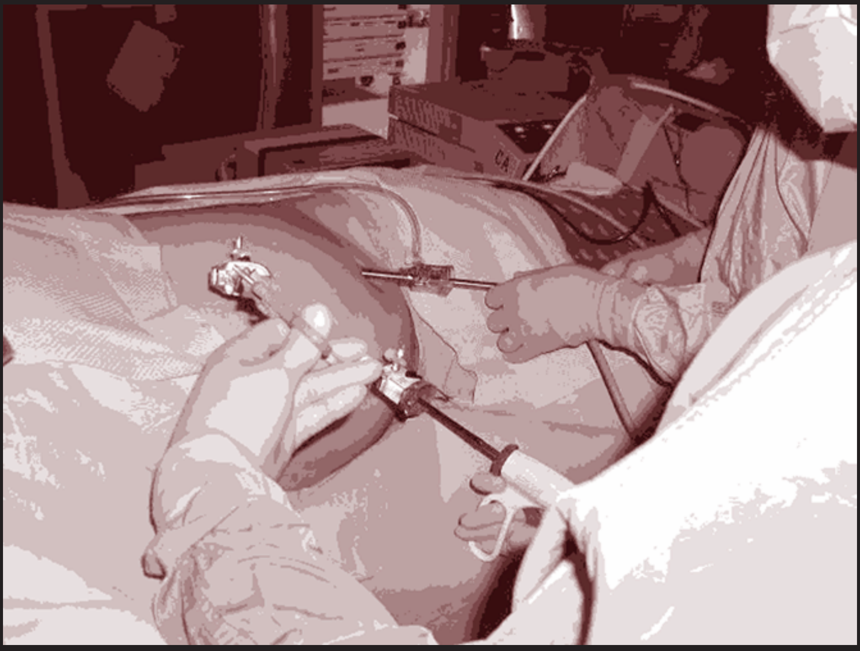
Essential Urologic Laparoscopy

The Complete Clinical Guide

Edited by

Stephen Y. Nakada, MD



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I humbly dedicate this book to my loving wife Deanna and my parents Frank and Ayako, without whom I would not be.

Preface

Urologic laparoscopy is in the midst of a clinical resurgence thanks to improvements in technology, education, and a new generation of urologic laparoscopists. At the time of this writing, the problem of educating and training the vast majority of practicing urologists in urologic laparoscopy is creating a significant burden on centers of excellence.

The purpose of *Essential Urologic Laparoscopy: The Complete Clinical Guide* is to provide a practical, step-by-step guide to creating, maintaining and expanding a successful practice in urologic laparoscopy. This text offers clear, concise chapters focused on getting started, laparoscopic instrumentation, and step-by-step procedural adult laparoscopy. Each chapter is organized so that the reader can easily identify key points, pitfalls, and take home messages. Each contributor was selected for his or her clinical expertise in procedural laparoscopy.

Essential Urologic Laparoscopy begins with chapters on getting started in laparoscopy, instrumentation, operating room set-up, and accessing the abdomen. What is unique about this text is a complete, cross-referenced instrumentation chapter that will enable operating room and hospital personnel to use *Essential Urologic Laparoscopy* as a reference guide for most laparoscopic operations. Next, simpler laparoscopic procedures, such as renal cyst decortication, pelvic lymph node dissection, and simple nephrectomy, are described in rich detail.

At this point in time, laparoscopic nephrectomy has emerged as the gold standard for most renal pathology. Therefore, three approaches to laparoscopic radical nephrectomy—transperitoneal, retroperitoneal, and hand-assisted—are detailed by the pioneers who have championed each approach. More advanced procedures, including laparoscopic adrenalectomy, partial nephrectomy, radical nephroureterectomy, live donor nephrectomy, and pyeloplasty are also described. Finally, cutting-edge procedures such as laparoscopic cystectomy with urinary diversion and laparoscopic radical prostatectomy are clearly detailed for the reader. *Essential Urologic Laparoscopy* ends with a chapter on laparoscopic complications, including issues of informed consent as they relate to urologic laparoscopy.

Essential Urologic Laparoscopy will empower the reader with a step-by-step manual to create an effective practice in adult urologic laparoscopy. This text is written in such a way that its value as a complete reference guide should endure for many years to come. Good luck performing urologic laparoscopy.

Stephen Y. Nakada, MD

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I would like to acknowledge the men who have guided me thus far in academic urology, both spiritually and professionally. My success has hinged on their teachings and support. I cannot thank these great men enough.

In order of acquaintance: Ronald Rabinowitz in 1988, Ralph V. Clayman in 1994, and David T. Uehling in 1995.

I would also like to acknowledge the skill and dedication of my first and only secretary since 1995, Tricia Maier.

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1 Getting Started in Laparoscopy

Joseph J. Del Pizzo, MD

Contents

INTRODUCTION

Laparoscopy was first performed by Kelling in 1901 *(1)*, as a method to view the abdomen of a dog. One hundred years later, this technique has gained global popularity and widespread use for many procedures in multiple specialities. The technique made a major advance in the early 1980s with the invention of the television-chip camera, which afforded advantages such as a magnified image with a binocular view, easy observation of the procedure by the entire operating room, and the ability of the surgeon to operate with both hands. Soon after this, the first successful laparoscopic appendectomy was performed. This was followed in 1985 by the first laparoscopic cholecystectomy, performed by Muhe, for which he received the highest award of the German Surgical Society *(2)*. Laparoscopic cholecystectomy became the procedure to showcase the benefits of laparoscopic surgery: lower morbidity, better cosmesis, shorter hospitalization, and more rapid convalescence. With this, laparoscopy moved into the mainstream of accepted surgical practice for a variety of general surgical disorders.

The adaptation of laparoscopy into the urologic armamentarium has been a slower process. The laparoscope was initially used to locate cryptorchid testicles and to plan a subsequent open procedure. Schuessler was the first to present a laparoscopic approach to a common urologic procedure, the pelvic lymphadenectomy *(3)*. Although the initial excitement over this new technology waned after the staging pelvic lymphadenectomy fell out of favor, the impact of Schuessler's report remained monumental as there was a

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surge in the types of urologic procedures attempted laparoscopically as well as a deluge of reports and videos generated to document the progress. Clayman et al. *(4)* were the first to show that laparoscopic extirpative renal surgery was possible, describing the first laparoscopic total nephrectomy in 1991. This was soon followed by the initial laparoscopic radical nephrectomy in 1992, the first laparoscopic radical prostatectomy in 1992, the first laparoscopic partial nephrectomy in 1993, and the initial laparoscopic live donor nephrectomy in 1995. Since these initial cases, the popularity of these procedures has increased and they have been adopted by many major medical centers *(5)*.

The overwhelming majority of extirpative urologic surgery is still done via an open technique. The main reason for this is the relatively steep learning curve that exists in performing laparoscopic cases safely and efficiently. The laparoscopist must learn to overcome several constraints performing procedures that they have done with little difficulty for years via an open approach. The three-dimensional operative field is viewed in two dimensions. There is a loss of the tactile sensation that the surgeon has longed relied on as a dissector, retractor, and hemostatic instrument. Other challenges arise from the inherent difficulty of laparoscopic suturing and knot tying. Another dissuasive factor is that, relative to our general surgical colleagues, there are few urologic interventions that are candidates for the laparoscopic approach. The level of difficulty of a laparoscopic nephrectomy far exceeds that of a laparoscopic cholecystecomy. In addition, most urologists do not see the volume of radical nephrectomies necessary to not only maintain the laparoscopic skills that they have acquired, but also to improve them to a point where more challenging procedures can be attempted, such as laparoscopic radical prostatectomy or laparoscopic radical cystoprostatectomy.

With this being said, the enthusiasm for laparoscopy as a defining tool for the urologist has never been at a higher level. Many urologists in practice are now interested in incorporating laparoscopy into their daily practice. More physicians are attending introductory training courses, working in training laboratories, observing experienced laparoscopic surgeons, and learning about requirements for attainment of laparoscopic privileges at their hospital. This chapter reviews the basic steps necessary for the urologist to bring laparoscopy into his or her everyday practice.

THE SURGEON

The prospective laparoscopic surgeon is the centerpiece of the project. Any urologist who wishes to incorporate laparoscopy into his or her practice must be dedicated to learning the skills, and just as important, to maintaining and developing them over time. To learn the skills, the surgeon has many options available. There are many introductory, hands-on laparoscopy courses given throughout the year. These courses include both didactic lectures and time in a dedicated, hands-on animate laboratory. The evolution of the hand-assisted technique for laparoscopic extirpative renal surgery has increased the number of training courses available, and has shortened the learning curve for many urologists, allowing them to combine their open surgical skills with the laparoscopic approach *(6)*. Upon completion of a course, the surgeon is encouraged to continue training through use of an inanimate laboratory or other laparoscopic training device. Before attempting his or her first laparoscopic case, which is most likely to be a simple or radical nephrectomy, the surgeon is encouraged to watch an experienced laparoscopic surgeon perform a case, preferentially another urologist performing a laparoscopic nephrectomy. Laparoscopic pelvic surgeries (prostatectomy, cystectomy/urinary diversion) are extremely complex procedures that require an advanced level of laparoscopic skills to perform safely. It is not recommended that the novice laparoscopic surgeon attempt these until a significant amount of experience in renal surgery has been attained.

The prospective surgeon must think ahead before scheduling his or her first laparoscopic case. This includes understanding and meeting the hospital's requirement for securing and maintaining laparoscopic privileges. In addition, the surgeon must secure the support of not only the hospital, but also his or her practice, ensuring that the partners in the practice will commit to supporting laparoscopy. This includes not only financial support, but also education of potential patients and referring physicians. Next, the surgeon should construct a dedicated laparoscopy team, including an experienced laparoscopist, a dedicated assistant, preferably a partner who has also completed a laparoscopic training course, an anesthesiologist familiar with the physiology of laparoscopy, and a dedicated operating room ancillary staff. Finally, the surgeon must become familiar with the basic instruments needed to safely perform the initial laparoscopic procedures.

"TEAM LAPAROSCOPY"

Experienced Laparoscopist

Taking a team approach to getting started in laparoscopy is the safest and most efficient way to adopt this technologically advanced procedure. The novice laparoscopic urologist will need an experienced laparoscopic surgeon available to assist on the first few cases. At many large centers, this is often another urologist. In many smaller community settings, the urologist often is more likely to know a general surgeon with significant laparoscopic experience. The experienced general surgeon represents an excellent source of knowledge for the novice laparoscopic urologist in terms of introduction of trocars, instrument set-up, and basic laparoscopic dissection technique. The urologist is encouraged, however, to rely on his or her expertise in open urologic surgery in performing the steps of the procedure (i.e., radical nephrectomy), as well as to draw on what was learned during introductory courses in terms of trocar placement and selection of instruments to use. When performing these initial cases, it is recommended that the two surgeons take turns assisting each other. This will afford the novice surgeon the opportunity to become comfortable both as the primary surgeon and as an assistant. Learning to operate the laparoscopic camera and becoming a good assistant is critical in the development and maintenance of laparoscopic surgical skills. If an experienced laparoscopic surgeon is not available in the community, the practice has the option of inviting one to proctor the initial cases.

Designated Assistant

The next component of the team to be assembled is a dedicated assistant. Ideally, this would be another urologist in the group who also has an interest in learning and supporting the influx of laparoscopy into the practice. It is recommended that the surgeons take any introductory courses together. This assistant should be available, if possible, for all of the initial cases. This will allow the pair to become comfortable operating with each other laparoscopically, to learn how to communicate with each other, and to anticipate each other's steps during the procedure. In addition, it will allow the novice surgeons to become familiar with the instruments together, and perhaps most importantly, to learn to troubleshoot problems when they arise. All of these facets of the team approach are important in shortening the learning curve and increasing the safety of the procedure in a novice surgeon's hands. This learning process should continue outside the operating room, as beginning surgeons should also practice together in animate and inanimate laparoscopic laboratories to maintain and improve their developing skills.

Anesthesiologist

The anesthetic care of the patient during laparoscopy is largely determined by the alterations in physiology associated with the pneumoperitoneum. With peritoneal insufflation, significant alterations in hemodynamics, pulmonary function, acid-base balance, urinary output, and hormonal secretion can occur. The anesthesiologist working these initial cases should have experience in monitoring these intraoperative parameters. With rapid systemic absorption of carbon dioxide, the peritoneal insufflation may result in hypercapnia with concominant pulmonary hypertension and systemic vasodilatation. An increase in peak airway pressures can be a manifestation of the positive intraperitoneal pressure. Other potential problems include extensive subcutaneous emphysema, pneumothorax, and gas embolism *(7)*. The fluid management of a patient with an induced pneumoperitoneum is also very important. A decrease in glomerular filtration rate (GFR) is seen, resulting in a relative oliguria during the course of the procedure. The anesthesiologist may be tempted to aggressively hydrate the patient based on this finding, which may lead to a fluid overload status postoperatively. Avoidance of nitrous oxide during the case is recommended, as it usually causes bowel distention and may impede the surgical dissection or increase the likelihood on an intraoperative bowel injury. An anesthesiologist with an understanding of the physiology of laparoscopy, and the potential physiologic compromises will be able to easily recognize and correct complications, or prevent them from occurring in the first place. This is a critical part of the laparoscopist's learning curve as he or she begins to take care of patients via a minimally invasive approach.

Operating Room Staff

The importance of the operating room and ancillary staff to the novice laparoscopist cannot be understated. The surgeon depends on this staff to keep the operating room organized and to have the equipment available and working properly. Dedicated scrub and circulating nurses should be made part of the team. This continuity will allow the nurses to become familiar with the instrumentation, including retractors and dissectors, reloading stapling devices, troubleshooting malfunction, and organizing the operative field. In addition, the scrub nurse will learn the operative steps, and be able to anticipate what instruments the surgeon prefers to use at distinct parts of the procedure. This will help the surgeon operate more efficiently and reduce avoidable delays in operative time. The circulating nurse is responsible for the room set up including monitors, laparoscopic towers, and all the equipment, including having back-up equipment available. Also, the circulator should always have an open instrument tray available in the operating room in anticipation of possible urgent or elective open conversion.

INSTRUMENTATION

A multitude of forceps, grasping instruments, dissectors, hemostatic agents, and trocars are available for use in a laproscopic urologic procedure. A detailed account of laparoscopic instrumentation is given in the following chapter. Table 1 includes a list

Table 1
Basic Operative Laparoscopic Instrumentation

- Laparoscopic cart
  - Television monitor
  - Color video chip camera
  - High-intensity light source
  - High-flow CO_2 insufflator
- Lapararoscope, 10 mm 30°, 45°
- Clip applicators, 5-mm, 11-mm
- Trocars, two 12 mm, two 5 mm, one 15 mm
- Scissors
- Harmonic scalpel
- Endovascular stapler
- Port closure device
- Endoscopic specimen bag
- Hemostatic agent, Surgicel, avitene
- Suction irrigator
- Grasping forceps, Maryland, right angle
- Hand access device (optional)

of the basic laparoscopic instruments recommended for the laparoscopist, presumably for a laparoscopic nephrectomy. With experience, each surgeon will develop his or her preferences for certain instrumentation, and should modify the list over time.

PATIENT SELECTION

With a dedicated team in place, the laparoscopist must choose a patient for his or her initial case. As stated, the urologist interested in learning laparoscopy will most likely apply it initially to radical nephrectomy in hopes of avoiding a flank incision and its attendant morbidity. More complex cases such as live-donor nephrectomy, radical prostatectomy, and radical cystectomy should not be attempted by the inexperienced laparoscopist, regardless of how adept that surgeon may be at the open procedures.

When selecting an appropriate initial case, the surgeon should make every effort to maximize the chance of completing the case laparoscopically. This will provide the most benefit for the patient, and will help the surgeon with his or her confidence level for future cases. Favorable renal tumors that can be approached laparoscopically by the novice surgeon include small tumors, lower pole tumors, and tumors away from the hilum. These cases are typically not associated with friable, parasitic vessels and will afford the surgeon the opportunity to approach the case systematically and most closely simulate the animate laboratory experience. On the contrary, initial cases to avoid include tumors near the hilum, tumors with a venous thrombosis, and large upper pole tumors, especially on the right side where the lesion may be close to the inferior vena cava.

Another key component to initial case selection involves avoiding cases in patients who have undergone extensive prior intra-abdominal surgery. This may significantly prolong operative time and increase the chance of injury to other intra-abdominal injury. In addition, very thin patients with tight abdominal musculature often prove a challenge, as their abdominal cavity does not expand much with insufflation, thereby limiting the working space for the surgeon. This will especially hinder the laparoscopist performing a hand-assisted nephrectomy, as the surgeon's hand will occupy much of the working space in this patient. Also, patients with are morbidly obese do not represent good initial cases, because these procedures are often long and require a much more laborious dissection through extensive perinephric fat.

A complete patient evaluation is recommended for any patient undergoing a laparoscopic nephrectomy. In preparation for initial cases, the novice surgeon will benefit from an advanced radiologic evaluation of the kidney, such as a computerized tomography (CT) angiogram, preferably with three-dimensional reconstructed images. This will detail the vascular anatomy for the surgeon and allow careful preoperative planning of the hilar dissection.

Another important component of patient preparation is the surgeon's preoperative discussion with the patient about the laparoscopic approach. The rationale for electing to use a laparoscopic approach should be detailed, including less postoperative pain, better cosmesis, and a shorter hospitalization. In addition, if indicated, assure the patient that the procedure adheres to all oncological principles of extirpative surgery. Most importantly, the laparoscopist should be honest with the patient about his or her experience with this new technique. If it is the initial case, the patient must know this, and be reassured that the first priority is to complete the surgery safely, even if this entails converting to an open procedure, if necessary. The patient should always be consented for a possible open procedure, regardless of the experience of the operating surgeon. It is important for all parties to understand that an open conversion is not a failed procedure. Conversion to an open procedure is part of the learning curve for any laparoscopic procedure, and remains a safe option for any laparoscopic case that fails to progress.

COST

This new technology has number of implications for patients, health care providers, and hospitals; for quality of care; and for society as a whole. One important consequence is in the allocation of resources. There have been numerous studies examining the "cost-effectiveness" of laparoscopy vs open surgery *(8–10)*. The evidence is not conclusive about whether laparoscopic surgery results in lower costs for the health care system. Laparoscopy does bring savings in a reduced hospital stay, and indirectly as a result of a reduced period of sick leave. From the point of view of the hospital, laparoscopic operations cost more than open operations because of the initial investment in instruments and initial longer duration of operating and anesthesia time. Owing to these direct costs, some novice surgeons may encounter resistance from their hospitals regarding these start up expenses (*see* Table 2). However, as laparoscopic skills are learned, operating times decrease and more patients are recruited to the hospital rather than away to seek minimally invasive treatment elsewhere. In addition, with a steady increase in the number of cases performed, investment in reusable instrumentation and trocars may be an opportunity for cost savings per case for the hospital.

The cost to the novice surgeon is primarily indirect. Initially, the surgeon will experience longer operative times, which translates into less revenue from time lost in the office and doing other procedures. With time, as skills are improved and maintained, the technology offers opportunities to expand the scope of the urologic practice and

Table 2
Direct Costs of Basic Laparoscopy Set-Up

Equipment	*Cost*
Laparoscopic cart	$37,000
Laparoscopes (3)	$12,000
Trocars (reposable)	$1,000
Instruments	$9,000
Harmonic scalpel	$20,000
Generator	
Hand pieces	
Hand access device (2)	$1,000
Total	$80,000

increase the referral base. Once again, this project begins with a prospective urologist who is dedicated to developing laparoscopic skills and incorporating a safe and effective treatment option to open surgery into his/her armamentarium.

CONCLUSIONS

Laparoscopic surgery is part of the rapidly growing field of minimally invasive therapy that has moved to the forefront in many urologic extirpative procedures, especially simple and radical nephrectomy. The adoption of laparoscopic surgery as a new therapy necessitates a considerable commitment by the prospective surgeon to endure the steep learning curve that exists in acquiring and maintaining basic laparoscopic skills. In addition, there is a significant financial commitment to be made by the hospital and the members of the practice.

TAKE HOME MESSAGES

There are several take home messages from this chapter for the prospective laparoscopic surgeon.

1. Take an introductory course featuring didactic lectures and training in an animate laboratory.
2. Work with an experienced laparoscopic surgeon during the initial cases.
3. Take a team approach to getting started in laparoscopy by designing a dedicated operating room team including a camera operator, anesthesiologist, and nursing staff.
4. Choose a “beginner-friendly” case to develop skills and build confidence.
5. Educate patients and referring physicians about laparoscopy in order to advance and maintain laparoscopic skills.

These concepts will help the novice laparoscopist develop the safest and most efficient way to adopt this technologically advanced procedure.

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2 Laparoscopic Instrumentation

Patrick S. Lowry, MD
and Stephen Y. Nakada, MD

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INTRODUCTION

Laparoscopic instrumentation has evolved significantly in the last decade. We now have less traumatic access devices, improved laparoscopes, a new generation of coagulation devices, better tools for managing vessels, and smaller instruments. Today, combined with advances in techniques, laparoscopy may be performed through fewer, smaller, and less painful incisions than ever, with equivalent results.

CAMERA SYSTEM

Current camera systems have a camera head, a camera system unit, and a monitor. The camera head has a coupling device that attaches to the eyepiece of the endoscope.

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The camera is then plugged into the camera processing unit, which delivers the image captured by the head to the monitor. The camera unit controls the brightness, focus, color, sharpness, and contrast. Laparoscopic cases generally have two monitors, one on either side of the patient, which allows all members of the operative team to participate in the surgery being performed.

Digital imaging offers advantages over analog systems, especially in picture clarity *(1)*. Traditional cameras allow the image to pass from the lens through the laparoscope to the camera, where it is captured and relayed to the processing unit. Recent advancements in camera technology have been along the avenue of digital imaging. The charged coupled device (CCD) is a tiny chip placed at the end of the scope under the lens system *(2)*. This allows the image to be captured by the CCD at the tip of the camera and transmitted through the scope by wires instead of an inner lens system. Allowing the image to pass through the scope via wires instead of a lens system may allow for smaller scopes without sacrificing picture quality. Recent three-chip systems have further improved clarity, although at increased cost. Digital technology also allows images to be saved digitally, and then printed, stored, or shared via the internet *(3)*.

LAPAROSCOPES

The laparoscopes most commonly used are 10 mm and 5 mm in diameter. Standard lenses come with 0, 30, and 45° of angulation (*see* Table 1). Some laparoscopes are also made with a deflectable tip to increase flexibility. Larger scopes give superior field of view, but technology is allowing the smaller, less invasive scopes to close the gap. As with the cameras, digital chips at the tip of the instrument allow for digital images, which should eventually allow scopes to become smaller without losing the digital clarity. Videolaparoscopes have the camera built in to the scope as one unit, preventing a potential loss of visual quality from the connection between the scope and the camera. Three-dimensional laparoscopes use scopes with two parallel lens systems that are in a slightly different orientation. These two images are captured separately, then viewed together by using a special set of glasses. This system produces an image with more depth of field, which may help in delicate procedures *(3)*. Fogging of the lens can be prevented with application of an anti-fog solution. A heating thermos keeps the lens at body temperature until use, which helps the lens from clouding on initial placement.

INSUFFLATION SYSTEM

The insufflator acts as the control mechanism that controls the rate of pressurized gas flow into the patient, as well as the pressure of the gas inside the patient. The insufflator bridges the conduit of tubing that brings gas from a pressurized canister of carbon dioxide to the patient. The insufflator is the key to making this a controlled transfer of gas.

