larger than 2 cm. The location of a polyp does not affect the risk of malignancy (E). Most colon cancers develop from adenomatous polyps. Peutz-Jeghers syndrome is characterized by hamartomatous polyps (C). They present with GI bleeding and intussusception. Although hamartomatous polyps are not considered premalignant, they can degenerate into adenomatous polyps, so there is a risk

of malignancy. The polyps in Peutz-Jeghers syndrome occur primarily in the small intestine, but they can also occur in the colon and rectum. Patients have melanin spots on the buccal mucosa and lips. Because of the diffuse nature of polyps throughout the GI tract, surgery is only indicated if there is evidence of obstruction or bleeding or evidence that a polyp has undergone adenomatous change. Inflammatory polyps or pseudopolyps are islands of regenerating mucosa seen most often in IBD (D).

**References:** Correa, P., Strong, J. P., Reif, A., et al. (1977). The epidemiology of colorectal polyps: prevalence in New Orleans and international comparisons. *Cancer*, 39(5), 2258–2264.

Hyman, N. H., Anderson, P., Blasyk, H. et al. (2004). Hyperplastic polyposis and the risk of colorectal cancer. *Diseases of the Colon and Rectum*, 47(12), 2101–2104.

17. C. Ischemic colitis occurs primarily in elderly patients at an average age of 70 years and may present with lower GI bleeding. Fecal immunochemical test has replaced the older fecal occult guaiac blood test because it has been shown to have superior adherence, usability, accuracy, sensitivity, and better detection of occult bleeding. Unlike acute small bowel ischemia, which develops in association with mesenteric arterial or venous occlusive disease, colonic ischemia is rarely the result of major vascular occlusion. Rather, it usually occurs as a result of a low-flow state, such as severe dehydration. As such, mesenteric angiography is typically not helpful (E). It tends to develop in watershed areas of blood supply, such as the splenic flexure (most common), known as Griffith's point, where collaterals are present between the superior mesenteric artery and inferior mesenteric artery (specifically, the middle colic artery and the ascending branch of the left colic artery, respectively); Sudeck's critical point (rectosigmoid junction), where collaterals are present between the sigmoid artery and superior rectal artery; and the ileocecal area. In addition to advanced age, risk factors for ischemic colitis include underlying cardiovascular disease, diabetes, vasculitis, and hypotension. Most cases are mild and result in painless, bloody diarrhea. More severe cases can result in bacterial translocation with fever and leukocytosis or, rarely, full-thickness necrosis with peritonitis. The diagnosis is via a combination of the history and examination, plain films to rule out an acute abdomen and that sometimes will show signs of mucosal edema (thumb printing), and CT scan (nonspecific colonic wall edema and fat stranding). The surgeon needs to be aware that the differential diagnosis includes colon cancer and IBD. As such, colonoscopy should eventually be performed, although it is not necessary in the acute phase (D). The exception is ischemic colitis after aortic surgery, in which case the endoscopy assists in the diagnosis, and CT scan findings may be hard to interpret due to postsurgical changes. Most patients are treated medically with bowel rest and broad-spectrum antibiotics. Surgery is reserved for patients who deteriorate and/or have evidence of diffuse peritonitis (A, B).

**References:** Balthazar, E., Yen, B., & Gordon, R. (1999). Ischemic colitis: CT evaluation of 54 cases, *Radiology*, 211:381–388.

Schreuders, E. H., Grobbee, E. J., Spaander, M. C., et al. (2016). Advances in fecal tests for colorectal cancer screening. *Current Treatment Options in Gastroenterology*, 14(1), 152–162.

18. A. Pseudomembranous colitis is predominantly due to *Clostridium difficile*. It is thought to primarily be due to antibiotic administration leading to the elimination of healthy bacteria in the gut and a subsequent overgrowth of *C. difficile*. However, not all cases have a history of recent antibiotic use (E). The antibiotic most commonly implicated is clindamycin, but it can occur with any antibiotic, even after just one dose, and as late as 4 to 5 weeks later. *C. difficile* produces at least two toxins, toxin A and toxin B, which can be detected in the stool and is usually all that is required to begin treatment. However, most hospitals now use a polymerase chain reaction (PCR) test because it is quicker and more accurate. If laboratory studies are unable to confirm the disease but suspicion for pseudomembranous colitis is high, the patient can undergo sigmoidoscopy to look for the classic yellow plaques called *pseudomembranes* (D). However, most clinicians elect to presumptively treat patients. Pseudomembranous colitis can progress to life-threatening toxic megacolon, which requires emergent total colectomy. Treatment for uncomplicated *C. difficile* colitis (WBC < 15,000 cells/μL and serum creatinine < 1.5× the premorbid levels) as outlined by the Infectious Disease Society guidelines involves immediately discontinuing all antibiotics and instituting oral metronidazole for 10 to 14 days. The first recurrence is also treated with a repeat 10- to 14-day course of oral metronidazole. Oral vancomycin is considered the drug of choice for a second recurrence and all complicated cases of *C. difficile* colitis (B). Oral vancomycin is not absorbed systemically and achieves predictably high levels in the colon while IV vancomycin is not

excreted appreciably into the colon and thus has no effect in treating *C. difficile* colitis (C).

**Reference:** Hurley, B., & Nguyen, C. (2002). The spectrum of pseudomembranous enterocolitis and antibiotic-associated diarrhea. *Archives of Internal Medicine*, 162(19), 2177–2184.

19. E. Cecal or cecocolic volvulus is much less common than sigmoid volvulus. It occurs in younger patients. There are two types including axial ileocolic volvulus (90%) and cecal bascule (10%). In the former, the cecum rotates up and over to the left upper quadrant. Cecal bascule occurs when the cecum flips upward and anterior in a horizontal plane. It is thought to be due to a congenital anomaly leading to a lack of fixation of the cecum to the retroperitoneum, and as such, the terminal ileum, cecum, and ascending colon twist and can become ischemic. It can sometimes be hard to diagnose radiographically because the patient will often also demonstrate dilated loops of small bowel with air–fluid levels, giving the appearance of a small bowel obstruction. Unlike sigmoid volvulus, endoscopic decompression for cecal volvulus is very difficult (D). The treatment of choice is to perform a right hemicolectomy with primary anastomosis (despite no bowel preparation). There is a high recurrence rate after operative detorsion and cecopexy (B). If the right colon is already gangrenous (e.g., leukocytosis, acidosis, high fever, peritonitis), right hemicolectomy with ileostomy and mucus fistula is the treatment of choice (C). However, this patient's presentation makes this finding unlikely.

**Reference:** Habre, J., Sautot-Vial, N., Marcotte, C., et al. (2008). Caecal volvulus. *American Journal of Surgery*, 196(5), e48–49.

20. D. Sigmoid diverticular disease is thought to occur due to a low-fiber diet leading to constipation. A long, redundant colon, found in populations that have a high-fiber diet, increases the risk of developing volvulus (E). Sigmoid diverticula are considered false because they are composed of only mucosa and submucosa. They occur at points of weakness between the taeniae coli where blood vessels penetrate the colonic wall. They occur most commonly in the sigmoid colon on the mesenteric side of the antimesenteric taenia (A). They occur due to increased intraluminal pressure so they are considered pulsion diverticula. Because the taeniae splay out at the rectum, diverticula do not develop in the rectum (B). Asymptomatic diverticula (sigmoid or cecal) do not require surgical management (C). Patients deemed surgical candidates for sigmoid resection are best served with a mechanical bowel preparation with IV and oral perioperative antibiotics. This decreases the rate of surgical site infection by more than 50%.

**Reference:** Kim, E. K., Sheetz, K. H., Bonn, J., et al. (2014). A statewide colectomy experience: the role of full bowel preparation in preventing surgical site infection. *Ann Surg*, 259(2), 310–314.

21. C. Purulent fluid found at appendectomy is indicative of peritonitis. The finding of a large amount of purulent fluid in the absence of a perforation in the appendix should alert the clinician to another diagnosis and should prompt a careful search for another source of perforation. Periappendicitis is a distinct clinical entity that signifies inflammation of the serosa of the appendix, but not a transmural inflammation, as is seen with appendicitis. The serosa becomes inflamed in response to another inciting infection, most often in association with acute salpingitis in women or another GI perforation, such as a perforated ulcer. The clinical presentation of a perforated duodenal ulcer can mimic appendicitis, particularly if the perforation seals and the spilled gastroduodenal contents gravitate down the right gutter to the cecal area. Silent 1920s film star Rudolph Valentino reportedly died of a perforated ulcer, although he presented with right lower quadrant pain suggestive of acute appendicitis (since known as Valentino's syndrome). Acute mesenteric adenitis (A) is often preceded by an upper respiratory infection, more common in children, and presents with a vague and diffuse tenderness without significant guarding as opposed to the localized tenderness seen with acute appendicitis. Familial Mediterranean fever, or Armenian disease, occurs primarily in Armenian or Mediterranean populations and can cause a polyserositis (B). It would not cause periappendicitis. Tuberculosis (D) is also not likely to lead to periappendicitis. Primary peritonitis (E) occurs most often in patients with nephrotic syndrome or cirrhosis who have ascites that becomes infected, typically by gram-positive cocci.

**References:** Fink, A., Kosakowski, C., Hiatt, J., et al. (1990). Periappendicitis is a significant clinical finding. *American Journal of Surgery* 159(6), 564–568.

Hsu, C. C., Liu, Y. P., Lien, W. C., et al. (2005). A pregnant woman presenting to the ED with Valentino's syndrome. *The American Journal of Emergency Medicine*, 23(2), 217–218.

Maardh, P., Woelner-Hanssen, P. (1985). Periappendicitis and chlamydial salpingitis. *Surgery Gynecology Obstetrics*, 160(4), 304–306.



Sarkisian, T., Ajrapetian, H., Beglarian, A., et al. (2008). Familial Mediterranean fever in Armenian population. *Georgian Medical News*, 156, 105–111.

22. **E.** Patients who present with a protracted history consistent with acute appendicitis and a palpable mass are likely to have a perforated and walled-off abscess. They are best managed by nonoperative therapy (IV antibiotics, bowel rest). Several large studies have shown a low recurrence rate in patients that undergo nonoperative management, so the paradigm in acute care surgery has now shifted such that interval appendectomy is not performed in most patients with a perforated appendicitis. Taking such a patient to the operating room for an open or laparoscopic appendectomy is acceptable (C, D). However, the intense inflammation and scarring will make the operation difficult and significantly increase the chances of having to perform an ileocecectomy (E). Additionally, routine CT-guided drainage of abscesses is not recommended particularly when the abscess is small (A).

**Reference:** Kaminski, A., Liu, I. L., Applebaum, H., et al. (2005). Routine interval appendectomy is not justified after initial nonoperative treatment of acute appendicitis. *Archives of Surgery*, 140(9), 897–901.

23. **D.** In determining management of this case, one must consider the indications for the colonoscopy, the timing of the perforation, and the intraoperative findings. Because the polyp is pedunculated and benign appearing, one can presume that it has been completely removed and that further colon resection is not needed. The vast majority of colonic injuries, whether iatrogenic or from penetrating trauma, can be repaired primarily. Furthermore, this patient has presumably undergone a bowel prep, so the bacterial load is decreased. Resection with colostomy (A–C) would be reserved for patients with long-standing perforation and diffuse fecal contamination. Conservative management (E) would be inappropriate for a patient with an iatrogenic and symptomatic colonic perforation.

24. **E.** The patient has a cecal fistula. The most common causes are slippage of the suture or necrosis of the remaining appendiceal stump. Colocutaneous fistulas, being low-output fistulas, are not associated with losses of large amounts of fluid, electrolytes, and nutrients. Therefore, total parenteral nutrition is not necessary to maintain adequate nutrition (A). Spontaneous closure is the rule in the majority of patients. Surgery is not an appropriate initial management option (C, D). Patients can be fed a low-residue diet because absorption is mostly complete by the time the contents reach the cecum. Octreotide does not help in assisting closure of a cecal fistula (B). If the fistula fails to close, one must suspect the possibility of either a neoplasm in the cecum, IBD, tuberculosis, or distal obstruction.

**Reference:** Hale, D., Molloy, M., Pearl, R., et al. (1997). Appendectomy: a contemporary appraisal. *Annals of Surgical*, 225(3), 252–261.

25. **D.** Current guidelines indicate that stage I (node negative, invades submucosa) colon cancer does not need chemotherapy. The role of chemotherapy in stage II (node negative, invades subserosa or direct invasion of adjacent organ) colon cancer remains debatable. The combination of 5-fluorouracil and leucovorin prolongs survival in stage III colon cancer (positive lymph nodes, no distant metastasis) but not stage IV (A). Until recently, there was no effective chemotherapy for stage IV cancers. Two recent drugs have been approved for stage IV colon cancer. They have been shown to prolong life, but not cure this advanced-stage cancer, and are very costly (C). Cetuximab (Erbix) is a monoclonal antibody that targets epidermal growth factor receptor. Bevacizumab (Avastin) is a monoclonal antibody against vascular endothelial growth factor A (E). Radiation therapy is not commonly used in the management of colon cancer but is used commonly in combination with chemotherapy for patients with rectal cancer (B).

26. **B.** This patient has uncomplicated diverticulitis, and the diagnosis can initially be suspected based on a history of fever, leukocytosis, and left lower quadrant pain. After hydration, bowel rest and the institution of broad-spectrum antibiotics, CT scanning is generally recommended to confirm the diagnosis and rule out an abscess. Plain abdominal x-rays are generally not helpful (A). Endoscopy in the acute setting is contraindicated because it would risk causing a perforation (C). However, a colonoscopy should be performed 6–8 weeks later to rule out cancer. Gastrografin enema is typically not necessary, and barium enema would also be contraindicated due to the risk of causing barium peritonitis (D, E).

27. **D.** Diversion colitis can occur after fecal diversion. When the fecal stream is diverted, colonocytes are not exposed to intraluminal nutrients and the deficiency of these compounds can lead to



mucosal atrophy and subsequent inflammatory colitis. Short-chain fatty acids (SCFAs) (acetate, butyrate, and propionate) are produced by bacterial fermentation of dietary carbohydrates such as lactulose. SCFAs are an important source of energy for the colonic mucosa, and their use is considered the first-line treatment (as rectal enema) for diversion colitis. The energy is used by colonocytes for processes such as active transport of sodium. Ketone bodies, glucose, or amino acids (glutamine) are not used as an energy source of colonocytes (A–C, E).

**Reference:** Harig, J., Soergel, K. H., Komorowski, R. A., et al. (1989). Treatment of diversion colitis with short-chain-fatty acid irrigation. *The New England Journal of Medicine*, 320(1), 23–28.

28. **E.** In a patient who tests positive for the *APC* gene, screening via sigmoidoscopy is recommended starting at age 10 to 12 years. Once polyps are detected, the recommendation is to remove the entire colon and rectum (A). Cyclooxygenase-2 inhibitors were shown to slow the growth of polyps in patients with FAP in a randomized study, but recent studies indicated that these drugs increased the risk of death from cardiovascular events (B). The best option is a restorative proctocolectomy with an ileal pouch–anal anastomosis. Total abdominal colectomy with ileorectal anastomosis is another option, but it requires careful lifelong surveillance of the rectal mucosa for polyps (C). Total proctocolectomy with continent ileostomy may be another option, but in a young patient, avoiding an ostomy, if possible, should be considered (D).

29. **B.** All the choices described are associated with acute appendicitis. In fact, Alvarado created a 10-point scoring system for acute appendicitis that included classic migration of pain, anorexia, nausea and vomiting, right lower quadrant tenderness, rebound, fever, leukocytosis, and left shift (A–C). Of these, the highest point assignments were given to right lower quadrant tenderness and leukocytosis. However, the most reproducible and reliable finding is localized tenderness at McBurney's point. With early appendicitis, marked leukocytosis with left shift may not be present. The obturator sign is not a constant finding and occurs primarily when the inflamed appendix lies against the obturator internus muscle within the pelvis (D). Rovsing's sign is pain elicited in the right lower quadrant while palpating the left lower quadrant and is suggestive of peritoneal irritation (E).

**Reference:** Alvarado, A. (1986). A practical score for the early diagnosis of acute appendicitis. *Annals of Emergency Medicine*, 15(5), 557–564.

30. **B.** The most common perianal lesion in Crohn disease is a skin tag, followed by fissures (A). Fissures are tears in the anoderm, and most are superficial and in the posterior midline (poorer blood supply). A deep fissure or one in an unusual location (lateral) should raise concern for Crohn disease. Crohn disease does increase the risk of developing hemorrhoids as well as perianal abscesses and fistulas (C–E). Most patients with anal manifestations will have Crohn disease elsewhere. Perianal involvement is extremely rare with UC.

31. **C.** Distention of the appendix stretches the surrounding *visceral* peritoneum and stimulates its afferent fibers, leading to vague and dull periumbilical pain that later transitions to right lower quadrant pain as the localized somatic fibers of the parietal peritoneum become inflamed (B). Additionally, patients subsequently have a stimulation of peristalsis and reflex nausea and vomiting (D). Nausea preceding abdominal pain is more consistent with gastroenteritis. Because the appendix has a luminal capacity of only 0.1 mL, even small amounts of ongoing intraluminal secretion combined with bacterial overgrowth lead to a rapid increase in intraluminal pressure (A). The increasing pressure eventually occludes the blood supply at the capillary and venule levels. Some episodes of acute appendicitis resolve spontaneously. Ruptured appendicitis can drain dependently into the rectovesical pouch leading to a pelvis abscess. Both recurrent and chronic forms of appendicitis occur and can mislead the clinician because of the longer history. In one study, recurrent episodes were reported in 6.5% of those who ultimately had an inflamed appendix removed. Children have a higher rate of perforation, and the concomitant underdeveloped omentum makes it more difficult to wall off the perforation (E).

**References:** Barber, M., McLaren, J., & Rainey, J. (1997). Recurrent appendicitis. *The British Journal of Surgery*, 84(1), 110–112.

Hawes, A., & Whalen, G. (1994). Recurrent and chronic appendicitis: the other inflammatory conditions of the appendix. *The American Surgeon*, 60(3), 217–219.

Rao, P., Rhea, J., Novelline, R., et al. (1998). The computed tomography appearance of recurrent and chronic appendicitis. *The American Journal of Emergency Medicine*, 16(1), 26–33.

32. **D.** Obstetric injury accounts for nearly 80% of all rectovaginal fistulas followed by Crohn disease

(C). Diverticulitis is the leading cause of colovesical fistulas (B). Other causes of colovesicular fistula include Crohn disease, radiation therapy, and colon and bladder cancer (A, E). The key elements include establishing the diagnosis and ruling out other causes. CT scanning is the best initial study because it will confirm the presence of a fistula by demonstrating air in the bladder and any associated masses. Sigmoidoscopy is useful to rule out any other mucosal abnormalities. A contrast enema may help define the course of the fistula, but small fistulas may be missed. Surgical management depends on whether the fistula is due to benign or malignant disease. If it is secondary to diverticulitis, management consists of sigmoid colectomy with repair of the bladder. If it is due to a malignancy, en bloc resection of part of the bladder wall should be performed.

**References:** Walker, K. G., Anderson, J. H., Iskander, N., et al. (2002). Colonic resection for colovesical fistula: 5-year follow-up. *Colorectal Disease*, 4(4), 270–274.

Baig, M. K., Zhao, R. H., Yuen, C. H., et al. (2000). Simple rectovaginal fistulas. *International Journal of Colorectal Disease*, 15(5–6), 323–327.

33. **B.** Previously, it was recommended that all patients should undergo surgery after the second episode of uncomplicated diverticulitis. However, several large studies have refuted this, and it is now recommended that surgical intervention be offered on a case-by-basis basis, taking into account the number of episodes, age, comorbidities, severity of attacks, and impact on quality of life. In particular, a lower threshold for surgery is recommended for diabetic and immunocompromised (taking steroids) patients. In contrast, it is recommended that all cases of complicated diverticulitis be offered definitive surgical intervention after the acute condition has resolved. One of the principles of surgery for diverticulitis is that one only needs to resect inflamed, thickened colon, despite the presence of diffuse diverticula (A, C, E). Once the distal colon is removed, the intraluminal pressure will decrease and the majority of the proximal diverticula will resolve. Recurrence is primarily the result of an inadequate distal resection, which inadvertently may leave behind sigmoid diverticula. Because diverticula do not occur in the rectum, the distal resection margin should be taken at normal-appearing rectum (D). The rectum can be identified by the fact that the taenia splay out.

**References:** Bullard, K. M., & Rothenberger, D.A. (2005). Colon, rectum and anus. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al. *Schwartz's principles of surgery* (pp. 1055–1118) (8th ed.). New York, NY: McGraw-Hill.

Chapman, J., Davies, M., Wolff, B., et al. (2005). Complicated diverticulitis: is it time to rethink the rules? *Annals of Surgery*, 242(4), 576–581.

Lipman, J. M. (2009). Laparoscopic management of diverticular disease. *Clinical Colon Rectal Surgery*, 22(3), 173.

Stocchi, L. (2010). Current indications and role of surgery in the management of sigmoid diverticulitis. *World Journal of Gastroenterology*, 16(7), 804–817.

34. **A.** The appendix is part of the gut-associated lymphoid tissue and primarily secretes IgA. However, removal of the appendix has no known adverse effect on immune function. A recent study from Duke University proposes that the appendix serves as a safe haven or reservoir for healthy bacteria that then repopulate the gut after illnesses have depleted them (E). IgG (D) is the most abundant antibody in serum and the predominant antibody in the secondary immune response. IgE (B) is the least abundant and mediates hypersensitivity reactions. IgM (C) is the largest immunoglobulin and the earliest major immunoglobulin produced in the primary immune response.

**Reference:** Bollinger, R., Barbas, A., Bush, E., et al. (2007). Biofilms in the large bowel suggest an apparent function of the human vermiform appendix. *Journal of Theoretical Biology*, 249(4), 826–831.

35. **B.** An Amyand hernia is one containing the Appendix. The importance of an Amyand hernia is that it can be confused with a standard strangulated hernia. Management should consist of appendectomy without the use of mesh. It is named after Claudius Amyand, who performed the first appendectomy in London in 1746. The patient was an 11-year-old boy with a scrotal hernia that contained the appendix perforated by a pin. Petit hernia is a type of lumbar hernia located in the inferior lumbar triangle (A). It is bound by the iliac crest inferiorly, the external oblique muscle anteriorly, and the latissimus dorsi muscle posteriorly. Littre hernia is a hernia containing Meckel diverticulum (C). Spigelian hernia is a hernia through the linea semilunaris and between two layers of abdominal wall, making these difficult if not impossible to palpate (D). Grynfeltt hernia is another type of lumbar hernia found in the superior lumbar triangle, which is bound by the

quadratus lumborum muscle on its floor, the internal oblique muscle anteriorly, and the 12th rib superiorly (E).

**Reference:** Logan, M., & Nottingham, J. (2001). Amyand's hernia: a case report of an incarcerated and perforated appendix within an inguinal hernia and review of the literature. *The American Surgeon*, 67(7), 628–629.

36. **C.** Although only a minority of patients (10%) who present with terminal ileitis progress to Crohn disease on long-term follow-up, the surgeon should always consider this diagnosis. The indications for resection would include free perforation, fistula, or stricture. The diagnosis can be confused with appendicitis. Provided the cecum is not inflamed, the appendix should be removed to avoid confusion in the future because recurrent abdominal pain may develop in the patient. However, in the presence of active inflammation of the cecum, appendectomy should not be performed because there is a higher risk of an enterocutaneous fistula formation (B). Similarly, biopsy should be avoided because this increases the risk for enterocutaneous fistula formation as well (D, E). Therefore, closure of the wound without further intervention is the correct management for this patient. This patient should subsequently receive a colonoscopy with random biopsies to look for evidence of inflammatory bowel disease.

37. **B.** Pylephlebitis is essentially an infectious inflammation of the portal venous system. These veins drain the gastrointestinal tract. It typically begins within the small veins draining an area of infection within the abdomen and is most often associated with diverticulitis and appendicitis. Extension of the thrombophlebitis into larger veins can lead to septic thrombophlebitis of the portal vein or its tributaries (superior mesenteric vein, splenic vein) as well as multiple small liver abscesses. Due to laminar flow patterns, the bacteria are more likely to lodge and form abscesses in the right lobe of the liver. Similarly, amebic liver abscesses also form in the right lobe but are usually singular (A). Patients with pylephlebitis are usually not jaundiced but have elevated liver enzymes (particularly alkaline phosphatase). Pylephlebitis was much more common in the preantibiotic era, but it has become very rare due to major advances in antibiotic and surgical treatment. Air bubbles or thrombi of the portal venous system are key findings of pylephlebitis on CT scan (D). The reported mortality rate is as high as 30% to 50%. Because of the rarity, established management protocols are lacking. The most prudent approach seems to be rapid administration of broad-spectrum antibiotics, removal of the infectious source (in this case by appendectomy), and anticoagulation (for the suspected thrombosed superior mesenteric vein). Carcinoid syndrome (C) or IBD (E) is unlikely to present with elevated alkaline phosphatase and total bilirubin nor does either fit the clinical history of the patient.

**References:** Chang, Y., Min, S., Joo, S., et al. (2008). Septic thrombophlebitis of the porto-mesenteric veins as a complication of acute appendicitis. *World Journal of Gastroenterology*, 14(28), 4580–4582.

Vanamo, K., & Kiekara, O. (2001). Pylephlebitis after appendicitis in a child. *Journal of Pediatric Surgery*, 36(10), 1574–1576.

38. **A.** The incidence of acute appendicitis in patients infected with human immunodeficiency virus (HIV) is 0.5%, which is higher than the population as a whole. The overall mode of presentation is often similar, but some patients can present with a nonspecific abdominal examination (B). In addition, an absolute leukocyte count is usually not elevated, but rather these patients may have a relative leukocytosis (E). The rupture risk is higher in HIV-infected patients, which may simply be a manifestation of a delay in presentation, although a low CD4 count seems to increase the risk of appendiceal rupture (C). Morbidity rates for HIV-infected patients with nonperforated appendicitis are similar to those seen in the general population but higher with perforation than in patients without HIV (D). Other important things to consider in the differential include cytomegalovirus (CMV) enteritis and typhlitis. CT of the abdomen/pelvis can be helpful in distinguishing these etiologies.

**References:** Binderow, S., & Shaked, A. (1991). Acute appendicitis in patients with AIDS/HIV infection. *American Journal of Surgery*, 162(1), 9–12.

Bova, R., & Meagher, A. (1998). Appendicitis in HIV-positive patients, *ANZ Journal of Surgery*, 68(5), 337–339.

39. **E.** Numerous studies have compared open and laparoscopic appendectomy. Laparoscopic appendectomy seems to be most advantageous in women of childbearing age, when the diagnosis is in question, or in obese patients. The cost and length of the operation are higher for a laparoscopic appendectomy (A). Length of hospital stay is slightly shorter (B), as is the wound

infection rate (D), degree of postoperative pain, and the time to return to work. Interestingly, in one meta-analysis, the rate of intra-abdominal abscess trended toward being higher with a laparoscopic appendectomy, and in another analysis, there was no difference (C).

**References:** Golub, R., Siddiqui, F., & Pohl, D. (1998). Laparoscopic versus open appendectomy: a meta-analysis. *Journal of the American College of Surgeons*, 186(5), 545–553.

Temple, L., Litwin, D., & McLeod, R. (1999). A meta-analysis of laparoscopic versus open appendectomy in patients suspected of having acute appendicitis. *Canadian Journal of Surgery*, 42(5), 377–383.

40. C. The association of parasites with appendicitis is somewhat controversial. The debate is whether the parasite is an incidental finding or the actual cause. *Ascariasis* is the most common parasite worldwide, with an estimated 1.4 billion persons infected. The majority of infections occurs in the low and middle income countries (LMIC) of Asia and Latin America but are beginning to appear more commonly in the United States owing to increased international travel and emigration from LMIC. *Enterobius vermicularis* (pinworm) is the second most common parasite (A). Intestinal parasites can cause appendicitis by obstructing the lumen. Thus, it is always important to check the final pathology because therapy with a helminthicide is necessary postoperatively. Mebendazole, pyrantel pamoate, and albendazole are the drugs of choice. *Strongyloides stercoralis* (threadworm) can lead to pneumonitis, malabsorption, and bleeding ulcers (B). *Echinococcus granulosus* can lead to hydatid cyst disease (D). *Clonorchis sinensis* (Chinese liver fluke) can increase the risk of pigmented (brown) gallstones and cholangiocarcinoma (E).

41. C. When deciding whether to perform an incidental appendectomy during another procedure, one must factor in the lifelong risk of appendicitis versus the risks of appendectomy and the additional costs. Because the lifelong risk of appendicitis is only 8.6% in men and 6.7% in women, incidental appendectomy is rarely recommended. In a large study of patients undergoing cholecystectomy with and without incidental appendectomy, low-risk patients undergoing appendectomy showed a significant increase in nonfatal complications (odds ratio of 1.53). Particular circumstances in which incidental appendectomy (during the course of another operation) would be recommended are for children about to undergo chemotherapy (due to risk of subsequent typhlitis), in the disabled (i.e., para/quadruplegic) who cannot react normally to abdominal pain, Crohn disease patients (because they have a significant risk of subsequent abdominal pain) whose cecum is free of macroscopic disease (to minimize risk of postoperative cecal fistula), and individuals who are about to travel to remote places where there is no access to medical/surgical care. The patients in the remaining answer choices (A, B, D, E) would not benefit from an incidental appendectomy.

**Reference:** Wen, S., Hernandez, R., & Naylor, C. (1995). Pitfalls in nonrandomized outcomes studies: the case of incidental appendectomy with open cholecystectomy. *The Journal of the American Medical Association*, 274(21), 1687–1691.

42. E. The presentation and findings are consistent with acute mesenteric adenitis (pseudoappendicitis). It is associated with *Yersinia enterocolitica*, *Helicobacter jejuni*, *Campylobacter jejuni*, and *Salmonella* or *Shigella* species, as well as streptococcal infections of the pharynx. It occurs more commonly in children and is often preceded by an upper respiratory infection (D). It is a diagnosis of exclusion. Physical examination typically reveals more vague and diffuse tenderness, without significant guarding, as opposed to the localized tenderness seen in appendicitis (B). Leukocytosis is usually present in patients with acute mesenteric adenitis with WBC counts between  $10$  to  $15 \times 10^3$  cells/ $\mu$ L, similar to those found in patients with appendicitis (C). CT may show generalized lymphadenopathy in the small bowel mesentery, but these findings are nonspecific. The diagnosis is often made intraoperatively. There is no need for nodal biopsy (A).

**Reference:** Abdel-Haq, N. M., Asmar, B. I., Abuhammour, W. M., et al. (2000). *Yersinia enterocolitica* infection in children. *The Pediatric Infectious Disease Journal*, 19(10), 954–958.

43. B. *Pseudomyxoma peritonei* is a confusing term because it has been applied to several different pathologies. It has been used in reference to any progressive process in which the peritoneal cavity becomes filled with a thick gelatinous substance. This gelatinous substance is thought to arise from mucus-secreting cells from a perforated, mucus-producing tumor, which can be either benign or malignant and can originate from the appendix, small bowel, or ovary. Even if these cells are benign, once it has spread throughout the peritoneum, it is difficult to eradicate, and with time, the patient's small bowel becomes mechanically obstructed. If the source is a malignant tumor, the

5-year survival rate is significantly reduced. The most common source of this condition is a benign mucinous cystadenoma of the appendix. The new terminology has been coined *disseminated peritoneal adenomucinosi*s to define patients with mucinous peritoneal implants that arise from a benign adenoma of the appendix. This is the most common variety. A more aggressive form has been called *peritoneal mucinous carcinomatosis* and features extensive proliferative epithelium, cytologic atypia, and a high mitotic rate. Treatment consists of aggressive removal of all peritoneal implants as well as an appendectomy. Intraperitoneal chemotherapy likewise shows promising results. The 5-year survival rate is approximately 50% but varies greatly by histology. Tuberculous peritonitis often presents as slowly progressive abdominal distention due to ascites, combined with fever, weight loss, and abdominal pain (C). Characteristic features at surgery are multiple whitish nodules scattered over the visceral and parietal peritoneum. *Salmonella enteritidis* typically presents with diarrhea, nausea, and vomiting with stool leukocytes (D). It can rarely lead to intestinal perforation, most commonly through an ulcerated Peyer patch. *Yersinia* infections can lead to mesenteric adenitis, colitis, and ileitis that can present in a similar fashion to acute appendicitis (E). *Yersinia* infections can also cause appendicitis. Meigs syndrome is seen in patients with a benign ovarian tumor (A) and presents with ascites and pleural effusion that resolve after resection of the tumor.

**Reference:** Wirtzfeld, D., Rodriguez-Bigas, M., Weber, T., et al. (1999). Disseminated peritoneal adenomucinosis: a critical review. *Annals of Surgical Oncology*, 6(8), 797–801.

44. **B.** Primary adenocarcinoma of the appendix presents most commonly as acute appendicitis. For this reason, it is always important to check the final pathology of the appendiceal specimen. Patients are at increased risk of synchronous neoplasms, particularly in the colon, and so examination of the large intestine should be done with full colonoscopy. Definitive treatment consists of a right colectomy regardless of the size of the tumor. If the final pathology reveals appendiceal cancer, the patient should be taken back for a right colectomy. In one series, the 5-year survival rate after curative resection was 61% and 31%. The remaining answer choices are not typically a common presentation of appendiceal adenocarcinoma (A, C–E).

**References:** Fujiwara, T., Hizuta, A., Iwagaki, H., et al. (1996). Appendiceal mucocoele with concomitant colonic cancer. *Diseases of the Colon and Rectum*, 39(2), 232–236.

Ito, H., Osteen, R., Bleday, R., et al. (2004). Appendiceal adenocarcinoma: long-term outcomes after surgical therapy. *Diseases of the Colon and Rectum*, 47(4), 474–480.

45. **D.** Most carcinoids are found at the tip of the appendix. As such, they are not usually the cause of appendicitis but are rather incidental findings. Over 95% of carcinoid tumors of the appendix are less than 2 cm in size (E). Tumors less than 1 cm rarely extend outside of the appendix and are treated simply by appendectomy. A right colectomy is indicated for tumors larger than 1 cm with extension into the mesoappendix or the base and for those that are larger than 2 cm and located at the tip (A). In contrast, adenocarcinoma of any size and at any location in the appendix is treated with a right hemicolectomy. Appendiceal carcinoids rarely cause carcinoid syndrome because widespread liver metastases are rare and there is no relation to tumor size and the development of carcinoid syndrome (B). There is no role for radiation or chemotherapy for appendiceal carcinoid (C). In one large series, the overall 5-year survival rate for localized lesions was 94%, 84.6% for regional invasion, and 33.7% for distant metastases. In approximately 15% of patients, noncarcinoid tumors at other sites were also evident.

**References:** Jaffe, B. M., Berger, D. H. (2005). Appendix. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al. *Schwartz's principles of surgery* (pp. 1119–1138) (8th ed.). New York, NY: McGraw-Hill.

Sandor, A., & Modlin, I. (1998). A retrospective analysis of 1570 appendiceal carcinoids. *The American Journal of Gastroenterology*, 93(3), 422–428.

Stinner, B., Kisker, O., Zielke, A., et al. (1996). Surgical management for carcinoid tumors of small bowel, appendix, colon, and rectum. *World Journal of Surgery*, 20(2), 183–188.

46. **A.** In the neutropenic patient with leukemia who presents with acute abdominal pain, one must suspect neutropenic enterocolitis, which is commonly referred to as typhlitis. The typical patient presents with abdominal pain and tenderness, fever, and diarrhea in association with severe neutropenia (defined as an absolute neutrophil count <1000 cells/ $\mu$ L). A CT scan is helpful in ruling out perforation and in the case of typhlitis will show thickening of the cecal wall with pericolic stranding. Some reports have also shown the utility of ultrasonography in establishing the diagnosis via the demonstration of cecal thickening. The majority of patients respond to bowel

rest and IV antibiotics. The mortality rate in children in contemporary series is 8% to 10%. Surgery should be reserved for patients with signs of perforation, although the need for surgical intervention is low (B–E).

**References:** Schlatter, M., Snyder, K., & Freyer, D. (2002). Successful nonoperative management of typhlitis in pediatric oncology patients. *Journal of Pediatric Surgery*, 37(8), 1151–1155.

Sloas, M., Flynn, P., Kaste, S., et al. (1993). Typhlitis in children with cancer: a 30-year experience. *Clinical Infectious Diseases*, 17(3), 484–490.

47. **D.** The most common cause of lower GI bleeding, diverticulosis, accounts for more than one-half of cases and is usually from right-sided lesions. Rarely, massive lower GI bleeding can be the result of an upper GI source. As such, placing a nasogastric tube and aspirating for blood are important first steps after the ABCs. Likewise, hemorrhoids can rarely be the cause. Thus, the next step is to perform a proctoscopy to rule out hemorrhoids. This will avoid the catastrophic situation of performing a total colectomy only to discover that the patient continues to bleed from a more distal source. After the proctoscopy, the management algorithm depends on the patient's response to resuscitation. If the patient stabilizes, she should undergo colonoscopy after a bowel prep (A). If the patient continues to bleed, the next step is to perform either mesenteric arteriography or a tagged red blood cell scan (nuclear scintigraphy) using technetium-99m (B, C). Arteriography can be both diagnostic and therapeutic (embolization). However, it is invasive and bleeding must be brisk (0.5–1 mL/min). It is also not as feasible to repeat the study in the case of a patient that stopped bleeding and rebleeds. Nuclear scanning detects bleeding at a much slower rate (only 0.1 mL/min), and since the radioactive agent remains labeled on the red blood cell for some time, repeat images can be obtained for up to 24 hours. If the patient cannot be stabilized and the source is not discovered, the patient should be taken to the operating room for an exploratory laparotomy with intraoperative endoscopy (E). If the source cannot be localized, a total colectomy should be performed.

**Reference:** Farner, R., Lichliter, W., Kuhn, J., et al. (1999). Total colectomy versus limited colonic resection for acute lower gastrointestinal bleeding. *American Journal of Surgery*, 178(6), 587–591.

48. **B.** This patient has a sigmoid volvulus. The common denominator in sigmoid volvulus is a large, redundant colon. Individuals with chronic constipation (elderly or institutionalized), a high-fiber diet (leads to an elongated and redundant colon), or megacolon (Chagas disease) are predisposed. Patients present with symptoms and signs of an acute large bowel obstruction. The important issues are the following:
1. Establishing the correct diagnosis. This can generally be done by classic radiographic findings of a markedly dilated colon with a “bent inner tube” appearance or an omega sign.
  2. Determining whether the patient already has an ischemic or dead bowel. This can be achieved via evidence of systemic toxicity (laboratory tests) and physical examination (peritonitis), and if these are present, the patient needs a laparotomy and sigmoid colectomy (D, E).
  3. Understanding the value of endoscopic detorsion. This can be performed with either a rigid proctosigmoidoscope or a flexible endoscope.
  4. Being aware that there is a high recurrence rate (as high as 40%). Thus, after detorsion, a recommendation should be made for a subsequent semielective colectomy (A, C).
  5. Distinguishing it from cecal volvulus, which cannot usually be endoscopically detorsed and requires surgery (right hemicolectomy).

**Reference:** Chung, Y., Eu, K., Nyam, D., et al. (1999). Minimizing recurrence after sigmoid volvulus. *The British Journal of Surgery*, 86(2), 231–233.

49. **D.** Stage for stage, colonic malignancy in Lynch syndrome has the same prognosis as sporadic cancer. In a small number of sporadic colon cancers, microsatellite instability and inappropriate DNA methylation leads to impaired DNA mismatch repair, increasing the risk for developing colon cancer. Lynch syndrome or HNPCC arises because of errors in the mismatch repair *genes* that code for the DNA mismatch repair enzymes. It is an autosomal dominant syndrome with an increased risk of colorectal carcinoma as well as other malignancies, with a lifetime risk of approximately 80% for colon cancer, 20% for gastric cancer, and a high risk of endometrial and upper genitourinary tract cancer (A, B). The colon cancers are more commonly right sided (as opposed to left sided in sporadic cancer); as such, screening requires colonoscopy, which is recommended at age 25 or 10 years less than the age at which colon cancer developed in other



family members (whichever is earlier) (C). Patients with FAP should begin screening much earlier (age 10–12). Upper endoscopy screening is also recommended starting at age 50. The modified Amsterdam criteria for clinical diagnosis of HNPCC can be remembered by the **3-2-1-1** rule: **3** or more relatives with histologically verified cancers in the colon, endometrium small intestine, or pelvis; **2** or more successive generations affected; **1** or more relatives diagnosed before age 50 (E); and **1** should be a first-degree relative of the other two. Additionally, FAP must be ruled out to diagnose Lynch syndrome.

**References:** Stigliano, V., Assisi, D., Cosimelli, M., et al. (2008). Survival of hereditary non-polyposis colorectal cancer patients compared with sporadic colorectal cancer patients. *Journal of Experimental & Clinical Cancer Research*, 27:39.

Watson, P., Lin, K., Rodriguez-Bigas, M., et al. (1998). Colorectal carcinoma survival among hereditary nonpolyposis colorectal carcinoma family members. *Cancer*, 83(2), 259–266.

Van der Post, R. S., Kiemeny, L. A., Ligtenberg, M. J., et al. (2010). Risk of urothelial bladder cancer in Lynch syndrome is increased, in particular among MSH2 mutation carriers. *Journal of Medical Genetics*, 47(7), 464–470.

50. **B.** The colon is responsible for both water and electrolyte reabsorption. Water absorption averages 1 to 2 L per day but can be as much as 5 L. However, the small intestine (mostly jejunum) is where the majority of water absorption occurs (A). Sodium is absorbed actively via  $\text{Na}^+, \text{K}^+$ -ATPase with water following passively. Chloride is actively absorbed, not secreted, through a chloride–bicarbonate exchange (D). Bacteria fermentation in the colon produces short-chain fatty acids, which are a primary source of energy for colonocytes (E). Decreasing colonic pH (as occurs with lactulose) results in a decrease in ammonia reassertion (C).

51. **D.** For patients with peritoneal studding from appendiceal adenocarcinoma, cytoreductive surgery with hyperthermic intraperitoneal chemotherapy (HIPEC) has shown promise in patients without evidence of distant organ metastasis. In a large series in which complete cytoreduction was defined as tumor nodules less than 2.5 mm in diameter remaining after surgery, patients with complete cytoreduction and adenomucinosis pathology had a 5-year survival rate of 86%. Incomplete cytoreduction had a 5-year survival rate of only 20%. Systemic or intraperitoneal chemotherapy alone leads to lower survival rates (B–C, E). Offering no treatment to a patient with peritoneal studding secondary to appendiceal adenocarcinoma would not be appropriate (A). HIPEC is being used for colorectal, gastric, and ovarian cancer, as well as intraperitoneal mesothelioma.

**References:** Jaffe, B. M., Berger, D. H. (2005). Appendix. In F. C. Brunicki, D. K. Andersen, T. R. Billiar, et al. *Schwartz's principles of surgery* (pp. 1119–1138) (8th ed.). New York, NY: McGraw-Hill.

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Sugarbaker, P., & Chang, D. (1999). Results of treatment of 385 patients with peritoneal surface spread of appendiceal malignancy. *Annals of Surgical Oncology*, 6(8), 727–731.

Sugarbaker, P., & Jablonski, K. (1995). Prognostic features of 51 colorectal and 130 appendiceal cancer patients with peritoneal carcinomatosis treated by cytoreductive surgery and intraperitoneal chemotherapy. *Annals of Surgery*, 221(2), 124–132.



# Alimentary Tract—Anorectal

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## Questions

- Which of the following is true regarding anorectal anatomy?
  - The levator ani marks the transition point between the rectum and sigmoid colon.
  - The presacral fascia separates the rectum from the presacral venous plexus and the pelvic nerves.
  - Waldeyer fascia is anterior to Denonvilliers fascia.
  - In men, Denonvilliers fascia separates the rectum from the sacrum.
  - The surgical anal canal is longer in women than in men.
- A 56-year-old male patient is found to have rectal adenocarcinoma just proximal to the dentate line. Which of the following is true about wide local excision (WLE) of such a lesion?
  - WLE is an option provided the tumor is 4 cm or less.
  - Staging should include careful assessment for inguinal lymphadenopathy.
  - The presence of lymphatic invasion precludes WLE.
  - WLE is reasonable provided the invasion remains within the serosa.
  - WLE is not a recommended option.
- The recommended initial treatment of anal canal melanoma is:
  - Abdominal perineal resection (APR)
  - Wide local excision (WLE)
  - WLE with regional lymph node dissection
  - Radiation therapy
  - Radiation therapy and chemotherapy
- Which of the following is true regarding epidermoid cancers of the anal canal?
  - They are associated with Epstein-Barr virus.
  - They tend to behave similarly regardless of cell type.
  - Small tumors can generally be excised locally.
  - They are often times asymptomatic.
  - Chemotherapy alone is an appropriate treatment option.
- A 30-year-old male presents with redness, pain, and fluctuance in the intergluteal cleft, about 4 cm posterior to the anus. There is considerable hair adjacent to the lesion. Which of the following is the most appropriate management?
  - Incision and drainage in the intergluteal cleft
  - Incision and drainage lateral to the intergluteal cleft
  - En bloc excision of the sinus tract with flap reconstruction
  - Excision with primary closure
  - Unroofing the tract and marsupializing
- A 35-year-old man with leukemia and severe neutropenia presents with severe anal pain. Physical examination at the bedside demonstrates induration but no obvious mass in the perianal region.

- Which of the following is the best management?
- Intravenous (IV) antibiotics only
  - Bedside anoscopy with bedside incision and drainage only if a fluctuant mass is detected
  - Bedside anoscopy with operative incision and drainage only if a fluctuant mass is detected
  - Examination with patient under anesthesia with wide debridement of perianal area
  - Examination with patient under anesthesia with biopsy of indurated areas and incision and drainage even if no pus is detected
7. Which of the following is true regarding the blood supply to the rectum?
- The superior and middle rectal arteries arise from the inferior mesenteric artery.
  - The middle rectal veins drain into the internal iliac veins.
  - The inferior rectal veins drain into the inferior mesenteric vein.
  - The superior rectal veins drain into the inferior vena cava.
  - There is excellent collateralization between the superior and middle rectal arteries.
8. Which of the following is true regarding hidradenitis suppurativa?
- It may mimic a complex anal fistula.
  - It is due to an infection of the eccrine sweat glands.
  - Radical excision and skin grafting are typically necessary.
  - It may progress beyond the anal verge into the anal canal.
  - It is not associated with keloid formation.
9. Rectal bleeding due to chronic radiation proctitis that is unresponsive to sucralfate enemas is best managed by:
- Argon plasma coagulation
  - Proximal diverting colostomy
  - Steroid enemas
  - Formalin
  - Proctectomy
10. Twelve hours after hemorrhoidal banding, a 45-year-old man presents to the emergency department reporting rectal and abdominal pain and an inability to urinate. His temperature is 102°F and heart rate is 110 beats per minute. Management consists of:
- Placement of a Foley catheter
  - Broad-spectrum IV antibiotics
  - Broad-spectrum antibiotics and rectal examination with the patient under anesthesia
  - Stool softeners and oral antibiotics
  - In-and-out catheterization of bladder and stool softeners
11. The most common cause of a rectovaginal fistula is:
- Carcinoma of the rectum
  - Crohn disease
  - Obstetric injury
  - Ulcerative colitis
  - Radiation
12. Approximately 3 hours after a hemorrhoidectomy a patient continues to have bleeding from the anus. The nurse has changed the pad multiple times and has attempted to pack the rectum with gauze. What is the next best step in management?
- Rubber banding the bleeding site
  - Rectal packing with epinephrine gauze
  - Suture ligation
  - Ice packs
  - Foley catheter balloon compression

13. A 60-year-old woman presents with severe perianal itching that is constant throughout the day. Examination reveals minimal erythema and excoriations. Which of the following is the best initial treatment?
- A. Exam under anesthesia
  - B. Biopsy and/or culture
  - C. Oral antibiotics
  - D. Improve perianal hygiene
  - E. Intravenous steroids
14. The chemotherapeutic agents commonly used and favored for anal canal carcinoma are:
- A. 5-Fluorouracil (5-FU) and mitomycin C
  - B. 5-FU and carmustine
  - C. Floxuridine and bleomycin
  - D. Vincristine and 5-FU
  - E. Cyclophosphamide and prednisone
15. A 65-year-old woman presents to the emergency department with severe perianal pain for 12 hours that came on after straining during a bowel movement. Physical examination reveals an exquisitely tender perianal mass with bluish discoloration under the perianal skin. Management consists of:
- A. Stool softeners and sitz baths
  - B. Rubber band ligation
  - C. Stab incision and drainage with the patient under local anesthesia in the emergency department
  - D. Elliptical excision of skin and drainage with the patient under local anesthesia in the emergency department
  - E. Rectal examination with the patient under general anesthesia with incision and drainage
16. Which of the following is true regarding anogenital warts?
- A. Human papillomavirus (HPV) types 6 and 11 predispose to malignancy.
  - B. No association exists with squamous intraepithelial lesions.
  - C. Treatment depends on location and extent of disease.
  - D. Immunomodulator therapy is ineffective when used topically.
  - E. Vaccine against HPV does not prevent anogenital warts.
17. Which of the following medical therapies results in the greatest healing rates for chronic anal fissures?
- A. Bulk agents and stool softeners
  - B. Topical nitroglycerin
  - C. Topical diltiazem
  - D. Topical bethanechol
  - E. Botulinum toxin injection
18. Which of the following is true regarding perianal disease in patients with human immunodeficiency virus (HIV)?
- A. It is uncommon to find concomitant infection with other sexually transmitted infections.
  - B. The incidence of dysplasia is equal to those without HIV.
  - C. The incidence of anal condyloma is low in the HIV-infected population.
  - D. Exam under anesthesia is needed to determine etiology of many perianal problems.
  - E. Highly active antiretroviral therapy (HAART) has decreased the incidence of perianal disease.
19. An 80-year-old woman presents with rectal prolapse. She has a history of chronic constipation. Colonoscopy findings are negative. Treatment would be best achieved via:
- A. Fixation of the rectum with prosthetic sling (Ripstein repair)
  - B. Anterior resection with rectopexy
  - C. Thiersch anal encirclement

- D. Resection of perineal hernia and closure of the cul-de-sac (Moschcowitz procedure)
- E. Perineal rectosigmoidectomy (Altemeier procedure)
20. Which of the following statements are true regarding perianal disease in association with Crohn disease?
- A. Anal fistulas tend to have a single tract.
- B. Magnetic resonance imaging (MRI) is not particularly helpful.
- C. The liberal use of multiple setons is helpful.
- D. Infliximab is ineffective in healing these fistulas.
- E. Aggressive use of fistulotomy provides the best chance of cure.
21. The most common bacterial cause of proctitis is:
- A. *Chlamydia trachomatis*
- B. *Neisseria gonorrhoeae*
- C. *Treponema pallidum*
- D. *Haemophilus ducreyi*
- E. *Shigella* species
22. Which of the following is true regarding fistula-in-ano?
- A. Drainage of an anorectal abscess rarely results in a persistent fistula-in-ano.
- B. The internal opening is generally easily identifiable.
- C. Fistulas are categorized based on their relationship to the anal mucosa.
- D. Surgical treatment is determined by the internal and external opening of the fistula.
- E. Injecting hydrogen peroxide or methylene blue into the external opening is contraindicated.
23. Hirschsprung disease presenting in an adult:
- A. Does not occur
- B. Is not associated with the RET mutation
- C. Is best diagnosed by a barium enema
- D. Requires a pull-through procedure for definitive management
- E. Can be treated with anorectal myomectomy
24. A 50-year-old woman presents with rectal pain, incomplete rectal voiding, and bright red blood and mucus per rectum. Colonoscopy reveals a solitary rectal ulcer in the distal rectum on the anterior wall. A biopsy specimen of the ulcer shows chronic inflammation. Management consists of:
- A. Transanal excision of the ulcer
- B. Perineal rectosigmoidectomy
- C. Abdominal rectopexy
- D. High-fiber diet and defecation training
- E. Rectal fixation with prosthetic sling

## Answers

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- B.** The presacral fascia is synonymous with Waldeyer fascia and separates the rectum from the presacral venous plexus and the pelvic nerves. It is posterior to Denonvilliers fascia (C). In men, Denonvilliers fascia separates the rectum from the bladder and prostate (D). In women, Denonvilliers fascia separates the rectum from the vagina. Levator ani marks the transition point between the rectum and anal canal (A). The surgical anal canal is 2 to 4 cm in length and is longer in men (E). It spans the area from the anorectal junction to the anal verge. The anal transition zone is just proximal to the dentate line and has features of columnar and squamous epithelium as well as cuboidal epithelium. Cancers above this area are usually adenocarcinomas, whereas those distal to this line are squamous or cloacogenic. It is approximately 1 to 2 cm in length.
- C.** The upper and middle rectum drain only into the inferior mesenteric nodes, whereas the lower rectum drains into both the inferior mesenteric nodes and internal iliac nodes. Distal to the dentate line, lymph drains into the inguinal lymph nodes but can also empty into the inferior

mesenteric and internal iliac lymph nodes. Thus, an important part of the physical examination in a patient with anal cancer is examining the inguinal region for lymphadenopathy. Since the above patient's cancer is proximal to the dentate line, it typically would not spread to the inguinal lymph nodes (B). WLE is an option in a limited number of cases for anorectal adenocarcinoma (E). Indications for WLE in anorectal adenocarcinoma include size < 3 cm, T1 status (invades only submucosa) (D), less than 30% involvement of bowel wall, proximity of 8 cm from anal verge, mobile and nonfixed lesion, and no lymphatic, neural, or venous invasion on imaging. WLE needs about a 2 mm margin. If WLE is contraindicated, abdominoperineal resection or low anterior resection is appropriate.

3. **B.** Melanoma of the anal canal is extremely rare, and the overall prognosis is poor. Given its rarity, established management protocols are lacking. Radiation therapy and chemotherapy can be considered as adjuvant therapy depending on melanoma depth and staging (D, E). However, surgical resection is the initial treatment. A recent meta-analysis showed no stage-specific survival advantage of APR over WLE (A). As such, WLE is the recommended management. Lymph node dissection has not been shown to improve survival but may incur significant morbidities (C).

**References:** Droesch, J. T., Flum, D. R., & Mann, G. N. (2005). Wide local excision or abdominoperineal resection as the initial treatment for anorectal melanoma? *American Journal of Surgery*, 189(4), 446–449.

Singer, M., Matthew, G., & Mutch, M. G. (2006). Anal melanoma. *Clinical Colon Rectal Surgery*, 19(2), 78–87.

4. **B.** Cancers in the anal canal include squamous, basaloid, cloacogenic, and transitional carcinomas, yet despite the variation in cell type, they tend to behave similarly. They can present with pruritus, bleeding, and/or a palpable mass (D). They are thought to be associated with human papillomavirus (HPV) (A). The currently accepted standard approach is to treat them using a combination of chemotherapy and radiation therapy, which was initially espoused by Nigro (E). The protocol includes 5-fluorouracil (5-FU) and mitomycin C as well as pelvic radiation. Anal canal cancers should be distinguished from anal margin tumors (perianal skin around anal verge). Anal margin tumors are generally treated by WLE (C). Abdominoperineal resection is appropriate for Nigro failures or recurrent cancer.

**Reference:** Flam, M., John, M., Pajak, T. F., et al. (1996). Role of mitomycin in combination with fluorouracil and radiotherapy, and of salvage chemoradiation in the definitive nonsurgical treatment of epidermoid carcinoma of the anal canal: results of a phase III randomized intergroup study. *Journal of Clinical Oncology*, 14(9), 2527–2539.

5. **B.** Pilonidal disease is theorized to exist because the intergluteal cleft creates a suction that draws hair into the midline pits when sitting. These ingrown hairs may become infected and present as an abscess in the sacrococcygeal region. However this is one theory of the origin; the true etiology is still unknown. Pilonidal disease can either present acutely with an abscess or chronically (prior drainage). Acute disease is best treated with incision and drainage of the abscess lateral to the intergluteal cleft, as opposed to directly in the cleft because the latter creates constant friction in the wound and therefore heals poorly (A). The remaining answer choices are used for chronic disease (E). Although there is not a “gold standard” for chronic pilonidal cyst management, the preferred treatment option depends on if the pilonidal cyst is simple or complex. Excision with primary closure off the midline for a simple, noninfected pilonidal cyst is the most appropriate treatment option (D). Complex pilonidal cysts will require an en bloc excision of the sinus tract with a flap reconstruction (C). A rhomboid flap is the favored approach.

**Reference:** Dunn, K. M., & Rothenberger, D. A. (2015). Colon, rectum, and anus. In F. C. Brunickardi (Ed.), *Schwartz's principles of surgery* (p. 1233) (10th ed.). New York, NY: McGraw-Hill Education.

6. **E.** Perianal pain may develop in neutropenic patients, yet the diagnosis of a perianal abscess may be difficult given the lack of inflammatory response to infection. Although broad-spectrum antibiotics may cure some of these patients, an examination with the patient under anesthesia should be performed to rule out an abscess that requires drainage (A–C). Although a discrete abscess may not be seen, any areas of induration should be incised and drained and a biopsy specimen obtained to exclude a leukemia infiltrate and cultured to aid in the selection of antimicrobial agents. Wide debridement of perianal area would not be indicated for a perianal abscess (D).

**Reference:** Cohen, J., Paz, I., O'Donnell, M., et al. (1996). Treatment of perianal infection following

bone marrow transplantation. *Diseases of the Colon and Rectum*, 39(9), 981–985.

7. **B.** The superior rectal arteries arise from the inferior mesenteric artery, which provides blood to the upper rectum. The middle rectal artery arises from the internal iliac artery and the inferior rectal artery arises from the pudendal artery (branch of the internal iliac artery), which provide blood to the rest of the rectum and the anal canal (A). Rich collaterals exist between the rectal arteries such that they are relatively resistant to ischemia. Sudak's point marks the superior rectal and middle rectal junction. It is considered a watershed area and thus is unique in that it has a poor blood supply (E). The middle rectal arteries are the least consistent and are absent in as many as three fourths of patients. The venous drainage follows the arterial supply (C). The superior rectal veins drain into the inferior mesenteric vein and then to the portal vein (D), whereas the middle and inferior rectal veins drain into branches of the internal iliac veins and into the inferior vena cava.

8. **A.** Hidradenitis suppurativa is disease of the follicular epithelium, involving areas containing cutaneous apocrine sweat glands (B). It occurs in the armpits, groin, under the breasts, and between the buttocks. The typical appearance is of multiple open comedones with sinus tracts and small abscesses. Scarring can lead to keloid formation (E). It can mimic complex anal fistula disease but stops at the anal verge because there are no apocrine sweat glands in the anal canal (D). It can also mimic perianal Crohn disease. Initial treatment is with warm compresses, as well as lifestyle changes such as weight loss, wearing loose fitting clothes, cessation of smoking, and local hygiene. If this fails, antibiotics and surgery may be needed to incise and drain acute abscesses and unroof fistulas with debridement of granulation tissue. Radical excision and skin grafting are almost never necessary (C).

**Reference:** Dunn, K. M., & Rothenberger, D. A. (2015). Colon, rectum, and anus. In F. C. Brunickardi (Ed.), *Schwartz's principles of surgery* (p. 1233) (10th ed.). New York, NY: McGraw-Hill Education.

9. **A.** Sucralfate enemas are currently considered to be the first line of treatment for chronic radiation proctitis. It is thought to work by forming a physical barrier around the rectum. Steroid and 5-aminosalicylic acid enemas have not been shown to be effective in the long term for treating radiation proctitis. Thus, if sucralfate enemas have failed, steroid enemas are unlikely to help (C). For patients with recurrent symptoms, two effective therapies have evolved: endoscopic therapy and topical formulas. Argon plasma coagulation is the currently favored endoscopic technique due to its limited depth of penetration. The success rate of improving bleeding symptoms is 90%, but multiple treatments are necessary. The main drawback is its lack of uniform availability. Formalin therapy has a success rate of 90%; it is inexpensive and effective with a single treatment. Recently, there was a report linking formalin use with anal canal stricturing. Nevertheless, it is an important option when sucralfate enemas fail (D). The need for surgical therapy is uncommon. For refractory bleeding, a colostomy may be offered, but diversion of the fecal stream is often unsuccessful in stopping the hemorrhage (B). For incapacitating symptoms from bleeding, strictures, and nonhealing ulcers, proctectomy with a coloanal anastomosis or end colostomy may be offered (E).

**References:** de Parades, V., Etienney, I., Bauer, P., et al. (2005). Formalin application in the treatment of chronic radiation-induced hemorrhagic proctitis—an effective but not risk-free procedure: a prospective study of 33 patients. *Diseases of the Colon and Rectum*, 48(8), 1535–1541.

Gul, Y., Prasannan, S., Jabar, F., et al. (2002). Pharmacotherapy for chronic hemorrhagic radiation proctitis. *World Journal of Surgery*, 26(12), 1499–1502.

Taïeb, S., Rolachon, A., Cenni, J., et al. (2001). Effective use of argon plasma coagulation in the treatment of severe radiation proctitis. *Diseases of the Colon and Rectum*, 44(12), 1766–1771.

10. **C.** Sepsis after the treatment of hemorrhoids has been described after banding, sclerotherapy, and stapled hemorrhoidectomy. Although very rare, it is life threatening. It is most common in immunocompromised patients. The patient usually presents within the first 12 hours after the procedure but can present in a delayed fashion. The most common symptoms are severe perineal pain, fevers, and urinary retention. Appropriate management of sepsis after hemorrhoidectomy includes hospital admission, fluid resuscitation, and IV antibiotics with coverage of gram-negative rods and anaerobes. Examination with the patient under anesthesia is recommended to rule out a necrotizing infection that may require debridement. Conservative management with medical management is not appropriate for a patient suspected of having sepsis (A,B,D,E).

**References:** Cirocco, W. C. (2008). Life threatening sepsis and mortality following stapled hemorrhoidopexy. *Surgery*, 143(6), 824–829.

McCloud, J. M., Jameson, J. S., & Scott, A. N. (2006). Life-threatening sepsis following treatment for

haemorrhoids: a systematic review. *Colorectal Disease*, 8(9), 748–755.

11. **C.** A rectovaginal fistula is most often due to an obstetric injury after a vaginal delivery in association with episiotomy typically in primigravidas. Other causes include inflammatory bowel disease (Crohn disease more than ulcerative colitis) (B, D), carcinoma of the rectum (A), radiation therapy for pelvic malignancies (E), and rarely perianal abscesses and diverticulitis. It can also be iatrogenic during low anterior resections, particularly in women who have had a hysterectomy. Treatment for low fistulas is with an endorectal advancement flap, and for high fistulas (more likely due to neoplasm, Crohn disease, radiation), management is via a transabdominal approach with resection of the affected rectal segment.
12. **C.** Bleeding can occur immediately or, in the case of hemorrhoidal banding, after 7 to 10 days, when the necrotic stump sloughs off. Options for the management of bleeding include rectal packing with epinephrine gauze (B), ice packs (D), and balloon compression with a Foley catheter (E). The majority of bleeding is mild and resolves with simple measures. However, if bleeding is copious, the patient should be taken back to the operating/procedure room, where visualization is better, anesthesia is adequate, cautery can be used, and suture ligation can be performed.  
**References:** Jongen, J., Bock, J., Peleikis, H., et al. (2006). Complications and reoperations in stapled anopexy: learning by doing. *International Journal of Colorectal Disease*, 21(2), 166–171.  
Ravo, B., Amato, A., Bianco, V., et al. (2002). Complications after stapled hemorrhoidectomy: can they be prevented? *Techniques in Coloproctology*, 6(2), 83–88.
13. **D.** Pruritus ani is a common problem with a multitude of etiologies. The possible etiologies include perianal infection, surgically correctable causes (prolapsing hemorrhoids, fissure, neoplasm, fistula), antibiotic use, noninfectious dermatologic causes (seborrhea, psoriasis, contact dermatitis), and systemic diseases (jaundice, diabetes). However, the majority of pruritus ani is idiopathic and probably related to local hygiene, neurogenic, or psychogenic causes. Treatment focuses on removal of irritant, improving perianal hygiene, dietary adjustments, and avoiding scratching (A–C). Biopsy and/or culture of the region may be necessary if the symptoms persist despite treatment (B). Hydrocortisone ointment can provide symptomatic relief but should not be used for prolonged periods because of risk of dermal atrophy that may lead to more pruritus (E).  
**Reference:** Dunn, K. M., & Rothenberger, D. A. (2015). Colon, rectum, and anus. In F. C. Brunickardi (Ed.), *Schwartz's principles of surgery* (p. 1231) (10th ed.). New York, NY: McGraw-Hill Education.
14. **A.** In 1972, the Nigro protocol revolutionized the way in which squamous cell carcinomas of the anus were managed. This regimen consists of 5-FU and mitomycin C combined with radiation therapy. This cures nearly 80% of cases. Recurrent cases require an abdominoperineal resection. Carmustine is a nitrosurea that is used in brain cancer (B). Floxuridine and bleomycin are infrequently used for colon cancer with liver metastasis (C). Vincristine is used in testicular cancer (D). Cyclophosphamide and prednisone have been used in various cancers including non-Hodgkin lymphoma (E).
15. **D.** Hemorrhoids should be distinguished as being either internal or external. Internal ones arise above the dentate line and as such are insensate. They may cause painless bleeding during straining to defecate, may prolapse, or may even become strangulated. If they strangulate, they can cause pain due to intense spasm of the anal sphincter. External hemorrhoids originate below the dentate line, are covered with anoderm, and may cause discomfort such as itching but generally only cause severe pain if they become thrombosed. Treatment of thrombosed external hemorrhoids, as in this case, consists of incision and drainage of the thrombosed hemorrhoid with the patient under local anesthesia. To prevent recurrence or inadequate drainage, it is important to excise an ellipse of skin and not simply perform a stab avulsion (C–E). Do not rubber band thrombosed external hemorrhoids because this is not well tolerated by patients secondary to severe pain (B). Nonoperative management is acceptable if the patient has had symptoms for greater than 72 hours, and the pain is already beginning to subside (A). Numerous studies have shown that local anesthesia is well tolerated.  
**Reference:** Jongen, J., Bach, S., Stübinger, S., et al. (2003). Excision of thrombosed external hemorrhoid under local anesthesia: a retrospective evaluation of 340 patients. *Diseases of the Colon and Rectum*, 46(9), 1226–1231.
16. **C.** Condyloma acuminata (anogenital warts) is caused by HPV. There are at least 66 types of HPV. Types 6 and 11 are found in benign anogenital wart and types 16 and 18 behave more aggressively and are more frequently associated with dysplasia and malignant transformation (A). There is an



association with squamous intraepithelial lesions and squamous cell carcinoma (B). Condylomas occur in the perianal region, the squamous epithelial of anal canal, and occasionally the mucosa of the distal rectum. The treatment depends on location and extent of disease. The options include caustic agents (podophyllin, trichloroacetic acid, nitric acid), cryotherapy, fulguration, surgical excisions, antineoplastic preparations (5-FU), laser therapy, interferon, immunomodulator therapy (imiquimod), cidofovir, and surgical excision (D). There are vaccines against HPV that potentially prevent anogenital warts (E).

**Reference:** Gordon, P. H. (2007). Condyloma acuminatum. In P. H. Gordon, & S. Nivatvongs (Eds.), *Principles and practice of surgery for the colon, rectum, and anus* (pp. 261–274) (3rd ed.). New York, NY: Informa Healthcare.

17. **E.** Anal fissures are thought to develop as the result of the passage of hard stools, causing trauma to the anoderm distal to the dentate line and typically in the posterior location owing to its poorer blood supply. Given their distal location, they cause exquisite pain with each defecation, often accompanied by blood on the toilet paper. To effect healing, softening of the stool is essential, using fiber and stool softeners, as is relaxation of the sphincter (A). Numerous topical agents have been used with varying degrees of success, including 2% lidocaine jelly, nitroglycerin ointment (0.2%), topical diltiazem, topical arginine (a nitric oxide donor), and topical bethanechol (a muscarinic agonist) (B–D). However, the best rate of healing with nonoperative treatment is via injection of botulinum toxin, which causes temporary paralysis of the sphincter muscle. Recent studies suggest that healing rates with botulinum toxin approach those of surgery, although surgery remains the gold standard for refractory cases. Surgery is generally reserved for those in whom medical management fails. Surgical management involves a lateral internal sphincterotomy. The right side of the internal sphincter should be divided and only the length of the fissure as this ensures the lowest rate of incontinence.

**References:** Giral, A., Memisoglu, K., Gültekin, Y., et al. (2004). Botulinum toxin injection versus lateral internal sphincterotomy in the treatment of chronic anal fissure: a non-randomized controlled trial. *BMC Gastroenterology*, 4:7.

Maria, G., Cassetta, E., Gui, D., et al. (1998). A comparison of botulinum toxin and saline for the treatment of chronic anal fissure. *The New England Journal of Medicine*, 338(4), 217–220.

18. **D.** Perianal disease is very common in patients infected with HIV. It is common to find concomitant infection with other sexually transmitted infections (*Chlamydia*, *herpes simplex virus*, *HPV*) (A). Anal condyloma in particular is common, and the incidence of dysplasia is high in the HIV-infected population (B, C). Many require examination under anesthesia with biopsy and cultures to determine the etiology of the perianal problem. HAART has changed the natural history of HIV infection, but it remains to be seen how these medications will affect the incidence of perianal disease (E).

**Reference:** Dunn, K. M., & Rothenberger, D. A. (2015). Colon, rectum, and anus. In F. C. Brunicaudi (Ed.), *Schwartz's principles of surgery* (p. 1236) (10th ed.). New York, NY: McGraw-Hill Education.

19. **E.** Procidentia (rectal prolapse) is much more common in women than men. It is more common in elderly women. In young men, it is more often associated with psychiatric disease. It involves all layers of the rectum and starts 6 to 7 cm from the anal verge. As a general rule, adults with rectal prolapse require surgery, whereas children can often be managed nonoperatively. Procedures are divided into abdominal and perineal procedures. In general, abdominal procedures are associated with a lower recurrence rate but a higher complication rate than are perineal procedures. As such, abdominal procedures are used for younger, lower-risk patients and perineal procedures for older, higher-risk patients (A, B). Recent studies have shown favorable results with the perineal rectosigmoidectomy in elderly high-risk patients. The perineal rectosigmoidectomy has a 15% recurrence rate and is a good option for older patients. Another well-accepted perineal operation is the Delorme procedure, which involves reefing the rectal mucosa. The Thiersch anal encirclement is no longer used (C). Moschcowitz procedure is more often performed for the management of vaginal prolapse (D).

**Reference:** Williams, J., Rothenberger, D., Madoff, R., et al. (1992). Treatment of rectal prolapse in the elderly by perineal rectosigmoidectomy. *Diseases of the Colon and Rectum*, 35(9), 830–834.

20. **C.** Anal fistulas in association with Crohn disease tend to be complex and have multiple fistulous tracts (A). MRI is particularly helpful to detect the extent of the fistula tract and identify abscesses, as well as to visualize the anal sphincter and pelvic floor muscle (B). These patients should also

undergo sigmoidoscopy, colonoscopy, and small bowel follow-through to determine the extent of disease. Antibiotics (metronidazole, ciprofloxacin) are used in treatment of fistulas to control symptoms and sepsis, but fistulas tend to recur when the antibiotics are discontinued. Immunomodulators (cyclosporine, tacrolimus, mercaptopurine, azathioprine, and infliximab) have been used as well with varying degrees of success. Of these, infliximab seems to be the most effective (D). The liberal use of setons is recommended. Aggressive use of fistulotomy should be avoided for low intersphincteric, suprasphincteric or extrasphincteric fistulae because it is associated with delayed healing and an increase in the risk of incontinence (E).

**Reference:** Vasilevsky, C. A. (2011). Anorectal abscess and fistula. In D. E. Beck, P. L. Roberts, T. J. Saclarides, et al., (Eds.), *The ASCRS textbook of colon and rectal surgery* (pp. 236–237) (2nd ed.). New York, NY: Springer Science + Business Media, LLC.

21. **B.** Proctitis typically presents with pain, tenesmus, rectal bleeding, diarrhea, and mucous discharge. It can be due to a bacterial infection, viral infection, trauma, radiation, and inflammatory bowel disease. Bacterial proctitis is often due to sexually transmitted diseases and is associated with anal intercourse. *N. gonorrhoeae* is the most common bacterial cause, followed by *Chlamydia*, which tends to produce fewer symptoms (A). *Treponema pallidum*, *Haemophilus ducreyi*, and *Shigella* species are uncommon causes of proctitis (C–E). Bacterial proctitis can also be due to non-sexually transmitted diseases, primarily in association with inflammatory bowel disease. Treatment of bacterial proctitis is with antibiotics, whereas for proctitis in association with inflammatory bowel disease, the treatment includes steroid and 5-aminosalicylic acid enemas.
22. **D.** Drainage of an anorectal abscess provides a cure in about half of patients, with the remaining going on to develop a persistent fistula-in-ano (A). Most fistulas are cryptoglandular in origin. Other causes, though less common, include trauma, Crohn disease, malignancy, radiation, and infections (tuberculosis, actinomycosis, and chlamydia). The external opening of the fistula is usually obvious, whereas the internal one is often hard to identify (B). Fistulas are categorized based on their relationship to the anal sphincter complex (intersphincteric, transsphincteric, and suprasphincteric) (C). Surgical treatment is determined by the location of the internal and external openings and the course of the fistula tract (D) and may include simple fistulotomy, draining or cutting seton, fibrin glue injection, fibrin plug, ligation of intersphincteric fistula tract (LIFT) procedure, or anorectal advancement flap. Gently injecting hydrogen peroxide or methylene blue into the external opening may help identify the internal opening (E). The main goal of treatment is to treat and eliminate sepsis, while at the same time maintaining continence.

**Reference:** Dunn, K. M., & Rothenberger, D. A. (2015). Colon, rectum, and anus. In F. C. Brunicaardi (Ed.), *Schwartz's principles of surgery* (pp. 1229–1231) (10th ed.). New York, NY: McGraw-Hill Education.

23. **E.** Hirschsprung disease rarely presents in adults (A). In this setting, the patient typically has a lifelong history of constipation and fecal impaction. A careful history will often reveal symptoms dating back to infancy. In most circumstances, Hirschsprung disease presenting as an adult consists of a short segment of aganglionosis. Although a barium enema can be diagnostic if an extremely dilated proximal colon, transitional zone, and contracted distal colon and rectum are seen, it may miss short-segment Hirschsprung disease if the rectal tube is introduced too far past the anal canal, bypassing the contracted segment (C). As such, the diagnosis is established by a rectal mucosal biopsy specimen demonstrating aganglionosis. As in children, Hirschsprung disease is associated with the RET mutation in a percentage of patients (B). Although a pull-through procedure, such as the Soave or Duhamel operation, is performed in children and in those with long segments of aganglionosis, in adults with short-segment aganglionosis, an anorectal myomectomy can be performed (D).

**Reference:** Wu, J., Schoetz, D., Jr., Collier, J., et al. (1995). Treatment of Hirschsprung's disease in the adult: report of five cases, *Diseases of the Colon and Rectum*, 38(6), 655–659.

24. **D.** Solitary rectal ulcer syndrome is an uncommon disorder that can be confused with malignancy because the patient presents with rectal bleeding and pain and evidence of straining during bowel movements. It is a benign process caused by an internal intussusception from chronic straining, leading to repetitive trauma to the mucosa. On proctoscopy, nodules or a mass may be found, in which case the term *colitis cystica profunda* is used. Biopsy should be performed to exclude malignancy. The diagnosis of an internal intussusception can be confirmed with anorectal manometry and defecography. Treatment is nonoperative and includes a high-fiber diet, defecation

training to avoid straining, and laxatives or enemas. Either abdominal or perineal repair, as for a patient with rectal prolapse, is recommended for failure of medical management (B, C). Transanal excision of a rectal ulcer is considered in the management of rectal cancer after determining the extent of tumor invasion through the bowel wall and evaluating the adjacent lymph nodes (A). Rectal fixation with prosthetic sling can be considered in the case of rectal procidentia (E).

**Reference:** Felt-Bersma, R., & Cuesta, M. (2001). Rectal prolapse, rectal intussusception, rectocele, and solitary rectal ulcer syndrome. *Gastroenterology Clinics of North America*, 30(1), 199–222.

# Breast

*Junko Ozao-Choy, Christine Dauphine, Areg Grigorian, and Christian de Virgilio*

## Questions

1. Which of the following is true regarding Poland's syndrome?
  - A. Both breasts are typically involved.
  - B. Men are more commonly affected.
  - C. It classically presents with a sunken chest.
  - D. It is due to an absence of the chest wall muscles.
  - E. It is not associated with symbrachydactyly.
2. Which of the following statements is true regarding the lymphatic anatomy of the breast?
  - A. Axillary lymph nodes are organized into three levels with respect to the pectoralis major muscle.
  - B. In a standard axillary dissection, only level I and II nodes are removed.
  - C. Approximately 30% of the lymphatic drainage from the breast goes to the contralateral lymph nodes.
  - D. Rotter nodes are otherwise called "anterior pectoral nodes" and are technically level I nodes.
  - E. Batson plexus is a network of lymphatics that drain the subareolar portion of the breast.
3. Which of the following is true regarding gynecomastia?
  - A. It is considered a risk factor for male breast cancer.
  - B. Tamoxifen can worsen gynecomastia.
  - C. It is uncommon after age 50.
  - D. It is due to accumulation of subareolar fat.
  - E. Mammography is excellent in differentiating true gynecomastia from malignant disease.
4. Which of the following is least likely to contribute to the development of breast infection (mastitis/abscess)?
  - A. Nipple ring insertion
  - B. Granulomatous mastitis
  - C. Smoking
  - D. Hidradenitis
  - E. Alcohol intake (>2 drinks/day)
5. A 48-year-old woman presents with a palpable tender mobile mass in the upper outer quadrant of her left breast. The overlying skin is normal and there is no adenopathy on exam. Ultrasound examination reveals a 2.5-cm cystic lesion. An ultrasound-guided cyst aspiration is performed. Which of the following is true?
  - A. The fluid should be sent for cytologic examination only if it is blood tinged.
  - B. Straw-colored fluid should prompt a core needle biopsy.
  - C. The presence of septations is associated with a low recurrence rate of the cyst after aspiration.
  - D. Thickness of the cyst wall does not correlate with cancer risk.
  - E. Viscous gel-like fluid is a poor prognostic sign.

6. Nipple discharge is most suspicious of breast cancer in which of the following women?
  - A. A 35-year-old woman with bilateral brown discharge that is only visible with squeezing of the nipple
  - B. A 45-year-old woman with unilateral serous discharge that is spontaneous
  - C. A 30-year-old woman who is lactating and notices unilateral bloody nipple discharge that is spontaneous
  - D. A 50-year-old woman with greenish colored discharge bilaterally that is sometimes spontaneous
  - E. A 40-year-old woman with bilateral milky discharge that occurs spontaneously onto her bra
7. Which of the following statements is TRUE regarding tamoxifen therapy?
  - A. Tamoxifen has been shown to reduce the risk of developing breast cancer by 90% in patients that are considered high risk.
  - B. The primary serious side effect of tamoxifen is loss of bone mineral density.
  - C. The mechanism of action of tamoxifen is to lower serum estrogen levels by decreasing estrogen production.
  - D. Tamoxifen is most effective when administered concurrently with chemotherapy.
  - E. Treatment with tamoxifen should be interrupted if a woman with a history of estrogen-receptor positive invasive breast cancer wishes to become pregnant.
8. Which of the following is most characteristic of a malignant lesion as seen on ultrasound imaging?
  - A. Taller-than-wide measurements
  - B. Hypoechoic mass
  - C. Anechoic mass
  - D. Homogenous internal structure
  - E. Bilateral edge shadowing
9. A 45-year-old premenopausal woman undergoes stereotactic core needle biopsy of calcifications seen on screening mammogram. The biopsy reveals atypical ductal hyperplasia (ADH). Which of the following is TRUE about the management of this patient?
  - A. Tamoxifen should be prescribed.
  - B. The lesion should be completely excised with a negative margin.
  - C. No further excision is required if the calcifications were completely removed.
  - D. Prophylactic bilateral mastectomy should strongly be considered.
  - E. Sentinel lymph node biopsy should be performed along with excision of the lesion.
10. A 50-year-old woman has undergone stereotactic needle biopsy of abnormal calcifications, showing a large, high-grade ductal carcinoma in situ (DCIS). Which of the following choices is the most appropriate treatment for this patient?
  - A. Lumpectomy alone
  - B. Modified radical mastectomy
  - C. Lumpectomy and sentinel lymph node biopsy
  - D. Lumpectomy and sentinel lymph node biopsy, followed by whole breast radiotherapy
  - E. Lumpectomy and sentinel lymph node biopsy with intraoperative radiotherapy
11. *BRCA1* and *BRCA2* are:
  - A. Proto-oncogenes
  - B. Cyclin-dependent kinase
  - C. Tumor suppressor genes
  - D. Mismatch repair genes
  - E. Tyrosine kinases
12. Which of the following is TRUE of invasive lobular carcinoma of the breast?
  - A. It is harder to detect metastasis on intraoperative frozen section analysis of sentinel nodes.
  - B. Lobular cancers are typically hormone receptor negative.

- C. Breast conservation therapy is contraindicated.
  - D. Invasive lobular cancers typically appear on mammogram and ultrasound as a discrete mass.
  - E. Lobular cancers comprise 40% of all invasive breast cancers.
13. A 45-year-old woman with locally advanced right breast cancer has fullness in the right supraclavicular area. Ultrasound-guided fine-needle aspiration of a supraclavicular node on the right side reveals metastatic breast cancer. Which of the following is TRUE regarding this lesion?
- A. It should be treated by surgical resection of the supraclavicular node at the same time as resection of the primary breast tumor, followed by chemohormonal therapy.
  - B. It should be treated with chemoradiation and resection only of the primary breast tumor.
  - C. Palliative chemohormonal therapy should be initiated without resection of the node or the primary breast tumor.
  - D. Palliative chemohormonal therapy should be initiated with resection only of the primary breast tumor.
  - E. Palliative hormonal therapy should be initiated alone, without resection of the node or the primary breast tumor.
14. A 78-year-old woman with mild dementia, chronic obstructive pulmonary disease (COPD), diabetes, end-stage renal disease, and a prior lower extremity amputation for peripheral vascular disease has an episode of severe chest pain 1 day after undergoing core biopsy of a 1.5-cm right breast mass. Angiogram demonstrates a critical stenosis of the left anterior descending artery and a drug-eluting stent is placed. She is subsequently placed on antiplatelet therapy. Her biopsy results later reveal invasive ductal carcinoma that is intermediate grade, 90% estrogen receptor (ER) and progesterone receptor (PR) positive, and *HER2* negative. Her axilla is clinically negative. What is the BEST therapeutic approach to this patient?
- A. Lumpectomy and sentinel node biopsy, followed by radiotherapy and hormone therapy
  - B. Lumpectomy and sentinel node biopsy, followed by chemotherapy then radiotherapy and hormonal therapy
  - C. Mastectomy and sentinel node biopsy, followed by hormone therapy
  - D. Chemotherapy, then consideration for surgical resection depending on response
  - E. Hormone therapy, then consideration for surgical resection depending on response
15. A 67-year-old asymptomatic female with a past history of stage III breast cancer for which she completed mastectomy, chemotherapy, radiotherapy, and 5 years of hormonal therapy is incidentally found on computed tomography (CT) scan to have several 1-cm liver lesions and bilateral pulmonary nodules consistent with metastatic breast cancer. Biopsy of one of the liver masses confirms the diagnosis of an ER-positive and PR-positive, *HER2*-negative metastatic breast cancer. There is no evidence of local recurrence or new primary breast cancer. The BEST treatment for this patient would be:
- A. Chemotherapy
  - B. Hormonal therapy
  - C. Radiation therapy
  - D. Metastectomy
  - E. Metastectomy and chemotherapy
16. Which of the following is TRUE of sentinel lymph node biopsy?
- A. Failure to identify the sentinel lymph nodes by either the blue dye or radioactive colloid occurs in less than 5%.
  - B. The procedure has a high false-negative rate.
  - C. There is no role in DCIS.
  - D. Utilization of the technetium radiocolloid is contraindicated in pregnancy.
  - E. If used in patients undergoing neoadjuvant chemotherapy, the procedure must be performed before initiating chemotherapy.
17. Which of the following is TRUE regarding radiotherapy for the treatment of early breast cancer?
- A. Radiotherapy should be performed if more than three nodes are positive.

- B. Radiotherapy should be performed in addition to axillary lymph node dissection if more than three nodes are positive.
  - C. Whole breast radiotherapy is most effective when given concurrent with chemotherapy.
  - D. Radiotherapy is less efficacious with small tumors compared with larger ones.
  - E. Higher energy radiation exerts more damage to skin.
18. Which of the following is true regarding chemotherapy for the treatment of breast cancer?
- A. Neoadjuvant chemotherapy has been shown to have better outcomes for ER-positive, *HER2*-negative breast cancer compared with adjuvant chemotherapy.
  - B. In patients with ER-negative, PR-negative, *HER2*-negative (triple negative) breast cancer, complete response to neoadjuvant chemotherapy is achieved in most patients.
  - C. Responses to chemotherapy can be predicted by testing whether certain genes are being expressed in cancer tissue.
  - D. Chemotherapy is most effective in infiltrating cancers that have low Ki67 and S-phase fractions.
  - E. Chemotherapy is indicated if the breast cancer is proven to be invasive.
19. Which of the following is NOT a well-known treatment toxicity related to breast cancer therapy?
- A. Steatosis and steatohepatitis associated with aromatase inhibitor therapy
  - B. Lymphedema after radiotherapy alone
  - C. Decreased cognitive and memory functions after chemotherapy
  - D. Irreversible numbness along the chest wall after modified radical mastectomy
  - E. Worsening vision due to cataract formation after tamoxifen therapy
20. Which of the following is TRUE regarding positive lymph nodes in breast cancer?
- A. Involvement of internal mammary lymph nodes is considered stage IV disease.
  - B. Completion axillary lymph node dissection should be performed if the sentinel lymph node biopsy is positive.
  - C. In a patient with a core biopsy-proven positive lymph node and no primary lesion detected on mammogram or physical exam, axillary lymph node dissection and serial 6-month mammograms should be performed.
  - D. Radiotherapy can be administered instead of performing axillary lymph node dissection for a positive lymph node that is nonpalpable.
  - E. Axillary dissection is no longer necessary if a 6-cm primary breast cancer and associated 3-cm nodes have all disappeared on ultrasound imaging after completion of preoperative chemotherapy (i.e., complete response).
21. A 52-year-old woman with a body mass index (BMI) of 25 is recommended to undergo a mastectomy for a 9-cm segmental regional distribution of calcifications that were shown to be DCIS on core needle biopsy. Physical exam and ultrasound of the axilla are negative. The patient has a small breast contour and desires reconstruction of her breast. In addition to sentinel node biopsy, which of the following would be the BEST management?
- A. Nipple-sparing mastectomy with immediate tissue expander placement
  - B. Nipple-sparing mastectomy with delayed reconstruction
  - C. Skin-sparing mastectomy with immediate tissue expander placement
  - D. Skin-sparing mastectomy with delayed reconstruction
  - E. Total mastectomy with delayed reconstruction after adjuvant therapy
22. After a modified radical mastectomy, a 45-year-old woman reports new-onset weakness in the ipsilateral arm when pulling down on a cord to adjust the blinds in her home. On examination, she has difficulty when attempting to internally rotate and adduct her arm. What is the best explanation for her deficits?
- A. Intentional transection of the intercostobrachial nerve
  - B. Application of surgical clips across the long thoracic nerve
  - C. Inadvertent transection of the thoracodorsal nerve
  - D. Complete cautery injury to the supraclavicular nerve



- E. Retractor injury to the medial pectoral nerve
23. A 35-year-old woman presents with burning pain and redness along the anterolateral right breast. On exam, a firm tender cord could be palpated just below the skin from the shoulder tracking down toward the lateral breast. Which of the following is TRUE regarding the initial management of this disease?
- A. Mammogram and ultrasound should be performed.
  - B. Systemic anticoagulation should be initiated.
  - C. Antibiotics covering gram-positive bacterial strains should be administered.
  - D. A short course of corticosteroid therapy should be prescribed for cases where the erythrocyte sedimentation rate (ESR) is elevated.
  - E. An incisional biopsy of the skin should be performed.
24. A 28-year-old lactating woman presents with a 2-day history of right breast pain and redness that is progressively worsening. On examination, a 4-cm area of skin adjacent to the nipple-areolar complex is erythematous and tender, with some focal edema and no detectable fluctuance. Focused ultrasound confirms the absence of a fluid collection. The appropriate initial management would consist of:
- A. Image-guided core needle biopsy
  - B. Cessation of breast-feeding and/or pumping
  - C. Incision and drainage
  - D. Oral antibiotics
  - E. Mammography
25. A 50-year-old woman presents with a 10-cm right breast mass. She notes that it has been rapidly growing, and the weight of the mass causes her right breast to rest lower than her left. Pathology from a core needle biopsy revealed a fibroepithelial lesion with notable leaflike projections of the stroma. Which of the following statements is true of this lesion?
- A. Stromal hypercellularity is the pathologic feature that typically distinguishes this lesion from fibroadenoma.
  - B. It commonly demonstrates an aggressive growth pattern similar to breast cancer, infiltrating surrounding tissues as it enlarges.
  - C. Sentinel lymph node biopsy has become standard in the management of borderline-malignant disease.
  - D. The addition of radiotherapy is routinely recommended to prevent recurrence after lumpectomy.
  - E. Most require mastectomy as a means of excision in order to achieve adequate margins.
26. A 55-year-old woman was found on routine mammography to have a new, 17 mm, stellate lesion with a translucent area in the central portion. Which of the following best describes appropriate management of this lesion?
- A. Observation only, since the mammographic appearance is sufficient to make the diagnosis
  - B. Repeat mammography in 6 months because this lesion is probably benign (<2% risk of malignancy), but short-interval imaging is warranted to confirm
  - C. MRI of the breast to confirm the diagnosis, then observation
  - D. Image-guided core needle biopsy followed by wire-localized excision, since this lesion is considered high risk
  - E. Image-guided core needle biopsy, followed by wire-localized wide excision with a negative margin since this lesion is malignant
27. A 50-year-old perimenopausal woman presents with three episodes of dark bloody discharge from her right nipple that stained her bra. This is most likely to be due to which of the following:
- A. Atypical ductal hyperplasia
  - B. Paget disease
  - C. Phyllodes tumor
  - D. Ductal carcinoma in situ

- E. Intraductal papilloma
28. A 50-year-old woman presents to her primary doctor with a palpable mass in the upper outer quadrant of her right breast. It has been present and unchanged for 3 months, and she has no personal or family history of breast or ovarian cancer. On examination, there is a 1.5-cm firm, non-tender mass with no associated skin or nipple abnormalities and no lymphadenopathy. Mammography is performed and there is no evidence of mass, asymmetry, or calcification. It is reported as normal. What is the next appropriate step?
- A. Observation, with repeat physical exam in 3 months
  - B. Order a repeat mammogram in 3 to 6 months
  - C. Order MRI of the breast
  - D. Order focused breast ultrasound
  - E. Excision of the mass
29. MRI of the breast is indicated in which of the following scenarios?
- A. 45-year-old woman with atypical ductal hyperplasia in 1-cm group of calcifications in the upper inner quadrant of her left breast
  - B. 45-year-old, average-risk woman with focal breast pain and normal mammogram and ultrasound workup
  - C. 45-year-old woman with fibrocystic changes on biopsy of her breast and infiltrating carcinoma found in an ipsilateral axillary node
  - D. 45-year-old woman with 2-cm area of DCIS with comedo necrosis
  - E. 45-year-old woman with lobular carcinoma in situ in a 1-cm group of microcalcifications in the upper outer quadrant of her left breast
30. Which of the following lesions found on core needle biopsy does not require excisional biopsy?
- A. Atypical lobular hyperplasia
  - B. Flat epithelial atypia
  - C. Radial scar
  - D. Lobular carcinoma in situ (LCIS)
  - E. Adenosis with apocrine metaplasia
31. A 45-year-old woman undergoes wire-localized excisional biopsy of a 12-mm group of microcalcifications that could not be biopsied by percutaneous core needle because of their posterior location. Pathology reveals LCIS. Which of the following is the most appropriate NEXT step in management?
- A. Bilateral prophylactic mastectomies, with or without reconstruction
  - B. If the margins of excision are negative, initiation of radiotherapy
  - C. If the margins of excision are positive, re-excision of the affected margin
  - D. Performance of sentinel lymph node biopsy to stage the ipsilateral axilla
  - E. Initiation of daily tamoxifen for 5 years
32. A 48-year-old female is being evaluated for a new left breast mass that was found on mammogram. She reports having 2 alcoholic drinks per day, is an active smoker with a 5-pack year smoking history, and has a mother who was diagnosed with breast cancer at age 55. Her past medical history is significant for atypical ductal hyperplasia that was excised 6 years previously. Which of the following factors is associated with the highest risk of breast cancer in this patient?
- A. Age
  - B. Mother with a history of breast cancer
  - C. Daily alcohol intake
  - D. Smoking
  - E. History of atypical ductal hyperplasia
33. Which histologic type of DCIS is most likely to progress to invasive ductal cancer?
- A. Comedo

- B. Micropapillary
  - C. Papillary
  - D. Cribriform
  - E. Solid
34. A 45-year-old woman undergoes wire-localized excision of an area of biopsy-proven, intermediate grade DCIS in the upper outer quadrant of her left breast. The final pathology shows no evidence of invasion, but there is DCIS involving the deep margin (i.e. positive margin). The NEXT appropriate step is:
- A. No further surgery; should initiate radiation therapy
  - B. No further surgery; should initiate tamoxifen
  - C. Re-excision of the deep margin only
  - D. Re-excision of the deep margin and sentinel node biopsy
  - E. Mastectomy
35. A woman with a history of glioblastoma, left lower limb osteosarcoma as a teenager and breast cancer at the age of 40 is likely to have which of the following:
- A. Cowden syndrome
  - B. Li-Fraumeni syndrome
  - C. Peutz-Jeghers syndrome
  - D. Ataxia-telangiectasia
  - E. *BRCA2* mutation
36. A 21-year-old woman with a strong family history of breast cancer has just been told she is a carrier of a *BRCA1* germline mutation. Which of the following is TRUE regarding this mutation?
- A. Breast cancers associated with *BRCA1* mutations are typically hormone receptor negative.
  - B. *BRCA1* mutations are considered “gain of function” mutations.
  - C. *BRCA* mutations account for 25% of all breast cancers.
  - D. Her lifetime risk of developing breast cancer is around 40% and can be reduced by half if she takes tamoxifen.
  - E. Male relatives of the patient have a 100-fold risk of developing breast cancer if they are carriers of the mutation.
37. Which of the following is TRUE regarding the histologic subtypes of breast cancer?
- A. Half of breast cancers are invasive ductal carcinoma, and the other half are invasive lobular carcinoma.
  - B. Tubular carcinoma is rarely associated with axillary metastasis and survival approaches 100%.
  - C. Papillary carcinoma is an aggressive form of breast cancer with a high rate of axillary metastasis.
  - D. Mucinous (colloid) carcinoma is associated with *BRCA1* mutation.
  - E. Medullary carcinoma is a form of lobular cancer that appears well differentiated histologically.
38. A 56-year-old woman is diagnosed with a 2 cm breast mass, which is estrogen and progesterone receptor negative with no overexpression of *HER2/neu*. Her axillary exam is normal. Aside from axillary evaluation by sentinel lymph node biopsy, what is the most appropriate recommendation for breast cancer therapy?
- A. Lumpectomy alone
  - B. Lumpectomy plus hormonal therapy
  - C. Lumpectomy plus radiotherapy
  - D. Lumpectomy plus chemotherapy
  - E. Lumpectomy plus radiotherapy and chemotherapy
39. Which of the following patients with a 1.5-cm invasive ductal breast cancer would be the most appropriate for breast conserving therapy?
- A. 33-year-old woman who is 10 weeks pregnant at diagnosis
  - B. 58-year-old woman who has a history of lumpectomy in the same breast for previous T1N0 breast

cancer

- C. 55-year-old woman with ipsilateral palpable lymph nodes that appear abnormal on ultrasound
  - D. 52-year-old woman with scleroderma
  - E. 50-year-old woman with synchronous, multicentric ipsilateral invasive lobular cancer
40. Which of the following is the most important predictor of 10-year survival for breast cancer?
- A. Primary tumor size
  - B. Histologic grade
  - C. Total number of positive lymph nodes
  - D. Estrogen-receptor status
  - E. Age at time of diagnosis
41. A 55-year-old woman presents with 1 month of breast erythema and swelling. On physical examination and mammogram, there is no evidence of a breast mass. However, there is diffuse skin thickening and edema associated with a 3-cm lymph node in the axilla. A trial of broad-spectrum antibiotics has been ineffective. A core needle biopsy reveals infiltrating carcinoma that is 10% estrogen-receptor positive and *HER2/neu* negative. Which of the following statements is TRUE regarding her management?
- A. Tamoxifen should be initiated immediately.
  - B. Modified radical mastectomy should be performed as soon as possible to increase chances of survival.
  - C. Radiation therapy should be performed concurrently with chemotherapy to improve response rates.
  - D. Chemotherapy should be initiated immediately.
  - E. Antibiotics should be continued because of the infectious signs.
42. Batson plexus provides a potential metastatic route of breast cancer to:
- A. Supraclavicular nodes
  - B. Bone
  - C. Liver
  - D. Adrenal glands
  - E. Lung
43. A 65-year-old female underwent left modified radical mastectomy followed by chemotherapy and radiation therapy for a stage II breast cancer when she was 40 years old. She has had long-standing swelling of her ipsilateral arm and recently developed raised purple nodules along the anterior upper arm. Which of the following is TRUE regarding treatment of this lesion?
- A. Treatment of this condition is largely conservative because it is a slow-growing tumor that rarely causes mortality.
  - B. Bevacizumab (angiogenesis inhibitor) plus paclitaxel has emerged as the treatment of choice.
  - C. Concurrent Adriamycin-based chemotherapy and radiation are considered the optimal treatment strategy, with surgical resection being reserved only for those with large residual tumors.
  - D. Surgical resection is the optimal primary treatment modality, and upper extremity amputation is often required.
  - E. Laser and radiofrequency ablation treatments are first-line therapy, followed by low-dose radiation therapy.
44. A 33-year-old female detects a 3-cm mass in her left breast when she is 16 weeks pregnant. Biopsy reveals infiltrating ductal carcinoma that is estrogen, progesterone, and *HER2* negative. Which of the following is TRUE regarding breast cancer staging and therapy in this patient?
- A. Sentinel lymph node biopsy using a radiotracer to stage the axilla is contraindicated in pregnancy.
  - B. CT scan of the chest and abdomen to stage breast cancer is contraindicated in pregnancy.
  - C. Cytotoxic chemotherapy, such as Adriamycin, can be administered cautiously during the second and third trimesters.
  - D. Radiotherapy can be administered cautiously during the second and third trimesters.

- E. Hormone therapy can be administered cautiously during the second and third trimesters.
45. A 58-year-old postmenopausal woman with a history of right breast cancer presents with a new 1.2-cm nodule within the scar of her lumpectomy incision. Her prior therapy consisted of a negative sentinel node biopsy, radiotherapy, and chemotherapy, and she is currently taking tamoxifen. Core needle biopsy reveals recurrent infiltrating ductal carcinoma that is hormone receptor positive and *HER2* negative. Which of the following is TRUE regarding her condition?
- A. Axillary dissection is required because the patient has already had a sentinel lymph node biopsy at her prior operation.
  - B. Neoadjuvant (preoperative) chemotherapy should be considered first in order to improve the chances of achieving breast conservation.
  - C. Tamoxifen should be continued for an additional 5 years after operative excision to prevent another recurrence.
  - D. The patient should undergo *BRCA* testing to determine whether or not she is a mutation carrier.
  - E. She will require mastectomy as her definitive surgical management.
46. A 65-year-old woman presents with an eczematoïd rash involving her right nipple and extending onto the areola. The rash has not resolved despite daily applications of steroid cream. Other than the skin changes on the nipple, the physical examination of the breast is unremarkable. Which of the following is TRUE regarding this condition?
- A. If mammography is benign, steroid cream should be continued, possibly at a higher dose.
  - B. Shave biopsy is the preferred biopsy technique given the involvement of the nipple.
  - C. Nipple discharge is nearly always present, and cytologic examination of the discharge is frequently diagnostic for this disorder.
  - D. This lesion is precancerous and associated with 7 to 10 times increased risk of developing breast cancer in the future.
  - E. Mastectomy is commonly required to treat this condition.
47. Which of the following is TRUE of breast lymphoma?
- A. Primary breast lymphoma is predominantly a T-cell lymphoma.
  - B. Secondary breast lymphomas are much more common than primary breast lymphoma.
  - C. Primary breast lymphoma does not respond well to chemotherapy that is standardly used for nonbreast lymphoma.
  - D. Breast lymphoma has a predilection for central nervous system recurrence.
  - E. Treatment of breast lymphoma tends to require mastectomy with node dissection in most cases.
48. The primary serious adverse reaction to trastuzumab that requires monitoring is which of the following?
- A. Hepatic toxicity
  - B. Renal toxicity
  - C. Cardiac toxicity
  - D. Pulmonary toxicity
  - E. Bone marrow toxicity (aplastic anemia)

## Answers

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1. **B.** Poland syndrome is a sporadic congenital disorder that classically affects the unilateral breast, chest wall, and upper extremity. It is present in at least 1 in 100,000 individuals, occurs more commonly on the right than left (2:1 to 3:1), and affects men more often than women (3:1). Underdevelopment or absence of the pectoralis, serratus, and latissimus dorsi muscles, symbrachydactyly (fused, missing, and/or shortened digits), shortened forearm, dextrocardia, rib abnormalities, absent axillary hair, athelia, diminished subcutaneous fat localized over the ipsilateral chest wall, and renal agenesis or hypoplasia (rare) have all been described as characteristics of Poland syndrome (E). The cause is thought to be due to interruption in the vascular supply to the affected chest wall and upper extremity in utero resulting in hypoplasia of

the chest wall muscles (D). Pectus excavatum is a separate congenital condition that is often inherited and results in a bilateral anterior chest wall deformity characterized by a sunken chest (A, C).

2. **B.** Axillary lymph nodes are classically organized into six anatomic groups based on their anatomic location (lateral, pectoral, scapular, central, subclavicular, and interpectoral). However, a more clinically useful classification is into levels based on their location relative to the pectoralis minor muscle, with level I being located lateral (most inferior) to the muscle border, level II being located behind the pectoralis minor, and level III nodes medial (A). Rotter nodes are interpectoral (between the pectoralis major and minor muscles) and are technically level II nodes (D). In a standard axillary dissection, level I and II nodes are removed. There are approximately 20 to 30 lymph nodes in the average axilla, and the lymphatic drainage is fairly predictable, following a hierarchical pattern to the first echelon of nodes, followed by secondary and then tertiary echelons. This pattern is the basis of the principle for sentinel lymph node biopsy. Most of the lymphatic drainage of the breast is to the axilla, with drainage to the contralateral breast being rare (C). For this reason, it is not standard to remove (or even check for) sentinel nodes in the ipsilateral supraclavicular and internal mammary or contralateral lymph node stations. The network of lymphatics that drains the subareolar region is called Sappey, and it is important because this is the principle behind subareolar injection of blue dye and radiocolloid for sentinel lymph node mapping. Batson plexus is instead a network of venous drainage that is thought to be a route for metastasis to the spine (E).

3. **E.** Gynecomastia is an asymptomatic condition resulting from the abnormal benign proliferation of glandular breast tissue in men. It is not considered a risk factor for breast cancer (A). After examination, it is not uncommon to find that most patients, in fact, have pseudogynecomastia, which is an accumulation of subareolar fat without a proliferation in glandular tissue (D). There are three stages where gynecomastia is more common—infancy, puberty, and after age 50. The stimulation of breast growth is attributed to an imbalance of the effects of estrogen versus testosterone. Older patients are more vulnerable to this imbalance and thus up to 70% of patients older than 50 have senescent gynecomastia (C). Spironolactone increases the metabolism and clearance of testosterone; marijuana alters the hypothalamic-pituitary-gonadal axis; uremia related to ESRD causes prolonged half-life of luteinizing hormone (LH), which leads to decreased secretion of LH and decreased testosterone levels; and cimetidine increases plasma prolactin levels, all of which are well-described causes of gynecomastia. Mammography is excellent in differentiating true gynecomastia from malignant disease with a sensitivity and specificity exceeding 90%. However the positive predictive value for cancer is low, as would be expected with such a low incidence of malignancy in this patient population. If the patient is bothered by the appearance of gynecomastia, antiestrogens such as tamoxifen are frequently used with success. Rarely, patients will require surgical removal.

**References:** Johnson, R. E., & Murad, M. H. (2009). Gynecomastia: pathophysiology, evaluation, and management. *Mayo Clinic Proceedings*, 84(11), 1010–1015.

4. **E.** Nonlactational breast infections predominantly occur when there is an obstruction or pseudo-obstruction of the lactiferous duct. The most common organism remains *Staphylococcus aureus*. Trauma to the nipple, which includes the placement of nipple rings, causes scarring and obstruction (A). Granulomatous mastitis is an inflammatory lesion of the breast, which may be autoimmune in nature, but is often recurrent and associated with superinfections of the inflammatory mass (B). Smoking causes a change in the epithelium of the breast duct (keratinizing squamous metaplasia) that leads to keratin plugs that obstruct the ducts (C). Hidradenitis is a skin infection that is caused by obstruction of the apocrine sweat glands, which often occurs in the periareolar, axillary, and inframammary regions of the breast (D). Alcohol does not have a known direct association with breast abscess.

5. **A.** Breast cysts are overwhelmingly a benign entity, occurring most frequently in women between the ages of 35 and 50. The typical presentation is that of a painful smooth, mobile firm mass that often fluctuates in size according to the timing of a woman's menstrual cycle. The exact etiology is largely unknown, but it is clear that hormones play a role in the course of disease. Breast cysts largely disappear after menopause, so the presence of a cyst in a postmenopausal woman should raise concern. The vast majority of breast cysts are termed "simple cysts" and do not require any action at all. The presence of a simple cyst does not elevate an individual's risk of subsequent breast cancer. Aspiration is primarily recommended if a woman is symptomatic, or if the cyst was

inadvertently discovered on mammographic imaging, and the sonographer cannot definitively determine a sonographic lesion to be cystic or concordant with the mammographic abnormality. Though most fluid aspirated from breast cysts is straw colored and watery, a viscous gel-like aspirate is common and not worrisome unless it contains blood (B, E). There is no need to send cyst aspirate for cytologic evaluation unless it is bloody. In the case of bloody aspirate, core needle biopsy should also be performed of the cyst wall. If suspicious features such as intracystic septations, thickened walls, and intracystic mass are present, these cysts are called “complicated cysts,” and core needle biopsy is recommended (D). Recurrence of a simple breast cyst (or perhaps an enlargement of a different nearby cyst) is common after aspiration, and no feature predicts high or low risk of cyst recurrence (C). However, if a cyst recurs within 2 weeks of the aspiration procedure, this should spark suspicion and consideration for biopsy.

6. **B.** Nipple discharge is considered “pathologic” if it is serous or bloody in color, unilateral, emanating from a single duct only, copious in amount, or spontaneous. When a woman experiences pathologic discharge after the age of 50, it is particularly more worrisome. Brown, green, white (milky), yellow, and blue discharge is more commonly “physiologic” and can usually be expressed from multiple ducts and/or bilaterally on examination. Bloody and serous types should raise concern for malignancy. Breast-feeding women can commonly have blood-tinged milk in the first weeks of pregnancy. This condition requires only observation, as it is most often self-limited. In the case of pathologic discharge, mammography and breast ultrasound should be performed in an attempt to identify an occult malignancy causing the discharge. If negative, ductal excision is recommended as both diagnostic and therapeutic. Malignant lesions are found in fewer than 10% of cases. From this list of patients, choice B is the most suspicious for breast cancer (A, C–E).
7. **E.** Tamoxifen is a selective estrogen-receptor modulator (SERM) that acts competitively at the estrogen receptor to halt cell division (C). Indications for its use are to reduce cancer risk in high-risk patients and as a cancer therapy in men and women with estrogen receptor-positive noninvasive and invasive breast cancer. In the NSABP-P01 trial, high-risk patients (5-year Gail risk >1.67% or lobular carcinoma in situ [LCIS]) experienced a 50% risk reduction in subsequent noninvasive and invasive breast cancers. A 90% risk reduction is associated with prophylactic mastectomy, not tamoxifen (A). The decision to give tamoxifen must always weigh the possible benefit against the potential side effects. Tamoxifen is associated with the development of endometrial adenocarcinoma and with an increased risk of venous thromboembolism and cataract formation. Tamoxifen is most effective when administered in sequence with chemotherapy, not concurrent (D). If a woman desires pregnancy after completing surgery, chemotherapy, and radiation treatments for breast cancer, tamoxifen therapy should be halted to avoid fetal exposure and reinitiated after pregnancy and lactation.
8. **A.** On ultrasound, lesions that are anechoic are fluid filled (i.e., cysts), and lesions that are hypoechoic are solid (C). Benign and malignant masses can appear hypoechoic, but having a homogeneous internal structure is a benign characteristic (D). Bilateral edge shadowing is also a typically benign finding on ultrasound as echoes are deflected off of a smooth-bordered rounded mass and appear as dark shadows below each edge of a lesion (E). Taller-than-wide measurements denote a lesion that is infiltrative of the natural elements of the breast, which run parallel to the chest wall. Lesions that are benign are typically wider-than-tall and grow along the natural elements of the breast.
9. **A.** Atypical ductal hyperplasia, along with atypical lobular hyperplasia and flat epithelial hyperplasia, is classified as a “proliferative lesion with atypia.” As such, it is associated with up to five times higher relative risk of breast cancer than normal breast tissue. The risk is higher with multifocal lesions. Stromal fibrosis and apocrine metaplasia do not have an increased risk for breast cancer and thus do not need any additional workup (D). Though ADH is a benign diagnosis, it is morphologically similar to low-grade ductal carcinoma-in-situ and must be less than 2 mm in size to be termed ADH. Surgical excision is recommended if ADH is diagnosed on core biopsy because of reported rates of upstaging (finding cancer) of 20% to 30% (C). It is not important to have a negative margin, but excision of the initial abnormal area must be contained in the surgical specimen for pathologic evaluation (B). Incorrect targeting (i.e., not seeing the clip on specimen radiograph) should spark consideration for retargeting and re-excision. Tamoxifen is a standard recommendation after excisional biopsy confirms the absence of cancer. Patients enrolled in the NSABP P-01 trial were randomized to tamoxifen versus placebo, and those who took tamoxifen had



a 50% reduction in subsequent invasive and noninvasive carcinoma of the breast. Axillary staging is not indicated given that ADH is benign, and bilateral prophylactic mastectomy should not be recommended for this relatively low-risk lesion (E).

10. **D.** From the NSABP B-17 trial, lumpectomy plus radiotherapy was established as superior to lumpectomy alone, given the significant reduction of ipsilateral breast tumor recurrence rates with the addition of radiotherapy (A, C). Sentinel lymph node biopsy is not absolutely indicated for DCIS when performing lumpectomy. However, it is often performed in cases of high-grade DCIS, and in those with large or palpable masses, to reduce the need for second surgeries if occult invasive disease is found within the specimen. Additionally, in most cases of lumpectomy (and all cases of mastectomy), the lymphatic drainage has been removed along with the tumor, and thus sampling the sentinel node would be impossible. Planned axillary dissection (as part of a modified radical mastectomy) would not be indicated for in situ disease (B). Intraoperative radiotherapy is not, as yet, standard of care and is only available at a few centers (E). The TARGIT-A trial demonstrated that intraoperative radiation had a similar rate of wound infection, local recurrence, and overall survival compared to external-beam radiation therapy. The advantage is that the patient only undergoes a single radiation event during the index operation compared to repeated episodes of radiation therapy over a 6-week period.

**Reference:** Vaidya, J. S., Wenz, F., Bulsara, M., et al. (2014). Risk-adapted targeted intraoperative radiotherapy versus whole-breast radiotherapy for breast cancer: 5-year results for local control and overall survival from the TARGIT-A randomised trial. *The Lancet*, 383(9917), 603–613.

11. **C.** *BRCA1* and *BRCA2* are examples of tumor suppressor genes, which normally regulate and inhibit growth of abnormal cells. A mutation in both copies of a tumor suppressor gene such as the *BRCA* gene (usually one inherited and one acquired) leads to loss of this protective function and unregulated growth of abnormal cells goes unchecked. On the other hand, proto-oncogenes (such as *ras*) typically code for proteins that stimulate cell growth, and mutations in these genes lead to upregulated cell division and therefore cancer (A). Mismatch repair genes code for proteins that recognize DNA errors and repair them, making them a type of tumor suppressor gene. Mutations in mismatch repair genes can then lead to cancer formation. A common example is the *MSH2* and *MLH1* associated with Lynch syndrome (D). Tyrosine kinases and cyclin-dependent kinases are groups of enzymes that are important for cell regulation and play key roles in development of many cancers (B, E).
12. **A.** Invasive lobular cancers comprise only 15% of all invasive breast cancers and arise from the terminal lobular components of the lactiferous ducts (E). These cancers are typically hormone receptor positive and tend to occur in postmenopausal women (B). Histologically, lobular cancers grow in a linear pattern infiltrating between tissue planes rather than distorting them. This growth pattern explains why lobular cancer can be very indiscrete on mammogram and ultrasound (poorly defined borders) (D). Although it can be difficult to determine the extent of the lesion and mastectomy is often recommended for lobular cancers, breast conservation is an acceptable option and is associated with low rates of recurrence (C). Since lobular cancer cells are small and difficult to distinguish from lymphocytes, metastatic cells are often not readily apparent on intraoperative analysis by frozen section, and results are often deferred pending definitive analysis.
13. **B.** Involved supraclavicular nodes denote an N3c nodal stage, which is a stage III breast cancer. Breast cancer would be stage IV if more distant nodes (contralateral, periaortic, hilar) are involved or cancer has metastasized to bone, brain, lung, visceral organ, etc. (C-E). With regard to treatment of supraclavicular nodes, chemotherapy and radiation to the supraclavicular fossa without surgical resection of the supraclavicular node are the recommended approaches. Resection of the supraclavicular node may be recommended if not fully treated by chemotherapy and radiation but it would not be the planned definitive therapy (A).
14. **E.** In elderly patients and in patients with multiple comorbidities that, in and of themselves, limit a patient's survival, the standard treatment algorithms may be altered to reduce potential adverse effects of treatment that have lower margins of benefit in patients with limited life spans. Given her recent myocardial infarction, surgical risk is extremely high. Therefore, chemotherapy and hormonal therapy are more appealing to avoid the risks associated with anesthesia and perioperative stress. In this patient, cardiac toxicities related to chemotherapy would likely preclude administration of standard agents. Therefore, a 3- to 6-month course of aromatase inhibitor therapy followed by reimaging to assess response is the best course of action (A–D).

15. **B.** In distal recurrence of breast cancer, the goal of therapy becomes progression-free survival and management of symptoms. There is no role for local therapies such as radiotherapy or mastectomy given that her disease is widespread systemically (C–E). Hormonal therapy has the best benefit to risk ratio and would include second-line agents, such as fulvestrant, in addition to aromatase inhibitors (A). Ideally, a patient such as this one is offered participation in a clinical trial. However, given the options provided, hormonal therapy is the best initial choice in an asymptomatic woman.
16. **A.** Sentinel lymph node biopsy is typically indicated as an axillary staging procedure for patients with clinically node-negative breast cancer. The success rate for identifying the sentinel nodes when using both a blue dye and radioactive colloid is 95% or higher, and the false-negative rate (inaccurately determining the axilla to be negative for metastatic cancer) is around 10% (B). By definition, DCIS is noninvasive and therefore cannot be associated with positive nodes in the axilla. However, when DCIS is found on core biopsy, the remaining lesion may contain invasive cancer, so sentinel node biopsy is recommended in cases where the upstage rate is highest (high grade DCIS) or if breast lymphatics will be removed/disrupted at the primary surgery (mastectomy or lumpectomy in upper outer quadrant of the breast) precluding performance of sentinel node biopsy at a second procedure if invasive cancer is unexpectedly found (C). Radioactive technetium is low dose and has been observed as safe for use in pregnancy (D). It is actually the blue dyes that require caution in pregnancy. Lastly, identification and false-negative rates are still favorable after neoadjuvant chemotherapy is administered and therefore does not preclude performance of sentinel node after chemotherapy (E).
17. **A.** Radiotherapy works by directly damaging DNA within cells, not by inducing ischemia. It exerts most of its effect during the M phase of the cell cycle by inducing formation of free oxygen radicals. As such, radiation therapy is more efficacious with smaller tumors that have a higher oxygen potential (D). Higher energy radiation has a skin-preserving effect as the maximal ionizing potential is not reached until the radiation beam reaches deeper structures (E). Additionally, it has been shown to be most effective when used sequentially after chemotherapy instead of concurrently (C). Nearly all patients undergoing lumpectomy for invasive and noninvasive breast cancer are candidates for radiotherapy. NSABP B17 established that radiotherapy significantly reduces local recurrence when administered after lumpectomy (D). Postmastectomy radiotherapy is generally indicated for locally advanced disease (T4, 4-cm tumor size or greater, and 4 or more lymph nodes positive). In general, positive margins should be excised and radiotherapy not relied upon to clear margins. ACOSOG Z0011 trial demonstrated that patients with early invasive breast cancer (T1 and T2) undergoing breast conserving therapy do not need completion axillary dissection if the sentinel lymph node biopsy is positive as there is no difference in mortality (B).  
**Reference:** ACOSOG Z0011: A randomized trial of axillary node dissection in women with clinical T1-2 N0 M0 breast cancer who have a positive sentinel node. (2010). Subcategory: Local-Regional Therapy Category: Breast Cancer - Local-Regional and Adjuvant Therapy. 2010 ASCO Annual Meeting: Oral Abstract Session, Breast Cancer - Local-Regional and Adjuvant Therapy, *Journal of clinical oncology*, 28(Suppl; abstr CRA506), 18s. <http://meetinglibraryasco.org/content/47842-74>.
18. **C.** Chemotherapy plays an important role in treating occult distant metastatic disease in invasive cancer. However, not all invasive cancers benefit from chemotherapy (E). Those that are low-grade, small, lymph-node negative, and have low S-phase fractions (<5%) or Ki67 (<20%) (markers of proliferation) may not benefit (D). Gene expression profile assays that test which genes are being expressed in cancer tissue have been able to categorize patients into groups that will likely benefit from chemo and those that will not. Chemotherapy timed preoperatively versus postoperatively has the same survival outcome for all cancer subtypes (A). However, newer research may be demonstrating benefits for triple negative and *HER2*-positive cancers. In triple negative breast cancer, a complete pathologic response (no more tumor seen at surgery) after neoadjuvant chemotherapy is approximately 20% to 45% (B).
19. **A.** Radiotherapy in and of itself is a well-known cause of lymphedema, although it appears to be less than that of axillary dissection (B). Chemotherapy often leads to alterations in cognitive function and memory (C). Injury or interruption of the intercostal nerves during mastectomy and axillary dissection can lead to irreversible numbness along the chest wall (D). An uncommon yet important side effect of tamoxifen is visual changes due to cataract formation (E). Steatosis and steatohepatitis do not occur as a result of aromatase inhibitor therapy. Both can occur after cytotoxic chemotherapy or tamoxifen.

20. **D.** In general terms, having grossly positive axillary lymph nodes is an indication for axillary dissection. However, the ACOSOG Z0011 trial established equivalent survival with axillary dissection and no axillary dissection in patients with early stage breast cancer undergoing lumpectomy and radiation therapy who have three or fewer positive nodes (B). The AMAROS trial further established that women with early breast cancer and no clinically palpable nodes could undergo radiotherapy in place of axillary dissection if lymph nodes were determined to be positive (D). However, for patients with locally advanced disease and palpable lymph nodes, axillary dissection remains an important component of treatment to prevent local recurrence (E). In a patient with an isolated positive node, magnetic resonance imaging (MRI) looking for a primary is indicated, and then mastectomy is indicated if the MRI is negative (C). Involvement of internal mammary lymph nodes represents advanced local disease not metastatic disease (A).

**Reference:** ACOSOG Z0011: A randomized trial of axillary node dissection in women with clinical T1-2 N0 M0 breast cancer who have a positive sentinel node. (2010). Subcategory: Local-Regional Therapy Category: Breast Cancer - Local-Regional and Adjuvant Therapy. 2010 ASCO Annual Meeting: Oral Abstract Session, Breast Cancer - Local-Regional and Adjuvant Therapy, *Journal of clinical oncology*, 28(Suppl; abstr CRA506), 18s. <http://meetinglibrary.asco.org/content/47842-74>.

21. **C.** Nipple-sparing mastectomy is contraindicated in patients with extensive intraductal cancer, associated nipple discharge, Paget disease, or cancer within 2 cm distance of the nipple (A, B). Whereas total mastectomy would be an oncologically sound operation, this patient desires reconstruction and has no contraindications to immediate placement of expanders and sparing the skin (D, E).

22. **C.** Modified radical mastectomy includes, by definition, a resection of level I and II axillary nodes along with the entire breast parenchyma under skin flaps. Several important nerves reside in the axilla, injury to which can lead to significant motor and sensory deficits. Avoidance of intraoperative use of neuromuscular blockade during anesthesia and careful identification of the long thoracic and thoracodorsal nerves are key to avoiding inadvertent injury. The intercostobrachial nerve are the lateral cutaneous branch of the second intercostal nerve. Resection does not lead to any motor loss, but it can cause loss of sensation over the medial aspect of the upper arm (A). The long thoracic nerve courses along the lateral chest wall in the midaxillary line on the serratus anterior muscle to innervate it. The serratus anterior muscle abducts and laterally rotates the scapula and holds it against the chest wall. Injury to the long thoracic nerve results in a winged scapula (B). The thoracodorsal nerve courses lateral to the long thoracic nerve on the latissimus dorsi muscle, following the course of the subscapular artery. It innervates the latissimus dorsi muscle. The latissimus dorsi muscle adducts, extends, and medially rotates the upper arm. Injury to this nerve generally does not cause a major disability, but it can lead to difficulty in arm adduction and medial rotation. Furthermore, preservation of this nerve and vessels is important if a subsequent latissimus dorsi flap is being considered. The medial pectoral nerve runs lateral to or through the pectoral minor muscle, actually lateral to the lateral pectoral nerve, with both innervating the pectoralis minor and major muscles. Injury to the medial pectoral nerve may lead to atrophy of the clavicular portion of the pectoralis muscles, resulting in atrophy of the pectoralis muscle (E). The anterior branches of the supraclavicular nerve are sensory nerves that supply a limited area of skin over the upper aspect of the breast, and therefore injury would not result in a motor deficit (D).

23. **A.** Mondor disease is a thrombophlebitis involving one or more of the superficial anterior chest wall veins (lateral thoracic vein, thoracoepigastric vein, or the superficial epigastric vein). Similar to superficial thrombophlebitis that presents elsewhere, it usually causes an acute onset of pain and tenderness. It is a result of an inflammatory-thrombotic process and not an infectious or autoimmune disease (C, D). Risk factors include recent trauma or surgery to the local area, heavy lifting, tight clothing, and underlying malignancy. Mondor disease typically presents over the lateral aspect of the breast and eventually turns into a palpable cord or hard mass. The veins most commonly involved include the lateral thoracic vein, the thoracoepigastric vein, and, less frequently, the superficial epigastric vein. The disorder is benign, self-limited, and not itself malignant or a risk factor for breast cancer. Mammography and ultrasound are typically performed to exclude underlying malignancy. Otherwise, the diagnosis is largely clinical and biopsy is not necessary (E). Treatment consists of nonsteroidal antiinflammatory drugs and warm compresses. Antibiotics, systemic anticoagulation, and corticosteroids are not warranted (B).

**Reference:** Mayor, M., Burón, I., de Mora, J., et al. (2000). Mondor's disease. *International Journal of*

24. **D.** Mastitis commonly complicates lactation and is characterized by erythema, warmth, and tenderness of the breast. It can often be associated with fever and malaise. The majority of patients present without an associated abscess. The etiology is thought to be due to bacteria ascending in the ductal tree of the breast through the nipple, coupled with relative milk stasis from intermittent clogging of ducts and long intervals between feedings. The initial treatment includes the administration of antibiotics covering *S. aureus* (dicloxacillin), hot compresses with breast massage, and continuation of breast-feeding or pumping to evacuate static milk (B). Hand evacuation may be necessary if the breast is too tender to allow feeding or pumping. Incision and drainage or percutaneous aspiration are usually not warranted in the absence of a clear area of fluctuance or a fluid collection seen on ultrasound (C). Mammography is typically not helpful in the workup of mastitis, often resulting in false-positive findings (mass, skin thickening). However, if symptoms and signs of redness and skin thickening persist, mammography and core needle biopsy with or without skin biopsy should be performed to rule out inflammatory breast carcinoma (A, E).
25. **A.** The described lesion is a phyllodes tumor, also historically referred to as cystosarcoma phyllodes. These tumors are rare, accounting for fewer than 1% of breast neoplasms, and consist of both an epithelial component and a cellular, spindle cell stromal component that forms a characteristic leaflike structure (hence the term *phyllodes*). They are predominantly benign, but borderline malignant and malignant variants occur in up to 40% of cases. Phyllodes tumors typically occur in women during the fifth decade of life and commonly present as a fast-growing, firm, mobile mass in the breast. At large sizes, the contours of the tumor are often visible beneath a thin stretched layer of skin, and the size and weight of the tumor cause the breast to take on the shape of a “teardrop.” On imaging, phyllodes tumors appear similar to fibroadenomas, with distinct well-circumscribed margins and macrolobulations (B). Core needle biopsy is the standard for obtaining a tissue diagnosis, particularly in a woman over 40 years of age. However, benign phyllodes tumors can still be difficult to distinguish from fibroadenoma with core sampling alone, most often being reported as a “fibroepithelial lesion,” which require excision in order to make the diagnosis. Distinguishing features of benign phyllodes from fibroadenoma are largely based on stromal hypercellularity and morphology. Recent studies suggest that the best way to distinguish the two lesions is by the proportion of individual long spindle nuclei (>30% is reliable for phyllodes tumors) amid dispersed stromal cells. Excision with a clear margin of breast tissue is the treatment of choice for the vast majority of phyllodes tumors, even malignant ones as long as a margin greater than 1 cm is achievable. For larger, borderline and malignant lesions, mastectomy may be required, but this is not common (E). Borderline malignant and malignant forms of the disease are associated with high local recurrence rates and metastasis via a hematogenous route, most commonly to the lungs. Therefore, sentinel node biopsy and axillary dissection are not indicated, given that phyllodes tumors very rarely metastasize to lymph nodes (C). Radiotherapy is not generally used after lumpectomy (as it is in breast cancer) since phyllodes are most often benign and, even in malignant variants, radiotherapy has questionable benefit (D). Chemotherapy has not been proven effective with these tumors and is typically not recommended.
- References:** Chen, W., Cheng, S., Tzen, C., et al. (2005). Surgical treatment of phyllodes tumors of the breast: retrospective review of 172 cases. *Journal of Surgical Oncology*, 91(3), 185–194.
- Krishnamurthy, S., Ashfaq, R., Shin, H., et al. (2000). Distinction of phyllodes tumor from fibroadenoma: a reappraisal of an old problem. *Cancer*, 90(6), 342–349.
26. **D.** Radial scars (RS) (<1 cm) and complex sclerosing lesions (CSL) (>1 cm) are, in and of themselves, benign and are classified as proliferative lesions without atypia (papillomatosis and sclerosing adenosis are two other examples). As such, they are associated with a mildly increased risk of subsequent breast cancer (1.5–2 times normal). These lesions can mimic carcinomas of the breast on mammography given their stellate appearance. However, presence of a translucent central area of fat within the lesion is the classical finding on imaging. Although these lesions have a specific appearance on mammography, core needle biopsy is necessary to exclude malignancy (A–C). Histologically, RS and CSL are characterized by a fibroelastic core from which ducts and lobules radiate. Though biopsy rarely reveals atypia, carcinoma-in-situ or invasive cancer, upstaging is not uncommon after excision. Therefore when core biopsy demonstrates RS or CSL, excisional biopsy of the entire lesion is generally recommended (E). It is notable that newer studies have suggested that excisional biopsy may not be necessary in cases where vacuum-assisted needle cores provide large volume biopsy specimens, atypical epithelial hyperplasia is absent, and when



mammographic findings are consistent with histologic findings. Regardless, it is important for the radiologist and pathologist to alert the surgeon to the presence of a radial scar due to its increased risk of associated and subsequent malignancy.

**References:** Alleva, D., Smetherman, D. H., Farr, G. H., Jr., et al. (1999). Radial scar of the breast: radiologic-pathologic correlation in 22 cases. *Radiographics*, 19:S27-S35, 1999.

Cawson, J., Malara, F., Kavanagh, A., et al. (2003). Fourteen-gauge needle core biopsy of mammographically evident radial scars: is excision necessary? *Cancer*, 97(2), 345–351.

Fasih, T., Jain, M., Shrimankar, J., et al. (2005). All radial scars/complex sclerosing lesions seen on breast screening mammograms should be excised. *European Journal of Surgical Oncology*, 31(10), 1125–1128.

Jacobs, T., Byrne, C., Colditz, G., et al. (1999). Radial scars in benign breast-biopsy specimens and the risk of breast cancer. *The New England Journal of Medicine*, 340(6), 430–436.

27. **E.** Intraductal papilloma is a benign intraepithelial tumor of the breast ductal tissues. When it occurs as a single lesion, it is classified as a nonproliferative lesion of the breast and confers no subsequent increased risk of breast cancer (adenosis, fibrosis, and squamous/apocrine metaplasia are other examples). A papilloma can grow as large as a few centimeters in diameter and most commonly presents with spontaneous, unilateral bloody or serosanguinous nipple discharge. It is the most common cause of bloody discharge (A–D). Although invasive and noninvasive carcinomas must be ruled out with diagnostic mammogram, focused ultrasound examination, and core needle biopsy, malignancy accounts for fewer than 10% of cases of bloody nipple discharge. Treatment for intraductal papilloma associated with nipple discharge is duct excision. The affected duct is localized on physical examination by digitally compressing around the areola until bloody discharge is elicited. Lacrimal duct dilators are then used to dilate the opening of the duct, and methylene blue dye is injected to assist in excision of the appropriate tissue. Ductography is often unnecessary but can further assist in identifying the location of the papilloma within the duct to help guide surgical excision. Intraductal papillomas that are diagnosed on core needle biopsy can be wire localized and directly excised.

**Reference:** Sauter, E., Sclatter, L., Lininger, J., et al. (2004). The association of bloody nipple discharge with breast pathology. *Surgery*, 136(4), 780–785.

28. **D.** It is important to note that mammography alone is insufficient to determine whether to perform further diagnostic workup of a palpable breast mass. Reportedly up to 10% of palpable malignancies can be missed if reliant only on the results of a mammogram as a result of varying breast density because some breast cancers can be mammogram occult. Therefore, choosing to observe, reevaluate or repeat the mammogram in 3 months would delay the diagnosis of a possible malignancy (A, B). Ordering additional breast imaging is the standard approach when there is a palpable finding and the initial mammogram is negative. Focused breast ultrasound is the recommended study to further assess the palpable area. There is no role for MRI at this point given the information provided (C). If the lesion is confirmed on ultrasound and is solid, core needle biopsy is then indicated. All breast imaging reports follow a standardized reporting system and use a well-established lexicon of descriptive terms. The Breast Imaging Reporting and Data System (BI-RADS) category classification for mammograms uses a 0- to 6-point scale as follows: 0, assessment incomplete and additional imaging required; 1, negative; 2, benign finding; 3, probably benign finding; 4, suspicious abnormality; 5, highly suspicious of malignancy; 6, known biopsy-proven malignancy. Recommendations by category for nonpalpable findings are as follows: 0, should obtain additional studies (such as ultrasonography); 1 and 2, continue routine screening; 3, short-term follow-up mammogram in 6 months; 4, perform needle biopsy; 5, biopsy and treatment; 6, continue with treatment plan.

**References:** Eberl, M., Fox, C. H., Edge, S. B., et al. (2006). BI-RADS classification for management of abnormal mammograms. *Journal of the American Board of Family Medicine*, 19(2), 161–164.

Kerlikowske, K., Smith-Bindman, R., Ljung, B. M., et al. (2003). Evaluation of abnormal mammography results and palpable breast abnormalities. *Annals of Internal Medicine*, 139(4), 274–284.

29. **C.** MRI has very few absolute indications for diagnostic workup of breast lesions. Perhaps the most established is evaluating for a primary breast cancer in a patient with known nodal metastasis and no obvious lesion within the breast. Having ADH or LCIS in a group of calcifications would require wire-localized excisional biopsy, and MRI has no role (A, E). A focus of

DCIS requires wide excision, followed by adjuvant treatments (D). In dense breasts, there could be a potential role for MRI to assess extent of disease, but having “C” as an option would obviate “D” as a choice. MRI does not have a role in the evaluation of breast pain (B).

30. E. The rationale for recommending excisional biopsy of a lesion after core biopsy result showing a high-risk pathology such as atypical ductal/lobular hyperplasia, flat epithelial atypia, radial scar, and LCIS is explained by the phenomenon of “upstaging” from high risk to malignancy (A–D). Core biopsy inherently has a sampling error associated with it since only a portion of the lesion is removed during biopsy. When the remaining portion of the lesion is removed during excisional biopsy, a more significant lesion is often found. In the list provided, all of the options except “E” are high-risk lesions associated with upstage rates close to 20%. Adenosis and apocrine metaplasia are two of the histologic findings associated with fibrocystic changes. These do not need to be routinely removed.

31. E. LCIS is a lobular neoplasia that is noninvasive and originates from the terminal lobular region of the lactiferous ducts. Unlike ductal carcinoma in situ, it is often not associated with calcifications and is instead most often an incidental finding on biopsy. There are two subtypes, classic and pleomorphic. LCIS is not considered to be a premalignant lesion (i.e., does not itself progress to cancer), and therefore wide excision with negative margins is not necessary (C) and neither is radiotherapy (B). It is a noninvasive lesion and does not require nodal evaluation (D). It is, however, a marker for the subsequent development of cancer, most often invasive, in either the ipsilateral or contralateral breasts. This risk is reportedly 7 to 10 times the average woman’s risk, but not high enough to warrant bilateral prophylactic mastectomy (A). Management of LCIS after excision is largely preventative, with either tamoxifen, raloxifene, or aromatase inhibitor, depending on menopausal status.

**References:** Frykberg, E. R. (1999). Lobular carcinoma in situ of the breast. *The Breast Journal*, 5(5), 296–303.

Sonnenfeld, M., Frenna, T. H., Weidner, N., et al. (1991). Lobular carcinoma in situ: mammographic-pathologic correlation of results of needle-directed biopsy. *Radiology*, 181(2), 363–367.

32. E. The most common risk factors for breast cancer are female sex, age, family history of breast cancer (specifically a primary relative), genetic mutations (*BRCA* genes, *PALB2*, *p53*), personal history of breast cancer, receiving therapeutic dose of radiation to chest wall before age 30, prior breast biopsy showing ductal or lobular atypia or lobular carcinoma-in-situ, obesity, first pregnancy after age 30, menses beginning before age 12 or ending after age 55, daily alcohol intake of 2 drinks or more, smoking, physical inactivity, and having dense breast tissue on mammography. The highest risk is associated with gene mutation carriers, where lifetime risk can be upwards of 80%. In the scenario presented above, the patient’s age does not particularly put her at risk, since most breast cancers occur after the age of 55. A woman in her 40s has a breast cancer risk of 1 in 69 compared to 1 in 29 for a woman in her 60s (A). Having a primary relative with breast cancer (without associated gene mutation) elevates a woman’s personal risk by a factor of 2 (B). Daily alcohol intake of 3 drinks or more increases a woman’s risk by 1.5 times (C). The effect of smoking on breast cancer risk remains controversial. It is generally understood, but not definitively proven, that smoking is a significant risk factor and, as such, smoking cessation is usually recommended to reduce risk (D). Having a history of ductal or lobular atypia is associated with 3.5 to 5 times increased risk, and a history of lobular carcinoma-in-situ (LCIS) carries a 7 to 10 times increased risk. Most of the remaining risk factors are related to increased exposure to estrogen and include an increased number of menstrual cycles such as young age at menarche, old age at menopause, and nulliparity.

33. A. DCIS is further classified histologically into micropapillary, papillary, cribriform, solid, and comedo subtypes. The former three being considered less aggressive than the latter two. The comedo subtype is considered the most aggressive, and because cells turn over more quickly, they can quickly outgrow their blood supply and the center of the duct may become plugged with dead cellular debris, often referred to as comedo necrosis (B–E). Comedo DCIS tends to also have a higher cytologic grade and is more likely to produce microcalcifications that deposit around necrotic tissue.

**Reference:** Nakhli, F., & Morrow, M. (2003). Ductal carcinoma in situ. *The Surgical Clinics of North America*, 83(4), 821–839.

34. C. The SSO-ASTRO Consensus guideline was published in 2014 defining a negative margin as “no

ink on tumor” and provided evidence that re-excisions should be performed if margins are positive according to this definition. Also, NCCN guidelines suggest re-excision of margins less than 1 mm for DCIS. Radiotherapy alone or tamoxifen alone would be inadequate to treat a positive margin (A, B). Sentinel node would only be indicated if the lumpectomy demonstrated invasive cancer (D). Mastectomy for positive margins is reserved for cases where multiple margins are positive or when margins remain positive after multiple re-excisions (E).

**References:** Boyages, J., Delaney, G., & Taylor, R. (1999). Predictors of local recurrence after treatment of ductal carcinoma in situ: a meta-analysis. *Cancer*, 85(3), 616–628.

Kestin, L. L., Goldstein, N. S., Martines, A. A., et al. (2000). Mammographically detected ductal carcinoma in situ treated with conservative surgery with or without radiation therapy: patterns of failure and 10-year results. *Annals of Surgery*, 231(2), 235–245.

Neuschatz, A., DiPetrillo, T., Steinhoff, M., et al. (2002). The value of breast lumpectomy margin assessment as a predictor of residual tumor burden in ductal carcinoma in situ of the breast. *Cancer*, 94(7), 1917–1924.

Silverstein, M., Lagios, M. D., Groshen, S., et al. (1999). The influence of margin width on local control of ductal carcinoma in situ of the breast. *The New England Journal of Medicine*, 340(19), 1455–1461.

35. **B.** All of the choices provided are inherited disorders that carry an increased lifetime risk of developing breast cancer. Cowden syndrome is caused by a mutation in *PTEN* and is characterized by multiple hamartomatous lesions as well as cancer of the breast, endometrium, kidney, and thyroid (A). Li-Fraumeni syndrome is caused by mutations in *p53* and is associated with breast cancer, sarcomas, glioblastoma, and adrenocortical cancers. Peutz-Jeghers syndrome is caused by mutations in *STK11* gene and classically is associated with the presence of hyperpigmented mucocutaneous spots, bowel hamartomas, and cancers of the gastrointestinal tract, pancreas, liver, breast, endometrium, and ovary (C). Ataxia-telangiectasia is caused by mutation of the *ATM* gene and, along with neurologic and vasculocutaneous findings for which this disorder is named, it carries an increased risk of breast cancer, lymphoma, and leukemia (D). *BRCA2* mutations are associated with breast, ovarian, fallopian tube, pancreas, prostate, and skin (melanoma) cancers (E).

**References:** Bland, K. L., Beenken, S. W., & Copeland, E. M. (2005). Breast. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 453–500) (8th ed.). New York, NY: McGraw-Hill.

Iglehart, S., & Kaelin, C. (2004). Breast. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (pp. 867–928) (17th ed.). Philadelphia, PA: W. B. Saunders.

36. **A.** Hereditary breast cancers (caused by mutations in *BRCA*, *PTEN*, *ATM*, *STK11*, *PALB2*, and *p53* genes) collectively account for only 10% of all breast cancers (C), with *BRCA* mutations accounting for 25% of all hereditary breast cancers. The mutations result in “loss of function” of the tumor suppression that *BRCA* genes normally provide (B). *BRCA1* mutations confer a 55-65% lifetime risk for breast cancer and a 35-45% lifetime risk for ovarian cancer. *BRCA2* mutations confer a lifetime risk of 40-55% for breast cancer and a 15-25% lifetime risk for ovarian cancer (D). Breast cancers in women with *BRCA1* mutations tend to be hormone receptor negative and are often triple negative. Therefore, the use of tamoxifen as chemoprevention is not generally recommended to reduce risk (D). Prophylactic bilateral mastectomy is the risk-reducing strategy most recommended, resulting in 90% overall risk reduction. Male breast cancer risk is typically elevated to 100-fold risk in individuals who have *BRCA2* mutations, not *BRCA1* (E).

**Reference:** Fossland, V., Stroop, J. B., Schwartz, R. C., et al. (2009). Genetic issues in patients with breast cancer. *Surgical Oncology Clinics of North America*, 18(1), 53–71.

37. **B.** Approximately, 1 in 10 invasive breast cancers are lobular, meaning that 80% or more are ductal in origin (A). Of the invasive ductal cancers, several histologic subtypes have been described based on histologic appearance and growth patterns. Tubular carcinomas comprise only 2% of all invasive breast cancers, they tend to be well-differentiated, and they have the most favorable prognosis. Papillary carcinomas comprise fewer than 1% of all invasive breast cancers and tend to occur in postmenopausal women. Generally, they have a favorable prognosis and few metastasize regionally or systemically (C). On the other hand, micropapillary carcinomas (similar name) are aggressive. Mucinous, or colloid, carcinomas account for about 5% of invasive breast cancers and are



characterized by the presence of a mucin component. They tend to be well-differentiated, with low rates of metastasis (D). Medullary carcinomas, not mucinous, are associated with *BRCA1* mutations. These cancers appear histologically to be poorly differentiated with aggressive features but they generally have a favorable prognosis (E).

**Reference:** Holland, D. W., Boucher, L. D., & Mortimer, J. E. (2001). Tubular breast cancer experience at Washington University: a review of the literature. *Clinical Breast Cancer*, 2(3), 210–214.

38. E. This question addresses the appropriate adjuvant therapy for early stage triple-negative breast cancer. First, all patients for whom lumpectomy is performed for an invasive cancer should undergo radiotherapy to reduce local recurrence and achieve similar survival outcome to mastectomy. Second, hormonal therapy is not indicated in patients who are hormone receptor negative. Chemotherapy is indicated for all triple negative breast cancer because of the more aggressive nature of the disease and lack of other systemic therapy options. Taken together, this patient requires the last option of radiotherapy and chemotherapy, without hormonal therapy (A–D).

39. C. Breast conservation, by way of lumpectomy, can be adequately performed to treat T1 and smaller T2 breast cancers as long as adjuvant radiotherapy is administered to reduce the risk of local recurrence. Contraindications to receiving radiotherapy therefore drive the contraindications of having a lumpectomy. Radiotherapy cannot be safely administered in pregnancy, so women who are diagnosed in their first 2 semesters are often recommended mastectomy (A). Women in their third trimester can often undergo operative therapy and wait until after childbirth to initiate radiotherapy. Women with locally recurrent breast cancer, where radiation therapy was previously completed, are also typically advised to undergo mastectomy because a second round of radiotherapy to the same breast would exceed maximal recommended doses (B). Active connective tissue disorders, such as scleroderma, may lead to increases in radiotherapy-related complications and therefore are considered relative to absolute contraindications to radiation (D). *Multicentric* cancers (being located in separate quadrants of the breast) can also preclude lumpectomy, particularly if there is insufficient breast tissue to allow for two separate wide excisions (E). It is important to note that *multifocal* cancers refer to multiple foci of breast cancer in the same quadrant and are amenable to breast-conserving therapy. The best choice is the woman with ipsilateral involved nodes because axillary dissection is performed separately and does not limit the ability to perform breast conservation.

**Reference:** Morrow, M., Strom, E. A., Bassett, L. W., et al. (2002). Standard for breast conservation therapy in the management of invasive breast carcinoma. *CA: a Cancer Journal for Clinicians*, 52(5), 277–300.

40. C. Large tumor size, poor histologic grade, and estrogen-receptor status can certainly denote a poorer prognosis but the strongest predictor is the presence of regional metastatic disease (A, B, D). Younger patients also tend to have more aggressive, higher grade, receptor-negative breast cancers, but nodal status is still more predictive (E). In more recent years, gene expression profiles have surpassed nodal status in the ability to predict cancer recurrence (i.e., need for systemic therapy).

41. D. Inflammatory breast cancer comprises only 1% of all breast cancers and is characterized by erythema and skin edema (called *peau d'orange*) that result from malignant obstruction of subdermal lymphatics. It is often mistaken initially with mastitis, and failure to respond to conventional antibiotic therapy is an indication to obtain tissue for analysis. Absence of a palpable mass is common; therefore, biopsy should be performed of the abnormal skin and abnormal lymph nodes to confirm the diagnosis. The best prognosis results from early treatment with systemic chemotherapy (i.e. neoadjuvant chemotherapy) followed by either surgery or radiotherapy depending on resectability (A, C). The surgical therapy of choice is modified radical mastectomy because there is no role for sentinel node biopsy in inflammatory cancer or in patients with clinically positive nodes (B). Concurrent chemotherapy and radiotherapy have been shown to be inferior to sequential therapy. There is no role to continue antibiotics because the erythema is due to the inflammatory cancer, not ongoing infection (E). The 5-year survival rate is still only 30% to 50%.

**Reference:** Cristofanilli, M., Buzdar, A. U., & Hortobagyi, G. N. (2003). Update on the management of inflammatory breast cancer. *Oncologist*, 8(2), 141–148.

42. B. Batson plexus is a venous network that runs in the paravertebral space and drains

abdominopelvic and thoracic regions. The veins are valveless and therefore have been implicated in the metastatic spread of prostate, breast, and colon malignancies to bone, particularly the pelvis, vertebral bodies, and skull. The Batson venous plexus also explains why patients may have bone metastases without first having pulmonary metastases because tumor cells enter the plexus and deposit in the vertebrae without first passing through the lungs (A, C–E).

**Reference:** Mundy, G. (1997). Mechanisms of bone metastasis. *Cancer*, 80(Suppl. 8), 1546–1556.

43. **D.** Purple nodular lesions occurring on an arm with long-standing lymphedema present is angiosarcoma, or lymphangiosarcoma, otherwise referred to as Stewart-Treves syndrome. Classically, the patient has undergone axillary dissection and radiotherapy for cancer treatment and develops lymphedema. The local immune response is impaired, allowing for development of this aggressive malignancy within the breast or ipsilateral arm. The diagnosis is established via open biopsy because fine-needle aspiration alone may not be sufficient. Characteristic features include pleomorphic nuclei, frequent mitosis, necrosis, and stacking up of the endothelial cells lining neoplastic vessels (particularly with high-grade lesions). The tumor is highly aggressive with a propensity for early metastasis to the lungs. Treatment consists of early wide surgical debridement, which may require amputation of the limb. Prognosis is poor with most patients surviving less than 2 years.

**References:** Heitmann, C., & Ingianni, G. (2000). Stewart-Treves syndrome: lymphangiosarcoma following mastectomy. *Annals of Plastic Surgery*, 44(1), 72–75.

Sher, T., Hennessy, B. T., Valero, V., et al. (2007). Primary angiosarcomas of the breast. *Cancer*, 110(1), 173–178.

Vorburger, S., Xing, Y., Hunt, K. K., et al. (2005). Angiosarcoma of the breast. *Cancer*, 104(12), 2682–2688.

44. **C.** Breast cancer during pregnancy is rare, with a reported incidence of 1 in 3000 pregnant women. Stage for stage, the prognosis appears to be the same as for nonpregnant women, although pregnant women tend to present with more advanced disease given the difficulty of distinguishing malignant changes from physiologic changes of breast tissue in pregnancy. Therapies for breast cancer in pregnancy vary depending on the trimester. Surgery and chemotherapy are generally considered safe in the second and third trimesters of pregnancy. On the other hand, radiotherapy and hormonal therapy are contraindicated in all trimesters of pregnancy (D, E). Therefore, surgical therapy that is dependent on radiotherapy, such as lumpectomy, is typically only performed well into the third trimester, with radiotherapy being performed after delivery. In regard to staging, sentinel lymph node biopsy is generally considered safe using radiotracer alone (without a blue dye), obviating the need for axillary dissection when the axilla is clinically negative (A). The decision to perform CT scan is based on the pretest probability of metastasis and contribution to decision-making. In general, excess radiation is avoided, but CT is not absolutely contraindicated (B).

**References:** Berry, D., Theriault, R. L., Holmes, F. A., et al. (1999). Management of breast cancer during pregnancy using a standardized protocol. *Journal of Clinical Oncology*, 17(3), 855–861.

Ring, A., Smith, I. E., Jones, A., et al. (2005). Chemotherapy for breast cancer during pregnancy: an 18-year experience from five London teaching hospitals. *Journal of Clinical Oncology*, 23(18), 4192–4197.

45. **E.** In breast cancer local recurrence, the receipt of prior radiotherapy precludes the option of breast conservation the second time around. Therefore, performance of neoadjuvant chemotherapy to achieve lumpectomy would not be recommended (B) because a second course of radiotherapy would exceed dose limits. Therefore, mastectomy is routinely indicated in local recurrence after lumpectomy and whole breast radiation. Repeat sentinel node biopsy has been shown to have adequate identification and false-negative rates, so axillary dissection can usually be avoided in this group if the lymph nodes remain clinically negative (A). Breast cancer recurrence is a different issue than having two separate primary breast cancers in one's lifetime. Typically, occurrence of cancer within a prior surgical incision is indicative of local recurrence and testing for gene mutations would not be indicated (D). Lastly, the local recurrence occurred while the patient was taking tamoxifen, so the patient should preferably be switched to a different agent. Given her postmenopausal status, aromatase inhibitor would be a better option (C).

