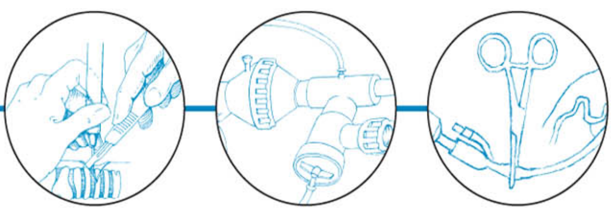
IMPROVISED MEDICINE

PROVIDING CARE IN EXTREME ENVIRONMENTS



KENNETH V. ISERSON

IMPROVISED MEDICINE

Providing Care in Extreme Environments

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Contents

Preface: How the Book Is Organized

This book is divided into several sections, beginning with introductory chapters that describe resource-poor situations that may require medical improvisation. Subsequent sections discuss: Basic Needs, Patient Assessment/Stabilization, Surgical Interventions, and Non-Surgical Interventions. The Appendices provide useful information about preparing a hospital disaster plan and assembling medical kits for different activities.

The Basic Needs section begins with communication alternatives, since difficult communication is the most frequently cited problem in resource-poor situations. Improvised methods for preventive medicine/public health come next, since supplying clean drinking water and suitable waste facilities saves more lives (in a non-dramatic way) than all the interventional medical treatments combined. Finally, I discuss improvised basic equipment for health care and methods for cleaning and reusing medical equipment under resource-poor conditions.

Not all improvised equipment is discussed in this section, since most equipment improvisations are described in the chapter appropriate for their use. Reusing medical equipment is, rightfully, a controversial subject, since inadequate cleaning, disinfection, and sterilization lead to passing diseases from one patient to another. The best available information has been used to provide guidance for when supplies and cleaning methods are suboptimal.

The Patient Assessment/Stabilization section describes methods and improvised equipment to assess vital signs, and to manage airways, breathing, circulation, and dehydration/rehydration (vital to saving children's lives). Also included are improvisations and alternatives for medications and medication delivery, imaging, laboratory testing, and patient movement/evacuation. Four chapters describe improvisations for analgesia, local and regional anesthesia, and general anesthesia. The Sedation and General Anesthesia chapter includes techniques for both non-anesthesiologists and anesthesiologists. The Ketamine, Ether and Halothane chapter describes the most common anesthetics used in developing countries, including unique administration methods. Younger anesthesiologists, as well as other practitioners who may be called upon to give ketamine or ether, may be unfamiliar with these medications or alternative administration techniques.

While not everything in the Surgical Interventions section is strictly surgical (e.g., there is a chapter on neurology/neurosurgery), dividing the chapters in this way provides a convenient method of locating information. The two Dental and the Orthopedics chapters occupy significant space, since health care professionals often need to apply these skills in resource-poor environments even if they have little training in these areas. All chapters in the Surgical Intervention section describe improvised equipment and techniques that can save lives. For instance, the Otolaryngology chapter describes the old, very basic, technique of placing posterior nasal packs, while the Obstetrics/Gynecology chapter describes balloon tamponade for peripartum and other vaginal bleeding.

The Non-Surgical Interventions chapters include improvisations that can be used both in traditional medical areas (e.g., gastroenterology, infectious diseases, pediatrics/neonatal, and psychiatry), as well as other areas in which health care professionals may need to be involved when resources are limited: recognizing and treating malnutrition, assisting with rehabilitation, and doing death notification, forensic investigation, and body management.

The Appendices provide a disaster plan for hospitals that includes transparent markers and clear actions for each progressive disaster level, and also suggest what to include in medical kits for several resource-poor situations.

Hopefully, *Improvised Medicine's* contents will help you provide excellent medical care to your patients in resource-poor settings. This information has already proven valuable when I had to provide care in such settings. My experience has convinced me that medical improvisation is both possible and highly useful.

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It has taken a huge international "village" to produce this strange compendium. The significant help I received is the only reason this book exists. First and foremost is the fantastic assistance and support from my wife, Mary Lou Iserson, CPA, who has also been a research medical technologist and a field member of the Southern Arizona Rescue Association. Acting as a skilled and persistent editor, she patiently explained why some sections made no sense—even before the manuscript went to the publisher.

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1 What Is Improvised Medicine?

Improvised medicine, as described in this book, encompasses a spectrum of ad hoc equipment and special methods and knowledge for advanced health care practitioners who already work capably within their own areas of expertise. Use *Improvised Medicine* when, due to the circumstances, you must reach beyond your comfort level and provide medical care usually provided by other specialists—or without the medications, equipment, and milieu to which you have become accustomed.

In the context of a disaster or a resource-poor environment, frustration may be defined as understanding what can be done, what needs to be done, and how to do it, but not having the necessary tools. Unlike paramedics, who are trained to expect the unexpected, most health care professionals (including physicians, dentists, podiatrists, physician assistants, and nurse practitioners) who work in high-tech health care systems don't expect that the power will fail, a fire will ignite, the computer system will crash, a facility will flood, or an epidemic will erupt. Yet these events occur on a routine basis and, given the state of the world, it is likely they will occur more frequently in the future.

How do you practice medicine in a disaster when you are confronted by increased numbers of patients, the need to extend your scope of practice beyond your comfort level, and the need to work with limited or alternative methods, equipment, and staff in unusual, often makeshift, locales? When a disaster's scope is regional or national, knowing what to do and how to improvise becomes even more crucial. For a health care provider to innovate, work, and provide leadership in resource-poor environments, especially when others are panicking, often requires superior knowledge and greater understanding. *Improvised Medicine* provides this.

In selecting material for this book, I have tried to anticipate both short-term and long-term resource deficiencies. Therefore, some improvised techniques in the book can be used immediately in sudden critical situations; others are long-term solutions for use when equipment and facilities will be lacking for some time. The most mundane, everyday occurrences include the lack of necessary equipment and difficulty with procedures (e.g., airway, IV). If this book's improvised methods help in these situations, great; but the real emphasis is on opening your mind to ways of solving problems in a crisis and providing options for you (and your patients) when alternatives seem limited or nonexistent.

METHODS AND EQUIPMENT

Farley wrote in 1938 that "original ideas for improvising equipment have been pretty well exhausted."[1]

This book is essentially an argument against Farley's thinking. *Improvised Medicine* represents both exploration and discovery. My adventure took the form of a search through the world's medical literature, both past and current, for procedures that can be used and equipment that can be improvised in resource-poor situations. Many techniques were tested to see if they actually work; some that exist in medical lore did not work when tested. Three major techniques that, initially, seemed like good ideas were the much-published auscultation for fractures, the use of papier-mâché (paper-maché) for casts, and the use of ham or portable radios for intra-hospital communication. I won't bore you with the details, but trust me, these methods don't work. (Thanks to my very patient wife for acting as the subject for the casting tests, and to Scott Clemans and Mykle Raymond of the Southern Arizona Rescue Association for helping with the radio tests—multiple times.)

New techniques and equipment in the book include a lightbulb beaker, two types of improvised saline locks, simplified vertical mattress sutures, makeshift medication atomizers (with and without pressurized gas), improvised stethoscope earpieces, a scalpel fashioned from a disposable razor, a nasal speculum made from a clothes hanger, and a number of other items that, while developed for this book, may have been previously improvised. These methods and equipment were tested in clinical practice. I learned and tested the simple and rapid method for vertically (down the stairs) evacuating patients from hospitals during a Disaster Medical Assistance Team exercise, although it does not seem to have been published before. Rapid-admixture blood warming, the amobarbital interview for conversion reactions, and hypnosis for fracture-dislocation reduction are not new. (Although either I originally published the technique [rapid blood warming] or my publications on the subject are among the most recent.) New mnemonics (like PAIN for tooth pain) are included to assist in remembering these important details. This book also rescues many techniques that were buried in dusty books or little-known publications. While some cynics and critics might contend that these techniques should remain in obscurity, I'm convinced that lives may be saved by resurrecting them.

ELEGANT IMPROVISATION

There is no one-size-fits-all in situations with limited resources. Circumstances will vary: in one, necessary equipment may be unavailable; in another, medications will be lacking; and in yet others, there will be no way to transport patients safely and quickly. Whatever the problem, the individuals making key decisions—and often the entire medical team—need to participate in fashioning the best medical treatment for their patients in that situation. However, as Dr. Maurice King wrote, "Failure to improvise, where this is at all possible, is never an adequate reason for not doing something."[2]

Nearly all the chapters contain material that is familiar to specialists in that field. The difficult balance has been to include enough information so that those not familiar with the field can perform adequately without a wealth of equipment or expert assistance. The idea is for any advanced clinician to be able to use the appropriate techniques in this book.

Naturally, a huge emphasis is placed on using improvised methods in less-developed countries, remote areas, and other resource-poor environments. My hope is that, while most clinicians will know many of these techniques, they will find new material that can be used to help their patients. Every effort has been made to supply enough information to perform the techniques or to make the equipment, even if the original sources lacked the details.

Ultimately, this book suggests ideas that should prod you into a *How can I do this?* mind-set. Problem solving is only part of the solution. The real issues are motivation and attitude. Your motivation is to help your patient; your attitude is "The difficult we do immediately. The impossible takes a little longer."[3]

Improvised Medicine is intended to help you and your health care team to problem-solve and find a workable solution. As the old medical adage about stethoscopes says, "It's not what goes in the ears, but what's between the ears that matters." A modern update, based on military medicine, says that while "technology is important, … the best instruments on the battlefield are your hands, fingers, and brain, trained for optimal use. They seldom break, they are hard to misplace, they can be upgraded continuously, and frequently invent new solutions."[4] In austere medical situations, it is the combination of the knowledge and skills of the entire team, not just of one individual, that may save the day. Note the following story:

> One very basic (and recent) example of improvisation occurred while I was considering what to include in this introduction. I had to drain an ischemic priapism in an austere situation and discovered that no large-bore butterfly needle was available. (The butterfly tubing permits movement of the needle without dislodging it during the drainage/irrigation/medication instillation process.) Once the team decided to go ahead with the procedure and not use a less-than-optimal piece of equipment (e.g., small-bore butterfly or fixed needle), a workable substitute was quickly devised using a large-bore hypodermic needle attached to a short piece of extension tubing.

This book can only supply ideas about how to "make do" when dealing with shortages. Problem-solving skills will take you the rest of the way when you are faced with missing equipment, personnel, or facilities. As is typical in medicine—and in life, generally—once we recognize that something can be done, we find ways to do it better. Over time, the hot air balloon evolved into a rocket ship, a daguerreotype into a digital video movie, an abacus into a computer, and the ancients' signal fires into the Internet. Many of the techniques and much of the equipment described in this book are either retrieved from our predecessors, essentially "lost knowledge," or innovations that colleagues have developed. Nearly all can be improved upon; it only takes more people thinking about how to do it better. That is where you come in. If you develop an improvement on the techniques or equipment described in this book, please forward it to me so it can be included (with credit to you or the originator, of course) in the next edition. Mail them to me c/o Galen Press Ltd., PO Box 64400-IM, Tucson, AZ, 85728-4400 USA; or e-mail me: kvi@galenpress.com.

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2 | What Are Resource-Poor Situations?

INTRODUCTION

In what types of situations would you need to improvise medical equipment and procedures? Experience demonstrates that the most likely scenario for physicians in the most-developed countries is when their usual procedures fail or equipment does not function. That is not the case outside these privileged medical practice arenas:

> The mother's blank stare and hurried manner reveals that she knows how sick the child, that she carries into the emergency department at a rural sub-Saharan district hospital, is. Still swaddled in a colorful cloth, the child stares unseeing from eyes with white palpebral conjunctivae; there's barely a grimace when she's stimulated. A nursing assistant quickly puts her ear to the child's chest to listen for a heartbeat and then applies a venous tourniquet in a vain attempt at finding an extremity IV site. The nurse wants to apply oxygen, but they used the last of it on the night shift; the oxygen concentrator promised for two years has never arrived. She then fashions a scalp tourniquet from a disposable glove and the physician uses an injection needle to place an IO line. The first blood sample is rushed to the lab along with the mother-donor; the blood bank has no blood and the child's findings show that her Hgb is <4 g/dL. More fluid is needed, so the physician starts an intraperitoneal infusion. Blood is not forthcoming, since the lab has run out of reagents and is having to use a coagulation test to check for compatibility.
>
> The child's respirations become labored and, using a makeshift fit with an adult mask, they assist her breathing. They improvise an endotracheal tube and prepare to intubate. They give IV quinine using aluminum foil to control the flow and IM ceftriaxone using a resterilized single-use syringe. Blood arrives; it's still warm. They begin transfusing. The child is doing a little better and the nursing aide steadfastly keeps monitoring the femoral pulse, since that's all that is available. It's going to be a long night.

Throughout the world, clinicians must practice medicine while having to make-do with minimal resources. Acute situations of scarcity often overwhelm the individuals immediately available to respond to them. These may be a local event where the sole medical provider lacks the materials to treat one or more patients, a more widespread calamity that influences an entire community or region, or a long-lasting degradation of care spanning entire countries. Situations of scarcity may last from only minutes to many days or even weeks. Or they may be chronic conditions. Limited-resource situations may be due to physical isolation (e.g., prisoner of war [POW] camp, airplane, ship), being in a remote area (e.g., wilderness, rural highway), being in a least-developed country with a chronic lack of health care resources, or being in a disaster/post-disaster setting.

These situations, especially when they occur in settings where resources are usually plentiful, often result in degraded levels of treatment (Fig. 2-1). But, if clinicians use their ingenuity, this need not be the case. Good medical treatment can often be provided using limited resources if clinicians willingly alter their approach and techniques to fit the circumstances.

Resource-poor situations are logically grouped into simple, extended, and complex disasters, depending on how long they are likely to last, how much help is required, and the degradation of health care and the social order (riots and unrest) that may occur.[1]

Throughout this book, methods that can and should be used in all four circumstances are discussed interchangeably. The focus in many sections is on the chronically resource-poor situations found in the least-developed countries, although these methods may be used anywhere. Each of the main limited-resource settings is briefly described later in this chapter.

Simple disasters last a short time and usually require only local resources. Examples include a multi-casualty motor vehicle crash, an apartment building collapse, a multi-casualty fire, a landslide, and a tornado going through a trailer park. The needed support systems include emergency medical services (EMS), fire services, medical services, and law enforcement. Social order generally remains intact.

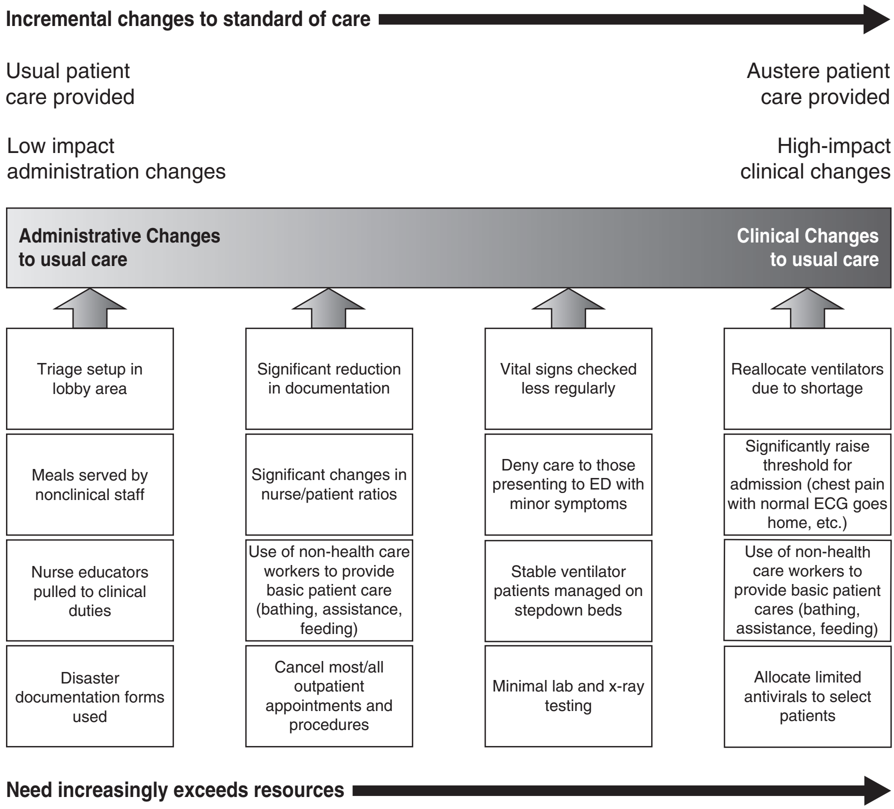

FIG. 2-1. Progression of changes in health care in resource-poor situations. *(Reproduced from Hick et al.[2])*

Extended disasters include widespread flooding, devastating hurricanes or tsunamis, massive heat waves, and major earthquakes. In these cases, the necessary support system also includes outside assistance to augment surviving local EMS, fire services, medical services, and law enforcement. The social order may or may not be partially intact.

Complex disasters are those chronic situations, usually in the least-developed countries, that often are the result of a major drought, famine, or war. A major nuclear incident would also fall into this category. Societal and social support systems are normally disrupted.

ISOLATED SETTINGS

Isolated settings are remote, without an immediate way to gather resources that are not already available. The classic isolated setting is in an internment camp, such as the World War II POW camps. However, isolated settings may also occur on a boat or an airplane or, the ultimate isolation, in space. One of the best-documented physician histories from a POW camp is that of Capt. Thomas H. Hewlett (Surgeon, US Army Medical Corps). He wrote,

> [In the camp,] our only available anesthesia consisted of several vials of dental Novocain tablets. Two of these tablets dissolved in a small amount of the patient's spinal fluid, and injected into the spine gave about forty-five minutes of anesthesia, giving us time to perform most operations that had to be done … . Dutch torpedo technicians were able to make surgical knives out of old British table silver-ware … . We treated fractures without x-rays … . We operated bare handed, [sic] the fingernails of the surgical team stayed black

> as a result of our using bichloride of mercury and 7% iodine in preparing our hands before surgery … . [However,] our infection rate in surgical patients never exceeded 3% … . Sharpened bicycle spokes were used as traction wires in the treatment of hip and leg fractures. Plaster of Paris was never available.[3]

REMOTE LOCATIONS

Remote locations classically include wilderness settings, such as deserts, mountains, caves, forests, and jungles. More commonly, even in the most-developed countries, it means coming across ("on-siding") a personal injury crash or medical emergency far from a source of help. Be prepared by carrying basic materials (see Appendix 2) and being ready to improvise.

Even organized and experienced search and rescue (SAR) teams who carry equipment into the field may have to improvise. While rescuing a patient deep in a cave shaft with a back injury, the SAR team found that no backboard could be maneuvered into the narrow space where she lay. After several hours of working in the hot, humid, cramped, and relatively dark area, they improvised an immobilizer and extricated her from the cave.

LEAST-DEVELOPED COUNTRIES

Chronic shortages are the norm in the least-developed countries. Health care workers know they must make-do with whatever supplies and equipment are available and functioning. As a nurse practitioner student on a medical mission to the rural Philippines wrote, "The challenge of the lack of equipment and medications taught me that we sometimes have to deal with the resources at hand and that there are ways to improvise in order to obtain the same results."[4]

An emergency physician working at a Latin American general hospital (used by the poorest people) found that only two or three vials of medication were available for resuscitation, and only 8-mm endotracheal (ET) tubes were available. The medications would change weekly, as would the ET tube sizes. The medical team made-do with available supplies when they could; when they couldn't, patients died. Improvisation was the norm.

DISASTERS/POST-DISASTER

The key features of disasters are "threat, urgency and uncertainty, which affect not only the victims themselves, but also the organizations that have to respond."[5] Disasters can be from man-made (e.g., multivictim vehicle crashes, terrorism, radiation leaks, and war) or natural (e.g., tsunamis, earthquakes, and epidemics) forces. Both often lead to resource-poor situations. The assistance provided varies greatly, depending on a host of factors.

The vagaries of war can overwhelm what seem to be adequate medical facilities. For example, during the Spanish-American War, three-fourths of all casualties came from the assault on San Juan Hill: "A temporary hospital at Siboney, established to care for only 200 men, was overwhelmed by so many injured that soldiers slept naked on the ground until tents could be set up for them … . For five straight days, doctors treated the wounded."[6]

Terrorist attacks have become common in many areas of the world. Immediate improvisation is often required until organized EMS and medical teams take control. Dr. Wesley Shum worked in "a surreal scene" at a makeshift hospital setup close to Ground Zero immediately after 9/11. We lacked "basic medical supplies like bandages and painkillers … [I] was forced to use cut-up cardboard boxes and strapping tape to make makeshift casts for [my] patients."[7] All of his patients were firefighters injured when the Twin Towers collapsed.

Specific problems associated with different natural disasters are listed in Table 2-1.

Presenting their own mini-disaster, health care facilities may be suddenly struck by an unexpected flood, water or power outage, computer crash, epidemic, or other occurrence that diminishes or overwhelms their capacity to treat patients. For example, when Tropical Storm Allison flooded Houston's Memorial Hermann Children's Hospital in June 1991, the facility lost all but its emergency power. As some nurses described it,

> We had no air-conditioning; garbage and medical supplies filled the hallways. Generators provided electricity as water was pumped out of the building, and the parking lot served as a cafeteria. We had only bottled water and portable toilets. The scene

TABLE 2-1 Common Medical Problems in Specific Situations

Earthquakes		
Long bone fractures	Head, spine fractures	Soft tissue trauma
Dust asphyxia	Crush or compartment syndrome	Animal attacks
Infectious disease problems generally related to water and food. Usually little increase in infectious diseases.		
Tsunamis		
Drowning	Blunt injuries	High mortality-morbidity ratio
Infectious diseases may temporarily decrease, in part due to elimination of insect vectors.		
Tornadoes		
Blunt, crush, and penetrating wounds		Eye injuries
Volcanoes		
Blunt, crush, and penetrating trauma	Dust asphyxiation	Burns
Eye injuries	Little evidence of increased infectious disease	

Adapted from Rega.[1]

> bordered on catastrophe. [The next day] the ground floor was under 4 feet of water; the basement was completely submerged … . We climbed the seven flights of stairs to the NICU in the dark and were immediately hit by hot, humid air and pitch-black darkness. The usual noises were strikingly absent: none of the cardiopulmonary monitors, ventilators, radiant warmers, or incubators worked. Every baby was covered with blankets to contain warmth.[8]

DISASTER MYTHS

As Jeff Arnold wrote, "At least one thing has become predictable about disasters in recent years—once a disaster begins to unfold, an outbreak of disaster mythology is likely to ensue."[9] The persistence of such myths is attested to by David Alexander,

> This reaction is particularly tragic in response to disasters, in which incorrect beliefs often are the basis for misguided actions that lead to avoidable casualties and suffering … . One of the most troublesome aspects of present-day responses to disasters is the crushing inevitability of the mistakes that are made, the myths that are propagated, and the inefficiencies that plague their management. For the people who live through them, disasters are times of accelerated learning … . Disaster myths are robust enough to survive Herculean attempts to debunk them.[10]

Many people, even experienced disaster workers, have trouble not believing all the myths in Table 2-2.

ETHICS

While it may seem obvious in the aftermath, making the decision that a significant resource-poor situation is developing into a disaster may, at the time, be difficult, bureaucratic, financially burdensome, and ethically charged. Specific, measurable, and widely known "triggers" must be in place so that an on-site individual can declare a disaster. This allows the mobilization of resources while they can still be most effective. (See Appendix 1, Hospital Disaster Plan, for a generic all-hazards approach to identifying and responding to localized or larger disasters.)

TABLE 2-2 Typical Myths and Misconceptions About Disasters

Myth: Disasters are unusual events.

Reality: Disasters occur frequently, and the same types often occur in the same locations (e.g., flooding in Bangladesh). Since 1995, on average, more than one natural disaster per day has been reported throughout the world.*

Myth: Disasters kill people without respect for social class or economic status.

Reality: The poor and marginalized are more at risk of death than are rich people or the middle classes.

Myth: Earthquakes commonly result in a large number of deaths.

Reality: The majority of earthquakes do not cause high death tolls. Deaths can be reduced further by constructing anti-seismic buildings and teaching people how to behave during earthquakes.

Myth: People can survive for many days when trapped under the rubble of a collapsed building.

Reality: The vast majority of people extracted alive from rubble are saved within 24 hours, and often within 12 hours of impact.

Myth: Panic is a common reaction to disasters.

Reality: Most people behave rationally in a disaster. While panic occasionally occurs, many disaster sociologists regard it as insignificant.

Myth: People flee in large numbers from a disaster area.

Reality: Usually, there is a "convergence reaction" and the stricken area fills with people. Few survivors leave, and even obligatory evacuations are short-lived.

Myth: After a disaster, survivors tend to be dazed and apathetic.

Reality: Survivors rapidly start reconstruction. Activism is much more common than fatalism. (This is the so-called "therapeutic community.") Even in the worst scenarios, only 15% to 30% of victims show passive or dazed reactions.

Myth: Disasters usually give rise to widespread, spontaneous manifestations of antisocial behavior (riots).

Reality: Generally, disasters are characterized by great social solidarity, generosity, and self-sacrifice, perhaps even heroism.

Myth: Looting is a common and serious problem after disasters.

Reality: Looting is rare and limited in scope. It mainly occurs when there are strong preconditions, as when a community is already deeply divided.

Myth: The disruption and poor health caused by major disasters nearly always cause epidemics.

Reality: Generally, the level of epidemiological surveillance and health care in the disaster area is sufficient to stop epidemics from occurring. However, the rate of disease diagnosis may increase due to a temporary increase in the availability of health care.

Myth: Disasters cause a great deal of chaos, preventing systematic management.

Reality: There are excellent theoretical models of how disasters function and how to manage them. The general elements of disaster are well known from more than 75 years of research. The same events tend to repeat themselves from one disaster to the next.

Myth: To manage a disaster well, it is necessary to accept all forms of aid that are offered.

Reality: It is better to limit acceptance of donations to goods and services that are actually needed in the disaster area.

Myth: Any kind of aid and relief is useful after disasters, provided it is supplied quickly.

Reality: Hasty and ill-considered relief initiatives create chaos. Only certain types of assistance, goods, and services are required. Not all useful resources that existed in the area before the disaster will be destroyed. Donation of unusable materials or manpower consumes resources of organization and accommodation that could more profitably be used to reduce the toll of the disaster.

TABLE 2-2 Typical Myths and Misconceptions About Disasters (*Continued*)

Myth: One should donate used clothes to the victims of disasters.

Reality: This often leads to accumulations of huge quantities of useless garments that victims cannot or will not wear.

Myth: Great quantities and assortments of medicines should be sent to disaster areas.

Reality: The only medicines that are needed are those that are used to treat specific pathologies, have not reached their sell-by date, can be properly conserved in the disaster area, and can be properly identified in terms of their pharmacological constituents. Any other medicines are not only useless but also potentially dangerous.

Myth: Companies, corporations, associations, and governments are always very generous when invited to send aid and relief to disaster areas.

Reality: They may be, but, in the past, disaster areas have been used as dumping grounds for outdated medicines, obsolete equipment, and unusable goods, usually garnering tax benefits for the donors, under the cloak of apparent generosity.

Myth: Unburied dead bodies constitute a health hazard.

Reality: Not even advanced decomposition causes a significant health hazard. Hasty burial demoralizes survivors and upsets arrangements for death certification, funeral rites, and, where needed, autopsy. The living rather than the dead are contagious.

Myth: Technology will save the world from disaster.

Reality: The problem of disasters is largely a social one. Technological resources are poorly distributed and often ineffectively used. In addition, technology is a potential source of vulnerability as well as a means of reducing it (e.g., computer crashes, power outages).

Myth: There is usually a shortage of resources when disasters occur, and this prevents them from being managed effectively.

Reality: The shortage, if it occurs, is almost always short-lived. There is more of a problem in deploying resources well and using them efficiently than in acquiring them. Often, there is also a problem of coping with a superabundance of certain types of resources.

Myth: International rescue workers save thousands of lives during the aftermath of natural disasters.

Reality: Lives are saved only during or immediately following the event. Search and rescue effectiveness declines rapidly after 12 to 24 hours.

Myth: Foreign-run field hospitals are the primary way to provide mass casualty treatment after disasters.

Reality: Local health care providers and systems provide most casualty management. Foreign workers often supply only ancillary help.

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*EM-DAT Emergency Disasters Data Base: Natural disasters reported 1900-2006. http://www.em-dat.net/disasters/img/Total%20reported%20damages%20in%202006%20billions%20from%20disasters%201900–2006.pdf. Accessed September 30, 2007.
Data from Alexander,[10] PAHO,[11] and De Ville de Goyet.[12]

Two excellent, free, online disaster resources are available: The World Health Organization's Health Library for Disasters (www.helid.desastres.net/) is available in English, French, and Spanish. Three short videos (in English and in Spanish) describing the method behind and the ethics of allocating scarce resources in disaster situations can be found at www.crestaznm.org.

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3 | Communications

Communication is the exchange of information. Successful communication reaches the correct recipient in a timely manner and is interpreted accurately. In resource-poor situations, especially following disasters, difficulty with communication is usually the major problem faced by health care and other service/rescue providers.

POST-DISASTER COMMUNICATION NEEDS

Multiple space-based satellite communication systems have been used internationally during disasters.[1] Even in the best circumstances, this type of communication may not be available until several hours, or even days, after major disasters. However, good communication is needed immediately. Whichever makeshift methods are used depends upon what resources are still available.

GENERAL PROBLEM

Relying on a predisaster or "normal" telecommunication system—such as landline telephones, cellular telephones, or pager systems—to work in austere circumstances is foolish. Communication systems fail during disasters due to (a) network/signal problems, (b) electrical power loss, (c) damage to infrastructure, (d) surviving infrastructure (telephone, cellular phones, etc.) overload, or (e) system damage that overwhelms repair crews.

COMMAND AND CONTROL

In disasters and other chaotic situations, successful control of the situation depends upon obtaining adequate information and distributing messages to those with "boots on the ground." This often takes ingenuity.

For example, rather than being used for rescue or extraction, the first helicopter on the scene of a widespread disaster, such as a commercial airliner crash, may best be used as a command and control center for subsequently arriving ground rescue units. The relative positions of the victims and rescue units can be better seen from an elevated vantage point than from the ground. Experience has shown that directing rescue units from the air in these circumstances may save the lives of victims who may otherwise not have been found in a timely manner. This approach also ensures more efficient use of rescue units.

Most ambulances now have large roof markings for identification from above. If ambulances do not have these, apply temporary markings using water-based paint or tape. Number and letter (alphanumeric) combinations should be used to minimize duplication. Symbols (star, box, tree) may also be used with or without an alphanumeric designation. Everything should be very large, so the controller can see it easily from the air.

In chaotic situations, it is often difficult to keep track of contact information for the multiple teams, agencies, and individuals. Keep and carry a personal log with this information, as well as a record of important events, directions, methods of making/procuring equipment or supplies, and so forth. During the response to Hurricane Katrina, such a log proved invaluable for tracking the constantly changing satellite and cell phone numbers for key contacts from multiple agencies. Use a small spiral notebook that can fit in your pocket, or a hardback, bound notebook, as some military personnel use.

TELEPHONES

During power outages and other crises, cell phones may often be used to bypass other failed systems. However, even with a functional system (i.e., the cell towers working), cell phones may not work inside all the areas of modern hospitals because of shielding and other dense barriers to the signals. More mundane, it may be difficult to locate cell phones or landlines designated for emergency use in the dark. Putting a piece of reflective tape on them can help, assuming that there is any light source.

One fix to the internal hospital communication problem is to use hard-wired, directly connected phones, similar to those used in caving. If possible, install direct lines in advance between key parts of the institution, such as between the emergency department, ICU, OR, command center, security, power station, laboratory, and medical records. In addition, use building wiring for a field phone conduit. The problem is getting surplus field phones. Wired intercoms may also be used if they can be configured to run on battery power. [Scott Clemans, Consulting Engineer, Tucson, Ariz., in a letter to the author, September 11, 2008.]

After an earthquake, be sure all phone handsets on the same line are in their cradles; if one is off the hook, no calls can be made or received. If you get a fast busy signal or an "all circuits are busy" recording, hang up and try again. You may have to wait several seconds for the dial tone as the circuits are rerouted. Have at least one phone that plugs directly into the phone jack in the wall. If a phone has an AC power adapter (cordless phone), it will not work if the power is out.

Even when the local circuits are overloaded, if telephone service remains uninterrupted, it may be possible to dial a long-distance number. Call a contact outside the local area (preferably in another state) who can call back into the affected area to relay messages.

Priority Status

Another solution (in the United States) is to arrange in advance for the organization or facility to obtain priority communication status. For landline communication, qualifying agencies may obtain this through the Government Emergency Telecommunications Service (GETS) program (http://gets.ncs.gov/; Tel: 866–627-2255). An equivalent service for wireless communication is the Wireless Priority Service (WPS) program (http://wps.ncs.gov/; Tel: 866–627-2255). These systems allow first responders, police and fire personnel, and federal, state, and local governments priority access to land and cell lines during a crisis. With GETS or WPS priority, the user dials a 710 phone number and then enters a code that grants priority to the call through the three major landline providers. If a call to the 710 number is made from a landline, the call is also granted priority on cellular providers' lines.[2]

Cellular Phones

Cellular phones are excellent communication tools when they function. However, there are three problems: (a) cell towers may be down (as after Hurricane Katrina); (b) power may not be available to recharge phones; or (c) buildings in which phones must be used have too much steel, concrete, and lead for cellular service to function effectively.

Interestingly, in some affected areas after Hurricane Katrina, text messaging seemed to work when voice messaging did not. Since Katrina, some hospitals are stocking cell phones with long-distance area codes, assuming that the phones will work even if the local cell towers are down. They won't.

Computer-Based Telephone

As with other computer applications, if the power is out and no batteries or generators are functioning, the computers (and thus Internet phones) will not work. If the power is on and the Internet provider is online, voice-over-Internet protocols (VoIP) are an excellent communication method. Some provide both audio and video connections.

PATIENT–CLINICIAN COMMUNICATION

Interpreters

In resource-poor circumstances, anyone who is willing and *says* that they are able to translate is often used as an interpreter. However, in such cases, there may be problems with a translation's accuracy and completeness. Additionally, the use of friends or family members as translators may interfere with patient confidentiality, cause patients to avoid sensitive issues, and disrupt established social roles.

Assessing translation skills can be difficult. Even when health care personnel are used as makeshift translators, accuracy may be an issue. About 20% of dual-role staff interpreters have insufficient bilingual skills to serve as interpreters in a medical encounter.[3]

FIG. 3-1. Pictorial communication cards. *(Source: Anon.[4])*

Pictures

Without interpreters, pictorial representations may be effective for limited clinician–patient communication. It is best to prepare these pictorial representations in advance (Fig. 3-1). You can, of course, also draw simple figures and hope that the patient understands them.

When working with the deaf, use the pictures and supplement them with written messages back and forth—if the patient writes a language you understand.

LOCAL-AREA COMMUNICATION

Makeshift Signals

In a localized area, preset signals may be used for communication. Signal bells have been used for decades in mines and on ships to indicate specific needs or actions (e.g., send lift down, danger, help, time, etc.). Flags, whistles, lights and mirrors, or even hand signals can be used to transmit a message. It is important to predetermine the meaning of signals and to make certain that they can be heard or seen by the recipients.

Tracking Patients

Blackboards or white (erasable/grease marker) boards are used throughout the world to keep track of patients, personnel assignments, and patients' orders, tests, and bed assignments. These boards are used in all clinical areas, including emergency departments, operating rooms, and patient wards. It generally should have columns for the patient's room number, name, age, sex, problem/diagnostics (widest column), physician(s), nurse(s), admitting area, and consultations.

While this may seem to be the most obvious and easy solution to tracking and locating patients in the emergency, outpatient, and inpatient units, experience shows that many, if not most, providers around the world detest using it. If an unused white board has become a "white elephant," wasting space, remove the lines and turn it into a teaching board to illustrate procedures and with cases ("case-of-the-day") and questions. The staff often appreciates this approach to teaching.

In recent years, boards have been replaced in many institutions with computerized tracking systems. When computers go down or the electricity fails, track down an appropriate board to use (the best place to look is in the institution's administrative area). Remember to grab the writing instruments needed for that type of board.

PATIENT INFORMATION

Patient Records

Patient medical records are the most elegant method of transferring patient information to other clinicians and helping them pursue a relatively straightforward track toward diagnosis and therapy. Records communicate to others which treatments have been performed, results of tests, successes and failures with different therapies, and plans for future interventions.

Transferring Patient Records

When transferring a patient to the care of other clinicians, it is vital that the patient's records be transferred as well. This may mean the records are sent from battlefield to medical facility, from emergency department to ward, from clinic to hospital, or over hundreds or thousands of miles.

An old, workable method of transmitting the vital information that a tourniquet has been applied to a trauma patient is to write a large "T" on the patient's forehead using lipstick, grease pencil, heavy marking pen, or the patient's blood.

Clothespins, safety pins, a lanyard, string, or paperclips can be used to attach information about patients to their clothing during mass casualty situations or when they are being transferred to another facility. Make a hole through the papers (or their container/envelope) and reinforce it with tape to avoid ripping. Then use a paperclip or clothespin to attach the records to their clothing through a buttonhole or another part of the garment. A string or cloth tie may also be used to attach the records. Note that records may be lost if attached to medical equipment. Information can also be written directly on postoperative abdominal dressings (Fig. 3-2) or included on a USB (thumb) drive. Similarly, after initially providing fracture care, provide the patient with a "Fracture Passport," the name given to writing vital information on the patient's cast (Fig. 3-3).[5]

Transmitting Images

The wide availability of the Internet, digital photography, and camera phones makes transmitting images of patients and radiographs much simpler than in the past—and possible even in austere circumstances. Images can be transmitted (a) to get advice from distant consultants, (b) to avoid repeating costly and time-consuming radiography, and (c) to provide sufficient information so that receiving facilities can make appropriate preparations for patients before their arrival.

Useful Patient Information to Send

Useful patient images and information to send to other practitioners, government authorities (in the case of missing or dead patients), or to the patients include identifying and relatives' contact information, graphic patient charting (e.g., vital signs, anesthesia records, or medication lists), other vital written records (e.g., the history/physical exam, discharge summary, and list of medical/surgical interventions), test and monitoring results (including ECGs, rhythm strips,

FIG. 3-2. Patient information written on postsurgical dressing.

EEGs, lab tests), images of the patient's injuries or intraoperative photos, gross pathology specimens, radiographic and ultrasound images, and information or images of unidentified bodies or noncommunicative patients.

Pictures may be sent using e-mail or text messaging. On some models, the memory card can be removed and inserted into a computer or printer using an adapter. If the phone company has

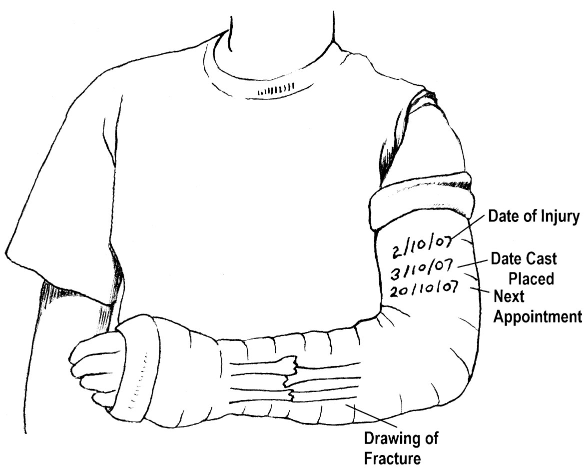

FIG. 3-3. Fracture "passport."

a way to transmit pictures (most do) and you subscribe, this should work smoothly. This photo may be sent to another cell phone or, for better resolution, to an e-mail address. To get the best photo, remain steady for at least a second after pushing the button, use the highest resolution, stand as close as possible to the subject, and do not use the digital zoom.

Transmitting Digital Camera Images

To transmit digital images via the Internet, download camera or digital x-ray images. Once downloaded to a computer, they can be sent via the Internet. In cases where bodies may need to be identified, images or information can be posted to a public Internet bulletin board.

For a digital radiograph, use a close-up setting and no flash; a standard radiograph, no flash; and for a patient/body photograph, no flash for close-ups. For studies with multiple images, such as CT scans, it is important to select and send the most clinically significant images, rather than the whole study.

Transmitting Images From a Phone's Camera

Images can be taken using the camera built into most cellular phones. They can then be downloaded to the Internet or sent through the same phone, depending upon the service provider and the services available on that phone. Both ends of these messages must be able to interpret the image format, or an "image protocol conversion" may be required. (This is not usually a problem while using standard photo formats.)

Images can be sent from most cellular phones to an e-mail address. The quality of the image, however, will be less than that is seen on an original photo or on the original document (e.g., ECG). However, it still should provide enough detail so clinical decisions can be made.

Images can also often be sent from one cell phone to another: This may not be available on all phones or with all cellular phone providers. When it works, it may take a while for the images to be transmitted. When transmitted, to best view the image, download it to a computer so the image can be manipulated.

INTRA-INSTITUTIONAL AND REGIONAL COMMUNICATION

Communicating Within Medical Facility

Paging Systems

Many modern hospitals rely heavily on their paging systems; these systems generally depend on the telephone system and on the normal power supply When backup generators kick in, these systems may fail. Prepare for this by keeping up-to-date contact lists, in paper and electronic forms. (Paper lists are important, since computers may not be operational.) Telephone numbers for vital sites within the facility (especially the radio or telephone hubs) as well as contact information for physicians and other hospital staff should be listed here.

Walkie-Talkies

Many hospitals plan to use walkie-talkies (low-wattage radios) for post-disaster internal communication. Except for line-of-sight (straight line without obstructions) communication, they are ineffective in modern buildings, such as hospitals.

Our tests have demonstrated that walkie-talkies and handheld radios (even up to 5 megawatts and with antenna repeaters placed) failed to transmit signals in any consistent manner in a modern hospital. The tests included checking transmission vertically and horizontally in the building. The only way these radios function in modern buildings is to use a "trunk" repeater (essentially, a giant antenna) running through the core of the building. Even then, experience shows that transmission is not consistent, and that there are numerous "dead" spots from which messages cannot be heard. These dead spots change daily, depending on atmospheric and other conditions.

Runners

When communication options are not available, it usually means there is (a) no electricity, (b) no Internet, and (c) no working land or cellular phones. To construct a runner system, remember that the goals of a runner system are to transmit messages between specific points ("nodes" or "hubs") within an institution or a local area in a manner that maximizes efficiency, that is, that uses the fewest runners (messengers) and has the fastest transmission times. Using set nodes or hubs is the efficient model that FedEx employs. [Alan Reeter, MSEE, Tucson, Ariz., in a conversation with the author, March 26, 2008.]

The types of messages transmitted between sites typically vary in volume and urgency. System efficiency can be increased if the senders designate each message as "1" urgent/stat, "2" important, or "3" routine or delay-tolerant. Category 1 messages are urgent requests for help, equipment, or supplies; critical lab reports; or urgent security warnings. Most clinical messages fall into category 2, while category 3 messages are administrative information, general announcements, and so forth. All level 3 messages can be routed to the central node, where they may be stored until several messages are collected to send to the same location. This "store-and-forward" technique conserves resources and decreases runners' frustrations from continually delivering status 3 messages.

Assuming that the message volume between different nodes (sites) varies and no mechanism exists to signal runners at different nodes that they are needed elsewhere to carry a message, the following method is a way to determine how many runners are needed.

The general scheme is to position the "command center" so that there is minimal distance between the command center and the nodes. With the normal scarcity of runners, base most runners at busiest nodes, with a minimum of one runner at every node. Have runners go in only one direction; let another runner return to the original node. (This system generally provides a rest period for the runners.)

The number of runners based at a node also depends upon the distance they need to travel (and the time it takes to do so) to reach the most distant or difficult-to-get-to site. In a hospital, this may mean running between a node in the basement and one in the 12th floor ICU. If the lab and pharmacy (two frequent-message sites) have satellite facilities near the busiest clinical nodes, this limits the number of messages (and runners) required.

The following formula helps to determine how many runners are needed. With a runner dedicated to each pair of nodes, the total number of runners will be $N \times (N - 1)$, where N = the number of message nodes. For example, 3 nodes require 6 runners, 4 nodes require 12 runners, and 6 nodes require 30 runners. Optimally, the number of runners at each node would be N minus 1, with each of 6 nodes having 5 runners (Fig. 3-4). Since this number is too large for most situations, either decrease the number of nodes or assign more runners to the high-priority nodes. (Be aware that doing so may decrease the system's efficiency.)

Runners need to work in shifts. Assuming that they work 12-hour shifts, the total number of runners required will be double the number for each shift (plus extras for illnesses and time off).

Typical hospital nodes may include the command center/central administration, emergency department, ICU 1, ICU 2, ward 1, ward 2, ward 3, OR, pharmacy, laboratory, personnel pool, security, food services, and ambulance bay/helipad. Adjacent areas (e.g., two wards next to each other) can share one communication node.

Regional Communication

Mobile Radios

The idea of using mobile radios is appealing. However, several problems exist. The first is that they can be very expensive, although the basic models cost only about $100 each. Next, there is

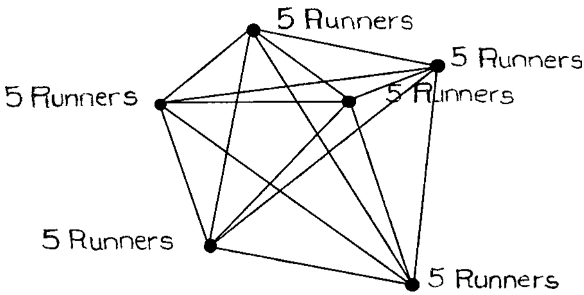

FIG. 3-4. Nodes-runner system.

the question of compatibility with other radios in use, concerns about message security, and the fact that the transmitting range diminishes depending on terrain, weather, buildings, body mass, and so forth. The range can be extended with one or more repeaters that rebroadcast the signals and thus increase their range.[6]

Despite these problems, consider using low-cost Family Radio Service radios to keep in touch with neighbors and family members. The range is 1 to 2 miles, and no license is required. Set up a network of these radios in your neighborhood to help each other in a disaster.[7]

Amateur Radio Operators (Hams)

Groups of amateur radio operators exist in many areas of the world to help with communications in disaster situations. In the United States, these groups are ARES and RACES. They generally have preset and tested equipment and can be activated in crises. This is an excellent method, even under austere circumstances, to communicate with others with similar amateur radio (not necessarily just ARES or RACES) capabilities.

LONG-DISTANCE COMMUNICATION

Depending upon the extent of the disaster, telephones and radios can often be used for long-distance communication. Other options include the use of satellite phones and the Internet, assuming these are available. Any of these methods can be used in any resource-poor situation for telemedicine consultation with experts. Depending upon the system, satellite phones can be difficult to use, expensive, and subject to the vagaries of weather.

Internet

If the local computers (or handheld devices), servers, and Internet providers are operating, e-mail and VoIP (phone) are excellent communication tools. The Internet was designed to survive a nuclear holocaust, so the system will not go down; you just may not be able to access it when you need it.

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4 | Preventive Medicine/Public Health

WATER

Emergency Water Supply

After breathable air, water is the next vital need people have. Water is necessary for drinking and food preparation (2-5 L/day), personal hygiene (2-6 L/day), and cooking (3-10 L/day). Potable water is required to lessen the chance of spreading water-borne diseases and to have a functioning health care facility.[1,2]

Even if water is available, a loss of water pressure or of electricity for the pumps can mean that toilets become inoperable. Wastewater can be used to "prime" the toilets, but a plan for disposing of waste is necessary.

If large alternative water sources can be identified, a method of transporting the water must also be found. For smaller, more immediate needs, sterile saline and sterile water may be used, in emergencies, for hand washing, although it may be better to save the sterile water for drinking and cooking. Using waterless hand wipes conserves water.

Preparing Drinking Water

Supplying sufficient amounts of clean drinking water is vital to prevent outbreaks of severe gastrointestinal disease. Nearly all springs, streams, and rivers are contaminated to varying degrees by commercial effluent, natural mineral run-off, or animal feces. Wells usually are not contaminated with microorganisms, but the water frequently has a high mineral content.

It seems logical to collect drinking water from atmospheric sources (rain, snow), but such water is often contaminated with dissolved and suspended substances. Even so, if properly collected, this water is within acceptable limits for potability. Using scrapings from the top layer of newly fallen snow is the best option. Less acceptable is collecting rainwater from a roof very shortly after a rain, using clean drain pipes. This method cannot, however, be used for snow, since it becomes contaminated prior to melting.

Improve the collected water's quality by filtering it through commercial filters or through white cotton cloth that has been boiled in soapy water and then rinsed thoroughly. Using that filter with new-fallen ground snow taken from the surface eliminates bacteria. Unfiltered ground snow has 44 bacteria/mL and cotton-cloth-filtered rainwater has 124 bacteria/mL. Unfiltered rainwater contains more than 1000 bacteria/mL with clumps of potentially pathogenic organisms. Filtering through filter paper, newspaper, four-layered gauze, and cotton is unsatisfactory.[3] Bangladeshi villagers used old cotton saris to filter homemade drinks. They folded the sari cloth (mesh size ~20 micrometers) so it had eight layers. Filtering through this cloth reduced the cholera incidence by 48%.[4]

When using dirty or cloudy water, clarify it before disinfecting it. Filter it through a cloth or sand filter, or allow it to stand so that particles and associated bacteria sink to the bottom.

Disinfect the water, if necessary. Boiling or heating can be effective for small amounts (as for households). Heat water to temperatures >70°C (160°F) for 30 minutes to kill all enteric pathogens. If the water temperature is raised to 85°C (185°F), pathogens are eliminated within a few minutes. If water is brought to a boil, it is safe, even at high altitudes.[5,6] Water can be partially disinfected if left in a clear or translucent storage container for an hour or more in the hot sun. (For what "hot" means, this was done in Beirut, Lebanon.)

If using chlorine, add 3 drops of chlorine solution to each liter of water, mix well, and wait for half an hour before drinking it. To make the chlorine solution: mix 3 level tablespoons (33 g) of bleaching powder in 1 L of water. This formula is for a bleaching powder that contains 30% concentration by weight of available chlorine. The quantity of bleaching powder to use should be adjusted depending on the available bleach.[7]

If using iodine tablets (tetraglycine hydroperiodide), dissolve one tablet in 1 L of water. Almost all water treated with this dose is safe for drinking. Use two tablets for heavily polluted water.[6] If 2% tincture of iodine is used, add 5 drops to 1 L of clear water; if the water is cloudy or cold, use 10 drops. Let the water stand for 30 minutes before drinking. If using 10% povidone-iodine or 1% titrated povidone-iodine, use 2 drops. (Betadine is usually 2% strength, so 10 drops will be needed.) Let stand for 30 minutes. If the water is cold and clear, wait 60 minutes; if it is very cold or cloudy, add 4 drops and wait 60 minutes.[6] Do not use iodine crystals.[8]

For chlorine bleach (liquid), place 2 drops of chlorine bleach (5.25% sodium hypochlorite) in a canteen of clear water. Let stand 30 minutes. If the water is cold or cloudy, wait 60 minutes. Remember that not all bleach is the same concentration; check the available level of sodium hypochlorite.

For formula-fed infants, use ready-to-feed formula, if available. If not, use bottled water to prepare powdered formula. Use boiled water only if bottled water is not available. A last choice is disinfected water.[9]

After purifying a canteen of water, partially unscrew the cap and turn the canteen upside down to drain unpurified water from the inside of the lid and the threads of the canteen, where your mouth touches.

While having the cleanest possible drinking water is important, "quantity is of greater importance than water quality: People are more likely to become ill as a result of having soiled hands, dirty eating utensils, or from eating food prepared with soiled hands than from drinking contaminated water. That is not to say that the quality of water is unimportant, merely that it is less important than having sufficient water. A large quantity of water that is not completely free of bacteria is better than a small amount of pure water."[10]

SANITATION

Food

Poor food handling and storage is often the cause for enteric disease outbreaks. If permeable food containers have been exposed to flood water, discard the containers and food. If a lack of power results in food being held at the wrong temperature for >2 hours, discard it. The appropriate refrigeration temperature is <40°F (4.4°C); hot food should be kept at >140°F (60°C). If there is no refrigeration, discard any perishable food items, including meat, fish, eggs, and leftovers. Also, discard any food with an unusual odor, color, or texture.[11]

Latrines

Since disease prevention can be much easier than treatment (although not as dramatic), the placement, design, and use of toilet facilities can markedly lessen the incidence of transmitted disease.

Place latrines >60 feet (20 meters) from all water (wells, rivers, springs, and streams) and living quarters (Fig. 4-1). If near a water source for people, latrines must be downstream.[12]

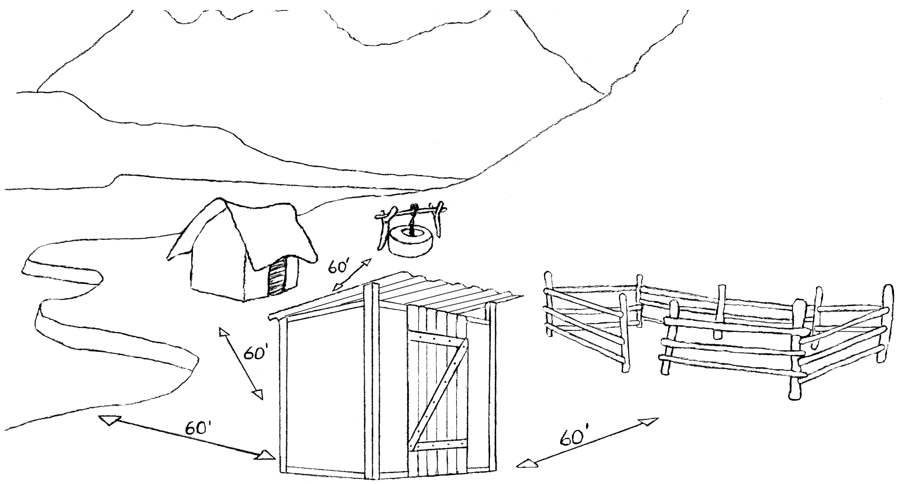

FIG. 4-1. Positioning the outhouse.

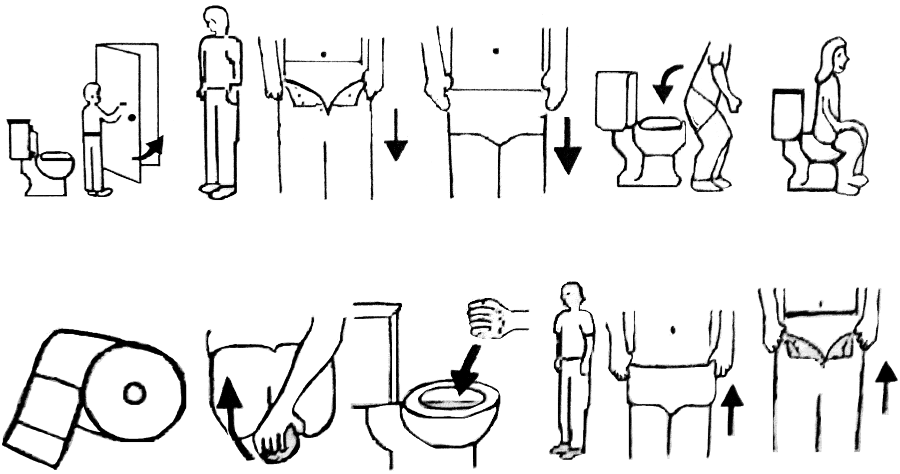

FIG. 4-2. Pictorial instructions for using flush toilets.

The simplest latrines are vertical or horizontal pits. Throwing dirt, lime, or ash into the hole after each use reduces the odor and the flies. A pile of this material and a scoop or shovel can be kept next to the hole. If vertical, the hole can be covered with a simple outhouse that can be moved to the next hole when the current one is filled. People are more likely to use the latrine if it is at least minimally comfortable, private, easily accessible, and kept clean.

Comfort starts with a place to sit (see Fig. 5-9). Position a simple portable toilet seat over a deep hole. Place a shovel next to a dirt pile to scoop over each person's waste. In Polar Regions, build outdoor latrine walls with ice bricks. Place a concrete cover over the pit toilet for longer-term situations.

In general, place a minimum of 1 latrine or toilet/20 beds or 50 outpatients in short-term, disaster situations. For long-term situations, the number should increase to 1 latrine/10 beds or 20 outpatients.

Even if flush toilets are available, people in remote locations may not be familiar with them, and some instruction may be necessary. To avoid embarrassing them, it may be easiest simply to place an instruction sheet on how to use the toilet on the wall (Fig. 4-2).

Incinerators

Deeply bury or incinerate dangerous and infectious waste. An incinerator for use in a home or small clinic can be fashioned from an empty coffee can. Punch holes in the bottom of the can and in the cover to provide the necessary draft. Place soiled gauze dressings and other small, easily flammable items in the can and put on top of a gas stove or open fire. After the gauze starts burning, put a wire mesh screen over it. The gauze will burn easily, completely, and safely.[13] Larger amounts of medical waste require the use of a formal incinerator.

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5 | Basic Equipment

AVAILABILITY AND IMPROVISATION

Basic medical equipment may not be available when needed. In developing countries, for example, even some of the largest hospitals lack basic medical equipment.[1] Louis Pasteur reportedly said, "Chance favors the prepared mind." Be prepared to improvise. This book supplies ideas about how to make-do when faced with shortages. Problem-solving skills will take you the rest of the way.

"When improvising medical equipment, consider whether it (A) Will accomplish the purpose for which it is intended? (B) Is practical? and (C) May cause an accident or increase danger to the patient or clinician?"[2]

FACILITIES

Health care resources, whether purchased, donated, or improvised, should be matched with the skills of the practitioners and the type of facility in which they are to be used. Table 5-1 describes the spectrum of health care facilities worldwide and is the basis for the "Essentials" tables in this chapter (Table 5-2) and elsewhere in the book.

Improvised (Safe) Medical Structures/Modification of Existing Structures

Any available site may be used to provide immediate health care when local facilities are overwhelmed. Generally, these will be buildings of convenience. Optimally, such buildings will be selected in advance and assigned a specific use (ambulatory care, hospital or nursing home overflow, minor acute hospitalization). Control (who runs and is responsible for it) and funding (who pays) for the facility, as well as the required supplies and equipment, should be predetermined. In most cases, a contingency contract with the building's owners will be necessary.

The following elements are necessary for any health care facility to function. They may need to be improvised at alternative sites, and even at regular health care facilities in disaster or austere situations.

Access

Identification as a Health Care Facility

Making the public aware of the availability of a makeshift medical facility is an often overlooked task. Workers assume that once they have set up shop, people will know where they are located. Not true! If possible, make easily visible signs with identifiable symbols (e.g., Red Cross, Red Crescent, Mogen David Adom, or Disaster Medical Assistance Team [DMAT]). Also, ask patients and others who visit the site to spread the word.

Ramps

If the facility you use has stairs at the entryway or inside the building between patient care areas, build ramps so that non-ambulatory patients and those with difficulty walking have easy access.

When elevators are not functional, use pulley systems to help get stretchers up ramps with steep inclines. Such pulley systems, similar to search and rescue haul systems, can be set up and operated by fire department/rescue teams.

Light Sources

Health care facilities must have ambient lighting and specialized task lighting for workers to perform examinations and procedures. Since electrical power may be limited or nonexistent, you may need to improvise.

Sunlight

Sunlight (or even a bright moon) can provide excellent general lighting. During the US Civil War, for example, surgeons often performed operations outside. This provided them with much

TABLE 5-1 Spectrum of Health Care Facilities

Basic	Village health posts Clinics with nurses or medical assistants Clinics with doctors
General Practitioner Hospital	General practitioner-staffed hospitals General practitioner-staffed with surgical capabilities
Specialty Hospital	Hospitals with general surgeons Hospitals with general and orthopedic surgeons Hospitals with general and orthopedic surgeons and other specialties
Tertiary Hospital	Tertiary care facilities with limited range of specialties Tertiary care facilities with full range of specialties

Adapted, with permission, from Mock et al.[3]

better light than they could get inside the hospital tent. It also was safer, since there was no need to have an open flame that could ignite the flammable anesthetic they were using.[4]

When using sunlight for illumination, it helps to know how much time you have until sunset. Hold your palm out flat toward the Western horizon. One fingerbreadth from the horizon to the bottom of the sun = 15 minutes until the sun sets.

Headlamps/Flashlights

Powerful illumination is, of course, necessary in the operating room (OR). It is also needed for many diagnostic and therapeutic procedures, including intra-oral and gynecological procedures. Even at major medical centers during normal conditions, extra light may be needed. Carrying a

TABLE 5-2 WHO Basic Diagnostic/Monitoring Essentials

	Facility Level			
Resources/Capabilities	Basic	GP	Specialist	Tertiary
Stethoscope	E	E	E	E
Blood pressure cuff	E	E	E	E
Flashlight (torch)	E	E	E	E
Thermometer	E	E	E	E
Fetal stethoscope	D	E	E	E
Urinary catheter and collection bag	D	E	E	E
Otoscope	D	E	E	E
Ophthalmoscope	D	D	E	E
Pediatric-length-based tape (Broselow)	D	D	D	D
Electronic cardiac monitoring	I	D	D	D
Central venous pressure monitoring	I	D	D	D
Right heart catheterization	I	I	D	D
Intracranial pressure monitoring	I	I	D	D

Abbreviations: D, desirable; E, essential resources; I, irrelevant.

Adapted, with permission, from Mock et al.[19]

powerful, small, battery-powered, and hands-free headlamp literally "saves the day" by providing sufficient light to examine patients and do procedures when the power fails or the existing light is insufficient.[5]

When choosing a headlamp, check the brightness and the focus at the distance you will need to perform procedures. Also, be sure it is comfortable to wear for several hours (or an entire shift) and that you can get extra batteries for it. (Rechargeable batteries are useless if the power is out.)

Very small flashlights, such as the penlights that health care professionals commonly carry, can be tucked into an elastic athletic headband or an elastic bandage wrapped around the head to make a headlamp. Laryngoscopes have been used for light when ORs unexpectedly lost power.

Room Lighting

Solar-powered garden lights work well as room lighting (if charged). They last for several hours and work best if put into an empty 2-L soda bottle (with a hole cut in the side). They can be carried around, and the plastic helps diffuse the light, like luminarias (paper bags half-filled with sand in which a candle sits). Just remember to put them in the sun to recharge.

Automobile Headlamp

One group successfully used an automobile headlamp as a light for the OR. They wrote that

> The halogen headlamp is preferable to an incandescent lamp because of greater light intensity. A 12-volt automobile battery serves as the power source … . A disadvantage is the periodic need to recharge the battery. The battery may remain in a vehicle (a mobile eye unit's Land Rover, operating on a 12-volt electrical system, for example) and a constant charge maintained with the engine running. The battery leads for the operating lamp are passed into the operating theatre through a window. The halogen lamp is affixed with a small metal hinge to a 10 × 20 × 2 cm section of wood with 4 drilled holes, one in each corner. Sturdy cord passed through these holes and to an IV pole will attach and elevate the lamp above the surgical field for an excellent surgical light source. The portable operating theatre light may be used as a back-up light source for eye surgery in communities where power shortages are frequent. It is also reliable for mobile eye work and surgery in rural areas where electricity is unavailable.[6]

Flaming Light

You may need to make a fire for light. More commonly, you can use one or more candles. For a short burst of light (or as a fire starter), petrolatum (Xeroform) gauze works well, as does an alcohol swab. The swab's flame lasts only seconds, but is especially useful for warming ENT mirrors. Always be careful when using open flames as there is always danger of igniting nearby objects (such as clothing) or combustible gases.

Patient Records

To make medical records and radiographs more accessible and less likely to "walk away," tie them to the end of the patient's bed or chair. Alternatively, radiographs and the patient's bedside chart (containing vital signs and intake/output) can be placed in a holder made from cloth or old x-ray film and taped to the head of the bed or wall.

If no other method is available, especially when there are large numbers of patients during a disaster or when transferring patients to another medical unit or facility, clip or pin patients' records and imaging studies to their clothing.

Refrigeration

The ability to keep laboratory reagents and medications cool is usually taken for granted. When there is no power, some type of system must be devised to keep them cool. It is important to remember that refrigeration is vital for vaccines, as well as for some other medications (e.g., epoetin alfa, total parenteral nutrition, some antibiotic IV solutions, and suppositories). Four types of refrigeration units can be improvised (described below). Note that **storing blood requires a relatively constant temperature of 4°C: this cannot be achieved using the methods mentioned below.**

Use Refrigerators Normally Used for Other Purposes

If you have electricity, but not a standard refrigerator, try to find an alternative. The best way to store refrigerated medical supplies is in a unit with a transparent door so that the contents are visible. Only commercial-product refrigerators, such as those used to dispense soda pop and cold water, have these. Some hospitals have appropriated them for use when necessary. Of course, they put a lock on them to avoid pilferage.

Refrigeration Using Ice[7]

To make an "icebox," use a 5- or 10-gallon can or jar with a cover. Place it in the center of a wooden box or barrel. Surround the can with chopped ice mixed with sawdust, bran, flaxseed, hay, straw, or similar material. Cover the entire box with newspapers or an old raincoat, robe, or quilt. Place the material to be cooled in the can. Do not let it remain uncovered for long when you retrieve the contents.

Alternatively, you can make an "in-ground" icebox. Dig a hole in the ground big enough for a large sealed can or jar plus a 1-foot space between the can and the sides of the hole. Put the can in the center and pack cakes of ice (as big as will fit) around it. Pack crevices with sawdust, leaving a generous covering on top of the ice. Put on another covering of hay or straw, followed by a thick layer of heavy mud. Leave about 8 inches of the container above ground for easy access; cover this part to protect it from the sun. Place the articles inside the can to cool. Take special care to close the cover tightly after opening the icebox.

Refrigeration Using Cool Outside Temperature

During cold weather, a "cold box" built into a window will keep items cold. Fit a wooden or metal box to the outside of a window with a vertical sash (the pane slides up). Raise the window to access the cold box. This still allows light to enter the upper half of the window. Extend the windowsill with a shelf supported by brackets. The cold box rests on the windowsill and the extended shelf, and is fastened to the window casing by screws or nails near the top and bottom of each side of the box. The box should have a sloping top to shed rain. Cut holes for ventilation in the ends of the box and cover with screen. Shelves in the box may be made of heavy screening, poultry netting, or wood. They rest on cleats fastened to the sides of the box (Fig. 5-1). Cover anything placed in the box to protect it from dust.[7]

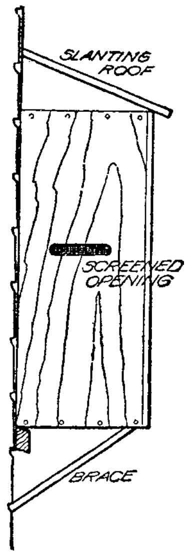

FIG. 5-1. Cold box (side view).

Refrigeration Using Evaporative Cooling

This iceless refrigerator is excellent for high-temperature, low-humidity conditions. It costs little to build and nothing to operate. Make a wooden frame 42 × 16 × 14 inches and cover it with screen wire, preferably rust-resistant. It should have a solid floor, but cover the top with wire screening. Attach the door with brass hinges and fit tightly; fasten it with a wooden latch. Wooden shelves or sheets of galvanized metal rest on side braces that can be spaced as needed. Place a 14 × 16-inch baking pan on the top and rest the frame in a 17 × 18-inch pan. Paint the wood, the shelves, and the pans with two coats of white paint and one or two coats of white enamel. Also paint the wire screen to prevent rusting.[7]

Make a cover of flannel, burlap, or canvas to fit the frame; this requires about 3 yards of material. Put the smooth side out if flannel is used. Secure this cover around the top of the frame and down the two sides and back, using buttons, hooks and eyes, safety pins, or similar easy-to-remove methods. On the front, arrange the hooks on the top of the door, instead of on the frame, and fasten the cover along the latch side of the door, allowing a wide hem of the material to overlap where the door closes. This allows the door to be opened without unbuttoning the cover. The bottom of the cover should extend down into the lower pan. Sew four double strips, which taper to 8 or 10 inches in width, to the upper part of the cover. These strips form wicks for the water to drip down the sides from the upper pan (Fig. 5-2).

Lowering the temperature inside the refrigerator depends upon the evaporation of water. Keep the upper pan filled with water. The water is drawn by capillary attraction through the wicks and drips onto the cover, saturating it. Capillary action starts more readily if the cover is dampened with water. The greater the rate of evaporation, the lower the temperature; therefore, the refrigerator works best with rapid evaporation. Place the refrigerator in a shady spot with a strong, preferably warm and dry, breeze. Evaporation takes place continuously, and the temperature inside the refrigerator may get as low as 50°F under ideal conditions. It works less well in damp or cool conditions. Clean and dry the refrigerator regularly. If possible, make a second cover, so the first can be removed for cleaning and thoroughly dried.

Beds and Amenities

Fixing a Sagging Mattress

Sagging mattresses and poor bedsprings are a universal problem in health care facilities, as well as in other sleeping accommodations. To fix this, place two smooth boards across the bed, between the mattress and the springs. Place the first about one-third of the way down from the

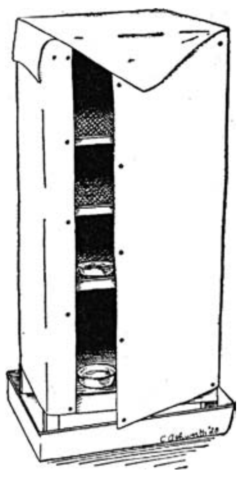

FIG. 5-2. Completed iceless refrigerator showing fitted canvas covering. *(Reproduced with permission from United States Bureau of Agriculture.[7])*

head and the other one-third of the way up from the foot.[8] You can also put one big piece of plywood under the entire mattress, if you have lots of wood.

Protecting Mattresses

Patient mattresses can still be protected from soiling, even if rubber, plastic, or similar impermeable materials are not available. Use heavy paper such as butcher's paper or newspapers stapled together (about 10-layer thick) to protect the mattress. Smooth them out, if necessary, by sewing or stapling them to heavy cloth, which may be tucked under the mattress.[8] Pieces of old raincoats, tents, or tarps can also be used.[9]

Heating the Bed

Heating a patient's bed or sleeping bag when the external temperature is low makes them feel better and may stave off hypothermia. Just remember to wrap hot objects to avoid burning the patient. Heat bricks or smooth stones, wrap in newspapers or old cloth, and place them in the bed. Sand, salt, sawdust, bran, oats, or wheat can be heated and then placed in bags, or just placed in bags or old cotton socks and then heated. (Turn filled bags frequently so they don't burn.) You can also make "hot-water bottles" using plastic bottles or bags, canteens, or similar items filled with hot water.[10,11]

Backrest for Patient Bed

On basic beds and stretchers, the head end cannot be raised. To elevate a patient's head, use a chair placed with its legs against the headboard and the seat facing the mattress. Pad it by putting pillows under the patient's head (Fig. 5-3).

A Cradle to Support Bed Linen Over the Body or an Extremity

Cradles to support bed sheets over sensitive areas, such as for burn patients, can be made by tying two or more wire hangers together. Put the ends of the hangers under the mattress or other support (Fig. 5-4). (See also Fig. 22-10, Improvised cradle over a burn patient.) Several supports should be used, depending upon the length needed. Another method is to string wire or twine the length of the bed above the patient and hang the sheet over the wire(s) (Fig. 5-5).[12]

Bedside Table/Tray

Construct temporary tables for meals by placing a board, supported on both ends by chairs, across the patient. Alternatively, use piles of books to support the corners of a square piece of wood or metal.[9]

Bed Screen

To screen one patient from another in multi-bed rooms, including in the emergency department, tape together bed sheets or newspapers and suspend them from string or wire, or from hooks in

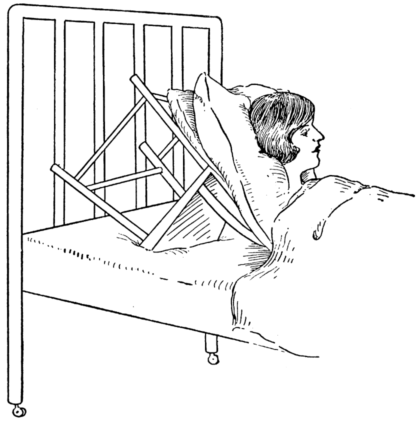

FIG. 5-3. Improvised back rest. *(Reproduced from Olson.[9])*

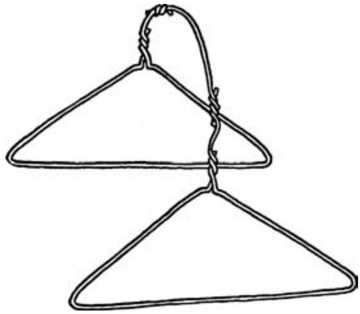

FIG. 5-4. Wire-hanger cradle for bed linen. *(Reproduced from Olson.[12])*

the ceiling. For more substantial and portable screens, make two or three lightweight wood frames that are tall enough to provide privacy (at least 6 feet). Each should be about 3-feet-wide. Put three hinges between the frames, one set going each way. Stretch a sheet or piece of cloth across the frames, and nail or staple it in place. When using this screen, angle the pieces slightly at the points where they are hinged, to give it stability. If desired, put small wheels on the bottom so that it can be moved.

Waste Basket

A "newspaper bag" pinned to the bedside will hold refuse and tissues. Fold a newspaper into a basket, with or without staples or adhesive, and attach it to the side of the patient's bed using safety pins or clothespins (Fig. 5-6).[13]

Bedpans/Urinals/Commodes

Bedpan

To improvise a bedpan, place a board (for the patient to sit on) across one end of a wide baking pan.[14] At the Nakom Paton Japanese prison camp during World War II, Allied medical personnel made bedpans from giant bamboo.[15] One disaster team lined bedpans with a plastic bag that, after use, was tied closed and put into a large red biohazard bag. The waste was incinerated on a daily basis.[5]

Commodes

The camp toilet for the same disaster team was a bucket lined with plastic. It had a padded toilet seat attached. Each team member was responsible for removing their bag and depositing it in the larger biohazard bag.[5]

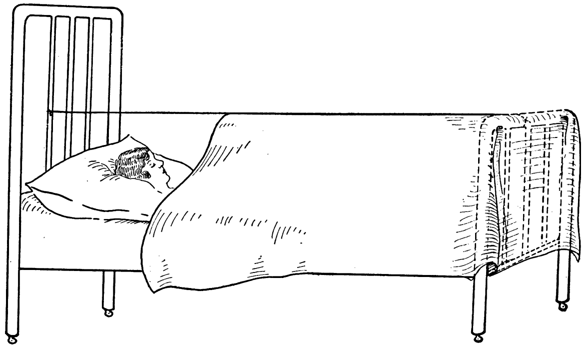

FIG. 5-5. Wire-based cradle for bed linen. *(Reproduced from Olson.[12])*

FIG. 5-6. Bedside newspaper trash can. *(Reproduced from Olson.[13])*

A bedside commode or toilet also can be fashioned by cutting a hole in the seat of an old kitchen chair and then putting padding and a plastic cover on it. Place the chair over a bucket at the patient's bedside. To hide the bucket, tack a piece of heavy cloth around the chair legs (Fig. 5-7). Similarly, you can put wheels on the legs of a chair that has a hole cut into the seat, and use it over a standard toilet or a bucket. This can also double as a wheelchair to take a non-ambulatory patient to the bathroom (Fig. 5-8).[16] Attaching legs to a standard toilet seat or to a padded piece of wood with a hole cut into it works, either over a bucket or as a movable seat over a pit latrine (Fig. 5-9).

Urinals

As every trucker knows, any waterproof container can be used as a urinal. For patients, a plastic bottle or carton, cut such that the diameter of the container's mouth is at least 2 inches (5 cm), serves as an adequate urinal. One nurse described a very usable urinal made from a bleach bottle with a large oval hole cut out opposite the bottle's large handle.[17]

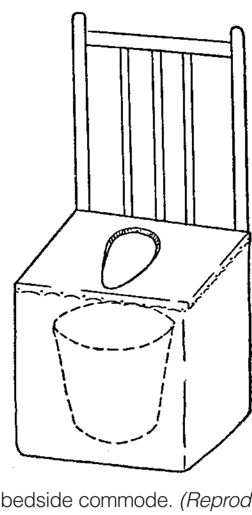

FIG. 5-7. Chair and wastebasket bedside commode. *(Reproduced from Olson.[16])*

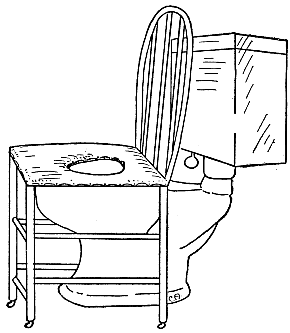

FIG. 5-8. Chair as improvised toilet seat. *(Reproduced from Olson.[16])*

A urine bag for an infant can be constructed from a small plastic sandwich bag, several pieces of tape, and a small straw or piece of IV tubing. Waxed paper can be used to store it until needed. To make this urine bag (Fig. 5-10), follow these directions[18]:

1. Make a hole in the plastic sandwich bag using radial cuts (A). The hole should be about the size of a small child's penis for a boy or, for a girl, large enough for the urethral opening.
2. With the holes lined up, attach a piece of adhesive tape with the same-size hole (B) (adhesive side out) to the outside of the bag with two smaller pieces of tape.
3. Insert the straw or a small piece of IV tubing into the bag, and fold the top piece of tape over the top of the bag to seal it closed (C). Fold the radial cuts out and stick them to the adhesive tape.
4. Then, take a smaller piece of adhesive with a slightly smaller hole (D), line the holes up, place it adhesive-to-adhesive, and fold its sides inward to form a smooth opening (E).
5. Cover the bag's exposed adhesive piece with wax paper if it is not being used immediately. Multiple bags can be made at one time and stored. They can also be sterilized using ultraviolet irradiation, such as is available in most laboratories and ORs.

ESSENTIAL EQUIPMENT

The World Health Organization (WHO) lists what they consider the essential basic equipment for patient diagnosis and monitoring worldwide (Table 5-2). This is in addition to the "Essentials" listed in other chapters, and varies with four levels of hospital capabilities shown in Table 5-1.[19]

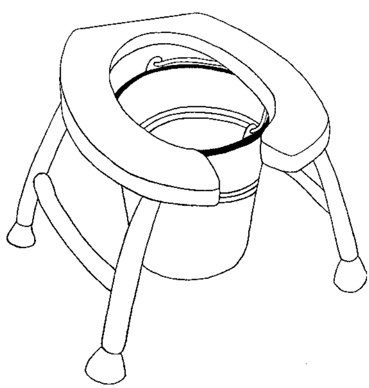

FIG. 5-9. Bedside commode from a toilet seat attached to legs.

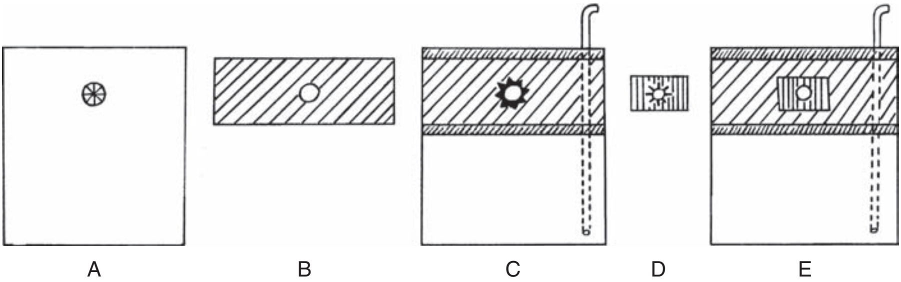

FIG. 5-10. Construction of an infant urine collection bag.

DIAGNOSTIC EQUIPMENT

Stethoscope

Ear to Patient

Before Laennec invented the stethoscope, direct auscultation—placing the physician's ear directly on the patient's chest—was an established practice.[20] If no other option is available, you can still put your ear directly against the chest, heart, or abdomen. The clarity of the sounds will not be as good as through a stethoscope (you probably cannot hear a murmur unless the murmur is also palpable), but you can get a general idea of cardiac rhythm, chest clarity, and bowel sounds (Fig. 5-11). As noted in Chapter 7, Vital Signs, Measurements, and Triage, directly listening to an infant's chest is the fastest and most accurate method for assessing the presence of cardiac activity.

Improvised Standard Stethoscopes

Stethoscopes can easily be fashioned by following Laennec's original method. As first described, Laennec used his original stethoscope on a young woman "because her age and sex did not allow him to directly place his ear on her chest. 'In 1816, I was consulted by a young woman presenting

FIG. 5-11. Direct auscultation of an infant's abdomen.

general symptoms of disease of the heart. Taking a sheaf of paper, I rolled it into a very tight roll, one end of which I placed over the praecordial [*sic*] region, while I put my ear to the other.' "[20]

To make a basic Laennec-type stethoscope, use a hollow wooden tube such as bamboo, or the cardboard tube from toilet paper or paper towels. Place one end on a person's chest and your ear at the other end; you can hear the heartbeat clearly, depending upon ambient noise and the person's habitus. Nearly any hollow tube can be (and has been) used as a monaural stethoscope. These include short lengths of garden hose, ivory or wood tubes, and metal pipes.

A slightly more sophisticated stethoscope can be made by attaching a funnel to two pieces of tubing. Use T-tubing scrounged from any source (including a juncture of IV tubing) to connect two long pieces of rubber tubing to a piece of short rubber tubing. Connect the short piece to the funnel. Put the tubing directly in your ears, or fashion earpieces as described in "Stethoscope Earpiece" below.

Precordial Stethoscope

One of the most useful anesthetic monitors is a precordial stethoscope taped to the patient's chest. It gives the anesthetist a continuous assessment of the patient's heart rate and rhythm and breath sounds. Only one earpiece is normally used, so that the anesthetist can also monitor everything else in the OR.[21] For infants, it is best to tape the stethoscope to the left chest, so that both the heartbeat and breath sounds can be heard.[22] In adults, it can be placed over the midsternum, in the suprasternal notch, in the paralaryngeal area, or in the axilla. If in the suprasternal notch or paralaryngeal areas, it facilitates recognizing the presence of vomitus in the hypopharynx.[23]

Several improvised methods will produce a workable precordial stethoscope that can also be used as a regular stethoscope. The basic method is to attach a piece of rubber tubing to the top of a screw-top plastic bottle that has a narrow, tapered opening, such as a ketchup/mayonnaise dispenser. Another way is to cut off the tapered end of a rubber bulb suction syringe and connect it to a piece of rubber tubing that runs to the ear.[24] If a stethoscope head is available, make an improvised precordial stethoscope by attaching about 1 meter of IV tubing to the stethoscope head.[21]

Some California anesthesiologists produced an excellent, easily constructed precordial stethoscope when they forgot theirs at home while on a medical mission (Fig. 5-12, A-E). They cut a 20-mL syringe 1 inch (2.54 cm) from the infusion end (A). They then smoothed the edges with a file and placed adhesive tape around the syringe's cut end to further smooth it. Next, they removed the rubber sealer from the plunger (B) and cut a large hole in its center (C). They then inserted the rubber piece into the small piece they cut off the syringe barrel (D). After securing this to a 3-way stopcock, they connected the stopcock to IV tubing (or other tubing) and then to an earpiece (E).[25]

Esophageal Stethoscope

Breathing and cardiac rhythm can be monitored with a tube passed into the esophagus—the esophageal stethoscope. To make an esophageal stethoscope, you need a rubber glove, a nasogastric (NG) tube, a suture, and a regular stethoscope. Cut a finger off the glove and tie the finger over the end of an NG tube (Fig. 5-13). Remove the head from the stethoscope. Pass the NG tube approximately halfway down the esophagus and connect the proximal end to the end of the stethoscope. The NG tube can also be passed through the nose (Fig. 5-14). In the OR, this stethoscope is often used with only one earpiece, so that the anesthetist can hear the rest of the surgical team.[26]

Hearing Aid

A stethoscope can be a substitute for a patient's hearing aid during an exam. You simply use the stethoscope in reverse by putting the earpieces in the patient's ears and talking into the diaphragm (Fig. 5-15). Unfortunately, experience shows that it only works for patients with specific types of hearing loss (but so do hearing aids).

Stethoscope Earpiece

When the earpieces for a stethoscope have been lost (a very uncomfortable situation), use the nipple from a baby bottle or a "binky" (pacifier) (Fig. 5-16). Make the normal pinhole opening

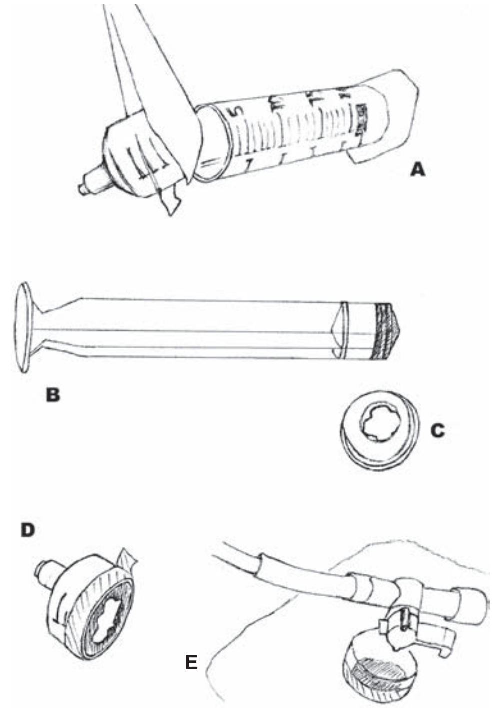

FIG. 5-12. Improvised precordial stethoscope. *(Reproduced with permission from Greenberg and Spurlock.[25])*

in the nipple slightly larger, and tie the nipple in place on the stethoscope. So you don't look ridiculous, cut the nipple so only the distal 1 to 2 cm of the rubber piece is used, rather than the entire nipple and the flange that holds it in the bottle cap. The rubber part (bulb) of a medicine- or eye-dropper can also be used in a similar fashion. Be sure to cut a hole to allow the sound to flow through it.

Sphygmomanometer

If you have a BP cuff, ideally it is accurate. However, aneroid devices (those without fluid) are easily damaged and can go out of calibration without it being detected. The

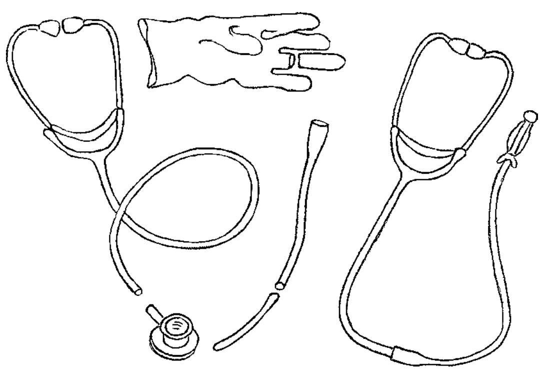

FIG. 5-13. Making an esophageal stethoscope.

FIG. 5-14. Esophageal stethoscope in use.

most common problems with these devices are that they leak, do not "zero," or go out of calibration.

"If a leak develops in the system, wrap the cuff around itself and secure the end. Inflate the cuff to 250 mm Hg; watch the pointer. If it slowly drops, there is a leak—it is most likely to be in the cuff or inflation bulb. It is fairly rare for a leak to occur in the gauge itself. A small pointed brush with soapy water on it will help find the smallest leak."[27]

If the gauge does not return to zero after the cuff has been deflated, "the easiest method of adjusting it is by removing the glass from the front of the gauge and carefully taking off the pointer and replacing it in the correct position. The pointer can usually be taken off using your finger and thumbnails. If this is not successful, find two very small screwdrivers or thin flat pieces of metal and lever the pointer upward using one on each side."[27]

Aneroid systems may go out of calibration, especially if dropped. Check them on a regular basis for accuracy against a mercury sphygmomanometer. To do this, "connect the gauges together with a plastic T-piece and connect the third arm to an inflation bulb. Inflate the bulb

FIG. 5-15. Stethoscope used as hearing aid.

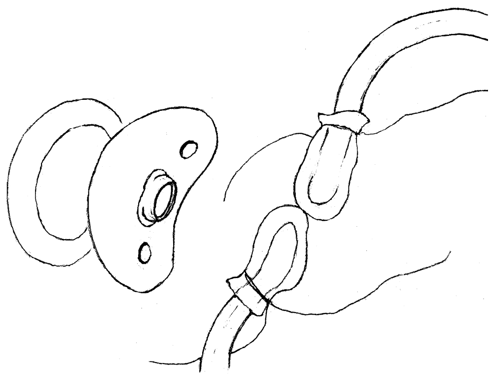

FIG. 5-16. Earpieces for a stethoscope.

slowly and note the readings showing on each instrument" at intervals of about 20 mm Hg. "If the readings are within a few millimeters of mercury throughout the scale this is acceptable for clinical use."[27] Someone who has experience with aneroid blood pressure machines should calibrate them.

One other common problem is that the glass breaks on the pressure gauge. Either get a watch repair person to fix it or make a cover from a thin plastic sheet.[27]

Mercury sphygmomanometers work longer and more consistently than do aneroid systems. However, if the mercury is not clean or if it continues to rise slowly after you have stopped inflating the cuff, it may need repair. Mercury is toxic. Find a reputable, qualified person to fix it.

Infant Spinal Tap Needle

If a standard infant lumbar puncture (LP) needle is not available, use a 22-gauge butterfly needle with the tubing cut short. It works as well as, or better than, the standard LP needle—as long as the little one is not too chunky.

TREATMENT SUPPLIES/EQUIPMENT

Gowns, Gloves, Masks, Booties, and Goggles

Standard Precautions

Standard, or universal, precautions start with protecting oneself against the microbes, fluids, and detritus that haunt the health care environment. The basic equipment is protective gear. In an austere environment, this paraphernalia often must be made, rather than purchased.

Gowns

The simplest gown that is waterproof is a plastic garbage bag with head and arm holes cut out. Arm pieces can also be cut from another bag and stapled on. Note this also works well as a raincoat, although if used for that purpose, the arm connections should be folded over and secured so that they do not leak.

While not waterproof and probably better for patient use than as medical equipment, a sheet cut like a poncho will also work. Fold a flat sheet so that one-third is doubled over to form the arms. In the center of the folded edge, cut out a hole large enough for your head to pass through. The sleeve is fashioned by cutting slits on both sides of the sheet, midway down the folded section. The slits should extend to the approximate site of the axilla (Figs. 5-17 through 5-19). Once the person dons the gown, the arms can be secured with safety pins, staples, or tape (Fig. 5-20). Wrap the large pieces around the back under the arms, and use the flap on the back as a tie for the gown.[28] (Depending upon the person's girth, the tie may also need to be pinned.)

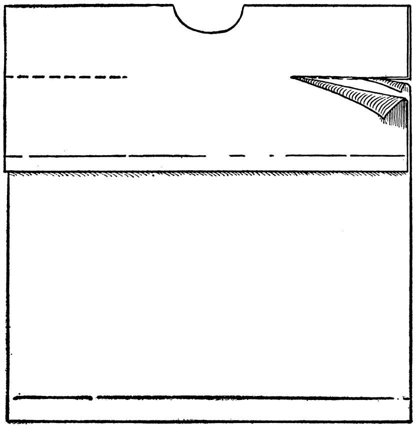

FIG 5-17. Improvised surgical/patient gown, Step 1. *(Reproduced from Olson.[28])*

Sometimes, you cope as best you can, as one disaster response team discovered. "Sterile gowns are bulky and consume precious space; therefore, the team considered other options, such as wearing one gown and changing gloves between each case, or wearing disposable aprons, sleeves, and gloves. [We] finally decided to use aprons over street clothes and boots covered with disposable covers."[5]

Caps and Masks

Masks are useful to protect both you and your patients against dust and particulate matter (i.e., inhaling ash is what often kills people after a volcanic explosion), virulent organisms that they or you carry, and nauseating smells, especially when working around decomposing bodies or opening feculent abscesses. Put some tincture of benzoin on your mask to disguise the smell. Caps protect the head and hair from any nasty stuff. They are also useful for protecting the patients' wounds from contamination by your hair.

The most basic masks are towels or cloth held to the mouth and nose, either with your hand or tied in place.

An improvised surgical mask and cap can be made using a piece of cloth about 18 × 12 inches (46 × 31 cm). Cut a 4-inch (10-cm) narrow oval to fit over the eyes, about 5 inches (12.5 cm)

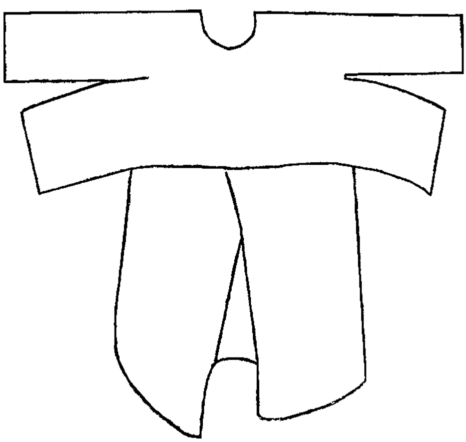

FIG. 5-18. Improvised surgical/patient gown, Step 2.

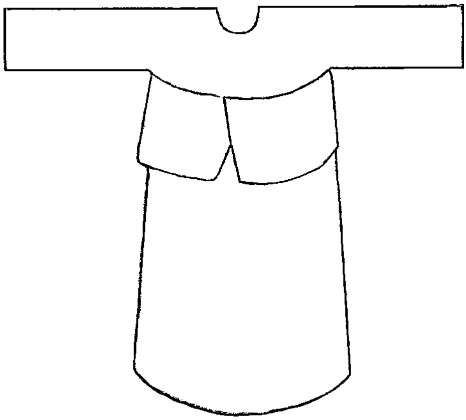

FIG. 5-19. Improvised surgical/patient gown, Step 3.

from one end. Be certain that you can breathe as easily through the cloth as through a normal surgical mask. Attach a long piece of tape that extends over the edges of the material, at both sides of the slit. Also, attach a long piece of tape to the bottom of the short end. The wearer can adjust the slit over the eyes, flip the long piece of material over the head for a cap, and then tie both pieces of the tape behind the neck (Fig. 5-21).

Make a simple cap by covering the head with a long cloth or towel (Fig. 5-22) and pinning or taping it to the nape of the neck.

Eye Protection

Wearing eyeglasses helps to protect the eyes from splattering blood and fluids. If your glasses are small or if the splatter is expected to be large, put tape around their edges. Goggles (such as for skiing, woodworking, etc.) also work and can often be worn over eyeglasses. Another option is to purchase a cheap pair of plain glass or plastic (no refraction) glasses with big lenses.

Gloves

To conserve exam gloves, cut the fingers off a glove and use each one as a finger cot for digital rectal exams, instead of the whole glove. That allows you to do five exams with one glove.

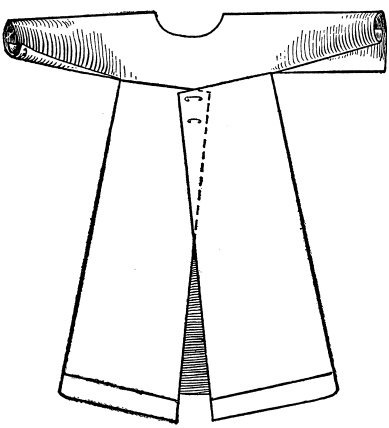

FIG. 5-20. Improvised surgical/patient gown, completed. *(Reproduced from Olson.[28])*

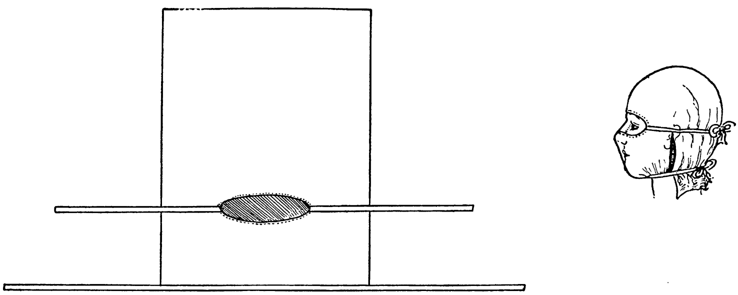

FIG. 5-21. Improvised cap-mask.

DIGITAL IMPACTION/OBSTETRIC GLOVES

Elbow-length gloves should be used for bimanual compression of the uterus, manual placental extraction, vaginal childbirth, disimpactions, and similar procedures where there is a great chance of contamination. When they are not available, you can make them from two pairs of standard surgical gloves. Cut the four fingers (not the thumb) off one pair of gloves just below the point where the finger portion of the glove begins (Fig. 5-23). If you are doing this sterilely, such as in the OR, or using the gloves for a disimpaction, then use the pieces as described below. Otherwise, for obstetric cases, sterilize or high-level disinfect those pieces along with a standard pair of uncut gloves. When ready to use the elbow-length gloves, first pull a fingerless piece of glove over your hand and up to the elbow. Do the same on the other arm. Then put on the surgical gloves so that the wrist portion overlaps the pieces already on the arm (Fig. 5-24). The overlapping section can be sealed with cyanoacrylate, although this is not usually necessary.[30] Rather than making long gloves, standard long kitchen or lightweight household gloves can also be used.

Booties

To fashion waterproof booties, cut a large plastic garbage bag open so that it lays flat. From that piece, cut out a portion that is as long as the distance from your foot to your knee and as wide as three lengths of your foot. Use larger dimensions if you need longer booties, such as in a bloody procedure or trauma. Secure them on your foot with duct tape. Do not make it too tight—you may be wearing them a while. One caveat: Take care when wearing these plastic boots; they can become very slippery on a wet or tiled surface.

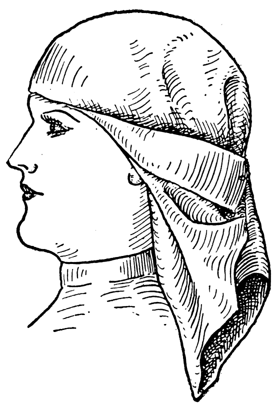

FIG. 5-22. Improvised cap. *(Reproduced from Olson.[29])*

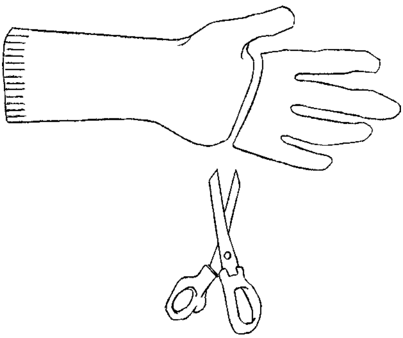

FIG. 5-23. Improvised long gloves, Step 1.

Dressings and Bandages

Dressings are the materials that go on the wound. They can be adherent or non-adherent, wet or dry, and absorbent or non-absorbent. Dressings are usually sterile and can be occlusive (airtight). Bandages cover dressings, and can be adherent (such as tape) or impermeable. Bandages can also be used to place pressure on the wound. Most clean fabric can be used as a dressing or a bandage. Avoid paper products such as tissues and paper towels, since they disintegrate when wet and leave fibers in the wound.

No Dressing

To make life simpler, consider not putting a dressing on the wound! Sound like sacrilege? It's not. You do not have to put a dressing on every wound. Most clean closed wounds do not need them. Not applying a dressing allows easy inspection for infection or dehiscence. It also does not form a moist, possibly anaerobic, space in which the wound can macerate and increase the likelihood of infection.

Not applying a dressing also makes it much easier to keep the wound clean. Forget the voodoo about keeping it dry for 24 hours. (You think they don't sweat for that time either?) After a few hours, let patients shower or swim. Have them keep the wound clean with soap and water.

Dressing Material

Even so, some wounds do better, at least initially, if dressed. A dressing helps absorb any serosanguineous drainage, keeps the wound moist (good initially for small plastic closures), protects them from further injury, and may lessen pain by keeping the air off open wounds (e.g., paper cuts always hurt less when covered).

Any absorbent material may be used as a dressing. If a highly absorbent dressing is needed, such as for wounds with lots of exudate, use a menstrual pad. Otherwise, use the more-absorbent cotton fabrics, rather than synthetics, which absorb less. In a pinch, use moss, especially sphagnum (peat) moss that many cultures traditionally use as an absorbent dressing.

Make non-adherent dressings from sheer synthetic materials, such as parachute cloth or nylon stockings. Occlusive dressings, such as those used over open-chest wounds, can be made from

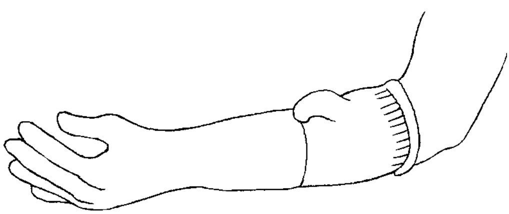

FIG. 5-24. Improvised long gloves, Step 2.

any clean piece of plastic sheeting, such as a plastic bag. If possible, first place a sterile dressing against the open wound.

One concern with dressings is their sterility. However, "provided the material used for dressings is clean, in most cases this will have very little impact on the incidence of infection."[31] If you need a sterile dressing—or need to sterilize dressings to reuse on other patients, the procedure is described under "Dressings and Other Textiles" in Chapter 6.

Bandages

The purpose of a bandage is to hold a dressing in place. If you need a bandage, the easiest and most available option is to use a piece of cloth that is expendable. Remember the damsel in old movies ripping up her petticoat to make bandages? She had the right idea. Another simple method is spirally cutting a shirt. If you prepackage bandages, be sure to label the package so you know what is inside.

If no cloth bandage is available, use duct tape to secure a dressing. Shave the area first, since when the tape comes off, it can hurt. Shaving can also help tape stick, which is a problem if the person's skin is wet. Poking holes in the tape (especially thick tape, like duct tape) helps by allowing fluids and sweat to escape. Clean the skin with soap and water, acetone, or alcohol to remove oils. Prepare the skin with tincture of benzoin to enhance "stickiness." To make an adhesive dressing, cover a small square of dressing with a piece of tape.

If you need to see the wound, but still want it covered, a clear bandage (like the standard steridrape) can be fashioned from clear plastic wrap (e.g., Saran Wrap) or a piece of clear plastic bag. In both cases, affix the edges to the skin with tape or cyanoacrylate glue.

A pressure bandage over dressings, used when there is significant seepage or concern about hematoma development, is most easily constructed from an elastic bandage, a bungee cord (use only over fabric stiff enough to distribute the cord's force), or the elastic from a piece of clothing or equipment.

Syringes and Needles

Sharps Containers

Sharps containers are often in shorter supply than needles, especially after disaster-mandated immunization clinics or in the homes of patients needing routine injections, such as for insulin. These are easily improvised.

For large volumes of sharps, use a large container such as a 5-gallon water bottle. Empty the container and tape a fitted piece of cardboard or thin plastic over the top. Cut an X-shaped slit in the cardboard to form a "one-way" opening. When it is full, tape the slits and dispose of it with other biohazardous waste. An alternative is to use a heavy cardboard box. Seal it completely and then cut a 3-inch "X" in one side. Push the sharps through the hole. Discard the box when it is full.

For clinic or patient use, get a large, empty coffee can with a plastic lid and clean and dry it. Then make two slits at 90-degree angles to each other in the center of the plastic lid. Securely tape the lid to the can. Put a syringe and needle through the opening, and then check to make sure that it can be easily pushed through the slits, but that a small child's fingers cannot get through. When the coffee can is full, tape the slits shut and dispose of it.

IV Fluids and Equipment

Venipuncture Tourniquet

Use a piece of IV tubing as a tourniquet for drawing blood or placing IVs. A rubber glove (sterile or unsterile, but "stretchy") works well as a venous tourniquet when starting intravenous lines or drawing blood. Cutting between the fourth and fifth fingers and onto the wrist part of the glove produces a nice tourniquet. Even better, cut the wrist portion off a surgical glove and slip it over the arm, as suggested by Daniel Tsze, MD, from Brown University (written communication, June 5, 2007). This is very effective as a tourniquet to locate an infant's scalp vein.

IV Needles

Needles used for injection also can be used as IV needles, although they may be more difficult to thread into a vein, since the injection needle will tend to puncture the vein, rather than slide

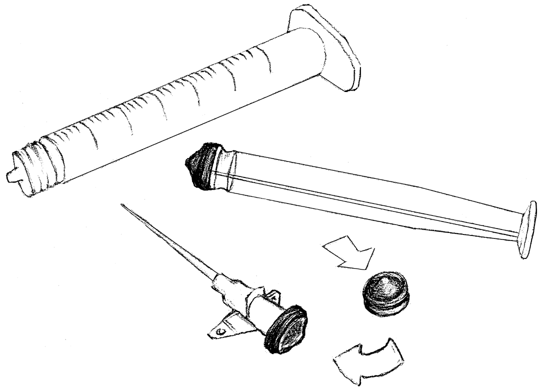

FIG. 5-25. Improvised saline lock.

in as the plastic-coated needle on a catheter does. Also, since they have a tendency to perforate the vessel, take extra care when securing them, and always check that they cannot be jostled or moved; use an arm board or generous bandaging, if needed.

Should you reuse needles in austere situations? If so, how do you sterilize them? The answers are in Chapter 6, Cleaning and Reusing Equipment. How to make surgical needles and suture is discussed in Chapter 21, Surgery/Trauma.

Saline Locks

Make an excellent, inexpensive saline lock easily by slipping the rubber end of the plunger from a 2- or 3-mL disposable syringe over the end of an IV catheter (Fig. 5-25). This also works on a straight needle, if that needs to be used as an IV catheter. Simply fill the catheter with saline (or heparin) as would normally be done.

Make an improvised saline lock by attaching a small syringe (either empty or with a small amount of saline) to the end of the IV catheter. To prevent the plunger from moving, which would allow blood to enter the catheter, fix a rubber band or tight adhesive tape over the barrel's end, or put a drop of cyanoacrylate cement at the juncture of the plunger and barrel. The smallest-size syringe on which a rubber band fits well is 3 cc, but adhesive tape or cyanoacrylate also can be used with a tuberculosis (TB) or an insulin syringe (Fig. 5-26).

IV Tubing

One method for adjusting an IV flow rate is to wrap a small piece of malleable metal (e.g., heavy aluminum foil) around the tubing. The flow rate is determined by how tightly it is wrapped on the tubing. Count the drops to get the desired rate.

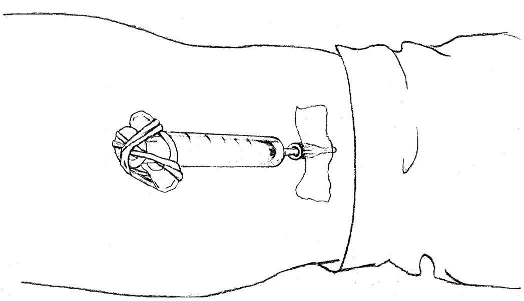

FIG. 5-26. Improvised saline lock, alternative method.

IV Bottles/Bags

There are multiple ways to increase the external pressure on IV or blood bags. These include inflating a blood pressure cuff around them and wrapping them with an elastic bandage, a belt ("stretchy" if possible), nylon stockings, a rope, or similar materials.

If external pressure is applied to an IV bag, it does not have to be hung. Rather, the pressurized IV bag can simply lie on, or next to, the patient. This facilitates transporting the patient. If the bag is placed under an adult patient, the pressure exerted by the body keeps the IV flowing. This is particularly useful when transporting a patient in the field.

To speed the flow of IV fluid running out of a plastic bottle, once it is hanging, insert a hypodermic needle into its uppermost part. This also helps to more accurately gauge the amount of delivered fluid, since without the needle to release the vacuum, the plastic deforms and gives a false reading on the quantity markers on the bottle's side.

With glass bottles, increase flow by inserting a needle into the stopper or end of the IV bottle to speed the flow by "venting," allowing air to enter as the fluid drips out. You can also "strip" the IV tubing by using your fingers to compress the tubing and continually running them down both sides of the IV tubing. This is marginally useful and very time consuming, but it is better than doing nothing.

If the IV pole will not accommodate the IV bag or bottle's "hanger," use a loop of IV tubing to connect the bottle's hanger to the pole or other available elevated hook.

Resuscitation/Equipment Cart

Use clear plastic bins to store clinical equipment. Israeli emergency physicians ask why everyone else seems to persist in "beautifying" their resuscitation rooms by storing critical equipment in opaque containers. They use clear plastic bins that contain only the most commonly used equipment and sizes at the bedside; the rest is stored across the room for use when needed. They also position most bins between adjacent beds, so that they can slide the bins open to either side—doubling their usability and conserving space.

Tubing Clamp/Organizer

How many uses can you think of for the common clothespin? It works well as a tubing clamp for urethral catheters and IVs: Double the tubing over and clamp it with a clothespin. It also works great as a wire/tubing organizer (Fig. 5-27): Gather up a number of wires and tubes and

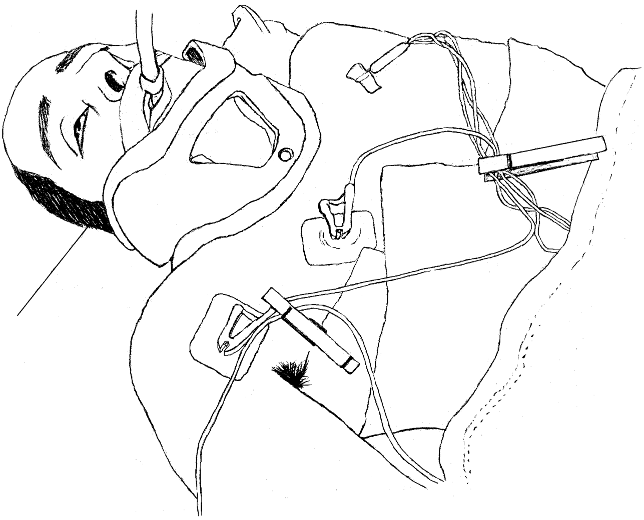

FIG. 5-27. Clothespins holding wires out of the way.

secure them with a clothespin. This is particularly helpful when patients are transported since it keeps the extraneous equipment from becoming entangled with ambulance or helicopter equipment. Of course, these clips can also be used to attach triage tags and medical records to patients' clothing.

Lubricants (for Rectal/Pelvic Exams and Nasal Packing)

Nearly any nontoxic lubricant works for rectal exams, if standard water-based lubricants are not available. Try vegetable oil, lard, cold cream, salad oil, sweet cream, unsalted butter, or sweet oil.[32]

For endotracheal tubes, you normally do not need lubricant unless you are doing an awake intubation or a nasotracheal intubation. In those cases, use a sterile, water-based lubricant. Similarly, it does not help much to put a little lubricant on an NG tube. It is better to apply some local anesthetic and wet the tube before insertion. Likewise, use warm water to lubricate a vaginal speculum. Sterile water is the safest, least-toxic substance.

Adhesives

Cyanoacrylate, duct or other tape, sutures, or surgical wire can be used to quickly secure, repair and construct medical equipment. A method to securely fix tapes and leads on a patient is to use tincture of benzoin. Absent that, the same effect can be achieved by saturating alcohol gauze with Betadine. As the alcohol evaporates, "you're left with the same residue as tincture of benzoin. It's convenient and readily applied without using extra 4 × 4s" (Darrell G. Looney, MD, personal written communication to author, received June 5, 2007).

Ice/Heat Packs

There are several ways to make ice packs, but all require something cold to fill them. The easiest is to simply fill a plastic bag with a cold source, which can be ice, frozen food, cold drinks, or snow. Be certain to put a cloth between the cold source and the skin. Without a portable cold source, an option is to put an affected extremity into cold water. Alternatively, use evaporative cooling in a warm, dry climate by putting a wet cloth over the area and exposing it to a hot breeze. It will cool quickly.

When you have significant facilities and want to prepare ice packs in advance, fill 1-gallon plastic bags that can be securely closed with 4½ cups of water and 1½ cups of 70% isopropyl alcohol. To prevent leaks, put each bag inside another securely locking plastic bag. Place the bags in a freezer for about 4 to 6 hours.[33]

Heat packs are a bit easier to make, although, of course, you need a heat source. To make a "Wheat Pillow" hot-pack,

1. Use dry long-grain rice or wheat grain (e.g., bird food) as the filler.
2. Put it into a heavy, wool sock or, if you want to make a larger pack, a piece of strong, breathable fabric that can be put in a microwave. Tie the end closed with a string.
3. Put it in a microwave on high for 1 to 2 minutes; use a longer heating time if the microwave is less powerful. You can also put it in an oven at low heat.
4. If the smell is bothersome, add some potpourri.
5. This heating pad works for 8 to 10 minutes and can be reheated and reused.

See also "Heating the Bed," above, for more ideas.

Dinnerware

It may seem mundane, but being able to supply plates and cups becomes vital, especially when a horde of patients descends on a facility after a disaster. Metal cans of various sizes can be cut down, if necessary, for use as cups, plates, pots, storage containers, and a wide variety of other items. The only caveat is that whenever cans are cut down for use, their edges must be folded inward or otherwise dulled, since they are very sharp. While most cans are used to store food, it is safest to both clean and sterilize them before using them for eating. What if you need forks, knives, and spoons? In a pinch, hands work great. Emily Post is not looking, but do wash your hands before eating!

PATIENT TRANSPORT

Transportation Within Health Care Facilities

Patients must be transported within health care facilities, once they arrive. How they arrive is discussed in Chapter 20, Patient Transportation/Evacuation.

Cushions for Wheelchairs, Exam Tables, Stretchers, Chairs

Any patient surface that will be used for a prolonged period should be cushioned. There are three ways to make cushions: (a) Stuff a bag with soft, quiet (feathers, cotton, etc.) materials—but use torn newspaper, if necessary—and sew up the open end. (b) Tie bicycle tire tubes or similar tubes together in an "S" pattern. Thin pieces of the tubing can be used to bind the tube together. If larger pieces are needed, such as to cover a gurney or a bed, use the tube strips to tie multiple "S" pieces together (Fig. 5-28). (c) Glue together multiple pieces of thick cardboard. Wet the cardboard and have someone sit on it to mold it. Then let it dry and varnish it. If rubber is available, use a 1-inch-thick piece to pad it.[34]

Wheels for Gurneys, Wheelchairs, or Other Equipment

Simple wheels can be made from circular pieces of wood at least 2 inches thick and with a diameter to fit the equipment on which it is to be used. If this thickness of wood is not available, glue one or more pieces together. The wood grain should run across, rather than through, the wheel. Cut a hole just large enough to fit the axle. Then cover the wheel rim by either gluing or nailing on a piece of rubber from an old car tire or inner tube. Or, cut a piece along the circumference of the wheel from a bicycle tire. Cutting notches in the side of the tire allows it to conform to the wooden wheel and prevents the nails from loosening.[35]

EQUIPMENT SAFETY/MAINTENANCE

Safety

Safety After Flooding

Many disasters result from flooding. Rather than simply beginning to use equipment that may have been damaged in a flood, take the following steps:

1. Check all power cords and batteries to make sure they are not wet or damaged by water. If electrical circuits and electrical equipment have gotten wet, turn off the power at the main breaker.
2. Make sure you check for water before plugging in your device. Do not plug in a power cord if the cord, the device, or the outlet is wet.

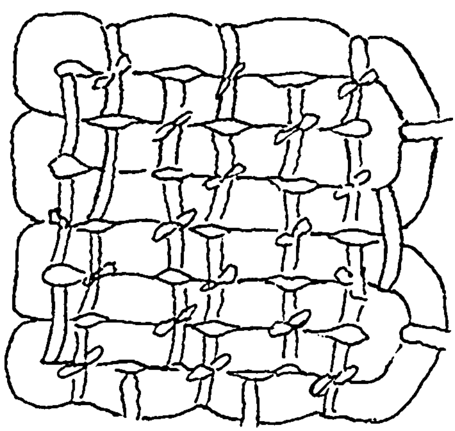

FIG. 5-28. Making a seat/stretcher cushion.

3. If there was a power outage, when the power is restored, check to make sure the settings on your medical device have not changed (often these devices reset to a default mode when power is interrupted).[36]

Generator Safety

Generators are the common source of electricity in austere circumstances. The problem is that they generate carbon monoxide. To be safe, never run a generator, pressure washer, or any gasoline-powered engine outside an open window or door where exhaust can vent into an enclosed area. Also, do not run them inside a basement, garage, or other enclosed structure, even if the doors or windows are open, unless the equipment has been professionally installed and the area properly vented.[36]

Maintenance

Heat and Humidity

Heat and humidity affect equipment anywhere, especially when electricity no longer powers air conditioning. In moist environments, frequently examine all equipment—including ophthalmoscopes, otoscopes, microscopes, tonometers, and endoscopes—for mildew. In addition, the US FDA offers these suggestions to protect medical devices from heat and humidity:

a. Use a dry cloth to wipe off devices regularly.
b. Keep devices out of direct sunlight.
c. Enclose medical products in plastic containers to keep them dry.
d. Do not use ice if there is a danger of water contamination; use dry ice or instant cold packs to keep your device cool.
e. Do not use disposable devices that are wet.[36]

Anesthesia Hoses

Black (antistatic) anesthetic breathing hoses, used with ether anesthesia, deteriorate rapidly in high humidity. After use, they will be wet inside from the water vapor in the patient's breath.

TABLE 5-3 The French Gauge System—Comparison With the Metric and (Stub's) Gauge Systems

Gauge Number	Inch	French*	mm
36	0.0040	0.305	0.102
28	0.0140	1.067	0.356
23	0.0250	1.905	0.635
19	0.0420	3.200	1.067
16	0.0650	4.953	1.651
10	0.1340	10.211	3.404
8	0.1650	12.573	4.191
	0.1839	14.000	4.667
	0.2101	16.000	5.333
	0.2364	18.000	6.000
	0.2627	20.000	6.667
	0.2889	22.000	7.333
	0.3152	24.000	8.000
	0.4728	36.000	12.000

*Although the French gauge system is based on three times the measurement in millimeters, some of the numbers appear to be other than exactly three times the millimeter equivalent due to rounding.

Adapted with permission from Iserson.[38]

After use, hang them vertically to allow them to dry. Inspect them regularly for cracks, especially between the corrugations, where they most often develop leaks. The normal polyethylene anesthetic hoses do not deteriorate as rapidly.[37]

MEASUREMENT EQUIVALENTS

In austere situations, you use what is available. That may include catheters, tubes, and needles sized in a system with which you are unfamiliar. This conversion chart (Table 5-3) can help you decide the appropriately sized equipment for the situation. Other measurement equivalents are listed in Chapter 19, Laboratory. For volume and length conversions, see Chapter 7, Vital Signs, Measurements, and Triage.

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6 Cleaning and Reusing Equipment

Much modern medical equipment is labeled "disposable." When resources are scarce, this luxury cannot be sustained. On the other hand, safety regarding reuse of equipment is paramount. Patients should not be put at risk either through introducing infections from previously used equipment or by using malfunctioning equipment. This section discusses the reuse, cleaning, and sterilization of equipment, including guidelines and techniques.

POLICIES ON REUSING MEDICAL EQUIPMENT

Major governments cannot seem to agree on their recommendations in trying to guide health care professionals in the reuse of single-use devices (SUDs). The United States' policy across several agencies is that SUDs can be reused.

A US government panel of experts stated that in resource-scarce situations, equipment and supplies "will be rationed and used in ways consistent with achieving the ultimate goal of saving the most lives (e.g., disposable supplies may be reused)." However, they also said guidelines are needed on "how to use and reuse common supplies and equipment, such as gloves, gowns, and masks."[1]

The US Food and Drug Administration (FDA) found that "no data to indicate that people are being injured or put at increased risk by the reuse of SUDs,"[2] while acknowledging that many SUDs are commonly being reused. Among these are many types of equipment, including those used in dentistry, orthodontics, otolaryngology, and laparoscopy. Specific equipment being reused also includes needles, scalpels, forceps, trocars, saw blades, staplers, drills, scissors, masks, syringes, gowns, and biopsy devices.[3,4] The problems they found with reusing SUDs include a "loss of elasticity in inflatable balloons, persistence of blood and biofilms, loss of original lubricants and resultant effect on catheter threading, and crystallization of liquid x-ray contrast material."[4]

The US Centers for Disease Control and Prevention (CDC) states that "in general, reusable medical devices or patient-care equipment that enters normally sterile tissue or the vascular system or through which blood flows should be sterilized before each use."[5] Except in rare and special instances, items that do not ordinarily touch the patient or that touch only intact skin are not involved in disease transmission and generally do not necessitate disinfection between uses on different patients. Special rules apply when patients are infected or colonized with drug-resistant or highly virulent microorganisms. In these cases, the CDC recommends that noncritical items be dedicated to one patient or patient cohort (someone with the same contagious illness) or that this equipment be subjected to low-level disinfection between patient uses. Reusable items that touch mucous membranes should, at a minimum, receive high-level disinfection between patients.[5]

The US Government Accounting Office (GAO) concluded that there is no evidence that reprocessed SUDs create an elevated health risk for patients. Testifying before the US Congress, Dr. Kenneth Kizer, a former undersecretary for health at the US Department of Veterans Affairs, said, "Single-use labeling is a real scam for a lot of devices, and by not using reprocessed devices where possible, it is wasteful and not environmentally responsive, since these items have to be disposed of as biomedical waste."[6]

Members of the European Community have multiple conflicting policies on reusing SUDs, with some allowing it, others regulating it, and some banning it.[7]

RISK STRATIFICATION

The infection risk that medical equipment poses to patients differs, and can be stratified according to its use into (a) high risk, (b) intermediate risk, and (c) low risk. Each group, under normal circumstances, has different decontamination requirements.

1. High-risk items (sterilization required) come into close contact with breaks in the skin or mucous membranes or are introduced into a normally sterile body area. These include surgical instruments, needles, and urinary or other catheters.

2. Intermediate-risk items (disinfection required) come into close contact with mucous membranes or are items contaminated with particularly virulent or readily transmissible organisms. This includes most respiratory equipment, for example, laryngoscope blades, endotracheal and tracheostomy tubes, and oropharyngeal and nasal airways.
3. Low-risk items (cleaning required) come into contact only with normal intact skin. These include stethoscopes, other physical examination equipment, stretchers and wheelchairs, and electrocardiogram (ECG) and electroencephalography (EEG) leads.[8]

DECONTAMINATION

Cleaning, disinfection, and sterilization all decontaminate medical equipment. Decontamination is the general term describing any method of reducing the risks of cross infection, that is, passing microbes from one infected person to a previously uninfected person.[8]

Table 6-1 contains recommended processes that can easily be accomplished in most settings for decontaminating and, then, cleaning different types of medical equipment.

When using chlorine solutions, avoid prolonged exposure of the equipment, as this causes metal to rust and rubber and cloth to deteriorate. To avoid dulling the edges, do not sterilize needles or instruments with a cutting edge at temperatures >160°C.

CLEANING

Cleaning is the process of removing any visible dirt or secretions, including dust, soil, large numbers of microorganisms, and organic matter (e.g., blood, vomit) on which microorganisms grow. Cleaning must be done before equipment is disinfected or sterilized; not doing so can impede effective disinfection or sterilization.[8]

Especially in austere circumstances, “clean items are sufficient to prevent infection in the majority of cases. For the vast majority of minor cuts and lacerations, clean is fine.”[10] Note that SUD needles cannot be cleaned adequately.

Method

Cleaning normally involves washing the equipment with detergent (soap) and water.[8] (To make soap, see “Soap Production” later in this chapter.) Mix fresh dilute soap solutions (and other disinfectant solutions) every 24 hours and store them in a cool place: bacteria may grow in dilute solutions (but not in concentrated solutions).

Clean equipment immediately after use. First, remove blood and other visible dirt by washing equipment thoroughly with warm water without soap. Then wash thoroughly with warm water and soap, rinse with water, and dry completely. Leave scissors and forceps open while drying.[11] Clean surgical instruments with a small brush, such as a soft toothbrush.[12]

Maintenance and Packing

Once the equipment is clean, perform any necessary maintenance (e.g., tighten screws, sharpen edges) and pack them for use or prepare them for disinfection or sterilization.

DISINFECTION

Disinfection is a process used to reduce the number of microorganisms, although not usually bacterial spores. The process does not necessarily kill or remove all microorganisms, but simply reduces their number to a level that is not harmful to health.[8] There are three levels of disinfection: high, intermediate, and low.[5]

High-level disinfection methods kill all organisms, except when there are large numbers of bacterial spores, through the use of a chemical germicide such as bleach or ethyl alcohol. Intermediate-level disinfection procedures kill mycobacteria, bacteria, and most viruses by using a chemical germicide registered as a “tuberculocide” by the US Environmental Protection Agency. Low-level disinfection kills some viruses and bacteria by using a chemical germicide such as soap.

TABLE 6-1 Recommended Decontamination, Cleaning, and High-Level Disinfection/Sterilization Methods

			Alternatives	
Instrument/Item	Decontamination	Cleaning	Sterilization	High-Level Disinfection
	The first step in handling used items; reduces risk of HBV and HIV/AIDS.	Removes all visible blood, body fluids, and dirt.	Destroys all microorganisms, including endospores.	Destroys all viruses, bacteria, parasites, fungi, and some endospores.
Airway (plastic)	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse and wash immediately.	Wash with soap and water. Rinse with clean water; air or towel dry.	Not necessary.	Not necessary.
Ambubag/CPR face mask	Wipe exposed surfaces with gauze pad soaked in 60% to 90% alcohol or 0.5% chlorine solution; rinse immediately.	Wash with soap and water. Rinse with clean water; air or towel dry.	Not necessary.	Not necessary.
Bed pan, urinal, and emesis basin	Not necessary.	Use a brush to wash with disinfectant, soap, and water. Rinse with clean water.	Not necessary.	Not necessary.
Cotton cord umbilical tie	Not necessary.	Not necessary.	Not practical.	Place in small metal bowl. Place bowl in steamer, steam for 20 min. Air dry.
Exam table or other large surface areas (cart and stretcher)	Wipe off with 0.5% chlorine solution.	Wash with soap and water if organic material remains after decontamination.	Not necessary.	Not necessary.
Hypodermic needle and syringe (glass or plastic)	Fill assembled needle and syringe with 0.5% chlorine solution. Flush ×3 and either dispose of needle or soak for 10 min before cleaning. Rinse by flushing ×3 with clean water.	Disassemble. Then wash with soap and water. Rinse with clean water; air or towel dry syringes (only air dry needles).	Preferable. 1. Dry heat for 2 hours after reaching 160°C (320°F) (glass syringes only). *—or—* 2. Autoclave at 121°C (250°F) and 106 kPa (15 lb/in^2) for 20 min (30 min if wrapped).	Acceptable. Steam or boil for 20 min. Use of chemical disinfection is not recommended, as chemical residue may remain (even after repeated rinsing in boiled water) and interfere with the action of drugs being injected.

(*Continued*)

TABLE 6-1 Recommended Decontamination, Cleaning, and High-Level Disinfection/Sterilization Methods (*Continued*)

			Alternatives	
Instrument/Item	Decontamination	Cleaning	Sterilization	High-Level Disinfection
Instruments (e.g., scissors, forceps, vaginal speculum, needle holder, needle)	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse or wash immediately.	Using a brush, wash with soap and water. Rinse with clean water. If will be sterilized, air or towel dry.	Preferable. 1. Dry heat for 1 hour after reaching 170°C (340°F). —*or*— 2. Autoclave at 121°C (250°F) and 106 kPa (15 lb/in^2) for 20 min (30 min if wrapped). For sharp instruments, use dry heat for 2 hours after reaching 160°C (320°F).	Acceptable. 1. Steam or boil for 20 min. —*or*— 2. Use chemical to high-level disinfect by soaking for 20 min. Rinse well in boiled water and air dry before use or storage.
Manual vacuum aspirator cannula (plastic)	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse or wash immediately.	Wash with soap and water, removing all particles.	Not recommended. Heat from autoclave or dry-heat oven damages cannula.	Steam or boil for 20 min.
Plastic apron and sheet	Wipe off with 0.5% chlorine solution.	Wash with soap and hot water. Rinse with clean water; air dry.	Not necessary.	Not necessary.
Personal protective equipment (cap, mask, gown), cloth drape, cloth to dry and wrap neonates	Not necessary. (Laundry staff should wear protective gowns, gloves, and eyewear when handling soiled linen.)	Wash with soap and hot water. Rinse with clean water; air or machine dry.	Not necessary.	Not necessary.
Stethoscope	Not necessary.	Wipe with 60% to 90% alcohol.	Not necessary.	Not necessary.

Storage container for instruments, specimen cup, test tube	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse or wash immediately.	Wash with soap and water. Rinse with clean water; air or towel dry.	1. Dry heat for 1 hour after reaching 170°C (340°F). *—or—* 2. Autoclave at 121°C (250°F) and 106 kPa (15 lb/in^2) for 20 min (30 min if wrapped).	Boil container and lid for 20 min. If container is too large: Fill container with 0.5% chlorine solution and soak for 20 min. Rinse in water that has been boiled for 20 min and air dry.
Suction bulb	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse and wash immediately.	Wash with soap and water. Rinse with clean water; air or towel dry.	Not necessary.	Not necessary
Suction catheter	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse or wash immediately.	Wash with soap and water. Rinse ×3 with clean water (inside and outside).	Not recommended. Heat from autoclave or dry-heat oven will damage catheter.	Steam or boil for 20 min. Use of chemical disinfection is not recommended, as chemical residue may remain (even after repeated rinsing with boiled water) and interfere with the action of drugs being injected.
Surgical gloves	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse or wash immediately.	Wash with soap and water. Rinse with clean water and check for holes. If will be sterilized, dry inside and out (air or towel dry) and package.	If used for surgery, autoclave at 121°C (250°F) and 106 kPa (15 lb/in^2) for 20 min. Do not use for 24 to 48 hours.	Steam for 20 min; dry in steamer.
Thermometer, oral	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse and wash immediately.	Wash with soap and water. Rinse with clean water; air or towel dry.	Not necessary.	Not necessary.
Thermometer, rectal	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse and wash immediately.	Wash with soap and water. Rinse with clean water; air or towel dry.	Not necessary.	Not necessary.

(*Continued*)

TABLE 6-1 Recommended Decontamination, Cleaning, and High-Level Disinfection/Sterilization Methods (*Continued*)

Instrument/Item	Decontamination	Cleaning	Alternatives: Sterilization	Alternatives: High-Level Disinfection
Forceps (pick-ups)	Not necessary. Reprocess each shift or when contaminated.	Using a brush, wash with soap and water. Rinse with clean water. If will be sterilized, air or towel dry.	Preferable 1. Dry heat for 1 hour after reaching 170°C (340°F). *—or—* 2. Autoclave at 121°C (250°F) and 106 kPa (15 lb/in^2) for 20 min (30 min if wrapped).	Acceptable. 1. Steam or boil for 20 min. 2. Use chemical to high-level disinfect by soaking for 20 min. Rinse well with boiled water and air dry before use or storage.
Urinary catheter	Soak in 0.5% chlorine solution for 10 min before cleaning. Rinse or wash immediately.	Use a brush to wash with soap and water. Rinse ×3 with clean water (inside and outside).	1. Dry heat for 2 hours after reaching 160°C (320°F) (metal only). *—or—* 2. Autoclave at 121°C (250°F) and 106 kPa (15 lb/in^2) for 20 min (30 min if wrapped) (metal only).	Steam or boil for 20 min.

Usefulness

While the effectiveness of disinfection depends on the method and the disinfectant that are used, some general principles apply[8]:

- Gram-positive bacteria are more sensitive than gram-negative bacteria.
- Mycobacteria and spores are relatively resistant.
- Non-enveloped viruses, such as *Coxsackie*, tend to be more resistant.
- Fungal spores can be killed by disinfectants. Other bacterial spores, such as *Clostridia*, are generally resistant.
- Tubercle bacteria (TB and related organisms) are more resistant to chemical disinfectants than other bacteria.
- Many common pathogenic viruses can be inactivated by exposing them for 10 minutes to 70% alcohol or for 30 minutes to 5.25% sodium hypochlorite (bleach). These include HBV (hepatitis B) and HIV (human immunodeficiency virus), as well as the viruses that cause rabies, Lassa fever, and other hemorrhagic fevers.

Methods

While chemical disinfectants are the norm, in austere environments, disinfection is best achieved by using boiling water, with or without soap. Heat disinfection is more effective than chemicals. At 80°C, most bacteria (but not their spores) will be destroyed within a few minutes. Boiling accelerates rusting of items with a sharp edge, such as scissors and knives. Using distilled or soft water reduces this problem.

Washing instruments in soap solution and then boiling for some minutes in water is an effective method of disinfection.[13] Various concentrations of soap solution may also be used to wash hands and operating fields before surgery, to wash bedding and clothes, and for personal hygiene.

Boiling

The general rule is to boil contaminated equipment in clean water (100°C [212°F] for 10 to 30 minutes at sea level). This kills all organisms except for a few bacterial spores. Do not start timing it until the water has come to a full boil. At higher altitudes, the temperature at which water boils decreases, so a longer boiling time is required. In theory, the time should be increased by 5 minutes for each 300-meter (1000-foot) rise in altitude.[14] For example, at 4000 meters (~12,000 feet) above sea level, water boils at 86°C (187°F), so ≥60 minutes is required for disinfection.

A way to increase the disinfectant effect of boiling is to use "double boiling." Boil the instruments for 30 to 40 minutes. Let them cool and then boil for another 30 to 40 minutes.[15]

Various techniques can be improvised to boil medical equipment, including using a sieve, a vegetable steamer, or a sling.[16] To use a sieve (or colander), place the instruments in it and put it into a pan of boiling water. When the time has elapsed, lift the sieve out and let everything air dry. With a vegetable steamer, place the instruments in it, cover it tightly, and steam the instruments. Then drain the water and the instruments can cool without being touched. Alternatively, use a sling made from gauze or other thin material. Stretch a piece of gauze, in the form of a hammock, over a pot and tie the ends to the handles. Place wrapped equipment in the hammock and put a tight-fitting lid on the pot. When finished boiling (this takes more time, up to 4 hours, since the equipment is sealed in packages), transfer the packages to a baking pan or an oven grate wrapped in heavy paper for drying. A net bag can also be used to suspend wrapped or unwrapped small equipment in a pot.

Chemicals

There are a number of chemical disinfectants available, even in austere environments. To disinfect against different organisms, the equipment must be immersed in the chemical for the appropriate amount of time.

Hypochlorite Solutions

Hypochlorite (e.g., bleach) in varying concentrations has a wide range of activity against bacteria, fungi, viruses, and bacterial spores. It is an effective disinfectant, both for equipment and for medical areas such as operating rooms.

TABLE 6-2 Uses of Hypochlorite (Bleach) in Health Care Facilities

Use on	Purpose
Potable water	Controls waterborne pathogens. Hyperchlorination controls *Legionella* spp during outbreaks
Hemodialysis water and machines	Reduce bacterial growth and prevents bacterial sepsis
Flower vase water	Reduces risk of fresh flowers acting as reservoir for gram-negative pathogens
Dental appliances	Disinfect contaminated dental equipment
Tonometers	Prevent cross-transmission of microorganisms, especially adenovirus and herpes viruses
Hydrotherapy tank	Reduce risk of cross-transmission from pathogens in water
Manikins	Prevent potential cross-transmission of herpes simplex virus and other pathogens when practicing mouth-to-mouth resuscitation
Syringes and needles	Reduce risk of HIV cross-transmission when the same needles and syringes are used by multiple people
Blood spills	Prevent acquisition of blood-borne pathogens, especially HIV and hepatitis B and C viruses, if there is contact with non-intact skin or there is a sharps injury
Environmental surfaces	Reduce risk of cross-transmission from health care personnel's hands during *Clostridium difficile* outbreaks
Laundry	Reduces risk of pathogen cross-transmission and laundry worker acquisition
Medical waste	Reduces microbial load associated with regulated medical waste
Antisepsis	Reduces risk of pathogen transmission from health care personnel's hands
Dental therapy	Disinfects root canal

Adapted, with permission, from Rutala and Weber.[17]

Thoroughly clean equipment before using bleach as a disinfectant, since its activity is reduced by the presence of a biofilm or organic material. Since bleach is corrosive to metal instruments, don't leave instruments in the solution longer than 30 minutes. As soon as they are removed, rinse and dry them.

In health care facilities, (Table 6-2) bleach is used to clean environmental surfaces, disinfect laundry and equipment, decontaminate blood spills, and decontaminate medical waste prior to disposal. Bleach has also been recommended as a good way for IV drug addicts to clean needles for reuse (see "Needles" in this chapter). In the past, health care workers used bleach to clean their hands.[17]

Alcohols

Alcohols (e.g., methanol, ethanol, and isopropanol) are active against bacteria and viruses. When an alcohol solution of ≥70% concentration is used, immerse the equipment in the solution for ≥10 minutes, and for 12 hours or more, if possible.[18] As with bleach, use alcohol as a disinfectant only after equipment has been cleaned—or, at least after all the visible surface dirt has been removed from the area to be disinfected.[8] To prepare a 70% ethanol solution, add 8 parts 90% ethanol to 2 parts water. To prepare a 70% isopropanol solution, add 7 parts standard isopropanol to 3 parts water.[14]

Aldehydes

Aldehydes (e.g., formaldehyde) are potent and potentially dangerous chemicals. Formaldehyde, usually available wherever a laboratory or mortuary exists, is active against bacteria, viruses, and fungi, but has a slow action against tubercle bacilli.[8] Prepare an aldehyde disinfectant solution by adding 1 part 4% formaldehyde to 3 parts water. Soak instruments for 30 minutes or, if they were used on infected patients, for 1 hour before drying and sterilizing.[11,14]

POVIDONE-IODINE

Povidone-iodine (PVP; Betadine) may be used for disinfecting instruments if nothing else is available. While exact information about this is sketchy, studies seem to support its use. The recommendation is to add 1 part 10% povidone-iodine solution to 3 parts water and soak instruments for 15 minutes.[14]

STERILIZATION

Sterilization removes or destroys all forms of microbial life, including bacterial spores.[8]

Methods

There are several methods for sterilization, but only the methods using heat are useful in austere environments. Clean and open instruments, then wrap them in paper (including newspaper) or tightly woven cloth. Double wrapping generally gives the equipment a shelf life of several weeks. The ideal wrap is a layer of cloth inside a paper cover.[14] If instruments or cloth packs are kept in metal boxes for autoclaving, the boxes must have multiple holes in the bottom to let the dry air "run out" of the box.[15]

Moist Heat: Pressure Cooker

Moist heat is the most effective method for sterilization in austere situations, although the necessary equipment may not be available.

If you can find one, a home pressure cooker will sterilize medical equipment very well. (Note that this is not a "double-boiler," but a sealed cooker with a pressure gauge, such as those used for home canning. The combination of steam and pressure sterilizes the equipment.) Home pressure cookers do not have a thermometer: use time and the pressure gauge to decide when sterilization is complete. Generally, you should boil items for at least 30 minutes under 3 to 5 pounds pressure.[16] For an extra measure of safety, add another 30 minutes.

To sterilize equipment using a pressure cooker[15]:

1. Add water, preferably distilled or fresh rainwater to lessen mineral deposits that have to be cleaned off. Add enough water so the cooker won't run dry during the process.
2. Put the equipment on the pressure cooker tray over the water and close the lid. Do not stuff the equipment in; the steam must circulate to be effective. Put any metal container containing equipment on its side with the top removed, so the steam will circulate.
3. Open the valve and apply heat. Bring the cooker to a full boil. It will begin whistling like a tea kettle when ready. When it stops expelling air and water from the valve, close it.
4. Only at that point should you begin timing. (The sterilization process will be ineffective if you begin timing before it is boiling.)
5. Once the process is done, take the cooker off the heat and, when it has cooled and the steam is out, open the valve. Unlock the cooker and let the equipment dry by evaporation as it cools. Equipment packs may need to be placed on a drying rack. The time required to cool off depends on the material, but usually is at least 30 minutes. Glass and culture media can take several hours to cool. To cool the equipment quickly, run cool (sterile) water over it. Caution: this may cause any glass to shatter.
6. Clean the pressure cooker with distilled water or fresh rainwater after each use; do not use detergents. Check the gasket, pressure vent, gauge, and other parts; you don't want it to explode on you. If the cooker has a manual, read it to determine any special maintenance requirements, time variations for sterilization, how much water to add, and how to tell when it is safe to open it.[14]

Dry Heat

OVEN

An oven is normally used for hot air sterilization, but this takes a long time. Equipment must be able to withstand temperatures of at least 160°C (320°F) for 120 minutes or 170°C (340°F) for

60 minutes.[19] Do not start timing until the desired temperature has been reached. Be careful not to exceed 170°C (340°F) or metal instruments may be damaged.

To eliminate most moisture and decrease the chance of metal equipment rusting, leave the door open for a few minutes while heating the oven. Use this method for surgical instruments and high-temperature glass or plastics, but not for textiles. (See "Dressings and Other Textiles" later in this chapter.) Heat the oven to 160°C (320°F) to disinfect oils, ointments, waxes, and powders. Bake them for 2 hours.

Fire

Equipment "soused" and "flambé" are two common methods to quickly disinfect small metallic medical equipment in austere settings. The recipients of this affection are usually pins (e.g., to trephine nails or open blisters), knives (e.g., to incise and drain abscesses or remove foreign bodies), and needles (e.g., to suture or remove foreign bodies). Dip the instrument in alcohol, preferably the highest concentration available, and set fire to it. This is not a completely reliable sterilization method and will damage the instruments. If alcohol is not available, heat the "business end" of the instrument with an open flame until it glows red. This is an effective sterilization method, but it will also damage any instrument on which it is used.[14]

REUSING SPECIFIC EQUIPMENT—METHODS AND SAFETY

Syringes

There are two types of syringes: disposable and reusable. The main differences relate to the material used to make the barrel and plunger of the syringe.

Reusable Syringes

A reusable syringe's body and plunger are made of either glass or a plastic that can be autoclaved. Even though these instruments may sometimes be called "permanent," autoclaving eventually breaks down the rubber on a "reusable" plastic plunger and the glazing on the glass plunger wears out.[10]

Sterilization

The best method to sterilize syringes is to use a rack to suspend the barrel and plunger. The World Health Organization (WHO) reports a 40% failure rate with other methods—probably because the syringe surfaces in contact with the tray are not accessible to the steam; thus, some organisms survive.

Make a holder by bending metal in an "S" configuration so that the syringe bodies, plungers, and needles can be suspended with minimal contact with the rack itself; they should hang freely. Be sure to take the plungers out of the syringes or they may break.

An alternate sterilization method is to wrap the plungers and cylinders in an operating room (OR) towel and push the needles through the cloth. No item should be in contact with another. Fold to make a pack and autoclave, or use a pressure cooker as described previously.[10]

Single-Use Syringes

The danger of reusing syringes, even though this practice is common throughout the world, appears to negate any good produced by medical treatment. Every year the reuse of dirty syringes infects millions of people with AIDS and hepatitis and "causes 1.3 million early deaths, a loss of 26 million years of life, and an annual burden of US $535 million in direct medical costs."[20] Young adults are most affected.

If you still plan on trying to sterilize disposable syringes, understand that they will generally melt when heated to sterilizing temperatures, but they can be autoclaved several times before deforming beyond usefulness.[10]

Needles

Reusable Needles

Reusable needles generally have a Luer lock attachment to fasten to the syringe (as do many disposable ones) and are made of a harder metal than the disposable needles so that they can be sharpened. They also come with a needle plunger so anything trapped in the needle cylinder can be removed.[10]

Sharpening Permanent Needles

According to the editors of *Survival and Austere Medicine*, this is how to sharpen a permanent needle[10]: Place a drop of light oil (sewing machine, light machine, or gun oil) on a fine sharpening stone. Draw the bevel of the needle (flat part of tip) back and forth at a uniform angle with no rocking. The goal is to keep the bevel the same length as on a new needle. Any rocking side to side will cause the bevel to become rounded, which need to be corrected. Changing the angle of attack against the stone will cause, at best, a dull needle and, at worst, a hook on the point. After sharpening for a bit, a burr will form on the sides of the bevel—this is a thin edge of metal. Remove it by gently drawing the needle on the side to the top, forming two facets along the top of the point.

Always finish by giving one rub along the bevel and one to each facet. When finished, check it with a magnifying glass. Needles should be soaked overnight in trichloroethylene to remove any oil. Then, polish with a soft cloth and push water through the needle to make sure the cylinder is clear. If you do not have access to oil and a solvent to remove it, then sharpen and clean the needle using hot soapy water (including inside the barrel using fine wire). This procedure should be done only when the needle seems to be getting dull, not after every use.[10] Maurice King's *A Medical Laboratory for Developing Countries* (Oxford University Press, 1973) contains more complete instructions and good illustrations.

Single-Use Needle on Same Patient

Patients with diabetes routinely reuse the same syringe for up to one week, which is fine if it is kept in a clean container. During this time, they do not decontaminate the syringe. Likewise, in situations of scarcity, a needle should be able to be used on the same patient over a short time period (e.g., 1 week). This assumes that care will be taken to keep the needle clean and that it won't be used on anyone else.[10]

Reuse of SUD Needles

Unsterilized SUD needles are responsible for 1.3 million deaths per year, mostly in developing countries.[21] In addition, it is estimated that 160,000 new HIV infections and millions of new cases of hepatitis B and C are caused each year from the use of dirty needles.[22]

Disinfection Method for Needles and Syringes

It is optimal either (a) to administer medications other than by injection when appropriate or (b) to use reusable needles with appropriate sterilization or new SUD needles when possible. When no other option exists, use high-level disinfection to make SUD needles and syringes as safe as possible. US governmental agencies recommend that needles and syringes potentially contaminated with HIV virus should be thoroughly cleaned and then immersed in full-strength bleach (5.25% sodium hypochlorite). They recommend using full-strength bleach because of the difficulty of cleaning the interior of needles and syringes for parenteral injection.[17]

Respiratory, Anesthesia, and Resuscitation Equipment

In general, it is unnecessary to sterilize respiratory and anesthetic equipment, since spore-bearing organisms are not a cause of respiratory infections.[8] High-level disinfection, or even a lower level of decontamination, often suffices.

Anesthesia Equipment

The internal circuit in mechanical ventilators can often be autoclaved. The external (or patient) circuit should be changed every 48 hours or between patients. Both the external circuit and the humidifiers require high-level disinfecting. Heated-water humidifiers, however, need only be cleaned, dried, and refilled with sterile water every 48 to 72 hours.[8]

Nebulizers should be cleaned and rinsed in alcohol every 48 hours.

Resuscitation/Respiratory Equipment

Bag-valve-masks (BVMs) should be washed and cleaned as soon as possible after each use. Laryngoscope blades should be washed after each use, ideally using hot, soapy water to remove secretions. A surgical brush helps to clean the blade. High-level disinfection should follow.[23]

SUD endotracheal tubes can be reused if they are cleaned and given high-level disinfection. Note that using heat will probably damage them, so immerse them in a 70% alcohol solution for 10 minutes. Allow the tubes to dry before reuse.[8]

Suction catheters can be difficult to clean. The best method is to suction clean water through them. Then use a high-level disinfectant and allow them to air dry before reuse.

Surgical Instruments

Sharp/Delicate Instruments

Sharp or delicate instruments should be chemically sterilized using alcohol. Acetone can also be used if the equipment does not contain plastic or polymers. Rinse them in hot, sterile water and let them dry before reuse.[12]

Lightweight Surgical Instruments

Lightweight surgical instruments, such as ophthalmic or plastic instruments, can be sterilized in a pressure cooker or autoclave. Heavier surgical instruments (without a fine tolerance or sharp edges), such as mosquito clamps, towel clips, and large needle holders, may be disinfected in boiling water.[12]

Endoscopic Equipment

Laparoscopic or arthroscopic telescopes (optic portions of the endoscopic set) should be sterilized before each use. If this is not feasible, use high-level disinfection. Sterilize heat-stable endoscopic accessories, such as trocars, using an autoclave/pressure cooker or dry-heat oven.[5]

Dressings and Other Textiles

Disinfection can be accomplished with the following methods[10,14]:

Ironing: Cover a table with a cloth that has previously been ironed. Then, dampen that cloth and the one to be disinfected with boiling water and press with a very hot iron for several passes. Steam as you iron.

Solar: Hang the textile in full sunlight for 6 hours per side.

Washing: When dressings are in short supply, they can be disinfected by (a) washing and then boiling them for 5 minutes or (b) washing, rinsing, and then soaking them for 30 minutes in a 0.1% chlorine solution or a 5% Lysol solution.

"Sterile" Dressings

Cloth for a dressing can be cleaned and disinfected by boiling it in water for 15 minutes or by saturating it with alcohol. It can also be sterilized using any of the sterilization methods described previously. Normally, clean and disinfected is sufficient. If using dry-heat (oven) sterilization, remember that the exact time and temperature required will vary according to the volume of material treated, volume of the autoclave, contamination level, and moisture content of the cloth: the minimum is 160°C to 170°C (320°F to 340°F) for 2 to 4 hours.[24]

When reusing dressings (common in austere battlefield conditions), wash the gauze dressings (or immerse in saline) to remove stains, dry them, and then sterilize using dry heat.[25]

For ease of use and to make sterilization easier, wrap dressings in aluminum foil and place the package on a flat pan in the oven. Bake at 350°F (177°C) for 3 hours. When they have cooled, label each dressing with its size.[26]

Gloves, Tubing, and Plastic Items

Gloves

While disposable gloves are preferred, they may not be available—or may be too expensive to use only once. Single-use surgical gloves may be reused up to three times if they are not obviously torn. After that, additional autoclaving breaks down the rubber and the gloves develop microscopic tears that put the patient and clinician at risk.

To prepare disposable gloves for reuse, first blow into them to ensure they do not leak. If there are holes, patch them from the inside. Next, decontaminate the gloves by soaking in a 0.5% chlorine solution for 10 minutes, or simply wash and rinse them. Cover the inside with talcum powder and let them dry thoroughly; otherwise, they will stick together and be unusable. Sterilize by autoclaving or perform high-level disinfection using steam or boiling.[27]

Rubber and Plastic

Rubber and plastic deteriorate with repeated sterilization. Wash all tubes, catheters, gloves, and other rubber or plastic equipment for reuse in cold water immediately after use, next wash in warm water with soap, and, finally, rinse in water. Dry rubber equipment thoroughly. It sticks to itself and becomes damaged if stored moist.[28]

Plastic Items (Airways, Syringes, and the Like)

How to sterilize plastic equipment depends on the type of plastic.[10] Unfortunately, that may be difficult to discern. General guidelines are as follows:

- HDPE (high-density polyethylene): Translucent. Autoclave at 121°C (250°F) for no more than 15 minutes.
- PP (polypropylene): Translucent. Autoclave at 121°C (250°F).
- PMP (polymethylpentene): Clear, brittle at room temperature, can crack or break if dropped. Autoclave at 121°C (250°F).
- PC (polycarbonate): Clear. Autoclave at 121°C (250°F).
- PTFE (polytetrafluoroethylene): Not translucent. Autoclave at 121°C (250°F) or put in oven at 160°C (320°F) for 2 hours or 170°C (340°F) for 1 hour.

Glassware

In general, clean and then sterilize glassware used for laboratory or patient care. Use a pressure cooker or autoclave. However, note that glassware can crack or shatter if the autoclave or pressure cooker is opened too soon or if cool water is poured over hot glass (known as speed cooling). Also, some glassware, especially pipettes, may not fit in a pressure cooker.

SOAP PRODUCTION

Soap is generally available, and cheap, in most places. Sometimes you may have to make your own. A very basic recipe for hand soap is

0.50 ounce (oz) (14 g) lye
0.25 cup cold water
0.50 cup lukewarm fat
1 Tablespoon lemon juice (optional)

In a plastic container, gently stir the lye into cold water with a wooden spoon. Slowly add lukewarm fat. Continue to stir until slightly thickened. Add lemon juice, stirring to mix thoroughly. Pour mixture into plastic molds. Cover with plastic wrap and leave for 24 hours. Remove soap from molds and allow to air dry for 14 days. This will make 1 to 2 medium-sized bars.

The details of making soap, including methods to make liquid, hard, and even "smelly" soap, can be found at: http://www.folksonline.com/folks/hh/tours/soapmkg.htm.

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7 | Vital Signs, Measurements, and Triage

AGE (PEDIATRICS)

Knowing a child's age is important to determine normal vital signs, disease prevalence, and the appropriate medications. It is also an indicator of social milestones. The easiest way to determine a child's age is to ask the parent or check available records. However, in cultures where birth records are unavailable, as well as during acute out-of-hospital or emergency department (ED) events, this information may not be easy to get.

Without records, one way to estimate a child's approximate age is to count the number of teeth present and then add six to derive the age in months.[1] Another way is to have the child sit upright (with the head in a neutral position), then raise one arm over his head and try to touch the opposite ear (Fig. 7-1). This "overhead test" has a sensitivity of 90% and a specificity of 78% (positive predictive value 93%; negative predictive value 68%). If the child successfully performs this test, he is most likely ≥6 years old, which is the age to begin school and to receive other benefits in many cultures. If a child fails this test, there is a good chance that he is <6 years old, but it is less clear, since other factors, such as malnutrition, may influence the results. The test works because a 6-year-old child's humerus is long enough to raise the elbow high enough to extend the forearm across the head and allow the fingers to reach the opposite side of the head.[2]

HEIGHT

Any firm surface can be marked in 0.5-cm (or 0.5-inch) increments to measure a patient's height. For ambulatory patients, use a vertical surface, such as a wall or the side of a doorway. For infants, children, and bed-ridden patients, mark the side rails of stretchers and beds with indelible ink. Once a child's height is known, the weight can be estimated.

Using a stretcher marked along the side to measure a child's height is extremely useful; knowing the child's height, you can estimate weight, and this provides the information necessary to calculate pediatric medication and fluid dosages.

If an adult's height can be measured only in a sitting position, such as a wheelchair-dependent patient, measure each arm span in centimeters, from mid-sternum to the end of the extended middle finger (half-arm span). Use the longer of these measurements in the

FIG. 7-1. A child less than 6 years old cannot reach his opposite ear.

following formula: Height ≅ (0.73 × [2 × half-arm span]) + 43 cm.[3] A simpler method is to double the longest measurement from mid-sternum to the tip of the patient's long finger.[4]

WEIGHT

Children

Need to estimate a child's weight? When asked, the parents of children aged from 1 to 11 years old can estimate their child's weight within 10% of the measured weight only 78% of the time. Accuracy when using the Broselow tape was within 10% of the measured weight only 61% of the time, and the accuracy was worse as children got older. At least in developed countries, the Broselow tape tends to underestimate children's weights.[5-8] All other forms of guessing a child's weight, including the Argyll, the Advanced Pediatric Life Support, and the Best Guess methods, perform poorly.[9] If the parents aren't available, use the following formula:

$$(2 \times \text{age in years}) + 8 = \text{weight in kilograms (kg)}$$

Beam Scale for Infants

If standard scales to weigh infants are not available, make a beam scale (Fig. 7-2). If finely calibrated, the beam scale may also be used to weigh smaller items, such as medications.

To make a beam scale, use a straight, rigid pole of bamboo, metal, or dry wood, ~1-m long. Mount a hook close to one end from which the beam will be suspended. Put another hook about 5 cm away, between the first hook and the nearest end of the beam. This is where the infant or substance to be weighed is suspended. A fixed weight is also suspended from the beam, but on a moveable slide (e.g., metal wire). The weight can be a bag, bottle, or other container filled with sand. Mark gradations on the beam for each weight increment. Use standard weights to calibrate the scale initially, so the gradations are accurate. Hang the known weight at the end of the scale (i.e., where the infant would be) and mark the point on the beam where the sliding weight is when the scale balances evenly.[10] Large increments (1 L of water weighs 2.2 kg, 0.5 L weighs 1.1 kg, etc.) and smaller increments (use the weight of a common coin and its multiples) can be easily determined. If a local merchant (jeweler, grain dealer, etc.) has standard weights, try to borrow them for more accurate calibration of the scale.

Adults

When experienced health care workers make weight estimates for adults, they are fairly accurate.[11] However, the following method for estimating adult weights has been shown to be better than that of experienced physicians, much better than that of nurses, but not as good as the patient's estimate of his own weight. These formulas can be preprogrammed in a computer for easier use.[12]

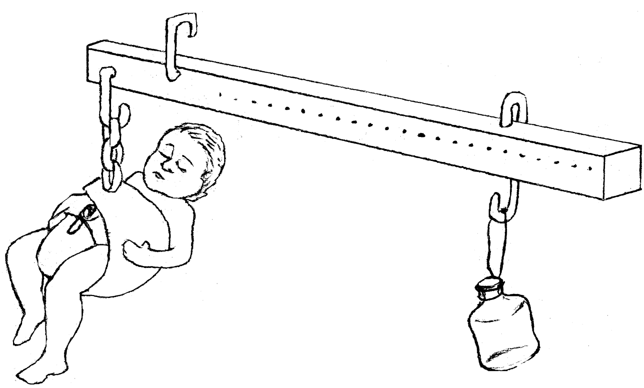

FIG. 7-2. Improvised beam scale to weigh infants.

$$\text{Male's weight (kg)} = [\text{knee height (cm)} \times 1.10] + [\{\text{MAC (cm)} \times 3.07\} - 75.81]$$

$$\text{Female's weight (kg)} = [\text{knee height (cm)} \times 1.101] + [\{\text{MAC (cm)} \times 2.81\} - 66.04]$$

Knee height: The distance between the thigh prominence with the knee bent at 90 degrees proximally and the plantar aspect of the foot at the heel with the ankle bent at 90 degrees distally.

MAC (mid-arm circumference): Palpate the humeral head proximally and the lateral humeral condyle distally. Wrap a tape measure around the arm midway between these landmarks so that it contacts the skin at all points but does not compress the soft tissue.

Adults' nutritional status best correlates with body mass index (BMI). The formula to calculate BMI is body weight (kg) divided by [height (m) squared], or [kg ÷ m^2].[3] For adults, a BMI ≥18.5 is normal; BMI <16 is severe malnutirition.[13]

MEASURING TEMPERATURE WITHOUT A THERMOMETER

In austere circumstances, a thermometer normally is not available. Generally, caregivers notice a tactile fever in only about half of all children with a measurable fever. Elevated tactile temperatures, as measured at home by mothers touching their child's forehead, have moderate (46% to 73%) correlation with fevers recorded in the ED or hospital.[14,15] However, for children >2 years old with a temperature ≥38.9°C (102.02°F), tactile assessment can determine that a child has a fever 98% of the time.[14]

If you do have a thermometer and you need to convert the numbers from Celsius (Centigrade; C) to Fahrenheit (F) or vice versa, use these formulas:

$$°F = (°C \times 1.8) + 32°$$

$$°C = (°F - 32°) \div 1.8$$

An Osborn or J wave on an electrocardiogram (ECG) can suggest hypothermia, especially in elderly patients in whom the diagnosis is not suspected. This elevation at the QRS-ST junction (Fig. 7-3) occurs in about 80% of hypothermic patients (a core body temperature ≤95°F[35°C]) and in nearly all patients whose temperature is <90°F (32.2°C). The waves' sizes appear to be inversely related to temperature, but otherwise they do not appear to have any prognostic value.[16]

PULSE AND RESPIRATIONS

Measuring Time

To time pulse or respiration measurements without a watch, clock, or other timepiece, you must either count the pulse beats or respirations yourself or make a timer.

FIG. 7-3. Osborn or J wave.

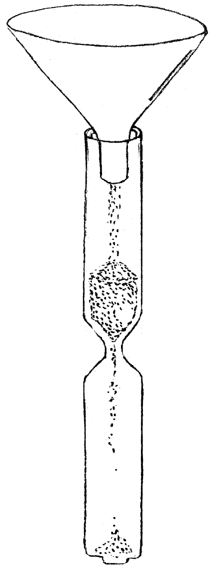

FIG. 7-4. Making a sand timer.

Counting is not as accurate as using a watch, but time may be measured by counting in any situation: Simply count "one-thousand-one, one-thousand-two," and so on, while someone else counts the pulse. To calculate pulse rate per minute, count to "one-thousand-six" (about 6 seconds), then multiply the counted pulsations by 10. Simply estimating time without counting always results in underestimation.

To make a simple, portable sand timer, use a blood collection tube or other piece of glass that can be molded when heated. Heat the middle of the tube and stretch to narrow the diameter. Then, if both ends of the tube are open, seal one end by heating it over a flame. Next, sift some sand through a fine strainer. Dry the sifted sand completely by using sunlight or an oven. Stand the tube upright and put enough sand in the top part so that the sand takes one minute to run from the top, through the narrow middle, to the bottom section (Fig. 7-4). During construction, you will need a watch, a clock, or a previously calibrated timer to check the initial timing. After the correct amount of sand is in the tube, seal the open end either by heating or with a stopper. Since these tubes break easily, store the timer in a padded box.

Water timers also work well. Heat the end of a long, narrow glass tube. Stretch that end and break it, leaving a very tiny opening. A micropipette with a very tiny opening may also suffice without the need to work with heated glass. In either case, make a narrow mark near the top (near the wide opening) of the tube with nail polish, tape, or another marker, or by etching the glass. Cover the narrow end of the tube and fill the tube with water exactly to the level of the mark. Let the water drip out of the tube for 1 minute. Mark the tube again at the exact point of the water level after 1 minute (Fig. 7-5). Voilà, you have a timer!

Finally, if you have no clock or wristwatch for measuring pulse and respirations, use the clock or timer function on the now ubiquitous (even in the least-developed regions of the world) cell phones—if it has a second hand.

Alternate Sites to Palpate Pulse

When you can't palpate a pulse at the typical wrist or femoral areas, try one of the sites listed here:

Carotid artery. Slide your fingers from the midline to the opposite side of the neck from where you are standing and stop at the anterior border of the sternocleidomastoid muscle. The carotid should be palpable. Don't press too hard and cause a vagal response.

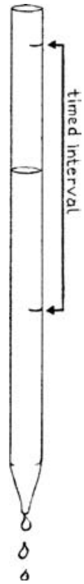

FIG. 7-5. Homemade water timer.

Superficial temporal artery. This is accessible in nearly all patients. Put two fingers just anterior to the ear at the superior part of the tragus. The finger most proximal to the ear will normally feel the pulsation without difficulty.

Dorsalis pedis and posterior tibial (foot/ankle) arteries. These are often used to check for peripheral vascular integrity, and also to monitor the pulse, especially when the other sites are inaccessible. These arteries can also be used to draw arterial blood gasses and are much easier and safer sites to draw from than, for example, femoral arteries.

Pulses in Infants

Palpating an infant's pulse, especially when they are critically ill and a decision must be made immediately about whether to begin resuscitation, can be very difficult. The easiest, fastest, and most successful method of determining infant cardiac activity can be applied in any situation, since it requires no equipment. It doesn't even require finding and palpating a pulse: Simply place your ear against the infant's chest wall and listen for heart sounds (Fig. 7-6).

A study with experienced pediatric nurses to find a pulse in infants showed that the mean time to correctly identify the pulse rate using direct auscultation was 2.4 ± 1.2 seconds, with a 100% success rate. Palpation methods took longer and were less successful. The frequently used femoral pulse rate took 9.1 ± 5.9 seconds to find, with only a 43% success rate.[17]

Radial Pulse and Trauma Prognosis

A weak radial pulse in most trauma patients (at least those 18 to 50 years old without a head injury) indicates a markedly increased mortality (29%) compared to only 3% of those with a normal pulse (odds ratio: 15.2). There is also a strong likelihood that trauma patients will require intubation (odds ratio: 7.5) and even admission to the intensive care unit (ICU) (odds ratio: 5.3). Patients with an absent radial pulse are usually dead or quickly will be dead.[18] In addition, tachycardia is a much more reliable sign of hypovolemia than is blood pressure.

FIG. 7-6. Direct precordial auscultation.

BLOOD PRESSURE

"The ability to obtain a blood pressure measurement in an austere environment is often limited by time constraints, equipment availability, and noisy conditions."[18]

Measuring Blood Pressure Without a Cuff

Estimating blood pressure (BP) when a pulse is palpable, for example, radial (>80 mm Hg), femoral (70 to 80 mm Hg), or carotid (60 to 70 mm Hg), overestimates the patient's actual BP.[19]

A useful finding is that patients with palpably cool extremities as compared with those of other patients have hypoperfusion. Especially when found in an arm and a leg, such patients have low cardiac indices, low pH, low bicarbonate levels, low mixed venous oxygen saturation (SvO_2), and elevated lactate levels.[20]

Measuring Blood Pressure Without a Stethoscope

When transporting patients by air or in a noisy ambulance, Korotkoff sounds (BP) may not be audible through a stethoscope. If a stethoscope is not readily available or cannot be used, palpate the systolic pressure. If done carefully, this method is as accurate as using a stethoscope.

If a pulse oximeter is available, it also can be used to measure the systolic BP when there is too much noise or vibration either to use a stethoscope or to palpate a pulse. Place the sensor on a finger, get a good waveform, inflate the sphygmomanometer until the waveform disappears, and then slowly deflate the cuff until the waveform reappears. The measurement when it reappears is an accurate measure of the systolic pressure.[21]

Makeshift/Alternative Blood Pressure Cuff

Neonatal arm BP cuffs can be used successfully on adult forefingers, producing a "finger cuff." Only the mean BP equates to that taken on the arm.[22] If a manometer is available, some disposable (or non-disposable) pressure pumps for intravenous (IV) fluids and blood can be used as (a) a BP cuff if attached to a manometer or (b) an extremity tourniquet (clamp the tube when inflated). In large adults, these devices may only fit on their calf or forearm.

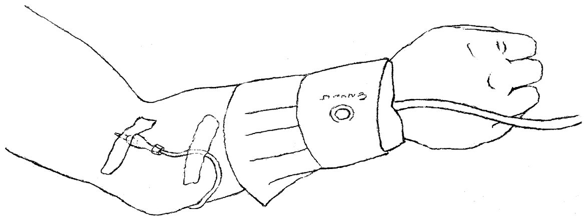

FIG. 7-7. BP cuff on forearm.

Wrist and Calf Blood Pressures

Blood pressure cuffs placed on the forearm (Fig. 7-7) and above the ankle (Fig. 7-8) deliver the same or nearly the same BP as when placed at the brachial artery (arm). Forearm or ankle measurement comes in handy with obese patients on whom the standard adult cuff is too small, for adults when only a child-sized cuff is available, or to avoid compressing an area with trauma. In addition, use a forearm or ankle BP to avoid periodically occluding an arterio-venous fistula (in dialysis patients) or an intravenous line. The mean and diastolic pressure readings are essentially equal in the arm and the ankle, but the systolic pressures are not. So, use the mean BP with a calf BP cuff. (Calculate this by multiplying the diastolic pressure by two and adding the systolic pressure. Then divide the result by three. Alternatively, take one-third of the difference between the systolic and diastolic pressures and add it to the diastolic pressure.)

This difference between the calf and the arm BP readings is reflected in the normal ankle–brachial index (ABI), used to test for vascular compromise in the leg. The calf's systolic pressure is normally higher than that in the arm. (ABI is calculated by dividing the systolic pressure in the arm over that in the leg.) A Doppler is generally used for accuracy. The normal result is <1.[23]

Preventing an IV Tube From Backing Up

To prevent an IV from backing up and possibly contaminating the IV solution when the BP cuff inflates on the same extremity, run the IV tubing under the cuff, so that when it inflates, the IV stops. When the cuff deflates, the IV starts flowing again. This technique, of course, does not prevent the IV from periodically stopping, as it does when a wrist or an ankle cuff is placed proximal to the IV.[24]

PEDIATRIC VITAL SIGNS

Children are not small adults; they have the disturbing habit of continually changing their height, weight, and normal vital signs as they grow. So, it helps to have some idea of what these are

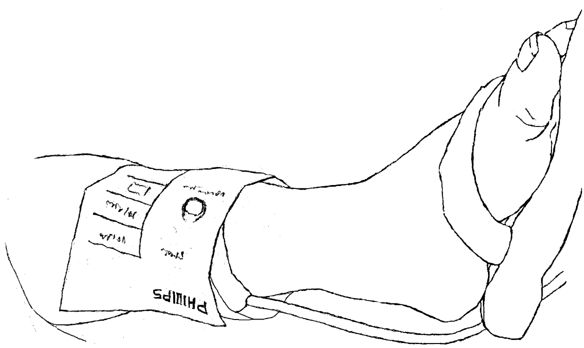

FIG. 7-8. BP cuff on the calf above the ankle.

TABLE 7-1a Normal Pediatric Vital Signs

	Pulse (beats/min)	Systolic BP (mm Hg)	Diastolic BP (mm Hg)
Newborn	95-145	60-90	30-45
Infant	125-170	75-100	30-70
Toddler	100-160	80-110	40-90
Preschool	70-110	80-110	45-85
School age	70-110	85-120	45-88
Adolescent	55-100	95-120	60-90

TABLE 7-1b Normal Pediatric Vital Signs

	Respiration (breaths/min)	Weight (kg)	Blood Volume (mL/kg)
Newborn	30-60	3.5	90
Infant	30-60	4-10	90
Toddler	24-40	12-14	90
Preschool	22-34	16-18	80
School age	18-30	20-26	80
Adolescent	12-16	>50	70

supposed to be (Tables 7-1a and 7-1b), especially when calculating fluid and medication requirements. This section includes both some simple formulas and more specific tables for various pediatric parameters.

Formulas for Quick Estimates (Normals)

Systolic BP in Children Aged >1 Year (Approximation)[25]

$$\text{Median systolic BP} = 90 \text{ mm Hg} + (2 \times \text{age in years})$$

$$\text{Minimum systolic BP} = 70 \text{ mm Hg} + (2 \times \text{age in years})$$

The Foot as a Vital Sign

In neonates, the sole of the foot may provide a general idea about the child's status. Cold or dusky soles can indicate one or all of the following: (a) hypothermia, (b) hypoxemia, or (c) hypotension, especially in a child with delays in capillary refill and without respiratory distress who does not respond to rewarming.[26]

Pediatric Milestones in Development

All parents question whether their children are normal. The answer to this question is that no child is "normal," but the child may be developing normally. When assessing the child's development, an easy way of remembering some basic developmental milestones is that a 1-year-old does one action, a 2-year-old does 2 actions, etc. An alternative method is:

1-year-old	Can say single words
2-year-old	Uses 2-word sentences Understands 2-step commands
3-year-old	Uses 3 words together Repeats 3 digits Rides tricycle (3-wheel bike)
4-year-old	Draws square (4 sides) Counts 4 objects

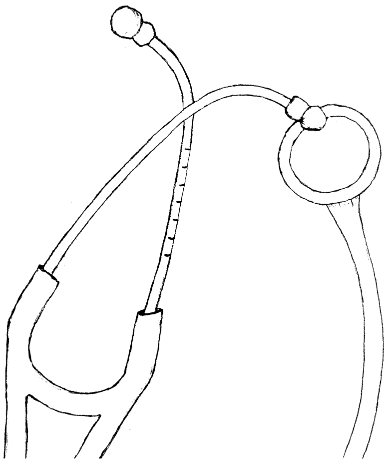

FIG. 7-9. Stethoscope marked to measure lengths.

MEASURING LENGTH, AREA, AND VOLUME

The practitioner needs to be able to judge the size of wounds and incisions, as well as skin and internal lesions. Standard measurements, in centimeters or in inches, can be made on personal medical equipment that you normally carry, such as the metal earpieces in a stethoscope (Fig. 7-9), the reflex hammer's handle, penlights, and scissors.

Since antiquity, practitioners have used their own body parts to make these measurements. Table 7-2 gives some approximate lengths and areas for the sites described on one's own body. These correspond most closely to adult Caucasian males. In practice, reasonable approximations such as these usually suffice. However, since body sizes vary greatly, especially between men and women, practitioners should measure these sites on their own body to use for approximations. (Figures 7-10 through 7-14 demonstrate how to take these measurements.) The area measurements are particularly useful for estimating the size of skin lesions.

Volume Measurement

Measuring volume is useful, not only to determine the output of urine and other secretions or bodily losses (such as blood), but also to measure fluids and medications to give patients.

Most food containers (cans, cartons, bottles) have their volume on the label. When empty, they can be used to accurately measure volumes. They generally only need to be cleaned of food or whatever else they previously contained. They need not be sterilized to measure bodily output, unless the specimen also has to go to the lab. Sterility, of course, is vital for anything used to measure material for injection. For items that will be taken orally, they need to be "potable clean," meaning that you could safely drink from them. The volume measures on some containers may not easily equate to those that you know (or need); Table 7-3 provides common conversions.

Kitchen-measuring devices can be used to measure volume. Those with a capacity of ≥32 ounces (oz) (1 L) are especially good for measuring urine output. A transparent container with measurement markings makes the task much easier. The container may be used a lot, so use something durable.[28]

Most glass or plastic containers normally are not marked with volume increments. Mark them either by fastening a piece of tape from the bottom of the container along its side, or by etching or marking them with an indelible marker. Add 1 mL (or 1 oz) at a time from a syringe or other source of known quantity. Mark the tape or the container at the level reached after each quantity is added. Repeat the process until the container is full.

COLOR

A patient's overall color can provide valuable information, especially in critical situations or in surgery. Abnormal skin coloring can signify a wide variety of diseases, including jaundice

TABLE 7-2 Clinical Measurements Using Body Parts

Approximate Length (inch, cm)	Measurement Site(s)
0.5, 1.26	Finger width: greatest width of the distal phalanx of the small finger
0.75, 1.90	Finger width: width of the small finger at the MP crease
1, 2.54	Phalanx: length of the middle phalanx of the small finger (Fig. 7-10)
	Phalanx: from the palmar MP crease to the proximal IP joint of the long (middle) finger
	Thumb: width of thumb at the IP joint
6, 15.24	Span: when opening the hand and spreading the fingers widely, from the tip of the thumb to the tip of the index finger (Fig. 7-11)
12, 30.48	Forearm: from the point of the elbow to the distal palmar crease
18, 45.72	Cubit: from the point of the elbow to the tip of the extended long (middle) finger (Fig. 7-12)
36, 91.44	Yard/ ~ meter: from the tip of the nose to the end of the extended long (middle) finger
Diameter (inch, cm)	
1.5, 3.81	Grasp: the greatest diameter of the circle formed with the thumb and index finger (Fig. 7-13)
4, 10.16	Contracted-finger circle: the greatest diameter when forming a circle with both hands, the thumbs touching, and with the first metacarpals of the index finger overlapping (Fig. 7-14)

Abbreviations: IP, interphalangeal; MP, metacarpal-phalangeal.

Data from White.[27]

(yellow), plethora (red), and paleness (blanched). One of the most important clues is the presence of cyanosis (blue), often indicating decreased oxygenation. Recognition of central cyanosis (due to deoxygenated hemoglobin) is best done by viewing the tongue. It is more sensitive for this finding than are the earlobes, conjunctivae, or nail beds.[29,30] Cyanosis of the tongue also can be recognized in dark-skinned patients, in whom skin color is not useful when making the diagnosis.[31]

In the operating room (OR),

> a patient breathing or being ventilated with air will not look as pink as the "supersaturated" patient familiar to the modern anesthetist using high concentrations of oxygen, but his arterial oxygenation is nonetheless likely to be adequate. Lighting conditions, green drapes, the reflecting quality and color of the walls, vasospasm, and venous congestion due to position can all cause an appearance of cyanosis. When there is any doubt, the color of the open wound is the most reliable clinical indication of oxygenation of the patient.[32]

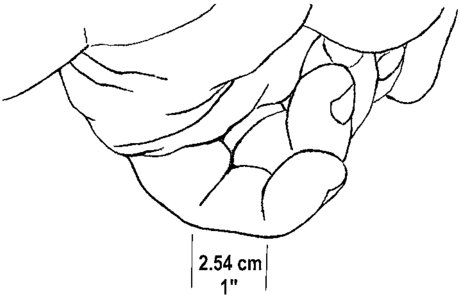

FIG. 7-10. Phalanx (1 inch, 2.54 cm).

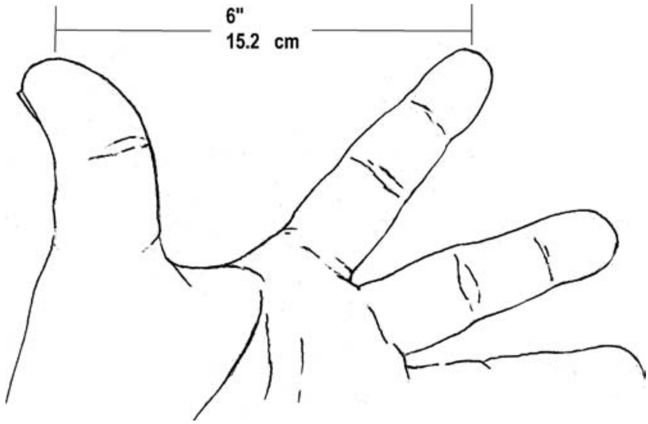

FIG. 7-11. Span (6 inches, 15.24 cm).