Carbon dioxide is used most commonly as an insufflant. CO_2 is relatively inert, and is very soluble in blood, which reduces the risk of embolus. It may be absorbed into the bloodstream, causing a mild respiratory acidosis. With general endotracheal anesthesia, however, this should not be a problem. Argon can be used because it is inert and inexpensive, but it is less easily absorbed than CO_2, making the risk of gas embolus greater. Helium, which is also inert, may also be used. Nitrous oxide should not be

Table 1
Instrumentation for Urologic Laparoscopy

Name of device[a]	*General description*	*Company*	*Chapter references*
Access devices			
Visiport device	Access device, visual trocar	U.S. Surgical	13
Optiview trocars	Access device, visual trocar	Ethicon	5,6,7,8,9,14,16,17
Hasson cannula	Access device, open technique	[b]	4,6
Veress needle	Accessdevice, closed technique	[b]	4,6,8,10,11,13,14
Trocar-mounted balloon	Access device for retroperitoneal approach	Origin Medical Systems, U	5,7
Blunt-tip trocar	Access device, open technique	[b]	7
Balloon trocar	Access and dissection	GSI, Cupertino, CA	6
Imaging technology			
5-mm 0° laparoscope	Imaging and visualization	[b]	6,8,16
5-mm 30° laparoscope	Imaging and visualization	[b]	6,7,8,13,16
10-mm 0° laparoscope	Imaging and visualization	[b]	5,8,14–16
10-mm 30° laparoscope	Imaging and visualization	[b]	5,8,12,13,14,16
Laparoscopic ultrasound probe	Imaging adjunct	Aloka	5,12
Dissection and retraction			
Hook electrode	Dissection and cautery	[b]	6,7,11,13–15
5-mm bipolar cautery	Dissection and cautery	[b]	6,11,13,16
5-mm Kitner	Dissection instrument	[b]	6,16
Harmonic scalpel, ultrasonic shear	Dissection instrument	[b]	1,8–14,16
Electrosurgical scissors	Dissection instrument	[b]	4,8,9,13–15
5-mm curved dissector (Maryland)	Dissection instrument	Storz	8,9,14,15
Fan retractor	Retraction instrument	[b]	4,12,13,15
10-mm right angle	Dissection instrument	[b]	8,9,11,13–15
5-mm irrigator/aspirator	Retraction and dissection	Nezhat	4,6,12,14–16
Endoholder	Retraction, holds laparoscope	Codman	11
Peer retractor	Retraction	Jarit	11
5-mm locking/grasping forceps	Retraction device	[b]	4,6,16
12-mm Endopaddle	Retraction device	U.S. Surgical	13

(continued)

Table 1 *(continued)*

Name of device[a]	*General description*	*Company*	*Chapter references*
Diamond-flex triangle retractor	Retraction device	Genzyme Surgical product	14
5-mm cold knife	Dissection instrument	[b]	16
Urethral sound, 24F curved	Adjunct for identifying urethra	[b]	16
One-inch cervical dilator	Retraction instrument	[b]	16
5-mm atraumatic small bowel clam	Retraction instrument	[b]	15
Special adjucts			
Microwave tissue coagulator	Hemostasis adjunct	[b]	10
Argon-beam coagulator	Hemostasis adjunct	Conmed	5
LapSac	Specimen retrieval bag	Cook Urologic	5,6,7,8,12
Endocatch bag, 10-mm, 15-mm	Specimen retrieval bag	U.S. Surgical	6,7,11,13,15,16
Carter-Thomason	Port-closure device	Inlet Medical	8
AESOP robotic arm	Robotic arm to hold laparoscope	Computer Motion	13,16
Open tray in room	Safety measure	[b]	All chapters
Hemostatis and reconstruction			
Endostitch	Reconstruction	U.S. Surgical	8,14
Lapra-ty clips and applier	Hemostasis and reconstruction	Ethicon	8
10-mm Satinsky clamp	Hemostasis device	Aesculap	8
Endo-GIA stapler, vascular load	Hemostasis	[b]	6–9,11,12,13,15
Reusable clip applier	Hemostasis	Weck	7,9,15
5- or 11-mm clip applier	Hemostasis	Ethicon	7,11,12,13,15
Ligasure device	Hemostasis device	ValleyLab	17
Laparoscopic needle drivers	Reconstruction	[b]	14–16
Fibrin glue	Hemostasis	[b]	10
Gelfoam	Hemostasis	[b]	10
Hand access devices			
Gel-Port	Hand access device	Applied	9–11
Lap-Disc	Hand access device	Ethicon	9,10
Omniport	Hand access device	Weck	9,10
Handport	Hand access device	Smith and Nephew	9,10

[a]Note that this list is not all encompassing, but it useful to identify items that are mentioned by multiple experts.
[b]Available from multiple vendors.

Fig. 1. Veress needle for closed insufflation of the abdomen. Note the retractable protective tip (top), which when pulled back (bottom), exposes the sharp needle tip.

used, either as an insufflant or as an anesthetic, because it can support combustion when used with cautery or laser.

ACCESS

The Veress needle, a 14-gauge needle with a spring-loaded protective tip, is most commonly used for closed insufflation of the abdomen (Fig. 1). After insertion, the position is confirmed by allowing water to freely drop through the needle. The needle is then removed and the trocar is then advanced into the peritoneal cavity. The remaining trocars are then placed under visualization of the camera.

Alternatively, a Hasson technique may be used. This involves a cutdown through the fascia with placement of the Hasson trocar under direct visualization. The abdomen is then insufflated, the camera inserted, and remaining trocars placed under visualization of the camera.

For retroperitoneal access, a balloon device may be inflated in the retroperitoneum to expand the potential space. With the camera in place, other trocars are placed.

TROCARS

Trocars are available in various options including bladed, nonbladed, reusable, and disposable (Fig. 2). Some allow the camera to be placed in the trocar sheath during placement, to help confirm proper insertion *(4)*. Bladed trocars have a sharpened tip designed to cut through the fascia (Fig. 3). After piercing the fascia, a protective tip springs back over the sharp tip to protect the abdominal contents. The fascia must be closed on all 10-mm ports, and 5-mm ports in children.

Nonbladed trocars do not have a sharpened blade, but a conical plastic tip that spreads the muscle and fascia, rather than cutting it (Fig. 4). Some allow the laparoscope to be placed into the trocar to visualize the various layers of the abdominal wall as it is being penetrated (Fig. 5). Other nonbladed systems have a sheath that dilates with introduction of the trocar. Recent studies have suggested that when using these dilating trocars, fascial closure may not be necessary *(5,6)*. We recommend closing

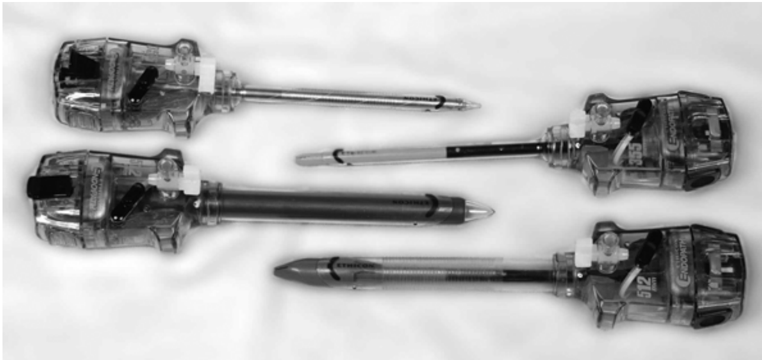

Fig. 2. Trocars. Left, 5- and 10-mm nonbladed trocars. Right, 5- and 10-mm bladed trocars.

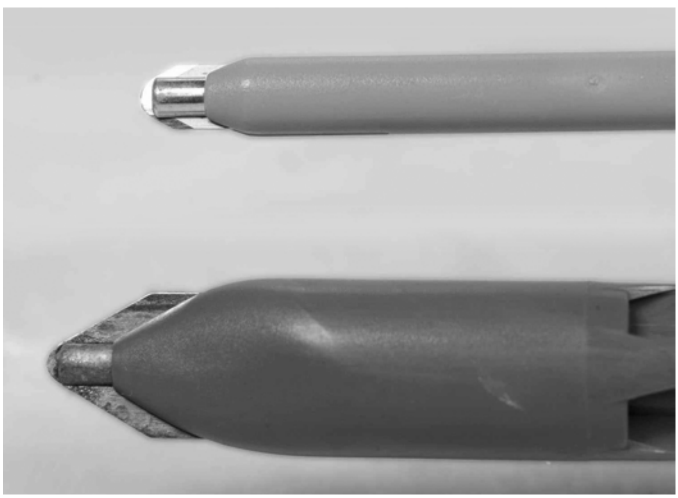

Fig. 3. Bladed trocars. Top, 5-mm (top) and bottom, 10-mm bladed trocar tips with protective sheath retracted to expose blades.

all 10-mm ports after one of our patients developed a hernia at a 10-mm nonbladed port site *(7)*.

Reusable trocars are less expensive in the long run, but can show signs of wear. At this point, they are not available with nonbladed tips. Disposable bladed trocars are more expensive in the long run, but have the advantage of safety shields that snap over the trocar tip as it passes into the abdomen, protecting intra-abdominal organs form injury.

HAND ACCESS DEVICES

Three first-generation devices include the HandPort (Smith and Nephew, Andover, MA), the Intromit (Applied Medical, Rancho Santa Margarita, CA), and the Pneumosleeve (Dexterity, Atlanta, GA) *(8)*. The HandPort and the Pneumosleeve are two piece devices that use a template on the abdomen and a sleeve worn by the surgeon. The sleeve attaches in an airtight manner to both to the abdominal template and the wrist of the surgeon, preventing loss of air. The Intromit is a one-piece device that inflates around the surgeon's wrist, causing an airtight seal by the pressure of the inflation.

Fig. 4. Nonbladed trocars. Five-mm and 10-mm nonbladed trocar tips. Note tips are clear so laparoscope may be used to watch introduction of scope through abdominal wall.

Fig. 5. Nonbladed trocar with laparoscope introduced through the trocar lumen.

Both the Intromit and the Handport will maintain the pneumoperitoneum with only an instrument or laparoscope in the device.

Second-generation devices include the Gelport (Applied Medical, Rancho Santa Margarita, CA), Omniport (Weck, Research Triangle Park, NC), and LapDisc (Ethicon, Cincinatti, OH). These devices allow introduction of instruments or scopes without loss of air. The Gelport uses a soft gel-type of cap with a small slit through which the surgeon places a hand (*see* Fig. 6). The port stretches around the wrist, providing an airtight seal. The Gelport allows transfer of the hand in and out of the port without loss of the pneumoperitoneum. The LapDisc prevents loss of air pressure by using an adjustable iris system that tightens around the wrist. The Omniport uses a one-piece design that inflates around the wrist.

CAUTERY

Several types of cautery exist for laparoscopic use. Monopolar cautery is usually used on a hook-type instrument, but can also be attached to endoshears and graspers. One must take care to stay well away from adjacent organs as dispersion of energy

Fig. 6. The Gelport hand access port device. The right shows the inner portion of the port placed on the abdomen for use. The left shows the port with gel cap in place and hand through port.

Fig. 7. The harmonic scalpel. Inset shows jaws open with active portion on the bottom.

can affect adjacent tissue several millimeters away. Bipolar forceps focus energy only between the jaws of the instrument. This decreases the chances for inadvertent injury of nearby structures, making bipolar cautery well-suited for laparoscopy. A tripolar system is being developed that, like the bipolar, keeps the energy between the grasping forceps. However, after coagulation, the tripolar has a blade that will transect the tissue.

The harmonic scalpel is an ultrasonic device that vibrates at a rate of over 55,000 times per second (Fig. 7). The ultrasonic energy simultaneously cuts tissue and seals blood vessels up to 3–4 mm in diameter. The harmonic graspers allow the tissue to be grasped between an ultrasonic energy arm and a Teflon™ arm for coagulation.

The argon-beam coagulator uses high-flow argon gas around an electrode that, when activated, produces a stream of electrons to the tissue. Surface bleeding can be controlled with little penetration of energy into the tissue. When using the argon beam laparoscopically, the ports must be opened to allow for gas leakage. This will prevent high abdominal pressures and potential complications such as air embolus or pneumothorax.

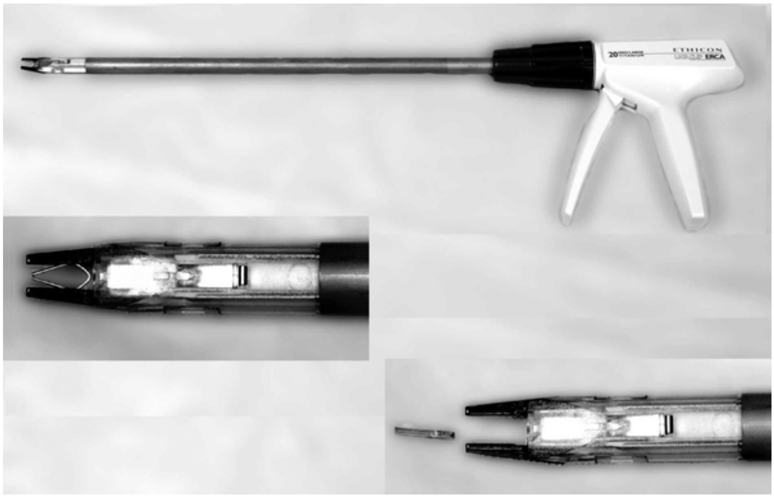

Fig. 8. Clip appliers. Inset shows clip being applied, with the tip coming together before the clip is fully compressed. This allows the clip to be adjusted if necessary prior to complete application.

HEMOSTASIS

Although coagulating devices are the mainstay of hemostasis, there are other tools that may help control bleeding, including clipping devices, staplers, and hemostatic agents.

Clips can control most vessels, even the renal artery, as long as the artery or vein can be manipulated in such a manner as to place the clip completely across the vessel. Clip appliers have rotating heads to facilitate clip placement (Fig. 8).

Stapling devices place two types of staples, bowel and vascular. The vascular staples are used for ligation and division of the vein, as well as the artery or even ureter, if desired. Vascular staples are 1 mm in height and designed for hemostasis, compared to the bowel staples, which are 1.5 mm in height and used for tissue approximation. Stapling devices have heads that not only articulate, but deflect at the tip (Fig. 9).

Hemostatic agents may also be used for control of bleeding. Surgicell (cellulose) can be placed into the operative field through a port, and applied to bleeding spots with mild to moderate pressure using an instrument. This will control many small vessels that are in a location not amenable to clip placement or cautery. Fibrin spray is available in a laparoscopic delivery system. When exposed to the factor XIII in the blood, fibrin monomers polymerize to form a stable clot. Like many laparoscopic instruments, cost is an issue as fibrin glue is expensive.

SUTURING

Freehand intracorporeal suturing with intracorporal knots is possible, but is a tedious process to learn and even more difficult to master. Improved needle holders have facilitated suturing somewhat, but the learning curve continues to be long.

The development of automated suturing devices has made suturing easier to perform, and has allowed reconstructive procedures, such as pyeloplasty and urinary diversion,

Fig. 9. Vascular stapler. Inset shows the capability of the ratcheting joint, which aids in aligning the stapler.

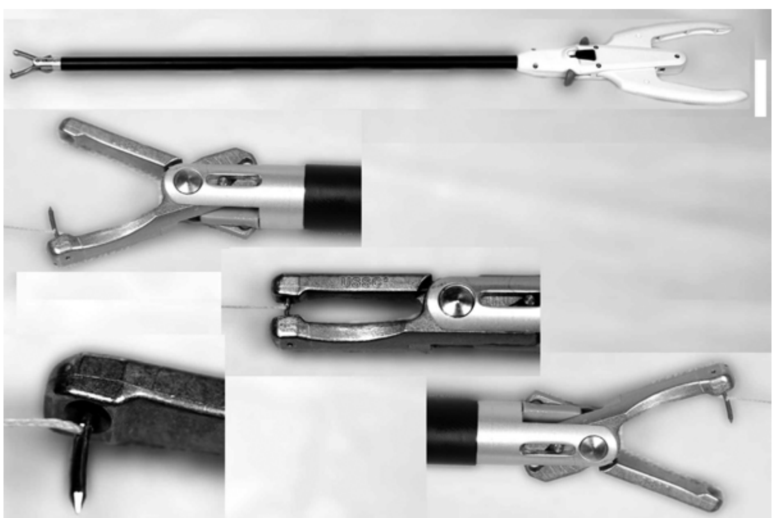

Fig. 10. Endostitch device. Insets show how needle with the stitch in its center is transferred from one arm to the other. Lower left inset is a magnified view of the needle in one of the jaw arms.

to become less time-consuming. The Endostitch device (Fig. 10) was the first automated device described *(9)*. This device employs a needle with a stitch attached to the middle of the needle. The needle is passed back and forth between the jaws of its needle holder. The control of the needle in the jaws of the needle driver also gives an advantage when tying the intracorporal knots. There are several other devices to aid in suturing coming to market at the time of this writing. Interested urologists should seek out all the latest options.

DISSECTING INSTRUMENTS

A wide variety of well-made dissecting instruments are available. A fine-tipped Maryland dissector is most commonly used, but Babcocks, Allis clamps, right angles,

Fig. 11. Dissecting instruments. Inset shows close up view of several types of instruments; (from top to bottom) atraumatic grasper, Maryland, alice, and cutting shears. All instruments rotate 360°.

dolphin-tipped, blunt-tipped, atraumatic graspers, kittners, and toothed graspers are all available (Fig. 11). Five-mm instruments have finer tips for more delicate work, while 10-mm instruments are stronger. Almost all instruments rotate 360°, with better actions than in the past. Many are nondisposable, but some instruments, such as scissors, preferably should be disposable. Nondisposable scissors require regular sharpening, and have fine actions that must work almost perfectly to be effective. Nondisposable instruments, however, give significant cost benefits to the procedure.

Mechanical tissue-dissection devices are designed to facilitate tissue dissection while minimizing blood loss. The pneumodissector uses bursts of air to dissect through tissue while leaving blood vessels relatively intact. These vessels are then controlled with some type of cautery or with clips. The cavitation ultrasound aspirator (CUSA) hydrodissector works on a similar principle, but uses water instead of air to dissect through tissue.

RETRACTORS

A fan retractor inflates a fan-shaped end, which is large enough for retraction, yet pliable enough to avoid damaging tissue. It must be placed through a 10-mm port.

A diamond flex triangle retractor (Genzyme) may be placed through a 5-mm port, and the end is formed into a loop for retraction (Fig. 12). This tool is excellent for retracting the liver. The Peer retractor (Jarit) is also an excellent retractor (Fig. 13), but can be traumatic if the surgeon is not careful.

NEEDLESCOPIC INSTRUMENTATION

Needlescopic ports have an outer diameter of 2 mm. Instruments available include scopes, graspers, scissors, and endoshears with electrocautery attachment. A suction irrigator is also available, but has limited utility owing to the tiny diameter of its lumen. The mechanism of the scissors and graspers are delicate, and all instruments bend easily if torque is applied.

Compared to the 5- and 10-mm laparoscopes, minilaparoscopes provide a smaller field of view and inferior image quality. In addition, because the focal angle is small, the scope must be close to the viewed structure, which increases glare. Minilaparoscopes are only available with a 0° lens. Slightly larger scopes are available in a 3.3-mm size.

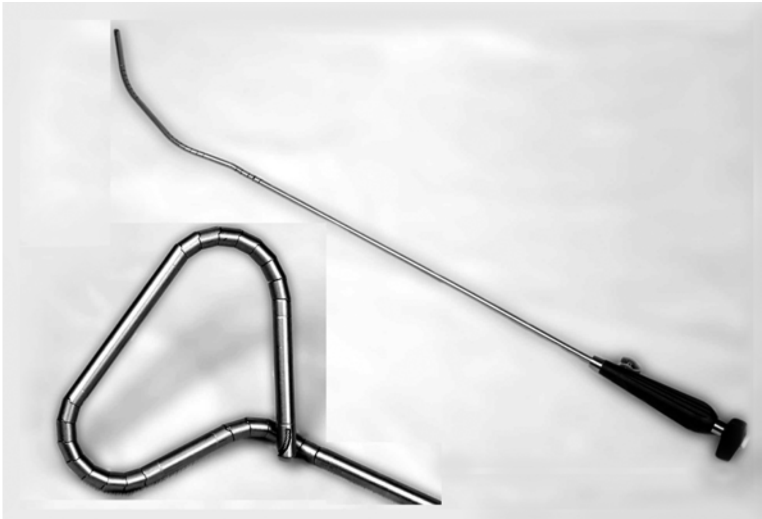

Fig. 12. The diamond flex triangle retractor (Genzyme). Inset shows the retractor after deployment.

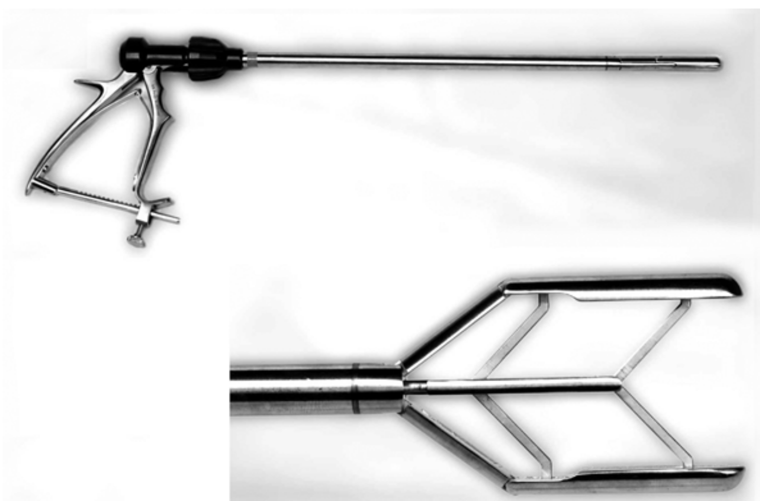

Fig. 13. The Peer retractor (Jarit). Inset shows retractor after deployment.

Available in 0 and 30°, they offer improved optics and somewhat larger viewing angle than the 2-mm scopes *(10)*.

ADJUNCT INSTRUMENTS

The laparoscopic ultrasound probe can evaluate the kidney for tumor extent or synchronous lesions in partial nephrectomy. It is also used to follow the ice formation during cryotherapy.

The Carter-Thomason device is excellent for placement of sutures for fascial closure in 10-mm port sites *(11)*.

For removal of specimens, the entrapment sacks are used to catch the organ, and then pull it toward a port or incision for removal (Fig. 14). If planning to morcelate a

Fig. 14. Endocatch device. Insets show device prior to introduction of the endocatch bag and after partial introduction of the endocatch bag. Note arrows, which point to the open end of the bag.

specimen, one must be aware that not all sacs are impermeable to cells. Morcellation can only be performed with specimen bags that are impermeable to fluid and tissue. Currently, the LapSac (Cook Urological, Bloomington, IA) is the only available sac impermeable to tumor cells.

Combination aspiration/irrigation systems allow for bleeding and clot formation to be washed away and cleared. The instrument may also be used as a dissector or retractor.

MORCELLATION

Morcellation using an impermeable entrapment sac is performed using instruments such as a Vanderbilt, Serat, or ring forceps to break up the specimen into pieces small enough to allow the sac to be pulled through the 10-mm port. Alternatively, an electrically driven device, when pressed against the specimen, will suck out 10-mm cores of tissue until the specimen is small enough to be brought out through the trocar site.

ROBOTIC SURGERY

Recently, robotic systems have been successfully trialed for all types of laparoscopic surgery. Advantages to these systems include a steady three-dimensional view by the camera and a steady hand of the surgeon. The tips of the instruments deflect, giving an added dimension for dissection and reconstruction. Potential advantages to robotic surgery over traditional laparoscopy include better visualization, shorter learning curve, and facilitated reconstruction during pyeloplasty and prostatectomy.

The da Vinci system Surgical System has three components; a console with a three-dimensional viewing system for the surgeon, a surgical cart with three telemanipulator arms, and a vision cart. The laparoscopic instruments have articulating tips called *EndoWrist* instruments, which give more control and operative capability *(12)*. The Zeus System also has three major components: a surgeon console, a computer controller, and three robotic arms. The image is controlled by the AESOP (automated endoscopic surgical optimal positioning) arm, which is controlled by either voice activation or foot pedals. The tips of the laparoscopic instruments are controlled by the *MicroWrist* technology to deliver wrist-like movements, enhancing precision of delicate movements.

Robotic systems have exited their infancy, and are perhaps already preferred for laparoscopic prostatectomy. Improvements in this technology, a decrease in its cost, and the use of robotics in other surgical disciplines should make this more available for hospitals, and consequently more accessible to urologists.

CONCLUSION

The future of laparoscopic instrumentation will continue offer the capability of performing similar surgery with more precision and less trauma for the patient. More instruments should be available for use through smaller ports, and with the aid of digital capability, better images should be available through smaller caliber laparoscopes. Further advances may allow trocar placement with less damage to the fascia, and improved needlescopic equipment would further decrease harm to the abdominal wall. Laparoscopy should continue the trend toward providing equivalent outcomes through fewer, smaller, and less painful incisions.

TAKE HOME MESSAGES

1. Instrumentation for laparoscopy is constantly evolving and improving, particularly as a result of the digital and robotic age.
2. The current trend is toward smaller instrumentation and trocars.
3. The endovascular stapler remains a mainstay of extirpative laparoscopic renal surgery.
4. Robotics has simplified laparoscopic reconstruction.

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3 Operating Room Set-Up and Accessing the Abdomen

Michael D. Stifelman, MD

Contents

INTRODUCTION

A laparoscopic procedure is similar to flying a commercial plane. There is the captain (surgeon), the co-pilot (assistant), and the crew (anesthesia, scrub nurse, and circulator). Each work simultaneously performing distinct tasks leading to one goal. Both rely heavily on technology and require careful and thorough preparation prior to embarking. Similar to the captain of a plane, it is the surgeon who is ultimately responsible for the outcome.

It is imperative that the surgeon arrive to the operating room (OR) with sufficient time to ensure all the equipment is present and functioning, similar to a pilot before take-off. The time to realize that the nurse opened the wrong endoscopic linear stapler is not while ligating the renal vein, it is during the set-up of the procedure. Arriving early will also allow proper positioning of the many different pieces of equipment to ensure ease of traffic throughout the room. The operating room has a tendency to become very tight, especially when it contains two monitors; an argon-beam coagulator; cautery generator; ultrasonic generator; compression stocking insufflator; and warming blanket, each with its own power cords, cables, and foot pedals.

OPERATING ROOM SET-UP

In an attempt to organize the preparation, we have created a checklist (*see* Table 1). It is separated into five components: Video equipment imaging system, Insufflation, Hemostatic generators, Laparoscopic instruments, and OR table. Not every laparoscopic case requires all the equipment listed; however, we have made the list comprehensive so as to provide a foundation with which to work. Subsequent chapters will deal specifically with each of these topics in greater detail.