46. **E.** Paget disease of the breast is an intraepithelial invasion of Paget cells (large, pale vacuolated cells) at the nipple surface causing an eczematoid appearance that is often confused for a contact

dermatitis (A). Failure to respond to topical treatments should raise concern for Paget disease, and full-thickness skin biopsy is the biopsy method of choice (B). Nipple discharge is rarely present, and cytologic evaluation of ductal fluid has no role in the diagnostic evaluation since the Paget cells are within the epithelial layer (C). Paget disease is not a precancerous lesion but instead is often simultaneously associated with extensive ductal carcinoma in situ or invasive ductal cancer extending deep to the visible lesion (D). Paget disease is most commonly treated with mastectomy given the extent of the underlying cancer.

**Reference:** Kollmorgen, D., Varanasi, J., Edge, S., et al. (1998). Paget's disease of the breast: a 33-year experience. *Journal of the American College of Surgeons*, 187(2), 171–177.

47. **D.** Breast lymphoma is a rare disease. The majority of cases are B-cell lymphomas, and the most common type is diffuse large B-cell lymphoma (40–70%) (A). Breast lymphomas are equally divided into primary and secondary (B). Treatment depends on whether the lesion is localized or diffuse as well as on the grade of lymphoma. With localized and low-grade lymphomas, primary excision may be all that is necessary, while standard combination therapy with CHOP (cyclophosphamide, doxorubicin, vincristine, prednisone) along with radiation therapy is recommended for intermediate- or high-grade lymphoma (C, E). Several studies have noted an unusual predilection for distant dissemination for breast lymphoma to the central nervous system.

**References:** Brogi, E., & Harris, N. L. (1999). Lymphomas of the breast: pathology and clinical behavior. *Seminars in Oncology*, 26(3), 357–364.

Wong, W., Schild, S. E., Halyard, M. Y., et al. (2002). Primary non-Hodgkin lymphoma of the breast: the Mayo Clinic experience. *Journal of Surgical Oncology*, 80(1), 19–25.

48. **C.** Herceptin (trastuzumab) is a humanized IgG1 kappa monoclonal antibody that selectively binds with high affinity to the epidermal growth factor receptor 2 (*HER2*) protein. Overexpression of *HER2/neu* (found in approximately 15–20% of breast cancers) is associated with a worse prognosis and an increased risk of recurrence but provides a specific target for the treatment of breast cancer. Trastuzumab is associated with cardiac failure manifesting as a decreased left ventricular ejection fraction (LVEF). Thus, serial assessments of the LVEF need to be performed while administering trastuzumab, particularly if given in conjunction with other agents that are cardiotoxic (such as anthracyclines) (A–B, D–E).

**Reference:** Seidman, A., Hudis, C., Pierri, M. K., et al. (2002). Cardiac dysfunction in the trastuzumab clinical trials experience. *Journal of Clinical Oncology*, 20(5), 1215–1221.

# Endocrine

*Areg Grigorian, and Christian de Virgilio*

## Questions

1. Which of the following features of Graves disease does not improve with antithyroid therapy?
  - A. Tremor
  - B. Anxiety
  - C. Graves dermopathy
  - D. Gastrointestinal disturbance
  - E. Exophthalmos
2. A 56-year-old male presents with refractory hypertension despite being started on hydrochlorothiazide and lisinopril by his primary care physician. His blood pressure is 182/92 mm Hg. Laboratory studies are remarkable for an aldosterone-renin ratio of 25 and hypokalemia. Which of the following is most likely to be the recommended treatment?
  - A. Unilateral adrenalectomy
  - B. Bilateral adrenalectomy with fludrocortisone postoperatively
  - C. Spironolactone
  - D. Phenoxybenzamine
  - E. Eplerenone
3. A 40-year-old female presents with a large thyroid nodule. Workup and subsequent resection demonstrates a 4-cm papillary thyroid carcinoma with positive lymph nodes and local extension but no evidence of distant disease. What stage is her cancer?
  - A. Stage 1
  - B. Stage 2
  - C. Stage 3a
  - D. Stage 3b
  - E. Stage 4
4. A 46-year-old female with a 3-cm palpable right-sided thyroid nodule has a fine-needle aspirate (FNA) performed, which is reported as nondiagnostic. What is the best next step?
  - A. Repeat FNA
  - B. Core needle biopsy
  - C. Right thyroid lobectomy
  - D. Total thyroidectomy
  - E. Ultrasound in 6 months
5. A 51-year-old male with a 2-cm palpable right-sided thyroid nodule has a FNA performed, which is reported as follicular lesion of undetermined significance (FLUS). Which of the following is true about this condition?
  - A. Repeat FNA is not recommended.
  - B. Molecular testing does not influence management.
  - C. Right thyroid lobectomy is an acceptable option.

- D. Total thyroidectomy is the next best step.  
E. Ultrasound follow-up in 6 months is the best option.
6. The thyroid gland is derived from which embryologic structure?  
A. First pharyngeal arch  
B. Third pharyngeal pouch  
C. Third pharyngeal arch  
D. Fourth pharyngeal pouch  
E. Fourth pharyngeal arch
7. Which of the following cancers most commonly metastasizes to the thyroid?  
A. Parathyroid gland  
B. Kidney  
C. Lung  
D. Breast  
E. Esophagus cancer
8. Which of the following enzymes is responsible for converting L-dopa into dopamine?  
A. Tyrosine hydroxylase  
B. Dopamine-beta-hydroxylase  
C. Phenylethanolamine N-methyltransferase (PNMT)  
D. Dihydroxyphenylalanine (DOPA)-decarboxylase  
E. Catechol-O-methyl transferase (COMT)
9. A 45-year-old woman with rheumatoid arthritis on chronic steroids loses her insurance and has not been able to get a refill on her medications including atenolol, methotrexate, and prednisone. She arrives to the emergency department with a fever, hypotension, nausea, and dizziness. The next best step is:  
A. Intravenous (IV) antibiotics  
B. IV hydrocortisone  
C. IV fluids  
D. Administer oral methotrexate  
E. Complete blood count, basic metabolic panel, and cortisol level
10. A 45-year-old male presents with a 2-day history of nausea, vomiting, and marked abdominal distention. He has no prior surgical history. Before this, he's had watery diarrhea for about a month. On exam, he has diffuse tenderness without rebound or guarding. Computed tomography (CT) scan demonstrates markedly dilated loops of small bowel with an abrupt transition in the mid jejunum with distal collapse. In addition there are two, 2-cm solid masses in the right lobe of the liver. At surgery, at the point of obstruction, there is a small mass in the mid ileum with surrounding fibrosis, causing tethering and kinking of the small bowel mesentery. The two lesions in the right lobe of the liver are not palpable. A segmental small bowel resection is performed. Additionally, which of the following is recommended?  
A. Cholecystectomy  
B. Ultrasound-guided liver biopsy  
C. Liver resection  
D. Appendectomy  
E. No additional procedure
11. Which of the following is true regarding Hürthle cell carcinoma?  
A. It contains an abundance of oncocytic or oxyphilic cells.  
B. Lymph node metastasis is exceedingly rare.  
C. Diagnosis of malignancy is usually made by FNA.  
D. Residual disease is effectively treated with iodine 131 ( $^{131}\text{I}$ ).  
E. Histologically they demonstrate Orphan Annie cells.

12. A patient presents with fatigue and bone pain. Serum calcium level is 11.1 mg/dL and parathyroid hormone (PTH) is elevated. The next step for localizing the disease is:
- A. Operative exploration
  - B. CT scan
  - C. Technetium-99m sestamibi imaging
  - D. Magnetic resonance imaging (MRI)
  - E. Ultrasound scan
13. Which of the following is true regarding follicular thyroid cancer?
- A. It is the most common thyroid malignancy.
  - B. It most commonly spreads via a hematogenous route.
  - C. Prophylactic nodal dissection is recommended.
  - D. It is best managed by hemithyroidectomy.
  - E. Multicentricity is common.
14. A 45-year-old woman presents with symptomatic primary hyperparathyroidism. During surgery it is noted that all four glands are markedly enlarged. Which of the following is the best recommendation?
- A. Removal of three and a half glands for parathyroid hyperplasia, leaving half of a gland in place
  - B. Removal of all four glands
  - C. Removal of all four glands with autotransplantation of half of a gland in the forearm
  - D. Biopsy all four glands
  - E. Remove one gland, and biopsy the other three
15. Which of the following is true regarding laparoscopic adrenalectomy?
- A. It is the procedure of choice for small functional adenomas.
  - B. It is contraindicated for pheochromocytoma.
  - C. It is contraindicated for bilateral pheochromocytoma.
  - D. It is contraindicated for tumors larger than 5 cm.
  - E. It is the procedure of choice for malignant tumors.
16. A 50-year-old woman presents to the emergency department with nausea, anorexia, irritability, and a serum calcium level of 14.5 mg/dL. Initial management is:
- A. IV normal saline
  - B. Furosemide
  - C. IV 5% dextrose and half normal saline
  - D. Mithramycin
  - E. Calcitonin
17. A 65-year-old woman with a history of Hashimoto thyroiditis presents with fever, dysphagia, and a painless thyroid mass that has enlarged over a short period of time. This most likely represents:
- A. Lymphoma
  - B. Follicular cancer
  - C. Anaplastic thyroid cancer
  - D. Acute suppurative thyroiditis
  - E. Medullary thyroid cancer (MTC)
18. Which of the following is true regarding the parathyroid glands?
- A. The inferior glands arise from the fourth branchial pouch and the superior ones from the third pouch.
  - B. The superior glands are more likely to be found in an ectopic position.
  - C. The superior glands are more likely to be found in the thymus.
  - D. Three glands are more common than five glands.
  - E. Ectopic superior glands are more likely to be found in the retro- or paraesophageal space.

19. In an asymptomatic patient, surgery for primary hyperparathyroidism would be least indicated for which of the following?
- A. Serum calcium of 11.6 mg/dL
  - B. A 40% reduction in creatinine clearance
  - C. Age older than 50 years
  - D. Bone density at the hip more than 2.5 standard deviations below matched controls
  - E. A 24-hour urine calcium excretion greater than 400 mg
20. A 45-year-old-woman presents with truncal obesity and hypertension. A 24-hour urine free cortisol level is markedly elevated and a low-dose dexamethasone suppression test fails to suppress the elevated plasma cortisol levels. Plasma adrenocorticotrophic hormone (ACTH) levels are also markedly elevated. A high-dose dexamethasone suppression test also fails to suppress the urinary free cortisol level. Which of the following would most likely demonstrate the cause of her symptoms?
- A. CT scan of the sella turcica
  - B. Petrosal sinus sampling for ACTH
  - C. Chest CT
  - D. MRI of the sella turcica
  - E. CT scan of the abdomen
21. Calcified clumps of cells on histology are consistent with:
- A. Papillary cancer
  - B. Hürthle cell cancer
  - C. Follicular cancer
  - D. Medullary thyroid cancer
  - E. Anaplastic cancer
22. Which of the following is true regarding pheochromocytoma?
- A. Risk of malignancy is higher in patients with familial tumors.
  - B. Malignancy is determined histologically by the number of mitoses.
  - C. Familial tumors are more likely to be unilateral.
  - D. Metaiodobenzylguanidine scanning is useful for localizing extra-adrenal pheochromocytomas.
  - E. Urine metanephrine has the highest sensitivity.
23. The most common type of thyroid cancer in children is:
- A. Papillary
  - B. Follicular
  - C. Medullary
  - D. Hürthle cell
  - E. Anaplastic
24. Which of the following is true regarding secondary hyperparathyroidism?
- A. Serum calcium levels are markedly increased.
  - B. It is usually associated with a parathyroid adenoma.
  - C. PTH levels are typically normal or high normal.
  - D. Cinacalcet is the initial treatment of choice.
  - E. Most patients will eventually require parathyroidectomy.
25. Which of the following is true regarding tertiary hyperparathyroidism?
- A. It is usually due to an underlying parathyroid carcinoma.
  - B. It is most commonly seen after successful kidney transplantation.
  - C. The serum calcium level is usually normal or low.
  - D. Distinguishing between secondary and tertiary hyperparathyroidism is essential because the management differs.
  - E. It only occurs in patients with chronic renal insufficiency.



26. Which of the following is true regarding pseudohypoparathyroidism?
- A. Treatment involves surgery.
  - B. The serum calcium level is high.
  - C. The serum phosphate level is low.
  - D. Patients have short stubby fingers.
  - E. It responds well to exogenously administered PTH extract.
27. A 45-year-old man with episodic severe hypertension is found to have an elevated plasma metanephrine level and a serum calcium level of 11.5 mg/dL. Which of the following would be indicated in the workup?
- A. CT scan of the sella turcica
  - B. Calcitonin level
  - C. Serum gastrin level
  - D. Serum prolactin level
  - E. A 24-hour urine cortisol
28. Which of the following laboratory findings is characteristically associated with primary hyperparathyroidism?
- A. Elevated serum phosphate
  - B. Increased serum chloride
  - C. Decreased urinary calcium
  - D. Metabolic alkalosis
  - E. Elevated calcium with a decreased PTH
29. A 60-year-old woman presents with a history of kidney stones and a palpable neck mass. Her serum calcium level is 14.1 mg/dL. The most likely diagnosis is:
- A. Parathyroid adenoma
  - B. Parathyroid hyperplasia
  - C. Parathyroid cancer
  - D. Breast cancer with bone metastasis
  - E. Secondary hyperparathyroidism
30. During neck exploration for primary hyperparathyroidism, only three parathyroid glands are identified, all of which appear normal in size. Which of the following would be appropriate?
- A. Perform a transcervical thymectomy.
  - B. Remove all three glands and reimplant one in the forearm.
  - C. Remove two and a half glands and then close.
  - D. Perform median sternotomy to look for ectopic parathyroid.
  - E. Obtain biopsy samples of all three parathyroid glands and then close.
31. After total thyroidectomy and postoperative iodine ablation for a 5-cm follicular thyroid cancer, the best test to monitor for recurrent disease is:
- A. Serum thyroid-stimulating hormone (TSH)
  - B. Serum calcitonin
  - C. Serum thyroglobulin
  - D. <sup>131</sup>I scan
  - E. Ultrasound scan of the neck
32. Which of the following is true regarding adrenal cortical carcinoma?
- A. Associated evidence of hormonal excess is common.
  - B. The diagnosis is generally made by CT-guided needle biopsy.
  - C. Staging is based on tumor histology.
  - D. Because of malignant potential, adrenal masses larger than 3 cm should be excised.
  - E. Mitotane is highly effective in patients with positive lymph nodes.

33. Malignancy within a thyroglossal duct cyst is typically:
- A. Follicular thyroid
  - B. Papillary thyroid
  - C. Squamous cell
  - D. Anaplastic thyroid
  - E. Hürthle cells
34. After a total thyroidectomy, the right vocal cord is noted to be fixed in a paramedian position. This most likely represents:
- A. Injury to the recurrent laryngeal nerve (RLN)
  - B. Injury to the external branch of the superior laryngeal nerve
  - C. Injury to the internal branch of the superior laryngeal nerve
  - D. Trauma from endotracheal intubation
  - E. Compression from hematoma
35. The most common pituitary neoplasm associated with MEN 1 secretes:
- A. ACTH
  - B. Prolactin
  - C. Growth hormone
  - D. Thyroid-stimulating hormone
  - E. Follicle-stimulating hormone
36. The most common extra-adrenal site of pheochromocytoma is the:
- A. Rectum
  - B. Bladder
  - C. Neck
  - D. Organ of Zuckerkandl
  - E. Sacrum
37. A 40-year-old female presents with incidentally discovered elevation in serum calcium. She is otherwise healthy. A PTH level is elevated as well. Both ultrasound and sestamibi scan of the neck are negative. Which of the following is true about this condition?
- A. It may represent tertiary hyperparathyroidism.
  - B. A 24-hour urine calcium is indicated.
  - C. She should proceed to neck exploration.
  - D. It should be treated with cinacalcet.
  - E. Selective venous sampling is indicated.
38. Which of the following is true regarding neuroblastoma?
- A. It is the third most common abdominal malignancy in children.
  - B. Prognosis is better for older children than those diagnosed before 1 year of age.
  - C. It is associated with aniridia and hemihypertrophy.
  - D. In the mediastinum, they are most often located anteriorly.
  - E. Amplification of the *N-myc* oncogene has an unfavorable prognosis.
39. During thyroidectomy the superior thyroid arteries were ligated a centimeter away from the thyroid capsule as opposed to immediately adjacent to it. This technical error would most likely result in which of the following complications?
- A. Voice fatigue
  - B. Hoarseness
  - C. Loss of airway
  - D. Aspiration
  - E. Ineffective cough

40. A 45-year-old woman with a history of a goiter presents to the emergency department with a high fever, heart rate of 130 beats per minute, tremors, sweating, and exophthalmos. Which of the following can exacerbate symptoms?
- A. Aspirin
  - B. Propylthiouracil
  - C. Beta-blocker
  - D. Methimazole
  - E. Steroids
41. Which of the following is true regarding substernal goiter?
- A. Surgical resection should be reserved for patients with tracheal deviation.
  - B. Most are primary mediastinal goiters with a blood supply arising from intrathoracic vessels.
  - C. Most can be resected by a cervical incision.
  - D. Most are highly responsive to prolonged thyroid suppression.
  - E. Because of the risk of tracheomalacia, most patients should have a prophylactic tracheostomy at the time of resection.
42. The most common cause of primary adrenal insufficiency in the United States is:
- A. Autoimmune
  - B. Tuberculosis
  - C. Metastatic disease
  - D. Adrenal hemorrhage
  - E. Exogenous steroid use
43. The most common cause of Cushing syndrome aside from exogenous corticosteroid administration is:
- A. Adrenal cortical carcinoma
  - B. Adrenal adenoma
  - C. Corticotropin (ACTH)-producing pituitary adenoma
  - D. Ectopic ACTH syndrome
  - E. Ectopic corticotropin-releasing hormone syndrome
44. Which of the following is true regarding the renin-angiotensin system?
- A. The juxtaglomerular cells are located within the renal efferent arteriole.
  - B. The juxtaglomerular cells secrete aldosterone in response to decreased blood pressure.
  - C. The juxtaglomerular cells detect changes in chloride concentration in the renal tubule.
  - D. Renin catalyzes the conversion of angiotensinogen to angiotensin I.
  - E. Angiotensin I directly stimulates the production of aldosterone.
45. Which of the following is true regarding the anatomy/blood supply to the adrenal glands?
- A. The arterial blood supply is more constant than the venous drainage.
  - B. Catheter-based venous hormonal sampling is easier to perform on the right adrenal vein.
  - C. On the right, the adrenal vein drains into the right renal vein.
  - D. Right adrenalectomy is more likely to lead to life-threatening hemorrhage than left adrenalectomy.
  - E. The majority of the arterial blood supply arises from the celiac trunk.
46. A 70-year-old man is found to have an incidental mass in his right adrenal gland on CT scan. He has no history of malignancy and has a normal blood pressure. The findings of the remainder of the history and physical examination are negative. Plasma free metanephrines are negative. The serum potassium level is normal. Urinary free cortisol is normal, and a 1-mg overnight dexamethasone suppression test shows a low cortisol level (1.5 µg/dL) the following morning. The mass is 4.5 cm on CT scan, has smooth borders, and has a low attenuation value. Which of the following is true regarding this condition?
- A. The patient should undergo a CT-guided needle biopsy.

- B. The patient should undergo a laparoscopic adrenalectomy.
  - C. The patient should undergo an open adrenalectomy.
  - D. A repeat CT scan should be performed in 6 months.
  - E. The mass is most likely malignant.
47. Which of the following is true regarding the histology of the adrenal gland?
- A. The zona glomerulosa is the inner layer of the adrenal cortex.
  - B. Cells in the zona fasciculata produce cortisol.
  - C. Cells in the zona reticularis produce aldosterone.
  - D. Medullary cells are chromaffin negative.
  - E. The zona reticularis is the middle layer of the adrenal cortex.
48. A 38-year-old female with stage 2 chronic kidney disease is diagnosed with primary hyperparathyroidism. Preoperative localization studies indicate a single enlarged left inferior parathyroid gland. She undergoes minimally invasive single gland parathyroidectomy under local anesthesia. An enlarged gland is identified and removed. Intraoperative PTH levels are sent 10 minutes later, and a 40% drop in PTH from baseline is noted. Which of the following is true?
- A. One should proceed to four-gland exploration.
  - B. Repeat PTH level should be obtained at 20 minutes.
  - C. It is acceptable to close the wound.
  - D. The vein from where the PTH was sampled does not affect PTH decline.
  - E. The PTH decline is affected by the patient's kidney disease.
49. The hallmark of multiple endocrine neoplasia type 2 (MEN 2) is:
- A. Unilateral pheochromocytoma
  - B. Bilateral pheochromocytoma
  - C. Multifocal and bilateral medullary carcinoma of the thyroid
  - D. Unifocal medullary carcinoma of the thyroid
  - E. Four-gland parathyroid hyperplasia
50. The most common cause of congenital adrenal hyperplasia is:
- A. 11 $\beta$ -Hydroxylase deficiency
  - B. 3-Hydroxydehydrogenase deficiency
  - C. 21-Hydroxylase deficiency
  - D. 17-Hydroxylase deficiency
  - E. Congenital adrenal lipoid hyperplasia
51. A 45-year-old man with a history of primary hyperparathyroidism presents for an enlarged thyroid nodule. Further workup reveals an elevated calcitonin level. Which of the following is true regarding the most likely condition?
- A. Total thyroidectomy without central node dissection is indicated.
  - B. Radiotherapy is an effective treatment modality.
  - C. The majority are multicentric.
  - D. The likelihood of nodal metastases is low.
  - E. Chemotherapy is effective for residual disease.
52. The most accurate test for hyperthyroidism is:
- A. Free thyroxine (T<sub>4</sub>)
  - B. Total T<sub>4</sub>
  - C. Total triiodothyronine (T<sub>3</sub>)
  - D. Thyroid-stimulating hormone (TSH)
  - E. Thyroid scan
53. Which of the following is true regarding the blood supply to the thyroid/parathyroid glands?

- A. The parathyroid glands are usually supplied by the superior thyroid arteries.
  - B. The inferior thyroid artery is the first branch of the external carotid artery.
  - C. The RLNs are at risk of injury during ligation of the superior thyroid arteries.
  - D. The external branch of the superior laryngeal nerve is at risk of injury when the inferior laryngeal arteries are ligated.
  - E. The thyroidea ima artery usually arises from the aorta.
54. Which of the following is true regarding the laryngeal nerves?
- A. The external branch of the superior laryngeal nerve provides sensation to the larynx.
  - B. Bilateral injury to the superior laryngeal nerves often results in acute airway obstruction.
  - C. The right RLN separates from the vagus after crossing the subclavian artery.
  - D. The recurrent laryngeal nerve is both motor and sensory to the larynx.
  - E. The RLNs provide motor function to the cricothyroid.
55. A non-RLN:
- A. Does not exist
  - B. Is more common on the left
  - C. Can occur in conjunction with a recurrent nerve on the right
  - D. Loops around the aorta on the right side
  - E. Is less prone to injury during surgery than a recurrent nerve
56. Which of the following is a direct effect of PTH?
- A. Stimulates hydroxylation of cholecalciferol in the kidney
  - B. Stimulates reabsorption of phosphate by the kidney
  - C. Stimulates reabsorption of bicarbonate by the kidney
  - D. Stimulates absorption of calcium by the small intestine
  - E. Stimulates hydroxylation of 25-hydroxyvitamin D in the kidney
57. Lateral aberrant thyroid in most instances represents:
- A. Metastatic papillary carcinoma
  - B. Metastatic follicular carcinoma
  - C. Metastatic Hürthle cell carcinoma
  - D. A congenital lesion related to thyroid descent
  - E. An extension of a thyroglossal duct cyst
58. A 45-year-old woman presents with a 1.5-cm right thyroid nodule. FNA findings are consistent with papillary carcinoma. Her history is significant for radiation therapy for lymphoma as a child. Optimal management of this patient would consist of:
- A. Right hemithyroidectomy
  - B. Right hemithyroidectomy plus central lymph node dissection
  - C. Total thyroidectomy
  - D. Total thyroidectomy with postoperative <sup>131</sup>I
  - E. Total thyroidectomy plus right modified radical neck dissection
59. Which of the following is LEAST likely associated with hyperparathyroidism?
- A. Cholelithiasis
  - B. Pancreatitis
  - C. Osteoclastomas
  - D. Diarrhea
  - E. Peptic ulcer disease
60. Following total thyroidectomy for follicular cancer, a 65-year-old female presents to the emergency department 4 days later complaining of circumoral numbness and tingling of her fingers. Phosphate level is normal. Which of the following is true about this condition?

- A. It likely represents hungry bone syndrome (HBS).
- B. It may lead to a shortened QT on ECG.
- C. The risk can be reduced by routine postoperative calcium and vitamin D supplementation.
- D. Most patients are symptomatic.
- E. It is more common with thyroidectomy for benign lesions.

## Answers

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1. **E.** Graves disease is the most common cause of hyperthyroidism in the United States and is due to antibodies targeting thyrotropin receptors, which increase production of thyroid hormone. Patients present with anxiety, rapid or irregular heart rate, heat intolerance, weight loss, thinning hair, decreased libido, diarrhea, thick and shiny skin (Graves dermopathy), and exophthalmos. The preferred therapy is radioactive iodine ablation, but medical therapy with propylthiouracil (PTU) or methimazole is also available. Exophthalmos develops in about 10% of patients and is the only symptom that is resistant to antithyroid therapy and even worsens after radioactive iodine ablation (A–D). Some studies suggest that the use of prednisone before antithyroid therapy can help improve exophthalmos.

**References:** Bartalena, L., Marcocci, C., Bogazzi, F., et al. (1998). Relation between therapy for hyperthyroidism and the course of Graves' ophthalmopathy. *The New England Journal of Medicine*, 338(2), 73–78.

Shiber, S., Stiebel-Kalish, H., Shimon, I., et al. (2014). Glucocorticoid regimens for prevention of Graves' ophthalmopathy progression following radioiodine treatment: systematic review and meta-analysis. *Thyroid*, 24(10), 1515–1523.

Stein, J. D., Childers, D., Gupta, S., et al. (2015). Risk factors for developing thyroid-associated ophthalmopathy among individuals with Graves disease. *JAMA: the Journal of the American Medical Association Ophthalmology*, 133(3), 290–296.

2. **C.** Primary hyperaldosteronism should be suspected in patients with hypertension and hypokalemia. Primary hyperaldosteronism results from autonomous aldosterone secretion, which, in turn, leads to suppression of renin secretion. The diagnosis is made by demonstrating a combination of inappropriate potassium excretion in the urine (kaliuresis), low plasma renin, and a high aldosterone-to-renin ratio (>20). While it was previously believed that an adrenal adenoma (Conn syndrome) was the most common cause of primary hyperaldosteronism, we now know that nearly 60% of cases are due to idiopathic bilateral adrenal hyperplasia (IBAH). It is important to clearly establish the etiology because the management is different. An adrenal adenoma should be removed with a unilateral adrenalectomy but IBAH is managed with medical therapy alone using a mineralocorticoid replacement such as spironolactone or eplerenone (A). A double-blind randomized controlled study demonstrated the superiority of spironolactone in controlling hypertension compared with eplerenone (E). Bilateral adrenalectomy is considered in cases of severe refractory hypertension. However, this has a high risk of complications and will subject the patient to lifelong dependence of mineralocorticoids (fludrocortisone) and steroids (B). Phenoxybenzamine is an alpha-1 receptor antagonist used in the preoperative management of pheochromocytoma (D).

**References:** Kaplan, N. M. (2004). The current epidemic of primary aldosteronism: causes and consequences. *Journal of Hypertension*, 22(5), 863–869.

Stowasser M. (2009). Update in primary aldosteronism. *The Journal of Clinical Endocrinology and Metabolism*, 94(10), 3623–3630.

Parthasarathy, H. K., Menard, J., White, W. B., et al. (2011). A double-blind, randomized study comparing the antihypertensive effect of eplerenone and spironolactone in patients with hypertension and evidence of primary aldosteronism. *Journal of Hypertension*, 29(5), 980–990.

3. **A.** Age is the most important factor in thyroid cancer. By definition, patients younger than 45 years of age can only be classified as stage I (no distant metastasis) or II (distant metastasis). Thus, for patients younger than age 45, lymph node status and tumor size are not taken into consideration. For patients older than 45, the tumor, nodes, and metastases (TNM) system for well-differentiated thyroid cancer also takes into account tumor size, the presence of positive lymph nodes, local extension, and the presence of distant metastasis.

**Reference:** Nguyen, Q. T., Lee, E. J., Huang, M. G., et al. (2015). Diagnosis and treatment of patients with thyroid cancer. *American Health Drug Benefits*, 8(1), 30–40.

4. **A.** The most important test in the evaluation of a solitary thyroid nodule is FNA. This can be performed with ultrasound guidance if the lesion is difficult to palpate. Before the routine use of FNA, there was a high rate of benign thyroid surgical resections. With current practice, the percentage of thyroid nodules resected that is found to be malignant is over 50%. The Bethesda system for reporting thyroid cytopathology classifies nodules into six groups: (1) nondiagnostic or unsatisfactory, (2) benign, (3) atypia of undetermined significance or follicular lesion of undetermined significance, (4) follicular neoplasm or suspicious for a follicular neoplasm, (5) suspicious for malignancy, and (6) malignant. Patients with a nondiagnostic or unsatisfactory FNA should have a repeat FNA performed (B–E).

**References:** Yassa, L., Cibas, E. S., Benson, C. B., et al. (2007). Long-term assessment of a multidisciplinary approach to thyroid nodule diagnostic evaluation. *Cancer*, 111(6), 508–516.

Cibas, E. S., Ali, S. Z., & NCI Thyroid FNA State of the Science Conference. (2009). The Bethesda system for reporting thyroid cytopathology. *American Journal of Clinical Pathology*, 132(5), 658–665.

5. **C.** As discussed in [question 4](#), FNA results are classified into six different groups. The management of FNA that is reported as FLUS is somewhat controversial. The current recommendation is to perform a repeat FNA (A). The risk of malignancy of FLUS has historically been around 5% to 15%. However, more recent series have found a malignancy rate closer to 30%. These authors recommend proceeding to thyroid lobectomy. Thus the decision as to whether to repeat the FNA or proceed to thyroid lobectomy depends on patient risk factors for malignancy; the institutional rate of malignancy with FLUS; ultrasound features of the lesion; and more recently, molecular testing (not always available and expensive) (B, E). Follicular neoplasms will require a surgical lobectomy, and FNA demonstrating malignancy or suspicious for a malignant process will require a total thyroidectomy (D). Core needle biopsy has been proposed as an additional adjunctive tool, particularly in cases of nondiagnostic FNA but there have not been any conclusive studies to demonstrate its usefulness, nor is it considered the current standard of care. It may be considered for patients that are hesitant to proceed with a surgical resection.

**References:** Cibas, E. S., Ali, S. Z., NCI Thyroid FNA State of the Science Conference. (2009). The Bethesda system for reporting thyroid cytopathology. *American Journal of Clinical Pathology*, 132(5), 658–665.

Yoon, J. H., Kim, E. K., Kwak, J. Y., et al. (2015). Effectiveness and limitations of core needle biopsy in the diagnosis of thyroid nodules: review of current literature. *Journal of Pathol Translational Medicine*, 49(3), 230–235.

6. **A.** The thyroid gland is one of the earliest endocrine glands to develop. It arises from the first and second pharyngeal arches. The superior parathyroid gland develops from the fourth pharyngeal pouch while the inferior parathyroid gland develops from the third pharyngeal pouch (B, D). An easy way to remember this is that the “Parathyroid derives from the Pouch.” The third pharyngeal arch helps in the development of the stylopharyngeus muscle while the fourth pharyngeal arch allows for the development of the cricothyroid muscle (C, E).
7. **B.** The most common primary tumor to metastasize to the thyroid is renal cell carcinoma. Other primary cancers that metastasize to the thyroid gland, in descending order, include lung, breast, and esophageal cancer (C–E). Parathyroid gland carcinoma does not metastasize to the thyroid gland (A).

**References:** Nakhjavani, M. K., Gharib, H., Goellner, J. R., et al. (1997). Metastasis to the thyroid gland. A report of 43 cases. *Cancer*, 79(3), 574–578.

Stevens TM. (2011). Tumors metastatic to thyroid neoplasms: a case report and review of the literature. *Pathol Research International*, Mar 31, 238693.

8. **D.** The synthesis of catecholamines is a complex process and is governed by various enzymes. Tyrosine hydroxylase is considered the rate limiting step and converts L-tyrosine to L-dopa, which is then converted to dopamine by dopa-decarboxylase (A). Dopamine is converted to norepinephrine by dopamine-beta-hydroxylase and norepinephrine is converted to epinephrine by PNMT (B, C). COMT metabolizes both norepinephrine and epinephrine (E). With the exception of PNMT, all the other enzymes have the name of the precursor as part of their nomenclature, which allows for an easy way to remember the key steps. PNMT is rarely present outside of the adrenal



medulla, which accounts for why extra-adrenal pheochromocytomas do not synthesize a high level of norepinephrine. The brain stem, retina, and cardiac tissue may also contain PNMT.

**Reference:** Ziegler, M. G., Bao, X., Kennedy, B. P., et al. (2002). Location, development, control, and function of extraadrenal phenylethanolamine N-methyltransferase. *Annals of the New York Academy of Sciences*, 971(1), 76–82.

9. **C.** Fever, hypotension, nausea, and dizziness in a patient taking chronic steroids that suddenly stopped taking all medications should raise concern for acute adrenal insufficiency. When the diagnosis is suspected, treatment should begin immediately before confirmatory tests become available (E). Initial treatment consists of IV normal saline volume resuscitation. This is then followed by either administration of 4 mg of dexamethasone or 100 mg of hydrocortisone (B). Dexamethasone is preferred because it will not interfere with cosyntropin stimulation testing, which should be done the next morning to confirm the diagnosis. IV antibiotics are not used in acute adrenal insufficiency (A). Cessation of methotrexate does not present with the aforementioned symptoms (D).
10. **A.** This patient has metastatic midgut neuroendocrine tumor (NET). The finding of fibrosis and tethering of the mesentery is highly suggestive of a carcinoid tumor. The accompanying diarrhea, combined with likely liver metastasis, is highly suggestive of carcinoid syndrome. Compared to the foregut, midgut, and hindgut, NETs have a greater 5-year survival rate. Chemotherapy has not been shown to have a significant role in increasing disease-free survival. Symptom control is achieved with somatostatin analogues such as octreotide. Some of the few accepted lifelong indications for the use of octreotide, endorsed by the American Association of Oncology, include patients with peptide/amine induced syndromes with clinical symptoms and for patients with progression of metastatic disease even without a syndrome. This patient will require postoperative octreotide given his history of watery diarrhea. Octreotide promotes biliary sludging and leads to a high rate of symptomatic cholelithiasis and as such, the patient will need a cholecystectomy performed at the time of surgery (E). This indication becomes stronger in patients that are planned to undergo hepatic artery embolization secondary to metastasis to the liver. Liver biopsy or resection is not appropriate during an emergency surgery (particularly when the lesion is not readily palpable) and his disease is likely amenable to less morbid procedures such as radiofrequency ablation and/or hepatic artery embolization (B, C). There is no indication to perform an appendectomy in the above patient (D).

**Reference:** Öberg, K., Kvois, L., Caplin, M., et al. (2004). Consensus report on the use of somatostatin analogs for the management of neuroendocrine tumors of the gastroenteropancreatic system. *Annals of Oncology*, 15(6), 966–973.

11. **A.** Hürthle cell carcinoma accounts for less than 10% of thyroid malignancies and is considered a subtype of follicular cancer. Like follicular cancer, the presence of malignancy is established by the demonstration of vascular or capsular invasion. FNA and frozen section do not reliably establish malignancy (C). The tumors contain sheets of eosinophilic cells packed with mitochondria, which are derived from oncocytic or oxyphilic cells of the thyroid gland. Hürthle cell carcinomas differ from follicular cell carcinomas in that they are often multifocal and bilateral, are more likely to metastasize to local nodes and distant sites, and are associated with a higher mortality rate (B). Residual disease is not effectively treated with radioactive iodine because Hürthle cell carcinomas do not take up radioactive iodine (D). Orphan Annie cells are a hallmark of papillary carcinoma (E). Unlike differentiated thyroid cancer, nodal metastases predict a worse outcome in widely invasive Hürthle cell carcinoma, as does extrathyroidal extension.

**Reference:** Stojadinovic, A., Ghossein, R., Hoos, A., et al. (2001). Hürthle cell carcinoma: a critical histopathologic appraisal. *Journal of Clinical Oncology*, 19(10), 2616–2625.

12. **C.** Technetium-99m sestamibi imaging is the most widely used and accurate modality, with sensitivity greater than 80% for detection of parathyroid adenomas. High-resolution ultrasonography in particular is complementary. The other imaging techniques are thought to be more useful when sestamibi scanning fails to identify the parathyroid pathology, for the workup of recurrent hyperparathyroidism, or when surgical exploration fails to identify the parathyroid lesion. Ultrasonography has an overall lower sensitivity, although it may be most useful in identifying intrathyroidal parathyroids (E). CT and MRI are also less sensitive than sestamibi scans but are helpful in localizing mediastinal glands (B, D). Sestamibi combined with single positron-emission computed tomography is particularly useful for localizing ectopic adenomas. False-

positive findings with these modalities are most likely to occur in the presence of thyroid nodules or lymphadenopathy. False-negative findings are more likely in patients with hyperplasia or multiple adenomas. More recently, the combination of preoperative technetium-99m sestamibi imaging and the rapid PTH assay has permitted successful directed parathyroidectomy using minimally invasive techniques. An additional modality is intraoperative gamma probe detection, although this approach lengthens the operation and is not routinely used. Operative exploration would be the next step after technetium-99m sestamibi imaging has been performed because this will likely identify the most likely location of the hyperfunctioning parathyroid gland. In 85% of cases it is just one of the four glands that is not responsive to calcium level and hypersecretes PTH (A).

**Reference:** Dackiw, A., Sussman, J., Fritsche, H., Jr., et al. (2000). Relative contributions of technetium Tc 99m sestamibi scintigraphy, intraoperative gamma probe detection, and the rapid parathyroid hormone assay to the surgical management of hyperparathyroidism. *Archives of Surgery*, 135(5), 550–555.

13. **B.** Follicular cancer is the second most common thyroid cancer, and it spreads primarily via a hematogenous route (A). Multicentricity is uncommon (E). Unlike papillary carcinoma, accurate diagnosis using FNA is not possible because cytologic features cannot distinguish a benign follicular lesion from a follicular carcinoma. To establish malignancy, demonstration of capsular or vascular invasion on histology is necessary. Thus, if FNA demonstrates a follicular neoplasm, the patient should undergo a thyroid lobectomy to determine malignancy. Once histologic confirmation of malignancy is made, total thyroidectomy is recommended with or without postoperative <sup>131</sup>I. Total thyroidectomy also permits the detection of subsequent metastasis using nuclear scanning (D). Postoperative radioactive iodine following total thyroidectomy is indicated for all tumors larger than 4 cm, gross extrathyroidal extension of the tumor regardless of size, lymph node metastases, and for high-risk features including tall-cell or columnar-cell variant (D). An added advantage of postoperative radiation is that it allows for continued monitoring for recurrence with thyroglobulin. Prophylactic nodal dissection is not required (C).
14. **C.** Surgical management of a solitary parathyroid adenoma consists of resection of the single enlarged gland. On rare occasion, double adenomas are present. For four-gland hyperplasia, resection of all four glands with reimplantation of half of one gland into the brachioradialis muscle in the forearm is recommended. Another option for four-gland hyperplasia is to leave half of a gland in the neck, although this might then require a reoperation in the neck if recurrent hyperparathyroidism develops (A). Removing all four glands without reimplantation increases the risk for hypoparathyroidism (B). Medical management is not appropriate for primary hyperparathyroidism. On occasion, distinguishing between adenoma and hyperplasia may be difficult if two glands are enlarged and the other two appear normal or slightly enlarged. In this circumstance, removal of the two enlarged glands and biopsy of an additional gland may be performed to rule out four-gland hyperplasia. However, in the presence of one enlarged gland, there is no role for biopsy of the other three glands because this may result in ischemia of the remaining parathyroid glands (D, E). Another frequent dilemma occurs when only three glands are found, and all appear normal. If an inferior one is missing, it may be found in the thymus, angle of the mandible, at the skull base, superior to the superior parathyroid glands, or, rarely, within the thyroid gland. If the ectopic gland is not found, transcervical thymectomy is recommended. If the superior gland is missing, it may be found within the thyroid gland, in the paraesophageal or retroesophageal grooves, or caudal to the inferior glands. Although ectopic glands are found in the mediastinum on rare occasion, median sternotomy is not recommended at initial exploration.

**References:** Chen, H., Sokoll, L., & Udelsman, R. (1999). Outpatient minimally invasive parathyroidectomy: a combination of sestamibi-SPECT localization, cervical block anesthesia, and intraoperative parathyroid hormone assay. *Surgery*, 126(6), 1016–1021.

Goldstein, R., Billheimer, D., Martin, W. H., et al. (2003). Sestamibi scanning and minimally invasive radioguided parathyroidectomy without intraoperative parathyroid hormone measurement. *Annals of Surgery*, 237(5), 722–730.

15. **A.** Laparoscopic adrenalectomy has become the procedure of choice for small- and medium-sized functional and benign adrenal tumors. Pheochromocytoma is not a contraindication to the laparoscopic approach and may be used successfully for unilateral or bilateral tumors (B, C). Tumor size alone is not a contraindication to the laparoscopic approach. For a large tumor that is

clearly malignant based on CT scan evidence of local invasion or lymph node metastasis, the laparoscopic approach is contraindicated (E). Open adrenalectomy is preferred for tumors larger than 6 cm. (D).

**References:** Assalia, A., & Gagner, M. (2004). Laparoscopic adrenalectomy. *The British Journal of Surgery*, 91 (10), 1259–1274.

Brunt, L. M., & Moley J. F. (2004). The pituitary and adrenal glands. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 1023–1070) (17th ed.). Philadelphia, PA: W. B. Saunders.

Laimore, T. C., & Moley, J. F. (2004). The multiple endocrine neoplasia syndromes. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 1071–1090) (17th ed.). Philadelphia, PA: W. B. Saunders.

Lal, G., & Clark, O. H. (2005). Thyroid, parathyroid and adrenal. In F. C. Brunicaudi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 1395–1470) (8th ed.). New York, NY: McGraw-Hill.

16. **A.** Severely elevated calcium levels represent a hypercalcemic crisis. Hypercalcemic crisis is a life-threatening emergency. Patients with calcium levels greater than 14 mg/dL or symptomatic patients with calcium levels greater than 12 mg/dL should be immediately and aggressively treated because severe hypercalcemia poses a risk of renal failure as well as severe central nervous system manifestations including coma. In addition, it leads to a shortening of the QT interval, tachycardia, and an increased sensitivity to digitalis. Treatment is divided into fast- and slow-acting modalities. Fast-acting modalities include those that induce a calciuresis (IV fluids), those that prevent bone resorption (bisphosphonates, calcitonin, mithramycin), and those that extract calcium (hemodialysis) (D, E). Slow-acting measures prevent gastrointestinal absorption of calcium (prednisone, reduced vitamin D and calcium intake). The first-line therapy for hypercalcemic crisis involves initiating standard resuscitative hydration with normal saline. A combination of 5% dextrose and half normal saline is most commonly used as a maintenance IV fluid (C). Urine output should be kept at more than 100 mL/hour. Once urine output is established, diuresis with furosemide is instituted (B). Furosemide works by increasing renal calcium clearance. If these methods are not successful, then additional fast-acting modalities should be used. Calcitonin is produced by thyroid C or parafollicular cells (located in the superior lateral aspect of the thyroid). In humans, it does not play an important role in regulating serum calcium levels. It is useful in treating hypercalcemic crisis by inhibiting osteoclast-mediated bone resorption. Additionally, a calcium level of this magnitude in a nonhospitalized patient is most likely suggestive of underlying malignancy.

**Reference:** Ziegler, R. (2001). Hypercalcemic crisis. *Journal of the American Society of Nephrology*, 12(Suppl. 17), S3-S9.

17. **A.** Hashimoto thyroiditis is an autoimmune disorder that leads to destruction of thyroid follicles by both cell- and antibody-mediated immune processes, including activation of helper lymphocytes and antibody formation against thyroglobulin and thyroid peroxidase. It is the leading cause of hypothyroidism and most commonly affects young females. It results in a lymphocytic infiltration. Treatment of Hashimoto thyroiditis is with thyroid hormone replacement. Hashimoto thyroiditis is associated with primary thyroid lymphoma. The chronic antigenic stimulation coupled with a chronic proliferation of lymphoid tissue in the thyroid is thought to lead to the development of lymphocytic transformation. In a patient with Hashimoto thyroiditis, lymphoma should be suspected in the setting of a rapidly enlarging thyroid mass (B–E). Patients additionally may report fever, cervical lymphadenopathy, dysphagia, and hoarseness. FNA may suggest the diagnosis, but flow cytometry (with core needle biopsy) is required to confirm the diagnosis. The treatment recommendation is chemotherapy using CHOP (cyclophosphamide, doxorubicin, vincristine, and prednisone) and radiation therapy in most cases of thyroid lymphoma. Hashimoto thyroiditis also does increase the risk of thyroid cancer.

**Reference:** Ansell, S. M., Grant, C. S., & Habermann, T. M. (1999). Primary thyroid lymphoma. *Seminars in Oncology*, 26(3), 316–323.

18. **E.** In one large autopsy study, 84% of patients had 4 parathyroid glands, 13% had more than 4 glands, and only 3% had 3 glands (D). The superior parathyroid glands are derived from the fourth branchial pouch, which also gives rise to the thyroid gland. The third branchial pouch gives rise to the inferior parathyroid glands and the thymus (A). Ectopic inferior glands are more likely to be

found within the thymus than the superior glands, whereas the superior glands are more likely to be found in the retro- or paraesophageal position (B, C). Given the longer descent of the inferior glands, they are overall much more likely to be in an ectopic position.

19. **C.** Patients with symptomatic hyperparathyroidism should undergo surgery. Symptoms are defined as having evidence of kidney stones; neuromuscular, neuropsychological, or bone symptoms; hypercalcemic crisis; or a history of pancreatitis or peptic ulcer. Conversely, controversy exists as to whether every patient who is asymptomatic should undergo parathyroidectomy. Natural history studies of patients with asymptomatic hyperparathyroidism indicate that one-fourth to one-third of patients without symptoms will progress to the development of symptoms over 15 years. Current National Institutes of Health conference guidelines for surgery in asymptomatic patients include at initial evaluation: (1) a serum calcium level more than 1 mg/dL above the upper limit of reference value, (2) reduced creatinine clearance of more than 30% compared with matched controls, (3) an increased urinary calcium excretion of more than 400 mg/day, (4) evidence of bone mass reduction more than 2.5 standard deviations below matched controls, and (5) unwillingness or inability to undergo continued follow-up.

**References:** Rubin, M., Bilezikian, J., McMahon, D., et al. (2008). The natural history of primary hyperparathyroidism with or without parathyroid surgery after 15 years. *The Journal of Clinical Endocrinology and Metabolism*, 93(9), 3462–3470.

Silverberg, S., Shane, E., Jacobs, T., et al. (1999). A 10-year prospective study of primary hyperparathyroidism with or without parathyroid surgery. *The New England Journal of Medicine*, 341(17), 1249–1255.

20. **C.** Measurement of elevated 24-hour urinary cortisol levels is a very sensitive (95–100%) and specific (98%) modality for diagnosing Cushing syndrome, and as such it should be the first test used to establish the diagnosis of Cushing syndrome. If the level is elevated, a low-dose dexamethasone suppression test should be performed. Suppression rules out Cushing syndrome. Failure to suppress cortisol levels establishes the diagnosis of Cushing syndrome. ACTH levels should then be measured. Low ACTH levels indicate a primary adrenal source of cortisol, and thus the next step would be to obtain an abdominal CT scan (E). A high ACTH level suggests either a pituitary or ectopic source of ACTH production. A high-dose dexamethasone suppression test should then be performed because a pituitary source of ACTH will result in some ACTH and cortisol suppression. If cortisol production is suppressed, pituitary MRI should be performed (D). CT scan is less sensitive in demonstrating a pituitary mass (A). Failure to suppress cortisol production with high-dose dexamethasone suggests an ectopic ACTH tumor. The most common causes of ectopic ACTH production are bronchial tumors and small cell lung cancer. Thus, the study of choice would be a chest CT scan. Petrosal sinus sampling of ACTH is an invasive procedure to determine which side of the pituitary gland an ACTH-producing tumor is located (B).
21. **A.** Psammoma bodies are calcified deposits representing clumps of sloughed cells. It is considered diagnostic of papillary carcinoma (B–E). Another histologic characteristic of papillary carcinoma is Orphan Annie nuclei.
22. **D.** Pheochromocytomas occur either sporadically, as part of multiple endocrine neoplasia (MEN) type 2A and MEN type 2B, in association with von Hippel-Lindau disease, and with von Recklinghausen disease. The diagnosis of a benign or a malignant pheochromocytoma cannot be accurately determined by the histologic appearance but rather is based on evidence of local invasion or the presence or absence of metastasis (B). The risk of malignancy is lower in patients with familial tumors than in patients with sporadic tumors, although familial tumors are more likely to be bilateral (A, C). The diagnosis of pheochromocytoma is established by demonstrating an increased level of catecholamines and their metabolites in the plasma and urine. Plasma metanephrine levels have the highest sensitivity for pheochromocytoma (99% sensitivity) and are used by most as the initial screening test (E).
23. **A.** Papillary cancer is the most common thyroid malignancy in adults and children (B–E). The rate of malignancy in thyroid nodules is higher in children. In adults, approximately 5% of thyroid nodules are malignant, whereas in children, the rate is approximately 25%. Prognosis in children overall is excellent.

**References:** Gauger, P. G., & Doherty G. M. (2004). The parathyroid gland. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 985–1000) (17th ed.). Philadelphia, PA: W. B. Saunders.

Hanks, J. B. (2004). The thyroid. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 947–984) (17th ed.). Philadelphia, PA: W. B. Saunders.

Lal, G., & Clark, O. H. (2005). Thyroid, parathyroid and adrenal. In F. C. Brunicaardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 1395–1470) (8th ed.). New York, NY: McGraw-Hill.

24. **D.** Secondary hyperparathyroidism is seen in the majority of cases in association with chronic renal failure (B). Rarely, it occurs secondary to intestinal malabsorption of calcium and vitamin D. The underlying etiology is a chronic overstimulation of the parathyroid glands. Renal failure leads to a decreased level of calcitriol (vitamin D<sub>3</sub>), an elevation in phosphate, and a drop in serum calcium levels (A). This leads to increased PTH secretion. PTH levels are typically very high, ranging from 500 to 1500 pg/mL (normal is ≤65 pg/mL) (C). As renal failure progresses, there is a decrease in vitamin D and calcium receptors, leading to parathyroid gland resistance to calcitriol and calcium. This vicious cycle worsens as renal failure worsens. Patients with secondary hyperparathyroidism are generally hypocalcemic or normocalcemic. The typical parathyroid gland pathology is four-gland hyperplasia. Medical management has historically consisted of a low-phosphate diet, phosphate binders, and oral supplementation with calcium and vitamin D. More recently, cinacalcet has been approved by the U.S. Food and Drug Administration for the treatment of secondary hyperparathyroidism due to chronic renal failure. Cinacalcet is a calcimimetic agent. It increases the sensitivity of the calcium-sensing receptor to activation by extracellular calcium and thus directly lowers PTH levels. The majority of patients with secondary hyperparathyroidism can be managed medically. The recent introduction of cinacalcet will likely lead to an even further reduction in the need for surgical management. In general, surgery is indicated for failed medical management (E). Indications include intractable bone pain, severe pruritus, calciphylaxis, and progressive renal osteodystrophy. Surgical treatment consists of removal of all four glands with autoimplantation of parathyroid tissue in the forearm muscle or removal of three and a half glands.

**References:** Block, G., Martin, K., de Francisco, A., et al. (2004). Cinacalcet for secondary hyperparathyroidism in patients receiving hemodialysis. *The New England Journal of Medicine*, 350(15), 1516–1525.

Lindberg, J., Culleton, B., Wong, G., et al. (2005). Cinacalcet HCl, an oral calcimimetic agent for the treatment of secondary hyperparathyroidism in hemodialysis and peritoneal dialysis: a randomized, double-blind, multicenter study. *Journal of the American Society of Nephrology*, 16(3), 800–807.

Shoback, D., Bilezikian, J., Turner, S., et al. (2003). The calcimimetic cinacalcet normalizes serum calcium in subjects with primary hyperparathyroidism. *The Journal of Clinical Endocrinology and Metabolism*, 88(12), 5644–5649.

Slatopolsky, E., Brown, A., & Dusso, A. (1999). Pathogenesis of secondary hyperparathyroidism. *Kidney International. Supplement*, 73, S14-S19.

25. **B.** Tertiary hyperparathyroidism most commonly occurs in the setting of a patient who has had long-standing secondary hyperparathyroidism in whom subsequently autonomously functioning parathyroid glands develop that continue secreting PTH despite high serum calcium levels (C). The most common clinical scenario in which it develops is the patient who has undergone renal transplantation (A, E). Distinguishing between secondary and tertiary hyperparathyroidism is not critical because the initial management is medical, and surgery is indicated for failure of medical management (D). Surgical treatment consists of removal of 3½ glands rather than all 4 glands with autoimplantation of parathyroid tissue in the forearm muscle in cases in which all four glands are enlarged.

**Reference:** Kebebew, E., Duh, Q. Y., & Clark, O. H. (2004). Tertiary hyperparathyroidism: histologic patterns of disease and results of parathyroidectomy. *Archives of Surgery*, 139(9), 974–977.

26. **D.** Pseudohypoparathyroidism is a genetic disorder in which there is insensitivity to PTH. It is characterized by hypocalcemia, hyperphosphatemia, and elevated PTH (B, C). Patients are typically of short stature and obese and have a round face and short, stubby fingers with dimpling of the knuckles when the fist is clenched. Because there is insensitivity to PTH, there is no role for exogenous PTH administration (E). Treatment is with oral calcium and vitamin D supplementation (A).

27. **B.** The elevated plasma metanephrine indicates a high suspicion for pheochromocytoma. Further workup for this should include a CT or MRI scan of the abdomen to detect an adrenal mass. The elevated calcium suggests hyperparathyroidism. The patient should have a PTH level measured and, if it is elevated, should undergo a sestamibi scan. Given these findings, the patient most likely has MEN type 2, which is characterized by pheochromocytoma, hyperparathyroidism, and MTC. Screening for MTC involves measuring the serum calcitonin level. MEN type 1 is characterized by hyperparathyroidism, pituitary tumor, and pancreatic tumors. CT of the sella turcica may be used to look for a pituitary tumor such as prolactinoma (A). An elevated prolactin level will also support a diagnosis of prolactinoma (D). Elevated gastrin level is associated with gastrinoma (C). A 24-hour urine cortisol level can be used in the workup for Cushing syndrome (E).
28. **B.** PTH inhibits phosphate reabsorption at the proximal convoluted tubule, thereby lowering phosphate levels (A). It also inhibits the  $\text{Na}^+/\text{H}^+$  antiporter. This leads to an inhibition of bicarbonate excretion in the urine, resulting in a mild metabolic acidosis and corresponding hyperchloremia (D). This subsequently results in an elevated chloride-to-phosphate ratio ( $>33$ ). PTH levels are increased (E). Hypercalcemia typically results in hypercalciuria, with the exception being in patients with familial hypocalciuric hypercalcemia (C).
29. **C.** Parathyroid carcinoma is extremely rare and accounts for less than 1% of cases of primary hyperparathyroidism. It should be suspected in the setting of severe symptoms of hypercalcemia, in association with very high serum calcium and PTH levels and a palpable neck mass (A, B). Benign causes of hyperparathyroidism very rarely result in a palpable neck mass. Determination of malignancy is difficult because, similar to other endocrine malignancies, there are not any classic histologic features that reliably distinguish parathyroid malignancy from benign disease. Thus, one must look for evidence of local invasion at the time of surgery as well as enlarged lymph nodes. Treatment is surgical and involves en bloc resection of the parathyroid tumor with the ipsilateral thyroid gland, as well as a modified radical lymph node dissection if nodal metastasis is present. Recently, cinacalcet was approved by the U.S. Food and Drug Administration and is effective in controlling the hypercalcemia associated with parathyroid carcinoma. Breast cancer with bone metastasis may be associated with a paraneoplastic syndrome in which a high level of PTH-related protein is found. This is unlikely to present with a palpable neck mass (D). Secondary hyperparathyroidism is associated with a low level of serum calcium (E).
- Reference:** Shane, E. (2001). Parathyroid carcinoma. *The Journal of Clinical Endocrinology and Metabolism*, 86(2), 485–493.
30. **A.** On occasion, despite careful neck exploration, only three parathyroid glands will be encountered. A careful search for the ectopic gland should be conducted (B, C). The inferior glands are more likely to be ectopic than the superior ones. Most inferior glands are to be found within 2 cm of the inferior thyroid pole. If not found, the next step is to perform a cervical thymectomy and send the tissue for frozen section. If still glands are not found, the carotid sheath should be opened. Intraoperative ultrasonography should then be used to determine whether there is an intrathyroidal parathyroid gland. If ultrasonography is not available, ipsilateral thyroid lobectomy should be considered. Another useful modality in this setting is intraoperative gamma probe detection. Likewise, intraoperative PTH assays can assist in determining whether the pathologic gland has been removed. Ectopic parathyroid glands are only rarely found in the mediastinum, so a median sternotomy is not recommended unless all other options are explored (D). Biopsy may result in ischemia of the parathyroid glands (E).
31. **C.** Serum thyroglobulin levels are the most useful modality to monitor patients for recurrence of differentiated thyroid cancer (papillary and follicular) after total thyroidectomy and radioactive iodine ablation. Thyroglobulin is a glycoprotein that is the primary component of colloid matrix within the thyroid follicle. Thyroglobulin levels in patients who have undergone total thyroidectomy should be 3ng/mL or less when the patient is receiving thyroid hormone replacement therapy and less than 5 ng/mL when thyroid hormone supplementation is withheld. Serum thyroglobulin levels seem to be most predictive of recurrence when patients are hypothyroid as documented by a high TSH level (A). An increase above these levels is highly suggestive of metastatic disease. The recommendation after thyroidectomy is to check thyroglobulin levels initially at 6-month intervals after surgery. If the thyroglobulin levels are elevated, an  $^{131}\text{I}$  scan is recommended (D). Recurrence of MTC is determined by calcitonin levels (B). Ultrasound of the neck is not used to monitor for recurrent disease (E).



**References:** Baudin, E., Do Cao, C., Cailleux, A. F., et al. (2003). Positive predictive value of serum thyroglobulin levels, measured during the first year of follow-up after thyroid hormone withdrawal, in thyroid cancer patients. *The Journal of Clinical Endocrinology and Metabolism*, 88(3), 1107–1111.

Duren, M., Siperstein, A., Shen, W., et al. (1999). Value of stimulated serum thyroglobulin levels for detecting persistent or recurrent differentiated thyroid cancer in high- and low-risk patients. *Surgery*, 126(1), 13–19.

Lal, G., & Clark, O. H. (2005). Thyroid, parathyroid and adrenal. In F. C. Brunicaudi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 1395–1470) (8th ed.). New York, NY: McGraw-Hill.

32. **A.** Adrenocortical carcinomas are rare. They should be suspected in the presence of large tumors (>5–6 cm) or if the CT scan shows evidence of necrosis, hemorrhage, or local invasion. Approximately 60% of patients with adrenocortical carcinoma present with hormonal excess, including Cushing syndrome and virilization. There are no distinctive histologic or cytologic features that distinguish adrenocortical carcinoma from an adenoma (C). Thus, one must rely on evidence of local invasion, lymph node metastasis, or distant metastasis. CT-guided needle biopsy is not recommended (B). The best chance for cure is surgical resection. Mitotane is an adrenal cytotoxic agent but has poor response rates (E). Adrenal masses that are hormonally active should be excised. In the absence of hormonal activity and in the absence of CT scan features suggestive of malignancy, resection is recommended for asymptomatic masses if they are larger than 5 to 6 cm (D).

**Reference:** Ng, L., & Libertino, J. (2003). Adrenocortical carcinoma: diagnosis, evaluation and treatment. *The Journal of Urology*, 169(1), 5–11.

33. **B.** The frequency of thyroid carcinoma among patients with a surgically removed thyroglossal duct cyst in one large series was 0.7%. The majority is papillary cancer that is found incidentally after a Sistrunk procedure (performed for the cyst) (A, C–E). If discovered incidentally, the patient should subsequently undergo a total thyroidectomy because additional cancer is usually found within the thyroid gland as well.

**Reference:** Heshmati, H., Fatourechi, V., van Heerden, J., et al. (1997). Thyroglossal duct carcinoma: report of 12 cases. *Mayo Clinic Proceedings*, 72(4), 315–319.

34. **A.** The RLN innervates the intrinsic muscles of the larynx, except the cricothyroid muscles, which are innervated by the external branch of the superior laryngeal nerve (B). The internal branch of the superior laryngeal nerve provides sensory input for the pharynx (C). Injury to one RLN leads to paralysis of the ipsilateral vocal cord. The cord becomes fixed in either the paramedian position or the abducted position. If the cord becomes fixed in the paramedian position, the patient will have a weak voice, whereas if it becomes fixed in the abducted position, the patient will have a hoarse voice and an ineffective cough. If both RLNs are injured, an airway obstruction may develop acutely in the patient. Trauma from endotracheal intubation or compression from hematoma does not typically cause vocal cord paralysis (D, E).

35. **B.** Pituitary tumors are the third most common tumors in MEN 1. The majority are prolactinomas (A, C–E). They may cause visual field defects due to local compression or may lead to amenorrhea and galactorrhea in women or hypogonadism in men. Women are more likely to present early in the course of the disease as they are more likely to have hormonal symptoms. Men typically present later with mass-effect of the tumor (visual changes, headaches, etc.).

36. **D.** The “rule of tens” regarding pheochromocytoma (10% bilateral, 10% extra-adrenal, 10% familial, 10% multifocal, 10% malignant) was taught for generations. It was ultimately disproved in the year 2000 after a series of reports described novel germline mutations causing pheochromocytoma. We now recognize that 20% to 40 % of pheochromocytomas arise as a result of an underlying familial syndrome and that clear genotype-phenotype correlations exist. The organ of Zuckerkandl is a para-aortic structure located at the take-off of the inferior mesenteric artery or at the aortic bifurcation. It consists of a small mass of chromaffin cells that are derived from the neural crest. In the fetal circulation, it is important in the regulation of blood pressure via the secretion of catecholamines but then regresses. Pheochromocytoma may rarely be found in the bladder and can present with symptoms during voiding (B). The remaining choices are very rare locations for pheochromocytoma (A, C, E).

**Reference:** Disick, G., & Palese, M. (2007). Extra-adrenal pheochromocytoma: diagnosis and



management. *Current Urology Reports*, 8(1), 83–88.

37. **B.** Surgery is indicated in asymptomatic patients under the age of 50 that are suspected to have primary hyperparathyroidism. Familial hypocalciuric hypercalcemia (FHH) causes mild increase in serum calcium and can initially be misdiagnosed as primary hyperparathyroidism. It is a benign condition due to mutations in *CASR*, which encodes a calcium receptor. The lack of calcium signal increases the PTH level, which increases renal calcium reabsorption. Thus part of the workup of primary hyperparathyroidism is to obtain a 24-hour urine calcium. Hypercalciuria with a high PTH level and high serum calcium level confirms primary hyperparathyroidism. A low urine calcium level suggests FHH. Once FHH is ruled out, four-gland neck exploration can be performed without the need for further imaging (C). Tertiary hyperparathyroidism typically occurs in patients with renal failure, most of whom have undergone kidney transplantation (A). Cinacalcet is indicated for patients with secondary hyperparathyroidism (D). Selective venous sampling is an invasive procedure that is indicated in patients with recurrent hyperparathyroidism, when other forms of imaging fail to identify the abnormal gland (E).

38. **E.** Neuroblastoma is the most common abdominal malignancy in children and the third most common overall and is of neural crest origin (A). It most often presents as an abdominal mass, and most patients have advanced disease at presentation. For stage I disease, surgical resection is the best treatment. The overall survival rate is less than 30% (C). The tumor may cross the midline, and a majority of patients show signs of metastatic disease at presentation. Because these tumors are derived from the sympathetic nervous system, catecholamines and their metabolites will be produced at increased levels. Prognosis is based on age at presentation (older or younger than 1 year of age), tumor biology, and tumor histology. Children less than 1 year of age have more advanced disease (B). Amplification of the *N-myc* oncogene has an unfavorable prognosis. High-risk groups have only a 20% long-term survival rate. In infants, spontaneous regression has been well described. In the mediastinum, they most often present in the posterior mediastinum (the most common location for neurogenic mediastinal tumors) (D). Neuroblastoma is associated with many different syndromes, including dancing eyes–dancing feet syndrome (cerebellar ataxia, nystagmus, and involuntary movements), catecholamine release, periorbital metastasis leading to proptosis and periorbital ecchymosis, skin metastasis that gives the appearance of a blueberry muffin, and severe diarrhea (due to release of vasoactive intestinal polypeptide). Aniridia and hemihypertrophy, however, are associated with Wilms tumor.

**Reference:** Meitar, D., Crawford, S., Rademaker, A., et al. (1996). Tumor angiogenesis correlates with metastatic disease, *N-myc* amplification, and poor outcome in human neuroblastoma. *Journal of Clinical Oncology*, 14(2), 405–414.

39. **A.** The external branch of the superior laryngeal nerve lies on the inferior pharyngeal constrictor muscle and descends alongside the superior thyroid artery before innervating the cricothyroid muscle. Injury to the external superior laryngeal nerve results in an inability to tense the ipsilateral vocal cord and difficulty hitting high notes, projecting the voice, and voice fatigue during a prolonged speech. Injury to the internal branch of the superior laryngeal nerve results in loss of sensory input from the pharynx and subsequent ineffective cough and/or aspiration (D, E). Injury to the recurrent laryngeal nerve can cause vocal cord collapse and hoarseness (B). Bilateral recurrent laryngeal nerve can result in loss of airway (C).

**References:** Gauger, P. G., & Doherty G. M. (2004). The parathyroid gland. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 985–1000) (17th ed.). Philadelphia, PA: W. B. Saunders.

Hanks, J. B. (2004). The thyroid. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 947–984) (17th ed.). Philadelphia, PA: W. B. Saunders.

Lal, G., & Clark, O. H. (2005). Thyroid, parathyroid and adrenal. In F. C. Brunicardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 1395–1470) (8th ed.). New York, NY: McGraw-Hill.

40. **A.** In the follicular cell, inorganic iodide is trapped and transported across the basement membrane. Iodide is oxidized to iodine. It is then coupled with tyrosine moieties. This leads to the formation of monoiodotyrosine or diiodotyrosine, catalyzed by thyroid peroxidase. Two diiodotyrosine molecules couple to form  $T_4$ , and one monoiodotyrosine and one diiodotyrosine combine to form  $T_3$ , both of which are bound to thyroglobulin. In the periphery, approximately 70%

to 75% of  $T_3$  and  $T_4$  is bound to thyroid-binding globulins (not to be confused with thyroglobulin), and most of the remainder is bound to thyroid-binding prealbumin and albumin, leaving only a small amount of unbound or active thyroid hormone.  $T_4$  is relatively inactive but is present in larger amounts.  $T_4$  is converted to the more active form of  $T_3$  in the liver, kidneys, pituitary, and other tissues. Thus, treatment of thyroid storm involves inhibiting several steps: (1) addressing the ABCs by determining whether an airway is needed, administering 100% oxygen, and starting aggressive fluid hydration; (2) decreasing new hormone synthesis; (3) inhibiting the release of thyroid hormone; and (4) blocking the peripheral effects of thyroid hormone. Propylthiouracil and methimazole both inhibit oxidation of iodide to iodine and inhibit the thyroid peroxidase-mediated coupling of iodotyrosines (D). Propylthiouracil also inhibits the conversion of  $T_4$  to  $T_3$  (B). Beta-blockers such as propranolol are useful in controlling the adrenergic response to thyroid storm (C). Propranolol also inhibits peripheral conversion of  $T_4$  to  $T_3$ . Steroids also inhibit the conversion of  $T_4$  to  $T_3$  in the periphery (E). Aspirin is contraindicated in thyroid storm because it is thought to decrease protein binding of thyroid hormones. Thus, it may increase the levels of unbound  $T_3$  and  $T_4$ .

**Reference:** Nayak, B., & Burman, K. (2006). Thyrotoxicosis and thyroid storm. *Endocrinology and Metabolism Clinics of North America*, 35(4), 663–686.

41. C. Substernal goiter is divided into primary and secondary forms. Primary forms, defined as ones that originate in the mediastinum with blood supply from intrathoracic vessels, are very rare (B). Most substernal goiters are extensions from cervical goiters. Most surgeons recommend resection for the mere presence of a substernal goiter because most are symptomatic, and those that are not can cause progressive compression of the trachea (A). In addition, they may harbor an unsuspected malignancy. The majority can be successfully removed with a cervical collar incision. Sternotomy is very rarely needed nor is tracheostomy because most can be intubated, even in the face of tracheal compression, with a pediatric endotracheal tube (E). They are not typically responsive to prolonged thyroid suppression (D).

**References:** Gauger, P. G., & Doherty G. M. (2004). The parathyroid gland. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 985–1000) (17th ed.). Philadelphia, PA: W. B. Saunders.

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Hedayati, N., & McHenry, C. R. (2002). The clinical presentation and operative management of nodular and diffuse substernal thyroid disease. *The American Surgeon*, 68(3), 245–251, discussion 251–252.

Lal, G., & Clark, O. H. (2005). Thyroid, parathyroid and adrenal. In F. C. Brunicaudi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 1395–1470) (8th ed.). New York, NY: McGraw-Hill.

42. A. Adrenal insufficiency has primary and secondary causes. The most common cause of primary adrenal insufficiency in the United States is autoimmune adrenal atrophy. The most common cause worldwide is tuberculosis (B). Other less common causes include infections (fungal cytomegalovirus, human immunodeficiency virus), adrenal hemorrhage, metastases, and infiltrative disorders (amyloidosis) (C, D). The most common cause of secondary adrenal insufficiency is exogenous glucocorticoid therapy, followed by bilateral adrenal resection and pituitary tumors (E). Symptoms and signs of acute adrenal insufficiency include fever, nausea and vomiting, abdominal pain, hypotension, hyponatremia, and hyperkalemia. As such, it can readily be confused with septic shock. The most specific test for adrenal insufficiency is the ACTH stimulation test. Cortisol levels are measured at 1, 30, and 60 minutes. Blood and urine cortisol levels normally rise with ACTH; failure to rise is indicative of adrenal insufficiency.

**Reference:** Arlt, W., & Allolio, B. (2003). Adrenal insufficiency. *Lancet*, 361(9372), 1881–1893.

43. C. Progressive truncal obesity is the most common symptom of Cushing syndrome, but it is not specific. Relatively specific findings include proximal muscle weakness, wide purple striae, spontaneous ecchymoses, and hypokalemic metabolic alkalosis. Hirsutism and acne are also associated with Cushing syndrome but are not specific. Cushing syndrome is most often due to exogenous corticosteroid administration. The most common pathology associated with Cushing

syndrome is an ACTH-producing pituitary adenoma, which is referred to as *Cushing disease*. Causes of Cushing syndrome are divided into ACTH dependent (ACTH-producing pituitary adenoma, ectopic ACTH syndrome, and ectopic corticotropin-releasing hormone syndrome) and ACTH independent (adrenal carcinoma, adrenal adenoma, and adrenal hyperplasia) (A, B, D, E).

44. **D.** The juxtaglomerular cells are modified smooth muscle cells located in the afferent arteriole of each glomerulus (A). They synthesize the precursor prorenin, which is cleaved into the active proteolytic enzyme renin. Renal hypoperfusion, decreased plasma sodium, and increased sympathetic activity are the major stimuli for renin secretion (B, C). Renin initiates a sequence of steps that begins with cleavage of angiotensinogen (a protein produced in the liver) to form angiotensin I. Angiotensin I is then converted to angiotensin II by angiotensin-converting enzyme, found primarily in the lung. Angiotensin II causes systemic vasoconstriction and stimulates aldosterone synthesis and release by the adrenal gland, leading to sodium and water retention and expansion of the plasma volume (E). In the glomerulus, it leads to vasoconstriction of the efferent arteriole. This leads to increased glomerular pressure in an attempt to maintain the glomerular filtration rate despite systemic hypoperfusion.

45. **D.** The arterial blood supply to the adrenal glands is highly variable, whereas the venous drainage is more constant (A). The adrenal glands are supplied by three primary sources: the inferior phrenic artery, adrenal branches directly off the aorta, and branches from the renal artery (E). Additional branches may arise from the intercostal and gonadal arteries. A single left adrenal vein empties into the left renal vein and is a relatively longer vein than the single right adrenal vein, which is very short and enters the posterior aspect of the inferior vena cava (C). Adrenalectomy (open and laparoscopic) is more challenging on the right side because of (1) the need to retract the liver (for a laparoscopic approach), (2) the need to mobilize the duodenum, and (3) the short, posteriorly located adrenal vein that drains into the inferior vena cava, posing a risk of inferior vena cava hemorrhage. Likewise, venous sampling of the right adrenal vein is more challenging (B).

**Reference:** Corcione, F., Esposito, C., Cuccurullo, D., et al. (2001). Vena cava injury: a serious complication during laparoscopic right adrenalectomy. *Surgical Endoscopy*, 15(2), 218.

46. **D.** Incidentally discovered adrenal masses are quite common and are termed *adrenal incidentalomas*. Most are nonfunctioning cortical adenomas. The differential diagnosis includes a functional tumor (pheochromocytoma, aldosteronoma, cortisol producing), metastatic cancer (from lung, breast, melanoma), and adrenocortical carcinoma. A careful history and physical examination should be performed to detect evidence of hormonal excess (hypertension, virilization, Cushing disease). If the patient has hypertension and a low potassium level, plasma aldosterone and renin levels should be obtained. If there is no evidence of hormonal excess, the following studies should still be obtained to rule out a functional tumor: plasma free metanephrines to rule out a pheochromocytoma and a 1-mg overnight dexamethasone suppression test to rule out a cortisol-producing tumor (in normal patients, this will markedly suppress endogenous cortisol production to a level <1.8 µg/dL). Characteristics on the CT scan should also be determined. A mass with smooth borders, that is, homogeneous, and low attenuation (using Hounsfield units) is very likely benign, whereas an irregular mass with evidence of local invasion, that is, inhomogeneous, and a high attenuation score is of much more concern for malignancy (E). Fine-needle aspiration biopsy is not helpful in distinguishing a benign adrenal adenoma from a malignant adrenocortical carcinoma because it is even difficult to distinguish the two on histologic examination. Fine-needle aspiration biopsy would only be useful in the patient with a history of malignancy to rule out an adrenal metastasis (A). Surgery is generally recommended for functional adrenal adenomas, pheochromocytomas, masses that have CT scan features suggestive of malignancy, and masses larger than 5 cm. Once surgery is indicated, laparoscopic adrenalectomy has replaced open adrenalectomy for most indications. Open adrenalectomy is still preferred for very large tumors (>6 cm) and, in particular, when malignancy is suspected (B, C). For nonfunctional adrenal adenomas that do not fit the above criteria, repeat CT scan in 6 months may be performed.

**Reference:** Grumbach, M., Biller, B., Braunstein, G., et al. (2003). Management of the clinically inapparent adrenal mass ("incidentaloma"). *Annals of Internal Medicine*, 138(5), 424–429.

47. **B.** The adrenal gland is divided into the outer cortex and the inner medulla. The cortex is further subdivided into three layers ("GFR": glomerulosa, fasciculata, reticularis). The zona glomerulosa is

the outermost layer and is responsible for aldosterone production (A). The middle layer, the zona fasciculata, produces glucocorticoids. The zona reticularis is the inner layer of the adrenal cortex (E). Adrenal androgens are produced by the deepest cortical layer, the zona reticularis (C). Cells of the adrenal medulla produce epinephrine (80%) and norepinephrine (20%). Medullary cells are chromaffin positive (D).

48. **B.** In patients with primary hyperparathyroidism secondary to a single adenoma, removal of the enlarged gland is considered the preferred treatment and biochemical cure is typically confirmed intraoperatively. The Miami criteria outlines targeted PTH values after gland resection, and the criterion to conclude surgery is a greater than 50% drop in PTH level after gland removal. Serum PTH has a half-life estimated to be 3 minutes. PTH sampling should first be performed at 10 minutes after gland removal and can be repeated after 20 minutes if the PTH level does not decrease by more than 50%. Previously, it was thought that older age, high body mass index, and poor renal function can lead to an insufficient decline in PTH level during surgical resection, but a recent *JAMA Surgery* study demonstrated that these factors did not have a significant impact on PTH half-life, and as such the Miami Criteria can be used in these patients as well (E). It would be inappropriate to proceed to a four-gland exploration or to close the wound without confirming biochemical cure (A, C). If the baseline PTH level is sampled from the internal jugular vein ipsilateral to a single adenoma, then the PTH level can take longer to drop; therefore longer wait times may be appropriate in this setting (D).

**References:** Calò, P. G., Pisano, G., Loi, G., et al. (2013). Intraoperative parathyroid hormone assay during focused parathyroidectomy: the importance of 20 minutes measurement. *BMC Surgery*, 13(1), 36.

Leiker, A. J., Yen, T. W., Eastwood, D. C., et al. (2013). Factors that influence parathyroid hormone half-life: determining if new intraoperative criteria are needed. *JAMA: the Journal of the American Medical Association Surgeons*, 148(7), 602–606.

49. **C.** The hallmark of MEN 2 is MTC. Eventually, nearly 100% of patients with MEN 2 develop MTC, whereas only approximately 40% develop pheochromocytoma and one-third have parathyroid hyperplasia (A, B, E). MTC is characteristically multifocal and bilateral and presents at a young age. MTC is associated with C-cell hyperplasia. It is caused by mutations in the RET proto-oncogene that are present in all thyroid C cells and thus lead to multifocal MTC (D).

50. **C.** Congenital adrenal hyperplasia results from inherited enzyme deficiencies that can lead to ambiguous genitalia, postnatal virilization, and problems with salt metabolism. The most common enzyme defect is 21-hydroxylase deficiency (>90% of cases). In the complete form, the deficiency leads to a decrease in both cortisol and aldosterone. This leads to ambiguous genitalia in females (due to androgen excess), salt wasting with hyponatremia, and hypokalemia. The remaining answer choices can also cause congenital adrenal hyperplasia but are less commonly found (A, B, D, E).

51. **C.** A patient with a history of primary hyperparathyroidism, newly enlarging thyroid nodule, and elevated calcitonin level likely has multiple endocrine neoplasm-2A. These patients are at risk for developing MTC. The characteristics of MTC that affect surgical approach include the following: (1) MTC is more aggressive than other thyroid cancers with higher recurrence and mortality rates. (2) MTC does not take up radioactive iodine, and radiation therapy and chemotherapy are ineffective (B, E). (3) MTC is multicentric in 90% of MEN-2 patients. (4) In patients with palpable disease, more than 70% have nodal metastases (D). (5) The ability to measure postoperative stimulated calcitonin levels has allowed assessment of the adequacy of surgical extraction. The two main factors affecting survival are stage and age at diagnosis (D). A key factor in survival is early detection via calcitonin screening in at-risk patients. In one large study, biochemical cure predicted a survival rate of 97.7% at 10 years. Management of MTC includes total thyroidectomy with routine central node dissection (A). It should be noted that MEN-2A is rare, and in fact, most MTCs are sporadic. Sporadic cases are less likely to be multicentric than those associated with MEN-2. Microscopically, a characteristic feature of MTC is the finding of abundant collagen and amyloid.

**References:** Kebebew, E., Ituarte, P. H., Siperstein, A. E., et al. (2000). Medullary thyroid carcinoma: clinical characteristics, treatment, prognostic factors, and a comparison of staging systems. *Cancer*, 88(5), 1139–1148.

Modigliani, E., Cohen, R., Campos, J., et al. (1998). Prognostic factors for survival and for biochemical cure in medullary thyroid carcinoma: results in 899 patients. The GETC Study Group.

52. **D.** TSH is the most accurate test in hyperthyroidism, with significant suppression in hyperthyroid states. In most states of hyperthyroidism, free  $T_4$ , total  $T_4$ , and total  $T_3$  are elevated (A–C). Thyroid scan is not used in the initial workup for hyperthyroidism (E).
53. **E.** The thyroid gland is supplied by paired superior thyroid arteries from the external carotid arteries and the inferior thyroid arteries from the thyrocervical trunk. The superior thyroid artery is the first branch of the external carotid artery (B). During thyroidectomy, care must be taken when ligating the superior thyroid arteries to avoid injury to the external branch of the superior laryngeal nerve (D). To avoid injury, ligating the artery and vein separately and close to the thyroid gland is recommended. In approximately 3% of individuals, a thyroidea ima artery also provides blood to the thyroid gland and arises either from the aorta or the innominate artery. When ligating the inferior thyroid arteries, care must be taken to avoid injury to the RLNs (C). The inferior thyroid arteries usually supply the parathyroid glands (A). Ligation of the main trunk of the inferior thyroid arteries during total thyroidectomy can lead to parathyroid gland ischemia. There are three main pairs of veins draining the thyroid gland: the superior, middle, and inferior thyroid veins. The middle veins are the least constant. The superior and middle veins drain into the internal jugular veins, whereas the inferior veins drain into the brachiocephalic veins.
54. **C.** The superior laryngeal nerve and RLN arise from the vagus nerve. The superior laryngeal nerve divides into two branches and is both motor and sensory to the larynx (D). The internal branch is sensory to the supraglottic larynx, and, although rare, injury during thyroid surgery would lead to aspiration (A). The external branch innervates the cricothyroid muscle. Injury to the external superior laryngeal nerve causes an inability to tense the ipsilateral vocal cord. This does not cause hoarseness, but rather results in voice fatigue, and in singers creates difficulty in hitting high notes. It has been referred to as the nerve of Amelita Galli-Curci or “high note” nerve after the opera singer who underwent thyroid goiter surgery in the 1930s and lost her ability to sing afterward. The left RLN loops around the aorta at the ligamentum arteriosum. The right RLN loops around the right subclavian artery. The RLN innervates the intrinsic muscles of the larynx with the exception of the cricothyroid muscle, which is innervated by the external laryngeal nerve (E). Injury to one RLN leads to paralysis of the ipsilateral vocal cord, which becomes fixed in the paramedian or abducted position. Bilateral RLN injury may lead to airway obstruction and complete loss of the voice (B).
55. **C.** A non-RLN is rare and occurs much more commonly on the right (A, B). It branches off the vagus nerve in the neck and heads directly to the larynx, as opposed to arising from the vagus after passing the subclavian artery (D). The anomalous location, as opposed to its normal position in the tracheoesophageal groove, makes it more prone to injury (E). On the right, a patient can have both a nonrecurrent nerve and a recurrent nerve. Nonrecurrent left laryngeal nerves have been reported but are extremely rare. The RLN is most vulnerable to injury during the last 2 to 3 cm of its course but also can be damaged if the surgeon is not alert to the possibility of nerve branches and nonrecurrent nerves, particularly on the right side.
56. **E.** PTH increases the bone resorption by stimulating osteoclasts and inhibiting osteoblasts, leading to the release of calcium and phosphate into the circulation. At the kidney, PTH limits calcium excretion at the distal convoluted tubule via an active transport mechanism and inhibits phosphate and bicarbonate reabsorption, the latter leading to a mild metabolic acidosis (B, C). PTH also enhances hydroxylation of 25-hydroxyvitamin D to 1,25-hydroxyvitamin D in the kidney, which in turn directly increases intestinal calcium absorption (not a direct effect of PTH) (D). Cholecalciferol is hydroxylated to 25-hydroxyvitamin D in the liver. This is not regulated by PTH (A).
57. **A.** Lateral aberrant thyroid is a term used to denote what appears to be ectopic thyroid tissue found within the neck. In most instances, it actually represents metastatic thyroid cancer within a lymph node, most often of the papillary type. It is not typically associated with the remaining answer choices (B–E).
- Reference:** De Jong, S., Demeter, J., Jarosz, H., et al. (1993). Primary papillary thyroid carcinoma presenting as cervical lymphadenopathy: the operative approach to the “lateral aberrant thyroid.” *The American Surgeon*, 59:172–176.
58. **C.** The accepted management of low-risk papillary thyroid cancer is either right hemithyroidectomy or total thyroidectomy with or without postoperative  $^{131}\text{I}$ . There is an

increasing trend toward performing a total thyroidectomy. In patients with papillary carcinoma with a history of radiation exposure, there is a higher rate of multicentricity. As such, total thyroidectomy is the recommended procedure (A, B). Postoperative radioactive iodine following total thyroidectomy is indicated for tumors larger than 4 cm, gross extrathyroidal extension of the tumor regardless of size, lymph node metastases, and for high-risk features including tall-cell or columnar-cell variant (D). An added advantage of postoperative radiation is that it allows for the continued monitoring for recurrence with thyroglobulin. Prophylactic *central* neck node dissection is gaining popularity as well. Modified radical neck dissection would not be indicated unless there were obvious lateral neck nodes (E).

**References:** Hay, I., Thompson, G., Grant, C., et al. (2002). Papillary thyroid carcinoma managed at the Mayo Clinic during six decades (1940–1999): temporal trends in initial therapy and long-term outcome in 2444 consecutively treated patients. *World Journal of Surgery*, 26(8), 879–885.

Guerrero, M. A., & Clark, O. H. (2011). Controversies in the management of papillary thyroid cancer revisited. *ISRN Oncology*, 2011, 303128.

59. **D.** Hyperparathyroidism is classically associated with “stones (calcium phosphate or oxalate kidney stones), moans (not feeling well), groans (vague abdominal pain, peptic ulcer disease, pancreatitis, gallstones, and constipation), bones (bone pain, osteoporosis, osteitis fibrosa cystica, brown [osteoclastic] tumors), and psychiatric overtones (depression, fatigue).” Pancreatitis tends to occur in patients with a very high serum calcium level (>12.5 mg/dL). The increased incidence of cholelithiasis is due to increased biliary calcium, leading to formation of calcium bilirubinate stones. Diarrhea is not typically associated with hyperparathyroidism (A–C, E).
60. **C.** Transient hypocalcemia following thyroidectomy is a known complication and can occur in 2% to 53% of patients undergoing total thyroidectomy. The etiology is likely multifactorial and includes reversible ischemia to the parathyroid glands, hypothermia to the glands, and endothelin-1 release (known to suppress PTH production). Additionally, iatrogenic removal of one or several parathyroid glands is possible during thyroidectomy and can contribute to postoperative hypocalcemia. Patients with hypocalcemia can present with neuromuscular excitability, tetany (Chvostek sign), circumoral paresthesia, seizures, QT prolongation on ECG, and cardiac arrest (B). However, most patients with transient hypocalcemia following thyroid surgery are asymptomatic (D). Independent predictors of hypocalcemia following thyroidectomy include low postoperative PTH level, female gender, and patients with a malignant neoplasm (E). Several studies have demonstrated that the routine use of postoperative administration of calcium and vitamin D can reduce the incidence and/or severity of hypocalcemia. HBS is extremely rare. It has also been proposed as a possible contributing factor but occurs more frequently after parathyroid surgery. However, similar to PTH, thyroid hormone can also provide a stimulus to break down bone, and once this stimulus is removed, the bones attempt to replete their calcium by removing it from serum, which can lead to HBS. This typically presents with hypophosphatemia and hypomagnesemia and is usually seen in patients with severe preoperative bone disease (A).

**References:** Grodski, S. & Serpell, J. (2008). Evidence for the role of perioperative PTH measurement after total thyroidectomy as a predictor of hypocalcemia. *World Journal of Surgery*, 32(7), 1367–1373.

Alhefdhi, A., Mazeh, H., & Chen, H. (2013). Role of postoperative vitamin D and/or calcium routine supplementation in preventing hypocalcemia after thyroidectomy: a systematic review and meta-analysis. *Oncologist*, 18(5), 533–542.



# Skin and Soft Tissue

*Areg Grigorian, and Christian de virgilio*

## Questions

1. A 29-year-old male presents with left wrist pain. He has a mass at the volar wrist that has been growing in size for the past 4 months and recently started causing him pain. The mass is compressible, freely moving but tethered in place, and transilluminates. Which of the following is true regarding this condition?
  - A. It affects the volar wrist more commonly than it does the dorsal wrist.
  - B. It is unlikely to resolve without intervention.
  - C. Ligation of the tethering pedicle is required to achieve the lowest recurrence rate.
  - D. Simple aspiration is the preferred treatment option.
  - E. The pain is likely secondary to compression of the terminal branches of the posterior interosseous nerve.
2. A 45-year-old male presents with a rapidly growing painless mass in the right upper leg. It measures 4 cm in diameter. He is otherwise healthy. The initial step in workup is:
  - A. Magnetic resonance imaging (MRI)
  - B. High resolution computed tomography (CT)
  - C. Incisional biopsy
  - D. Excisional biopsy
  - E. Core needle biopsy (CNB)
3. A 76-year-old female with a history of chronic lymphocytic leukemia (CLL) presents with a painless blue, firm nodule on the right shoulder. It first appeared several weeks prior and was pink in color. It now has overlying ulceration and measures 2 cm in diameter. Immunohistochemistry analysis of a skin sample demonstrates polyomavirus genome. Which of the following is the best next step in management?
  - A. Expectant management
  - B. Wide local excision with 1-cm margin and adjuvant radiation
  - C. Wide local excision with 1-cm margin, sentinel lymph node biopsy (SLNB), and adjuvant radiation
  - D. Wide local excision with 2-cm margin and adjuvant chemoradiation
  - E. Neoadjuvant chemoradiation followed by wide local excision with 2-cm margin
4. Which of the following is least likely to affect prognosis in patients with melanoma?
  - A. Level of invasion
  - B. Regional lymph node involvement
  - C. Ulceration
  - D. Mitotic rate
  - E. Serum lactate dehydrogenase (LDH)
5. Which of the following is true regarding dermatofibrosarcoma protuberans (DFSP)?
  - A. Gross clinical margins are helpful in guiding width of excision.
  - B. The tumor is not radiosensitive.



- C. If it occurs on the neck, wide local excision is the surgical treatment of choice.
  - D. Local recurrence rate is lower with Mohs micrographic surgery compared with wide local excision.
  - E. Sentinel lymph node biopsy should be performed.
6. Which of the following is true regarding SLNB in melanoma?
- A. A 0.5-mm deep melanoma with ulceration does not require SLNB.
  - B. SLNB is unnecessary for melanoma that has more than a 4-mm thickness.
  - C. There is a survival benefit for completion lymphadenectomy following a positive SLNB.
  - D. Blue dye used for lymph node mapping should be injected outside of the planned wide local excision.
  - E. All nodes whose radioactivity count is greater than or equal to 10% of that of the hottest node should be removed.
7. A 51-year-old female presents with complaints of night sweats, fevers, and weight loss. On exam, she has enlarged cervical (2 cm), axillary (2 cm), and inguinal lymph nodes (3 cm). She is otherwise healthy. Which of the following would be the next step in establishing a diagnosis?
- A. Fine-needle aspirate (FNA) of inguinal lymph node
  - B. Surgical biopsy of cervical lymph node
  - C. Core needle biopsy of inguinal lymph node
  - D. FNA of cervical lymph node
  - E. Surgical biopsy of axillary lymph node
8. Which of the following is true regarding sarcoma?
- A. Kaposi sarcoma is a common cause of death in patients with AIDS.
  - B. Embryonal subtype is a rare childhood rhabdomyosarcoma.
  - C. Embryonal subtype has the worst prognosis in childhood rhabdomyosarcoma.
  - D. Osteosarcoma arises from stromal cells.
  - E. Osteosarcoma is one of the rarest malignant bone tumors.
9. A 19-year-old autistic male presents with severe pain in the second digit of the right hand. He has a fever of 103°F. His mother states that he has recently been biting his nails. On exam, he is tender lateral to the nail fold of the digit, and it appears swollen and red. Which of the following is the best management?
- A. Warm compresses and oral antibiotic coverage for skin flora
  - B. Incision and drainage at the mid-digital pulp
  - C. Incision at lateral nail fold
  - D. Incision at lateral nail fold plus oral antibiotic coverage for skin flora
  - E. Incision at lateral nail fold plus oral antibiotic coverage for skin flora and anaerobic bacteria
10. A 45-year-old male with human papilloma virus (HPV) presents to clinic to discuss his care after being diagnosed with Bowen disease of the anus. Which of the following is true regarding his condition?
- A. This is considered an invasive cancer.
  - B. Wide local excision should be performed.
  - C. It can be managed initially with imiquimod.
  - D. HPV 6 and 11 are the most common subtypes leading up to this condition.
  - E. Negative margins prevent local recurrence.
11. A 65-year-old female presents with a 5-cm right-sided rubber-like mass located on her back that has recently been causing pain. It has been slowly growing for the past year. On imaging, she has an unencapsulated mass with a lenticular shape. It has alternating streaks of fibrous and fatty tissue and is located between the subscapular region at the inferior pole of the scapula and the serratus anterior muscle over the thoracic rib cage. Which of the following is true regarding this condition?
- A. This is a malignant condition.
  - B. It is a benign tumor composed of adipose tissue.

- C. Biopsy is necessary even when radiologic findings are typical.
  - D. Simple excision should be performed.
  - E. Wide local excision should be performed.
12. A 21-year-old male presents to the emergency department (ED) with pain at his upper mid buttocks. On exam, he has a tender mass at the intergluteal region overlying the natal cleft with a sinus tract draining purulent fluid. A single strand of hair is seen protruding from the tract. He reports that he has been treated for this condition several times. Which of the following is most correct?
- A. Control of hair growth at the intergluteal cleft is unlikely to prevent recurrence.
  - B. Incision and drainage should be performed in the ED.
  - C. Surgical excision of the sinus tract and marsupialization of the wound should be performed in the OR.
  - D. The pathogenesis likely involves apocrine glands.
  - E. CT scan of the pelvis should be performed.
13. The most common cause of primary lymphedema is:
- A. Congenital lymphedema
  - B. Lymphedema praecox
  - C. Lymphedema tarda
  - D. Filariasis
  - E. Malignancy
14. Primary management of lymphedema consists of:
- A. Complete decongestive physiotherapy
  - B. Benzopyrone (coumarin)
  - C. Prophylactic long-term antibiotics
  - D. Graded compression stockings
  - E. Diuretics
15. Which of the following is least likely to be associated with lymphedema?
- A. Predisposition to recurrent cellulitis
  - B. "Buffalo hump" appearance of the dorsum of the foot
  - C. Hyperpigmentation of the skin
  - D. Peau d'orange appearance of the skin
  - E. Thickening and squaring of toes
16. The test of choice for suspected lymphedema is:
- A. Lymphoscintigraphy
  - B. Lymphangiography
  - C. CT scan
  - D. MRI
  - E. Positron emission tomography (PET) scan

## Answers

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1. **C.** This patient has a ganglion cyst, which is also colloquially known as a "Bible cyst" because they were historically managed by slamming a Bible on the cyst allowing for decompression. The etiology has not been elucidated but is likely multifactorial. The leading theory is a simple herniation of the joint capsule. It consists of connective tissue from the synovial membrane of the joint or tendon sheath and most commonly affects the dorsal wrist (A). Most patients are asymptomatic but pain, discomfort, and paresthesia can occur. Compression of the terminal branches of the posterior interosseous nerve may be responsible for pain in the case of dorsal ganglion cysts while compression of the branches of the median or ulnar nerve contribute to the paresthesia experienced by patients with volar ganglion cysts (E). About 50% of cases resolve spontaneously within several months to 2 years (B). Intervention is indicated for patients that have

pain or that are bothered by the cosmetic appearance. Simple aspiration or surgical excision alone has a high recurrence rate (up to 50%). To achieve a recurrence rate less than 10%, surgical excision with ligation of the pedicle is required and is now considered the gold standard in the treatment of a ganglion cyst.

**References:** Meena, S., & Gupta, A. (2014). Dorsal wrist ganglion: current review of literature. *Journal of Clinical Orthopaedics et Traumatologica*, 5(2), 59–64.

Rizzo, M., Berger, R. A., Steinmann, S. P., et al. (2004). Arthroscopic resection in the management of dorsal wrist ganglions: results with a minimum two-year follow-up period. *The Journal of Hand Surgery*, 29(1):59–62.

2. **A.** Soft-tissue sarcoma (STS) is a malignant tumor derived from mesodermal tissue and most commonly affects the extremities with the majority occurring in the upper leg or buttock. It can grow rapidly depending on the aggressiveness of the tumor. For tumors smaller than 3 cm, excisional biopsy is appropriate (D), but for those larger than 4 cm, MRI should first be performed to identify the anatomic relation to adjacent structures and to plan for surgical removal. CT is used in the workup of retroperitoneal sarcoma (B). The next step after imaging is a CNB followed by an en bloc resection without cutting into the tumor capsule (E). Incisional biopsy was once considered the gold standard, but it has been replaced by CNB owing to its low complication rate and high diagnostic accuracy (C). Local recurrence is high, and the most common site of distant disease is the lung. Recurrence or metastasis can occur years after surgical removal. Radiation therapy is indicated for high grade STS that is larger than 5 cm. With the exception of rhabdomyosarcoma and Ewing sarcoma, chemotherapy is largely ineffective in the management of sarcoma.

**References:** Sinha, S., & Peach, A. H. (2010). Diagnosis and management of soft tissue sarcoma. *BMJ*, 341, c7170.

Yang, J.C., Chang, A.E., Baker, A.R., et al. (1998). Randomized prospective study of the benefit of adjuvant radiation therapy in the treatment of soft tissue sarcomas of the extremity. *Journal of Clinical Oncology*, 16(1), 197–203.

3. **C.** Merkel cell carcinoma (MCC) is a rare but aggressive skin cancer of neuroendocrine origin arising from specialized touch receptor cells in the epidermis of the skin. It occurs in elderly, light-skinned patients and those with a history of sun exposure or immunosuppression, particularly CLL. The clinical features can be remembered by the mnemonic “AEIOU:” Asymptomatic, Expanding rapidly, Immunosuppression, Older than 50 years old, and UV-exposed area. It often first appears as a pink nodule and progresses to a violaceous blue color with or without ulceration. About 80% of patients with MCC have Merkel cell polyomavirus genome found in tissue samples. It is unclear how this leads to the progression of MCC as Merkel cell polyomavirus is ubiquitous and found on most human skin. Wide local excision with 1- to 2-cm negative margins is the mainstay of treatment (A). Because there is a high propensity of lymph node spread, all patients (with the exception of head and neck MCC) without palpable lymphadenopathy should have SLNB performed at the time of surgery (B). Additionally, all patients should receive adjuvant radiation to control local recurrence (10% recurrence rate with radiation and 50% without) (E). Chemotherapy is likely going to play an important role in the future, but as of yet there are no conclusive studies to recommend this as a standard treatment modality for all patients with MCC (D).

**References:** Medina-Franco, H., Urist, M. M., Fiveash, J., et al. (2001). Multimodality treatment of Merkel cell carcinoma: case series and literature review of 1024 cases. *Annals of Surgical Oncology*, 8(3), 204–208.

Heath, M., Jaimes, N., Lemos, B. et al. (2008). Clinical characteristics of Merkel cell carcinoma at diagnosis in 195 patients: the AEIOU features. *Journal of the American Academy of Dermatology*, 58(3), 375–381.

Santos-Juanes, J., Fernandez-Vega, I., Fuentes, N., et al. (2015). Merkel cell carcinoma and Merkel cell polyomavirus: a systematic review and meta-analysis. *The British Journal of Dermatology*, 173(1), 42–49.

4. **A.** The most recent edition of the American Joint Commission on Cancer staging for melanoma has replaced Clark’s level of invasion with more predictive factors of prognosis including serum LDH, ulceration, and mitotic rate (C–E). Tumor size/depth, lymph node involvement, and distant disease are still used in the staging of melanoma (B).

**Reference:** Edge, S. B., et al. (2010). Melanoma of the skin. *AJCC Cancer Staging Manual* (7th ed.).

New York, NY: Springer-Verlag.

5. **D.** DFSP is considered the second most common cutaneous soft-tissue sarcoma following Kaposi sarcoma. It is a locally aggressive cancer with low metastatic potential. The majority of patients have a unique chromosomal translocation (t:17;22) leading to overexpression of PDGFB, a tyrosine kinase. It can occur at any age but most commonly presents in the fourth decade of life. DFSP first appears as a firm nodule that slowly enlarges and most commonly affects the trunk. Core needle biopsy is used for tissue diagnosis. The mainstay of treatment is wide local excision. Since it has an infiltrating growth pattern, extension beyond the clinical margins is common; thus good clinical margins are not helpful (A). This may help explain the high rate of local recurrence following surgery. DFSP occurring in the head and neck is better served with Mohs microscopic surgery to achieve superior cosmesis (C). Like most sarcomas, DFSP is radiosensitive and radiation therapy has been demonstrated to decrease local recurrence (B). However both systemic and local metastases are rare and thus, sentinel lymph node biopsy is not necessary (E). A recent meta-analysis demonstrated a lower recurrence rate with Mohs microscopic surgery compared with wide local excision (1.1% vs 6.3%). The prognosis of DFSP is excellent with a 10-year survival close to 100%.

**References:** Gloster, H. M., Jr. (1996). Dermatofibrosarcoma protuberans. *Journal of the American Academy of Dermatology*, 35:355–374.

Foroozan, M., Sei, J., Amini, M., et al. (2012). Efficacy of Mohs micrographic surgery for the treatment of dermatofibrosarcoma protuberans: systematic review. *Archives of Dermatology*, 148(9), 1055–1063.

Kreicher, K. L., Kurlander, D. E., Gittleman, H. R., et al. (2016). Incidence and Survival of Primary Dermatofibrosarcoma Protuberans in the United States. *Dermatologic Surgery*, 42, S24–S31.

6. **E.** Lymph node metastases are not uncommon in melanoma. SLNB can provide accurate staging in melanoma and is recommended for all melanoma larger than 1 mm deep or for those with overlying ulceration regardless of depth (A, B). Most surgeons perform SLNB using a radioactive tracer, blue dye, or both. There has not been any conclusive data to show that any one particular agent is better than the other. Ironically, the radioactive tracer is considered to be safe in pregnancy but the blue dye is not. The radioactive tracer can be mapped with a Geiger counter, and the lymph node that takes up the largest amount of tracer (hot node) is assumed to be the sentinel lymph node. All nodes whose radioactivity count is greater than or equal to 10% of that of the hottest node should be removed because it is possible to have more than one sentinel lymph node. The most common blue dye used is isosulfan blue. Since the dye can stay around the skin for several months, it is recommended that the dye be injected within the boundary of the planned wide local excision so it is also removed with the specimen (D). Rarely, isosulfan blue dye has been associated with a severe anaphylactic reaction. Additionally, all grossly suspicious lymph nodes should be removed as well. Although the role of SLNB has been firmly established in current practice, completion lymphadenectomy is a point of debate in the surgical community. Recently, the Multicenter Selective Lymphadenectomy Trial (MSLT-1) trial showed that there was no survival benefit in patients with positive SLNB who underwent completion lymphadenectomy compared with those that were observed (C). These results are currently undergoing validation with the MSLT-2 trial planned for completion in 2022. Until then, the National Comprehensive Cancer Network (NCCN) continues to recommend that all patients with a positive SLNB should have a completion lymphadenectomy performed. Despite this, less than half of all practicing surgeons abide by these guidelines. Clinically palpable lymph nodes will require a therapeutic lymph node dissection. However, this should first be confirmed with a fine needle aspiration (FNA) biopsy.

**References:** Bilimoria, K. Y., Balch, C. M., Bentrem, D. J., et al. (2008). Complete lymph node dissection for sentinel node-positive melanoma: assessment of practice patterns in the United States. *Annals of Surgical Oncology*, 15(6), 1566–1576.

Coit, D. G., Andtbacka, R., Anker, C., et al. (2013). Melanoma, version 2.2013: featured updates to the NCCN guidelines. *Journal of the National Comprehensive Cancer Network*, 11(4), 395–407.

Morton, D. L., Thompson, J. F., Cochran, A. J., et al. (2014). Final trial report of sentinel-node biopsy versus nodal observation in melanoma. *The New England Journal of Medicine*, 370(7), 599–609.

Raut, C. P., Hunt, K. K., Akins, J. S., et al. (2005). Incidence of anaphylactoid reactions to isosulfan blue dye during breast carcinoma lymphatic mapping in patients treated with preoperative prophylaxis. *Cancer*, 104(4), 692–699.

7. **B.** Diffuse adenopathy suggests a systemic disease, such as tuberculosis, mononucleosis, HIV, and systemic lupus. In addition, in a patient presenting with B-symptoms (night sweats, fevers, and weight loss) and diffuse lymphadenopathy, lymphoma should strongly be considered. Workup should begin with a careful history and physical, followed by a complete blood count and chest x-ray. Once a decision is made to biopsy a node, consideration should be given to (1) the best method of biopsy (FNA, core needle, open), (2) what disease(s) is/are most suspected, and (3) which nodes typically provide the highest yield. If the history is highly suggestive of recurrent or metastatic cancer, FNA is usually sufficient. So for instance with isolated cervical nodes, and suspected head and neck cancer, FNA would be appropriate. With lymphoma, there are a few studies suggesting that FNA with cytomorphology and flow cytometry may be appropriate and others indicating that core needle biopsy is adequate. Nevertheless, open surgical biopsy of the entire node remains the gold standard because sampling error and false negatives may be unacceptably high (A, C–E). Supraclavicular lymph nodes are almost always pathologic, so biopsy of such nodes have the highest yield, whereas inguinal lymph nodes have the lowest yield. Nodes smaller than 1 cm are almost never malignant. However, there is no improved diagnostic yield for a 2- vs a 3-cm node.  
**References:** Chen, C. Y., Wu, C. W., Lo, S. S., et al. (2002). Peritoneal carcinomatosis and lymph node metastasis are prognostic indicators in patients with Borrmann type IV gastric carcinoma. *Hepatogastroenterology*, 49(45), 874–877.  
Doberneck, R. C. (1983). The diagnostic yield of lymph node biopsy. *Archives of Surgery*, 118(10), 1203–1205.
8. **D.** Kaposi sarcoma is considered the most common malignancy in AIDS but is rarely a cause of death (A). It is a vascular and cutaneous sarcoma most commonly occurring in the oral and pharyngeal mucosa and often presents with hemoptysis and dysphagia. Rhabdomyosarcoma is the most common soft-tissue sarcoma in childhood with the embryonal subtype being the most common and with a good prognosis (B). Alveolar subtype has the worst prognosis (C). Osteosarcoma is derived from mesenchymal stromal cells and is considered the most common malignant bone tumor in adults.  
**References:** Ottaviani, G., & Jaffe N. (2009). The epidemiology of osteosarcoma. In *Pediatric and adolescent osteosarcoma* (pp. 3–13). New York, NY: Springer US.
9. **E.** This patient has acute paronychia, which is an inflammation involving the proximal or lateral fingernail folds. It presents with sudden onset of pain at the nail fold with erythema and swelling. Acute paronychia is a clinical diagnosis but must be differentiated from a felon, which can have lasting consequences if not managed early. A felon is an abscess of the digital pulp and does not involve the nail bed. The appropriate management for a felon is an incision and drainage of the digital pulp at the midline to avoid injuring digital nerves (two sensory nerves medially and two sensory nerves laterally) (B). In contrast, most cases of acute paronychia are treated with warm compresses (A). In more severe cases (e.g., fever of 103°F), incision and drainage should be performed by placing a surgical blade under the cuticle margin and extending it laterally along the side of the affected nail fold. Oral antibiotics should be given for 5 days after drainage and should include coverage for skin flora, particularly with the use of an antistaphylococcal agent (C). However, in a patient with a history of nail-biting or in a patient with hand trauma and oral contact (e.g., punching the face), antibiotics should also cover oral flora including anaerobic bacteria (D).  
**References:** Brook, I. (1993). Paronychia: a mixed infection. Microbiology and management. *The Journal of Hand Surgery. British*, 18(3), 358–359.  
Clark, D. C. (2003). Common acute hand infections. *American Family Physician*, 68(11), 2167–2176.
10. **C.** Bowen disease is squamous cell carcinoma in situ (not invasive) of the perianal margin and most commonly caused by HPV-16 and 18 (A, D). High-grade lesions are more likely to be symptomatic and present as a scaly, erythematous, pigmented, plaque that may have a moist surface. Ulceration is suggestive of malignant transformation. Patients with known HPV infection should undergo screening for anal intraepithelial neoplasia (AIN). Some regard high-grade AIN as Bowen disease. Screening is often done in the operating room (OR) using Lugol's solution, which is selectively taken up by normal perianal tissue but not by AIN because it lacks glycogen, giving it a characteristic tanned appearance and allowing for tissue biopsy. Previously, it was standard for all patients with high-grade AIN or Bowen disease to undergo wide local excision (B). However, this has come under scrutiny as several reports have reported a high rate of recurrence (up to 40%) even with negative margins and particularly in patients with HPV (E). This is likely due to the fact

that the remaining perianal skin continues to harbor HPV leading to continued transformation of normal cells. Initial treatment of Bowen disease includes imiquimod or topical 5-FU. Surgical excision can be considered for patients with severe symptomatic disease such as refractory pruritus. Patients should receive frequent biopsies to look for invasive cancer.

**References:** Brown, S. R., Skinner, P., Tidy, J., et al. (1999). Outcome after surgical resection for high-grade anal intraepithelial neoplasia (Bowen's disease). *The British Journal of Surgery*, 86(8), 1063–1066.

Gordon, P. H., & Nivatvongs, S. (2007). *Principles and practice of surgery for the colon, rectum, and anus* (3rd ed.). Boca Raton, FL: CRC Press.

11. **D.** Elastofibroma dorsi is a benign, slow-growing process that is often mistaken for a soft-tissue sarcoma. Some consider it to be a reactive process; therefore, it is sometimes termed a *pseudotumor*. There has never been a report of malignant transformation (A). They are almost exclusively found in the subscapular or infrascapular region between the scapula and rib cage. Elastofibroma dorsi occurs more commonly in women older than 55. They are frequently right sided, often unilateral, and typically asymptomatic. The pathogenesis is thought to be due to repetitive microtrauma, but this has not been proven conclusively. Biopsy is unnecessary when radiologic findings are typical (C). MRI is the preferred imaging modality and will demonstrate a mass with streaks of fibrous and fatty tissue located beneath the scapula. Patients with asymptomatic lesions do not require intervention. Symptomatic patients should undergo simple excision (not wide local excision) (E). Local recurrence does not occur. A lipoma is a benign tumor composed of adipose tissue (B).

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Muratori, F., Esposito, M., Rosa, F. et al. (2008). Elastofibroma dorsi: 8 case reports and a literature review. *Journal of Orthopaedics et Traumatologiae*, 9(1), 33–37.

12. **B.** This patient has a pilonidal cyst with recurrent intergluteal abscess formation. Pilonidal cysts occur most commonly at the upper border of the intergluteal cleft and most commonly in young males. The pathophysiology is unclear but likely has to do with clogged hair follicles (D). Occasionally, hair may be seen protruding from the sinus tract. Inflamed apocrine glands are thought to be the culprit in patients with hidradenitis suppurativa. The diagnosis is made clinically and not with imaging or laboratory studies (E). Patients with an acute infection will present with a tender abscess draining purulent fluid at the pilonidal cyst site. This should be managed as all other cutaneous abscesses are treated, with incision and drainage (C). This will most likely recur, so the patient should have a referral to see a colorectal surgeon to discuss definitive repair after the acute condition has resolved. Although there is not a “gold standard” for chronic pilonidal cyst management the preferred treatment option depends on if the pilonidal cyst is simple or complex. Excision with primary closure off the midline for a simple, non infected pilonidal cyst is the most appropriate treatment option. Complex pilonidal cysts will require an en bloc excision of the sinus tract with a flap reconstruction. A rhomboid flap is the favored approach. Interestingly, there have been several studies demonstrating that control of intergluteal hair growth, either with clippers or laser treatment, will lead to decreased recurrence of disease (A).

**References:** Humphries, A. E., & Duncan, J. E. (2010). Evaluation and management of pilonidal disease. *The Surgical Clinics of North America*, 90(1), 113–124.

Khan, M. A., Javed, A. A., Govindan, K. S., et al. (2016). Control of hair growth using long-pulsed alexandrite laser is an efficient and cost effective therapy for patients suffering from recurrent pilonidal disease. *Lasers in Medical Science*, 31(5), 857–862.

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13. **B.** Lymphedema is divided into primary (with no cause) and secondary (there is a known cause). Primary lymphedema is subdivided into three types: congenital, praecox, and tarda. Congenital lymphedema is present at birth (A). A familial version of congenital lymphedema is called Milroy disease. Lymphedema praecox develops during childhood or teenage years and accounts for 80% to 90% of cases of primary lymphedema and is 10 times more common in women (praecox is primary). It starts usually in the foot or lower leg. Lymphedema tarda is defined as starting after age 35 (C). Secondary lymphedema is more common than primary lymphedema. Worldwide

infestation by *Wuchereria bancrofti* (filariasis) is the most common cause, whereas in the United States, the most common cause is post-axillary node dissection typically done for underlying breast cancer (D, E).

14. **D.** It is important when treating patients with lymphedema that they recognize that there is no curative therapy. Patients with lymphedema are at significantly increased risk of contracting recurrent infections and the development of progressive swelling and disability of the leg. With this in mind, compression stockings have been shown to be useful in reducing edema and are the mainstay of treatment. The stockings should ideally be custom fitted. The amount of compression needed for lymphedema is typically greater than for venous stasis and is as high 60 mm Hg. The effect of benzopyrone (coumarin) on lymphedema has been studied in two prospective randomized trials. In one study, there was benefit, and in the other, there was none. The latter study was limited to women with postsurgical arm lymphedema, whereas the first study included primary lymphedema (B). Coumarin (which has no anticoagulant effect) is thought to reduce edema through the stimulation of macrophages that enhance proteolysis. Complete decongestive physiotherapy has been shown to be effective and involves manual massage of the extremity. It must be used in combination with compression stockings (A). Compression pumps have also been shown to be effective. Diuretics may temporarily improve lymphedema, especially with mild cases and early on, but do not have any long-term benefit (E). Patients with lymphedema are predisposed to the development of cellulitis, and these infections can further damage lymphatics. As such, an aggressive approach to the treatment of infection is warranted. However, prophylactic antibiotics have no role (C). For advanced cases that do not respond to conservative management, the Charles procedure has been performed, which involves complete and circumferential excision of the skin, subcutaneous tissues, and deep fascia of the leg and dorsum of the foot. The exposed muscle is then grafted with a full- or split-thickness skin graft.

**References:** Casley-Smith, J., Morgan, R., & Piller, N. (1993). Treatment of lymphedema of the arms and legs with 5,6-benzo-[alpha]-pyrone. *The New England Journal of Medicine*, 329(16), 1158–1163.

Ko, D., Lerner, R., Klose, G., et al. (1998). Effective treatment of lymphedema of the extremities. *Archives of Surgery*, 133(4), 452–458.

Loprinzi, C., Kugler, J., Sloan, J., et al. (1999). Lack of effect of coumarin in women with lymphedema after treatment for breast cancer. *The New England Journal of Medicine*, 340(5), 346–350.

15. **C.** Distinguishing between chronic venous stasis and lymphedema on physical examination can be difficult, particularly early in their course. Both patient groups will report heaviness and fatigue in the limb, which tends to worsen at the end of a day of prolonged standing. Venous stasis tends to be more pitting and lymphedema nonpitting. Venous stasis tends to spare the foot and toes, whereas lymphedema involves them. The swollen dorsum of the foot has a buffalo hump appearance, and toes look squared off (B, E). Recurrent cellulitis is a common complication of lymphedema (A). In advanced lymphedema, the skin develops a peau d'orange appearance (similar to inflammatory disease of the breast), lichenification, and hyperkeratosis (D). Hyperpigmentation of the skin, due to hemosiderin deposition, is seen in venous insufficiency and not usually with lymphedema.

16. **A.** Although the diagnosis of lymphedema can be fairly obvious in advanced stages, early on it may be difficult to determine based on physical examination alone. If the cause of the lymphedema is obvious, such as post-lymph node dissection, then further workup is not necessary. Conversely, in situations in which lymphedema is suspected but the diagnosis is unclear, lymphoscintigraphy is the diagnostic test of choice. Once the diagnosis of lymphedema is established, CT and/or MRI can be useful to rule out other pathology that may be precipitating the lymphedema and to more accurately stage the degree of lymphedema (C, D). Lymphangiography is more invasive, involves direct injection of dye into the lymphatic vessels, and can irritate the lymphatic vessels, leading to further damage, so it is only recommended for the rare patient who is to undergo a direct lymphatic reconstruction (B). PET scan is not typically used in the workup for lymphedema (E).

**Reference:** Cambria, R., Gloviczki, P., Naessens, J., et al. (1993). Noninvasive evaluation of the lymphatic system with lymphoscintigraphy: a prospective, semiquantitative analysis in 386 extremities. *Journal of Vascular Surgery*, 18(5), 773–782.



# Surgical Critical Care

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## Questions

1. Which of the following is true regarding medications commonly used for sedation in the intensive care unit?
  - A. Propofol is associated with tachycardia.
  - B. Midazolam can lead to propylene glycol toxicity when given as a continuous infusion.
  - C. Dexmedetomidine has a similar method of action to clonidine.
  - D. Lorazepam has active metabolites leading to a longer duration of action.
  - E. Ketamine inhibits protective airway reflexes.
2. A 70-year-old male with chronic obstructive pulmonary disease (COPD) presents to the emergency department (ED) after a stab wound to the left anterior thoracoabdominal region. His vitals are stable. The patient develops progressively worsening shortness of breath and noninvasive positive pressure ventilation (NPPV) with bilevel positive airway pressure (BiPAP) is started for a presumed COPD exacerbation. The patient's blood pressure then abruptly drops to 70/40 mm Hg. Which of the following statements is true?
  - A. This complication could have been prevented with a higher expiratory pressure on BiPAP.
  - B. The cardiopulmonary compromise is likely secondary to obstructive shock.
  - C. Immediate endotracheal intubation is mandatory.
  - D. BiPAP is contraindicated with COPD.
  - E. A nasogastric tube should have been placed before initiation of BiPAP.
3. A 24-year-old obese male with a traumatic brain injury is 6 hours post procedure from a percutaneous dilatational tracheostomy tube placement. The nurse calls to state that the tracheostomy tube was accidentally dislodged. Which of the following is recommended?
  - A. Immediately reinsert the tube
  - B. Immediately reinsert the tube using ultrasound guidance
  - C. Bag patient and urgently transport to the operating room for open reinsertion
  - D. Perform bedside cricothyroidotomy
  - E. Endotracheal intubation
4. A 50-year-old female was admitted to the intensive care unit (ICU) 36 hours ago with worsening hypoxic respiratory failure secondary to pulmonary contusion following a motor vehicle collision. The most recent chest radiograph shows new bilateral pulmonary infiltrates. Current arterial blood gas shows a  $\text{PaO}_2$  of 70 mm Hg. Current ventilator settings include a  $\text{FiO}_2$  of 60% and a positive end-expiratory pressure (PEEP) of 8 cm  $\text{H}_2\text{O}$ . She has no history of heart disease. Which of the following is true?
  - A. An objective surrogate for pulmonary artery capillary wedge pressure (PAWP) must be obtained before making a diagnosis.
  - B. Prone ventilation should be initiated and can potentially improve her survival.
  - C. Inhaled nitric oxide will confer a mortality benefit.
  - D. If initiated early, high-frequency oscillatory ventilation (HFOV) can potentially improve her

survival.

- E. Neuromuscular blockade in this setting has been shown to increase ventilator days and hospital stay.
5. A 52-year-old male is preadmitted for a coronary artery bypass graft for three-vessel disease. While attempting to obtain a pulmonary artery capillary wedge pressure with the balloon inflated, the patient begins to cough and has a small amount of hemoptysis. However, this resolves quickly, and the patient shows no other signs of distress. Which of the following is the next best step in management?
- A. Deflate the balloon, withdraw the catheter into the right ventricle and refloat into the pulmonary artery.
  - B. Deflate the balloon and remove the pulmonary artery catheter entirely.
  - C. Leave the balloon inflated and prepare the patient for a catheter-based angiography.
  - D. Take immediately to the operating room for emergent thoracotomy.
  - E. Hyperinflate the balloon and advance the catheter as much as possible.
6. A 68-year-old male has new onset of an irregular, narrow complex tachycardia with a ventricular rate of 125 beats per minute. A single dose of metoprolol is administered with minimal affect. The patient subsequently becomes diaphoretic and the blood pressure drops to 72/35 mm Hg. What is the next best step in management?
- A. Unsynchronized cardioversion
  - B. Synchronized cardioversion
  - C. Defibrillation
  - D. Amiodarone push followed by a continuous drip
  - E. Intravenous (IV) push of adenosine
7. Which of the following is true regarding septic shock?
- A. It is characterized by poor perfusion of end organs.
  - B. Maintaining hemoglobin level greater than 10 g/dL is recommended.
  - C. In early septic shock, whole body oxygen consumption is decreased.
  - D. Positive fluid balance is associated with increased mortality.
  - E. The liver can serve as a continued source of inflammatory products.
8. A 27-year-old male (75 kg) with severe peritonitis due to perforated appendicitis develops hypotension requiring pressors following laparotomy. He has low systemic vascular resistance and high cardiac output. Over the past 12 hours his urine output dropped to less than 10 cc/hour despite receiving adequate IV fluids. His creatinine increased from a baseline of 0.9 mg/dL on admission to 2.2 mg/dL. He is not acidotic nor hyperkalemic and does not appear to be volume overloaded. Which of the following is true for this patient?
- A. Hemodialysis (HD) should be initiated.
  - B. Increased level of interleukin-8 (IL-8) is associated with decreased dependence on renal replacement therapy (RRT).
  - C. Early initiation of continuous renal replacement therapy (CRRT) will improve survival.
  - D. CRRT will require vascular access that differs from that of HD.
  - E. The timing of initiating CRRT does not change the length of hospital stay.
9. A 21-year-old man who was the driver in a head-on collision has a pulse of 140 beats per minute, respiratory rate of 36 breaths per minute, and systolic blood pressure of 70 mm Hg. His trachea is deviated to the left, with palpable subcutaneous emphysema and absent breath sounds over the right hemithorax. The next best step in the management of this patient is:
- A. Resuscitative thoracotomy
  - B. Ultrasonography or chest radiograph to confirm diagnosis
  - C. Intubation and ventilation
  - D. Tube thoracostomy
  - E. Needle thoracostomy

10. A 68-year-old (70-kg) male nursing home resident is admitted for an altered mental status. His vital signs demonstrate orthostatic hypotension. Laboratory studies reveal a serum sodium level of 168 mEq/L, a serum potassium level of 4.0 mEq/L, a serum chloride level of 118 mEq/L, an  $\text{HCO}_3^-$  level of 28 mEq/L, a blood urea nitrogen (BUN) of 30 mg/dL, and a serum creatinine level of 1.6 mg/dL. His free water deficit is:
- A. 3 L and all of it should be replaced over the next 12 hours
  - B. 4 L and all of it should be replaced over the next 24 hours
  - C. 5 L and 2.5 L should be replaced over the next 24 hours
  - D. 6 L and 3.0 L should be replaced over the next 24 hours
  - E. 10 L and 5 L should be replaced over the next 24 hours
11. Which of the following electrocardiographic changes is least likely to occur with hypokalemia?
- A. ST segment depression
  - B. T-wave inversion
  - C. Second- or third-degree atrioventricular block
  - D. Premature ventricular complexes
  - E. U waves
12. A 42-year-old woman with metastatic breast cancer is lethargic and has mental status changes. Her serum calcium is 14.5 mg/dL, serum alkaline phosphatase is 2000 IU/L, BUN is 42 mg/dL, and serum creatinine is 1.1 mg/dL. Initial treatment of the hypercalcemia should be:
- A. Mithramycin
  - B. Bisphosphonates
  - C. Loop diuretics
  - D. Thiazide diuretics
  - E. Normal saline infusion
13. A 75-year-old man becomes hypotensive (systolic blood pressure of 70 mm Hg) after repair of an inguinal hernia. Urine output is low, and he is unresponsive to fluid administration. A pulmonary artery catheter is inserted. Cardiac output is 3 L/min; systemic vascular resistance (SVR) is 2140 dynes/sec  $\times$  cm<sup>-5</sup>; SvO<sub>2</sub> is 55%; pulmonary capillary wedge pressure (PCWP) is 24 mm Hg. Which of the following is most likely to elevate the systolic blood pressure?
- A. 500 mL of Ringer's lactate to improve preload
  - B. Lasix (furosemide) 20 mg intravenously to improve urine output
  - C. Nitroprusside at 0.5  $\mu$ g/kg/L/min to decrease the SVR
  - D. Dobutamine at 5 to 10  $\mu$ g/min for inotropic support
  - E. Neo-Synephrine (phenylephrine) at 1  $\mu$ g/L per min to increase blood pressure
14. Nosocomial pneumonia among intensive care unit patients:
- A. Has the same mortality rate as does community-acquired pneumonia (CAP)
  - B. Is the most common nosocomial infection
  - C. Can be avoided by early tracheostomy
  - D. Is directly related to the duration of intubation
  - E. Can be prevented by early institution of prophylactic IV antibiotics
15. Blood samples for the determination of mixed venous oxygen saturation (SvO<sub>2</sub>) are ideally obtained from:
- A. Right atrium
  - B. Pulmonary artery
  - C. Pulmonary vein
  - D. Two peripheral veins mixed together
  - E. Central venous pressure line
16. Which of the following variables has the least influence on oxygen delivery?

- A. Hemoglobin
  - B. Cardiac contractility
  - C. Heart rate
  - D. Carbon monoxide concentration
  - E. Partial pressure of dissolved oxygen in the blood
17. A 25-year-old man with insulin-dependent diabetes mellitus is admitted to the intensive care unit with severe hyperglycemia. He has a 1-day history of nausea, vomiting, and diarrhea, and he withheld insulin because of poor oral intake. His blood pressure is 100/60 mm Hg, his heart rate is 104 beats per minute, his respiratory rate is 28 breaths per minute, and his temperature is 99°F. Physical examination reveals dry mucous membranes and mild diffuse abdominal tenderness. Laboratory testing reveals a serum sodium level of 135 mmol/L, a serum potassium level of 3.5 mmol/L, a serum chloride level of 110 mmol/L, a CO<sub>2</sub> of 8 mmol/L, a BUN of 22 mg/dL, a serum creatinine level of 1.2 mg/dL, a serum albumin level of 4.1 g/dL, and a serum glucose level of 350 mg/dL. Arterial blood gas demonstrates pH of 7.25, PaCO<sub>2</sub> of 20 mm Hg, and PaO<sub>2</sub> of 95 mm Hg on room air. Serum ketones are present at a 1:8 dilution. Which one of the following is the best explanation for the acid-base abnormality in this patient?
- A. Diabetic ketoacidosis
  - B. Diabetic ketoacidosis with hyperventilation
  - C. Diabetic ketoacidosis and diarrhea
  - D. Diabetic ketoacidosis and nausea/vomiting
  - E. Laboratory error
18. Which one of the following findings is most likely to be present in a patient with severe magnesium deficiency?
- A. Respiratory depression
  - B. Bradycardia
  - C. Tetany
  - D. Hypotension
  - E. Loss of patellar reflex
19. A 54-year-old man who weighs 100 lb comes to the ED after vomiting for 3 days and losing 10 lb. His serum electrolytes are as follows: sodium 136 mEq/L, potassium 3.1 mEq/L, chloride 88 mEq/L, and carbon dioxide 37 mEq/L. Which one of the following would be most helpful in determining the cause of his acid-base disorder?
- A. Urine sodium
  - B. Urine creatinine
  - C. Urine chloride
  - D. Urine pH
  - E. Urine potassium
20. In hemorrhagic shock, which of the following is the most accurate sign of adequate fluid resuscitation?
- A. An increase in blood pressure
  - B. An increase in urine output
  - C. An increase in arterial oxygenation
  - D. A decrease in thirst
  - E. A decrease in tachycardia
21. A 50-year-old woman who is septic from ascending cholangitis is transferred to the surgical ICU. She undergoes cholecystectomy and common bile duct exploration after a failed endoscopic sphincterotomy. Because of hypotension and marginal urine output, a Swan-Ganz catheter is placed. Which of the following readings is least consistent with the patient's clinical course?
- A. Central venous pressure 5 cm H<sub>2</sub>O
  - B. SVR 300 dynes/sec × cm<sup>-5</sup>

- C. Cardiac index 2.0 L/min/cm<sup>2</sup>
  - D. Pulmonary capillary wedge pressure 10 cm H<sub>2</sub>O
  - E. SvO<sub>2</sub> 86%
22. Prolonged QT intervals are seen in association with:
- A. Hypomagnesemia
  - B. Hypercalcemia
  - C. Hyperphosphatemia
  - D. Hyperkalemia
  - E. Hypokalemia
23. Acute symptoms of hypermagnesemia are treated by:
- A. Fluid hydration with normal saline
  - B. IV insulin
  - C. Calcium chloride
  - D. Dextrose
  - E. Dialysis
24. A morbidly obese 48-year-old male is admitted to the ICU following an open cholecystectomy via a midline incision. The patient's PaO<sub>2</sub> is 50 mm Hg on a FiO<sub>2</sub> of 60% and PEEP of 5 cm H<sub>2</sub>O. After increasing PEEP to 10 cm H<sub>2</sub>O, which of the following parameters is likely to increase?
- A. Arterial partial pressure of carbon dioxide (PaCO<sub>2</sub>)
  - B. Cardiac output
  - C. Functional residual capacity (FRC)
  - D. Left ventricular end-systolic volume
  - E. Pulmonary edema
25. Which of the following is most commonly associated with transfusion-transmitted bacterial infection?
- A. *Staphylococcus aureus*
  - B. *Staphylococcus epidermidis*
  - C. β-Hemolytic streptococcus
  - D. *Bacillus fragilis*
  - E. Gram-negative organisms
26. Abdominal compartment syndrome (ACS) should be suspected when bladder pressures exceed:
- A. 10 cm H<sub>2</sub>O
  - B. 20 cm H<sub>2</sub>O
  - C. 35 cm H<sub>2</sub>O
  - D. 40 cm H<sub>2</sub>O
  - E. 45 cm H<sub>2</sub>O
27. After an elective low anterior resection for rectal cancer, palpitations develop in a 59-year-old man with a history of congestive heart failure and an ejection fraction of 20% in the ICU. On the electrocardiogram, he is noted to be in a ventricular tachycardia (VT) at a rate of 120 beats per minute. He is currently awake and conversing with the nurse. His blood pressure is 130/75 mm Hg. The best initial treatment of this arrhythmia would be:
- A. Epinephrine 1 mg IV push
  - B. Amiodarone 150 mg IV over 10 minutes
  - C. Immediate defibrillation with 360 J
  - D. Synchronized cardioversion with 150 J
  - E. Diltiazem 15 mg IV over 2 minutes

28. In patients with acute kidney injury, the most immediate threat to the patient is:
- A. Acidosis
  - B. Hyperkalemia
  - C. Platelet dysfunction
  - D. Fluid overload
  - E. Malnutrition
29. Which of the following is true regarding hepatorenal syndrome?
- A. Type II is rapidly progressive with a poor prognosis.
  - B. It is associated with intense renal vasodilation.
  - C. It is associated with splanchnic vasoconstriction.
  - D. The urine sodium is typically less than 10 mEq/L.
  - E. Type I is relatively stable.
30. A 19-year-old man presents to the ED after a motor vehicle collision. The patient is alert and oriented but is unable to move his arms and legs. Results of a focused assessment with sonography for trauma (FAST) scan and chest and pelvic radiographs are all negative. On physical examination, the patient has a blood pressure of 80/60 mm Hg and a heart rate of 70 beats per minute. His feet are warm and pink, and he is noted to have priapism. Which of the following is the next best step in management?
- A. Phenylephrine
  - B. Intravenous fluid administration
  - C. Dobutamine
  - D. Epinephrine
  - E. Norepinephrine
31. Pulmonary artery occlusion pressure (PAOP) reflects which of the following physiologic variables?
- A. Cardiac output
  - B. Pulmonary arterial pressure
  - C. Left atrial pressure
  - D. Pulmonary compliance
  - E. Systemic vascular resistance (SVR)
32. Argatroban:
- A. Activates antithrombin
  - B. Is cleared by the kidneys
  - C. Is reversed with fresh-frozen plasma
  - D. Can be monitored by the activated partial thromboplastin time
  - E. Has a 3-hour half-life
33. Lepirudin:
- A. Is a direct thrombin inhibitor
  - B. Is cleared by the liver
  - C. Is reversed with cryoprecipitate
  - D. Is monitored by the international normalized ratio
  - E. Binds to platelet factor 4

## Answers

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1. **C.** Benzodiazepines (particularly lorazepam and midazolam) are commonly used medications for long-term sedation in the intensive care unit (ICU). While they are equally efficacious when administered in doses of equivalent potency, they differ in onset of action and duration. Midazolam is highly lipophilic and has a quick onset of action when compared with lorazepam. Duration of action is much more multifactorial. Initially, it is also determined heavily by lipophilicity because

of rapid redistribution from the central nervous system to the peripheral tissues. However, as tissue levels build up with continuous infusion, the duration of effect lengthens. Midazolam, in particular, also has active metabolites, which further prolong its duration; this effect is worsened by hepatic or renal failure. In contrast, lorazepam has no active metabolites, but mobilization to and from the peripheral tissues is much slower (D). With prolonged usage at high doses, lorazepam can lead to propylene glycol toxicity because it is included in the diluent. However, this is not used in the formulation of midazolam (B). For the above reasons, benzodiazepines are poor choices for prolonged sedation in the ICU. Propofol, which is believed to work on the GABA receptor, is a highly lipophilic anesthetic with very quick onset and short duration. It quickly distributes to tissues and is rapidly metabolized by the liver, leading to short duration of action. However, it has significant cardiovascular effects including hypotension and bradycardia (A). Ketamine is a potent sedative that blocks glutamate NMDA receptors within sensory nerve endings. It creates a dissociative anesthetic effect where patients remain conscious without inhibition of respiratory drive or protective airway reflexes (E). Unlike propofol, ketamine is considered to have analgesic properties. However, because of significant psychoactive effects, its use is limited. Dexmedetomidine and clonidine are both selective alpha-2 receptor antagonists, though the former has a much higher affinity for alpha-2 receptors than clonidine. Dexmedetomidine is a sedative with anxiolytic and analgesic properties without significant respiratory depression. Patients transition easily from undisturbed sedation to being aroused with stimuli.

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2. **B.** Traumatic pneumothorax should be suspected in all patients with a penetrating thoracoabdominal injury. The addition of NPPV increases intrathoracic pressure and can convert a pneumothorax into a tension pneumothorax, which can subsequently decrease venous return and result in obstructive shock (as demonstrated in the above case). Similarly, endotracheal intubation also increases intrathoracic pressure and can result in shock (C). In a stable patient without classic exam findings for pneumothorax (decreased breath sounds, tympanic chest), a chest x-ray can be performed to look for the collapsed lung. This can be followed by insertion of a tube thoracostomy (chest tube). NPPV can be delivered using continuous positive airway pressure (CPAP) or BiPAP, with the former providing continuous positive pressure support on a single setting and the latter providing different amounts of pressure support during the expiratory and inspiratory phase. The theoretical benefit of BiPAP is that it allows for a lower amount of pressure support during the expiratory phase, which can help patients blow off carbon dioxide. In patients with COPD, this is particularly useful because they are at increased risk for hypercapnia (D). NPPV is a useful adjunct for respiratory failure if used in select patients without contraindications. It is currently recommended for first-line treatment of acute respiratory failure from COPD and congestive heart failure (CHF) with pulmonary edema (A). There are some data to suggest a trial of NPPV should be attempted first in select patients with acute hypoxic respiratory failure as this may prevent intubation. However, failure to improve within the first 1 to 2 hours of treatment should prompt conversion to intubation. Contraindications to NPPV include: cardiac or respiratory arrest, inability to cooperate and protect the airway or clear secretions, severely impaired consciousness, nonrespiratory organ failure, facial trauma or deformity, high risk of aspiration, recent upper gastrointestinal (GI) anastomosis, anticipated prolonged duration of mechanical ventilation, bullous lung disease such as emphysema (can result in pneumothorax), or hypotension (intrathoracic pressure can decrease venous return and thus cardiac output). Placement of a nasogastric tube can potentially complicate NPPV by impairing its ability to form an effective seal and increasing the risk of pressure ulcer formation, and it has not been definitively shown to decrease risk of aspiration (E).

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3. **E.** The percutaneous method of tracheostomy placement has become widely used in critically ill patients because there is no need to transport the patient; the complications seem to be equivalent or lower to open tracheostomy, and the cost of the procedure is reduced. Initially there was concern about the safety of this relatively novel method, especially in obese patients. However, a single-center study with over 3000 patients demonstrated that percutaneous tracheostomy placement had a lower complication rate. The study also indicated no higher complication rates for obese patients, especially with the advent of longer tracheostomy tubes. Early tracheostomy dislodgment is a relatively rare but potentially fatal complication associated with tracheostomy tube placement. Before the development of a mature tract, it is possible to inadvertently place the tracheostomy into the subcutaneous tissue, which would manifest with subcutaneous emphysema and oxygen desaturation. While replacement during this time period is possible in experienced hands, immediate endotracheal intubation is the recommended management (A–C, D). Although ultrasonography or a tracheostomy obturator does facilitate easier placement, it is still possible to place the tracheostomy tube in false tissue tracts (B).

**Reference:** Dennis, B., Eckert, M. J., Gunter, O. L., et al. (2013). Safety of bedside percutaneous tracheostomy in the critically ill: evaluation of more than 3,000 procedures. *Journal of the American College of Surgeons*, 216(4), 858–865.

4. **B.** Acute respiratory distress syndrome (ARDS) was redefined in 2012 under the Berlin Definition into a three-tiered grading system consisting of mild ( $\text{PaO}_2 / \text{FiO}_2 = 200\text{--}300$ ), moderate ( $\text{PaO}_2 / \text{FiO}_2 = 100\text{--}200$ ), and severe ( $\text{PaO}_2 / \text{FiO}_2 < 100$  mm Hg). The purpose of the consensus meeting was to correlate a new naming system with predicted mortality and to remove some outdated requirements (inclusion of the PAWP in the definition). In place of the PAWP, clinical suspicion and a known inciting factor of ARDS in the last 7 days are sufficient for inclusion in the definition (A). Based on these criteria, this patient would fall into moderate ARDS ( $\text{PaO}_2 / \text{FiO}_2 = 117$ ). A lung protective strategy of ventilation using  $<6$  mL/kg of tidal volume and higher levels of PEEP continues to be the mainstay of treatment. In addition, prone ventilation for more than 12 hours per day has also shown a mortality benefit when instituted early in moderate to severe ARDS but not in mild ARDS. While inhaled nitric oxide will improve a patient's oxygenation, there have been no studies to date that have definitively proven that it confers a mortality benefit (C). And, there are some data to indicate that its use could potentially increase the risk of renal impairment. Similarly, HOFV has come under scrutiny after Ferguson and others published a *New England Journal of Medicine* article in 2013, which showed a trend toward increased mortality with early initiation of HFOV (D). Though the data are conflicted in regards to the utility of neuromuscular blockade, there is some evidence to suggest that cisatracurium may increase the number of ventilator-free days and days outside of the ICU, as well as potentially providing a mortality benefit (E).

**References:** Ferguson, N., Fan, E., Camporota, L., et al. (2012). The Berlin definition of ARDS: an expanded rationale, justification, and supplementary material. *Intensive Care Medicine*, 38(10), 1573–1582.

Ferguson, N., Cook, D., Guyatt, G., et al. (2013). High-frequency oscillation in early acute respiratory distress syndrome. *The New England Journal of Medicine*, 368(9), 795–805.

Bein, T., Grasso, S., Moerer, O., et al. (2016). The standard of care of patients with ARDS: ventilatory settings and rescue therapies for refractory hypoxemia. *Intensive Care Medicine*, 42(5), 699–711.

5. **C.** Pulmonary artery rupture is one of the most dreaded complications of pulmonary artery catheter placement. The most common etiologies are a balloon that is inflated too distal into the pulmonary system or too much force is used to obtain a wedge pressure. Most of the time, the rupture of the artery is heralded by an initial small volume hemoptysis as the injury is initially contained within a pseudoaneurysm. In suspected cases, the balloon should be left inflated and the patient taken for catheter-based angiography. By leaving the catheter in place, this allows for an immediate route of access for angiography. Additionally, the balloon may stop further bleeding (B). Overinflation of the balloon or repeated attempts at placement have the potential to worsen the initial injury and should be avoided (A, E). Open repair in the operating room is technically possible, but exposure of the pulmonary artery branch responsible is a morbid procedure and time consuming (D). Embolization of the pseudoaneurysm before full rupture is the preferred treatment modality.

6. **B.** The patient's new onset irregular, narrow complex tachycardia is likely atrial fibrillation with a rapid ventricular response. While it is reasonable to attempt medical cardioversion in a stable patient, conversion to unstable tachycardia requires immediate electronic synchronized cardioversion (as outlined in ACLS). The "synchronization" refers to delivering a low energy shock at the peak of the QRS complex. This explains why there is a brief pause between pressing the shock button and delivery of the shock. The theoretical benefit of synchronized cardioversion is avoidance of the shock during cardiac repolarization, which may precipitate ventricular fibrillation. In contrast, unsynchronized cardioversion, also known as defibrillation, delivers a high-energy shock as soon as the button is pressed. This is reserved for pulseless ventricular tachycardia/fibrillation in which any delay in shock delivery leads to poorer outcomes (A, C). Amiodarone should be used with caution if a patient has paroxysmal atrial fibrillation or the chronicity is unknown because this can potentially chemically convert the patient to a sinus rhythm and embolize any clot that has formed (D). Adenosine is typically reserved for monomorphic narrow complex tachycardia consistent with supraventricular tachycardia (E).
  7. **D.** The essential management of the septic patient includes early recognition, broad spectrum IV antibiotics, pressors (norepinephrine first, then vasopressin) and fluid resuscitation. There is a notable absence of large randomized, controlled trials demonstrating improved survival of adjunctive treatment options aside from the above essentials. Sepsis is an inflammatory cascade that is triggered by injury or bacterial invasion in an attempt to control the noxious stimuli. The location and type of pathogen or injury is irrelevant and does not influence outcomes or survival. The core problem of septic shock is the poor utilization of oxygen. Blood delivery (and perfusion to end organs) is not significantly impaired and as such maintaining the hemoglobin above a certain threshold provides little benefit (A, B). Inflammatory mediators chiefly impair mitochondrial oxidation by inhibiting pyruvate dehydrogenase and cytochrome oxidase and thus destroy the cell's ability to produce its energy currency, adenosine triphosphate (ATP) (this is termed *cytopathic hypoxemia*). Additionally, whole oxygen body consumption is actually *increased* in early septic shock as inflammatory mediators induce production of toxic oxygen free radicals (respiratory burst) in an attempt to break down bacterial cell membranes, denature proteins, and destroy DNA (C). Although endogenous antioxidants are plentiful in homeostasis and prevent free radicals from causing havoc on normal functioning cells, the septic patient has an exaggerated, large, and widespread production of free radicals that exceed endogenous antioxidant protection; this is known as *oxidant stress*. Additionally, inflammatory mediators induce production of nitrous oxide resulting in systemic vascular dilation and high cardiac output (from increased heart rate). However, due to the increased stress put on the cardiovascular system, cardiac output begins to fall late in untreated septic shock and portends a poor prognosis. The systemic venodilation leaves the majority of the intravascular volume dormant in the venous system, which is the basis of why fluid resuscitation is essential early in septic shock. However, a large positive fluid balance should be avoided as it is associated with increased mortality. And lastly, although there is a systemic vascular dilation, there is relative splanchnic vasoconstriction resulting in gut ischemia and mucosal injury. This allows for enteric pathogen translocation and additional subsequent inflammatory mediators resulting in further splanchnic vasoconstriction and mucosal injury; this self-sustaining process of continued inflammation is known as the "motor" of multiorgan failure (E).
- References:** Babior, B. M. (1984). The respiratory burst of phagocytes. *The Journal of Clinical Investigation*, 73(3), 599.
- Meakins, J. L., et al. (1986). The gastrointestinal tract: the "motor" of MOF. *Archives of Surgery*, 121(2), 197–201.
- Abraham, E., & Singer, M. (2007). Mechanisms of sepsis-induced organ dysfunction. *Critical Care Medicine*, 35(10), 2408–2416.
8. **C.** The kidneys work continuously to filter plasma and excrete toxic metabolites in urine. When cardiac output is normal and thus renal perfusion is maintained, an adult should produce at a minimum of 0.5 to 1 cc/kg of urine every hour. The first step in the management of oliguria is often a fluid challenge; the hypovolemic patient will respond with a correspondent increase in urine output. In a septic patient (as in this case), oliguria is a result of intrinsic renal dysfunction secondary to widespread inflammation and thus a fluid bolus is unlikely to result in improved urine output. In the surgical ICU, the emphasis is placed on "preventative" critical care management, when appropriate (e.g., gastrointestinal [GI] prophylaxis to prevent ulcers). In this case, this translates into providing RRT *before* the overt presence of renal dysfunction: acidosis,

hyperkalemia, volume overload, and azotemia. RRT is provided by either HD or CRRT in patients with acute kidney injury and/or renal failure. Both can be started using a nontunneled multilumen dialysis catheter (D). HD allows for rapid fluid and solute removal in a 4- to 5-hour time period, which can result in hypotension during dialysis. In contrast, CRRT works continuously with a slower unloading of fluid and solutes; this slow but continuous filtration allows for a larger *overall* amount of fluid removed. The primary modality for RRT in the septic patient is CRRT because HD is relatively contraindicated in hypotensive patients requiring pressors owing to the large fluid shifts that can occur with HD (A). Additionally, since septic shock is largely a result of widespread inflammatory mediators (see [question 7](#)), CRRT can be used in an ultrafiltration mode to lower plasma concentrations of inflammatory mediators and thus decrease the risk of multiorgan failure. The less porous interface used in the filtration membrane of HD is inferior to CRRT in removing inflammatory mediators. However, this benefit is theoretically lost if CRRT is not employed early in the course of septic shock before widespread multiorgan damage and/or failure. Until recently, the timing of CRRT was up for debate because there were no large randomized studies demonstrating improved survival. However, in 2016, the ELAIN trial published in *JAMA* was the first large randomized controlled trial demonstrating improved 90-day mortality (39% versus 54%) with the initiation of early CRRT (defined as within 8 hours of acute kidney injury onset). The duration of renal replacement therapy and length of hospital stay (but not ICU stay) were significantly shorter in the early group versus the delayed group (E). However, there was no difference in the rate of requirement of RRT after day 90 between the two groups. Patients with an increased level of IL-8 had an increased risk of RRT dependence after hospital discharge (B).

**Reference:** Honore, P. M., Jamez, J., Wauthier, M., et al. (2000). Prospective evaluation of short-term, high-volume isovolemic hemofiltration on the hemodynamic course and outcome in patients with intractable circulatory failure resulting from septic shock. *Critical Care Medicine*, 28(11), 3581–3587.

Zarbock, A., Kellum, J., Schmidt, C., et al. (2016). Effect of early vs delayed initiation of renal replacement therapy on mortality in critically ill patients with acute kidney injury: the ELAIN randomized clinical trial. *JAMA: the Journal of the American Medical Association*, 315(20), 2190–2199.

9. E. As with all trauma patients, the primary survey begins with checking airway and breathing. The patient is exhibiting signs of a tension pneumothorax with evidence of hypotension, tracheal deviation, and decreased breath sounds over the right hemithorax. Tension pneumothorax is a clinical diagnosis and does not require radiographic confirmation before instituting therapy (B). Treatment options include needle thoracostomy first followed by chest tube insertion (D). Intubation and application of positive pressure ventilation should not occur before decompressing a tension pneumothorax because this will worsen the tension physiology and further impede preload and cardiac output (C). If the patient continues to decompensate after tube thoracostomy, intubation can be considered. Resuscitative thoracotomy or tracheostomy is not indicated in this patient (A).
10. E. Free water deficit =  $(\text{serum sodium} - 140) / (140) \times \text{total body water}$ . Total body water is 50% of lean body mass in men and 40% in women. The free water deficit calculates to be 10 L, half of which should be replaced over the next 24 hours. The correction must be made slowly to avoid neurologic complications such as cerebral edema.
11. C. Electrocardiographic changes associated with hypokalemia include U waves, T-wave flattening, ST-segment changes, and arrhythmias (A, B, D, E). Atrioventricular block is more common with hypercalcemia and hyperkalemia. Hypokalemia is a common electrolyte abnormality in surgical patients, occurring because of inadequate supplementation with total parenteral nutrition and excessive IV fluids.
12. E. The treatment of hypercalcemia of malignancy should begin first with inducing calciuresis. This is accomplished by saline volume expansion. Once volume has been expanded, the next step is to administer loop diuretics because this similarly induces calciuresis (loops lose calcium) (C). Thiazide diuretics will have the opposite effect (D). Mithramycin acts directly on bones, lowering calcium levels, but the effect takes more than 24 hours (A). In contrast, bisphosphonate drugs are indicated in addition to IV hydration and loop diuretics in patients with cancer. This class includes zoledronic acid (superior) and pamidronate, which inhibits osteoclast activity, resulting in lower calcium levels in patients with bony metastasis. However, these agents may take 48 to 72 hours before reaching full therapeutic effect (B). Additionally, calcitonin lowers serum calcium levels within hours by inhibiting bone resorption that is occurring from metastatic disease; calcitonin is

indicated in hypercalcemic crisis. Corticosteroids are most useful in hypercalcemia related to sarcoidosis and multiple myeloma. They may be useful in patients with bony metastasis, but they take as long as 1 week to work.