BLOOD LOSS

The amount of blood a patient has lost determines whether he will receive blood (and how much) for resuscitation. Initially, clinicians may need to estimate this, especially in the ED or other uncontrolled situations. In the operating room, it should be possible to measure at least some of the blood loss.

Estimates

After blood loss, an inability to stand secondary to postural dizziness or a large postural pulse change (≥30 beats/min) strongly suggests that a patient is significantly hypovolemic. After

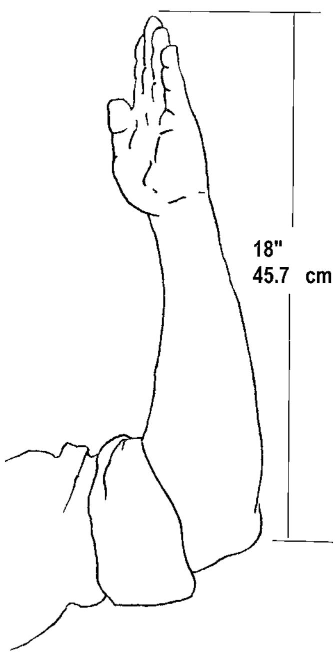

FIG. 7-12. Cubit (18 inches, 45.72 cm).

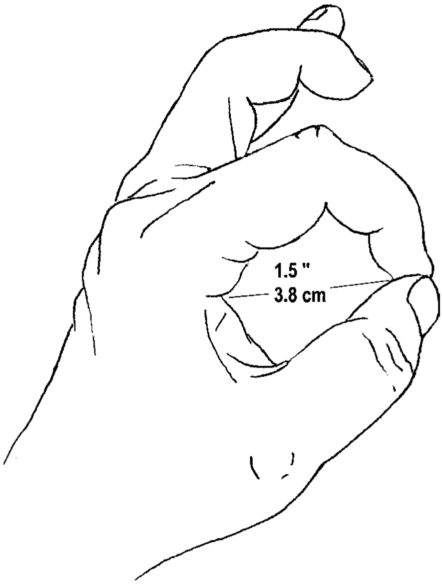

FIG 7-13. Grasp (1.5 inches, 3.81 cm).

moderate blood loss—or loss over a long period of time (e.g., slow gastrointestinal [GI] bleed)—a patient may not have this symptom. Postural hypotension is much less useful for hypovolemia due to dehydration.[33]

Excluding closed fractures and stab wounds, the patient's fist and open hand can be used to help estimate blood loss from soft tissue wounds.[34,35] The volume of an adult male's fist is about 500 mL (1 unit of whole blood; 2 units of packed erythrocytes); an adult female's fist is between 250 and 350 mL. Use this measurement when the blood lost can be seen or place a fist over areas of the body where there is soft tissue swelling to approximate occult blood loss.[36]

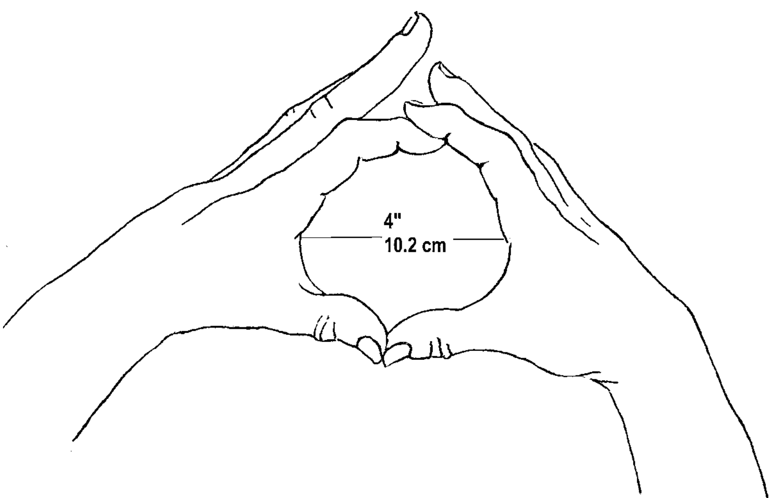

FIG 7-14. Contracted-finger circle (4 inches, 10.16 cm).

TABLE 7-3 Conversion of US Volume Measures to Metric

US/English Volume	Metric Volume	Other
Gallon US	3.785 liters	4 quarts 16 cups 0.8333 imperial gallon
Quart	0.9463 liter	4 cups 32 fluid ounces US
Pint	473.2 milliliters	2 cups 16 fluid ounces US
Fluid ounce	29.57 milliliters	6 teaspoons 2 tablespoons
1 liter	1000 milliliters	2.1 liquid pints US 1.057 liquid quarts US 0.26 gallon US 33.8 fluid ounces US
1 milliliter	1 cubic centimeter (cm^3)	0.34 fluid ounce US 0.002 liquid pint US
1 tablespoon	14.8 milliliters	3 teaspoons 0.5 fluid ounce US
1 teaspoon	4.93 milliliters	80 drops 0.1667 fluid ounce US

Likewise, tissue damage equal to one of the patient's fists or skin loss equal to the area of one of the patient's open hands equates to a blood volume loss of ~10% (i.e., 500 mL in an adult, where normal blood volume = 80 mL/kg). This figure includes both the initial loss at the time of injury plus continuing loss through exudation and into tissue (swelling) in the first 48 hours.[36] While this is a rough estimate, wounds with more than 5 "hands" of tissue damage lost ≥50% of the total blood volume.[34] Table 7-4 gives the approximate blood loss from injuries to various areas of the body.[36,37]

TABLE 7-4 Body Area Injured and Estimated Blood Loss

Body Part Injured	Estimated Blood Loss
Hand injury (crush)	1.6 L
Ulnar artery at wrist	0.5-2 L
Upper extremity fracture	500 mL
Pelvic fracture	1-3 L
Femoral shaft fracture	0.4-1.7 L
Tibial/fibula fractures	0.5-2 L, depending on swelling
Rib fracture (each)	100 mL
Crushed chest	1.5-2 L
Any open fracture	+ additional 250-500 mL
Abdominal or thoracic injury (adult)	>3 L

Measurements

To maintain adequate blood volume during surgery, it is essential to continually assess blood loss throughout the procedure, especially in neonates and children where even a small amount lost can represent a significant proportion of blood volume. Weigh blood-soaked swabs and suction bottles, and estimate the blood lost into surgical drapes and onto the floor; then subtract the volume of irrigation fluids. An alternative is to use the estimate that 10 well-soaked large abdominal swabs represent a blood loss of 1.0 to 1.5 L.[37]

MONITORING PATIENTS

Repeat Physical Exams

In resource-limited situations, the repeat physical examination remains one of the best tools in the clinician's armamentarium. When the same clinician examines the patient over time, diagnoses for abdominal and, often, chest and neurological conditions become clearer.

Attaching Electrocardiogram Leads

If an electrocardiogram (ECG) or a cardiac monitor is available, but the way of attaching the leads to the patient is missing, several methods work well. The key is to remove any device hiding the bare metal leads (that usually are covered by devices that attach to tape leads on Western ECG machines). After removal, place the leads directly on small saline or alcohol pads in the same limb positions as normal. Affix them using phlebotomy tourniquets. If chest leads are needed, these can be placed on the skin in the same manner, using tape to temporarily secure them. If they must be kept on for some time or if the patient has injuries (e.g., burns) precluding the use of tape, insert small-gauge needles just beneath the epidermis and use alligator clips to make a connection (Fig. 7-15).

DISASTER TRIAGE

Prehospital

A disaster involves multiple casualties that require more resources than are currently available. Triage is the system for quickly allocating the few medical resources.

FIG 7-15. Electrocardiogram leads attached using a variety of improvised methods.

Patient Classification

Patients are generally classified into one of four groups, depending upon the gravity of their medical problem: Immediate/Emergent (Red), Delayed/Urgent (Yellow), Minor/Non-urgent (Green), and Dead/Unsalvageable/Expectant (Black).

Triage Tags

Use easily recognized triage tags to avoid confusion, to accurately transmit information to other providers, and to avoid duplicated triage efforts. At least initially, premade (formal) triage tags may not be available. Informal tags include marking the patient with the generally accepted triage term, such as "Immediate" or "Delayed" or prominently tying on ribbons that are the triage color (e.g., Black is Expectant or Dead). Paper tags can be secured to the patient's clothes with a clothespin or safety pin and to an extremity with twine or a rubber band. Or write on the patient's forehead (easily seen) with an available marker, such as lipstick or a grease pencil.

An alternative is to use the system the Japanese developed after the sarin subway attack. They use large colored clothespins not only to deal with the standard triage categories, but also to separate patients into those who need "wet" and "dry" decontamination after a chemical exposure. The Simple Triage and Rapid Decontamination of Mass Casualties with Colored Clothes Pegs (STARDOM-CCP) system uses inexpensive (~5 cents each, US) plastic clothespins in the typical triage colors: red, yellow, green, and black, as well as white for patients needing dry decontamination and blue for wet decontamination. Each patient gets a standard (welfare) and decontamination clothespin.

The clothespins are large enough to be easily handled and recognized by responders in protective gear. The tags also survive wet decontamination, although the patients must often hold the pins after their clothes are removed. They recommend having a large sign on-site describing the triage process and colors.[38] This type of triage tag can be quickly fashioned from standard clothespins and colored markers or paint.

START (Simple Triage And Rapid Treatment)

This system (Table 7-5) is designed for adult patients in the prehospital setting. Ideally, it allows providers to triage each patient in <30 seconds with the goal of finding the sickest, or "immediate," patients.[39] This system (and those who use it) tends to overestimate ("over-triage") the severity of the patients evaluated. The Australians use an almost-identical system that they call Triage Sieve/Triage Sort.[40]

JumpSTART

For children, use JumpSTART (rather than START) for triage (Table 7-6), since children may normally have a respiratory rate >30/minute, may not follow commands (age and behavioral), and may have a "salvageable period" where they are apneic with a pulse.

SAVE (Secondary Assessment of Victim Endpoint)[41]

SAVE triage is designed for catastrophic disasters where there are limited transportation and medical resources. Transport may be delayed for days and prolonged when it occurs, and the patient's condition may deteriorate during the interim. This is a secondary (and tertiary) triage system and assumes that START triage has already been done. The system's priorities are based on the following equation:

$$\text{Value} = (\text{Benefit expected} \div \text{Resources required}) \times \text{Probability of survival}$$

Patient Classification (in Order of Priority)

A. Those who will benefit from limited, immediate field intervention. Provide treatment based on two questions:
   1. What is the patient's prognosis with minimal treatment?
   2. What is the patient's prognosis with treatment using available resources?

B. Those who will survive whether or not they receive treatment. Provide basic care, as available. Periodically reassess patient status.

C. Those who will die regardless of treatment. Periodically reassess for improvement.

TABLE 7-5 START Triage Method (Adults)

1. Ask everyone who can walk to move to another safe location. They can be reassessed there as conditions and resources allow. Walking makes them a "Green," unless a secondary triage finds otherwise.
2. Begin triaging (using the RPM method) where you stand. Spend 30-60 seconds with each patient.
3. If possible, begin transporting "Immediate" patients first. Track where they are going.
RPM (Respiration, Perfusion, Mental status) Method
Respiration
Not breathing? Clear mouth and open airway
If they breathe or need airway assistance = Immediate. If still not breathing = Dead
>30/min = Immediate; <30/min ➔ Assess Perfusion
Perfusion
Radial pulse absent or irregular = Immediate
Radial pulse present and regular ➔ Assess Mental Status
(Capillary refill >2 seconds is sometimes used as the discriminatory criteria, but that can be difficult to assess in many low-light situations.)
Mental status
Follows simple verbal commands (i.e., "squeeze my hand," "open your eyes") = Delayed
Unresponsive or cannot follow commands = Immediate

Patients who are treated should be reclassified if they do not respond. Identify and mark those who would benefit most from transportation to a medical facility (should transportation become available).

Hospital/Health Care Facility

The Israelis use a "continuous" triage method to avoid under-identifying seriously injured patients. They have found that, although experienced triage officers may not be able to initially identify as many as 50% of the victims who suffered life-threatening injuries, the continuous triage system reduced that number to <4%.

The Israeli method incorporates both the decisions made by the triage officers and the primary evaluations performed in the ED. The Israelis divide their ED into three sections according to the severity of injury: (a) mild, (b) moderate, and (c) severe. The decisions made by the triage officer help distribute the victims between the various sections. Once the casualty arrives at the appropriate site, medical personnel quickly perform primary and secondary surveys to identify the severely injured victims. The medical team refrains from using diagnostic resources on those whose exam suggests that they are not seriously injured. If a patient is identified as suffering a life-threatening injury, the trauma surgical team assumes care and transfers the patient to a secondary treatment site. This method has worked well in more than 20 multi-casualty incidents involving >600 patients, missing only 3.8% of those suffering from life-threatening injuries. These patients all had distracting injuries.[42]

ICU Admission Triage in Disasters

Initial Triage Criteria for ICU Treatment in Disasters/Resource Scarcity

The most useful criteria for deciding which patients should not receive limited intensive care resources come from those developed for use in pandemics (Table 7-7). These patients should then receive standard medical and, when appropriate, palliative care.[43-45]

TABLE 7-6 JumpSTART Triage Method (Children)

1. Ask everyone who can walk to move to another safe location. They can be reassessed there as conditions and resources allow. Walking makes them a “Green,” unless a secondary triage finds otherwise. Infants being carried should initially be assessed in the Green area.
2. Begin triaging (using the RPM method) where you stand. Spend no more than 1 minute with each patient.
3. If possible, begin transporting “Immediate” patients first. Track where they are going.
RPM (Respiration, Perfusion, Mental status) Method
Respiration Respiratory rate <15/min or >40/min = Immediate Respiratory rate 15/min to 40/min ➔ Assess Perfusion
If apneic, open airway If begins breathing = Immediate If no breathing and no pulse = Dead If no breathing, but pulse present, ventilate × 15 seconds If begins spontaneous breathing = Immediate If still not breathing = Dead
Perfusion A peripheral pulse absent = Immediate A peripheral pulse present ➔ Assess Mental Status (Capillary refill >2 seconds is sometimes used as the discriminatory criteria, but may be difficult to assess in many low-light situations.)
Mental status (AVPU method) Alert? Responds to Voice? Responds to Pain? Unresponsive? Unresponsive or inappropriate response to pain = Immediate Alert, responds to voice or localizes pain = Delayed/Urgent

DIAGNOSING DEATH

When to Abandon Resuscitation

If an attempt has been made to resuscitate a patient, it is pointless to continue when it becomes obvious that there is no hope of recovery. The following signs, if present after 30 minutes of intensive resuscitation, indicate a poor prognosis: fixed and dilated pupils, impalpable femoral and carotid pulses, and no respirations.[46]

Death Diagnosis With Limited Resources

With limited resources, especially with no access to an ECG or cardiac monitor, clinicians must rely on their clinical exams to determine whether death has occurred—or will quickly and inevitably occur (the “Expectant” [or black] triage category). Without an ECG, mistakes have and will be made. The ECG was the first advance for diagnosing death since biblical times, and it remains the most useful method to accurately determine death.[47]

Other ways physicians can diagnose death at the bedside are to listen with a stethoscope, feel a carotid or femoral pulse, use an ophthalmoscope to see whether blood in the vessels in the eye has broken into the stationary segments (“boxcars”) that signal absence of cardiac activity, and look for cardiac activity with an ultrasound.[48,49]

Even better are the basic signs used by ambulance crews to determine which patients cannot be resuscitated: rigor mortis, livor mortis (purplish color changes in dependent areas), algor

TABLE 7-7 Patients NOT TO RECEIVE ICU Treatment

A. SOFA score >11
B. Severe trauma
C. Severe burns of patient with any two of the following:
Age >60 years >40% of total body surface area affected Inhalation injury
D. Cardiac arrest with any of the following:
Unwitnessed cardiac arrest Witnessed cardiac arrest, not responsive to electrical therapy (defibrillation or pacing) Recurrent cardiac arrest
E. Severe baseline cognitive impairment
F. Advanced untreatable neuromuscular disease
G. Metastatic malignant disease
H. Advanced and irreversible immunocompromise
I. Severe and irreversible neurologic event or condition
J. End-stage organ failure meeting the following criteria: *Heart*: NYHA class III (marked limitation of activity; they are comfortable only at rest) or class IV (should be at complete rest, confined to bed or chair; any physical activity brings on discomfort and symptoms occur at rest) heart failure. *Lungs*: (1) COPD with FEV_1 <25% predicted, baseline PaO_2 <55 mm Hg, or secondary pulmonary hypertension; (2) cystic fibrosis with post-bronchodilator FEV_1 <30% or baseline PaO_2 <55 mm Hg; (3) pulmonary fibrosis with VC or TLC <60% predicted, baseline PaO_2 <55 mm Hg, or secondary pulmonary hypertension; (4) primary pulmonary hypertension with NYHA class III or IV heart failure, right atrial pressure >10 mm Hg, or mean pulmonary arterial pressure >50 mm Hg. *Liver*: Child-Pugh score ≥7 (equating to moderate, or Class B, dysfunction).
K. Age >85 years
L. Elective palliative surgery

Abbreviations: COPD, chronic obstructive pulmonary disease; FEV_1, forced expiratory volume in 1 second; ICU, intensive care unit; NYHA, New York Heart Association; PaO_2, partial pressure of arterial oxygen; SOFA, Sequential Organ Failure Assessment; TLC, total lung capacity; VC, vital capacity.

Data from Christian et al,[43] Vincent et al,[44] and Ferreira et al.[45]

mortis (cooling to room temperature), or an injury incompatible with survival. Note that, when a patient has been exposed to very cold temperatures, severe hypothermia may simulate death. In that situation, warm the patient, if possible, to check for signs of life. Within reason, patients should not be considered dead until they are warm and dead.

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8 | Airway

BASIC AIRWAY MANAGEMENT

Establishing or maintaining a patent airway is one of the most fundamental lifesaving skills. Despite circumstances, clinicians must be able to secure an airway with limited or unusual equipment. Depending on a single technique or device is potentially dangerous for the patient.[1]

Positioning for Safe Airway

It is much better to prevent aspiration than to treat it. When there is concern about a patient maintaining his airway, especially if there are copious secretions or vomitus, place the patient in the "rescue" or "recovery" position—on his side with his face aimed toward the bed to prevent aspiration. If possible, also raise the foot of the bed so that the patient is in the head-down position.

Even patients with extensive and penetrating facial injuries may not need endotracheal intubation if they are put into the recovery position.[2]

If the individual has a suspected cervical spine injury, use the High Arm IN Endangered Spine (HAINES) position (Fig. 8-1). The differences from the recovery position are that the dependant upper limb is fully abducted and lies under the head where it reduces lateral neck flexion, and both lower limbs are flexed at the hip and the knee resulting in one lying on top of the other, possibly reducing torque on the thoracolumbar spine. A single rescuer can easily put a patient in the HAINES position.[3]

Opening the Airway

Chin Lift/Jaw Thrust

Perhaps the easiest method to maintain an open airway is to simply push the chin up. For somnolent and sedated patients, this is often all that is needed to keep the airway patent. If a cervical spine injury is suspected, push the jaw forward from the mandibular angles.

Head Turn

Head turn is a simple, but rarely used, procedure to open an airway. In patients with significant amounts of redundant tissue in the pharynx and hypopharynx (and no history of possible acute cervical spine injury), simply turn the head to one side to improve airflow.[1]

Positioning the Tongue

If the patient's tongue still blocks the airway after positioning the head, or if the head cannot be repositioned because of a suspected cervical spine injury, grasp the tongue with gauze and pull it forward. This is a temporizing measure only. For better control over longer periods, put a heavy (~2-0) suture or a wire or suture substitute (such as fishing line) vertically through the tip of the tongue in the midline (Fig. 8-2). Placing it anterior and midline avoids significant bleeding. An assistant can hold the suture or it can be passed through the skin of the lower lip and then tied.[4] A towel clip (Fig 8-3) or a safety pin (Fig. 8-4) can also be placed vertically in the midline

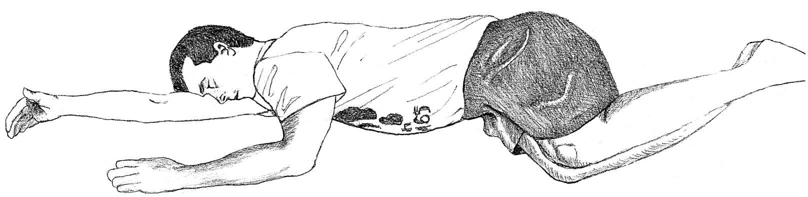

FIG. 8-1. HAINES position.

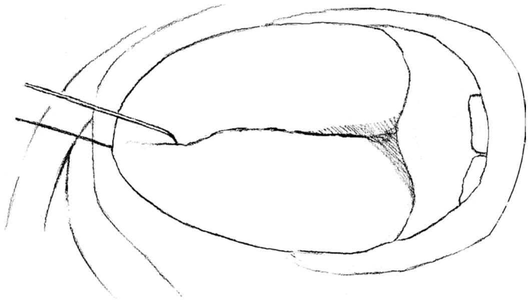

FIG. 8-2. Suture used to hold tongue out.

to hold the tongue. Do not use a clamp or forceps that "may in the excitement of the moment be so firmly applied as to nip a piece out of the tongue."[5] Physicians, surgeons, and anesthetists have used these methods since at least the 19th century without complication.[6]

Opening a Clenched Mouth

If the mouth is clenched and the patient needs to be ventilated, first ventilate through the nose. Try to open the mouth by putting pressure on the temporomandibular joints. If neuromuscular blockers are available and you are comfortable with your advanced airway skills, use them to relax the jaw.

If the patient is apneic with a clenched jaw, press your fingers between his teeth and gums, behind the last molars. This will usually open the jaw wide enough to pass a laryngoscope or to place an airway.

Nasal Airways

A nasal airway, or "trumpet," is one of the most useful pieces of airway equipment. However, for some reason, it is hardly ever used, even though they are easy to improvise.

To make a nasal airway, use any soft piece of rubber tubing that is the appropriate size for the patient's nose and put a safety pin through the end so that it cannot disappear down their nose (Fig. 8-5). Most adults do well if the length of the tube beyond the safety pin equals the length from their nares to the meatus of their ear (4.5 to 5 inches; 11.5 to 13 cm). This device has been

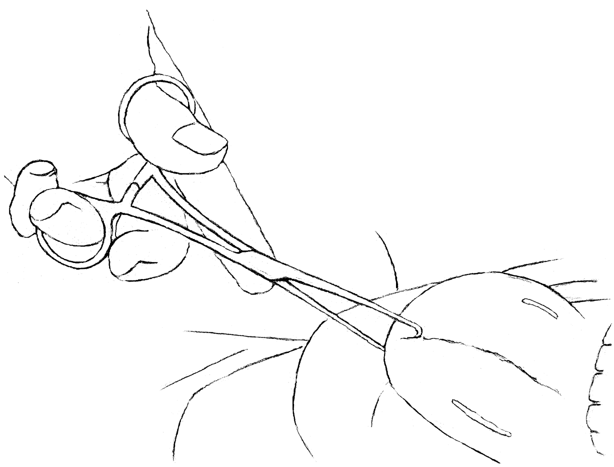

FIG. 8-3. Towel clip holding tongue out.

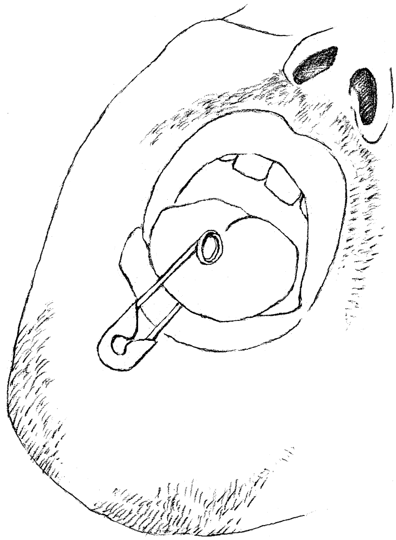

FIG. 8-4. Safety pin holding tongue out.

termed a "Goldman's nasopharyngeal airway."[7] The Goldman's airway can be made to fit any nose. Some clinicians cut an uncuffed endotracheal tube to size; others suture it to the nasal septum (midline between the cartilage and skin) to keep it in place.[1]

If one nasal airway works, two may sometimes work better. Consider using a "binasal airway"—you need only an extra piece of tubing and a second safety pin or suture. When placing a nasal airway, lubricate it well and pass it along the floor of the nose (straight back, not cephalad).

EVALUATE FOR DIFFICULT INTUBATIONS

Pediatric

When intubating children, the two key elements are (a) using the laryngoscope correctly and (b) correctly estimating the endotracheal tube (ETT) size.

No matter what type of laryngoscope is used, the most common reason practitioners cannot intubate a child is that they advance the laryngoscope too far. If the laryngoscope does not immediately produce a view of the cords, keep looking at the larynx and slowly back the laryngoscope out. The epiglottis usually pops into view.

For pediatric intubations, you need to have the correct ETT size. Because cuffed tubes are now being used for most children and for infants other than neonates (and even for some neonates), many of the older formulas for uncuffed tubes don't work. See Table 8-1 for the standard and formula-calculated sizes for cuffed and uncuffed pediatric ETTs. The size of a cuffed tube to use will be smaller than for an uncuffed tube, since the tube itself does not need to occlude the

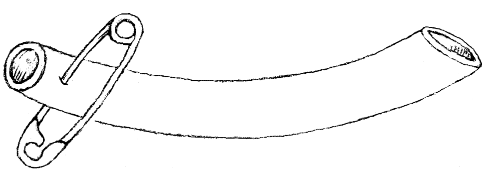

FIG. 8-5. Goldman's nasopharyngeal airway.

TABLE 8-1 Pediatric Endotracheal Tube Sizes and Weights

Age (years)	Weight Using "Simple" Method (kg)	Tube Internal Diameter (mm)				
		Uncuffed Tubes			Cuffed Tubes	
		Standard	Formula #1	Formula #2	Standard	Formula #3
Newborn		3.0	4.5	–	3.0	3.0
1	10	3.5-4.0	4.5	–	3.5	3.0
2		4.5	5.0	4.5	4.0	3.5
5	20		5.5	5.0	5.0	4.0
10	30	6.0	7.0	6.5	6.0	5.5
10-15		6.0-7.5	5.5-8.0	6.5-7.5	6.5-7.0	5.5-7.0

Formula #1: ETT size (mm Internal Diameter [ID]) = (age in years/4) + 4.5
Formula #2 (for children from 2 to 10 years old): ID (mm) = (age + 16)/4
Formula #3: ID (mm) = (age in years/4) + 3

airway: only the balloon has to occlude the airway. Keep cuff inflation pressure <20 cm H_2O to avoid tracheal necrosis.

The ETT should be inserted to a distance (in centimeters) equal to (10 + age in years) or (3 × ETT size) at the lips. Table 8-2 gives the placement for newborns.

Adult

Adults have anatomical, physiological, and situational issues that may complicate intubation. However, improvised solutions are available, as described below.

Special Situations

Most intubations won't be dramatic. However, patients may be in a variety of unusual positions, especially in out-of-hospital situations. Knowing some alternative positions to use for intubation can lessen the stress.[8]

Seated Vehicular Entrapment

When patients are trapped in a sitting position, face the victim when managing the airway. Even in this position, if bag-valve-mask (BVM) or mouth-to-mask ventilation is necessary, an adequate mask seal may be difficult to achieve. If a controlled airway is necessary and the patient is still breathing, use blind nasotracheal or digitial intubation (see descriptions under "Non-laryngoscopic Intubation" in this chapter), a Combitube, a laryngeal mask airway (LMA), retrograde intubation (often unsuccessful), or a cricothyrotomy. If the patient has lost muscular tone and can no longer bite down, use digital intubation. If a patient is not breathing, perform an "inverted" intubation by holding the laryngoscope handle toward the patient's lap and visualizing the glottis from the front. It may be easier to perform this

TABLE 8-2 Position of ETT at Lips for Newborn

Weight (kg)	Distance to Insert Tube (cm)
1	7
2	8
3	9
4	10

maneuver by using the laryngoscope in the nondominant hand and guiding the tube with the dominant hand.

For a patient strapped into stretcher with rigid sides (e.g., Stokes basket), straddle the patient and face him, then do the intubation as with a seated vehicular entrapment.

Difficult Airway—What Next?

If the patient is difficult to intubate, stop trying and return to using bag-and-mask ventilation. The maximum time allotted to intubate should be no longer than the time you can hold your breath; patient who need intubation can't hold their breath that long. If you can use a BVM to ventilate the patient, use that to buy yourself time to consider any adjuncts or procedures that may help you to intubate.

If you are unable to ventilate the patient despite using the adjuncts mentioned, consider trying one of the airway methods described in the following paragraphs and call for help. If none of these is an option, wake the patient if appropriate (such as in the operating room [OR]) or prepare for an emergency cricothyroidotomy.

IMPROVISED NON-INTUBATION AIRWAYS

Poor-Man's Laryngeal Mask Airway

The Poor-man's LMA consists of blindly passing a cuffed ETT (of the appropriate size to intubate the patient) into the oropharynx so that the cuffed portion of the tube lies between the tongue and the posterior pharyngeal wall (Fig. 8-6). Insert the ETT with the balloon fully inflated. Then the operator pinches the patient's nose closed and seals the lips around the tube, while the assistant bags the patient through the tube in the normal fashion.[9] This does not work as well as a normal LMA, so replace this with another airway method as soon as possible.

Transtracheal Ventilation

Although transtracheal ventilation (TV) seems like the perfect solution for the problem airway, as with many of the improvised methods suggested in the literature and in protocols, it simply does not work, at least not in adults.[10] The method is discussed here, since it may work in children and because so many protocols still include it. To be assured of success, use this method only in very small children, and do a surgical cricothyrotomy on everyone else who needs this type of intervention.

The problems with doing a TV are (a) placing the needle/catheter correctly, (b) preventing the catheter from kinking, and (c) obtaining adequate flow through the catheter. So, the guiding principle is that if the cricothyroid membrane will be violated in austere circumstances, use a knife, not a needle.

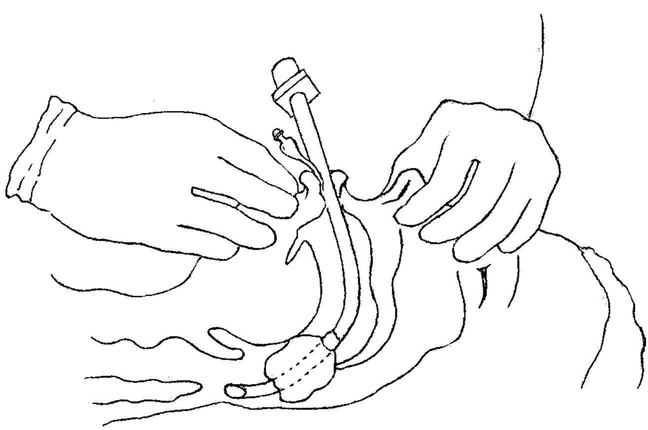

FIG. 8-6. Poor-man's laryngeal mask airway.

For TV, the needle/catheter can be placed in either the cricothyroid space or the trachea. Determining where to place the needle can be daunting for those not familiar with the process. The key is to find the midline. (See "Cricothyrotomy" in this chapter for more details.)

Catheters

The catheters used for jet ventilation range from 14 to 18 gauge in both adults and children. Special catheters that don't kink have been used for most tests of TV. But most clinicians use 14-gauge IV catheters for the procedure, and these standard over-the-needle IV catheters may kink at their hub due to the acute angle as they pass into the trachea.[11] This may be ameliorated somewhat by holding the catheter at its hub.[12]

An alternative is to use a larger (13-Fr/ >4-mm outside diameter [OD]; 9-Fr/3-mm internal diameter [ID], ~6 inch) catheter, which is about the same size as an ETT for a newborn (12-Fr/4-mm OD; 2.5-mm ID). These catheters generally are used as central lines or as "introducers" for large lines. While they may not provide much better oxygenation or ventilation than a 14-gauge catheter, the polyvinyl chloride structure and the length provide enough strength to prevent collapse and decannulation. It also avoids the catheter slipping into the subcutaneous space where, if the oxygen is being delivered under pressure, it can result in a massive buildup of subcutaneous air, leading to collapse of the tracheal lumen and death.[13] A real benefit is that these catheters also can be easily turned cephalad and used to do a retrograde intubation.[14]

Flow

Once the catheter is placed and functions, the real problem begins: how to oxygenate/ventilate the patient without a standard transtracheal jet ventilator. The basic parameter to consider is that a 70-kg patient requires a flow rate of >1100 mL/second to be adequately ventilated. The only makeshift method that supplies this flow through a 14-gauge catheter is to use unregulated wall oxygen that delivers about 1400 mL/second at about 65 psi. (This is not oxygen from a "wide-open" regulator: that delivers only about 350 mL/second.[10]) This can be controlled using a simple "Y" device in the tubing connecting the oxygen source and the patient (Fig. 8-7). When using this device, occlude the opening for 1 second to allow inspiration and release it for 3 seconds during expiration.[15] Additionally, in the OR, the catheter can be connected to the "oxygen flush valve" on the anesthesia machine; this is essentially a jet ventilator.[16] To do this, connect stiff tubing to the common gas outlet with a standard 15-mm ETT connector. Most modern machines, however, are fitted with a safety valve to prevent overpressure and therefore may not be suitable for this purpose.[17]

The danger when using an unregulated oxygen source is that it can cause barotrauma to the lungs. However, adequate jet ventilation is just that—ventilation. The high flow rate not only supplies oxygen, but also forces CO_2 out of the lungs.[18] It also appears to protect against aspiration as well as a cuffed ETT.[19]

How about connecting a 15-mm ETT adapter and using a BVM? This has been suggested repeatedly in the literature and in medical protocols. Any IV catheter can be attached to a 3.5-mm ETT adapter, although removing the adapter from the tube may require cutting it off, since they are very firmly attached. An easier method is to insert a 6.5- to 8.5-mm cuffed ETT into a 5-, 10-, or 20-mL syringe barrel, inflate the balloon, and connect the syringe to the IV catheter. The ETT provides the 15-mm BVM adapter.[20]

The problem then is that ventilating with a BVM is not only physically challenging, but also quickly results in hypercarbia, even when a 4-mm ID catheter is used (about three times the ID of a 14-gauge catheter). Therefore, unless a jet ventilator, unregulated wall oxygen, or an anesthesia machine's oxygen flush valve is used, consider TV a temporizing method not to be used for more than a few minutes. In most cases, this makes it not worth the trouble. Use another method!

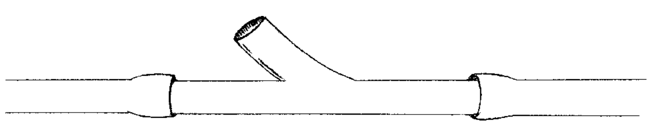

FIG. 8-7. Flow control for direct oxygen connection to cricothyrotomy.

INDICATIONS TO INTUBATE

Intubation is probably used far too often in Western tertiary care centers, and not often enough elsewhere. However, ask yourself why you are *not* intubating a patient who

- Tolerates an oral airway
- Is too agitated to fully evaluate and cannot be easily or safely sedated
- Is not oriented to time, place, person, and events after head trauma
- Is not maintaining, or may not be able to maintain, a patent airway
- Cannot or may not be able to handle their secretions without aspirating
- Has had an acute mental status change

Many of these patients do not need intubation immediately. In these cases, ask yourself: Why am I not intubating this patient now? Make a conscious decision to either intubate them or carefully observe them.

IMPROVISED INTUBATION EQUIPMENT

Suction Device

It is possible, and often necessary, to remove airway debris manually with your fingers or by sucking it out with a bulb syringe or large-mouth (Toomey) syringe. However, the best option for long-term use is to build a simple foot-operated suction device (Fig. 8-8). One way to do this is to modify an automobile or truck tire pump so that its valves suck instead of pump. Attach this to two wide-mouth unbreakable 1-L bottles, and then to the sucker.[21]

Improvised ETTs

Many tubes can be used as uncuffed endotracheal, cricothyrotomy, and tracheostomy tubes in emergency situations. The wide variety of medical tubing available in hospitals and clinics offers the benefits of cleanliness and various degrees of flexibility. For example, connector tubing for suction devices and chest tubes are useful for this purpose. Even though very large urethral catheters could be used for infant ETTs if their tips are cut off, their soft rubber walls may collapse. Some polyvinyl tubes and heavier rubber tubes offer less flexibility than others

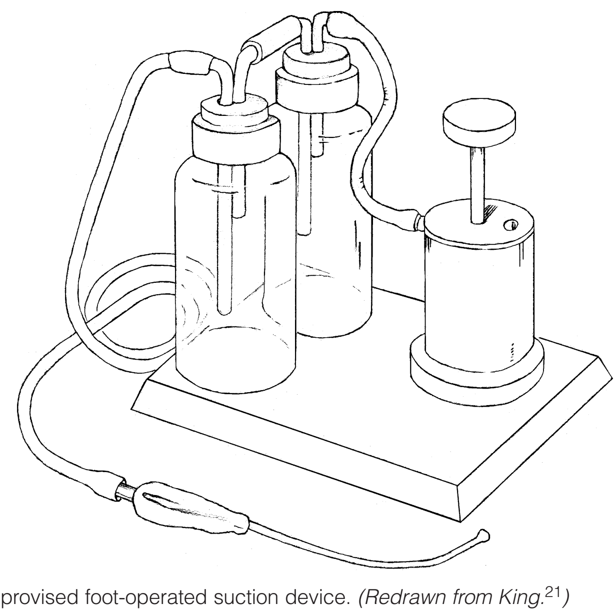

FIG. 8-8. Improvised foot-operated suction device. *(Redrawn from King.[21])*

(e.g., chest tube). Typical chest tube sizes (OD = ETT size) that work appropriately as ETTs are 10 Fr (3.3 mm), 12 Fr (4.0 mm), 16 Fr (5.3 mm), 20 Fr (6.7 mm), and 24 Fr (8.0 mm). Cut any tube to the appropriate length before use.

Any hollow tubing that can go through the airway also can be used as an ETT, at least temporarily. If the tube is straight and rigid (like a rigid bronchoscope), such as a small pipe or a piece of bamboo, the patient must be kept fully sedated and, if possible, paralyzed, to avoid breaking the teeth or causing other trauma. The patient must also be in a condition to have his head extended (i.e., no neck injury).

The biggest problem with makeshift ETTs is how to connect them to a BVM or a ventilator. Whatever tubing is used, and no matter what size is needed—from neonatal to large adult—the tube can quickly and easily be adapted to fit a standard ventilator or bag-valve connector using the technique described in the following section.

ETT Adapter

If an alternative tube is used as an ETT, if the standard ETT you have does not fit the ventilation device being used, or if the standard adapter that fits the ventilation device is lost or broken, a simple fix is at hand. Made from the nipple of a standard infant feeding bottle, this adapter is similar to a Foregger-Racine adapter and other more-complex equipment described for the same purpose.[22] Enlarge the nipple hole so that the ventilator end of the ETT can just fit through with a tight seal. Push the tube through the hole so that the BVM/ventilator end is inside the nipple. The other (bottle) end of the nipple connects to the ventilation device (Fig. 8-9). Experience shows that any size pediatric or adult ETT, or any equivalent that is being used as a makeshift endotracheal, cricothyrotomy, or tracheostomy tube, will fit.[23]

Improvising an ETT "Cuff"

ETTs work best if they are cuffed. If an ETT (regular or improvised) is not cuffed or if its balloon breaks, there may be a significant air leak, which may increase the chance of aspiration. In those

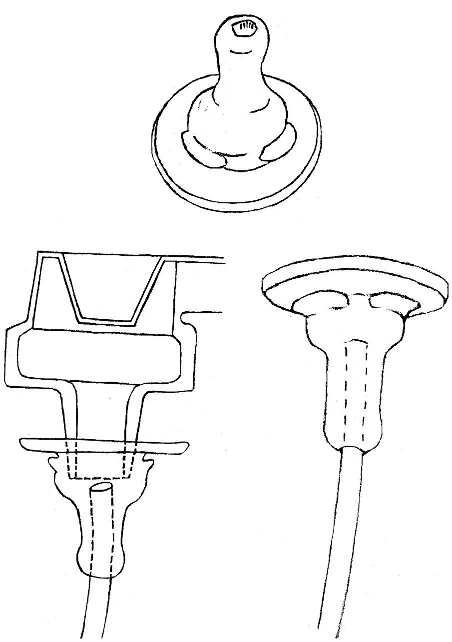

FIG. 8-9. Improvised endotracheal tube with 15-mm adapter. Use any hollow tube, but preferably flexible polyvinyl.

cases, pack the pharynx under direct vision with a wide piece of gauze or cloth, using Magill or similar forceps. As when packing the nose or an abscess, use only one length of packing material so that, when it is removed, there is no chance of leaving an unobserved second piece behind. Tie one end of the packing to the ETT to ensure its removal at the end of the operation.[7] Use saline-soaked gauze or cloth for this. Don't use petroleum jelly (e.g., Vaseline) or other petroleum-containing products to soak the gauze, since that might cause pneumonitis.[24]

Fixing an ETT

If a polyvinyl ETT is torn, the best solution is not to use it. If it is already in place, replace it. However, if this is not possible or is too dangerous for the patient, two temporizing methods exist: (a) To quickly seal a small hole, put a moist sponge over it. (b) For a more permanent seal, use a small amount of cyanoacrylate (i.e., Super glue, Dermabond) to immediately and completely seal the hole. Before using the glue, thoroughly dry the torn portion of the tube so that it will seal properly.[25]

Stylet

Stylets are invaluable for keeping an ETT in the shape desired by the intubating clinician. But when stylets are used repeatedly, especially those used for neonatal intubations, they can break at their tip from constant bending.[26] To make an improvised stylet, take a piece of any malleable wire and put it into a nasogastric (NG) tube or a small urethral catheter. Voilà! A stylet.

A coat hanger slips into a 12-Fr NG tube, thus producing stylets for ETTs size 5 and above. Fashion stylets for smaller tubes using smaller NG tubes. These can be easily resterilized for repeated use.[27] Alternatively, batches of stylets can be made from copper wire that is the appropriate diameter for the ETT in which they will be used.

To keep a tube rigid without using a stylet, and if time is available to wait, put the ETT in ice water. Freezing it also works. This tends to work better for smaller caliber ETTs. (Written communication from Daniel Tzse, MD, Brown University, received June 5, 2007.)

Makeshift Laryngoscope

Transillumination With Makeshift Laryngoscopes

The problem with laryngoscopes is that either their light doesn't work or doesn't exist when you need to intubate a patient urgently. In these cases, use either the dead laryngoscope or an alternative made from a tongue depressor, shoehorn, spatula, or spoon. If using a nonmalleable improvisation, use it to extend the tongue out of the mouth as far as possible, or grasp and pull the tongue to achieve the same result. The larynx should be visible if illuminated. A spoon handle can be bent to act as a laryngoscope blade to facilitate this view (Fig. 8-10). Illuminate the larynx, either directly through the mouth (e.g., pen light, operating room light) or transillumination through the cricothyroid membrane using a portable light (e.g., pen light, headlamp).[28-30] Boulton wrote that "the larynx is seen as a brightly illuminated area in a black field."[7] John C. Sakles, MD, a colleague at the University of Arizona who has used the transillumination method, commented, "It is extremely dark in there. Not much light gets through. Red light works best." (Written communication, September 5, 2008.)

Homemade Laryngoscope

Gillett and Patkin developed and used an inexpensive laryngoscope constructed of simple materials for situations where standard laryngoscopes are too expensive or are simply unavailable (Fig. 8-11).

> The handle is made of oak or beech, and two penlight batteries are attached to it by Sellotape [heavy clear tape] or by two light aluminum bands. At one end they are held by the blade, and at the other by a small piece of Perspex [acrylic glass; Plexiglas] which bears a simple pivot switch. The blade is of twin-track aluminum from which one of the three flanges have been removed entirely, while the other two have been partly cut away towards the tip. It is shaped by bending in a heavy vice. In the track that is left there is an inexpensive prefocused torch bulb with a lead soldered to its base. The rest of this track has in it some hard rubber tubing about this lead, and this stops the metal of the blade

FIG. 8-10. Cricothyroid membrane transillumination and spoon laryngoscope.

> knocking on to the upper teeth or the gum when the instrument is in use. The bulb lies in a shallow hammered recess. The blade is held on to the wooden handle with two strong chrome screws.[31]

This device costs almost nothing to make and, "in a well-equipped workshop an inexperienced person can make a batch of these instruments at the rate of two an hour." This laryngoscope was successfully used on 88 patients in its initial trial.[31] Similar inexpensive laryngoscopes have been made at other small hospitals.[32]

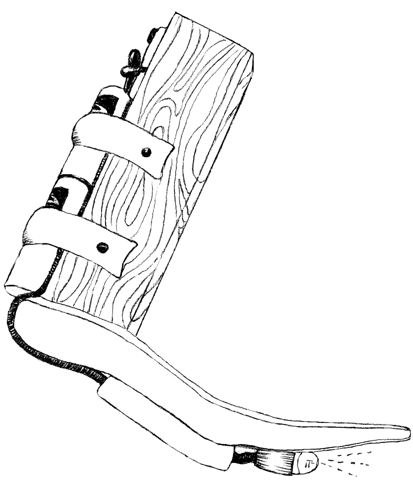

FIG. 8-11. Makeshift laryngoscope.

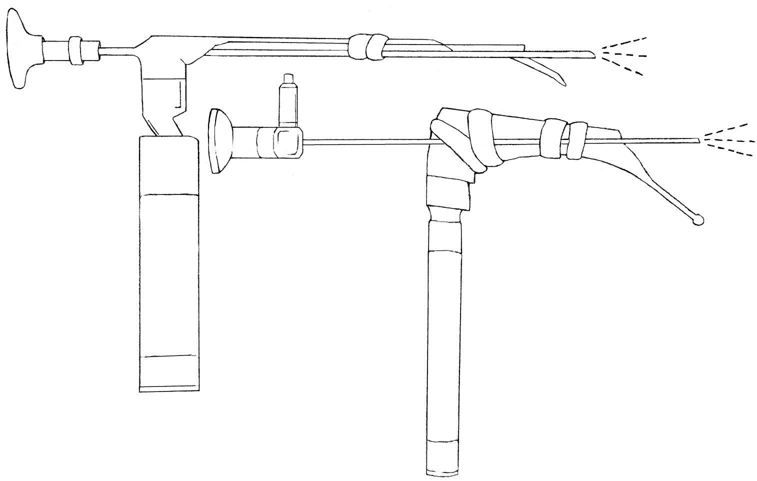

FIG. 8-12. Cystoscope/arthroscope used to supply light to Miller and Macintosh laryngoscope blades.

Laryngoscope Problems

If the laryngoscope light fails to work, it may be due to a loose or faulty bulb, dead batteries, or an electrical problem. First, tighten the bulb; this is the most common problem. Second, clean the little pins (contacts) on both the blade and the handle. (These meet to complete the electrical circuit for the light.) A pencil eraser should work, but the contacts may need to be scraped with a sharp-edged implement. Third, insert fresh batteries. Fourth, replace the bulb, remembering that light bulbs for laryngoscopes come in large and small sizes that are not interchangeable. Having a spare light means having one that not only works, but also fits the laryngoscope blade you are using. Finally, if the laryngoscope is still not working, check the electrical pathway with an electrical meter.

Electrical problems may be caused by corrosion from disposable batteries. Remove them (but not rechargeable, nickel–cadmium batteries) if the laryngoscope will not be used for a few days. If corroded batteries are stuck in the handle, boil the handle in a pan of water to try to loosen them. If not, use a large drill to remove them, being careful not to drill deep enough to damage the contact at the top of the handle. Then clean the inside of the handle and make it as neat as possible.[33]

To quickly provide a light source for the laryngoscope, place a cystoscope, arthroscope, or any other small fiberoptic scope into the groove of a Miller blade or through the introducing hole in a Macintosh blade (Fig. 8-12). Then use the blade in the normal fashion.[34]

If the chrome is peeling off the laryngoscope, it may seem to be a mundane problem—until the sharp edge cuts a patient. Use a scalpel blade to carefully remove loose chrome. Then use fine sandpaper (an emery board or a nail file also work) and some water to smooth the remaining chrome. When done, check that it is smooth by running cotton over it; any rough edges will catch the cotton.[33]

NON-LARYNGOSCOPIC INTUBATION

Blind Nasotracheal Intubation

The only tools necessary to do a blind nasotracheal intubation are an ETT (called a nasotracheal tube [NTT] for this procedure), skill, and a breathing patient. Attempt the procedure only in patients who are spontaneously breathing; the patient's exhalations are the guide to placing the tube. Patients can be either awake or not awake. The technique can be performed in a controlled manner; clinicians experienced in this technique have a success rate of about 90%. Neophytes often use the "push-and-hope" (not using exhalations as a guide) method, which actually works about 40% of the time.[35,36]

Procedure

Before beginning the procedure, wipe the connector and the tube with alcohol and firmly push the connector at the end of the tube into the long part of the tube; it is surprising how many times the connector and tube come apart and the tube has to be "fished out" using the pilot balloon.

To do this procedure, anesthetize both nostrils thoroughly using a local anesthetic. In an emergency, simply lubricate the tube. If there is time (at least 8 minutes) and it is available, 4% cocaine is the optimal drug since it is an excellent anesthetic/vasoconstrictor. Position the patient's head in a neutral position—with the patient supine (usual) or sitting (in severe congestive heart failure). With firm, steady pressure, introduce the tube—about 0.5 to 1 mm smaller than would be used endotracheally—through the nose and into the nasopharynx. As when placing an NG tube, the NTT goes straight back into the nose, not up. At that point, resistance lessens and the breath sounds through the tube become a little harsher.[35]

Once in the nasopharynx, patience and skill are necessary to place the tube properly. While watching the patient's chest for exhalation and putting an ear next to the tube to hear exhalation, push the tube 0.5 to 1 inch each time exhaled breath is heard and felt through the tube. If this exhaled air is not heard or felt each time after the tube is advanced, back up the tube the same amount it was just advanced, reposition the tube (by twisting) or the patient's head (generally, more flexed), and advance it a small bit again. If the patient coughs, the tube has hit the vocal cords and should be quickly pushed into the trachea. Often, this does not occur, and the tube is fully advanced to its hub (a normal position for a nasotracheal intubation) with breath sounds still being heard. That means it has been successfully placed. Another indication of success is that the patient cannot speak. Patients with severe congestive heart failure often seem to suck the tube into their trachea. These are the easiest patients on whom to perform this procedure. Asthmatics, with their poor breath sounds, are the most difficult.[35]

Teaching/Learning the Technique

A model[37] has been devised to teach this technique by using an intubating head model with one of the "lungs" removed and replaced with a BVM to simulate breathing (Fig. 8-13).

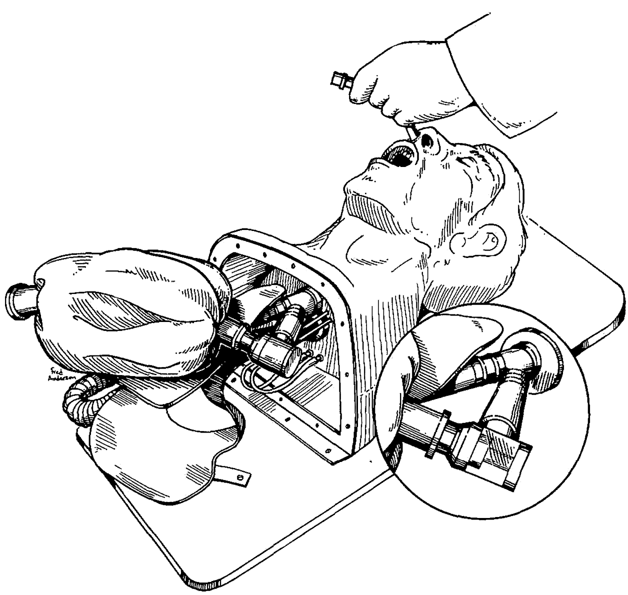

FIG. 8-13. Model to teach blind nasotracheal intubation. *(Reproduced with permission from Iserson.[37])*

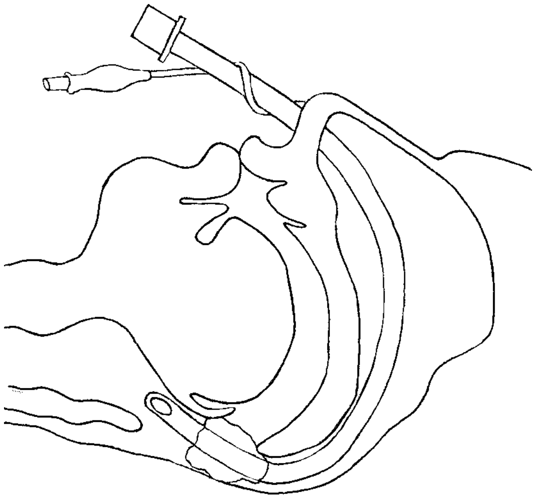

FIG. 8-14. Balloon partially inflated during blind nasotracheal intubation.

Improving Nasotracheal Intubation Success Rate

BOGGY BALLOON

Once the tube (the same tube is used for endotracheal and nasotracheal intubation) enters the oropharynx, inflate the cuff with 15 to 20 mL of air (Fig. 8-14). Then, when a slight resistance is felt as the cuff contacts the vocal cords, deflate the cuff and advance the tube into the trachea. This technique has up to a 95% success rate but often only after three attempts (which is not unusual in blind nasotracheal intubations).[38-40]

LIGHTED TUBE

This method, a forerunner of the lighted stylet, can easily be improvised. Using an insulated wire, attach a small bulb from a pediatric laryngoscope to a laryngoscope handle or other low-voltage electrical source. Put the wire through the NTT until it just barely protrudes from the end; mark that spot on the wire with tape. Next, insert the tube into the pharynx and insert the light through the tube up to the taped line. This positions the bulb just past the tip of the tube. In a darkened room, the tip of the tube can be visualized, and you will see if it goes off midline. If the light vanishes, it is in the esophagus. To prevent aspiration, bulb must be tightly secured to the wire. This method could also be used for oral intubations if the stylet is run through the ETT next to the wire. In that case, either tie the stylet to the wire or remove the stylet first, so that the light does not pop off and get aspirated.

NASOGASTRIC TUBE USED AS A GUIDE

If the NTT seems to be at the larynx (coarse breath sounds are heard or the patient coughs when the tube is advanced) but won't pass through it, hold the NTT in position and pass an NG or suction tube through it (Fig. 8-15). This should easily go into the trachea. Then, withdraw the NTT slightly and either pass it into the trachea over this "guide" or remove it and pass a smaller tube over the guide.[41-43] Another option that can be used simultaneously is to rotate the tube to move the tip off the arytenoid cartilage.

Is the Tube Going Into the Right Place?

To detect breathing through the tube during blind nasotracheal intubation, cut a finger from a rubber glove and attach it to the end of the tube. Cut a small hole in the other end. It will give you "the finger" as it fills with each exhalation (Fig. 8-16). Once the tube is in the trachea, remove the glove finger quickly, or the patient will become hypoxic and hypercarbic.

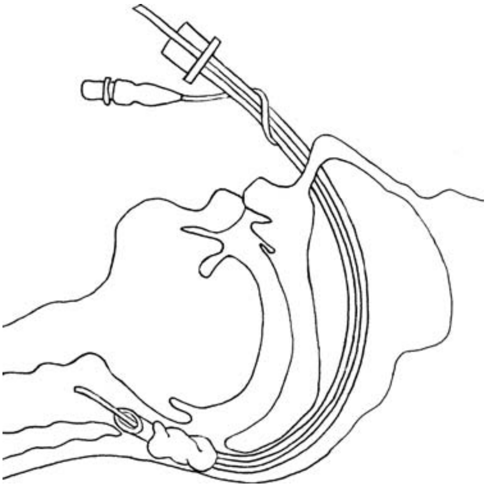

FIG. 8.15. Nasogastric tube passed through ETT as a guide.

Digital/Tactile Intubation

This technique, used since the 18th century, has the clinician palpate the larynx while guiding the tube into it.[44]

Adult Digital Intubation

As with blind nasotracheal intubation, digital intubation requires only the ETT and experience with the technique. As opposed to blind nasotracheal intubation, these patients are (preferably) not breathing and have no gag reflex (and no ability to bite the clinician's hand). Clinicians commonly complain that their fingers are too short, their hands are too large, or the patient's mouth is too small to do digital intubation successfully. This is not true. Experience has shown that most in-hospital and prehospital clinicians can use this method to digitally intubate a majority of adult, pediatric, and neonatal patients. With minimal instruction, physicians and emergency medical service (EMS) personnel have been able to successfully intubate ~90% of patients using this method.[45,46] One benefit of the procedure is that it can be performed with only an ETT and, preferably, a stylet and gloves. Other benefits are that

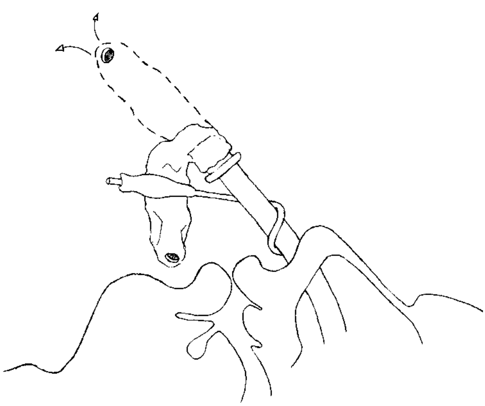

FIG. 8.16. Breathing detection device for blind nasotracheal intubation.

FIG. 8.17. Digital intubation, adult. Note that the intubating clinician is on the patient's right side, and dragging down the right side of the mouth with the left hand.

c-spine immobilization can be maintained and that the clinician is not at the head of the bed where other activities may be occurring.

Reasons to use this method include being unable to visualize vocal cords with a laryngoscope (copious secretions, structural abnormality, technical reasons); no (or a nonfunctioning) laryngoscope; cramped quarters; apnea during blind nasotracheal intubation; both intubation and cervical immobilization are required; or it is a clinician's preferred intubation method.[45,47,48]

To perform digital intubation in an adult or an older child, position yourself on the patient's RIGHT side, and slide the volar surface of your LEFT index and middle fingers over the base of the tongue into the hypopharynx. Drag down the corner of the mouth until the epiglottis can be palpated with both fingers and, if necessary, flipped up. Before advancing the tube with your right hand, push the intraoral fingers farther into the hypopharynx, posterior to the larynx (Fig. 8-17). Your fingers then act as a "backstop" for the tube—forcing it anteriorly through the glottis as it advances. Flexing the index finger may help guide the tube through the glottis. If a stylet is used, acutely flexing the tip of the tube anteriorly improves the success rate. If the patient is able to bite your fingers during the procedure, use a bite block between the molar teeth.[45,47,48]

Pediatric/Neonatal Digital Intubation

Digital intubation has been successfully used in neonates for more than 75 years. Since neonates are edentulous and have a shorter distance to their airway than adults, the procedure is both less risky and potentially easier.

To do the procedure, stand on either side (or at the head or the feet) of the child, holding an ETT with or without a stylet. (Most clinicians initially prefer using a stylet.) Put a slight bend in the end of the tube. Moisten the index finger of your left hand and put it into the pharynx beyond the epiglottis, so that the fingertip lies behind and superior to the larynx and the nail touches the posterior pharyngeal wall. In a limp newborn infant, the epiglottis feels like a band running across the base of the tongue. Moisten the ETT tip with saline and, holding it like a

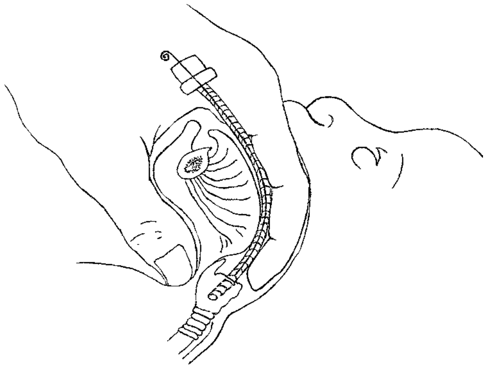

FIG. 8-18. Digital intubation in neonate.

pencil with the right hand, pass it over your finger until the tip lies in the midline of the distal phalanx. Use the index finger to shift the catheter until the tip is just above and in line with the glottic opening. At that point, with the index finger still in place, put your left thumb on the infant's neck just below the cricoid cartilage, in order to grasp the body of the larynx between your thumb and finger (Fig. 8-18). While the thumb and finger gently steady the larynx to prevent side-to-side motion, the right hand advances the tube through the glottis for a distance of about 1 cm. You will feel a slight give or tightening as the catheter passes the glottis, but no force is needed for insertion. If the tube slips into the esophagus, it can be felt between the finger and the larynx. Leave your finger in the infant's mouth to maintain tube position during resuscitation.

Most infants weighing more than 2 kg, and many as little as 1.5 kg, can be intubated using this method, although the clinician may need to use his small, rather than index, finger. This method can also be used for tracheal suctioning, changing ETTs and quickly reintubating an accidentally extubated baby. It can be done anywhere, even in cramped quarters, so neither the child nor other equipment needs to be moved, and the clinician does not have to stoop or bend to do the procedure.[49,50] Experienced practitioners can do this in a few seconds.

Retrograde Endotracheal Intubation

Retrograde intubation can be used to obtain a controlled airway when other methods have failed or to convert a needle cricothyrotomy into an orotracheal intubation. The technique is very useful when all else has failed, but it can also be used as a planned procedure (Fig. 8-19). It can be done with only basic equipment. Contraindications are few, but include infection, the presence of a large hematoma or tumor in the area, and clotting disorders. Unlike fiberoptic bronchoscopy, the presence of blood in the airway does not hinder the procedure.[17]

As with a number of other airway procedures, a question that naturally occurs is: If the cricothyroid membrane has been identified and will be violated, why not simply open it and introduce the endotracheal or tube, which is a much simpler procedure for most clinicians?

Procedure

Do a cricothyroid puncture using a 12- to 16-gauge needle, with the bevel facing cephalad to help direct the wire toward the oropharynx. Attach a syringe to aspirate air and confirm positioning in the trachea. It is important to make sure that the needle used is large enough to allow the guidewire to pass through it easily; using a central intravenous line kit works well. An IV over-the-needle catheter may kink and thus not allow the guidewire to pass, even if it is an appropriate diameter. Once the needle is positioned, the syringe is removed and the guidewire is passed through it toward the oropharynx.

Whatever retrograde guide is used, it must be at least twice the length of the ETT, and preferably longer. It may be an epidural catheter or a vascular guidewire, such as those used for

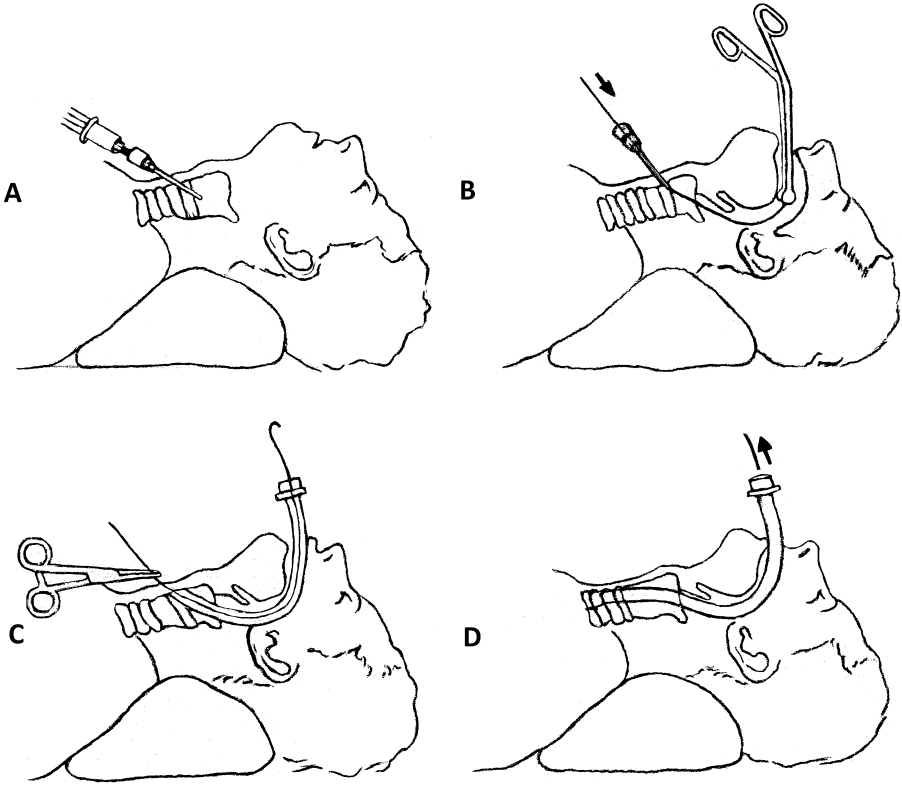

FIG. 8-19. Retrograde intubation procedure: (A) introducing the needle through the cricothyroid membrane; (B) passing the wire through the needle and out the mouth, using a Magill forceps or similar device to grab it; (C) passing an endotracheal tube over the wire while holding the neck end of the wire with a forceps; and (D) withdrawing the wire with the endotracheal tube in place.

insertion of a central venous catheter. These are stiffer wires and have a "J" tip that is less traumatic to the airway.

Many other types of makeshift guides have been suggested for this procedure, including central venous through-the-needle catheters or guidewires, and guidewires for several other types of medical procedures. Many of these are too supple to pass easily, frequently become stuck in the soft tissues, make their own false passages, or reverse direction when they strike an obstruction.

When the wire is visualized in the oropharynx, it is pulled out through the mouth with a forceps or, if necessary, with one's fingers. The needle should be removed from the neck and the wire clamped at the insertion point, so an assistant can hold it in place. Some clinicians insert their needle just below the cricoid cartilage, rather than through the cricothyroid membrane. They have found that this location is preferable, partly due to less vascularity, but mostly because it allows a longer depth of insertion for the ETT, which prevents it from dislodging when inserted over the retrograde guidewire.

At this point, one option that may increase the likelihood of a successful intubation is to pass a nasogastric (NG) tube over the wire, after first cutting it to about two-thirds the length of the guidewire and removing any side ports. The NG tube is a stiffer and more reliable guide for the ETT. The guidewire still must remain in place.

If only a guidewire is used, the wire is passed through the distal-side port (Murphy eye) of the tube; if the guidewire–NG tube is used, it passes up through the end of the tube. As the ETT is

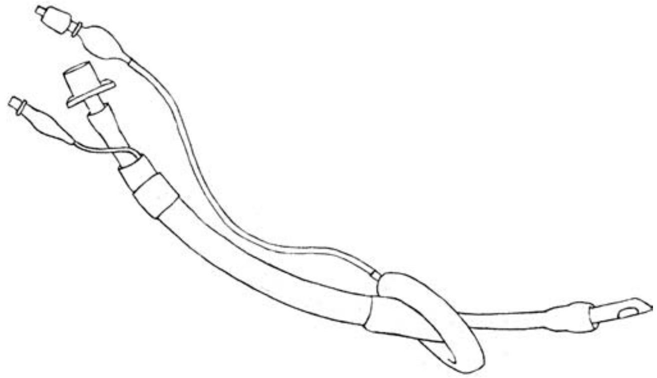

FIG. 8-20. Long endotracheal tube made from standard endotracheal tubes.

passed over the guidewire or guidewire–NG tube, it meets resistance, either at the point where the guidewire curves up toward the skin puncture site or at more proximal structures. If the tube is at the point where the guidewire curves toward the skin, trying to advance the tube further pulls on the guidewire at the larynx. If unsure that the tube has passed the vocal cords, withdraw the tube slightly, turn it 90 degrees and advance it again.[51]

The procedure can be performed on an awake patient after appropriate local anesthesia is applied to the airway. Sedation makes the procedure more comfortable for the patient.

Intubation Through a Non-intubating Laryngeal Mask Airway

The use of an LMA has become a routine practice in the ED, the prehospital setting, and the OR. Often, especially in critically ill patients, the LMA is changed to an ETT for long-term ventilation. This is usually done through an intubating LMA that is specifically designed for this purpose. It uses an accompanying special (and very expensive) ETT.

If the special ETT for an intubating LMA is not available, or if an intubating LMA is not available, intubation can be successfully accomplished with a 6-mm-ID ETT passed through a size 3 or 4 LMA.[52] Two difficulties are encountered. The first is that the normal ETTs are not long enough to pass through the LMA and completely through the vocal cords. Standard ETTs are about 28.5-cm long, and need to be about 32 cm to accomplish the task. The solution is to cut a 3.5-cm-long piece of ETT and, using cyanoacrylate, bond the two together (Fig. 8-20). This adhesive should take only a few minutes to dry; test the adhesive and bonding time in advance. The second difficulty is that unlike an intubating LMA, the distal end of the standard LMA has plastic "bars" that impede the passage of the ETT. The solution, opening the web at the patient end of the LMA, requires only a few snips of a scissors.

Once the patient is intubated, the LMA can be left in place with a small risk of soft tissue injury, or it can be removed using a variety of methods. Improvised methods to remove the LMA include using another ETT of the same or slightly smaller size as a buttress to hold the ETT steady as the LMA is withdrawn over it. Once the LMA is partially withdrawn, it is often possible to grasp the ETT in the posterior pharynx to stabilize it.[53] A tube changer can also be used to remove the LMA, although if the ETT slips out, it may need to be passed over the tube changer ("railroaded") back into the trachea.[54]

LARYNGOSCOPIC INTUBATION

Exposed Trachea

In cases where an injury to the neck or face exposes the larynx or trachea to direct visualization, an ETT can simply be placed into the airway without any manipulation except for holding the soft tissues away from the hole.

Unanesthetized Intubation

When safety takes precedence over patient comfort, the simplest and safest way to intubate a patient in an emergency, including for emergency surgery,

> is with the patient awake, and this is almost always possible with neonates and infants aged less than 2 months, in whom it is the technique of choice. Many adults, especially if they are sick, will also tolerate intubation while awake if you explain what you intend to do and why. Use a well-lubricated laryngoscope blade, and insert it gently and slowly. When you can see the larynx (it may take a minute or two) pass the tracheal tube through it, trying not to touch the sides of the pharynx on the way down, as this may make the patient gag and you will have to start again. On intubation the patient will probably cough, and your assistant may need to restrain the patient's hands. Immediately after intubation, you can safely [sedate the patient or] induce anesthesia.[55]

Experience has demonstrated that it is almost always possible to at least use local anesthetic on awake patients before intubating them orotracheally using the methods described below.

Oropharyngeal Anesthetic

One of the safest ways to intubate orally is by using local oropharyngeal anesthetics. These can be applied via gargle, spray, or inhalation.

Cooperative patients can gargle 30 mL of 2% to 4% lidocaine as either a topical liquid or a mixture of the liquid and viscous forms. Gargling is best done in three or four stages, using a portion of the 30 mL for each gargle, with the patient spitting out the residual anesthetic after each gargle to avoid excessive drug exposure. Allow at least 1 minute between gargles for the anesthetic to take effect. Local spray anesthetic can be used before and after the gargles.[56]

Oral intubation can be done (carefully) after locally anesthetizing the posterior tongue, palate, uvula, tonsillar pillars, and the posterior pharynx. This can be done using a commercial lidocaine aerosol spray (10 mg per spray), up to 3 to 4 mL of 2% lidocaine, or with a similar anesthetic using an improvised atomizer (see Figs. 13-5 and 13-6) or syringe and blunt needle or plastic IV catheter. (Be careful not to overdose the patient.) The key is that local anesthesia takes a few minutes to act; don't hurry. Lidocaine, for example, takes about 1 minute to take effect when applied to the mucosal surface, has a peak effect in 2 to 5 minutes, and lasts between 30 and 45 minutes.[56]

Initially direct the spray onto the mouth and throat. After careful laryngoscopy, spray additional anesthetic onto the laryngopharynx, larynx, and trachea. Anesthetize the area below the cords, if necessary, by spraying the area using a curved hollow stylet under direct vision.[56-59] Inhaling lidocaine can quickly produce anesthesia in the nasopharyngeal cavity, pharynx, larynx, trachea, and nose. (See Chapter 25, Otolaryngology [ENT], for more details.) Experience shows that this is also an excellent and safe technique to use for direct laryngoscopy, either for examination or for foreign body removal.

Transcricoid Anesthesia

Transcricothyroid or transtracheal injection is an excellent method of anesthetizing the whole tracheobronchial tree for intubation or endoscopy—especially in emergency situations. Patients are told to hold their breath while a 21- or 22-gauge needle is inserted either through the cricothyroid space or immediately above the cricoid cartilage. Aspirate air to ensure proper position, immediately inject 2 mL of 4% lidocaine, and remove the needle. For the patient to tolerate this, it must be done rapidly. The patient will immediately cough due to the presence of the lidocaine, spreading the analgesic up and down the trachea. Anesthesia reaches the superior aspect of the cords in 95% of cases.[60] Intubation is often possible after this procedure alone. If necessary or if bronchoscopy is to be done, also spray the laryngeal structures as described in the preceding text. Contraindications include neck infections.[61-64] Complications are very rare.[56,65,66]

TESTS FOR ETT IN TRACHEA

Detecting Esophageal and Endobronchial Intubations

Unrecognized esophageal and endobronchial intubation cause significant morbidity and mortality. While sophisticated (and expensive) devices have proven reliable at recognizing this, clinicians may often be in situations in which they must use alternative methods (Table 8-3).

Listening over both the upper abdomen and the lungs during ventilation provides a reliable method for determining whether the ETT is in the lungs. Listening over only the lungs results in mistakes 15% of the time.[68] Alternatively, the ETT can be advanced into the right mainstem bronchus while listening for unilateral breath sounds. This test is somewhat less useful, since it

TABLE 8-3 Tests for Tracheal Intubation

Test	Result	Significance	Reliability
Look			
At patient	Pink after intubation	Tracheal placement	Good (for those with good color vision)
At patient	Cyanotic after intubation	Esophageal placement	Excellent (reposition in trachea)
With laryngoscope	Tube between vocal cords	Tracheal placement	Excellent
At tube for condensation	Condensation seen if in trachea	Tracheal placement	Unreliable
Listen/Feel			
At proximal end of tube	Breathing through tube	Tracheal placement	Good
Listen			
Over lung apices, axillae, bases	Good air entry	Tracheal placement	Unreliable; ~15% error
Over lung apices, axillae, bases	Air entry only or better on one side (usually right)	Tube in mainstem bronchus	Unreliable; ~10% error (withdraw tube to get equal breath sounds)
Over stomach	Air entry, "gurgling" sound	Esophageal placement	Good (reposition in trachea)
Over lungs and stomach	Air entry into chest; no sound in stomach	Tracheal placement	Good
	-*or*- "gurgling" sound in stomach	Esophageal placement	Good (reposition in trachea)
Inflate With BVM			
And observe chest	Chest rises and falls	Tracheal placement	Good
And listen over stomach	"Gurgling" sound	Esophageal placement	Good (reposition in trachea)
Esophageal Detection Device			
	Air returned or reinflates	Tracheal placement	Good (patients ≥2 years old)
	No air returned, does not reinflate, or unusual noise heard	Esophageal placement	Good (reposition in trachea)

Abbreviations: BVM, Bag-valve-mask, also known as a self-inflating bag. (Data from Dobson.[67])

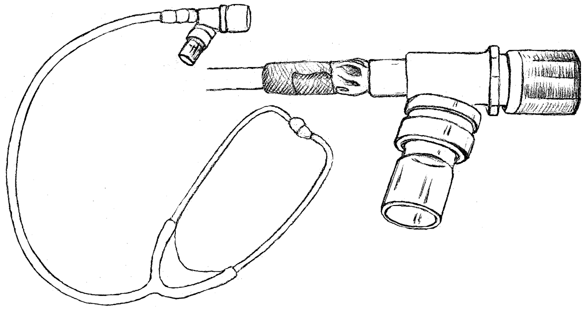

FIG. 8-21. In-line stethoscope (overview and close-up).

provides accurate identification only 91% of the time. It can, however, be a useful adjunct to other methods.[69] If the ETT is not placed into the trachea correctly, withdraw it to its proper position above the carina after the test.

For those comfortable with using a gum-elastic bougie for intubation, the clinician can confirm tracheal placement by passing the bougie through the ETT and feeling, at ~30 cm, its "hockey stick" end pass over the tracheal rings, which is sometimes described as "a hold up" of the bougie.[70]

An in-line stethoscope inserted between the ETT and BVM has also been used successfully to determine esophageal versus tracheal intubation (Fig. 8-21). To make this device, remove the bell and diaphragm (head) from an ordinary stethoscope. Cover the end of the stethoscope tubing with a finger cot or the finger cut from a surgical glove; tape it on tightly so that it forms a new diaphragm for the stethoscope. Insert the covered tubing end into an airway connector normally used for fiberoptic bronchoscopy. The stethoscope fits where the bronchoscope normally enters. Connect the ETT to the connector at the distal end; the other end goes to the BVM.

When placed in-line during ventilation, the stethoscope allows the clinician to assess the type and quality of sounds in the system. When using the device, give six breaths to the patient. An ETT in the trachea produces loud breath sounds with a rapid decrease in volume during the expiratory phase. Esophageal intubation is indicated by an absence of sound or by the presence of squeaks, flatus-like noises, or any sound heard in expiration that does not rapidly decrease in volume. This device is accurate 95% to 99% of the time. It can also be used to monitor patients during helicopter transport and, since it is less invasive than the esophageal stethoscope, to monitor patients during surgery.[71]

Esophageal Detector Devices

The simple and reliable esophageal detector devices (EDD) can generally differentiate esophageal from tracheal intubations. EDDs aspirate air through the ETT, using the differences in tracheal and esophageal anatomy to indicate tube placement.[72,73] If air can be aspirated easily through the tube, it is in the non-collapsible trachea; failure to aspirate air means that the tube is in the collapsible esophagus.

The two major nonelectronic EDDs are a syringe type (Fig. 8-22) and a bulb type (Fig. 8-23). The syringe-type EDD is made by using a short length of rubber tubing attached to a 60-mL catheter-tip (Toomey) syringe using a right-angled ETT connector, such as is found at the end of a BVM. The Mapleson C (anesthesia) disposable breathing system also contains soft plastic adapters for wall-mounted oxygen delivery that can form the connection.[70]

A baby bottle nipple also works well as a connector from the ETT to the syringe. Enlarge the hole slightly in the nipple and insert the syringe toward the nipple's wide bottle-end opening. Slip the bottle-end opening over the ETT; it fits perfectly.

A mechanical EDD must be airtight to work correctly. Test it by occluding the open end with a finger and pulling back on the syringe plunger. If you feel resistance or a negative pressure, it is ready for use. Once the device is joined to an ETT, use the syringe to aspirate. An esophageal

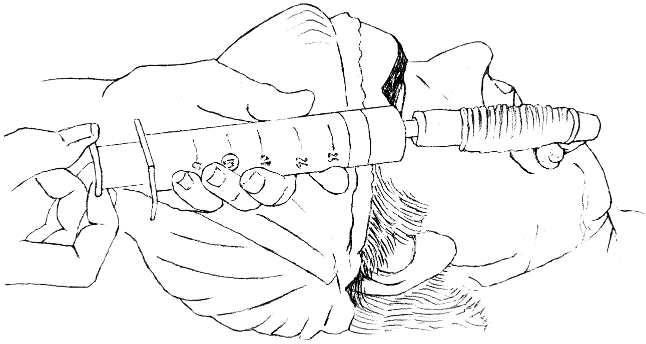

FIG. 8-22. Syringe endotracheal detection device.

intubation usually causes resistance when the syringe is aspirated and the esophagus collapses with the negative pressure; the plunger usually rebounds to its original position when released. Aspirating 30 mL of air without the plunger rebounding when released generally indicates a tracheal intubation.[72,73]

A simpler way to construct an EDD is to attach a self-inflating rubber bulb (such as may be used for newborn suctioning) directly to a right-angled ETT connector (Fig. 8-23). Cut the suction end to accommodate the attachment. Squeeze the bulb and attach it to the ETT. Rapid passive reinflation indicates a tracheal intubation. When placed on a tube that is in the esophagus, it fails to reinflate due to esophageal collapse with the negative pressure, often producing a "flatus-like noise."[74]

The advantages of EDDs are that they: (a) can be easily and inexpensively constructed with commonly available equipment, (b) are both portable and reusable, (c) do not require electricity, (d) are easy to use in-hospital or prehospital settings with minimal instruction, and (e) produce highly reliable results rapidly, even during resuscitation efforts after a cardiac arrest.[75]

The disadvantages of EDDs include both false-positive and false-negative results, although the incidence of either is extremely low.[76] False-positive results (showing that the ETT is in the trachea when it is actually in the esophagus) are due to the regurgitation of gas from the stomach, esophageal distension with gas, or an EDD with a leak. False-negative results (showing that the ETT is in the esophagus when it is actually in the trachea) can occur when thick secretions block the ETT, when the end of the ETT is occluded by the tracheal wall, in obese patients, or with

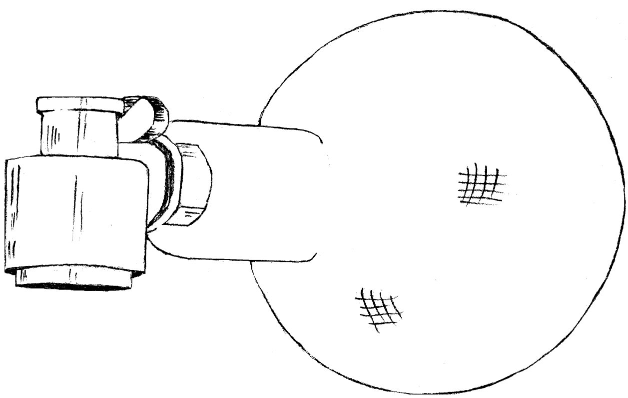

FIG. 8-23. Bulb endotracheal detection device.

bronchial intubation, bronchospasm, tracheal compression, and chronic obstructive pulmonary disease.[75]

The devices are unreliable in infants <1 year old, although they work well in children ≥2 years old, even when using uncuffed tubes.[77,78] In children, use the device before any breaths are given through the tube, since extra air in the esophagus or stomach can give a false result. Only 10 cc should be aspirated if using a syringe device. Begin with the syringe plunger at the 10-mL mark, rather than at "0," to avoid an initial suction effect from the syringe.[77]

POST-INTUBATION MANAGEMENT

Securing the ETT

When securing an ETT, carefully note the depth, so that if the tube slips, it can be repositioned correctly.

Interdental wiring (small-gauge wires or wire sutures) or heavy silk sutures can be used to secure ETTs in place. This becomes particularly useful in patients with severe burns or injuries to the face. Loop a wire around an anterior tooth, usually an incisor, and twist it until it is tight. A needle holder or pliers helps to hold the wire ends when tightening them (Fig. 8-24). Then loop the free ends of the wire around the ETT and twist it until an indentation is noted in the tube.[79] When using a heavy ("0") silk suture, remove the needle and tie the suture very tightly around the base of the tooth. Tie in the ETT as with the wire suture, but add an additional tie on the ETT. A problem with using a silk suture is that it may break with intraoral manipulation, or it may slide down the silastic ETT, predisposing to unplanned extubation.[80]

Suctioning an ETT

If an ETT suction catheter is not available, use a number-10 rectal tube. This size works well for adult ETTs.[7]

Tube Changer

ETTs may need to be changed due to leaking cuffs, the tubes being too small, or inspissated secretions causing partial obstructions. Simply repeating the intubation may be a daunting task, especially if the airway has become edematous, the original intubation was difficult, or the clinician is inexperienced.

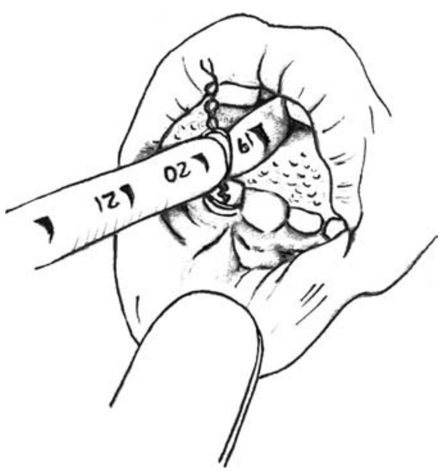

FIG. 8-24. Interdental wire securing endotracheal tube.

To lessen the chance that a problem will occur during the change—such as not being able to reintroduce the tube into the trachea—a tube changer can be used. A tube changer is a long guidewire, coated with a lubricant, which passes through the ETT currently in place and into the trachea. After preoxygenating the patient, pass the guidewire through the ETT and into the trachea. Carefully remove the ETT tube so the guide is not displaced. Then, gently elevate the jaw and slide the replacement tube over the guidewire into the trachea. If the tube gets hung up, back it up slightly, rotate it 90 degrees, and advance it again.

Tube changers are normally gum-elastic bougies. Multiple pieces of equipment have been used as tube-changing guides. These include NG tubes with the flared ends and side ports cut off, feeding tubes, radiology catheters (such as for angiography), or any piece of wire at least 2.5 times as long as the ETT. If a wire such as an unwound wire coat hanger is used, cover it with an NG tube or double over the ends of the wire to avoid cutting the tissues. Bend the wire to conform to the ETT that is in the patient. Cut off the "twisty" end of a coat hanger (the part that cannot be straightened easily). Success with improvised tube changers varies with their diameter relative to the ETT and on their stiffness.[81]

SURGICAL AIRWAYS

Surgical airways, although once common, now are rarely used in emergency situations in developed countries. With their wide variety of intubating medications and sophisticated airway devices, clinicians usually have no need to apply a knife to the neck to get an emergent airway. Yet, when a patient needs an immediate airway and no other method is practicable, a surgical airway may be the best option. Some type of knife and a tube—even if they are not the optimal choices—are nearly always available. Having to perform a surgical airway is much more likely in austere medical situations than in normal circumstances.

Prediction of Difficult Surgical Airway

A quick assessment can determine whether obtaining a surgical airway may be problematic. These are not contraindications, only observations to suggest that a surgical airway may be difficult. Use the mnemonic "SHORT" to recall what to observe, or to ask if there is sufficient time: Does the patient have (a) evidence of previous neck **S**urgery? (b) a **H**ematoma or abscess in the anterior neck? (c) **O**besity or other neck enlargement, such as from subcutaneous emphysema or edema? (d) prior **R**adiation to the neck area? or (e) a **T**umor in the neck area?[82]

In reality, in an emergency, the answers to those questions may not matter; you have to get an airway no matter what the situation. Knowing that these problems exist, however, may sway you toward another airway option, if it is available.

Cricothyrotomy

Cricothyrotomy is lifesaving. "This is an emergency procedure to be done at the site of injury, without anesthesia, with any sharp knife at hand."[83]

Position

To locate the correct site for a cricothyrotomy, use the "4-finger rule." When you lay the tip of the small finger in the sternal notch, the tip of the index finger lies over the cricothyroid membrane. This works for most adults. For a child, lift their hand to their neck to use their fingers.

Procedure

Emergency cricothyroidotomies have been performed with scissors, pocket or hunting knives, razor blades, broken glass, and the jagged edges of the lid from a tin can. If using a scalpel, simply turning the scalpel blade's handle in the cricothyroid incision is as effective as using an intraoperative Trousseau dilator (the formal piece of equipment used in the OR to dilate the hole for a tracheostomy) to widen the hole to insert the tube. Using a skin hook allows a slightly larger-size ETT to be placed.[84] (For a skin hook fashioned from a bent needle, see Fig. 21-5 in Chapter 21, Surgery/Trauma.)

Another method of putting the tube in the trachea is to use the Seldinger technique. As soon as entry is made into the trachea, pass a guide, such as a wire, through it. Then, using the eyehole at the end of the ETT, pass the tube into the trachea.

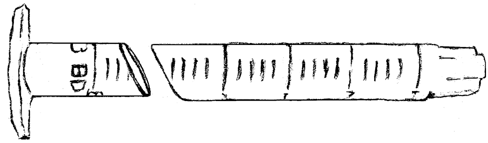

FIG. 8.25. Cricothyrotomy tube cut from 3-cc syringe.

Hold the Hole Open

Once the cricothyroid membrane is opened, if the patient is breathing spontaneously, such as when an upper airway obstruction has been relieved, the hole only needs to be held open manually. In these cases, the incision through the cricothyroid membrane needs to be slightly larger than normal. Airways also have been held open in these circumstances with paper clips and nail clippers.

Cricothyrotomy Tubes

ENDOTRACHAEL AND TRACHEOSTOMY TUBES

Placing an ETT through an emergency cricothyrotomy is optimal. It is easily handled, is readily available in most health care settings, is long enough not to slip out, and has a small enough balloon so that it does not get torn as it passes into the trachea. A tracheostomy tube, if available, is a good alternative, although it is shorter and has a bulky balloon, potentially increasing complications in stressful situations.

OTHER TUBES

A wide variety of tubes has been suggested; some have even been tested. Some will be available only in health care facilities. Others are designed for use in out-of-hospital austere circumstances. The problem is that some don't work; many are dependent on the object's design and diameter. But in these circumstances, you have to use what is available. While not a sophisticated plan, research does show that in critical situations when a cricothyrotomy tube is needed, it is best to use the largest hollow tube available that will fit through the hole. Be creative.

SYRINGE BARREL

An excellent cricothyrotomy tube can be fashioned from the flanged portion of a 2-mL or 3-mL syringe barrel cut to 45 degrees (Fig. 8-25). Remove the syringe plunger and cut the barrel at an approximate 45-degree angle, at a point one-third of the way toward the tip (needle end). Insert the cut end of the syringe through the surgical opening at a right angle to the trachea, with the long end entering through the caudal (upper) part of the incision (Fig. 8-26). The flanges on the

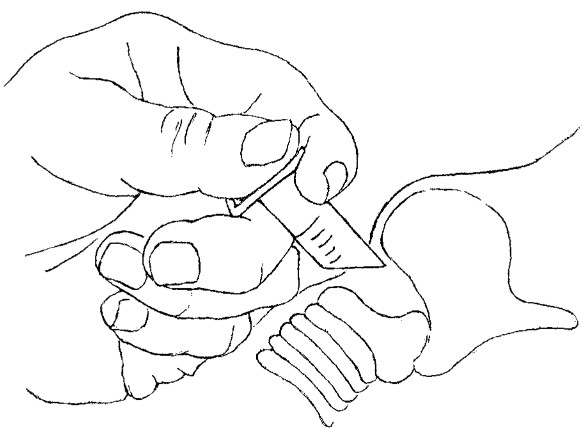

FIG. 8-26. Improvised cricothyrotomy tube inserted (lateral view).

barrel act as a stopper and provide a site for securing the tube. The problem with this device, as with many other improvised cricothyrotomy tubes, is how to attach a BVM, if one is available. Mouth-to-tube ventilation may be the only option for an apneic patient.[85]

Sports Bottle Straws

Not only have the relatively rigid and large-bore sports bottle straws been successfully used for emergency cricothyrotomies, but also, when tested, both the ribbed and flat types have about the same airway resistance as do 7.0-mm ETTs and 8.0-mm tracheostomy tubes. They also have the benefit that, if available subsequently, a standard adapter from a 7.0-mm ETT can be inserted, so a bag-valve device can be used without reintubating the patient. Of course, as with all improvised devices, the straw lacks a cuff, so the patient's mouth must be sealed during mouth-to-straw ventilations. It is, however, long and flexible enough to fit into the trachea with enough extra length for the operator to perform ventilations.[86]

Tubes and Small Hollow Objects

Consider any available hollow tubing as a possible cricothyrotomy tube when doing an emergency procedure. Many small hollow objects also have been suggested, although these are not often used as cricothyrotomy tubes. These include small flashlight or penlight casings, very small pill bottles, plastic throat swabs containers with the bottom cut out, and pen barrels.

Pen barrels have actually been tested. Although they are discussed in medical texts as being useful, at least the standard-issue US military ballpoint pen (Skilcraft, Alexandria, VA) produces so much airway resistance, even with the tapered tip cut off, that it is essentially useless as an airway—except, perhaps as a route for transtracheal jet ventilation or for temporary apneic oxygenation.[86]

IV Drip Chamber

The drip chamber from either regular intravenous tubing or one part of the “Y” from blood tubing has been suggested as a cricothyrotomy cannula.[87,88] The drip chamber is cut ~3 cm distal to the spike that goes into the IV bag/bottle. After cutting through the skin over the cricothyroid membrane (a vertical incision is best if you are not certain of the landmarks), insert the spike through the membrane.[89]

Although the drip chamber supposedly fits well onto a standard BVM, tests show that it only works with some IV tubing. Even with tubing that is too small to fit well, “V-shaped” cuts can be made on both sides of the drip chamber and the BVM can be forced into or around it. Test this before inserting it into the neck, so that modifications can be made before it is in place. Also, consider attaching the BVM before inserting the tube, since attaching it may require more leverage than is possible once the tube is in place.

Postprocedure Bleeding

Protect yourself, if possible, from the spray of blood that invariably accompanies opening the trachea. If you are midline, you can control any bleeding after the tube is in place by packing the area around it with petroleum jelly-impregnated or other gauze. Sutures or cautery are rarely needed to control this bleeding. If you have strayed off midline, however, you may be into the major vessels of the neck—and won't find the trachea. Use a vertical incision and, once through the skin, feel for the cricothyroid membrane, or use the needle-guided method (as with an emergency tracheostomy, described below) if you are concerned about staying in the midline.

Emergency Tracheostomy

Because of its difficulty and potential complications, a true emergency “crash” tracheostomy should be the last option, but is useful if no other method of establishing an adequate airway is available. An emergency tracheostomy is also useful in children needing an immediate surgical airway, since their cricothyroid area is generally too small for a cricothyrotomy. It is also useful (and the author has used it successfully) for patients in whom massive neck swelling from bleeding or from subcutaneous emphysema obscures the cricothyroid landmarks. The basic principle is to stay in the midline. The following technique provides a solution and has proved easy to learn and to use.

This emergency tracheostomy technique requires only a fluid-filled syringe, a needle, a knife, and a tube. To perform the tracheostomy using this technique[90]: locate the midline of the neck and secure the trachea between the thumb and index finger of the nondominant hand. Incise the

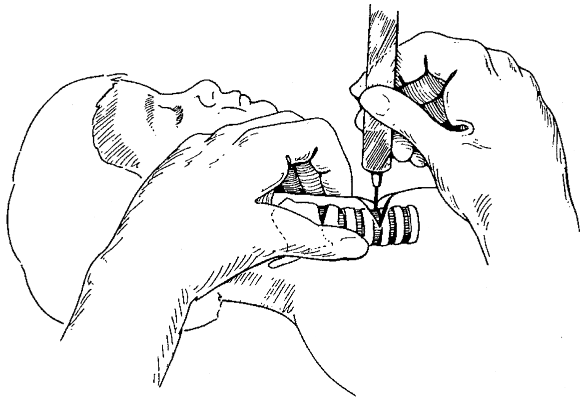

FIG. 8-27. Insert fluid-filled syringe with needle into midline until there is no resistance when pushing the plunger. *(Reproduced with permission from McLaughlin and Iserson.[90])*

overlying skin transversely. Use a finder needle, attached to a saline (or any nontoxic fluid)-filled syringe, to locate and stabilize the tracheal lumen prior to incision and cannulation. Insert the needle into the midline between the prominent thyroid cartilage and the sternal notch, aiming for the anterior trachea (Fig. 8-27). Inject the fluid gently; when it flows without resistance, the needle has entered the trachea. Aspiration of air confirms correct positioning within the lumen. While holding the needle steady, make a vertical stabbing incision lateral to and against the needle (Fig. 8-28). Using the knife handle to open the stoma, remove the needle and insert a standard ETT (Fig. 8-29). Secure the tube with tape and, if necessary, pack the wound to control bleeding.

Another (slower) tracheostomy method, only appropriate in nonurgent situations, requires some equipment that may not be readily available. Based on the method described previously, it uses the Seldinger (wire-through-needle) technique. With the larynx firmly stabilized with the nondominant hand, make a 1.5- to 2.0-cm transverse or vertical incision just below the cricoid

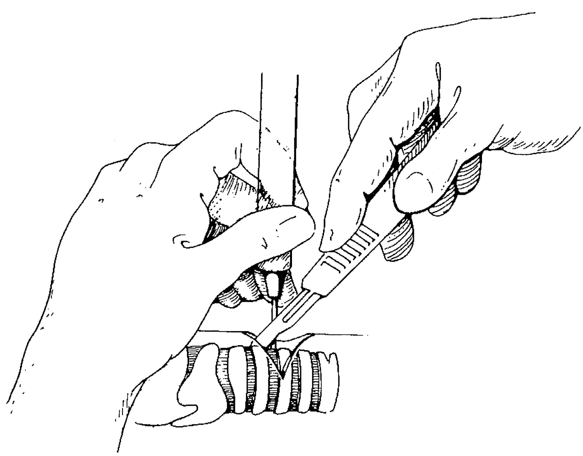

FIG. 8-28. Vertical incision in trachea. This is done with the needle still in place, “cutting down on” the needle. *(Reproduced with permission from McLaughlin and Iserson.[90])*

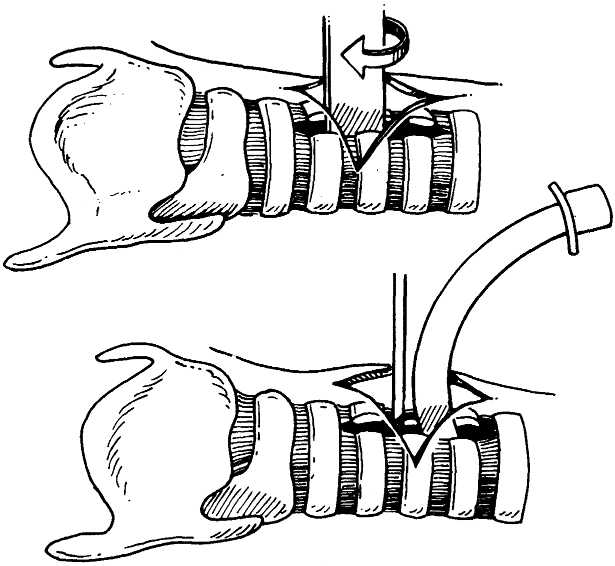

FIG. 8-29. Opening stoma with knife handle and introducing endotracheal or tracheostomy tube. *(Reproduced with permission from McLaughlin and Iserson.[90])*

cartilage. Then pass a large-gauge needle through the incision and into the trachea. Optimally, the needle is specifically designed to accommodate the wire, such as with an arterial line or a central line kit. Using a fluid-filled syringe attached to the needle simplifies locating the trachea with the needle, as described previously. Once the trachea is entered, carefully remove the syringe and pass the wire through the needle into the trachea. Pass small (artery-dilating Howard-Kelly) forceps along the wire through the soft tissues of the neck until you feel resistance at the outside of the trachea. Open the forceps to dilate the opening down to the trachea. Then close the forceps and pass them over the wire through the tracheal wall. Advance the forceps until the tip is in the long axis of the trachea; spread the forceps and the tracheostomy tube or, if the wire is long enough, pass an ETT over the guidewire.[91,92]

Dislodged Tracheostomy Tube

The only sign that the tracheostomy tube is dislodged may be the inability to pass a suction catheter through it, although this can also occur when concretions block the tube.

A mature (>30 days) tracheostomy tube can usually be replaced without too much difficulty if no granulation tissue or foreign body blocks the passage. Simply replace the obturator and pass it into the mature stoma. With tracheostomies <1-month-old, it may be difficult to put a dislodged tube back into the trachea (or trying to do so may cause a false passage) due to stoma closure. In these cases, place an ETT, rather than the shorter tracheostomy tube; a tracheostomy tube can be placed once the airway is again secure.

As a guide, use a urethral catheter with the tip cut off, a suction catheter, or similar tubing connected to an oxygen source. Pass it through the ETT and then gently into the trachea. If the trachea cannot be visualized, pass a pediatric laryngoscope into the trachea, followed by the tube/guide. Once the tube is in the trachea, remove the guide.[93]

Post-tracheostomy Bleeding

Post-tracheostomy bleeding can be deadly. While mild incision bleeding is typical 1 to 3 weeks post tracheostomy, 85% of tracheo-innominate artery fistula bleeds also occur in the first month. They have a mortality rate of 80% even with treatment. Post-tracheostomy bleeding is often from granulation tissue in the stoma or trachea, erosion of the thyroid vessels or gland, or the tracheal wall due to overzealous suctioning.[94]

Methods to help control the bleeding while getting the patient to the operating room or interventional radiology include hyperinflating the tube's cuff, putting mild anterior traction on the tube, or replacing the tracheostomy tube with an ETT and hyperinflating the balloon, which should be placed, if possible, just distal to the site of bleeding to tamponade it. The best technique is to stick one's finger into the stoma and apply local digital pressure to compress the innominate artery. If this doesn't work on one side, go to the other side.[95]

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9 | Breathing/Pulmonary

LUNG SOUNDS

Clinicians are exhorted to always place their stethoscopes directly on a patient's skin. Yet when patients are examined in hallways and prehospital settings or in locations where cultural norms prevent patients from disrobing, this rule is often violated. That is not a problem: By applying pressure on the stethoscope head, all the sounds normally heard on bare skin can be heard through up to two layers of indoor clothing—including double-layered flannel shirts. Of course, inspection and percussion cannot be done through clothing, and clothing-induced acoustic artifacts may create problems.[1]

PULMONARY TREATMENT

Aerosols and Spacers

The use of aerosol spacers more than doubles the amount of medication delivered to the lungs from metered-dose inhalers (MDI); for steroid inhalers, an aerosol spacer diminishes the incidence of oral candidiasis by decreasing deposition in the oropharynx. The tube from a roll of toilet paper works well as an aerosol spacer, as does a piece of ventilator tubing.

Dr. Lara Zibners-Lohr wrote that in remote areas of the world, she uses large Styrofoam cups. The cup lip (open end) goes over the nose and mouth. The MDI goes through a hole in the bottom end of the cup. She uses just the blue tubing from a nebulizer for older children: they close their mouth around one end and put the MDI in the other. (Personal written communication, received, June 5, 2007.)

Dr. Karen Schneider uses a dry water bottle with a hole in the bottom for the MDI. The hole is sealed with tape, leaving a small opening to allow air movement from the outside when the child inhales. The inside of the bottle must be dry; otherwise, the aerosolized particles will stick to the water. When the MDI is activated, the child places her mouth over the drinking end and inhales a few times until the mist is cleared (Fig. 9-1). It is important that the child not exhale into the bottle because this will blow the mist out the small hole. (Written communication, received, June 5, 2007.)

Improvised spacers have been shown to be just as effective as the expensive commercial spacers.[2]

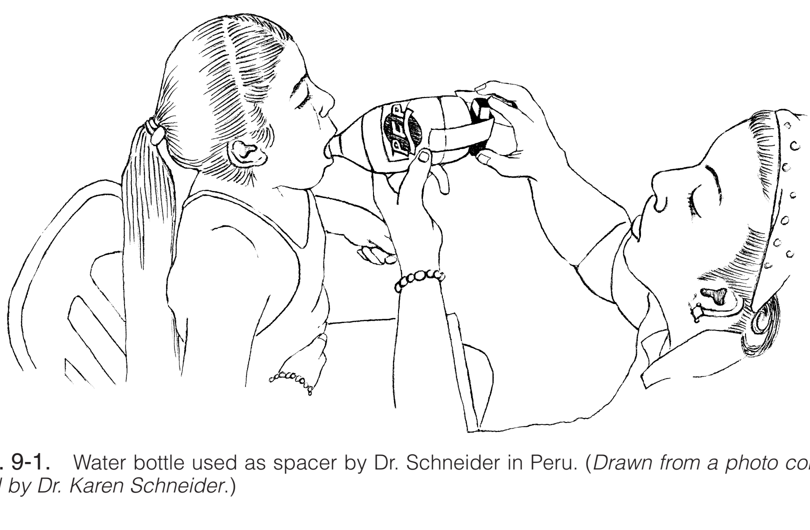

FIG. 9-1. Water bottle used as spacer by Dr. Schneider in Peru. (*Drawn from a photo contributed by Dr. Karen Schneider.*)

Treating Persistent Cough

An unremitting cough may be due to airway hyperirritability caused by an upper respiratory infection, toxic inhalation, asthma (sometimes unrecognized), allergens, or the use of angiotensin-converting enzyme (ACE) inhibitors. The cough is uncomfortable for the patient and may worsen bronchospasm. For adults and children, add 0.5 mg/kg of lidocaine to 0.3 mL of albuterol solution in 3 mL of normal saline; administer the combination by aerosol nebulization. Lidocaine suppresses the cough reflex while the sympathomimetic agent relieves the bronchospasm.[3]

Positioning to Improve Lung Function

In patients with unilateral lung disease, positioning the healthy lung down—in the most dependent position possible—may improve the ventilation–perfusion mismatch and raise oxygen saturation levels. This may buy valuable time, turning an emergent situation into an urgent one.[4]

Under anesthesia, and probably in other critical care situations, morbidly obese patients have a wide alveolar–arterial oxygen gradient [$P(A\text{-}a)O_2$]. However, when they are placed in the reverse-Trendelenburg position (RTP), with their head higher than their feet, their A-a gradient shows a significant improvement and a return toward baseline. In addition, total respiratory system compliance is significantly higher in RTP, suggesting that RTP is an appropriate position for obese subjects who can tolerate it, because it causes minimal arterial blood pressure changes and improves oxygenation.[5]

Having a ventilated patient sit up has been shown to help avoid gastric aspiration. This simple maneuver can be used in any patient whose blood pressure can tolerate a semi-recumbent or upright position.[6]

MAKESHIFT SPIROMETERS

To encourage patients to breathe deeply after surgery, trauma, or illness, use an incentive spirometer such as a balloon or a surgical glove. Have the patient blow one up several times an hour while awake. It works, however, only if the patient has received adequate analgesia.[7]

Incentive spirometers can also be made from plastic bottles, such as those for milk or soda. Fill the bottle about halfway with water. Insert a tube, with an internal diameter (ID) of at least 0.5 cm so the resistance is not too great (Fig. 9-2). Insert the tube into the bottle's open mouth; this can be messy if the bottle tips over. The tube can also be inserted through a hole drilled in the resealed cap, although in that case, either the cap must be left loose or a small additional hole made so that air can escape. Adjust the water height (resistance) for the patient; less water may be necessary for children and for the elderly and infirm. Have the patient blow bubbles. Coloring the water with food coloring makes it more fun for children. Spirometers improvised to measure lung function produce unreliable measurements.

MAKESHIFT BI-LEVEL POSITIVE AIRWAY PRESSURE

Bi-level positive airway pressure (BiPAP) is becoming an increasingly useful modality to avoid intubations. In settings with ventilators but no BiPAP equipment, BiPAP can be improvised. For example, after Hurricane Katrina, Peter DeBlieux, MD, FACEP, reported that physicians at Charity Hospital improvised BiPAP machines from mechanical ventilators. "We used a pressure-cycled ventilator with pressure support of 10 cm H_2O and PEEP [positive end-expiratory pressure] of 5 cm H_2O and attached it to the circuit. [However,] ventilators do not tolerate the leak associated with noninvasive ventilation (NIV or NIPPV) and the alarms sound frequently with mouth opening and poor mask fit. A full-face mask is necessary when using this system, rather than a smaller nasal mask. Using BiPAP as invasive ventilators is not the standard, but could be used in a pinch for pressure supported ventilation." (Written communication, received February 2008).

OXYGEN

Oxygen is one of the most basic drugs we have. In many acute illnesses, such as acute respiratory infections, asthma, fetal asphyxia, and shock, the availability of an oxygen supply can save a patient's life. It becomes especially important during resuscitations, in the operating room, or

FIG. 9-2. Incentive spirometer made from cola bottle.

when treating cardiopulmonary illnesses and any illness (including acute mountain sickness) at altitude.

Industrial Oxygen

In austere medical situations, industrial (or research or aviation) oxygen can be used instead of medical oxygen. Oxygen gas is produced from the boiling-off of liquid oxygen, so it would appear that industrial oxygen is the same as medical oxygen. However, there is an ongoing controversy about whether there is any difference between four kinds of oxygen that are sold: aviation, medical, welding, and research. They are all at least 99.5% pure (usually 99.9% pure), and all are produced from an identical—often the same—system. Any humidity present in medical oxygen is added at the bedside. Purity is not an issue, since the purity required for welding is more critical than that for breathing. The major differences between medical oxygen and industrial oxygen are how it is filtered and the amount of liability insurance paid by the manufacturer. Microscopic filtration is used to remove air particles from both, but medical oxygen is run through filters that can also remove bacteria, and so is considered sterile.[8-10]

Oxygen Cylinders

Oxygen often comes in bulky, expensive cylinders. It may be difficult to identify which cylinders contain oxygen. The international standard requires oxygen cylinders to be painted white. In the United States, however, they are green, and in British Commonwealth countries, they are usually black with white shoulders. Industrial oxygen cylinders may be painted almost any color, so don't rely on the cylinder's color to identify its contents.[11] Note that you may see one of two terms used in descriptions of flow rates, either the term psi (pounds-force per square inch) or psig (pounds-force per square inch gauge; i.e., pressure related to the surrounding atmosphere). For medical purposes, they are generally equivalent. In this book, I will use the term "psi."

Oxygen cylinders vary in size from the small portable D or E cylinders (which supply 1 to 10 hours of oxygen) to the larger stationary M, H, or K cylinders (which, at very low flow rates, supply oxygen for up to 56 hours). The duration depends on the oxygen flow rate. For example:

D cylinder: 350 L @2200 psi (23 min @ 15 L/min)
E cylinder: 625 L @ 2200 psi (42 min @ 15 L/min)
M cylinder: 3000 L @ 2200 psi (200 min @ 15 L/min)
H and K cylinders: 6900 L @ 2200 psi (690 min @ 10 L/min; ~33 hours @ 3 L/min)

Therefore, it is helpful to know how much oxygen each type of cylinder commonly contains, and how long it will last.

Oxygen Concentrators

Oxygen concentrators extract the nitrogen from room air to produce 95% oxygen. They do this by using zeolite granules to adsorb the nitrogen from compressed air.[12] Zeolite crystals can be expected to last at least 20,000 hours—about 10 years' use.[10]

Concentrators are available in sizes ranging from domestic models with flows of up to 4 L/min to very large installations that supply an entire hospital. They typically deliver 2 to 5 L/min of oxygen.[13] Oxygen concentrators require 350 to 400 W of electric power and can run off a small gasoline generator, a solar- or wind-powered system with battery storage, or a domestic or commercial power source.[14] However, the machine's power requirements must match the available power supply.

The price to purchase an oxygen concentrator is about half that of purchasing a 1-year supply of oxygen in cylinders.[10] The cost (electricity) to run them, regardless of the oxygen flow, is about 2.5 p/hr (UK) or 5 ¢/hr (US). This is much cheaper than using cylinder oxygen, which costs from 10 p/hr (UK) or 20 ¢/hr (US) at a flow rate of 0.5 L/min up to £1.00/hr (UK) to $2/hr (US) at 5 L/min.[10]

Anesthesia

Oxygen concentrators can be used to supplement oxygen to anesthetized patients, but the outlet pressure is insufficient to power an anesthesia machine.[10] A flow splitter allows oxygen from a concentrator to be supplied to up to four separate sites simultaneously if required, depending on the concentrator's capacity and the patients' needs.[12]

The oxygen must be introduced upstream from the vaporizer in a drawover system or it will dilute the inspired vapor concentration.[12] If added using a reservoir attachment above the vaporizer inlet, the 95% oxygen at a flow rate of 1 L/min produces a FiO_2 of from 35% to 40%; a rate of 5 L/min produces a FiO_2 of up to 80%.[15]

To increase the FiO_2 even more and provide an improved margin of safety, prefill a large plastic sack (e.g., trash bag) with concentrator oxygen and then attach this reservoir to the inlet side of the draw over system during preoxygenation. Remove the empty sack as soon as preoxygenation and intubation are completed.[16,17]

Oxygen Delivery

Improvised Oxygen Tent

Oxygen tents are not the best way to administer oxygen. But, when nothing else is available, the top of a plastic cake server with a hole cut out of the side for the neck works well as an oxygen tent for infants (Fig. 9-3).

Splitter

High-pressure oxygen sources (25 or 50 psi) can be split for use by up to seven patients with commercially available devices. These can also be "jury-rigged" by knowledgeable respiratory therapists. Low-pressure oxygen sources (cylinders/concentrators) can also be split, depending upon the patients' needs.

Mouth-to-Mouth/Mouth-to-Tube Resuscitation

For mouth-to-mouth resuscitation, make a shield by cutting out about half the length of the third (long) finger from a medical glove. Extend the part of the finger still on the glove into the patient's mouth, and stretch the remainder of the glove over the mouth and nose as a protective shield.[18] This works, but a handkerchief draped over the mouth and nose might work

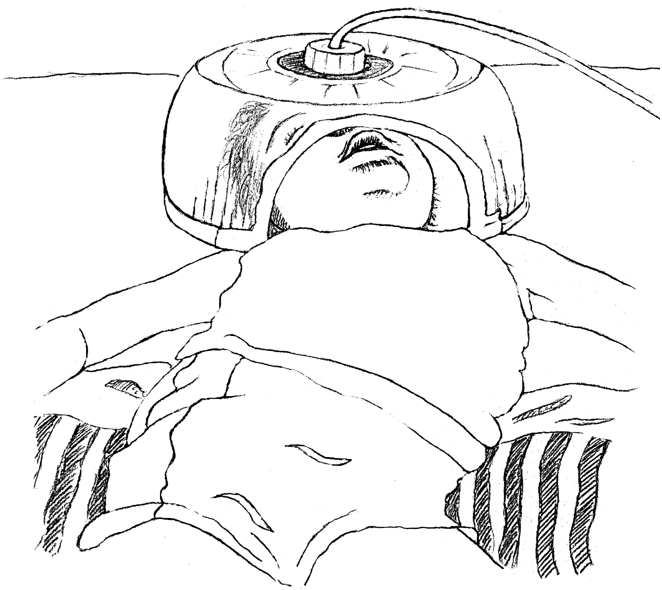

FIG. 9-3. Improvised pediatric oxygen tent.

as well or better to protect the rescuer from at least the "big stuff." With the new, "continuous" cardiopulmonary resuscitation (CPR), rescue breathing is taking a back seat to chest compressions, at least for cardiac events.

Often forgotten is that, if no other means is available, patients can be given mouth-to-tube ventilation through an ETT, an LMA, a tracheostomy tube, an esophageal obturator airway (EOA), a Combitube, a makeshift cricothyrotomy tube, or similar device. The problem is, other than covering the tube's end with a thin cloth (e.g., a handkerchief) to avoid contact with large amounts of blood or other secretions, none of these devices provides infectious protection to the rescuer.

VENTILATION

Mask

Even the most experienced clinicians under optimal conditions have difficulty using a mask to ventilate in 2% to 5% of patients because of poorly fitting masks.[19]

Incorrect Mask Size

When a mask is too small for the patient, place the mask over only the nose. Seal the mouth by placing your long finger under the chin, or even with a piece of transparent dressing. With very large patients (BMI >26), hold the mask with both hands over the mouth and nose, or just the nose, while someone else ventilates the patient.[20]

If the mask is too large for the patient's face, as often happens with infants and children, bring the bottom of the mask below the chin (i.e., between the underside of the chin and the hyoid). This forms an adequate seal until the properly sized mask can be found. Occasionally, turning the mask upside-down so that the nasal angle is caudad (toward the feet) and the more rounded edge of the seal is across the nasal bridge may help achieve a seal.[20]

Lack of Teeth

It may be difficult to establish an effective seal in patients with no, or few, teeth. If the patient has dentures, leave them in place (as long as they are firmly attached) until the patient is ready for laryngoscopy, at which time the upper teeth should be removed. Not only is this safe but it also decreases the incidence of difficulty with mask ventilation from 16% to 4% in this group.[20,21]

If the patient lacks teeth and dentures, place a large oral airway down the midline of the tongue. Then use a large mask to cover the lateral aspects and angle of the mouth. Put your third finger across the bottom of the jaw to keep the mouth closed and ventilate mainly through the nose.[20]

Beard

In wartime, during disasters, and in many remote areas, most male patients have a beard. If a beard is causing problems with getting a good mask seal, "simply shaving the beard may solve the problem."[20]

Another option is to apply petroleum or KY jelly, or other soluble grease around the edge of the mask. The beard has to be "filled" with the lubricant, which makes the mask slippery. It doesn't work as well as shaving the beard, but the following method works almost as well. Apply a large defibrillator pad or transparent sticky plastic dressing (i.e., Tegaderm or another clear plastic adhesive sheet) with a hole cut in it to expose the nose and mouth. The sheet keeps the beard in check as the mask is applied.[22,23] This also works well for continuous positive airway pressure (CPAP)/BiPAP masks.

A simpler solution may be to insert cotton between the mask and the skin. After administering anesthesia for operations near the front lines during World War I, Flagg wrote: "The great majority of the patients one sees are unshaven. In this connection it might be well to emphasize the great advantage of placing a layer of cotton between the skin and the facepiece [mask]."[24]

Bag-Mask-Valves

Caring for a BVM (Ambu) Valve

Regularly inspect your reusable bag-valve-masks (BVM) to be certain that the valves function properly. If the BVM valve is stuck or needs cleaning, unscrew the two ends that do not go to the patient. Then remove the lugs on the leaflets. Don't pull on the flaps—they are fragile and you may tear them. Wash the inside and outside of the valve with warm, soapy water, and allow the parts to dry thoroughly. Most of these BVMs can be disinfected with antiseptics or autoclaved, but this is only necessary if the bag has been used on an infected patient. Carefully reassemble the valve, making sure that the flaps are not wrinkled. Also, check the bag for cracks and deterioration of the rubber. This is almost impossible to repair, although you should be able to make a temporary patch with cyanoacrylate.[25]

The disposable BVMs have sealed valve chambers that cannot be opened without breaking the equipment. These are designed for one-time use, but in settings with limited resources, they may be used many times. Use either a moist cloth or steam to try to clean BVMs between uses; however, this may be less than adequate for infection control.

Improvising a BVM

Nothing seems to work well as a substitute to a BVM, other than mouth-to-mouth ventilation. A number of alternatives, including using a plastic soda bottle, have been suggested; they don't work. Do not waste precious time trying them.

Improvised One-Way Valves

One-way valves in ventilation devices allow the exhalation to the atmosphere of "used" air to prevent a buildup of CO_2. While various types of one-way valves are commercially available, these can be improvised, although the system required both hands and was found to be somewhat cumbersome.

Pearson and Safar wrote about one system: "A large hole, in the wall of the tracheal tube adapter, to permit exhalation through the hole and inflation while the hole is occluded with the finger…systems are relatively clumsy, as they occupy both hands of the anesthesiologist."[26] Although described for use with an endotracheal tube, this could also be used for a patient who is undergoing anesthesia with only a mask.

Mechanical Ventilator Use With Multiple Patients

Short-term mechanical ventilation can be lifesaving. The lack of ventilators represents a major limitation on medical treatment capabilities, both acutely during pandemics and chronically in many areas of the world. It is unlikely that medical facilities or governments will be able to

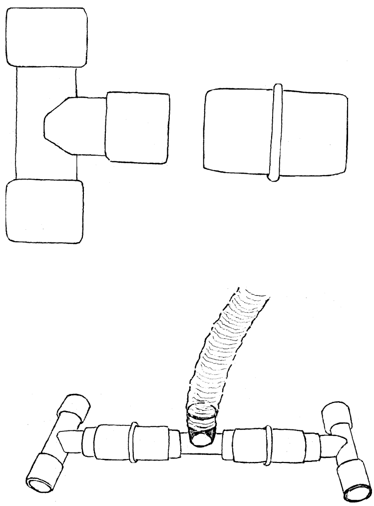

FIG. 9-4. Detail of circuit for multiple-patient ventilation.

stockpile sufficient mechanical ventilators (and, in the case of governments, distribute them in a timely manner) to meet the need during pandemics or other widespread disasters involving agents that affect the respiratory system.

While not the optimal solution, one ventilator can, theoretically, be used to ventilate four patients simultaneously in both pressure- and volume-controlled modes. This may be a temporizing measure when alternatives are not available—or when the only alternative is to not ventilate a patient and let him die. This design is for "last-ditch ventilation," and only a simulation model has been published. I describe the method used in detail, to provide the maximum information in case it needs to be used clinically.[27]

Four sets of standard ventilator tubing (Hudson) are connected to a single ventilator (Puritan-Bennett, 840 series) via two flow splitters (one on the patient inflow limb of the circuit, and one on the patient exhaust limb). Each flow splitter is constructed from three Briggs T-tubes with included connection adapters (Hudson) (Fig. 9-4), but with the valves removed. The Briggs T-tube is used clinically (and generally available) to provide flow-by oxygen to a patient with an endotracheal or a tracheostomy tube and for in-line aerosol treatments of ventilated patients. The T-tubes are arranged so that the two side ports of a central T-tube are attached to the bottom ports of the two side T-tubes via adapters that come with the T-tube. Standard ventilation tubing connects this device to the ventilator. This configuration (Fig. 9-5) allows air flowing from the ventilator to be split evenly to four patients and the air returning from the four patients to flow back into the single exhaust port on the ventilator.[27]

For pressure control, the ventilator settings were dialed to a peak pressure of 25 cm H_2O, 0 cm of PEEP, and a respiratory rate of 16 breaths/min. The ventilator software chose an inspiratory/expiratory ratio of 1:2 automatically. For volume control, settings of 2000 mL tidal volume (500 mL per test lung) and a respiratory rate of 16 breaths/min were chosen to approximate physiologic parameters. The ventilator software chose an inspiratory/expiratory ratio of 1:1 automatically. In the model, the four simulated lungs, pressures did not exceed 35 cm H_2O and tidal volumes approximated 7 mL/kg for a 70-kg patient.[27]

Potential problems with this system include the differences in the four patients' lung compliance, the risk of passing infection from one patient to another, the different tidal volumes required by patients of differing sizes, and the need for constant supervision by a knowledgeable health care provider. Patients will probably need to be completely sedated and chemically paralyzed, require frequent suctioning (airway toilet), and be able to be temporarily removed from the system to use bag-valve ventilation, if necessary.[27]

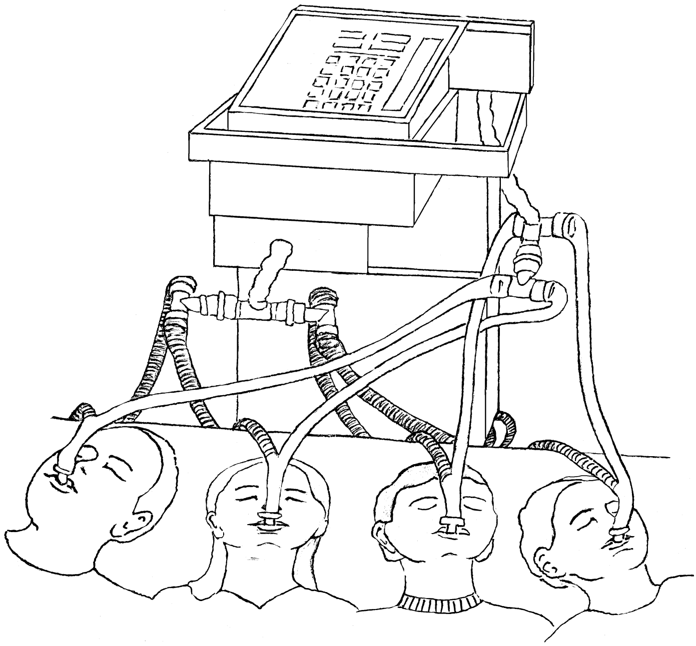

FIG. 9-5. Multiple patients ventilated by one machine.

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10 | Circulation/Cardiovascular

Few improvised methods are available for diagnosing and treating cardiovascular abnormalities. The most basic treatment, cardiopulmonary resuscitation (CPR), can be performed without extra equipment. However, not even MacGyver would really be willing to try cardioversion without a defibrillator, and the most basic treatments used for cardiovascular care require at least certain medications and equipment.

DIAGNOSIS: ECG

No Calipers

To measure electrocardiogram (ECG) intervals without calipers, mark a card or piece of paper with vertical lines: | | | | | | | | |. The marks can be spaced for the top of the R or the P waves, depending on what you are looking for. Move the marks to another part of the ECG to determine if the rates are constant or to find a P wave hidden in a QRS complex.

Alternate ECG Positions and Leads

If there is no room to lay a patient down, the ECG can be done with the patient in a standing position (Fig. 10-1). The resulting ECG is just as interpretable as one done in a supine position.

If standard ECG leads are not available, leads can be attached using needles (as is often done for burn patients) or by simply holding the bare ends of the leads down with venous tourniquets or tape. If the leads have been modified to hold a tape lead, just pull that lead straight off. You can use alcohol pads or a lubricant (oil, KY jelly) between the skin and the lead, but that is not essential to obtain a good ECG reading (see Fig. 7-15).

FIG. 10-1. Standing ECG with improvised leads.

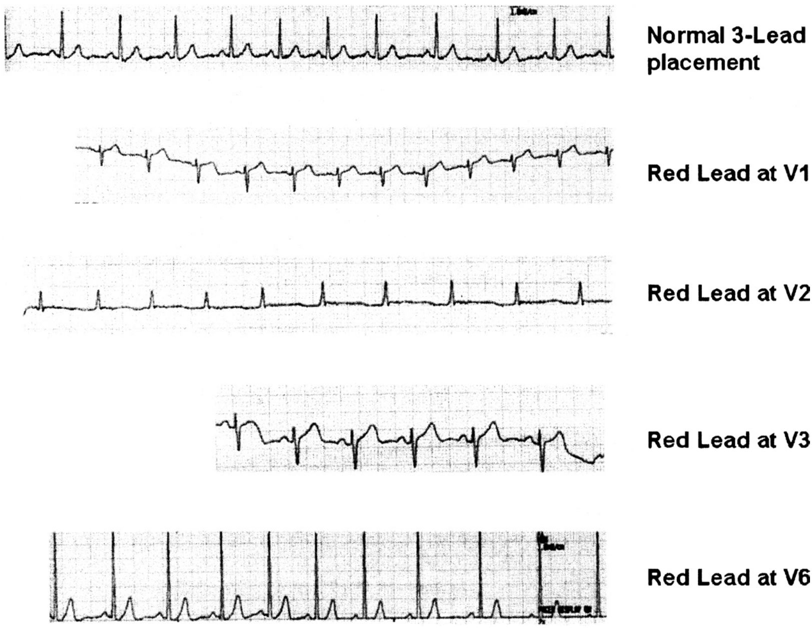

FIG 10-2. A normal ECG (I, V1, V2, V3, V6) done using only the three leads from a monitor. The additional limb lead tracings taken by changing settings on the monitor are not shown. The "Normal" tracing is lead I, although on most machines it also can do tracings of the other limb leads.[1]

"12-Lead" ECG Using 3 Leads

Normal 12-lead ECG machines may not be available when additional ECG information is needed for a diagnosis. In this situation, clinicians can use a 3-lead machine to obtain an ECG tracing that produces most of the information provided by a 12-lead ECG. To do this, do a tracing with the ECG pads placed in the normal 3-lead positions:

White = right chest just below the clavicle
Black = left chest just below the clavicle
Red = left lower abdomen just above the umbilicus

Then, do four more tracings, each time moving the Red (Left Leg) lead to the V1, V2, V3, or V6 positions (Fig. 10-2).[1] Many monitors can also show leads II, III, aVL, aVR, and aVF by moving a dial on the machine with the leads kept in their normal position.

TREATMENT

Paroxysmal Supraventricular Tachycardia

The simplest method to convert paroxysmal supraventricular tachycardia (PSVT) is to use vagal maneuvers. However, if the patient is unstable, cardiovert immediately if that option is available. Use either saline pads or the same gels as used for ultrasound examinations.

Valsalva Maneuver

The Valsalva maneuver, bearing down against a closed glottis, is consistently the most effective vagotonic technique. Its efficacy can be increased by pressing firmly over the right hypochondrium (over the liver) while the patient exhales and bears down. This increases venous return to the right side of the heart and augments the effect on cardiac stretch receptors, thereby increasing the chance of successfully terminating the arrhythmia.[2]

Older Methods

Stimulating the diving reflex works best on children. Ask children who are old enough to cooperate to hold their breath and dunk their face into a pan of ice water resting on their lap. Do not force their head into the water or hold it under! For younger children, have a parent hold a towel that has been dipped in ice water over the child's face—while keeping the airway clear.

Pressor drugs can occasionally terminate AV nodal reentry by inducing reflex vagal stimulation mediated by baroreceptors in the carotid sinus and aorta. This requires the systolic blood pressure (BP) to be elevated to about 180 mm Hg, so should be used carefully or not at all in the elderly or in patients who have structural heart disease, significant hypertension, hyperthyroidism, or an acute myocardial infarction. Given over 1 to 3 minutes, the adult doses for these agents are phenylephrine 1%, 1 mg (0.1 mL) to 10 mg (1 mL); methoxamine, 3 mg to 5 mg; or metaraminol, 0.5 mg to 2.0 mg. If edrophonium is used, administer it over 15 to 30 seconds—it is very short acting.

Ineffective Congestive Heart Failure Treatments

To have improvised methods to treat pulmonary edema accompanying heart failure would be superb. The hallmark of treatment is preload reduction, that is, reducing the volume of blood entering the heart. You may think that some old treatment methods might work in austere situations; they don't.

"Congesting cuffs" or "rotating tourniquets" were often applied to the extremities to treat patients with acute pulmonary edema secondary to left heart failure. The theory was that rotating tourniquets would provide some benefit until medications could be administered. They don't work.[3-5]

Practiced since biblical times, the removal of volumes of blood to treat heart failure continued into the late 20th century. Unfortunately, the technique also has been shown to be ineffective except in patients with hemochromatosis or polycythemia.

Central Venous Pressure

Both the catheters and the manometers used for central venous pressure (CVP) monitoring are disposable, but, if necessary, they can be boiled (disinfected) and reused. The danger in reusing catheters is that particulate matter may remain within them, so the disinfection may not be effective.[6]

For measuring CVP, attach a manometer to either a 3-way stopcock or a sterile "Y" tube. A manometer can readily be constructed from another intravenous set taped over or beside an upright ruler or cardboard marked in centimeter increments. The manometer is filled from the intravenous bottle and then connected via a central line to the patient. Any drip going through the line is stopped. The zero point is the mid-axillary line with the patient in a supine position.[7] (The normal reading is 5 to 10 cm H_2O.)

To be accurate, the zero ("0") mark on the CVP manometer must be level with the supine patient's mid-axillary line. Use a long piece of wood with a level taped on top, so you can check that it is parallel with the floor. Place one end of the wood at the patient's mid-axillary line and, while watching the level, attach the CVP manometer to an IV pole so that the zero ("0") is even with the wood's other end. An alternative is to use a piece of IV tubing that has been half-filled with colored water and then formed into a loop by connecting the two ends. The two menisci (where the water meets the air) in the tube will always be at the same level if the loop is held vertically. Figure 10-3 illustrates how to use such a tube to adjust the manometer height.[6]

Peripheral Edema/Lymphedema

Developed by Dr. Robert Jones to help treat fractures, the Jones compression dressing also effectively eliminates edema caused by systemic problems such as chronic venous insufficiency, lymphedema, and other illnesses causing lower extremity swelling.[8] However, since the dressing does not treat the underlying problems, when possible, these should also be treated.

To make your own compression dressing, apply three to five rolls of 4-inch cast padding, or equivalent material, with minimal compression: Going distal to proximal creates a pressure gradient that permits the swelling to increase. Over these layers, wrap a 6-inch elastic bandage,

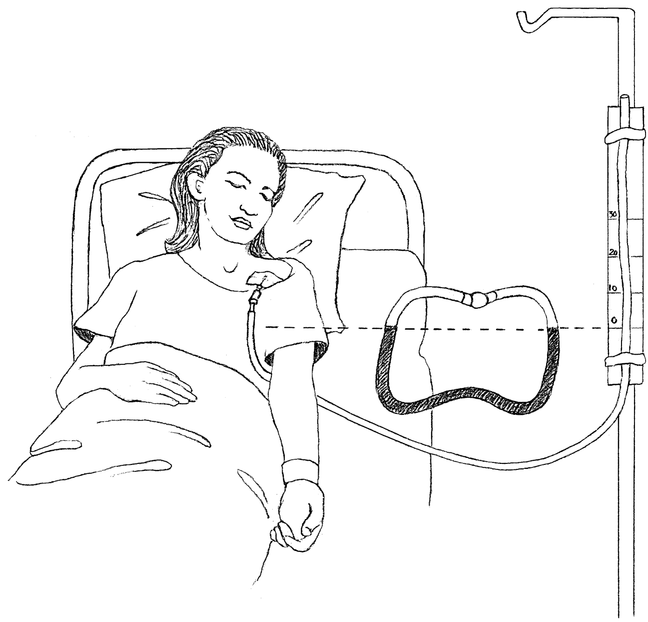

FIG. 10-3. Makeshift CVP monitor with leveling loop.

again in a distal to proximal manner so that it also creates a compression gradient. With severe edema, place cotton between the toes.

Repeat the padding layer with three to five more padding rolls followed by another 6-inch elastic bandage. Apply each layer with increasing tightness to maintain the compression gradient effect. The result is that each layer is applied with greater pressure distally and less pressure proximally. A layer of plaster can be added if additional support is needed. If plaster is added as a splint, it is generally not used posteriorly.

Change the dressing every 5 to 7 days. When used for a fracture, this dressing virtually eliminates the need to remove a cast that becomes "too tight." However, burning or numbness with application may indicate tissue ischemia. If that occurs, remove the dressing and reapply it.

DISINFECTING CPR MANIKINS

Manikins are used throughout the world to teach CPR. To prevent a possible transmission of herpes simplex virus and other pathogens among those who share manikins for mouth-to-mouth resuscitation training, disinfect the manikin's contact surfaces at the end of each class. To do this, wet all surfaces with a 500-ppm sodium hypochlorite (bleach) solution, leave it on for 10 minutes, rinse with fresh water, and immediately dry. Between students or after the instructor demonstrates a procedure, wipe the face and interior of the manikin's mouth with 500-ppm hypochlorite solution or 70% alcohol.[9]

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11 | Dehydration/Rehydration

Sir William MacGregor, MD, at the end of his term as Papua New Guinea's colonial governor, wrote: "Dysentery causes more deaths than any other disease in tropical countries. No other malady is so universally distributed and of such constant occurrence … [Dysentery has become] the chief agent in the rapid depopulation of the Pacific."[1]

Rehydration does not have the drama of other medical interventions—but it saves more lives than all other disease treatments combined.

ASSESSMENT

Diarrhea

Diarrhea causes most cases of lethal dehydration, especially among infants and children. Acute diarrhea is ≥3 loose or watery stools/day or a definite decrease in stool consistency and an increase in stool frequency for the individual. The volume of fluid lost through stools can vary from 5 mL/kg body weight/day (approximately normal) to ≥200 mL/kg body weight/day.[2] Because of the use of oral rehydration therapy (ORT), the annual worldwide deaths from diarrhea have decreased from >5 million in 1978 to 2.6 million in 2009 (1.1 people >5 years old and 1.5 children <5 years old).[3]

Pediatric Dehydration

Assessing a child's level of dehydration is a clinical diagnosis. This assessment should be no harder in austere situations than in standard practice—except that the confounder of malnutrition may play a big role in a child's appearance. Laboratory studies, including serum electrolytes, are usually unnecessary.[4] Stool cultures are indicated in dysentery, but are not usually indicated in acute, watery diarrhea for an immunocompetent patient.

Table 11-1 is a pediatric dehydration assessment tool that is easy to use and has good interrater reliability.[5] It relies on: (a) a change in mental status, (b) dry mucous membranes, (c) poor skin turgor or tenting, and (d) tachycardia or hypotension.[6]

Dehydration Versus Septic Shock in Malnourished Children

In children with severe malnutrition, dehydration and septic shock are difficult to differentiate. Both present with signs of hypovolemia and worsen without treatment. Rather than using the normal signs to assess dehydration, use the signs and symptoms presented in Table 11-2. Otherwise, dehydration will be overdiagnosed and its severity overestimated, and it will be difficult to recognize and treat children with both dehydration and septic shock.[7]

TABLE 11-1 Clinical Pediatric Dehydration Scoring System

	Points for Physical Findings		
Finding	1	2	3
Alertness	Normal	Restless, irritable, abnormally quiet, drowsy, or floppy	Delirious, comatose, or shocky: "very ill"
Pulse	Strong, <120/min	120-140/min	>140/min
Respirations	<30/min	30-40/min	>40/min
Skin elasticity	Normal	Moderately reduced	Extremely reduced
Eyes: sunken eyeballs	Normal	Moderate	Extreme; hypotonic

<6 points = normal to mild dehydration
6-10 points = moderate dehydration
11-14 points = severe dehydration
15 points = critical/impending death

TABLE 11-2 Differentiation of Dehydration and Shock in the Malnourished Child

Clinical Sign	Some Dehydration	Severe Dehydration	Incipient Septic Shock	Developed Septic Shock
Watery diarrhea	+	+	+/–	+/–
Thirst	Drinks eagerly	Drinks poorly	No	No
Hypothermia	–	–	+/–	+/–
Sunken eyes	+	+	–	–
Weak or absent radial pulse	–	+	+	+
Cold hands and feet	–	+	+	+
Urine flow	+	–	+	+
Mental status	Restless/irritable	Lethargic/comatose	Apathetic	Lethargic
Hypoglycemia	+/–	+/–	+/–	+/–

Data from World Health Organization.[7]

REHYDRATION PLAN

Utilize available resources to provide the maximal benefit for dehydrated, usually pediatric, patients. That generally means reserving non-oral hydration for the sickest patients and for those who fail a good trial of oral therapy. Then, escalate treatment methods, depending on the patient's condition, the clinician's skills, and the available resources.

Treatment includes two phases: rehydration and maintenance. In the rehydration phase, the fluid deficit is replaced quickly (i.e., within 2 to 4 hours). In the maintenance phase, the normally required amounts of calories and fluids are administered, accompanied by rapid realimentation.[8]

Mild Dehydration

Patients with mild dehydration rarely present to health care facilities in austere circumstances unless the dehydration is accompanied by another significant disease process. For mild dehydration, oral rehydration solutions (ORS) (up to 50 mL/kg over 12 to 24 hours) are generally the first and only treatment needed.[9] One method is to give 20 mL/kg over the first hour and 10 mL/kg over the next 6 to 8 hours.[10] Give the remaining balance over the following 16 to 18 hours. Some children will not respond to the oral method. In these cases, use one of the alternative parenteral methods (discussed later in this chapter). However, keep trying to hydrate patients orally and switch them back to ORT alone as soon as possible.

Moderate Dehydration

Start patients with moderate dehydration on ORS (25 to 50 mL/kg over 6 to 12 hours) with or without simultaneous intravenous (IV) or other parenteral intervention.[9] A common method is to give 20 mL/kg and the balance over the next 5 to 11 hours.[10] If patients don't respond quickly, start fluids via a parenteral method. Keep trying to hydrate patients orally; switch them back to ORT alone as soon as possible.

If IV therapy is needed, give from 20 to 40 mL/kg normal (0.9%) saline (NS) or lactated Ringer's solution over 1 to 2 hours. Administer additional boluses of 10 to 20 mL/kg/hr NS or Ringer's to normalize heart rate and blood pressure, as needed.

Severe Dehydration

Table 11-3 describes the general plan for rehydrating severely dehydrated patients. Some patients may need more parenteral fluid than noted in the chart. Also, while intraperitoneal rehydration works well for mild to moderate dehydration, the fluid is not absorbed quickly enough to be the sole method of treating severe dehydration.

TABLE 11-3 Progressive Treatment for Severe Dehydration

Fluid Type	mL/kg	Time Until Fluid Administration Completed
INFANT		
1. Normal saline or Ringer's lactate IV/IO	30	<1 hour
2. Normal saline or Ringer's lactate IV	40	Next 2 hours
3. ORS (po)	40	Next 3 hours
OLDER CHILD/ADULT		
1. Normal saline or Ringer's lactate IV/IO	110	<4 hours; Initially as fast as possible until palpable radial pulse
2. ORS (po)	15-30	Next 3-4 hours, depending upon ongoing fluid loss

Data from Ree and Clezy.[11]

In cases of severe dehydration, especially if hypotension is present, parenteral rehydration is optimal. Even in these patients, if they are conscious and able to drink, supplement parenteral therapy with oral rehydration. Oral rehydration has been effective, even in many cases of severe dehydration, if parenteral methods are not available. Successful treatment depends upon replacing fluids and electrolytes at least as fast as they are being lost. In general, however, use parenteral rehydration for patients:

- Who present with severe dehydration
- With continued, frequent vomiting despite small, frequent feedings
- With worsening diarrhea and an inability to keep up with fluid losses
- In stupor, coma, or who are unable to swallow without aspirating
- With intestinal ileus (no bowel sounds heard)

See Table 11-7, later in this chapter, for the composition of standard IV fluids.

RAPID REALIMENTATION

Rapid realimentation follows rapid rehydration to return the patient to an age-appropriate, unrestricted diet, including solids. Gut rest is not indicated. Breast-feeding should be continued at all times, even during the initial rehydration phases. Increase the patient's diet as soon as tolerated, to compensate for lost caloric intake during the acute illness. Lactose restriction is usually not necessary (although it might be helpful in cases of diarrhea among malnourished children or among children with a severe enteropathy), and changes in formula usually are unnecessary. Full-strength formula usually is tolerated and allows for a more rapid return to full energy intake.[8]

Other Additives

Adding zinc to the diet of a patient with diarrhea has been shown to have significant benefits, including a reduction in the duration of the acute phase, reduced stool output and frequency, and decreased recurrence. Naturally available sources of zinc include beans, lentils, yeast, nuts, seeds, and whole grain cereals. Pumpkin seeds are one of the most concentrated sources of zinc.

Diarrhea reduces the absorption of, and thus increases the need for, vitamin A. Zinc deficiency exacerbates vitamin A deficiency, which can lead to blindness and death. Supplementing vitamin A decreases the severity of, and the number of, deaths from diarrhea (and measles). Dairy products, raw carrots, sweet potatoes, cantaloupe, and spinach are good dietary sources of vitamin A.

If an antiemetic is available and there are no contraindications to its use, it may improve the success of ORT in children with acute gastroenteritis and dehydration by reducing emesis.[12]

Breast-Feeding

Nipple Shield

If a mother is breast-feeding and has a nipple too sore for the child to use, use a breast pump or manually drain the breast into a bottle, or use a nipple shield until the nipple heals. The shield must fit tightly and form a seal around the breast. It can be fashioned from the rubber nipple from a baby's bottle. Use vegetable oil to help form the seal, although the mother may still have to hold it in place. The shield must be boiled between uses.[13]

Supplementing Breast-Feeding Neonates

Families with exclusively breast-fed newborns, especially during those first few days of life when mother's milk production has not yet been well established, often present with concerns about poor feeding, adequate urine output, and insufficient milk supply. The solution is to make a supplemental nursing device to allow the infant to continue to breast-feed. It provides the needed stimulation to increase milk production and ensures that the infant will get at least 1 to 2 ounces of volume per feeding, preventing some infants from needing an IV or switching to bottle feeding, which can foil attempts to breast-feed.

Method

Jeffrey S. Blake, MD, a physician at Mary Bridge Children's Hospital in Tacoma, Wash, suggests this method for supplemental nursing. Attach a 5-Fr feeding tube or an equivalent size urethral catheter to a 30- or 60-mL syringe filled with pumped breast milk or formula. Do one of the following: (a) tape the tip of the feeding tube along the breast with the tip positioned alongside the nipple so that the infant will latch onto both the nipple and the tube tip or (b) have the parent insert the tip of the tube ~1 to 2 cm into the corner of the infant's mouth after the child has already latched onto the breast. Because the tube is so small, neither method interferes with the infant's latch to the breast. Then, hold the syringe elevated above the infant's head or hang it around the mother's neck with string, like a necklace. Allow gravity to help slowly trickle the formula/breast milk in as the infant sucks at the breast. With the infant's sucking, along with help from gravity, pushing the syringe plunger is usually not necessary. Adjust the syringe height so that only the sucking is needed to regulate the flow. (Personal written communication received June 5, 2007.)

Disinfecting Baby Bottles/Nipples

Since small children often use baby bottles to take ORS, it is important to clean the bottles, especially in an austere environment where no ready replacements may be available. Both methods described in the following paragraphs disinfect, rather than sterilize, the nipples and bottles; that is sufficient.

Boiling

After washing the bottles and nipples with a brush, put several bottles and nipples in a pan filled with clean water. Cover and bring it to a boil. At sea level, leave the bottles in the water for an additional 30 minutes. (For more information, see "Boiling" in Chapter 6, Cleaning and Reusing Equipment.) Then drain the water and leave the bottles and nipples in the pan until needed.

Sodium Hypochlorite/Bleach

After washing the bottles and nipples with a brush, put several bottles and nipples in a plastic bowl covered with clean water. Be sure that the air is out of the bottles. For every liter (quart) of water, add two teaspoons (10 mL) of household bleach (sodium hypochlorite). Leave the bottles and nipples in the solution for at least 1 hour or until the next feeding. Remove the bottle and nipple using clean hands, and empty the sodium hypochlorite out of the bottle. The bottle need not be rinsed. Make new solution each day.[14]

ORAL REHYDRATION

More lives are saved throughout the world by rehydrating children with acute diarrhea than by any other medical intervention except for immunization. Worldwide, there are approximately

4 billion cases of diarrhea annually that kill about 2.2 million people, nearly all of whom are <5 years old and living in developing countries.[15] Up to 70% of these deaths are due to dehydration.

More than 90% of patients with acute infectious diarrhea can be successfully resuscitated using ORS correctly.[16] Yet <25% of those who could benefit from appropriate ORT receive it.[17] Oral rehydration therapy generally results in rehydration and the resumption of solid food intake in 4 to 8 hours.[18]

Administering Oral Rehydration Solutions

For infants, use a clean eyedropper or a syringe without the needle. Drop small amounts into the mouth every 1 to 2 minutes. Also, continue breast-feeding. An alternative is to make a tiny puncture at the tip of a rubber glove finger, fill the finger or glove with ORS (while holding the hole closed), and use that as a nipple. The plastic sheath in which some 3-mL disposable syringes are still packed also works well as a mini-bottle for small-volume liquids or medications.[19] Slip a standard baby bottle nipple over the open end; it holds 9 cc.

For children or adults, give the ORS using a clean spoon or cup. Do not use feeding bottles unless they can be properly cleaned. Offer children <2 years old a teaspoonful every 1 to 2 minutes. Alternate other fluids, such as breast milk and juices, with the ORS. Older children and adults should sip from the cup every 1 to 2 minutes. Adults and large children should drink at least 3 L (3 quarts) per day until the diarrhea stops. Chilling the ORS before giving it to the patient may make it more palatable.

Continue to try to feed the drink to the patient slowly, small sips at a time. The body will retain some of the fluids and salts needed, even though there is vomiting. If the patient vomits, wait for 10 minutes and then begin again. Have the patient slowly sip ORS after every loose bowel movement.

In severely dehydrated, but conscious, patients, have them sip ORS every 5 minutes until urination returns to normal (4 to 5 times/day and yellow color) and they no longer feel thirsty.

Oral Rehydration Solutions/Oral Rehydration Therapy

Standard and Reduced-Osmolarity Oral Rehydration Solutions

Oral rehydration solutions come as premade commercial packets, hospital-made solutions, or homemade solutions. In 2002, the WHO began recommending a new, low-osmolarity ORS containing less sodium and glucose (Table 11-4). This change has led to some cases of severe hyponatremia, while not significantly changing patients' disease course.[20] The solution does, however, replace bicarbonate with citrate, improving its stability in tropical climates. When stored in temperatures up to 60°C (140°F), no discoloration occurs and the solution has a shelf life of about 3 years.

TABLE 11-4 Composition of the WHO Oral Rehydration Solutions

	Standard ORS (1975)	Reduced-Osmolarity ORS (2002)
Na^+, mEq/L	90	75
K^+, mEq/L	20	20
Cl^-, mEq/L	80	65
$Citrate^{-3}$, mmol/L	10	10
Glucose, mmol/L*	111	75
Osmolarity, mOsm/L	311	245

*In some areas, locally produced ORS uses rice instead of glucose. When patients eat a rice-based diet soon after correction of dehydration, the glucose-based ORS leads to less need for additional ORS than with rice-based ORS, and also shortens the duration of diarrhea, and decreases stool volumes.
Data from Fayad et al.[21]

Preparing Oral Rehydration Solutions

Commercial Oral Rehydration Solution Packets

To reconstitute a commercial ORS packet, add 1 packet to 1 L (1 quart, 5 cupfuls) of clean water. (Filter the water using cloth or gauze and boil it, if necessary; let it cool.) Stir the mixture until all the contents dissolve. Even if the powder clumps or hardens, there should be no difficulty in producing a satisfactory solution.[22]

Homemade Oral Rehydration Solutions

Three methods for making homemade ORS are described in the following paragraphs. Once prepared, store the ORS in a cool place. If you have a refrigerator, store it there. If the patient still needs ORS after 24 hours, make a fresh solution. Do not use too much salt or the patient may refuse to drink it. A rough guide to the amount of salt is that the solution should taste no saltier than tears. Too little salt is less effective in restoring the needed chemicals to the body—and may lead to hyponatremic seizures. If only a 0.5-L (1-pint) container is available, use only half the listed amounts of ingredients to prepare ORS.

Method #1

To prepare 1 L (1 quart) of homemade ORS. Start with 1 L (1 quart; 5 cupfuls) clean water. (Filter the water using cloth or gauze and boil it, if necessary; let it cool.) Add 1 level teaspoon of salt and 8 level teaspoons of sugar. Mix the solution. Add 0.5 cup orange juice or half a mashed banana to provide potassium and improve the taste.[22]

Method #2

To prepare 1 L (1 quart) of homemade ORS. Start with 1 L (1 quart; 5 cupfuls) clean water. (Filter the water using cloth or gauze and boil it, if necessary; let it cool.) Add one-fourth teaspoon baking soda (bicarbonate of soda) and one-fourth teaspoon salt. Double the amount of salt (to one-half teaspoon) if baking soda is not available. Mix the solution. Add 2 tablespoons sugar or honey and mix until everything dissolves. Add 0.5 cup orange juice or half a mashed banana to provide potassium and improve the taste.[22]

Method #3

Plantain-based ORS. Plantain flour-based ORS uses green Hartón plantain (*Musa paradisiaca*) that is common in Columbia and elsewhere. (There are many plantain/banana varieties; several can be used for ORS.) Remove the plantain's peel and cut it into very thin slices. Dry these slices in the sun and grind them into powder. Add 50 g plantain flour to 1100 mL water and 3.5 g sodium chloride. Mix these and boil the mixture for 12 minutes. This results in an ORS with a mean osmolarity of 134 mOsm/L.

This ORS formulation was shown to decrease diarrhea frequency by one-third and the volume by one-half over that in children taking the WHO formula. However, some children taking this formula had nonclinically significant hyponatremia and hypokalemia.[23]

Alternatives to Oral Rehydration Solution

If ORS is not available or cannot be made, reasonable alternatives are breast milk, vegetable or chicken soup with salt, other salted drinks (e.g., salted rice water, salted yogurt drink), or other normally unsalted drinks to which 3 g/L salt has been added.

Two pinches of salt using three fingers (thumb, index, and long fingers coming together) are often said to equal about 3.5 g and this measure is used as an improvised salt measure for homemade ORT solutions.[10] However, this commonly used measure is highly inaccurate and can vary by a factor of 30 between individuals, meaning that it can deliver a negligible amount of salt or nearly 4 g with each pinch.[24] A more accurate measure is to use one-fourth teaspoon iodized salt, which equals 1.5 g and which, in 1 L of water, produces a concentration of 90 mmol/L; using slightly less will yield the currently recommended ORS concentration of 75 mmol/L.

As can be seen in Table 11-5, some alternative rehydration solutions commonly used at home (e.g., apple juice, Coca Cola Classic) are not suitable due to their osmolarity, electrolyte composition, or both.

TABLE 11-5 Composition of Commonly Used Rehydration Solutions

Solution	Carbohydrate* (g/L)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride† (mmol/L)	Base‡ (mmol/L)	Osmolarity (mOsm/L)
WHO ORS (2002)	13.5	75	20	65	30	245
WHO ORS (1975)	20	90	20	80	30	311
Commercial Sugar-Electrolyte Solutions						
Pedialyte	25	45	20	35	30	250
Pedialyte Freezer Pop	25	45	20	35	30	250
Enfalyte	30	50	25	45	34	200
Rehydralyte	25	75	20	65	30	305
Cerealyte	40	50-90	20		30	220
Gatorade (premixed)	46	20	3	3	20	330
The following solutions are generally NOT appropriate for rehydration due to their osmolarity, electrolyte content, or both.						
Commercial Clear Liquids						
Jell-O	20	22-27	1.3-2.0	26	–	570-640
Coca Cola (Classic)	112	1.6	–	–	13.4	650
Ginger ale	53	2.7	0.1-1.5	0.2	4	520-540
7-Up	74	5.0-5.5	1-2	6.5	–	520-560
Kool-Aid (sugarless)	–	0.5-1.2	0.1-1.3		–	250-590
Popsicles	180	4.7-5.6	0.5-2.0	6	–	670-720
Fruit Juices						
Apple (liquid)	120	0.4	44	45	–	730
Grape (concentrate)	151	0.8-2.8	31-44	4	32	1170-1190
Orange (concentrate)	86	0.1-2.5	46-65	20	50	540-710
Other Liquids						
Beef bouillon (cubes)	–	110-170	5.5-11	130	300-390	
Chicken broth (canned)	–	170-250	2.2-8.2	210	–	380-500
Tea (unsweetened)	–	0	5	5	–	~0
Milk	4.9	22	36	58	30	260

*Glucose, fructose, or corn syrup.
†Chloride, in most cases the Cl^- content is calculated from other ingredients.
‡Actual or potential bicarbonate, such as citrate, lactate, or acetate.
Data from Centers for Disease Control and Prevention[8] and Synder.[25]

Self-Administered Oral Rehydration

ORS can be self-administered with a straw. For adults and cooperative older children, a simple and inexpensive method exists for them to administer their own ORS—if they can resist the temptation to drink too much or too often. Self-administration markedly reduces staff time associated with managing nasogastric (NG) feedings or parenteral infusions, especially for children without an adult family member who can administer ORS. Simply fill a disinfected or sterile IV container, other bottle, or a commercial ORS bottle with the desired liquid and hang it (inverted) from an IV pole or hook.

Hang a loop of the tubing higher than the fluid level in the bottle and give the other end to the patient. Depending upon the size of the bottle and the tubing, adjust the bottle level until there is no spontaneous flow. (No flow controller is needed.) When the patient sucks on the tube, a mouthful of fluid comes out; when suction stops, the fluid flow stops. Do not use this for patients who cannot suck the fluid or who have difficulty swallowing.[26]

Use a piece of orthopedic stockinet, stretch bandage, or even the sleeve from a shirt to hang bottles or bags without hooks or handles. Insert the bottle into the material, and tie the end at the bottom of the container (the end away from the IV tubing) to a pole or hook. Cut a slit in the other end so it can be tied—and retied—tightly around the end with the IV tubing. Many Pedialyte bottles now come so a straw can be inserted. An IV tubing connection fits this hole perfectly.

Wounded Patients

Under normal circumstances, adult surgical patients are kept NPO (nothing by mouth), and are not allowed to ingest oral food or liquid for hours prior to surgery. But, in rudimentary environments, some latitude is needed so as not to exacerbate the situation.

Boulton and Cole, writing about care in austere circumstances, noted that "the emptying time for fluids is often overestimated—two hours for water or clear fluids is normally adequate. Nonmedical auxiliaries and first aid workers should be encouraged to give moderate amounts of water to injured patients who are conscious and not vomiting; this is especially necessary in isolated circumstances where evacuation is likely to be prolonged and medical aid delayed."[27]

NASOGASTRIC REHYDRATION

Uses

Nasogastric (NG) rehydration with commercially prepared or homemade ORS can be used for patients who are moderately to severely dehydrated and who are vomiting or refuse to drink.[28] It can be used in cases of both primary dehydration (e.g., gastroenteritis) and secondary dehydration (e.g., malnutrition, measles, pneumonia).

Many malnourished or dehydrated children will not take sufficient oral intake, due to poor appetite, weakness, and painful stomatitis. Feed these children with an NG tube after they have taken as much as they can by mouth. Stop the NG feeds when the child is taking three-fourths of the daily requirements orally or takes two consecutive full feedings orally. If sufficient fluids and calories are not taken orally in the following 24 hours, reinsert the tube.[29]

For postoperative patients needing an NG tube, if a limited ability to provide IV hydration exists (limited fluids or equipment), insert a short (gastric) and longer (distal duodenal or jejunal) tube. These can be fashioned from IV tubing, if necessary. To reduce the need for hydration while preventing aspiration in these patients, suction through an NG tube while reinfusing the aspirate and additional fluids into the distal tube.[30]

Patients with extensive burns can also be fluid-resuscitated using NG (or even oral) salt solutions. This method can be used when IV therapy is unavailable or delayed, such as in mass disasters and combat casualties. Enteral resuscitation of burn shock is effective for patients with from 10% to 40% body surface area (BSA) burned and for some patients with more severe injuries. Even when not used exclusively, hypovolemic burn and trauma patients can benefit from enteral resuscitation as an initial alternative and as a supplement to IV therapy. Use this method if there is no bowel injury or plans for immediate anesthesia. Vomiting is a complication of enteral resuscitation, occurring less often in children than adults, and much less often when therapy is initiated within the first postburn hour.[31]

Method

If other methods are not suitable, use a slow NG drip to rehydrate a child or adult. A modification of oral rehydration, this economical method can be easily accomplished with few adverse consequences, even with few resources and basic staff. Available NG equipment is employed, including used but cleaned/sterilized IV tubing (the NG tube) and fluid bags/bottles.

The bags are filled with standard ORS and continuously dripped in, with the total amount based on the patient's weight, level of dehydration, and symptoms. The following drip rates are a good approximation[32]:

<6 kg = 25 drops/min (~1.25 mL/min; 75 mL/hr)
6 to 12 kg = 35 drops/min (~1.75 mL/min; ~100 mL/hr)
>12 kg = 50 drops/min (~2.5 mL/min; 150 mL/hr)

For adult patients, add any estimated fluid losses or deficits to their hourly maintenance. This may be most easily calculated as: Weight in kg + 40. For example, for a 70-kg man, 70 kg + 40 = 110 mL/hr maintenance fluids.

Commercial and homemade ORS (see recipes in the previous paragraphs) are much cheaper to use than IV fluids. The ORS can be put into an old IV bottle (clean, not necessarily sterile) and connected to IV tubing, which is used both as the NG tubing and to drip in the solution. If the tube is curled or kinked, it can be straightened by holding a small flame (such as a match) under it for a moment. The IV drip chamber and rate control device on the IV tubing are used to adjust the drip rate. Once it is certain that the NG tube is in the stomach, it must be securely attached to the patient's face to prevent irritation from movement and accidental removal. A piece of tape across the bottom of the nose that covers the tubing and extends to the hairline near one ear is usually effective.[32] Dripping fluid through an NG tube to feed premature infants (gavage feeding) can also be used in this manner.

Encourage mothers to continue breast-feeding or else provide ORS by mouth during NG rehydration. Discontinue NG feeding when the child is able to drink and no longer appears seriously dehydrated. Nasogastric tubes can be left in the stomach for up to 3 days without adverse effects.

INTRAVENOUS HYDRATION

Why Use Intravenous Hydration?

Intravenous hydration is a rapid method that ensures that the fluid is entering the vascular space. In addition, it is appropriate for administering at least one form of nearly all parenteral medications and fluids. In severely dehydrated patients, rapid volume replacement (also called rapid rehydration therapy) saves lives.[33-36] Patients who present with severe dehydration (indicated by a weight loss of ≥10%), with impaired circulation (as measured by rapid pulse and a reduced capillary fill time), and evidence of interstitial fluid loss (including loss of skin turgor and sunken eyes) should be rehydrated intravenously over 1 to 2 hours with isotonic saline. To rapidly restore extracellular fluid (ECF), administer IV lactated Ringer's solution and/or normal saline at 40 mL/kg over 1 to 2 hours. If skin turgor, alertness, or the pulse does not return to normal by the end of the infusion, infuse another 20 to 40 mL/kg over 1 to 2 hours. Repeat that infusion as needed. Initiate ORT as soon as tolerated.[9]

In situations of scarcity, multiple problems exist with using IV hydration, including lack of equipment, skilled personnel, and ability to monitor patients adequately. The most obvious problem is scarcity of equipment and personnel trained to place IV catheters and administer IV solutions. The lack of adequate patient monitoring can lead to critically over-hydrating patients, especially infants and the elderly.

Reusing Intravenous Tubing

Reusing either IV tubing or needles poses a serious risk of passing on blood-borne diseases, a result that may not be immediately obvious. Reusing IV tubing may be the safer of the two, since, if tubing has not been contaminated with patient secretions or blood, it may be relatively safe to use if disinfected. To disinfect IV tubing, first try to boil it for 5 minutes. If that destroys the tubing, disinfect subsequent tubing by soaking it in sodium hypochlorite (bleach) or another antiseptic for several hours. Be sure to also soak the inside of the tubing, which can be done by

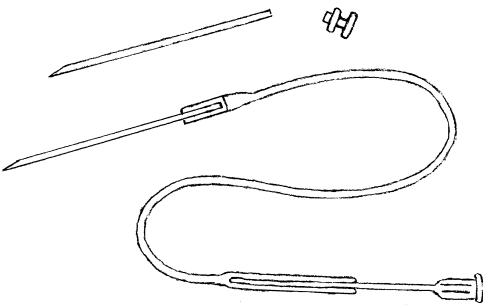

FIG. 11-1. Making a scalp vein IV.

sucking the solution into the tube with a syringe. Before using it on another patient, wash thoroughly with boiled water, inside and out, to remove the disinfectant.

Reusing needles is more problematic. Classed as high-risk devices, needles must be sterilized, not just disinfected, before reuse.[37] That can be a challenge, since the interior is difficult to clean of residual materials, a prerequisite to adequate sterilization. See Chapter 6, Cleaning and Reusing Equipment, for further details on cleaning, disinfecting, and sterilizing equipment.

Making Intravenous Equipment

Necessity is the mother of invention, and making IV equipment is a good example. Physician–prisoners working in POW camps along the Thai/Burma Railway during World War II, for example, made IV sets "from stethoscope tubing and sharpened bamboo sticks."[38] Injection needles can be used as IV needles after slightly bending the needle so that the hub will not exert as much tension on the skin.[39]

To make a scalp vein IV unit, break off the adapter of a short needle of the appropriate gauge (Fig. 11-1). Insert the needle's broken end into the end of a short piece of thin plastic tubing. (This type of tubing is often used in laboratory equipment.) If the tube fits loosely over the needle, soften the plastic by heating it over a small flame (e.g., match). When soft, squeeze it tightly around the needle. Put an ordinary injection needle into the other end of the tubing; that end may also need to be crimped. Nearly all IV tubing adapters fit the ends of these needles. When constructing this equipment, use forceps to hold the pieces. Disinfect this unit before use. Generally, it is best to have the scalp vein filled with fluid when entering a vein so that the blood doesn't clot.[40]

Sterile Water for Injection

Sterile water for injection is useful to have. Fill a bottle with distilled water, close and sterilize it, and use it to mix with powdered drugs for injection. Any autoclavable drug can be mixed and sterilized for injection.[41]

Finding a Vein

Seeing or feeling the vein obviously helps when inserting the IV catheter. If applying a standard venous tourniquet doesn't produce a vein, drop the extremity below the level of the heart and apply a blood pressure cuff. Inflate it first to about 35 mm Hg. If that doesn't produce a vein, inflate the cuff to halfway between the systolic and diastolic pressures. If the cuff's tubes leak, clamp them to keep the cuff at that pressure.

Applying heat to the limb also helps. Use a hot, wet towel, but squeeze out the water before applying it to the limb, so you do not burn the patient. The distal extremity can also be immersed in warm water for 10 minutes, as they once did for donors for person-to-person transfusions.

Intravenous Drip Rates

If you must calculate IV drip rates and a nurse is not available, macro-infusion (adult) drip sets are generally set for 10 drops/mL; micro-infusion (pediatric) rates are 60 drops/mL (Table 11-6).

TABLE 11-6 Macro- and Micro-Infusion Drip Rates

Macro-infusion Set—10 gtt/mL	
Solution per Hour (mL)	Drop Rate Interval (Seconds)
50	7.2
100	3.6
150	2.4
200	1.8
250	1.4
300	1.2
360	1
Micro-infusion Set—60 gtt/mL	
Solution per Hour (mL)	Drop Rate Interval (Seconds)
10	6
20	3
30	2
40	1.5
50	1.2
60	1

Adapted from Canadian Air Division.[42]

Increasing Infusion Rate

Intravenous infusion rates depend on the internal diameter (ID) of the equipment. The size of the smallest element of the system (IV catheter, connector, IV tubing) is the rate-limiting size factor.[43,44] The other factors are the viscosity of the fluid (blood generally flows slower than crystalloid) and the external pressure on the system. The pressure is often the easiest component to adjust when a high-flow infusion is needed, such as during resuscitation.

Pressurize intravenous (IV) solution bags by wrapping them with elastic bandages, standing on them, or inflating blood pressure (BP) cuffs around them. During patient transport, laying the (adult) patient on the IV bag generally supplies sufficient pressure to keep the fluid flowing.

One method of increasing the speed of infusion using IV bottles (rather than bags) is to use a 3-way stopcock attached to the IV near the catheter. A syringe is alternately filled from the drip set while closing the line to the patient and then closing the line to the bottle and injecting the fluid into the patient. Increasing the air pressure by injecting air into the bottle and closing the air inlet also works. Finally, either with bottles or bags, the drip chamber in the IV line can be pumped; the ball valve closes the inlet when external pressure is applied.

Warming Intravenous Fluids

Three methods of warming IV bags have been advocated in cold, austere circumstances: using body heat, soaking in hot water, and applying external heat packs. Carrying IV bags next to one's body to warm the solution in a cold environment, even when the person carrying them is doing vigorous exercise, warms the bags only about 10°C, if the bags are initially cold (~5°C). If the bags are pre-warmed, they still lose their warmth steadily.[45,46]

When IV bags were warmed to 58°C, their temperatures dropped to 35°C in 2 hours, even though they were kept in a pouch against a thin undergarment while rescuers were hiking. If this method is used, you will need to apply external chemical heat packs to the bags to augment the saline's temperature before administering it.

Researchers in two studies warmed 500-mL bags of NS in a pot over a wood stove to an external bag temperature of 75°C. Bags in one study reached an initial 58°C fluid temperature, while the other researcher obtained temperatures of 39°C to 40°C. This suggests that great care must be taken when employing this method so as not to overheat the fluids.[45,46]

A technique that does produce body-temperature fluid is to tape two meals-ready-to-eat (MRE) heating bags to the outside of a 5°C 500-mL saline bag for 10 minutes. Then remove the MRE bags and wait 10 more minutes for some cooling to occur before infusion. It helps to cover the bag and the proximal IV line with insulation such as a coat or sleeping bag.[46]

Saline Lock

If an IV has been started and is secure, consider using a saline lock to give intermittent fluid boluses or to decrease the amount of unnecessary equipment during patient transport. (See Chapter 5, Basic Equipment, for two easy ways to improvise a saline/heparin lock.) This avoids the need for nursing personnel to constantly monitor infusions in small children and allows the child, if not too ill, to return home between bolus infusions. Do not use this for an intraperitoneal line, since the risk of infection is great and, if one results, it can be devastating.

ALTERNATIVES TO IV HYDRATION

Hypodermoclysis (Subcutaneous Hydration)

Hypodermoclysis is a well-tested, safe, inexpensive, and easy method for hydrating adult and pediatric patients which was used from the late 19th century until IV hydration became common in the mid-20th century.[47,48] Hypodermoclysis is used acutely if starting an IV is difficult and for chronic hydration in patients who cannot take sufficient oral fluids due to nausea and vomiting, intestinal obstruction, neurological disease, or a diminished level of consciousness. In at least one case, it was used in a wilderness setting to resuscitate an adult in shock from gastrointestinal bleeding.[49]

The advantages of this method are that it has a relatively low cost, is easy to administer without skilled personnel, and is generally more comfortable for the patient than having an IV. In addition, it does not cause thrombophlebitis, generally does not cause local or system infection, and can be stopped and restarted at any time without fear of the needle clotting or the system failing.[50]

Limitations

This method can be slower (~1 mL/min) than IV hydration, and can be used to administer only those medications that can be given subcutaneously. However, these include potassium chloride (up to 40 mmol or mEq/L), opiates (hydromorphone requires only a very small volume, although morphine also works), antiemetics (such as metoclopramide, lorazepam, diphenhydramine, dexamethasone, or promethazine), and sedative/anxiolytics (such as lorazepam and midazolam). Other medications that have been reported to be successfully given via hypodermoclysis—but using an infusion pump—include atropine, haloperidol, hydroxyzine, methadone, methotrimeprazine, metoclopramide, octreotide, phenobarbital, and scopolamine.[51,52] In some countries, it is not unusual to give other medication classes through this route: antipsychotics (levopromazine; UK), antibiotics (ceftriaxone, amikacin; France), and other analgesics (tramadol, demerol/pethidene, buprenorphine; Switzerland, Germany, UK, France).[53]

Method

Clean the skin with antiseptic and insert a 23- to 25-gauge butterfly needle or other small-gauge needle for injection into a subcutaneous site at a 45- to 60-degree angle, with the bevel up. These needles fit onto the end of standard IV tubing. If the needle is too deep (e.g., in the muscle), the infusion causes pain. If blood appears, a vessel has been entered; apply pressure and select another infusion site.[51]

Generally, infusion sites are the medial or lateral abdominal wall, along the iliac crest, in the anterior chest wall below or lateral to the breast, around the scapula, or in the anteromedial or anterolateral thigh. The abdominal wall and iliac crest areas are said to cause the least discomfort.[54] In extremely agitated patients, the inter- or sub-scapular area can be used to prevent them from pulling at the needle.[51] Typical sites for needle placement in infants and children are shown in Fig. 11-2.

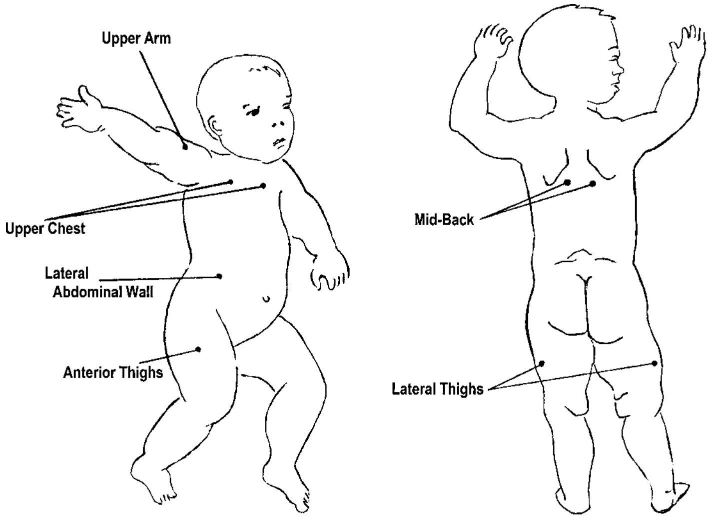

FIG. 11-2. Sites for hypodermoclysis needle placement in infants and children.

Attach intravenous tubing to the needle and secure it with an occlusive clear plastic dressing, if available. Normal (0.9%) saline (NS) is most commonly used, although 0.45% saline and 5% dextrose in 0.45% saline (D5 half normal) have also been used, often at two infusion sites. The infusion rate is typically 1 mL/min/site (1.5 L/day/site), 1 to 2 L overnight, or 500 mL over 1 to 2 hours three times a day (tid). Hypotonic (e.g., glucose in water) and hypertonic (e.g., glucose in NS) solutions should not be given subcutaneously, since the body must convert the administered fluid pool into its normal fluid and electrolyte composition before it can be absorbed.[55,56] Hypotonic solutions, including 5% dextrose in water (D_5W), have caused hyponatremia; blood and colloids are ineffective via this route.[57]

In infants and children, infuse no more than 200 mL/injection site. In premature infants during the neonatal period, fluid should not exceed 25 mL/kg body weight at no more than 2 mL/min.[58]

Ideally, you should change the needles and tubing every 1 to 4 days. Change the site after each liter of fluid, and sooner if there are signs of local reaction.[54] Families and nonclinical caregivers can be instructed how to provide this therapy at home.

Although it is uncertain whether it is effective, if available, hyaluronidase is often used to reduce local edema and pain and to increase the fluid absorption rate. In adults, add 150 to 300 units to each liter of infusate or inject 75 to 150 units combined with 1 mL of anesthetic at the infusion site.[54,59] For infants and children, add up to 30 units of hyaluronidase to each 200 mL of infusate.[58]

Complications

Check the infusion site for evidence of edema or infection. Edema can often be relieved by massaging the area. Infection at the infusion site is rare, although at remote locations without professional medical supervision, a significant number of abscesses, presumably resulting from poor cleansing of the injection sites, have been noted.[50] Observe all patients for signs of fluid overload.

Rectal Rehydration/Proctoclysis

Rectal hydration (proctoclysis) can be used to instill fluids into children or adults who do not have profuse diarrhea. Use rectal hydration in patients who cannot tolerate hypodermoclysis because of generalized edema, pain on injection, or bleeding disorders.[60]

This method of fluid administration was popular into the 1930s, but its use declined with the development of IV technology.[54] Recently, rectal hydration has been used in the terminally ill, but it may also be of value in survival situations, for postoperative patients, and in those with mild dehydration where other routes of hydration are not available. It is safe, inexpensive, and so easy to use that it is generally administered by relatives to homebound patients.[54,60]

Method

Place the patient on his side with the buttocks raised on two pillows or folded blankets. Gently insert a well-lubricated 22-Fr NG tube or a large Foley catheter 10 to 40 cm into the rectum. Do not force the tube, since the primary danger is perforating the bowel. After taping the tube to the buttocks, attach a longer length of tubing (e.g., IV tubing) and an IV bag, enema bag, or a funnel. Elevate the bag, clamp the tube, and add the fluid to the bag. Use this to infuse warm NS, standard oral rehydration fluid, or tap water (take care to limit the amount, especially in children). Sodium and potassium may be added to the fluid.[61] Note that infusing cool fluid often causes the patient to immediately expel it.

Start the infusion at 100 mL/hr and increase it to a maximum of 400 mL/hr, or until fluid leak from the rectum appears. Another method is to start by infusing 200 mL of fluid over 15 to 20 minutes. (If more than 400 to 500 mL is administered faster than over 20 minutes, reflex abdominal cramping will expel it.) Then clamp the catheter and leave it in place. Instill another 200 mL every 4 hours, delivering up to 1200 mL/24 hr in an adult. After the infusion of a desired total daily volume of fluid, the catheter is removed; it can be reinserted daily for weeks or more at a time.[54,60,62]

In children, insert the smallest available catheter to minimize local irritation. Place it 8 to 12 cm beyond the anal sphincter. Begin instilling fluid at 1 drop/second.[63]

Complications include discomfort, leakage, tenesmus, and stool production (enema effect). If there is stool production after an infusion, decrease the infusion rate.

Emergency Use

One successful method for using proctoclysis for resuscitation employed a surgical glove with one fingertip cut off, which was secured to the end of a 14-Fr urethral catheter with waterproof tape. The glove supposedly acted as a "reservoir," although it also probably caused some added discomfort. Unlike other methods, these clinicians inflated the catheter bulb and then pulled down to seat it against the rectum. They administered 1 L of double-strength ORT and then 2 L of standard ORT over a 3-hour period. Oral rehydration followed.[49]

Fluid Maintenance

Rectal drips can be valuable in cases when maintenance or perioperative fluids are needed. Postoperatively, this can often be done for 2 or 3 days. One suggestion is to instill up to 2.5-L tap water into the (adult) anesthetized patient over 2 to 3 minutes at the end of the operation. Two hours later, begin a slow rectal drip of tap water or other appropriate solution at the rate of 2.5 L/24 hours.[64]

Using tap water conserves sterile fluids if they are scarce. Better than plain tap water is to add 0.5 teaspoon of sodium chloride/L and 0.25 teaspoon of potassium citrate/L for maintenance fluids. Replace gastric losses with an equal quantity of saline (1 level teaspoonful of salt/L tap water) that contains 20 mmol of potassium per liter.[65]

Intraosseous Infusion

Intraosseous (IO) infusion is one of the quickest ways, both in children and in adults, to establish access for the rapid infusion of fluids, drugs, and blood products in emergency situations.[66-68] However, in some cultures, almost any other method, including intraperitoneal infusion, is preferable to IO infusion.[6]

Use

Placing an IO needle and beginning the infusion generally takes less than 1 minute; this is much faster than placing an IV in critical situations, especially in infants/small children or in any patient in shock or in cardiac arrest.[67,69] Standard practice is to use an IO needle in resuscitation situations when venous access cannot be obtained after either three attempts or within 90 seconds of starting the procedure, or when the clinicians do not believe they can quickly get venous access.