Room arrangement depends on the surgical procedure to be performed; however, there are some general principals that pertain to all cases. The surgeon, operative

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
Edited by: S. Y. Nakada © Humana Press Inc., Totowa, NJ

Table 1
OR Set-Up Check List

- Video equipment imaging system
  - Main monitor and slave monitor
  - Camera box with three-chip camera or better
  - Fiber optic light cord and Xenon light source. (Check quality of light cord by holding end, which connects xenon light source to fluorescent light. Look at cord that connects to laparoscope. Each black dot represents a broken fiber optic fiber. There should be less than 15% of areas blacked out.
  - Laparoscope: 0° and 30° diameter (3-, 5-, 10-mm) is preferable
  - Sterile camera bag
  - +/– Video recorder. Note that a digital camcorder can easily be connected to the camera box via an S video cable.
  - Connect all equipment, white balance, and focus
- Insufflation
  - High-flow insufflator, max flow 18 L/min, positioned on main monitor (especially useful for hand-assisted laparoscopy)
  - Full CO_2 tank, connected without leak and turned on. Check level of tank on insufflation unit.
  - Full spare CO_2 tank in room
  - Insufflator tubing
  - Set flow to 15 mmHg, check flow shut-off mechanism
- Hemostatic generators
- Electrocautery
  - Grounding pad in place
  - Cord on table and settings selected
  - If using bi-polar, cord is on table with bipolar instrumentation
  - Foot pedal is on surgeon's side of table
- Harmonic scalpel/ligasure
  - Laparoscopic handle assembled and connected
  - Function tested by activating on moist sponge
  - Foot pedal is on surgeon's side of table
- Argon-beam coagulator
  - Laparoscopic handle on field and connected
  - Argon gas tank is full, connected without leak, and turned on
  - Function tested by activating on moist sponge
  - Foot pedal is on surgeon's side of table
- Laparoscopic instruments
  - Veress needle
  - Trocars
  - Advanced laparoscopic set
  - Basic surgical tray
  - Laparotomy tray and self-retaining retractor opened and in room
- OR table
  - Electric motor that has capability of flexion, airplane tilt, and Trendelenberg

field, and monitor should be in a straight line (Fig. 1). This ensures the surgeon is optically correct, not in mirror image. The insufflator should be placed just below the main monitor or next to the main monitor so that the surgeon may have a constant and direct view. The surgeon should always be aware of the insufflation pressure, flow rate,

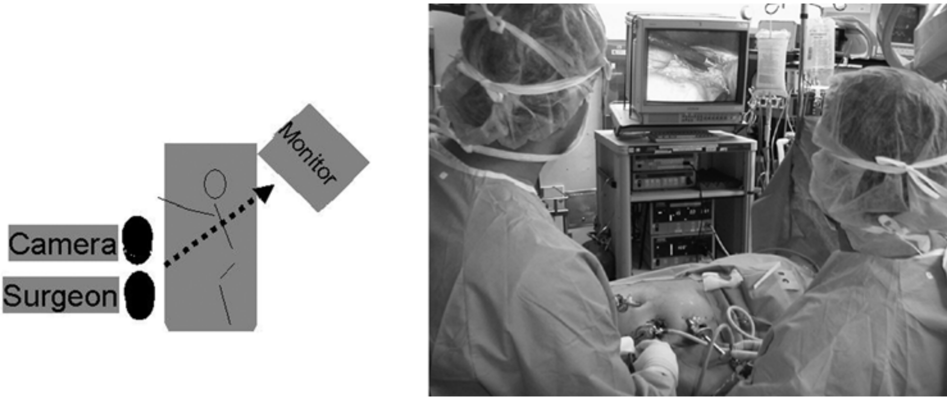

Fig. 1. Surgeon positioned to avoid mirror.

Fig. 2. Laparoscopy drape.

volume used, and tank status. Typically the camera and light source are also stored on the main monitor in direct view of the surgeon.

In addition to the "lines" for the insufflation tubing, camera, and light cord, there are many other lines that must enter the operative field, including suction, irrigation, bovie, harmonic scalpel, and so on. It is important to secure all lines to the operative field to minimize tangling and to allow all devices, including the laparoscope, to be placed within any of the trocars. To facilitate this, we recommend a specialized laparoscopy drape that has built in straps to secure lines and pockets to store and prevent instruments from falling off the field. There are many available drapes on the market; one designed by Allegiance is pictured in Fig. 2.

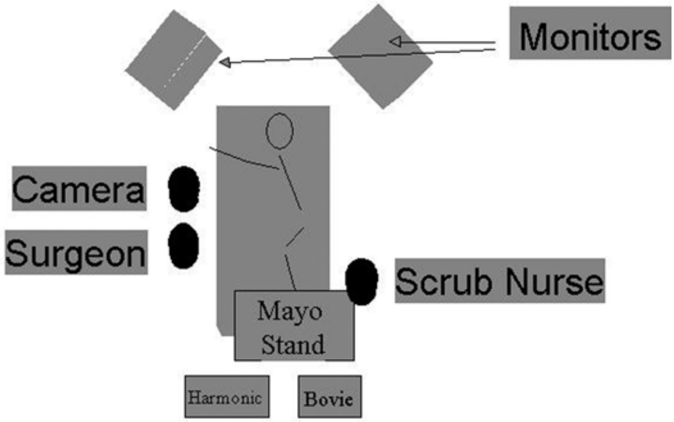

Fig. 3. Room set-up for transperitoneal procedure.

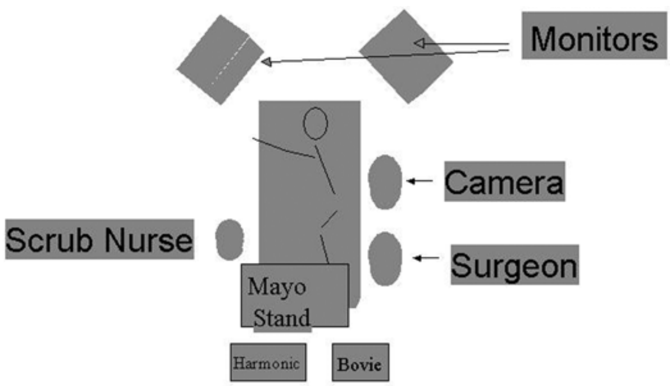

Fig. 4. Room set-up for retroperitoneal procedure.

We suggest that the scrub nurse and mayo be positioned opposite the surgeon so that instruments may be exchanged without having to turn one's head or lose eye contact with the monitor. This rule is less important in pelvic surgery, where the nurse may stand on either side of the operative table as long as he/she is below the surgeon in line with the monitors. The hemostatic equipment should be placed at the foot of the bed, thus preventing the surgeon from being "entrapped" by cords or grounding pads.

We have outlined our preferred OR set-up for transperitoneal, retroperitoneal, and pelvic procedures (Figs. 3–5).

GAINING ACCESS

When the room is set up, checklist completed, patient intubated, positioned, prepped, and draped, it is time to begin. The first step requires obtaining access and establishing a pneumoperitoneum. This can be done through either an open or a closed access technique. In either scenario, it is important to have a Foley catheter and oral gastric tube to decompress the bladder and stomach. In addition, it is recommended that the anesthesiologist avoid nitrous oxide to decrease bowel distention.

The closed technique traditionally has been performed using a Veress needle (Fig. 6). This specially designed needle measures 8 mm in length and is 1.2 mm in diameter.

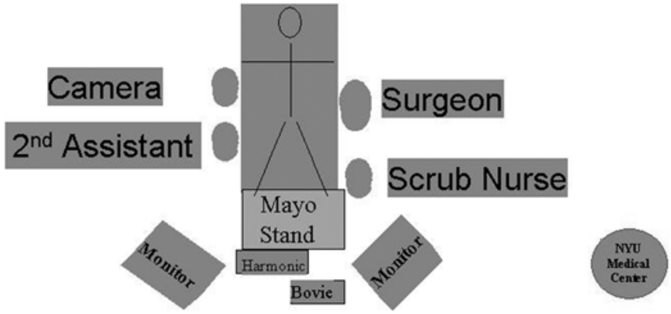

Fig. 5. Room set-up for pelvic procedure.

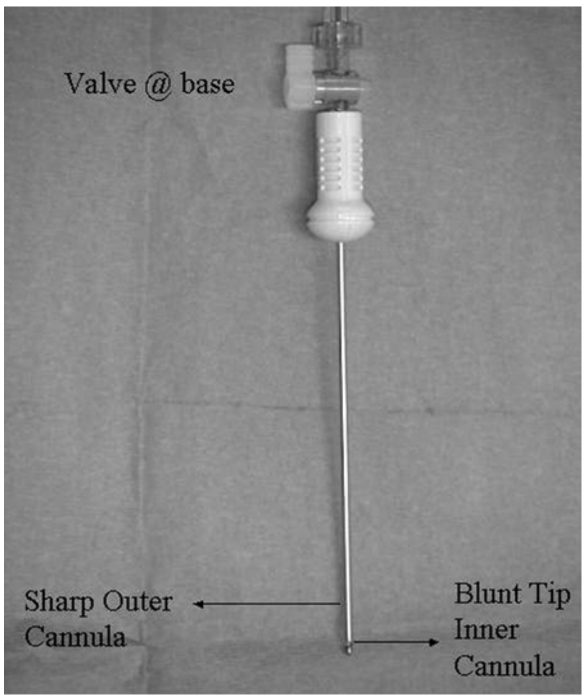

Fig. 6. Veress needle.

The outer cannula has a beveled edge for cutting through tissue. The inner cannula has a blunt-tip stylet that springs forward upon entering a space of low pressure such as the peritoneal cavity. This blunt stylet protects the abdominal contents from the sharp-tipped outer cannula. On the opposite end of the needle is a stopcock, which is contiguous with the inner cannula, allowing CO_2 to be insufflated into the abdomen.

When performing the closed access technique, the Veress needle is placed first. This allows the abdominal cavity to be insufflated separating the abdominal wall from the intra-abdominal viscera. A trocar is then placed blindly, providing laparoscopic access. In theory, the preliminary insufflation provided by the Veress needle decreases the risk of inadvertent injury to the abdominal viscera or vessels by separating the abdominal wall from the intra-abdominal viscera. Because this technique requires two blind "sticks," a thorough understanding of this approach, as well as the checks and balances, is required to minimize complications.

Fig. 7. Making trocar incision.

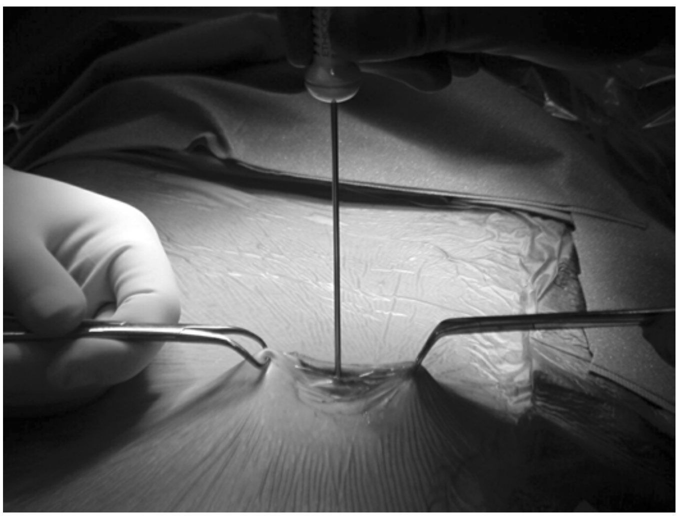

Fig. 8. Inserting Veress needle.

We prefer to obtain closed access at the level of the umbilicus. Here the abdominal wall is tethered to the fascia and the abdomen is most easily penetrated. If a midline scar is present, we recommend using an alternate access site lateral to the rectus in the quadrant opposite the site of previous surgery. The skin incision is curvilinear when obtaining access peri-umbilically, vertical when placed anywhere else along the midline, and horizontal for access obtained away from the midline. It is important to ensure the skin incision is large enough to accommodate the outer diameter of the trocar thus preventing excess force being placed on the trocar during insertion. One way to ensure this is to take the outer cannula of the trocar, make an impression on the skin, and use this as a guide for the length of the incision (Fig. 7).

After the incision is created, it is important to lift the abdominal wall away from the underlying viscera either by using towel clips placed just lateral to the edges of the incision or by using traction of the nondominant hand (Fig. 8). The Veress needle is then grasped like a dart and advanced at a right angle to the fascia. Elevation is maintained as the needle is advanced through the fascia and peritoneum. Often two distinct pops may be felt as the abdominal wall is traversed and an audible click heard

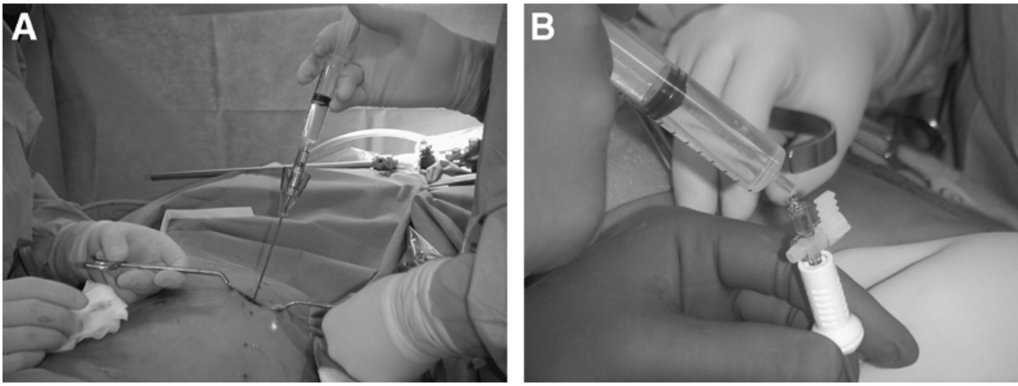

Fig. 9. Checking placement of Veress needle via **(A)** aspiration and **(B)** water test.

as the inner cannula springs forward upon entering the peritoneum. Deep penetration into the abdominal cavity should be avoided to minimize the risk of great vessel injury.

To ensure correct placement, a 10 cc syringe with saline is attached to the needle and aspirated to look for blood, enteric contents, or excessive air (Fig. 9). If blood is seen, the Veress needle should be removed. Secondary to the small diameter of the needle and blunt-tip inner cannula, it is usually safe to simply remove the needle and replace it. Once access is obtained, the initial puncture site as well as the retroperitoneum should be inspected for evidence of vascular injury or expanding hematoma. If the patient becomes hemodynamically unstable or vascular control is not feasible laparoscopically, emergent laparotomy should be performed. If enteric contents or excessive air is noticed, then the needle should be left in place and a new access site should be chosen. Once laparoscopic access is obtained via the second site, the initial needle placement can be confirmed and any perforation repaired. The decision to repair the injury laparoscopically or via an open approach is based on the experience and comfort of the surgeon. Though these complications are rare, in 0.05–0.2% of cases they do occur and vigilance is mandatory *(1–3)*.

Assuming no negative events have occurred, the next step is to inject 10 cc of saline through the needle and aspirate while maintaining elevation on the abdominal wall. No fluid should return. Next, a water droplet is placed at the hub of the needle and visually confirmed to pass freely into the abdominal cavity while elevating the abdominal wall. Inability to perform either of these steps suggests that the needle is not in the correct position and likely preperitoneal. The needle should be removed, repassed, and the steps listed previously performed from the beginning. The final step is attaching the insufflator to the trocar. The initial pressure reading should be low (<8 mmHg), the abdomen insufflated at a low flow rate (1–2 L/min), and no resistance confirmed. Once these steps have been completed, the flow rate may be increased and a four-quadrant pneumoperitoneum obtained.

Traditionally a sharp-tip, cone-shaped trocar was used to penetrate the abdominal wall. Recently, newly designed disposable trocars have been introduced in an attempt to further decrease the risk of inadvertent injury. These include trocars with flat blades that retract upon entering the abdominal cavity; blunt-tip trocars that radially dilate as they are inserted; and “one-step” trocars that utilize a mesh-like sleeve, which is introduced with the Veress needle and serves as a tract through which a blunt-tip radially dilating

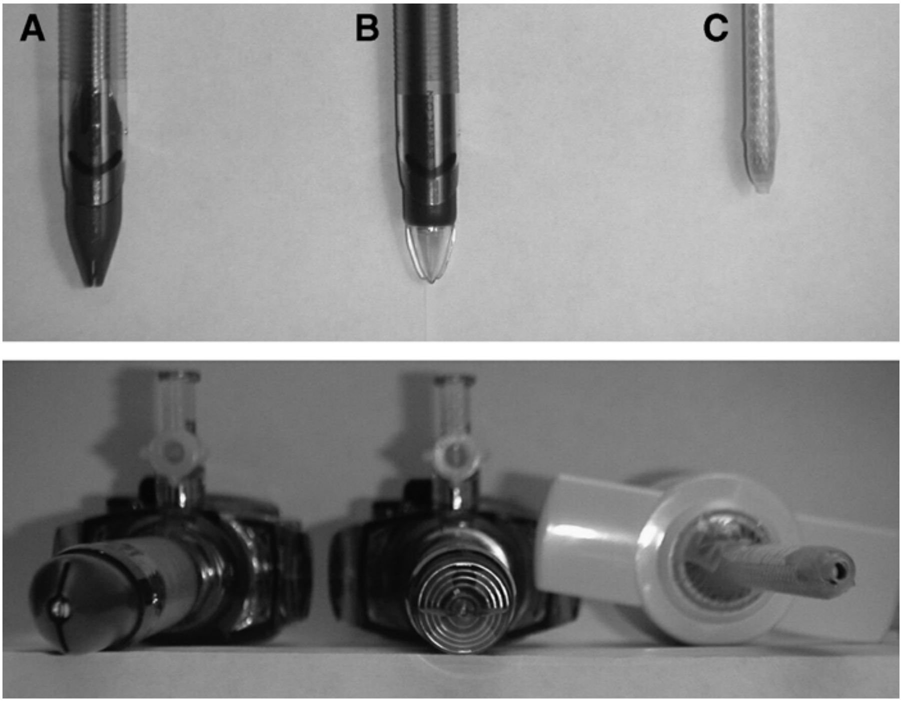

Fig. 10. Specialized trocar tips (two views): **(A)** cutting flat blade, **(B)** clear noncutting blunt tip, and **(C)** radially expanding.

trocar may be placed (Fig. 10A–C). Theoretic advantages of the radially dilating trocars are that they may not require closure of the fascia once removed and may cause less pain than traditional cutting trocars *(4,5)*. Most recently, clear trocars, which allow a 0° laparoscope to be placed within the tip of the trocar, have been introduced. This allows the surgeon to visualize the different layers of the abdominal wall as the trocar is placed into the peritoneum. Some surgeons have used this clear-tip trocar to access the abdomen without prior insufflation *(6,7)*.

In general, trocars with a sharp tip, designed for cutting tissue, should be inserted without rotation. Trocars with a blunt tip, designed to dilate the tissues, should be inserted by rotating the trocar between the 10 and 2 o'clock positions and applying a steady downward force. All trocars should be held in the palm of the hand with the index finger extended down the shaft to act a safety break from inserting the trocar too far too quickly (Fig. 11). Once in position, the inner cannula of the trocar is removed immediately and the laparoscope placed to ensure proper placement and to inspect the viscera.

The other option to obtain laparoscopic access is via the open technique. Hassan introduced this approach in an attempt to minimize the risk of inadvertent injury thought to be associated with the closed technique *(8)*. The open technique may be utilized during any transperitoneal approach and we recommend it in cases of previous intra-abdominal surgery, in all retroperitoneal approaches, and when hand-assisted laparoscopy is to be performed. When performing a transperitoneal approach, a semicircular incision is created either infra- or supra-umbilical (Fig. 12A). If there is a previous midline scar, the incision may be placed away from the scar, in an alternate

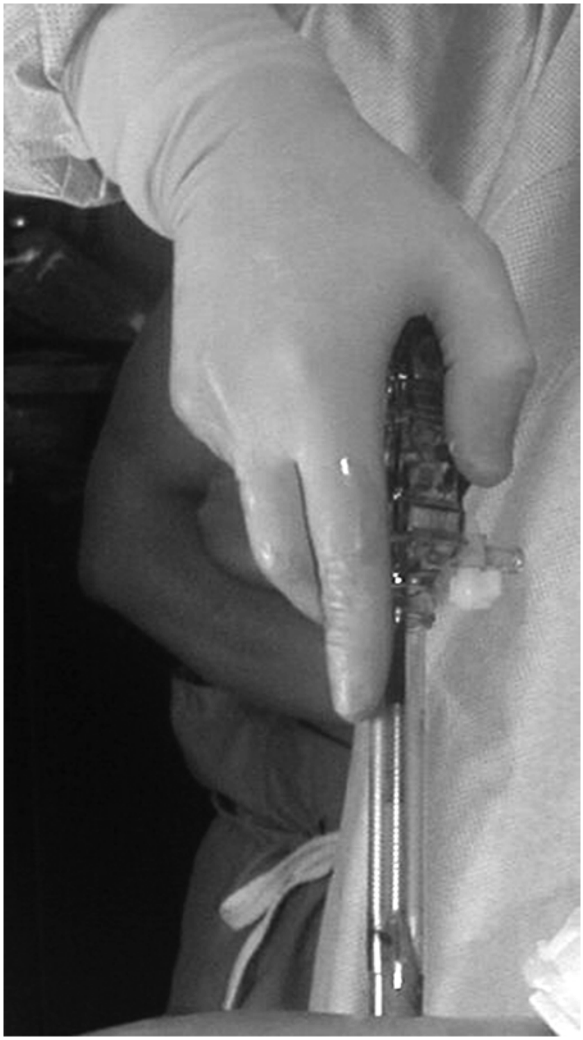

Fig. 11. Technique for inserting trocar.

position, usually lateral to the rectus and in a quadrant away from the previous surgery. The subcutaneous fat is cleared from the fascia using a combination of S retractors and a Kelly clamp. A 1.5-cm incision is created within the fascia, and an anchoring suture is placed on each side of the fascial incision. Next the peritoneum is identified, grasped between two clamps, and incised sharply (Fig. 12B). Entry to the abdominal cavity is confirmed visually or by placing a finger into the cavity and circumferentially palpating the smooth peritoneum lining the anterior abdominal cavity (Fig. 12C).

For a retroperitoneal approach, a horizontal incision is placed 2 cm inferior to the tip of the 12th rib (Fig. 13A). The subcutaneous fat is cleared from the fascia using a combination of S retractors and a Kelly clamp. The lumbodorsal fascia is either incised or traversed bluntly with a Kelly clamp. Palpating the psoas muscle and/or visualization makes confirmation of entry into the retroperitoneum (Fig. 13B). A balloon dilator is inserted and expanded to increase the working space prior to placement of any

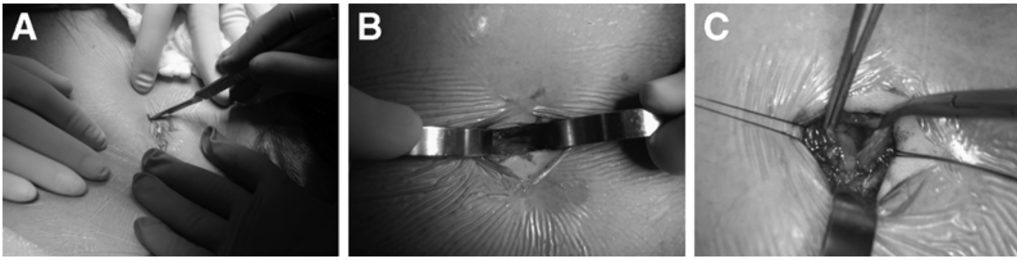

Fig. 12. Hassan technique transperitoneal: **(A)** semi-circular incision, **(B)** identifying fascia with "s reactors," **(C)** sutures anchoring fascia and peritoneum incised.

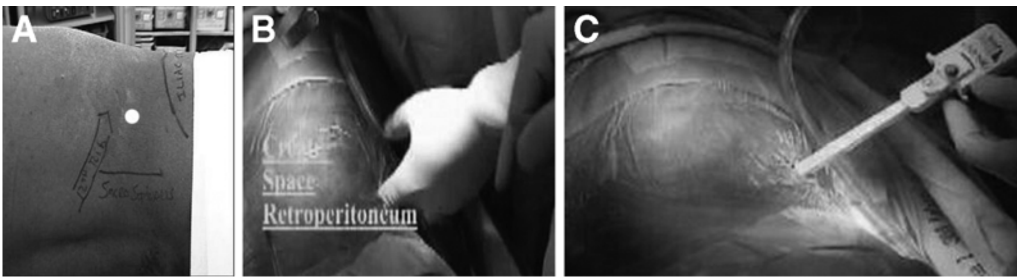

Fig. 13. Hassan technique retroperitoneal: **(A)** retroperitoneal access site, **(B)** palpitating psoas to confirm access, **(C)** balloon dilator being introduced.

trocars. The laparoscope may be inserted into the clear balloon dilator to confirm proper placement by identifying the psoas, ureter, and gonadal (Fig. 13C,D).

Once access is confirmed, either transperitoneally or retroperitoneally, a Hassan trocar is placed. The Hassan has three parts: the outer sheath, a blunt obturator, and a cone that is movable along the sheath and may be locked into position. In addition, the Hassan has wings or olives at the base of the trocar's outer sheath where fascial sutures are wrapped and locked. The fascial sutures placed on each side of the incision help to wedge the trocar and cone tip firmly in the incision, preventing CO_2 leakage (Fig. 14). Another option is to place a purse string suture within the fascia incision to prevent CO_2 leakage and lock these about the wings of the Hassan trocar. Recently a new type of trocar has been introduced with an inflatable balloon at the tip. This may be used instead of a traditional cone-shaped Hassan trocar and does not need fascial sutures. Once inserted, the balloon is inflated and the base of the trocar is pressed against the skin, creating an airtight seal (Fig. 15). A tight, secure fit that allows for movement of the trocar while also maintaining an airtight seal is crucial to all trocars used for open access.

Finally, in cases utilizing hand-assisted laparoscopy, we recommend creating the hand incision initially to gain access to the peritoneal cavity. Our preferred hand incision sites for a nephrectomy are outlined in Fig. 16. All of the second generation devices allow a trocar to be placed through the device, allowing insufflation and inspection of the intra-abdominal cavity with the laparoscope (Fig. 17). The secondary trocars may be placed either under direct vision or by palpation with the nondominant hand in the abdomen protecting the intra-abdominal organs. We have found this approach to be most efficacious and effective.