**Reference:** Major, P., Lortholary, A., Hon, J., et al. (2001). Zoledronic acid is superior to pamidronate in the treatment of hypercalcemia of malignancy: a pooled analysis of two randomized, controlled clinical trials. *Journal of Clinical Oncology*, 19(2), 558–567.

13. **D.** The patient is in cardiogenic shock as evidenced by a low cardiac output, elevated SVR, and elevated PCWP. He has already shown to not have a persistent response to fluids so an additional bolus is unlikely to be helpful (A). Inotropic support in the form of dobutamine is indicated to improve cardiac contractility and cardiac output, while decreasing afterload. Alternative inotropes (vasoactive agents) include epinephrine and a phosphodiesterase inhibitor, such as milrinone. Given the patient's elevated PCWP, it is unlikely that further fluid resuscitation to increase preload is necessary. Lasix (furosemide) is not a good option because his low urine output is a reflection of poor forward flow versus volume overload (B). Nitroprusside is a vasodilator and could potentially improve cardiac output, but blood pressure is unlikely to improve without inotropic agents (C). It should not be used as the next step in treating this patient. Neo-Synephrine (phenylephrine) is an  $\alpha_1$ -agonist that will increase SVR (afterload) and can increase blood pressure. However, the patient is already maximally vasoconstricted as you would expect in cardiogenic shock and as evidenced by the high SVR. Phenylephrine would be a poor choice in a patient with cardiogenic shock (E).
14. **D.** Nosocomial pneumonia is the second most common nosocomial infection (the most common is urinary tract infection) and the most common nosocomial infection among ventilated patients (B). The risk of ventilator-associated pneumonia increases 5% per day and is as high as 70% at 30 days. The 30-day mortality rate from nosocomial pneumonia can be as high as 40%, which is significantly higher than community-acquired pneumonia (CAP) (A). Nosocomial pneumonias are frequently polymicrobial, and gram-negative rods are the predominant organisms. The criteria for diagnosis include fever; cough; development of purulent sputum in conjunction with radiologic evidence of an infiltrate; suggestive Gram stain findings; and positive sputum, tracheal aspirate, pleural fluid, or blood cultures. Prophylactic use of IV antibiotic has not been shown to reduce rates of nosocomial infection or to improve survival (E). However, there are some data to suggest that oral decontaminant regimens (gentamicin/colistin/vancomycin 2% in Orabase gel every 6 hours) can reduce the rate of ventilator-associated pneumonia. However, this is not yet the standard of care. Although early tracheostomy can reduce the number of days on the ventilator, it does not lead to reduced rates of pneumonia (C).
- Reference:** Bergmans, D. C., Bonten, M. J., Gaillard, C. A., et al. (2001). Prevention of ventilator-associated pneumonia by oral decontamination: a prospective, randomized, double-blind, placebo-controlled study. *American Journal of Respiratory and Critical Care Medicine*, 164(3), 382–388.
15. **B.**  $SvO_2$  is an indirect measurement of oxygen delivery. It is measured from a blood sample obtained from the pulmonary artery. A true  $SvO_2$  includes blood from the vena cava and the coronary sinus (A, C–E).  $SvO_2$  is a marker for adequacy of resuscitation and reversal of hypoxemia. However, mixed venous gas is most commonly sampled from the superior vena cava using a central venous catheter.
16. **E.** Oxygen delivery ( $DO_2$ ) is determined solely by the cardiac output and the oxygen content of blood ( $CaO_2$ ), so anything that affects these two variables is going to have a direct effect on the  $DO_2$ . Because cardiac output is determined by the stroke volume and heart rate, a change in cardiac contractility will directly influence  $DO_2$  (B, C). The oxygen content of blood can be defined by the equation  $CaO_2 = (Hg \times 1.34 \times SaO_2) + (PaO_2 \times 0.003)$ , where Hg is the concentration of hemoglobin,  $SaO_2$  is the percent saturation of hemoglobin, 1.34 is the oxygen carrying capacity of 1 gram of hemoglobin,  $PaO_2$  is the partial pressure of oxygen dissolved in the blood, and 0.003 is the measure of  $O_2$  (in mL) dissolved in 1 dL of blood per mm Hg of pressure. So hemoglobin and carbon monoxide (which decreases the percent saturation of hemoglobin by oxygen) will both affect oxygen delivery as well (A, D). The  $PaO_2$  only contributes 1% to 2% of the total oxygen content (E). However, it is important to keep in mind that the  $SaO_2$  is partly reliant on the  $PaO_2$  as can be demonstrated by the oxyhemoglobin dissociation curve.
17. **C.** The first step in approaching an acid-base disorder is to identify the primary metabolic

disorder. In this case, the low pH and low CO<sub>2</sub> point toward a primary metabolic acidosis. The next step is to determine if there is an anion gap by subtracting the chloride and CO<sub>2</sub> from the sodium. In this example, the anion gap = 135 (Na) – 110 (Cl) – 8 (CO<sub>2</sub>) = 17, clearly indicating the presence of an anion gap metabolic acidosis. Combined with the hyperglycemia and the presence of serum ketones, diabetic ketoacidosis is the clear primary disorder. However, the next question to ask is whether or not the change in the anion gap can account for the current CO<sub>2</sub> level by calculating the bicarbonate gap (Change in the anion gap – change in CO<sub>2</sub>). The normal values for anion gap and CO<sub>2</sub> are lab specific and this should be done using the normal values for each institution. For this calculation, normal values of 12 for anion gap and 27 for CO<sub>2</sub> will be used. The change in the anion gap (17 – 12 = 5) and the change in CO<sub>2</sub> (27 – 8 = 19) gives a bicarbonate gap (5 – 19) of –14 mmol/L. Because CO<sub>2</sub> change should be proportional to the addition of anions (ketoacids), a negative value indicates that the CO<sub>2</sub> has changed more than would be expected and that there is an additional non-anion gap metabolic acidosis. A highly positive value would have indicated the presence of an alkalosis. The only cause of this non-anion gap metabolic acidosis is diarrhea, which causes a metabolic acidosis due to gastrointestinal loss of bicarbonate (C). Hyperventilation would cause respiratory alkalosis (B). Nausea and vomiting would cause a metabolic alkalosis from loss of hydrogen chloride (D). There is no reason to believe there was a laboratory error (E).

18. **C.** Gastrointestinal and renal losses are the two major mechanisms whereby hypomagnesemia occurs. Other causes include starvation, malabsorption, IV fluids or total parenteral nutrition without supplementation, and chronic alcohol use. Neuromuscular and central nervous system hyperactivity is a primary manifestation of magnesium deficiency. Hypomagnesemia is characterized by neuromuscular and central nervous system hyperactivity, and symptoms are similar to those of calcium deficiency, including hyperactive reflexes, muscle tremors, and tetany with a positive Chvostek sign (C). Severe deficiency can lead to delirium and seizures. Respiratory arrest and cardiac arrest, with loss of tendon reflexes, are characteristic of hypermagnesemia (A, D, E). Abnormalities in cardiovascular repolarization, calcium metabolism, and hypokalemia are also common in patients with hypomagnesemia.
19. **C.** With a bicarbonate level of 37, this patient has a metabolic alkalosis. The cause of metabolic alkalosis can be determined by whether it is chloride responsive or resistant. Chloride-responsive cases (urine chloride < 15 mEq/L) are much more common in surgical patients and result from vomiting (gastrointestinal loss of hydrogen ions), diuretics (genitourinary loss of chloride), and volume depletion (aldosterone-stimulated hydrogen ion loss in urine). Conversely, chloride-resistant types (urine chloride > 25 mEq/L) result from mineralocorticoid excess or potassium depletion.
20. **B.** Hemorrhagic shock is a form of hypovolemic shock and the most common cause of shock in trauma patients. In response to hypovolemia, the sympathetic and cardiovascular systems increase the heart rate, myocardial contractility, and SVR to maintain blood pressure. This response occurs secondary to an increase in norepinephrine secretion and a decrease in vagal tone. The cardiovascular system also redistributes blood flow to the brain, heart, and kidneys and shunts it away from the skin, muscle, and gastrointestinal tract. The kidneys respond to hemorrhagic shock by increasing reabsorption of sodium and water, which results in a small volume of concentrated urine. When a patient is adequately resuscitated, the first sign is an improvement in urine output (A, C–E). There are 4 classes of hemorrhagic shock: Class 1 (up to 750 cc or <15% of total blood volume loss) does not have any hemodynamic changes; Class 2 (750–1500 cc or 15–30%) can have tachycardia, decreased pulse pressure, and typically normal blood pressure; Class 3 (1500–2000 cc or 30–40%) can have tachycardia, decreased pulse pressure, and decreased blood pressure; Class 4 (>2000 cc or >40%) can have tachycardia, decreased pulse pressure, and significantly decreased blood pressure, which may be incompatible with life.
21. **C.** Sepsis produces high-output cardiac failure with elevated cardiac index. If this goes untreated, the cardiac index will eventually decrease. SVR is decreased due to toxins that produce vasodilation (B). This is reflected in a low systemic blood pressure. Central venous pressures are low from the loss of intravascular volume due to increased capillary permeability (A). Wedge pressures are generally unaffected (D). SvO<sub>2</sub> will be high because the tissues are unable to extract oxygen from the blood for consumption (E).
22. **A.** Magnesium depletion is a common problem in hospitalized patients, particularly in the



intensive care unit. The kidney is primarily responsible for magnesium homeostasis through regulation by calcium/magnesium receptors on renal tubular cells that sense serum magnesium levels. Hypomagnesemia results from a variety of causes ranging from poor intake (starvation, alcoholism, prolonged administration of IV fluids, and total parenteral nutrition with inadequate supplementation of magnesium), increased renal excretion (alcohol, most diuretics, and amphotericin B), gastrointestinal losses (diarrhea), malabsorption, acute pancreatitis, diabetic ketoacidosis, and primary aldosteronism. Magnesium depletion is characterized by neuromuscular and central nervous system hyperactivity, and symptoms are similar to those of calcium deficiency. Signs include hyperactive reflexes, muscle tremors, and tetany with a positive Chvostek sign. Severe deficiencies can lead to delirium and seizures. Electrocardiographic changes including prolonged QT and PR intervals, ST-segment depression, flattening or inversion of P waves, torsade de pointes, and arrhythmias can also be seen (B–E). When hypokalemia or hypocalcemia coexists with hypomagnesemia, magnesium should be aggressively replaced to assist in restoring potassium or calcium homeostasis.

23. C. Treatment of hypermagnesemia includes withholding exogenous sources of magnesium, correcting volume deficits, and correcting acidosis if present. To manage acute symptoms, calcium chloride should be administered to antagonize the cardiovascular effects (C). If elevated levels or symptoms persist, dialysis is indicated (E). Insulin, dextrose, and dialysis are typically used in the treatment of hyperkalemia (A, B, D).
24. C. PEEP increases intrathoracic pressure, which may result in a decreased cardiac output via decreased preload, particularly in patients who are hypovolemic (B). PEEP does not decrease lung water, reduce vascular permeability, or hasten the resolution of pulmonary edema. PEEP may shift some edema fluid from the alveolar to the extra-alveolar interstitial space, but PEEP does not reduce the overall degree of pulmonary edema (E). PEEP is often an effective way of increasing arterial oxygen content by increasing FRC through the recruitment of collapsed or atelectatic alveoli in patients who have decreased lung compliance, thereby improving  $\text{SaO}_2$ . PEEP does not affect  $\text{PCO}_2$  nor does it alter cardiac contractility (A). PEEP can improve cardiac output by reducing left ventricular (LV) afterload and is a useful adjunct in patients with CHF exacerbations (D). It is important to keep in mind, however, that changing the PEEP will not have an immediate effect on oxygenation because it takes time to increase the FRC.
25. E. Although rare, the incidence of bacterial contamination of infused blood is higher than the incidence of viral infection transmission and can be acquired as a result of environmental contamination (collection bags or contaminated water baths) or from the donor's skin, blood, or phlebotomist's skin. Gram-negative organisms, especially *Yersinia enterocolitica* and *Pseudomonas* species, which are capable of growth at  $4^\circ\text{C}$  ( $39.2^\circ\text{F}$ ), are the most common cause (A–D). Gram-positive organisms are more frequently encountered as platelet contaminants. Clinical manifestations include fever, chills, abdominal cramps, vomiting, and diarrhea. There may be hemorrhagic manifestations and increased bleeding. If the diagnosis is suspected, the transfusion should be discontinued and resuscitative efforts initiated. Blood should be cultured and workup for a transfusion reaction should be performed. Emergency treatment includes oxygen, adrenergic blocking agents, and the administration of broad-spectrum antibiotics.

**References:** Mullins, R. (2004). Shock, electrolytes, and fluid. In C. Townsend, R. Beauchamp, B. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 67–112) (17th ed.). Philadelphia, PA: W. B. Saunders.

Peitzman, A., et al. (2005). Shock, electrolytes and fluid. In F. Brunicaudi, D. Andersen, T. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 85–108) (8th ed.). New York, NY: McGraw-Hill.

26. B. Intra-abdominal hypertension is defined as a sustained increase in intra-abdominal pressures greater than or equal to 12 mm Hg. The increased pressure may be acute, subacute, or chronic. ACS is defined as sustained intra-abdominal pressures greater than 20 mm Hg associated with new organ dysfunction. ACS occurs in patients who have sustained multiple traumas, severe burns, or retroperitoneal injuries; have undergone an operation for massive intra-abdominal infection; or have undergone a complicated, prolonged abdominal operation. Massive IV fluid resuscitation with resultant third spacing of fluid and marked bowel wall edema places patients at high risk of the development of this complication. The symptoms and signs include progressive abdominal distention, increasing peak airway pressure, decreased cardiac output, and oliguria. These complications are the result of the abdominal pressure decreasing venous return from the

inferior vena cava and renal veins and from decreased pulmonary compliance. Renal failure, severe pulmonary compromise, and intracranial hypertension can eventually develop in patients. Intra-abdominal pressures transduced from the bladder can be readily measured by instilling 25 mL of saline into the aspiration port of a Foley catheter with the drainage tube clamped. An 18-gauge needle attached to a pressure transducer may then be inserted into the aspiration port at which point the system should be zeroed at the level of the midaxillary line. A pressure of greater than 20 mm Hg with evidence of physiologic compromise as manifested by renal, respiratory, or neurologic compromise is considered diagnostic. Treatment consists of opening the abdomen or paracentesis in select cases.

27. **B.** Patients with underlying cardiac disease are at increased risk of arrhythmias, seeming to be more sensitive to hypoxia, hypercarbia, and electrolyte abnormalities than patients without heart disease. VT is a serious wide-complex tachycardia that warrants immediate treatment because it may progress to unstable ventricular rhythms. Management of VT is dependent on the stability of the patient. For those without hypotension, altered mental status, signs of shock, chest pain, or acute heart failure, pharmacologic treatment with antiarrhythmic infusions is indicated. Amiodarone is the drug of choice, although procainamide and sotalol are also acceptable provided that the QT interval is not prolonged. If the patient exhibits altered mental status and/or hypotension, immediate synchronized cardioversion is indicated with an initial recommended dose of 100 J (C, D). Consideration should be given to the administration of sedation or analgesia before cardioversion, if possible. Epinephrine is indicated in pulseless VT and is not first-line management in the stable patient (A). Diltiazem is useful in atrial tachycardia but has no place in VT (E). Most importantly, a search for and correction of any reversible causes should be undertaken.

28. **B.** All are consequences of acute kidney injury; however, hyperkalemia is generally the most immediately life-threatening complication and can predispose the patient to ventricular tachycardia and fibrillation (A, C–E).

29. **D.** Hepatorenal syndrome is a functional renal problem that likely results from relative hypovolemia, splanchnic and peripheral arterial vasodilation, and intense vasoconstriction of the renal circulation (B, C). The syndrome is probably the final consequence of extreme underfilling of the arterial circulation secondary to arterial vasodilation in the splanchnic vascular bed. It is characterized by azotemia, oliguria, a very low urinary sodium (<10 mEq/day), and a high urine osmolarity. Prognosis is poor. Type 1 is mainly associated with acute liver failure or alcoholic cirrhosis, but it can develop in any other form of liver failure. It is characterized by rapid deterioration of renal function, with a marked increase in serum creatinine and blood urea nitrogen over a short period of time (E). Optimal treatment is liver transplantation, but the patients may not receive the transplant in time. Hyponatremia and hyperkalemia are typical. Type 2 is a more stable form (A). The decrease in the glomerular filtration rate and the increase in creatinine are moderate. It occurs mostly in patients with a relatively preserved hepatic function. In one study, a combination of midodrine, an  $\alpha$ -agonist, and octreotide improved 30-day survival.

**Reference:** Ginès, P., Guevara, M., Arroyo, V., et al. (2003). Hepatorenal syndrome. *Lancet*, 362(9398), 1819–1827.

30. **B.** The presentation is consistent with neurogenic shock. Findings suggestive of neurogenic shock include hypotension with relative bradycardia, warm, well-perfused extremities reflecting loss of sympathetic tone, evidence of a high spinal cord injury, and priapism (sustained erection due to unopposed parasympathetic stimulation). In a patient with a high cervical spine injury and evidence of hypercarbic or ventilatory failure, the first step is to secure an airway. The phrenic nerve is supplied by the C3 to C5 nerve roots. Thus, patients with an injury above C5 will routinely require ventilatory support. After the airway is secured and ventilation is adequate, fluid resuscitation and restoration of intravascular volume will often improve perfusion in neurogenic shock. Most patients with neurogenic shock will respond to restoration of intravascular volume alone, with satisfactory improvement in perfusion and resolution of hypotension. It is always important to rule out hypovolemia due to hemorrhage in the trauma setting. In addition, one must always be aware that in the presence of spinal cord injury, one cannot rely on the abdominal examination. Thus, an abdominal and pelvic CT scan would be indicated to rule out visceral injury. If the patient does not respond to fluids, administration of vasoconstrictors will improve peripheral vascular tone, decrease vascular capacitance, and increase venous return but should only be considered once hypovolemia is excluded as the cause of the hypotension and the



diagnosis of neurogenic shock is established (A, C–E). Restoration of blood pressure and circulatory perfusion is also important to improve perfusion to the spinal cord, prevent progressive spinal cord ischemia, and minimize secondary cord injury.

31. **C.** PAOP or pulmonary artery wedge pressure (PAWP) provides an indirect estimate of both left atrial and left ventricular diastolic pressure. These pressures can be measured using a Swan-Ganz or pulmonary artery catheter, which is a flexible balloon-tipped catheter that is inserted into the pulmonary artery and inflated, thereby occluding pulmonary artery pressures and reflecting left heart pressures. In diastole, there are no valves between the open mitral valve and closed pulmonic valves. In this unobstructed pathway between the left ventricle and the closed pulmonic valves, as well as the relatively low compliance of the pulmonary artery circulation, there exists a column of blood from the catheter tip in the pulmonary artery through the pulmonary capillary bed, pulmonary vein, left atrium, and left ventricle. The measured pressure approximates the pressure in the LV during end-diastole and is used as a measure of LV preload. With the balloon wedged and the ventricles in systole, PAWP now measures pressures reflected by the LA provided there are no significant mitral valve abnormalities. Swan-Ganz catheters provide both direct and indirect measurements of cardiac performance and these measurements are contingent upon when during the cycle the measurements are taken as well as whether or not the catheter is wedged.
32. **D.** Argatroban and lepirudin are both direct thrombin inhibitors and used for heparin-induced thrombocytopenia (HIT) and thrombosis. Both can be monitored by the activated partial thromboplastin time and both have relatively short half-lives (60–90 minutes for lepirudin and 40–50 minutes for argatroban). Neither can be reversed and neither requires the presence of antithrombin to be effective. Argatroban is cleared by hepatic metabolism, whereas lepirudin is cleared by the kidneys. In addition to being used for HIT, argatroban is approved in patients with or at risk of HIT who are undergoing percutaneous coronary intervention. Argatroban has a short half-life (40–50 minutes) and reaches a steady state with IV infusion at 1 to 3 hours. Because it is cleared by hepatic metabolism, it is the drug of choice for patients with HIT and renal insufficiency.
33. **A.** Lepirudin is made by recombinant DNA but was first derived from the leech (and called hirudin). The loading dose is 0.4 mg/kg, followed by a continuous infusion of 0.15 mg/kg. Because it is cleared by renal metabolism, it is the drug of choice for patients with HIT and hepatic insufficiency. It does not bind to platelet factor 4.

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# Trauma

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## Questions

1. A 45-year-old man presents with second- and third-degree burns to the anterior surface of both arms and entire right leg. He also has superficial burns to both hands. What is his estimated total body surface area (TBSA) burned?
  - A. 25%
  - B. 27%
  - C. 29%
  - D. 36%
  - E. 38%
2. A 22-year-old male presents to the emergency department (ED) after a gunshot wound (GSW) to the abdomen. He is hypotensive. Which of the following intravenous (IV) routes is the most appropriate way to deliver rapid fluid resuscitation to this patient?
  - A. 18-gauge peripheral catheter
  - B. 20-gauge peripheral catheter
  - C. 6-French femoral vein central line catheter
  - D. 7-French subclavian vein central line catheter
  - E. 7-French internal jugular vein central line catheter
3. Which of the following is the leading cause of death in the trauma patient reaching the hospital alive?
  - A. Head injury
  - B. Hemorrhagic shock
  - C. Multiorgan failure
  - D. Sepsis
  - E. Cardiac injury
4. A 35-year-old male is taken to the ED after being stabbed in the right abdomen. He complains of minimal abdominal pain with no rebound or guarding. During local wound exploration (LWE), it appears that the anterior fascia is not violated. His vital signs are normal. Which of the following is the most appropriate management?
  - A. Admission for 24-hour observation
  - B. Discharge after 6 hours if abdominal exam does not change
  - C. Computed tomography (CT) scan of the abdomen and pelvis
  - D. Focused assessment with sonography for trauma (FAST)
  - E. Discharge home
5. A 45-year-old male is brought to the ED after a GSW to the right leg. He is hypotensive in the ED, with a large amount of blood loss at the scene. Massive transfusion protocol is initiated. Following interposition vein graft for a superficial femoral artery transection, he is admitted to the ICU for observation. The following morning he is found to be oliguric, has rising peak airway pressures, and has a distended abdomen. Which of the following would be expected in this patient?

- A. Increased pulmonary compliance
  - B. Increased functional reserve capacity (FRC)
  - C. Decreased pulmonary vascular resistance
  - D. Increased pulmonary capillary wedge pressure
  - E. Increased venous return
6. A 45-year-old male presents with nausea, vomiting, and dyspnea. Past history is significant for a motor vehicle collision (MVC) 5 years earlier for which he was hospitalized for a week, without requiring surgery. There are decreased breath sounds in the left chest. Chest x-ray (CXR) demonstrates an elevated left hemidiaphragm, with blunting of the costophrenic angle, as well as multiple gas bubbles in the left lower chest. WBC count is 18,000 cells/ $\mu$ L. Which of the following is the best management recommendation?
- A. Left tube thoracostomy
  - B. Left chest pig tail catheter
  - C. Video-assisted thoracoscopic surgery (VATS)
  - D. Intravenous antibiotics
  - E. Exploratory laparotomy
7. Which of the following is true with regards to burn injury?
- A. Superficial partial-thickness burns do not have blistering.
  - B. Full-thickness third-degree burns can involve underlying fascia.
  - C. Deep partial-thickness burns have a loss of hair follicles.
  - D. Deep partial-thickness burns often heal spontaneously.
  - E. Superficial partial-thickness burns are not painful.
8. Which of the following is correct regarding common topical antimicrobials used in burn care?
- A. Mafenide acetate leads to a respiratory alkalosis by increasing minute alveolar ventilation.
  - B. Silver sulfadiazine has broad coverage against *Pseudomonas*.
  - C. Bacitracin has gram-negative coverage.
  - D. Silver nitrate can be used in patients with a sulfa allergy.
  - E. Silver sulfadiazine can lead to electrolyte abnormalities.
9. Which of the following is an indication to transfer a patient to a burn center?
- A. 45-year-old female with first-degree burns 30% TBSA
  - B. 10-year-old female with third-degree burns 4% TBSA
  - C. 21-year-old male with a chemical burn to the right hand
  - D. 30-year-old female with second-degree burns 18% TBSA
  - E. 71-year-old female with second-degree burns 8% TBSA
10. A 28-year-old morbidly obese male arrives at the ED after suffering an electrical shock. He was working on his car at the time of injury. He has a burn mark on his hand and his forearm appears swollen. Which of the following is true regarding this patient?
- A. The source of the shock was likely a direct current.
  - B. Renal failure is the main cause of death in those who survive the initial injury.
  - C. He likely had repetitive, tetanic muscle contractions at the time of electrocution.
  - D. His body habitus will likely protect him from deep thermal injury.
  - E. Red urine on admission is suggestive of bladder injury.
11. A 36-year-old alcoholic female arrives at the ED during a winter storm with a frostbite to the right arm and hand. She passed out in a park with her arm exposed on a freezing metallic bench. Her right hand has several areas of what appear to be hemorrhagic bullae. It has been 7 hours since she was brought to the ED. Which of the following is true regarding this patient?
- A. She likely has a second-degree frostbite.
  - B. She should receive early debridement of obviously necrotic tissue.

- C. She will likely respond favorably to tissue plasminogen activator (tPA) treatment.
  - D. Reperfusion injury is an important contributor to the damage seen with her injury.
  - E. Rewarming in warm water should be done gradually.
12. A 33-year-old alcoholic female presents to the ED after a high-speed MVC. She is drunk, combative, and promptly intubated. On computed tomography (CT), she is found to have a Chance fracture at L1, has free fluid in the abdomen, but does not have any evidence of solid organ injury. Her vitals are normal and stable. The next step in management is:
- A. Admission to the ICU for close monitoring
  - B. Magnetic resonance imaging (MRI) of the spine
  - C. Exploratory laparotomy
  - D. FAST scan
  - E. Repeat CT scan of the abdomen in 6 hours
13. A 42-year-old female presents to the ED complaining of abdominal pain after a MVC. CT scan shows contrast extravasation in the spleen with a significant hemoperitoneum. Heart rate is presently 120 beats per minute and blood pressure (BP) is 90/70 mm Hg. Hemoglobin is 7.1 g/dL. She is a Jehovah's Witness and refuses blood transfusions. Which of the following is the most appropriate next step in management?
- A. Document refusal of blood products and administer normal saline to keep BP above 100 mm Hg
  - B. Document refusal of blood products and perform a splenectomy
  - C. Document refusal of blood products and perform angiography with embolization
  - D. Document refusal of blood products and consult the hospital ethics committee
  - E. Administer 2 units of packed red blood cells given life-threatening situation and perform splenectomy
14. A 29-year-old male arrives at the ED after a high-speed MVC with a Glasgow Coma Scale (GCS) of 4. He has a cervical collar that was placed by emergency medical services (EMS). He is intubated and taken for a CT scan, which demonstrates a large subdural hemorrhage and diffuse punctate hemorrhage with no evidence of cervical spine injury. He is admitted to the ICU. With regard to the management of the cervical collar, which of the following is recommended?
- A. Remove immediately.
  - B. MRI cervical spine (c-spine) and remove the cervical collar if there are no injuries identified.
  - C. Continue cervical collar until the patient can be clinically evaluated.
  - D. Exchange the cervical collar placed by EMS with a soft-collar.
  - E. Exchange the cervical collar placed by EMS with a soft-collar and order MRI c-spine.
15. Which of the following is true regarding pneumothorax in the trauma patient?
- A. A small asymptomatic pneumothorax identified on CT scan will resolve within 24 hours using 100% inspired supplemental oxygen.
  - B. A small asymptomatic pneumothorax should be managed with a tube thoracostomy if the patient is to undergo general anesthesia.
  - C. A small asymptomatic pneumothorax in a ventilated patient in the ICU, discovered on re-review of admission CT, should be managed with a tube thoracostomy.
  - D. A persistent air leak identified on postinjury day 3 is best managed with VATS.
  - E. Penetrating injuries leading to pneumothorax have concomitant hemothorax less than half of the time.
16. Which of the following is the most common electrolyte abnormality seen in the burn patient?
- A. Hypernatremia
  - B. Hyponatremia
  - C. Hypercalcemia
  - D. Hypoglycemia
  - E. Hypermagnesemia

17. A 31-year-old obese female presents to the ED after a large refrigerator fell on her. She is complaining of severe pain at her hips. Her hemoglobin is 7.9 g/dL. Her heart rate is 128 beats per minute, and her systolic blood pressure is 105 mm Hg. She has no evidence of extremity injuries, and distal pulses are normal. She has an unstable pelvis, so a pelvic binder is applied. Massive transfusion protocol is initiated. She is rushed to the angiography suite and undergoes embolization, then stabilizes. The following day, her CK levels rise to 40,000 and her urine turns red tinged. The most likely source is the muscles of her:
- A. Thighs
  - B. Buttocks
  - C. Abdominal wall
  - D. Arms
  - E. Calves
18. A 46-year-old woman presents to the ED hemodynamically stable after a high-speed MVC. A CT scan of the abdomen and pelvis reveals a right perinephric hematoma with a deep laceration in the inferior aspect of the renal parenchyma with some localized urine extravasation within the collecting system. Management consists of:
- A. Observation
  - B. Right nephrectomy
  - C. Attempt at partial nephrectomy
  - D. Attempt at renal salvage with suture repair of the parenchyma
  - E. Nephrostomy tube
19. A 28-year-old male presents to the ED 2 days after being involved in a bar fight where he punched another patron in the mouth. His right hand appears to have a soft-tissue infection. Which of the following is the most likely pathogen?
- A. *Treponema pallidum*
  - B. *Prevotella* spp.
  - C. Hepatitis C
  - D. *Propionibacterium* spp.
  - E. *Bacteroides*
20. A 45-year-old male arrives at the ED with a GSW to the head. He has declined organ donation on his driver's license registration which is several years old. He is declared to be brain dead the following morning. His parents and sister fly in from out of state. His sister has end-stage renal disease and would like to receive her brother's kidney because she states he was tested "and found to be a match." His parents are saddened by their son's passing but agree that their daughter should receive the kidney and that their son would have wanted this. The treating physician should:
- A. Arrange for organ harvesting and coordinate with a transplant surgeon to perform the kidney transplant
  - B. Contact an organ donation service to facilitate a discussion with the family
  - C. Remove the patient from ventilator support
  - D. Administer a lethal dose of morphine sulfate
  - E. Consult the hospital ethics committee
21. A 30-year-old male presents to the ED after a high-speed MVC complaining of chest pain. He is found to have a right-sided hemothorax and a tube thoracostomy (chest tube) is performed. After initial insertion, 400 cc of blood is drained. The following day he continues to have evidence of retained hemothorax on chest x-ray. The next step is:
- A. Continue with current chest tube
  - B. Remove the current chest tube and insert a new chest tube one intercostal space above
  - C. Place a second chest tube
  - D. VATS
  - E. Start IV antibiotics

22. A 45-year-old male presents to the ED following a high-speed MVC with evidence of severe facial fractures and bilateral lower extremity deformities. Paramedics report a significant amount of blood in his airway, and the patient's respirations are being assisted with bag-valve mask ventilation. On exam, the patient is hemodynamically stable with an O<sub>2</sub> saturation of 85% on a non-rebreather mask and GCS is 7. Attempts at rapid sequence intubation are unsuccessful because of the inability to visualize the airway as a result of ongoing bleeding. Attempts at bagging become more difficult. Which of the following is the next best step in management?
- A. Needle cricothyroidotomy
  - B. Nasotracheal intubation
  - C. Surgical cricothyroidotomy
  - D. Fiberoptic bronchoscopic-assisted intubation
  - E. Apneic oxygenation
23. A 36-year-old male is brought to the ED after a high-speed head-on MVC with significant front-end damage to the vehicle. Extrication of the patient took nearly 4 hours. On arrival, the patient is complaining of left-sided chest and abdominal pain. His systolic blood pressure is 80 mm Hg and heart rate is 120 beats per minute. Breath sounds are present and equal bilaterally. Abdominal exam reveals significant tenderness to palpation. Plain films of the chest and pelvis show a widened mediastinum (10 cm). Pelvic x-ray is normal. FAST is positive for free fluid in the abdomen. Following a 2-L crystalloid bolus, the patient's blood pressure is unchanged. Which of the following is the most appropriate next step in management?
- A. Administer a bolus of tranexamic acid (TXA) and continue infusion on the way to the OR for an exploratory laparotomy
  - B. Take patient to the OR for an exploratory laparotomy and provide a bolus of TXA intraoperatively
  - C. Take patient to the OR for an exploratory laparotomy without administration of TXA
  - D. Transthoracic echocardiography
  - E. Endovascular repair of thoracic injury followed by exploratory laparotomy
24. A 22-year-old man sustains a GSW to the right leg below the knee. Vital signs are within normal limits. Physical exam reveals a single GSW to the lateral leg with minimal swelling and no obvious deformity. Pulse exam reveals diminished pedal pulses on the right in comparison to the left. Which of the following is the most appropriate next step in management?
- A. CT angiogram
  - B. OR and angiogram
  - C. Administration of IV papaverine
  - D. Formal angiogram
  - E. Arterial-pressure index (API)
25. A 60-year-old male presents to the ED following a MVC in which he was a restrained passenger. CT of the abdomen reveals an isolated grade III splenic injury with active extravasation and a low volume hemoperitoneum. The initial systolic blood pressure was 90 mm Hg, but it has now improved to 110 mm Hg after 2 L of normal saline. Hemoglobin is stable at 12 g/dL. Which of the following is the best next step in management?
- A. Laparotomy with splenectomy
  - B. Laparotomy with attempt at splenorrhaphy
  - C. Angiography with embolization
  - D. Serial abdominal examinations and hematocrits in the ICU
  - E. Laparoscopic splenectomy
26. An 18-year-old male is brought to the ED following a motorcycle crash. He is hemodynamically stable and complains of severe pelvic pain. Examination reveals blood at the urethral meatus, scrotal ecchymosis, and a scrotal hematoma. A pelvic x-ray confirms the presence of a pelvic fracture. Which of the following is the most appropriate next step in diagnosis?
- A. Insertion of a Foley catheter
  - B. CT abdomen with IV contrast

- C. Retrograde urethrogram (RUG)
  - D. Cystogram
  - E. Intravenous pyelogram
27. A 90-year-old female presents to the ED following a ground level fall. Her GCS is 13 (E4 V4 M5). The patient has a known history of atrial fibrillation and is currently prescribed warfarin. Laboratory results demonstrate an INR of 4.0. A CT scan of the head reveals a right subdural hematoma with frontal intraparenchymal contusions. Which of the following is the most appropriate next step in management?
- A. Insertion of an intracranial pressure monitor
  - B. Administration of fresh frozen plasma
  - C. Administration of prothrombin complex concentrate (PCC)
  - D. Repeat head CT in 4 to 6 hours
  - E. Administration of activated recombinant factor VII
28. A 70-kg adult male is struck by a motor vehicle and sustains bilateral femur fractures with an estimated blood loss of 2 L. Which of the following statements is true of this patient?
- A. The patient is in Class II hemorrhagic shock.
  - B. Tachycardia and tachypnea would be uncommon in this patient.
  - C. Urine output should not be affected.
  - D. Pulse pressure will remain unchanged.
  - E. His estimated blood loss is 30% to 40% of his blood volume.
29. A 28-year-old man sustains a GSW to the right supraclavicular area with no exit wound. On arrival, his systolic blood pressure is 60 mm Hg and he is confused and combative. Which of the following is the most appropriate next step in the management?
- A. Endotracheal intubation
  - B. Right tube thoracostomy
  - C. Normal saline bolus
  - D. Resuscitative (ED) thoracotomy
  - E. Median sternotomy
30. A 30-year-old man sustains a GSW to the left mid neck. On arrival at the ED, his systolic blood pressure is 70 mm Hg, heart rate is 120/min, and his GCS is 5. An airway is immediately established and IV fluids are given but his blood pressure remains low. There is no hematoma in the neck, no active bleeding, and no bruit. The next most appropriate step in management is:
- A. Head CT scan
  - B. CT angiography of the neck
  - C. Standard four-vessel arteriography
  - D. Surgical neck exploration
  - E. Triple endoscopy
31. Which of the following is the best indication for resuscitative (ED) thoracotomy?
- A. Severe blunt abdominal and head trauma with sudden arrest in the ED
  - B. Abdominal stab wound with no signs of life (SOL) in the field, cardiopulmonary resuscitation (CPR) en route
  - C. Blunt trauma with loss of pulse in the field, CPR en route
  - D. Stab wound to chest with agonal breathing on transport, no pulse in ED
  - E. GSW to abdomen with asystole as presenting rhythm and no pericardial tamponade on FAST
32. An 11-month-old boy presents to the ED with hypotension after being involved in a MVC. He has obvious deformities of both legs below his knees. Numerous attempts are made to establish venous access at the antecubital fossa without success. The best option for establishing access for fluid administration would be:
- A. Internal jugular central line



- B. Distal saphenous vein cutdown
  - C. Femoral vein central line
  - D. Intraosseous (IO) cannulation of the proximal tibia
  - E. IO cannulation of the distal femur
33. Which of the following is true regarding the pregnant trauma patient?
- A. Blood volume increases proportionally less than red blood cell volume.
  - B. A pregnant patient tends to have a mild respiratory acidosis.
  - C. Use of radiographs is unsafe for the fetus in the third trimester.
  - D. The 2,3-diphosphoglycerate level is increased.
  - E. The glomerular filtration rate decreases.
34. A 30-year-old man sustains a GSW to the right chest. His blood pressure in the emergency department is 70/40 mm Hg. A chest tube is placed in the right chest with 500 mL of initial output. A follow-up chest radiograph reveals a complete whiteout of the right lung. The patient is taken to the operating room and a right thoracotomy is performed. On evaluation of the right lung, there is a through-and-through injury to the right lower lobe that appears to have an active air leak and ongoing bleeding. Surgical management should consist of:
- A. Formal right lower lobectomy
  - B. Pneumonectomy
  - C. Closure of both the anterior and posterior parenchymal defects with interrupted sutures
  - D. Pulmonary tractotomy
  - E. Ligation of the right lower lobe pulmonary artery
35. Which of the following is true regarding flail chest?
- A. The initial chest radiograph provides a useful predictor of subsequent pulmonary insufficiency.
  - B. Respiratory failure is primarily caused by the paradoxical motion of the chest wall.
  - C. Operative chest wall stabilization in patients without pulmonary contusion may shorten the length of intubation.
  - D. Aggressive fluid resuscitation is an important management adjunct.
  - E. Once the diagnosis is established, the patient should be intubated.
36. Which of the following is true regarding blunt cardiac injury (BCI)?
- A. Creatine kinase-myocardial band (CK-MB) enzyme determination lacks sensitivity.
  - B. It commonly results in serious ventricular arrhythmias.
  - C. It usually results in traumatic thrombosis of a coronary artery branch.
  - D. Presence of a sternal fracture predicts the presence of BCI.
  - E. It should be suspected in patients with transient sinus tachycardia.
37. A 55-year-old man presents to the ED with a stab wound to the left chest just below the nipple. His blood pressure is 100/60 mm Hg, heart rate is 120 beats per minute, and his respiratory rate is 14 breaths per minute. GCS is 14. On exam, he has distended neck veins, heart sounds are muffled, and breath sounds are clear bilaterally. The next best step in the management is:
- A. Endotracheal intubation
  - B. Left tube thoracostomy
  - C. Pericardiocentesis
  - D. FAST scan
  - E. Median sternotomy
38. Exposure is most difficult for which of the following vessels?
- A. Innominate artery
  - B. Proximal right subclavian artery
  - C. Proximal left subclavian artery
  - D. Proximal left common carotid artery

- E. Proximal vertebral artery
39. Which of the following surgical maneuvers is most correct to access the listed vessel?
- A. Left-sided medial visceral rotation or Mattox maneuver for the mid inferior vena cava (IVC)
  - B. Transection of the neck of the pancreas for the superior mesenteric artery
  - C. Right-sided medial visceral rotation or Cattell maneuver for the suprarenal aorta
  - D. Kocher maneuver for the celiac axis
  - E. Division of the right common iliac artery for the distal vena cava and common iliac vein bifurcation
40. In the setting of trauma, ligation is best tolerated for which of the following vessels?
- A. Right renal vein
  - B. Left renal vein
  - C. Brachial artery
  - D. Popliteal artery
  - E. Suprarenal IVC
41. In a patient with a mangled extremity, primary amputation for trauma should be strongly considered in a pulseless lower extremity when open tibia and fibula fractures are combined with:
- A. Popliteal vein transection
  - B. A 2-hour ischemia time
  - C. Deep peroneal nerve transection
  - D. Persistent blood pressure less than 90 mm Hg
  - E. Inability to dorsiflex the foot
42. Which of the following is true regarding compartment syndrome?
- A. The soleus muscle must be detached from the tibia to decompress the deep posterior compartment of the lower leg.
  - B. A compartment pressure greater than 45 mm Hg is necessary to establish the diagnosis.
  - C. The lateral compartment is the most commonly affected lower leg compartment.
  - D. An early sign of anterior compartment involvement of the lower leg is numbness on the plantar aspect of the foot.
  - E. It does not occur in the buttocks.
43. A 17-year-old boy is brought to the ED after being involved in a high-speed motorcycle collision. He is hypotensive with a systolic pressure of 60 mm Hg. A FAST scan is positive. At laparotomy, he is found to have a large amount of bleeding from behind the liver. Temporary application of a Pringle maneuver does not control the bleeding. However, laparotomy packs are placed, and the bleeding appears to slow down. The systolic blood pressure increases to 110 mm Hg after aggressive resuscitation. The patient's pH is 7.06 and his temperature is 34°C. The next best step in management is:
- A. Obtain control of the IVC above and below the liver
  - B. Perform a median sternotomy for atriocaval shunt placement
  - C. Damage control closure and transport to ICU
  - D. Damage control closure and transport to interventional radiology (IR) suite for hepatic embolization
  - E. Obtain control of aorta at the diaphragmatic hiatus
44. A 55-year-old man is brought in to the ED after a high-speed MVC. The patient is hemodynamically stable. Gross hematuria is present. CT cystography reveals air in the bladder and an accumulation of contrast in the right paracolic gutter. Which of the following is the best management option?
- A. Foley catheter drainage
  - B. Suprapubic cystostomy tube placement
  - C. Open repair of the intraperitoneal bladder injury with chromic catgut sutures
  - D. Obtaining a formal cystogram
  - E. Open repair of the intraperitoneal bladder injury with silk sutures

45. A 30-year-old man sustains a GSW to the abdomen and presents to the ED with a systolic blood pressure of 60 mm Hg. Emergent laparotomy reveals a 2-L hemoperitoneum with an injury to the IVC and right iliac vein. Both injuries are successfully repaired. Further exploration demonstrates a distal right ureteral injury below the level of the iliac vessels with a 3-cm defect. After 10 units of blood products, the patient's blood pressure is 80/60 mm Hg, his heart rate is 110 beats per minute, and his temperature is 96°F. Which of the following is the best management option?
- A. Proximal and distal ligation of the ureter
  - B. Ureteroureterostomy
  - C. Transureteroureterostomy
  - D. Psoas hitch
  - E. Ureteroneocystostomy
46. After a MVC, a 17-year-old girl with blunt abdominal trauma is found to have free fluid on abdominal CT without evidence of liver or spleen injury. She is hemodynamically stable. Her abdomen is diffusely tender. She is taken to the operating room. At surgery, she is found to have a 75% luminal circumference injury to the first portion of the duodenum. Surgical management consists of:
- A. Pyloric exclusion
  - B. Duodenal diverticulization
  - C. Primary duodenal repair
  - D. Whipple resection
  - E. Resection with duodenoduodenostomy
47. A 10-year-old boy presents to the ED with repeated episodes of vomiting 2 days after a MVC. Abdominal CT scan with oral and IV contrast is negative for free fluid. However, the wall of the second portion of the duodenum appears to be thickened with a slight amount of adjacent retroperitoneal stranding. There is no extraluminal air and no contrast extravasation. Which of the following is true about this condition?
- A. The patient should undergo exploratory laparotomy.
  - B. This type of injury is more common in adults than children.
  - C. The surgical procedure of choice is an intestinal bypass.
  - D. It can develop in the absence of trauma in patients with hemophilia.
  - E. Total parenteral nutrition is rarely needed.
48. A 36-year-old woman sustains a GSW to the right upper quadrant and has marked abdominal tenderness. At surgery, she is found to have a blast injury with nearly complete transection of the second portion of the duodenum and a deep laceration to the head of the pancreas. On exploration of the pancreatic wound, the main pancreatic duct and the intrapancreatic portion of the common bile duct are both transected. Management consists of:
- A. Primary repair of duodenum and Roux-en-Y pancreaticojejunostomy and choledochojejunostomy
  - B. Pancreaticoduodenectomy (Whipple procedure)
  - C. Roux-en-Y duodenojejunostomy and primary repair of the pancreatic and common bile ducts
  - D. Primary repair of the duodenum and drainage
  - E. Pyloric exclusion
49. A 29-year-old man presents with a GSW to the right upper quadrant. On physical examination, the patient has a tender abdomen. At surgery, the patient is found to have a 500-mL hemoperitoneum with a through-and-through injury to the right lobe of the liver that is no longer actively bleeding. Further management would consist of:
- A. Closing the injury with a liver suture
  - B. Packing the injury with omentum
  - C. Application of a fibrin sealant
  - D. No further management
  - E. Drainage with a Penrose drain

50. A 20-year-old morbidly obese man sustains a GSW to the abdomen. His blood pressure is 110/70 mm Hg and his heart rate is 100 beats per minute. At surgery, he is found to have a blast injury to the sigmoid colon involving 75% of the circumference of the bowel, with a moderate amount of fecal contamination. Which of the following is the best option?
- A. Sigmoid colectomy with primary anastomosis with a diverting ileostomy
  - B. Primary repair of the sigmoid colon
  - C. Sigmoid colectomy with primary anastomosis
  - D. Primary repair of the sigmoid colon with exteriorization of the repair
  - E. Sigmoid colectomy with a proximal colostomy and oversewing of the rectal stump
51. A 25-year-old man presents with a GSW to the buttocks. Abdominal examination is unremarkable, and the patient is hemodynamically stable. Proctoscopy reveals blood and stool in the distal rectal vault, but an injury cannot be identified. Computed tomography (CT) scan of the abdomen and pelvis with rectal contrast is unremarkable. Which of the following is the best management option?
- A. IV antibiotics with close observation
  - B. A proximal diverting colostomy
  - C. Exploratory laparotomy with primary closure of rectal injury, diverting colostomy, distal rectal irrigation, and presacral drainage
  - D. Presacral drainage and IV antibiotics
  - E. Abdominal perineal resection

## Answers

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1. **B.** Estimated TSBA burned is useful to determine appropriate fluid resuscitation volumes. Each upper extremity accounts for 9% of the TBSA (anterior surface would be half that or 4.5%), each lower extremity accounts for 18%, the anterior and posterior trunk each accounts for 18%, the head and neck account for 9%, hands are 1% each, and the perineum accounts for 1%. First-degree burns are not included. For this patient, the anterior surface of both arms accounts for 9%, the entire leg is 18%, and the hands are not counted (first-degree burns), totaling 27% (A, C–E). The most widely used approach to fluid resuscitation in a burn patient is the Parkland formula: 4 mL/kg for each percentage of TBSA burned over the first 24 hours, with one-half of that amount administered in the first 8 hours and the remaining half over the next 16 hours. For children, some use a modified Parkland formula with 6 mL/kg. Keep in mind that Ringer's lactate is the fluid of choice. Normal saline in such large volumes will lead to hyperchloremic metabolic acidosis.
2. **A.** In the emergent setting, the fastest way to gain vascular access is by a peripheral catheter, often at the median antecubital fossa, because this will typically accommodate a large bore IV and is easy to cannulate. Short wide catheters are used to maximize volume flow for rapid resuscitation. The rate of fluid flow is proportional to the cross-sectional area of the catheter and inversely proportional to the fourth power of its radius. As such, an 18-gauge catheter is preferred over a 20-gauge catheter since the 18-gauge catheter has a larger diameter (B). Central vein catheterization is not the preferred mode of vascular access in the immediate trauma setting because it is time consuming and has a high rate of complications. These complications are exacerbated by the urgency of the line placement, central veins often being collapsed due to hypovolemia, and suboptimal use of sterile technique. Central line-associated bloodstream infections alone have a mortality rate as high as 20%. A short but large central vein cordis will allow for a faster route for infusion but is not appropriate in the initial trauma setting for the aforementioned reasons (C–E).  
**Reference:** Mermel, L. A., Allon, M., & Bouza, E., et al. (2009). Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. *Clinical Infectious Diseases*, 49(1), 1–45.
3. **A.** Trauma is the leading cause of death for individuals over the age of 45 years in the United States. Although all the listed choices are causes of death in the trauma patient, traumatic brain injury (TBI) is the single largest contributor accounting for nearly half of all trauma deaths and is the most common cause of death in trauma patients reaching the hospital alive (B–E). Hemorrhagic shock is the most common cause of death in trauma patients within the first hour. An important component to the management of TBI is the prevention of secondary injury to the brain by

avoiding hypotension and hypoxia.

**References:** Baker, C. C., Oppenheimer, L., & Stephens, B., et al. (1980). Epidemiology of trauma deaths. *American Journal of Surgery*, 140(1):144–150.

Traumatic Brain Injury in the United States: a Report to Congress, CDC, Dec 1999.

4. **E.** The anterior abdomen is bounded by the nipples, groin crease, and anterior axillary lines. Stab wounds to this area are divided into thirds; one-third do not penetrate the peritoneal cavity, one-third penetrate the peritoneal cavity but don't cause significant intra-abdominal injury, and one-third penetrate the peritoneal cavity causing significant intra-abdominal injury. Immediate exploratory laparotomy is mandated in the hemodynamically unstable patient or in the presence of diffuse peritonitis. In a hemodynamically stable patient without peritonitis, the surgeon has several options to choose from. These include admission for serial abdominal exams, CT scan, FAST scan (which has a lower sensitivity than CT but is quick and inexpensive), and LWE (C, D). The main advantage of LWE is that if the study is negative (anterior fascia has not been penetrated), the patient can be discharged from the ED. If LWE is positive, it does not mean the peritoneum has been violated. Taking all positive LWE patients to the operating room (OR) will result in a high negative laparotomy rate. As such several options exist: proceed to CT scan, admission for serial abdominal exams, diagnostic peritoneal lavage or diagnostic laparoscopy. The decision of which to perform depends on the institution (A, B).

**References:** Shanmuganathan, K., Mirvis, S., Chiu, W., et al. (2004). Penetrating torso trauma: triple-contrast helical CT in peritoneal violation and organ injury—a prospective study in 200 patients. *Radiology*, 231(3), 775–784, 2004.

Cothren, C. C., Moore, E. E., & Warren, F. A., et al. (2009). Local wound exploration remains a valuable triage tool for the evaluation of anterior abdominal stab wounds. *American Journal of Surgery*, 198(2), 223–226.

5. **D.** This patient has received a large volume of fluid resuscitation that led to abdominal compartment syndrome, which presents with the triad of oliguria, rise in peak airway pressures, and increased intra-abdominal pressure. Bladder pressure (as measured via an indwelling Foley) is used as a surrogate to determine abdominal pressure. Intra-abdominal hypertension has somewhat arbitrarily been defined as a sustained intra-abdominal pressure greater than or equal to 12 mm Hg. End-organ damage typically occurs with pressures greater than 20 mm Hg. As the pressure in the abdomen increases, the diaphragm's ability to contract is compromised, and this subsequently lessens pulmonary compliance and FRC (A, B). This translates to an increased intrathoracic pressure resulting in decreased venous return, increased pulmonary vascular resistance, and increased pulmonary capillary wedge pressure (C, E). Treatment is to perform a decompressive laparotomy, leaving the abdomen open (though covered with a protective bag).

**Reference:** Papavramidis, T. S., Marinis, A. D., & Pliakos, I., et al. (2011). Abdominal compartment syndrome—intra-abdominal hypertension: defining, diagnosing, and managing. *Journal of Emergency Traumatology Shock*, 4(2), 279.

6. **C.** Most traumatic diaphragmatic hernias (TDHs) present acutely. Delayed presentation of a TDH (as in this case) is rare, is easily misdiagnosed, and can therefore lead to significant morbidity and mortality (due to incarcerated/strangulated bowel). Most commonly TDH is confused with pneumonia, pleural effusion, or empyema. As such, the initial instinct would be to insert a chest tube into what might be misdiagnosed as a loculated, gas-forming empyema (A, B). The keys to the diagnosis include a history of blunt or penetrating thoracoabdominal trauma and a combination of gastrointestinal (GI) (nausea and vomiting) and respiratory (dyspnea, chest pain) symptoms. Additional clues to the diagnosis include bowel sounds auscultated in the chest, an elevated hemidiaphragm on CXR, and (importantly) a CXR with a nasogastric (NG) tube that is in the chest. Although CXR is the best initial tool to diagnose TDH, it can miss more than 50% of cases. CT scan has a higher sensitivity and specificity in demonstrating the herniation. Prior studies showed that most TDH were due to blunt trauma, but more recent series point to penetrating trauma as the leading cause. GSW leads to a higher incidence of diaphragmatic injury and herniation compared to stab wounds. If TDH is diagnosed immediately after injury, the gold standard is to perform an exploratory laparotomy. In a patient with a delayed diagnosis, VATS (with possible thoracotomy) is preferred because it allows for evaluation of herniated viscera, pleural adhesions, reduction of herniated contents, and repair of the hernia defect (primary repair for small defects and use of synthetic mesh for larger defects). However, sometimes adhesions are too dense both above and

below the diaphragm. In such cases the addition of laparoscopy and/or laparotomy may be necessary if reduction of herniated contents can't be achieved via the thoracic approach alone (D, E).

**References:** Chandra, A. et al. (2007). Surgical management of diaphragmatic injuries. *Indian Journal of Thoracic and Cardiovascular Surgery*, 23(3), 202–207.

Scharff, J. R., & Naunheim, K. S. (2007). Traumatic diaphragmatic injuries. *Thoracic Surgery Clinics*, 17(1), 81–85.

Fair, K. A., Gordon, N. T., & Barbosa, R. R., et al. (2015). Traumatic diaphragmatic injury in the American College of Surgeons National Trauma Data Bank: a new examination of a rare diagnosis. *American Journal of Surgery*, 209(5), 864–869.

7. **C.** Burn injuries are classified into 5 categories with second-degree burns having two sub-classifications. First-degree, or superficial, burns only involve the epidermis with red skin, no blisters, and pain. Sunburns are considered first-degree burns. Second-degree burns are divided into two categories: (1) Superficial partial-thickness burns are characterized by blistering, pain, blanching, and intact hair follicles, are limited to the dermal layer, and do not typically require any skin grafting. (2) Deep partial-thickness burns are characterized by blistering, are less sensitive (sometimes painless) and nonblanchable, and involve loss of hair follicles (A, E). Since the hair follicles offer the regenerative capacity for the skin, deep partial-thickness burns will not heal spontaneously and will often require intervention such as skin grafting (D). Third-degree burns are considered full thickness because they involve all the layers of the skin and are characterized by a white leathery appearance. Fourth-degree burns are also considered full thickness but also involve either underlying muscle, fascia, or bone and typically lead to disfigurement (B).

**Reference:** Tiwari, V. K. (2012). Burn wound: how it differs from other wounds? *Indian Journal of Plastic Surgery*, 45(2), 364–373.

8. **D.** Prophylactic use of IV antibiotics should be discouraged in the burn patient because this will breed multidrug-resistant organisms. However, several topical ointments are available that are used widely in burn care to prevent bacterial colonization. Silver sulfadiazine is considered a broad-spectrum agent, but it has poor coverage for *Pseudomonas*, has poor eschar penetration, and can lead to neutropenia and thrombocytopenia (B). It should be avoided in patients with a sulfa allergy. An advantage is its painless application. Silver nitrate, also considered a broad-spectrum agent, does not work against *Pseudomonas*, and its application is painful. It has poor eschar penetration, causes tissue discoloration, and can lead to severe electrolyte derangements (depletes  $\text{Na}^+$ ,  $\text{K}^+$ , and  $\text{Cl}^-$ ) (E). It can be used in patients with a sulfa allergy. Bacitracin and neomycin have a painless application, limited eschar penetration, and poor gram-negative coverage (C). Mafenide acetate (Sulfamylon) is considered a broad-spectrum agent including activity against *Pseudomonas* and *Enterococcus* spp. and has good eschar penetration. Since it is a carbonic anhydrase inhibitor it can lead to a hyperchloremic metabolic acidosis, and thus its use should be limited to small areas of full-thickness burns (A).

**Reference:** Dai, T., Huang, Y., & Sharma, S., et al. (2010). Topical antimicrobials for burn wound infections. *Recent Patents on Anti-Infect Drug Discovery*, 5(2), 124.

9. **C.** The American College of Surgeons and American Burn Association have set guidelines as to which patients should be transferred to a burn center. These patients have been demonstrated to have improved outcomes and survival when treated in a nationally recognized burn center that can approach the burn patient with a multidisciplinary approach. Indications for transfer are as follows: (1) second- or third-degree burns greater than 20% TBSA in patients age 10 to 50 years old; (2) second- or third-degree burns greater than 10% TBSA in patients younger than 10 years or older than 50 years; (3) third-degree burns greater than 5% TBSA in any age; (4) any second- or third-degree burn to hands, feet, face, eyes, genitalia, perineum, or skin over major joints; (5) any electrical or chemical burn; and (6) any concomitant inhalation injury or multiple trauma. From the available answer choices, the only patient that has an indication for transfer to a burn center is the 21-year-old male with both a hand burn and a chemical burn (A, B, D, E). First-degree burns do not need referral.

**References:** [No authors listed]. 1990. Hospital and prehospital resources for optimal care of patients with burn injury: guidelines for development and operation of burn centers. *Journal of Burn Care & Rehabilitation*, 11(2), 98–104.

Resources for Optimal Care of the Injured Patient: 1993. 1993 by the American College of Surgeons, p. 64.

10. **A.** Electrical shock requires the expertise of a burn center, and all patients should be transferred as soon as they are stable. The two types of electrical currents are alternating and direct. An alternating current will lead to repetitive, tetanic muscle contractions (C). An example of this is a city worker who gets electrocuted on a power line that emits an alternating current. Since flexor muscle tone is generally stronger than extensor muscle tone, patients will often grip the source of electricity leading to a prolonged exposure. In contrast, direct current electrocution will often result in a single, large muscle contraction that will throw the patient several feet away from the source. A car battery has a direct current, so this patient likely suffered a direct current electrocution. Adipose tissue has a high resistance to electricity, which will result in an increased tissue temperature and subsequent coagulation; thus obese patients will have a higher amount of deep thermal burns (D). The main cause of death in the early post electrocution period is cardiac arrhythmias (B). Other immediate complications of electrocution injury include posterior shoulder dislocation and spinal cord injury. Long term, patients are at increased risk of cataracts, polyneuritis, and ototoxicity. The skin burn mark with an electrical injury can vastly underestimate the severity of the burn. Often there is severe injury to the underlying muscle and connective tissue despite a relatively minor outer skin burn. As such, these patients are susceptible to rhabdomyolysis, which would be suggested by the presence of red urine. Thus creatine kinase (CK) levels should routinely be sent (E). These patients should be admitted, placed on cardiac monitoring, and resuscitated with IV fluids to maintain high urine output.

**Reference:** Wesner, M. L., & Hickie, J. (2013). Long-term sequelae of electrical injury. *Canadian Family Physician Medecin de Famille Canadien*, 59(9), 935–939.

11. **D.** Frostbite can occur when tissue is exposed to temperatures below  $-2^{\circ}\text{C}$  or  $28^{\circ}\text{F}$ . The severity of the injury increases proportionally to the duration of exposure. Frostbites are classified as follows: (1) First degree are hyperemic without necrosis and characterized by a yellow plaque; (2) second degree have superficial vesicles with hyperemia and partial-thickness necrosis; (3) third degree have hemorrhagic bullae and full-thickness necrosis; and (4) fourth degree are characterized by frank gangrene with involvement of underlying muscle and bone (A). Treatment begins with rewarming the extremity in a warm water bath between  $40$  to  $42^{\circ}\text{C}$ . It should be done rapidly (E). Because tissue viability will often take weeks to determine, early debridement and/or amputation should be avoided (B). Tissue freezing and reperfusion both contribute to the tissue damage seen in frostbite burns. Crystallization of the extracellular space leads to an increased extracellular oncotic pressure resulting in cellular dehydration and impaired intracellular metabolism. An inflammatory response ensues ultimately leading to thrombosis, tissue ischemia, and endothelial injury. Reperfusion injury occurs when blood flow is restored, and it is for this reason that tPA has had an emerging role in the management of frostbite burns. Thrombolytic therapy will limit microvascular thrombosis and prevent reperfusion injury. Predictors of poor response to tPA include warm ischemia time longer than 6 hours, more than 24 hours of cold exposure, and multiple freeze-thaw cycles. Because this patient has had a warm ischemia time of 7 hours, she is ineligible for tPA treatment (C). Patients that are deemed appropriate candidates for tPA therapy should continue until there is evidence of tissue reperfusion, 48 hours have passed, or the treating team feels there is no further therapeutic gain from continued infusion.

**Reference:** Gross, E. A., & Moore, J. C. (2012). Using thrombolytics in frostbite injury. *Journal of Emergency Traumatology Shock*, 5(3), 267–271.

12. **C.** Chance fractures are also called seat-belt fractures. In children, they occur when the child is only wearing a lap belt. They are flexion-distraction type injuries of the spine. There is a significant association with intra-abdominal injuries (most commonly hollow viscus and pancreas). Recent reports using large-scale trauma registry data suggest that the rate of intra-abdominal injury is close to 33% (previously reported much higher). The presence of a Chance fracture is in and of itself not an indication for a laparotomy. However, the patient presented has an unreliable abdominal examination. In addition, the presence of free fluid on CT, in the absence of a solid organ injury, should raise the suspicion of a hollow viscus injury. As such laparotomy is indicated. In an alert and oriented, nonventilated patient, serial abdominal examination would be the initial management (in spite of the free fluid) (A). MRI of the spine will be helpful to determine spinal cord impingement, but this will need to be performed after exploratory laparotomy (B). Until then, the patient should remain in strict spine precautions. Repeat imaging alone is not appropriate if



there is concern for a hollow-viscous injury (D, E).

**References:** Neugebauer, H., Wallenboeck, E., & Hungerford, M. (1999). Seventy cases of injuries of the small intestine caused by blunt abdominal trauma: a retrospective study from 1970 to 1994. *Journal of Traumatology* 46(1), 116–121.

Tyroch, A. H., McGuire, E. L., & McLean, S. F., et al. (2005). The association between Chance fractures and intra-abdominal injuries revisited: a multicenter review. *The American Surgeon*, 71(5), 434–438.

13. **B.** Adult Jehovah's Witnesses have the right to refuse blood products, even in lifesaving situations. Anemia does not render the patient incapable of making an informed decision and giving blood products against the patient's wishes is a violation of her autonomy, and the physician may be reprimanded by the American Medical Association (E). The patient should still continue to receive the care she would otherwise get if she did consent to blood transfusion (A). With the relative hemodynamic instability (tachycardia and hypotension), contrast extravasation in the spleen, anemia, and hemoperitoneum, there is little margin for error, so the patient should undergo a splenectomy. The physician should document the patient's refusal of blood products in the electronic medical record because this places her at higher risk for death given her present anemia. Angiography with embolization is considered an appropriate option for hemodynamically stable patients with contrast extravasation (C). In a true emergency setting, there is no time to consult the ethics committee (D).

14. **A.** In the trauma patient, c-spine clearance is accomplished using the National Emergency X-Radiography Utilization Study (NEXUS) criteria. Patients that have any one of the NEXUS criteria should continue with spinal precautions until a CT scan of the c-spine is performed. The NEXUS criteria can be remembered by the "NSAID" mnemonic: Neurologic deficit, Spinal (cervical) tenderness, Altered mental status, Intoxicated, or Distracting injury. Patients with a negative CT c-spine can then be clinically cleared and the c-collar may be removed. This is not possible in an obtunded or intubated patient. If the patient is only expected to be obtunded or intubated for a short period of time (e.g., combative drunk patient), it is reasonable to keep the c-collar on and assess the c-spine once the patient is awake. This patient has extensive traumatic brain injury and is likely going to be intubated for a prolonged period of time. Prolonged application of a hard cervical collar appears to compress the jugular veins, causing venous outflow obstruction, and thus increasing intracranial pressure (ICP). The collar also creates a nociceptive stimulus, which might also contribute to elevated ICP; therefore keeping the c-collar on for a prolonged period of time increases the risk for complications (C). Previously, this patient would have received a MRI c-spine and if no injuries were identified, the c-collar would then be removed. However, the Eastern Association for the Surgery of Trauma (EAST) has recently recommended that in an obtunded adult blunt trauma patient, the c-collar should be removed after a negative CT c-spine alone. MRI c-spine may no longer have a role in the obtunded trauma patient as it has been demonstrated that it may lead to a higher complication rate and longer ICU stay as occult injuries that are not clinically relevant may be identified and acted upon (B). There are no studies showing improved outcomes in switching to a soft-collar (D, E).

**Reference:** Patel, M. B., Humble, S. S., & Cuillinane, D. C., et al. (2015). Cervical spine collar clearance in the obtunded adult blunt trauma patient: a systematic review and practice management guideline from the Eastern Association for the Surgery of Trauma. *Journal of Traumatology Acute Care Surgery*, 78(2), 430.

15. **D.** Pneumothorax is a common complication of both penetrating and blunt trauma. It is a clinical diagnosis that can be made during the primary survey. Patients with decreased breath sounds, trachea deviation, and hypotension should be suspected of having a tension pneumothorax and should have needle decompression or tube thoracostomy performed immediately. In equivocal cases, imaging can be helpful. Occult pneumothorax is one that is not seen on the initial radiograph but may be demonstrated on CT. Pneumothorax as a result of penetrating trauma has a concomitant hemothorax up to 80% of the time (E). Small pneumothoraces identified on CT can be observed if the patient is stable. Normally, 1.25% of the pneumothorax volume is absorbed in 24 hours. Additionally, the use of 100% inspired supplemental oxygen is controversial because it can result in oxygen toxicity (A). EAST recommends that an occult pneumothorax can be safely observed in a stable patient undergoing general anesthesia. This recommendation was based on two prospective randomized studies that supported the notion that occult pneumothoraces will

likely not progress regardless of the presence of positive pressure ventilation (B). Similarly, an occult pneumothorax can be observed in a ventilated patient that remains asymptomatic (C). EAST also recommends that persistent air leaks on postinjury day 3 should be further evaluated with VATS because this can be suggestive of underlying bronchial injury or bronchopleural fistula.

**References:** Sharma, A., & Jindal, P. (2008). Principles of diagnosis and management of traumatic pneumothorax. *Journal of Emergency Traumatology Shock*, 1(1), 34–41.

Mowery, N. T., Gunter, O. L., & Collier, B. R., et al. (2011). Practice management guidelines for management of hemothorax and occult pneumothorax. *Journal of Traumatology*, 70(2), 510–518.

16. **A.** Burn patients are subject to severe electrolyte derangements with the most common being hypernatremia primarily due to insensible water loss through the burn wound. Iatrogenic hyponatremia can occur once the burn patient is fully resuscitated (B). Hypernatremia, but not hyponatremia, has been demonstrated to be an independent predictor of mortality in burn patients. Hyperglycemia may also occur as a result of increased glucose production and widespread insulin resistance (D). Calcium can be sequestered in the burned skin leading to hypocalcemia (C). Infrequently, burn patients may also have muscle cramps secondary to hypomagnesemia (E).

**Reference:** Stewart, I. J., Morrow, B. D., & Tilley, M. A., et al. (2013). Dysnatremias and survival in adult burn patients: a retrospective analysis. *American Journal of Nephrology*, 37(1), 59–64.

17. **B.** The patient described has evidence of muscle ischemia/necrosis and has developed rhabdomyolysis as evidenced by the rise in CK. Rhabdomyolysis can present with CK levels of 10,000 to 200,000 u/L; no other condition can cause such an extreme rise in CK (normal is 45–260 u/L). Rhabdomyolysis can occur in any setting that causes ischemia to the muscles (such as hypotension after trauma), or from prolonged pressure on muscle compartments during surgery. It is likely exacerbated by obesity and improper padding on the OR or procedure table. The ischemia/reperfusion cycle that ensues places the patient at risk of developing compartment syndrome. A small study of obese patients undergoing roux-en-y bypass found that body mass index (BMI) was an independent risk factor for the development of postoperative rhabdomyolysis. In a patient positioned in the supine position, the muscles that would most likely be compressed are the gluteal ones. In addition, pelvic embolization, as performed for trauma or endovascular abdominal aortic aneurysm (AAA) repair, is a known risk for developing buttock claudication. Rarely, it is associated with devastating pelvic ischemia and/or buttock ischemia/necrosis (A, C–E). So in this patient, in addition to aggressive fluid hydration, it would be imperative to roll the patient over to inspect the buttock muscles.

**References:** Yasumura, K., Ikegami, K., & Kamohara, T., et al. (2005). High incidence of ischemic necrosis of the gluteal muscle after transcatheter angiographic embolization for severe pelvic fracture. *Journal of Traumatology*, 58(5), 985–990.

Benevides, ML. et al. (2006). Rhabdomyolysis secondary to gluteal compartment syndrome after bariatric surgery: case report. *Revista Brasileira de Anestesiologia*, 56(4), 408–412.

18. **A.** Kidney injuries are graded from I to V, with grade I being a contusion or subcapsular, nonexpanding hematoma and grade V a completely shattered kidney or an avulsion of the renal hilum. Grade I and II injuries are considered minor, grade III injuries are deep lacerations that do not involve the collecting system, whereas grade IV injuries are lacerations extending into the collecting system or an injury to the main renal artery. The vast majority of blunt renal injuries (approximately 90%) can be managed nonoperatively. The injury described in this patient would be a grade IV and, in a stable patient, can be managed nonoperatively (B–D). Grade IV injury from blunt trauma can be managed nonoperatively provided the patient is hemodynamically stable. Most urinary extravasation resolves. If it persists, or if the patient demonstrates evidence of sepsis, it should be treated using a combination of endourologic and percutaneous techniques (such as a percutaneous nephrostomy) (E). The decision to explore a Zone II or perinephric retroperitoneal hematoma at the time of operation and in the absence of a preoperative imaging has classically been based on the mechanism of injury and hemodynamic status of the patient. Following blunt trauma and in the absence of hemodynamic instability or a rapidly expanding or pulsatile perinephric hematoma, these perinephric hematomas should not be explored. Following penetrating trauma and in the absence of preoperative imaging to assist in the identification of a renal injury, the presence of a perinephric retroperitoneal hematoma mandates exploration. If indicated, nephrectomy should be preceded by palpation for a contralateral kidney. Surgery is

indicated for vascular or renal pedicle injuries or in a completely shattered kidney.

**References:** Tinkoff, G., Esposito, T. J., & Reed, J., et al. (2008). American Association for the Surgery of Trauma Organ Injury Scale I: spleen, liver, and kidney, validation based on the National Trauma Data Bank. *Journal of the American College of Surgeons*, 207(5), 646–655.

Kuan, J. K., Wright, J. L., & Nathens, A. B., et al. (2006). American Association for the Surgery of Trauma Organ Injury Scale for kidney injuries predicts nephrectomy, dialysis, and death in patients with blunt injury and nephrectomy for penetrating injuries. *Journal of Traumatology*, 60(2), 351–356.

19. **B.** A patient who has punched another person in the mouth is at risk for a human bite wound. The most common organism found isolated in wounds from infected human bites is *Streptococcus* followed by *Staphylococcus*. Other common organisms include *Eikenella*, *Fusobacterium*, *Prevotella*, and *Porphyromonas*. *Treponema pallidum* is the organism that causes syphilis and has been reported to be transmitted by a human bite, but this is rare (A). *Propionibacterium* and *Bacteroides* are anaerobic organisms and unlikely to be transmitted from a human bite (D, E). Hepatitis C is the leading cause of death from liver disease in the United States and the most common etiology leading to liver transplantation. However, transmission from infected persons is rare (C). Hepatitis B is more likely to be transmitted from a human bite.

**References:** Talan, D. A., Abrahamian, F. M., & Emergency Medicine Human Bite Infection Study Group. (2003). Clinical presentation and bacteriologic analysis of infected human bites in patients presenting to emergency departments. *Clinical Infectious Diseases*, 37(11), 1481–1489.

Stevens, D. L., Bisno, A. L., & Changers, H. F., et al. (2014). Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014 update by the Infectious Diseases Society of America. *Clinical Infectious Diseases*, 59(2), 147–159.

20. **B.** Brain death is diagnosed by a standardized set of tests including electroencephalography, nucleotide brain scan, apnea test, and clinical assessment including brain stem reflexes. Brain death is both a medical and legal determination of death. It is appropriate to support a brain dead patient using a ventilator for a limited period of time. This will help the patient's family come to terms with their loss and will help coordinate possible organ donation. This should always be facilitated by an organ donation service and not by the physician. If the patient is not registered for or against organ donation, the decision regarding organ donation should be guided by the standard of substituted judgment. This involves a family member or close friend making the decision based on the known wishes or preferences of the patient at the time of death. However, this should never be refereed by the physician. If a query for organ donation is initiated from a family member, a third-party service should be made available to the family to facilitate a discussion. Any inconsistencies of the patient's wishes regarding organ donation should be properly investigated by an organ donation service (A, B). Administering a lethal dose of morphine sulfate, or euthanasia, is only practiced in several states and requires an awake patient to consent (D). Consulting the hospital ethics committee would not be appropriate in this situation (E).

**Reference:** Emanuel, E. J., & Emanuel, L. L. (1992). Proxy decision making for incompetent patients: an ethical and empirical analysis. *JAMA*, 267(15), 2067–2071.

21. **D.** Hemothorax is treated similar to a pneumothorax with tube thoracostomy, but a larger-bore chest tube should be used for the former (36 French). A chest tube that drains more than 1500 cc of blood after initial insertion or more than 250 cc of blood per hour for 3 hours should be taken to the OR for a thoracotomy. In all other cases, chest tube drainage should continue and a daily CXR should be performed. EAST discourages placement of a second chest tube in patients that are found to have a retained hemothorax because these patients are at increased risk for fibrothorax, which is unlikely to be treated with a second chest tube. These patients are better served with early VATS (A–C). A prospective randomized trial has demonstrated that patients with retained hemothorax undergoing VATS have a shorter hospital stay and lower hospital cost than compared with patients that have a second chest tube placed. There is no indication that this patient has developed an infection, and as such IV antibiotics would not be indicated (E).

**Reference:** Mowery, N. T., Gunter, O. L., & Collier, B. R., et al. (2011). Practice management guidelines for management of hemothorax and occult pneumothorax. *Journal of Traumatology*, 70(2), 510–518.

22. **C.** In the uncommon scenario in which a patient “cannot be intubated nor ventilated,” a surgical cricothyroidotomy should be immediately undertaken. This is performed using an 15 blade via a transverse or vertical incision of the skin directly over the cricothyroid membrane followed by a

transverse incision through the cricothyroid membrane. A vertical incision is preferred on the skin and subcutaneous tissue to avoid injuring the anterior jugular veins. The airway should be dilated using one's finger allowing for insertion of an appropriately sized endotracheal or tracheostomy tube (6 Fr or smaller). Needle cricothyroidotomy is traditionally reserved for children under the age of 12 years old because a surgical or open cricothyroidotomy in this population may result in subglottic stenosis (A). In the absence of a percutaneous needle cricothyroidotomy kit, a high-jet insufflator is typically required to permit temporary oxygenation of patients in whom a needle cricothyroidotomy has been performed. A nasotracheal intubation requires that a patient is spontaneously breathing and is contraindicated in a patient with severe maxillofacial fractures or in those with the potential for a cribriform plate fracture (B). Due to the significant amount of bleeding, fiberoptic bronchoscopy is unlikely to be of benefit in this situation (D). Issues related to setup, equipment, and availability also limit the use of this modality in emergent trauma situations. Apneic oxygenation is a technique of providing supplemental high flow oxygenation via nasal cannula in addition to standard preoxygenation techniques. This adjunct may decrease the incidence of desaturation in patients undergoing intubation but is not a replacement for a definitive airway (E).

**Reference:** American College of Surgeons Committee on Trauma. (2012). *Advanced trauma life support program for doctors* (9th ed.). Chicago, IL: American College of Surgeons.

23. C. This patient is hemodynamically unstable with a positive abdominal FAST following blunt trauma. Additionally, the patient is a nonresponder to fluid resuscitation. In general, patients in hemorrhagic shock are classified as responders, transient responders, and nonresponders on the basis of whether or not their vital signs improve following a fluid challenge. Transient and nonresponders should be considered to have ongoing blood loss until proven otherwise. Given these findings, the patient should be taken to the operating room for an exploratory laparotomy. Shock and peritonitis are two absolute indications for laparotomy in trauma patients. Evisceration of abdominal contents is also an indication for laparotomy. The CRASH-2 trial demonstrated that the early administration of TXA (antifibrinolytic agent) in blunt trauma reduced all-cause mortality. Antifibrinolytics have previously been demonstrated to reduce the overall need for blood transfusion by 33%. TXA is administered as a bolus with continued infusion for up to twelve hours. The benefit of TXA is best seen if given within the first hour of trauma and non-existent after three hours. In fact, TXA given after three hours may increase mortality secondary to bleeding. The finding of chest pain, a widened mediastinum, in conjunction with the high-speed deceleration injury is concerning for blunt aortic injury. Management of traumatic blunt aortic injury typically begins with blood pressure and pain control. Studies comparing immediate versus delayed endovascular stenting of blunt aortic injuries have demonstrated improved mortality in patients undergoing delayed repair (E). Additionally, if an aortic transection or severe aortic injury had occurred, the patient would have likely expired in the field. What is more likely to lead to imminent death in a patient with hemodynamic instability and positive FAST scan is bleeding in the abdomen. A transthoracic echocardiogram may provide information regarding cardiac function and volume status, but it is not indicated given the patient's ongoing hemodynamic instability (D). However, the role of transthoracic echocardiogram as serving as an extension of the FAST exam during the secondary survey is gaining popularity. Some authors have suggested that it can help reduce transfusion of blood products, duration of time from the trauma bay to the operating room, and overall mortality. Due the patient's ongoing shock and nonresponsiveness to a crystalloid challenge, administration of blood products or a repeat bolus of fluids is not warranted. Transfusion of blood products and balanced resuscitation, in conjunction with hemorrhage control, should be initiated.

**References:** American College of Surgeons Committee on Trauma. (2012). *Advanced trauma life support program for doctors* (9th ed.). Chicago, IL: American College of Surgeons.

CRASH-2 Trial Collaborators, Shakur, H., Roberts, I., & Bautista, R., et al. (2010). Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial. *Lancet*, 376(9734), 23–32.

Demetriades, D., Velmahos, G. C., & Scalea, T. M., et al. (2009). Blunt traumatic thoracic aortic injuries: early or delayed repair—results of an American Association for the Surgery of Trauma prospective study. *Journal of Traumatology*, 66(4), 967–973.

Henry, D. A., Carless, P. A., & Moxey, A. J., et al. (2007). Anti-fibrinolytic use for minimising perioperative allogeneic blood transfusion. *Cochrane Database Syst Rev*, 4 (CD001886).

24. E. Penetrating extremity trauma may be accompanied by hard or soft signs of vascular injury. Hard signs including shock, pulsatile bleeding, expanding or pulsatile hematoma, palpable thrill or bruit, or absent distal pulses warrant immediate operative exploration (B). Soft signs are findings on the physical exam that are suggestive of a potential vascular injury and require further diagnostic testing. Soft signs include diminished pulse, proximity of wounds to vessels, hematomas, and reports of significant blood loss. Given the absence of a hard sign, this patient is stable to undergo further diagnostic workup and does not require an immediate operation. Ankle-brachial index (ABI) is both sensitive and specific for extremity vascular injuries. In comparison to CT angiography or formal angiography, ABI does not require ionizing radiation or the administration of contrast (A, D). ABI less than 0.9 is suggestive of vascular injury and prompts a CT angiography. Significant vascular injury can be excluded with a negative predictive value of 99% when ABI is >0.9. An alternative to ABI is API and is used in the same way. API is the arterial pressure just distal to the injury compared to the uninjured contralateral extremity. Although arterial vasospasm may occur following proximity trauma, this diagnosis is usually one of exclusion and does not warrant immediate treatment with papaverine (C).

**References:** Johansen, K., Lynch, K., & Paun, M., et al. (1991). Non-invasive vascular tests reliably exclude occult arterial trauma in injured extremities. *Journal of Traumatology*, 31(4), 515–522.

Feliciano, D.V., Moore, F. A, & Moore, E. E., et al. (2011). Evaluation and management of peripheral vascular injury. Part 1. Western Trauma Association/critical decisions in trauma. *Journal of Traumatology*, 70(6), 1551–1556.

Feliciano, D. V., Moore, E. E., & West, M. A., et al. (2013). Western Trauma Association critical decisions in trauma: evaluation and management of peripheral vascular injury, part II. *Journal of Traumatology Acute Care Surgery*, 75(3), 391–397.

25. C. Nonoperative management (NOM) of solid organ injuries is a well-accepted treatment modality. Several criteria should be considered when selecting patients for NOM of splenic injuries. Patients should have no other indications for laparotomy on the basis of physical exam findings (peritonitis or hemorrhagic shock) or the results of other diagnostic tests (free air on CT scan of the abdomen) and should be evaluable (absence of a complete high spinal cord injury or intoxication). Also, the appropriate resources and personnel should be available to manage and treat these patients. The presence of a traumatic brain injury does not preclude NOM nor does older age. An increasing volume of hemoperitoneum is associated with higher failure rates of NOM as is an increasing American Association for the Surgery of Trauma (AAST) grade of injury. Angiography should be considered for patients with AAST injury grade of greater than III, presence of a contrast blush, moderate hemoperitoneum, or evidence of ongoing splenic bleeding (requiring >2 units of packed red blood cells [PRBC]). Patients with presence of a pseudoaneurysm or suspected arteriovenous fistula should also undergo selective angiography and embolization provided that they are hemodynamically stable. Serial abdominal exams and trending the hematocrit would be inappropriate in the presence of active extravasation of contrast (D). Laparoscopic and open splenectomy are both reasonable options in hemodynamically stable patients that meet the above indications for surgery (A, E). Attempts at splenic preservation via splenorrhaphy are also a reasonable alternative in hemodynamically stable patients (B).

**Reference:** Stassen, N. A., Bhullar, I., & Cheng, J. D., et al. (2012). Selective nonoperative management of blunt splenic injury: An Eastern Association for the Surgery of Trauma practice management guideline. *Journal of Traumatology Acute Care Surgery*, 73(5 Suppl. 4), S294–S300.

26. C. The physical exam findings are concerning for the presence of a urethral injury. The most common location is at the prostatic urethra. Genitourinary injuries may occur in up to 15% of patients with pelvic fractures. Head injury is the most common associated injury seen in patients with pelvic fractures. Clinical suspicion of a urethral injury warrants the performance of a RUG to identify the presence and location of a urethral injury. Blind insertion of a Foley catheter is contraindicated in this patient (A). CT abdomen with IV contrast is helpful for identifying injuries to the kidneys and delayed acquisition images may also aid in the identification of ureteral or bladder injuries (B). A CT cystogram accurately diagnoses both extraperitoneal and intraperitoneal bladder injuries (D). Intravenous pyelogram is used to identify renal injuries and is rarely performed (E). Management of urethral injuries depends on the location and severity of injury, as

well as presence of associated injuries, and surgical expertise.

**Reference:** Johnsen, N. V., Dmochowski, R. R., & Mock, S., et al. (2015). Primary endoscopic realignment of urethral disruption injuries—a double-edged sword? *The Journal of Urology*, 194(4), 1022–1026.

27. **C.** Given the patient's known anticoagulation status and supratherapeutic international normalized ratio (INR) in the setting of a potentially life-threatening hemorrhage, this patient requires urgent reversal of her warfarin with PCC. PCC is an inactivated concentrate of proteins C and S, and factors II, IX, and X, with variable amounts of factor VII. PCC with normal amounts of VII are known as 4-factor PCC, while those with low levels of VII are 3-factor PCC. Since 3-factor PCC has low levels of factor VII, the addition of fresh frozen plasma is sometimes necessary for full reversal of warfarin and thus, 4-factor PCC is superior. These products have a clotting factor concentration approximately 25 times higher than normal plasma. PCC is an effective and rapid treatment for the reversal of warfarin-associated bleeding that has similar efficacy to plasma. PPC has several advantages over FFP; it does not need to be thawed (it is lyophilized [i.e., freeze dried]), it has a more rapid correction of INR, and it can be infused faster and with less volume (ideal for patients with ESRD or CHF) (B). Recombinant factor VIIa will lower INR faster than PPC. However, the concerns regarding recombinant factor VIIa include the potential for inducing thrombosis (stroke, deep venous thrombosis) as well as the high cost (E). Insertion of an intracranial pressure monitor may be considered if her GCS drops to less than or equal to 8 or if she develops clinical signs of herniation (e.g., blown pupil) (A). Repeat head CT will likely be useful, but this should be decided after consultation from the neurosurgical service (D).

**Reference:** Patanwala, A. E., Acquisto, N. M., & Erstad, B. L. (2011). Prothrombin complex concentrate for critical bleeding. *The Annals of Pharmacotherapy*, 45(7-8), 990–999.

28. **E.** This patient is in class III hemorrhagic shock. Hemorrhagic shock is classified into four classes on the basis of signs and symptoms of hypoperfusion that manifest as end-organ dysfunction. Patients in classes I and II hemorrhagic shock are associated with up to 750 mL or between 750 and 1500 mL of blood, respectively. This reflects a 15% or 15% to 30% blood loss for classes I and II hemorrhagic shock. Patients in class II hemorrhagic shock will usually have tachycardia (often the earliest sign of blood loss) and a decreased pulse pressure. Class III hemorrhagic shock is associated with 1500 mL to 2000 mL of blood loss or 30% to 40% of blood volume, whereas class IV is associated with >40% or >2000 mL blood loss. In addition to decreased blood pressure, pulse pressure, and urine output, these patients are typically confused and anxious with an increased heart rate and tachypnea.

**Reference:** American College of Surgeons Committee on Trauma. (2012). *Advanced trauma life support program for doctors* (9th ed.). Chicago, IL: American College of Surgeons.

29. **A.** Following arrival, the initial management of all trauma patients begins with the primary survey that includes an assessment of the: Airway (with cervical spine precautions); Breathing; Circulation (with hemorrhage control); Disability and Exposure/Environment. The first crucial step is to assess the patient's airway for patency and provide supplemental oxygen. Simultaneously, the patient should receive insertion of two large-bore IV catheters into the antecubital fossa and aggressive resuscitation with normal saline or lactated Ringer's solution (C). Some medical centers are now providing initial resuscitation with blood products for the trauma patient in shock. Given the location of the injury (zone I of the neck), one should have a high suspicion for a right subclavian or innominate artery injury. Following the primary survey, the next step would be to take the patient directly to the operating room, given the hemodynamic instability. Proximal control of such an injury on the right is best achieved by a median sternotomy (E). If the same injury were present on the left, proximal control of the left subclavian artery is best achieved via a left anterolateral thoracotomy. If blood is exsanguinating through the bullet hole, manual compression in this area is ineffective. Temporary tamponade can be achieved via insertion and inflation of a Foley balloon directly into the wound, permitting rapid transportation to the operating room. Thoracostomy is indicated for pneumothorax or hemothorax seen on radiograph imaging or after primary survey suggestive of these conditions (B). The above patient has not had a cardiopulmonary arrest nor does he meet any indication for ED thoracotomy (D).

**References:** American College of Surgeons Committee on Trauma. (2012). *Advanced trauma life support program for doctors* (9th ed.). Chicago, IL: American College of Surgeons.

Demetriades, D., Chahwan, S., & Gomez, H., et al. (1999). Penetrating injuries to the subclavian and



axillary vessels. *Journal of the American College of Surgeons*, 188(3), 290–295.

30. **D.** The first step in the management algorithm of a penetrating neck trauma is establishing the airway, particularly in the presence of an expanding hematoma (which may rapidly compress the trachea) or depressed level of consciousness. Next, it must be determined whether the patient has a “hard sign” of a vascular injury. These include a rapidly expanding or pulsatile hematoma, visible exsanguination, palpable thrill or audible bruit, or dense neurologic deficit (such as this patient with GCS 5). The presence of a hard sign mandates immediate transfer to the operating room for a neck exploration. The decision to go directly to the operating room is sometimes more difficult to make in the absence of these signs. However, in the presence of hemodynamic instability, the presumption should be that the patient exsanguinated in the field. Thus, shock is another indication for immediate surgical exploration. In the absence of hard signs, the next step would be to perform arteriography of the neck vessels. This historically has been achieved with formal arteriography, but this has been replaced by CT angiography because of the ease and rapidity of its use (B, C). In addition, an assessment for injuries to the aerodigestive tract (triple endoscopy and/or esophagography) and cervical spine needs to be performed (E). The treatment of penetrating carotid artery injuries remains controversial, particularly in the setting of a comatose patient. As a general guide, repairing a carotid artery injury in a patient with a neurologic deficit is recommended because it may result in improved neurologic function, whereas carotid ligation typically does not. If at surgery, the carotid artery is thrombosed, most vascular and trauma surgeons would recommend repair in the face of a neurologic deficit, provided back-bleeding from the internal carotid artery is obtained after resecting the injured segment. Repair can be achieved by arteriorrhaphy, resection with a primary reanastomosis, or interposition graft placement (saphenous vein or polytetrafluoroethylene). If a graft is needed, the saphenous vein is preferred, provided the patient has now been stabilized in the operating room. While harvesting the vein, a temporary shunt should be inserted in the proximal and distal ends of the artery. If the patient does not adequately stabilize, the shunt can be placed inside the polytetrafluoroethylene graft. This allows the distal anastomosis and part of the proximal anastomosis to be performed while maintaining cerebral perfusion. The shunt can then be removed just before completing the second anastomosis. As soon as the repair is complete and provided the patient is stable, it is important not to forget to search for the bullet via radiograph of the head, neck, and chest. Head CT scan can be considered, if indicated, after repair of the acute vascular injury (A).

31. **D.** Resuscitative thoracotomy is a potentially lifesaving procedure. Indications and guidelines continue to evolve. There are many articles in the literature on the topic, with variable findings and recommendations. However, several overarching themes consistently permeate these studies. Outcomes are better for those with SOL than those without, penetrating trauma than blunt, chest trauma than abdominal, isolated injury than multiple injuries, without head injury than with, short duration of CPR than long duration, and stab wounds than GSW (A–C, E). Thus, the best scenario for resuscitative thoracotomy would be an isolated stab wound to the chest, with SOL (survival from pooled data is 21%). Such a patient is much more likely to have arrested due to cardiac tamponade and therefore has not suffered exsanguinating hemorrhage. Conversely, at the other extreme, for blunt trauma without SOL, survival was only 0.7%. The following are considered SOL: agonal respirations, cardiac electrical activity, palpable pulse, measurable blood pressure, spontaneous movement, or pupillary reactivity. Thus, the benefit of resuscitative thoracotomy for SOL and penetrating chest trauma is clear. Less compelling but still potentially beneficial indications would be penetrating chest trauma without SOL, penetrating extrathoracic injury with or without SOL, and blunt trauma with SOL. There is no benefit for blunt trauma with no SOL. For those that survive, a surprising majority survive with favorable neurologic outcomes.

**References:** Burlew, C. C., Moore, E. E., & Moore, F. A., et al. (2012). Western Trauma Association critical decisions in trauma: resuscitative thoracotomy. *Journal of Traumatology Acute Care Surgery*, 73(6), 1359–1363.

Seamon, M. J., Haut, E. R., Van Arendonk, K., et al. (2015). An evidence-based approach to patient selection for emergency department thoracotomy: a practice management guideline from the Eastern Association for the Surgery of Trauma. *Journal of Traumatology Acute Care Surgery*, 79(1), 159–173.

32. **E.** The preferred access for young children and infants following trauma is via the peripheral percutaneous route (antecubital fossa or saphenous vein at the ankle). After two unsuccessful attempts, consideration should be given to intraosseous (IO) infusion via a bone marrow needle



(18 gauge in infants, 15 gauge in young children). IO cannulation of the proximal tibia provides good short-term access for resuscitation because it targets the noncollapsible veins of the medullary sinus. The optimal site of insertion is the anteromedial tibia 2 to 3 cm below the tibial tuberosity, ensuring to angle away from the growth plates. This can be performed using a bone marrow needle or an IO vascular access system such as the EZ-IO®. Once the patient has been resuscitated, follow-up attempts at peripheral access should be made. If a patient has obvious deformities in the tibiae (as in this patient), the next location for IO cannulation would be the distal femur just above the femoral condyles (D). In adults, there has been a shift in recent years, and sternal IO access is now considered the preferred initial site for cannulation (thinner cortex and abundant red bone marrow) followed by the tibia. It is also important to note that serum electrolytes, blood gases, and type and cross can all be performed using blood from interosseous access. A distal saphenous vein cutdown is another option in children ages 1 to 6 years, but in a child younger than 1 year of age, it would be challenging and not appropriate in the setting of obvious leg deformity (B). In hypovolemic pediatric patients younger than 6 years of age, percutaneous femoral vein cannulation is another alternative but is associated with an increased risk of venous thrombosis and would be much more challenging in a child younger than 1 year (C). Subclavian and internal jugular central lines would be too difficult to perform in the trauma setting in such a small child and would be associated with an increased risk of iatrogenic injury (A). The interosseous cannula should be removed expeditiously (within 24 hours) because of the potential risk of infectious complications including osteomyelitis. Extremity compartment syndrome is another potential complication of IO infusion.

**References:** Cullen, P. M. (2011). Intraosseous cannulation in children. *Pediatric Critical Care*, 13(1), 28–30.

Pasley, J., Miller, C., & DuBose, J., et al. (2015). Intraosseous infusion rates under high pressure: a cadaveric comparison of anatomic sites. *Journal of Traumatology Acute Care Surgery*, 78(2), 295–299.

33. **D.** Both blood volume and red cell volume increase in the pregnant patient, but blood volume increases more than red cell volume. Blood volume increases by approximately 50% as term approaches, whereas red cell volume increases by approximately 30%, resulting in a functional hemodilution and resultant physiologic anemia of pregnancy (A). Thus, pregnant patients are less likely to manifest signs of blood loss such as tachycardia and hypotension, and if such signs are present, they are indicative of an even more severe blood loss than in the nonpregnant patient (on the order of 1500–2000 mL of blood loss). The pregnant patient has an increased tidal volume and minute ventilation, designed to increase oxygen release to the fetus. This results in a mild respiratory alkalosis, with a  $PCO_2$  in the 27 to 32 range (B). Oxygen consumption is increased, and functional residual capacity is decreased. In addition, the 2,3-diphosphoglycerate level is increased to enhance release of oxygen to the fetus. However, these physiologic changes result in less pulmonary reserve in an acutely ill pregnant patient. Use of radiographs is thought to be safe for the fetus after the 20th week of gestation (C). The glomerular filtration rate increases, resulting in a decrease in serum creatinine (E). Other important aspects to be aware of are that the gravid uterus can compress the IVC, resulting in decreased venous return. Therefore, the pregnant patient should be placed in the left lateral position at approximately 15 degrees. Pregnant patients are more prone to aspiration, so early NG tube decompression is important. Finally, the progressive stretching of the peritoneum leads to desensitization so that a pregnant patient is less likely to demonstrate peritoneal signs.

**Reference:** Shah, A. J., & Kilcline, B. (2003). Trauma in pregnancy. *Emergency Medicine Clinics of North America*, 21(3), 615–629.

34. **D.** In the past, the injury described would have been dealt with by performing a formal lobectomy (A). However, pulmonary tractotomy is now used as a less aggressive alternative. The technique involves using a linear stapling device to insert directly into the injured bullet tract. Two hemostatic staple lines are created, and the lung is divided in between. This allows direct access to the bleeding vessels within the parenchyma as well as any leaking bronchi. Bleeding vessels can then be oversewn with a polypropylene monofilament (C). Lobectomy is a better choice for a completely devascularized or destroyed lobe. A pneumonectomy is rarely indicated, and in the trauma setting is associated with an 80% mortality rate (B). Similarly, ligation of a lobar pulmonary artery has a high rate of morbidity (E).

**References:** Kim, D. Y., & Coimbra, R. (2014). Thoracic damage control. In S. Di Saverio, G. Tugnoli,

& F. Catena, et al. (Eds.). *Trauma surgery, Vol. 2: thoracic and abdominal trauma*. Milan, Italy: Springer-Verlag.

Cothren, C., Moore, E., & Biffl, W., et al. (2002). Lung-sparing techniques are associated with improved outcome compared with anatomic resection for severe lung injuries. *Journal of Traumatology*, 53(3), 483–487.

35. **C.** Flail chest occurs when two or more ribs are fractured in at least two locations. Paradoxical movement of this free-floating segment of chest wall is typically not sufficient alone to compromise ventilation (B). Rather, pain and splinting, in conjunction with underlying pulmonary contusions, may result in hypoxemia and hypercarbia due to shunting and ineffective ventilation, respectively. Most patients can be managed without intubation (E). Respiratory failure often does not occur immediately, and frequent re-evaluation is warranted. The initial chest radiograph usually underestimates the degree of pulmonary contusion, and the lesion tends to evolve with time and with fluid resuscitation (A). Intravenous fluid administration should be limited as overzealous resuscitation may result in blossoming of pulmonary contusions (D). The most important aspect of treatment of flail chest is pain control. Standard approaches include the use of patient-controlled analgesia and oral pain medications and the placement of continuous epidural catheters. Although the treatment of flail chest has historically been non-operative, recent literature indicates that internal fixation of the chest wall in select patients without pulmonary contusion decreases intubation time, decreases complications, and improves cosmetic and functional results. In the presence of a pulmonary contusion, however, internal fixation does not seem to be as beneficial. Situations in which internal fixation should be considered include flail chest in patients who are already undergoing thoracotomy for an intrathoracic injury, flail chest without pulmonary contusion, noticeable paradoxical movement of a chest wall segment while a patient is being weaned from the respirator, and severe deformity of the chest wall.

**References:** Voggenreiter, G., Neudeck, F., & Aufmkolk, M., et al. (1998). Operative chest wall stabilization in flail chest—outcomes of patients with or without pulmonary contusion, *Journal of the American College of Surgeons*, 187(2), 130–138.

Leinicke, J. A., Elmore, L., & Freeman B. D., et al. (2013). Operative management of rib fractures in the setting of flail chest: a systematic review and meta-analysis. *Annals of Surgery*, 258(6), 914–921.

36. **A.** BCI should be suspected in anyone with severe blunt chest trauma. Attempts to identify a BCI and stratify severity on the basis of CK-MB, nuclear scans, and echocardiography have not been successful because these modalities lack sensitivity. ECG is the most commonly recommended tool for the initial diagnosis of BCI. The presence of a sternal fracture is not a marker for BCI (D). A normal screening ECG has a negative predictive value of 95% (E). Addition of a normal cardiac troponin increases the negative predictive value to 100%. If a stable patient has an abnormal cardiac troponin level or ECG, he/she should be admitted for observation to a monitored bed. However, troponin level does not correlate with risk of cardiac complications in BCI. If the patient is unstable, an emergent echocardiogram should be performed. If a tamponade is seen, emergent sternotomy should be performed for suspected cardiac rupture. Very rarely, blunt cardiac injury can lead to coronary artery thrombosis, valvular disruption, or septal disruption (C). In an unstable patient with BCI without an anatomic abnormality on echocardiography, invasive blood pressure monitoring with pressor support should be instituted. Most patients with a diagnosis of myocardial contusion have a benign course, with very few developing arrhythmias or heart failure (B).

**References:** Velmahos, G., Karauskakis, M., & Salim, A., et al. (2003). Normal electrocardiography and serum troponin I levels preclude the presence of clinically significant blunt cardiac injury. *Journal of Traumatology*, 54(1), 45–50.

Clancy, K., Velopulos, C., & Bilaniuk, J., et al. (2015). Screening for blunt cardiac injury: an Eastern Association for the Surgery of Trauma practice management guideline. *Journal of Traumatology Acute Care Surgery*, 73(5), S301–S306.

37. **D.** The patient's presentation is highly suggestive of a cardiac injury and pericardial tamponade. Given that he is protecting his airway, there is no need for urgent intubation (A). In fact, in patients with cardiac tamponade and impaired right heart filling, application of positive pressure ventilation may further exacerbate the tamponade physiology by further decreasing RV preload, stroke volume, and cardiac output. It is for this reason that, time permitting, patients with cardiac tamponade are prepped and draped before intubation. Tension pneumothorax and cardiac

tamponade are the most common forms of obstructive shock following trauma. And both may present with distended neck veins and hypotension. Tamponade is associated with the classic findings of the Beck's triad (hypotension, distended neck veins, and muffled heart sounds) and pulsus paradoxus, but these are not reliably present. The presence of muffled heart sounds and normal breath sounds are highly suggestive of pericardial tamponade and not tension pneumothorax, and thus, insertion of a left-sided chest tube is not warranted (B). The next best step would be to perform an emergent FAST scan to look for pericardial fluid. If the FAST scan findings are positive for pericardial fluid, the diagnosis of tamponade is confirmed, and the patient should be rapidly transported to the operating room. The incision of choice is a median sternotomy (E). If the patient were to suddenly decompensate before transport or before the FAST scan, a left anterolateral thoracotomy should be performed in the ED. The pericardium should first be opened longitudinally with care to avoid the phrenic nerve (C). The clot should be removed, and the cardiac injury temporarily controlled with a finger, staples, or a temporary suture. In general, the insertion of Foley balloon catheters into the cardiac wound should be avoided because this tends to enlarge the wound.

**References:** Asensio, J. A., Berne, J. D., & Demetriades, D., et al. (1998). One hundred five penetrating cardiac injuries: a 2-year prospective evaluation. *Journal of Traumatology*, 44(6), 1073–1082.

Asensio, J. A., Petrone, P., & Pereira, B., et al. (2009). Penetrating cardiac injuries: a historic perspective and fascinating trip through time. *Journal of the American College of Surgeons*, 208(3), 462–472.

38. C. Exposure of the innominate, proximal right subclavian and proximal right and left common carotid arteries is fairly straightforward and is achieved with a median sternotomy (A, B, D). Likewise, exposure of the proximal vertebral artery, just at its take-off from the subclavian artery, is readily achieved with a supraclavicular incision (E). This will require division of the anterior scalene muscle and clavicular head of the sternocleidomastoid muscle and protection of the phrenic nerve that overlies it and on the left side avoidance of the thoracic duct. Conversely, exposure of the mid portion of the vertebral artery is not readily feasible because it travels through a bony foramina adjacent to the vertebral body. Exposure of the proximal left subclavian artery presents a difficult challenge. The left subclavian artery arises from the aortic arch posteriorly, and thus, it is not readily approached with a median sternotomy. The best exposure of the proximal left subclavian artery is with an anterolateral thoracotomy at the third intercostal space. Distal control can then be achieved via a supraclavicular approach. On occasion, resection of the medial head of the clavicle as well as a partial median sternotomy is needed to connect the two horizontal incisions and raise a chest wall flap. The ribs can also be cut laterally for additional exposure, creating a so-called trapdoor thoracotomy.

**Reference:** Hoyt, D. B., Coimbra, R., & Potenza, B. M., et al. (2001). Anatomic exposures for vascular injuries. *The Surgical Clinics of North America*, 81(6), 1299–1330.

39. E. The Cattell maneuver involves a right medial visceral rotation of the cecum and ascending colon. It is achieved by incising the peritoneal reflection at the white line of Toldt. It is useful for exposing right retroperitoneal structures, such as the IVC and the right ureter (C). Further cephalad, mobilization and medial rotation of the duodenum (Kocher maneuver) additionally assists in exposing the suprarenal IVC below the liver. The Kocher maneuver is not useful for exposing the celiac axis (D). This is best done by combining a Mattox maneuver with division of the left crus of the diaphragm and dividing the celiac plexus (A). The Mattox maneuver consists of a left medial rotation of the descending colon (again at the line of Toldt), spleen, and/or kidney toward the midline. Exposure of injuries to the distal IVC and iliac vein bifurcations can be exceedingly difficult. On occasion, division of the right common iliac artery is needed to expose and repair an injury of this area. A primary repair of the iliac artery can then be performed. On rare occasion, with massive bleeding, the junction of the superior mesenteric vein (not artery), splenic, and portal veins may need to be exposed by division of the neck of the pancreas (B).

**References:** Asensio, J. A., Chahwan, S., & Hanpeter, D., et al. (2000). Operative management and outcome of 302 abdominal vascular injuries. *American Journal of Surgery*, 180(6), 528–533.

Hoyt, D. B., Coimbra, R., & Potenza, B., et al. (2001). Anatomic exposures for vascular injuries. *The Surgical Clinics of North America*, 81(6), 1299–1330.

40. B. Most veins can be safely ligated in the setting of traumatic injury. However, certain veins are

less likely to tolerate ligation well. These include the superior vena cava (because it may result in an acute superior vena cava syndrome), the renal veins close to the renal parenchyma (because there is then inadequate outflow for the kidney), the IVC above the renal veins (because it will impair outflow to both kidneys), or just at the diaphragm (because this will cause an acute Budd-Chiari syndrome), and the portal vein (because it supplies 75% of the blood to the liver) (A, E). An exception to the aforementioned is ligation of the left renal vein close to the IVC is well tolerated because drainage can occur via the adrenal, gonadal, and iliolumbar veins. This is sometimes performed during open abdominal aortic aneurysm repair. The portal vein has been ligated successfully, provided adequate fluid is administered to compensate for the dramatic but transient edema that occurs in the bowel, but ligation seems to be associated with a higher mortality rate than repair. Ligation of the IVC below the renal veins is better tolerated than the suprarenal IVC; however, marked leg swelling may develop and may require fasciotomies. Ligation of the superior mesenteric vein is also fairly well tolerated and better tolerated than portal vein ligation, although again it is preferable to repair the superior mesenteric vein if the patient is stable and it is technically feasible, because there is similarly marked bowel edema and risk of bowel infarction as with portal vein repair. Arteries for which repair should always be attempted include the innominate, brachial, superior mesenteric, proper hepatic, iliac, femoral, and popliteal arteries and the aorta (C, D). If definitive repair is precluded due to hemodynamic instability or if a damage control approach is deemed appropriate, perfusion or flow may be maintained via a temporary intravascular shunt. In the forearm, either the radial or ulnar artery can be ligated, provided the other vessel is palpable. Similarly, in the lower leg, at least one of the two palpable vessels (anterior or posterior tibial artery) should be salvaged. Because of the excellent collateralization around the shoulder, ligation of the subclavian artery is well tolerated. In fact, the artery is often occluded during stent-grafting of thoracic aneurysms or aortic transection.

**Reference:** Rich, N. M., & Spencer, F. C. (2004). *Vascular trauma* (2nd ed.). Philadelphia, PA: Elsevier Science.

41. **D.** The decision to perform a primary amputation or attempt reconstruction in a mangled extremity is a complex one. Factors that need to be taken into consideration include (1) the degree of soft tissue and bony defects, (2) the hemodynamic stability of the patient, (3) the severity of ischemia in the extremity, (4) the duration of ischemia, (5) the mechanism (energy level) of injury, (6) presence of tibial nerve injury, and (7) age of the patient (>50 years). Numerous scoring systems have been developed in an attempt to predict which patients require amputation. To date, no scoring system is definitive. One of the more commonly cited is the Mangled Extremity Severity Score. The scoring is based on four factors: the degree of energy of the injury, degree of limb ischemia, presence and degree of shock, and patient age. Attempts at prospective validation of this and other scoring systems have been met with mixed results. Good scores generally predict limb salvage, but high scores do not necessarily rule out the ability to save the limb. Although attempting limb salvage and reconstruction intuitively seems appropriate for all mangled extremities, this must be tempered by the fact that such attempts may lead to literally dozens of operations for nonunion and osteomyelitis and yet may still result in an anesthetic, nonfunctional limb that will be prone to ulceration. Thus, the trauma surgeon in conjunction with the orthopedic surgeon must use his or her best clinician judgment. Interestingly, a recent prospective multi-institutional study observed that patients with a mangled extremity reported a quality of life that was similar whether they underwent primary amputation or limb salvage. Primary amputation should generally be considered for patients with a mangled lower extremity who are hemodynamically unstable and those with profound ischemia of more than 6 hours duration (B), a complete amputation of the limb, and a Gustilo grade IIIC tibia/fibula fracture (>10 cm of soft-tissue defect that will require coverage and with arterial injury) with a transection of the tibial nerve (A, C–E). Tibial nerve transection is critical because this injury leads to paralysis of the muscles in the superficial and deep posterior compartments as well as complete anesthesia of the plantar surface of the foot. The Gustilo classification was created for open tibia fractures and is based on the degree of soft-tissue defect and on the vascular status (types I, II, IIIA, IIIB, and IIIC). Injury to the deep peroneal nerve would lead to loss of function of muscles in the anterior compartment with a subsequent footdrop due to an inability to dorsiflex the foot as well as numbness in the first web space. Such a deficit could be managed with an ankle-foot orthotic (C, E). Similarly, popliteal vein injury can be repaired with primary repair or interposition vein graft with minimal comorbidity. In an unstable patient, venous ligation may be considered.

**References:** Bosse, M., McCarthy, M., & Jones, A., et al. (2005). The Lower Extremity Assessment Project (LEAP) Study Group: the insensate foot following severe lower extremity trauma: an indication for amputation? *The Journal of Bone and Joint Surgery. American Volume*, 87(12), 2601–2608.

Ekim, H., Basel, H., & Odabasi, D. (2012). Management of traumatic popliteal vein injuries. *Injury*, 43(9), 1482–1485.

42. **A.** Extremity compartment syndrome can occur anywhere in the extremities, including the buttocks, shoulders, and hands (E). The mechanisms of compartment syndrome are numerous and can be divided into extrinsic and intrinsic causes. Extrinsic causes include constriction by a cast, tight circumferential dressings, or eschar from a burn. Intrinsic causes are divided into bleeding, edema, and exogenous fluid. Bleeding is usually due to trauma but can also be seen after relatively minor injuries in patients with an underlying coagulopathy or those receiving anticoagulants. Edema of the compartment is the largest and broadest category. It is most often seen after reperfusion of an ischemic limb, from either an arterial embolus or thrombosis or trauma. Ischemia/reperfusion is also seen in a person with a drug overdose or an alcoholic who falls asleep on the limb, in patients with profound shock in whom diffuse muscle ischemia with subsequent reperfusion develops, and after massive iliofemoral deep venous thrombosis. Finally, inadvertent infusion of IV fluid into the subcutaneous tissue can lead to compartment syndrome. Diagnosis of compartment syndrome begins by having a high clinical index of suspicion and knowing the clinical scenarios in which it occurs. The most common features are severe pain in the limb typically out of proportion to the physical exam, pain on passive motion of the limb, and tense edema with tenderness on palpation of the compartment. Distal arterial pulses typically remain palpable with compartment syndrome. The anterior compartment of the leg is usually the first compartment to be involved in the lower extremity (C). The deep peroneal nerve runs within it so that numbness in the first web space of the toe is one of the early findings (D). Once the diagnosis is suspected, confirmation is sought by doing direct pressure measurements of the individual compartments. If the pressures are increased more than 30 mm Hg in any of the compartments, then strong consideration should be given to performing a four-compartment fasciotomy. The use of an absolute value has been questioned because the perfusion pressure necessary for oxygenation is partly dependent on the patients' blood pressure and, therefore, could lead to unnecessary fasciotomies (B). The use of differential pressure ( $\Delta p$  = diastolic blood pressure – intracompartmental pressure), with a proposed threshold of 30 mm Hg, has been proposed to be of greater diagnostic value. It is also important to remember that there is no absolute pressure level that rules compartment syndrome in or out. The measurements should be used in conjunction with the patient's clinical examination. The deep posterior compartment is the one that is most commonly inadequately decompressed. Because this compartment contains the tibial nerve, missing this compartment can have devastating consequences. The soleus muscle must be detached from the tibia to decompress the deep posterior compartment. Buttock compartment syndrome has been described in obese patients after prolonged anesthesia as well.

**Reference:** von Keudell, A. G., Weaver, M. J., & Appleton, P. T., et al. (2015). Diagnosis and treatment of acute extremity compartment syndrome. *Lancet*, 386(10000), 1299–1310.

43. **C.** The management of liver injuries has undergone a major evolution in the past 25 years, from routine laparotomy in the past to the current application of selective nonoperative management in hemodynamically stable patients, liberal use of angiographic embolization, and operative management with selective packing and damage control when the patient is cold and coagulopathic. In a patient who has sustained blunt trauma and is hemodynamically stable, a CT scan with IV contrast should be performed. If a contrast blush is seen in the liver, the patient should be taken to angiography for embolization, provided there are no other injuries that require operative intervention. Conversely, if the patient is hemodynamically unstable (as in this patient), the patient should be taken to the operating room and undergo packing of all four quadrants to obtain temporary hemostasis while anesthesia attempts to “catch up” or adequately resuscitate the patient. Strong consideration should be given to activating the institutional massive transfusion protocol in addition to administering tranexamic acid. Given that this patient had continued bleeding despite application of a Pringle maneuver, he has likely sustained an injury to the retrohepatic IVC or hepatic veins. If the bleeding is controlled with packing and, in addition, the patient is cold (temperature  $<34^{\circ}\text{C}$ ), coagulopathic, and with a refractory acidosis (as in this patient), the best option would be to perform a damage control operation and transfer the patient to the ICU for resuscitation (A, B, D, E). If, conversely, the bleeding is not controlled, the next step

would be to rapidly take down the hepatic ligaments including the ligamentum teres, falciform ligament, triangular ligament, and the right coronary ligament, and perform a Kocher maneuver. This allows better direct compression with packing in the retrohepatic space. A decision must then be made as to whether to attempt repair of a retrohepatic IVC injury. This decision depends on the experience of the surgeon, the clinical status of the patient, and whether bleeding is controlled. If bleeding has now stopped with packing, one option is to take the patient back to the ICU to resuscitate and rewarm. If bleeding persists, total vascular exclusion of the liver is now possible because control of the IVC just below the diaphragm and just inferior to the liver can be performed, combined with the Pringle maneuver. Alternatively, an atriocaval (Schrock) shunt could be placed or venovenous bypass initiated.

**References:** Asensio, J., Demetriades, D., & Chahwan, S., et al. (2000). Approach to the management of complex hepatic injuries. *Journal of Traumatology*, 48(1), 66–69.

Kozar, R. A., Feliciano, D. V., & Moore, E. E., et al. (2011). Western Trauma Association/critical decisions in trauma: operative management of adult blunt hepatic trauma. *Journal of Traumatology*, 71(1), 1–5.

44. C. The majority of bladder injuries occur following a blunt mechanism of injury, and over 80% of patients with a bladder rupture will have a concomitant pelvic fracture. Bladder injuries are classified as extraperitoneal, intraperitoneal, or combined, with extraperitoneal injuries being the most common (as many as 70%). Extraperitoneal bladder injuries often result from perforation due to adjacent pelvic bony fragments or spicules, whereas intraperitoneal injuries typically occur due to a sudden increase in pressure when a full bladder sustains a direct blow (i.e. MVC following binge-drinking). These injuries usually result in large tears involving the dome of the bladder. Hematuria in the presence of a pelvic fracture should increase the suspicion for a bladder injury. If blood is visible at the urethral meatus, then a Foley catheter should not be inserted until a retrograde urethrogram is performed to rule out a urethral injury (A). Otherwise, in the presence of hematuria, the diagnosis of a bladder injury can usually be made by stress cystography. This may be performed using a standard radiographic or CT technique. Advantages of CT cystography include the ability to assess other abdominal and pelvic injuries. Typically, 300 to 400 cc of iodinated contrast is instilled into the bladder via the Foley catheter, which is then clamped. When extravasation is seen, it is important to determine whether it is intraperitoneal, extraperitoneal, or both. Contrast above the peritoneal reflection is intraperitoneal (the paracolic gutter would be intraperitoneal). The management of an extraperitoneal rupture of the bladder is nonsurgical in most instances and consists of placing an 18- to 20-French or larger Foley catheter for 7 to 10 days followed by a repeat cystogram to ensure no further extravasation of contrast before catheter removal. Intraperitoneal injuries are managed operatively via a transabdominal approach. Before closure of the injury, palpation and visualization of the interior of the bladder should be performed to ensure absence of other injuries. Repair is undertaken using absorbable sutures. Silk suture is inappropriate because permanent sutures in the bladder will increase the risk of ongoing bladder mucosal irritation and are lithogenic (E). A suprapubic cystostomy is generally not required in the absence of very large wounds or the presence of significant devitalized tissue (B). If CT cystography is equivocal, a formal cystogram should be obtained; it is otherwise unnecessary (D).

**Reference:** Myers, J. B., Taylor, M. B., & Brant, W. O., et al. (2013). Process improvement in trauma: traumatic bladder injuries and compliance with recommended imaging evaluation. *Journal of Traumatology Acute Care Surgery*, 74(1), 264–269.

45. A. Ureteral injuries are relatively uncommon and most often occur following penetrating trauma. Surgical management is dictated by the patient's hemodynamics, as well as level of injury (upper, middle, or lower third), degree of ureteral loss, and status of surrounding tissues. Ureteral repairs following trauma are usually repaired over a stent. For upper and middle third urethral injuries that have a small ureteral segment missing (<2 cm), a primary repair can often be done. Reimplantation to the bladder (ureteroneocystostomy) is preferred for small segment injuries of the lower third as it is technically easier to perform compared with primary repair (E). For larger ureteral injuries involving the upper or middle ureter, the ideal repair entails debriding devitalized tissue, spatulating the two ends, and performing an end-to-end anastomosis over a double J stent (ureteroureterostomy) using an absorbable monofilament (B). Some mobilization of the ureter is feasible, but mobilization risks interrupting the blood supply that runs just adjacent to the ureter. As such, the dissection should be maintained approximately 1 cm away from the ureter so as not to disrupt its blood supply. A good guide to the viability of the two ends of the ureter is whether the



cut edges are bleeding. Lower ureteral injuries may require reimplantation of the ureter into the bladder if there is not enough distal ureter for a primary anastomosis. When a large segment of ureter has been injured and primary reanastomosis is not possible, several options are available. A psoas hitch involves mobilization of the bladder, which is then sutured to the iliopsoas fascia above the iliac vessels, to perform a tension-free reimplantation of the ureter (D). If a tension-free repair cannot be achieved following mobilization of the bladder, a Boari or bladder flap may be considered. More complex techniques include anastomosing the ureter to the contralateral ureter (transureteroureterostomy), ileal-ureteral replacement, and renal autotransplantation (C). In this patient, however, with massive blood loss and hemodynamic instability, a damage control approach should be used. There are two options. The first is to simply ligate the ureter proximally and distally followed by placement of a percutaneous nephrostomy once the patient is stabilized. The patient can later be taken back for a more elective repair of the ureter. The other option is to perform a temporary cutaneous ureterostomy over a single J stent, placing a tie around the ureter and stent and then bringing the stent up to the level of the skin. Given the location of the injury and the length of injured ureter, the patient would eventually likely need a psoas hitch or other more complex repairs.

**Reference:** Smith, T. G., 3rd, & Coburn, M. (2013). Damage control maneuvers for urologic trauma. *The Urologic Clinics of North America*, 40(3), 343–350.

46. **E.** Management of duodenal injuries depends on location, extent of injury, associated pancreatic injury, and clinical status of the patient. Duodenal injuries are graded from I to V, with grade I being a hematoma or partial-thickness injury and grade V being a massive disruption of the pancreaticoduodenal complex or complete duodenal devascularization. If a simple duodenal hematoma is recognized preoperatively, it can be managed without surgery, with nasogastric decompression and parenteral nutrition. If it is found intraoperatively, it is left alone if small (<2 cm). If it is a large hematoma (involving >50% of the lumen), it is recommended to incise the serosa, drain the hematoma, and then reclose the serosa. The majority of full-thickness lacerations of the duodenum can be repaired primarily in a transverse fashion to avoid narrowing the lumen, with or without placement of an overlying omental patch (C). Conversely, if the injury involves more than 50% of the luminal circumference, more extensive surgical treatment is required. If such an injury is in the first, third, or fourth portion of the duodenum, then resection with duodenoduodenostomy or duodenojejunostomy can be performed (as in this patient). If the injury is in the second or third portion of the duodenum and the ampulla is not injured, then a Roux-en-Y duodenojejunostomy is a better option. The second portion is tethered to the head of the pancreas by its blood supply and the ducts of Wirsung and Santorini, so the length of duodenum that can be mobilized from the pancreas is very limited. Attempts to suture repair the second portion when tissue is lost often result in an unacceptably narrow lumen, and end-to-end anastomosis is not possible. If the injury is distal to the ampulla of Vater, the distal portion of the duodenum is oversewn, the jejunum is anastomosed end to end to the proximal duodenum, and the defunctionalized distal duodenum and proximal jejunum are drained into the jejunum. Pyloric exclusion is rarely needed and involves either stapling or oversewing the pylorus and creating a gastrojejunostomy (A). Duodenal diverticularization requires repairing the duodenal injury, antrectomy, vagotomy, gastrojejunostomy, duodenostomy, choledochostomy, and feeding jejunostomy (B). It is not generally recommended. When there is a combined duodenal and pancreatic injury, it is recommended to treat each one separately. In other words, perform duodenal repair for a less than 50% circumference injury and pancreatic drainage for a pancreatic injury without ductal disruption or distal pancreatectomy for a distal pancreatic injury with ductal disruption. A Whipple procedure is rarely needed in the situation of a combined massive disruption of the pancreatic head and duodenum (D).
47. **D.** Duodenal hematomas are caused by a direct blow to the abdomen and occur more often in children than adults (B). Obstruction occurs as fluid is sequestered into a hyperosmolar hematoma, which accumulates between the seromuscular and submucosal layers of the bowel. The diagnosis is suspected by the onset of vomiting after blunt abdominal trauma, usually on the third postinjury day. A CT scan with oral and IV contrast is the best diagnostic modality and helps differentiate a duodenal hematoma from a free perforation. The presence of contrast extravasation or free air indicates a free perforation and mandates exploratory laparotomy (A). In the absence of these findings, a presumptive diagnosis of a duodenal hematoma is made. An alternative imaging study is a water soluble upper gastrointestinal study with oral contrast. The classic finding of



duodenal hematoma on this study is a coiled-spring appearance of the duodenal wall. The majority of such injuries in children are effectively managed nonoperatively by NG tube decompression and parenteral nutrition (E). Resolution of the obstruction in most patients occurs at an average 1 to 2 weeks. Failure to improve should prompt reevaluation with a repeat CT scan. If surgical intervention becomes necessary, evacuation of the hematoma by a partial-thickness incision in the duodenal wall, followed by closure, is associated with equal success but fewer complications than with a bypass (C). This may be performed laparoscopically or via an open approach. Irrespective of the technique, a thorough and careful assessment of the duodenum and pancreas should be performed.

**References:** Shilyansky, J., Pearl, R. H., & Kreller, M., et al. (1997). Diagnosis and management of duodenal injuries in children. *Journal of Pediatric Surgery*, 32(6), 880–886.

Kashuk, J. L., & Burch, J.M. (2008). Duodenum and pancreas. In D. V. Feliciano, K. L. Mattox, & E. E. Moore (Eds.). *Trauma* (6th ed.). New York, NY: McGraw Hill.

48. **B.** Pancreatic injuries are graded from I to V. Grade I is a minor contusion or laceration without a duct injury, whereas grade V is a massive disruption of the pancreatic head. Most pancreatic injuries can be managed by closed suction drainage. The key issue is whether the main pancreatic duct is injured and whether such an injury is to the left of the superior mesenteric vessels. Determining whether the main pancreatic duct is injured can be done by intraoperative pancreatography, which can be performed by a needle injection of contrast into the gallbladder. A disruption of the pancreatic duct to the left of the superior mesenteric vessels can be managed by a distal pancreatectomy. Injury to the main duct to the right of the superior mesenteric vessels in the absence of major pancreatic head disruption is best managed by drainage with subsequent pancreaticoenteric anastomosis if an ensuing fistula fails to heal. Performing such an anastomosis in the emergent trauma setting poses a high risk of anastomotic breakdown. If there is massive destruction of the pancreatic head, as in the present case, a pancreatoduodenectomy will be necessary (A, C–E). It is important to note that such an operation does not and should not be performed immediately. Undoubtedly, most of these patients will often have associated extensive bleeding. Therefore, a damage control procedure can be performed and a definitive procedure delayed until after resuscitation. Another indication for a Whipple procedure would be massive devascularization of the duodenum, particularly when the ampullary complex is involved.

**Reference:** Biffl, W. L., et al. (2013). Western Trauma Association critical decisions in trauma: management of pancreatic injuries. *Journal of Traumatology Acute Care Surgery*, 75(6), 941–946.

49. **D.** Various techniques may be employed to control bleeding from the liver. The simplest method of controlling bleeding from the liver is the application of manual compression with or without the use of topical hemostatic agents such as microfibrillar collagen, oxidized cellulose, and gelatin matrix thrombin sealants. If these are unsuccessful, a Pringle maneuver should be performed. Ongoing bleeding following occlusion of the porta hepatis suggests the potential for a retrohepatic IVC injury. In addition to packing, several other hemostatic maneuvers can be used in patients with severe parenchymal injury. Liver sutures can be placed, using a chromic suture with a blunt-tipped needle. This is best used for relatively superficial lacerations. Another option is to perform a hepatotomy via a finger fracture technique to access the bleeding site to directly suture it. However, profuse bleeding from a small hole in the liver presents a more difficult dilemma because bleeding may be emanating from the center of the liver, and a hepatotomy may not be feasible. In this circumstance, one novel approach that has been well described is to fashion a balloon tamponade catheter. A catheter with side holes is placed through a Penrose drain, and a tie is placed on either end of the Penrose drain (E). The catheter is advanced into the bullet wound, and air with or without contrast is insufflated into the catheter, effectively inflating the Penrose drain and creating a tamponade effect. In this case, however, because the bleeding has stopped, there is no role for any additional treatment (A–C). Placing liver stitches is unnecessary and does increase the risk of causing liver necrosis. Packing the injury with omentum is useful in large stellate lesions, but hemostasis is better achieved in that setting with packing. The use of drains is controversial. For smaller wounds, drains are not recommended. For larger injuries, closed suction drainage is used by some surgeons. In general, open drains should not be employed because of a potentially increased risk of infection.

**Reference:** Kozar, R. A., Feliciano, D. V., & Moore, E. E., et al. (2011). Western Trauma Association/critical decisions in trauma: operative management of adult blunt hepatic trauma.

50. **C.** Increasingly, colon injuries are being treated with either primary repair, if feasible, or resection with a primary anastomosis (A, B, D, E). This approach applies to both right- and left-sided colon injuries. Primary repair is used when less than 50% of the circumference of the bowel is involved, whereas resection is recommended for larger wounds. Once a resection is performed, a decision must be made as to whether to perform a primary reanastomosis or a colostomy. The primary contraindication to attempting a primary reanastomosis is hemodynamic instability. In these situations, damage control surgery should be performed and the decision to reanastomose or create a colostomy can be made at a subsequent operation when the patient has stabilized and been fully resuscitated. Factors associated with intra-abdominal complications in patients with severe colon injuries undergoing resection include severe fecal contamination, transfusion of 4 or more units of blood in the first 24 hours, and administration of single-agent antibiotics. The use of vasopressors at the time of repair may also be associated with anastomotic leaks, whereas the method of performing the anastomosis (handsewn versus stapled) has not been shown to effect leak rates. Another important consideration is obesity. Morbid obesity makes the creation of a stoma difficult, predisposes the stoma to the development of ischemia, and, if this occurs, increases the risk of the development of a necrotizing soft-tissue infection. It also makes the subsequent colostomy takedown more challenging. As such, strong consideration should be given in obese patients to a primary reanastomosis.

**References:** Demetriades, D., Murray, J., & Chan, L., et al. (2002). Handsewn versus stapled anastomosis in penetrating colon injuries requiring resection: a multicenter study. *The Journal of Traumatology*, 52(1), 117–121.

Naumann, D. N., Bhangu, A., & Kelly, M., et al. (2015). Stapled versus handsewn intestinal anastomosis in emergency laparotomy: a systemic review and meta-analysis. *Surgery*, 157(4), 609–618.

51. **B.** The management of a rectal injury depends on whether it is intra- or extraperitoneal, the degree of tissue destruction, and the hemodynamic status of the patient. As a general rule, intraperitoneal injuries can be repaired primarily (they are treated like a colon injury). If it is an extraperitoneal injury, there are two basic options: primary repair of the injury or a diverting colostomy. The decision of whether to do primary repair relates to its accessibility. Proximal extraperitoneal injuries can be repaired primarily. In general, when primary repair of the extraperitoneal injury is performed, diversion via a colostomy is not necessary (C). In addition, by exposing the extraperitoneal injury to the peritoneal cavity, it effectively renders it an intraperitoneal injury; thus, presacral drainage would not be indicated (D). If the extraperitoneal injury cannot be identified and repaired, a proximal diverting colostomy has been shown to be effective in allowing the injury to heal itself. Although still controversial, recent studies indicate that distal irrigation of the rectum and routine drainage of the presacral space are not necessary and may even contribute to forcing fecal material out from a rectal laceration. In particular, if the injury is to the anterior rectum, the drainage will be ineffective. Abdominoperineal resection would not be indicated (E). IV antibiotics alone are not appropriate (A). A CT scan is not reliable enough to rule out a distal rectal injury. As such, the finding of blood on proctoscopy is enough of an indication of an injury to proceed with stool diversion.

**References:** Gonzalez, R. P., Falimirski, M. E., & Holevar, M. R. (1998). The role of presacral drainage in the management of penetrating rectal injuries. *Journal of Traumatology*, 45(4), 656–661.

Demetriades, D., Murray, J., & Chan, L., et al. (2001). Penetrating colon injuries requiring resection: diversion or primary anastomosis? An AAST prospective multicenter study. *Journal of Traumatology*, 50(5), 765–775.

Bosarge, P. L., Como, J. J., & Fox, N., et al. (2001). Management of penetrating extraperitoneal rectal injuries: an Eastern Association for the Surgery of Trauma practice management guideline. *Journal of Traumatology Acute Care Surgery*, 80(3), 546–551.

# Vascular—Arterial

*Samuel Schwartz, Areg Grigorian, and Christian de Virgilio*

## Questions

- Which of the following is true regarding the timing and/or indications for carotid endarterectomy (CEA) in a patient with a stroke?
  - CEA is indicated in the setting of a disabling stroke.
  - CEA is best performed within 6 to 8 weeks after the stroke.
  - CEA is best performed 3 months after the stroke.
  - CEA should be performed urgently.
  - CEA is best performed within 2 weeks of the stroke.
- Which of the following is true regarding CEA for asymptomatic internal carotid artery (ICA) stenosis?
  - According to the Asymptomatic Carotid Atherosclerosis Study (ACAS), CEA reduces the 5-year risk of stroke and death from 20% to 10% in patients with high-grade stenosis.
  - It is beneficial provided the perioperative stroke and death rates are less than 10%.
  - ACAS involved using both aspirin and a lipid-lowering agent in the medical arm of the trial.
  - It is indicated for patients with ICA stenosis ranging from 50% to 100%.
  - There is less benefit in women.
- Which of the following would provide the greatest benefit from CEA?

Symptom	Percentage ICA Stenosis
A. Asymptomatic	Right 90%
B. Right eye amaurosis fugax	Left 60%
C. Right arm/leg transient ischemia attack	Right 80%
D. Left eye amaurosis fugax	Left 80%
E. Right arm/leg paresis	Left 45%

- Thirty minutes after arriving in the recovery room after a right CEA, the patient develops left hemiparesis. The most appropriate next step would be:
  - Immediate operative re-exploration of the carotid artery
  - Tissue plasminogen activator (tPA) infusion
  - Cerebral angiography
  - Carotid duplex ultrasound scan
  - Head computed tomography (CT)
- Following a right CEA, a 65-year-old male develops a severe 10/10 right frontal headache followed by a seizure. There are no focal neurologic deficits. Which of the following is true regarding this condition?
  - It typically presents within 24 hours after surgery.

- B. It is usually self-limited.
  - C. Postoperative hypertension is a risk factor.
  - D. Vasodilators are useful in the treatment.
  - E. The patient will likely need a return to the operating room.
6. Mobilization of the hypoglossal nerve during carotid endarterectomy is achieved by:
- A. Division of the occipital artery
  - B. Division of the posterior belly of the digastric muscle
  - C. Division of the omohyoid muscle
  - D. Division of the artery to the sternocleidomastoid
  - E. Division of the superior laryngeal nerve
7. A 25-year-old woman presents with several episodes of dizziness, syncope, upper extremity claudication, and an elevated erythrocyte sedimentation rate. On examination, she has no radial, brachial, or carotid pulses. Her blood pressure is 70/50 mm Hg in her right arm and 60/40 mm Hg in her left. Magnetic resonance angiography reveals occlusion of both subclavian arteries as well as high-grade stenosis of both common carotid arteries at their mid portion. Which of the following is true about this condition?
- A. Methotrexate is not helpful.
  - B. Transluminal angioplasty is the treatment of choice.
  - C. Surgery should be performed urgently.
  - D. The disease can involve the pulmonary and coronary arteries.
  - E. Antihypertensive agents are contraindicated.
8. A 40-year-old woman presents to the emergency department after a motor vehicle accident with a seat-belt mark and bruising across her right neck. She is neurologically intact. She is otherwise hemodynamically stable, alert, and oriented. A CT scan of the head is negative for an intracranial bleed but demonstrates an intimal injury of the right internal carotid artery. Which of the following is true about this injury?
- A. Heparin is the treatment of choice.
  - B. Associated Horner syndrome is extremely rare.
  - C. The injured carotid artery should be stented.
  - D. Complete healing of the carotid artery is rare.
  - E. Urgent surgical intervention is indicated.
9. A 60-year-old man presents with a right arm and leg hemiparesis that has persisted for 1 hour. He has a history of a left modified radical neck dissection and neck irradiation for cancer 10 years previously. CT angiography reveals a 75% stenosis of the left internal carotid artery just distal to the bifurcation. Which of the following is recommended as the definitive management?
- A. Aspirin
  - B. Aspirin and clopidogrel
  - C. Carotid endarterectomy
  - D. Resection of the diseased carotid artery with an interposition graft
  - E. Carotid stenting with a cerebral protection device
10. Four months after CEA, a duplex ultrasound scan reveals recurrent 70% ICA stenosis. The patient reports no symptoms. Optimal management would consist of:
- A. Repeat CEA
  - B. Carotid stenting
  - C. Observation
  - D. Interposition saphenous vein bypass
  - E. Interposition polytetrafluoroethylene bypass
11. A 35-year-old woman presents to the emergency department with right-sided headache, right eye ptosis, and sudden onset of left arm and leg weakness that lasts 1 hour and then resolves

spontaneously. There is no history of trauma. Duplex ultrasound scan of the right carotid artery reveals a complete occlusion of the ICA. CT angiography confirms a tapering of the ICA with occlusion approximately 2 to 3 cm distal to the bifurcation. Management consists of:

- A. CEA
- B. Lytic therapy with tissue plasminogen activator
- C. Carotid stenting
- D. Anticoagulation
- E. Fogarty embolectomy

12. Thromboangiitis obliterans (Buerger disease) is characterized by:

- A. Frequent coronary artery involvement
- B. Frequent involvement of aortoiliac arterial segments
- C. Disease limited to pedal arteries
- D. Successful treatment with saphenous vein bypass
- E. Corkscrew collaterals

13. Which of the following is true regarding noninvasive hemodynamic assessment?

- A. In normal resting subjects in the supine position, the ankle pressure can be lower than that in the arm.
- B. There is poor correlation between ankle-brachial index (ABI) and severity of symptoms.
- C. End-stage renal failure can cause a false elevation of the ABI.
- D. In diabetic patients, toe pressures are usually falsely elevated.
- E. In diabetic patients, transcutaneous oximetry is unreliable.

14. Which of the following is true regarding the use of thrombolytic therapy for arterial limb ischemia?

- A. It can safely be used in patients within a week of cataract surgery.
- B. Bleeding risk does not correlate with fibrinogen levels.
- C. It is useful in patients with a profound motor deficit in the ischemic limb.
- D. It is ideally used within 2 weeks of the onset of symptoms
- E. It can safely be used for as long as 72 hours.

15. Occlusion of a reverse saphenous vein femoral-to-popliteal artery bypass 3 weeks after surgery is most often due to:

- A. Myointimal hyperplasia
- B. Progressive atherosclerosis
- C. Hypercoagulable state
- D. Technical error
- E. Persistent valve

16. A 65-year-old man presents with a 4-hour history of sudden onset of left leg pain. He has no pulses in his left femoral artery or distally. The calf is tender to palpation. The foot is cool and pale with diminished capillary refill. He has a normal motor and sensory exam in his left foot and leg. On the unaffected side, the femoral, popliteal, and distal pulses are normal. After administration of heparin, the next step in management would be:

- A. Diagnostic arteriography
- B. Thrombolytic therapy
- C. Transfemoral embolectomy
- D. Echocardiogram
- E. CT angiogram of abdomen, pelvis, and extremities

17. A 60-year-old woman presents with sudden onset of acute abdominal pain. On examination, the patient is writhing because of severe pain, yet the abdomen is only mildly tender, without guarding or rebound. The cardiac examination reveals an irregularly irregular rhythm. She denies a history of abdominal pain. The serum lactate level is elevated. Serum amylase is slightly elevated. Plain abdominal radiographs are negative. A computed tomography (CT) scan of the abdomen reveals

- diffuse edema of the small bowel wall. The next step in the management would be:
- A. Thrombolytic therapy
  - B. Arteriography
  - C. Intravenous heparin
  - D. Exploratory laparotomy
  - E. Duplex ultrasound scan
18. A 45-year-old man presents with a 2-week history of vague, diffuse abdominal pain and distention. He reports that his mother and grandmother both had leg blood clots. On examination, he has mild diffuse tenderness without guarding or rebound. A CT scan reveals thickened loops of small bowel and failure of opacification of the superior mesenteric vein. The best management approach would consist of:
- A. Catheter-directed thrombolytic therapy
  - B. Intravenous (IV) heparin followed by 3 months of warfarin
  - C. IV heparin followed by lifelong warfarin
  - D. Arteriography with papaverine infusion
  - E. Immediate operative exploration
19. Claudication symptoms are most improved with the use of:
- A. Pentoxifylline
  - B. Aspirin
  - C. Cilostazol
  - D. Clopidogrel
  - E. Coumadin (warfarin)
20. Four days after a left femoral-to-popliteal arterial bypass with ipsilateral reverse saphenous vein, the patient reports swelling in the left leg. This most likely indicates:
- A. Deep venous thrombosis
  - B. Reperfusion edema
  - C. Decreased venous return from saphenous vein harvest
  - D. Cellulitis
  - E. Lymphatic disruption
21. A 65-year-old male smoker presents with right calf claudication that limits his walking to half a block. He denies rest pain in his foot. On physical examination, he has a normal femoral pulse on the right and absent popliteal and distal pulses. Arterial noninvasive studies reveal a 40-mm Hg decrease in segmental pressure from the upper thigh to the knee. The ABI is 0.7 on the right and 0.8 on the left. The next step in the management of this patient would be:
- A. Standard arteriography
  - B. Magnetic resonance arteriography
  - C. Duplex ultrasound scan
  - D. Smoking cessation and exercise
  - E. CT angiography
22. A 65-year-old man with a history of a coronary artery bypass graft 2 years earlier presents with recurrent chest pain. He describes the pain as substernal and radiating to his jaw. He works as a carpenter and also states that his left arm tires out easily with use. Blood pressure in the right arm is 150/90 mm Hg and 100/60 mm Hg in the left arm. Relief of his chest pain is likely best achieved with:
- A. Redo coronary artery bypass graft
  - B. Coronary stenting
  - C. Increasing the dose of nitrates
  - D. Subclavian artery stenting
  - E. Increasing beta-blocker dose
23. Which of the following is most appropriate in the surgical management of bowel ischemia due to an

- embolus to the superior mesenteric artery (SMA)?
- A. Intraoperative angiography
  - B. Planned second-look laparotomy
  - C. Dopamine
  - D. Longitudinal arteriotomy of SMA
  - E. Resection of bowel with questionable viability
24. The 5-year risk of limb loss in a patient with claudication is estimated to be:
- A. Less than 1%
  - B. Less than 5%
  - C. 10%
  - D. 20%
  - E. 30%
25. At surgery for suspected acute mesenteric ischemia, almost the entire small bowel as well as the right colon appears ischemic. However, the proximal jejunum, duodenum, and left colon appear healthy. The most likely etiology of these findings is:
- A. Thrombosis of the SMA
  - B. Embolus to the SMA
  - C. Superior mesenteric vein thrombosis
  - D. Portal vein thrombosis
  - E. Nonocclusive mesenteric ischemia
26. A 29-year-old female is undergoing splenectomy for idiopathic thrombocytopenic purpura. Intraoperatively, the surgeon notes a significant amount of bleeding at the splenic hilum during mobilization. The surgeon would like to temporarily stop bleeding with a hemostatic agent. Which of the following would be the least effective choice for this patient?
- A. Microfibrillar collagen
  - B. Oxidized cellulose
  - C. Thrombin
  - D. Fibrin sealant
  - E. Glutaraldehyde cross-linked peptide
27. A 60-year-old, relatively healthy diabetic male patient presents with gangrene of his right great toe. The patient has normal femoral and popliteal pulses but no distal pulses. ABI is 0.5. Angiography reveals patent iliac, femoral, and popliteal arteries with a long-segment occlusion of the trifurcation vessels with reconstitution of the anterior tibial artery just above the ankle and runoff into the dorsalis pedis artery. Bilateral saphenous veins are 4 mm in diameter on ultrasound. Which of the following is the best option?
- A. Common femoral-to-anterior tibial bypass with ipsilateral saphenous vein
  - B. Common femoral-to-anterior tibial bypass with contralateral saphenous vein
  - C. Popliteal-to-anterior tibial bypass with ipsilateral greater saphenous vein
  - D. Endovascular stenting of anterior tibial artery
  - E. Great toe amputation only
28. Which of the following is the most common cause of death at 5 years in patients with claudication?
- A. Stroke
  - B. Myocardial infarction
  - C. Cancer
  - D. Lower extremity gangrene
  - E. Ruptured aortic aneurysm
29. A 32-year-old woman notes that her hands become cold and painful when exposed to cold temperatures. The hand changes in color from pale to cyanotic to red. Her medical history is negative, and vascular pulse examination is normal. Arterial noninvasive studies reveal a marked



- decrease in digital blood pressure with exposure to cold temperatures. Symptoms persist despite wearing gloves and avoidance of cold exposure. The next step in management is:
- A. Upper extremity sympathectomy
  - B. Prostaglandins
  - C. Fluoxetine
  - D. Arteriography
  - E. Diltiazem
30. The most common visceral artery aneurysm is:
- A. Celiac
  - B. Splenic
  - C. Superior mesenteric artery (SMA)
  - D. Hepatic
  - E. Pancreaticoduodenal
31. Which of the following is true regarding femoral pseudoaneurysms that occur after arteriography?
- A. Ultrasound compression is the procedure of choice.
  - B. Ultrasound compression is usually successful even if the patient is receiving anticoagulation therapy.
  - C. Surgical repair typically requires interposition vein grafting.
  - D. It can be managed with ultrasound-guided direct thrombin injection.
  - E. A trial of observation is contraindicated because of the high risk of bleeding.
32. One day after open abdominal aortic aneurysm (AAA) repair, watery diarrhea and abdominal distention develop in the patient. On examination, the patient has mild lower left quadrant tenderness without guarding. WBC count is 14,000 cells/ $\mu$ L. Which of the following is appropriate for this patient?
- A. Proctosigmoidoscopy
  - B. CT angiography
  - C. Exploratory laparotomy
  - D. Diagnostic laparoscopy
  - E. Transfemoral arteriography
33. A 69-year-old man presents to the emergency department with sudden onset of left flank and back pain, abdominal tenderness, a blood pressure of 100/50 mm Hg, and a tender pulsatile midline abdominal mass. Which of the following is true about this condition?
- A. The patient should receive a 3-L bolus of normal saline.
  - B. A CT scan of the abdomen and pelvis is reasonable to obtain if the endovascular approach is available.
  - C. Bedside ultrasound is useful to rule out rupture.
  - D. Endovascular repair offers a lower perioperative mortality than open repair.
  - E. Risk of ischemic colitis is similar to elective repair.
34. Which of the following is true regarding popliteal artery aneurysms?
- A. An asymptomatic 3-cm popliteal aneurysm should be observed.
  - B. An asymptomatic aneurysm with intraluminal thrombus should be repaired only when it is larger than 2 cm in size.
  - C. Bypassing the aneurysm with saphenous vein with interval ligation is the standard operative approach.
  - D. Popliteal aneurysms are infrequently bilateral.
  - E. A posterior approach to the aneurysm is not technically feasible.
35. One year after open AAA repair, a patient presents to the emergency department vomiting blood. Vital signs are stable. Upper endoscopy is negative. CT scan shows some mild inflammatory changes around the aortic graft. Which of the following is true regarding this condition?

- A. Inflammatory changes around the graft are common 1 year after surgery.
  - B. Arteriography is useful in establishing the diagnosis.
  - C. A tagged nuclear white blood cell scan is unlikely to aid in the diagnosis.
  - D. There is a low likelihood that excision of the graft will be needed.
  - E. In situ placement of an aortic homograft will likely be needed.
36. The threshold for elective repair of an asymptomatic common iliac aneurysm is greater than:
- A. 2.0 cm
  - B. 2.5 cm
  - C. 3.5 cm
  - D. 4.0 cm
  - E. 4.5 cm
37. The most common symptom of a popliteal aneurysm is:
- A. Rupture
  - B. Thrombosis
  - C. Distal embolization
  - D. Adjacent nerve compression
  - E. Adjacent venous compression
38. Which of the following is true regarding AAA repair?
- A. The appropriate diameter threshold for elective repair for men and women is the same.
  - B. The diameter threshold for endovascular aneurysm repair (EVAR) in a low-risk patient is lower than that for open repair.
  - C. Women have higher perioperative mortality rates in both EVAR and open AAA repair when compared with men.
  - D. Careful surveillance of AAA up to 6.0 cm is safe.
  - E. In a high-cardiac risk patient with a 5.0-cm AAA, the EVAR approach should be used rather than delay surgery.
39. The most common endoleak after an EVAR is type:
- A. I
  - B. II
  - C. III
  - D. IV
  - E. V
40. A 61-year-old male with end-stage renal disease (ESRD) presents with a cold, painful right leg of 2-hour duration. He has an irregularly irregular heart rate on exam. CT angiography confirms an occlusion of the common femoral artery. He is appropriately treated with a heparin drip and surgical embolectomy with symptom resolution. Four days later the symptoms recur, and the pulses disappear. He is taken back for a repeat embolectomy, at which time a whitish-appearing clot is removed. Which of the following is true regarding this condition?
- A. He should receive bivalirudin.
  - B. tPA would have been a good alternative to re-exploration.
  - C. He likely has antithrombin-III deficiency.
  - D. He should receive lepirudin.
  - E. He should receive argatroban.

## Answers

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1. E. The timing of CEA after a stroke is controversial. A delay in surgery increases the risk of a recurrent stroke. The risk is highest within the first month. Conversely, operating too early (within 24 hours) creates a potential risk of a reperfusion injury, particularly if a large infarction is present

on computed tomography (CT) and if hypertension cannot be controlled postoperatively. Intracranial bleeding is thought to occur because of altered autoregulation and hyperperfusion of ischemic tissue. In the North American Symptomatic Carotid Endarterectomy Trial (NASCET), however, postoperative intracranial hemorrhage occurred in only 0.2% of patients. Until recently, CEA was routinely delayed 4 to 6 weeks after a stroke. Subsequent analysis of the NASCET showed that patients with a stable, nondisabling acute stroke, a normal CT scan, and a normal level of consciousness can safely undergo CEA shortly after the diagnosis is made, the symptoms have stabilized, and preoperative risk assessment is complete. Thus the operation is not urgent (D). Delaying the surgery for 6 weeks or more eliminates much of the benefit of CEA because the risk of recurrent stroke is greatest early on (B, C). Current treatment guidelines from the American Academy of Neurology and from the American Stroke Association/American Heart Association recommend that CEA for patients with nondisabling strokes should preferably be performed within 2 weeks of the primary stroke. Patients with a large stroke on CT scan or those with a midline shift may be at higher risk of reperfusion injury, particularly if they have a depressed level of consciousness. Operation should be delayed until these patients improve and plateau in their clinical recovery, in the range of 4 to 6 weeks. If the stroke is completely disabling (A), there remains little if any motor cortex to protect from future stroke, so CEA is not indicated. Thus, patients with severe neurologic deficits, without meaningful recovery or with marked alteration of consciousness, are not candidates for CEA because the goal of CEA is to prevent further damage to the ipsilateral motor cortex.

**References:** Henderson, R., Eliasziw, M., Fox, A., et al. (2000). Angiographically defined collateral circulation and risk of stroke in patients with severe carotid artery stenosis. North American Symptomatic Carotid Endarterectomy Trial (NASCET) Group. *Stroke*, 31(1), 128–132.

North American Symptomatic Carotid Endarterectomy Trial Collaborators. (1991). Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *The New England Journal of Medicine*, 325, 445–453.