Since the marrow cavity is contiguous with the venous circulation, the IO route can be used to infuse fluids and medications, and to take blood samples for crossmatch. Any fluid, blood product, or medication (except for cytotoxic agents, such as chemotherapeutic drugs) can be given through the IO route. The onset of action and drug levels during cardiopulmonary resuscitation (CPR) using the IO route are similar to those given intravenously.[68]

Contraindications

Intraosseous infusion is contraindicated when (a) there is a femoral fracture on the ipsilateral side and the lower extremity will be the site of needle placement, (b) the tibia (or other bone where the needle will be placed) is fractured, or (c) osteomyelitis exists in the bone to be used.[68]

Intraosseous infusion is also contraindicated in patients with osteogenesis imperfecta or osteopetrosis, with an infection or burn overlying the infusion site, with a bleeding diathesis, and who have already had multiple IO needles or attempts at the same site.

Needles

Ideally, IO infusions are done through a special IO needle or a bone marrow aspiration needle with an obturator. Alternatively, use any needle with a stylet. A large-gauge spinal needle and stylet can be cut down to a 3-cm length, beveled, sharpened, resterilized, and packaged in advance for IO use.[70,71]

In emergencies or situations of scarcity, use a standard 14- to 20-gauge butterfly/injection/IV needle; all connect to syringes and standard IV tubing. Using smaller-gauge or longer needles, however, risks their being too fragile or flexible to penetrate the bony cortex. Occasionally, when using such a needle without an obturator, the lumen becomes plugged with bone. If aspiration or running fluid under pressure does not clear the obstruction, another needle can immediately be placed in the same hole—although this may be more difficult than it sounds.

Sites

Common sites for IO placement are the proximal anteromedial tibia (1 to 3 cm below the tibial tuberosity on the anteromedial surface) or distal anterior femur in children, the anterior-superior iliac spine or above the medial malleolus (adult or child), and the sternum (in adults with special equipment).

The thickness of the bone precludes the use of the tibia or distal femur in children, and almost always in adults. However, the area just above the medial malleolus has proven to be easy to use in both pediatric and adult patients (Fig. 11-3). Enter the bone at a 90-degree angle (perpendicular) to the skin.[67] Using the sternum has the potential for lethal injuries, so avoid this site unless a sternum-specific needle, or an IO drill, is used.

Method

Use aseptic technique and a sterile needle. Placing a bone marrow needle without using a sterile technique increases the chance of osteomyelitis and cellulitis. Clean the skin. In awake patients,

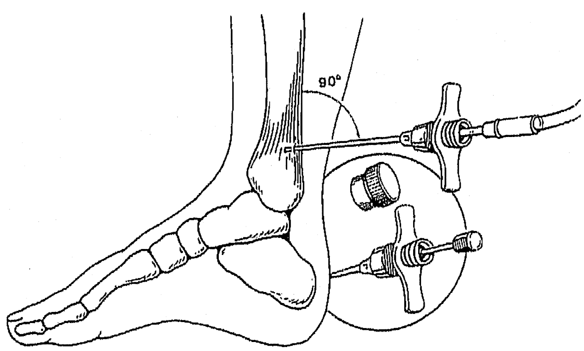

FIG. 11-3. Intraosseous needle insertion at ankle: pediatrics or adult. *(Reproduced with permission from Iserson.[67])*

inject a small amount of local anesthetic in the skin and continue to infiltrate down to the periosteum. Hold the insertion site firmly to stabilize it. Do not put your hand behind the insertion site; it could get stabbed with the needle.

Insert the needle with a pressing and twisting (or "drilling") motion until you feel a "give" as the needle passes through the cortex.

Remove the obturator (if there is one) and attach a 5-mL syringe to aspirate a blood sample—both to confirm placement and to draw a sample for analysis. (A larger syringe may not be able to generate sufficient negative pressure.)

Another method to confirm needle placement is that the needle remains upright without support, although this may not be as obvious in infants because they have softer bones than older children or adults. Also, with correct placement, fluid flows freely through the needle without swelling of the subcutaneous tissue.[68]

Even if blood cannot be aspirated (which occurs about one-third of the time), attach IV tubing or a syringe and infuse solution, generally 0.9% saline or the equivalent, under pressure. If it flows easily, the needle is in the correct location. Pressure can be applied to the system by putting a 3-way stopcock on the IO needle and using a syringe to push the fluid. This is especially useful if the IV solution is in a bottle, which cannot be pressurized.

If no blood can be aspirated, the needle may be blocked with marrow. To unblock the needle, slowly inject 10 mL of NS. Check that the limb does not swell and that there is no increased resistance. If the tests are unsuccessful, remove the needle and try another site. (If using extremities, use a more proximal site.)

Secure the needle if necessary with adhesive tape or, if the needle is longer than the short IO needle, clamp the needle where it enters the skin and tape it to the patient. Daniel Tsze, MD, of Brown University, has used tongue depressors to stabilize it. Break one tongue depressor in half (width-wise), and then make a "sandwich" of the two halves with the IO needle in between. The tongue depressor edges are against the skin (Fig. 11-4). Apply tape circumferentially. (Personal written communication, received June 5, 2007.)

Complications

Complications are rare, the most common being local skin or bone infections, fluid extravasation, tibial fracture (especially in neonates), and compartment syndrome. The most common complication is putting an IO needle distal to a fracture or a prior IO infusion site: the infused fluid leaks out.[68]

Intraperitoneal Infusion

Use

Intraperitoneal instillation of saline is a simple, safe, and effective technique to rehydrate adult and pediatric patients with ongoing fluid losses when the patient cannot tolerate oral or NG fluid administration or when local personnel, for whatever reason, cannot easily establish an IV.[6,72,73] It is most commonly used in children up to 3 years old (and older, if they are small for their age).

The procedure can be repeated and also may be used for continuous rehydration in postoperative patients.[74] Benefits of using this technique when resources are limited are that (a) it can be

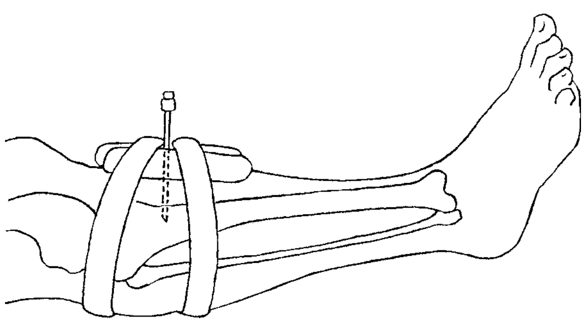

FIG. 11-4. Securing the intraosseous needle using tongue depressors and tape.

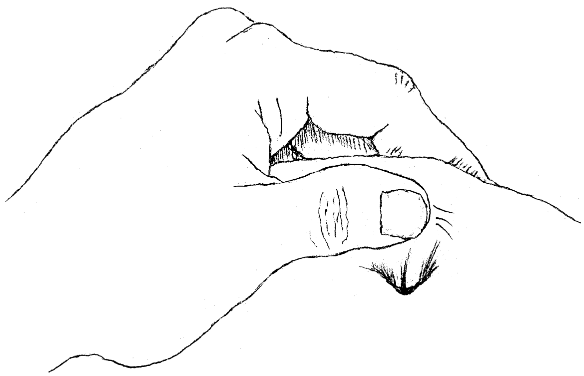

FIG. 11-5. Pinch abdominal wall and lift.

done in 5 to 10 minutes once a day using only one health care worker, and (b) it lessens the discomfort and the danger of over-hydration from IV infusion.

Intraperitoneal rehydration is useful for the mild to moderately dehydrated child. The procedure itself is fast (<10 minutes) and usually permits the child to return home for the next 24 hours. The patient normally returns the next day to assess whether the procedure must be repeated. However, the method does not allow fluid to be absorbed fast enough (it takes about 4 hours to be absorbed) to be the only method used for resuscitating those who are severely dehydrated. The other drawbacks are that it uses expensive IV fluids and it must be done aseptically, using sterile equipment.[75]

Method

The child can be restrained or mildly sedated, if necessary.[73] Lay the patient supine and palpate (or ultrasound) the abdomen to be certain that the liver, spleen, and bladder are not distended; if these organs are enlarged, they can be perforated by this procedure.

Use a 16-gauge needle to transfuse blood or an 18-gauge needle to administer fluids. Optimally, use a catheter-over-needle (typical IV catheter), although a hypodermic needle will also work. Try to use a catheter that is at least 18-gauge; smaller ones have a tendency to kink, so may need to be held in place or readjusted several times during the infusion. Leaving the needle in the catheter (pulled back so that the needle tip is within the plastic) may not be an option, since the IV tubing may not connect to it.

After thoroughly cleansing the overlying skin, pinch a fold of skin in the midline; use local anesthetic if needed. Insert the needle either 2 cm below or 2 cm above the umbilicus in the midline. Alternatively, since the abdominal wall is generally lax in dehydrated (and especially emaciated) children, insert a thumb into the umbilicus pointing cephalad, pinching and lifting the abdominal wall between the thumb and index finger (Fig. 11-5). Apply traction and push the needle obliquely and cephalad through the abdominal wall (Fig. 11-6). Some clinicians hold the needle vertically; others insert it at an angle. In part, this depends upon the thickness of the abdominal wall. Note that introducing the needle midway between the umbilicus and the symphysis pubis, which was once advocated, has resulted in severe hemorrhage from puncture of the iliac arteries.[76]

If an ultrasound machine is available, use it to guide needle entry. For additional safety, as soon as the needle enters the subcutaneous tissue, the fluid line is opened so that entering into the peritoneal cavity is marked by free flow of fluid—effectively pushing away any bowel. Run fluid "wide open," using gravity. Once the needle is in the abdominal cavity, the fluid will flow very fast; the fluid pushes any bowel loops out of the way of the needle. If the catheter kinks because of its small caliber (larger sizes may not be available), lift the umbilicus so that the catheter is clear of any bowel obstructing its flow. Use the initial "pinch" to both grab and lift the umbilicus. The technique is so safe that technicians and nurses have repeatedly performed this procedure independently.[73]

Fix the needle with adhesive tape. Cover it with gauze, if available.

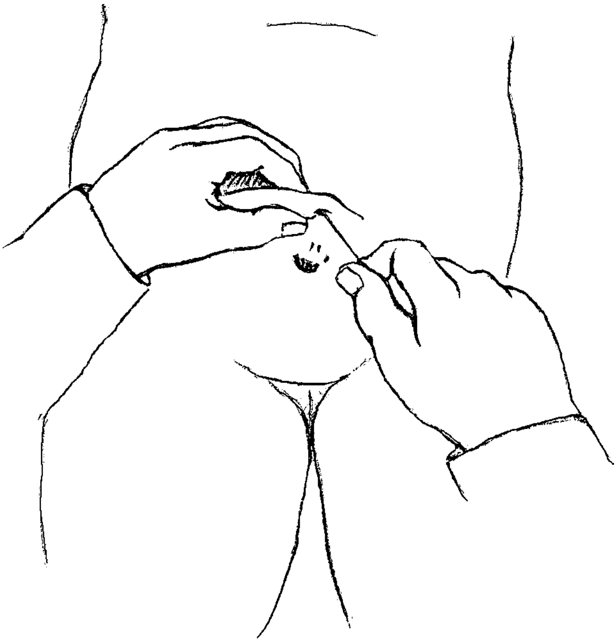

FIG. 11-6. Push needle through abdominal wall.

Infuse crystalloids after the bottle or bag has been carefully warmed in an oven or hot water bath. Blood can be warmed using the rapid admixture method described in Chapter 17, Transfusion. Since many infants and children with emaciation and dehydration are also relatively hypothermic, the warm fluid also helps that condition.[6]

For blood, give 20 to 25 mL/kg as fast as possible, usually over 5 to 15 minutes. For fluids, give 40 to 70 mL/kg as fast as possible.[77] If the child is still in the medical facility and remains dehydrated, administer another intraperitoneal bolus 4 hours later.[75]

Infants weighing 12 pounds (5.45 kg) usually tolerate about 235 mL (0.5 pint; 43 mL/kg) of fluid. Children weighing 20 pounds (9.1 kg) usually tolerate about 473 mL (1 pint; 52 mL/kg). Any discomfort they experience stems from abdominal distention. Adding hyaluronidase does not seem to be of any benefit. The rate of fluid absorption varies, although fluid overload does not seem to occur.[6]

After infusing the fluid, remove the needle. Keep a child in a half-sitting position, preferably on mother's lap, for about 2 hours after infusion. Note that even if the needle pierces the intestine (which is rare), it will not cause any harm but may cause some rectal blood to appear.[77]

Fluids

In children <15 years old, infuse hypotonic crystalloids; in adults, administer isotonic solutions (e.g., 0.9% saline).[6] Other solutions that have been used include half-strength Darrow's solution with glucose (sodium, 61 mmol; potassium, 17 mmol; chloride, 52 mmol; lactate, 27 mmol; glucose, 50 g; and calories, 200/L), lactated Ringer's solution (Na^+, 130 mEq/L; K^+, 4 mEq/L; Ca^{++}, 3 mEq/L; Cl^-, 109 mEq/L; lactate, 28 mEq/L), normal (0.9%) saline (Na^+, 154 mEq/L; Cl^-, 154 mEq/L), and 0.45% saline (28 mEq KCl/L).[55,78] Table 11-7 shows the composition of standard IV fluids.

Note that hypotonic solutions, such as half-strength Darrow's, while suitable for children who are primarily dehydrated, should not be used for other forms of shock.[78] Blood transfusion through this route is beneficial for the treatment of chronic anemia, rather than for resuscitation due to acute blood loss (i.e., shock).[79,80]

TABLE 11-7 Composition of Standard IV Fluids

	Electrolyte Concentration (mEq/L)						
	Na^+	K^+	Ca^{++}	$HCO3^-$	Cl^-	Glucose (g/L)	Osmolarity
Normal (0.9%) saline	154				154		308
Dextrose 5%; 0.45% normal saline	77				77	50	406
Dextrose 5%						50	252
Ringer's lactate (Hartmann's solution)	131	5	4	28	112		275
Half-strength Darrow's solution	60	18		26	52		273

Data from Ree and Clezy.[11]

Contraindications

Do not perform this technique on children with ascites, distended and tympanitic abdomens, cellulitis over the abdomen, or who may have adhesions from infection (e.g., tuberculosis) or prior surgery.[11,76] If there is concern about adhesions from prior abdominal surgery or injury, insert the needle under ultrasound guidance or using a semi-open technique as is done for peritoneal lavage. Also consider other hydration methods, including IO infusion.

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12 | Medications/Pharmacy/Envenomations

SEVEN PROBLEMS INVOLVING MEDICATION

Six primary problems regarding medications arise in austere medical situations. In some cases, more than one of these exist simultaneously. You can have (a) no medications; (b) medication, but have no clue what it is for or how to use it; (c) some medication, but not the primary choice for the condition you need to treat; (d) medication, but in the wrong form; (e) only outdated medication; or (f) medication that might have been contaminated or that has degraded. Each of these is discussed separately.

Have No Medication

If you have no medication, you will have to use local herbal remedies, physical treatments (osteopathic manipulation, thermal treatment, surgery), street drugs, or donated medications.

Donated Medications

After disasters and in Third World countries, the management of drug donations becomes extremely important. The key issue is to specify what you want and need, how much, and when it should arrive. Managing large quantities of unwanted and unneeded pharmaceuticals consumes valuable personnel time and space. After Hurricane Katrina, for example, the area was awash not only in water, but also in cartons of ridiculously inappropriate donated medications. Safely disposing of this mountain of useless pharmaceuticals became an unwanted headache.

Similar problems occur across the globe. A Harvard School of Public Health study found that about 30% of donated medications had an expiration date <1 year from the time they were shipped; 6% had <100 days left before they (officially) expired. Up to 42% of the drugs were not on either the country's list or the World Health Organization's (WHO) list of essential drugs, nor were they therapeutic alternatives for the essential drugs.[1]

To help lessen problems with international drug donations, WHO has developed the following *Guidelines for Drug Donations*[2]:

1. All drug donations should be based on an expressed need and be relevant to the disease pattern in the recipient country. Drugs should not be sent without prior consent by the recipient.
2. All donated drugs or their generic equivalents should be approved for use in the recipient country and appear on the national list of essential drugs, or, if a national list is not available, on the *WHO Model List of Essential Drugs* (www.who.int/medicines/publications/essentialmedicines/en/), unless specifically requested otherwise by the recipient.
3. The presentation, strength, and formulation of donated drugs, as much as possible, should be similar to those of drugs commonly used in the recipient country.
4. All donated drugs should be obtained from a reliable source and comply with quality standards in both donor and recipient country. The WHO *Certification Scheme on the Quality of Pharmaceutical Products Moving in International Commerce* (www.who.int/medicines/areas/quality_safety/regulation_legislation/certification/en/index.html) should be used.
5. No drugs should be donated that have been issued to patients and then returned to a pharmacy or elsewhere or that were given to health professionals as free samples.
6. After arrival in the recipient country, all donated drugs should have a remaining shelf life of at least 1 year. An exception may be made for direct donations to specific health facilities, provided that: The responsible professional at the receiving end acknowledges that (s)he is aware of the shelf life and that the quantity and remaining shelf life allow for proper administration prior to expiration. In all cases, it is important that the date of arrival and the expiry dates of the drugs be communicated to the recipient well in advance.
7. All drugs should be labeled in a language that is easily understood by health professionals in the recipient country; the label on each individual container should at least contain the International Nonproprietary Name (INN) or generic name, batch number, dosage form, strength, name of manufacturer, quantity in the container, storage conditions, and expiry date.
8. As much as possible, donated drugs should be presented in larger quantity units and hospital packs.

9. All drug donations should be packed in accordance with international shipping regulations and be accompanied by a detailed packing list, which specifies the contents of each numbered carton by INN, dosage form, quantity, batch number, expiration date, volume, weight, and any special storage conditions. The weight per carton should not exceed 50 kg. Avoid mixing drugs with other supplies in the same carton.
10. Recipients should be informed of all drug donations that are being considered, being prepared, or are actually under way.
11. In the recipient country, the declared value of a drug donation should be based upon the wholesale price of its generic equivalent in the recipient country or, if such information is not available, on the wholesale world-market price for its generic equivalent.
12. Costs of international and local transport, warehousing, port clearance, and appropriate storage and handling should be paid by the donor agency, unless specifically agreed otherwise with the recipient in advance.

What Is This Medication?

Describing this situation at a World War II prisoner of war (POW) camp where Allied prisoners were in desperate condition, Dr. Ian Duncan wrote: “It was ironic that immediately after cessation of hostilities, a large carton of penicillin was dropped almost on top of the hospital in Camp 17, Omuta, Japan. Unfortunately, we had never heard of it and, as no instructions were enclosed, it was never used though we had many men suffering from pneumonia, osteomyelitis, infected wounds and boils.”[3]

This is but one story demonstrating that many common medications have different names in different countries. For example, do you know how to use pethidine? US physicians wouldn’t have a clue, unless you told them that it was meperidine. Or, how would you use the common medication, paracetamol? Many clinicians would not know unless they were told that it was another name for acetaminophen. Common drugs with alternative names exist throughout the world. If you face this problem, local practitioners, pharmacists, or Internet sources may provide a solution.

Some medications may no longer be used for their original indication in the most-developed countries, but are still in common use around the world. Four, as examples, are aspirin, scopolamine, chloramphenicol, and chlorpromazine.

Now relegated to the role of antiplatelet drug in developed countries, aspirin can still be used as a potent analgesic and anti-inflammatory agent when other nonsteroidal anti-inflammatory drugs (NSAIDs) are unavailable. The standard dose is 325-650 mg (po or pr) q4-6h prn; or 650-1300 mg (enteric coated) po q8h (adult); 40-60 mg/kg/d divided q6h po or pr (pediatric). For juvenile rheumatoid arthritis, the dose can be up to 60-110 mg/kg/day divided q6-8h.

Scopolamine (Buscopan), common in “seasickness patches,” is a potent anticholinergic, often used for stomach cramps, renal calculi, and bladder spasms. As hyoscine butylbromide, the dose is 10 to 20 mg intramuscularly (IM). Chlorpromazine (Thorazine, Largactil), a potent antipsychotic, antiemetic, and anti-hiccup medication, may be the only available antipsychotic available. The adult dose is 50 to 100 mg parenterally. While it is generally administered intramuscularly (IM), it is given slowly intravenously (IV) throughout world. Chloramphenicol (parenteral only), an excellent antibiotic, is recommended by WHO for severe infections and commonly used in the world’s least-developed regions.

Other medications are not used in some countries (such as the United States) or may be older versions of those commonly used. These include diclofenac (parenteral NSAID used throughout the world), flucloxacillin (antibiotic), quinine and a wide variety of artemesinin-based medications to treat malaria, and equine snake antivenin.

Have Medication, but Not the Primary Choice for Condition

Alternative Drugs

Multi-use Medications

If you don’t have what you need, use what you have. A number of standard medications can be used for a variety of purposes. Use your normal pharmacology references, poison/drug information center, and pharmacist to determine all the possible uses for available medications.

Some commonly available medications with a wide variety of uses (not all listed) include:

Diphenhydramine: sedative, antiemetic, antihistamine, local anesthetic
Chlorpromazine: antipsychotic, hiccup therapy, local anesthetic
Epinephrine/adrenaline: asthma treatment, cardiac stimulant, vasoconstrictor, allergy/anaphylaxis treatment
Dexamethasone: reduce tumor edema, bronchiolitis/croup treatment, allergy/anaphylaxis treatment, antiemetic, inflammatory/vasculitis treatment, COPD (chronic obstructive pulmonary disease) treatment
Lidocaine: antiarrhythmic, local/regional anesthetic
Dextrose solution: medication admixture, hypoglycemia treatment, osmotic diuretic, sedative ($D_{25}W$) on a child's pacifier (i.e., binky)
Oxygen: hypoxia treatment, carbon monoxide poisoning treatment, cluster headache treatment, antiemetic[4]

USING STREET DRUGS AS MEDICATIONS

With the caveat that the purity and even the identity of medications purchased from nontraditional sources may be in doubt, they may be beneficial when nothing else is available. Some uses for a group of commonly available street drugs are:

Marijuana: antiemetic, sedative
Heroin, fentanyl (and other narcotics): analgesic, local anesthetic, cough suppressant
Ketamine: analgesic, anesthetic
Cocaine: local anesthetic, vasoconstrictor
Benzodiazepines (various): antiepileptic, sedatives, antianxiety, muscle relaxant
Barbiturates (various): sedative/hypnotic, antiepileptic
Ethanol: sedative, disinfectant, antidote methanol poisoning, anesthetic
LSD or psilocybin: cluster headaches[5]

Medication Substitutions

While many medications have therapeutic substitutes, medications in the following drug classes may be more amenable to substitution than others[6]:

Calcium-channel blockers	ACE (angiotensin-converting enzyme) inhibitors	Tricyclic antidepressants
Nonsteroidal anti-inflammatory drugs (NSAIDS)	Diuretics	H_2 antagonists
Sympathomimetic bronchodilators	Benzodiazepines	Topical agents
Cough and cold medications	Phenothiazines	Antibiotics (most)

When substituting another medication, put a note on the medication label or give it to the patient saying: "As a result of the recent emergency, your medication is very similar, but not the identical medication to the one you normally take. When possible, please go to your usual pharmacy to continue with your previously prescribed medication."

Have Medication, But in Wrong Form

Often, medications will be available but in the wrong form or dose for the patient and circumstances. Encourage the pharmacy staff to improvise (and search their literature) for ways to solve these problems. Powders may be used to produce injectables under emergency circumstances. Parenteral drugs can usually be administered rectally at the IV/IM dose.

Nitroglycerine Drip

A university pharmacy sent a message to all their emergency physicians, cardiologists, and intensivists saying that they would be unable to procure IV nitroglycerine for several months (unknown reason). Some physicians asked why the pharmacy couldn't simply make the nitroglycerine drip in-house, as they had done a decade before when it was first being used. The pharmacy staff responded that "one old pharmacist" also thought of that. (The information below was obtained from the inpatient pharmacy, University Medical Center, Tucson, Arizona by Megan Brandon, PharmD, March 22, 2008.)

Prepare a nitroglycerine drip from tablets as follows:

1. Dissolve 125 tablets of 0.4 mg nitroglycerin SL (sublingual) in 50 to 60 mL of 5% dextrose. The pharmacy typically does this in a 60-mL syringe. The solution will be cloudy due to excipients (undissolved materials in the tablets).
2. Using a 0.22-micron filter needle, add the solution to a glass container of D_5W and dilute to a final total volume of 250 mL.
3. This solution will be at its final concentration of 50 mg/250 mL.

NITROGLYCERINE—ALTERNATIVE TITRATION

When a patient presented to the emergency department (Casualty; ED) in resource-poor rural Ghana with severe congestive heart failure and chest pain, it appeared as if he would soon die: Almost no options were available to us and we lacked sufficient nitroglycerin tablets—and a filter and a glass D_5W container—to make a drip. Instead, we had his wife administer a tablet of 0.4 mg nitroglycerin SL about every 5 minutes for the next 6 hours. By morning, he was over the acute episode and moved to the ward.

Penicillin Solution to Instill in Newborn's Eyes

A penicillin solution is used particularly to treat gonococcal conjunctivitis in newborns. To make a penicillin solution of 10,000 units/mL, use one of these two methods: (a) Boil a clean cup and let it cool. Then add 100 mL sterile water and 1 level teaspoon of salt or add 100 mL sterile saline. Dissolve 600 mg benzylpenicillin in the saline. (b) Dissolve 600 mg benzylpenicillin in 10 mL water for injection. Then mix 1 mL of this solution with another 10 mL of water for injection.[7]

Converting Tablets/Capsules Into Palatable Form

Some patients (especially children, the elderly, and the less-than-conscious patient) cannot swallow tablets. Some medications don't come as a liquid; in austere situations, you may not have the liquid form, even if a medication is manufactured as a liquid.

There are several ways to convert tablets to a more palatable form. For non-extended-release drugs, break or crush tablets into sections—or open up the capsule and pour out the contents. Crush tablets using a hammer, after first putting the tablet in a plastic bag or wrapping it in a paper towel so the pieces do not escape. You can also use a mortar and pestle, a similar implement used to grind grains, or a coffee grinder.

If necessary, administer the medications through a nasogastric tube. Patients can dissolve the powder in liquid to drink, or sprinkle the powder onto food and eat it. Another alternative is simply to mix larger pieces into mashed potatoes, applesauce, or foods of similar consistency.

Storing Parenteral Medication for Reuse

In resource-poor situations, the temptation is to "cap" open vials containing partially used medication. In some parts of the world, medical staff routinely seal partially used medication vials with sterile gauze and tape. Even when the resource is scarce, this is a bad idea, since it promotes bacterial growth and can seriously harm subsequent patients. Rather, store the extra medication in a labeled syringe with a capped needle. Ideally, this can be placed in a cool area for short-term storage.[8,9]

Medication Is Outdated

Don't believe the expiration date you see on the pharmaceutical packaging. It has little relationship to the quality, potency, or safety of most medications. "Medical authorities uniformly say it is safe to take drugs past their expiration date—no matter how "expired" the drugs purportedly are. Except for possibly the rarest of exceptions, you won't get hurt and you certainly won't get killed."[10]

Two types of expiration dates may be on medications. The first is a manufacturer's or pharmacist's date, which generally has no major significance. The second type is placed on a partially used, often liquid, medication; pay close attention to this date.

"Manufacturers put expiration dates on for marketing, rather than scientific, reasons. It's not profitable for them to have products on a shelf for 10 years. They want turnover," said one Food and Drug Administration (FDA) pharmacist.[10] "Two to three years is a very comfortable point of commercial convenience," stated Mark van Arandonk, senior director for pharmaceutical development at Pharmacia & Upjohn Inc. "It gives us enough time to put the inventory in warehouses, ship it and ensure it will stay on shelves long enough to get used."[11] In addition, many US states require that pharmacists assign a "beyond-use" date to medications dispensed in a container; this is routinely set at 1 year shorter than the manufacturer's date.[12]

A long-term FDA program studying the shelf life of medications for the US military and the Strategic National Stockpile (of medications) has shown that nearly all medications last far beyond their official expiration dates. Some, despite being kept in markedly suboptimal conditions, retained their original quality for decades. Many of the so-called degraded medications undergo only a change in their appearance, rather than their potency. Even when a medication loses potency over time, it often can still be used. In austere situations, use the medication despite the stamped expiration date. Generally, if you need more medication due to lack of adequate effect, it will become evident. However, there are some exceptions.

The practice, for example, has been to avoid using expired tetracycline. Nitroglycerine tablets lose potency over time, as does insulin, some liquid antibiotics, water-purification tablets, and mefloquine hydrochloride (for malaria).[11]

In an obvious effort to avoid having pharmaceutical manufacturers "dump" nearly outdated and unsellable medications by donating them, WHO's guidelines (as previously discussed) disallow the donation of drugs within a year of expiration; many companies, of course, routinely ignore that rule. However, these medications are, for the most part, still effective. It's sort of a catch-22 situation.

In sum, as Army Col. George Crawford, a pharmacist who oversaw the government's program to test drug stability, said, "Nobody tells you in pharmacy school that shelf-life is about marketing, turnover, and profits."[11]

Pay close attention, however, to "beyond-use" dates that clinicians write on partially used medications. Some medications for injection and irrigation come in multiple-dose vials or large irrigation bottles containing enough medication to be administered several times. Both drug stability and sterility affect how long these medications can be used after being opened. The stability of many medications decreases once the package has been opened—or once medications have been reconstituted from a powdered form. Such medications must be used within a specific time; that time should be marked on the vial or bottle. After that, they must be discarded.

As for sterility, when a sterile medication is opened and exposed to air, the potential exists for bacteria to grow in the vial or bottle. Some medications have a preservative in them; others do not. For example, large irrigation bottles typically do not have a preservative. If the contents are used for sterile irrigation, the bottle should be discarded within 24 hours of being opened.[13]

Medication Is Possibly Contaminated or Spoiled

Contamination

In situations with significant airborne contamination, such as after an earthquake or sandstorm, prefilled medication syringes maintain sterility, but medication from glass ampules do not.[14]

Medications that have been exposed to floodwater, seawater, or unsafe municipal water may become contaminated. If they are not lifesaving medications, or if replacements are readily available, they should be discarded. If, however, they are lifesaving medications that cannot easily be replaced and, although the container is contaminated, the medication seems to be unaffected (such as tablets being dry, intact, and the normal color), then use them until they can be replaced. If the medication itself appears contaminated, discard it.[15]

Temperature Control

When possible, keep pharmaceutical products at the temperature specified by the manufacturer. For general purposes, the *US Pharmacopeia* definitions suffice[6]:

Controlled room temperature: 59°F to 86°F (15°C to 30°C)
Refrigeration: 39°F to 46°F (3.9°C to 8°C)
Freezing: −4°F to 14°F (−20°C to −10°C)

Medications That Do Not Need Cooling

Some medications, such as insulin, may not need refrigeration to maintain clinical efficacy. Regular insulin has been tested after being stored at 25°C (77°F) for 12 months; it lost only about 2% bioactivity.[16] Intermediate-acting insulin was tested after being stored at 25°C (77°F) and at 34°C (93°F) for 60 days; it lost no biological activity.[17] Lente insulin (insulin zinc suspension) has been found to take 5 weeks to lose 2% of its bioactivity, and 14 weeks to lose 5%. Even at 40°C (104°F), soluble porcine insulin takes 14 weeks and lente takes 4 weeks to lose 5% of bioactivity; most patients use a vial of insulin within this time.[16]

Medications That Require Refrigeration

Some medications, such as succinylcholine (suxamethonium chloride), require refrigeration, and deteriorate if left unrefrigerated. Disasters can occur if the deterioration goes unrecognized. "During a surgery on what turned out to be a huge hernia, the anesthetist tried to use the 'Sux' that was on the shelf as he hastily converted an operation under local anesthesia to one under general. The 'Sux' had deteriorated to the extent that he had to use 20 vials to get an effect."[18]

Refrigeration is usually available, even in remote areas. For example, in Africa's poorest regions, more than one-third of diabetics have access to refrigeration for their medications (which may not need cooling), although the refrigerator often may belong to friends, relatives, or even to the local butcher shop or beer parlor.[19]

Medications That Require Freezing

Many medications and vaccines require a "cold chain" to exist between the manufacturer and the end user. In the case of live virus vaccines, for example, this means that there must be a way of keeping them frozen throughout their journey to the patient. Two vaccines that are particularly vulnerable are the measles-mumps-rubella (MMR) vaccine and the varicella virus vaccine live. MMR may retain potency at room temperature. The varicella vaccine, however, must remain continually frozen (–15°C [5°F] or colder). The Centers for Disease Control (CDC) recommends that if any refrigerated or frozen vaccines are warmed, the manufacturer or CDC should be contacted for advice before the vaccines are used.[20] Other medications, especially other types of vaccines, must be kept at cool temperatures throughout their travels.

Keeping Liquid Medications/Vaccines Cold

In many areas of the world, electricity for refrigeration may be unreliable or nonexistent; this may even occur in the most-developed countries or regions after a disaster. Refrigerators can also be improvised. (See "Refrigeration" in Chapter 5, Basic Equipment.)

The use of traditional cooling methods may not be an effective method to refrigerate medications. For example, porous, unglazed clay pots have often been used as cooling mechanisms in parts of Africa. They are partially filled with soil and water, then buried in a shady place. Tests show that even under optimal circumstances, these lower the inside temperature only by 1°C or 2°C.[21]

Most vaccines require refrigeration or freezing, and so do not do well with power outages. While most refrigerated vaccines are relatively stable at room temperature for a limited period of time, it is best not to open the refrigeration units until power has been restored or the vaccines are to be transferred to a functioning cooling unit. The best method to preserve refrigeration- or freezer-dependent medications is to have alternative refrigeration/freezing sites available. When planning to store medications in disaster situations, alternative locations may include any site that has a dependable generator as well as the required cooling devices. To be useful, medical personnel must not only be aware of the availability of such facilities, but they must also have access to them during a disaster. "Access" means they should know the floor plan (to be able to find the cooling units), have portable lights (in case no light is available), have any keys or access codes to unlock doors and equipment, and be aware of any alarm systems that might be activated—and how to deactivate them.

For example, in St. Bernard Parish, Louisiana (adjacent to New Orleans' Ninth Ward), after Hurricane Katrina destroyed nearly everything in the vicinity (including the hospital), quick-thinking physicians took their supply of vaccines to the refrigerators in the telephone switching station, which they knew had a reliable generator. Not only did the vaccines survive, but they also were used to inoculate thousands of people.

Alternatively, refrigerated trucks or train cars can provide temporary storage, as can an available supply of dry ice.

KEEPING PHARMACEUTICALS WARM

A major problem in cold climates is preventing medications and IV solutions from getting too cold or even freezing. Prehospital personnel often use their own body heat for this. Refrigerators or freezers (when turned off), with their excellent insulation, can also function to prevent liquids from freezing.

THE PHARMACY

Pharmacy Layout

While the concept of setting up a field/improvised pharmacy may seem to be a “no-brainer,” it may be a challenge to meet the requirements for storage and safe dispensing. Limited workspace may be available, and pharmaceuticals may be mixed together, sometimes in a multitude of unlabeled boxes and bags. Among these may be many donated pharmaceuticals that are unrecognizable or useless.

Basic principles to follow when planning a field pharmacy include:

- The pharmacy should be situated so that access is limited and be arranged so that the personnel and pharmaceuticals within it are secure. If possible, have a locked box or area for controlled substances, such as narcotics.
- For confidentiality, place the dispensing area away from, or at the end of, the flow pattern for patients and personnel.
- Store medication so that pharmaceuticals can quickly be identified and dispensed. Additional materials for dispensing, recordkeeping, and reference should also be easily accessible.
- When possible, separate the larger storage area from the dispensing area.
- Store everything off the ground to prevent water damage. Placing boxes on pallets or empty litters usually suffices.
- Whenever possible, ensure a secure source of electricity for lighting, refrigeration, computers, and other equipment.

Medication Organization

In patient care areas, it may be difficult to keep medications organized. One method is to use a cardboard egg carton to sort medications (Fig. 12-1). Another alternative is to cut down the height of a typical cardboard box in which small bottles are shipped. Both make excellent medication organizers for wards and clinics.

FIG. 12-1. Egg carton medication organizer.

Calculating Drug Doses

Basic medication math that many people forget is how to calculate correct doses. While others may do that for you in routine circumstances, the following may help if you are dispensing or administering medications without much help.

1. To calculate the correct dose of drugs expressed as mg/kg or mcg/kg or as $mg.kg^{-1}$ or $mcg.kg^{-1}$, multiply the drug dose by the patient's weight.
   Example: the dose of atropine is 20 mcg/kg.
   For a 25-kg patient, give: 20 mcg/kg × 25 kg = 500 mcg = 0.5 mg
2. When using drugs prepared in solution, calculate the number of milligrams of the drug per 1 mL. Do this by multiplying the number in the percentage of the solution by 10.
   Examples:
   For a 2% lidocaine solution, use: 2 × 10 = 20 mg/mL
   0.5% bupivacaine = 0.5 × 10 = 5 mg/mL
   2.5% thiopental = 2.5 × 10 = 25 mg/mL
3. Some solutions, such as adrenaline (epinephrine), may be expressed as 1:1000, or 1:10,000 or 1:100,000. This means that in a 1:1000 adrenaline ampule there is one part adrenaline to 1000 parts solution. To work out how many milligrams of adrenaline are present, use the following equation:
   1:1000 solution adrenaline = 1 g adrenaline in 1000 mL solution = 1000 mg adrenaline in 1000 mL solution = 1 mg/mL.
   1:10,000 solution adrenaline = 1 g adrenaline in 10,000 mL solution = 1000 mg adrenaline in 10,000 mL solution = 1 mg/10mL, which can also be expressed as 100 mcg/mL.

Weighing Medications

To make a balance scale for medications, use tin cans or the bottoms from two plastic bottles attached to each end of a wood or metal rod by string or wires. Suspend the rod at its center from a fixed point. Have a nail or other indicator sticking up from the center of the rod. When the balance is empty, mark the indicator's "balance point" position. Ideally, it will point up along the suspension wire. Put an unknown quantity in one side of the scale. Then put objects of known weight (such as small coins) on the other, adding weight until the marker returns to the original "balance point" position. Coins and similar items can be "weighed" by putting them in water and measuring the amount of water they displace. Water has a known weight per volume of 1 kg/L. It may be easier to weigh an object using a known volume/weight of water as a counterweight.

Prescription Amounts for Topical Preparations

If prescribing topical preparations, use the following approximations to determine how much to prescribe:

1 g covers 100 cm^2 (10 cm × 10 cm).
22 g will cover an average-sized body.
1 fingertip unit (FTU) dispenses 0.5 g, which covers the area of 2 adult palms.
42 g covers one arm if applied bid for 1 week.
400 to 800 g covers the entire adult body if applied bid for 1 week.

Containers for Dispensing Medication

Medications dispensed to patients do not always have to be in the standard packaging. Rather, the container, the label with instructions, and the manner in which they are packaged may all vary with the situation.

The first concern is the container. Some acceptable containers for various forms of medications include:

Pills/capsules: Small plastic bag, envelope, old pill bottle (relabled)
Powders: Envelope, sealable plastic bag, bottle
Liquids: Clean empty bottle (glass or plastic) with tight cap

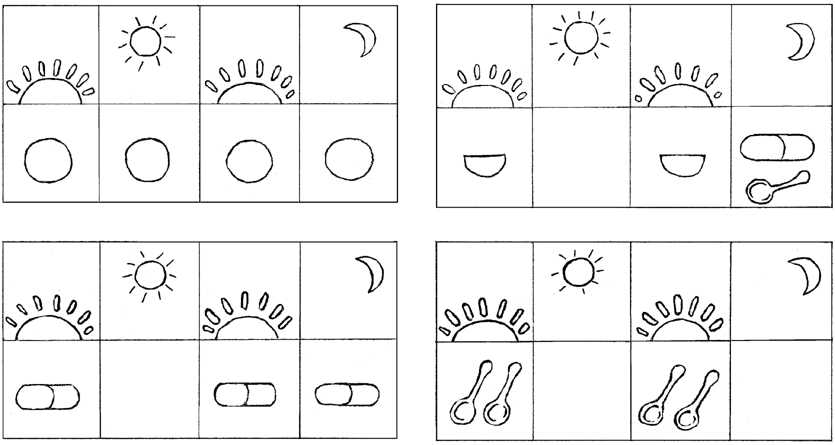

FIG. 12-2. Pictorial patient instructions for medication use. *(Redrawn from Werner.[22])*

Encourage patients to bring these types of containers with them. When refilling medications, ask patients to bring the container from the last time they got the pills.

Label medication containers in the patient's native language. They should have both the generic and the brand names; this allows other practitioners to identify the medication. The label should also contain the total medication dispensed, the patient's and prescriber's names, and the date. The dose and how to take it may need to be illustrated. The medication's expiration and storage information (e.g., refrigerate) may also be useful.

Language difficulties between the practitioner and patient often complicate prescribing medications—either due to differences in language or because the patient cannot read. Use illustrations to specify how much of each medication should be taken at specific times. Figure 12-2 shows a system where each label has symbols illustrating four times of day (sun rising = morning; sun high = noon; sun setting = evening; moon up = night). Beneath each symbol is another box that can be filled in with a picture of one or more tablets, portion of a tablet, capsule(s), or spoon(s) to show how much of the medication should be taken at that time.[22]

To specify which medication goes with which instructions, use different colors of paper or use a crayon or marker to put a stripe on the instructions that is the same color as the stripe on the corresponding medication. Alternatively, use treatment-related pictures on medication labels and instructions that are culturally relevant and that can be drawn or duplicated—for example, a picture of a heart (cardiac medicine), a drop of water (diuretic), a lightning bolt (analgesic), or a thermometer (antipyretic).

Prepackaged Medications

Prepackaged "pill packs" provide a rapid method of dispensing commonly used medications to many patients or to groups of patients that may encounter similar problems (e.g., soldiers in battle). They are especially helpful when clinics are inundated with patients during a disease outbreak (e.g., flu season), and when a large number of patients need appropriate antibiotic packs, potassium iodide, or self-injector antidotes as treatment for exposure to a specific toxin (e.g., anthrax, radiation or nerve agent). On the battlefield, the US military now supplies Special Operations troops with a package of antibiotics and analgesics for them to take if wounded.[23]

Estimating Counts: Tablets and Capsules

When preparing to dispense huge numbers of the same medications to a population, such as during an epidemic, approximating the number of tablets and capsules may be much more expeditious than counting them out. One method, successfully used by the pharmacy staff aboard the

USNS Comfort hospital ship, is to use scoops cut from paper cups or plastic medication bottles. Cut the first one so that it contains the proper number of tablets/capsules (or perhaps 10% more, to allow for error). Then cut more of the same size for each person to use when filling baggies, envelopes, etc. with the medications.

Making a Tablet/Capsule Counter

An improvised device to count tablets and capsules for dispensing to patients can be built easily and inexpensively (for a few dollars) from wood. It consists of a two-floor, varnished wooden box, with two exits and a sliding wall.[24] The box's interior dimensions are 20-cm-long by 10-cm-wide, the height to the groove for the slide is 4.5 cm, the height of the upper floor is 2.5 cm, and the dispensing holes have a diameter of 2 cm. The sliding separator is 2 cm vertical by 5 cm horizontal. Sand the slide so that it is smooth and moves easily; the wood varnish facilitates cleaning the box (Fig. 12-3).

Operate the counter by first sliding the separator to the middle of the box. This allows sufficient space to place medications from a larger container while blocking them from passing to the lower space where they go when counted (Fig. 12-3, A). Then slide the separator to the extreme left to allow the medication to fall into the lower space when counted (Fig. 12-3, B). When the correct number of tablets has been pushed to the lower space, move the slider to cover any medication remaining from the original stock. Put a dispensing container under the tube next to the patient's medication and pour the tablets into the container (Fig. 12-3, C). Then put the medication stock bottle under the tube at the upper ledge and tilt the box, returning the medication to stock (Fig. 12-3, D).

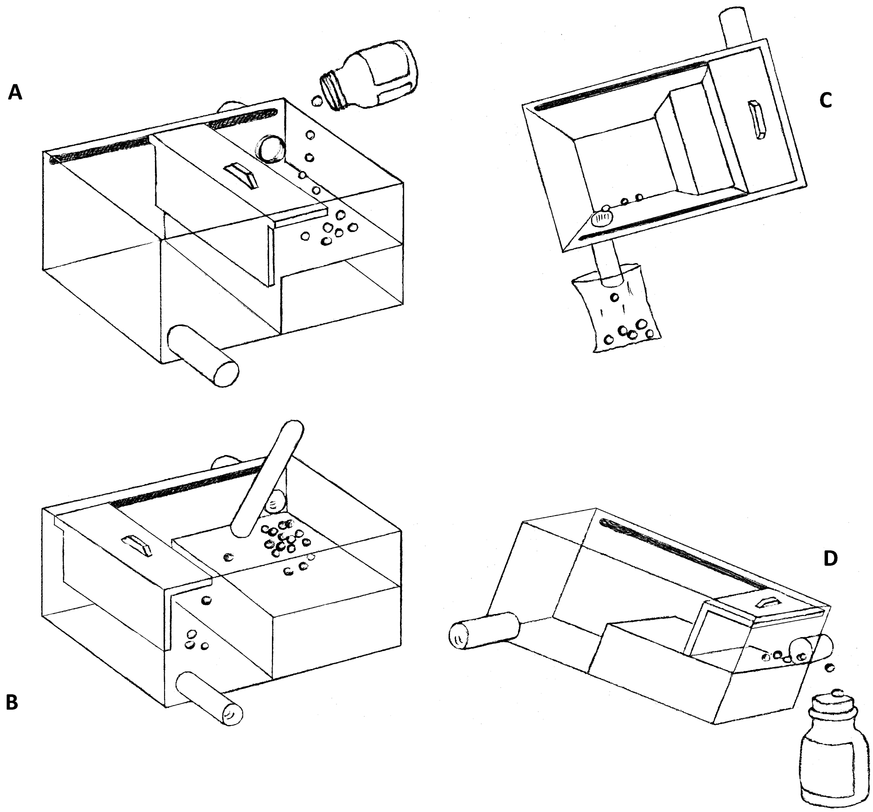

FIG. 12-3. Operation of improvised medication counter.

Tablet Cutters

To cut large-dose tablets (but not capsules or extended-release medications) into smaller-dose pieces, use any inexpensive tablet cutter. Otherwise, use a razor blade or scalpel (this method may be more accurate). If the tablet is carefully cut, the pieces should contain fairly accurate doses, especially when using a scored tablet. It helps to weigh the pieces to see if they are equivalent.[25]

Cutting tablets increases drug availability and reduces costs. For example, the ubiquitous sildenafil citrate (Viagra) generally costs about $10, regardless of the dose. Since many patients require only 6.25 to 12.5 mg to get an effect, 100-mg tablets are the most economical: dividing the 100-mg tablets increases the medication supply and decreases the cost.[26]

Intravenous Admixtures

Experience shows that in situations where inventory or electrical resources are limited, most IV solutions should be prepared immediately prior to use rather than in large batches on a daily basis.[6]

TREATMENT OF VENOMOUS BITES AND STINGS

Jellyfish

All members of this large group envenomate through thousands of tiny stinging nematocysts whenever an object (such as a person's skin) comes into contact with their tentacles. Most cause immediate, severe pain and some cause a rash. Treatment for the common box jellyfish sting is the immediate, liberal use of vinegar (4% to 6% acetic acid) over any area where stingers adhere to the skin. This inactivates the nematocysts' discharge. If vinegar is not available, a baking soda slurry may suffice. Then, remove any tentacles with a forceps or gloved hands, since even dry nematocysts can be reactivated if later exposed to water.[27] Then, if possible, treat the pain by taking a hot shower or immersing the part in water, as hot as tolerable or 45°C (113°F), for 20 minutes or as long as the pain persists. Hot packs or dry cold packs may work if hot water is not available.

Venomous Fish Stings

Pain from stings often can be relieved by putting the affected area in water that is as hot as can be tolerated (generally 40°C to 43°C [104°F to 110°F]), but care should be taken not to burn the patient. Also remove any foreign bodies.[27]

Stingray Wounds

Dozens of types of stingrays live in the world's coastal waters; they are venomous. Many have more than one stinger on their tail. Stingrays whip their tails backward in a reflexive defensive action that, depending upon the animal's size, may be powerful enough to penetrate leather boots, a diver's wetsuit, rubber, or even the side of a wooden boat. Most of those injured have either been wading in the surf or they are fishermen who have inadvertently landed a stingray. The wound may be a puncture or a laceration with or without an observable foreign body. Victims describe the pain as "being prodded by a soldering iron"; the pain is generally out of proportion to what appears to be a trivial wound. Treat by immersing the affected part in hot (up to 113°F [45°C]) water. Remove any obvious foreign bodies as soon as possible; be aware, as with all penetrating injuries, that some may require intraoperative removal if they are near vital structures. Debride and irrigate the wound, give potent analgesics and antibiotics, and advise the patient that healing may take many months.[28]

Arthropods

Arthropods include bees, wasps, centipedes, fire ants, and spiders. Aside from other treatments, most arthropod bites and stings usually respond to the application of cold.[29] Treat anaphylactic reactions with available or improvised resources.

Scorpion stings can be extremely painful, with the pain requiring opioids over an extended period (sometimes months). In little children, and sometimes in the elderly, scorpion stings can produce acute delirium. Treat this with sedation, if possible. If not, carefully observe patients and protect them from self-harm as they throw themselves around the bed. Delirium usually passes in 24 hours.

Reptiles

Viperidae: True Vipers and Pit Vipers (subfamily Crotalinae)

Except for inebriated men who try to play with (and, yes, even kiss) pit vipers (e.g., rattlesnakes, moccasins, puff adders), most of these injuries occur in austere wilderness circumstances. About half of these snakes' bites do not inject venom. Of the others, most patients will live, albeit with some deformity of the bitten extremity, even if they do not get antivenin. Victims of most concern are little children and the elderly.

The real key is to know what *not* to do. Do *not* put a tourniquet, ice, or anything else on the wound. Do *not* cut the wound to try to suck out the venom; this is not only ineffective, but also injects flora from your very dirty mouth into the wound.[30]

Ideally, the victim should keep their arm at heart level and remain calm until help arrives (yes, even after a snakebite). When no help is available, assist the patient to slowly walk to get help. If antivenin is available without a laboratory to do clotting tests, perform a whole-blood clotting assay. Use a glass-walled test tube and let a sample of the patient's blood sit at room temperature for 20 minutes. If no clot forms, it indicates that there is a coagulopathy and antivenin should be administered. This abnormality should begin to resolve 4 to 6 hours after antivenin administration.[31]

Elapidae

These include the mamba, cobra, coral, and sea snakes. This family produces neurotoxic venom. Unfortunately, other than supportive care, there is nothing much you can do without antivenin. These are nasty envenomations.

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13 Analgesics

Pain is one of the most common reasons for a patient to visit a clinician, and pain relief is one of the most consistently useful interventions clinicians make. With limited resources, the goal is to provide the best analgesia using the fewest and cheapest resources.

ASSESSING PAIN

To treat patients' pain, it is vital to assess it. There are several common methods to do this, including:

1. The 5-point pain scale using words, in which patients point to the word that best expresses their pain level (Fig. 13-1). However, to use this, the patient must understand each of the terms for gradations of pain. (The words in the figure are provided in several languages.)
2. Faces pain scales (Figs. 13-2 and 13-3), which can be used by nonverbal patients or when language difficulties exist.[1]
3. Pain Assessment for Children (Table 13-1) can be used for children <4 years old and for those children who are nonverbal or noncommunicative. It provides a rough guide to their discomfort level.

Intravenous Drug Challenges

Pain can also be assessed using intravenous (IV) drug challenges, in conjunction with repeated use of the pain scales, to rapidly determine the potential effect of analgesic treatment. Such evaluations can be done with minimal equipment, and with commonly available medications. In addition, they can often be combined with sequential sensory neurological exams. The two most

It sometimes helps, especially to communicate the pain level to other providers, if numbers are also assigned to the words, as in the English example, below.

	No Pain 1	Mild 2	Moderate 3	Severe 4	Excruciating 5
Spanish	No hay dolor	Leve	Moderada	Severa	Insoportable
French	Pas de douleur	Légère	Modérée	Sévère	Atroce
German	Ohne Schweiss	Mild	Moderat	Schwere	Quälenden
Russian	Не болей	Мягкий	Умеренная	Тяжелая	Мучительной
Chinese	沒有疼痛	輕度	溫和	嚴重	痛苦
Arabic	لا الألم	معتدل	معتدل	حاد	طاحنه
Japanese	痛み	軽い	穏健派	重度	耐え難い
Portuguese	Não Dor	Leve	Moderado	Grave	Dor tão mau

FIG. 13-1. 5-point pain scale using words.

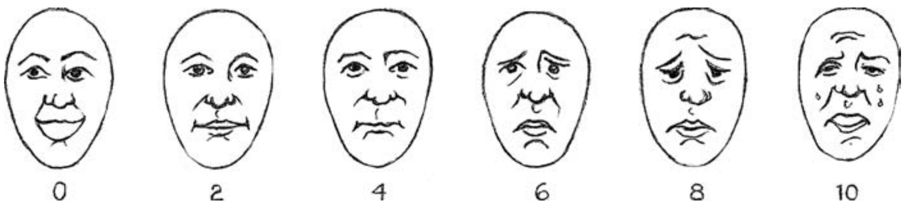

FIG. 13-2. Faces pain scale: adult.
This scale can be used (a) with patients without language ability, (b) where a language barrier exists between the patient and health care provider, (c) with preverbal children, or (d) with those who are deaf. The numbers 1 to 10 on this scale correlate to those used on the other linear scales.

common drugs used for this test are lidocaine and ketamine. If they significantly reduce a patient's pain, this can indicate additional treatment options.

Lidocaine Infusions

These are often successful, especially in treating peripheral nerve pain. The safest, especially in patients with a history of arrhythmias or seizures, is a 4-hour infusion of 2 mg/kg IV. This is best done by diluting the lidocaine in 240 mL of normal (0.9%) saline and running it at 1 mL/min. Monitor pain scores every 15 minutes. If available, use cardiac monitoring and oximetry. A positive response (less pain) to the lidocaine infusion may be repeated by additional periodic lidocaine infusions. It may also indicate that mexiletine (an oral medication in the same class) may be effective, although it may not be available.[3]

Ketamine Infusions

Ketamine has successfully treated a wide variety of pain syndromes, including those that have become resistant to opioids. The method is to administer 0.15 mg/kg over 20 minutes. Diluting the ketamine in 20 mL of normal saline or glucose (D_5W) allows administration of 1 mL/min. Monitoring and pain testing should be as with the lidocaine infusion. Terminate the infusion (positive test) if the pain scale is ≤ 2 out of 10. With a positive response, oral ketamine can be considered. Calculate a starting dose as 10% to 20% of the amount needed to lessen the patient's pain significantly, with a maximum adult starting dose being 100 mg/day.[3] (See "Ketamine" in this chapter and also in Chapter 16, Anesthesia: Ketamine, Ether, and Halothane for more information about ketamine.)

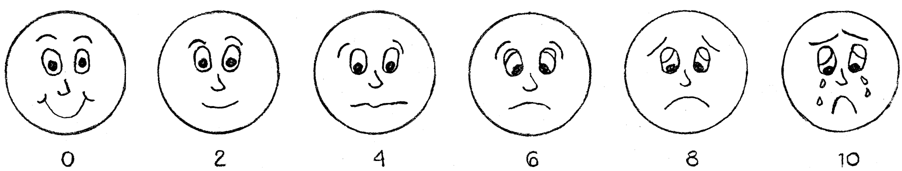

FIG. 13-3. Faces pain scale: children.
This figure may work well with children.[1] Explain to the child that each face is for a person who feels happy because he has no pain (hurt) or who feels sad because he has some or a lot of pain. Ask the child to point to the face that best describes how he is feeling. The numbers correlate to those used on the other linear scales.

Face 0 is very happy because he doesn't hurt at all.
Face 2 hurts just a little bit.
Face 4 hurts a little more.
Face 5 hurts even more.
Face 8 hurts a whole lot more.
Face 10 hurts as much as you can imagine, although you do not have to be crying to feel this bad.

TABLE 13-1 Pain Assessment for Children <4 years old

If the child is asleep, no further assessment is needed. If the child is awake, check the following:

		Score
1. Cry?	Not crying	0
	Crying	1
2. Body position?	Relaxed	0
	Tense	1
3. Facial expression?	Relaxed or happy	0
	Distressed	1
4. Response?	Responds when spoken to	0
	No response	1

Total score: 1 = slight pain; 2 = moderate pain; 3 = severe pain; 4 = the worst pain possible.
Adapted with permission from Charlton.[2]

TREATING PAIN

Pain should be treated whenever possible. This requires safely using both the correct medications and, when appropriate, medical devices. The use of analgesics varies widely around the world and in varying circumstances.

An unreasonable fear of analgesia's side effects or of addiction coupled with minimal staff and training may propagate "a culture of nonintervention," in which nontreatment of pain becomes the norm. In addition, although narcotics are the gold standard for treating moderate to severe pain, many countries either ban their use outright or have so many restrictions or regulations governing their importation and use that clinicians rarely employ them.

Pain Treatment Ladders

A treatment pain ladder describes an optimal treatment stategy, starting with the weakest medications and progressively increasing the strength of the medication. If the patient has no relief, they are moved from a nonsteroidal anti-inflammatory drug (NSAID) or another non-opioid drug to a weak opioid with or without another agent, and, finally, to strong opioids. The weak opioids are generally regarded as codeine and propoxyphene.[4]

A pattern of using the medications that has been advocated for use with this pain ladder is by the mouth" (use oral medications, if possible), "by the clock" (don't wait until the pain develops and is hard to control: use the medications on a fixed schedule to avoid getting the pain), and "by the ladder" (use the progressive system).[5]

The World Federation of Societies of Anaesthesiologists (WFSA) Analgesic Ladder uses regional anesthesia and a limited number of analgesics in a three-step approach.[2] A combination of these two methods (Fig. 13-4) represents the way clinicians should actually deliver analgesia to achieve optimal results. The type of analgesic intervention begins along the continuum, depending upon the acuity, severity, and nature of the pain.

Pain in Children

Rather than parenteral administration, whenever possible, give analgesics by mouth or via the rectum in children. Avoid aspirin, because of its association with Reye's syndrome.

Analgesic Effectiveness

If supplies are or will be limited, it helps to know which analgesics provide the most "bang for the buck." Although analgesic use is more often guided by tradition than by science, the Oxford League's Table of Analgesic Efficacy provides some guidelines.

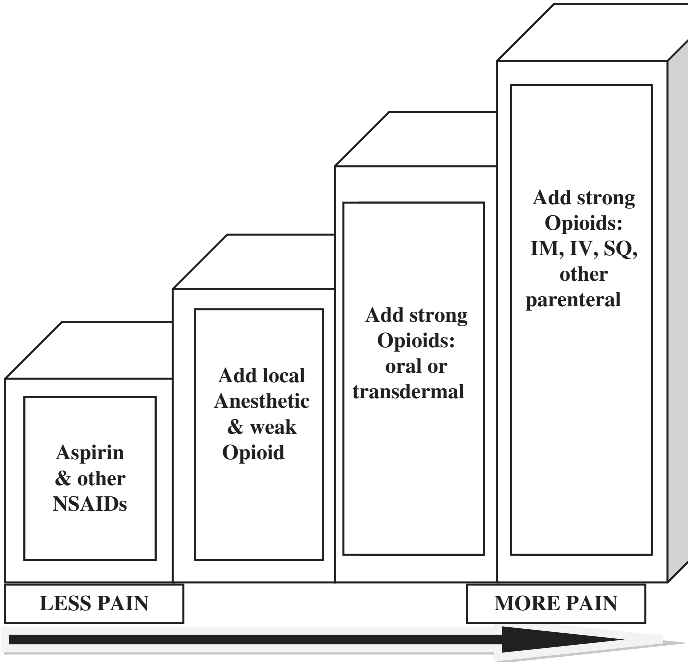

FIG. 13-4. Combined pain ladder.

The Oxford League Table of Analgesic Efficacy

Based on published reviews, the Oxford League Table of Analgesic Efficacy (Table 13-2) lists commonly used analgesic medications (not IV) and the percentage of patients achieving at least 50% pain relief over 4 to 6 hours as compared with a placebo in randomized, double-blind, single-dose studies in patients with moderate to severe pain. Drugs were oral, unless specified. Note that commonly used medications such as tramadol, codeine (alone or in combination with paracetamol/acetaminophen, aspirin, or dextropropoxyphene), dextropropoxyphene alone, and lower doses of the listed medications were less effective in relieving pain than were many others that are commonly available.[6]

Although clinicians regularly administer opioid analgesics, those may not always be available or parenteral narcotics may need to be used orally. Table 13-3 lists the equianalgesic doses when using parenteral opioids by mouth.

UNCOMMON ANALGESICS AND ADJUVANTS

Ketamine

Ketamine is available throughout the world as an anesthetic. (See Chapter 16, Anesthesia: Ketamine, Ether, and Halothane, for a discussion of its use as an anesthetic.) Its availability combined with its effectiveness as an analgesic makes it an excellent choice for treating severe pain. Ketamine provides good analgesia when administered intramuscularly (IM), intravenously (IV), and in much lower doses, via the oral, intranasal, transdermal, rectal, and subcutaneous routes. It has proven effective for refractory neuropathic pain, such as postherpetic neuralgia, postamputation pain, spinal ischemia, brachial plexopathy, and HIV and cancer neuropathies. It is also effective in nociceptive pain, including myofascial and ischemic pain.[8-11]

Subanesthetic concentrations of ketamine also provide effective analgesia for short painful procedures, such as burn-dressing changes, radiotherapeutic procedures, bone marrow aspiration, and minor orthopedic procedures.[12]

Note that ketamine analgesia (1 mg/kg IV) has a pressor effect in circulatory shock and is the analgesic of choice for trauma patients in shock, especially if it is being used within 6 to

TABLE 13-2 The Oxford League Table of Analgesic Efficacy

Analgesic (mg)	Percentage With ≥50% Pain Relief (%)
Ibuprofen 800	100
Piroxicam 40	80
Ibuprofen 600	79
Valdecoxib 40	73
Oxycodone IR 15	73
Valdecoxib 20	68
Diclofenac 100	67
Oxycodone IR 10 + acetaminophen 1000	67
Oxycodone IR 10 + acetaminophen 650	66
Acetaminophin (paracetamol) 1500	65
Rofecoxib 50	63
Diclofenac 50	63
Piroxicam 20	63
Bromfenac 100	62
Aspirin 1200	61
Acetaminophen 500	61
Oxycodone IR 5 + paracetamol 500	60
Naproxen 220/250	58
Ketorolac 20	57
Acetaminophen 1000 + codeine 60	57
Ketorolac 60 (IM)	56
Lumiracoxib 400	56
Ibuprofen 400	56
Oxycodone IR 5 + paracetamol 1000	55
Diclofenac 25	54
Meperidine (Pethidine) 100 (IM)	54
Bromfenac 50 mg	53
Ketorolac 30 (IM)	53
Bromfenac 25	51
Naproxen 440	50
Ketorolac 10	50
Morphine 10 (IM)	50

Abbreviations: IM, Intramuscular; IR, intrarectal.
Data from the Oxford League Table of Analgesics in Acute Pain.[6]

12 hours after injury. More care is needed if the patient is farther out from the injury, when it may cause hypotension. In patients with eye injuries, it may cause increased intraocular pressure at low doses.[13]

Oral and Parenteral Administration

Oral ketamine in a dose of 0.5 mg/kg has an analgesic effect at about 30 minutes post-ingestion. Dilute the parenteral preparation in orange juice or cola to make it more palatable.[11]

TABLE 13-3 Equianalgesic Oral-Parenteral Opioid Dosing Chart

	Equianalgesic Dose (mg)	
Opioid	Oral	Parenteral
Morphine	30	10
Fentanyl	N/A	0.1
Hydromorphone	7.5	1.5
Methadone	20 (acute) 2-4 (chronic)	10 (acute) 2-4 (chronic)
Oxycodone	20	N/A
Codeine	200	120
Meperidine	300 (not recommended)	75
Propoxyphene	N/A	130-200

Adapted with permission from Amabile and Bowman.[7]

Subcutaneous ketamine can be used to control both acute and chronic pain. Ketamine 0.1 mg/kg subcutaneously controls acute trauma pain better than IV morphine. In addition, it produces less drowsiness, causes no nausea or vomiting, and requires no breakthrough medications.[14] In cancer patients with intractable pain, give an initial subcutaneous injection of 10 mg ketamine followed by a continuous subcutaneous infusion of 10 mg/hr. An additional 2.5 mg/day can be added, up to a rate of 15 mg/hr. Most patients obtain pain relief; the side effects are site inflammation, salivation, and insomnia. Over 5 to 7 months, some patients develop a tolerance to ketamine's analgesic effect.[10]

Ketamine is frequently given IV or IM at a dose of 0.5 mg/kg, which produces rapid and profound analgesia.[15] Follow this with 0.25 mg/kg (250 micrograms/kg [mcg/kg]) doses, as necessary.[12]

In Combination With Other Medications

Ketamine reduces the amount of morphine needed to treat acute severe pain in trauma patients.[16] It is safe to use with morphine: Administration of 0.25 mg/kg IV ketamine lessens the pain of patients whose pain is poorly controlled with IV morphine. In addition, their nausea and vomiting is reduced.[15,16]

When given as 0.4 mg/kg IM (with 0.05 mg/kg midazolam), ketamine provides long-term analgesia in about one-third of patients with constant neuropathic trigeminal pain who have not responded to other modalities.[17]

Postoperative Analgesia

Postoperative patients may also benefit from low-dose ketamine's analgesic effects.[18,19] Ketamine is especially useful in patients who have a tolerance to opiates.[20] While both IV infusions and oral ketamine have been effective, patients appear to experience fewer side effects with oral ketamine.[21]

For adult patients in severe pain, give a loading dose of 0.5 to 1 mg/kg IM ketamine. Follow this with an infusion of 60 to 180 mcg/kg/hr (4 to 12 mg/hr for a 70-kg adult). A practical regimen is to add 50 mg of ketamine to a 500-mL bag of normal saline or dextrose (0.1 mg/mL of ketamine) and run this at 40 to 120 mL/hr (i.e., over 4 to 12 hours for a 70-kg adult). This regimen is safe, since even the total volume will not deeply anesthetize the patient.[21]

Local Anesthetics and Blocks

While local anesthetics are frequently used for surgery, they are often neglected for use either postoperatively or in other situations needing analgesia. When an appropriate anatomical region is involved and the clinician has the skills, consider giving local or regional anesthetics, especially blocks with the long-acting anesthetics. Some useful blocks are described in Chapter 14, Anesthesia—Local and Regional and Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment. While these might not result in perfect analgesia, they usually lessen the pain enough for other analgesics to be effective.

Neuropathic Pain

Neuropathic pain is much more common that clinicians recognize. It stems from damage to or dysfunction of the peripheral or central nervous system (CNS) and results in pain far greater than that which would be expected from the injury. It is usually characterized by dysesthesias (burning pain, often with a "stabbing" component) and, sometimes, a deep ache. There may also be hyperesthesia (increased sensitivity to sensory stimuli), hyperalgesia (abnormally increased sensitivity to pain), allodynia (pain due to a benign stimulus), and hyperpathia (a particularly unpleasant, exaggerated pain response). Symptoms typically persist after resolution of the primary cause due to CNS remodeling. Although neuropathic pain may respond to opioids, the most effective treatment is often to give antidepressants, ketamine, anticonvulsants, baclofen, and topical medications.

Tricyclic antidepressants have been shown to be effective in most types of neuropathic pain and will often be available and inexpensive. Their analgesic effect may begin immediately (unlike their delayed action when used for depression). This group of medications includes amitriptyline, imipramine, desipramine, and nortriptyline. Their use is contraindicated in patients with liver, renal, or cardiac disease or those with orthostatic hypotension. To reduce side effects, start amitriptyline at 25 to 50 mg hs (before bed) and increase it, as necessary, to 100 mg hs after a week. As with other analgesics, these medications are not effective for all patients. For every two patients treated, only one may get >50% pain relief. Other effective agents that may not be available, and that are more expensive, include antiepileptics (e.g., gabapentin at 300 mg twice a day [bid] to a maximum of 1200 mg tid).[22,23]

Ketamine successfully treats chronic pain states, such as complex regional pain syndromes,[24] phantom-limb pain,[25] and central and peripheral neuropathic pain.[26] Use 50 mg po (by mouth) in adults 3 times a day (tid). Increase this to 100 mg tid, as needed. Problems with hallucinations and excessive salivation are rare. Gradually decrease the dose after about 3 weeks of good pain relief to see if it is still needed. It can be reinstituted, if necessary.[21]

Hypnosis

Hypnosis provides significant pain relief for most patients, sometimes even better relief than from traditional medications. This relief is different from the relief obtained from acupuncture and that from placebos. Hypnosis offers a moderate to large analgesic effect for many types of pain.[27,28] See "Hypnosis" in Chapter 14, Anesthesia—Local and Regional, for instructions on doing clinical hypnosis.

"Street" Drugs

When drug supplies are extremely limited, some drugs may be available from unusual local sources. Whenever medications are obtained from nontraditional sources, extreme care should be taken, since identifying the real drug, dose, and purity may be in doubt. Additional information about using street drugs can be found in Chapter 12, Medications/Pharmacy/Envenomnations.

Methadone

Methadone is both a prescription medication and a drug used and sold by opiate addicts. When purchased in tablet form, it can usually be identified as coming from a legitimate pharmaceutical company. Methadone has the same actions as morphine and meperidine. Its unique quality is that it is well absorbed orally. It has a prolonged duration of action, making it more suitable for use in chronic rather than acute pain, although it has been used successfully for acute pain. Orally, the dose ranges from 2.5 to 25 mg given every 6 to 12 hours. The parenteral formulation can be administered IM at from 7.5 to 10 mg every 4 to 6 hours.[2]

ALTERNATIVE ADMINISTRATION METHODS

In areas of the world where strong opioids are available (they are not permitted for medical use in some countries and are unbelievably expensive in others[29]), IM administration may be the best method for clinical use. They should generally be administered on a scheduled, rather than on an as-needed, basis. With outpatients, oral administration may be the easiest and the best tolerated.

However, normal methods of drug delivery or the forms generally used for that type of delivery (e.g., tablets, capsules, liquid) may not be available. In those cases, if the patient needs the medication or analgesic effect, consider alternative administration routes.

Oral Administration

Some opioids, although generally not given orally, can be very effective through that route (Table 13-3). Oral fentanyl, for example, can be self-administered over 15 minutes. Between 25% and 50% of the fentanyl dose is absorbed through the oral mucosa. It has a rapid onset (5 to 10 minutes) and reaches its maximum serum level in 10 to 20 minutes.[30]

As mentioned previously, ketamine works very well as an oral analgesic.

Rectal Administration

Rectal administration of drugs results in direct systemic absorption, usually resulting in greater drug availability than through the oral route, although this varies with the medication, the presence of feces, and other factors. If in suppository form, the drug must be placed in the middle or inferior rectum to avoid being absorbed through the superior rectal vein (directly to the portal system).

Morphine in solution given rectally is absorbed more slowly than oral morphine or a morphine hydrogel suppository. If the suppository is inserted into a colostomy, there is wide variability in absorption. NSAIDs as rectal suppositories are associated with ~20% fewer adverse gastrointestinal (GI) effects.[31] Codeine also has good rectal absorption, although it is slower than with IM administration and results in lower blood concentrations. The normal rectal doses of acetaminophen and NSAIDs in children are usually considerably less than what is needed to get an effective blood level; the formulations vary.[32]

To administer partenteral analgesics rectally, use a 2-mL syringe (without needle). Administer the IV formulation, generally at the same dose as would be given IV, and leave the syringe in for 2 minutes to prevent the medication from leaking out. The effect is generally rapid.[33]

Nasal Administration

Improvised Atomizers

Nasal absorption of medications is highly dependent on obtaining a small-particle mist, rather than the droplets normally produced by squirting a medication through an IV cannula into the nose. These two improvised atomizers can be built using commonly available medical equipment: one with and the other without a source of pressurized air or oxygen.[34]

If an air/oxygen supply is available, this atomizer (Fig. 13-5) can quickly be assembled from a piece of oxygen tubing, IV extension tubing, and a 22-gauge plastic IV catheter. Place one end of the oxygen tubing on either the air or the oxygen port and set the flow to 3 L/min. Attach the female end of the IV extension tubing to the oxygen tubing by pressing them together firmly. Attach the 22-gauge catheter to the male end of the IV extension tubing. Attach the syringe with the medication to be administered to one of the access ports on the IV extension tubing. Slowly introduce the medication; it will atomize at the catheter into a fine mist. At higher air/oxygen flow rates, it becomes more difficult to push the medication out of the syringe.

If an air/oxygen supply is not available, make an atomizer by attaching a 22-gauge catheter (with the needle removed) to the male end of an IV extension set (Fig. 13-6). A 1-cc syringe containing the medication is attached to the farthest port (not the female end) of the extension tubing. On the female end of the tubing, attach a 60-cc syringe filled with air, and inject approximately 1 to 3 cc of air for every 0.1 to 0.2 cc of medication from the 1-cc syringe pushed into the tubing. This creates several very small air bubbles in the line. The medication is now in the tubing distal to the 60-cc syringe. Next, disconnect the 60-cc syringe and fill it with air again. This volume of air is then pushed through the extension tube, delivering nebulized medication to the patient. While this does work, it does not atomize quite as well as when it is connected to oxygen.

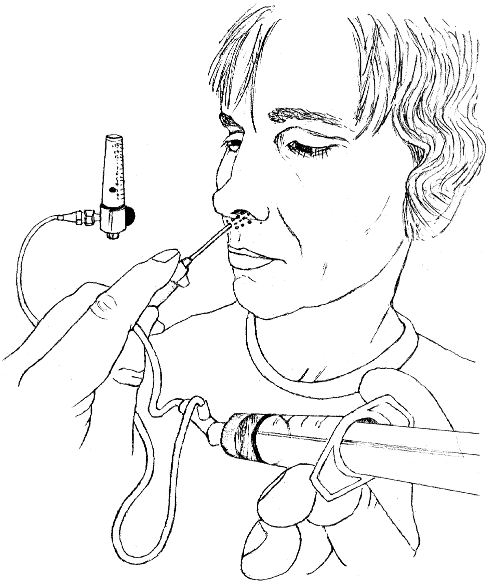

FIG. 13-5. Improvised atomizer with pressurized air/oxygen supply.

Nasal Opioid Administration

Nasally administering fentanyl, alfentanil, sufentanil, butorphanol, oxycodone, buprenorphine, meperidine, and diamorphine for analgesia in acute pain situations is highly effective, if done correctly (Table 13-4).

Even if the necessary equipment and expertise are available for parenteral access, nasal administration of analgesics avoids the need to establish it and is much kinder to patients, especially children and some chronically ill patients. Nasal analgesic can be as effective as IV analgesia and provides a method for patient-controlled analgesia without the fancy equipment.

FIG. 13-6. Improvised atomizer without pressurized air/oxygen supply.

TABLE 13-4 Nasally Administered Opioids

Drug	Nasal Dose (mg)	Frequency of "As Needed" Administration	Mean Time to Pain Control (minutes)
Alfentanil	0.54		
Fentanyl	0.027 (27 mcg)	q5min	30
Sufentanil	0.015		
Oxycodone	0.1		
Buprenorphine	0.3		
Butorphanol	1-2	q1-4hr	45
Meperidine/pethidine	27	q5min	30
Diamorphine/heroin	0.1 mg/kg	q20min	5

Data from Dale et al[36] and Kendall et al.[37]

The medications have rapid onset, bypass gastrointestinal and hepatic presystemic elimination, and are useful in nauseated and vomiting patients. The same side effects exist as with the parenteral administration of these drugs. Nasal effects may include a bad taste for some drugs (not fentanyl) and, after a few days of use, nasal congestion, irritation, and epistaxis.

The basic principles are: (a) a potent medication must be delivered in small quantities; (b) a higher dose should be used, since the nasal mucosa does not absorb all the medication; (c) the drug must be delivered so the nasal mucosa can optimally absorb it (i.e., as a spray rather than as drops); and (d) the maximum surface area should be used, which means using both nostrils in some patients.[35]

The ideal volume for each nostril is from 0.2 to 0.4 mL. Giving more than 1 mL causes the medication to run into the throat or out of the nose, making the actual dosage administered uncertain. For fentanyl, use 1.4 times the usual IV dose. It can be pulsed in divided doses if the total volume is too large. One alternative is to use a powdered opiate, such as diamorphine, diluting the proper dose in 0.2-mL normal saline. Another option is to use the more potent sufentanil, which is inexpensive and eight times as potent as fentanyl.[36]

Nasal Administration of Other Medications

Other medications (Table 13-5) can be delivered intranasally using cotton swabs, a syringe with an IV catheter (often more a dropper than atomizer), or an atomizer. Use an improvised atomizer (see earlier discussion "Improvised Atomizers" in this chapter) or one that is normally used for other purposes (e.g., perfume) that has been thoroughly cleaned. The intranasal

TABLE 13-5 Nasal Medication for Non-analgesic Use

Indication	Drug	Nasal Dose/Volume	Additional Information
Sedation	Midazolam	0.4-0.5 mg/kg	Titrate for effect
	Sufentanil	0.2-1.0 mcg/kg	
	Fentanyl	1.5-3.0 mcg/kg	
	Ketamine	3-8 mg/kg	
Seizures	Midazolam	0.2-0.3 mg/kg (10 mg in teenagers and adults)	Use 5 mg/mL form Effect in ~6 min
	Lorazepam	2 mg (adults)	~10 min
Opiate reversal	Naloxone	2 mg	Use 1 mg/mL form
Nasal procedures and epistaxis	4% Lidocaine plus Oxymetazoline (Afrin)	1.5 mL 0.5 mL	
	4% Cocaine	Up to 4 mL in adults	

Data from Wolfe and Bernstone,[39] Wermeling et al,[40] Lahat et al,[41] and Abrams et al.[42]

route, particularly traversing the olfactory epithelium, allows many drugs to bypass the blood-brain barrier.[38]

Inhalation

Inhaled morphine provides analgesia within 5 minutes, but requires 6 to 20 times as much for an equianalgesic effect to IM morphine. Part of this is due to the amount that does not reach the lungs with a typical inhaler.[31]

Sublingual, Buccal, and Transmucosal

Sublingual, buccal, and transmucosal routes of administering medications provide direct drug entry to the systemic circulation without first being metabolized or going through gastric emptying. Buprenorphine (Stadol) and fentanyl are quickly (~2.5 minutes) absorbed in the mouth. In contrast, it takes 6 hours for morphine to be absorbed through the oral mucosa. Buprenorphine administered transnasally results in >50% bioavailability, with onset of analgesia within 15 minutes and peak concentrations reached in 30 to 60 minutes.[31]

Transdermal

Transdermal absorption works for highly lipid-soluble drugs, such as fentanyl, sufentanil, salicylates, and certain other NSAIDs.[31]

Lidocaine patches (homemade, if needed) effectively treat acute herpes zoster pain and postherpetic neuralgia. See Chapter 14, Anesthesia—Local and Regional, for more information on topical anesthesia, including patches.

Continuous Subcutaneous

Continuous subcutaneous opioid infusions are effective, even if their absorption is unpredictable. Change the infusion site about every 4 days. These infusions are interchangeable with IM injections.[31] Note that they can be used in conjunction with hypodermoclysis. (See Chapter 11, Dehydration/Rehydration.)

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14 | Anesthesia—Local and Regional

When the equipment and the experienced personnel to give deep sedation or general anesthesia are not available, local and regional anesthetic techniques should be used. As one experienced anesthesiologist wrote, "We must assume that supplies of compressed gases will soon run out and replacements will be unobtainable. This leaves us with local techniques, spinal and epidural analgesia, all of which can be given by the surgeon in the absence of a trained anesthetist."[1]

TOPICAL ANESTHETICS

Pharmacology

Topical anesthetics are slowly absorbed through normal skin. However, they are rapidly absorbed through the mucosa as well as through abraded, burned, and denuded skin. When using topical anesthetics in these areas—especially if used in the tracheobronchial tree—the maximum dose should be considerably less than that used for infiltration.[2,3] Tetracaine, for example, produces higher blood levels at 5 minutes with mucosal application than with subcutaneous infiltration.[4] When used in dentistry, topical anesthetics generally anesthetize only the outer 1 to 3 mm of mucosa.[5]

Common Anesthetics

Good topical anesthetics include lidocaine (lignocaine), cocaine, and tetracaine. Some anesthetics, such as procaine and mepivacaine, are not effective topically due to poor mucous membrane penetration.[3]

Lidocaine/lignocaine (amide) (2% to 10%) has a peak anesthetic effect in from 2 to 5 minutes. Its maximum safe total dose in a healthy 70-kg adult is ~250 mg and it is 3 mg/kg in children. Anesthetic effect lasts 30 to 45 minutes.[2,3] Lidocaine gel 4% can be made by adding 2 mL of 2% lidocaine without epinephrine to 1 mL of a water-soluble jelly (e.g., K-Y). This gel works well, if placed under an occlusive dressing, to ease the pain of herpes zoster and other skin lesions.

Bupivacaine (amide) (0.25% to 0.5%) has a peak anesthetic effect in 2 to 5 minutes. Its maximum safe total dose in a healthy 70-kg adult is 400 mg/24 hours; it is 2 mg/kg in children, although it is not officially recommended for use in children <12 years old. Similarly, it is not recommended as a spinal anesthetic in those <12 years old. Anesthetic effect lasts 4 to 8 hours.

Cocaine (ester) (4% = usual dose) has a unique vasoconstricting effect. It reaches peak anesthetic effect in 2 to 5 minutes. However, it is addictive. The maximum safe total dose in a healthy 70-kg adult is 200 mg (2 to 3 mg/kg) and it is 2 mg/kg in children. The anesthetic effect lasts from 30 to 45 minutes.[2,3] Staying within the maximum adult dose is easy if the standard package of 4 mL of the 4% solution is used. While making your own topical solution with cocaine obtained from noncommercial vendors may seem logical in an emergency, the problem is that neither the strength nor the purity of the ingredient is known.

Tetracaine (ester) (0.5% = usual dose) has a peak anesthetic effect in 3 to 8 minutes. The maximum safe total dose in a healthy 70-kg adult is 50 mg and it is 0.75 mg/kg in children. Its anesthetic effect lasts 30 to 60 minutes.[2,3]

Toxicity

Local anesthetics can produce allergic reactions, tissue damage, and systemic toxicity. Allergic reactions are most common with the amino-ester preparations (e.g., procaine, tetracaine). There is no cross-reactivity between the esters and amides (e.g., lidocaine, bupivacaine, mepivacaine). Allergic reactions to local anesthetics are rare, with most reported allergies not representing actual allergic reactions. Local tissue neurotoxicity can also occur, but it is rare.

Systemic toxicity is the most common and significant problem associated with local anesthetic use. Usually associated with inadvertent intravenous (IV) or intra-arterial injections, only mental status changes may occur before the onset of seizures. Classically, the progression from systemic toxicity is tongue numbness, light-headedness, visual disturbances, muscular twitching, unconsciousness, and seizures. Of course, patients receiving local anesthetics while sedated may have muscular twitching as the only sign before seizures. The treatment is to stop local anesthetic use, manage the airway, control the seizures, and support the patient until the central nervous system (CNS) effects of the drug wear off. The local anesthetics themselves do not cause CNS damage. Rather, the damage stems from hypoxia during the seizure and the associated coma.[6]

"Magic Mouthwash"

Many topical oral anesthetic formulations ease the pain from mucosal lesions. One that seems to work well, and that uses commonly available ingredients, is a mixture of equal parts of 2% viscous lidocaine, diphenhydramine elixir, and Maalox or Kaopectate (as a binder).[2] Swish for 1 to 2 minutes and spit. This is especially useful in children with oral lesions that prevent the child from drinking/eating.

Sprays

Lidocaine for injection can be nebulized as an effective topical mucosal anesthetic. Some patients experience a strong bitter taste when lidocaine is administered this way; however, the taste is usually transient and this should not prevent the patient from receiving the medication. (Personal communication from Angela M. Plewa, Pharm.D., received April 8, 2008.) To use it, the best course is to dilute it to a 0.5% solution so that the maximum safe dose is not exceeded.

Creams

Anesthetic creams are useful to reduce pain before suturing, phlebotomy, or IV insertions. They are primarily used in children.

LET (lidocaine 4%, epinephrine 0.1%, and tetracaine 0.5%), which can be compounded locally, can be used to anesthetize small lacerations on the face and scalp before repair. This works particularly well in children and has less toxicity than TAC (tetracaine 0.25% to 0.5%, adrenaline 0.025% to 0.05%, and cocaine 4% to 11.8%), which was previously widely used. In an emergency, either works well. They both work in about 75% to 90% of patients. An older formulation mixing epinephrine in cocaine, termed "cocaine mud," had a very high complication rate; don't use it.

For LET solution, mix 100 mL 20% lidocaine HCl, 50 mL 2.25% racemic epinephrine (HCl salt), 125 mL 2% tetracaine HCl, 315 mg sodium metabisulfite, and 225 mL water. Make the gel by mixing the solution with methylcellulose.

The LET formula is effective both in a solution and as a gel. For the solution, paint it onto the wound edges with a cotton-tipped applicator. Then apply a cotton ball saturated with the solution to the wound. In about 20 minutes, the wound appears blanched and is ready to suture. Apply the gel to both the wound edges and the wound with a cotton-tipped applicator. As with the solution, the wound edges look blanched and the wound is ready to suture in about 20 minutes. Remove the gel before suturing.[7]

Patches

Anesthetic patches effectively anesthetize the skin and underlying area of painful lesions. They can be used for herpetic, post-herpetic, and rib fracture pain. They don't work when applied for joint pain.

To improvise a topical anesthetic patch for abrasions and wounds, soak gauze with a mixture of injectable lidocaine, tetracaine, and epinephrine and place it directly onto the wound for approximately 5 minutes.[8] For rib fractures, use 700 mg lidocaine under a 10×14 cm occlusive dressing.

LOCAL ANESTHETIC INFILTRATION

Local anesthetic infiltration generally works well, even when given by novices and those who don't use it regularly. It works by diffusing through the tissues without needing to know the specific neuroanatomy.

The key to giving successful local infiltration (also for regional blocks) is to wait long enough for them to take effect. There is a delay, a latent period, of up to 15 minutes between when the anesthetic is administered and when the area is anesthetized. (A good practice is to do the block, leave and do any paperwork associated with the case, and then return to do the procedure.) If pain—not pressure or touch sensation—still exists after 15 minutes, administer additional anesthetic. You can also give the patient mild sedation as an anxiolytic (often called a paramedication when given during the procedure). The most common reason that local anesthesia and anesthetic blocks do not work is that the clinician does not wait long enough.

Infiltration anesthesia uses larger volumes of weaker anesthetics (e.g., 100 mL of 0.5% lidocaine). Regional blocks of larger nerves use smaller volumes of more concentrated anesthetics (e.g., 10 mL of 2% lidocaine).

To maximize efficiency when large numbers of patients require procedures done under local anesthesia, group them together. Do not interpose cases under general anesthesia, as this will only slow patient flow. Block the next patient while the surgeon is scrubbing for the first patient.[9] When you must do a series of very short procedures under local or regional anesthesia, you can often block several patients at once using a longer-acting anesthetic (often containing epinephrine 1:200,000).

Local Anesthetic Medications

If a patient tells you that he is allergic to a local anesthetic, avoid that class of medications (usually an ester). Anesthetics in the ester class do not have an "I" before "caine" in their name (e.g., procaine, cocaine). The name of anesthetics in the amino amide class has an "I" before "caine" (e.g., lidocaine/lignocaine, mepivacaine). If you cannot use an anesthetic from the class that the patient is not allergic to (or if the patient doesn't know the drug he is allergic to), use one of the alternative medications described in the next section.

Anesthetics come as percent concentrations, with 1% equaling 10 mg/mL or 1 g of anesthetic per 100 mL. To dilute a local anesthetic, add sterile injectable saline. For example, adding 1 mL of anesthetic to 1 mL of saline changes a 1% solution into a 0.5% solution. If 3 mL of saline were added, it would become a 0.25% solution. An easy way to calculate the dose in milligrams is to use the formula: Volume (mL) × Concentration (%) × 10 = Dose (mg).[10]

When medication is scarce, reduce the needed dose of anesthetic either by diluting the solution or by adding epinephrine (adrenaline). Vasoconstriction increases an anesthetic's length of action. Yet, except for cocaine, local anesthetics (without epinephrine added) are vasodilators. Don't add epinephrine to cocaine; it is unnecessary and dangerous.

Premixed lidocaine with epinephrine may not be available. To determine the amount of epinephrine to add to the local anesthetic, remember that the typical 1:100,000 concentration means 1 mg of epinephrine for every 100 mg anesthetic; 1:200,000 concentration means 1 mg of epinephrine for every 200 mL anesthetic. Therefore, to make a 1:200,000 epinephrine-lidocaine solution, add 0.1 mL (0.1 mg) epinephrine 1:1000 to 20 mL of lidocaine. To do this, take 1 mL of epinephrine 1:1000 and dilute it to 10 mL with saline. Now you have a 1:10,000 epinephrine solution. Take 1 mL of this mixture and add 19 mL lidocaine. The total amount of solution you have is now 20 mL and the original epinephrine has been diluted 200 times = 1:200,000 solution.[11]

To reduce burning from the acidic pH of most local anesthetics (pH 4 to 5), add 1 mL sodium bicarbonate (1 mEq/mL) to every 10 mL of 1% lidocaine.[12] While the traditional teaching is that local anesthetics are unreliable when used in the acidic environment of an abscess, reports suggest that a "double-buffered" solution of 2 mL of bicarbonate with 8 mL of lidocaine works well.[13] Heating the anesthetic to body temperature also helps reduce pain.[14]

Alternatives to Local Anesthetics

If standard local anesthetics are not available or if the patient claims to be allergic to local anesthetics, a variety of alternatives can be used. These include medications with antihistamine activity, bacteriostatic normal saline (NS) with benzyl alcohol, sterile water, local cold, and pressure.

Antihistamines

Most injectable medications with antihistamine activity can be used as local anesthetics if diluted to a 0.05% solution with NS. None are as effective as standard local anesthetics, but they will certainly do if nothing else is available.[15]

Diphenhydramine hydrochloride (Benadryl) has been used successfully for dermal, urological, and dental anesthesia. It is very soluble in water. A 1% solution is prepared by diluting 1 mL of a standard 5% diphenhydramine solution for injection with 4 mL single-use NS solution for injection (without preservatives).[12] It shouldn't be used in concentrations >1%, since that may cause ulcerations or tissue necrosis. Its duration of action is less than that of lidocaine with epinephrine and, even if buffered, it is more painful than lidocaine. A 0.5% solution can also be used, but it is considerably less effective than 1% lidocaine. Complications include sedation (occasional), local erythema (common), persistent soreness lasting up to 3 days (common), and skin sloughing (rare).[12,16] Dimenhydrinate (Dramamine) also has local anesthetic activity.[15]

Tripelennamine (aka: pyribenzamine [PBZ]), a highly water-soluble antihistamine, is effective for a wide variety of regional nerve blocks in a 1% solution. As clinically effective as diphenhydramine, tripelennamine has fewer and less severe side effects. It can be used for urethral anesthesia[17] and, in a 4% solution, as a mucosal anesthetic on the gums. In powdered form, it immediately relieves toothaches in a decayed tooth. It has been used as a 1% solution for topical anesthesia in the mouth and esophagus and, usually with epinephrine, for skin and dental block infiltration.[18] Addition of epinephrine reduces local reactions and lengthens the anesthetic's effect up to four times. For pain relief, use between 5 mL (lingual nerve block) and 20 mL (dorsal sympathetic nerve block). For surgery done with a tripelennamine nerve block, use between 10 mL (finger block) and 35 mL (tendon graft). The anesthetic effect is prolonged by adding 1:100,000 epinephrine.[19]

Phenothiazines (e.g., promethazine [Phenergan], chlorpromazine [Thorazine]) are 23 times more potent than procaine as a local anesthetic.[20] Chlorpromazine is effective as a local anesthetic at concentrations of between 0.1% and 0.2%. It has a wide safety margin, but should not be used with epinephrine. Even without a vasoconstrictor, it has a longer duration of action than most local anesthetics. One complication, orthostatic hypotension, usually occurs when chlorpromazine is used IV or in large doses.[21] Although it has significant local anesthetic properties, chlorpromazine has never been generally used as a local anesthetic in humans.[20-22]

Water

Sterile water is a suitable anesthetic. Known to our predecessors as "aquapuncture," this method uses unpreserved sterile water, produced by simply boiling distilled water. As with other local anesthetic infiltration, injecting water works better on loose tissues and is less painful when the water is at body temperature and injected slowly. The analgesia lasts 10 to 15 minutes.[23]

Allen described the procedure he used, "To obtain the full analgesic effect, it is necessary to infiltrate the tissues to the point of producing a glassy edema, the skin or mucous membrane must be infiltrated intradermally and the infiltration carried down the full depth of the proposed incision; when this is done, analgesia is usually as profound as after infiltration with the weaker anesthetic solution, but tactility is little or not at all affected; the after-pain or discomfort is about the same as that following the use of other anesthetic solutions."[23]

Bacteriostatic Normal Saline

Benzyl alcohol, the preservative in bacteriostatic NS, is an ideal alternative local anesthetic. Inexpensive and readily available, bacteriostatic NS is frequently used to flush IV catheters and to dilute or reconstitute medications for parenteral use.

Benzyl alcohol (0.9%) can be mixed to a solution with 1:100,000 epinephrine. This formulation is less painful, but slightly less effective, than 0.9% buffered lidocaine. In children, the pain on injection is about the same as that with lidocaine.[24] Without epinephrine, the anesthetic effect of benzyl alcohol lasts only a few minutes.[25] With epinephrine, the anesthetic effect begins to diminish about 20 minutes after injection. Prepare a benzyl alcohol-epinephrine solution by adding 0.2 mL epinephrine 1:1000 to a 20-mL vial of multi-dose NS solution containing benzyl alcohol 0.9%.[12]

Antidepressants

Some antidepressants, such as amitriptyline, have shown good activity as both topical and injectable anesthetics. When the need is desperate, these can be used, although questions about their safety preclude their use under normal circumstances.[26]

Narcotics

Neither morphine nor meperidine (Demerol, Pethidine) works well as a local anesthetic. They have a potency about half that of chlorpromazine and slightly less than that of promethazine.[22,27]

Cold/Freezing (Local Anesthesia)

Apply cold to tissues to produce either local or regional anesthesia. (See also "Refrigeration Anesthesia: Amputations" later in this chapter.)

Locally applied cold provides extremely short-acting superficial anesthesia for "stab" abscess drainages, venipunctures, injections, and similar procedures. If ice is used, it must be in direct contact with the skin for at least 10 seconds immediately before the procedure. The effect lasts only a few seconds.[28]

Cold sprays for local anesthesia were developed in the mid-19th century. Various substances with low boiling points can be used, including ether, and alcohol cooled to −10°F (−23.33°C).[29]

Ethyl chloride (chloroethane) spray effectively anesthetizes a very small area of intact skin for a few seconds—approximately enough time to do a stab incision for an abscess. It works by "freezing" the skin. Because of its potent general anesthetic effect, ethyl chloride should never be used on the mucosa. It is available commercially as a cleaner (e.g., for VCR heads and computer keyboards) and as a medical spray. This chemical is flammable, and fires have occurred while using it with diathermy, for example, to remove a wart.[30] It is a potent and potentially dangerous general anesthetic with abuse potential. Tetrafluoroethane spray, used to remove dust from personal computers, can serve as a handy substitute.[31] (Don't inhale it; you'll pass out.)

An atomizer is used to spray the anesthetic. Directions for two homemade atomizers can be found under "Alternative Administration Methods" in Chapter 13, Analgesics. Hold the atomizer far enough from the body part being anesthetized to maximize the amount of spray reaching the skin before dissipating. If held too far away, the spray evaporates without anesthetizing. Protect sensitive parts, such as the eyes and anus, before the anesthetic is sprayed on surrounding areas.

Pressure

Direct pressure over an area produces a very transient anesthesia. As Allen wrote in 1918, "The benumbing effect of long-continued pressure upon any part of the body is well known; although some pain may be produced in the surrounding parts, it is possible to carry it to a point of depressing both tactile and painful impressions to a considerable degree; this is brought about in two ways, first the compression directly paralyzes the nerve-endings of the part, and, secondly, the anemia [actually, tissue hypoxia] intensifies this effect."[32]

Local Infiltration Techniques

Injection

Inject the anesthetic slowly. This markedly diminishes the patient's discomfort. Using buffered lidocaine also decreases pain, as described in the previous text.

Field Block

Use a simple field block for circumscribed lesions, such as cysts or small abscesses, and for larger structures, such as ears. Visualize a diamond surrounding the area to be anesthetized, and then inject two small wheals at the apex of the diamond. Next, block the four sides of the diamond through those wheals.

Local wound infiltration is effective for inguinal and umbilical hernia surgery, dental procedures, strabismus (eyes) surgery, and burr holes/craniotomies.[33] For craniotomies, anesthetize the scalp surrounding the entire surgical area, as well as the underlying muscles and the periosteum.[34] Use the greatest possible anesthetic dose, since the scalp is so vascular. Always use anesthetic with epinephrine.

Infiltrate-and-Cut Anesthesia

In situations where there is no alternative, almost any surgical procedure can be done by cutting through a site that has been locally infiltrated with anesthetic, with continued anesthetic injections given as the operation proceeds.

The Vishnevsky technique, an "inject-and-cut" procedure once employed extensively in Russia, is possibly the simplest use of local anesthetics, since no knowledge of anatomy is required. The technique works very well for surgery outside of the abdomen and chest. Abdominal surgery is not quite as easy; it is simple enough to open the abdomen with this technique, but handling the viscera is a different matter. The technique is to inject unlimited volumes of weak procaine solutions (0.25% to 0.5%) without epinephrine. Procaine is the only completely safe anesthetic to use for this procedure, since it is metabolized very rapidly. Other local anesthetics are metabolized more slowly, and the patient can become toxic.[35] If lidocaine is used, the limit is 200 mL of 0.25% lidocaine with adrenaline 1:500,000.

The primary danger of the Vishnevsky technique is inadvertent intravascular injection, which can be avoided by aspirating before injecting and keeping the needle moving. A "continuous apparatus" with Luer-Lok fittings is advantageous.[36]

Premedication/Paramedication

Premedicating patients may be useful when giving either regional or general anesthesia. It reduces patient anxiety and often lessens the amount of anesthetic that is needed. The drugs used for premedication, such as benzodiazepines, phenothiazines (especially the commonly used promethazine), and barbiturates, are commonly available. They can be administered orally, parenterally, or rectally.[37] Benzodiazepines and barbiturates have the added benefit of raising the seizure threshold.

Hypnosis, even if patients use a hypnosis recording, is effective as a premedication. The significant benefits of hypnosis include decreased anxiety, decreased blood pressure, reduced blood loss, enhanced postoperative well-being, improved intestinal motility, shorter hospital stays, reduced postoperative nausea and vomiting, and a reduced need for analgesics.[38] Hypnotic techniques are described later in this chapter.

If patients become anxious or experience pain while a regional block is being done or during a procedure after the administration of a regional block, give the patient an analgesic or an anxiolytic as paramedication. Paramedications that should be available in most situations are mild sedatives, opioids, or ketamine.

REGIONAL BLOCKS

Regional blocks are more problematic for inexperienced practitioners than infiltration anesthesia. Nevertheless, simple nerve blocks are effective for a wide variety of procedures and operations. The blocks described here will usually provide good analgesia, even when the practitioner does them for the first time. Note that this book is not designed to describe the wide variety of regional blocks, even though they are remarkable tools when resources are scarce. Descriptions of nearly all the blocks you may need can be found at the New York School of Regional Anesthesia's free Web site: www.nysora.com/techniques/.

Scalp Block

The nerves to the forehead and scalp all run upward from about the line of the eyebrow anteriorly, and from the base of the skull posteriorly. Therefore, to block a region above this line you need only to inject a horizontal line of anesthesia below the area.[39] The key is to make the anesthesia line long enough to block the cross innervation from nerves that are lateral to the site of injury. A good rule for blocking the face and scalp is to block both sides unless the lesion is very far to one side.

Hematoma Block

Hematoma blocks can provide sufficient analgesia in the distal forearm and some areas of the face (such as the nose) to reduce fractures. Useful in both adults and children, it is easier to perform, but less effective than an IV regional block (e.g., intravenous regional anesthesia [IVRA], Bier block) for forearm fractures.[40] Nevertheless, if the necessary equipment or skilled personnel are not available to do IVRA, then a hematoma block offers a quick and easy method to obtain at least some, if not very good, anesthesia.

This block may be particularly useful in mass casualty situations, but it is not effective to treat fractures >24 hours old, since by then the hematoma has begun to organize.[35]

Technique

Palpate the fracture site and, under aseptic conditions, place the needle into the fracture hematoma. Aspirate to ensure that blood returns. Unlike other regional blocks, blood should be aspirated before injecting, to ensure that the needle is in the fracture hematoma so that the anesthetic can diffuse through it. Then, very slowly inject 5 to 10 mL of 2% lidocaine without epinephrine. Buffered lidocaine may cause less pain than unbuffered solution.

The block should take effect in approximately 5 minutes. This technique, useful both in adults and children, is most successful when applied as soon as possible after injury, as clotted blood will limit the spread of the analgesic. Infection is not thought to be a hazard if sterile solutions and apparatus are used and adequate skin preparation employed.[36] The US military has found it occasionally useful to use ultrasound to locate the hematoma and guide needle placement.

Intra-articular Anesthesia

If anesthesia (other than hypnosis) is needed to reduce a shoulder dislocation, an easy technique is to inject 20 mL of 1% plain lidocaine into the joint.[41,42] This must be done under aseptic conditions. The technique is remarkably simple, since the joint space is easily identified (it's where the shoulder used to be) and accessible. It is at least as effective as using narcotics and benzodiazepines for the reduction.[43]

Intravenous Regional Anesthesia

Intravenous regional anesthesia (IVRA) involves administering a local anesthetic into an upper or lower extremity while blocking arterial flow and venous return with an inflated cuff.[44] Used for more than 100 years, the technique is successful in >95% of cases. The advantages of this block, especially in austere situations, are that it is easy to perform, is not dependent on anatomical knowledge, requires minimal personnel, avoids the potential side effects of general anesthesia and systemic sedation, and provides rapid and complete anesthesia, muscle relaxation, and a bloodless field.[45] Disadvantages include the limited duration of anesthesia (60 minutes), the relatively large dose of local anesthetic required, and the fact that it provides no postoperative analgesia.

Method

Place an intravenous (IV) line in the hand or the foot, depending on which extremity requires anesthesia. One or preferably two inflatable cuffs are placed over padding on the proximal extremity and secured by wrapping strong adhesive tape around them so they do not accidentally come off when inflated. The extremity is then exsanguinated by lifting it straight up and then wrapping it tightly, distal to proximal, with an Esmarch or other elastic bandage. If placement of an elastic bandage on the extremity is too painful due to trauma, compress the axillary or femoral artery for 5 minutes with the extremity elevated.

While the extremity is still elevated and wrapped, inflate the most proximal of the cuffs to well above arterial pressure (palpated at the distal extremity) or, if there is an attached manometer, to at least 250 mm Hg. Use a hemostat to clamp the inflation tube on the cuff, since the valves tend to leak (Fig. 14-1).

Remove the constricting bandage on the extremity and slowly inject (60 to 90 seconds) 0.5 mL/kg 0.5% lidocaine without preservative or epinephrine for upper extremity procedures and 1 mL/kg for the lower extremity.[36,46] (Do not use more than 4 mg/kg lidocaine: For a 70-kg patient, this is 280 mg or 56 mL of 0.5% lidocaine.) The limb becomes blanched. At that point, inflate the more distal cuff (that is now over an anesthetized area) to the same pressure as the first cuff and deflate the first cuff. This usually reduces the patient's discomfort from the tourniquet.

Tourniquet pain usually begins about 20 minutes after single tourniquet inflation, although this can be delayed by using adjuvant medications (described in the subsequent text). Using the second, more distal tourniquet, significant pain typically occurs about 40 minutes after tourniquet inflation.[47] Tourniquet pain is usually the limiting factor for how long the block can be used.[44] There is also a minimum time for the tourniquet to remain in place. To prevent toxic effects from the anesthetic, do not release the tourniquet for at least 20 minutes after the injection, even if the procedure has been completed in less time. After 20 minutes, release the

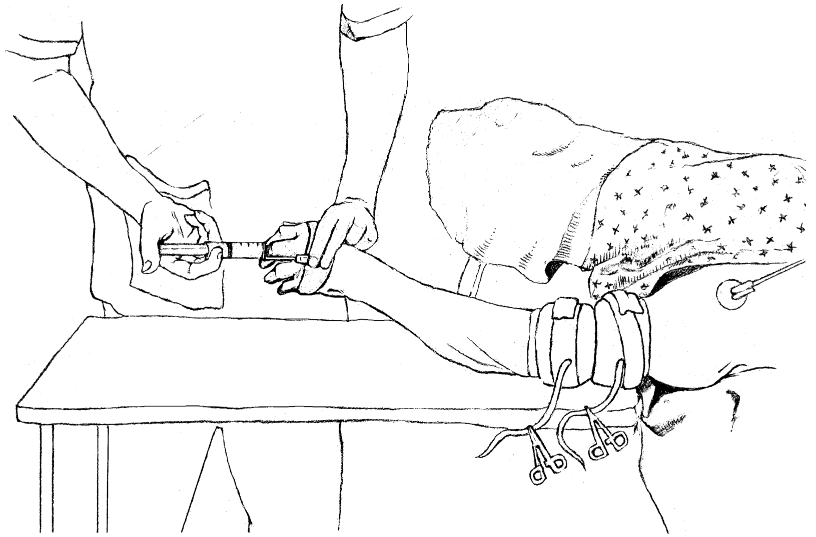

FIG. 14-1. Intravenous regional anesthesia using two blood pressure cuffs with tape wrapped around them for safety.

tourniquet for 5 seconds and reinflate it for 30 seconds three or four times. This permits the anesthetic to gradually be released into the circulation.

Because of the rapid reperfusion of the limb after tourniquet deflation, IVRA has typically provided minimal analgesia after surgery. Postoperative analgesia has traditionally been a major advantage of brachial plexus analgesia compared to IVRA.

This technique is contraindicated in patients with peripheral artery or sickle cell disease, with hypersensitivity to the anesthetic (although an alternative can be used), and with cellulitis at the injection site.[48]

Alternate/Improvised Methods

Improvised IVRA equipment can be fashioned from two normal blood pressure (BP) cuffs, enough adhesive tape to wrap completely around the cuffs several times so they don't "pop" off during the procedures, clamps for the BP cuff tubing so it doesn't leak during the procedure, an elastic bandage or similar elastic cloth (such as nylon stockings) to help exsanguinate the arm, an IV, a syringe, and the medications.

If BP cuffs are not available, you can use other cuffs, such as those often used to pressurize IV fluids. If there is no inflatable cuff, wrap a wide tourniquet around the extremity and use a dowel as a windlass to tighten it (similar to the tourniquets described in Chapter 21, Surgery/Trauma). The absence of a distal pulse that was previously palpable determines when arterial pressure has been exceeded. Carefully secure the windlass so it does not accidentally unwind during the procedure.

Forearm tourniquets may be an option for some distal upper extremity procedures. Several advantages are evident. Forearm tourniquet pain occurs later and is less severe than an upper arm tourniquet. In addition, approximately 50% less local anesthetic solution can be used with a forearm tourniquet, lowering the risk of toxicity. Finally, only half the amount of any adjuvant medication needs to be used to prolong the anesthetic effect or to decrease tourniquet pain.[36,47] Calf tourniquets work well for foot and ankle anesthesia. Use them in a similar manner to a forearm tourniquet. Concerns regarding increased risk of nerve injury or poor tourniquet function with a forearm tourniquet have never been substantiated.[47]

For very short foot or hand/wrist cases, a "super-low" IVRA method is applicable. Prepare the patient as usual and inflate the cuff on the upper arm or upper leg. Just before injecting the

TABLE 14-1 Local Anesthetics for Intravenous Regional Anesthesia

Anesthetic	Concentration (%)	Volume (mL)	Dose (mg/kg)	Severe Adverse Effects
Prilocaine	0.5-1	40-50	3-4	Methemoglobinemia
Lidocaine	0.25-0.5	40-50	3	Seizures
Bupivacaine	0.25-0.5	40-50	1.5-3	Cardiac arrest
Chloroprocaine	0.25-2	40-50	8	Thrombophlebitis
Ropivacaine	0.2-0.375	40-50	1.2-1.8	Seizures

Adapted with permission from Barry et al.[48]

anesthetic, place a 2-cm-wide rubber tourniquet, like the ones used to draw blood, above the wrist or ankle. Use about half the amount of anesthetic that would normally be injected for a standard IVRA. Both the upper leg and the upper arm tourniquet can be removed within 10 minutes. The benefit is that less anesthetic is used.[49] The drawback may be pain from the tourniquet.

Alternative Anesthetics

A number of other anesthetics can be used if lidocaine is not available. Prilocaine seems to be the safest, although it is now widely unavailable. When bupivacaine, rather than lidocaine, is used for Bier blocks, the block's onset is slower, but analgesia is continued for 3 to 4 hours into the postoperative period.[47,50] Alternative anesthetics used for IVRA are listed in Table 14-1.

Adjuvant Medications

A number of medications can be added to the injected solution to reduce the tourniquet and post-procedure pain associated with IVRA. They also decrease the amount of anesthetic needed.

Ketamine 0.1 mg/kg added to the anesthetic solution dramatically reduces tourniquet pain and decreases the need for paramedication during IVRA. Ketorolac (0.1 to 0.02 mg/kg, up to 20 mg) added during a standard IVRA reduces tourniquet pain and also provides 12 to 16 hours of postoperative analgesia. (There is no further benefit with larger doses.) Using a forearm tourniquet, 10 mg ketorolac IVRA provides even better postoperative analgesia than 20 mg of ketorolac does with an upper arm tourniquet.[47]

Adding clonidine (1 to 2 micrograms/kg) to IVRA significantly reduces tourniquet and postoperative pain. While better than local anesthetic alone, it is a less effective adjunct than ketamine.[47,48,51] Narcotics should not be added. It's not clear that they are beneficial, and all produce nausea, vomiting, and dizziness when the cuff is deflated.[47]

Abdominal Operations

Several options are available to provide anesthesia for abdominal surgery other than using general anesthetics. These include abdominal field blocks, spinal or caudal blocks, local infiltration, and "tie and cry." The benefit is that these methods may avoid the need to use muscle relaxants and controlled respiration, which may not be possible depending upon the available resources. These techniques are particularly valuable on operations in the lower abdomen.

Intra-abdominal

Local Abdominal Anesthesia

When patients are very ill and equipment, skills, or both are in short supply, consider using local anesthesia plus appropriate preanesthetic medication to do abdominal procedures. Allen wrote, "All simple operations, such as gastrostomy, gastrotomy, colostomy, appendectomy, and gall-bladder drainage, are quite satisfactorily performed on suitable subjects (when not too nervous or apprehensive) when the parts are fairly easily accessible, and not matted down by inflammation or adhesions to the parietal peritoneum or surrounding organs."[52]

Thin patients with relaxed abdominal walls are ideal for this type of anesthesia. However, "as a general rule all very stout individuals and those with tense rigid abdominal walls are difficult

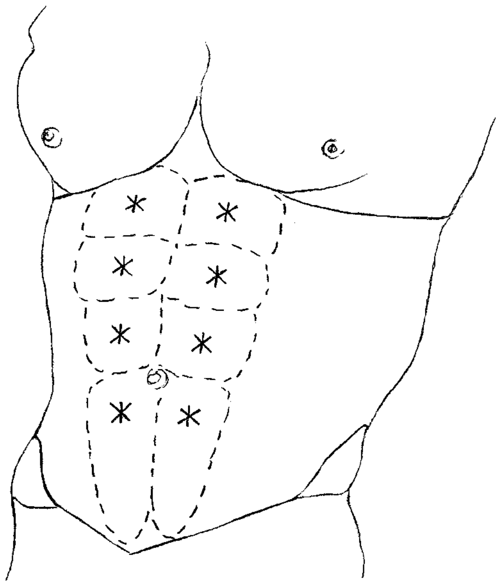

FIG. 14-2. Anesthetic for abdominal incision.

to handle in any serious intra-abdominal operation, for as soon as the abdomen is opened the contents bulge out."[52] During laparotomies using only a local anesthetic block, patients sense a vague intra-abdominal weight or fullness that becomes crampy if the surgeon puts traction or pressure on the internal organs. If you encounter an inflamed appendix or diseased gall bladder while using local anesthetic for a midline incision, make a separate incision to take them out rather than displacing them toward the midline.[52]

Field Block

Use a rectus muscle block to provide anesthesia for a laparotomy incision. This can be combined with sedation or light general anesthesia. To do the block, place anesthetic beneath the rectus muscle in each of its ten compartments (five on each side). Using a 20-gauge, 5-cm needle, enter the abdominal wall through anesthetic skin wheals (marked * in Fig. 14-2) raised at the center of each compartment. After aspirating, inject 10 mL of 0.5% lidocaine with 1:500,000 epinephrine at each site. Insert the needle vertically into each compartment, feeling the resistance from the anterior sheath as it is penetrated. After traversing the muscle, resistance from the posterior sheath is felt. At that point, after aspirating, inject the anesthetic. A midline or paramedian surgical incision line should also be infiltrated with 0.25% lidocaine with 1:500,000 epinephrine. This only blocks the abdominal wall for the incision. Blocking visceral reflexes requires the surgeon to block the vagus and the splanchnic plexus once the abdomen is open and the viscera mobilized.[36]

Braun's Method

Another method to anesthetize the abdominal wall for an abdominal midline incision is to inject around the field in a more-or-less rhomboid shape (Fig. 14-3, method illustrated on upper abdomen). Inject anesthetic two or three fingerbreadths on each side of the midline. Starting on this line,

> At two or more points, depending upon the extent of the proposed incision, a long needle is directed obliquely outward, injecting as it is advanced, piercing the rectus sheath, which is recognized by its slight resistance to the needle, and advancing some little distance within this muscle until it is quite freely injected; the needle is then partially withdrawn, when it is advanced again in two or more directions above and below, slightly increasing

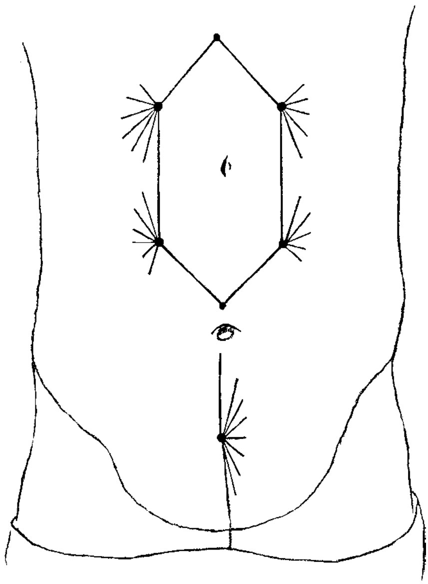

FIG. 14-3. Abdominal infiltration for laparotomy.

the angle each time, thus making the injection in something of a fan-like shape; this is done along the line of cutaneous anesthesia at two or more points, having the fan-like areas of infiltration come in contact with the one above or below. The same procedure is repeated on the opposite side. These two lateral lines of infiltration are joined above and below by subcutaneous infiltration.[52]

ALLEN'S METHOD

While Braun's method works well in thin subjects, a better technique in obese patients is to establish a wall of anesthesia along the proposed incision line from the skin to the peritoneum. Raise an intradermal wheal midway along the proposed incision line. Insert a long needle through the wheal and liberally inject anesthetic superiorly and inferiorly, and then into the rectus sheath on either side (Fig. 14-3, method illustrated on lower abdomen). As with the other methods, deeper injections are made once the abdomen is open.[52]

Inguinal Hernia Repair

Inguinal hernia repair is much more common in Third World countries than it is in the West. As one group of surgeons wrote, "Local anesthesia has been identified as the most favorable anesthesia for elective inguinal hernia repair with respect to complication rate, cost-effectiveness, and overall patient satisfaction… . All surgeons in resource-poor countries should be encouraged to use local anesthesia more frequently for elective inguinal hernia repair. Valuable resources in sub-Saharan African hospital could be saved, especially if used in combination with outpatient surgery."[53]

The simplest anesthetic technique for inguinal and femoral hernia repair is for the surgeon to continuously infiltrate the area of incision, then directly infiltrate the neck of the sac.[36] This infiltrate-and-cut or Vishnevsky technique was described earlier in this chapter.

Amid and colleagues describe a more precise method of using local anesthesia for elective hernia repair: (a) subdermal infiltration along the line of incision (approximately 5 mL), (b) intradermal injection along the line of incision (approximately 3 mL), (c) deep subcutaneous injection (approximately 10 mL), (d) subfascial infiltration immediately underneath the aponeurosis of the external oblique to anesthetize all three major subfascial nerves (approximately 8 to

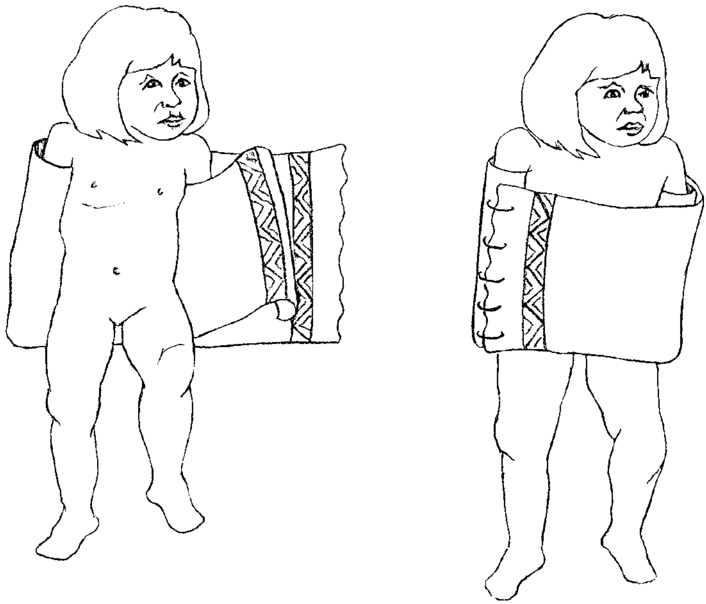

FIG. 14-4. Tie-and-cry restraint with sheet.

10 mL), (e) pubic tubercle and hernia sac injection—as much as required for complete anesthesia, and (f) splashing local anesthetic into the canal and in the subcutaneous space before closing to reduce postoperative pain (optional).[54]

Tie-and-Cry Method

Tie-and-cry anesthesia may be the safest way of anaesthetizing a child if there is no access to either special pediatric anesthesia equipment or ketamine. The general principle is that if your skills are limited, do only what is safe for the child.

While seemingly barbaric, under such circumstances, the safest anesthesia for an abdominal operation in a child weighing >15 kg is to use an intramuscular injection of midazolam 0.15 mg/kg or lorazepam 0.05 mg/kg. (Intramuscular diazepam has erratic absorption.) Combine this mild sedation with local lidocaine infiltration, being careful not to exceed the maximum safe dose.

Restrain the child by papoosing in a sheet (Fig. 14-4) or tying the arms and legs to splints or to a papoose board. Secure the child's limbs, but provide access to the airway, chest, and abdomen. The descriptive name for this procedure comes from the child remaining at least partly conscious and crying.

A problem with this technique, as with many abdominal cases using local anesthesia, is that returning the intestines to the peritoneal cavity may be difficult since the abdominal muscles are not relaxed. As King wrote, "Such anesthesia is far from ideal, but when anesthetic skills really are minimal, it probably gives the child the best chance of living. It really is a procedure for desperate emergencies only."[55]

Fascia-Iliaca (Ilio-fascial) Block

The fascia-iliaca compartment block (FICB) is an excellent method to relieve pain from a fractured hip and, in many cases, knee pain. The FICB is similar to the commonly used 3-in-1 block, although the FICB has been shown to be simpler to perform, safer (being distant from any major structures), faster acting, and more effective (at least in adults) for simultaneously blocking the lateral femoral cutaneous nerve of the thigh and the femoral nerves.[56] It is ideal for austere situations, since it can easily be done by novices, and remedies the difficult problem of analgesia without monitoring for fractured hips and femurs.

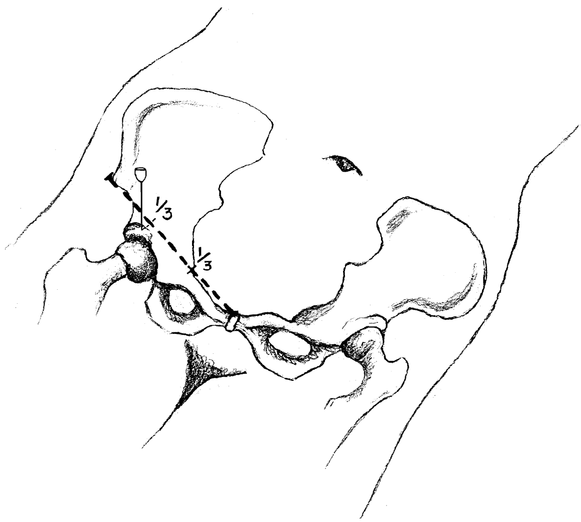

FIG. 14-5. Insertion point for the fascia-iliaca compartment block.

To do the block, place the patient in the supine position and identify the inguinal ligament. Prepare the skin and drape the site. Identify the (imaginary) line that joins the middle of the pubic tubercle to the anterior superior iliac spine. Find the point 1 cm below the juncture of the lateral and medial two-thirds of that line. Insert a 21-gauge, 2-inch injection needle perpendicular to the skin at that point (Fig. 14-5). Insert the needle until you feel a loss of resistance as the needle passes through the fascia lata. Keep advancing the needle until a second loss of resistance occurs as the fascia iliaca is pierced (often described as two "pops"). With an attached syringe, first aspirate to exclude intravascular injection, and then inject approximately 0.3 mL/kg of 0.25 bupivacaine or 1% lidocaine.[56]

Foot/Ankle Blocks

Blocking completely around the ankle at the level of the top of the malleoli (along with one deep injection to block the hallux [big toe] if necessary) completely blocks the entire foot.

A 4-cm-long, 23-gauge needle works for all injections. Low concentrations of local anesthetic (e.g., 0.25% bupivacaine) will suffice in most cases, since it's necessary to block only the smaller sensory nerves.[14]

All five nerves can be blocked with the patient supine, although it is often easier to block the posterior tibial and sural nerves with the patient prone and the foot hanging off the end of the stretcher. To block the posterior tibial nerve in a supine position, flex the knee and place the ankle on top of the contralateral shin. This allows access to the medial and lateral malleolus.

Plantar (Sole) Surface

All ankle blocks are at the level of superior portion ("top") of the malleoli. Enter at the border of the Achilles tendon and aim the needle toward the tibia (medially) and fibula (laterally). If the patient gets paresthesias with either insertion, withdraw the needle slightly and inject 3 to 5 mL of a local anesthetic, such as 0.25% bupivacaine. If not, for posterior tibial infiltrations, advance the needle until it contacts the tibia, withdraw 0.5 cm, and inject 5 to 7 mL of anesthetic. For the sural nerve, if the patient does not experience paresthesias, advance to the fibula and inject 5 to 7 mL as you withdraw the needle to the skin.

Dorsum of Foot

The three other blocks, all done from one injection site, anesthetize the dorsum of the foot. For all three blocks, insert the needle 1 cm lateral to the extensor hallucis longus tendon or just lateral to the anterior tibial artery, if it can be palpated.

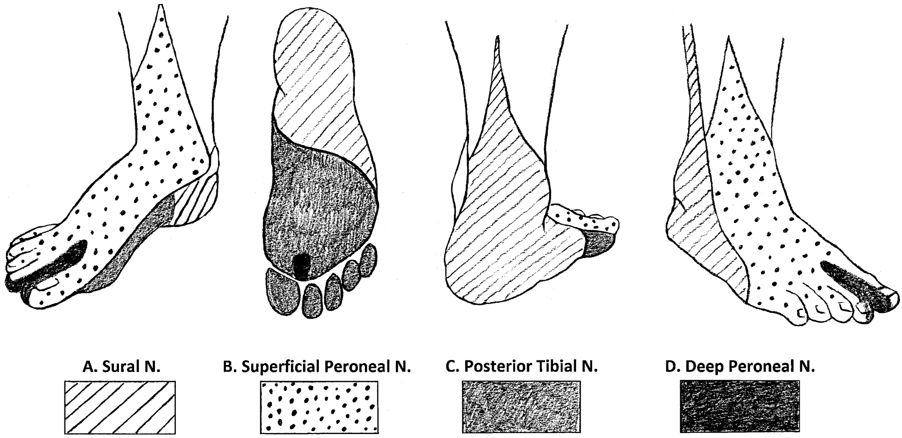

FIG. 14-6. Ankle and foot block anesthetic areas, A-D.

To block the deep peroneal nerve (blocking the area between the hallux and second toe; see Fig. 14-6, shading D), insert the needle at 90 degrees to the skin and inject 3 to 5 mL of 0.25% bupivacaine deep to the fascia on either side of the tibial artery. This is an important block for any surgery on the hallux, such as removing an ingrown toenail.

For the superficial peroneal nerve (most of the dorsal surface of the foot; see Fig. 14-6, shading B), withdraw the needle to just below the skin surface and aim it toward the lateral malleolus. Inject 5 mL subcutaneously between the lateral malleolus and the anterior border of the tibia.

To block the saphenous nerve (the medial malleolus area) inject 5 mL as the needle progresses toward the medial malleolus, trying not to enter the saphenous vein.[14]

Acupuncture

Acupuncture works well in the hands of clinicians with superb training in the technique. However, that is not true for treatment from those who dabble in it. Although the only necessary equipment is needles, the real requirement is skill and practice. Unfortunately, acupuncture is not a technique that a novice can improvise.

REFRIGERATION ANESTHESIA: AMPUTATIONS

Background

Direct application of cold to a body part can produce temporary anesthesia. For example, Baron Larrey, Napoleon's chief surgeon, reported that soldiers' wounds barely hurt and that amputations were "practically painless" if the limbs were exposed to the cold air. (The ambient temperature at the Battle of Eylau, February 1807, was –28°C [–18.4°F].) Arnott first used ice bags with salt to anesthetize limbs during surgery. In most settings, ice bags are preferable to, and more readily available than, cold exposure, although both work. Cooling also intensifies the action of all local anesthetics.[29]

In the early 1940s, surgeons at major US hospitals and in the US Navy found that they could perform lower extremity amputations on elderly and unstable patients using ice for intraoperative anesthesia and postoperative analgesia.[57]

Use

The following method provides complete surgical anesthesia for about 1 hour. The anesthesia is sufficient to perform extremity amputations without pain.[58,59]

This method is not truly a "freezing" technique, since the temperature of ice is 0°C (32°F), and a body's tissues have a freezing point below 0°C. In addition, a film of water at 0°C, rather than the ice, is in contact with the skin. After the ice has been applied for four hours, the skin temperature measures 20°C.[58]

Most often used on patients with infected or gangrenous limbs, refrigeration anesthesia has proved to be a safe option in aged and high-risk patients. Patients with ischemic limbs do the best with the technique, since the cooling does not drop their core temperature. (Little of the extremity's cold blood ever circulates. That's why the limb is being amputated.) Using this procedure, the general diabetic status of the patients did not deteriorate, even when the amputations were done through infected areas. The patients did well postoperatively, and they were usually hungry and ate soon after the operation. They generally had no appreciable change in their vital signs during refrigeration, the operative procedure, or postoperatively. Overall, the mortality and morbidity in these patients was reduced at major hospitals that used this method.[58]

Adjunctive Meds

Little adjunctive analgesia is necessary for this procedure. Some protocols routinely administered a narcotic before doing anything. In some cases, narcotics were administered as the leg was being manipulated or immediately after preoperative tourniquet placement, but that was rarely necessary.[57,58,60]

Nearly all patients experienced pain during only the first 15 to 20 minutes after immersion in the ice pack, before the extremity got numb. After this period, the patient often read, rested, or slept.[60]

Preparing for Refrigeration

Since the basic idea is to immerse the extremity in ice, a suitable container is needed. For feet and ankles, use a bucket. For more proximal surgery, a metal tank with a removable lid to add ice and a padded hole through which to place the leg is required. (A wooden box or a rubber bag—such as a body bag—can also be used, but these will deteriorate with repeated use.) The metal troughs (Fig. 14-7) have a round padded (with sponges or rubber) opening at their upper end, with a sliding top through which the extremity is inserted. At the lower end of the tank, there is a hole for drainage with a spigot, which can be closed when en route to the operating room.[57,60]

To prepare the supine patient, first protect his bed with a full-length rubber sheet and place a thin blanket under him for warmth.[60] Then elevate the limb and apply three bags of cracked ice to an area just above where the amputation is to occur. Secure them with a dressing; leave them

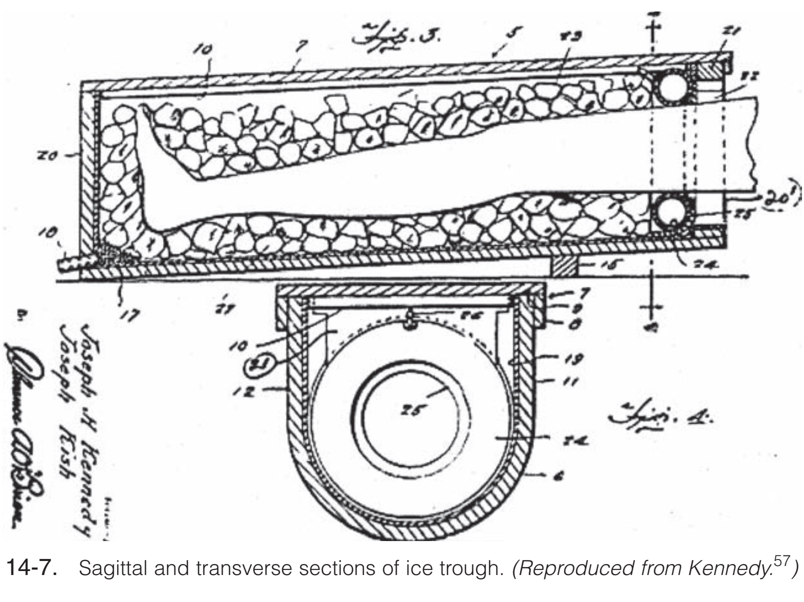

FIG. 14-7. Sagittal and transverse sections of ice trough. *(Reproduced from Kennedy.[57])*

in place for 15 minutes. This is where a tourniquet will be applied. Just before the 15 minutes are up, apply an Esmarch (or other elastic) bandage from above the area of inflammation to the tourniquet site.[57,58] Then immediately remove the ice bags, put cotton batting or a bandage over area to protect the skin, and apply the tourniquet.

Tourniquet

Wrap rubber tourniquets around the limb twice and secure with a surgical clamp. Some physicians apply two tourniquets, in case one loosens. Once the tourniquet is in place, remove the Esmarch bandage.[57] The tightness of constriction necessary to stop circulation differs with the patient, the location on the limb, and other variables. Difficulties seem to be less in the thigh, in spite of its thickness, than in the upper part of the calf, where the main artery is protected between bones.[59] It is unclear whether the tourniquet should be placed close to the amputation site, so as to leave the narrowest possible zone of chilled and bloodless tissue, or whether it can be placed higher, for example, above the knee for amputation through the calf.

Ice

Immediately after the application of the tourniquet, immerse the extremity in ice. If patients can sit up, those needing amputations of the foot and lower leg can immerse the area in a bucket of ice water and cracked ice. For amputations of the thigh, pack the extremity in finely cracked ice, with the patient lying in bed, and usually in one of the troughs described previously.

Using the trough, place a thin layer of chipped ice (approximately 1 to 2 inches deep) in the bottom. Gently place the leg on the ice, taking care that no sharp pieces pierce the skin. Place the tank as high into the groin as possible, using the padding for protection. Protect the genitals with a bath blanket or Turkish towel. Cover the entire limb with crushed ice (about 150 pounds is sufficient). The ice must extend to 2 inches above the tourniquet. Because of the size and awkward shape of the trough, it is difficult to anesthetize the upper thigh. However, you can form a pouch by pulling a rubber draw sheet through the hole in the upper end and then fill it with ice.[57,58,60]

Raise the head of the bed by placing small blocks under the bed frame at that end; this tilts the bed and facilitates drainage from the foot of the bed (Fig. 14-8). The bevel in the ice

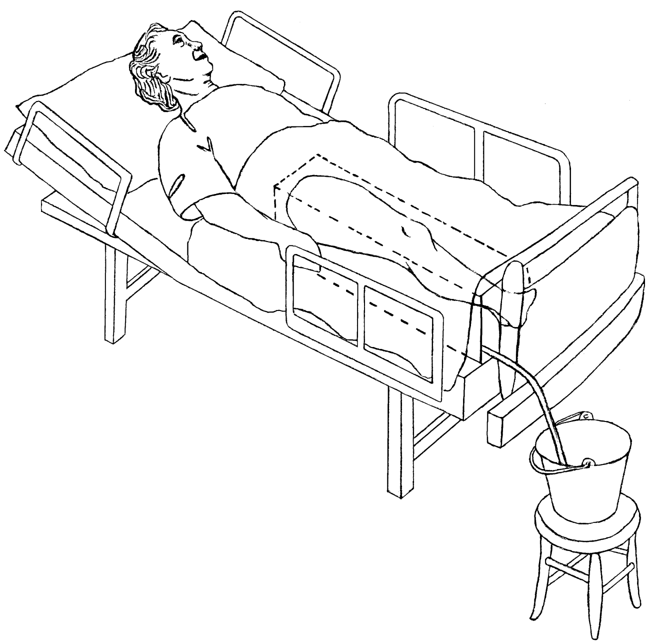

FIG. 14-8. Ice-box drainage system. *(Redrawn from Van Blarcom.[60])*

container at the proximal end may be used as a urinal or bedpan.[57] Place hot water bottles (120°F[49°C]) around the genitals and along the unaffected leg to protect them from the cold. Use care to prevent burning the patient. Remake the top of the bed with a bath blanket next to the patient.[60]

Since the metal tank "sweats," wrap it in a large rubber sheet with a hole connected to a tube going to the bucket at the foot of the bed.[60] Completely cover the tank by drawing the large rubber sheet around it.

It is prudent to inspect the limb one or more times 20 or 30 minutes after beginning refrigeration. Blanching of the foot is the rule, especially if the leg was elevated before applying the tourniquet. If any sizable arteries remain open, the foot will be darkly cyanosed, and the tourniquet should be readjusted. Any influx of blood makes for incompleteness or delay of anesthesia.[59]

The optimum length of preoperative refrigeration varied with the amputation level. In the typically thin, weak patients with arteriosclerosis, the optimum length of preoperative limb refrigeration for amputations at the thigh was 2 to 2.5 hours[57-59]; for disarticulation at the knee or through the middle of the leg, 2 hours; for the lower half of the leg or the foot, 1.5 hours[58,59]; and for the metatarsus or the toes, 1 hour.[59] The limbs were examined at intervals, and ice was added as necessary.

Operating Room

Bring the patient to the operating room (OR) with the extremity in ice.[58,60]

When the surgical team is ready, place the patient on the table and unpack his extremity from the ice. Remove the limb from the ice, dry it off, and it is ready for amputation. Do not remove the tourniquet, but prepare the extremity as usual and amputate. If the tourniquet is properly applied and securely fastened and the chilling is continuous to all parts at the correct temperature, there is complete local anesthesia so that the patient is not aware when the nerve is cut or the bone is sawed.[59]

After removing the limb, ligate the large vessels, remove the tourniquet, and then ligate other small bleeders. It is imperative to use cold instruments and cold normal saline solution in the procedure. About half of the cases are closed without drains. In the face of definite infection, the stump can either be drained or be left open.[58]

Postoperative Care

The usual dressing consists of one layer of petroleum jelly gauze across the wound, then a few layers of dry gauze, surrounded by bare ice bags. For example, place one bag beneath the stump and two sloping tent-like bags at the sides to avoid pressure on the limb.[59] Pain can usually be controlled with the ice bags and a small bandage over the incision.[58]

The nurses should prepare the routine postoperative bed for the patient, who is often placed in a semi-Fowler's position immediately. Because no nausea or shock is present, the patient can immediately begin progressing to a normal diet.[60]

Gradually warm the wound over several postoperative days. One method to raise the temperature is to make the dressings a little thicker each day.[59] Another is to apply three ice bags to the stump for the first 24 hours, then two ice bags for the second 24 hours, and one ice bag for the third postoperative day.[57]

Both the degree and the duration of cooling are entirely empiric, guided by the wound's appearance.[59] The warming time for the extremity depends upon the blood supply and the degree of infection present. In the presence of good blood supply, remove the ice bags in 24 hours. Infection increases the time of postoperative thawing.[58] Sutures are normally left in for an unusually long time, since healing is slowed proportionally with the low temperature.[59]

Crossman and colleagues found that no harm was caused by either the duration or the extent of refrigeration. Tourniquet marks were visible for a day or two without significance; neither contractures nor paralysis was seen. Likewise, there was no sign of thrombosis or other damage to blood vessels, and no special tendency to necrosis or infection indicating lowered tissues resistance.[59]

TESTING AN ANESTHETIC BLOCK

Testing an anesthetic block is a two-edged sword. Boutlon advised that

> Elaborate testing of the block with needles is undesirable. A patient will tolerate a surgical incision felt by him as light touch on a numb area and will be surprised and pleased when he is told that the operation is in progress but, if he is repeatedly asked, 'do you feel that', before or at the start of the procedure, he will give a positive answer even if he feels only the slightest sensation because he loses confidence thinking that the doctor himself is unsure of the efficiency of the block. Testing should be surreptitious; if a needle is boldly inserted through the skin of the surgical area, and the patient does not react, all is well![36]

In practice, minimal testing, such as touching the skin with the back of the scalpel at the incision point, allows the patient an opportunity to receive additional anesthetic, if needed.

SPINAL ANESTHESIA

Spinal anesthesia is an excellent, safe technique that has a wide range of uses, especially in austere situations. One caution in hypovolemic or seriously ill patients is that spinal blocks cause vasodilation. A rule of thumb is first to give patients 500 to 1000 mL normal (0.9%) saline (NS). At that point, if a patient's pulse rate is higher than their systolic blood pressure, do not use this technique.[61]

Spinal anesthesia is one procedure you might not be willing to do without prior experience. Non-anesthesiologists who have experience performing lumbar punctures (spinal taps) may be able to provide anesthesia with these blocks with little difficulty. Administering epidural blocks requires some prior hands-on experience under supervision.

Medications for Spinal Anesthesia

Local anesthetic agents are either heavier (hyperbaric) or have the same specific gravity (isobaric) as the cerebral spinal fluid (CSF). Hyperbaric solutions tend to spread down (due to gravity) from the level of the injection, while isobaric solutions are not influenced in this way. It is easier to predict the spread of spinal anesthesia when using a hyperbaric agent. Isobaric preparations may be made hyperbaric by the addition of dextrose.

Any medication injected into the thecal space must be taken from a previously unopened vial. Do not use anesthetics from multi-dose vials, as they contain potentially harmful preservatives and solutions may be infected from prior use.

Lidocaine and bupivacaine are commonly used for spinal anesthesia, although tetracaine and procaine are used occasionally if the procedures are very short (procaine) or very long (tetracaine). They usually come as regular (isobaric) or "heavy" (hyperbaric) solutions (Table 14-2).

TABLE 14-2 Medications for Spinal Anesthesia

Hyperbaric (Heavy)	Isobaric (Regular)	Dose (mg)*	Usual Volume (mL)*	Time Until Block Effects Diminish (minutes)	Time Until Block Effects Are Gone (minutes)
Tetracaine 0.5% in 5% dextrose	Tetracaine 0.5% in NS	5-20	1-4	90-140	240-380
Bupivacaine 0.75% in 8.25% dextrose	Bupivacaine 0.75% in NS	5-20	1-3	90-140	240-380
Lidocaine 5% in 7.5% dextrose	Lidocaine 5% in NS	25-100	1-2	40-100	140-240
Procaine 10% in water	Procaine 10% in NS	50-200	1-2	30-50	90-120

*Lowest doses are for saddle blocks.
Abbreviations: NS, normal saline.
Data from Covino et al[64] and Barash et al.[65]

TABLE 14-3 Spinal Levels and Technique for Various Procedures

Spinal Level	Procedure	Solution and Patient Position
L1-L2	Perianal, perirectal	Hyperbaric solution, sitting position, - *or* - Isobaric solution, lying horizontally
T10	Lower extremity and hip Genitourinary (e.g., TURP) Vaginal/cervical	Isobaric solution
T6-T8	Herniorrhaphy Pelvic procedures Appendectomy	Hyperbaric solution, lying horizontally
T4-T6	Abdominal, C-section	Hyperbaric solution, lying horizontally

Data from Barash et al.[65]

Administering increasing amounts of the same anesthetic preparation results in higher levels being blocked.[62] The amount of anesthetic needed varies with the medication used, the level to be blocked, and whether the medication is isobaric or hyperbaric. Even with the same amount and type of medication, however, the level blocked varies with the patient's position and characteristics (age, height, weight, pregnancy, sex), site and speed of injection, and direction of the needle's bevel.[63] Table 14.3 lists typical types of solutions and patient positions to block the appropriate levels for several typical surgical procedures.

If available, isobaric bupivacaine 0.5% is best for lower limb surgery. It provides longer anesthesia than lidocaine. Hyperbaric 0.5% lidocaine or bupivacaine is useful for lower abdominal and pelvic/urogenital surgery. Add 5% glucose (D_5W) to the anesthetic to make the heavy solution, if it is not premixed. Dependent on gravity, hyperbaric medications localize based on the patient's position.

A number of alternative local anesthetics can be used for spinal anesthesia. If standard solutions are not available, modifying some of these medications with epinephrine, dextrose, or NS may be necessary.

Bupivacaine 0.5% hyperbaric (heavy bupivacaine) is the best agent to use if it is available. Plain (isobaric) 0.5% bupivacaine can also be used. Bupivacaine usually lasts from 2 to 3 hours. Cinchocaine 0.5% hyperbaric (heavy) solution is similar to bupivacaine.

Lidocaine/lignocaine achieves its best results when using a 5% hyperbaric (heavy) lidocaine solution. This lasts 45 to 90 minutes. Isobaric lidocaine 2% can also be used, but it has a shorter duration of action. Add 0.2 mL epinephrine 1:1000 to lidocaine to prolong its duration of action. Mepivacaine, if used as a 4% hyperbaric (heavy) solution, is similar to lidocaine.

Tetracaine 1% solution can be prepared with dextrose, NS, or water for injection. It has a long duration of action.

If typical spinal anesthetics are unavailable, use meperidine/pethidine 5% solution (50 mg/mL), which has local anesthetic properties and is a versatile agent. The standard IV preparation is preservative-free and isobaric. A dose of 0.5 to 1 mg/kg is usually adequate for spinal anesthesia. It has a rapid onset but can also wear off quickly.[66] Using meperidine is less expensive than using bupivacaine for spinal anesthesia.[67]

Technique

Premedicate the patient, if possible. Some patients may be very anxious about being awake during surgery, especially for amputations or other mutilating procedures. Do a lumbar puncture with the needle's bevel facing toward the patient's head. (While the official doctrine is to have the bevel aimed laterally, experienced anesthesiologists have found that this forces the needle to move laterally as it passes through the tissues. [Denny Bastrom, MD, oral communication, September 1, 2008.]) If a caudal (saddle) block is desired, place the patient in the sitting position.

To reduce the incidence of a post-spinal tap headache, use a large intramuscular injection needle as an introducer through the skin and muscle, if a Sise introducer is unavailable. Insert the needle through the interspinal ligament (not through the dura) and then pass a small-gauge spinal needle through this larger needle. However, before doing this, be certain that the first needle is large enough to allow the spinal needle to pass through it. Insert the needle through the dura into the subarachnoid space, keeping the bevel lateral.[68]

When CSF appears, immobilize the needle by resting the back of the nondominant hand firmly against the patient while using the thumb and index finger to hold the needle's hub. Tightly attach the syringe with the anesthetic to the needle. Hyperbaric solutions are viscous and, with a high resistance to injection, may spill if the syringe is not firmly connected. Gently aspirate to check if CSF can still be withdrawn; then slowly inject the local anesthetic. Once injected, withdraw the needle.[66]

Hyperbaric solutions tend to settle in the dependent portions of the sac, while isobaric solutions usually will stay where they were injected, diffusing slowly in all directions. When hyperbaric agents have been used, putting a patient "head-down" can cause the block to extend cephalad for about 20 to 30 minutes after it was performed.[66] Using this principle, a saddle (perineal) block using a hyperbaric anesthetic is best done in the sitting position, with the patient remaining in that position until the anesthetic level has become "fixed."[62]

Testing the Spinal Block

To test the block's effectiveness, ask the patient to lift her legs. If she can't, the block is at least at the level of the mid-lumbar region. To test sensation, first test for a loss of temperature sensation using an ether or alcohol-soaked swab. Touch the patient's chest or arm where they can feel the cold swab. Then test the legs, moving up to the lower abdomen until the patient again feels the swab's coldness. If this is ambiguous, gently pinch blocked and unblocked areas until the level can be ascertained. Do not touch the patient and ask, "Do you feel this?" Touch sensation may persist even if there is no pain.[66]

Several problems can occur with spinal blocks: having no apparent effect, being too low, affecting only one side, or being too high. Note that moving a patient in any way in the first 10 to 20 minutes following injection increases the height of the block.

No Block

If the patient still has full power in her legs and normal sensation after 10 minutes, repeat the block.

Not High Enough

If using a hyperbaric solution, tilt the supine patient head down so the solution runs up the lumbar curvature. Also, raise the patient's knees to flatten the lumbar curvature. If using a plain solution, turn the patient 360 degrees, from supine to prone, and back to supine.

One-Sided or Too Low on One Side

If using a hyperbaric solution, place the patient on the inadequately blocked side for a few minutes and tilt the table into a slightly "head-down" position. If using an isobaric solution, place the patient on the side that is blocked.

Too High

While rare, this can occur quickly. These patients often complain of difficulty breathing or of their arms or hands tingling. Do not tilt the table "head-up." Get help; this is life-threatening. Treat this by monitoring, assisted ventilation, treating hypotension (raising legs and using a vasopressor, such as ephedrine or phenylephrine), and treating bradycardia (atropine first, then ephedrine or epinephrine).

EPIDURAL BLOCKS

For those experienced in doing epidural blocks, some improvisation may be necessary. For example, since the block should be done using a fairly thick needle with a rounded, not-too-sharp point, if a standard Touhy needle with a Huber point is not available, make one by bending the end of an ordinary spinal needle at a 45-degree angle. Grind off the tip so that only a small part of the bent end remains and then smooth it with a grindstone or file. Be certain that the lumen remains open so that the plastic catheter can pass through.[68]

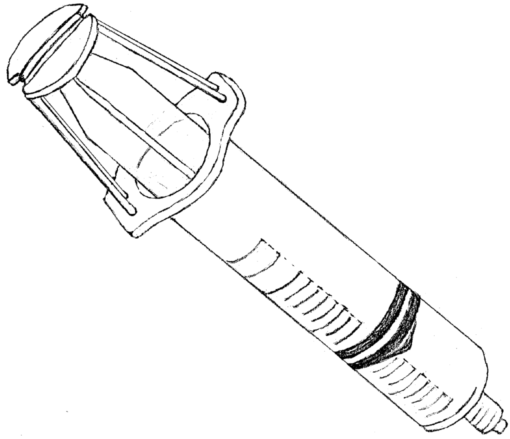

FIG. 14-9. Improvised epidural syringe.

A simple and cheap alternative to the standard spring-loaded syringe to identify the epidural space can be easily improvised (Fig. 14-9). Make two wedge-shaped slots on opposite sides of a standard disposable syringe plunger. Then carefully make two holes on each side of the syringe barrel's flange. The holes on each side and the slot in the plunger should line up. Cut a rubber band, pass it through one set of holes, and insert the ends through the holes on the other side of the syringe. Tie the rubber band's ends. Then slip the rubber band over the top of the plunger, lodging it in the plunger's slots so it doesn't slip off.[69]

If a standard epidural medication is not available, ketamine may be used either alone or as an adjunct to local anesthetics. Using ketamine greatly prolongs the analgesia provided by single-shot epidural techniques, although preservative-free ketamine preparation must be used to avoid neurotoxicity.[70]

HYPNOSIS

Hypnosis is perfectly suited to be an anesthetic technique in austere circumstances. Easy to learn, the technique requires no equipment, has a rapid onset, can be used for anesthesia and analgesia, and has no complications. Additionally, patients can later use it themselves for post-procedure pain relief.

Hypnosis, a state of wakeful suggestibility, has been used for millennia in medical and religious practices under various names. In the 19th century, the English surgeon John Elliotson and the Scottish surgeon James Esdaile performed hundreds of surgical procedures with hypnosis as the sole anesthetic, with decreased mortality compared with other methods.[71] On the battlefield, Podiapolsky found that nearly all wounded soldiers, no matter what their nationalities, responded "with exceptional facility" to hypnosis, although he did not use it for major operations.[72]

Hypnosis is being used successfully to anesthetize patients for a wide variety of operations and procedures requiring conscious sedation.[73,74] Much of the benefit is due to the patient's relaxed state and to distraction, rather than to specific suggestions to not feel discomfort.[38] Potential symptom-oriented uses of hypnosis include: (a) to treat possible conversion reactions; (b) to treat pain associated with dislocation and fracture reductions; (c) to treat acute stress reactions, posttraumatic stress disorders, and factitious seizure; (d) to relieve the anxiety of needle phobias; (e) to treat the pain of burns; (f) to treat headaches; (g) to prepare patients for surgery, pelvic or post-rape examinations, or labor; and (h) to relieve pain and anxiety prior to emergency department (ED) procedures, such as suturing or incisions and drainage. If no other option exists, it can also be tried as anesthesia, although it works best as an adjunct to low-dose anesthesia.[41,42]

Technique

Although practitioners use many methods for inducing hypnosis, physicians and emergency medical services personnel have found the following method extremely easy to learn and use. The process is described to the patients as a way to relax, so any misconceptions they have about hypnosis will not interfere with their cooperation.[41,42] As Boulton described it, "In the particular context of 'difficult circumstances' hypnosis is often best practiced without the patient being aware that it is being employed; all that is necessary is that the patient should not be actively hostile to the technique. A tranquil and secure atmosphere and warm, comfortable conditions are important in promoting the successful practice of hypnosis."[36]

The clinician first explains the concept of patient and clinician cooperation, frequently described as permissive hypnosis. This helps allay the common adult fear of domination, control, or coercion by the clinician; children rarely experience this.[41,42]

During the "preinduction" phase, rapport is established with the patient. (In adults having prior experience with or exposure to hypnosis, their experiences and the relationship between this technique and their experiences are discussed.) A key element in all cases, but especially in a noisy prehospital or ED environment, is to reinforce that the patient should listen only to the clinician and that the process will proceed at the patient's pace without pressure. The clinician should speak in a firm, quiet manner, in no way reacting to any of the noisy or distracting activities in the immediate vicinity.[41,42]

Induction

Begin by instructing the patient to close his eyes and to relax. Unlike adults, children in stressful conditions are already considered in Stage 1 hypnosis, and so are generally more susceptible to hypnotic suggestions. The patient is then asked to concentrate on his toes, imagining/producing sensations of heaviness and pleasant warmth in the limbs as "all of the muscles in your toes relax." For most people, feelings of heaviness are easier to imagine than warmth, but this is not consistent. The clinician should continue to suggest both sensations. A significant amount of time (30 to 45 seconds) is spent helping the patient to concentrate on and relax the toes. If this can be accomplished, the remainder of the procedure is much easier.[41,42]

The clinician then suggests that the patient feel the warmth or heaviness flow up into the feet, then the legs, thighs, and so forth. A significant indication that the technique has been successful is the regularization of the patient's breathing. A suggestion to the patient at this time should be to slow their rate of breathing and further allow the entire body to relax. Suggest that with each exhalation, the patient will become more and more relaxed. The patient is then told that he will feel relaxed, sleepy, and will "travel in your mind to a very pleasant place, perhaps a beach or mountain." A suggestion can be made that the patient will not remember the process of and pain during the upcoming procedure.[41,42] Then do the procedure.

Testing the depth of hypnosis is pointless in a clinical setting; results are what matter. The key is whether the patient cooperates with the procedure, relaxes enough (e.g., joint reductions), or has diminished pain.

Emergence

The techniques related to getting patients to emerge from a hypnotic state may not be needed. If hypnosis is being used alone for the manipulation associated with reducing forearm fractures (or joint dislocations), the patient normally arouses immediately following the procedure. However, if a posthypnotic suggestion for pain relief or selective amnesia has been given, this still may be in effect. It can be reversed before the end of hypnosis, if desired.[41,42]

For those patients in very deep hypnosis (~15% of patients), it may be necessary to deliberately awaken them at the end of the procedure. The simplest method is to say: "I am going to count to ten and your eyes will open and you will feel perfectly normal. 1, 2, beginning to wake, 3, 4, lighter and lighter, 5, 6, eyes beginning to open, 7, 8, nearly awake, 9, 10, quite awake."[36]

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15 | Sedation and General Anesthesia

INTRODUCTION

The following vignette provides an excellent picture of typical operating room (OR) anesthesia in a resource-poor venue[1]:

> John, an anaesthetic clinical officer, is administering a general anaesthetic [and] performs a rapid sequence induction with thiopental and suxamethonium and intubates using his own laryngoscope and a tracheal tube that has been used dozens of times before … John carries all his own equipment with him, along with a supply of drugs for the day—anything left in theatre will disappear by tomorrow. Normal saline is running in through an 18G cannula that the patient's family were asked to buy from the local pharmacy.
>
> John administers 50 mg of pethidine—this may be the last analgesic the patient receives until the unpredictable visit of the night matron to the ward in 9 h time—and turns up the OMV [Oxford Miniature Vaporizer] to deliver 2% halothane. The inspired concentration must be estimated clinically because the halothane "expired" 8 months ago and the clinical effect is unpredictable. The EMO [Epstein-Macintosh-Oxford] vaporiser and a bottle of ether are on stand-by behind the anaesthetic machine, as we are down to our last bottle of halothane…. The modern anaesthesia monitor, looking out of place in these surroundings, was purchased, along with eight others, by the European project. The screen has a psychedelic tinge to it and I suspect it is on its last legs. The capnograph trace is flat, as the last remaining moisture trap has been "borrowed" for use in ICU, where it will be circulated around the four beds. The ECG trace is true, but periodically interrupted as the long out-of-date electrodes require a small drop of thiopental to improve their conductivity. The oximetry probe is a paediatric one and roughly taped with grubby Elastoplast around the man's little finger.
>
> John ventilates the patient using the Oxford Inflating Bellows as part of a draw-over system, aiming to keep him deeply anaesthetised and apnoeic using a high concentration of halothane. There are no muscle relaxants apart from suxamethonium. Emergency drugs, atropine and adrenaline, are drawn up on a redundant Boyle's machine, which acts as a trolley and equipment store. A lone size H oxygen cylinder is deep in dust in the corner and has been empty for several years.
>
> John requests a nasogastric tube, so I head to the locked anaesthetic store room where 10 or so years of unsorted donations to the department have piled up. After 15 min, I find one at the bottom of a box of out-of-date NG feed. I can tell by the look on his face that John is torn between using this valued commodity for this patient or saving it for the next.

Anesthesia in Austere Circumstances

Anesthesia's three principal functions are to keep the patient alive through surgery, to make surgery painless, and to provide the best possible surgical conditions.

The purpose of this chapter and, in fact, this entire book is illustrated by two questions that Drs. Boulton and Cole posed in their series entitled, "Anaesthesia in Difficult Situations"[2]:

1. What would I do if had to give an anesthetic and operate on a patient in an isolated hospital 100 miles from the nearest outpost of civilization?
2. What would I take on an expedition to the Arctic … or in the Himalayas … or on a ship … or to an area of devastation following an earthquake or nuclear holocaust?

This chapter and the next are for clinicians who may need to administer anesthesia in austere situations with limited supplies and equipment. These chapters highlight medications that can safely be used by non-anesthesiologists (e.g., ketamine), little-used anesthetics that are generally available in austere situations (e.g., IV ethanol), and anesthetics available in austere settings that are not familiar to younger anesthesiologists from industrialized nations (e.g., ether, halothane), as well as classic basic methods of delivering anesthesia (e.g., open-drop). Those trained in anesthesia obviously are more familiar with these medications and techniques than are other clinicians. The key to providing safe and effective anesthesia is to use equipment and techniques that employ the skills you already possess.

Standards and Shortages

Although international standards for anesthesia administration exist, the norm is that shortages of trained anesthesiologists, equipment, and medications limit how these standards can be implemented.

Scarcity of Trained Anesthetists/Anesthesiologists

A worldwide shortage of trained anesthetists means that in developing countries, other practitioners, including physicians, dentists, nurse practitioners, physician assistants, and paramedics, may need to provide general anesthesia with limited additional training and with minimal supervision.

The basic rule of thumb is that "a practitioner faced with the necessity of giving an emergency anesthetic, perhaps for the first time since his student days, is well advised to stick to a technique which he has at least seen used at one time or another." If an experienced anesthetist must supervise or manage multiple inexperienced practitioners giving anesthesia, which may be the case in many situations, "the technique employed would have to be as simple as possible so that it could be quickly taught."[2]

Commonly, the clinician must be both the surgeon and the anesthetist. In these cases, the rule is "use local and regional methods where you can. If you have to give a general anesthetic, secure the patient's airway and make sure that there is [an IV] running before you start. With a clear airway and [an IV line], most of your problems will be over. Induce and intubate the patient yourself, and don't operate until anesthesia is stable."[3] During the procedure, have an assistant monitor the patient by continually checking the blood pressure (BP) and the pulse using an esophageal or precordial stethoscope.[3,4] (See Chapter 5, Basic Equipment, for how to improvise these devices.)

Medication Standards and Scarcity

The World Health Organization (WHO) lists what they consider to be the essential medications for anesthetic care, although cost and supply problems may limit the anesthetics and associated medications (Table 15-1) that are available for local, regional, and general anesthesia.

GENERAL ANESTHESIA GUIDELINES

Goals of General Anesthesia

Administering general anesthesia provides three benefits: (a) hypnosis, putting the patient to sleep; (b) analgesia, relieving pain; and (c) relaxation, easing the muscles sufficiently to perform the procedure, primarily in abdominal and some orthopedic cases.[6]

Safety

An anesthetist's primary goal is to anesthetize patients and have them recover without ill effects from the anesthesia. Whether this happens depends a great deal on the anesthetist's abilities and how carefully he follows the rules for safely anesthetizing patients (Table 15-2).

Essential Elements

Four of the five essential elements for general anesthesia may need to be improvised or omitted in austere situations: premedication, monitoring, induction medications, and oxygen. Additionally, alternative maintenance drugs (anesthetics) or delivery methods may need to be used.

Premedication

Premedication provides mild sedation for the patient and counteracts some side effects, primarily excess salivation and increased vagal tone.

A wide variety of narcotics, benzodiazepines, phenothiazines, and other medications may be used for premedication. Try to use sedating anticholinergics (e.g., those with antihistamine activity) if the normal medication cannot be used. Premedications are usually administered parenterally, but many may be given orally.

TABLE 15-1 Availability of Anesthetic and Related Medications in the Developing World

	Percentage of Anesthetists With Medications Available		
	Always (%)	Sometimes (%)	Never (%)
Nitrous oxide	—	3	92
Naloxone	9	16	60
Neuromuscular blocking agent	15	12	69
Neostigmine	16	6	69
Magnesium	19	38	39
Blood for transfusion	23	59	16
Labetalol	29	29	30
Hydralazine	30	34	30
Halothane	38	16	39
Spinal local anesthetic	39	28	30
Narcotic (IV/IM)	45	30	21
Vasopressor	45	21	28
Succinylcholine	54	23	19
Oxytocin	57	31	7
Thiopental	59	24	15
Oxygen	63	25	10
Ether	68	20	9
Intravenous fluid	68	27	2
Local block anesthetic	70	18	7
Epinephrine	74	18	3
Diazepam	81	17	—
Ergometrine	81	14	1
Atropine	84	6	6
Ketamine	92	3	4

Abbreviations: IM, intramuscular; IV, intravenous.
Data from Hodges et al.[5]

Promethazine 50 mg (1 mg/kg) tablets (which also have anticholinergic activity) can be used in adults for nausea and very mild sedation. Give promethazine about 2 hours before anesthesia. This medication is particularly good if ketamine is used as a general anesthetic. Diazepam tablets, 10 to 20 mg (0.15 to 0.25 mg/kg), can be used as a tranquilizer before either regional or general anesthesia. Oral diazepam has a more rapid and reliable onset than does intramuscular (IM) diazepam.[8] Diphenhydramine (Benadryl) is cheap, and almost always available. It can be given parenterally or orally, and is both sedating and anticholinergic.

Considered by many anesthesiologists to be the only essential preoperative medication, atropine 0.4 to 0.6 mg dries secretions and diminishes vagal tone on the heart. Atropine may be administered IM 30 to 40 minutes before induction or diluted and given IV immediately before anesthesia.[6] Atropine can also be administered orally in tablet form (0.5 mg in an adult) at least 20 minutes before the general anesthetic is administered. There is no harm if the patient takes it with a small amount (~20 mL) of water.[8]

TABLE 15-2 Ten Rules for Safely Anesthetizing Patients

1.	Assess the patient carefully to be aware of any underlying medical condition or medication that might interfere with the anesthesia or surgery.
2.	If possible, keep the patient NPO for ≥6 hours before the procedure. (Modify for infants and small children.) Small sips of water taken with a preanesthetic medication are acceptable. Also consider this course for procedures done under local or regional blocks, since you may have to switch to using general anesthesia during the procedure.
3.	Use a tilting OR table, so that you can put the patient in a head-down position if there is a risk of emesis. During surgery, turning the patient on his side may not be an option.
4.	Check available drugs and equipment before you start. The truism is that, whatever you don't have available or that doesn't function properly will be what you need in a crisis.
5.	Have suction instantly available. This is the most-often-neglected piece of equipment. Check that the parts are assembled, the equipment is turned on or ready to be quickly turned on, and the vacuum works. When you don't have suction available, it is almost certain that you will need it—quickly.
6.	Keep the patient's airway clear. Use a nasal or an oral airway, as needed. If the patient doesn't need it, he will spit out an oral airway.
7.	Be ready to control ventilation. No matter what anesthetic you use (including ketamine), you may need to assist ventilations with a BVM, with or without a controlled airway device such as an LMA or ET tube.
8.	Have an IV running. This is not only therapeutic, but also an excellent precaution if something goes awry. In a crisis, it is far easier to begin administering medications or fluids through an established IV than to struggle to insert one.
9.	Continually monitor the pulse, BP, and skin color (and the color of any blood from the surgical site). A precordial or esophageal stethoscope, a BP cuff that is used on a regular basis (q5min), and good observation are all that is required for basic monitoring.
10.	Have an assistant in the room who can help in an emergency.

Abbreviations: BP, blood pressure; BVM, bag-valve-mask; ET, endotracheal; LMA, laryngeal mask airway; NPO, nothing by mouth; OR, operating room.
Data from King.[7]

Basic Monitoring

In austere situations, anesthesia with only the most basic monitoring (even more basic than what you're thinking) is the norm. Often the only monitoring is checking the pulse: either constantly with an esophageal or precordial stethoscope (improvised models of both instruments are described in Chapter 5, Basic Equipment) or at least every 5 minutes while taking a BP. You can also monitor the pulse by laying a finger just anterior to the tragus of the ear to feel the superficial temporal artery pulsate. Also, monitor the patient's skin color, capillary refill, and the color of any blood from the surgical site, since this requires little or no apparatus. A wisp of cotton taped near the nostril is a useful indicator that the patient is still breathing.[6]

Esophageal stethoscopes are particularly important during thoracic procedures. Only one earpiece is needed, although a modified stethoscope can also be used. Precordial stethoscopes (that can also be placed over the back) are particularly important to use during procedures on babies. Likewise, only one earpiece is needed, but the bell should be securely taped to the patient before the procedure begins.

Induction

Both IV and inhalation agents are often used for induction. Ketamine needs no induction agent.

Benzodiazepines, although not often used for induction, can be used for this purpose. Diazepam, often the most readily available benzodiazepine, can be used as an IV induction agent, although it has a longer onset and longer duration (i.e., longer "hangover") than most other agents.[9] The newer benzodiazepines generally work faster and have shorter half-lives.

The most feared complication during induction is laryngospasm. Since a neuromuscular blocking agent may or may not be available, provide constant positive pressure with an anesthesia bag or a *bag-valve-mask* (BVM). This normally breaks the spasm. If not, spray the cords with lidocaine, and be prepared to do a cricothyrotomy (rarely needed).

Oxygen

In austere situations, oxygen is frequently unavailable, and so is considered a luxury. If oxygen is scarce, use it only to preoxygenate patients who will undergo brief apneic procedures, to induce and intubate small children[10], and to supplement anesthesia at altitudes >9000 feet (2743 meters). Also provide it for patients with laryngospasm, acute desaturation, significant anemia (Hgb <9 g/dL), or heart or lung disease, and to those in shock.[9]

Also consider using oxygen when (a) inducing anesthesia in a patient using ether and air; (b) giving anesthesia with more than 8% ether; (c) doing a Cesarean section (C-section), but use only until the baby is delivered; (d) patients have any respiratory disease or considerable airway secretions; and (e) the preoperative BP has fallen by >30%.

Stages of Anesthesia

Theoretically, all patients may go through four stages (plus substages, or planes) of anesthesia, no matter which agent is used (Table 15-3). Ether is the anesthetic that shows all the classic stages, so the pattern with ether is described more fully under "Ether" in Chapter 16, Anesthesia: Ketamine, Ether, and Halothane.

When anesthesia is given with basic equipment and few medications, tracking anesthetic stages can be a useful safeguard against over-medication.

Anesthetics vary widely in their effects, so staging must be used with the particular drug's effects in mind. The general pattern follows the oversimplified, but useful, concept that anesthetics suppress the central nervous system from above downward, as blood concentration increases. This progression (stages) is based upon the patient's body movements, respiratory rhythm, oculomotor reflexes, and muscle tone. The classic anesthetic stages are detailed in the following paragraphs.

TABLE 15-3 Signs of General Anesthesia Stages and Planes (Levels of Stages)

Stage	Plane	Respiration	Response to surgical stimulus	Eye signs	Cardiac
I. Analgesia		Voluntary control	Voluntary control	Voluntary movement	Adequate output
		Consciousness Lost			
II. Excitement (Delirium)	1. Early	Irregular Coughing* Spasm	Actively purposeful*	Lash reflex goes* Variable movement	Possibly arrhythmias
	2. Late	Phonation Breath holding*	Weakly purposeful*	Disconjugate gaze	
III. Surgical Anesthesia	1. Light	Regular*	Absent	Lid reflex gone*	Adequate output†
	2. Moderate	Adequate		Eyes fixed*	
	3. Deep	Tracheal tug‡		Pupil dilated*	Hypotension†
IV. Medullary Paralysis		Absent*		Pupil of anoxia*	Good contraction†
Death					Cardiac arrest

*Applicable to all anesthetics.
†Applicable only to ether.
‡Paradoxical respiration.
Adapted with permission from Boulton.[6]

Stage 1: Analgesia

There is suppression of the highest cerebral centers, with the patient gradually losing the sensation of pain. Patients remain conscious and rational, and have decreased pain perception. Muscle tone, breathing, and pulse are normal. Stage 1 anesthesia is indicated for obstetric analgesia, and as a supplement to local anesthesia for minor procedures.

Stage 2: Excitement (Delirium)

This stage begins when patients lose consciousness and become excited, struggle, and (possibly) become difficult to control. Patients retain their gag reflex and can protect their airway, although they breathe irregularly and may hold their breath. Their pupils generally become dilated. Their abdominal muscles contract during expiration. They lose their eyelash reflex and have roving eye movements and dilated but reactive pupils. They retain reflex responses to any painful or irritating stimuli, including noxious anesthetic vapors.

Stage 3: Surgical Anesthesia

In this stage, patients no longer respond to painful stimuli. Muscular relaxation progressively increases, spontaneous respiration diminishes, and patients lose their protective gag reflex. Non-anesthesiologists need only recognize two planes: acceptable ("Light") and too deep.[11]

PLANE: LIGHT SURGICAL ANESTHESIA

This is the optimal anesthetic level for most patients during surgery. Patients' breathing becomes regular again, although they will inspire deeply every 2 to 3 minutes. The eyes no longer move and, as the anesthesia level deepens, the pupils gradually dilate. The patient no longer moves and muscular tone decreases. The abdomen and chest move synchronously. An artificial airway or endotracheal (ET) tube may be inserted in this plane—but not earlier.

PLANE: DEEP SURGICAL ANESTHESIA (TOO DEEP)

In this plane of anesthesia, patients' intercostal muscles become progressively paralyzed, eventually having paradoxical movement (moving in with inspiration). Sudden inspirations pull on the mediastinum and trachea, drawing it downward (the "tracheal tug"). Patients' pupils become progressively less reactive to light. Abdominal surgery is actually very difficult at this anesthesia level if the patient is not pharmacologically paralyzed.

Stage 4: Medullary Depression (Way Too Deep)

During stage 4, the brainstem's respiratory center becomes depressed, which causes patients to stop breathing and lose all muscle tone. Their pupils are fixed and dilated. The heart may (as with chloroform) or may not (as with ether) be dangerously depressed.[6] If a patient stays in this stage too long, his heart stops and he dies.[11]

ANESTHESIA IN SPECIAL CIRCUMSTANCES

Trauma Patients

Assume that all trauma patients have full stomachs; the elective anesthesia standard of "nothing-by-mouth (NPO) for six hours" is a pure fantasy. Airway control, preventing aspiration, and being prepared to provide anesthesia immediately to hypovolemic, unstable patients optimize trauma anesthesia.

Altitude and General Anesthesia

High altitude (arbitrarily considered to be above 3000 meters or 10,000 feet) and extreme cold may affect anesthesia delivery. Three types of individuals may present for anesthesia at high altitude: the unacclimatized newcomer, the acclimatized newcomer, and the resident native.

Patients

The unacclimatized newcomer, who has been at altitudes above 3000 meters for less than 4 months, is in an extremely unstable physiological state, and initially may suffer from acute mountain sickness (e.g., high-altitude pulmonary edema, high-altitude cerebral edema).[12] This makes sedation and general anesthesia precarious, at best.

Acclimatized newcomers may also be in danger of pulmonary edema. They have probably acquired similar physiological characteristics to the natives, including polycythemia, hypervolemia, increased pulmonary blood volume, pulmonary hypertension, right ventricular hypertrophy, and increased diffusion capacity. Nevertheless, give oxygen to these patients during any emergency surgery and, if at all possible, return them to sea level for surgical treatment.[12]

Resident natives, who were born and live at altitude, are capable of exhaustive physical exercise despite their often plethoric, cyanotic, and barrel-chested appearance. After visiting lower altitudes for a few days, however, they too may get acute pulmonary edema on returning to altitude.[12]

Anesthetic Agents

The conduct and choice of anesthesia and analgesia at high altitudes depends on three factors: (a) the patient's pathophysiological state, (b) the decreased oxygen tension due to low barometric pressure, and (c) the peculiarities of inhalational agents. With some modifications, particularly the addition of oxygen, general inhalation anesthesia may be administered.[13]

When preparing to deliver general anesthesia above 3000 meters (approx. 10,000 feet), try not to use any drug that depresses the respiratory center. If you must use such a drug, reduce the dose of premedication. The increase in respiratory tract secretions at high altitudes, especially when using ether, suggests using higher doses of atropine even though that risks increasing preexisting tachycardia. Provide careful fluid replacement because of the increased risk of pulmonary edema.

During surgery, use oxygen supplementation, if available, on all anesthetized patients. To achieve an oxygen tension equivalent to that at sea level (150 mm Hg), 32% supplementation is required at 3000 meters (approx. 10,000 feet) and 42% at 5000 meters (16,500 feet). However, unsupplemented ether–air anesthesia has been successfully used at altitudes of 2500 to 3000 meters.[12] On the other hand, nerve blocks and anesthetic infiltration may be limited by the vasoconstriction accompanying hypothermia.[13]

Consider using IV ketamine, since at doses of 2.0 mg/kg, it produces a dissociative anesthesia while not depressing the hypoxic drive or interfering with the pharyngeal or laryngeal reflexes. Use supplemental oxygen when available, especially during recovery, for less-acclimatized individuals.[14,15] Avoid using N_2O.

Equipment

Both anesthetics and the associated equipment work progressively less well as the altitude increases. The practical limits for general inhalation anesthesia are not precisely known, but, whenever possible, surgery should not be performed at altitudes higher than 4000 meters (~13,000 feet).[16]

Extreme Cold and General Anesthesia

Use caution when giving general anesthesia—or doing surgery—in extremely cold environments. Aside from the obvious problem of IV fluids freezing if not properly insulated, vasoconstriction reduces the size of veins, which makes IV placement difficult and reduces the absorption of drugs injected subcutaneously. Increased static electricity and open-flame heating units may augment the explosive hazard of the inhalational agents. To humidify the extra-dry air, use an IV infusion set to deliver normal (0.9%) saline (NS) at 2 to 4 drops/minute through a very fine hypodermic needle inserted into the connector between a BVM and the patient's ET tube.[13]

PROCEDURAL SEDATION

What Is Sedation?

While sedation implies that patients have a depressed consciousness rather than being asleep, there is often little difference between procedural sedation and short-term general anesthesia, except that the former usually does not include the use of neuromuscular blockade or invasive airways (e.g., ET tube or *laryngeal mask airway* [LMA]). The similarity between the two is highlighted in the ASA's description of sedation levels (Table 15-4).

Uses

In the acute, outpatient setting, the most common reasons to sedate patients are for fracture reductions/treatments, joint relocations, laceration repairs, and lumbar punctures. The fewest

TABLE 15-4 American Society of Anesthesiologists' Sedation Levels

	Minimal Sedation	Moderate Sedation	Deep Sedation	General Anesthesia
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response following repeated or painful stimulation	Unarousable even with painful stimulation
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

Data from Godwin.[17]

complications occur with ketamine (0.7% of cases), propofol (0.8%), or morphine (2.9%). The most complications occur when the sedative is hydromorphone (9.7%), fentanyl (9.5%), midazolam (6.4%), or etomidate (6.2%).[18]

Sedation is often used for pediatric procedures. However, if a practitioner does not have the skills or the appropriate medications and equipment to sedate the child safely, "tie and cry" (see Fig. 14-4) with liberal use of local or regional anesthesia is a more prudent way to proceed.[19]

Medications

Various medications can be used for sedation, depending upon their availability and the clinician's comfort level and experience using them. These include ketamine, narcotics, ethanol, benzodiazepines, and propofol (Table 15-5).

Ketamine

Ketamine is often used for sedation, especially in children, and is discussed in Chapter 16, Anesthesia: Ketamine, Ether, and Halothane.

Narcotics

Using IV narcotics to a point short of anesthesia is a valuable technique to know when "extreme emergency" conditions are physically dangerous to both the patient and clinician.[2,6] An initial dose of l0 mg of diluted morphine or 50 mg of meperidine will give you an idea of the patient's reaction, but at least 30 mg of morphine or 200 to 300 mg of meperidine may be required before adequate sedation is achieved if local anesthesia is not used simultaneously.[6] Maintaining an adequate airway may become a problem when using this method.