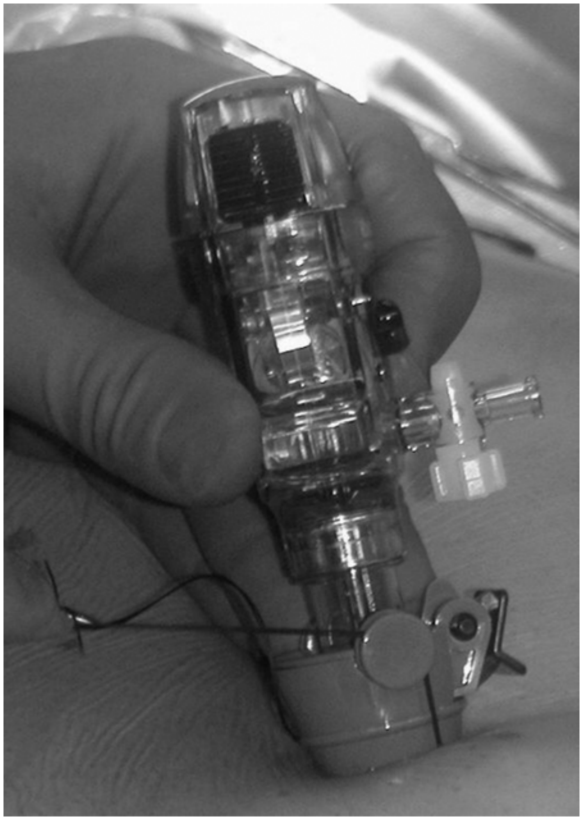

Fig. 14. Securing Hassan on olive.

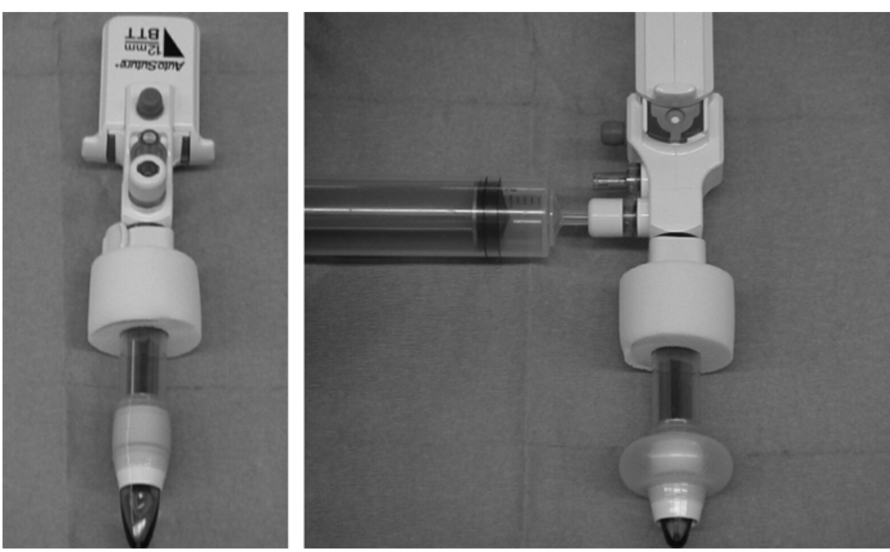

Fig. 15. Balloon-tipped trocar.

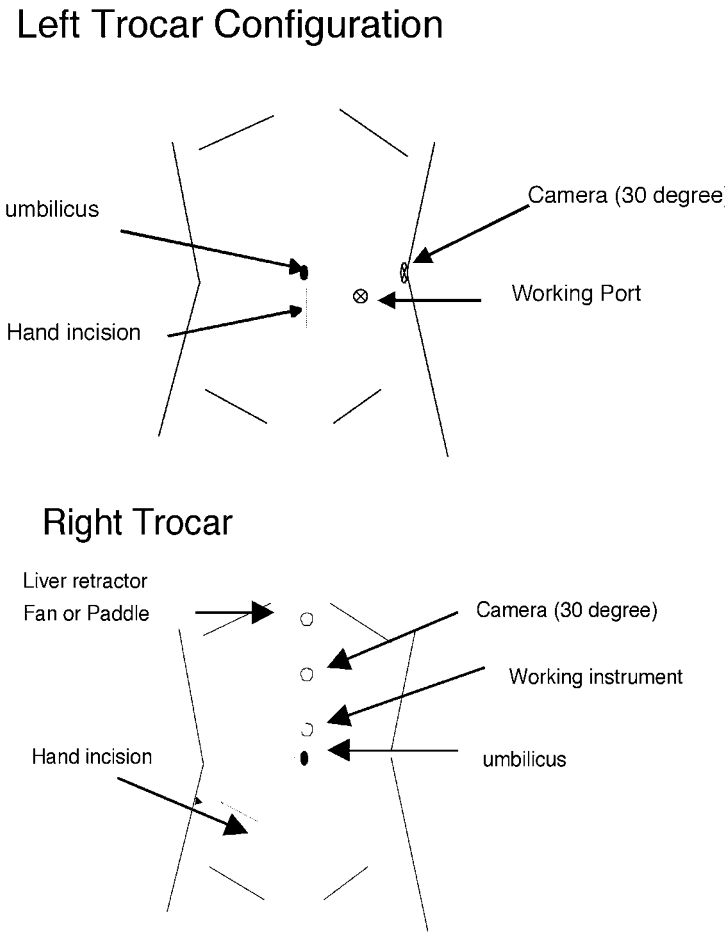

Fig. 16. HAL incision site for left and right nephrectomy.

Fig. 17. Trocar placed through hand device allowing insufflation and placement of laparoscope to visualize insertion of secondary trocars.

TAKE HOME MESSAGES

1. When performing a laparoscopic procedure, it is imperative that the surgeon arrive early to confirm that all the equipment is present and functioning. A checklist should be created for the OR staff to ensure the imaging system, insufflation system, hemostatic generators, and instrumentation are present and functioning.
2. The room should be set up ergonomically to allow free flow of traffic within the room and around the table. The surgeon should be able to visualize the insufflation readout and patient vitals while viewing the monitor.
3. Access is required for all laparoscopic cases. Understanding the advantages, disadvantages, and contraindications of each technique is essential to ensure patient safety.
4. Not all trocars are created equally. One must understand the design differences to guarantee correct placement and avoid unnecessary complications to the patient.

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4 Laparoscopic Pelvic Lymphadenectomy

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and Howard N. Winfield, MD

CONTENTS

INTRODUCTION

Schuessler et al. first reported in 1999 the application of laparoscopic pelvic lymph node dissection (L-PLND) for staging of adenocarcinoma of the prostate *(1)*. Subsequently, the performance of laparoscopic limited obturator pelvic lymph node dissection and in select cases, extended obturator and iliopsoas node dissection, for staging of adenocarcinoma of the prostate, became the primary initial application of urologic laparoscopic surgery as a diagnostic and therapeutic technique *(2)*. Follow-up studies on L-PLND clearly indicated that this procedure was comparable in accuracy and significantly less morbid than open pelvic lymphadenectomy (*see* Table 1) *(3–6)*. In addition, earlier studies showed a longer operative time for L-PLND when compared with open PLND, but also demonstrated a significant reduction in postoperative pain, hospitalization, and time of convalescence *(3–5)*. As expected, L-PLND has been shown to have increased overall cost when compared with open PLND. However, with gradual refinements of laparoscopic technique, a reduction in the need for expensive specialized laparoscopic instrumentation, and the use of reusable equipment, overall total cost is now likely to be equivalent to open PLND *(7–9)*.

In the early 1990s, L-PLND was widely used as a means of determining which patients with adenocarcinoma of the prostate were candidates for localized and

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Table 1
Comparison Between Laparoscopic and Open Pelvic Lymph Node Dissection for Cancer of the Prostate

	Study					
	Winfield et al. (3)		*Kerbl et al. (4)*		*Parra et al. (5)*	
Item	*L-PLND*	*O-PLND*	*L-PLND*	*O-PLND*	*L-PLND*	*O-PLND*
# patients	89	26	30	16	12	12
Av. age	68	65	69.7	65.5	67.0	67.9
Av. Gleason score	6	7	—	—	7.5	5.25
Av. # nodes removed	9	11	—	—	10.7	11
Av. EBL (mL)	<100	215	100	212	<100	<100
Av. OR time (min)	154	124	199	102	185	—
Av. postoperative NPO (h)	9	24	14	67	—	—
Av. parenteral narcotic (MS equivalent mg)	6.5	32.4	1.55	47	—	—
Av. postoperative time, hospitalization (d)	1.5	6.5	1.7	5.3	—	—
Av. convalescence (wk)	7	17	4.9	42.9	—	—

Abbreviations: O-PLND, open pelvic lymph node dissection; Av, average; EBL, estimated blood loss; OR, operating room; NPO, nothing by mouth; MS, morphine sulphate; d, day; wk, weeks.

potentially curative therapy in the form of surgery or radiation. Refinements in prostate-specific antigen (PSA) testing and large-scale studies have both better defined which patients are candidates for localized and potentially curative procedures for prostate cancer, and as such, have diminished the need for PLND. Possible indications today for this procedure include one factor or a combination of factors listed in Table 2. A frank discussion concerning the significance of these clinical situations and their association with the possibility of metastatic disease should take place with the patient. This discussion will also play a key role in the determination of whether L-PLND is necessary in each specific case.

Case-specific indications for individual cases involving other forms of genitourinary malignancy also exist. Extended obturator node and iliopsoas node dissection has also been applied for the staging and evaluation of genitourinary malignancies such as bladder cancer, and other less common entities such as penile and urethral cancer. These procedures generally require considerable laparoscopic experience, and such extended dissections are obviously more time-consuming. However, the majority of these patients are still discharged home within 24 h. These procedures also generally yield positive nodes more often than limited PLND performed for cases involving adenocarcinoma of the prostate *(10,11)*.

Complications for L-PLND in general have been relatively low (8 and 6% for major and minor complications, respectively). The most common intraoperative complications, in descending order, have been vascular, ureteral, bladder, bowel, and obturator nerve injury. The most common postoperative complications, in descending order, have been urinary retention, prolonged ileus, lymphedema, and lymphocele formation. There have been no reported operative mortalities *(12,13)*. Clearly, L-PLND was the stepping-stone for urologists in gaining laparoscopic experience and proceeding to more advanced procedures. It has since allowed urologists to apply laparoscopic

Table 2
Indications for Obturator Laparoscopic PLND

Clinical stage T2b-T3a cancer of the prostate whether surgery, radiation therapy, or hormonal manipulation is being considered; bone scan and computerized tomography scan are negative for metastatic disease
Patients with T1b cancer with Gleason scores greater than or equal to 7
Prostate-specific antigen levels greater than 20 ng/mL
Patients scheduled to undergo a perineal prostatectomy or laparoscopic prostatectomy who have a risk of node positivity of >25%
Patients with suspicious lymph nodes visualized on computerized tomography that are not amenable to guided needle biopsy

Table 3
Relative and Absolute Contraindications to Laparoscopic Surgery *(11)*

Relative
Gross obesity
Hiatal hernia
Umbilical hernia
Significant previous intraperitoneal surgery
Abdominal wall infection
Bowel obstruction
Absolute
Generalized peritonitis
Severe obstructive airway disease
Coagulopathy-uncorrectable
Cardiac disease-inoperable
Shock
Morbid obesity

principles to other genitourinary disease entities, as is demonstrated today by the increasing application of laparoscopy to renal, bladder, and prostatic pathologies.

PREOPERATIVE PATIENT SELECTION, ASSESSMENT, AND PREPARATION

Selection and Assessment

As with open surgery, a complete assessment of the patient as an adequate candidate for L-PLND is necessary. Table 3 lists the relative and absolute contraindications for L-PLND. Relative contraindications may become less of an issue as the surgeon gains laparoscopic experience. As with all laparoscopic procedures, the patient should always be informed that the potential for an open procedure exists should there be difficulty with complex anatomy or unforeseen complications not readily manageable by laparoscopic means.

Preparation

Specific preoperative preparation involves a limited bowel preparation of 1 gallon of Golytely® (Braintree Laboratories, Inc., Braintree, MA) or two bottles of magnesium

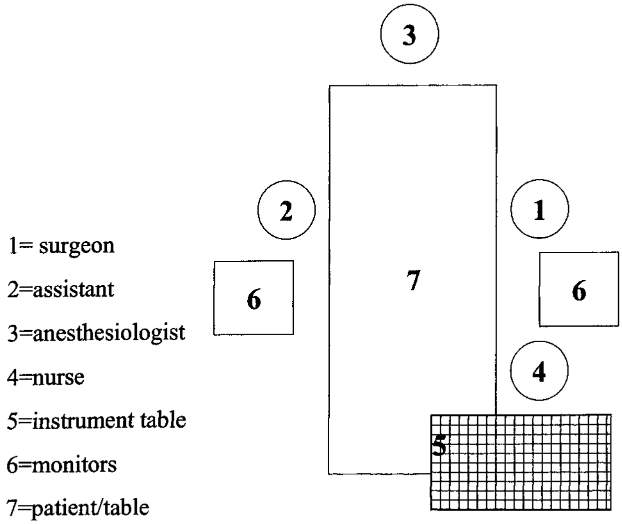

Fig. 1. Schematic of operating room set-up for L-PLND.

citrate on the evening prior to surgery. A type and screen for blood products may be obtained depending on the surgeon's laparoscopic experience. A broad-spectrum antibiotic should be administered on call to the operating room *(11)*.

Patients undergoing L-PLND in which the lymph nodes are negative on frozen section may be scheduled to proceed directly to radical prostatectomy in either an open or laparoscopic approach. As such, these patients should already be prepared with a full bowel preparation as well as a cross match or preoperative collection of autologous blood.

OPERATING ROOM SET-UP, TROCAR CONFIGURATION, AND PATIENT POSITIONING

Operating Room Set-Up

The operating room (OR) set-up for L-PLND is shown in Fig. 1. The monitors are placed at the level of the hips of the patient on each side. The surgeon stands on the side of the table opposite the site of planned lymph node dissection. The nurse stands on the left side of the patient just below the surgeon or the assistant. The anesthesiologist is at the head of the table. As one more routinely performs laparoscopic surgery, it is quite helpful to have a regular operating room staff that is familiar with the dynamics and equipment needs of laparoscopic surgery.

Patient Positioning and Preparation

When the patient is brought to the OR, he or she is placed on an operating table capable of being placed in the Trendelenburg position and lateral rotation (*see* Fig. 2). The patient is placed in the supine position. Pneumatic boots are then placed on the lower extremities. The patient is then given general anesthesia, preferably without the ongoing use of nitrous oxide, as this agent may cause gradual distention of the intestine resulting in possible compromise of the laparoscopic working space. An indwelling urethral catheter and orogastric tube are then placed for decompression of the bladder and stomach, respectively. The arms are padded and tucked in by the patient's sides.

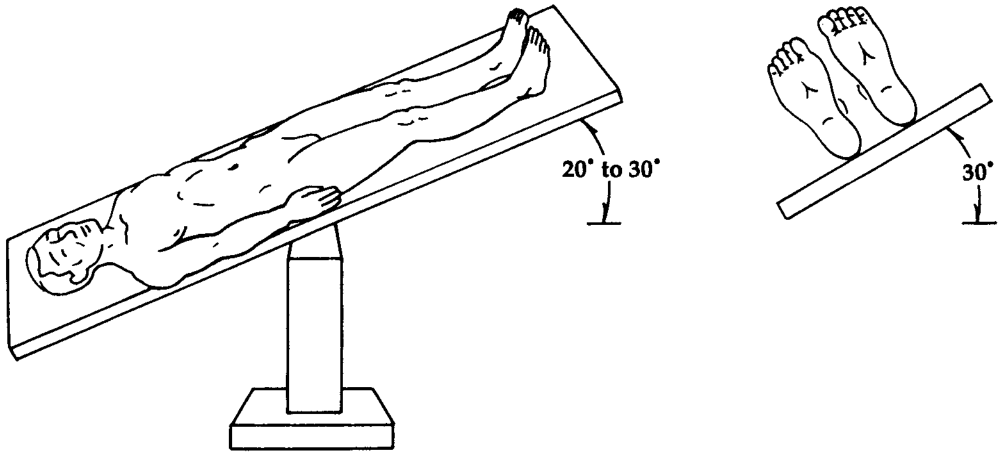

Fig. 2. Trendelenburg positioning and lateral rotation. (From ref. *11*, permission granted.)

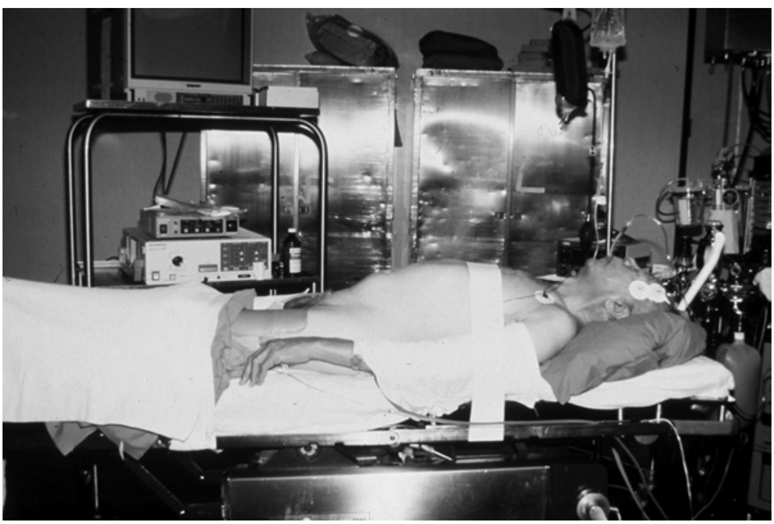

Fig. 3. Preparation of patient for L-PLND. With the patient well secured, the table can be safely placed in Trendelenburg, with lateral rotation as needed. (From ref. *11*, permission granted.)

The lower extremities, including the heels of the feet, should also all be well-padded. Wide adhesive tape is then placed across the chest and thighs, which secures the patient and allows for table movement during the case as needed. The anesthesiologist should be informed that the patient is being secured across the chest to ensure that this measure is not causing any respiratory compromise. The properly positioned patient should appear as in Fig. 3.

NECESSARY INSTRUMENTATION

The continuing advancement of technology as it pertains to laparoscopic surgery results in a constant availability of new equipment. As such, access to high-quality imaging equipment is now widespread. Two television monitors, a three-chip camera, and use of both 0° and 30° lenses are sufficient for L-PLND. High-quality insufflators and light sources/cables are also readily available.

Table 4
Instrumentation for Laparoscopic Pelvic Lymphadenectomy *(10)*

Necessary equipment

- Towel clips—to secure drapes/instrumentation
- No. 15 surgical blade—for skin incision
- 14-gauge Veress needle—for initial entry
- For possible initial entry by minilaparotomy: Hasson type cannula, two Sinn/S-type retractors, two absorbable sutures
- Trocars: standard—two 5-mm and two 10-/11-mm (For obese patients, use two 5-mm and three 10-/11-mm trocar reducers)
- One 5-mm electrosurgical scissors
- Two 5-mm atraumatic grasping forceps (spoon and dolphin types)
- One 5-mm traumatic locking/grasping forceps (rat tooth)
- One 5-mm fan-type retractor
- One 5-mm aspirator/irrigator (recommended: Nezhat-Dorsey irrigator/aspirator)
- Two or three 0-absorbable sutures to close 10-mm ports
- 4-0 absorbable sutures to close port-site skin incisions
- Needle holder
- Suture scissors
- Two Kelly clamps

Other optional equipment

- Container for warm water to prevent scope fogging, or anti-fog solution (e.g., FRED)
- Entrapment sacs for lymph nodes
- 10-mm multiload occlusive clip applier
- One 5-mm Babcock
- One 5-mm dissecting scissors
- One 5-mm right-angle "hook" electrosurgical probe
- One 5-mm straight fine-tip dissector
- Carter-Thomason® (Inlet Medical Inc., Eden Prairie, MN) port closure set (consists of cone and suture passer)
- Steri-strips
- Tegaderm dressing

In addition to the required camera, lens, light-source equipment, and insufflator, a standard laparoscopy tray is needed for this procedure. Our equipment tray incudes the items listed in Table 4 *(10)*.

OPERATIVE APPROACH

Trocar Placement

L-PLND may be performed by a transperitoneal or extraperitoneal approach. Our preference is the transperitoneal route, and as such this is described first. We then describe the extraperitoneal approach and notable differences with which it is associated.

Transperitoneal L-PLND

Prior to initiation of the procedure, all equipment is assembled, inspected, tested, and positioned so that it is ready for use. For the transperitoneal approach, the patient is first placed in 10° Trendelenburg. The Veress needle is placed in the inferior umbilical crease. When correct entry has been achieved, carbon dioxide insufflation is

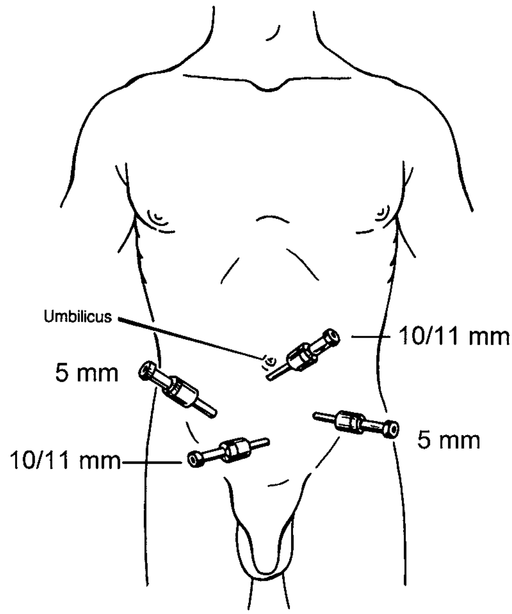

Fig. 4. Standard trocar arrangement for L-PLND. (From ref. *11*, permission granted.)

initiated and brought up to a pneumoperitoneal pressure of 20 mmHg. A 10-/11-mm trocar/sheath unit is then inserted. Inspection of the abdominal cavity is then performed with the 10 mm laparoscope to ensure that no injury has occurred upon entry. A survey of the abdominal organs is also performed, with particular attention to the presence of abdominal adhesions that may in any way hinder the procedure. Additional ports are then placed under direct laparoscopic guidance. Our usual "diamond" shape arrangement of ports and sizes is shown in Fig. 4. Obese patients with abundant fatty tissue may require additional retraction, and as such four working ports may be required. An alternative port and size configuration is shown in Fig. 5. This alternative array is commonly referred to as the "fan" or "inverted U" array. Spatial arrangement of the ports may further vary in specific cases *(13)*. In addition, if laparoscopic radical prostatectomy is planned, the port placement may again vary to include five ports. When all ports have been placed, the surgeon may elect to secure them to the skin with 2-0 silk sutures to avoid potential dislodgement during the procedure. At this point, abdominal pressure is lowered to 15 mmHg, the patient is placed in 30° Trendelenburg, and the table is laterally rotated to the left to allow the abdominal contents to fall away from the right-side field of dissection. The reverse would be required for left-sided pelvic lymph node dissection.

Once ports have been placed, the relevant pelvic anatomy must be identified. When one views the true pelvis from the umbilical region, the obliterated umbilical ligaments and testicular vessels should be identified. In thin patients, the vas deferens can often be seen under the posterior peritoneum (*see* Fig. 6). Dissection should normally be initiated on the side where most or all of the prostate tumor is present according to the prostate biopsy, or on the side where there is suspicious lymphadenopathy *(10)*. Trendelenburg position is usually sufficient to mobilize any intestinal contents away from the area of intended dissection.

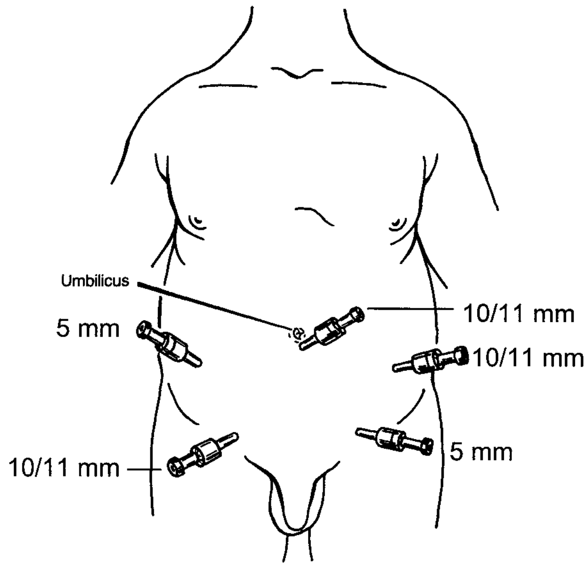

Fig. 5. Alternative trocar arrangement for L-PLND. (From ref. *11*, permission granted.)

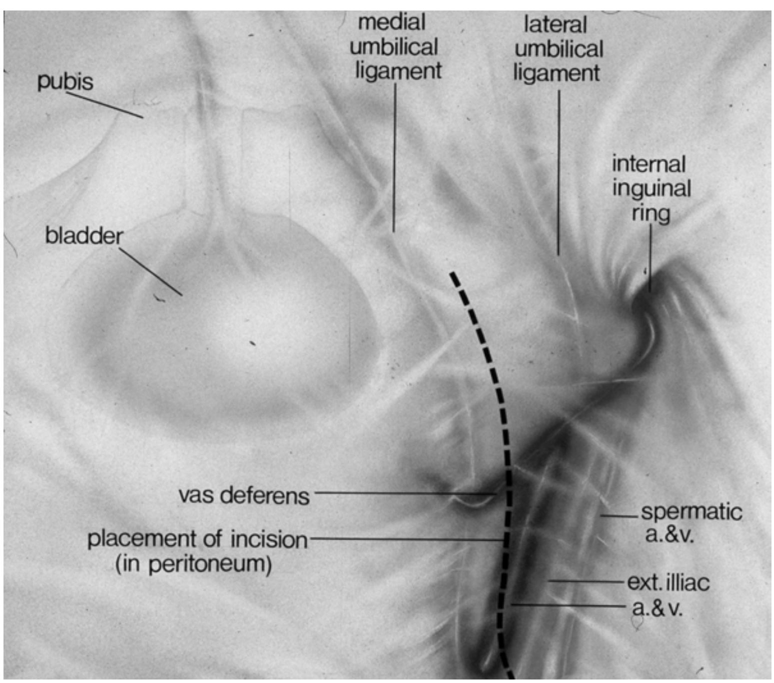

Fig. 6. Relationship of pelvic structures to peritoneal incision used for L-PLND.