Sacco, R., Adams, R., Albers, G., et al. Guidelines for prevention of stroke in patients with ischemic stroke or transient ischemic attack: a statement for healthcare professionals from the American Heart Association/American Stroke Association Council on Stroke: Co-sponsored by the Council on Cardiovascular Radiology and Intervention: the American Academy of Neurology affirms the value of this guideline. *Circulation*, 113(10), e409–e449.

2. E. The ACAS randomized patients with asymptomatic carotid artery stenosis of 60% to 99% to either CEA and aspirin or aspirin alone (C). The study was interrupted because of a significant benefit identified in patients undergoing CEA. A relative reduction in stroke rate by 50%, from 11% to 5% at 5 years was observed in patients undergoing CEA (A). The Asymptomatic Carotid Surgery Trial confirmed the ACAS findings, in that in patients with 60% to 99% stenosis, the net 5-year risk was 6.4% for all strokes or death in patients undergoing CEA versus 11.8% in those not undergoing surgery. This was a net absolute gain of 5.4% (relative risk reduction, 46%). The trial also showed that patients who underwent CEA were much less likely to have a fatal or disabling stroke (3.5% in the surgery group vs 6.1% in the no-surgery group). The studies have found that there is less or no benefit in women (E). The greatest benefit was in men younger than 75 years of age. CEA for asymptomatic stenosis will only benefit the group as a whole if the combined stroke and death rate is less than 3% (B). Keeping this combined endpoint low is dependent on both patient risk and surgeon skill (C). There is no benefit to CEA once the ICA is completely occluded (100%) (D). There is no further flow in the artery, thus the embolic risk is eliminated. The benefit with aggressive medical management (including antiplatelet agents) is that it can also be protective from coronary events. The biggest limitation of ACAS is that it did not include the use of a statin, which in addition to its lipid-lowering response also has pleiotropic effects such as plaque stability, which may prove to be a more important contributor in preventing the progression to stroke in carotid disease. The Aggressive Medical Treatment Evaluation for Asymptomatic Carotid Artery Stenosis (AMTEC) trial attempted to compare modern medical management with CEA, but the study was prematurely terminated and the results are not yet available. Newer studies are needed to determine if modern medical therapy continues to be inferior to surgical intervention in patients with carotid disease. Some authors have suggested that we shift away from using decreased luminal caliber as our primary determinant of choosing which asymptomatic patients to offer surgery. Newer methods of identifying high-risk patients such as those with plaque ulceration and instability should be studied to either replace or supplement

existing societal guidelines.

**References:** Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. (1995). Endarterectomy for asymptomatic carotid artery stenosis. *The Journal of the American Medical Association*, 273(18), 1421–1428.

Halliday, A., Mansfield, A., & MRC Asymptomatic Carotid Surgery Trial (ACST) Collaborative Group. (2004). Prevention of disabling and fatal strokes by successful CEA in patients without recent neurological symptoms: randomised controlled trial. *Lancet*, 363(9420), 1491–1502.

Kolos, I., Loukianov, M., Dupik, N., et al. (2015). Optimal medical treatment versus carotid endarterectomy: the rationale and design of the Aggressive Medical Treatment Evaluation for Asymptomatic Carotid Artery Stenosis (AMTEC) study. *International Journal of Stroke*, 10(2), 269–274.

Weyer, G. W., & Davis, A.M. (2015). Screening for asymptomatic carotid artery stenosis. *The Journal of the American Medical Association*, 313(2), 192–193.

3. **D.** The first NASCET study found that CEA was of benefit for symptomatic severe ICA stenosis (70–99%). A symptomatic carotid artery stenosis was defined as a nondisabling stroke, a hemispheric transient ischemic attack, or a retinal symptom (amaurosis fugax). Life-table estimates of the cumulative risk of any ipsilateral stroke at 2 years were 26% in the aspirin group and 9% in the aspirin and CEA group. In the second NASCET study, there was no benefit for symptomatic patients with less than 50% stenosis (E). For symptomatic patients with stenosis from 50% to 69%, there was a very modest benefit: 5-year risk of ipsilateral stroke was 15.7% in the CEA group and 22.2% in the medical group ( $P = 0.04$ ). The benefit was greatest in men, in those with hemispheric symptoms (as opposed to retinal ones), and with recent stroke. Women appeared to have less risk of stroke and also had higher perioperative mortality than men. ACAS demonstrated the benefit of CEA compared with aspirin for ICA stenosis of 60% to 99%. However, the benefit is much less than for symptomatic high-grade stenosis. Thus in this question, choice A would be beneficial but of less benefit than choice D (symptomatic). Choice B would be of no benefit because the stenosis is moderate, and the symptoms are on the wrong side (retinal is ipsilateral). In choice C, the symptoms are also on the wrong side with respect to the stenosis.
4. **A.** New neurologic deficits that present within the first 12 hours of operation are almost always the result of thromboembolic phenomena stemming from the CEA site. Possibilities include the development of thrombus on the endarterectomized arterial surface, a residual intimal flap in the ICA leading to occlusion, or a residual flap in the external carotid artery (ECA) leading to ECA thrombosis and retrograde embolization of the clot into the ICA. Immediate heparinization and exploration are indicated without the need for confirmatory arteriography or noninvasive tests. On re-exploring the wound, the ECA and ICA should be palpated for the presence of a pulse. If there is no pulse, this indicates thrombosis, and initial on-table arteriography is not necessary. The artery should be reopened and inspected to look for a cause of the thrombosis. Before closing the arteriotomy, care should be taken to ensure that there is good back-bleeding from the ICA. Fogarty balloon embolectomy of the cephalad ICA should be avoided because this can lead to a carotid-cavernous sinus fistula. The arteriotomy should then be reclosed with a patch. On-table arteriography should then be performed to ensure that the distal ICA is patent and to determine whether there is an embolus in the middle cerebral artery. If an embolus is present in the intracranial carotid or middle cerebral artery, local infusion of a lytic agent should be considered (B). If on reopening the wound, an excellent pulse is present in the ICA and ECA, with normal signals on hand-held Doppler ultrasonography, on-table arteriography is performed (C, D). If arteriography reveals an intimal flap or irregular mural thrombus at the endarterectomy site, then reopening of the vessel is indicated. Neurologic deficits that develop 12 to 24 hours after the operation are usually due to thromboembolic phenomena stemming from the CEA site but may also be caused by a postoperative hyperperfusion syndrome. These latter conditions may be worsened by immediate heparinization and re-exploration. Therefore, deficits occurring 12 to 24 hours after the operation should be promptly investigated with head CT and CT arteriography (E).
5. **C.** The incidence of hyperperfusion syndrome after a CEA is reportedly 0.3% to 1%. It is thought to occur as a result of impaired autoregulation of cerebral blood flow and does not need to be taken back to the OR (E). The thought is that long-standing, severe carotid stenosis leads to hypoperfusion, leading to a compensatory dilation of cerebral vessels distal to the stenosis as part of the normal autoregulatory response to maintain adequate cerebral blood flow. After CEA

restores normal pressure, however, autoregulation is impaired and does not immediately adjust to the sudden increase in blood flow. Risk factors associated with cerebral hyperperfusion include recent stroke, surgery for very tight ICA stenosis, concomitant contralateral ICA occlusion, evidence of chronic ipsilateral hypoperfusion, staged bilateral CEA performed within 2 months of each other, and poorly controlled pre- and postoperative hypertension. Pathologic changes range from mild cerebral edema and petechial hemorrhage to severe intracerebral hemorrhage and death, particularly if not promptly treated (B). The syndrome is heralded by an ipsilateral frontal headache, most commonly occurring at a median of the fifth postoperative day (A). By that time, the patient is already at home. Thus it is imperative to warn patients of this rare syndrome and ideally have the patient check his or her blood pressure daily for the first week postoperatively. The headache may be followed by focal motor seizures that are often difficult to control. Management consists of controlling blood pressure, ideally with a beta-blocker, with the avoidance of vasodilators (as these may increase cerebral blood flow), and use of antiseizure medications (D).

**Reference:** Schroeder, T., Sillesen, H., Sorensen O., et al. (1987). Cerebral hyperperfusion following carotid endarterectomy. *Journal of Neurosurgery*, 66(6), 824–829.

6. **D.** During CEA or in the trauma setting, difficulty is sometimes encountered in achieving adequate exposure of the carotid artery. This is particularly true for carotid lesions extending beyond the bifurcation into the distal ICA and/or in patients with high carotid bifurcations. The carotid bifurcation is typically at the junction of the third and fourth cervical vertebrae, but it varies. The bifurcation level can be assessed on preoperative imaging such as CT angiography. It is also important to determine preoperatively whether the carotid plaque is localized to the bifurcation or whether it extends for some distance distally. A high carotid bifurcation is a relative contraindication for CEA, and thus stenting should be considered. Useful and acceptable steps to gain better distal exposure include division of the posterior belly of the digastric muscle for better cephalad exposure, division of the occipital artery, nasotracheal intubation, and anterior sublaxation of the mandible (rarely performed), with care not to dislocate the mandible (A, B). These maneuvers don't specifically help with mobilizing the 12th cranial nerve. The 12th nerve is typically tented by the artery to the sternocleidomastoid. Dividing this artery (along with dividing the ansa cervicalis) helps mobilize the nerve more anteriorly. The ansa cervicalis has a superior root and an inferior root. The superior root fibers are formed by branches of the first cervical nerve and accompany the hypoglossal nerve. The ansa cervicalis then branches off and descends in the carotid sheath (where it is called the descendens hypoglossi). It sends off branches to the omohyoid, sternothyroid, and sternohyoid muscles and is then joined by the inferior root. Division of the omohyoid muscle is used to obtain better caudad exposure of the common carotid artery (C). Division of the superior laryngeal nerve does not help (E) and would result in voice fatigue and difficulty swallowing.
7. **D.** This patient has Takayasu arteritis, an inflammatory disease of the aorta and its branches as well as the coronary and pulmonary arteries. It occurs most commonly in young women, with a median age of 25 years. The clinical course has been described as beginning with constitutional symptoms such as fever and malaise; however, a National Institutes of Health study showed that only one-third of patients recall such symptoms. Characteristic clinical features include hypertension, retinopathy, aortic regurgitation, cerebrovascular symptoms, angina, congestive heart failure, abdominal pain or gastrointestinal bleeding, pulmonary hypertension, and extremity claudication. The gold standard for diagnosis is arterial imaging, with the demonstration of occlusive disease in the subclavian arteries. Unlike atherosclerosis, which tends to affect the origin of these vessels, Takayasu arteritis affects the mid portions of these arteries. Characteristic signs and symptoms include pulselessness or blood pressure differential in the arms, upper or lower extremity claudication, syncope, amaurosis fugax, blurred vision, and palpitations. Treatment consists of steroid therapy initially with the addition of cytotoxic agents used in patients who do not achieve remission. Carotidynia, which is pain along inflamed arteries, is pathognomonic for Takayasu arteritis. Surgical treatment with arterial bypass is only performed in advanced states and in situations in which the patient does not respond to medical therapy. It should ideally be performed when the disease is not active. Because the disease causes transmural arterial inflammation with concentric fibrosis, there is no role for endarterectomy, and angioplasty has not met with good results.
8. **A.** The most common mechanisms of blunt carotid injury include motor vehicle accidents, fist fights, hanging, and intraoral trauma. However, it has also been reported with relatively minor

trauma, such as after chiropractic manipulation of the neck and forceful sneezing. Biffl et al. have graded blunt carotid injury as follows: grade I: luminal irregularity or dissection with less than 25% luminal narrowing; grade II: dissection or intramural hematoma with greater than or equal 25% luminal narrowing; grade III: pseudoaneurysm; grade IV: occlusion; grade V: transection with free extravasation. Horner syndrome (oculosympathetic paresis) is common with this injury and is thought to be related to the involvement of the internal part of the pericarotid sympathetic plexus (B). The decision to perform surgery is based on (1) injury severity, (2) presence or absence of symptoms, and (3) surgical accessibility of the lesion (C). In general there is little role for surgical intervention in patients with grade 1 or 2 blunt carotid injury as in this patient (E). Anticoagulation (with heparin) is the treatment of choice. Aspirin is also an equivalent treatment option. However, most centers chose to use heparin initially in the case that the trauma patient may need to go to the operating room for a missed injury. Minor (intimal) injuries tend to heal themselves (D). Pseudoaneurysms typically do not and are a relative indication for surgery if accessible in the neck. Screening for blunt carotid injury should be performed in the following settings: severe cervical hyperextension/rotation or hyperflexion, closed head injury consistent with diffuse axonal injury, near hanging resulting in anoxic brain injury, seat-belt abrasion or other soft-tissue injury of the anterior neck resulting in significant swelling or altered mental status, basilar skull fracture involving the carotid canal, and cervical vertebral body fracture.

**References:** Biffl, W. L., Moore, E. E., Offner, P. J., et al. (1999). Blunt carotid arterial injuries: implications of a new grading scale. *The Journal of Trauma*, 47(5), 845–853.

Bromberg, W. J., Collier, B. C., Diebel, L. N., Dwyer, K. M., Holevar, M. R., Jacobs, D. G., & Vogel, T. R. (2010). Blunt cerebrovascular injury practice management guidelines: the Eastern Association for the Surgery of Trauma. *Journal of Trauma and Acute Care Surgery*, 68(2), 471–477.

Cothren, C. C., Biffl, W. L., Moore, E. E., Kashuk, J. L., & Johnson, J. L. (2009). Treatment for blunt cerebrovascular injuries: equivalence of anticoagulation and antiplatelet agents. *Archives of Surgery*, 144(7), 685–690.

Fabian, T., Patton, J., Jr., Croce, M., et al. (1996). Blunt carotid injury: importance of early diagnosis and anticoagulant therapy. *Annals of Surgery*, 223(5), 513–525.

9. E. The patient has a symptomatic high-grade carotid stenosis, and, as such, an intervention is indicated. With the history of radiation therapy and neck dissection, the patient has what is termed a “hostile neck.” This increases the risk of carotid endarterectomy, in terms of cranial nerve injury and wound healing. The previous neck dissection results in a paucity of tissue coverage between the skin and the carotid artery. This can lead to the catastrophic complication of carotid blow out. The best alternative in this patient would be to perform carotid stenting with a cerebral protection device (A–D). Patients with asymptomatic ICA stenosis in the 50–69% range should be started on medical therapy with an antiplatelet agent (for all patients), anti-hypertensive agent (if they have hypertension), and the use of a statin (if they have hyperlipidemia).

**Reference:** Harrod-Kim, P., Yasha Kadkhodayan, Y., Derdeyn, C., et al. (2005). Outcomes of carotid angioplasty and stenting for radiation-associated stenosis. *AJNR. American Journal of Neuroradiology*, 26(7), 1781–1788.

10. C. Recurrent carotid stenosis can occur after CEA. The risk of more than 50% restenosis is 5.8%, 9.9%, 13.9%, and 23.4% at 1, 3, 5, and 10 years, respectively; however severe (>80%) stenosis develops in only 2.1% of patients. Early (within 4 weeks) restenosis is usually due to a technical error. Recurrent carotid stenosis occurring beyond 1 month but within the first 2 years after CEA is usually secondary to myointimal hyperplasia. This type of stenosis tends to have a benign course (the lesion is smooth and less prone to embolization), with a low risk of recurrent stroke. In addition, reoperative CEA carries a higher risk of cranial nerve injury (7.3% rate of permanent injury in one series) (A). The patient is asymptomatic. If the patient had a symptomatic recurrence, the best option would be carotid stenting (B). When the recurrent stenosis develops 2 or more years after CEA, recurrent atherosclerosis is the usual cause.
11. D. Sudden occlusion of the ICA in a young patient is highly suggestive of a spontaneous dissection. This is further supported by the tapered occlusion seen on imaging (described as “flame shaped”). On the other hand, occlusion due to atherosclerosis typically occurs flush with the common carotid, and in older patients ICA dissection may occur either spontaneously or after trauma. Cervical artery dissection is a significant cause of stroke in patients younger than 40 years. Common presenting symptoms of ICA dissection are headache, transient ischemic attack and/or

stroke, and Horner syndrome (ptosis, miosis, anhydrosis). Risk factors for dissection include history of infection (syphilis), smoking, Ehlers-Danlos syndrome type IV, cystic medial necrosis, Marfan syndrome, family history, oral contraceptives, and atherosclerosis. In a young female, fibromuscular dysplasia would be high on the differential. The diagnosis is made by duplex scan and/or CT angiography. Duplex scan may be diagnostic, if it demonstrates a membrane within the lumen, consistent with a dissection. The most likely mechanism of acute dissection is an intimal tear followed by an acute intimal dissection, which produces luminal occlusion due to secondary thrombosis. The occlusion angiographically is typically 2 to 3 cm beyond the bifurcation. Autopsy studies have shown a sharply demarcated transition between the normal carotid artery and the dissected segment. Treatment is with anticoagulation and, in most cases, results in complete resolution within a few months. Stenting may be an option in symptomatic patients in the absence of occlusion (C). CEA, Fogarty embolectomy, or lytic therapy is not appropriate for a spontaneous dissection (A, B, E).

12. **E.** Thromboangiitis obliterans (Buerger disease) is a progressive nonatherosclerotic segmental inflammatory disease that most often affects small- to medium-sized arteries, veins, and nerves of the upper and lower extremities (C). The typical age at onset is 20 to 50 years, and the disorder is more common in men who smoke. The disease also affects the veins, and specifically the upper extremities may be affected by a migratory superficial thrombophlebitis. Patients initially present with foot, leg, arm, or hand claudication. Progression of the disease leads to ischemic rest pain and ulcerations of the toes, feet, and fingers. Characteristic angiographic findings may show disease confinement to the distal circulation, usually infrapopliteal and distal to the brachial artery. The occlusions are segmental and show skip lesions with extensive collateralization, the so-called corkscrew collaterals. The diagnosis is difficult to establish and is a diagnosis of exclusion because there are no pathognomonic features. As such, the disease can be confused with chronic embolization and other diseases. Several criteria have been established to confirm the diagnosis: age younger than 45 years; current (or recent) smoker; distal extremity ischemia (claudication, pain at rest, ischemic ulcers, gangrene); exclusion of autoimmune diseases, hypercoagulable states, and diabetes mellitus; exclusion of a proximal source of emboli by echocardiography and arteriography; and characteristic arteriographic findings in the involved limbs. The aortoiliac segments are typically spared, as are the coronary arteries (A, B). The mainstay of treatment revolves around smoking cessation. In patients who are able to abstain, disease remission is impressive and amputation avoidance is increased. The role of surgical intervention is minimal because there is usually no acceptable target vessel for bypass (D). Sympathectomy may result in mild improvement of symptoms.

**Reference:** Olin, J. (2000). Thromboangiitis obliterans (Buerger's disease). *The New England Journal of Medicine*, 343(12), 864–869.

13. **C.** Normally the ABI varies between 1 and 1.2 because the ankle pressure in the supine position can be as much as 20% higher than in the arm (A). Peripheral arterial disease has been defined as a value less than 0.9 and indicates some degree of stenosis. Patients with claudication typically have an ABI between 0.5 and 0.7, and those with rest pain have an ABI less than 0.4 (B). Patients with diabetes and end-stage renal disease are at risk of developing calcification of the arterial medial layer, known as medial calcinosis or Mönckeberg arteriosclerosis. This process makes blood vessels rigid and difficult to compress, causing falsely increased pressure readings. The process tends to affect tibial vessels primarily and spares digital vessels in the toes. As such, toe pressures are more reliable, as are other measures of distal perfusion such as transmetatarsal pulse volume recordings and transcutaneous oximetry (D, E).

**Reference:** Belkin, M., Whittemore, A., Donaldson, M., et al. (2004). Peripheral arterial occlusive disease. In C. M. Townsend Jr, R. D. Beauchamp, & B. M. Evers (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice*. (p. 1992) (17th ed.). Philadelphia, PA: W. B. Saunders.

14. **D.** Absolute contraindications to thrombolytic therapy include recent stroke or transient ischemic attack, active or recent bleeding, and significant coagulopathy. Relative contraindications include patients with recent major surgery (within 2 weeks, and greatest with recent neurosurgery or eye surgery), recent trauma, uncontrolled hypertension, intracranial tumors, and pregnancy (A). Thrombolytic therapy is most effective in patients with ischemia of less than 2 weeks' duration. The risk of bleeding with thrombolytic therapy is increased with longer duration of therapy and with decreasing fibrinogen levels (B). In most series, thrombolytic therapy is used for as long as 48 hours, at which point the bleeding risk increases significantly (E). The causes of acute limb



ischemia can be divided into embolic and thrombotic. The heart is the most common source of emboli leading to acute ischemia, most often in the setting of atrial fibrillation. Other cardiac sources include mural thrombus after an acute myocardial infarction, valvular disease, and atrial myxoma. Other sources of emboli include arterial aneurysms and atherosclerotic plaques. Thrombosis is most often caused by underlying atherosclerosis in the peripheral arteries, and these patients typically will have a history of claudication. The severity of acute limb ischemia is based primarily on the motor and sensory examination. Patients should be placed in four categories: class 1 (nonthreatened) has normal motor and sensory function; class 2 (threatened) includes 2A—sensory deficit only, and 2B—(immediately threatened) both motor and sensory deficit; and class 3 indicates irreversible complete motor and sensory loss. In addition, consideration should be given to the duration of ischemia. As a general rule, patients with class 1 ischemia can be treated with multiple options, a trial of heparin alone, thrombolytic therapy, or operative embolectomy/bypass. Patients with class 2 ischemia need prompt restoration of blood flow so that heparin alone is not acceptable. With class 2B ischemia, the threat of limb loss is more immediate. Since thrombolytic therapy may require more than 24 to 48 hours to restore flow, class 2B ischemia (motor and sensory deficit) is a relative contraindication to thrombolysis (C). Such a patient should be taken to the operating room. Category 3 ischemia is considered irreversible and requires amputation. Irreversible ischemia is confirmed by an absence of arterial or venous Doppler signals, duration of ischemia of more than 6 to 8 hours, presence of mottling of the skin, absence of capillary refill, and complete anesthesia and paralysis.

**References:** Norgren, L., Hiatt, W., Dormandy, J., et al. (2007). Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). *Journal of Vascular Surgery* 45(Suppl. S), S5–S67.

Semba, C. P., Murphy, T. P., Bakal, C. W., et al. (2000). Thrombolytic therapy with use of alteplase (rt-PA) in peripheral arterial occlusive disease: review of the clinical literature. The Advisory Panel. *Journal of Vascular and Interventional Radiology*, 11(2), 149–161.

[No authors listed]. (1994). Results of a prospective randomized trial evaluating surgery versus thrombolysis for ischemia of the lower extremity. The STILE trial. *Annals of Surgery*, 220(3), 251–268.

15. **D.** Early failure (within 30 days) after surgery generally indicates a technical error. Technical errors include anastomotic stenosis, a kink or twist within the graft, poor choice of proximal or distal target, and inadequate-caliber saphenous vein. Intermediate failures, from 30 days to 2 years after bypass, are generally caused by myointimal hyperplasia (A). Late graft failures (beyond 2 years) are caused by progression of atherosclerotic occlusive disease, either within the inflow or outflow vessels (B). A persistent valve would be a potential problem with an in situ vein bypass (not with a reverse vein), in which case valves are intentionally cut with a valvulotome (E). Young patients may have a more aggressive form of atherosclerotic disease (virulent disease), and some have postulated that this may be secondary to an underlying hypercoagulable state (C).

**Reference:** McCready, R. A., Vincent, A. E., Schwartz, R. W., et al. (1984). Atherosclerosis in the young: a virulent disease. *Surgery*, 96(5), 863–869.

16. **E.** In an acutely ischemic limb, in addition to the neurovascular exam of the ischemic limb, the most important aspects of the physical examination are the cardiac exam and the neurovascular examination of the *nonischemic* limb. If the nonischemic limb has normal pulses and no other evidence of chronic ischemia (e.g., hair loss, thin dry skin), then the ischemia is most likely embolic in nature. Finding an irregularly irregular rhythm would further confirm that the heart is the most likely source of clot due to atrial fibrillation. With an absent femoral pulse, the embolus has likely lodged in the common femoral artery. Because the patient described has class 1 ischemia (not threatened), there is no immediate urgency to going to the operating room. Heparin should be started. It is then useful to obtain imaging to confirm the diagnosis. This can be achieved via an arterial duplex scan or an angiogram. Diagnostic arteriography was once considered the gold standard, but this has been replaced by CT angiography (A). An advantage of CT over angiogram is that it may detect etiologies of acute ischemia that would otherwise be unsuspected, such as an aortic dissection or aneurysms. An advantage of CT over duplex scan is that one can image the chest and abdomen for possible pathology. Following diagnosis, the patient may undergo definitive treatment via thrombolytic therapy or open embolectomy (B, C). Native arterial occlusions due to cardiac embolization tend to respond less favorably to thrombolytic therapy. Thus, open embolectomy is preferred by some. A transfemoral approach is optimal because this

can be done with the patient under local anesthesia, and it allows selective embolectomy down the superficial femoral and profunda femoral arteries. The below-knee popliteal artery approach to embolectomy is reserved for situations in which the patient has normal femoral and popliteal pulses, and the embolus is lodged in the tibial vessels. However, such an approach is technically more difficult. As such, distal clot is better managed by lytic therapy as the tPA can be directed via catheter directly into the involved vessel. Echocardiogram would eventually be useful to look for a cardiac source of thrombus, but it would not be of immediate help in the management (D). With the advent of hybrid operating rooms, patients with more advanced ischemia (class 2) can be taken directly to the operating room where a diagnostic angiography followed by immediate intervention can be achieved.

**Reference:** [No authors listed]. (1994). Results of a prospective randomized trial evaluating surgery versus thrombolysis for ischemia of the lower extremity. The STILE trial. *Annals of Surgery*, 220(3), 251–268.

17. C. This patient's history and CT scan findings are most consistent with acute mesenteric ischemia. Acute mesenteric ischemia can be divided into four major causes. Embolization from a cardiac source is the most common cause (30–50% of cases), is seen most often in the setting of atrial fibrillation, and is the likely etiology in the patient presented. The finding of an irregularly irregular heart rhythm suggests an arterial embolism from atrial fibrillation. The most common site of mesenteric embolization is the superior mesenteric artery (SMA) (due to its angle from the aorta). The embolus typically occludes the SMA just distal to the middle colic artery. These patients often have sparing of the proximal jejunum and transverse colon because the middle colic artery remains patent. Celiac artery embolization is rare given its take-off at a right angle to the aorta. The inferior mesenteric artery orifice is so small that a cardiac thrombus rarely lodges inside. Mesenteric arterial thrombosis is usually due to underlying mesenteric artery atherosclerosis. In this situation, the patient will typically have a long-standing history of pain after eating, fear of eating, and weight loss, and the physical examination will reveal evidence of diffuse atherosclerosis and bruits. Mesenteric venous thrombosis is a third etiology and is most often seen in patients with hypercoagulable states. The acute venous occlusion leads to massive bowel edema with secondary arterial insufficiency from bowel wall distention. Patients with mesenteric venous thrombosis tend to present in a less dramatic fashion, often with days or weeks of abdominal pain. Finally, nonocclusive mesenteric ischemia results from shock that creates hypoperfusion to the bowel, such as with cardiac failure or severe hypovolemia. The classic findings in acute mesenteric ischemia are sudden onset of severe pain out of proportion to the physical examination findings. Elevated serum lactate levels should raise the suspicion for ischemic bowel, but they are not sensitive enough to detect early bowel ischemia. A plain abdominal radiograph is often unremarkable, although it may demonstrate evidence of edema in the small bowel wall. If the patient has peritoneal signs on abdominal examination, this would indicate that the bowel is already infarcted. In the absence of peritonitis and because the differential diagnosis is extensive, CT provides the greatest diagnostic yield initially (E). However, CT scan may not be diagnostic because it may not necessarily demonstrate opacification in the mesenteric veins or arteries (depending on the timing of contrast). The first step in the management is the administration of intravenous heparin. Following heparin, for an embolus, immediate surgery offers the best chance of treatment and would involve an SMA embolectomy (D). If the history were suggestive of underlying mesenteric atherosclerosis (long-standing postprandial abdominal pain and weight loss) with thrombosis, arteriography would be helpful because the management would involve an arterial bypass or stenting (B). If the CT scan revealed a thrombus in a mesenteric vein, definitive treatment would be heparin alone, provided there is not peritonitis. For nonocclusive ischemia, correcting the underlying shock is the initial management. Catheter directed papaverine may also be useful. There are some case reports in which mesenteric emboli have been successfully managed with lytic therapy, but this is not the standard approach and not the best option with elevated lactate suggesting compromised bowel (A).
18. C. Mesenteric venous thrombosis accounts for approximately 10 to 15 % of cases of mesenteric ischemia. It tends to have a slow, insidious onset, as in this case. Risk factors for mesenteric venous occlusion include hypercoagulable states such as factor V Leiden, antithrombin III deficiency, and protein C and S deficiency as well as liver disease with portal hypertension, pancreatitis, and any intraperitoneal inflammatory conditions. Venous thrombosis is less dramatic than arterial occlusion. Abdominal pain is vague, and tenderness is mild or equivocal. CT may demonstrate a

thickened bowel wall with delayed passage of intravenous contrast agent into the portal system and lack of opacification of the portal or superior mesenteric vein. If the diagnosis is established from the CT scan, further diagnostic tests are unnecessary. Another useful diagnostic modality is duplex ultrasound scanning. Arteriography may demonstrate venous congestion and lack of prompt filling of the portal system (D). If the patient is manifesting peritoneal signs, operative exploration is indicated (E). However, in the absence of peritonitis, therapy should consist of fluid hydration, hemodynamic support, anticoagulation with heparin, and serial examination. If peritonitis subsequently develops, exploratory laparotomy is appropriate to assess bowel viability with segmental bowel resection. Surgical thrombectomy of the venous system is not likely to be successful. Fibrinolytic therapy has been used increasingly, but is not yet the standard treatment of choice, and is ideal when symptoms are of short duration (A). Following heparin, warfarin is recommended for 3 to 6 months if the hypercoagulable state is provoked or temporary (B). Lifelong warfarin is recommended if the venous thrombosis is unprovoked or associated with a permanent thrombophilic state. The family history of venous thrombosis in this patient is highly suggestive of an inherited hypercoagulability and would warrant lifelong anticoagulation.

**Reference:** Kumar, S., Sarr, M., & Kamath, P. (2001). Mesenteric venous thrombosis. *The New England Journal of Medicine*, 345(23), 1683–1688.

19. C. Cilostazol has a number of functions including inhibiting platelet aggregation and smooth muscle proliferation, increasing vasodilation, and lowering high-density lipoprotein and triglyceride levels. Cilostazol has been shown to significantly increase walking distance by 50% to 67% in patients with claudication in several randomized trials and results in improvement in physical functioning and quality of life. This drug is more effective than pentoxifylline in the treatment of claudication (A). Pentoxifylline is a methylxanthine derivative that has hemorrheologic properties. Two meta-analyses showed that it improves walking distance, but in some more recent randomized studies, it proved to be no better than placebo. Pentoxifylline improves symptoms of claudication by increasing red blood cell flexibility and reducing blood viscosity. Antiplatelet medications such as aspirin are used in the treatment of peripheral vascular disease and for cardiac and stroke prevention but do not appear to improve walking distance (B). Aspirin has been found to reduce the vascular death rate by approximately 25% in patients with any manifestation of atherosclerotic disease (e.g., coronary, peripheral). Clopidogrel is effective in reducing overall acute cardiovascular events, especially in patients with lower extremity occlusive disease, but is much more expensive (D). It does not seem to directly improve walking distance. Pure vasodilators have not been efficacious in the treatment of peripheral vascular disease because most patients with such occlusive disease already exhibit marked vasodilation. Anticoagulants also have not been shown to alter the course of peripheral atherosclerosis (E).

**Reference:** Money, S., Herd, J., Isaacsohn, J., et al. (1998). Effect of cilostazol on walking distances in patients with intermittent claudication caused by peripheral vascular disease. *Journal of Vascular Surgery*, 27(2), 267–274.

20. E. Leg edema after femoral-to-popliteal arterial bypass is common. In most instances, it is due to lymphatic disruption. This disruption occurs at both the groin and popliteal incisions as well as from harvesting of the saphenous vein. Deep venous thrombosis can occur after this procedure but is relatively uncommon (A). Reperfusion edema may be associated with compartment syndrome and can present with the P's (pain, pallor, paralysis, paresthesia, and poikilothermia) (B). It is more likely to present after revascularization due to acute limb ischemia. The saphenous veins are part of the superficial venous system, which contributes a minority of the venous drainage in the leg, so swelling secondary to venous congestion is not expected after a saphenous vein harvest (C). Cellulitis would present with erythema, pain, warmth, and possible systemic signs such as fever or leukocytosis (D).

**Reference:** AbuRahma, A., Woodruff, B., & Lucente F. (1990). Edema after femoropopliteal bypass surgery: lymphatic and venous theories of causation. *Journal of Vascular Surgery*, 11(3), 461–467.

21. D. The normal ABI ranges from 1 to 1.2 and a value less than 0.9 indicates some degree of peripheral vascular disease. Patients with claudication typically have an ABI in the 0.6 to 0.8 range. Calf claudication is usually due to disease in the superficial femoral artery (SFA). The pulse deficit between the femoral and popliteal arteries further confirms disease in the SFA. The segmental pressures also help localize the site of the obstruction to the SFA as the pressure decrease is between the upper thigh and knee. Because the initial management of claudication should be

medical, no further imaging is needed. Claudication is not considered limb threatening in the absence of ischemic rest pain, ulceration, or gangrene. The goal of medical management is to prevent progression of peripheral vascular disease, reduce the risk of major cardiovascular events elsewhere, and improve function in symptomatic patients. Smoking cessation is the most important factor in determining the outcome of patients with claudication. Smoking cessation has been shown to result in a reduction of the 10-year mortality rate from 54% to 18%. In addition to smoking cessation, the patient should be placed on an exercise program and be prescribed a statin and aspirin. Hypertension should be controlled. Duplex ultrasound scanning is an appropriate arterial noninvasive study that is often used in conjunction with segmental pressures and ABI. However, given that the patient has already undergone an ABI, the next step would be to institute medical management. Magnetic resonance imaging, CT, or standard arteriography should be reserved for patients in whom an intervention is being planned (A, B, E). Duplex ultrasound scan would be the appropriate study to look for deep venous thrombosis (C).

22. **D.** The patient's history and examination are most consistent with symptoms of coronary-subclavian steal syndrome. Most patients with a coronary artery bypass graft have undergone a left internal mammary artery-to-left anterior descending graft. In the setting of subclavian artery stenosis or occlusion proximal to the take-off of the internal mammary artery, arm exercise leads to vasodilation of the arm vessels and lower resistance. Blood will travel through the path of least resistance and flow in a reverse fashion from the left anterior descending artery into the left internal mammary artery and toward the arm, leading to the development of angina. The differential blood pressure in the arms is the clue, as is the left arm claudication. Treatment involves relieving the subclavian artery obstruction. This can generally be done by subclavian artery stenting but on occasion requires a carotid-to-subclavian artery bypass (A). Since the problem is not related to underlying cardiac disease, carotid stenting, increasing beta-blocker dose, or increasing dose of nitrates will not resolve the patient's chest pain with exercise (B, C, E).

**Reference:** Bryan, F., Allen, R., & Lumsden, A. (1995). Coronary subclavian steal syndrome: report of 5 cases. *Annals of Vascular Surgery*, 9(1), 115–122.

23. **B.** Initial management of patients with acute mesenteric ischemia includes fluid resuscitation and systemic anticoagulation with heparin sulfate to prevent further thrombus propagation. Significant metabolic acidosis should be corrected with sodium bicarbonate. A central venous catheter, peripheral arterial catheter, and Foley catheter should be placed for fluid resuscitation and hemodynamic status monitoring. Appropriate antibiotics are given before surgical exploration. The operative management of acute mesenteric ischemia is dictated by the cause of the occlusion. For an SMA embolus, exposure of the SMA is obtained via rotation of the small bowel to the right and sharply dissecting the ligament of Treitz. The SMA will be found at the root of the mesentery. The primary goal in the surgical treatment of embolic mesenteric ischemia is to restore arterial perfusion with removal of the embolus from the vessel. This is done by performing a Fogarty embolectomy using a transverse arteriotomy (longitudinal arteriotomy will cause stenosis upon closure) (D). It is important to avoid resecting bowel until perfusion has been restored; that way, bowel viability can be better established. After restoration of SMA flow, an assessment of the intestinal viability is made, and nonviable bowel is resected. Because the amount of bowel resected can be extensive and this places the patient at risk of short bowel syndrome, bowel that is of borderline viability should be left in place with a planned second-look procedure performed 24 to 48 hours later to reassess whether additional bowel resection is needed (E). Low-dose dopamine leads to vasodilatation of mesenteric arteries; however, its benefit is unclear (C). Intraoperative angiography will not provide any additional information that would assist in the surgical management of SMA embolus (A).

24. **B.** Major amputation is a relatively rare occurrence in patients who have claudication without ischemic rest pain or ulceration. In two recent reviews, the risk of major amputation at 5 years ranged between 1% and 3.3% (A, C–E). In the Framingham studies, the risk of limb loss was less than 2%. Thus, when evaluating and counseling patients with claudication, it is important to reassure them that they do not have an imminently limb-threatening problem. Likewise, the low risk of limb loss further supports the premise that the initial management of claudication should be medical.

**Reference:** Norgren, L., Hiatt, W., Dormandy, J., et al. (2007). Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). *Journal of Vascular Surgery*, 45(Suppl. S):S5–S67.

25. **B.** The most common cause of mesenteric ischemia is a cardiac embolus to the SMA. The SMA provides blood to the bowel from the ligament of Treitz to the mid transverse colon. Cardiac embolus tends to lodge just past the SMA origin at a point where the artery begins to narrow, which is just beyond the first jejunal branches. These patients often have sparing of the proximal jejunum and transverse colon because the middle colic artery remains patent. Thrombosis of the SMA, conversely, is usually caused by underlying atherosclerotic disease that occurs at the SMA origin and would thus not spare the proximal jejunum (A). Mesenteric venous thrombosis and nonocclusive mesenteric ischemia would more likely cause patchy areas of ischemia (C–E).
- Reference:** Jens Eldrup-Jorgensen, J., Hawkins, R., & Bredenberg, C. (1997). Abdominal vascular catastrophes. *The Surgical Clinics of North America*, 77(6), 1305–1320.
26. **A.** Hemostatic agents are increasingly used intraoperatively to provide a temporary measure of controlling bleeding when cautery is dangerous or inaccessible. Collagen can provide hemostasis by allowing a large surface area for platelet adherence leading to thrombus clot. However, this will not work well in patients with thrombocytopenia. Oxidized cellulose promotes red cell lysis generating an artificial clot and can even be used during endoscopic procedures. It may also have an antimicrobial effect since it decreases local tissue pH (B). Thrombin uses blood as a source of fibrinogen to create a clot (C). In contrast, fibrin sealant is composed of both fibrinogen and thrombin (D). Glutaraldehyde cross-linked peptide (commonly albumin) forms a scaffold for clot formation and can be used even on wet surfaces (E).
- References:** Skinner, M., Velazquez-Avina, J., & Monkemuller, K. (2004). Overtube-assisted endoscopic application of oxidized cellulose to achieve hemostasis in anastomotic ulcer bleeding. *Gastrointestinal Endoscopy*, 80(5), 917–918.
- Emilia, M., Luca, S., Francesca, B., et al. (2011). Topical hemostatic agents in surgical practice. *Transfusion and Apheresis Science*, 45(3), 305–311.
27. **C.** The ipsilateral greater saphenous vein is the conduit of choice for lower extremity distal bypass for peripheral arterial disease (contralateral vein for trauma). An ideal conduit should be a minimum of 3 mm (but ideally 4 mm). When the greater saphenous vein is not available, options include the lesser saphenous and cephalic veins. Ectopic veins (i.e., lesser saphenous, arm veins) are generally inferior to a single-segment saphenous vein, although they are still superior to the performance of synthetic grafts. A composite graft, which is a vein graft sewn to a polytetrafluoroethylene graft, has a patency rate similar to that of a prosthetic graft and tends to develop neointimal hyperplasia. The bypass should be as short as possible (proximal inflow from the most distal normal artery (in this case popliteal), and distal outflow to where the artery reconstitutes most proximally (in this case above the ankle)). Options A and B are suboptimal because it involves a longer bypass than is necessary given the patent femoral artery and normal popliteal pulse and harvesting contralateral vein. Endovascular approaches (such as angioplasty) are options but are less durable, particularly in the presence of a long segment of occlusion. However, in a relatively healthy patient, with a good saphenous vein and good runoff into the foot, a bypass is likely the better option (D). Amputation of the toe is unlikely to heal in the absence of a palpable pedal pulse and such a low ABI (E).
- Reference:** Gentile, A., Lee, R., Moneta, G., et al. (1996). Results of bypass to the popliteal and tibial arteries with alternative sources of autogenous vein. *Journal of Vascular Surgery*, 23(2), 272–279.
28. **B.** The 5-year survival rate of patients with claudication is only 70%; 40% to 60% of deaths are caused by coronary artery disease (A, C–E). Cerebrovascular disease accounts for an additional 10% to 20% of deaths. Thus, the primary focus of the management of those with claudication is to aggressively treat the underlying risk factors for atherosclerosis, including the use of aspirin and statins, as well as smoking cessation.
- Reference:** Norgren, L., Hiatt, W., Dormandy, J., et al. (2007). Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). *Journal of Vascular Surgery*, 45(Suppl. S):S5–S67.
29. **E.** This is Raynaud disease. First described in 1862 by Maurice Raynaud, the term *Raynaud disease* applies to a heterogeneous symptom array associated with peripheral vasospasm, more commonly occurring in the upper extremities. The characteristically intermittent vasospasm classically follows exposure to various stimuli, including cold temperatures, tobacco, or emotional stress. Formerly, a distinction was made between Raynaud disease and Raynaud phenomenon for describing a benign disease occurring in isolation or a more severe disease secondary to another underlying disorder,

respectively. However, collagen vascular disorders develop in many patients at some point after the onset of vasospastic symptoms; the rate of progression to a connective tissue disorder ranges from 11% to 65% in reported series. Characteristic color changes occur in response to the arteriolar vasospasm, ranging from intense pallor to cyanosis to redness as the vasospasm occurs. The digital vessels then relax, eventually leading to reactive hyperemia. The majority of patients are women younger than 40 years of age. As many as 70% to 90% of reported patients are women, although many patients with only mild symptoms may never present for treatment. Geographic regions located in cooler, damp climates such as the Pacific Northwest and Scandinavian countries have a higher reported prevalence of the disease. Certain occupational groups, such as those that use vibrating tools, may be more predisposed to Raynaud disease or digital ischemia. The exact pathophysiologic mechanism behind the development of such severe vasospasm remains elusive, and much attention has focused on increased levels of  $\alpha_2$ -adrenergic receptors and their hypersensitivity in patients with Raynaud disease, as well as abnormalities in the thermoregulatory response, which is governed by the sympathetic nervous system. There is no cure for Raynaud disease; thus, all treatments mainly palliate symptoms and decrease the severity and perhaps frequency of attacks. Conservative measures predominate, including the wearing of gloves, use of electric or chemically activated hand warmers, avoiding occupational exposure to vibratory tools, abstinence from tobacco, and relocating to a warmer, drier climate. The majority (90%) of patients will respond to avoidance of cold and other stimuli. The remaining 10% of patients with more persistent or severe syndromes can be treated with a variety of vasodilatory drugs, albeit with only a 30% to 60% response rate. Calcium channel blocking agents such as diltiazem and nifedipine are the drugs of choice. The selective serotonin reuptake inhibitor fluoxetine has been shown to reduce the frequency and duration of vasospastic episodes but is not the first-line treatment (C). Intravenous infusions of prostaglandins have been reserved for nonresponders with severe symptoms (B). Upper extremity sympathectomy may provide relief in 60% to 70% of patients; however, the results are short-lived, with a gradual recurrence of symptoms in 60% within 10 years (A). Cervical sympathectomy has fallen out of favor and has been replaced by localized digital sympathectomy using microsurgery. This involves stripping the adventitia of digital arteries and thus removing sympathetic fibers. A cold stimulation test or nail fold capillaroscopy may be used to confirm the diagnosis of Raynaud disease, but there is no role for arteriography (D).

30. **B.** Aneurysms of the visceral arteries are rare. Splenic artery aneurysms are the most common type and make up as many as 60% of cases. Hepatic artery aneurysms are the second most common, with as many as 20% of cases (D). Aneurysms of the celiac, superior mesenteric, and pancreaticoduodenal arteries together compose less than 10% of all visceral aneurysms (A, C, E).

**References:** Bell, R. B., & Seymour, N. E. (2005). Abdominal wall, omentum, mesentery, and retroperitoneum. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 1317–1328) (8th ed.). New York, NY: McGraw-Hill.

Turnage, R. H., Li, B., & McDonald, J. C. (2004). Abdominal wall, umbilicus, peritoneum, mesenteries, omentum and retroperitoneum. Peripheral arterial occlusive disease. In C. M. Townsend Jr, R. D. Beauchamp, & B. M. Evers (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice*. (pp. 1171–1198) (17th ed.). Philadelphia, PA: W. B. Saunders.

31. **D.** Pseudoaneurysms can manifest with pain, a pulsatile mass, and/or compression of adjacent structures. Large, expanding, painful pseudoaneurysms are at significant risk of rupture and should be repaired urgently. Smaller, stable pseudoaneurysms may be observed (E). Duplex ultrasonography has been the diagnostic procedure of choice because it helps define size, morphology, and location. Pseudoaneurysms less than 2 cm in diameter have a higher likelihood of spontaneous thrombosis with compression therapy, whereas larger ones and those in patients receiving anticoagulation therapy are likely to persist. More recent studies, however, have reported high failure rates with this ultrasound compression (A, B). Ultrasonography-guided thrombin injection is a newer treatment option and in many centers is now the treatment of choice. Surgery is reserved for infected or rapidly expanding pseudoaneurysms (C).

**Reference:** Wixon, C. L., Philpott, J. M., Bogey, W. M., Jr., et al. (1998). Duplex-directed thrombin injection as a method to treat femoral artery pseudoaneurysms. *Journal of the American College of Surgeons*, 187(4), 464–466.

32. **A.** Colonic ischemia is a recognized complication after AAA repair, whether open or endovascular. It occurs in approximately 1% to 3% of cases. It is thought to be due to either ligation of the



inferior mesenteric artery (IMA) or ligation or exclusion of internal iliac arteries. The most common presentations include an unexpectedly early return of bowel function manifested by diarrhea, left lower quadrant pain, abdominal distention, persistent leukocytosis, elevated white blood cell count, and lactic acidosis. Diagnosis is confirmed by flexible proctosigmoidoscopy, which reveals a friable mucosa. Proctosigmoidoscopy may not be able to accurately distinguish partial ischemia from full-thickness necrosis. Initial management is medical and consists of nasogastric tube decompression, IV hydration, placing the patient on NPO, and broad-spectrum antibiotics. Full-thickness necrosis of the colon should be suspected in patients with evidence of peritonitis or unremitting acidosis. In such cases, laparotomy with colonic resection and colostomy is indicated (C, D). The mortality rate after emergent colectomy approaches 50%. Arteriography would not typically be helpful because the usual cause is an intended ligation or exclusion of an internal iliac artery or IMA (B, E).

**Reference:** Becquemin, J., Majewski, M., Fermani, N., et al. (2008). Colon ischemia following abdominal aortic aneurysm repair in the era of endovascular abdominal aortic repair. *Journal of Vascular Surgery*, 47(2), 258–263.

33. **B.** The presentation is consistent with a ruptured AAA. If the patient is hemodynamically unstable, he should be taken directly to the operating room. If the patient is stable, a CT scan is reasonable to determine feasibility of endovascular repair, provided there is a coordinated multidisciplinary ruptured aneurysm team that has immediate endovascular capabilities. That being said, current literature suggests similar long-term mortality rates for open and endovascular repair of ruptured AAA (D). Additionally, a recent Cochrane analysis demonstrated no difference in 30 day mortality for patients with ruptured AAA that were treated with an endovascular approach compared to an open approach. It should be noted that in elective repair of AAA the endovascular approach has a lower perioperative mortality. Long-term mortality rates for open and endovascular repair of elective AAA are similar. Although ultrasonography is useful for determining the presence of an AAA, it is not accurate for determining the presence of a retroperitoneal rupture (C). Ultrasonography would be reasonable to perform in this patient if no pulsatile mass could be felt on physical examination to confirm that an aneurysm was present. Once in the operating room, the patient should be prepped and draped before anesthesia induction because the anesthesia may induce a precipitous decrease in blood pressure. Because of the large retroperitoneal hematoma that is typically found, proximal control is best achieved by clamping the aorta at the diaphragm. Most surgeons would recommend a policy of “permissive hypotension” en route to the operating room. Excessive fluid administration and elevation of the blood pressure may further exacerbate bleeding (A). The risk of ischemic colitis is much higher than after elective AAA repair (E).

**References:** Badger, S. A., Harkin, D. W., Blair, P. H., Ellis, P. K., Kee, F., & Forster, R. (2016). Endovascular repair or open repair for ruptured abdominal aortic aneurysm: a Cochrane systematic review. *BMJ open*, 6(2), e008391.

Lee, W., Hirneise, C., Tayyarah, M., et al. (2004). Impact of endovascular repair on early outcomes of ruptured abdominal aortic aneurysms. *Journal of Vascular Surgery*, 40(2), 211–215.

van der Vliet, J. A., van Aalst, D. L., & Schultze Kool, L. J. (2007). Hypotensive hemostasis (permissive hypotension) for ruptured abdominal aortic aneurysm: are we really in control? *Vascular*, 15(4), 197–200.

34. **C.** Popliteal aneurysms are the most common peripheral artery aneurysms (overall, aortic and iliac aneurysms are more common). They can be suspected on physical examination. They are bilateral in 50% of patients (D). Patients who are found to have a popliteal aneurysm should undergo screening for an AAA because 30% will have a concomitant AAA. The most frequent complication of popliteal aneurysms is leg ischemia. Guidelines for repair are controversial. Some authors recommend repair for all popliteal aneurysms. Most would agree that indications for repair are (1) all aneurysms larger than 2 cm, (2) aneurysms with intraluminal thrombus, regardless of size, or (3) those that are symptomatic or have evidence of previous embolization (A, B). Diagnosis is made by duplex ultrasonography, which can measure the aneurysm size and detect the presence of thrombus. Arteriography assists in operative planning but should not be used for diagnosis because it does not detect the thrombus nor accurately measure the size. The surgical approach to the popliteal artery is either via the medial approach or the posterior approach (E). The posterior approach is ideal if the aneurysm is just behind the knee joint. Magnetic resonance imaging and



CT angiography can be used as alternatives for operative planning. The standard operative approach involves bypassing the aneurysm with saphenous vein and interval ligation of the popliteal artery. With this approach, the aneurysm sac is not opened, and as such, there is a small risk of continued aneurysm expansion and compression of adjacent structures. Formal endoaneurysmorrhaphy, as is done with an open AAA repair, is another alternative. In the setting of acute thrombosis, lytic therapy is the initial treatment of choice.

**References:** Ascher, E., Markevich, N., Schutzer, R. W., et al. (2003). Small popliteal artery aneurysms: are they clinically significant? *Journal of Vascular Surgery*, 37(4), 755–760.

Lowell, R. C., Glaviczki, P., Hallet, J. W., et al. (1994). Popliteal artery aneurysms: the risk of nonoperative management. *Annals of Vascular Surgery*, 8(1), 14–23.

35. **E.** A patient with an upper gastrointestinal bleed and a history of aortic surgery should be presumed to have an aortoenteric fistula until proven otherwise. The treatment algorithm depends on the hemodynamic stability of the patient. If the patient is unable to be stabilized due to massive hemorrhage, the patient should be taken emergently to the operating room, even if a diagnosis has not yet been established. Oftentimes, the patient will have a so-called herald bleed, after which the bleeding may temporarily stop, allowing a workup for an aortoenteric fistula. The diagnosis can be difficult to establish. Upper endoscopy has the highest yield, but is negative surprisingly often. Duodenal graft erosion typically occurs at the fourth portion of the duodenum, and findings may be subtle, such as mild mucosal erosion. If the endoscopy findings are negative, repeating the upper endoscopy with a pediatric colonoscope may reveal an abnormality. The next study of choice would be CT. It is unlikely to show blood extravasation but rather may demonstrate perigraft fluid, air, or inflammation, indicative of a graft infection. Fluid and inflammatory changes around a graft would be abnormal findings beyond 6 weeks after surgery (A). If the CT scan findings are negative, a nuclear tagged white blood cell scan may be useful for establishing a graft infection (C). Arteriography is of limited benefit for the diagnosis of vascular graft infections but can be useful in preoperative planning (B). In some instances, no source of an upper gastrointestinal bleed is found, and thus one must empirically proceed to graft excision (D). The classic operative management consisted of obtaining proximal aortic control of the aorta at the diaphragm, graft excision, closure of the aortic stump in two layers, closure of the duodenum, placing omentum in the area of the aortic stump closure, followed by an extra-anatomic axillobifemoral bypass. Recently, the more accepted treatment is excision of the aortic graft and in situ placement of a human aortic homograft.

**Reference:** Berger, P., & Moll, F. L. (2011, December). Aortic graft infections: is there still a role for axillobifemoral reconstruction? In *Seminars in vascular surgery* (Vol. 24, No. 4, pp. 205-210). WB Saunders.

36. **C.** Common iliac aneurysms are usually diagnosed incidentally. In most cases, they are found in association with an aortic aneurysm. Rare presentation includes the development of a fistula with the adjacent iliac vein or compression of the iliac vein. The natural history of common iliac aneurysms is less well defined. In a recent study, the expansion rate of common iliac aneurysms was 0.29 cm per year, and hypertension predicted faster expansion. Because no rupture of a common iliac aneurysm smaller than 3.8 cm was observed, the recommended threshold for elective repair of asymptomatic patients was larger than 3.5 cm (A, B, D, E). Treatment options include open surgical replacement with prosthetic graft or endovascular stent grafting. In patients with suitable anatomy, namely, the presence of proximal and distal landing zones, stent grafting has become the treatment of choice. Endovascular repair is associated with fewer complications overall but poses a higher risk of creating buttock claudication due to occlusion of the internal iliac artery.

**Reference:** Huang, Y., Gloviczki, P., Duncan, A., et al. (2008). Common iliac artery aneurysm: expansion rate and results of open surgical and endovascular repair. *Journal of Vascular Surgery*, 47(6), 1203–1210.

37. **B.** Popliteal aneurysms rarely rupture (A). Most commonly, they cause acute or chronic ischemia. In most series, the most common symptom is thrombosis, in as many as 49%, followed by distal embolization. As the aneurysm continues to grow, less commonly, it can compress adjacent structures, such as the popliteal vein (D, E). Chronic embolization can lead to occlusions of the infrapopliteal vessels and can complicate revascularization (C). If they present with acute ischemia, thrombolysis is the intervention of choice, followed by operative repair. Recently, endovascular stent grafting has been used, although long-term patency data are still lacking.

**References:** Dorigo, W., Pulli, R., Turini, F., et al. (2002). Acute leg ischemia from thrombosed popliteal artery aneurysms: role of preoperative thrombolysis. *European Journal of Vascular and Endovascular Surgery*, 23(3), 251–254.

Shortell, C. K., DeWeese J. A., Ouriel K., et al. (1991). Popliteal artery aneurysms: a 25-year surgical experience. *Journal of Vascular Surgery*, 14(6), 771–776.

38. **C.** Recent studies have shown that AAAs as large as 5.5 cm in diameter can be safely observed (D). Another recent randomized study indicated that although the perioperative mortality rate of EVAR is lower than that of open repair, long-term mortality is the same (C). Women have been shown to have higher perioperative mortality rates than men with either EVAR or open repair. EVAR should not lower the size threshold for repair in a high-cardiac risk patient if the AAA has not yet reached the 5.5-cm threshold (B). Guidelines for treatment of AAAs, as reported by a subcommittee of the Joint Council of the American Association for Vascular Surgery and Society for Vascular Surgery, follow:

1. The arbitrary setting of a single-threshold diameter for elective AAA repair that is applicable to all patients is not appropriate because the decision for repair must be individualized in each case.
2. Randomized trials have shown that the risk of rupture of small AAAs is quite low and that a policy of careful surveillance of those with a diameter of as large as 5.5 cm is safe, unless there is rapid expansion (>1 cm/yr) or symptoms develop. However, early surgery is comparable to surveillance with later surgery, so patient preference is important, especially for AAAs 4.5 to 5.5 cm in diameter.
3. Based on the best available current evidence, a diameter of 5.5 cm appears to be an appropriate threshold for repair in an average patient. However, subsets of younger low-risk patients with a long projected life expectancy may prefer early repair. If the surgeon's personal documented operative mortality rate is low, repair may be indicated at smaller sizes if that is the patient's preference.
4. For women or for AAAs with a greater than average rupture risk, 4.5 to 5 cm is an appropriate threshold for elective repair (A).
5. For high-risk patients, delay in repair until the diameter is larger is warranted, especially if endovascular aortic repair is not possible (E).
6. In view of its uncertain long-term durability and effectiveness as well as the increased surveillance burden, EVAR is most appropriate for patients at increased risk of conventional open aneurysm repair. EVAR may be the preferred treatment method if anatomy is appropriate for older high-risk patients, those with a hostile abdomen, or other clinical circumstances likely to increase the risk of conventional open repair.
7. Use of EVAR in patients with unsuitable anatomy markedly increases the risk of adverse outcomes, the need for conversion to open repair, or AAA rupture.
8. At present, there does not seem to be any justification that EVAR should change the accepted size threshold for intervention in most patients.
9. In choosing between open repair and EVAR, patient preference is of great importance. It is essential that the patients be well informed to make such choices.

**References:** Brewster, D., Cronenwett, J., Hallett, J. Jr., et al. (2003). Guidelines for the treatment of abdominal aortic aneurysms. Report of a subcommittee of the Joint Council of the American Association for Vascular Surgery and Society for Vascular Surgery. *Journal of Vascular Surgery*, 37(5), 1106–1117.

Mureebe, L., Egorova, N., McKinsey, J., et al. (2010). Gender trends in the repair of ruptured abdominal aortic aneurysms and outcomes. *Journal of Vascular Surgery*, 51(4), 9S–13S.

39. **B.** Endoleak is a common complication after EVAR that can lead to aneurysm enlargement and even rupture. Endoleaks occur in as many as 40% of patients after EVAR. Most endoleaks are found in the immediate postoperative period, but late endoleaks also develop. For this reason, routine lifelong postoperative surveillance with CT scanning is recommended. New endoleaks have been identified as late as 7 years after EVAR. Endoleaks are classified into five major types (types I–V) based on the source of communication between the circulation and the aneurysm sac. The most common type of leak after endovascular repair is a type II leak, which results from retrograde filling of the aneurysm sac from the lumbar arteries or the IMA. Management of type II leaks is

controversial and is based on whether the aneurysm is enlarging or stable. Options include coil embolization of the vessel, laparoscopic ligation, or observation. Type I leaks occur at the stent-graft attachment sites (either at the aorta or at the iliac arteries) (A); type III leaks occur at a stent-stent interface and are also known as modular disassociations (C); type IV leaks are directly through the graft and are due to graft material porosity (D). They usually heal spontaneously. The most dangerous type of leak is a proximal type I leak because there is a failure to achieve a proximal seal, leading to continued filling of the aneurysm sac at systemic pressures. Type I leaks require immediate treatment when discovered, typically by deploying another stent or, if unsuccessful, by open surgical conversion. Type III endoleaks represent a true mechanical failure of the endograft and require repair with an additional endograft to eliminate systemic flow and pressure in the aneurysm. Type V leak is also referred to as endotension. This can be considered idiopathic because the aneurysmal sac may appear to be enlarging without any evidence of a leak site on imaging (E).

**Reference:** Corriere, M., Feurer, I., Becker, S., et al. (2004). Endoleak following endovascular abdominal aortic aneurysm repair: implications for duration of screening. *Annals of Surgery*, 239(6), 800–807.

40. E. This patient most likely has an arterial thrombus secondary to heparin-induced thrombocytopenia thrombosis (HITT). The classic laboratory finding is a decrease in the platelet count of more than 50%. Although thrombocytopenia usually increases the risk of bleeding, HITT is paradoxically known to cause a hypercoagulable state; it is the second most common acquired hypercoagulable state (smoking is the most common). There are two types of HITT with type 2 being more common and responsible for the clinical syndrome. HITT type 2 is caused by antibodies to platelet-factor 4 and heparin sulfate resulting in a prothrombotic state (will appear as a white clot). It typically occurs 3 to 5 days after starting heparin. If this is suspected, heparin should be discontinued, and the patient should be started on a direct thrombin inhibitor. Argatroban is the recommended agent for patients with HITT and renal impairment. Lepirudin and bivalirudin both undergo renal excretion and should be avoided in patients with ESRD (A, D). The patient initially had acute limb ischemia secondary to cardiac emboli from atrial fibrillation. His symptoms resolved with initiation of heparin so it is unlikely that he has underlying antithrombin-III deficiency (C). More studies are needed to evaluate the role of tPA in HITT (B).

**References:** Guzzi, L. M., McCollum, D. A., Hursting, M. J., et al. (2006). Effect of renal function on argatroban therapy in heparin-induced thrombocytopenia. *Journal of Thrombosis and Thrombolysis*, 22(3), 169–176.

Visentin, G. P., Ford, S. E., Scott, J. P., et al. (1994). Antibodies from patients with heparin-induced thrombocytopenia/thrombosis are specific for platelet factor 4 complexed with heparin or bound to endothelial cells. *The Journal of Clinical Investigation*, 93(1), 81–88.

# Vascular—Venous

*Michael D. Sgroi, Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 44-year-old male presents to the emergency department (ED) with a temperature of 103°F. He is hypotensive despite a 2-L fluid bolus. He is prepped for a right internal jugular 9-French central venous line to start pressors while being worked up for an underlying cause. Following placement of the catheter, pulsatile bleeding is noted from the catheter. What is the best next step?
  - A. Downsize to a smaller catheter in the ED, transfer the patient to the intensive care unit (ICU), and remove it in several hours.
  - B. Immediately remove the catheter, and hold pressure for 10 to 15 minutes.
  - C. Immediately remove the catheter, and then get a duplex ultrasound study of the neck.
  - D. Remove the catheter under direct surgical exposure.
  - E. Transfer patient to the ICU, then remove, hold pressure, and place a suture in the skin.
2. A 45-year-old woman presents with a nonhealing ulcer at the medial malleolus associated with leg edema and hyperpigmentation but no signs of infection. First-line management consists of:
  - A. Wet-to-dry dressings
  - B. Split-thickness skin grafting
  - C. Subfascial perforator ligation
  - D. Local wound debridement followed by intravenous antibiotics
  - E. Compression dressings
3. A 50-year-old male presents with a venous stasis medial malleolar ulcer that has failed to heal with conservative management. He has large varicose veins in the lower leg, edema, and hyperpigmentation. There is no deep vein thrombosis (DVT) identified on duplex ultrasound. However, there is incompetence of the superficial, deep, and perforator systems. Which of the following is the best next step?
  - A. Vein stripping of the greater saphenous vein and ultrasound-guided sclerotherapy of perforators
  - B. Radiofrequency ablation (RFA) of the greater saphenous vein and ultrasound-guided perforator sclerotherapy
  - C. RFA of the greater saphenous vein and compression stockings
  - D. Stab avulsion of varicose veins
  - E. Ultrasound-guided perforator vein sclerotherapy
4. A 35-year-old female presents with left leg swelling. There are no precipitating factors. Ultrasound confirms a left iliofemoral DVT, and the patient is started on heparin. Workup reveals no evidence of risk factors for DVT, such as recent surgery, prolonged immobilization, nor any evidence of malignancy. Which of the following is most likely to be of long-term benefit?
  - A. Low-molecular-weight heparin (LMWH)
  - B. Long-term (>12 months) anticoagulation
  - C. Lifelong compression stocking
  - D. Right-to-left femoral vein bypass
  - E. Venous thrombectomy

5. Which of the following is true regarding the management of DVT?
- A. For patients with proximal DVT of the leg and no cancer history, direct Xa inhibitor is recommended over warfarin.
  - B. For a leg DVT in association with malignancy, warfarin is preferred over LMWH.
  - C. For incidentally discovered DVT, anticoagulation is unnecessary.
  - D. In patients with isolated distal (calf) DVT of the leg, anticoagulation therapy is superior to serial imaging.
  - E. In patients with a second episode of DVT, lifelong anticoagulation is indicated.
6. A 58-year-old male with newly diagnosed metastatic colon cancer presents to the ED with a massively swollen right leg and severe pain that started 1 day earlier. On exam, he has massive edema of the right leg and is tender to palpation. His foot appears blue. Duplex scan confirms a DVT. Which of the following is true about this condition?
- A. The risk of limb loss is low.
  - B. This occurs more commonly on the right side.
  - C. A pale, white foot carries a worse prognosis than a blue foot.
  - D. Associated hypotension is usually the result of sepsis.
  - E. Catheter-directed thrombolysis should be performed.
7. Which of the following is true regarding starting a heparin drip in a 100-kg patient with a newly diagnosed DVT?
- A. A bolus of 10,000 units of heparin should be given before starting the drip.
  - B. The drip should be started at 18 units/kg per hour.
  - C. The international normalized ratio (INR) needs to be checked daily.
  - D. Activated partial thromboplastin time (aPTT) should be titrated to 100 to 120 seconds after starting the drip.
  - E. Heparin should be stopped if the platelet count increases by more than 50%.
8. Which of the following is true regarding venous circulation?
- A. The perforating veins in the leg direct blood flow from deep to the superficial system.
  - B. The common iliac veins have valves.
  - C. In a healthy person, venous pressure increases with walking.
  - D. The greater saphenous vein joins the femoral vein to become the common femoral vein.
  - E. Muscle contraction plays no role in venous return.
9. Which of the following is the most common risk factor for spontaneous venous thromboembolism?
- A. Antithrombin III deficiency
  - B. Factor V Leiden
  - C. Protein C deficiency
  - D. Protein S deficiency
  - E. Antiphospholipid syndrome
10. A 40-year-old woman presents with pain and tenderness at the site of a long-standing varicose vein in her calf. There is a palpable cord with surrounding erythema. Management consists of:
- A. Intravenous (IV) heparin sodium
  - B. Subcutaneous low-molecular-weight heparin
  - C. Warm compresses and nonsteroidal anti-inflammatory drugs
  - D. Ligation of saphenous vein at saphenofemoral junction
  - E. IV antibiotics
11. A 60-year-old male presents with pain, tenderness, and redness over his left mid, medial thigh. He had a similar event in his other thigh a month earlier. He has noted a decreased appetite. On exam he has no varicose veins, nor evidence of hyperpigmentation or leg swelling. Duplex scan shows an 8-cm segment of thrombosis of the mid saphenous vein but no DVT. Which of the following is recommended?

- A. Systemic anticoagulation
  - B. Warm compresses and a CT of the abdomen
  - C. Ligation and stripping of the left saphenous vein
  - D. Systemic anticoagulation and a CT of the abdomen
  - E. Warm compresses and nonsteroidal antiinflammatory drugs (NSAIDs)
12. Which of the following is the best indication for placement of an inferior vena cava (IVC) filter?
- A. For a pregnant patient in the third trimester diagnosed with a new DVT
  - B. In a patient with severe pelvic fractures
  - C. For a patient with a large free-floating vena cava thrombus
  - D. For a recurrent DVT in a patient who is already therapeutic on warfarin
  - E. Before planned thrombolysis of a new DVT
13. A 25-year-old male college swimmer presents with sudden onset of right arm swelling and pain. A duplex ultrasound scan demonstrates thrombosis of the axillary-subclavian vein. The patient is started on IV heparin. The most important additional adjunctive therapy for this patient is:
- A. First rib resection
  - B. Catheter-guided thrombolysis
  - C. Lifelong anticoagulation
  - D. Venous stenting
  - E. Physical therapy
14. The most common electrocardiographic change after pulmonary embolism (PE) is:
- A. Atrial fibrillation
  - B. Right bundle branch block
  - C. Nonspecific ST and T wave changes
  - D. S1, Q3, T3 pattern
  - E. Sinus tachycardia
15. Trauma patients sustaining what type of injury are at highest risk of venous thromboembolism?
- A. Head trauma
  - B. Femur fracture
  - C. Pelvic fracture
  - D. Splenectomy
  - E. Spinal cord injury

## Answers

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1. **D.** The right internal jugular vein is the preferred option for central line placement because it is easily accessible and has a lower risk of pneumothorax compared to a subclavian line. It also has a straight course into the right atrium. In 70% of individuals, the internal jugular vein lies anterolateral to the carotid artery. However, in some cases it may lie directly anterior or posterior to the carotid artery, increasing the risk of a carotid artery cannulation. If the carotid artery is entered with the probe needle (as evidenced by pulsatile bleeding), the needle should be immediately removed and pressure should be held for 10 minutes. If the artery is cannulated with a dilator or catheter, then the catheter should not be removed blindly. This could lead to a potential airway-threatening hemorrhage. It is safer to remove the catheter in the operating room via direct surgical exposure, followed by suture repair of the artery (A–C, E).

**Reference:** Kron, I., & Ailawadi, G. (2011). Cardiovascular monitoring and support. In J. E. Fischer (Ed.), *Fischer's mastery of surgery* (6th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

2. **E.** This patient has classic signs of chronic venous insufficiency. Venous stasis ulcers are classically located at the medial malleolus. The precise cause of venous stasis ulcers is unclear but seems to be multifactorial. The increased venous pressure from incompetent valves results in an impedance of capillary flow, which leads to leukocyte trapping. These leukocytes release oxygen free radicals

and proteolytic enzymes that lead to local inflammation. The increased venous pressure also leads to the leakage of protein, such as fibrinogen, which acts as a barricade to oxygen and growth factors necessary for wound healing. The first-line therapy for treatment of venous stasis ulcers is compression therapy (A–D). The workup for this patient should include a duplex ultrasound scan of the venous system, specifically looking for valvular incompetence of the deep, superficial, and perforating veins. A popular and effective compression bandage is the Unna boot, which contains zinc oxide, glycerin, gelatin, and calamine lotion. The boot should be wrapped starting at the foot, up to just below the knee. It can remain in place for as long as a week. It should not be used in the setting of an active infection of the ulcer. In this situation, debridement and antibiotics will be needed first.

3. **C.** A spectrum of chronic venous disorders, from varicose veins to venous stasis ulcers, afflicts 20% to 25% of the population. The underlying etiology is incompetence of the venous valves in either the deep, superficial (saphenous), or perforator veins. Patients with chronic venous disease are classified and treated based on the severity of their disease. The CEAP (clinical, etiologic, anatomic, and pathophysiologic) classification is used worldwide to standardize this evaluation. It is important when discussing treatment with a patient that he or she understands that this is an incurable disease and that the goal of intervention is to minimize symptoms and prevent recurrence. In general, superficial incompetence is dealt with first. In a patient with a nonhealing wound that has incompetent valves in all three venous systems, (superficial, perforator, and deep) and is unresponsive to compression therapy, the superficial venous incompetence is addressed first by obliterating the saphenous vein along with compression therapy. This can be done via saphenous vein stripping, foam sclerotherapy, or RFA. A recent randomized study demonstrated equal results with all three approaches. That being said, RFA is generally preferred and is the current recommendation of the American Venous Forum, due to its less invasive nature as compared with stripping (A, B–E). Freedom of reflux has been seen in 93% of patients at 2 years after ablation therapy. Primary venous insufficiency is a recognized risk factor for the development of DVT, and it is important to rule this out before intervention to minimize treatment failure. If treating the superficial system is not successful, the next step is to treat the perforator incompetence. This is done via ultrasound-guided sclerotherapy. There is no surgical treatment that is reliably effective for deep system incompetence. Stab avulsions of varicose veins alone are not sufficient because they do not address the valvular incompetence (D).

**References:** Meissner, M. H. (2016). What is effective care for varicose veins? *Phlebology*, 31(Suppl. 1), 80–87.

O'Donnell, T., Passman, M., Marston, W. et al. (2014). Management of venous leg ulcers: clinic practice guidelines of the Society for Vascular Surgery and the American Venous Forum. *Journal of Vascular Surgery*, 60(Suppl. 2), 3S-59S.

Shaydakov, M. E., Comerota, A. J., & Lurie, F. (2016). Primary venous insufficiency increases risk of deep vein thrombosis. *Journal of Vascular Surgery Venous Lymphatic Disorders*, 4(2):161–166.

4. **B.** DVT and pulmonary embolism (PE) affect up to 900,000 people per year in the United States, and their incidence increases with age. When a patient presents with a DVT, always try to determine what part of the Virchow triad (stasis, vascular injury, and hypercoagulability) can explain the event. This will serve as a reminder to perform a careful history and physical examination to assess risk factors for DVT. In most cases, the cause is multifactorial. The duration and type of anticoagulation depends on whether the DVT is provoked (i.e., malignancy, recent surgery, prolonged immobilization) or unprovoked, what the provoking factor is, and on the location (proximal, distal leg) of the DVT. Proximal (iliofemoral) DVTs are more likely to lead to massive swelling and long-term sequelae of postphlebotic syndrome. As such, more consideration should be given to the type of anticoagulant, the duration, use of thrombolytics, and mechanical thromboembolectomy as compared with distal DVT. LMWH is not as efficacious for proximal DVT (A). For a proximal (iliofemoral) DVT, that is unprovoked (no clear contributing factors), the recommendation is for long-term (>12 months) anticoagulation. The benefit of compression stockings to prevent postphlebotic syndrome is controversial (C). Most authors recommend 2 years of compression; lifelong compression has no benefit, has poor patient compliance, and is associated with significant costs of renewing expensive stockings every 6 months. A right-to-left femoral vein bypass (with right leg saphenous vein) is rarely performed and would be a last resort for chronic venous stasis that is unresponsive to endovascular options (D). Thrombolytic therapy is an option for select patients with severe iliofemoral DVT, particularly if they present with



phlegmasia. Venous thrombectomy is reserved for patients with phlegmasia who have failed thrombolytic therapy (E).

**Reference:** Heffner, J. E. (2016). Update of antithrombotic guidelines: medical professionalism and the funnel of knowledge. *Chest*, 149(2), 293–294.

5. **A.** The American College of Chest Physicians released updated guidelines in 2016 for the management of DVTs. One major change is that patients with proximal DVT of the leg and no cancer history should now be treated with a direct Xa inhibitor (dabigatran, rivaroxaban, apixaban, or edoxaban) over warfarin. Additionally, initial parenteral anticoagulation with a heparin drip is not required when using rivaroxaban and apixaban. However, a heparin drip should be started before administering dabigatran or edoxaban and overlapped with warfarin therapy. Several reports have shown the superiority of these novel oral anticoagulant agents, but there has been reluctance in using them liberally as there were no reversal agents available. Only recently has idarucizumab received expedited approval by the U.S. Food and Drug Administration (FDA) to be used as a reversal agent for dabigatran. With a reversal drug now available coupled with the new CHEST guidelines, these agents will likely become the standard of care in the next few years for noncancer patients with DVTs. In patients with a cancer history and proximal DVT of the leg, LMWH is recommended over warfarin and direct Xa inhibitors (B). This is unchanged from the prior guidelines. In patients with a proximal DVT of the leg provoked by surgery, 3 months of anticoagulation therapy is recommended over a longer time-limited period (6, 9, 12, or 24 months). This recommendation applies to patients with both low and high bleeding risks. The management of isolated calf DVT remains controversial. Anticoagulation is recommended for those with severe leg symptoms or those with risk factors for propagation. In patients with an isolated distal DVT of the leg and without severe symptoms or risk factors for extension, serial imaging of the deep veins for 2 weeks is recommended over anticoagulation therapy (D). There is no consensus on the duration of therapy for patients with a second episode of DVT because this depends on the presence of reversible risk factors, underlying cause, malignancy, life expectancy, and burden of therapy. However, most surgeons would recommend at least 1 year of anticoagulation therapy for patients with a second episode of DVT and lifelong anticoagulation for patients with more than two episodes of DVT (E). Incidentally discovered DVT should be treated with anticoagulation (C).

**References:** Connors, J. M. (2015). Antidote for factor Xa anticoagulants. *The New England Journal of Medicine*, 373(25), 2471–2472.

Heffner, J. E. (2016). Update of antithrombotic guidelines: medical professionalism and the funnel of knowledge. *Chest*, 149(2), 293–294.

6. **E.** Massive iliofemoral DVT can lead to impaired arterial blood flow due to massive swelling. Early on the limb turns pale and is referred to as phlegmasia alba (white) dolens. In a subgroup of patients, this may progress to impending gangrene phlegmasia cerulea (blue) dolens as in the patient described. When the majority of the deep venous channels are burdened with clot, the relatively smaller superficial venous channels are tasked with draining the entire leg. Patients develop a tender, pale, and edematous extremity. This is known as “milk-leg” since the pale extremity appears whitish (alba). As the disease progresses and the superficial venous channels are also affected, the entire venous drainage of the leg is compromised causing massive edema in the leg. As the swelling continues, arterial malperfusion ensues leading to severe ischemia (blue extremity) risking limb loss (C). DVT and as an extension, phlegmasia, both occur more commonly on the left. This is a result of the left iliac vein frequently being compressed by the right iliac artery (known as May-Thurner syndrome) (B). The most common risk factor identified for phlegmasia is underlying malignancy. The fastest and safest method of confirming the diagnosis is with duplex ultrasound. CT angiography is not required unless history, exam, and ultrasound findings are equivocal. Initial treatment is similar to an acute DVT, with some qualifiers. More emphasis should be placed on leg elevation. Due to fluid sequestration, patients may present with hypovolemic shock and thus may need massive volume resuscitation (D). Risk of limb loss, pulmonary embolism, postphlebitic syndrome, and mortality are all high (A). As such, thrombolytic therapy has emerged as the treatment of choice.

**Reference:** Chinsakchai, K., Ten Duis, K., Moll, F., et al. (2011). Trends in management of phlegmasia cerulea dolens. *Vascular and Endovascular Surgery*, 45(1), 5–14.

7. **B.** If a heparin drip is started, a bolus of 80 units/kg (8,000 units for the above patient) should first be given followed by the continued infusion of heparin at 18 units/kg per hour (A). In patients with

DVT, the aPTT needs to be drawn every 6 to 12 hours with a goal rate of 60 to 90 seconds (D). INR is checked in patients on warfarin (C). Heparin can potentially lead to heparin induced thrombocytopenia (HIT). This usually happens 5 days or more after the initiation of heparin and will present as a 50% drop in platelet count (E).

**Reference:** Hirsh, J., Bauer, K., Donati, M., et al. (2008). Parenteral anticoagulants. American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*, 133(Suppl. 6), 141–159.

8. **D.** The lower extremity veins are divided into superficial, perforating, and deep veins. The superficial venous system consists of the greater saphenous and lesser saphenous veins. The deep veins follow the course of major arteries. Paired veins parallel the anterior and posterior tibial and peroneal arteries and join to form the popliteal vein. The popliteal vein becomes the femoral vein as it passes through the adductor hiatus. In the proximal thigh, the greater saphenous vein joins in with the femoral vein to become the common femoral vein. Multiple perforating veins traverse the deep fascia to connect the superficial and deep venous systems. The most important perforators are the Cockett and Boyd perforators. The Cockett perforators drain the lower part of the leg medially, whereas the Boyd perforators connect the greater saphenous vein to the deep vein higher up in the medial lower leg, approximately 10 cm below the knee. Blood flows from the superficial to the deep venous system (A). Incompetence of these perforators is a major contributor to the development of venous stasis and ulceration. There are no valves in the portal vein, superior vena cava, or inferior vena cava (IVC), or common iliac vein (B). The calf muscles serve an important function in augmenting venous return by acting as a pump to return blood to the heart (E). For this reason, patients who are bedridden are prone to venous stasis. Venous pressure drops dramatically with walking because of the action of the calf muscles but increases in patients with venous obstruction because this leads to persistent stasis that muscle contraction cannot overcome (C). This is why compression stockings are recommended in these patients, as an adjunct to normal venous return.
  9. **B.** The primary risk factors for spontaneous venous thromboembolism (VTE), as described by Virchow, include stasis of blood flow, endothelial injury, and hypercoagulability. In cases of spontaneous VTE, hypercoagulability is most important. Factors that contribute to hypercoagulability include factor V Leiden, prothrombin gene mutation, protein C and S deficiency, antithrombin III deficiency, elevated homocysteine levels, and antiphospholipid syndrome. In addition, nonacquired causes of VTE include smoking (most common), obesity, pregnancy, malignancy, and use of oral contraceptives. In surgical patients, the cause of VTE is multifactorial because postoperative stasis from prolonged bed rest and endothelial injury from trauma or recent surgery are significant factors. In trauma patients, spinal cord injury has the highest risk for VTE. Other risk factors for VTE include history of VTE, advanced age, and varicose veins. Factor V Leiden is the most common genetic defect associated with thrombophilia (A, C–E). Factor V Leiden is a single-point mutation in the gene that codes for coagulation factor V. It makes factor V resistant to inactivation by activated protein C (which is a natural anticoagulant protein). The mutation is transmitted in an autosomal dominant fashion and accounts for 92% of cases of anticoagulant protein resistance. The mutation is present in 4% to 6% of the general population and is associated with a sixfold increased risk of VTE in heterozygotes. In homozygotes, the risk is 80-fold. In patients with their first VTE, factor V Leiden was present in 15% to 20%. There is no standard guideline to the duration of anticoagulation therapy in patients with an acquired hypercoagulable state. It is believed an individualized approach should be taken assessing each person's risk of a recurrent VTE and comparing this to their relative risk of a bleeding event. Interestingly, in one study, the risk of recurrent VTE was similar among carriers of the factor V Leiden gene compared with those without this mutation, suggesting that they do not need longer anticoagulation than standard recommendation for a first-time event.
- References:** Bauer, K. A. (2010). Duration of anticoagulation: applying the guidelines and beyond. *Hematology / the Education Program of the American Society of Hematology. American Society of Hematology. Education Program*, 2010, 210–215.
- Mazza, J. (2004). Hypercoagulability and venous thromboembolism: a review. *WMJ: official publication of the State Medical Society of Wisconsin*, 103(2), 41–49.
10. **C.** The patient has superficial venous thrombosis (SVT) or thrombophlebitis. This entity is essentially a clotted surface vein. A palpable cord is suggestive of the diagnosis, as are accompanying pain and erythema. There are a few pitfalls in the diagnosis and management of

SVT. Patients with SVT may have a concomitant DVT (5–40%); thus, a duplex ultrasound scan of the venous system is essential. Second, SVT can easily be misdiagnosed as cellulitis, in which case antibiotics may be inappropriately prescribed and a duplex ultrasound scan not obtained. SVT is generally best managed with warm compresses and NSAIDs. IV antibiotics are reserved for septic thrombophlebitis, which is typically associated with an intravenous line (E). Systemic anticoagulation is reserved for a SVT that is near the deep system (A, B). If anticoagulation is contraindicated, ligation of the saphenous vein at the saphenofemoral junction is indicated for a saphenous vein SVT (D). Varicose veins cause stasis and thus predispose to SVT.

11. **D.** Unlike the vignette in [question 10](#), which was a provoked SVT (stasis in a varicose vein), unprovoked SVT, and in particular, recurrent unprovoked SVT, and more specifically recurrent, unprovoked SVT in different limbs (superficial migratory thrombophlebitis) should prompt concern for hypercoagulability and, in particular, malignancy. Superficial migratory thrombophlebitis is particularly associated with pancreatic cancer (Trousseau's sign) and, to a lesser degree, stomach and lung cancer. Thus treatment should include a targeted workup for malignancy (that should be tailored to findings on history, review of systems, and physical exam) (B, C–E). SVT within the saphenous vein in the upper thigh, within 3 cm of the saphenofemoral junction and those with long segments (>5 cm), have an increased risk of propagating into the deep system and thus benefit from anticoagulation (A). A recent study comparing fondaparinux with placebo demonstrated a decrease in DVT, recurrent thrombophlebitis, and clot progression with fondaparinux. If it is not close to the femoral vein, a follow-up duplex ultrasound scan should be performed in 5 to 7 days to determine evidence of more proximal propagation.

**References:** Chengelis, D., Bendick, P., Glover, J., et al. (1996). Progression of superficial venous thrombosis to deep vein thrombosis. *Journal of Vascular Surgery*, 24(5), 745–749.

Jorgensen, J., Hanel, K., Morgan, A., et al. (1993). The incidence of deep venous thrombosis in patients with superficial thrombophlebitis of the lower limbs. *Journal of Vascular Surgery*, 18(1), 70–73.

12. **D.** Enthusiasm for the aggressive use of IVC filters is tempered by the sobering fact that filters left in place for long periods of time, although effective in preventing PE, do not come without consequences. Some of these complications include migration of the filter, fracturing of the legs of the filter, vena cava perforation, as well as the *increased* risk of a recurrent DVT. Filters decrease the risk of a PE but increase the risk of DVT. In a prospective randomized study of patients with DVT, the routine addition of an IVC filter did not improve mortality compared with heparin and warfarin alone. Additionally, PREPIC 2 trial has also demonstrated an increase number of recurrent PEs in the filter group compared to the anticoagulation only group (3% vs 1.5%). IVC filters can be either permanent or retrievable. Retrievable filters should optimally be removed within 9 to 12 weeks, which is why they are ideally used in a situation in which there is a short-term need for protection against PE. Absolute indications for permanent IVC filter placement include a venous thromboembolic event (VTE [DVT or PE]) in a patient who has a contraindication to anticoagulation (such as active gastrointestinal bleeding), a new VTE that develops in a patient who is already receiving therapeutic anticoagulation, or a patient with a VTE who is already receiving anticoagulation and in whom a major hemorrhage develops (B, C–E). Relative indications for a retrievable filter placement include before planned thrombolysis of a new DVT (as the thrombus may break off toward the lungs during the lysis process), a recent DVT and planned major surgery, and prophylaxis in severe head, pelvic, or spinal cord trauma. Relative indications for a permanent IVC filter include a patient with a VTE who is poorly compliant with anticoagulant therapy, recurrent episodes of VTE, and the presence of a large free-floating thrombus in the IVC. There are eight different permanent filters and three different retrievable filters available in the United States. Pregnant patients diagnosed with a new DVT should be started on anticoagulation with low-molecular-weight heparin for the remainder of the pregnancy and up to 6 weeks postpartum (A). Warfarin should be avoided since it is teratogenic.

**References:** Decousus, H., Leizorovicz, A., Parent, F., et al. (1998). A clinical trial of vena caval filters in the prevention of pulmonary embolism in patients with proximal deep-vein thrombosis. *The New England Journal of Medicine*, 338(7), 409–415.

Millward, S., Oliva, V., Bell, S., et al. (2001). Günther tulip retrievable vena cava filter: results from the Registry of the Canadian Interventional Radiology Association. *Journal of Vascular and Interventional Radiology*, 12(9), 1053–1058.

Rajasekhar, A. (2015). Inferior vena cava filters: current best practices. *Journal of Thrombosis and Thrombolysis*, 39(3), 315–327.

13. **A.** Paget-Schroetter syndrome, also known as effort-induced thrombosis, is a spontaneous thrombosis of the axillary-subclavian vein. It is thought to be, in most instances, a manifestation of thoracic outlet syndrome, whereby a hypertrophied or aberrant muscle compresses the axillary-subclavian vein as it passes between the first rib and the clavicle. It tends to develop in young active patients after vigorous activity (swimming, pitching, weightlifting), although it can also occur spontaneously. It usually presents in men more often than women. Secondary axillary/subclavian vein thrombosis can also present in those with mediastinal tumors, congestive heart failure (CHF), and nephrotic syndrome. Diagnosis is best established via duplex ultrasonography. The patient should be promptly started on IV heparin. The most important adjunctive measure to prevent recurrence and long-term swelling is thoracic outlet decompression via first rib resection. The timing is controversial but is not time sensitive. Many authors also recommend catheter-directed thrombolysis for this condition, currently using tissue plasminogen activator (B). However, thrombolysis is associated with increased bleeding risk and costs, and the benefit is unclear, as many patients recanalize the vein spontaneously with anticoagulation. A follow-up venogram is frequently obtained to identify any correctable anatomic abnormalities. Stenting a residual stenosis in this area without decompressing the thoracic outlet is contraindicated because the ongoing compression will invariably crush the stent and cause further venous damage, making any further intervention even more difficult. Residual venous stenoses can be treated with angioplasty, although some authors recommend doing this after the first rib resection. A recent meta-analysis demonstrated a significant improvement in symptoms in those that received a first rib resection compared to those that did not. More than 40% of patients in the control group needed to have a rib resection due to recurrent symptoms. In an active athlete, and in particular one who performs repetitive movement with the arm overhead (which by itself can compress the vein), first rib resection is the best option (C–E).

**References:** Angle, N., Gelabert, H., Farooq, M., et al. (2001). Safety and efficacy of early surgical decompression of the thoracic outlet for Paget-Schroetter syndrome. *Annals of Vascular Surgery*, 15(1), 37–42.

Lee, W., Bradley, B., Harris, E., et al. (2000). Surgical intervention is not required for all patients with subclavian vein thrombosis. *Journal of Vascular Surgery*, 32(1), 57–67.

Machleder, H. I. (1993). Evaluation of a new treatment strategy for Paget-Schroetter syndrome: spontaneous thrombosis of the axillary-subclavian vein. *Journal of Vascular Surgery*, 17, 305–315.

Urschel, H., & Razzuk, M. (2000). Paget-Schroetter syndrome: what is the best management? *The Annals of Thoracic Surgery*, 69(6), 1663–1668.

Lugo, J., Tanious, A., Armstrong, P., et al. (2015). Acute Paget-Schroetter syndrome: does the first rib routinely need to be removed after thrombolysis? *Annals of Vascular Surgery*, 29(6), 1073–1077.

14. **E.** The most common finding on electrocardiography after a PE is sinus tachycardia (present in almost one half of patients) (A–D). A heart rate greater than 100 beats per minute with associated tachypnea in the setting of suspected PE should further raise concern. The classic finding on an electrocardiogram is the S1, Q3, T3 pattern, which consists of a prominent S wave in lead I and a Q wave and inverted T wave in lead III. This electrocardiographic finding indicates right ventricular strain from a large PE, but it is not commonly present. A large PE will lead to an enlargement of the right ventricle causing the interventricular septum to deviate to the left. The right bundle branch stretches, leading to a right bundle branch block.
15. **E.** The increased risk of the development of VTE in surgical patients is multifactorial. Patients will have a period of activated coagulation, transient depression of fibrinolysis, and temporary immobilization. In addition, many patients may have a central venous catheter in place and have concomitant cardiac disease, malignancy, or intrinsic hypercoagulable states, all of which increase a patient's chance of a VTE. Trauma patients, in particular, have a high risk of VTE. In trauma patients, spinal cord injury (odds ratio, 8.33) and fracture of the femur or tibia (odds ratio, 4.82) were the injuries with the greatest risk of VTE (A–D). In one large prospective study, other risk factors in trauma patients on multivariate analysis included older age, blood transfusion, and need for surgery.

**Reference:** Geerts, W., Code, K., Jay, R., et al. (1994). A prospective study of venous thromboembolism after major trauma. *The New England Journal of Medicine*, 331(24), 1601–1606.

# Vascular—Access

*Jerry Kim, Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 45-year-old male with long-standing diabetes presents to the emergency department (ED) with progressive shortness of breath, vague abdominal pain, and marked leg edema. Laboratory values are remarkable for metabolic acidosis and azotemia. Dialysis is urgently needed. Dialysis access would be best instituted via:
  - A. Right internal jugular vein permacath
  - B. Right subclavian vein permacath
  - C. Left internal jugular vein permacath
  - D. Left subclavian vein permacath
  - E. Right femoral vein permacath
2. During placement of a central line, the patient takes a sudden deep breath, introducing a large rush of air into the line. What is the best initial step in management?
  - A. Place the patient in Trendelenburg with the left side down.
  - B. Place the patient in Trendelenburg with the right side down.
  - C. Place the patient in reverse Trendelenburg.
  - D. Quickly aspirate from the catheter.
  - E. Immediately remove the central venous catheter and hold pressure.
3. A left internal jugular vein central line is placed. Fifteen minutes later, the patient is hypotensive. Distended neck veins are noted. Breath sounds are clear bilaterally. What is the most likely cause of the patient's hypotension?
  - A. Perforated right atrium
  - B. Perforated subclavian vein
  - C. Perforated subclavian artery
  - D. Tension pneumothorax
  - E. Perforated right ventricle
4. A 65-year-old female with end-stage renal disease presents with recurrent episodes of congestive heart failure. She is currently dialyzed via a left arm brachiocephalic arteriovenous fistula. Upon compression of the fistula, her heart rate decreases from 80 to 60 beats per minute, and blood pressure increases from 120/70 to 140/80 mm Hg. Which of the following is true about this condition?
  - A. The fistula should be ligated.
  - B. It is unlikely that the fistula is contributing to the patient's heart failure.
  - C. Plicating the fistula may help prevent another episode of heart failure.
  - D. She should undergo a distal revascularization and interval ligation.
  - E. The fistula should be converted to a graft.
5. A 65-year-old woman undergoes creation of a forearm brachial artery-to-cephalic vein loop arteriovenous (AV) graft for hemodialysis in the left arm using a 6-mm polytetrafluoroethylene graft. Four days postoperatively, the patient reports marked coolness, pallor, and numbness in the hand as



- well as decreased strength. On examination, there is no palpable pulse at the radial artery and only a monophasic Doppler signal that becomes biphasic on graft compression. Which of the following is the best management option?
- Distal revascularization and interval ligation of the brachial artery
  - Ligation of the AV graft and placing the upper arm graft in same arm
  - Ligation of the AV graft and placing the fistula in the dominant arm
  - Banding of the AV graft adjacent to the arterial anastomosis
  - Banding of the AV graft adjacent to the venous anastomosis
6. A 45-year-old male develops progressive end-stage renal disease secondary to severe hypertension. His glomerular filtration rate is 19 mL/min, and dialysis is anticipated within the next 6 months. He is right handed and appears to have good veins in both arms and normal pulses. Which of the following is the best management plan for dialysis access?
- Delay access until about a month before anticipated dialysis.
  - Proceed with left radiocephalic arteriovenous fistula (AVF) (Cimino fistula).
  - Proceed with left brachiocephalic AVF.
  - Proceed with left brachio basilic AVF.
  - Proceed with right radiocephalic AVF.
7. A 45-year-old female with end-stage-renal disease presents with recent onset of headaches, hoarseness of her voice, and bilateral arm swelling for 2 days. She has a history of multiple procedures in both arms and legs for hemodialysis access. Most recently she underwent an arteriovenous graft (AVG) in her right upper arm 2 weeks earlier. On examination her neck appears to be engorged and her face swollen. There are numerous visible veins on her chest wall. Which of the following is the best management option?
- Ligation of the AVG
  - Plication of the AVG
  - Attempt venoplasty of superior vena cava (SVC)
  - Place stent in SVC
  - Move AVG to right arm
8. A 50-year-old male with long-standing history of hemodialysis via a left brachiocephalic AVF presents with an aneurysm within the midportion of the AVF. He reports that there has recently been excessive bleeding when the needles have been pulled out. On physical examination, the aneurysm is about 3 cm in size. The overlying skin appears supple, without ulceration. The next step in the management consists of:
- Fistulogram
  - Resection/plication of the aneurysm
  - Replacement of fistula with an AV graft
  - Ligation of the fistula
  - Observation
9. In comparing the three modalities used for hemodialysis (central venous catheter [permacath], AV graft, and AV fistula), which of the following is true?
- They are equal in terms of 1-year patient mortality.
  - The primary patency for AV fistula and AV graft is similar.
  - The secondary patency for AV fistula and AV graft is similar.
  - Time to maturation for AV fistulas and grafts is similar.
  - A permacath is the best dialysis option in the elderly.
10. An intubated patient in the OR develops an air embolism after central venous catheter insertion. Which of the following murmurs are associated with this condition?
- Austin-Flint murmur
  - Carey Coombs murmur
  - Means-Lerman scratch murmur

- D. Still's murmur
- E. Millwheel murmur

## Answers

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1. **A.** When hemodialysis is urgently needed, temporary rapid vascular access must be established with a catheter that will support high flow (generally >400 cc/min) via two lumens. The tunneled hemodialysis catheter, or permacath, is placed into a central vein and exits the skin at least 10 cm away via a subcutaneous tract. Tunneled catheters are ready to use immediately and are less prone to infection than a nontunneled catheter (Quinton catheter). The right internal jugular vein is the first choice because it is the most direct route to the right atrium. Left-sided placement is less preferable because it jeopardizes venous patency for future permanent access in the left arm (as most patients are right-hand dominant). Left-sided catheters also result in lower catheter blood flow rates and increase the risk of stenosis/thrombosis due to the longer and more tortuous length of contact with central vein side-wall (C). The subclavian position is associated with higher rates of complications, namely central vein stenosis, and pneumothorax and in some studies has a higher risk of infection when compared with internal jugular catheters (B–D). The femoral position carries the highest risk of infection, which is a significant cause of mortality in patients with temporary access catheters (E). Femoral lines may compromise a future kidney transplant because it may lead to proximal iliac vein stenosis/thrombosis.

**Reference:** [No authors listed]. (2006). NKF-K/DOQI clinical practice guidelines for vascular access. *American Journal of Kidney Diseases*, 48(Suppl. 1), S227–S409.

2. **A.** An air embolism is a potential complication of central venous catheterization as well as in trauma, during craniotomy in sitting position, cesarean section, hip replacement, and cardiac surgery under bypass. Initial symptoms manifest within the cardiovascular, pulmonary, and neurologic systems. Therefore, patients may experience chest pain, dyspnea, headache, or confusion, and stroke or myocardial infarction may ensue. Transesophageal echocardiogram is diagnostic. However, treatment should not be delayed if a patient is suspected of having an air embolism. In the operating room (OR), the only clinical clue may be an abrupt increase in end-tidal CO<sub>2</sub> followed by a decrease in end tidal CO<sub>2</sub> and hypotension. When recognized during a procedure, the patient should immediately be placed in Trendelenburg position with left side down (Durant's maneuver) and air aspirated from a central venous catheter. Trendelenburg position allows air to move to the apex of the right ventricle, and the left-side down position allows air to float away from the pulmonary outflow tract (B, C). Aspiration is not effective until the patient is correctly positioned (D). The venous catheter should not be removed because it is required to aspirate the trapped air (E).

**Reference:** Gordy, S., & Rowell, S. (2013). Vascular air embolism. *International Journal of Critical Illness Injury Sciences*, 3(1), 73–76.

3. **A.** Clinical signs of cardiac tamponade include hypotension, distended neck veins, and muffled or distant heart sounds (Beck triad). This patient exhibits two of these signs after an invasive procedure of the chest and likely developed cardiac tamponade as a result of perforation of the right atrium. Tamponade caused by central venous catheter placement is a known complication resulting from puncture by the wire, introducer, or the catheter itself. Perforation of the right atrium more often occurs because it has a thinner wall compared to the right ventricle (E). Placing the catheter tip at the right tracheobronchial angle helps avoid placing the catheter tip in the right atrium. A perforated subclavian artery or vein would likely lead to hemothorax rather than pericardial tamponade (B, C). A tension pneumothorax is a known complication of line placement and may result in hypotension and distended neck veins, but breath sounds would not be clear bilaterally (D).

**References:** Barton, J. J., Vanecko, R., & Gross, M. (1968). Perforation of right atrium and resultant cardiac tamponade: a complication of catheterization to measure central venous pressure. *Obstetrics and Gynecology*, 32(4), 556–560.

Darling, J. C., Newell, S. J., Mohamdee O., et al. (2001). Central venous catheter tip in the right atrium: a risk factor for neonatal cardiac tamponade. *Journal of Perinatology*, 21(7), 461–464.

Hunt, R., & Hunter, T. B. (1988). Cardiac tamponade and death from perforation of the right atrium



by central venous catheter, *AJR. American Journal of Roentgenology*, 151(6), 1250.

4. **C.** Blood flow through an arteriovenous fistula is essentially a left-to-right shunt and a portion of the cardiac output is stolen by the fistula (B). Although there is no change in peripheral oxygen consumption after fistula placement, there is a drop in peripheral vascular resistance (PVR). Consequently, a compensatory increase in cardiac output occurs. The increase in venous return increases cardiac preload and causes rises in atrial natriuretic peptide (ANP) and brain natriuretic peptide (BNP). The decrease in afterload results in a decrease in aldosterone and renin levels. This subsequently leads to a decrease in afterload as well as suppression of the renin-aldosterone-angiotensin system and thus promotes natriuresis. Compressing the fistula increases PVR and afterload, leading to a decrease in pulse rate and an increase in blood pressure (Nicoladoni-Branham sign). Patients with higher fistula flow will exhibit greater hemodynamic changes with fistula occlusion. Objectively, the minimum fistula flow rate required to support hemodialysis is greater than 400 to 500 cc/min. However, when the flow rate exceeds 2000 cc/min or 30% of the cardiac output there is a risk of high output cardiac failure. These patients and those with clinically evident episodes of cardiac failure should undergo intervention aimed at reducing flow rates. Surgical plication (narrowing the vein just beyond the anastomosis to the artery by suturing or banding) reduces the flow rate and can partially reverse the hemodynamic changes and prevent future episodes of heart failure. If heart failure continues to occur after appropriate reduction in flow rates, eventual ligation of the fistula is indicated (A). Distal revascularization and interval ligation (DRIL) is used to treat steal syndrome causing ischemic steal syndrome distal to the fistula. The procedure increases resistance to the fistula and decreases resistance to the distal extremity but may not effectively reduce fistula flow in the setting of cardiac failure (D). Converting a native fistula to a graft would not help because the large diameter of a graft would maintain high flow rates (E).

**References:** MacRae, J. M., Levin, A., & Belenkie, I. (2006). The cardiovascular effects of arteriovenous fistulas in chronic kidney disease: a cause for concern? *Seminars in Dialysis*, 19(5), 349–352.

High arteriovenous (AV) access flow and cardiac complications. NKF Task Force on Cardiovascular Disease, *American Journal of Kidney Disease*, 32(5).

5. **A.** A patient presenting with marked coolness, pallor, decreased strength, and hand numbness in the immediate postoperative period following an AV fistula creation should be suspected of having steal syndrome. Ischemic steal syndrome occurs in approximately 1% to 2% of patients with AV fistulas created for hemodialysis. Risk factors for steal syndrome include diabetes, age > 60, and use of the brachial artery. Proximal fistulas have a higher risk of developing steal syndrome while distal wrist fistulas (Cimino fistulas) have a very low risk. AV grafts also have a greater risk of steal compared with native AV fistulas (B). This is likely due to the fact that the large diameter of the graft creates a low-resistance bed. In addition, steal secondary to grafts tends to occur early after the access placement, whereas steal after native AV fistulas has a bimodal distribution, with some presenting early and others late after the native vein has undergone dilation with lowered resistance. Some degree of physiologic steal occurs in every patient with an AV fistula, but only a small minority manifests severe symptoms. The steal syndrome is caused by a diversion of blood flow from the anastomosed artery to the low-resistance vein. In addition, the low-resistance venous anastomosis leads to blood flowing in a retrograde fashion from the distal circulation into the fistula. Mild steal can be managed conservatively with exercise. More severe symptoms require intervention. Although ligation of the AV graft would have a great chance of resolving the steal syndrome, the patient will require a new access and will again be at risk of developing steal (C). Several options exist for the management. The most effective treatment that maintains fistula function is distal revascularization and interval ligation. The disadvantage of this procedure is that it requires creating a new bypass, usually with saphenous vein, from the native artery proximal to the AV graft to the artery distal to it, with interval ligation of the native artery just proximal to the distal anastomosis. Banding or plicating of the AV graft, adjacent to the arterial anastomosis, serves to increase the resistance in the graft and reduce steal. The primary disadvantage of this approach is that inadequate banding leads to persistent steal, and excessive banding causes graft thrombosis (D, E). Banding or plication is a more attractive option for steal in an autologous AV fistula, such as a brachial artery cephalic vein fistula, because the vein is more resistant to thrombosis. This is not as yet the standard approach, however.

**References:** Walz, P., Ladowski, J., & Hines, A. (2007). Distal revascularization and interval ligation

(DRIL) procedure for the treatment of ischemic steal syndrome after arm arteriovenous fistula. *Annals of Vascular Surgery*, 21(4), 468–473.

Yaghoubian, A., & de Virgilio, C. (2008). Plication as primary treatment of steal syndrome in arteriovenous fistulas. *Annals of Vascular Surgery*, 23(1), 103–107.

Yu, P., Cook, T., Canty, R., et al. (2008). Hemodialysis-related steal syndrome: predictive factors and response to treatment with the distal revascularization-interval ligation procedure. *Annals of Vascular Surgery*, 22(2), 210–214.

6. **B.** When permanent hemodialysis access is needed, the nondominant arm (E) should be considered first in order to mitigate the effects of potentially devastating complications including: severe steal syndrome and limb ischemia, ischemic monomelic neuropathy, and nerve injury. Once the side is determined, the type of AVF must be considered. Radiocephalic fistulas should generally be placed first (assuming adequate artery and vein) because subsequent thrombosis will not preclude the placement of a brachiocephalic or brachio basilic fistula more proximally in the arm. Additionally, radiocephalic fistulas may cause dilation of the proximal arm veins allowing higher success of future more proximal fistulas. Radiocephalic fistulas also rarely require a second stage superficialization or transposition procedure because the forearm cephalic vein is close enough to the skin to be used upon maturation. If radiocephalic is not possible or has failed, a brachiocephalic should be considered next (C). Brachiocephalic fistulas allow fistulas to form on the dorsal surface of the upper arm and allow easier cannulation and use during hemodialysis. Further, depending on body habitus, brachiocephalic fistulas may also not require a second stage to superficialize the fistula close to the skin. The third choice for autogenous fistula is the brachio basilic fistula. Since the basilic vein is deep, it requires superficialization of the vein. Many surgeons perform this in two stages so as to allow the vein to mature before superficialization (D). Maturation of a fistula typically requires at least 6 weeks and may require additional interventions. Waiting until 1 month before dialysis will result in placement of a temporary dialysis catheter, which carries high mortality risks (A). Despite the advantages, the radiocephalic fistula has a higher early failure or nonmaturation rate and may not be a good option in diabetics due to medial calcinosis within the radial artery. Further, when a patient is already hemodialysis dependent via tunneled catheter, there is ongoing debate about whether the ability to rapidly cannulate a graft (~2 weeks) shifts the preferences toward initial graft placement rather than fistula first. A forearm loop graft also has the advantage of dilating the basilic and upper cephalic veins for future fistula creation.

**References:** Disbrow, D. E., Cull D. L., Carsten C. G., 3rd., et al. (2013). Comparison of arteriovenous fistulas and arteriovenous grafts in patients with favorable vascular anatomy and equivalent access to health care: is a reappraisal of the Fistula First Initiative indicated? *Journal of the American College of Surgeons*, 216(4), 679–685; discussion 685–686.

Hakaim, A. G., Nalbandian, M., & Scott, T. (1998). Superior maturation and patency of primary brachiocephalic and transposed basilic vein arteriovenous fistulae in patients with diabetes. *Journal of Vascular Surgery*, 27(1), 154–157.

[No authors listed]. (2006). NKF-K/DOQI clinical practice guidelines for vascular access. *American Journal of Kidney Diseases*, 48(Suppl. 1), S227-S409.

7. **D.** The patient is presenting with superior vena cava (SVC) syndrome with bilateral arm, neck, and face swelling and hoarseness of the voice. The patient likely has a preexisting central vein stenosis (in the SVC). A high proportion of patients with end-stage renal disease have central vein stenosis (25–40%) due to prior central venous access. These stenoses are often asymptomatic, and if SVC syndrome does develop, it is usually insidious in onset. However, placement of an upper arm AVG access creates a sudden massive increase in venous return that cannot be accommodated by the stenosis, leading to abrupt venous congestion (E). Central venous stenosis complicates hemodialysis access because it impairs venous fistula outflow and can reduce flow rates and reduce likelihood of maturation in fistulas. Further, when access is placed ipsilateral to a stenotic lesion, there is a high likelihood of symptoms due to the increased venous congestion combined with high venous resistance. Arteriovenous grafts are more likely to cause symptoms than fistulas, and upper arm access is more likely to cause symptoms than forearm access. When central stenosis is suspected, either from history or symptoms, central venogram should be performed to diagnose the lesion. Concomitant endovascular venoplasty is a reasonable option and has a high rate of success. However, first line treatment is now endovascular stenting of the SVC. This is appropriate

for both benign and malignant cases of SVC syndrome. Ligation or plication of the graft is not indicated because this destroys the access and does not address the underlying pathology (A, B). Open SVC repair via sternotomy for a benign lesion is overly invasive and unnecessary given the high initial success rates of endovascular treatment.

**References:** Jones, R. G., Willis, A. P., Jones, C., et al. (2011). Long-term results of stent-graft placement to treat central venous stenosis and occlusion in hemodialysis patients with arteriovenous fistulas. *Journal of Vascular and Interventional Radiology*, 22(9), 1240–1245.

Rizvi AZ, et al. (2008). Benign superior vena cava syndrome: stenting is now the first line of treatment. *Journal of vascular surgery*, 47(2), 372–380.

Trerotola, S. O., Kothari, S., Sammarco, T. E., et al. (2015). Central venous stenosis is more often symptomatic in hemodialysis patients with grafts compared with fistulas. *Journal of Vascular and Interventional Radiology*, 26(2), 240–246.

8. **A.** Arteriovenous fistula can eventually undergo aneurysmal degeneration over time, and intervention is required to prevent rupture and exsanguination (E). High outflow resistance is a common cause of aneurysm formation and must be ruled out by fistulogram. Repeated needle cannulation can cause stenosis resulting in higher pressures distal to the lesion and subsequent aneurysm formation. Alternatively, repeated needle cannulation can also lead to aneurysmal degeneration of the vein at the stick site. Therefore, cannulation must be avoided in areas undergoing aneurysmal change. Fistulogram is diagnostic of the stenotic lesion and potentially therapeutic via venoplasty with or without stent placement. Further, fistulogram will also help distinguish between a true and pseudo aneurysm. If no lesion is seen on fistulogram, a central venogram should be performed to rule out a central stenosis as a cause of high outflow pressures. After treatment of the venous stenoses, bleeding may resolve because the abnormally high pressures within the fistula return to normal. Thinned/atrophic skin, translucent skin, ulceration, suspected infection, intraluminal thrombus, high output cardiac failure, steal syndrome, or spontaneous bleeding from the fistula prompts consideration for revision by resection and plication or reanastomosis with a healthy vein (B). The size of the aneurysm is not an indicator for revision. If no healthy vein is available, graft implantation is an option (C). If outflow cannot be salvaged, the access may require ligation (D).

**Reference:** Cronenwett, J. L., & Johnston, K.W. (2010). *Rutherford's vascular surgery*. Philadelphia, PA: W. B. Saunders.

9. **C.** Fistulas are superior to grafts, which are superior to catheters in terms of patient survival, mainly because of infection risks of prosthetic material (A–E). Diabetics have an exaggerated increase in mortality due to their depressed immune system. Interestingly, despite the risk of high output cardiac failure associated with fistula and graft, patients with tunneled catheters also have the highest risk of cardiac-related mortality. When comparing patency, fistulas are known to have higher primary patency (intervention-free patency of 85% at 1 year, 50% at 5 years) compared to grafts (60% at 1 year, 10% at 5 years) (B). However, fistulas have a higher rate of primary failure (nonmaturation or early thrombosis) of up to 40%. Further, when comparing secondary patency (patency with interventions to maintain or reestablish flow), fistulas and grafts are similar. Grafts do not require maturation because their lumen diameter does not change (D). However, healing time of at least 10 days must be observed after graft placement before cannulation to avoid massive pseudoaneurysm formation. Fistulas require at least 6 weeks for maturation during which time the outflow vein undergoes remodeling secondary to increased flow resulting in an increase in diameter and further increase in flow. Fistulas are deemed to be mature if they meet the rule of 6's: at 6 weeks, must be 6 mm in diameter, less than 6 mm from skin surface, support 600 ml/min flow (although a minimum of 400 ml/min is adequate), and have a 6-inch straight segment for use.

**References:** [No authors listed]. (2006). NKF-K/DOQI clinical practice guidelines for vascular access. *American Journal of Kidney Diseases*, 48(Suppl. 1), S227–S409, 2006.

Lok, C. E., Sontrop, J. M., Tomlinson, G., et al. (2013). Cumulative patency of contemporary fistulas versus grafts (2000–2010). *Clinical Journal of the American Society of Nephrology*, 8(5), 810–818.

10. **E.** Intubated patients with an air embolus may have an abrupt increase in end-tidal CO<sub>2</sub> followed by a decrease in end tidal CO<sub>2</sub> and hypotension, and auscultation may reveal a “millwheel” murmur. This is often described as a loud churning sound. An Austin-Flint murmur is associated with aortic insufficiency and is a mid-diastolic rumble heard best at the apex (A). Carey Coombs

murmur is also a mid-diastolic rumble that is associated with rheumatic fever (B). Means-Lerman scratch murmur sounds similar to a pericardial rub and may be heard in patients with hyperthyroidism (C). Still's murmur is associated with a small ventral septal defect and is described as a vibratory systolic ejection rumble (D).

# Transplant

*Areg Grigorian, and Christian de Virgilio*

## Questions

1. Which of the following is the best indication for pancreas transplantation in type 1 diabetes?
  - A. 45-year-old male with stage 2 chronic kidney disease and recurrent episodes of marked hyperglycemia
  - B. 66-year-old female with end-stage renal disease who underwent kidney transplantation 10 years ago
  - C. 41-year-old male with severe emotional problems associated with insulin therapy, refractory gastroparesis, and recurrent episodes of marked hyperglycemia
  - D. 38-year-old female that was recently hospitalized for metabolic complications associated with diabetes
  - E. 51-year-old male with stage 3 chronic kidney disease and recurrent episodes of marked hyperglycemia
2. Which of the following poses the highest risk of death in a patient awaiting renal transplantation?
  - A. Chronic obstructive pulmonary disease (COPD)
  - B. Cerebrovascular accident
  - C. Smoker
  - D. Black race
  - E. Congestive heart failure
3. Which of the following is true regarding kidney transplant donation?
  - A. The most common cause of death postoperatively for kidney donors is acute renal failure.
  - B. The most common postoperative complication for kidney donors is acute tubular necrosis.
  - C. Donors must prove to have a glomerular filtration rate (GFR) greater than 80 mL/min to be considered appropriate candidates.
  - D. The serum creatinine will be persistently higher following kidney donation.
  - E. The rate of live kidney donation has increased in the past 10 years.
4. A brain dead trauma victim is being considered for kidney donation. Which of the following donor conditions would be a contraindication to kidney donation?
  - A. History of arm melanoma status post wide local resection 10 years ago
  - B. History of low-grade glioblastoma multiforme diagnosed 4 months ago
  - C. Current urinary tract infection
  - D. Recent hospitalization for meningococemia, now with negative blood cultures
  - E. Open cholecystectomy 4 months ago
5. A 45-year-old male arrives at clinic 1 year after liver transplantation. He would like to discuss his recent laboratory studies and the health of his liver. Which of the following is the best measure of the function of his liver?
  - A. Aspartate aminotransferase (AST)
  - B. Alanine transaminase (ALT)

- C. Total bilirubin
  - D. Serum albumin
  - E. International normalized ratio (INR)
6. A 42-year-old male with end-stage renal disease secondary to glomerulonephritis has been matched with a deceased donor kidney and arrives at the hospital for transplantation. Which of the following is a guiding principle in this surgery?
    - A. The right peritoneum is the preferred initial implant site.
    - B. The left retroperitoneum is the preferred initial implant site.
    - C. Baseline biopsy of the donor kidney should be obtained at the conclusion of the case.
    - D. The native kidney should not be removed.
    - E. The renal artery should be anastomosed to the internal iliac artery.
  7. A 28-year-old female with end-stage renal disease secondary to lupus nephritis undergoes a living-related donor kidney transplant and is making appropriate urine at the conclusion of the case. On postoperative day 2, the surgical intern finds that her urine output has dropped from 180 cc the previous hour to only 4 cc in the last hour. The indwelling Foley is flushing well. Which of the following is the most appropriate next step in management?
    - A. Take patient to the operating room (OR)
    - B. Ultrasound
    - C. Magnetic resonance angiography (MRA)
    - D. Computed topography (CT)
    - E. Urinalysis
  8. A 46-year-old male with end-stage renal disease secondary to diabetes arrives at clinic to discuss his placement in the kidney transplant list. His panel reactive antibody (PRA) score is 85%. He had a failed kidney transplant 5 years ago. Which of the following is true?
    - A. He has a low risk of rejection.
    - B. Given his high PRA, he will be given priority on the transplant list.
    - C. He will lose points in the kidney allocation algorithm because he had a previous kidney transplant.
    - D. He will experience a shorter wait time compared to a similar patient with a lower PRA.
    - E. PRA is calculated using nationally pooled data.
  9. A 41-year-old male with end-stage renal disease secondary to diabetes is undergoing routine renal ultrasound 1 month after kidney transplantation. He has a 4-cm fluid collection next to the donor kidney. He has no complaints and he is making adequate urine. Which of the following is the best next step?
    - A. Observation
    - B. Ultrasound-guided aspiration for culture and creatinine
    - C. CT scan
    - D. Internal drainage in the OR
    - E. External pigtail catheter drainage
  10. Which of the following is true regarding posttransplant lymphoproliferative disorder (PTLD)?
    - A. It is usually of monoclonal T-cell origin.
    - B. It occurs more commonly in renal transplants compared to heart transplants.
    - C. The risk of developing PTLD is lowest in the first year following transplant.
    - D. Epstein-Barr virus (EBV)-negative patients are at a lower risk than EBV-positive patients.
    - E. Cytomegalovirus (CMV)-negative patients are at higher risk once they seroconvert following transplant.
  11. A 39-year-old female is undergoing kidney transplant. Shortly after performing the arterial anastomosis, the surgeon notes that the donor kidney appears soft, flabby, mottled, and edematous. The patient's heart rate is 136 beats per minute and blood pressure is 90/60 mm Hg. Which of the following is true?

- A. This is a T-cell mediated response.
  - B. The patient should be started on pressors and the operation completed.
  - C. The donor kidney should be immediately removed without further workup.
  - D. Lymphokines are involved in this process.
  - E. This complication occurs more commonly in liver transplants than with kidney transplants.
12. A 50-year-old male trauma patient was recently pronounced brain dead. He is accompanied by various family members including his ex-wife and male life partner of the past 10 years. An organ procurement agency has been called and would like to discuss organ donation with the family. From whom should they get permission for organ donation?
- A. Father
  - B. Mother
  - C. Adult son from previous marriage
  - D. Ex-wife
  - E. Male life partner
13. Which of the following patients with hepatocellular carcinoma is eligible for liver transplantation?
- A. Single 3-cm tumor in segment 2 with regional lymphadenopathy
  - B. Single 6-cm tumor in segment 4 with no regional lymphadenopathy
  - C. Single 2-cm tumor in segment 5 with vascular invasion
  - D. 1-cm, 2-cm, and 2.5-cm tumors in segments 3 and 4 with no evidence of lymphadenopathy
  - E. 1-cm and 3.5-cm tumors both in segment 4 with no lymphadenopathy or distant disease
14. The most clinically important viral infection in transplant recipients is:
- A. Varicella zoster
  - B. Cytomegalovirus (CMV)
  - C. Epstein-Barr virus
  - D. Hepatitis C virus
  - E. Herpes simplex

## Answers

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1. **C.** Pancreas transplantation has been shown to improve survival and quality of life in patients with type 1 diabetes. It may halt progression of diabetes-related disease such as retinopathy and may even reverse disease including neuropathy and autonomic dysfunction. It does not lead to reversal of vascular disease secondary to diabetes. The American Diabetes Association has provided indications for pancreas transplantation: (1) diabetic patients with imminent or established end-stage renal disease who have had or plan to have a kidney transplant or (2) patients meeting all three of the following criteria: frequent episodes of metabolic complications related to diabetes (hypoglycemia, ketoacidosis, hyperglycemia), emotional problems with insulin therapy that are severe enough to be incapacitating, and consistent failure of insulin-based management to prevent complications. From the answer choices provided, the best indication is for the 41-year-old male with severe emotional problems associated with insulin therapy, refractory gastroparesis, and recurrent episodes of marked hyperglycemia (A, D, E). Pancreas transplantation should be avoided in patients older than 45 to 65 because these patients have poor graft and 5-year survival (B).

**References:** Robertson, R. P., Davis, C., Larsen, J., et al. (2006). Pancreas and islet transplantation in type 1 diabetes. *Diabetes Care*, 29(4), 935.

Siskind, E., Malone, C., Akerman, M., et al. (2014). An analysis of pancreas transplantation outcomes based on age groupings—an update of the UNOS database. *Clinical Transplantation*, 28(9), 990–994.

2. **A.** While it is true that the most common cause of death in patients with diabetes is cardiac related, a history of coronary artery disease does not place patients at the highest risk for death while awaiting renal transplantation (E). This speaks to the prevalence of heart disease in this patient population. A large multivariable survival model analyzing over 160,000 patients demonstrated that



COPD is the most significant factor independently associated with death among patients awaiting renal transplantation (adjusted hazard ratio 1.31). This is followed by, in descending order, smoker status, nonambulatory status, coronary artery disease, peripheral vascular disease, congestive heart failure, cerebrovascular disease, and hypertension (B, C). Black patients awaiting kidney transplantation survive longer than white patients, but this reverses when black patients receive kidney transplantation (D). Additionally, COPD is the most significant risk factor associated with poor graft function and survival following kidney transplant.

**References:** Kapur, A., & De Palma, R. (2007). Mortality after myocardial infarction in patients with diabetes mellitus. *Heart*, 93(12), 1504–1506.

van Walraven, C., Austin, P. C., & Knoll, G. (2010). Predicting potential survival benefit of renal transplantation in patients with chronic kidney disease. *CMAJ: Canadian Medical Association Journal*, 182(7), 666–672.

3. **C.** As the incidence of diabetes and end-stage renal disease has steadily risen in the past several decades, the number of patients awaiting kidney transplantation has also been increasing. Due to a multidisciplinary approach and the concerted efforts of transplant groups including the United Network for Organ Sharing (UNOS), the availability of deceased kidney donors has risen. However, the rate of live kidney donation has dropped in greater numbers leaving a total deficit in the availability of kidney donors despite the increase in deceased donors (E). There are several societal guidelines to determine candidacy of live kidney donors, and one prevailing requirement across all governing bodies is the requirement of a GFR greater than 80 mL/min confirmed with a nuclear test or 24-hour urine collection. The most common cause of death postoperatively for kidney donors is pulmonary emboli (A). The most common complication for kidney donors postoperatively is wound infection (B). Although the serum creatinine may be higher in the immediate postoperative period it will eventually go back down and the baseline creatinine will remain the same or close to the baseline as the donor will continue to have one functioning kidney remaining (D).

**References:** Clinical Practice Guidelines for Living Kidney Donors. Kidney Disease Improving Global Outcomes; KDIGO, 2015.

Najarian, J. S., Chavers, B. M., McHugh, L. E., et al. (1992). 20 years or more of follow-up of living kidney donors. *Lancet*, 340(8823), 807–810.

Organ Procurement and Transplantation Network (OPTN)/United Network for Organ Sharing (UNOS). National data reports, transplants by donor type, latest data, 2015.

4. **A.** Since the availability of kidney donors has been declining, establishing appropriate guidelines for diseased kidney donation is imperative to maximize the scarcity of available organs. Several absolute contraindications to organ donation exist including patients with HIV (unless the recipient also has HIV), hepatitis (unless the recipient also has the same hepatitis type), cirrhosis, and active systemic infection with positive blood cultures. A previous hospitalization for systemic infection is not considered an absolute contraindication as long as the patient has proven to have negative blood cultures (D). Similarly, urosepsis would preclude organ donation, but urinary tract infection in and of itself will not (C). History of cholecystectomy in a patient without significant liver disease does not preclude from organ donation (E). A history of cancer often precludes patients from organ donation. Some exception can be made for patients with a remote history of low-grade visceral malignancy such as colorectal cancer or patients with less aggressive cancers such as basal cell carcinoma. Melanoma in particular poses risk for transmission even in patients with a remote history, so this will prevent the patient from being an eligible donor. Interestingly, low-grade primary central nervous system (CNS) tumors have not been demonstrated to have a high risk for transmission; therefore these patients can be successful deceased organ donors (B).

**References:** Birkeland, S. A., & Storm, H. H. (2002). Risk for tumor and other disease transmission by transplantation: a population-based study of unrecognized malignancies and other diseases in organ donors. *Transplantation*, 74(10), 1409–1413.

Feng, S., Buell, J., Cherikh, W., et al. (2002). Organ donors with positive viral serology or malignancy: risk of disease transmission by transplantation. *Transplantation*, 74(12), 1657–1663.

5. **E.** Liver function test (LFT) measures the levels of AST, ALT, and alkaline phosphatase but does not reflect the synthetic function of the liver and thus LFT is a misnomer (A, B). The best test to determine the liver's function is the prothrombin time (PT) or INR. Albumin and PTT are also helpful (D). Total bilirubin is influenced by biliary tree obstruction, intrinsic hepatic disease, and

hemolysis (C).

6. **D.** Kidney transplantation has led to improved survival and quality of life in patients with end-stage renal disease. It was first performed in France by Rene Kuss in 1951, and the surgical approach originally described has changed very little in modern practice. The peritoneum is a poor choice for implantation because it poses a high risk for graft contamination and infection. The retroperitoneum and pelvic fossa is the preferred site (A). Most surgeons prefer the right side because the iliac vessels are longer and more horizontal allowing for a technically easier anastomosis (B). However, if there are any previous dissections or operations involving mesh (e.g., herniorrhaphy) to the right side, the left side can be chosen. Generally, it is preferable to perform an end-to-side arterial anastomosis first followed by the venous anastomosis and then ureteral reconstruction. This will reduce vein clamping time, which decreases the risk for graft thrombosis and will reduce cold ischemia time to the kidney. The external iliac vein and artery are the preferred targets for the anastomosis (E). This is because dissection of the internal iliac vessels is technically challenging, which increases operative time and subjects the patient to additional risk such as autonomic plexus injury (e.g., erectile dysfunction). The standard ureteral reconstruction is ureteroneocystostomy because it avoids the deep dissection necessary for a ureteroureterostomy. The utility in obtaining a baseline biopsy is controversial at best. The argument against it is that it exposes the patient to a biopsy-induced vascular thrombosis, which can compromise the graft (C). It should be noted that the native kidney should remain in place because it can often continue to have a small role by secreting erythropoietin.

**Reference:** Zhao, J., Wang, K., & Gao, Z. (2011). The transplantation operation and its surgical complications. In J. Ortiz, & J. Ortiz (Eds.), *Understanding the Complexities of Kidney Transplantation*. INTECH. Retrieved from <http://www.intechopen.com/books/understanding-the-complexities-of-kidney-transplantation/the-transplantation-operation-and-its-surgical-complications>.

7. **B.** Providing adequate fluid resuscitation following kidney transplantation is essential in preventing graft failure. Although there is no consensus on the optimal postoperative fluid regimen in kidney transplantation, the use of crystalloids should be the volume replacement of choice, and most transplant surgeons would agree to aim to achieve a urine output greater than 100 cc per hour. The most common cause of postoperative oliguria is acute tubular necrosis (ATN), which can be initially worked up with a urinalysis (E). However, ATN will present with a gradual decrease in urine output and will frequently respond to a fluid bolus. A sudden drop in urine output or anuria is concerning for graft thrombosis. This could have catastrophic outcomes if not diagnosed early. In fact, it is considered the main cause of graft failure in the first year with the majority occurring at 48 hours. It typically involves the renal vein, but the renal artery can also be affected. The first step in any patient with a sudden decrease in urine output is to flush the Foley to ensure there is no kinking preventing urine flow. The next step is to perform a bedside ultrasound to look for vascular thrombosis. If this is identified, the next step is to go to the OR for surgical revascularization or intra-arterial thrombolytic therapy (A). If ultrasound findings are equivocal, the next step is to perform an adjunct imaging study such as MRA, CT, or renal scintigraphy (C, D).

**References:** Ponticelli, C., Moia, M., Montagnini, G. et al. (2009). Renal allograft thrombosis. *Nephrology, Dialysis, Transplantation*, 24(5), 1388–1393.

Schnuelle, P., & Johannes van der Woude, F. (2006). Perioperative fluid management in renal transplantation: a narrative review of the literature. *Transplant International*, 19(12), 947–959.

8. **B.** PRA is performed in all patients that are listed for a kidney transplant. This tests the patient's blood against blood from a panel of donors in the same geographic area (E). The panel serves as the HLA makeup of the potential organs available for donation for the recipient. Patients that have a high PRA are considered to be "highly sensitized" and will have a higher likelihood of rejection (A). Patients with a PRA greater than 80% will need to wait much longer to match with a compatible donor, so they are given additional points on the kidney allocation algorithm prioritizing them to the top of the list. However, even though their names come up frequently as potential matches for newly available kidneys, they are frequently incompatible, so their wait times are much longer than patients with lower PRAs (D). Having a previous kidney transplant likely contributed to his high PRA, but this in and of itself does not factor in the kidney allocation algorithm (C).

**Reference:** The organ procurement and transplant Network; CPRA and its importance in organ transplantation. United Network For Organ Sharing (UNOS), 2015.

9. **A.** Patients that have undergone kidney transplantation commonly have fluid collections around the donor kidney. This frequently is an asymptomatic finding and incidentally discovered during routine imaging studies often in the first year. If the fluid collection is small (<5 cm), it is unlikely to cause any symptoms, and the patient can initially be observed with no additional studies required (C). Possible etiologies include lymphocele, seroma, urine leak, and hematoma. The most common cause is lymphocele, which occurs secondary to severed lymphatic vessels during surgery. This is a self-limited complication and will resolve with time. With larger fluid collections, patients may develop oliguria (extrinsic compression of the ureter), graft failure (extrinsic compression of renal artery or vein), or infection. Symptomatic fluid collections will need to be treated with image-guided drainage or surgical drainage (E). In recurrent cases, a peritoneal window allowing internal drainage can be performed (D). Additionally, the fluid creatinine level should be compared to the serum level (B). This will help determine if the patient has a urine leak. In this case the patient may need to receive a renal stent or nephrostomy tube and, rarely, ureteral reconstruction in the OR.

**Reference:** Fuller, T. F., Kang, S. M., Hirose, R., et al. (2003). Management of lymphoceles after renal transplantation: laparoscopic versus open drainage. *Journal of Urology*, 169(6), 2022–2025.

10. **E.** PTLD is the second most common cancer affecting patients with solid organ transplants with the majority occurring in the first year (C). The most common cancer is squamous cell carcinoma of the skin with most occurring about 8 years after the transplant. The most common type of PTLD is of monoclonal B-cell origin (A). It occurs more commonly in heart and lung transplants compared to liver and renal transplants (B). Early diagnosis requires a high index of suspicion because this can present with nonspecific symptoms including fevers (most common), lymphadenopathy, night sweats, and weight loss. Declining graft function can also be a presenting symptom. Diagnosis begins with checking serum EBV viral load, although EBV-negative patients can also develop PTLD. In fact, EBV-negative patients are at higher risk than EBV-positive patients (D). Additionally, CMV-negative patients are at increased risk once they seroconvert following transplant.

**References:** Opelz, G., & Henderson, R. (1993). Incidence of non-Hodgkin lymphoma in kidney and heart transplant recipients. *Lancet*, 342(8886–8887), 1514–1516.

Walker, R. C., Paya, C. V., Marshall, W. F., et al. (1995). Pretransplantation seronegative Epstein-Barr virus status is the primary risk factor for posttransplantation lymphoproliferative disorder in adult heart, lung, and other solid organ transplantations. *The Journal of Heart and Lung Transplantation*, 14(2), 214–221.

Walker, R. C., Marshall, W. F., Strickler, J. G., et al. (1995). Pretransplantation assessment of the risk of lymphoproliferative disorder. *Clinical Infectious Diseases*, 20(5), 1346–1353.

11. **C.** This patient is experiencing a hyperacute rejection. This will present with the donor kidney appearing soft, flabby, mottled, and edematous and can progress to widespread interstitial hemorrhage and necrosis. This occurs within minutes to hours after the arterial anastomosis and is mediated by preformed recipient antibodies to donor HLA antigens (A). The antibodies bind the graft endothelium and ensue a cascade of events resulting in tissue necrosis. This is an uncommon complication, but renal grafts are more commonly affected. Liver transplants are largely resistant to hyperacute rejection for reasons that are unclear, but it is thought to be related to the enormous size of the liver and its ability to absorb circulating antibodies (E). The only treatment for hyperacute rejection is immediate removal of the donor kidney because this can result in hemodynamic instability, multiorgan failure, and death if left untreated (B). This is particularly important in a patient that is already hypotensive. Acute rejection is a T-cell mediated response with activated monocytes secreting soluble mediators including lymphokines IL-1 and IL-2 (D). This typically occurs 1 to 2 months after the transplant and should be confirmed with a renal biopsy. Patients will present with oliguria and/or rising creatinine. Treatment involves high-dose steroids. Chronic graft rejection is a poorly understood process that can occur years after having a well-functioning donor graft. Immunosuppression is largely ineffective in these cases.

**References:** Bhowmik, D. M., Dinda, A. K., Mahanta, P., et al. (2010). The evolution of the Banff classification schema for diagnosing renal allograft rejection and its implications for clinicians. *Indian Journal of Nephrology*, 20(1), 2–8.

Gordon, R. D., Iwatsuki, S., Esquivel, C. O., et al. (1986). Liver transplantation across ABO blood groups. *Surgery*, 100(2), 342–348.

Ramsey, G., Welford, J., Boczkowski, D. J., et al. (1987). The Lewis blood group system in liver transplantation. *Transplantation Proceedings*, 19(6), 4591–4594.

12. **E.** Organ donation should always be discussed by a third party such as an organ procurement agency and never by the physician. The hierarchy for permission from next of kin for organ donation is as follows: spouse, adult child, either parent, and adult sibling. This hierarchy is determined based on who is at the best position to use the standard of substituted judgment. This involves making the decision for organ donation based on the known wishes or preferences of the patient and for this patient, his life partner for the past 10 years would be the most appropriate person to do this (A–D).

**Reference:** Greenfield, L. J., Mulholland, M. W., Oldham, K. T., et al., (Eds.). (1997). *Essentials of surgery: scientific principles and practice*. Philadelphia, PA: Lippincott-Raven.

13. **D.** Liver transplantation can be offered to patients with hepatocellular carcinoma and if appropriate candidates are selected, outcomes can be favorable. Mazzaferro and others demonstrated that patients with certain tumor characteristics that undergo liver transplantation can achieve a 4-year survival of 75%. This is now known as the Milan criteria and is used by UNOS to select appropriate candidates. Milan criteria are as follows: single tumor 5 cm or smaller or up to three tumors *with none larger than 3 cm*, and no evidence of vascular invasion, regional lymphadenopathy, or distant disease (A–C, E). Tumors limited to a particular liver segment do not factor into selecting appropriate candidates.

**Reference:** Mazzaferro, V., Regalia, E., Doci, R., et al. (1996). Liver transplantation for the treatment of small hepatocellular carcinomas in patients with cirrhosis. *The New England Journal of Medicine*, 334(11), 693–700.

14. **B.** CMV is a member of the herpesvirus family and is the most clinically significant viral infection in transplant recipients. In healthy, nonimmunosuppressed individuals, CMV is clinically silent or mild. In immunosuppressed transplant recipients, CMV is associated with increased mortality and graft loss. In one large study of liver transplant recipients, CMV infection was found to be an independent risk factor for graft failure. In a cardiac transplantation study, CMV-negative recipients of CMV-positive donor hearts had impaired distal epicardial endothelial function and an increased incidence of cardiovascular-related events and death during follow-up.

**References:** Burak, K., Kremers, W., Batts, K., et al. (2002). Impact of cytomegalovirus infection, year of transplantation, and donor age on outcomes after liver transplantation for hepatitis C. *Liver Transplantation*, 8(4), 362–369.

Petrakopoulou, P., Kübrich, M., Pehlivanli, S., et al. (2004). Cytomegalovirus infection in heart transplant. *Circulation*, 110(Suppl. 1):II207–II212.

# Thoracic Surgery

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## Questions

1. A 60-year-old male presents to the emergency department (ED) with dyspnea. He has a 40 pack-year smoking history. He reports a 20-pound weight loss over the past 2 months. On exam, he has facial and neck swelling. Chest x-ray demonstrates a large mass in the right upper lobe. Which of the following is the best management?
  - A. Chemotherapy
  - B. Chemotherapy and radiation
  - C. Radiation therapy
  - D. Endovascular stenting
  - E. Thoracotomy
2. A 42-year-old male with gastroesophageal reflux disease (GERD) undergoes Nissen fundoplication. A left internal jugular central venous catheter was placed before the case. On postoperative day 3 the patient develops shortness of breath. He is afebrile with a normal white blood cell (WBC) count. Chest x-ray demonstrates a large left-sided pleural effusion, and a chest tube is inserted evacuating 1.5 L of turbid fluid. Fluid analysis for which of the following would be most beneficial in establishing the most likely diagnosis?
  - A. Sudan stain
  - B. Lactate dehydrogenase (LDH)
  - C. Culture and sensitivity
  - D. Cholesterol
  - E. Eosinophil count
3. A 45-year-old male presents to the ED with 200 mL of hemoptysis. He continues to expectorate blood but is able to protect his airway and is speaking comfortably. His blood pressure is 110/70 mm Hg and his heart rate is 100 beats per minute. A chest radiograph reveals bilateral infiltrates. Which of the following offers the highest likelihood of definitive control of this patient's bleeding?
  - A. Intubation with a double lumen endotracheal tube
  - B. Rigid bronchoscopy with topical application of epinephrine 1:20,000
  - C. Bronchial artery embolization
  - D. Pulmonary arteriography with selective embolization
  - E. Flexible bronchoscopy
4. Which of the following is true regarding pulmonary sequestration?
  - A. MRI is considered the diagnostic imaging of choice.
  - B. The majority of cases are asymptomatic.
  - C. It does not communicate with the tracheobronchial tree.
  - D. Extra-lobar pulmonary sequestration remains within the visceral pleura of the native lung.
  - E. The majority of asymptomatic cases can be observed.
5. A 49-year-old male has a right-sided perihilar mass incidentally found on CT scan performed after a



- motor vehicle trauma 1 month ago. He has a 30 pack-year smoking history. He reports his clothes fit more loosely. On examination, he has purple striae on his abdomen and prominent fat on his posterior neck. CT scan confirms a 4-cm irregular mass without enlarged lymph nodes. Treatment is most likely to involve which of the following?
- A. Radiation therapy alone
  - B. Combination chemotherapy and radiation
  - C. Surgical resection
  - D. Mediastinoscopy and if node negative, then surgical resection
  - E. Surgical resection followed by radiation therapy
6. A rare but well-recognized complication of bronchial artery embolization performed for massive hemoptysis is:
- A. Esophageal necrosis
  - B. Pulmonary infarction
  - C. Paraparesis
  - D. Vocal cord paralysis
  - E. Tracheal necrosis
7. Which of the following is true regarding aortic stenosis (AS)?
- A. In low-risk patients with severe symptomatic AS, transcatheter aortic valve replacement is preferred.
  - B. The most common cause of AS is rheumatic fever.
  - C. Symptoms generally develop when the valve area is less than 2 cm<sup>2</sup>.
  - D. Swollen legs and elevated brain natriuretic peptide portend a poor prognosis.
  - E. Valve repair is preferred to valve replacement.
8. Which of the following is true regarding intra-aortic balloon pump (IABP)?
- A. It improves cardiac function in patients with cardiogenic shock due to aortic regurgitation.
  - B. It is beneficial in patients with aortic dissection.
  - C. It improves coronary blood flow during systole.
  - D. It is only beneficial in patients that have exhausted coronary autoregulation.
  - E. It is not indicated in acute myocardial infarction.
9. A 68-year-old diabetic female undergoes coronary artery bypass grafting (CABG) for three-vessel disease. Ten days later, she returns to the ED with high fever and chest pain, and a crunching sound is heard over her chest on auscultation. Her sternum feels unstable and there is drainage from her sternal incision. Her WBC count is 18,000 cells/ $\mu$ L. Which of the following is true about this condition?
- A. It is usually due to multiple organisms.
  - B. CT scan of the chest should be performed next.
  - C. Avoidance of bilateral internal mammary bypasses reduces the risk.
  - D. This has an excellent prognosis with timely intervention.
  - E. Obesity is not a risk factor.
10. A 45-year-old male with adenocarcinoma of the right lung presents to clinic to discuss surgical resection. Which of the following is the most important pulmonary function study to order for this patient?
- A. Arterial blood gas
  - B. Forced expiratory volume 1 (FEV<sub>1</sub>)
  - C. Total lung capacity
  - D. Minute ventilation
  - E. Diffusing capacity of the lung for carbon monoxide (DLCO)
11. The patient in [question 10](#) undergoes pulmonary function testing for a planned lobectomy of the right lung and his FEV<sub>1</sub> is 1.2 L. Which of the following is true?

- A. The patient is not a candidate for lobectomy.
  - B. Surgery can proceed as the plan is for a lobectomy.
  - C. Ventilation-perfusion (VQ) scan should be performed.
  - D. He should undergo respiratory muscle training with incentive spirometer.
  - E. Repeat testing should be performed following breathing treatment with albuterol.
12. What happens to the partial pressure of arterial oxygen as blood flows from the pulmonary capillaries to the left atrium?
- A. Increase
  - B. Decrease
  - C. Stay the same
  - D. Depends on cardiac output
  - E. Depends on pulmonary vascular resistance
13. Which of the following is true of thoracic anatomy?
- A. The left lung has three lobes.
  - B. The azygous vein runs along the left side draining into the subclavian vein.
  - C. The vagus nerve runs anterior to the lung hilum.
  - D. The sternocleidomastoid muscle is considered an accessory muscle to breathing.
  - E. The phrenic nerve runs superior to the lung hilum.
14. A 35-year-old male with diffuse axonal injury following a motorcycle collision is recovering in the surgical intensive care unit (ICU). He has been intubated for 3 weeks. This morning the patient developed an endotracheal air leak that persisted even with tube exchange and hyperinflation. His abdomen appears distended. Bronchoscopy is performed and demonstrates yellow-colored secretions in both main stem bronchi. Which of the following is true?
- A. The patient should be switched to low tidal volume ventilation.
  - B. Early conversion to tracheostomy decreases the risk for this complication.
  - C. Nasogastric tube increases the risk for this complication.
  - D. Low intracuff pressure contributes to the development of this complication.
  - E. CT scan of the abdomen should be performed.
15. A 65-year-old man presents with anorexia, nausea, lethargy, and hyponatremia. A chest radiograph reveals a large right upper lobe nodule. This most likely represents:
- A. Adenocarcinoma
  - B. Small cell carcinoma
  - C. Squamous cell carcinoma
  - D. Carcinoid
  - E. Bronchoalveolar carcinoma
16. Which of the following is true regarding Lambert-Eaton myasthenic syndrome?
- A. Less than 50% will have a small cell carcinoma of the lung.
  - B. 3,4-Diaminopyridine is not effective in treating symptoms.
  - C. Intravenous (IV) immunoglobulin is effective in treating symptoms.
  - D. Thymectomy is effective in patients in whom medical management fails.
  - E. Patients present with distal muscle weakness.
17. The most common mediastinal tumor in children is:
- A. Neurogenic
  - B. Lymphoma
  - C. Thymoma
  - D. Germ cell tumor
  - E. Cyst
18. Which of the following statements is true regarding tracheal anatomy?



- A. The blood supply is predominantly from the superior thyroid arteries.
  - B. The rich collateral blood supply allows circumferential mobilization.
  - C. As much as 50% of the length of the trachea can be resected with a primary anastomosis following resection.
  - D. A tracheostomy tube is ideally placed through the first tracheal ring.
  - E. The first complete cartilaginous ring is the thyroid cartilage.
19. A 24-year-old woman presents with recurrent episodes of right-sided pneumothorax requiring chest tube insertion. A diagnosis of a catamenial pneumothorax as the cause of recurrent pneumothorax in this patient would be supported by the finding of:
- A. Pneumocystis
  - B. Endometriosis
  - C. Cystic fibrosis
  - D. Idiopathic pulmonary fibrosis
  - E. Apical blebs
20. A 40-year-old female undergoes drainage of a left-sided pleural effusion. Analysis of the fluid reveals 85% lymphocytes. The patient is initially managed with a medium chain triglyceride diet, but this fails to resolve the effusion. Drainage is 1.1 L per day over 5 days. Which of the following is the recommended management?
- A. Octreotide
  - B. NPO and parenteral nutrition
  - C. Video-assisted thoracoscopic surgery (VATS) via the left chest
  - D. VATS via the right chest
  - E. Left thoracotomy with thoracic duct ligation
21. The most common cause of lung abscess is:
- A. Aspiration
  - B. Bronchial obstruction by tumor
  - C. Pneumococcal pneumonia
  - D. *Pneumocystis jiroveci* pneumonia
  - E. *Mycobacterium tuberculosis* pneumonia
22. The most common primary chest wall malignancy is:
- A. Osteochondroma
  - B. Chondrosarcoma
  - C. Ewing sarcoma
  - D. Plasmacytoma
  - E. Primitive neuroectodermal tumors
23. Which of the following is considered a contraindication to surgical resection of a primary (non-small cell) carcinoma of the lung?
- A. Invasion of the chest wall
  - B. A positive ipsilateral mediastinal lymph node
  - C. A malignant pleural effusion
  - D. Stage 3A disease
  - E. Invasion of parietal pericardium
24. A 47-year-old woman presents to the ED with worsening fatigue and moderate dyspnea on exertion. She is a lifelong nonsmoker. A chest radiograph demonstrates a 3-cm nodule in the periphery of the left lung with a mild pleural effusion. She reports night sweats and a 20-pound weight loss in the past 3 months. Which of the following is the most likely diagnosis?
- A. Squamous cell carcinoma
  - B. Adenocarcinoma

- C. Small cell carcinoma
  - D. Bronchoalveolar
  - E. Carcinoid
25. Rasmussen aneurysms form in association with:
- A. Aspergillosis
  - B. Mucormycosis
  - C. Cryptococcosis
  - D. Tuberculosis
  - E. Small cell lung cancer
26. Which one of the following statements is true regarding thymoma?
- A. The primary treatment modality is chemotherapy.
  - B. Malignancy is determined by mitotic activity.
  - C. The majority of patients with myasthenia gravis have an associated thymoma.
  - D. In patients with myasthenia gravis, thymectomy results are more favorable in those without a thymoma than those with one.
  - E. It is not associated with SVC syndrome.
27. A woman who had an osteogenic sarcoma of the femur removed 2 years earlier now presents with two small lesions in the right lung and one small lesion in the left lung. A metastatic workup reveals no other abnormalities. The treatment of choice is:
- A. Bilateral wedge resections
  - B. Chemotherapy
  - C. Radiation therapy
  - D. Immunotherapy with (bacille Calmette-Guérin) vaccine
  - E. Observation
28. A 50-year-old Central American man presents with a chronic cough and a draining sinus in his left chest wall. Examination of the drainage reveals sulfur granules. Which of the following is true regarding this condition?
- A. Surgical resection is indicated.
  - B. The organism involved is likely *Nocardia asteroides*.
  - C. The organism involved is an anaerobe.
  - D. Optimal treatment consists of trimethoprim-sulfamethoxazole.
  - E. Central nervous system involvement is common.
29. A 65-year-old woman presents with a chronic nonproductive cough of 2 months duration. A chest radiograph reveals a 2-cm mass in the right upper lobe. A CT scan of the chest confirms the presence of the 2-cm mass corresponding to that found on the chest radiograph, which appears to be malignant, along with 5-mm nodes in the mediastinum. The next step in the management would be:
- A. Positron emission tomography (PET) scan
  - B. Abdominal CT
  - C. Bone scan
  - D. Mediastinoscopy
  - E. Brain CT
30. Four months after prolonged intubation after a motor vehicle accident, a 40-year-old woman presents with stridor and dyspnea on exertion. Endoscopy reveals marked tracheal stenosis 4 cm in length. Management consists of:
- A. Laser ablation
  - B. Bronchoscopic dilation
  - C. Primary resection of all scarred segments with primary anastomosis
  - D. Primary resection of all scarred segments, primary anastomosis, and temporary tracheostomy

## Answers

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1. **D.** This patient has superior vena cava syndrome (SVC) secondary to lung cancer. This presents most commonly with dyspnea, but patients may also have facial swelling, headache, chest pain, hoarseness, and stridor. About 65% of cases are secondary to a malignant process (most commonly small cell lung cancer) with the remainder due to infectious etiologies and iatrogenic sequelae of percutaneous intervention. The increasing instrumentation of central veins for dialysis access and pacemaker insertion has led to an increase in SVC obstruction from scarring and fibrosis. The presence of SVC syndrome is considered a contraindication to surgical resection of the primary tumor (E). Relief of symptoms associated with SVC syndrome is best achieved with endovascular stenting of the SVC. This is appropriate for both benign and malignant cases of SVC syndrome. Previously, radiation was the first-line treatment, but this led to persistent symptoms for the majority of patients (B, C). Chemotherapy will likely be required to treat the underlying cancer, but this can be considered after the acute process has been addressed and the cancer confirmed with tissue biopsy (A).

**References:** del Río Solá, M. L., Fuente, G. R., Gutierrez, A. V., et al. (2014). Endovascular treatment of superior vena cava syndrome caused by malignant disease. *Journal of Vascular Surgery*, 59(6), 1705–1706.

Rizvi, A. Z., Kaira, M., Bjarnason, H., et al. (2008). Benign superior vena cava syndrome: stenting is now the first line of treatment. *Journal of Vascular Surgery*, 47(2), 372–380.