TABLE 15-5 Agents Commonly Used for Conscious Sedation

Medication	Side Effects	Route	Total Dose*	Onset	Duration
		Barbiturates			
Methohexital†	Respiratory depression, Hypotension	IV	0.75-1.00 mg/kg	45 sec	5-10 min
		PR	20-30 mg/kg	8-10 min	45-60 min
Pentobarbital†	Respiratory depression, Hypotension	IV	2.5 mg/kg	45 sec	15 min
		IM	2.5 mg/kg	10-15 min	NA
		PO/PR	2-6 mg/kg	15-60 min	1-4 hr
Thiopental†	Respiratory depression, Hypotension	PR	25 mg/kg	10-15 min	1-2 hr

TABLE 15-5 Agents Commonly Used for Conscious Sedation (*Continued*)

Medication	Side Effects	Route	Total Dose*	Onset	Duration
			Benzodiazepines		
Midazolam	Respiratory depression	IV (<5yr)	0.05-0.1 mg/kg; then titrate to 0.6 mg/kg	2-3 min	30-60 min
		IV (6-12yr)	0.025-0.05 mg/kg; *then* titrate to 0.4 mg/kg	2-3 min	30-60 min
		IM	0.1-0.15 mg/kg	2-20 min	1-2 hr
		PO	0.5-0.75 mg/kg	15-30 min	60-90 min
		PR	0.25-1 mg/kg	10-30 min	45-90 min
		Nasal	0.2-0.5 mg/kg	10-15 min	45-60 min
Diazepam	Respiratory depression	IV	0.15-0.2 mg/kg	1-5 min	
		PO	0.15-0.2 mg/kg	30 min	
		PR	0.2 mg/kg	3 min	
			Opioids		
Fentanyl	Respiratory depression	IV	2 mcg/kg	1-2 min	20-30 min
Morphine	Respiratory depression, Hypotension, Nausea, and Vomiting	IV	0.1-0.2 mg/kg	1-5 min	3-4 hr
		IM/SQ	0.1-0.2 mg/kg	30 min	4-5 hr
			Other sedative agents		
Chloral hydrate†	Prolonged sedation	PO/PR	25-100 mg/kg; *may repeat* 25-50 mg/kg after 30 min	15-30 min	1-2 hr
Ketamine	Post-emergence delirium	IV	0.5-1 mg/kg	1 min	15 min
		IM	4 mg/kg	3-5 min	15-30 min
		PO	5-10 mg/kg	30-40 min	2-4 hr
		PR	5-10 mg/kg	5-10 min	15-30 min
		Nasal	3-6 mg/kg	5-10 min	15-30 min
Propofol	Respiratory depression, Hypotension	IV over 20-30 sec;	0.5-1 mg/kg	30 sec	<5 min
		then repeat boluses, *or*	0.5 mg/kg prn	30 sec	5-15 min
		IV Drip	0.05-0.1 mg/kg/min	30 sec	5-15 min
Etomidate	Myoclonus, Nausea, Respiratory depression, Adrenocortical suppression	IV	0.15-0.2 mg/kg	30 sec	5-15 min

Abbreviations: IM, intramuscular; IV, intravenous; NA, not available; PO, by mouth; PR, per rectum; SQ, subcutaneous.
*Doses should be administered in fractional boluses (e.g., one-quarter to one-half) and titrated to effect.
†Particularly useful for sedation during diagnostic imaging.
Data from Spitalnic et al[20], Green et al[21], and other sources.

Ethanol

Since ancient times, ethanol (ETOH) has been a known soporific.[22-24] Intravenous alcohol has been used successfully as an anesthetic induction agent for nearly a century.[25] In the 1960s, Dundee used an 8% (weight/volume) solution prepared by adding 110 mL of 95% ethanol to a 1-L bag of Hartmann's solution (similar to lactated Ringer's solution). Its pH was about 6.4. Each otherwise healthy adult patient received just over 500 mL of the solution. Of those receiving a strong opiate (meperidine) and often pentobarbital as a premedication, 70% could be induced with ethanol–nitrous oxide and 60% had the surgery completed with only these medications. He found that the onset of sleep with ethanol induction was accompanied by a progressive fall in oxygenation (PaO_2) and that any post-ethanol delirium could be rapidly controlled by small IV doses of benzodiazepines.[26]

Benzodiazepines

Benzodiazepines can induce relaxation and cooperation, and often provide an amnestic response. Titrate doses (Table 15-5) to patient tolerance depending upon the patient's age, the patient's other illnesses, the use of additional medications, and the procedure's complexity. Significant respiratory depression can occur, but is more common if these medications are combined with opiates. The two most commonly used medications in this class are midazolam (best) and diazepam (most readily available worldwide).

Midazolam is short-acting, with a short recovery period. A dose of 0.02 mg/kg to 0.1 mg/kg IV typically produces sedation in 2 to 3 minutes, with the clinical effects lasting from 10 to 30 minutes. In elderly or debilitated patients, use lower doses, since these patients may be more sedated and have longer recovery periods at lower doses. Repeat doses until the desired effect is achieved. Side effects include dose-related respiratory depression, especially in elderly patients, patients with chronic obstructive pulmonary disease (COPD), or patients who have taken alcohol, barbiturates, opioids, or other central nervous system depressants. Hypotension can be significant in hypovolemic and elderly patients. Midazolam has no analgesic activity. It crosses the placenta and enters breast milk.[27]

Diazepam is also used for conscious sedation. However, because of its long half-life, it may be difficult to titrate and may provide a duration of action that is longer than desired. Compared to midazolam, diazepam poses greater risk for phlebitis, has less associated amnesia, and has erratic absorption if given IM. If no other sedative agent is available, it may be useful, especially if given orally about 30 minutes prior to a procedure.

Propofol

Propofol, due to its high cost, will often be unavailable in austere settings. If it is available, use it in increments of 0.5 mg/kg every 60 seconds IV until the desired effect is achieved and to maintain that level of sedation. Because of its pharmacokinetics, oral administration will not sedate the patient. (Angela M. Plewa, PharmD, personal communication, April 8, 2008.) Similarly scarce will be the popular ketamine-propofol combination (ketofol), which is a 1:1 mixture of ketamine 10 mg/mL and propofol 10 mg/mL titrated in 1- to 3-mL aliquots to attain deep or dissociative sedation.

INTRAVENOUS GENERAL ANESTHESIA

Introduction

One method of administering IV agents is to use a syringe attached to an in-line three-way stopcock. This allows frequent administration of anesthetic boluses; a reservoir of additional anesthetic is in the IV bag/bottle. If supplies are limited and there has been no backward gross contamination from the patient (which is probably more common than realized), only the IV needle and the extension tubing flowing from the three-way stopcock to the patient need be changed between patients.[6]

Narcotics, ketamine, and short-acting barbiturates can be used in this fashion.

How much to give? In resource-scarce situations in which patients do not receive neuromuscular blockade, slight movements of the fingers or toes indicate a need for supplementary anesthetic injections [28]

Neuromuscular Blockade

Do not even consider using a neuromuscular blocking agent unless you are highly proficient at obtaining (and have the equipment to control) an airway using several means (e.g., BVM, intubation, LMA, and cricothyrotomy).

If a neuromuscular blockade (NMB) is to be used, it may be important, especially for those not experienced in giving general anesthesia, to know whether the patient is awake. During surgery, paralyzing a patient who is awake is not, to say the least, good medical practice. The "isolated arm test" can help to determine whether a patient is awake. Just before administering the NMB, inflate a BP cuff on one arm to about 30 mm Hg above the systolic pressure, effectively isolating that arm from blood flow. Ten minutes after giving the NMB, ask the patient to signal to you by squeezing your hand or moving his thumb. If he does it, he is not asleep. Then, of course, deflate the BP cuff and either put the patient to sleep or stop the procedure—or both.[29,30]

GENERAL INHALATION ANESTHETICS

Overview

This section is designed only for clinicians who are highly experienced in airway and critical care monitoring and management. Optimally, general anesthesia will be administered only by clinicians experienced in delivering anesthetics, although that may not be possible in resource-poor situations. The most common inhalation anesthetics used in resource-poor settings are discussed in Chapter 16, Anesthesia: Ketamine, Ether, and Halothane.

Basic Pharmacology

Inhaled anesthetics pass through the lungs, enter the circulation, and produce anesthesia in the brain. Anesthetics that are more soluble in blood, such as ether, take longer to act (induction) and to wear off (emergence; recovery). Those, such as N_2O, that are relatively insoluble in blood have much faster induction and emergence.

Shortages

Ether (most portable) and halothane (inexpensive) are the inhalation agents commonly used in Africa and other places where resources are limited. Other inhaled anesthetics commonly used by anesthesiologists in developed countries, including N_2O, are generally not available. As Boulton noted, "In all isolated situations, the most likely commodities to be in short supply are composed medical gases. Not only are cylinders heavy and bulky and difficult to transport in regions where communications are limited, but they provide relatively few 'anesthesia-hours' in proportion to their bulk in comparison with volatile agents vaporized in ambient air."[2]

Cost

Both logistics and cost affect the availability of anesthetic agents. The following are approximate costs for common anesthetics, which vary greatly by region; some are also available from chemical supply companies.[31,32]

Chloroform—$27.00 (100 mL)
Halothane—$50.00 (200 mL)
Ether—$5.00 (500 mL)
Procaine—(for injection) $1.66 (20 mg/2 mL)
Ketamine—$7.69 (500 mg/10 mL)

Anesthesia Machines

In austere circumstances, improvising even the most basic methods of delivering anesthetic gases is vital, since more modern anesthesia machines may not be available. So-called "portable" anesthesia machines may not really be so portable in rough terrain. As Boulton and Cole pointed out, "If the only available transport is the flat-footed anesthetist himself, even such apparatus as the EMO [Epstein-Macintosh-Oxford] air-ether outfit, which weighs 25 lb (11 Kg), or the 'Haloxair' halothane-air-oxygen apparatus [at] 13 lb (6 Kg) may prove to be intolerably heavy. In such a circumstance, the anesthetist might well prefer [a very] simple apparatus or even a resuscitator bag and intravenous drugs alone."[2] A can of ether and a mask, of course, weigh much less than any of these, and they don't even take much backpack space.

Using Volatile Agents

Anesthetic gases can be used for both the induction and the maintenance phases of anesthesia. Alternatively, an IV induction agent or a faster-acting volatile agent (e.g., chloroform to induce ether) can be used, followed by an anesthetic gas for maintenance.[33] Intravenous inductions are done with the agents discussed previously in "General Anesthesia Guidelines: Essential Elements." Take great care not to cause respiratory depression from the synergistic action of the induction agent and the inhaled anesthetic.

Inhalational induction requires a seal between the face and the mask for the gas to be drawn through the vaporizer. If there is no seal, the patient will breathe room air around the mask and remain conscious. In adult anesthesia it is relatively easy to coax a mask on the face and still keep the patient calm and cooperative."[34] Premedicating patients, especially anxious ones, assists the process.

Use in Closed Spaces

Using anesthetic gases is problematic in closed spaces, such as on a ship or in "closed down" conditions such as might occur after a nuclear, chemical, or biological attack or contamination. This situation becomes more dangerous when using open methods, such as open-drop ether. Try to eliminate as much of the ambient anesthetic as possible.[35]

Nitrous Oxide

Nitrous oxide (laughing gas; N_2O), in combination with oxygen, is a commonly used anesthetic gas in developed countries. It has a sweet, pleasant aroma (although to a patient, it appears odorless in the presence of the smell from the anesthesia mask) and, when inhaled, it is absorbed by the body and has a calming effect. Normal breathing eliminates N_2O from the body. Nitrous oxide has a rapid onset and recovery. It is a good analgesic supplement for halothane and reduces the incidence of awareness. It produces minimal cardiovascular and respiratory effects.

A World War I physician described the benefits of nitrous oxide: "Nitrous oxide is particularly useful for multiple short procedures in mass casualty situations. Induction and emergence take a matter of seconds rather than minutes and most of the patients can walk out of the OR alone or with minimal assistance."[36]

The main problem with N_2O is that it will usually be unavailable in situations of scarcity, since it is expensive to produce and transport. Anesthesiologists familiar with disaster and austere environments believe that N_2O should not be used due to the logistical nightmare of supplying it, the possibility of errors when using it, the high cost, and its tendency to diffuse into air-containing spaces, such as pneumothoraces, the gut, middle ear, and ET tube cuff.[33,35]

At least 50% N_2O must be delivered to be effective. It is delivered to the patient through a rotameter (a clear tapered tube with a float inside that is pushed up by flow and pulled down by gravity) and is mixed with oxygen to produce an inspired mixture of not less than 30% O_2. A hypoxic gas mixture may result from using it with an oxygen concentrator. Nitrous oxide should not be used in draw-over circuits and should never be given to a patient with an untreated pneumothorax or who has been scuba diving within the previous 24 hours due to the potential for decompression sickness.[33] Some places may have cylinders of a 50% mixture of nitrous oxide in oxygen, primarily used for self-administered outpatient analgesia.

RECTAL ANESTHESIA

Rectal anesthesia, sedation, or analgesia (see also Chapter 13, Analgesics) is relatively uncommon, although it has been shown to be effective in children for "preinduction" sedation. This method requires less technical skill and equipment than IV or IM drug administration.

A major limitation of this method is the poor predictability of the clinical effects. These are determined by the anatomical properties of the patient's rectum and, owing to individual variance, the result is inconsistent anesthetic absorption and elimination.[37] Using hydrophilic solutions and larger volumes with lower concentrations results in improved absorption by enlarging the mucosal surface in contact with the drug.

In clinical practice, rectally administering anesthetic medications is more common for procedural sedation or as an anesthetic premedication, where a lighter stage is needed and the exact timing of medication onset is not as vital. The medication can be delivered to children via a lubricated tip of a small (14-Fr) suction catheter or nasogastric tube. A similar-sized urethral catheter also works, as does simply using a syringe and holding it there for 2 or 3 minutes. Medications for sedation and anesthesia that can be used rectally include the benzodiazepines, barbiturates, and ketamine. Ether, although not commonly administered by this method, is also an option.

Doses and Method

- *Midazolam* 1.0 mg/kg (preinduction): Administer at least 30 minutes, but no longer than 90 minutes, prior to anesthetic induction.[38]
- *Methohexitone* (Methohexital): Administer 15 mg/kg of 10% methohexitone for anesthetic induction or for short procedures.[39]
- *Ketamine* 10 mg/kg: This medication has a delayed onset. Ketamine occasionally causes respiratory distress and, at the recommended 10 mg/kg rectal dose, may result in prolonged postoperative sedation if used for brief procedures.[37,40]

ANESTHESIA FOR CESAREAN SECTIONS

A common, but somewhat dangerous situation is for the surgeon doing the Cesarean section (C-section) also to administer the anesthetic. If this is the only option, employ one of the methods (described in the following paragraphs) using ketamine. Other methods include local infiltration (described in the subsequent text), spinal anesthesia (discussed here and also in Chapter 14, Anesthesia—Local and Regional), or epidural anesthesia for those having experience with the technique. In these cases, having a trained assistant to monitor and care for the patient throughout the operation is vital.

Local Infiltration

The main advantages of using local anesthesia infiltration in austere situations are that it is safe, inexpensive, and uses few resources. Especially for mothers in poor condition and those who are hypotensive, local anesthesia may provide the best safety margin, especially if adjunctive sedatives are not used. Epinephrine added to the anesthetic reduces local bleeding. However, using local infiltration requires significant operator experience, and even then, it may not be completely effective. It also takes time to administer.[41]

Technique

Determine the maximum safe anesthetic dose and, if not premixed, add 0.1 mL epinephrine 1:1000 to each 20 mL of anesthetic to make a 1:200,000 solution. If available, give oxygen to the mother until delivery. Using a 10-cm (4-inch) needle, infiltrate two long bands of skin on either side of the proposed incision line. Keep the needle parallel to the skin; remember that the abdominal wall is very thin at term—do not stick the needle into the uterus. Infiltrate the rectus sheath after incising the skin. To anesthetize the parietal peritoneum, inject 10-mL anesthetic under the linea alba. Then inject 5 mL more into the loose visceral peritoneum of the uterus where the incision will be made.

Collins provided some additional advice: “Reassure the patient and explain that after the local anesthetic has been given, she will still feel certain sensations of touch. She may experience discomfort if the head is well engaged in the pelvis. However, the anesthetic will prevent her feeling significant pain.”[41] Giving additional sedatives or analgesics, while desirable from an anesthetic standpoint, may adversely affect the baby. It is optimal to give nothing until the cord is clamped, after which small doses of narcotic or sedative may be used.

Ketamine

Ketamine is contraindicated in pregnancy before term, since it is oxytocic and is a US FDA fetal-risk category C drug. It is also relatively contraindicated in patients with eclampsia or preeclampsia. When the woman goes into labor, ketamine 10 mg to 20 mg IV can be used to provide analgesia. It can be repeated every 2 to 5 minutes, but do not administer >1 mg/kg in 30 minutes; the total dose should not exceed 100 mg.[14]

While ketamine may be used for vaginal delivery, only an experienced anesthetist who can adjust the dose according to the circumstances should use it.[42]

Ketamine is often used for C-sections because it has some unique advantages: (a) There is less discomfort than with spinal or epidural anesthesia for patients in advanced labor. (b) Although ketamine crosses the placenta easily and concentrations in the fetus are the same or higher than those in the mother, its use results in less fetal and neonatal depression than with other anesthetics.[14-16] (c) Babies have good APGAR scores, even after periods of neonatal asphyxia—an important consideration when limited neonatal resuscitation equipment is available. This depends in part on the skill and speed of the surgeon.[43] However, be careful with the dose, since a dose above 2 mg/kg may cause both respiratory depression and chest wall rigidity in the newborn.[44] (d) Uterine contractility is unimpaired, so there is less danger of postpartum hemorrhage. (e) Ketamine supports maternal blood pressure, which may be important in the face of significant hypotension.[14] This blood pressure increase can be ameliorated for those with eclampsia by using hydralazine or similar medications.[45]

If the mother experiences an emergence reaction to the ketamine, do not administer sedatives (benzodiazepines) to block the reaction until the baby is delivered, since these also can cause respiratory depression in the newborn. In cases of fetal distress, avoid ketamine, since it causes the uterus to contract.[44]

Methods for Cesarean Section

The following two methods describe how ketamine can be used successfully for C-sections.

In a remote Kenyan hospital, Dr. Veeken describes the successful use of a combination of local infiltration and a ketamine drip:

> No premedication is given. An intravenous line is set up; local anesthesia (lidocaine 0.5%) is injected in the midline from symphysis up to the umbilicus. The doctor then scrubs. Opening is performed under this local anesthesia only. It's impressive how well the women tolerate this. If necessary, more local anesthetic could be administered for the deeper layers, but we never do. Atropine 0.6 mg is given IV. Just before the opening of the uterus, a bolus of 75 mg ketamine is given IV. The child is quickly delivered. The uterus is closed during the effect of the ketamine; a bilateral tubal ligation can be performed. Usually the women start waking up while closing the abdomen, the local anesthesia still enables us to close the fascia and the skin. If necessary, diazepam is given IV during the closure. This method is very safe for both mother and child.… Although not very elegant, it is satisfactorily cheap, very easy to administer, and extremely safe. It is highly recommended for working under primitive circumstances.[46]

Dr. Zimmermann described the method used in Bangladesh for 8000 C-sections (with one avoidable anesthetic death): "Routine premedication is omitted.… If necessary, oxygen is administered via mask or nasal tube. For induction, 0.6 mg atropine plus 100 mg ketamine diluted to 5 cc is administered IV over about 60 seconds."[45] While ketamine is normally given as an mg/kg dose, a standard dose is used to avoid errors. It results in <2 mg/kg in virtually all these patients. This injection achieves an adequate surgical stage of anesthesia, and the patient continues to breathe spontaneously. For C-sections, administer oxygen if there is fetal distress. Maintenance anesthesia is achieved using a ketamine drip of 200 mg ketamine diluted in 200-mL NS or dextrose solution, resulting in 1 mg ketamine/1 mL fluid. This is run at 20 to 30 drops/min, which is 1 to 1.5 mg/min. A benzodiazepine (diazepam 10 to 20 mg has been used successfully) can be added once the baby is delivered. It provides a sound sleep and decreases possible psychomimetic reactions. The ketamine drip is discontinued once the surgical incision is closed.[45]

ANESTHESIA DELIVERY SYSTEMS

Improvised Vaporizers

Vaporizers deliver safe concentrations of volatile anesthetic vapor into the anesthetic system going to the patient. The volatile agent enters the vaporizer in liquid form, and comes out as a vapor. Vaporizers can be improvised.

The ideal vaporizer has a clear chamber so the amount of anesthetic is visible. Keeping the anesthetic temperature relatively constant is also important, since the liquid's temperature falls as it passes into vapor. This, in turn, lowers the output of the vaporizer. In improvised vaporizers, the equipment sits in a water bath, which transfers heat to the anesthetic to minimize any fall in temperature.[34]

The Coffee Jar Vaporizer

Boulton devised a very workable vaporizer for a draw-over system using two sizes of jars. To make the large vaporizer suitable for ether administration, he used a 135-g (118-mL; 4-oz) Maxwell House coffee jar (7.5-cm [3-inch] diameter, 13-cm [5-inch] tall). Other containers of THIS SIZE can be used instead. The jar's size partially determines the anesthetic concentration. The smaller jar, which can be used for ether, halothane, or trichloroethane, has a 5-cm diameter and is 19-cm (7.5-inch) tall.

Put a piece of plastic tubing with a 1.25-cm (0.5-inch) diameter through one of two holes of that size that you have punched into the lid; the tube should just fit. Cut the end of this obliquely, so that fluid is less likely to be sucked through it. Cut a wide hole in the tube, in such a position that you can lift it above the lid to reduce the vapor concentration, if necessary (Fig. 15-1). Fix a piece of cotton at one edge of the other open hole in the lid. Each time the patient breathes, it will move, allowing you to monitor his ventilation. If available, add oxygen through a tube that fits loosely in the open hole.[6]

Fill the large jar by adding 150 mL—about 4-cm deep—of ether. Once the patient is induced, the vaporizer is ready to put in-line with whatever system you are using (a non-rebreathing valve and an Oxford bellows or a self-inflating bag, or attached directly to a tracheal tube). The initial 11% ether concentration falls to 8% in 5 minutes and remains relatively constant thereafter. Gently shaking the bottle for 1 minute doubles the concentration. The concentration can be halved by opening a T-piece closed by the finger cot (the cut finger from a surgical glove) and still further reduced by tightening the screw clamp. Using trichloroethane, a constant 1% concentration is obtained, which is halved by opening the T-piece. Halothane gives too high a concentration for use with the larger vaporizer.

The apparatus is converted to a "semi-one-way" system by snipping off the end of the finger cot, thus creating a simple valve that closes on inspiration and opens on expiration. As it vaporizes, the ether will get cold and the concentration will diminish. At that point, gently agitate the bottle for about a minute, or put it in a bath of warm water. When using trichloroethylene, no water bath is needed.

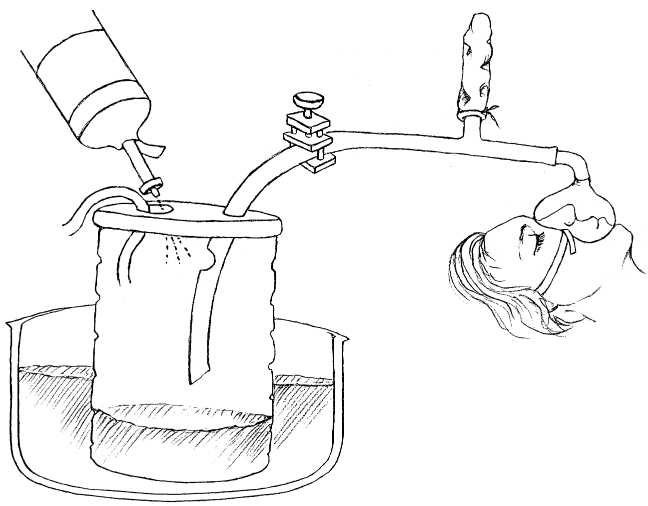

FIG. 15-1. Coffee jar vaporizer. *(Redrawn from Boulton.[6])*

If using the smaller bottle, prepare it the same way, but with 50 mL of halothane. A constant 1% vapor concentration is obtained, which is halved by opening the T-piece or doubled by shaking the jar for 1 minute. Secure this bottle firmly to the table or another fixed structure—the vaporizer is dangerous if knocked over.[6,47]

Anesthesia (Plenum) Machines

Under normal circumstances, anesthesiologists in developed countries use plenum machines to deliver inhalational anesthetics. Boulton described the "frustrating experience of administering anesthesia with the 'rag and bottle' in a well-equipped OR while a typical modern anesthesia machine stood idle because of the lack of cylinders."[2]

POSTOPERATIVE RECOVERY

In situations with limited resources and few trained personnel, the safest place for an anesthetized patient to recover is in the operating room. The key is ensuring that the patient is awake when he leaves the OR. Boulton notes that "if vigilance is relaxed when the drama of the operating room is over, death can still strike if the patient is left unsupervised."[48] To prevent this, leave the patient intubated until pharyngeal reflexes return.[49]

Postoperatively, place patients in the "recovery" position, lying on their side (see Fig. 8-1). As often as possible, check their airway, vital signs, blood loss, and temperature. The latter is important because, while many operating rooms in hot climates are now air-conditioned or cooled, patients run the risk of hyperpyrexia when they are transferred to a hot ward.[48]

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16 Anesthesia: Ketamine, Ether, and Halothane

WHY THIS CHAPTER?

A group of anesthesiologists familiar with international disaster relief operations wrote, “There is a danger of the modern practitioner becoming an ‘anesthetic dinosaur,’ unable to survive except in a sophisticated technological environment.”[1] Inexperience with ketamine, ether, and halothane, anesthetics commonly used in developing countries, may come to haunt those trying to deliver inhalational anesthesia in austere circumstances. Ketamine is an easy and safe anesthetic to give, even by non-anesthetists; ether is extremely safe, portable, and deliverable by improvised means. Modern anesthetists often lack a familiarity with halothane. Therefore, a description of these three anesthetics will help clinicians deliver safe anesthesia.

KETAMINE

Ketamine merits a detailed discussion because of its wide spectrum of safe uses (e.g., sedation, regional and general anesthesia, analgesia, and psychiatry) and its availability throughout the world, even in areas with resource scarcities. (A discussion of ketamine use for C-sections is in Chapter 15, Sedation and General Anesthesia.)

“Ketamine is remarkably safe and is certainly the safest anesthetic if you are inexperienced.”[2] Not surprisingly, in some hospitals without a trained anesthetist, up to 90% of the operations are done under ketamine.[3]

Ketamine is unique, producing hypnosis (sleep), analgesia (pain relief), and amnesia (short-term memory loss).[4] Patients given ketamine rapidly go into a trance-like “dissociative” state, becoming detached from their surroundings. Patients’ eyes are wide open, and they have a slow nystagmus, preserve their corneal and light reflexes, and make reflexive movements.[5,6] A major benefit of using ketamine is that, unless high doses are used or smaller doses are given rapidly, the patient’s airway remains open and he breathes spontaneously.[2,5] Even if transient apnea occurs, brief bag-valve-mask (BVM) ventilation suffices until spontaneous respirations return. Another major benefit is that patients maintain their blood pressure (BP), even in shock.[7] Laryngeal spasm is an extremely rare complication.[2]

Pharmacology

Being water and lipid soluble, ketamine can be administered intravenously, intramuscularly (IM), orally, rectally, subcutaneously, transnasally, transdermally, and via an epidural block. Ketamine has a slower onset than other intravenous (IV) anesthetic agents after an IV bolus (1 to 5 minutes), and its duration of action depends on the route of administration (20 to 30 minutes for IM; 10 to 15 minutes for IV).[6]

Ketamine comes in three concentrations: 10 mg/mL, 50 mg/mL, and 100 mg/mL. If only one strength is to be kept in a hospital, the 50-mg/mL ampoule is the best compromise, since it can be used for IM injections or may be diluted down to 10 mg/mL for IV use. Protect the medication from light when stored. Ketamine’s physiological effects are shown in Table 16-1.

Do not mix barbiturates or diazepam in the same syringe or infusion as ketamine, since they are chemically incompatible. Other cerebral depressant medications prolong ketamine’s effects and delay recovery.[5,8] Patients who receive repeated sedations, such as for dressing changes, often develop tolerance to ketamine and require progressively higher doses. Stop ketamine administration for 3 days to allow patients to regain their normal response to ketamine.[6]

Common Uses

Ketamine has a wide variety of uses. A frequent medication for procedural sedation in medical settings (Table 16-2), ketamine is also an excellent drug to use during rescues, such as for an amputation on a trapped patient.[5,9] The continued presence of a gag reflex under ketamine makes operations inside the mouth problematic, although teeth can be wired for stabilization

TABLE 16-1 Ketamine's Physiological Effects

System	Effects			
Cardiovascular system	⇧ Heart rate	⇧ BP	⇧ CVP	⇧ CO_2
	Baroreceptors: Normal function	Dysrhythmias: Rare		
Respiratory system	Bronchodilation	⇧ Respiratory rate	Preservation of airway reflexes	
Central nervous system	⇧ Cerebral blood flow	⇧ Metabolic rate	⇧ Intraocular pressure	
Autonomic system	Nausea and vomiting	⇧ Salivation		
Genitourinary system	⇧ Uterine tone			
Other	Emergence delirium/dreams/hallucinations			

Abbreviations: BP, blood pressure; CVP, central venous pressure; CO_2, carbon dioxide.
Data from Stevenson.[5]

using ketamine. Bronchoscopy cannot be done under ketamine unless neuromuscular blockers are used.

Ketamine is the ideal anesthetic for elderly, poor-risk, and dehydrated patients. It sustains rather than decreases the BP, and provides bronchodilation and decreases bronchospasm in COPD and asthma patients. For that reason, it is often used to intubate and treat patients in status asthmaticus.

Ketamine can be used as an anesthetic premedication (orally or parenterally), for anesthesia induction prior to administration of inhalational anesthetics, or for both induction and maintenance of anesthesia. It is of particular value for patients in shock, for children requiring frequent repeated anesthetic, for procedures with the patient in a prone (face-down) position that without intubation might make controlling the airway difficult, for emergency surgery when a patient has recently eaten, for surgery on patients who may be difficult to intubate, and when other anesthetics, equipment, or techniques are not available.[5,8]

Advantages

Anesthesia persists for up to 15 minutes after a single IV injection and is characterized by profound analgesia. (See also Chapter 13, Analgesics.) Ketamine also produces retrograde amnesia. Children receiving an IM injection, for example, will not recall getting the injection when they awaken.

Apnea is unusual unless ketamine is administered rapidly IV or another respiratory depressant drug (e.g., opioid) is given. If only ketamine has been administered, the apnea lasts only a short time (up to 1 minute) and can easily be managed with a BVM. After a slow IV induction, breathing is well maintained and may even increase slightly.[4]

Airway reflexes and skeletal muscle tone are relatively well preserved, but salivary and tracheobronchial secretions increase. Despite the retention of protective reflexes, normal airway care must be maintained to prevent obstruction or aspiration.[4] Laryngospasm occurs in about 1 in 500 cases after ketamine administration, although this is far less than the nearly 9 per 500 incidence with other agents.[7]

TABLE 16-2 Common Procedures/Surgeries Using Ketamine Sedation

Fracture reduction	Joint relocation	Dressing changes
Abscess drainage	Burn debridement	Head/neck surgery
Dilation and curettage	Cesarean sections	Endoscopy
Foreign body removal	Laceration repair (children)	Cast changes
Radiotherapy	Chest tube placement	Bone marrow aspiration

Ketamine stimulates the cardiovascular system, increasing the heart's workload slightly while maintaining systemic vascular resistance. Since it does not induce hypotension, the patient does not have to remain supine. Its sympathomimetic effects are of particular value in patients who are shocked, severely dehydrated, or severely anemic.[8] Ketamine raises the BP (in patients with an intact sympathetic response) by about 25% (systolic pressure increases by ~20 to 30 mm Hg) and the heart rate increases by ~20%. In the majority of patients, the BP rises steadily over 3 to 5 minutes and then returns to normal 10 to 20 minutes after injection, although there is wide individual variation that is related neither to dose nor to preexisting hypertension. Benzodiazepine premedication, such as with diazepam, reduces this rise in BP; additional small doses may control the pressure during the sedation.[4] This is particularly important if ketamine must be given to patients with uncontrolled hypertension, increased intracranial pressure, thyrotoxicosis, congestive heart failure, or eclampsia.

Disadvantages

The main problem with ketamine anesthesia is that there is no muscle relaxation. For abdominal operations or procedures on large joints (e.g., hip), a neuromuscular blocking agent and a controlled airway may be needed, requiring considerably more anesthetic prowess and eliminating one of the great benefits of using ketamine.

Preserved muscle tone may make airway control, if needed, more difficult. Unless other medications are given, the use of an LMA or oral intubation will be extremely difficult.[5] Ketamine does raise intraocular pressure, although only for a few minutes after administration. Eye movements may continue throughout surgery, making it unsuitable for patients with perforating eye injuries or for ophthalmic surgery where a nonmoving eye is required.[4]

Patients receiving ketamine may have a prolonged recovery time, sometimes accompanied by nausea and vomiting. Hallucinations can occur during recovery (although less commonly noticed in children), but they are avoided if ketamine is used solely as an induction agent and followed by a conventional inhalational anesthetic. Their incidence may also be greatly reduced by administering diazepam both as a premedication and after the procedure.[8]

Contraindications

Ketamine is contraindicated in a number of conditions (Table 16-3). When relative contraindications exist, balance the need to use ketamine with the risks involved.

TABLE 16-3 Contraindications to Ketamine

Absolute Contraindications	Relative Contraindications	
Hypersensitivity to ketamine	Moderate to severe hypertension	Intracerebral mass or hemorrhage
Open eye procedures	Ischemic heart disease	Other causes of raised intracranial pressure
Acute porphyria	Congestive cardiac failure	Eye injury and increased intraocular pressure
Liver failure	Preeclampsia	Psychiatric disorders (e.g., schizophrenia, acute psychoses)
	History of cerebrovascular accident	Hyperthyroidism (not controlled)
	Acute or chronic alcohol intoxication	Patients taking thyroxin
	Cerebral trauma	Patients with glaucoma

Data from Stevenson,[5] Craven,[6] World Health Organization,[8] and King.[10]

Monitoring During Use

Despite its safety record, patients should be carefully monitored during ketamine anesthesia. Secretions can cause obstruction and, although airway reflexes are usually preserved, laryngospasm and aspiration can occur. If there is no monitoring equipment, using your palm to check their breathing pattern and palpating the rate and quality of the patient's pulse are usually sufficient.[5]

Judging depth of anesthesia under ketamine can be difficult, since there are few obvious signs. Spontaneous movement and eye opening may occur during adequate anesthesia, but are more common during subanesthetic doses.[5]

Premedicating Patients

Because of the increased salivation with ketamine, the general recommendation has been to pretreat patients either with atropine or scopolamine 20 micrograms/kg (mcg/kg) (to a maximum dose of 0.5 mg) given IM (or IV) 30 minutes before ketamine administration or with 10 to 20 mcg/kg (to maximum 0.5 mg) of either medication given IV at the time of induction.[4,11] Alternatively, glycopyrrolate, which may be a better choice due to its lower psychotropic and chronotropic effect, may be administered IV at 0.01 mg/kg (to a maximum 0.2 mg).[5,6] When ketamine is used for sedation, in children, routine atropine pretreatment is probably unnecessary, since excessive salivation is uncommon and the associated airway complications are rarely seen.[12]

Clonidine or diazepam may also be useful premedications before ketamine anesthesia. Oral clonidine (5 mcg/kg) reduces the hypertensive response. To reduce the dose of ketamine needed, give diazepam 0.15 mg/kg orally in adults, or promethazine 0.5 mg/kg orally in children, 1 hour prior to ketamine administration. Alternatively, give diazepam 0.1 mg/kg IV on induction.[4,5] To diminish any unpleasant hallucinations and decrease muscle tone, which is particularly important in abdominal surgeries, give diazepam (0.22 mg/kg) IV just before induction or orally 1 hour before induction.[11] The downside to this is that, especially in infants, the routine administration of benzodiazepine reduces ketamine's safety margin, and so should be avoided. A better method to prevent hallucinations is to treat patients with small doses of IV diazepam during recovery.[6]

Ketamine as an Anesthetic Premedication

Ketamine can be used to premedicate children before anesthesia with other agents. Oral ketamine 8 mg/kg is effective, although recovery from anesthesia is longer than normal. Intranasal ketamine can be used both as a premedicant and an analgesic. In children, 3 mg/kg diluted to 2 mL with NS (give 1 mL per nostril) produces analgesia and sedation, but not anesthesia. (For best effect, use an atomizer. Improvised atomizers are described in Chapter 13, Analgesics.) This allows mask-inhalation anesthesia induction and does not cause prolonged recovery.[5] Ketamine has also been used orally or rectally as a form of premedication/sedative, but its effect is unpredictable.[4]

Intramuscular Administration

Intramuscular (IM) ketamine can be used in analgesic/sedative doses or for anesthesia induction and maintenance (Table 16-4). The retrograde amnesia means that the child generally will not remember receiving the injection. IM doses last longer and wear off more slowly than do IV doses.[13]

For pediatric sedation, use 2 mg/kg + atropine 20 mcg/kg IM. It takes about 5 minutes until the child is ready for the procedure.[6] To induce surgical-level anesthesia, administer 5 to 10 mg/kg ketamine + 20 mcg/kg atropine mixed in the same syringe, by deep IM injection. The child will be asleep in 3 to 5 minutes and anesthesia will last about 25 minutes.[6,8] Anesthesia can be prolonged by using additional IV or IM doses of ketamine. If the IM route is used, administer additional doses of 3 to 5 mg/kg ketamine or 25% to 50% of the initial dose, as required. The need for supplementary doses is primarily determined by the patient's moving in response to surgical stimuli.[4,6,8]

Ketamine's effective dose seems to vary with a child's nutritional status or the amount of alcohol an adult normally consumes. In malnourished children, always use less than the normal

TABLE 16-4 Intramuscular Ketamine Administration

Step	Alternatives
Advance premedication (alternatives)	Atropine: 20 mcg/kg IM 30 min pre-op Diazepam: 0.15 mg/kg orally 1 hr pre-op (adults) Promethazine: 0.5 mg/kg orally 1 hr pre-op (children) No premedication
Premedication at surgery	Atropine 10-20 mcg/kg IV prior to ketamine *OR* No premedication
Induction	1-2 mg/kg IV
Maintenance	IV boluses 0.5 mg/kg *OR* IV drip 1-2 mg/min

Data from Tomlinson[4] and other sources.

dose; in alcoholics, the dose should be higher. Experience shows that if a patient shows no signs of anesthesia after receiving three times the normal dose, a different agent should be used.[4,14]

If ketamine is scarce, consider giving it IV or with a neuromuscular blocker. King notes that "While 12 mg/kg IM ketamine (~840 mg for a 70-kg patient) provides an adult patient with about an hour of anesthesia; the same result comes from using about 280 mg IV. Only about half that much is needed if a muscle relaxant is used simultaneously."[15]

Intravenous Administration

IV Pharmacodynamics

The action of IV ketamine is faster than IM, but slower than other IV anesthetics. For example, within 3 to 5 minutes after an IM injection of 6 to 8 mg/kg (mixed with atropine), the patient will be ready for surgery, yet the patient should be ready in only 1 to 3 minutes following an IV injection of 1 to 2 mg/kg (mixed with atropine).[9]

Induction

Induce a patient with 1 to 2 mg/kg ketamine by slow IV injection over a period of 60 seconds or in boluses of one-third of that dose every 60 seconds. More rapid administration may result in respiratory depression or apnea, as well as an enhanced pressor response. A dose of 2 mg/kg produces surgical anesthesia within 1 to 3 minutes that should last from 10 to 15 minutes.[4,5,8]

Maintenance Boluses

Maintenance anesthesia with ketamine can be achieved using IV boluses. Either give intermittent boluses of IV ketamine (0.5 mg/kg or 50% of the original IV dose) every 15 to 20 minutes, or give boluses according to the patient's response to surgical stimuli—pupil size, heart rate, BP, movement, and so forth.[5,6,8,9] During longer procedures, the clinician should note the time interval between induction and the first supplemental dose, so that she can begin to inject further increments slowly at the next appropriate time.[4]

Maintenance Infusion

Maintaining anesthesia using a ketamine drip (a) allows better control of the anesthetic depth than do the IM or bolus IV methods, (b) has a rapid induction and recovery, and (c) is less likely to cause a respiratory arrest than using IV boluses.[16] In circumstances in which non-anesthetists (and even nonmedical personnel) must give anesthesia, a ketamine drip permits a standardized protocol that most physicians and nurses can follow to administer anesthesia safely with minimal instruction.[17]

To use this method, make a ketamine solution of 1 mg/mL by dissolving 10 mL of ketamine containing 50 mg/mL in 500 mL of 5% dextrose or normal (0.9%) saline (NS). For short procedures, mix smaller volumes, but keep it at 1 mg/mL for ease of administration. If the surgeon will also be giving the anesthetic (not unusual in the developing world), she should start the ketamine drip (using a 10 drop/mL infusion set) before she begins to scrub.

The method that King and others use for an average size adult is to start the drip at 1 to 2 drops/kg/min (non-micro drip IV chamber 15 drops/mL), which equals 1 to 2 mg/min ketamine, to maintain spontaneous ventilation. Some patients may need as much as 4 mg/min. Adjust the rate of infusion according to the depth of anesthesia achieved and required, as well as the size of the patient. "Continue the drip beyond the point at which the patient becomes unconscious, until surgical anesthesia is reached. This is easy to recognize, but difficult to describe. [The patient] develops a vacant stare, he does not respond to pain, but he still has his eyelash, corneal, and pharyngeal reflexes. Test his sensation of pain by pricking him with a pin. When surgical anesthesia has been reached, slow the drip to 60 to 80 drops/minute. This is about one drop/minute/Kg body weight (4 mg/Kg/hour)."[10] In part, the nature of the surgery determines the required level of anesthesia, with minor procedures needing a smaller dose. The dose also depends on whether the patient has received a premedication. "If the patient is shocky, give him the smallest dose of ketamine that will keep him quiet. If he seems to react to the pain of the operation, increase the speed of the drip to 120 drops a minute. Stop operating until conditions are again satisfactory. Later, you may be able to slow the drip."[10] Generally, the ketamine will need to be discontinued 10 to 20 minutes before the end of the operation to avoid delayed emergence.[4-6]

Depth of Anesthesia

During ketamine anesthesia, spontaneous patient movement is common, which may bother both the surgeon and the anesthetist. However, these patients are still anesthetized and the movements should not deter surgery. Surgeons and anesthetists who have experience using ketamine should be able to differentiate between spontaneous ketamine movements occurring during full ketamine anesthesia and spontaneous movements as a result of "lightening" of anesthesia.[4]

With Other Sedatives

Use a smaller dose of IV ketamine (i.e., 1 mg/kg) if IV diazepam (0.1 mg/kg) is also used. While diazepam helps to reduce hypertensive responses, it may suppress the patient's respiratory drive.[4]

With a Neuromuscular Blockade (NMB)

Ketamine infusion may be administered with an NMB and intubation. This combination provides the muscle relaxation needed for abdominal and some large joint operations.

Dobson describes his procedure: "Use atropine and preoxygenate. Induce anesthesia with a fast-running ketamine infusion containing 1 mg/mL (average adult dose 50 to 100 mL). Give succinylcholine and intubate. Maintain anesthesia with ketamine 1 to 2 mg/min (more if no premedication given). After breathing returns, give a non-depolarizing relaxant. At the end of surgery, reverse muscle relaxant and extubate."[18]

Oral Administration

While the IV ketamine preparation is effective orally, an oral elixir is available. Oral bioavailability is 16% to 20%, so the adult oral dose is 500 mg of ketamine plus 5 mg diazepam. For children, the oral dose is 15 mg/kg. One problem with oral administration is that the parenteral preparation tastes very bitter. Having the patient drink pure fruit juice or cola just before the medication or mixing it in that solution helps hide the taste. After oral administration, it takes 15 to 30 minutes to achieve sedation/anesthesia. Sedation begins earlier than anesthesia, but responses may be unpredictable and the onset may take longer.[5,6]

Complications

Complications with ketamine involve the airway and ventilation, GI upset, psychiatric symptoms, unusual motor movements, and a series of relatively minor problems.

Administering ketamine too rapidly or in too large a dose can result in transient respiratory depression that may necessitate BVM or, rarely, mechanical ventilatory support.[8] Excess secretions may also lead to aspiration. Though rare, laryngospasm does occur and must be aggressively managed.

Nausea, vomiting, and hallucinations may accompany recovery. In patients with schizophrenia, ketamine may reactivate psychoses, but there are no long-term sequelae to transient hallucinosis in nonschizophrenic patients.[6]

Tonic and clonic movements resembling seizures occur in some patients. These do not usually indicate a light plane of anesthesia or the need to give additional anesthetic. Although a slight increase in ketamine dose may be tried, further increases may increase the movements. At that point, benzodiazepines or analgesics may help, although this risks respiratory depression.[6] Occasionally, patients under ketamine anesthesia become rigid. This can be a serious event and requires an NMB and intubation.

Other, infrequent reactions include: anorexia, pain and exanthems at the injection site, transient generalized erythema and morbilliform rashes, laryngospasm and other forms of airway obstruction, and transient postoperative diplopia, nystagmus, and elevated intraocular pressure.[8]

Recovery

Return to consciousness is gradual. In contrast to the smooth induction of anesthesia, 5% to 30% of patients may be agitated when recovering from ketamine. This occurs most often in adults, women, and those receiving large doses or rapid IV boluses.[6] A state called emergence delirium (during which the patient may be disorientated, restless, and crying) sometimes occurs. The incidence of this reaction is reduced if the patient is not unnecessarily disturbed during recovery and is allowed to recover in a quiet area. However, in some tragic cases, isolating the patient has resulted in unsupervised recovery with fatal airway obstruction.

Emergence reactions are unlikely to occur if diazepam is administered preoperatively (usually diazepam 0.15 mg/kg orally 1 hour preoperatively or 0.1 mg/kg IV on induction) and supplemented, if necessary, by an additional 5 to 10 mg IV at the end of the procedure.[4,8] Alternatively, promethazine can be used; this has the added advantage of an antiemetic effect. Promethazine may be given as an oral premedication (age 2 to 5 years, 15 to 20 mg by mouth [per os]; 5 to 10 years, 20 to 25 mg by mouth) or by IV at induction (25 to 50 mg IV in adults). It is not recommended for use in children <2 years old due to the risk of severe respiratory depression.[6] Haloperidol can also be used to treat these reactions.[19] Patients may continue to experience unpleasant dreams up to 24 hours after ketamine administration.[4]

Pediatrics

In the absence of facilities for the safe administration of inhalational anesthesia, "ketamine anesthesia is considered the standard of care for children" in many developing countries.[3] Intramuscular ketamine is ideal to use in children, especially those who require repeated painful procedures. Atropine can be mixed with ketamine for a single injection.[5] The IM route is particularly useful in small infants prior to insertion of an IV.

Ketamine as a sole anesthetic agent is less successful in small babies, and repeated doses may lead to apnea. In children, especially neonates, respirations can be tenuous, so always insert an airway and use a precordial stethoscope for continuous monitoring. In babies, do not use ketamine with neuromuscular blockers. Give IM atropine 15 to 30 minutes before the procedure, except in hot climates where hyperthermia may become an issue.[20] In small children, anesthesia with ketamine as the sole agent for prolonged surgery may lead to delayed recovery, especially if combined with opioids.[3]

ETHER

Pharmacology

Ether (diethyl ether) is a colorless, highly volatile, and flammable liquid that was first used as an anesthetic in the mid-19th century. It should be stored at temperatures >25°C in tightly sealed dark bottles or cans. These protect the ether from light, which may decompose it. Ether is a poor anesthetic at altitudes over 2000 meters (6000 feet), although it has been used at altitudes up to 3500 meters (~11,000 feet).[21]

Availability

Ether is probably the most widely used inhalational anesthetic in the world.[22] Where the supply of medical-grade ether is limited, industrial-grade ether can be used instead.[23] Industrial ether is the same as anesthetic ether, only much less expensive. But, since it comes in drums, it must be poured into dark bottles or sealed cans for use.[24] Common types of ether for anesthesia, many of which can be found in industrial settings, include trifluoroethyl vinyl, ethyl vinyl, divinyl, diethyl, and dichloro-difluoroethyl methyl.[25] Of these, ethyl vinyl ether is the safest and most potent, and has the most rapid onset of anesthesia and the shortest recovery time, while divinyl ether is the least potent agent for surgical anesthesia and the most likely to produce respiratory arrest.[26]

Production

Ether (divinyl [anesthetic] and ethyl/diethyl ether) can easily be produced locally since ethanol and sulfuric acid are available nearly everywhere.[27] However, non-chemists should try to produce ether only in the most desperate situations, and then only after consulting a reputable organic chemistry text and, if possible, a real chemist.

The substances involved in ether production are highly volatile; the risk of explosion is very real. Essentially, the process is to dehydrate ethyl alcohol with sulfuric acid. Here's how: (a) Obtain ethyl alcohol (i.e., drinking alcohol), since other alcohols will not produce diethyl ether and will be very dangerous. (b) Obtain sulfuric acid, which can often be taken from a lead-acid battery. If necessary, sulfuric acid can be made by burning sulfur and saltpeter (potassium nitrite) together, although this may prove more difficult than finding it premade. The sulfuric acid is reusable and catalyzes the process. (c) Heat the ethanol-sulfuric acid mixture in a glass distillation chamber (such as from any basic chemistry lab). This produces ether vapor, which condenses to liquid. It has to be maintained within a certain temperature range for the reaction to occur. The process is essentially a continuous one with repeated addition of further alcohol.[28]

Advantages

The main advantage to using ether is that it has proved to be very safe, especially in unskilled hands, with a wide margin between satisfactory anesthesia and a lethal overdose.[21,27,29,30] Another advantage is that with a vaporizer and mask—or just the ether and a makeshift mask—ether can be used whenever a general anesthetic is needed. Ether is considered one of the anesthetics of choice for major operations requiring intubation and for poor-risk cases (using a low dose), and it is the volatile agent of choice when general anesthesia is needed but no oxygen is available.[30]

Unlike many modern anesthetics, ether provides intrinsic analgesia, so it does not require the simultaneous use of N_2O. It also provides intrinsic neuromuscular relaxation, is a bronchodilator, rarely potentiates the dysrhythmic effect of sympathomimetic agents, causes little uterine relaxation, stimulates blood flow (helpful in shocky patients), and stimulates respiration (useful if no oxygen is available). Even if the patient receives enough ether to depress respirations, cardiac function remains good, and so ether has a wide safety margin.

The classic slow changes of anesthesia depth—the "stages" (see Table 15-3) with their attendant physical signs—are easily observed, suggesting that when one does not have the necessary monitoring equipment and needs to use an inhalation anesthetic, ether is the best choice.[21,27,30-33]

Disadvantages and Side Effects

Disadvantages associated with using ether are that it has an unpleasant smell (that both the patient and the staff notice) and slow induction and recovery times. In addition, the vapor irritates the bronchial tree, which bothers many patients, and often is accompanied by postoperative nausea, vomiting, and drowsiness.[24,27] It helps to get the patient accustomed to the ether smell before anesthesia begins.[34]

Laryngeal spasm is common during induction and when the anesthesia is too light. Stop surgery and deepen the anesthesia; add oxygen, if available, until the patient breathes normally.[21] Administer atropine to prevent excess secretion production.

Patients may vomit during ether induction, usually during the delirium stage when anesthesia is light. Since laryngeal reflexes persist at this stage, tilt the table head down, turn the patient on his side, and clean out the mouth and pharynx. As long as the patient's breathing, pulse, and color are normal, the patient probably has not aspirated and it is safe to continue anesthetizing him. If apnea develops, consider whether the patient has received too much ether, has an airway obstruction, is breath-holding, or is in cardiopulmonary arrest. Treat the problem.[21]

Nausea and vomiting after ether anesthetic are due to a central emetic effect caused either by prolonged deep-stage anesthesia or by gastritis from ether dissolving in the patient's saliva. Premedicate the patient with atropine or give ether through an ET tube to lessen the chance of this occurring.[21]

Ether also potentiates non-depolarizing neuromuscular blocking agents and may cause myocardial depression in patients on beta-blockers. Transient postoperative effects include liver function impairment and leukocytosis.[33]

Operating room staff, including the surgeon and anesthetist, may complain about the ether smell and claim that it gives them headaches or makes them sleepy. Some symptoms improve over time; others may require efficient "scavenging" (i.e., redirecting excess ether). For example, if using a non-rebreathing valve, fit an exhaust tube to the valve and vent the exhaust gases to the floor.[21,30] Also, if the end of the scavenging tube is placed on the floor (away from any possible sources of ignition), then the heavy ether vapor will remain at floor level.[24] When using open-drop ether, the best choice is to have air circulating in the room.

Contraindications and Risks

While there are no absolute contraindications to using ether, it is best avoided in patients with moderate or severe preeclampsia, with liver or renal failure, with increased cerebrospinal fluid pressure, or who have pheochromocytoma.[30,33]

Ether is highly flammable in air and explosive when mixed with oxygen or N_2O. It is not explosive when mixed with air.[21] "Under clinical conditions, it is difficult to ignite and almost impossible to explode air-ether mixtures." That is because ether vapor at a 2% or 3% concentration in air will not burn. As soon as it escapes from the vaporizer circuit or beyond the ether mask, it is diluted beyond the limit of flammability. Even if it is not diluted, it only burns slowly. But, if as little as 1 L/min of oxygen or N_2O is added, ether becomes explosive. The risk of flames and explosions is greatest close to the expiratory valve.[35]

The safe distance between ether vapor and potential heat or spark sources is unknown, but the ether vapor "zone of risk" may be up to 100 cm (~40 inches). Ether vapor is heavier than room air, so the floor up to a height of 50 cm must be clear of any electrical appliances, sockets, and plugs. Electrical sockets and switches situated within 1 meter of the floor should be spark-proof. No potential source of combustion or sparking should be allowed within 30 cm of an expiratory valve emitting ether vapor.[23,27,33]

Particularly in a very dry atmosphere such as in hot-dry or very cold climates, make all anesthetic equipment conductive, including all surgical booties and stretcher wheels, so that any electric charges go to ground.[21,33] In tropical countries, the high humidity (above 50%) offers added protection against static electricity build-up.[27]

Ether Anesthesia Stages

Being able to identify the stages of ether anesthesia (Fig. 16-1) makes the induction, maintenance, and emergence much more elegant. Identifying these stages is relatively easy, since they were developed for use specifically with ether.

Ether anesthesia is given in one of three ways: (a) Using ether without any adjuvant drugs. This requires enough medication to reach deep ("too deep") Stage 3 to provide the muscle relaxation required for intra-abdominal surgery. (b) Using ether with 10% to 20% of the normal neuromuscular block (NMB) dose. Moderately deep Stage 3 can be achieved. Patients usually resume breathing spontaneously without the need to reverse the neuromuscular blockade. (c) Using ether with 50% of the normal NMB dose. Light ether anesthesia can be maintained, but patients may need NMB reversal to resume normal breathing.[27] The second and third methods require both an NMB and controlled ventilation, which usually will not be available in austere situations.

Stage 1 anesthesia is useful for obstetrics and minor painful procedures. It can be self-administered. Give the patient a face mask delivering 2% to 3% ether and ask the patient to take deep breaths when he or she has pain. Tie the mask to their wrist; if they drop the mask, ether administration ceases.

Titrating ether's effects on spontaneously breathing patients is vital to be able to get them to and keep them at the right level. When you touch the patient's eyelash and the lid no longer contracts when touched, the patient is unconscious and is ready for surgery.[31] If the patient

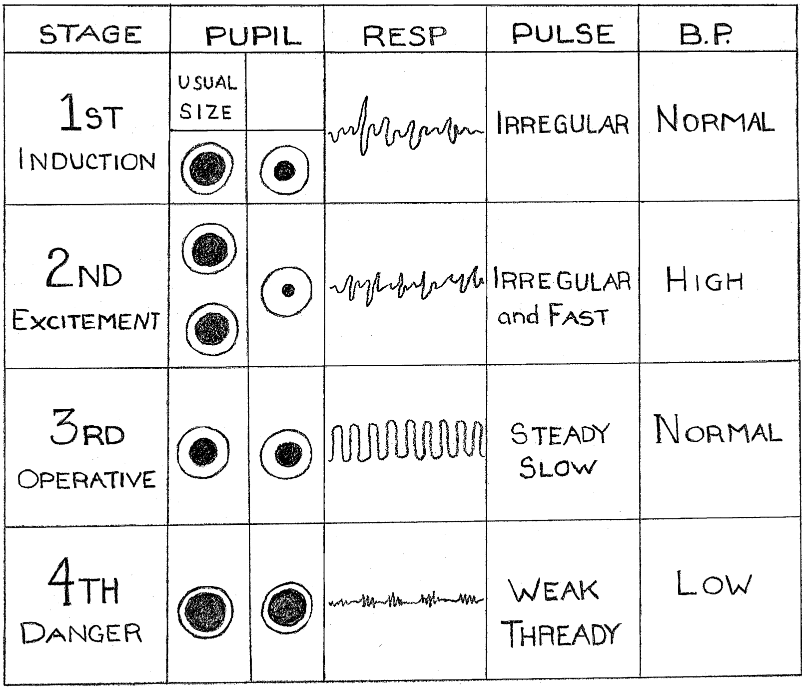

FIG. 16-1. Ether anesthesia stages.

struggles and is difficult to control, holds his breath or moves slightly as a surgical incision is made, or moves his eyes about, the anesthesia is too light. Re-induce the patient steadily. Don't give the patient a sudden high concentration of ether or he may start to cough.[21,31]

If the patient's pupils become steadily larger, his chest falls on inspiration, and a "tracheal tug" develops (the patient's diaphragm contracts causing a "tug" on his trachea), the patient is too deeply anesthetized.[21,31] An overdose leads to severe medullary depression, with respiratory failure. Promptly stop ether administration and assist the patient's breathing; spontaneous respiration usually resumes quickly.[33]

Open-Drop Ether Anesthesia

The first method of administering inhalational anesthesia, now a relic of bygone days, is very safe and requires the least amount of equipment to administer.

When working in a major disaster or in other settings where resources are extremely limited, those giving general anesthesia may "have to confine themselves to the simplest possible method … that meant 'rag and bottle' with ether as the main volatile agent."[36] A benefit of ether anesthesia is that it is effective for most patients and most surgical procedures, except craniotomy and thoracotomy, just by dripping it on a gauze mask. "Without an anesthesia machine or ketamine, open-mask [open-drop] ether may be the safest way to administer anesthesia."[37]

When giving open-drop ether, premedicate the patient with atropine or scopalamine to reduce salivary and bronchial secretions. While the open-mask technique is very wasteful of ether, it needs only a dropping bottle and a "Schimmelbusch mask," which is merely a few thicknesses of gauze held in a wire frame (Fig. 16-2). Unfortunately, a smooth ether anesthetic is difficult to give with an open mask, especially in a large adult.[37] Since diethyl ether is a weak anesthetic with a slow uptake, induction may be tedious and prolonged in a robust patient because it is difficult to reach more than 14% concentration. All the patient's inspired air must pass through the mask.

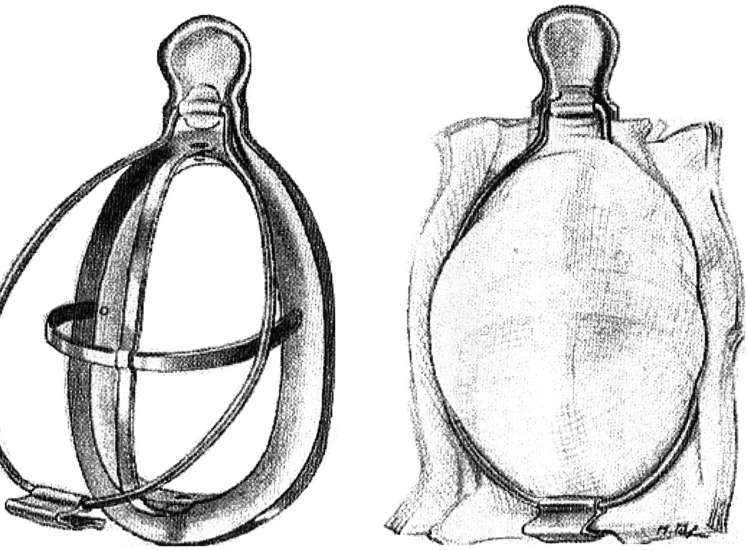

FIG. 16-2. Schimmelbusch mask. *(Source: Unknown original source. Illustration from 1894.[39])*

Open-Drop Equipment

DROPPER

To improvise a "dropping bottle," use "any clean glass bottle with a rubber stopper. Two tubes should pass through the stopper; one is for ether to come out and the other for air to enter the bottle" (Fig. 16-3). An alternative is to cut two slits in the bottle's stopper, inserting a cloth (the proverbial "rag") through one opening and leaving the other slit open to allow air to pass into the bottle. If the ether is in a can with a rubber top, "put a safety pin horizontally through the rubber stopper. The ether then drips from the pin."[38] (See Fig. 16-4.)

IMPROVISED MASK

Administer open-drop ether by dripping it onto a piece of cloth (gauze or other absorbent material) held over the patient's face with a wire frame. The frame is to facilitate airflow and to

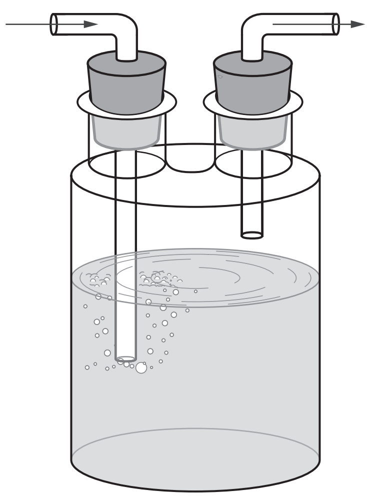

FIG. 16-3. Wolff (Woulff) bottle.

FIG. 16-4. Safety-pin-through-ether-can drip delivery system. Drawn from original photograph. *(Adapted from De Lee.[38])*

prevent the ether from coming in direct contact with the eyes and skin, which could cause serious burns. Cover the rest of the patient's face and eyes with gauze to protect them and, if available, apply petroleum jelly to exposed skin.

Make an improvised mask (preferably two) by stretching gauze over a small kitchen sieve, a large coffee strainer, a tea strainer (often an excellent infant mask), or a piece of screen that has been bent and sewed into the desired shape. The ideal mask just fits over the patient's mouth and nose and should look like the classic Schimmelbusch mask (shown in Fig. 16-2). Place 6 or 7 layers of gauze (depending on the size of their mesh) over the masks. Have extra gauze; it may need to be changed frequently because, when the ether evaporates, a "frost" forms on the gauze that interferes with its effectiveness. You should be able to see light through the full thickness of the gauze; otherwise, sufficient air will not pass through it.[21,40] Do not place the mask directly on the patient's face; use cotton padding around the edges. Otherwise, the metal mask may get very cold and burn the patient.

Open-Drop Induction

The first part of giving the anesthetic is to induce the patient, or make the patient unconscious. To do this, the patient must receive as much ether as he can tolerate, which depends on how well the patient is breathing and his reaction to the ether. Ether is irritating, so too much will make the patient cough, gag, and hold his breath. Thus, induction with ether alone often takes 20 minutes.[21]

Either parenteral or inhalational agents can be used to smooth and speed inductions with ether, provided that the dose is small enough so that it does not depress respiration. Ketamine (1 mg/kg IV or IM) or a benzodiazepine (e.g., diazepam 0.1 to 0.2 mg/kg IV) eliminates slow induction.[21,27] An alternative is to drop 3 mL of halothane slowly onto the mask from a glass or nylon syringe. (Some disposable plastic syringes dissolve if used with these liquids.)[21] Then, immediately begin the ether maintenance. Don't let the surgeon start until the patient is at the surgical stage of anesthesia.

Take a thick piece of cotton or several layers of gauze and cut a hole for the patient's nose and mouth. Hold the mask above the gauze, and drop ether onto it (12 drops/min for 2 minutes, then 1 drop/sec until the patient loses consciousness—usually within 5 minutes). Drop ether sparingly at first to accustom the patient to the irritating vapor. Never place the mask directly on the face of a conscious patient, or he will feel suffocated. Wait until his eyelash reflex has gone, and then put on the mask. As soon as he begins to tolerate the ether, drop it on faster. Keep the stream of ether drops moving steadily over the mask to avoid freezing. Listen to every breath and make adjustments for any airway problem. Don't pour it on so fast that it makes the patient cough. If the patient does cough or hold his breath, give him a breath of air. You may have given him too

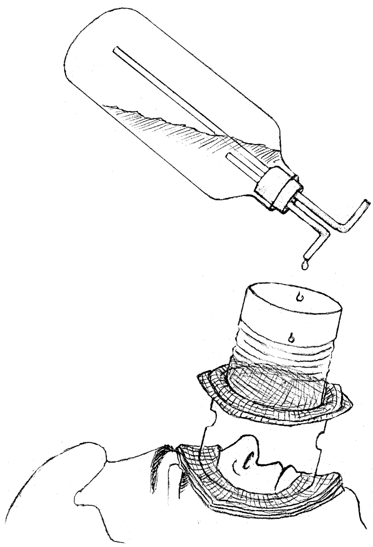

FIG. 16-5. Ether chimney.

much ether too quickly, given it irregularly, or have a poor fit between the mask and his face. As things settle down, adjust the rate to provide the required depth of anesthesia. Give a few breaths of air and continue more slowly. Deep levels of surgical anesthesia cannot be achieved with this technique in less than 20 to 30 minutes.[21,33]

Ether is a weak anesthetic, so a patient must breathe a high concentration of vapor. In adults, it is useful to increase the ether concentration by using the "ether chimney." Improvised by prisoners of war (POWs) during World War II, the ether chimney is a metal column that sits over the mask, increasing the vapor concentration close to the face, which in turn increases the inspired concentration of ether. You won't need this for a child.

Construct an ether chimney using two cans that fit into one another (Fig. 16-5). Place one can over the patient's mouth and nose. Three (not more) layers of gauze go between the cans, and the second can fits into the first, holding the gauze. For use during long operations, make some side holes in the lower can to increase the air flow; tape them up during shorter operations.[21,31]

Open-Drop Maintenance

Keeping patients at the right anesthetic stage is a difficult art that must be individualized to the patient and the circumstances. "Most anesthetists like to err on the side of being just-too deep. If the patient becomes too light, regaining control will not be easy."[21] Table 16-5 presents a rough guide to open-drop ether use.

When the mask becomes so cold that it is covered with frost, change it for a fresh one. To diminish the amount of ether escaping into the atmosphere and affecting the anesthetist and surgical team, put two layers of gauze over the mask after pouring the ether. Replace it with fresh (non-etherized) gauze each time that additional ether is poured.[21]

During long operations, if oxygen is available and all the precautions are in place to avoid an explosion (see the previous text), feed a small oxygen tube under the mask with a flow of 2 to 5 L/min.

Recovery

To avoid a prolonged recovery, discontinue ether administration about 20 minutes prior to closure. After a long operation (with more saturation of the tissues), stop giving ether 15 minutes before the last stitch. If conditions allow, assist ventilation to promote ether washout and make recovery faster and to help decrease the incidence of nausea/vomiting.[27] Put the patient in the recovery position (on his side); don't send him back to the ward until it is safe to leave him alone:

TABLE 16-5 Guide to Ether Maintenance Dosing

Ether (drops/min)	Time (min)
12	1st min
24	2nd min
48	3rd min
96	4th-15th min
50	15th-30th min
20-30	after 30 min

Adapted with permission from The Remote, Austere, Wilderness and Third World Medicine Discussion Board Moderators.[34]

The patient should be able to talk, be breathing quietly and easily, and have warm hands and a good pulse.[21,30]

Special Situations: Pediatrics and Obstetrics/Gynecology

Pediatrics

Open-drop ether administration is one of the safest inhalation methods for children, especially if you lack specialized pediatric equipment. The anesthetic stages in children are the same as in adults. Take care not to administer more ether than necessary. An additional sign in babies is that they relax their grip as they become anesthetized.[21]

In febrile children, exposure to ether increases the risk of potentially fatal seizures. If seizures occur, immediately stop ether administration and lower the child's body temperature by sponging the child with tepid water. Administer small doses of a benzodiazepine or thiopental until convulsions cease.[33]

Obstetrics/Gynecology

Use ether during pregnancy only when the need outweighs any possible risk to the fetus. However, at term, ether is especially useful for C-sections because the baby tolerates it and the uterus contracts well.[30] Use low concentrations (no more than 4%) in obstetric procedures to avoid loss of uterine tone, excessive postpartum hemorrhage, and neonatal respiratory depression.[33]

Intravenous Ether Anesthesia

Intravenously administered ether is an excellent anesthetic, especially for procedures not needing profound relaxation, such as intra-abdominal surgery. Using this method, both adults and children can be anesthetized to Stage 3, Plane 1 anesthesia—in which there is a normal or increased rate and depth of respirations (see Table 15-3). Intravenous ether anesthesia at this stage has been successfully used for head and neck surgeries, including bronchoscopy, laryngoscopy, tonsillectomy, and oral surgery. Not only are the necessary tools for this anesthetic technique readily available, but they are also quite inexpensive.[41]

Begin by preparing a 5% ether solution. Dissolve 50 mL diethyl ether in 1 L 5% glucose solution (D_5W). Cool the mixture to about 4°C (40°F) in a refrigerator to facilitate dissolving the ether. Shake the mixture vigorously for about 1 minute to mix it thoroughly, which is necessary to obtain good anesthesia. Keep the solution at 4°C until it is used. Shake it again before use to obtain thorough mixing.[41]

To anesthetize the patient, attach the bottle with the ether solution to a D_5W IV using a three-way stopcock or Y-tubing. After inducing the patient into a light sleep with an IV induction agent, open the ether solution to its maximum flow (with a "macro drip"); increase the flow by raising the bottle or by using a pressure cuff on the bag. Keep the ether solution flowing "wide open" during induction. By the time 100 to 400 mL of the solution is administered over the first 5 to 10 minutes, the patient is usually well anesthetized. The patient reaches a surgical level of anesthesia in about 10 minutes. As the operation progresses, control the flow rate to maintain Stage 3, Plane I anesthesia. If available, administer oxygen continuously.[41]

The patient usually sleeps quietly. Jaw relaxation is adequate for oral surgery or endoscopy without the need to use a neuromuscular blocker. If necessary, use an airway. Should there be unwanted motion of the extremities or the head, give a small additional dose of the IV induction medication. Prolonged postanesthesia nausea and vomiting is rare.[41]

HALOTHANE

Halothane vies with ether as the most commonly used volatile inhalational anesthetic agent worldwide. Its use is limited by the need for an anesthetic machine and monitoring equipment during surgery, and by its relatively high cost.[32,33]

Pharmacology

Halothane is a colorless, volatile, nonirritant liquid with a sweet odor. It is neither flammable nor explosive. In anesthetic doses, it depresses both cerebral function and sympathetic activity and it produces little, if any, preliminary excitement.[33] Halothane should be stored below 25°C in tightly closed, amber-colored glass containers to protect it from ultraviolet light. It contains thymol as a stabilizing agent.[24,33] Ideally, only those with anesthesia experience will use halothane, since it is used most frequently with various anesthesia machines, which will be unfamiliar to non-anesthesiologists.[27]

Advantages

Induction with halothane is smooth and rapid, and surgical anesthesia can be produced in 2 to 5 minutes. It is well tolerated and nonirritating, with a low dose needed for maintenance. It does not cause excess salivary or bronchial secretions. Patients have a rapid recovery with a low incidence of postanesthesia nausea and vomiting. There is a predictable, dose-related depression of respiration and cardiac function. While it can be used for virtually all general anesthesia, it has a special role for inhalation induction, especially in upper airway problems such as partial obstruction or in patients with status asthmaticus who need to be ventilated.[24,33]

Disadvantages

Halothane's poor analgesic properties necessitate deep planes of anesthesia before surgery can be tolerated. For this reason, it is generally not suitable as a sole agent without an analgesic supplement, for example, N_2O, opiates, trichloroethylene, local anesthetic blocks, or other analgesics. It provides no postoperative analgesia and causes uterine relaxation and hemorrhage, particularly if >0.5% halothane is used.[24]

Halothane-induced cardiovascular depression may cause bradycardia, hypotension, and a reduction in cardiac output. These effects may be marked in children, who should receive atropine, either as premedication or by IV at induction. Always give supplemental oxygen with halothane.[24] Little margin exists between the doses needed to produce respiratory depression and vasomotor depression. Overdoses result in death from cardiovascular depression.

Halothane also sensitizes the heart to epinephrine and predisposes the patient to developing arrhythmias, most commonly in patients who are retaining CO_2 or who are in pain. Such patients can usually be managed by supporting the ventilation, reducing the amount of halothane, and providing additional analgesics. If these are not effective, IV lidocaine or propranolol (avoid in asthmatics) usually works.[24,33]

Using epinephrine during halothane administration (such as in a local anesthetic) increases the risk of ventricular dysrhythmias. If possible, avoid epinephrine; if epinephrine must be used, monitor the pulse closely and support ventilation. The total epinephrine dose should never be more than 20 mL of a 5 mcg/mL (1:200,000) solution in 10 minutes or 30 mL in 1 hour. (Do not use higher concentrations.)[24,33]

"Halothane hepatitis" occurs on rare occasions, and is almost unheard of in children.[24] Halothane is, therefore, contraindicated in patients with a history of unexplained jaundice following previous halothane exposures. If it does occur, fever typically develops 2 or 3 days after anesthesia and is accompanied by anorexia, nausea, and vomiting. In more severe cases, this is followed by transient jaundice or, rarely, fatal hepatic necrosis. Allow at least 3 months to elapse between each reexposure to halothane. Repeated and frequent administration increases the risk of liver damage.[24,33]

Halothane also increases intracranial pressure and, with succinylcholine (suxamethonium), may increase the risk of malignant hyperthermia.[24,33]

Method

Always give halothane through a calibrated vaporizer. It is not suitable for open-drop anesthesia, although a few drops applied to a face mask may smooth the subsequent administration of ether. The maintenance dose is 1% to 2% for spontaneously breathing patients and 0.5% to 1% during controlled ventilation. Overdoses may occur easily with higher doses. If draw-over machines or inhalers are used, supplemental oxygen or assisted ventilation may be necessary to maintain full oxygenation, even when air is used as the carrier gas.[24,33]

If halothane is used alone (rather than with another induction agent), start a flow of gas containing at least 30% oxygen. Gradually introduce halothane and increase the concentration every few breaths until the inspired gases contain 2% to 3% halothane (adults) or 1.5% to 2% (children).[33] This method is well tolerated by all patients, and Stage 2 effects are minimized.[24]

Monitor the pulse and blood pressure throughout anesthesia, and if hypotension develops, reduce the inspired halothane concentration—or stop administering the anesthesia. Premedicating patients with atropine reduces the risk of hypotension and bradycardia.[33]

Recovery time is relatively short, but varies with the concentrations of halothane used and the length of surgery. If ketamine is used for induction, recovery may be prolonged. Patients commonly shiver during recovery, but this can be readily controlled with warm blankets and, if this is insufficient, by administering a benzodiazepine or a small (~12.5 mg) dose of IV meperidine.[33]

Obstetrics

Use halothane during pregnancy only when the need outweighs any possible risk to the fetus. Employ low concentrations (no more than 0.5%) for Cesarean sections or for evacuating retained products of conception or the placenta, since a loss of uterine tone may result in excessive hemorrhage.[24,33]

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17 | Transfusion

In austere situations, there may be no blood available for transfusion. If blood is available, there is a greater risk that it could be contaminated and infect the patient than under optimal circumstances. In addition, the methods to rapidly rewarm blood to avoid the complications of hypothermic transfusion may not be available.

DANGERS IN BLOOD SUPPLY

Blood can easily transmit human immunodeficiency virus (HIV), *hepatitis B virus* (HBV), *hepatitis C virus* (HCV), Chaga's disease, malaria, and other diseases. Only about 66% of developed countries and 46% of least-developed countries screen blood for HIV, although there is about a 90% seroconversion rate following the transfusion of blood infected with HIV. Even where (often, for-profit private) blood banks purport to screen for HIV, many either don't screen or use insensitive tests. Government oversight is sparse.[1,2]

AVOIDING BLOOD TRANSFUSION

Use non-blood substitutes, if possible. They are much safer, easier to use, and (sometimes) less costly than using blood. Substitutes include crystalloids, synthetic colloids (e.g., Dextran), and noninfectious plasma derivatives. For all but crystalloids, however, both cost and availability may be a problem.

To avoid a transfusion, especially in the operative patient: (a) restrict preoperative diagnostic phlebotomy, (b) use meticulous intraoperative surgical hemostasis, (c) use blood/cell salvage, (d) employ hemodilution, (e) use pharmaceutical hemostasis agents, (f) maintain normothermia, and (g) position patients to minimize blood loss and hypertension. Postoperatively, (a) use blood/cell salvage, (b) tolerate anemia (as described later in this chapter), (c) optimize fluid and volume management, and (d) restrict diagnostic phlebotomy. The units of blood potentially saved by not doing a transfusion with each strategy are shown in Table 17-1.[3]

DECIDING WHEN TO TRANSFUSE

The decision to transfuse blood depends on the clinical condition of the patient and on their ability to compensate for reduced tissue oxygenation. Patients with evidence of severe cardiac or respiratory disease or with preexisting anemia have a limited ability to compensate.[4] In critically ill, non-bleeding adult patients <55 years old and without evidence of an acute myocardial

TABLE 17-1 Blood Conservation Methods in the Surgical Patient

Preoperative Options	Units of Blood Conserved
Tolerance of anemia (reduce transfusion trigger)	1-2
Increase preoperative red blood cell mass	2
Preoperative autologous donation	1-2
Intraoperative Options	
Meticulous hemostasis and operative technique	1 or more
Acute normovolemic hemodilution	1-2
Blood salvage	1 or more
Postoperative Options	
Restricted phlebotomy	1
Blood salvage	1

infarction or unstable angina, keeping the hemoglobin (Hgb) >7.0 g/dL, rather than >10 g/dL, results in no change in mortality.[5] The mortality increases dramatically when the Hgb drops below 5 to 6 g/dL, especially in postoperative patients.[6]

Severe Anemia

Levels of anemia that would not be tolerated under optimal conditions can, and must, be tolerated when the blood supply is scarce or dangerous. The World Health Organization (WHO) defines very severe anemia in a child as an Hgb <4 g/dL (40 g/L) or a hematocrit (packed-cell volume; Hct) <12%. If the blood supply is tested for HIV and HBV, transfuse these children with 10 mL/kg packed red blood cells (RBCs). If the blood supply may be tainted, wait to transfuse until the Hgb is <3 g/dL (30 g/L) or the Hct is <10%.[7] Also, limit the amount transfused. Critically ill children in modern intensive care units do as well when transfusions keep their Hgb >7 g/dL as they do when kept at the more common Hgb level of 9.5 g/dL.[8]

In adults, an arbitrary Hgb level of 10.0 g/dL generally has been used to indicate that a transfusion is necessary. But patients can tolerate lower Hgb levels than previously believed.[6] Except for patients with ischemic cardiovascular disease, keeping critically ill patients' Hgb levels between 7.0 and 9.0 g/dL is as safe as keeping them between 10.0 and 12.0 g/dL.[3,9]

Acute Bleeding

Avoid Using Blood

The primary method of avoiding the need for transfusion in patients with acute hemorrhage is to stop the bleeding as soon as possible. Aside from that, it is unclear whether hypertonic (7.5%) saline, plasma expanders, or crystalloids are the best choice of resuscitation fluid other than blood. It is also unclear whether "permissive hypotension," resuscitating acutely bleeding patients to a mean arterial pressure lower than normal, is beneficial. If patients bleed enough, they will require blood: only hemoglobin transports oxygen to the cells.[10-12]

Massive Transfusions

To survive, some patients need rapid, massive transfusions (i.e., ≥10 units of fresh whole blood or packed red cells within 24 hours after injury). This can be accurately predicted in patients with a penetrating injury if they have Hgb ≤11 g/dL (odds ratio of 7.7 of needing a massive transfusion) and an international normalized ratio (INR) of >1.5. These patients, even when transport times were <60 minutes, usually were coagulopathic on arrival at a medical facility.[13]

How to Determine Adequate Blood Replacement

If a patient has been adequately transfused after acute blood loss (assuming that the bleeding has ceased), the skin will become warm, dry, and, if the patient is Caucasian, pink. The nose will again be warm, and the capillary refill will be brisk (immediate). This is in contrast to the skin being cold, damp, and white, and having a delayed (not "brisk") capillary refill when acutely anemic. These clinical results of transfusion may be delayed, especially if the blood loss was severe or prolonged. A urine output of ≥1 mL/kg body weight is also an excellent sign of adequate blood replacement.[14]

HOW TO TRANSFUSE AUTOLOGOUS BLOOD

Acute Normovolemic Hemodilution

The easiest method for decreasing red cell loss during surgery in relatively normovolemic adults is to use acute normovolemic hemodilution (ANH), also known as acute isovolemic hemodilution. This is when the patient's blood is removed (to keep for later transfusion) and replaced with 500 mL to 1 L crystalloid (or occasionally colloid) immediately before surgery. This dilutes the blood volume and results in a smaller decrease in hematocrit for the same volume of blood loss.[1] Since this process reduces the loss of RBC mass during surgery, it can be used for urgent or elective procedures to decrease the requirement for preoperative blood donation and the use of banked blood.[15]

This technique provides fresh whole blood for use in the operating room (OR) and is safe (uses the patient's own blood), convenient for the patient, simple to perform, and inexpensive.

Use ANH if the surgical blood loss is anticipated to be >15 mL/kg and the patient has an Hgb ≥10 g/dL before surgery. For nonemergent surgery, give iron to patients with a lower Hgb to raise their Hgb level before the operation. Patients excluded from this procedure are those with sickle cell disease, severe cardiac disease, bacteremia, liver disease, or bleeding disorders.[16] At the conclusion of surgery or if there is an indication that a transfusion is necessary during the procedure, collected blood may be returned to the patient.[3] It is especially useful for hospitals with limited or no blood bank facilities.[17-19]

ANH Procedure

At the onset of surgery in a stable patient who is not hemorrhaging, use a 14-gauge IV catheter in an antecubital vein to remove either 2 L of blood or enough so the hematocrit is 28%, whichever comes first. Drain the blood into a sterile container with anticoagulant (generally 64 mL CPD [citrate-phosphate-dextrose] or the equivalent/500 mL blood).

The volume to be removed (V) is determined using the formula[17]:

$$V = EBV \times [(H1 \text{ minus } H^2) \div H^{avg}]$$

where: EBV (patient's estimated blood volume) = body weight (kg) × 70 mL/kg
H1 = patient's initial Hct
H^2 = patient's target Hct after hemodilution
H^{avg} = the average Hct (average of H^1 and H^2)

As the first liter of blood is removed, it is simultaneously replaced with an equal volume of colloid solution, if available, and then with crystalloid in a 2:1 ratio. (Up to a 3:1 ratio can be used if only 1 unit is removed.)[19] If colloid is not available, use crystalloid for all replacements. If there is only one IV line, the blood collection and the infusion of replacement fluids are alternated. If there are two IV lines, they occur simultaneously.[16] Immediately label all blood units with the patient's identifying information.

Obtain Hct levels and vital signs immediately before hemodilution, after the removal of each 500 mL of blood, and at the end of the hemodilution procedure. Patients should receive hemodiluted blood intraoperatively to maintain their Hct >25%. Transfuse all hemodiluted blood before discharging the patient from the recovery area.[17]

Unlike preoperative autologous blood donations (described subsequently), ANH requires minimal preoperative preparation and produces negligible patient inconvenience. The procedure can be used for some patients requiring unplanned operations—including Cesarean sections. Probably most important in austere situations is that the blood does not require a blood bank: it is stored at room temperature at the patient's bedside and administered only to that patient. This also reduces the human errors inherent in the process of giving the correct blood to the patient.[16,17]

Blood/Cell Salvage—Autotransfusion

Blood or cell salvage is when shed blood is collected from a wound or body cavity and then reinfused into the same patient. The general rule is to use this technique if the patient seems likely to lose <20% blood volume,[1] although this technique works well to supplement allogenic (another patient's) or presurgically donated blood.

This technique is often used for patients presenting with ruptured ectopic pregnancies, which are a common cause of massive intraperitoneal hemorrhage. Many of these women present in hypovolemic shock, because considerable time often elapses between the ectopic rupture and the patient's arrival at the hospital. Part of the high mortality associated with ectopic pregnancies in both developed and least-developed countries is due to the scarcity of blood available for transfusion. Using blood salvage and autotransfusion often leads to a normal recovery.[20] The techniques are also used for hemothoraces from penetrating chest injuries and for blunt abdominal injuries with hepatic or splenic bleeding.[21]

What Blood to Use?

Use autologous transfusion only if blood can be removed from a cavity (usually the chest or abdomen) where it has been for less than 24 hours, although some clinicians try to limit it to 12 hours or less.

Blood from sterile cavities, such as the chest or abdomen, without visceral injuries or evidence of overt hemolysis is preferred.[1] Contraindications to salvage include blood contaminated with bowel contents, bacteria, fat, amniotic fluid, urine, malignant cells, and irrigation fluids.[4,16] Blood from contaminated abdominal wounds can be used, but with an increased risk of systemic infection.[22] The patient's condition determines when the blood is reinfused, although the units should be used within a few hours to limit the chance of bacterial growth. If possible, it is best to wait to transfuse until bleeding has been surgically controlled.

Technique: Abdomen

Draining the blood from abdominal bleeding (usually due to a ruptured ectopic pregnancy or blunt abdominal trauma) is often called pre-incision needle drainage, but it can also be performed through a tiny opening in the peritoneum once it is exposed. To do this, make a small peritoneal incision while "tenting" the peritoneum to avoid spillage. If the intraperitoneal blood appears fresh and is the normal color, collect it in small containers. If the hospital has a blood bank, the first aliquot of blood should be sent for type and cross-match, in case additional blood is needed.

Multiple variations of the following two methods have been described. The first method is to collect the blood by scooping it (or letting it drain) into a sterile bowl and then pouring it through gauze into another sterile container. A person wearing sterile gloves then uses 50-mL syringes to infuse the blood into a transfusion bag. The syringe may need to be rinsed with normal (0.9%) saline (NS) occasionally to prevent the plunger from sticking.[23]

The second method, faster and more elegant, to use for ruptured ectopic pregnancies (but that could also be used for hemothoraces) is to position the patient so that the fluid is dependent. With a hemoperitoneum, that will usually be in a feet-down (i.e., reverse Trendelenburg) position with the patient turned slightly to the right side. After prepping the area, introduce a 15-gauge needle into the right iliac fossa. Connect it to a standard blood set and blood collection bag with anticoagulant. Gently manipulate the needle, allowing the blood to flow freely into the bag. Another method to increase flow is to lavage the abdomen with NS, although this results in lowering the Hgb of the collected blood. The blood is transfused using a filter to avoid clots.[24,25] The bowel is rarely injured when using the percutaneous needle since, like draining ascites, the bowel normally floats away from the needle. Of course, the process can be done under ultrasound guidance, which may be even safer.[20]

After removing most of the fresh blood, enlarge the peritoneal incision and clamp the bleeding site. At that point, some clinicians scoop (not suck) blood from the abdomen into sterile containers[1]; others use gentle suction (<40 mm Hg).[20]

Technique: Chest

When there is bleeding into the chest cavity, blood is commonly drained out through a chest tube using gravity. Blood drains through a funnel lined with several layers of gauze and into a sterile glass bottle containing anticoagulant such as CPDA-1 (citrate-phosphate-dextrose-adenine) (Fig. 17-1). The bottle can then be inverted and directly infused through an IV with a 200-micrometer filter.[21]

Filtration/Anticoagulation

Gauze is frequently used to filter the blood. No less than three, and preferably eight, layers of sterile gauze should be used to screen out small clots and tissue fragments that could cause pulmonary emboli or disseminated intravascular coagulation, before putting the blood into sterile bags or bottles with anticoagulant (if available).[1,4,20]

For each 500 mL of blood, add 60 mL of 3.8% sodium citrate (3.8 g/L) or 12 mL of citric acid monohydrate-trisodium citrate dihydrate-glucose solution. If clots appear, re-filter the blood. Reinfuse this blood immediately; do not store for later use.[25] If anticoagulant is not available, prepare acid-citrate/dextrose (ACD) by mixing 2 g sodium citrate and 3 g dextrose in enough sterile water to make a total volume of 120 mL, which is sufficient for 1 unit of blood.[20]

An alternate formula for preparing ACD is to combine 8 g citric acid monohydrate, 22 g tri-sodium citrate dihydrate, and 24.5 g dextrose monohydrate, mix, and add it to 1000 mL distilled water to make the ACD solution. Then place 75 mL of the ACD solution in a 500-mL blood

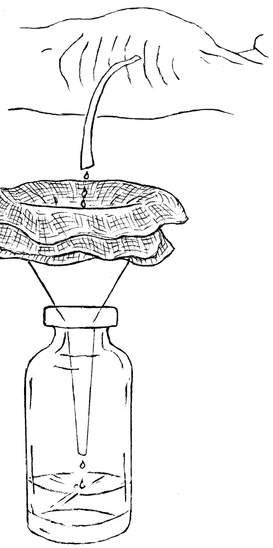

FIG. 17-1. Improvised cell salvage from a chest tube.

bottle and autoclave it. Alternatively, the dry ACD mixture can be separated into 4-g portions and wrapped in waxed paper. A 4-g packet is the amount necessary for one 500-mL blood bottle. Each time blood bottles are made up, empty the contents of one packet into the bottle, add 75 mL of distilled water, and autoclave the bottle.[26]

In some cases, especially in dire emergencies, cell salvage may be used either without anticoagulants or with alternative anticoagulants (such as heparin).[21,27] Blood that flows freely and has been in contact with serosal surfaces (e.g., peritoneum, pericardium, and pleura) usually lacks fibrinogen and may not need an extra anticoagulant. Either using heparin anticoagulation or not using anticoagulants has been used without any complications. If CPDA-1 is in short supply, a half-dose (30 mL/500 mL blood) can also be used.[21]

Advantages

Cell salvage has been shown to be safe, simple to use, and culturally acceptable. The method poses no risk of either transfusion reactions from mismatches or the transmission of blood-borne diseases. The blood is immediately available, since there is no need to do a type and cross-match. The method is so simple that it can be done in resource-poor settings without elaborate equipment or the electricity needed for blood refrigeration. In cultures that fear or ban blood donation or receiving blood from others, this method may overcome some of their concerns.

Disadvantages/Complications

The potential harmful complications of infection, embolism, or coagulopathies are far outweighed by the lifesaving potential of the procedure. The chance of infection from the transfusion is markedly lessened by using sterile equipment and by discarding blood from a contaminated source, such as an abdomen with ruptured bowel or tubo-ovarian abscess. Transfuse blood as soon as possible to avoid the proliferation of any bacteria that are present. Coagulopathy is more common when this technique is used with ruptured ectopic pregnancies (due to trophoblastic products) than with other abdominal or chest injuries. Yet, few complications have been reported. Some of these complications, including renal failure from transfusing hemolyzed blood, have led some clinicians to limit its use to bleeding sites that are no more than 3 hours old.[21]

Preoperative Autologous Blood Donation

Preoperative autologous blood donation (PABD) is one of the safest methods of obtaining blood for anticipated surgical blood loss. The method can be used anywhere a blood bank exists. Ideally, 4 to 5 weeks before an elective operation, the patient donates blood for use during surgery.

However, PABD is expensive, since it requires that there be a functioning blood bank in which to store the blood. The procedure is also prone to some human error, since the correct patient's blood must be identified and administered. Moreover, since patients can donate only a limited amount of blood, that amount may be insufficient to replace the blood lost at surgery.[1]

TYPING BLOOD

Blood typing and Rh testing requires special chemicals that are normally available only in a blood bank. Cross-matching is used to test whether a specific unit of blood is compatible with the patient. Cross-matching tests red blood cells (RBCs) from the donor unit against the recipient's plasma/serum. The principle is that if the patient's serum contains antibodies against the antigens present on the donor's RBCs, agglutination occurs. Agglutination indicates that the donor unit is incompatible for that specific patient. If no agglutination occurs, the unit can be transfused into that patient.

Obtaining Samples

When drawing blood for either ANH or cell salvage, if a blood bank is available, send the first aliquot to them, in case additional banked blood is needed. In an emergency, blood can be scooped off the patient or out of an open wound. Just be sure that it is the patient's blood.

Emergency Cross-Matching

While emergency blood cross-matching is not optimal, if no other option exists, doing this is better than transfusing without any testing. This may be used in austere situations when blood for transfusion is being obtained from a "walking blood bank" (see subsequent section). Even for this simple test, you need a centrifuge, a magnifying lens or microscope, a pipette or syringe, and time.

Simple Method (White Tile)

The white tile method[22] uses a drop of the donor blood mixed with the recipient's serum. Put this mixture on a white ceramic tile and examine it after 4 minutes (a hand lens may be useful). If no agglutination occurs, the blood is acceptable for transfusion into that recipient.

More Complex Method

1. Put 10 mL of the donor's blood in a tube and centrifuge it for 5 minutes at 3000 rpm. The serum and cells should separate. Use a pipette or syringe to remove the serum.
2. Add 2 drops of 0.9% NaCl (normal saline, NS).
3. Mix the donor's cells with the NS using a wooden stick filling the tube with NS.
4. Fill the tube with NS and centrifuge for 1 minute at 3000 rpm. Use the pipette or syringe to remove the NS.
5. Add 2 drops of the patient's serum to the donor cells.
6. Set the mixture aside for 5 minutes at 20°C to 25°C (68°F to 77°F).
7. Spin the mixture again for 1 minute at 3000 rpm.
8. Using magnification, examine the sediment. No agglutination indicates that the donor blood may be used for transfusion. Agglutination indicates an antibody–antigen reaction, and this donor blood should not be used for this patient.[28]

WALKING BLOOD BANK

The term walking blood bank (WBB), also called "blood on the hoof,"[29] refers to obtaining blood for transfusion from donors who are present or who can be called upon when the blood is needed.

The US Navy has used the WBB since transfusions became a part of medical therapy,[30] and it is part of the emergency medical plan for most military units, including the Allied invasion at Normandy during World War II.[31] WBB also has been described for use in neonatal ICUs and rural hospitals.[32,33] It also should be included in disaster plans and in developing blood services in resource-poor regions where culture, finances, or poor management leads to scarcity of transfuseable blood.[34] Since a WBB is a community effort, it helps to involve religious leaders when generating potential donor lists for pretesting. Blood from a WBB donor is not stored, but rather transfused immediately. Samples should be retained (frozen, if possible) for "look-back" testing for blood-borne pathogens.

In planning for a disaster, if the use of a WBB using a defined group of people as donors is probable, donors should be prescreened (discussed in next section) and a potential donor list prepared. The WBB procedures, including quickly locating the donors, should be practiced in advance.[22,35]

Donors

Prescreening

In ideal situations, donors have been prescreened for a history of high-risk behaviors (e.g., sexual practices, parenteral drug abuse, or recent tattoos), blood-borne diseases, or prior rejection as a blood donor. Their blood should also have been typed and screened for laboratory evidence of anemia, hepatitis, dyscrasias, and hemoglobin variants, such as sickle cell trait, thalassemia minor, or glucose-6-phosphate dehydrogenase deficiency.[35] If possible, most individuals identified as potential donors for disaster situations should be blood type O (universal) donors. (Forty-six percent of the US population has type O blood.) For the donor list used during community blood shortages, the entire spectrum of blood types should be included. Donors should wear or carry information about their blood types.[28] Whenever possible, their blood should be screened again when donated.

Emergency (No Prescreened/Identified Donors)

In situations where a WBB must be used unexpectedly, attempt to determine potential donors' blood types with local testing. If this is not possible, use information from the donor, from dog tags, or from other records, but realize that this information is often incorrect. Even under the best circumstances, information about blood typing printed on dog tags is wrong 2% to 11% of the time.[31,36]

Try to select donors who have previously (ideally, recently) donated blood to a blood bank; they will have been tested for the appropriate infectious diseases. Even among this group, screen out all donors with a history of high-risk behavior.

Blood Storage

Whenever possible, collect the blood using standard blood collection bags that have a 600-mL capacity and that contain 63 mL of CPD or CPDA-1 anticoagulant. If enough blood is drawn so that the bag is almost full, it will contain 450 mL of blood. Label each bag clearly with the blood type and donor identification information.

The longer that warm blood is kept without being cooled or transfused, the greater the risk of bacterial growth and of the loss of clotting factors. Blood units should be kept at room temperature for no longer than 24 hours—and preferably for <6 hours. After 24 hours, destroy any warm whole-blood units: It is no longer safe to administer them—even in emergency situations. (Under normal circumstances, hospitals destroy blood units if they exceed 10°C for 30 minutes.)

If absolutely necessary, blood collected from WBB donors can be kept in a refrigerator or on wet ice for up to 3 weeks. While the RBCs remain viable, platelets may become inactive in whole blood stored cold (1°C to 10°C) for >24 hours, losing one of the main benefits of fresh whole blood.[22]

Advantages

The WBB is a source of fresh whole blood when replacement is absolutely necessary to preserve life and limb. For example, the US military used fresh whole blood in Iraq.[36] When standard blood component therapy is unavailable, the use of fresh whole blood can be lifesaving. Because whole blood contains clotting factors, it is effective for treating dilutional coagulopathy associated with massive blood loss and fluid resuscitation.[22]

Disadvantages

Critics of the WBB argue that planning for the use of blood in this manner constitutes an endorsement of substandard practice.[35] In some situations, donor performance may be impaired after donation, especially at high altitudes (where blood donation should be avoided if at all possible) and in tactical/battlefield circumstances. Women donors who are still menstruating should be on supplemental iron before and after donation.[22]

BLOOD BANK

Operating a blood bank requires an abundance of resources that are often not available. These include a constant source of power, laboratory and blood collection equipment, skilled personnel, and a ready supply of blood donors.

Blood should ideally be refrigerated and kept at from 3°C to 6°C; it must not be frozen. Blood undergoes considerable deterioration if the storage temperature fluctuates greatly. An ordinary refrigerator capable of maintaining the required temperature can be used. (The refrigerator needs alarms that detect temperature variations and a source of backup power.) Refrigeration can also be achieved by melting ice, since ice melts at 4°C, which is ideal for blood storage. The melting ice method is most often used when transporting blood, but it can also be used for longer periods if there is a constant and assured ice source. In well-insulated containers, ice can maintain the necessary 4°C for up to 72 hours.[37]

Even if a blood bank is available, there is often a problem getting sufficient blood donations to meet the need. One method of maintaining a stocked blood bank, if such facilities are available, is to try to make donating a unit of blood a requirement of performing any minor surgery.[38]

In poorly nourished populations, blood may have hemoglobin contents much lower than those seen in well-nourished populations. That is of particular concern when most transfusions are performed, as they are at many rural hospitals around the world, by using a relative's fresh whole blood for transfusion.[39]

BLOOD WARMING

Rapid Admixture Blood Warming

Patients needing rapid blood transfusions benefit tremendously from blood being warmed to 37°C from the 4°C temperature that is the standard for banked blood. Clinicians' ability to warm blood units suffers from the time constraints of needing to infuse blood quickly, the frequent need to infuse blood simultaneously through multiple IV lines, and the cost of blood-warming equipment.[40] The following method of "rapid admixture blood warming" is a rapid, safe, easy-to-use, and inexpensive method for warming blood that has been used at the University Medical Center Level 1 Trauma Center (Tucson, AZ) for more than 20 years with great success and no complications (Fig. 17-2).

Rapid admixture blood warming involves combining 250 mL of 70°C NS with a standard unit of packed RBCs (or erythrocytes, the common unit of "blood" transfused) using one of the two ports on the bag. Standard "plasma transfer set" male–male adapter tubing links the two bags. When the ~30-second mixing, performed manually, is complete, the blood unit is at 35°C to 37°C.

Concerns about RBC safety led to measurements of survival times for warmed cells: They survived longer than normal in a human subject. This method also dilutes the unit, leading to faster infusions and fewer complications. To avoid infection after warming the blood to body temperature, the transfusions are completed within 30 minutes after warming.[41,42]

The only piece of capital equipment needed is a standard 70°C laboratory incubator in which to preheat the saline bags. Only one incubator is needed for an emergency department (ED), OR, or ICU; if they are in close proximity, only one is needed for all of them. (The initial warming oven at University Medical Center lasted nearly 20 years!) The cost of tubing is minimal. Since the method utilizes standard nursing procedures, little time is needed to teach the procedure. Standard intravenous (IV) equipment is used, so all of a patient's lines can have warmed blood using this method. ***Caution all personnel using this technique that the 70°C normal saline must never be used for direct infusion.***

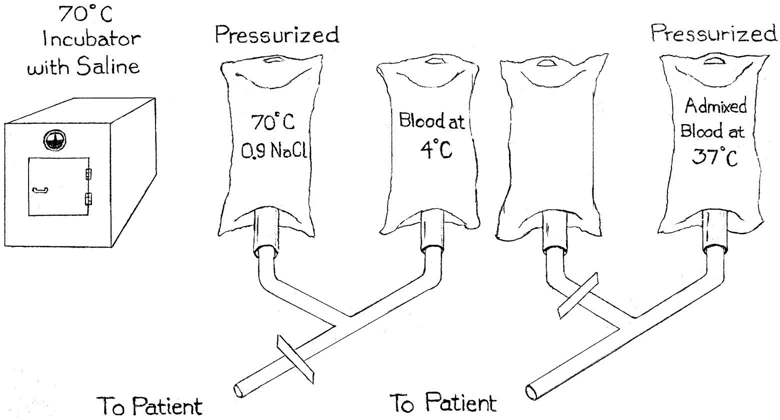

FIG. 17-2. Rapid admixture blood warming technique. *(Redrawn from Iserson et al.[43])*

Rapid admixture blood warming is so inexpensive, simple, safe, and fast that it should be the primary method used for blood warming in most parts of the world.[43-45]

Other Heating Methods

One of the most common blood warming methods throughout the world is to simply lay the blood bag (often of variable quantity) in a pan of tap water at about room temperature for 10 to 15 minutes. While the resulting temperature is unpredictable, this process will not harm the red cells and may provide some patient benefit.

Another simple, slow method of blood warming is to add extra lengths of IV tubing between the blood and the patient (Fig. 17-3). Coil this excess tubing and immerse it in a bucket containing 40°C water.[46] Unlike the rapid-admixture technique where the cells are not affected by 70°C temperatures, the slow passage of the cells through the tubing means that the cells can be damaged if the water temperature is higher than 40°C.

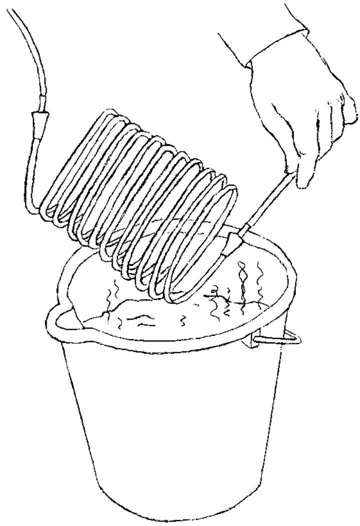

FIG. 17-3. Coiled IV tubing in bucket of water for "in-line" warming.

ALTERNATIVES TO STANDARD TRANSFUSION

Blood will usually be infused intravenously. However, it can also be administered intraosseously and, to treat severe chronic anemia in children, intraperitoneally using the technique described in Chapter 11, Dehydration/Rehydration.[47]

Intraperitoneal Transfusion

Intraperitoneal transfusion can be used only for children with chronic anemia, since it takes from 4 to 6 days to completely raise the Hgb to the levels expected from the infusion. It can be safely used in children up to 4 years old, although most are <3 years old. The optimal volume to infuse is 20 mL/kg over 5 to 15 minutes. This generally raises the Hgb by 4 g/dL. Giving more than 35 mL/kg does not improve the outcome and increases complications. This technique is safe, fast, and easily performed by nurses. It has fewer complications than venous cutdowns and does not require the skills necessary to place IV catheters in very small children.[47]

Transient dyspnea occurs in some cases when the volume distends the abdomen. (Limit the infusion to 20 mL/kg to lessen the risk of this occurring.) Very rarely, if the bowel is perforated, some rectal blood is seen but this does not develop into peritonitis and needs no treatment.[47]

Person-to-Person "Direct" Transfusion

In this method, blood flows directly (or with a brief interlude in an in-line syringe) from one person to another. Direct transfusion should be used only in the most critical situations when there is no other option. If the amount of blood being taken from donors cannot be measured, carefully monitor their vital signs and physical condition to avoid over-phlebotomizing them.

In venous–venous transfusion, the venous tourniquet is removed from the recipient's arm when the IV needle (or, if a cutdown, the cannula) is placed in the recipient's vein. The tourniquet remains on the donor's arm until the procedure is complete. In 1917, Bernheim

FIG. 17-4. Bernheim's direct transfusion device. *(Reproduced from Bernheim.[48])*

described his device for direct venous-venous transfusion: a glass syringe connected to a two-armed, double-needle IV tube. It had a revolving plug, the precursor to the three-way stopcock (Fig. 17-4). Used with IV needles and a three-way stopcock, the amount of blood delivered can be measured and most health professionals should be able to place the lines. The blood transfused is measured by counting how many syringes of blood are infused. Problems with clotting may occur, however.

The advantage of direct transfusion is that it immediately provides a patient with whole blood using minimal equipment. The disadvantages are that probably no more than 2 units of blood (~1 L) can be removed acutely from one individual. Except in transfusions from adults to children, this often may not be enough. In desperate circumstances, taking blood from one member of the group may weaken him/her at a critical time, further endangering the group. Also, even if you "know" the donor, you cannot be absolutely certain without testing that the person does not have HBV, HCV, malaria, HIV, or another blood-borne disease. The potential donor may not even know they have it.

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18 Radiology/Imaging

NON-IMAGE DIAGNOSES

In situations without imaging capacity, clinicians need to rely more on the history, physical exam, observation with repeat exams, and, in some cases, exploratory surgery.

ESSENTIALS

The World Health Organization (WHO) lists what they consider the essential diagnostic imaging equipment worldwide (Table 18-1).[1] This varies with the four levels of hospital capabilities (see Table 5-1 in Chapter 5, Basic Equipment).

VIEWING X-RAYS

Limited Imaging Situations—The Hot Light

Even if radiology is available, it may be intermittent and the images may be of poor quality. Film, rather than digital images, may be the norm.

To help illuminate dark areas of the film, make a "hot light." Using a lamp with a 25-watt regular lightbulb, take off the shade and slip a tin can with both ends cut out over the shade's support wires. The can should fit tightly so the wires support the can. If this is not the case, cut the can lengthwise and wind tape around it so that it sits securely on the shade supports. Then take a piece of heavy cardboard, aluminum foil, or thin metal and cut a 2- to 3-inch-diameter hole in the center. Lay this on top of the can and tape it in place. If using cardboard, be careful that it doesn't get too hot and burn. When you need to see a dark area on the film, turn on the light and hold the film over it—but not too close or it will begin to burn. Don't bother trying to use flashlights (too diffuse a beam) or pen lights (too narrow).

TABLE 18-1 WHO Imaging Essentials

	Facility Level			
Resources/Capabilities	Basic	GP	Specialist	Tertiary
Plain radiography	D	D	E	E
Portable plain radiography	I	D	D	E
Ultrasound for trauma (pleural cavity/abdomen for hemoperitoneum; fluid/heart for pericardial effusion)	I	D	D	D
Computerized axial tomography (CT scan)	I	D	D	D
Contrast radiography (barium, Gastrografin)	I	I	D	D
Angiography	I	I	D	D
Image intensification/fluoroscopy	I	I	D	D
Magnetic resonance imaging (MRI)	I	I	D	D
Nuclear medicine imaging	I	I	D	D

Abbreviations: D, desirable; E, essential resources; GP, general practice; I, irrelevant.
Adapted with permission from Mock et al.[1]

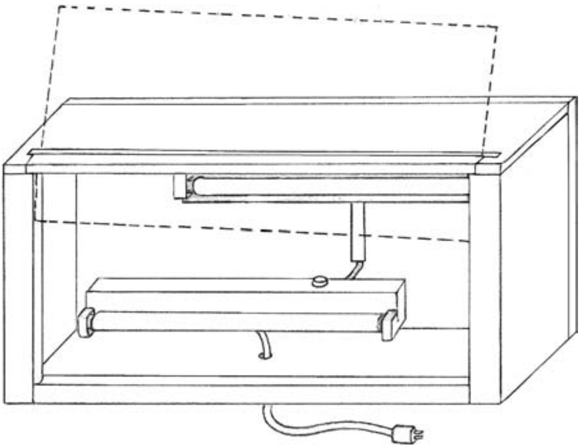

FIG. 18-1. A locally made radiographic viewing box. *(Reproduced with permission from Iserson and Timeb.[2])*

Light Boxes

Light boxes (view boxes) to view radiological images may be scarce. View boxes can be made (Figs. 18-1 and 18-2) or the film can be read without one. Methods to view films without a view box include the following:

- Hold the radiograph up to a light source such as a lamp or ceiling light. If you just want to get a general look at an x-ray (perhaps to make sure it's the right one), then all you need is some basic background lighting to reveal the contrast. If you want to see something more detailed about the film, you will need more than just a desk lamp.

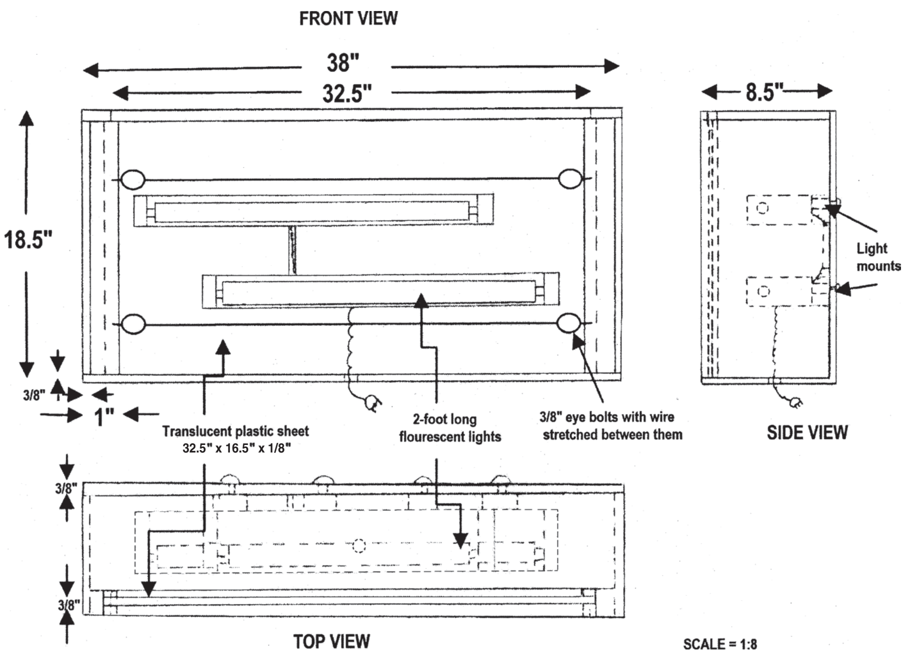

FIG. 18-2. Technical drawing for viewing box. *(Reproduced with permission from Iserson and Timeb.[2])*

- Place the radiograph against a brightly lit window. You can also tape the film in place if it will be needed for some time, such as in the operating room (OR) or when teaching. This works in a way similar to a light box by back-lighting the radiograph so that you can see the contrast.

A view box can quickly (3 hours) and inexpensively (~$63 US) be made from locally available materials, as we did in Kintampo Municipal (District) Hospital in rural Ghana. Our view box is a wooden case containing fluorescent bulbs with a translucent plastic viewing screen. The bulbs are the same as those used in the hospital's ceiling lights. The plastic, available locally, slides into grooves cut in the sides of the box, and can easily be lifted out to change the bulbs. Radiographs rest on a lip at the bottom of the box, and are held in place with both the top wooden slat that anchors the plastic sheet and two wires strung across the front of the box to eye bolts in the sides. The activation switch on the electrical socket is used to turn the light box on and off. Our light box design accommodates two full-size radiographs simultaneously. The light box can be set on a desk or shelf or, as at our hospital, mounted on the wall using standard brackets.[2]

Makeshift X-Ray Markers

Film Markers

Which is the right side? Normally, films are labeled with either "right" or "left" markers. (On chest and abdominal films, except with *situs inversus*, it should be obvious.) These metallic markers are small and easily lost. Bend a paper clip into an "L" (easier) or "R" (if you're talented) and tape it on the film as you would with a standard marker.

Foreign-Body Markers

Makeshift markers for foreign-body localization or for entrance/exit wounds in penetrating trauma can be fashioned from BBs (metallic pellets for air rifles), lead markers for radiographs (especially the "O"), vitamin E capsules (for MRIs and CT scans, since they are visible but don't cause scatter), hypodermic needles, electrocardiogram (ECG) or electroencephalogram (EEG) leads, or paperclips.

Paperclips are often most effective as markers if they are "unwrapped," so that only a single wire points to the wound. With plain radiographs, at least two views should be obtained to better localize any foreign body. When using foreign-body markers for a CT scan, unbending them also minimizes scatter at the end of the marker nearest the wound.

One variation on the paperclip foreign-body marker has a "forward arrow" (Fig. 18-3) pointing to penetrating wounds that enter anterior to the anterior axillary line (the front of the body)

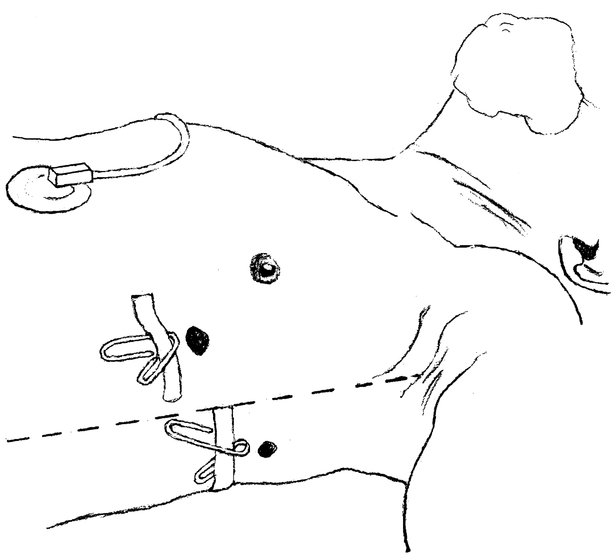

FIG. 18-3. "Forward"/anterior and "backward"/posterior paper clip arrow markers.

and a "backward arrow" pointing to those that enter posterior to that line (back of the body). This helps with localizing the penetrating foreign body's (usually a bullet) trajectory.[3] Of course, everyone has to know what the different markers mean.

ESTIMATING THE SIZE OF A PNEUMOTHORAX

The treatment of pneumothoraces depends on their size. Rather than just inserting a chest tube (and using many resources), patients without dyspnea who are <50 years old with a first-time unilateral spontaneous pneumothorax that is "small" can be managed with observation.[4]

To avoid using any of the complex and often inaccurate formulas and nomograms to calculate pneumothorax size, the British Thoracic Society (BTS) suggests the use of a simple method that works well in clinical practice. They recommend that for a spontaneous pneumothorax, a "small" collapse is when the average interparietal distance (AID) is <2 cm. The AID is an average of the distance between the parietal and visceral pleura at three points: the lung apex, and one-third and three-fourths of the way down the lung. Other recommendations state that the distance between the apex of the chest to the cupula of the lung should be <3 cm to be considered "small."[5]

CONTRAST STUDIES

Contrast Esophagrams

If necessary, use barium for these studies, since aspirating small amounts of barium causes no problems. Keep the patient sitting upright to reduce the aspiration risk. To reduce the amount of contrast used, patients can swallow a barium-soaked cotton ball rather than the liquid. However, if a foreign body must be extracted after contrast has been used, the procedure can be more difficult. These studies can be done with a portable x-ray machine.

Use water-soluble contrast (e.g., Gastrografin) first if perforation is suspected, since it causes less mediastinal inflammation if extravasated. (Any iodine-containing contrast diluted with water can also be used.) If aspirated, it causes a severe chemical pneumonitis. Do not use it in cases of complete esophageal obstruction. To test for a perforation, have the patient swallow progressively larger amounts of contrast, up to about 50 mL. If that is negative, repeat the procedure with half-strength and then full-strength barium. If fluoroscopy is available, use it. It is easy to miss a perforation using portable radiographs, since you can take only one film with each swallow.

Gas Contrast

Air and carbon dioxide are effective, inexpensive, and readily available contrast agents for the stomach or colon. Inject air directly into these areas using a nasogastric (NG) or enema tube. Children's effervescent tablets can also produce gas if swallowed. Air injected through an NG tube usually provides sufficient contrast to make the diagnosis of a tracheoesophageal fistula in infants. It avoids introducing barium with the real and dangerous risk of aspiration.[6]

Computed Tomography Contrast

The typical contrast material used for abdominal CT studies is expensive and is not well tolerated by many patients. Whole milk (4%), which is much less expensive, works well as a substitute contrast agent for abdominal CT studies. It seems to work better than 2% milk, water, or no oral contrast agent. Whole milk functions as well as barium suspension for gastrointestinal distention, mural visualization, and bowel loop and pancreas-duodenum discrimination.[7] In addition, patients are much more willing to drink the milk and they have fewer subsequent gastrointestinal effects.[8]

Magnetic Resonance Imaging Contrast

Several positive oral contrast agents for MRI can be improvised. These include pediatric formula and homemade oil emulsions.[9] If you have MRI, however, you probably don't need to improvise.

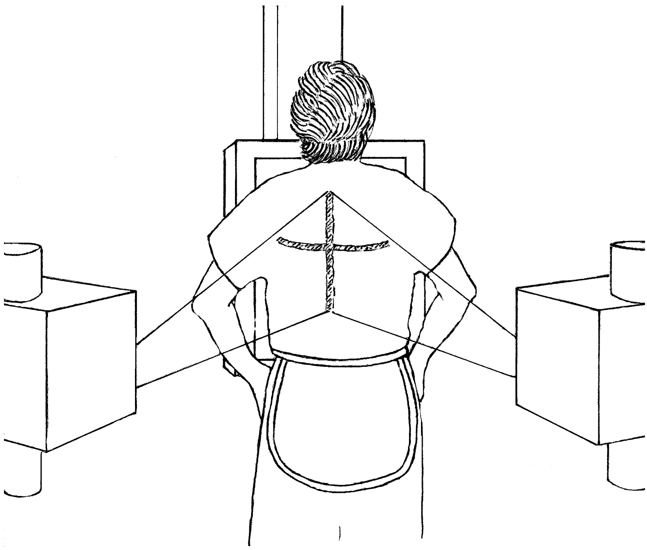

FIG. 18-4. X-ray positions to take a stereoscopic radiograph.

STEREOSCOPIC IMAGING

Poor-Man's CT/Tomogram

When CT scanning is not available, plain radiographs can provide a "poor-man's CT scan" of complex structures using stereoscopic imaging. Used until the mid-1980s in the United States, the technique clarifies difficult-to-read films and can localize lesions within a space (such as bullets or cavitary lesions in a chest or skull). It was commonly used for facial bones (such as Water's views) and P-A chest radiographs. It can also be used for complex fractures.

Taking Stereoscopic Films

Stereoscopic films are taken by keeping the part of the body (head, chest, and limb) being filmed still while first taking one film 5 degrees lateral from midline and then another film 5 degrees lateral from midline in the opposite direction (Fig. 18-4). Alternatively, for each film, move the x-ray head to either side of midline, 10% of the distance between the x-ray head and the x-ray plate. The x-ray heads must be kept in the same horizontal plane. Be certain that the patient does not change position while you are changing x-ray plates. Note that some modern x-ray heads cannot be adjusted to shoot films at these angles, although it can be done with all portable machines.

The tube motion must be in the direction of the grid lines if a grid is used to reduce x-ray scatter. (X-ray technicians will understand this.) The grid is usually along the long axis of the table, and built into the x-ray table's Bucky cassette holder. It is also built into wall units, usually with a vertical orientation. The cassette may be placed against the patient (without a grid), although there will be more scatter and lower contrast than with a grid.

If only digital radiography is available, use the same technique to take the films and put them up side by side using the "compare" feature that comes with most digital radiographic readers. The films may need to be rotated to make them line up correctly.

Viewing the Images

Reading stereoscopic radiographs requires either a stereoscopic viewer (generally rare in austere medical situations) or a little practice in crossing one's eyes to form a 3-D image between the two slightly different films. A way to practice this eye-crossing technique is to use the old postcard-type images from a stereopticon or the images from Fig. 18-5. Just slightly cross your eyes until the two images merge in the middle, giving a 3-D picture. This is also how it is done

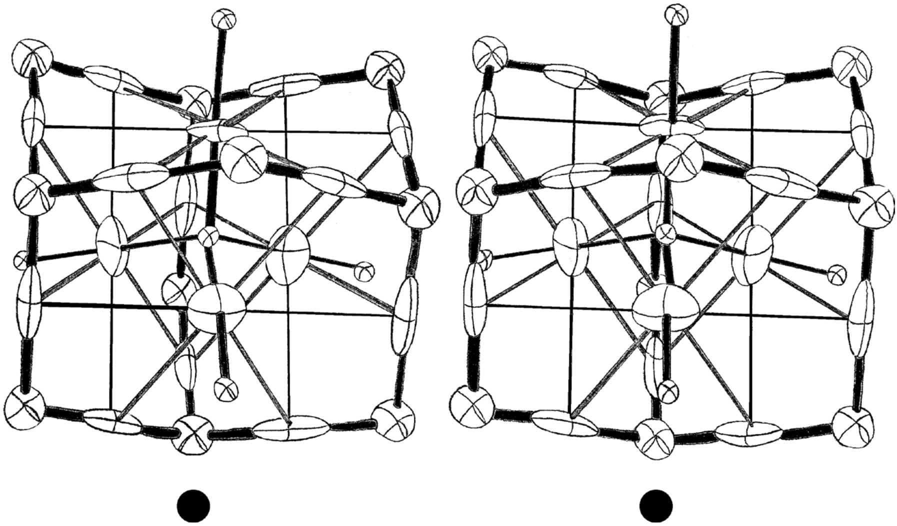

FIG. 18-5. Stereoscopic diamond. *(Source: Anon.[10])*

with radiographs. Some people find it easier to merge specific points, such as the black dots below the figures, and then look at the image.

For those who can't cross their eyes to see the stereoscopic image, Dr. E.B. Morton devised a simple stereoscopic viewer using cardboard[11]:

> The simplest stereoscope for X-ray negatives or prints may be improvised in a few minutes. Take a piece of cardboard about 6 in. by 8 in., and cut a rectangular opening in the middle, say 2 in. by 1½ in. The two plates or prints are set upright side by side in a good light and from four to six feet from the observer. The card is held at arm's length, more or less, until the observer's right eye sees only the left hand plate, the left eye being closed, while the left eye sees only the right hand plate when the right eye is closed. Now open both eyes, concentrating attention on the edges of the opening in the card; in a few seconds or less the two images will coalesce, giving a perfect stereoscopic effect. At first it may be a little difficult to secure this, and there may be some ocular fatigue from the use of the muscles in an unaccustomed way, but this very soon disappears, and it is worth while learning how to use a device that can be made in a moment from a piece of dark paper if nothing better is at hand.

To make a similar viewer, enlarge the template in Fig. 18-6 to fit a letter-sized sheet of paper and cut it as indicated. The sides fold up so that it ends up looking like a trough with a hole at one end (marked with an eye) through which you view the images (Fig. 18-7). Use it in the same manner as described by Dr. Morton.

ULTRASOUND

Ultrasound has become the standard imaging modality in many austere situations. It has multiple clinical applications and can easily be operated by the clinician. In addition, its low cost (in comparison to other imaging hardware) and portability are ideal for remote areas. While clinicians now perform a wide variety of ultrasound exams (the E-FAST and gallbladder being the most common), only the less common, but easily performed exams to diagnose fractures and neonatal intracranial bleeding, are described here. Eye exams are discussed in Chapter 27, Ophthalmology.

Ultrasound Gels

In austere situations, "disposable" often means unavailable. That is frequently the case with ultrasound gel. Substitutes include ECG jelly, liquid soap, any water-soluble gel (e.g., K-Y Jelly), and

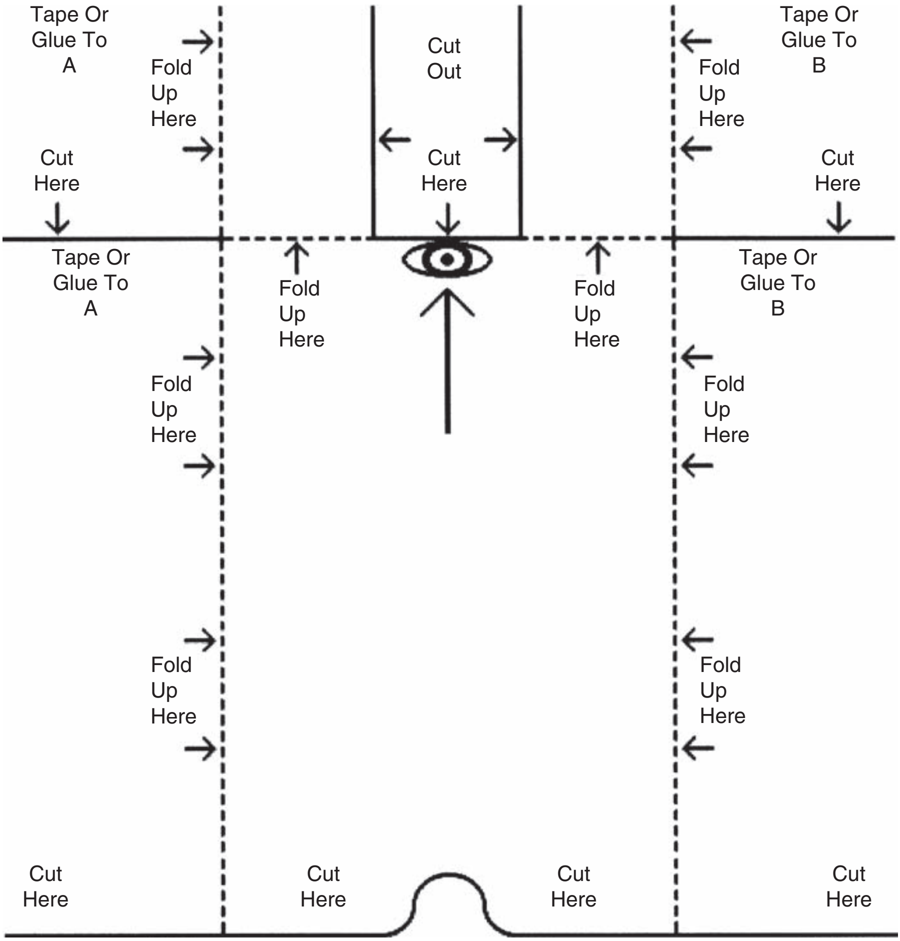

FIG. 18-6. Homemade stereoscopic viewer. *(From Samuel.[12])*

vegetable oil. All provide images comparable to those produced using commercial gels. The problem with vegetable oil, however, is that it is not water-soluble and it stains everything it touches with oil marks. While ordinary soap or water can be used as ultrasound gel, do not use petroleum-based materials, such as Vaseline, since they reportedly damage ultrasound heads.

Probe Protectors

A nonsterile very thin plastic bag, large condom, or rubber glove can be used to protect the ultrasound head when it is being used in the vagina or mouth. Put contact gel into the bag or glove before inserting the probe. Then put additional gel on the outside of the plastic for a good seal. When a sterile probe cover is needed to help guide procedures done under aseptic conditions (e.g., paracentesis, central line placement, and bladder aspiration), use sterile surgical gloves as a probe cover.

Neonatal Ultrasound of the Head

Use cranial ultrasound in infants to check for bleeding. Cranial ultrasonography can easily identify a subependymal hemorrhage or intraventricular blood. It can also be used to identify

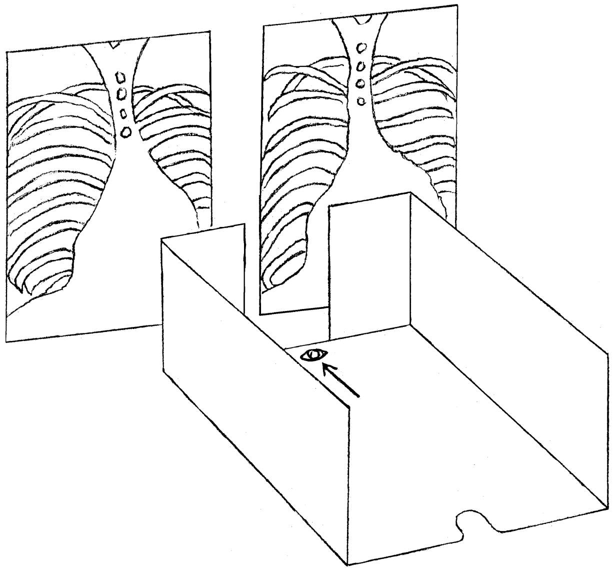

FIG. 18-7. Method to use homemade stereoscopic viewer.

posthemorrhagic ventricular dilation reasonably well and midline shifts. Evaluation of arterial flow (especially in the neck) and intraparenchymal lesions is operator dependant.

Use a 7.5 MHz probe for premature infants <32 weeks gestation or <1500 g, and a 5.0 to 3.0 MHz probe for older infants with an open fontanelle. With enough gel on the head and probe and with the child restrained, place the probe over and perpendicular to the anterior fontanelle in the coronal plane (across the head) and slowly angle it forward and backward to see the entire brain. The structures, especially those that are blood-filled, should be easy to see. Repeat the process with the probe oriented in the sagittal plane (front to back) and slowly angle it from side to side to see the lateral ventricles and temporal lobe.

Orthopedic Ultrasound

Although bone is a natural obstacle to high-frequency sound transmission, the large difference in acoustic impedance between soft tissue and bone results in a strong acoustic interface. This leads to an almost total reflection of sound energy from the bone, providing an excellent way to examine patients for fractures.[13]

Selecting the correct patients for examination is the key to using ultrasound for fracture diagnosis (Fig. 18-8). In patients exhibiting signs and symptoms of a fracture, clinicians with minimal training can diagnose many fractures using ultrasound, even those that cannot be seen on radiographs. In patients with a medium-to-low probability of fracture, they are able to successfully rule out the presence of long-bone fractures.[14]

The ultrasound exam for fracture, which generally takes less than 5 minutes to complete, is usually performed with a high-frequency linear probe (10 to 5 MHz). Physicians can become proficient in administering the exam with only an hour-long standardized formal training session and a practice session on a live normal model.[14] Although, demonstrating on a child with a femur fracture, I taught rural Zambian nurses to successfully recognize fractures with ultrasound in 5 minutes. Some inexperienced examiners use pictorial reference cards to locate both ultrasound equipment controls and where to place the probe for various examinations.[15]

Method

The most common exam is of a long bone. Especially for those not completely familiar with the technique, a useful way to begin is to examine the unaffected extremity and to adjust the depth

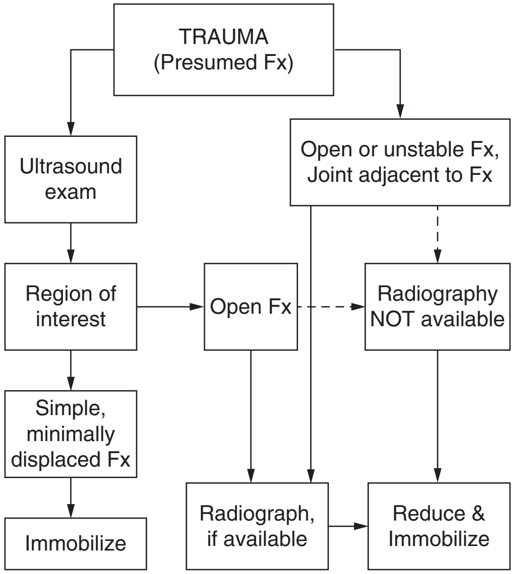

FIG. 18-8. Algorithm for use of ultrasound in fracture diagnosis. *(Abbreviation: Fx, fracture)*

and maximize visualization of the cortical interface during this part of the exam. The cortical interface appears as an unbroken, strongly echoic line. Using sufficient gel, place the transducer transversely (across) the extremity just proximal to the patella or elbow. Identify the femur or humerus and rotate the transducer 90 degrees so that it lies along the long axis of the bone. Slide it up the extremity (Fig. 18-9). Either the smooth shaft or an obvious discontinuity will be seen. Approaching the femoral neck, angle and rotate the transducer slightly and continue scanning to the midpoint of the inguinal ligament to visualize the femoral neck, head, and pelvic acetabulum. Near the shoulder, scan just distal to the acromial process of the scapula to visualize the humeral head.[14,16] If significant bleeding around the fracture has occurred, there may be an overlying hematoma that appears acutely as a hyperechoic area; the hematoma appears hypoechoic in the subacute stage.[13]

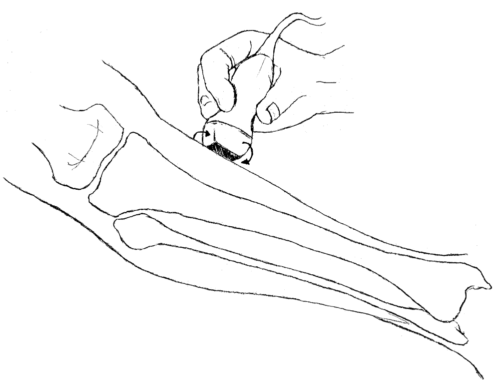

FIG. 18-9. Ultrasound of tibia.

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19 | Laboratory

LABORATORY SERVICES

Clinical laboratory tests have relatively little utility in most resource-poor settings, although lives can be saved if a few simple tests are available, such as those for urine pregnancy, and in endemic/high-prevalence areas, HIV, malaria, and TB screening. This chapter discusses how to improvise various materials, equipment and tests when clinicians need lab tests and the normal procedure for doing them is unavailable.

ESSENTIALS

Table 19-1 lists essential laboratory tests worldwide, which differ depending on the facility's capabilities (described in Table 5-1 in Chapter 5, Basic Equipment).

EQUIPMENT AND MATERIALS

Water

Use filtered rainwater rather than distilled water to make laboratory reagents, such as stains. Collect rainwater in places where it won't be contaminated, such as in rooftop tanks.[1] Besides laboratory use, distilled water is best for use in autoclaves and in pressure cookers used as sterilizers. If available, it should also be used to produce IV fluids.

Distillation involves boiling water and collecting the steam, which then condenses back to water. The water from condensed vapor does not contain salt and other impurities. In austere situations, improvising distillation systems saves many lives, as is seen in the following story from a World War II prison camp:[2]

> Some six weeks before the outbreak I had constructed, as a precaution, a small plant for distilling water for intravenous saline. It was a very primitive affair, the condenser being

TABLE 19-1 Laboratory Testing Essentials

Resources/Capabilities	Facility Level			
	Basic	GP	Specialist	Tertiary
HIV*	E	E	E	E
Urine pregnancy	E	E	E	E
Hemoglobin/hematocrit	D	E	E	E
Malaria*	D	E	E	E
Urinalysis	D	E	E	E
Glucose	I	E	E	E
Gram stain	I	D	E	E
Tuberculosis*	I	D	E	E
Sickle cell prep	I	D	E	E
Bacterial cultures	I	D	D	D
Electrolytes (Na, K, Cl, CO_2, BUN, creatinine)	I	D	D	D
Arterial blood gas measurements	I	D	D	D
Serum lactate	I	I	D	D

Abbreviations: D, desirable; E, essential resources; I, irrelevant.
*In endemic/high-prevalence areas.

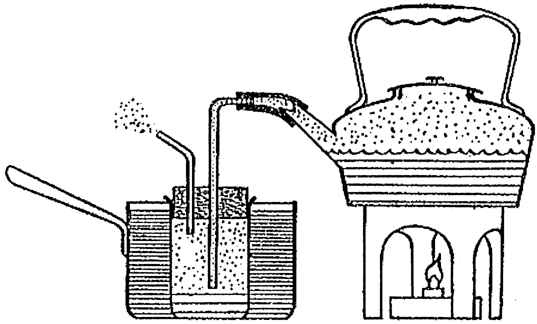

FIG. 19-1. Water distiller. *(Reproduced from UNESCO Source Book for Science Teaching.[3])*

> a coiled rubber tube inside a hollow bamboo in which cold water was circulated. The boiler was a 4-gallon kerosene can. Within 24 hours of the outbreak we were able to give intravenous saline. The plant was producing 40 pints daily, and eventually double that figure. The giving IV bottle was a jam-jar connected to a needle by a rubber tube.

If distilled water is required, it can be easily obtained using a tea kettle and a collecting jar (Fig. 19-1). Heat water in the kettle and run rubber tubing from the spout through a hole in the lid of a collecting jar. Use another small tube as a vent in the jar's lid. Seal all joints with adhesive tape, clay, or glue. Immerse the collecting jar in a pan of cool water so the steam will condense quickly. Voilà, distilled water!

An alternative method of distilling small amounts of water is to fill a large pot one-half to three-quarters full of water. Invert the lid and suspend a heat-resistant cup from a cradle made from wires (coat hangers may be used) attached to the lid's handle. The cup should hang right-side up without dangling in the water when the lid is upside-down. This takes about 5 minutes to set up. As the water boils and steam collects on the lid, it drips down the handle into the cup.[4] If only a little water is used, watch the pot more closely (Fig. 19-2).

Power

In austere situations the electrical supply is often intermittent, if available at all. Suitable AC current for instruments can be obtained from rechargeable batteries using a solar or DC/AC inverter.

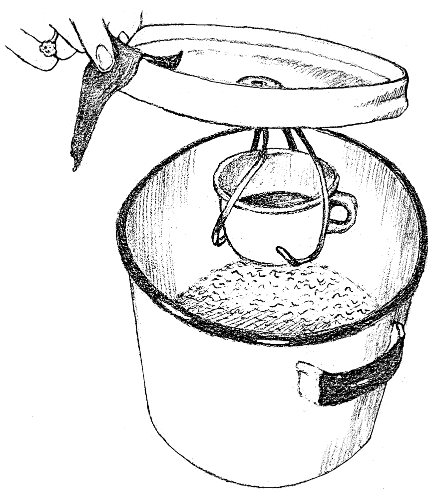

FIG. 19-2. Alternative water distillation method (for small amounts).

Microscope

Having a microscope greatly increases one's ability to do laboratory tests. In a World War II prison camp, a Dutch physician, Dr. Bras, "arrived in camp with a crude microscope constructed of bamboo tubing and field-glass lens."[5] That takes a lot of skill and ingenuity.

When the electricity fails, use a mirror and sunlight or a battery-operated light as your light source.

Filters

If you need to filter solutions, including stains, use a flower pot with the hole in the bottom. Loosely plug the hole with cotton, fill the pot with several inches of sand, and pour in the liquid. Collect the filtered solution in a jar placed under the pot (put it up on a stand). Replace the sand frequently.

Fire-Fighting Equipment

To quash laboratory fires, keep buckets of sand available to put out small fires. Water may not be readily available (or appropriate for all laboratory fires) and fire extinguishers are both expensive and need regular maintenance.

Lab Burner

Speaking of fires, a simple laboratory burner can be made from a shoe polish container. Make a hole in the lid and fill the container with denatured or wood alcohol. If desired, a small piece of tin can be soldered to the lid to hold a cloth or cotton wick.

Refrigeration

Refrigeration may be needed for some samples and reagents. Improvised refrigeration methods and equipment are discussed in Chapter 5, Basic Equipment.

Flasks

Laboratory flasks can be made from dead lightbulbs. Spotlight-type bulbs are the best, since they have flat "bottoms." If regular lightbulbs are used, an egg carton can serve as a holder. When doing this, wear gloves and eye protection, and cover the bulb's glass with a cloth.

With either type of bulb, first use a pair of needle-nose pliers to pull off the little black button that holds the bulb's electrical contact (Fig. 19-3, left). Doing so leaves a hole in the bulb's porcelain base. Put one of the pliers' jaws into that hole and gently work it around until the porcelain cracks (Fig. 19-3, center). Remove the pieces. The hole (with the filament) becomes visible.

After gently breaking off any protruding glass pieces in the hole, sharply tap the glass piece holding the filament (Fig. 19-3, right) to break it, and it will fall into the bulb. Turn the bulb over and dump the pieces out. A thin metal disc may remain in the bulb. Grab it with the pliers, bend it in two, and remove it. Then bend down any sharp edges on the metal (screw part) that remains on the bulb, rinse it out, and begin using it (Fig. 19-4).

This whole process takes about 5 minutes. Use a known amount of liquid to measure the flask's volume and mark it on the outside at convenient increments (e.g., 50 mL, 100 mL).

Test Tube Holder

To hold test tubes over a burner, fashion a test tube holder by bending a wire hanger or similar material (Fig. 19-5). Use pliers (rather than just your fingers) to do the bending.

Scales

Tiny Scale

To measure small quantities or objects, build a scale using a jar lid and a heavy rubber band (Fig. 19-6). Insert a nail in an upright piece of wood. Make four holes that are equidistant

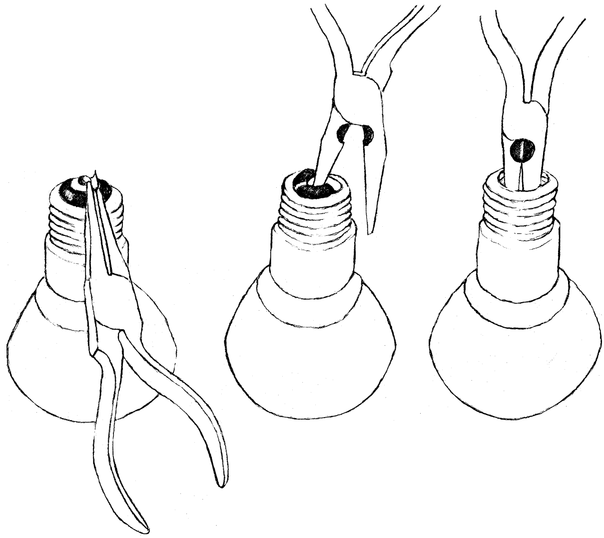

FIG. 19-3. Flask from a floodlight bulb. Remove button (left), remove porcelain base (center), and break inner filament holder (right).

FIG. 19-4. Finished lightbulb flask.

FIG. 19-5. Test tube holder. *(Reproduced from UNESCO Source Book for Science Teaching.*[6]*)*

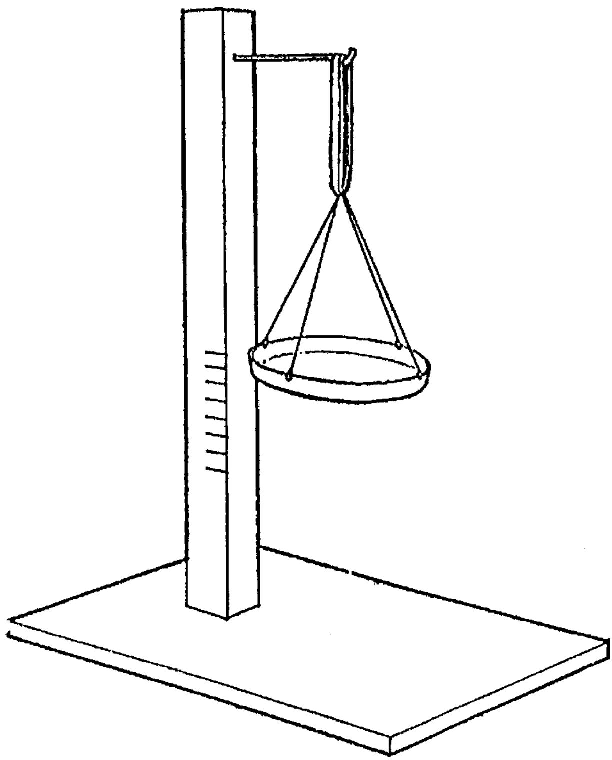

FIG. 19-6. Tiny scale. *(Reproduced from UNESCO Source Book for Science Teaching.[7])*

around the lid, attach a wire to each, and tie or twist all the ends together. (Sutures or fishing line may also be used in place of wire.) Use a paper clip (unwound to an "S" shape) to join the wires and the rubber band. Now that the scale has been assembled, it must be calibrated. Attach a piece of tape that you can write on to the upright wood, and mark the gradations as you add small known weights. (Small quantities of water can also be used.) Once the scale is calibrated, either keep the original set of weights or find small stones (mark each stone with its weight) that can be used to recalibrate this scale. Change the rubber band and recalibrate the scale daily.

Heavy-Duty Scale

Used for heavier weights, this scale holds larger items and measures in kilograms. Attach a heavy spring from a chair or automobile cushion to a solid wooden base. Affix two upright posts on opposite sides (Fig. 19-7). These steady the structure and can be marked with incremental measurements when the scale is calibrated. Affix a metal pan to the top of the spring, either by soldering it to the spring or by passing wires through the pan onto the spring. Calibrate the scale by putting objects of known weights on it and marking the slat as the spring is depressed. Known quantities of water (1 kg = 1 L = 2.2 lb) work well. Use the top of the pan as the marking point.

"Steelyard" Scale

Several types of "steelyard" scales can easily be made. Make the long beam from either wood or metal; use pieces of metal pipe for the sliding counterweights. Fasten the beam and the pan together with wire. For support, place the entire balance on a stiff piece of wire that goes either through or around the beam (Fig. 19-8). As with the other scales, use known weights to calibrate this scale.

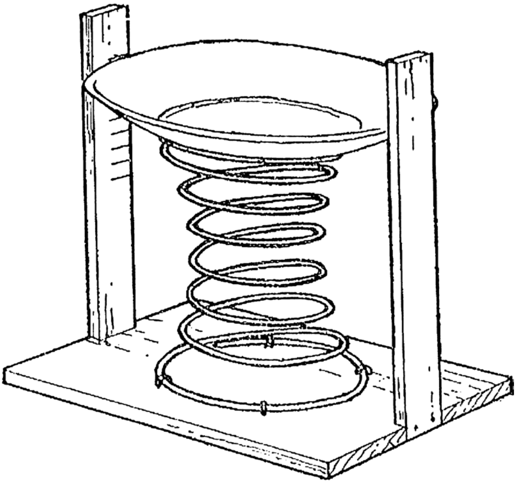

FIG. 19-7. Heavy-duty scale. *(Reproduced UNESCO Source Book for Science Teaching.[7])*

Incubator and Culture Media

Making media for bacteriology is a complex process; so, if you really need to grow cultures, buy the prepackaged powder.

To build an incubator, get a 20-gallon glass aquarium or any container having the same volume (Fig. 19-9). A cardboard box will do in a pinch, but it may not last long. Turn the container on its side with the open end facing front. Tape a piece of heavy plastic sheeting to the top, draping it down so that it covers the open end. The sheeting is the incubator's "door." A bacteriology incubator is normally kept at body temperature, 98.6°F (37°C). Tape a standard thermometer to the inside of the container so that you can easily read it. Set a standard incandescent lamp enclosed in a can or small pail inside the incubator with the electrical cord going out the "door" to a plug. Begin with a 40-watt bulb and assess the temperature after 12 to 24 hours. If it needs

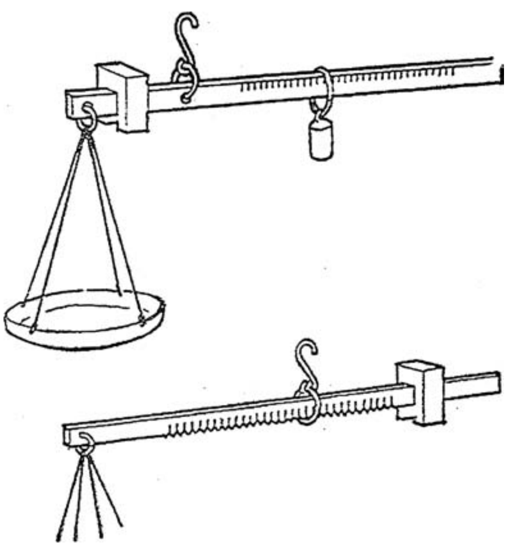

FIG. 19-8. "Steelyard" scales. *(Reproduced from UNESCO Source Book for Science Teaching.[8])*

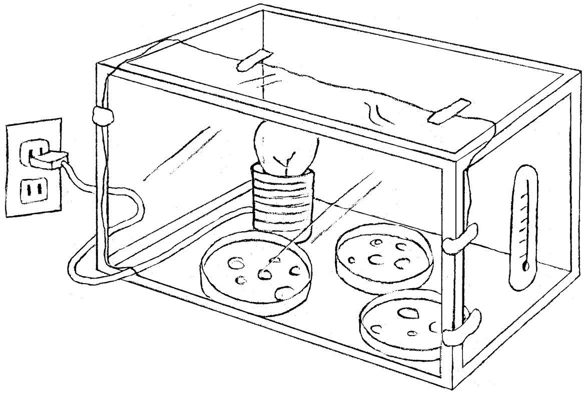

FIG. 19-9. Improvised incubator.

to be warmer, use a higher-wattage bulb. It will probably not be exactly 98.6°F, but if it is a little cooler, that will still work. To be more accurate, use a higher-watt bulb with a dimmer switch to modulate the emitted heat.[9]

Centrifuge

Centrifuges separate liquid suspensions into their component parts, such as consolidating urine sediment or separating blood cells from serum. They are useful for laboratory work.

If possible, procure a real centrifuge. The difficultly with building a centrifuge is getting it balanced correctly. If it is not balanced, not only does it make a lot of noise, but it will also self-destruct. And although improvised machines often will not produce the rotational speeds needed for some tests, even the simplest centrifuge can cause significant damage if the tubes break or fly out of the machine while it is spinning. Given those caveats, relatively simple and workable centrifuges can be made if necessary.

Hand-Drill Centrifuge

A hand-powered centrifuge can be built using a wooden spoon, a hand drill, plastic test tubes, small eye-screws (with 0.5-inch eyes), and cotter pins (Fig. 19-10). It is very rudimentary, but can be used to spin urine, small aliquots of blood, and similar specimens.[10]

1. Cut two 1-inch pieces off the end of the spoon handle. These are the "stoppers."
2. Check to be certain that the spoon's handle fits securely into the drill—where a bit would go. If it is too big, shave it down until it fits.
3. At this point, if you have an extra piece of wood with a wide base, drill a hole into it with a little larger diameter than the spoon handle. This can serve as a stand while completing the rest of the construction, and also later when working with fluid-filled tubes.
4. Link the two pairs of eye-screws by opening one of each pair, inserting the other, and closing it again.
5. Drill tiny guide holes in the top of the stoppers and twist an eye-screw from each pair into that hole.
6. Drill little holes through the plastic test tubes, 0.5 inch from the top. They must be exactly opposite to each other at the widest part of the tube (180 degrees apart).
7. Insert the stoppers into the test tubes and mark where the test tube holes meet the stopper.
8. Drill a small hole very carefully through each stopper from the mark on one side to the mark on the other side.
9. Put the stoppers into the test tubes and insert the locking pins. If they fit, remove them for the moment.
10. Screw the other eye-screw from each pair into opposite sides of the widest part of the spoon.

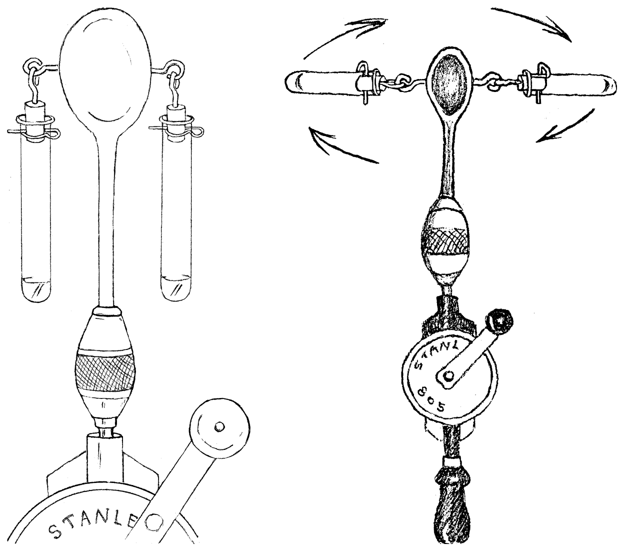

FIG. 19-10. Hand-drill centrifuge: close-up (left) and in operation (right).

11. Reinsert the stoppers into the tubes, insert the cotter pins through the holes, and bend one side of each cotter pin so that it forms a locking pin for the test tubes.
12. If a vice is available, use it to secure the drill handle. This makes the centrifuge much easier to use. If no vice is available, steady the drill base on a hard surface before operating your centrifuge.
13. Gently rotate the drill handle.
14. *Caution*: Significant centrifugal force is created. Wear goggles, and if the centrifuge can be operated inside a container (put it in a large cardboard box and make holes to stick your hands through), it would be best. Note that this is dangerous enough with a hand drill. Do not use a power drill.
15. If the system works, add water to the test tubes and try it again.
16. Still okay? Then add your test materials.
17. If you have slightly larger amounts of material, use two identical small plastic screw-top jars in place of the test tubes. Drill holes in their lids the same size as the test tube stoppers. When using jars, put the stoppers through these holes; the cotter pins go underneath the lids.

CONVERSION FACTORS

Table 19-2 contains a variety of conversion factors needed when working in different locales.

SPUTUM

Diagnoses Without a Lab

If laboratory tests (or imaging) are not available, the evaluation of sputum volume, stratification, color, consistency, and odor can help make the diagnosis.

Volume

No more than 20 mL of sputum is normally produced daily. An increase in volume to ≥100 mL/24 hours occurs in (a) pulmonary edema, (b) bronchiectasis, (c) chronic bronchitis, (d) advanced pulmonary tuberculosis (TB), (e) lung abscess, (f) asthma, (g) pulmonary gangrene, and (h) extrapulmonary lesions (e.g., amoebic liver abscess bursting into the lung). Observing daily sputum volume is a good indicator of deterioration or improvement of lung conditions. Sudden cessation of sputum is highly suggestive of bronchial plugging.[11]

TABLE 19-2 Conversion Factors

Unit A	Symbol	Conversion Factor	Unit B	Symbol
1 unit A multiplied by the conversion factor = 1 unit B				
Celsius	°C	Multiply by 1.8, then add 32	Fahrenheit	°F
centimeter	cm	2.54	inch	in
		0.1	millimeter	mm
		30	foot	ft
centimeter square	cm^2	6.5	square inch	sq in
cubic foot water	cu ft H_2O	62.3	pound	lb
cubic meter	m^3	0.03	cubic foot	cu ft
cup	c	2	pint	pt
dram	dr	8	ounce	oz
Fahrenheit	°F	First subtract 32, then multiply by 0.555	Celsius	°C
foot	ft	0.33	centimeter	cm
		3.3	meter	m
gallon	gal	31.5	barrel	bb
gallon water (UK)	gal H_2O (UK)	10	pound	lb
gallon water (US)	gal H_2O (US)	8.33	pound	lb
grain	gr	480	ounce	oz
		5760	pound	lb
gram	g	28	ounce	oz
hectar	ha	0.4	acre	ac *or* A
inch	in	0.4	centimeter	cm
inches cubic	in^3	277	gallon	gal
kilogram	kg	0.45	pound	lb
kilometer	km	1.6	mile	mi
kilometer square	km^2	2.6	square mile	sq mi
liter	L	0.24	cup	c
		3.8	gallon	gal
		0.95	quart	qt
meter	m	0.9	yard	yd
microliter	µL	10^6	liter	L
milliliter	mL	103	liter	L
		30	ounce (fluid)	fl oz
		15	tablespoon	Tbsp
		5	teaspoon	tsp
millimeter	mm	10	centimeter	cm
ounce	oz	12	pound	lb

TABLE 19-2 Conversion Factors (Continued)

Unit A	Symbol	Conversion Factor	Unit B	Symbol
1 unit A multiplied by the conversion factor = 1 unit B				
peck	pk	4	bushel	bu
pint	pt	2	quart	qt
pound	lb	2.2	kilogram	kg
quart	qt	1.05	liter	L
		8	peck	pk
		4	gallon	gal
teaspoon	tsp	3	tablespoon	Tbsp
yard	yd	1.1	meter	m

Stratification

Sputum from many patients with lung infections separates into three layers when left standing in a tall narrow container; the top layer is frothy, the middle is faintly turbid, and the bottom layer consists of tissue debris. Such layering occurs in (a) bronchiectasis, (b) lung abscess, and (c) gangrene of the lung.[11]

Color and Consistency

Various disease processes and organisms will produce characteristic changes in the color and consistency of sputum.[11] This can assist clinicians in making a diagnosis.

Type (color, consistency) of sputum	Diagnosis
Tenacious sputum	Asthma
"Rusty" sputum	Lobar pneumonia, mitral stenosis
Blood-streaked sputum	Early pulmonary TB
Mucopurulent or purulent sputum	Bronchopneumonia, bronchiectasis
Greenish sputum	*Bacillus pyocyaneus* infection
Black sputum	Anthracosis
Red frothy sputum	Hemoptysis with alkaline reaction to litmus
Nummular (coin-like) sputum	Fibrocaseous TB
Chocolate-colored sputum	Amoebic abscess

Odor

A putrid odor is associated with bronchiectasis and lung abscess.[11]

Tuberculosis Testing

The laboratory exam for TB should begin with an acid-fast stain (read by someone who is not color blind). If that is negative, concentrate the sputum and stain the concentrate using the acid-fast method. Without sophisticated laboratories, that is the most that can be done.

Concentrating Sputum

Using concentrated sputum to test for TB greatly improves the sensitivity of staining for the organism. In austere situations, a centrifuge may not be available to perform the typical concentration technique used in labs. If an initial stain for TB is negative, use the overnight sedimentation technique discussed below. This procedure increases the sensitivity of direct TB smears as much as standard centrifugation techniques.[12]

Collect three sputum samples. While these have traditionally been obtained on successive days, if they are all collected at different times on the same day they are just as likely to contain the organism.[13] Put the sample in a flask and add twice that volume of a solution containing 3% ammonium sulfate and 1% sodium hydroxide. Shake the mixture by hand and let it stand overnight (≥12 hours) at room temperature. After sedimentation occurs, decant the supernatant fluids and make smears from the sediment. The sensitivity of the smears against the culture is 58% for the direct method and 81% for the concentration method.[14]

Using a similar method, add 5% sodium hypochlorite (bleach) to an equal quantity of the sputum, agitate by hand for 10 minutes, and then add 4 times the amount of distilled water and let stand overnight. As an example, add 1 mL 5% sodium hypochlorite to 1 mL sputum. After 10 minutes, add 8 mL distilled water and let stand for ≥12 hours. This method is statistically equivalent to the classic concentration and centrifugation methods—and much cheaper and easier to do.[15]

BLOOD

Hemoglobin Measurement

WHO-sponsored, commercially available colorimetric determination kits have been shown to be accurate for estimating hemoglobin (Hgb) levels, particularly in neonates and young infants.[16] No special skills are necessary except for being able to obtain a drop of blood. Normal color vision and color interpretation are also important.

The kits, containing 200 to 1000 test strips, include a small card with six shades of red representing Hgb levels of 4, 6, 8, 10, 12, and 14 g/dL. The results indicate whether the patient is anemic, and can be used to decide whether the patient needs a blood transfusion, formal blood count, or referral. Results cannot be used to identify minor changes in Hgb during treatment.

To use the kit, place a drop of blood on the test strip (~2 ¢ each). Wait 30 seconds and immediately compare the strip to the Haemoglobin Colour Scale that accompanies each kit. The comparison must be made in bright light. Training nonprofessionals to use the kit takes about 30 minutes.[17] One benefit of this kit is that it also screens out sickle cell anemia, since these patients always have grave anemia; a Hgb level above 8 G% (Hct 24%) excludes the disease.[18]

Coagulation Tests

While more sophisticated coagulation tests will not be available in resource-poor settings, health care workers can easily do a bedside clotting time, which is vital to determine which patients need snake (Crotalid) antivenin after envenomations. The less-useful bleeding time test can also be easily done.

Clotting Time

Put 1 to 2 mL of blood into a new, never-washed test tube and let it sit for 20 minutes. At 20 minutes, tip the tube upside down once. If no clot is seen, the test is positive (they are not clotting sufficiently). If *any* clot is present, even a very small one, the test is negative.[19] In some remote settings, the syringe in which the blood sample was drawn is used in place of a test tube; in other cases, the blood is injected into an empty ceftriaxone bottle. Limited studies show that these three methods produce congruent results.

Bleeding Time

Doing a bedside bleeding time may have some utility for: (a) determining the cause for ongoing bleeding; (b) explaining previous bleeding episodes; and (c) diagnosing hereditary bleeding disorders, especially von Willebrand's disease.[20] However, without standardization, the results must be interpreted cautiously.

To perform the test, seat the patient with his elbow slightly flexed and his forearm resting on a steady support with the volar surface exposed. Place a sphygmomanometer above the antecubital fossa and clean the forearm with alcohol, letting it air dry. Inflate the cuff to 40 mm Hg and wait 30 seconds. Holding a sterile #11 scalpel blade at right angles to the skin, make two 1-mm-deep punctures about 1.5 cm from each other, parallel to the antecubital crease, and about 5 cm distal to the antecubital fossa. Avoid cutting superficial veins. Begin timing immediately after the incisions are made. Blot the incisions with filter paper every 30 seconds until blood no longer stains the filter paper. Do not blot the wound edges. The bleeding time is the average of the time it takes for each of the two cuts to stop bleeding. A normal value is <11 minutes.[21]

TABLE 19-3 Urine Color and Associated Pathology

Color	Substance	Pathology
Yellow foam	Bilirubin	Obstruction of bile duct system or severe hepatocellular damage
Greenish foam	Biliverdin	Increased red cell destruction or liver pathology produces bilirubin oxidation product
Reddish	Hemoglobin, porphyrins	Renal or bladder bleeding, pernicious or hemolytic anemia, lead or barbiturate poisoning, congenital porphyria
Light red to red-brown	Hemoglobin	Renal or bladder bleeding, malaria, paroxysmal hemoglobinuria, transfusion reaction
Orange	Pyridium	Iatrogenic (urinary analgesic)
Smoky red to brown	Blood	Renal or bladder bleeding, acute nephritis, kidney infarction
Dark or smoky	Phenol	Phenol poisoning
Brown to black	Melanin	Leukemia, malignant melanoma, ochronosis, liver carcinoma
Blue	Methylene blue	Iatrogenic
Milky	Chyle	Filariasis

Data from Kothare.[11]

URINE

Color

Normal urine varies from yellow to amber, depending on its concentration. Edible dyes, including those in medications and certain illnesses, can change its color (Table 19-3).

Urinalysis

Urine is easily tested with multifunction sticks. These can test for the presence of protein, glucose, ketones, nitrites, bilirubin, urobilinogen, red blood cells (RBCs) or free Hgb, white blood cells (WBCs), leukocyte esterase, pH, and specific gravity, depending on the stick used. The strips must also not have deteriorated due to moisture or temperature.

Cloudy urine can be due to a variety of reasons. Usually, it is due to the presence of blood (generally pink or red), crystals, or infection. If signs and symptoms of infection are present, do the three-glass test to improve the chance of localizing the infection. During a single void, collect the first 5 mL in one container. Collect nearly all the rest of the urine in a second container. In the third container, collect the last 5 mL or so. If the first container is very cloudy, but the urine clears in the second and third containers, the infection is probably urethral. If the second and third containers are cloudier than the first, the infection probably resides in the bladder or kidney. If the third container is the cloudiest, the prostate is probably the culprit.

Rather than spinning urine, with or without a Gram stain, an easier method to determine the presence of infection in a good urine sample is to look for ≥1 bacterium/HPF (high-powered field). That correlates well with >100,000 organisms/mL if the same specimen is cultured.

Taste

Even the ancients knew that urine that tastes like sugar indicates diabetes mellitus. Go ahead—taste it. That's real austere medicine. (I prefer to use the test strips.)

Protein

If a urine dipstick to measure protein is not available, another way to check for proteinuria is to fill a test tube three-quarters full with a clean-catch specimen and heat the top half of the tube over a low flame. Use metal tongs to hold the tube, and rotate the tube while heating it so that the glass does not shatter. If the urine turns cloudy and white, add a few drops of vinegar (2% acetic acid). If it stays cloudy or gets whiter, there is protein in the urine.[22] Protein can appear in the urine due to infection, bleeding, intrinsic renal disorders, or preeclampsia.

Gram Stain

Gram stains of urine specimens are done either on spun sediment or on bacteria from urine cultures. Gram-staining slides can provide a tentative identification of bacteria in urine, pus, sputum, cerebral spinal fluid (CSF), and bacterial cultures. Although not highly accurate for identifying species, a Gram stain enables the clinician to make an educated guess about the appropriate antibiotic to use, if the information is combined with knowledge of the clinical situation. The test requires several chemical solutions to prepare the slide and a microscope to view the end product.

The basic “sure-fire” technique is to make a slightly uneven smear from the specimen. Unless you are in a grave hurry, air-dry rather than heat-fix the slide. Wear gloves to avoid staining your hands rather than using forceps to handle—and often drop—the slide. Once the slide is dry, cover the slide with ammonium oxalate crystal violet and wash off the back (not the front) of the slide using a thin stream of water. While smears of pus are relatively durable, urine sediment is fragile and, if washed directly, will go down the drain. Then, do the same with Gram’s iodine solution. The amount of time the stains are on the slide (3 seconds to 3 minutes) does not matter—but they must be identical. Then, hold the slide with one end slanting down, and drip on the acetone-alcohol until the color draining from the slide sharply decreases. Immediately wash the back of the slide. Pour on the safranin and immediately wash it off. Dry the back of the slide and, if in a hurry, dry the front by waving the back of the slide over a Bunsen burner, alcohol lamp, or similar heat source. With uneven smears, WBCs in the thin areas will have pink nuclei, but they will be bluish or purple in the thicker areas. Note that the organisms may vary in color. That is usually because, unlike laboratory specimens grown at the same time, “bugs” from real specimens are at different stages in their life cycle, and hence will have different colors.[23]

Draw conclusions with care—accuracy depends on training and skill. Gram-positive bacteria may appear gram-negative if they are old, if the patient has been treated with antibiotics, or if you washed the stain off the slide. Artifacts, such as particles of crystal violet, may be misinterpreted as cocci or bacilli. Some material from the smear may have disappeared during staining if you did not fix it properly or if you made the smear too thick.

STOOL

Parasite Exam

The presence of parasites in stools is common, especially in austere situations. Microscopic examination for a wide variety of intestinal parasites is easier and more successful using the following technique than with other common methods.[24] Even with this method, however, experts will identify only about 38% of the patients who have parasites. Get other samples if you think the patient has an intestinal parasite.

1. Collect the stool in a container.
2. Mix it with an applicator stick until uniform or homogeneous.
3. Use the same applicator to place a thick circular stool smear over an area 1- to 1.5-cm diameter on a glass slide.
4. If the stool is dry, hard, or well-formed, add a few drops of sterile saline so that it has the consistency of paste.
5. Before the specimen dries, add 1 to 2 drops of lacto-phenol cotton blue (LPCB) stain. This is one of the most commonly available laboratory stains in the world.
6. Examine the slide for ≥5 minutes.

Presence of Mucus

A stool with fresh or altered blood and plenty of mucus is passed in amoebid dysentery. It often has an acidic reaction to litmus paper. Fresh, watery stools with mucus flakes, an alkaline reaction to litmus paper, and an offensive odor accompany bacillary dysentery. “Rice water” and “pea-soup” stools are passed with cholera and typhoid, respectively. Increased mucus or mucus in tape-like form is often passed in mucous colitis. Large frothy stools are associated with pancreatic dysfunction, celiac disease, and tropical sprue.[11]

CEREBROSPINAL FLUID

A devastating and common disease, bacterial meningitis may be difficult to distinguish from viral meningitis and normal patients—especially with clear or bloody cerebrospinal fluid (CSF). In austere situations, this differentiation is vital, both to conserve resources (antibiotics, hospital beds, personnel time) and to treat those patients who actually have bacterial meningitis.

Bacterial Meningitis Diagnosis

Urine test strips can help distinguish patients with bacterial meningitis from those with viral meningitis or no meningitis, despite the CSF being clear or bloody. That is, they help make the decision to treat patients who might otherwise go untreated even though they have the disease.

Rapid differentiation between bacterial and viral meningitis can be made using three components of typical urine test strips, with a specificity of 100% and sensitivity of 97%. This test helps in making a rapid decision about whether to use antibiotics in patients with suspected meningitis. If adequate CSF is available, the reagent strip is dipped directly into a tube that will not be used for microbiologic tests. Otherwise 1 to 2 drops of CSF are placed on the glucose, protein, and leucocytes portions of the strip. Wash off the strips after 60 seconds and compare the color change against the standard on the test strip container. The presence of leukocytes is graded as negative, 10 to 25, 75, and 500/microL; protein as 30, 100, and 500 g/L; and glucose as <2.8, 2.8, and 5.5 mmol/L.

A diagnosis of viral meningitis is made if the glucose is from 2.8 to 5.5 mmol/L, protein is present, and the leukocyte count is from 10 to 75/microL. Patients with values lower than this do not have meningitis; those with higher values have bacterial meningitis.[25] This test, however, will not detect all patients with bacterial meningitis.[26] A positive urine nitrite strip test may also help to indicate which patients with turbid, bloody or, most importantly, clear CSF have bacterial meningitis. The test is negative in patients with CSF malaria.[27]

Protein Evaluation

Without urine test strips, Pandy's test is an alternative method of testing for CSF protein. Prepare Pandy's solution by filling a bottle (~100 mL) one-quarter full with phenol and the other three-quarters with clean water. Shake the bottle and let it stand 24 hours. The two fluids will partially separate, with phenol being at the bottom of the bottle and a phenol-water (Pandy's) solution being at the top. Carefully decant a few drops of the top mixture (avoid including phenol from the bottom layer) into a test tube and add a few drops of the CSF. If the mixture in the tube is cloudy against a dark background, it is positive for excess protein. It becomes positive with 25 to 35 mg/dL protein. While a weak positive may sometimes occur in young children (who may have up to 40 mg/dL protein), a strongly positive test is always abnormal.

CSF Turbidity

CSF turbidity, if present, is one way to identify patients with bacterial meningitis. Although this test may often be falsely negative, checking for CSF turbidity may be the only method of diagnosing meningitis. To have the best chance of identifying turbidity, use clean water to fill an identical tube to the tube with the CSF sample. Compare the two in good light, or at least with a strong light behind them. If the CSF is as clear as the water, there are probably <100 WBCs/microL.[22] Note that when looking only for CSF turbidity, one misses a significant number of bacterial meningitis cases.

BEDSIDE/HOME TESTS

Home pregnancy tests and home blood glucose tests have become ubiquitous and are generally adequate for clinical use. Also, they are often much less expensive than similar tests sold for professional use. The only caveat is that heat and humidity can make them inaccurate.[28] If using them in a health care facility, store them properly. (See Chapter 28, Obstetrics/Gynecology, for additional pregnancy tests.)

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20 | Patient Transport/Evacuations

MEDICAL TRANSPORT IN AUSTERE CIRCUMSTANCES

In austere circumstances, a functioning emergency medical system (EMS) may not exist or an existing system may not function as it should. In these circumstances, you may not be able to reach patients or they may not be able to get to you using normal methods (e.g., the roads are impassible). This chapter discusses improvised methods to transport patients or medical personnel.

TRANSPORT THE PATIENT?

The first question, however, is whether to transport the patient. In resource-poor settings, the decision whether to transport a patient is a delicate balance between patient benefit and the appropriate use of available resources. It comes down to asking two vital questions: CAN we transfer and SHOULD we transfer? The detailed parts of each question are listed in Table 20-1. All the parts must be answered "Yes" for a transfer to take place.

IVs DURING TRANSPORT

If the patient has an IV in place, keep it flowing during transport: either put a pressure cuff (or blood pressure cuff or elastic bandage) around the bag or place the bag under the patient to maintain pressure and flow. The danger of this practice is not paying attention to the now-hidden IV bag, which results in letting the bag run dry, thus ruining the IV access port.

If the patient has an IV but doesn't currently need fluids—or needs them only intermittently—use a saline lock and put the IV fluids through it in boluses, as necessary. That also accommodates stopping the fluids and restarting them at a later time without having to restart an IV. Improvised saline (or heparin) locks are described in Chapter 5, Basic Equipment.

TRANSPORTING PATIENTS WITHOUT LITTERS

If a litter is not readily available or if one cannot be improvised, rescuers can choose from a variety of methods to transport patients, including carrying or dragging the patient. Evacuation from a multistory hospital is discussed later in this chapter.

TABLE 20-1 Elements of Patient Transfer Decisions

Can we transfer?	
Yes	**No**
Higher level of care (facility/equipment/skills) reasonably available (time/distance)	No higher level of care reasonably available
Referral facility accepts transfer	Referral facility refuses transfer
Transfer method available	Transfer method unavailable
Transfer safe for personnel	Unacceptable danger to personnel
Should we transfer?	
Yes	**No**
Patient benefit probable	Patient benefit uncertain
Patient will probably survive transfer	Patient will probably die during transfer
Resources used for transfer not needed immediately by other patients and can be replaced before other patients need them	Other current patients need the resources to be used for transfer, or resources can't be replaced before needed by other patients
Patient/surrogate wants/accepts need for transfer	Patient/surrogate does not want/accept need for transfer

FIG. 20-1. Tied-hand crawl. *(Source: US Navy.[1])*

One-Person Drags

Patients can be dragged head or feet first for short distances to remove them from a dangerous, time-critical situation or when they are in a confined space and no other method is practicable. If the time and circumstances allow, wrapping the patient in a sheet, blanket, or similar cloth makes it easier to drag them. This also provides more protection from any debris the patient may be dragged over.

One-person drags are particularly useful when it is necessary to go under low obstructions. The downside is that there is no way to support the victim's head. Place the patient in a supine position. Cross the patient's wrists and tie them together with any available material (e.g., belt, rope, hose, scarf), then kneel over the patient and lift the tied wrists over your head so they rest on the back of your neck (Fig. 20-1). When crawling forward, raise your neck just high enough so that the patient's head does not bump against the ground.

One-Person Carries

Most people can carry a person in their arms for a short distance, as long as they are relatively small and lightweight compared to the rescuer.

Larger patients can be transported more easily across the rescuer's back (Fig. 20-2). If the person is standing or can be lifted into a standing position, the rescuer drapes the patient's arms over his shoulders and holds the wrists with one hand (pack-strap carry). Once upright, the rescuer should lean slightly forward so the patient's feet are just off the ground and then begin to move.

To get an adult on your back takes extra effort if a patient is supine and no one is available to help the patient stand. With the patient supine, lie on your side alongside the uninjured or less-injured side. Position your shoulder next to the patient's armpit, and pull his far leg over your own, holding it there if necessary. Grasp the patient's far arm at the wrist and bring it over your upper shoulder as you roll and pull the patient onto your back. Get up to your knees, using your free arm for balance and support. Hold both the patient's wrists close against your chest with your other hand. Lean forward as you rise to your feet, and keep both of your shoulders under the patient's armpits.[1] If this carry is to be used for more than a short distance, tie the patient's wrists together with any available material to secure a better handhold on the arms.

Two-Person Carries

It is much easier for two people to carry a patient, especially for long distances.

The most basic two-person carry has both rescuers squatting on the same side of the patient, with one at chest level and the other at the thighs. The person at the chest passes both arms under the patient while the other rescuer puts one arm under the knees and his other arm over the pelvis, gripping his partner's wrist. They then pull the patient toward their own chests and move forward (Fig. 20-3). This carry, as well as some of the others, can be used for bed-bound patients

FIG. 20-2. Pack-strap carry. *(Source: Community Emergency Response Team.[2])*

by first moving them to a sitting position in the bed and then having the two rescuers sit on either side of the patient to begin their lift.[3]

Another method that can be used for longer distances starts with rescuer A squatting at the victim's head. Then rescuer B lifts the patient to a sitting position by pulling on the patient's arms, if necessary. Rescuer A grasps the patient from behind around the midsection, holding his own wrist with the other hand for security. Rescuer B then squats between the patient's legs and grasps the knees. This rescuer can face toward or away from the patient (Fig. 20-4); for longer distances, the rescuers should face in the same direction and walk forward. Both rescuers then stand while holding the patient.