The surgeon uses the left lateral 5-mm port and the suprapubic 10-mm port when operating on the right pelvic lymph nodes. The assistant holds the camera through the umbilical port and retracts through the 5-mm right lateral port. For obese patients, the surgeon would use the two lateral ports on his/her side. The initial incision is through the posterior peritoneum just lateral to the right obliterated (medial) umbilical ligament (*see* Fig. 6). This incision is extended above the level of the internal inguinal

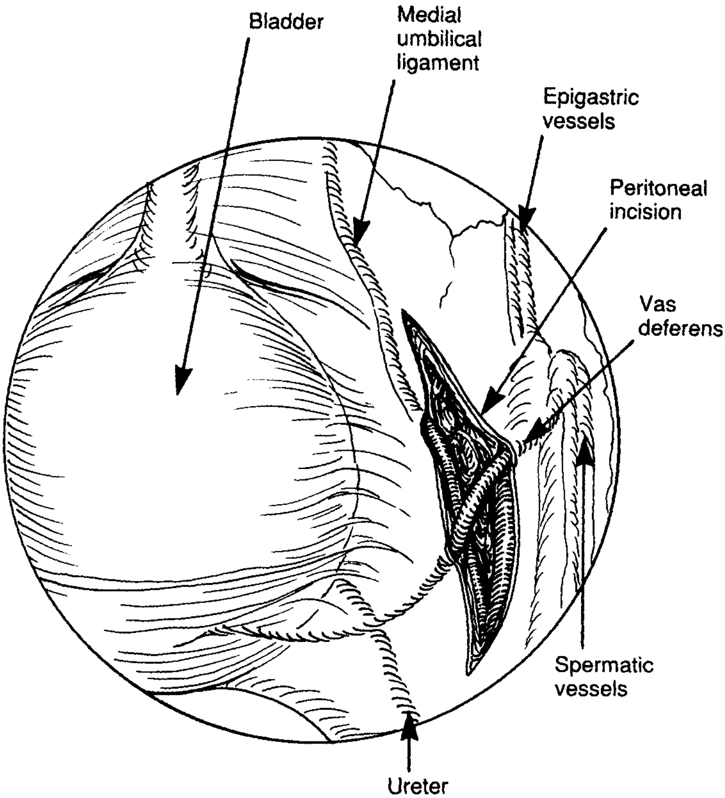

Fig. 7. The vas deferens is encountered after the peritoneal incision is made. (From ref. *11*, permission granted.)

ring anteriorly and is brought downward, just medial to the pulsations of the right external iliac artery, which can usually be seen. This incision is completed posteriorly by continuing toward the level of the bifurcation of the common iliac vessels. This incision is best made by first scoring with electrocautery the line of incision, and then grasping the edges of the incision and further opening it with scissors attached to electrocautery.

After the peritoneum has been opened, dissection through the immediate underlying fat will reveal the vas deferens (Fig. 7). The vas is safely and easily divided with cautery.

Dissection is then continued just inferior and medial to the pulsations of the external iliac artery until the external iliac vein is seen (*see* Fig. 8). Our method of dissection used throughout this procedure generally involves careful spreading of the tissue into packets and then carefully thinning them. These packets are then slowly cauterized and divided after we have noted the absence of any other significant structures within them. The assistant aids the surgeon with lateral retraction through the right lateral port. The fibrolymphatic tissue over the vein is cleared off the surface of the vein. We prefer to do this with a straight dissector. Once proper development of this layer has begun, it is continued down to the pelvic sidewall. This defines the lateral border of the lymph node dissection.

After the nodal tissue has been swept free of the pelvic sidewall, dissection is continued inferiorly to the level of the pubic bone (*see* Fig. 9), which is usually

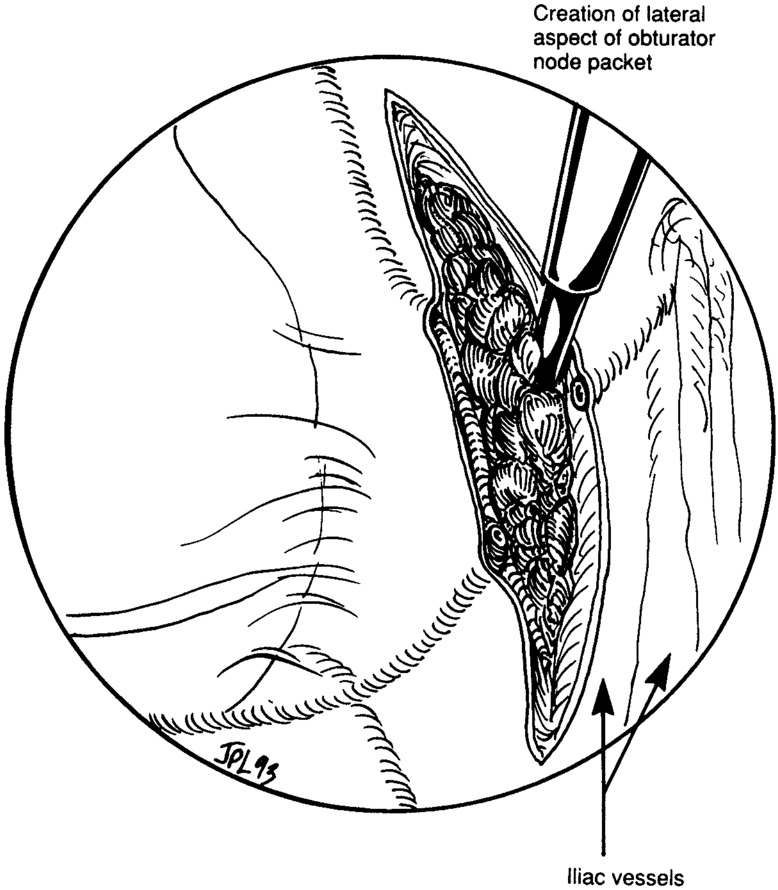

Fig. 8. The iliac vessels are identified. (From ref. *11*, permission granted.)

easily identified visually as well as by tapping on it with one of the instruments. As one proceeds in the inferior direction, one must be mindful of the course of the obturator nerve and vessels located posteriorly. As dissection is carried out in the inferior direction, the posterior fat is carefully and slowly dissected through until these structures are identified. One must be mindful that the obturator vessels are prone to significant variations, and as such meticulous dissection is required. The nodal tissue is carefully swept off these structures (*see* Fig. 10).

The next step is to create the medial border of the lymph node package. This is done by first retracting the obliterated umbilical ligament medially, and the identified lymph node package laterally (*see* Fig. 11). This plane is developed with the same technique of carefully isolating packets of fibrofatty tissue, thinning them, and then proceeding with cautery. This dissection is continued inferiorly to the pubic bone. The lymph node package is then divided inferiorly right at the level of the pubic bone. This end of the package can then be retracted upwards, and dissection is continued cranially toward the bifurcation of the common iliac artery where the cranial end is divided (*see* Fig. 12A,B). The level of the obturator nerve is used as the posterior boundary for this portion of the dissection. Now that the lymph node package has been completely freed, it is removed using the 10-mm spoon shaped graspers through the inferior midline 10 mm

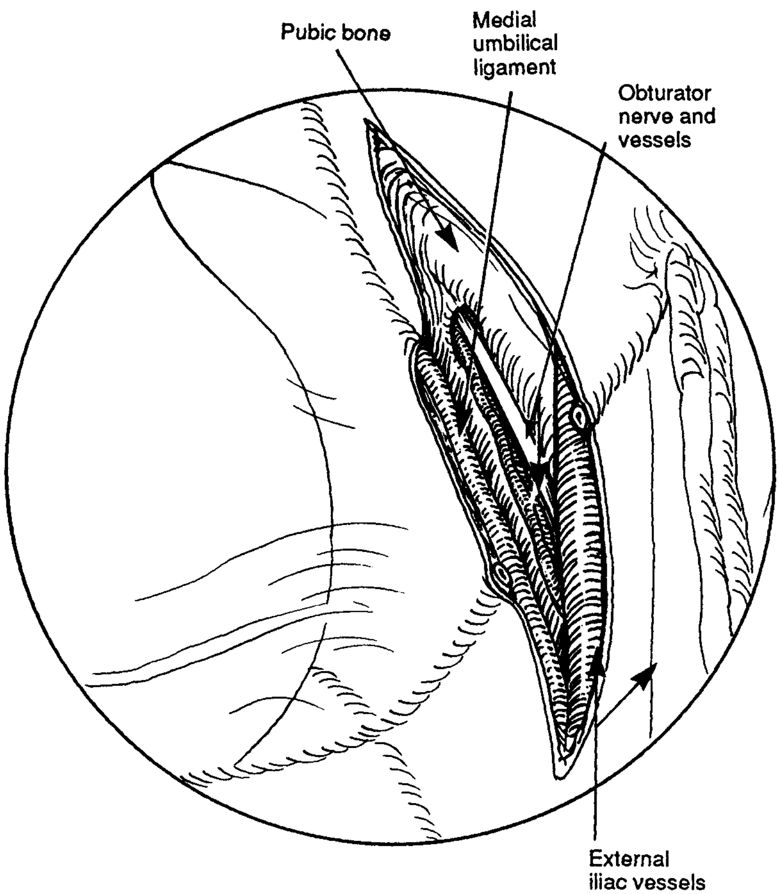

Fig. 9. The pubic bone is identified at the inferior aspect of the dissection. (From ref. *11*, permission granted.)

trocar site. Alternatively, they may be placed in an entrapment sac and pulled out of one of the trocar sites with the trocar. The resection bed is then carefully inspected and any bleeding is controlled. Frozen section pathological analysis is only performed if immediate radical prostatectomy is being considered, or if there is high suspicion of cancer that would preclude contralateral dissection.

Left-sided dissection is carried out when right-sided frozen section analysis is negative or when a bilateral procedure has been planned from the outset. Dissection is carried out in a similar fashion on the left side with only a few additional considerations and variations in technique. Often the sigmoid colon has a peritoneal attachment over the initial incision site (Fig. 13). As such, dissection of this peritoneal attachment is performed by incising along the white line of Toldt, which will, with the aid of gravity (with the patients left side now rotated up) result in medial reflection needed prior to creation of an incision that is a mirror image of that made on the right (Fig. 14). Electrocautery should be used sparingly for this initial portion of the dissection so as to minimize the risk of bowel injury. For left-sided dissection, it may also be beneficial for the surgeon to use the right and left lateral ports instead of the suprapubic trocar/sheath unit. For obese patients, the port configuration would allow the surgeon the use of the two right-sided ports, whereas the assistant would use the two left-sided ports.

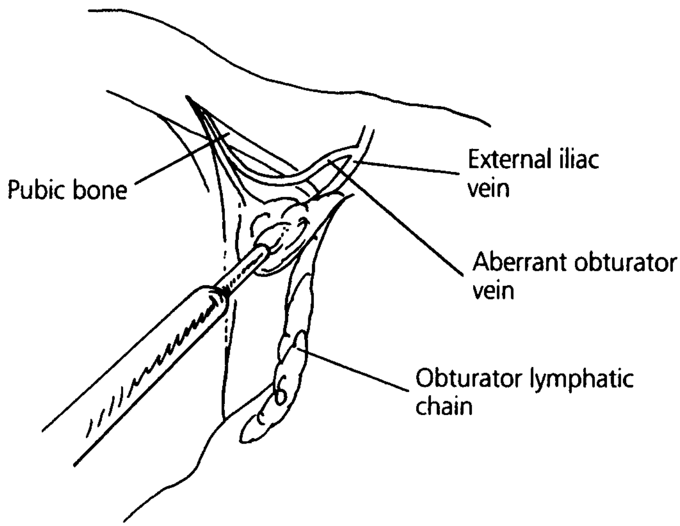

Fig. 10. The lymph node package is carefully freed from associated vessels. (From ref. *10*, permission granted.)

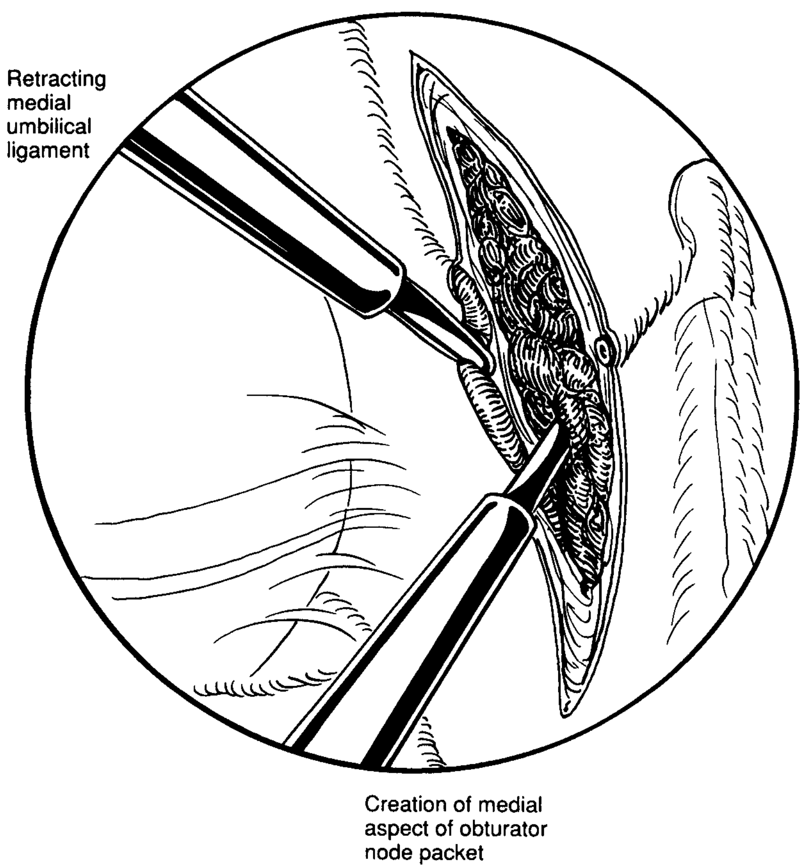

Fig. 11. The medial border of the dissection is then developed. (From ref. *11*, permission granted.)

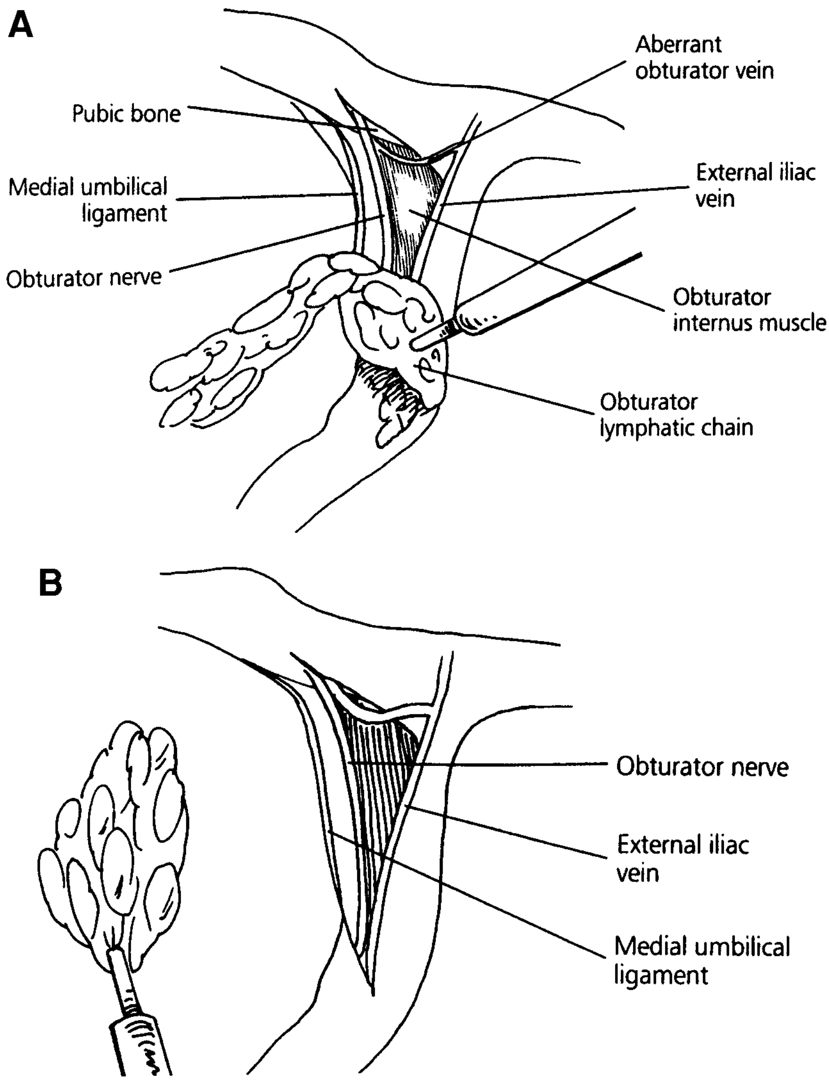

Fig. 12. **(A)** The lymph node package is retracted superiorly; **(B)** dissection is continued until the package is completely free. (From ref. *10*, permission granted.)

Extraperitoneal Approach

The extraperitoneal approach to pelvic lymph node dissection has also been employed, although not as commonly as the transperitoneal route. This may be owing in part to the need to open the retropubic space with balloon dissection, which may result in some distortion of the normal anatomy. This procedure was developed after transperitoneal L-PLND with the belief that an extraperitoneal approach would, by maintaining the integrity of the peritoneal membrane, decrease the risks of visceral injury, preclude intraperitoneal spillage of potentially tumor-laden tissue, and prevent the potential postoperative development of intra-abdominal adhesions associated with instrumentation and manipulation of intraperitoneal contents. Such an approach may

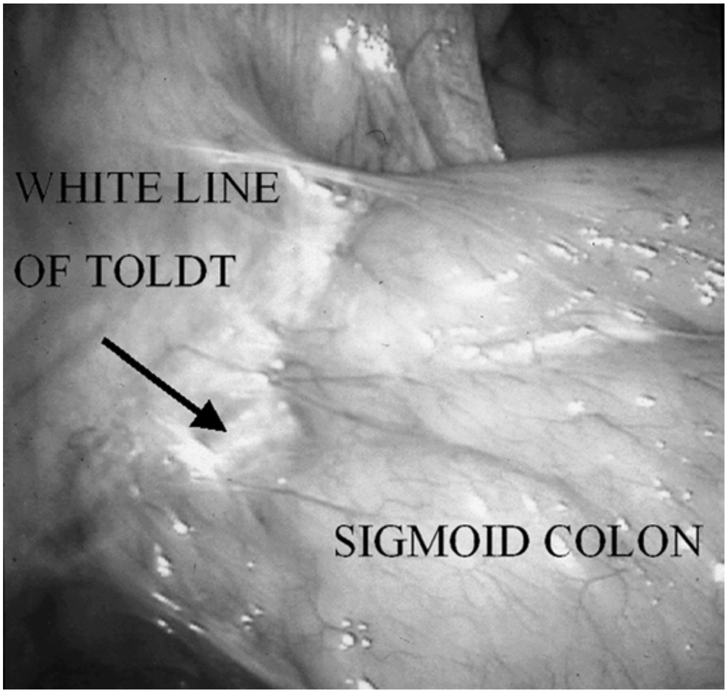

Fig. 13. The sigmoid colon must often be mobilized prior to initiation of left sided L-PLND.

Fig. 14. The white line of Toldt is incised.

also preclude potentially time-consuming adhesiolysis in specific cases and bowel mobilization needed for extended lymph node dissection. The intact peritoneum may also aid in adequate exposure, which is difficult at times in the obese patient. However, the space developed by balloon dissection is small compared to the working space

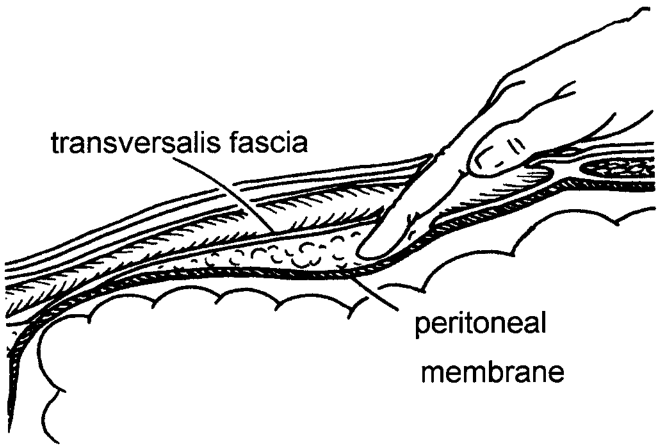

Fig. 15. Identification and development of the working space used in the extraperitoneal approach.

available for a transperitoneal approach. Furthermore, studies have revealed that patients treated in such an extraperitoneal fashion appear to have higher postoperative analgesic requirements, possibly owing to the stretching or tearing of nerve fibers during creation of a the retropubic space needed for dissection. Balloon dissection also creates a space not as well-defined by natural planes, and as such at times may be confusing to the surgeon *(14)*. Studies have also suggested that patients treated by the extraperitoneal route appear to have greater absorption of carbon dioxide resulting in respiratory acidosis, which at times may be difficult to compensate for. Hypercarbia and acidosis have also been associated with cardiac arrhythmias and cardiovascular compromise *(15)*. This technique may be contraindicated in patients with significant preexisting cardiopulmonary pathology. Patients who have undergone previous lower abdominal or inguinal surgery are also more prone to peritoneal membrane disruption during balloon dilation, which can further complicate the procedure.

Extraperitoneal L-PLND: Operative Approach

This procedure is initiated with a subumbilical incision that is deepened down to the level of the rectus fascia. The fascia is divided in the midline, and creation of the properitoneal space is initiated with blunt finger dissection (Fig. 15) to the point at which a balloon inflation device may be inserted. At this point, an individually fashioned or specifically manufactured balloon inflation devices have both been used. Winfield et al. describe an easily fashioned device that consists of the finger cot of a transurethral resection drape tied to a 20 French red rubber (Robinson) urethral catheter *(16)*. Many commercial devices also exist. Whichever device is used, it is inserted and inflated with approx 800–1000 cc of saline to create an extraperitoneal working space needed to perform the dissection. A Hasson-type cannula is then placed though the subumbilical incision, secured, and carbon dioxide insufflation up to 15 mmHg is begun. The laparoscope is then placed to completely survey the expanded space, with particular attention to any injury or peritoneal tears created by balloon inflation. It is important to recognize that this balloon dissection has created a space in which the pubic symphysis is already exposed. The obliterated umbilical ligaments are neither as apparent nor as necessary a landmark for dissection. The vas deferens is now situated superiorly against the peritoneal membrane, and as such usually does not need to be transected.

Ports are placed in the same diamond configuration described for transperitoneal L-PLND. These ports must be placed into the properitoneal space in a fashion so that they do not traverse the peritoneal membrane, and are placed under direct laparoscopic guidance. If the peritoneal membrane is divided, collapse of the properitoneal space will result. This will also necessitate conversion to a transperitoneal procedure with subsequent intraperitoneal port placement.

The key to dissection in this procedure involves identifying the pulsations of the external iliac vessels. At this point, dissection is begun by elevating the fibrofatty and adventitial tissue off the external iliac vein and from this point the remainder of the procedure continues in a fashion similar to transperitoneal dissection.

Extended Lymph Node Dissection

Though obturator lymph node dissection is satisfactory for evaluation of prostate cancer, an extended lymph node dissection is usually required in cases of bladder, urethral, and penile cancer. An extended pelvic lymph node dissection may sometimes be carried out in patients with prostate cancer and negative obturator nodes that are highly suspected of having metastatic local disease (such as in cases of clinical T3 disease and/or markedly elevated PSA [≥60] *(11)*. For extended pelvic lymphadenectomy the "fan" or "inverted U" array as previous described is preferred because it allows for more assistance with retraction.

Lymph node dissection for these disease entities usually involves carrying the dissection out to the genitofemoral nerve laterally, to the bladder wall and ureter medially, to the pubic bone caudally, and up to the bifurcation of the aorta cranially. This procedure has many similarities to standard pelvic lymph node dissection with a few modifications that account for inclusion of a larger lymph node package with the aforementioned borders of dissection.

The initial peritoneal incision is made in a similar fashion, but now is extended along the white line of Toldt up toward the kidney. On the right-hand side, this extended dissection will require mobilization of ceco-appendiceal attachments, and on the left will require more extensive mobilization of the sigmoid colon. The vas is similarly then incised. This procedure then requires dissection and identification of the bifurcation of the iliac vessels and the ureter. After identifying the ureter, the tissue just lateral to the ureter is dissected. The assistant retracts tissue laterally, while the surgeon uses graspers and shears attached to cautery to retract medially and dissect. This dissection is continued caudally, staying lateral to the medial umbilical ligament and along the lateral sidewall of the bladder. When dissecting along the bladder wall, it is important to stay in the fatty plane that easily partitions with blunt dissection. Bleeding and excessive sharp dissection in this area usually signifies that one is too close to the bladder wall. If there is any suspicion of bladder injury, the urinary catheter drainage bag should be inspected for blood, and the bladder should be filled with dye to delineate any inadvertent cystotomy, which should then be laparoscopically repaired with suturing. Dissection is continued to the pubic bone, which brings one to the caudal and medial border of the dissection.