2. **A.** Esophageal dissection is the most common iatrogenic cause of chylothorax and presents 2 to 7 days after injury to the thoracic duct. Other etiologies include trauma (more common with penetrating), neoplastic obstruction (most common is lymphoma), and central venous catheter insertion. The thoracic duct originates from the cisterna chyli located posterior to the abdominal aorta and ascends toward the thorax entering the aortic hiatus at T-12 travelling to the right of the vertebral column. It crosses over to the left thorax at T5-6 and drains at the junction of the subclavian and internal jugular vein. Injury to the thoracic duct can result in pleural effusion secondary to chylothorax. Not all cases present with the white milky color suggestive of the diagnosis. In fact, 50% of patients present with bloody, yellow, or serosanguinous effusion. The gold standard for diagnosis is by lipoprotein electrophoresis. However, pleural fluid analysis demonstrating chylomicrons and/or triglycerides is highly suggestive of chylothorax. This can be done with a Sudan fat stain, which identifies chylomicrons (stains orange) (B–E). Of note, chylothorax fluid is resistant to infection; thus there is no role for intravenous (IV) antibiotics.

**References:** McWilliams, A., & Gabbay, E. (2000). Chylothorax occurring 23 years post-irradiation: literature review and management strategies. *Respirology*, 5(3), 301–303.

Rahman, N. M., Chapman, S. J., Davies, R. J. (2004). Pleural effusion: a structured approach to care. *British Medical Bulletin*, 72(1), 31–47.

Seitelman, E., Arellano, J., Takabe, K., et al. (2011). Chylothorax after blunt trauma. *Journal of Thoracic Diseases*, 4(3), 327–330.

3. **C.** Massive hemoptysis is variably defined as expectoration of 100 to 1000 mL of blood in a 24-hour period. Patients tend to be stratified based on this definition so as to identify patients who need interventions. The estimated anatomic dead space of the upper airways is 150 mL, a volume that can easily overcome by bleeding despite coughing and the mucociliary clearance mechanism. Sources of bleeding in massive hemoptysis include the proximal airway structures and their diseases (malignant lesions of the trachea or bronchus, tracheoinnominate fistula, Dieulafoy lesions of the proximal airways) or the distal airway structures and their diseases (vasculitis, infections such as tuberculosis or aspergillosis, pulmonary parenchymal disease, and malignancy). Initial management should always follow standard resuscitation protocols, with securing the airway being of paramount importance. Definitive management of massive hemoptysis depends on the briskness of bleeding and the anatomic location of the bleeding. There are myriad options available, including flexible and rigid bronchoscopy, interventional radiology interventions (bronchial artery embolization, pulmonary artery catheterization and embolization) and surgery. For this patient, it is likely that many of the listed therapies could be attempted; however, it is unlikely that most will definitively control the patient's bleeding. Intubation with a double lumen

tube, by itself, will not offer any therapeutic intervention to this patient (A). Furthermore, double lumen endotracheal tubes sometimes preclude bronchoscopic intervention given the smaller diameter of each lumen, as well as the possibility that these types of endotracheal tubes will obscure the source of bleeding. Rigid bronchoscopy is an excellent diagnostic and therapeutic tool that can be used in massive hemoptysis; however, topical application of dilute epinephrine is unlikely to offer a definitive solution (B). Pulmonary arteriography and embolization are sometimes necessary for massive hemoptysis, but more than 90% of cases are due to bronchial artery bleeding (high pressure system) as opposed to the pulmonary arteries (estimated at 5% of cases, a low pressure system) (D). Flexible bronchoscopy is a diagnostic tool; it can be used with additional therapeutic interventions, such as electrocautery or injection sclerotherapy (E).

**Reference:** Yendamuri, S. (2015). Massive airway hemorrhage. *Thoracic Surgery Clinics*, 25(3), 255–260.

4. **C.** Pulmonary sequestration is a rare anomaly of the lung and is classified into two types, intralobar and extralobar, with the former being more common. The key to the diagnosis is that they both have no connection to the tracheobronchial tree, with the intralobar type remaining within the visceral pleura of the native lung and the extralobar type enveloped in a separate pleural lining (D). They also have their own arterial supply with the intralobar type most commonly receiving its blood supply from the thoracic aorta while the extralobar type receives its supply from the abdominal aorta. For reasons that are unclear, the left side and lower lobes are more commonly involved. Men are more commonly affected in a 3:1 ratio. In the largest case series involving 2625 patients, the most common presentations were productive sputum, fever, and hemoptysis with only 13% of patients presenting with no respiratory symptoms and incidental imaging findings (B). The gold standard to confirm the diagnosis is pulmonary angiography but CT angiography is considered the diagnostic imaging of choice because it is less invasive and has high sensitivity/specificity (A). Surgical resection (segmentectomy preferred over lobectomy) is the standard of care for all patients given the potential for recurrent infections and massive hemoptysis (E).

**References:** Hertenberg, C., Daon, E., & Kramer, J. (2012). Intralobar pulmonary sequestration in adults: three case reports. *Journal of Thoracic Diseases*, 4(5), 516–519.

Tashtoush, B., Memarpour, R., Gonzalez, J., et al. Pulmonary sequestration: a 29 patient case series and review. *Journal of Clinical Diagnostic Research*, 9(12).

5. **B.** Small cell carcinoma of the lung (SCLC) accounts for 20% of all lung cancers and most patients are diagnosed with stage 2 disease (nodal involvement), which has a dismal 5-year survival less than 5% without intervention. The term *limited SCLC* is given to patients with locoregional disease and offers the only hope for cure. In such patients, the recommendation is to administer combination chemotherapy with cisplatin and etoposide with concurrent radiation therapy, with a 5-year survival rate of only 25% (A). There is generally no role for surgery (C–E). The exception is the rare patient who presents with an incidentally discovered small pulmonary nodule in whom the diagnosis is not established preoperatively. Additionally, this patient's small cell carcinoma is complicated by ectopic adrenocorticotrophic hormone (ACTH)-secretion resulting in Cushing syndrome as evidenced by purple striae on the abdomen along with prominent fat on the posterior neck (buffalo hump). Lymph node sampling allows for tissue biopsy and N-status for tumor, nodes, and metastases (TNM) staging. Bronchoscopy is appropriate to check for airway invasion in patients presenting with symptoms suggestive of airway obstruction. Mediastinoscopy and endobronchial ultrasound (EBUS) are appropriate to sample mediastinal lymph nodes. However, they are unable to reach the aortopulmonary nodes; this requires an anterior thoracotomy or parasternal mediastinotomy, also known as the Chamberlain procedure. This can also be accomplished with a video-assisted thoracoscopic surgery (VATS). Positron emission tomography-computed tomography (PET-CT) is the best test for M-status.

**References:** Adjei, A. (2000). Management of small cell cancer of the lung. *Current Opinion in Pulmonary Medicine*, 6(4), 384–390.

Ferraldeschi, R., Baka, S., Jyoti, B., et al. (2007). Modern management of small-cell lung cancer. *Drugs*, 67(15), 2135–2152.

Olak, J. (1996). Parasternal mediastinotomy (Chamberlain procedure). *Chest Surgery Clinical North America*, 6(1), 31–40.

6. **C.** Bronchial artery embolization is an effective tool for treating patients with hemoptysis because

most cases arise from the bronchial circulation rather than the pulmonary artery circulation. Embolization is highly effective in stopping the hemoptysis; however, recurrent bleeding will develop in as many as 50% of patients. The blood supply to the spine (anterior spinal artery) may have a common origin with a bronchial artery, or the bronchial arteries themselves may contribute to the spinal blood supply. As such, the clinician must be aware of this rare but potentially devastating complication. Clinically apparent necrosis or infarction of the other structures is not well recognized (A–B, D–E).

**Reference:** Fraser, K. L., Grosman, H., Hyland, R., et al. (1997). Transverse myelitis: a reversible complication of bronchial artery embolization in cystic fibrosis. *Thorax*, 52(1), 99–101.

7. **D.** Aortic stenosis is most commonly due to senile calcific aortic valve disease and becomes symptomatic later in life. Since the advent of penicillin, rheumatic fever has become an uncommon etiology for this disease (B). The classic signs of aortic stenosis are angina, syncope, and congestive heart failure (CHF) (which can present with swollen legs and elevated brain natriuretic peptide). Of these three, CHF portends the worst prognosis, with median survival as low as 2 years. Patients do not have symptoms until the stenosis is severe, which occurs when the aortic valve area decreases below 1 cm<sup>2</sup> or the mean gradient increases above 40 mm Hg (C). Aortic and pulmonary stenosis both present with a systolic murmur. Symptomatic patients that are appropriate surgical candidates should undergo aortic valve replacement. In high-risk patients (and some intermediate-risk patients) with severe symptomatic AS, transcatheter aortic valve replacement is preferred (A). Valve repair is preferred over valve replacement in patients with mitral valve disease (E).

**Reference:** Bonow, R. O., Crabello, B. A., Chatterjee, K., et al. (2008). 2008 focused update incorporated into the ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to revise the 1998 guidelines for the management of patients with valvular heart disease) Endorsed by the Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *Journal of the American College of Cardiology*, 52(13), e1–e142.

8. **D.** IABP is being used more frequently in patients with low cardiac output states. The balloon is positioned in the descending thoracic aorta just distal to the left subclavian artery. The principal use of IABP is to augment coronary blood flow and thus myocardial oxygen supply. This is accomplished by the balloon deflating at systole, thereby reducing left ventricular afterload, and inflating at diastole, resulting in higher diastolic aortic pressure and higher coronary perfusion pressure. The coronary blood flow is improved during diastole (C). The three widely recognized indications for IABP include high-risk percutaneous coronary intervention, acute myocardial infarction, and cardiogenic shock (E). Its use outside of these clinical scenarios has led to less than ideal outcomes in several recent large randomized trials causing some to speculate if there is an added benefit in the use of IABP. The major limiting factor in these studies was poor patient selection. IABP only works by improving myocardial blood flow, which it can only do when coronary autoregulation is exhausted; otherwise the increased coronary perfusion will be counteracted by the increased coronary vascular resistance, which under normal physiologic conditions works with high fidelity to guarantee constant myocardial blood flow over a wide range of aortic pressures. There are several absolute contraindications to IABP including aortic regurgitation because it can worsen the magnitude of regurgitation (A). Additionally, IABP should be avoided in patients with suspected aortic dissection (because it can extend into the false lumen) and used with caution in patients with abdominal aortic aneurysm (because it can result in rupture) (B).

**Reference:** van Nunen, L. X., Noc, M., Kapur, N. K., et al. (2016). Usefulness of intra-aortic balloon pump counterpulsation. *The American Journal of Cardiology*, 117(3), 469–476.

9. **C.** This patient has developed acute mediastinitis following CABG. This is the most lethal infection of the thorax with a mortality rate close to 30% (D). The source of the mediastinitis is likely to be a sternal wound infection, combined with instability of the sternum that permits bacteria to enter the mediastinum. It can present with chest pain, fever, leukocytosis, increased drainage from the sternal wound, and Hamman's sign (crunching sound heard with a stethoscope over the precordium). It is usually due to a single pathogen (*Staphylococcus aureus* and *Staphylococcus epidermidis* account for the majority of cases) (A). Obesity is considered a risk factor for mediastinitis (E). Prognosis is not related to age, gender, or kind of pathogen. The diagnosis can be

confirmed with CT scan demonstrating dehiscence of the sternum and stranding, fluid, and air pockets within the anterior mediastinum. However, in patients with clinical findings highly suggestive of the condition, CT scan may delay intervention unnecessarily (B). The definitive management is surgical debridement, drainage, antibiotics, and rewiring the sternum. Using a pedicled bilateral internal mammary artery graft increases the risk of mediastinitis, particularly in patients with diabetes and as such should generally be avoided.

**Reference:** Jabłoński, S., Brocki, M., Kordiac, J., et al. (2013). Acute mediastinitis: evaluation of clinical risk factors for death in surgically treated patients. *ANZ Journal of Surgery*, 83(9), 657–663.

10. **B.** Pulmonary function studies are routinely performed when any resection greater than a wedge resection is planned. FEV<sub>1</sub> is regarded as being the best for predicting complications of lung resection in the initial assessment of patients. If the FEV<sub>1</sub> is greater than 2.0 L (or >80% expected), the patient can tolerate a pneumonectomy, and if it is greater than 1.5 L, the patient can tolerate a lobectomy. One must bear in mind that these rough guidelines do not factor in such things as the patient's age, body size, and predicted postsurgery FEV<sub>1</sub>. All of the following pre-operative pulmonary function values are predictive of increased complications and mortality after pneumonectomy: FEV<sub>1</sub> less than 2.0 L; maximal voluntary ventilation less than 55% of predicted; DLCO less than 50% of predicted; and forced expiratory flow, midexpiratory phase (FEF<sub>25%-75%</sub>) less than 1.6 L/sec. If a patient is only going to undergo lobectomy, the pre-operative values predictive of increased complications and mortality include: FEV<sub>1</sub> less than 1.5 L, maximal voluntary ventilation less than 40% of predicted; FEF<sub>25%-75%</sub> less than 0.6 L/sec; and DLCO less than 50% of predicted. (E) Total arterial blood gas, lung capacity, and resting minute ventilation are not included in these predictors (A, C–D).
11. **C.** If pulmonary function testing is within normal limits, no further testing is required, and the patient can be scheduled for surgery (B). If it is below the accepted limits, further testing is recommended including quantitative VQ scan or differential lung scan; this permits calculation of postoperative pulmonary reserve. The minimum acceptable predicted postoperative FEV<sub>1</sub> is 800 mL. If the desired lobe has minimal contribution to FEV<sub>1</sub>, then the patient can still tolerate a resection (A). If the predicted FEV<sub>1</sub> is less than 800 mL, the patient should then be referred to an oncology physician to discuss nonsurgical management. Respiratory muscle training with incentive spirometer has not been demonstrated to improve pulmonary function test results (D). Breathing treatments may have a slight improvement in pulmonary function testing but will not correct the underlying disease (E).
12. **B.** Deoxygenated blood leaves the right ventricle via the pulmonary arteries to receive oxygen in the lungs. The hemoglobin travelling in the pulmonary capillaries participates in air exchange at the alveolar sac. The newly oxygenated hemoglobin is then carried by blood in the pulmonary veins to drain into the left atrium. Additionally, bronchial veins carrying deoxygenated blood used by the lung parenchyma also drain into the pulmonary veins and ultimately the left atrium. This results in blood at the left ventricle having a partial pressure of arterial oxygen that is 5 mm Hg lower than that of blood in the pulmonary capillary (A, C). Cardiac output and pulmonary vascular resistance do not change the general flow of blood (D–E).
13. **D.** There are several key anatomic landmarks in the thorax that all surgeons must know. The right lung has three lobes including the upper, middle, and lower lobes, while the left lung has two lobes including the upper and lower lobes (A). The left lung also has the lingula, which is considered an extension of the upper lobe. The azygous vein runs along the right side draining into the superior vena cava (B). The majority of breathing occurs by using the diaphragm but accessory muscles can contribute up to 20% of the work of breathing. These include the sternocleidomastoid muscle, intercostal muscles, anterior scalene, and oblique muscles. The phrenic nerve runs anterior and the vagus nerve runs posterior to the lung hilum (C, E). Of note, the azygous vein is typically divided in infants during repair of esophageal atresia.
14. **C.** This patient has developed a tracheoesophageal fistula (TEF) as a result of prolonged intubation. This is the most common cause of benign TEF with an incidence up to 3% in ventilated patients. Risk factors include high cuff pressure (single most important), high airway pressure, excessive tube motion, prolonged intubation, esophagitis, hypotension, steroids, and advanced age (D). If the endotracheal tube is placed against a rigid nasogastric tube in the esophagus, it can produce an ischemic necrosis resulting in an abnormal communication. TEF can also manifest after

the patient has been extubated and will present with expectoration of food, deglutition followed by cough, and bronchopulmonary suppuration. In ventilated patients, TEF is suggested by persistent air leaks even with a hyperinflated cuff, abdominal distention (air entering the stomach through the TEF), and bronchial contamination with food and bile-colored (e.g., yellow) secretions. Bronchoscopy can often identify the TEF, but esophagram can help confirm the diagnosis; water-soluble contrast should be used to prevent chemical pneumonitis. Repair should be avoided until after the ventilator is weaned off and includes tracheal resection with primary anastomosis and flap reconstruction for the esophagus. Performing tracheostomy early has not been demonstrated in any large studies to prevent or decrease the development of this complication (B). Low tidal volume ventilator management is preferred for adult respiratory distress syndrome (A). CT scan of the abdomen is not required (E).

**References:** Kaur, D., Anand, S., Sharma, P., et al. (2012). Early presentation of postintubation tracheoesophageal fistula: perioperative anesthetic management. *Journal of Anaesthesiology Clinical Pharmacology*, 28(1), 114–116.

Paraschiv, M. (2014). Tracheoesophageal fistula—a complication of prolonged tracheal intubation. *Journal of Medicine Life*, 7(4), 516–521.

15. **B.** This patient likely has SCLC with syndrome of inappropriate secretion of antidiuretic hormone (SIADH). This paraneoplastic syndrome develops in as many as 40% of patients with SCLC. The diagnosis is made by a combination of hyponatremia, low serum osmolality, and high urine sodium and osmolality. In mild cases, treatment consists of free water restriction. In more severe cases, treatment consists of hypertonic saline with loop diuretics. SIADH would be unusual with the other tumors listed (A, C–E). Hypercalcemia is associated with squamous cell carcinoma due to production of parathyroid hormone (PTH)-related protein.

16. **C.** Lambert-Eaton or Eaton-Lambert myasthenic syndrome is a paraneoplastic syndrome associated with several malignancies, but in particular with small cell carcinoma. It presents with proximal muscle weakness and can be confused with myasthenia gravis (E). More than 50% have or will be discovered to have SCLC (A). The syndrome is thought to be caused by antibodies directed against presynaptic calcium channels in the neuromuscular junction that prevent the release of acetylcholine. Treatment is aimed at the underlying malignancy; however, medications shown to improve symptoms include 3,4-diaminopyridine, IV immunoglobulin, and steroids (B). Unlike in myasthenia gravis, neostigmine is not helpful and thymectomy is not effective (D).

**References:** Illa, I. (2005). IVIg in myasthenia gravis, Lambert Eaton myasthenic syndrome and inflammatory myopathies: current status, *Journal of Neurology*, 252(Suppl. 1), I14–I18.

Maddison, P., & Newsom-Davis, J. (2005). Treatment for Lambert-Eaton myasthenic syndrome. *Cochrane Database of Systematic Reviews*, 18(2), CD003279.

17. **A.** Neurogenic tumors are the most common mediastinal tumors in children (B–E). They are most often located in the posterior mediastinum. They arise from the sympathetic ganglia, intercostal nerves, or paraganglia cells. The most common type is a neurilemmoma (schwannoma). Other examples include gangliomas, neuroblastomas, and neurofibromas. Most are benign. Thymomas are the most common neoplasm of the mediastinum in adult. There is an association between thymoma and various syndromes, including myasthenia gravis, red cell aplasia, aplastic anemia, Cushing syndrome, and hypogammaglobulinemia.

18. **C.** The cricoid cartilage is the first complete cartilaginous ring of the airway and consists of an anterior arch and a posterior broad-based plate (E). The tracheal blood supply is segmental via the inferior thyroid and bronchial arteries (A). Each arterial branch supplies a 1- to 2-cm length of the trachea. Circumferential mobilization will disrupt the blood supply (B). The trachea has approximately 18 to 22 rings and is approximately 10 to 13 cm long. As much as 6 cm of length can be resected primarily using laryngeal release procedures. A tracheostomy is ideally placed between the second and third or third and fourth tracheal rings; higher placement increases the risk of tracheal stenosis and lower placement increases the risk of tracheoinnominate fistula (D).

19. **B.** Catamenial pneumothorax is an uncommon cause of pneumothorax in women that occurs around the time of menstruation. The exact etiology is unclear but in most instances is associated with endometriosis and endometrial deposits on the pleura. The endometrial deposits lead to pleural irritation. Treatment with hormonal therapy has been effective in preventing recurrent attacks. In other instances, however, there is no evidence of endometriosis, and the patient does not respond to hormonal therapy. In such instances, it is postulated that air enters the pleural



cavity through diaphragmatic fenestrations. Loss of the cervical mucous plug during the menstrual cycle permits air to enter from the environment into the peritoneal cavity via the fallopian tubes and into the pleural space through these congenital diaphragmatic fenestrations. Apical blebs along with the other given choices are also possible etiologies of spontaneous pneumothorax but are less likely to be the cause in a patient diagnosed with catamenial pneumothorax (A, C–E).

20. **D.** Most cases of chylothorax can be managed conservatively with NPO or medium-chain triglyceride diet, tube thoracostomy, and parenteral nutrition (B). This has a high success rate of 88%. Predictors of failure for conservative therapy include daily chyle leak of more than 1 L/day for more than 5 days or more than 1.5 L in any 1 day. These patients are better served with surgical intervention. Although open thoracostomy will allow for thoracic duct ligation, VATS is a less invasive approach and better tolerated by patients (E). Most surgeons prefer ligation on the right regardless of where the thoracic duct is injured (C). This allows for a technically easier procedure as the thoracic duct is more robust closer to its origin at the cisterna chyli and thus easier to find and ligate. Additionally, it has the advantage of stopping flow from any of the accessory ducts that may have been injured and not recognized. This has a success rate close to 95%. Octreotide has been shown in some animal models and several case reports to help improve closure of a chyle leak but this is not yet widely accepted. A newer treatment option includes percutaneous thoracic duct embolization which is less invasive than VATS and has been shown in several reports to have high success rates. This is not available at all centers and is not yet considered the standard of care.

**References:** Miyamura, H., Watanabe, H., Eguchi, S., et al. (1994). Ligation of the thoracic duct through transabdominal phrenotomy for chylothorax after heart operations. *The Journal of Thoracic and Cardiovascular Surgery*, 107(1), 316.

Patterson, G. A., Todd, T. R., Delarue, N. C., et al. (1981). Supradiaphragmatic ligation of the thoracic duct in intractable chylous fistula. *The Annals of Thoracic Surgery*, 32(1), 44–49.

Seitelman, E., Arellano, J., Takabe, K., et al. (2011). Chylothorax after blunt trauma. *Journal of Thoracic Diseases*, 4(3), 327–330.

21. **A.** Lung abscess usually results from an aspiration event that causes a suppurative bacterial infection, leading to localized pulmonary parenchymal necrosis. Primary lung abscess, sometimes also referred to as simple, nonspecific, or putrid lung abscess, has similar risk factors as does aspiration pneumonia, including: history of alcohol abuse, poor dentition or gum disease, and seizure disorder or altered level of consciousness. Other potential, less common causes of lung abscess include bronchial obstruction by tumor leading to postobstructive pneumonia, septic pulmonary emboli from infected indwelling catheters or prosthetic devices, and various opportunistic infections (*Nocardia*, *M. tuberculosis*, etc.) in the immunocompromised host (B–E).

**Reference:** Federman, D. D., & Nabel, E. G. (Eds.). (2014). *Infectious diseases: the clinician's guide to diagnosis, treatment, and prevention*. Hamilton, Ontario: Decker Publishing.

22. **B.** Chondrosarcomas are the most common primary malignancy of the chest wall (A, C–E). They usually arise anteriorly. They are a low-grade malignancy and slow growing. Treatment is wide excision. They are not sensitive to chemotherapy or radiation.

23. **C.** Stage 4 non–small cell lung cancer is treated primarily with chemotherapy and radiation therapy. There may be a role for surgical intervention for palliation of symptoms (e.g., thoracentesis or pleural window for recurrent pleural effusions), but, in general, stage 4 disease is not managed surgically. Of the aforementioned findings, malignant pleural effusion is a marker for stage 4 disease (an effusion with malignant cells is considered M1a disease) (A, B, D, E). Other clinical findings that are diagnostic of stage 4 disease include distant metastases, a positive contralateral mediastinal lymph node, and bilateral endobronchial tumor. Attempts at surgical resection are generally reserved for stages 1–3A. Relative contraindications to surgical intervention include recurrent laryngeal nerve involvement; Horner syndrome; pericardial involvement; and SVC syndrome. Surgery may be indicated for selected patients with stage 3A disease in combination with neoadjuvant chemotherapy and radiotherapy. A positive ipsilateral mediastinal lymph node is N2 disease (at minimum stage 3A), a potentially resectable lesion. A contralateral mediastinal lymph node is at least a stage 3B (N3 disease). Patients with stage 1 have only a 50% 5-year survival rate with resection. Stage 2 patients have a 5-year survival rate after surgery of only 30%, whereas those with stage 3A have a 17% 5-year survival rate. The stage 3B survival rate is 5%, and the stage 4 survival rate approaches zero.

**References:** Silvestri, G., Tanoue, L., Margolis, M., et al. (2003). The noninvasive staging of non-

small cell lung cancer: the guidelines, *Chest* 123(Suppl. 1), 147S-156S.

*Non-Small Cell Lung Cancer* Version 7; National Comprehensive Cancer Network Clinical Practice Guidelines, 2015.

24. **B.** Adenocarcinoma is the most common lung cancer in nonsmokers (and overall). It is also more common in women and is most commonly a peripheral lesion. Though this could be many different types of malignancy, given the patient's age, life-long nonsmoking status, and the findings on chest radiograph, adenocarcinoma is the most likely diagnosis (A, C–E). Additionally, the pleural effusion is concerning for stage 4 disease.

**Reference:** Nason, K. S., Maddaus, M. A., and Luketich, J. D. (2010). Chest wall, lung, mediastinum, and pleura. In F. C. Brunicki, D. K. Andersen, T. R. Biliar, et al., (Eds.), *Schwartz's principles of surgery* (9th ed.). New York, NY: McGraw-Hill.

25. **D.** Active tuberculosis can lead to massive hemoptysis. Most hemoptysis is due to bronchial artery bleeding and is managed via bronchial artery embolization. Rarely, hemoptysis is due to a Rasmussen aneurysm, which is a pulmonary artery aneurysm adjacent to or within a tuberculous cavity (A–C, E). Such an aneurysm would be managed by pulmonary arteriography and selective distal embolization. CT scanning is useful in hemoptysis to help localize the source and guide interventional management.

**Reference:** Picard, C., Parrot, A., Boussaud, V., et al. (2003). Massive hemoptysis due to Rasmussen aneurysm: detection with helicoidal CT angiography and successful steel coil embolization. *Intensive Care Medicinal*, 29(10), 1837–1839.

26. **D.** Thymoma is the most common neoplasm of the anterior mediastinum. Malignancy is determined based on evidence of local invasion of adjacent structures or capsular invasion, not on cellular or histologic characteristics (B). Treatment is by surgical resection (A). Thymomas are radiosensitive, so radiation therapy is used as an adjunct in locally advanced cases. As many as 50% of patients with thymomas have symptoms of myasthenia gravis. Conversely, less than 10% of patients with myasthenia gravis are found to have a thymoma on imaging (C). Nevertheless, thymectomy improves or resolves symptoms of myasthenia gravis in as many as 90% of patients without a thymoma compared with only approximately 25% of patients with thymomas. Due to their location, large thymomas can present with SVC syndrome (E).

27. **A.** Increase in overall survival has been achieved with resection of isolated lung metastases (B–E). This is especially true of osteogenic sarcoma, but it has been reported for other malignancies as well. Prior to metastasectomy, however, several conditions must be met. Ideally lung metastases present metachronously, and the primary tumor has already been controlled; the metastatic lesion should be completely resectable, and there should be no evidence of diffuse carcinomatosis. Pulmonary metastasis occurs in as many as 40% to 60% of all primary sarcomas of the limbs within 3 years, and a 30% to 50% 5-year survival rate can be achieved with metastasectomy. In general, solitary metastases have a better prognosis. However, multiple pulmonary metastases due to osteogenic sarcoma treated with metastasectomy have achieved similar positive results as solitary metastatic lesions. Factors associated with survival following metastasectomy include a disease-free interval from primary tumor to initial evidence of metastasis, surgical resectability, tumor doubling time, and number of metastases.

**Reference:** Antunes, M., Bernardo, J., Salete, M., et al. (1999). Excision of pulmonary metastases of osteogenic sarcoma of the limbs. *European Journal of Cardio-Thoracic Surgery*, 15(5), 592–596.

28. **C.** Given the draining sinus and sulfur granules, the patient most likely has actinomycosis, a chronic disease usually caused by *Actinomyces israelii* that occurs most commonly in the head and neck region. Because of its rarity and chronicity, the diagnosis is often delayed and unrecognized. A key to the diagnosis is the finding of chronic sinuses with discharge of purulent material containing yellow-brown sulfur granules. The organisms enter the lungs via the oral cavity. The organisms are often not cultured out because they are anaerobes. Lung involvement can present with progressive pulmonary fibrosis. Central nervous system involvement is not common (E). Prolonged, high-dose penicillin is the treatment of choice (D). Surgery is generally not indicated; however, pulmonary actinomycosis can easily be confused with a lung cancer, prompting surgical intervention (A). *Nocardia asteroides* is a gram-positive rod that mimics fungi microscopically because of its branched filamentous morphology and causes nocardiosis in immunocompromised patients (B). It is associated with pneumonia, endocarditis, and central nervous system abscess. The treatment is trimethoprim-sulfamethoxazole.

**Reference:** Hsieh, M., Liu, H., Chang, J., et al. (1993). Thoracic actinomyces. *Chest*, 104(2), 366–370.

29. A. The recommended sequential workup for a potentially resectable lung cancer should begin with a CT scan of the chest, followed by a PET scan. If there are no mediastinal lymph nodes greater than 1 cm, the likelihood of positive lymph nodes is low (<10%) but should be confirmed with a PET scan. If the CT scan shows a mediastinal lymph node greater than 1 cm or if a mediastinal lymph node lights up on PET scan, mediastinoscopy is indicated (D). PET scanning has replaced multiorgan scanning in the search for distant metastases to the liver, adrenal glands, and bones (B, C, E). If PET scanning detects potential metastasis, it is important to obtain a tissue diagnosis before denying a possible resection.

**References:** Maddaus, M. A., & Lukeitch, J. D. (2005). Chest wall, mediastinum, and pleura. In F. C. Brunicki, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 545–610) (8th ed.). New York, NY: McGraw-Hill.

Silvestri, G., Tanoue, L., Margolis, M., et al. (2003). The noninvasive staging of non-small cell lung cancer: the guidelines. *Chest*, 123(Suppl. 1), 147S–156S.

30. C. Tracheal stenosis is most commonly due to trauma from prolonged endotracheal intubation or tracheostomy. The risk of stenosis is greater when tracheostomies are placed too high (through the first tracheal ring) or for cricothyroidotomies (the cricothyroid membrane marks the narrowest portion of the trachea). Patients with tracheal stenosis present with stridor and dyspnea on exertion, which can be confused with asthma, and usually present within 2 to 12 weeks after decannulation or extubation. The treatment of tracheal stenosis is resection and primary anastomosis. As much as 6 cm of trachea can be resected in most adult patients using laryngeal release procedures. Most patients can be immediately extubated without tracheostomy placement (D). Laser ablation, dilation, and stenting are not definitive treatment options and not indicated for circumferential scar formation or a stenotic segment greater than 1 cm (A, B, E).

**Reference:** George, M., Lang, F., Pasche, P., et al. (2005). Surgical management of laryngotracheal stenosis in adults, *European Archives of Oto-Rhino-Laryngology*, 262(8), 609–615.

# Pediatric Surgery

*Steven Lee, Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 4-year-old boy presents with a midline anterior neck cystic mass that moves up and down when he sticks his tongue out. The most appropriate management is:
  - A. Observation
  - B. Incision and drainage
  - C. Hemithyroidectomy
  - D. Fine-needle aspiration
  - E. Surgical resection with removal of part of the hyoid bone
2. Which of the following is true regarding Bochdalek type of congenital diaphragmatic hernia (CDH)?
  - A. Urgent surgical repair is indicated upon diagnosis.
  - B. Associated pulmonary hypoplasia leads to hypocarbia.
  - C. Most defects are on the right.
  - D. Pulmonary hypertension is a prominent feature.
  - E. The diaphragmatic defect is anteromedial.
3. A female newborn is in respiratory distress. A chest radiograph demonstrates a hyperlucent left upper lobe with adjacent lobar compression and mediastinal shift to the right. The treatment of choice for this patient is:
  - A. Left upper lobectomy
  - B. Left tube thoracostomy
  - C. Left pneumonectomy
  - D. Positive pressure ventilation until condition resolves
  - E. Bronchoscopy
4. A full-term baby is born with drooling, coughing, and cyanosis after the first feeding, but these resolve quickly and spontaneously. The next step in management should be:
  - A. Immediate intubation
  - B. Placement of orogastric tube
  - C. Two-view abdominal x-ray
  - D. Two-view chest x-ray
  - E. Upper gastrointestinal (UGI) contrast series
5. A 4-week-old infant presents to the emergency department (ED) with increasingly projectile vomiting that is nonbilious and a palpable small right upper quadrant mass. The most appropriate resuscitation for this patient is:
  - A. 5% dextrose in water (D5W) 0.5 normal saline (NS) + 20 potassium chloride (KCL) at 2 times maintenance
  - B. 20 mL/kg NS bolus
  - C. 10 mL/kg lactated Ringer's (LR) bolus
  - D. D5W 0.25 NS + 10 KCL at 1.5 times maintenance

- E. 10 mL/kg 5% albumin at maintenance
6. A patient is diagnosed with pyloric stenosis after 3 days of nonbilious emesis. This patient's electrolyte and acid/base balance will result in:
- A. Respiratory alkalosis
  - B. Hyperkalemia
  - C. Aciduria
  - D. Hyperchloremia
  - E. Hyponatremia
7. A 900-g, premature infant develops formula intolerance with vomiting, abdominal distention, and bloody stools. Labs show an elevated white blood cell (WBC) count and platelets of 100,000. Abdominal x-rays show dilated loops of bowel with pneumatosis intestinalis. The most appropriate treatment should be:
- A. Blood and platelet transfusions
  - B. Antibiotics and bowel rest/decompression
  - C. Ultrasound and paracentesis
  - D. Placement of a bedside peritoneal drain
  - E. Exploratory laparotomy
8. A healthy 2-week-old girl develops bilious emesis. On exam, her abdomen is nontender and nondistended. What is the most appropriate study to make the diagnosis?
- A. 2-view abdominal x-ray
  - B. Ultrasound
  - C. UGI series
  - D. Contrast enema
  - E. Computed tomography (CT) scan of abdomen/pelvis
9. Operative management for a patient with malrotation and midgut volvulus typically includes reduction of the volvulus, division of Ladd bands, and which of the following?
- A. Placement of the small intestine in the left lower quadrant
  - B. Cecopexy and gastropexy
  - C. Appendectomy
  - D. Placement of the cecum in the right upper quadrant
  - E. Reconstruction of the ligament of Treitz
10. An 11-month-old boy presents to the ED with crampy abdominal pain and vomiting for 24 hours. His exam and abdominal x-rays are normal. His complete blood count (CBC) is normal, and the electrolyte panel reflects slight dehydration. The most appropriate step in his management is:
- A. Intravenous (IV) fluid bolus and discharge from the ED
  - B. Abdominal ultrasound
  - C. Contrast enema
  - D. UGI contrast series
  - E. IV antibiotics and admission
11. A 2-week-old boy presents with constipation and abdominal bloating. He failed to pass meconium on the first 2 days of life. Contrast enema demonstrates a slightly dilated sigmoid colon with a constricted rectum. What is the next most appropriate step in management?
- A. Rectal irrigations and IV antibiotics
  - B. Creation of a leveling ostomy
  - C. Suction rectal biopsy
  - D. Change to an elemental formula
  - E. Obtain an UGI contrast series with small bowel follow-through
12. A full-term, healthy newborn boy is noted to have imperforate anus. After 24 hours, no meconium is

- visualized in the perineal area. The most appropriate management should be:
- A. Observation for another 24 hours
  - B. Diverting ileostomy
  - C. Sigmoid colostomy
  - D. Primary repair through the perineum
  - E. Laparoscopic primary repair
13. A 10-month-old boy is being worked up for an abdominal neuroblastoma. In counseling, the parents should be informed of which of the following statements?
- A. The mass most likely originates from the kidney.
  - B. The prognosis is associated with size of the tumor.
  - C. The prognosis is associated with patient age.
  - D. No treatment is needed because of the excellent prognosis.
  - E. The prognosis is associated with urinary vanillylmandelic acid levels.
14. A 36-week, 2.7-kg newborn is born with a 12-cm sacral mass. Workup demonstrates no internal involvement of the presacral area. The most appropriate management is:
- A. Observe because regression of the mass is likely
  - B. Embolization of the mass and resection at 1 year of age
  - C. Diverting ileostomy and resection of the mass at 1 year of age
  - D. Chemo/radiation therapy, then resection
  - E. Resection of the mass including the coccyx
15. A newborn is in severe respiratory distress and has a markedly scaphoid abdomen. Which of the following is true regarding this condition?
- A. A chest tube should be promptly placed.
  - B. The patient should be ventilated with bag-mask ventilation.
  - C. Overall survival is about 50%.
  - D. Ventilation with high-frequency oscillation is contraindicated.
  - E. Urgent thoracotomy is required.
16. An 8-year-old boy is involved in a bike crash. He is hemodynamically stable. On examination, he has ecchymosis on the left upper quadrant. A focused assessment with sonography for trauma (FAST) scan demonstrates free fluid in the pelvis. The next most appropriate step in management is:
- A. CT scan of abdomen and pelvis
  - B. Admission to the intensive care unit (ICU) with serial CBC and exams
  - C. Two-view abdominal x-rays
  - D. Diagnostic laparoscopy
  - E. Transfusion of 10 mL/kg of packed RBCs
17. A 1-day-old, full-term infant presents with bilious emesis. Abdominal x-rays show multiple loops of dilated bowel. A contrast enema shows a microcolon. What is the pathophysiology behind this obstruction?
- A. It is due to a fetal mesenteric vascular accident
  - B. Failure of recanalization of the bowel
  - C. Lack of proper rotation of the bowel
  - D. Lack of ganglion cells in the bowel
  - E. A duplication of a segment of bowel
18. A newborn baby is born with an abdominal wall defect. The defect involves the umbilicus and has a membrane associated with it. Which of the following is true regarding this type of defect?
- A. This patient requires immediate surgical closure.
  - B. Mortality is most often the result of persistent sepsis.
  - C. It is thought to occur due to an umbilical vein vascular accident.

- D. The defect is usually associated with intestinal atresia.
- E. These patients commonly have associated cardiac and genetic abnormalities.
19. A 2-month-old infant has persistent jaundice. Ultrasonography fails to demonstrate a gallbladder. Technetium-99m iminodiacetic acid scanning with phenobarbital pretreatment reveals uptake in the liver but not in the intestine.  $\alpha_1$ -Antitrypsin and cystic fibrosis determination is normal. The most appropriate surgical management would be:
- A. Kasai operation (hepatportoenterostomy)
  - B. Liver transplantation
  - C. Percutaneous transhepatic liver drainage
  - D. Endoscopic biliary stent placement
  - E. Choledochojejunostomy
20. The most common indication for extracorporeal membranous oxygenation (ECMO) in neonates is:
- A. Congenital diaphragmatic hernia
  - B. Respiratory distress syndrome
  - C. Meconium aspiration
  - D. Persistent pulmonary hypertension
  - E. Congenital cardiac abnormalities
21. A full-term, boy is noted to have facial features of trisomy 21 and bilious emesis. The rest of his exam is normal. Abdominal x-rays show a double-bubble sign with no distal gas. Which of the following is the best next step in management?
- A. Serial abdominal x-rays
  - B. UGI contrast study
  - C. Contrast enema
  - D. Operative exploration
  - E. Echocardiogram
22. A 2-year-old child presents with an abdominal mass, "raccoon eyes," and "blueberry muffin" skin lesions. This most likely represents:
- A. Rhabdomyosarcoma
  - B. Neuroblastoma
  - C. Wilms tumor
  - D. Hepatoblastoma
  - E. Teratoma
23. The most common anomaly associated with gastroschisis is:
- A. Cardiac
  - B. Renal
  - C. Limb
  - D. Malrotation
  - E. Down's syndrome
24. A 3-year-old girl presents to the ED with crampy abdominal pain for 24 hours. The pain is increasing in frequency and duration. Ultrasound demonstrates a target sign. The most common pathologic lead point is:
- A. Appendix
  - B. Small bowel polyp
  - C. Ectopic pancreatic tissue
  - D. Meckel diverticulum
  - E. Intraluminal hematoma
25. A newborn baby is born with a distended abdomen and bilious emesis. Both parents are carriers for cystic fibrosis. On examination, the patient has a distended but soft abdomen. Abdominal x-rays



- show dilated loops of bowel with a ground glass appearance. The most appropriate initial management is:
- Water-soluble contrast enemas
  - Resection of terminal ileum with stoma
  - Resection of terminal ileum with primary anastomosis
  - UGI with small bowel follow-through
  - Small bowel enterotomy with evacuation of meconium
26. A 6-month-old boy presents to the ED crying in pain and has bilious emesis. On exam, he has a distended abdomen, and there is a tender mass in the right groin. Appropriate management should be:
- Ultrasound of right groin
  - Bedside incision and drainage (I&D) of right groin
  - IV antibiotics
  - Attempt reduction
  - Operative exploration
27. A 4-year-old girl presents with recurrent jaundice. Ultrasound shows a 5-cm fusiform dilation of the common bile duct. During surgery, this posterior aspect of the cystic mass is firmly adherent to the portal vein. The most appropriate management is:
- Abort surgery, IV antibiotics, and reoperate in 3 months
  - Place a drain into the cyst, IV antibiotics, and reoperate in 3 months
  - Resect the anterior cyst, mucosectomy of the posterior cyst with reconstruction
  - Internal drainage of the cyst with a Roux-en-Y cystojejunostomy
  - Resect the cyst and portal vein with reconstruction of the portal vein and common bile duct (CBD)
28. A 3-week-old, ex-25 week premature boy is diagnosed with a left inguinal hernia while in the neonatal ICU (NICU). His current weight is 1 kg, and he requires supplemental oxygen. The hernia is easily reducible. The next appropriate step in management is:
- Ultrasound evaluation
  - Immediate open operative repair
  - Immediate laparoscopic repair
  - Observation and consider repair at the time of discharge
  - Delay repair until 1 year of age
29. A 30-kg child has an estimated hourly fluid requirement of:
- 40 mL/hr
  - 50 mL/hr
  - 60 mL/hr
  - 70 mL/hr
  - 80 mL/hr
30. The pathogenesis of necrotizing enterocolitis (NEC) is thought to be related to:
- A genetic predisposition
  - An enzyme deficiency
  - A period of intestinal hypoperfusion
  - Preexisting intestinal atresia
  - An antibiotic reaction
31. The intestines appear viable after operative reduction of a midgut volvulus. The key to prevent a recurrent volvulus is to:
- Place the intestines back in the normally rotated position
  - Fix the bowel to the abdominal wall/retroperitoneum
  - Divide the bands over the duodenum

- D. Broaden the base of the mesentery to the intestine
  - E. Perform ileostomy and mucus fistula
32. A 3-year-old girl presents with recurrent maroon-colored stools. Her physical exam is normal. Technetium-99m scintigraphy shows enhancement and a blush above and separate from the bladder. The most appropriate management is:
- A. Start the patient on proton-pump inhibitors
  - B. Embolization with interventional radiology
  - C. Endoscopic embolization of the bleeding site
  - D. Laparoscopic diverticulectomy
  - E. Segmental ileal resection
33. A newborn baby with a prenatal diagnosis of gastroschisis is born with the entire small intestine outside of the abdomen. The bowel appears ischemic and the abdominal wall defect is small and tight. The most appropriate next step in management is:
- A. Place a bedside silo
  - B. Primary reduction and closure
  - C. Open the abdominal wall defect
  - D. Resect the ischemic bowel
  - E. Create a diverting ileostomy
34. A 1-week-old, full-term baby with abdominal distention, fever, tachycardia, and low urine output is transferred to the NICU. The patient has not passed meconium. He had a suction rectal biopsy showing aganglionosis. Digital rectal examination shows explosive, foul smelling liquid stools. Despite broad-spectrum IV antibiotics and rectal irrigation, he is clinically deteriorating. The next step in management is:
- A. Perform contrast enema
  - B. Perform loop colostomy
  - C. Perform subtotal colectomy and ileostomy
  - D. Perform abdominal decompression for abdominal compartment syndrome
  - E. Add additional antifungal coverage
35. A 4-week-old infant presents with bilious vomiting, irritability, abdominal wall edema, and erythema. Plain films reveal proximal dilated bowel, with a paucity of distal bowel gas. Which is true regarding this patient?
- A. An urgent UGI series is indicated.
  - B. A trial of nasogastric tube decompression is often helpful.
  - C. Endoscopic decompression is often beneficial.
  - D. A CT scan of the abdomen and pelvis should be obtained.
  - E. Delay in management may lead to a need for intestinal transplantation.
36. A neonate is found to have bilateral undescended testes that are not palpable in the inguinal canal. Which of the following is true regarding this condition?
- A. A bilateral orchiopexy should be performed by 1 year of age.
  - B. Orchiopexy does not improve fertility potential.
  - C. Orchiopexy reduces the risk of malignancy in the testicles.
  - D. Chorionic gonadotropin does not aid in testicular descent.
  - E. The testicular arteries must be preserved during operation.

## Answers

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1. **E.** The patient described has a thyroglossal duct cyst, which is one of the most common lesions of the neck found in the midline. Most are asymptomatic. Thyroglossal remnants produce midline masses extending from the base of the tongue to the pyramidal lobe of the thyroid. Complete failure of thyroid migration results in a lingual thyroid. Ultrasound or radionuclide imaging may

be used to identify the presence of a normal thyroid gland within the neck. Elective surgical resection should be performed to avoid complications of infection and the small risk of cancer (papillary thyroid carcinoma) developing in the cyst (A). Initial incision and drainage may be required if the cyst presents as an infection and is not responsive to antibiotics (B). The incidence of ectopic thyroid within or near the cyst is 10% to 45%. A solid mass on ultrasound would be suggestive of ectopic thyroid and should be followed with a thyroid scan (C). The treatment of a thyroglossal duct cyst is the Sistrunk procedure, which involves complete excision of the cyst in continuity with its tract, the central portion of the hyoid bone, and the tissue above the hyoid bone extending to the base of the tongue. Fine-needle aspiration is not helpful for the diagnosis of this benign congenital process (D).

**References:** Brousseau, V., Solares, C., Xu, M., et al. (2003). Thyroglossal duct cysts: presentation and management in children versus adults. *International Journal of Pediatric Otorhinolaryngology*, 67(12), 1285–1290.

McAteer, J., Waldhausen, J. H. T. (2014). Head and neck sinuses and masses. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 1028–1041) (6th ed.). Philadelphia, PA: Saunders Elsevier.

2. **D.** Approximately 90% of CDHs occur on the left side (C). Rarely, they may be bilateral. The cause of CDH is unknown, but it is believed that they result from failure of normal closure of the pleuroperitoneal canal in the developing embryo. As a result, the abdominal contents herniate through the defect in the diaphragm and compress both lungs, with the ipsilateral lung more severely affected. Compression of the developing lungs leads to pulmonary hypoplasia, which is clinically manifested with hypercarbia (B). There is a higher incidence of malrotation in patients with CDH. A Bochdalek hernia is in the posterolateral location and most commonly on the left side (E). The most significant physiologic abnormality in patients with CDH is pulmonary hypertension which can lead to significant hypoxia. Extracorporeal membrane oxygenation (ECMO) may be required in some patients with significant pulmonary hypertension. Urgent surgical intervention is not indicated because reducing the hernia will not correct the pulmonary hypertension. In fact, surgical repair may temporarily worsen pulmonary compliance and hypertension. Thus, the infant's condition should be medically optimized before performing the repair (A). Although there is no ideal timing to repair a congenital diaphragmatic hernia, most surgeons will wait until the infant's pulmonary vascular resistance drops, which occurs several days to weeks after birth. Bochdalek hernias are distinguished from Morgagni hernias, which are another type of congenital hernia and typically of the anteromedial diaphragm. The Morgagni hernia defect is small and asymptomatic and typically presents as a density on chest radiograph in adulthood.

**Reference:** Lally, K., Paranka, M., Roden, J., et al. (1992). Congenital diaphragmatic hernia: stabilization and repair on ECMO, *Annals of Surgery*, 216(5), 569–573.

3. **A.** Congenital lobar emphysema in its most severe form presents as respiratory distress at birth. It is due to excessive hyperexpansion of one or more lobes of the lung from either abnormal cartilage in the bronchus (creating a one-way valve effect) or external compression from a cardiac abnormality such as left atrial enlargement. As the lung overinflates, atelectasis of the adjacent lobes ensues. Eventually mediastinal shifting occurs with compromise of the opposite lung. It is most common in the upper lobes of the lung. In mild forms, the infant may present later with mild respiratory distress. Diagnosis is made by chest radiograph, which shows a hyperlucent affected lobe, adjacent lobar compression and atelectasis, and mediastinal shift to the opposite side. Bronchoscopy is contraindicated because it will exacerbate the overinflation (E). Treatment involves urgent thoracotomy and resection of the affected lobe. The chest radiograph can be confused with a pneumothorax, and inadvertent placement of a chest tube in the distended lung will further worsen an already life-threatening situation (B). Immediate thoracotomy with resection of the lung lobe may be lifesaving, but pneumonectomy is not necessary with involvement of a single lobe (C). Recent studies suggest that in asymptomatic or mild symptomatic cases, nonsurgical therapy is acceptable (D).

**Reference:** Mei-Zahav, M., Konen, O., Manson, D., et al. (2006). Is congenital lobar emphysema a surgical disease? *Journal of Pediatric Surgery*, 41(6), 1058–1061.

4. **B.** Esophageal atresia (EA) and tracheoesophageal fistula (TEF) are congenital interruptions or discontinuities of the esophagus resulting in esophageal obstruction. Most present at birth with excessive drooling and choking or coughing after an attempted feed. There are five types (A to E).

The most common type is type C in which there is proximal EA with a distal TEF. The most appropriate next step is to attempt to place an orogastric tube. In patients with proximal EA and distal TEF, the tube will not be able to be passed into the stomach but will curl in the upper esophageal pouch. A two-view chest x-ray should follow to confirm the diagnosis (D). An esophagram or UGI series is not needed to make the diagnosis and increases the risk for aspiration (E). An abdominal x-ray is obtained after attempted placement of the orogastric tube (C). The abdominal x-ray will help determine the presence of a TEF by showing gas in the intestines. A gasless abdomen suggests an isolated EA. Intubation and positive pressure ventilation should be avoided because this increases the risk of ventilating through the TEF resulting in respiratory failure (A).

**Reference:** Rothenberg, S. (2014). Esophageal atresia and tracheoesophageal fistula malformations. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 365–384) (6th ed.). Philadelphia, PA: Saunders Elsevier.

5. **B.** This patient has pyloric stenosis. These patients will present with progressively worsening non-bilious emesis at several weeks of age. A physical exam finding is a palpable olive-shaped epigastric mass, although this finding is usually very difficult to elicit. Patients with pyloric stenosis are typically dehydrated secondary to persistent emesis. The first step in management is to fluid resuscitate these patients. The correct volume for any crystalloid fluid bolus in infants is 20 mL/kg. In almost all pediatric patients, NS is the most appropriate fluid used for resuscitation. Ten mL/kg is the correct volume for blood products (packed RBCs, platelets, fresh frozen plasma) and when administering 5% albumin (C). However, this patient requires crystalloid resuscitation (E). Once the patient receives a bolus, then intravenous (IV) fluids given at a maintenance rate may be administered (A, D). For patients with pyloric stenosis, D5W 0.5 NS is administered at 1.5 times maintenance. Once the patient voids, then the fluids are switched to D5W 0.5 NS + 20 KCL. Pyloromyotomy to correct the obstruction is not an emergency and should be delayed until laboratory parameters have normalized. Postoperatively, infants are allowed to resume enteral feedings. Vomiting after surgery occurs frequently but is self-limited. Recent studies indicate that the laparoscopic approach is equally effective and has the advantage of a shorter hospital stay, a quicker recovery, and a smaller scar. Although the scar for open pyloromyotomy is small, it tends to become more sizable and grow as the infant grows.

**References:** Jabaji, Z., Sullins, V. F., & Lee S. L. (2015). Infant with nonbilious emesis. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review*. New York, NY: Springer.

Fujimoto, T., Lane, G., Segawa, O., et al. (1999). Laparoscopic extramucosal pyloromyotomy versus open pyloromyotomy for infantile hypertrophic pyloric stenosis: which is better? *Journal of Pediatric Surgery*, 34(2), 370–372.

6. **C.** Pyloric stenosis occurs in 1 in 300 live births. Most often it occurs in males between 3 and 6 weeks of age. Infants with pyloric stenosis present with projectile, nonbilious vomiting. As the disease progresses, an almost complete gastric outlet obstruction develops, and the infant is no longer able to tolerate even clear liquids. The classic electrolyte disorder that results from protracted vomiting is a hypochloremic hypokalemic metabolic alkalosis (A, B, D). The urine pH level is high initially because of the alkalosis but eventually becomes acidic and is known as paradoxical aciduria. The explanation for this is that the renal tubule initially reabsorbs sodium in exchange for potassium. However, gastric juice has a high potassium concentration, and as vomiting continues, serum potassium levels drop. To conserve potassium as well, the renal tubule switches to reabsorbing sodium in exchange for hydrogen ions in the urine (E).

**References:** Fujimoto, T., Lane, G., Segawa, O., et al. (1999). Laparoscopic extramucosal pyloromyotomy versus open pyloromyotomy for infantile hypertrophic pyloric stenosis: which is better? *Journal of Pediatric Surgery*, 34(2), 370–372.

Jabaji, Z., Sullins, V. F., & Lee, S. L. (2015). Infant with nonbilious emesis. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 343–349) (1st ed.). New York, NY: Springer.

7. **B.** In all infants suspected of having necrotizing enterocolitis (NEC), feedings are discontinued, an orogastric tube is placed for decompression, and broad-spectrum parenteral antibiotics are given. Staging of NEC can be done with the Bell criteria. Patients with Bell stage I (suspicious for NEC) are ruled out for NEC and kept NPO and on IV antibiotics for 3 to 7 days before enteral nutrition is

reinitiated. Patients with Bell stage II (definite NEC) require close observation for 7 to 14 days. Infants with Bell stage III (advanced NEC) either have definite intestinal perforation or have not responded to nonoperative therapy, and thus require surgery. These patients have signs of peritonitis, acidosis, sepsis, and disseminated intravascular coagulation, all of which are associated with a high mortality rate. This patient is Bell stage II and should continue treatment with antibiotics and bowel rest/decompression. Blood transfusions should be based on the patient's clinical status and hemoglobin/hematocrit. A platelet count of 100,000 does not require transfusion (A). Options C, D, and E are reserved for patients with Bell stage III. Ultrasound and paracentesis may guide the decision to proceed with operative intervention. Surgical intervention may be with a peritoneal drain or exploratory laparotomy.

**References:** Bell, M., Ternberg, J., Feigin, R., et al. (1978). Neonatal necrotizing enterocolitis: therapeutic decisions based upon clinical staging. *Annals of Surgery*, 187(1), 1–7.

Dominguez, K. M., & Moss, R. L. (2014). Necrotizing enterocolitis. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 454–473) (6th ed.). Philadelphia, PA: Saunders Elsevier.

8. **C.** The diagnosis of malrotation with midgut volvulus should be suspected in an infant presenting with bilious vomiting and evidence of a bowel obstruction. Plain radiographs are likely to be normal or nondiagnostic (A). Some authors have recommended ultrasonography to look for a sonographic clockwise whirlpool pattern of the superior mesenteric vein and mesentery around the superior mesenteric artery, however, the gold standard for diagnosis is a UGI series (B). Historically, contrast enemas were used to make the diagnosis but are less accurate than a UGI series (D). CT scan of the abdomen/pelvis may suggest malrotation in older children or adults with vague symptoms (E).

**Reference:** Sullins, V. F., & Lee, S. L. (2015). Infant with bilious emesis. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 335–343) (1st ed.). New York, NY: Springer.

9. **C.** After malrotation and midgut volvulus is diagnosed, the infant should be urgently taken to the operating room because a delay risks the development of gangrene of the entire small bowel. The first step is to reduce the volvulus. The goal of the Ladd procedure is to broaden the narrow base of the mesentery to prevent the volvulus from recurring. The bands between the cecum and abdominal wall and between the duodenum and terminal ileum are sharply divided to splay out the superior mesenteric artery and its branches. This brings the duodenum into the right lower quadrant and the cecum into the left lower quadrant and anatomically creates a complete nonrotation (A, D, E). The appendix is typically removed to avoid diagnostic errors later in life, but this is not absolutely required because imaging techniques and diagnostic capabilities have improved. The cecum and stomach are not fixed to the abdominal wall because this will increase the risk of a twist at these sites (B).

**References:** Pracros, J., Sann, L., Genin, G., et al. (1992). Ultrasound diagnosis of midgut volvulus: the “whirlpool” sign. *Pediatric Radiology*, 22(1), 18–20.

Sullins, V. F., & Lee, S. L. (2015). Infant with bilious emesis In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 335–343) (1st ed.). New York, NY: Springer.

10. **B.** Intussusception is the primary cause of intestinal obstruction in the young child. It is more common in boys, with a male-to-female ratio of 3:1 that increases to 6:1 in older children. It is a condition in which the intestine telescopes or invaginates into itself. It most often begins in the terminal ileum and extends distally into the ascending colon. Intussusception is called *idiopathic* when there is no distinct pathologic leading point. This is the case in most infants aged 6 to 24 months in whom the intussusception is usually due to hypertrophy of the Peyer patches in the terminal ileum from a previous viral infection. The symptoms of intussusception include intermittent bouts of crampy abdominal pain and vomiting. The passage of bloody mucus and “currant jelly” stool is a late finding and present in a minority of infants. Between attacks, the infant may act normally. In the absence of peritonitis, the child should first undergo ultrasound evaluation to make the diagnosis. The classic finding is a target sign. Once the diagnosis is made, radiographic reduction by contrast or air enema should be performed (C). An upper GI contrast series (D) is the preferred diagnostic modality for midgut volvulus. If reduction is incomplete, operative intervention is indicated because gangrene and perforation may result. If peritonitis is present on the initial examination or the child is systemically ill, one should forgo enema attempts,

and an urgent operation is indicated. At surgery, the intussusception is reduced manually by gentle distal pressure rather than by pulling out the bowel. Recurrence rates after hydrostatic or operative reduction are in the 5% to 10% range. Intussusception in an older child or an adult is more likely due to an underlying pathology in the bowel (e.g., tumor, polyp, Meckel diverticulum). Patients should be given IV fluids, but not discharged from the ED without a diagnostic workup (A). Similarly, IV antibiotics should not be started without a diagnostic workup (E).

**Reference:** Guo, J., Ma, X., & Zhou, Q. (1986). Results of air pressure enema reduction of intussusception: 6,396 cases in 13 years. *Journal of Pediatric Surgery*, 21(12), 1201–1203.

11. C. Hirschsprung disease is characterized by an absence of ganglion cells in the Auerbach plexus and hypertrophy of associated nerve trunks. The cause is thought to be a defect in the migration of neural crest cells. The rectosigmoid junction is affected in 75% of cases, the splenic flexure or transverse colon in 17%, and the entire colon with variable extension into the small bowel in 8%. The presentation of the disease is characterized as a functional distal intestinal obstruction. Similar to ulcerative colitis, the disease is always present distally and extends a variable distance proximally and continuously. In the neonatal period, the most common symptoms are abdominal distention, failure to pass meconium, and bilious emesis. Infants can also present with enterocolitis, which is characterized by abdominal distention and tenderness and is associated with manifestations of systemic toxicity. Enterocolitis is the most common cause of death in uncorrected Hirschsprung disease. The initial management of a patient with Hirschsprung-associated enterocolitis is rectal irrigations and IV antibiotics (A). The definitive diagnosis of Hirschsprung disease is made by rectal biopsy at least 2 cm above the dentate line to avoid sampling error. A contrast enema is useful because it will often help localize the transition zone between the dilated proximal ganglion containing the colon and the narrowed aganglionic distal segment but is not as helpful in the immediate neonatal period because the proximal segment may not be as markedly dilated yet. A small bowel follow-through is not helpful because the obstruction is in the colon (E). Multiple surgical operations exist for the management of Hirschsprung disease. Recently, primary repair with a pull-through procedure without a temporary colostomy has been performed. A leveling colostomy may be performed as part of a staged procedure. However, this is only done after the diagnosis is made (B). Most patients with Hirschsprung disease will tolerate breast milk or normal formulas after surgery and will not require an elemental formula (D).

**Reference:** Carcassonne, M., Guys, J., Morrison-Lacombe, G., et al. (1989). Management of Hirschsprung's disease: curative surgery before 3 months of age. *Journal of Pediatric Surgery*, 24(10), 1032–1034.

12. C. In patients with an imperforate anus, the rectum fails to descend through the external sphincter complex. The pathophysiology is thought to be due to failure of the urorectal septum to descend. The rectal pouch ends blindly in the pelvis, above (high lesion) or below (low lesion) the levator complex. Sixty percent of males have high lesions compared with only 30% of females. In most cases, the blind rectal pouch communicates more distally with the genitourinary system or with the perineum through a fistulous tract. In male patients with a high imperforate anus, the rectum usually ends as a fistula somewhere along the urethra. In females, a high imperforate anus often occurs in the context of a persistent cloaca. Approximately 60% of patients have an associated malformation; the most common is a urinary tract defect. Skeletal defects are also seen, and the sacrum is most commonly involved. Spinal cord anomalies are common, especially with high lesions. Imperforate anus is also associated with VACTERL (vertebral defects, anal atresia, cardiac defects, tracheoesophageal fistula, renal anomalies, and limb abnormalities) syndrome. Evaluation should include plain radiographs of the spine as well as an ultrasound scan of the spinal cord. A plain chest radiograph and careful clinical evaluation of the heart should be conducted. The most common defect is an imperforate anus with a fistula between the distal colon and the urethra in boys or to the vestibule of the vagina in girls. When there is no visible meconium in the perineal area after 24 hours, the patient is considered to have a high imperforate anus malformation. Patients with a high lesion should undergo primary sigmoid colostomy followed by a definitive pull-through at 3 to 6 months of life (B). Waiting an additional 24 hours may lead to worsening abdominal distention and respiratory compromise (A). Low lesions can be repaired by a perineal procedure at birth (D). High lesions may be repaired through a posterior sagittal approach (PSARP) or laparoscopic assisted approach (E). Low lesions have better prognosis with respect to continence as the anatomy more closely resembles complete descent and development.

**Reference:** Georgeson, K., Inge, T., & Albanese, C. (2000). Laparoscopically assisted anorectal pull-through for high imperforate anus: a new technique. *Journal of Pediatric Surgery*, 35(6), 927–931.

13. C. Neuroblastoma is an embryonal tumor of neural crest origin. It is the third most common pediatric malignancy (behind lymphoma and brain cancer). Neuroblastoma is the most common solid abdominal malignancy in children < 2 years of age. It is most commonly found in the adrenal medulla (A). Measurement of vanillylmandelic acid and homovanillic acid in the serum and urine can assist in the diagnosis but does not correlate with prognosis (E). Patient age and tumor biology are the key factors predicting prognosis, not specifically tumor size (B). Children < 1 year of age have the best prognosis. In contrast, > 3 copies of N-myc amplification has a poor prognosis. The majority of patients have advanced disease at the time of presentation and the overall survival rate is less than 30% (D). Two-thirds of cases are first found as an asymptomatic abdominal mass. The tumor may cross the midline, and a majority of patients may show signs of metastatic disease. Because these tumors derive from the sympathetic nervous system, catecholamine and its metabolites will be produced at increased levels. Unlike Wilms tumor, the prognosis in advanced stages is poor, with a 2-year survival rate of only 20% in stage 4 disease despite aggressive chemotherapy.

**Reference:** Davidoff, A. M. (2014). Neuroblastoma. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 883–905) (6th ed.). Philadelphia, PA: Saunders Elsevier.

14. E. A sacrococcygeal teratoma presents as a large mass extending off of the sacrum in the neonatal period. It is the most common teratoma in neonates. Most tumors are identified at birth and are benign (D) thus there is no role for chemo/radiation therapy. However, the mass may undergo malignant degeneration and should not be observed (A–C). The diagnosis may be established by a prenatal ultrasound scan. In fetuses with evidence of hydrops and a large teratoma, the prognosis is poor; thus, prenatal intervention is being advocated in such patients. The mass may be as small as a few centimeters in diameter or as massive as the size of the infant. The tumor has been classified based on the location and degree of intrapelvic extension. Lesions with growth predominantly into the presacral space often present later in childhood. Complete resection of the tumor as early as possible is essential. The coccyx is also removed to minimize the chance of recurrence. The rectum and genital structures are often distorted by the tumor but can be preserved during resection. Very large teratomas detected antenatally can lead to high output failure and placentomegaly (hydrops) and fetal demise. Hydrops is one indication for intrauterine surgery, which has been successful in case series.

**Reference:** Hecher, K., & Hackelöer, B. (1996). Intrauterine endoscopic laser surgery for fetal sacrococcygeal teratomas. *Lancet*, 347(8999), 470.

15. C. Normally neonates have a protuberant abdomen, so the presence of a scaphoid abdomen, combined with respiratory distress at birth, should raise the suspicion for CDH. Overall survival is about 50%. The abdomen is scaphoid because the majority of the abdominal contents are herniated into the chest. In infants with CDH, both lungs are hypoplastic (ipsilateral lung worse than the contralateral lung) and there is decreased bronchial and pulmonary artery branching. The infants are prone to the development of pulmonary hypertension. Pulmonary vasculature is distinctly abnormal in that the medial muscular thickness of the arterioles is excessive and extremely sensitive to the multiple local and systemic factors known to trigger vasospasm. Between 80% and 90% occur on the left side, and the defect is posterolateral as opposed to the Morgagni hernia, which is an anteromedial defect. Once the patient is stabilized, they should be taken to the operating room to reduce the bowel and repair the defect with or without mesh and to run the entirety of the bowel to look for associated anomalies such as malrotation. Because of the lung hypoplasia, prompt reduction of the bowel contents does not immediately improve ventilatory function (E). Ventilation with high-frequency oscillation is effective, as is the use of inhaled nitric oxide (D). Refractory cases should be placed on ECMO. Placement of a nasogastric tube is also important to prevent gastric distention, which may slightly worsen the lung compression, mediastinal shift, and ability to ventilate. Chest tubes are not indicated because these may injure the underlying lung and worsen the prognosis (A). Bag-mask ventilation will distend the stomach and GI tract leading to further lung compression and worsen the patient's condition (B).

**Reference:** Lally, K., Paranka, M., Roden, J., et al. (1992). Congenital diaphragmatic hernia: stabilization and repair on ECMO. *Annals of Surgery*, 216(5), 569–573.

16. A. This patient will most likely have a splenic injury. Because he is hemodynamically stable, a CT



scan of the abdomen and pelvis with IV contrast is the most appropriate study to evaluate for a solid organ injury. If a splenic injury is detected, nonoperative management should be instituted. Depending on the grade of the injury, this patient may require admission to the ICU (B). Transfusion of packed RBCs may be required if the patient becomes symptomatic (E). Abdominal x-rays will not be of much utility for the detection of blood (C). Diagnostic laparoscopy may be indicated if the patient fails nonoperative management (D).

**Reference:** Gaines, B. A., & Austin, K. M. (2014). Abdominal and renal trauma. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 200–214) (6th ed.). Philadelphia, PA: Saunders Elsevier.

17. **A.** This patient has a jejunal or ileal atresia. Intestinal atresias are caused by in utero mesenteric vascular accidents leading to segmental loss of the intestinal lumen. Due to the small bowel atresia, the colon has been unused in utero, and is therefore of small diameter. They are classified into four types based on the severity. Infants with jejunal or ileal atresia present soon after birth with bilious vomiting and progressive abdominal distention. More distal obstructions produce more distension on physical exam and radiographs. In cases in which the diagnosis of complete intestinal obstruction is ascertained by the clinical picture and the presence of staggered air–fluid levels on plain abdominal films, the child can be brought to the operating room after appropriate resuscitation. In these circumstances, there is little extra information that can be gained by a barium enema. When the diagnosis is uncertain, a barium enema may be used. The initial treatment of jejunal atresia is nasogastric tube decompression and fluid resuscitation. Definitive treatment involves surgical resection of the atretic loop and primary reanastomosis. Failure of recanalization of the bowel (B) is associated with esophageal and duodenal atresias. Lack of proper 270-degree counterclockwise rotation of the bowel (C) is a feature of midgut volvulus. Lack of ganglion cells in the bowel (D) is seen with Hirschsprung disease, whereas a duplication would lead to duplication cysts (E).

**Reference:** Touloukian, R. J. (1993). Diagnosis and treatment of jejunoileal atresia. *World Journal of Surgery*, 17(3), 310–317.

18. **E.** Omphalocele refers to a congenital defect of the abdominal wall at the midline in which the bowel and solid viscera are covered by peritoneum and the amniotic membrane. The abdominal wall defect can measure 4 cm or more in diameter and is caused by lack of complete development of the abdominal wall muscles (C). Omphalocele is less of a surgical emergency than gastroschisis because the bowel is protected by the covering (A). Conversely, omphalocele is associated with many other congenital abnormalities that are not seen with gastroschisis. The most common anomalies associated with omphalocele are cardiac and musculoskeletal. The size of the defect may be small or so large that it contains most of the abdominal viscera. There is an increased occurrence of cardiac and chromosomal abnormalities. Omphalocele is associated with premature and intrauterine growth retardation while gastroschisis is associated with intrauterine rupture of the umbilical vein. Immediate treatment of an infant with omphalocele consists of maintaining normal vital signs and body temperature. The omphalocele should be covered with saline-soaked gauze, and the trunk should be wrapped circumferentially. No attempt should be made to manually reduce the abdominal contents because this maneuver may increase the risk of sac rupture or interfere with abdominal venous return. Gastroschisis, on the other hand, may be associated with intestinal atresia (10–15%) (D). Mortality for omphalocele is largely based on the underlying comorbidities and is usually not due to sepsis (B). Additionally, omphalocele has a higher mortality than gastroschisis due to associated congenital anomalies.

**Reference:** Wagner, J. P., & Lee, S. L. (2015). Infant born with abdominal wall defect. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 349–357) (1st ed.). New York, NY: Springer.

Benjamin, B., & Wilson, G. N. (2014). Anomalies associated with gastroschisis and omphalocele: analysis of 2825 cases from the Texas Birth Defects Registry. *Journal of pediatric surgery*, 49(4), 514–519

19. **A.** Jaundice within the first 24 hours of life or jaundice that persists beyond 2 weeks after birth is generally considered pathologic. Pathologic jaundice may be caused by biliary obstruction, increased hemoglobin load, or liver dysfunction. One must rule out obstructive disorders, including biliary atresia, choledochal cyst, and inspissated bile syndrome; ABO incompatibility; Rh incompatibility; spherocytosis; metabolic disorders;  $\alpha_1$ -antitrypsin deficiency; galactosemia; and

congenital infection including syphilis and rubella. The most common cause of neonatal jaundice requiring surgery is biliary atresia, which is an obliterative process of the extrahepatic bile ducts and is associated with hepatic fibrosis. The infant produces acholic stools and demonstrates a failure to thrive. Left untreated, it will progress to liver failure and portal hypertension. Nuclear scanning after pretreatment with phenobarbital is a useful study. One is specifically looking to see whether the radionuclide appears in the intestine, which would confirm that the extrahepatic bile ducts are patent. This finding excludes biliary atresia. If the radionuclide is normally concentrated in the liver but not excreted and the metabolic screen results are normal, this is highly suggestive of biliary atresia. The presence of a gallbladder does not exclude the diagnosis of biliary atresia. The diagnosis can be confirmed with a biopsy demonstrating bile plugging and periportal fibrosis. The most effective initial treatment of biliary atresia is portoenterostomy, as described by Kasai. The procedure involves anastomosing an isolated limb of jejunum to the transected ducts at the portal plate of the liver. The likelihood of surgical success is increased if the procedure is performed before the infant reaches the age of 2 months. If the patient remains symptomatic after the Kasai operation, he or she will require liver transplantation (B). Independent risk factors that predict failure of the procedure include bridging liver fibrosis at the time of surgery and postoperative cholangitis episodes. Percutaneous drainage does not offer long-term decompression and does not address the lack of enteric bile (C). Options D and E are not possible because of a lack of extrahepatic biliary tree in this disease.

**Reference:** Ohhama, Y., Shinkai, M., Fujita, S., et al. (2000). Early prediction of long-term survival and the timing of liver transplantation after the Kasai operation. *Journal of Pediatric Surgery*, 35(7), 1031–1034.

20. C. In neonates with respiratory distress syndrome, management includes high-frequency ventilation, surfactant, and inhaled nitric oxide. When those interventions fail, ECMO is used. ECMO can be performed by either venovenous or venoarterial cannulation. The major indications for ECMO include meconium aspiration, respiratory distress syndrome (B), persistent pulmonary hypertension (D), sepsis, and CDH (A). Meconium aspiration is the most common indication for neonatal ECMO. ECMO has also been used to temporize infants with decompensation due to a congenital cardiac abnormality (E). The most dreaded complication of ECMO is intracranial hemorrhage secondary to the heparin required to prevent circuit clotting. Additionally, premature neonates have an underdevelopment of the cerebral microvasculature and intolerance of physiologic insults further increasing the risk of intracranial bleeding.

**References:** Kugelman, A., Gangitano, E., Taschuk, R., et al. (2005). Extracorporeal membrane oxygenation in infants with meconium aspiration syndrome: a decade of experience with venovenous ECMO. *Journal of Pediatric Surgery*, 40(7), 1082–1089.

Hines, H. M. (2005). ECMO and congenital heart disease. *Seminars in Perinatology*, 29(1), 34–39.

21. E. The history and radiograph findings are consistent with duodenal atresia. Duodenal atresia occurs because of failure of recanalization of the duodenum from its solid core state. It is associated with prematurity, Down syndrome, maternal polyhydramnios, malrotation, annular pancreas, and biliary atresia. In most cases, the duodenal obstruction is distal to the ampulla of Vater, and infants present with bilious emesis in the neonatal period. The classic radiographic finding is the “double-bubble sign” (an air-filled stomach, a functioning pylorus, and a distended proximal duodenal bulb). If there is no distal bowel gas, complete atresia is confirmed and no further studies are necessary (A–C). Conversely, if distal air is present, a UGI contrast study should be done to rule out malrotation and midgut volvulus. The finding of distal air in association with a double bubble could also indicate a duodenal stenosis or web or an annular pancreas that does not cause a complete obstruction. Patients may also have associated cardiac malformations and an echocardiogram is needed before surgical intervention (D). The treatment of duodenal atresia is surgical bypass of the obstruction as either a side-to-side or proximal transverse-to-distal longitudinal duodenoduodenostomy or a duodenojejunostomy. When the proximal duodenum is markedly dilated, a tapering duodenoplasty may be performed.

**Reference:** Sullins, V. F., & Lee, S. L. (2015). Infant with bilious emesis. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 335–343) (1st ed.). New York, NY: Springer.

22. B. Neuroblastoma is the most common solid abdominal malignancy in children < 2 years of age. Wilms’ tumor is the most common after 2 years of age. The presenting symptoms of

neuroblastoma depend on the site of the primary tumor, the presence of metastatic disease, the age of the patient, and the metabolic activity of the tumor. The most common presentation is a fixed lobular mass extending from the flank toward the midline. The tumor can also extend into the neural foramina and cause symptoms of spinal cord compression. It tends to metastasize to cortical bones, bone marrow, and the liver, and patients may present with localized swelling and tenderness, limp, or refusal to walk. Periorbital metastases account for proptosis and ecchymosis, resulting in “raccoon eyes.” In infants, liver metastases may expand, causing hepatomegaly. Metastatic lesions to the skin produce the blueberry muffin appearance. Wilms tumor (C) also presents as an abdominal mass, in association with Beckwith-Wiedemann syndrome (macroglossia, hypoglycemia, gigantism, and visceromegaly), and as part of the WAGR complex (Wilms tumor, aniridia, genitourinary abnormalities, and mental retardation). Rhabdomyosarcoma is a soft-tissue tumor (A). The most common primary sites are the head and neck. Sacrococcygeal teratoma is the most common type of teratoma (E). It presents as a large mass extending off of the sacrum in the newborn period. Hepatoblastoma, although the most common liver malignancy in children, is a rare solid organ malignancy (D).

**Reference:** Davidoff, A. M. (2014). Neuroblastoma. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 883–905) (6th ed.). Philadelphia, PA: Saunders Elsevier.

23. **D.** Gastroschisis, unlike omphalocele, is not typically associated with systemic or chromosomal abnormalities (A–C, E). There is an abdominal wall defect to the right of the umbilicus, and the bowel herniates through without a peritoneal covering. Because the bowel is eviscerated and exposed, this condition is a surgical emergency. The bowel can be thickened and covered with an exudate. All patients with gastroschisis will have intestinal malrotation. However, midgut volvulus is unlikely due to the adhesions created from the gastroschisis. Intestinal atresia is also seen in 10% to 15% of patients with gastroschisis. If the defect cannot be primarily closed, a staged-closure utilizing a silo may be required.

**Reference:** Wagner, J. P., & Lee, S. L. (2015). Infant born with abdominal wall defect. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 349–357) (1st ed.). New York, NY: Springer.

24. **D.** Infants 6 to 24 months of age with intussusception typically have no pathologic lead point on pathologic examination, but instead have hypertrophied Peyer's patches in the ileum. Conversely, older children have a much higher likelihood of having a pathologic lead point. As such, they have a much greater need for operative intervention to resect the segment of bowel that includes the pathologic area. The most common pathologic lead point for intussusception in children is a Meckel diverticulum. Other causes include polyps (B), appendicitis (A), intestinal lymphoma, submucosal hemorrhage (E), foreign body, ectopic pancreatic (C) or gastric tissue, and intestinal duplication.

25. **A.** Meconium ileus is a result of cystic fibrosis, in which the meconium becomes thick and viscous due to deficits in pancreatic enzymes. It creates a small bowel obstruction, and as such, the infant may present with bilious vomiting. In the most severe forms, it can lead to intestinal perforation. The radiograph typically demonstrates a “ground-glass” appearance, which represents small pockets of gas trapped inside the thickened meconium. The treatment strategy depends on whether the patient has complicated or uncomplicated meconium ileus. Patients with uncomplicated meconium ileus can be treated nonoperatively. Administering a water-soluble enema such as dilute gastrograffin per rectum allows the meconium to soften as it takes on more water. Optimally, the contrast should be inserted in the dilated portion of the ileum under fluoroscopic visualization. The enema may be repeated every 12 hours over several days as needed. An UGI with SBFT is not indicated or used in the initial management of meconium ileus (D). Surgery is required if nonoperative management fails or if the patient already has evidence of perforation. Complicated cases are usually amenable to bowel resection and primary anastomosis (B, C, E) provided there is no evidence of giant cystic meconium peritonitis.

**Reference:** Rescorla, F., & Grosfeld, J. (1993). Contemporary management of meconium ileus. *World Journal of Surgery*, 17(3), 318–325.

26. **D.** This patient presents with an incarcerated right inguinal hernia (RIH). The bilious emesis and abdominal distention are highly suggestive of a small bowel obstruction. Thus, the most appropriate management is to attempt reduction of the incarcerated RIH. If reduction of the hernia is successful, the patient should be admitted for observation and repair in 24 to 48 hours.

The edema from the incarcerated RIH makes immediate surgical repair more difficult. Repairing the hernia after 24 to 48 hours will allow the edema to resolve. Incarcerated hernias should be diagnosed based on history and physical exam without the need of ultrasound (A). Ultrasound may be useful if testicular torsion is suspected. Erythematous masses may be misdiagnosed for abscesses. But in this case, the history and physical exam is consistent with an incarcerated inguinal hernia. IV antibiotics and possible incision and drainage is the treatment for abscesses (B, C). Operative exploration is performed if the incarcerated hernia cannot be reduced (E). When an incarcerated hernia cannot be reduced, there should be a heightened suspicion for the presence of ischemic bowel.

**Reference:** Fraser, J. D., Snyder, C. L. (2014). Inguinal hernias and hydroceles. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 689–701) (6th ed.). Philadelphia, PA: Saunders Elsevier.

27. C. Choledochal cysts have been classified into five types. The most common is type I, which is fusiform dilatation of the bile duct. Type II is a diverticulum of the CBD. Type III is a choledochocoele. Type IV is multiple cysts. Type V is known as Caroli disease, which are cysts limited to the intrahepatic bile ducts. The cysts lead to recurrent bouts of cholangitis and have a risk of malignancy. The treatment of a type I choledochal cyst is resection of the cyst and reconstruction with a Roux-en-Y choledochojejunostomy or a simple choledochoduodenostomy. If the cyst is adherent to the portal vein, the anterior portion of the cyst should be excised along with mucosectomy of the posterior cyst to prevent future malignant degeneration. Antibiotics and/or drainage will not result in a more favorable operation (A, B). Antibiotics should be used to treat cholangitis before definitive surgery. Internal drainage alone will still predispose the patient for future risk of malignant degeneration (D). The portal vein should not be resected during this operation (E).

**Reference:** Liem, N. T., & Holcomb, G. W., III. (2014). Choledochal cyst and gallbladder disease. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 593–606) (6th ed.). Philadelphia, PA: Saunders Elsevier.

28. D. Inguinal hernias result from the processus vaginalis failing to close. Inguinal hernias occur more commonly in males and premature infants and are more common on the right side. The diagnosis of an inguinal hernia should be based on history and physical examination without the need of ultrasound (A). The timing of herniorrhaphy in premature infants is debatable and based on the clinical scenario. If the hernia is easily reducible, many surgeons will repair the hernia at the time of discharge. By repairing the hernia before discharge, the risk of re-presenting to the ED with an incarcerated inguinal hernia is eliminated. On the other hand, many surgeons would discharge patients and repair the hernia when the postconceptional age (the gestational age + age of patient) is around 55 weeks (E). By waiting, there is a lower anesthetic risk, and the operation is not as challenging. Thus, the decision to repair should be considered at the time of discharge. Immediate repair in this patient is not required because the patient can be safely observed while in the NICU (B, C). Inguinal hernias in children only require high ligation of the sac. A Bassini repair may also be required to reinforce a weakened floor of the inguinal canal and involves sewing the conjoint tendon to the inguinal ligament. Mesh is rarely ever required in pediatric patients with inguinal hernias.

**Reference:** Fraser, J. D., & Snyder, C. L. (2014). Inguinal hernias and hydroceles. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 689–701) (6th ed.). Philadelphia, PA: Saunders Elsevier.

29. D. Daily maintenance fluids for children can be estimated using the 4-2-1 rule (4 mL/kg/hr for the first 10 kg, 2 mL/kg for the second 10 kg, and 1 mL/kg for any additional kilograms). For this child who weighs 30 kg, maintenance fluids calculate to be  $4 \text{ mL/kg} \times 10 \text{ kg} = 40 \text{ mL}$ ,  $2 \text{ mL/kg} \times 10 \text{ kg} = 20 \text{ mL}$ ,  $1 \text{ mL/kg} \times 10 \text{ kg} = 10 \text{ mL}$ ;  $40 \text{ mL} + 20 \text{ mL} + 10 \text{ mL} = 70 \text{ mL/hr}$ . A mathematical shortcut for this is  $40 + \text{patient weight in kilograms} = \text{maintenance rate}$ . However, this requires the patient to be at a minimum 20 kg.
30. C. The pathogenesis of NEC is thought to be intestinal hypoperfusion (A, B, D, E). This occurs most frequently in the setting of perinatal stress. The period of hypoperfusion is followed by a period of reperfusion, and the combination of ischemia and reperfusion leads to mucosal injury. The damaged intestinal mucosa barrier becomes susceptible to bacterial translocation that initiates an inflammatory cascade. Various proinflammatory mediators are released, which in turn

leads to further epithelial injury and the systemic manifestations of NEC. It is postulated that maintenance of the gut barrier is essential for the protection of the host against NEC. It has always been taught that NEC classically presents with bloody stools after the first feeding. However, the earliest signs are non-specific including apnea, bradycardia, lethargy and temperature instability. The most common GI symptoms are feeding intolerance and high gastric residuals while the most common sign is abdominal distention. Grossly bloody stools are infrequently seen. Management is initially conservative with NPO, fluid resuscitation, broad spectrum IV antibiotics, TPN, and decompression with orogastric tube. Surgical intervention is indicated for failure of conservative management, free air on plain films or CT, and peritonitis.

**Reference:** Dominguez, K. M., & Moss, R. L. (2014). Necrotizing enterocolitis. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 454–473) (6th ed.). Philadelphia, PA: Saunders Elsevier.

31. **D.** The key to preventing a recurrent midgut volvulus in a patient with malrotation is to broaden the base of the mesentery. In order to achieve a broad base of the mesentery, the duodenum needs to be mobilized and directed to the right lower quadrant. In addition, the right colon is mobilized and placed on the left, with the ileocecal valve in the left upper quadrant. Once complete, the patient will anatomically be nonrotated (A). Dividing the bands (Ladd bands) that cross over the duodenum will relieve any constriction of the duodenum, but by itself, this maneuver will not decrease the risk of a recurrent volvulus (C). Fixation of the bowel to abdominal wall or retroperitoneum will increase the risk of a segmental volvulus around the fixation points and thus, should be avoided (B). An ileostomy and mucous fistula is not indicated when the bowel is viable (E).

**Reference:** Sullins, V. F., & Lee, S. L. (2015). Infant with bilious emesis. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 335–343) (1st ed.). New York, NY: Springer.

32. **E.** This patient has a bleeding Meckel diverticulum which is due to a persistent vitelline duct. Episodic painless rectal bleeding in a young child is the classic presentation of a bleeding Meckel diverticulum. Bleeding Meckel diverticulum accounts for over 50% of all lower gastrointestinal bleeding in children. The bleeding is a result of ectopic gastric mucosa leading to acid production. An ulcer will then develop next to the base of the diverticulum or on the mesenteric side of the ileum. However, a Meckel diverticulum is classically found on the antimesenteric border of the bowel. To ensure excision of all ectopic tissue and removal of the ulcer, a segmental ileal resection is preferred over simple diverticulectomy (A–D). The next most common complication associated with a Meckel diverticulum is small bowel obstruction. This obstruction is typically the result of an internal hernia. Finally, Meckel diverticulitis may develop in less than 5% of patients and is often misdiagnosed as appendicitis. Thus, when performing an appendectomy, if the appendix appears normal then the small bowel should be examined for an inflamed Meckel diverticulum.

**Reference:** Leys, C. M. (2014). Meckel diverticulum. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 689–701) (6th ed.). Philadelphia, PA: Saunders Elsevier.

33. **C.** Management of a newborn with gastroschisis involves stabilizing the airway, preventing hypothermia, orogastric decompression, establishing IV access, and administering IV fluids and antibiotics. The bowel should also be placed in a sterile, clear plastic wrap to prevent further volume and heat loss. The bowel must also be carefully inspected for signs of ischemia. If the bowel appears ischemic, the bowel must be inspected to rule out a simple twist or kink in the mesentery. The defect is also examined to be sure that it is not tight and the cause for the ischemia as in this case. If the defect is too tight, then the defect must be opened immediately. The best direction to open the defect would be to the patient's right (away from the umbilicus) in order to avoid the umbilical structures/vessels. After the defect is opened up, then a silo is typically indicated (A). Primary reduction and closure should only be attempted when there is no risk to the bowel (B). Resection of ischemic bowel should be reserved for grossly necrotic bowel because patients with gastroschisis are at risk of developing short gut syndrome (D). Any questionable bowel should be observed with serial exams. A diverting ileostomy is not indicated in this patient (E).

**Reference:** Wagner, J. P., & Lee, S. L. (2015). Infant born with abdominal wall defect. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 349–357) (1st ed.). New York, NY: Springer.

34. **B.** This patient has a diagnosis of Hirschsprung disease (HD). The patient then developed Hirschsprung-associated enterocolitis (HAEC). The initial management for HAEC is IV antibiotics, bowel rest, and rectal irrigations. However, if the patient deteriorates, then urgent colostomy is needed to decompress the colon and may be life-saving. A contrast enema is contraindicated in patients with active HAEC (A). Because the level of HD is not known, a colectomy should not be performed. In addition, patients are often too sick to withstand a prolonged operation (C). This patient does not have abdominal compartment syndrome or fungal sepsis (D, E).

**Reference:** Langer, J. C. (2014). Meckel diverticulum. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 474–491) (6th ed.). Philadelphia, PA: Saunders Elsevier.

35. **E.** The infant is exhibiting signs of malrotation with midgut volvulus. By the time that abdominal wall edema is evident, there is a high likelihood of intestinal gangrene. As such, no further studies are indicated, and the infant requires urgent laparotomy (A, B). Confirmation with an upper GI series is only indicated when the patient is stable and the diagnosis is unclear. Endoscopy has no role in diagnosis or treatment (C). Resection of extensive dead bowel may result in short-gut syndrome and necessitate intestinal transplantation to avoid long-term parenteral nutrition. Ladd bands extend from the cecum to the lateral abdominal wall (D), crossing the duodenum, which increases the potential for obstruction. Additional clues to the presence of advanced ischemia include erythema of the abdominal wall. Sometimes gangrenous loops of bowel may be seen transabdominally as a discolored mass. If untreated, the infant will progress to shock and death. It must be reemphasized that the index of suspicion for this condition must be high because abdominal signs are minimal in the early states. Abdominal films show a paucity of gas through the intestine with a few scattered air–fluid levels. In early cases, the patient does not appear ill initially, and the plain films may suggest partial duodenal obstruction. Under these conditions, the patient may have malrotation without volvulus. This is best diagnosed by an upper GI series that shows incomplete rotation with the duodenojejunal junction displaced to the right. When volvulus is suspected, early surgical intervention is mandatory if the ischemic process is to be avoided or reversed. Volvulus occurs clockwise and should be untwisted counterclockwise.

**Reference:** Sullins, V. F., & Lee, S. L. (2015). Infant with bilious emesis. In C. de Virgilio, A. Grigorian, & P. N. Frank (Eds.), *Surgery: a case based clinical review* (pp. 335–343) (1st ed.). New York, NY: Springer.

36. **A.** Children born with bilateral undescended testes have a much higher rate of subsequent infertility. When the testicle is not in the scrotum, it is subjected to higher temperatures, resulting in decreased spermatogenesis. Even when the testicles are placed in the scrotum, fertility, although improved (B), is still not normal. It is recommended that undescended testicles be repositioned by 1 year of age to maximize chances of improving fertility. The use of chorionic gonadotropin sometimes is effective in achieving descent in patients with bilateral undescended testes, suggesting that they may have a hormonal deficiency (D). If the intra-abdominal testes can be effectively mobilized to reach down into the scrotum, a two-stage Fowler-Stephens procedure is used. In the first stage, the testicular vessels are clipped laparoscopically. In addition to the testicular arteries, the testicles receive collateral blood from the cremasteric artery, a branch of the inferior epigastric artery, and the artery to the vas, a branch of the superior vesical artery. Thus, division of the testicular artery is usually well tolerated and does not usually result in testicular necrosis (E). The orchiopexy is then performed through the groin approximately 6 months later, after which time collateral flow has increased. Undescended testicles are at higher risk of malignant degeneration, which is not altered by orchiopexy; however, their location in the scrotum facilitates earlier detection (C).

**Reference:** Lee, J. J., & Shortliffe, L. M. D. (2014). Undescended testes and testicular tumors. In G. W. Holcomb III, J. P. Murphy, & D. J. Ostlie (Eds.), *Ashcraft's pediatric surgery* (pp. 689–701) (6th ed.). Philadelphia, PA: Saunders Elsevier.

Chan, E., Wayne, C., Nasr, A., FRCSC for Canadian Association of Pediatric Surgeon Evidence-Based Resource. (2014 Jan). Ideal timing of orchiopexy: a systematic review. *Pediatric surgery international*, 30(1), 87–97.



# Plastic Surgery

*Hossein Masoomi, Michael D. Sgroi, Areg Grigorian, and Christian de Virgilio*

## Questions

1. Which of the following is true regarding skin grafts?
  - A. Full-thickness skin grafts (FTSG) are more amenable to imbibition compared with split-thickness skin grafts (STSG).
  - B. Allografts will eventually get vascularized.
  - C. The most common reason for skin graft loss is a nonviable wound bed.
  - D. The degree of primary contraction is inversely proportional to the amount of dermis in the skin graft.
  - E. Secondary contraction is greater with FTSG.
2. Which of the following is the most important principle in repair of a lip laceration?
  - A. Closure of the mucosal layer
  - B. Primary closure of the muscularis
  - C. Reapproximation of the vermilion-cutaneous junction
  - D. Minimal stitching
  - E. Alignment of the underlying teeth
3. A 64-year-old male with chronic obstructive pulmonary disease (COPD) presents to the ED with full-thickness burns to the majority of the right arm after his robe caught on fire while he was cooking. Several days later he undergoes a planned STSG using his left anterior thigh as a donor site. Halfway through the anticipated harvest of donor skin using the dermatome, the resident notes visible fat. Which of the following is the best next step?
  - A. Terminate the procedure and reschedule.
  - B. Continue harvesting with the dermatome at the same site while attempting to aim more superficially to obtain the planned STSG.
  - C. Continue harvesting with the dermatome at the same site with no change to the angle of the dermatome in an attempt to now harvest full-thickness skin graft.
  - D. Stop the dermatome at the current site, and attempt harvesting at another site.
  - E. Stop the dermatome at the current site, suture the skin, and attempt harvesting at another site.
4. Which of the following is a contraindication for negative-pressure wound therapy (NPWT)?
  - A. Newly grafted skin
  - B. Wounds with a fistula
  - C. Diabetic wounds
  - D. Ischemic wounds
  - E. Venous stasis wounds
5. Which of the following is an important reason to use meshed STSG as opposed to nonmeshed STSG?
  - A. Meshed STSG allows for use in a wound bed with poor granulation tissue.
  - B. Meshed STSG allows for use in an ischemic wound bed.
  - C. Meshed STSG allows drainage of fluid and blood when absolute hemostasis cannot be performed.



- D. Widely meshed skin is associated with less scarring.
  - E. With meshed STSG increased amounts of adnexal structures are available.
6. In general, what is the correct order of the reconstructive ladder for complex defect closures?
    - A. Healing by secondary intention, primary tissue closure, skin graft, local/regional tissue transfer, free tissue transfer
    - B. Healing by secondary intension, local/regional tissue transfer, free tissue transfer, skin graft
    - C. Healing by secondary intension, local/regional tissue transfer, free tissue transfer
    - D. Skin graft, free tissue transfer, primary tissue closure
    - E. Skin graft, local/regional tissue transfer, primary tissue closure
  7. Which of the following is the recommended surveillance regimen to detect silent rupture for a 45-year-old woman with silicone gel-filled bilateral breast implants?
    - A. Annual ultrasound
    - B. Ultrasound as needed for pain/discomfort
    - C. Magnetic resonance imaging (MRI) 3 years after implant surgery and then every 2 years for life of the implant
    - D. Annual plain films
    - E. Computed tomography (CT) every 5 years for the life of the implant
  8. Which of the following is an appropriate candidate for repair of a cleft lip?
    - A. 1-year-old female with hemoglobin of 9 g/dL
    - B. 6-month-old male with a body weight of 9 pounds
    - C. 12-week-old male with hemoglobin of 11 g/dL
    - D. 1-year-old male with prealbumin less than 3 mg/dL
    - E. 6-month-old female with concurrent pulmonic stenosis
  9. Which of the following is required along with vitamin C to complete cross-linking of proline residues in collagen?
    - A. Oxygen
    - B. Oxygen and vitamin A
    - C. Iron and alpha-ketoglutarate
    - D. Oxygen, iron, and alpha-ketoglutarate
    - E. Oxygen, iron, and penicillamine
  10. In planning for elective component separation for ventral hernia repair in a morbidly obese patient (body mass index [BMI] 36 kg/m<sup>2</sup>), placement of mesh between which layers will have the least risk of recurrence?
    - A. Skin and anterior rectus sheath
    - B. Between rectus muscle defects
    - C. Anterior rectus sheath and rectus muscle
    - D. Rectus muscle and posterior rectus sheath (retrorectus)
    - E. Rectus muscle and peritoneum (preperitoneal)
  11. Which artery is the dominant vascular supply of the rectus abdominis muscle and paired with the correct feeding vessel?
    - A. Superficial epigastric artery from the internal thoracic artery
    - B. Inferior epigastric artery from the external iliac artery
    - C. Superficial epigastric artery from the intercostal arteries
    - D. Inferior epigastric artery from the internal iliac artery
    - E. Deep circumflex iliac artery from the internal iliac artery
  12. What is average tissue survival rate for a microvascular free flap?
    - A. Less than 5%
    - B. 5–30%

- C. 30–60%
  - D. 60–90%
  - E. More than 95%
13. What is the mainstay of postoperative flap monitoring?
- A. Doppler ultrasound
  - B. Pulse oximetry
  - C. Clinical observation
  - D. Quantitative fluorometry
  - E. Surface temperature probing
14. A 40-year-old female who has a desire for reconstructive breast surgery after a mastectomy is offered a deep inferior epigastric perforator (DIEP) flap. What is the disadvantage to performing a DIEP flap compared to a standard pedicle flap in this patient?
- A. It has a higher rate of flap necrosis.
  - B. It has an elevated rate of donor site morbidity.
  - C. Patients have permanent nerve dysfunction.
  - D. Patients have increased pain.
  - E. It is a longer operation.
15. What is the most common early postoperative complication in gynecomastia surgery?
- A. Wound infection
  - B. Hematoma
  - C. Under-resection of tissue
  - D. Asymmetry of breast tissue
  - E. Nipple/areola depression
16. The most important reason to avoid STSG over an extremity joint is:
- A. There is an increased risk of infection over joints.
  - B. The rate of contracture over a joint can be debilitating.
  - C. The blood flow to these regions is low and often leads to a necrotic graft.
  - D. There is a high rate of seroma formation compared with other areas on the body.
  - E. There is reduced imbibition.
17. Which statement is true regarding facial trauma?
- A. Isolated facial fractures are associated with 30% cervical spine injury.
  - B. Maxillary fracture is the most common type of facial fracture.
  - C. Mandibular fractures are frequently multiple.
  - D. A small septal hematoma can be managed conservatively.
  - E. Intranasal exam is not necessary in nondisplaced nasal fractures.
18. Which of the following bones is the most common isolated orbital bone fracture?
- A. Ethmoid
  - B. Frontal
  - C. Maxillary
  - D. Lacrimal
  - E. Zygomatic
19. A 21-year-old female has a flash burn to her face, sustaining a 3-cm full thickness wound to her right cheek. Which of the following would be the best skin graft?
- A. Full thickness from behind the ear
  - B. Full thickness from the waist at the inguinal fold
  - C. Full thickness from the wrist fold
  - D. Split thickness from the anterior thigh

E. Split thickness from the posterior thigh

## Answers

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1. **B.** Full-thickness and most deep-partial thickness wounds will require skin grafting. This should take place after the wound has been debrided and a healthy, viable wound bed is available. If the wound bed is not ready for skin grafting, biologic coverage can be achieved with either allograft/homograft (cadaver skin) or xenograft (bovine skin). Unlike xenograft, allograft will eventually vascularize. However, both will be rejected and so are only used as a temporary measure. The only permanent solution is autograft (using the patient's own skin). The surface area and location of the wound will determine if STSG (contains all epidermis and some dermis) or FTSG (contains all epidermis and dermis) will be needed. The FTSG donor site will need to be primarily closed, and thus FTSG is appropriate only for small wounds in the face and hands to ensure a cosmetically and functionally sound repair. In the case of STSG, meshing the harvested skin in a 1:1 to 4:1 ratio will allow for coverage of a larger area. The grafts are subjected to immediate shrinkage, or primary contraction, as well as secondary contraction. Primary contraction is dependent on the recoil of elastic fibers in the dermis; thus this occurs more frequently with FTSG. The degree of secondary contraction is inversely proportional to the amount of dermis in the skin graft and thus occurs more commonly with STSG (D, E). The newly grafted skin survives by three main mechanisms. The first 3 days the graft passively absorbs nutrients from the wound bed by simple diffusion (imbibition). On days 3 and 4, inosculation allows for a direct connection of the skin graft to vessels in the wound bed. By day 5, neovascularization and angiogenesis have occurred allowing the graft to survive with its own blood supply. STSG have a higher chance of survival because the thinner skin makes it easier for imbibition and inosculation to occur early in the healing process (A). Skin grafts fail by four main mechanisms with the most common being hematoma or seroma formation preventing the necessary contact of the skin graft to the wound bed (C). Other mechanisms of failure include infection, poor wound bed, and sheer forces.

**Reference:** Mathes, S. J. (1997). *Reconstructive surgery: principles, anatomy and techniques*. New York, NY: Elsevier Science.

2. **C.** The reapproximation of the vermilion-cutaneous junction is the main goal of a lip laceration repair. This will optimize both cosmesis and function following repair. The vermilion border is initially closed with interrupted sutures. This is followed by closure of the muscularis, and then interrupted absorbable sutures in the mucosa (A, B). Because each layer will need to be closed, multiple stitches will be used (D). The teeth are not a priority in this situation and can be fixed at a later time (E).
3. **E.** Patients with home oxygen are at higher risk for burn injuries. This includes patients with COPD, migraines, and cluster headaches. This patient suffered a full-thickness burn to the majority of the upper extremity and thus will require split thickness skin grafting. Full-thickness skin grafting is not appropriate for a large wound bed. STSGs are around 0.015 inches deep and take about 7 to 14 days to reepithelialize. The harvesting of skin is highly dependent on both the user and the dermatome. If the angle, set depth, and pressure are not correct, one risks harvesting skin that is too thin or cutting too deep. Seeing visible fat indicates that the user was either using too much force, or the dermatome was set at an inappropriate depth. In this case, the best next step is to stop the dermatome, suture the skin, and attempt harvesting at an alternative site (A–D).

**References:** Kim, S., Chung, S. W., & Cha, I. H. (2013). Full thickness skin grafts from the groin: donor site morbidity and graft survival rate from 50 cases. *Journal of Korean Association Oral Maxillofacial Surgery*, 39(1), 21–26.

Weber, R.S., Hankins, P., Limitone, E., et al. (1995). Split-thickness skin graft donor site management: a randomized prospective trial comparing a hydrophilic polyurethane absorbent foam dressing with a petrolatum gauze dressing. *Archives of Otolaryngology-Head & Neck Surgery*, 121(10), 1145–1149.

4. **D.** NPWT works by multiple mechanisms including reduction of edema and removal of wound fluid rich in destructive enzymes that is produced by both the patient and by local bacterial contamination. In addition, employing the cyclic compression mode allows stimulation of the mechanotransduction pathways in the wound resulting in increased growth factor release, matrix production, and cellular proliferation. Common clinical scenarios amenable to NPWT include

lymphatic leaks, venous stasis wounds, diabetic wounds, wounds with fistula, sternal wounds, orthopedic wounds and abdominal wounds (B, C, E). Likewise, NPWT is used frequently as an alternative to bolster dressings for split skin grafts reducing the risk of a seroma or hematoma under the graft (A). There are several contraindications to the use of NPWT, and these include the presence of malignancy, use on wounds characterized by ischemia, as well as inadequately debrided or badly infected wounds. There have been reports of extension of the zone of necrosis when used on ischemic wounds. Patients with ischemic wounds should be considered for revascularization before application of NPWT.

**Reference:** Thorne, C. (Ed.). (2014). *Techniques and principles in plastic surgery. Grabb & Smith's plastic surgery textbook* (pp. 1–12) (7th ed.). Philadelphia: Lippincott Williams & Wilkins.

5. **C.** STSG contains epidermis and various amounts of dermis. Meshing allows for increased tissue coverage as well as drainage of fluid and blood when absolute hemostasis cannot be performed. However, widely meshed skin is subject to increased scarring and longer healing times (D). Poor granulation tissue and an ischemic or infected wound bed are relative and absolute contraindications for skin grafting, respectively (A, B). Adnexal structures are contained in the dermis and thus are more abundantly available with FTSG (E).
6. **A.** Plastic surgeons are often consulted regarding closing complex defects. When analyzing a wound, whether cutaneous or more complex, the options for closure are evaluated beginning with the simplest and progressing up the “reconstructive ladder” to the more complex. This progression from primary closure to skin graft, to local flap, to regional flap, and to microvascular free flap provides a framework that can be applied to any reconstructive situation. Application of the simplest option that meets the reconstructive requirements ensures a “lifeboat” should the procedure fail. In many situations, however, a higher “rung” on the ladder is initially chosen. For example, a local flap may be selected over a skin graft for a defect on the nose because it may provide a superior result, or a free flap may be chosen for a breast reconstruction when an attached or pedicled flap would suffice because the blood supply of the former is superior (has a more robust feeding artery). The reconstructive ladder goes as follows: (1) allow the wound to heal by secondary intention; (2) direct tissue closure; (3) skin graft; (4) local tissue transfer; (5) regional tissue transfer; (6) free tissue transfer.

**Reference:** Simman, R. (2009). Wound closure and the reconstructive ladder in plastic surgery. *Journal of American College of Certified Wound Specialists*, 1(1), 6–11.

7. **C.** Breast implants are not generally lifetime devices and will often need reoperation or implant removal with or without replacement. Common indications for reoperation include capsular contracture, rupture, poor cosmesis, infection, and pain. MRI continues to be the most sensitive and specific modality available to detect silent rupture of breast implants. The Food and Drug Administration issued guidelines in 2011 recommending that all recipients of silicone gel-filled breast implants receive MRI screening 3 years after implant surgery and then every 2 years for the life of the implant. CT is less sensitive for the detection of silent rupture and exposes patients to unnecessary radiation (E). Ultrasound can also be used but is not as accurate compared with MRI (A, B). Plain films are not used in the detection of ruptured breast implants (D).

**Reference:** FDA Update on the Safety of Silicone Gel-Filled Breast Implants. (2011). Centers for Devices and Radiological health, US Food and Drug Administration. Available at <http://www.fda.gov/downloads/MedicalDevices/ProductsandMedicalProcedures/ImplantsandProsth>

8. **C.** Cleft lip is one of the most common congenital deformities. Intervention is aimed at restoring facial appearance and oral function. There is still debate as to the ideal timing for repair but the “rule of 10s” is a general guideline to help select appropriate candidates for repair. This includes a hemoglobin greater than 10 g/dL, older than 10 weeks, and a body weight more than 10 pounds (A, B). Contraindications to repair include severe malnutrition and concurrent cardiac anomalies requiring repair (D, E). Cleft palate involves the hard palate anterior to the incisive foramen and repair should be delayed until 1 year of age to prevent interference with maxillofacial growth. Repairing too early risks increased incidence of middle ear infections and resultant hearing loss.
9. **D.** Oxygen, iron, vitamin C, and alpha-ketoglutarate all participate in the hydroxylation and subsequent cross-linking in collagen (A, C). Vitamin A is essential because it promotes epithelialization in collagen synthesis for wound healing, but it does not participate in cross-linking of proline residues in collagen (B). Penicillamine is associated with a reduction in numbers of T-lymphocytes, inhibition of macrophage function, decreased numbers of IL-1 and rheumatoid

factor. In addition, it prevents collagen from cross-linking (E).

**Reference:** Thorne, C. (Ed.). (2014). Techniques and principles in plastic surgery. *Grabb & Smith's plastic surgery textbook* (pp. 1–12) (7th ed.). Philadelphia: Lippincott Williams & Wilkins.

10. **D.** Generally, the rate of recurrence is high in large ventral hernia repair but significantly lower when mesh is used (40–50% in primary repair versus 10% with mesh repair). Mesh placement can be performed in various layers. Placement of mesh between the skin and anterior rectus sheath is referred to as the “onlay technique.” Mesh placed between rectus muscle defects is called the “inlay technique.” Additional locations for mesh placement include between the anterior rectus sheath and rectus muscle as well as between the rectus muscle and peritoneum. Retrorectus mesh placement between the rectus muscle and posterior rectus sheath, or underlay, has been shown to have a lower recurrence rate compared with other types of mesh placement (A–C, E).

**Reference:** Holihan, J. L., Nguyen, D. H., Nguyen, M. T., et al. (2016). Mesh location in open ventral hernia repair: a systematic review and network meta-analysis. *World Journal of Surgery*, 40(1), 89–99.

11. **B.** The rectus abdominis muscle has a dual dominant blood supply. The upper vessel is the superior epigastric artery, which is one of the terminal branches of internal thoracic artery (previously known as the internal mammary artery). The lower vessel is the inferior epigastric artery arising from the external iliac artery above the level of the inguinal ligament (D). The *superficial* (not superior) epigastric artery arises from the femoral artery (A, C) and does not supply the rectus abdominis. Deep circumflex iliac artery arises from the external iliac artery and supplies the iliac crest (E).

12. **E.** Any surgery performed with the aid of an operative microscope is termed microsurgery; such anastomoses are therefore termed *microvascular anastomoses*. The first successful free tissue transfer in humans was transfer of a jejunal free flap for cervical esophagus reconstruction performed in 1957. Free flaps were initially considered to be a last-resort option to reconstruct the most complex defects. However, as a result of improved microsurgical techniques, proper patient and free flap selection, and effective postoperative monitoring methods, the success rates have increased to exceed 95% (A–D). Today, free tissue transfer is often the first-choice treatment for many defects and is no longer considered a last-ditch effort.

**Reference:** Losee J. E., Gimbel M. L., Rubin J, et al. (2014). Plastic and reconstructive surgery. In F. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (10th ed.). New York, NY: McGraw-Hill.

13. **C.** Flap color, capillary refill, tissue bleeding, and flap temperature are all assessed to ensure adequate flap perfusion. The gold standard for assessing the viability of transferred tissue is clinical examination (A, B, D, E). Identification of a failing or insufficiently perfused flap can occasionally be challenging for even the most experienced microsurgeon. A Doppler probe can be a useful adjunct to assess vascular flow within the pedicle and/or specific areas of the flap. Experienced personnel are essential for monitoring a flap postoperatively. Doppler monitoring is, however, subject to error (both false-positive and false-negative) and thus should never replace clinical assessments. A number of clinical signs (present either singly or in combination) may suggest malperfusion. Pale flap color, reduction in flap temperature, loss of capillary refill, and loss of flap turgor may indicate arterial insufficiency. Venous insufficiency, on the other hand, can result in a purple or blue hue in the flap, congestion, swelling, and rapid capillary refill in the early stages followed by eventual loss of capillary refill. Venous congestion may be addressed by surgical measures as well as application of medical *Hirudo medicinalis* leeches or by chemical “leeching,” which is topical heparin combined with dermal punctures.

**References:** Losee J. E., Gimbel M. L., Rubin J, et al. (2014). Plastic and reconstructive surgery. In F. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (10th ed.). New York, NY: McGraw-Hill.

Thorne, C. (Ed.). (2014). Techniques and principles in plastic surgery. *Grabb & Smith's plastic surgery textbook* (pp. 1–12) (7th ed.). Philadelphia: Wolters Kluwer.

14. **E.** A fasciocutaneous flap, also known as a perforator flap, is a reconstructive flap in which the skin and subcutaneous fat are removed from a distant or adjacent part of the body to be used to reconstruct another site. The major advantage of a perforator flap is that it reduces the morbidity at the patient's donor site, mainly because it does not manipulate the fascia or muscle (B). Because the fascia stays intact, so too do the nerves innervating the muscle, and thus nerve dysfunction is kept to a minimum, and without nerve or muscle damage, the pain is reduced (C, D). Finally,

keeping the fascia intact reduces the risk of hernias from the donor site. The major disadvantage is that it must be done by a microsurgery specialist and takes a significantly longer time compared to a standard pedicle flap. When comparing a DIEP to a transverse rectus abdominis musculocutaneous (TRAM) pedicle flap, DIEP is associated with a shorter hospital stay, a decreased rate of donor site hernias, and a statistically significantly lower rate of fat necrosis (17.7% vs 58.5%) (A).

**Reference:** Garvey, P. B., Buchel, E. W., Pockaj, B. A., et al. (2006). DIEP and pedicled TRAM flaps: a comparison of outcomes. *Plastic and Reconstructive Surgery*, 117(6), 1711–1719.

15. **B.** Gynecomastia is an asymptomatic condition resulting from the abnormal benign proliferation of glandular breast tissue in men. Most patients will only need reassurance, but some desire repair for cosmesis. This can be done with surgical excision, suction-assisted lipectomy, or ultrasound-assisted liposuction. If surgical excision is chosen, a periareolar incision is made at the junction of the areola and the skin. Next, a cuff of tissue 1 to 1.5 cm in thickness is preserved directly deep to the nipple/areola complex. This maneuver prevents postoperative nipple/areola depression or adherence of the nipple/areola to the chest wall skin (E). The most common early complication after gynecomastia surgery is hematoma. The hematoma should be evacuated, if possible. Under-resection of tissue is the most common long-term complication of gynecomastia surgery (C). Postoperative wound infection is uncommon because it is a clean operation (A). The use of prophylactic antibiotics, particularly in liposuction cases, may account for the low incidence of this complication. Newer techniques allow for superior cosmesis, and as such, asymmetry is uncommon (D).

**Reference:** Thorne, C. (Ed.). (2014). Techniques and principles in plastic surgery. *Grabb & Smith's plastic surgery textbook* (pp. 1–12) (7th ed.). Philadelphia: Wolters Kluwer.

16. **B.** Contraction, resulting from centrifugal forces in the center of the wound, constitutes an important wound closure mechanism. Myofibroblasts, specialized fibroblasts characterized by intracellular smooth muscle actin filaments, may contribute to this. An extension of wound contracture over a joint will lead to a debilitating scarring process that will compromise return of function in many patients with joint burns (A, C–E). Rehabilitation with stretching, exercising, and splinting can minimize contracture development. Surgical release of tight bands may also be necessary to restore normal function.
17. **C.** Facial fractures are often complicated by cervical spine injuries; 5% to 8% of isolated facial fractures and 7% to 11% of cases of multiple facial fractures will have an associated cervical spine injury (A). The nose is the most common facial fracture site because of its prominent location; and the fracture can involve the cartilaginous nasal septum, the nasal bones, or both (B). It is important to perform an intranasal examination to determine whether a septal hematoma is present, even with nondisplaced fractures. If present, a septal hematoma must be incised, drained, and packed to prevent pressure necrosis and resorption of the cartilaginous septum, which can result in a saddle nasal deformity (D, E). Mandibular fractures are frequently multiple. Treatment of all but the simplest orbital injuries should include evaluation by an eye specialist to assess visual acuity and rule out globe injury.
18. **C.** Most isolated orbital fractures involve the orbital floor, which is made up mainly of the maxillary bone (A, B, D, E). Most pure blowout fractures involve the orbital floor. The most common complication after an orbital floor fracture is entrapment. There are two uncommon complications after orbital bone fracture. *Superior orbital fissure syndrome* results from compression of structures contained in the superior orbit. These include cranial nerves III, IV, and VI. Compression of these structure leads to symptoms of eyelid ptosis, globe proptosis, and paralysis of extraocular muscles. If the optic nerve is also involved, symptoms include blindness, and the syndrome is dubbed *orbital apex syndrome*. Both these syndromes are medical emergencies, and steroid therapy or surgical compression should be considered.
19. **A.** FTSG is ideal for visible areas on the face (D, E). This helps improve cosmesis by grafting skin that can ultimately match the adjacent skin with respect to color, texture, and thickness. Additionally, FTSGs undergo less secondary wound contracture. Harvesting skin from the upper eyelid, nasolabial fold, postauricular region, or supraclavicular fossa are the ideal donor sites to choose from for FTSG. The inguinal fold, or groin, can also be used and will likely heal but will not have as good of a skin match (B). The wrist crease can also be used, but many do not like the future appearance of the scar on the wrist (C).

- References:** Janis, J., Kwon, R. K., & Lalonde, D. H. (2010). A practical guide to wound healing. *Plastic and Reconstructive Surgery*, 125(6), 230–244.
- Kim, S., Chung, S. W., & Cha, I. H. (2013). Full thickness skin grafts from the groin: done site morbidity and graft survival rate from 50 cases. *Journal of Korean Association Oral Maxillofacial Surgery*, 39(1), 21–26.



# Genitourinary

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## Questions

1. Which of the following is true regarding renal anatomy?
  - A. The renal vein is posterior to the renal artery.
  - B. The left renal vein can be ligated without irreversible renal damage.
  - C. Glisson capsule surrounds the kidney.
  - D. The left renal vein crosses posterior to the aorta.
  - E. The renal arteries are supplied by the hypogastric artery.
2. A 57-year-old male presents to the emergency department (ED) with a severe headache that started suddenly. His systolic blood pressure is 220 mm Hg which improves with labetalol. He does not have any medical problems but reports some scrotal discomfort over the past month. On exam, his left testicle has a mass that feels like a “bag of worms.” When he lies supine, the mass does not disappear. Urinalysis demonstrates 18 red blood cells per high power field. Which of the following is the best next step in management?
  - A. Computed tomography (CT) of the head
  - B. Testicular ultrasound
  - C. CT of the abdomen/pelvis
  - D. Renal ultrasound
  - E. Reassurance and referral to primary care physician to begin antihypertensives
3. A 24-year-old male is brought to the ED after a motor vehicle collision. He has no complaints, and his imaging is negative for any traumatic injuries. His urinalysis is positive for nitrite and leukocyte esterase with some bacteria identified but no squamous cells present. Which of the following is the best next step in management?
  - A. Discharge home
  - B. Renal ultrasound
  - C. Renal ultrasound and post-void residual bladder volume
  - D. Renal ultrasound, post-void residual bladder volume, and cystoscopy
  - E. Renal ultrasound, post-void residual bladder volume, cystoscopy, and 7 day course of oral antibiotics
4. A 45-year-old male presents to clinic with his wife to discuss having a vasectomy. Which of the following is true regarding this procedure?
  - A. It is typically performed by a urologist in the operating room (OR) under general anesthesia.
  - B. It involves ligating the vas deferens.
  - C. The patient can safely have intercourse 1 month after the procedure with little risk of pregnancy.
  - D. Reversal of vasectomy is associated with a pregnancy rate of less than 10%.
  - E. There is an increased risk for testicular cancer.
5. A 67-year-old male undergoes an uneventful radical prostatectomy for prostate cancer. Eight days later, he has a fever and feculent material is noted in his urine. Pelvic CT reveals a 9- × 8-cm

- heterogeneous perirectal fluid collection. The best course of management is administering parenteral antibiotics, percutaneous drainage of the fluid collection, and:
- Repeat CT in 2 weeks
  - Initiation of total parenteral nutrition
  - Initiation of enteric feeding via a Dobhoff tube
  - Insertion of a suprapubic cystostomy tube
  - Diverting colostomy creation
- A 19-year-old male presents to the ED with a stab wound to his left lower back. He is hemodynamically stable and has no evidence of peritonitis. A CT scan of the abdomen and pelvis with oral and intravenous (IV) contrast demonstrates a subcapsular hematoma of the left kidney and a small posterior left kidney laceration with no extravasation of contrast or injury to the collecting system. There is no fluid or free air in the peritoneum. Distal ureters are intact bilaterally. The next best step is:
    - Observation
    - Retrograde ureteropyelogram
    - IV methylene blue and local exploration of wound
    - Retroperitoneal exploration and renal reconstruction
    - Exploratory laparotomy, retroperitoneal exploration, and renal reconstruction
  - A 45-year-old male presents to the ED with nausea, vomiting, and a sharp right groin pain that started 6 hours ago. He is unable to find a comfortable position and moves around frequently in the hospital bed. He is afebrile and hemodynamically stable. CT abdomen/pelvis without contrast reveals a 4-mm right-sided stone at the ureterovesical junction (UVJ) with mild hydronephrosis and some periureteral stranding. He has no dysuria, and his urinalysis is negative for infection. His pain and nausea improve with medical therapy. Which of the following is the most appropriate course of management?
    - Medical expulsive therapy (tamsulosin, nonsteroidal antiinflammatory drugs [NSAIDs]) and outpatient follow-up
    - Ureteral stent placement
    - Extracorporeal shock wave lithotripsy (ESWL)
    - Ureteroscopy and laser lithotripsy
    - Percutaneous nephrostomy tube placement
  - An 18-year-old woman presents to the ED following a motorcycle collision. She is hemodynamically stable but has an obvious pelvic fracture. On exam, blood is found at the vaginal introitus. CT abdomen/pelvis demonstrates a severe pelvic fracture with normal appearing kidneys. The best next step is:
    - Urethral catheter
    - Cystogram
    - Retrograde urethrogram and cystogram
    - Urethroscopy, vaginoscopy, and cystogram
    - Suprapubic bladder catheter
  - A 27-year-old male presents to the ED after sustaining a gunshot wound to the pelvis. He undergoes exploratory laparotomy and is found to have a left sigmoid colon injury, which is repaired primarily. He is hemodynamically stable. On examination of the left distal ureter, it appears to be contused. Intravenous indigo carmine is administered, and no extravasation is seen from the ureter. Which of the following is the most appropriate next step?
    - Observation
    - Ureteral stent
    - Percutaneous nephrostomy
    - Resect damaged ureter and reimplant ureter into bladder
    - Resect damaged ureter and repair with end-to-end ureteral anastomosis

10. A 62-year-old male with a history of diverticulitis presents with pneumaturia, urinary frequency, and dysuria for several days. He is afebrile and hemodynamically stable. Urine culture grows multiple organisms. The best study to diagnose the etiology of his urinary symptoms is:
- A. Barium enema
  - B. Plain films of abdomen/pelvis
  - C. Colonoscopy
  - D. CT abdomen/pelvis with oral contrast
  - E. Cystoscopy
11. For the patient in [question 10](#), the definitive management consists of:
- A. Total parenteral nutrition, bowel rest, and antibiotics
  - B. Colon resection with primary closure of bladder
  - C. Colon resection and excision of cuff of bladder
  - D. Partial cystectomy
  - E. Cystoscopy with fulguration
12. A 49-year-old male undergoes a low anterior resection for rectal cancer. During mobilization and dissection of the sigmoid colon, the left ureter is injured. There is a 1-cm segment destroyed above the pelvic brim. The patient is hemodynamically stable. Which of the following is the appropriate management for this ureteral injury?
- A. Resect injured segment and perform a primary end-to-end ureteral anastomosis over a stent
  - B. Ligate ureter and place a percutaneous nephrostomy tube
  - C. Mobilize ureter and reimplant into the bladder after performing a psoas hitch
  - D. Perform a nephropexy and ureteroureterostomy
  - E. Perform an ileum interposition
13. A 15-year-old boy presents to the ED with severe left testicular pain that woke him from sleep 3 hours ago. He denies scrotal trauma or recent infections. He had a similar episode 6 months ago that resolved within minutes. Physical exam reveals an enlarged, firm, and tender left testicle with abnormal lie. Stroking the left inner thigh does not elicit elevation of the hemiscrotum. Manual elevation of the scrotum does not relieve the pain. Which of the following is the best next step in management?
- A. Testicular ultrasound
  - B. Attempt left testicular detorsion in the ED followed by left testicular orchiopexy in the OR
  - C. Attempt left testicular detorsion in the ED followed by bilateral orchiopexy in the OR
  - D. Take to the OR to perform left testicular detorsion and bilateral orchiopexy
  - E. Take to the OR to perform a left orchiectomy
14. A 22-year-old male presents to the ED with an erection that has lasted for 9 hours and is becoming exceedingly painful. He denies genitourinary trauma, drug use, or recreational use of phosphodiesterase-5 inhibitors. He also denies any personal or family history of hematologic diseases. He had a similar episode 8 months ago that resolved spontaneously after 4 hours, but now he is having severe worsening penile pain. Management of his condition involves:
- A. Oxygen, IV hydration, and close monitoring
  - B. Oral phenylephrine
  - C. Penile Doppler ultrasound
  - D. Corporal aspiration and irrigation with saline
  - E. Urgent cavernoglandular shunt
15. A 36-year-old female is admitted to the hospital after being struck by an automobile while riding her motorcycle. Plain films demonstrate a fracture at her inferior pubic ramus. Upon urethral catheter placement, she was found to have gross hematuria. CT cystogram revealed contrast extravasation into the extraperitoneal space with no bony structures within the bladder wall. The patient is hemodynamically stable. Laboratory studies are unremarkable. The next step is:
- A. Prolonged indwelling urethral catheter

- B. Replace urethral catheter with suprapubic cystostomy
  - C. Open operative repair of bladder injury
  - D. Cystoscopy to visualize bladder perforation site
  - E. Bilateral nephrostomy tubes for temporary urinary diversion
16. A 67-year-old male with a history of nocturia and urinary frequency due to bladder outlet obstruction from an enlarged prostate undergoes a transurethral resection of the prostate using a monopolar resectoscope with sterile water used as an irrigant. Estimated blood loss was over 300 mL. In recovery, the patient is found to be somnolent and has two episodes of emesis. Blood pressure is 196/100 mm Hg, and heart rate is 47 beats per minute. Which of the following would be most useful in determining the etiology for the patient's current condition?
- A. Complete blood count
  - B. Basic metabolic panel
  - C. Urinalysis
  - D. CT head
  - E. CT cystogram
17. A 3-year-old girl with a history of surgical correction for a high imperforate anus presents with persistent urinary incontinence. A voiding cystourethrogram (VCUG) reveals a large trabeculated bladder, grade 2 vesicoureteral reflux on the right, and incomplete bladder emptying. Two normal kidneys without hydronephrosis are noted on renal ultrasound. The most appropriate next step is:
- A. Clean intermittent catheterization
  - B. Spinal ultrasound
  - C. Alpha-blocker
  - D. Spinal magnetic resonance imaging (MRI) scan
  - E. Vesicostomy
18. A 32-year-old male is brought to the ED by ambulance after a motorcycle accident at 45 mph. Abdominal CT scan with contrast demonstrates a deep renal laceration with urinary extravasation into the retroperitoneum. After observation for 10 days, a repeat CT urogram shows persistent urinary extravasation with development of a small urinoma. There is no hydronephrosis. He is hemodynamically stable and afebrile. The most appropriate next step is:
- A. Continued observation
  - B. Surgical exploration and repair
  - C. Insertion of a ureteral stent
  - D. Percutaneous nephrostomy drainage
  - E. Percutaneous perinephric drainage

## Answers

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1. **B.** There are two kidneys, but humans can survive with just one without a clinically significant decrease in renal function or rise in creatinine. Gerota capsule surrounds the kidney while Glisson capsule surrounds the liver (C). Both renal arteries come off the abdominal aorta (E). The renal vein is the most anterior structure at the renal hilum, the renal pelvis is the most posterior structure, and the renal artery is between the two (A). The right renal vein is short and drains immediately into the inferior vena cava (IVC) while the longer left renal vein is joined by collateral vessels before entering the IVC. Since the left side has a longer left renal vein, it is the preferred side for a donor kidney. The left renal vein is joined by the left adrenal vein superiorly, left gonadal vein inferiorly, and left lumbar vein posteriorly. The left renal vein can be ligated distally (close to the IVC); this still permits venous drainage via collaterals without irreversible renal damage or hydronephrosis. The right renal artery passes posterior to the IVC while the left renal vein passes anterior to the aorta (D). Rarely, a retroaortic left renal vein is present. This variant can present problems during infrarenal aortic surgery because the vein is prone to injury and difficult to repair.
2. **C.** Scrotal discomfort accompanied by a mass that feels like a "bag of worms" and does not disappear while lying supine is suggestive of a varicocele. A scrotal mass that does disappear when

laying supine and that transilluminates is likely to be a hydrocele. An adult with a new (acute onset) left-sided varicocele is concerning for obstruction at the IVC, with renal cell carcinoma (RCC) being the most common etiology. The classic triad for RCC includes a flank mass, flank pain, and hematuria, but less than 10% have all three findings. In addition, RCC can initially present with a paraneoplastic syndrome that includes hypertension from renin secretion (likely in the above patient), hypercalcemia from parathyroid hormone (PTH)-related peptide secretion, polycythemia from erythropoietin secretion, hypoglycemia from insulin secretion, and hepatic dysfunction (Stauffer's syndrome); all of which resolve with treatment of RCC. About 40% of patients with RCC have an elevated renin level. Risk factors for RCC include smoking, alcohol, obesity, cystic disease of the kidney, and diabetes. The next best step in this patient is to order a CT scan of the abdomen/pelvis with a urogram phase to evaluate for a renal mass and visualize his upper urinary tracts (A, B, D, E). Although metastasis accounts for the majority of renal tumors (typically from breast cancer), the most common primary renal tumor is RCC. The lung is the most frequent site of distant spread. Tissue diagnosis is required before surgical intervention. Patients with resectable disease and without distant spread can undergo partial nephrectomy for smaller tumors, or radical nephrectomy for larger tumors or those with local invasion (such as this patient).

**Reference:** Palapattu, G. S., Kristo, B., & Rajfer, J. (2002). Paraneoplastic syndromes in urologic malignancy: the many faces of renal cell carcinoma. *Reviews in Urology*, 4(4), 163–170.

3. **A.** The above patient has asymptomatic bacteriuria, which is defined by the presence of bacteria or markers thereof (positive for leukocyte esterase, nitrites) in an appropriately collected urinalysis (absence or low number of squamous cells) and without any signs or symptoms of a urinary tract infection (e.g., urinary frequency, urgency, dysuria). With the exception of pregnancy and those undergoing urologic intervention (e.g., prostatectomy, prostate biopsy), adult patients with asymptomatic bacteriuria do not require any treatment (B–E). In contrast, all symptomatic patients require treatment. Women are at higher risk for *symptomatic* urinary tract infection (UTI) owing to their shorter and straighter urethra. Additionally, its close proximity to the vaginal orifice colonized by bacteria makes them vulnerable to infection. Most uncomplicated cases can be managed with a 3-day course of nitrofurantoin or trimethoprim-sulfamethoxazole (TMP-SMX). Due to increasing microbial resistance to ciprofloxacin it should be reserved for demographics with TMP-SMX resistance or in cases where nitrofurantoin or TMP-SMX cannot be used due to availability, allergy, or tolerance. Complicated cases require a 7-day course of oral antibiotics and include those with previous urinary manipulation, abnormal anatomy, and all male patients. Given the rarity of symptomatic UTI in young men, one should suspect abnormal anatomy predisposing him to bacteriuria and subsequent infection. Young males and most women with recurrent infections should be referred to a urologist to undergo renal ultrasound and measurement of post-void residual bladder volume.

**Reference:** Zalmanovici-Trestioreanu, A., Lador, A., Sauerbrun-Cutler, M. T., et al. (2015).

Antibiotics for asymptomatic bacteriuria. *Cochrane Database of Systematic Reviews*, 8(4), CD009534.

4. **B.** Vasectomy is a very effective method for male contraception. It is less costly, safer, and associated with a shorter recovery time compared with tubal ligation. However, vasectomy is performed less frequently, which is likely related to patient misinformation and public stigma. There are a variety of methods to perform a vasectomy, and it can be done by urologists as well as general surgeons typically in the office with local anesthesia (A). The guiding principle involves ligation of the vas deferens, which can be achieved with two small scrotal incisions. Although the success rate exceeds 95%, patients should not have unprotected intercourse for 3 months after the procedure and only after confirming sterility with a semen analysis to look for azoospermia (C). The probability of obtaining a natural pregnancy following vasectomy reversal is 50% (D). There is no evidence to suggest that patients who have undergone vasectomy have an increased risk for testicular cancer (E).

**References:** Aradhya, K. W., Best, K., & Sokal, D. C. (2005). Recent developments in vasectomy. *British Medical Journal*, 330(7486), 296–299.

van Dongen, J., Tekle, F. B., & Roijen, J. H. (2012). Pregnancy rate after vasectomy reversal in a contemporary series: influence of smoking, semen quality and post-surgical use of assisted reproductive techniques. *BJU International*, 110(4), 562–567.

5. **E.** A well-known complication of radical prostatectomy is rectal injury, with an incidence of 1.5%. If identified intraoperatively and the patient completed a bowel prep, it may be repaired primarily. If

the bowel injury is recognized postoperatively as a vesicorectal fistula (as in this case), conservative management is not appropriate (A–D). Since the patient has systemic signs of infection, he needs to be started on parenteral antibiotics and the fluid collection needs to be drained. Additionally, a large fluid collection suggests a sizeable rectal injury and perforation; this will need to be treated with a colostomy to temporarily divert his stool with the intent to perform a delayed repair.

**References:** Harpster, L. E., Rommel, F. M., Sieber, P. R., et al. (1995). The incidence and management of rectal injury associated with radical prostatectomy in a community based urology practice. *The Journal of Urology*, 154(4), 1435–1438.

Rovner, E. S. (2007). Urinary tract fistula. In W. S. McDougall, A. J. Wein, L. R. Kavoussi, et al., (Eds.), *Campbell-Walsh urology* (9th ed.). Philadelphia, PA: Saunders Elsevier.

6. **A.** Historically, the general recommendation has been that penetrating trauma to the kidney mandates surgical exploration. However, that algorithm has recently been challenged. In select cases where the patient is hemodynamically stable, the penetrating injury is due to a stab wound or a low velocity gunshot wound, there are no intra-abdominal injuries, and the renal injury is low grade, a nonoperative approach can be implemented (B–E). The main concern with a penetrating flank or back wound would be a missed colon injury. Renal trauma is graded according to the severity of renal parenchymal injury and disruption of the renal pelvis and renal vascularity. Grade I is a subcapsular renal hematoma or renal contusion, with no renal laceration. Grade II is a parenchymal laceration less than 1 cm in depth with the hematoma contained within the Gerota fascia. Grade III is a laceration larger than 1 cm in depth, into the medulla, with the hematoma contained in the Gerota fascia. Grade IV is a laceration into the collecting system or the renal pelvis or a disruption of the ureteropelvic junction (seen oftentimes in children). Injury to a segmental renal artery or vein also qualifies as Grade IV. A Grade V injury is a disruption of the main renal artery or vein or a shattered kidney. If the patient is already undergoing a laparotomy for a penetrating abdominal injury, and a renal injury is noted, the question arises as to whether the renal injury should be explored. Similarly, if there is no large or expanding hematoma, and no active bleeding, such an injury is now increasingly being observed without exploration. Exploring such wounds requires opening the Gerota fascia, and releasing its tamponade effect, which in turn may lead to bleeding and a nephrectomy (in other words, destabilizing a stable condition). As a general rule, grades I and II rarely need operative management. Grades III and IV can be observed if no intraperitoneal injuries are noted. Delayed bleeding occurs in 20% of Grade III to IV renal injuries and can be managed with arteriographic embolization. Grade V injuries should be explored in the OR.

**References:** Buckley, J. C., & McAninch, J. W. (2011). Revision of current American Association for the Surgery of Trauma Renal Injury grading system. *The Journal of Trauma*, 70(1), 35.

Heyns, C. F. (2004). Renal trauma: indications for imaging and surgical exploration. *BJU International*, 93(8), 1165–1170.

Santucci, R., Wessells, H., Bartsch, G., et al. (2004). Evaluation and management of renal injuries: consensus statement of the renal trauma committee. *BJU International*, 93(7), 937–954.

7. **A.** This patient presents with an obstructing 4-mm right UVJ stone causing acute pain. The majority are calcium-oxalate stones, which are radiopaque. Uric acid stones account for 10% of all nephroliths and are radiolucent, which is why initial workup should include a noncontrast stone protocol CT. In the setting of an obstructing distal ureteral stone without evidence of urinary tract infection, it is reasonable to observe and medically treat the patient with tamsulosin 0.4 mg daily (relaxes ureteral smooth muscle and facilitates stone passage) and NSAIDs, assuming the patient's pain is well controlled and oral intake is adequate. Given the stone's location, there is greater than a 75% chance of spontaneously passing this stone within 3 weeks. Medical expulsive therapy is less successful for stone passage if it is larger than 7 mm or if it is in the proximal ureter. ESWL and ureteroscopy/laser lithotripsy are not initially indicated because this stone has a high chance of passing with medical management alone, but may be indicated later if his symptoms persist (C, D). Ureteral stent placement and percutaneous nephrostomy tube placement would be indicated to decompress the urinary system if the patient meets criteria for prompt intervention (B, E). This includes the following: (1) high-grade unilateral urinary obstruction, (2) bilateral urinary obstruction, (3) urinary obstruction to solitary kidney, (4) urinary obstruction with urinary infection or sepsis, (5) inability to tolerate oral intake from nausea/vomiting, (6) severe pain not controlled by oral analgesics.



**References:** Coll, D. M., Varanelli, M. J., & Smith, R. C. (2002). Relationship of spontaneous passage of ureteral calculi to stone size and location as revealed by unenhanced helical CT. *American Journal of Roentgenology*, 178(1), 101–103.

Miller, O. F., & Kane, C. J. (1999). Time to stone passage for observed ureteral calculi: a guide for patient education. *The Journal of Urology*, 162(3 Pt 1), 688–690.

Parsons, J. K., Hergan, L. A., Sakamoto, K., et al. (2007). Efficacy of alpha-blockers for the treatment of ureteral stones. *Journal of Urology*, 177(3), 983–987.

Preminger, G. M., Tiselius, H. G., EAU/AUA Nephrolithiasis Guidelines Panel, et al. (2007). 2007 guideline for the management of ureteral calculi. *Journal of Urology*, 178(6), 2418–2434.

8. **D.** Open pelvic fractures are associated with very high impact injuries. It occurs most commonly following high-speed motorcycle accidents. They have a high rate of significant bleeding and associated injuries and can lead to life-threatening pelvic sepsis, particularly if a rectal injury is unrecognized. Thus, in the setting of a pelvic fracture, it is essential to examine the perineum for evidence of external wounds, as well as for blood in the rectum or vagina (and never assume that vaginal bleeding is due to menses). Any external perineal wounds or rectal/vaginal blood should be presumed to be due to an open pelvic fracture until proven otherwise. Given the blood found at the vaginal introitus, this patient is at risk of having sustained injury to the urethra, vagina, bladder, or rectum. She will require an exam under anesthesia, urethroscopy, vaginoscopy, and cystogram to evaluate for vaginal, urethral, or bladder trauma (B). A retrograde urethrogram is technically difficult to perform in a younger female because of a short urethra (around 4 cm); thus it is not used in the diagnosis of female urethral trauma (C). A suprapubic bladder catheter is not necessary without evaluation of the urethra (E). A urethral catheter should be delayed until a urethral injury is ruled out given the gross blood (A).

**References:** Morey, A. F. & Dugi, D. D. (2010). Genital and lower urinary tract trauma. In W. S. McDougall, A. J. Wein, L. R., Kavoussi, et al., (Eds.), *Campbell-Walsh urology* (10th ed.). Philadelphia, PA: Saunders Elsevier.

Kong, J. P., Bultitude, M. F., Royce, P., et al. (2011). Lower urinary tract injuries following blunt trauma: a review of contemporary management. *Reviews in Urology*, 13(3), 119–130.

9. **B.** Blast injury can cause extensive direct and indirect soft tissue damage. The initial blast can cause immediate tissue damage, but there is oftentimes tissue injury that appears later. Victims suffer burns from the heat discharged from the explosive device or the blast. Gunshot wounds resemble such blast injuries. The degree of injury corresponds to the type of weapon, caliber of bullet, and distance from the projectile to the victim. Bullet velocity has the greatest effect on soft tissue damage. The faster the bullet, the larger the temporary cavity created, indicating a larger extent of soft tissue injury. These blast injuries tend to evolve with time and become more widespread after several days. A minor ureteral contusion is managed with ureteral stent placement to prevent ureteral narrowing from resultant scar tissue. If the ureteral damage was greater, the microvascular supply to the ureter would be compromised, leading to ureteral breakdown or stricture that would manifest days to weeks after the initial injury. This would necessitate excision of the damaged ureteral segment and either end-to-end anastomosis of the remaining ureter (ureteroureterostomy) or reimplantation of the remaining ureter to bladder (ureteroneocystostomy) (D, E). Percutaneous nephrostomy is not indicated in this case because ureteral stenting is possible (C).

**Reference:** McAninch, W., & Santucci, R. A. (2007). Renal and ureteral trauma. In W. S. McDougall, A. J. Wein, L. R., Kavoussi, et al., (Eds.), *Campbell-Walsh urology* (9th ed.). Philadelphia, PA: Saunders Elsevier.

10. **D.** This patient is suffering from a colovesical fistula secondary to diverticulitis. Other common etiologies include Crohn disease, colorectal carcinoma, radiation, infection, and trauma. Most patients present with lower urinary tract symptoms (dysuria, pneumaturia, frequency), suprapubic pain, hematuria, and/or tenesmus. While the diagnosis is oftentimes made clinically, the test of choice for diagnosis is CT scan. The triad of findings on CT suggestive of a colovesical fistula include (1) bladder wall thickening adjacent to a loop of thickened bowel, (2) air in the bladder (in absence of previous urinary tract manipulation), and (3) presence of colonic diverticula. CT scan is the most sensitive and specific test to diagnose a colovesical fistula because of its ability to detect very small amounts of air in the bladder. However, an active UTI or recent indwelling Foley catheter may create false positives. Oral contrast allows visualization of contrast tracking into the bladder for better localization of the fistula. Barium enema and colonoscopy have a low sensitivity



in diagnosing colovesical fistula (A–C). Cystoscopy may identify a potential lesion in the bladder, but these are oftentimes nonspecific and can include erythema or papillary change (E). Plain films do not help identify a colovesical fistula (B).

**References:** Kirsh, G. M., Hampel, N., Shuck, J. M., et al. (1991). Diagnosis and management of vesicoenteric fistulas. *Surgery Gynecology and Obstetrics*, 173(2), 91–97.

Rovner, E. S. (2010). Urinary tract fistula. In W. S. McDougall, A. J. Wein, L. R., Kavoussi, et al., (Eds.), *Campbell-Walsh urology* (10th ed.). Philadelphia, PA: Saunders Elsevier.

11. **B.** Definitive treatment of a colovesical fistula due to diverticulitis involves colon resection with primary closure of the bladder (C). Partial cystectomy would not resolve the underlying disease (D). Though there are some case reports of nonoperative management, this is not the standard recommendation (A). An exception is in patients with Crohn disease. Due to the chronic relapsing nature of the disease, medical management with antibiotics, azathioprine, steroids, and/or infliximab may resolve the fistula, obviating the need for resection of part of the bladder. If the colovesical fistula were due to malignancy, then an en bloc resection would be recommended. With operative management of a colovesical fistula, an omental flap is placed between the repaired bladder and bowel to prevent overlapping suture lines and provide a well-vascularized surface for healing. Cystoscopy with fulguration and endoscopic stenting are not used in the management of colovesical fistulas (E).

**References:** Fiocchi, C. (2004). Closing fistulas in Crohn's disease—should the accent be on maintenance or safety? *The New England Journal of Medicine*, 350(9), 934–936.

Ferguson, G. G., Lee, E. W., Hunt, S. R., et al. (2008). Management of the bladder during surgical treatment of enterovesical fistulas from benign bowel disease. *Journal of the American College of Surgeons*, 207(4), 569–572.

Rovner, E. S. (2010). Urinary tract fistula. In W. S. McDougall, A. J. Wein, L. R., Kavoussi, et al., (Eds.), *Campbell-Walsh urology* (10th ed.). Philadelphia, PA: Saunders Elsevier.

Zhang, W., Zhu, W., Li, Y., et al. (2014). The respective role of medical and surgical therapy for enterovesical fistula in Crohn's disease. *Journal of Clinical Gastroenterology*, 48(8), 708–711.

12. **A.** Ureteral injury and repair is an important part of general surgery training because it is a well-known complication during pelvic dissection and mobilization of the iliac arteries (ureters cross anterior to the common iliac vessels bifurcation). Ureteral repair is divided into thirds and depends on whether a large (>2 cm) or small (<2 cm) segment is missing. The upper and middle thirds of the ureter are defined as above the pelvic brim. If a small segment is injured above the pelvic brim, the recommended management is resection of the injured segment followed by a primary end-to-end ureteral anastomosis over a stent. For small injuries to the distal third, the recommended management is reimplantation into the bladder. For larger injuries to the upper and middle third, nephropexy (anchoring the kidney caudad) to bring the ureteral ends closer together to create a tension-free end-to-end ureteral anastomosis (ureteroureterostomy) is an option (D). For large injuries to the distal third of the ureter, reimplantation into the bladder is recommended. However, with larger distal ureteral injuries, the ureter may not reach, so the bladder will need to be mobilized. This can be performed with a psoas hitch maneuver in which the bladder is pulled up and anchored to the psoas muscle to reach the injured ureter (C). Additionally, a Boari bladder flap can be performed in which the bladder is tubularized to create additional length. In cases where the patient is unstable, the surgeon can ligate the ureter and place a percutaneous nephrostomy tube (B). The patient can be brought back at a later date for repair, which may include ileal interposition (E). Absorbable sutures should always be used to avoid stricturing, calculi formation and to prevent a nidus for infection. Most surgeons prefer to leave drains for ureteral injuries.

13. **C.** This patient presents with the classic clinical picture for testicular torsion. Incidence of torsion occurs in a bimodal pattern; infant boys (due to the tunica vaginalis not yet secured to the gubernaculum in the scrotum) and adolescent boys (rapidly growing testicle during puberty) are at highest risk of torsion, though it can occur at any age. Torsion presents with acute onset of severe testicular pain, with or without swelling. This patient's history also suggests possible intermittent torsion that resolved spontaneously, though this is difficult to diagnose definitively. Physical exam findings include a tender firm testicle, horizontal lie of testicle, high-riding testicle, and absent cremasteric reflex (stroking the inner thigh elicits elevation of the hemiscrotum). In contrast to epididymis, patients with testicular torsion have a negative Prehn sign (manual elevation of the

scrotum relieves pain). Torsion is diagnosed clinically, and surgical exploration should not be delayed to perform other imaging studies if suspected (A). If the diagnosis is questionable and it has been less than 4 hours, a scrotal Doppler ultrasound is a reasonable option. This would demonstrate an absence of flow and more heterogeneous texture of the testicular parenchyma compared with the contralateral testis. A torsed testicle is usually viable if detorsed within 6 hours. This can be initially attempted in the ED with proper pain medication but still necessitates an urgent bilateral orchiopexy in the OR (D). After surgical detorsion, both testes are sutured to the scrotal dartos muscle (orchiopexy) to prevent future torsion episodes (contralateral testis has higher risk of torsion as well, necessitating concurrent contralateral orchiopexy) (B). A common imitator of testicular torsion is epididymo-orchitis, differentiated by pain relief with testicular elevation, normal or increased flow in the testicle or epididymis on Doppler ultrasound (increased flow indicating inflammation), and a urinalysis suggesting bacteriuria. Sexually transmitted infections must also be ruled out if epididymo-orchitis is suspected. If the testicle is found to be ischemic and does not recover color and appearance after detorsion, testicular infarction has resulted and an orchiectomy is necessary (E).

**References:** Dajusta D. G., Granberg, C. F., & Villanueva, C. (2013). Contemporary review of testicular torsion: new concepts, emerging technologies and potential therapeutics. *The Journal of Pediatrics Urology*, 9(6 Pt A), 723–730.

Johnston, B. I., & Wiener, J. S. (2005). Intermittent testicular torsion. *BJU International*, 95(7), 933–934.

Sharp, V. J., Kieran, K., & Arlen, A. M. (2013). Testicular torsion: diagnosis, evaluation, and management. *American Family Physician*, 88(12), 835–840.

14. **D.** This patient is suffering from ischemic priapism, a urologic emergency requiring urgent intervention to prevent permanent erectile dysfunction. This is due to decreased venous outflow from the cavernosa and subsequent increased intracavernosal pressure. This also results in decreased arterial inflow, causing stasis of blood and resultant local hypoxia and acidosis. On exam, the patient has a fully erect, rigid, and tender penis, but the glans and corpus spongiosum are soft (corpora cavernosa are the involved compartments in priapism). Early intervention is very important. In the ED, the patient should undergo a corporal aspiration and irrigation with normal saline to drain static blood from the corpora and to flush out old clots; this achieves detumescence. Phenylephrine may be injected intracorporally as well, but the patient must be on a cardiac monitor before doing so because of the risk of hypertension, tachycardia, reflex bradycardia, and arrhythmia if the phenylephrine is systemically absorbed. If detumescence is not successfully achieved by corporal aspiration/irrigation, the patient should undergo a cavernoglandular shunt procedure, though this is more invasive and has a higher risk of permanent erectile dysfunction (E). Oral phenylephrine has not been shown to be beneficial for priapism (B). In sickle cell patients with priapism, first-line management is medical therapy with oxygen, IV hydration, and pain control (A). Blood exchange transfusions to reduce the concentration of HbS is indicated in sickle cell patients if initial medical therapy fails. Penile Doppler ultrasound is not routinely done for priapism, though it may be useful to differentiate ischemic from nonischemic priapism (nonischemic priapism is managed conservatively and often resolves with observation) (C). Nonischemic priapism is nontender and is partially rigid. It is usually due to penile trauma causing a fistula between the corporal tissue and cavernous artery and is not an emergent condition.

**References:** Broderick, G., et al. (2010). Priapism recommendations. *Sexual Medicine: Sexual Dysfunction in Men and Women. Third International Consultation on Erectile Dysfunction (3rd ICUD)*. In F. Montorsi, et al., (Eds.), *Plymouth*. United Kingdom: Health Publication Ltd.

Tay, Y. K., Spermat, D., Rzetelski-West, K. (2011). Acute management of priapism in men. *BJU International*, 109(Suppl. 3), 15–21.