The two-person chair carry is more useful over longer distances. The two rescuers squat on either side of the patient and slide their arms under the patient's back and thighs. Although Fig. 20-5 shows the two rescuers holding onto the patient's side, it is more secure if they hold onto each other's arms in the back and grab each other's wrists under the thighs. They then stand and begin walking forward.

Chair Carry

Two rescuers can also sit a patient in a chair, with one grasping the back of the chair and the other the bottom of the chair's front legs. Starting from a squatting position, they tilt the chair backward and stand, both facing in the same direction (Fig. 20-6). The rear person (the more

FIG. 20-3. Two-person carry, side view. *(Source: US Navy.[1])*

FIG. 20-4. Two-person carry, anterior-posterior view. *(Adapted from Community Emergency Response Team.[2])*

strenuous position) must also support the patient's head and shoulders. A key to success is finding a sturdy chair that is not too heavy.

LITTERS

Litters can be used either as the only means of transporting patients or to get them to another form of transportation. At that point, they often are used as the patient's "bed" while in transit. When no litter is available, improvise one from available materials. This is an emergency measure; always use standard litters when available.

FIG. 20-5. Two-person chair carry. *(Source: US Navy.[1])*

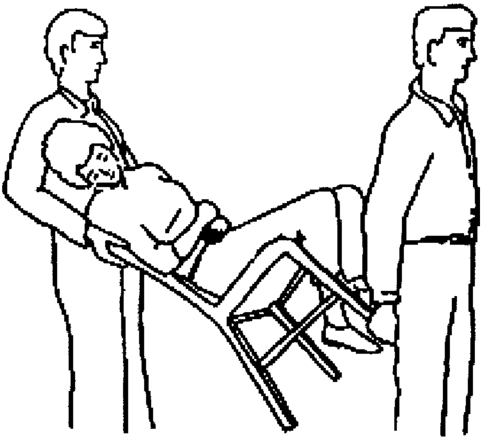

FIG. 20-6. Carry using chair. *(Adapted from Community Emergency Response Team.[2])*

When using any type of litter, designate a team leader to keep those carrying the litter synchronized. Once the team is squatting in position holding the litter, it is customary for the leader to announce, "Ready to lift on the count of three: One, two, three, lift." Once they are standing, the leader should say, "Ready to move on the count of three: One, two, three, move." The team begins moving. The leader gives the same directions for "Ready to stop" and "Ready to lower."

Be kind to the patient if using a rigid litter—pad it. Use any available soft material, such as clothing or sleeping bags. For a head or neck rest (assuming the person does not need to be in a cervical collar), use a roll of toilet paper. Stand on it to squash it. It is the right size and softness for a head/neck support. If it is too thick, unroll some of it.[4]

Improvised Litters

Litter Without Poles

If material for poles is not available, a blanket, sheet, poncho, cloth sack, or similar item can be rolled from both sides toward the center so that the rolls can be gripped for carrying a patient. Bunch up a blanket lengthwise next to the patient. Push one side under the patient; the patient may need to be log rolled to get the blanket underneath. Roll the edges as close as possible to the patient. All rescuers should squat facing the same direction, three on each side. They each grasp a rolled-up portion of the blanket, and the team leader instructs the team to lift in unison (Fig. 20-7). They stand and begin carrying.

Rescuers should pull out sideways on the blanket as they lift, which avoids straining their backs and prevents the blanket from sagging too much in the middle. This type of litter is useful

FIG. 20-7. Blanket/sheet litter. *(Source: US Navy.[1])*

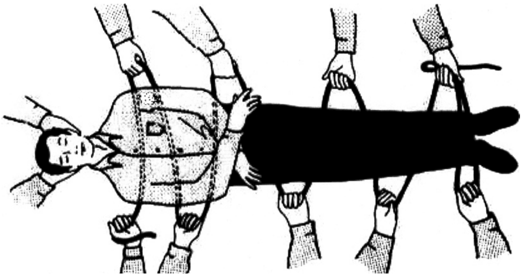

FIG. 20-8. Rope litter. *(Source: US Navy.[1])*

for carrying a patient only for limited periods, since it is much more tiring than using one with poles. At least six people are needed to safely move an adult patient.

Rope Litter

Make a rope litter by passing a strong rope back and forth beneath the patient, with the loops extending past the patient's body. Rescuers on each side use these loops and each end of the rope as handholds to carry the patient (Fig. 20-8). Another rescuer supports the patient's head. These litters are useful only over relatively short distances.

Flat-Surfaced Objects

Most flat objects that are not too heavy can be used as a litter. These include doors, slabs of wood or light metal, benches, ladders, and cots. This type of rigid stretcher is excellent for patients with suspected spinal injuries. An ingenious litter can be fashioned from two chairs by tying or wiring them together with one back overlapping the other.[5] The two back legs serve as handles (Fig. 20-9). In a similar manner, some backpack frames can be linked together to form a stretcher.

Blanket and Poles

To improvise a stretcher using a blanket and two poles, lay one pole lengthwise across the middle of the blanket. Then, fold the blanket over the pole. Place the second pole across the middle of the folded blanket. Fold the free edges of the blanket over the second pole so the edge is almost at the first pole. The patient's weight on the litter will keep the blanket from unfolding when carried (Fig. 20-10). Poles can be fashioned from strong tree branches, tent poles, skis, pipes, and so forth.

Shirt/Jacket Litter

Use two long-sleeved shirts or jackets. Button the shirts or jackets and turn them inside out, leaving the sleeves inside. Pass the poles through the sleeves. Two to four shirts or jackets will often be needed to make an adequate litter (Fig. 20-11).

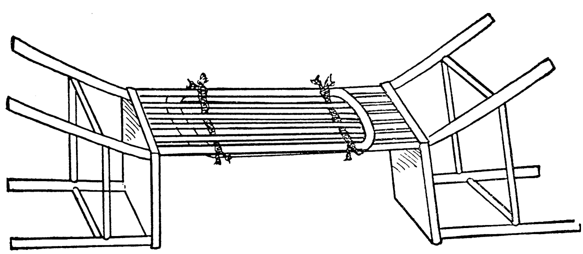

FIG. 20-9. Two-chair litter. *(Reproduced with permission from Olson.[5])*

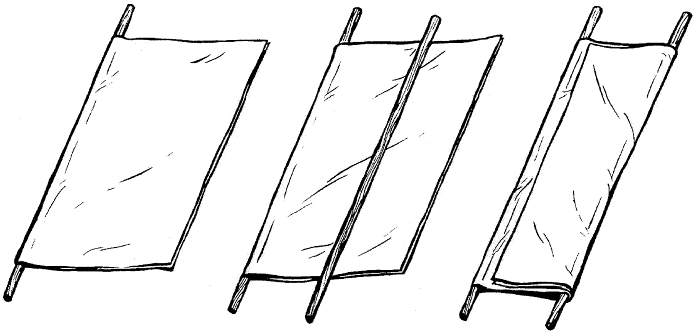

FIG. 20-10. Blanket litter. *(Source: US Dept. of the Army.[6])*

Sleeping Bag/Cloth Sack Litter

A sleeping bag may also be used as a litter. Zip it up completely and make a small hole at each of the two corners away from the opening. Put carrying poles through the bag's wide opening and then through the new holes. The patient lies on top of the sleeping bag. Gunny sacks, grain bags, or similar containers made of cloth may also be used in this manner, although two or more will be needed, depending on the height of the patient.

Standard Litters Not Used in Hospitals

Military Collapsible Litter

The US military's standard collapsible litter (Fig. 20-12) will probably be available in large-scale emergencies when organizations, including hospitals, begin using their disaster resources. The collapsible litter is commonly used in conjunction with military transport vehicles, including fixed-wing aircraft. It folds lengthwise and has a cotton cover to hold the patient. There are four wooden handles for carrying it and four metal stirrups (one bolted near the end of each pole) to support the litter when it is placed on the ground. Two spreader bars (one near each end of the litter) are extended crosswise at the stirrups to hold the cover taut when the litter is open.

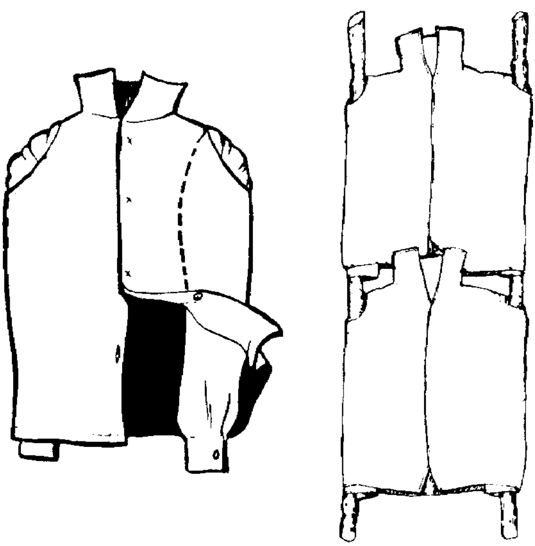

FIG. 20-11. Shirt/jacket litter. *(Source: US Dept. of the Army.[7])*

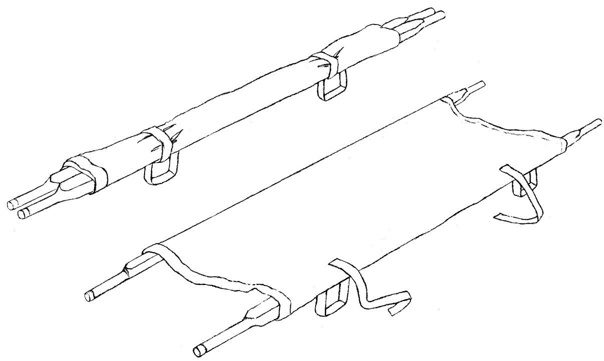

FIG. 20-12. Standard litter, closed and open. *(Source: US Dept. of the Army.[8])*

Two straps secure the litter when it is closed. Most also have straps to secure the patient. The litter weighs 15 pounds, and is 90 inches long by 22.88 inches wide. The patient area is 72 inches long and 22.88 inches wide.

Stokes Litter

The Stokes litter provides maximum security for the patient when the litter is tilted, such as during ground-to-helicopter, ship-to-ship, or vertical-ground transfers. Its steel or aluminum tubular frame supports wire mesh netting on which the patient lies—after the basket is padded with blankets or other material. If it doesn't come with patient straps, they can be improvised using webbing or rope secured to the end of one side rail and passed back and forth over the patient—first toward the head and then back toward the feet, forming a crisscross pattern. It may also have carabineers and cables for attaching to helicopter long lines or ship-to-ship transfer cables. Some baskets are fitted with handles so they can also be used as a litter. A search and rescue improvisation is to attach a large wheel to the underside to assist in moving the patient long distances. The standard basket is 84 inches long, 23 inches wide, and, without attachments, weighs 3.5 pounds.

Specialized Litters

Litter With Skis

Many types of litters can be fitted with skis. The formal type is known as an Ahkio. This Alaskan sled is particularly useful where patients must be evacuated through deep snow.

Litter for Paralyzed Patients

An improvised method of making prolonged litter extrications more tolerable for paralyzed or immobile patients is to use two stretchers. The first stretcher has a hole for the patient's face and a hole for urine output when the patient is in the face-down position (Fig. 20-13). The second stretcher has a hole for stool output, to be used when the patient is in the face-up position. Turn the patient every 2 to 4 hours, by first sandwiching the patient between the two stretchers and then flipping them over. This also prevents the patient from developing pressure sores or autonomic dysreflexia from a distended bladder.[9]

VERTICAL TRANSPORT

Vertical Intra-Hospital Transport

Non-ambulatory patients may need to be moved down stairways or lowered out of windows when a hospital needs to be evacuated.

Lowering Patients

In some circumstances, such as when normal hospital exits are blocked, patients may need to be lowered out of the windows to safety. For this risky maneuver, get the most experienced people to help, such as fire department and rescue personnel.

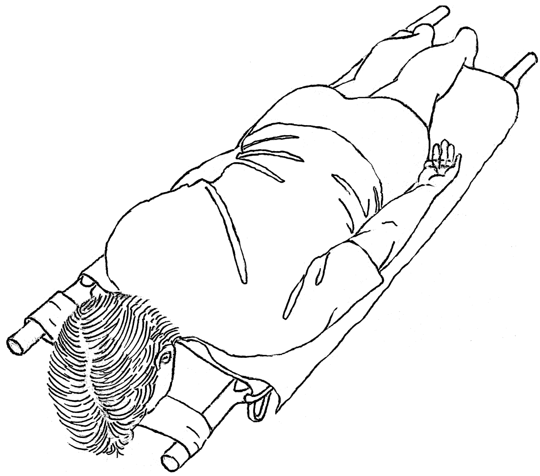

FIG. 20-13. Litter modified for face-down position.

The basic technique, without normal litters and ropes, involves securing the patient as well as possible into sheet slings and using additional sheets as "ropes." Bed-sheet ropes can be anchored to hospital beds, or the rigid "standpipes" in stairwells can be used to belay the patients.

Down the Stairs

It may be necessary to move non-ambulatory patients down the stairs when the elevators do not work. This has traditionally been an extremely slow process, involving fire department stretchers and many teams of strong people.[3,10]

However, this method, which can be used in nearly any situation, is much faster, takes only a few people of normal strength to operate, and requires no specialized equipment.

1. Check the entire length of the stairwell to be certain that it is clear and that an exit is available at the bottom. For safety, station someone at the bottom of the stairway to ensure that the exit stays open and to warn the team if it doesn't.
2. Place patient mattresses end-to-end on the stairs. Cover each flight of stairs (the stairs between a flat landing) with mattresses by putting a mattress even with the top stair and having mattresses extend to the landing. Push all the mattresses against the wall side of the stairway so there is a narrow area for personnel to walk.
3. Repeat the process for the entire length of stairs to be traversed.
4. Prepare the patients to be transported by wrapping them with two sheets (Figs. 20-14 and 20-15), leaving their faces uncovered. Both sheets should be tied individually at the head and foot ends with square knots. Wrapping the patient in two sheets provides extra support and allows the two rescuers at the head end to each hold a different sheet (for safety). The rescuer at the foot end holds both sheets.
5. To get the patient off the bed, turn the mattress 90 degrees on the bed, with the foot end on the floor. Using the sheet for control and one or two people holding the sheets on each end, slide the patient off the mattress and onto the floor. With most smooth hospital floors, two health care workers can easily slide most normal-sized patients to the head of the stairs.
6. Once at the stairs, lift the patient's foot, using the sheets, onto the end of the mattress at the top of the stairs. The person holding that (foot) end begins walking down the stairs, sliding the patient. The person holding the head end of the sheet follows, simultaneously holding onto the stairway handrail and slowing the patient's slide as necessary. If available, it often helps to have a third person hold the top (head) person's belt to steady him (Fig. 20-16).

FIG. 20-14. Tying patient into sheets.

7. Once at the landing, slide the patient to the next set of mattresses and repeat the process, continuing to the bottom of the stairs.
8. Once each team clears a landing, the next patient can be started down the mattress ramp from the flight above.

NON-AMBULANCE TRANSPORTATION

Any type of vehicle or transport method can be used to get health care workers and equipment to patients, and to get patients to initial or better-equipped health care facilities. For example, in Kenya, current methods of emergency transportation include canoes, bicycles

FIG. 20-15. Carrying patient.

FIG. 20-16. Sliding patient down mattresses.

with trailers, tricycles with platforms, tractors with trailers, reconditioned public vehicles, and ox carts. (Charles O. Otieno, MD, in a letter to the author, received June 22, 2008.) Bicycle EMS services have been used in many locales for special events involving large numbers of people, for wilderness search and rescue operations, and for disaster response.[11]

Domesticated Animals

Riding

Any domesticated animal can be used to transport either health care workers or patients, and are especially good in rugged terrain.[12] However, experience has demonstrated that (a) a patient's fear can make using a pack animal dangerous, (b) some individual animals that are typically used for transport (including horses or donkeys) may not have the calm temperament needed to carry patients, (c) having experienced handlers available for the animals helps greatly, (d) patients may need to be removed from the animals when going over especially difficult terrain, and (e) putting a safety strap around the patient helps.

Travois

A travois (Fig. 20-17) is a crude sled lashed to a horse or similar animal. The animal drags the travois along the ground. A travois may also be lashed between two animals in single file and

FIG. 20-17. Travois with one animal.

carried level. A travois is made from two long poles fastened together by two crossbars and a litter bed fastened to the poles and crossbars.[13] The patient is secured on the litter bed. If the travois is pulled by only one animal, the bearers should lift up the end from the ground when going uphill, fording streams, or crossing obstacles.

Motorized Vehicles

All-terrain vehicles (ATVs) equipped with advanced life-support supplies have been used to decrease response times at mass gatherings.[14] Golf carts, motorcycles, snowmobiles, mopeds, motorized bicycles, and similar vehicles also can be equipped for medical purposes.

Flat-bed trucks are particularly useful for transporting morbidly obese patients who cannot fit into a standard ambulance or on a standard ambulance stretcher. The "stretcher" can be the patient's own mattress or a large canvas sheet. Trucks can also be used to transport multiple casualties, although one must take care to see that there is adequate light, ventilation, and protection from the elements (if an open-bed truck).

Trains

For the past two centuries, trains have been used to transport large numbers of casualties. For trains not specially configured to transport casualties, seat ambulatory patients in normal passenger cars, in box cars (provided there is adequate light and ventilation, perhaps with doors fully or partially open), on flat cars (although there is no protection from the elements), or on top of passenger or box cars (if there is no other space and the risk of injury or death from falling off the train is less than from leaving patients behind).

Litters can be placed over the backs of the seats in passenger cars and firmly tied down, put in passenger cars after the seats have been removed (or in box cars, again providing there is adequate ventilation), or put on flat cars, exposed to the elements. To stack litters in a car, make improvised fittings using strapping, ropes, or wood (like bunk beds). These must be firmly affixed to the wall of the train compartment, since the load on them—due to the patient's weight compounded by the train's movements—will be significant.

Ships/Boats

Rafts, canoes, inflatables, jet skis, and similar small boats can be used for rescues and to transport both medical personnel to patients and patients to medical facilities.

Small ships, such as ferries and military landing craft, may be requisitioned either to transport patients or for use as medical facilities. Ships are self-contained units, and so can often provide food, shelter, air-conditioning, and other amenities that are lacking in a devastated locale.

Hospital ships are set up to care for patients. The primary issue will be getting to them, or getting them to you.

Those responsible for medical care aboard a ship must know the ship's exact capabilities and limitations, as well as what situations will trigger medical evacuation of patients off the ship. The ship's captain must also be aware of these, especially if the ship is to travel beyond the reach of air transportation or to areas where on-shore hospitals offer limited care.[15] Plans must be in place to evacuate patients under specific circumstances.

Medical Evacuation at Sea

Medical evacuation at sea should be considered only after predetermined medical criteria are met, telemedicine consults have been fully exploited, and the risks of evacuation are outweighed by the patient's needs. Improvised transfers can be accomplished by using a smaller boat to carry the patient from one ship to another, but this can be very dangerous. The best way to transfer a patient to a medical facility is from a ship docked at the pier.[16]

AEROMEDICAL TRANSPORT

Air transport is often the optimal method to deliver advanced medical supplies, and to transfer patients for initial treatment during medical emergencies or to tertiary care centers, especially when the patient is far from medical facilities or, even, civilization. Yet, aeromedical transport is a costly, often scarce commodity, so practitioners must use it wisely.

Two general types of aircraft are used for aeromedical transport—fixed-wing planes and helicopters—each is discussed separately.

General Problems

Major adverse events occur in about 12% of aeromedical evacuations. These are often the result of high altitude, rushed patient assessments, hurried evacuation of unstable patients, a patient's long immobilization during flight, health care worker fatigue, the difficulty of in-flight evaluation and treatment, and the unpredictable availability and length of evacuation.[17,18]

Special problems arise when arranging for international nonmilitary air transport. The cost, which may be $100,000 or more for a transoceanic air ambulance, must be paid, or guaranteed by an insurance agency, in advance. Other problems may include communicating with the transferring and accepting physicians, obtaining visas, and obtaining transportation for the patient at both ends of the flight.[18]

In all aeromedical transport, preparation lessens the chance for untoward events. Preparation includes completing all the paperwork before taking the patient to the plane and carefully envisioning any medical problems that may occur en route. The medical preparation should include placing any tube or doing any procedure that may become necessary during the flight. If possible, have sufficient battery power and oxygen, medications, functioning IV lines, and any other equipment you may need—even if the trip is delayed.

Specific Problems

The major problems in air transport stem from the decreased barometric pressure at altitude and transporting contaminated patients. Additionally, the noisy environment may interfere with the ability to hear monitors, use stethoscopes, and communicate with the patient, other staff, and the aircraft's crew.

Decreased Barometric Pressure

The diameter of a gas bubble in liquid (such as blood) or in tissues doubles at 5000 feet above sea level, doubles again at 8000 feet, and once again at 18,000 feet. Cabin pressure in most passenger planes is maintained at 5000 to 8000 feet; on military aircraft, cabin pressure is between 8000 and 10,000 feet. Not all aircraft can increase their internal pressure to simulate sea level. At a cabin altitude of 8000 feet, a normal person's oxygen saturation drops to 90%: Correct this by using 2 L/min of oxygen to raise saturation levels to between 98% and 100%. During the flight, the lowest possible "cabin altitude" should be maintained; if necessary, that may mean flying at a lower altitude, which will increase both the flight time and fuel consumption.

Maintaining the lower cabin altitude (ask the aircrew if this can be done) is most important when transporting patients who have penetrating eye injuries with intraocular air, free air in any body cavity, or severe pulmonary disease. It may also be necessary if gas expansion would cause a tension pneumothorax, surgical wound dehiscence, intracranial hemorrhage, or irreversible ocular damage. Patients at greatest risk for this are those who have had recent surgery or head or chest trauma. Unfortunately, problems related to gas expansion can be difficult to diagnose or treat aboard an aircraft.

It is vital to maintain a constant ground-level cabin pressure throughout the flight when transporting patients with decompression sickness or arterial gas embolism. If there is no aircraft that can maintain this, the cabin altitude should not exceed 800 feet (242 meters), especially with helicopter evacuations. These patients must also be on 100% oxygen (by aviator's mask, if available).[19]

Before they are transported in any aircraft without ground-level (1 atmosphere) cabin pressure, prepare patients by[17]:

- Inserting a chest tube with a Heimlich valve or collection system, even for small, asymptomatic pneumothoraces.
- Venting ostomy collection bags to prevent excess gas from dislodging the bag from the stoma wafer. Use a straight pin to put two holes in the bag above the wafer ring.

- Using rigid splints, rather than air splints, since the air within them expands at altitude and they would need to be readjusted frequently.
- Doing fasciotomies or escharotomies if they could conceivably be necessary in flight.
- Bivalving casts if the cast is over a surgical wound site. This "window" permits tissue expansion and emergency access.
- Adjusting ventilator settings in neurosurgical patients to meet increased oxygen demands at altitude.

Situations Requiring Decontamination

Aeromedical transport may be limited or delayed in environments contaminated with radiological, biochemical, or infectious agents. These situations may limit or delay air resources due to (a) the time needed to decontaminate aircraft after the flight, (b) the availability (or lack) of an aircrew that is not contaminated and is willing to fly, (c) the need to batch similarly exposed patients, and (d) the ability to isolate patients on the aircraft.[17] Prior to transport, decontaminate any patients with external contamination. During the flight, isolate any patient with a communicable disease.

Fixed-Wing Aircraft

Military Aircraft

When large numbers of patients require transport, military planes generally are used. In such situations, prioritizing patients is a concern. Load the sickest ones first; they should be off-loaded first as well. Plan for cabin temperatures ranging from 15°C (59°F) to 25°C (77°F) in the winter and from 20°C (68°F) to 35°C (95°F) in the summer.

Safety

Safety is a major concern when using military fixed-wing aircraft. Unlike commercial passenger planes, which are normally entered through a controlled point in the terminal (even for litter patients), military planes usually sit on the tarmac without an obvious approach path.

A "circle of safety" exists around the aircraft. It is an imaginary circle 10 feet from the plane's nose, wings, and tail (Fig. 20-18). Vehicles and people must not enter the safety circle unless instructed to do so by the flight crew. Vehicles within that area (such as those carrying patients) must have a spotter when in motion and use chocks when parked.

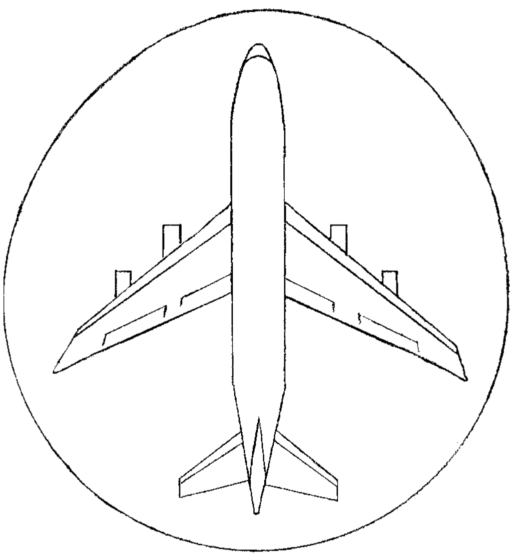

FIG. 20-18. Circle of safety around aircraft. *(Redrawn from Cocks and Liew.[20])*

When entering the aircraft, use a flashlight, preferably one with a low light intensity and a red or blue filter, to avoid compromising the aircrew's night vision.

On an aircraft equipped with webbing along the sides (primarily military), a bandana or cravat can be tied through the webbing and around the patient's forehead to provide support when sitting for long periods.

Other safety caveats are as follows: (a) do not run near any aircraft; (b) do not walk under the wings or propellers, even when the engines are not running; and (c) wear eye protection near the aircraft, especially when the propellers are in motion.

Passenger Airlines

The most common situations involving passenger airlines are using them to transport patients or confronting medical emergencies during a flight.

Transporting Patients

Transporting patients via a regularly scheduled commercial passenger airliner is cheaper and, usually, more readily available than is an air ambulance. If the patient can sit, simply purchase a seat for her and for the medical attendant(s). Airlines may get a bit nervous, however, about accommodating medical equipment; check with them in advance.

Getting a stretcher-bound patient onto a commercial aircraft may be difficult, since the aisles are too narrow to accommodate standard ambulance stretchers. Patients must be taken aboard using a soft (scoop) stretcher or an improvised stretcher. The stretcher is then usually placed in the back of the plane across several seats; the medical team sits across the aisle. Some airlines permit stretcher patients only in the first-class cabin. Some airlines specifically prohibit access to the aircraft's electrical systems. This requires operating any equipment on battery power, which may be difficult on long flights. The airlines generally do allow hanging IV solutions from overhead bins, as well as taping flow sheets and other medical information to them.[18]

Hypoxia can be treated with supplemental oxygen. Bring extra oxygen in case of delays in air travel or another unexpected need for additional oxygen. Aircrews prefer not to provide oxygen from their medical supplies.

Even on commercial aircraft, airframe vibrations may interfere with monitoring devices, and the high ambient noise level can interfere with using a stethoscope or communicating with the patient, other team members, or the aircraft crew.[18]

Medical Emergencies During a Flight

Few locations are more isolated than the small tube of an airliner 35,000 feet above the ground, with limited space and medical equipment. Fortunately, medical emergencies on board aircraft are relatively rare. Recent estimates are that between 1 in 10,000 and 1 in 40,000 passengers will have a serious medical event, and between 1 in 3 million and 1 in 5 million passengers will die while in the air.[20]

The goal of in-flight medical assistance on commercial airline flights is to stabilize the patient's condition until the aircraft has landed. The most common in-flight emergencies on commercial aircraft are vasovagal, cardiac, neurologic, gastrointestinal, and respiratory events, and trauma.[21] Alcohol consumption and more stressful flying conditions have increased the need to restrain passengers for disruptive and violent behavior.[22] While this may seem like a medical emergency, it is best to let restraint experts, such as police, security personnel, an air marshal, or a psychiatric worker, intervene. Health care professionals can be useful if sedation is necessary.

The option to ask for advice from ground-based health care providers is now commonly available. Many commercial airlines have links to physicians with experience in on-board medical emergencies.

Treatment options include providing oxygen and using the patient's medications, medications (labeled) from other passengers, or the medications and supplies in the plane's emergency medical kit. You can also request that the plane fly at a lower altitude to increase cabin pressure. That may alleviate altitude-related chest pain, dyspnea, and abdominal pain by resolving relative hypoxia and decreasing the expansion of gas that resulted from the decreased pressure at altitude.[21] The final option is to ask that the plane be diverted to the closest airport, if possible.

Ask the captain to land at the closest airfield if a passenger (a) has chest pain, shortness of breath, or severe abdominal pain that does not improve with basic interventions; (b) is persistently unresponsive; (c) has cardiac arrest that has responded to initial treatment; or (d) has an acute coronary syndrome, severe dyspnea, stroke, refractory seizure, or severe agitation.[21] Note that if a patient does not respond to CPR, initial attempts at defibrillation (many planes are now equipped with automatic external defibrillators [AEDs], especially those flying internationally), and the administration of cardiac drugs (e.g., epinephrine, atropine), the patient will not survive, so diverting the plane will not help the patient.

In-flight medical incidents are stressful. There is not much light, it is hard to lie someone flat, the seats are cramped, and it is noisy. Hearing anything through a stethoscope is nearly impossible. Personal experience demonstrates that resuscitation in a plane's narrow aisle can be challenging. The widest space is near the galley; if possible, get patients who need to be supine to that area. There may even be enough room to spread out the plane's medical kit and, if necessary, to position the AED. Use a pillow under your knees—a plane's floor has paint-thin carpeting. Also, ask the flight attendant to help steady you during landing if you absolutely must stay with the patient. On miniscule regional planes or in small private planes, there may be no place to position a patient supine except near the exit.

Helicopters

Working With a Medical/Rescue Helicopter

Helicopters are often used in austere medical environments both to transport health care professionals to patients and to extract patients who need a higher level of medical care. When extracting patients, the health care provider may need to prepare and direct ground operations. This is outside the training for most health care workers, so they need to be aware of how (a) to set up a landing zone and (b) to work safely around a helicopter.

Special Situations

When the helicopter used to transport patients is neither medically configured nor staffed (most commonly military helicopters in disasters), patients do not receive medical care during the flight.[17] Patients may be dangled in a basket (horizontally) or in a restraint device (vertically) at the end of a "long-line" attached to the helicopter. When patients will experience any of these exciting/scary excursions, tell them what will occur. Then, secure them tightly into the basket or follow the crew's instructions about using the vertical restraint device. Be careful to let the long-line touch the ground before touching it yourself, to avoid getting hit by a static electricity charge; it's not pleasant.

Establishing a Landing Zone

It may be necessary to establish a landing zone (LZ) before you can evacuate a patient from a difficult environment. While action movies often show helicopters hovering or doing one-skid landings to offload people (and skilled pilots can do that in emergencies), loading a patient normally requires a stable platform—the LZ. There are five major considerations in locating an LZ[23]:

1. *Surroundings*. Ideally, it should be free from overhead wires, trees, poles, structures, or anything else that could damage the aircraft.
2. *Size*. An LZ should be 100 feet by 100 feet to permit safe landing and lift-off. Pace off an "X" of 50 steps in each direction from a central point. Assuming that an adult's pace is about 2.5 feet, that provides at least the needed space. The center of the "X" is the landing spot.
3. *Slope*. Find a relatively flat site. If the slope is >15 degrees, there is a chance that the aircraft could roll over.
4. *Surface*. Dust or snow will reduce the pilot's visibility. Some surfaces may not support the craft. Clear the LZ of debris. Any loose debris can be blown up into the air and, if struck by a rotor blade, can seriously damage the blade.

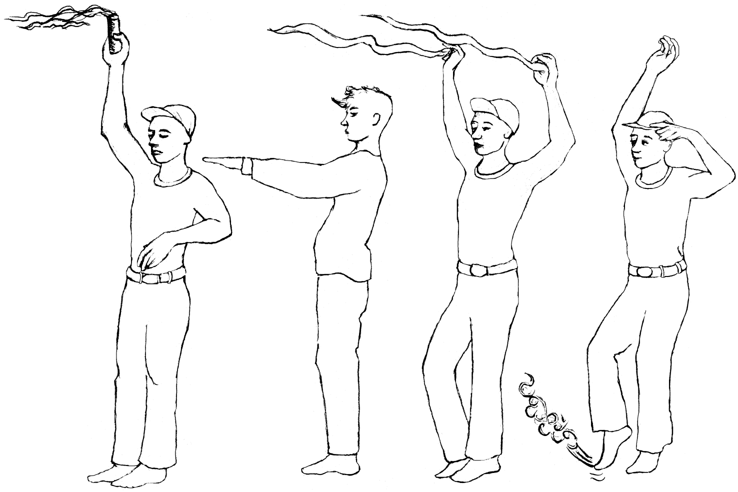

FIG. 20-19. Methods of signaling wind direction.

5. *Access*. Place the LZ at least 200 feet away from the medical facility, so that the facility won't be damaged by rotor wash. But remember that you need easy access for patients, personnel, stretchers, and equipment.

Other considerations for the LZ are as follows[24]:

- If the LZ will be used multiple times, find a way to prevent unauthorized people from entering it.
- Mark the LZ's corners to identify it for the pilot. Do not use material (e.g., cones, cloth) that can blow around; fluorescent surveyor's tape is excellent. At night, use red- or yellow-colored lights or strobe lights (not flares) to mark the LZ perimeter.
- Protect the pilot's night vision by not using bright white lights.
- If the LZ must be on a highway or in an area where vehicles are present, use their headlights to illuminate the LZ.

Wind conditions are extremely important for helicopter operations, so be prepared to signal the wind direction, especially if the pilot asks that you do so. Several methods may be appropriate, including using flares, hand signals, ribbons, and kicking dirt into the air (Fig. 20-19).[25]

Safety

Safety is a huge concern when working around a helicopter. Horrific accidents have occurred when these rules have been violated.

1. Do not approach the craft until instructed to do so by the flight crew. If you must approach the craft for a "hot on-load" or "hot offload," approach only from the front, between 3 o'clock and 9 o'clock (Fig. 20-20).
2. Danger can come from the main rotor blades or the tail rotors. The tail rotor, which can be as low as shoulder height, is difficult to see when it is spinning. Stay away from the rotors!
3. Wear eye and, preferably, ear protection. Secure any loose items that the blades could pick up (clothing, supplies, equipment).
4. Do not radio the helicopter during the last 30 seconds of the landing, except to warn of an immediate hazard. If there is an immediate hazard, radio "Abort Landing" or "Wave-Off." Repeat the message until you see them lifting or hovering. If you have no radio, use the hand signal shown in Fig. 20-21.

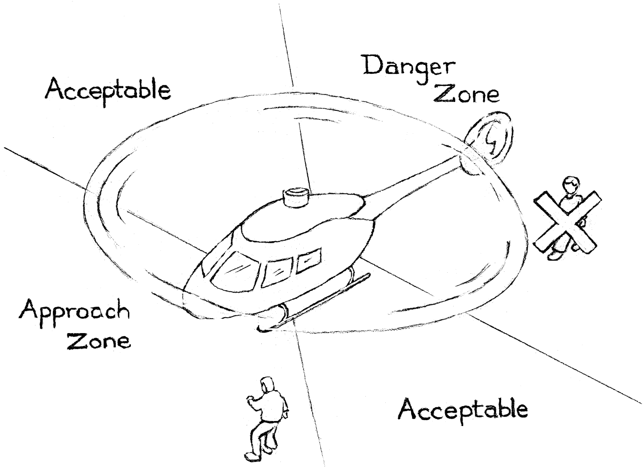

FIG. 20-20. Safe and dangerous zones around a helicopter.

Patients must be prepared for safe helicopter transport. Insulate the patient from cold—especially when under the spinning rotors. If traveling over water, put the patient in a survival vest that does not need inflating. Secure patients to the litter with quick-release straps, if possible. Any oxygen or IV tubing must be secured so it cannot become entangled with aircraft equipment. Most patients should receive supplementary oxygen, if it is available.[16]

HOSPITAL/HEALTH CARE FACILITY EVACUATION

A major part of disaster planning is preparing for the evacuation of hospitals and other health care facilities. Facilities should be assessed in advance for their ability to survive disasters and to safely shelter-in-place their patients and staff.[26]

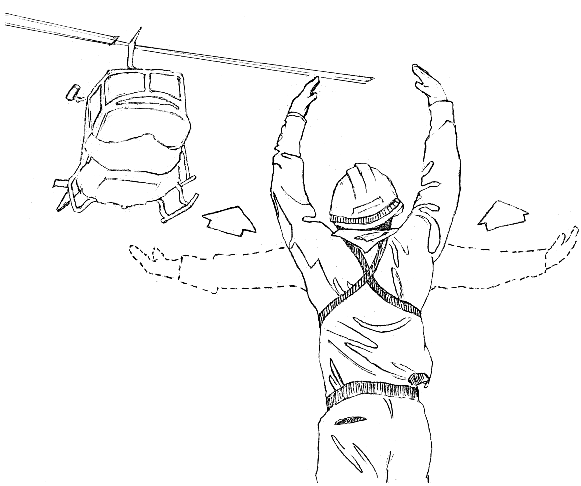

FIG. 20-21. “Abort-landing” hand signal.

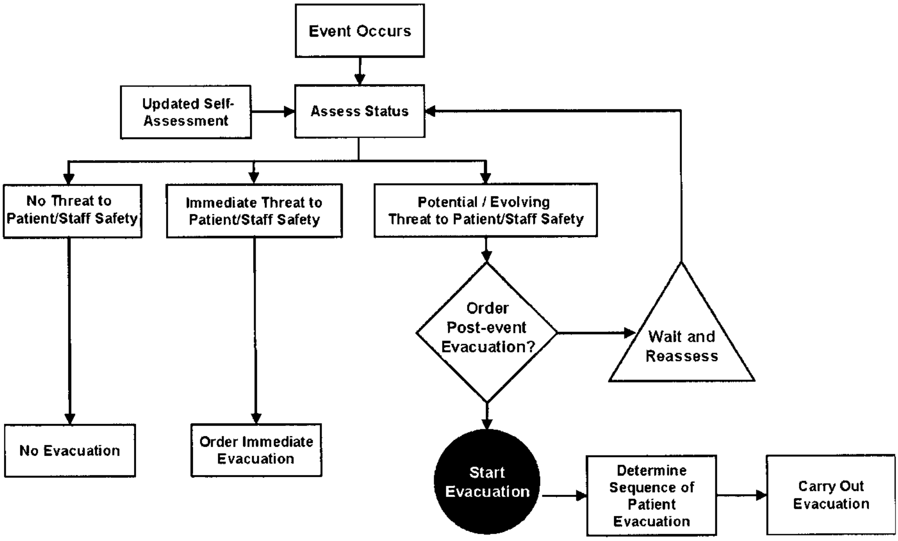

FIG. 20-22. No-advanced-warning-event evacuation decisions. *(Reproduced with permission from Zane et al.[27])*

Should/Must Patients Be Evacuated?

A major question, either after a disaster strikes (Fig. 20-22) or when one is expected (Fig. 20-23), is whether to evacuate or to shelter-in-place. Making this decision is difficult and its implementation can be costly. Who makes this decision may be as important as how to make the decision (see Appendix 1, Hospital Disaster Plan, for "triggers" that force decisions and how to identify the decision makers). The question of whether to order an evacuation relies on the infrastructure assessment, which includes knowing how long the hospital can maintain a safe clean environment without city water during hot months and how long the facility can maintain essential backup power with only the current on-site fuel supply (Table 20-2).

If the critical infrastructure still functions (or it is assumed that it will function after the event), the hospital's ability to shelter-in-place will depend largely on whether the supply of critical consumable resources can meet the needs of patients and staff without relying on outside supplies.

How Long Will It Take to Safely Evacuate?

If the decision to evacuate the facility is made, how long will it take? Table 20-3 lists factors to consider. The most important of these are the number of patients, the mix of patient acuity, available staff, exit routes within the hospital, patient transportation requirements, available transportation resources (personnel, vehicles and equipment), road and traffic conditions, and the locations of the receiving care sites.

Time is the major issue in hospital disaster evacuations: the time needed to empty the building and to transport the patients safely. In planning, one must distinguish between an orderly, planned evacuation that maximizes safety for patients and staff, and a "drop everything and go" evacuation, such as during a major fire. In emergencies posing an immediate danger, you may need to abandon optimal procedures for safely moving patients in favor of getting everyone out as fast as possible.

The time to empty the building includes the time required to move patients from their location inside the hospital (e.g., rooms, OR, emergency department, clinics) to an ambulatory area in which they can be assessed and discharged or an area for non-ambulatory patients from which

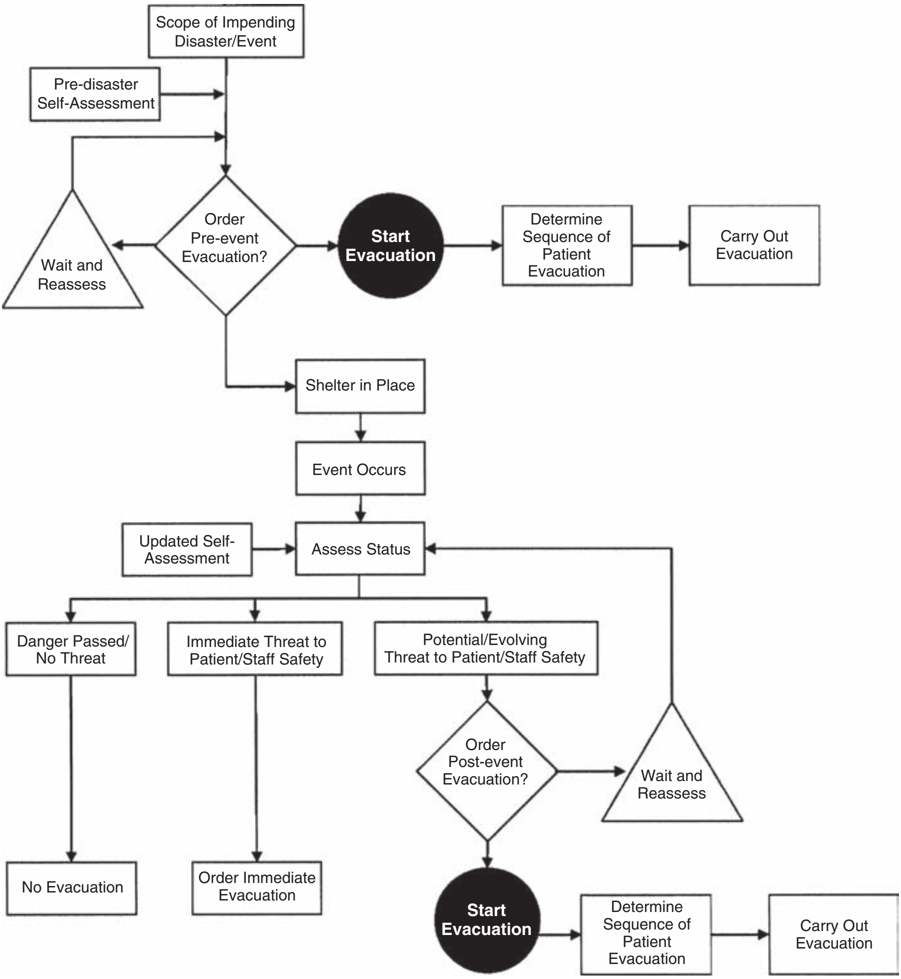

FIG. 20-23. Advanced-warning-event evacuation decisions. *(Reproduced with permission from Zane et al.[27])*

they can be loaded into ambulances and other vehicles for transport. One factor that determines how elegantly and quickly this can be done is whether the facility has a means of tracking patients and generating patient discharge summaries. In addition, evacuation time depends on whether elevators are operational (or staff have practiced using the evacuation method described under "Vertical Intra-Hospital Transport" earlier in this chapter), and how quickly additional staff can arrive to help with the evacuation.

Evacuation time also depends on the time needed to transport patients from the assembly/staging areas to receiving hospitals or other appropriate health care facilities.

When Can the Facility Be Reopened?

Subsequent decisions about whether, how, and when to move back into a damaged and evacuated health care facility is a complex decision involving many people. A US government publication, *Hospital Assessment and Recovery Guide*, describes the process and provides detailed checklists.[30] It is available on-line at http://www.ahrq.gov/prep/hosprecovery/hosprecovery.pdf.

TABLE 20-2 Pre-disaster Evacuation Decision Factors

Factor	Issues to Consider	Implication
	Event Characteristics	
• Arrival	• When is the event expected to "hit" the hospital? The metropolitan area? • How variable is the time the event is expected to "hit"?	• The amount of time until the event "hits," combined with the anticipated time to evacuate patients, determines how long an evacuation decision can be deferred.
• Magnitude	• What is the expected strength of the event? • How likely is the event to gain or lose strength before it reaches the hospital? The metropolitan area?	• The magnitude of the event forewarns of the potential damage to a facility and utilities, which could cut off the supply of key resources, or otherwise limit the ability to shelter-in-place and care for patients.
• Area impacted	• How large a geographic area will be affected by the event? • How many vulnerable health care facilities are in this geographic area?	• Competition for resources needed to evacuate patients (especially vehicles) increases when several facilities evacuate simultaneously.
• Duration	• How long is the event expected to last? • How variable is the expected duration of the event?	• The duration of the event will affect how long hospitals have to shelter-in-place or operate using backup, alternative, or less predictable sources of key resources.
	Anticipated Effect on Key Resources	
• Water source	• Is the main city water supply in jeopardy? Already nonfunctional? • Is there a backup water supply (a well, nearby building with intact water mains)? If not, how soon will city water return?	• Water loss of unknown duration (more than 1-2 days) is almost always cause for evacuation.
• Heat source	• Is the heat source in jeopardy (steam, water for boilers, etc.)? Already nonfunctional? • Is there a backup (intact nearby building that still has power/heat)? • If not, will the building become too cold for patient safety before adequate heat returns?	• Loss of heat, especially during a northern winter, is almost always a cause for evacuation—often within 12 hours.
• Electricity	• Is power in jeopardy? Just for the hospital or for a wider area? • Are backup generators functional? How long can they run without refueling? Is refueling possible (e.g., intake not under water)? • Can some sections/wings be shut down to reduce fuel consumption and stretch fuel supplies?	• Loss of electricity endangers ventilated patients, among others, and may affect the sequence in which patients are evacuated.

TABLE 20-2 Pre-disaster Evacuation Decision Factors (*Continued*)

Factor	Issues to Consider	Implication
• Building's structural integrity	• Is the building obviously/visibly unsafe? All of it or only portions (e.g., can people be consolidated in safer sections)? • Was there a water tower on the roof, and is it intact? • Is a building engineer needed to determine structural integrity/safety?	• Earthquakes or explosions may cause rooftop water towers to fall, flooding the building. • Safety/integrity may not be obvious to untrained occupants.
	Anticipated Effect on the Surrounding Environment and Community	
• Road conditions	• Are major routes from the hospital to potential receiving care sites closed? • Is traffic at gridlock on major routes from the hospital to potential receiving care sites? • Are access routes to the hospital cut off?	• There may be a limited window of opportunity to carry out a ground-based evacuation. • Increased use of helicopters to evacuate patients may be required. • Staff may not be able to get to the hospital to relieve existing staff or assist in the evacuation.
• Community/building security	• Have any nearby areas experienced increases in disorder or looting? • Are local law enforcement agencies understaffed due to self-evacuations or significant additional responsibilities? • Are additional private security officers available to secure the hospital?	• If patient and staff safety cannot be assured, evacuation will be necessary.
• Evacuation status of nearby health care facilities	• Are other hospitals or health care facilities evacuating or planning to evacuate, or have they decided to shelter-in-place?	• If other hospitals or health care facilities are evacuating: – the competition for ambulances, wheelchair vans, and buses may be substantially increased. – the hospital may be asked to accept additional patients. – patients may have to be relocated to facilities further away than anticipated.
• State/county/local evacuation orders	• Have evacuation orders been issued in areas that are closer to the event? • Have any public or private statements been issued regarding the possibility of an evacuation order? • Have any other incidents occurred that increase the likelihood that an evacuation order will be issued?	• You may have no choice but to evacuate.
• Availability of local emergency response agencies	• Are local emergency response agencies understaffed (or otherwise unavailable) due to self-evacuations or additional responsibilities?	• Unavailability of local fire agencies increases the risk of sheltering-in-place.

Adapted from Zane et al.[28]

TABLE 20-3 Factors Affecting Facility Evacuation Time

Evacuation-Relevant Resources	Implications
People	
• If a mandatory city-wide evacuation order is issued, what percentage of your staff is likely to leave with their families (and not report for work)?	High % = more vulnerable
• Has additional trained staff been identified/located to assist, if necessary, with the evacuation?	No = more vulnerable
Patient Census and Mix	
• How many patients are in the ICU (including adult, pediatric, and neonatal ICUs) and other units (e.g., burn units) with special evacuation needs (e.g., patient must be accompanied by two health care professionals)?	The more ICU and special care patients, the more limited the options for where they can be taken.
• Typical census of adult and pediatric patients.	
• Typical census of patients with special evacuation needs (e.g., psychiatric patients, bariatric patients, patients from correctional facilities).	
Patient Transportation Needs	
• What percentage of patients could self-evacuate (e.g., be taken home or evacuated by family/friends)?	The higher the percentage, the more vulnerable.
• What percentage of patients are ambulatory (e.g., could be evacuated by bus)?	
• What percentage can sit up but not walk (e.g., could be evacuated in wheelchair vans)?	
• What percentage requires medical attention at the BLS level during transport?	
• What percentage requires life support equipment (e.g., could only be evacuated in an ALS ambulance or medevac helicopter)?	
Evacuation Transportation	
• Does the hospital have an *exclusive* contract with transportation providers to supply vehicles, or is it dependent on public/private vehicles that must also provide services to other hospitals?	No exclusive contract = more vulnerable
• Has the hospital established relationships with state and regional emergency management agencies and developed coordinated plans for sharing transportation resources?	No = more vulnerable
• How long would it take to get all patients out of the hospital and on the road to another location (assuming the hospital is full, roads are not damaged/blocked, and appropriate vehicles and staff are available)?	Hours = time until evacuation
• Does the hospital plan specify an off-site “assembly point” where patients could be moved without vehicles and from which transportation/loading into vehicles would be faster?	No off-site “assembly point” specified = more vulnerable
• How long would this two-stage evacuation take?	Hours = time until evacuation
• How quickly could all the patients be moved out of the building (e.g., in case of a fire)?	Minutes = time until evacuation

Adapted from Zane et al.[29]

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21 | Surgery/Trauma

AUSTERE SURGICAL SITUATIONS

According to RS Bransford, a Western surgeon working in an African hospital, "The OR [operating room] is only marginally clean. You can see through the cloth you put on your operating table. Most in the OR, including their doctors, are marginally safe with regard to sterile technique."(Personal communication, January 21, 2007.)

In 2007, *Anaesthesia* published [2007;62(suppl 1):54-60] the following composite description of an OR in a least-developed country written by Drs. BA McCormick and RJ Eltringham, anesthesiologists with considerable Third World experience:

> The general theatre has a cement floor painted red and polished, with pale green-washed walls. The windows are open because of the stifling heat and flies hover overhead, occasionally coming to rest on the surgeon's mask or even the patient himself. The patient lies on an archaic-looking operating table. One end is supported on a trolley that prevents its faulty tilt mechanism from allowing it to collapse to the floor. The surgeon is calmly rejecting numerous drapes that are riddled with holes and can serve no purpose in maintaining a sterile field. Normal saline is running in through an 18G cannula that the patient's family were asked to buy from the local pharmacy; the best we could offer from the department stores was a 22G. The surgeon is keen to start operating as the procedure was delayed for 2 h waiting for supplies of sterile and nonsterile rubber gloves to arrive. Shortages of all consumables have been a major problem since additional financial support to the hospital and medical school from a European government programme was withdrawn 6 months ago. It appears that the infrastructure for procurement, storage and delivery of essential items dwindled during this time of plenty, when supplies were 'parachuted in' via alternative routes.
>
> John administers 50 mg of pethidine—this may be the last analgesic the patient receives until the unpredictable visit of the night matron to the ward in 9 h time. The surgeon asks for some antibiotics to be given and we enquire whether he would like chloramphenicol, gentamicin or both, as this is all the pharmacy can currently supply to us. The ex-pat surgeon nods at his lockable trolley, packed with privately procured goods for use in this theatre only. A sense of irony hits me as I reach past his iPod and speakers for a vial of cefotaxime, taking care not to interrupt the tones of Steve Harley and Cockney Rebel.

Essential Surgical and Trauma Care

The surgeons who run the international "Primary Trauma Care" course, which is taught in many developing countries, take issue with using the normal Advanced Trauma Life Support (ATLS) methods in those regions. They wrote that "the reality of trauma management in developing countries is, however, substantially different. The reasons for these differences are multifactorial, but they include geographical factors, relative lack of resources, funding, manpower and education … The [ATLS] so-called 'golden hour' must be extended into the 'silver day' or the 'bronze week'." They also note that the goals of transferring a stabilized patient on a firm stretcher for definitive care and of treating people in intensive care for complications of trauma are "often unrealistic in the developing world with minimal resources."[1]

The World Health Organization (WHO) lists what they consider essential to treat abdominal (Table 21-1) and chest (Table 21-2) injuries worldwide, varying with four levels of hospital capabilities (described in Chapter 5, Basic Equipment).

Should You Operate?

Clinicians may find themselves in situations in which they must perform a critical procedure with which they are not completely comfortable. In these situations, "time is the critical factor. Basic life-saving surgery can be done with simple standard equipment under IV ketamine anesthesia. The procedures must not be delayed and should be done by the surgeon

TABLE 21-1 WHO Essentials to Treat Abdominal Injuries

Resources	Facility Level			
	Basic	GP	Specialist	Tertiary Care
Clinical assessment	E	E	E	E
Diagnostic peritoneal lavage	I	D	E	E
Ultrasonography (pleural cavity/abdomen for fluid; heart for pericardial effusion)	I	D	D	D
Skills and equipment for intermediate laparotomy	I	PR	E	E
Skills and equipment for advanced laparotomy	I	I	E	E
Computerized axial tomography (CT)	I	I	D	D

Abbreviations: D, desirable; E, essential resources; GP, general practice; I, irrelevant; PR, probably required.

Adapted with permission from Mock et al.[2]

at hand on dying patients or dying limbs when the alternative to nonintervention may be death."[4] The surgeon should also not be deterred when surgery is required urgently, but a trained anesthetist is unavailable.[5]

The following guidelines, while primarily for surgeons, also apply to clinicians doing other invasive procedures on patients, such as placing drainage tubes, intubating or placing a surgical airway, and placing central or intraosseous (IO) vascular access lines. The real skill of a medical practitioner is making the decision when to do a procedure; nearly anyone can be taught to actually do the procedures. These questions, adapted from King and colleagues, can help you make the decision[6]:

1. What happens if you don't do the procedure?
2. How difficult is the procedure? Will you be able to do it?
3. How safe is the procedure in your hands? What disasters may occur? Can you deal with them?
4. Do you have the necessary equipment and staff to do the procedure?
5. Are you inclined to do procedures too readily—or not readily enough?

TABLE 21-2 WHO Essentials to Treat Chest Injuries

Resources	Facility Level			
	Basic	GP	Specialist	Tertiary Care
Adequate pain control for chest injuries/rib fractures	D	E	E	E
Respiratory therapy for chest injuries/rib fractures	I	E	E	E
Rib block or intrapleural block	I	PR	E	E
Skills and equipment for intermediate thoracotomy	I	I	D	E
Autotransfusion from chest tubes	I	D	D	D
Epidural anesthesia for pain control	I	I	D	D
Skills and equipment for advanced thoracotomy	I	I	I	D

Abbreviations: D, desirable; E, essential resources; GP, general practice; I, irrelevant; PR, probably required.

Adapted with permission from Mock et al.[3]

Improvised Surgery

If surgery will be performed in austere circumstances, the clinician must understand that "this is minimum-level surgery and you have to improvise ... . Select an assistant for the surgery. Instruct him on the need to keep everything sterile, and not to touch anything without your explicit permission. His main function is to provide manual retraction in the wound."[7]

Surgical Location

Surgery can be and has been performed in many settings. If there are several locations to choose from, consider factors such as lighting, space where equipment is located, temperature, and ventilation in relation to the type of surgery, assistants, etc. Operating outdoors provides light from the sun; in addition, operating outdoors may actually lessen the chance of infection due to the presence of sunlight. If operations are being performed with non-vented volatile anesthetics (e.g., open-drop ether), fresh air quickly dilutes it so that the surgical team is not affected.

A concern with operating outside, however, is the ambient temperature. This may be a significant factor with young or elderly patients who cannot easily regulate their body temperatures. It may also affect patients with extensive burns, whose body cavities would be open for a prolonged period, or who have suffered significant trauma. A rule-of-thumb is that basic lifesaving surgery with severe bleeding should not last >1 hour to prevent hypothermia.[8] Insects, inclement weather, and the onset of darkness also may limit the ability to operate in the open.

Cleanliness

Patients who survive a thoracotomy done in the emergency department (ED) have the same or lower incidence of infection than patients whose thoracotomies were done in the OR. Sterility is important, but it is the time the patient is open that matters most in terms of infection.

Even so, it is harder to maintain total sterility when operating outside of the OR; you will have to be prepared for minimal sterility.

"Scrubbing Up"

Surgery may need to be done bare-handed. If so, it is best if the surgeon does not have an open wound on the hand or arm, to avoid either contracting or transmitting an infection. This, of course, may not be possible. Try to scrub with ordinary soap and water for 10 minutes prior to surgery.[9,10]

In less-austere circumstances, clean tap water (not sterile water as has been required in some countries) is more than adequate for scrubbing before surgery. Rather than using special soaps and sterile brushes, gently rub the hands and forearms under tap water with a standard disinfecting soap (e.g., 7.5% povidone iodine or chlorhexidine gluconate). Using a quick-drying alcohol-based disinfectant scrub as the final step may be helpful. The faucets should be kept clean, and the water's chloride level should be >0.1 ppm.[11]

Using nonsterile gloves for wound repair (not surgery) in immunocompetent patients has been shown to have an equivalent risk of wound infection as using sterile gloves. The caveats are that the clinician must wash his or her hands before—and, for safety, after—the repair and that the gloves must be kept dry. Damp gloves can become contaminated with fungus. While comfort in austere circumstances is not a huge issue, some clinicians may find working with poorly fitting nonsterile gloves to be awkward.[12]

Prioritizing Patients for the OR

As with all medical care under austere circumstances, priority for the OR should be given to patients with the best chance of benefiting. For example, when prioritizing multiple patients with penetrating abdominal injuries, keep these statistics in mind[13]:

- If operating <3 hours after the injury, there is a 10% mortality rate.
- If operating >10 hours after the injury, there is a 50% mortality rate.
- Stable patients with abdominal wounds should be prepared for surgery, but can wait up to 4 hours post-injury for surgery.

For patients in shock, assume that these unstable patients have ongoing abdominal bleeding. A laparotomy is the only effective basic life support. Control external bleeding, administer volume and transfuse (type O or type-specific), and perform a laparotomy without further examination.

Patients who arrive >10 hours after injury have a high risk of complications from surgery, which does not increase much with a further delay. Provide basic fluid and airway support; give broad-spectrum antibiotics, if available; and, at surgery, concentrate on establishing a diversion stoma and effective drainage.

Telesurgery

Modern telecommunication allows clinicians who have never done a procedure to do it under audio, and sometimes even video, guidance from more experienced clinicians at a remote location. This technology is still not used as frequently as it might be. On occasion, however, the use of telemedicine in austere situations has expended resources that could have been used more productively elsewhere; this situation must be avoided.[14,15] See Chapter 3, Communications, for a further discussion of telemedicine.

SURGICAL EQUIPMENT

Surgical instruments may need to be manufactured. Physician prisoners of war (POWs) in World War II camps made surgical appliances from scrap materials using common items, including forks and spoons. With these rudimentary instruments, they performed thousands of successful operations.[16,17]

A relatively simple method for obtaining basic surgical equipment is to recycle instruments that are labeled as "single-use" or "disposable." The most common of these are disposable suture and suture-removal kits. Made completely of metal, they can be easily sterilized and safely reused.

Wound Glues

While cyanoacrylate, either the medical or the household variety, is the most commonly available glue to use for closing wounds, others can also be used. The problems are that they may not hold the tissue well, may irritate the tissues, and may even have some toxic properties. Among those that have been used are wood glue, panel adhesive, hobby cement, and various native substances. One caution: When using glue to close a wound, tell the patient that he should avoid putting an antibiotic ointment on the wound. Most have a petroleum base that will dissolve the glue.

Cyanoacrylate

Availability

Cyanoacrylate (e.g., "superglue"), which comes in a wide variety of commercial brands for medical and nonmedical use, is a methacrylate resin that bonds surfaces almost instantly. Nonmedical cyanoacrylate is not approved for medical use, although the medical literature shows that it has been used without difficulty in multiple situations. (Remember, the techniques in this book are primarily for austere medical circumstances; so if approved compounds are available, use them.)

Uses

Cyanoacrylates have been used successfully as a wound adhesive, for emergency dental repairs, and to treat corneal ulcerations and perforations, urinary and esophagobronchial fistulas, variceal bleeding, and esophagogastric varices (obliteration). They have also been used to repair peripheral nerves and for therapeutic embolism of vascular abnormalities.[18,19] During the Vietnam War, both liquid and spray forms of *n*-butyl cyanoacrylate were successfully used to control bleeding from penetrating wounds of the liver, retroperitoneum, kidney, pancreas, and vascular anastomoses after standard surgical treatment failed.[20,21]

Nonmedical superglues effectively close wounds in a similar manner to medical tissue adhesives. However, they are not sterile, which is likely to have little impact. One benefit of the medical form, which is 2-octyl cyanoacrylate (2-OC), is that it forms a bond about four times stronger than butyl cyanoacrylate.

Advantages/Disadvantages

The advantages of using cyanoacrylate are: (a) it is easy to obtain, (b) it can be applied rapidly, (c) it requires little technical knowledge, (d) a small amount can be used for many patients, and (e) it can be used on many parts of the body (e.g., skin, oral, intra-abdominal). Cyanoacrylate can also bolster thin edges of flaps or lacerations so that they can be primarily closed. This is particularly useful in the elderly and for those on chronic steroids.[22] It can also protect skin that surrounds fistulas when other modalities are not available.[23]

The primary disadvantages to using cyanoacrylate on wounds are dehiscence and contamination of other body parts.

Dehiscence

Because of cyanoacrylate's lower tensile strength compared to sutures, wounds dehisce more readily than when closed with sutures. The incidence of dehiscence can be lessened if (a) cyanoacrylate is not used for wound closure over areas under tension, such as joints; and (b) it is only used in areas and for wounds where a 5-0 suture would be appropriate.[24]

Contamination of Other Areas

Prevention

When using cyanoacrylate to close wounds around the eyes or the mouth, do not let it get onto the lids or lips: it can seal them shut for hours. The easiest way to avoid this is to position the patient so that any extra cement will run away from, rather than toward, the patient's eye or mouth. This may require having the patient turn her head away from the wound, lie on her side, sit up, or, if the wound is above the eye, lie in a Trendelenburg position.

Cyanoacrylate can be kept away from sensitive areas in two other ways: by using petroleum jelly (e.g., Vaseline) or an adhesive plastic drape. Petroleum jelly can be used to make a barrier around the wound to protect other tissues and sensitive areas (such as on the eyelids) from the adhesive.

If you have an adhesive drape (e.g., Tegaderm), fold it in half and cut a half-circle in the middle to make a hole. When opened, it forms a circular area that can be placed over the wound to be closed. The rest of the drape protects the surrounding areas. The edges of the drape closest to the wound must firmly adhere to the skin to make a successful barrier to the adhesive.

Treatment

There are several treatment modalities if cyanoacrylate does get on an unwanted area during wound closure, or when someone tries to remove the cap with their teeth or accidentally squirts a cyanoacrylate tube at home.

To remove cyanoacrylate, most commonly from the eye or an eyelid, use a petroleum-based product such as ophthalmic bacitracin, erythromycin ointment, or mineral oil. The alternative is to wait (usually less than a day) and the lids will open without treatment.

Table 21-3 is a modified version of a list of complications seen with cyanoacrylate's use on wounds. It was compiled by Dr. Loren Yamamoto from Kapiulani Medical Center in Hawaii.

Staples

Staples are a great way to rapidly close wounds. They can be used quickly for multiple patients on a variety of body parts. However, they cannot be improvised. The best suggestion, if you know that you will be in an austere medical situation, is to take staple guns and the staples with

TABLE 21-3 Cyanoacrylate Wound Adhesive, Complications and Solutions

Complication	Solution/Prevention
Latex glove stuck to wound	Use vinyl gloves that can be removed with gentle tension
Gauze stuck to wound	Use damp gauze rather than dry gauze
Cyanoacrylate hardens inside wound	Maintain pressure on wound edges to prevent this
Hematoma formation	Ensure hemostasis before using glue
Adhesive applied over sutures	This makes suture removal difficult; don't do it

Data from Yamamoto.[25]

you. They are lightweight and relatively inexpensive. (They may not be permitted in your carry-on luggage.)

To avoid using scarce resources to sedate a child while stapling a small laceration, use two people and two staple guns. Fire both at the same time; the child has a brief moment of pain, starts crying, and it is all over.

Other methods to bind wound edges together are the ordinary clips used to clamp paper pages together and safety pins—primarily to provide some closure to large gaping wounds. Nature's staples (i.e., ant or other insect pincers) are used in remote areas of the world to close wounds. Don't try this at home! If a native healer with experience wants to use them, they will probably work well.

Binding/Taping

Nearly any tape can be used to close a wound. There is no magical quality to medical tapes. Other than cleaning and debriding the wound, this requires no technical expertise and is amazingly fast, painless, and virtually cost-free. Duct tape (originally "Duck tape," by the way), as well as any adhesive tape, can be used. Cut it lengthwise into strips if you want to still see part of the wound.

Tapes don't stick well on areas that are hairy (shave the area, if necessary), wet or prone to perspiring, or under tension, such as joints. As with medical tape, you may need to use benzoin, cyanoacrylate, or another adhesive to help it stick. Alternatively, wrap a bandage around it, or use additional tape.

Suture Materials

Many items can be used as suture materials. Some are used routinely (e.g., nylon fishing line) around the world. Others must be improvised from available materials. The key is, use common sense but don't be "picky."

Bulk Suture Material

Monofilament (suture material) can be purchased in rolls. If used with ordinary sewing needles, the suture materials for a single operation cost almost nothing. Purchasing prepackaged monofilament suture material costs 20,000% more than buying it in reels.[26]

Fishing Line

Often sold as "colorless fishing nylon," fishing line is about 1/30th to 1/500th the cost of suture material sold in bulk. (Nylon carpet thread is very similar.) It can be precut to length and sterilized on the tray with other surgical instruments.[27] It retains its strength after autoclaving, and if translucent (uncolored) line is used, it is inert and nonallergenic once autoclaved. It provides comparable results to commercial nylon suture.[28] It should not be used where permanent suture is needed, such as in tendons. If employing improvised needles made from hypodermic needles (for a method to make these, see under "Suture Needles"), use the correct size line (Table 21-4).

Natural Materials

Hair Tying (With Glue) for Scalp Wound Closure

Scalp lacerations <10 cm long in patients with long hair (≥3 cm) near the wound can be closed by either tying or twisting hair on opposing sides of the wound. To tie the hair, twist a few strands together on each side of the laceration. Tie them and immediately secure them with benzoin, Nobecutane wound dressing, or a similar adhesive to prevent slippage. These knots will need to be cut out of the hair after the wound heals.

An alternative is to take several strands of hair from each side of the wound, pull them across the laceration to the opposite sides, and twist them around each other—once. Immediately put a drop of cyanoacrylate at the juncture (Fig. 21-1). These will not have to be removed, since the cyanoacrylate will gradually wear off. Instruct patients not to wash their hair or put petroleum hair products near the wound for 48 hours. This technique is extremely fast, cost-effective, and can be done with virtually no technical skills or equipment.[30,31]

TABLE 21-4 Fishing Line Approximating Standard Non-absorbable Suture Sizes and Appropriate Improvised Needle Sizes

Nonabsorbable Suture Size, USP (Metric)	Diameter Limits, in mm	Fishing Line Size by Breaking Strength, in Pounds (Approximate Diameter, mm)	Uses	Minimum Improvised Syringe Needle Gauge (Inner Diameter, mm)
7-0 (0.5)	0.045-0.60	N/A	Corneas, blood vessels	N/A
6-0 (0.7)	0.070-0.099	N/A	Face, eyelids, blood vessels	31 (0.114 mm)
5-0 (1)	0.100-0.149	1 lb (0.12-0.14 mm)	Face, neck, blood vessels, plastic closures	29 (0.165 mm)
4-0 (1.5)	0.150-0.199	2-4 lb (0.15-0.20 mm)	General use—neck, hands, limbs, tendons, scalp	26 (0.241 mm)
3-0 (2)	0.200-0.249	6 lb (0.23-0.26 mm)	Limbs, trunk, scalp, bowel, over joints	24 (0.292 mm)
2-0 (3)	0.300-0.339	8-10 lb (0.30-0.33 mm)	Trunk, fascia, viscera	22 (0.394 mm)
0 (3.5)	0.350-0.399	12-14 lb (0.35-0.39 mm)	Very heavy suture—abdominal wall closure; fascia; muscle; suturing drains, tubes, and lines; bone	22 (0.394 mm)
1 (4)	0.400-0.499	15-20 lb (0.40-0.48 mm)		20 (0.584 mm)
2 (5)	0.500-0.599	25-30 lb (0.50-0.58 mm)		18 (0.838 mm)
3 and 4 (6)	0.600-0.699	N/A		18 (0.838 mm)
5 (7)	0.700-0.799	50 lb (0.70-0.77 mm)		18 (0.838 mm)

Data from Pereira and Cotton.[29]

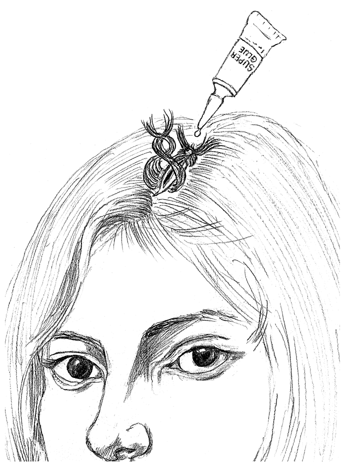

FIG. 21-1. Wound closure with hair and cyanoacrylate.

Chicken Egg Membrane

A fresh chicken egg membrane can be used to close wounds and reduce bleeding. The membrane contains types I, V, and X collagen, retains albumen, prevents penetration of bacteria, and is essential for the egg's formation. This low-cost dressing has been used as a skin-graft donor-site dressing to relieve pain, protect the wound, and promote healing.[32] One patient used a chicken egg membrane to close a full-thickness lip laceration, stop its profuse bleeding, and allow it to heal. He removed the membrane 3 days later and did well with no other therapy.[33]

Horsehair Sutures

Black or brown hairs from the tail of a horse make excellent sutures for skin wounds. They should be washed with soap and water, and then with alcohol. When needed, they are easily sterilized in boiling water or in steam. They are not as strong as silk.[34]

Other Nontraditional Materials

Dental Floss

Frequently cited as a suture alternative, most dental floss approximates a size 0 or 00 suture. It also may be made of many different fibers (e.g., silk, nylon, or Teflon) and can be single-stranded or braided.[35] This should only be used as suture material when truly desperate.

Stainless Steel Wire

Wire is often used for surgical sutures. Nonsurgical stainless steel wire can easily be sterilized and used in a similar fashion. To swag it onto a needle requires using a large gauge hypodermic needle. (See Fig. 21-2.)

Cotton Thread

Cotton and linen threads were long used as the standard surgical suture. Both are easily sterilized and do not irritate the skin. If using colored thread, choose one with a color-fast dye, or else boil it long enough to extract as much of the dye as possible.[36] In austere circumstances, "use ordinary sewing cotton, No. 30, white, for the heavier work on the abdominal wall, and No. 40 or No. 50, black, for finer work on intestine or delicate tissues."[37]

Disinfecting/Sterilizing Alternative Suture Materials

Rather than sterilizing, high-level disinfection is most practical for most alternative suture material. Some methods that can be used are to boil them in water or to soak them in alcohol (medicinal, drinking), hydrogen peroxide, bleach, surgical or regular soapy water, or lemon juice. Some residual materials (alcohol, bleach, lemon juice) on the suture may be painful if no local anesthetic is available.

To sterilize suture materials, wrap them in foil and either use an autoclaving method (see Chapter 6, Cleaning and Reusing Equipment) or put them in or near the coals from a fire. How well that works without destroying the suture material will vary. Wire sutures can be flame-sterilized.

Infection

While infection from using alternative suture materials depends on the material used, it is primarily a function of wound cleaning and debridement.

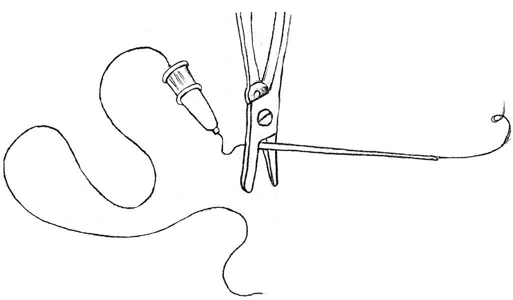

FIG. 21-2. Improvised swaged suture.

Suture Needles

A wide variety of needles (with eyes to pass the suture through) can be used. Tailor's round needles can be used in soft tissues, while triangular sharpened leather (cutting) needles can be used for fascia, tendons, etc.[38]

Suture needles can be fashioned from the appropriate-size hypodermic needles. (See Table 21-4.) Use a file to score the needle as close as possible to its hub and break it off. Make a loop of a fine wire (e.g., one strand of a thin braided electrical wire) and insert the two ends into the cut end of the needle. Use pliers to crimp this end and to bend the needle into a shallow arc; keep the needle's beveled end inside the arc. After sterilizing the needle, thread the suture material through the loop.[39]

Another method to convert a hypodermic needle into a suture needle is to pass the suture through the needle from the sharp end. Once it appears at the needle's hub, hold the suture in place and break off the hub by repeatedly bending it (Fig. 21-2). The suture can then be pulled through the needle so that only a small amount remains within the needle. Then crimp the "hub" end of the needle to fix the suture in place. Since all this can be done under sterile conditions at the patient's bedside, the "swaged" suture can be used immediately.[40] Alternatively, prepare several in advance, wrap the suture around a piece of cardboard, and autoclave them en masse.[41] Note that it may not be possible to use the newer safety needles (those designed to prevent personnel from being inadvertently stuck) for some of the improvised techniques involving needles described in this book.

For safety, rather than using a finger to buttress the other side of a wound when passing a needle through, use the cap from a disposable hypodermic syringe, the back end of a pair of tweezers (pick-ups), or a hemostat.

Needle Holders

Small needle-nosed pliers, locking pliers, or similar tools can be used as needle holders. They can be sterilized in an autoclave, although any rubber handle(s) may need to be removed first. While any of these can be used in austere circumstances, the best result will be obtained when they fit the clinician's hand and are as similar to regular needle holders as possible. These tools may work better than the straight hemostat that is often used in a pinch.

Scalpels

In desperation, surgery can be performed with any clean, preferably sterile, sharp object. This could include the lid from a can (partially folded over to form a non-sharp handle) or a piece of glass. Nearly any piece of metal can be sharpened to act as a knife. (For example, see how well prisoners do making "homemade" knives.) To hone the blade, not just the tip, to surgical sharpness takes special metal, tools, and expertise. The best option, if this is the route you must take, is to start with a cutting knife and sharpen it as well as possible.

A frequent situation is to have a scalpel blade, but no handle. (In many places around the world, they are still packaged separately.) In those cases, clamp the base of the blade with a straight clamp, such as a needle holder, and use the clamp as a handle. Alternatively, clamp the blade with needle-nosed pliers or similar tools, which are often found on universal tools (e.g., Leatherman, Victorinox, SOG, Gerber).

More commonly, improvised scalpels are knives that have been suitably cleaned and sharpened, if possible. They may even become the routine surgical instruments, as happened periodically during World War II. Dr. J. Markowitz, the surgeon at Chungkai jungle hospital camp in Thailand, crowded with 7000 POWs, performed 1200 operations using "a carpenter's saw and a few butcher knives, sharpened and re-sharpened."[17]

Surgical-grade scalpels with blades of various sizes can be easily made using a razor blade (disposable multiblade, single flat blade, or other), cyanoacrylate (i.e., Superglue or Dermabond), and a flat piece of metal to use as a handle. The handle must be flat for the blade to adhere; for butter and similar knives, the straight part (back) of the blade can be used. Old-fashioned flat razor blades can be used as very inexpensive (about 1¢ US/blade) and excellent scalpels, even for delicate intraocular ophthalmic surgery. The best way is to hold pieces of the blade with a razor blade breaker, no longer common in industrialized countries, but sold and used

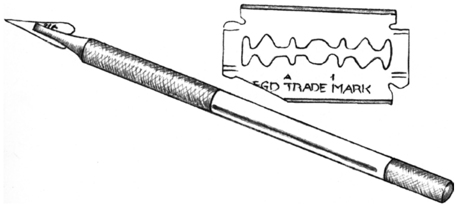

FIG. 21-3. Scalpel made from razor blade.

internationally. Carbon steel blades work better than stainless steel blades but, to retain their sharpness, must be chemically sterilized rather than steam-autoclaved or boiled. One razor blade provides up to six surgical knives, three blades from each edge.[42] (Fig. 21-3.) They can also be easily affixed to the flat handles of eating utensils. (Spoons seem to be the easiest handles to hold.)

To use multiblade disposables razors, carefully separate the blade from its holder by using a tool to bend one end, which will make the blades pop out (Fig. 21-4). Then put a few drops of cyanoacrylate on both the blade and the utensil/holder. Experience shows that you may need to wait about 10 minutes before the larger blades are firmly fixed. Be sure that the blade extends over the side of the handle and that the blade is parallel to the other side for better control of the scalpel.

Reusing scalpels is, of course, an option. Cleaning, sterilizing, and reusing equipment is discussed in Chapter 6, Cleaning and Reusing Equipment.

Skin Hooks

Skin hooks are the best way to handle wound tissue with the least amount of trauma. They are also excellent for retrieving and stabilizing torn tendons during repair.[43] Small instruments, they are frequently unavailable when needed, but can be easily improvised (Fig. 21-5).

A small-gauge needle bent at the tip and attached to a 1- to 10-cc syringe (depending on the size of the clinician's hand) or a straight hemostat makes an excellent skin hook. Using a hemostat, a double skin hook can be fashioned by clamping the hubs of two bent needles; to have more space between the ends, cross two needles and clamp them where they cross.[44] Use a 30-gauge needle when handling fine tissues, such as during shave excisions and biopsies.[45] A skin hook can also be made by unbending a safety pin so that the two "limbs" on each side of the spring form a straight line; put a small bend in the tip and sterilize it.[46]

Mayo Safety Pin

Used to hold and organize any surgical instruments with finger holes during sterilization and storage, these can be fashioned from heavy wire, such as a clothes hanger (Fig. 21-6).

Sponges/Lap Pads/Gauze Substitutes

The basic substitute for gauze bandages may be to reuse them, as was done in a POW camp during World War II. As they wrote, "Due to the scarcity of surgical gauze it was necessary to

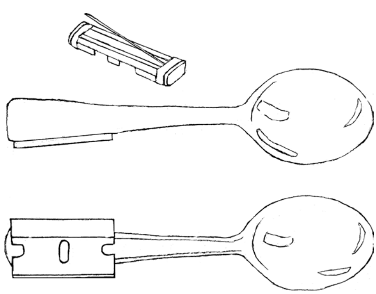

FIG. 21-4. Disposable razor blades fashioned into scalpel.

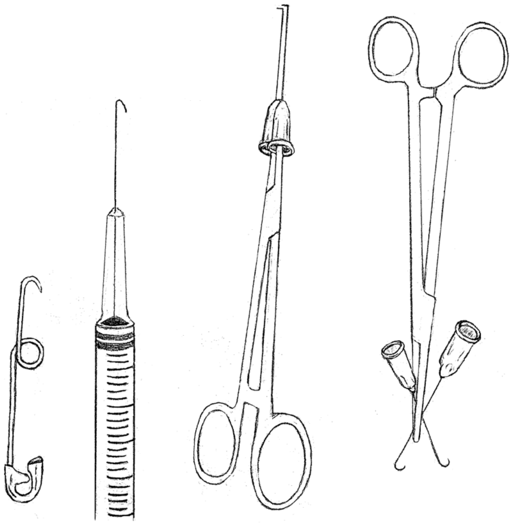

FIG. 21-5. Improvised skin hooks.

save and wash bandages and dressings for use over and over again."[16] Although not as good, but acceptable if nothing else is available, you can cut up and sterilize toilet paper (or even better, paper towels) to use as swabs.[47]

While gauze is often called a "sponge," especially when folded, if gauze is in short supply, actual sponges can be used instead. Cellulose surgical sponges are excellent as absorbent dressings over draining wounds or fistulas, either in place of gauze or as wound or graft dressings. Sponges can be made by cutting 1-cm cubes from long strips of cellulose that are widely available, often as packaging material. Another alternative is to cut up an old polyurethane foam mattress or cushion. The sponges should be sterilized before use. Do not discard them after use, but rather wash and re-sterilize them. They often can be used three or four times.[47-49]

To make laparotomy pads, fold linen sheets into several layers, sew them to the size you want, and then sterilize them. If thick gauze is at a premium, sew enough pieces of 20-cm × 25-cm gauze together to make a 5-mm layer. Attach a tape to one end so that it can be clamped with a hemostat and not disappear in the wound. Lap pads are a convenient and economical way of washing and reusing gauze.[47]

Cautery

Disposable microcautery units, although intended for one-time use, may be used for multiple surgeries—up to 20 ophthalmic surgeries, for example. Note that chemical or steam sterilization ruins the instrument. Once it has been used, hold the contaminated handle with a sterile towel and clean the tip with alcohol-soaked cotton.[50]

A makeshift cautery can be made using a platinum-tipped hollow metal tube attached by a hose to an atomizer bottle of benzene. First heat the tip over an alcohol lamp and keep it hot by infusing the tip with benzene.[50]

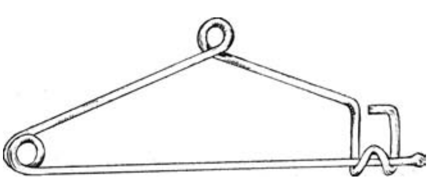

FIG. 21-6. Mayo safety pin.

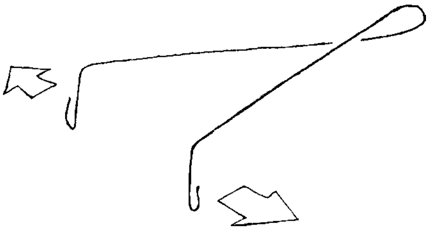

FIG. 21-7. Lightweight self-retaining retractor.

Sucker

A microsurgical sucker can be quickly assembled by cutting a small wedge from the end of suction tubing and inserting the tubing end into the barrel of a 5-mL syringe. Attach an intravenous (IV) catheter (without the needle) to the syringe's Luer lock connection. Use as small a size as needed and begin sucking.[51]

Petroleum Jelly Gauze

To make sterile "petroleum jelly" gauze for wound dressings, spread petroleum jelly onto layers of ordinary gauze. Place them in a watertight can and autoclave them.[52]

Retractors

Self-retaining retractors are excellent tools to have when working alone or with inexperienced assistants. (These retractors can make doing an open peritoneal lavage, for example, much faster.) Bend stiff metal rods into the form shown in Fig. 21-7. Use 3-mm rods for minor surgery and heavier rods for major wounds.[38] For working on more delicate tissues, they can also be fashioned from lighter material, such as paper clips.

Tweezers

Tweezers, or "pickups," for surgical procedures can easily be fashioned from pieces of the metal strapping used to secure boxes to pallets. These straps come in various widths and can be cut to any length. Fold them with a slight bulge in the end to avoid having them break at the fold after repeated use (Fig. 21-8). File down the ends to as sharp a point as you need.[53] Alternatively, two pieces can be riveted together, although that takes more effort. These instruments can be autoclaved repeatedly.

Tiny foreign bodies in the skin, such as a thorn, can be removed using the hinge of a pair of metal eyeglasses. Haywood Hall, MD, president of PACEMD, explains that you simply close one of the "temples," the long part extending to the ears, as you would when storing the glasses. Then place the hinged area over the foreign body and open the glasses as you would to wear them. The hinge area closes around the foreign body like a pair of tweezers would. (Personal communication, received February 6, 2007.)

Sterile Drapes

Sterile drapes can easily be fashioned from sheets that have been autoclaved. An alternative that disinfects rather than sterilizes, is to hang them in sunlight. (See Chapter 6, Cleaning and Reusing Equipment, for more information.)

FIG. 21-8. Surgical "pickups."

Surgical Table

Nearly any surface can and has been used as a surgical table. Surgeons once routinely cleared the kitchen or dining room table for operations done in homes.[54] During World War II, POW surgeons performed an emergency appendectomy using a ship's "hatch cover as operating table and a mosquito bar for protection against insects."[16] Disaster teams use cot-like stretchers placed on rigid metal sawhorses.[55]

Protection Against "Sharps"

Since a sharps container may not be readily available when you have finished using a needle or when reusing a needle multiple times during the same procedure, to avoid getting or giving needle sticks to other health care personnel, turn the needle around on the needle driver so that the needle's pointed end faces the handle and is locked between the instrument's jaws.[56]

NECK

Penetrating neck injuries are commonly treated using an ever-changing set of rules that often depend on the resources available. That luxury is not available in austere circumstances. With limited evaluation and monitoring resources, exploration may often be the safest treatment, especially for Zone 2 injuries (Fig. 21-9), if any doubt exists regarding injury to deep structures.

When faced with severe hemorrhage from neck or facial injuries that cannot be stopped any other way, Dr. Husum and colleagues advise that "the internal jugular vein or the carotid artery on one side may be ligated for life-saving reasons: The brain is well drained through the other side. Some neurological problems may follow ligature of a bleeding carotid artery, but in most cases the blood supply from one carotid artery is sufficient."[57]

ABDOMEN

Cholecystitis and Appendicitis

When imaging, laboratory, and surgical resources are limited, practicing "elegant" medicine involves using only those resources absolutely necessary. That means making diagnoses on history and physical examination alone.

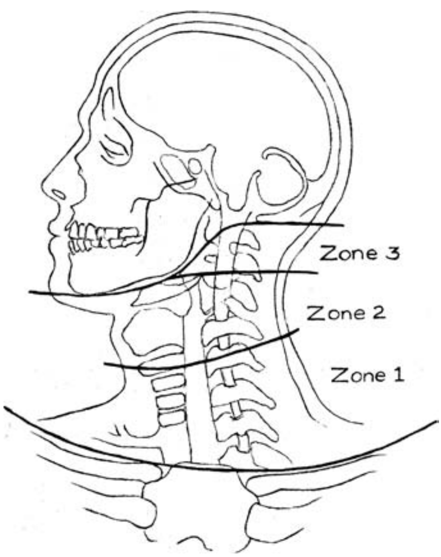

FIG. 21-9. Neck injury zones.

TABLE 21-5 Clinical Findings in Cholecystitis

Factor	Likelihood Ratio (LR)	Sensitivity	Specificity
Murphy's sign	2.8	0.65	0.87
Emesis	1.5	0.71	0.53
Fever	1.5	0.35	0.80
RUQ tenderness	1.6	0.77	0.54
Rebound	1.0	0.30	0.68

Cholecystitis

The following clinical findings may help you decide who needs further evaluation or intervention in patients with suspected cholecystitis. Table 21-5 ranks them in order of their helpfulness in making a correct diagnosis.[58] If the patient has a Murphy's sign (and still has a gallbladder), this is the person who should get the ultrasound rather than laboratory tests. In the absence of evidence for acute cholecystitis, unrelieved emesis or pain, biliary obstruction, or perforation, treat the patient with analgesics and have the patient return if symptoms do not resolve.

Appendicitis

Right-lower-quadrant pain is a very strong predictor of appendicitis in adults, with a likelihood ratio of having appendicitis of 7.3 to 8.5. It is also an excellent predictor in older children. Independently, fever, anorexia, nausea, and vomiting are poor predictors of appendicitis in both adults and children. Rebound and the psoas sign have an intermediate reliability in both groups. A relatively simple scoring system helps determine if a child has appendicitis. While it uses a white blood cell count and a differential as two of its parameters, the other six factors come from the clinical history and physical examination. The MANTRELS scoring system (Table 21-6)—the name is a mnemonic for the elements scored—provides between a 3.8 and 5.0 positive likelihood ratio that the child will have appendicitis if the score is ≥7, and between a 0.09 and 0.40 likelihood ratio that no appendicitis exists if the score is <7.[59]

If surgery is not an immediate option, treat presumed appendicitis with antibiotics alone.[60] Delaying surgery for most adult patients with presumed appendicitis does not significantly alter their morbidity or mortality, but does slightly increase their postoperative hospital stay. The highest risks when doing this are in women and the elderly, who may have other serious intra-abdominal pathology that the antibiotics may mask and not treat.[61]

TABLE 21-6 The MANTRELS Appendicitis Score

Symptom	Score
Migration of pain to the right lower quadrant	1
Anorexia	1
Nausea/Vomiting	1
Tenderness in the right lower quadrant	2
Rebound pain	1
Elevation of temperature (≥37.3°C)	1
Leukocytosis (WBC >10,000/μL)	2
Shift of WBC count to the left (>75% neutrophils)	1
Maximum Score	**10**

TABLE 21-7 Emergency Laparotomy

Reasons and Methods
Is done on dying patients, or on unstable patients before prolonged evacuation.
Can be lifesaving.
Should be done immediately, to be effective.
Uses a few simple surgical instruments.
Is performed in the field.
Use intermittent IV ketamine anesthesia.
The operator should be anyone ("paramedic") trained in the procedure.
Procedures to Shorten Emergency Laparotomy
Pack tears of abdominal organs with dry gauze.
Then pack the bleeding quadrants with large, dry gauze packs, 40 cm by 40 cm.
Consider leaving vascular clamps until the second-look laparotomy without tying ligatures.
Tie the intestines proximal and distal to intestinal wounds with ribbon gauze.
Consider closing the midline incision with towel clamps.
Distended abdomen: Suture plastic infusion bags to the abdominal wall fascia to close the midline incision temporarily.

Data from Husum et al.[62]

Abdominal Procedures

Emergency Laparotomy

In critical, austere situations, a decision to open an abdomen may be lifesaving—or lethal. In their book, *War Surgery*, Dr. Husum and colleagues list the reasons (Table 21-7) to perform laparotomies under these circumstances, suggest widening the scope of who can do them, and detail ways of shortening the procedure.

Diagnostic Peritoneal Lavage

An excellent technique that has all but disappeared in developed countries with the advent of ultrasound and CT scans, diagnostic peritoneal lavage (DPL) requires few resources and is a good tool to diagnose intraperitoneal bleeding, perforations, and infections. This relatively simple and fast procedure helps a clinician decide whether to do exploratory laparotomy after blunt abdominal injuries. It can be done using local infiltration or low-dose ketamine anesthesia.

The abdomen is entered 2 cm inferior or superior to the umbilicus. (Go above the umbilicus if a pelvic fracture is suspected.) The technique can be done through an incision or by using the Seldinger (catheter-through-needle) technique. Using the Seldinger technique, insert the needle into abdomen and pass a catheter through the needle into the peritoneal space. This method may be hazardous in patients with prior abdominal surgery due to adhesions and the possibility of bowel perforation. This method is much faster and has, in reality, proved to be as safe as the open method.[63]

The more common technique is to make a small midline incision through the abdominal wall. The reason this method fails is that the midline cannot be identified. Experience shows that by using a self-retaining retractor, the midline is much easier to find and the procedure is easily and quickly done with one clinician. When the peritoneum is identified, make a small hole and insert a soft catheter, such as IV tubing in which additional side holes have been cut distally.

Once the catheter is in the peritoneum, immediately aspirate to check for ≥10 mL of gross blood, which indicates a "positive" lavage and the need for a laparotomy. Otherwise, tie a purse-string suture around the tube and close the incision tightly. Instill 1 L normal saline; once it is instilled, let it drain from the abdomen using gravity by putting the IV bag or bottle on the floor.

A diagnostic lavage requires 250 mL to return out of the abdomen. A positive result is not being able to read newspaper-sized print through the tubing. (Don't assess the IV container's clarity, since it may vary with the amount of fluid in the bag or bottle.) If laboratory testing is available, a positive lavage will have >100,000/mL red blood cells (RBCs) in blunt trauma patients or >10,000/mL RBCs for penetrating trauma patients, a white blood cell count >500/mL, elevated amylase (>175 IU), elevated bilirubin, food particles, or a high bacterial count in the effluent.

Laparoscopy

An 18-gauge spinal needle can be used to establish pneumoperitoneum prior to laparoscopy if the normal needle is not available. After draining the bladder, make a 1-cm transverse incision in the midline just below the umbilicus. Grasp and elevate the lower abdominal wall, and introduce the spinal needle at 45 degrees to the horizontal plane, aiming toward the hollow of the sacrum. There is a distinct "give" when the needle passes through the linea alba. Remove the stylet and attach a syringe, aspirating to check that the needle has not entered either a vessel or the bowel. Inject 5 mL of saline and then attempt to withdraw it. Free flow and an inability to withdraw the saline suggest proper needle placement. Then attach the gas supply to the spinal needle and establish a pneumoperitoneum.[64]

Cystoscopes, available in most rural locations, can be successfully used both for diagnostic laparoscopy and to perform simple laparoscopic surgery. The method is to pass the scope through a small abdominal incision that is tightened around the scope with a purse string suture or a towel clip (Fig. 21-10). For example, to do an appendectomy, insert the instrument through a small (~3-cm) incision at McBurney's point. Then produce a pneumoperitoneum with an inflation bulb with a valve, such as from a sphygmomanometer, attached to the scope's proximal inflation port. Use the working port to take biopsies or do surgery.

For an appendectomy, an alligator forceps (flexible grasper) holds the tip of the appendix; bring it and the cystoscope out through the incision. The normal dissection of the appendix occurs and the wound is closed. This procedure also has been used diagnostically for infertility assessments, ascites diagnoses, evaluations of probably stomach carcinoma, liver biopsies, abdominal mass evaluations, and acute abdomen evaluations.[65,66]

Urobag Zipper Laparostomy

To avoid repeating laparotomies on patients with gross intraperitoneal sepsis, the laparotomy incision is often left open, with a zippered laparostomy bag attached. An excellent inexpensive alternative exists to these high-cost commercial devices—the improvised zipper bag.[67,68] Construct one using the commonly available Urobag and a handbag or suitcase zipper, choose a zipper length appropriate for the incision size and sterilize it in an autoclave. Immediately before attaching it to the abdominal wall, cut the Urobag to exactly fit the incision. Then, attach the

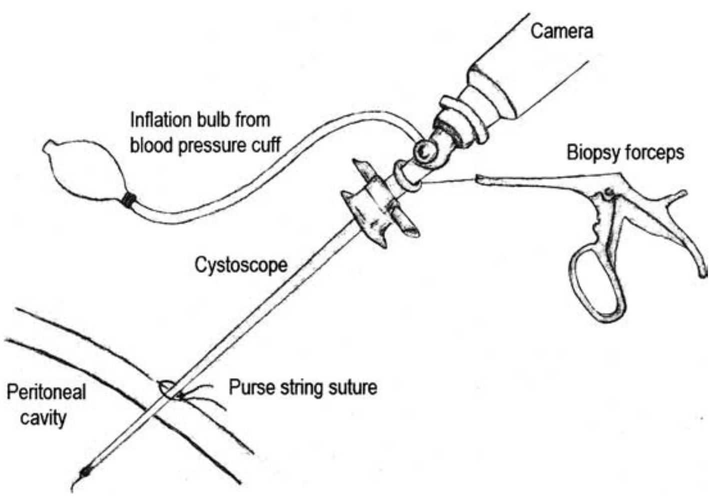

FIG. 21-10. Cystoscope used for diagnostic laparoscopy. This figure shows a camera attached.

zipper to the bag with a running, nonabsorbable suture (e.g., silk, polypropylene). The bag is fixed to the rectus sheath on either side and at the angles using nonabsorbable sutures. It is sutured to the fascia when the sheath is not available or retracted. The bag is periodically removed and resutured at the bedside, using local anesthesia.

Chewing Gum for Postoperative Ileus

After abdominal surgery, if patients are allowed to chew gum beginning their first postoperative day, they may nearly halve the time until they begin taking oral sustenance. In one group of post-laparoscopic colectomy patients, it stimulated bowel motility when they chewed the gum three times a day.[69]

CHEST

Open Chest Wounds

Chest wounds can be open or closed. Open, or "sucking," chest wounds should be covered with what amounts to a one-way valve. To do this, tape three sides of an airtight dressing over the hole in the chest. Many things fit that description, but some commonly used materials include plastic food wrap, aluminum foil or aluminum foil packaging, and MRE (meal-ready-to-eat, a military food container) packaging. If the patient has increased difficulty breathing or diminished pulses or blood pressure, remove the dressing.

Pneumothorax

Needle Decompression

The common teaching is that a tension pneumothorax is easily treated with simple 14-gauge-needle thoracentesis.[70] Maybe that is true in children and thin adults, but it is not true in other cases.

Needle thoracostomy is most successful in children and younger men due to their smaller chest-wall size. Whether the standard 14-gauge over-the-needle catheter (5-cm-long needle; 4.5-cm-long catheter) relieves a pneumothorax in adult patients depends on their position, gender, and age. If the chest puncture is in the second intercostal space at the mid-clavicular line, the catheter won't reach the pleural cavity in one-half to three-fourths of women and in one-fifth to one-third of men in the arms-down position, which is the typical position of patients needing chest decompression. Even if the catheter does reach the pleural space, it can easily pop out when the patient is moved. If the catheter is placed with the patient's arms raised, it pops out as soon as they lower their arms.[71]

Alternatives are to place a longer needle or catheter, to place it in the mid-axillary line that has less tissue, or to place a chest tube. However, using longer needles and blind insertions at the mid-axillary line risks injuring the lung parenchyma or the heart. When the patient needs chest decompression and the 14-gauge needle either doesn't work or doesn't continue to work after an initial rush of air, consider introducing the needle at a different site; using a longer needle, such as a 12-gauge, 3-inch (7.6-cm) IV catheter; or doing a mini-thoracotomy if the patient is intubated.[72]

Mini-Thoracotomy

Pneumothoraces in critical trauma patients can be treated initially without a chest tube if there is no tube, if there are questions about the sterility of the surroundings, or if cramped quarters (helicopter, ambulance, etc.) do not permit easy manipulation of the tube. In patients who are intubated and being ventilated—usually with a chemical paralytic agent in use, a "simple thoracostomy" without a chest tube has been found to be initially preferable to using a simple needle thoracostomy. This technique is safe and effective for intubated trauma patients who are being ventilated rather than breathing on their own, and who have evidence of decreased breath sounds, subcutaneous emphysema, serial rib fractures with chest wall instability, or a penetrating chest wound.

The technique is to thoroughly clean the chest wall at the fifth intercostal space between the anterior and mid-axillary line and make a 5-cm incision, bluntly dissecting down to and entering the pleural cavity. (This can also be done at the mid-clavicular line if access to the side presents a problem.) Cover the incision with a sterile gauze dressing that should be taped down on only three sides. Any air in the pleural space naturally exits as the intrapleural pressure rises with ventilation, while no air enters the chest.[73] A chest tube is inserted when the patient arrives at the hospital or at another facility that can easily and safely insert one.[74]

Pneumothorax Aspiration

Rather than inserting a chest tube (with many resources used), patients <50 years old with a first-time unilateral spontaneous pneumothorax that is <40% collapsed can usually be managed without a chest tube. Observation alone is adequate treatment for healthy young patients who present with a small (<20% of the hemithorax) primary spontaneous pneumothorax. The intrinsic reabsorption rate of intrapleural air is about 1% to 2% of the total lung volume per day. Administering 100% oxygen increases the reabsorption rate three- to fourfold (~5%/day). For those with <20% collapse, simply observe for 6 hours and repeat imaging.

If the collapse is >20% but <40%, aspirate the air. (Determining the percent of collapse for a pneumothorax is always an approximation; see Chapter 18, Radiology/Imaging, for reasonably accurate methods to assess it.) Do this under local anesthesia through the second intercostal space in the mid-clavicular line using a 16-gauge cannula, a three-way stopcock, and a 50-mL syringe. Repeat imaging in 6 hours. If, after 6 hours, the collapse is still >20%, either repeat the protocol once or insert a chest tube. If, at any point, the patient becomes dyspneic or the lung collapse significantly increases in size, insert a chest tube. Have the patient return for a reassessment in 1 week.[75]

Heimlich Valve

Use

One-way (Heimlich) valves are commonly used to treat pneumothoraces. A contraindication to using them is the drainage of large volumes of fluid or viscous secretions, which may cause the flutter valve to malfunction.[76] It handles smaller or less viscous amounts of fluid without difficulty.[77]

For example, British physicians involved in the Falkland Islands (Malvinas) War wrote, "All penetrating wounds of the chest were treated with intercostal drainage with, in many cases, relief of respiratory embarrassment by the drainage of substantial volumes of blood. Heimlich valves were used to provide a one-way seal to these drains and these often became blocked if blood was draining. The only solution was to change the valves frequently."[78]

Even with this caveat, Heimlich valves have been jury-rigged to collect chest drainage using urine (standard and leg) collection bags, sterile gloves, colostomy bags, and similar containers. To attach the valve to urine collection bags may require cutting off the bag's standard adapter for attaching it to the urethral catheter and inserting the Heimlich valve's universal adapter.[79] Other connection adaptations are the same as with a chest tube, and are discussed below.

Containers attached to a Heimlich valve must be vented with a hole in the proximal (or least dependent) part of the bag. The patient and caregivers must be warned never to seal that hole and to remove the drainage system (but not the Heimlich valve) if breathing difficulties ensue. Also, they must keep the collecting container upright so that the fluid does not drain out.[80]

Makeshift Heimlich Valves

The standard Heimlich valve is a small (about 3-cm diameter by 10-cm long) plastic cylinder, with a rubber one-way valve in the center, and universal adapters ("Christmas tree adapters") on either end. Similar flutter valves can be easily improvised and, if fluid drainage is required, may actually work better than commercial devices.

Fashion a flutter valve by tying a condom or the finger from a medical glove to a standard or makeshift chest tube or needle thoracostomy (Fig. 21-11). For ease, tie it on before inserting the needle or put the needle through the fingertip end of the glove's finger, leaving the glove intact or cutting it at the finger's base.[81]

Adjust the hole in the glove to vary the pressure required for air to exit. If fluid is draining from a chest tube, a large hole is useful. (If using a chest tube, use only the glove's finger.) This results in significant "PEEP" (positive end-expiratory pressure), and so should be used with caution. If the entire-glove method is used and the patient experiences difficulty breathing, one solution is to cut the glove so that only the finger portion remains.

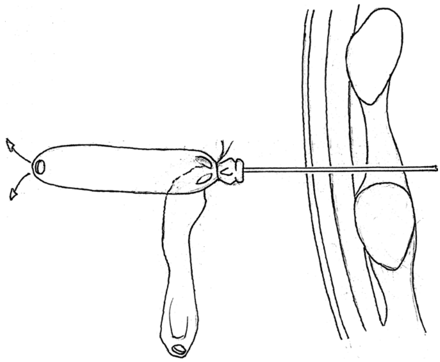

FIG. 21-11. Heimlich valve, improvised.

If draining fluid through improvised flutter valves, incorporate them into the drainage system by putting the valve, along with the end of the chest tube, into the drainage bag.

Chest Tube

In resource-poor situations, problems with chest tube drainage include not having an appropriate tube, lacking a connection to the drainage system, and not having a drainage system to begin with—especially one that doesn't break easily.[82] Not all these problems can be solved.

The purpose of the drainage system for chest tubes is to collect fluid and to prevent air from leaking back into the pleural space. A sterile water bottle, IV tubing, and an IV bag can serve as a chest tube drainage system with an underwater seal.

Thoracostomy Tube

CHEST TUBE PLACEMENT FOR AUSCULTATION AFTER A CHEST INJURY

If imaging is not available to confirm the pneumothorax, some physical findings may help confirm the diagnosis.

1. "Dull drum sound and weak stethoscopic lung sounds: Hemothorax ⇨ insert chest tube!
2. Hyper-resonant drum sound and weak stethoscope lung sounds: Pneumothorax ⇨ insert chest tube!
3. Hyper-resonant drum sound at top level, dull drum sound at the lung base and weak stethoscopic lung sounds: Combined hemopneumothorax ⇨ insert chest tube!"[83]

Improvised Chest Tube

The chest tube is made of plastic or rubber and has multiple perforations at one end, to prevent clogging. If a standard chest tube is unavailable, use any catheter or tubing to improvise one. Cut multiple holes in the end that will be inserted into the patient.[84] Any clean (preferably sterile) hollow tube works well as a chest tube, although the connections to a drainage system or Heimlich valve should be considered in advance. Some of those that have been used are:

- Stiff plastic water tubes of appropriate diameter. Trim the tube end and add some side holes.[20]
- A urethral catheter can be used, especially as a pediatric chest tube. The problem is that both the pressure of the chest wall and any suction applied to them collapse the tube.
- Endotracheal tubes work well as chest tubes. They don't kink like a urethral catheter and, with a bigger diameter, drain much better. A standard or homemade Heimlich valve can be connected to the end.
- A piece of hollow metal tubing, such as a tent pole, could also be used in a dire emergency. While not pretty, it can keep a thoracostomy incision open, relieving a tension pneumothorax. If the patient is being ventilated, that is all that is required.

Chest Tube Position

There is no uniformly correct placement site for a chest tube. Place it where it will be easiest to use, where access is available depending on the patient's position (e.g., a patient trapped so only the back is accessible), and in a place where it will make the patient more comfortable and provide the best subsequent cosmesis.

Chest tubes can be placed in the anterior, mid-, or posterior axillary lines. They can be placed in the second intercostal space at the mid-clavicular line, which may be more accessible. However, in patients with significant breast tissue, have an assistant push the breast down (caudally) to get the least amount of interposed tissue. (This is also useful when placing a subclavian line in this area.) Chest tubes can also be placed posteriorly. With the patient sitting, insert the tube at the second interspace just medial to the medial border of the scapula. Note that the chest is 3- to 7-cm thick at this point, so it is not a particularly easy procedure.[85]

Connections

Think about how to connect the tubes while assembling your improvised thoracic drainage system. Don't assume that an appropriate tube connector will be available, even in well-stocked facilities.

Some connectors that are easily fashioned from readily available equipment or techniques are:

- *Glove fingers*: Cut a finger from a glove and also cut off the fingertip. Put each end over a tube end and tie or tape them tightly and close together.
- *Distensible (rubber) tubing*: Cut a relatively short piece of distensible tubing that has a smaller or equal size to the tubing being attached. Use a hemostat to pull an end over each of the tubes being connected. Reinforce this with tape, sutures, or cyanoacrylate.
- *Highly adhesive tape*: Put the tubing ends as close together as possible and wrap with electrician, duct, medical rubberized, or a similar very adhesive tape.
- *Syringe barrel*: Cut off both the flange and the Luer lock ends of a plastic syringe barrel that approximates the inside, or outside, diameters of the tubes to be connected. Put the tubes over or inside the barrel (or one inside; the other outside) and tape them in place.
- *Cut tubing*: Tubing can often be forced into a slightly larger tube if a "V"-shaped cut is made in the larger tubing end. At least one of the tubes should be stiff, such as is the typical chest tube.

Drainage System (Plastic Bottles/Bags)

The fundamental idea of a chest tube drainage system is for the air to leave the thorax (chest) without any air being able to reenter the chest via the system. Figure 21-12 shows the simplest arrangement, which can be made from virtually any bottle and tubing. A tube that extends

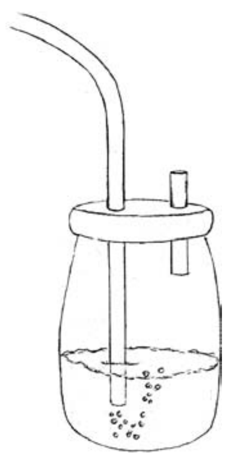

FIG. 21-12. One-bottle chest drainage system.

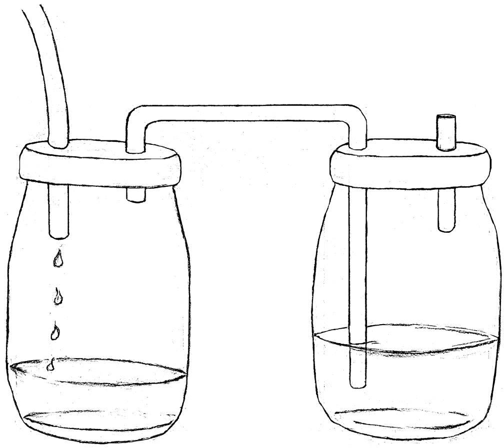

FIG. 21-13. Two-bottle chest drainage system.

beneath the water in the container is connected to the patient's chest tube. The hydrostatic pressure of the water keeps air in the bottle from returning up the tube. A patient with a pneumothorax expels (bubbles) air out, but it cannot return. The vent in the bottle keeps the pressure within the bottle from rising as new air enters from the patient. If the patient has fluid in his chest (e.g., blood, empyema), this system can still be used. However, the bottle will need to be emptied periodically.

Instead of using chest tube suction, use a soap solution in place of water in the collecting bottle, give the patient analgesia, and then have him blow up a child's balloon or surgeon's glove. The positive respiratory pressure inflates his lungs and promotes chest drainage.[20]

Figure 21-13 illustrates a two-bottle system. The system pressure is maintained in the second bottle, while the first is used solely to collect fluids from the chest. This system has the same connections as the one-bottle system. Note that either system can be open to the air or attached to suction. Many types of plastic or glass bottles can be used for these systems.

A US Navy physician constructed a two-bottle chest tube drainage system from an empty 1-L plastic sterile-water bottle, a 1-L IV bag, two IV tubing sets, and a 24-Fr chest tube.[86] This system collects and measures the fluid that drains out of the tube. To reproduce this system, empty a plastic sterile-water bottle and put one hole in the cap and another in the bottle's neck; each hole should barely allow passage of the IV tubing (Fig. 21-14). Cut the patient (IV–catheter attachment) end off one (the "first") IV tubing set and insert this cut end into the hole in the top of the empty bottle. The other (IV bag-spike) end of this tube should fit into the end of the 24-Fr chest tube. Next, take the other (the "second") IV tubing set and cut off the spike end between the filter and the reservoir. Position the fluid-filled IV bag with its ports up and the saline bag down, and insert the cut-off spike from the second IV tubing set into one port in the IV bag. This is now the system's air vent. Open the other port (cut or remove the rubber cap) and insert the cut end of the second IV tubing so that it is well beneath the level of the saline in the bag. Then place the other end of the second IV line through the hole in the neck of the empty bottle. Use cyanoacrylate, any other cement, or duct tape to seal the tubes in position. Keep the IV bag inverted to provide a water seal for the system. To dispose of any accumulated fluid, clamp the chest tube, unscrew the cap from the water bottle, and empty it out. Then screw the cap back on and unclamp the chest tube.

Drainage Bag

Chest drainage systems, either with chest tubes or flutter valves, must often be constructed that allow the patient some mobility, especially for outpatient treatment. A variety of disposable, inexpensive alternatives have been used. The most common is an "urosac" or "UroBag" that usually has graduated markings to measure output and a method of draining it without separating the chest tube, and may include its own one-way flutter valve that prevents backflow into the tube.[87-89] They often can hang the bags from a thong around a patient's neck.

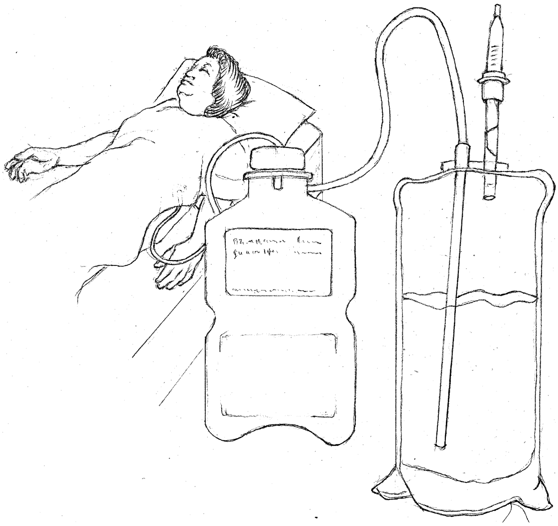

FIG. 21-14. Chest tube drainage with water bottle and saline bag.

Improvised Median Sternotomy

As just one example of improvisation in the face of necessity, one surgeon who lacked the standard tools did a median sternotomy with a heavy pair of scissors ("trauma shears"), saving the patient's life. This patient, who had suffered a stab wound and had a positive cardiac FAST exam, dropped his pressure abruptly, precipitating this response. His cardiac laceration and tamponade were quickly repaired.[90]

INJURIES

Vital Signs After Trauma

When trauma patients arrive at a hospital with a normal systolic blood pressure, reports from prehospital personnel that the patient was hypotensive before arrival are often downplayed. That is a mistake. Patients for whom trained ambulance personnel report prehospital hypotension are more than three times as likely to need an operation to repair damaged organs as are those reported as being normotensive. Their mortality is also more than twice as high.[91]

Gunshot Wounds to Extremities

Low-velocity gunshot wounds to the legs are part of the "urban war" being waged between gangs around the world. Rather than tying up resources observing or studying them, patients who present hemodynamically stable with no associated fractures and with a normal ankle-brachial index (ABI) (≥0.90) can be discharged after a short observation period.[92]

Without a sphygmomanometer (or a Doppler for a true ABI), the best method is to compare the circulation in both limbs. Assess "capillary refill." It will either be "brisk" or "impaired," meaning possible vascular compromise. Also, carefully check neurological status; damage to the nerve associated with an artery is often an early sign of vascular injury.[93]

High-velocity and large-projectile wounds, as well as blast injuries, will often require the use of tourniquets.

Tourniquets

Tourniquet Use and Dangers

Placing a tourniquet can be lifesaving; it also can cost the patient their limb. In civilian settings, tourniquets should only be used to control a hemorrhaging extremity if direct pressure is not adequate or possible (e.g., multiple injuries, inaccessible wounds, multiple

TABLE 21-8 Indications for Tourniquet Application

Cannot stop bleeding with direct pressure or injury does not allow direct pressure
Amputation
Bleeding from multiple locations
Protruding foreign body (not seen in their study)
Need for immediate airway/breathing management
Injury under fire in combat
Injury in total darkness
Mass casualty event

Data from Lakstein et al.[97]

victims). Tourniquets can be left in place for up to 2 hours "warm ischemic time,"[94,95] and longer if the limb is cool. However, if tourniquets are left on for ≥6 hours, the limb will probably need to be amputated.

Tourniquets may be overlooked when they are hidden under clothing, a jumble of bandages, or the other clutter surrounding a badly injured patient. Make it clear to any subsequent health-care provider that your patient has a tourniquet. Place a large "T" with a marker on the patient's forehead as well as the time that the tourniquet was placed.

Tourniquet Attributes

To be effective, a tourniquet must be designed so that it may be placed easily and quickly. The device must also be compact and light enough to be carried, simple to use, and rugged. Although upper-extremity wounds may not require tourniquets as often as lower-extremity wounds, it is vital that a tourniquet can be used on both upper and lower extremities. Single-arm operation, while optional, permits a person who has a wounded upper extremity to, if still alert, apply the device without assistance.[96]

Combat Use

An Israeli Defense Force (IDF) review of prehospital tourniquet use on soldiers in combat and on civilians after terrorist attacks found that there was no indication to use a tourniquet in about half the tourniquets placed by physicians, medics, or fellow soldiers (Table 21-8). They attributed this to "the stressful situation and the relatively little prior experience of most medical care providers" with tourniquet use.

They also found that 94% of tourniquets applied to the upper extremity were effective; only 71% applied to the lower limb were effective. The "Spanish Windlass," also known as the "Improvised" or "Russian" tourniquet, was the most effective type of tourniquet to use on a lower extremity. There was a relatively low incidence of complications (5.5%), primarily neurological. No deaths resulted from uncontrolled limb hemorrhage, although in Vietnam, it caused about 10% of all deaths and 60% of preventable deaths.[97]

The standard procedure for tourniquet use in the IDF is to (a) place it as distally as possible, but at least 5 cm proximal to (above the) injury; (b) place it above as few joints as possible; (c) place it on exposed skin to avoid slipping; (d) place a second tourniquet above the first if the first one fails to work—leaving the first, ineffective, tourniquet in place; and (e) convert it to a pressure dressing as soon as possible.[97]

"Russian" Tourniquet

A "Russian" tourniquet is the typical first-aid model, with a nonelastic cloth tied around the limb. It has been used on battlefields since at least 1674, and is often the only one available for use when needed. A short stick is placed over the knot and tied into the bandage (Fig. 21-15). It is then twisted to wind the cloth until tight, and then tied in place.

Tests show that this tourniquet, when placed correctly, eliminates the palpable pulse in an extremity 70% of the time and Doppler pulses in 30% of cases. It takes about 32 seconds to apply. In simulated winter conditions, it eliminates 80% of palpable and 50% of Doppler pulses,

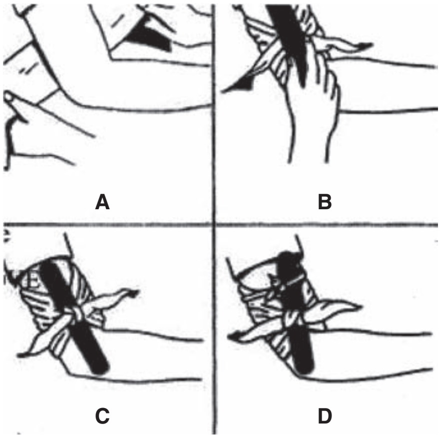

FIG. 21-15. "Russian" tourniquet application. (*Source: US Navy.*[98])

but takes nearly 39 seconds to apply. While it causes the most pain in simulated patients, this is probably not a huge issue when a tourniquet is needed.[99]

Other Good Tourniquets

The only tourniquet that always (100% success) stops bleeding from the upper and lower extremities is the manual blood pressure cuff used for Bier blocks.[96] As with Bier blocks, a standard manual blood pressure cuff will work successfully if adhesive tape or another secure tie is placed around the cuff after it is inflated so that it won't "pop" off. A clamp is often needed on the tubing to the inflation device and manometer so that they don't leak.

In one test, 0.5-inch-diameter latex tubing, readily available in most health care facilities, was found to be the lightest, least-expensive, fastest to apply, and easiest-to-learn tourniquet. First used in the 1870s, it was very popular in World War II. Under ideal conditions, application of this tourniquet eliminated the palpable pulse 100% of the time and the Doppler pulse in 90% of cases. It took less than 24 seconds to apply. The results were similar in simulated winter conditions. Medics prefer using this tourniquet rather than many others that are available. While it is relatively difficult to secure, a heavy clamp does the trick.[99]

Improvised Tourniquets

While a multitude of devices are often recommended for use as tourniquets, most do not work or work well. Belts, wires, and similar materials were shown to rarely function as tourniquets and some caused major problems. If nothing else is available, women's stockings reportedly do make adequate tourniquets.[97]

Civilian Use of Tourniquets

While the tourniquet has been shown to be very useful in military situations, it is rarely used in the civilian world. When it is, it is generally used for penetrating trauma from firearms and stabbings (although these low-velocity injuries rarely require tourniquets), blast injuries (terrorist or accidental/industrial), remote/wilderness environments, and industrial accidents. Other suggested nonmilitary indications for tourniquet use, adapted from Lee and colleagues, include[100]:

1. Extreme life-threatening limb hemorrhage or limb amputation/mangled limb with multiple bleeding points. The tourniquet can be used until the airway and any other immediate, life-threatening problems are treated. Its use can then be reassessed.
2. Multiple casualties and a lack of resources to adequately staunch hemorrhage in all patients.
3. The point of significant hemorrhage is not accessible for compression or clamping.
4. Any other reason that life-threatening limb hemorrhage cannot be controlled.

The following algorithm (Table 21-9) should be used for assessing the need for tourniquets in civilian injuries.

TABLE 21-9 Algorithm for Civilian Tourniquet Use

Apply direct pressure over a dressing ± limb elevation
⇩
Pack wound
⇩
Apply direct pressure using the windlass technique*
⇩
Apply indirect pressure
⇩
Apply a tourniquet
⇩
Use topical hemostatic agent (at any time)

*The windlass technique involves increasing the pressure directly on the wound. A dressing directly on the wound is cinched down using a circumferential bandage that has a knot directly over the wound. The entire bandage is cinched tight using a dowel, pen, eating utensil, or similar device and secured in place. Unlike a tourniquet, it is not above, but rather on top of the wound. Also, it is not meant to stop distal flow, only to staunch the flow from the wound.

Data from Lee et al.[100]

HYPERTHERMIA, HYPOTHERMIA, AND FROSTBITE

Hyperthermia

The treatment for acute, severe hyperthermia, such as might be found in heat stroke, can be done with minimal equipment. First remove the heat source and quickly cool the patient. Only treating airway and breathing problems should delay cooling. If the patient has cardiovascular collapse, begin cooling first and then try to treat that problem.

To cool the patient, remove most or all of his clothing and cover him with a thin sheet of cloth. Soak the cloth thoroughly with any available liquid and generate as much breeze over the cloth as possible. Use a fan, if available, or do it by hand. The idea is to evaporate the water in the cloth, since it cools as the water evaporates. This rapidly cools the patient.

Hypothermia

Hypothermia is a significant problem for infants and small children, the elderly, those with prolonged cold exposure, and major trauma and burn patients.[101] "Hypothermia secondary to hemorrhagic shock is as bad a problem now (2004 Iraq war) as it was in 1918."[70] Hypothermia can also be iatrogenic, being seen in patients with open abdomens or chests in cold operating rooms or, more commonly, in those who receive large volumes of cool crystalloid or cold blood. (See Chapter 17, Transfusion, for how to easily avoid this last problem.)

The easiest way to treat hypothermia is to prevent it. Use insulation to protect patients when they are being transported or otherwise are at risk of hypothermia. Good insulation includes paper, such as newspaper or paper bags. Even better is corrugated cardboard, such as from boxes, since it has an air layer sandwiched between the paper sheets.

The first step in treating these patients is to remove any wet clothing and dry the patient. Use layered material to insulate the patient from the cold, including sleeping bags, plastic sheets, blankets, bubble-wrap, and foam pads. The next steps consist of passive or active rewarming. Both can be done in most resource-poor environments.

Passive external rewarming is useful if core temperature is >90°F (32°C). Remove any wet clothing, cover the patient in insulating material, and, if possible, warm the room to >72°F (22°C).[102] Some of the "field expedient" [US Army's term] rewarming techniques include placing patients in cardboard boxes and administering warm fluids. The fluids are often warmed by "placing a lightbulb in a cardboard box to warm IV fluids up to 40°C, the innovative use of the meals-ready-to-eat (MRE) warming units for warming a liter of Ringer's lactate to 44°C, a handheld hair dryer and cardboard box unit that can be placed over casualties in a bed, which allows efficient warming when bed huggers are not available, and finally, a radiator that was pulled off the wall and stuck under a sheet next to the casualty."[70]

Another (some would say expedient, but morbid) method for passive rewarming is to put hypothermic patients into body bags, leaving their face and arms free (cut holes for their arms). The arm openings are used for IV lines and monitoring cables, if available. Use tape to seal the openings around the extremities to prevent the egress of warmed air.

Active external rewarming should be limited to putting the person in a sleeping bag or other insulated container along with a warm person, and applying insulated hot water bags or bottles to their axillae and groin. Insulate the hot water bags with mittens or cloth. Additional active external rewarming drops the patient's core temperature ("afterdrop" or "rewarming shock") as it transfers blood from the core to the suddenly dilated periphery.

Active core rewarming is indicated for moderate to severe hypothermia with core temperatures <90°F (32°C). These techniques are additive, so they should be used simultaneously whenever possible. Depending on your situation, all can be done in austere environments.

Deliver warm, up to 45°C (113°F), humidified oxygen. It must be humidified to warm sufficiently. This technique works better when using an ET tube rather than using a mask, but the difference is not enough to warrant intubating the patient.

Infuse crystalloid warmed to 40°C to 42°C (104°F to 108°F). Insert a peritoneal lavage catheter (see above) and infuse isotonic dialysate (1.5% dextrose with potassium) at 40°C to 45°C (104°F to 113°F). Alternatively, use normal saline or lactated Ringer's as the dialysate. Infuse 10 to 20 mL/kg; retain it for 20 to 30 minutes and then aspirate it.[103]

Irrigate through a nasogastric or rectal tube, using crystalloid no warmer than 45°C (113°F). Infuse ≤300-mL aliquots in an adult; aspirate and replace that volume every 15 minutes. Don't bother irrigating a urethral catheter; there isn't enough surface area to make much difference.[103] Warmed fluid can also be lavaged through large-bore thoracostomy tubes, with one placed anteriorly (second or third interspace, mid-clavicular line) and the other posteriorly on the same side (fifth or sixth interspace posterior axillary line). Run 40°C to 42°C (104°F to 107.6°F) crystalloid into the anterior tube and drain it out the posterior tube. If only one tube is used, use 200- to 300-mL aliquots.[103]

Frostbite

As with hypothermia, it is far better to prevent than to treat frostbite. If frostbite or any of its precursors (such as "frostnip") occur, rewarm the area by immersion in or soaking with water between 37°C and 40°C (98.6°F and 104°F) for 20 to 30 minutes. Do not place chemical warmers directly on the affected skin, since they can easily burn tissues.[104] Since the nose and ears are often involved, soaking or carefully using chemical warmers over a thin cloth, rather than immersion, may be required. Once thawed, prevent the area from being refrozen, since that will worsen the injury. Using anti-inflammatory medications, such as ibuprofen 12 mg/kg/d and topical aloe vera, may decrease tissue loss.[105]

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22 | Wounds and Burns

WOUND CARE

Essentials

The World Health Organization (WHO) lists what it considers to be the essentials for wound care worldwide (Table 22-1), varying with four levels of hospital capabilities (described in Chapter 5, Basic Equipment).

Bleeding Control

Wound Tourniquets

The best wound inspections (for deep structure injury and foreign bodies) and wound closures occur when the area can be visualized. To visualize wounds, it helps to stop the bleeding; finger tourniquets are a good way to do this. However, "rubber band" tourniquets are generally not a good idea since it is easy to inadvertently leave them on after the procedure is complete. One alternative is to use a large venous tourniquet tightened around the base of the finger or toe with a large clamp (Fig. 22-1). No one will forget they have a hemostat attached to their hand.

Another method is to cut the finger off a surgical glove and put it on the finger to be sutured. Or better yet, put the entire glove on the patient's hand. It is safer if you leave the entire glove on the hand so no one forgets the tourniquet is there. Then cut a small hole at the top and roll the rubber down to the finger or toe's base and, voilà, a dry field in which to explore and suture the laceration or remove part of the toenail. The cut-off glove finger alone works well on a toe, especially the hallux if an ingrown nail needs to be removed (Fig. 22-2).

Pyramid Dressing

While large pressure dressings, tourniquets, and vessel ligation can all stop bleeding from a wound, an elegant and easily improvised pyramid dressing can often stop significant bleeding using fewer resources. Once a briskly bleeding area is identified—often from a relatively small wound—occlude it with finger pressure. Then replace the finger with a tightly folded "nugget" of gauze held tightly on the spot. If the positioning is correct, the bleeding should cease. Then place several layers of progressively larger, or less-folded, pieces of gauze over this (Fig. 22-3). This "focuses" the pressure on the bleeding point. Only a very light-pressure dressing needs to be placed over this pyramid of gauze, since it conforms to the equation: Pressure = Force/Area.[2]

TABLE 22-1 WHO Wound Treatment Essentials

	Facility Level			
Resources/Capabilities	Basic	GP	Specialist	Tertiary
Assess wounds for potential death and disability	E	E	E	E
Nonoperative management: clean and dress	E	E	E	E
Tetanus prophylaxis (toxoid, antiserum)	D	E	E	E
Minor surgical—cleaning and suturing	PR	E	E	E
Major surgical—debridement and repair	I	PR	E	E

Abbreviations: D, desirable resources; E, essential; GP, general practitioner hospital; I, irrelevant; PR, probably required.

From Mock et al.[1]

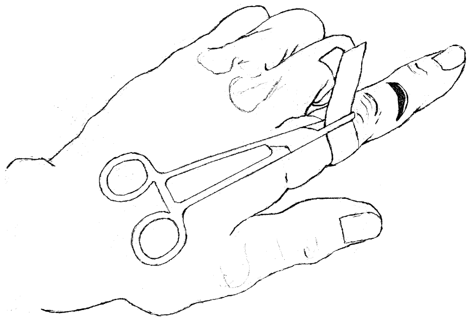

FIG. 22-1. Safe method of applying tourniquet to finger.

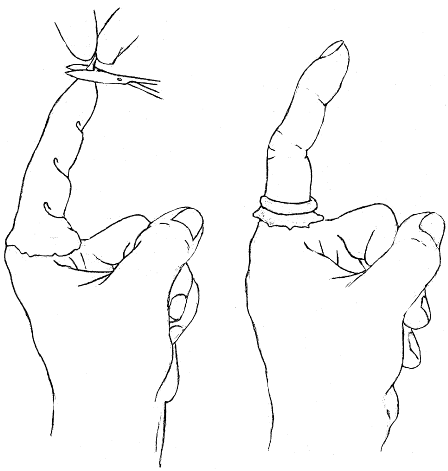

FIG. 22-2. A finger tourniquet made by rolling a glove's finger or finger cot down the digit.

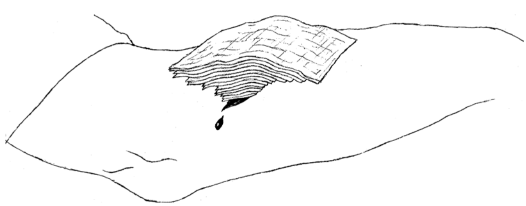

FIG. 22-3. Pyramid of gauze over bleeding point.

Alternative Wound Treatments

Honey

Honey has been used to treat wounds, scalds, and burns at least as far back as ancient Egypt. It is readily available, inexpensive, and easy to apply. Honey has antibacterial and anti-inflammatory activity, has a deodorant effect, aids debridement, and provides a moist healing environment. It also creates a non-adherent interface between the wound and the dressing.[3-7]

Dressing wounds, burns, and skin ulcers with unprocessed natural honey (under bandages) may work in place of antibiotics, or even may work in some cases that are resistant to antibiotics (such as with some cases of methicillin-resistant and vancomycin-resistant *Staphylococcus aureus*).[8] Theoretically, honey works by depriving microbes of water and by frequently releasing low levels of hydrogen peroxide into wounds. While natural honey may have batch-to-batch variability in its bacteriocidal activity, the main difference between natural and medical-grade honey is the cost. In austere situations, use whatever honey is available. It works.

If using honey on wounds or burns, first clean the site. Apply 15 to 30 mL pure, unprocessed, undiluted honey and bandage the area. One drawback is that honey attracts insects. Bandaging helps reduce this problem. Change the dressing daily.[9,10]

Sugar Paste

Pharmaceutical sugar paste, a similar treatment to honey for wounds and abscesses, was developed at Northwick Park Hospital (UK). Available in both thin and thick consistencies, sugar paste is said to be very effective on large abscesses. How well it works is unclear, but the basic ingredients are inexpensive and readily available. The originators specify that the sugars used are "pharmaceutical grade" and that the paste is to be made under sterile conditions. If the paste is used immediately, this is not necessary.[11]

Formulae for Thick and Thin Sugar Pastes[11]

Material	Thin Paste	Thick Paste
Fine granulated sugar	1200 g	1200 g
Powdered sugar	1800 g	1800 g
Polyethylene glycol 400	1416 mL	686 mL
Hydrogen peroxide 30%	23.1 mL	19 mL

Thin Sugar Paste

Thin sugar paste is used for small abscesses. Prepare it by mixing 23.1 mL 30% hydrogen peroxide (final concentration 15% volume to weight [v/w]) with 1416 mL polyethylene glycol 400. Mix 1200 g fine granulated sugar with 1800 g additive-free powdered sugar. Combine the two mixtures in a heavy blender until smooth. Store in sterile screw-capped bottles. The mixture is stable for 6 months at 4°C. Apply to the wound with a syringe and catheter.

Thick Sugar Paste

Thick paste is used for large open wounds. Prepare it by mixing 19 mL 30% hydrogen peroxide (final concentration 15% v/w) with 686 mL polyethylene glycol 400. Mix 1200 g fine granulated sugar with 1800 g additive-free powdered sugar. Combine the two mixtures in a heavy blender until smooth. Store the paste in sterile screw-capped bottles. If prepared sterilely, the mixture is stable for 6 months at 4°C. Apply by molding like clay into wounds.

Vacuum Wound Dressings

Poorly healing wounds pose a problem for clinicians and patients. A highly successful and inexpensive treatment employs a topical vacuum that can be fashioned from materials readily available in resource-limited settings.

After cleaning the wound and packing it with sugar, place a piece of gauze in the wound. Insert a sterile 14-Fr nasogastric (NG) tube into a sterile (autoclaved, if possible) sanitary napkin, and place this over the wound. Use cellophane paper tacked down with adhesive tape to seal the edges and make the wound airtight. (Clear plastic can also be used.) Apply intermittent (15 min/h) suction to the NG tube. In place of a suction machine, a glass IV with a vacuum can be a low-cost suction device.

Normally, these dressings should be changed daily or every 2 days if cellophane adhesive is used; it does not stay firmly attached to the skin longer than this and the vacuum is lost.[12]

Debridement

Basic Methods

Leaving dead tissue in wounds is a nidus for infections. Remove it. Use a scalpel. For those not used to debriding wounds, follow this principle: if it bleeds or blanches, it is living tissue; if it doesn't, debride it.

If there is a question about which tissue is nonviable, use a delayed primary closure (described under "Wound Closure" later in this chapter). This is especially important in vital areas where cosmesis or function may be compromised by too much debridement. In 3 to 5 days, the viable and nonviable tissues will be clearly demarcated.

Those uncomfortable doing sharp debridement can rely (at least partly) on wet-to-dry dressings. Put thin dressings moistened with normal (0.9%) saline (NS) on the wounds. When they dry and are removed, the necrotic tissue comes along. Change the dressing 3 to 4 times a day.[13]

Maggots for Wound Debridement

Maggot therapy is a relatively rapid and effective debridement method, particularly for large necrotic wounds. Also known as biosurgery, maggot debridement therapy (MDT), and larval therapy, it is useful for treating chronic ulcers, chronic osteomyelitis, and other pus-producing infections. In some cases, this therapy avoids amputations. It is quite easy to do this in an austere environment with basic equipment. The key is to use sterile maggots of the right variety. Identifying the correct fly species may present a problem.

The species used must eat only dead tissue. A number of species fit this criteria, although *Lucilia sericata* (sometimes called *Phaenicia sericata*), a green bottle blowfly, is the species that seems to work best. Getting the wrong species can be a problem, since some fly larvae eat living tissue. Many flies look alike to non-entomologists.[14] So, rather than collecting the wrong flies and then trying to raise sterile maggots, it may be easier to purchase some sterile (medical) maggots of the correct variety.

When a supply of maggots is available, give the patient a tetanus shot and inform the patient of the process so he doesn't "freak out." Most patients tolerate the procedure well—especially since it probably will cure a chronic problem.

Apply an adhesive (hydrocolloid, if available) dressing over the wound and surrounding tissue. Cut out the dressing immediately over the wound. Tape a piece of nylon mesh with a small central hole directly over the hole in the adhesive dressing. Put the maggots through that central hole and seal it completely with another dressing. Apply surgical pads to the dressing to absorb wound exudate.

Depending on the size and depth of the wound, 50 to 1000 maggots ($\leq$10 larvae/cm^2 wound area) that are 24 to 48 hours old should be placed on the skin and left for 1 to 2 days. This should be done 2 to 5 times weekly. At the end of each period, wash the maggots from the wound with a jet of sterile NS and, if necessary, remove them with forceps.[15]

Patients completing MDT can often be grafted or treated with normal wound dressings.

Wound Cleansing

When irrigating wounds, use soap and water, especially if disinfectants are scarce or nonexistent. Then use a disinfectant, if available. Even for open fractures, irrigating wounds with hand soap is at least as effective as irrigation with an antibiotic solution.[16]

Wound irrigation under pressure can be beneficial. Irrigate uncontaminated wounds with potable tap water or NS using a pressure of 8 to 13 psi (lb/inch^2). Filtered (if necessary), boiled,

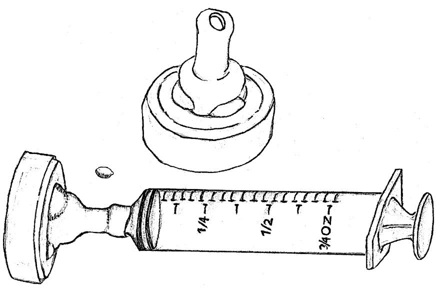

FIG. 22-4. Wound irrigator with splashguard.

then cooled water is an alternative if suitable tap water or NS is not available.[17] While higher irrigation pressures have a theoretical disadvantage, the bottom line is to use whatever means are available to thoroughly irrigate wounds, especially when subsequent treatment may be difficult or not available. The exact amount of irrigation fluid to use is unclear and depends on the size, depth, and cleanliness of the wound. A general rule is "the more, the better." It must be at least enough to remove any visible foreign material. Complex wounds may need to be irrigated with 9 L or more.[18]

An IV bag connected to a 19-gauge needle pressurized to 400 mm Hg with a blood pressure (BP) cuff (and kept at that pressure, even when the volume in the bag diminishes) generates from 6 to 10 psi. A 35- or a 65-mL syringe with a 19-gauge needle generates about 35 psi and 27.5 psi, respectively.[19] An improvised splash guard/irrigator can easily be made with the nipple end of a baby bottle and a syringe. Attach a catheter or needle to the syringe and you have a perfect manually operated system (Figs. 22-4 and 22-5). Other types of sealed bags under mechanical pressure should provide equivalent pressure, while commonly used and recommended irrigation methods produce inadequate pressure. These include a bulb syringe (0.05 psi), gravity flow from a fluid-filled bag, manual pressure on an IV bag (5 psi) or any plastic bag or bottle (2 psi) punctured with a needle.[19]

Although using water directly from a faucet has been suggested as "pressure irrigation," that depends on whether the water is potable (generally not in austere circumstances) and on the water pressure/flow rate (usually insufficient). If the water is suitable, increase the pressure generated onto the wound by decreasing the size of the outlet. Do this by tying the finger from a rubber glove with a small hole to the end of the spigot.

If no irrigation methods exist or they are impractical, copiously cleanse the wound with dressing material or a swab using potable tap water, sterile NS, or boiled and cooled water. This is an especially effective technique in wounds more than 3 hours old. Irrigation does not replace the debridement of devitalized tissue from a wound.

Cleaning extensive areas of road rash is a common and uniquely difficult problem. Analgesia is usually required to help patients tolerate a thorough cleaning, which is necessary to reduce scarring and lessen the chance of infection from foreign bodies. Dr. Larry Raney, Director of Emergency Services at the Medical University of South Carolina, devised an improvised pressure washer for large areas of road rash. The only problem is that it requires a jet insufflation device such as is occasionally used with a needle cricothyrotomy. So, if you have one, put it to

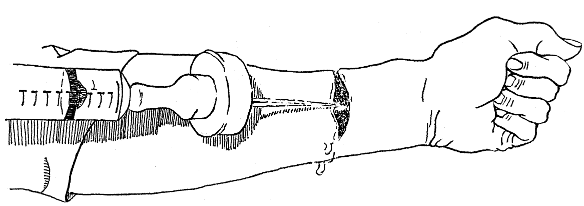

FIG. 22-5. Improvised wound irrigator in use.

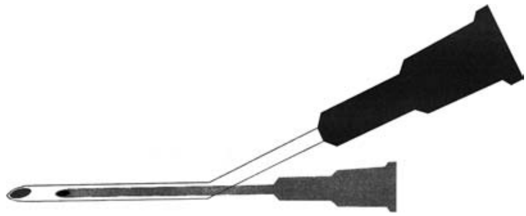

FIG. 22-6. Improvised road rash irrigator. (*Image contributed by Laurence.*[20])

good use. Take a 21-gauge needle and a 16-gauge IV catheter with the inner needle removed. Insert the 21-gauge needle into a 16-gauge IV cannula so that the needle is in the center of the catheter, with the tip fully inside and below the tip of the catheter. Attach the needle-jet insufflation device to the inner 21-gauge needle and IV tubing to the 16-gauge catheter (Fig. 22-6). Tape the needle, catheter, and tubing together (firm enough to hold the unit like a pencil). Placing one piece of tape at the juncture and one a few inches up is enough. Turn on the IV and jet-insufflator and begin irrigating. A large area takes about 1 hour to clean. (Written communication with author, received August 3, 2007.)

Foreign Bodies

Localizing foreign bodies, including bullets, in soft tissues in puncture wounds can be challenging. Two radiopaque markers used to localize embedded foreign bodies on radiographs include placing venipuncture needles at right angles to the puncture and putting an "O" used in radiology over the puncture. A simple but highly effective marker can be made from two paperclips with one wire of each opened to about 45 degrees. They are taped over and around the wound using clear adhesive tape. More can be used if the wound is extensive. Postero-anterior (P-A) and lateral radiographs help to localize the foreign body in relation to the paperclips. Once the site is determined, mark it with methylene blue or another skin marker before removing the paperclips.[21]

Even in open wounds, it may be difficult to visualize foreign bodies. Even if you can visualize the bottom of a wound, 7% of glass particles seen on x-ray will be missed. For deeper wounds, the missed glass rate is 21%.[22] If available, use high-resolution ultrasound, which can detect nonradiopaque foreign bodies ≥ 1 by 2 millimeters in size more than 95% of the time.[23]

Removing Metallic Foreign Bodies

Although the dramatic extraction of bullets or other metal fragments seems to be a part of every war movie, the reality is that most should be left in the body. The worldwide experience with these injuries is that it is usually far worse to operate to remove these fragments than to leave them in situ. Migrating bullets or fragments are rare occurrences and lead poisoning from retained bullet and shotgun fragments usually does not occur.

The International Red Cross recommends that a metallic foreign body should be removed intentionally only if it[24]:

- Causes a localized infection, such as an abscess or non-healing fistula.
- Disturbs function, such as when it is located within a joint or in a body area that is subjected to repeated pressure (e.g., sole of foot, palm back, sacrum, or subcutaneously over the elbow).
- Can easily be retrieved and is an obvious source of pain.
- Causes documented (blood levels >40 micrograms/dL [mcg/dL] in an adult or >10 mcg/dL in a child; positive EDTA challenge test; or bone marrow evaluation) lead poisoning. Even then, the lead level should be treated before removing the offending fragments.
- Has lodged in the spinal cord and there is clear evidence that it is causing cord compression. But this should be done only if an experienced surgeon is available.
- Is in the anterior chamber of the eye and both an experienced surgeon and the proper equipment are available.

Marking the Skin

It may be necessary to mark a patient's skin to determine the spread of cellulitis or the swelling after an envenomation, to denote the proper side of the body or limb for invasive procedures, to designate incision points for complex plastic surgical procedures, or to help localize a foreign body. Such marks can be applied with normal ballpoint or felt-tip pens, or by using methylene blue, gentian violet, or self-made dyes applied with a toothpick or the wooden end of a swab. One formula for skin-marking dye is to add 1.3 g basic fuchsin dye, 5.6 mL acetone, and 11 mL alcohol to 100 mL distilled water. (It can be further diluted by adding alcohol.) The benefit of this self-made dye is that it will remain visible on the skin after five scrubs with Betadine, as might occur preoperatively. It does not stand up that well to repeated scrubs with povidone iodine.[25]

If a dye is used, the cap from an 18-gauge or similar-sized needle works well as an inkwell for a toothpick "pen." Use a pipette to transfer dye into the needle cap. One benefit is that, even when the cap is lying on its side, the dye does not run out due to surface tension.[26]

Sterile Gloves

Studies have shown that the rate of infection of simple, uncomplicated lacerations is no different when using sterile gloves versus when using clean, nonsterile gloves. This is true in the following patients: those who are ≥1 year old with uncomplicated lacerations, those who are not immunologically compromised (diabetes mellitus, renal failure, asplenia, AIDS, immunosuppressive therapy, cirrhosis), those who do not form keloid scars, those who do not have an open fracture at the wound site, those without a tendon or nerve injury, those with no penetrating trauma, those with a late (>12 hours) presentation, or those with evidence of infection on presentation.[27,28]

If possible, clinicians should wear some type of glove to protect themselves against potential pathogens. Wearing caps and masks helps protect the clinicians, but does not reduce the incidence of wound infection, even during surgery.[29]

Sutures, Needles, and Glue

For a discussion of these, see "Surgical Equipment" in Chapter 21, Surgery/Trauma.

Wound Closure

Materials Cost

The cost of materials may vary greatly in resource-poor situations. Table 22-2 lists cost differences among the three most common types of wound closure, as well as their complication rates. Consider cost when choosing wound closure methods, especially when large numbers of patients need attention.

Delayed Closure

Not every wound needs to be closed; every wound that will be closed need not be closed immediately. Do not increase the risk of infection, especially in areas in which infections can become life- or limb-threatening, such as the palm or sole, by immediately closing a dirty wound.

TABLE 22-2 Cost for Wound Closure Materials and Frequency of Complications

	Sutures	Adhesives	Glues
Complication: Dehiscence	1.6%	2.0%	4.0%
Complication: Infection	1.9%	1.6%	0.7%
Cost of materials	$15	$3	$24
Labor (time)	8.6 min	3.7 min	4.0 min

Data from Zempsky et al.[30]

Delayed Primary Closure

This is an excellent method of treating any contaminated wound, including most war injuries. Delayed primary closure markedly reduces the infection rate for the same type of wounds that are closed immediately. This reduces both the morbidity of and the resources needed to treat infected wounds. After thorough cleaning and debridement, dress the wound using fine mesh gauze, or an equivalent dressing, to separate the wound edges and permit the wound to drain. Apply a bulky dressing.

Have the patient return in 3 to 4 days, or earlier if he has pain, drainage, or fever. At that time, the wound should be cleaned, debrided, and, if there is no infection, closed in the same manner as a primary wound closure. If the wound appears infected or if any necrotic tissue was excised, wait to do a secondary closure at 7 to 10 days. For particularly contaminated wounds, a more aggressive approach is to examine and clean the wound daily for 3 to 5 days. If there is no sign of infection at that point, the wound can be closed.[31-34]

One group of wounds that is often thought to need delayed primary closure is dog and cat bites to the hand. Yet whether they are treated with primary closure or closure is delayed, they have equivalent (6% to 8%) infection rates. Neither needs antibiotics unless they are on the hand; human bites do better with antibiotics, if they are available.[35,36]

Secondary Closure

At 7 to 10 days, if a wound appears clean and granulation tissue is present, it can be safely closed. Sharply debride wound edges that have an inadequate blood supply to heal directly. Use a tourniquet to control bleeding, and undermine the wound so it is not under tension. Gently scrape the granulation tissue off the wound surface. Remove the tourniquet and close the wound with simple sutures. If the edges cannot easily be opposed, a graft will be necessary.[37]

Healing by Secondary Intention

Healing by secondary intention means letting the wound heal on its own, without any type of formal closure. This simple method is particularly useful for treating both small lacerations and wounds with a high risk of infection due to the type or location of injury. It can also be used for patients who will be unavailable for delayed closure. This method still requires irrigation and, where necessary, debridement. This method results in scar formation followed by contracture that reduces the wound size. In some cases, it has the same cosmetic result as primary closure.[38] The disadvantage is that it takes longer to heal than when the wound is formally closed.

Suture Techniques

Improvised sutures and needles are discussed under “Surgical Equipment” in Chapter 21, Surgery/Trauma.

Conserving Sutures

To conserve as much suture material as possible, use instrument rather than hand ties.

Removing Subcuticular Sutures

To remove a subcuticular suture that has become hung up, insert the sterile hook of a small crochet needle or bent tip of a blunt hypodermic needle into the wound margin and pull out the suture where it is caught.[39]

Vertical Mattress Sutures

For vertical mattress sutures, use the easy near-near, far-far technique. Put your first suture in like a simple interrupted stitch. Lift the two suture ends, everting the wound edges (Fig. 22-7). Place your next stitch in the same plane as the first, but farther from the wound edges. Voilà! A perfect vertical mattress suture, if you don’t tie it too tightly.

Single-Layer Closures

Time can be saved, less suture material can be used and a reduced incidence of dehiscence achieved by closing abdominal incisions with a single layer of monofilament suture (nylon, Prolene, stainless-steel wire). This layer should include the fascia and all layers excluding the

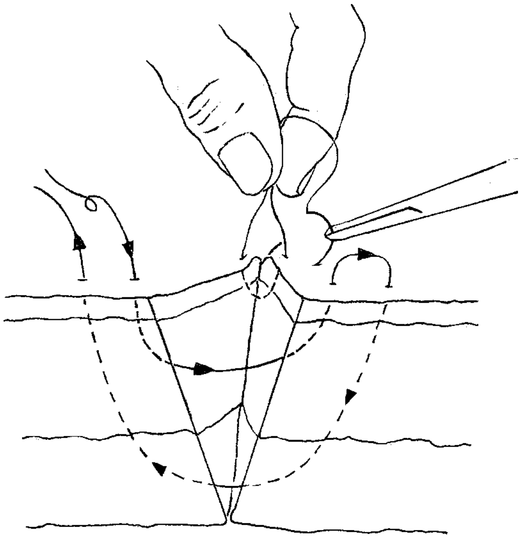

FIG. 22-7. "Near-near, far-far" method for placing a vertical mattress suture.

skin. Use a continuous non-locking one-layer suture with "big bites and slack suturing." For cosmetic reasons, close the skin as a separate layer.[40]

Friable Skin

Teflon pledgets (small pieces) have long been used in the operating room (OR) to prevent sutures from tearing through friable tissue. This can also be applied to outpatient wounds, especially in pretibial lacerations and flaps in elderly patients. If standard pledgets are not available, place sterile wound-closure tapes (e.g., Steri-Strips) parallel to both sides of the wound edges and sew through them.[41]

Operative Wound Drainage and Irrigation

For larger wounds, including those after fasciotomy and debridement, any piece of sterile rubber (e.g., bicycle tube), cloth/canvas, or synthetic rope can be used as a drain [42]

Constant wound or joint irrigation systems are usually improvised, although commercial systems exist. A simple method is to cut additional holes in the end of a sterile tube, such as a small multi-port urethral catheter. Insert it into the joint or wound as it is being closed. Attach one end to the irrigation solution and the other to the drainage bag. This system can be used to irrigate with NS or antibiotic solution.[43]

While drains are best avoided in simple wounds, a variety of innovative wound drains can be made, limited only by the imagination and the equipment on hand. For small wounds, cut off the IV and make multiple small holes on the side of the distal (patient) end of the tube for a butterfly IV or in an infant feeding tube. This is best done by folding the tube and using a scalpel. Insert the tube into the wound through a separate stab incision. Sew the wound tightly to obtain an airtight closure and connect the tube to the end of a 20- or 50-mL syringe (the size depends on the wound size and the expected drainage). To obtain suction, pull out the plunger of the syringe and tape the plunger of a 10-mL syringe (or smaller, if less suction is desired) to the large syringe. Interpose the smaller syringe between the flange on the barrel and the flange on the plunger. Although Fig. 22-8 shows the suction applied with the drains outside the wound, this is only so the device can be better seen. The catheters must be sewed into the wound before the suction is applied.[44]

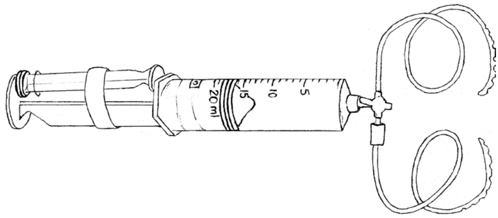

FIG. 22-8. Wound suction device.

Vacuum blood tubes make an excellent suction drain for small wounds. Remove the Luer lock connector for a butterfly (scalp vein) needle. Cut holes into the tubing to facilitate drainage and insert the sterile tubing into the wound. When the IV needle enters the tube, it begins suctioning. The tube needs to be changed hourly, which can be done by the patient.[45]

Vacuum suction can also be fashioned by attaching a large syringe to the Luer lock of a tubing inserted into a wound and pulling the plunger out to form a vacuum. The plunger is kept in that position by passing a K-wire or sterilized nail through the syringe's plastic plunger as close as possible to the syringe barrel.[46]

T-Tube Substitute

After exploring a common duct, a T-tube is usually left in place. When a standard T-tube is not available, one can be fashioned from a 16-gauge NG tube or other similar tubing. After the fenestrated section of tubing is removed, a short section (long enough to act as the portion within the bile duct) is cut off and then split lengthwise. A small hole is cut on the convex side of that piece and the end of the remaining long piece of tubing is pushed into the hole. It is sewed together using 2-0 atraumatic nylon or Prolene sutures. (Alternatively, cyanoacrylate might work well.) The resulting T-tube is a little stiffer than normal, although no problems were found when using it. Note that the "logical" improvised T-tube, made by simply splitting the end of the tube and spreading it into a "T" shape, may cause problems, because the ends tend to slide out of the common duct.[47]

Draining Hematomas

Drain hematomas without incision and drainage (I&D) using simple equipment. Large hematomas often cause discomfort by exerting excessive pressure on the overlying dermal and subdermal capillaries. Because of the clots that are usually present, they may be difficult to aspirate, so a modified liposuction method is used.

When I&D is not possible, try this method using only three instruments: a 50-mL syringe, a 10-mL syringe, and a 16-gauge needle IV. The needle is attached to the 50-mL syringe and is advanced into the hematoma at an oblique angle or "Z-track." The sharp angle is used to prevent subsequent leakage when the catheter is withdrawn. The syringe plunger is withdrawn so that the 10-mL syringe can be inserted on the outside of the syringe between the 50-mL syringe plunger and barrel. (This employs the same technique seen in Fig. 22-8.) This maintains suction without the need to use a vacuum suction device. The needle is moved back and forth in the hematoma to break up any clots, which can then be aspirated into the syringe. If the syringe fills, it is emptied and then reattached to the needle and the procedure is continued. A simple dressing is placed over the needle hole. This technique has been used successfully even with patients who are on therapeutic levels of warfarin. While it may not be possible to evacuate the entire hematoma, no significant reaccumulation occurs.[48]

Treating Abscesses

Incision and Drainage

When incising an abscess, avoid recurrence and reaccumulation by either making an "X" incision through the abscess roof or removing an oval piece of skin from the abscess roof. If using multiple small strips of cloth/gauze to pack an abscess or similar lesion (including packing in the nose), tie the ends together to make one long strip. This minimizes the chance that a piece of gauze will be left behind when the packing is removed.

After thorough debridement, consider closing the abscess cavity with sutures. Superficial abscesses requiring drainage were found to need many fewer resources if, after draining and irrigating, the abscess cavity was obliterated using interrupted vertical mattress skin sutures. Place a wound drain, if necessary. This treatment results in improved outcome, shorter-than-normal healing time, and less pain. If the patient is hospitalized, this treatment also results in a shorter length of hospitalization and less need for nursing assistance.[49]

Moist Occlusive Dressings for Cellulitis and Small Abscesses

Widely used before antibiotics became available, this method of locally warming infected skin continues to be used to augment or supplant antibiotic treatment. Nurses commonly use warm moist dressings after an IV has infiltrated. Applying warm moist dressings can also be used to identify veins for venipuncture. Its benefit relies on the leukotactic effect and vasodilatation produced by locally warming the skin. This method can be used, with slight modifications, on any skin area.

To use the technique, select a towel, washcloth, or similar material of a size that will cover the affected area. Soak it under the hot water tap or in a pan of hot (~49°C[120°F]) water. Do not use boiling water, as some macho patients are wont to do! Wring out the cloth and apply over the affected area of skin. Quickly cover the cloth and surrounding areas with a plastic bag, plastic sheeting (such as sandwich wrap), or other impermeable material. Leave it on for 20 minutes. Repeat every 2 to 3 hours while awake, until the area is healed.

Localizing Lesions for Excision

Once a local anesthetic has infiltrated the injection site, it can be difficult to localize small subcutaneous lumps for removal. Impaling the lesion exactly in its center with a 30-gauge needle prior to injection helps to localize the lesion and guide the incision, despite the fact that after anesthetizing the lesion, the lump often cannot be palpated. This technique causes the patient little discomfort and does not rupture even tiny cysts, which can be removed intact.[50]

BURNS

Developing countries have a major problem with burned patients. Most of the world's burn injuries, and 98% of the fire-related deaths, occur in developing countries. In part, this is due to exposure to open fires for cooking, heating, and other household tasks. Children in developing regions usually suffer burns from hot water and other liquids such as soup, from direct contact with flames, and from electrocution. Aside from the infections common after major burns, patients often suffer from anemia, malnutrition, persistent hypothermia, and tetanus.[51]

Among the vital clinical issues in treating burns are: (a) the burns distract patients from sensing other injuries that may be more serious, (b) the burn injury may not be obvious (e.g., electrical and respiratory burns), and (c) the burns may indicate child or spousal abuse.

Essentials

WHO lists (Table 22-3) what it considers to be the essential resources for burn care worldwide, varying with four levels of hospital capabilities (described in Chapter 5, Basic Equipment).

Estimating Burn Size

Burns involving <15% of body surface area (BSA) in adults and <10% BSA in children are considered "minor"; more extensive burns are "major." Major burns also include first-degree burns to the perineum and genitals, as well as inhalation burns. The BSA calculation normally considers only burns that are second-degree (partial thickness), third-degree (full thickness), and fourth-degree (full thickness plus underlying structures).

A common method for (generally, over-) estimating the percentage of BSA burned is to use the area of the patient's palm as 1% BSA. However, the actual area of the palm alone is only 0.6% BSA in adult males and 0.56% BSA in females. The area of the palm plus the palmar surface of the fingers (not including the thumb) averages 1.2% of the individual's BSA in males

TABLE 22-3 WHO Burn Treatment Essentials

Resources/Capabilities	Facility Level			
	Basic	GP	Specialist	Tertiary
Ability to assess depth and extent of wound	E	E	E	E
Sterile dressings*	D	E	E	E
Topical antibiotic dressings	D	E	E	E
Physiotherapy and splints to prevent contractures in burn wounds	I	E	E	E
Ability to debride wounds	I	PR	E	E
Ability to perform escharotomies	I	PR	E	E
Skin graft capability	I	PR	E	E
Reconstructive surgery	I	I	D	E
Early excision and grafting	I	I	D	D
Clean dressings*	E	I*	I*	I*

Abbreviations: D, desirable resources; E, essential; GP, General Practitioner hospital; I, irrelevant; PR, probably required.

*Sterile dressings supersede clean dressings.

Adapted with permission from Mock et al.[1]

and 1.15% BSA in females. For overweight individuals, the palm alone approximates 0.5% BSA and the palm plus fingers is 1% BSA.[52] For most individuals, the calculation should be made using the area of 2 palms (without fingers) = 1% BSA.

Tar/Bitumen Burns

Commonly seen, tar burns pose a particular problem because they may continue to burn for some time. Tar is difficult to remove from the skin. There are two treatment options—use the one that requires the fewest resources. In all cases, cool the tar immediately to reduce continued burning. To do this, an extremity can be immersed in ice water for a short period. After that, there is a choice: to remove the tar or not.

British burn surgeons report excellent results with leaving the tar in place if it is in a low-risk area of the body. The tar comes off as the skin desquamates. If located in a high-risk area, such as the eye, it can be removed with a nontoxic solvent, such as Neosporin. The British surgeons found that removing the tar did not change either the need for surgery or the time to heal.[53]

If you must remove the tar, first cool it so that it hardens (but don't make the patient hypothermic). Then wipe it off using mineral or baby oil, alcohol, ether, acetone, kerosene, or gasoline. Many of these may cause further damage to the skin. Neosporin ointment or cream is an antibiotic dissolved in a petroleum base, so this will generally remove tar over a 12-hour period. Polysorbate (Tween 80) or De-Solv-It also are frequently available and work well without reported side effects.[54] The question is, though, why bother?

Pain Control

Non-opioid and mild opioid analgesics often are all that is necessary when treating burns. If a stronger analgesic is needed, especially for extensive dressing changes on partial-thickness burns, sedation is useful. Ketamine works well in these instances.

Alternatives to pharmacologic analgesics are available. Clinicians and patients willing to try hypnosis (see Chapter 14, Anesthesia—Local and Regional) will find it useful. Another, easier method is to use music or videos as a distraction, especially during debridement. Equipment to do this is always available, since the most basic method is singing to or with the patient. Other modalities are to watch videos, listen to music, or play games based on either the video or music. These distractions lessen patients' anxiety and usually diminish the pain response.[55,56]

Basic Monitoring and Treatment

Urine Output

Evidence supports using hourly urine output to guide fluid therapy in burn resuscitation.[57]

Temperature

Hypothermia can be deadly in burn patients, especially if they were treated with saline wraps in a cool environment. Prevent thermal (cold) stress by keeping the environment as warm as possible, preferably from 80°F to 85°F (17°C to 29°C).[58]

ECG Leads

ECG leads can be placed using non-invasive methods, including with small hypodermic needles, as shown in Fig. 7-15.

Nasogastric Tubes

Decompressing the stomach early is vital in patients with major burns. The ileus they develop can lead to aspiration and respiratory distress, if not corrected.

Nasogastric tubes can be secured in patients with facial burns by passing a large suture through the thin area between the anterior nasal septum and the skin (columella). When doing this, leave both suture ends long enough to make a knot below the nose and then wrap it around the NG tube and tie it. Leave some distance between where you tie a secure knot and the nose to prevent pressure necrosis on the columella. Use the remainder of the suture to tightly tie the NG tube.

A less-invasive alternative is to use a 3-cm-long piece of rubber tubing with ≥1 cm internal diameter (ID). Cut an "X" through opposing sides of the tubing (Fig. 22-9) and a small hole at each end. Pass an NG tube through the "X." The friction should keep it in place; if not, use a suture to tie the NG tube to the small tubing. Fix the rubber tubing to the patient with a tie or thin tubing passed through the two holes at its ends. A second X-shaped hole can be made in the rubber tube to accommodate a second NG tube, an oxygen tube, or a nasal monitor (i.e., CO_2).[59]

Infection

"Experience in 'need-based' countries has shown that patients treated in a large, airy ward with good cross ventilation are less likely to get infected than those treated in a small air-conditioned room. However, fly-proofing the ward with nets on the doors and windows and ensuring that the distance between two beds is at least 5 feet are simple, but important, requisites which should not be ignored."[60]

Burn patients often develop a rim of erythematous tissue at their wound margins. If it extends beyond this and the patient shows signs of infection, treat for beta-hemolytic streptococcal cellulitis.

FIG. 22-9. Method of securing nasogastric tube in burn patient.

Nutrition

As soon as any ileus resolves, provide high-caloric nutrition orally or via an NG tube. See Chapter 33, Malnutrition, for feeding information.

Burn Depth

If the patient is conscious, even if nonverbal (e.g., a small child), their reaction to a pinprick can often differentiate between second-degree and third-degree burns. Using a sterile hypodermic needle, first touch a non-burned area. The adult patient should feel the touch as being sharp; a child should give an appropriate response for their age. A similar reaction results if the burn is second-degree (partial). In full-thickness (third-degree or fourth-degree) burns, the nerves are dead and there should be no reaction to the pinprick.

All burns, or all parts of burns, are not always easy to categorize. A good rule is that any burn that remains unhealed after 3 weeks should be considered a full-thickness burn and should be treated by excision of the eschar (if still present) and skin grafting.[60]

Fluid Therapy

The American Burn Association's Practice Guidelines for Burn Resuscitation say that, based on the quality of available evidence,[57]

- Adults and children with burns >20% BSA should undergo formal fluid resuscitation using estimates based on body size and surface area burned.
- Common formulas used to initiate resuscitation estimate a crystalloid need of 2 to 4 mL/kg body weight/%BSA during the first 24 hours.
- Fluid resuscitation, regardless of solution type or estimated need, should be titrated to maintain a urine output of approximately 0.5 to 1.0 mL/kg/hr in adults and 1.0 to 1.5 mL/kg/hr in children.
- Maintenance fluids should be administered to children in addition to their calculated fluid requirements caused by injury.
- Increased volume requirements can be anticipated in patients with full-thickness injuries, inhalation injuries, and delays in resuscitation.

Options

The addition of colloid-containing fluid following burn injury, especially after the first 12 to 24 hours postburn, may decrease overall fluid requirements.

Consider oral resuscitation for awake, alert patients with moderately sized burns.

Deficit on Arrival

Fluid loss and the calculations for fluid replacement begin at the time of burn, not when the patient arrives for medical care. In Zimbabwe, for example, the average delay in getting to medical treatment is 6 hours; in many regions or circumstances, it will be much longer. After 6 hours, for example, the fluid deficit is already about 6/8 × 2 mL/kg/%BSA burned. With that level of delay, one recommendation is to initially administer 2 mL/kg/hr Ringer's lactate until the fluid deficit is corrected.[61]

The keys are (a) to administer the least amount of fluid necessary to maintain adequate organ perfusion and (b) to titrate the volume infused continually to avoid both under- and over-resuscitation.[62]

Fluid Replacement Formulas

STANDARD REGIMEN

All standard burn resuscitation formulas from burn centers in the United States use lactated Ringer's solution. Although lactated Ringer's is the most popular choice of crystalloid to use, there is no good evidence to support its use over normal (0.9%) saline (NS) or other similar isotonic crystalloid solutions.

The formulas all give one-third the calculated amount of fluid over the first 8 hours post-burn; the balance is given over hours 9 to 24.

PARKLAND (BAXTER-SHIRES) FORMULA[63]

- 4 mL × kg body weight × %BSA burned. Give ½ total calculated volume in the first 8 hours post-burn. Give the balance over hours 9 through 24.

Modified Brooke Formula

The Modified Brooke formula is "often quoted, [but] it is rarely correctly applied."[61] Use this only for replacement fluids.

- 2 mL × kg body weight × %BSA burned. Give half the total calculated volume in the first 8 hours post-burn. Give the balance over hours 9 through 24.

Children's Formulas

Children require more fluids than do adults with similar-sized burns, in part due to their higher BSA-to-weight ratio. They need maintenance fluid in addition to the resuscitation fluid. An estimate is that children require 6 mL/kg/%BSA burned in the first 24 hours.[64]

Shriners-Cincinnati (Older Children) Formula

- 4 mL/kg/%BSA burned + 1500 mL/m^2 BSA
- For younger children, they add 50 mEq $NaHCO_3$ to the solution for the first 8 hours and change to 5% albumin in lactated Ringer's for the third 8-hour period.

Galveston Formula

- 5 L/m^2 %BSA burned + 2 L/m^2 BSA

Special Cases

Patients with deeper burns, a delay in resuscitation, or inhalation injuries may need more fluid than is specified in these formulas.

Fluid Creep

In what has been termed "fluid creep," most seriously burned patients receive more rather than less fluid than is required, often more than 5 to 7 mL/kg/%BSA burned over the first 24 hours.[65,66] This results in serious complications. Decrease fluid administration when urine output exceeds the target goal.

Burn Patient Hydration—Oral

In burned patients with no contraindications, such as an abdominal injury or intestinal obstruction, give oral salt and sodium bicarbonate solutions, such as Moyer's solution (3 g NaCl plus 1.5 g $NaHCO_3$ in 1 L of water).[67] Alternatively, use WHO's oral replacement therapy formula (20 g glucose, 3.5 g sodium chloride, 3 g sodium citrate, and 1.5 g potassium chloride in 1 L of clean water). The traditional mixture of one fistful of sugar, three pinches of common salt, and half a lemon in 1 L of clean water may also be used, especially during what may be a long transport to the nearest hospital.[60] These solutions are adequate for adults with burns of up to 15% BSA and have been successfully used to treat burns of up to 30%.

Burn Dressings

General Principles

In resource-poor environments that lack both the materials and personnel to do intensive burn dressing changes, treating significant burns open ("exposure method") may be the best course; the saline method may be used on deep burns. Outpatient burns, especially those on the extremities, can be treated with occlusive dressings, while those on the hands and feet can be encased in plastic bags. Special dressings can be used when transferring patients to burn centers.

Rapid Transfer Dressings[68]

Standard plastic wrap (polyvinyl chloride) makes an excellent short-term burn dressing, especially for patients that must be transferred to burn centers. The benefits are that it is extremely inexpensive, is rapidly and easily applied and removed, does not adhere to the burns, does not cause hypothermia as saline dressings might, and allows clinicians at the burn center to more accurately estimate the size and depth of the burns, since there are no ointments or creams obscuring the burn wounds.

To use plastic wrap in this fashion, use standard rolled sheets and, taking care to touch only the edges, lay it over the burned areas and adjacent areas to provide adequate margins. The plastic adheres to itself and decreases the patient's pain by barring air flow to first- and second-degree burns and other open wounds. Sheets, blankets, and clothing may be laid over wrapped areas without discomfort.

On arrival, the plastic wrap is simply unwrapped or cut off. The wrap does not adhere to the burns, so the patient has no pain from this procedure. Because of concern about bacterial growth beneath the plastic, it has generally been used only for short-term dressings.

Treating Burned Hands or Feet

In resource-poor settings, treat significant burns of the hands or feet in a clear plastic bag. (Of course, it violates the rule to use plastic occlusive dressings only for short periods of time, but this has proven to be effective and safe.) The bag must be large enough for the patient to easily move his hand or foot; do not use a synthetic glove.

Wrap gauze around his wrist or ankle and secure it with tape. Cover the hand or foot, or fill the bag with an antiseptic, such as silver sulfadiazine, if available. Place the hand or foot in the bag and use another bandage to secure the bag to the wrist or ankle over the initial gauze dressing. This forms a watertight "sweat band" to prevent the generally large amount of murky burn exudates from dripping down the forearm or leg.

Encourage the patient to actively use his hand or foot immediately, but keep it elevated to reduce the inevitable swelling. Change the bag every 24 hours, washing the hand or foot thoroughly with soap and water, and replace the antiseptic, as necessary. Observe the vascular supply to the extremity to assess the need to do escharotomies, especially of the fingers or toes.[58,69]

Occlusive Dressings

Usually done poorly due to inadequate materials, personnel, or understanding, this method should not be used for inpatient burn treatment in resource-poor environments. As Dr. King wrote, "Done badly, this method is a disaster, and too easily converts a partial thickness burn into a full thickness one."[70] That is due to applying too little dressing over too small an area with infrequent dressing changes.

If applying occlusive dressings on outpatients, the burned area needs to be covered in silver sulfadiazine or an alternative or with petroleum jelly gauze, followed by a thick (≥2.5-cm) dressing to occlude the wound and absorb exudate. The bandaging should extend 10 cm beyond the burned area. For partial-thickness burns, the dressings can remain in place for 10 days if there are no signs of infection (exudate seeping through bandages, swelling, increasing pain, fever, regional lymphadenitis, or decreased perfusion distal to the burn). Little children can have plaster splints applied to keep them from removing the dressing. In full-thickness burns, the dressing should be changed at least every 4 days or if any of the signs or symptoms noted above occurs. If using 0.5% silver nitrate, change the dressing daily.[71]

Exposure (Open) Method

Best used for partial-thickness burns, this method requires little nursing involvement. Clean the burned areas after providing adequate sedation and analgesia. Do not break intact blisters. Place the patient on sterile sheets in a warm (40°C[104°F]) room with ≥40% humidity. Make a cradle over him to keep a top sterile sheet off the burns (Fig. 22-10). (Other methods to improvise bed cradles to support top sheets are shown in Chapter 5, Basic Equipment, Figs. 5-4 and 5-5.) Use topical antibiotics, if available.[72]

Saline Treatment Method

The saline method of burn treatment keeps the burned area constantly wet with half-strength NS until it heals. Boiled sea water may also be used.[73] This method is very useful for full-thickness burns.

In this method, use a relatively thin layer of gauze and keep it constantly moist, not wet, by periodically dripping NS onto it from a container. The gauze only needs to be changed once a day; this is best done in a bath or under a shower. As the burns are mainly full thickness, dressing changes are not too painful, but give analgesics (generally paracetamol/acetaminophen) as necessary.

Extremity wounds can also be treated this way, generally by dipping the extremity in the NS.

Saline treatment is reported to be an excellent—and the least expensive—method of treating burns; however, it is time consuming. It is best done in a tiled burn-treatment room that also has a bath or shower. Family or friends can assist in this treatment.

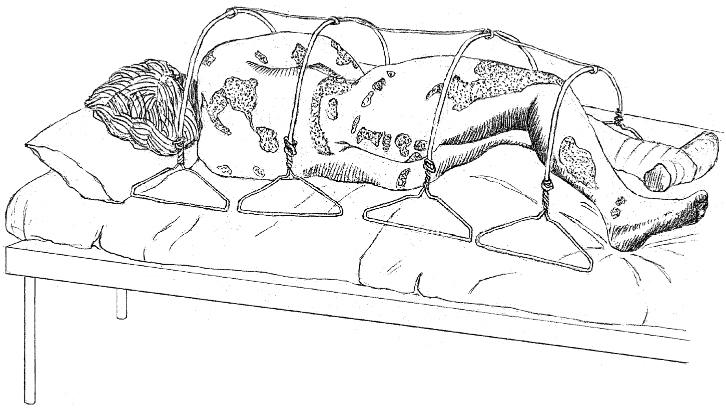

FIG. 22-10. Improvised cradle over a burn patient. Place a sheet over the cradle.

An obvious danger with this method, especially if treating a large surface area, is hypothermia. This occurs if the room is cool or if, even in a warm room, there is a draft. (Evaporation quickly cools the body.)

Some clinicians use Eusol rather than NS if there is any sign of pseudomonas (the typical smell and green blue staining of dressings). In those cases, also use 0.5% silver nitrate (or silver sulfadiazine).[74]

Debridement

Using either the saline or exposure methods, debridement can be accomplished by "simple bathing or showering once or twice a day with 'soap and water' … [which] not only reduces pressure on the nurses but is more humane, less painful and far less costly. It also allows the active involvement of a relative or friend who can help with the bathing and feeding of the patient."[60]

Escharotomy

The two indications for an escharotomy are difficulty breathing and a pulseless extremity. Breathing problems stem from circumferential burns around the neck or chest. Pulseless extremities can be assessed by the lack of an audible pulse (use a Doppler, if available) or of a palpable pulse if that is all that is available. If using a Doppler, listen for pulses in the palm, not at the wrist. The decision to perform an escharotomy is clinical and, if the life or extremity is to be saved, the procedure must be done immediately. Note that progressive edema can develop rapidly, especially in the face of fluid over-hydration.

The stiff eschar of a deep circumferential limb burn may cause a compartment syndrome when edema accumulates under it. Wide eschars on the chest, neck, and abdomen may restrict breathing. "Escharotomy may be done bed-side without anesthesia as the eschar itself is insensible. One or more longitudinal incisions are made through the eschar into bleeding subcutaneous tissue. The soft tissue pressure will widen the incisions and confirm that the escharotomy was necessary."[75]

To perform an escharotomy, no anesthesia is necessary as incisions are made through dead, insensate tissues. Using a scalpel, incise the burned area into the underlying subcutaneous fat. When you have gone through the eschar (correctly), the tissue "pops" apart. For a thoracic escharotomy, begin the incision high in the midclavicular line (Fig. 22-11). Continue the incision along the anterior axillary lines down to the level of the costal margin. Extend the incision across the epigastrium as needed. For an extremity escharotomy, make the incision through the eschar along the mid-medial or mid-lateral joint line.[76]

Skin Grafts

Many burns and escharotomy sites eventually require grafting. Small, full-thickness burns should be immediately excised and grafted.[58] Thin partial-thickness skin grafts are the best

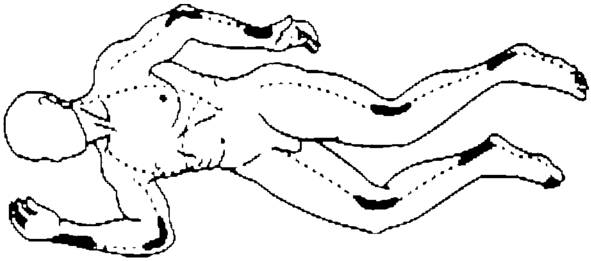

FIG. 22-11. Escharotomy sites. The dashed lines indicate the preferred sites for escharotomy incisions. The bold lines indicate the importance of extending the incision over involved major joints. (*Source: US Army.*[76])

dressing possible—they stimulate healing and help prevent wound infection. Improvise equipment to take partial thickness grafts when the normal equipment is not available.