Next, the lateral border of the package, which includes dissection from the pubic bone up to the level of the common iliac artery and medial to the external and internal iliac vessels, obturator internus muscle, and genitofemoral nerve. This is begun by

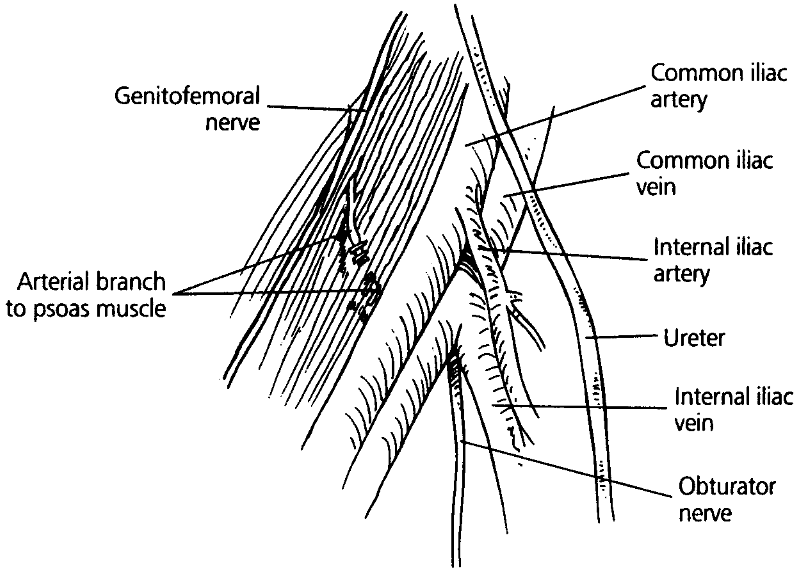

Fig. 16. Anatomy seen in extended L-PLND; if a small arterial branch going toward the psoas muscle is seen, it is usually clipped and ligated. (From ref. *10*, permission granted.)

dissecting the package off the anterior surface of the common iliac artery. As dissection takes place at this level, the genitofemoral nerve is located lateral to the common iliac artery. The nerve is swept lateral, and the associated lymphatic tissue is swept medially. A lateral branch from the common iliac artery going toward the psoas muscle may be seen here. It should be clipped on both sides and ligated (*see* Fig. 16). The package is divided cranially at this level. Clips may be placed on the cranial side to occlude any lymphatic channels located here. The package is then mobilized caudally. Dissection is continued caudally along the anterior surface of the external iliac artery down to the level of the circumflex iliac vein, which is the caudad lateral border of the dissection. At this point the common and external iliac arteries can be rolled medially, exposing the obturator internus muscle laterally and posteriorly the internal iliac vein and the obturator nerve running beneath it (*see* Fig. 17). The lymphatic tissue in this area is carefully dissected out, being mindful of small vascular branches. Upon completion, the common and external iliac arteries are returned to their normal position. At this point, the clearly identifiable lymphatic tissue lateral and anterior to the internal iliac vein is carefully dissected free. During this part of the procedure, the assistant retracts the internal iliac vein laterally, while the surgeon retracts the tissue medial to the vein and pelvic sidewall medially. As described for obturator lymph node dissection, blunt dissection is initially used to free this tissue into packets that are then individually cauterized. The 5 mm hook electrode may be useful in dissecting tissue free from the internal iliac vein and pelvic sidewall. It is important to note that an aberrant obturator vein may be entering the medial wall of the external iliac vein just superior to the pubis (as shown in Fig. 18). Identification of this vessel may also aid in dissection toward the obturator fossa and nerve.

At this point, the caudal border of the packet may be dissected off the pubic bone. This portion should be performed most meticulously, with cautery used as necessary to avoid bleeding. Care should also be taken in that the dissection crosses the medial

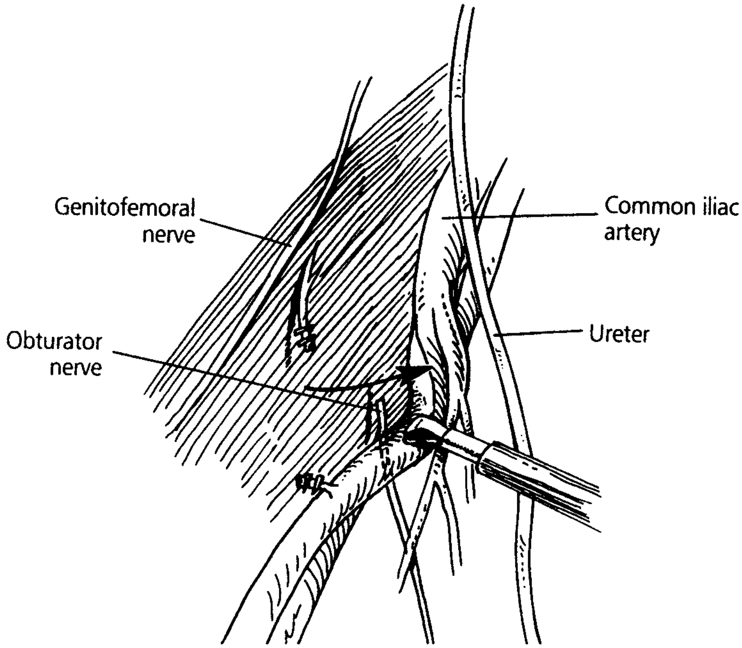

Fig. 17. The iliac artery is carefully mobilized in order to free all lymphatic tissue in this region. (From ref. *10*, permission granted.)

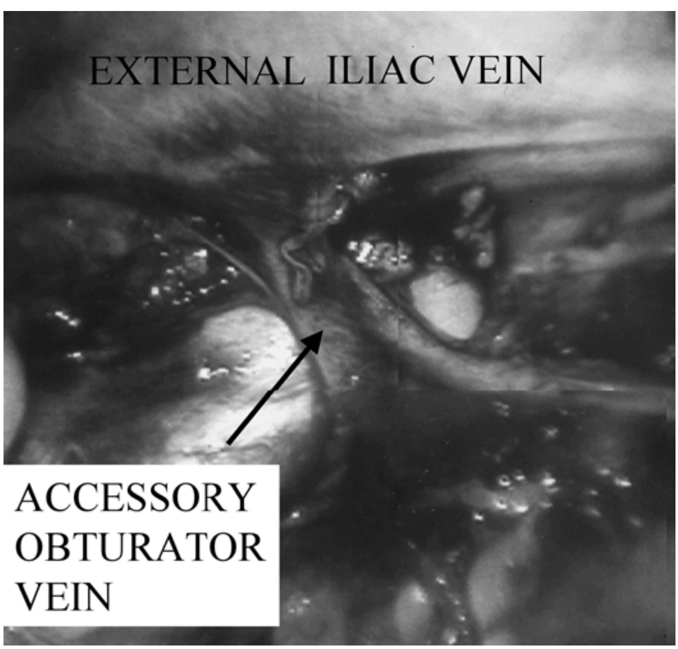

Fig. 18. Accessory obturator vein.

edge of the external iliac artery and the entire surface of the internal iliac vein. Also, at the lowest edge of the dissection, the superficial epigastric vein may be exiting from the femoral vein, traveling superomedially.

Now the packet can be retracted in the cephalad direction and posterior dissection carried out. This plane will free up with light retraction and blunt dissection, exposing the obturator nerve and the obturator vessels located inferomedial to the nerve. These vessels are dissected free and preserved. The obturator nerve is followed to where it goes behind the internal iliac vein, after which it has already been dissected free. Tissue deep to the obturator must be carefully teased free, as there are many small vessels here. It is important to include this tissue as the presciatic nodes are located here, and may be the only positive nodes in the dissection *(17)*. Again, the hook electrode is useful in elevating this tissue off of the obturator nerve and then carefully cauterizing through it. The assistant may also judiciously use the aspirator/irrigator in this region to retract the external iliac vessels laterally while keeping the operative field clear. Dissection is continued cephalad along the medial surface of the internal iliac artery until it gives rise to the obliterated umbilical artery. The notch at the junction of these two structures is completely dissected, thus freeing the package. The hook electrode is again used in lifting tissue off of the internal iliac artery, and then cauterizing it in small portions. The cephalad border of the package may also be secured with clips and divided. The nodal packet is then removed either in pieces with the 10 mm spoon forceps, or removed in its entirety all at once in an entrapment sac.

If the frozen section on the first side is negative or if bilateral dissection is planned from the outset, contralateral dissection is begun. This dissection is identical in every aspect to the contralateral side, with the exception that as this procedure is initiated adhesions between the colon and the side wall must be taken down prior to incision of the white line of Toldt. Again, electrocautery should be used carefully for this portion of the procedure.

Closure

Closure for all approaches is similar. Prior to closure the resection sites are again inspected under lower intra-abdominal pressure (5 mmHg) to ensure there is no active bleeding. The 10-mm laparoscopic ports can be easily and reliably closed with use of the Carter-Thomason ® (Inlet Medical Inc., Eden Prairie, MN) closure set, which consists of an insertable cone and a pointed suture passer. Under direct vision, the 10-mm trocar is removed, and the cone inserted with its holes for suture passage at 90° to the line that the fascial incision was made. Using the Carter-Thomason suture passer, an 0-absorbable suture is passed through one hole of the cone, through the fascia into the abdomen under direct vision, and is held with a grasper inserted through another trocar site. The passer is removed and inserted through the opposite hole and underlying fascia. The suture within the abdomen is grasped and brought out this same hole. The cone is removed and the trocar can be replaced if more 10-mm sites need to be closed. When all 10-mm sites have sutures placed across them, the 5-mm trocars are removed under direct vision, as are the 10-mm sites. The carbon dioxide is completely evacuated from the abdomen, and then the last 10-mm trocar is removed. The fascial sutures on the sites are tied. The wounds are irrigated and the skin closed with a 4-0 absorbable stitch. Benzoin, steristrips, and Tegaderm may be then applied.

POSTOPERATIVE STEPS

Following the procedure, regardless of technique, the patient is admitted to the short-stay ward. The nasogastric/orogastric tube is removed in the operating room. The patient usually receives two more doses of antibiotics postoperatively. The urethral catheter is removed as soon as the patient is alert and oriented, and diet is advanced as tolerated.

The pneumatic boots are usually removed 4–6 h after the procedure, and patients usually begin ambulation within hours following surgery. Most postoperative pain can be managed with oral analgesics. Intravenous narcotics are rarely necessary. Excessive pain immediately postoperatively is usually owing to carbon dioxide diaphragmatic irritation. Nonsteroidal anti-inflammatory agents, such as ketorolac tromethamine, generally suffice. Postoperative monitoring is standard, with monitoring of vital signs for any evidence of bleeding or infection. Delayed abdominal pain that is constantly worsening and requiring narcotic analgesia may signify a significant complication, such as bowel perforation or retroperitoneal hematoma, and depending on the results of clinical evaluation of the patient, computerized tomography (CT) of the abdomen and pelvis may be required for evaluation in these cases. Most patients are discharged within 24 h and can resume normal activity within 1 wk.

TAKE HOME MESSAGES

1. L-PLND is the first urologic laparoscopic procedure in which urologists gained proficiency. Urologists having their first introduction to laparoscopy through performance of L-PLND can gain proficiency in this procedure without much difficulty, and use it as a "stepping-stone" for training in more advanced urologic laparoscopic procedures.
2. L-PLND is as accurate a staging procedure as open PLND. With experience, it requires only slightly more time to perform, and its cost may be reduced to that of open PLND. Furthermore, it offers significant postoperative benefits including decreased hospitalization time, decreased postoperative pain, and decreased convalescence time, which may more than offset any increased hospital costs associated with this procedure.
3. L-PLND may once again be commonly employed in that many patients are now electing minimally invasive treatments such as brachytherapy as a treatment for localized prostate cancer. L-PLND has a useful role in the performance of a complete evaluation of these patients as candidates for such localized therapy. Furthermore, with the advent of laparoscopic radical prostatectomy, a laparoscopic approach to the lymph nodes will be required.
4. L-PLND as a staging modality may also be applied to evaluation of urologic malignancies other than prostate cancer. However, extended L-PLND for the evaluation of such entities requires more laparoscopic experience and operative time. Again, postoperative benefits of this procedure compared with open surgery are significant.

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5 Laparoscopic Renal Cyst Decortication

Yair Lotan, MD, *Margaret S. Pearle,* MD, PhD, *and Jeffrey A. Cadeddu,* MD

Contents

INTRODUCTION

Renal cysts are common and occur in approximately one-third of individuals over the age of 50 *(1,2)*. Although renal cysts may be either congenital or acquired, most are simple, asymptomatic, and of unknown etiology. The need for intervention occurs when cysts are determined to be complex by radiographic criteria or when they are associated with pain, infection, hemorrhage, or urinary obstruction. Some congenital diseases such as autosomal dominant polycystic kidney disease (ADPKD), the most common form of renal cystic disease in the United States, are commonly associated with symptomatic cysts *(3)*. Other cystic diseases such as von-Hippel-Lindau (VHL), tuberous sclerosis, multilocular cystic nephroma, and acquired cystic disease have a predisposition toward malignant degeneration. The need for intervention in some cases of symptomatic or suspicious cysts has led to the development of new strategies for renal cyst management *(4)*. This chapter discusses the role of laparoscopy in renal cyst exploration and decortication.

PREOPERATIVE ASSESSMENT

The diagnosis of a renal cyst is made radiographically either as an incidental finding or during evaluation of symptoms such as flank or abdominal pain, early satiety, hematuria, hypertension, or urinary tract infection. Ultrasound or computed

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
Edited by: S. Y. Nakada © Humana Press Inc., Totowa, NJ

Fig. 1. Nonenhanced CT scan for patient with symptomatic right renal cyst.

Fig. 2. Nonenhanced CT scan after laparoscopic cyst decortication.

tomography (CT) provide the most reliable means of diagnosing renal cysts (Figs. 1 and 2). Intravenous urography (IVU) may suggest the presence of a cyst indirectly by demonstrating distortion of the collecting system, but in general IVU is not a reliable imaging modality for identification of renal cysts.

A history of ADPKD, VHL, or tuberous sclerosis may prompt screening radiographic studies for monitoring the development or degeneration of renal cysts (Fig. 3). Likewise,

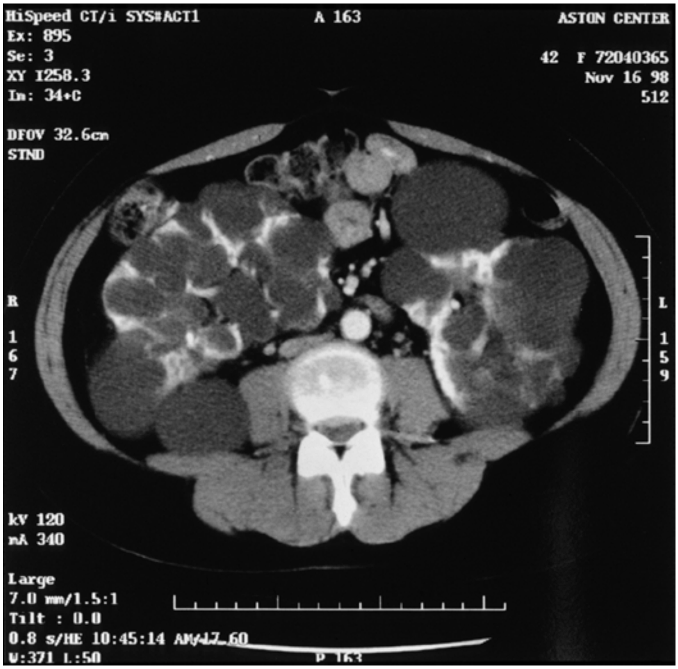

Fig. 3. Nonenhanced CT scan for patient with ADPKD.

patients with end-stage renal failure frequently develop renal cystic disease with a known potential for malignant degeneration, and should be monitored radiographically.

Physical examination may reveal a palpable mass in rare cases but is usually not contributory in the diagnosis of renal cysts. Urinalysis is also generally nondiagnostic except to show proteinuria in cases of renal failure or pyuria or hematuria in association with infection.

MANAGEMENT ALGORITHMS

Complex Cysts

An attempt to predict the malignant potential of renal cysts has resulted in a classification scheme based on radiographic appearance. The Bosniak classification relies on criteria to categorize cysts into low-, medium-, or high-risk groups (Table 1) *(4)*. In a recent meta-analysis, Bosniak Class II, III, and IV cysts were found to have a risk of 24, 41, and 90%, respectively *(5)*.

If the suspicion of malignancy is high, percutaneous aspiration of the cyst fluid for cytological examination may be performed, although the risk of a false-negative cytology remains. A comprehensive meta-analysis by Wolf et al. found an overall sensitivity of cyst aspiration in diagnosing malignancy of 90%, a specificity of 92%, positive predictive value of 96% and negative predictive value of 80% *(5)*. The risk of a false negative aspiration has been estimated at 20%, and the occurrence of tumor seeding along the needle tract has been reported *(6–12)*. Consequently, definitive management of complex cysts has historically involved open exploration and cyst excision. Recently, laparoscopic cyst decortication and cyst wall biopsy has been offered as a minimally invasive means of exploring suspicious or treating symptomatic renal cysts.

Table 1
Bosniak Criteria for Renal Cysts Based on Computer Tomography *(4)*

Type	*Calcification*	*Septa*	*Wall*	*Enhancement*
I	None	None	Thin	None
III	Minimal	Few	Thin	None
III	Extensive	Multiple	Increased thickness	None
IV	Significant, associated with a solid component	Numerous, very irregular	Thick	Yes

Symptomatic Simple Cysts

For symptomatic simple renal cysts, an initial attempt at conservative therapy with analgesics should be undertaken. If these measures fail, percutaneous aspiration or sclerosis or surgical decortication may be tried. Cyst aspiration for simple, peripheral cysts can be performed using CT or ultrasound guidance and enables sampling of the cyst fluid for cytology. Unfortunately, simple percutaneous drainage is associated with a high rate of fluid reaccumulation, resulting in the frequent addition of a sclerosing agent *(13,14)*. Multiple compounds have been used as sclerosing agents, including alcohol *(15–17)*, tetracycline *(18)*, minocycline *(13)*, and povodine-iodine *(19)*, with success rates ranging from 75–97% and complication rates from 1.3–20%. As such, percutaneous sclerosis should be the preferred therapy for most simple cysts once the benign nature of the cyst is established.

One caveat to this approach is the management of peripelvic cysts. These cysts present a special management challenge owing to their proximity to the renal hilum and collecting system, making them frequently inaccessible to percutaneous access and rendering instillation of sclerosing agents potentially dangerous.

For patients who fail percutaneous cyst aspiration and/or sclerotherapy or are unsuitable candidates, endoscopic, open or laparoscopic cyst decortication provide an alternative treatment option. The role of endoscopic resection for management of renal cysts has been limited *(19–22)*. Plas and Hübner reported a 50% radiographic success rate at 46 mo follow-up for percutaneous resection of renal cysts *(20)*.

Open cyst decortication historically was reserved for percutaneous and/or endoscopic failures, but the procedure was associated with a high rate of perioperative complications *(23)*. Laparoscopic cyst decortication offers a less morbid, but equally efficacious approach for unroofing renal cysts *(24–26)*. The laparoscopic approach enables direct visualization of the cyst during aspiration, unroofing, and biopsy of the cyst wall. Hemostasis can be easily obtained and the procedure performed with less morbidity than open procedures.

Adult Polycystic Kidney Disease

Laparoscopic cyst decortication has also been described for the management of symptomatic ADPKD. ADPKD is the most common renal cystic disease, accounting for 9–10% of patients on chronic dialysis *(3)*. The disease typically presents in the third or fourth decade of life and is progressive in nature. Mutations in at least three genes thought to be responsible for the disease have been identified: PKD-1, PKD-2, and PKD-3, with a mutation in the PKD-1 gene on the short arm of chromosome 16 accounting for 85% of cases *(27,28)*. The most common presenting symptoms are back, flank, or abdominal pain, which are seen in up to 60% of patients *(3)*. Hypertension affects 40–60% of patients and is thought to contribute to progressive loss of renal function *(29)*. Diagnosis is usually made by radiologic studies and depends on the patient's risk profile *(3)*.

Although the primary management goal of ADPKD is control of hypertension and delay in loss of renal function, many patients suffer debilitating pain associated with expansion of the renal cysts. Medical management with non-narcotic analgesics is the recommended initial therapy, although nonsteroidal anti-inflammatory drugs (NSAIDs) may potentially exacerbate renal failure. Surgical management is reserved for those patients who fail conservative therapy. Percutaneous cyst aspiration has been used with variable success, but usually results in only transient relief owing to cyst fluid reaccumulation and the limited ability to identify the symptomatic cysts in ADPKD *(30)*.

Open cyst decortication offers a more durable pain response especially when more aggressive cyst decortication is performed *(31,32)*. Ye and colleagues reported successful relief of pain at 1 yr in 92% of patients, but at 5 yr, success rates dropped to 81% *(32)*. Likewise, Elzinga and colleagues reported relief of pain in 80% of 26 patients at 1 yr, but only 62% at 2 yr *(31)*.

Interestingly, there have also been reports of a reduction in hypertension and stabilization of renal function associated with open decortication *(32,33)*. Unfortunately, open cyst decortication has been associated with a 33% perioperative complication rate, which has minimized the popularity of the procedure *(23)*. Recently, laparoscopic cyst decortication for ADPKD has been successful in several series while decreasing surgical morbidity *(34–39)*.

OPERATIVE TECHNIQUE

Patient Preparation

In preparation for surgery, all patients undergo routine laboratory studies such as serum creatinine, hematocrit and urine culture. Confirmation of contralateral renal function is mandatory in cases in which the possibility of nephrectomy is present, such as in treatment of complex cystic disease. Similarly, the patient should be informed of the potential for conversion to an open procedure or the need for a nephrectomy in case of complications. A preoperative bowel preparation is not required but may be beneficial in cases of ADPKD or infected renal cysts.

Prior to initiating the procedure, it is important to determine that the necessary equipment is open or readily available. Table 2 lists the equipment recommended for laparoscopic renal cyst decortication.

Antibiotic prophylaxis with a cephalosporin or aminoglycoside is initiated prior to surgery. After induction of anesthesia, the stomach and bladder are decompressed with a nasogastric tube and bladder catheter, respectively. In patients with peripelvic cysts or deep parenchymal cysts with a potential for violation of the collecting system, an open-ended ureteral catheter is placed at the start of the procedure for retrograde instillation of methylene blue to facilitate identification of an inadvertent collecting system injury. The ureteral catheter can be converted to an internal ureteral stent at the conclusion of the procedure if necessary.

Table 2
Instruments for Laparoscopic Cyst Decortication

- Cystoscopy equipment, if planned
- Veress needle
- Direct Vision Access port (e.g., Visiport, U.S. Surgical Corporation)
- Laparoscopic lens
- Two–three 10-/12-mm ports
- Two 5-mm ports
- Laparoscopic instruments including scissors, graspers, and suction-irrigator
- Laparoscopic ultrasound
- Argon beam coagulator
- Retrieval bag
- 5-mm and 10-mm clip appliers
- Oxidized cellulose
- Laparoscopic aspiration needle

Patient Positioning

Anterior cysts are best approached transperitoneally, whereas isolated posterior cysts may be more easily approached retroperitoneally.

For the transperitoneal approach, the patient is placed in a 45° modified flank position with a roll under the back to support the scapula. An axillary roll is placed to elevate the shoulder and protect the axilla from a brachial plexus injury. The table may be slightly flexed. Sequential compression devices are applied to the legs, which are padded and secured, while the arms are folded over a pillow on the chest. The upper body and legs are then secured to the bed with wide tape. The table should be rotated in both directions to ensure the patient is secure prior to commencing the procedure. For obese patients, a more lateral position can be used to allow the pannus to fall medially.

For a retroperitoneal approach, a full flank position is utilized. After placing an axillary roll, the lower arm is positioned on an arm board and the upper arm is flexed across a pillow or an elevated support. The legs are well-padded and both the upper and lower extremities are secured. The table is flexed and kidney rest elevated.

Trocar Placement

Transperitoneal Approach

Pneumoperitoneum is established using either the Veress needle or open canula technique. A 12-mm port is placed at the umbilicus, and the remaining ports are placed under laparoscopic vision as follows: On a left-sided cyst decortication, a 12-mm port is placed just below the umbilicus along the midclavicular line and a 5-mm port is placed midway between the xyphoid and the umbilicus along the midline. For a right-sided procedure, a 5-mm upper midline is placed midway between the xyphoid and the umbilicus and a 12-mm port is placed just below the level of the umbilicus at the right midclavicular line. An optional 3- or 5-mm port may be placed in the upper midline to facilitate retraction of the liver or spleen (Fig. 4).

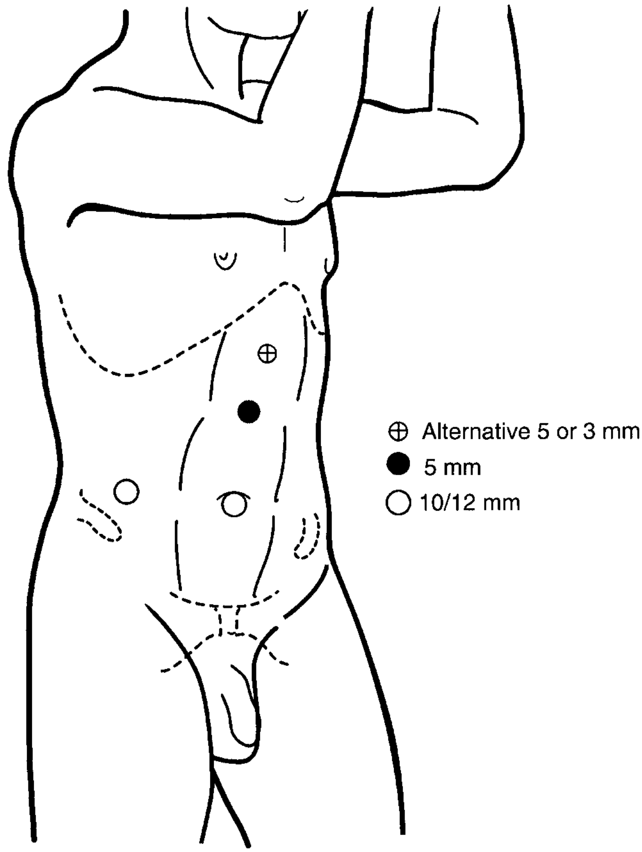

Fig. 4. Three ports are used for the transabdominal approach: the first 12-mm laparoscopic port is placed at the umbilicus, and the remaining ports are placed under laparoscopic vision as follows: a 12-mm port is placed just below the umbilicus along the midclavicular line and a 5-mm port is placed in the midline between the xyphoid and the umbilicus. Reprinted with permission from ref. *51*.