15. **A.** Bladder injury is usually caused by pelvic fracture or by blunt trauma to the lower abdomen when the bladder is distended. Bladder injuries include bladder contusions (hematuria without extravasation), extraperitoneal bladder rupture, and intraperitoneal bladder rupture. Gross hematuria is the most common presenting sign of rupture and can be accompanied by concurrent pelvic fracture and suprapubic discomfort/tenderness. Bladder rupture is diagnosed with a cystogram; the bladder is filled with 300 to 400 cc of contrast through a foley catheter and observed for contrast extravasation. Intraoperative bladder ruptures can be similarly diagnosed by filling the

bladder with colored dye (methylene blue, indigo carmine) to assess for leakage. Management of an extraperitoneal bladder rupture is managed by a 2-week course of an indwelling Foley catheter and repeat cystogram to ensure bladder healing. Replacing the Foley catheter with a suprapubic cystostomy is invasive and unnecessary (B). However, in the setting of persistent hematuria, concomitant pelvic organ injury, bladder foreign bodies (bullet, bone fragment), persistent urine leak, or penetrating trauma, operative repair of an extraperitoneal bladder rupture is indicated. Open surgical repair is also necessary for intraperitoneal ruptures as soon as feasible to prevent peritonitis. Intraperitoneal ruptures typically occur at the bladder dome, which is lined by peritoneum. The bladder is closed in 2 to 3 layers with absorbable suture (using non-absorbable suture for bladder wall closures results in calcification of the suture line and bladder stones) (C). Occasionally, bladder injuries are not immediately detected, and a urinoma may develop. If there is concern for infected urinoma, the patient may benefit from interventional radiology (IR) drainage, though adequate bladder drainage is usually sufficient. Cystoscopy is a diagnostic option for intraoperative bladder perforations. However, in the setting of a traumatic bladder rupture, a cystogram is the best diagnostic approach because it is quicker, less invasive, and can differentiate between intraperitoneal and extraperitoneal perforations (D). In poor operative candidates who have persistent urine leakage from the bladder despite urethral drainage, bilateral nephrostomy tubes may help divert the urine temporarily and allow a better opportunity for the bladder to heal (E).

**References:** Morey, A. F. & Dugi, D. D. (2012). Genital and lower urinary tract trauma. In W. S. McDougall, A. J. Wein, L. R., Kavoussi, et al., (Eds.), *Campbell-Walsh urology* (10th ed.). Philadelphia, PA: Saunders Elsevier.

Mundy, A. R. & Andrich D. E. (2010). Pelvic fracture-related injuries of the bladder neck and prostate: their nature, cause and management. *BJU International*, 105(9), 1302–1308.

16. **B.** A classic postoperative complication seen in 2% of patients following transurethral resection of the prostate (TURP) is dilutional hyponatremia causing neurologic symptoms (confusion, convulsions, somnolence, visual disturbance), hypertension, bradycardia, and nausea/vomiting. This is termed *TUR syndrome* and is due to hypotonic fluid (sterile water) rushing into the open venous sinuses of the prostate during prostatic resection. Thus, obtaining a basic metabolic panel to assess for hyponatremia is the next best step. This complication is becoming less common because of the more widespread use of the bipolar resectoscope, which uses normal saline as irrigant, versus the monopolar resectoscope that requires a hypotonic irrigant such as sterile water or glycine. TUR syndrome is prevented by reducing the irrigant pressure, shortening operative time, and minimizing the opening of venous sinuses intraoperatively. It can be managed by administering 3% hypertonic saline and furosemide (10–20 mg IV  $\times$  1) postoperatively to correct the hyponatremia and diurese free water from the patient. Blood loss of 300 mL is not significant enough to result in cerebral hypoperfusion and altered mental status and thus a complete blood count is not necessary (A). Similarly, urinalysis is unlikely to add any useful information (C). Imaging studies are not useful in managing TUR syndrome (D, E).

**Reference:** Fitzpatrick, J. M. (2010). Minimally invasive and endoscopic management of benign prostatic hyperplasia. In W. S. McDougall, A. J. Wein, L. R., Kavoussi, et al., (Eds.), *Campbell-Walsh urology* (10th ed.). Philadelphia, PA: Saunders Elsevier.

17. **D.** Spinal cord abnormalities, including tethered cord or thickened filum terminale, are noted in a large portion (20–50%) of patients with imperforate anus. The severity of the rectal lesion corresponds with the severity of the spinal cord lesion. In this patient, her constellation of symptoms and radiographic findings (incomplete bladder emptying, trabeculated bladder, vesicoureteral reflux on the right) suggest possible neurogenic bladder dysfunction. The best next step is to obtain a spinal MRI to rule out spinal cord lesions. A spinal ultrasound is suboptimal because ossifications of the spine prevent ruling out a tethered spinal cord (B). A formal diagnosis of a neurogenic bladder and urodynamic studies are needed before clean intermittent catheterization, alpha-blockers, and vesicostomy can be used (A–C, E).

**Reference:** Yeung, C. K., Sihoe, J. D., & Bauer, S. B. (2007). Voiding dysfunction in children: non-neurogenic and neurogenic. In W. S. McDougall, A. J. Wein, L. R., Kavoussi, et al., (Eds.), *Campbell-Walsh urology* (9th ed.). Philadelphia, PA: Saunders Elsevier.

18. **C.** Blunt injuries to the kidney are often managed conservatively with observation alone even in the presence of urinary extravasation on early imaging studies. Extravasation resolves

spontaneously in 85% of renal injuries without further intervention. However, patients with persistent extravasation should be managed by drainage of urine with an internal ureteral stent. A Foley catheter may also be needed to maximally decompress the bladder and prevent urine from refluxing up the stented ureter to allow closure of the collecting system injury. Percutaneous nephrostomy tubes are difficult to place without hydronephrosis and provide no advantage over internal stents in the above case (D). Perinephric drainage is unnecessary without evidence of infection or large urinoma formation (E). Surgical exploration is excessively invasive and may result in more damage to the kidney (B).

**Reference:** Alsikafi, N. F., McAninch, J. W., Elliot, S. P., et al. (2006). Nonoperative management outcomes of isolated urinary extravasation following renal laceration due to external trauma. *The Journal of Urology*, 176(6 Pt 1), 2494–2497.

# Gynecology

Michael D. Sgroi, Areg Grigorian, and Christian de Virgilio

## Questions

1. A 23-year-old female has had two Pap smears over the last 24 months showing Atypical Squamous Cells of Undetermined Significance (ASC-US). On subsequent cervical biopsy, she is found to have mild dysplasia. Which of the following is the most appropriate treatment?
  - A. Pap smear in 1 year
  - B. Pap smear in 6 months
  - C. Cryoablation
  - D. Loop electrosurgical excision procedure (LEEP)
  - E. Cold knife conization
2. A 28-year-old female would like to know if she is currently pregnant. Which of the following combinations of imaging and lab threshold is most likely to accurately demonstrate an intrauterine gestational sac the *earliest*?
  - A. Transabdominal ultrasound with a serum beta human chorionic gonadotropin (hCG) of 3500 mIU/mL
  - B. Transvaginal ultrasound with a urine beta hCG of 1500 mIU/mL
  - C. Transvaginal ultrasound with a serum beta hCG of 2000 mIU/mL
  - D. Transvaginal ultrasound with a urine beta hCG of 2500 mIU/mL
  - E. Transabdominal ultrasound with a serum beta hCG of 5500 mIU/mL
3. A 35-year-old woman presents to the emergency department (ED) complaining of abdominal pain and irregular vaginal spotting. Her last menstruation was 8 weeks ago. On physical exam, she has tenderness in her right adnexa. Laboratory data demonstrates leukocytosis of 18,000 cells/mL and beta hCG of 3,000 mIU/mL. She is hemodynamically stable. Which of the following is true regarding the most likely condition?
  - A. This is most commonly seen in women after HPV infection.
  - B. Intrauterine devices (IUDs) increase one's risk of this condition.
  - C. Immediate laparotomy is warranted.
  - D. Immediate laparoscopy is warranted.
  - E. Methotrexate could be given with successful outcomes.
4. Which of the following is true regarding adnexal torsion?
  - A. Adnexal torsion is most commonly due to an ovarian malignancy.
  - B. Doppler ultrasound is the best diagnostic test to confirm vascular compromise caused by torsion.
  - C. CT imaging is the preferred method to confirm diagnosis.
  - D. Hysterectomy is the recommended treatment in patients with signs of necrosis.
  - E. The majority will detorse on their own.
5. A 38-year-old G1P1 female presents with abnormal vaginal bleeding. She reports having spotting throughout the month with some pelvic discomfort. She denies any recent sexual activity. Which of the following is least indicated for this patient?

- A. Serum beta hCG
  - B. Magnetic resonance imaging (MRI) abdomen/pelvis
  - C. Endometrial biopsy
  - D. Transvaginal ultrasound
  - E. Pelvic examination
6. A 50-year-old female presents to her obstetrician complaining of heavy menstrual bleeding that appears to be worsening. She is having significant abdominal cramping with her menses and is having trouble with urinary frequency and urgency. Which of the following is true regarding the most likely condition?
- A. The condition tends to get better during pregnancy.
  - B. MRI is most often required to confirm the diagnosis.
  - C. Most cases are associated with vaginal bleeding.
  - D. This is a benign condition.
  - E. Uterine artery embolization is preferred in younger women.
7. A 33-year-old female who is 18 weeks pregnant presents to the ED with hypotension, altered mental status, and tachycardia. The paramedics report that she was in a car accident earlier in the day and were called when she became altered. She has obvious vaginal bleeding, and the bedside nurse states that she is persistently bleeding from her peripheral IV site. Which of the following is true about this condition?
- A. Low fibrinogen levels are rare.
  - B. Transfusion of blood products is the cornerstone of management.
  - C. This condition can be excluded in cases with no vaginal bleeding.
  - D. Ultrasound is the best initial screening test.
  - E. Delivery of the fetus should be performed.
8. Which of the following is true regarding cervical cancer?
- A. Cervical cancer is the most common gynecologic malignancy in the United States.
  - B. Cervical cancer is staged during surgical exploration.
  - C. Stage 3 disease requires surgical intervention.
  - D. Cervical cancer screening should be performed 3 years after initiation of sexual intercourse regardless of age.
  - E. Cervical cancer screening should be performed 3 years after initiation of sexual intercourse but no later than age 21.
9. A 4-year-old girl arrives to the ED accompanied by her mother after noticing blood in her underwear. The girl is sitting on her mother's lap and appears comfortable. The child was adopted and no family history is known. On physical examination, a bleeding, friable "grape-like" mass is appreciated at the vaginal introitus. Which of the following is true for this patient?
- A. It is more commonly seen in young adult females.
  - B. The lesion is slow growing.
  - C. The lesion is likely benign.
  - D. A sexual assault evidence collection kit is indicated.
  - E. The child should be referred for vaginoscopy and biopsy.
10. Which of the following is true in regard to ovarian cancer?
- A. It is the most common malignant tumor in the female genital tract.
  - B. It is staged similarly to cervical cancer.
  - C. Bilateral ovary involvement is considered stage 4 disease.
  - D. Krukenberg tumor classically demonstrates signet ring cells.
  - E. Oral contraceptive pills increase the risk of ovarian cancer.
11. A 32-year-old female presents to the ED 1 week after vaginal delivery of her first child. She has persistent right lower quadrant abdominal pain, nausea, and leukocytosis. Pelvic examination is

unremarkable. An ultrasound demonstrates a tubular hypoechoic structure that extends superiorly from the adnexa, with absence of flow on Doppler. Which of the following is true about this condition?

- A. MRI is generally not helpful in establishing the diagnosis.
- B. Therapeutic anticoagulation and IV antibiotics should be started.
- C. Exploratory laparotomy should be performed.
- D. Diagnostic laparoscopy should be performed.
- E. She likely has retained products of contraception.

## Answers

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1. **A.** The goal of screening for cervical cancer is to circumvent progression of cancer while avoiding the overtreatment of lesions that are likely to regress. This patient had a concerning pap smear result that required follow up with colposcopy and biopsy. Prior to colposcopy, biopsy was done with a large excisional procedure, such as LEEP or cold knife conization. However, directed biopsies are now possible with colposcopy. Cervical intraepithelial neoplasia (CIN) is a premalignant condition ranging from low to high grade that can be identified on cervical biopsy and is grouped into 3 broad categories: CIN 1 is mild dysplasia, CIN 2 is moderate to marked dysplasia, and CIN 3 is severe dysplasia. Because cervical biopsies with colposcopy don't sample the entire cervix, invasive cancer can't be confirmed (or excluded). Thus, CIN is most useful to help identify women that would most benefit excisional cervical biopsies to rule out cancer or can simply proceed with less invasive screening. CIN 2-3 has a much simpler algorithm for management compared to CIN 1. Since the risk of concurrent cancer and/or progression to cancer is high, treatment is recommended for all women (C-E). With the advent of colposcopy, this can be performed with ablative (cryoablation or laser ablation) or excisional methods. Ablative options are popular among reproductive-aged women as the risk of adverse outcomes such as preterm delivery and prenatal mortality is lower. The decreased risk of adverse events is possible because the depth of tissue destruction is lower when compared to excisional techniques. This explains why excision offers a more accurate sample and is preferred in older women or younger women that are not concerned with future fertility. The management of CIN 1 or mild dysplasia depends on the age of the patient. Women aged 21-24 are at a very low risk for cervical cancer and so these women can be managed conservatively with a repeat pap smear in 1 year (not 6 months) (B). If the Pap smear is concerning at that time, repeat colposcopy and biopsy should be performed. For women older than 25 with CIN 1, the management is tailored based on current HPV status, results of any previous pap smears, and patient preference, but most would agree that repeat pap smear in 1 year along with HPV testing is appropriate.

**References:** Khan, M. J., & Smith-McCune, K. K. (2014). Treatment of cervical precancers: back to basics. *Obstetrics and Gynecology*, 123(6), 1339-1343.

Massad, L. S., Einstein, M. H., Huh, W. K., et al. (2013). 2012 updated consensus guidelines for the management of abnormal cervical cancer screening tests and cancer precursors. *Obstetrics and Gynecology*, 121(4), 829-846.

2. **B.** Either transvaginal or transabdominal ultrasound can be used concurrently with serum or urine beta hCG level to identify and estimate the gestational age of an intrauterine pregnancy. Transvaginal ultrasound is a more accurate way of determining gestational age at a significantly earlier point in the pregnancy. With the advent of quantitative urine tests, the accuracy and sensitivity of detecting pregnancy is comparable to serum beta hCG. The earliest an intrauterine gestational sac can be visualized is with a transvaginal ultrasound in a patient with a urine or serum beta hCG greater than 1500 mIU/mL (A, C-E). In fact, nonvisualization of an intrauterine sac on transvaginal ultrasound in a patient with a urine or serum beta hCG of more than 1500 mIU/mL is concerning for an ectopic pregnancy. The intrauterine sac is visible on trans-abdominal ultrasound when the urine or serum beta hCG is greater than 6000 mIU/ml.

**Reference:** Grossman, D., Berdichevsky, K., Larrea, F., et al. (2007). Accuracy of a semi-quantitative urine pregnancy test compared to serum beta-hCG measurement: a possible screening tool for ongoing pregnancy after medication abortion. *Contraception*, 76(2), 101-104.

3. **E.** A common and potentially life-threatening cause of abdominal pain in women is ectopic



pregnancy. An ectopic pregnancy is defined as gestation in which implantation has taken place in a site other than the endometrium; 97% of cases occur in the fallopian tubes. In a patient who is hemodynamically stable and is interested in reproduction later in life, methotrexate can be given in a single dose with a median success rate of 84%. Absolute contraindications include a beta hCG level greater than 5000 mIU/mL, an intrauterine gestational sac greater than 4 cm with no fetal cardiac activity, or an intrauterine gestational sac greater than 3.5 cm with fetal cardiac activity. Ectopic pregnancies are often seen in patients with pelvic inflammatory disease (PID). Women with HPV are not at risk for PID (A). Even though patients with IUDs have a 5% risk of ectopic pregnancy, the overall risk is still lower than those who do not use contraception (B). Based on multiple studies, the data have consistently shown laparoscopic surgery to be safer than open laparotomy. However, this should only be performed in patients with an acute abdomen or that are hemodynamically unstable (C, D). These patients have shorter hospital stays, less blood loss, and less use of postoperative narcotics. Finally, patients that are Rh-negative will need to receive an anti-D globulin injection within 72 hours of medical or surgical intervention (E).

**References:** Hajenius, P. J., Engelsbel, S., Mol, B. W., et al. (1997). Randomised trial of systemic methotrexate versus laparoscopic salpingostomy in tubal pregnancy. *Lancet*, 350(9080), 774–779.

Murphy, A. A., Nager, C. W., Wujek, J. J., et al. (1992). Operative laparoscopy versus laparotomy for the management of ectopic pregnancy: a prospective trial. *Fertility and Sterility*, 57(6), 1180–1185.

4. **B.** Adnexal torsion occurs when the ovary and/or fallopian tubes become twisted and the vascular supply becomes compromised. Adnexal torsion is generally a disease of reproductive-aged women. Torsion is commonly related to ovarian or tubal enlargement, including benign neoplasms (benign cystic teratoma, paraovarian cyst, cystadenoma, fibroma) and pregnancy-related changes (corpus luteum cyst, ovarian enlargement from ovulation induction). It is rarely related to an ovarian malignancy (A). While CT imaging can be used to assist with the diagnosis of adnexal torsion (C), Doppler ultrasound is the preferred method of imaging. In patients with signs of tubal necrosis on imaging, adnexectomy is the treatment of choice (D). Once a diagnosis has been confirmed, the patient needs to be taken to the operating room immediately to determine viability of the adnexa (E). Laparoscopic detorsion can usually be performed in the majority of patients.

**References:** Chang, K. H., et al. (1998). Conservative therapy of adnexal torsion employing color Doppler sonography. *The Journal of the American Association of Gynecologic Laparoscopists*, 5(1), 13–17.

Jung, S. I., Park, H. S., Jeon, H. J., et al. (2016). CT predictors for selecting conservative surgery or adnexectomy to treat adnexal torsion. *Clinical Imaging*, 40(4), 816–820.

Sommerville, M., Grimes, D. A., Koonings, P. P., et al. (1991). Ovarian neoplasms and the risk of adnexal torsion. *American Journal of Obstetrics and Gynecology*, 164(2), 577–578.

5. **B.** There is a large differential diagnosis in a patient with abnormal vaginal bleeding including intrauterine pregnancy, ectopic pregnancy, endometriosis, adenomyosis, fibroids, and malignancy. The American Congress of Obstetricians and Gynecologists (ACOG) recommends that all women with abnormal vaginal bleeding receive a full history and physical examination, including pelvic exam, and blood work including a pregnancy test (A, E). This should be followed by diagnostic imaging such as a transvaginal ultrasound (D). Additionally, all patients older than 35 years old should undergo endometrial biopsy. MRI, while potentially useful to identify a mass, would not be needed during the initial examination in a patient with abnormal bleeding.

**Reference:** Sweet, M. G., Schmidt-Dalton, T. A., Weiss, P. M., et al. (2012). Evaluation and management of abnormal uterine bleeding in premenopausal women. *American Family Physician*, 85(1), 35–43.

6. **D.** Uterine fibroids, also known as uterine leiomyomas, are benign smooth muscle tumors of the uterus. These most commonly occur in patients between 40 and 50 years old with prevalence ranging from 20% to 80%. Most are asymptomatic, however, bleeding caused by leiomyomas is the most common indication for hysterectomy in the United States (C). Malignant degeneration occurs in less than 1% of cases and is usually encountered in the menopausal years. High levels of pregnancy hormones (estrogen and progesterone) frequently cause significant enlargement of preexisting myomas, which may lead to distortion of the uterine cavity resulting in recurrent miscarriages, intrauterine growth restriction, abruption, preterm labor, and pain from degeneration (A). Diagnosis is usually made by transvaginal ultrasound, but MRI, CT, and hysterosalpingography can also be performed and help to distinguish submucosal and intrauterine myomas (B). Conservative management includes oral contraceptive pills, medroxyprogesterone

acetate, gonadotropin-releasing hormone (GnRH) agonists, uterine artery embolization, and myomectomy. Uterine artery embolization is contraindicated in patients planning on future pregnancy (E). GnRH should be given for 3 months before surgery to reduce blood loss and assist in normalizing the hematocrit.

7. E. Disseminated intravascular coagulation (DIC) is a pathologic disruption of hemostasis. Massive activation of the clotting cascade results in widespread thrombosis, which leads to depletion of platelets and coagulation factors and excessive thrombolysis. In DIC, excessive production of thrombin leads to widespread intravascular fibrin deposition and fibrinolysis (A). This results in depletion of coagulation factors and platelets, along with production of fibrin degradation products, causing a profound bleeding diathesis. This can result in massive hemorrhage, thrombosis, and multiorgan failure. Since DIC is considered a consumptive process, blood transfusions are not considered the definitive management. In fact, they may worsen symptoms. The best management is to treat the underlying cause (B). DIC in pregnancy occurs in 0.03% to 0.035% of cases but does not occur in isolation; most cases are initiated by a trigger. In pregnancy, these triggers include postpartum hemorrhage, preeclampsia, HELLP syndrome (hemolysis, elevated liver enzymes, low platelet count), acute fatty liver disease, amniotic fluid embolism, sepsis, and traumatic placental abruption (as in the above patient). Although placental abruption is often accompanied by vaginal bleeding, patients with a concealed placental abruption can present with an absence of vaginal bleeding (C). Since the above patient is unstable with DIC secondary to traumatic placental abruption, the best management is delivery of the fetus. This will often resolve obstetric conditions initiating DIC. Ultrasound can be a useful adjunct in equivocal cases of placental abruption (D).
8. E. Cervical cancer is the third most common gynecologic malignancy in the United States (A). Although many types of HPV can contribute to the development of cervical cancer, HPV-16 and HPV-18 are responsible for 70% of cases. The ACOG recommends that annual cervical cytology screening with pap smear should begin 3 years after initiation of sexual intercourse but no later than 21 years old (D). Staging of cervical cancer is based on physical examination (bimanual rectovaginal examination, cystoscopy, proctoscopy) and appropriate adjuvant radiographs (chest radiography, barium enema, intravenous pyelogram). The stage of cervical cancer is not based on surgical exploration (B). Five-year survival in stage 1 (cancer confined to the cervix) disease is 88%, compared with 63% for stage 2 (invasion beyond the uterus but not the pelvic wall), 38% for stage 3 (pelvic wall involvement), and 10% to 20% with stage 4 (bladder and rectum involvement). The presence of metastasis in pelvic or para-aortic lymph nodes (as determined by either lymphangiography or retroperitoneal lymphadenectomy) has been shown to be a significant negative prognosticator. Surgical candidates include patients that have stage 1 to stage 2b invasive cervical cancer. Stage 2a is defined by tumor without parametrial invasion while stage 2b is defined by tumor with parametrial invasion. Patients with stage 1 to 2b disease have the highest rate of cure with hysterectomy (simple or radical depending on tumor characteristics), which exceeds 90%. Patients with stage 2b and above do not benefit from surgical intervention and should be offered chemoradiation (C).

**References:** Benedet, J., Odicino, F., Maisonneuve, P., et al. (1998). FIGO annual report on the results of treatment in gynaecological cancer: carcinoma of the cervix uteri. *Journal of Epidemiology and Biostatistics*, 3, 5–34.

Long, H. J. III, Laack, N. N., & Gostout, B. S. (2007). Prevention, diagnosis, and treatment of cervical cancer. *Mayo Clinic Proceedings*, 82(12), 1566–1574.

9. E. Sarcoma botryoides, or rhabdomyosarcoma of the bladder or vagina, is the most common malignant condition of the lower genitourinary system presenting in childhood (A, C). The tumor grows rapidly, may be observed protruding from the introitus, and often appears as a “grape-like” friable mass (B). Patients typically present with blood spotting on the undergarments. The diagnosis is confirmed with vaginoscopy and biopsy. The extent of the lesion is best determined by pelvic ultrasound or CT scan. This type of tumor has an excellent outcome, with more than 90% of patients surviving with limited fertility-preserving surgery and multimodal chemotherapy. Sexual abuse should always be considered in young patients presenting to the ED with an unusual history and/or exam. Suspicious findings include bruising or fracture in a nonambulatory child, burns, long-bone fractures inconsistent with the reported mechanism, head injury or skull fracture, or children that appear socially isolated and/or uncomfortable around their caretakers. In cases where child abuse is suspected, the child should not be allowed to leave the hospital, a complete skeletal

survey should be performed, an ophthalmoscopic examination should be performed to look for retinal hemorrhages, and a social work consult should be requested. In cases where sexual abuse is suspected, a sexual evidence collection kit is required (D). The above patient appears comfortable with her mother and has a history and exam consistent with sarcoma botryoides so child abuse is unlikely.

**Reference:** Mousavi, A., & Akhavan, S. (2010). Sarcoma botryoides (embryonal rhabdomyosarcoma) of the uterine cervix in sisters. *Journal of Gynecologic Oncology*, 21(4), 273–275.

10. **D.** Although ovarian cancer is considered the leading gynecologic cause of death, the most common malignant tumor in the female genital tract is endometrial cancer (A). A woman's lifetime risk of being diagnosed with ovarian cancer is 15%. Since most women with early stage ovarian cancer have very few symptoms, nearly two-thirds of cases are diagnosed in the later stages. Risk factors include early menarche, nulliparity, and late menopause; all of these share in common increased estrogen exposure. Oral contraceptive pills decrease the risk of ovarian cancer (E). They do increase the risk of breast cancer which can persist for about 10 years after cessation of oral contraceptive pills. After this time, the risk returns to baseline. Krukenberg tumor refers to an ovarian tumor that has metastasized from another site, classically the stomach. The classic pathology associated with this is a signet ring cell. Women with ovarian cancer may complain of vague abdominal pain or pressure, nausea, early satiety, constipation, abdominal swelling, loss of weight, urinary frequency, and abnormal vaginal bleeding. Transvaginal ultrasound and CA-125 should be performed during the initial workup. However, staging is completed with surgery (unlike cervical cancer) (B). This allows for the best evaluation of the extent of disease and thus determine the need for adjuvant therapy. Interestingly, bilateral ovarian involvement is still considered stage 1 disease (C). In patients with localized ovarian cancer (stage 1 and some cases of stage 2) who wish to retain fertility, a unilateral oophorectomy, peritoneal biopsies, and unilateral lymphadenectomy may be performed, with hysterectomy and contralateral oophorectomy delayed until after completion of childbearing. In all other situations, a total abdominal hysterectomy with bilateral salpingo-oophorectomy is recommended. Although few randomized clinical trials have evaluated the concept of "debulking surgery" to reduce the volume of ovarian cancer to a microscopic residual, it is generally accepted that patients with smaller volumes of tumor following staging laparotomy have an improved survival when cytoreduction is performed compared with patients in which cytoreduction is unable to be performed. The goal of cytoreduction is to minimize the diameter of the remaining disease because survival is directly proportional to the tumor volume following cytoreduction.

**References:** [No authors listed]. (1995). NIH Consensus Development Panel on Ovarian Cancer. Ovarian cancer: screening, treatment, and follow-up. *The Journal of the American Medical Association*, 273(6), 491–497.

Ries, L. A. G., Eisner, M. P., Kosary, C. L., et al., (Eds.). (2004). SEER cancer statistics review, 1975–2001. National Cancer Institute.

11. **B.** This patient has ovarian vein thrombophlebitis (OVT). Patients with OVT usually present with fever and abdominal pain within 1 week after delivery or surgery. The majority (80%) occur on the right side. Some patients may also have nausea and/or ileus. Postpartum pelvic thrombophlebitis is often preceded by Virchow triad involving (1) endothelial damage with delivery, (2) venous stasis as a result of pregnancy-induced ovarian venous dilatation and low postpartum ovarian venous pressures, and (3) the hypercoagulable state of pregnancy. The diagnosis is often challenging and a diagnosis of exclusion, but one clinical clue is often persistent fever despite broad-spectrum IV antibiotics. There is no single imaging modality that has proven to be most effective in assisting with a diagnosis. Ultrasound can be useful but may be limited by bowel gas. Both CT and MRI are useful (A). The current recommended management is antibiotic therapy in conjunction with systemic anticoagulation (C–E).

**Reference:** Nezhat, C., Farhady, P., & Lemyre, M. (2009). Septic pelvic thrombophlebitis following laparoscopic hysterectomy. *Journal of the Society of Laparoendoscopic Surgeons/Society of Laparoendoscopic Surgeons*, 13(1), 84.

# Head and Neck

*Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 2-year-old male presents with a well-defined anterior neck mass, located midline and above the cricoid cartilage. The mother reports no other medical history. It elevates when he swallows and is nontender. He has no cervical adenopathy. Which of the following is recommended before considering surgical excision?
  - A. Computed tomography (CT) scan of the neck
  - B. Thyroid scintigraphy
  - C. Fine-needle biopsy
  - D. Magnetic resonance imaging (MRI) of the neck
  - E. Ultrasound
2. A 42-year-old female smoker presents with bilateral masses overlying the angle of the mandible. She has no other complaints. Which of the following is the most likely diagnosis?
  - A. Papillary cystadenoma lymphomatosum
  - B. Mucoepidermoid carcinoma
  - C. Pleomorphic adenoma
  - D. Basal cell adenoma
  - E. Oncocytoma
3. A 45-year-old male with squamous cell carcinoma at the floor of the mouth is recovering from a resection, mandibular flap reconstruction, and tracheostomy performed at the third tracheal ring. Several hours later the surgical resident gets called to the postoperative recovery suite because the patient develops some bleeding at the tracheostomy site. Which of the following is true?
  - A. Making the tracheostomy at the second tracheal ring could have prevented this complication.
  - B. He should be taken to the operating room (OR) to undergo a median sternotomy.
  - C. He likely has a traumatic injury of the anterior jugular vein.
  - D. Immediate bronchoscopy should be performed.
  - E. Overinflating the tracheostomy cuff should be avoided.
4. A 15-year-old male arrives at the emergency department (ED) with refractory right-sided epistaxis. He has not stopped bleeding for the past 3 hours. Vital signs are normal. On exam, he has a flesh-appearing mass in the right nares. His hemoglobin is 12 g/dL. The next step is:
  - A. Place nasal packing and discharge home
  - B. Take to the operating room (OR) for biopsy of mass
  - C. High resolution CT scan of the head and sinuses
  - D. Urgent radiation therapy
  - E. Angiography with embolization
5. The most common cause of hearing loss in an adult is:
  - A. Acute otitis media
  - B. Chronic otitis media

- C. Otosclerosis
  - D. Cerumen
  - E. Presbycusis
6. Sialolithiasis most commonly arises from:
- A. Parotid gland
  - B. Submandibular gland
  - C. Sublingual gland
  - D. Minor salivary gland
  - E. Stensen duct
7. A 6-year-old male with recurrent otitis media presents to the ED with fever and right-sided earache. Methylene blue confirms a sinus tract from the right submandibular area to the external auditory canal. Which of the following branchial cleft cysts does this patient most likely have?
- A. First
  - B. Second
  - C. Third
  - D. Fourth
  - E. Fifth
8. The brachial plexus is located:
- A. Posterior to the middle scalene muscle
  - B. Anterior to the middle scalene muscle
  - C. Anterior to the anterior scalene muscle
  - D. Posterior to the posterior scalene muscle
  - E. Anterior to the posterior scalene muscle
9. A 44-year-old male with recurrent melanoma of the scalp and cervical adenopathy arrives at clinic to discuss the risks of cervical lymph node dissection. The most likely injured nerve during this procedure is the:
- A. Spinal accessory nerve
  - B. Greater auricular nerve
  - C. Lesser occipital nerve
  - D. Transverse cervical nerve
  - E. Phrenic nerve
10. Which of the following is true regarding nasopharyngeal carcinoma?
- A. It is not associated with alcohol.
  - B. Most patients present with cervical lymph node metastasis.
  - C. The standard of care involves surgical excision followed by chemoradiation.
  - D. Plummer-Vinson syndrome increases the risk for development of nasopharyngeal carcinoma.
  - E. It is commonly confused with otitis externa.
11. The cranial nerve most commonly injured by a temporal bone fracture is the:
- A. Fifth nerve
  - B. Seventh nerve
  - C. Eighth nerve
  - D. Ninth nerve
  - E. Eleventh nerve
12. Which of the following is true regarding epistaxis?
- A. Ninety percent of bleeds are from the posterior part of the nose.
  - B. Posterior bleeds are associated with hypertension and atherosclerosis.
  - C. Anterior bleeds have an associated 5% mortality rate.

- D. Posterior bleeds are best managed by applying digital pressure to the nose.
  - E. Anterior bleeds often require packing combined with a Foley catheter.
13. Which of the following statements is true regarding parotid gland tumors?
- A. The majority are malignant.
  - B. Benign mixed tumor is the most common type.
  - C. Pleomorphic adenomas are managed by total parotidectomy.
  - D. All malignant tumors require resection of the facial nerve with the specimen.
  - E. The most commonly injured nerve in parotid surgery is the facial nerve.
14. A 65-year-old male presents with a persistent firm lateral neck mass that measures approximately 2.5 cm. Careful history and physical examination of the head and neck are negative. The next step in the management is:
- A. Positron emission tomography
  - B. Computed tomography scan of the head and neck
  - C. Fine-needle aspiration of the neck mass
  - D. Chest radiograph
  - E. Panendoscopy (esophagoduodenoscopy, bronchoscopy, laryngoscopy)
15. A 12-week-old male infant with trisomy 21 presents with a large posterolateral neck mass extending into the axilla that transilluminates. The mass has been growing continuously for the past several weeks. Optimal management would consist of:
- A. Radiation therapy
  - B. Repeat needle aspirations
  - C. Radical wide excision
  - D. Observation
  - E. Conservative excision
16. A 54-year-old man presents with a tender left neck mass with a draining sinus. Microscopic examination reveals sulfur granules. Optimal management would be:
- A. Penicillin
  - B. Radical excision
  - C. Penicillin and surgical drainage
  - D. Trimethoprim-sulfamethoxazole
  - E. Trimethoprim-sulfamethoxazole and surgical drainage
17. A 50-year-old male presents with a right-sided slow-growing rounded neck mass located anterior to the sternocleidomastoid. The mass appears to move side to side only. CT of the neck is performed and demonstrates widening of the carotid bifurcation by a well-defined tumor blush. The mass is 3 cm. Optimal management consists of:
- A. Radiographic embolization
  - B. Radiation therapy
  - C. Chemotherapy
  - D. Surgical excision in a periadventitial plane
  - E. Wide excision including carotid bifurcation
18. A 35-year-old man presents with a new dark mole on the face anterior to the tragus as well as clinically suspicious palpable neck nodes. Excisional biopsy confirms melanoma. Optimal management is:
- A. Wide re-excision of the primary tumor and modified radical neck dissection
  - B. Modified radical neck dissection only
  - C. Wide re-excision of the primary tumor, modified radical neck dissection, and superficial parotidectomy
  - D. Wide re-excision of the primary tumor and sentinel node biopsy
  - E. Interferon

19. The most likely site of origin for a metachronous cancer in a patient with a history of laryngeal cancer is the:
  - A. Esophagus
  - B. Lung
  - C. Floor of mouth
  - D. Tongue
  - E. Hypopharynx
20. Which of the following is true regarding carcinoma of the lip?
  - A. Upper lip carcinoma is more common.
  - B. The majority present with nodal metastasis.
  - C. Squamous cell carcinoma is the most common type of cancer in the lower lip.
  - D. Radiation therapy is the treatment of choice for most lip cancers.
  - E. Prophylactic neck dissection is usually indicated.
21. Which of the following is true regarding salivary gland tumors?
  - A. Parotid tumors are more likely to be malignant than submandibular gland tumors.
  - B. Submandibular gland tumors are more likely to be malignant than minor salivary gland tumors.
  - C. Pleomorphic adenomas may undergo malignant degeneration.
  - D. Warthin's tumor is malignant.
  - E. Facial nerve palsy is common, even with benign tumors.
22. The most common malignant salivary gland tumor is:
  - A. Acinic cell carcinoma
  - B. Mucoepidermoid carcinoma
  - C. Adenoid cystic carcinoma
  - D. Basal cell adenocarcinoma
  - E. Papillary cystadenocarcinoma

## Answers

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1. **E.** This patient has a thyroglossal duct cyst, a remnant of thyroid gland descent and the most common midline congenital malformation of the neck. Though present at birth, these do not often appear until age 2 as baby fat recedes. It presents as an anterior midline cystic mass that moves with swallowing or sticking out the tongue. Definitive management involves surgical intervention. The operation, known as the Sistrunk procedure, removes the cyst, tract, and central portion of the hyoid bone as well as a portion of the tongue base up to the foramen cecum. However, given the increased association of an ectopic thyroid gland in patients with a thyroglossal duct cyst, preoperative imaging needs to be performed to confirm the correct anatomic location of the thyroid gland. This will help avoid excising an ectopic thyroid gland inadvertently during the Sistrunk procedure. Ultrasonography is the preferred option since it is noninvasive, widely available, and cost effective. Thyroid scintigraphy is equally as effective but is used less often (B). Additionally, ultrasound has several advantages over scintigraphy including the absence of ionizing radiation, and it has the ability to characterize the thyroglossal duct cyst with high fidelity. MRI or CT scan is not required for the diagnosis and should not be performed in young patients (A, D). Fine-needle aspiration (FNA) biopsy is appropriate for a suspected thyroid nodule (C). Serial exams/observation would not be appropriate because these cysts have an increased risk of recurrent infections and malignant transformation.
2. **A.** Parotid gland tumors are 80% benign and 20% malignant. Mucoepidermoid carcinoma is a malignant lesion (B). The remaining answer choices are all types of benign parotid gland tumors. However, only papillary cystadenoma lymphomatosum, also known as Warthin tumor, will present with bilateral masses up to 20% of the time (D, E). Additionally, it is the only one that has been shown to have a strong association with smoking. Warthin tumor is the second most common benign salivary tumor following pleomorphic adenoma (C).



**References:** Chulam, T. C., Noronha, F., Goncalves, F., et al. (2013). Warthin's tumour of the parotid gland: our experience. *Acta Otorhinolaryngologica Italica*, 33(6), 393–397.

De Ru, J. A., Plantinga, R. F., Majoor, M. H., et al. (2004). Warthin's tumour and smoking. *B-ENT*, 1(2), 63–66.

3. **C.** Bleeding from around the tracheostomy site could have dire consequences and should be evaluated quickly. The lag time between tracheostomy creation and hemorrhage helps narrow down the possible etiology. Hemorrhage within the first 48 hours is more likely to be secondary to local trauma such as injury to the inferior thyroid artery or anterior jugular veins. Additionally, this patient has likely received heparin since he had a flap reconstruction performed. Systemic coagulopathy could also contribute to continued bleeding in the immediate postoperative period. The first line of management involves applying direct pressure, which can be performed by overinflating the tracheostomy cuff (E). If this does not control bleeding and the patient continues to have stable vital signs, a bronchoscopy can be considered (D). However, if there is any concern for massive hemorrhage or airway compromise the patient should be immediately returned to the OR for neck exploration. Tracheo-innominate fistula (TIF) is a rare and fatal complication that requires, at a minimum, 48 hours to develop. It often presents with a herald bleed that will progress to massive exsanguination. Performing a tracheostomy above the third tracheal ring will help decrease the risk of developing this complication (A). If TIF is suspected, placing one's finger through the tracheostomy with digital pressure applied between the TIF and the posterior surface of the sternum can control bleeding until the patient is taken to the OR to have a median sternotomy and fistula ligation performed (B).

**References:** Grant, C. A., Dempsey, G., Harrison, J., et al. (2006). Tracheo-innominate artery fistula after percutaneous tracheostomy: three case reports and a clinical review. *British Journal of Anaesthesia*, 96(1), 127–131.

Muhammad, J. K., Major, E., Wood, A., et al. (2000). Percutaneous dilatational tracheostomy: haemorrhagic complications and the vascular anatomy of the anterior neck. A review based on 497 cases. *International Journal of Oral and Maxillofacial Surgery*, 29(3), 217–222.

4. **C.** A young adolescent male presenting with severe unilateral epistaxis and a flesh-appearing nasal mass has juvenile nasal angiofibroma until proven otherwise. This is a highly vascular benign neoplasm arising from around the pterygopalatine fossa. Patients may report history of recurrent epistaxis or nasal obstruction and/or discharge. If there is any concern for airway compromise due to massive bleeding, the patient should be intubated. If the patient has symptomatic blood loss, he should be transfused with blood products. The next step is to confirm the diagnosis with CT scan and look for extension of the fibroma into the sinuses. Biopsy of the mass is avoided because it can lead to life-threatening hemorrhage (B). Nasal packing should be used initially to help stop bleeding. However, the patient should be admitted and observed (A). Additionally, nasal packing for a prolonged period of time can lead to toxic shock syndrome secondary to *Staphylococcus aureus*, and as such, a patient discharged with nasal packing that is to remain in place for a prolonged period of time should also be given oral antibiotics. If bleeding continues, the patient will need to be taken to the angiography suite for embolization of the internal maxillary artery (E). The definitive intervention is surgical excision, which can now be performed with a transnasal endoscopic approach. Coagulation studies would be indicated. Radiation therapy used to be a treatment option, but it is no longer performed, particularly in adolescents (D).

**References:** English, G. M., Hemenway, W. G., & Cundy, R. L. (1972). Surgical treatment of invasive angiofibroma. *Archives of Otolaryngology*, 96(4), 312–318.

Gullane, P. J., Davidson, J., O'Dwyer, T., et al. (1992). Juvenile angiofibroma: a review of the literature and a case series report. *Laryngoscope*, 102(8), 928–933.

Nicolai, P., Schreiber, A., & Bolzoni Villaret, A., (2012). Juvenile angiofibroma: evolution of management. *International Journal of Pediatrics*, 2012, 412545.

5. **D.** Hearing loss can be divided into two categories including conductive and sensorineural loss. Conductive hearing loss occurs more commonly with cerumen (earwax) being the major contributor. Otosclerosis can also lead to conductive hearing loss (C). The majority of patients are asymptomatic, and contrary to popular belief, cerumen should not always be removed because it serves as a protective layer for the skin of the ear canal and helps protect against infection. Patients that present with hearing loss, earache, or fullness should have cerumen removed. Otitis media is more likely to result in hearing loss in children (A, B). Presbycusis is a sensorineural hearing loss

and affects older patients (E).

**References:** Isaacson, J. E., & Vora, N. M. (2003). Differential diagnosis and treatment of hearing loss. *American Family Physician*, 68(6), 1125–1132.

Roland, P. S., Smith, T. L., Schwartz, S. R., et al. (2008). Clinical practice guideline: cerumen impaction. *Otolaryngology--Head and Neck Surgery*, 139(3 Suppl. 2), S1–S21.

6. **B.** Although all salivary glands are capable of producing stones, the largest contributor is the submandibular gland (produces over 90% of stones) (D). The parotid gland is the second most common site for sialolithiasis (A). Stensen duct drains the parotid gland and exits at the buccal mucosa (E). The small but multiple ducts of Rivinus drain the sublingual gland at the floor of the mouth (C).

**Reference:** Pfaff, J., & Moore, G. P. (2002). Otolaryngology. In J. Marx (Ed.), *Rosen's emergency medicine: concepts and clinical practice*. St. Louis, MO: Mosby.

7. **A.** There are only four branchial cleft cysts (E). The above patient has a first branchial cleft cyst presenting with recurrent infection. The accompanying sinus tract typically traverses from the submandibular area to the external auditory canal, and it is a result of incomplete closure of the ectoderm during development. Definitive intervention involves a superficial parotidectomy. The most common branchial cleft cyst is a second branchial cleft cyst, which appears anterior to the sternocleidomastoid muscle and can also present with recurrent infections (B). Third branchial cleft cysts are rare but most commonly appear on the left side near the lateral neck (C). Fourth branchial cleft cysts also appear on the lateral neck and can lead to neck swelling and airway compromise (D).

**References:** Pincus, R. L. (2001). Congenital neck masses and cysts. In B. J. Bailey (Ed.), *Head & neck surgery - otolaryngology* (3rd ed.). New York, NY: Lippincott Williams & Wilkins.

Zhong, Z., Zhao, E., Liu, P., et al. (2013). Management and classification of first branchial cleft anomalies. *Journal of Otolaryngology - Head and Neck Surgery*, 27(13), 691–694.

8. **B.** The subclavian vein, artery, and brachial plexus are all part of the posterior neck triangle, and their relative relation to the scalene muscles is important to appreciate during neck and upper extremity dissection. Additionally, the pathway that each of these structures takes in the neck, upper thorax, and upper extremity helps in understanding the pathophysiology of thoracic outlet syndrome (TOS). The most common type of TOS is neurogenic, presenting with sensory and motor loss in the ulnar nerve distribution. The brachial plexus and subclavian artery pass posterior to the anterior scalene muscle but anterior to the middle scalene muscle (A, C–E). The subclavian vein passes anterior to the anterior scalene muscle and can develop an area of narrowing between the first rib and clavicle.
9. **A.** Although all the nerves listed are at risk during a cervical lymph node dissection, the most commonly injured nerve during cervical dissection is the spinal accessory nerve also known as cranial nerve eleven (CN XI) (B–E). The superficial course of this nerve at the posterior neck triangle makes it particularly susceptible to injury. It travels through the sternocleidomastoid muscle. It can lead to trapezius palsy presenting with shoulder weakness and pain. The phrenic nerve travels anterior to the anterior scalene muscle and passes posterior to the subclavian vein before entering the chest.

**References:** Lima, L. P., Amar, A., & Lehn, C. N. (2011). Spinal accessory nerve neuropathy following neck dissection. *The Brazilian Journal of Otorhinolaryngology*, 77(2), 259–262.

Wiater, J. M., & Bigliani L. U. (1999). Spinal accessory nerve injury. *Clinical Orthopaedics and Related Research*, (368), 5–16.

10. **B.** Nasopharyngeal carcinoma is associated with Epstein-Barr virus. In fact, Epstein-Barr virus titers can be used to follow the response to treatment. Nasopharyngeal carcinoma is endemic in certain areas of southern China. Previously, alcohol was not thought to increase the risk for nasopharyngeal carcinoma but a recent systemic review suggests heavy alcohol use may have a contributing role (A). Plummer-Vinson syndrome has not been shown to be associated with nasopharyngeal carcinoma (D). Nasopharyngeal carcinoma often presents with a middle ear effusion and can initially be confused with otitis media (E). The majority of patients (up to 90%) have cervical lymph node metastasis on presentation. Whites born in the United States have a lower risk of developing nasopharyngeal carcinoma. However, whites born in China have an increased risk. Several studies have demonstrated that a combination of chemotherapy and

radiation yields a higher survival rate than either modality alone. In a randomized study, the 3-year survival rate was 46% for patients randomized to radiation therapy and 76% for the chemotherapy and radiation therapy group. Surgery is generally not indicated (C).

**References:** Al-Sarraf, M., LeBlanc, M., Giri, P., et al. (1998). Chemoradiotherapy versus radiotherapy in patients with advanced nasopharyngeal cancer: phase III randomized intergroup study 0099. *Journal of Clinical Oncology*, 16(4), 1310–1317.

Chen, L., Gallicchio, L., Boyd-Lindsley, K., et al. (2008). Alcohol consumption and the risk of nasopharyngeal carcinoma: a systematic review. *Nutrition and Cancer*, 61(1), 1–15.

Tomita, N., Fuwa, N., Ariji, Y., et al. (2014). Factors associated with nodal metastasis in nasopharyngeal cancer: an approach to reduce the radiation field in selected patients. *The British Journal of Radiology*, 84(999), 265–270.

11. **B.** The facial nerve is the nerve most commonly injured by a temporal bone fracture (A, C–E). This fracture is also the most common cause of traumatic facial nerve injury. Partial or delayed paralysis of the face generally resolves spontaneously, whereas immediate paralysis may benefit from nerve decompression.

**References:** Darrouzet, V., Duclos, J., Liguoro, D., et al. (2001). Management of facial paralysis resulting from temporal bone fractures: our experience in 115 cases. *Otolaryngology--Head and Neck Surgery*, 125(1), 77–84.

Lorenz, R. R., Netterville, K. L., & Burkey, B. B. (2004). Head and neck. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 833–866) (17th ed.). Philadelphia, PA: W. B. Saunders.

Wein, R. O., Chandra R. K., & Weber R. S. (2005). Disorders of the head and neck. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 501–544) (8th ed.). New York, NY: McGraw-Hill.

12. **B.** It is important to recognize that epistaxis has the potential of being life threatening. Epistaxis has anterior and posterior sources. Anterior epistaxis is most common (A) and is caused by trauma in most cases, which causes rupture of superficial mucosal vessels (Kiesselbach plexus). For anterior bleeds, most of them stop with simple direct pressure (E) and are not considered to be dangerous (C). If this fails, then anterior packing is performed. Posterior bleeds are more dangerous and potentially life threatening. Bleeding is most commonly from a branch of the sphenopalatine artery. It is associated with hypertension and atherosclerosis. Direct pressure cannot tamponade posterior bleeds. Treatment involves posterior packing (D). Posterior packing has the potential to compromise the airway and cause hypoventilation; therefore, patients need to be admitted to a monitored setting. Part of the mortality risk with posterior bleeds can be attributed to the patient population that is frequently affected—the elderly with significant underlying disease.

13. **B.** Most salivary gland tumors are in the parotid gland, and approximately 80% of parotid gland tumors are benign (A). Submandibular and sublingual gland tumors are approximately 50% malignant, and minor salivary gland tumors are predominantly malignant. The largest salivary gland is the parotid gland. The most common type of parotid gland tumor is a pleomorphic adenoma (also called a *benign mixed tumor*). Bilateral lesions are extremely rare (0.2% of all parotid gland tumors). The most commonly injured nerve in parotid surgery is the greater auricular nerve (E). The treatment of choice for benign parotid tumors is a superficial parotidectomy (C). For malignant tumors, every effort should be made to preserve the facial nerve if it is not invaded by tumor (D).

**Reference:** Huang, J. T., Li, W., Chen, X. Q., et al. (2012). Synchronous bilateral pleomorphic adenomas of the parotid gland. *Journal of Investigative and Clinical Dentistry*, 3(3), 225–227.

14. **C.** In adults, the most likely etiology of a persistent neck mass larger than 2 cm is cancer. Most often the cancer is from the head and neck and is squamous cell carcinoma. Careful physical examination is essential. If the physical examination is unremarkable, the next step is to establish whether the mass is malignant. This is best achieved by fine-needle aspiration. Once metastatic cancer is confirmed, panendoscopy with guided biopsies is performed in the OR under general anesthesia to locate the primary mass (E). CT scan of the head and neck and chest radiograph are also performed to assist in locating the mass (B, D). If the primary mass is still not localized, the role of positron emission tomography is debatable (A). Several studies have shown that it has a

low sensitivity and does not alter outcome. If the mass is not localized after panendoscopy, an excisional biopsy should be performed. Adenocarcinoma would suggest a primary lung, breast or gastrointestinal tumor.

**References:** Grau, C., Johansen, L., Jakobsen, J., et al. (2000). Cervical lymph node metastases from unknown primary tumours: results from a national survey by the Danish Society for Head and Neck Oncology, *Radiotherapy and Oncology*, 55(2), 121–129.

Kole, A., Nieweg, O., Pruim, J., et al. (1998). Detection of unknown occult primary tumors using positron emission tomography. *Cancer*, 82(6), 1160–1166.

McGuirt, W. F. (1999). The neck mass. *The Medical Clinics of North America*, 83(1), 219–234.

15. **E.** The presentation is consistent with a cystic hygroma (CH) given the age of the patient, the location of the mass, and the fact that it transilluminates. CH occurs more commonly in patients with trisomy 21 and Turner syndrome. CH is a lymphatic malformation. Most present in the posterior neck, and the next most common site is the axilla. More than half present at birth, and the remainder become apparent within the first 2 years of life as baby fat recedes. On occasion, intralesional bleeding can make the mass grow significantly in a short amount of time. Complete surgical excision is preferred; however, if the mass is adjacent to nerves, it is best managed with a conservative excision (C). Radiation has no role in the management of CH (A). Although repeated needle aspirations (B) may shrink the mass, it will only be a temporary intervention. Observing the mass is an appropriate consideration for patients that are asymptomatic (e.g., mass is not growing) (D).

16. **C.** *Actinomyces israelii* and other *Actinomyces* species occur in the normal flora of the mouth and tonsillar crypts. They are anaerobic, gram-positive, branching filamentous bacteria. They do not stain acid-fast positive (unlike *M. tuberculosis* or *Actinomyces*). The face and neck are the most common sites of infection and usually develop after minor trauma or a tooth extraction. *Actinomyces* infections generally occur in association with other bacteria. The infection tends to form abscesses that then drain. Microscopic examination may reveal the classic appearance of sulfur granules, which are masses of filamentous organisms. Optimal treatment is with penicillin and surgical drainage, not antibiotics alone (A). Surgical excision can be considered for complicated cases (e.g., fibrotic lesions, extensive abscesses) (B). However, it is rarely successful without concurrent antibiotic therapy. Although *Nocardia* is also an anaerobic, gram-positive, branching filamentous bacteria, it is considered a weakly acid-fast organism. It is treated with trimethoprim-sulfamethoxazole (D, E).

17. **D.** Widening of the carotid bifurcation by a well-defined tumor blush (lyre sign) on CT is considered a pathognomonic finding for a carotid body tumor. Patients typically present in the fourth or fifth decade with a slow-growing rounded neck mass. It is usually located anterior to the sternocleidomastoid near the angle of the mandible. Carotid body tumors can only be moved side to side but not up or down because of their location within the carotid sheath (Fontaine sign). Treatment of carotid body tumors is surgical. One dangerous pitfall in excising these tumors is that, in an effort to excise completely, the dissection is carried too close to the artery. In so doing, part of the adventitia of the carotid artery may inadvertently be removed. Since the adventitia is the strongest layer, the artery may weaken and blow out postoperatively. Thus, excision should be done in a periadventitial plane. If a subadventitial plane is inadvertently entered, this increases the risk of hemorrhage and arterial injury. Because of their vascular nature, biopsy is contraindicated. Routine preoperative embolization is not necessary but should be considered in large tumors (>4 cm) (A). Radiation therapy may be considered for long-term tumor control in patients that are not candidates for surgery (e.g., inaccessible site) (B). Chemotherapy has no role in the management of these tumors (C). Excising the carotid bifurcation should be avoided (E).

**References:** Davidovic, L. B., Djukic, V. B., Vasic, D. M., et al. (2005). Diagnosis and treatment of carotid body paraganglioma: 21 years of experience at a clinical center of Serbia. *World Journal of Surgical Oncology*, 3(1), 1.

Hinerman, R. W., Amdur, R. J., Morris, C. G., et al. (2008). Definitive radiotherapy in the management of paragangliomas arising in the head and neck: a 35-year experience. *Head and Neck*, 30(11), 1431–1438.

18. **C.** For lesions on the face, anterior scalp, and ear, sentinel lymph node biopsy can be performed as in other areas, but it is technically more challenging. However, in the situation in which clinically palpable lymph nodes are present, superficial parotidectomy to remove parotid nodes and a

modified neck dissection are recommended (A, B, E). The nodes between the lesion and the regional nodes are removed in continuity. If no nodes were palpable, performing a sentinel node biopsy would be the appropriate next step (D).

**References:** Barr, L., Skene, A., Fish, S., et al. (1994). Superficial parotidectomy in the treatment of cutaneous melanoma of the head and neck. *The British Journal of Surgery*, 81(1), 64–65.

Ollila, D., Foshag, L., Essner, R., et al. (1999). Parotid region lymphatic mapping and sentinel lymphadenectomy for cutaneous melanoma. *Annals of Surgical Oncology*, 6(2), 150–154.

19. **B.** Patients with head and neck cancers have approximately a 14% risk of the development of a second primary tumor. Most of these are metachronous (beyond 6 months). For laryngeal cancer patients, the most common metachronous malignancy is lung cancer (C–E). For patients with oral cavity and pharyngeal cancers, the most common metachronous cancer is esophageal (A).
20. **C.** Ninety percent to 95% of lip cancers occur in the lower lip (A). Sun exposure and tobacco use are the most important risk factors. Lip cancers occur most often in elderly white men. They are most often due to squamous cell carcinoma. Upper lip cancers are usually basal cell carcinomas. The most common presentation is an ulcerative lesion on the vermilion or skin surface (B). Early stage lesions can be treated with surgery or radiation therapy, but surgical resection is preferred and is the treatment of choice for larger lesions (D, E).
21. **C.** Salivary gland neoplasms are rare. Most arise in the parotid gland. The ratio of malignant to benign tumors varies by site. Parotid gland tumors are 80% benign and 20% malignant, submandibular gland and sublingual gland tumors are 50% benign and 50% malignant, and minor salivary gland tumors are 25% benign and 75% malignant (A, B). Warthin's tumor is the second most common benign salivary tumor and is strongly related to smoking (D). The facial nerve involvement is highly suggestive of a malignant tumor (E). Although benign, pleomorphic adenomas have a known risk of malignant transformation that becomes as high as 10% to 25% when present beyond 15 years. Fine-needle aspiration is useful in the diagnosis.
22. **B.** Mucoepidermoid carcinoma is the most common malignant salivary gland tumor. It ranges from low to high grade. Treatment depends on the location. Superficial parotidectomy is indicated for superficial tumors, whereas total parotidectomy is indicated for those that extend into the deep lobe. All efforts should be made to preserve the seventh cranial nerve, provided the tumor does not encase the nerve. The second most common malignancy is adenoid cystic carcinoma (C). The remaining salivary gland tumors occur less frequently (A, D, E).

# Nervous System

*Patrick T. Delaplain, Areg Grigorian, and Christian de Virgilio*

## Questions

1. Which of the following is true regarding head trauma and/or intracranial hemorrhage?
  - A. The most common cause of subarachnoid hemorrhage is rupture of a berry aneurysm.
  - B. Epidural hematoma is typically associated with acceleration-deceleration injuries.
  - C. A single episode of systolic blood pressure (BP) less than 90 mm Hg doubles mortality in patients with head trauma.
  - D. Xanthochromia is virtually pathognomonic for acute subdural hemorrhage.
  - E. In the absence of other findings, reimaging for cerebral contusion is generally unnecessary.
2. A 25-year-old male is being evaluated in the emergency department (ED) after sustaining a blow to the head with an unknown object during an assault. He has a 6-cm, stellate laceration with an underlying hematoma. Computed tomography (CT) scan shows evidence of a skull fracture. In which of the following situations can this patient be managed nonoperatively?
  - A. Dural but not brain penetration
  - B. 1.5 cm of skull depression
  - C. Involvement of the frontal sinus without other areas affected
  - D. Pneumocephalus
  - E. Linear basilar skull fracture with evidence of cerebrospinal fluid leak (CSF) leak
3. A 26-year-old male presents with a traumatic head injury. Glasgow Coma Scale (GCS) is 6 and an intraparenchymal pressure monitor is placed after he is intubated. He is admitted to the intensive care unit (ICU). Two days later his intracranial pressure has risen above 30 mm Hg. Which of the following is least indicated for this patient?
  - A. Neuromuscular blockade
  - B. Change intraparenchymal pressure monitor to external ventricular drain for intermittent CSF drainage
  - C. Administer gamma-aminobutyric acid (GABA) agonist
  - D. Hyperventilate with PaCO<sub>2</sub> goal of 30 to 35 mm Hg
  - E. Continuous infusion of 3% hypertonic saline
4. A 45-year-old female arrives at the ED after diving head first into a half-empty swimming pool. She is combative and appears intoxicated. She does not respond to painful stimuli of the lower extremities or trunk. You observe her lifting her arms and bending at the elbows but are unable to assess any movement in her hands. It has been 30 minutes since she first sustained her injury. Which of the following is true regarding this patient?
  - A. The likely site of her injury is C3-C4.
  - B. In the absence of other injuries, methylprednisolone should be administered immediately.
  - C. This is a rare spinal cord injury after a diving accident.
  - D. Anticoagulation should be started within 2 to 3 days and continued for 2 to 3 months.
  - E. Mean arterial pressure should be maintained between 65 and 75 mm Hg for the first 7 days.

5. Neurogenic thoracic outlet syndrome most commonly affects which nerve?
- A. Radial
  - B. Ulnar
  - C. Median
  - D. Musculocutaneous
  - E. Axillary
6. A 26-year-old intubated male is opening his eyes to voice and attempts to open his mouth. His only consistent motor movement is to occasionally withdraw from painful stimuli. What is his current GCS score?
- A. GCS 4T
  - B. GCS 8T
  - C. GCS 9T
  - D. GCS 11T
  - E. GCS 13T
7. An 88-year-old female is brought by ambulance to the ED after being struck by a vehicle while crossing the street. She is only responsive to painful stimuli and is promptly intubated for airway protection. Her secondary exam reveals only a small abrasion to the left forehead. Her systolic blood pressure suddenly increases to the 200s, and her left pupil becomes dilated and unresponsive to light. What is the next best course of action?
- A. Hypertension control with nicardipine continuous infusion
  - B. Placement of intraparenchymal intracranial pressure monitor
  - C. Immediate mannitol bolus
  - D. Rectal lorazepam and initiation of levetiracetam
  - E. Raise head of bed
8. A 17-year-old boy presents to the ED via ambulance after new onset seizure activity that started 30 minutes ago. He is unable to provide a good history because of word finding issues but is able to convey that his head hurts. His parents state that he was completely normal until about 4 weeks ago when he began to complain of left ear pain. Vital signs reveal a mild tachycardia and high fever. Physical exam shows absent light reflex in the left eye and papilledema. Which of the following is contraindicated in the workup and subsequent treatment of his condition?
- A. Lumbar puncture
  - B. Computed tomography with intravenous contrast
  - C. Stereotactic needle aspiration
  - D. Surgical debridement
  - E. Corticosteroids
9. Which of the following is true with regard to Cushing's triad?
- A. The pulse pressure narrows.
  - B. The heart rate increases.
  - C. It does not lead to changes on electrocardiogram.
  - D. It is associated with hypocarbia.
  - E. It is a late manifestation of increased intracranial pressure.
10. Which of the following statements is true regarding spinal or cranial nerves?
- A. Cervical spinal nerve 1 carries motor but not sensory fibers.
  - B. Cranial nerve IV is primarily sensory.
  - C. Cervical spinal nerve 8 arises from above its corresponding vertebrae.
  - D. Spinal nerves do not carry autonomic fibers.
  - E. Thoracic spinal nerves arise from above their corresponding vertebrae.
11. An 85-year-old female presents to the ED after falling and striking her chin on the kitchen counter. She is unable to lift her arms or hands off the bed and does not respond to painful stimuli. However,



- she is able to wiggle her toes and seems to feel pain at her feet. She has a history of cervical radiculopathy. Digital rectal exam reveals good sphincter tone and squeeze pressure. What is the most likely incomplete spinal cord injury that she has sustained?
- Posterior cord syndrome
  - Anterior cord syndrome
  - Cauda equina syndrome
  - Brown-Séquard syndrome
  - Central cord syndrome
12. Which of the following is true regarding central nervous system (CNS) tumors?
- Astrocytoma is the most common tumor of the CNS in adults.
  - Focal neurologic deficits are more common with infratentorial versus supratentorial tumors.
  - Most brain tumors in children are infratentorial in origin.
  - Craniopharyngioma is a common brain tumor in children.
  - The majority of spine tumors are malignant.
13. A 4-day-old female infant weighing 1400 g born at 28 weeks' gestation is being monitored in the neonatal critical care unit because of multiple episodes of respiratory distress and difficulty with feeding. Supplemental oxygen has been sufficient to maintain saturations. Over the last several hours, she has had waxing and waning alertness and decreased spontaneous eye movements. Which of the following is the most appropriate next step?
- Immediate administration of furosemide and acetazolamide
  - Serial ultrasound screening
  - Serial lumbar punctures
  - Placement of temporary ventricular drainage device
  - Intraventricular administration of tissue plasminogen activator (tPA)
14. Which of the following is true regarding ruptured intracranial aneurysms?
- Following repair, fluid restriction is recommended.
  - Most arise from the posterior circulation.
  - The initial study of choice is a contrast-enhanced CT head.
  - Following repair, the risk of cerebral vasospasm causing stroke persists for 3 weeks.
  - Outcomes overall are quite favorable.
15. A 35-year-old male is in the ICU after sustaining a closed head injury 5 days ago. Initial CT scan showed a 5-mm subdural hematoma, which increased in size to 9 mm on repeat CT scan 24 hours later. His neurologic status has not improved, and a subsequent MRI 48 hours after the initial injury is suggestive of diffuse axonal injury with no progression of the hematoma. Physical exam reveals unilateral left leg swelling and an ultrasound study confirms a deep vein thrombosis (DVT). What would have been the best way to prevent this complication for this patient?
- Prophylactic anticoagulation should have been started at 24 hours.
  - Prophylactic anticoagulation should have been started at 72 hours.
  - Routine lower extremity DVT ultrasound screening should have occurred at 72 hours.
  - An inferior vena cava filter should have been placed.
  - This is an unpreventable complication.

## Answers

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- C.** Traumatic brain injuries are among the most common presenting symptoms in emergency departments in the United States with over 1.7 million admissions each year. The early recognition and management of brain injury is critical in this patient population because it is considered the most common cause of trauma-related death in patients reaching the hospital alive. Preventing secondary injury is an important part of management, and this involves maintaining cerebral perfusion pressure greater than 60 mm Hg. One prospective trial found that a single episode of

hypotension with a systolic blood pressure less than 90 mm Hg doubled mortality in patients with brain injury. Trauma is considered the most common etiology of subarachnoid hemorrhage followed by rupture of berry aneurysms (A). In nontraumatic cases, patients may report mild “sentinel” headaches in the prior weeks leading up to a severe, unrelenting, “thunderclap” headache. Noncontrast computed tomography (CT) scan is the diagnostic tool of choice to look for hyperdensities suggestive of acute bleeding. Additionally, xanthochromia of cerebrospinal fluid is considered pathognomonic for subarachnoid hemorrhage (D). Epidural hematoma is generally the result of direct trauma to the skull causing disruption of arterial vessels, particularly the middle meningeal artery. It initially presents with unconsciousness from the concussive effects of the injury, followed by a “lucid” interval that progresses to somnolence, lethargy, and eventually a coma as the hematoma grows. Noncontrast CT scan will demonstrate a lentiform (biconvex), hyperdense clot that does not cross suture lines. Acute subdural hematoma is generally the result of acceleration-deceleration injuries that tear the bridging veins as the brain shifts in relation to the dura (B). Patients are often unconscious from the moment of impact. Noncontrast CT scan will demonstrate a hyperdense, lunar (crescent-shaped) lesion that does not cross the midline. Cerebral contusion is due to the brain directly striking the skull in either a coup or countercoup mechanism after closed head injury. Lesions on noncontrast CT scan are typically scattered, hyperdense, and intraparenchymal, though they can also present as hypodense lesions. There is a significant propensity for these lesions to worsen, and repeat imaging is typically recommended in the first 24 hours (E).

**References:** Chesnut, R. M., Marshall, L. F., Klauber, M. R., et al. (1993). The role of secondary brain injury in determining outcome from severe head injury. *The Journal of Trauma*, 34(2), 216–222.

Faul, M., Xu, L., Wald, M. M., et al. (2010). Traumatic brain injury in the United States: emergency department visits, hospitalizations and deaths 2002–2006. Center for Disease Control and Prevention, National Center for Injury Prevention and Control: Atlanta, GA. Retrieved from [https://www.cdc.gov/traumaticbraininjury/pdf/blue\\_book.pdf](https://www.cdc.gov/traumaticbraininjury/pdf/blue_book.pdf).

2. E. Any skull fracture with an overlying laceration is considered an open fracture. Traditional teaching is that all of these patients should be taken to the operating room to prevent infection. However, there seems to be a subset of patients that can be treated expectantly without significant increases in morbidity. Nonoperative management of open skull fracture can be considered in patients without evidence of dural penetration, significant intracranial hematoma, frontal sinus involvement, wound infection, pneumocephalus, or gross wound contamination (A, C–D). Additionally patients with less than 1 cm of skull depression can be managed nonoperatively (B). In general, linear skull fractures are considered nonoperative and most CSF leaks will resolve spontaneously. However, persistent CSF drainage may require eventual surgical intervention.

**Reference:** Bullock, M., Chesnut, R., Ghajar, J., et al. Surgical management of depressed cranial fractures. *Neurosurgery*, 58(Suppl. 3), 56–60.

3. E. The American College of Surgeons Trauma Quality Improvement Project (TQIP) currently recommends a three-tiered approach to the management of intracranial pressures that are sustained above 20 to 25 mm Hg with steady progression to a higher tier if the interventions are unsuccessful. Tier 1 includes head of bed elevation to 30 degrees, sedation and analgesia using short-acting agents, intermittent drainage of CSF, and repeat CT to evaluate for surgically treatable mass effect. Tier 2 includes changing from a parenchymal pressure monitor (can only monitor pressure) to an external ventricular drain (can monitor pressure and remove cerebral spinal fluid) (B), hyperosmolar therapy with hypertonic saline or mannitol boluses, PaCO<sub>2</sub> goal of 30 to 35 mm Hg (D), and neuromuscular paralysis “test bolus.” Tier 3 includes decompressive hemicraniectomy or bilateral craniectomy, continuous neuromuscular paralysis (A), and inducing a barbiturate (GABA agonist) coma (C). Hypertonic saline is not currently recommended as a continuous infusion by the TQIP or Brain Trauma Foundation guidelines because of unclear efficacy and, based on current knowledge of blood-brain barrier function, is ineffective at creating an acute osmotic disequilibrium when given as an infusion. It is also important to note that mild hyperventilation is only indicated when there is adequate perfusion to the brain because it can potentially worsen hypoxic injury.

**References:** Diringer, M. (2013). New trends in hyperosmolar therapy? *Curr Opin Crit Care*, 19(2), 77–82.

Ropper, A. (2012). Hyperosmolar therapy for raised intracranial pressure. *The New England Journal*

*of Medicine*, 367(8), 746–752.

Shafi, S., Nathens, A. B., Cryer, H. G., et al. (2009). The Trauma Quality Improvement Program of the American College of Surgeons Committee on Trauma. *Journal of the American College of Surgeons*, 209(4), 521–530.

4. **D.** Although it is difficult to ascertain the exact level of spine injury in a noncooperative patient, complete paralysis of the lower extremities and the trunk with preservation of her shoulders and elbows most likely indicates an injury at C5 or below (A). The most common spinal injury after a diving accident is C5 followed by C6 (C). The use of steroids in spinal cord injury has been controversial. However, recent level 1 evidence recommends against the use of steroids in the management of acute spinal cord injury (B). Among trauma victims, patients with spinal cord injury and head injury have the highest risk of venous thromboembolic events (VTEs). Without prophylaxis, the risk of VTE is about 40% after complete spinal cord injury. Mechanical prophylaxis with compression devices should be started immediately. Anticoagulation should be started within 72 hours and continued for 2 to 3 months. Low-molecular-weight heparin is preferred over heparin. Mean arterial pressure should be maintained between 85 and 90 mm Hg for the first 7 days (E).

**References:** Bailes, J. E., Herman, J. M., Quigley, M. R., et al. (1990). Diving injuries of the cervical spine. *Surgical Neurology*, 34(3), 155–158.

Theodore N., et al. (2013). Guidelines for the management of acute cervical spine and spinal cord injuries. *Neurosurgery*, 72(2), 1–259.

5. **B.** Neurologic symptoms occur in 95% of cases of thoracic outlet syndrome. The lower two nerve roots of the brachial plexus, C8 and T1, are most commonly (90%) involved, producing pain and paresthesias in the ulnar nerve distribution (A, C–E). The second most common anatomic pattern involves the upper three nerve roots of the brachial plexus, C5, C6, and C7, with symptoms referred to the neck, ear, upper chest, upper back, and outer arm in the radial nerve distribution.
6. **B.** The Glasgow Coma Scale uses the combined scores from a motor, verbal, and speech section to give an estimate of a patient's level of functional status. The scoring is as follows. For Eye opening: 4: Spontaneously, 3: To verbal command, 2: To pain, 1: No response. Best motor response scores: 6: Obeys command, 5: Localizes pain, 4: Flexion withdrawal, 3: Flexion abnormal (decorticate), 2: Extension (decerebrate), 1: No response, and for Best verbal response: 5: Oriented and converses, 4: Disoriented and converses, 3: Inappropriate words; cries, 2: Incomprehensible sounds, 1: No response. If the patient is intubated, the maximum score that he or she can get in the verbal category is 1T (the letter T indicating intubated) and maximum overall score of 11T. This patient opens his eyes to voice commands but not spontaneously, which correlates with an eye score of 3. The best calculated motor score is a 4 for withdrawing from pain. This places his total GCS at 1T (verbal) + 3 (eye opening) + 4 (motor) = 8T.
7. **C.** Without a CT scan, one cannot be sure of the exact etiology of these neurologic findings, but, based on the history and physical exam findings, this likely represents a closed head injury with an elevated intracranial pressure (ICP). A “blown” pupil in the setting of head trauma is consistent with uncal herniation, which is often fatal and will cause permanent neurologic deficits if not treated promptly. Systolic blood pressure greater than 180 mm Hg can aggravate vasogenic brain edema and intracranial hypertension. However, systemic hypertension may be a physiologic response to reduced cerebral perfusion. Thus early and aggressive treatment of hypertension should be avoided until ICP monitoring has been established (A). While this patient likely needs an ICP monitor, a diagnosis still needs to be made before surgical treatment or invasive monitoring (B). Additionally, an external ventricular drain is a better choice in this patient because it allows therapeutic drainage of cerebrospinal fluid. Current indications for a mannitol bolus are for situations just like the above—a quick bailout maneuver to be used as a bridge to more definitive therapies. Mannitol immediately improves cerebral perfusion due to the fact that it decreases blood viscosity and therefore increases cerebral blood flow and cerebral oxygen delivery. Its osmotic properties take 15 to 30 minutes to work. There is some evidence that prolonged or scheduled use will render it ineffective at best and potentially harmful. Immediately following mannitol, the patient needs a CT scan and should be evaluated for possible surgical drainage of an intracranial hematoma. Lorazepam and levetiracetam (Keppra) are both medications used for the treatment of seizures, which is not consistent with her exam at this time (D). Raising the head of bed can lower ICP, but with a blown pupil, the patient needs more aggressive treatment (E).

**Reference:** Brain Trauma Foundation, et al. (2007). Guidelines for the management of severe

traumatic brain injury. *Journal of Neurotrauma*, 24(Suppl. 1), S91–S95.

8. **A.** The triad of headache, focal neurologic deficits, and fevers should raise concern for brain abscess; however, this classic presentation is present in less than half of all patients. The most common presenting symptom is headache, which is present in approximately 70% of patients. They arise primarily by two forms of spread: hematogenously from distant sites and direct spread from contiguous sites of infection (otitis media being most common). This leads to a wide array of potential pathogens, though the most common are *Streptococcus* spp. and *Staphylococcus* spp. Initial diagnosis should be obtained by CT scan with contrast, which will show a rim-enhancing collection (B). Lumbar puncture is generally not diagnostic and contraindicated in the setting of elevated ICP. Changes in cerebrospinal fluid volume in this setting can precipitate herniation. All patients should be started on broad-spectrum antibiotics, which can be tailored once cultures are obtained. Total duration of treatment is typically 4 to 6 weeks. Traditional management included surgical drainage and excision of the abscess cavity (D). However, serial needle aspiration has now become the treatment of choice unless the abscess is traumatic in origin (potentially has foreign debris), fungal, multiloculated, or does not improve with needle aspiration (C). Corticosteroids are controversial in this setting but may be considered when there is substantial mass effect from the abscess (E).

**References:** Brouwer, M., Coutinho, J. M., & van de Beek, D. (2014). Clinical characteristics and outcome of brain abscess: systematic review and meta-analysis. *Neurology*, 82(9), 806–813.

Muzumdar, D., Jhawar, S., & Goel, A. (2011). Brain abscess: an overview. *International Journal of Surgery (London, England)*, 9(2), 136–144.

9. **E.** Cushing's triad is a vasomotor and respiratory response to an elevated ICP that includes bradycardia, irregular breathing, and elevation in systolic blood pressure with a widened pulse pressure (A). The increased ICP leads to impaired respiration, which worsens hypercarbia (D). Typically, Cushing's triad is a late sign of elevated ICP and suggests imminent herniation. In addition to bradycardia on ECG, Mayer waves can be seen with elevated ICP (B). The waves are cyclic changes in arterial blood pressure brought about by oscillations in baroreceptor and chemoreceptor reflex control systems and are noted on ECG (C).
10. **A.** All spinal nerves carry a combination of motor, autonomic, and sensory nerves to and from the spinal cord; the one exception to this rule is C1 (D). This nerve carries solely motor fibers to the flexor muscles of the neck. The trochlear nerve (cranial nerve IV) is entirely motor and innervates the superior oblique muscle of the eye. It is also unique because it innervates the superior oblique muscle of the contralateral eye, unlike other cranial nerves, which innervate ipsilateral structures only (B). All cervical spinal nerves, with the exception of cervical spinal nerve 8, arise from above their corresponding vertebrae and all thoracic nerves arise below (C, E).
11. **E.** Central cord syndrome is the most common type of incomplete spinal cord injury and is primarily found in patients that suffered a hyperextension injury in the setting of previous cervical spine abnormalities. Symptoms include muscle weakness of the upper extremities with relative sparing of the lower extremities. Sensory function is variable. Posterior cord syndrome is a relatively rare entity typically caused by infarction of the posterior spinal artery. Classic presentation includes sparing of muscles with the loss of proprioception and vibration sensation below the level of the lesion with preservation of most motor function (A). Anterior cord syndrome can be caused by either infarction of the anterior spinal artery or, less frequently, by fracture or dislocation of vertebrae. It is characterized by loss of motor function, pain sensation, and temperature sensation but preservation of touch and proprioception (B). Cauda equina syndrome can be caused by trauma, mass lesions, or lumbar spinal stenosis and occurs at the level that the spinal cord has split into nerve roots. Symptoms can be variable but generally include paresthesia of the perineum, anus, and external genitalia ("saddle anesthesia"), bilateral or unilateral paralysis, and incontinence of bowel and bladder (C). Brown-Séquard syndrome is hemisection of the spinal cord from a mass lesion or more commonly trauma. It causes an ipsilateral loss of motor, proprioception, and vibration sensation with contralateral loss of pain and temperature sensation (D).
12. **C.** Metastatic lesions are approximately 10 times more common than primary CNS tumors (A). Lung cancer is the most common source of metastasis in men and women. Metastases from breast cancer occurs more commonly in women. The symptoms of CNS tumors are primarily based on their location. Supratentorial lesions tend to present with focal neurologic deficits based on their

location, and infratentorial lesions frequently present with signs of increased ICP from compression of the fourth ventricle (B). Adults, in general, are more likely to present with supratentorial lesions, and children are more likely to present with infratentorial lesions. Astrocytoma is the most common primary CNS tumor in adults while medulloblastoma is the most common in children. Craniopharyngioma accounts for less than 5% of all brain tumors in children (D). When comparing brain tumors to spinal tumors, brain tumors are more commonly malignant, and spinal tumors are more commonly benign (E).

**References:** Ricard, D., Idbaih, A., Ducray, F. et al. (2012). Primary brain tumours in adults. *Lancet*, 379(9830), 1984–1996.

Brunicardi, F., Andersen, D., & Schwartz, S. (Eds.). (2010). Neurosurgery. In *Schwartz's principles of surgery* (pp. 1515–1555). New York, NY: McGraw-Hill Education.

13. **B.** Intraventricular hemorrhage (IVH) occurs in approximately 15% to 20% of infants born with a birth weight of less than 1500 g. Because of the frequency of this condition, serial ultrasound screening is recommended in all premature infants and any infants that show signs of IVH. In premature infants, the relative fragility of the germinal matrix makes them sensitive to changes in cerebral blood flow with subsequent hemorrhage into the ventricles. Predisposing factors in addition to prematurity include maternal chorioamnionitis or preeclampsia and neonatal respiratory distress, hypotension, or academia. While 25% to 50% of infants can have clinically silent IVH, symptoms range from nonspecific changes in alertness to stupor or coma. Once it has been diagnosed, management is largely supportive to prevent long-term complications such as posthemorrhagic hydrocephalus (PHH). All of the other answer choices represent historical treatments of PHH. Though furosemide and acetazolamide have been used in older children with PHH, they do not seem to alter the course in premature infants and could potentially be deleterious (A). Serial lumbar puncture and intraventricular tPA have also been tried with no significant change in deterioration or progression to permanent ventricular drainage procedures (C, E). Temporary ventricular drainage with transition to permanent drainage procedures if necessary is currently the treatment of choice for PHH with elevated intracranial pressures (D).

**References:** Mazzola, C. A., Choudhri, A. F., Auguste, K. I., et al. (2014). Pediatric hydrocephalus: systematic literature review and evidence-based guidelines. Part 2: management of posthemorrhagic hydrocephalus in premature infants. *Journal of Neurosurgery Pediatrics*, 14(Suppl. 1), 8–23.

Robinson, S. (2012). Neonatal posthemorrhagic hydrocephalus from prematurity: pathophysiology and current treatment concepts. *Journal of Neurosurgery Pediatrics*, 9(3), 242–258.

14. **D.** Intracranial aneurysms affect 4% of the population but are asymptomatic in the majority of cases, and most patients are unaware of the diagnosis. Risk factors include female gender, polycystic kidney disease, and Marfan syndrome. The majority of the aneurysms occur in the circle of Willis with the anterior communicating artery being the most frequent site (B). When the aneurysm ruptures, it can result in intraparenchymal and subarachnoid hemorrhage, which is a catastrophic event with a mortality rate up to 50% (E). Noncontrast CT head is the study of choice to confirm the diagnosis (C). Bleeding on brain parenchyma elicits a vasospasm response, which can result in stroke and patients are at increased risk for 21 days; thus most neurosurgeons will start calcium channel blockers. Because cerebral autoregulation is compromised, these patients should be given volume to maintain adequate cerebral perfusion pressure (A).

**Reference:** Keedy, A. (2006). An overview of intracranial aneurysms. *McGill Journal of Medicine*, 9(2), 141.

15. **B.** The current guidelines published by the Trauma Quality Improvement Project are based on a series of studies that have shown reduced rates of venous thromboembolism when chemical prophylaxis is started within 72 hours of the initial head injury (E). The guidelines base their recommendations around a modified bleeding risk assessment for intracranial hemorrhages: high risk (ICP monitor placement, craniotomy, and evidence of bleed progression at 72 hours), medium risk (subdural/epidural hematoma larger than 8 mm, contusion or intraventricular hematoma larger than 2 cm, multiple contusions per lobe, subarachnoid hemorrhage with abnormal CT angiogram, and evidence of progression at 24 hours), and low risk (no characteristics of high or medium risk). Based on this scale, anticoagulation is recommended for patients with stable CT scans at 24 hours in the low-risk group and 72 hours in the medium-risk group. This patient represents a medium-risk patient with a progression of the head bleed, and he should have been

started on VTE prophylaxis at 72 hours (A). The high-risk group is perhaps the most difficult, and there is not enough evidence to recommend a specific practice guideline. Instead it is left up to the physician to choose among placement of an IVC filter, DVT screening with ultrasound, and prophylactic anticoagulation despite the risk (D). This algorithm is largely based off the DEEP I study, which showed no evidence of significant progression of intracranial hemorrhage in low-risk groups when started on enoxaparin at 24 hours. Another study, published in the *Journal of Neurotrauma* showed decreased rates of VTE and no increased incidence of bleeding when anticoagulation was started within 72 hours after the injury. There is currently not enough evidence to recommend routine DVT screening (C).

**References:** Jamjoom, A., & Jamjoom, B. (2013). Safety and efficacy of early pharmacological thromboprophylaxis in traumatic brain injury: systematic review and meta-analysis. *Journal of Neurotrauma*, 30(7), 503–511.

Phelan, H. A., Wolf, S. E., Norwood, S. H., et al. (2012). A randomized, double-blinded, placebo-controlled pilot trial of anticoagulation in low-risk traumatic brain injury: the Delayed Versus Early Enoxaparin Prophylaxis I (DEEP I) study. *Journal of Trauma and Acute Care Surgery*, 73(6), 1434–1441.

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## PART II

# Medical Knowledge

### OUTLINE

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- 28. Anesthesia
- 29. Fluids, Electrolytes, and Acid-Base Balance
- 30. Immunology
- 31. Infection and Antimicrobial Therapy
- 32. Nutrition and Metabolism
- 33. Oncology and Tumor Biology
- 34. Pharmacology
- 35. Preoperative Evaluation and Perioperative Care
- 36. Transfusion and Disorders of Coagulation
- 37. Wound Healing



# Anesthesia

*Patrick T. Delaplain, Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 9-year-old male has been in the pediatric intensive care unit for the last 7 days after presenting to the hospital with influenza infection leading to respiratory failure requiring mechanical ventilation. He is receiving a continuous fentanyl and propofol drip for pain control and sedation, respectively. This morning he developed bradycardia, and his urinary output dropped. Laboratory values show rising creatinine, hyperlipidemia, hyperkalemia, and acidosis. Which of the following is true regarding his condition?
  - A. It is more common in adults than children.
  - B. Splenomegaly is common.
  - C. Early initiation of hemodialysis is curative.
  - D. Treatment with catecholamines is effective.
  - E. Daily screening with lactate and creatine phosphokinase (CPK) may prevent this complication.
2. A 55-year-old diabetic male underwent right-sided video-assisted thoracoscopic surgery (VATS) for an empyema yesterday. This morning he is complaining of pain along his medial left forearm and paresthesia of his fourth and fifth digits. Which of the following is true regarding this complication?
  - A. It would have been prevented with appropriate positioning and padding.
  - B. Obesity is a significant risk factor.
  - C. Early electromyography (EMG) will show signs of denervation.
  - D. For complete neuromotor injuries, early operative intervention is indicated.
  - E. Diabetic neuropathy is a risk factor.
3. Which of the following is true regarding invasive lines used for the monitoring of surgical patients?
  - A. Trauma patients show improved mortality with placement of a pulmonary artery catheter (PAC).
  - B. A normal Allen Test before radial artery cannulation will reduce incidence of hand ischemia.
  - C. PAC will provide direct measurement of systemic vascular resistance, cardiac output, and pulmonary artery pressure.
  - D. Systolic blood pressure measured on a radial artery catheter will typically be higher than the aortic pressure.
  - E. Any arrhythmia seen on electrocardiogram is considered a contraindication for PAC placement.
4. A 47-year-old female with chronic pain from degenerative disk disease is recovering from pneumonia complicated by multiorgan system dysfunction. She is now dialysis dependent after sepsis-related acute kidney injury. This morning a rapid response was called for respiratory depression and confusion, which improved after administration of naloxone. Which of the following medications most likely contributed to the respiratory compromise?
  - A. Transdermal fentanyl patch
  - B. Hydromorphone patient-controlled anesthesia
  - C. Scheduled morphine injections every 12 hours
  - D. Scheduled oral methadone every 8 hours
  - E. Extended-release oxycodone

5. A 37-year-old female is postoperative day 1 from a percutaneous bedside tracheostomy tube placement. Over the last hour, she has developed significant subcutaneous emphysema of the neck and her current oxygen saturation is 80%. Respiratory therapy has already attempted directional suctioning, but they were unable to pass the catheter. What is the most appropriate next step in management?
  - A. Remove the tracheostomy tube and attempt recannulation with a smaller caliber cannula
  - B. Remove the tracheostomy tube and recannulate over a suction catheter
  - C. Remove the tracheostomy tube and recannulate over a fiberoptic bronchoscope
  - D. Replace the tracheostomy tube using a percutaneous tracheostomy kit
  - E. Orotracheal intubation
6. Which of the following is true regarding invasive mechanical ventilation?
  - A. Synchronized intermittent mechanical ventilation (SIMV) is associated with the lowest work of breathing.
  - B. Airway pressure release ventilation (APRV) mandates higher levels of sedation because of patient discomfort.
  - C. Assist-control (AC) ventilation is associated with lower hemodynamic effects than SIMV.
  - D. AC ventilation is equivalent to SIMV in a patient that is not breathing spontaneously.
  - E. High-frequency oscillatory ventilation (HFOV) is contraindicated in paralyzed patients.
7. Which of the following parameters is most likely to predict successful discontinuation of mechanical ventilation?
  - A. Rapid shallow breathing index (RSBI) ( $f/V_T$ ) less than 105
  - B. Negative inspiratory force (NIF)  $-20$  to  $-30$  cm  $H_2O$
  - C. Successful spontaneous breathing trial (SBT)
  - D. Respiratory rate less than 30 breaths per minute
  - E. Tidal volume greater than 5 mL/kg
8. Which of the following statements is true regarding anesthetic induction and maintenance agents?
  - A. Isoflurane is superior to sevoflurane for neurosurgical anesthesia.
  - B. Propofol is preferred in hemodynamically unstable patients.
  - C. Nitrous oxide is contraindicated in patients with pneumothorax.
  - D. Etomidate can be used as a continuous drip in hypotension to avoid cardiovascular effects of other agents.
  - E. Desflurane is the preferred agent for inhalation induction.
9. A 75-year-old female is brought to the operating room for laparoscopic cholecystectomy. She was previously residing in an assisted-living facility because of progressive dementia and is unable to provide a medical history. Fifteen minutes into the operation, anesthesia begins to have difficulty ventilating the patient, and she develops a diffuse maculopapular rash with urticaria. Which of the following is the most likely offending agent?
  - A. Rocuronium
  - B. Latex
  - C. Cefazolin
  - D. Sevoflurane
  - E. Propofol
10. Which of the following postoperative complications has *not* been shown to correlate with The American Society of Anesthesiologists' (ASA) classification of physical status?
  - A. Mortality
  - B. Operative duration
  - C. Intraoperative blood loss
  - D. Wound infection
  - E. Anastomotic leak

11. A 29-year-old male undergoes a laparoscopic cholecystectomy for symptomatic cholelithiasis. Shortly after induction, the anesthesiologist notes an increase in core body temperature and end-tidal CO<sub>2</sub>. After administration of dantrolene and aborting the operation, his status improves. Which of the following is true regarding this condition?
- A. It is an autosomal recessive disorder.
  - B. Genetic analysis is required for diagnostic confirmation.
  - C. It is more common in elderly patients.
  - D. It may present as late as 24 hours after anesthesia.
  - E. Mortality rate is less than 5%.
12. After excision of multiple subcutaneous lipomas under local anesthesia, a 42-year-old woman seizes violently. The surgeon should be aware that the maximum safe dose of a local anesthetic agent in a 70-kg woman is:
- A. 10 to 20 mL 1% lidocaine
  - B. 40 to 50 mL 2% lidocaine with epinephrine
  - C. 40 to 50 mL 1% lidocaine with epinephrine
  - D. 40 to 50 mL 0.5% lidocaine
  - E. 40 to 50 mL 1% lidocaine without epinephrine
13. A 30-year-old 40-kg male is about to undergo anterior cruciate ligament repair of his left knee. Soon after anesthetic induction, the anesthesiologist notes rigidity of the patient's masseter muscle, an end-tidal CO<sub>2</sub> of 65 mm Hg, tachycardia to 120 bpm, and a rise in blood pressure to 160/100 mm Hg. All anesthetic agents are discontinued, and 90 mg of dantrolene is administered. However, 5 minutes later, the aforementioned parameters persist. The next step in the management is:
- A. Additional dose of dantrolene
  - B. Calcium channel blocker
  - C. Beta-blocker
  - D. Alpha-blocker
  - E. Intravenous (IV) fluid hydration
14. A 20-year-old male is about to undergo arthroscopic surgery of his left shoulder. During anesthetic induction, the anesthesiologist notes trismus that persists for 2 minutes. End-tidal CO<sub>2</sub>, heart rate, and temperature remain normal. Which of the following is the best recommendation?
- A. Administer additional neuromuscular blocker.
  - B. Proceed with surgery provided trismus resolves within the next minute.
  - C. Cancel surgery and send patient home.
  - D. Cancel surgery, administer dantrolene, and admit for 24 hours of observation.
  - E. Cancel surgery, admit for 24 hours of observation, and refer for muscle biopsy.
15. The best way to confirm proper placement of endotracheal intubation is:
- A. Direct visualization of tube passing through the vocal cords
  - B. Auscultation of lungs
  - C. Observation of condensation within tube
  - D. Chest x-ray
  - E. End-tidal CO<sub>2</sub>
16. A 65-year-old male is undergoing urgent surgery for gangrenous cholecystitis. The patient has a history of moderate aortic valve stenosis that was recently diagnosed on echocardiography but denies symptoms. Which of the following would be most important in the anesthetic management?
- A. Preload reduction
  - B. Afterload reduction
  - C. Avoidance of hypotension
  - D. Heart rate control with beta-blockade
  - E. Liberal use of ephedrine

17. A 66-year-old female presents in septic shock due to a perforated duodenal ulcer. She is taken urgently to the operating room for an exploratory laparotomy. Due to persistent hypotension, dopamine is infused by the anesthesiologist and is eventually titrated to a rate of 15 mcg/kg per minute. At that rate, which of the following receptors is exerting the predominant effect?
- A.  $\alpha_1$ -Adrenergic
  - B.  $\alpha_2$ -Adrenergic
  - C.  $\beta_1$ -Adrenergic
  - D.  $\beta_2$ -Adrenergic
  - E. Dopaminergic
18. A 55-year-old male with a history of chronic obstructive pulmonary disease (COPD) undergoes regional block using an interscalene approach with bupivacaine for anticipated surgery of a left humerus fracture. Soon after placement of the block, the patient develops significant dyspnea. Breath sounds are equal to auscultation. The shortness of breath is most likely due to:
- A. Pneumothorax
  - B. COPD exacerbation
  - C. Inadvertent intravascular injection of bupivacaine
  - D. Air embolism
  - E. An elevated left hemidiaphragm
19. After completion of surgery, an anticholinesterase is administered to reverse the neuromuscular blockade. Which of the following muscles would be expected to recover first?
- A. Diaphragm
  - B. Adductor pollicis
  - C. Ocular muscles
  - D. Pharyngeal
  - E. Quadriceps femoris
20. Concerns with the use of propofol to supplement anesthesia would be greatest in a patient with:
- A. End-stage renal disease
  - B. Poor cardiac function
  - C. Cirrhosis
  - D. Neutropenia
  - E. Recent burn
21. A 40-year-old cirrhotic male undergoes induction of general anesthesia with succinylcholine for repair of an incarcerated inguinal hernia. At the end of the procedure, a peripheral nerve stimulator demonstrates no recovery of muscle twitches despite 60 minutes of time elapsing. Which of the following is true regarding this condition?
- A. It is best treated with transfusion of whole blood.
  - B. It is best treated with transfusion of fresh frozen plasma.
  - C. It is unlikely to be related to his liver disease.
  - D. It also affects the metabolism of cocaine.
  - E. It is inherited in an autosomal dominant fashion.
22. Which of the following is associated with barbiturate toxicity?
- A. Myocardial depression
  - B. Acute tubular necrosis
  - C. Hepatotoxicity
  - D. Peripheral neuropathy
  - E. Seizures
23. A patient is given benzocaine spray in anticipation of a bedside flexible laryngoscopy. After several minutes, he becomes cyanotic. Pulse oximetry continues to read 100%. Which of the following is the

most appropriate treatment?

- A. Intubation
- B. Intravenous methylene blue
- C. Discontinue benzocaine and administer prilocaine
- D. Metoclopramide
- E. Thiosulfate

24. A 16-year-old male trauma patient has been undergoing cardiopulmonary resuscitation for the last 30 minutes. The emergency room physician intubates the patient and confirms tube placement via direct visualization of the endotracheal (ET) tube passing through the cords. Capnography reveals abnormally low end-tidal CO<sub>2</sub>. What is the next best course of action?

- A. Removal of the ET tube and reintubation
- B. Chest x-ray to confirm placement
- C. Transtracheal ultrasound
- D. Arterial blood gas
- E. Continue bagging with 100% FiO<sub>2</sub>

## Answers

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1. E. Propofol infusion syndrome is a clinical condition that is associated with higher doses of propofol infusion that are continued for more than 48 hours. It is associated with metabolic acidosis, arrhythmias (most often bradycardia), rhabdomyolysis, hyperlipidemia, hepatomegaly (not splenomegaly), renal failure, and eventual cardiovascular collapse (B). The first case report was in the pediatric population, and though the correlation with age is unclear, children may be at a higher risk (A). Once it has been diagnosed, immediate cessation of propofol is mandatory with early hemodialysis. However, treatment is largely ineffective, especially in the setting of arrhythmias (C). The combination of high-dose propofol with exogenous catecholamine (or steroid) administration appears to trigger the syndrome. Catecholamines and steroids aggravate propofol inhibition of fatty acid metabolism, promoting rapid and irreversible peripheral and cardiac muscle injury (D). While the incidence is relatively low, current recommendations are to change propofol to another medication if sedation is expected to last more than 48 hours. A novel screening tool for this condition has been proposed that includes daily CPK and lactate levels because these may be the first indication that propofol infusion syndrome has developed.

**References:** Fodale, V., & La Monaca, E. (2014). Propofol infusion syndrome. *Drug Safety*, 31(4), 293–303.

Schroepfel, T., Fabian, T. C., Clement, L. P., et al. (2014). Propofol infusion syndrome: a lethal condition in critically injured patients eliminated by a simple screening protocol. *Injury*, 45(1), 245–249.

2. E. The American Society of Anesthesiologists has identified perioperative peripheral nerve injuries as among the top three medical malpractice claims directed at anesthesiologists and operating rooms' staff. And, despite the fact that over 60% included documentation of appropriate padding and position, almost half of the cases involved payment. Of these injuries, ulnar and brachial plexus injuries appear to be the most common. These injuries appear to happen by one of several mechanisms: direct nerve damage, stretch/compression, and ischemia or toxicity of locally injected medications. However, despite increased efforts to prevent these injuries, they can still occur in the setting of appropriate positioning and padding (A). Preoperative risk factors also appear to play a role including body weight and preexisting neuropathy, such as diabetic neuropathy. Obesity is actually protective, and thinner patients are more commonly affected (B). The risk goes up even further in the setting of intraoperative hypotension or preoperative malnutrition. Because it can take several days for denervation of the affected muscles to take place, EMG is often normal in the immediate postoperative period. However, EMG should still be done early because any abnormalities likely represent a preexisting neuropathy that was simply exacerbated by the operation (C). Most of these injuries will heal with time. However, operative intervention can be performed depending on the severity of injury and failure to improve with conservative measures (D).

**Reference:** Winfree, C., & Kline, D. G. (2005). Intraoperative positioning nerve injuries. *Surgical Neurology*, 63(1), 5–18.

3. **D.** Though invasive hemodynamic monitoring of the critically ill patient provides valuable information, complications of placement must always be measured against the potential advantages. PAC was considered the standard of care for many critically ill patients but is being used less frequently now because of multiple studies showing no improvement in mortality (A). Based on these findings, invasive hemodynamic monitoring is no longer recommended for routine use. However, there may still be a role in patients with unknown volume status, severe cardiogenic shock, pulmonary artery hypertension, or severe underlying cardiopulmonary disease. Before placement, an electrocardiogram must be obtained to rule out left bundle branch block (LBBB). There is a high incidence of temporary right bundle branch block with placement, and in the setting of a LBBB, a complete heart block could be incited. However, there is no contraindication to placement in most other arrhythmias (E). The PAC directly measures cardiac output, central venous pressure, mixed venous oxyhemoglobin saturation, right-sided cardiac pressures, and pulmonary artery pressures. From this information, systemic vascular resistance, cardiac index, and oxygen delivery/uptake can be calculated (C). Invasive arterial blood pressure monitoring provides continuous measurement of blood pressure as well as easy access for arterial blood gas samples. However, it too comes with potential complications, the most significant being arterial thrombosis. The radial artery is generally preferred because of adequate collaterals through the ulnar, relative ease of cannulation, and lower incidence of infection. Though the Allen test is currently considered mandatory before radial arterial line placement, it does not seem to accurately predict risk of hand ischemia. Several trials looking at the Allen test have shown disagreement on what constitutes a positive test, high variability among observers, and inconsistent prediction of collateral flow when compared with less subjective tests such as ultrasound (B). It is also important to remember that systolic blood pressure in the radial artery will be higher than the aorta, but mean arterial pressure should be preserved. A higher systolic pressure occurs with distal progression, smaller arterial caliber, and older age.

**References:** Barone, J. & Madliner, R. (2006). Should an Allen test be performed before radial artery cannulation? *Journal of Trauma*, 61(2), 468–470.

Fischer, J. (2012). Cardiovascular monitoring and support. In *Fischer's mastery of surgery*. New Delhi: Wolters Kluwer Health/Lippincott Williams & Wilkins.

Vincent, J. (2012). The pulmonary artery catheter. *Journal of Clinical Monitoring and Computing*, 26(5), 341–345.

4. **C.** Opioid pain medications undergo metabolism in the liver to a variety of metabolites that are generally excreted in the urine. Morphine is unique because it has multiple active metabolites, one of which is more potent than morphine. This is generally not an issue because they are quickly excreted in the urine, but in the setting of renal injury, they can persist for much longer. Morphine and codeine (metabolized to morphine) should be avoided in renal failure. Hydromorphone (Dilaudid) does have an active metabolite, but these metabolites don't have the increased potency that is seen with morphine (B). Fentanyl and methadone are likely the safest medications to use in dialysis patients because all of the metabolites are inactive (A, D). All oral medications undergo first-pass metabolism in the liver, and metabolites of these medications either need to be active, or higher doses need to be given. Data regarding the specific use of oxycodone in renal failure are lacking, but there is no evidence that it has metabolites that are as significantly active as morphine (E). It is also important to keep in mind that pruritus is a common adverse reaction with opioids that is caused by degranulation of mast cells and histamine release and does not constitute a true allergic reaction.

**References:** Dean, M. (2004). Opioids in renal failure and dialysis patients. *Journal of Pain and Symptom Management*, 28(5), 497–504.

Schumacher, M. et al. (2015). Opioid agonists & antagonists. In B. Katzung, & A. Trevor (Eds.), *Basic & clinical pharmacology* (13th ed.). New York, NY: McGraw-Hill.

5. **E.** Early dislodgement of the tracheostomy tube is an infrequent but potentially devastating complication associated with placement. In general, the first tube exchange happens between postoperative days 3 and 7. Accidental removal before a planned exchange can potentially cause loss of the airway. Additionally, manipulation of the endotracheal tube by ancillary staff may promote a false passage. Despite positioning of the tracheostomy in a false passage, patients may

be able to maintain some oxygenation despite its location. This can manifest as respiratory distress (in a nonventilated patient) and with subcutaneous emphysema. Replacement of the tube can be attempted via multiple methods including trying to use a small caliber cannula, using a suction catheter or fiberoptic bronchoscope as a guide, or using the equipment in a percutaneous tracheostomy kit (A–D). If the patient is unstable, securing the airway quickly becomes the priority and endotracheal intubation should be performed.

**References:** Halum, S., Ting, J., Plowman, E., et al. (2012). A multi-institutional analysis of tracheotomy complications. *Laryngoscope*, 122(1), 38–45.

Subroto, P., & Colson, Y. (2014). Tracheostomy. In D. Sugarbaker, R. Bueno, & Y. Colson (Eds.) *Adult chest surgery* (2nd ed.). New York, NY: McGraw Hill Professional.

6. **D.** Data showing improved survival of one mode of ventilation over another in specific disease states are inconsistent at best; however, theoretically, each mode of ventilation offers certain advantages and disadvantages. The conventional modes of mechanical ventilation can be considered on a spectrum based on the amount of support that is provided to the patient and how the machine supports patient-initiated breaths. On the lowest end of the spectrum is continuous positive airway pressure (CPAP), in which all breaths are triggered by the patient and no additional support is provided. The mechanical ventilator simply provides a constant pressure and allows patients to breath at a rate and volume that they determine. Pressure support ventilation (PSV) allows the patient to determine the rate and volume of breaths but provides additional pressure to support a patient-triggered breath. SIMV allows the clinician to mandate a certain number of breaths per minute at a set volume or pressure but allows the patient to breath spontaneously in between the machine-triggered breaths. It is frequently combined with PSV to provide additional pressure to support the patient-triggered breaths. Proponents advocate that it allows patients to exercise their respiratory muscles, but this comes at the expense of an increased work of breathing, which can potentially fatigue the diaphragm. AC allows patients to trigger breaths, but every breath has a mandated volume or pressure. This allows patients to change their work of breathing simply by increasing the respiratory rate, and, because every breath is machine delivered, it has the lowest associated work of breathing. APRV is a mode designed to maximize alveolar recruitment by maintaining relatively constant higher pressures. While there is potential for patient-ventilator dyssynchrony with APRV, in general, spontaneous breathing should be encouraged and sedation kept as low as possible. HOFV is a mode of ventilation that works off of the assumption that high airway pressures can be tolerated by patients as long as they are not sustained for prolonged periods of time. The goal is to maintain the lungs at a relatively constant volume that can recruit alveoli but does not cause overdistention. Current approved ventilators in the United States do not support spontaneous breathing with HOFV; heavy sedation or paralysis is generally required with HOFV. Current recommendations are to limit its use to high volume centers because of the increased training required of the staff and the time-intensive nature of treatment.

**References:** Brochard, L., & Lellouche, F. (2013). Pressure-support ventilation. In M. Tobin (Ed.), *Principles and practice of mechanical ventilation* (3rd ed.). New York, NY: McGraw-Hill Medical.

Froese, A., & Ferguson, N. (2013). High-frequency ventilation. In M. Tobin (Ed.), *Principles and practice of mechanical ventilation* (3rd ed.). New York, NY: McGraw-Hill Medical.

Higgins, J., Estetter, B., Holland, D., et al. (2005). High-frequency oscillatory ventilation in adults: respiratory therapy issues. *Critical Care Medicine*, 33(3), S196–S203.

Mancebo, J. (2013). Assist-control ventilation. In M. Tobin (Ed.), *Principles and practice of mechanical ventilation* (3rd ed.). New York, NY: McGraw-Hill Medical.

Putensen, C. (2013). Airway pressure release ventilation. In M. Tobin (Ed.), *Principles and practice of mechanical ventilation* (3rd ed.). New York, NY: McGraw-Hill Medical.

Sassoon, C. (2013). Intermittent mandatory ventilation. In M. Tobin (Ed.), *Principles and practice of mechanical ventilation* (3rd ed.). New York, NY: McGraw-Hill Medical.

7. **C.** The term *weaning* when describing discontinuation of mechanical ventilation refers to an old concept of slowly reducing ventilator support until a patient is ready to take over the work of breathing on his or her own. Because this practice is no longer encouraged, there has been a push to change the term to *liberation* from the mechanical ventilator. In 2001, “Evidence-Based Guidelines for Weaning and Discontinuing Ventilatory Support” was published in *Chest* by a task force specifically assembled to assess current weaning strategies. The basis of these recommendations was that daily evaluation of readiness for extubation should be done, underlying



conditions corrected, and that the ventilator should be discontinued as early as possible. Delay in extubation in patients ready for spontaneous breathing showed an increase in mortality, increased nosocomial pneumonia, and prolonged hospital stay. They also looked at the most predictive factors for successful extubation, and, by far, the most predictive parameter was successful SBT (A, B, D, E). Current recommendations include a daily screening for SBT readiness; this includes improvement in underlying disease state, adequate gas exchange (high  $\text{PaO}_2$ , low  $\text{FiO}_2$ , low PEEP: $\text{FiO}_2$  ratio), hemodynamic stability off pressors, and patient capability of generating a spontaneous breath. Once these parameters are met, the patient should undergo a spontaneous breathing trial. Data regarding choice of SBT (CPAP vs pressure support vs T-piece) are inconclusive and likely not significant. A patient is considered to have “failed” a spontaneous breathing trial if any of the following criteria are met: worsening gas exchange, hemodynamic instability, significant increase in respiratory rate (RR), change in mental status, diaphoresis, or signs of increased work of breath. Patients that pass a spontaneous breathing trial should be considered for immediate discontinuation of the mechanical ventilator. Though several specific values have shown some predictive value (e.g., RSBI 60–105, tidal volume 4–6 mL/kg, NIF –20 to –30 cm  $\text{H}_2\text{O}$ , minute ventilation 10–15 L/min,  $\text{RR} < 30$ ), consistency between studies is lacking and their overall value is debatable. RSBI is considered an excellent predictor of failing extubation but should not be used solely to determine readiness for extubation. Though the current goal is for early extubation, this needs to be weighed against the fact that reintubation is associated with an 8-fold increased risk of nosocomial pneumonia and a 6- to 12-fold increased risk of mortality.

**References:** Celli, B. (2015). Mechanical ventilatory support. In D. Kasper, A. Fauci, S. Hauser, et al., (Eds.), *Harrison’s principles of internal medicine* (19th ed.). New York, NY: McGraw-Hill.

MacIntyre, N., Cook, D., Ely, E., et al. (2001). Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians; the American Association for Respiratory Care; and the American College of Critical Care Medicine. *Chest*, 120(Suppl. 6), 375S–395S.

McConville, J., & Kress, J. (2012). Weaning patients from the ventilator. *The New England Journal of Medicine*, 367(23), 2233–2239.

8. C. Each of the volatile anesthetics has specific advantages and disadvantages that need to be considered when selecting them for use. Nitrous oxide is relatively insoluble compared with the other anesthetic agents, and it readily diffuses into cavities containing air. For this reason, it can potentially double the size of a pneumothorax. Halothane is largely being replaced by newer agents but remains the inhalation anesthetic of choice for induction because of lower levels of bronchospasm and its being the least pungent of the agents. However, it is associated with the most significant amounts of cardiac depression and, rarely, with hepatitis. Desflurane is extremely pungent and is associated with significant bronchospasm, making it a very poor choice as an induction agent (E). It has the advantage of very short induction and emergence time because of its relatively lower solubility. All inhalation anesthetics are associated with some degree of increased intracranial pressure during neurosurgery, though halothane appears to be the worst offender. When comparing the other agents, there appears to be little difference. A study done in *Anesthesiology* in 2003 comparing intracranial pressures with propofol, sevoflurane, or isoflurane as an anesthetic agent showed decreased intracranial pressure and increased cerebral perfusion pressure with propofol but no difference between the two volatile anesthetics (A). Etomidate as an induction agent has the lowest cardiovascular effects of any agent, and it was previously used as a continuous drip in critical care units. However, significant adrenal suppression stopped its use as a drip (D). Propofol, in comparison, has relatively significant hemodynamic effects (B).

**Reference:** Petersen, K., Landsfeldt, U., & Cold, G. E. (2003). Intracranial pressure and cerebral hemodynamics in patients with cerebral tumors: a randomized prospective study of patients subjected to craniotomy with propofol-fentanyl, isoflurane-fentanyl, or sevoflurane-fentanyl anesthesia. *Anesthesiology*, 48(1), 14–15.

9. A. A study done in France from 1997 to 2004 looked at all patients that had immediate hypersensitivity reaction presumed to be from allergic reaction. Of the 1816 patients that met criteria for the study, the top three offending agents for immediate hypersensitivity reaction were neuromuscular blocking agents (58%), latex (20%), and antibiotics (13%) (B, C). Allergy to inhaled anesthetics and hypnotics was much less common (D, E). In children, latex was more common than neuromuscular blocking agents, but the sample size for this population was much lower.

**References:** Butterworth, J., Mackey, D., Wasnick, J., et al. (Eds.). (2013). Inhalation anesthetics. In *Morgan & Mikhail's clinical anesthesiology* (5th ed.). New York, NY: McGraw-Hill.

Butterworth, J., Mackey, D., Wasnick, J., et al. (Eds.). Intravenous anesthetics. In *Morgan & Mikhail's clinical anesthesiology* (5th ed.). New York, NY: McGraw-Hill.

Mertes, P., Alla, F., Trechot, P., et al. (2011). Anaphylaxis during anesthesia in France: an 8-year national survey. *The Journal of Allergy and Clinical Immunology*, 128(2), 366–373.

10. **E.** The ASA Classification of Physical Status has been in use in its current form since 1961, and even when validated against more objective findings like National Surgical Quality Improvement Program data, it remains one of the top 10 predictors of perioperative complications. A study done in 1996 showed correlation between ASA Classification and operative duration, blood loss, hospital stay, ICU stay, wound infection, urinary tract infections, pulmonary complications, cardiac complications, and even mortality (A–D). Interestingly, anastomotic leak rates were the only studied variable that did not correlate significantly with ASA Classification. However, despite significant correlation with surgical outcomes, the test remains flawed in its objectivity with only 40% to 60% agreement on ASA class when individual anesthesiologists are presented with the same patient.

**References:** Davenport, D., Bowe, E., Henderson, W., et al. (2006). National Surgical Quality Improvement Program (NSQIP) risk factors can be used to validate American Society of Anesthesiologists Physical Status classification (ASA PS) levels. *Annals of Surgery*, 243(5), 636–644.

Wolters, U., Wolf, T., Stutzer, H., et al. (1996). ASA classification and perioperative variables as predictors of postoperative outcome. *British Journal of Anaesthesia*, 77(2), 217–222.

11. **D.** This patient likely has malignant hyperthermia, a rare autosomal dominant disorder of skeletal muscle (A). The condition is characterized by a hypermetabolic state triggered by exposure to certain inhalation anesthetics or succinylcholine. The older anesthetic agents associated with this reaction include halothane and enflurane. Malignant hyperthermia occurs when uncontrolled amounts of intracellular calcium accumulate in skeletal muscle. Symptoms may develop as early as 30 minutes after anesthetic administration and as late as 24 hours postoperatively. The initial clues occur in the operating room after induction. Rather than achieve complete paralysis, the anesthesiologist may notice rigidity in the masseter muscle. Other findings include an increase in end-tidal CO<sub>2</sub>, tachycardia, and an increase in temperature. It is imperative that all anesthetics are immediately stopped and dantrolene given (2.5 mg/kg every 5 minutes) until resolution of symptoms. Dantrolene stabilizes muscle channels in the sarcoplasmic reticulum. The mortality rate approaches 30% (E). A functional test on skeletal muscle biopsy (Caffeine Halothane Contracture Test) is used for diagnosis (B). More than 50% of the families show linkage of the in vitro contracture test phenotype to the gene encoding the skeletal muscle ryanodine receptor. The test requires a muscle biopsy with exposure of the muscle to halothane and caffeine. A positive test will cause significant muscle contraction. The majority of cases occur in children or young adults (C).

**Reference:** Jurkat-Rott, K., McCarthy, T., & Lehmann-Horn, F. (2000). Genetics and pathogenesis of malignant hyperthermia. *Muscle and Nerve*, 23(1), 4–17.

12. **C.** There are relatively few side effects of local anesthetic agents such as lidocaine, unless they are injected intravenously by mistake or administered in doses higher than recommended. Toxicity begins with light-headedness, facial paresthesias, blurred vision, and tinnitus. However, it can progress to lethargy, tremors, tonic-clonic seizures or, rarely, cardiac arrest. Maximum doses for local injection of lidocaine are 5 mg/kg without and 7 mg/kg with epinephrine because the vasoconstriction delays the systemic release of lidocaine. Because a 1% solution of lidocaine contains 10 mg/mL, an easy way to remember this is to multiply the patient's weight by either 5 (no epinephrine) or 7 (with epinephrine) and then divide by 10. Therefore, for this patient: 70 kg × 5 mg/kg = 350 mg and divide by 10 mg/mL = 35 mL of 1% lidocaine. For lidocaine with epinephrine, 70 kg × 7 mg/kg = 490 mg and divide by 10 = 49 mL of 1% lidocaine. For a 2% lidocaine solution, one would divide by 20 (24.5 mL and 17.5 mL, respectively, with and without epinephrine), and for a 0.5% solution, one would divide by 5 (70 mL and 98 mL, respectively, with and without epinephrine). There have been recent case reports suggesting that “lipid rescue” using an IV intralipid solution, is useful in severe overdose cases.

**Reference:** Warren, J., Thoma, R., Georgescu, A., et al. (2008). Intravenous lipid infusion in the successful resuscitation of local anesthetic-induced cardiovascular collapse after supraclavicular

brachial plexus block. *Anesthesia and Analgesia*, 106(5), 1578–1580.

13. **A.** Dantrolene is a hydantoin derivative that directly interferes with muscle contraction by inhibiting calcium ion release from the sarcoplasmic reticulum, possibly by binding to ryanodine receptor type 1 (RYR-1). The initial dose is 2.5 mg/kg, repeated every 5 minutes until reversal of the reaction occurs or a total dose of 10 mg/kg (or 20 mg/kg, according to some practitioners) is reached (B–E). If the condition does not resolve after the total dose is reached, the diagnosis of malignant hyperthermia is unlikely and additional conditions should be considered.

**Reference:** Schneiderbanger, D., Johannsen, S., Roewer, N., et al. (2014). Management of malignant hyperthermia: diagnosis and treatment. *Journal of Therapeutics and Clinical Risk Management*, 10, 355–362.

14. **E.** Masseter muscle rigidity, or trismus, is considered a normal reaction to administration of neuromuscular blocking agents. However, if this condition persists for more than 20 to 30 seconds, it is considered an abnormal response, and the clinician needs to have a high level of concern for malignant hyperthermia (B). Persistent trismus is not a sign of inadequate neuromuscular blockade (A). The surgery should be canceled and the patient admitted for at least 24 hours of observation to watch for the development of rhabdomyolysis (C). In the absence of hemodynamic instability, elevated CO<sub>2</sub>, or temperature, it is unnecessary to administer dantrolene (D). However, these patients should be referred to a center that can perform the necessary testing, including genetic testing and caffeine halothane contracture test (muscle biopsy test). After muscle biopsy, the tissue is only viable for several hours, so testing must take place in centers specialized in diagnosing malignant hyperthermia (E).

**Reference:** Schneiderbanger, D., Johannsen, S., Roewer, N., et al. (2014). Management of malignant hyperthermia: diagnosis and treatment. *Journal of Therapeutics and Clinical Risk Management*, 10, 355–362.

15. **E.** Though direct visualization of the tube passing through the vocal cords, auscultation of the lungs, visualization of condensation within the tube, and pulse oximetry are good adjuncts to confirm initial placement of the endotracheal tube, interpretation is subjective and not as accurate as more objective methods for confirming position of the endotracheal tube within the trachea (A–C). Both the American College of Emergency Physicians and the American Society of Anesthesiologists recommend capnography or end-tidal CO<sub>2</sub> detection devices as the preferred confirmatory test for tracheal intubation. Chest x-ray should be performed after endotracheal intubation to ensure that the endotracheal tube tip is 3 to 6 cm from the carina (D).

**References:** American Society of Anesthesiologists Task Force on Management of the Difficult Airway. (2003). Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology*, 98(5), 1269–1277.

Pauze, D. & Burton, J. (2009). Focus on: confirmation and assessment of endotracheal tube location. *ACEP New*, 2009. Retrieved from <https://www.acep.org/Clinical--Practice-Management/Focus-On--Confirmation-and-Assessment-of-Endotracheal-Tube-Location/>.

16. **C.** While asymptomatic aortic stenosis is not a contraindication to surgery, it requires careful intraoperative monitoring. The increased pressures required to overcome the stenosis causes concentric hypertrophy of the left ventricle, which, in turn, reduces the compliance of the ventricle. This makes these patients heavily preload dependent for ventricular filling and careful attention should be paid to maintaining adequate intravascular volume (A). In addition, up to 40% of left ventricular end-diastolic volume is provided by the atrial kick. Atrial arrhythmias can quickly lead to heart failure and should be aggressively treated, preferably with defibrillation. Bradycardia should also be avoided because cardiac output is significantly affected with a reduction in heart rate. Hypotension and reductions in afterload will reduce coronary artery filling and increase the likelihood of cardiac ischemia (B). Any hypotension should be treated with small doses of selective  $\alpha$ -adrenergic agents such as phenylephrine (C, E). Sinus tachycardia and hypertension should be treated by increasing the depth of anesthesia. Because of the potential for bradycardia and hypotension with beta-blockers, these agents should be used with caution, and short-acting agents, such as esmolol, are preferred (D). To summarize, the goals of anesthesia in patients with aortic stenosis are avoidance of hypotension, ensuring adequate left ventricular end-diastolic volume (LVEDV) and maintenance of normal sinus rhythm.

**Reference:** Christ, M., Sharkova, Y., Geldner, G., et al. (2005). Preoperative and perioperative care for patients with suspected or established aortic stenosis facing noncardiac surgery. *Chest*, 128(4), 2944–2953.

17. **A.** Dopamine is an  $\alpha$ - and  $\beta$ -adrenergic agonist that exerts a variable effect dependent on the dose. However, regardless of dose, its effect on  $\alpha$ - and  $\beta$ -adrenergic receptors is generally weaker than epinephrine and norepinephrine. At lower doses (1 to 2 mcg/kg per minute), its predominant effect is on the dopaminergic receptors causing renal and visceral vasodilation (E). As you increase the dose to 3 to 10 mcg/kg per minute, the  $\beta_1$ -adrenergic receptors predominate; this is most similar to the effects of dobutamine or low dose epinephrine. This causes an increase in cardiac output primarily by increasing stroke volume (C). As you increase the dose further to greater than 10 mcg/kg per minute, the  $\alpha_1$ -adrenergic receptors predominate, leading to peripheral vasoconstriction; this is most similar to the effects of phenylephrine. Dopamine infusions do not significantly affect  $\alpha_2$ - and  $\beta_2$ -adrenergic receptors.

**Reference:** Han, J., et al. (2015). Sepsis, severe sepsis, and septic shock. In J. B. Hall, G. A. Schmidt, & J. P. Kress (Eds.), *Principles of critical care* (4th ed.). New York, NY: McGraw-Hill Professional.

18. **E.** Interscalene nerve block is a frequently performed and generally well-tolerated adjunct for upper extremity surgery. Local anesthetic is injected into the interscalene groove, which then disperses to block the brachial plexus (C5-T1). However, the origin of the phrenic nerve (C3-C5 nerve roots) is in close proximity to the target area of the block, especially high in the neck, and ipsilateral diaphragmatic paralysis is possible. One small study showed 100% incidence of diaphragm dysfunction when evaluated with ultrasound. This complication is generally well tolerated by patients with an adequate pulmonary reserve, but it can be very problematic in patients with lung disease. Ultrasound guidance, targeting the brachial plexus at a lower level in the neck, and lower volumes of anesthetic agent are used to help prevent this complication, but cranial spread of the agent is still possible. Pneumothorax is a known complication, but with bilateral breath sounds it would be unlikely (A). COPD exacerbation is also unlikely with such an acute onset (B). Air embolism is also unlikely with a percutaneous block (D). The toxic doses of intravenous bupivacaine are associated with cardiac and neurotoxicity, not isolated dyspnea (C).

**Reference:** Urmey, W., Talts, K., & Sharrrock, N. (1991). One hundred percent incidence of hemidiaphragmatic paresis associated with interscalene brachial plexus anesthesia as diagnosed by ultrasonography. *Anesthesia and Analgesia*, 72(4), 498–503.

19. **A.** Not all muscles respond in the same fashion to neuromuscular blockade. In general, central muscles (e.g., diaphragm) have a greater blood supply and will have a quicker onset and quicker recovery from paralysis compared with peripheral muscles (e.g., quadriceps femoris), which will have slower onset and slower recovery (E). Because of the variability in muscle relaxant duration and the potentially devastating complications of incomplete recovery before extubation, many argue that quantitative train of four testing should be routine for all cases. One important exception to this rule involves the muscles of the upper airway and pharynx, which have quick onset but slow offset (D). The ocular muscles tend to behave like central muscles and, for this reason, are an ideal muscle group to monitor at induction and during the operation because they will serve as a surrogate for measuring adequate blockade of the central muscles (C). Conversely, adductor pollicis is a good muscle group to monitor at the end of anesthesia because return of function will ensure that the central muscles and pharynx have recovered from blockade (B).

**Reference:** McGrath, C., & Hunter, J. (2006). Monitoring of neuromuscular block. *Continuing Education in Anaesthesia, Critical Care & Pain*, 6(1), 7–12.

20. **B.** Propofol is the most widely used drug for induction of anesthesia and has essentially replaced barbiturates for this indication. Because of its quick onset, relatively quick recovery, and antiemetic properties, it is an ideal agent for sedation. However, it is important to recognize that it has no analgesic properties and pain must be treated with coadministration of another drug. It is rapidly metabolized by the liver and excreted in the urine as an inactive metabolite, but plasma clearance is greater than would be expected for liver metabolism alone and another clearance mechanism, likely by the pulmonary system, is hypothesized (C). The main side effect of propofol is significant cardiac suppression and hypotension with induction, so use in the setting of depressed cardiac function or preexisting hypotension should be judicious. Propofol should be used within 8 hours of unsealing the bottle because there is a risk of bacterial contamination, but there is no contraindication to its use in neutropenia (D). Morphine, hydromorphone, and midazolam can all

accumulate in renal failure and should be used cautiously. Also, certain neuromuscular blockers (pancuronium, rocuronium, vecuronium) rely on a certain amount of renal excretion (A). The only anesthetic drug that is contraindicated in burns is succinylcholine, which can cause a rapid increase in intravascular potassium (E).

**Reference:** Eilers, H., et al. (2015). General anesthetics. In B. G. Katzung, & A. J. Trevor (Eds.), *Basic & clinical pharmacology* (13th ed.). New York, NY: McGraw-Hill.

21. **D.** Failure to regain muscle twitches after neuromuscular blockade should raise concern for a pseudocholinesterase deficiency. This patient was given succinylcholine for induction and because pseudocholinesterase is necessary for the degradation of succinylcholine, he is unable to reverse the neuromuscular blockade. The etiology of this disease process can be either acquired, such as in liver disease (C), or because of a genetic abnormality, inherited in an autosomal recessive fashion (E). Unfortunately, treatment is mainly supportive and patients have to be maintained on mechanical ventilation until spontaneous recovery takes place (A, B). Pseudocholinesterase also affects the metabolism of ester local anesthetics and up to 50% of the metabolism of cocaine, which increases their risk of life-threatening cocaine toxicity. The diagnosis is confirmed by a laboratory assay demonstrating decreased plasma cholinesterase enzyme activity.

**Reference:** Soliday, F., Conely, Y., & Henker, R. (2010). Pseudocholinesterase deficiency: a comprehensive review of genetic, acquired, and drug influences. *AANA Journal*, 78(4), 313–320.

22. **A.** Barbiturates are a class of medications that were previously used for anesthetic induction and seizures; however, they have largely been replaced by other agents for these two indications. As such, barbiturate toxicity is relatively rare. They are a central nervous system depressant and can cause effects ranging from drowsiness to general anesthesia. They inhibit neuron firing and are actually protective against seizures (E). Higher doses of barbiturates inhibit the respiratory drive and normal rhythmic respirations. Hepatotoxicity is not seen in barbiturate toxicity; however, it does inhibit CYP enzymes, which can increase concentrations of other drugs that undergo hepatic degradation (C). At the level of the peripheral nervous system, barbiturates decrease transmission through the autonomic nervous system and suppress nicotinic receptors, which contribute to hypotension but not peripheral neuropathy (D). At anesthetic doses, barbiturates do minimally suppress cardiac reflexes because of suppression of the autonomic ganglia, which is only problematic in patients with underlying cardiac disease. However, at toxic doses, there is direct suppression of cardiac contractility. Renal injury is likely secondary to hypotension rather than having any direct effect on the kidneys (B).

**Reference:** Mihic, S., et al. (2011). Hypnotics and sedatives. In L. L. Brunton, B. A. Chabner, & B. C. Knollmann (Eds.), *Goodman & Gilman's: the pharmacological basis of therapeutics* (12th ed.). New York, NY: McGraw-Hill.

23. **B.** Benzocaine toxicity can manifest as methemoglobinemia. In this condition, the ferrous component of hemoglobin is oxidized to form ferric hemoglobin, which does not effectively carry oxygen. Mild to moderate methemoglobinemia can cause marked cyanosis but is generally well tolerated and does not typically require mechanical intubation (A). Pulse oximetry will not reliably assess the degree of hypoxemia. It will be falsely elevated initially and can be falsely low after treatment. The partial pressure of oxygen in the blood ( $\text{PaO}_2$ ) will remain normal, so standard arterial blood gas analyzers, which calculate the oxygen saturation based off of the  $\text{PaO}_2$ , will show a falsely elevated oxygen saturation. Treatment is with intravenous methylene blue, which will reduce hemoglobin back to the ferrous state (B). Prilocaine has similar toxicity to bupivacaine and will not treat the underlying issue (C). Metoclopramide is used for delayed gastric emptying (D). Thiosulfate is used in the treatment of cyanide toxicity (E).

**Reference:** Blanc, P. (2012). Methemoglobinemia. In K. R. Olson (Ed.), *Poisoning & drug overdose* (6th ed.). New York, NY: McGraw-Hill Lange.

24. **C.** The gold standard to confirm endotracheal intubation is capnography. However, its use is dependent on appropriate pulmonary blood flow, and as such its utility is limited in the event of cardiopulmonary arrest. Additionally, capnography requires several breaths before it can produce an accurate result. And lastly, any airway obstruction as a result of epinephrine, which is used in advanced cardiac life support, will produce false-negative results. For these reasons, ultrasound is a useful adjunct when the use of capnography is limited. Its sensitivity and specificity in confirming ET placement are both 98%. In the above case, the low end-tidal  $\text{CO}_2$  is not a result of improper

placement but rather a direct consequence of prolonged cardiac arrest; thus removal of the ET tube and reintubation will not be helpful (A). Arterial blood gas is not appropriate to confirm ET tube placement because this requires a long turn-around time from the laboratory (D). Similarly, chest x-ray would take too long to be used as a way of confirming placement (B). Continuing to bag with 100% FiO<sub>2</sub> without confirming placement would be inappropriate (E).

**Reference:** Das, S. K., Choupoo, N. S., Haldar, R., et al. (2015). Transtracheal ultrasound for verification of endotracheal tube placement: a systematic review and meta-analysis. *The Canadian Journal of Anesthesia*, 62(4), 413–423.



# Fluids, Electrolytes, and Acid-Base Balance

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## Questions

1. A 25-year-old female is postoperative day 1 from a laparoscopic, converted to open cholecystectomy for acute cholecystitis. Since surgery, she has had one episode of emesis, urinary output has decreased to 0.3 cc/kg per hour, and serum sodium is found to be 131 mEq/L. Serum creatinine is normal, but antidiuretic hormone (ADH) level is elevated. What is the most likely cause of these findings?
  - A. Syndrome of inappropriate antidiuretic hormone secretion (SIADH)
  - B. Normal physiologic response to surgery
  - C. Acute kidney injury
  - D. Emesis
  - E. Congestive heart failure
2. A 65-year-old male with massive intracranial hemorrhage after a ruptured berry aneurysm is currently in the neurosurgical intensive care unit (ICU). Two days ago, he underwent intravascular coiling of the lesion. Because of increased urinary output over the last 24 hours, a urine sodium was measured and found to be 35 mEq/L. Current labs include a serum sodium of 128 mEq/L and a hemoglobin of 18 g/dL. Central venous pressure is 2 mm Hg. Which of the following is the most appropriate initial treatment?
  - A. Normal saline
  - B. Free water restriction
  - C. Desmopressin
  - D. Demeclocycline
  - E. Tolvaptan
3. A 75-year-old male is in the ICU due to sepsis 5 days after a colectomy for a perforated diverticulitis. While the nurse is checking his blood pressure, his hand went into a spasm. Which of the following is the most likely etiology?
  - A. Hypercalcemia
  - B. Hypermagnesemia
  - C. Hypomagnesemia
  - D. Hyponatremia
  - E. Hyperkalemia
4. The most effective method for the prevention of contrast-induced nephropathy (CIN) from computed tomography with intravenous contrast is:
  - A. Intravenous N-acetylcysteine
  - B. Normal saline bolus immediately before the exam followed by 6 hours of sodium bicarbonate and normal saline after the exam



- C. 12 hours of intravenous normal saline before and after the exam
  - D. Intravenous fluids with sodium bicarbonate 2 hours before exam and 12 hours after, as well as N-acetylcysteine
  - E. 6 hours of half normal saline before and after the exam
5. Which of the following causes of acidosis in the intensive care unit is best treated by administration of sodium bicarbonate?
- A. Lactic acidosis
  - B. Diabetic ketoacidosis
  - C. Respiratory acidosis from acute respiratory distress syndrome (ARDS)
  - D. Cardiac arrest
  - E. Renal tubular acidosis (RTA)
6. A 76-year-old female is postoperative day 4 from sigmoid colon resection. Her postoperative course has been uneventful, but she has not yet started passing flatus. Overnight, the urinary output has decreased to 20 cc/hour, and the patient has had several episodes of emesis. Lab work includes a blood urea nitrogen (BUN) of 40 mg/dL and serum creatinine of 1.5 mg/dL. Urinary sodium is 10 mEq/L. What is the most likely etiology of oliguria in this patient?
- A. Postoperative ileus
  - B. Intra-abdominal hemorrhage
  - C. Intraoperative hypotension
  - D. Inadvertent ligation of the left ureter
  - E. Drug-induced nephrotoxicity
7. Which of the following is true regarding dehydration and/or hypovolemia in children?
- A. Children only need to lose 5% of total body water to produce significant symptoms of hypovolemia.
  - B. Hypovolemia refers to a reduction in free water.
  - C. Dehydration will primarily result in extracellular fluid losses.
  - D. Profound hypernatremic hypovolemia should be corrected initially with hypotonic fluids.
  - E. Oral fluid replacement is adequate in most children with insensible fluid losses.
8. Which of the following is considered a normal physiologic change in pregnancy?
- A. Decrease in blood pH
  - B. Decrease in minute ventilation
  - C. Increased vital capacity
  - D. Right-shift of oxyhemoglobin dissociation curve
  - E. Relative leukopenia
9. Which of the following is true regarding sodium and water maintenance in the geriatric patient?
- A. There is an increase in the ratio of intracellular to extracellular water.
  - B. A hyperactive thirst response predisposes geriatric patients to hyponatremia.
  - C. Elevated antidiuretic hormone levels predispose patients to sodium retention.
  - D. Atrial natriuretic peptide level increases with aging.
  - E. There is a relative increase in the activity of the renin-angiotensin-aldosterone system.
10. An elderly patient presents to the emergency department (ED) with increased thirst and urinary output. Which of the following findings would be most helpful to suggest diabetes insipidus (DI) as the likely etiology in this patient?
- A. Hypernatremia
  - B. Hyperglycemia
  - C. Hyponatremia
  - D. Low urine osmolality
  - E. High serum-to-urine osmolality ratio

11. A 58-year-old male alcoholic presents to the ED complaining of increased abdominal girth over the last several weeks. He underwent a diagnostic ultrasound 1 year ago, which showed evidence of cirrhosis. Physical exam reveals pitting edema of the lower extremities and positive abdominal fluid wave. In addition to alcohol cessation, what is the next step in management?
- A. Free water restriction
  - B. Transjugular intrahepatic portosystemic shunt
  - C. Intravenous furosemide with transition to PO once ascites resolves
  - D. Strict sodium restriction (<1 g per day)
  - E. Combination of oral furosemide and spironolactone
12. A 45-year-old male with congestive heart failure is being treated in the ICU for sepsis secondary to pneumonia. Over the last 24 hours, he has received 11 L of crystalloid and was started on vasopressors for hypotension. His urine output has dropped to 20 mL/hour. Delivered tidal volumes on the mechanical ventilator have also significantly decreased. Physical exam reveals a tense abdomen, abdominal fluid wave, and anasarca. Current bladder pressure is 25 mm Hg. The most appropriate initial management is:
- A. Neuromuscular blockade
  - B. Immediate decompressive laparotomy
  - C. Percutaneous drainage of intra-abdominal fluid
  - D. Continuous renal replacement therapy
  - E. Change resuscitative fluid to albumin
13. Which of the following is true regarding lactated Ringer's solution when used as an intravenous fluid?
- A. It is equally suitable as a maintenance or resuscitative fluid.
  - B. It is useful in acidosis because of the bicarbonate content of the solution.
  - C. It is an aqueous solution composed of only sodium chloride, sodium lactate, calcium chloride, and potassium chloride salts.
  - D. The pH of the solution itself is 7.5.
  - E. Sodium content is equivalent to normal serum.
14. Which of the following is true regarding serum osmolarity and serum osmolality?
- A. Large proteins, like albumin, are the most important contributors to serum osmolality.
  - B. The presence of an osmolar gap indicates the presence of a foreign molecule that readily distributes across cell membranes.
  - C. The difference between serum osmolarity and serum osmolality is highly variable depending on the physiologic state.
  - D. Sodium is multiplied by two in the calculation for serum osmolarity because of its increased osmotic activity.
  - E. The number of molecules, and not the size, is the most important contributor to serum osmolarity.
15. A 62-year-old female was recently diagnosed on upper endoscopy with a near obstructing distal gastric tumor but was subsequently lost to follow-up. She now returns to the ED with 24 hours of nonbilious vomiting and abdominal pain. What is the most significant contributing factor to hypokalemia in this patient?
- A. Intracellular shift
  - B. Increased excretion in the urine
  - C. Loss of potassium with emesis
  - D. Metabolic acidosis
  - E. Hypokalemic fluid replacement
16. Which of the following is true regarding commonly used resuscitative or maintenance fluids?
- A. Normal saline is preferred over lactated Ringer's solution in burn patients.
  - B. Five percent albumin solution draws fluid from the extravascular space by increasing colloid oncotic pressure.

- C. Five percent dextrose in water is iso-osmolar to serum.
  - D. Lactated Ringer's solution will worsen an existing lactic acidosis.
  - E. In order to replace lost intravascular volume, twice the volume of crystalloid must be infused.
17. A 48-year-old male with past medical history of alcoholic cirrhosis and refractory ascites is admitted to the ICU recovering from spontaneous bacterial peritonitis (SBP). He is now off of antibiotics, and there is no evidence of continued infection. Over the course of his hospitalization, his creatinine level increased from 1.0 to 1.6 mg/dL. Urinalysis reveals no evidence of proteinuria or microhematuria. Which of the following is the initial step in management?
- A. Fluid resuscitation with normal saline
  - B. Cessation of diuretics
  - C. Terlipressin and albumin
  - D. Initiation of continuous renal replacement therapy
  - E. Transjugular intrahepatic portosystemic shunt (TIPS)
18. A 24-year-old female underwent a jejunal resection complicated by abdominal compartment syndrome and an open abdomen after a motor vehicle collision. She is eventually discharged home but returns 1 week later with copious output of yellowish fluid from her midline wound. She has noted diminished urinary output, is tachycardic, and has decreased skin turgor. What combination of electrolyte abnormalities is most likely present in this patient?
- A. Hyponatremia, hypokalemia, and metabolic acidosis
  - B. Hypokalemia, hypochloremia, and metabolic alkalosis
  - C. Hyponatremia, hyperkalemia, and metabolic acidosis
  - D. Hypernatremia and metabolic acidosis
  - E. Hyperkalemia and metabolic alkalosis
19. A 55-year-old male is admitted to the hospital with altered mental status. Paramedics report that they found multiple empty beer cans in his home. He is found to have a serum alcohol concentration of 255 mg/dL and a serum sodium concentration of 118 mEq/L. Fluid resuscitation is initiated with normal saline and sodium levels return to normal by the next morning. On hospital day 5, he develops spastic quadriplegia and is unresponsive to external stimuli. Which of the following is true regarding this condition?
- A. It could have been prevented with the use of hypertonic saline.
  - B. Desmopressin can be used as an adjunct to fluid replacement to prevent this complication.
  - C. Cerebral adaptations to hyponatremia take up to a week to develop.
  - D. Recovery is impossible after the onset of neurologic symptoms.
  - E. Injury is restricted to the pons.
20. A 50-year-old, type I diabetic male is admitted to the hospital for the workup of vague abdominal pain and subjective fevers. Past medical history includes total proctocolectomy with ileostomy for ulcerative colitis. Routine laboratory values include: pH 7.26, pCO<sub>2</sub> 24 mm Hg, pO<sub>2</sub> 100 mm Hg, sodium 129 mEq/L, potassium 2.9 mEq/L, chloride 110 mEq/L, and bicarbonate 12 mEq/L. Which of the following is the most likely diagnosis?
- A. Excessive ileostomy output
  - B. Kidney failure
  - C. Diabetic ketoacidosis
  - D. Lactic acidosis
  - E. Methanol intoxication
21. A 16-year-old girl arrives via ambulance after the family became concerned that she was behaving strangely. She appears disoriented and will answer simple questions but is evasive in answering questions about events leading up to her arrival. Vital signs are normal except for a respiratory rate of 7 and a body mass index (BMI) of 16. Arterial blood gas and basic metabolic panel are consistent with a metabolic alkalosis. Which of the following tests will be most helpful in establishing a diagnosis?
- A. Urine drug screen

- B. Computed tomography of the brain
  - C. Spot urine chloride concentration
  - D. Electrocardiogram (ECG)
  - E. Abdominal ultrasound
22. After cardiac arrest and successful return of spontaneous circulation in a 63-year-old male, mild therapeutic hypothermia (MTH) is initiated. Which of the following is true regarding the physiologic changes associated with this treatment?
- A. Central venous pressure will decrease.
  - B. During rewarming, hypokalemia can be problematic.
  - C. Acidosis and elevated lactate are indicative of treatment failure.
  - D. Hypothermia induces diuresis by the kidneys.
  - E. It is frequently deleterious on cardiac function.
23. A 57-year-old female with end-stage renal disease on peritoneal dialysis is postoperative day 1 from a small bowel resection. A basic metabolic panel reveals a potassium level of 6.3 mEq/L. An electrocardiogram is obtained that shows no significant change from baseline. The resident administers 1 g of calcium gluconate, 50 mL of 50% dextrose in water, and 10 units of intravenous insulin and delivers a nebulized albuterol treatment. The patient then undergoes urgent hemodialysis. Six hours later, the potassium level is found to be 7.0 mEq/L. Which of the following is true?
- A. Monotherapy with calcium gluconate was likely adequate.
  - B. Sodium polystyrene sulfonate (Kayexalate) in sorbitol should have been administered.
  - C. Sodium bicarbonate should have been included in the treatment regimen.
  - D. Calcium gluconate, dextrose, insulin, and albuterol were not indicated.
  - E. Peritoneal dialysis would have provided superior clearance of potassium.

## Answers

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1. **B.** After a major operation, there is both an endocrine and a cytokine response to the stress. This can be partly inhibited by blocking painful stimuli from reaching the central nervous system, but it is also mediated by the effects of local tissue damage. Of the numerous physiologic responses, retention of sodium and water is likely the most significant. This is dependent on multiple factors, including the effects of anesthetic drugs, renal vasoconstriction from catecholamines, increased plasma cortisol and aldosterone, and increased secretion of antidiuretic hormone (ADH). During an operation, ADH levels will increase up to 100× normal. Though they begin to drop at the end of the operation, they remain elevated for several days. This response is largely secondary to the loss of intravascular volume by sequestration in injured tissues or “third-spacing,” dehydration from prolonged fasting, and insensible losses during the operation. This results in postoperative oliguria and hyponatremia. In this setting, the elevated level of ADH is not “inappropriate”; instead this is a normal physiologic response to stress and decreased intravascular volume. In critically ill patients, the ADH level may get inappropriately high due to dysregulation of the hypothalamus-pituitary axis resulting in SIADH. This subsequently leads to secretion of the natriuretic peptides to induce loss of sodium and water resulting in a euvolemic state. Additionally, the loss of sodium is much greater than that of water such that patients with SIADH have a significantly lower level of sodium compared with the mild hyponatremia seen postoperatively (A). By definition, this patient cannot have acute kidney injury with a normal creatinine clearance (C). Excess vomiting can present as hyponatremia, but a single episode of emesis is unlikely to produce this effect (D). Congestive heart failure is an unlikely cause of hyponatremia without other associated symptoms (E).

**Reference:** Rassam, S. et al. (2005). Perioperative electrolyte and fluid balance. *Continuing Education in Anaesthesia, Critical Care & Pain*, 5(5), 157–160.

2. **A.** In a neurologically injured patient with hyponatremia and elevated urinary sodium, the two most likely diagnoses are SIADH or an isolated natriuresis from elevated atrial natriuretic peptide (cerebral salt wasting syndrome). SIADH can have a natriuresis component as described in

**question 1.** Though they have similar laboratory findings, the hyponatremia in cerebral salt wasting is caused by excessive urinary losses of sodium as opposed to excess water retention with SIADH. This means that the only measurable difference between SIADH and cerebral salt wasting is the intravascular volume status of the patient, hypovolemia for the latter and euvolemia or hypervolemia for the former. Cerebral salt wasting is classically described as a patient with a subarachnoid hemorrhage and a sudden increase in urine output, which leads to hyponatremia and hypovolemia. The cause of cerebral salt wasting syndrome has not been completely characterized, and it is unclear whether natriuretic factors are released from the brain or are simply a downstream consequences of hormonal effects from the brain injury. The proposed theoretic mechanism is excessive release of atrial natriuretic peptide (ANP) from the cardiac myocytes in the right atrium. However, there are some authors who argue that this is simply a manifestation of SIADH because ANP levels will naturally rise to counteract the effects of ADH. Regardless, the low central venous pressure (CVP) and elevated hemoglobin in this patient indicate a reduction in intravascular volume, which should be replaced with normal saline. Fluid restriction, in an attempt to treat SIADH, could potentially cause worsening cerebral ischemia (B). Desmopressin is an ADH analogue used to treat central diabetes insipidus (inadequate production of ADH), which is characterized by excessive output of dilute urine and normal to high plasma sodium (C). Demeclocycline is a tetracycline antibiotic that blocks the responsiveness of the renal collecting tubules to ADH; it is used off-label as an adjunct to treat SIADH that is unresponsive to fluid restriction (D). The “vaptans” are a category of medications that function as vasopressin receptor antagonists and have also been used to treat SIADH (E).

**References:** Robinson, A. (2011). The posterior pituitary (neurohypophysis). In D. G. Gardner, & D. Shoback (Eds.), *Greenspan's basic & clinical endocrinology* (9th ed.). New York, NY: McGraw-Hill.

Ropper, A., et al. (2014). The hypothalamus and neuroendocrine disorders. In A. H. Ropper, M. A. Samuels, & J. P. Klein (Eds.), *Adams & Victor's principles of neurology* (10th ed.). New York, NY: McGraw-Hill.

3. **C.** Hypomagnesemia is one of the most common electrolyte abnormalities in hospitalized patients (11–65%) and particularly in critically ill patients. Most patients are asymptomatic but can become symptomatic as the level drops below 1.2 mg/dL. Symptoms can manifest as simple neuromuscular irritability, as demonstrated above by the presence of Trousseau sign (spasm of the forearm and hand with occlusion of the brachial artery) or, in more serious cases, as tetany, nystagmus, and seizures. Depletion of magnesium also leads to both atrial and ventricular arrhythmias. However, hypomagnesemia commonly presents in the presence of other electrolyte deficiencies, and the individual contribution of magnesium is often difficult to determine. Replacement therapy for symptomatic magnesium deficiency is mandatory, but the treatment of asymptomatic hypomagnesemia is less well defined. Rubeiz et al. showed increased mortality in patients with hypomagnesemia on admission to the medical ICU or ward. Similarly, a review article published in the *Journal of Clinical Medicine Research*, which included 20 different studies, showed a correlation between low magnesium levels and increased adverse outcomes and mortality in patients with sepsis. Hypercalcemia, hypermagnesemia, hyponatremia, and hyperkalemia would not present with neuromuscular irritability (A, B, D, E).

**References:** McEvoy, C., et al. (2015). Electrolyte disorders in critical care. In J. B. Hall, G. A. Schmidt, & J. P. Kress (Eds.), *Principles of critical care* (4th ed.). New York, NY: McGraw-Hill.

Rubiez, G., Thill-Baharozian, M., Hardie, D., et al. (1993). Association of hypomagnesemia and mortality in acutely ill medical patients. *Critical Care Medicine*, 21(2), 203–209.

Velissaris, D., Karamouzou, V., Pierrakos, C., et al. (2015). Hypomagnesemia in critically ill sepsis patients. *Journal of Clinical Medicine and Research*, 7(12), 911–918.

4. **C.** CIN is a controversial topic in the medical literature. Some sources, such as the American College of Radiology Manual on Contrast Media, believe the actual incidence to be much lower because of the currently loose definitions of inclusion and a relatively poorly understood physiologic mechanism. While others, such as Mitchell and colleagues in *The Clinical Journal of the American Society of Nephrology*, believe that we may be underreporting and underemphasizing the clinical importance of this disease. Likewise, methods for the prevention of CIN are equally controversial and have varied significantly over the last several decades. The American College of Radiology, The Canadian Association of Radiologists, and The Renal Association (a British nephrology organization) all agree that the most important aspect of prevention is fluid hydration.



While the most significant reduction in CIN is seen with 12 hours of pre- and postscan hydration (D), all organizations recognize that this is likely unfeasible for outpatient procedures and that shorter time periods can likely be used safely. Normal saline is the fluid of choice (E). While sodium bicarbonate was shown initially to be a helpful adjunct, follow-up studies were unable to produce the same clinically significant benefit. While unlikely to be deleterious, the extra cost and possibility of compounding errors make normal saline a more attractive option (B). All three organizations make similar recommendations about N-acetylcysteine; it is likely safe but there is no convincing evidence for its routine use (D). There is some argument that N-acetylcysteine may actually mask the presence of CIN, rather than treat it, because of an observed reduction in creatinine in normal healthy patients (A).

**References:** ACR Committee on Drugs and Contrast Media. (2015). Post-contrast acute kidney injury and contrast-induced nephropathy in adults. *ACR Manual on Contrast Media*, v10.1.

Lewington, A., MacTier, R., Hoefield, R., et al. Prevention of contrast induced acute kidney injury (CI-AKI) in adult patients. *The Renal Association, British Cardiovascular Intervention Society and Royal College of Radiologists*, 2013. Retrieved from [http://www.renal.org/docs/default-source/guidelines-resources/joint-guidelines/Prevention\\_of\\_Contrast\\_Induced\\_Acute\\_Kidney\\_Injury\\_CI-AKI\\_In\\_Adult\\_Patients.pdf](http://www.renal.org/docs/default-source/guidelines-resources/joint-guidelines/Prevention_of_Contrast_Induced_Acute_Kidney_Injury_CI-AKI_In_Adult_Patients.pdf).

Mitchell, A., Jones A., Tumlin, J., et al. (2010). Incidence of contrast-induced nephropathy after contrast-enhanced computed tomography in the outpatient setting. *Clinical Journal of the American Society of Nephrology*, 5(1), 4–9.