Grafting Procedure

To take a graft, infuse the subcutaneous area (hypodermoclysis) with saline solution containing 1:1,000,000 dilution of epinephrine. This smoothes the site and reduces bleeding. This is essential when taking grafts from the scalp, and is helpful at other locations.

While obtaining the graft, get hemostasis by applying warm gauze soaked in a 1:100,000 epinephrine solution. Once the graft is taken, dress the site with fine mesh petroleum jelly gauze. Apply a heat lamp until the gauze is dry, and leave the site open.

Obtaining Partial-Thickness Grafts

Free-hand split-thickness skin grafts can be taken with an ordinary scalpel. Even better is to use a razor blade with a needle holder handle or a barber's razor. These can take grafts of any thickness.[42]

An easy way to perform this procedure is to first anesthetize the skin with a field block around the site. Hold uniform tension on the skin using two wooden blocks. Then make parallel incisions the length of the grafts and slightly wider apart than the scalpel blade's length. Initially, hold the blade at a 20-degree angle to the skin. After the first 0.5 cm of the graft is cut, hold the blade parallel to the skin and cut with a sawing motion.[77] Hold the free edge of the graft with a skin hook (Fig. 22-12).

Graft Preparation and Dressings

When a skin mesher is not available for skin grafting, hand meshing can work as well. A #15 surgical blade can be used to make a 1:15 expansion graft; a #20 blade works well to make a 1:3 expansion graft.[78]

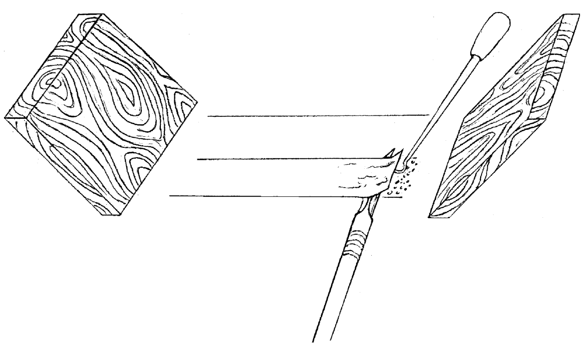

FIG. 22-12. Obtaining split-thickness grafts with scalpel.

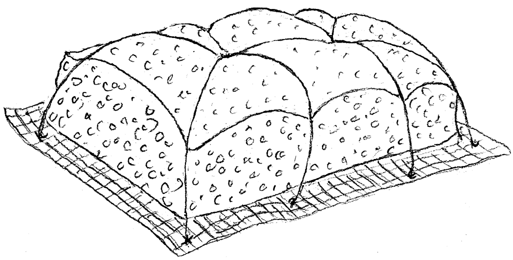

FIG. 22-13. Absorbent sponge dressing over graft or graft site.

Skin grafts and donor areas can be covered with a piece of sponge, which acts as an absorbent dressing. Put a layer of non-adherent petroleum jelly-impregnated gauze over the site and then suture the sponge onto the site using long sutures that cross over the sponge like it was a package (Fig. 22-13). The grafts themselves need not be sutured. Petroleum jelly dressings can be easily made; don't add antibiotic if they will be used on grafts.[79]

Graft sites on extremities should be immobilized for 4 to 5 days and not inspected earlier unless there are indications of infection.

Rehabilitation

Early physical therapy reduces the incidence of post-burn contractures and subsequent limited function.

Various devices have been fabricated using inexpensive and readily available materials such as wood, cane, coat hanger wire, foam, rubber bands, clothes' pins, and plaster. The devices include hand (static and dynamic), elbow, knee, and mouth splints, as well as axillary pads. Underwear elastic, spandex material, and animal-leather sheets are used to fabricate inserts and pressure garments such as gloves, sleeves, and face masks. Airplane splints (for arms/shoulders) are fabricated with plaster and wood. Appropriate positioning of the burn patient in the emergent and acute phase of recovery can be achieved with homemade cane "IV" poles, pieces of wood, and foam.[80]

Lethal Burns

When health care resources are scarce, a decision must be made about the treatment of extensive serious burns. With limited resources and experience, it may be rare to save the lives of patients with 50%, or even 30%, BSA deep burns, due to "pseudomonas infection, anemia, lack of extra nutrition and patient exhaustion."[74] A physician group wrote: "Under these circumstances, it seems reasonable to utilize the limited resources of a 'need based' country like India to concentrate on saving the lives of those with burns of less than 50% of body surface area."[60]

If a decision is made not to aggressively treat such patients, they still should receive the maximum comfort care possible.

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23 Dental: Diagnosis, Equipment, Blocks, and Treatment

"Love conquers everything except poverty and toothaches." Mae West, *Irish Times*

Unlike much of the rest of this book that assumes health care professionals already have the skills and knowledge to provide treatment, but not their normal equipment, this section describes dental diagnoses and basic treatments in considerably more detail. Treating dental emergencies is a critical skill, especially in situations of resource scarcity. Even though these emergencies are common, painful, and may occur with little or no warning, non-dentists rarely have in-depth knowledge about these problems.

BASIC DENTAL ANATOMY

Describing Teeth

When annotating the patient's medical record or communicating with another health care provider, such as a dentist, use a picture in the medical record. When communicating with another provider by phone or radio, describe the type and position of the tooth.

Teeth are either baby or adult teeth.

They are either maxillary or mandibular, and are on either the right or the left side of midline. Midline is defined as the space between the front two teeth (incisors).

There are four types of teeth (Fig. 23-1).

Those with *one* root:

- Incisors
- Canines
- Premolars

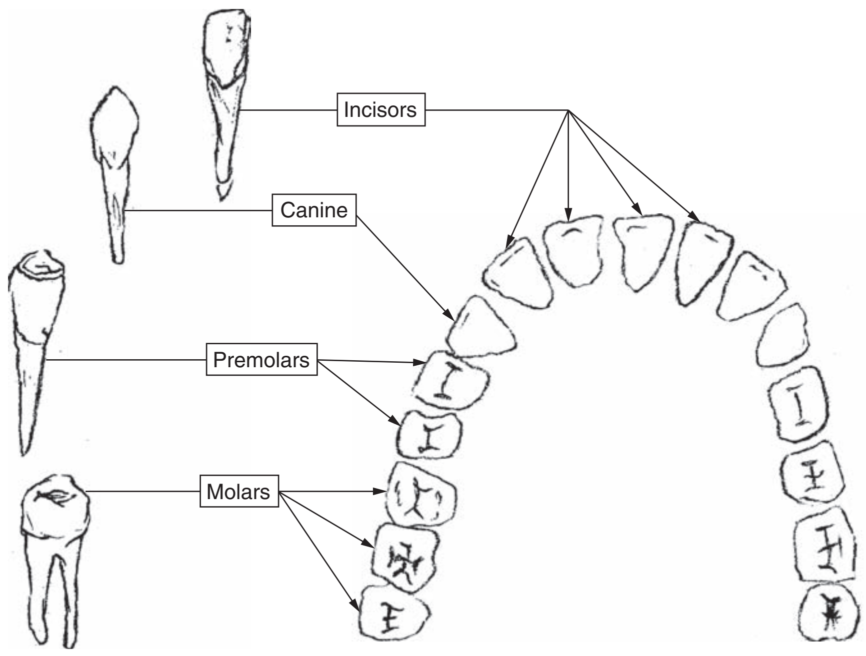

FIG. 23-1. Types of teeth.

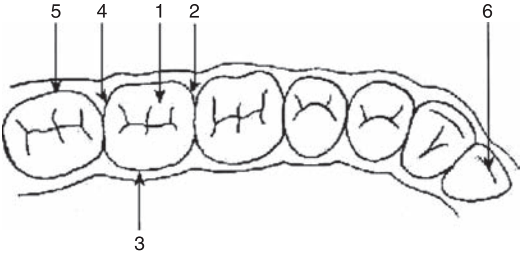

FIG. 23-2. Tooth surfaces. (*Redrawn from Frencken et al.*[1])

Those with *two* or more roots:

- Molars

Tooth Surfaces

The following names are used for the surfaces of the teeth. The number corresponds to those in Fig. 23-2.

1. *Occlusal surface*: the chewing surface of molars and premolars.
2. *Mesial surface*: the surface nearest the midline of the body (medial).
3. *Lingual surface*: the surface nearest to the tongue in the lower jaw; it is called the palatal surface in the upper jaw.
4. *Distal surface*: the surface furthest from the midline.
5. *Buccal surface*: the surface nearest to the lips and cheek.
6. *Incisal edge*: the incisors and canines have a cutting edge instead of an occlusal surface.
7. (Not shown) *Proximal surfaces*: surfaces that are close together, that is, the mesial surface of one tooth may touch the distal surface of the next tooth. The two surfaces are described as proximal surfaces.

A Tooth's Three Layers

Tooth problems may involve any of the tooth's three layers or their supporting structures (Fig. 23-3).

CROWN

The part of the tooth above the gum line is the crown. Covered with hard enamel, the crown protects the other layers. Do not confuse the term "crown" as part of the tooth with the dentist's "crown" (also known as a "cap"), which is a dentist-made covering for a tooth.

DENTIN

Softer than enamel but about the same density as bone, dentin is a yellowish substance that lies under the enamel and surrounds the tooth's pulp cavity.

PULP CAVITY

The "heart" of the tooth, the pulp cavity contains nerves and blood vessels. Generally, it extends from the gum line to the end of the root. The vessels and nerves then continue into the alveolar bone of the mandible or maxilla.

Tooth Attachments

Every tooth has tight attachments to the bone and gums. These are the periodontal ligaments. They must be severed below the gum line when removing a tooth.

PREVENTION/CLEANING

The primary culprit in dental pathology is plaque: the soft, white or yellow layer that sticks to the teeth. Consisting primarily of bacteria, plaque also contains dried saliva, blood cells, and

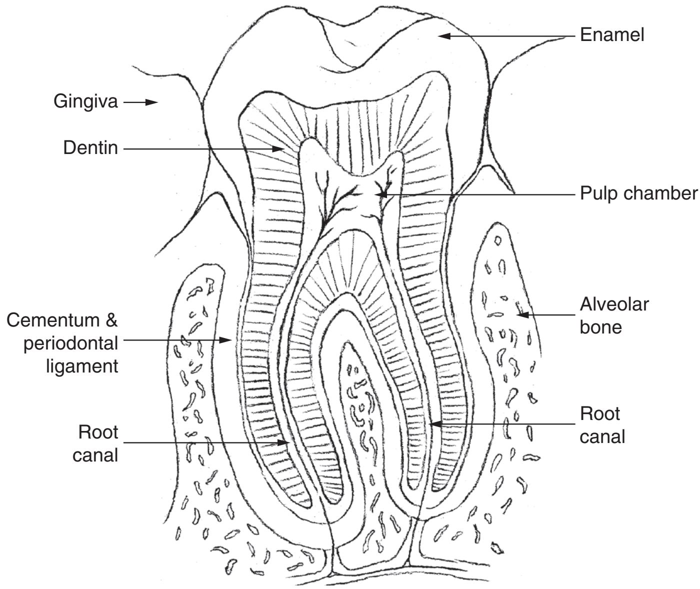

FIG. 23-3. Tooth anatomy.

food particles. It accumulates at the base of the teeth, in the grooves of the teeth's occlusal (chewing) surfaces, and in the spaces between the teeth. When still sticky, the simplest way to remove it from tooth surfaces is to wipe it off with a cloth. A common alternative method is to thoroughly chew a green twig from a non-poisonous plant until it becomes soft and fibrous. The end can be used to brush the teeth and gums. Eventually, this sticky, mineralized deposit (calculus) hardens and requires formal removal. At that point, it must be scraped off with a thin, bent metal tool. Dentists use a "scaler" or "dental pick." Alternatively, practitioners can use a small blunt needle to make a suitable instrument. First, cut off and sand the sharp end of the needle. Then, bend the end and attach it to a small syringe, which becomes a handle.

PAIN WITHOUT TRAUMA

Oral Lesions

Many types of lesions can cause pain and swelling in the mouth and face.[2,3] Table 23-1 provides a brief overview of the presentation, diagnosis, and treatment of various causes of mouth and jaw pain.

Mucosal Diseases and Facial Swelling

The most common painful oral lesions are aphthous ulcers (canker sores), traumatic ulcerations, and cold sores (*Herpes labialis*), and all can be treated with "tincture of time." They may heal faster, and pain may also be reduced, if they are covered. All three can be covered, at least for several hours, with any lip balm or salve, such as petroleum jelly. These usually relieve the pain—until they are licked off. As effective and possibly longer-lasting is cyanoacrylate (e.g., commercial Super Glue and multiple brands for medical wound closure).[4]

Multiple intra-oral lesions, including mucositis in immunocompromised (e.g., cancer, AIDS) patients, may be helped by "magic mouthwash." Patients use magic mouthwash by taking a mouthful every 2 to 3 hours, swishing it around in their mouth, and spitting it out. The solution can be made with any of dozens of formulations. The most common basic elements for magic mouthwash are diphenhydramine (e.g., Benadryl) elixir, viscous lidocaine 2%, and a liquid antacid, such as Maalox. Other common ingredients are tetracycline or erythromycin (that may be helpful with

Table 23-1 Diagnosis and Treatment of Mouth and Jaw Pain

Presentation	Diagnosis	Definition	Complications	Treatment
Pain, erythema, and swelling.	Cellulitis	Diffuse soft tissue bacterial infection	Regional spread	Antibiotics and root canal or extraction
Jaw hurts when touched. Teeth do not fit together properly or difficulty opening mouth. Recent trauma.	Mandible fracture	Mandible broken; may communicate using mouth (open fracture)	Malocclusion, infection, continued pain	Soft diet, wire jaw (stabilization)
Swelling under or behind jaw, worsens when hungry or smells food.	Salivary gland infection or obstruction	Usually stone in salivary duct; occasionally tumor	Infection, abscess, continued pain	Increase salivation: suck on tart candy, stone, etc. Antibiotics, if infected
Non-tender swelling in front of ear or on neck.	Branchial cleft cyst	Residual from embryological development	Infection (rare)	Surgery, if desired
Tender swelling in front of both ears with fever.	Mumps	Viral infection involving parotid glands	Orchitis in older males	Isolate from non-immunized individuals, provide support
Swelling present for a long time. It is firm and does not seem to get better.	Tumor	Cancer	Local tissue destruction and metastatic disease	Biopsy. Excision, radiation, or chemotherapy, as indicated
Gums between teeth have died and are no longer pointed. Foul odor from mouth due to pus and blood around teeth.	Necrotizing Ulcerative Gingivitis (Trench mouth, Vincent's angina or stomatitis)	Infection from mouth flora due to poor oral hygiene and life situation	Pain and decreased oral intake, continued gum deterioration and tooth loss	Clean/debride area. Gentle daily brushing; qh warm salt H_2O or bid 1.5% H_2O_2 or 0.12% chlorhexidine rinses. Improve diet. Antibiotics if thorough teeth cleaning not available
Sore or small abscess near root of bad tooth.	Gum bubble	Extension of periapical abscess through a fistula	Cellulitis	Incision/drainage and root canal or extraction
Pain and clicking sound from in front of ear when moving jaw, including when chewing.	Temporo-mandibular joint (TMJ) pain	Degeneration of the temporo-mandibular joint from trauma, arthritis, etc.	Continued pain, decreased oral intake, sleeplessness, depression	Analgesics, bite guard, local injections, soft diet. Surgery only as last resort

Data from Dickson[2] and Douglass and Douglass.[3]

bacterial infections in the mouth) or, especially for cancer and immunocompromised patients, a steroid such as dexamethasone or hydrocortisone, or nystatin. One common formula uses 4 parts nystatin suspension 100,000 units/mL, 3.5 parts diphenhydramine elixir, and 1 part lidocaine viscous 2%. If the solution is made with a substance such as Kaopectate or sucralfate (Carafate), the ingredients can adhere to surfaces, and so can be applied directly to the intra-oral lesions.

A very common oral lesion is candidiasis (thrush). If standard oral agents are not available, treat oral candidiasis by having the patient suck on a vaginal anti-yeast suppository or apply a vaginal anti-yeast cream to the lesion 4 times a day.

Gum Inflammation and Pain

Painful gums can result from poor oral hygiene, infections, inflammation over an erupting tooth, or dental appliances such as orthodontics.

To avoid or treat inflamed gums resulting from poor oral hygiene, patients gently brush their teeth and gums and by floss with dental floss or a substitute. They also can rinse their mouth with warm saltwater (0.5 tsp table salt in 4 oz of warm potable water) or a solution containing 1 part potable water and 1 part 3% hydrogen peroxide (H_2O_2) several times a day.[5]

More serious, and much more painful, is necrotizing ulcerative gingivitis, also known as trench mouth, Vincent's angina or stomatitis, or necrotizing ulcerative periodontitis. This serious but treatable disease of the gums and deeper tissues usually begins abruptly; the patient may be febrile. The gums are very painful and bleeding, with punched-out ulcers covered with a gray pseudo-membrane. Patients have extremely foul breath, pain on talking or swallowing, and may have lymphadenopathy. Treatment consists of gently debriding the area over several days. Wipe the gums with cotton or other absorbent cloth soaked in 3% H_2O_2. Use 1 part H_2O_2 to 5 parts water in children. Then scrape off the larger pieces of tartar. Have the patient gently brush their teeth and gums daily with a soft brush and rinse every waking hour with warm saltwater or twice a day with 1.5% H_2O_2 or 0.12% chlorhexidine. For the pain, use non-steroidal analgesics and, if available, local anesthetic on the gums—after drying them. Encourage patients to avoid spicy foods and to improve their diet. They may need to be on a liquid or soft diet for a while. They should drink lots of liquids, take supplemental vitamin C, and avoid smoking and chewing betel nuts or tobacco. If thorough cleaning and debridement is not available, give oral penicillin VK 500 mg, erythromycin 250 mg, or tetracycline 250 mg q6hr until 72 hours after the symptoms resolve.

Pericoronitis occurs when inflammation develops around a partially erupted (usually molar) tooth. A flap of gingival tissue remains over the tooth, which traps food particles and is irritated by chewing. Local swelling may cause enough irritation to make it difficult to fully open the jaw. To treat this, gently irrigate the area under the flap. Have the patient rinse his mouth with warm saltwater for 10 minutes every 2 hours while awake. If no dentist will be available within a few days, excise the flap over the tooth.

If orthodontic appliances are causing pain, use a blunt object, such as a tongue depressor or pencil eraser, to bend the wire away from the gum. If it cannot be bent, cover it with wax (candle or dental) or a tiny piece of cloth or cotton. Paradoxically, chewing (preferably sugarless) gum reduces the general pain caused by orthodontic appliances.

Toothache

Most of the cases for which non-dentists will need to provide emergency dental treatment will be for toothaches. While teeth can be transiently painful for a number of reasons, constant, often excruciating pain in a tooth constitutes a toothache. Generally, toothaches are caused by fractures or decay (caries; causes cavities) that extends into the tooth's central area (pulp). A tooth in which the pulp is no longer healthy often has a history of persistent, often severe and throbbing, pain after eating hot or cold food. Cold stimulus causes prolonged pain, but the tooth is generally not sensitive to palpation.

Diagnosis

To locate the painful tooth, have the patient point to it or gently tap on teeth in the affected area with an instrument until the patient experiences discomfort. When a tooth is tender to percussion, it is likely that there is a periapical abscess. The affected tooth can also be located by touching it with the corner of an ice cube. A normal tooth will briefly feel the cold stimulus; a diseased, but salvageable, tooth with some healthy pulp may have slightly more prolonged pain after withdrawal of the ice and is not usually sensitive to percussion. These can be treated as described in the subsequent paragraphs. Be sure to check adjacent teeth for their relative sensitivity to percussion and cold. An unsalvageable tooth generally has no sensation to percussion or a cold stimulus.

Table 23-2 provides a method of diagnosing about 90% of non-trauma-related toothaches. However, for the clinician faced with a patient's sore tooth, this table may not help in differentiating between an abscess and pulpitis. (Pulpitis is inflammation of the pulp, or center, of the tooth that contains vessels and nerves). To make this differentiation easier, remember the mnemonic *PAIN* to indicate that pain on **P**ercussion (the tap test on the tooth) = **A**bscess (periodontal or periapical) and pain with **I**ce (test the tooth by touching ice to it) = **N**erve pain (pulpitis).

Treatment

First try to treat a toothache conservatively. Have the patient rinse vigorously with warm water. Then clean out the tooth defect and insert an analgesic gauze or filling. (See "Filling Cavities" in Chapter 24, Dental: Fillings, Extractions, and Trauma.) The cleaning can be done using dental floss, a toothbrush, a toothpick, or a similar narrow and relatively blunt tool. If an abscess is present, treat accordingly.[6] (See "Dental Abscesses," below.)

Using small tweezers, a hemostat, or a similar instrument, put a very small piece of cotton or other cloth soaked in local anesthetic, such as oil of cloves (long-acting) or benzocaine, into the cavity or over the fracture site. A paste of oil of cloves and zinc oxide can also be used effectively, if available. When using oil of cloves rather than the less-potent commercial products containing eugenol, avoid using too much or letting it drip onto the gums or mouth tissues, since it causes mucosal burns. This provides immediate, but temporary, pain relief.

Cover this anesthetic dressing with a temporary soft putty-like filling material that can be molded to the cavity. Wax from a candle can be used: melt some wax, let it cool until it is pliable, and then place it over the affected area. An alternative is to use cyanoacrylate glue.

If this doesn't work, open the pulp chamber (center of tooth) to drain the tooth. As a last resort, extraction may be necessary (see "Extractions" in Chapter 24, Dental: Fillings, Extractions, and Trauma).

Dental Abscesses

Dental (periapical and periodontal) abscesses are adjacent to the affected teeth. The presence of abscesses can often be recognized by swelling of the cheek, the mouth, or the neck. The adjacent tooth will generally be very tender to gentle percussion. The patient with a periapical abscess may also have increased pain when recumbent, have a bad taste in his mouth, or say that the tooth feels "longer" than adjacent teeth. In addition, he may have a gumboil (an abscess under the gum at the end of a sinus tract extending from the periapical abscess). The abscess may also develop into facial cellulitis with significant swelling. Periodontal abscesses may be more localized than periapical abscesses and usually result from chronic gingival disease, rather than caries.

Treat these by having the patient rinse the abscessed area with warm saltwater for 10 minutes every 2 hours while awake. This may provide some immediate relief and can help the abscess drain spontaneously. Apply ice to the face. Nonsteroidal analgesics may decrease the pain; opioids may be required.

If no dental care will be readily available and the abscess is pointing, drain it using a scalpel, needle, or fishhook that has been thoroughly cleaned. Be sure to remove the barb before using a fishhook. Subsequent warm saltwater rinsing, although initially painful, will help the drained abscess resolve more quickly.

If the tooth is loose due to the abscess or, if not, as a last resort after more conservative treatment has failed, extract the tooth (see "Extractions" in Chapter 24, Dental: Fillings, Extractions, and Trauma). Since the tooth acts similar to any infected foreign body (such as a splinter), the infection is best treated by removing the tooth as soon as possible once it is determined that the tooth cannot be salvaged. (Daniel Kemmedson, DMD, personal written communication received June 5, 2008.) If extraction is not possible, treat the patient with antibiotics, if available, to cover mouth flora (usually penicillin); have the patient use warm moist soaks over the affected area and warm water rinses in the mouth.

Antibiotics

Since antibiotics may be scarce, it is worthwhile to consider whether they are necessary for dental lesions.[7] While antibiotics may not make a difference in most outcomes, "without good

TABLE 23-2 Differential Diagnosis of Toothache

Presentation	Diagnosis	Definition	Complications	Treatment
Pain after eating or drinking Caries: present Cold test: negative Tap test: negative Biting pain: negative	Caries (cavity)	Hole in tooth enamel	Pulpitis	Clean hole, filling (temporary)
Pain after eating or drinking Caries: present; previously filled Cold test: negative Tap test: negative Biting pain: negative	Lost or broken filling	Caries, previously filled, with lost or broken filling	Pulpitis	Clean hole, filling (temporary)
Pain on eating hot, cold, or sweet food Caries: present Cold test: +/– Tap test: negative Biting pain: negative	Reversible pulpitis	Inflammation of tooth pulp	Periapical abscess, cellulitis	Filling
Spontaneous, persistent, poorly localized pain Caries: present Cold test: persistent Tap test: negative Biting pain: negative	Irreversible pulpitis	Inflammation of tooth pulp	Periapical abscess, cellulitis	Root canal, extraction
Severe, constant, localized pain and swelling—even when trying to sleep; recent toothache; tooth may feel slightly loose Caries: present Cold test: negative Tap test: positive Biting pain: positive	Periapical dental abscess	Localized bacterial infection	Cellulitis	Incision/ drainage and root canal or extraction
Moderate to severe, constant, localized pain; recent toothache Caries: absent Cold test: negative Tap test: positive Biting pain: positive	Periodontal dental abscess	Localized bacterial infection	Cellulitis	Incision/ drainage and root canal or extraction
Difficulty in or pain on opening mouth; constant, localized pain and swelling over back tooth; recent toothache Caries: present or absent Cold test: negative Tap test: positive Biting pain: positive	Dental abscess around molar	Localized bacterial infection around back tooth	Cellulitis	Incision/ drainage and root canal or extraction

TABLE 23-2 Differential Diagnosis of Toothache (*Continued*)

Presentation	Diagnosis	Definition	Complications	Treatment
Steady pain, erythema, bad taste, and swelling, probably from a back molar; difficulty opening mouth; patient 16 to 24 years old	Pericoronitis	Inflamed gum over partially erupted tooth	Cellulitis	Irrigation, antibiotics if cellulitis also present
Pain when breathing cold air; recent trauma	Tooth fracture	Cracked or broken tooth	Pulpitis and sequelae	Filling, with or without root canal, extraction
Pain in tooth when scuba/hard-hat diving or in airplane	Barotrauma	Pain from pressure change in space under filling, abscess, or sinus	Disruption of filling; inability to continue dive or flight	Analgesics, drainage (medications for sinus; repair for fillings)

Cold test: touch the tooth with the corner of an ice cube. Tap test: tap the tooth gently with the oral mirror or a similar tool. Biting pain: pain when biting on a tongue depressor or similar object.

Data from Dickson,[2] Douglass and Douglass,[3] and Shiller.[6]

radiographic and pulpal evaluation or good follow-up, and [given] the potential of serious deep-space infection risk, antibiotics should probably be prescribed for at-risk patients."[8] So, prescribing antibiotics will depend on both the specific circumstances and the availability of the medication. If used, antibiotics for dental infections include penicillin VK 500 mg po qid, erythromycin 500 mg po qid, and clindamycin 300 mg po tid.

Lost Filling or Lost Crown (Cap)

If a dentist-formed crown, otherwise known as a "cap," is lost, gently clean out the hole where the filling resided. Do not try to replace the cap unless the patient is in so much pain that there is no other choice or if dental care will not be available in a timely manner. Save the cap for a dentist to use at a later time. The danger in replacing the cap is that it could come off again and the patient might aspirate it. In the meantime, the exposed pulp can be covered with softened candle wax, cyanoacrylate, or a commercial temporary tooth filling material.

If a cap must be replaced by a non-dentist, gently clean out any residual cement from the inside of the cap with a very small knife, paperclip, the filament from a lightbulb, or similar tool. Then place a thin layer of dental filling, denture adhesive, cyanoacrylate, or a thick mixture of flour and water inside the crown. Having the patient gently bite down on the replaced cap helps position it correctly. Remove any excess material. Advise the patient not to use that tooth when eating; the cap will most likely come off.

Cavities

If a tooth has a cavity but is not abscessed, try to put in a temporary filling. (A permanent filling requires the skill and equipment that only a dentist can provide.) This decreases the chance of further tooth decay, prevents an abscess from forming, decreases the patient's pain, and may ultimately save the tooth.[9]

Do not put a filling in an abscessed tooth! It will only make the pain and swelling worse. If the tooth has an abscess and you are in a situation with few resources and no dentist, pull the tooth. (Even if you break the tooth, it will allow the abscess to drain, improving the patient's condition.[9])

Chapter 24, Dental: Fillings, Extractions, and Trauma, provides detailed information on how to do fillings and extractions.

DENTAL INSTRUMENTS AND EQUIPMENT

If dental instruments (hand tools) are available, great! If not, they can often be fashioned from many different items. For example, Native healers fashion knives and dental extractors from beaten iron nails.[10]

Use small, thin, flat screwdrivers to loosen teeth by breaking the periodontal ligaments before extracting them. Don't use them to lever one tooth against another.

General Equipment

Before beginning any dental procedure, three things are necessary: the patient should be correctly positioned, there should be adequate light, and you should have a way to dry and isolate the tooth.

Chair

A key element of successful dental work is not to be bending over. Raise the patient's mouth to a level where you can work comfortably. The patient is most comfortable if his head, back, and neck are supported. One method of putting the patient in the proper position for dental work is to use a regular office-type chair, back it up to a desk or table, and place the patient's head on several pillows on that surface.[6] Modify a chair with two side posts (Fig. 23-4) by securely attaching two pieces of wood or metal and tying a cloth between them. Have the patient rest his head on the cloth. You can also use a low chair with a back. If the chair is too low for you to work comfortably, have the patient sit on books.

Headlamp/Light Source

A headlamp is standard equipment for all surgical procedures in austere situations.If you don't have a headlamp, use any available light source, including a lamp, laryngoscope, or fiber-optic light. To direct the light so that it illuminates the part of the patient's mouth you are working on, use a hand mirror or have someone hold the light source (or a mirror) in the best position. To work in the sunlight, position the patient toward the sun. (In some cases, you may want to cover his eyes.) If indoors, position the patient to face the window.

Secretion Barriers

To isolate a tooth from mouth secretions, position cotton rolls or 2×2 gauze squares inside the lip next to the tooth and between the tongue and the tooth. If working on a maxillary tooth, place the gauze or cloth roll over Stensen's duct (opening of the parotid salivary gland).

Dental Drill

Dental drills should only be used by trained dentists.

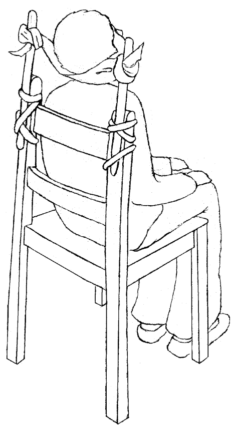

FIG. 23-4. Improvised dental/ENT chair.

Mirror

Use a mirror to reflect light onto the field of operation, to view the cavity indirectly, and to retract the cheek or tongue as necessary. A mouth mirror can be fashioned by taping the edges of a small piece of broken mirror (to protect the patient from the sharp edges) and gluing it onto the end of a short piece of a coat hanger or other relatively stiff metal wire.

Needed to Fill Cavities

Besides a headlamp and a mirror, a standard set of instruments to apply a temporary filling includes the following items:

Probe (Explorer)

Use a probe (Fig. 23-5) to identify where soft carious dentine is present. Take care not to penetrate very small caries (this may destroy the tooth's surface) or obvious deep cavities (this may damage the pulp). A probe can be fashioned from a small (23- or 25-gauge) needle that has the tip filed off and is bent on the end. Use a small syringe or wooden dowel (e.g., Q-tip, cotton swab) as a handle.

Cotton Pledgets/Absorptive Gauze

Use cotton pledgets or any small pieces of absorptive gauze to soak up any saliva and keep the work area dry.

Mixing Block and Tool (Cement Spatula)

If a polymer with two components, generally a liquid and a powder, is used, these have to be mixed. A piece of glass or a rigid plastic sheet will work as a mixing block. A piece of wood can be used as a spatula.

Tweezers (Pickups)

Use a tweezers to place materials in the mouth. This is more elegant than using your fingers, which are what you use if tweezers, hemostats, or similar devices are not available.

Dental Hatchet

This is used to widen the entrance to a cavity so there is better access for the excavator. It is also used to remove the thin, unsupported carious enamel that remains after carious dentine has been removed. A thin piece of rigid metal, such as a large-gauge (12- or 14-gauge) needle with its point filed off, should be used. It helps if it is bent at the end.

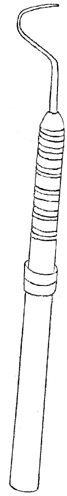

FIG. 23-5. Dental probe (explorer).

Spoon (Spoon Excavator)

Use a spoon excavator to remove soft carious dentine. A needle that fits into the carie can be used instead. The sharp tip can be filed down to make it easier to use.

Filling Tool (Filling Instrument)

If a dental filling tool to put the filling material into the cavity and smooth it over is not available, use a small thin piece of metal. If using cyanoacrylate, the top of the tube often works well.

Sterilizing Dental Equipment

While the mouth is not sterile, failing to sterilize dental equipment between patients can lead to transmission of serious diseases, such as hepatitis and HIV. Before sterilizing instruments, they should be cleaned of any visible grime. Chemically sterilizing dental equipment is inadequate. Likewise, standard boiling-water devices are not effective. In austere environments, use dry-heat ovens with an uninterrupted cycle, including a holding time of 60 minutes at 160°C (320°F).[11] Whenever possible, autoclaving should be used to sterilize dental instruments.

CYANOACRYLATE FOR DENTAL EMERGENCIES

Cyanoacrylate (e.g., Super Glue) as a surgical adhesive is discussed more thoroughly under "Wounds" in Chapter 22, Wounds and Burns.

To use any cyanoacrylate properly, all surfaces must be dry. Use gauze, tissue paper, or cloth to dry the affected tooth and to keep saliva away from it during the process. Use the top of the cyanoacrylate tube or a small piece of metal to keep pressure on the tooth for the few seconds it is drying. Try not to use your fingertip, since that will result in its being stuck in the patient's mouth for a while. After the glue sets, have the patient salivate and wet the entire area at once.

While gluing the gums may be part of the stabilization for some dental problems, if the application of glue to the gums is not necessary for the procedure, try to keep the glue off the gums. Glue near the gums can irritate them; excess glue also can form a rough edge that irritates the tongue. The latter can be corrected by carefully filing the edge or by covering the area with a small amount of additional glue.

Using the glue so that the bite is normal can be a problem when repairing dentures or teeth. People notice even the smallest change in their dental occlusion. Excess glue can be filed down. See the method for optimizing the patient's bite using carbon paper in Chapter 24 , Dental: Fillings, Extractions, and Trauma ("How to Fill a Tooth," step 6). Even if the fit is not perfect, whatever you can do will probably improve the situation. As a non-dentist, you are using these techniques only to buy time until the patient can see a dentist.

If cyanoacrylate is used, the patient should be warned not to put too much pressure on the tooth and to try not to bite with it. These dental repairs generally last days to weeks, but eventually the procedures must be redone. Of course, if the patient can see a dentist, that is optimal.

Cyanoacrylate adhesives can be used for many dental problems. These include protecting or repairing oral soft tissues, repairing dentures and teeth, and even protecting hypersensitive teeth.

Oral Soft Tissues

People have applied cyanoacrylate to aphthous lesions (canker sores) for many years to reduce the pain. One need only apply the glue to the lesion. It remains until the moisture of the lip and natural turnover of skin make it peel off. Of course, anything that covers the lesion (such as a lip balm) will lessen the discomfort. In 1999, the US Food and Drug Administration (FDA) approved a cyanoacrylate (Colgate Orabase Soothe-N-Seal Liquid Protectant) for over-the-counter use in the treatment of aphthous ulcers, mouth sores, and traumatic ulcerations. This formulation has much less tensile strength than do the standard medical formulations and will slough off in only 6 to 10 hours; so it may have to be replaced if continued coverage is needed.[12]

Cyanoacrylate is also useful for repairing abrasions and lacerations to the lip and oral mucosa.[13,14] Perhaps because of its occasionally unpleasant taste, some people have tried to develop flavored products. Cyanoacrylate has been used for wound closure in oral surgery; it compares favorably with sutures, showing normal healing of incisions and immediate hemostasis. It has also been useful in relieving the pain when dressing donor sites and mucosal ulcerations, while helping them to heal quickly.[14]

Orthodontic Appliances

Cyanoacrylate can also be used to re-bond loose orthodontic brackets, although care must be taken to be sure they remain in the correct location.[15]

Denture Repair

Cyanoacrylate can be used to temporarily glue a tooth or part of a tooth back into a denture (dental prosthesis). The glue may not be strong enough to repair a denture that breaks in half, depending on the denture material.[16] If the denture is made of acrylic, it can be repaired using cyanoacrylate adhesive. In the developing world, acrylic is still widely used for dental prostheses because of its relatively low cost.

When doing these repairs, the dentures must be properly aligned. If done incorrectly and the dentures no longer fit well, the adhesive can be very difficult to remove.[17]

Dental Trauma

As noted above, cyanoacrylate can be used to repair tooth fractures, to glue on pieces of fractured teeth, and to attach temporary dental splints.[18]

Filling Cavities

Cyanoacrylate has been shown to be very effective in filling holes for root canals. It also controls micro-leakage of oral fluid at the tooth–filling interface, and so is effective, at least temporarily, for filling a cavity.[19,20]

Gluing Avulsed Teeth

While gluing in avulsed teeth may help temporarily, and has been used to temporarily keep avulsed teeth in position, it is best to use cyanoacrylate as part of a splinting process as described above. One patient was found to have repeatedly used cyanoacrylate over a year to retain an avulsed second upper incisor.[21] Another man, who had four adjacent maxillary teeth fractured in a baseball game, glued them to each other and repeatedly glued the group back onto adjacent teeth over a period of a year until seen by a dentist (and, since he was lost to follow-up due to a lack of insurance, probably after that). His technique was to first carefully dry the crowns and roots that were broken, and glue them together with nonmedical cyanoacrylate while in the correct position in his mouth. The four teeth were also bonded together. (Having used a larger amount of glue than necessary, it adhered to his palate but separated "after a few hours.") He then removed the four-tooth piece and "shaped it with a file," reinserting it into position and gluing it to the adjacent teeth. He removed the four-tooth piece every 4 to 6 weeks, cleaned it, filed it as necessary to improve the fit, and re-glued it to adjacent teeth. While he initially used the liquid cyanoacrylate, he eventually switched to the gel, which worked better. The patient's lack of pain during the initial procedure was attributed to the pulp (and nerves) being dead.[22]

Hypersensitive Teeth

Cyanoacrylate has also been shown to be more effective than some standard methods for treating hypersensitive teeth. The hypersensitive area is dried and cyanoacrylate applied and allowed to dry. Patients then rinse their mouths thoroughly with lukewarm water. For approximately half of all patients, the treatment lasts for about 3 months; it can then be repeated.[23]

ANESTHESIA AND ANALGESIA

Analgesics

Oral analgesics effective for most dental problems include acetaminophen 650 to 1000 mg q6hr and nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen 400 to 800 mg q6hr. For severe pain, these drugs may be combined with opioids, such as 5 mg codeine.[24]

Local Anesthetics for Dental Blocks

Standard local anesthetics can be used for dental blocks, with or without epinephrine. Two easy methods are available to dose children with local anesthetics. The first is Clark's rule, which says that the maximum dose of any local anesthetic = (weight of child in lb/150) × max adult dose (mg). For example, the dose of lidocaine without epinephrine for a child weighing 50 lb would be: (50 lb/150) × (2.0 mg/lb × 50 lb) = 1/3 × 100 mg = 33 mg.

An even simpler method is to use 1.8 cc of 2% lidocaine/20 lb. The volume of a normal dental anesthetic "carpule" used in dental syringes is 1.8 cc.

Blocking Individual Teeth

Supraperiosteal Infiltration

Supraperiosteal infiltration can be used to block individual teeth. If topical benzocaine (20%) is available, first apply it to the injection site using a cotton swab. Then retract the lip and shake it to get access and provide some mechanical anesthesia (or useful distraction). Using a 25-, 27-, or 30-gauge needle (or the smallest gauge available), enter at the junction of the lip and the gum directly over and parallel to the long axis of the affected tooth. Advance the needle 3 to 4 mm and inject 0.5 cc of 2% lidocaine with 1:100,000 epinephrine or 0.5% bupivacaine (Marcaine) with 1:100,000 epinephrine (adults). Repeat the procedure, as needed. If a mandibular tooth is being blocked, more anesthetic will be needed because the mandibular bone is denser than the maxilla.[25] (The maximum dose of bupivacaine for intra-oral injection is 90 mg. The maximum intra-oral dose of lidocaine with epinephrine or articaine with epinephrine is 500 mg.)

Infraorbital Block

While an infraorbital block is actually a regional block for the upper (maxillary) incisors, the upper lip, and the side of the nose, the procedure is a simple extension of supraperiosteal infiltration. (See Fig. 25-9.) The needle inserted over the upper canine tooth need only advance about 2 cm, so that needle tip is over the most prominent part of the cheek (malar eminence). Experience shows that injecting 2 to 3 cc of 2% lidocaine with or without epinephrine works nearly 100% of the time and is very effective.

Regional Blocks

Inferior Alveolar Block

This blocks all mandibular teeth on the side injected and, if done correctly, can also block the side of the tongue.

PROCEDURE

The needle is directed through the mouth from the opposite side to the side to be blocked. The operator's thumb is placed in the coronoid notch of the mandible, and the index finger is on the mandible external to the mouth (Fig. 23-6). The coronoid notch can be located by passing the thumb over the lower molars until it contacts the mandibular ramus. The notch is the hole that the thumb tip naturally falls into when doing this.

A 25- or 27-gauge needle is directed toward the mucosa on the medial border of the mandibular ramus. Generally, this should be just next to (just medial to) the tip of the thumb in the coronoid notch. This should place the needle 6 to 10 mm above the mandibular molars. Insert the needle about 25 mm (1 inch) and, after a negative aspiration, inject ~0.5 to 1.5 cc of local anesthetic, such as bupivacaine. Continue to aspirate and inject ~0.5 to 1.0 cc on removal from injection site to anesthetize the lingual branch (side of the tongue).

Inject another 0.5 to 1.0 cc of anesthetic into mandibular coronoid notch (where the thumb was, just distal to the last molar) to perform a long buccal nerve block. This anesthetizes the buccal surface of the mandibular molars and adjacent gum.

Gow-Gates Technique: Alternative to Inferior Alveolar Block

The Gow-Gates mandibular block is another technique for mandibular anesthesia, especially when the standard inferior alveolar nerve block fails to supply adequate anesthetic effect. It anesthetizes the inferior alveolar, lingual nerve, and the long buccal nerve with one injection.[26]

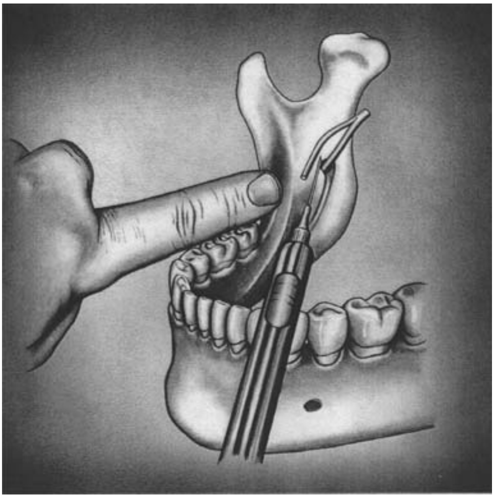

FIG. 23-6. Inferior alveolar block.

Perform the Gow-Gates block by inserting the needle higher than with a standard alveolar block. The technique will anesthetize the mandibular teeth to the midline, the buccal tissues and bone, the floor of the mouth and tongue to the midline, lingual tissues and bone, the body of the mandible, and the skin over the zygoma.

TECHNIQUE

Insert a 25- or 27-gauge needle distal to the last (second or third) molar on the medial surface of the mandibular ramus. Guide the needle on an imaginary line from the intertragic notch (ear) to the corner of the mouth (Fig. 23-7). Use a thumb in the coronoid notch and the index finger over the head of the condyle. (Find the head of the condyle at the temporomandibular joint by having the patient open and close his mouth to feel it move.) The needle is aiming for the head of the mandibular condyle. Keep the barrel of the needle approximately over the mandibular premolars on the same side and insert the needle using the landmarks of the tragus and second molar. Keep the needle parallel with the imaginary line from the corner of the mouth and the intertragic notch and advance the needle slowly until bone is contacted. This will be the head of the condyle. Insert the needle to the same depth as for the inferior alveolar nerve block—about 25 mm in an adult. If bone is not contacted, slightly withdraw the needle and reinsert it.

Once the needle contacts bone, withdraw it about 1 mm and aspirate. Positive aspiration for this injection occurs less often than with similar blocks (<2% of the time), but aspiration is still necessary. If positive, the needle is probably in the internal maxillary artery, inferior to the target. In that case, withdraw the needle, get new anesthetic solution, and redirect the needle superiorly to the previous injection site.

If the aspiration is negative, slowly deposit ~2 to 3 cc of local anesthetic. After the needle is withdrawn, have the patient keep his mouth open for a few minutes for the anesthetic to properly diffuse and until he reports signs of inferior alveolar anesthesia.[26] To help the patient keep his mouth open, have him bite down on the syringe you just used. Onset of anesthesia may take longer because the nerve is denser at this point and the area of deposition is somewhat farther from the nerve. The patient's tongue and lower lip should be numb. Check all areas for anesthesia before proceeding with treatment.[27]

Infraorbital Block

Infraorbital blocks are discussed in Chapter 25, Otolaryngology (ENT).

FIG. 23-7. Gow-Gates block.

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24 | Dental: Fillings, Extractions, and Trauma

Non-dental health care providers fear few things more than having to do dental procedures. The most common dental problems that non-dentists face in austere environments are filling cavities, extracting teeth, and managing oral trauma. The information in this chapter will help you manage these cases, even with limited or no formal dental equipment or training. (See also Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment, for basic information about filling teeth and how to improvise some of the equipment you will need.)

FILLING CAVITIES

Depending on the materials used, a temporary filling will last from only a few weeks to a few months. It should be replaced, as soon as practicable, with a permanent filling. In the meantime, the temporary filling helps the patient to feel more comfortable.[1]

Never put a filling in an abscessed tooth. You can fill the cavity (it probably doesn't have an abscess) if:

- There is no swelling of the face or gums near the bad tooth.
- The tooth hurts only occasionally—such as when eating or breathing cold air.
- The tooth is not tender to percussion.

Filling Materials and Equipment

To fill a cavity, you first need material to use for the filling. The basic filling material is usually zinc oxide powder and oil of cloves liquid (eugenol). These materials come in a wide variety of brands, but are usually readily available. Intermediate restorative material (IRM) may be available, and provides more durable fillings. Often much easier to obtain is cyanoacrylate, which works well as a temporary filling, although it may not last as long as traditional materials.

While dentists routinely use drills to help fill teeth, these will usually not be available in austere circumstances. In addition, a dental drill is not a tool that the inexperienced practitioner should use. Instead, use any available dental hand tools to fill cavities. Such hand tools can easily be used by non-dentists, can be improvised or purchased at a relatively low cost, and can be easily sterilized between uses. Hand tools are also less painful for the patient than a low-speed drill, such as a foot-pedal-powered drill that may be available in remote or austere settings.

Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment, lists dental equipment you will need to fill a tooth and suggests ways to improvise these items.

How to Fill a Tooth

If your patient has a cavity that needs filling, these are the steps to do it.

1. The initial task is to isolate the tooth so you can keep the cavity dry. A dry cavity allows you to see what you are doing and, more importantly, strengthens the bond with the cement you are using. To keep the tooth and cavity dry, put cotton or other absorbent cloth between the cheek and gums. When working on a lower (mandibular) tooth, put some under the tongue. Change the cloth whenever it becomes wet and wipe the cavity itself while you work. Leave a piece of cloth inside the cavity if you mix the filler (unnecessary if using cyanoacrylate). Using continuous suction in the mouth helps reduce the saliva; give the suction to the patient to hold in the hand opposite the side on which you are working.
2. Then remove some of the decay from the cavity. As you remove the pieces, put them on a piece of cloth or cotton gauze that sits on the patient's chest. Removing them as you go along prevents the patient from swallowing them. Scrape the walls and the edge of the cavity to remove all decay from the cavity's edge. This prevents later enlargement of the defect when germs and food lodge in the space between the cement and the cavity. If the edge is thin and weak, you can break it with the end of your instrument, which will result in stronger sides to hold the cement; non-dentists need not do that. Use the spoon tool (or a large-bore needle) to

lift out soft decay from inside the cavity, but don't try to remove decay at the cavity's bottom; it may be covering a nerve. There is no problem leaving some decay at the bottom of the cavity if you cover it with filling material so it stops growing. Enlarge the cavity just enough to give the cement a suitable bonding area. Use a mirror to carefully examine the cavity's edges for additional decay. Put some cotton (or cloth) inside the cavity and leave it there while you mix the cement.

3. If using cement that needs mixing (such as commercial dental filling material), mix the cement on a piece of smooth glass or plastic. To mix zinc oxide powder and eugenol, place some zinc oxide powder on the glass and, a distance away from it, a few drops of eugenol liquid. Use a mixing tool, such as a piece of a tongue depressor or a coffee stirrer, and add a small amount of the powder to the liquid, mixing them together. Continue adding small amounts of the powder until the cement mixture becomes thick. It helps to practice with the cement in advance to hone the mixing technique, determine the time it takes for the cement to harden, and see how best to manipulate it. Using this cement is much easier when it is thick and not too sticky. To test for "stickiness," roll some between your fingers; if it sticks to the fingers, it is not ready. Add more powder and then try it again.
4. Once the filler is prepared or you're ready to use the cyanoacrylate, remove any cotton or cloth from the cavity and make certain that the cavity is dry. Then press (or drip, in the case of cyanoacrylate) some filling material into the cavity. The method for dental filler is, while keeping the area dry with cotton or absorbent cloth around the tooth, to put a small ball of cement on the end of a filling tool (or a small, thin flat screwdriver) and spread it over the floor of the cavity. Be sure that it gets into the corners of the cavity. Add another ball of cement, pressing it against the cement already in the hole and against the sides of the cavity. The key is to pack the cavity completely and tightly to stop the growth of decay. Keep adding cement until the cavity is over-filled. Then, smooth the extra cement against the edge of the cavity. If a cavity goes down between two teeth, one other step is necessary. You need to take care that the cement does not squeeze and hurt the gum. Before you spread the cement, place something thin between the teeth. You can use the soft stem from a palm leaf, a toothpick, or a tooth from a comb, but be sure it has a rounded end to prevent damage to the gums.[2] If you are using cyanoacrylate, no filling tool is needed, but you must avoid leaving air bubbles in the cement.
5. Remove the extra cement before it gets too hard. Press the flat side of the filling tool against the cement and smooth it toward the edge of the cavity. As you smooth the cement, shape it to look like the top of a normal tooth. This way, the tooth above or below it can fit against the filling without breaking it. If you are using cyanoacrylate, work fast to smooth the filling, since it dries very quickly. Do not touch it with your finger or you may get stuck to the patient! After you take out the object you have placed between the teeth, smooth the cement. Remove any pieces of cement that stick out, are in the gum pocket, or are not smooth. These may injure the patient's gums and may break off, allowing food and bacteria to enter the cavity. Check carefully that no pieces of cement are in the gum pocket below the tooth.
6. After removing the cotton or cloth used to absorb saliva from around the tooth, ask the patient to gently bring his teeth together. (Too much pressure on the filling may break it.) The teeth should come together normally and not first hit against the filling. Always check to see if part of the filling is high: (a) If the cement is still wet, you can see the smooth place where the opposite tooth bit into it. Scrape the cement away from this place. (b) If the cement is dry, have the patient bite on a piece of carbon paper. (If you have no carbon paper, darken some paper with a pencil.) If there is too much cement, the carbon paper will darken the cement. Scrape away that extra cement. The patient must not leave your clinic until the filled tooth fits properly against the other teeth.[3]
7. Does the tooth hurt more than before? If the tooth hurts more after the filling is in place, there is probably an abscess. Extract the tooth now or, if there is too much swelling, extract it after the swelling has been treated.
8. After-care instructions: So that the temporary filling does not break or loosen, ask the patient not to eat anything for 1 hour so that the cement has time to harden. The patient should try not to use that tooth for biting or chewing until there is a permanent filling, since the cement and sides of the cavity are weak.

EXTRACTIONS

Teeth should be extracted only when absolutely necessary. However, extraction may represent the only possible care that can be delivered in austere circumstances.[4] The general reasons to extract a tooth are[5]:

- The patient has constant pain from the tooth.
- The tooth is loose and painful when moved.
- The tooth is already broken with an exposed nerve root.

General Extraction Techniques

In old movies, extractions appear to be a simple procedure. But in reality, the extraction of a tooth is difficult and painful to accomplish without breaking the tooth. A dental, preferably a regional, anesthetic block is required. (See the section on blocks in Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment.)

Rather than simply pulling a tooth out, the basic principle is to break the periodontal ligaments holding the tooth to the bone and then rock/lever the tooth out. Generally, the ligaments holding the tooth to the gum and jaw are loosened using a tiny sharp instrument inserted between the tooth and the gum all the way around the tooth.

The keys to successful extractions are patience and finesse. Don't simply try to yank the tooth out; this will only break it off. A number of techniques have proved successful most of the time, but the main requirement is not to hurry the procedure. Michael A. Grossman, DDS, of Tucson, AZ, says that one method is to push down and rotate or move the tooth in a figure-eight pattern, with movement in any direction lasting 8 seconds. (Personal communication, received May 9, 2008.)

Another experienced dentist, Dr. Manuel Bedoya, gently rocks the tooth outward and inward until it can be levered out. He has found that this technique of leveraging the tooth and rocking it back and forth is the easiest way to remove a tooth. Once the tooth rocks back and forth, he advises letting it "rest" for 20 to 30 minutes and then returning to pull the tooth out. During the rest period, enzymes are generated that further help to loosen the tooth. (Personal communication, received December 23, 2007.)

If a tooth breaks (as it often does) when being extracted by non-dentists or with makeshift extractors, pry out the remaining fragments using small metal instruments. Or, send the patient to a dentist later, since the key element, drainage, is accomplished when the tooth breaks.

Tools

Although commonly suggested, using regular pliers wrapped in gauze for extractions generally just pulverizes the tooth at the gum line—especially if the tooth is diseased. Use either a dental extractor (a pediatric universal extractor should work in most situations) or cut off the end of an awl, file it flat, and put a tiny notch on the side of the filed tip. A large-gauge needle with the sharp end filed down also works. Push it between the tooth to be extracted and the gum, breaking the ligaments. Then, carefully lever the tooth out of the socket. (Michael Grossman, DDS, Tucson, AZ. Personal communication, received December 22, 2006.)

Dental forceps are designed to fit the shape of the teeth, including their roots. The inexperienced operator will find it simpler to rely on one pair of universal forceps for the upper jaw and one pair for the lower jaw.[6] If channel-lock pliers or a bone rongeur that has jaws curved inward like dental pliers is available, use that. There is less chance of breaking off the enamel, especially if you follow Dr. Manuel Bedoya's advice and pad the tool's ends with gauze or other suitable cloth. Dr. Bedoya adds that even a screwdriver, if used gently, can help to pry the tooth from the socket. (Personal communication, received December 23, 2007.) (Also see Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment, for improvising dental tools.)

Extracting Abscessed Teeth

If the tooth is abscessed, try to extract it. Tooth extraction is the best way to drain an apical abscess when no facilities are available for root canal treatment. Removing a tooth is appropriate if it cannot be preserved, it is loose and tender, or it causes uncontrollable pain. In these circumstances, according to Barnett R. Rothstein, DMD, even if you must use pliers or a similar instrument that breaks the tooth, opening the abscess in this manner will allow it to drain, thus avoiding the severe complications (e.g., Ludwig's Angina, airway compromise, sepsis) that might otherwise occur. (Personal oral communication, received April 9, 2007.)

According to Dr. Manuel Bedoya, the abscess will still drain even if part of the tooth remains, and the rest of the tooth will eventually work its way out without complications. (Personal oral communication, received December 23, 2007.) One benefit is that it is easy to extract loose teeth with periodontal laxity/destruction.

Positioning the Patient

The first step is to position the patient correctly. Patients needing a *lower* tooth extracted should be sitting *lower* than the clinician, since the extraction technique for the lower jaw is to push down and then to pull up on the tooth. Standing on a stable platform, such as a box, may be useful for the practitioner. Position patients who need an *upper* tooth removed *higher* than the clinician. That is because the extraction technique for the upper jaw is to push up and then pull down on the tooth. Sitting the patient on several cushions often accomplishes the necessary height adjustment.[7] It also helps to have a dental chair that prevents the patient from pulling his head back during the procedure. A dental chair can be fashioned from a straight-back chair, two broomsticks, tape, and some webbing (see "Dental Instruments and Equipment" in Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment).

Tooth Extraction: Procedural Steps

1. Seat the patient in a chair with a high back that will support his head. After he has rinsed his mouth, swab the gum with 70% ethanol. Do a supraperiosteal or other dental block, as described in Chapter 23 under "Blocking Individual Teeth." Wait 5 minutes for the anesthetic to work, and then test to be sure the tooth is numb. If the patient still feels pain, give another injection.[8]
2. Position yourself to best work on the tooth you are extracting. Right-handed clinicians should stand behind and to the right of the patient when extracting lower right molar or premolar teeth. Face the patient, to the patient's right, when working on all other teeth.
3. The first step is to separate the gum from the tooth. This is vital so that the gum does not tear when the tooth is removed. Torn gums bleed more and take longer to heal. Slide the end of the instrument along the side of the tooth and into the gum pocket alongside the tooth. At the deepest part of the pocket, you can feel the place where the gum attaches to the tooth. The attachments are strong, but thin. Push the dental instrument or blunted needle between these attachments and the tooth. Then separate the tooth from the gum by moving the tool back and forth. Do this on both the buccal (cheek) and the lingual (tongue) side of the tooth. Take care not to go too deep and to cut only the attachments to the tooth.[8]
4. Next, loosen the tooth. While a loose tooth may not break when you extract it, a strong one will if you don't loosen it first. While a dentist will use an elevator to loosen the tooth, you may need to use a small flat screwdriver. Either tool can cause harm if not used carefully. The blade goes between the bad tooth and the good one in front of it. Put the face of the blade against the tooth you are removing and slide it down the side of the tooth, as far as possible under the gum. Turn the handle so that the blade moves the top of the bad tooth backward and loosens it. Rest your first finger on the adjacent tooth while you turn the handle. This will control it.[8] Now that you have loosened the tooth, waiting about 20 minutes will allow the tooth to loosen even more, according to Dr. Manuel Bedoya. (Personal communication, received December 23, 2007.) You may want to get a cup of coffee or do any required paperwork for this patient.
5. You are now ready to remove the tooth. While supporting the gum and underlying bone with the thumb and finger of your nondominant hand, apply the forceps to either side of the crown, parallel with the long axis of the tooth. Push your grasping tool (extractor, pliers, etc.) as far toward the roots as possible. The idea is for the forceps to grasp the tooth's root under the gum. Your fingers will feel the bone expanding a little at a time as the tooth comes free. Rather than "pulling" the tooth, think about rocking it back and forth or levering it out.[6] To decide which way to move a tooth, think about how many roots it has. If a tooth has one root, you can turn it. If a tooth has two or three roots, you need to tip it back and forth. Take your time. If you *hurry and squeeze your forceps too tightly*, you can break a tooth. As Dr. Dickson wrote in *Where There Is No Dentist*, "Removing a tooth is like pulling a post out of the ground. When you move it back and forth a little more each time, it soon becomes loose enough to come out."[9] If the tooth does not begin to move, loosen the forceps, push them deeper, and repeat the rocking

movements. Avoid excessive lateral force on a tooth, as this can lead to its fracture.[6] After you extract the tooth, examine its roots to be certain that you haven't broken any part.

6. Stop the bleeding. Apply direct pressure by squeezing the sides of the socket for 1 to 2 minutes and covering it with cotton gauze or absorbent cloth. Have an adult patient bite firmly against it for 30 minutes; a child should continue biting for 2 hours.[9] After the patient has rinsed his mouth, inspect the cavity for bleeding. If the bleeding continues, if you have removed two or more teeth, or if the gums are torn or loose, suture the extraction site with absorbable (if available) mattress sutures across the cavity.[6,10]
7. Carefully inspect the extracted tooth to confirm its complete removal. A broken root is best removed by loosening the tissue between the root and the bone with a curved elevator. After the tooth has been completely removed, squeeze the sides of the socket together for a minute or two and place a dental roll over the socket. Instruct the patient to bite on it for a short while.
8. Instruct the patient[6,10]:
   - Not to rinse his mouth again for the first 24 hours: if he does, the blood clot may be washed out, leaving a dry socket. But after 24 hours, he should rinse his mouth frequently with warm saltwater during the next few days.
   - To bite on cotton gauze or absorbent cloth if bleeding starts again.
   - To take acetaminophen or, if there has not been much bleeding, nonsteroidals for pain, if needed.
   - Not to explore the cavity with his finger.
   - To drink lots of cool fluids. He should not drink hot liquids like tea or coffee, because they promote bleeding.
   - To eat soft food that is easy to chew. He should try to chew food on the side opposite from where the tooth was removed.
   - To keep his mouth clean, especially the teeth near the extraction site.

Extraction Problem: Broken Tooth

Even when handled with care, extractions sometimes lead to a broken tooth. If you can see the root, try to remove it. If you leave a broken root inside the bone, it can become the nidus for an infection. However, small broken roots are better left inside the socket. They will loosen over the next week or so, and will be easier to remove.[11]

If you do try to remove a tooth root, use one of the techniques below.

To remove a broken *upper* root[11]: Slide the blade of a straight elevator or thin flat screwdriver along the wall of the socket until it meets the broken root (Fig. 24-1). Then,

1. Force the blade between the root and the socket.
2. Move the root away from the socket wall.

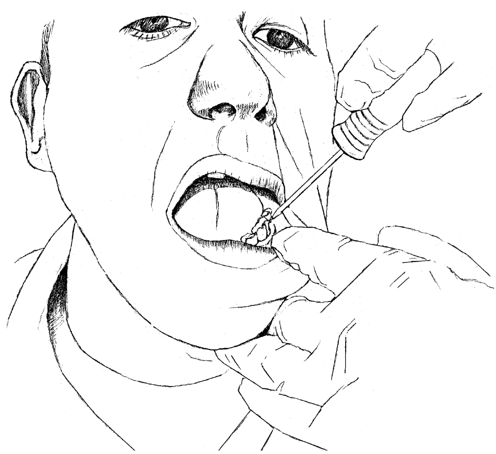

FIG. 24-1. Screwdriver used for tooth extraction.

3. Move the root further until it is loose.
4. Grab the loose root and pull it out.

To remove a broken *lower* root[11]: Use a straight elevator (or a curved elevator if you have one). If the broken root is from a molar tooth, slide the blade into the socket beside the broken root.

1. Break away the bone between the root and the blade.
2. Force the blade between the root and the socket.
3. Move the root away from the socket wall.
4. Grab the loose root and pull it out.

If dental equipment is not available, this technique is recommended if you have a bright light to work under: Dry the socket with gauze and then firmly wedge a 26-gauge needle into the root canal of the errant piece. "With gentle manipulation it is possible to retrieve the root fragment impaled onto the stainless steel needle."[12]

Post-extraction Problems

Bleeding

Post-extraction bleeding usually occurs in the small vessels. If the patient presents with persistent bleeding after a tooth extraction, remove any clots extending out of the socket with gauze. Then take a small folded gauze pad or a moist (regular) tea bag wrapped in a thin cloth or gauze, place it over the socket, and have the patient gently bite on it for 1 hour. The tea contains a procoagulant as well as tannic acid, which helps relieve pain. This should be repeated as necessary; it often takes two or three times. Patients should be told to wait at least 1 hour before checking the site so they do not disrupt clot formation. If bleeding continues, give a local anesthetic block and then curette and irrigate the socket with normal saline to remove the existing clot and to freshen the bone. If this does not stop the bleeding, suture the area with gentle tension.[13] If bleeding is excessive, including in anticoagulated patients, drying the area as much as possible and then applying cyanoacrylate has been effective.[14]

Pain

If a patient presents with severe pain about 2 to 3 days after a tooth extraction, it is most probably due to alveolar osteitis, a "dry socket." A dry socket occurs most commonly after wisdom tooth extraction, in patients using oral contraceptives, and in smokers. It is due to losing the clot from the socket, with a subsequent growth of anaerobic organisms leading to a localized alveolitis. The pain can be localized to the tooth or extend throughout the dentition on that side. While it generally resolves spontaneously in about 2 weeks, the patient will be in so much pain that treatment should be instituted to resolve the problem.

Treatment

Block the tooth. Then gently rinse the socket with warm saline or potable water. Gently place a piece of gauze or cloth soaked in iodine or a saline/anesthetic solution (or with a 1- to 2-inch iodoform gauze strip saturated in eugenol or coated with an anesthetic ointment, such as lidocaine 0.5%) in the socket. A piece of gauze with eugenol, oil of cloves, or a local substitute (damp, but not wet) can also be used, as can cyanoacrylate (not the best choice in this case). The patient should bite down on a piece of dry gauze, cotton, or cloth over the tooth dressing. That cloth can be discarded after 1 hour. The dressing gauze should be changed every 1 to 3 days until symptoms do not return when the gauze is left out for a few hours. This procedure eliminates the need for systemic analgesics. If the symptoms last a month, suspect osteomyelitis and evaluate the patient for long-term antibiotic treatment.

Root (Pulp) Extraction

Dentists use a thin barbed wire to extract the pulp. While a thin wire like a filament will get down the canal, removing the pulp requires a hook or lateral projections to pull or scrape the soft tissue out. However, Daniel Kemmedson, DMD, suggests that making a very small bend on the bevel portion of a thin (25-, 27-, or 30-gauge) hypodermic needle might work. (Personal written communication, received June 7, 2008.)

ORAL TRAUMA

Gum Lacerations

Many gum lacerations need no treatment other than keeping them clean. They can, of course, be sutured. Alternatively, apply cyanoacrylate directly to the wound.

Tooth Injuries: Spectrum

Multiple methods exist for describing injuries to teeth. The simplest that has clinical applicability is that teeth may be:

- Subluxed (loose, but without change in position)
- Luxated (loose and in a different position than normal)
- Fractured (missing a part of the tooth)
- Avulsed (missing)

Loose Teeth: General Approach

A common presenting complaint is that a patient's tooth is loose. Table 24-1 describes the symptoms, complications, and treatment for various causes of loose teeth. These are described in more detail in subsequent sections of this chapter.

TABLE 24-1 Loose Teeth: Presentation, Diagnosis, Complications, and Treatment

Presentation	Diagnosis	Definition	Complications	Treatment by Non-dentist
Tooth in good position, but loose.	Tooth subluxation	Loose tooth	Dead tooth (rare)	Mechanically soft diet until tooth is stable
Tooth appears taller, shorter, or out of alignment with adjacent teeth. Recent trauma.	Tooth luxation	Very loose tooth	Aspiration of tooth, pulpitis, dead tooth	Splinting, extraction
Tooth injured and now loose. No obvious injury.	Root fracture	Tooth root broken under the gum	Pulpitis, dead tooth	Extraction
Bone around a loose tooth, as well as the adjacent tooth, moves. May have had recent trauma.	Fracture of alveolar bone *- or -* Osteomyelitis	Broken bone around the tooth's roots *- or -* Infection inside the bone, probably from "Trench Mouth" (Vincent's angina or stomatitis)	Progressive infection, infection in sequestered bone, dead tooth	Stabilize tooth (fracture) or prolonged antibiotics, and drainage, if necessary
Missing tooth, recent trauma.	Tooth avulsion	Missing tooth	Ankylosis (tooth immobility due to direct attachment to bone), resorption of bone	Reimplantation and splinting

Data from Dickson[15] and other sources.

Subluxed: Loosened Tooth

If the tooth is minimally loose but in normal position, patients should be placed on a liquid or soft diet progressing slowly to a normal diet. Follow-up with a dentist is rarely required. If the teeth need to be stabilized, dental follow-up is recommended within 48 hours, if possible.

Luxation

A luxated or displaced tooth is shifted out of normal position but remains intact. (Whether it is really intact may be unclear without radiographs.) The surrounding alveolar bone is normally fractured. Luxated teeth, usually the upper front teeth (incisors), may either be in normal position or loose (subluxed), pushed back, or partially or completely out of the socket. When communicating with a dentist, they are described as extrusive = coming out; intrusive = pushed inward; or lateral = to the side.

The treatment depends on the tooth's position. If the tooth appears longer than the others (extrusion), try to push it back firmly into the socket with steady, gentle pressure. You can get a better grip on the tooth if you use a piece of gauze to hold it. If the tooth seems to be pushed ahead of or behind the other teeth (lateral displacement), also try to firmly realign it. If it is loose, the patient can gently bite on a piece of gauze or cloth. The tooth should then be splinted in position, as described in "Splinting/Wiring" later in this chapter. If it seems shorter than surrounding teeth (intruded), it probably won't survive and there is little that can be done in adults without advanced dental equipment.[16] In children, intruded teeth are allowed to re-erupt.

Tooth Fractures

If a tooth breaks (generally the crown, which is the part of the tooth above the gum line), treatment is often necessary to reduce pain. Tooth fractures may initially seem to have significant bleeding, although much of this may be a mixture of saliva and blood. If the patient can bite down on a gauze or cloth, the bleeding generally stops. Although the following classifications seem obvious, if it is unclear how much damage was done to the tooth, watch it over several days. If it changes color or if signs of an abscess develop, extract it.

Classification of Tooth Fractures

Fractured Enamel

The most common dental injuries are those of the tooth's crown, involving the enamel and the enamel-dentin without pulp involvement. These usually involve a child or young adult's anterior maxillary incisors. About one in four children worldwide will have such an injury before age 18 years, with most occurring between the ages of 6 and 13 years.[4]

If only the tooth enamel is fractured, the tooth will not be sensitive to temperature or touch and has a very small (<3%) chance of pulp necrosis. Although the tooth may later need filling, no treatment is required immediately. If no dental care is available, smooth any sharp edges with sandpaper, a small file, an emery board, or a hard stone.[4]

Reattaching the tooth fragment is the ideal treatment when the piece is available, since it can improve both the appearance of the tooth and its function. While dentists can use a variety of techniques to accomplish this reattachment, including the use of special preparations and cements, using a simple adhesive, such as cyanoacrylate, can restore 25% or more of the tooth's pre-injury strength. This method provides immediate cosmetic improvement and allows a dentist to provide more definitive care at a later time. Until the tooth fragment is reattached, it can be kept in sterile water, milk, or Hank's Balanced Salt Solution (see the formula under "Preservation" later in this chapter).[17,18] Gently dry both the tooth and the fragment before applying the cement. If the fragment is not reattached and the patient will see a dentist, immerse it in a preservative solution (see "Avulsed Tooth" in this chapter) and send the piece to the dentist with the patient. The patient should be placed on a liquid or soft diet until seen by a dentist and told not to pick at the adhesive. The tooth or the cement may irritate the patient's tongue or lip. If this irregularity bothers the patient, it can be smoothed with a variety of instruments, as described in steps 5 and 6 under "How to Fill a Tooth" earlier in this chapter.

Dentin Fracture

If the dentin is fractured, it will usually be visible as a deep, golden yellow inside the tooth. The tooth will be very sensitive to percussion, temperature, and air. Pulp necrosis (dead tooth) occurs in 7% to 10% of these patients. After blocking the tooth, dry it and cover it with calcium hydroxide (CaOH) paste or cyanoacrylate. The CaOH paste will stay in place for about a week if the patient is on a soft/liquid diet. To apply cyanoacrylate, drop it onto the tooth and, with a metal tool or the top of the adhesive tube, rapidly try to smooth it. Have the patient keep their mouth open for a few minutes to let it dry. For CaOH paste, use a flat instrument, such as a knife blade (cover the cutting edge), ice pop (e.g., Popsicle) stick, or similar tool to place dental filling material or wax over the area. Have the patient bite down gently, and remove the excess material. They will have to avoid using that tooth to eat; the piece may come loose.

Pulp Exposed

A tooth's pulp space may be fractured with the tooth in place or with a piece missing. If the tooth remains in place and the root is broken, the tooth will move if you firmly grasp the alveolar bone (by holding the gum over the bone) and try to move the tooth. Of course, the bone doesn't move unless it is broken. If the pulp is exposed, a piece of the tooth is missing and blood will be visible coming from the pulp cavity. This is generally quite painful since the nerve is exposed also. But, if the nerve is concussed, it may not hurt. In that case, pulp necrosis (dead tooth) is likely.

Treatment

The first priority is to help control the pain and bleeding. These teeth can be gently treated without anesthetic or after using one of the blocks discussed in Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment. The specific block to use depends on which tooth is involved.

The basic principle is to dry and cover the tooth. The tooth can be covered using either standard dental materials or cyanoacrylate. If using standard dental materials, cover the tooth with a mixture of cotton fibers in a zinc oxide and eugenol paste. This paste should be very thick. It is applied over both the injured tooth and several adjacent teeth. If possible, leave the gum line clear so the patient can keep it clean. Caution the patient not to bite into food with these teeth until seen by a dentist.[19] If dental supplies are not available, use cyanoacrylate to stabilize the tooth.

Adequate pain control may require removing the tooth pulp from the chamber. If the tooth fracture has exposed the pulp space and a very tiny pulp removal tool is available, remove the pulp. A lightbulb filament with a tiny drop of cyanoacrylate may suffice in a pinch. Whether or not the pulp can be removed, use a small piece of gauze or cotton to seal the hole and avoid contamination. Cover it with oil of cloves or zinc oxide. If only cyanoacrylate is available, use that to cover the hole.

An alternative is to gently wash the tooth and try to reattach it with cyanoacrylate. A splint is normally required to keep it in place (see "Splinting/Wiring" later in this chapter). The tooth can be splinted in place until a dentist can do a root canal or the tooth can be extracted. (Extracting this type of fractured tooth is very difficult, especially for the novice.) Occasionally, a tooth may split vertically and, after drying, may be able to be glued together with cyanoacrylate in situ. This, however, may be only temporary, since such teeth may have too much intrinsic damage to be retained.[20]

Fractured Bone

If the bone moves when you attempt to move the teeth after an injury, the alveolar bone is most likely fractured. Do not take those teeth out until the bone is healed. Otherwise, bone will come out with the teeth and there will be a big hole in the patient's jaw. Instead, support the teeth in order to hold both sides of the bone steady. Stabilize the tooth with a splint (e.g., interdental wires) or cyanoacrylate to attach it to the adjacent tooth. If more than the alveolar bone is fractured (a substantial maxillary or mandibular fracture), wiring may be the only option. See "Splinting/Wiring" and Fig. 24-2.

Avulsed Tooth

Avulsion means that the entire tooth has come out of the socket. If the tooth is out, the ligaments that hold the tooth as well as the nerve and blood vessels for that tooth have been completely torn. Handle the tooth only by the enamel (crown), since the root structures can be damaged easily and this would prevent the tooth from being successfully reimplanted.

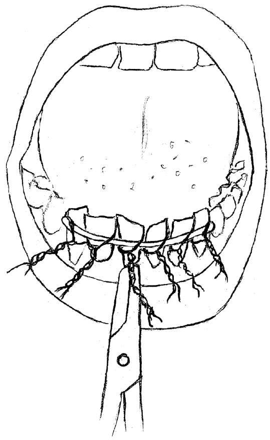

FIG. 24-2. Splint stabilized with wires.

Preservation

If the tooth cannot be reimplanted immediately, store it for up to 4 hours in sterile saline, potable water, milk (better), or Hank's Balanced Salt Solution (HBSS; best). The practice of placing the tooth between the patient's gum and lip is not as good. Use this method only if there is no risk of the patient aspirating the tooth. A chemist or pharmacist can compound HBSS in advance. To make a 100 mL solution, add to distilled water: 0.80 g NaCl, 0.04 g KCl, 0.014 g $CaCl_2$ anhydrous, 0.01 g $MgSO_4$-$7H_2O$, 0.01 g $MgCl_2$-$6H_2O$, 0.006 g Na_2HPO_4-$1H_2O$, 0.006 g KH_2PO_4, 0.1 g Glucose, 0.035 g $NaHCO_3$, and usually, 20 mg Phenol red.[21] Sterilize the solution, if necessary, by filtering rather than heating it. For dental work, no sterilization is needed.

Treatment

If the tooth is whole, reimplant it within 30 minutes after the injury, if possible. Hold the tooth only by the crown (enamel) so as not to injure the periodontal ligament covering the root. Gently rinse it off with sterile saline, potable water, milk, or HBSS. Don't scrub it or use any chemicals. Gently rinse the socket with warm water to clean out any debris and clot. After doing a supraperiosteal, alveolar, or Gow-Gates block, push the tooth into the socket with firm, gentle, steady pressure; it often "snaps" into place. (See Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment, for dental blocks.) Hold it in place for about 5 minutes. Then have the patient bite down lightly on a piece of gauze or cloth. If dental care is not readily available, the tooth then can be stabilized by splinting or wiring it to adjacent teeth (see "Splinting/Wiring" below). The tooth may still darken and die months or years later. In that case, the option is to extract it or for a dentist to do a root canal.

Children

Deciduous teeth, also known as milk teeth, baby teeth, temporary teeth, and primary teeth, need not be reimplanted, since if they are replaced, they typically become necrotic, and then infected. They may also become fused to the bone (ankylosed) and not fall out, or they can fuse to the erupting adult teeth, interfering with the eruption of the permanent tooth.[22,23]

Splinting/Wiring

Teeth and surrounding boney structures can be stabilized with glue, glue and wire, splints, or interdental wiring.

Glue Only

To stabilize a tooth, cyanoacrylate or dental cement may the easiest and best makeshift method. After drying the affected tooth and the adjacent teeth and gums, apply the adhesive to the teeth and to the gingiva below them. Apply the adhesive to both the labial (exterior) and lingual (interior) sides of the teeth.

Glue or Wire and Splint

Simpler than using wires alone to stabilize teeth, an effective temporary method, suggested by Barnett R. Rothstein, DMD is to combine adhesive and wire. (Personal communication received May 7, 2007.) Cut a piece of wire to the length necessary to cover multiple teeth. If used for loose or avulsed teeth, the wire need only cover four or five teeth; if used for a mandibular or maxillary fracture, cover as many teeth as possible. The wire can be thin orthopedic wire; a small-gauge spinal needle with the ends clipped; a thin paperclip; or similar thin-gauge, malleable, but relatively rigid, wire. Bend the wire so it conforms to the convexity of the normal tooth configuration.

Beginning with four teeth on either side of the fracture line—or all the teeth that will be used in the case of a loose or avulsed tooth—dry the teeth thoroughly. Hold the lip away from the teeth manually or by using gauze or absorbent cloth between the lip and gum. Put cyanoacrylate or dental cement on the anterior tooth and embed the wire in the glue. Be certain that the teeth are aligned as well as possible. Continue the same process until the entire wire is cemented.[24]

A more secure alternative is to use wires or heavy nonabsorbable sutures around the teeth to secure the stabilizing wire (Fig. 24-2).

These are only temporary fixes. The patient must be placed on a liquid or soft diet and be seen by a dental professional as soon as possible.

Makeshift Splints

Wax Splint

Another alternative to stabilize a loose tooth is to use beeswax. According to Dr. Dickson, in *Where There Is No Dentist*, the method is to

> Soften some beeswax and form it into 2 thin rolls. Place 1 roll near the gums on the front side of five teeth: the loose tooth and the two teeth on each side of it. Press the wax firmly, but carefully, against these teeth. Do the same with the second roll of wax on the back side of the same teeth, again near the gums. It is good if the wax on the back side is touching the wax on the front side. This helps the wax hold the teeth more firmly. To do this, you can push the wax between the teeth with the end of your cotton tweezers.[25]

Splint From Dental Filling Material

Cotton fibers can be mixed in with standard temporary filling mix to form a fibrous mix. This then can be molded to make a splint between the injured tooth and its healthy neighbors.[24]

Interdental Wires for Dental Stabilization

Interdental wire fixation simply means tying wires around stable and unstable teeth, and then affixing these to a heavy wire splint laid across the involved teeth. This can be used for unstable teeth or fractures of the mandible or maxilla. Since extracting teeth when the alveolar bone is fractured can leave a big hole in the jaw, supporting the teeth with a splint until the bone heals is the optimal treatment.

Interdental wiring is much easier to do on anterior teeth than on others, especially with limited equipment. If dental equipment is not available, a pair of scissors and small pliers can be used to cut and manipulate the wire.

Alternative Techniques

A basic method is to place a double strand of wire around several teeth (one to three teeth) and twist it tight. Place the wires so that, if possible, they do not touch the gums. Tuck the cut ends between the teeth.[4]

Another method for applying interdental wires is to use your thumb and finger to gently move the loose teeth and bone back into normal position.[26] Cut a wire to use as a splint. It should be long enough to lie across two strong teeth on each side of the loose tooth or teeth. The splint can be a thin orthopedic wire; heavy electrical wire with the insulation removed; a small-gauge spinal needle with the ends clipped; a thin paperclip; or thin-gauge, malleable, but relatively rigid wire. Curve the wire so that it fits the curve of the teeth. If using a needle, smooth the sharp end with a file or stone. Then tie each tooth to the splint wire using short pieces of 20-gauge ligature wire or, if that is not available, heavy surgical suture, dental floss, or nylon fishing line.

Put one end of the ligature under the splint. Bring it around the back of one tooth and out to the front again over the needle. Use the end of a small instrument to hold down the ligature at the back of the teeth. Then twist or tie the ends together. Tighten the ligature around each of the six teeth. If using wire ligatures, cut the ends and bend them toward the teeth, so they will not cut the lip. If using wire ligatures, tighten them the next day, and then once each week. But be careful: Only half a clockwise turn usually is needed ("Righty tighty; lefty loosey"). More, and the wire will break.

Patient Aftercare Instructions

Explain to the patient that it takes 4 weeks for the bone to heal. The wires must remain on the teeth for this time. To help the teeth to heal, ask the patient to use other teeth for chewing, to clean both the teeth and the wires with a soft brush frequently, to rinse with 2 cups warm saltwater every day, and to return to have the wires tightened every week.

After 4 weeks, cut and remove the ligatures. Ask the patient to watch those teeth. A dark tooth and gum bubble are signs that the tooth is dying. If those appear, the patient must return for the tooth to be extracted or be referred for specialized dental treatment.

Dental Wiring for Facial Fractures

To wire teeth to treat a maxillary or mandibular fracture, an adequate number of teeth must be included. With facial fractures, wires are placed on both upper and lower teeth and then tied together for increased stability.

With a fracture of either bone, tie the wires around at least six teeth in the maxilla and the same number of mandibular teeth. Twist the wires to attach them to the teeth. Try to adjust the teeth so that they appear aligned. This will place the facial fracture segments in correct position. Tie the upper and lower wires together, tying the lateral ones together first, then others, crossing some ties over the fractured area. Tie them loosely at first, and then tighten them.[27] A specific contraindication for interdental wiring for facial fractures is poorly controlled seizures, since the patient could easily vomit and, without the ability to open their mouth, aspirate.

Wiring for mandibular/maxillary fractures should remain in place for 6 weeks. During that time, the patient will be on a liquid diet and should carry a wire cutter on a string around his neck in case there is a need to emergently cut the wires—such as if he has an airway problem.

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HEADREST

A headrest for head and neck surgery can be fashioned from foam packing material (Styrofoam) or a piece of foam cushion or mattress. Use a 25-cm × 25-cm × 10-cm piece of the material and hollow out the middle so that it is only one-third of the original depth. This space is for the patient's head. The foam material will provide traction to keep it on the operating room (OR) table.[1] This headrest can also be used as a sleeping pillow if the individual needs, or wants, to be only on their back.

REGIONAL NERVE BLOCKS

Most of the regional nerve blocks useful for ear, nose, and throat (ENT) procedures are discussed in Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment.

To relieve most or all orofacial pain in adults, use a simple paravertebral block. This is an extremely safe procedure, since the injection is made with a 1.5-inch-long, 25-gauge needle. Inject 1.5 mL of 0.5% bupivacaine into the paravertebral musculature on both sides, 1 inch lateral to the seventh cervical spinous process. Bupivacaine provides good pain relief within 15 minutes for adults with toothache (odontalgia), mandibular fractures and dislocations, temporomandibular joint (TMJ) syndrome, ocular pain, facial pain from a variety of other causes, and headaches.[2,3]

EAR

Otoscope

If an otoscope is not available, use an ophthalmoscope to look through any type of speculum into the ear canal. Objects that can substitute for a speculum include a pen casing (cut the tapered point off a little and smooth it), a 1-cc syringe barrel with the end cut off and smoothed, a nasal speculum (be careful not to put it in too far), and similar objects. Note that many late-19th century otoscopes looked no different than modern nasal speculums. They used a direct or an indirect (head mirror) light source.[4]

Foreign Body/Cerumen Removal

Knowing how to remove foreign bodies from an ear can save time and resources. There is no evidence to support choosing one method over another in most cases, and many different techniques are available. It is also useful to know which cases may need to go to the OR to have foreign bodies removed under sedation. The most difficult foreign bodies to remove from an ear are spherical objects, those in contact with the tympanic membrane, and those that have been in the ear for more than 24 hours.[5] Most foreign bodies can be removed from the ear using irrigation, dissolution, suction, glue, or by other physical means. Removing insects and metal objects are special cases.

Anesthesia

Current sedation techniques (see "Procedural Sedation" in Chapter 15, Sedation and General Anesthesia) make it safe to administer sedation to both adults and children before undertaking painful, or what may be prolonged, attempts at foreign body removal. Anesthetizing the ear can gain the patient's cooperation, although good anesthesia in the ear canal is difficult to achieve. Topical anesthetic can be dropped into the canal (if the foreign body is neither vegetable matter nor a button battery), although it usually has only a modest effect.

Irrigation

Irrigation is the least traumatic way to remove cerumen and smaller foreign bodies close to the tympanic membrane (TM). If the TM is not perforated, irrigate the ear with clean water at body temperature. (Cold water produces emesis.) For earwax, it may help to put in a softening agent for a few days before trying this.

Use a small piece of tubing connected to a syringe; the catheter from an IV or the tubing from a butterfly cannula—with the needle cut off—works well. An alternative is to use a bulb syringe or a turkey baster. With both, low-pressure volume, rather than a directed stream of water, works better. Other methods that have been used successfully include using oral jet irrigators (this may have too high a pressure, depending on the state of the batteries),[6] a recreational water gun,[7] and mouthfuls of water instilled (by the patient's nurse-wife) through a cocktail straw.[8] Aim the fluid stream at the superior aspect of the ear and, if possible, pulse the fluid for best results. Alternatively, direct the stream along the wall of the ear canal and around the object, flushing it out.

Do not irrigate the ear to remove hygroscopic objects such as vegetables, beans, and other food matter as these may swell. More common in noses than in ears, button batteries should not be irrigated out. That only accelerates the tissue necrosis. Also, avoid nasal and otic drops in these patients.

Dissolve

Styrofoam is a common foreign body found in the ear. It is often compressed and tightly impacted in the ear canal. The friable substance tends to fragment if grabbed with forceps. The best removal method is to instill acetone or ethyl chloride, both organic solvents. This results in rapid and near-complete dissolution of the Styrofoam without any patient discomfort.[9]

Suction

Objects that are light and move easily can often be quickly removed with suction. Use a small soft-rubber suction catheter (e.g., pediatric feeding tube), a standard metal suction tip (e.g., Frazier tip), or a specialized flexible tip. It takes 100 to 140 mm Hg (or higher) negative pressure to attach an object, so using your mouth to suck on a tube won't work.

Mechanical Removal

Mechanically removing an object involves grabbing the object and pulling it out of the ear. This is most commonly done with cerumen, but can often be done with compressible objects by using tiny (alligator) forceps. Alligator forceps are best for grasping soft objects like cotton or paper.

To remove cerumen and small, visualized foreign bodies, fashion improvised spoons by bending the end of a paper clip into a very tiny "U" shape. Don't do this with your fingers—use pliers or a similar tool. This can also be used for removing foreign bodies from the nose.[10] If the foreign body is at all irregularly shaped and is not made of organic material, it can often be grasped with any available forceps or hemostat and removed.

Metallic objects, such as the appropriately feared button batteries, can sometimes be removed from the ear using a magnetized screwdriver.[11] (Ask your maintenance staff for one to use.) Note that batteries must be removed immediately to prevent corrosion or burns. A delay of only an hour or two, or a missed diagnosis of a battery in a nose or an ear, may lead to a particularly severe outcome. Upon contact with most tissue, this type of alkaline battery is capable of producing a liquefactive necrosis extending deep into tissues. Do not crush the battery during removal. Avoid nasal and otic drops. These electrolyte-rich fluids enhance battery corrosion and leakage, the generation of an external current, and local injury. After removing the battery, irrigate the canal to remove any alkali residue.

Glue

If the object is dry and smooth, put a tiny amount of cyanoacrylate (Super Glue) on the wooden end of a tiny swab (e.g., Q-tip) and touch the object. It will dry in about 15 seconds and then both can be extracted. The danger is gluing the stick to the patient. If so, don't fret—it can be removed with acetone or simply by waiting several hours.[12]

Removing Insects

Insects are a special case of organic foreign body. They are the most frequent ear foreign body in adults. Generally, they are alive, and often panic the patient because of both the pain and the noise they generate.

Kill the insect before attempting to remove it. Quickly drop in any liquid that will not injure the ear canal (e.g., mineral or cooking oil, lidocaine, liquid soap, alcohol, etc.) to kill the insect—and to restore the patient to relative calm. Plain water or normal saline usually is ineffective. Most insects die in less than 3 minutes after liquid is put in the ear.[13]

Improvised Ear Wick

Patients with edematous otitis externa need a method of getting the medication into the ear canal. This usually requires an ear wick. To improvise an ear wick, use thin ribbon gauze, impregnated at the bedside with antibiotic/anti-inflammatory ointment. This can be removed by patients, is inexpensive, and requires fewer visits than when patients use ear wicks.[14]

Alternatives to Otic Medications

Acetic acid (10% vinegar) is an amazing, nontoxic, inexpensive, and widely used preventive and treatment for most cases of external otitis. Scuba divers routinely use it. Mix one part acetic acid (vinegar) with nine parts water. Instill enough to fill the ear canal as often as needed. The only side effect is a streak of white where it drips out of the ear. Simply wipe it off. *One caveat*: diabetic patients and individuals whose ear canals have swollen shut need additional treatment; the latter can be treated with this medication if an ear wick is inserted. While patients with diabetes may be able to temporize with acetic acid, they should also have the appropriate antibiotics or antifungals instilled, if these are available. A mixture of 50% rubbing alcohol, 25% white vinegar, and 25% distilled water can also be used for external otitis. This should only be used QID.[15]

Myringotomy

A myringotomy may need to be done if the patient is in pain from otitis and no analgesic, decongestant, or antibiotic is available. If a myringotomy is necessary, nearly any local anesthetic drops will anesthetize the tympanic membrane if you wait 10 minutes after they are put in. For example, use one spray of 10% lidocaine aerosol directed into the clear external meatus onto the tympanum.[16] Another option is to put in 1 drop (only!) of 10% phenol. If phenol is used, start the procedure immediately, since the anesthetic effect lasts only 10 minutes. (Phenol also can anesthetize other areas, such as pilonidal cysts.) To do the myringotomy, insert an 18-gauge needle into the anterior-inferior part of the tympanic membrane. To take a culture, attach a TB syringe. Avoid puncturing the membrane posteriorly. (David Merrell, MD, oral communication, October 2006.)

NOSE

Nose Drops and Washes

Nose drops and washes are reasonably benign ways to make “stuffed up” patients feel better and, in some cases, to “clear the way” for other medications. There are a variety of recipes that you can prescribe for patients to make at home, if the commercial varieties are not available.

- *Recipe #1*: Mix ½ teaspoon salt in 8 oz warm water and store the solution in an empty spray bottle. Make a new solution after 2 days.[17,18]
- *Recipe #2*: Add 2 to 3 heaping teaspoons of table salt and 1 rounded teaspoon of baking soda to 1 quart of boiled tap or bottled water. Store it in a 1-quart glass jar. If the mixture is too strong, reduce the salt to 1 to 2 teaspoons. If the patient’s nose is dry, add 1 tablespoon of corn syrup to the mix. Stir or shake before each use and store in the refrigerator; mix a fresh batch weekly.

For adults, use two to three times daily. Instill with a bulb, ear, or medical syringe. Warm the solution to body temperature and have patients stand over the sink or in the shower as they squirt toward the back of each nostril. Avoid contaminating the stock solution. For children, instill 3 drops as often as necessary in each nostril while they are supine with their head turned to one side. Have them blow their nose after 1 minute or, for younger children, use a suction bulb to remove mucous.[18]

Anesthesia

Using intranasal anesthetic gains a patient’s cooperation for any manipulation. Good intranasal anesthesia can be obtained in several ways. Use 1 to 3 sprays of 10% lidocaine aerosol in the nose. Or spray the nose with 2 to 3 mL 4% lidocaine plus 1 drop (0.05 mL) of 1:1000 epinephrine. Then pack the nose with gauze soaked in the same solution.[16]

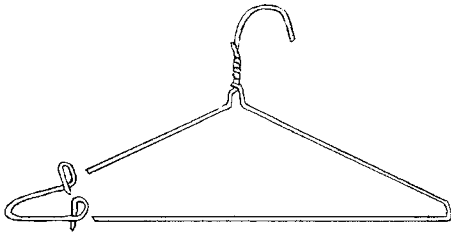

FIG. 25-1. Improvised nasal speculum.

To anesthetize the entire nasal cavity, hyperextend the head and pour 20 mL of 1.25% lidocaine with 0.25 mL of 1:1000 epinephrine into each nostril; allow it to remain there for 3 minutes. (Before instilling the liquid, warn the patient to close his glottis by forming but not saying a "ggg" sound while the liquid is in his nose.) The patient then blows their nose.[16] A less traumatic method is to attach a standard face mask to a nebulizer containing the solution and have the patient breathe through the nose.[19] A variation is to connect wall oxygen to an atomizer using oxygen tubing with a lateral hole cut in it. By intermittently occluding the hole with a fingertip, a spray of lidocaine is produced from the atomizer nozzle. Held at the nostril, the nozzle can deliver 2% lidocaine throughout inspiration and produce dense anesthesia of the airway from the nose to the trachea in less than 5 minutes.[20]

Nasal Speculum

A nasal speculum provides an excellent view when examining the nose and is vital when doing procedures, including packing the nose for epistaxis or draining a septal hematoma. The problem is finding the right-size speculum when it is needed. There are at least two methods to improvise a speculum, depending on the available resources.

If disposable otoscope specula are available, simply snip off the end of one to get the size you need, put it on an otoscope, and you have a speculum adequate to examine the nose.[21]

For a speculum that approximates the standard instrument, snip the corner off a wire hanger and bend the ends to the size you need (Fig. 25-1). Note that the loops bend inward so that the handle can be oriented toward the cheek (Fig. 25-2). Be careful to bend the V-shaped "corner" of the wire so that it exerts less pressure than you might need if making this into a self-retaining retractor.

Epistaxis

Epistaxis is one of the most common complaints. It can be either remarkably simple to treat or a life-threatening event. Nasal bleeds are either anterior, posterior, or a combination of the two. While many clinicians use prepackaged materials to stop nasal bleeds, these are usually not available in austere situations.[22]

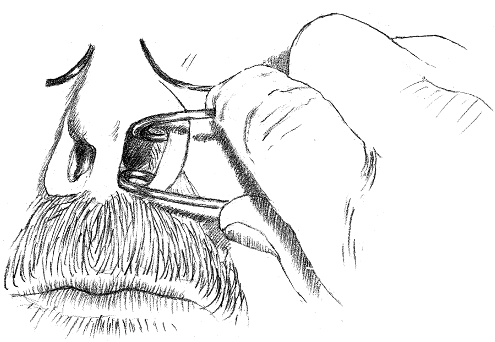

FIG. 25-2. Improvised nasal speculum in use.

Adding a vasoconstrictor to an intranasal anesthetic stops up to 65% of anterior bleeds. A number of different, often readily available, anesthetics work well. Cocaine 4% is safe when used appropriately. Use a maximum of 200 mg (4 mL) or 2 to 3 mg/kg. Try to avoid using it in patients with coronary artery disease.[22] Lidocaine 4% plus phenylephrine has an effect equivalent to that of cocaine.[23] The maximum dose of lidocaine is 4 mg/kg. If using the injectable form, use up to 7 mg/kg lidocaine plus epinephrine. Tetracaine 1% plus 0.05% oxymetazoline (Afrin) works as well as lidocaine plus phenylephrine.[24] It also lasts longer, up to 60 minutes. The maximum adult dose of tetracaine is 50 mg.

Anterior Bleeds

Direct Pressure

The vast majority (90%) of nosebleeds arise from the mucosa in the anterior part of the septum (Little's area, Kiesselbach's Plexus). Ask the patient to blow their nose to remove any inadequate clots and then press their anterior nose for 10 minutes without stopping. Show them how to press directly over the ala nasi (the soft part of the nose nearest the nares). Use a clock or a watch to time it or they will stop too early. This technique stops nearly all anterior bleeds. (Do not press over the nasal bones, as even experienced personnel often do.[24]) Alternatively, make a nasal pressure device by tightly taping two tongue depressors together at one end. The non-taped end can be spread apart and placed on either side of the nares to apply pressure.

These techniques work even better if you first insert cotton or gauze with a small amount of oxymetazoline (Afrin), phenylephrine (Neo-Synephrine), or other vasoconstrictor into the anterior nose before applying the pressure. For patients with von Willebrand's disease or with other clotting problems, David Merrell, MD, says that packing fresh (uncooked) liver or bacon in the nose often helps because of the clotting factors they contain. (Oral communication received October 2006.)

Iced Lavage

If neither vasoconstrictors nor direct external pressure stops the bleeding, try an iced normal saline lavage of each nostril, with the patient leaning forward. This may help decrease or stop the bleeding and allow better assessment of bleeding sites. The patient must be seated during both the examination and the therapeutic procedures to lower his blood pressure.[25]

Packing

Anterior packing is almost a lost art among many clinicians. Lubricating a vaginal tampon and slipping it into the nose can make an improvised "prepackaged" anterior pack. (David Merrell, MD, oral communication, October 2006.) As with anything else inserted into or through the nose, insert the tampon straight back along the floor of the nose.

If other measures do not stop the bleeding, an actual anterior pack may be required. For this, you need a cooperative patient, a petroleum gauze strip, a long forceps or hemostat, a nasal speculum, and a strong arm. Having a support behind the patient's head, even if only a wall, is helpful to stop the patient from continually backing away from you—the natural response. (See Fig. 23-4 and how to make a dental/ENT chair in Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment.)

After anesthetizing and vasoconstricting the nasal cavity, sit the patient upright in a chair with a headrest. While lighting is not vital, using a headlight or a head mirror is useful. Sit facing the patient and insert the nasal speculum with the handle pointing away from the nasal septum. It often helps to have an assistant hold the petroleum gauze so that you can easily pick it up at each step of the packing process. You will use only one long piece of gauze. If the piece you have is not long enough to fill the nose, tie another piece onto the first one and continue. Never use more than one piece in each side; they will get lost in there.

Pick up one end of the ribbon gauze and insert it as far back as possible. Try not to let it drop into the nasopharynx, but it should be almost there. The most common error in doing anterior packs is that they don't extend far enough back into the nose. Then, pick up the gauze at a point about twice the distance that the first portion went in (Fig. 25-3). Try to push this back in the nose as far as the first piece went, layering the gauze. Continue this process—forcefully—until

FIG. 25-3. Anterior nasal packing with petroleum gauze.

absolutely no more gauze can fit into the nose. Cut off any remaining gauze. Have the patient return in 2 to 3 days to have the packing removed. Many of these patients will need analgesics.

Posterior Bleeds

Without a fancy balloon designed to stop posterior nasal bleeding, two options, aside from surgery, are available: a balloon-tipped urethral (Foley) catheter and a posterior nasal pack.

Foley Catheter Method[26]

1. If possible, anesthetize the nose and posterior pharynx.
2. If a flow-control roller clamp from an IV infusion set is available, slide it over a large (14 Fr) urethral (Foley) catheter with 30-mL balloon.
3. Trim the distal tip of the catheter; do not cut the balloon.
4. Slide the well-lubricated large catheter through the nares that is bleeding the most. Pass it along the floor of the nose until it is visible in the nasopharynx (~8 to 10 cm).
5. Fill the balloon with 15 to 30 cc of water.
6. Pull the balloon back until it firmly seats against the posterior nasal opening (choana).
7. If an intravenous roller clamp was placed on the catheter, put a gauze pad against the nares for protection and, while holding gentle traction on the catheter to apply pressure to the posterior bleeding site, slide the roller clamp to the nares and lock it in place.
8. Otherwise, pad the nose, pull the catheter tight against the back of the nose, and secure it with tape, a safety pin, or a nasogastric or umbilical clamp.
9. Pack the anterior nose, as in section above, around the catheter.
10. If significant bleeding continues, repeat the entire process on the other side. If it still continues, consider surgery.
11. Place the patient (irrespective of age or medical condition) on oxygen, since they are nearly always going to be hypoxic.

Posterior Nasal Gauze-Pack Method[27]

1. Fold two 4 × 4 pieces of gauze or, if not available, a similar quantity of clean cloth into a small ball. Tie them securely at the middle of a very long piece of heavy thread or silk suture. Wrap the ties around the cloth several times in each direction. You will use these strings later to secure anterior nasal packing.
2. If possible, anesthetize the nose and posterior pharynx.
3. Pass a small-gauge urethral catheter or an infant feeding tube through the nares that is bleeding the most. When it is visualized in the posterior pharynx, grasp it with an instrument and pull it out through the mouth (Fig 25-4).
4. Tie the free end of the heavy thread to the mouth end of the catheter (Fig. 25-5) and pull it out through the nose, bringing the thread with it through the nares. Cut the string connecting the catheter and discard the catheter.
5. Gently pull on the string and, with the other hand, guide the cloth pack tightly up into the nasopharynx until it firmly lodges against the posterior nasal opening (choana) (Fig. 25-6).

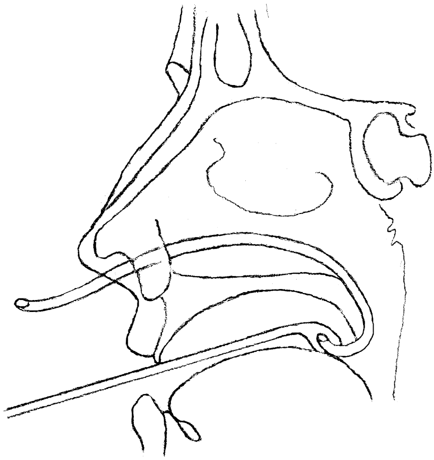

FIG. 25-4. Posterior pack, step 1: Pull catheter out through mouth.

6. Have your assistant hold traction on the thread while you pack the anterior nose (as described earlier).
7. Place a small piece of gauze or a cloth against the anterior nose and tightly tie the ends of the thread connected to the nasopharyngeal pack. This secures both the anterior and posterior nasal packs.
8. If significant bleeding continues, repeat the entire process on the other side. If it still continues, consider surgery.
9. Place the patient (of any age or medical condition) on oxygen, since they are nearly always going to be hypoxic.

Foreign Body Removal

Foreign bodies in the nasal passages are common and occur almost exclusively in children. The danger of working on a nasal foreign body is that it might accidentally get dislodged into the airway. Try to position the patient in a sitting or lateral position so that this is less likely. Vasoconstrictors are immensely helpful, including the otherwise little-used 4% cocaine solution.

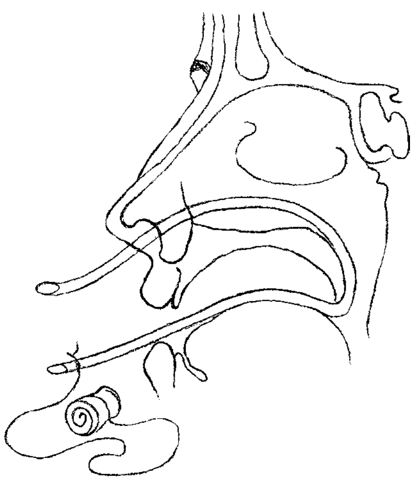

FIG. 25-5. Posterior pack, step 2: Tie gauze pack to catheter.

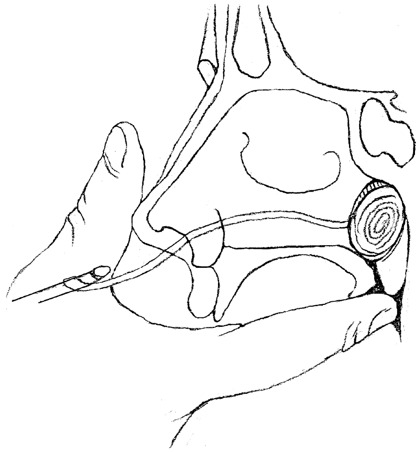

FIG. 25-6. Posterior pack, step 3: Push gauze pack firmly into nasopharynx.

(Be careful of toxicity from using too much.) Oxymetazoline (Afrin) or phenylephrine hydrochloride (Neo-Synephrine) can also be used. Patient cooperation may be gained by using anesthetics, such as spraying 4% lidocaine (or cocaine). Anesthesia is the same as discussed earlier in this chapter under "Epistaxis."

Mechanical Removal

If a nasal foreign body can be seen, it can sometimes be retrieved by getting behind it using an ear curette, a right-angle ear hook, or the tip of a paper clip or calcium alginate swab (Calgiswab) whose metal-shaft has been bent to a 90-degree angle. With the paper clip, bend it by clamping the tip between the handle end of bandage scissors; the swab shaft is thin enough to easily bend by hand.[28]

Small malleable objects close to the anterior nares can often be grasped with bayonet or alligator forceps. Harder objects may be retrieved with hemostats.

Magnetic metallic objects, such as the dreaded button battery, may be retrieved with a magnetic screwdriver or other tool, or by using metal forceps and a magnet. Place a magnet on the outside of the nose and touch the magnetized forceps to the foreign body. Place the magnet against the nasal skin and slide toward the tip of the nose. The metallic object is often attracted to the magnet and can be easily removed without pain.[29]

Suction

Suction, as in the ear, may work. However, the other methods usually work so well that suction is not needed. If it is used, turn the suction to 100 to 140 mm Hg, touch the foreign body with a thin rigid suction catheter (Frazier) tip, and withdraw the catheter and, hopefully, the foreign body with it.

Glue

Also not often needed, cyanoacrylate glue can be used on the end of a wooden or plastic applicator stick. Press it against the foreign body for approximately 1 minute and then remove it, trying not to also glue the stick to the patient's nasal mucosa. However, since the nasal mucosa is moister than the ear canal, if the patient is inadvertently glued to the stick, it comes off faster.

Catheter

A fast, reliable method is to pass a well-lubricated catheter with a balloon (urethral, vascular, or cardiac catheter) behind the foreign body. A vascular catheter is stronger and stiffer than a urethral catheter, and may pass by the object more easily. Use the smallest diameter available. Don't try to visualize or guide the catheter—just gently let it find its own passage around the object. Once the catheter enters the nasopharynx, inflate the balloon with 2 to 3 cc of air (not liquid!). Take the syringe used to inflate the balloon off the catheter before removing it from the nasopharynx. One common mistake is that the balloon inflation is not maintained during catheter removal. To avoid this, "lock" the inflation by removing the syringe or by clamping the catheter with a hemostat before it is removed from the nose.

Positive Pressure

Positive pressure behind the nasal object has also been shown to be an effective removal method. If a child is cooperative, first ask the child to blow his nose while you, the parent, or the child occludes the other nostril. Sneezing, which can be stimulated with pepper, may also work.

If that doesn't work, a parent can forcefully do one or two breaths of mouth-to-mouth breathing on a child with the opposite nostril occluded. The method is to tell the child that the parent will be giving him or her "a big kiss." Have the child sitting, standing, or, if supine, in the Trendelenburg position. Reassure and calm the patient, then have the parent firmly seal the child's open mouth with theirs, as in mouth-to-mouth resuscitation, and give a short, sharp puff of air. This usually results in the foreign body being blown onto the parent's cheek. When it doesn't work the first time, reposition the parent and child and try again.[30] If the parent is not willing to do "the kiss," a bag-valve-mask can be used in a similar manner.[31]

An easy method is to use air pressure from wall oxygen or an air outlet, if that is available. Connect a tubing (Christmas tree) adapter to the end of oxygen tubing. Spray phenylephrine in both nostrils and lay the child on his side, with the foreign body side down. Make sure the other side is unobstructed. Hold the child securely, with one person keeping control of the head. Turn the oxygen flow meter to 15 L/min or slightly higher. Quickly place the tubing connector into the nostril without a foreign body (Fig. 25-7). Usually within several seconds, the offending object blasts out of the other nostril. (Don't stand in the line of fire.) It's postulated that, startled by the air blast, the child temporarily lifts his soft palate, forcing the air to flow out of the opposite nostril.[32] Dr. David Merrell suggests that if the patient is cooperative, have them say "K, K, K" to close the soft palate while doing this. (Letter to author, September 3, 2008.)

MOUTH/PHARYNX

Anesthesia

Local anesthesia of the oral cavity, pharynx, larynx, and trachea can be obtained using a standard nebulizer fitted with a mouthpiece to administer 4 mL of 4% lidocaine at 8 L/min oxygen flow over 3 minutes.[33]

FIG. 25-7. Christmas tree adapter for positive-pressure foreign body removal.

To anesthetize the tonsil, after applying topical anesthesia, inject 1 mL of 1% lidocaine with 1:250,000 epinephrine above the tonsillar fossa, followed by 1 mL infiltration of both the posterior and the anterior pillar, followed by 1 mL injected through the anterior pillar into the tonsillar bed to "float" the tonsil forward.[16]

Direct Laryngeal Exam

Direct laryngoscopy is a relatively easy way to examine the larynx and vocal cords. The only tools needed are a laryngoscope and topical local anesthetic for the oral mucosa, tongue, oropharynx, and larynx.

Topical anesthesia can be as simple as spraying lidocaine and having the patient gargle with 4% lidocaine viscous to anesthetize the oral cavity and pharynx. The vocal cords can then be sprayed under direct vision when the laryngoscope is inserted. An alternative method of anesthetizing the vocal cords, if that is necessary to remove a foreign body, is to spray or syringe 2 mL 4% lidocaine into the nose. Then insert a nasal airway coated with lidocaine ointment, apply cricoid pressure, and spray or inject 4 to 5 mL of 4% lidocaine down the tube directly at the larynx.[16]

If topical anesthetic is not available, an oral block that includes the tongue, such as the Gow-Gates block (see the section on blocks in Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment), may be used.

Carefully explain the procedure to the patient: You need their full cooperation. Stand at the patient's head as you would when intubating. Have suction available, as well as long blunt (Magill) forceps if you suspect a foreign body. Lay the patient nearly flat with his head on a level with your mid-chest. Then, carefully insert the laryngoscope into the patient's mouth, trying not to touch any non-anesthetized structures. Ask the patient to pant, say "E," and do the other maneuvers to have the vocal cords move or to otherwise evaluate the larynx, and to visualize and remove a foreign body.

Peritonsillar Abscess

After anesthetizing the mouth and pharynx, use a laryngoscope to provide exposure when draining a peritonsillar abscess. The patient should be sitting and the laryngoscope handle should point down toward the patient's waist.

Possibly less intimidating to the patient than the laryngoscope, the bottom half of a disposable, clear plastic gynecologic speculum, with a light source attached, can be used to depress the tongue and illuminate the pharynx.[34] Another option is to tape a penlight to the proximal end of a tongue blade—this provides direct vision and allows the practitioner to have one hand free to do procedures.

Pharyngitis

Patients' sore throats can be relieved with a variety of solutions, including warm saltwater gargles, a topical anesthetic, lozenges, and so forth. Not often used is gargling with a suspension of two crushed, regular-strength aspirin tablets dissolved in a small amount of warm water. Relief usually lasts for several hours. However, using coated or buffered aspirin does not work; neither does acetaminophen.[35]

Oral Mucositis Analgesia

Patients on chemotherapy and radiation therapy often have intractable pain from oral mucositis. Ketamine provides effective analgesia if used as an oral rinse. To make a rinse, mix 0.2 mL ketamine 100 mg/mL (20 mg) with 5 mL of artificial saliva. Have the patient swish it around his mouth and expectorate after 1 minute. The artificial saliva (1% sodium carboxymethylcellulose and 3% sorbitol) helps local irrigation and mucosal retention. Repeat this every 3 hours as needed, for months if necessary.[36]

TRAUMA

General Principle

As described by Dr. Sir Harold Gillies during World War I, patients with maxillofacial trauma die if their airways are not protected.[37] His method was to sit patients up or put them on their side with their face down. If a patient with a severe maxillofacial injury has no neck injury or is awake and cooperative so that he can protect his spine, the patient will be best served by sitting him up or putting him in the "recovery" position.

Nasal Fractures

To reduce brisk bleeding from a nasal fracture, intermittently pack the nose with adrenaline-saline gauze.

Most nasal fractures do not need to be immediately reduced, and when swelling exists, there is no good way of determining the proper orientation. If a nasal fracture does need reduction, stabilize the septum with metal scalpel handles or major artery forceps wrapped in gauze or with rubber tubes slipped over their blades. "Grasp the nose septum and wings: Mobilize the fragments by traction and careful twisting. Model the nose into normal configuration."[38] Then pack both sides of the nose for 1 week.

Midface Fractures

Midface fractures, if displaced backward, may occlude the airway. If this is suspected, simply grab the midface and pull it forward. If it is unstable, maintain manual traction on the nose to keep the segment forward.[39] If necessary (and if the patient is unconscious or chemically paralyzed), one or two fingers can be introduced behind the soft palate to pull it forward. If this works, use heavy sutures placed around stable anterior teeth as a handle to continue traction.

Lacerations

Tongue Lacerations

Suture any tongue laceration >1 cm long or that splits the tongue anteriorly. Also suture any laceration large enough to trap food particles. Anesthetize the tongue using a Gow-Gates or an inferior alveolar block (see the section on blocks in Chapter 23, Dental: Diagnosis, Equipment, Blocks, and Treatment), which may need to be done bilaterally. Alternatives are to do a lingual nerve block or, if the laceration is small, apply gauze soaked in 4% lidocaine to the wound for 5 minutes.

To perform a lingual nerve block, insert a 25- or 27-gauge needle just posterior and medial to the most distal molar. After aspirating, inject ~1 mL of local anesthetic with epinephrine. The needle should be inserted 0.5 cm in children and 1 cm in adults.

Before suturing begins, secure the tongue by having an assistant (or the patient, if cooperative) hold the tip with gauze. An alternative is to place a suture, towel clamp, or safety pin vertically through the tip (as shown in Figs. 8-2 through 8-4). Irrigate the wound and close it with 4-0 or 5-0 absorbable sutures. (You don't want to have to take these stitches out!) Pass the suture through at least one-half of the tongue's thickness with each stitch. Tie the sutures loosely, since the tongue tends to swell. Tying the knots over an instrument or the wooden end of a cotton swab lying on the laceration helps keep the sutures loose enough. Put 4 to 6 knots in each suture or they will unravel when the patient talks, eats, or just fiddles with the sutures. Applying cold (e.g., ice, Popsicles) to the tongue for the next day or so helps relieve the swelling and pain.

Lip Lacerations

The most difficult part of treating lip lacerations is carefully approximating the vermillion border. Anesthetizing the lip with an infraorbital block makes it easier to do this since it does not distort the tissues. This block is also effective for the anterior maxillary teeth and the external anterior nose.

While an infraorbital block is actually a regional block for the upper (maxillary) incisors, the lip, and the side of the nose (Fig. 25-8), the procedure is a simple extension of a supraperiosteal infiltration. It often has to be performed bilaterally, especially for lacerations involving the middle third of the upper lip.[40] The needle, inserted over the upper canine tooth, needs only to advance about 2 cm so that the needle tip is over the most prominent part of the cheek (malar eminence) (Fig. 25-9). Experience shows that injecting 2 to 3 cc of 2% lidocaine with or without epinephrine works nearly 100% of the time.

Gingival Mucosa

To close a laceration at the juncture of the upper lip and gingiva above the upper incisors, pass a 4-0 or 5-0 absorbable suture through one piece of the mucosa of the avulsed lip, completely

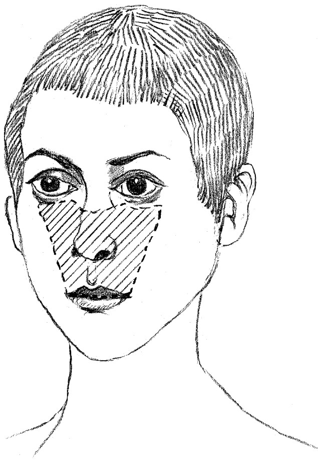

FIG. 25-8. Areas anesthetized with bilateral infraorbital block.

around the adjacent tooth to the inside of the mouth and then out. When it is on the other side of the tooth, pass it through the avulsed tissue flap again and tie it. Repeat this process at the level of each tooth that abuts the laceration. Remove these sutures, even if absorbable, in 1 week. If the teeth are so tight that the sutures cannot be passed between them, insert them using a flossing action.[41]

Mandible

Mandibular Dislocations

Always attempt to reduce temporomandibular joint (TMJ) dislocations using standard methods and local or general anesthetics. In austere situations, patients may not present for some time after the dislocation occurs. Mandibular dislocations that have been out for more than 48 hours may be difficult to reduce. In difficult cases, try one of the following methods.

In either difficult cases or when no anesthetic is available, a TMJ dislocation can be gradually reduced by first placing as many tongue depressors as possible, stacked one on top of the other,

FIG. 25-9. Infraorbital block technique.

into the existing space on the side with the most prominent dislocation. Then insert new tongue depressors, one at a time, into the stack. The TMJ spasm should gradually relax enough for the joint to relocate.[42] If that doesn't work, try placing splints on the upper and lower teeth (see Chapter 24, Dental: Fillings, Extractions, and Trauma for splinting techniques.)

Mandibular Fractures

The first screen for a mandible fracture is to ask the patient if their teeth or, even better, their dentures fit like they used to. The absence of malocclusion virtually rules out a mandible fracture. A remarkably accurate test (96% sensitive, 65% specific) for mandibular fractures is to put a tongue blade between a patient's teeth (or have them do it) and ask them to bite down on it, bend it, and try to break it. People with normal mandibles are able to do it. Mandible fractures can be treated with soft diets and splints, as described in Chapter 24, Dental: Fillings, Extractions, and Trauma.

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26 | Neurology/Neurosurgery

EVALUATION/DIAGNOSIS/TREATMENT

Lumbar Punctures

Lumbar punctures provide invaluable information if the local culture allows them to be done and if the laboratory can analyze the specimen. In children <5 years old, consider using a short small-gauge hypodermic needle; a butterfly needle works well in infants. For children >5 years old, use a standard lumbar puncture needle, if one is available. Otherwise, a longer small-gauge hypodermic needle may work, depending on the child's size.

Lumbar puncture needles may need to be reused. While this is potentially dangerous, it may be safer to reuse these needles than to reuse hypodermic needles. The obturator allows large material to be cleaned out of the needle's core. After cleaning, the needles should be steam autoclaved. If that is not possible, high-level disinfection by boiling has been recommended.[1] To do this:

1. Put the needles into a pan and cover them with 3 cm of potable water. Put the lid on the pan and bring the water to a boil. Once it begins to boil, keep it boiling for 15 minutes.
2. While holding the lid on the pan, pour out the water without letting the needles fall out. This is not as easy as it sounds; practice this before you boil the needles.
3. Leave the nearly dry needles in the covered pan until they are needed. Never put them anywhere else.

Psychogenic Disorders and Malingering

Patients with psychogenic neurological disorders may present with bizarre motor findings and neurological tests that indicate a functional disorder (described below). They usually will have normal muscle tone, no atrophy or fasciculations, and no ataxia, although they may try to simulate it. The following are a number of quick, easy tests that suggest a patient may be malingering—or not. In resource-poor settings, you will have to rely on these simple tests; in other settings, they can save clinicians time and effort.

The Hoover Crossed-Leg Test is for leg strength. A supine person who tries to lift his straight leg against gravity or resistance will push down (for leverage) with the other heel. To do the test, the examiner asks the patient to lift the affected leg while keeping one hand under the patient's other heel. No or little pressure on the examiner's hand while the person says he is trying to lift his leg signifies malingering—as long as both legs are not affected. A more effective modification is for the examiner to put a thumb over both ankles while doing the test (Fig. 26-1). This provides additional resistance to lifting the leg and also provides information on the relative strength exerted by each leg.

The Crossed-Hand Test (Fig. 26-2) is used to discover whether a complaint of unilateral hand numbness is valid. Have the patient cross his arms at the forearm level, turn the palms facing each other, and interlock the fingers. Then, if the patient is limber enough, he can bring his hands up in front of his face. With the patient watching, test the sensation in the fingers. Visual miscues due to the hand position will cause malingerers to pause before responding to sensation when the examiner touches each finger; they often identify the sensation incorrectly.

"Splitting the tuning fork" identifies patients with psychogenic sensory disturbance. These patients typically have a sharply demarcated loss of sensation to the midface. Use a tuning fork to test vibratory sensation on both sides of the forehead. These patients often complain that they lack vibratory sensation when tested on the affected side of the forehead, but will have intact vibratory sensation on the unaffected side. Of course, that isn't possible, as the vibration is transmitted through the frontal bone to both sides.[2]

"Opticokinetic testing" is used for individuals who claim to be blind but aren't. To induce opticokinetic nystagmus (vertical, horizontal, or rotational), have the patient look at moving visual stimuli, usually on a special rotating drum. If patients have nystagmus, it means they

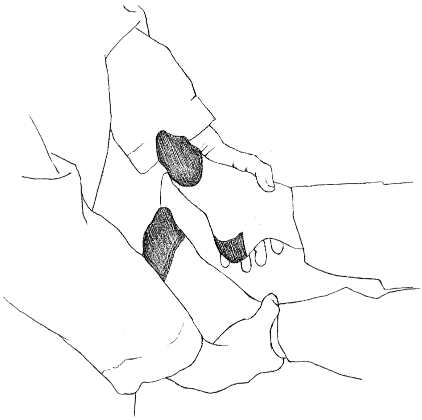

FIG. 26-1. Hoover crossed-leg test.

can see the drum. Improvising opticokinetic testing equipment is easy: Make an opticokinetic drum by attaching a paper with alternating black and white stripes around an empty soda can. Alternatively, use a black sheet of paper with multiple strips of white tape (about 2 cm wide) attached so that there are alternating stripes of black and white. Make a photocopy of this and wrap it around an empty soda can. Extend a straight piece of metal, such as a hanger, through the top and bottom parts of the can as a handle to rotate the drum. Another method of eliciting opticokinetic nystagmus is to pass a vertically striped cloth (such as a striped tie) horizontally across the patient's visual field at about 5 to 10 cm/second. A measuring tape with large markings also works well. This reflex can be elicited starting at about 4 to 6 months of age, and confirms cortical vision.[3]

Tunnel vision may be another manifestation of psychogenic visual disturbance. Patients may complain that they can see only a tiny part of the visual field in the center of vision, not unlike looking through a soda straw. To test whether such a complaint is legitimate, do the following: Make a small hole (about the diameter of a pencil) in a piece of paper. Have the patient close one eye and hold the paper with the hole positioned over their open eye. Move your face in front of the paper such that the patient can see only your nose and then move back 3 to 6 feet from the patient and ask them what they see. If they say that they can see only your nose, they are feigning, because the degree of visual arc subtended has increased. In other words, they should

FIG. 26-2. Crossed-hand test.

see your whole face (at the very least). (Geoffrey Ahern, MD, PhD, University of Arizona, Tucson. Personal written communication received September 1, 2008.)

If the patient complains of being blind, but you do not think he is, leave some money on the floor and see how the patient reacts when he enters the room. (Joseph Miller, MD, PhD, University of Arizona, Tucson. Personal written communication received September 8, 2008.)

Another simple test is the "hand–face drop" test, used in patients with psychogenic coma who appear flaccid. When the patient's hand is held over their face and dropped, the patient in psychogenic coma typically avoids letting the hand hit their face by making subtle movements to the side.[2]

Monocular diplopia that does not correct using a pinhole device is almost always a functional problem.[4] And eyelids that flutter when a person is in "coma" means that they are completely awake. If you don't have time to wait for their spontaneous awakening, break two or three ammonia capsules and hold them under their nose.

Neuropathies

An early sign of a peripheral neuropathy is the inability to feel vibration. If a low-pitched tuning fork is not available, use a pager or a cell phone (set on vibratory mode) to see if a patient feels vibrations over bony prominences.[5]

If concerned about polyneuropathy in a patient, test their Achilles tendon reflex. Patients with normal Achilles reflexes rarely have a clinically significant polyneuropathy.[6]

Migraine Treatments

A large number of patients, especially when populations are under stress, will come in with the complaint of headache, often a "migraine." Historical and physical findings usually can differentiate their headaches from more serious problems. If a migraine is diagnosed, and if medications are limited, try using a medication from Table 26-1.

Migraine headaches may also be treated with paraspinal injections of local anesthetic and steroids, as described in Chapter 14, Anesthesia—Local and Regional.

Cluster headaches, often considered the most painful type of headache, can be aborted with oxygen by face mask, if it is available. Various medications, including corticosteroids, can suppress attacks during cluster periods. Two "street drugs," the ergot derivative lysergic acid diethylamide (LSD) and the related drug, psilocybin, have been the only ones to induce remissions of a cluster period. In "sub-hallucinogenic doses," LSD aborted the cluster period after one dose; psilocybin generally took three doses.[11]

Stroke Syndrome ("Brain Attacks")

Predicting a Stroke After a Transient Ischemic Attack

If a patient with a transient ischemic attack (TIA) presents, how many resources must you devote to this patient? In other words, what is the chance of this patient developing a stroke in the next seven days? Use a scoring system, such as the one below, to help determine the answer.

The six-point ABCD Scale uses a score calculated on the basis of the patient's **A**ge, **B**lood pressure (BP), and **C**linical features, as well as the **D**uration of symptoms. Assign points according to the list below and then add them to get the ABCD score:

Age	≥60 years = 1 point
	<60 years = 0 points
Blood pressure	systolic >140 mm Hg or diastolic >90 mm Hg = 1 point
Clinical features	unilateral weakness = 2 points
	speech disturbance without weakness = 1 point
	other symptoms = 0 points
Duration of symptoms	≥60 minutes = 2 points
	10-59 minutes = 1 point
	<10 minutes = 0 points

TABLE 26-1 Migraine Treatment, Selected Alternative Medications

Medication	Dose
I. ABORTIVE AGENTS	
A. Oral or Sublingual	
Acetaminophen	325-1300 mg
Acetaminophen/butalbital/caffeine	325-650 mg acetaminophen
Aspirin	325-1950 mg
Aspirin/butalbital/caffeine	325-650 mg aspirin
Dexamethasone	4-8 mg
Ergotamine tartrate (sublingual)	2 mg; then 1 q30min PRN. Max 6 tabs/24 hr and 10 mg/week
Ergotamine tartrate/caffeine	2 tabs, then 1 q30min × 4, PRN. Max 6 tabs/attack
Ergotamine tartrate/caffeine (suppository)	0.5-2 mg ergotamine; may repeat once after 1 hour
Ibuprofen	400-800 mg
Indomethacin	25-50 mg
Isometheptene/acetaminophen/dichloral phenazone	325-975 mg acetaminophen
Ketorolac	10 mg
Naproxen	500-1000 mg
Sumatriptan	50-100 mg; may repeat in 2 hours. Max 200 mg/24 hr
B. Parenteral	
Butorphanol	2 mg IM or intranasally
Chlorpromazine	7.5-37.5 mg IV (slowly) or 25-50 mg IM
Dexamethasone	12-20 mg IV or IM, may follow with prednisone taper: 60 mg × 1 day; 40 mg × 1 day; 20 mg × 1 day
Dihydroergotamine	0.75-1 mg IV or SQ, or IV over 2-3 minutes (premedicate with 10 mg metoclopramide or prochlorperazine); may repeat qh to max 3 mg/24 hr and 6 mg/week 1 spray (0.5 mg) into each nostril; may repeat q15min Max 3 mg/24 hr
Droperidol	2.5 mg IV or IM
Ergotamine/caffeine	1 rectal suppository; may repeat in 1 hour
Hydrocortisone	100-250 mg IV over 10 min; may follow with prednisone taper: 60 mg × 1 day; 40 mg × 1 day; 20 mg × 1 day
Ketorolac	30 mg IV or 60 mg IM
Magnesium sulfate	2 g IV over 30 minutes
Metoclopramide	10-20 mg IV
Oxygen	100% by mask at 8-10 L/min for 30 minutes
Prochlorperazine	5-10 mg IV
Sumatriptan	6 mg SQ; 5-20 mg intranasally; may repeat after 2 hours. Max 40 mg/24 hr
Zolmitriptan	5 mg intranasally; may repeat after 2 hr

(*Continued*)

TABLE 26-1 Migraine Treatment, Selected Alternative Medications (*Continued*)

Medication	Dose
II. PROPHYLACTIC AGENTS	
Amitriptyline	30-150 mg qhs
Candesartan	8-32 mg qd
Divalproex sodium	250-500 mg bid; extended release 500 mg-1g qd
Lisinopril	5-40 mg qd
Metoprolol	50-100 mg bid; extended release 100-200 mg qd
Nadolol	20-40 mg qd
Naproxen	250 mg bid or tid
Nortriptyline	10-150 mg qhs
Propranolol	160-240 mg/d divided bid, tid, or qid; extended release 160-2400 mg qd
Timolol	10-15 mg bid or 20 mg qd
Topiramate	50 mg bid
Verapamil	80 mg tid or qid; extended release 240 mg qd

Abbreviations: bid, twice a day; IM, intramuscular; IV, intravenous; qd, once a day; qhs, at bedtime every night; qid, four times a day; SQ, subcutaneous; tid, thrice a day.
Data from Shah and Kelly,[7] Editors to Medical Letter,[8] Tintinalli,[9] and Rapoport.[10]

In one validation study of 274 consecutively enrolled patients with TIA (based on World Health Organization [WHO] standards), no patient with an ABCD score ≤3 had a stroke within 30 days. Of the patients suffering a stroke within 7 days, 20% had an ABCD score of 4, 40% scored 5, and 40% scored 6.[12]

Stroke Diagnosis

Nearly one-third of patients presenting with a possible stroke have a different diagnosis. With limited imaging and consultation, rapid clinical differentiation becomes especially important. It saves resources and can guide therapy and diagnostic measures in the correct direction.

The likelihood that the patient had an acute stroke increases dramatically if there is a definite history of focal neurological symptoms (odds ratio = 7.21), if you know the exact time that symptoms began (odds ratio = 2.59), or in the presence of any cardiovascular abnormality (systolic BP >150 mm Hg, atrial fibrillation, valvular heart disease, or absent peripheral pulses; odds ratio = 2.54).[13] On presentation, a stroke is more likely if the patient has facial paresis, arm drift, or abnormal speech (odds ratio = 5.5). If none of these symptoms are present, it is unlikely that the patient had a stroke (odds ratio = 0.39).[14]

TRAUMA

Head Injury

Determining True Coma/Level of Consciousness

Is the patient unconscious? Hysteria, psychological disease, drugs, or alcohol may all make patients seem unconscious when they are not. The following are simple, rapid methods to test for the level of wakefulness in these patients:

- *Sternal rub*: Use your knuckles and progressively increase pressure as you rub.
- *Ammonia capsules*: Break three or four and cup them in your hand. Place your cupped hand firmly over the patient's mouth and nose.

- *Supraorbital nerve pressure*: Similar to a sternal rub; be careful that your finger doesn't slip and injure the eye.
- *Jaw pull*: Place your second and third fingers behind the ascending ramus of the mandible and pull the patient's jaw forward.
- *Nose-hair tickle*: Use cotton strands (e.g., from a cotton swab) and gently stimulate the hair inside the nares.
- *Rectal exam*: Part of the normal full exam for unconscious patients, this procedure may arouse the hysteric. When done in unconscious patients who are about to be chemically paralyzed for intubation, the absence of tone means they are paralyzed from a spinal injury.
- *Foley catheter* (especially males): This stimulation will usually awaken any male who can be awakened by external stimuli.

The simplest way to transmit information about the level of head injury is by using the Glasgow Coma Score (GCS; also known as the Glasgow Coma Scale). An alternative is the AVPU scale widely used in prehospital care: **A** = alert; **V** = responsive to verbal stimuli; **P** = responsive to painful stimuli; and **U** = unresponsive. Neurological consultants will want to know this critical information, especially when you ask for their advice or when you want to transfer head-injured patients to them.

Common Mistakes

Do not rely on the ophthalmoscopic exam to show evidence of acute rises in intracranial pressure. These changes appear only in chronic conditions, but retinal hemorrhages can be seen in infants with head injuries from child abuse.

In the midst of turmoil, be careful not to let easily salvageable head-injured patients die because (a) you confused a bad scalp laceration with an open skull fracture or (b) you did not control significant scalp bleeding. Control scalp hemorrhage by simply wrapping a tourniquet-type bandage around the head above the eye line. (Remember that all vessels to the scalp travel up from the neck.) When the bleeding slows, quickly use scalp clips, staples, or big sutures to stop the bleeding; then remove the tourniquet. Do a better closure later, if necessary.

Unsalvageable Head Injuries

Knowing which patients will not survive is the key to maximizing the use of limited resources to treat hordes of multiple and severely injured patients. As the US military recognizes, "the prognosis of brain injuries is good in patients who respond to simple commands, are not deeply unconscious, and do not deteriorate. The prognosis is grave in patients who are rendered immediately comatose (particularly those sustaining penetrating injury) and remain unconscious for a long period of time."[15]

Similarly, Dr. Husum and colleagues, in their book, *War Surgery*, write about patients who are "beyond salvation," saying that "bilateral dilated pupils that do not improve after a few hours in a comatose [head-injured] patient are a sign of major brain injury which normally will not respond to treatment. Operation in such cases is wasted."[16] In a similar vein, the US military writes that "a GCS ≤5 indicates a dismal prognosis despite aggressive comprehensive treatment, and the casualty should be considered expectant [comfort care provided, but not treatment]."[17]

Head Injury Decision Rules

In austere situations where computed tomographic (CT) scans are not readily available, it may be an extremely weighty and costly decision to send patients for a CT scan. The question is: How much chance of making an error is reasonable in your situation?

In resource-poor environments, the best option may be to use the Canadian Rules (Adult and Child), since these will detect more patients who actually need neurosurgical intervention.

Canadian Adult Rule (≥16 Years Old; GCS 13 to 15)

- GCS <15 within 2 hours after injury
- Suspected open or depressed skull fracture
- Any sign of basilar skull fracture (hemotympanum, raccoon eyes, otorrhea, rhinorrhea, Battle's sign)
- ≥2 episodes of emesis
- >65 years old
- Moderate risk of brain injury on CT scan

- Retrograde amnesia ≥30 minutes
- Dangerous injury mechanism (pedestrian struck by motor vehicle, ejection from motor vehicle, fall from 3 feet/1 meter or ≥5 stairs)

The Canadian Adult Rule has a sensitivity of 100% and a specificity of 38% for detecting any lesion requiring neurosurgical intervention, and a sensitivity of 87% and a specificity of 39% for detecting any clinically important CT abnormality.[18]

CANADIAN CHILD RULE

- Age <2 years
- GCS <15
- Mental status change
- Sensory deficit
- Palpable skull defect
- Any sign of basilar skull fracture (hemotympanum, raccoon eyes, otorrhea, rhinorrhea, Battle's sign)

The Canadian Child Rule has >95% sensitivity and ~49% specificity, with a negative predictive value of >99% and a positive predictive value of >11%.[19]

Head Injury Treatment in Austere Situations

Skull radiographs are still valuable in head injury management if other imaging is not available. Radiopaque foreign bodies, usually bullets, can be located using both postero-anterior (P-A) and lateral or stereoscopic films (see Chapter 18, Radiology/Imaging). Also, finding a skull fracture is useful because: (a) a patient with a simple skull fracture and no abnormal signs has a 1:30 chance of developing an intracranial hematoma; (b) if there are abnormal signs with the fracture, the risk rises to 1:4; and (c) an intracranial hematoma nearly always will be on the side of, and at the site of, the fracture.[20]

Spinal Injury

Positioning

Patients with facial injuries or who are not fully conscious should, as previously mentioned, be placed in the lateral decubitus or "recovery" position to preserve their airway. If a spinal injury is suspected, the method of rolling them into the recovery position, and the recovery position itself, should be slightly altered.

The HAINES (High Arm IN Endangered Spine) modified recovery position (see Fig. 8-1) has the patient's dependent arm (the one nearest the ground) extended above his head before he is rolled into the lateral decubitus position. When on his side, his head rests on that arm. This reduces lateral neck flexion to less than half of what it is when the dependent arm extends away from the body and the head droops down, as is normally the case. For patients in the HAINES position, flex their legs so the patients are supported on their side.[21]

Spinal Immobilization

CRITICAL DECISIONS

In remote or dangerous locations or in disaster settings when resources are minimal, decisions must be made about whether to follow standard field guidelines, that is, to immobilize the spine of anyone with a possible spinal injury.

As the National Association of Emergency Medical Services Physicians wrote, "Full-spine immobilization, if it is not required, can be unnecessarily difficult, impractical, impossible, and even dangerous during prolonged evacuation, especially in severe environments or when using improvised equipment."[22] That is not to say that you shouldn't make a reasonable effort to protect the patient's spine, but other factors may take precedence. Using the cervical spine decision rule as described under "C-Spine Decision Rule," later in this chapter, may help, but a situational assessment must accompany its use. Note that even after a decision about immobilization is made, it is necessary to reassess the patient over time, as the clinical picture may change.

C-Collar/Spine Immobilizers

While only bilateral sandbags held together with tape over the forehead has been proven to immobilize the spine in the prehospital and emergency department setting,[23] in emergency situations, cervical immobilization collars can be fashioned from a sleeping pad; a padded hip belt from a pack; any cloth, padding, or clothing; a tarp; or a tent flap. They may also be made from cotton and gauze and bandages (Schanz collar), newspapers, cardboard, blankets, plaster of Paris, or polyvinyl chloride (PVC) pipe, as described below.

Gauze (Schanz) Collar

To make a Schanz collar, wind a 5-inch-wide strip of cotton around the patient's neck several times. Over this, apply gauze to compress the cotton. Add additional layers of cotton and gauze, winding the gauze tighter as the collar's thickness increases. To get the desired effect, this collar should fill the entire submental space. As the collar loosens over time, apply additional cotton under the edges, with a tighter gauze bandage over it.[24] Although similar to a commercial "soft collar," a Schanz collar provides considerably more support.

Newspaper Collar

To fashion a useable c-collar from newspaper and socks, stack 10 open sheets of newspaper. Fold the stack in half along its longest dimension. Then fold it in thirds. The width should be appropriate for an adult. For a child, use seven sheets and fold them in half until the correct width for that child is found. Then slip a heavy sock over each end, pass the collar around the patient's neck, and secure it with tape, a scarf, a necktie, or bandage material.

Cardboard/Plastic Collar

The framework for this c-collar is made either from a corrugated cardboard box, such as that in which stores receive merchandise, or by cutting off the top of a plastic bucket. Cut an 18- × 6-inch piece and cut an indentation in the middle of one long edge to accommodate the chin; cut two shallower pieces from the sides where the collar passes over the shoulders. Finally, cut a shallow indentation on the upper (chin) side at each end of the piece to accommodate the occiput.

If using cardboard, bend it at multiple sites along its length so that it will easily encircle the neck. Next, wrap the cardboard with cotton, socks, or other soft padding materials. Then slip it into a stockinet or long sock, or wrap it with a tight elastic or gauze bandage (Fig. 26-3). Secure it around the neck with additional bandaging, tape, a belt, or a similar tie. The tightness of these ties determines how much stability the collar will have.[24]

Blanket Collars

Blanket rolls can be made and easily stored for use as cervical collars for patients who are supine, who are prone, or who must be kept on their sides. Blankets can also be used to make a collar for a seated patient. First, fold a heavy blanket lengthwise once. Then tightly roll it toward

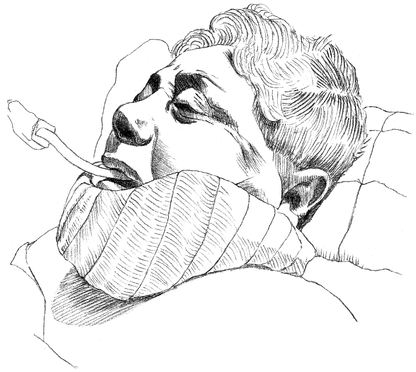

FIG. 26-3. Cervical collar from wrapped cardboard.

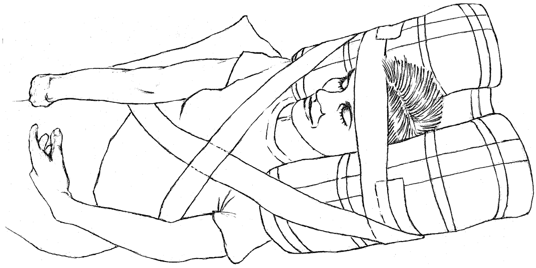

FIG. 26-4. Blanket roll as c-spine stabilizer for supine patient.

the middle from both ends. When the two rolls meet, tape the entire package together for storage. Experience shows that it needs two layers of tape. When a collar is needed, the tape can be cut and the rolls opened as far as necessary.

For a cervical collar (patient supine, prone, or on his side), open the two rolls wide enough to accommodate the patient's head and position the back of the roll behind the head (Fig. 26-4). Then put tape around the package. This is often easiest if the patient is on a backboard. For a seated patient, unroll the package, but keep the blanket folded. Roll it tightly lengthwise and wrap it around the patient's neck, with the ends overlapping across his chest. Tightly tape the two ends of the blanket together (Fig. 26-5).[25]

PLASTER OF PARIS COLLAR

Plaster of Paris has long been used as a c-collar. It can be placed over virtually any type of padding as a primary collar, or can be used to hold other materials (such as clothing being used as a c-collar) in place.[26] A c-collar made totally of plaster is heavy, so it is not generally used in ambulatory patients.

The cast must extend the entire length of the c-spine. It must have a broad weight-bearing base over the shoulders and support the jaw and occiput. Unless the patient is already in cervical traction, someone must maintain traction while the plaster is applied and until it sets. To apply it, put thick padding over the shoulders, jaw, and occiput. Next apply two broad plaster slabs—one anteriorly and the other posteriorly. Then apply the plaster around the neck to secure these slabs.[27] The problem with this collar is that once applied, it is difficult to adjust. "After the first day, or two, a certain amount of play will develop from compression of the padding material."[24]

FIG. 26-5. Blanket roll stabilizing c-spine in seated patient.

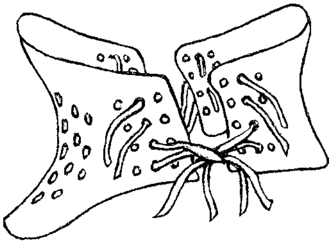

FIG. 26-6. C-collar from PVC pipe.

PVC Pipe Collars

More durable cervical collars can be made from pieces of a large plastic (PVC) drain pipe. Although these collars take some time to make, PVC pipe is ubiquitous and the collars last a long time.

Use a piece of pipe that has an internal diameter of the neck(s) you want to stabilize, and saw the piece in half. Drill 0.25- to 0.5-inch holes in it so air can pass through to the neck for comfort. Drill smaller holes along the edges that fit together and use lacing to close the two halves around the neck (Fig. 26-6). Making multiple rows of holes for lacing material allows this collar to be used on various sized patients.

Shape the collar so that it will fit better around the neck, chin, and occiput by placing it in boiling water or by using a welding torch or other low-intensity flame to soften it. If a flame is used, take care not to burn the plastic.[28] (See Chapter 27, Ophthalmology, for more information on making medical equipment using PVC pipe.)

Thoracic and Lumbar Spine

A number of makeshift litters are described in Chapter 20, Patient Transport/Evacuation. However, many are not rigid enough to provide optimal support for suspected thoracic or lumbosacral spine injuries. Ideally, patients with a suspected thoracic spine injury should be immobilized from head to pelvis, with their hips adjusted for comfort. Patients with potential lumbar-pelvic injuries should have their thoracic spine, pelvis, and hips (in a position of comfort) splinted. This generally requires using a backboard, which can be made from a flat door, a piece of wood or metal (usually too heavy), or another strong flat object.

C-Spine Decision Rule

NEXUS C-Spine Rule

The NEXUS C-Spine Rule (Table 26-2) uses five very subjective criteria. If the patient meets all five criteria, he has a low probability of a clinically significant ("likely to result in any harm to patient") cervical spine injury. The NEXUS C-Spine Rule has a sensitivity of 99% and a negative predictive value of 99.8%.[29]

Removing the Collar

In austere medical situations when the patient cannot be imaged, you will need to make a decision at some point to remove the collar—or to leave it on long term. Remove spinal immobilization (without imaging) if the patient meets the c-spine rules for not applying a collar and the patient (a) is conversant, alert, and not inebriated on any substance; (b) has no spontaneous complaint of neck or back pain; (c) has no major distracting (painful) injury; and (d) has no neurological compromise on exam (i.e., can move all extremities, no tenderness on palpation of spine).

Traction

Reasons for Use

Cervical spine injury with neurological signs indicates the need for cervical traction.[30] For unstable c-spines, surgery or braces are generally used rather than traction. However, in austere

TABLE 26-2 NEXUS C-Spine Rule

1. No tenderness at the posterior midline of the cervical spine.*
2. No focal neurological deficit.†
3. A normal level of alertness.‡
4. No evidence of intoxication.§
5. Absence of clinically apparent pain that might distract the patient from the pain of a cervical-spine injury.‖

*Midline posterior bony cervical-spine tenderness is present if the patient reports pain on palpation of the posterior midline neck from the nuchal ridge to the prominence of the first thoracic vertebra, or if the patient evinces pain with direct palpation of any cervical spinous process.

†A focal neurologic deficit is any focal neurologic finding on motor or sensory examination.

‡An altered level of alertness can include any of the following: a GCS ≤14; disorientation to person, place, time, or events; an inability to remember three objects at 5 minutes; a delayed or inappropriate response to external stimuli; or other findings.

§Patients should be considered intoxicated if they have either of the following: a recent history provided by the patient or an observer of intoxication or intoxicating ingestion, or show physical evidence of intoxication on examination (such as an odor of alcohol, slurred speech, ataxia, dysmetria, other cerebellar findings, or any behavior consistent with intoxication). Patients may also be considered intoxicated if tests of bodily secretions are positive for alcohol or drugs that affect the level of alertness.

‖No precise definition of a painful distracting injury is possible. This category includes any condition thought by the clinician to be producing pain sufficient to distract the patient from a second (neck) injury. Such injuries may include, but are not limited to, any long-bone fracture; a visceral injury requiring surgical consultation; a large laceration, degloving injury, or crush injury; large burns; or any other injury causing acute functional impairment. Physicians may also classify any injury as distracting if it is thought to have the potential to impair the patient's ability to appreciate other injuries.

circumstances, traction may be the only option. The problem is that unless traction is being used only symptomatically for cervical disc pain or to reduce a subluxation, prolonged traction, long-term c-collar use, or surgery may have to follow at some point. Traction used for fractures of subluxations nearly always needs to be followed using radiographs. That is the only way to determine if there is sufficient weight pulling in the correct direction.

Halter Traction

Halter or sling traction is the easiest and least-invasive traction method; it can be used not only for unstable c-spines and subluxations, but also for cervical disc pain. If used for disc pain, it can be applied intermittently as an outpatient or used in the patient's home. When using this method, do not exceed 5 kg of weight (which may not be sufficient in spinal injuries). If used for spinal injury, attempt to replace it with a more formal traction method within 24 hours.[31]

Halter traction equipment can be easily and inexpensively made from local resources. The basic parts of the system are the pulleys, cord, head harness, and weights.[32] Pulleys are made from small pipes grooved to allow passage of the cord. These can be taken from orthopedic traction devices and attached to the end of the bed or stretcher. Any cotton or nylon rope is suitable, as long as it is strong enough to hold the weights and fits in the pulley grooves.

The head harness should be well padded with a soft cloth. It can be made from cow leather and sandal buckles. It could also be made from jeans or khaki clothing material, or from canvas (Fig. 26-7). Remember, the hole between the two strips must be wide enough to slip over the head.

Weights can be fashioned from 5-L heavy-plastic bags (irrigation bags), large jars, or plastic bottles. They should be calibrated in kilograms by water weight: add 1 L of water at a time and mark them at each level (1 L water = 1 kg). Hooks can be made from 0.25-inch metal rods shaped into an S.

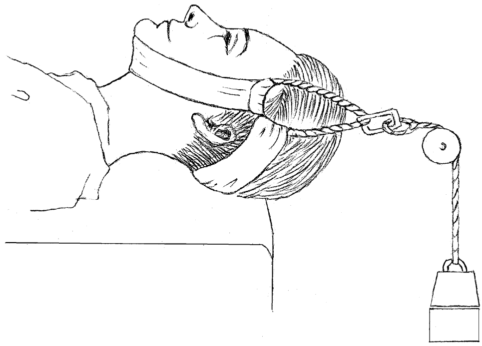

FIG. 26-7. Improvised halter.

Cervical Traction Management

These rules apply to most cases where cervical traction is being applied for acute trauma.[33,34]

1. Traction is strictly neutral—the patient's neck should be neither in flexion nor in extension.
2. Apply counter-traction by elevating the head of the bed about 4 cm for each kilogram of weight applied (as with femoral traction).
3. Traction weight for adults (larger individuals may need more): C1, use 2.5 to 5 kg; C2, 3 to 5 kg; C3, 4 to 7 kg; C4, 5 to 10 kg; C5–6, 7 to 15 kg.
4. Increase the weight stepwise, adding 2 kg every 4 to 6 hours. Use lateral c-spine radiographs at each step. The spinal deformity will gradually reduce under traction.
5. Analgesia prevents muscle spasms and makes the traction more effective.
6. Most c-spine fractures are in the correct position within 24 hours. The traction weights are then gradually reduced under radiographic control.
7. Displaced neck fractures >1 week old may require several days to reduce.
8. Displaced neck fractures >3 weeks old may not respond to traction. Stabilize them in a cast or a collar.

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27 | Ophthalmology

As with most medical areas, ophthalmology generally divides into diagnosis and treatment, although these frequently overlap. For clarity, this chapter divides ophthalmology topics into the broad categories of diagnosis and treatment.

DIAGNOSTIC EXAMINATION AND EQUIPMENT

Visual Acuity Testing

Testing visual acuity is, by far, the most important diagnostic test on the eyes; yet, it is frequently overlooked. Even with penetrating or apparently corneal-occluding injuries (e.g., alkali burns), test visual acuity in this order: light perception, movement, counting fingers, and reading/identifying at distance. Testing takes only a short time—just seconds if stopped at counting fingers—but provides invaluable information to the ophthalmologist.

Opticokinetic nystagmus can be elicited in children as young as 4 to 6 months old. The presence of nystagmus with an opticokinetic stimulus confirms cortical vision and the integrity of the frontal and parietal lobes and visual fields. A nonverbal or an uncooperative child's visual acuity also can be tested by offering the child various toys and seeing how he reaches for and plays with them.[1] (See Chapter 26, Neurology/Neurosurgery, for improvising opticokinetic test equipment.)

If an eye chart is not available, use a newspaper or magazine. Begin with the fine print. Stop if the patient can read that. If not, work up to the largest print the patient can read. That gives a rough gauge of the patient's visual acuity.

Standard eye charts are easy to manufacture. Copies can be downloaded from multiple internet sites, including the US National Eye Institute (www.nei.nih.gov/photo/keyword.asp?conditions=Eye+Charts). If copies are available, even in miniature, local printers can enlarge them to produce standard Snellen visual acuity charts, as well as "illiterate" eye charts (Landolt ring chart and "E" chart), on heavy paper and cardboard. Mount these on a heavier board and, if possible, laminate or cover charts with a plastic sheet for protection. Simultaneously, printers can produce small, pocket-sized charts for clinicians to use.

For patients who present without their corrective lenses or for those who have never gotten lenses but should have, there are two ways to test visual acuity: using either an ophthalmoscope or a pinhole device.

To test visual acuity using an ophthalmoscope, have patients cover one eye while looking at the eye chart through the ophthalmoscope. Have the patient hold the instrument as would a practitioner; the examiner should adjust the lenses to find the optimal one for the patient. If the visual acuity exam is done after an ophthalmoscope exam, start with the lens setting with which the patient's disc is best seen. If only a wall-mounted ophthalmoscope is available, a pocket eye chart may be needed to get the patient at the proper distance from the chart (generally 6 feet for a pocket chart and 20 feet for a standard chart). For supine patients, such as those suffering trauma, get a helper to stand on a stool and hold the eye card. Dr. Joseph Miller, a professor of ophthalmology at the University of Arizona, says that another option is to borrow someone's reading glasses and test the patient's vision with and without the glasses. (Personal written communication, received September 8, 2008.)

A pinhole device can also be used to determine a patient's optimal visual acuity. Make this device by cutting a 5-cm circular piece of opaque x-ray film and attaching it to a handle. Puncture the center of the film to produce a hole about the size of the head of a pin. Putting in more holes may improve the chance of some patients finding a hole to look through. Alternatively, use a paper cup with holes punched in the bottom rather than x-ray film (Fig. 27-1).

An even easier method is to remove the top from a salt shaker and use that as the pinhole device. While it may be little messy, a soda (e.g., Saltine) cracker with holes may also be used. Many elderly patients use cracker holes to read the menu in restaurants, so we know it works.

FIG. 27-1. Pinhole device improvised from paper cup.

Color Testing

Color vision testing probably won't be important in austere circumstances. But, if it becomes necessary, the only method is to ask the patient if he (nearly always a "he") can tell you the color of various objects in the room. Choose red, green, violet, and pink objects, since red-green color blindness is most common. The only caveats are (a) be certain that you have good color vision yourself to get a baseline and (b) be aware that there is a spectrum of "normal" color vision.

Retracting Eyelids

Eyelids may need to be manually opened for examination or treatment, particularly in patients with periorbital swelling due to trauma or infection or to look under the lids for foreign bodies. Perform this exam as early as possible after the patient presents; the swelling may progress enough that it may be nearly impossible to examine the eye later without surgery. Opening massively swollen eyes may reveal the most surprising result—a normal eye with normal vision. Without the exam, however, you won't know that.

The best way to open swollen eyelids is to use lid retractors. If the patient is conscious, drop in some topical anesthetic. Open a paperclip so that the small (inside the clip) and large (outer part of the clip) pieces are in the same plane (i.e., flat) (Fig. 27-2). Use a clamp to hold one end and bend it 180 degrees. (With some paperclips, this can also be done by hand, although that's not recommended.) Bend the larger side for use in adults; the smaller side is best for children. Clean the paperclip and use it as a lid retractor. Use two if both the upper and lower lids must simultaneously be retracted, which is usually the case (Fig. 27-3). These can be sterilized and reused.

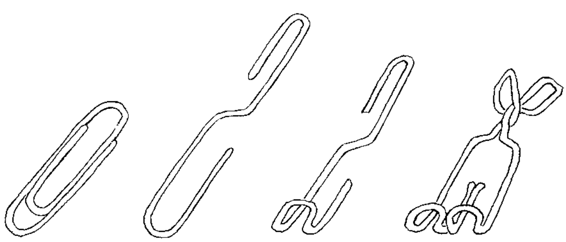

FIG. 27-2. Eyelid retractors from paperclip.

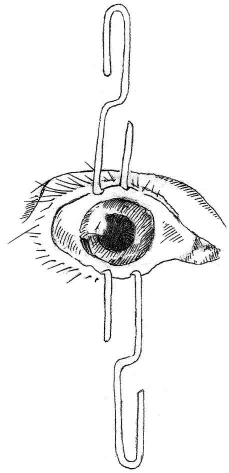

FIG. 27-3. Using eyelid retractor made from a paperclip.

In the operating room, tie a suture to the paperclip and secure that to the drape. If you have a sterile rubber band, secure that to the paper clip: it provides additional laxity, if you need it. Occasionally, a 7-0 (or smaller) silk or nylon suture is used for lid retraction. Pass it through the lid just above the lash line and pass it back through so it is just on the other side of the lashes. Do not penetrate the palpebral conjunctiva.

Ophthalmoscope

For a better view of the sclera and cornea during the examination, use an ophthalmoscope or put a (an additional) pair of reading glasses or a handheld magnifying lens between your eye and the patient's.

Focusing With an Ophthalmoscope

In truth, many clinicians no longer routinely use an ophthalmoscope. So, using the ophthalmoscope may be challenging. This method helps you get a clear view of the fundus if you are unable to focus when using the diopter lenses. Wear your glasses and have the patient put on his eyeglasses. Flip the ophthalmoscope lenses until the fundus comes into focus. Then both of you remove your glasses so you can take a closer look.[2,3]

Improvised Ophthalmoscope

A method of constructing an improvised ophthalmoscope uses a flashlight, a 2-cm-diameter piece of black polyvinylchloride (PVC) pipe, aluminum foil, glue, a drill, a small saw, and an oven (Fig. 27-4).

1. Cut a 15-cm piece of pipe; then cut one end so that it has a 45-degree angle "beveled edge" (B).
2. Cut another 10-cm piece of pipe and split it lengthwise; heat it to obtain a flat piece of PVC. (See "Heating PVC Pipe" that follows.)
3. Cut this flat piece into two discs: one disc (C) is the same diameter as the glass at the front of the flashlight, which it will replace. (If you have a small [mini-] mag light, that may provide a better view.) Drill a 2-cm hole in its center. Cut the other disc (A) so that it fits over the beveled end of the long pipe (B).
4. Cover the inside of the pipe (B) with aluminum foil, except for the tip at the beveled end. The bright side of the aluminum foil should face the center of the pipe to increase illumination.
5. Cover one side of the flat PVC disc (A) with aluminum foil and drill a small hole through its center (D).
6. Drill another, slightly larger, hole (E) directly opposite to where the disc's hole will be, at the end of the long piece of PVC pipe (B). This (hole E on pipe B) is the viewing port.

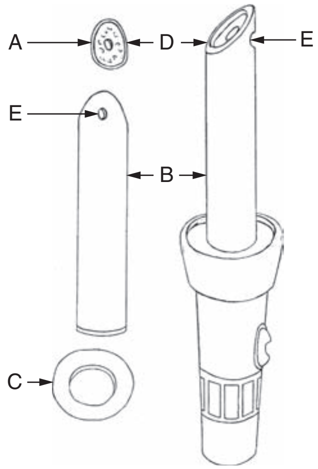

FIG. 27-4. Ophthalmoscope improvised from PVC pipe and a flashlight.

7. Attach the oval disc (A) to the beveled end of the PVC pipe (B) with glue.
8. Glue the "non-viewing" end of the long pipe (B) to the round piece with the 2-cm hole (C). Both PVC glue and cyanoacrylate work. Remove the flashlight's glass and replace it with the flat end of the device. The ophthalmoscope is ready for use. This device provides enough light to observe an upright image of the optic disc without needing to dilate the eye. For refraction, use either a lens-correcting set (such as optometrists use) or various eyeglass lenses.[4]

Heating PVC Pipe

To flatten pieces of PVC pipe, they must be heated. Since PVC pipe emits dioxins and other toxic, potentially cancer-causing gasses, heat it in a well-ventilated area, preferably outside, while wearing a good protective mask. If possible, work on a large flat piece of wood since it acts as a good insulator, allowing the pipe to stay warmer longer. Wear gloves to protect your fingers and slowly heat the PVC with one of the following: (a) a propane torch (keep enough distance to not burn the pipe); (b) a heat gun, which will not burn the pipe; (c) very hot or boiling water (dip the piece into the water until it heats completely through and repeat as necessary); (d) an ordinary heat lamp; or (e) another heat source, such as a kerosene heater. Keep testing the pipe with a gloved finger until it becomes flexible, like rubber. Put a flat, fireproof object (like metal) on it. Once the PVC pipe is flat, cool it by spraying it with or dunking it in cool water.

Indirect Ophthalmoscopy

Ophthalmologists who want to do indirect ophthalmoscopy, but who don't have the standard equipment, may succeed in the unconscious patient with fixed, dilated pupils. Hold a ≥2-inch-diameter handheld magnifier positioned at arm's length, about 4 cm from the patient's eye. Use a direct ophthalmoscope as a light source (preferred), a transilluminator (second choice), or a Mini-Maglight (focused to the smallest possible spot, a distant third choice as it can be quite tricky). You can get a nice, wide-field view of the retina and optic nerve. It is the best way to see hemorrhages and so forth. With good-quality 4X and 5X magnifiers (corresponding to about 20-diopter lenses), it works well. However, the cheapest handheld magnifiers (3X magnification, costing about 30 cents) produce too poor an image to use. If using the direct ophthalmoscope, set it so you can see the magnifying glass clearly and in focus. An aerial image of the retina forms about 3 inches in front of the lens. This wonderful trick does not require the fancy headlamp that ophthalmologists routinely use. (Joseph Miller, MD, PhD. Personal written communication, received September 8, 2008.)

Non-traumatic Eye Conditions

Non-traumatic eye complaints are common. Table 27-1 provides a method of differentiating among them. Some, such as an external hordeolum (sty), are usually minor problems; a corneal ulcer can be a serious, and potentially sight-threatening, condition.[5]

Glaucoma

If a tonometer is not available, a gross screen for glaucoma is to check visual fields. Bilateral loss of lateral vision is common with late glaucoma because of the damage to the optic nerve.

Another option to assess the intraocular pressure by using your fingers is known as digital ocular compression. This method is highly inaccurate. However, left with no other choice, it is worth trying. Ask the patient to close their eyes and try to stare straight ahead. Alternate between depressing and releasing the cornea of one eye using two index fingers placed side by side. Pushing with just one finger or somewhere on the eye other than on the cornea simply tests how easy it is to push the eye back into the orbit. The easiest method to "calibrate" this exam is to do it on a normal subject (not yourself) and immediately do it on the patient. (Joseph Miller, MD, PhD. Personal written communication, received September 8, 2008.)

Another useful tool, which has been the gold standard for more than 50 years, is the Schiøtz indentation tonometer (Fig. 27-5). It is inexpensive and does not require a power source. It measures how far a fixed, weighted plunger can indent the cornea. Although less accurate than applanation tonometers, if used correctly it provides good information about intraocular pressure. To use the Schiøtz tonometer correctly, (a) anesthetize the eye with a topical anesthetic, (b) zero it using the fixed metal piece that comes in its case, (c) open the lids widely, (d) hold it only by the "side rails" (Fig. 27-6), and (e) have the patient hold his ipsilateral thumb in front of him to stare at during the procedure. The mean intraocular pressure (IOP) in normal adults is 15 to 16 mm Hg; the normal range (mean ±2 SD) is 10 to 21 mm Hg.

Ultrasound

Ultrasound, available in many remote and austere circumstances (e.g., the International Space Station), provides an excellent diagnostic tool for intraocular abnormalities. Ultrasound may be able to define lesions that cannot be seen due to their being obscured by blood or due to the lack of an ophthalmoscope (or the ability to use one well).

To examine the eye with ultrasound, use a linear array transducer in the 7.5- to 15-MHz frequency, which is the same one used for soft tissue exams, line placement, and musculoskeletal exams. Set the machine on a "small parts" setting if there is one. Have the patient close his eyes and fill the orbit you will examine with a large amount of gel—a really whopping amount. (Put lots and lots of gel into the orbit!) That allows an exam without any discomfort to the patient; the transducer should never touch the eyelid.[7]

To avoid a shaky image, the examiner should rest his arm on a bony part of the patient's face, such as the ridge of the nose or the eyebrow. The anterior and posterior chambers, the lens, and the optic nerve are easily seen. During the procedure, adjust the gain to avoid artifacts. The transducer should be used not only in the vertical and horizontal positions, but also swept side to side across the eye. The patient, if cooperative, can help by moving the eye in various directions when instructed to do so.[7]

Common abnormalities that can be evaluated using ultrasound are retrobulbar hematomas; vitreous hemorrhage; globe perforations; foreign bodies; optic nerve abnormalities; lens dislocations; and vitreous, choroidal, and retinal detachments. As with any imaging study, the more experience one has, the better he can define and understand the images.

Disinfecting Ophthalmological Equipment

If disposable covers are not used, applanation tonometers routinely become contaminated. In austere situations, even if tonometers are available, there probably will not be disposable covers. This poses a risk of contaminating patients with a variety of organisms, including those causing epidemic keratoconjunctivitis. Rather than the ineffective practice of wiping them with 70% isopropyl alcohol, which is frequently done, tonometers can be disinfected by immersing them for 10 minutes in 0.05% sodium hypochlorite (1:100 dilution of bleach in water) or a 3% hydrogen peroxide solution. Soaking them in 70% alcohol destroys the tip.[8]

TABLE 27-1 Differential Diagnostic Features of Non-traumatic Eye Complaints

Symptoms and Signs	External Hordeolum (Sty)	Internal Hordeolum	Chalazion	Conjunctivitis	Anterior Uveitis	Corneal Ulcer
Eye pain	Sensation of foreign body	Sensation of foreign body possible	Sensation of foreign body possible. After a few days, signs and symptoms resolve	Itching or burning	Moderate to severe dull ache	Moderate to severe
Vision	Normal	Normal	Normal	Normal	Blurred	Blurred
Photophobia	Possible	Absent	Absent	Absent to moderate	Present	Present
Discharge	Lacrimation	Absent	Absent	Present (purulent or watery)	Absent	Purulent
Redness/ inflammation	Usually localized, but may be diffuse	Localized	Grayish-red, freely moveable mass in lid. Conjunctiva red and elevated	Entire eye red, more pronounced away from cornea	Pink to red flush around cornea	Entire eye red, darker away from cornea
Pupil size	Normal	Normal	Normal	Normal	Constricted	Normal or constricted
Pupil shape	Normal	Normal	Normal	Normal	May be irregular	Normal
Pupil reaction to light	Normal	Normal	Normal	Normal	Diminished or absent	Normal or diminished
Special notes	Small, round, tender area of induration on lid margin	Small elevation or yellow area at site of affected gland, on conjunctival side of lid	If mass is nonmobile, it may be malignant	Rarely a serious condition	Moderately serious condition	Very serious condition

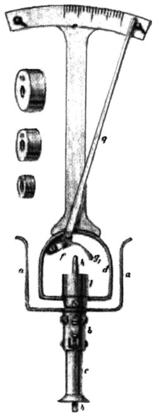

FIG. 27-5. Schiøtz indentation tonometer. (*Reproduced from Meller and Sweet.*[6])

Most other ophthalmological equipment can be disinfected in the same manner, using 0.05% bleach or 3% hydrogen peroxide. If equipment needs to be sterile, meaning no spores are present, they should be autoclaved.[9] (See Chapter 6, Cleaning and Reusing Equipment, for additional information.)

TREATMENT AND EQUIPMENT

Eyeglasses

Fitting for Eyeglasses

Commonly, donated or stock prescription glasses are available. Most clinicians are clueless about how to examine a patient for proper refraction, even if an optician is available to make the lenses. One option is to have the patient try on glasses until she can see objects clearly when they are held 15 inches (40 cm) from the eyes. That works for most patients.

Replacing Eyeglass/Surgical Loupe Hinges

Eyeglasses and surgical loupes (which provide magnification for both outpatient and operating room [OR] procedures) often break at their hinges. If the miniscule screw holding a hinge together is lost, the loss of eyewear can render a person incapable of functioning.

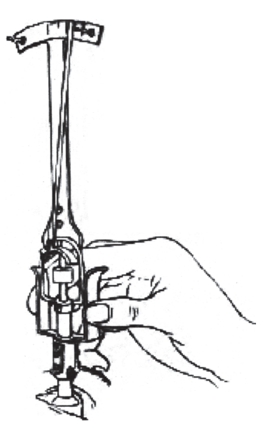

FIG. 27-6. Schiøtz indentation tonometer in use.

A simple temporary (or not-so-temporary) fix exists: while holding the hinge in position, pass a very small needle and 4-0 (or smaller) nylon suture through the hole for the screw. Depending on the hole's size, several passes may be made with the suture before it is tied in place. Experience proves that this works well.[10]

If the hinge joint has a larger screw hole, use a paperclip, safety pin, or similar small wire to hold it in place, at least temporarily. Of course, in a pinch, duct tape also works.

Nose Pads for Eyeglasses

Eyeglasses become almost nonfunctional without their nose pads—those little discs that allow the glasses to rest, more or less comfortably, on the nose. One successful method of replacing them is to sew small shirt buttons onto the metal posts coming out from the eyeglass rims.[11] For a balanced feel, both nose pads will probably need to be replaced if one is missing.

Improvised Glasses

Eyeglasses generally are improvised for two reasons—to see more clearly and to protect the eyes from damage caused by glare off snow, ice, or water.

To see more clearly, apply the same principle as for pinhole visual acuity testing: if a person looks through a small hole, only the rays passing straight through to the fovea are seen. This is, theoretically, the person's best vision. For temporary eyeglasses, punch multiple holes in a cardboard eye mask over both visual axes (Fig. 27-7, right). The person can wear the mask by attaching two paper clips or safety pins and connecting them with a rubber band. This works, but limits vision to a small area directly in front of the person.

Similar "glasses" can be made to protect the eyes from glare. To improve peripheral vision, make slits rather than holes in the eye mask (Fig. 27-7, left). An alternative is to stick wide black tape to itself (sticky side to sticky side) and punch holes or slits in it. Tie or tape it around the head. To make slits in eyeglasses, cover most of the lenses with black tape. Use additional tape to block the glare around the lenses and on the sides, since that can also cause eye damage. Innovative (or desperate) people have also used leaves, palm fronds, or other materials as sun-blocking glasses.

Eye Irrigation

In resource-poor situations, Morgan lenses for irrigating the eyes after chemical exposure are generally unavailable. An alternative is to use a standard nasal prong cannula attached to a saline bag. Place the patient supine with towels or other material to collect the water. Position the nasal prongs at the bridge of the nose pointing downward. Put a piece of tape over the connector between the two prongs to hold it in place. Attach the IV tubing to the end of the nasal cannula tubing and open the "IV" all the way. This irrigates both eyes. To irrigate just one, clamp one "prong" or just use the end of the IV tubing at the medial side of the affected eye. (Joe Lex, MD, FACEP, FAAEM. Personal oral communication, May 25, 2007.)

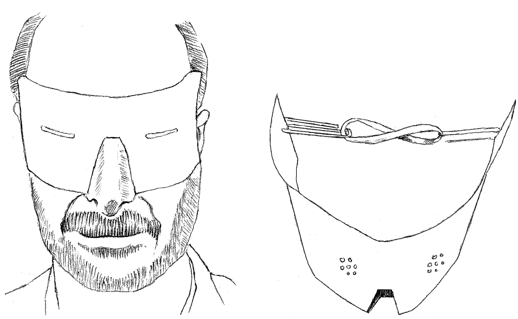

FIG. 27-7. Improvised sun-blocking eyewear, with slits (left) or holes (right).

Analgesia

Most eye pain resolves with normal analgesics.

For an alternative, or to supplement the medicine, use warm moist soaks. One method is to have the patient wrap a cloth around a spoon, dip it in very hot water, and bring it as close as possible to the eye. Do not use this method in a child. The other option is to put a cloth in hot water, such as from the faucet, wring it out, and cover the eye. Put a piece of plastic over the cloth to retain the heat and moisture. Leave the cloth on until it cools; repeat as often as needed for comfort.

Using Eye Drops

No one likes drops placed directly in their eyes. Children squirm and many attempts and hands are needed to accomplish the task; adults grit their teeth and bear it. Often, trying to put in eye drops (e.g., antibiotics, pilocarpine, or other medication) at home leads patients to abandon the treatment. Ease the process by always instilling eye drops at the medial canthus. This also avoids having to get the dropper close to the eyelashes; touching them contaminates the dropper.

Tell patients who need eye drops to tilt their heads back, with the affected eye up. Instruct adults and older children to close their eyes first; infants will do this automatically. Hold the medication container well above the face and instill two drops of medication into the medial canthus. Keep patients in this position until their eye opens, even a little, and the medication will enter—without effort. At home, have adults use this technique on themselves; parents should also use this technique with their children.

Ophthalmic Antibiotics

For most ophthalmic conditions, antibiotic drops are not needed, even though they may be prescribed. The most common example of this is most cases of conjunctivitis. Save resources by not using antibiotics unnecessarily.

If you need antibiotics, chloramphenicol, which is still widely available around the world, works well. Dissolve two 250 mg capsules in 100 mL sterile water. Filter the solution into sterile 10 mL dropper bottles. Screw the caps loosely onto the bottles and put them in a hot water bath at 100°C for 30 minutes without letting the water splash over the bottles' necks. After removing them from the water, tighten the tops and check them again when cool, as the glass may contract, causing the tops to loosen. Refrigerate them at 2°C to 8°C for up to 2 months. Chloramphenicol, since it penetrates the eye when given systemically, is also useful for more severe eye infections.[12]

When using ophthalmic ointment, Dr. Joseph Miller says the easiest method is to place a dab on a clean cotton swab and transfer it to the inside of the retracted lower eyelid. (Personal written communication, received September 8, 2008.)

Eye Shield

A protective eye shield can be made from a small paper cup by cutting off the top half or top three-fourths of the cup. Put tape around the cut edges so that they don't irritate the patient's face. Tape the cup to the face, so that the bottom and sides protect the eye.

Alternatively, make a protective cone by cutting a 6-cm circle in a piece of x-ray film or lightweight cardboard, then making one cut to the center of the circle. Overlap the cut ends to form a cone. Tape the film in that form and then tape the cone over the eye.[13]

Corneal Foreign Body Removal

Rather than using an eye burr to remove a corneal foreign body, use a TB or insulin needle with the syringe attached as a handle. Try to do the procedure under magnification—the needle will look enormous. Alternatively, use the sterile plastic 20- or 22-gauge catheter from an IV.

Corneal Ulcer

Corneal ulcers, a common problem among malnourished children in the tropics, usually respond to aggressive therapy. However, children tend to remove bandages and rub their eyes, which often results in a secondary infection and can cause blindness. So, how do you keep an uncooperative child's hands away from the eye while it is healing?

One solution is to use a splint made from an empty disposable plastic container, such as a 0.5- or 1-L bottle of bleach or irrigation solution. Cut off the top and bottom to form a uniform diameter cylinder. Then cut the container in half lengthwise and smooth the rough edges by covering them with a piece of plaster or duct tape. After padding the inside with soft cloth, fit the plastic bottle around the child's elbow and fix it in place with a plaster sheath and an elastic bandage. The child can still bend his arms slightly (for comfort), but cannot remove the eye dressings, thus preserving his vision.[14]

Local Anesthesia for Eye Procedures

If the normal topical anesthetic for the eye is not available, two other commonly available options exist: lidocaine and cocaine. As Boulton wrote, "Lidocaine 4% is a suitable surface analgesic for the cornea which is as efficacious as a topical analgesic as is 2% cocaine; it does not dilate the pupil or the corneal vessels."[15]

If performing a procedure under or with the aid of topical anesthetic, apply 2 to 3 drops to the cornea and conjunctiva every 5 minutes, starting about 20 to 30 minutes before surgery. Give additional drops, as needed, throughout the procedure.[16]

Glaucoma Treatment

If acute narrow-angle glaucoma affects someone in an austere setting, several actions can be taken to ameliorate the problem. Atropine 1% can be applied topically six times a day.[17] Epinephrine also works, although it irritates the eye and may need to be used in high concentrations or frequently.[18,19] Commonly carried and used by high-altitude groups, acetazolamide (250 mg qid) or other carbonic anhydrase inhibitors can be used to decrease aqueous humor production, lowering intraocular pressure. So can beta-blockers, which are generally administered bid. However, these measures only temporize the situation until the patient can be put on a chronic medical regimen or have surgery.[17]

Improvising Operating Room Instruments

For cataract surgery: "If a formal operating room is not available, any clean room and a body-length table will suffice. A clean water source is necessary."[20]

A small-gauge surgical hook that can be used intraocularly for ophthalmologic surgery can be fashioned from a 27-gauge needle. Similar to fashioning a skin hook (see Chapter 21, Surgery/Trauma), make it by bending the tip of a 5/8-inch, 27-gauge needle with a needle holder. After sterilization, this can be used alone or connected to a 1-mL syringe as a handle.[21]

A metal lid plate for eyelid surgery (provides lid support and elevation) can be made from the handle of a stainless steel soup spoon. It has the benefits of being available without alteration, its length makes it easy to handle, and it does not distort the nasal and temporal aspects of the lid.[22]

Corneoscleral sutures can be made by attaching a bent 30-gauge needle to size 9-0 monofilament nylon (or the fishing line equivalent).[23] Swag the suture onto the needle as described in Chapter 21, Surgery/Trauma.