Retroperitoneal Approach

A 2-cm skin incision is made just at or posterior to the 12th rib at the superior lumbar triangle. Using blunt finger dissection, a space is created anterior to the psoas muscle and outside Gerota's fascia to accommodate a balloon dilator. A commercially available trocar-mounted balloon (Origin Medsystems, Menlo Park, CA) or a modified Gaur balloon comprised of the middle finger of a size 8 latex surgeon's glove mounted on a 16F red rubber catheter is used to expand the retroperitoneal space to 800–1000 cc. A 12-mm blunt-tipped cannula is placed at this site. A second 12-mm trocar is placed under laparoscopic vision along the anterior axillary line in line with the first trocar, taking care to avoid inadvertent injury to the peritoneum. A third 5-mm trocar is placed a few fingerbreadths posterior to the second trocar (at the lateral border of the paraspinous muscles) or superior the 12 mm trocar in the anterior axillary line (Fig. 5).

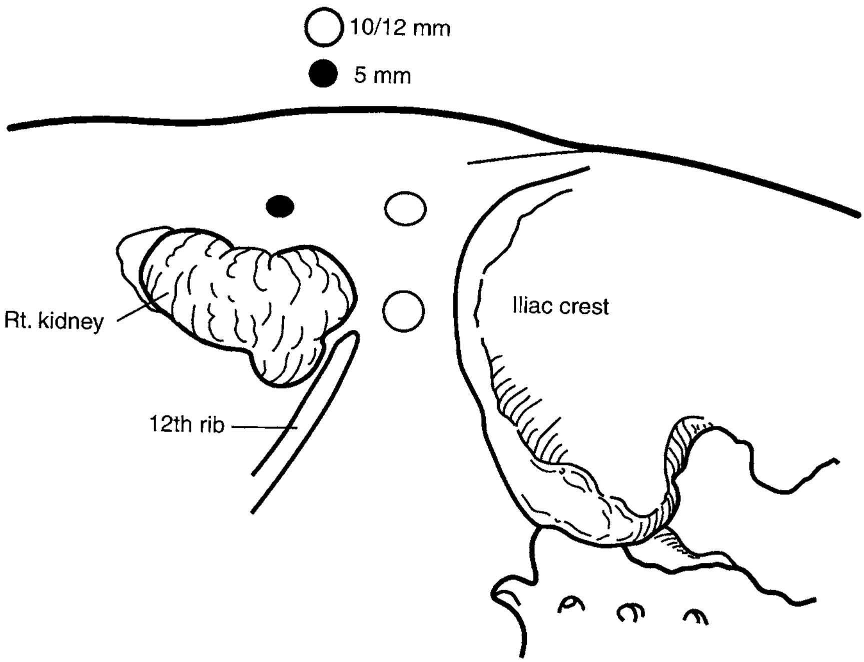

Fig. 5. In the retroperitoneal approach, a 12-mm blunt-tipped cannula is placed just at or posterior to the 12th rib at the superior lumbar triangle, and a second 12 mm trocar is placed in the anterior axillary line in line with the first trocar. This is placed under direct vision with care to avoid injury to the peritoneum, which can be swept medially as necessary. A third 5-mm trocar is placed a few fingerbreadths posterior (at the lateral border of the paraspinous muscles) under direct vision or superiorly above the 12-mm trocar in the anterior axillary line. Reprinted with permission from ref. *51*.

Procedure

Transperitoneal Approach

Once the trocars are secured, the line of Toldt is incised from the iliac vessels to the splenic or hepatic flexure and the colon is mobilized medially. On the left side, the splenicocolic and phrenicocolic ligaments are divided. The spleen should be lifted anteriorly as necessary to assist with this maneuver, which should provide access to the upper pole. On the right side, the hepatic flexure should be mobilized, which may require an additional 3- or 5-mm trocar in order to elevate the liver. Additionally, it may be necessary to mobilize the duodenum, particularly for treatment of medial and peripelvic cysts (Fig. 6). At this point, the portion of Gerota's fascia, where it overlies a solitary cyst, is opened. The kidney need not be mobilized in its entirety for unroofing of a single cyst. In contrast, the entire kidney is mobilized and the hilum exposed to provide optimal access to the maximum number of cysts in ADPDK.

For a solitary cyst, the perinephric fat overlying the cyst is mobilized until a rim of normal renal parenchyma is exposed (Fig. 7). For large cysts, dissection may be facilitated by partially decompressing the cyst using an 18-gauge spinal needle placed percutaneously and guided by laparoscopic vision (Fig. 8). The cyst wall is then grasped and electrocautery scissors are used to excise the wall until it is flush with the renal capsule (Fig. 9). The specimen is then sent for histopathologic evaluation and the aspirated cyst fluid for cytology. The base of the cyst is inspected for suspicious nodules

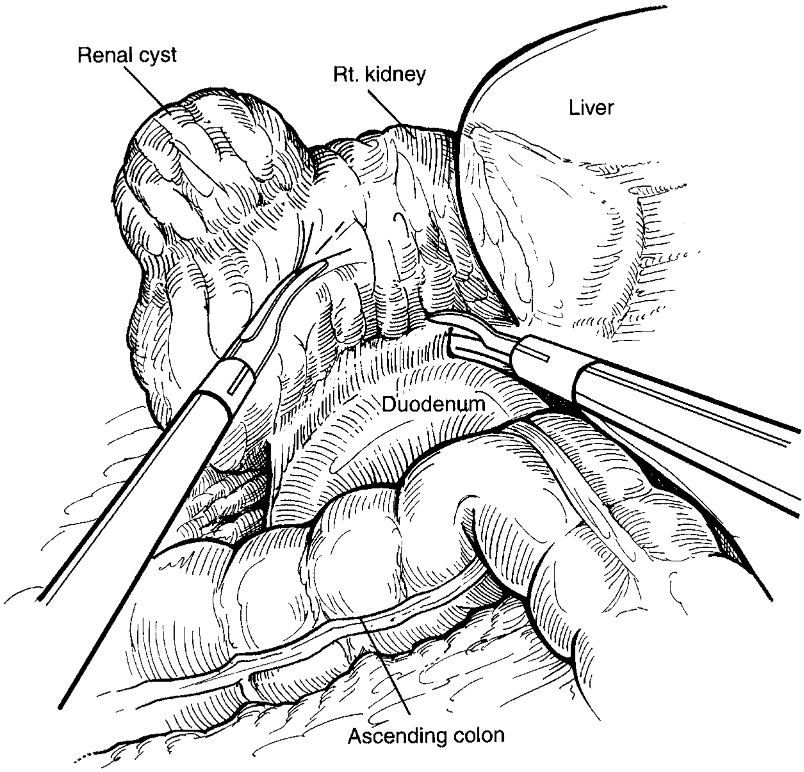

Fig. 6. On the right side, the colon is reflected medially and a Kocher maneuver may be necessary to fully expose the kidney. Reprinted with permission from ref. *51*.

or irregularities that may be biopsied with cup biopsy forceps (Fig. 10). Hemostasis is obtained at the biopsy site and along the incised cyst wall with judicious use of electrocautery or the argon beam coagulator. Routine coagulation of the base of the cyst is discouraged owing to the risk of collecting system injury *(40)*. Perirenal fat, a tongue of omentum, or a polytetrafluoroethylene (Gore-Tex) wick *(34)* may be placed into the cyst cavity to act as a wick to divert cyst fluid and prevent reaccumulation. For large cysts, a 7-mm suction drain may be placed through a lateral port and left for 1–2 d.

In the case of an intrarenal cyst, laparoscopic cyst decortication may be a challenge. The use of intraoperative ultrasound to locate the cyst or the preoperative placement of a percutaneous nephrostomy tube may facilitate localization of the cyst and help distinguish it from the collecting system; however, decortication involves dissection of renal parenchyma and may result in significant hemorrhage. As such, internal renal cysts should be approached cautiously, if at all.

Peripelvic cysts are more difficult to approach laparoscopically than simple peripheral renal cysts. The location of the cysts near the hilum mandates that meticulous dissection be performed to avoid vascular injury or entry into the collecting system. A ureteral catheter should be placed prior to the procedure to enable injection of indigo carmine-stained saline to help distinguish the cyst from the collecting system. Use of electrocautery should be avoided during the dissection owing to the close proximity to the renal vessels and collecting system. The use of laparoscopic ultrasound may help distinguish the cyst from the renal vein *(40)*.

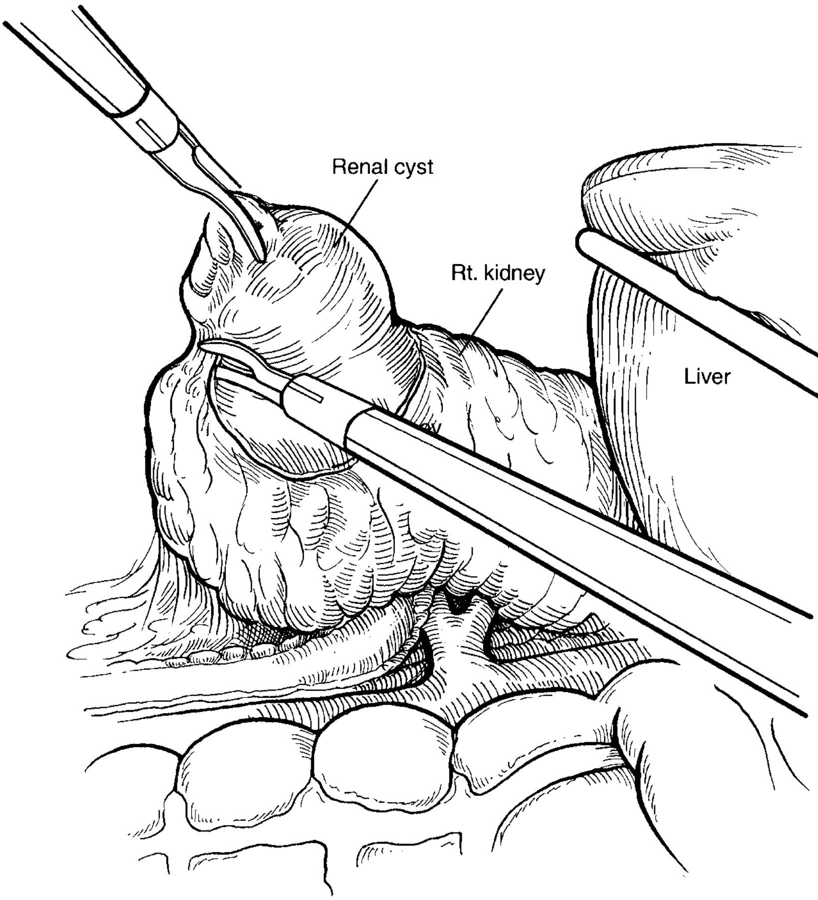

Fig. 7. The renal cyst can be identified through Gerota's fascia and the perinephric fat is mobilized until a rim of normal parenchyma is exposed. Reprinted with permission from ref. *51*.

For patients with ADPKD, direct laparoscopic vision facilitated by intraoperative ultrasound is critical in order to find, identify, and unroof as many cysts as possible (Figs. 11 and 12). Typically, hundreds of cysts will be unroofed or punctured in ADPDK (Figs. 13 and 14). If safe excision of a cyst wall is precluded by overlying parenchyma, aspiration of the cyst may be performed. Placement of a suction drain at the conclusion of the procedure is advisable.

Retroperitoneal Approach

The retroperitoneal approach is used most commonly for posterior and lower pole cysts; however, some authors advocate this approach for any peripheral or peripelvic cyst *(41)*. After trocar placement, the peritoneum is swept medially and the psoas and quadratus lumborum muscles are identified, allowing Gerota's fascia to be opened. Perinephric fat may be used to elevate the kidney. Once the cyst is identified, it is managed similarly to the transperitoneal approach.

Postoperative Care

Most patients begin clear liquids on the night of surgery and the diet is advanced the next morning. The bladder catheter is removed the morning after surgery. Antimi-

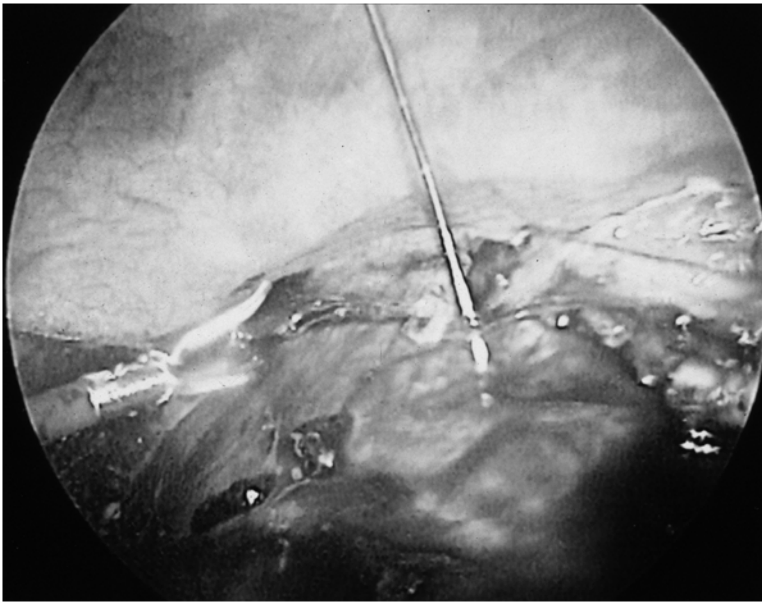

Fig. 8. For large cysts, dissection may be facilitated by partially decompressing the cyst using an 18-gauge spinal needle placed percutaneously and if necessary guided by laparoscopic vision. The cyst fluid is sent for cytopathologic evaluation.

crobial prophylaxis with a cephalosporin is continued for three additional doses postoperatively.

In the event of a persistent ileus, fever, or abdominal distention, an urinoma or retroperitoneal hematoma should be considered and is best diagnosed with a contrast-enhanced CT. If an injury to the collecting system is suspected intraoperatively, injection of indigo carmine-stained saline may confirm it and an internal stent should be placed at the conclusion of the case. For a previously unsuspected urinoma, a Foley catheter should be reinserted and a percutaneous nephrostomy tube or ureteral stent placed. For the rare retroperitoneal hematoma, conservative management with or without transfusion suffices in most cases; rarely, a renal arteriogram and transcatheter embolixation is necessary to identify and treat the source of hemorrhage.

RESULTS

Simple Renal Cysts

Reports of laparoscopic cyst decortication for simple renal cysts using both the transperitoneal and retroperitoneal approaches abound in the literature *(34,36,42–48)*. Among series with at least 10 patients, success rates of (77–100%) have been reported, although follow-up is short (under 1 yr) in most series (Table 3). In most series, the indication for surgery was persistent pain requiring narcotic analgesics. Most investigators used cyst resolution as the primary outcome parameter and determinant of success; however, resolution of pain was reported in greater than 75% of patients in most series *(34,36,42,45,48)*. The need for transfusion was rare and most groups reported minimal blood loss, few complications, and only rare cases required open conversion. Indeed, Fahlenkamp reviewed 139 cases of laparoscopic cyst decortication at four centers and noted only five complications *(47)*. Complications that have been

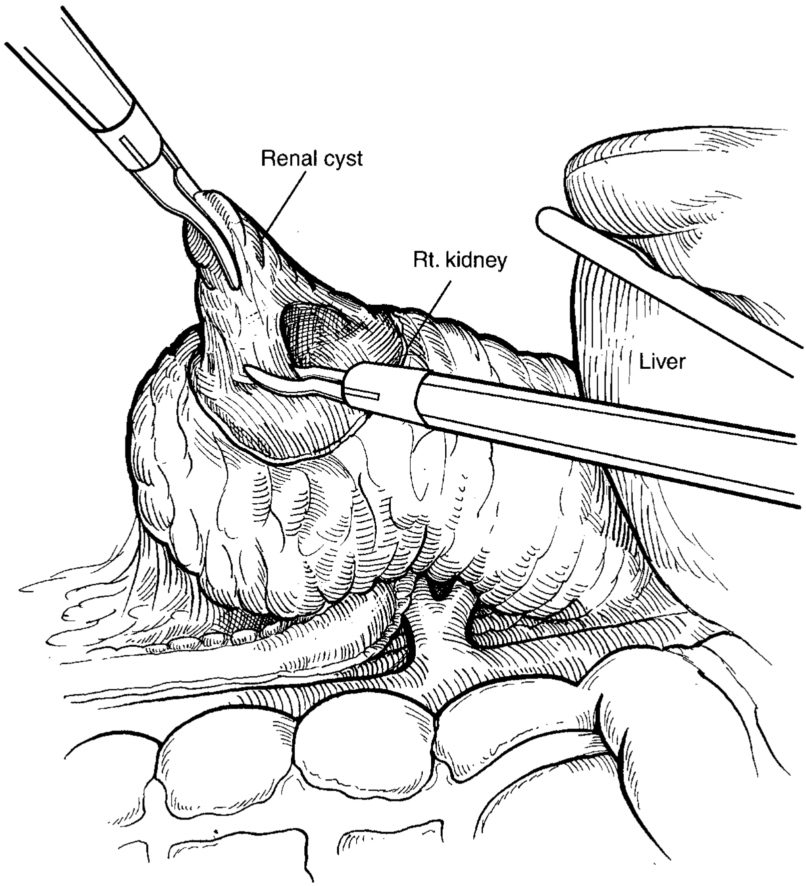

Fig. 9. The cyst wall is then grasped and electrocautery scissors used to excise the wall until it is flush with the renal capsule. Reprinted with permission from ref. *51*.

reported include bleeding, open conversion, ileus, urinary fistula, and nerve paresthesia. The overall complication rate of 6.2% (Table 3) compares favorably with the 32% rate reported for open cyst decortication *(23)*.

Indeterminate Cysts

The laparoscopic management of complex cysts is controversial. Although most Bosniak IV cysts require nephrectomy, the incidence of malignancy in class II and III cysts is lower and may warrant laparoscopic evaluation to rule out malignancy *(36,46,48,49)*. Santiago and colleagues reviewed their series of 35 patients with Bosniak II and III cysts who underwent laparoscopic cyst decortication. Among these patients, five (14.5%) were found to have renal cell carcinoma, four of whom underwent immediate partial or radical nephrectomy and one of whom underwent a delayed partial nephrectomy after a change in pathologic interpretation. No recurrences were detected in this group of patients at a mean follow-up of 20 mo *(49)*.

Roberts and colleagues also performed laparoscopic cyst decortication in eight patients with Bosniak class II/III cysts. One patient with a finding of a 0.8-cm

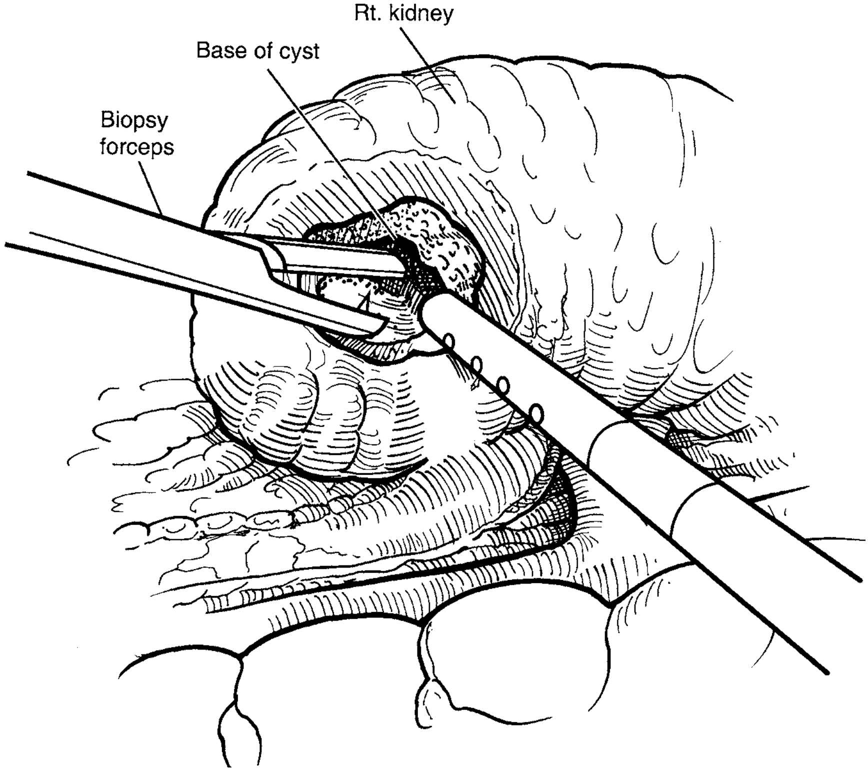

Fig. 10. The base of the cyst is inspected for suspicious nodules or irregularities that may be biopsied with cup biopsy forceps. Reprinted with permission from ref. *51*.

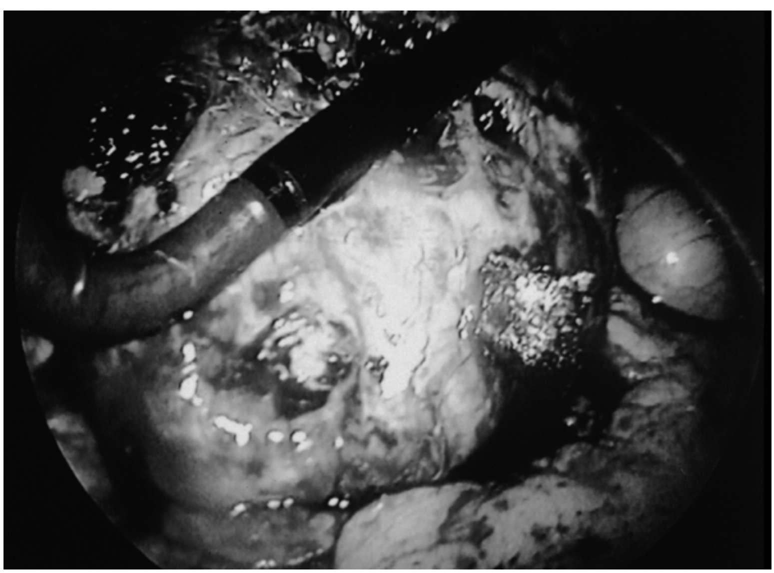

Fig. 11. The laparoscopic ultrasound facilitates detection of cysts and is particularly useful in ADPKD and for intraparenchymal cysts.

Fig. 12. Multiple subsurface cysts visualized using laparoscopic ultrasound.

focus of papillary renal cell carcinoma on permanent histopathological examination subsequently underwent an open radical nephrectomy with excision of the trocar site that was used for specimen extraction. With 60 mo follow-up, no recurrence has been detected *(48)*. Although these results are encouraging, the safety of this approach from a tumor control standpoint is still uncertain. Until longer follow-up and more patients are evaluated, this technique should be employed cautiously and selectively.

Peripelvic Cysts

Few reports are currently available regarding the outcome of laparoscopic decortication of peripelvic cysts *(34,40,48)*. The largest series to date was reported by Roberts and colleagues in which 11 patients with peripelvic cysts underwent laparoscopic decortication with no open conversions, no transfusions, and no recurrences. The only complication was a prolonged urine leak and associated ileus. Not surprisingly, operative time and mean blood loss were statistically greater for treatment of peripelvic cysts compared with simple cysts (164 vs 233 min [$p = 0.003$], 98 vs 182 mL [$p = 0.04$]) *(48)*.

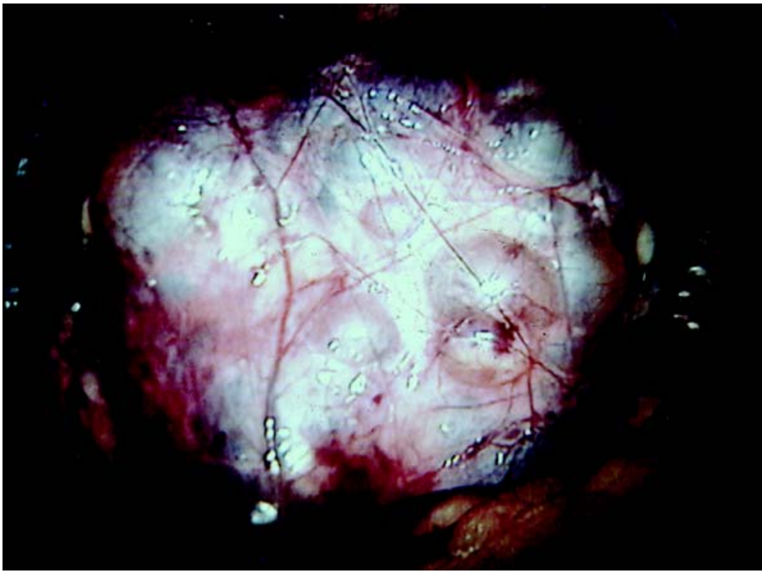

Fig. 13. Laparoscopic view of a kidney in a patient with ADPKD.