Owen, R., Hiremath, S., Myers, A., et al. (2014). Canadian Association of Radiologists consensus guidelines for the prevention of contrast-induced nephropathy: update 2012. *Canadian Association of Radiologists Journal*, 65(2), 96–105.

5. **E.** Acidosis has multiple, well-documented physiologic consequences ranging from cardiovascular (decrease inotropy and conduction defects) to metabolic (insulin resistance and protein wasting) to electrolyte disturbances. However, in certain situations, this acidosis may actually be beneficial, such as the shift of the oxyhemoglobin curve to favor unloading of oxygen at the tissues. As our understanding of acid-base disorders improves, treatment has begun to focus more on augmenting respiratory compensation and treating the underlying condition than directly buffering the blood. While the use of sodium bicarbonate can potentially increase blood pH, this does not seem to translate to improved survival and can be potentially deleterious. Treatment relies on adequate ventilation to deal with the CO<sub>2</sub> produced by buffering of hydrogen ions by bicarbonate. When CO<sub>2</sub> begins to accumulate it diffuses readily into cells and worsens intracellular acidosis, even in the setting of an improved blood pH. One important exception is the use of bicarbonate to treat certain forms of RTA. Because the primary problem is impaired buffering of the urine, use of sodium bicarbonate or alkalinizing potassium salts will correct the acidosis and improve the electrolyte disturbances. Current literature does not support the use of sodium bicarbonate with lactic acidosis or diabetic ketoacidosis (A, B). While the original ARDS net studies allowed the use of blood buffering with sodium bicarbonate, its benefit on mortality has yet to be definitively shown (C). Current Advanced Cardiovascular Life Support (ACLS) guidelines do not recommend the routine use of sodium bicarbonate in cardiac arrest, except in specific situations such as hyperkalemia or tricyclic antidepressant overdose (D).

**References:** Kaufman, D., et al. (2015). Acid-base balance. In J. B. Hall, G. A. Schmidt, & J. P. Kress (Eds.), *Principles of critical care* (4th ed.). New York, NY: McGraw-Hill.

Wiederkehr, M., & Moe, O., (2013). Core concepts and treatment of metabolic acidosis. In D. B. Mount, M. H. Sayegh, & A. J. Singh (Eds.), *Core concepts in the disorders of fluid, electrolytes and acid-base balance* (pp. 235–274). New York, NY: Springer U.S.

6. **A.** The first step in identifying the etiology of oliguria is an adequate history and analysis of the BUN:creatinine ratio. A BUN:creatinine ratio of greater than 20 with a history of hypoperfusion or hypotension is virtually diagnostic of prerenal azotemia. However, no such history is provided in this vignette. At this point, urinalysis is necessary. A low urinary sodium concentration (<20 mEq/L) or a low fractional excretion of sodium (<1%) is indicative of a prerenal cause of acute kidney injury. In the presence of emesis and failure to pass flatus, ileus is the most likely diagnosis (A). Ileus or small bowel obstruction can lead to significant intra-abdominal fluid sequestration that without adequate fluid resuscitation decreases renal blood flow and subsequently urinary output. The low urinary sodium is the result of physiologically elevated ADH secondary to the hypovolemia.

Though intra-abdominal hemorrhage would lead to a similar clinical picture, bleeding is more common earlier in the postoperative period (POD 0-1) (B). You would also expect the consequences of intraoperative hypotension to present earlier (C). Drug-induced nephrotoxicity is an intrinsic acute kidney injury and urinary sodium would not be low (E). Inadvertent ligation of the ureter typically does not present with oliguria unless both sides are affected (D).

7. **E.** Though frequently used interchangeably, dehydration and hypovolemia are separate clinical entities. Dehydration refers to a reduction in free water (fluid loss in excess of solute loss), while hypovolemia is a loss of circulating extracellular volume (B). This is an important distinction because of the distribution of total body water. Two-thirds of total body water is intracellular, which means that dehydration will primarily result in intracellular fluid losses (C). In fact, almost 10% of total body water needs to be lost before significant signs of hypovolemia manifest. Hypovolemia from dehydration is relatively rare in people with access to water because the increase in plasma osmolality stimulates a strong thirst response, which is why it typically only presents when people are reliant on others (children and the elderly) (A). In hypovolemia, the serum sodium will correspond with the type of fluid lost and any prehospital replacement that has taken place. Insensible losses, such as sweating, will result in hypernatremia because the fluid lost is hypotonic to plasma and increases in ADH will result in sodium and water retention. Secretory diarrhea or bleeding, on the other hand, results in fluid losses that are isotonic to plasma and don't have a direct effect on serum sodium levels. However, replacement of these losses with hypotonic fluids will lead to hyponatremia. Profound hypernatremic hypovolemia mandates rapid intravascular volume replacement with intravenous isotonic fluids. After the severe volume depletion is treated, replacement of the free water deficit can take place more slowly. Care should be taken to avoid rapid correction of the hypernatremia because it can precipitate cerebral edema (D). Unless there are direct contraindications, such as altered mental status or vascular compromise, oral replacement therapy is likely adequate and is the preferred replacement strategy by the American Academy of Pediatrics.

**Reference:** Spandorfer, P., Alessandrini, E., Joffe, M., et al. (2005). Oral versus intravenous rehydration of moderately dehydrated children: a randomized, controlled trial. *Pediatrics*, 115(2), 295–301.

8. **D.** Pregnancy causes a number of physiologic changes either to improve conditions for the developing fetus or as a side effect of the increased metabolic demands placed on the mother. From a respiratory standpoint, the changes are primarily related to the increased production of progesterone and the mass effect of the uterus on the diaphragm. Progesterone acts on the central nervous system to lower  $\text{CO}_2$  levels. In an effort to lower  $\text{pCO}_2$ , the tidal volume and respiratory rate increase causing an increase in minute ventilation (B). This reduction in the  $\text{pCO}_2$  causes a respiratory alkalosis (A). Mass effect from the uterus causes a reduction in inspiratory and expiratory reserve, as well as functional and residual capacity. However, vital capacity remains relatively unchanged (C). The increased metabolic demands require an increase in oxygen delivery. This is accomplished by an increase in cardiac output. The total blood volume increases proportionally to the cardiac output, but the increase in plasma volume is greater than the increase in red blood cell mass, which causes a dilutional anemia. The increased cardiac output proportionally increases the glomerular flow rate of the kidney and reduces circulating urea. The oxyhemoglobin dissociation curve also shifts to the right to facilitate unloading of oxygen to the fetus. In addition to the increased affinity of fetal hemoglobin for oxygen, there is an increase in 2,3-DPG, which further facilitates delivery of oxygen to the fetus. There is a mild reduction in platelets, likely because of increased platelet aggregation from hypercoagulability. However, there is an increase in circulating white blood cells (E).
9. **D.** Numerous physiologic changes to aging diminish the geriatric population's ability to adapt to changes in environment or health, especially regarding the maintenance of water and electrolyte balance. Loss of lean body mass decreases total body water and decreases the ratio of intracellular to extracellular water (A). This results in a diminished ability to respond to fluid losses because there is less water to mobilize from the intracellular space. In addition, the older population has a diminished thirst response to changes in serum osmolality (B). The kidney itself also undergoes structural changes that result in a diminished glomerular filtration rate, which decreases the kidneys' ability to dilute urine in response to a water load. However, the kidney also shows diminished ability to concentrate the urine in response to dehydration. This is partly due to



reduced responsiveness to ADH in the aged kidney (C). Atrial natriuretic peptide levels, on the other hand, increase, which further contributes to renal salt and water wasting. The renin-angiotensin-aldosterone system is also suppressed, leading to dysregulation of sodium and potassium balance (E).

**References:** El-Sharkawy, A., Sahota, O., Maughan, R., et al. (2014). The pathophysiology of fluid and electrolyte balance in the older adult surgical patient. *Clinical Nutrition (Edinburgh, Scotland)*, 33(1), 6–13.

Miller, M. (2009). Disorders of fluid balance. In J. B. Halter, J. G. Ouslander, M. E. Tinetti, et al., (Eds.), *Hazzard's geriatric medicine and gerontology* (6th ed.). New York, NY: McGraw-Hill.

10. E. DI is a disease process characterized by either a low level of ADH (central DI) or diminished renal response to ADH (nephrogenic DI). The first step in the evaluation of polyuria is the measurement of serum electrolytes, serum glucose, and urine and serum osmolality. In the absence of osmotic diuresis from hyperglycemia (i.e. diabetes mellitus), primary polydipsia, central DI and nephrogenic DI are the most common etiologies (B). All three entities will show increased production of dilute urine, or low urine osmolality (D). However, in primary polydipsia this is a normal response to increased water intake. Serum sodium levels will generally be low because of the increased intake of water. Increased urinary output with hyponatremia, low urine osmolality, and low or normal serum osmolality is virtually diagnostic (C). Diabetes insipidus, on the other hand, will be associated with low urine osmolality in the presence of elevated serum osmolality. Though hypernatremia is possible because of the excessive loss of water in the urine, in general, patients are able to compensate for the increased urinary output with increased oral intake of water (A). Suspensions can be confirmed with a water deprivation test. In primary polydipsia, the urinary output will decrease and the urine osmolality will increase as the test progresses because the stimulus for the polyuria has been removed. However, patients with DI lack the ability to concentrate urine so the production of dilute urine will continue, despite rising serum osmolality. Once the patient's serum osmolality increases to a sufficient level, the administration of vasopressin will differentiate between nephrogenic and central DI. In central DI, the vasopressin will allow the kidneys to concentrate the urine. In nephrogenic DI, no response to exogenous vasopressin will be expected because the problem is the kidney's response to, not the absence of, ADH.
  11. E. The mobilization of ascites in cirrhotic patients requires a negative sodium balance. This is accomplished through limiting oral intake of sodium and initiation of diuresis. In the absence of significant hyponatremia ( $<125$  mEq/L), free water restriction is generally not indicated (A). The problem lies in the inappropriate retention of sodium by the kidney, not excess free water. Diuresis should be initiated with an initial goal of negative 1 L/day, though 500 mL/day is likely adequate in the absence of peripheral edema. Oral spironolactone and furosemide should be initiated at an initial dose of 100 mg and 40 mg, respectively, per day. These can be increased to a maximum daily dose of 400 mg spironolactone and 160 mg furosemide. Simultaneous administration of these two medications potentiates the natriuretic effect of each and limits the potassium imbalance that can be seen with either agent alone. Unlike ascites secondary to heart failure, intravenous administration of diuretics in cirrhotics with new onset ascites should generally be avoided because it can frequently result in azotemia (C). While strict sodium restriction will result in faster mobilization of ascites, the diet is more difficult to adhere to and can potentially worsen any malnutrition that is present; a sodium restriction of less than 2 g/day is generally all that is required (D). All patients should be considered for liver transplant because the onset of ascites is associated with a significantly worsened prognosis. Patients with ascites refractory to diuretics can be considered for serial paracentesis or portosystemic shunt. Transjugular intrahepatic portosystemic shunt is preferred over surgical shunts (B).
- References:** Runyon, B. (2012). Management of adult patients with ascites due to cirrhosis: update 2012. *AASLD Practice Guideline, AASLD*. Retrieved from [http://www.aasld.org/sites/default/files/guideline\\_documents/adultascitesenhanced.pdf](http://www.aasld.org/sites/default/files/guideline_documents/adultascitesenhanced.pdf).
- Wong, P., et al. (2012). Cirrhosis and its complications. In S. C. McKean, J. J. Ross, D. D. Dressler, et al., (Eds.), *Principles and practice of hospital medicine*. New York, NY: McGraw-Hill.
12. C. Abdominal compartment syndrome is defined as a sustained intra-abdominal pressure of greater than 20 mm Hg that is associated with new onset organ failure. Early clinical signs are oliguric acute kidney injury and increased peak airway pressures or decreased tidal volumes in a

pressure mode of ventilation. It is further subdivided into primary and secondary depending on the etiology. Primary abdominal compartment syndrome refers to etiologies that arise in the abdomen (such as volvulus or colonic pseudo-obstruction), and current recommendations are for immediate decompressive laparotomy (B). However, in secondary abdominal compartment syndrome, such as cirrhotics or patients with congestive heart failure with tense ascites, nonsurgical treatments can first be attempted. In 2011, Cheatham and others treated abdominal compartment syndrome from ascites with percutaneous drainage and 81% of study participants were successfully treated without a decompressive laparotomy (C). While the most recent consensus guidelines released by the World Society of the Abdominal Compartment Syndrome still advocate surgical intervention for abdominal compartment syndrome, they also maintain that the use of percutaneous catheter drainage for the treatment of obvious intraperitoneal fluid contributing to abdominal compartment syndrome should be used in place of decompressive laparotomy when it is technically feasible because it may alleviate the need for surgery. While neuromuscular blockade and diuresis may help with the treatment of intra-abdominal hypertension, worsening kidney and lung function requires immediate intervention (A, D). The role of albumin in abdominal compartment syndrome is still controversial (E).

**References:** Cheatham, M., & Safcsak, K. (2011). Percutaneous catheter decompression in the treatment of elevated intraabdominal pressure. *Chest*, 140(6), 1428–1435.

Kirkpatrick, A., Roberts, D., De Waele, J., et al. (2013). Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome. *Intensive Care Medicine*, 39(7), 1190–1206.

13. **C.** Lactated Ringer's solution is a crystalloid solution that was designed to mimic normal physiologic concentrations of ions. It is made by creating an aqueous solution using sodium chloride, sodium lactate, calcium chloride, and potassium chloride salts. Though ion concentrations can change slightly between manufacturers, the ionized content of lactated Ringer's solution is 130 mEq of sodium, 109 mEq of chloride, 28 mEq of lactate, 4 mEq of potassium, and 3 mEq of calcium (E). It is generally considered a poor maintenance fluid because of the low potassium concentration, absence of glucose, and the propensity to develop metabolic alkalosis (A). The lactate in the solution is metabolized and the net result is release of a bicarbonate ion, which has a net effect of alkalinizing the blood (B). While it does have an alkalinizing effect on blood pH, the pH of the solution itself is actually slightly acidic at 6.5 (D).
14. **E.** Osmolarity and osmolality represent the number of osmotically active solutes (osmoles) in a given solution. Osmolarity is the number of osmoles in a liter of solution, and osmolality is the number of osmoles in a kg of water. Because the volume of a solution can vary slightly depending on temperature, osmolality is technically more precise, but under normal physiologic conditions the terms are essentially interchangeable because 1 L of water weighs 1 kg (C). Because the kinetic energy of dissolved solutes is based on the number, and not the size, large proteins like albumin have a relatively low contribution compared to more abundant molecules, like sodium (A). In order to contribute osmotic pressure across a semipermeable membrane, the dissolved solute must not be able to readily diffuse across the membrane. Thus, a foreign molecule that readily distributes intracellularly does not contribute to serum osmolality or an osmolar gap (B). The equation for the calculation of serum osmolality is  $2 [\text{Na}] + [\text{glucose}]/18 + [\text{BUN}]/2.8$ . Sodium is multiplied by two to account for the corresponding anions (chloride and bicarbonate) that would otherwise need to be added separately (D). Serum osmolality can also be directly measured, normally by freezing point depression, and compared to the calculated value. If there is a significant difference between the calculated and measured serum osmolality, it indicates the presence of an osmotically active foreign solute, like methanol.
15. **B.** Gastric outlet obstruction and large volume emesis results in significant volume loss in addition to hydrogen and chloride ions. Though gastric juice has a higher concentration of potassium than serum, at 10 mEq/L, the overall potassium content is low and relatively insignificant compared with the loss of hydrogen and chloride (C). This subsequently leads to a hypochloremic metabolic alkalosis, not an acidosis (D). The volume depletion, initially, is counteracted by mobilization of extravascular fluids so the kidney maintains a relatively constant flow. Initially, the kidney responds by excreting the excess bicarbonate in the urine in combination with sodium and potassium to balance the negative charge. However, as more sodium is lost and hypovolemia becomes more apparent, the renin-angiotensin-aldosterone system is activated. This

increases the absorption of sodium and water, but potassium continues to be excreted, leading to hypokalemia. Eventually the kidney will begin to compensate for the hypokalemia by exchanging potassium ions for hydrogen ions, which perpetuates the alkalosis and causes the paradoxical aciduria associated with excessive loss of gastric contents. Though alkalosis does cause an intracellular shift of potassium ions, the effect is variable and does not account for the significant hypokalemia seen with metabolic alkalosis (A). Before replacement of the hypokalemia, volume expansion with crystalloid is recommended, which will reduce the effects of aldosterone and potassium loss in the urine (E).

**References:** Aronson, P., & Giebisch, G. (2011). Effects of pH on potassium: new explanations for old observations. *Journal of the American Society of Nephrology*, 22(11), 1981–1989.

Hamm, L., Hering-Smith, K., & Nakhoul, N. (2013). Acid-base and potassium homeostasis. *Seminars in Nephrology*, 33(3), 257–264.

16. **C.** Intravenous fluids can be broadly categorized into colloids or crystalloids based on how they contribute to colloid oncotic pressure. Osmotic pressure can be simplified as the propensity to keep water on one side of a semipermeable membrane (i.e., the cell wall). Any molecule dissolved in solution that cannot cross the membrane contributes to this pressure. Physiologically, this is primarily determined by sodium and its associated anions. Colloid oncotic pressure is the portion of osmotic pressure that is contributed by large molecules. In plasma, this is primarily determined by albumin and makes up less than 1% of the total osmotic pressure. However, it contributes heavily to keeping water in the intravascular component of the extracellular space. Finally, tonicity is the difference in osmolality between two solutions and is only determined by solutes that cannot cross a specific semipermeable membrane. This is important because certain solutions, like 5% dextrose in water, can be iso-osmolar but still hypotonic. Because dextrose is rapidly taken up by cells, the water in the solution rapidly distributes between the intracellular and extracellular (intravascular plus interstitial) space. Isotonic crystalloids, like normal saline, attempt to approximate the electrolyte composition of plasma. These electrolytes are able to distribute evenly throughout the entire extracellular space. Functionally, this means that water distributes in a similar manner. At approximately 15 minutes, this distribution is complete. So, for every liter of intravascular volume that is lost, three to four times that volume in crystalloid must be infused to replace the deficit (E). Lactated Ringer's solution is a balanced crystalloid solution that attempts to mimic normal electrolyte concentrations. Unlike the lactate seen with lactic acidosis, lactated Ringer's solution contains the anionic portion of lactate that is conjugated with sodium. And, through its metabolism, actually consumes hydrogen ions. It cannot worsen or create a lactic acidosis except in the complete absence of liver function (D). Colloids, on the other hand, contain large molecules that cannot leave the intravascular space. The colloid oncotic pressure of 5% albumin is nearly equivalent to normal plasma (20 mm Hg). The net effect is the retention of the entire infused volume in the intravascular portion of the extracellular space. However, it does not "pull" fluid from extravascular compartments (B). In contrast, 25% albumin solution has a colloid oncotic pressure of 100 mm Hg. For every 250 mL infused, 750 mL of fluid will be "pulled" from the interstitial space resulting in a 1-L increase in intravascular volume. And finally, lactated Ringer's solution is the preferred resuscitative fluid in burn patients (A).

**References:** Reddi, A. (2013). *Fluid, electrolyte and acid-base disorders: clinical evaluation and management*. New York, NY: Springer.

17. **B.** More than 50% of patients with cirrhosis and renal failure will die within 1 month of the diagnosis. The most common cause of renal failure in patients with cirrhosis is prerenal azotemia, so the cessation of diuretics and volume expansion with human albumin and not normal saline (A) is the initial step when acute kidney injury is suspected. Failure to respond to these measures raises the concern for hepatorenal syndrome. The current diagnostic criteria for hepatorenal system include: cirrhosis with ascites, serum creatinine greater than 1.5 mg/dL, no improvement of serum creatinine after at least 2 days of diuretic withdrawal and volume expansion with albumin, absence of shock, no current or recent treatment with nephrotoxic drugs, and the absence of parenchymal kidney disease (no proteinuria, no microhematuria, and a normal renal ultrasound). In addition, urine sodium is very low (<10 mEq/L). The most important physiologic change in hepatorenal syndrome is splanchnic vasodilation, which causes a cascade effect resulting in increased sympathetic nerve activity, increased activity of the renin-angiotensin system, increased nonosmotic vasopressin release, renal vasoconstriction, abolished autoregulation of the kidney, activation of the hepatorenal reflex, and a decrease in renal blood flow. Treatment depends on the

severity of illness and whether or not the patient is in the ICU. In the critically ill, treatment with albumin and norepinephrine can be initiated. In the non-critically ill, terlipressin (a vasopressor analogue) and albumin volume expansion have shown the greatest incidence of renal recovery (C). However, in countries where terlipressin is unavailable, like the United States, therapy can be initiated with midodrine and octreotide. The ideal treatment is liver transplantation but is limited by availability. Dialysis or renal replacement therapy should only be used as a bridge to transplant because it hasn't been shown to decrease mortality or improve renal recovery (D). TIPS can be considered in patients with refractory ascites, but its role in the treatment of hepatorenal syndrome is unclear (E).

**References:** Israelsen, M., Gluud, L., & Kraq, A. (2015). Acute kidney injury and hepatorenal syndrome in cirrhosis. *Journal of Gastroenterology and Hepatology*, 30(2), 236–243.

Lenz, K., Buder, R., Kapun, L., et al. (2015). Treatment and management of ascites and hepatorenal syndrome: an update. *Therapeutic Advances in Gastroenterology*, 8(2), 83–100.

Runyon, B., et al. (2012). Management of adult patients with ascites due to cirrhosis: update 2012. *AASLD Practice Guideline*, AASLD. Retrieved from

[http://www.aasld.org/sites/default/files/guideline\\_documents/adultascitesenhanced.pdf](http://www.aasld.org/sites/default/files/guideline_documents/adultascitesenhanced.pdf).

18. **A.** The corresponding electrolyte abnormalities seen with hypovolemia are heavily dependent on the composition of the corresponding secretions that are lost. Because of the relatively higher concentration of bicarbonate and potassium in small bowel and pancreatic secretions, it is common for excessive losses to result in hypokalemia and metabolic acidosis. The sodium content is generally isotonic, or even slightly hypotonic, to plasma. However, patients with an intact thirst mechanism will typically replace fluids with free water, making hyponatremia much more common on presentation. Stomach secretions are high in hydrogen and chloride, which results in a hypochloremic metabolic alkalosis. The renal response to these losses results in hypokalemia (B). The highest concentration of potassium in any gastrointestinal secretion is saliva, followed by the large intestine. Excessive losses of these fluids frequently present with hypokalemia. Sweat is typically hypotonic to plasma and effectively results in free water loss, though the sweat gland's ability to absorb sodium does diminish as output increases. This can lead to a hypernatremic metabolic acidosis if oral intake is inadequate (D). Hyponatremia, hyperkalemia, and a mild metabolic acidosis can be seen in adrenal insufficiency (C). Hyperkalemia is not typically seen in conjunction with metabolic alkalosis because the renal response to alkalosis causes the wasting of potassium in the urine (E).

19. **B.** Osmotic demyelination syndrome (ODS), formally known as *central pontine myelinolysis*, is a condition brought on by a change in serum osmolality classically described with the rapid correction of chronic hyponatremia. Chronic hyponatremia results in the loss of osmotically active solutes and water from brain cells, which protects against cerebral edema. This process starts with the initiation of hyponatremia and is generally completely in place by 48 hours (C), which is why hyponatremia that develops over this time period is generally not associated with significant symptoms. While the exact mechanism is unknown, studies in animals have shown that the areas of the brain that are slowest at replacing the lost solutes are the most likely to undergo demyelination. This process was originally described in the pons, but it has now been described in other areas of the brain as well (E). While some recovery has been described weeks after the onset of neurologic symptoms and there has been some data to support reinstitution of hyponatremia to improve prognosis (D), prevention is the mainstay of treatment. This involves slow correction of chronic or unknown chronicity hyponatremia by no more than 9 mEq/L per day. In cases of associated hypovolemia, volume replacement can remove the stimulus for ADH release resulting in free water diuresis and increased rate of sodium correction. Desmopressin has been advocated for use in this scenario to allow the production of more concentrated urine and prevent rapid autocorrection of sodium. The use of hypertonic saline is generally unnecessary unless the cause of hyponatremia is clearly acute by history and there are signs of cerebral edema or elevated intracranial pressures (A). As one might expect, cerebral mechanisms deal with chronic hypernatremia by increasing the concentration of these same osmotically active solutes and rapid correction can result in cerebral edema.

**Reference:** Mount, D. (2015). Fluid and electrolyte disturbances. In D. Kasper, A. Fauci, S. Hauser, et al., (Eds.), *Harrison's principles of internal medicine* (19th ed.). New York, NY: McGraw-Hill.

20. **A.** A low pH with a corresponding low pCO<sub>2</sub> and low bicarbonate is indicative of a metabolic



acidosis. Calculation of the anion gap  $[129 (\text{Na}) - 110 (\text{Cl}) - 12 (\text{HCO}_3)]$  reveals a value of 7, which is consistent with a non-anion gap metabolic acidosis (normal 8-16). The patient's history of total proctocolectomy and non-anion gap metabolic acidosis is consistent with gastrointestinal (GI) losses from excessive ileostomy output. All of the other answer choices listed will contribute to an anion gap (B-E).

21. **C.** Severe metabolic alkalosis leads to hypoventilation due to inhibition of the respiratory center in the medulla. The etiology of metabolic alkalosis is generally clear from history (excessive emesis, diuretic use) alone. However, in scenarios where the patient is unable, or unwilling, to provide a history (such as bulimia), the measurement of urine chloride concentration can provide important diagnostic information. When metabolic alkalosis is associated with hypovolemia, the urine chloride concentration will be appropriately low ( $<20 \text{ mEq/L}$ ) in response to the corresponding hypochloremia and volume contraction. Examples of chloride responsive metabolic alkalosis include excessive vomiting or laxative abuse, such as in anorexia-nervosa or bulimia-nervosa. Diuretic use is another common etiology, though recent use will increase the urine chloride concentration. Chloride unresponsive metabolic alkalosis (urine chloride concentration  $> 20 \text{ mEq/L}$ ) can be associated with hypervolemia in the setting of excessive mineralocorticoid concentrations (primary aldosteronism) or conditions that mimic mineralocorticoid excess (licorice ingestion). Disorders that lead to increase urinary salt wasting (Bartter or Gitelman syndrome) will also be chloride unresponsive but will be associated with hypovolemia. Most drugs of abuse that would lead to altered mental status and hypoventilation will be associated with a respiratory acidosis, not a metabolic alkalosis (A). Electrocardiogram may show signs of hypokalemia, but that is a common finding in metabolic alkalosis (D). Computed tomography and abdominal ultrasound may be useful in the workup of altered mental status, but laxative abuse or self-induced vomiting is a much more likely diagnosis in this scenario (B, E).

22. **D.** Mild therapeutic hypothermia has been shown to improve survival and neurologic outcomes if instituted after cardiac arrest. However, it also results in significant physiologic changes that should be closely monitored. As the core body temperature decreases, blood begins to shunt from the extremities to warm the central system via peripheral vasoconstriction. This causes an increase in central venous pressure despite relative systemic hypovolemia (A). The kidneys respond with increased diuresis resulting in hypokalemia, hypomagnesemia, and hypophosphatemia. There is also an intracellular shift of potassium that will reverse upon rewarming, and hyperkalemia can be problematic during this stage (B). Rewarming will also unmask the hypovolemia as systemic vascular volume redistributes to the extremities. The overall result of MTH is decreased total body oxygen demand, but this comes at the expense of a shift from aerobic to anaerobic metabolism. During MTH, there is an expected drop in serum pH and an increase in serum lactate, which does not require intervention (C). While improved neurologic function is the most significant benefit of MTH, there may be a protective cardiac effect as well. This is primarily facilitated by hypothermia-induced bradycardia, reduction in cardiac output, and decreased myocardial oxygen demand (E).

**Reference:** Noyes, A., & Lundbye, J. (2015). Managing the complications of mild therapeutic hypothermia in the cardiac arrest patient. *Journal of Intensive Care Medicine*, 30(5), 259–269.

23. **D.** Although the patient's potassium level is high and needs to be reduced, there is no indication that urgent reduction is needed. Urgent treatment of hyperkalemia is necessary when serum concentrations are very high ( $>6.5 \text{ mEq/L}$ ) or when there are ECG changes such as peaked T waves. It should also be considered in a patient with rhabdomyolysis because the potassium level is expected to continue to rise rapidly as a result of ongoing muscle necrosis. Treatment is divided into three categories: stabilization of the cardiac membrane, driving potassium into the intracellular space, and potassium removal from the body. Administration of calcium will directly antagonize the effects of hyperkalemia on the cell membrane within minutes, but the effect is short-lived (30–60 minutes) and does not directly address the issue of hyperkalemia. Consequently, it should never be used as monotherapy (A). Driving the potassium into the intracellular space can be accomplished primarily by the administration of insulin or beta-agonists, such as albuterol. This effect is more prolonged, but eventually the potassium will equilibrate and serum potassium will return to its previous level. Administration of sodium bicarbonate was initially included in this category, but it is generally no longer recommended unless the etiology is extracellular shift from a metabolic acidosis (C). These first two categories are generally unnecessary with mild to moderate hyperkalemia and can potentially inhibit potassium clearance by dialysis. These therapies have two effects on subsequent dialysis. The first is reduced clearance of potassium because less is available

in the serum; the second is creating the potential for rebound hyperkalemia. Dialysis increases serum osmolality, which provides a gradient for the egress of water and potassium from the intracellular space when the effects of albuterol and insulin wear off. Peritoneal dialysis is significantly inferior to hemodialysis in the removal of potassium (E). In addition to dialysis, loop diuretics and cation exchange resins (sodium polystyrene sulfonate) can also facilitate removal of potassium. However, the Food and Drug Administration (FDA) has recommended that sodium polystyrene sulfonate no longer be combined with sorbitol because of the risk of intestinal necrosis. This risk is further increased in certain patient populations, such as recent bowel surgery. Even in the absence of sorbitol, administration carries a risk of intestinal necrosis and should only be used if dialysis is not available (B).

**References:** Allon, M., & Shanklin, N. (1995). Effect of albuterol treatment on subsequent dialytic potassium removal. *American Journal of Kidney Diseases*, 26(4), 607–613.

Mount, D. (2015). Fluid and electrolyte disturbances. In D. Kasper, A. Fauci, S. Hauser, et al., (Eds.), *Harrison's principles of internal medicine* (19<sup>th</sup> ed.). New York, NY: McGraw-Hill.

# Immunology

*Areg Grigorian, and Christian de Virgilio*

## Questions

1. Which of the following is true regarding apoptosis?
  - A. It does not occur during embryogenesis.
  - B. It is characterized by a loss of membrane integrity.
  - C. It induces an inflammatory response.
  - D. CD-8 T cells can initiate apoptosis in cells that are virally infected.
  - E. *p53* inhibits apoptosis while *BCL-2* promotes apoptosis.
2. Spontaneous regression of cancer due to the immune system is best exemplified by which of the following malignancies?
  - A. Melanoma
  - B. Thymoma
  - C. Colon
  - D. Pancreas
  - E. Lung
3. Which of the following is true regarding the immune response to bacterial infection?
  - A. CD-4 T cells transform B cells into plasma cells.
  - B. Class 1 major histocompatibility complex (MHC) molecules harboring bacterial-derived proteins are expressed on the surfaces of antigen-presenting cells.
  - C. Cells infected by bacteria are destroyed by cytotoxic T cells.
  - D. Activated CD-4 T cells secrete antibodies.
  - E. Class-2 MHC cells are present on all nucleated cells.
4. Which of the following is true regarding the immediate cellular response to a paper cut injury?
  - A. L-selectin is expressed on endothelial cells.
  - B. The majority of the cytokine response is released by circulating platelets.
  - C. ICAM expressed on endothelial cells binds to beta-2 integrin on leukocytes.
  - D. This is not affected by diabetes mellitus.
  - E. Integrins are involved in platelet rolling, while selectins are involved in platelet adhesion.
5. Which of the following is true regarding cyclosporine?
  - A. It is primarily excreted by the kidneys.
  - B. It is associated with thrombocytosis.
  - C. It inhibits the release of IL-2.
  - D. It inhibits activation of B cells.
  - E. It is more potent than FK-506.
6. A 28-year-old male with type A blood develops a high fever, chills, jaundice, and hematuria shortly after receiving a blood transfusion. The nurse checks the blood bag and realizes this patient received type B donor blood. Which of the following is true regarding this condition?



- A. This is an example of serum sickness.
  - B. He developed a T-cell mediated response.
  - C. Direct Coombs test will demonstrate IgG bound to red blood cells.
  - D. His symptoms are a result of an overexaggerated response from basophils and mast cells.
  - E. This response does not involve complement activation.
7. Which of the following is true regarding cytokines?
- A. IL-2 is a major endogenous pyrogen.
  - B. IL-6 is considered a potent stimulus for the production of acute phase reactants.
  - C. IL-10 is responsible for enhancing macrophage function.
  - D. Neutrophils are considered the largest producers of tumor necrosis factor (TNF)-alpha.
  - E. During an inflammatory response, C-reactive protein production is dampened.
8. Which of the following is true regarding natural killer (NK) T cells?
- A. NK T cells can commence cell destruction with the presence of both an activation signal and an inhibitory signal on the target cell surface.
  - B. NK T cells can commence cell destruction with the absence of both an inhibitory signal and an activation signal on the target cell surface.
  - C. NK T cells can only commence cell destruction when the target cell surface has both the presence of an activation signal and the absence of an inhibitory signal.
  - D. IL-12 inhibits activation of NK T cells.
  - E. NK T cells require activation by lymphocytes.

## Answers

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1. **D.** Apoptosis (programmed cell death) is a critical process governing homeostasis and begins during embryogenesis with the shedding of skin between digits (A). This continues lifelong and promotes the growth of healthy cells and tissue while facilitating the disposal of infected, damaged, or transformed cells that may give rise to cancer. The two pathways of apoptosis share in common the activation of caspases, which serve as the final step for cell destruction. The intrinsic pathway is regulated by two important genes; *p53* promotes apoptosis while *BCL-2* inhibits apoptosis (**p** for *p53* and **p**romotes) (E). Li-Fraumeni syndrome is characterized by an absence of *p53* and thus apoptosis does not occur, leading to large solid tumors. The extrinsic pathway is activated by several external “death” receptors that are expressed in infected cells or cells with DNA damage. CD-8 T cells are responsible for recognizing the FAS-death receptor in virally infected cells and initiating cell destruction. Apoptosis is characterized by DNA fragmentation, compartmentalization of cytoplasmic particles into apoptotic bodies, which are then broken down further by activated caspases and ultimately undergo phagocytosis by macrophages without inducing an inflammatory response (C). In contrast, cell necrosis is characterized by a violation of the cell membrane, release of cytoplasmic products, and a subsequent inflammatory response (B).  
**Reference:** Elmore, S. (2007). Apoptosis: a review of programmed cell death. *Toxicologic Pathology*, 35(4), 495–516.
2. **A.** Spontaneous regression of malignant tumors refers to cases of complete or partial tumor destruction and/or involution without any particular therapy. This occurs in most cancers, but certain tumors regress more commonly. Melanoma, testicular germ cell tumors, and neuroblastoma are cancers that regress with increased frequency. This is due to a combination of cell apoptosis, immune mediators, and tumor microenvironment. Regression not only occurs in primary tumors but also can occur in metastases. The remaining answer choices regress less frequently (B–E).  
**Reference:** Ricci, S. B., & Cerchiari, U. (2010). Spontaneous regression of malignant tumors: importance of the immune system and other factors (Review). *Oncology Letters*, 1(6), 941–946.
3. **A.** The only cells capable of initiating humoral immunity to bacterial invasion are antigen-presenting cells, which include dendrites, macrophages, and B cells. This begins with endocytosis and processing of bacterial proteins, which are coupled to class-2 MHC molecules and are expressed on the cell surface (B). Next, CD-4 T cells recognize the bacterial protein motif and bind

to the receptor. The newly activated CD-4 T cell finds B cells that are bound to the bacterial antigen and help transform them into plasma cells (secreting antibodies) and memory B cells conferring long-term immunity to a particular bacterial antigen (D). The immune response to a viral infection works by a different mechanism. Firstly, all nucleated cells (most notably absent are red blood cells) have class 1 MHC molecules, which are able to bind to viral proteins and translocate to the cell surface (E). This is then recognized by CD-8 or cytotoxic T cells and marked for destruction (C).

4. **C.** The immune response involved in healing a paper cut or similar small injury is a complex one. There are three stages including platelet rolling, tight adhesion, and emigration. The damaged endothelial cell expresses E-selectin (E for endothelium), which binds to P-selectin on platelets and L-selectin on leukocytes (A). This promotes weak binding, which allows for platelet rolling initiating a platelet plug. Circulating macrophages release cytokines and chemokines, which induce the expression of various endothelial receptors and attract other immune modulators (B). One of these newly expressed endothelial receptors includes *ICAM*, a type of integrin that promotes stable binding allowing for platelet adhesion. Next, *PECAM* and *VCAM* are expressed on the endothelial surface, which facilitates emigration of circulating leukocytes from the vasculature toward the inflammatory stimulus. Selectins are involved in platelet rolling while integrins are involved in platelet adhesion (E). This response is dampened in patients with diabetes and those with chronic steroid use, which helps explain why these patients have difficulty with wound healing. The most notable syndrome affecting this process is leukocyte adhesion deficiency, which is characterized by defunct integrin molecules leading to recurrent bacterial infection and the classic presenting sign of delayed umbilical cord sloughing.
5. **C.** Cyclosporine is an immune modulator that was commonly used in transplant patients as maintenance therapy. It has largely been replaced by tacrolimus. Cyclosporine works by inhibiting cyclophilin protein on calcineurin and thereby inhibits synthesis of IL-2 and IL-4, which are interleukins that activate T cells (D). FK-506 works by a similar mechanism but is considered more potent than cyclosporine (E). The adverse effects of cyclosporine include nephrotoxicity, gingival hyperplasia, hirsutism, and thrombocytopenia (B). The drug undergoes hepatic metabolism and is primarily excreted in bile. Less than 5% undergoes renal excretion (A).

**Reference:** Burckart, G. J., Starzl, T. E., Venkataramanan, R., et al. (1986). Excretion of cyclosporine and its metabolites in human bile. *Transplantation Proceedings*, 18(6 Suppl. 5), 46–49.

6. **C.** This patient has developed a type II hypersensitivity reaction from receiving an incorrect blood type transfusion. The cause of ABO incompatibility in blood transfusion is clerical error as demonstrated in the above case. There are four types of hypersensitivity reactions. The first three types occur quickly and are antibody and complement mediated while type IV is a delayed response and is T-cell mediated. Type I is the only IgE-mediated reaction and occurs when a stimulus activates eosinophils, which in turn activate mast cells and basophils, which results in a systemic release of bradykinin, serotonin, and histamine (D). Type I reactions are our immune system's adaptation as a protective mechanism against parasites; which is less threatening in the modern age. Instead, type I hypersensitivity reactions occur most frequently with exposure to allergens, such as bee stings, peanut exposure or hay fever. Type II hypersensitivity is an IgG- and IgM-mediated response resulting in complement activation (opsonization), cell lysis, and phagocytosis (E). In the case of ABO incompatibility, patients will present with widespread hemolysis. A direct Coombs test will demonstrate IgG bound to RBC and an indirect Coombs test will measure free antibodies in the serum. Of note, not all type II hypersensitivity reactions are cytotoxic; myasthenia gravis is a noncytotoxic variant of type II hypersensitivity. Type III hypersensitivity is an immune complex-mediated response in which immune conglomerates deposit into healthy tissue and thus inflict damage; serum sickness, systemic lupus erythematosus (SLE), and rheumatoid arthritis are examples of this (A). Type IV hypersensitivity is a delayed reaction and is preceded by T-cell sensitization (B). Tuberculosis skin test and contact dermatitis are considered type IV hypersensitivity reactions.
7. **B.** Cytokines are largely responsible for cell signaling during an inflammatory response. TNF-alpha and IL-1 are the two main cytokines responsible in propagating the inflammatory response during the early stages of injury and/or infection. The largest producers of these cytokines are macrophages (D). Both are responsible for soliciting additional cytokine production and immune cell recruitment. IL-1, in particular, is considered the primary endogenous pyrogen (A). It regulates the thermal set point in the hypothalamus (by binding to the CD-121 family receptor) resulting in fever. Alveolar macrophages producing IL-1 has been classically taught to surgical residents to be

responsible for the fever seen in patients with atelectasis. Additionally, corticosteroids can inhibit production of IL-1; this may explain why patients with acute adrenal insufficiency develop a high fever (due to the disinhibition of IL-1). Some authors do not agree that atelectasis is involved in post-operative fever and others have suggested that IL-6 more closely correlates with post-operative fever. IL-2 is primarily produced by T cells and helps recruit and activate additional T cells and enhances interaction between T and B cells. IL-6 is the most potent stimulus of hepatic acute phase reactants including C-reactive protein, amyloid A, and ceruloplasmin (E). In contrast, prealbumin and transferrin production decrease during inflammation; this explains why prealbumin as a measure of nutritional status can't be interpreted without measuring one of the acute phase reactants. IL-10 is considered the largest inhibitor of the inflammatory response including the function of macrophages (C).

**References:** Losa García, J. E., Rodriguez, F. M., Martin de Cabo, M. R., et al. (1999). Evaluation of inflammatory cytokine secretion by human alveolar macrophages. *Mediators of Inflammation*, 8(1), 43–51.

Mavros, Michael, N., George C. Velmahos., & Matthew E. Falagas. (2011). Atelectasis as a cause of postoperative fever: where is the clinical evidence? *CHEST Journal*, 140.2, 418–424.

8. C. NK T cells are part of the innate immune system and are responsible for destroying tumor cells and/or virally infected cells. Since they are not dependent on helper T-cell activation, NK T cells rely on recognition of certain receptor motifs directly on the target cell surface (E). However, their activity can be enhanced by IL-12 (D). Activation of NK T cells requires a two-step activation in order to destroy a target cell (A, B). The first involves an activation signal that most cells are capable of producing when they are infected with a pathogen or when they are transformed by a malignant process. The second step involves a lack of an inhibitory signal. This inhibitory signal is the class 1 MHC molecule expressed on the surface of all nucleated cells. When the NK T cell recognizes a self-class 1 MHC molecule it does not commence cell destruction; this explains why cancer or virally infected cells down-regulate production of class 1 MHC molecules.

**Reference:** Bessoles, S., Grandclément, C., Alari-Pahissa, E., et al. (2014). Adaptations of natural killer cells to self-MHC class I. *Frontiers in Immunology*, 5, 349.

# Infection and Antimicrobial Therapy

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## Questions

1. A 52-year-old male smoker with chronic obstructive pulmonary disease (COPD) presents to the emergency department (ED) complaining of fevers and foul-tasting sputum for the past 4 weeks. He was recently admitted to an outside hospital for treatment of a COPD exacerbation and has a history of vancomycin-resistant *Staphylococcus aureus* bacteremia. Chest radiograph shows a 4-cm air-fluid level within the right lung. He reports a 20-pound weight loss over the past 5 months. Appropriate management includes:
  - A. Administration of intravenous daptomycin
  - B. Thoracotomy and decortication
  - C. Pulmonary lobectomy
  - D. Percutaneous drain placement
  - E. Diagnostic bronchoscopy
2. Which of the following is true regarding the management of parapneumonic effusions?
  - A. If discovered within the first 5 days after the onset of pneumonia, tube thoracostomy is generally all that is required.
  - B. Intrapleural fibrinolytics are highly efficacious in patients with loculated effusions.
  - C. Large diameter chest tubes (>28 French) are required for adequate drainage.
  - D. Treatment of the organizing phase requires open drainage (e.g., Eloesser flap).
  - E. Video-assisted thoracoscopic surgery should be performed if an empyema does not respond to chest tube drainage.
3. Which of the following is true regarding antibiotic mechanisms?
  - A. Penicillin-derivative antibiotics bind the bacterial cell membrane and increase its permeability.
  - B. Piperacillin-Tazobactam (Zosyn) works partly by binding  $\beta$ -lactamases.
  - C. Metronidazole, though limited, has some effect against aerobic bacteria.
  - D. Linezolid competitively inhibits the 30S ribosome.
  - E. Clindamycin, like the macrolides, reversibly binds the 50S ribosome.
4. Which of the following should be used as part of a screening tool designed to identify non-ICU patients that are at increased risk of organ failure from infection?
  - A. Temperature higher than 38°C
  - B. Heart rate greater than 90/min
  - C. Altered mentation
  - D. White blood cell (WBC) count greater than 12,000/mm<sup>3</sup>
  - E. PaCO<sub>2</sub> less than 32 mm Hg
5. A 56-year-old HIV-positive (with a low CD4 count) female presented to the ED with a spontaneous

- pneumothorax and underwent a tube thoracostomy procedure. While trying to recap the 20-gauge needle used for anesthetizing the skin, the resident that performed the procedure was inadvertently stuck resulting in visible bleeding from the skin. Which of the following is true regarding this exposure?
- Postexposure prophylaxis with a two-drug regimen should be administered for 8 weeks.
  - Postexposure prophylaxis with a three-drug regimen should be administered for 4 weeks.
  - Potential HIV infection should be disclosed to future patients.
  - At least 6 months of postexposure treatment is recommended.
  - The hollow bore needle used for this procedure lowers the risk of HIV transmission.
- A 45-year-old HIV-positive male presents to the ED with perianal pain for the past 2 days. Physical exam reveals a small area of tenderness in the right posterolateral position distal to the external sphincter that is extremely tender. His CD4 count is 550 cells/mL, and he is currently on highly active antiretroviral therapy (HAART). Which of the following is the most correct management of this patient?
    - Intravenous (IV) antibiotics, exam under anesthesia (EUA), and if an area of fluctuance is identified, then incision and drainage (I&D) and biopsy
    - EUA and if an area of fluctuance is identified, then I&D and biopsy
    - IV antibiotics, EUA, I&D and biopsy of area of tenderness even if no fluctuance is identified
    - EUA, I&D, and biopsy of area of tenderness even if no fluctuance is identified
    - IV antibiotics
  - A 62-year-old man is postoperative day 6 from an elective laparoscopic sigmoid colectomy for recurrent diverticulitis. He had return of bowel function 2 days ago and was getting ready to be discharged home. Throughout his hospital course, he has been having low-grade fevers. He is now complaining of tenesmus and urinary retention. Which of the following represents the most appropriate next step in management?
    - Transition to nonnarcotic pain medications
    - Bladder scan and in-and-out catheterization as needed
    - Abdominal radiography
    - Computed tomography (CT)
    - Diagnostic laparoscopy
  - A 47-year-old female with history of pulmonary sarcoidosis is discovered to have a right upper lobe mass on chest radiograph that is outlined by a crescent of air superiorly. On a left lateral decubitus film, the crescent of air shifts to remain in a nondependent position. The patient is currently asymptomatic. What is the next step in management?
    - Diagnostic bronchoscopy with bronchoalveolar lavage
    - CT-guided biopsy
    - IV voriconazole
    - Pulmonary wedge resection
    - No further workup or treatment is required
  - A typical serologic panel for hepatitis B gives levels for hepatitis B surface antigen (HBsAg), hepatitis B surface antibody (anti-HBs), total hepatitis B core antibody (anti-HBc), and IgM antibody against hepatitis B core antigen (IgM anti-HBc). Which of the following profiles would you expect for a patient with chronic hepatitis B infection?
    - HBsAg<sup>-</sup>, anti-HBs<sup>-</sup>, anti-HBc<sup>-</sup>, IgM anti-HBc<sup>-</sup>
    - HBsAg<sup>-</sup>, anti-HBs<sup>+</sup>, anti-HBc<sup>+</sup>, IgM anti-HBc<sup>-</sup>
    - HBsAg<sup>-</sup>, anti-HBs<sup>+</sup>, anti-HBc<sup>-</sup>, IgM anti-HBc<sup>-</sup>
    - HBsAg<sup>+</sup>, anti-HBs<sup>-</sup>, anti-HBc<sup>+</sup>, IgM anti-HBc<sup>+</sup>
    - HBsAg<sup>+</sup>, anti-HBs<sup>-</sup>, anti-HBc<sup>+</sup>, IgM anti-HBc<sup>-</sup>
  - Which of the following is the best choice for post-exposure prophylaxis for anthrax?
    - Ciprofloxacin

- B. Second-generation cephalosporin
  - C. Rifampin
  - D. Trimethoprim-sulfamethoxazole
  - E. Clindamycin, rifampin, and ciprofloxacin
11. A 32-year-old male is recovering in the ICU 1 day after extensive debridement of the left leg for a necrotizing soft-tissue infection (NSTI). He is intubated and requiring 80% FiO<sub>2</sub>. He has leukocytosis that has been rising and an elevated serum lactate. He is on broad-spectrum antibiotics. Which of the following is the best next step in management?
- A. Amputation of left leg
  - B. Second-look operation
  - C. Add antifungal coverage
  - D. CT scan of the leg
  - E. Start pressors
12. Which of the following is least likely to contribute to a surgical site infection?
- A. American Society of Anesthesiologists physical status
  - B. Length of operation
  - C. Serum glucose level
  - D. Body temperature
  - E. Hemoglobin level
13. The organism most commonly associated with acute mesenteric lymphadenitis is:
- A. *Campylobacter jejuni*
  - B. *Escherichia coli*
  - C. *Enterococcus*
  - D. *Yersinia enterocolitica*
  - E. Pinworms
14. Forty-eight hours after total mastectomy, high fever, diarrhea, vomiting, redness of the skin of the entire body, and hypotension develop in a 30-year-old patient. The mastectomy incision appears unremarkable. The following day diffuse desquamation develops. The most likely etiology is:
- A. *Clostridium perfringens*
  - B. *Clostridium difficile*
  - C.  $\beta$ -Hemolytic *Streptococcus*
  - D. *Staphylococcus aureus*
  - E. *Staphylococcus epidermidis*
15. A 60-year-old man presents with gas gangrene of his left leg requiring below-knee amputation. Wound cultures were positive for *Clostridium septicum*. Additional workup should include:
- A. Head CT scan
  - B. Bronchoscopy
  - C. Colonoscopy
  - D. HIV serology
  - E. Chest CT scan
16. Which of the following is true regarding gentamicin?
- A. It has strong activity against streptococci.
  - B. It has a high therapeutic index.
  - C. It has poor activity against *Serratia*.
  - D. It has some synergism with penicillin against *Enterococcus*.
  - E. It has strong activity against anaerobes.
17. Peripheral neuropathy with prolonged use is most commonly associated with:

- A. Clindamycin
  - B. Metronidazole
  - C. Ciprofloxacin
  - D. Gentamicin
  - E. Vancomycin
18. Which of the following is true regarding tetanus?
- A. It is highly contagious.
  - B. Trismus is usually the first sign.
  - C. It is caused by a gram-negative anaerobic rod.
  - D. Immunization is not required if there is a previous history of surviving tetanus.
  - E. The diagnosis is established by demonstrating the organisms in a wound.
19. Which of the following is associated with an endotoxin?
- A. *Streptococcus pyogenes*
  - B. *Bacteroides fragilis*
  - C. *Clostridium tetani*
  - D. *Staphylococcus aureus*
  - E. *Clostridium perfringens*
20. Which of the following is true regarding occupational risk of hepatitis in health-care workers?
- A. The risk of transmission is greater for hepatitis C than hepatitis B.
  - B. If the exposed person has been vaccinated for hepatitis B, no hepatitis B treatment is needed.
  - C. If the patient has hepatitis C, the exposed person should be given ribavirin.
  - D. Most hepatitis B transmissions are the result of needlestick injuries.
  - E. Hepatitis B virus can survive on dried blood for at least a week.
21. A 65-year-old female presents to the ED with diffuse mild abdominal pain and distention, as well as diarrhea. She is recently recovering from an episode of pneumonia. Her temperature is 101°F, blood pressure is 110/70 mm Hg, and heart rate (HR) is 100 bpm. WBC count is 24,000 cells/μL and lactate is normal. CT scan shows a moderately dilated colon throughout, with mild thickening of the cecal wall, without evidence of obstruction or free fluid. The patient is admitted, placed NPO, and empirically started on oral metronidazole for presumed *Clostridium difficile* colitis. However, the following day, she develops an altered sensorium, with a blood pressure of 80/50 mm Hg. Repeat WBC count is 30,000 cells/μL, and lactate is now 5.0 mmol/L. She is given fluids and low-dose pressor support. Which of the following is the recommended management?
- A. Switch to vancomycin orally.
  - B. Add vancomycin orally and per rectum.
  - C. Add vancomycin orally and per rectum and switch metronidazole to IV route.
  - D. Emergent subtotal colectomy
  - E. Repeat CT scan.

## Answers

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1. E. Lung abscesses typically present with an indolent course over several weeks. Patients often complain of fevers, purulent sputum, and cough. Single lung abscesses are frequently monomicrobial and are usually associated with an aspiration pneumonia. As such, they are typically found in segments of the lung that are dependent in the supine position (i.e., the posterior segment of the upper lobes or the superior segments of the lower lobes). An air-fluid level on chest radiograph and purulent sputum is virtually diagnostic of an anaerobic lung infection. However, coinfection with antibiotic-resistant gram-positive organisms is possible in patients with frequent hospitalizations. Most lung abscesses will resolve with antibiotics alone, but daptomycin cannot be used to treat lung infections because it is inhibited by pulmonary surfactant (A). In addition to intravenous (IV) antibiotics, a patient with risk factors for lung cancer (e.g., smoking, recent weight loss) should undergo bronchoscopy to rule out an underlying neoplasm



(obstruction leading to infectious process). Surgical treatment may be necessary for infections that fail to respond to medical management, abscesses greater than 6 cm in size, and abscesses secondary to an obstructed bronchus from a foreign body or neoplasm. This typically involves either lobectomy or pneumonectomy (C). Percutaneous drain placement can be considered in patients who are poor surgical candidates (D). Thoracotomy and decortication is a treatment option for empyema, not lung abscess (B).

**References:** Mandal, K. (2014). Thoracic infections. In D. D. Yuh, L. A. Vricella, & S. C. Yang (Eds.), *Johns Hopkins textbook of cardiothoracic surgery* (2nd ed.). New York, NY: McGraw-Hill Professional.

2. **E.** Parapneumonic effusion refers to the accumulation of pleural fluid in response to a respiratory infection. It is generally divided into three stages: exudative, fibrinopurulent, and organizing. The first (exudative) stage is characterized by the development of sterile pleural fluid in response to increased capillary permeability. In general, antibiotic treatment of the pneumonia is all that is required (A). After 5 days, bacteria begins to enter the fluid and inflammatory cells follow. This marks the beginning of the fibrinopurulent phase and drainage of the collection is mandatory to prevent further progression. Generally, this can be accomplished by placement of chest tubes into the collection. The diameter of the chest tube does not seem to be important so long as smaller caliber tubes are routinely flushed to prevent blockage of the catheter (C). As the fibrinopurulent phase progresses, loculations begin to form within the collection, making drainage with a single catheter or tube thoracostomy difficult. Several studies have been done evaluating the use of intrapleural fibrinolytics, such as alteplase, to prevent progression to surgery. However, the results are controversial at best and a 2008 Cochrane Review of the practice found no consistent benefit (B). At this stage, video-assisted thoracoscopic debridement and adhesiolysis are viable options, though a certain number of patients will still need to be converted to thoracotomy (E). After 2 to 3 weeks of untreated infection, fibroblasts begin to form a pleural peel and the final (organization) stage is reached. Once this membrane has formed, formal decortication via thoracotomy is generally necessary. In patients that are unfit for surgery, open drainage (e.g., Eloesser flap) may be considered. However, this subjects patients to months of dressing changes and significant morbidity (D).

**References:** Light, R. (2006). Parapneumonic effusions and empyema. *Proceedings of the American Thoracic Society*, 3(1), 75–80.

Cameron, R., & Davies, H. R. (2008). Intra-pleural fibrinolytic therapy versus conservative management in the treatment of adult parapneumonic effusions and empyema. *Cochrane Database of Systematic Reviews*, 2(2).

Davies, H., Davies, R. J., Davies, C. W., et al. (2010). Management of pleural infection in adults: British Thoracic Society pleural disease guideline 2010. *Thorax*, 65(Suppl. 2): ii41–ii53.

3. **B.** All penicillin-derivative antibiotics ( $\beta$ -lactams) inhibit the final step of bacterial cell wall synthesis by binding transpeptidases or penicillin-binding proteins (A). Cephalosporins work by the same mechanism but are more resistant to degradation by  $\beta$ -lactamases. Tazobactam, sulbactam, and clavulanic acid bind  $\beta$ -lactamases and are frequently combined with penicillin-derivative antibiotics to increase their effectiveness. Examples of this include Zosyn (piperacillin-tazobactam) and Augmentin (amoxicillin-clavulanic acid). Metronidazole is an antibiotic that only has action against anaerobic bacteria by inhibiting nucleic acid synthesis. It is not effective in aerobic cells because it requires reduction to its active state, which only takes place in anaerobic cells (C). Aminoglycosides and tetracyclines inhibit the 30S ribosome. Linezolid, on the other hand, inhibits the 50S ribosome subunit. Several other antibiotics (macrolides, linezolid, chloramphenicol) also inhibit the 50S ribosome; however, it is a slightly different process (D). Clindamycin is a lincosamide antibiotic, which interferes with the amino acyl-tRNA complex (E). Aminoglycosides and tetracycline antibiotics inhibit the 30S ribosome.
4. **C.** The *Third International Consensus Definitions for Sepsis and Septic Shock*, published in JAMA in 2016, redefined the current definition used for sepsis and septic shock. The panel came to the conclusion that the previously used definition of sepsis (2+ SIRS criteria and a source of infection) was too nonspecific and generally unhelpful in the identification of patients at increased risk of mortality from infection (A, B, D, E). Instead, the committee recommended a bedside screening tool called the quick Sequential Organ System Failure score (qSOFA) for identification of patients that are likely to have a poor outcome as the result of an infection. If a patient meets two of the three criteria (respiratory rate > 22/min, altered mental status, and systolic blood pressure < 100

mm Hg), further workup and treatment for sepsis is indicated. The term *sepsis* has also been changed to represent a more serious physiologic process. Sepsis is now defined as an infection with 2 or more points on the Sequential (Sepsis-Related) Organ Failure scoring system, or SOFA score. This score takes objective criteria for multiple organ systems (respiration, cardiovascular, coagulation, liver, central nervous system, and renal) and assigns a score based on the amount of organ dysfunction. A score of 2 or more is associated with a 10% or greater increase in mortality. Finally, the term *septic shock* has been redefined as sepsis that requires vasopressors to keep the mean arterial pressure (MAP) greater than 65 mm Hg and a lactate level greater than 2.0 mmol/L. The term *severe sepsis* is no longer being encouraged as a formal diagnosis.

**Reference:** Singer, M., Deutschman, C. S., Seymour, C. W., et al. (2016). The third international consensus definitions for sepsis and septic shock (Sepsis-3). *JAMA*, 315(8), 801–810.

5. **B.** With a blood exposure, the first step is to determine the risk (severity) of the exposure and the risk of the patient. The risk of puncture by hollow needle with fresh blood is greater than the risk of puncture with a solid (surgical) needle, which is greater than the risk of splashing of a few blood drops on mucous membranes or nonintact skin, which is greater than the risk of blood drops on intact skin (no risk) (E). Depending on the combination of severity of exposure and severity of HIV, the recommendation is either a basic regimen of two drugs (4 weeks of zidovudine and lamivudine) or an expanded one of three drugs (basic regimen plus either indinavir or nelfinavir for 4 weeks). Given that the health-care worker had visible skin penetration by fresh blood with a hollow, large bore needle (high-exposure severity), and the patient described has a low CD4 count (high-risk HIV status), the recommendation would be a three-drug regimen (A). The three-drug regimen is recommended whenever a hollow needlestick pierces the skin and the patient is HIV positive, regardless of his or her viral load or CD4 count. With a solid needle (as in the OR), because the risk of transmission risk is lower, the severity of HIV is considered, and a two-drug regimen is recommended if the patient is low-risk HIV positive (no active infection, low viral load, high CD4 count); a three-drug regimen is recommended if the patient is high-risk HIV positive. Follow-up testing to confirm HIV negative status in health-care workers is recommended 3 to 6 months later (D). Part of the initial evaluation of the exposed health-care worker should involve counseling regarding appropriate precautions including the use of barrier protection, not to donate blood, practicing safe sex, and to avoid breast-feeding if possible. If the HIV status of the patient is unknown, it depends on the perceived risk of HIV and type of exposure. So if it is a solid needle, in a patient at a low risk for HIV, prophylaxis is generally not recommended; whereas with a large bore hollow needle, prophylaxis is generally recommended until the patient tests negative. The average risk of HIV transmission after a percutaneous exposure to HIV-infected blood is overall very low (approximately 0.3%). For health-care workers there is no need to stop working or to inform patients of a possible exposure (C). The most recent statement from the American College of Surgeons states that “HIV-infected surgeons may continue to practice and perform invasive procedures and surgical operations unless there is clear evidence that a significant risk of transmission of infection exists through an inability to meet basic infection control procedures” and that “the HIV status of a surgeon is personal health information and does not need to be disclosed to anyone.”

**References:** American College of Surgeons. (2004). Statement on the Surgeon and HIV Infection. *Bulletin of the American College of Surgeons*, 89(5), 27–29.

Kuhar, D. T., Henderson, D. K., Strubel, K. A., et al. (2013). Updated US Public Health Service guidelines for the management of occupational exposures to human immunodeficiency virus and recommendations for postexposure prophylaxis. *Infection Control and Hospital Epidemiology*, 34(9), 875–892.

6. **C.** Anorectal disease is the most common indication for surgery in the HIV-infected patient, and it can frequently be the first presenting symptom for an undiagnosed patient. However, diagnosis can be difficult because HIV patients with anorectal abscesses may be unable to mount an adequate response; thus patients may present with a small area or a complete absence of fluctuance at the abscess site (depending on CD4 count) (A, B). Additionally, they often have significant tenderness that is out of proportion to exam findings. Previously, operative interventions were avoided because of the risk of perianal sepsis. However, HAART therapy has allowed these patients to be managed with the same practice standards as the noninfected patient with similar outcomes given that they are not neutropenic. Incision and drainage is recommended for this patient (even if no fluctuance is detected) with a concurrent seton placement in the event a

fistula is discovered. Anoscopy with biopsy should also be performed because a perianal abscess may be the presenting symptom of an anal or rectal malignancy, particularly in an HIV-positive patient. Ordinarily, antibiotics are not recommended for perianal abscess. The exception is the immunocompromised patient. Thus for the HIV patient, antibiotics are routinely used, even in the setting of adequate drainage, and wound cultures should be sent for the identification of atypical organisms (D, E).

**References:** Miles, A., Mellor, C., Gazzard, B., et al. (1990). Surgical management of anorectal disease in HIV-positive homosexuals. *The British Journal of Surgery*, 77(8), 869–871.

Steele, S., Kumar, R., Feingold, D. L., et al. (2011). Practice parameters for the management of perianal abscess and fistula-in-ano. *Diseases of the Colon and Rectum*, 54(12), 1465–1474.

Vasilevsky, C. (2013). Anorectal abscess and fistula. In D. E. Beck, S. D. Wexner, T. L. Hull, et al., (Eds.), *The ASCRS manual of colon and rectal surgery* (2nd ed.). New York, NY: Springer.

7. **D.** Over 80% of all intra-abdominal abscesses are post-surgical and diagnosed in the post-operative period. They typically arise from one of two mechanisms: persistent walled off infection after the resolution of peritonitis or after an anastomotic breakdown or perforation that is effectively controlled by peritoneal defense mechanisms. Presentation can be highly variable depending on their location, ranging from hiccoughing with subphrenic abscesses to a palpable mass in the paracolic gutter or even sepsis. Pelvic abscesses can also present primarily with urinary or fecal symptoms such as urinary retention or tenesmus. These typically present on postoperative days 5 to 7, and suspicious symptoms should be evaluated with an abdominal CT. Plain abdominal radiography has been essentially replaced by CT because of increased diagnostic sensitivity and specificity for intra-abdominal pathology (C). Though narcotic pain medications or underlying benign prostatic disease can cause urinary retention after surgery, a more serious etiology needs to be ruled out first (A, B). Almost all intra-abdominal abscesses can be treated with percutaneous drainage and antibiotics. In the absence of diffuse peritonitis, operative intervention is likely unnecessary (E).

**Reference:** Tawadros, P. S., Simpson, J., Fischer, J. E., et al. (2013). Abdominal abscess and enteric fistulae. In M. Zinner, & S. W. Ashley (Eds.), *Maingot's abdominal operations* (12th ed.). New York, NY: McGraw-Hill.

8. **E.** *Aspergillus* species are widely dispersed in the environment and, when implicated as a pathogen, primarily affect the lung. It typically presents as one of four syndromes: aspergilloma, allergic bronchopulmonary aspergillosis (ABPA), chronic necrotizing *Aspergillus* pneumonia, and invasive aspergillosis. Aspergilloma typically presents as an asymptomatic radiographic finding in patients with a preexisting cavitary lung disease such as sarcoidosis. A soft-tissue mass within a cavity that is surrounded by a crescent of air (Monod sign) is diagnostic, and because the aspergilloma is not adherent to the cavity walls, the air will remain in a nondependent position. Biopsy or bronchoscopy is not indicated or necessary for diagnosis (A, B). As long as the patient is asymptomatic, no further workup or treatment is necessary. The most common symptom associated with aspergilloma is hemoptysis, which can occasionally be life threatening. In this setting, an emergency bronchial artery embolization should be performed followed by surgical resection (D). ABPA is a noninvasive hypersensitivity disease that, if left untreated, can lead to fibrotic lung disease. Therapy is aimed at treatment of acute exacerbations either with inhaled bronchodilators/steroids (mild disease) or systemic corticosteroids (severe disease) to prevent long-term sequelae. Serial chest radiographs, pulmonary function tests, and IgE levels should be monitored because permanent pulmonary damage can take place even in asymptomatic patients. Invasive aspergillosis and chronic necrotizing *Aspergillus* pneumonia are both treated with intravenous antifungals (C). Invasive disease can be rapidly fatal and is typically only found in immunocompromised hosts. High-risk transplant patients, such as bone marrow recipients, receive prophylactic agents to prevent invasive infection.

**Reference:** Limper, A. H., Knox, K. S., Sarosi, G. A., et al. (2011). An official American Thoracic Society statement: treatment of fungal infections in adult pulmonary and critical care patients. *American Journal of Respiratory and Critical Care Medicine*, 183(1), 96–128.

9. **E.** Hepatitis B surface antigen is found on the surface of the hepatitis B virus and is found in high quantities in the serum of individuals with acute or chronic infection. Antibodies against this antigen (anti-HBs) are considered to represent an immunity to the virus either from previous infection or vaccination. All patients with chronic hepatitis B infection will be anti-HBs negative.

Antibodies against hepatitis core antigen (anti-HBc) appear at the onset of symptoms and persist for life, though they do not confer immunity to the disease. Vaccination will not produce antibodies to hepatitis B core antigen. Presence of these antibodies indicates either active or previous infection with hepatitis B but do not confer a timeline associated with that infection. However, IgM against hepatitis B core antigen is only present for the first 6 months of infection, so its presence indicates a recent exposure to the virus. The aforementioned serologic profiles represent: A, susceptible to infection; B, immunity from previous infection; C, immunity from vaccination; D, acute infection; E, chronic infection.

10. **A.** Postexposure prophylaxis consists of ciprofloxacin or doxycycline. Agents such as cephalosporins and trimethoprim-sulfamethoxazole are not effective against *Bacillus anthracis* (B, D). Inhalational anthrax develops after a 1- to 6-day incubation period, with nonspecific symptoms including malaise, myalgia, and fever. Over a short period, these symptoms worsen with the development of respiratory distress, chest pain, and diaphoresis. If symptoms develop in the exposed patient, the mortality rate is very high. Treatment for fulminant anthrax infection includes combination therapy with ciprofloxacin, clindamycin, and rifampin (E). Clindamycin is added to block toxin production and rifampin is added for its ability to penetrate the central nervous system and intracellular locations (C).
11. **B.** NSTI is a broad term that encompasses infections limited to skin and subcutaneous tissue (necrotizing cellulitis) and those involving the fascia (necrotizing fasciitis) and muscle (myonecrosis). They can be extremely difficult to accurately diagnose early on because fewer than half present with obvious hard signs of NSTI, such as bullae, skin necrosis, gas on radiograph, and crepitus. Other signs include tense edema, violaceous skin color, severe pain, and neurologic deficit. Several laboratory values have been shown to be useful in distinguishing NSTI from simple cellulitis. The LRINEC (Laboratory Risk Indicator for Necrotizing Fasciitis) score uses the total WBC count, hemoglobin, sodium, glucose, serum creatinine, and C-reactive protein levels. A simpler model uses an admission WBC count greater than  $15.4 \times 10^9/L$  and/or a serum sodium level less than 135 mEq/L. This latter model is more useful for its negative predictive value (99%). A low serum sodium is theorized to be the result of either sepsis-induced syndrome of inappropriate antidiuretic hormone or adrenal insufficiency, but this has not been confirmed. Risk factors for NSTI include diabetes, illicit IV drug abuse, immunosuppression, and liver disease. Seventy percent to 80% of NSTIs are due to polymicrobial infection. Of those that are caused by a single organism, *Klebsiella*, *S. pyogenes*, and *C. perfringens* are the most common. NSTI is subdivided into two categories. Type I infections are caused by polymicrobial infection with aerobic and anaerobic bacteria (e.g., *Clostridium* and *Bacteroides* spp.), which work synergistically to produce infection. Type II infections are caused by group A *Streptococcus* with or without *Staphylococcus*. Treatment includes rapid administration of broad-spectrum antimicrobial agents, aggressive fluid resuscitation, and aggressive surgical debridement. The mortality rate remains at 20% to 40% and is higher with surgical delays, particularly beyond 24 hours. A rising WBC count and lactate after debridement are highly suggestive of progression of the NSTI. A second-look operation is often required and should be performed for this patient in order to ensure that no additional tissues have become involved since the initial debridement. Amputation may be necessary, but only a second-look operation will indicate whether this is the case (A). CT scan in the postoperative setting may not be useful because interpretation can be difficult secondary to postsurgical changes (D). With septic shock, pressors may be necessary, but this would not be the definitive treatment (E). Additionally, no hemodynamic parameters (blood pressure, central venous pressure) are provided that would indicate that pressors are needed. Similarly, adding antifungal coverage can be considered, but this is not a definitive intervention (C).

**References:** Anaya, D. A., & Dellinger, E. P. (2004). Surgical infections and choice of antibiotics. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 257–282) (17th ed.). Philadelphia, PA: W. B. Saunders.

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Wall, D., Klein, S., Black, S., et al. (2000). A simple model to help distinguish necrotizing fasciitis from nonnecrotizing soft tissue infection. *Journal of the American College of Surgeons*, 191(3), 227–231.

Wong, C., Khin, L., Heng, K., et al. (2004). The LRINEC (Laboratory Risk Indicator for Necrotizing Fasciitis) score: a tool for distinguishing necrotizing fasciitis from other soft tissue infections. *Critical Care Medicine*, 32(7), 1535–1541.

Yaghoubian, A., de Virgilio, C., Dauphine, C., et al. (2007). Use of admission serum lactate and sodium levels to predict mortality in necrotizing soft-tissue infections. *Archives of Surgery*, 142(9), 840–846.

12. **E.** The risk of the development of surgical site infections is related to several factors, including microbial contamination during surgery, length of the operation, and patient factors such as diabetes, nutritional state, obesity, and immunosuppression (cancer, renal failure, immunosuppressive drugs) (B–D). The National Nosocomial Infection Surveillance risk index is a useful tool to assess the risk of wound infection. This index includes (1) American Society of Anesthesiologists score higher than 2, (2) class III or IV wounds, and (3) duration of an operation greater than the 75th percentile for that particular procedure (A). Wounds are classified as clean (class I) (e.g., hernia repair, breast biopsy), clean/contaminated (class II) (e.g., cholecystectomy, elective gastrointestinal surgery), contaminated (class III) (e.g., bowel injury from trauma or inadvertent enterotomy), and dirty (class IV) (e.g., perforated appendicitis, diverticulitis, necrotizing soft-tissue infections [NSTIs]). Hemoglobin level has not been shown to increase the risk of wound infection. In a randomized study of patients undergoing colorectal surgery, surgical wound infections were found in 19% who were permitted to become hypothermic but in only 6% who were actively kept normothermic. In a randomized study of clean surgery (breast, varicose vein, hernia), those who were actively warmed 30 minutes before surgery had only a 5% wound infection rate versus 14% in nonwarmed patients. Active control of glucose via continuous infusion was shown to decrease sternal wound infection in diabetic patients undergoing cardiac surgery. The main concern with aggressive glucose control, however, is that it may incite episodes of hypoglycemia. A recent study also highlighted the risk of blood transfusion in wound infection, likely the result of its immunosuppressive effects.

**References:** Campbell, D., Henderson, W., Englesbe, M., et al. (2008). Surgical site infection prevention: the importance of operative duration and blood transfusion—results of the First American College of Surgeons–National Surgical Quality Improvement Program Best Practices Initiative. *Journal of the American College of Surgeons*, 207(6), 810–820.

Furnary, A., Zerr, K., Grunkemeier, G., et al. (1999). Continuous intravenous insulin infusion reduces the incidence of deep sternal wound infection in diabetic patients after cardiac surgical procedures. *The Annals of Thoracic Surgery*, 67(2), 352–360.

Kurz, A., Sessler, D. I., & Lenhardt, R. (1996). Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization: study of Wound Infection and Temperature Group. *The New England Journal of Medicine*, 334(19), 1209–1215.

Melling, A., Ali, B., Scott, E., et al. (2001). Effects of preoperative warming on the incidence of wound infection after clean surgery: a randomized controlled trial. *Lancet*, 358(9285), 876–880.

13. **D.** Acute mesenteric adenitis presents most commonly in children and young adults. It can frequently be confused with appendicitis in children. Usually, an upper respiratory infection is present or has recently resolved. The abdominal pain is usually diffuse, but true rigidity is rare. Laboratory values are of little help in establishing the diagnosis. More than 50% have an elevated WBC count. Although infection with the other answer choices can lead to mesenteric lymphadenitis, *Yersinia enterocolitica* is the most commonly associated organism in children (A–C, E). If the diagnosis is clear preoperatively (which is usually not the case), treatment is supportive because it is a self-limited disease. The diagnosis can also be made with CT by the demonstration of enlarged, clustered mesenteric lymph nodes in the right lower quadrant in the absence of acute appendicitis. However, with the increasing reluctance to expose children to the radiation associated with CT scanning, the diagnosis is most often made during laparoscopy.
14. **D.** A rare cause of infection in the first 48 hours after an operation is wound toxic shock syndrome. Toxic shock syndrome is an acute onset, multiorgan illness that resembles severe scarlet fever. It was originally described in menstruating women in association with tampon use, but it has been increasingly recognized in postsurgical wounds. In the majority of cases, the illness is caused by *S. aureus* strains that express toxic shock syndrome toxin-1, enterotoxin B, or enterotoxin C. It has rarely been described in association with *S. pyogenes* (group A streptococci) (C). The remaining answer choices are not associated with toxic shock syndrome (A, B, E). Half of the postsurgical

toxic shock syndrome cases present early, within 48 hours of operation. Symptoms include fever, diarrhea, vomiting, diffuse redness of the skin, and hypotension. This is followed a day or two later by diffuse desquamation. Physical examination findings of wound infection are often unremarkable. Wound drainage and antibiotics are recommended. Administration of clindamycin may be helpful because it inhibits exotoxin production.

**Reference:** Reingold, A., Dan, B., Shands, K., et al. (1982). Toxic-shock syndrome not associated with menstruation: a review of 54 cases. *Lancet*, 1(8262), 1–4.

15. **C.** *C. septicum* has been associated with colonic and hematologic malignancies. In a review of the literature involving 162 cases of *C. septicum* infection, 81% had an associated malignancy, including 34% with colon carcinoma and 40% with a hematologic malignancy. In 37%, the malignancy was occult. The survival rate was only 35%. As such, patients discovered to have an infection with *C. septicum* should have an outpatient colonoscopy scheduled (A, B, D, E).

**Reference:** Kornbluth, A., Danzig, J., & Bernstein, L. (1989). *Clostridium septicum* infection and associated malignancy: report of 2 cases and review of the literature. *Medicine (Baltimore)*, 68(1), 30–37.

16. **D.** Gentamicin is an aminoglycoside that is effective against gram-negative rods. It is most active against *Enterococcus* and *Serratia* (C). It has poor activity against *Streptococcus* (A). It has some synergism with penicillin or vancomycin against enterococci. It has no activity against anaerobes (E). It is associated with nephrotoxicity and cranial nerve VIII toxicity. Like other aminoglycosides, the therapeutic index (ratio of toxicity to effective doses) is very low and thus, serum monitoring is generally recommended (B).
17. **B.** Metronidazole is effective against anaerobes and protozoa. It is used for perforated bowel, pelvic inflammatory disease, *H. pylori* infections, amebic dysentery, and amebic liver abscesses, among others. It has an Antabuse (disulfiram)-like reaction, so it cannot be used in conjunction with alcohol. It is cleared by the liver. Prolonged use has been associated with peripheral neuropathy. The remaining answer choices are not commonly associated with peripheral neuropathy (A, C–E).
18. **B.** Tetanus is an acute, often fatal, disease caused by an exotoxin produced by *Clostridium tetani* that enters the body through a wound. The mean incubation period is 7 to 8 days (range 3–21). In the presence of anaerobic (low oxygen) conditions, the spores germinate. The causative organism is a gram-positive anaerobic rod (C). *C. tetani* produces two exotoxins: tetanolysin and tetanospasmin. Tetanospasmin is a neurotoxin and causes the clinical manifestations of tetanus. The toxins act at several sites within the central nervous system, including the peripheral motor end plates, spinal cord, brain, and sympathetic nervous system. The toxin interferes with the release of neurotransmitters, blocking inhibitor impulses, leading to unopposed muscle contraction and spasm. It is characterized by generalized rigidity and convulsive spasms of skeletal muscles. It typically involves the jaw muscles (hence the term *lockjaw*) and neck (trismus) and then becomes generalized. The back spasms can be so intense that they can lead to spontaneous vertebral fractures. Intense facial spasms can lead to a classic appearance known as risus sardonicus (sardonic smile, a smile of contempt or of pain). Laryngospasm and/or spasm of the muscles of respiration leads to interference with breathing. There are no laboratory findings that are characteristic of tetanus. Culture of the wound or blood is not helpful. The diagnosis is clinical (E). Treatment includes human tetanus immunoglobulin, airway protection by early placement of a tracheostomy, IV magnesium for muscle spasm prevention, high calorie replenishment, and benzodiazepines. Due to the extreme potency of the toxin, contracting tetanus does not result in immunity (D). Tetanus immune globulin (TIG) is recommended for persons with tetanus. Active immunization with tetanus toxoid should begin or continue as soon as the person's condition has stabilized. Tetanus is not transmittable from person to person. Interestingly, it is the only vaccine-preventable disease that is infectious but not contagious (A).
19. **B.** As a general rule, gram-positive organisms produce exotoxins, and gram-negative organisms have endotoxins. *S. pyogenes* produces streptokinase, which acts as a fibrinolytic (A). *B. fragilis*, a gram-negative organism, does not produce an exotoxin and has defective lipopolysaccharide and lipid A. *C. tetani* produces tetanospasmin, which acts as a neurotoxin (C). *S. aureus* produces hemolysin and leukocidin, which damage plasma membranes of the host, and exfoliatin, which cleaves desmosomes (D). *C. perfringens* produces heat-labile enterotoxin causing watery diarrhea (E).



20. **E.** The risk of developing hepatitis B from a needlestick injury is far greater than hepatitis C, particularly when the patient is hepatitis Be surface antigen (HBsAg) positive (A). If the patient's blood is both HBeAg and HBsAg positive, the risk of developing clinical hepatitis is very high (22–31%). If the blood is HBsAg positive but HBeAg negative, the risk drops to 1% to 6% (although seroconversion is still high at 23–37%). Hepatitis B is highly infectious, and the virus can survive on dried blood and on environmental surfaces for at least a week. The majority of health-care workers infected with hepatitis B do not recall a needlestick exposure, though they were in contact with a hepatitis B–positive patient (D). For health-care workers who have never been vaccinated for hepatitis B, or are seronegative, treatment with both HBIG (immunoglobulin prepared from human plasma known to contain a high titer of antibody to HBsAg) and hepatitis B vaccine is recommended (B). Data on clinical hepatitis C following exposure is lacking. However, the average incidence of anti-HCV seroconversion from an HCV-positive source is very low (only 1.8%), suggesting that the risk of transmission from a needlestick injury is very low. In fact, some studies suggest that the risk of hepatitis C transmission from a solid surgical needle is negligible. No effective prophylaxis for HCV has been identified. Immunoglobulin and antiviral agents are not recommended for HCV postexposure prophylaxis (C).

**Reference:** Updated U.S. Public Health Service Guidelines for the Management of Occupational Exposures to HBV, HCV, and HIV and Recommendations for Postexposure Prophylaxis. (2013).

21. **D.** *C. difficile* colitis is a very common nosocomial infection and can lead to significant morbidity and mortality. The incidence has been rising, and women and older patients are more commonly affected. Antibiotic use is the most widely recognized risk factor and patients believed to have antibiotic-associated *C. difficile* should first begin management with cessation of the suspected antibiotic agent. Patients with mild to moderate *C. difficile* colitis (defined as WBC < 15 cells/ $\mu$ L and/or Cre < 1.5  $\times$  baseline) should initially be managed with oral metronidazole. Patients with severe *C. difficile* colitis (WBC > 15 cells/ $\mu$ L and/or Cre > 1.5  $\times$  baseline) should be treated with oral vancomycin. IV vancomycin does not reach the colonic lumen so is not useful. Additionally, oral vancomycin has near 0% bioavailability and so remains fully in the colonic lumen. Patients that fail to respond to therapy after 5 to 7 days should receive oral and rectal vancomycin as well as IV metronidazole. In patients that develop complicated *C. difficile* colitis, surgical intervention is considered in addition to the above antibiotic regimen. Indications for surgery include hypotension requiring pressor support, organ failure, WBC greater than or equal to 50,000 cells/ $\mu$ L, and a lactate level greater than 5 mmol/L (A–C, E).

**Reference:** Surawicz, C. M., Brandt, L. J., Binion, D. G., et al. (2013). Guidelines for diagnosis, treatment, and prevention of *Clostridium difficile* infections. *The American Journal of Gastroenterology*, 108(4), 478–498.



# Nutrition and Metabolism

*Patrick T. Delaplain, Areg Grigorian, and Christian de Virgilio*

## Questions

1. Which of the following is true regarding daily caloric and/or protein requirements?
  - A. Preterm infants may need up to 2 g/kg per day of protein.
  - B. A 60-kg adult needs about 90 g/day of protein.
  - C. A respiratory quotient greater than 1.0 suggests overfeeding.
  - D. Burn victims generally require less protein than other trauma victims.
  - E. A respiratory quotient (RQ) of 0.8 suggests starvation.
2. A 23-year-old male was admitted 7 days ago for multisystem trauma including multiple long-bone fractures, subdural hematoma, and pulmonary contusions and is still on the ventilator. Which of the following is true regarding tools for assessing nutritional status?
  - A. Use of serial measurements of albumin and prealbumin is the “gold standard” for trauma patients.
  - B. Measurement of nitrogen balance is limited because it underestimates nitrogen input.
  - C. The Mini Nutritional Assessment is designed specifically for hospitalized patients.
  - D. Creatinine height index may overestimate lean body mass in trauma patients.
  - E. Out of all of the serum protein measurements, transferrin seems to correlate the closest to nitrogen balance.
3. Which of the following is true regarding the risk of hypoglycemia following cessation of total parenteral nutrition (TPN)?
  - A. It commonly occurs in patients with liver disease.
  - B. TPN should be tapered in most patients so as to avoid this complication.
  - C. This complication is relatively common.
  - D. It is more likely to occur in a diabetic patient.
  - E. It is more likely to occur in patients with renal disease.
4. Which of the following is true about the pharmacologic treatment of cancer cachexia?
  - A. There is no evidence that ghrelin mimetics are of benefit.
  - B. Cannabinoids are superior to megestrol acetate in stimulating appetite and weight gain.
  - C. When initiated early, megestrol acetate has been demonstrated to improve survival.
  - D. Megestrol is a progesterone derivative.
  - E. Anabolic steroids have been shown to have lasting improvements in appetite and improved long-term weight gain.
5. Which of the following is true regarding energy homeostasis during periods of fasting or starvation?
  - A. The largest source of energy after glycogen is depleted is free fatty acids.
  - B. Skeletal muscle has the largest store of glycogen available systemically.
  - C. Glucose is converted to lactate in the liver.
  - D. Red blood cells are reliant on aerobic metabolism of glucose.

- E. The brain is unable to utilize ketones.
6. Which of the following is true regarding fluid homeostasis during and immediately after a 4-hour laparotomy?
- A. The majority of postoperative oral fluid replacement will be primarily absorbed in the colon.
  - B. Laparoscopic and open abdominal causes have similar unmeasured fluid losses.
  - C. Administration of 5% albumin pulls third-space fluids into the intravascular space.
  - D. Insensible fluid deficit may be as high as 4 L
  - E. About 50% of a crystalloid fluid bolus will remain intravascular.
7. A potential complication of massive red blood cell transfusions is:
- A. Metabolic acidosis from citrate preservative
  - B. Hypocalcemia from citrate preservative
  - C. Hypokalemia due to prolonged red cell storage
  - D. A rise in 2,3-diphosphoglycerate (DPG)
  - E. Shift of the oxyhemoglobin dissociation curve to the right
8. Which of the following amino acids can be synthesized de novo in humans in any physiologic state?
- A. Tryptophan
  - B. Tyrosine
  - C. Glycine
  - D. Serine
  - E. Any branched-chain amino acid
9. Which of the following is true regarding the use of preoperative TPN to prevent postoperative complications?
- A. It is useful even if used for as little as 3 days.
  - B. It is efficacious if the patient has lost more than 15% weight before surgery.
  - C. There is no evidence that it lowers the complication rate.
  - D. Slightly overfeeding for 7 days is preferable as a means to maximize replacement of caloric deficits.
  - E. TPN is efficacious even in mild to moderate malnutrition.
10. Which of the following is true regarding nutritional deficiencies following a partial gastrectomy with a Billroth II (gastrojejunostomy) reconstruction?
- A. Calcium absorption will be minimally affected because this primarily occurs in the ileum.
  - B. Iron deficiency anemia is more common with a Billroth I (gastroduodenostomy) than a Billroth II.
  - C. Vitamin B<sub>12</sub> deficiency will present with a low mean corpuscular volume.
  - D. The stomach has no intrinsic absorptive ability.
  - E. Carbohydrate absorption is not impaired after surgery.
11. The most important amino acid used for gluconeogenesis by the liver is:
- A. Glutamine
  - B. Serine
  - C. Alanine
  - D. Tyrosine
  - E. Asparagine
12. A 65-year-old male with a malignant tumor has an elevated serum level of tumor necrosis factor alpha (TNF- $\alpha$ ) and an elevated urine level of proteolysis-inducing factor (PIF). Which of the following cancers does this patient most likely have?
- A. Colon
  - B. Prostate
  - C. Pancreas

- D. Breast
  - E. Liver
13. Poor glucose control is a manifestation of deficiency of:
- A. Zinc
  - B. Copper
  - C. Chromium
  - D. Molybdenum
  - E. Selenium
14. Which of the following is true regarding long-term TPN?
- A. Fat is considered the nutritional basis of TPN.
  - B. It may lead to a mucin gel matrix of cholesterol crystals and calcium bilirubinate in the gallbladder.
  - C. Hepatic dysfunction related to TPN is less likely to be lethal in infants than in adults.
  - D. It has not been shown to lead to hepatic fibrosis.
  - E. Carnitine supplementation has been shown to reverse TPN-related liver damage.
15. Which of the following amino acids has shown potential for increasing the absorptive capability of the intestine in patients that have undergone large segment small bowel resection?
- A. Glutamine
  - B. Serine
  - C. Alanine
  - D. Tyrosine
  - E. Arginine

## Answers

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1. **C.** The daily recommended protein requirement in an adult is approximately 0.8 g/kg per day. However, this can increase in the setting of physiologic stress. Burn patients' protein requirement is closer to 2 to 2.5 g/kg per day (D). There is also an increased demand for protein in pediatric patients because of active growth, with the largest being preterm infants who may need 3 to 4 g/kg per day (A). A 60-kg adult needs approximately 48 g protein/day ( $60 \text{ kg} \times 0.8 \text{ g/kg per day}$ ) (B). The RQ is the ratio of carbon dioxide produced to oxygen consumed, and it can be used to estimate what energy source is the primary substrate for energy production. However, it must be measured at a steady state. By knowing the RQ, you are able to determine the primary substrate being used for energy production: greater than 1 for lipogenesis (overfeeding state), 1.0 for carbohydrates, 0.8 for proteins, and 0.7 for fatty acids. This can then be extrapolated to the nutritional state of the patient by knowing what substrates are being used at various phases of fasting. A normal RQ is around 0.85 because the body is using about 50% carbohydrates and 50% fatty acids. The overfed state is predominated by conversion of glucose into fats and correlates with a RQ of more than 1. Starving patients are primarily using fatty acids as the primary fuel source and have a RQ of less than 0.7.

**References:** Guyton, A. C., & Hall, J. E. (2006). *Textbook of medical physiology*. Philadelphia, PA: Elsevier Saunders.

Barrett, K. E., & Ganong, W. F. (2010). *Ganong's review of medical physiology*. New York, NY: McGraw-Hill Medical.

2. **D.** Nutritional assessment in the hospitalized patient is limited by multiple confounding factors. While there are lots of tools available for nutritional assessment, no single item has proven to be infallible in assessing a patient's nutritional status. Current Eastern Association for the Surgery of Trauma (EAST) Guidelines for nutritional assessment in the trauma patient use nitrogen balance as the "gold standard" by which all other tests are evaluated (A). Though nitrogen balance is a fairly accurate measurement of nutritional status, it is limited by the impracticality of 24-hour urine collection and the often inaccurate recording of daily nitrogen input. Nitrogen output is often underestimated and input is often overestimated (B). Of the serum proteins, prealbumin seems to correlate the closest with nitrogen balance (E). Many of the serum proteins used for

nutrition assessment—albumin, prealbumin, transferrin, and retinol binding protein—are altered in times of stress or infection, so most sources recommend including an acute phase reactant such as CRP to put these values in context. While the creatinine height index can give you an estimate of lean body mass, changes in creatinine excretion from systemic processes (e.g., trauma, renal disease, etc.) can make the results unreliable. The Mini Nutritional Assessment is specifically designed for the elderly (C).

**References:** Elmadfa, I., & Meyer, A. L. (2014). Developing suitable methods of nutritional status assessment: a continuous challenge. *Advances in Nutrition*, 5(5), 590S–598S.

Jacobs, D. G., Jacobs, D. O., Kudsk, K. A., et al. (2004). Practice management guidelines for nutritional support of the trauma patient. *The Journal of Trauma*, 57(3), 660–679.

Norton, J. A. (2003). *Essential practice of surgery: basic science and clinical evidence*. New York, NY: Springer.

3. **D.** Hypoglycemia following the abrupt cessation of TPN has been reported, though it is very rare (C). Hypoglycemia can present with diaphoresis, confusion, agitation, tachycardia, and, if severe, diabetic coma. Most patients will tolerate abrupt cessation of TPN and tapering is generally unnecessary. Two studies published in 1995 and 2000 both showed no difference in symptomatic hypoglycemia or serum glucose measurements between a TPN-dependent group randomized to abrupt cessation versus step-wise tapering (B). However, in the diabetic patient, and in those with poor glucose control, tapering of TPN should be considered (A–E).

**References:** Nirula, R., Yamada, K., Waxman, K. (2000). The effect of abrupt cessation of total parenteral nutrition on serum glucose: a randomized trial. *The American Surgeon*, 66(9), 866–869.

Eisenberg, P., Gianino, S., Clutter, W., et al. (1995). Abrupt discontinuation of cycled parenteral nutrition is safe. *Diseases of the Colon and Rectum*, 38(9), 933–939.

4. **D.** Cancer-related cachexia/anorexia has been associated with failure of cancer treatment, delay in initiation of treatment, increased treatment toxicity, early discontinuation of treatment, and shorter survival in terminal cancer patients. It has even been implicated as a direct cause of death in 20% to 40% of cancer patients. Current National Comprehensive Cancer Network (NCCN) Guidelines recommend early screening and early treatment of this condition. Before initiation of appetite stimulation, treatable causes of anorexia such as oral candidiasis or depression should be addressed. Megestrol acetate (Megace) is the most widely studied and, so far, most efficacious medication available to help improve appetite and weight gain in this patient population. Megestrol acetate is a synthetic, orally active derivative of progesterone. It has been found to improve appetite, caloric intake, and nutritional status in several clinical trials. A study done in 2010 demonstrated that megestrol acetate used in combination with olanzapine was associated with improvements in weight gain, appetite, nausea, and overall quality of life when compared with megestrol acetate alone, even when corrected for improvements in depression. Unfortunately, megestrol acetate, either alone or in combination with olanzapine, has not been demonstrated consistently in the literature to improve survival (C). It is also important to note that 1 in 23 patients using megestrol acetate will have a thromboembolic event; therefore it should be used with caution in susceptible patients. While it has been demonstrated that steroids have results equivalent to megestrol acetate, they are short-lived and patients quickly return to baseline after cessation of the drug (E). Cannabinoids have been looked at extensively in chemotherapy-related nausea and AIDS-cachexia, but studies done in the cancer population tend to show inferiority to megestrol acetate (B). Ghrelin mimetics have been demonstrated to improve lean body mass (A).

**References:** Navari, R., & Brenner, M. (2009). Treatment of cancer-related anorexia with olanzapine and megestrol acetate: a randomized trial. *Support Care Cancer*, 18(8), 951–956.

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Nagaya, N., Kojima, M., & Kangawa, K. (2006). Ghrelin, a novel growth hormone-releasing peptide, in the treatment of cardiopulmonary-associated cachexia. *Internal Medicine (Tokyo, Japan)*, 45(3), 127–134.

5. **A.** After a meal, carbohydrates are rapidly used, and any excess is stored as fatty acids or as glycogen (primarily in the liver and skeletal muscle). Though the skeletal muscle has proportionally more glycogen stored, it is not available systemically during fasting because these cells lack glucose-6-phosphatase, which is the final step needed for creation of glucose from

glycogen (B). As such, the glycogen stores are used only locally. Liver stores of glycogen are normally used within 16 to 36 hours, but it can be shorter in certain disease states. After glycogen stores are depleted, the body turns to the breakdown of skeletal muscle and lipids for energy. The largest source of energy is free fatty acids, but they are a relatively poor source of free glucose. While amino acids from protein breakdown can be used for gluconeogenesis in the liver (early in starvation) and kidney (late in starvation), most proteins serve an important role in bodily functions. Lactate and glycerol can also be used as substrates for gluconeogenesis (C). During prolonged fasting, tissues that are able to use alternate fuel sources (i.e., breakdown products of fatty acids) begin to do so, and subsequently, the breakdown of muscle slows and breakdown of body fat increases. However, gluconeogenesis never completely stops because several cells are heavily reliant on glucose as a fuel source. Red blood cells are solely reliant on the anaerobic conversion of glucose to lactate because they lack a mitochondria required for the utilization of fatty acids or for aerobic breakdown of glucose (D). In addition, white blood cells, cells in the adrenal medulla, and peripheral nerves are all obligate glucose users. While the brain is heavily reliant on glucose as a fuel source, it can use ketones to some degree (E).

**References:** Brunicaudi, F. C., Andersen, D. K., & Schwartz, S. I. (2015). *Schwartz's principles of surgery* (10th ed.). New York, NY: McGraw-Hill Education.

Cahill, G. F. (2006). Fuel metabolism in starvation. *Annual Review of Nutrition*, 26(1), 1–22.

6. **D.** Open abdominal cases, more so than laparoscopic, can be associated with significant insensible losses ranging anywhere from 0.5 to 1 L/hour (B). However, caution should be used when interpreting this information because the fluid status should be evaluated by a combination of factors including urinary output, calculated losses, and hemodynamic status. Isotonic crystalloids such as normal saline or lactated ringers administered during or after the case will replete some of the fluid deficit, but only about 33% of crystalloid will remain intravascular after it has had time to equilibrate (E). While the use of 5% albumin is a tempting option to replace intravascular fluid losses, it does not work by pulling fluid into the intravascular space. Albumin has a similar osmotic pressure to serum; it will stay intravascular longer (up to 24 hours), but it will not “pull” fluids from the extravascular space to augment it (C). While many patients can undergo oral fluid resuscitation, most of this fluid is absorbed by the small bowel, not the colon (A). One of the colon’s primary functions is the absorption of water, but in terms of total volume it doesn’t match that of the small bowel.
7. **B.** Hypocalcemia is a very common sequela of massive transfusion and can worsen coagulopathy and potentially increase mortality if not addressed. This is primarily caused by the chelation of calcium by citrate, which is used to prevent clotting of stored blood. While it is found in relatively small volumes in packed RBCs, it is much higher in stored plasma and platelets. Generally, it is not a problem with small volume transfusions because it is rapidly cleared by the liver. However, in the trauma patient receiving massive transfusion, the higher number of transfused products, the corresponding hypothermia, and multiorgan system dysfunction all contribute to reduced clearance. A study done in 2015 showed that 90% of trauma patients requiring activation of a massive transfusion protocol had some degree of calcium deficiency. The strongest predictor of severe hypocalcemia was transfusion of more than 15 units of total blood products. The severe hypocalcemia group in this study showed a significantly higher mortality (49% vs 24%), potentially highlighting its importance in clinical practice. However, this group also required more blood products so causation is difficult to determine. Patients with massive transfusions also can develop hyperkalemia due to potassium leakage from lysed red blood cells (C). Additionally, the metabolism of citrate in the liver can result in metabolic alkalosis (A). As the shelf time of stored red blood cells increase, the intracellular adenosine triphosphate (ATP) and 2-3 DPG decrease, which subsequently results in a left shift of the oxyhemoglobin dissociation curve (D, E).

**Reference:** Giancarelli, A., Birrer, K. L., Alban, R. F., et al. (2015). Hypocalcemia in trauma patients receiving massive transfusion. *The Journal of Surgical Research*, 202(1), 182–187.

8. **D.** Amino acids are the building blocks used for the synthesis of proteins. The nonessential amino acids are those that can be created de novo without an exogenous source. In humans, these include alanine, aspartic acid, asparagine, glutamic acid, and serine. The essential amino acids are those that cannot be synthesized and require an exogenous source: phenylalanine, threonine, tryptophan, methionine, lysine, and histidine (A–E). In addition, all the branched-chain amino acids (leucine, isoleucine, and valine [LIV]) are essential amino acids. A third category of amino

acids includes those that can become essential in certain physiologic states, such as the premature infant or severe states of distress. These include arginine, cysteine, glycine, glutamine, proline, and tyrosine. Patients with phenylketonuria (PKU) need to keep intake of phenylalanine low, and because it is the precursor to tyrosine, it can become an essential amino acid in this disease state (B, C).

9. **B.** Providing nutritional intervention should be limited to patients with severe malnutrition and immunologic dysfunction. In a Veterans Affairs multicenter trial, malnourished patients that lost more than 15% of their baseline body weight had decreased operative septic complications when they received preoperative nutritional intervention for 7 to 10 days (A). However, in the group stratified as having mild to moderate malnutrition, the decrease in surgical complications was more than offset by the increase in catheter-related infectious complications (E). TPN-induced hyperglycemia is likely a contributor to adverse outcomes (D). Thus, improperly administered TPN increases the risk of catheter-related and non-catheter-related infection (C). Buzby proposed the following guidelines: (1) Postoperative TPN should be considered when oral or enteral feeding is not anticipated within 7 to 10 days in previously well-nourished patients or within 5 to 7 days in previously malnourished or critically ill patients. (2) Preoperative TPN should be considered in patients who cannot or should not eat or receive enteral feedings if the operation must be delayed for more than 3 to 5 days. (3) Preoperative TPN should be considered in the most severely malnourished surgical candidates if an operative delay is not contraindicated. In patients with only mild to moderate degrees of malnutrition, preoperative TPN is not indicated.

**References:** Bozzetti, F., Gavazzi, C., Miceli, R., et al. (2000). Perioperative total parenteral nutrition in malnourished, gastrointestinal cancer patients: a randomized, clinical trial. *JPEN. Journal of Parenteral and Enteral Nutrition*, 24(1), 7–14.

Buzby, G. (1993). Overview of randomized clinical trials of total parenteral nutrition for malnourished surgical patients. *World Journal of Surgery*, 17(2), 173–177.

10. **E.** The main deficiencies of clinical concern that can be seen after gastrectomy are iron (most common), calcium, and vitamin B<sub>12</sub>. Stomach acid helps reduce dietary iron from a ferric to a ferrous state, which allows it to be actively absorbed in the duodenum and jejunum. This can put patients at risk for an iron-deficiency anemia following partial or total gastrectomy. It does occur more commonly with a Billroth II compared to a Billroth I (B). Calcium absorption takes place primarily in the duodenum by an active process that is regulated by vitamin D and parathyroid hormone. After gastrectomy with Billroth II reconstruction, patients are at risk for nutritional deficiencies primarily because of quicker gastric emptying and anatomically bypassing the duodenum (A). Parietal cells located in the gastric fundus and corpus are responsible for the production of intrinsic factor, which is required for the absorption of vitamin B<sub>12</sub> in the terminal ileum. Vitamin B<sub>12</sub> deficiency will present with a megaloblastic anemia (increased MCV) and peripheral neuropathy (C). While the stomach does not typically absorb many nutrients, it can absorb some lipid-soluble compounds such as alcohol, aspirin, and nonsteroidal antiinflammatory drugs (NSAIDs) (D). Though fatty acid absorption has been shown to be effected after gastrectomy, there is no evidence that carbohydrate absorption is impaired in any way.

**References:** Guyton, A. C., & Hall, J. E. (2006). *Textbook of medical physiology*. Philadelphia, PA: Elsevier Saunders.

Lee, J. H., Hyung, W. J., Kim, H. I., et al. (2013). Method of reconstruction governs iron metabolism after gastrectomy for patients with gastric cancer. *Annals of Surgery*, 258(6), 964–969.

11. **C.** In humans, the main substrates for gluconeogenesis are lactate, pyruvate, amino acids, and, to a lesser extent, glycerol. This is primarily stimulated by glucagon. Alanine is the most important amino acid precursor in gluconeogenesis. When the liver has exhausted all of its alanine supply, the kidney takes over gluconeogenesis where glutamine may be used for gluconeogenesis (A). Additionally, alanine and phenylalanine are the only amino acids that increase during times of stress. Serine, tyrosine, and asparagine are not substrates for gluconeogenesis (B–D, E).
12. **C.** Cachexia is a progressive wasting syndrome characterized by extensive loss of adipose tissue and skeletal muscle. It occurs in approximately one-half of all cancer patients and is most prominent in upper gastrointestinal cancers, particularly pancreatic, as well as lung cancer (A, B–E). However, it is noticeably absent in breast cancer (D). Patients with cancer often have anorexia, but the energy deficit alone does not explain the pathogenesis of cachexia. PIF has been found in

the urine in a significant number of patients with weight loss due to pancreatic cancer. It is thought that TNF- $\alpha$  and PIF can both induce catabolism and activate the ubiquitin-proteasome pathway in muscle. Exocrine insufficiency seen in pancreatic cancer may be more of an important contributor to weight loss. Sixty-five percent of patients with pancreatic cancer have weight loss, and this has been shown in several studies to be associated with worse morbidity and is a negative prognostic factor for survival.

**References:** Bruera, E., Strasser, F., Palmer, J., et al. (2003). Effect of fish oil on appetite and other symptoms in patients with advanced cancer and anorexia/cachexia: a double-blind, placebo-controlled study. *Journal of Clinical Oncology*, 21(1), 129–134.

Dewys, W. D., Begg, C., Lavin, P. T., et al. (1980). Prognostic effect of weight loss prior to chemotherapy in cancer patients. Eastern Cooperative Oncology Group. *The American Journal of Medicine*, 69(4), 491–497.

Papadoniou, N., Kosmas, C., Gennatas, K., et al. (2008). Prognostic factors in patients with locally advanced (unresectable) or metastatic pancreatic adenocarcinoma: a retrospective analysis. *Anticancer Research*, 28(1B), 543–549.

Tisdale, M. (2003). Pathogenesis of cancer cachexia. *The Journal of Supportive Oncology*, 1(3), 159–168.

13. **C.** Chromium is a cofactor involved in utilization of insulin at the tissue level, and deficiency often manifests as a sudden diabetic state in which blood sugar is difficult to control, along with peripheral neuropathy and encephalopathy. Zinc deficiency has numerous manifestations, including alopecia, poor wound healing, immunosuppression, night blindness or photophobia, impaired taste or smell, neuritis, and a variety of skin disorders (A). Copper deficiency manifests as microcytic anemia, pancytopenia, depigmentation, and osteopenia (B). Essential mineral and vitamin deficiency may occur with increased frequency in patients receiving long-term parenteral nutrition. Molybdenum deficiency is characterized by the toxic accumulation of sulfur-containing amino acids and encephalopathy (D). Selenium deficiency may result in diffuse skeletal myopathy and cardiomyopathy, loss of pigmentation, and erythrocyte macrocytosis (E).
14. **B.** Glucose is considered the nutritional basis of TPN, while fat is considered the nutritional basis of peripheral parenteral nutrition (PPN) (A). Liver dysfunction is commonly observed in patients receiving TPN. It develops in 40% to 60% of infants who require long-term TPN for intestinal failure. The clinical spectrum includes cholestasis, biliary sludge (mucin gel matrix of cholesterol crystals and calcium bilirubinate), cholelithiasis, hepatic fibrosis with progression to biliary cirrhosis, and the development of portal hypertension and liver failure (D). Predisposing factors include short gut syndrome, a history of bacterial overgrowth, and recurrent sepsis or a chronic inflammatory state. Lack of enteral feeding contributes by leading to reduced gut hormone secretion, decreased bile flow, and biliary stasis. Deficiencies in particular nutrients such as carnitine, taurine, cysteine, and S-adenosylmethionine are also implicated in TPN-related liver disease. Hepatic steatosis may be improved with carnitine supplementation, but there is no evidence that it will reverse TPN-related liver damage (E). Hepatic dysfunction is more serious and lethal in infants dependent on TPN compared with adults (C). Even when enteral feeding is begun and TPN is discontinued, hepatic dysfunction may persist and may progress to cirrhosis and death. The ultimate solution is combined liver and small bowel transplantation.  
**Reference:** Kelly, D. (1998). Liver complications of pediatric parenteral nutrition: epidemiology. *Nutrition*, 14(1), 153–157.
15. **A.** In two randomized studies, patients with short gut syndrome secondary to small bowel resection were seen to have modest improvements after the administration of supplemental glutamine, exogenous growth hormone, and a modified diet with increased fiber. One study showed an improvement in calorie, protein, and carbohydrate absorption as well as a reduction in stool volume. However, the second study failed to show an increase in the absorption of macronutrients and only showed an improvement in electrolyte absorption and a reduction in delayed gastric emptying. These specific interventions seemed to exert bowel-specific trophic effects, which may influence nutritional absorption. However, it is unclear whether this is through a direct or indirect mechanism. It is important to keep in mind that these studies were done on a small number of patients, but it shows some promise in patients that would otherwise be completely TPN dependent. The remaining answer choices have not been shown to improve intestinal absorption efficiency (B–E). Interestingly, glutamine can also lead to improved immunologic function when given to critically ill patients in catabolic states (e.g., sepsis, trauma).



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- Scolapio, J., Camilleri, M., & Fleming, C. (1997). Effect of growth hormone, glutamine, and diet on adaptation in short-bowel syndrome: a randomized, controlled study. *Gastroenterology*, 113(4), 1074–1081.
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# Oncology and Tumor Biology

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## Questions

1. A 60-year-old male with cirrhosis presents to clinic with a newly diagnosed 4-cm hepatocellular carcinoma (HCC) in segment 6. There is no evidence of gross vascular invasion and no regional nodal or extrahepatic distant metastases. His international normalized ratio (INR) is 1.2, creatinine is 1.0 mg/dL, bilirubin is 2.5 mg/dL, and albumin is 4 mg/dL, and his computed tomography (CT) scan shows no evidence of ascites. Which of the following would be the best treatment option?
  - A. Transarterial chemoembolization (TACE)
  - B. Liver resection
  - C. Radiofrequency ablation (RFA)
  - D. Irreversible electroporation
  - E. Liver transplantation
2. Which of the following is true regarding the development of skin cancers?
  - A. Ultraviolet (UV) radiation both initiates and promotes DNA damage.
  - B. UVA is the ultraviolet frequency most responsible for chronic skin damage.
  - C. An increased level of skin melanin increases the risk of developing basal cell carcinoma.
  - D. UV radiation damages the DNA mismatch repair gene.
  - E. Mutations in the *BCL-2* gene are a known mechanism for the development of skin cancer.
3. Which of the following is true regarding the interaction between radiation therapy and tumor cells?
  - A. Radiation therapy leads to cancer cell death by directly inhibiting adenosine triphosphate (ATP) production in the mitochondria.
  - B. As the energy used in radiation therapy increases, collateral damage to overlying skin also increases.
  - C. Larger tumors are more sensitive to radiation therapy.
  - D. The S-phase of the cell cycle is most sensitive to radiation effects.
  - E. Correcting anemia can increase the efficacy of radiotherapy.
4. A 43-year-old male is diagnosed with a high-grade right lower extremity osteosarcoma and undergoes surgical resection and adjuvant chemotherapy with MAP (methotrexate, doxorubicin, and cisplatin). After the third treatment cycle, the patient develops severe nausea, vomiting, and altered mental status. Workup reveals increased liver transaminases, a reduction in glomerular filtration rate (GFR), as well as leukopenia and thrombocytopenia. What medication can potentially reverse these effects?
  - A. Omeprazole
  - B. Folinic acid
  - C. Folic acid
  - D. Folate
  - E. Cobalamin
5. Which of the following statements is true regarding patterns of metastatic spread?
  - A. The most common metastatic location for breast cancer is the brain.

- B. The most common metastatic location for colon cancer is the lungs.
  - C. Metastases to the adrenal gland most commonly originate in the lungs.
  - D. The most common metastatic location for melanoma is the small bowel.
  - E. The transverse colon is frequently the first location of metastatic spread of pancreatic cancer.
6. Which of the following statements is true regarding the human protein p53?
- A. Germline mutations of the p53? gene result in Cowden Syndrome.
  - B. The unregulated growth seen with human papilloma virus (HPV) is partly due to binding and inactivation of the p53 protein.
  - C. The p53 gene suppresses the translation process in DNA sequencing and cell growth.
  - D. Overexpression of this gene leads to uncontrolled cell growth.
  - E. Mutations frequently result in benign neoplastic growth rather than malignancy.
7. A 77-year-old male who resides in a subacute care facility has just finished adjuvant chemotherapy (FOLFOX and Bevacizumab) for metastatic colon cancer. Despite a normal albumin, minimal weight loss, and meticulous local wound care, his nurses have been unable to adequately treat a nonhealing sacral decubitus ulcer. The wound base looks clean, and he has no signs of systemic infection. Which of the following is true?
- A. The sacral wound should be preemptively debrided to avoid infection and facilitate wound healing.
  - B. Supplemental enteral nutrition will facilitate faster wound healing.
  - C. Rescue therapy can be attempted with leucovorin.
  - D. The patient should be converted to Cetuximab.
  - E. Barriers to healing will likely resolve in 6 months.
8. An 87-year-old female presents to the emergency department (ED) with weight loss, vomiting, obstipation, and a distended abdomen. She has not had a bowel movement in 3 days. Past history is significant for a non-ST segment elevation myocardial infarction (NSTEMI) 6 weeks earlier. A computed tomography (CT) scan with oral contrast shows evidence of an obstructing mass in the sigmoid colon. However, the lumen does appear to be patent. Her vitals are stable. Which of the following is the best recommendation?
- A. Diverting ileostomy
  - B. Diverting transverse colostomy
  - C. Open sigmoid resection with proximal colostomy
  - D. Colonoscopy with placement of a temporizing stent followed by an elective surgery
  - E. Laparoscopic sigmoid resection with proximal colostomy
9. A 55-year-old male presents to the ED with vomiting and an inability to tolerate oral intake for the last week. CT scan shows a significantly distended stomach, with a thickened mass near the pylorus. Upper endoscopy shows a large mass in the stomach that completely occludes the distal lumen. Biopsy is consistent with low-grade mucosa-associated lymphoid tissue (MALT) lymphoma. He takes proton-pump inhibitors for acid reflux. Which of the following is true regarding his condition?
- A. Eradication of *H. pylori* should be attempted before any other interventions.
  - B. The patient should be given chemotherapy along with *H. pylori* eradication.
  - C. Radiotherapy has no role in the treatment of gastric MALT lymphoma.
  - D. Partial or total gastrectomy should be performed.
  - E. In *H. pylori*-negative patients, eradication therapy with antibiotics has no role.
10. A 70-year-old male with a history of colon adenocarcinoma that was treated with a formal resection returns 2 years later with a 3-cm lesion on his liver that appears to be a metastasis. Which of the following is the most appropriate next step?
- A. Chemotherapy only
  - B. Surgical resection only
  - C. Surgical resection followed by chemotherapy
  - D. Chemotherapy followed by surgical resection

- E. Surgical resection followed by radiation
11. A patient with metastatic colon cancer is to about to undergo chemotherapy, and the oncologist recommends the use of an anti-EGFR monoclonal antibody. Which of the following genetic profiles is most likely to show benefit from addition of this agent?
- K-ras* wildtype gene
  - BRAF* mutation
  - NRAS*
  - PIK3CA* mutation
  - K-ras* mutant gene
12. Which of the following patients should be referred to a genetic counselor for *BRCA* testing?
- Family history of breast cancer in mother at the age of 55
  - Adopted and unknown family history, developed breast cancer at 55
  - Both parents are Sephardic Jews.
  - 55-year-old female with breast cancer in bilateral breasts
  - 55-year-old female with an inflammatory breast cancer

## Answers

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1. **E.** Once the diagnosis of HCC is established, the choice of therapy must be individualized to each patient and based on tumor burden, presence of underlying liver disease, patient performance status, and the overall possibility of side effects or complications balanced with acceptable results. When feasible, anatomic resection is the treatment of choice in patients *without* liver disease and appears to be superior to simple wedge resection. There is a growing body of evidence that RFA may be used in select patients with similar survival benefit to surgical resection. Feng et al. randomized 168 patients with small (<4 cm) hepatocellular carcinomas to surgical resection or RFA. There was no statistical difference in survival between the two groups, though complications were significantly lower in the RFA group. That being said, locoregional therapies (RFA, irreversible electroporation, proton beam therapy) are typically reserved for tumors that are not amenable to surgical resection or as bridge therapy to transplant (C). The best results have been seen with tumors that are less than 4 cm in size. Irreversible electroporation (Nanoknife) therapies show some promise but are still not included in the current National Comprehensive Cancer Network (NCCN) guidelines for treatment of hepatocellular carcinoma (D). Patients *with* liver disease and elevated bilirubin are less likely to tolerate any surgical intervention. In fact, the Barcelona Clinic Liver Cancer group identified the absence of clinically relevant portal hypertension and normal bilirubin level as major determinants for successful liver resection (B). The only treatment modality left then to cirrhotics with HCC is liver transplantation. The most widely used standard to choose appropriate patients is known as the Milan criteria, and it is used by United Network for Organ Sharing (UNOS) to select candidates. The Milan criteria are as follows: single tumor less than or equal to 5 cm or up to three tumors *with none larger than 3 cm*, and no evidence of vascular invasion, regional lymphadenopathy, or distant disease. TACE is another useful therapy for individuals not eligible for resection or regional treatment due to severity of their cirrhosis or other comorbidities (A). However, it is still contraindicated in Child class C cirrhosis or for cases in which the location precludes selective treatment. The only chemotherapy currently approved for HCC is sorafenib, which has been shown to slightly improve survival from 7.9 to 10.7 months.

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Mazzaferro, V., Regalia, E., Doci, R., et al. (1996). Liver transplantation for the treatment of small hepatocellular carcinomas in patients with cirrhosis. *The New England Journal of Medicine*, 334(11), 693–700.

2. **A.** UV radiation is a known risk factor for squamous cell carcinoma, basal cell carcinoma, and

possibly malignant melanoma. It acts as both an initiator and promoter of direct DNA damage and damage of DNA repair mechanisms. The degree of risk depends on the type of UV rays and the intensity of exposure. A higher quantity of melanin in skin is protective (C). The UV portion of the electromagnetic spectrum can be divided into three wavelength ranges—UVA (320–400 nm), UVB (280–320 nm), and UVC (200–280 nm). Of these, UVB is the most significant contributor to skin damage (B). The mechanism of carcinogenicity by UVB is by formation of pyrimidine dimers in DNA (D). This damage can be repaired by the nucleotide excision repair pathway. With excessive sun exposure, it is postulated that the capacity of this pathway is overwhelmed, and some DNA that is damaged remains unrepaired. Mutations in the *ras* and p53 genes occur early in skin cancers, mainly at the dipyrimidine sequences. The *BCL-2* gene is involved in regulating cell apoptosis (E).

**References:** Marcus, C., et al. (2012). Tumor biology and tumor markers. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (19th ed.). Philadelphia, PA: Elsevier Saunders.

Ziegler, A., Leffell, D., Kumala, S., et al. (2003). Mutation hotspots due to sunlight in the p53 gene of nonmelanoma skin cancers. *Proceedings of the National Academy of Sciences of the United States of America*, 90(9), 4216–4220.

3. **E.** Despite long-standing use in the treatment of cancer, the complete mechanism of radiotherapy-induced cancer cell death has yet to be fully elucidated. Charged particles, usually photons, are delivered to the target cells by one of three mechanisms: external beam, brachytherapy, or as a radioactive isotope (e.g., iodine-131 in thyroid cancer). These charged particles interact with the outer layer of loosely bound electrons in normal atoms. Energy is transferred from the photon, and the electron is deflected out of orbit with a lower energy creating a “free radical.” This effect is called the Compton effect. The energy dissipated by these ionizing events leads to the disruption of chemical bonds, most importantly those in DNA. While the ionizing radiation has a direct effect on DNA in certain cells, it also indirectly affects other cells by forming oxygen-free radicals (A). The most important effect seems to be the creation of double-stranded DNA breaks. While normal cells can repair this damage to some degree, tumor cells often have damaged or inhibited DNA repair mechanisms. As the energy of the photon beam increases, the penetration of tissue increases. The skin is spared by the production of higher-energy electrons that travel forward and achieve full intensity at a depth below the skin’s surface (B). Tissue hypoxia has been shown to significantly reduce radiation damage and is one of the patient-modifiable factors that is actively being researched to improve the effectiveness of radiotherapy. The relative hypoxia within large tumor cells is one of the reasons they tend to be more resistant to radiation (C). Along this theme, systemic anemia seems to have a deleterious effect on radiotherapy and correction before radiation therapy is helpful. In regard to the cell cycle, M phase has been found to be the most vulnerable stage to radiation therapy (D).

**Reference:** Harrison, L., Chadha, M., Hill, R., et al. (2002). Impact of tumor hypoxia and anemia on radiation therapy outcomes. *Oncologist*, 7(6), 492–508.

4. **B.** Folinic acid, also known as leucovorin, is frequently given as “rescue therapy” for methotrexate toxicity. Folinic acid is a 5-formyl derivative of tetrahydrofolic acid that does not require the action of dihydrofolate reductase (DHFR) for its conversion and therefore is not affected by methotrexate’s inhibitory action on DHFR. While the mechanism is not fully understood, proton pump inhibitors, such as omeprazole, delay the elimination of methotrexate and can potentially increase toxicity. These medications should be stopped during therapy, if possible (A). Folate is the natural form of vitamin B<sub>9</sub>, while folic acid is the equivalent synthetic form. Both are reliant on the DHFR for metabolism and will have no effect on methotrexate toxicity (C, D). Cobalamin, or vitamin B<sub>12</sub>, can be effective in treating megaloblastic anemia, but this will have no effect on the myelosuppression caused by methotrexate.

**References:** Jiranantakan, T., et al. (2012). Methotrexate. In K. R. Olson (Ed.), *Poisoning & drug overdose* (6th ed.). New York, NY: McGraw-Hill.

Suzuki, K., Doki, K., Homma, M., et al. (2009). Co-administration of proton pump inhibitors delays elimination of plasma methotrexate in high-dose methotrexate therapy. *British Journal of Clinical Pharmacology*, 67(1), 44–49.

5. **C.** Metastatic spread to the adrenal glands is common with breast and lung cancer, with the latter being more prevalent. While breast cancer is able to spread to the brain via Batson’s plexus, the

most common location of metastatic disease is the lungs (A). Colon cancer spreads in a predictable pattern starting with the corresponding nodal basin and then following the portal system to the liver. Though it is possible for colon cancer to spread to the lungs, the liver is more common (B). Pancreatic metastases can be seen throughout the abdominal cavity, but the liver is frequently the first location following locally invasive disease (E). While the most common metastatic tumor of the small bowel is from melanoma, melanoma frequently spreads to the lungs first (D).

6. **B.** p53 is a protein encoded by tumor suppressor gene *TP53* that is located on the short arm of chromosome 17p13.1. It is important for cell cycle regulation, DNA replication, and apoptosis in response to DNA damage. The p53 protein binds to sequences of DNA in the promoter region of other genes to enhance or regulate transcription (C). p53 typically interacts with and enhances the effects of genes involved with inhibition of cell growth or replication (D). Mutations in the *TP53* tumor suppressor gene result in unregulated cell growth and predisposition to the development of malignant neoplasms (E). Li-Fraumeni syndrome is an autosomal dominant, hereditary disorder characterized by a germline mutation of the *TP53* tumor suppressor gene (A). However, it can also arise sporadically and is seen in more than half of all human cancers. HPV, for example, encodes the protein E6, which binds and inactivates the p53 protein. This, in part, contributes to the development of cervical dysplasia.

**References:** Angeletti, P., Zhang, L., Wood, C., et al. (2008). The viral etiology of AIDS-associated malignancies. *Advances in Pharmacology*, 56, 509–557.

Muller, P., & Vousden, K. (2013). p53 mutations in cancer. *Nature Cell Biology*, 15(1), 2–8.

7. **E.** Bevacizumab (Avastin), is a humanized monoclonal antibody against vascular endothelial growth factor (VEGF). It has been shown to significantly prolong survival when added to intravenous 5-fluorouracil-based chemotherapy in first-line chemotherapy for metastatic colorectal cancer. Unfortunately, bevacizumab has numerous adverse effects, with delayed wound healing being one of the most prevalent. The inhibitory effect on VEGF receptors limits angiogenesis, which is critical in wound healing. Potentially the most devastating complication is spontaneous bowel perforation, but this is relatively infrequent. The effects of the chemotherapy regimen on wound healing last about 6 months, with no studies showing an effect on wound healing after this time period (E). In a patient that is already showing signs of impaired wound healing, additional surgery will likely be unhelpful and potentially deleterious, especially in the absence of clinical signs of infection (A). Supplemental nutrition in the absence of proven nutritional deficit has not been shown to improve wound healing (B). Leucovorin, or folinic acid, is given in conjunction with 5-FU to reduce side effects but has no effect on bevacizumab (C). Cetuximab, a monoclonal antibody against epidermal growth factor receptor (EGFR) has shown to improve survival when used with FOLFIRI compared with bevacizumab. However, wound healing complications were found to be no different (D).

**References:** Heinemann, V., vonWeikersthal, L., Decker, T., et al. (2014). FOLFIRI plus cetuximab versus FOLFIRI plus bevacizumab as first-line treatment for patients with metastatic colorectal cancer (FIRE-3): a randomised, open-label, phase 3 trial. *The Lancet Oncology*, 15(10), 1065–1075.

Scappaticci, F., Fehrenbacher, L., Cartwright, T., et al. (2005). Surgical wound healing complications in metastatic colorectal cancer patients treated with bevacizumab. *Journal of Surgical Oncology*, 91(3), 173–180.

8. **D.** Symptoms of obstruction are the initial presenting symptom in up to 8% of colorectal cancers. Emergency surgery has been classically considered the treatment of choice in these patients. However, in the majority of studies, emergency colorectal surgery is burdened with higher morbidity and mortality rates when compared with elective surgery, and many patients require temporary colostomy, which deteriorates their quality of life and becomes permanent in 10% to 40% of cases. The aim of a temporizing stent is to avoid emergency surgery and plan for elective surgery (which can be laparoscopic) in order to improve surgical results, obtain an accurate tumor staging (harvest appropriate number of lymph nodes), and detect the presence of any synchronous lesions. Additionally, this can allow for the medical optimization of the patient's comorbidities. Although stenting has multiple benefits, a recent prospective randomized study demonstrated no advantage to stenting over emergency surgery. However, in an 87-year-old female with a recent NSTEMI, operative risk would be prohibitive. Despite the potential immediate benefits of temporizing stents, the possible implication on long-term results of oncologic treatment remains to be seen. However, obstruction must still be treated surgically if stenting is not possible (A–C, E).

**References:** Abdussamet Bozkurt, M., Gonenc, M., Kapan, S., et al. (2014). Colonic stent as bridge to

surgery in patients with obstructive left-sided colon cancer. *JSLS*, 18(4), pii.

Park, S., Lee, K., Kwon, S., et al. (2016). Stenting as a bridge to surgery for obstructive colon cancer: does it have surgical merit or oncologic demerit? *Annals of Surgical Oncology*, 23(3), 842–848.

van Hooft, J.E., Bemelman, W., Collaborative Dutch Stent-In Study Group, et al. (2011). Colonic stenting versus emergency surgery for acute left-sided malignant colonic obstruction: a multicentre randomised trial. *The Lancet Oncology*, 12(4), 344–352.

9. **D.** Gastric MALT lymphoma is a subset of slow-growing non-Hodgkin lymphoma that typically occurs in the setting of chronic *H. pylori* infection. While these tumors were originally treated with surgical resection, like most lymphomas, the focus has moved away from surgery. Initially, systemic therapy mimicked that of other gastric lymphomas with good response rates to systemic chemotherapy and radiotherapy alone, as opposed to surgery (B, C). However, as the connection between *H. pylori* and gastric MALT lymphoma became more apparent, initial therapy has now moved toward attempted treatment with *H. pylori* eradication and reservation of chemotherapy and radiation for patients who do not respond, have recurrence, or have metastatic disease at the time of diagnosis (A). Zullo et al. were even able to demonstrate treatment response in *H. pylori*-negative patients and advocate for a trial of eradication in all patients with gastric MALT lymphoma regardless of *H. pylori* status (E). While the role for surgical intervention is extremely limited, it remains the treatment strategy of choice in patients with complete gastric outlet obstruction or uncontrollable bleeding.

**References:** Mahvi, D., et al. (2012). Stomach. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: The biological basis of modern surgical practice* (19th ed.). Philadelphia, PA: Elsevier Saunders.

Yoon, S., Coit, D., Portlock, C., et al. (2004). The diminishing role of surgery in the treatment of gastric lymphoma. *Annals of Surgery*, 240(1), 28–37.

Zullo, A., Hassan, C., Ridola, L., et al. (2013). Eradication therapy in *Helicobacter pylori*-negative, gastric low-grade mucosa-associated lymphoid tissue lymphoma patients: a systematic review. *Journal of Clinical Gastroenterology*, 47(10), 824–827.

10. **C.** Recent literature shows a conferred survival benefit for the resection of hepatic metastases in colorectal cancer. Multiple high-volume centers have demonstrated 5-year survival for patients with metastatic colorectal cancer to the liver to be 25% to 58% with resection of the metastatic lesion. Over the last two decades, the perioperative mortality associated with hepatic resection has fallen significantly, with most high-volume centers reporting a 30-day perioperative mortality of less than 2%. The presence of any of the following risk factors had a negative, and additive, effect on survival in patients with hepatic metastases from colorectal cancer: (1) node-positive primary tumor, (2) disease-free interval less than 12 months, (3) multiple liver metastases, (4) largest hepatic metastasis greater than 5 cm, and (5) serum carcinoembryonic antigen (CEA) level greater than 200 ng/mL. Those with none of these risk factors have the greatest 5-year survival at 60%. Treatment will vary depending if it is a synchronous or metachronous lesion. Synchronous lesions can be safely treated with combined colon and liver resection, provided the hepatic resection is limited (<3 segments). By combining the two surgeries, initiation of adjuvant chemotherapy is quicker. Interestingly, for synchronous rectal cancer (that is both nonobstructing, nonbleeding) with liver metastasis, some experts are now advocating liver resection first, followed by chemoradiation therapy (because this therapy may downstage the rectal cancer). For metachronous disease, the timing of surgery and chemotherapy is still controversial but seems to lean more heavily to a surgery-first treatment strategy (B). Nordlinger and colleagues published the results of a large randomized trial comparing surgery alone versus perioperative chemotherapy and surgery in patients with resectable liver metastases, which showed a higher rate of complications in the preoperative chemotherapy group and no difference in survival. Many have used this to infer that preoperative chemotherapy is deleterious without conferred benefit, but the study was not powered to examine survival as a primary endpoint (D). In this potentially curable patient, surgery first is likely to confer the largest survival benefit. Patients with unresectable disease, or other poor prognostic indicators, should be considered for systemic chemotherapy, followed by restaging and consideration for surgical therapy (A). Radiation is never in the treatment algorithm for colon cancer (E).

**References:** Martin, R., Augenstein, V., Reuter, N., et al. (2009). Simultaneous versus staged resection for synchronous colorectal cancer liver metastases. *Journal of the American College of*



*Surgeons*, 208(5), 842–850.

Nordlinger, B., Sorbye, H., Glimelius, B., et al. (2013). Perioperative FOLFOX4 chemotherapy and surgery versus surgery alone for resectable liver metastases from colorectal cancer (EORTC 40983): long-term results of a randomised, controlled, phase 3 trial. *The Lancet Oncology*, 14(12), 1208–1215.

Yin, Z., Liu, C., Chen, Y., et al. (2013). Timing of hepatectomy in resectable synchronous colorectal liver metastases (SCRLM): simultaneous or delayed? *Hepatology*, 57(6), 2346–2357.

11. **A.** In 2012, the Food and Drug Administration (FDA) approved cetuximab, an anti-EGFR monoclonal antibody, to be used with FOLFIRI, as the first-line treatment of *k-ras* mutant negative (wildtype) metastatic colorectal cancer. This approval was largely based on the CRYSTAL trial, as well as two other supportive studies. A statistically significant overall survival and progression-free survival were appreciated in the cetuximab group (23.5 months vs 19.5 months). The recommended dose and schedule for cetuximab is 400 mg/m<sup>2</sup> administered intravenously as a 120-minute infusion as an initial dose, followed by 250 mg/m<sup>2</sup> infused over 30 minutes weekly in combination with FOLFIRI. Other studies have demonstrated the negative effects and poor response rate cetuximab has in patients with mutations in *BRAF*, *NRAS*, and *PIK3CA* (B–D). *K-ras* mutations are seen in 35% to 45% of patients with colorectal cancer, and this group of patients will not benefit from cetuximab therapy. The most common mutation is on chromosome 12 and 13. These have also been shown to predict treatment failure with cetuximab (E).

**References:** De Roock, W., Claes, B., Bernasconi, D., et al. (2010). Effects of KRAS, BRAF, NRAS, and PIK3CA mutations on the efficacy of cetuximab plus chemotherapy in chemotherapy-refractory metastatic colorectal cancer: a retrospective consortium analysis. *The Lancet Oncology*, 11(8), 753–762.

Tan, C., & Du, X. (2012). KRAS mutation testing in metastatic colorectal cancer. *World Journal of Gastroenterology*, 18(37), 5171–5180.

Van Cutsem, E., Lenz, H. J., Köhne, C. H., et al. (2015). Fluorouracil, leucovorin, and irinotecan plus cetuximab treatment and RAS mutations in colorectal cancer. *Journal of Clinical Oncology*, 33(7), 692–700.

12. **D.** In December 2013, the United States Preventive Services Task Force recommended that women who have family members with breast, ovarian, fallopian tube, or peritoneal cancer be evaluated to see if they have a family history that is associated with an increased risk of a harmful mutation in one of the *BRCA* genes. Some risk factors that increase the likelihood of having one of these harmful genes include breast cancer before 50 years old, cancer in both breasts in the same woman, both breast and ovarian cancers in the same family, multiple breast cancers, known *BRCA* in the family, cases of male breast cancer, and Ashkenazi Jewish descent (C). The others listed may have an increased risk developing breast cancer as per the GAIL model; however, they have no increased risk that would necessitate genetic counseling (A, E). For adopted patients, the recommendation for genetic testing is given only if they have had breast cancer at an age younger than 50 years (B).

**References:** U.S. Preventive Services Task Force. Risk Assessment, Genetic Counseling, and Genetic Testing for BRCA-Related Cancer in Women: Clinical Summary of USPSTF Recommendation. AHRQ Publication No. 12-05164-EF-3, 2013. Retrieved from <https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/brca-related-cancer-risk-assessment-genetic-counseling-and-genetic-testing>.

# Pharmacology

*Michael D. Sgroi, Patrick T. Delaplain, Areg Grigorian, and Christian de Virgilio*

## Questions

1. A 56-year-old male with non-Hodgkin lymphoma presents to the emergency department (ED) with mental status changes, decreased urine output, and lethargy. He recently was started on chemotherapy. Physical exam is remarkable for a newly placed implantable venous access device below the right clavicle. The port site has no evidence of erythema. Gentle tapping anterior to his external auditory canal results in contraction of his facial muscles on that side. Which of the following is true in regards to this condition?
  - A. Dialysis is unlikely to help.
  - B. The risk of this complication has decreased in the past years with the advent of newer therapy agents.
  - C. Alkalinization of the urine should be performed.
  - D. The standard initial treatment is allopurinol.
  - E. Laboratory exam will likely demonstrate a metabolic alkalosis.
2. A 78-year-old female is recovering in the intensive care unit (ICU) from a small bowel resection due to a strangulated femoral hernia. She is known to have long-standing hearing loss. On postoperative day 2 she becomes increasingly agitated and confused. Laboratory exam and infection workup are unrevealing. She is attempting to pull out her intravenous (IV) lines. Which of the following is true regarding her condition?
  - A. Lorazepam may worsen her agitation.
  - B. Low doses of diphenhydramine are often useful.
  - C. She should be placed in physical restraints.
  - D. It is unlikely that a hearing aid could have prevented this condition.
  - E. Haloperidol is contraindicated.
3. Which of the following has the strongest causal link with retroperitoneal fibrosis?
  - A. Entacapone
  - B. Methysergide
  - C.  $\alpha$ -Methyldopa
  - D. Beta-blockers
  - E. Hydralazine
4. Initial treatment of retroperitoneal fibrosis consists of:
  - A. Cyclosporine
  - B. Tamoxifen
  - C. Ureterolysis
  - D. Prednisone
  - E. Azathioprine
5. Intravenous administration of Haldol should be accompanied by:
  - A. A review of admission electrocardiogram (ECG) for a prolonged QT interval

- B. A review of admission ECG for Q waves
  - C. Continuous ECG monitoring for development of peaked t waves
  - D. Continuous O<sub>2</sub> saturation monitoring
  - E. Serial serum creatine phosphokinase (CPK) measurements
6. Which of the following is true regarding the prophylactic role of histamine-2 (H<sub>2</sub>) blockers and/or proton pump inhibitors (PPIs) in hospitalized patients?
- A. Both agents will result in a similar rate of upper gastrointestinal bleeding.
  - B. Effective stress ulcer prophylaxis with these agents involves achieving an intragastric pH greater than 5.
  - C. Intravenous administration of PPI results in a higher intragastric pH compared with oral administration when given at the same dose and frequency.
  - D. There is no difference in the rate of nosocomial pneumonia.
  - E. Critically ill and/or ventilated patients that receive PPI have lower mortality rates.
7. A 57-year-old Child class A cirrhotic male presents to the ED with severe left lower quadrant pain. Physical exam is concerning for peritonitis, and free air under the diaphragm is seen on chest x-ray. In the operating room (OR) he is found to have feculent peritonitis secondary to a perforated sigmoid diverticulitis and undergoes a Hartmann procedure. The following day the respiratory therapist in the ICU has difficulty ventilating and oxygenating. The patient has complete white out of both lung fields on x-ray, and the PaO<sub>2</sub>/FiO<sub>2</sub> ratio is 180. Low tidal volume ventilation is commenced and the decision to paralyze the patient is made. Which agent should be used?
- A. Rocuronium
  - B. Vecuronium
  - C. Atracurium besylate
  - D. Suxamethonium chloride
  - E. Pancuronium
8. Which of the following is true in regard to correcting metabolic acidosis?
- A. Giving bicarbonate alone will be efficient in correcting an acidosis.
  - B. Correction will fix the pulmonary vasodilation seen in metabolic acidosis.
  - C. Administration of sodium bicarbonate can lead to hyperkalemia.
  - D. Sodium bicarbonate may interfere with oxygen delivery.
  - E. Lactic acidosis will often improve after sodium bicarbonate administration.
9. A 62-year-old female with a known history of chronic pancreatitis and subtotal gastrectomy presents to the ED with abdominal pain, altered mental status, unsteady gait, and aphasia. Physical exam is significant for ophthalmoplegia on the right. The patient is confused and unable to answer any questions, but her husband claims she was doing well several hours ago. He also states that this is the first time she has behaved this way. Which of the following is the best treatment?
- A. Intravenous glucose
  - B. Oral vitamin B<sub>12</sub>
  - C. Intramuscular vitamin B<sub>12</sub>
  - D. Parenteral vitamin B<sub>1</sub>
  - E. Intravenous magnesium
10. Which of the following medications would lead to a patient requiring a higher warfarin dose to remain therapeutic?
- A. Ketoconazole
  - B. Cimetidine
  - C. Amiodarone
  - D. Rifampin
  - E. Allopurinol

11. Which of the following is true in regard to the bioavailability of medications?
- A. IV ciprofloxacin has a similar bioavailability to the oral form.
  - B. Drugs that are absorbed in the stomach have better bioavailability than drugs absorbed in the small intestine.
  - C. Hydrophobic drugs are better absorbed than hydrophilic drugs.
  - D. Sublingual medications have lower bioavailability than medications absorbed through the gastrointestinal tract.
  - E. The dose of chloramphenicol needs to be decreased in patients when given IV to decrease the chance of toxicity compared to the oral route.
12. A 79-year-old female develops atrial fibrillation on postoperative day 2 after repair of an incisional hernia. The patient is started on digoxin. Which of the following is true about digoxin?
- A. Digoxin slows down the release of electrical impulses from the SA node to decrease atrial contraction and slow down the heart rate.
  - B. Adverse effects are more commonly seen when patients are hyperkalemic.
  - C. When toxicity occurs, it should be immediately treated with dialysis.
  - D. Increased intracellular concentration of calcium is what leads to a stronger cardiac contraction.
  - E. Therapeutic digoxin will lead to a prolonged QT interval seen on ECG.
13. A 67-year-old female is brought into the ED in septic shock of unknown origin. She is hypotensive, diaphoretic, febrile, and found to have a leukocytosis and altered mental status. A rapid sequence intubation (RSI) is performed. On hospital day 2, the patient continues to have hypotension despite fluid resuscitation and the use of vasopressors. She is given a dose of hydrocortisone and vastly improves. Which of the following explains the patient's symptoms?
- A. Poor perfusion of the adrenal gland in the setting of shock
  - B. The use of etomidate during RSI
  - C. She is on steroids at home.
  - D. Overuse of vasopressors
  - E. Pituitary dysfunction with insufficient release of adrenocorticotrophic hormone (ACTH)
14. Which of the following medications is safe to give a patient who is 10 weeks pregnant?
- A. Acetaminophen
  - B. Aspirin
  - C. Propylthiouracil (PTU)
  - D. Coumadin
  - E. Lisinopril
15. Choose the medication that is correctly paired with its mechanism of action.
- A. Cyclosporine—purine synthesis inhibitor
  - B. Vincristine—microtubule formation and stabilization
  - C. 5-Fluorouracil—thymidylate synthase inhibitor
  - D. Taxol—microtubule inhibitor
  - E. Infliximab—Vascular endothelial growth factor (VEGF) inhibitor
16. A 52-year-old male with atrial fibrillation presents to the ED with a large biloma identified on ultrasonography 1 week after undergoing a laparoscopic cholecystectomy. He complains of abdominal pain but does not appear to be in significant discomfort. He was restarted on warfarin after the operation and his international normalized ratio (INR) is currently 2.7. The plan is to attempt CT-guided drainage the following day. How should his INR be corrected?
- A. Oral vitamin K
  - B. Slow IV infusion (over 30 minutes) of vitamin K
  - C. Fresh frozen plasma (FFP)
  - D. Allow warfarin to autocorrect
  - E. Prothrombin complex concentrate

17. A 58-year-old male postoperative patient develops a hypertensive crisis with a blood pressure of 220/100 mm Hg and heart rate of 60 beats per minute. He is started on a nitroprusside drip, and the blood pressure improves. The patient subsequently develops generalized weakness and becomes unresponsive. He is immediately intubated and an arterial blood gas demonstrates a high anion-gap acidosis with a high SVO<sub>2</sub>. His skin color appears pink, and he has the smell of bitter almonds on his breath. Which of the following should you administer next?
  - A. Sodium nitrite
  - B. Amyl nitrite
  - C. Sodium thiosulfate
  - D. Hydroxycobalamin
  - E. Methylene blue
18. A 75-year-old male with stage 4 chronic kidney disease (CKD) and symptomatic peripheral arterial disease is scheduled for a catheter-based angiography. Which of the following should be administered before the study?
  - A. Alkalinization of the urine with sodium bicarbonate intravenously
  - B. N-acetylcysteine
  - C. Aggressive fluid resuscitation with normal saline
  - D. N-acetylcysteine and aggressive fluid resuscitation with normal saline
  - E. Alkalinization of the urine with sodium bicarbonate intravenously, N-acetylcysteine, and aggressive fluid resuscitation with normal saline
19. Which of the following medications is paired with the correct side effect?
  - A. Furosemide—nausea
  - B. Metronidazole—tinnitus
  - C. Spironolactone—fulminant hepatic necrosis
  - D. Halothane—gynecomastia
  - E. Vancomycin—cutaneous flushing

## Answers

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1. **B.** Tumor lysis syndrome (TLS) is not uncommonly seen in patients recently started on chemotherapy and primarily occurs in those with poorly differentiated lymphoproliferative disease such as lymphomas or leukemia but may also occur with solid organ tumors. It is commonly characterized by electrolyte abnormalities that lead to acute renal failure. Although hyperphosphatemia and hyperuricemia occur most commonly, these are often accompanied by hyperkalemia, hypocalcemia, and a metabolic lactic acidosis (E). The above patient has a physical exam sign consistent with hypocalcemia; Chvostek's sign is muscle spasm with gentle tapping over the facial nerve. Newer monoclonal antibody therapies have demonstrated a decreased risk of causing TLS. Treatment includes aggressive hydration in an attempt to normalize the electrolyte abnormalities and improve renal function. Although alkalinization of urine was thought to be a useful adjunct in TLS, there are newer studies suggesting that it may contribute to renal dysfunction. This is now considered a controversial adjunct and not widely used (C). Allopurinol is used to treat the hyperuricemia of malignancy; however, this can lead to an increased risk of xanthine and calcium phosphate crystals. Newer approaches include use of urate oxidase, which can provide effective treatment while having a safer profile. Hydration remains the best treatment modality (D). In refractory cases, dialysis can be used (A).

**References:** Davidson, M. B., Thakkar, S., Hix, J. K., et al. (2004). Pathophysiology, clinical consequences, and treatment of tumor lysis syndrome. *The American Journal of Medicine*, 116(8), 546–554.

Firwana, B. M., Hasan, R., Hasan, N., et al. (2012). Tumor lysis syndrome: a systematic review of case series and case reports. *Postgraduate Medical Journal*, 124(2), 92–101.

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*Hematology*, 95(4), 563–573.

Jeha, S. (2001). Tumor lysis syndrome. *Seminars in Hematology*, 38(4 Suppl. 10), 4–8.

Marin, G. R., & Majek, E. (2012). Acute kidney injury secondary to steroid-induced tumor lysis in an adolescent with acute lymphoblastic leukemia: role of urinary alkalinisation and peritoneal dialysis. *Archivos Argentinos De Pediatría*, 110(6), e118–e122.

2. **A.** Patients in the ICU often experience ICU delirium. It has been shown that anywhere between 20% to 80% of elderly patients in the ICU will experience delirium. The Hospital Elder Life Program (HELP) is an inpatient strategy to prevent ICU delirium and focus on primary prevention with the use of regular reorientation, encouraging proper sleep-wake cycles, meeting needs for nutrition, early mobilization activities, and providing visual and hearing adaptations for patients with sensory impairments (D). Physical restraints should be avoided because they lead to decreased mobility, increased agitation, greater risk of injury, and prolongation of delirium (C). Certain patients will still require pharmacologic therapy. Benzodiazepines are not uncommonly administered to elderly patients for agitation, insomnia, and anxiety. However, they are known to have adverse and paradoxical effects so their use should be limited. Patients may experience drowsiness, depression, confusion, vertigo, insomnia, or worsened agitation. When benzodiazepines are given to patients with ICU delirium, up to 23% may experience an adverse event including hypotension, dystonia, laryngeal spasm, malignant hyperthermia, glucose dysregulation, and urinary retention. Diphenhydramine may demonstrate a similar effect in the elderly population and should be used with caution (B). Haloperidol is often the first-line treatment in the management of an aggressive and agitated patient in the context of delirium (E).

**References:** Kruse, W. H. (1990). Problems and pitfalls in the use of benzodiazepines in the elderly. *Drug Safety*, 5(5), 328–344.

Girard, T. D., Pandharipande, P. P., & Ely, E. W. (2008). Delirium in the intensive care unit. *Critical Care (London, England)*, 12(Suppl. 3), S3.

Fong, T. G., Tulebaev, S. R., & Inouye, S. K. (2009). Delirium in elderly adults: diagnosis, prevention and treatment. *Nature Reviews Neurology*, 5(4), 210–220.

3. **B.** Although all the answer choices are associated with retroperitoneal fibrosis, the strongest association is with methysergide, a semisynthetic ergot alkaloid used to treat migraine headaches (A, C–E).

**References:** Graham, J., Suby, H., LeCompte, P., et al. (1966). Fibrotic disorders associated with methysergide therapy for headache. *The New England Journal of Medicine*, 274(7), 359–368.

Koehler, P. J., & Tfelt-Hansen, P. C. (2008). History of methysergide in migraine. *Cephalalgia*, 28(11), 1126–1135.

4. **D.** Steroids are the mainstay of treatment for retroperitoneal fibrosis because this condition is thought to be related to an autoimmune process. Supporting this theory, circulating antibodies to ceroid are present in more than 90% of patients. It is important to first obtain a tissue diagnosis. Ureterolysis (C), ureteral stenting, or nephrostomy tubes are reserved for those who do not respond or those who have massive hydronephrosis with alteration of renal function. Patients are also at risk for the development of thrombosis of the iliac veins or inferior vena cava. As such, they may require oral anticoagulation. For those who do not respond to oral steroids, cyclosporine, tamoxifen, and azathioprine have been successfully used (A, B–E). Biologic therapies such as B-cell depletion with rituximab are starting to emerge as potential treatment options in difficult-to-treat patients. The overall prognosis is excellent with 5-year survival rates reportedly in the 90% to 100% range.

**References:** Kardar, A., Kattan, S., Lindstedt, E., et al. (2002). Steroid therapy for idiopathic retroperitoneal fibrosis: dose and duration. *The Journal of Urology*, 168(2), 550–555.

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5. **A.** Elderly patients in the hospital will often experience agitation that can potentiate to aggressive behavior. In this type of situation, the patient will need to be sedated before hurting himself or others. Haloperidol (Haldol) is often the first-line treatment in the management of an aggressive and agitated patient in the context of delirium. Before the administration of haloperidol, an ECG should be performed to rule out a prolonged QT syndrome that the drug can potentiate and lead to life-threatening torsades de pointes and/or heart failure. Peaked T waves can occur with



hyperkalemia while Q waves are usually present following myocardial infarction (B, C). Continuous oxygen saturation monitoring is not required before Haldol administration (D). Serial serum CPK measurements are recommended for patients receiving continuous infusions of propofol (E).

**References:** Kaneko, T., Cai, J., Ishikura, T., et al. (1999). Prophylactic consecutive administration of haloperidol can reduce the occurrence of postoperative delirium in gastrointestinal surgery. *Yonago Acta Medica*, 42, 179–184.

Kalisvaart, K. J., deJonghe, J. F., Bogaards, M. J., et al. (2005). Haloperidol prophylaxis for elderly hip-surgery patients at risk for delirium: a randomized placebo-controlled study. *Journal of the American Geriatrics Society*, 53(10), 1658–1666.

6. **D.** Gastrointestinal stress ulceration occurs in 1% to 4% of all critically ill patients with a 50% mortality rate. The use of PPI versus H<sub>2</sub>-blockers has been widely studied. A recent meta-analysis of eight randomized controlled trials looking at critically ill patients found no difference in the rate of nosocomial pneumonia or mortality in either group (E). However, the use of PPI may lead to an increased risk of *Clostridium difficile* infection. Additionally, the PPI group did have a decreased rate of clinically significant upper gastrointestinal bleeding (A). It has been demonstrated that achieving an intragastric pH greater than 6 results in clot stabilization and increased platelet aggregation (B). Intravenous or oral PPIs are equipotent in achieving a prophylactic intragastric pH to prevent ulcer formation when given at the same dose and frequency (C).

**References:** Alhazzani, W., Alenezi, F., Jaeschke, R. Z., et al. (2013). Proton pump inhibitors versus histamine 2 receptor antagonists for stress ulcer prophylaxis in critically ill patients: a systematic review and meta-analysis. *Critical Care Medicine*, 41(3), 693–705.