Cataract Surgery

Cryoextractor

Cataracts—especially those that are mature, intumescent, or hypermature—are often extracted by allowing the cold tip of a cryoextractor to form an adhesion with the cataract. A cryoextractor is expensive and often not available. It can, however, be improvised by passing a short length of copper electrical wire into the barrel of a 5-mL syringe (Fig. 27-8).

Most of the wire extruding from the syringe tip (~1 cm) should remain covered with insulation; only remove the insulation from a very small part of the wire at the tip. Also, remove the insulation from about 1 cm of the wire inside the syringe barrel. Invert a container of refrigerant, such as dichlorodifluoromethane (i.e., Freon, Frigen), and hang it from an IV stand. Run 1 to 2 mL of Freon through the tubing on the Freon container, and into the syringe. The evaporation of the Freon immediately freezes the copper wire. Experience shows that the Freon should be

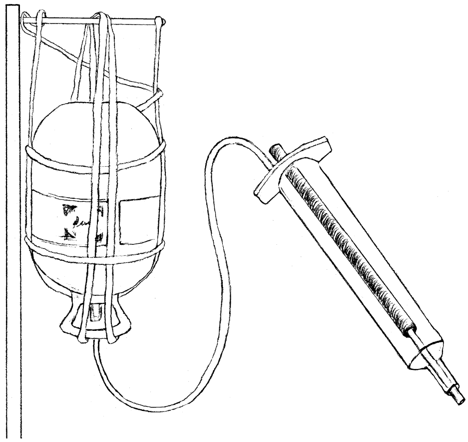

FIG. 27-8. Improvised cryoextractor.

refilled in the syringe, if necessary, so that contact with the cataract lasts 10 to 15 seconds before extraction.[24,25]

Aphakic Surgery Problems

Blindness, both from cataracts and from a lack of eyeglasses post-cataract surgery, is a common problem in areas with scarce resources.[26] Anyone doing cataract surgery should understand that the main problem with aphakic surgery (removing the lens for a cataract) is that patients often cannot get or replace their eyeglasses after the surgery. This leaves them essentially no better, or even worse, than prior to the surgery.

One solution is to hold or tape a single magnifying lens over an eye. Even better is to fit two lenses into a makeshift holder to use as a pair of glasses. Instruct the patient to move the makeshift glasses closer to or further from the eyes until the right focal distance is found. For these aphakic individuals, even a pair of reading glasses can produce an in-focus image. However, the patient must hold the glass a very long distance from his eye. This way, the patient gets a reduced field of view but the image is focused. (Joseph Miller, MD, PhD. Personal written communication, received September 8, 2008.)

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28 | Obstetrics/Gynecology

GYNECOLOGY

Contraception

Contraceptive methods include medications, intrauterine devices (IUDs), surgery (e.g., vasectomy, tubal ligation), spermicides, barriers (e.g., condoms), and "natural" methods. Only condoms protect against sexually transmitted diseases (STDs).

Non-medication Methods

The so-called natural contraceptive methods are not very effective. However, without other means to control pregnancy, these have to be used. They include the abstinence, withdrawal, breastfeeding, temperature measurement, mucous, and counting days (rhythm) methods.

Abstinence is hard to sustain and therefore doesn't work. Withdrawal is not much better, since the male often does not withdraw in time, or even know exactly when to withdraw. Breastfeeding often protects a woman from pregnancy in the first 6 months after delivery if she has not had menses, feeds the child nothing other than breast milk, and never goes more than 6 hours between breastfeedings. The temperature measurement method relies on keeping track of very small temperature changes over time, so is unlikely to be useful in austere situations.

The mucous method requires the woman to check her vaginal mucous every day, at the same time, before she has intercourse. She wipes her vagina with a clean finger, paper, or cloth. If the mucous is clear, wet, and slippery, it means that she is fertile and should not have intercourse. If there is no mucous or if it is white, dry, and sticky, intercourse is probably safe two days later. If using this method, the woman should not douche or wash her vagina. The method is completely useless in the presence of vaginal infections.[1]

The counting or rhythm method is somewhat effective for women with a regular menstrual cycle of 26 to 32 days. Counting from the first day of menstrual bleeding, she abstains from sex from the 8th day through the 19th day of her cycle. She can have sex again on the 20th day. Women should use a chart to mark these days or, as an alternative, a bead chain with different colors. Each bead designates 1 day. To make a bead chain, string 32 beads on a string in this order: 1 red bead followed by 6 blue beads, 12 white beads, and 13 more blue beads. Use a small string or rubber grommet to mark where she is in her cycle. The red bead marks the onset of menses. The 6 blue beads are "safe" days for sex, as are the other 13 blue beads. The white beads are her fertile days.[2]

Male and female condoms are both successful contraceptive methods, but they cannot be improvised. Buy them! They also have medical uses as described elsewhere in the book (e.g., controlling postpartum hemorrhage, as ultrasound probe covers, improvising esophageal stethoscopes, and so forth).

Emergency Contraception

Even in austere circumstances, emergency contraception may be an important issue. The medication of choice after unprotected sexual intercourse (UPSI) is levonorgestrel (LNG), which is now widely available. Table 28-1 lists specific indications for this treatment. It should be given as a single 1.5-mg dose as soon as possible and, for the most efficacy, within 72 hours. If the woman can tolerate only a 0.75-mg dose of the drug, repeat it in 12 hours.

The alternatives are to use birth control pills with adequate doses of ethinyl estradiol (EE) and LNG within the first 120 hours after UPSI or to insert a copper-containing IUD within 5 days of UPSI. If combination birth control pills are used, the dose must be ≥100 micrograms (mcg) EE plus 0.50 mg LNG or 0.75 mg LNG alone. This means the woman will have to take between 2 and 20 pills at one time. She repeats the same dose 12 hours later. Taking diphenhydramine (Benadryl) or a similar medication 1 hour before the contraceptive markedly reduces the frequent incidence of emesis. If emesis occurs within 2 hours of taking the contraceptives, repeat the dose.[3]

TABLE 28-1 Indications for Emergency Contraception

Normal Contraceptive Method	Indications for Emergency Contraception
Combined pills (21 active tablets)	If *three or more* 30-35 mcg EE or if *two or more* 20 mcg EE pills have been missed in the first week of pill taking (i.e., days 1-7) *AND* UPSI occurred in week 1 or in the pill-free week.
POP	If *one or more* POPs have been missed or taken >3 hours late *AND* UPSI has occurred in the subsequent 2 days.
Intrauterine contraception	If there has been complete or partial expulsion of the IUD, or if it is removed at mid-cycle *AND* UPSI has occurred in the last 7 days.
Progestogen-only injectables	If the contraceptive injection is late (>14 weeks from the previous injection for medroxyprogesterone acetate or >10 weeks for norethisterone enanthate) *AND* UPSI has occurred.
Barrier methods	If there has been failure of a barrier method.

Abbreviations: EE, ethenyl estradiol; IUD, intrauterine device; POP, progestogen-only pill; UPSI, unprotected sexual intercourse.

Data from AHRQ.[4]

Note that if the contraceptive contains norgestrel, only half of this is the effective medication LNG; double the dose. Women who are using liver enzyme-inducing drugs (e.g., some antiepileptics, antibiotics, St. John's wort) must take between 2.25 and 3 mg of LNG. If necessary, women can use emergency contraception more than once during each menstrual cycle.

Vaginal Speculum

If a vaginal exam or procedure needs to be done, the lack of a speculum should never be a deterrent, since one can easily be made. The only additional requirement is a light source. Use a headlamp, if available.

When a vaginal speculum is not available or is not the right size to examine a patient, simply revert to what our forebears used: retraction. In austere circumstances, clinicians still fashion vaginal retractors from spoons, surgical retractors, or barbecue tongs. (Personal written communication from Col. Patricia R Hastings, AMEDDCS, received April 9, 2007.) The only problem with using them is that they require an assistant to hold the posterior retractor while the examiner elevates the anterior vagina with another retractor.

Test tubes are often used to examine the vaginas of small girls. Using a tube of the appropriate size, this can be easily accomplished. The problem is that the ability to do procedures through it is limited.

Sexually Transmitted Diseases

In austere situations, syndromic treatment of sexually transmitted diseases (STDs) is the best approach to this common problem. (See "Tests for Sexually Transmitted Diseases" in Chapter 32, Infectious Diseases.)

Bartholin's Abscess

An abscess of Bartholin's gland can easily be treated with a stab incision and placement of a short Word catheter. However, these catheters are unlikely to be available. An alternative is to use a balloon urethral catheter and run the catheter down the leg, with a gauze or plastic bag over the end to catch any pus that drains. Use a pediatric catheter, if available, since they are shorter. Do not cut the catheter; it destroys the balloon port.

Cervical Dysplasia

Remarkably, an improvised test may be nearly as good as cytology (Pap smear) for detecting high-grade cervical lesions (squamous intraepithelial lesions) or invasive cervical cancers. It may also be better than cytology for detecting moderate dysplasia. In resource-poor areas, the World Health Organization (WHO) suggests that clinicians use a "visual inspection with acetic acid" (VIA) and "visual inspection with Lugol's iodine" (VILI) for detection of cervical dysplasia.

Position the speculum without using gel. First do a VIA, applying 3% to 5% acetic acid (white vinegar) to the cervix with a cotton-tipped applicator. The vinegar may sting a little. After 1 minute look for white patches. (The high-protein-content areas of premalignant and malignant cells coagulate and appear white when acetic acid is applied.) If they are there, it signifies a pathological lesion—which may be dysplasia, human papilloma virus, cervical cancer, or an STD. The test has a sensitivity of 56% and a specificity of 71% (positive predictive value 30%; negative predictive value 88%).

Then do a VILI by applying iodine to the cervix with a cotton-tipped applicator. If the entire cervix stains with iodine, it is a negative test; otherwise, it is positive. (Normal squamous cells are rich in glycogen that takes up iodine.) The test has a sensitivity of 87% and a specificity of 49% (positive predictive value 31%; negative predictive value 93%).[5]

These tests require no special magnification or tools. Patients who test positive should get further testing, if possible. If that is not possible and cryotherapy is available, use it. It is much less dangerous than letting untreated cervical cancer progress.[6]

Lacking equipment for colposcopy, gynecologists aboard the United States Navy Ship (USNS) Comfort, on their Continuing Promise 2009 mission to Latin America, used eye loupes to provide sufficient magnification to view the cervix. (Commander Chris Reed, MD, USNS Comfort, oral communication received June 3, 2009.)

Female Circumcision

Rarely encountered in industrialized countries, female circumcision comes in three forms: (a) partial or complete removal of the clitoris, (b) clitorectomy with removal of the labia minora, and (c) infibulation, the removal of the labia majora, labia minora, and clitoris with the vaginal opening sewed nearly closed. The latter causes most of the severe problems seen by health care workers and it should be treated soon after it occurs. The complications of infibulation include heavy vaginal bleeding, possibly with shock; infection (tetanus or wound infection initially, but human immunodeficiency virus [HIV] and hepatitis are common some time later); severe pain; and dysuria, urinary retention, or other urinary tract problems. Treatment is to stop the bleeding, treat pain and infection, and, if necessary, place a urethral catheter.

When a woman who has had an infibulation tries to deliver a child vaginally, problems can ensue. Be prepared to "deinfibulate" her by cutting through the scar.

Vaginal Bleeding

Acute Massive Hemorrhage

The control of acute hemorrhage from the nonpregnant uterus can be difficult, since the cervical os may not be wide open. The hemorrhage may be due to a variety of sources, including gynecologic procedures. Historically, curettage has been used to halt the bleeding; when this fails, hysterectomy has often been a last resort. However, it may be prudent to first try mechanical methods.

One of these methods that stops acute, profuse uterine hemorrhage in most patients is to insert a balloon urethral (Foley) catheter into the uterine cavity. This requires no special expertise, equipment, or anesthesia. Once the catheter is in place, inflate the catheter balloon full enough with saline to tamponade the bleeding against the semi-rigid uterine wall. Leave the catheter in place from several hours to 2 days, depending on the etiology of the hemorrhage.[7]

As described under "Postpartum Hemorrhage Control" later in this chapter, if the uterine cavity is larger than normal, tie a condom over the end of the catheter, then insert the catheter and inflate the condom, rather than the catheter (see Fig. 28-5 later in this chapter).

Bleeding Mass

A hemorrhaging mass in the vagina is most likely cervical cancer. The vagina should be packed to tamponade the bleeding after placing a urethral catheter. Placing sutures is generally futile and may make the bleeding worse.[8]

Medical Abortions

While surgical evacuation of the uterus takes special equipment, medical abortions do not. Most tested regimens use mifepristone or methotrexate plus misoprostol.

Using mifepristone, give 100 to 600 mg orally, followed in 6 to 72 hours by misoprostol 400 mcg orally or 800 mcg vaginally. Using methotrexate, give 50 mg/m^2 intramuscularly (IM) or orally, followed by misoprostol 800 mcg vaginally in about 3 days. If the pregnancy persists 1 week after the methotrexate administration, give another dose of misoprostol.

With either regimen, if the pregnancy persists, a surgical abortion is indicated.[9]

OBSTETRICS

Obstetric Emergencies

Approximately 15% of pregnant women develop complications that require special obstetric care, with up to 5% requiring surgery, including C-sections. Basic obstetric care includes the ability to assess the mother and fetus; do episiotomies; manage hemorrhage, infection, and eclampsia; deliver multiple births and breech presentations; use a vacuum extractor; and provide care for women after genital mutilation.[10]

An excellent online professional resource for routine and emergency obstetric care (with good illustrations) is WHO's book, *Managing Complications in Pregnancy and Childbirth: A Guide for Midwives and Doctors.* Download it at www.who.int/reproductive-health/impac/.

Another excellent professional resource is the Johns Hopkins Program for International Education in Gynecology and Obstetrics (JHPIEGO) book, *Emergency Obstetric Care: Quick Reference Guide for Frontline Providers*, which is available to download from the USAID web site: http://dec.usaid.gov/index.cfm?p=search.getCitation&CFID=4497507&CFTOKEN=62906948&rec_no=127959.

Diagnosing Pregnancy

Signs and Symptoms

Diagnosing pregnancy without a human chorionic gonadotropin (HCG) level relies on signs and symptoms, some of which can be quite nebulous. The only three physical findings of pregnancy that most clinicians can rely on are palpating the enlarged uterus, hearing the fetal heartbeat, and seeing the baby in the birth canal.

Rudimentary Lab Tests

If you really must have lab test results to diagnose pregnancy in austere circumstances, use the frog test, which is much easier than the fabled rabbit test. Using a male frog (the common North American frog, *Rana pipiens*), the test is simple, rapid, and inexpensive. Inject 1 mL of the patient's early-morning, concentrated urine sample (or blood serum obtained at any time) into the frog's dorsal lymph sacs (back area behind the head). Blood serum is preferable, since it can be obtained any time and is less likely to cause toxic deaths in the frogs. Using a microscope, examine the frog's urine at 30-minute intervals for 3 hours. If the test is positive, the frog will have spermatozoa in its urine. During the summer, the accuracy of the test decreases, but this can be partially compensated for by refrigerating the frogs.[11]

How Pregnant?

Without ultrasound to date the pregnancy, the less-reliable method of counting from the patient's last menses must be used. One way to get the due date is to add 9 months and 7 days from the onset of the patient's last period. For those using lunar time for measurements rather than a calendar, assuming that the woman's cycles are "1 moon" (4 weeks) apart, the due date would be "10 moons" after the onset of the patient's last menses.

Once the fundus can be felt, the gestational age is closely related to the fundal height (Fig. 28-1).

Fetoscope

Any hollow tube made from wood, bamboo, plastic, clay, or metal can be used as a fetoscope. The optimal size is a piece about 15 cm long, with a hollow core 3 to 4 cm in diameter.[12,13]

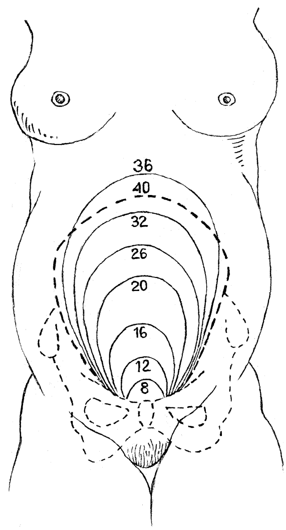

FIG. 28-1. Fundal height related to gestational age.

Counting the fetal heart rate with a stethoscope or Doppler is accurate and has good inter-observer reliability.[14] Skilled practitioners can often hear the baby's heartbeat by the seventh or eighth month just by putting their ear to the patient's belly in a quiet room. However, the heartbeat is easier to hear with a stethoscope or a fetoscope. (For improvised stethoscopes, see Chapter 5, Basic Equipment.)

If the baby's heartbeat is heard best below the umbilicus, the baby is probably in the head-down position. If it is heard best above the umbilicus, the baby is most likely head-up (breech).

Analgesia in Pregnancy

Non-pharmacological treatment includes locally applied heat and cold. Heat can be applied as a hot water bottle, hot bath, or microwaved wheat pillow (see "Heating the Bed" in Chapter 5, Basic Equipment). Locally applied ice packs often work well for headaches. If non-pharmacological treatment is ineffective, consider using local anesthetic infiltration or regional anesthetic blocks, depending on the location of the pain. If those don't work or they are not applicable, use acetaminophen 1 g q6hr.[15]

Miscarriage

If a woman passes tissue during her first trimester and the os has closed again, check her vital signs and, if normal, send her home. Tell her to return if there is increased bleeding or any sign of infection.

If she is spotting, reassure her that most pregnancies with only spotting go to term without difficulty. Check her vital signs; if normal, send her home.

If she has been bleeding and the os is open, she has an incomplete or inevitable miscarriage. She can wait for passage of more tissue and for the os to close. If the os remains open, she will need the products of conception removed.

Products at Cervical Os

If vaginal bleeding occurs after a miscarriage, delivery, or abortion, and a speculum or forceps is not available, use a sterile- or clean-gloved hand to feel the cervical os. Check for products of conception that are not permitting the os to contract. If necessary, use a non-gloved, but clean, hand. If material seems to be at the os, but it is too slippery to hold, use sterile gauze or a cloth boiled in water wrapped around your fingers to try to grasp and remove the tissue.

Obstetric Checks

Simple tests can help to determine a pregnant woman's well-being.

Checking her weight may be the most difficult test to improvise without a scale. However, other observations, such as her overall body habitus (e.g., extremely thin or fat face), may help a little. You are trying to see that the woman is not too thin due to parasites, HIV, drug use, hyperemesis, or lack of food. She should gain at least 20 lb (9 kg) during the pregnancy. You also want to be sure that she has not gained more than 42 lb (19 kg) during the pregnancy, or more than 3 lb (1.5 kg) a week or 8 lb (3 kg) in a month, especially during the last 2 months of pregnancy. If she has gained too much weight, check her for diabetes, preeclampsia, or twins.

Check the mother's vital signs. (See Chapters 7, Vital Signs, Measurements, Triage, and 5, Basic Equipment, for ways to improvise these tests.) If her blood pressure (BP) is >140/90, beware of preeclampsia. Also check for peripheral edema, especially in the hands and face, and for very brisk reflexes (clonus).

Test her urine for protein. While the easiest method is a urine dipstick, you can also test for protein by heating the urine. (See "Protein" under "Urinalysis" in Chapter 19, Laboratory, for the method.)

If an ultrasound is available, what you can do with it depends on both the machine's and your own capabilities. Dating the pregnancy by measuring the fetus is relatively easy. Determining the sex and looking for fetal abnormalities or the placenta's position can all be done with relatively little training.

Without ultrasound, use external measurements to help determine the pregnancy's progress. The basic rule is that the fundal height increases by ~2 fingerbreadths each month. At 3 months, the fundus is just above the pubic symphysis. At 5 months, it is at the umbilicus, and at 8.5 to 9 months, it is almost up to the costal margin. One or two weeks before delivery, it drops a bit. Use a tape measure to check the fundal height and record it for each visit (see Fig. 28-1).

Most pregnant women, especially those in resource-poor situations, need to have supplemental iron. Mix ferrous salts in a palatable solvent (e.g., juice) to make an acceptable iron mixture.[16]

Ectopic Pregnancy

Ectopic pregnancies can be life threatening. Women presenting with abdominal pain, vaginal bleeding, or hypotension need to have this diagnosis excluded or treated. While ultrasound has virtually eliminated the use of diagnostic culdocentesis from the developed world, it still is valuable for diagnosing ectopic pregnancies and pelvic infections in austere circumstances.

The procedure is simple (for the clinician). Pick up the posterior cervix with a single-tooth tenaculum (Fig. 28-2). This is often when patients feel the most pain. Apply it very slowly,

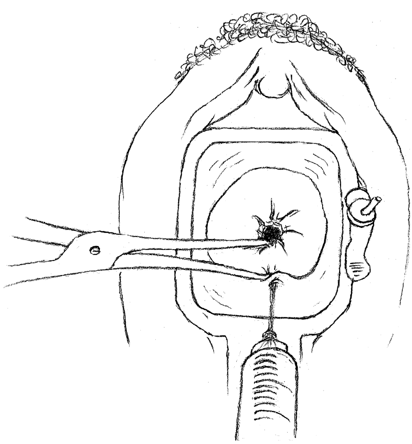

FIG. 28-2. Culdocentesis from the clinician's viewpoint.

counting from "1" to "30" while the teeth are applied. Then infiltrate the posterior fornix with a local anesthetic. Insert a 16- or 18-gauge needle into the cul-de-sac. Aspirate. If blood returns, wait 6 minutes to see if it clots. If it does, it is most probably due to the needle entering a pelvic vein. If it doesn't clot, the blood is from a ruptured ectopic pregnancy or ovarian cyst. If pus returns, the patient has pelvic inflammatory disease. If a small amount of straw-colored fluid is withdrawn, that is physiologic. If no fluid is returned, the tap is non-diagnostic; repeat it.

Preeclampsia/Eclampsia Diagnosis and Treatment

Preeclampsia's hallmarks are hypertension and proteinuria after 20 weeks' gestation. Hypertension is a BP ≥140/90 in a woman who has not previously been hypertensive. (Improvised methods to take the BP are described in Chapter 7, Vital Signs, Measurements, and Triage. A qualitative urine protein test can be found in Chapter 19, Laboratory.) The women also frequently have sudden weight gain or the presence of swelling of the face and hands—especially upon awakening. Indicators of severe preeclampsia include the presence of severe headaches, hyperreflexia, blurred or double vision, upper abdominal pain, oliguria, and pulmonary edema. Depending on available resources, women with preeclampsia or severe preeclampsia should be treated.

The first drug to try (that may be available) to treat active seizures in eclampsia is diazepam 10 mg IV over 2 minutes. If necessary, the IV preparation can also be given rectally.[17,18] Repeat this dose if another seizure occurs. If referral is delayed or if the woman is in late labor, start a maintenance drip of 40 mg diazepam in 500 mL normal (0.9%) saline (NS) or lactated Ringer's solution, run over 6 to 8 hours at a level to keep the patient sedated, but arousable. Limit the dose to 100 mg diazepam in 24 hours. Stop the drip if respirations slow to ≤16/min.[19]

Since diazepam has erratic absorption IM and, in some situations, it may not be possible to start an IV in edematous or seizing patients, the rectal route has been successfully used. Demonstrating its utility in remote areas, Dr. Povey wrote,

> At Maputo Central Hospital [Mozambique] we have many times used it to control eclamptic convulsion, following which it is possible to access a vein and to continue management with magnesium sulphate . . . We use 20 mg of the IV preparation of diazepam in a 10-mL syringe. The needle is removed, the barrel is lubricated, and the syringe is inserted into the rectum for half its length. The contents are discharged, the syringe is left in place, and the bullocks are held together for 10 min to prevent expulsion of the drug. If convulsion is not controlled within 10 min, an additional 10 mg is instilled. Alternatively, the drug can be injected into the rectum through a urinary catheter. In circumstances in which IV administration is impossible or dangerous, as in a primary care unit that lacks the appropriate equipment or skills, we advise the rectal loading dose described above followed by an hourly rectal dose of at least 10 mg, depending upon the size of the woman and her clinical response. This method is invaluable when a patient must be transported for a long distance by human carriers, animal cart or truck.[18]

Magnesium sulfate ($MgSO_4$) is traditionally the first-line medication used for preeclampsia and eclampsia.[20] However, it is not available in many of the world's hospitals and birthing centers.[19] Magnesium sulfate treatment is expensive, not only because of the medication but also because of the need to hospitalize and monitor the patient. However, $MgSO_4$ treatment for preeclampsia costs less and prevents more eclampsia in less-developed countries than in the developed countries.

To use it, administer a loading dose of 4 g $MgSO_4$ IV over 5 minutes. (Warn the patient that she will feel warm when the drug is given.) Then, immediately give 5 g $MgSO_4$ (50% concentration is best) mixed with 1 mL 2% lidocaine in each buttock as a deep IM injection. After 15 minutes, if seizure persists or recurs, give 2 g $MgSO_4$ IV over 5 minutes. If referral is delayed or the woman is in late labor, repeat the IM injections in each buttock using half the dose of $MgSO_4$ (i.e., 5 g total). Give it in alternate buttocks every 4 hours for 24 hours after delivery or the last seizure. Before every $MgSO_4$ dose, be certain that the respiratory rate is ≥16/min, patellar reflexes are present, and urine output is ≥30 mL/hr. The antidote for respiratory depression is calcium gluconate 1 g (10 mL of 10% solution) IV administered over 10 minutes.[19]

The third drug to try, if available, is phenytoin (Dilantin). It is not as effective as $MgSO_4$. Give 10 mg/kg IV at a rate of ≤25 mg/min. Two hours later, give 5 mg/kg IV. Begin a maintenance dose of 200 mg tid IV or po 12 hours later.[17]

Terminating the pregnancy is the definitive treatment for preeclampsia. In almost all cases, this means a term or near-term delivery.

Inducing Labor

If the woman's membranes have broken but labor has not started, labor sometimes can be inducted by administering an enema (carefully, so as not to infect the vaginal area) or by giving 60 mL castor oil in 240 mL fruit juice.[21]

Anesthesia

Local

Boulton described the method (not often used) of using local anesthesia for the perineum and vagina: "The technique of topical analgesia of the skin of the perineum and the mucous membrane of the introitus of the vagina for spontaneous delivery, suction extraction and suturing of perineal lacerations is simple and efficacious. Lidocaine gel 2% can be used for the purpose but the 10% aerosol is superior. The dose should not exceed 200 mg lidocaine to mucous membranes and 200 mg to the surrounding skin. [More than] 90% of patients receiving spraying alone report satisfactory relief of pain; blood lidocaine did not exceed 2.4 mcg/mL, which is well below the toxic level (10 mcg/mL)."[22]

Pudendal Blocks

Bilateral pudendal blocks provide excellent anesthesia over the perineum and lower third of the vagina. They reduce pain during vaginal delivery and minor gynecological procedures, provide some introital relaxation, and are adequate anesthesia for repairing lacerations or episiotomies. A pudendal block does not, however, provide adequate anesthesia when extensive obstetric manipulation is required.

This block requires a small-gauge (22-gauge) spinal needle, 10 mL 1% lidocaine for each side, and a needle guide (e.g., Iowa trumpet) that allows the needle to protrude only 1.5 cm out of the distal end. The needle guard can be improvised by cutting 1.5 cm off the needle's plastic sheath, as is done when making a needle guard to aspirate peritonsillar abscesses. This guide can also be used when doing a paracervical block.

Then palpate the ischial spine through the vagina. The spine can be felt as a distinct boney "bump" quite separate from the rest of the pelvic wall. Insert the needle guide along the palpating finger to a point on the sacrospinous ligament, about 1 cm from its insertion onto the ischial spine. Insert the needle through the guide and into the sacrospinous ligament. Aspirate and then slowly infiltrate 3 mL 1% lidocaine. Advance through the ligament and inject 3 mL more anesthetic as the plunger loses resistance. Then withdraw the needle into the guide, and move the guide just above the ischial spine; inject the rest of the anesthetic. Repeat the process on the other side. It takes 10 to 20 minutes for the block to take effect. If the block does not work on one side, administer another 5 mL of anesthetic on that side. When giving a pudendal block during labor, locally infiltrate the area for an episiotomy, in case that procedure needs to be done before the block takes effect.

Spinal

Spinal anesthesia is discussed in Chapter 14, Anesthesia—Local and Regional. However, giving these blocks to pregnant patients involves some special considerations. First, these women should receive at least 1.5 L crystalloid before the lumbar puncture (LP). Be careful if the woman has a bleeding disorder, such as occurs in moderate to severe eclampsia. Also, in general, pregnant patients need less anesthetic medication to achieve the same level of anesthesia than women who are not pregnant. The general doses and techniques are given as follows.

For a C-section, the block should extend to T6, about the level of the sternum. Use one of the following typical doses to achieve that level[23]:

2.0 to 2.5 mL hyperbaric 0.5% bupivacaine, *—or—*
2.0 to 2.5 mL of isobaric 0.5% bupivacaine, *—or –*
1.4 to 1.6 mL hyperbaric 5% lidocaine, *—or –*
2.0 to 2.5 mL isobaric 2% lidocaine with 0.2 mL 1:1000 epinephrine.

If the spinal is for a forceps delivery, 1 mL of a hyperbaric anesthetic, given with the mother in a sitting position, is usually adequate. When removing a retained placenta, inject 1.5 mL hyperbaric solution with the mother sitting up; then lay her down.

Anesthesia for C-sections

The methods for using local and general anesthetics, including ketamine for C-sections, are discussed in Chapters 14, Anesthesia—Local and Regional, and 15, Sedation and General Anesthesia.

Dystocia

In certain cases of obstructed labor or when there is head dystocia (and a C-section is not possible and alternative maneuvers have not succeeded), two procedures might work: symphysiotomy and, if the fetus has died, fetal craniotomy.

Symphysiotomy

Recommended by WHO to avoid maternal and fetal complications during difficult vaginal deliveries, symphysiotomy is surgically dividing the cartilage of the symphysis pubis, usually under local anesthesia.[24] Performed in the second stage of labor, it temporarily enlarges the pelvic outlet from 1 to 3 cm, permitting a vaginal delivery. Contraindications include a dead fetus (see "Fetal Craniotomy" below), incomplete cervical dilatation, and a non-longitudinal lie.

The 2- to 3-minute procedure, generally done in the labor ward, was commonly performed throughout the 20th century. After inserting a catheter to drain the bladder, use local anesthesia to liberally anesthetize the area. Place a finger in the vagina behind the pubic symphysis and make a 1.5- to 3-cm skin incision. Then divide the cartilage at the pubic symphysis. Deliver the baby.

Although women often experience more and longer postoperative pain after this procedure than with a Cesarean section, most women can walk using a walker or chair within 2 to 4 days; 95% can be discharged from hospital within 2 weeks.

Scar tissue between the pubic bones permanently enlarges the pelvis. Post-symphysiotomy patients sometimes experience pain over the symphysis or in the sacroiliac joints or urinary incontinence—although less often than after normal vaginal deliveries. Rarely, problems with walking occur.[25]

Fetal Craniotomy

If the fetus has died or the mother's life is at risk and the child cannot be delivered in any other way, reduce the fetal head size with a craniotomy. This makes a vaginal delivery possible. If a fetus has hydrocephalus, passing a needle into the head to drain the fluid can reduce the head size sufficiently for vaginal delivery.

Craniotomies were often performed before C-sections became common. In cases of fetal death and hydrocephalus, they are still frequently done in less-developed countries. Drs. Smith and Neill describe the craniotomy procedure (Fig. 28-3):

> In some cases, where the sutures are very loose, the evacuation of the brain is often sufficient, as the bones of the cranium collapse so much by the pressure of the womb that the child may be expelled by the natural powers. Should this not be the case, the brain must be evacuated, and extracting force applied. The instruments required are of two kinds, the one to perforate the skull, and the other to extract.
>
> It is not absolutely necessary . . . that the os uteri should be entirely dilated, although the wider the orifice is, the less danger will there be of injuring that organ. The rectum and bladder having been previously emptied, the woman is to be placed in the [lithotomy] position. The perforator should then be carefully applied upon the groove between two fingers of the left hand, previously introduced, and placed upon the part of the head,

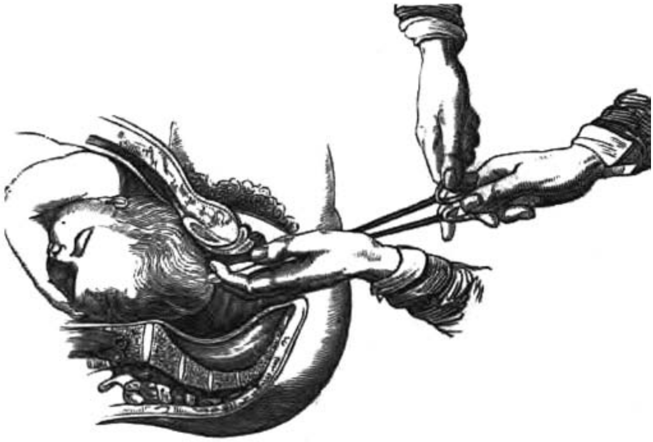

FIG. 28-3. Craniotomy for head dystocia. (*Reproduced from Smith and Neill.*[27])

> which it is proposed to open. It must now be passed forwards with a semi-rotatory motion until it penetrates the bone; if the scissors are used [to perforate the skull, then separate] the handles as widely as possible. The cutting edges are then to be placed at right angles to the first incision, and again separated, so as to make an [x-shaped] opening. The instrument should now be passed into the skull, and the brain broken up, after which [the instrument] should be withdrawn. Then [use an instrument to grasp] the inside or outside of the head, and [extract the fetus], being very careful to guard the soft parts of the mother. If the head cannot be delivered in this manner, recourse must be had to the craniotomy forceps and the bones broken up and extracted in pieces.[26]

Drs. Smith and Neill go on to note that the mother will need special care after this procedure.

Antepartum/Intrapartum Hemorrhage

About 4% of pregnant women experience significant antepartum hemorrhage from placenta previa, abruptio placenta, or uterine rupture.[28]

In cases of placenta previa when the mother is hemorrhaging during labor and when there is no other option (e.g., C-section), you may have to revert to the old methods to save the woman's and, possibly, the child's life. These include moving the baby (i.e., version) so the foot protrudes from the vagina for traction, using a towel clip or forceps to grab the baby's scalp (if it is a vertex presentation) to apply traction, or, in less-severe cases, rupturing the membranes.

Using forceps on the fetal skull to tamponade the bleeding is very effective. It can be done even when the os has dilated only enough to admit one finger at a time. Once the forceps are applied, mild traction (1 to 1.5 lb) abruptly stops the bleeding. This method saves nearly all the mothers' lives, although the neonatal mortality varies widely. Using traction, only 44% of the children survived. This, however, was better than the 7% survival using "version."[29]

Dead Fetus—Breech

Removing a dead fetus can prove difficult if it is in the breech position. One method of removal is to pass a large balloon (Foley) catheter into the fetus's rectum, inflate it with water, and pull on the catheter. According to Verkuyl, this makes extraction easy and avoids maternal complications.[28]

Emergency Childbirth

Emergency Childbirth Kit (~1.5 lb)

This kit is designed to be carried in a 36- × 36-inch baby blanket. For births occurring outside the medical facility or in shelters or refugee camps, this portable kit may prove useful.

- One 36- × 36-inch "receiving" blanket
- Plastic to wrap around the kit
- One or two diapers
- Four sanitary napkins (wrapped)
- ID bands for mother and baby
- Short pencil
- Soap
- Sterile package containing:
  Small pair of blunt-end scissors
  Four pieces of white cotton tape, 0.5 inches wide by 9 inches long
  Four cotton balls
  Roll of 3-inch-wide gauze
  Six 4-inch squares of gauze
  Two to six safety pins

Additional medical supplies that may prove useful for those who know how to use them are: a syringe with oxytocin; bulb syringe; intubation equipment; ketamine; IV needles, tubing, and normal (0.9%) saline (NS); surgical scrub; sterile gloves; and scalpel. These take a bit more room and double or triple the kit's weight. Most importantly, only those who have the knowledge required to use them correctly should use these items.

To prepare the kit, lay out the plastic sheet and open the blanket onto it. Put all the equipment in the center. (If additional medical supplies are included, the IV solutions and tubing may have to be carried separately.) Pull the two opposite corners of the blanket and plastic together and tie them. Do the same with the opposite corners, pulling them tight enough so that nothing will fall out. Add another knot so there is a loop to sling over the arm for carrying the kit.

Procedure

Preparation for Childbirth

1. Have the mother lie on a clean surface. Waterproof the mattress with plastic sheeting or pads made from several thicknesses of paper covered with cloth. Over this, put a clean bed sheet. Place the mother on her left side for labor and gather available equipment for delivery and care of the neonate.
2. Prepare a bed for the baby which, when lined with a blanket, can be a clothes basket; a box; or a dresser drawer placed on a table, stable chairs, or the floor. If possible, warm the baby's blanket, shirt, and diapers with a hot water bottle, warm bricks, or a bag of salt that has been heated.
3. Examine the patient to determine how much the cervix has dilated. The woman should begin pushing when the cervix is completely dilated (10 cm) and no cervix can be felt on either side of the fetal head.
4. Check the fetal heart rate every 15 minutes prior to pushing and following each contraction. Normal fetal heart rate is 120 to 160 beats/min. While the heart rate often drops with the contractions, it should recover to normal prior to the next contraction.

An immediate C-section is indicated if any one of the following is present: (a) The fetal heart rate drops below 100 beats/min and stays low for more than 2 minutes. (b) The baby's head is not the presenting part. Use an ultrasound, if available. (c) Acute uterine hemorrhage persists for more than a few minutes (suggestive of placental abruption or previa).[30]

Delivery

1. Place the patient on her back or tilted slightly to the left. When the patient begins pushing, flex her hips to optimally open the pelvis. Have assistants support her legs when she pushes and relax them between contractions.

2. Clean her perineum with sterile antiseptic solution or soap and water. If this is the patient's first delivery, anesthetize the perineum in case an episiotomy is needed.
3. The fetal head delivers by extension. Push upward on the fetal chin through the perineum to assist this process. Control the rate of the head's delivery with the opposite hand.
4. If an episiotomy is needed, cut the posterior midline from the vaginal opening approximately half the length of the perineum, and extend about 2 to 3 cm into the vagina.
5. After delivering the head, suction the baby's mouth and nose, and then palpate the neck for a nuchal cord. If a nuchal cord is present, loop it over the child's head or clamp it twice and cut it.
6. Put your hands along the side of the child's head and have the mother push again to deliver the anterior shoulder. Apply gentle downward traction to get the shoulder to clear the pubis. Direct the fetus anteriorly to allow delivery of the posterior shoulder. The remainder of the body rapidly follows. Wrap the infant in dry towels.
7. Once the neonate is delivered, double-clamp or double-tie the cord and cut it between the ties. Sterilized shoestrings or strips of a sheet folded into narrow bands 1 inch wide and 9 inches long can be used to tie the umbilical cord. Boil them for about 20 minutes or immerse them in 70% isopropyl alcohol for at least 20 minutes before use. Have four ready to use, just in case any are dropped.
8. To cut the umbilical cord, use a sterilized knife, pair of scissors, or razor blade. Either boil these utensils (preferred) or immerse them in 70% isopropyl alcohol for no less than 20 minutes and, preferably, for 3 hours.
9. The placenta usually delivers within 15 minutes of delivery, but may take up to 60 minutes. Delivery of the placenta is heralded by uterine fundal elevation, lengthening of the cord, and a gush of blood. While waiting, place gentle pressure on the cord, but avoid vigorous uterine massage and excessive cord traction.
10. Immediately put an ID anklet or bracelet on the child. This is especially important if the child is born in a large group shelter or refugee camp.
11. Inspect the placenta for evidence of fragmentation that can indicate retained products of conception. Following placental delivery, administer oxytocin 20 units by drip or IM, methylergonovine maleate 0.2 mg IM, or have the patient breastfeed (although breastfeeding is not that effective in helping the uterus to contract).[30]

INSPECTION AND REPAIR

1. Following delivery of the placenta, inspect the vagina (especially the posterior fornix), cervix, perineum, and periurethral areas for lacerations.
2. Repair vaginal and cervical lacerations with 3-0 absorbable suture, if available.
3. If the anal sphincter is lacerated, repair it with 2-0 absorbable suture using interrupted or figure-eight stitches.
4. If the patient's rectum has torn, carefully repair the rectal-vaginal septum with interrupted 3-0 absorbable sutures. A second layer of sutures overlapping the tissue layers decreases the risk of breakdown.
5. Patients with a periurethral tear may require urethral catheterization. In addition to lacerations, hematomas in the vulva, vagina, or retroperitoneum may occur.[30]

Complications

Even in the United States under routine conditions, home deliveries had a high rate of neonatal complications: nuchal cord (12% of the time), cyanosis (9%), apnea/pulseless (6%), apnea only (4%), feet-first breech (3%), toilet bowel retrievals (3%), amniotic sac intact (1%), and twins (1%). Maternal complications were minimal.[31]

Warm Chain

A system for keeping newborns warm and for improving survival has been termed the "warm chain" or "Kangaroo care." It is described in Chapter 34, Pediatrics and Neonatal.

Squatting Chair for Delivery

Fashion a squatting chair for vaginal deliveries by firmly attaching strong, outward-facing legs (for stability) to the underside of a toilet seat. Figure 5-9 shows the seat being used as a bucket toilet. Generally these seats are made of wood, so they need to be sanded and covered with several coats of polyurethane or similar varnish.[32]

Unusual Obstetric Presentations

Entire books have been written on how to manage unusual presentations. Rather than using improvised equipment, managing them takes extensive knowledge and experience. Prepare in advance: read the books, get help, or do a C-section. (Think of a C-section as the cricothyrotomy of pregnancy. When nothing else works, that gets the patient out of trouble.)

Emergency C-Section

C-sections in a dead or dying mother have little chance of success. Since fetal distress precedes maternal hemodynamic instability, fetal survival is unlikely in hypovolemic cardiac arrests. In non-hypovolemic cardiac arrests (or in severe shock, where taking the baby may be the only way to save the mother), a C-section must be done within 4 to 5 minutes if the baby is to survive.[33] Generally, emergency C-sections are done because of problems with the pregnancy or the delivery.

Local Anesthesia for C-Section

In case you have to do a C-section without spinal or general anesthesia, you can administer local anesthesia with good effect. Make a wheal of local anesthetic 3 to 4 cm on either side of the midline, from the symphysis pubis to 5 cm above the umbilicus. Inject the anesthetic through all layers of the abdominal wall with a long needle. Keep the needle almost parallel to the skin, being careful not to pierce the peritoneum or insert the needle into the uterus, which is easy to do since the abdominal wall is very thin at term. Use up to 100 mL of 0.5% lidocaine with epinephrine 5 mcg/mL (1:200,000). Although infiltrating the abdomen may be uncomfortable for the mother, don't administer IV analgesics or sedatives; they adversely affect the baby. If necessary, you can safely give up to 0.5 mL/kg IV ketamine for analgesia. Once the baby is delivered, give the mother IV opiates, if needed.[34]

C-Section Procedure[35]

1. Place the patient with her left side up, using an IV bag or towel to displace the uterus to the left. Quickly prep her from just below the breasts to mid-thigh. See Fig. 28-4.
2. Enter the abdomen through a lower-midline incision.
3. Identify and incise the peritoneal reflection of the bladder transversely, and create a bladder flap to retract the bladder out of the field.
4. Carefully incise the uterus transversely across the lower uterine segment (where the uterine wall thins).
5. Once the amniotic membranes are visible or opened, extend the incision laterally, either bluntly or by carefully using bandage scissors. Avoid the uterine vessels laterally. If necessary, extend the incision at one or both of its lateral margins in a J-fashion with a vertical incision.
6. Elevate the presenting fetal part into the incision, with an assistant providing fundal pressure.
7. Deliver the fetus, suction the nose and mouth, and clamp and cut the cord. Hand the infant off for care.
8. Apply gentle traction on the cord to deliver the placenta; massage the uterus.
9. Begin oxytocin (or an alternative), if available.
10. Using a gauze sponge, clean the inside of the uterus, and vigorously massage the fundus to help the uterus contract.
11. Quickly close the incision with large (size 0) absorbable sutures. A single layer (running, locking to provide hemostasis) is adequate for transverse incisions. Avoid the lateral vessels. If the incision has a vertical extension, close it in 2 or 3 layers.
12. Once hemostasis is assured, close the fascia and abdomen.

Postpartum Hemorrhage

Hemorrhage is the underlying cause of >25% of maternal deaths in the developing world. Blood loss occurs rapidly, since the gravid uterine blood flow is 600 to 900 mL/min at term. With

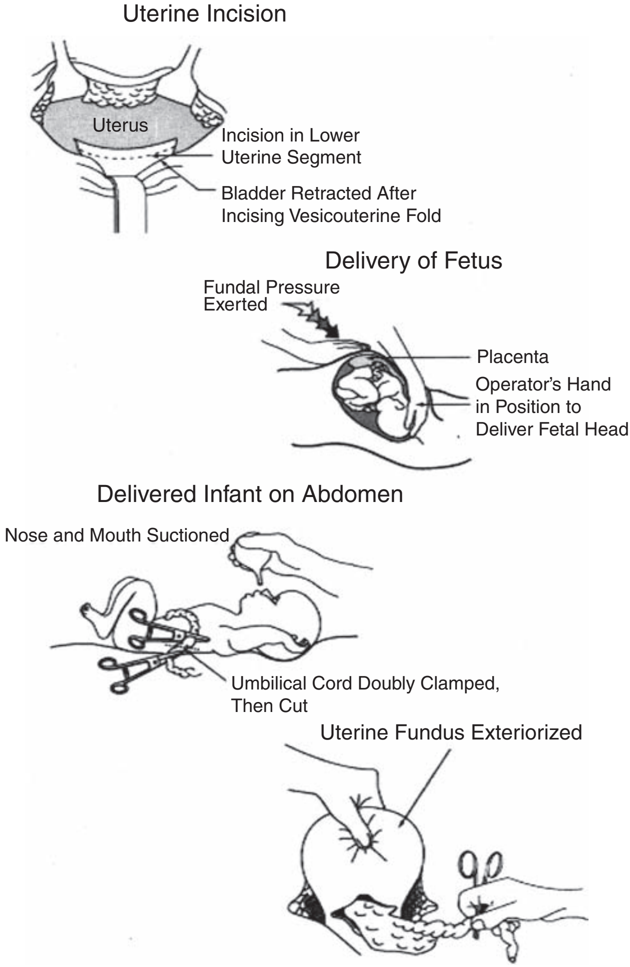

FIG. 28-4. Emergency C-section. (*Source: US Army.*[36])

uterine atony, the woman loses blood at the rate of >500 mL/min. Early postpartum hemorrhage is seen in 10% of women due to uterine atony (1:20 incidence), genital lacerations, retained placenta, and uterine inversions (1:6400 incidence).[37]

Uterine Atony

Most postpartum hemorrhage stems from uterine atony (failure of uterine contracture). This bleeding may be torrential and fatal.

Initial management includes manual uterine exploration for retained placenta. Without anesthesia or with only a pudendal block, this procedure is painful. Place an open sponge (gauze) around the fingers of your dominant hand and place the opposite hand on the patient's uterine fundus. Apply downward pressure. Gently guide your fingers through the open cervix and palpate for retained placenta. The inside of the uterus should feel smooth, and retained placenta will feel like a soft mass of tissue. Remove this tissue manually or with a large curette, if available.[38]

If no tissue is encountered, use both hands to apply vigorous uterine massage to improve uterine tone. Give medications, if available. Usually, that will be oxytocin: 40 international units (IU) in 1000 cc IV or up to 10 IU given IM. Never give it IV push. If no medication is available and the bleeding is not heavy, encourage the patient to breastfeed or do nipple stimulation to increase endogenous oxytocin release.

If these measures do not stop the bleeding quickly, begin the measures described below.

Postpartum Hemorrhage Control

Significant postpartum hemorrhage (>500 mL within 24 hours after delivery or enough to affect physiological functions) is not uncommon, occurring in about 3% of women in many populations. This results in ~150,000 annual deaths. Up to 90% of women with significant postpartum hemorrhage have no identifiable risk factors. So, in a delivery, one should always assume that it might occur.

The problem with treating postpartum hemorrhages effectively is that clinicians often do "too little, too late." They delay in transfusing blood, transfuse too little, and delay initiating surgical treatment. Often, the delays are due to trying different oxytocics and massaging the uterus in the hope that this would stop the hemorrhage.[39] There is also a reluctance to perform unnecessary and difficult surgery.[40]

If available, oxytocin, ergotamine, and 800 mcg of misoprostol can often successfully stop hemorrhage. Oxytocin normally works within 3 minutes. If the problem is a retained placenta, injecting 20 to 30 IU oxytocin mixed with an equal amount of NS into the umbilical vein may allow the placenta's removal without resorting to anesthesia.[41]

The key element to managing these patients is to immediately prepare for, and then quickly go on to, the next step if the method being used does not immediately show results. If the patient is already in shock, use the next step—tamponading the uterus and giving blood and blood products—while giving oxytocics. If the bleeding does not stop, prepare for surgery.

If the bleeding occurs while the abdomen is open for a C-section, infuse oxytocics while compressing the uterus with two longitudinal sutures along its long axis to prevent it from relaxing and filling with blood.[42] If that is not effective, use a balloon device and prepare to do a hysterectomy if that does not immediately stop the bleeding.

Visual estimation is an inaccurate method to determine how much blood a woman is losing intra- and postpartum. To measure the amount of blood loss, employ the same method as in cholera; that is, while the woman is in the birthing position, use a plastic sheet to funnel blood into a bucket. After about 2 hours, move her to a cholera bed (with the same bucket) so that any blood lost continues to flow into the bucket.[43] Mark several buckets in advance, inside and outside, at 500-mL increments.

Packing

Do not use uterine packing to control postpartum hemorrhage unless no other options are available.[44] Problems with using packing to control postpartum hemorrhage include the trauma inflicted by blindly placing gauze packs, the time it takes to insert them, and the need to pack them tightly enough to control the hemorrhage. Most importantly, you cannot tell whether the procedure is successful until after the blood soaks through the gauze—demonstrating that it has failed.[40]

Condom and Foley Catheters

Condom catheters can be successfully used to tamponade massive postpartum hemorrhage. Use a heavy suture to tightly tie a large condom to the end of a urethral balloon (Foley) catheter. Insert it through the open os until the condom is completely within the uterus and inflate it through the main catheter lumen with 250 to 500 mL NS, or until the bleeding completely stops. Clamp the catheter. If it doesn't stop immediately, the bleeding usually stops within 15 minutes. Most clinicians pack the vagina around the catheter (Fig. 28-5).

Some clinicians have kept the balloon in place for 24 to 48 hours, depending on the initial intensity of blood loss. However, it probably needs be in place for 12 hours. If bleeding recurs, it can quickly be replaced. Even with longer placements, however, no intrauterine infections usually occur.[45]

Anti-shock Garment

A temporizing measure, while waiting to transfer the patient for surgery or transfusion, is to place a pneumatic anti-shock garment (e.g., military anti-shock trousers [MAST] or a similar

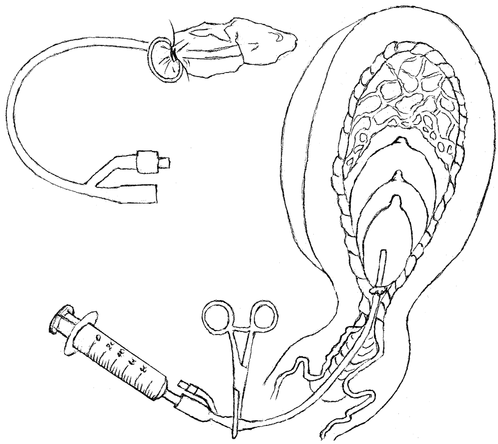

FIG. 28-5. Inflated condom-urethral balloon catheter.

device). While a similar non-inflating device has been successfully tested for postpartum hemorrhages, even though they are relatively inexpensive (<$200 US), they are not likely to be available.[46] MAST or an improvisation to apply pressure to the pelvis and legs is worth trying, since it may help the resuscitation process.[47] Be careful not to overinflate the trousers, and don't apply too much external pressure.

Uterine Inversion

Uterine inversion is a rare cause of major postpartum hemorrhage and shock, often presenting with abdominal pain and an impalpable or vaginally appearing uterus (procidentia). It most often occurs with fundal implantation of the placenta and inappropriate traction on the umbilical cord in the presence of an atonic uterus.

Pharmacologic relaxation may be needed to reinsert the uterus. One readily available option is to use sublingual nitroglycerine (NTG), which causes rapid uterine relaxation. Its onset is 30 to 45 seconds, with peak action at 90 to 120 seconds. It lasts up to 5 minutes. Intravenous NTG can also be used, but is less readily available. Sublingual NTG 800 mcg should completely relax a partially inverted uterus within 30 seconds, so that it can be reduced.[37]

Nipple Infections

Gentian violet (1% solution in water) is an excellent improvised treatment for *Candida albicans* nipple infections. About 10 mL is sufficient for an entire treatment. Nursing mothers with a yeast infection of the nipple may experience severe nipple pain, as well as deep breast pain. The pain is often burning, lasts throughout the feeding, and may radiate into the mother's armpit or into her back. Gentian violet nearly always brings rapid relief.

Have the patient dip a cotton-tipped applicator into the gentian violet and put it in the baby's mouth to suck on for a few seconds. If the entire mouth isn't colored with the dye, have her spread the dye over the tongue and buccal mucosa. Then have the baby breastfeed. If both nipples are not purple at the end of feeding, paint the nipples with gentian violet. Repeat this treatment once a day for 3 to 4 days. If the patient is not better by the third day, consider other diagnoses.

Advise the patient that the gentian violet stains clothing, but not skin. Any skin discoloration disappears in a few days. While using this treatment, boil or stop using any artificial nipples.[48]

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29 Orthopedics

Orthopedic and related soft-tissue injuries are some of the most common reasons for doctor visits. These injuries are likely to present problems when medical equipment is scarce, especially in settings with high levels of injury (e.g., wilderness, war) or where having a disability is a threat to survival (e.g., treks, battles, subsistence economies). Extremity injuries are the primary cause of injury-related disability in many countries, especially in the developing world.[1] In developed countries, they account for about 6% of all adult emergency department visits.[2]

This chapter discusses the diagnosis and treatment of fractures and dislocations, including emergency amputations. To reduce edema, soft tissue joint injuries are best treated with compression dressings and cold packs (usually crushed or cubed ice). Interrupt the cold application every 20 minutes, or more often if the cold causes discomfort.

WHO has developed a list of essentials for treating extremity trauma at facilities with different levels of treatment capability throughout the world (see "Facilities" in Chapter 5, Basic Equipment). Table 29-1 suggests what equipment and skills may need to be improvised in situations of scarcity.

TABLE 29-1 Worldwide Essentials for Diagnosing and Treating Extremity Injuries

	Facility Level			
Resources	Basic	GP	Specialist	Tertiary
Ability to recognize neurovascular and disability-prone injuries	E	E	E	E
Basic immobilization (sling, splint)	E	E	E	E
Wrap pelvic fractures for hemorrhage control	E	E	E	E
Hand injury assessment and basic splinting	E	E	E	E
Spine board availability/use	D	E	E	E
Proper management of immobilized patient	D	E	E	E
Radiology available	D	D	E	E
Closed reduction of fractures/dislocations	PR	PR	E	E
Compartment pressure measurement	I	D	D	E
Operative wound management	I	PR	E	E
External fixation (or pins and plaster)	I	PR	E	E
Skeletal traction	I	PR	E	E
Skin traction	I	PR	E	E
Tendon repair	I	PR	E	E
Hand injury debridement and repair	I	PR	E	E
Amputation	I	PR	E	E
Fasciotomy for compartment syndrome	I	PR	D	E
Internal fixation	I	I	E	E

Abbreviations: D, desirable; E, essential resources; GP, general practitioner; I, irrelevant; PR, possibly required.

Modified with permission from Mock et al.[3]

DIAGNOSIS OF FRACTURES AND DISLOCATIONS

Lacking radiographs or other imaging capability, clinicians need to rely on physical signs and symptoms to make presumptive diagnoses of fractures and dislocations. Table 29-2 lists the common signs and symptoms of fractures, with a comment about their diagnostic utility. (Radiographs are included in the list to identify their relationship with the physical exam. Many factors affect the usefulness of radiographs as diagnostic tools, including their technical quality and the skill of those interpreting the images.)

Using Tuning Forks/Percussion

One of the most persistent myths in orthopedics is that fractures can be diagnosed using a stethoscope with a tuning fork or percussion. This fallacy continues to be sustained by experts in academia and wilderness medicine.[6-9] Yet our forbears knew that this was nonsense. Stimson, for example, wrote in 1910 that even under the best circumstances, this adds nothing to the diagnosis. "Auscultatory percussion," he wrote, "the stethoscope being moved from one fragment to the other while percussion is made upon the first, will sometimes give a marked change in the sound as the line of fracture is crossed; but it is rarely significant, except in cases in which the diagnosis can be made by other means."[10] What Stimson didn't mention is that the percussion usually hurts over the fracture site: not a great finding, but enough to suggest that there might be a fracture.

No study has demonstrated the validity or reliability of the tuning fork test in detecting simple acute fractures.[11] My own tests, done with naïve optimism, used not only percussion, but also tuning forks of various recommended frequencies. These tests demonstrated that while percussive diagnosis works occasionally—usually in cases where the fracture is clinically obvious anyway—there are many false positives and false negatives, making the method virtually worthless. False negatives were especially frequent when hematomas overlaid the fracture site.

Using Ultrasound

See Chapter 18, Radiology/Imaging, for information about how to use ultrasound for orthopedic injuries.

Physical Diagnosis

The balance of this section deals with the physical diagnosis of fractures and dislocations, which is an art seemingly lost to a reliance on imaging. Physical diagnosis consists of (a) observation, (b) measurement, and (c) palpation. Using these three modalities, the clinician can diagnose many acute orthopedic disorders without imaging.

Upper Extremity

Carpal Bone Fractures

Unlike many other fractures, carpal bone fractures may not produce much deformity, or even edema. After trauma, the patient's wrist pain, limitation of motion, and tenderness on palpation should provide enough information, without imaging, to treat an injury as a probable fracture and immobilize it. Even with imaging, some fractures, especially those of the scaphoid, may not be seen.

If all the following signs are present, they have 100% sensitivity and 74% specificity for a scaphoid fracture.[12] Assume that there is a scaphoid fracture, even if it appears normal on imaging, when there is:

1. Tenderness when pressing the anatomical snuffbox. The anatomical snuffbox is the groove between the tendons of extensor pollicis longus (on the ulnar side) and of extensor pollicis brevis and abductor pollicis longus (on the radial side).
2. Tenderness when pressing on the scaphoid tubercle. The scaphoid tubercle is the palpable prominence visible at the distal flexor crease when the wrist is extended and radially deviated.
3. Tenderness when longitudinally pushing the thumb toward the scaphoid while holding the wrist.

TABLE 29-2 Usefulness of Clinical Information for Diagnosing Fractures (10 = Most Useful, 1 = Least Useful)

Open fracture with observable bone fragments (10)	When bone fragments or fat-containing blood extrude from a wound, the question is no longer whether a fracture exists, but rather its extent and how to treat it.
False point of motion (10)	Definitive proof of a disruption in the bone and, after acute trauma, indicates a fracture. Its absence does not indicate anything.
Palpable discontinuity in bone (9)	This is an excellent indicator of bony discontinuity, especially in the patella, long bones, and diastasis of the symphysis pubis. Soft tissue defects, edema, and hematomas may limit palpation of or simulate this defect.
Results of radiograph (9)	Excellent, if positive. The usefulness of radiographs depends on obtaining the correct images, the radiographic technique, the practitioner's skill at interpreting radiographs, and the type of fracture. Some fractures will not be seen initially on radiographs (e.g., stress fractures, some hip fractures), so clinical evidence must always weigh more heavily with negative studies.
Examination under anesthesia (8)	Giving local, regional, or general anesthesia to examine the possible fracture site may aid in making the diagnosis, especially in children or uncooperative adults. Once anesthetized, test the patient for abnormal movement, deformity, and crepitus. Fractures may exist without any of these being found.
Deformity (8)	Presume diagnosis of fracture or dislocation if it can be discerned. Deformities are more likely to be seen if the patient presents before there is significant edema or several days later when edema has resolved, and if the fracture is away from the joints, is angular, is not a partial (e.g., stress, torus) fracture, and is not a compression fracture. Old fractures and some chronic bone deformities, such as rickets, may give the appearance of a fracture, although generally not with the acute pain and skin tenting often seen after trauma.
Crepitus (8)	Crepitus, or a grating sound caused by contact of the broken surfaces with each other, is highly suggestive of a fracture. Patients generally feel a rough, grinding sensation. In fractures with many spicules, the sensation is often that of a click. Badly comminuted or impacted fractures and those days or weeks old may have no crepitus [Hamilton]. Occasionally, chronic joint disease or blood clots near a suspected fracture may produce crepitus, so the sign is not perfect. Test for crepitus.
Shortening of a limb (7)	This is a convincing sign of a long-bone fracture. Both extremities should be measured using easily identified landmarks (e.g., anterior iliac spine and medical malleolus). The difference may be an inch or more. Dislocations or prior injuries on either side may also cause shortening, but other signs can often differentiate between the two problems. Measurements can also be used to determine if adequate traction has been applied. The measurements must be taken accurately. For details, see "Measuring Legs for Diagnosis" and "Angle Measurement Using a Goniometer" in this chapter.
Loss of function (4)	Many injuries can limit a patient's ability or willingness to use the extremity. There is often inability to lift the limb, owing to pain or to the separation of the bony lever upon which the muscles act, but this inability does not extend to all fractures, and especially does not exist in all partial or impacted fractures [Hamilton]. Mild, non-sedating analgesics may help make the diagnosis by allowing a patient to better test their use of an extremity.

(*Continued*)

TABLE 29-2 Usefulness of Clinical Information for Diagnosing Fractures (10 = Most Useful, 1 = Least Useful) (*Continued*)

Pain and tenderness (1)	Unreliable sign. Often present, even severe, with only soft tissue injury; may be minimal or absent with a fracture.
Swelling (1)	Unreliable acutely. Swelling is such a common sign that it loses its diagnostic significance. If the swelling is out of proportion to the soft-tissue injury or persists longer than such apparent damage would warrant, it may indicate a fracture. If deep swelling persists after the skin edema resolves, it often indicates a displaced bone or callus.
Ecchymosis (1)	Although ecchymosis is more common in fractures than in dislocations [Hamilton], even if it occurs acutely, it has minimal diagnostic value. If it persists over several days, it probably indicates ongoing bleeding from a deep (probably bony) vessel.
Altered percussion (1)	Although highly touted, clinicians who have tried the technique of listening for changes of tone across fractures produced by either percussion or tuning fork have found it to be grossly unreliable. False-positive and false-negative results are the rule, rather than the exception.

Data from Foote[4] and Hamilton.[5]

Shoulder Dislocation

Diagnosing a shoulder dislocation without a radiograph is quite simple: Just feel for the "hole" when your finger falls into the now-empty joint at the glenoid (Fig. 29-1). If there is any doubt, feel the other side. Other signs include a flattening of the shoulder, projection of the elbow with the impossibility of bringing it to the side of the body, and, most important, the presence of the head of the bone in an abnormal situation, usually below the coracoid process. If measured from the tip of the acromion to the external condyle of the humerus, the affected arm will be shorter than the other; this difference is increased by abducting the arm.[13]

Fracture of the Proximal Humerus

Patients with a fracture of the proximal humerus usually have localized pain, especially when pressing the elbow upward. If the elbow is rotated slightly, the tuberosities fail to move. With marked displacement, the arm appears to be at an abnormal angle, with the axis of the humeral shaft pointing medially. Any movement usually produces pain at the groove between the pectoralis and the deltoid near the coracoid. Dislocation of the shoulder is excluded by recognizing that the humeral head is still in place.[14]

Elbow Injuries

With injuries at the elbow, the clinician must differentiate between fracture, dislocation, and sprain. If signs of the first two are not present, the diagnosis of exclusion—which must be given with caution—is sprain. History is usually of no help, so you must rely on the clinical exam.

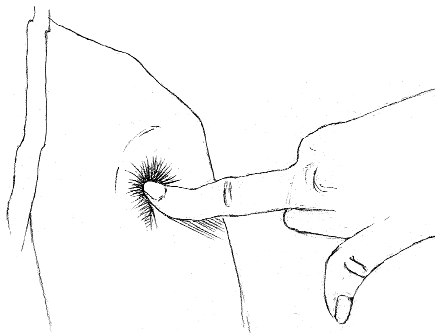

FIG. 29-1. Digital diagnosis of shoulder dislocation.

Examination of the elbow is much easier if done early, before significant swelling impedes the exam. If there is swelling, try to reduce it by having the patient hold his arm down or by using an elastic bandage. When doing the exam, concentrate on the area where the swelling first appeared or where it remains after reducing it.

If the anatomical relationship of the olecranon and epicondyles and the radial head is normal, the elbow is not dislocated. So, to begin the exam, simultaneously hold the two epicondyles and the tip of the olecranon to determine if their relative positions are normal. At 90-degree flexion and viewed from the back (posteriorly), the three should look like an isosceles triangle—with the two equal sides being from the olecranon to the condyles. Next, palpate the radial head to determine its position.

If the exam shows no dislocation, and if the patient can cooperate with the exam, test to see what areas are painful. Grasping the elbow with one hand and the humeral shaft with the other, first press the two together and then sideways. Then, with your thumb and fingers on the epicondyles, check the distal humerus for abnormal mobility and trace the humeral shaft downward to determine its relation to the condyles. If a supracondylar fracture is suspected, confirm its presence by palpating the condyloid ridge for points of pain and irregularity.

Supracondylar fractures also have abnormal lateral mobility. If examined on an extended arm, abnormal adduction and abduction of the forearm can be demonstrated. Grasp the condyles firmly with one hand and the shaft with the other to demonstrate free mobility of one upon the other, usually with crepitus. Pressing upward with the hand under the flexed elbow causes pain, but pressing the condyles together does not cause pain unless the line of the fracture also runs between them (T-fracture), nor can the condyles be moved independently of each other.[15]

If there is no evidence of a supracondylar fracture, press the condyles together and then hold each separately to check for pain or abnormal movement. If either moves independently, often with crepitus, a fracture is present. Local, regional, or general anesthesia may greatly facilitate this examination—for both the patient and the clinician.[16]

Pelvis/Hip

Pelvic Trauma

Many trauma protocols require pelvic radiographs, but in situations of scarcity, access to imaging may be limited or nonexistent. The following information is helpful to determine which trauma patients really need radiographs.

A clinically significant pelvic fracture will exist only if a trauma patient has at least one of the following findings: (a) Glasgow Coma Score <14, (b) complaint of pelvic pain, (c) pelvic tenderness on physical examination, (d) distracting injury, or (e) clinical intoxication. One study found that if one or more of the above criteria were present in adult patients after blunt trauma meeting Level 1 (serious) criteria, those patients had a 12% chance of having a significant fracture.[17] After trauma, the presence of diastasis (separation) at the pubic symphysis or movement when the iliac wings are simultaneously pressed posteriorly ("rocked") suggests a fracture, whether or not the patient has pain.

Hip Dislocation

Since long-term disability can be lessened by the quick recognition and treatment of hip dislocations and the treatment may depend on the type of dislocation, rely on the patient's clinical appearance to determine the type of dislocation (Figs. 29-2 and 29-3). Palpating the femoral head in the groin is also a common clue to the correct diagnosis. If there is severe pain in the hip without rotation, consider femoral neck fracture.

Hip Fracture

Unlike many other areas of orthopedics, patient history may play a large role in the diagnosis of a hip fracture—especially in an elderly patient. As Helferich noted, "One should always think of the possibility of a fracture of the femoral neck when an old person, after a fall on the knee or side of the body, cannot stand up, and when the injured limb is shortened and rotated outward. In the diagnosis, contusions and dislocations of the hip and fractures of the pelvis have to be considered. It is hardly possible to mistake the injury for a dislocation (with outward rotation only a forward dislocation could be possible)."[20] A confounder is that elderly hip fracture patients may complain about knee, rather than hip, pain.

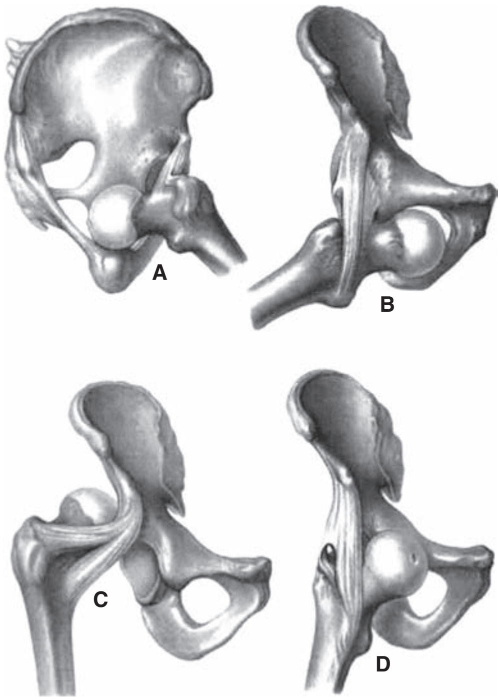

FIG. 29-2. Anatomical appearance of different hip dislocations. A, anterior dislocation onto the ischium; B, anterior-central dislocation into the obturator foramen; C, posterior dislocation onto the ilium; and D, anterosuperior dislocation onto the pubic rami. (*Reproduced from Helferich.*[18])

With hip fractures, normally (a) the patient cannot lift his leg off the bed, (b) the leg is shortened to various extents (you may need to measure the limbs, see "Measuring Legs for Diagnosis" below), (c) passive motion of the foot laterally and medially causes hip pain, (d) crepitus is felt unless the fracture is impacted or the fragments are widely separated, (e) the leg may be externally rotated, and (f) the greater trochanter can be felt above Nélaton's line, an imaginary line from the anterior superior iliac spine to the ischial tuberosity (Fig. 29-4).[20]

MEASURING LEGS FOR DIAGNOSIS

Measuring limbs to detect a discrepancy between the two sides after an acute injury is a technique that has been lost over time. However, it is still useful, especially when imaging is not available and the clinician must rely solely on the physical exam to diagnose fractures and dislocations—of any extremity.

With regard to hip fractures, Stimson wrote that leg length discrepancy "may vary in extent from a small fraction of an inch to two or three inches." It may occur immediately or "appear gradually or suddenly after the lapse of a few hours or days." He added that it is vital "to have them form the same angle with the pelvis, that each is in the same position of extension and abduction… . The measurements are usually made between the anterior superior spine of the ileum and a malleolus."[22]

Lower Extremity

FEMUR, MID-SHAFT FRACTURE

This injury nearly always shows the typical signs of a fracture. It may, however, be confused, on occasion, with a large hematoma.

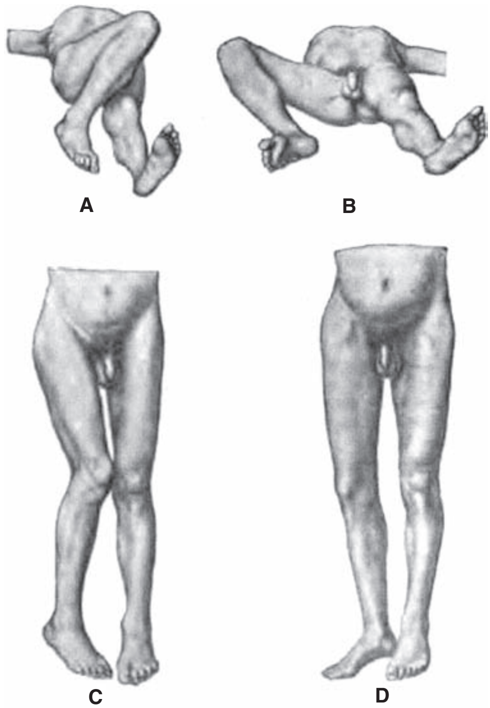

FIG. 29-3. Clinical appearance of different hip dislocations. A, anterior dislocation onto the ischium; B, anterior-central dislocation into the obturator foramen; C, posterior dislocation onto the ilium; and D, anterosuperior dislocation onto the pubic rami. (*Reproduced from Helferich.*[19])

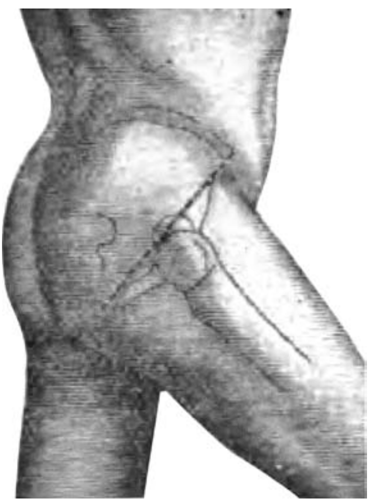

FIG. 29-4. Nélaton's line. (*Reproduced from Helferich.*[21])

Knee and Ankle Fractures

The Ottawa Knee Rule, the Ottawa Ankle-Foot Rule, and the Pittsburgh Knee [Decision] Rule (discussed below) are validated diagnostic criteria for two commonly injured joints. They are useful when radiographic imaging is present, but limited. If there is no imaging, the clinician must assume that patients who are "positive" using these rules have a fracture that must be treated with immobilization or by providing non-weight-bearing assistance with crutches or other devices.

Use and Limitations of the Rules

These rules are for patients with blunt trauma, including twisting injuries, falls, and direct blows. These rules have not been validated in children (<18 years old), pregnant women, or those with diminished ability to follow the test (e.g., head injury, intoxication).[23]

The knee and ankle-foot rules all have nearly 100% sensitivity and are modestly specific.[24,25] The Pittsburgh Knee [Decision] Rule is 99% sensitive and 60% specific for the diagnosis of knee fractures. Of patients in whom the rule indicated a fracture, 24% had a knee fracture. For patients in whom the rule suggested no fracture, 99.8% had no fracture. The Ottawa Knee Rule was 97% sensitive and 27% specific for knee fractures.[26]

Ottawa Ankle-Foot Rule

There is a high suspicion of fracture (obtain an ankle radiograph, if available) if there is pain near a malleolus *plus* one of the following:

- Bone tenderness at the posterior edge of the distal 6 cm or at the tip of either malleolus.
- The patient could not bear weight for at least four steps immediately after the injury and still cannot at the time of evaluation.

There is a high suspicion of fracture (obtain a foot radiograph, if available) if there is pain in the mid-foot *plus* one of the following:

- Bone tenderness at the navicular or the base of the fifth metatarsal.
- The patient could not bear weight for at least four steps immediately after the injury and still cannot at the time of evaluation.

Ottawa Knee Rule

A knee radiograph is required *only if* a knee injury patient has one of the following[27]:

- Age >55 years
- Isolated tenderness of the patella
- Tenderness at the head of the fibula
- Inability to flex to 90 degrees
- Inability to walk four weight-bearing steps immediately after the injury and at the time of the evaluation

Pittsburgh Knee [Decision] Rule

A patient with a knee injury following blunt trauma or a fall needs a radiograph *only if* they have either[28]:

- Age <12 years or >50 years, or
- Inability to walk four weight-bearing steps at the time of the evaluation

Tibia-Fibula Fractures

Because the tibia is subcutaneous for much of its length, the clinician can diagnose fractures of the tibial spine by palpating the entire shin.

REDUCTION AND TREATMENT OF FRACTURES AND DISLOCATIONS

As with all procedures in this book, the techniques described for fracture and dislocation reduction and treatment are for use only by medically trained personnel who are in wilderness, isolated, Third World, or disaster settings in which more expert help, the normal equipment, or another needed resource is not available. In these settings, treating fractures and dislocations is often complicated because radiographs are not available.

The three goals of fracture treatment are:

1. Reposition bone fragments. Correct any bone angulation and pull the limb out to length, especially when there are no pulses below the site of the injury or when the patient must be moved and the limb's position will interfere with that effort. The best time to undertake a dislocation reduction is immediately after the injury, when there is minimal muscle spasm and resistance. Try to minimize pain during this process by using local, regional, or general sedation/anesthesia. (See Chapter 13, Analgesics, and Chapter 14, Anesthesia—Local and Regional.)
2. Immobilize the fragments. Keep the limb at length if required (traction) and immobilize it while the bone heals.
3. Restore function. This requires evaluating the limb's (and the patient's) neurovascular status before and after any manipulation.

Reduction and Treatment Without X-Rays

In resource-poor settings, the closest x-ray machine may be located hours away; often radiographs are not available at all. In such cases, you will have to rely on physical signs (such as remeasuring limbs, see below) to achieve the treatment goals above.

Battlefield Management

As Husum and colleagues wrote, battlefield fracture management means

> Immediate reduction! Every fracture, open as well as closed, should be reduced as soon as possible after injury… . Early fracture reduction improves the local circulation, reduces pain and improves the general condition. During the first 1–2 minutes after the injury, manipulation of the fracture is less painful, and any fracture may be aligned without anesthesia. Reduction more than two minutes after the time of injury, should be done with local anesthesia (10–20 mL lidocaine injected into the fracture hematomas; or low-dose IV ketamine anesthesia).[29]

Remeasure

After any attempted fracture reduction where shortening of the extremity has occurred, measure the two extremities again. Generally, if the shortening continues to be >0.5 inch, reduction is unsatisfactory: Either the fragments have not been restored to their normal position or the muscles have distracted them again. At that point, make another attempt to reduce the fracture under better anesthesia or, if that fails, splint to await additional intervention—which may include surgery.[30]

Open Fractures

For open fractures, the first step is to control bleeding. Direct pressure on soft-tissue bleeding sites usually works best. If absolutely necessary, a tourniquet can be used. (See Chapter 21, Surgery/Trauma.)

Irrigate the wound extensively: at least 5 to 10 L of fluid are needed for the typical open fracture. Use the cleanest fluid possible. Tap water works well if the water supply is relatively clean (i.e., can be used for drinking). If not, boil the water first. Prepackaged sterile fluids are not necessary. Since dilute iodine solution is useful for wound irrigation in open fractures, adding a single povidone-iodine pad to each liter of water is thought to provide the equivalent antibacterial efficacy; however, this has not been proven.[31,32]

A continuous fracture irrigation system (that may also be used, if desired, for continuous antibiotic instillation into a wound) can be improvised using any closed drainage system. The most commonly available, other than intravenous (IV) systems, is a urethral catheter drainage system: just insert a small-gauge urethral catheter into the wound and hang the drainage bag to drip in fluids for irrigation.

After cleaning the wound, reduce the fracture as well as possible, and put the bone beneath the skin. This can be done either by extending the limb or by pulling the skin aside with the fingers, with the handle of a metal spoon, the blunt end of a tweezers ("pickup") or similar firm instrument.[33] Experience shows that these methods work well to lift skin over extruding segments of bone in an open fracture. "If these measures do not succeed, the skin may be slit open freely … Enlarging the opening does not generally complicate the case—sometimes it is even advantageous."[33]

Don't close the wound. Pack it open with gauze; soak the gauze in a dilute iodine solution if you have some. Change the packing at least twice a day and do not let the wound close until there is no sign of infection and there is good granulation tissue. Then, allow the wound to close by secondary intent—bottom-up and inside-to-outside without the skin closing over the wound, until it fills in with granulation tissue.

If available, give antibiotics, immobilize the limb using plaster or traction, and begin rehabilitation as soon as practicable.

Upper Extremity

Shoulder Reduction

Anterior shoulder dislocations are common. Clinicians need a "bag of tricks" to reduce these deformities, since any single method does not seem to work in every case. Especially in austere circumstances, methods that do not require sedation are helpful. When sedation is needed, consider using hypnosis or intra-articular injection, which have both worked well for joint reductions.[34,35] (See also Chapter 14, Anesthesia—Local and Regional.)

The shoulder reduction technique first described by Stimson in 1900 may be the easiest one to use in the midst of multiple casualties or limited resources. With the patient prone, extend the affected arm vertically from the exam table. Attach a 10- to 15-lb weight to the wrist and allow it to hang there for approximately 6 to 20 minutes to achieve reduction. Stimson used a cot with a hole in it for the patient's arm to go through or "two tables placed end to end, so that the body would rest on one and the head on the other, the arm hanging down between."[36]

The easier, and faster, Snowbird traction technique has the patient sit facing the back of the chair, with their affected arm draped over the back. Place a pad under the axilla and flex the elbow to 90 degrees. Drape a stockinet or cloth loop over the proximal forearm and let it hang to the floor. Using the chair back as counter-traction, the clinician should place his foot in the loop and apply a firm, steady downward traction. This way, his hands are free to apply pressure or to rotate the arm, as needed (Fig. 29-5). This method has been reported to be successful in 97% of cases without complications; >90% can be done without sedation or narcotic analgesia.[37] Alternatively, have the cooperative patient keep his arm straight while the clinician (with strong arms and a good back) applies traction in line with the arm. As the muscles relax, have the patient stand; this increases the traction.[38]

FIG. 29-5. Snowbird traction for anterior shoulder dislocation.

Cooper first described the Milch technique in 1825. With the patient supine, the clinician abducts the affected arm while simultaneously applying pressure to the humeral head. External rotation and traction are applied when the arm is fully abducted, that is, straight “up” so that the arm is in line with the body. Few patients require sedation or analgesia for this procedure.[39,40]

The Hippocratic method of shoulder reduction is very old and some have suggested that this method is dangerous, since it can cause nerve damage to the axilla. However, recent studies show that the Hippocratic method may actually be safe, but it often requires sedation or significant analgesia to be successful. Place the patient supine, and put traction on the patient’s hand and forearm while an assistant provides counter-traction at the axilla with a sling. Pull the arm along its axis in approximately 30 degrees of abduction to move the humeral head from its dislocated position into apposition with the rest of the joint.[41]

The scapular manipulation/rotation method, often used along with other methods, supposedly has a success rate of >90% when used alone, although that presumes significant relaxation. With the patient sitting, have an assistant hold the affected arm straight out from the patient with the palm up (the patient’s shoulder should be flexed to an angle of 90 degrees) while resting his other hand on the patient’s ipsilateral clavicle. This applies gentle traction. The clinician then pushes the tip of the scapula medially and upward while pushing the superior part of the scapula laterally. A palpable “clunk” confirms reduction. The patient can also be positioned prone, with the arm dangling and an assistant maintaining gentle traction with the hand in supination.[42]

The external rotation maneuver is a modification of the Kocher maneuver. It can be performed in any position with the assistance of only one person or by the patient himself. If the patient is very cooperative, he can sit and allow the muscles to relax. Then, flex the elbow at a 90-degree angle, stabilize it against the trunk, and, slowly, externally rotate the arm at intervals. This allows time for any muscle spasms to subside. Most dislocations are reduced after about 5 minutes of external rotation.[43]

Supracondylar Fractures

Both open and closed supracondylar fractures can be successfully treated with traction and splinting. As Stimson wrote,

> In the higher fractures in adults and the late lateral angular deviation in the low ones in children, the overriding can be corrected by traction, preferably with the elbow at a right angle, and its recurrence effectively opposed by anterior and posterior molded splints, or a plaster encasement, aided sometimes by a weight attached to the forearm close by the elbow, with the wrist supported by a sling. In the low form in children … even very marked deformity disappears rapidly in the young by absorption of projecting bone and the filling up of hollows, and functional limitations are rarely caused by it. In compound [open] fractures, I always use vertical suspension of the limb for about a fortnight [two weeks] unless the wound heals sooner. It is of great value in controlling reaction as well as preventing gross displacements; minor adjustments can still be made after the wound has healed or has become unimportant.[44]

Colles’ (Distal Radial) Fractures

A Colles’ (or other similar) fracture can be reduced by suspending the arm. A hematoma block helps relieve discomfort. Make a finger trap by forming a girth hitch with bandage material, other cloth, or thick rope (Figs. 29-6 and 29-7). Loop these around the thumb and index finger, or the index and long fingers, and suspend the material from a hook or an IV pole. Traditional Chinese finger traps used as toys also work well to hold fingers aloft. Usually made of folded paper, they may not be good for more than a few patients before they need to be replaced.[45] Do not use string, wire, or anything else that might compromise circulation to the fingers, even if you are not using any added weight to assist fracture reduction. From 2.3 to 4.5 kg can be suspended from a padded cloth at the proximal forearm to speed the reduction. After 20 to 30 minutes, return and make any necessary minor adjustments. To make life simple, keep the arm suspended while the splint or cast is applied.

Metacarpal Fractures

The usual treatment for most metacarpal fractures and dislocations is nonoperative. The goal is to preserve function. This section describes nonoperative management and refers to surgery only when

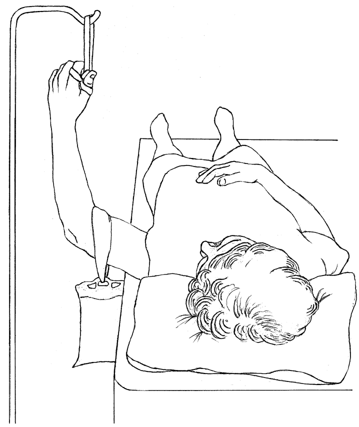

FIG. 29-6. Improvised finger traps in use.

that is the only option. In austere circumstances, that may mean operating outside your comfort zone, waiting or referring for treatment, or advising the patient that there may be a poor outcome.

If you cannot splint the hand or reduce the fractures, the hand can be treated using an old and less-than-optimal method[46]:

> Fill the palm with a mass of tightly packed cotton or similar substance or with a ball, over which the fingers are closed and fastened down with a bandage or adhesive plaster. If there is no displacement or tendency thereto, a simple immobilizing dressing of cotton held snugly with a roller-bandage is sufficient; the fingers being left free to prevent their stiffening. The flexion of the finger over the firm mass tends to draw the knuckle downward, and thus prevent shortening. The support furnished by the adjoining bones is an additional aid against displacement, and the back of the hand can be left partly uncovered for inspection.

Proximal Metacarpal (Base) Fractures

Reduce these fractures if there is >2 mm of articular surface displacement or if there is significant angular deformity or dislocation of the carpometacarpal joint. Hematoma blocks usually don't work, so a regional block or sedation may be necessary. Use traction and direct digital pressure with the clinician's thumb to reduce the fracture. Although fractures of the base of the

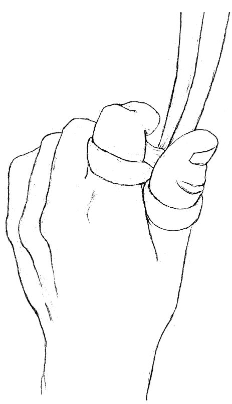

FIG. 29-7. Improvised finger trap, close-up.

fifth metacarpal are usually pinned, in austere circumstances, treat it like the others until or unless orthopedic services are available. Splint the wrist in 20- to 30-degree extension with the metacarpophalangeal (MCP) joints flexed for ≥4 weeks, with continued active motion of the finger interphalangeal (IP) joints.[47]

Metacarpal Shaft Fractures

Reduce metacarpal shaft fractures if there is significant palmar angulation (>10 degrees for second or third metacarpals, 20 degrees for fourth metacarpals, 30 degrees for fifth metacarpals) or any rotational angulation. To reduce the fracture, anesthetize it with a hematoma block and flex the affected finger's MCP joint and the proximal IP joints to 90 degrees. Apply upward pressure on the middle phalanx and downward pressure over the dorsal apex of the fracture. Use the finger to control or correct any rotation. Splint for <4 weeks, followed by active range of motion.[47]

Fractures at the Distal End

Splint non-displaced fractures of the metacarpal head (distal end) for 3 weeks, and follow with gentle motion. Use an ulnar gutter splint for the most common fractures, those of the fourth and fifth metacarpal heads. For fractures of the neck (just proximal to the head), such as a Boxer's fracture, you can splint most of them for 3 or 4 weeks. If there is too much palmar angulation (≤15 degrees in the second or third metacarpals; ≤45 degrees in the third, fourth, or fifth metacarpals) or any rotational deformity, reduce it like a shaft fracture. A splint maintains about 50% of the initial correction.[47]

Metacarpophalangeal Dislocations

Attempt to reduce MCP dislocations under local or regional anesthesia. The easy ones still will be in extreme (60 to 90 degrees) hyperextension. Flex the wrist and IP joints; gently put traction on the finger and bring the joint toward the palm. If it doesn't go in, the only option is to wait for a surgeon, since soft tissue or the volar plate is keeping it dislocated. Splint it dorsally for a short while, so that flexion can occur.[47]

Splinting Metacarpal Injuries

Once these fractures or dislocations are reduced, apply a forearm-based splint that covers both the dorsal and palmar surfaces of the metacarpal, but allows the IP joints to move. The dorsal splint should extend to the IP joints; the volar aspect should end at the distal palmar crease. The wrist should be in 20 to 30 degrees of extension and the MCP joints in 70 to 90 degrees of flexion. Buddy-tape the fingers of the involved metacarpal to maintain rotational control. Encourage the patient to begin moving the IP joints immediately and, as soon as the splint is removed, encourage active movement of the fingers and wrist.[47]

Pelvis/Hip

Risk of Bleeding From Pelvic Fractures

Unstable pelvic fractures may cause life-threatening hemorrhage. Patients with a high risk (>60%) of pelvic arterial bleeding are those with a pulse of ≥130/min, a hematocrit ≤30%, ≥1 cm diastasis of the pubic symphysis, and displacement of an obturator ring fracture. A patient with three or more indicators has a high (>60%) probability of major arterial pelvic hemorrhage. Those with one indicator have a 14% risk; those with two have a 46% risk.[48] An unconscious patient may be hypotensive on arrival. A conscious patient may splint the fracture with his muscles, so significant bleeding may not occur until after he is paralyzed for intubation, which causes the pelvis to fall open and the patient to become hypotensive. If pelvic fracture bleeding is a real or potential concern, apply a pelvic binder.

Pelvic Binder

A pelvic binder tightly encircles the entire pelvis at the level of the iliac wings (or the greater trochanters if the patient will soon go to surgery for an external fixator). The technique is first, to fold a long sheet or other strong cloth lengthwise to get a width of 15 cm; this will be used as

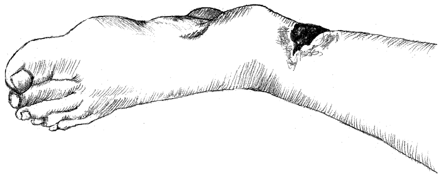

FIG. 29-8. Open ankle fracture-dislocation.

a draw sheet. Next, tightly roll a pillow and tape it, and place this behind the patient's knees. Then secure the patient's lower thighs and calves together with gauze or a similar bandage. This internally rotates both lower limbs, which act as levers on the displaced pelvis.

Ease the draw sheet beneath the patient. The two people applying the binder should stand on either side of the patient, lean toward each other, and pull on an end of the sheet while they each simultaneously push their side of the pelvis. When it is tight, secure the sheet with a cable tie or square knot. Then place a dowel, wooden branch, or metal bar against the knot and tie another square knot. Use the rod as a windlass to tighten the sheet. A tight belt or webbing may also be used, but these usually cannot be tightened enough to get a good effect.[49]

Hip Fractures Without Surgery

If the patient has a non-displaced intracapsular fracture and surgery is not available, don't fret. There seems to be little difference in outcome between surgery and conservative treatment in these cases.[50,51]

Lower Extremity

Ankle Fracture-Dislocations

A fracture-dislocation of the ankle (Fig. 29-8) is a devastating injury that, if not properly aligned, can be disabling when healed. Use a Dupuytren's splint to achieve and maintain alignment (Fig. 29-9). Apply the splint to the inner side of the leg; the foot will be pulled toward the splint when the bandage is wrapped around it. Note that there is no padding under the ankle joint.[52]

Hip Fracture

In austere conditions without the availability of x-ray or operative intervention, closed reduction and traction are the only options for treating hip fractures.

Fractures of the neck of the femur are the most common fractures seen in the elderly. These fractures can heal with bed rest, but patients often have chronic pain and may not be able to walk. Our forbears got good results with traction. Helferich wrote that extension and inward rotation should be secured with weight extension by means of strapping. A weight of 12 to 15 lb is usually required to overcome thigh muscle spasm, with the leg slightly abducted. Maintain traction for 2 weeks; then use crutches and physical therapy for 10 weeks or so. Have the patient change position on a regular basis to avoid decubitus ulcer formation.[53]

Fractures of the femoral head, if not displaced, usually heal fairly well with 8 to 12 weeks of bed rest. If the femoral head is displaced, the patient will probably have avascular necrosis, a

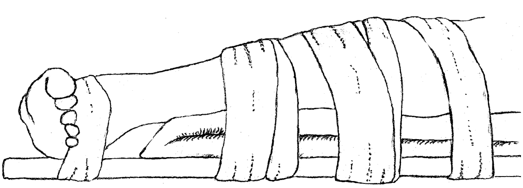

FIG. 29-9. Dupuytren's splint applied to ankle fracture-dislocation.

loss of range of motion, and chronic hip pain. However, if there is a central fracture-dislocation (the femoral head has pushed through the acetabulum), use 25 lb or more of traction in each of two directions: pulling the hip both laterally away from the body and in line with the body. This traction is needed for 6 to 10 weeks, followed by crutches. Even after this prolonged therapy, don't expect a great result from this major injury.[54]

OTHER TREATMENT

Hematoma Under the Nail

Subungual hematomas should be drained if they are painful. Use either a sharp, sterile tool (such as a needle or pin) or a thin wire (such as a paperclip) heated with an open flame. Neither of these requires anesthetizing the digit as long as the "drilling" stops as soon as blood exudes from the hole.

Do not remove the nail and repair the nail bed, even if the hematoma occupies >50% of the nail surface. It uses additional resources and causes increased patient morbidity.[55] The original nail can be used to protect a nail bed after an injury, as can artificial nails if the original nail is gone.

Compression Dressing

For patients with major fracture dislocations who cannot have an immediate operation, apply a Robert Jones dressing to control and minimize edema. Easily improvised, in addition to reducing edema and fracture blisters, it makes the patient more comfortable and improves surgical results by permitting better visualization of the tissues. The technique for applying this dressing can be found in Chapter 10, Circulation/Cardiovascular, where it is described for use as a treatment for peripheral edema.

Improvised External Fixator

Used for the treatment of complicated lower-leg fractures with soft-tissue damage, an external skeletal fixator can be easily improvised using wood. In each of two wooden boards (3.5 cm × 2 cm × 45 cm), drill holes about 1 cm apart, the same diameter as 5-mm Steinmann pins. The apparatus has greater strength if the holes are drilled across, rather than through, its width. The holes in the two boards must line up exactly with each other. Under appropriate local anesthesia or sedation, cleanse the wound and reposition the fracture. Then drill two Steinmann pins through the bone on both sides of the fracture, keeping a safe distance from injured tissues. Apply the boards to both sides of the leg. Place the pins through the holes in the wooden board that most closely match the anatomical position. As soon as the wounds heal, usually within 3 to 4 weeks, remove the external fixator and replace it with a plaster cast. The primary problem with this device is that it is not strong enough to allow walking exercises and weight bearing.[56]

Vacuum Dressing

To make a vacuum (negative-pressure) dressing, pack the wound with soap-free surgical sponges retrieved from single-use scrub brushes. Make holes in a sterile suction tube or in IV tubing with a small (#15 or #11) scalpel. Place the tubing over the sponges and seal the wound with a plastic adhesive dressing or similar airtight dressing. Connect the tubing to a continuous suction device.[57]

Amputation

Emergency amputations may need to be done outside a medical facility either to extricate trapped people or to complete a nearly complete amputation.

Mass casualty situations may precipitate more amputations than might otherwise occur. As Husum wrote, "Mass casualties are different! Attempts to salvage seriously damaged limbs are time- and staff-consuming; the clinic capacity will influence the reasons to do primary amputation."[58]

Indications

According to the US Army's Medical Corps, the "goals for initial care are to preserve life, prepare the patient for evacuation, and leave the maximum number of options for definitive treatment." The Medical Corps lists the following as indications for amputation[59]:

1. Partial or complete traumatic amputation.
2. Irreparable vascular injury or failed vascular repair with an ischemic limb.
3. Life-threatening sepsis due to severe local infection, including Clostridial myonecrosis.
4. Severe soft-tissue and bony injury to the extremity precluding functional recovery. "The surgeon must balance the realistic likelihood of ultimate reconstruction of a functional extremity against the risk of death associated with attempts to preserve a limb."

One should remember, though, that there are functional differences between arms and legs. As Husum and colleagues wrote, "Arms and legs are different! An arm with permanent nerve injury and partial loss of skin sensation may well be useful; a leg is not. An arm with bone loss and/or contracted joints may well be useful; a leg of that kind cannot bear weight—and is useless."[58]

Stressing the need not to procrastinate when an amputation is indicated, Dr. Gross wrote, "The results of the military surgery in the Crimea show that the success of amputations was very fair when performed early, but most unfortunate when they were put off for any length of time."[60]

One caveat is that cold injuries are not an indication for amputation—wait until the edges demarcate.

Emergency Prehospital Technique

In a dire emergency when on-scene amputation needs to be done, give whatever anesthesia is available and safe for the patient. Ketamine (IM or IV) or an opiate works well. (See Chapter 14, Anesthesia—Local and Regional, and Chapter 15, Sedation and General Anesthesia, for more detailed options.) The limb can also be infiltrated with a local anesthetic, although this generally will be less than optimal.

Control the bleeding by pressing on the pressure point, or by using a tourniquet and then tying the vessels. Cut through the limb or what remains of it as far distally as possible. Cut the tissues using a sharp knife. The bone can be more difficult to remove if a comminuted fracture is not present at that site. Use a carpenter's saw, a sharp chisel, or a straight gouge to cut the bone. An alternative is to make small-caliber drill-holes close to each other around the bone at the level to be amputated, and then manually fracture the bone transversely. Another option is to make a track in the outer cortex around the entire circumference of the bone by hitting the knife with light hammer blows, and then manually breaking the bone. Then apply a firm pressure dressing to the stump to control any bleeding.[61,62]

Method

Emergency amputations should be done as low as possible, with a final amputation done by experts later. Preserve as much viable skin and soft tissues distal to the bone amputation as possible; it can be used to later close the amputation stump; this eventually translates to a better fitting and more functional prosthetic.

US Army's Amputation Technique[63,64]

Surgically prepare the entire limb, since the injured tissues may extend much higher than initially thought. Especially in blast injuries, explosive forces drive debris proximally along fascial planes. To ensure adequate debridement, the incision may need to be extended proximally. Tourniquet control is mandatory. If a tourniquet is in place for hemorrhage control, prep it within the surgical field.

1. Make a circumferential incision through the skin and deep fascia at the lowest viable level. Allow this layer to retract.
2. Expose the muscle bundles and then divide circumferentially at the new level of the skin edge. The muscle bundles then promptly retract, exposing the bone.
3. Excise nonviable tissue, including necrotic skin and subcutaneous tissue or skin without vascular support; muscle that is friable, shredded, grossly contaminated, or non-contractile (this muscle is usually at the level of the retracted skin); and bone that is grossly contaminated or is devoid of soft-tissue support.
4. Place upward pressure on the proximal muscle stump and transect the bone at a still higher level. Cut the bone at a level that can be covered with skin. The surgical wound will have the appearance of an inverted cone.

FIG. 29-10. Skin traction after an amputation.

5. Isolate, clamp, and ligate blood vessels as they are encountered, to prevent and control hemorrhage. Apply bone wax to the open ends of bone to prevent oozing.
6. Transect major nerves. Identify major nerves, apply gentle traction on them, and ligate and cut them proximally at the highest level possible.
7. Do not suture preserved muscle flaps, but rather hold them in position with a dressing.
8. Do not construct flaps during the initial surgery or close an amputation primarily.

For makeshift anesthesia for amputations using refrigeration, see "Refrigeration Anesthesia: Amputations" in Chapter 14, Anesthesia—Local and Regional.

Care After an Amputation

Place a layer of fine mesh gauze over the wound and pack the recess loosely with fluffed gauze. Apply a stockinet over the stump, securing it with tape. Wrap the stump with elastic wraps (Ace bandage) using compression decreasing proximally and applying 5 to 6 lb of traction. Continued traction results in secondary skin closure over the stump.[64]

Provide analgesics, as available, in sufficient quantities to lessen the patient's postoperative pain. To prevent possible hemorrhage from the surgical site, for the first week post-injury, keep a tourniquet at the patient's bedside and during transport.

While surgeons working in a relatively stable environment may be able to treat post-amputation patients by delayed primary closure, many patients will need to be transferred for definitive treatment. Place these patients in skin traction to leave the wound open and prevent skin retraction. Ideally, skin traction will be maintained throughout the treatment course (Fig. 29-10). One way to maintain skin traction, while also maintaining traction on the residual limb, is by using a cast. The cast should be well padded, with integral skin traction maintained by use of an "outrigger."[65]

SPLINTS AND CASTS

Outpatient treatment of fractures, sprains, and strains, as well as postoperative treatment for various soft-tissue repairs, relies on immobilization to aid the healing process. Improvised immobilizers for extremities can be divided into (a) non-rigid splints, (b) rigid splinting materials that are not suitable for circumferential casting, and (c) casting materials. Casting materials can be used for circumferential casting, and include plaster of Paris and its many alternatives.

Non-rigid Splints

Sling (Arm)

A sling is the most basic extremity support. If nothing else is available, improvise a sling by putting the patient's wrist inside his shirt and buttoning the buttons around it. For more support, and if using a long-sleeved shirt, pin the sleeve containing the affected arm to the shoulder area on the opposite side of the shirt. Or double up the bottom of a short-sleeve shirt or a T-shirt over the forearm and pin it to both shoulder areas of the shirt.

A more formal sling can be made of any available material. A strip of material pinned so there is a loop around the wrist and around the neck makes a "collar-cuff" sling, which is ideal when movement of the shoulder can be tolerated or is desired to avoid a frozen shoulder. Alternatively, use any strip of cloth, webbing, belt, and so forth.

Buddy Taping

One of the simplest effective methods of splinting an injured finger or toe is to tape it to the adjacent digit. The key to success is to put absorbent cloth or gauze between the digits before taping and to change the material at least three times a day, or any time it gets wet, to avoid macerating the tissues. Keep it on until it feels better without it than with it.

Buddy taping can also be used for humerus fractures in infants. Bandage the arm to the torso and it will quickly heal. (Consider child abuse in these cases.)

A field-expedient method of stabilizing long-bone fractures in a lower extremity is to buddy tape the legs together, preferably with some padding between them. This may be more comfortable for a patient than a rigid splint.

Pillow Splints

Splints for joint fractures, dislocations, or other injuries can be made from pillows, blankets, sleeping bags, sleeping pads, or any similar items (Figs. 29-11 and 29-12). Wrap the pillow or multiple layers of other items around the injured part. Secure it tightly with any bandaging material. This is often a more comfortable method of splinting than using traditional materials.

Sandbag Splints

Extremities can be effectively splinted using a garbage bag, fanny pack, or similar soft-sided container filled with sand or dirt. Mold it to the extremity and tape or bandage it in place. Since this is heavy, the patient tends to move the extremity less than with a pillow splint.

Heel Pad

A heel pad made from thick foam with a hole cut in the center can be placed in a shoe or boot beneath the heel to help ameliorate pain in the calcaneal area. Long thought to be due to exostosis (extra bone growth), this pain is probably due to nonspecific inflammation.

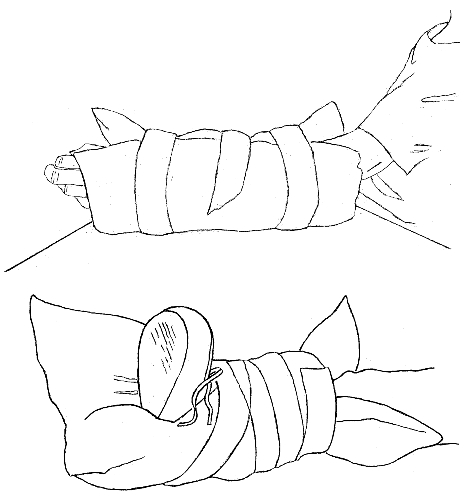

FIG. 29-11. Pillow splints on forearm and ankle.

FIG. 29-12. Pillow splint on knee.

Rigid Splints Not for Circumferential Casting

Fixation splints may be made of plaster of Paris; celluloid; pasteboard; wood; stiffened felt, paper, or leather; gutta-percha; wire; polyvinyl chloride (PVC) pipe; aluminum; or other available materials. Keep splints in place with bandages or other similar ties.

Metal

Caused by disruption of the extensor tendon to the distal phalanx, a mallet or dropped finger can be managed by splinting the affected joint in full extension with a paperclip for 8 weeks. The splint should be worn at all times. Pad the paperclip with soft cloth and tape it to the dorsal surface of the finger so the digit can still be used. A disposable plastic spoon or a section of a Popsicle stick can also be used.[66]

A metal can makes a useful splint for a broken wrist or to help support an injured knee or ankle. Carefully open the can at both ends, cut it up the side, and tape the sharp edges so they don't injure the patient. Then bend the metal to fit the patient's wrist, enclose in cloth for padding, and wrap in place with a bandage or tape. Likewise, a car's hood support is just the right length to make a long leg splint. Bandage it onto the injured leg.

Splints made of galvanized wire or tin mesh (Fig. 29-13) can easily be fashioned to support arm, knee, or ankle injuries. "They can be readily made from sheets of wire by taking a strip of suitable size and cutting it partly through at the angle, and tying together the meshes which overlap where it is bent."[67]

Plastic Pipe

Durable splints have also been made from pieces of appropriately sized plastic (PVC) drainpipes (Fig. 29-14). First, saw them in half, and then shape them so they conform to the extremity. To do this, heat the pipe by placing it in boiling water or using a welding torch or other low-intensity flame. (See Chapter 27, Ophthalmology, for additional instructions on how to work with PVC pipe). If a flame is used, take care not to burn the plastic or to inhale the toxic fumes.[68]

Tongue Depressors

The lowly tongue depressor (or Popsicle sticks) can be useful as splinting material in many situations and may also be used to make a metatarsal arch bar. These remarkably simple devices lessen toe pain, especially from injuries to the large toe (hallux), and pain from metatarsal fractures or pain over the metatarsal heads or sole of the foot. This can be invaluable when treating patients who must keep walking to survive, such as on a trek or in combat. The metatarsal arch

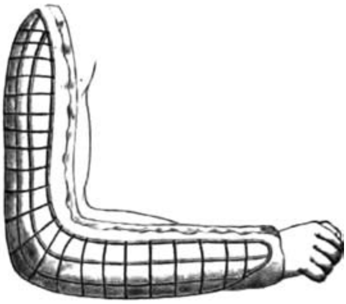

FIG. 29-13. Wire splint.

bar functions by eliminating much of the stress of rotating and pushing off from the forefoot and hallux—a key part of walking. The arch bar can be quickly and easily made to use over shoes. (Of course, some patients may not be able to obtain shoes.)

Make an arch bar by breaking or cutting three tongue depressors or other material to the width of the widest part of the shoe or boot. Tape the tongue depressors together. Then tape the entire piece across the sole of the shoe at its widest part by wrapping the tape around the bar and the outside of the shoe (Fig. 29-15). If the patient has more than one pair of shoes, it is easy to re-tape the arch bar onto a different shoe or to make another bar for that shoe.

Pediatric Fracture Treatment

Removable splints may be as good as casts for minor, or "buckle," fractures of the wrist, particularly in toddlers and preschool infants. These splints even allow for the final removal at home with no further follow-up. Removable splints, either plastic or plaster, generally keep the fractures aligned as well as casts but provide greater comfort and less restriction, allowing children to bathe and participate in other activities.[69] Some orthopedic surgeons, however, are concerned that such small children will not keep their splints in place.

Rigid Circumferential Casting Material

Because of its lightness, porosity, and ability to rapidly harden, plaster of Paris is the best, most commonly available material for making splints that are molded to the body. There are many ways to use plaster of Paris; some are discussed in the following paragraphs. In addition, there are a multitude of alternative materials that can be used to make casts. For how to make plaster bandages for casting and splinting, see "Making Plaster of Paris Bandages" in this section.

Some Ways to Use Plaster of Paris

Plaster Box

If no other option is available, try this old method using liquid plaster of Paris to immobilize an extremity. Make a box of cardboard or wood into which the extremity (usually the forearm) will fit. Coat the skin with oil or lubricant or, better yet, wrap it with thin cloth to protect the skin from the heat and irritation from the plaster, and to prevent it from adhering to the skin when removed. Pour enough plaster into the box to surround the arm completely. When the plaster sets, remove the box. These casts are too heavy and cumbersome for patients to be ambulatory and must be removed with a mallet and chisel.[70]

FIG. 29-14. Forearm splint made from plastic drainpipe.

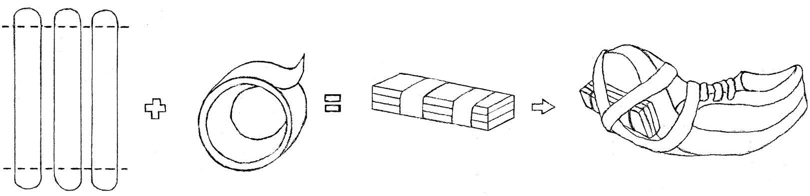

FIG. 29-15. Metatarsal arch bar made from tongue depressors.

PLASTER CREAM

An alternative method that may be easier to use than preparing rolled plaster bandages is to immerse large pieces of cloth in a plaster cream (Fig. 29-16). Prepare this cream by sifting dry plaster into water (3 parts water and 4 parts plaster of Paris). Take previously cut splint/cast material and either soak it in the cream or spread the cream onto it just before you apply it to the limb. Note that the plaster cream must be thoroughly worked into the material.[71,72]

Hamilton described the use of plaster cream at New York's Bellevue Hospital in the 19th century: "The usual practice has been to envelop the limb with a dry roller, and to apply the plaster with a paint brush as the successive turns of the roller are laid upon the limb. It hardens very quickly, and in this regard it has an advantage over flour paste or starch; but it is heavy, and not so generally accessible, and for this reason its use is more restricted."[73]

Making Plaster of Paris Bandages

Commercial plaster bandages are excellent, but they may not be available due to general scarcity or cost. Homemade plaster bandages are about one-tenth as expensive. To make them:

1. Get plaster of Paris (dried calcium sulfate; or use hemi-hydrate gypsum plaster). Although it is readily available as a building material, the best type for casts and splints is dental casting plaster. (Other types work, but they set more slowly.) Since it becomes inert if exposed to moisture or cold, keep the plaster in a tightly sealed container and, if possible, in a warm, dry location. To get plaster to set more quickly, add one-twentieth-part Portland cement (1:20 mixture), which may also strengthen the cast and make it lighter.[75] Mixing the plaster with water in the proportion of 75 to 100 by weight, and adding 2 parts of boiled starch may produce a similar result.[73]
2. Obtain bandage material. Crinoline, a high-quality open-mesh cloth, or muslin (30 to 35 threads/inch) works best, but good quality gauze with about 8 to 10 holes/cm^2 (20 holes/inch^2) also works well. If necessary, cheesecloth also can be used.[75,76] One group in India finally found that suitable gauze has about 16 threads per inch; and that the thickness is also important. If the gauze is too thin, it does not hold the plaster powder; if it is too thick, the plaster takes too long to set and dry.[77]

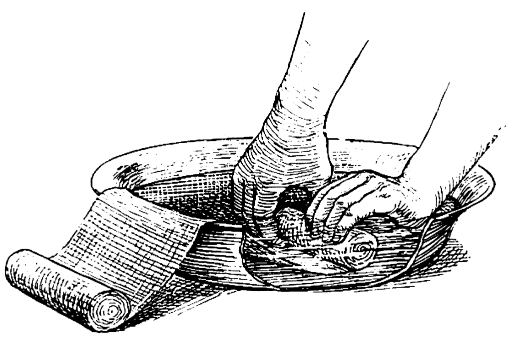

FIG. 29-16. Wetting bandage in plaster cream. (*Reproduced from Ware.*[74])

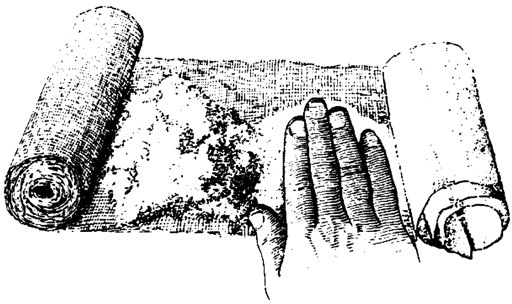

FIG. 29-17. Rubbing plaster into bandage material. (*Reproduced from Ware.*[74])

3. If using gauze or cheesecloth, dip it into a weak laundry starch solution or a bucket of rice water (left over from cooking rice) and let it dry. This helps maintain the bandage's shape.[77]
4. Cut the cloth into strips of the desired length and width. Some workers have found that 12-foot lengths are easy to handle; the width will depend on the need, but generally 4 or 6 inches are sufficient.[77]
5. Rub plaster powder into the cloth by unrolling a portion of the bandage on a dry table with a smooth top and gently but firmly rubbing the powder into the cloth mesh (Fig. 29-17). Rub the plaster in by hand or scrape it in with a straight-edged knife or stick. It is important that neither too much nor too little plaster be used; the proper amount is just enough to thinly cover the fabric mesh.[75] As one section is covered in plaster, roll it up and begin the same process with the next section until the entire roll has been powdered.
6. If you are making many plaster bandages, such as for a hospital or large clinic, a simple plaster application machine is worth constructing (Fig. 29-18). Developed in India, the large inclined tray, with plaster powder at three places, allows workers to easily impregnate the bandages with plaster as they are pulled across the top. Construct an 8- to 10-inch-wide tray, on a base that is inclined at 15 degrees and that has an open-top catch box at the end. Stretch three strands of #8 rubber tubing (8 mm diameter) across the tray to hold the bandage down and distribute the plaster powder. Place strips of wood along the sides to hold the tubing in place and help keep the plaster on the tray. Place a pile of plaster powder above each length of rubber tubing. When the bandage material is pulled under the taut tubing, it becomes impregnated with plaster powder; the open box in the base will catch any loose plaster.[77]
7. As the bandage is finished, loosely roll it up. Use immediately or store it in a dry place for future use. Be careful not to roll it too tight as this will prevent the water from penetrating it sufficiently when the bandage is dipped in water before application.[75,76]

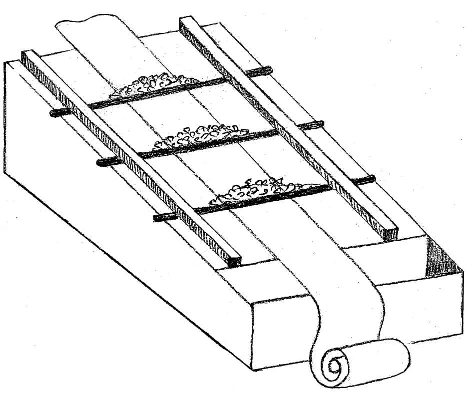

FIG. 29-18. Plaster-application device.

8. To store premade bandages, roll them loosely. If you need to make slabs for splinting, double the plaster over itself in strips, wrap in old newspapers or plastic bags, and put these in an airtight container. Do not prepare too many at a time. They can absorb moisture and harden.[78]

Applying Homemade Plaster Bandages

A common problem with homemade plaster bandages is that the gauze does not hold enough powdered plaster. If enough plaster is in the bandages, rubbing each wet bandage layer into the next should make the threads of cloth disappear into the smooth, plaster surface. If this is not the case, there is not enough plaster and it will not set hard. A possible solution is to try the method used by Antonius Mathijsen, a 19th-century Dutch Army physician. Rather than soaking them in water, he used a wet sponge or brush to moisten homemade plaster-impregnated bandages as he applied them to the patient, rubbing them by hand until they hardened.[70] Another useful trick is to have some dry plaster powder ready while casting, then sprinkle it over each layer of bandage and rub it smooth with your wet hands. Add more to the final layer and rub it in to form a polished surface.

To reduce the amount of plaster lost into the water, dip the bandage gently into water and then take it out and let it drip. If you must squeeze it, hold the ends of the roll and squeeze gently toward the center. To speed drying, use hot water or else add salt or zinc oxide to the water. If the plaster has been exposed to the air before use, dry it in an oven; this may make it more useable and speed its setting.[72]

Homemade plaster casts are heavier than casts made with proprietary bandages, but they work well in all circumstances and are much cheaper.[77]

Improvised and commercial plaster bandages can be made water resistant by painting the dried plaster of Paris with a mixture of shellac dissolved in alcohol, or by varnishing them or pouring melted wax on them.[72,79]

Alternatives to Plaster of Paris

Although plaster of Paris is the preferred casting material, it may not be available in any particular situation. There are a number of alternative materials that may be used for casts. Most have the disadvantage that they take a long time to harden.

Sand

In the early 1800s, German physicians treated leg fractures by aligning them in a long box that was then filled with firmly packed moist sand.[70] Unfortunately, this is not a very practical method, since the patient must remain immobile while the fracture heals.

Thick Cardboard

Louis Jean Seutin, the Belgian Army's chief surgeon who fought against Napoleon, developed a rigid splint made of cardboard pieces that, after being moistened, were conformed to the injured extremity, and then wrapped with wet bandages that had been soaked in a solution of laundry starch. It required 2 to 3 days to dry, but this was shortened to about 6 hours when the 19th-century French anatomist/surgeon, Alfred-Armand-Louis-Marie Velpeau, replaced the starch with dextrin (i.e., starch gum, vegetable gum).[80]

In his 1899 text, Stimson wrote[81]:

> Pasteboard [thick cardboard] is used by softening one or two strips of suitable size by immersion in hot water, and then molding them to the limb by binding them on snugly with a roller bandage. Temporary support must usually be given by other splints until the pasteboard has become hard by drying. When it is necessary to bend the pasteboard at a sharp angle, cuts should be made in it in suitable directions and places and the overlapping portions stitched together. Leather and felt are prepared in the same manner.

Papier Mache

Folklore abounds with tales of using papier mache as a splint or a cast. Our test showed that it was time consuming and extremely messy; the resulting casts were heavy and took from many hours to days to dry. Papier mache is useless for orthopedic purposes, but might be a fun activity for children.

TRACTION

Traction is generally applied to leg fractures, particularly the femur or hip. It can, however, also be applied to the arm or the finger.

General principles for using traction on the leg are to apply 10 to 15 lbs of weight, or the amount needed to reduce the affected leg to the same length as the other leg. Always take care to ensure that traction does not compromise the extremity's pulses, perfusion, or neurological status, especially in the foot below the ankle hitch. Traction should also maintain anatomic position, including reducing any rotation and angulation.

Improvised traction includes many of the methods taught in first-aid classes, including using ski or tent poles, canoe paddles, ice axes taped together at the handles, a piece of wood, a tree branch, or, most commonly, the foot of a litter. In reality, with many of these makeshift devices, it may be difficult to secure them proximally at the hip to ensure that they provide adequate counter-traction and do not cause the patient pain. Ankle hitches often go over the boot or shoe, and can be made from webbing or rope as long as they don't compromise blood flow to the foot. Traction can be tightened by winding the ankle traction with any short, rigid piece of equipment, such as a sheathed knife, wooden ruler, or solid stick. Once tightened, secure it so it does not unwind. Check this periodically, since the patient may move and loosen the traction or the neurovascular status could become compromised.

Improvised traction also includes techniques that can be used in medical facilities that lack either clinicians comfortable with doing invasive orthopedic procedures for traction or the necessary orthopedic equipment.

Improvised Traction in the Field

Sock/Plaster Boot Traction

The US Army described a field-expedient traction method (Fig. 29-19) during World War I:

> An excellent traction may be obtained by a light-weight army sock. The lower leg, ankle, and foot, with the exception of the toes and the plantar surface, are painted with glue [cyanoacrylate can be used] and the sock slipped on. The toe of the sock is cut off and a piece of light splint wood or the ladder splint material, cut the length of the foot, is inserted between the sole and the sock. Traction may then be made on this by means of pieces of bandage or cord passed through the sock and around the wood or the rods of the ladder splinting.[82]

Rather than gluing the sock to the foot (a rather drastic measure), after placing the splint to be used for traction, cover the sock with plaster or, if that is unavailable, a non-stretch bandage.

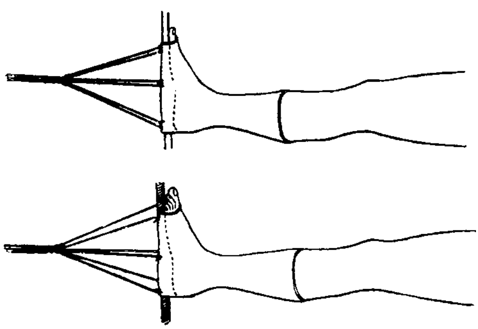

FIG. 29-19. Traction using socks. (*Reproduced from US Orthopedic Council.*[82])

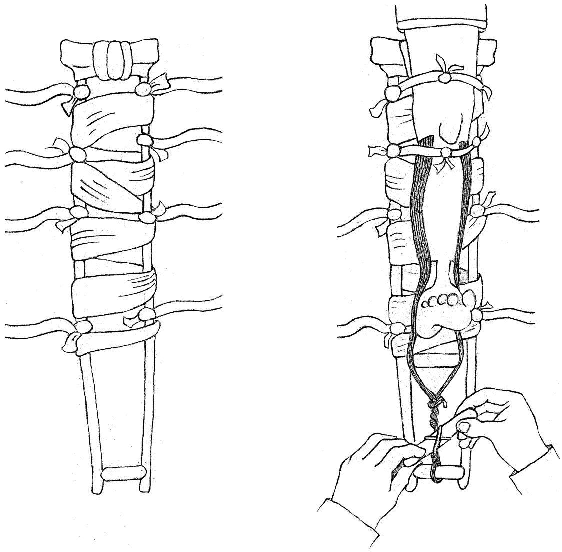

FIG. 29-20. Traction from crutch.

Traction Using a Crutch

A crutch makes an excellent traction device (Fig. 29-20). Use a crutch that is 8 to 12 inches longer than the affected leg (or adjusted to that length); measure it against the good leg. Remove the rubber piece from the bottom (ground end) of the crutch and securely tape the axillary pad to the crutch. Remove the handgrip and screw it into the lowest hole at the bottom of the crutch. Securely tie four pieces of gauze, fabric, or belting material, beginning just below the axillary pad, on each side of the crutch. These should be evenly spaced and opposite each other, since they will be used to secure the leg to the splint. Then wind gauze around the crutch to support the leg. The crutch/splint can then be positioned under the patient's legs, so that the top (padded) end of the crutch lies under the ischial tuberosity, with the other end extending at least 12 inches beyond the foot.

Apply ankle traction by securing a wide piece of tape to either side of the leg, from just below the knee and extending past the end of the crutch. Use tincture of benzoin, if available, so the tape will adhere more securely to the leg. Use wide tape or an elastic bandage around the lower leg to help hold the long pieces in place. Place some gauze or fabric over both ankles, so the tape doesn't stick to them. Just below the foot, cut a small hole in each piece of tape and insert three tongue blades or a small dowel through the holes to hold the two pieces of tape apart. Tape these tongue blades to the long pieces of tape. Then, below the tongue blades, bring the two long pieces of tape together and firmly attach the end of the tape to the crutch handle at the bottom of the splint. Cut a hole midway in this joined piece of tape and insert three tongue blades or an equivalent sized dowel. Twist these to provide traction on the leg. When adequate traction is achieved, tape the tongue blades to the sides of the crutch. Secure the leg to the splint with the fabric tied to each side of the crutch.[83]

Skin Traction

Skin traction requires pressure on the skin to maintain the pulling force across the bone. A maximum of 5 kg of weight may be applied using this method if the skin is in reasonable condition. More than 5 kg of weight causes the tightly wrapped strapping to slip, resulting in skin excoriation with blistering and pressure sores. If the straps are wrapped more tightly to prevent slipping, it can cause a compartment syndrome.[76]

If more than 5 kg of weight is needed to control the fracture, use an alternate form of traction.

Do not apply traction to skin with abrasions, lacerations, surgical wounds, or ulcers. In addition, do not apply traction to areas with loss of sensation, or in patients with peripheral vascular disease or a tape allergy.

Technique[76]

1. Clean the limb with soap and water and dry it. Gather adhesive tapes, traction cords, spreader bar, and foam or other material to protect the malleoli.
2. Use adhesive bandages in place of standard traction bandages. Shave the skin and use benzoin to increase bandage adhesion to the skin. Then wrap a nonadhesive bandage around the extremity. Wrapping an adhesive bandage can make it too tight.
3. Measure the appropriate length of adhesive strapping and place it on a level surface with the adhesive side up. The tape should extend on both sides of the limb up to, but not above, the fracture.
4. Place a piece of wood in a loop of the long wraps to keep the bandage from rubbing against the malleoli and to provide a site to secure the weights for traction.
5. Gently elevate the limb off the bed while applying longitudinal traction. Apply the strapping to the medial and lateral sides of the limb, allowing the spreader to project 15 cm below the sole of the foot.
6. Pad bony areas with felt or cotton and wrap crepe or ordinary gauze bandage firmly over the strapping.
7. Elevate the end of the bed, and attach a traction cord through the spreader with enough weight, up to 5 kg, to reduce and align the fracture (Fig. 29-21).
8. The traction cord can be any strong cord or wire. If the area that the cord drapes over is not smooth, attach a 60-cc syringe barrel to the site and run the cord through it. The weight can be bags of water or sand, bricks, or other heavy objects. Be certain that, whenever possible, the weights are measured, not just estimated. (The weight of water is 1 kg [2.2 lbs] per liter; if you know the volume, you can figure out the weight.)
9. Skin traction also can be used on the arm (e.g., Dunlop's traction for supracondylar fractures) (Fig. 29-22).

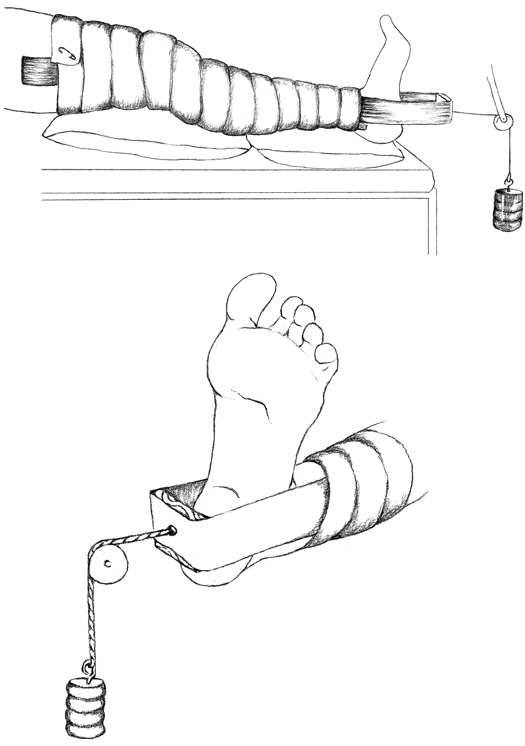

FIG. 29-21. Skin (Buck's) traction of leg. Overview (top) and close-up of weight connection (bottom).

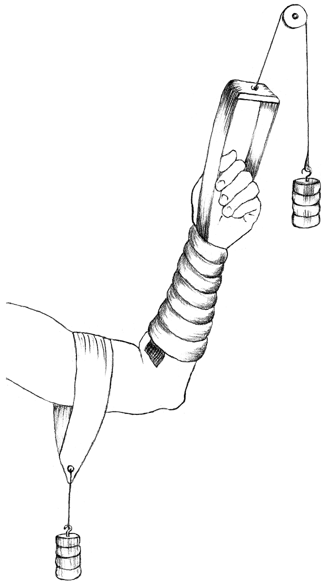

FIG. 29-22. Dunlop's traction.

"Gallows" Traction in Children

In children weighing <12 kg, vertical or "gallows" traction using skin traction works well for femur fractures. Both legs are generally kept in traction taut enough to just raise the buttocks off the bed (Fig. 29-23).

Another way to treat fractures in newborns and small children, and certainly the simplest, "consists in fixing the thighs, strongly flexed upon the abdomen, by means of a broad band of strapping passed round the back and thigh."[84]

Skin Traction in Adults

There are several makeshift skin traction devices for adults. Figures 29-24 and 29-25 show the easily constructed Volkmann's apparatus, which allows the foot piece to slide as weight is

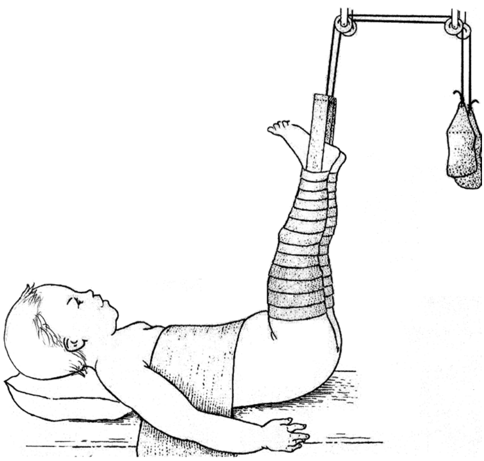

FIG. 29-23. Gallows traction.

FIG. 29-24. Rudimentary leg traction device. (*Reproduced from Helferich.*[85])

applied: counter-traction is best obtained by raising the foot of the bed and using a wooden block to stabilize the uninjured limb.

Traction Using Plaster

Similar in principle to skin traction, using plaster has fewer restrictions and can accommodate more weight without causing complications (Fig. 29-26). Taylor described the technique[86]:

> [Apply plaster] to the leg, which is fastened by buckles to a stirrup carrying a cord passing over a pulley to a weight, the patient being in bed … The adhesive plasters should be evenly applied nearly to the groin; if they do not reach high enough injurious strain comes upon the knee. If the thigh is flexed or adducted, the leg is placed upon an inclined plane, and the weight and pulley so arranged as to pull in the line of the deformity; the knee should be slightly flexed. Symptoms are frequently aggravated by pulling against the hip deformity. As the muscles gradually relax to the traction, the pulley is lowered until the pull is in line with the bed and the body. Five or six pounds in a sand or shot bag, flat iron, or brick are usually sufficient for a child; ten or twelve pounds for an adult. It is important that the feet should not touch the foot of the bed or the weight touch the floor; a metal bedstead is the most convenient, and should be long enough to allow six or eight inches space below the foot; the mattress should be hard to prevent sagging. If necessary, thin boards may be placed under the mattress. To prevent the patient from being drawn downward by the pull of the weight, the foot of the bed should be elevated six to eight

FIG. 29-25. Leg traction when there is contracture at the knee. (*Reproduced from Helferich.*[85])

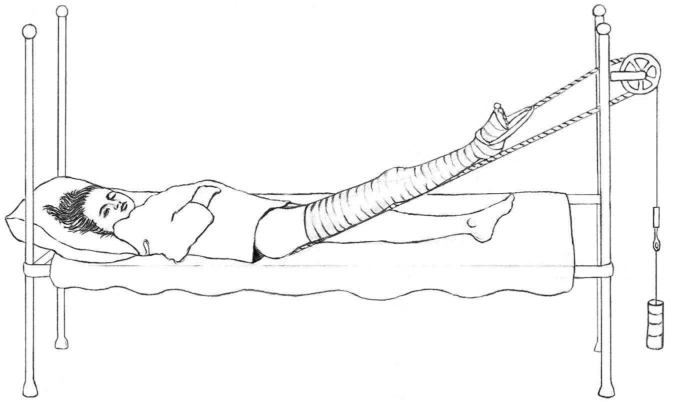

FIG. 29-26. Traction using plaster.

inches, or the patient should have counter-traction from perineal straps attached to a frame or to the bed… . In addition to raising the foot of the bed, a towel is pinned around the patient below the ribs, and the back of this is fastened to the head of the bed by a bandage.

Plaster of Paris traction is also useful to treat femur fractures when you need to quickly ambulate the patient, to treat patients with delirium tremens, or to treat young children. Ambulatory treatment of fractures of the femur has many detractors, but one method of doing it with some success is to ambulate patients using a Thomas splint. The Thomas splint is commonly available worldwide and, besides its usefulness for treating femur fractures in adults and children, it can also be used as part of "ambulatory" fracture treatment after the patient has been in traction for 3 or 4 weeks. Do not attempt to do this if the fracture site is in the upper one-third of the femur.[87]

MANAGEMENT OF COMPLEX FRACTURES

Pseudoarthrosis

When absolutely no other option is available, treat fractures of the neck of the femur by promoting the development of a pseudoarthrosis (false joint). Inject the joint with 5 mL of 2% lidocaine and encourage the patient to walk with crutches or a walker. The claim is that, while the result will not be perfect, it will be better than traction or inexpert nailing.[88] This is complex treatment because it is so foreign to most medical standards.

Improvised Traction Pins

Husum and colleagues recommend that an ordinary awl and drill be used to make a hole for a traction pin. The pin itself can be a thick welding rod inserted by careful blows with a hammer. Others have suggested that any strong wire that has been sterilized will work. Apply corks against the skin at the rod ends and attach plain ropes tied to sandbags for traction. For olecranon traction (arm fractures) and trochanter traction (pelvic acetabular fractures), Husum recommends that carpenter's eye screws be used for about 4 to 6 weeks, although they may cause some irritation.[62]

FRACTURE HEALING TIMES

Healing time is the generally expected interval of time for physiological wound repair following an injury or surgery. This differs from the time to overcome injury-related disability, that is, the time required to return to pre-injury activity level. The time to overcome the disability is always longer than the healing time.

Fractures take varying lengths of time to heal, depending on the patient's age and physical condition, simultaneous disease or injury, and overlying soft-tissue damage. Table 29-3 shows estimated healing times in patients who do not have open reductions and fixation of their fractures.

ANALGESIA

Trigger Point Injections

This is easy: Don't bother. There is no rationale for, or benefit from, injecting so-called trigger points, even though this has often been the cornerstone of myofascial pain treatment.[92] How you explain this to the patient who has been receiving injections for years is another matter.

TABLE 29-3 Average Fracture Healing Times (No Surgery)

Fracture	Weeks*
Complex facial fractures	16-26
Clavicle	6-8; Child 4
Humerus	6-26
Elbow	6
Forearm	6
Distal radius (wrist)	6
Carpal bones	6-20
Metacarpal	4-6
Mallet finger	6-8
Phalanges (finger/toe)	4-6
Vertebral body compression (any level)	12-36
Spinal fracture	52
Pelvis (acetabulum stable)	12-26
Pelvis (1 fracture)	12-26
Pelvis (2 or more rami)	12-52
Hip (non-displaced impacted)	8-12
Hip displaced (no surgery)	26-52
Femoral shaft	10-12
Tibia	26-36
Ankle-trimalleolar	8
Talus	6-8
Metatarsal	6-26
Calcaneus	12-36

*Healing times vary widely. Open (compound) fractures, those in patients with poor nutrition, and those in elderly patients generally take longer to heal.

Data from Palmer,[89] *STEP MANUAL,*[90] and *New Brunswick General Guidelines for Expected Healing Times.*[91]

Intra-articular Injections

When oral analgesics are not readily available, intra-articular injections may be used. The injections are relatively easy to do at the knee, elbow, shoulder, and any joint that is dislocated. However, they are not very good at providing immediate analgesia.

Although immediate analgesic effects may not be significant, intra-articular morphine injections can result in up to 3 days of analgesia due to its low lipid solubility and the joint's low blood flow.[93] After arthroscopy, the addition of bupivacaine 0.25% (20 to 30 mL) into the knee joint provides significant pain relief. Intra-articular morphine instillation may also reduce postoperative pain; clonidine (1 to 2 micrograms/kg [mcg/kg]) adds to morphine's analgesic effect. Adding an injectable NSAID, however, is not effective.[94]

Postoperative Infusions of Local Anesthetics

When local anesthetics are more readily available than other analgesics, postoperative infusions of local anesthetics can reduce pain. Local anesthetics have been shown to provide relief following bone graft harvest when infused into the cavity made in the anterior superior iliac spine. At the end of surgery, place the infusion catheter (usually an epidural catheter) in the bed of the bone graft donor site in proximity to the periosteum. Inject local anesthetic, usually 0.25% bupivacaine, through the catheter either intermittently (10 mL q6hr) or by continuous infusion at 10 mL/hr. Clamp any vacuum drainage tube during the intermittent boluses. Local anesthetics have provided analgesia when infused into the subacromial space after acromioplasty and rotator cuff repair. Insert the catheter close to the incision site and infuse 0.25% bupivacaine 2 mL/hr or 2% lidocaine 2 mL/hr.[94]

REHABILITATION

Angle Measurement Using a Goniometer

A goniometer measures a joint's angle during its range of motion. It can also be used on radiographs to measure the angle of fracture deformities. Acutely, the clinician can use it to assess the joint's movement and, during rehabilitation, to document improvement in range of motion. A homemade goniometer can easily be constructed using a piece of wood, such as a ruler, with a hole drilled in one end (Fig. 29-27). Cut a circular piece of cardboard and mark degree gradations (0 to 350 degrees) in 10-degree increments around the side. Punch a hole in the center of the cardboard and cement it to the wood with the 0-degree mark over the wood and the hole in the cardboard fitting over the hole in the wood. Then tie a string to the hole. The wood is placed parallel with the extremity above the joint and the string follows the extremity below the joint. The string should align with the angle of flexion/extension.[95]

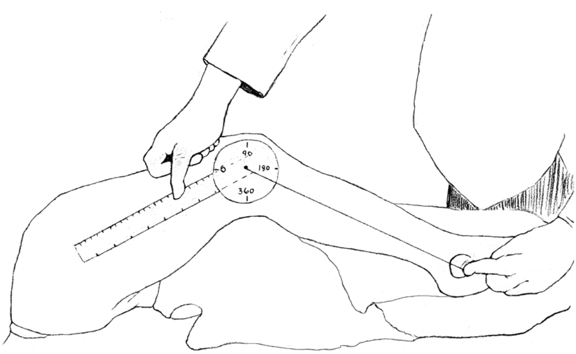

FIG. 29-27. Makeshift goniometer.

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30 Urology

Urinary drainage and penile obstructions are the two most common urological problems needing improvised treatment.

BLADDER DRAINAGE/TUBES

Urethral Lubrication/Anesthesia

Anesthetic jellies (gels), such as lidocaine 2%, reduce the discomfort of male catheterization, although this is not true in women.[1,2] Lidocaine jelly may not be available, so it helps to know about the alternatives.

Diphenhydramine (e.g., Benadryl) and promethazine (e.g., Phenergan) may be used effectively as urethral anesthetics. The dose is the same, or less, than would be used orally. Inject the drug into the urethra using a bulb syringe and keep it in place for about 5 minutes using a penile clamp or equivalent. Some patients experience an initial burning sensation. The anesthesia lasts about 1 hour. To obtain more extensive anesthesia, coat a small urethral sound with an ointment of these medications and leave in it place about 5 minutes before passing larger sounds.[3]

Use mineral oil to lubricate urethral catheters if standard lubricating jellies are unavailable.[4] In women, apply 10% cocaine jelly with a cotton-tipped applicator for an effective urethral anesthetic. Leave this in place for 5 minutes.[5]

Difficult Urethral Catheter Placement

Passing a urethral catheter is almost routine from the clinician's perspective. Some catheters are difficult to pass, especially in older men. When calling the urologist is not an option, the following technique may make catheter insertions more successful.

In males >50 years old, use a syringe to inject 25 to 50 mL lidocaine jelly 2% into the urethra before attempting to pass any catheter. If lidocaine jelly is not available, use any sterile gel (e.g., K-Y). If you anticipate that passing a urethral catheter will be difficult, use at least an 18- to 20-Fr Foley rather than a smaller-sized catheter. Smaller catheters simply bend if they hit an obstruction, rather than passing into the bladder. Use slow, steady pressure to insert it all the way to the Foley's hub. Do not inflate the balloon until the catheter is fully inserted and urine returns. Inflate balloons with water only; do not use normal (0.9%) saline. (See "Retained Urethral Catheters" later in this chapter.)

Use a coudé catheter if you suspect that the patient may have an enlarged prostate. A coudé catheter has a gentle upward curve at its distal 3 cm that allows easier passage through an enlarged prostate. When inserting a coudé catheter, point the tip anteriorly. This means that the balloon inflation side port should be facing up (on the same side as the curve). If the patient has a red catheter in place, it generally means that it is either a coudé or a Councill (used by urologists to pass over a guidewire). In either case, beware of removing it for replacement.

If multiple attempts at catheter placement have failed, a suprapubic aspiration using a needle and large syringe can easily buy time until a suprapubic tube can be placed or an experienced clinician can use alternative methods (e.g., filiforms and followers) to drain the bladder.

Bladder Clots

Bladder clots are reasonably common, and often cause painful obstructive symptoms. Assuming that you know why these are occurring (chronic infection, tumor, anticoagulant), treat the acute problem and ensure bladder drainage. To do this, put in a ≥4-Fr catheter. Do not place a 3-way catheter, which is normally used for continuous bladder irrigation, until the clot is removed—the opening is too small, since two smaller catheters and an inflation port must fit into the one catheter. Advance the catheter all the way. It may pass beyond the clot and allow the urine to drain. Then use an irrigation syringe to instill 60 to 120 mL aliquots of sterile water, which is more lytic than saline. Give up to 200 to 300 mL total. Then withdraw the fluid and repeat the process. If the clot cannot be removed in this fashion, a surgical approach may be necessary. If surgery is not an option, some clinicians have instilled thrombolytics.[6,7]

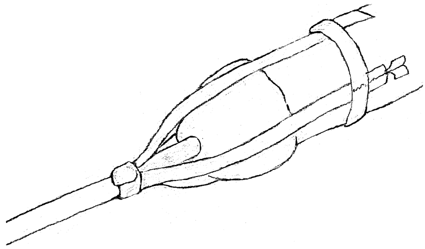

FIG. 30-1. Securing a straight, non-balloon catheter, method #1.

Securing Non-balloon Catheters/Tubing

If only a straight (non-balloon) catheter or a makeshift catheter (e.g., a nasogastric tube) must be placed, the trick is securing it to the penis. After inserting the tube, secure it to the penis using three long strips of adhesive tape. First, attach about 1 inch of a tape strip to the catheter just as it exits the urethra. Lay the rest of the tape along the penis. Do the same for the two other pieces of tape. Use benzoin, if necessary, to keep the pieces in place. Then wrap one or two non-constricting circular pieces of tape around the penis to secure the long strips further (Fig. 30-1).

Another method of securing a non-balloon catheter is to tie a suture around the catheter just beyond the external meatus and carry the ends along the body of the penis (Fig. 30-2). Secure the ends with a piece of tape, wrapping it in a spiral beginning at the catheter and then around the penis.[8]

In infants, using a pediatric feeding tube as a catheter is common. Matt Steinway, MD, an urologist in Phoenix, AZ, suggests securing these with a clear adhesive dressing (e.g., OpSite) or with a suture placed through the glans and tied to the tube at the meatus. (Personal written communication, received February 2008.)

In women, securing a straight catheter may be less successful. It can be taped to the labia, after shaving.[9] Alternatively, as Keyes wrote in 1917, "In the female, the (non-balloon) catheter is held in place by tying a number of silk strings to it as it issues from the vulva and fixing these to the pubic hairs in front, and by means of adhesive strapping to the lateral gluteal creases behind."[10]

External Catheter

A condom (external) catheter can easily be improvised using a normal condom and any tube that connects to the collecting bottle or bag. Slip the end of the tube completely into the condom. Make a small hole at the end of condom, but don't pass the tube through it or it will rub against the penis. Tie the end of the condom tightly around the end of the tube and invert the condom so it dangles free of the tube (Fig. 30-3). Put the condom over the penis and secure it with tape around the penis, extending the tape onto the anterior abdomen.

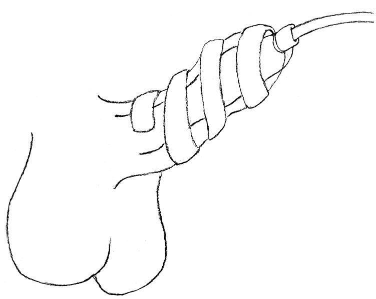

FIG. 30-2. Securing a straight, non-balloon catheter, method #2.

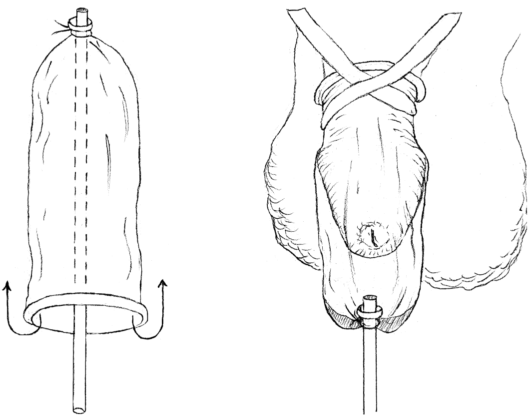

FIG. 30-3. Condom catheter. Putting it on (left) and in place (right).

Cleaning Reusable Catheters

For intermittent catheterization of the same patient, clean catheters as follows:

Wash the catheter using plain liquid soap (without deodorant or fragrance); rinse well until the soap residue is gone. Shake out any excess fluid, air dry the catheter, and then place it on a clean paper towel or in a clean basin. Alternatively, soak the catheter for 30 minutes in a homemade vinegar solution (one part white vinegar to three parts room-temperature water). Rinse, thoroughly shake out excess water, and air dry.

Store the washed catheters in a clean zip-top bag, tampon case, toothbrush holder, small camera case, or other clean container. Discard reusable catheters when they become hard, brittle, or cracked, or when they change color.[11]

Retained Urethral Catheters

Retained urethral catheters (those that cannot easily be removed by simply deflating the balloon) are a common problem. The longer the catheter is left in place, the more chance this will occur. Most often, the inability to deflate the balloon is due to either a complete or a partial obstruction of the catheter's inflation canal.

The first step should be to cut off the balloon valve. If that is the problem, as it often is, the balloon deflates and can be removed. If not, pass a thin wire, such as a wire from a catheter introducer, through the balloon port to either burst the balloon or alter its shape so that it can be removed.

A number of methods may be used to deflate the balloon and remove the catheter. These include injecting ether,[12] liquid paraffin (kerosene), chloroform,[13] or toluene[14] to dissolve the balloon, although these may cause chemical cystitis to varying degrees.[15,16] A common practice in some developing countries has been to deflate the balloons in malfunctioning urethral catheters by injecting 2 to 3 mL of mineral oil through the balloon port.[4] The balloon deflates (ruptures?) within about 2 hours.[17] Even though mineral oil is inert and generally considered innocuous and causes no discomfort to the patient, reports have suggested that the presence of mineral oil in the urinary tract may cause oil granulomas in a small number of patients.[18]

The balloon can also be punctured by using a suprapubic, transvaginal, or perineal approach.[19-21] Use these methods, with or without ultrasound guidance, only after other methods have failed. For the suprapubic approach, use the stylet from an 18-gauge spinal needle. With the catheter balloon pulled against the floor of the bladder, direct the stylet vertically downward until the balloon is punctured or the entire stylet has been introduced. If this is unsuccessful, withdraw the stylet and reinsert it progressively caudally or cranially, 10 to 15 degrees from vertical. In men, the mean angle for puncture is 2 degrees cephalad of vertical; in women, it is 17 degrees caudal of vertical.[20]

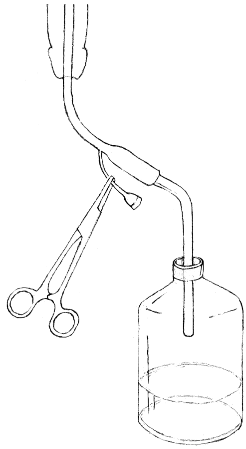

FIG. 30-4. Empty IV bottle used for urinary drainage.

One concern is that pieces of the punctured balloon may be retained in the bladder, causing irritation and infection. While this seems to occur frequently with in vitro tests,[16] in practice, it is rarely seen.[22] The chances of this seem to be lessened if catheter balloons with a 30-mL capacity have ≤40 mL of fluid injected before puncture; balloons with a 10-mL capacity should have ≤15 mL before puncture.[16]

A relatively simple method of deflating these balloons is to inject the balloon with normal saline until it bursts, which may take up to 500 mL! If the inflation canal is blocked at its proximal port so no fluid can be injected, pull the catheter so that its original light brown color is visible. At that point, clamp the catheter so it does not retract and cut it. Then carefully insert a 21-gauge needle with an attached syringe into this part of the exposed inflation canal and either deflate the balloon or, more commonly, inflate it until the balloon ruptures; then remove the catheter. This reportedly works ≥90% of the time.[22] Use this technique cautiously, since if the Foley is misplaced (such as in the urethra), overinflating the balloon could cause significant pain and, possibly, damage to the patient.

Rarely, an encrustation on the end of the catheter blocks removal. This may require surgical removal of the catheter.

Alternative Urine Collection Bags/Systems

Use old IV or irrigation bottles, rather than disposable urine collection bags, to collect urine from urethral catheters. Make tubing for the bottle from an old intravenous set (Fig. 30-4). Put a tape on the side of the bottle and mark it as you add water in 100-mL increments (Fig. 30-5). Empty the bottle, put a hole in the lid for the tube, and it is ready to collect and measure urine output.

Pediatric urine collection bags (a technique not useful for urinalysis or culture) can be made inexpensively from disposable plastic bags, adhesive tape, old IV tubing, and waxed paper (or something similar).[24] (For details, see Fig. 5-10 in Chapter 5, Basic Equipment, and "Urine Collection" in Chapter 34, Pediatrics and Neonatal.)

PENIS AND PROSTATE

Local Anesthesia for Penile Procedures

Anesthetizing the penis may be necessary to repair injuries, remove a zipper, do a circumcision, provide postoperative analgesia, and do other surgical procedures. Two common methods are the circumferential and the dorsal penile blocks: use a long-acting anesthetic.

A circumferential block is the easiest method. It requires placing a ring of anesthetic (without epinephrine) subcutaneously and intradermally around the base of the penile shaft. However, it may cause a hematoma, and it may not be effective in every case.[25,26]

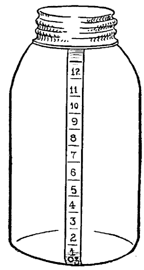

FIG. 30-5. Improvised collecting jar with volume measurements. *(Adapted from Olson.*[23])

Anesthesia of the dorsal/ventral penile nerves blocks sensory nerves to the distal one-third of the penis. Insert a needle into the infrapubic space dorsally at the base of the penis; a pop is felt as the needle enters the fascia of the compartment. Aspirate and direct the needle to each side of the penile shaft; inject 5 mL of a non-epinephrine-containing anesthetic.[26] Block the paraurethral branches by injecting ventrally. Pull the penis up, aspirate, and inject into the grooves between the corpus cavernosum and corpus spongiosum.[25]

Anesthesia for a dorsal slit may be necessary for phimosis or paraphimosis. To anesthetize this area, simply inject anesthetic with epinephrine along the area of the foreskin to be cut (Fig. 30-6).

Foreign Bodies

According to Yacobi et al., "creative thinking is essential to remove heavy metal objects" from a penis when they get stuck there after unusual sexual activities.[28]

The simplest method to remove a constricting device is to use a string wrap, as is done to remove a ring from a swollen finger. If that is ineffective, drain blood from the penis to help shrink it and allow removal of the foreign object. The patient's tolerance will determine whether sedation or anesthesia is needed. A penile block (without epinephrine) often helps.

If the only way to remove a constricting device is to cut it, always cut on opposite sides of the penis, while protecting the skin to avoid avulsions. Ordinary hospital equipment is often insufficient to do the job. Maintenance staff, the fire department, or a rescue team may have to supply bolt cutters, powered rotary tools, heavy-duty air grinders, or pneumatic saws, especially to remove heavy iron and steel objects encircling the penis. Consider letting the people supplying these tools operate them, since they are more experienced. The operating room may be able to supply portable dental drills and power surgical saws. When nothing else is available, a hammer and chisel may have to be used. To help cool and protect the area, continuously pour large volumes of water over the area being cut. The entire process often takes up to 90 minutes. If any

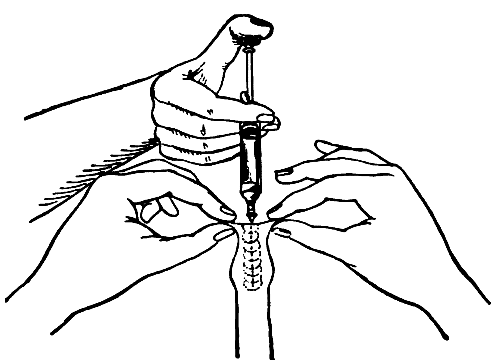

FIG. 30-6. Anesthesia for dorsal slit of the foreskin. *(Adapted from Allen.*[27]*)*

question about penile tissue viability exists once the object has been removed, inject fluorescein (15 mg/kg) IV, wait 20 minutes, and examine the penis under a Wood's lamp. Doppler flow ultrasound may also be used.[28]

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31 | Gastroenterology

TREATMENT

Hiccups

Multiple drug and non-drug methods have been used to disrupt the hiccup reflex arc. When a patient's hiccups are protracted, home remedies are generally ineffective and other means must be employed.[1] One non-drug method uses a nasogastric (NG) tube. Insert the NG tube into the stomach and immediately remove it. The hiccups should stop at once. If not, try a second time. It's postulated that the mechanism involved is irritation of the posterior nasal mucous membrane and lower esophageal sphincter.[2]

Another method of treating hiccups that is relatively benign, generally available, inexpensive, and simple to use is intravenous (IV) lidocaine. On multiple occasions, it has worked successfully when other medications have failed. Reported successful procedures with lidocaine doses, in both children and adults, have involved loading the patient with 1 to 2 mg/kg and then generally beginning a 2 mg/kg (sometimes up to 4 mg/kg) drip for 4 to 12 hours. This often had to be repeated within 24 hours.[3-6] My personal experience with this technique was in a remote location with an adult who had had several severe and debilitating hiccup attacks over the prior decade. I used an infusion of 2 mg/kg lidocaine over 20 minutes, which stopped the hiccups as the infusion was ending. Although they did not recur, I gave him a 20-minute infusion of 1 mg/kg on each of the next 2 days. He did not have a recurrence over the next 5 months.

Nausea and Vomiting

Treatments for the common complaint of nausea and vomiting vary around the globe. Some medications, such as the phenothiazines that are commonly used in some countries, are unavailable for this use in other countries. Other common treatments, such as metoclopramide and ginger root, are ineffective.[7]

Some generally available and inexpensive medications that have been shown to be effective for nausea and vomiting include dexamethasone, 5 to 10 mg IV (pediatric dose: 0.5 to 1.5 mg/kg); droperidol, 0.625 to 1.25 mg IV; dimenhydrinate, 1 to 2 mg/kg IV; and ephedrine, 0.5 mg/kg intramuscularly (IM).[8] A side benefit of using dexamethasone is that it often relieves bowel obstruction along with the accompanying nausea and vomiting in cancer patients.[9]

Acupressure, as both a preventive (anesthesia and pregnancy) and a treatment, has shown mixed results. Acupressure may be more effective in controlling nausea symptoms than in preventing emesis.[10] But, since it costs nothing, has no side effects, is simple to use, and is available in any situation, it is probably worth trying. The Pe6 Neiguan point where acupressure is applied can be located on the volar forearm about 2 inches proximal to the distal wrist crease (in adult males) between the tendons of the flexor carpi radialis and palmaris longus. For others, it is one-sixth the distance between the distal wrist crease and the elbow flexor crease (Fig. 31-1). Apply pressure to this site using a marble, ball bearing, or similar object placed beneath an armband, such as used for a venous tourniquet, or an elastic bandage. Begin by compressing the sphere intermittently for a few minutes; then apply the pressure constantly under the band.[11]

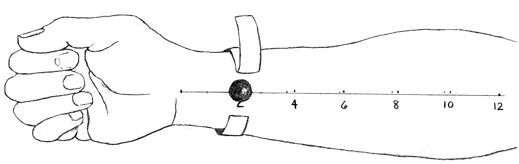

FIG. 31-1. Acupressure site for nausea and vomiting.

Diarrhea

Diarrhea afflicts nearly everyone at some point.

Among the Bataan prisoners of war (POWs), physician–prisoners "created pills for dysentery from cornstarch, guava leaves and charcoal."[12] Pepto Bismol tablets are frequently used for symptomatic treatment of non-dysenteric diarrhea.

Probiotics (live nonpathogenic microorganisms, usually bacteria or yeast) may benefit patients with infectious and antibiotic-associated diarrhea, including *Clostridium difficile*-associated disease. Yogurt with *Lactobacillus* species and *Saccharomyces boulardii* has been shown to be effective.[13,14]

Irritable Bowel Syndrome

Irritable bowel syndrome (IBS) is characterized by mild to severe abdominal pain, discomfort, bloating, and alteration of bowel habits. In some adult patients with IBS, administering intrarectal lidocaine (300 mg) jelly may reduce rectal pain. It works within 15 minutes of administration and is reported to be safe and effective.[15]

Constipation

Constipation is a common complaint, especially in postoperative and pregnant patients, the elderly, those on several types of medications, and those with diabetes, hypothyroidism, depression, and inflammatory bowel disease.

Treatment for constipation can either be mechanical (i.e., enema) or with oral agents. Table 31-1 lists some inexpensive, readily available oral agents that have been shown to be effective. There is good evidence to suggest that increased dietary fiber and increased physical activity can also reduce the incidence of constipation.

Constipation can also be treated with enemas. Enemas, of course, may also be used to administer medications and to provide parenteral fluids, as described under "Rectal Hydration/Proctoclysis" in Chapter 11, Dehydration/Rehydration. Multiple types of improvised equipment can be used to give an enema. With an improvised connection, nearly any tubing can be attached to a tea or coffee pot, an IV bag, or a funnel.

Rectal Pain

Proctalgia Fugax

Rectal pain from intermittent spasm is often a chronic condition. Patients can be taught to relieve the spasm by using a few ounces of warm water as an enema. The pain usually resolves within a minute.[17]

TABLE 31-1 Readily Available Oral Agents to Treat Constipation

Mechanism/Class	Agent	Typical Adult Dose	Time to Action (Hours)
Bulking or hydrophilic agents	Dietary fiber (most often, bran)	20-40 g*	12-72
Osmotic agents	Magnesium hydroxide (milk of magnesia)	15-60 mL	0.5-6
	Sorbitol syrup (10.5 g/15 mL)	15-60 mL	0.5-3
Stimulant laxative	Senna (standardized concentrate)	15-60 mg	0.25-1
	Cascara sagrada (fluid extract)	5 mL	0.25-1
	Castor oil (ricinoleic acid)	30-60 mL	0.25-1
Lubricating agent	Mineral oil	15-30 mL	6-8

*Given in divided doses.

Data from Schiller.[16]

Hemorrhoids

Common and painful, hemorrhoids are enlarged vascular cushions in the anal canal. They most commonly present with painless rectal bleeding, but patients often have pruritus, swelling, prolapse, discharge, or soiling. Hemorrhoids normally appear at 3 o'clock (left lateral when patients are in the lithotomy position), 7 o'clock, and 11 o'clock around the anus. Severe pain occurs when hemorrhoids are thrombosed or strangulated. Note that anal cancer presents very much like prolapsed hemorrhoids.

Those familiar with the technique can use rubber band ligation on all prolapsed hemorrhoids except those that cannot be reduced. Up to three hemorrhoids can be banded at each visit. Make the bands by cutting a Foley catheter into 1/16-inch-wide segments. Up to 150 bands (which also can be used to band esophageal varices) can be made from one catheter. Use thread seal to fasten the bands to the application cylinder on the scope.[18] To minimize pain, banding should be done above the dentate line (transition from squamous to columnar epithelium). Most patients are happy with the outcome, but delayed bleeding 5 to 10 days after the procedure is possible.[19]

Submucosal injection of 5% oily phenol (sclerotherapy) is an inexpensive and easily performed alternative to treat first-degree and second-degree hemorrhoids. The difficulty is that this does not seem to have any better result than fiber supplementation, and it has a relatively high failure rate.[20] Opening thrombosed hemorrhoids under less-than-ideal circumstances may initially relieve the pain but soon leads to bleeding, increased pain, and increased incidence of infection.

Anal Fissures

Painful anal fissures are often treated with surgery. They are thought to be due to increased internal sphincter pressure causing an ischemic ulceration distal to the dentate line. Usually, they lie in the posterior midline and can progress to chronic fissures. Acute anal fissures (ischemic ulcers) often persist because the pain causes spasm of the internal anal sphincter that results in more pain and bleeding. Without surgery, acute fissures can often be successfully treated with topical nitroglycerine or by using a "frozen finger."

Topical nitroglycerine cures about 60% of adult patients with acute fissures; it does less well treating chronic fissures. How well it works in infants and children is unknown. Make a 0.2% glyceryl trinitrate ointment by mixing 2 g glyceryl trinitrate (standard preparation) with 20 g fatty yellow petroleum jelly. Tell the patient to keep the ointment refrigerated. The patient should apply it to the anus and in the anal canal three times daily for 4 weeks.[21]

Another simple and effective treatment is to use a "frozen finger" to reduce the symptoms and promote healing.[22] To make a frozen finger: fill an ordinary rubber exam glove with water and tie off the fingers with string. Empty the rest of the glove and cut off each of the fingers, leaving a generous margin of glove. Put them in a freezer and leave them there until needed.

To use a frozen finger, apply 5% lidocaine jelly to the anus and insert the frozen finger through the anal ring, leaving the strings used to tie it closed and a small part of the finger outside of the anus so that it can be removed easily. Leave it in place until it is no longer cold and stiff—about 7 minutes. Once shown how to do this, patients can place the fingers themselves once a day. Fingers work very well when accompanied by the standard patient recommendations to eat a high-fiber diet, hydrate well, and use anesthetic creams, laxatives, and sitz baths, as possible, for 3 months. They generally provide immediate temporary pain relief and significant ongoing pain relief within 2 weeks; 60% of the fissures heal within 2 weeks (as opposed to only 10% in the "non-finger" group).[22] This technique also works well for symptomatic relief from thrombosed external hemorrhoids.[23]

PROCEDURES

Esophageal Foreign Bodies

Esophageal foreign bodies most commonly get stuck at the cricopharyngeal constriction (Fig. 31-2). In adults (who usually have food impactions, rather than foreign bodies), objects often lodge in the mid-esophagus or at the gastroesophageal junction. The safest and simplest solution may be simply to observe the patient if he can still swallow liquids.[24]

A safe, fast, and inexpensive method for removing coins (and probably other non-sharp objects) from the pediatric esophagus is to push them through to the stomach using an esophageal dilator.

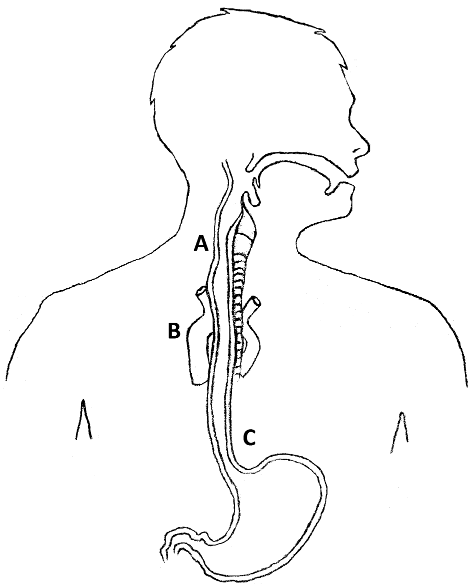

FIG. 31-2. Areas of esophageal constriction: A, cricopharyngeal area; B, bronchial constriction; C, diaphragm/gastroesophageal junction.

First, take a radiograph to be sure that a non-sharp foreign body is present in the esophagus. Select an appropriate esophageal dilator size and measure the proper depth by using the distance from the tip of the nose to the ear and then to the epigastrium. To maintain airway reflexes and because the procedure is so brief, no sedation is used and no IV started. Topical anesthetic can be applied to the posterior pharynx, but that is not necessary. Lubricate the dilator tip with water-soluble gel. Seat the child on a parent or an assistant's lap. Wrap the child in a sheet and hold him in a "bear hug." Put a stack of tongue depressors between the anterior-lateral teeth as a bite block and quickly pass the dilator to the premeasured depth; immediately remove it. This "bougienage" takes less than 5 seconds. Tell the parents to watch the stool; if a radio-opaque foreign body doesn't appear within 2 weeks, they should return for a follow up exam and a repeat abdominal radiograph.[25]

If a child has a coin stuck in the esophagus and can still swallow water without difficulty, the following method has been successful at getting most coins with diameters from 2.5 to 3.2 cm to pass (including those stuck at the cricopharyngeal constriction). Spray the pharynx three times with local anesthetic and have the child swallow the spray. Then give the child another test dose of water to be sure he can swallow normally. If so, have him swallow 10 to 20 mL of cooking oil, followed by eating a solid meal. (In the article cited here, they used meals of vegetables and cereal.) If the foreign body has been in place ≥15 days prior to seeking medical care, this method will probably not work; removal by esophagoscopy may be the only option.[26]

Use a balloon (e.g., Foley) catheter to remove a proximal foreign body—with or without fluoroscopy. First, put the patient in a lateral decubitus-head-down (Trendelenburg) position to avoid aspiration. To remove an object, gently pass a urethral catheter with balloon past the obstruction. Inflate the balloon with water and withdraw the catheter using steady traction. Success has been as high as 98%, but there is a risk of the patient aspirating the foreign body.[27,28] If the foreign body does not come out easily, consider another method.

Esophagoscopy

If available, a sigmoidoscope or bronchoscope of the appropriate size can be used for esophagoscopy.[29] If not, improvise a crude pediatric esophagoscope by slipping a curtain rod over the straight blade of a pediatric laryngoscope. The thin tube (or equivalent) should have an outer diameter of ~15 mm and a thickness of 1 mm. Its length can be 30, 40, or 50 cm, depending on patient size and what needs to be examined. The distal end of the pipe is beveled at 45 degrees

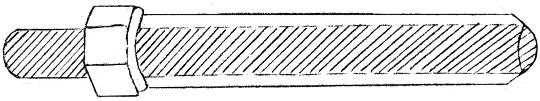

FIG. 31-3. Improvised proctoscope/anoscope.

with the cut edges filed smooth. Used in children primarily around 5 years old for various indications, it provides moderately bright illumination.[30]

Rectal Foreign Bodies

Rectal foreign bodies can lead not only to partial obstruction but also to mucosal erosions and perforations. So, if they don't pass spontaneously, they must be removed. If sedation is available, this can often be done outside the operating room. Several makeshift methods have been described and are commonly used. One method uses a urethral balloon catheter that is passed beyond the object so that the liquid-inflated balloon pushes the object out (from behind). This method also has the benefit, even if it doesn't work, of helping break the vacuum seal that often prevents the object from passing by itself. Another method is to use a rigid sigmoidoscope or an infant/adult pelvic speculum (with internal light, if available) to visualize and grab the object.

Actually keeping hold of the usually slippery object can be difficult. The best method depends on the object's shape, size, and consistency. Irregular objects may be held with any clamp. Rubber objects can be firmly grasped with a single-toothed tenaculum (used in gynecologic surgery or culdocenteses to grasp the cervix). This allows the object to be rotated, if necessary, and extracted without difficulty.

Anoscopy/Sigmoidoscopy

A standard test tube can be used as an anoscope for infants. For adults, an improvised proctoscope (anoscope) can be easily made from the container for a 10-mL syringe and the container for a chest tube. Cut off the end of the syringe container and insert the rounded end of the chest tube container as an obturator; cut it just a little longer than the length of the syringe container (Fig. 31-3). Use a headlamp or penlight to provide illumination.[31]

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32 | Infectious Diseases

EPIDEMICS/OUTBREAKS

Confirming an Outbreak

Confirming the existence of an epidemic is not always straightforward. In part, that is because clear definitions of outbreak thresholds do not exist for all diseases. For some diseases, a single case may indicate an outbreak. These include cholera, measles, yellow fever, shigella, and the viral hemorrhagic fevers.

General guidelines for meningococcal meningitis are that for populations >30,000, 15 cases/100,000 persons/week in 1 week indicates an outbreak. However, with a high outbreak risk (i.e., no outbreak for 3+ years and vaccination coverage <80%), this threshold is reduced to 10 cases/100,000 persons/week. In populations <30,000, an incidence of 5 cases in 1 week or a doubling of cases over a 3-week period confirms an outbreak.

For malaria, an increase in the number of cases above what is expected for the time of year among a defined population in a defined area may indicate an outbreak.[1]

Post-disaster Infectious Diseases

Following natural disasters, multiple factors increase the risk of contracting a communicable disease. These include inadequate sanitation, crowded conditions, food shortages, contaminated water, and inadequate immunization. Take all preventive measures possible and be alert for signs of potential epidemic diseases to avoid or quell a secondary disaster.

The diseases listed in Table 32-1 are common following disasters. All but tetanus have the potential of developing into epidemics. The best strategy is prevention, since adequate resources may not be available for treatment—or there may be no good treatment. Unfortunately, some preventive measures, such as hand washing, may not be easy to abide by in austere circumstances.

Conserve scarce resources for those who can benefit from them by limiting treatment to those who have a reasonable chance of surviving. The definition for "reasonable" depends on the amount of resources available in relation to the number of patients.

PREVENTION

Immunizations

Individuals who are not used to giving intramuscular (IM) injections, including physicians, dentists, pharmacists, and EMTs, may be asked to help during mass immunizations or when trained personnel are scarce or are busy elsewhere. As a reminder, IM injections and immunizations can be given in the lateral arm in the deltoid muscle; in the anterior thigh, especially with infants or struggling psychiatric patients; or in the upper outer-quadrant of either buttock (to avoid hitting the sciatic nerve). Do not give flu shots or rabies vaccine anywhere but in the arm. Administer rabies immune globulin half at the bite site and half in the arm that does not get the vaccine.

Cholera

Acidification of water rapidly kills *Vibrio cholerae* organisms. Adding the juice of one lime to a liter of drinking water is sufficient, depending on the type of lime, to rapidly kill *Vibrio*. This technique has been successful in multiple locations around the world where the local limes' pH is <2.5. In any cholera outbreak, it is prudent to first test the local limes' ability (i.e., pH level) to kill *Vibrio* before suggesting it to the population.[4,5]

Decontamination

Many diseases may be transmitted through contact with body fluids, including hepatitis B virus, hepatitis C virus, and human immunodeficiency virus (HIV). Use hypochlorite concentrations

TABLE 32-1 Infectious Diseases Frequently Seen Post-disaster

Disease	Transmission	Prevention/Control	Clinical Features	Incubation Period
Waterborne				
Cholera	Fecal/oral, contaminated water or food	Hand washing, proper handling of water/food and sewage disposal	Profuse watery diarrhea, vomiting	2 hr to 5 days
Leptospirosis	Fecal/oral, contaminated water	Avoid entering contaminated water; safe water source	Sudden-onset fever, headache, chills, vomiting, severe myalgia	2-28 days
Hepatitis	Fecal/oral, contaminated water or food	Hand washing, proper handling of water/food and sewage disposal; hepatitis A vaccine	Jaundice, abdominal pain, nausea, diarrhea, fever, fatigue, loss of appetite	15-50 days
Bacillary dysentery	Fecal/oral, contaminated water or food	Hand washing, proper handling of water/food and sewage disposal	Malaise, fever, vomiting, blood and mucous in stool	12-96 hr
Typhoid fever	Fecal/oral, contaminated water or food	Hand washing, proper handling of water/food and sewage disposal; mass vaccination in some settings	Sustained fever, headache, constipation	3-14 days
Acute respiratory				
Pneumonia	Person-to-person by airborne respiratory droplets	Isolation; proper nutrition. If cause is *Streptococcus*, give polyvalent vaccine to high-risk populations	Cough, dyspnea, tachypnea, retractions	1-3 days
Direct contact				
Measles	Person-to-person by airborne respiratory droplets	Rapid mass vaccination within 72 hr of initial case report (priority to high-risk groups if limited supply); vitamin A in children 6 months to 5 years old (prevents complications, reduces mortality)	Rash, high fever, cough, runny nose, red/watery eyes. Serious post-measles complications (5%-10% of cases) are diarrhea, croup, pneumonia	10-12 days
Bacterial Meningitis (meningococcal meningitis)	Person-to-person by airborne respiratory droplets	Rapid mass vaccination	Sudden-onset fever, rash, nuchal rigidity; altered consciousness; bulging fontanel if <1 year old	2-10 days

(*Continued*)

TABLE 32-1 Infectious Diseases Frequently Seen Post-disaster (*Continued*)

Disease	Transmission	Prevention/Control	Clinical Features	Incubation Period
Wound-related				
Tetanus	Soil	Thorough wound cleaning, tetanus vaccine	Difficulty swallowing, trismus, muscle rigidity and spasms	3-21 days
Vector-borne				
Malaria	Mosquito (*Anopheles* spp)	Mosquito control; insecticide-treated nets, bedding, and clothing	Fever, chills, sweats, head and body aches, nausea and vomiting	7-30 days
Dengue fever	Mosquito (*Aedes aegypti*)	Mosquito control, isolation of cases, mass vaccination	Sudden-onset severe flu-like illness, high fever, severe headache, pain behind the eyes, and rash	4-7 days
Japanese encephalitis	Mosquito (*Culex* spp)	Mosquito control, isolation of cases, mass vaccination	Quick onset, headache, high fever, neck stiffness, stupor, disorientation, tremors	5-15 days
Yellow fever	Mosquito (*Aedes* spp, *Haemagogus* spp)	Mosquito control, isolation of cases, mass vaccination	Fever, backache, headache, nausea, vomiting. Toxic phase: jaundice, abdominal pain, kidney failure	3-6 days

Data from Waring and Brown[2] and World Health Organization.[3]

ranging from 500 (1:100 dilution of household bleach) to 5000 ppm (1:10 dilution of household bleach) to clean spills of blood or body fluids such as cerebrospinal fluid and peritoneal fluid. The concentration depends on the amount of organic material to be cleaned up and the area to be disinfected. During *Clostridium difficile* outbreaks, disinfecting environmental surfaces with dilute sodium hypochlorite solutions (between 500 and 1600 ppm) effectively reduces the levels of environmental contamination.[6]

Stability of Hypochlorite (Bleach) Solutions

When 1:100-dilution hypochlorite solutions are stored in non-opaque spray or wash bottles, they retain 40% to 42% of their initial activity 30 days later. Solutions diluted 1:50 or 1:5 that are stored in closed brown opaque bottles retain their original activity at 30 days.

Either store hypochlorite solutions in sealed brown opaque bottles or prepare the initial hypochlorite dilutions at twice the final concentration of the chlorine level desired following 1 month of storage. For example, to have a solution containing 500 ppm of available chlorine on day 30, prepare an initial solution containing 1000 ppm of chlorine.[6]

Infection Prevention Among Health Care Workers

Additional standard precautions (SPs) for use when resources or improvised resources are available can be found in Table 32-2.

DIAGNOSIS

Syndromic Treatment

Clinicians use the constellation of patient-reported symptoms and observed physical signs to diagnose and treat patients. They often add imaging and laboratory testing; these may not exist in austere situations. Therefore, clinicians have to go back to the basics, relying on their knowledge and experience. In international medicine, this has been called "syndromic treatment." In the old days, we called it good medical practice. The primary disadvantage of using this approach is the overdiagnosis and overtreatment it promulgates.[7]

Syndromic treatment regimens must be adapted to the local disease prevalence, antibiotic susceptibility, medication availability, and the patient's ability to follow up.

Exposure and Incubation Periods

A history of specific exposure, and the interval until disease onset, can often suggest the diagnosis, as illustrated in Table 32-3.

Pattern Recognition

Only awareness and reasonable suspicion can help signal the presence of an epidemic, a new disease, or the use of a biowarfare agent in the civilian community. Alerting authorities to any of the following problems may get you assistance; it may also signal the onset of some austere times ahead. Clues are:

- Previously healthy people present with severe diseases, including severe pneumonia, sepsis (possibly with coagulopathy), fevers and rash, and diplopia with progressive weakness.
- Multiple patients with similar complaints present from a common location.
- Many more patients than normal present with fever plus respiratory or gastrointestinal complaints.
- An endemic disease appears during an unusual time of year.
- The occurrence of an unusual number of rapidly fatal cases.

Sexually Transmitted Diseases

Tests for Sexually Transmitted Diseases

Sexually transmitted diseases (STDs) constitute a huge problem. In developing countries, due to technical and cost constraints, the most useful tests to confirm the diagnosis of STDs are the Gram stain (gonorrhea, bacterial vaginosis); wet mount (*Trichomonas*); and rapid plasma reagin

TABLE 32-2 Precautions Against Infectious Agents for Health Care Personnel

	Standard Precautions (SP)	Airborne Precautions	Droplet Precautions	Contact Precautions	Drug-Resistant Organism Precautions
When to use? (disease examples)	For all patients	TB, chickenpox, disseminated zoster, measles (only immune staff care for patient), smallpox, SARS (also use droplet precautions)	Bacterial meningitis, *Neisseria, Haemophilus*, diphtheria, *Mycoplasma*, pneumonia, pertussis, pneumonic plague, group A *Streptococcus* (in children), mumps, rubella, serious viral disease	Gastroenteritis (incontinent patient), *Clostridium difficile* (active diarrhea), RSV, skin infections, herpes simplex, impetigo, non-contained wounds, lice, scabies, zoster (localized), smallpox, SARS, varicella (chickenpox or disseminated)	MRSA, VRE, Gram-negative rods resistant to multiple drugs, hemorrhagic fevers
Infectious material	All moist body substances and mucous membranes	Small droplet nuclei	Large droplets	Body secretions and skin, possibly the environment/ equipment	Body secretions and skin, possibly the environment/equipment
Private room	No	Yes, negative pressure	Yes	Preferred	Yes
Visitors	No restriction	Wear TB-grade mask	Wear surgical mask	Hand hygiene; barriers for patient care	Hand hygiene; barriers for patient care
Gloves; hand hygiene (most important)	Use gloves when touching body substances, mucous membranes, open wounds, between patients, when contaminated; routine	SP; routine	SP; routine	For direct patient contact; mandatory	For room entry if touching the patient or room environment; mandatory
Gowns	When soiling of clothing is likely	Per SP	Per SP	For direct patient contact	For room entry if clothing may touch environment/ patient

(*Continued*)

TABLE 32-2 Precautions Against Infectious Agents for Health Care Personnel (*Continued.*)

	Standard Precautions (SP)	Airborne Precautions	Droplet Precautions	Contact Precautions	Drug-Resistant Organism Precautions
Masks; eye protection	When splash to face or eyes is likely	TB-grade mask; per SP, use eye protection for SARS	Surgical mask within 3 feet of patient; per SP	Per SP	Surgical mask within 3 feet of patient. With respiratory case or infected site, per SP
Waste, linen, equipment	Per normal policy; follow sharps safety guidelines	Per normal policy	Per normal policy	Disinfect all reusable equipment leaving room; waste/laundry per normal policy	Disinfect all reusable equipment leaving room; waste/laundry per SP
Transport	Hand hygiene For all patients: wash hands between patients and if patient contact; notify receiving dept of precautions needed	Discouraged; patient wears surgical mask	Discouraged; patient wears surgical mask	Gown and gloves for direct contact. Wear clean gloves/gown for transport in hall/public area. Disinfect all surfaces patient has contact with	Gown and gloves for direct contact. Mask, as above under "Mask." Wear clean gloves/gown for transport in hall/public area. Disinfect all surfaces patient has contact with

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; RSV, respiratory syncytial virus; SARS, severe acute respiratory syndrome; TB, tuberculosis; VRE, vancomycin-resistant enterococci.

TABLE 32-3 Simplified Guide to Possible Infectious Disease: History and Incubation Periods

	Incubation Period With Possible Infections			
Exposure	<21 days	~21 days	>21 days	Variable
Untreated water, unpasteurized dairy products	Typhoid fever Yellow fever Salmonellosis Shigellosis Hepatitis C Brucellosis		Amebic liver abscess Leishmaniasis	Hepatitis A, B, E Amebiasis
Raw/undercooked meat or fish	Enteric infections Cestodiasis Trichinosis			
Mosquitoes	Dengue fever			Malaria
Ticks	Viral hemorrhagic fever (Crimean-Congo) Rickettsial diseases Tularemia			
Reduviid bugs	American trypanosomiasis (Chagas' disease)			
Tsetse flies	East African trypanosomiasis		African trypanosomiasis	
Animal contact	Tularemia		Q Fever Brucellosis Echinococcus	Rabies
Freshwater-contaminated			Schistosomiasis Leptospirosis	
Barefoot exposure				Strongyloidiasis Cutaneous larva migrans
Sexual contact	Gonorrhea Herpes *Chlamydia*	Acute HIV infection	Hepatitis B	Syphilis
Infected person	Viral hemorrhagic fever SARS Enteric fever Meningococcal disease		TB	

Abbreviations: HIV, human immunodeficiency virus; SARS, severe acute respiratory syndrome; TB, tuberculosis.

Data from Centers for Disease Control and Prevention.[8]

(RPR; syphilis) tests. Even these tests may not be available in many locations, so the syndromic treatment described in the following paragraphs is the best option.

Sexually Transmitted Disease Syndromes

Treating presumed STDs using the following criteria leads to a higher proportion of patients being treated and, in some cases, a lessening of the disease's prevalence in communities. Patients with these syndromes are usually treated at their first visit. If possible, treatment is a single dose of antibiotics taken immediately. Patients must return after 7 days if treatment fails (i.e., symptoms persist or return).[8]

Vaginal Discharge

Treat for gonorrhea, chlamydia, *Trichomonas vaginalis*, and bacterial vaginosis whether or not pruritus is present. If it appears to be *Candida albicans*, treat only for that. Three non-medication treatments often are effective against vaginal yeast infections. The first is to have the patient sit in a pan of clean, warm water containing vinegar or yogurt twice a day until she feels better. Or, have her mix 3 tablespoons of vinegar in 1 L of boiled, cooled water; then soak a piece of cotton in this liquid and insert it into her vagina each night for three nights. Remove the cotton each morning. The third alternative is to insert the cotton as above, but soak it in 1% gentian violet.[9]

Lower Abdominal Pain (Female)

In a female patient with painful cervical motion that is not a surgical/obstetric emergency, treat for pelvic inflammatory disease (PID): gonorrhea, chlamydia, anaerobic bacteria, *T. vaginalis*, and bacterial vaginosis.

Urethral Discharge Syndrome (Male)

Discharge is spontaneous or present after "milking" the urethra. First, treat for gonorrhea and chlamydia. If the treatment fails, treat for *T. vaginalis* or, if antibiotic-resistant gonorrhea is suspected, add second-line therapy.

Genital Ulcer Syndrome

If patients present with genital ulcers (but excluding typical herpes blisters), treat for chancroid and syphilis. In countries with a high prevalence of granuloma inguinale (donovanosis), treat for that. Improvised treatment for typical vaginal herpes lesions is to treat the discomfort, rather than to cure the problem. Other than analgesics (see Chapter 13, Analgesics), locally applied agents can often help. Tell the patient to apply ice directly to the area as soon as it feels like a new outbreak is occurring. The patient can also hold a wet cloth soaked in cooled black tea or clove tea on the lesions. Other options are to apply witch hazel or a paste of baking soda or cornstarch in water to the lesions.[10]

Epididymo-ochitis (Male)

The patient has a hot, tender, painful scrotum. If there is no evidence of surgical (trauma, tumor, torsion) or medical (mumps) causes, treat for gonorrhea and chlamydia.

Inguinal Bubo

Patients have painful swollen inguinal lymph nodes without an ulcer. If there is no other infection causing regional lymphadenopathy, treat for chancroid and lymphogranuloma venereum.

Pharyngitis

Group A beta-hemolytic *Streptococcus* (GABHS) causes only about 10% of adult pharyngitis cases, although it may be higher in children.[11] Antibiotic treatment benefits only those patients with GABHS infection. To determine which patients should get antibiotics, use Centor's criteria[12]: no cough, tender anterior cervical lymphadenopathy, a history of fever, and tonsillar exudates. Each of these equals 1 point. (Remember them as "CAFE" criteria: **C**ough absent, **A**denopathy, **F**ever, **E**xudate.) Without the ability to test for streptococcal pharyngitis (including cultures in children), treat only those patients with ≥3 criteria (points).[13] Always treat patients who have 4 criteria.

Bacterial Meningitis Mortality

When deciding how to allocate scarce resources, consider that the risk of death among patients with a single episode of community-acquired meningitis is twice as high for patients ≥60 years old as it is for patients <60 years old. The risk of death is three times higher for those with obtunded mental status on admission than for those who are awake, and four times greater for those in whom seizures began within 24 hours of admission.[14] This trend can be extrapolated to other causes of meningitis.

SKIN LESIONS

Diagnosis and Communicating With Consultants

Describing lesions correctly also helps make the diagnosis, either when using the algorithms found in many texts or when speaking with consultants. Table 32-4 gives the standard nomenclature for skin lesions. Figure 32-1 illustrates some of these lesions.

Once the lesions are described, use a standard algorithm, such as the one in Table 32-5, to narrow the possible diseases.

After a diagnosis is made and the patient is being followed or has been referred for consultation, documenting their condition may be problematic, especially when trying to identify specific lesions. Measure the lesion and then localize it. One way to localize it is to mentally place the center of a clock face over a specific, identifiable point on the patient's anatomy (e.g., right tragus, left nasal ala, right nipple) and then describe the lesion(s) in relation to that point. For example, to document a lesion 2 inches above and behind the left eye (Fig. 32-2), write "0.4-cm lesion 5-cm 1 o'clock left lateral canthus." For a lesion 2 inches behind and below the left side of the nose, write "0.6-mm lesion 5-cm 4 o'clock left ala." This pinpoints the lesion and facilitates a later comparison by you or another clinician. This is especially helpful when there are several lesions in the same area. In addition, this system is easily understood.[16]

Tinea Versicolor

Tinea versicolor is a common skin condition caused by an overgrowth of yeast on the skin, primarily in oily areas such as the neck, upper chest, and back. It results in an uneven skin color (dyspigmentation) and scaling, and it may be pruritic.

TABLE 32-4 Standard Description of Skin Lesions

Lesion	Description	Size (Diameter)	Position
Petechiae	Blood in skin	<0.5 cm	Flat
Macule	Discoloration, color varies	<1 cm	Flat
Papule	Solid, color varies	<0.5 cm	Raised
Plaque	Circumscribed, solid; may be confluence of papules	>0.5 cm	Raised
Nodule	Solid	>0.5 cm	Raised
Wheal	Firm, transient	Varies	Raised
Vesicle	Circumscribed, fluid filled	<0.5 cm	Raised
Bulla	Circumscribed, fluid filled	>0.5 cm	Raised
Pustule	Circumscribed, pus filled	Varies	Raised
Erosion	Does not penetrate below dermal-epidermal junction; heals without scarring	Varies	Depressed
Ulcer	Focal epidermal and dermal loss; heals with scarring	Varies	Depressed

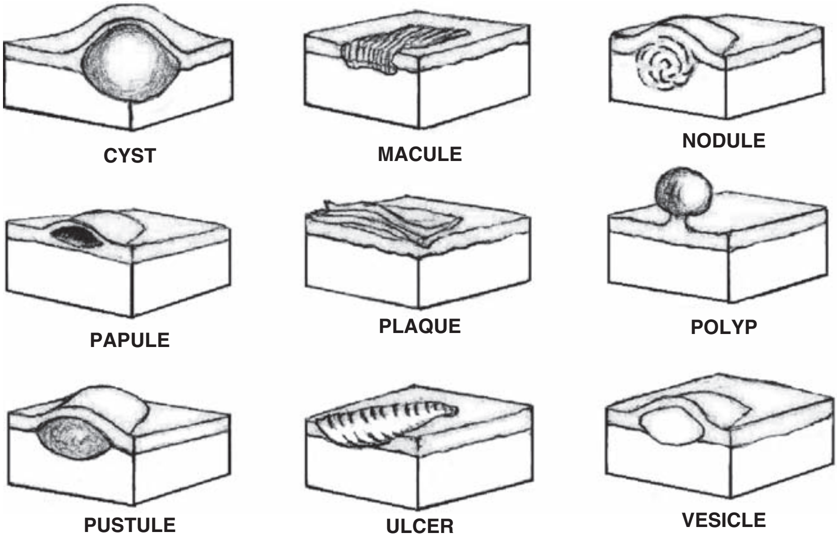


FIG. 32-1. Common skin lesions.

To treat this condition, use an antifungal cream. If one is not available, make a cream with sulfur and lard (1 part sulfur to 10 parts lard) and apply it to the whole body every day until the lesions disappear. Although treatment of the infection takes a few weeks, it takes a few months for the pigmentation to return as the epidermis replaces itself. Even better is to treat the lesions with sodium thiosulfate, which anyone still developing photographic film will have on hand. Dissolve a tablespoon of this in a glass of water and apply it to the whole upper body. Then rub the skin with a piece of cotton dipped in vinegar. The treatment often must be repeated every 2 weeks to keep the spots from returning. Selenium sulfide (in dandruff shampoo) or Whitfield's ointment may also help, but it must be applied in 5 to 10 minutes before getting into the shower. Use it daily from the neck down for 4 to 6 weeks. (Julie Dixon, MD, in a written communication, received September 4, 2008.) Whitfield's ointment is a mixture of 6% salicylic acid and 12% benzoic acid (or 6% benzoic acid plus 3% salicylic acid) in a lanolin or petroleum jelly base. All these ingredients are readily available and inexpensive. Although effective, treatment with Whitfield's ointment can be uncomfortable, since the patient feels a burning sensation.

Herpes Zoster

Herpes zoster is a reactivation of the varicella zoster virus along any dermatome in the body, although it rarely occurs on the extremities. To ease the discomfort of herpes zoster, use a light bandage over the area so that it does not rub on or stick to clothing. Zoster pain and post-herpetic neuralgia often respond to tricyclic antidepressants (e.g., amitriptyline) better than to narcotics. Post-herpetic neuralgia sometimes responds to hypnotherapy. Patients would need to do self-hypnosis, which is not difficult. See "Hypnosis" in Chapter 14, Anesthesia—Local and Regional, for details.

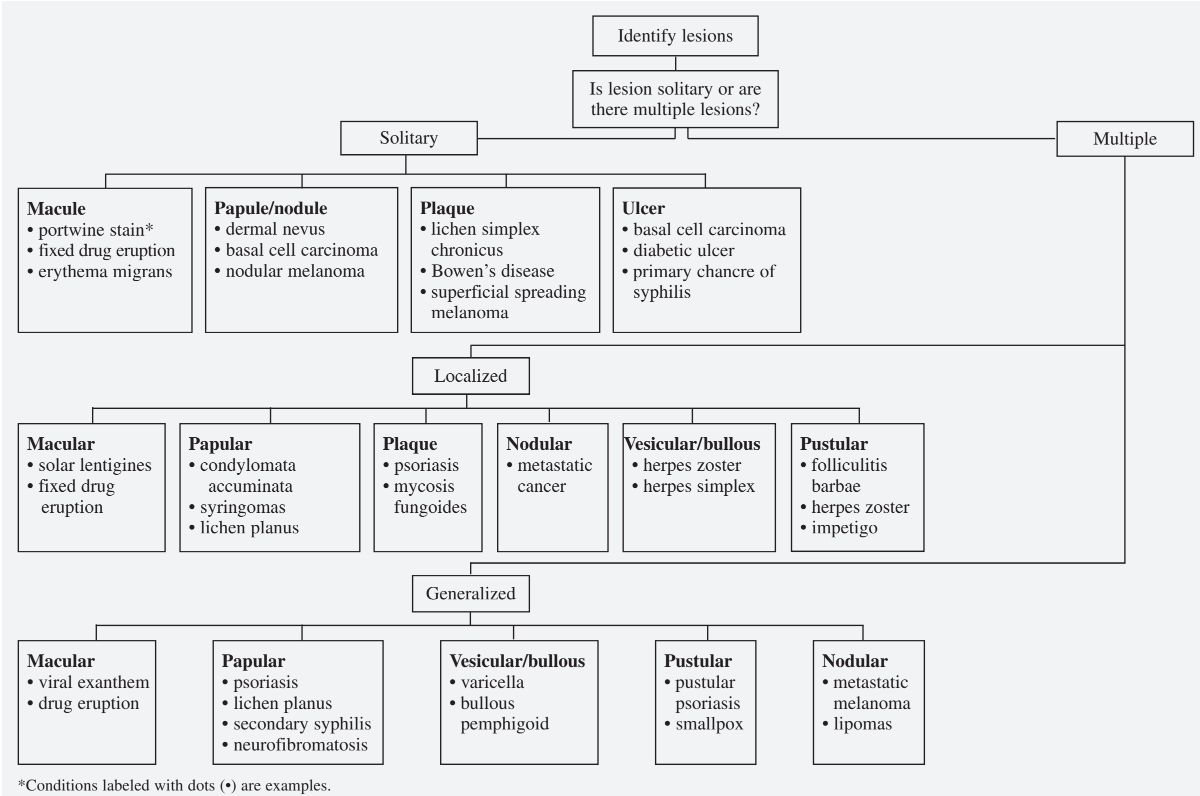
Topical lidocaine under occlusive patches works well both for acute pain and for post-herpetic neuralgia; its action may last up to 1 week. Use it as a cream, gel, ointment, jelly, or solution. In general, place about 700 mg lidocaine under a 10-cm × 14-cm occlusive dressing.

Both the acute attack of zoster and post-herpetic neuralgia have been successfully treated with a topical licorice (*Glycyrrhiza glabra*, *Glycyrrhiza uralensis*) gel. While safe topically, it can be dangerous if given orally.[17]

Verruca (Warts)

Duct tape seems to work on common warts if applied continuously (24 hours at a time; change after bathing) for 6 (out of 7) days of the week. This treatment takes weeks or months to work,

TABLE 32-5 Algorithm for Narrowing Possibilities for Skin Lesions*



*The listed diseases represent some of the most common disorders.
Reproduced with permission from Wolff et al.[15]

FIG. 32-2. Clock-face identification of lesions.

but the wart eventually becomes macerated and then stimulates a host immune response and eliminates the virus. (Dr. Julie Dixon, a dermatologist in Tucson, AZ. Personal written communication received September 4, 2008.)

For those using liquid nitrogen to freeze a wart, it helps to have steady hands. An alternative is to funnel the liquid nitrogen spray directly onto the lesion using a plastic earpiece from an otoscope. This removes any fear of damaging the surrounding tissue.[18] Another method is to dip a cotton-tipped applicator into the liquid nitrogen and press it into the tip of an otoscope held above the lesion. As you press harder on the applicator, more liquid nitrogen is released.[19] These treatments also likely require a number of applications over a few months.

TREATMENT

Cutaneous Myiasis

Cutaneous myiasis may be the one parasitic disease amenable to alternative treatments. It is caused by botfly (*Dermatobia hominis*) maggots under the skin. They have strong hooked spine rings around their midsections, and so cannot be removed easily while alive.

Many folk methods supposedly remove the larvae, including by using venom extractors (which are of no use for extracting venom); by occluding the skin hole with petroleum jelly, beeswax, or pork fat or sealing the hole with duct tape to reduce their air supply; or by applying native tobacco leaf, injecting ether or chloroform, or topically applying 5% chloroform in olive oil to immobilize the larvae. Natives of endemic areas claim that putting a small piece of meat over the affected area will eventually cause the larvae to burrow through the meat to gain access to oxygen, at which point the meat may be removed with the larvae trapped inside.

Two certain methods to remove the larvae exist. The safest and surest method of ridding oneself of botflies is to wait for the fly to develop and leave the body on its own (this takes about a month). That is both uncomfortable and a bit discomfiting. However, there may be no other option. If surgical skill and equipment exist, and the lesion is in an area without vital superficial structures, the botfly can be removed by excising an ellipse of skin and subcutaneous tissue, including the larva's subcutaneous burrow. Leave the wound open to heal by secondary intention. No antibiotics are necessary.[20]

Cholera

Cholera treatment consists of measuring output and replacing that amount with electrolyte-containing fluids. This treatment is extremely effective in reducing the case-fatality rate (CFR) in outbreaks that can normally reach as high as 50%. The first trick is to measure the massive output.

To determine the volume of "rice water" stool output, place patients on cholera beds, if possible. These are cots with a hole in the middle; buckets to collect the output are placed beneath the hole (Fig. 32-3). Using these beds allows patients, in their weakened state, to stay in their beds (and avoid possible cross-contamination of others) rather than going to a latrine. This practice also simplifies nursing care. In an epidemic, however, such beds may be at a premium. Rather than putting two patients in one bed (a common practice), which makes the bed much less useful and much more uncomfortable, improvise these beds using military stretchers. Cut a circular, 40-cm-diameter hole in the middle to fit the patients' buttocks. (Cut a smaller hole, of course, for children.) Then put the stretcher on blocks with a bucket underneath the hole.[21]

Once you have determined the output, begin treatment by rehydrating the patient. Oral rehydration therapy (ORT) is amazingly effective. For patients presenting in shock, limited IV therapy precedes ORT. See Chapter 11, Dehydration/Rehydration, for additional information on ORT and on making oral rehydration solutions (ORS).

Malaria

The best treatment for malaria is prevention. However, the disease is endemic in the tropics. Although antimalarial drugs are widely available, increasing resistance makes the choice of medication a moving target. When treating malaria, an alternative to administering quinine intramuscularly or intravenously in children is to administer it intra-rectally. This method has been used successfully in children with severe malaria or with malaria with severe emesis and no diarrhea. The dose of the injectable quinine dihydrochloride administered via intrarectal tube is 20 mg/kg bid diluted in 2 mL water.[22]

In patients diagnosed with *falciparum* malaria, hematuria on the urine dipstick is highly sensitive and specific for impending renal failure. This can be used in conjunction with or in the absence of appropriate blood tests. The presence of urine protein does not have the same correlation.[23]

Convalescent Serum

In situations where no antibiotics or, more likely, no antiviral agents are available or effective, transfuse serum or the blood from a patient that has recovered from the disease. Without adequate treatment for some viral illnesses that have high case-fatality rates, the use of convalescent serum as a treatment may be the only option—if blood-banking facilities are available.

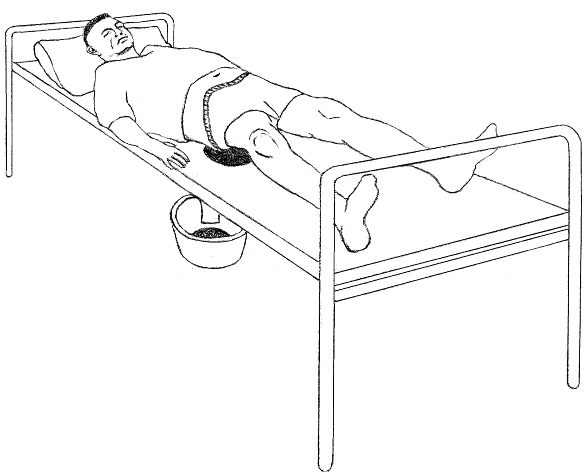


FIG. 32-3. Cholera bed.

In the early, pre-antibiotic 20th century, convalescent serum taken from patients who had just recovered from the same disease was routinely used to treat patients with scarlet fever, measles, poliomyelitis, erysipelas, mumps, and pneumonia. This serum was obtained at various times (e.g., 4 to 7 weeks after patients had scarlet fever). The results of treatment using convalescent serum depended on the timing of the treatment and the disease. For measles, small aliquots of serum (5 to 10 mL) injected into susceptible contacts of an active case within 6 days of exposure prevented the disease. If the serum was given 6 to 9 days after exposure, it modified the disease. After that, it was of no benefit.[24]

More recently, convalescent serum has been used to treat hemorrhagic fevers in animals and humans with good results.[25] For the human cases, the serum was obtained from patients discharged from the hospital after recovering from Ebola virus 4 to 6 weeks earlier. Their blood was typed, tested, and anticoagulated per standard blood bank protocols. Adults received an infusion of between 250 and 400 mL of blood. Children received 150 mL infusions. While only 1 of 8 patients receiving convalescent serum died (much lower than the normal CFR), it is unclear what role the serum played in this.[26]

This "old medical trick" has also been successfully applied to treat "severe cases of H1N1 flu." In those cases, clinicians gave plasma donated from patients who had recovered from H1N1 to severely ill patients with the disease. The treatment markedly reduced their mortality compared to those receiving standard therapy. None suffered any adverse effect from the transfusion.[27] Dr. John A. McLean of Australia used this technique for decades to cure typhoid fever.[28]

Sepsis (or Systemic Inflammatory Response Syndrome)

When limited resources are available to monitor and treat sepsis, such as during epidemics, use the following basic methods, which do not require expensive equipment, to evaluate patients' progress. (Note that the new name for sepsis is systemic inflammatory response syndrome [SIRS].) If a patient fails to improve or deteriorates at any stage, promptly reassess the patient (ABC, history, examination, and so forth). Consider whether the original diagnosis was correct, whether new problems have arisen, and if the current treatment is appropriate. Signs of deterioration may include:

- Persistent or worsening tachycardia
- Persistently elevated or swinging temperature
- Rising white blood cell (WBC) count or C-reactive protein (CRP)
- Falling blood pressure, or increasing vasopressor requirement
- Deteriorating renal output
- Deteriorating level of consciousness
- Deteriorating respiratory function[29]

Since no scoring system accurately predicts the outcome for individual patients with severe SIRS/sepsis, survival depends on the patient's age, previous health, delay before medical intervention, and medical care provided. In epidemic situations, resources are limited, so physicians must face difficult decisions concerning which patients should receive potentially lifesaving treatments. (An extensive discussion of this is found in the short videos, *The Most Difficult Healthcare Decisions*, available free [English and Spanish] at http://www.crestaznm.org/crest/ecs/courses/onlineCourses.html?ctid=97 [English].[30])

Neglected Tropical Diseases

Eliminating or treating some common tropical diseases may actually be easier than many clinicians think. The "neglected tropical diseases" comprise 17 diseases found in the poorest parts of the world; they afflict 1 billion people. Seven of these diseases—ascariasis, trichuriasis, hookworm infection, schistosomiasis, lymphatic filariasis, trachoma, and onchocerciasis—can be treated (and probably controlled or eliminated if an entire population were to be treated) using a rapid-impact package of drugs. Called "rapid-impact" because community-based workers can quickly distribute them, these drugs result in rapid physical improvements and, in some cases, interruption of disease transmission. These packages include four of six drugs: albendazole or mebendazole, praziquantel, ivermectin or diethylcarbamazine, and azithromycin. They are readily available in many developing countries and generally cost about 50 cents a package, since some of the medications are routinely donated. An additional benefit is that this drug combination also effectively treats scabies, strongyloidosis, pediculosis, tungiasis, and cutaneous larva migrans.[31,32]

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33 | Malnutrition

Malnutrition is a huge problem throughout the world, and it worsens in disaster situations. Estimates are that malnutrition contributes to more than half (54%) of all deaths of children <5 years old worldwide (Fig. 33-1). It usually occurs in resource-poor situations. The keys are both to recognize it and to treat it effectively.

RECOGNIZING MALNUTRITION

Malnutrition can be identified using arm circumference or by comparing a child's height and weight with standard charts.

Arm Circumference

Measuring a child's arm circumference halfway between the point of the shoulder and the elbow can help to determine the degree of malnourishment. This technique is at least as good at predicting mortality from malnutrition as is a child's position on a weight/height growth chart. Arm circumference is measured, in centimeters, at the midpoint of the left upper arm. From 1 to 5 years of age, the mid-arm circumference remains fairly stable, because the increasing growth in muscle mass is balanced by a decrease in arm fat. The median value for this age group is 16.5 cm. In the first 12 months of life, arm circumference changes so rapidly that it is not a reliable indicator of malnutrition. And, while skin thickness over the scapula or triceps can be measured, this requires the use of calipers and provides little additional information.[1]

To make the measurement, have the child keep the arm hanging straight down by his side (Fig. 33-2). If the arm circumference of a child between the ages of 1 and 5 years is below 12.5 cm, he is severely malnourished. If it is between 12.5 and 14 cm, he is moderately malnourished. Above 14 cm is normal.[2,3]

If a measuring tape is not available, a marked piece of non-stretchable cloth or a string with knots at the appropriate distances can be used, although it may stretch a little. Another method is to use a strip of x-ray film. Scratch or paint the film at the 0-cm mark, and again at the 12.5-cm and 14-cm marks. For clarity, the area between the 0- and 12.5-cm marks can be colored red; the area between 12.5 and 14 cm, yellow; and the area above 14 cm, green.

CLASSIFICATION OF MALNUTRITION

The classification of malnutrition is based on the child's position on the standard weight-height-for-age charts, which can be accessed at the Centers for Disease Control and Prevention: *Growth Charts*

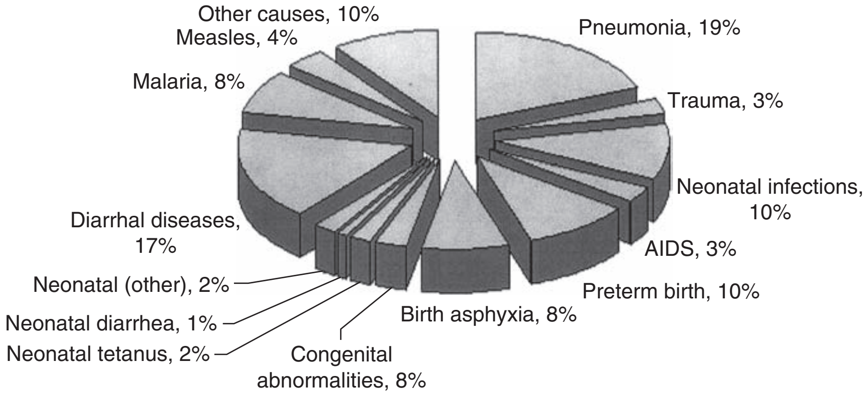

FIG. 33-1. Causes of death in children, worldwide.

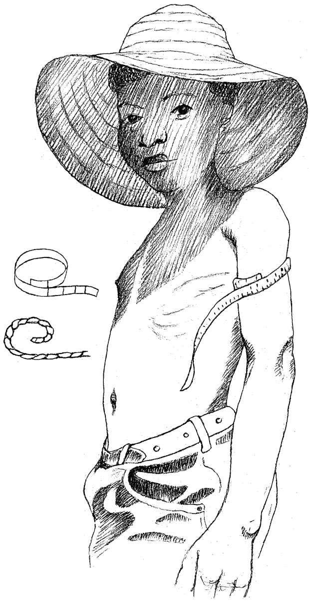

FIG. 33-2. Measure the mid-upper arm circumference to assess malnutrition.

(www.cdc.gov/growthcharts/). Height (length for a supine infant) and weight can be measured using standard means or by the improvised methods described in Chapter 7, Vital Signs, Measurements, and Triage. The results can be interpreted using the Welcome Classification system:

Percentage of Standard	Edema Present	Edema Absent
60-80	Kwashiorkor	Underweight
<60	Marasmic-kwashiorkor	Marasmus

MALNUTRITION MANAGEMENT

Severe malnutrition takes the form of either marasmus (wasting; Fig. 33-3) or kwashiorkor (edema; Fig. 33-4), or a combination of the two. The reasons for a progression of nutritional deficit into one rather than the other are unclear and cannot be explained solely by the composition of the deficient diet.[4]

Moderate Malnutrition

The child's weight is 60% to 80% of the expected weight, with a flat or falling position on the weight chart; there is no edema. Treat the child as an outpatient. Discuss one or two of the following "nutrition messages" with the child's parent(s).[5]

1. Start giving soft food as well as breast milk when your child is 4 months old. If you do not know the child's age, start this when he or she can roll over.
2. Add extra coconut cream, pan drippings, or margarine to the child's food.
3. Feed your child four to six times a day.
4. Feed your child cooked and mashed peanuts, beans, or fish every day.
5. Continue to feed your child when he or she is sick and give extra food after sickness.
6. Eat plenty of food when pregnant or breastfeeding.

Check and treat the child for diseases that cause malnutrition, such as worms, anemia, chronic diarrhea, other infections, resistant malaria, and tuberculosis (TB). Admit only if another illness is present or if there is no improvement after 1 month of outpatient treatment.

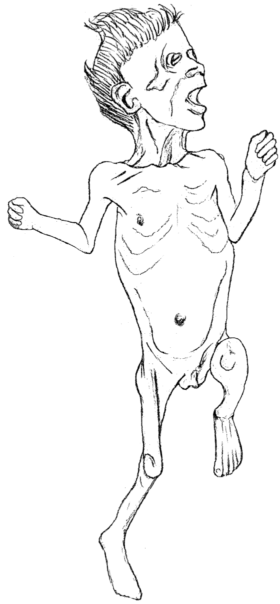

FIG. 33-3. Marasmus.

Severe Malnutrition

If the child's weight-for-height is <70% for the population and he or she has a flat or falling position on the standard weight chart, if there is obvious severe wasting, or if the child has edema of both feet, then he or she has severe malnutrition. Admit the child to the hospital and treat any infection and anemia. Rule out resistant malaria and TB.

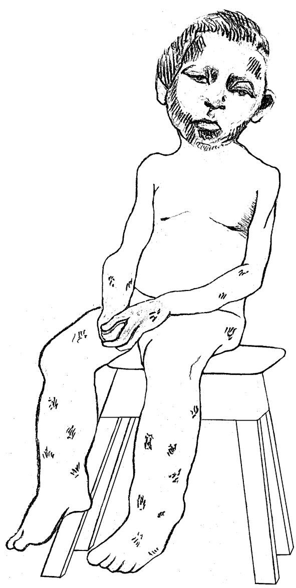

FIG. 33-4. Kwashiorkor.

TABLE 33-1 Caring for Severely Malnourished Children (Approximate Timeline)

		Stabilization		Rehabilitation
		Days 1-2	Days 3-7	Weeks 2-6
1	Prevent/treat hypoglycemia	→		
2	Prevent/treat hypothermia	→		
3	Treat/prevent dehydration	→		
4	Correct electrolyte imbalance	———	———	———→
5	Treat infections	———	———→	
6	Correct micronutrient deficiencies	No Iron ———	———	With Iron ———→
7	Start cautious feeding	———	———→	
8	Rebuild wasted tissues (catch-up growth)		———	———→
9	Provide loving care and play	———	———	———→
10	Prepare for follow-up/counsel parents		———	———→

Data from Ashworth et al[6] and Parry et al.[7]

Severely malnourished hospitalized children die primarily from hypoglycemia, hypothermia, cardiac failure (over-hydration and potassium deficiency), and missed or untreated infections. The basic steps, and a timeline, for treating severely malnourished children are described in Table 33-1.

Feeding Severely Malnourished Children[8]

Immediately give 50 mL of 10% glucose or sucrose solution (1 rounded teaspoon of sugar in 3½ teaspoons water) orally or by nasogastric (NG) tube. If it will be quicker, give starter formula (Table 33-2) or Formula-75 (F-75; see Table 33.3 for homemade F-75). Always use water that has been boiled.

1. Prepare the F-75 formula by adding the dried skimmed milk, sugar, cereal flour, and oil to some water and mix. Boil the mixture for 5 to 7 minutes. After the mixture cools, add the mineral mix and vitamin mix, and mix the solution again. Add enough boiled water to bring the volume up to 1000 mL.
2. Alternatively, make a similar formula with 35 g whole dried milk, 70 g sugar, 35 g cereal flour, 17 g oil, 20 mL mineral mix, 140 mg vitamin mix, and enough water to make 1000 mL. Another alternative is to use 300 mL fresh cows' milk, 70 g sugar, 35 g cereal flour, 17 g oil, 20 mL mineral mix, 140 mg vitamin mix, and enough water to make 1000 mL.
3. If cereal flour is not available or if there are no cooking facilities, make a comparable formula with 25 g dried skimmed milk, 100 g sugar, 27 g oil, 20 mL mineral mix, and 140 mg vitamin mix in enough water to make 1000 mL. Note that this formula has a high osmolarity (415 mOsmol/L) and may not be well tolerated by all children, especially those with diarrhea.
4. Commercially available isotonic versions of F-75 (280 mOsmol/L) contain maltodextrins to replace cereal flour and some of the sugar.

If the child will eat, give him food and, if needed, start rehydration immediately. Feed every 2 to 3 hours, day and night, to prevent hypoglycemia and hypothermia.

For the first 1 to 7 days (stabilization phase), give small frequent feedings of commercial or homemade F-75 or milk-based starter formula. The norm is 130 mL/kg/d, or 100 mL/kg/d if the child has severe edema.

As the child's appetite returns, switch to Formula-100 (F-100) solution (see Table 33-3) or to catch-up formula (see Table 33-2). Add 10 mL to each feeding until some remains uneaten. This should provide about 200 mL/kg/d.

1. To prepare the F-100 diet, mix dried skimmed milk, sugar, and oil into warm water that has been boiled. Add the mineral mix and vitamin mix, and stir the solution. Add more boiled water to make 1000 mL.

TABLE 33-2 Formulas for Milk-Based Starter and Catch-Up Feeding

For full-cream milk powder, use:		
	Starter	Catch-up
Full-cream milk powder	35 g	110 g
Sugar	100 g	50 g
Vegetable oil	20 g (or mL)	30 g (or mL)
Electrolyte/mineral solution	20 mL	20 mL
Bring volume up to 1000 mL with cooled, boiled water.		
For dried skimmed milk, use:		
	Starter	Catch-up
Dried skimmed milk	25 g	80 g
Sugar	100 g	50 g
Vegetable oil	30 g (or mL)	60 g (or mL)
Electrolyte/mineral solution	20 mL	20 mL
Bring volume up to 1000 mL with cooled, boiled water.		
For fresh or long-life cows' milk, use:		
	Starter	Catch-up
Fresh or long-life milk	300 mL	880 mL
Sugar	100 g	75 g
Vegetable oil	20 g (or mL)	20 g (or mL)
Electrolyte/mineral solution	20 mL	20 mL
Bring volume up to 1000 mL with cooled, boiled water.		

To prepare solutions: Place the ingredients in a 1-L electric blender. Add water up to the 1-L mark and blend. (Do not add 1 L of water as this makes solution too dilute.) If a blender is not available, mix the oil and sugar thoroughly, then mix in the milk and electrolyte/mineral solution and bring volume up to 1 L. Whisk thoroughly to prevent the oil from separating out.

Data from Ashworth et al[7] and Parry et al.[10]

2. Make a similar formula using 110 g whole dried milk, 50 g sugar, 30 g oil, 20 mL mineral mix, 140 mg vitamin mix, and boiled water to make 1000 mL. Alternatively, use 880 mL fresh cows' milk, 75 g sugar, 20 g oil, 20 mL mineral mix, 140 mg vitamin mix, and sufficient boiled water to make 1000 mL.

After 1 to 2 days, the child normally regains his appetite and should be given frequent feedings of unlimited amounts of either F-100 or the catch-up formula. If the child is still being breast-fed, continue this after providing the F-100, which has more protein. For children on solid foods, peanut butter (paste) or commercial ready-to-use therapeutic food (RUTF), such as Plumpy'nut, is used in place of some or all the formulas at this stage.[12] Encourage the child to eat: good foods to give are mashed ripe banana, bread or wheat meal with margarine, ground-up roasted or boiled peanuts, sweet potato, rice, or similar local foods.[5]

Feedings can be supplemented with snacks: children love to eat snacks. That they are healthy is a side benefit. Available high-carbohydrate, high-protein snacks may include high-protein biscuits, peanut paste, peanut balls, banana, pawpaw, other appropriate local foods, and egg or milk balls.[5]

- *Peanut balls*: mix 2 cups mashed sweet potato (or taro, yam, or sago) and ¼ cup peanut paste. Roll into balls of about 1 teaspoonful and allow to dry.
- *Milk balls*: mix 6 tablespoons milk powder, 1 tablespoon sugar, and 1 tablespoon cocoa. Then mix in 3 tablespoons boiled water. Roll into balls of about 1 teaspoonful and let dry.

TABLE 33-3 Homemade F-75 and F-100 Formulas

Homemade F-75 Formula	
Ingredient	Amount
Dried skimmed milk	25 g
Sugar	70 g
Cereal flour	35 g
Vegetable oil	27 g
Mineral mix*	20 mL
Vitamin mix*	140 mg
Clean water	1000 mL
Homemade F-100 Formula[11]	
Ingredient	Amount
Dried skimmed milk	80 g
Sugar	50 g
Vegetable oil	60 g
Mineral mix*	20 mL
Vitamin mix*	140 mg
Clean water	1000 mL

*Usually a commercial mix, but pharmacies can also make them.
Data from World Health Organization.[11]

Treat hypothermia in infants and neonates as described under "Hyperthermia, Hypothermia, and Frostbite" in Chapter 21, Surgery/Trauma, or under "Neonatal Hypothermia" in Chapter 34, Pediatrics and Neonatal.

Do not overhydrate the child; confusing dehydration with malnutrition is a common problem. Use parenteral fluids only if necessary.

Give vitamin A (<6 months, 50,000 IU; 6-12 months, 100,000 IU; >12 months, 200,000 IU) immediately. Repeat if there is xerophthalmia. Give daily doses of multiple-vitamin liquid, folic acid (5 mg immediately, then 1 mg/d), zinc (2 mg/kg/d), and copper (0.3 mg/kg/d), or give an electrolyte mixture that contains these elements. Wait to give iron until the child has a good appetite, and then give 3 mg Fe/kg/d.[8]

Treat infections or presumed infections. Administer vaccines (if due or overdue), especially against measles.

Discharging the Patient

Both the child and the parent/caregiver must be ready before discharge. Do not discharge the child until he is stable and the parents/caregivers have been taught how to prevent a recurrence.

Discharge only if the child:

- has completed antibiotic treatment
- has no edema
- is eating very well
- shows good weight gain
- has had 2 weeks of potassium and vitamin supplements (or can continue them at home)

Discharge only if the parents/caregivers know:

- when and how to follow up with neighborhood clinics
- what to feed the child, and how much and how often, using foods that will support continued catch-up growth and are affordable and culturally acceptable

- how to keep their child healthy at home
- how to provide play and stimulation to promote development
- to take their child for follow-up at 1, 2, and 4 weeks, then monthly, and for booster immunizations and vitamin A (every 6 months)

PREVENTABLE NUTRITIONAL DISORDERS

Early recognition and innovation can overcome problems of nutritional deficiencies.

Vitamin A

Vitamin A deficiency is one of the most common vitamin deficiencies. The presence of any of the following vitamin A deficiency (xerophthalmia) indicators over the specified prevalence levels in children aged 6 to 71 months signifies a public health problem that must be addressed: night blindness present at 24 to 71 months (>1%); Bitot spots (>0.5%); corneal xerosis/ulceration/keratomalacia (>0.01%); or corneal scars (>0.05%).[13] Vitamin A deficiency can be treated by providing oral or parenteral supplements. Since adequate vitamin A contributes to disease-fighting capability, it is given to every severely malnourished child.

Iodine Deficiency

Iodine is an essential element for thyroid function and is necessary for normal growth, development, and functioning. A diet deficient in iodine is associated with a wide spectrum of illnesses, collectively known as iodine deficiency disorders. The most obvious result is goiter. If a goiter is present in school-age children (6 to 12 years old), the severity level of the public health problem is high when ≥30% of population has goiter; moderate, if 20% to 29.9%; and mild, if 5% to 19.9%.[13] To treat iodine deficiency, add iodized salt to the diet; eat milk, egg yolks, and saltwater fish; add iodine to the water source; or inject iodized oil.

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GENERAL APPROACH TO CHILDREN

"Little Adults"

Clinicians who don't regularly care for children often are fearful of them, particularly because many are nonverbal and may not cooperate with an exam. While children are not just "little adults," they will be much more willing to cooperate with the exam, and even procedures, if you spend a few minutes interacting with them, rather than interacting only with the parent. As much as possible, talk with children directly, as if they were an adult patient. Also, tell children the truth. If a procedure is going to hurt, tell them. They may not like that it hurts, but they will trust that, when you do something else and you tell them it won't hurt, you are telling the truth.[1]

Pediatric Developmental Milestones

Failure to progress through normal developmental milestones may indicate underlying medical problems, including malnutrition, anemia, HIV, hearing loss, chronic infections, lung disorders, and chronic toxicity (e.g., lead poisoning).[2] To determine how well children are progressing, remember the four important milestones listed below.

Action	50% Do It By	97% Do It By
1. Sits unsupported	6 months	9 months
2. Walks 10 steps unsupported	12 months	18 months
3. Speaks 3 or 4 single words	14 months	20 months
4. Says phrase ("Daddy go work")	24 months	36 months

For more complex testing, use the developmental assessment provided in Table 34-1, which was initially created to assess children in rural India.

HOSPITALIZED AND VERY ILL CHILDREN

Parents Caring for Children in the Hospital

In many cultures, a parent, usually the mother, traditionally helps to care for her own child in the hospital. While this should be encouraged in nearly all instances, in situations of scarcity, it has several advantages. It provides (a) low-cost bedside care, (b) continued breastfeeding, (c) emotional support from a known caregiver, (d) warmth for babies if mother and child sleep together, and (e) an opportunity to teach the mother important health care practices.

When to Refer Patients

In remote areas or in situations with scarce resources, it is important to know which children must immediately be referred to a hospital for admission or to specialists (possibly in a less urgent manner). The following rules (Table 34-2) were developed for practitioners in Papua-New Guinea, which has a chronic scarcity of health resources.[5] However, the rules can be applied to all scarce-resource circumstances.

NEONATES/INFANTS

Normal Vital Signs

Knowing the normal neonatal vital signs for preterm infants (Table 34-6 later in this chapter) helps to determine whether a neonate needs resuscitation (assuming that the resources to do this are available) and whether the infant has been successfully resuscitated.

TABLE 34-1 Pediatric Developmental Assessment

Age	Test Type	Behavior
3 months	T	Visually very alert, particularly interested in human faces.
	T	Moves head deliberately to look around.
	T	Definite response to mother's voice, either by becoming quiet or by smiling.
6 months	A, T	Can roll over from belly to back.
	T	If placed face down (prone), will lift head and chest, supporting himself on extended arms.
	T	If held standing with feet touching a hard surface, the baby bears his weight on his feet and bounces up and down actively.
	A, T	Reaches for and grasps small objects.
9 months	A, T	Sits alone for 10-15 minutes on a firm surface.
	A, T	Moves on the floor by rolling or squirming.
	A, T	Tries to crawl on hands and legs.
	T	If the baby is held standing, he steps on one foot then the other.
	A, T	Can distinguish strangers from known persons. May become distressed with strangers.
12 months	A, T	When lying down, can get into a sitting position.
	A, T	Pulls himself to standing and lets himself down again, holding on to furniture.
	A, T	If the baby's hands are held, he will walk, and may even walk without help.
	T	Gives objects to an adult on request.
15 months	T	Walks unevenly with feet wide apart and arms raised for balance.
	A, T	Speaks 2-6 recognizable words. Understands more.
	T	Points to familiar persons, animals, toys when asked to do so.
18 months	T	Picks up a toy from the floor without falling.
	T	Shows his own hair, nose, and eyes when asked to do so.
	A, T	Demands desired objects by pointing and making a noise.
	A, T	Explores his surroundings energetically.
2 years	T	Runs safely on whole feet, easily stopping and starting to avoid obstacles.
	A, T	Puts two or more words together to form a simple sentence.
	A, T	Refers to himself by name.
	A, T	When asked, correctly shows his hair, hands, feet, nose, eyes, and mouth, and repeats their correct names.
2.5 years	T	Jumps with two feet together.
	T	Can stand on tip-toe if shown how to do so.
	A, T	Uses the pronouns I, me, and you.

(Continued)

TABLE 34-1 Pediatric Developmental Assessment (*Continued*)

Age	Test Type	Behavior
3 years	T	Stands for a short time on one foot when shown how to do so.
	T	Can have simple conversations and talk about past experiences.
	A	Likes to help with adult activities.
	A	Plays with other children.
4 years	T	Hops on one foot.
	A	Climbs ladders and trees.
	T	Gives a connected account of recent experiences.
	A	Needs other children to play with, and is alternatively co-operative and aggressive.
5 years	T	Runs lightly on his toes.
	T	Can stand on one foot for 8-10 seconds.
	T	Can hop 2-3 meters forward on each foot.
	A	Undresses and dresses alone.

Abbreviations: A = Ask the mother, although this may be unreliable; T = Test by putting the child in a situation where the desired activity is likely to be undertaken.
Data from Milestones suggested by Penelope Hubley[3] and Shann et al.[4]

Which Newborns Need Resuscitation?

As soon as an infant is delivered, evaluate his condition to determine if additional intervention is needed. To do this, I devised the simple mnemonic, "BoTToM," which stands for the status of the normal newborn: **B**reathing spontaneously (Bo), **T**erm infant (T), normal muscle **T**one (T), and no **M**econium staining (oM). If the baby does not meet the BoTToM criteria, have other practitioners (preferably two) take the child to a heated area of the room for further evaluation and, if necessary, resuscitation. If the baby meets all these criteria, dry the child and put him on the mother's chest for "Kangaroo care." (Kangaroo care is explained in detail in the following text.)

Stimulation

In most cases, neonates begin breathing without any stimulation. If not, drying and suctioning them is sufficient stimulation.

Suction

For neonates, sucking the mucous and meconium may require mouth suction. The easiest way to make a mouth-operated suction device is to punch two holes in the top of a sealed container, insert two rubber tubes through these holes, and begin sucking on one of the tubes (Fig. 34-1). The suction pressure is easily controlled by how hard the clinician sucks. Once common, use of these devices has decreased due to the risk of infection posed to health care workers. Yet mouth-operated suction devices have many advantages: They are easy to make, inexpensive, disposable, and portable; can be operated using one hand; and do not require a power source other than the clinician. Some studies found that using these devices is a relatively safe procedure, although others have found that they occasionally can transmit pathogens.[6,7]

In some regions, mothers of older children, in what is a type of a reverse mouth-to-mouth procedure, suck the mucus out of their baby's noses with their mouths.[8] The danger of passing pathogens from baby to mother is probably a moot point.

Neonatal Hypothermia

Hypothermia can be devastating to neonates, especially those who are premature or small-for-dates. In fact, all infants <12 months old are highly susceptible to hypothermia, as are any

TABLE 34-2 When to Send and Admit Children to the Hospital

Born with an imperforate anus	<4 weeks old with meningitis, severe jaundice, or sepsis who are not improving after 2 days of treatment	Neonates with any sign of infection, including fever in infant <28 days old
Moderate to severe dehydration	Fever and not sucking	Babies with bile-stained vomit
Intercostal retractions	Newborns with frequent vomiting and marked salivation in the first few hours of life	<6 months old with whooping cough
Stridor	Suspicious injuries that do not fit the history	Edema
Continued abdominal pain and vomiting	Convulsion with fever (tropical setting with concern for TB, malaria, HIV)	Sudden onset of paralysis
Weight <60% of predicted for age, and flat or falling weight curve	Mid-upper arm circumference <12.5 cm	Snakebite with evidence of envenomations (edema, ecchymosis, hematologic or systemic signs)
Poison ingestion	Child in coma	Distended, tender abdomen
Suspected meningitis who are not improving after 2 days of treatment	Hematuria, with or without edema, who do not improve after 2 days of treatment	Hematochezia
History of unconsciousness after head injury and not back to normal when seen	Fever, tenderness and swelling of a limb or a joint that does not improve after 2 days of treatment	Suspected diabetes mellitus
*Malnourished children not responding to treatment	*Not responding to standard medical/surgical treatment	*Babies with ambiguous genitalia
*Slow development	*Poorly responsive w/umbilical hernia	*Persistent heart murmur

Abbreviations: HIV, human immunodeficiency virus; TB, tuberculosis.

*Important, possibly not emergent, pediatric referrals.

Data from Shann et al.[5]

children with marasmus (previously termed "protein-energy malnutrition"), large areas of damaged skin, or serious infections. Hypothermia is defined as a rectal temperature <35.5°C (95.9°F) or an axillary temperature <35.0°C (95.0°F). All hypothermic children must also be treated for hypoglycemia and for serious systemic infection.

The "warm chain" for infants (as opposed to the "cold chain" for vaccine preservation) is a set of interlocked procedures designed to minimize the likelihood of hypothermia around the time of birth.[9] These include ensuring that the place of delivery is draft-free and is stocked with the appropriate materials to immediately dry and wrap the infant (including a warm cap for the head). In addition, the mother and baby should be covered together, and start early breastfeeding. When keeping the mother and baby covered together is continued over the first days and weeks of life for small or premature infants, it is referred to as "Kangaroo Care."[10]

"Kangaroo Care" for Very-Low-Birth-Weight Infants

Developed for resource-poor areas, Kangaroo care provides an appropriate heat source (mother) that helps maintain neonates' temperatures, improves survival rates, and spurs weight gain.[11]

It allows low-birth-weight (<1500 g) babies, some as small as 700 g, to be safely fed, warmed, and bonded to their mothers. The technique is to breast-feed the infant with skin-to-skin contact.

FIG. 34-1. Mouth-operated suction.

Place the child on the mother's bare chest or abdomen (skin-to-skin) and cover both of them. Alternatively, clothe the child well (including the head), cover with a warmed blanket, and place him in an incubator with an incandescent lamp over, but not touching, the child's body. Even in a public setting, mothers can continue such care under a loose dress. After the infant is discharged home, they should continue to use Kangaroo care.[12,13]

Kangaroo care reduces the risk of reflux and aspiration, reduces apnea and infection, and shortens the hospital stay. It also encourages bonding between mother and baby, improves lactation, decreases the amount of time health care workers must spend with the family, and apparently improves the infant's psychological adjustment.[14,15]

Baby Bags

A simple way to maintain the neonatal warm chain is to swathe the child in a plastic "baby bag" immediately upon birth.

"Baby bags" are made by loosely swaddling the infant in polyethylene doubled over on itself, with one thickness above and two below the infant. This retains the neonate's body temperature and moisture. Dry the head, *but do not cover the baby's head with plastic wrap*! This material, often used as household plastic wrap and industrial packing, is inexpensive (<5¢ US) and lightweight (<20 g for a piece to cover an infant). Optimally, it is used in conjunction with a radiant warmer. Similarly, a thermal blanket laid over an infant helps preserve heat and moisture. Covering the baby's large head with a hat might further maintain heat.[16-18]

Incubators

Commercial incubators often do not work in developing countries, usually because they are not maintained properly. The use of one working incubator for several infants only serves to facilitate cross-infections. Using electric heating pads to warm babies tends to overheat them, may produce burns, and has led to deaths.[17] For ways to improvise incubators, see "Equipment" later in this chapter.

Airway/Ventilation

Oxygenated Mouth-to-Mouth Resuscitation

Without equipment, neonates can be successfully resuscitated using mouth-to-mouth breathing. The best way is to run an oxygen tube into the corner of the child's mouth, with oxygen flowing at 3 to 4 L/min. The clinician uses her cheeks as bellows and "puffs" into the neonate's mouth. Observe chest rise to determine if the ventilation is adequate.[19]

Frog Breathing

This technique of ventilation, known as Frog breathing, is suitable only for temporary use in babies under about 5 kg.[20] However, this is true ventilation, not apneic oxygenation.

1. Insert an 8- or 10-Fr nasogastric tube through one nostril into the stomach. Drain it to gravity to prevent the stomach from overinflating.
2. Give nasopharyngeal oxygen at 2 L/min. Insert the oxygen cannula to a depth equal to the distance between the side of the baby's nose and the tragus (front of the ear). Do not insert it farther than this, or it may go into the esophagus.
3. With one hand, slightly lift the baby's chin, extend the neck, and pinch the mouth shut. With the other hand, pinch the baby's nose for about 2 seconds so that oxygen fills the lungs. Then release the nose for about 2 seconds and allow the elastic recoil of the lungs to empty them; you must allow adequate time for the exhalation phase. Watch the chest expand and deflate.
4. Give 12 to 15 breaths per minute. Ensure that the stomach does not inflate. If ventilation is inadequate, intubate the infant. (See Chapter 8, Airway.)

Using a Bird Ventilator for Children

In situations with limited resources, ventilators should be used only for those patients who have a good prospect of benefitting, generally quickly, from mechanical ventilation, such as patients with acute poisoning and for some neonates. The Bird "green box" pressure-cycled ventilator (Figs. 34-2 and 34-3), while relegated to museums in developed countries, is commonly used in remote areas. It is easy to disassemble and clean, requires relatively few parts, and has been a reliable piece of medical equipment for more than 50 years. It can also be used for intermittent positive-pressure ventilation (IPPV). To ventilate a child <12 months old, use an infant breathing circuit, which is usually supplied with the ventilator.[21]

Pressure-cycled means that the patient's inspiratory effort triggers the respirator, and gas flows at the rate determined by the gas flow-rate control. Gas continues to flow into the patient's lungs until the pressure in the system rises to the level set on the expiratory pressure control, then the

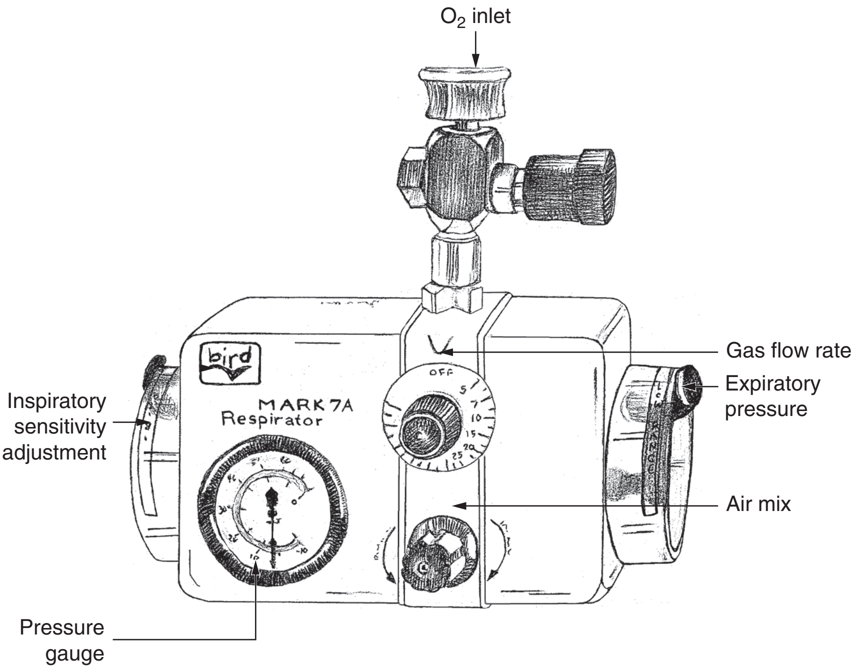

FIG. 34-2. Bird pressure-cycled ventilator.

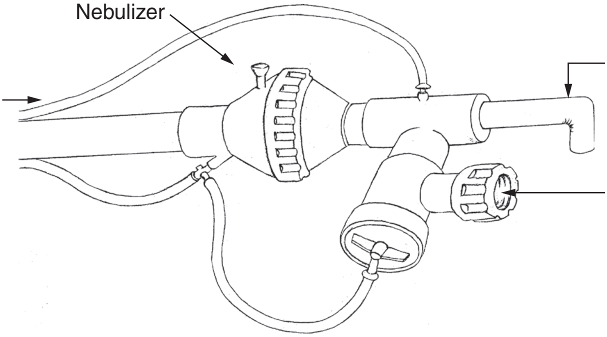

FIG. 34-3. Breathing circuit on Bird ventilator.

flow stops until the patient triggers the respirator again. If the patient is too small or too weak to make even the minimal effort required to trigger the flow of gas, the gas flow can be started automatically by turning on the expiratory time control. The air-mix control adjusts the concentration of expired oxygen to 40% (knob out) or 100% (knob in).

Set the controls on the Bird ventilator as described in Table 34-3.

TABLE 34-3 Using the Bird Pressure-Cycled Ventilator

1. Before connecting the patient, adjust the controls (see Fig. 34-2) so that: — Expiratory pressure control sets the depth of inspiration. Start at a setting of 15. — Air-mix: PULL OUT AND LOCK. This gives 40% oxygen. — Expiratory time for apnea: OFF. (This control is not present on all models.) — Inspiratory sensitivity effort control determines the inspiratory effort from the patient that is required to begin gas flow. Start at a setting of 10. — Gas flow-rate control: OFF. This sets the length of inspiration. — Negative-pressure generator: OFF. (This control is not present on all models.)
2. Check that the breathing circuit is connected correctly, with no leaks (Fig. 34-3).
3. Remove the nebulizer cap and instill 2 mL sterile water. Check that fine mist appears in the nebulizer with each inspiration. Add water every hour.
4. Connect the ventilator to an oxygen supply, if available. It uses about 1.7 L/min O_2 with the air-mix control out (40% oxygen) and the flow-rate control on 10 L/min.
5. Turn the gas flow-rate control to 15, then immediately connect the breathing circuit to the patient's endotracheal tube.
6. If the patient breathes in but gas does not flow, adjust the inspiratory sensitivity effort control lower, e.g., 5-10.
7. Alter the expiratory pressure control by observing chest excursion. Adjust it until it is on the lowest setting that gives full excursion, e.g., 10-15.
8. Adjust the gas flow-rate control to alter the length of inspiration. A lower setting (e.g., 5-10) gives a longer inspiration than a higher setting (e.g., 10-15). If the patient is too weak to breathe at all, turn on the expiratory time control to set the desired time of expiration. In an older child or adult (without lung disease), inspiratory and expiratory times should be at a ratio of about 1:2 and the respiratory rate should be about 12 breaths/min. (Patients with lung disease may need an expiratory time that is much longer than the inspiratory time.) In the absence of blood gas analysis and noninvasive pCO_2 monitors, adjust the ventilation using clinical observations, such as skin color, pulse rate, and blood pressure, as well as the timing, character, and magnitude of chest movements.

Data from Shann et al.[22]

Fluids

Storing Breast Milk

Breastfeeding is the norm in resource-poor areas. Yet pumping the breast and storing breast milk introduce the problems of contamination and bacterial growth. Table 34-4 describes various storage methods and their potential safe periods.

Newborn Fluid Requirements

Fluid requirements relate to a neonate's weight. Table 34-5 gives the normal daily fluid requirement, in mL/kg/d, for each birth weight.

EQUIPMENT

Nasogastric Tube

Neonatal-sized nasogastric (NG) or feeding tubes can be made from the insulation on an electrical cord (2- to 2.5-mm external diameter). To remove the insulation, make a cut in the insulation at the length needed and slip it off the wire core. Smooth out the patient's end by passing it over a flame. Clean it before use.[25]

Neonatal Incubator

A neonatal incubator is one of the easiest pieces of medical equipment to improvise. A number of methods are described below. Use your imagination to construct your own incubator from existing supplies.

One disaster team wrote, "The nurses made cribs out of cardboard boxes lined with cotton and covered with plastic-lined incontinent pads… . Each infant was placed in the makeshift bassinet with two warmed intravenous fluid bags placed on either side of the baby's body."[26]

A wash boiler, broiler, or large metal pan, such as a turkey roaster, can be used as an incubator. Place a layer of hot bricks in the bottom and cover them with wire mesh. Place a pillow and blanket over this, leaving about 4 inches on all sides for warm air to circulate. Make small ventilation holes by cutting openings in the cover and at each end. When moist air is needed, a vat

TABLE 34-4 Human Milk Storage for Healthy Infants

Location	Temperature	Duration	Comments
Countertop, table	Room temperature <77°F (<25°C)	6-8 hours	Cover containers and keep as cool as possible; covering container with a damp towel may keep milk cooler.
Insulated cooler bag	5°F to 39°F (−15°C to 4°C)	24 hours	Keep ice packs in contact with milk containers at all times; limit opening cooler bag.
Refrigerator	39°F (4°C)	5 days	Store milk in the back of main part of refrigerator.
Freezer compartment of refrigerator	5°F (−15°C)	2 weeks	Store milk toward the back of freezer, where temperature is most constant.
Freezer section of refrigerator/freezer with separate doors	0°F (−18°C)	3-6 months	Milk stored for 3-12 months is safe, but some lipids degrade, resulting in lower quality.
Chest or upright manual-defrost freezer	−4°F (−20°C)	6-12 months	

Data from Eglash et al.[23]

TABLE 34-5 Newborn Fluid Requirements (mL/kg/d)

Birth Weight	Day 1	Day 2	Day 3	Day 4	Day 5	Days 6-7
Preterm <1000 g	80-90	90-110	110-130	120-150	130-160	160-180
Preterm >1500 g	60-80	75-100	90-120	110-150	130-160	135-160
Term neonate	60-120	80-120	100-130	120-150	140-160	160-180

Data from Anon.[24]

of hot water may be used in place of the bricks. Be sure to keep the air holes open, or leave the top partially open.[27]

Line a clothes basket with flannel or soft padding that has sewn-in pockets to hold 10- or 12-oz bottles. Fill the bottles with hot water and put them in the pockets. Keep the temperature even by refilling every other bottle at regular intervals.[27]

Another method is to use a laundry basket and make a support for two or three electric lightbulbs to fit over the top (Fig. 34-4). Cover with a blanket or comforter. Shield the baby's eyes from the light.[27]

Crib/Playpen

Make a basic crib or playpen by inverting a table and draping mosquito netting over it (Fig. 34-5). Be sure that the table's underside is smooth; if not, cover it with a blanket or piece of canvas. Tack it down well. Note that this also protects the child from mosquitoes, which is highly desirable, and even lifesaving, in many regions.[29]

Phototherapy Box

Light therapy is often needed for neonatal jaundice, which arises due to a transient deficiency in bilirubin conjugation combined with an increased turnover of red cells, or in exclusively breastfed infants when the breastfeeding results in poor caloric intake. The goal of light therapy is to lower the concentration of circulating bilirubin or to keep it from increasing by converting it to molecules that can be excreted even when normal conjugation is deficient.[30]

A simple phototherapy device for neonatal jaundice can be constructed from a wooden box and six 40-watt daylight fluorescent tubes (Fig. 34-6). Cut the box to a depth about double the diameter of the light tubes. Mount the tubes parallel to each other on the inside of the box lid, and line the inside lid with a white reflecting surface to direct the light downward. Then, mount the box on supports so that it sits about 18 inches above the baby. A box 140 cm × 75 cm × 20 cm (55 inches × 30 inches × 8 inches) can be used over three cots or two incubators; the size and materials can be varied to meet local needs. Be certain that the baby's eyes are covered during phototherapy.[31]

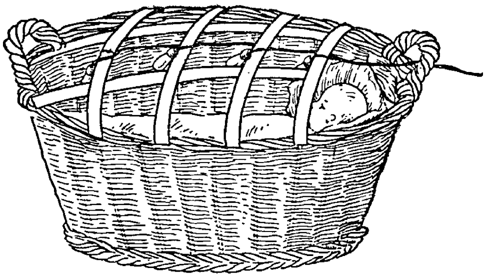

FIG. 34-4. Infant incubator from a laundry basket, with electric lights to provide heat. (*Reproduced from Olson.*[28])

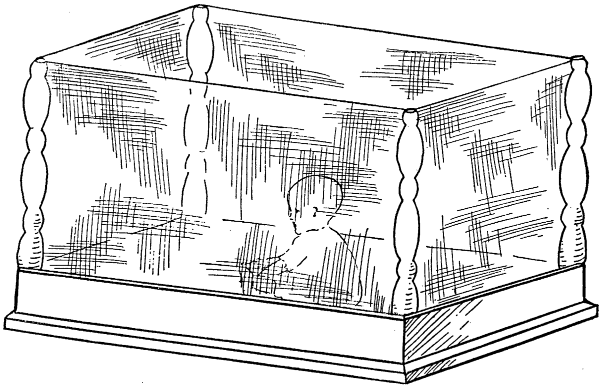

FIG. 34-5. Improvised mosquito-proof playpen. (*Reproduced from Olson.*[29])

Infant Bathtub

A baby's bathtub can be made by attaching a piece of canvas, tarp material, or plastic sheeting to the outside edge of a wooden box about the baby's size (Fig. 34-7). Leave some slack in the center. Fill with water before placing the baby in the bathtub.[32]

PROCEDURES

Urine Collection

For an improvised infant urine collection bag, see Chapter 5, Basic Equipment.

Measuring Volume

In neonatal units with limited nursing staff, being able to provide constant urine output measurements for noncatheterized infants can be valuable. To do this, first make an acrylic (Perspex) V-shaped tray that fits into an incubator. The tray should have a downward slope, so that the point of the V is in the center. Cover this with a fine (100 threads/inch) mesh (georgette) that is stretched over the tray's frame and attached with Velcro strips—two 2-cm strips on either side and three strips at either end (Fig. 34-8).

The mesh covering should keep neonates who are placed on this tray suspended above the bottom. Only urine and the most-liquid stools will pass through the mesh into the tray, collect in the tray's most dependent area, and drain out of the incubator through one of the low hood ports into a collecting/measuring bag.[33]

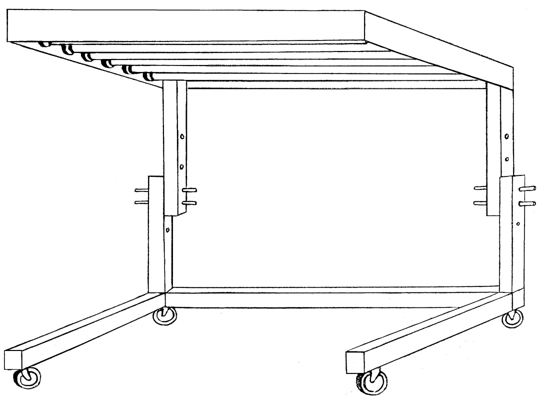

FIG. 34-6. Phototherapy device.

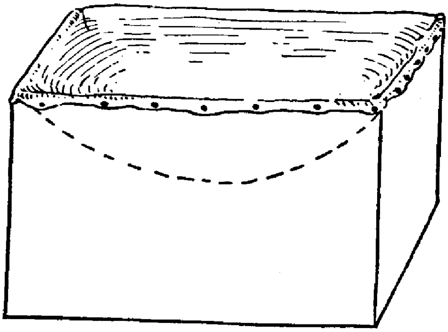

FIG. 34-7. Improvised bathtub for infant. (*Reproduced from Olson.*[32])

Restraint Devices/Methods

Sedation is not always available, safe, or appropriate. Therefore, infants and children may need to be restrained. Figure 14-4 shows one method to restrain a child. Note that under light ether anesthesia or ketamine, children may need to be restrained simply for safety.

Proctoscopy

Complaints of fecal blood are relatively common in infants and are usually due to anal fissures. However, investigating them, and the less frequent complaint of frankly bloody stools, may be difficult due to a lack of adequate equipment. To get a better view of an infant's rectosigmoid than can be obtained with an ear speculum (the commonly used method), fashion an infant proctoscope.

To make an infant proctoscope, take an appropriate length of rubber or plastic tubing (1 to 2 inches, depending on the child's size) and slip it over the end of a nasal speculum attachment or directly onto the end of an otoscope (without an ear speculum attached). A large-size NG, rectal, or similar tubing can be used. Immerse the tubing's end in hot water and stretch it onto the speculum using a hemostat. Smooth the cut edge with an open flame. With the child in a knee-chest position, lubricate the tube and carefully insert it under visualization.[34] As with sigmoidoscopy, always aim for the lumen when it is advanced. If you don't see a lumen, don't advance it further (Fig. 34-9).

Inguinal Hernias

Inguinal hernias are common in infants and children. Reducing them is generally the first maneuver; surgery may not even be an option in austere circumstances. While it helps to provide some type of mild analgesic, a warm bath may work as well. An old maneuver, similar to the

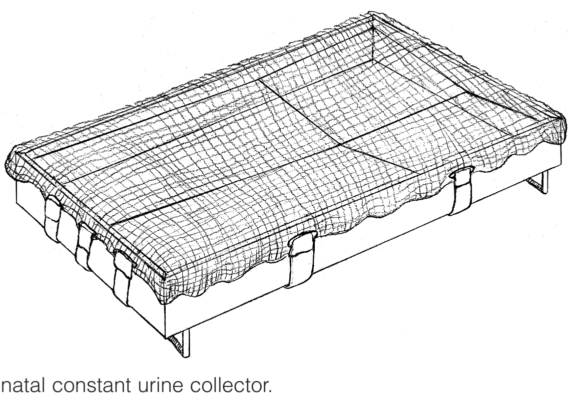

FIG. 34-8. Neonatal constant urine collector.

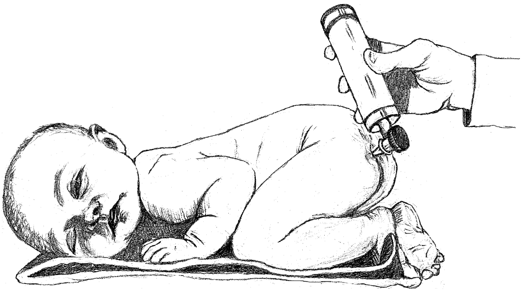

FIG. 34-9. Pediatric proctoscope.

acute Trendelenburg position, in which adults are often placed for reduction, is to "lift the patient straight up by the legs, letting the body hang down; then pull the scrotum up and shake the contents back into the abdominal cavity."[35]

Subdural Effusions

Subdural effusions are particularly likely in meningitis due to *Haemophilus influenzae* and in children <2 years old, occurring in up to 20% of children <1 year old. In neonates with meningitis, measure the head circumference twice a week. Suspect an effusion if most of the following symptoms are present[36]: (a) fever persists for >3 days, (b) vomiting persists or recurs, (c) difficulty with feeding occurs, (d) head circumference increases, (e) papilledema appears, (f) focal neurological signs appear, (g) cerebrospinal fluid (CSF) protein rises, and (h) there is persistent or increased bulging of the fontanel (Fig. 34-10). Also consider a subdural bleed in critical neonates doing poorly after neonatal trauma (or suspected trauma) with a bulging fontanelle.

In resource-poor situations, ultrasound or transillumination may be the only available confirmatory tests. Transillumination is best done in a dark room using a standard 2-cell flashlight held tightly to the anterior fontanelle or, even better, a powerful narrow-beam flashlight with a rubber adapter over the light end to form a tight seal over the skull. If it produces >2 cm transillumination around the edge of the beam or there is asymmetry of the transillumination, it suggests

FIG. 34-10. A sunken (top left), normal (center), and bulging (top right) fontanel.

underlying pathology. With unilateral intracranial fluid or swelling, the two sides appear different. However, this may not be true with bilateral pathology. Since findings may vary with the child's prematurity and age, the light source used, and the operator's technique, perform the procedure on a normal infant if there is any question about the results.[37]

Subdural Tap

If imaging or transillumination suggest a subdural effusion or if the clinical situation is dire and there is no time or ability to do any testing, perform the remarkably simple subdural tap. This is one of those times when, to save a life, you may need to "suck it up" and proceed.

SUBDURAL PUNCTURE TECHNIQUE[36]

1. Shave the anterior half of the scalp and swab it with iodine.
2. Scrub as for surgery and put on sterile gloves, cap, and mask.
3. Drape the child's head but allow adequate space for breathing.
4. Have someone else hold the child's head firmly.
5. With a 19-gauge or 20-gauge short-bevel needle, puncture the scalp obliquely at the extreme lateral corner of the anterior fontanel, at least 3 cm from the midline. Advance the needle until the resistance gives at a depth of 0.5 to 1 cm. *DO NOT GO DEEPER THAN THIS*. Allow up to 15 mL of fluid to drain. *DO NOT ASPIRATE FLUID*. If necessary, rotate the needle, but do not move it from side to side (Fig. 34-11).
6. Unless there is definite proof (CT scan or an excellent ultrasound interpretation) that there is no fluid collection on the other side, repeat the puncture there.
7. Until there is no further drainage, repeat the procedure over the next several different days. Up to 15 mL per side may safely be removed each day.

CHILDREN

Pediatric Vital Signs

You must know the normal vital signs for a child's age to appreciate and to treat deviations. Table 34-6 has the normal vital signs (and the amount of initial fluid bolus) for children from preterm (3 kg) to 14 years old.

Pneumonia

You do not need a radiograph to tell that a child does not have pneumonia. Large studies have shown that a diagnosis of pneumonia can reliably be ruled out if the child has no tachypnea, no increased work of breathing, and clear lungs on auscultation. This avoids doing a chest radiograph and using antibiotics.[39]

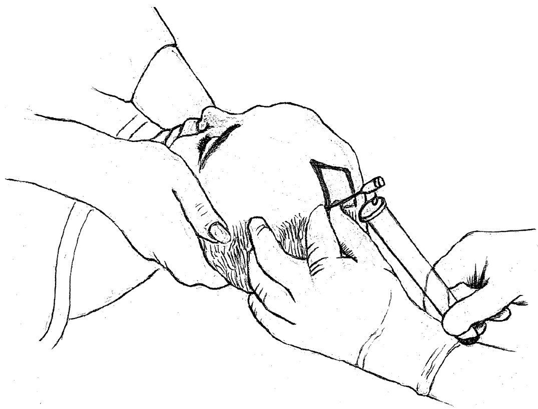

FIG. 34-11. Subdural tap for subdural effusion (or hematoma).

TABLE 34-6 Normal Pediatric Vital Signs at Various Ages

	Preterm	Term	6 months	1 year	3 years	6 years
Weight (lb)	3	7.5	15	22	33	44
Weight (kg)	1.5	3.5	7	10	15	20
Heart beats/min	140	125	120	120	110	100
Respirations/min	40-60	40-60	24-26	22-30	20-26	20-24
Systolic BP (mm Hg)	50-60	70	90 ± 30	95 ± 30	100 ± 25	100 ± 15
Fluid challenge (mL)	30	70	140	200	300	400

	8 years	10 years	11 years	12 years	14 years
Weight (lb)	55	66	77	88	99
Weight (kg)	25	30	35	40	45
Heart beats/min	90	90	85	85	80
Respirations/min	18-22	18-22	16-22	16-22	14-20
Systolic BP (mm Hg)	105 ± 15	110 ± 20	110 ± 20	115 ± 20	115 ± 20
Fluid challenge (mL)	500	500	500	500	500

Abbreviation: BP, blood pressure.
From Canadian Air Division.[38]

For clarity, an increased work of breathing is the presence of flaring at the nostrils, retraction, or grunting.

Tachypnea (with the respiratory rate counted for 60 seconds) is:

0 to 2 months old: >60 breaths/min
2 to 12 months old: >50 breaths/min
>12 months old: >40 breaths/min

Interpret abnormal auscultation with caution, since it has only fair inter-rater reliability, except for patients with wheezing.

Diagnosis of Urinary Tract Infection Without Lab

In verbal children >24 months old, use a simple algorithm and basic urine dipsticks to make a presumptive diagnosis of urinary tract infection (UTI) (Table 34-7). While a urinalysis and culture are optimal, treatment can begin before these laboratory tests are performed (or without them, if they are unavailable).

Hypoglycemia With Decreased Level of Consciousness

Hypoglycemia is common in critically ill children. Treat it by wetting your finger, dipping it into granulated sugar (so that sugar sticks on the finger), and rubbing the sugar-coated finger on the inside (buccal portion) of the child's cheek or inside the lip. Repeat as often as necessary. Do not put your fingers between the teeth, since the patient may bite down as they awaken.

Oral rehydration solution (ORS) or sugar water can be given, generally with an NG tube, to provide sugar. See Chapter 11, Dehydration/Rehydration, for more information about these solutions.

Disabilities

Childhood disabilities present in situations of scarce resources as frequently as in other circumstances. All children, however, cannot be sent to specialists for evaluation. The following questions form a simple screening method to determine whether a child has developmental disabilities. A positive answer to any one question suggests the need for further screening by specialists.

TABLE 34-7 Determining the Probability of UTI Using Symptoms and Dipstick

Verbal females and uncircumcised male* children with urinary or abdominal symptoms		
	⇩	
	Dysuria or Frequency?	
⇩	⇩	
YES	**NO**	
Obtain urinalysis and culture, if available	Abdominal pain, back pain, or new-onset incontinence?	
⇩	⇩	⇩
⇩	**YES**	**NO**
⇩	Obtain urinalysis and culture, if available	UTI unlikely; consider other conditions
⇩	⇩	⇩
Urine dipstick nitrite *AND* Leukocyte esterase	Urine dipstick nitrite *OR* Leukocyte esterase	Urine dipstick nitrite *AND* Leukocyte esterase
NEGATIVE	**POSITIVE**	**POSITIVE**
Prob of UTI = 4%-8%	Prob of UTI = 60%-80%	Prob of UTI = 80%-92%

*Circumcised males: consider a urinalysis and culture if multiple signs and symptoms of UTI or if the child has had prior UTIs.
Data from Shaikh et al.[40]

General Questions for All Children[41]

1. Compared with other children, was there a major delay in your child's sitting, standing, or walking?
2. Compared with other children, does your child have difficulty seeing at any time—day or night?
3. Does your child have problems hearing?
4. Does your child understand you when you tell him/her to do something?
5. Does your child have any stiffness or weakness in his/her arms or legs or difficulty walking?
6. Does your child ever have fits, become rigid, or lose consciousness?
7. Can your child learn to do things as well as other children his/her age?
8. Does your child speak any recognizable words and is he/she understood?
9. Does your child appear dull or slow compared with children of his/her age?
10. For 3- to 9-year-olds, also ask: Is your child's speech clear enough to be understood by people outside your immediate family?

Or

For 2-year-olds, also ask: Can your child name at least one object (such as an animal, a toy, a cup, a spoon)?

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All medical practitioners should be able to recognize stress-induced psychiatric illness and be prepared to do basic interventions. Psychiatric help is often not immediately available in austere situations.

BASIC APPROACH

In austere medical situations, mental health professionals and psychiatric facilities will usually be inadequate or nonexistent. Psychiatric medications may be scarce or of limited variety. The first step for the nonpsychiatrist when working with patients with psychiatric disorders is to review Table 35-1. It describes the general approaches for common psychiatric presentations.

The most critical patients are those with new presentations of psychiatric disorders, including delirium. These symptoms represent serious disease states, often from a systemic disease or drug effect, that often respond to rapid treatment.

TABLE 35-1 Common Psychiatric Presentations and Clinical Responses

Patient Presentation	Clinical Response
Patient <40 years old with new-onset psychiatric symptoms and normal vital signs. (If ≥40 years old, do as complete a medical evaluation as possible.)	Brief medical workup and, if available, admit to psychiatric facility. Begin atypical antipsychotics, if available. The presentation of new-onset psychiatric symptoms usually warrants inpatient care or the use of antipsychotics.
Any patient with an altered mental status whose condition appears to vary over time without an obvious cause.	Look for causes of delirium, including alcohol or drug withdrawal. Sedate or medicate the patient only if absolutely necessary and with the smallest dose possible.
Cooperative patient with known psychotic illness but taking no medication.	Try to find "last known good" regimen and restart, if possible. Otherwise, prescribe effective agent based on side-effect profile matched to patient factors.
Uncooperative manic bipolar patient with known organic disease.	Ensure everyone's safety; use restraints, if necessary. If available, use disintegrating tabs of antipsychotics. Oral medications may work; use parenteral agents when necessary.
Agitated and dangerous patient with unknown pathology in need of sedation.	Use antipsychotics, benzodiazepines, or both. Choose agents based on degree of sedation desired. Use enough medication.
Elderly patient with psychosis or dementia and possibly ill.	Evaluate for delirium. Use low-dose antipsychotics. Atypicals are presumed safe for limited exposure. Avoid benzodiazepines.
Elderly patient with known psychiatric illness and psychotic symptoms.	Evaluate for delirium or causes of psychosis. Antipsychotics are useful. Avoid benzodiazepines.
Agitated patient on alcohol.	If available, use lorazepam or clonidine. If not, antipsychotics are safe for sedation; benzodiazepines are drug of choice for withdrawal.
Agitated patient on other psychoactive agents.	Antipsychotics are drugs of choice. Use benzodiazepines if more sedation is needed.

Data from Angelino and Cordover.[1]

MENTAL HEALTH TRIAGE

In any setting, use Table 35-2 to screen patients for mental health problems. It can be helpful with both mentally healthy people who are responding to abnormal situations and individuals with preexisting mental health problems who are in abnormal situations. Note that if the patient has more than a "moderate symptom" rating for any of the first six items or exhibits *any* symptom in items 7 to 18, the presence of a mental disorder (psychiatric or organic) must be investigated.

Disasters represent a special case for psychiatric evaluation and treatment since, no matter their scope, they may generate psychiatric problems for both rescuers and victims. Table 35-3, which is specifically designed for use in disaster settings, helps identify key behavioral symptoms that often signal problems. The columns in Table 35-3 focus on three observable elements of personality, the ABCs (**A**, Arousal; **B**, Behavior; and **C**, Cognition). Arousal refers to one's general level of alertness, which may be abnormal by being overly activated (such as in mania) or underactive (retarded, as in severe depression). Behavior refers to how we act, and Cognition refers to thought and understanding (i.e., orientation, judgment, memory, attention, concentration, and insight).

Using Table 35-3, identify the phrases describing the patient's general behavioral patterns. If *any* of these behaviors falls into the "Caution" or "Danger" zones, follow the recommended speed of intervention (Immediate or Likely Appropriate) for further psychiatric evaluation and treatment. If the person falling into the caution or danger zones is part of the disaster team, he should immediately be relieved of his duties.

DIAGNOSIS

Stress Disorders

Recognizing Crisis-Induced Psychiatric Illness

People in stressful situations fall into one of three categories: adequately functioning, anxious and agitated, or shocked and subdued.[5]

ADEQUATELY FUNCTIONING

This category includes the vast majority of people. However, be aware that some people in this group will suppress their feelings until things, or they, return to a more normal setting or environment. Thus, they may need counseling at a later time. If there is any question that they may be "on the edge," if possible, move them for a time to a separate rest area so they will not feel the need to assist others. If you are not able to move them, assign them less-stressful tasks.

ANXIOUS AND AGITATED

Obviously distressed, these individuals demonstrate it by loud or unmistakable crying and screaming, fainting, rapid pacing, and other signs of panic and histrionic behavior. Some may convert their distress into physical symptoms, such as nausea, dizziness, or confusion. These individuals should be isolated from any work environment and buddied with someone who can "talk them down" and monitor their behavior. They should be restrained or sedated only if absolutely necessary, since this may only increase the amount of work necessary to care for them.

SHOCKED AND SUBDUED

Often attracting the least attention, these individuals may wander aimlessly or sit and stare. Physical signs may include confusion and disorientation, and even signs consistent with shock. After a medical evaluation to determine whether they are seriously injured, treat them the same as the "anxious and agitated" group.

Crisis Intervention

The principles of crisis intervention are[6]:

- *Simplicity*: Use simple, rather than complex, approaches to the patient.
- *Brevity*: Do brief interventions over a short time period.
- *Innovation*: Use whatever methods work.
- *Pragmatism*: Advise patients to do only what is possible in their current situation.
- *Proximity*: Conduct the intervention in a safe area close to where the person works/lives.
- *Immediacy*: A key to recovery is providing help soon after the event.
- *Expectancy*: Promote patient expectations that they will recover. Patients who believe this have a much better chance to recover fully.

TABLE 35-2 Screen for Mental Health Dysfunction

Symptom	Not Present	Mild	Moderate	Serious	Severe
1. *Somatic concern*—preoccupation with physical health, fear of physical illness, hypochondriasis					
2. *Anxiety*—worry, fear, overconcern for present or future					
3. *Emotional withdrawal*—lack of spontaneous interaction, isolation, does not relate to others					
4. *Conceptual disorganization*—thought processes confused, disconnected, disorganized, or disrupted					
5. *Guilt feelings*—self-blame, remorse for past behavior					
6. *Tension*—physical and motor manifestations of nervousness, overactivity, tension					
7. *Mannerisms/posturing*—peculiar, bizarre, unnatural motor behavior (not including tics)					
8. *Grandiosity*—exaggerated self-opinion, arrogance, conviction of unusual power or abilities					
9. *Depressed mood*—sorrow, sadness, despondency, pessimism					
10. *Hostility*—animosity, contempt, belligerence, disdain for others					
11. *Suspiciousness*—mistrust, paranoia, belief that others harbor malicious or discriminatory intent					
12. *Hallucinations*—perceptions without normal external stimuli					
13. *Motor retardation*—slowed or weakened movements or speech, reduced body tone					
14. *Uncooperativeness*—resistance, guardedness, rejection of authority					
15. *Unusual thought content*—odd, strange, bizarre thoughts					
16. *Blunted affect*—reduced emotional tone, reduced emotional intensity, flatness					
17. *Excitement*—heightened emotional tone, agitation, increased reactivity					
18. *Disorientation*—confusion or lacking knowledge of person, place or time					

Data from Overall and Gorham.[2]

TABLE 35-3 Disaster Mental Health: Triage Observations

	Observations		
Triage Priority Categories	Arousal	Behavior	Cognition
0. DOING WELL Currently NO specific behavioral needs.	Not particularly increased or decreased	No specific functional or safety issues Coping well	Cognitive functions intact
1. OKAY FOR NOW Behavior indicates mild impairment of ability to function in this setting. At present, NO significant indication of direct harm to self/others due to psychological state.	*Increased:* Upset but can be comforted Some anxiety/ agitation Some increased vigilance *Decreased:* Mildly withdrawn	Disturbed sleep but some rest Crying at times Irritable, then apologetic Clings to family/ helpers Needy, but can be alone	Aware of circumstances Needs extra effort to maintain attention/ concentration Some decreased memory Aware of needs/ responsibilities and able to perform with effort and resolve Judgment generally intact
2. CAUTION INTERVENTION LIKELY APPROPRIATE. Behavior indicates moderate to very substantial impairment of ability to function in this setting. At present, NO significant indication of direct harm to self/others due to psychological state.	*Increased:* Significant agitation/ anxiety Occasional panic Able to be calmed or comforted for brief time Hyper-vigilance *Decreased:* Withdrawn Reduced responsiveness Detached	Disturbed sleep with little rest Fleeting self-harm ideation possible Crying often Irritable, but able to control self Isolates self from family/ helpers Very needy	Generally aware of circumstances Some decreased attention/concentration possible Some decreased memory Aware of needs and responsibilities but impaired ability and impetus to organize efforts (disturbed goal-directed behavior) Judgment mostly intact
3. DANGER! INTERVENTION REQUIRED IMMEDIATELY. Behavior indicates serious impairment of ability to function in this setting *OR* significant potential for harming self or others based on present psychological state.	*Increased:* Extreme agitation/ anxiety Constant panic Cannot be calmed or comforted Active mania *Decreased:* Severe withdrawal Catatonia	No sleep or rest Specific self-harm plan or action Pacing incessantly Bizarre behaviors Brought in by Security Fighting, yelling Intrusive, “out of control” Mute Constant crying	Not able to appreciate reality of circumstance Generally confused/ disoriented Denies obvious needs Markedly deficient memory or attention Markedly disturbed judgment Hopeless/helpless

Data from Hipshman[3] and Hipshman.[4]

Table 35-4 provides crisis intervention techniques that any health care professional should be able to use. Begin with the "Initial Steps" and proceed to the "Subsequent Steps" as the situation stabilizes.

Panic Disorder

Panic "attacks" are common and can be disabling. Panic attacks occur in 1% to 3% of the population, and in up to 8% of primary care patients. Twice as common among women as among men, the incidence of panic attacks peaks in late adolescence and again in the mid-30s.[7]

Diagnosis

Patients often present with typical symptoms that appear suddenly without an obvious cause. This can be disabling—and can diminish limited personnel resources if it occurs in a health care worker. The patient often gives a history of having been diagnosed with or having had recurrent symptoms consistent with a panic disorder, simplifying the diagnosis and treatment course. Table 35-5 lists the criteria to make a diagnosis of panic disorder.

Treatment

Medications and cognitive behavior therapy (CBT) have equal success in treating panic disorder, although trained personnel will probably not be available to do CBT. Benzodiazepines (e.g., diazepam 5-30 mg/d), tricyclic antidepressants (e.g., imipramine 100-300 mg/d), and SSRIs (e.g., sertraline 25-100 mg/d) can be used to treat panic disorder. While benzodiazepines and tricyclics are now rarely used by many psychiatrists for this disorder, their low cost and ready availability may make them the first-line medication in austere situations.[7,8]

Seasonal Affective Disorder Depression

Seasonal affective disorder (SAD), a type of severe "wintertime blues," diminishes many people's ability to function in the autumn and winter. It becomes more prevalent the farther people live from the equator, as there are fewer hours of daylight.

TABLE 35-4 Modern Crisis Intervention Techniques

Initial Steps	Subsequent Steps
1. Establish rapport. Introduce self and develop relationship.	1. Actively listen.
2. Rapid assessment. Determine the level of distress and identify problems.	2. Encourage emotional ventilation.
3. Stabilize situation. Take control of the situation; protect person and others.	3. Reflect feelings.
4. Contain situation. Remove antagonists; set boundaries; avoid spread to others.	4. Get the person to tell his or her story.
5. Lower stimuli. Cut visual, auditory, and olfactory stimuli.	5. Reframe the experience.
6. Reduce symptoms. Calm the person and provide reassurance that help is there.	6. Explore alternative solutions.
7. Lessen impact of event. Be active, calm, and in control; inform victim.	7. Assist person to return to adaptive function.
	8. Assist in resolving crisis.
	9. Help the person develop a sense of cognitive mastery over the event.
	10. Achieve recovery or refer the person to the next level of care.

Data from Mitchell and Thoumaian.[5]

TABLE 35-5 Criteria for Diagnosing Panic Disorder

A panic attack is defined as a discrete period of intense fear or discomfort with ≥4 of the following symptoms that develop abruptly and peak in intensity within 10 minutes:
Palpitations, pounding heart, or accelerated heart rate
Sweating
Trembling or shaking
Sensations of shortness of breath or smothering
Feelings of choking
Chest pain or discomfort
Nausea or abdominal distress
Feeling dizzy, unsteady, light-headed, or faint
Derealization or depersonalization
Fear of losing control or going crazy
Fear of dying
Paresthesias
Chills or hot flashes
To diagnose panic disorder, the patient must have both:
• Recurrent unexpected panic attacks (as described above) that are not caused by (a) drugs or medications, (b) a medical condition (e.g., hyperthyroidism), or (c) another psychiatric condition (e.g., phobias).
• At least 1 attack followed by ≥1 month of at least one of the following:
Persistent concern about having additional attacks
Worry about the implications of the attack or its consequences
A significant change in behavior related to the attack

Data from Katon,[7] Gorman,[8] and American Psychiatric Association.[9]

Patients generally have the symptoms listed in Table 35-6. However, unlike those with typical depression, these patients are less likely to have feelings of worthlessness or suicidal thoughts.

Treatment can be through self-help therapy (Table 35-7) or the use of light therapy, with or without fluoxetine (Prozac) 20 mg/d. Patient self-help and light therapy can both be used in austere situations when mental health professionals are a scarce resource.

Light Therapy (Phototherapy)

Exposure to bright artificial light improves symptoms in about 50% to 80% of people with SAD. Light therapy and fluoxetine (Prozac) seem to have equivalent effectiveness alone, and they may be synergistic if used together.[10] Devices for delivering bright light include: (a) light-emitting caps or visors that are worn on the head like a baseball hat; (b) dawn simulators, such as bedside lights connected to an alarm clock, which mimic a sunrise and gradually awaken the user; and

TABLE 35-6 Symptoms of Seasonal Affective Disorder

• Depressed mood most of the day	• Irritability	• Eat more than usual
• Excessive sleepiness	• Lethargy	• Weight gain
• Difficulty concentrating	• Anxiety	• Decreased libido
• Crave carbohydrates		

TABLE 35-7 Patient Self-Help Behavior for SAD

• Go outside every day	• Sit near windows while inside
• Learn relaxation techniques	• Do regular, moderate exercise
• Eat a well-balanced diet	• Use light colors to decorate the house
• Avoid stress whenever possible	
• Leave any major projects until summer and plan ahead for winter	

(c) specially made light boxes that provide ≥10,000 lux (measure of light intensity at least 10 times stronger than that emitted by normal lightbulbs) and emit white, not blue, light.

An effective dose, if administered as soon as possible after awakening, is 5000 lux/d, either as 2500 lux for 2 hours or as 10,000 lux for 30 minutes. Most people notice an improvement in symptoms within 3 to 4 days, although therapy needs to be continued until spring.

Sedative-Hypnotic Interview

Patients may present with complaints of sudden, non-traumatic paresis or paralysis of the extremities and in catatonia-like states. Usually, such patients consume an inordinate amount of resources. The use of sedative-hypnotic interviews (also called "amobarbital interviews") can quickly alleviate acute symptoms, confirm or rule out a psychiatric basis for the symptoms, and assist with treatment and disposition. In other words, these interviews can be both diagnostic and therapeutic.[11,12]

An easy procedure that takes about 20 minutes, the sedative-hypnotic interview quickly resolves conversion-reaction symptoms, preventing them from becoming permanent. Sedative-hypnotic interviews have also been used (a) to treat acute panic states following traumatic events such as rape, catastrophic loss, or disaster; (b) to diagnose and treat benign stupor (mute and unresponsive patients) or acute hysterical amnesia; (c) to diagnose malingering; (d) to reveal suicidal ideations; (e) to gain information in criminal cases (of dubious merit or legal worth); and (f) to differentiate between organic illness or psychosis and functional psychosis.

This interview technique is not used for the commonly seen patient with psychogenic unresponsiveness who is usually hysterical and whose symptoms last only several minutes. Such patients can quickly be identified, since they actively resist anyone trying to open their eyelids and, when opened, the eyelids close rapidly rather than with the smooth motion seen in coma. These patients normally respond quickly to noxious stimuli and a firm approach by the clinicians. Patients in a catatonic-like state, however, often present either in a state of mute wakefulness without response to verbal or tactile stimuli, or in a mildly stuporous condition. The former will often track the observer with his eyes (coma vigil, akinetic mutism) and may show a waxy flexibility of the extremities.

While most of the experience with this technique has been using amobarbital, some clinicians have used thiopental, mixtures of thiopental and amobarbital, chloroform, *Cannabis indica*, paraldehyde, scopolamine, chloral hydrate, most modern barbiturates, benzodiazepines, or other sedative-hypnotic agents for the same purpose.

Interview Technique

Place the patient in a relatively quiet room with a relative or chaperone in attendance. Having relatives observe the interview is helpful, because it is often difficult for them to comprehend that certain symptoms, such as paralysis, have a psychogenic basis. Through an intravenous line of D_5W, administer sodium amobarbital (10% solution) at 50 mg (0.5 cc)/min. A conversation (or monologue, in the stupor cases) is held with the patient during induction. This is limited to benign, nonthreatening topics. The clinician's calm, reassuring attitude and suggestions similar to hypnotic inductions are useful; the interview effect sometimes is as great as that of the medication.

The stages of narcosis are: (a) fully alert and responsive patients; (b) Stage I, when patients describe their first symptoms—fatigue, ligh-theadedness or dizziness, blurring or double vision; (c) Stage II, when patients become euphoric or drowsy, or when the unresponsive patient begins answering questions; and (d) Stage III, the absence of corneal reflexes in the patient, which should be avoided.

It usually requires 100 to 500 mg of amobarbital to reach Stage II. Once Stage II is reached, ask the patient questions about personal identification data (when necessary), their current situation and predisposing factors, and any further medical history needed (including drug ingestion). Then suggest that the patient again has the ability to use the affected part, or, for the previously mute/unresponsive patient, that he must remain responsive once the medication wears off.

In patients with conversion reactions causing paralysis or other physical symptoms, once the symptom, such as paralysis, resolves, the interviewer should reinforce the fact that the extremity is now back to normal and that it will continue to be normal after the patient leaves the hospital. This is analogous to the familiar posthypnotic suggestion. Do not confront the patient with a psychiatric diagnosis at this time. When spontaneous speech or movement returns to the catatonic or unresponsive patient, emphasize that such a responsive state is normal and desirable.

Patients with organic/toxic psychoses will not respond verbally and will merely fall asleep or become more sedated during the interview. If this occurs, terminate the interview and presume that the patient has an organic etiology that needs further evaluation.

Only respirations need be monitored during the procedure; the patients need to be observed for 2 to 4 hours post-interview. Refer the patient for psychiatric treatment, if available.

Dementia

Formal mental status testing is time-consuming and often unnecessary for general medical evaluations. However, if a patient with reasonable hearing looks at his or her companion more than twice before answering direct questions during history taking, there is a strong likelihood of incipient dementia.[13] In these cases, administer a cognitive screening test.

Studies have shown that when time is limited, a rapid (1- to 2-minute) assessment of dementia can produce results comparable to those from much longer, more complex testing. The quickest method is to use the Six-Item Screen for Cognitive Impairment found in Table 35-8. When using Table 35-8, ≥3 errors suggest dementia (88% sensitivity and specificity). Getting more items wrong correlates with a greater chance of cognitive impairment.[14]

Once a patient is recognized as having cognitive impairment, the challenge becomes differentiating dementia from delirium or acute psychosis. Each has a different prognosis, as well as different methods of evaluation and treatment. Table 35-9 lists some of the clinical factors that can help differentiate them.

TABLE 35-8 Six-Item Screen for Cognitive Impairment

Tell the patient the following:
I would like to ask you some questions that require you to use your memory. I am going to name three objects. Please wait until I say all three words; then repeat them. Remember what they are because I am going to ask you to name them again in a few minutes. Please repeat these words for me: APPLE—TABLE—PENNY. (Interviewer may repeat names three times if necessary.)
1. What year is this?
2. What month is this?
3. What day of the week is this?
What were the three objects I asked you to remember? (They should answer:)
4. Apple
5. Table
6. Penny

≥3 incorrect answers strongly correlates with cognitive impairment.

Data from Callahan et al.[14]

TREATMENT

Psychological First Aid

A series of basic psychological treatment techniques, which can be taught to all health care workers (and non-health care workers), have been termed psychological first aid. These techniques are designed to ameliorate acute distress following exposure to trauma, such as the traumatic distress that leads to posttraumatic stress disorder (PTSD). They are essentially the same techniques as are listed in Table 35-4.

Using Restraints

The rule is to keep yourself safe, to keep your staff safe, and then to worry about your patient's safety. This is rarely an issue. But when patients (or others) become violent and threaten other people's safety, physical or chemical restraint (or both) may be needed. Remember that most violent patients who are still aware (i.e., not on an illicit stimulant or alcohol) do not want to hurt anyone. Try a "show of force": gather a group of really big people and approach the patient in a nonthreatening manner. Ask, and then tell, the patient to lie down to be restrained. This technique often works well—and no one gets hurt.

TABLE 35-9 Clinical Features Helpful in Distinguishing Dementia, Delirium, Acute Psychosis, and Depression

Characteristic	Delirium	Dementia	Acute Psychosis	Depression
Onset	Acute; sudden	Usually insidious	Acute	Acute, often with prior history
Course over 24 hours	Marked fluctuations	Stable	Stable	Stable
Long-term course	Transient	Progressive decline	Fluctuating	Variable duration
Consciousness	Reduced	Normal	Normal	Normal
Attention	Usually impaired globally	Normal, unless dementia severe	May be disturbed	Slowed
Cognition	Impaired	Impaired	Unimpaired if cooperative	Appears impaired; fluctuates
Orientation	Impaired	Often impaired	May be impaired	Normal
Hallucinations	Visual, ±auditory	Rare	Mostly auditory	Absent
Delusions	Transient, poorly organized	Usually absent	Sustained	Usually absent
Psychomotor activity	Increased or reduced, varies unpredictably	Often normal	Increased or reduced; does not shift rapidly	Usually slowed
Tremor	Asterixis; tremor may be present	Usually absent, unless from other condition	Absent	Absent
Speech	Incoherent, slow, or rapid; disorganized	Word finding impaired, normal pace	Normal, slow, or rapid	Usually slow or normal

Data from Basten and McGuire,[15] Lipowski,[16] and Wells.[17]

Although using restraints is generally frowned upon, most health care workers can easily improvise some in a crisis. The most common method is to use a web-type bandage (e.g., Kerlix) to form a slip knot and put the loop over the patient's wrists and ankles. The body can be restrained with sheets or the stretcher straps. Rather than straps for extremities, socks can be used. (Col. Patricia R Hastings, AMEDDCS. Personal communication received April 9, 2007.) Any patient in restraints should not be lying on their back; this is the death-from-aspiration position.

Outside the confines of medical facilities, the idea of restraint gets a bit dicier. "Fearful that extensive training on airline violence would adversely affect their image, several major US airlines refuse even to carry plastic handcuffs on the plane. In the case of an emergency, the flight crew is left to devise makeshift restraints from their neckties, headset wires, seatbelt extensions or even panty hose."[18]

If available, chemical restraint, such as haloperidol, chlorpromazine (beware postural hypotension), or other sedatives, may be used. If a psychiatric patient is supposed to receive a sedating medication for treatment, try to use that drug.

Depression

Major depression (vegetative signs) is common and often difficult to treat. Antidepressants often take weeks to work and have significant side effects. They also may be expensive and unavailable. Ketamine, commonly used around the world for conscious sedation, analgesia, and anesthesia, is a rapid acting treatment for depression.

Ketamine improves depressive symptoms within 2 hours in some patients and within 24 hours in 50% to >70% of patients; about one-third of these are nearly symptom free. The dose is usually 0.5 mg/kg IV over 40 minutes. Side effects are rare.[19-21] If the dose is 1 mg/kg, >5% of patients become hypotensive.[22] The improvement generally lasts a week or more.

Posttraumatic Stress Disorder

Posttraumatic stress disorder (PTSD) is a catch-all term that encompasses stress caused by any traumatic event. Usually, PTSD is discussed in the context of situations where the individual or group (a) was exposed to dead, dying, or mutilated bodies or too many injured people; (b) felt that their own or a loved one's life was in danger; (c) heard the screams of those in pain or who were dying; (d) was trapped; (e) was lost or became separated from loved ones; (f) witnessed a devastating event (e.g., mutilating deaths); (g) suffered or was at risk of suffering a severe illness or injury; or (h) had lost major possessions. Posttraumatic stress disorder also can occur when the disaster is unexpected (e.g., earthquake), is human-made (e.g., terrorist attack), or leads to prolonged stress. Particularly in children, the loss of or separation from a parent (or the fear of such a death or separation, or of a recurrence of the disaster) can lead to PTSD.[23]

Often, there are not enough mental health professionals to help the large numbers of people suffering from PTSD or to help those whose PTSD could have been prevented by early intervention. Many health care workers and members of the helping professions may feel—incorrectly—that they are too strong to suffer from PTSD or that seeing a mental health professional would be stigmatizing. Because of this, colleagues may need to step in.

The first step for health care and rescue workers is to try to avoid PTSD through pre-event counseling, engaging in specific behaviors while on-scene (Table 35-10), and participating in critical incident stress debriefing (CISD). Lumped together, these actions constitute critical incident stress management (CISM).

In general, CISD follows the format shown in Table 35-11. Remember two key points: (a) some, or even many, PTSD victims cannot tolerate any reminder of the incident and (b) referring to participants as patients and to their responses as symptoms indicates that they are ill, and may alienate participants. Lawrence Hipshman, MD, of Oregon Health Sciences University, says that, in fact, participants are generally not ill, but rather are having predictable responses to severe stress. (Personal written communications, received October 4, 2008.)

After an incident, screen patients for PTSD by asking the first question from each category in Table 35-12. Use all the questions for a more complete assessment that focuses on the three main elements of PTSD: reexperiencing symptoms, avoidance, and arousal. Frame the questions to fit the patient's complaints or behavior.

TABLE 35-10 On-scene Posttraumatic Stress Disorder (PTSD)-Avoidance Strategies

Concentrate on the task at hand
Concentrate on your work's benefit to society
Avoid humanizing dead bodies
Do not look at corpses' faces
Do not learn victims' names

Adapted from *Critical Incident Stress*.[23]

Treating PTSD

Three good treatments are available for PTSD. The only one that works in situations where mental health resources are scarce is using medication, generally a selective serotonin reuptake inhibitor (SSRI), if available. When mental health resources are available, CBT, eye movement desensitization, and reprocessing (EMDR) have proved beneficial.

Suicide Risk

Many patients initially classed as "suicidal" may be released into the community for later treatment. Some suggested criteria (that will never be 100% correct) are listed in Table 35-13.

TABLE 35-11 Phases of Critical Incident Stress Debriefing

1. *Introduction Phase*: CISD team members introduce themselves and explain the purpose of the group meeting and the process they will follow. Hopefully, this will create an environment in which participants feel comfortable, can overcome their resistance, and cooperate during the debriefing intervention. Team members answer questions to alleviate anxiety, encourage participants to help each other, and start the process by asking the first questions.
2. *Fact Phase*: Participants are asked to describe the traumatic event from their perspective. They are asked to describe themselves, their role during the incident, and what they saw happen.
3. *Thought Phase*: The CISD team asks participants to state the first or most prominent thought they had once they stopped functioning on "autopilot." This helps participants begin to identify their emotional, rather than fact-based, reactions to the event by describing their response on a more personal level.
4. *Reaction Phase*: Each member is asked to identify the aspect of the event that was most personally traumatic and his or her emotional reactions. This part of the debriefing tends to be the most emotionally powerful.
5. *Symptom Phase*: To diffuse the emotions before ending the debriefing, participants are asked to describe any affective, behavioral, cognitive, or physical reactions they may have encountered while working at the scene or afterward. To get the group moving in this direction, team members may need to give several examples of stress-related symptoms, such as angry feelings, trembling hands, difficulty making decisions, or severe fatigue.
6. *Teaching Phase*: The entire CISD debriefing process helps teach the most common symptoms of stress and provides a variety of stress survival and management strategies. This part of the debriefing is didactic and designed to distance participants from the emotional content in the reaction phase. This phase continues until participants exhaust the topics that are most important to them.
7. *Reentry Phase*: This summary phase helps clarify issues, answers questions, and reviews the CISD intervention. This provides closure on the debriefing discussions and allows the session to end on a positive note.

Abbreviation: CISD, critical incident stress debriefing.

Data from Mitchell et al.[24]

TABLE 35-12 Detailed Posttraumatic Stress Disorder Assessment Questions

To assess a patient's reexperiencing symptoms or events, ask the following questions:
• Have you been bothered by recurrent thoughts, images, or nightmares about the event?
• Have you felt that the event was reoccurring, or had any flashbacks to the event?
• Have you seen or heard anything that wasn't really there?
• Have you experienced psychological distress? Have you noticed any physical symptoms, such as sweating, increased heart rate, shortness of breath, or shakiness?
To assess avoidance or numbing symptoms, ask the following questions:
• Have you tried to avoid thinking or talking about the event?
• Do you have difficulty remembering any aspects of the event?
• Have you had decreased interest or lack of interest in activities that you normally enjoyed?
• Do you feel detached from people around you? Have you had difficulty socializing and enjoying being around people?*
• Have you had difficulties expressing your feelings? Do you feel emotionally numb?*
• Do you feel as if your future is shortened since the event? Do you feel that the future is hopeless?*
To assess symptoms of increased arousal, ask the following questions:
• Have you been more frequently angry or irritable since the event? Has your mood been affected by the event?*
• Have you had any problems concentrating? Have you been easily distracted or preoccupied with thoughts of the event? Do you find that you are easily startled when something reminds you of the event?*
• Have you had any difficulty falling or staying asleep since the event?

*Alternate ways of asking the same question.
Data from Mitchell et al[25] and other sources.

Psychosis—Treatment in Crisis Situations

A time-efficient method that can be used to easily elicit psychiatric symptoms is to ask the person to write down their thoughts. Psychosis will often immediately become evident, including suicidal and homicidal ideations. Patients may be much more willing to write down these thoughts than to discuss them with a clinician. Table 35-14 lists a general way to classify major psychiatric conditions by their presenting symptoms.

TABLE 35-13 Criteria for Releasing Patients With Suicidal Ideations*

- No need for inpatient medical treatment.
- No history of suicide attempt, psychiatric disorder, or substance abuse.
- No evidence of suicide intent or plan (not actively suicidal).
- A competent adult agrees to remove all potentially lethal substances and means from the patient's environment.
- A competent adult agrees to monitor the patient until follow-up.
- Follow-up with a health care (preferably mental health) professional within 48 hours.
- Patient demonstrates understanding of and agreement with the plan.
- The patient may sign a "contract" agreeing not to harm self (unclear whether this is helpful).

*Criteria must be appropriately applied to each patient.

TABLE 35-14 Symptoms of Major Psychiatric Conditions

Syndrome	Behavior	Speech	Thought Content	Perception	Affect	Orientation and Memory	Onset and Duration	Physical Findings
Delirium	Agitation (occasionally quiet) carphologia	Nonspecific	Variable, delusions	Illusions Hallucinations	Fear, anxiety	Disoriented, memory impaired, clouded consciousness	Acute with fluctuating symptoms	Abnormal vital signs
Dementia	Apathy, apraxia, echopraxia	Echolalia, aphasia	Variable, few, if any, delusions	Few, if any, hallucinations	Lability	Disorientation, memory impairment	Insidious	Frontal lobe release signs (such as grasp reflex)
Schizophrenia	Social withdrawal, agitation	Rambling, mutism	Bizarre, persecutory delusions, ideas of reference	Hallucinations	Blunt, flat, inappropriate affect	Intact	Symptoms for 6 months	None
Mania	Hyperactivity, gregariousness	Rapid, forceful	Delusions of grandeur Paranoia	Hallucinations (possible)	Elation, frequent irritability	Intact	Symptoms for 1 week	None
Depression	Motor retardation, occasional agitation	Lack of spontaneity, slow pace and monotone	Helplessness, hopelessness, delusions of guilt, somatic delusions	Few, if any, hallucinations	Depression, sadness, despondence	Intact	Symptoms for 2 weeks	None

From US Air Force.[26]

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36 | Rehabilitation

When health care resources are limited, rehabilitation services are rare. You may need to improvise rehabilitation equipment for use in therapy or to help patients with mobility and activities of daily living (ADL). Therapy devices help patients gain or regain activity levels as close as possible to normal. Equipment used for mobility and ADL helps patients function better in their daily lives, despite decreased physical ability. For convenience, I will discuss each of these separately.

THERAPY

Transfer Belt

Transfer belts (aka walking belts or gait belts) are used to transfer people who have difficulty walking. These belts also enable helpers to lift patients safely (and without straining their backs), get them into and out of beds, and get them out of chairs.

To make a transfer belt, place a 3-inch-wide webbing (or several loops of it), a wide clothing belt, or a sturdy (e.g., canvas) wide piece of cloth and a buckle around a patient's waist, and use it as a handhold while transferring them or helping them to walk.

Parallel Bars

Patients use parallel bars to practice walking. Fashion these from two long, sturdy poles set into Y-shaped supports at each end. Place the poles parallel to one another, and low enough so patients can use their arms to steady themselves as they walk. Make sure the apparatus is solidly fixed in place, since patients depend on it if their legs give out.

Child's Walker

When children need to use walkers or to practice walking, such as when they are healing from a leg fracture, it helps to make it fun. Use your imagination to craft these devices. Girls especially enjoy using a baby buggy. (You can add a doll to make it more fun.) For boys, decorate a walker with cardboard or paint to make it look like a car or boat. When using a baby buggy, be sure to put enough weights in the bottom so that it provides the child with support and won't tip over.

Cervical Traction

Cervical traction helps lessen the pain for patients with cervical disc disease. It can be applied in a clinic for 30 minutes twice a day or at home more frequently for shorter periods of time.

To make a cervical suspension device:

1. Build an overhead suspension frame using a flat 2-inch × 12-inch metal bar bent to hook over a door.
2. Bend a 0.5-inch-diameter × 6-inch-long rod into a horseshoe shape and then weld both ends to the flat bar.
3. Fashion a head harness from leather, jeans, or khaki clothing material and fasten with sandal buckles. Pad it well with soft cloth. Use a cotton rope purchased from a local market. Tie one end of the cord to the support.
4. Make two hooks from 0.25-inch metal rods shaped into an "S." Tie these to both ends of the cord.
5. Loop the cord from the head harness through the metal loop on the door hanger and attach it to a bag, bucket, or jar, which acts as a weight. As shown in Fig. 36-1, the cord can be wrapped around the door hanger to reduce the tension. One alternative to the weight is to use a clothesline tightener between the head harness and the door hanger. Another alternative is to hang the weight over the end of a bed, as is done when using cervical traction for spinal injuries. (See Fig. 26-7 in Chapter 26, Neurology/Neurosurgery.)
6. When water is used as weight, start with 2 L for an adult, then add water until the patient is comfortable and no longer has pain.[1]

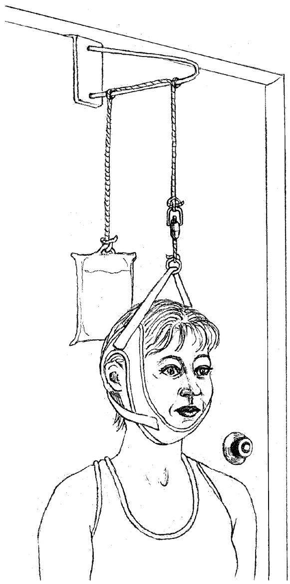

FIG. 36-1. Cervical traction, improvised.

MOBILITY AND ACTIVITIES OF DAILY LIVING

A wide variety of devices can be improvised to assist patients' mobility or to help them perform their daily activities.

Canes

The cane is the easiest mobility device to improvise. Patients often do not use their cane because it is the wrong size for them or they are not told how to use it correctly.

To use a cane, patients should hold it in the hand opposite to their injury or weakness. In addition, they need sufficient upper-extremity strength to bear 20% to 25% of their body weight on the cane. (If they use it in the wrong hand, they need to support >50% of their weight.)

To determine the correct size of cane, measure the cane against the patient while he is standing. Turn the cane upside down and rest it on the ground next to the standing patient. Cut the bottom of the cane at the level of the patient's flexor wrist crease. Then, apply a rubber tip to the end of the cane.

Canes are easier to fashion than are crutches. You can make canes from a tree limb or small tree that has a small sturdy branch that extends at a right angle. It should be light enough so that the patient can easily use the cane. Remove any bark, extra branches, or leaves and smooth down the surface. Canes and walking sticks are used for balance rather than to support an injured limb.[2] A cane with an arm brace can be fashioned by attaching a piece of polyvinyl chloride (PVC) pipe to the tree limb (Fig. 36-2).

Crutches

Crutches must be used when the patient's leg, ankle, or foot injury requires that he bear no, or only minimal (that is, toe-touching), weight on them. Crutches can be used individually or in pairs. Not everyone needs two crutches. When crutches are in short supply, give only one crutch to those patients for whom one will suffice. This allows another patient to use the extra crutch.

To fit crutches correctly, align the axillary pad three fingerbreadths below the axilla. When crutches are in use, the patient's elbows should be slightly bent.

To make crutches, start with one sturdy tree branch (or a matched pair of branches if two crutches are needed). Use the "Y" formed by the branches (Fig. 36-3A). When choosing a branch, remember

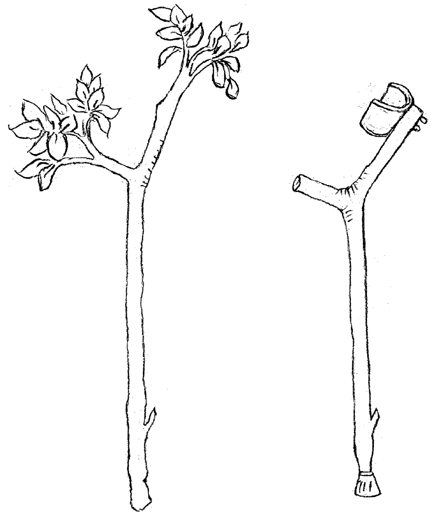

FIG. 36-2. Makeshift cane with polyvinyl chloride (PVC) arm brace.

that the crutch has to support his weight, but should be light enough so the patient can use it. You can also use a straight green sapling (2.5 cm diameter if hardwood, 3 cm diameter if soft wood). Split a sapling halfway down its length (Fig. 36-3B), then insert a crosspiece (2.5- to 3.5-cm-diameter dowel or similar piece of wood) as a handhold for the patient about a third of the way down; firmly secure the crosspiece to the two sides using screws or cement. Tape the area where the split ends to prevent the sapling from continuing to split on its own. To finish the crutch, secure a padded crosspiece at the top and put a piece of rubber at the bottom.[2] Hang a basket from one of the crosspieces, so the patient can carry items (e.g., phone, keys) that they need to access quickly.

Wheelchairs

Although there are kits to transform plastic lawn chairs into wheelchairs,[3] the materials for makeshift wheelchairs most often need to be scrounged locally. Alternatives include removing the legs from an easy chair and fastening the chair to the frame of a baby carriage (Fig. 36-4, left),

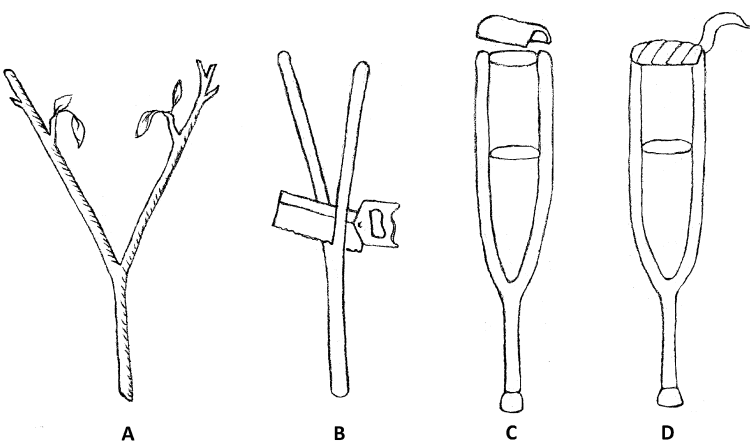

FIG. 36-3. Making a crutch: begin with either a "Y" tree limb (A) or by cutting a straight pole (B). Add padding to the top (C), then wrap the padding and add a rubber piece to the bottom (D).

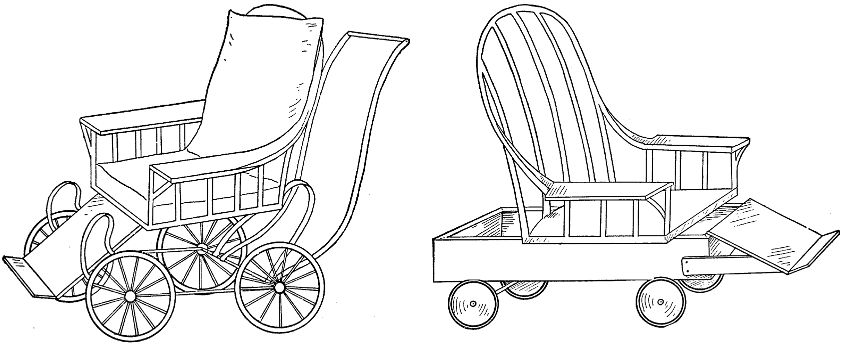

FIG. 36-4. Multiple conversions of chairs to wheelchairs.[4]

fastening the upper half of a chair to a child's wagon (Fig. 36-4, right), and fastening a pair of roller skates onto a rocking chair's runners.[4]

A simple alternative is to use a child's wagon to transport small children or small adults. However, using a wagon as a wheelchair for long periods is not recommended because (a) there is no support for the patient's back, although one can easily be fashioned; (b) patients must keep their legs extended rather than dependent; and (c) this method of transport is difficult for patients to use on their own.

Another way to make a wheelchair is to use a chair as the base, and attach bicycle wheels (especially those from mountain bikes) and an axle to the back legs. Simply fitting the wheels onto the back legs of most chairs will not work; you must use the axle as well. Smaller wheels that swivel, such as from a grocery cart, can be fitted to the bottom of the chair's front legs—metal chairs work best because they are stronger. Fashion a handle out of metal or wood to fit onto the back of the chair to assist in moving the patient.

Enhancing Zipper Pulls

A common problem for patients is not being able to hold a zipper pull to zip it closed. (Or, the pull has fallen out and you need a substitute.) To remedy this, you can slide a jumbo paper clip, a large safety pin, a string, a twist tie, or a ribbon through the hole at the end of the existing zipper pull or on the slider to make it easier to grip.

Toilet Accommodations

Bedside Commode

Many patients need a bedside commode to avoid climbing stairs or going out to the latrine. Remove the seat from a metal kitchen-type chair, cut a hole in the seat of a wooden chair, or use a toilet seat with legs attached. Place a bucket underneath.[5] (See Figs. 5-7 through 5-9 in Chapter 5, Basic Equipment.)

Raised Toilet Seat

Patients in spica casts find sitting on a normal toilet seat impossible. Solve this problem by cutting the bottom off a tapered plastic waste can so that it just fits into the top of the toilet bowl. Then use a heat gun to soften the plastic and mold the can top so there is an indentation two-thirds of the way toward the front and also a pointed spout at the front (Fig. 36-5). To use it, wedge the bottom firmly into the toilet bowl. For an elderly patient who simply needs a raised seat, attach a standard toilet seat to this device.

Raised Bed

Patients with limited mobility often have difficulty using low beds or cots. To raise the bed safely, drill holes into four wooden blocks of the same size and insert the bed frame legs. Use this method to raise cots for use as cholera beds; these have a hole cut in the center of their plastic-sheet mattress and a bucket placed underneath (see Fig. 32-3 in Chapter 32, Infectious Diseases).

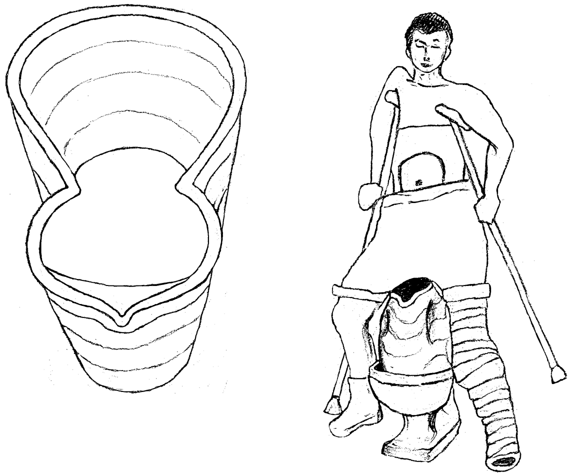

FIG. 36-5. Raised toilet seat. (*Redrawn from Ford.*[6])

Protective Sandals

Thick-soled protective sandals may be needed for patients with severe peripheral neuropathy, such as from diabetes or leprosy. To make an inexpensive sandal that will last about a year, have the patient step on a piece of soft insulating/microcellular/foam rubber (such as that used as packing material) and draw a pattern of his foot on it, about 1.5 cm away from the foot (Fig. 36-6). Make holes for the straps, which are made from leather or cut from a tire's inner tube. Securely sew the straps onto the foam. Cut a piece of automobile tire and glue it to the bottom of the foam. After the glue completely dries, cut the tire to match the foam's shape. If desired, sew on buckles (or attach them with rivets).

Thoracic Brace

A chest, or thoracic, brace is useful for multiple purposes, including protecting chest and thoracic spine injuries while healing occurs. Figure 36-7 shows a chest brace fashioned from PVC pipe. See "Heating PVC Pipe" in Chapter 27, Ophthalmology, for how to work with PVC pipes.

Pads for Pressure Sores

Filling a rubber air mattress with water forms a cushion for the beds of patients prone to develop decubitus ulcers.[7] To make a pad to use on a chair, wheelchair, or hard bed, tie inner tubes together (see Fig. 5-28 in Chapter 5, Basic Equipment). One inner tube pad can be used on a chair or several can be linked together to form a mattress (Fig. 36-8).

Sitting Support

Patients may need support to sit upright in a chair because of weakness or instability. (Do not sit or prop them up if their difficulty sitting is due to hypotension! They will simply pass out—or

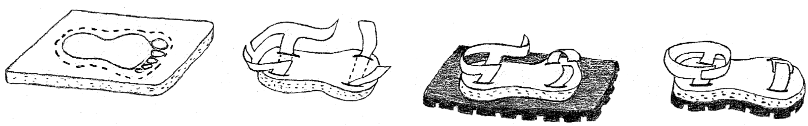

FIG. 36-6. Protective sandals.

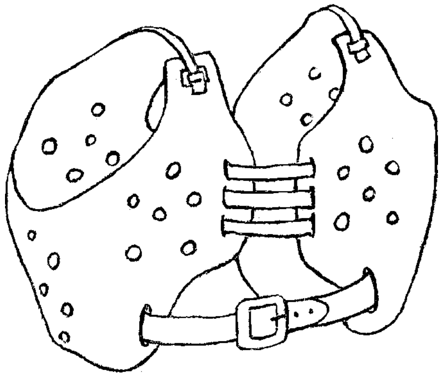

FIG. 36-7. Chest brace from polyvinyl chloride pipe.

maybe have a stroke.) Use sheets, folded towels, or pieces of cloth to fashion a harness similar to that shown in Fig. 36-9.

Handles for Utensils

Patients with a weak hand grip after a stroke, with other neuromuscular diseases, and with arthritis often have trouble holding eating utensils, writing implements, and toothbrushes. Patients often do well if a handle is enlarged so that they can grip it with their entire hand closed over the handle in a fist.

For an eating utensil, cut a hole in a large sponge or rubber ball and shove the item or its handle through it (Fig. 36-10). For a pen or pencil, push it through the hole in a spool of thread. Enlarge the hole and tape it in place, if necessary.[9]

Prostheses for Amputees

In resource-poor environments, you will need to fashion the prosthesis. One way to do this is, after padding the stump well, to form a plaster cast around the stump, remove the cast, and fit it with a sawn-off, thinned-down crutch. Then fix it in place with additional plaster. This works for both above-the-knee (AK) and below-the-knee (BK) amputations. (It looks similar to the pirates' peg legs in the movies and works fine.)

If both legs must be amputated above the knees, consider making short, so-called "stumpy" prostheses. These can simply be boots pulled over the stumps and held on by cords over the shoulders. They are easier for the patient to balance on, although he will need two short walking sticks to assist him.[11]

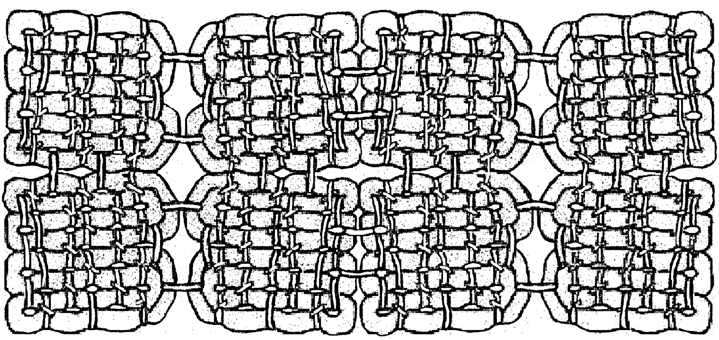

FIG. 36-8. Improvised mattress.

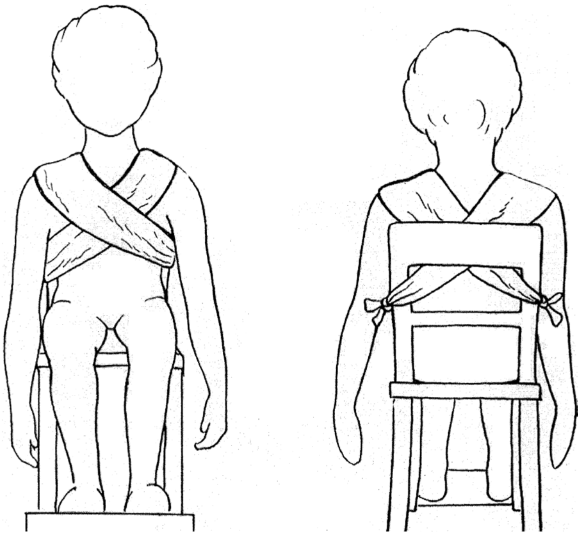

FIG. 36-9. Support harness. (*Redrawn from Arey.*[8])

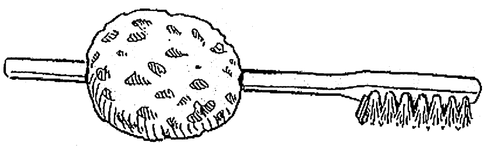

FIG. 36-10. Toothbrush with sponge-ball handle grip. (*Reproduced with permission from Arey.*[10])

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37 | Death and Survivors

Maximizing the utilization of resources means that some deaths will be unavoidable, especially in resource-poor situations. When resources are limited, you will have to forego trying to save patients whose deaths are imminent or unavoidable. You must be prepared to deal with the consequences as best you can. Considerable improvisation may be required to fashion body bags, to equip holding areas, to set up a body-identification system, and even to embalm a body or to perform an autopsy.

RISK OF DISEASE FROM CORPSES

The myth that human and animal corpses pose a public health threat following natural or human-made disasters continues to lead to the misallocation of many scarce resources needed to help the living. Corpses pose only a limited health threat, because even the most resistant bacteria and viruses die quickly in a dead body as the internal temperature drops and the body desiccates. This limits any microbe's ability to transfer to vectors that could infect humans. In fact, corpses pose a much lower risk of infecting people than do the living who are harboring an infection.[1]

General Population

Dead bodies from natural disasters do not cause epidemics. They are not infected when they die and, thus, do not spread diseases. Despite the hysteria from the media and politicians, the risk to the public from even masses of corpses is negligible. However, corpses can leak fecal material that can contaminate rivers or other water sources, causing diarrheal illness. Don't drink untreated water that has had dead bodies in it. In reality, routine disinfection of drinking water is sufficient to prevent waterborne illness.

In cases in which people died of an endemic, communicable disease (e.g., cholera, hemorrhagic fevers), see that the populace uses the best hygiene possible. Also, try to prevent direct contact between corpses and family members; one way to do this is to give the body to the family in an airtight box for rapid burial.[2] Spraying bodies with disinfectant or lime powder has no effect. It does not hasten decomposition or provide any protection to the living against disease.[3]

Body Handlers

Those handling corpses have a small, but real, risk of contracting diseases through the bodies' blood and feces. Handlers are especially at risk for contracting hepatitis B and C, human immunodeficiency virus (HIV), tuberculosis (TB), and diarrheal diseases. However, the infectious agents responsible for these diseases do not last more than 2 days in a dead body (except for HIV, which may survive up to 6 days).[3] Tuberculosis can pose a hazard during autopsy or if handling a body when air is expelled from the respiratory tract. To reduce this risk, place a cloth over the corpse's mouth and ensure adequate ventilation in any temporary morgue.[4]

Precautions

In austere circumstances, body-recovery workers can wear normal clothing, along with rubber gloves and boots, if available. However, they must adhere to basic hygiene practices, such as washing their hands with soap and water after handling bodies and before eating, and not wiping their face or mouth with their hands. They should wash and disinfect all equipment, clothes, and vehicles used for transporting bodies.

The primary function of facemasks is to lessen the smell from decaying bodies. The smell is unpleasant, but it is not a health risk in well-ventilated areas. There is no danger of contamination through the respiratory tract (unless the patient had TB) since there is no respiratory function in dead bodies. Even though wearing a facemask is not required for health reasons, it may help lessen workers' anxiety. However, normal facemasks do not filter the air or provide protection against most things (except bad smells) for very long. The problem with masks is that they limit ventilation and increase the work effort.[3,5]

If entering potentially hazardous structures, body recovery personnel should use the same protective gear as search and recovery personnel. If recovering bodies from confined, unventilated spaces, first ventilate the area, since after several days of decomposition, potentially hazardous toxic gases can build up. Body recovery teams should also receive priority status for tetanus immunization because of the hazardous locations in which they often work.[6]

BODY RECOVERY AND DISPOSITION

One of the first activities after a natural disaster is to expend great efforts and resources collecting corpses. While rapid retrieval helps when trying to identify the dead, this effort should never take priority over or use resources that are needed to care for survivors.

Place recovered bodies and body parts (e.g., limbs) in body bags along with non-perishable personal belongings, such as jewelry. If body bags are unavailable, use plastic sheets, shrouds, bed sheets, or other locally available material. Place personal documents in a plastic bag, which should be kept with the body.

Transporting Bodies

Generally, bodies need to be taken to either a short-term holding area or to a site for long-term storage or final disposition. Normally, specialized mortuary vehicles are used to transport dead bodies. However, in major disasters, these may be in short supply or unavailable, so you may need to improvise. (Always check local regulations to determine if the use of certain vehicles for this purpose is prohibited.)

While open flatbed trucks can be used, it is preferable to use closed trucks or vans and to cover the floors with plastic. If possible, use refrigerated trucks normally used to transport perishable items. Try to cover any lettering or symbols, including license plates, that identify the companies or individuals who own the vehicles. This avoids any negative repercussions for the vehicles' owners when the public sees them being used in this way. Once they are no longer needed, any vehicles used to transport bodies must be thoroughly cleaned. Any commercial vehicles should then be inspected and approved by government officials as being safe to transport their normal cargo.[7]

Never use ambulances to transport the dead; they are valuable resources designed to help the living. While this is commonly, and inappropriately, done during minor incidents, using ambulances in this way when there are mass fatalities is dangerous and potentially harms survivors. Even in mass casualty situations with few survivors (e.g., airplane crash), use alternative vehicles such as trucks, pickups, hearses, and vans to transport the remains of the dead.

Short-Term Holding Areas

Bodies initially need to be taken to a short-term holding area (temporary morgue). Ideally, this site will have controlled access, sufficient space, good ventilation, and be air-conditioned—or at least be out of the sun—to avoid rapid decomposition. It should also have facilities for the staff and areas in which to counsel relatives and, if necessary, to do limited autopsies and embalming. Planning the layout as soon as the site is selected is a key element in organizing body identification.

Sophisticated computer programs are often used to help sort and identify remains. Good on-site organization is essential. Sort bodies by category so that specific bodies can easily be found when the family arrives or identifying information is found. Place the remains in groups by gender and age (e.g., elderly men) and then further divide them into subgroups, such as by skin color, and then by hair color. For example, there may be six initial parts of the holding area for groups of men and women, each divided into elderly, adult, and child/teenager. With a sizable number of casualties, each of these areas can be subdivided for bodies of a different skin color (e.g., black, white, other) and hair color (e.g., black, brown, blond, other). If the number of bodies is substantial, these groups can be further subcategorized by height and hair length. Then, even with hundreds or thousands of bodies, the small subset with the six characteristics can be easily located.

Storage

Several methods may be available to store bodies. Use any or all of these as the situation requires. Before storing bodies, put each body or body part in a body bag or wrap it in a sheet. Since these will often be unidentified bodies, give each a unique identification number matched to a master list of bodies. Put any identifying information with the body or part, and put their identification number on waterproof labels (e.g., paper in sealed plastic). Do not write the identification numbers directly on the body or body bag/sheet, since they get rubbed off during storage.

Refrigeration

Cold storage is optimal, especially in hot climates where decomposition advances so rapidly that facial recognition is not possible after 12 to 24 hours. The optimal temperature for storage is between 2°C and 4°C. If available, the refrigerated transport containers used by commercial shipping companies can each store up to 50 bodies. Since sufficient refrigeration is rarely available immediately at a disaster site, try to obtain commercial refrigerator trucks. They can be moved close to the site to be used for temporary storage and later to transport remaining corpses.

Burial

Burial can be used either as temporary storage or as a permanent disposition.

Temporary burial provides a good option for immediate storage, sometimes at the disaster site itself, when no other method is available or when longer-term temporary storage is needed. This can also be used for individual deaths in remote areas when the body cannot safely be removed at that time. One benefit is that temperatures are lower underground than at the surface; this helps to preserve the body. Temporary burials should be designed so that it is possible later to locate and recover the bodies. To ensure retrieval, use individual burials for a smaller number of bodies and trench burial for a larger number. All bodies should have waterproof identification tags on them and in the body bags or sheets.

Mass common graves, however, should not be used. Rushing to dispose of bodies without proper identification traumatizes families and communities, cannot be justified as a public health measure, violates important social norms, wastes scarce resources, and may make it difficult or impossible to recover and identify remains later.[3,8] Likewise, mass cremations are not only technically and logistically difficult, but also waste tremendous amounts of scarce resources (mainly fuel, and usually wood). They also destroy evidence for any future identification. Complete incineration is difficult, usually resulting in partially incinerated remains that must be buried.[9]

Grave Construction

If possible, human remains should be buried in clearly marked, individual graves, although after very large disasters, communal graves may be unavoidable. When digging the graves, consider what the prevailing religious practices say about the bodies' orientation, such as the head must be facing east or toward Mecca and so forth. Each body must be buried with its unique reference number on a waterproof label. This number must be clearly marked at ground level and mapped for future reference.

The following are the general guidelines for constructing graves, although the distances may have to be increased depending on soil conditions. Graves should be ≥1.5 meters (5 feet) deep. Communal trench graves should consist of a single row of bodies placed parallel, ≥0.4 meter (1.5 feet) apart. Bury them in one layer, and never stack the bodies on top of each other. Graves with fewer than 5 bodies should allow for ≥1.2 meters (4 feet) between the bottom of the grave and the water table or any level to which groundwater rises; allow ≥1.5 meters (4.5 feet) if the burials are in sand. Communal graves should have ≥2 meters (6 feet) between the bottom of the grave and the water table or any level to which groundwater rises.[10]

Grave Location

When choosing any burial site, consider (a) the number of bodies needing burial—allow some leeway; (b) soil conditions; (c) the highest water-table level; (d) the location's acceptability to nearby communities; and (e) the distance from nearby water sources. Clearly mark burial sites and surround them with a buffer zone ≥10 meters (30 feet) wide to allow the community to plant deep-rooted vegetation and to separate it from inhabited areas.

For public health reasons, burial sites must be at least 200 meters (600 feet) from any water source, such as wells, streams, lakes, springs, waterfalls, beaches, and the shoreline. The distance, in part, will vary with the number of bodies being buried, soil porosity, and the water-table level.

TABLE 37-1 Distance of Grave From Water Sources

Number of Bodies	Distance From Drinking Water Source
≤4	200 meters (600 feet)
5-60	250 meters (750 feet)
≥60	350 meters (383 yards)
≥120 bodies per 100 m^2	350 meters (383 yards)

Data from Morgan.[11]

The more porous the soil and the higher the water table, the farther the grave should be from the water source.[10] The suggested distances between burial sites and drinking-water sources are listed in Table 37-1.

Ice and Dry Ice

Ice is not the optimal method for preserving bodies in warm climates. It melts quickly and large quantities are needed. When it melts, ice produces large amounts of dirty wastewater that must be disposed of so that it doesn't seep into the water supply system. In cold regions, using the ambient cold temperatures or existing ice and snow may be an option.

Dry ice, solid carbon dioxide (CO_2) frozen at −78.5°C (−109.3°F), may be suitable for short-term storage. To use it most effectively, build a low wall of dry ice (i.e., 0.5 meters high [1.5 feet]) around groups of about 20 bodies and cover them with a plastic sheet, tarpaulin, or tent. Do not place dry ice on top of bodies, even when wrapped—it damages them. You will need about 10 kg of dry ice per body per day, depending on ambient temperature. Use dry ice preservation only in well-ventilated areas (e.g., outdoors), since it produces carbon dioxide gas when it melts. Use gloves to handle dry ice to avoid "cold burns."[12]

Long-Term Disposition

Generally, the simplest body disposition is to release all identified bodies to relatives or their communities for disposal according to local custom and practice. Long-term storage is required for the remaining unidentified bodies.

Embalming

Embalming requires skills acquired through special training. However, when necessary, rudimentary embalming using the steps[13] outlined here can be accomplished by any clinician with basic surgical skills. The goal is to inject approximately the person's blood volume (~70 mL/kg) of embalming fluid. Of course, some of the blood will normally have to be drained out and disposed of (safely) first.

Place the body supine and extend the extremities. Incise the inside of the upper left arm and expose the brachial artery. Pass two ligatures, 5 cm apart, under the artery. Then make a transverse incision just large enough to insert a trocar, feeding tube, or very large needle pointing distally. Tighten the proximal ligature and inject embalming fluid. Loosen the ligature and redirect the trocar proximally, tie the distal ligature, and tighten the proximal ligature around the trocar. Inject most of the embalming fluid in this direction. Then remove the trocar, tie off the vessel, and close the incision. This procedure can also be done through the carotid or femoral arteries.

A less-effective but simple alternative or supplement to this procedure is to insert a trocar into the abdomen (Fig. 37-1) and then into the chest at multiple points, and aspirate any gas or liquids. Then, inject at least 16 oz (~500 mL) of embalming fluid into each cavity. This can also be done in a male's genitals. Sew the trocar holes closed. To embalm the cranial cavity, inject embalming solution through the carotid arteries or insert a trocar through the cribriform plate via the nose.[14]

Embalming solution can be made from 40% formaldehyde (formol) and carbolic acid. The more commonly used solution is 10% formaldehyde plus alcohol and glycerin: for each liter of formaldehyde, use 0.5 L alcohol. If formaldehyde is not available, use 20% zinc chloride in

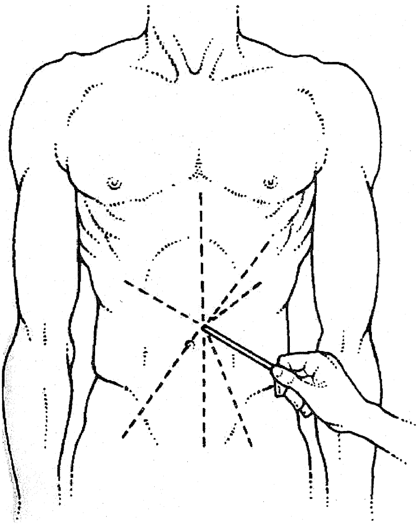

FIG. 37-1. Cavity embalming using a trocar. *(Reproduced with permission from Iserson.[15])*

alcohol or glycerin. One formula, recommended by the Pan-American Health Organization, uses the following ingredients[16]:

30% formaldehyde, 300 mL
80-proof ethanol, 700 mL
Glacial acetic acid, 5 mL
Phenol, 20 g

To embalm body fragments, first attempt to suture them together, and to the body, if available. Then inject them with preservative. Alternatively, preserve the fragments using powdered forms of calcium hydroxide (lime), zeolite, or formalin that will adhere to the surface. Then place the fragments in plastic bags wrapped tightly with adhesive tape. This generally prevents fluid leaks and reduces odors during handling.

Embalm a fetus by instilling preservative fluid though the umbilical vein. Use gravity to instill ~1 L fluid. For a newborn, either use this method or inject 1 to 2 L of preservative through the brachial, axillary, or femoral artery and fill the abdominal and thoracic cavities with preservative-soaked material.

In cases of rapid putrefaction and bloating, the affected areas can be punctured to release the gasses. This is most common in the perineum, scrotum, and the female mammary folds. Facial swelling can be lessened by incising the mucosa on the interior cheeks and compressing them with gauze.

Contaminated Bodies

Bodies may have radiological, biological, or chemical contamination. Individuals handling these bodies should wear the appropriate personal protective equipment. These bodies should generally not be embalmed, and those performing autopsies should take special precautions. In these cases, cremation is the preferred method of disposition, although burial in sealed containers may be permitted by local health officials.

If part of local custom, viewing can generally be permitted for most bodies with death due to a disease that requires a vector (e.g., tularemia, Rocky Mountain spotted fever) or due to radiological contamination (they are generally not "contaminated," but rather affected by radiation). Viewing should not be permitted when death was due to a chemical warfare agent or an infectious disease with person-to-person transmission (e.g., anthrax, hemorrhagic fever, smallpox).[17]

Animal Corpses

Three factors determine whether animal bodies can harm humans: (a) if the animal carcasses have specific infectious agents, particularly *Cryptosporidia*, *Campylobacter*, and *Listeria*; (b) if the pathological microbe can survive the animal's death; and (c) if the corpse is leaking contaminating material into drinking water.[18] Unless all three of these elements are present, the dead animal presents no threat to humans. Note that the microorganisms mentioned survive only briefly if the animal's carcass is on dry land.

Three methods for disposing of animal remains exist: bagging, burying, and burning. Usually, the easiest is to bag the body. The University of Virginia's protocols for disposing of animal remains after natural death or disasters recommends putting animal bodies in sealed, thick plastic bags until they can be taken to an area designated for final disposal.[19]

Burying animal remains is more labor intensive, especially when there are large numbers of dead animals. The danger is that other animals may unearth these burials. Place a layer of a thorny plant (such as cactus or brambles) over the animal and burial site. This discourages dogs, foxes, and other canines from digging up the site. In the case of herbivores that have a large amount of grass in their four stomachs, putrefaction often swells the body, causing the soil over the animal to rise. Puncture the stomach to allow gas to escape before interring the animal. To be effective, bury animal carcasses at least 3 feet deep. Initially, they can be sprayed with oil and then covered with soil to protect them from predators until they can be destroyed or buried.[20]

Cremating animals in austere circumstances is generally a bad idea. Not only does it waste valuable resources, but it also often fails to incinerate the body fully, which makes it more difficult to inter the body at a later time.[20]

POST-DISASTER FORENSICS

Post-disaster forensics usually means identifying the bodies. Rarely are there significant questions about the mechanism of death.

Body Identification Process

Even in the worst conditions, any physician who uses common sense can organize the procedures for victim identification and markedly advance the process. On-site health care professionals have the best opportunity to identify victims before the bodies decompose. When trying to identify victims, the basic principle is that the sooner the process is started, the more successful it will be. Once bodies have decomposed, they are much more difficult to identify and forensic expertise is often needed. Mobilizing forensic resources may take several days. This means that in the absence of forensic specialists, many types of health care professionals may need to help with the identification process. Others who may be a valuable part of the process are veterinarians, biologists, pharmacists, funeral administrators, and even gravediggers. The latter have the psychological preparation to carry out the work under supervision.

Identification of dead bodies is done by matching the deceased (physical features, clothes, and so forth) with similar information about individuals who are missing or presumed dead. This is most effectively done using photographs, fingerprints, and forensic dental comparisons. These are rapid, inexpensive, and efficient methods of identification that can be accomplished with relatively few resources. Transmission of visual information via the Internet or telephone has speeded long-distance identification of remains.

There are five key steps to identification: (a) assign unique reference numbers, (b) label items, (c) photograph, (d) record, and (e) secure.[21]

Assign Unique Reference Numbers

Perhaps the most important part of the identification process is to assign a unique identification number to each body and body part, so that any materials or information connected to it can be cataloged under that number. This allows information to be found quickly, and is useful when trying to identify the remains. Why also assign a number to body parts? Any part that proves a person is dead can aid in identification and subsequent closure for relatives, and therefore should be managed the same as a whole body.

Forms to use when recovering bodies can be downloaded (MSWord or PDF file formats) at: www.paho.org/english/dd/ped/DeadBodiesFieldManual.htm. This site also has forms to use to inventory corpses, to assign sequential numbers (up to 500) to recovered bodies, and to collect data on missing persons.

Label Items

Write the unique reference number on a waterproof label (e.g., paper sealed in plastic), then securely attach it to the body or body part. A waterproof label with the same unique reference number must also be attached to the container for the body or body part (e.g., body bag, cover sheet, or bag for the body part).

Photograph

Visual identification of fresh bodies on-scene or using photographs are the simplest and most efficient identification methods during the early, nonspecialist identification process. However, visual identification and photographs can result in mistaken identification. Clean the body sufficiently to allow facial features and clothing to be properly represented in the photographs. Identification errors increase with injuries to the decedent, or with the presence of blood, fluids, or dirt, especially around the head.[21]

For each corpse or body part, complete a set of photos to use for identification (Fig. 37-2). When taking photographs, always include a clearly visible and readable label with the corpse's unique ID number. Take at least the following shots: (a) full length of the body, front view; (b) whole face; and (c) any obvious distinguishing features. If circumstances permit, or at a later time, take additional photographs (including the unique reference number) of (a) upper part of the body, (b) lower part of the body, and (c) all clothing, personal effects, and distinguishing features.

When taking photographs, remember these tips:

- Steady the camera or use a tripod—blurred photographs are useless.
- Take close-ups. The face should fill most of the frame.
- Stand at the middle of the body when taking the picture, not at the head or feet.
- The photo is useful only if the unique ID number is clearly visible and readable.

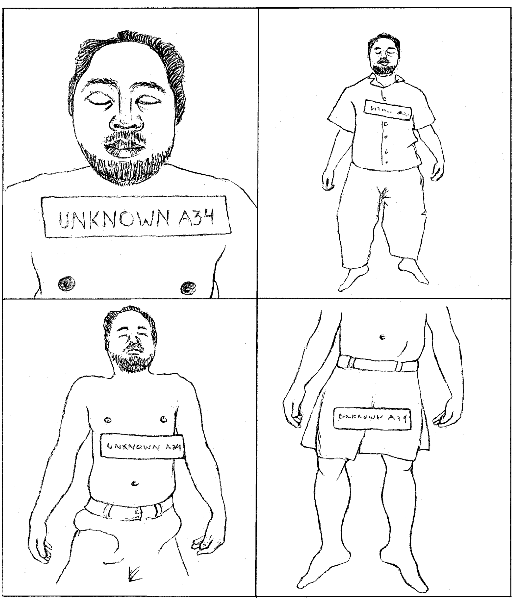

FIG. 37-2. Typical set of photographs for identification.

Record

Even if photographs have been taken, record the following data on a sheet with the unique ID number[21]:

- Gender (look at genitals to confirm)
- Age range (infant, child, adolescent, adult, elderly)
- Personal belongings (jewelry, clothes, identity card, driver's license, and so forth) on or near the body
- Obvious specific skin marks (e.g., tattoo, scar, birthmark) or deformity
- Where body or belongings were found
- The exact burial location, if buried for temporary storage

If no photographs are taken, also record:

- Race
- Height
- Color and length of hair
- Color of eyes

Secure

Personal belongings should be securely packaged, labeled with the same unique ID number, and stored with the body or body part. Data sheets and photographs should be kept in a secure site; PAHO recommends also sending data via the Internet to one or more secure sites, if possible.

Identification and Release of the Body

Although there may be no alternative following large disasters, the psychological impact of viewing dozens or hundreds of dead bodies may reduce the validity of the identification. Rather than further traumatizing relatives by having them personally identify bodies, have them view photographs. This also increases the reliability of visual identification.

Visual identification should be confirmed by other information such as identification of clothing or personal effects. A dead body should be released only when identification is certain. Children should never be expected to help visually identify corpses.

Record the name and contact details of the person who claimed the body together with the body's unique ID number. Care should be taken before releasing bodies that are not whole, as this may complicate subsequent management of body parts. Properly store bodies that cannot be recognized by visual identification (see "Storage" earlier in this chapter) until forensic specialists can investigate.

Information Management

For early data collection, you may use paper forms, but information should later be entered into an electronic database. To optimally use collected information, coordination of all data through one central processing point is essential. This increases the possibility of finding a match between missing person reports and known information about dead bodies. To do this, establish information centers at regional and local levels that feed their data into a central data bank. Local centers are particularly necessary for receiving requests, acquiring photographs and information from relatives, and releasing information about found or identified persons.[22]

Information can also be transmitted using the Internet, public information boards, and the media (newspapers, television, radio).

Tentative Identifications

Once there is a general idea of a body's identity, search for the information needed to create identification files corresponding to the case.[23] Interviews with people having close ties to the victim are common sources of basic information. In addition to the interviews, use available documents and personal articles to obtain essential information.

Physical characteristics from examining the remains can be coupled with known physical attributes, such as age, gender, race, and stature; scars, blemishes, birthmarks, or tattoos; hair color (natural and dyed) and characteristics; presence of moustache or beard and their characteristics;

dental prostheses, dental chart, and other dental studies; blood type and other genetic information; x-rays and other relevant laboratory tests; data about any ante-mortem trauma, abnormalities, and orthopedic and other prostheses; known illnesses; surgery experienced and special consequences, if any; and any other particular information for each case.[23]

Known Identification

When a body is recovered within a few hours of death, you may want to place an additional ID tag inside the mouth, since rigor mortis will cause the mouth to remain tightly shut so that the tag cannot be lost. In austere circumstances, that may be beneficial. The disadvantage of putting the ID tag in the mouth is that incisions have to be made to extract the tag to check coding.[24]

DNA Samples

DNA analysis, while slow and expensive, is now available after disasters in most regions of the world, either through local sources or nongovernmental organizations (NGOs).

DNA can help to identify individuals even when on-scene investigators cannot. The keys are to collect the correct type of samples and to package them correctly. All samples must be labeled with any reference number referring to the body, the type of sample, where it was taken, and who is sending it. Table 37-2 lists the samples generally needed to help identify corpses in different states of decomposition.

TABLE 37-2 DNA Evidence

	State of Corpse			Transport Method
	Well-preserved	Charred	Decomposed	
Blood	10 mL in an anticoagulant (EDTA) tube	Semisolid blood from inside heart	**N/A**	Protective container; refrigerate if possible.
Skeletal muscle	Two fragments ~10 grams each and 2 cm wide; use plastic screw cap container	**N/A**	Any tissue remaining on bone	Jar with screw-on lid or air-tight closure; seal with tape. Refrigerate, if possible.
Teeth	Four teeth, preferably molars; do a dental chart first	**N/A**	Four teeth, preferably molars; do a dental chart first	Cardboard box or paper bag; seal with tape. Refrigeration not necessary.
Bone	**N/A**	Fragments from deep in body	An entire long bone—femur, if possible	Cardboard box or paper bag; seal with tape. No refrigeration.
Hair, Scabs, Skin, Nails, etc.	**N/A**	**N/A**	**N/A**	Collect in small pieces of paper; carefully fold and put in paper bag; seal with tape. No refrigeration.
Dry, sterile swabs	**N/A**	**N/A**	**N/A**	Put in small cardboard box, or label with identifying information and dry completely at room temperature in protected area. Seal in a shipping container. Refrigeration not needed.

Adapted from Pan American Health Organization.[25]

TABLE 37-3 Protocol to Support Disaster Survivors

Meet survivors as they arrive at the morgue waiting (or other gathering) area. Staff should wear identification: Armbands color-coded to an individual's job, such as support, medical, counselor, clergy, etc., are optimal.
After identifying the survivors, give them all information currently available. (Accurate information is priceless in disaster situations.)
If there are enough counselors on each shift, assign them to specific survivor family groups to monitor.
Keep track of which survivors are present or where they have gone.
Give survivors an overview of the identification process, forms they need to complete, and required autopsy or other forensic investigations. Assist them with the necessary formalities and paperwork.
Assess survivors involved in the disaster for injuries.
Provide a means of communicating with distant relatives, and comfortable rest areas, bathrooms, and eating facilities while survivors wait to hear news of their loved ones. (This may require logistical support from local hospitals, the National Guard, Red Cross, Salvation Army, or similar local agencies.)
Have a staffed play area for small children. (Surviving children's need for immediate psychological support is often neglected.)
Support emotionally distressed relatives who are waiting to identify bodies.
Provide a liaison with the disaster scene and local hospitals.
Accompany survivors to any mass briefings held for them.
Protect survivors from the media and, when desired, act as their spokesperson or intermediary. (The media can help to publicize that mental health services are available for survivors who were not at the morgue.)
Support survivors through the process of identification. Assure them that they have not misidentified their loved one or otherwise made an error (a common fear). This may be particularly stressful, since the bodies are often burned, dismembered, or mutilated and may have begun decomposing for lack of refrigeration.
Give survivors information about available funerary facilities, if asked.
Provide crisis psychiatric intervention, as necessary.
Help identify the survivor's normal support system to further assist them.
Collect survivors' identifying information so follow-up can be done.
During the event (usually at each change of shift) and after the event, the notifier/mental health team should hold debriefings to share information and to relieve their own stress.

Reproduced with permission from Iserson.[26]

SURVIVORS

Survivors are often neglected in the hubbub of a crisis. Yet these are the patients for whom we can do the most. The first task is to deal with them compassionately, both during and subsequent to the identification or notification process. They may need counseling for posttraumatic stress disorder (PTSD; see "Posttraumatic Stress Disorder" in Chapter 35, Psychiatry). Inevitably, they will want to follow their religio-cultural rituals for parting with their loved ones. The following protocol (Table 37-3) provides a model to use when dealing with large numbers of disaster survivors.

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Appendix 1 Hospital Disaster Plan

Generic All-Hazard Hospital Disaster Resource-Allocation Plan

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This plan is designed for health care facilities in resource-sufficient regions. **It may not apply completely to those facilities in resource-poor areas.**

(All "Actions" or "Treatment Priority" items listed are in addition to or modify those listed for the preceding Levels. The "Triggers" change with each Level.)

Level 0	
Triggers*	"Normal" demand-to-available-resource ratio.
Actions	Normal activity.
Treatment Priority	5-level nurse-run triage in emergency department (ED). Immediately lifesaving surgeries before urgent surgeries before elective surgeries. ICU bed allocation based on greatest need. Patients' attending physicians and intensivist make decisions.
Level 1	
Triggers*	50% of ED beds are filled with admitted patients.[†] *- or -* Staffed inpatient beds are 98% filled.[†] *- or -* External incident(s) is likely to generate or has already generated a combination of critical and/or noncritical patients exceeding 30% of normal ED bed capacity in a short period of time. *- or -* Only 75% of any critical resource[‡] will be available for a significant period during the next 24 hours.
Actions	Activate Hospital Incident Command System (HICS).[§] Stop all elective admissions and do not begin any elective surgeries.[‖] Refuse to accept transfers from other facilities if patients can be treated elsewhere.[‖] Whenever possible, transfer admitted ED patients to other institutions.[#] Immediately discharge all patients from the hospital (a) whose discharge is planned to occur within 12 hours and (b) who can be safely managed at home or in another available facility. The vacated bed must be available for new patients within 2 hours of discharge papers being signed.[‖] Fill all physical beds, use all levels of nursing personnel (expand their scope of practice to the extent that safety and the law permit), and, if necessary, decrease nurse-to-patient ratios.** Discharge all ambulatory patients. Send them to other appropriate facilities, if available.[‖] If the situation is caused by an infectious agent or other contaminant, institute protective measures, including isolation and quarantine. Activate "overcapacity" plan(s), including opening pre-identified locations to accommodate "surge capacity."[††] Consider implementing disaster plan.[§§] Consider using a trained risk communicator to inform the public about the situation.[§§,##]

Treatment Priority	The most experienced ED physician triages incoming patients. Do not start any elective surgeries. Physician Crisis Triage Officer (CTO)*** asks individual attending staff to discharge ICU patients who will probably not benefit from ICU care.
Level 2	
Triggers*	75% of ED beds are filled with admitted patients.[†] *- or -* Staffed adult inpatient beds are >100% filled.[†] *- or -* External incident is likely to generate patients rapidly or has already generated 6 to 20 critical and/or 31 to 100 noncritical patients. *- or -* Only 50% of any critical resource[‡] will be available for a significant period during the next 24 hours.
Actions	[Take actions as described for prior Levels, modifying them as described for this Level.] Refuse to accept transfers except for those that are immediately life-threatening and that cannot be treated elsewhere.[‖] Divert noncritical ambulance traffic if other EDs are open. Immediately discharge all patients from the hospital as listed in Level 1, plus those (c) who do not require acute care hospitalization.[‖] Implement disaster plan, including opening pre-identified locations to accommodate “surge capacity.”[§§] Consider asking for assistance from local, regional, or national authorities.[§§] ICU beds and ventilator use may be rationed. Use a trained risk communicator to inform the public of the situation and, if possible, work with the local and regional authorities to establish an area-wide risk-communication system.[##]
Treatment Priority	Clinics outside the institution are asked to take “Triage Levels 4 and 5” patients (those requiring the least resources for treatment). Physician CTO*** decides, in conjunction with patient’s primary treating physician, about ICU bed allocation (continued use and new admissions) and the use of ventilators, other critical equipment, and medication in short supply. These decisions are based on greatest need - *and* - the probability of benefit from ICU treatment based on current knowledge.
Level 3	
Triggers*	76% to 95% of ED beds are filled with admitted patients.[†] *- or -* External incident is likely to generate rapidly or has already resulted in ≥21 critical and/or ≥101 noncritical patients.
Actions	[Take actions as described for prior Levels, modifying them as described for this Level.] Refuse to accept all transfers.[‖] Fill all physical beds, *stretchers*, and *cots*; use all nursing personnel, decreasing the nurse-to-patient ratios as necessary.**
Treatment Priority	Ask for assistance from local, regional, or national authorities, if not already done.[§§]

	Level 4
Triggers*	>95% of ED beds are filled with admitted patients.[†] *- or -* Disaster plan activated and already have maximum number of inpatients under the plan.[†] *- or -* Only 25% of any critical resource[‡] will be available for a significant period during the next 24 hours.
Actions	[Take actions as described for prior Levels, modifying them as described for this Level.] Ask for additional assistance from local, regional, or national authorities.[§§]
Treatment Priority	The Physician CTO*** informs all clinical staff that, until further notice, all medical resources will be distributed to all patients using the following treatment priorities: Those with a high probability of successful medical intervention. Those who perform essential emergency response roles, especially if they may quickly return to work after treatment. Those not needing excessive resources. Those in caretaker roles. Those with essential community roles.
	Level 5
Triggers*	Contamination (including radiation); fire, flood, structural damage, or bomb threat requiring evacuation. *- or -* The disruption of a major support service (pharmacy, food service, supply/distribution, power, water). *- or -* Dangerous police-related situation within the institution.[§§§]
Actions	[Take actions as described for prior Levels, modifying them as described for this Level.] Transfer current patients. Stop all admissions from any source and do not begin any surgeries.[‖]
Treatment Priority	No treatment of new patients within the facility until situation stabilizes. Physician CTO*** determines evacuation priority and, if necessary, which patients will not be evacuated.[‡‡] Ambulatory first aid rendered, if possible.
	Level 6
Triggers*	No hospital services available—for whatever reason. *- or -* At least one critical resource[‡] will be completely unavailable for a significant period during the next 24 hours.
Actions	[Take actions as described for prior Levels, modifying them as described for this Level.] All patients evacuated from hospital and ED.[‖] Physician CTO*** determines evacuation priority and, if necessary, which patients will not be evacuated.[‡‡]
Treatment Priority	Inpatient facility closed.

*Demand-to-available-resource ratio (Triggers).

[†]This information can be assessed frequently (elegant markers) and represents the institution's current ratio of patient demand to available resources (personnel, equipment, and space). The

"number of ED beds" must be determined in advance, but should include only those beds that can safely accommodate admitted patients under normal circumstances. The "number of inpatient beds" should include only those beds that can be used for acute adult or pediatric medical-surgical patients (not NICU beds).

‡Critical Resources are: essential medical gasses (e.g., oxygen and nitrous oxide), electricity, water (including a method to purify before use), natural gas (used for heating and cooking), ventilation system, food, key pharmaceuticals for the event, waste and garbage disposal, linen, essential computer systems (admission, discharge, transfer [ADT] system; pharmacy information system; radiology information system; lab information system; network; telephone and paging; and interface engine). Those responsible for providing and maintaining critical resources must provide their best estimate of the percentage of the resource that will be available over the next 24 hours.

§The Hospital Incident Command System (HICS) is an emergency management system that employs a logical management structure, defined responsibilities, clear reporting channels, and a common nomenclature to help integrate hospital operations with other emergency responders. There are advantages to all hospitals using this particular emergency management system. It is designed to minimize the confusion and chaos commonly experienced by the hospital staff at the onset of a medical disaster. HICS is the standard for health care disaster response and offers the following features:

Predictable chain of management

Flexible organizational chart allows quickly tailoring the response to emergencies

Prioritized response checklists

Accountability of position function

Enhanced documentation for improved accountability and cost recovery

Common language to promote communication and facilitate outside assistance

Cost-effective emergency planning within health care organizations

The HICS, to work effectively in disasters, must also be used during lower-Level situations. The site(s) used as the Command Center must have excellent, redundant internal and external communication systems.

‖Hospital Chief Medical Officer (CMO) or designate(s) must approve all admissions and surgeries, and enforces hospital discharge policies, as specified for each Level. At Levels 5 and 6, he also enforces the "no admission/no surgery" and "transfer all patients" policies.

#Social Services will assist with these arrangements.

**Hospital Chief Nursing Officer (CNO) or designate(s) modifies staffing patterns to use all physically available beds. (All nursing staff, including those who often function in a "Case Manager" role, will be assigned tasks to maximize their clinical effectiveness.)

††Pre-identified surge-capacity locations may include clinical (e.g., ambulatory surgery, GI lab, minor treatment areas, cardiac catheterization lab) or nonclinical (e.g., cafeteria, waiting room) areas.

§§Decision made by institution's Incident Commander, or the CMO, CNO, and Chief Operating Officer (COO) or their designates. They are also responsible for downgrading to a lower Disaster Plan Level, when appropriate.

##Risk Communication provides timely, accurate information through multiple sources, with the chief communicators being credible spokespeople. In health crises, these will usually be physicians. Knowledgeable risk communication specialists must educate this team in these techniques (i.e., using scripts, how to work with the press) in advance of any crisis. The same professionals will work with the designated key communicators throughout the crisis.

***Crisis Triage Officer (CTO) is a member of the medical staff who allocates critical resources using the criteria of best outcome related to the resources needed (amount of resources times length of time used). Whenever possible, these decisions will be consistent with evidence-based medical literature. The CTO will never be the primary physician of the patient for whom a resource-allocation decision is being made. Decisions are made, whenever possible, with input from the treating team and, when necessary and if possible, other expert consultants. These decisions should be reassessed if the demand-to-resource ratio changes. However, the CTO's decisions may not be overruled.

This is the most difficult position in the triage system and, without proper experience and education, the CTO will not function effectively. CTOs, in some cases, will need to ration or deny resources to patients who, under normal circumstances, would probably survive. This includes, at Level 6, abandoning some patients whose transfer would be too dangerous or would consume too many resources. (This is analogous to triaging patients into the “Expectant” category.)

CTOs will be designated in advance. The cadre of CTOs must become familiar with the triage criteria, participate in frequent discussions with the Bioethics Committee to understand the moral basis for these resource allocation decisions, and practice this role in lower-Level situations. The senior medical and nursing staff, as well as the senior hospital administrators, must understand the CTO’s role and be prepared to fully support his decisions—no matter how painful.

CTOs should be relieved every 4 to 6 hours and have an 8- to 12-hour rest period without other duties (as should others in high-stress positions during a disaster). Their rest areas should be quiet and away from any disturbance. It is essential that excellent communication (e.g., a log book with vital details and decisions) is maintained among CTO team members.

[‡‡]If moving a patient places staff at risk or if the time and resources it would take would compromise the lives of other patients, the CTO will decide if the patient is to be evacuated or not.

[§§§]Lockdown of the facility or evacuation of all or part of the facility may be done immediately by any senior clinician or administrator or at the direction of the law enforcement authorities. This may require moving to Disaster Level 6. Follow other parts of the plan for this Level, if possible and required by the situation.

Appendix 2 | Medical Kits

An appropriate medical kit should be durable, padded, weatherproof, and easy to carry.[1]

If you carry medications, include a weatherproof/laminated drug-treatment card for each medication, since a wide variety of practitioners may end up using the same kit. These cards should include: (a) correct pediatric and adult doses for specific conditions, (b) information on how to reconstitute (if a powder) and administer the medication, and (c) contraindications and adverse effects.

FIELD MEDICINE KIT

A "one-man mobile forward clinic" consists of a clinician carrying a backpack with a complete basic life support kit and simple surgical instruments. "In skilled hands and with support from the local population, the one-man mobile forward clinic may handle close to 80% of all casualties."[2]

Dr. Matthew Lewin, who equips scientific teams for remote expeditions, suggests that some of the basics for any kit are: ear plugs, nail clippers, superglue (small wounds), suture stapler (larger wounds), thermometer (to determine if there really is a fever), duct tape (lots of uses), condoms (no need for pregnancy or STDs in the field), pregnancy tests (to know if care must be modified), zip ties (to prevent tampering with the kit, but still allow it to be opened quickly), adrenaline (envenomations and allergic reactions), and antibiotics. For any other medications, use pills rather than capsules, which may crack in an arid environment; even better are vacuum-sealed medications. What he does not include are venom suction extractors (worthless), rehydration salts (use salt and sugar), or unnecessary narcotics (potential for abuse is great).[3]

AUTOMOBILE MEDICAL KIT

The most common situation in which health care professionals may need to provide medical treatment with few resources is while driving. I believe that all advanced health care professionals should carry medical supplies in their vehicle. Not to do so is more than irresponsible: it is a repudiation of the healer's moral codes. (I believe it's unacceptable to hide behind any fear of liability. If your services are gratis and you have no preexisting requirement to intervene, at least in the United States, you are completely protected from liability.)

I follow two rules as to when to stop and ask if help is needed. I stop when (a) people seem to be in distress and no one else seems to be helping or (b) prehospital personnel seem to need help. (A clue to this is when one or more of them is kneeling next to a patient.) I have intubated, performed cricothyrotomies, put in chest tubes, and done other advanced procedures at the roadside over the years. If you don't have these skills, that is no problem. Use what you know, the equipment you carry, and lots of improvisation. It will be appreciated.

The equipment you should carry depends, in part, on the skills and knowledge you have. However, in lifesaving situations, you do not want to be missing key equipment that you may need. Note that this medical kit should not contain your own personal medical supplies and equipment (e.g., daily medications, first aid creams, Band Aids), but rather it should contain items to save lives and reduce suffering when no one else can help. Over many decades, I have found the equipment listed in Table A-1 to be adequate.

FIRST AID EQUIPMENT FOR A MASS GATHERING

What do you stock to anticipate illness and injuries in a large group of rambunctious teenagers (or a similar group)? The list in Table A-2 was compiled based on supplies used from a group medical kit to treat actual injuries among a large number of Boy Scouts (nearly 4000 person-days) in a wilderness setting. It is designed to provide guidance to individuals about what supplies to stock in a first-aid kit in these circumstances. Note that this is a first-aid, rather than a medical, kit. The quantities are designed for 2 weeks with 12 individuals in the party (168 person-days).[4]

TABLE A-1 Health Care Professional's Automobile Medical Kit

General Equipment	
Personal protective equipment (PPE, e.g., masks, gloves, gown, booties) Blood pressure cuff (Also used as a tourniquet if tubing is clamped and tape wrapped around it so that it doesn't come loose.) Grease pencil (to write vital information on bandages or patient's forehead, such as "T" for tourniquet applied and the time) Emergency thermal (metallic) blanket Adhesive tape, heavy (rubberized, electrical, or duct) Short dowel (for tourniquet) Scalpels (#10 and #15) Stethoscope	Headlamp (to see and be seen) Lubricant (water-soluble) Foley catheter and drainage bag (the bag is also useful for nasogastric tube and chest tube drainage) Trauma shears (heavy scissors) Roadside flares Sheet (to help move person or cover body) Small notepad and pencil Gloves (sterile; also useful as Heimlich valve) Alcohol-based hand cleaner gel or wipes Nasogastric tube
Airway/Breathing (Know How to Use the Equipment You Carry)	
Nasal airways Oral airways Endotracheal cuffed tubes, sizes 4-0, 6-0, 70, 8-0) Bag-valve-mask Spare batteries Pocket mask	Bulb or other manually operated suction Laryngoscope 10-cc syringe Alternative airway devices, adult and pediatric (e.g., esophageal-tracheal tube, laryngeal mask airway)
Bone/Joint Injuries	
Malleable padded splints Triangular bandages Elastic bandage with Velcro closure or safety pins Cervical collar or sandbags	Chemical ice pack Collapsible long-leg splint (optional and expensive)
Wound Treatment (This Is For Emergencies, Not For Plastic Closures.)	
Staples Sutures (4-0 nylon) on large needle Suture kit Wound closure tape and benzoin Staple remover/suture removal kit	Bandages Cyanoacrylate (as wound adhesive) Dressings (gauze and non-adherent) Liquid soap
IV Supplies	
Normal 0.9% saline IV tubing	Butterfly catheters IV catheters
Medications	
Benzodiazepine (PO and parenteral) Syringes (1-cc, 3-cc, and 5-cc) Aspirin Albuterol inhaler Epinephrine (1:1000) Ketorolac (parenteral) Benadryl Antiemetic (parenteral, to use with narcotic) Needles (25-, 21-, and 18-gauge) Glucose (paste, granules, and $D_{50}W$)	Lidocaine 1% Acetaminophen/Panadol Naloxone Butorphanol (or other agonist-antagonist parenteral narcotic. It is unlikely that this will be a target for drug addicts.)

TABLE A-2 First-Aid Kit for 2-Week Trip*

Item/Quantity
Dressings and Wound Care
Adhesive bandages (Band Aid), 12
Adhesive tape (2-inch roll), 2
Conforming gauze bandage (3-inch roll, Kling), 2
Elastic bandage (3-inch wrap, Ace), 1
Moleskin sheets, 2
Spenco Second Skin (3-inch by 4-inch pads), 4
Sterile gauze compresses (4-inch by 4-inch), 6
Oral OTC Preparations
Antacid (chewable tablet), 6
Antihistamine (diphenhydramine 50 mg), 6
Bismuth subsalicylate (Pepto Bismol, chewable), 6
Ibuprofen (200-mg tablets), 6
Topical OTC Preparations
Alcohol swabs (for cleaning equipment), 10
Antibiotic ointment (Neosporin, 0.9-g packets), 6
Hydrocortisone 1% cream (30-g tube), 1
Povidone/iodine solution (individual swabs), 8
Tincture of benzoin (30-mL bottle), 1

*Group of 12 people.

Data from Welch.[4]

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