Barkun, A. N., Cockeram, A. W., Plourde, V. et al. (1999). Review article: acid suppression in non-variceal acute upper gastrointestinal bleeding. *Alimentary Pharmacology and Therapeutics*, 13(12), 1565–1584.

Barkun, A. N., Bardou, M., Pham, C. Q., et al. (2012). Proton pump inhibitors vs. histamine 2 receptor antagonists for stress-related mucosal bleeding prophylaxis in critically ill patients: a meta-analysis. *The American Journal of Gastroenterology*, 107(4), 507–520.

Hartmann, M., Ehrlich, A. Fuder, H., et al. (1998). Equipotent inhibition of gastric acid secretion by equal doses of oral or intravenous pantoprazole. *Alimentary Pharmacology and Therapeutics*, 12(10), 1027–1032.

7. **C.** In a patient with underlying liver disease, the paralytic of choice is atracurium besylate or cisatracurium. These are nondepolarizing neuromuscular blocking agents metabolized by Hoffman degradation, thereby bypassing the liver. Cisatracurium is approximately threefold stronger than atracurium besylate and more commonly used in this patient population. Additionally, cisatracurium does not lead to histamine release resulting in flushing and hypotension when compared to atracurium besylate, making it a better alternative. The remaining answer choices are excreted either wholly or partly by the liver (A, B, D, E).
8. **D.** Persistent metabolic acidosis can lead to widespread dysfunction but most commonly affects the cardiovascular and respiratory systems. This will result in peripheral vasodilation and pulmonary vasoconstriction in addition to enzymatic and hormone dysfunction (B). Sympathetic stimulation functions poorly because catecholamines are unable to exert their effect on tissue damaged by a low pH. Bicarbonate as an anion alone cannot be given to a patient. It is therefore paired with a hypertonic sodium solution (A). The use of sodium bicarbonate does have some adverse effects, including hypernatremia, hypokalemia, and a left shift in the oxyhemoglobin dissociation curve (C). The left shift is concerning because this can increase the affinity hemoglobin has for oxygen and leave tissue hypoxic, which in turn will lead to worsening acidosis (E). The main goal of using sodium bicarbonate is in patients who are persistently severely acidotic and are starting to have negative cardiovascular symptoms.
9. **D.** The patient is demonstrating Wernicke encephalopathy, which is caused by a deficiency in thiamine (vitamin B<sub>1</sub>). Thiamine deficiency occurs most commonly in alcohol-dependent patients with a poor diet. It may also be seen in post-gastrectomy patients who are predisposed to large gastrointestinal losses and can become deficient in this vitamin. Administration of thiamine quickly reverses the symptoms, particularly in the setting of acute Wernicke encephalopathy. Administering glucose before thiamine may be counterproductive because glucose oxidation is a thiamine-intensive process and may deplete any remaining thiamine that may be available (A).



Magnesium may be indicated particularly in alcoholic patients because thiamine administration may be refractory in the setting of hypomagnesemia. However, there is no information provided in the vignette to suggest this patient is an alcoholic (E). Vitamin B<sub>12</sub> deficiency will have a more insidious onset and present with macrocytic anemia, peripheral neuropathy, and ataxic gait. Confusion, aphasia, and ophthalmoplegia are not characteristic of vitamin B<sub>12</sub> deficiency (B, C).

10. **D.** Cytochrome P450 is a part of the superfamily of proteins containing a heme factor and is involved in the metabolism of warfarin. There are inhibitors and inducers of CYP450 that will enhance or dampen the effect of warfarin, respectively. Clinically relevant inhibitors of CYP450 include amlodipine, cimetidine, ciprofloxacin, cyclosporine, diltiazem, ketoconazole, isoniazid, and propranolol. Patients using these medications will need to decrease the dose of warfarin to maintain the same therapeutic international normalized ratio (INR). Inducers of CYP450 include barbiturates, phenytoin, prednisone, rifampin, as well as omeprazole. Patients on these medications will need to increase their warfarin dosage (A–C, E).
11. **A.** Bioavailability of a medication refers to the rate at which an administered drug is absorbed by the circulatory system. The bioavailability of a medication that is given intravenously theoretically has 100% bioavailability, but this does not always prove to be the case. Generally, the IV route provides a higher bioavailability when compared with the oral form. One notable exception is ciprofloxacin, which has similar bioavailability with either IV or oral form. Additionally, the location of absorption is important. Most drugs absorbed in the small intestine have greater bioavailability than drugs absorbed in the stomach because the bowel has 1000-fold increased surfaced area for absorption compared with the stomach (B). Medications absorbed by the intestines are routed to the portal circulation first and therefore are initially metabolized by the liver; this is known as “first-pass metabolism.” Because of this, the medication has a lower initial bioavailability. However, this does not hold true for sublingual, rectal, intramuscular, and subdermal medications because they do not pass through the liver before their systemic spread (D). Another notable exception is chloramphenicol, an antibiotic used commonly in developing countries but less so domestically because it can cause life-threatening aplastic anemia. This drug has better bioavailability when given orally than IV (E). Serum concentrations of IV chloramphenicol are only 70% of those achieved when compared with the oral form.

**References:** Glazko, A. J., Dill, W. A., Kinkel, A. W., et al. (1977). Absorption and excretion of parenteral doses of chloramphenicol sodium succinate in comparison with per oral doses of chloramphenicol. *Clinical Pharmacology and Therapeutics*, 21, 104.

Drusano, G. L., Standiford, H. C., Plaisance, K., et al. (1986). Absolute oral bioavailability of ciprofloxacin. *Antimicrobial Agents and Chemotherapy*, 30(3), 444–446.

12. **D.** Digoxin is a cardiac glycoside that has been used for cardiac arrhythmias as well as heart failure. Digoxin inhibits the Na<sup>+</sup>/K<sup>+</sup> ATPase in the myocardium. By inhibiting this, it leads to an increase in intracellular sodium and a reversal in the sodium-calcium exchanger. This in turn causes increased intracellular calcium, which leads to a stronger cardiac contraction and a lengthened phase 4 and 0 of the cardiac action potential. Digoxin acts on the AV node and by slowing the electrical conduction through this location, it can be used in an attempt to cardiovert the heart back into a regular rhythm (A). Because digoxin works on the Na<sup>+</sup>/K<sup>+</sup> ATPase, a toxic level can be achieved much faster in a hypokalemic patient (B). If a patient is experiencing digoxin toxicity, the treatment is anti-digoxin. Dialysis is not efficient enough to reduce the level of digoxin quickly (C). Therapeutic digoxin will lead to a shortened QT interval seen on ECG (E).
13. **B.** Etomidate is the preferred anesthetic agent for RSI because it has minimal cardiopulmonary affects. It is also frequently used in the trauma population because it leads to a decreased cerebral metabolic rate and may assist in decreasing intracranial pressure. One notable disadvantage is that it can result in adrenal dysfunction because it is a known inhibitor of cortisol synthesis (11β-hydroxylase). A systematic review performed between 1983 and 2010 identified 21 studies that fit criteria evaluating the adverse effects of etomidate. It demonstrated that patients that received etomidate had an increased relative risk of 1.64 for adrenal insufficiency and an increased relative risk for mortality of 1.19. A single dose can suppress the adrenal gland for up to 72 hours. There is no information given to suggest this patient is on chronic steroids (C). Hypoperfusion of the adrenal glands in the setting of shock, overuse of vasopressors, and pituitary dysfunction are all possible, but etomidate is more likely given the use of RSI (A, D, E).

**Reference:** Albert, S. G., Ariyan, S., & Rather A. (2011). The effect of etomidate on adrenal function

in critical illness: a systematic review. *Intensive Care Medicine*, 37(6), 901–910.

14. **C.** Propylthiouracil (PTU) has been proven to be safe during the first trimester of pregnancy to treat patients with hyperthyroidism, while methimazole has fallen out of favor because of the increased risk of congenital hypothyroidism (cretinism). ACE-inhibitors have been linked to congenital malformations and renal failure (E). Coumadin crosses the blood/baby barrier and can lead to skeletal and CNS defects (D). Aspirin and acetaminophen have both been linked to increased miscarriages and therefore should be avoided if at all possible (A, B). Acetaminophen, which had previously been thought to be safe, has now been linked to hyperkinetic and behavioral disorders such as autism. It is considered a category B drug.

**References:** Hackmon, R., Blichowski, M., & Koren, G. (2012). The safety of methimazole and propylthiouracil in pregnancy: a systematic review. *Journal of Obstetrics and Gynaecology Canada*, 34(11), 1077–1086.

Liew, Z., Ritz, B., Virk, J., et al. (2016). Maternal use of acetaminophen during pregnancy and risk of autism spectrum disorders in childhood: a Danish national birth cohort study. *Autism Research*, 9(9), 951–958.

15. **C.** 5-Fluorouracil, or 5FU, is a thymidylate synthase inhibitor that inhibits purine and DNA synthesis. When used in combination with Leucovorin, it has increased activity and increased toxicity. Cyclosporine is an immunosuppressant that binds to cyclophilin proteins and inhibits genes for cytokine synthesis, particularly IL-2. Side effects of cyclosporine include nephrotoxicity, hepatotoxicity, tremors, seizures, and hemolytic uremic syndrome (A). Vincristine is a chemotherapeutic agent that works by inhibiting microtubule formation (B). Taxol is also a chemotherapeutic agent but works by microtubule formation and stabilization (D). Finally, infliximab is a monoclonal antibody against TNF- $\alpha$ . By binding to TNF- $\alpha$ , it inhibits its ability to bind to receptors and reduces the autoimmune inflammatory response. Bevacizumab is a VEGF inhibitor and has been demonstrated to improve survival in patients with metastatic colorectal cancer (E).

16. **A.** Reversing warfarin depends on the clinical situation. If the patient is actively bleeding, and therefore reversal is urgent, prothrombin factor concentrate is now preferred over FFP (C, E). However, in a patient that is therapeutically anticoagulated and requires an invasive intervention electively, urgent reversal is not needed. The metabolism of warfarin is regulated by diet and concomitant medications. The half-life is 48 to 72 hours, which allows the drug to continue its effects for about 4 to 6 days after cessation (D). As such, allowing warfarin to autocorrect can take up to 6 days. This patient is in no distress and there are no hard signs to intervene urgently, and therefore the correction can be done slowly with administration of oral vitamin K. This takes up to 24 hours to have an effect and is the ideal choice in a patient undergoing CT-guided drainage the following day. IV push (over 3–5 minutes) administration of vitamin K is generally discouraged because there is a risk of thrombosis and anaphylaxis (B). However, slow IV infusion over 30 minutes is acceptable, and it usually takes 8 to 12 hours for it to have an effect.

**References:** DeZee, K. J., Shimeall, W. T., Douglas, K. M., et al. (2006). Treatment of excessive anticoagulation with phytonadione (vitamin K). *Archives of Internal Medicine*, 166(4), 391–397.

Fiore, L. D., Scola, M. A., Cantillon, C. E., et al. (2001). Anaphylactoid reactions to vitamin K. *Journal of Thrombosis and Thrombolysis*, 11(2), 175–183.

17. **B.** The patient is experiencing cyanide poisoning, which can occur following the administration of a nitroprusside drip. Nitroprusside is metabolized into nitric oxide and cyanide. The accumulation of cyanide leads to a left shift in the oxyhemoglobin dissociation curve resulting in decreased oxygen delivery. This leads to a severe lactic acidosis, which is a hallmark of cyanide poisoning. Additionally, the hemoglobin holding on to the oxygen content leads to an increase in the SVO<sub>2</sub>. The initial treatment is inhaled amyl nitrite followed by intravenous sodium nitrite (A). These agents are considered methemoglobin inducers, which allows for methemoglobin to reversibly bind with cyanide to make cyanomethemoglobin. Sodium thiosulfate is then administered, which helps convert cyanomethemoglobin to thiocyanate, a harmless metabolite that is renally excreted (C). Hydroxycobalamin, a form of vitamin B<sub>12</sub>, is a new medication used to reverse the effects of cyanide by binding to cyanide to form cyanocobalamin, which is then excreted through the urine. Although this drug shows promise, it is not yet the standard of care (D). Methylene blue is used in the treatment of methemoglobinemia (E).

18. C. N-acetylcysteine, alkalization of the urine, and aggressive fluid resuscitation have all been shown to have a theoretic benefit, but only intravenous fluid hydration has consistently demonstrated a clinical benefit when used in patients with CKD undergoing a contrast study (A, B, D, E). Additionally, the degree of nephrotoxicity is dose dependent and increases with ionized contrast versus nonionized contrast.

**References:** Sun, Z., Fu, Q., Cao, L., et al. (2013). Intravenous N-acetylcysteine for prevention of contrast-induced nephropathy: a meta-analysis of randomized, controlled trials. *PLoS One*, 8(1), e55124.

Klima, T., Christ, A., Marana, I., et al. (2012). Sodium chloride vs. sodium bicarbonate for the prevention of contrast medium-induced nephropathy: a randomized controlled trial. *European Heart Journal*, 33(16), 2017–2079.

19. E. Furosemide is a loop diuretic and can result in hypocalcemia, hypokalemia, gout, ototoxicity, and tinnitus (A). Metronidazole is an antibiotic used frequently in patients in need of anaerobic coverage and can lead to intractable nausea and emesis, particularly if taken with alcohol (disulfiram-like reaction) (B). Spironolactone is a potassium-sparing diuretic that can result in hyperkalemia and gynecomastia (C). Halothane is an anesthetic agent that may rarely result in fulminant hepatic failure (D). Vancomycin will induce peripheral vasodilation resulting in cutaneous flushing, and rarely, it can cause red man syndrome.

**Reference:** Sivagnanam, S., & Deleu, D. (2003). Red man syndrome. *Critical Care (London, England)*, 7(2), 119–120.

# Preoperative Evaluation and Perioperative Care

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## Questions

1. A 65-year-old woman is admitted to the hospital with a large bowel obstruction. Workup reveals a sigmoid cancer, and on hospital day 4, she undergoes laparoscopy with a plan to perform a resection with a proximal colostomy. During the operation, her end-tidal carbon dioxide suddenly drops, and she develops tachycardia to the 120s with occasional premature atrial contractions. Her systolic blood pressure is 80 mm Hg. Which of the following would be most helpful in establishing the presumptive diagnosis?
  - A. Electrocardiogram
  - B. Cardiac enzymes
  - C. Transesophageal echocardiogram
  - D. Arterial blood gas
  - E. Flexible bronchoscopy
2. A 59-year-old male with a coronary artery bypass grafting 1 year prior for multivessel disease undergoes a right knee replacement surgery. His postoperative course is complicated by pneumonia requiring mechanical ventilation. Electrocardiogram shows a stable Q wave in lead II. Heart rate is 80 bpm and blood pressure is 116/82 mm Hg. Chest radiograph shows bilateral patchy infiltrates. Laboratory exam demonstrates PaO<sub>2</sub> of 70 mm Hg, a white blood cell count of 17,000 cells/ $\mu$ L, and hemoglobin of 7.4 g/dL. Which of the follow is true regarding the management of his anemia?
  - A. Blood transfusion will facilitate weaning from the mechanical ventilator.
  - B. He should be transfused to a hemoglobin goal of 10 g/dL.
  - C. Red blood cell transfusion is independently associated with lower mortality.
  - D. Recombinant human erythropoietin may reduce his overall transfusion requirements.
  - E. Hemoglobin-based oxygen carriers offer a good alternative to transfusion in this patient.
3. Four days after a pancreaticoduodenectomy for pancreatic adenocarcinoma, a 65-year-old man develops a fever and tachycardia. Exam reveals tenderness, edema, and erythema over the angle of the jaw. Which of the following is true regarding this condition?
  - A. It is usually due to *Streptococcus*.
  - B. Massage of the area is beneficial.
  - C. It can be prevented with antibiotics.
  - D. It is associated with decreased saliva formation.
  - E. It can be avoided with the use of anticholinergics.
4. A 69-year-old woman presents with copious diarrhea, fever, dehydration, and abdominal pain. She was hospitalized 4 weeks ago for pneumonia. The patient demonstrates diffuse abdominal tenderness on examination with guarding and rebound. Plain abdominal radiographs reveal a markedly distended colon without free air. Temperature is 103°F and the white blood cell count is 25,000 cells/ $\mu$  L. After fluid hydration, definitive management should consist of:

- A. Oral Flagyl (metronidazole)
  - B. Oral vancomycin
  - C. Intravenous (IV) Flagyl (metronidazole)
  - D. Colonoscopic decompression
  - E. Colectomy
5. A 69-year-old patient with a tumor at the rectosigmoid junction undergoes laparoscopic sigmoid colectomy. Postoperative pain is well controlled with patient-controlled thoracic epidural anesthesia. On postoperative day 1, prophylactic anticoagulation is started with low-molecular-weight heparin (LMWH). The bladder is undergoing drainage with an indwelling Foley catheter. Which of the following is true regarding epidural anesthesia?
- A. Bladder catheterization should continue while the thoracic epidural is in place.
  - B. LMWH should be held for 24 hours before removal of the thoracic epidural.
  - C. The risk of urinary tract infection is the same regardless of whether the urinary catheter is removed on postoperative day 1 versus postoperative day 3.
  - D. Risk of urinary retention is not significantly higher with early removal of the Foley catheter.
  - E. Unfractionated heparin should not be restarted for at least 4 hours after removal of an epidural catheter.
6. A 25-year-old woman develops a fever of 104°F 12 hours after an open cholecystectomy. On examination, she has foul-smelling, purulent drainage from her wound. She undergoes the appropriate treatment, and culture of the wound grows gram-positive rods. Which of the following is true regarding this patient and her condition?
- A. The causative organism is an aerobe.
  - B. This condition can be managed conservatively but should be taken to the OR if there is diffuse peritonitis.
  - C. Broad-spectrum antibiotics and fluid resuscitation alone resolve the majority of cases.
  - D. The organism produces an endotoxin.
  - E. Clindamycin should be included in the management.
7. A 34-year-old woman undergoes a subtotal thyroidectomy for Graves disease. In the recovery room, she develops anxiety and progressive respiratory distress with stridor. Her incision is bulging and tense on exam. The most important initial step would be:
- A. Nebulized racemic epinephrine
  - B. Rapid-sequence intubation
  - C. Needle aspiration of the neck wound
  - D. Ultrasound examination of the neck
  - E. Rapidly opening the incision at the bedside
8. One day after a left colectomy for recurrent diverticulitis, a patient is noted to have an elevation of his serum creatinine. Other laboratories are unremarkable. He has a urine output of 30 to 50 mL/hour. A renal ultrasound shows no evidence of abnormalities with the exception of ascites. Computed tomography (CT) scan demonstrates discontinuity of the left ureter with contrast extravasation at the level of the pelvic brim. Which of the following about this injury is true?
- A. Placement of ureteral stents would have prevented this complication.
  - B. Immediate reoperation should not be performed.
  - C. A percutaneous nephrostomy should be placed.
  - D. A retrograde stent should be placed.
  - E. A ureteroneocystostomy will likely be a better option than a ureteroureterostomy
9. Two days after sustaining significant crush injury to her bilateral lower extremities from a motor vehicle collision, a 32-year-old female becomes oliguric and is only producing scant dark urine. Urine dipstick reveals 4+ blood, and follow-up urinalysis shows 5 to 10 red blood cells per high power field. Prevention of acute kidney injury is best achieved by which of the following?
- A. Urgent four compartment fasciotomies

- B. Loop diuretics
  - C. Vigorous IV fluid hydration
  - D. Alkalization of urine with intravenous sodium bicarbonate
  - E. Mannitol
10. Five days after a laparoscopic Roux-en-Y gastric bypass, a patient develops fever with rigors, hypotension, tachycardia, and pain in the left shoulder. This most likely represents:
- A. Gas bloat syndrome
  - B. Acalculous cholecystitis
  - C. Wound dehiscence
  - D. Internal hernia involving the Roux limb
  - E. Disruption of the gastric pouch–jejunal anastomosis
11. A 28-year-old woman undergoes adhesiolysis for an acute small bowel obstruction. During the course of the surgery, she requires a segmental ileal resection with primary anastomosis. On postoperative day 6, she is noted to have thick bile-colored fluid emanating from the midline wound. After IV hydration, the next step in the management should be:
- A. CT scan of the abdomen
  - B. Water-soluble upper gastrointestinal series with small bowel follow-through
  - C. Fistulogram
  - D. Operative re-exploration
  - E. Octreotide
12. The most important predictor of colonic ischemia after repair of a ruptured abdominal aortic aneurysm is:
- A. Age
  - B. Presence of preoperative shock
  - C. Time to operation
  - D. Presence of associated cardiac disease
  - E. Intraoperative ligation of a patent inferior mesenteric artery
13. Five days after surgery for perforated appendicitis, liquid stool emanates from the right lower quadrant wound. Which of the following is true about this condition?
- A. Mortality is high for this complication.
  - B. The majority will close spontaneously.
  - C. The patient should be placed immediately on TPN.
  - D. Fluid and electrolyte derangements are common.
  - E. The patient should be returned immediately to the operating room for surgical repair.
14. Five days after a Billroth II gastric resection for a bleeding ulcer, high fever, hypotension, tachycardia, and generalized peritonitis develop in the patient. This most likely represents:
- A. Postoperative pancreatitis
  - B. Acalculous cholecystitis
  - C. Duodenal stump blowout
  - D. Intra-abdominal hemorrhage
  - E. Wound dehiscence
15. Which of the following modalities is LEAST likely to assist in the prevention of postoperative pulmonary complications in a 65-year-old male smoker?
- A. Postoperative use of an incentive spirometer
  - B. Postoperative deep-breathing exercises
  - C. Postoperative use of continuous positive airway pressure
  - D. Smoking cessation 1 week before surgery
  - E. Placement of a nasogastric tube

16. Which of the following preoperative studies is most strongly associated with an increased risk of pulmonary-related postoperative complications?
- A. Blood urea nitrogen
  - B. Incentive spirometry
  - C. Chest radiograph
  - D. Serum albumin
  - E. Room air arterial blood gas
17. A 67-year-old male recovering from a pelvic exenteration secondary to locally advanced rectal cancer is started on total parenteral nutrition for prolonged ileus via a right-sided peripherally inserted central catheter (PICC) line. Several days later the nurse reports that she is unable to draw blood from his PICC line. The arm is swollen. Ultrasound confirms clot in the basilic and axillary veins. What is the appropriate management of his condition?
- A. Warm compress and nonsteroidal antiinflammatory drugs (NSAIDs)
  - B. Immediately remove the line.
  - C. Immediately remove line and then start heparin.
  - D. Start heparin and move the line to an alternate site.
  - E. Start heparin, keep the line in place, and therapeutic anticoagulation for 3 to 6 months
18. A 76-year-old diabetic male is admitted to the surgical intensive care unit after a fall. His injuries include a right femoral neck fracture and subarachnoid hemorrhage. He continues to have intermittent elevation in his intracranial pressure and is still requiring respiratory support after 2 days. Which of the following is true regarding nutritional supplementation in this patient?
- A. Postpyloric feeding may reduce his risk of developing pneumonia.
  - B. Gastric feeding is associated with a longer length of ICU stay.
  - C. Diabetic patients have better outcomes with gastric versus postpyloric feedings.
  - D. Postpyloric feeding more closely simulates normal physiologic feeding.
  - E. Gastric feeding is associated with increased total nutrition.
19. A 55-year-old obese female with chronic obstructive pulmonary disease (COPD) is undergoing preoperative evaluation for ventral hernia repair. She has a 30 pack-year smoking history, though she quit 1 year ago. Her COPD symptoms are well controlled with her current medication regimen, and her last admission for COPD exacerbation was over 2 years ago. Which of the following is true regarding risk assessment for postoperative pulmonary complications in this patient?
- A. Obesity is not a significant risk factor.
  - B. Preoperative pulmonary function tests (PFTs) should be obtained.
  - C. A nasogastric tube should be used postoperatively to decrease pulmonary complications.
  - D. Upper midline and lower midline laparotomy confer similar risk for pulmonary complications.
  - E. A  $\text{PaCO}_2$  of more than 45 is an absolute contraindication to major abdominal surgery.
20. Which of the following is true regarding PFTs?
- A. Total lung capacity (TLC) is generally reduced with aging.
  - B. A preoperative forced expiratory volume in one second ( $\text{FEV}_1$ ) of less than 1.5 L is a contraindication for pulmonary lobectomy.
  - C. Diffusion capacity of the lungs for carbon monoxide (DLCO) will stay relatively constant with age so long as there is no intrinsic lung disease.
  - D. Percent-predicted postoperative  $\text{FEV}_1$  of  $>40\%$  is acceptable for a lobectomy but not pneumonectomy.
  - E. Chest wall compliance decreases with age.
21. A 45-year-old male with end-stage renal disease is undergoing placement of a tunneled hemodialysis catheter. During the operation, the anesthesiologist notices a sharp decline in the continuous capnography and the calculated physiologic dead space is increased. This is followed by massive myocardial infarction and cardiac arrest. Which of the following is true regarding this condition?
- A. Electrocardiogram (ECG) will most commonly demonstrate right heart strain.



- B. A congenital heart defect likely contributed to the cardiac arrest.
  - C. The patient should be placed in left side-up position.
  - D. Bedside transesophageal echocardiography is generally not sensitive enough to detect this complication.
  - E. Aspiration from the central line is usually helpful.
22. A 65-year-old man with Barrett esophagus and new onset dysphagia is being evaluated for diagnostic esophagogastroduodenoscopy (EGD), endoscopic ultrasound (EUS), and mucosal biopsy. He is on warfarin for mechanical mitral valve and has a history of embolic stroke 10 years ago. What is recommended for his anticoagulation regimen before this procedure?
- A. Hold warfarin for 3 to 5 days and bridge with low-molecular-weight heparin.
  - B. Hold warfarin for 48 to 72 hours, bridge with unfractionated heparin, and hold heparin 4 to 6 hours before the procedure.
  - C. Perform EGD and EUS while therapeutic on warfarin; if indicated, the mucosal biopsy can be performed at a later date after holding warfarin.
  - D. Continue warfarin without interruption.
  - E. Hold warfarin 3 to 5 days before procedure and restart within 24 hours after the procedure.
23. A patient in the surgical intensive care unit was started on bolus enteral feeds approximately 3 hours ago and is now having significant respiratory distress. No medications were administered recently, and the nursing staff did not notice any significant events. Following intubation, an arterial blood gas demonstrates a PaO<sub>2</sub> of 70 mm Hg on a FiO<sub>2</sub> of 75%. Which of the following is true about this condition?
- A. Early bronchoscopy is indicated.
  - B. Corticosteroids should be administered.
  - C. It is most commonly caused by gram-negative organisms.
  - D. Tumor necrosis factor alpha (TNF- $\alpha$ ) and interleukin-8 (IL-8) have been implicated as causative agents.
  - E. Feeding via percutaneous endoscopic gastrostomy (PEG) tube is superior to nasogastric tube in preventing this condition.
24. A 42-year-old female with long-standing systemic lupus erythematosus (SLE) complicated by lupus nephritis and debilitating arthritis is in the ICU following an emergency bowel resection 4 days earlier. Over the next several hours, she becomes febrile, hypotensive, and complains of abdominal pain. She is given fluid boluses, but the blood pressure does not respond. Her abdominal exam is unremarkable. Laboratory values reveal a white blood cell count of 12,000 cells/L with eosinophilia, serum Na of 133 mEq/L, serum bicarbonate of 20 mEq/L, and serum K of 5.3 mEq/L. Which of the following represents the best management of this condition?
- A. Two liters of normal saline followed by 4 mg of dexamethasone
  - B. Exploratory laparotomy
  - C. Vasopressin
  - D. Immediate administration of broad-spectrum antibiotics and 100 mg of hydrocortisone
  - E. Fluid resuscitation, vasopressor support, and AM cosyntropin test
25. Which of the following is true regarding the use of beta-blockers in the perioperative period for patients undergoing noncardiac surgery?
- A. Starting a beta-blocker within 24 hours of surgery may increase the incidence of perioperative death.
  - B. Beta-blockers should be stopped at least 1 week before surgery so as to reduce the risk of postoperative bradycardia and hypotension.
  - C. In low- and intermediate-cardiac risk patients beta-blockers should be initiated 2 to 3 weeks before surgery.
  - D. Beta-blockers should be avoided even in the high-cardiac risk group.
  - E. Perioperative initiation of beta-blocker decreases the incidence of nonfatal stroke.
26. Which of the following is true regarding venous thromboembolism (VTE) prophylaxis in surgical

patients?

- A. Intermittent pneumatic compression (IPC) prevents DVT by increasing circulating tissue plasminogen activator (tPA).
- B. Thigh-high IPC is superior to knee-high IPC.
- C. IPC is equivalent to pharmacologic prophylaxis in the majority of patients.
- D. Unfractionated heparin is superior to lower-molecular-weight heparin (LMWH).
- E. LMWH is superior to IPC.

## Answers

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1. **C.** The differential diagnosis for a sudden drop in end-tidal CO<sub>2</sub> in the operating room (OR) includes an obstructed airway, accidental extubation, disconnection of the circuit, cardiac arrest, and pulmonary embolism (PE). The patient described has at least three risk factors for PE including malignancy, a heart rate greater than 100, and more than 3 days of immobilization (Wells criteria). PE is estimated to occur in 1% to 2% of surgical patients in the perioperative period. While dyspnea, anxiety, tachycardia, and tachypnea are the most common findings in awake patients, physical signs of PE will be limited in patients under general anesthesia. In this situation, an astute clinician can recognize PE as presenting with hypotension, tachycardia, decreased end-tidal CO<sub>2</sub>, and hypoxemia. In general, laparoscopic procedures have been associated with a low risk of both fatal and nonfatal PE (E). This complication is associated with 10% to 15% mortality in the perioperative period (D). Electrocardiogram changes have been shown to be present in up to 83% of patients, but they are generally nonspecific (A). Uncommonly, PE can present with a prominent S wave in lead 1, Q wave in lead 3, and inverted T wave in lead 3; this is suggestive of right heart strain. Despite potential cardiovascular consequences of massive PE, an elevated cardiac enzyme level occurs in less than 50% of cases and is not specific for PE (B). The two most sensitive tests that can be done to help diagnose PE are a transesophageal echocardiogram (TEE) and calculating the physiologic dead space to look for elevations (though it can be time-consuming). TEE has been shown to yield a diagnosis in an average of 9.6 minutes with a sensitivity of 80% and specificity of 97% and is ideal in the OR setting. Although TEE is relatively poor at visualizing the PE, it is excellent at demonstrating right heart strain, which provides indirect evidence of PE. Arterial blood gas in awake patients with PE may demonstrate a low CO<sub>2</sub>, but this may not be the case for a ventilated patient under general anesthesia (D). Flexible bronchoscopy is not helpful in diagnosing PE (E).

**Reference:** Desciak, M., & Martin, D. (2011). Perioperative pulmonary embolism: diagnosis and anesthetic management. *Journal of Clinical Anesthesia*, 23(2), 153–165.

2. **D.** Red blood cell transfusion has been independently associated with longer intensive care unit (ICU) and hospital stays, increased complications, and increased mortality (C). It is also an independent risk factor for multiorgan system failure and systemic inflammatory response syndrome (SIRS). Most societal guidelines agree that a liberal transfusion strategy (goal of 10 g/dL) is no better and likely worse than a more restrictive strategy (goal of 7–9 g/dL) in the majority of patients. The Transfusion Requirements in Critical Care (TRICC) trial demonstrated that critically ill patients without active bleeding fared better with a restrictive transfusion strategy. However, notably absent from this study was a subanalysis of patients with a history of cardiovascular disease; thus controversy still surrounds the transfusion goal for this patient population. The FOCUS trial showed a slight trend toward increased cardiac events in this group receiving a restrictive transfusion strategy but did not independently look at patients with active disease and those with simply a history of cardiac disease. A 2013 pilot study demonstrated a trend toward improved outcomes in the setting of *symptomatic* coronary artery disease and recommended a hemoglobin goal of 10 g/dL. There are no convincing data to support this goal in patients with stable cardiac disease (as in the above patient) (B). While hemoglobin can improve oxygen delivery to tissues, it has not been shown to decrease time on the mechanical ventilator, improve oxygen consumption, or improve outcomes in patients with adult respiratory distress syndrome or acute lung injury (A). In fact, it has been associated with worse outcomes in this population of patients. Because of the negative effects of blood transfusion, alternative methods of managing anemia are actively being researched, including the use of recombinant human erythropoietin (EPO) and

hemoglobin-based oxygen carriers. Trials designed specifically looking at administering exogenous erythropoietin in trauma patients, the EPO-1 and EPO-2 trials showed reductions in required blood transfusions and improved mortality, respectively. The EPO-3 trial, which included follow-up to 140 days continued to show the improvement in mortality but no difference in number of transfusions. The best current evidence indicates that recombinant human erythropoietin is likely safe and may reduce the number of necessary blood transfusions. While hemoglobin-based oxygen carriers show some promise, they are not currently approved for use in the United States (E).

**References:** Hebert, P. C., Wells, G., Blajchman, M. A., et al. (1999). A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. *The New England Journal of Medicine*, 340(6), 409–417.

Carson, J., Terrin, M. L., Noveck, H., et al. (2011). Liberal or restrictive transfusion in high-risk patients after hip surgery. *The New England Journal of Medicine*, 365(26), 2453–2462.

Carson, J. L., Grossman, B. J., Kleinman, S., et al. (2012). A red blood cell transfusion: a clinical practice guideline from the AABB. *Annals of Internal Medicine*, 157(1), 49–58.

Carson, J., Brooks, M. M., Abbott, J. D., et al. (2013). Liberal versus restrictive transfusion thresholds for patients with symptomatic coronary artery disease. *American Heart Journal*, 165(6), 964.

Corwin, H., Gettinger, A., Rodriguez, R., et al. (1999). Efficacy of recombinant human erythropoietin in the critically ill patient: a randomized, double-blind, placebo-controlled trial. *Critical Care Medicine*, 27(11), 2346–2350.

Corwin, H., Gettinger, A., Pearl, R. G., et al. (2002). Efficacy of recombinant human erythropoietin in critically ill patients: a randomized controlled trial. *JAMA*, 288(22), 2827–2835.

Napolitano, L., Fabian, T., Kelly, K., et al. (2008). Improved survival of critically ill trauma patients treated with recombinant human erythropoietin. *The Journal of Trauma*, 65(2), 285–297.

Napolitano, L., Kurek, S., Luchette, F., et al. (2009). Clinical practice guideline: red blood cell transfusion in adult trauma and critical care. *Critical Care Medicine*, 37(12), 3124–3157.

3. **D.** This patient has postoperative parotitis. This most commonly occurs in elderly patients with poor oral hygiene, poor oral intake, prolonged nasogastric tube decompression, and dehydration, all leading to a decrease in saliva production. The pathophysiology involves obstruction of the salivary ducts with secondary infection and is more common in the diabetic or immunocompromised patient. Most patients will be diagnosed with parotitis 4 to 12 days postoperatively. Signs and symptoms begin with pain and tenderness over the angle of the jaw that can then progress to high fevers and leukocytosis, as well as significant edema involving the floor of the mouth. If left undiagnosed and untreated, it can lead to life-threatening sepsis. Initial treatment is with high-dose broad-spectrum antibiotics with *Staphylococcus* coverage (A) and warm compresses (B). If the patient does not improve, surgical incision and drainage are indicated. In extreme cases involving progressive airway obstruction, emergent tracheostomy may be indicated. Use of measures to stimulate salivary flow, such as sucking on candy, seems to help prevent this complication, but prophylactic antibiotics are generally not indicated (C). Additionally, the use of anticholinergics will decrease salivary flow and increase the risk of developing postoperative parotitis (E).
4. **E.** This presentation is consistent with toxic megacolon that is most likely secondary to *Clostridium difficile* infection. In the absence of a history of inflammatory bowel disease, a patient presenting with toxic megacolon should be presumed to have *C. difficile* colitis until proven otherwise. The incidence of *C. difficile* colitis is increasing, and patients may not necessarily present with the classic history of diarrhea or previous antibiotic administration. Presumably the patient received antibiotics when hospitalized previously for pneumonia. *C. difficile* makes two toxins, A and B. A particularly virulent strain, known as the NAP1 strain, is more resistant to antibiotics and makes 16 times more toxin A and 23 times more toxin B than other strains. However, *C. difficile* is now most commonly diagnosed by DNA polymerase chain reaction (PCR) because results are generally available within 1 day and only one sample is required. Both oral and IV Flagyl (metronidazole) and oral vancomycin are effective in treating uncomplicated *C. difficile* colitis (A–C). IV vancomycin is not effective because it is not transported across the GI tract mucosa. This is also why oral dosing for vancomycin is not indicated for diseases outside of the GI tract. The presence of peritonitis mandates exploratory laparotomy and colectomy. Endoscopy can be useful for *C. difficile* under certain conditions, such as high suspicion after multiple negative diagnostic tests, necessity

of prompt diagnosis before laboratory tests can be obtained, and disease refractory to antibiotic therapy. However, endoscopy can be potentially dangerous in the setting of fulminant colitis and is not indicated when there are signs of peritonitis and sepsis (D). Delay in therapy will likely increase the risk of an adverse outcome. In a recent review, the mortality for *C. difficile* colitis with toxic megacolon was 50%.

**Reference:** Berman, L., Carling, T., Fitzgerald, T., et al. (2008). Defining surgical therapy for pseudomembranous colitis with toxic megacolon. *Journal of Clinical Gastroenterology*, 42(5), 476–480.

5. **D.** Epidural anesthesia is an excellent tool to control postoperative pain and has been shown to decrease cardiac morbidity, and as such, it has been gaining popularity in clinical practice. Routine use of urinary drainage in the setting of epidural anesthesia remains controversial. However, postoperative day 1 removal of the Foley with thoracic epidurals has been shown to significantly decrease the incidence of urinary tract infections with minimal change to the rate of urinary retention as measured by rates of recatheterization (A–C). Current recommendations for the placement and removal of epidural catheters in patients receiving prophylactic low-molecular-weight heparin (LMWH) is intended to prevent an epidural hematoma and subsequent paralysis. For the placement of epidural catheters, LMWH must be held at least 24 hours before placement, and it should not be removed within 12 hours of the last dose. Prophylactic anticoagulation can be restarted 6 hours after placement and no sooner than 4 hours after removal of the epidural (B). Unfractionated heparin may be restarted after 1 hour (E).

**References:** Hendren, S. (2013). Urinary catheter management. *Clinics in Colon and Rectal Surgery*, 26(3), 178–181.

Horlocker, T. T. (2011). Regional anaesthesia in the patient receiving antithrombotic and antiplatelet therapy. *British Journal of Anaesthesia*, 107(10), i96–i1061.

Low Molecular Weight Heparins: Drug Safety Communication - Recommendations to Decrease Risk of Spinal Column Bleeding and Paralysis. (2013). *FDA Safety Information and Adverse Event Reporting Program*. Retrieved from

<http://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/uc>

Townsend, C., & Sabiston, D. (2004). *Sabiston textbook of surgery: The biological basis of modern surgical practice*. Philadelphia, PA: W. B. Saunders.

Zaouter, C., Kaneva, P., & Carli, F. (2009). Less urinary tract infection by earlier removal of bladder catheter in surgical patients receiving thoracic epidural analgesia. *Regional Anesthesia and Pain Medicine*, 34(6), 542–548.

6. **E.** Postoperative necrotizing soft-tissue infection is a rare but well-described complication. The description of “dishwater pus” is classic for a postoperative clostridial wound infection. The causative organisms are typically *Streptococcus pyogenes* or *Clostridium perfringens*. *C. perfringens* is an anaerobic gram-positive rod that produces alpha-toxin; this is a virulent exotoxin that leads to extensive tissue necrosis and cardiovascular collapse (A–D). Clindamycin has been shown to limit toxin production, which decreases the virulence, slows tissue destruction, and can potentially reduce inflammatory cytokine release. Effective therapy requires rapid administration of broad-spectrum antibiotics including aerobic coverage (C) and source control via emergent operative excision of necrotic infected tissue, including fascia. Conservative management is not appropriate if a necrotizing soft-tissue infection is suspected (B).

**Reference:** Hakkarainen, T. W., Kopari, N. M., Pham, T. N., et al. (2014). Necrotizing soft tissue infections: review and current concepts in treatment, systems of care, and outcomes. *Current Problems in Surgery*, 51(8), 344–362.

7. **E.** Postoperative hematomas after neck surgery (thyroid, parathyroid, carotid artery) can have catastrophic consequences. Physical examination findings can be deceptively benign. Attempts at intubation may be hampered by tracheal compression and deviation (B). Furthermore, the recent neck dissection, combined with the hematoma, causes venous and lymphatic obstruction, leading to airway edema, further compromising attempts at intubation. Rapidly opening the incision at the bedside is necessary because urgent decompression is the fastest way to restore proper respiratory function. Definitive hemostasis must then be obtained in the operating room. Although ultrasonography is an important diagnostic aid for hematomas (D), clinical suspicion is sufficient in this emergent situation and the urgency of decompression does not permit waiting for an ultrasound examination. Needle aspiration would not be sufficient (C). While nebulized racemic epinephrine is used for the treatment of stridor in conditions like croup, it is not appropriate when

the cause of stridor is external compression of the airway (A).

8. E. The ureters first pass medial to the psoas muscle and travel alongside the transverse processes of the lumbar vertebrae and cross anterior to the common iliac arteries near the bifurcation into the internal and external iliac arteries. The anatomic position places the ureters at risk for injury during pelvic surgery, and the situation is particularly precarious when inflammation, abscess, and/or phlegmon are present. The highest risk of ureteral injury is during an abdominoperineal resection. During mobilization of the left colon and ligation of the inferior mesenteric artery, visualization and protection of the ureter from injury are imperative. Placement of ureteral stents before the operation may help to identify the ureters and assist with identifying an injury intraoperatively, but this does not seem to correlate with reduction in the number of injuries (A). Presence of blue dye in the operative field after intravenous administration of indigo carmine or methylene blue is diagnostic for injury to the ureter. The decision to immediately reoperate is based on the delay associated with injury recognition, the severity of the injury, and whether the patient has developed urosepsis. If discovered within a week postop, reoperation is generally recommended (B). Beyond 10 days, the inflammation present will make reoperation hazardous. In this latter case, percutaneous nephrostomy and/or retrograde drainage with a ureteral stent is indicated (C, D). The type of repair depends on the location and extent of the injury. For midureter injuries, a ureteroureterostomy is preferred. For pelvic injuries, ureteroneocystostomy is needed. If this is not possible, a psoas hitch or a Boari flap (from the bladder) may be needed.

**Reference:** Bothwell, W., Bleicher, R., & Dent, T. (1994). Prophylactic ureteral catheterization in colon surgery: a five-year review. *Diseases of the Colon and Rectum*, 37(4), 330–334.

9. C. Crush injury to the extremities causing significant muscle injury is often complicated by rhabdomyolysis, which can lead to acute renal failure. Degradation products of both hemoglobin and myoglobin are toxic to the nephron in acidic urine. Elevated serum creatine phosphokinase, hyperkalemia, and the presence of heme without a significant amount of red blood cells on urinalysis are indicative of rhabdomyolysis. Management consists of aggressive IV hydration to maintain a urine output of more than 100 mL/hour and should begin with infusion rates of at least 200 cc/hour. Myoglobin concentrates in the renal tubules precipitates when it comes in contact with Tamm-Horsfall protein. This precipitation is enhanced under acidic conditions. Routine administration of bicarbonate (D) and mannitol (E) in the prevention of acute kidney injury from rhabdomyolysis is controversial, but, theoretically, alkalinization of the urine increases the solubility of the myoglobin–Tamm-Horsfall protein P complex and should increase myoglobin washout. It also prevents lipid peroxidation and renal vasoconstriction and seems to have relatively few negative side effects if used in patients without high serum bicarbonate and without alkalosis. However, it reduces the amount of ionized calcium so should be used with caution in patients with hypocalcemia. Historical treatment of rhabdomyolysis has included forced diuresis with mannitol, but its routine use is being questioned now in the literature and may actually increase risk of developing renal failure. A retrospective study published in *The Journal of Trauma* in 2004 looking at over 2000 patients with elevated creatine kinase showed no difference in renal failure, need for hemodialysis, or mortality in patients receiving bicarbonate and mannitol versus volume resuscitation alone. Mannitol may aid in decreasing muscle swelling and compartment pressures, but the mainstay of treatment remains decompression of muscle compartments (A). However, in the case of crush injury, normal compartment pressures would not change your strategy for preventing acute kidney injury because tissue damage alone could cause the release of myoglobin. Loop diuretics are not used in the prevention of acute kidney injury in the setting of rhabdomyolysis (B). While retrograde urethrogram would assist in the diagnosis of missed urethral injury, the urine is positive on the dipstick from myoglobin, not hemoglobin.

**References:** Brown, C. V., Rhee, P., Chan, L., et al. (2004). Preventing renal failure in patients with rhabdomyolysis: do bicarbonate and mannitol make a difference? *The Journal of Trauma*, 56(6), 1191–1196.

Holt, S., & Moore, K. (2001). Pathogenesis and treatment of renal dysfunction in rhabdomyolysis. *Intensive Care Medicine*, 27(5), 803–811.

10. E. Fever, chills, tachycardia, hypotension, and peritoneal irritation occurring together within 1 week of any surgery involving a new bowel anastomosis should immediately raise suspicion for an anastomotic disruption. Left shoulder pain is often a consequence of left diaphragm irritation and, in this case, correlates with the gastric pouch–jejunal anastomosis. Water-soluble contrast studies



can aid in the diagnosis and indicate how large the leak is because contained leaks can often be managed nonoperatively. However, in this patient, hypotension and signs of peritonitis necessitate operative exploration and repair of the anastomosis. Gas pain and cholecystitis are less likely given the history of a recent operation and wound dehiscence would be readily apparent on exam (A–C). Internal hernia is less likely given the timeline and left shoulder pain indicative of diaphragmatic irritation (D).

11. **A.** This case represents an enterocutaneous fistula, likely resulting from either an anastomotic leak or an unrecognized intraoperative bowel injury away from the anastomosis. Management of enterocutaneous fistulas should begin with stabilizing the patient via aggressive fluid hydration and control of sepsis (if present). If the patient is manifesting signs of sepsis, prompt administration of IV antibiotics should be instituted. Sepsis, dehydration, and electrolyte/nutrient losses are the most devastating early consequences. Prompt return to the operating room is not recommended because the peritoneal cavity will likely have highly vascular adhesions, making reentry treacherous, and early attempts to reclose fistulas typically fail (D). Once the patient has been stabilized, the best initial study is a CT scan of the abdomen. This will identify whether any intra-abdominal abscesses are present that might require percutaneous drainage and rule out whether there is a distal obstruction (B, C). Fistulas are loosely categorized as high and low output. High output is defined as outputs of more than 500 mL/day and low output as less than 200 mL/day. High-output fistulas are less likely to close and often cause significant fluid, electrolyte, and nutritional challenges. Factors that predict whether a fistula will close (mnemonic “FRIEND”) include *f*oreign body, *r*adiation to the bowel, *i*nflammation/infection (such as inflammatory bowel disease), *e*pithelialization of the fistula tract, *n*eoplasia at the fistula site, and *d*istal obstruction. The mortality rate of enterocutaneous fistulas remains significant at 10% to 15%. Approximately 50% close spontaneously. Conservative treatment should be continued for at least 6 weeks before any reoperation is performed. Operating before 6 weeks results in higher mortality and fistula recurrence rates. Octreotide has not been shown in randomized trials to aid in earlier fistula closure but does not decrease mortality (E).

**Reference:** Sancho, J., di Costanzo, J., & Nubiola, P. (1995). Randomized double-blind placebo-controlled trial of early octreotide in patients with postoperative enterocutaneous fistula. *The British Journal of Surgery*, 82(5), 638–641.

12. **B.** Colonic ischemia after repair of a ruptured abdominal aortic aneurysm occurs in 1% to 6% of operations but can occur in up to 25% of cases under certain circumstances. The greatest risk factor is the presence of prolonged hypotension preoperatively. In a patient with stable blood pressure, age, time to operation, and the presence of cardiac disease have little effect on the incidence of colonic ischemia after aortic repair (A–C, D). Intraoperative ligation of a patient’s inferior mesenteric artery is also not a good predictor of colonic ischemia because of significant avenues of collateral flow (E). Symptoms and signs of ischemia include bloody diarrhea, abdominal pain/distention, and elevated white blood cell count. If the patient has evidence of peritonitis, urgent reoperation is indicated. Otherwise, urgent endoscopy is required to view the colonic mucosa. The majority of cases of colonic ischemia can be managed nonoperatively with bowel rest, hydration, and IV antibiotics. If the patient requires colon resection, mortality rates are as high as 75%.
13. **B.** This case represents a cecal fistula. The most common causes are slippage of the suture or necrosis of the remaining appendiceal stump, leading to leakage of the enteric contents into the peritoneal cavity. Much less commonly, distal colon obstruction can cause this condition and is usually the result of external compression from an intraperitoneal abscess. Cecal fistulas are low-output fistulas and are not associated with losses of large amounts of fluid, electrolytes, or nutrients (D). Therefore, TPN is not necessary to maintain adequate nutrition (C) and mortality rates are low in the absence of other serious complications (A). Spontaneous closure is promoted in as many as 75% of patients maintained on low-residue diets because absorption is mostly complete by the time the contents reach the cecum (B, E).
14. **C.** Duodenal stump blowout occurs after Billroth II operations, where back pressure on the duodenal stump results in breakdown of the stump closure, leading to abdominal sepsis and peritonitis. Acute pancreatitis is associated postoperatively with Billroth II gastrectomy and jejunostomy, in which increased intraduodenal pressure can cause backflow of activated enzymes into the pancreas but is unlikely to cause peritonitis (A). Wound dehiscence is characterized as sudden dramatic drainage of relatively large volumes of a clear, salmon-colored fluid and is

apparent on physical exam (E). Acalculous cholecystitis can also occur postoperatively; however, the clinical presentation would mainly consist of right upper quadrant pain (B). Intra-abdominal hemorrhage would be less likely to present with sepsis (D).

15. **E.** Smoking is a predictor of postoperative pulmonary complications. The respiratory epithelium is altered in smokers, and poor ciliary activity combined with the production of more viscous mucus leads smokers to be more reliant on coughing to clear secretions from their lungs. Several days after patients have stopped smoking, there may be a transient increase in sputum volume. The above reasons have typically prevented health professionals from encouraging smoking cessation in the weeks leading up to surgery. However, a meta-analysis published by the American Medical Association has concluded that the concern that stopping smoking only a few weeks prior to surgery might worsen clinical outcomes is unfounded and clinicians should advise smoking cessation as soon as possible (D). Postoperative lung expansion modalities (A–C) reduce postoperative pulmonary complications, although there is no added benefit from using all three. Routine use of a nasogastric tube may increase aspiration risk because the tube stents open the gastroesophageal junction. However, selective use in patients with nausea, bloating, and/or vomiting is probably protective.

**References:** Bluman, L., Mosca, L., Newman, N., et al. (1998). Preoperative smoking habits and postoperative pulmonary complications. *Chest*, 113(4), 883–889.

Lawrence, V., Cornell, J., Smetana, G., et al. (2006). Strategies to reduce postoperative pulmonary complications after noncardiothoracic surgery: systematic review for the American College of Physicians. *Annals of Internal Medicine*, 144(8), 596–608.

Myers, K., Hajek, P., Hinds, C., & McRobbie, H. (2011). Stopping smoking shortly before surgery and postoperative complications: a systematic review and meta-analysis. *Archives of Internal Medicine*, 171(11), 983–989.

16. **D.** A serum albumin less than 3.5 g/dL is the single most important laboratory predictor of adverse pulmonary events after surgery. Blood urea nitrogen (>21 mg/dL) is also useful, although the correlation is not as strong (A). Routine spirometry for all operations does not seem to add value beyond a careful history and physical examination (B). An exception for the use of spirometry would be for lung resection. Chest radiograph and arterial blood gas are diagnostic studies that would only be predictive of postoperative complications if there were abnormal findings (C, E).

**References:** Lawrence, V., Cornell, J., Smetana, G., et al. (2006). Strategies to reduce postoperative pulmonary complications after noncardiothoracic surgery: systematic review for the American College of Physicians. *Annals of Internal Medicine*, 144(8), 596–608.

Qaseem, A., Snow, V., Fitterman, N., et al. (2006). Risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: a guideline from the American College of Physicians. *Annals of Internal Medicine*, 144(8), 575–580.

17. **E.** Thrombosis of superficial and deep veins of the upper extremity is caused by intravenous catheters in most cases. While superficial venous thrombosis generally presents with pain and tenderness over the course of the vein, deep venous thrombosis (DVT) can be asymptomatic. A DVT may present with feelings of fullness in that extremity (e.g., jewelry not fitting) or as massive edema. Inability to withdraw from the line is another potential clinical clue. Management begins with anticoagulation and determining the necessity for the line; in the above case, there is a continued need of TPN via a PICC line as the patient has not yet demonstrated return of bowel function. Studies have shown that it is not necessary to remove the PICC line despite the DVT. Therapeutic anticoagulation for 3 to 6 months is recommended. Thus removal of the catheter without anticoagulation is not acceptable because there is a risk of PE (B). Indications to remove a line include infection and a contraindication to anticoagulation. If the line is to be removed, anticoagulation is still recommended; however, the recommendation is to wait 5 to 7 days after the initiation of heparin before removing it (due to the theoretic fear that pulling the line with a fresh clot might dislodge the thrombus) (C, D). Warm compresses and NSAIDs would be appropriate for a superficial thrombophlebitis (A).

**Reference:** Kucher, N. (2011). Deep-vein thrombosis of the upper extremities. *The New England Journal of Medicine*, 364(9), 861–869.

18. **A.** While there are many theoretic advantages between each method of feeding, a 2015 Cochrane review comparing postpyloric and gastric feedings showed only two significant differences: lower rates of pneumonia in the postpyloric group and some evidence for increased total nutrition



delivered in the postpyloric group (E). There was no significant difference in length of ICU stay, mortality, or time on the ventilator (B). There was also no significant difference in associated complications with tube placement between the two study groups. While postpyloric feeding was associated with a longer time to initiation of tube feeding, this did not seem to affect the time it took to reach nutritional goals. Advantages of gastric feeding include a better approximation of normal physiology, ease of placement, and convenience (D). It may be a reasonable choice in patients without risk for aspiration, but patients with delayed gastric emptying (which is common in ICU patients), diabetes, and gastroesophageal reflux should be considered for postpyloric feeds (C). In terms of timing, there is abundant evidence that earlier enteral feeding in critically ill patients results in better outcomes.

**Reference:** Alkhawaja, S., Martin, C., Butler, R. J., et al. (2015). Post-pyloric versus gastric tube feeding for preventing pneumonia and improving nutritional outcomes in critically ill adults. *Cochrane Database of Systematic Reviews*, (8), CD008875.

19. **A.** Patient-related risk factors for the development of postoperative pulmonary complications include: age more than 50 years, COPD, congestive heart failure, American Society of Anesthesiologists (ASA) class greater than 2, serum albumin less than 3.5 g/L, obstructive sleep apnea, pulmonary hypertension, and current smoking. Notably absent from this list is obesity, which has not been shown to independently significantly increase the risk of postoperative pulmonary complications. While a preoperative PaCO<sub>2</sub> greater than 45 does increase the surgical risk, there is currently no definitive number that prohibits abdominal surgery (E). Current American College of Physicians Guidelines recommend against the routine use of preoperative chest radiography or PFT (B). Although it is important to identify patients with COPD, and some COPD patients may benefit from preoperative interventions, patients who require additional testing can be identified by history of new symptoms or physical examination findings. Thus PFT should be restricted to those who have current symptoms or signs based on history and physical. Location of the surgical incision is an important risk factor for postoperative pulmonary complications, with incisions closer to the diaphragm inferring more risk (D). When patients have been identified as high risk for pulmonary complications, current evidence supports the use of perioperative deep-breathing exercises and incentive spirometry. Routine use of nasogastric decompression has been associated with increased rates of pneumonia and atelectasis. Current recommendations are for more selective use in patients with nausea, vomiting, or gastric distention (C).

**Reference:** Qaseem, A. (2006). Risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: a guideline from the American College of Physicians. *Annals of Internal Medicine*, 144(8), 575.

20. **E.** Pulmonary function testing generally includes three separate tests: spirometry, lung volumes, and the diffusion capacity of the lungs. Expected changes with aging include an increase in the functional residual capacity and the residual volume, with a corresponding decrease in the vital capacity. This reciprocal change generally means the TLC is preserved (A). DLCO will also decrease with age (C). Compliance of the lung can be misleading because even though the compliance of the lung tissue itself increases with age, the chest wall compliance is significantly reduced. In general, this means that the overall compliance of the pulmonary system is reduced. Preoperative pulmonary function tests are mandatory for the evaluation of potential pulmonary resection. The preoperative values to remember are FEV<sub>1</sub> greater than 2 L for pneumonectomy, FEV<sub>1</sub> greater than 1.5 L for lobectomy, FEV<sub>1</sub> greater than 80% predicted, and DLCO greater than 80% predicted. However, these numbers are not absolute indications, and failure to meet them simply necessitates more workup; this includes getting a ventilation/perfusion scan to determine the contribution of the predicted segment (B). If the percent-predicted postoperative FEV<sub>1</sub> and DLCO are greater than 60%, then the patient is a candidate for resection of the proposed segment without further testing (D). If the percent-predictive postoperative FEV<sub>1</sub> and DLCO are less than 60%, exercise tolerance should be tested.

**Reference:** Brunelli, A., Kim, A., Berger, K., et al. (2013). Physiologic evaluation of the patient with lung cancer being considered for resectional surgery. *Chest*, 143(Suppl. 5), 166S–190S.

21. **B.** Venous air embolism is a rare and typically asymptomatic condition. Though it is often associated with the placement of central venous access catheters, it has been associated with other conditions including trauma, head and neck procedures, and neurosurgical procedures. When

suspected, the patient should be immediately placed in Trendelenburg position and left lateral decubitus or right side up (Durant maneuver) (C). This maneuver is designed to trap the air embolus in the right ventricle and prevent it from going into the pulmonary arteries. Physical exam findings include jugular venous distention, millwheel murmur, and a sucking sound as air enters the venous system through a catheter. The most sensitive bedside test for diagnosis is likely transesophageal echocardiography, which can detect even small volumes of air (D). ECG suggestive of right heart strain is associated with pulmonary emboli (A). Treatment includes correct positioning as previously described, increasing inspired oxygen, mechanical ventilation, hyperbaric oxygen, and, as a last resort, closed-chest cardiac massage to try to force the air out of the pulmonary arteries and into the smaller capillaries of the lung. An attempt can be made to aspirate the air from the ventricle either through an existing central line or directly through the chest wall, but return of air with these procedures is generally low (E). Myocardial infarction is uncommon with venous air embolism and is typically the result of the air entering the arterial system via a congenital heart defect, such as a patent foramen ovale, and occluding the coronary arteries. The volume for a fatal venous air embolism is typically estimated at 3 to 5 mL/kg injected at a rate of 100 mL/s, but these are largely based on animal studies. The volume is much lower if the air enters the arterial system.

**Reference:** Gordy, S., & Rowell, S. (2013). Vascular air embolism. *International Journal of Critical Illness and Injury Science Journal*, 3(1), 73–76.

22. **D.** This patient is scheduled for a low-risk endoscopic procedure and represents a high risk for thromboembolic events (mechanical valves and previous thromboembolic event), so anticoagulation should be continued without interruption. When considering endoscopic procedures for patients on anticoagulation or antiplatelet therapy, three main things need to be considered: the urgency of the procedure, patient's risk of thromboembolic events (and in this case, the type of valve), and risk of bleeding during the proposed intervention. If the anticoagulation is temporary (e.g., treatment of venous thrombosis) or discontinuation will be safer at a later date (e.g., recent myocardial infarction [MI] with stent placement) and the endoscopy is completely elective (such as screening), the endoscopy should be delayed. The type of prosthetic valve matters too. Prosthetic mitral valves have a much higher risk of thrombosis than aortic valves (much higher flow) with cessation of anticoagulation. As such, bridging is typically not needed for aortic valves. Low-risk endoscopic procedures can safely be performed on therapeutic anticoagulation or antiplatelet therapy and these medications should be continued regardless of the intervention. Examples of these procedures are diagnostic endoscopy with mucosal biopsy, ERCP without sphincterotomy, EUS, enteroscopy, and stent deployment. In all high-risk endoscopic procedures (polypectomy, sphincterotomy, therapeutic dilation, fine-needle aspiration, endoscopic hemostasis, tumor ablation, cyst gastrostomy, and treatment of varices), anticoagulation should be discontinued with or without bridging. However, aspirin and NSAIDs can safely be continued in all endoscopic procedures. For patients on antiplatelet therapy with agents other than aspirin, they should be held 7 to 10 days before the procedure unless the thromboembolic risks are high, in which case patients may need to be switched to aspirin or, in the case of dual antiplatelet therapy, aspirin continued and the other agent discontinued. If thromboembolic risk is low, anticoagulation can be stopped and simply restarted after the procedure. For anticoagulation with warfarin in patients with high thromboembolic risk, bridge therapy with low-molecular-weight heparin (LMWH) or unfractionated heparin should be considered. Use of LMWH and mechanical valves is controversial because of reported events of fatal thromboembolism on LMWH in these patients. In general, anticoagulation can be restarted within 24 hours after the procedure. (A–C, E).

**Reference:** ASGE Standards of Practice Committee, Anderson, M., Ben-Menachem, T., et al. (2009). Management of antithrombotic agents for endoscopic procedures. *Gastrointestinal Endoscopy*, 70(6), 1060–1070.

23. **D.** Aspiration of 0.3 mL/kg of gastric contents with a pH of less than 2.5 is all that is required for the development of aspiration pneumonitis (Mendelson's syndrome). However, pH is less important if particulate food matter is also aspirated. Though one would assume that removing the offending agent via routine bronchoscopy would help ameliorate the effect, the chemical damage to the lung parenchyma happens almost instantaneously and, in general, bronchoscopy is not indicated (A). The exception to this rule is in recent witnessed aspiration or if there are suspected foreign bodies in the airway. Because of the rapid release of inflammatory cytokines, such as TNF- $\alpha$

and IL-8, and the increased permeability caused by acid damage, aspiration pneumonitis can rapidly lead to hypoxic respiratory failure and ARDS. Blunting the inflammatory response with corticosteroids has not been shown to reduce complications or mortality associated with this condition (B). Because this condition is caused by chemical damage to the airways and not bacterial infection, management is largely supportive in nature and the routine use of antibiotics is not encouraged unless there is failure to improve within the first 48 hours (C). Though rates of pneumonia are generally lower in critically ill patients receiving postpyloric feeding, there has been no documented difference between nasogastric or PEG tube feedings in preventing aspiration or pneumonia (E). In contrast, aspiration pneumonia is characterized by the development of a lung consolidation. The aspiration event is typically unwitnessed. Early studies on aspiration pneumonia implicated anaerobic organisms as the causative agents. However, these patients were typically late in the course of disease with abscesses or empyema that allowed transcutaneous sampling. Follow-up studies in the 1990s failed to show significant anaerobic isolates obtained from bronchoalveolar lavage or brushings. Instead, they implicated *Streptococcus pneumoniae*, *Staphylococcus aureus*, *H. influenzae*, and *Enterobacter* species as the causative organisms in community-acquired aspiration pneumonia and gram-negative species, such as *Pseudomonas*, in hospital-acquired aspiration pneumonia.

**Reference:** Marik, P. (2001). Aspiration pneumonitis and aspiration pneumonia. *The New England Journal of Medicine*, 344(9), 665–671.

24. **A.** Refractory hypotension in the postoperative period in patients with conditions such as SLE that are commonly treated with steroids should raise concern for acute adrenal insufficiency. When the diagnosis is suspected, treatment should begin immediately before confirmatory tests become available (E). Initial treatment consists of: volume resuscitation, laboratory studies (electrolytes, glucose, adrenocorticotrophic hormone [ACTH], cortisol), and administration of either 4 mg of dexamethasone or 100 mg of hydrocortisone. Dexamethasone is preferred because it will not interfere with cosyntropin stimulation testing, which should be done the next morning to confirm the diagnosis. Glucocorticoids can then be tapered to regular maintenance doses. Routine administration of “stress-dose steroids” for patients on long-term corticosteroids has recently come into question because of relatively low incidence of perioperative adrenal crisis and significant side effect profile of excess exogenous steroids. It is now recommended that patients on long-term steroids should not be given high-dose perioperative corticosteroids. They should be continued on their regular maintenance dose with the consideration of additional steroids only if they develop refractory hypotension suggestive of adrenal insufficiency. While the cosyntropin stimulation test can be instrumental in detecting acute adrenal insufficiency, its usefulness as a preoperative measure for assessing risk of postoperative adrenal crisis is lacking sufficient data to support its routine use. While septic shock in the early postoperative period is possible, this vignette provides insufficient data to point to this diagnosis (C, D). Exploratory laparotomy is not an appropriate option for the above patient (B).

**References:** Brunicki, F., Andersen, D., & Schwartz, S. (2015). *Schwartz's principles of surgery*. New York: McGraw-Hill Education.

Marik, P. (2008). Requirement of perioperative stress doses of corticosteroids. *Archives of Surgery*, 143(12), 1222.

Kelly, K. N., & Domajnko, B. (2013). Perioperative stress-dose steroids. *Clinics in Colon and Rectal Surgery*, 26(3), 163–167.

25. **A.** The 2008 POISE trial was a randomized controlled trial to measure the effects of perioperative initiation of beta-blockers. The control group received a placebo while the study arm was started on metoprolol the day of surgery and received it for 30 days postoperatively. The study found that patients who received metoprolol had lower incidence of myocardial infarction, cardiac revascularization, and clinically significant atrial fibrillation. However, patients in the study arm also had increased mortality, stroke, hypotension, and bradycardia (E). This increase in mortality was not seen in the previously published DECREASE trials, which also showed a reduction in myocardial infarction. However, several of these studies were retracted because of falsified data and questionable data collection techniques. Without any other large randomized trials to counter the POISE trial, it has largely become the basis for current guidelines regarding perioperative use of beta-blockers. The 2014 ACC/AHA guidelines for perioperative beta-blocker therapy can be summarized as: (1) Beta-blockers should be continued if patients are on them chronically. (2)

Management of beta-blockers after surgery should be based on clinical judgment to avoid negative consequences such as hypotension or bradycardia (B). (3) Beta-blockers should not be started the day of surgery. (4) It is unclear what the risk of starting beta-blockers is in the 2 to 45 days before surgery (C). (5) It should be considered in high-risk individuals (D).

**References:** POISE Study Group. (2008). Effects of extended-release metoprolol succinate in patients undergoing non-cardiac surgery (POISE trial): a randomised controlled trial. *Lancet*, 371(9627), 1839–1847.

Wijeysundera, D., Duncan, D., Nkonde-Price, C., et al. (2014). Perioperative beta blockade in noncardiac surgery: a systematic review for the 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. *Journal of the American College of Cardiology*, 64(22), 2406–2425.

26. E. VTE prophylaxis is generally divided into two categories: pharmacologic and mechanical. Mechanical prophylaxis includes static compression devices (like graduated compression stockings) and intermittent pneumatic compression devices. While graduated compression stockings work primarily by preventing venous stasis in the legs, IPC combines that with its effects on the intrinsic fibrinolytic system. It was originally hypothesized that intermittent compression caused the release of agents like tPA from the vascular endothelium. However, when these levels are directly measured they seem to be relatively constant despite an increase in tPA activity. The currently proposed mechanism is related to measured decreases in plasminogen activator inhibitor-1 (PAI-1), which functions as a tPA inhibitor (A). Currently, there is no evidence that one IPC device is superior to another in preventing VTE (B). While there are relatively few contraindications to mechanical prophylaxis, traumatic injury to the extremity and evidence of ischemia secondary to peripheral vascular disease are both contraindications. Additionally, patients with confirmed DVT in the lower extremity should not be placed on IPC. Limitations of its usefulness are primarily related to interruption in treatment and improper application. Comparison between mechanical and pharmacologic VTE prophylaxis shows that in certain low-risk patients there is an equivalent reduction in incidence of DVT and PE, though combination therapy is superior to mechanical prophylaxis alone (C). It can be considered as sole therapy in low-risk patients and patients with contraindications to pharmacologic agents. In terms of pharmacologic prophylaxis, unfractionated heparin (UFH) and low-molecular-weight heparin (LMWH) are the two most commonly used agents. LMWH is generally regarded as more effective, especially in certain populations (e.g., trauma patients) (D).

**References:** Comerota, A., Chouhan, V., Harada, R. N., et al. (1997). The fibrinolytic effects of intermittent pneumatic compression. *Annals of Surgery*, 226(3), 306–314.

Ho, K., & Tan, J. (2013). Stratified meta-analysis of intermittent pneumatic compression of the lower limbs to prevent venous thromboembolism in hospitalized patients. *Circulation*, 128(9), 1003–1020.

Morris, R., & Woodcock, J. (2004). Evidence-based compression. *Annals of Surgery*, 239(2), 162–171.

# Transfusion and Disorders of Coagulation

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## Questions

1. Which of the following is true in regard to von Willebrand disease (vWD)?
  - A. It is the second most common congenital defect in hemostasis.
  - B. Type 1 vWD is transmitted in an autosomal recessive fashion.
  - C. DDAVP (desmopressin) is helpful in type 3 vWD.
  - D. Increased partial thromboplastin time (PTT) rules out vWD.
  - E. DDAVP is ineffective for type 2B vWD.
2. A 40-year-old obese female presents with a swollen left lower extremity, and ultrasound confirms a deep venous thrombosis (DVT). The patient is started on therapeutic heparin but despite progressively increasing the dose, the pharmacy is having difficulty achieving a therapeutic partial thromboplastin time (PTT) after 24 hours. Which of the following is the best option?
  - A. Convert from unfractionated heparin to low-molecular-weight heparin.
  - B. Administer fresh frozen plasma.
  - C. Start a direct thrombin inhibitor.
  - D. Place an inferior vena cava filter.
  - E. Continue to increase heparin dose as needed.
3. Which of the following is true regarding prothrombin complex concentrate (PCC)?
  - A. Three-factor and 4-factor PCC refer to varying concentrations of factor II.
  - B. It is thawed more rapidly than fresh frozen plasma (FFP).
  - C. PCC reverses warfarin to an international normalized ratio (INR) less than 1.5 within 30 minutes.
  - D. PCC lowers INR as profoundly as recombinant factor VIIa.
  - E. It reverses the anticoagulant effect of dabigatran.
4. A 31-year-old woman who is in her third trimester of pregnancy presents with fever, headaches, and myalgia. She is a former intravenous drug user. She denies pruritus, but her skin appears jaundiced. Blood pressure is normal. Her laboratory exam is remarkable for elevated aspartate aminotransferase (AST) and alanine transaminase (ALT), hyperbilirubinemia as well as thrombocytopenia, anemia, and severe hypoglycemia. Which of the following conditions is she most likely suffering from?
  - A. HELLP (hemolysis, elevated liver enzymes, low platelet count) syndrome
  - B. Acute fatty liver of pregnancy (AFLP)
  - C. Intrahepatic cholestasis of pregnancy (ICP)
  - D. Preeclampsia
  - E. Hepatitis E
5. A 90-year-old male presents to the emergency department (ED) after a fall from standing. He takes warfarin for atrial fibrillation and a daily 81 mg aspirin. Computed tomography (CT) of the head

- demonstrates a subdural hematoma. Which of the following is true in regard to the anticoagulation and antiplatelet therapy in this patient?
- A. INR should be slowly reversed with cryoprecipitate.
  - B. The warfarin should be allowed to wear off.
  - C. If repeat imaging shows no expansion of the hematoma 24 hours later, prophylactic anticoagulation can be started immediately.
  - D. Empiric platelet transfusion leads to a lower mortality.
  - E. Recombinant factor VIIa (rFVIIa) should be given.
6. Which of the following is correct with regard to unfractionated heparin (UFH) versus low-molecular-weight heparin (LMWH) in postoperative patients?
- A. LMWH is preferred in patients with renal disease.
  - B. LMWH has a higher risk of heparin-induced thrombocytopenia.
  - C. UFH is preferred in cancer patients.
  - D. LMWH levels can be monitored by anti-Xa assay.
  - E. For morbidly obese patients, LMWH dosing does not need adjusting.
7. Which of the following electrolyte abnormalities are the most likely to occur with massive blood transfusion?
- A. Hypocalcemia, hypokalemia, and metabolic acidosis
  - B. Hypercalcemia, hyperkalemia, and metabolic alkalosis
  - C. Hypocalcemia, hyperkalemia, and metabolic alkalosis
  - D. Hyponatremia, hyperkalemia, and metabolic alkalosis
  - E. Hyponatremia, hyperkalemia, and metabolic acidosis
8. A 75-year-old male with a history of atrial fibrillation presents to the ED with an acute onset of left lower extremity pain. Heparin is started. He is found to have a popliteal artery thrombosis. The clot is successfully cleared with thrombolytic therapy. He remains on a heparin drip with plans to convert to warfarin. However, on hospital day 5 his platelet count drops to 160,000 u/L (from an admission level of 370,000 u/L). Which of the following is true with regard to the drop in platelet count and the concern for heparin-induced thrombocytopenia (HIT)?
- A. Because the platelet count is above 100,000 u/L, heparin can be continued.
  - B. The risk of recurrent thrombosis at this point is low.
  - C. Because the platelet count dropped on day 5, the concern for HIT is low.
  - D. HIT is less common in men.
  - E. Warfarin should be started.
9. A 1-month-old infant with mild skeletal abnormalities arrives at the ED in respiratory distress. He has a cardiac arrest and passes away shortly after. On autopsy he is found to have extensive thrombosis in his coronary arteries. Which of the following is the most likely underlying condition?
- A. Factor V Leiden mutation
  - B. Prothrombin gene mutation
  - C. Antithrombin III deficiency
  - D. Homocystinuria
  - E. Protein deficiency
10. A 12-year-old female is brought to the ED in extremis after massive blood loss. Her mother refuses to allow the transfusion of blood products because they are Jehovah's Witnesses. Which of the following is the most appropriate next step in management?
- A. Proceed with packed red blood cell transfusion.
  - B. Obey the mother and carefully document her wishes.
  - C. Ask the mother to sign a blood-refusal consent and continue with fluid resuscitation.
  - D. Administer hetastarch as a substitute for blood replacement.
  - E. Administer albumin as a substitute for blood replacement.

11. The most common cause of transfusion-related death is:
- A. Infection
  - B. ABO incompatibility
  - C. Acute lung injury
  - D. Delayed transfusion reaction
  - E. Graft-versus-host reaction
12. A 35-year-old female develops postpartum hemorrhage and requires a transfusion of packed red blood cells and platelets. Twelve hours after transfusion, the patient abruptly develops rigors and chills. Her temperature increases to 39°C, her blood pressure drops from 110/70 to 70/40 mm Hg, and her heart rate increases from 80 to 120 bpm. Urine output drops, although the urine is clear. Despite attempts at resuscitation, the patient expires within 24 hours. The death is most likely due to:
- A. Gram-positive sepsis
  - B. ABO incompatibility
  - C. Acute lung injury
  - D. Anaphylaxis
  - E. Gram-negative sepsis
13. Persistent life-threatening bleeding in a patient with Hemophilia A with high titers of inhibitors (factor VIII alloantibodies) is best treated with:
- A. A higher dose of factor VIII
  - B. Fresh frozen plasma
  - C. Cryoprecipitate
  - D. Recombinant factor VIIa
  - E. DDAVP (desmopressin)
14. Levels of factors VIII and IX should be increased to what level before major surgery in a hemophiliac?
- A. 10%
  - B. 30%
  - C. 50%
  - D. 75%
  - E. 100%
15. After a transurethral prostate resection in a 50-year-old man, persistent bloody urine develops. The patient has no history of bleeding disorders, has had previous surgery without incident, and had a normal preoperative coagulation profile and platelet count. Which of the following is most likely to be of benefit?
- A. Fresh frozen plasma
  - B. Platelets
  - C. Cryoprecipitate
  - D. Amicar (aminocaproic acid)
  - E. DDAVP (desmopressin)
16. Which of the following does not affect the bleeding time?
- A. Aspirin
  - B. Von Willebrand disease
  - C. Hemophilia A
  - D. Severe thrombocytopenia
  - E. Qualitative platelet disorders
17. A deficiency of which of the following factors would increase INR but not prolong the PTT?
- A. II
  - B. V



- C. VII
  - D. IX
  - E. X
18. The most important preoperative assessment to determine the risk of abnormal intraoperative bleeding is:
- A. Bleeding time
  - B. Activated partial thromboplastin time (aPTT)
  - C. International normalized ratio (INR)
  - D. History and physical examination
  - E. Platelet count
19. Glanzmann thrombasthenia is characterized by:
- A. Normal bleeding time
  - B. Treatment response to DDAVP (desmopressin) infusion
  - C. Autosomal dominant inheritance
  - D. Defect in platelet aggregation
  - E. Prolonged INR
20. The most useful laboratory test to assess both risk of bleeding and response to therapy in patients with uremia is:
- A. Bleeding time
  - B. Platelet count
  - C. INR
  - D. aPTT
  - E. Thrombin time
21. Which of the following is most likely to be useful in the treatment of bleeding in the uremic patient?
- A. Desmopressin
  - B. Cryoprecipitate
  - C. Fresh frozen plasma
  - D. Recombinant human erythropoietin
  - E. Estrogens
22. In a patient with abnormal bleeding, which of the following findings would support primary fibrinolysis as the more likely cause than disseminated intravascular coagulation (DIC)?
- A. Normal platelet count
  - B. Prolonged thrombin time
  - C. Prolonged aPTT
  - D. Low fibrinogen level
  - E. Increase in fibrin degradation products
23. A 55-year-old patient undergoes surgery, during which blood transfusions were given. One week later, skin lesions develop that appear to be purpura. The platelet count decreases from 250,000 cells/ $\mu$ L to 10,000 cells/ $\mu$ L, and an upper gastrointestinal bleed develops. The patient has not been receiving any medication that could affect platelets. Which of the following is true about this condition?
- A. It is more common in middle-aged men.
  - B. Severe bleeding is best managed by platelet transfusions.
  - C. It can occur without prior antigenic exposure.
  - D. It is an antibody-mediated reaction.
  - E. Platelet counts are typically higher than with heparin-induced thrombocytopenia.
24. Which of the following is true in regard to clopidogrel (Plavix)?
- A. It functionally mimics the pathophysiology of Bernard-Soulier disease.

- B. It has been linked to fatal episodes of pulmonary hypertension.
  - C. It is recommended that clopidogrel be stopped 3 days before a major operation.
  - D. It inhibits platelet aggregation within 2 hours of oral administration.
  - E. It can inhibit the release of von Willebrand factor.
25. A 35-year-old man has been in the intensive care unit with severe pancreatitis, ventilator dependence, and pneumonia for 2 weeks. He is receiving nutrition parenterally. The INR is 2.0. The aPTT is normal. The total bilirubin level is normal. The platelet count is normal. Which of the following is the most likely etiology?
- A. Factor VIII deficiency
  - B. DIC
  - C. Vitamin K deficiency
  - D. Primary fibrinolysis
  - E. Chronic liver disease
26. A 60-year-old man with diabetes presents with right upper quadrant pain and leukocytosis. The patient has an elevated INR of 2.5 and a prolonged PTT of 60 seconds, a low fibrinogen level, and a platelet count of 70,000 cells/ $\mu$ L. An ultrasound scan reveals gas in the wall of the gallbladder. The most important part in management of this patient would be:
- A. Administration of fresh frozen plasma
  - B. Administration of cryoprecipitate
  - C. Checking the D-dimer assay
  - D. Emergent cholecystectomy
  - E. Administration of platelets
27. Cryoprecipitate contains a low concentration of which of following?
- A. Fibrinogen
  - B. Factor VIII
  - C. Von Willebrand factor
  - D. Fibronectin
  - E. Factor XI
28. A 76-year-old male is undergoing a laparoscopic colectomy for sigmoid colon cancer. Which of the following is the best prophylaxis for venous thromboembolic events (VTEs)?
- A. Leg compression device
  - B. Unfractionated heparin (UFH) until fully ambulatory
  - C. Leg compression device intraoperatively, UFH until fully ambulatory
  - D. Leg compression device intraoperatively, LMWH until fully ambulatory
  - E. Leg compression device intraoperatively, LMWH for 4 weeks after surgery
29. A 50-year-old male undergoes a resection of a large retroperitoneal leiomyosarcoma. There is an estimated blood loss of 750 cc. The next day, the patient is found to be anemic and is given 2 units of blood. Halfway through the first unit, the patient develops chills and his temperature increases from 37° to 39°C. Which of the following is true in regard to this patient's condition?
- A. The transfusion does not need to be stopped.
  - B. This occurs more commonly when given packed red blood cells versus platelets.
  - C. Filtration is more effective than leukocyte washing in preventing this condition.
  - D. Aspirin is more effective than acetaminophen in treating this condition.
  - E. Pretransfusion administration of acetaminophen and diphenhydramine is the most effective prevention.

## Answers

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1. E. The most frequent congenital defect in hemostasis is vWD (A). Laboratory tests will

demonstrate increased bleeding time with a normal prothrombin time (PT). Patients may have a normal or increased PTT because von Willebrand factor (vWF) is considered a stabilizing factor for factor VIII (D). There are three types of vWD: Type I is an autosomal dominant disease characterized by a low level of vWF and considered the most common form of vWD (B). Type I is treated with DDAVP because this increases circulating vWF released from endothelial cells. Type 2 vWD is also inherited in an autosomal dominant fashion and is characterized by a qualitative defect in which there is an appropriate amount of vWF, but it does not function properly. Type 2 has multiple variants, some that can be treated with DDAVP or cryoprecipitate. Type 2B, in particular, when treated with DDAVP can induce thrombocytopenia and form platelet complexes leading to a prothrombotic state. DDAVP is contraindicated in type 2B but may be useful in other type 2 variants. Finally, type 3 is the most severe form because there is no vWF produced by endothelial cells. It is transmitted in an autosomal recessive fashion. For type 3, the recommended treatment is recombinant vWF and factor VIII because these patients do not make any vWF and therefore DDAVP will have no effect (C).

**References:** Holmberg, L., Nilsson, I., Borge, L., et al. (1983). Platelet aggregation induced by 1-des-amino-8-D-arginine vasopressin (DDAVP) in type II B von Willebrand disease. *The New England Journal of Medicine*, 309(14), 816–821.

Tosetto, A., & Castaman, G. (2015). How I treat type 2 variant forms of von Willebrand disease. *Blood*, 125(6), 907–914.

2. **B.** Heparin resistance is defined as the need for more than 35,000 units in 24 hours to prolong the PTT into the therapeutic range or as an activated clotting time (ACT) less than 400 seconds despite excessive demand for heparin (>400–600 IU/kg). Heparin resistance is most commonly the result of antithrombin-III (ATIII) deficiency. Heparin binds to ATIII causing a conformational change that results in its activation. Activated ATIII then inactivates thrombin and other proteases involved in blood clotting, most notably factor Xa. ATIII deficiency can be congenital or acquired. Hereditary ATIII deficiency is rare (much less common than Factor V Leiden deficiency) and can lead to venous thrombosis. Causes of acquired ATIII deficiency include pregnancy, liver disease, disseminated intravascular coagulation (DIC), nephrotic syndrome, major surgery, acute thrombosis, and treatment with heparin. For this latter reason, measurement of ATIII levels while on heparin is an inaccurate method of identifying heparin resistance. Treatment of heparin resistance consists of either administering FFP or ATIII concentrates. FFP has the highest concentration of ATIII, and therefore patients should be initially treated with FFP to replete ATIII in plasma, followed by readministration of heparin. A direct thrombin inhibitor (argatroban) is a potential alternative; however, it has the disadvantage of having no way of being reversed in the case of overdosage and bleeding. A disadvantage of FFP in the cardiac surgery setting is that large volumes may be required and it exposes the patient to the risks of transfusions, including transfusion-related lung injury (TRALI). Thus in the setting of cardiac bypass, ATIII concentrate is another alternative (though it is very costly). Low-molecular-weight heparin has no effect on ATIII deficiency and should not be used in this event (A). An inferior vena cava (IVC) filter would be indicated if the patient began to bleed while on heparin but not for heparin resistance. In fact, a filter, though protective against PE, increases the risk for DVT, due to the stasis it may create (D). Most patients achieve therapeutic PTT within 6 to 18 hours of starting heparin, so simply increasing heparin dose is not appropriate (E).

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Kearon, C., Aki, E., Comerota, A., et al. (2012). Antithrombotic therapy for VTE disease: antithrombotic therapy and prevention of thrombosis, (9th ed.). American College of Chest Physicians evidence-based clinical practice guidelines. *Chest*, 141(Suppl. 2), e419s–e4494s.

3. **C.** PCC is an inactivated concentrate of proteins C and S, and factors II, IX, and X, with variable amounts of factor VII. PCC with normal amounts of factor VII is known as 4-factor PCC, while PCC with low levels of factor VII is 3-factor PCC (A). Since 3-factor PCC has low levels of factor VII, the addition of fresh frozen plasma is sometimes necessary for full reversal of warfarin and thus, 4-factor PCC is superior. When a non-bleeding patient on warfarin needs INR reversal, vitamin K is given, either orally (slower acting) or intramuscularly. If a patient is bleeding with an elevated INR, vitamin K and an exogenous clotting factor formulation are given. The options are FFP, PCC, or recombinant factor VII (less often used). PPC has several advantages over FFP; it does not need to

be thawed (it is lyophilized, [i.e., freeze dried]), it has a more rapid correction of INR, and it can be infused faster and with less volume (this also makes it ideal for patients with congestive heart failure or chronic kidney disease) (B). Recombinant factor VIIa will lower INR faster than PCC (D). However, the concerns regarding recombinant factor VIIa include the potential for inducing thrombosis (stroke, deep venous thrombosis) as well as the high cost. PPC does not reverse the anticoagulant effect of dabigatran; this can be accomplished with idarucizumab (E).

4. **B.** AFLP is an uncommon but potentially fatal complication that occurs in the third trimester of pregnancy or during the early postpartum period. It typically presents with a viral prodrome characterized by fever, lethargy, malaise, and nausea and vomiting. It is thought that AFLP may be the result of mitochondrial dysfunction resulting in microvesicular fatty infiltration of hepatocytes without significant inflammation or necrosis. The mortality rate previously was very high; however, with prompt diagnosis and treatment, the maternal and perinatal mortality have decreased to 18% and 23%, respectively. Prompt delivery and intensive supportive care are the cornerstones in management of AFLP. Laboratory abnormalities in AFLP include elevations of AST and ALT (usually less than 1000 IU per L), prolongation of PT and PTT, decreased fibrinogen, renal failure, profound hypoglycemia, and hyperbilirubinemia. Laboratory studies of AFLP are similar to HELLP, but the key finding to help differentiate the two is hypoglycemia, which does not occur commonly in HELLP (A). In addition, patients with HELLP typically have preeclampsia, evidence of hemolysis, and thrombocytopenia. Preeclampsia presents with hypertension, proteinuria, and rapid weight gain and can progress to seizures (eclampsia) (D). Patients with ICP report an intense pruritus most commonly in the hands and soles of the feet that is unrelieved with antihistamines (C). Hepatitis E is caused by a single-stranded RNA virus. In men and nonpregnant women, it tends to be mild. However, it can lead to severe fulminant hepatic failure in pregnant patients in the third trimester, with a mortality rate up to 25% (particularly in developing countries) (E).

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Rahman, T. M., & Wendon, J. (2002). Severe hepatic dysfunction in pregnancy. *QJM*, 95(6), 343–357.

Vigil-De Gracia, P. (2001). Acute fatty liver and HELLP syndrome: two distinct pregnancy disorders. *The International Journal of Gynecology and Obstetrics*, 73(3), 215–220.

5. **C.** Twelve percent to 14% of patients with an acute intracranial hemorrhage (ICH) are undergoing treatment with oral anticoagulants. The current recommendation is to reverse the warfarin with prothrombin complex concentrate (PCC). This is the quickest way to normalize INR. However the effect is not permanent, so it should be given in conjunction with vitamin K (which takes about 12 hours to work, but is permanent). Another alternative is to give FFP alone or in combination with vitamin K (A, B). Recombinant factor VIIa (rFVIIa) was originally intended to treat patients with hemophilia but has been used in the setting of acute ICH. Although it can rapidly normalize the INR, it does not replenish all vitamin K factors and therefore may not restore thrombin generation. The American Society of Hematology currently recommends against the routine use of rFVIIa for warfarin reversal because of its known increased risk of serious venous thromboembolic events (E). Since the patient is on aspirin, empiric use of platelets is appealing. However, studies on the effect of platelet transfusion on ICH, hematoma growth, and patient outcomes have shown conflicting results, and there is no clear benefit in terms of mortality. Currently, it is not the standard of practice to regularly transfuse patients with platelets if they are taking an antiplatelet medication (D). Patients with acute ICH have a high risk of a thromboembolic event. The current guidelines for venous thromboembolism prophylaxis in ICH patients is published by the Trauma Quality Improvement Project and are based off of a series of studies that have shown reduced rates of venous thromboembolism when chemical prophylaxis is started within 72 hours of the initial injury. The guidelines base their recommendations around a modified bleeding risk assessment for intracranial hemorrhages: high risk (ICP monitor placement, craniotomy, and evidence of bleed progression at 72 hours), medium risk (subdural/epidural hematoma > 8 mm, contusion or intraventricular hematoma > 2 cm, multiple contusions per lobe, subarachnoid hemorrhage with abnormal CT angiogram, and evidence of progress at 24 hours) and the low risk group (no characteristics of high or medium risk). Based on this scale, anticoagulation is recommended for stable CT scans at 24 hours from admission in the low risk group and 72 hours from admission in the medium risk group. The high-risk group is perhaps the most difficult and there is not enough evidence to recommend a specific practice guideline. Instead it is left up to the physician to determine between placement of an IVC filter, DVT screening with ultrasound and prophylactic

anticoagulation despite the risk.

**References:** Boeer, A., Voth, E., Henze, T., et al. Early heparin therapy in patients with spontaneous intracerebral haemorrhage. *Journal of Neurology, Neurosurgery, and Psychiatry*, 54(5), 466–467.

Jamjoom, A., et al. (2013). Safety and efficacy of early pharmacological thromboprophylaxis in traumatic brain injury: systematic review and meta-analysis. *Journal of Neurotrauma*, 30(7), 503–511.

Morgenstern, L., Hemphill, J. C., Anderson, C., et al. (2010). Guidelines for the management of spontaneous intracerebral hemorrhage: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*, 41(9), 2108–2129.

6. **D.** Both UFH and LMWH have established roles in preventing and treating venous thromboembolism (VTE) in postoperative patients. Multiple studies have been performed, with the majority demonstrating no statistically significant difference in mortality when comparing LMWH and UFH (C). Some studies have suggested that there is a decreased incidence of bleeding complications with the use of LMWH when compared with UFH (B). Because LMWH undergoes renal excretion, it is recommended that patients with renal disease be treated with UFH for VTE prophylaxis (A). UFH acts by binding to antithrombin III, causing a conformational change and increasing its activity. It targets the intrinsic pathway of the coagulation cascade; therefore PTT should be monitored (not PT). LMWH more specifically targets factor Xa; thus it is not monitored by PTT, but it can be monitored with a factor-Xa assay. Obese patients have a larger volume of distribution of lipophilic drugs such as LMWH and as such will require dose adjusting to reach adequate levels for thromboprophylaxis (E).

**References:** Antman, E. M., Morrow, D. A., McCabe C. H., et al. (2006). Enoxaparin versus unfractionated heparin with fibrinolysis for ST-elevation myocardial infarction. *The New England Journal of Medicine*, 354(14), 1477–1488.

Freeman, A. L., Pendleton, R. C., Rondina, M. T., et al. (2010). Prevention of venous thromboembolism in obesity. *Expert Review of Cardiovascular Therapy*, 8(12), 1711–1721.

Hirsh, J., Warkentin, T. E., Shaughnessy, S. G., et al. (2001). Heparin and low-molecular-weight heparin: mechanisms of action, pharmacokinetics, dosing, monitoring, efficacy, and safety. *Chest*, 119(Suppl), 64S–94S.

Hirsh, J., & Raschke, R. (2004). Heparin and low-molecular-weight heparin: the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest*, 126(Suppl. 3), 188S–203S.

7. **C.** The correct answer is hypocalcemia, hyperkalemia, and metabolic alkalosis (A, B, D, E). Severe hypocalcemia with massive blood transfusion is uncommon and does not typically manifest unless the patient is receiving more than 1 unit of packed red blood cells (PRBC) every 5 minutes. The hypocalcemia is the result of citrate toxicity because the citrate in the transfused blood binds to circulating calcium in the patient. Because citrate is metabolized in the liver, hypocalcemia can be more severe in patients with hepatic dysfunction. Additionally, the citrate is metabolized to bicarbonate leading to a metabolic alkalosis. Potassium concentration of stored (PRBC) is higher than human plasma potassium level. This is thought to occur as a result of red blood cell lysis during storage, releasing potassium in the supernatant. The concentration of potassium in PRBC increases linearly and is approximately equal to the number of days of PRBC storage.

**Reference:** Vraets, A., Lin, Y., & Callum, J. (2011). Transfusion-associated hyperkalemia. *Transfusion Medicine Reviews*, 25(3), 184–196.

8. **D.** HIT occurs in approximately 1% to 1.2% of patients receiving heparin. A scoring system has been devised to assess risk of HIT. Variables that should heighten suspicion of HIT include a platelet count drop greater than 50%, occurrence between days 5 to 10 (both are present in this patient), nadir of platelet count greater than 20,000 (nadir below 10,000 is less likely HIT), no other reason for platelet count drop, and new skin necrosis or VTE (C). Thus, more important than the absolute nadir is the percentage drop (A). HIT is caused by antibodies that attack the heparin-platelet factor 4 (PF4) complex. Heparin-PF4 antibodies (sometimes called “HIT antibodies”) in the resultant multimolecular immune complex activate platelets via their FcγIIa receptors, causing the release of prothrombotic platelet-derived microparticles, platelet consumption, and thrombocytopenia. The microparticles in turn promote excessive thrombin generation, frequently resulting in thrombosis. Patients receiving any type of heparin at any dose and by any route of administration are at risk of developing HIT antibodies. It does occur less commonly in men and occurs more frequently in the elderly. However, not all of those with HIT antibodies will necessarily

develop the clinical syndrome. If this is suspected, heparin should be discontinued, and the patient should be started on a direct thrombin inhibitor (E). If anticoagulation is not initiated, the chance of another thromboembolic event is approximately 5% to 10% per day (B).

**References:** Ahmed, I., Majeed, A., & Powell, R. (2007). Heparin induced thrombocytopenia: diagnosis and management update. *Postgraduate Medical Journal*, 83(983), 575–582.

Jang, I. K., & Hursting, M. J. (2005). When heparins promote thrombosis: review of heparin-induced thrombocytopenia. *Circulation*, 111(20), 2671–2683.

Warkentin, T. E., Hayward, C. P., Boshkov, L. K., et al. (1994). Sera from patients with heparin-induced thrombocytopenia generate platelet-derived microparticles with procoagulant activity: an explanation for the thrombotic complications of heparin-induced thrombocytopenia. *Blood*, 84(11), 3691–3699.

Wheeler, H. B. (1985). Diagnosis of deep vein thrombosis. Review of clinical evaluation and impedance plethysmography. *American Journal of Surgery*, 150(4A), 7–13.

9. **D.** Although all the answer choices can increase the risk of venous thromboembolism, homocystinuria is the most common inherited condition predisposing patients to *arterial* thrombosis and affects 5% to 10% of the population. It is an autosomal recessive disease. Homocystinuria is most commonly caused by a deficiency of cystathionine beta-synthase resulting in an elevated level of homocysteine in plasma and urine. The toxic effect of an elevated level of homocysteine in the brain results in mental retardation as well as seizures. Skeletal abnormalities may occur secondary to interference of collagen cross-linking. Patients are at increased risk of thrombosis due to the disruption of vascular endothelium by homocysteine leading to platelet activation and aggregation. Patients identified early to have this condition will benefit with administration of pyridoxine (vitamin B<sub>6</sub>) to induce cystathionine beta-synthase activity. Factor V Leiden mutation is the most common inherited condition increasing the risk of venous thromboembolism followed by prothrombin gene mutation (A, B). Patients that do not have a response to the administration of unfractionated heparin may have antithrombin III deficiency (C). Protein C deficiency is a rare cause of venous thromboembolism (E).

**References:** D'Angelo, A., & Selhub, J. (1997). Homocysteine and thrombotic disease. *Blood*, 90(1), 1–11.

Greico, A. J. (1977). Homocystinuria: pathogenetic mechanisms. *The American Journal of the Medical Sciences*, 273(2), 120–132.

Rosendaal, F. R. (1997). Risk factors for venous thrombosis: prevalence, risk, and interaction. *Semin Hematol*, 34(3), 171–187.

10. **A.** Adult Jehovah's Witnesses have the right to refuse lifesaving intervention, and this includes the administration of blood products. The Federal Child Abuse Prevention and Treatment Act protects minors under the age of 18 who may be children of Jehovah's Witnesses from being refused blood products as part of their parent's religious beliefs. The law defines child abuse or neglect as any act resulting in imminent risk of serious harm, death, serious physical or emotional harm, sexual abuse, or exploitation. This child should be transfused with packed red blood cells immediately (B, C). Hetastarch should be avoided because it has been shown to be associated with worsened mortality in critically ill patients (D). Although albumin is derived from human blood products, some Jehovah's Witnesses may agree to receiving this as a blood substitute. However, this would be an inferior substitute to blood for a patient in extremis (E).

**References:** Child Abuse Prevention and Treatment Act (CAPTA) (2003 version), 42 U.S.C. 5101, et seq. Retrieved from <http://www.acf.hhs.gov/sites/default/files/cb/capta2003.pdf>.

Navickis, R. J., Haynes, G. R., & Wilkes, M. M. (2012). Effect of hydroxyethyl starch on bleeding after cardiopulmonary bypass: a meta-analysis of randomized trials. *The Journal of Thoracic and Cardiovascular Surgery*, 144(1), 223–230.

11. **C.** The leading causes of allogeneic blood transfusion (ABT)–related mortality in the United States (in the order of reported number of deaths) include transfusion-related acute lung injury (TRALI), ABO and non-ABO hemolytic transfusion reactions, and transfusion-associated sepsis (A, B, D). Graft-versus-host reaction is not a common cause of ABT (E). Additionally, it has been demonstrated that non-leukocyte-reduced blood transfusions have been associated with increased mortality when compared with leukocyte-reduced blood transfusions.

**Reference:** Vamvakas, E., & Blajchman, M. (2009). Transfusion-related mortality: the ongoing risks



of allogeneic blood transfusion and the available strategies for their prevention. *Blood*, 113(15), 3406–3417.

12. **E.** Bacterial contamination of blood is the most frequent cause of death from transfusion-transmitted infectious disease and is the third most common cause of death overall in a large series (after acute lung injury and ABO incompatibility) (B, C). A key feature of ABO incompatibility (hemolytic reaction) is the development of red urine (hemoglobinuria). Patients also often complain of back pain and a sense of doom. Acute lung injury manifests with rapid onset of dyspnea and tachypnea around 6 hours after transfusion. Anaphylactic reaction occurs rarely (D). Bacterial contamination now accounts for 1 in every 38,500 cases of blood transfusion. This increase had coincided with a dramatic decrease in viral infections. The highest risk of bacterial infection is from pooled platelet transfusions because many microorganisms can live and propagate under the storage conditions of platelets (20–24°C). Gram-negative sepsis is the most lethal (A), and *Yersinia* is one of the most common organisms. Gram-negative sepsis can become clinically apparent within 9-24 hours after blood transfusion. Cytomegalovirus is the most common infectious agent transmitted, but because it is so ubiquitous, it is generally not a threat to most patients. The exception to that rule is the transplant recipient.

**References:** Benjamin, & Richard, J. (2016). Transfusion-related sepsis: a silent epidemic. *Blood*, 127(4), 380–381.

Bihl, F., Castelli, D., Marincola, F., et al. (2007). Transfusion-transmitted infections. *Journal of Translational Medicine*, 5, 25.

Kuehnert, M., Roth, V., Haley, N., et al. (2001). Transfusion-transmitted bacterial infection in the United States, 1998 through 2000. *Transfusion*, 41(12), 1493–1499.

13. **D.** Hemophilia A is a sex-linked recessive genetic condition and considered the most common coagulation disorder, accounting for 80% of all inherited coagulation disorders. With time, as many as 10% to 15% of patients with factor VIII-deficient hemophilia A develop inhibitors (alloantibodies) against factor VIII. This is usually from previous factor VIII transfusions. In situations in which life-threatening hemorrhage develops, recombinant factor VIIa is the best option. Another option is porcine factor VIII, but there is approximately a 25% cross-reactivity with inhibitors. Factor VIIa complexes with tissue factor at the site of injury, resulting in an activation of factor X, which then results in clot formation. Factor VIIa bypasses the requirement for factor VIII and IX and thus has been shown to be effective in prevention and treatment of joint hemorrhage, the treatment of life-threatening bleeding, and the prevention of surgical bleeding. Restimulation of antibodies to factors VIII and IX should theoretically be less problematic than with the use of plasma-derived products. The primary concerns with recombinant factor VIIa are the potential for inducing thrombosis (stroke, deep venous thrombosis) and the high cost. A higher dose of factor VIII would not defeat production of patient antibodies (A). Both fresh frozen plasma and cryoprecipitate contain factor VII but would be diluted with other factors including factor VIII (B, C). DDAVP would not help a patient with a coagulation defect (E). Other options that have been used but are only a temporary fix in patients with significant bleeding are plasmapheresis and immune absorption.

**References:** Kenet, G., Lubetsky, A., Luboshitz, J., et al. (2003). New approach to treatment of bleeding episodes in young hemophilia patients: a single bolus megadose of recombinant activated factor VII (NovoSeven). *Journal of Thrombosis and Haemostasis*, 1, 450–455.

DiMichele, D. (2008). Inhibitors in hemophilia: a primer. *Treatment of Hemophilia*, (7), 1–4.

14. **E.** For patients with hemophilia A and B, the levels of factors VIII and IX should be increased to 30% of normal to prevent bleeding after dental extraction (B). Levels should be increased to 50% of normal if major joint or intramuscular bleeding is already present and to 100% in cases of life-threatening bleeding or before a major operation (C, D).
15. **D.** Patients undergoing a transurethral prostate resection are at increased risk of bleeding from primary fibrinolysis. Transurethral prostate resection leads to the release of urokinase and tissue plasminogen activator from the prostate. The fibrinolytic agent urokinase was originally made from urine. The urine bathes the resected area, potentially leading to bleeding. However, several studies have demonstrated efficacy of antifibrinolytic agents such as Amicar (aminocaproic acid) and Cyklokapron (tranexamic acid) in the treatment of bleeding during transurethral prostate resection. FFP, platelets, cryoprecipitate, and DDAVP would be less effective in the setting of primary fibrinolysis (A–C, E).



**References:** Nielsen, J., Gram, J., Holm-Nielsen, A., et al. (1997). Postoperative blood loss after transurethral prostatectomy is dependent on in situ fibrinolysis. *British Journal of Urology*, 80(6), 889–893.

Rannikko, A., Pétaš, A., & Taari, K. (2004). Tranexamic acid in control of primary hemorrhage during transurethral prostatectomy. *Urology*, 64(5), 955–958.

16. **C.** Bleeding time tests platelet adhesion and aggregation and will be normal in derangement of the coagulation pathways. Hemophilia A is associated with a factor VIII deficiency, which manifests as an abnormality in the coagulation cascade and presents with a prolonged PTT. Drugs that inhibit platelet function, such as aspirin (which works by inhibiting cyclooxygenase), will increase bleeding time (A). Von Willebrand disease will result in prolonged bleeding time because of the qualitative or quantitative deficiency in Willebrand factor, which is required for platelet adhesion to other platelets via the IIb/IIIa receptor (B). Severe thrombocytopenia (quantitative) and platelet dysfunction (qualitative) both prolong bleeding time (D, E). Fibrinogen deficiency also prolongs bleeding time because fibrinogen is required for platelet aggregation.
17. **C.** The INR detects abnormalities in the extrinsic and common pathways. The extrinsic pathway is triggered by exposure of the injured vessel to tissue factor and starts with factor VII. It then merges with the intrinsic pathway at factor X (E) and is followed by activation of factors V and II and fibrinogen (factor I) (A, B). Thus both the prothrombin time and the PTT will be prolonged in factors I, II, V, and X because they are all part of the common pathway between the intrinsic and extrinsic pathways. Factor IX is part of the intrinsic pathway and a deficiency would prolong PTT only (D).
18. **D.** The most important element in detecting an increased risk of abnormal bleeding before surgery is a detailed history and physical examination. A systematic review in 2008 demonstrated the poor value of using coagulation tests when it came to identifying the risk of bleeding during an operation (A–C, E). Other studies have likewise shown that routine use of laboratory testing is neither sensitive nor specific for determining increased risk of bleeding. One needs to inquire about a history of prolonged bleeding after minor trauma, tooth extraction, menstruation, and in association with major and minor surgery. In addition, one must make inquiries into medications and over-the-counter supplements that might affect hemostasis. If a careful history is negative and the planned surgical procedure is minor, then further testing is not necessary. A potential pitfall in relying solely on the history is that the history obtained might not be sufficiently thorough or the patients might not recall or recognize that they had previous abnormal bleeding after an operation. If a major operation is planned that is not a high-bleeding risk, then a platelet count, a blood smear, and an aPTT are recommended. If the history suggests abnormal bleeding or the operation is either a high bleeding–risk operation or one in which even minor bleeding may have dire consequences (neurosurgery), then a bleeding time and INR should be added and a fibrin clot to detect abnormal fibrinolysis. If there is high suspicion for a history of abnormal bleeding, a hematology consult should also be obtained.

**References:** Chee, Y., & Greaves, M. (2003). Role of coagulation testing in predicting bleeding risk. *The Hematology Journal*, 4(6), 373–378.

Chee, Y. L., & Greaves, M. (2008). Guidelines on the assessment of bleeding risk prior to surgery or invasive procedures. *British Journal of Haematology*, 140(5), 496–504.

Klopfenstein, C. (1996). Preoperative clinical assessment of hemostatic function in patients scheduled for a cardiac operation. *The Annals of Thoracic Surgery*, 62(6), 1918–1920.

Suchman, A., & Mushlin, A. (1986). How well does the activated partial thromboplastin time predict postoperative hemorrhage? *JAMA*, 256(6), 750–753.

19. **D.** Glanzmann thrombasthenia is an autosomal recessive disorder that results in absence of functional glycoprotein IIb/IIIa (C). Glycoprotein IIb/IIIa is a receptor for fibrinogen and von Willebrand factor and causes platelet adhesion and aggregation. Therefore, bleeding time will be prolonged, but aPTT and INR will be normal (A–E). These patients will not respond to DDAVP because there is no quantitative defect in the endothelial release of von Willebrand factor or factor VIII (Von Willebrand disease) (B). The bleeding tendency for patients with Glanzmann's is variable. Treatment is with platelets. Repeated use of platelet transfusions can induce antiglycoprotein IIb/IIIa alloimmunization, rendering the treatment ineffective. In this circumstance, recombinant factor VIIa may be useful.

**References:** d'Oiron, R., Ménart, C., Trzeciak, M., et al. (2000). Use of recombinant factor VIIa in 3

patients with inherited type I Glanzmann's thrombasthenia undergoing invasive procedures. *Thrombosis and Haemostasis*, 83(5), 644–647.

Nurden, A. T. (2006). Glanzmann thrombasthenia. *Orphanet Journal of Rare Diseases*, 1, 10.

20. **A.** In uremic patients, the bleeding time is the most useful clinical laboratory test to assess both bleeding risk and response to therapy. The etiology of abnormal bleeding in uremic patients is multifactorial, but the most important is impairment of platelet function due to a functional defect in von Willebrand factor, which leads to impaired platelet aggregation. INR and PTT are less important because the pathophysiology is platelet dysfunction (C, D). Uremic patients may also have a decreased platelet count, but the absolute count does not accurately reflect their risk of bleeding (B). The most common bleeding manifestation in uremic patients is excessive bleeding from puncture sites, followed by nasal, gastrointestinal, and genitourinary bleeding. A key concept is that platelet defects cause superficial bleeding and defective initial hemostasis while defects to the coagulation cascade cause deep space bleeding and platelet plug instability. Thrombin time will be prolonged with a low fibrinogen level, which can be congenital or acquired (E). Acquired causes of low fibrinogen include DIC, liver disease, elevated fibrin degradation products, and primary fibrinolysis, and it may develop during institution of thrombolytic therapy. Warfarin does not prolong thrombin time, whereas heparin does.

**References:** Hedges, S., Dehoney, S., Hooper, J., et al. (2007). Evidence-based treatment recommendations for uremic bleeding. *Nat Clin Pract Nephrol*, 3(3), 138–153.

Weigert, A., & Schafer, A. (1998). Uremic bleeding: pathogenesis and therapy. *The American Journal of the Medical Sciences*, 316(2), 94–104.

21. **A.** DDAVP (desmopressin) seems to enhance the release of von Willebrand factor by endothelial cells. A single dose of 0.3 to 0.4 mcg/kg is given intravenously or subcutaneously. It has a rapid onset and relatively short duration (4-6 hours). Dialysis is also effective in the treatment of uremic bleeding by removing toxins that cause platelet dysfunction. Cryoprecipitate has high concentrations of von Willebrand factor as well as factor VIII and fibrinogen and may also be effective; however, it should not be first-line therapy (B). Recombinant human erythropoietin (Epogen [epoetin alfa]) has been shown to help uremic bleeding in several studies as well (D). In addition to stimulating erythropoiesis, Epogen (epoetin alfa) enhances platelet aggregation. The increased red cell mass also seems to displace platelets from the center of the blood vessel and places them closer to the endothelium. Estrogens have been shown to help with bleeding in men and women. The exact mechanism is unknown, but it is theorized that they decrease arginine levels, which decreases nitric oxide. This may lead to increases in thromboxane A<sub>2</sub> and adenosine diphosphate (E). FFP does not have high concentrations of von Willebrand factor and thus is not effective for uremic bleeding (C).

**Reference:** Hedges, S., Dehoney, S., Hooper, J., et al. (2007). Evidence-based treatment recommendations for uremic bleeding. *Nature Clinical Practice. Nephrology*, 3(3), 138–153.

22. **A.** Primary fibrinolysis is rare and can be very difficult to distinguish from DIC. This is because DIC itself leads to a secondary fibrinolysis. Thus, the coagulation profile can be very similar. Primary fibrinolysis can be triggered by several conditions, including malignancy, shock, sepsis, cirrhosis, and the use of cardiopulmonary bypass. It seems to be induced by the release into the circulation of excess plasminogen activator. Tumor cells contain plasminogen activators. Plasminogen is then converted to plasmin, which degrades fibrin, fibrinogen, and factors V and VIII, causing the coagulopathy. The primary treatment for both DIC and primary fibrinolysis is to correct the underlying trigger. However, with primary fibrinolysis, inhibitors of fibrinolysis can be helpful, such as aminocaproic acid or tranexamic acid, which acts by inhibiting plasminogen activation. Both DIC and primary fibrinolysis result in decreased fibrinogen levels and a prolonged thrombin time (B, D). Both also result in the consumption of coagulation factors, so both the INR and PTT can be prolonged (C). Therefore, fibrin degradation products will be increased in both (E). In pure primary fibrinolysis, the platelet count is normal (as opposed to decreased in DIC) (A). Another distinguishing feature is a normal D-dimer in primary fibrinolysis (as opposed to an increase in DIC). Amicar (aminocaproic acid) and antifibrinolytic agents (tranexamic acid) have been used in orthopedic surgery to reduce bleeding. Another antifibrinolytic, aprotinin, was frequently used in cardiac surgery for bleeding but was withdrawn because recent studies showed an increased long-term mortality rate. There is no evidence of an increased mortality rate with the use of Amicar (aminocaproic acid) and tranexamic acid.

**Reference:** Ray, M., Hatcher, S., Whitehouse, S. L., et al. (2005). Aprotinin and epsilon aminocaproic acid are effective in reducing blood loss after primary total hip arthroplasty—a prospective randomized double-blind placebo-controlled study. *Journal of Thrombosis and Haemostasis*, 3(7), 1421–1427.

23. **D.** Transfusion purpura is an uncommon cause of thrombocytopenia and bleeding after transfusion. A small minority of patients lack the HPA-1a antigen on their platelets that is present in almost all humans. Transfusion purpura requires that the patient has been previously sensitized to the HPA-1a antigen; this happens usually by a prior pregnancy or previous blood transfusion. When these patients later receive blood products that contain a small number of platelets with the ubiquitous HPA-1a, they produce alloantibodies that attack both the donor's and the patient's own platelets (C). This usually presents 5 to 12 days after a transfusion and leads to profound thrombocytopenia and bleeding that can last for weeks. Mortality occurs in 10% to 20% due to hemorrhage. Although sensitization can occur after prior blood transfusions, it has become less common with leukocyte-reduced red cells and therefore this issue is most common in women who have been pregnant (A). Diagnosis is made by demonstrating platelet alloantibodies with an absence of the corresponding antigen on the patient's platelets. Treatment is primarily with intravenous immunoglobulin (IVIG). Plasmapheresis and corticosteroids are also a potential option. Treatment with platelet transfusions can exacerbate the disease process (B). The presentation can easily be confused with heparin-induced thrombocytopenia without appropriate testing. A platelet count of less than 15,000 cells/ $\mu$ L is more suggestive of transfusion purpura (E).

**References:** Hillyer, C. D., Hillyer, K. L., Strobil, F. J., et al. (2001). *Handbook of transfusion medicine* (p. 328) (1st ed.). San Diego, CA: Academic Press.

Lubenow, N., Eichler, P., Albrecht, D., et al. (2000). Very low platelet counts in post-transfusion purpura falsely diagnosed as heparin-induced thrombocytopenia: report of four cases and review of literature. *Thrombosis Research*, 100(3), 115–125.

24. **D.** Clopidogrel (Plavix) irreversibly inhibits platelet aggregation within 2 hours of administration and its effects last 5 to 7 days (the half-life of platelets is 1 week) (C, D). It works by indirectly inhibiting the activation of the glycoprotein IIb/IIIa complex (E). It does this by antagonizing the ADP receptor which, when activated, inserts glycoprotein IIb/IIIa receptors on the platelet's surface. This is functionally similar to Glanzmann's thrombocytopenia which is characterized by a GpIIb/IIIa receptor deficiency on platelets preventing fibrin from linking platelets together. Bernard-Soulier disease is characterized by GpIb receptor deficiency on platelets which prevents vWF from linking the platelet to exposed collagen on damaged tissue (A). Clopidogrel has been shown to decrease the rate of a combined endpoint of cardiovascular death, myocardial infarction, and stroke in patients with acute coronary syndromes. Use with aspirin increases the risk of bleeding. Clopidogrel has been associated with the development of thrombotic thrombocytopenic purpura, even with short-term use (<2 weeks). Treatment is with plasma exchange. The mortality rate is as high as 29%. It has not been associated with pulmonary hypertension (B).

25. **C.** Several studies have demonstrated that patients in the ICU have a high incidence of coagulopathy and that vitamin K deficiency is the most common cause (B, D, E). The differential diagnosis for an elevated INR with a normal aPTT would include a factor VII deficiency, warfarin administration, the acute phase of liver disease, and vitamin K deficiency. Vitamin K is not stable in patients receiving total parenteral nutrition; therefore, in this case, the prolonged PT correlates with vitamin K deficiency. Prolonged parenteral nutrition often leads to cholestatic liver disease, which in turn leads to the liver's inability to use vitamin K appropriately. Factors II, VII, IX, and X as well as proteins C and S all require vitamin K and will be deficient in these patients (A). Twenty percent of hospitalized patients given intravenous nutrition over a 3-week period developed elevations of INR. Vitamin K should be given at least 6 to 12 hours before a procedure in patients with adequate liver function. IM route of administration is preferred because an IV push may result in anaphylaxis. In patients with hepatocellular disease, FFP or whole blood is required. Platelets and cryoprecipitate are unrelated to prolonged prothrombin time.

**References:** Chakraverty, R., Davidson, S., Peggs, K., et al. (1996). The incidence and cause of coagulopathies in an intensive care population. *British Journal of Haematology*, 93(2), 460–463.

Crowther, M., McDonald, E., Johnston, M., et al. (2002). Vitamin K deficiency and D-dimer levels in the intensive care unit: a prospective cohort study. *Blood Coagulation & Fibrinolysis*, 13(1), 49–52.

Shearer, M. J. (2009). Vitamin K in parenteral nutrition. *Gastroenterology*, 137(Suppl. 5), S105–S118.

Duerksen, D. R., & Papineau, N. (2000). Is routine vitamin K supplementation required in hospitalized patients receiving parenteral nutrition? *Nutrition in Clinical Practice*, 15, 81–83.

Fiore, L. D., Scola, M. A., Cantillon, C. E., et al. (2001). Anaphylactoid reactions to vitamin K. *Journal of Thrombosis and Thrombolysis*, 11(2), 175–183.

26. **D.** This is a classic presentation of emphysematous cholecystitis complicated by sepsis, which then resulted in DIC. Elderly male diabetic patients are at higher risk of emphysematous cholecystitis, and gas in the gallbladder confirms the diagnosis. DIC leads to a dysregulation of the coagulation cascade, leading to clotting and resultant bleeding. The consumption of fibrinogen, platelets, and coagulation factors from the overactivation of the coagulation cascade results ultimately in diffuse bleeding. There is no specific test for DIC, but thrombocytopenia, hypofibrinogenemia, prolonged PT and PTT, and the presence of increased fibrin degradation products are sufficient to suggest the diagnosis of DIC (C). Fresh frozen plasma, platelets, and cryoprecipitate are all important components of the treatment, especially for an actively bleeding patient, but the most important part in the management of DIC is to identify and correct the underlying source, which in this case is by broad-spectrum intravenous (IV) antibiotics and emergent cholecystectomy (A, B, E). Without removal of the source, DIC will continue to consume transfused products. The mortality rate from DIC ranges between 10% and 50%.

**Reference:** Levi, M., Toh, C., Thachil, J., et al. (2009). Guidelines for the diagnosis and management of disseminated intravascular coagulation. British Committee for Standards in Haematology. *British Journal of Haematology*, 145(1), 24–33.

27. **E.** Cryoprecipitate contains all items listed as well as factor XIII. However, it contains low concentrations of factor XI (A–D). Cryoprecipitate was originally created as a treatment for hemophilia; however, it is now more often used in patients receiving massive resuscitation in conjunction with fresh frozen plasma to replenish fibrinogen levels. Factor XI deficiency is also known as hemophilia C or Rosenthal syndrome, occurs more often in the Ashkenazi Jewish population, and is treated with fresh frozen plasma (during bleeding episodes).
28. **E.** Patients undergoing surgery should be assessed for VTE risk and categorized as very low, low, moderate, and high-risk patients. The Caprini score can be used to facilitate the estimation. A score of 5 or more places a patient at high risk. Age of 75 years or more = 3 points, cancer = 2 points, and major open or laparoscopic surgery longer than 45 minutes is also 2 points. As such this patient would be considered high risk. In low-risk patients, mechanical prevention (compression device) is recommended. In moderate risk, pharmacologic prophylaxis with either UFH or LMWH is recommended. High-risk patients should get both mechanical and pharmacologic prophylaxis. The drug should be administered in close proximity to surgery and continued until the patient is fully ambulatory. Recent data in high-risk patients (such as those with cancer) demonstrate enhanced VTE prophylaxis with extended LMWH for 4 weeks after surgery (A–D). Interestingly, recent data indicate that patients undergoing colectomy for inflammatory bowel disease (IBD) are also at very high risk for VTE (though inflammatory bowel disease [IBD] is not included in the Caprini score).

**Reference:** Vedovati, M. C., Becattini, C., Rondelli, F., et al. (2014). A randomized study on 1-week versus 4-week prophylaxis for venous thromboembolism after laparoscopic surgery for colorectal cancer. *Annals of Surgery*, 259(4), 665–669.

29. **C.** The patient is likely manifesting a febrile nonhemolytic transfusion reaction (FNHTR), the most common blood transfusion reaction. It occurs in 0.5% to 1.5% of all cases of blood transfusion (A). It is defined as a rise in temperature of at least 1.8°C from baseline and is not accounted for by the patient's clinical condition. However, FNHTR is a diagnosis of exclusion. As such, it is generally recommended to at least temporarily stop the transfusion and assess the patient. In particular, attention should be paid to additional symptoms and signs such as respiratory compromise, cyanosis, back pain, and hypotension; these may suggest a hemolytic reaction, TRALI, or sepsis from contaminated blood. FNHTR is more common in pregnancy and in patients with immunocompromised states (such as leukemia, lymphoma). It occurs more commonly after the transfusion of platelets but can also occur with PRBC or FFP (B). Pretreatment with acetaminophen was thought to reduce the severity of the complication. However, the only randomized controlled trial to date demonstrated no difference in the rate of febrile nonhemolytic transfusion reaction in patients that were pretreated with acetaminophen and diphenhydramine when compared to a placebo (E). The incidence of febrile reactions can be greatly reduced by the use of leukocyte-reduced blood products. Filtration removes 99.9% of the white blood cells and platelets and is

more effective than washing. Leukocyte reduction prevents almost all febrile transfusion reactions. There is debate in the literature as to whether leukocyte reduction leads to a decrease in postoperative infections or mortality. Aspirin is not advised given its effects on platelets and bleeding (D).

**References:** Wang, S. E., Lara, P. N., Lee-Ow, A., et al. (2002). Acetaminophen and diphenhydramine as premedication for platelet transfusions: a prospective randomized double-blind placebo-controlled trial. *American Journal of Hematology*, 70(3), 191–194.

Hebert, P. C., Fergusson, D., & Blajchman, M. A. (2003). Leukoreduction Study Investigators. Clinical outcomes following institution of the Canadian universal leukoreduction program for red blood cell transfusions. *JAMA*, 289(15), 1941–1949.

# Wound Healing

*Patrick T. Delaplain, Areg Grigorian, and Christian de Virgilio*

## Questions

1. The following agent has been shown to clinically reduce the deleterious effects of corticosteroids on wound healing:
  - A. Vitamin C
  - B. Vitamin A
  - C. Zinc
  - D. Copper
  - E. Transforming growth factor- $\beta$  (TGF-  $\beta$ )
2. Which of the following is true about wound healing?
  - A. Angiogenesis is the major contributor to the erythema seen in wounds.
  - B. Pain in the first 48 hours is secondary to newly active fibroblasts attempting to contract the wound edges.
  - C. At 48 hours, phagocytic cells predominate in the wound bed.
  - D. In the first 36 hours, macrophages are the predominate cells in the wound bed.
  - E. While erythema and pain can be normal, induration is typically pathologic.
3. Which of the following is NOT true regarding hypertrophic scarring and keloid formation?
  - A. Both have an increased deposition of collagen.
  - B. Both have a normal amount of fibroblasts.
  - C. Both have a genetic predisposition.
  - D. Both have a propensity to develop following a postsurgical wound infection.
  - E. Both tend to recur with re-excision.
4. A severely malnourished 12-year-old boy presents with multiple pigmented spots on his bilateral thighs, bleeding gums, loose and missing teeth, and several weeping wounds. He recently arrived as a refugee from an underdeveloped country. His medical history is sparse. His diet primarily consisted of cooked grains. Which of the following is true regarding the most likely vitamin deficiency in this patient?
  - A. It plays an essential step in proteoglycan synthesis.
  - B. Delayed wound healing is caused by failure to hydroxylate lysine and proline during collagen synthesis.
  - C. It does not affect iron absorption.
  - D. Exogenous administration has been shown in animals to have a corticosteroid-like effect on wound healing.
  - E. After hydroxylation by the liver and kidney, it helps with bone mineralization.
5. Which of the following is true regarding cell junctions in humans?
  - A. Hemidesmosomes do not interact with intermediate filaments.
  - B. Tight junctions, by definition, do not allow the passage of solutes through adjacent cell membranes.

- C. Connexons allow for direct communication between two adjacent cells.
  - D. Adherens junctions are a specialized type of tight junction.
  - E. Desmosomes function primarily to anchor a cell to the extracellular matrix.
6. Which of the following is true regarding nutritional status and nonhealing wounds?
    - A. Short periods of starvation before surgery generally have minimal effect on wound healing.
    - B. Malnutrition prolongs the inflammatory phase of wound healing.
    - C. Prealbumin will provide an accurate estimation of nutritional status over the previous several weeks.
    - D. Nutritional supplements have been shown to decrease interval time to complete healing of pressure ulcers.
    - E. Presence of granulation tissue is not predictive of adequate wound healing ability.
  7. A 22-year-old female with history of a gun-shot wound to the abdomen requiring multiple bowel resections has been on chronic total peripheral nutrition (TPN) for short gut syndrome. She presents for a clinic follow-up stating that her hair has started to fall out, and she has developed multiple bruises over her arms and legs. In addition, she has a diffuse scaly rash and dry skin. Which of the following nutrients or trace elements is she likely deficient in?
    - A. Copper
    - B. Vitamin C
    - C. Linoleic acid
    - D. Zinc
    - E. Selenium
  8. Which of the following is true regarding the care of chronic wounds?
    - A. Necrotic tissue should be debrided regardless of etiology.
    - B. OPSITE dressing provides an impermeable barrier between the environment and the wound.
    - C. Compression is the mainstay of treatment for heel wounds.
    - D. Negative pressure wound therapy works primarily by increasing wound contraction.
    - E. Wet-to-dry dressings can cause wound desiccation, which can potentially delay healing.
  9. Which of the following is true regarding diabetic foot wounds?
    - A. Patients generally remember the inciting injury that led to the nonhealing wound.
    - B. Foot deformity in this patient population can significantly increase ulcer formation.
    - C. Most of these ulcers are due to ischemia.
    - D. This complication is multifactorial and generally independent of blood glucose levels.
    - E. Noninfected wounds should not be casted because it limits evaluation of the wound.
  10. Which of the following is true regarding skin antiseptic techniques before surgery?
    - A. Iodine-based preps are superior to chlorhexidine for preventing surgical site infections.
    - B. Chlorhexidine-based preps are safe on all body surfaces as a preoperative cleanser.
    - C. Preoperative bathing with chlorhexidine has been shown to reduce incidence of surgical site infections.
    - D. The bactericidal effect of iodine is from its ability to form an extracellular crystal matrix and destabilize cell membranes.
    - E. Povidone iodine was formulated to decrease the availability of molecular iodine.
  11. Which of the following drugs has not been shown to directly affect wound healing?
    - A. Corticosteroids
    - B. Nonselective nonsteroidal antiinflammatory drug (NSAID)
    - C. Infliximab
    - D. Sirolimus
    - E. Bevacizumab
  12. Which of the following diseases is correctly paired with the type of collagen that is affected?



- A. Alport syndrome: type III collagen
  - B. Ehlers-Danlos syndrome: type VII collagen
  - C. Epidermolysis bullosa: type VII collagen
  - D. Osteogenesis imperfecta: type II collagen
  - E. Bullous pemphigoid: type I collagen [?]
13. Which of the following is true regarding the healing of a small-bowel anastomosis?
- A. Leaks are less likely to occur with a hand-sewn anastomosis as compared with stapled.
  - B. There is an increased level of collagenase when compared to healing skin wounds.
  - C. The serosa plays a minimal role in the healing of a small-bowel anastomosis.
  - D. The submucosa provides the most significant strength layer of the entire gastrointestinal tract.
  - E. Free omental flaps have been shown to improve outcomes when doing a small-bowel anastomosis.
14. Match the surgery, the correct wound class, and prophylactic antibiotic recommendation:
- A. Cardiac surgery, class I, no need for prophylactic antibiotics
  - B. Carotid endarterectomy, class I, no need for prophylactic antibiotics
  - C. Breast cancer surgery, class I, administer prophylactic antibiotics
  - D. Hemodialysis access surgery, class II, no need for prophylactic antibiotics
  - E. Elective laparoscopic cholecystectomy, class II, administer prophylactic antibiotics

## Answers

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1. **B.** Vitamin A has been shown to counter the deleterious effects of both corticosteroids and radiation on wound healing in both human and animal studies. The benefit was seen even in the absence of vitamin deficiency. This held true whether it was administered topically or systemically as well. The mechanism of action of vitamin A is thought to be reversal of the antiinflammatory effects of steroids. Vitamin A increases lysosomal membrane lability, increases macrophage influx and activation, and stimulates collagen synthesis. Hepatic stellate cells (Ito cells) in the perisinusoidal space (space of Disse) can store high levels of vitamin A. TGF- $\beta$  released during local injury to the liver can lead to the differentiation of Ito cells into myofibroblast-like cells (E). This can cause hepatic fibrosis and, ultimately, liver cirrhosis. TGF- $\beta$  is considered to be immunosuppressive. Vitamin C, a free radical scavenger, has been investigated as a possible adjunct in the management of the reactive oxygen species generated by thermal injury (A). Zinc deficiency has numerous manifestations, including alopecia, poor wound healing, immunosuppression, night blindness or photophobia, impaired taste or smell, neuritis, and a variety of skin disorders (C). Copper deficiency manifests as microcytic anemia, pancytopenia, depigmentation, and osteopenia (D).

**References:** Dayton, M. T. (2004). Surgical complications. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 297–332) (17th ed.). Philadelphia, PA: W. B. Saunders.

Shapiro, M. L., Angood, P. B. (2005). Patient safety, errors, and complications in surgery. In F. C. Brunickardi, D. K. Andersen, T. R. Billiar, et al., (Eds.), *Schwartz's principles of surgery* (pp. 333–360) (8th ed.). New York, NY: McGraw-Hill.

Tawa, N. E., Maykel, J. A., & Fischer, J. E. Metabolism in surgical patients. In C. M. Townsend Jr, R. D. Beauchamp, B. M. Evers, et al., (Eds.), *Sabiston textbook of surgery: the biological basis of modern surgical practice* (pp. 137–182) (17th ed.). Philadelphia, PA: W. B. Saunders.

2. **C.** Wound healing is typically divided into three or four phases: hemostasis/inflammation (combined in the three-phase model), proliferation, and maturation (or remodeling). The hemostasis/inflammation phase is initiated with the disruption of capillaries resulting in hemorrhage. This immediately causes vasoconstriction to assist with the formation of a platelet plug. After 10 to 15 minutes, local tissue factors and platelets begin to facilitate vasodilation and increased vascular permeability. The infiltration of fluid and cells (mainly neutrophils) causes the wound to become erythematous (A). In addition, the wound is warm and edematous (induration) (E). At this point, changes in tissue pH and local tissue destruction cause the wound to be painful (B). The first cells to arrive after formation of a platelet plug are neutrophils, which don't seem to

be critical to healing and mainly help with phagocytosis of bacteria and destruction of dead tissue. Neutrophil predominance persists for 48 hours, at which point they are largely replaced by macrophages, which will remain in the wound until the completion of healing (D). Macrophages are arguably the most important cell in healing because of their effects on angiogenesis, matrix deposition, and remodeling via the release of cytokines and growth factors. By day 4, the proliferative phase begins and endothelial cells and fibroblasts begin to appear in the wound. By days 5 to 7, there is no longer a significant population of inflammatory cells. The previously created matrix of type III collagen is slowly replaced with type I collagen, angiogenesis takes place, granulation tissue begins to form, and wound contraction commences. This phase persists for 3 to 4 weeks and finally gives way to the remodeling phase. At this point, vascularity decreases, collagen is continuing to be synthesized but at the same rate it is being broken down and collagen cross-linking occurs.

**References:** Brunicki, F. C., Andersen, D. K., & Schwartz, S. I. (2015). *Schwartz's principles of surgery*. New York, NY: McGraw-Hill Education.

O'Leary, J. P., Tabuenca, A., & Capote, L. R. (2008). *The physiologic basis of surgery*. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins.

3. **C.** Hypertrophic scarring and keloid formation are both examples of pathologic excessive healing. Both are caused by the increased deposition of collagen, with a relatively normal number of fibroblasts (A). Formation of keloids has a large genetic component that is inherited in an autosomal dominant fashion. It is also more prominent in darker skinned individuals. Hypertrophic scarring is generally caused by a delay in wound healing or by excessive tensile forces on a new wound. They do not spread outside of the borders of the original wound, unlike keloids. As such, they tend to respond better to surgical excision if the initial etiology of the wound healing has been treated, such as infection. While steroids have been used to treat keloids and hypertrophic scarring as a primary treatment, it is now largely an adjuvant therapy to surgical excision similar to radiation. In general, surgery should be avoided if possible because the lesions are at high risk of recurrence (E). While steroids have been shown to improve both types of abnormal healing, use as an adjuvant to surgery or early on for scar preventing is the main indication (D). Several other adjuncts have also been shown to reduce scarring including silicone bandages, occlusive dressings, and extremity compression devices.

**References:** Greenfield, L. J., & Mulholland, M. W. (2011). *Greenfield's surgery: scientific principles and practice*. Philadelphia, PA: Lippincott, Williams & Wilkins.

O'Leary, J. P., Tabuenca, A., & Capote, L. R. (2008). *The physiologic basis of surgery*. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins.

Gauglitz, G. G., Korting, H. C., Pavicic, T., et al. (2011). Hypertrophic scarring and keloids: pathomechanisms and current and emerging treatment strategies. *Molecular Medicine*, 17(1-2), 113–125.

4. **B.** This patient most likely has scurvy caused by a deficiency in vitamin C and uncommon in the modern age. It is typically seen in patients with severe malnutrition often from underdeveloped countries without access to fresh fruits and vegetables. Patients present with loose or missing teeth, open sores, pigmented spots on the extremities, bleeding mucous membranes, and vague myalgias and fatigue. It is a key cofactor in the hydroxylation of lysine and proline during collagen synthesis; as such, collagen cross-linking is extremely diminished in patients with vitamin C deficiency. It can even cause the involution of previous scars because remodeling continues, but patients are unable to synthesize new collagen. Vitamin C is also involved in iron absorption (C). Vitamin A is another essential vitamin in wound healing and assists with epithelialization, proteoglycan synthesis, and normal immune function (A). It has also been shown to reverse the effects of steroids on wound healing. Vitamin D is consumed in the diet and produced in the skin. It then undergoes activation (hydroxylation) by the liver and kidney to play an essential role in calcium metabolism (E). Exogenous vitamin E has been shown in animal trials to cause delayed wound healing via an inflammatory mechanism similar to corticosteroids (D).

**Reference:** O'Leary, J. P., Tabuenca, A., & Capote, L. R. (2008). *The physiologic basis of surgery*. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins.

5. **C.** All humans have three main types of cell junctions: anchoring junctions, communicating (gap) junctions, and tight junctions. The first group (anchoring junctions) is further subdivided into desmosomes, hemidesmosomes, and adherens junctions (D). Hemidesmosomes and desmosomes

both connect with intermediate filaments in the cytoskeleton, but the former connects cells to the underlying extracellular matrix, and desmosomes connect adjacent cells to one another (A, E). Adherens junctions serve the same purpose but use actin filaments as their cytoskeletal anchor. Anchoring junctions, as a whole, provide structural integrity to a tissue made up of individual cells. Communicating junctions allow direct chemical communication between adjacent cells. This is facilitated by six individual subunits, called connexins, which form a central pore, called a connexon. When two connexons from adjacent cells come in contact, a channel is formed allowing communication between the two cells. The final group, tight junctions, refers to a group of proteins that allow the selective diffusion of molecules based mainly on size, molecular charge, and polarity. These primarily act as selective barriers such as in the different layers of the skin (B).

6. **B.** Delayed wound healing is a multifactorial problem with many identifiable risk factors including malnutrition, vitamin deficiencies, smoking, obesity, diabetes, and hypoxemia. However, few systemic factors have been shown to speed up wound healing. Short periods of starvation can have negative effects on postoperative wound healing (A). This seems to occur primarily by prolongation of the inflammatory phase because there are inadequate building blocks for cell proliferation, protein synthesis, and creation of new DNA. The notion that malnutrition plays a key role in the development of chronic wounds led to multiple studies aimed at determining if nutritional supplementation can prevent chronic wounds or speed recovery. A Cochrane review done in 2014 looking at 23 randomized controlled trials evaluating the effect of enteral and parenteral nutrition on the prevention and treatment of pressure ulcers found no clear benefit of any intervention (D). By knowing the half-lives and current serum measurements of certain proteins, we are able to estimate the synthetic ability of the liver over a given time period. Albumin (14–20 days), transferrin (8–9 days), and prealbumin (2–3 days) all give a snapshot into someone's nutritional status but need to be combined with the entire clinical picture (C). Granulation tissue, if present, is predictive of adequate wound healing (E).

**References:** Greenfield, L. J., & Mulholland, M. W. (2011). *Greenfield's surgery: scientific principles and practice*. Philadelphia, PA: Lippincott, Williams & Wilkins.

Langer, G., & Fink, A. (2014). Nutritional interventions for preventing and treating pressure ulcers. *The Cochrane Database of Systematic Reviews*, (6), CD003216.

Stechmiller, J. K. (2010). Understanding the role of nutrition and wound healing. *Nutrition in Clinical Practice*, 25(1), 61–68.

7. **C.** A deficiency of trace elements and essential fatty acids is a relatively rare entity in patients taking food by mouth. However, it has occurred with increased frequency with the advent and widespread use of TPN, particularly in patients with a history of short gut syndrome. Copper is primarily associated with anemia resistant to iron supplementation, leukopenia, and neurologic defects (A). Vitamin C deficiency, or scurvy, causes delayed wound healing, bleeding gums, loose teeth, and abnormal bone deposition in children (B). Selenium deficiency is associated with a fatal cardiomyopathy (E). Zinc and essential fatty acid deficiency (linoleic acid and alpha-linolenic acid) have many similar features including delayed wound healing, increased infections, diarrhea, and a rash. However, the essential fatty acid rash tends to be more scaly and is associated with dry skin, and the rash from zinc is primarily located in the perioral area and intertriginous skin of the fingers and toes. While alopecia and thrombocytopenia can be found with both conditions, it is more closely associated with free fatty acid deficiency. Conversely, the loss of appetite, impaired taste, and night blindness are more closely related with zinc deficiency (D).

**References:** Jeppesen, P., Høy, C., & Mortensen, P. (1998). Essential fatty acid deficiency in patients receiving home parenteral nutrition. *The American Journal of Clinical Nutrition*, 68(1), 126–133.

Kumar, V., Fausto, N., Abbas, A. K., et al. (2004). *Robbins and Cotran's pathologic basis of disease*. Philadelphia, PA: Elsevier Saunders.

O'Leary, J. P., Tabuenca, A., & Capote, L. R. (2008). *The physiologic basis of surgery*. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins.

8. **E.** The mainstay of wound care is ensuring an environment that is moist, sterile, has adequate blood supply, and is free of excess necrotic material. While removal of dead tissue and exudate is generally suggested in all wounds because it provides a media for bacterial growth, one exception is the noninfected, dry eschar of arterial ulcers. These should be revascularized before debridement (A). Although compression is standard for venous insufficiency (medial malleolar) wounds, it will likely worsen ischemic arterial wounds or pressure ulcer wounds, both of which

would be likely etiologies in heel wounds (C). The ideal dressing for chronic wounds should keep the wound from drying, remove excess exudate, relieve pain, and prevent additional trauma to the tissue bed. The surgeon is faced with a plethora of choices when it comes to wound care management, none of which are perfect. While wet-to-dry dressings have provided the cornerstone of wound care in surgical practice for years, there is some evidence that they can cause wound desiccation (extreme drying) at the base of wounds, are often inadequate at controlling heavily exudative wounds, and provide inadequate barrier protection from the environment (E). OBSITE and Tegaderm dressings are semipermeable barriers that allow the passage of water vapor and oxygen between the environment and the wound but remain impermeable to liquids and organisms (B). Negative pressure wound therapy is a relatively novel device that can be used for the treatment of many chronic wounds. It is believed to primarily work by removing edema, increasing blood flow and promoting the formation of granulation tissue. Increased wound contraction is not a mechanism for wound healing in negative pressure therapy (D).

**References:** Argenta, L. C., & Morykwas, M. J. (1997). Vacuum-assisted closure: a new method for wound control and treatment. *Annals of Plastic Surgery*, 38(6), 563–577.

Fonder, M. A., Lazarus, G. S., Cowan, D. A., et al. (2008). Treating the chronic wound: a practical approach to the care of nonhealing wounds and wound care dressings. *Journal of the American Academy of Dermatology*, 58(2), 185–206.

9. B. Diabetic foot wounds are multifactorial and neuropathy, foot deformity, and ischemia play the three largest roles (D). Of these factors, neuropathy is the most significant (C). Most of the time diabetic foot ulcers are due to unrecognized injury from occult trauma (e.g., tight-fitting shoes) (A). The motor portion of the neuropathy causes a distinct foot deformity called Charcot's foot, which is collapse or dislocation of the interphalangeal and metatarsophalangeal joints. This changes the pressure points of the foot to relatively unprotected areas. In the setting of noninfected wounds, specialized orthotics or even casting can be an adjuvant to healing (E).

**Reference:** Brunicki, F. C., Andersen, D. K., & Schwartz, S. I. (2015). *Schwartz's principles of surgery*. New York, NY: McGraw-Hill Education.

10. E. Surgical site infections have been shown to increase the cost of hospitalizations and length of hospital stays prompting the Surgical Care Improvement Project (SCIP) to address this major economic burden to modern health care. While preoperative bathing with antiseptic solution has been shown to decrease bacterial colonization of skin, it has not been proven to be associated with decreased rates of surgical site infections (C). Multiple preparations for preoperative skin antisepsis have been designed; however, the two most commonly in use are iodine-based and chlorhexidine-based in either an aqueous or alcohol solution. Iodine works primarily by passing through the bacterial cell membrane and replacing intracellular ions with molecular iodine and oxidizing various structures within the bacterium (D). It is also, however, toxic to normal tissues, so it is generally combined with a carrier molecule (e.g., povidone) to reduce the systemic availability of molecular iodine and reduce its toxicity. In contrast, chlorhexidine works by its ability to destabilize cellular membranes. A Cochrane review done in 2015 comparing iodine-based and chlorhexidine-based preoperative antiseptic techniques found the latter to be superior in preventing surgical site infections (A). However, it is generally not recommended for use above the chin because of ototoxicity and potential for causing damage to the cornea in higher concentrations (B).

**References:** Dumville, J. C., Mcfarlane, E., Edwards, P., et al. (2015). Preoperative skin antiseptics for preventing surgical wound infections after clean surgery. *Cochrane Database of Systematic Reviews*, (4), CD003949.

Mangram, A. J., Horan, T. C., Pearson, M. L., et al. (1990). Guideline for the prevention of surgical site infection. *Infection Control and Hospital Epidemiology*, 20, 247–280.

11. C. While some studies implicate infliximab as a potential factor in postoperative infection, there is no definitive evidence that it affects wound healing in the absence of infection. All of the other choices (A, B, D, E) have been shown in selected studies to directly slow the healing of wounds through a variety of mechanisms. Any drug that inhibits angiogenesis, epithelialization, collagen synthesis, cell proliferation, or DNA synthesis will have a potentially negative effect on wound healing. Most authorities recommend perioperative cessation of these types of medications in the absence of direct contraindications.

**Reference:** Busti, A. J., Hooper, J. S., Amaya, C. J., et al. (2005). Effects of perioperative

antiinflammatory and immunomodulating therapy on surgical wound healing. *Pharmacotherapy*, 25(11), 1566–1591.

12. C. The most common types of collagen located in the body include types I to V, though there are many more that are clinically relevant in certain diseases. Type I collagen makes up 90% of the body's collagen and is found to some degree in most tissue, including skin, bones, tendons, arterial walls, and scars. It is implicated in disease like osteogenesis imperfecta (D). Type II collagen makes up about 50% of the protein in hyaline cartilage (carTWOlidge). Type III collagen is found in bone, cartilage, and multiple types of connective tissue, and abnormalities have been found in Dupuytren's contracture and the formation of aneurysms. Type IV collagen is found primarily in the basement membrane (type four is floor) and has been associated with Alport and Goodpasture syndrome (A). Type V collagen is closely associated with type I and is in most of the same tissues but with the addition of placental tissue. While there exist clinically significant collagens outside of these main five, such as type VII (epidermolysis bullosa) and type XVII (bullous pemphigoid), they are not nearly as prevalent (E). Ehlers-Danlos is a spectrum of connective tissue disorders that can affect multiple types of collagen (B). However, the most common is type V (seen in classic type Ehlers-Danlos).

**Reference:** De Paepe, A., & Malfait, F. (2004). Bleeding and bruising in patients with Ehlers-Danlos syndrome and other collagen vascular disorders. *British Journal of Haematology*, 127(5), 491–500.

13. B. While healing of the gastrointestinal tract goes through the same basic steps as healing of the skin, there are several key differences and unique features. Skin wounds undergo a relatively steady increase of the tensile strength of the wound over time. In contrast, the increased collagenase activity in the small bowel allows collagen breakdown to exceed collagen deposition at days 3 to 5 after an anastomosis (B). This is why anastomotic leaks in the gastrointestinal (GI) tract occur with increased frequency in this critical time period. However, the GI tract is quicker to reach maximal tensile strength when compared with the skin. The submucosa provides most of the tensile strength for an anastomosis because of the coarse, interwoven fibers that make it up. However, the mucosa and serosa are equally important, and both help provide a quick, leakproof barrier over the first several days (C). One can appreciate this effect in action by noting the relatively higher leak rates with portions of the GI tract that lack serosa such as the esophagus. In contrast to small-bowel mucosa, which is designed primarily for absorption, the esophageal mucosa is made up of thicker squamous epithelium that actually provides a more significant tensile strength than the submucosa (D). Multiple adjuncts and techniques have been tried to decrease the rate of anastomotic leaks, and while there may be a trend toward fewer leaks with a stapled anastomosis in certain circumstances, there still isn't conclusive evidence that one is superior to the other in all cases (A). While omental wrapping has been shown to improve outcomes in certain situations, a devitalized "omental free flap" will necrose and will not help with the anastomosis (E).

**References:** Brunnicardi, F. C., Andersen, D. K., & Schwartz, S. I. (2015). *Schwartz's principles of surgery*. New York, NY: McGraw-Hill Education.

Thornton, F. J., & Barbul, A. (1997). Healing in the gastrointestinal tract. *Neurosurgery Clinics of North America*, 77(3), 549–573.

14. C. The wound classifications are used clinically to assess the approximate risk of wound infection; the risk increases with each class. Class I (clean) wounds are an uninfected operative wound without inflammation and without opening the respiratory, alimentary, genital, or urinary tract. Class I wounds have a less than 2% risk of developing a surgical site infection (SSI) and include mastectomy, thyroidectomy, herniorrhaphy, vascular surgery, and cardiac surgery. Antibiotic prophylaxis with cefazolin is warranted for breast cancer procedures. In the case of cardiac surgery, antimicrobial prophylaxis reduces the occurrence of surgical site infection significantly and is recommended, typically with a first or second generation cephalosporin (A). Similarly, patients undergoing carotid endarterectomy should receive prophylactic antibiotics due to the frequent use of prosthetic material (B). Hemodialysis access surgery is considered a class I wound and most surgeons would agree to provide prophylactic antibiotics (D). Class II wounds (clean-contaminated) include those involving the aforementioned tracts in a controlled environment without a major break in technique. Class II wounds have a 4% to 10% risk of SSI and include colon resection, bronchoscopy, and uncomplicated cholecystectomy. Multiple meta-analyses have failed to demonstrate a consistent benefit in receiving prophylactic antibiotics in patients

undergoing elective laparoscopic cholecystectomy (E). Class III wounds (contaminated) have a greater than 20% risk of SSI and involve entering the aforementioned tracts in an uncontrolled environment such as acute appendicitis, gallbladder spillage during cholecystectomy, and diverticulitis. Class IV wounds (dirty) have a greater than 40% risk of SSI and are characterized as having devitalized tissue, perforation of viscera, and/or peritonitis. The assumption is that the infection was present in the field before operating. Class IV wounds include wound debridement, incision and drainage of abscess, and an old traumatic wound (>6 hours).

**References:** Culver, D. H., Horan, T. C., Gaynes, R. P., et al. (1991). Surgical wound infection rates by wound class, operative procedure, and patient risk index. National Nosocomial Infections Surveillance System. *The American Journal of Medicine*, 91(3B), 152S–157S.

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# Mục lục

Title page	2
Table of Contents	3
Copyright	6
Dedication	8
Contributors	9
Foreword	10
Preface	11
Acknowledgments	12
Part I. Patient Care	13
1. Abdomen—General	14
2. Abdomen—Hernia	23
3. Abdomen—Biliary	35
4. Abdomen—Liver	51
5. Abdomen—Pancreas	69
6. Abdomen—Spleen	83
7. Alimentary Tract—Esophagus	93
8. Alimentary Tract—Stomach	104
9. Alimentary Tract—Small Bowel	125
10. Alimentary Tract—Large Intestine	143
11. Alimentary Tract—Anorectal	167
12. Breast	177
13. Endocrine	198
14. Skin and Soft Tissue	222
15. Surgical Critical Care	230
16. Trauma	245
17. Vascular—Arterial	274
18. Vascular—Venous	296
19. Vascular—Access	304
20. Transplant	311
21. Thoracic Surgery	318
22. Pediatric Surgery	331
23. Plastic Surgery	348
24. Genitourinary	356
25. Gynecology	367
26. Head and Neck	373
27. Nervous System	382
Part II. Medical Knowledge	390
28. Anesthesia	391
29. Fluids, Electrolytes, and Acid-Base Balance	404
30. Immunology	418
31. Infection and Antimicrobial Therapy	422
32. Nutrition and Metabolism	433
33. Oncology and Tumor Biology	441
34. Pharmacology	448
35. Preoperative Evaluation and Perioperative Care	457
36. Transfusion and Disorders of Coagulation	472
37. Wound Healing	487