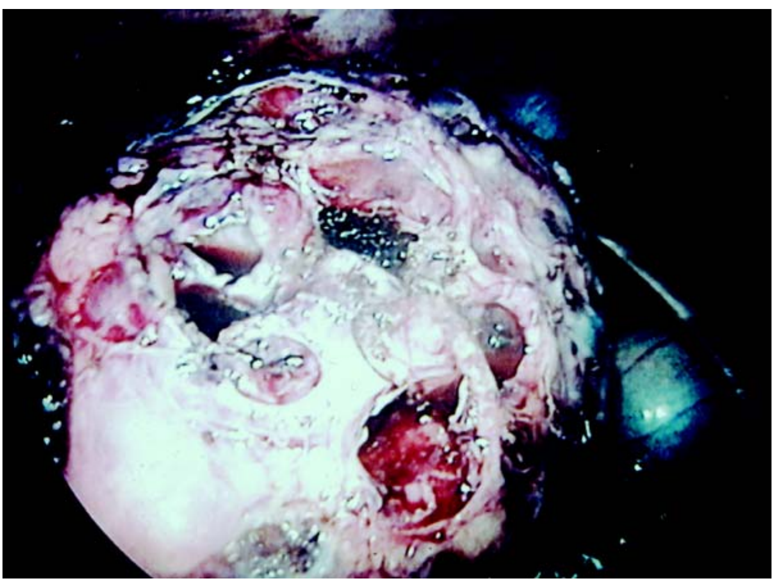

Fig. 14. Laparoscopic view of a kidney in a patient with ADPKD after decortication.

Hoenig and associates treated four patients with peripelvic cysts using both the transperitoneal ($n = 3$) and retroperitoneal ($n = 1$) approaches. The sole failure occurred in the only patient who underwent a retroperitoneal approach, and the authors concluded that this approach might offer less optimal visualization of the hilum *(40)*. From these small series, it appears that with careful technique, laparoscopic decortication of peripelvic cysts is feasible and efficacious.

Table 3
Laparoscopic Cyst Decortication for Symptomatic Cysts

Author	*Pts*	*TP/RP*	*OR Tm (min)*	*Transf.*	*Conversion*	*Complic.*	*LOS (d)*	*Conval. (wk)*	*F/U (mo)*	*Success (%)*
Rubenstein *(34)*	10	9/1	147	10%	10%	20%	2.2	1	10	100
Guazzoni *(42)*	20	TP	75	0%	0%	0%	2.2	1	3–6	100
Valdivia *(43)*	13	TP	–	–	0%	–	–	–	0–>12	–
W*ada (44)*	13	TP	–	–	7.7%	7.7%	–	–	3	77
Ou *(45)*	14	RP	78	–	–	7	4.2	1	8	100
Denis *(46)*	10	8/2	92	–	10%	10%	5.4	–	8.3	100
Fahlenkamp *(47)*	139	–	–	–	–	3.5%	–	–	–	–
Roberts *(48)*	21	13/8	164	0%	0%	14%	1.9	–	15.8	95
Total	**240**	**83/18**	**129**	**2.0% (1/51)**	**3.4% (3/87)**	**6.2% (14/227)**	**2.9**	**1**	**–**	**–**

Autosomal Dominant Polycystic Kidney Disease

Laparoscopic cyst decortication for ADPKD has been reported in a few small series (Table 4) *(31,35–39,50)*. Although the early series do not note the number of cysts decorticated, several recent studies emphasize the importance of extensive cyst decortication. Dunn and co-workers marsupialized on average 204 cysts/procedure with the hope that more aggressive cyst decortication may lead to more durable pain relief *(38,50)*. It should be noted that extensive cyst decortication is a time-consuming and tedious operation with an average published time of 226 min (Table 4).

Short-term pain relief is typical after laparoscopic cyst decortication. Lifson and colleagues reported complete pain resolution in 71%, and 57% of seven patients were pain-free at 6 mo and 2 yr, respectively *(36)*. Dunn and coworkers also noted a reduction in pain in 73% of 15 patients at 2 yr, with an average pain reduction of 62% *(38)*.

The impact, if any, of cyst decortication on the natural history of ADPDK-related hypertension and renal function is unclear. Dunn and colleagues found no change in blood pressure in 40%, improvement in 20%, resolution in 7%, and worsening in 33% of 12 ADPDK patients undergoing extensive laparoscopic cyst decortication. Serum creatinine levels remained stable in 87% of patients *(38)*.

CONCLUSION

Renal cysts diagnosed either as part of a workup in a symptomatic patient or as an incidental finding are common problems in urology. Percutaneous cyst aspiration and/or sclerotherapy should constitute first-line therapy for simple symptomatic renal cysts that fail conservative management. However, complex cysts, cysts associated with ADPKD, and peripelvic cysts may be best managed initially with laparoscopic or open exploration. Laparoscopic cyst decortication has been demonstrated to be a safe, efficacious, and minimally invasive approach for treatment of renal cysts.

TAKE HOME MESSAGES

1. A trial of conservative management or percutaneous sclerotherapy for simple cysts should precede laparoscopic cyst decortication.
2. The laparoscopic approach to complex renal cysts is controversial and patient candidates for laparoscopic exploration and/or decortication require careful selection. For Bosniak II/III cysts, aspirated cyst fluid should be sent for cytology and samples of the cyst wall and base should be sent for histopathologic evaluation.
3. Peripelvic cysts require careful dissection around the hilum and retrograde injection of methylene blue to rule out inadvertent injury to the collecting system.
4. Aggressive cyst decortication of as many surface and subsurface cysts as possible is advisable for ADPKD. Laparoscopic ultrasound will facilitate identification of accessible cysts.

Table 4
Laparoscopic Cyst Decortication for ADPKD

Author	*Pts*	*TP/RP*	*EBL (ml)*	*OR Time (min)*	*Transf.*	*Convers.*	*Complic.*	*LOS (d)*	*Recur.*	*F/U (mo)*	*Pain relief*
Elzinga *(31)*	3	TP	–	–	–	–	–	–	–	–	–
Chehval *(37)*	3	TP	–	–	0	0	0	2.3	0	16.7	100% initial and 100% at F/U
Brown *(39)*	8	TP	<150	164	0	0	0	<2	25%	12–28	85% initial, 50% at F/U
Elashry *(50)*	2 (5 proc)	TP	85	207	0	0	0	2.4	0	9	100% initial and 6–22 mo
Lifson *(36)*	8 (11 proc)	10/1	116^	137^	9%	0	9%	2.2		28.6% (2/7)	11–65 71% at 6 mo, 57% at 2 yr
Dunn *(38)*	15 (21 proc)	TP	88	330	0	0	33%	3.2	13.30%	26.4	86.7% initial, 73% at 2 yr
TOTAL	**39 (51 proc)**	**50/1**	**108**	**226**	**4.2% (2/48)**	**0%**	**16.7% (8/48)**	**2.55**	**15.7% (6/38)**	**–**	**–**

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6 Laparoscopic Simple Nephrectomy

Transperitoneal and Retroperitoneal Approaches

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CONTENTS

INTRODUCTION

Clayman and associates performed the initial laparoscopic nephrectomy in 1990 *(1)*. Since then, the laparoscopic approach has proven to be an effective alternative to traditional open nephrectomy, while providing significant advantages such as decreased analgesia requirements, reduced hospital stay, and an abbreviated convalescence period for the patient *(2,3)*. Refinements such as entrapment bags and tissue morcellators have improved both the efficiency of specimen removal and the minimally invasive nature of the procedure.

Although the term "simple" has been associated with nephrectomies that are performed for benign indications, this description continues to be one of the great misnomers in the field of urologic surgery. Inflammation, fibrosis, and scarring often affect the involved kidney, making the process of dissection much more difficult than that of the typical radical nephrectomy. When present, these factors make the laparoscopic approach to the simple nephrectomy a challenge for even the most experienced laparoscopic surgeons. This chapter provides a comprehensive overview of the laparoscopic simple nephrectomy, concentrating on critical dissection points when utilizing the transperitoneal and retroperitoneal approaches. In addition, tips for dealing with specific pathologic entities will be provided. It is hoped that this detailed review will facilitate the performance of the laparoscopic simple nephrectomy and assist in preventing the complications associated with this procedure.

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Preoperative Assessment for Laparoscopic Simple Nephrectomy

Laparoscopic simple nephrectomies are performed for benign pathologic conditions involving the kidney. Most often, these entities result in problems such as pain, bleeding, hematuria, or chronic infection. In addition, some benign processes cause massive enlargement of the kidney, leading to displacement of adjacent structures and symptoms such as dyspnea, early satiety, and gastroesophageal reflux.

Symptomatic indications include the following:

1. Chronic pyelonephritis
2. Adult dominant polycystic kidney disease (ADPKD)
3. Reflux nephropathy
4. Chronic renal obstruction/hydronephrosis
5. Renovascular hypertension
6. Large renal stone burden with minimal residual renal function
7. Xanthogranulomatous pyelonephritis
8. Renal tuberculosis

Nonsymptomatic indications include:

1. Poorly functioning, enlarged kidney (i.e., hydronephrotic, ADPKD), which requires removal prior to placement of renal transplant

When one is starting on the learning curve of laparoscopic simple nephrectomy, it is prudent to begin with kidneys that are affected by a minimal amount of inflammation, such as those with vascular disease causing renovascular hypertension, or those involved in symptomatic, chronic obstruction without infection. Smaller specimens like those resulting from reflux nephropathy are also ideal for the inexperienced laparoscopic surgeon. As the surgeon becomes more skilled in laparoscopy, large kidneys (hydronephrosis or ADPKD) that are more difficult to mobilize and dissect can be treated. The most difficult kidneys to treat laparoscopically, those affected by infections, previous surgery, or global scarring/fibrosis, should be reserved for surgeons with a significant amount of laparoscopic experience. This is especially true in cases of xanthogranulomatous pyelonephritis (XGP) or renal tuberculosis.

Absolute contraindications to the laparoscopic approach for simple nephrectomy include the presence of active peritonitis, uncorrected coagulopathy, bowel obstruction, and severe cardiopulmonary insufficiency. A relative contraindication to the transperitoneal laparoscopic approach is a history of abdominal surgeries with subsequent adhesions. If a significant number of intra-abdominal adhesions are suspected preoperatively, it is safest to proceed with open Hasson trocar placement when contemplating this method. The retroperitoneal laparoscopic approach is preferred in these cases, because the peritoneal contents are bypassed entirely.

In the past, obesity was considered to be another relative contraindication to laparoscopy *(4,5)*. Initial access in obese patients can be very difficult, resulting in a higher probability of abdominal wall vessel injury and subcutaneous dissection during pneumoperitoneum establishment. However, more recent studies have shown favorable outcomes for laparoscopic nephrectomies in the obese population. For example, although donor nephrectomies take significantly longer to perform in obese individuals, no significant differences in postoperative morbidity have been noted *(6,7)*. Doublet et al. examined the outcomes of retroperitoneal laparoscopic nephrectomies in nine obese patients, compared to those of 46 nonobese patients *(8)*. Again, the rate of postoperative complications was similar in the two groups, occurring in 11 and 8.5% of the obese and nonobese patients, respectively. No open conversions were required in the obese cohort when the retroperitoneal approach was utilized.

In summary, obese patients can have comparable outcomes to nonobese patients when undergoing laparoscopic nephrectomy. However, we recommend that experience should first be obtained in the nonobese population, in order to minimize complications. It is also prudent to emphasize the increased open conversion risk that is associated with the obese population, especially with the transperitoneal laparoscopic approach *(7)*.

Preoperative Work-Up

As part of the preoperative work-up, all patients should have a complete history and physical, with particular attention to past surgical history. During the physical exam, the patient's body habitus, location of previous surgical incisions, and the presence of skeletal deformities should be noted. Each of these factors can influence the choice of the laparoscopic approach as well as the surgical positioning of the patient.

Full informed consent must be obtained from the patient, with emphasis placed on the risks of the procedure, which include bleeding, injury to peritoneal contents, and the possibility for open conversion, which occurs in approx 5% of laparoscopic nephrectomies *(9,10)*. For laparoscopic simple nephrectomies, however, the incidence of complications and open conversions is potentially higher (Tables 1 and 2). In a series of 100 laparoscopic nephrectomies, Keeley et al. showed that the presence of an inflammatory process (XGP, pyonephrosis, staghorn calculus) increased the chances of conversion to 12% *(9)*. As a result, the patient must be made aware of the lower threshold for open conversion under these circumstances.

Preoperative laboratory studies include a complete blood count, serum chemistries, coagulation panel, urinalysis, and urine culture. A type and screen is obtained, and two units of packed red cells are crossed-matched. As more laparoscopic experience is gained, the surgeon may opt to eliminate preoperative cross-matching. A positive urine culture should be treated appropriately prior to surgery.

All patients should have an imaging study performed preoperatively to assist the surgeon in choosing the appropriate laparoscopic approach. An abdominal/pelvic computed tomography (CT) scan is our imaging modality of choice, because it provides an excellent representation of existing anatomy such as the main renal vessels and ureters. The surgeon can also assess the relationship of the kidney to adjacent structures and gain an accurate representation of the amount of perirenal and pararenal fat that is present. Finally, CT is very sensitive in detecting stranding within the perirenal fat, which is the hallmark of inflammation and fibrosis.

CT scans are also helpful in delineating the presence of aberrant renal vessels, which are known to occur in 25–40% of kidneys *(11)*. If an aberrant vessel is suspected but still not well-defined on CT, some groups recommend that an angiogram (CT, magnetic resonance, or traditional) should be performed to rule out the presence of vascular variants *(12)*. In patients with a history of atherosclerosis, one should also carefully examine the noncontrast images of the CT scan, because calcifications of the renal artery may be detected. If mural calcification is present, the renal artery is dissected to a point where the arterial wall is free of disease (further distally to the aorta) and clips are placed in this area. Fracture of calcified vessels during clip application can cause sudden, uncontrollable arterial hemorrhage.

Table 1
Results of Contemporary Adult Transperitoneal Laparoscopic Simple Nephrectomy Series

Study	*No. of patients*	*No. of lap simple nephrectomies*	*Mean operating room time (min)*	*Mean estimated blood loss (cc)*	*Conversions*	*Complications (major)*	*Mean length of stay (d)*	*Mean convalescence (d)*
Keeley et al. *(9)*	100	79	147	–	5 (6.3%)	1 (1.3%)	4.8	–
Parra et al. *(60)*	12	12	145	140.7	1 (8%)	2 (16.7%)	3.5	16
Ono et al. *(61)*	27	27	265	455	6 (22%)	6 (22.2%)	10[a]	17[a]
Kerbl et al. *(62)*	20	20	355	200	1 (5%)	(15%)	3.7	28 (0.93 mo)
Rassweiler et al. *(2)*	18	18	206.5	–	2 (11.1 %)	2 (11.1%)	6.6	24
Eraky et al. *(63)*	60	60	210	–	6 (10%)	4 (6.7%)	3.2	–

[a]Cases completed laparoscopically

Table 2
Results of Contemporary Adult Retroperitoneal Laparoscopic Simple Nephrectomy Series

Study	*No. of patients*	*No. of lap simple nephrectomies*	*Mean operating room time (min)*	*Mean estimated blood loss (cc)*	*Conversions*	*Complications (major)*	*Mean length of stay (d)*	*Mean convalescence (d)*
McDougall et al. *(64)*	9	9	336	141	0 (0%)	1 (11.1%)	3.5	–
Hemal et al. *(65)*	185	185[a]	100	133	18 (9.7%)	7 (3.8%)	3.0	–
Doublet et al. *(66)*	19	20	115	–	0 (0%)	1 (5.3%)	3.8	–
Rassweiler et al. *(2)*	17	17	211.2	–	1 (5.9 %)	2 (11.8%)	6.3	21
Gaur *(67)*	38	38	131.8	83.5	(16%)	(45%)[b]	2.7	13.3
Ono et al. *(68)*	20	20	198	135	0 (0%)	1 (5%)	8.0	19

[a]Includes 31 nephroureterectomies performed for benign conditions
[b]Includes major and minor complications

The need for preoperative bowel preparation depends on the anticipated difficulty of the case. If the kidney is not involved in an inflammatory process (i.e., atrophic kidney with resultant renovascular hypertension, or hydronephrotic kidney causing pain), the patient is placed on a clear liquid diet the day before surgery and the bowel prep omitted. Another option is a limited bowel preparation protocol consisting of a clear liquid diet and a bottle of magnesium citrate the day before surgery. If significant difficulty in dissection is likely, however, the patient should undergo a full mechanical bowel preparation along with antibiotics consisting of neomycin (1 g) and erythromycin base (500 mg), which are given at 2, 4, and 6 PM the day prior to surgery. If the kidney is suspected to be chronically infected (pyonephrosis, struvite calculi), appropriate antibiotics should be given for at least 1 wk prior to surgery. All other patients should be given a parenteral antibiotic, usually a first-generation cephalosporin such as cefazolin, in the preoperative holding area.

Transperitoneal Simple Nephrectomy

The transperitoneal route is considered the traditional laparoscopic approach to renal surgery. The main advantages of this approach include good anatomic landmarks within the peritoneal cavity and a large working space that allows for optimal port placement. These advantages can be important when treating enlarged kidneys or those involved with a generalized, massive inflammatory process. Disadvantages to this approach include the need to retract or dissect other intraabdominal organs, such as the liver, spleen, and bowel, away from the kidney to provide adequate exposure. In addition, previous intraabdominal surgery can often make trocar placement difficult.

PROCEDURE:

Essential equipment for laparoscopic transperitoneal simple nephrectomy is as follows:

- 15 blade scalpel
- 10-mm 0° laparoscope
- 10-mm 30° laparoscope
- 5-mm 0° laparoscope
- 5-mm 30° laparoscope
- 14-gauge Veress needle
- 12-mm Optiview trocar (Ethicon Endo-Surgery Corporation, Cincinnati, OH)
- 12-mm trocar
- Two 5-mm trocars
- 5-mm ultrasonic dissector
- 5-mm hook electrode (right angle)
- 5-mm Maryland dissector
- 5-mm suction/irrigation probe
- Two 5-mm graspers
- Three 5-mm Kitners
- 5-mm locking grasper with teeth
- 5-mm bipolar grasper
- 5- and 10-mm straight clip appliers
- Endovascular GIA stapler
- Endoscopic scissors
- Entrapment bag: 10-mm and 15-mm Endocatch bags (U.S. Surgical Corporation, Norwalk, CT) or LapSac (Cook Urological, Incorporated, Spencer, IN)

Fig. 1. Patient positioning for laparoscopic nephrectomy with appropriate padding of pressure points.

- Carter-Thomason® fascial closure device (Inlet Medical Incorporated, Minneapolis, MN)
- Open laparotomy tray

Step 1: Initial Positioning

The patient is brought into the operating theater. A bean bag should be in place prior to transfer of the patient onto the operating table. General anesthesia is established while the patient is in the supine position.

If significant difficulty in renal dissection is anticipated because of existing inflammation (e.g., XGP or tuberculosis), a ureteral catheter should be placed to assist the surgeon in identifying the ureter laparoscopically. We prefer to use a 7F ureteral occlusion balloon catheter, which has an inflatable balloon (2 cc of contrast maximum) that can be seated against the ureteropelvic junction, thus lessening the chance of catheter dislodgement. If desired, additional catheter stiffness can be achieved by inserting a super-stiff guide wire through the balloon catheter *(13)*.

A 16F Foley catheter is inserted for bladder drainage and urine output monitoring. In addition, a naso or orogastric tube is placed for stomach decompression. The patient's position is then adjusted such that the break in the table on flexion is between the anterior superior iliac spine and the subcostal margin. The patient is then positioned in a modified flank position, with the thorax rotated back slightly at 30°. The lower hand is padded and placed on an armrest. The lower leg is flexed 90°, while the upper leg is left extended. Pillows are placed between the legs for adequate support. Padding is placed under the lower ankle to relieve pressure in this area. An axillary roll is also placed 5 cm caudal to the axilla to protect the brachial plexus from a stretch injury. Additional padding is placed under the lower elbow to prevent ulnar nerve compression. Finally, the upper arm is placed on a padded support (Fig. 1).

The table is then flexed and the kidney rest elevated such that exposure between the costal margin and iliac crest is optimized. However, one should avoid an excessive

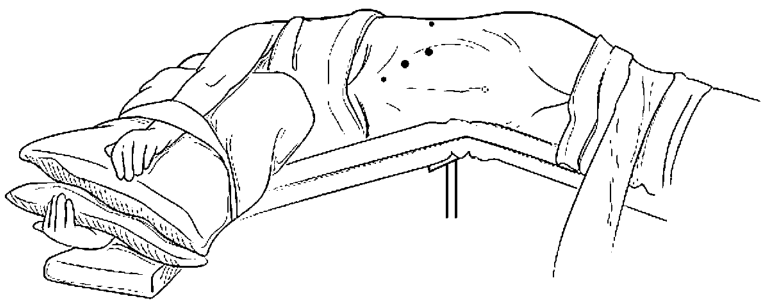

Fig. 2. Port configuration for laparoscopic transperitoneal nephrectomy. ©IUSM 2001, Medical Illustration Dept., C.M. Brown.

kidney rest height or amount of table flexion, in order to minimize the possibility of transient ischemia to the downside kidney *(14)*. When adequate positioning is achieved, the bean bag is deflated under constant suction to hold the patient in place. Surgical towels are placed over the skin at the shoulder, hip, and knee levels, and 3-inch tape wrapped circumferentially at these levels to completely secure the patient to the table. Careful attention to this portion of the case is essential, because the patient may need to be rotated laterally or medially during the case to optimize exposure to the kidney.

One should always ensure that an open laparotomy tray is within the room and readily available, before beginning the procedure.

Step 2: Establishment of Pneumoperitoneum

The patient's flank and abdomen are prepped and draped sterilely. Important anatomic landmarks for initial access are the subcostal margin, the umbilicus, and the rectus abdominus muscle. Although a 14-gauge Veress needle can be used to insufflate the abdomen, we prefer using the Optiview trocar (Ethicon Endo-Surgical Corporation, Cincinnati, OH) because this instrument allows direct visualization of all layers of the abdominal wall during puncture.

When utilizing the Optiview trocar, initial access is obtained at the lateral border of the rectus abdominus muscle, 8 cm below the costal margin (Fig. 2). A 15 blade is first used to make a 12-mm transverse incision into the subcutaneous fat. The Optiview trocar, along with a 10-mm 0° laparoscope, is then placed using constant pressure and a continuous twisting motion (supination and pronation) with the forearm. Steady pressure should be applied through the surgeon's shoulder, never with the elbow, as this has been shown to reduce the incidence of forceful trocar entry and the probability of vascular or bowel injury *(15)*. As the trocar passes through the abdominal wall, the blunt tip spreads apart intervening muscle and fascial layers until the peritoneum is penetrated. Intraperitoneal fat or bowel is easily visible once the peritoneal cavity is entered. At this point, the visual obturator is removed, and the 10-mm 30° scope is placed through the port. Insufflation is then begun with CO_2 to raise the intra-abdominal pressure to 14 mmHg under direct vision.

Should a Veress needle be employed, gentle pressure is applied with the needle at the initial access site described previously. The surgeon should feel two sequential points of resistance as the needle punctures the intervening fascial layers to enter the peritoneum. Once the needle is felt to be in correct position, the surgeon should confirm proper placement by first applying gentle suction through the needle using a 10-cc syringe, to insure that no bowel contents or blood is aspirated. The drop test is then used, where saline is dripped onto the needle hub. If the needle is within the peritoneum, the saline should flow freely into it secondary to the negative intra-abdominal pressure. Finally, 5–10 cc of normal saline are injected through the needle and an attempt made to aspirate the saline. No return should occur if the needle is within the peritoneal cavity.

At no point should the surgeon move the needle laterally in a back and forth motion or rotate the tip of the needle in an attempt to confirm position, as this can exacerabate potential vascular or bowel injuries if the needle is placed near or within these structures. If the needle is suspected to be in a suboptimal position, it should be removed and another placement attempt made.

Once the Veress needle is in proper position, insufflation is then initiated with CO_2 to raise the intra-abdominal pressure to 14 mmHg. The surgeon should examine and percuss the abdomen periodically during insufflation to confirm that the process is proceeding normally and that no significant subcutaneous emphysema is developing. When the intra-abdominal pressure is sufficient, the needle is then removed and a 15 blade used to make a 12-mm incision at the skin level. A 12-mm trocar is then placed, and a 10-mm 30° lens placed through the port. The intra-abdominal contents are examined, beginning with the area directly beneath the trocar entry point. The contents of the abdomen are then inspected carefully for signs of injury, beginning initially with the structures immediately beneath the point of trocar entry.

Step 3: Completion of Port Placement

Other ports are then placed under direct vision in a subcostal configuration (Fig. 2). Trocar placement should be monitored under direct vision with the 30° laparoscope through the 12-mm port. Another 12-mm port is placed 8 cm below the costal margin along the anterior axillary line. The most lateral trocar is a 5-mm port that is placed subcostally in the plane of the midaxillary line, halfway between the anterior superior iliac spine and the costal margin. Another 5-mm epigastric port is also placed, 3 cm below the costal margin at the lateral border of the rectus abdominus muscle. Finally, an additional 5-mm port can also be placed in the midline 2 cm below the xiphoid process (subxiphoid port), to assist with retraction of structures such as the liver or spleen.

Step 4: Initial Dissection

On the right and left sides, the ascending and descending colon, respectively, must be reflected off the anterior surface of the kidney as the initial step. This is accomplished by incising the line of Toldt along the axis of the colon, proceeding to the pelvic brim. We prefer using an ultrasonic dissector, as it allows the surgeon to grasp, incise, and dissect tissue securely, with effective coagulation *(16)*. The blunt tip of the suction probe serves as an effective tool for upward traction against the superior border of the line of Toldt during initial dissection. When the plane between the lateral border of the colon and the abdominal wall is developed, the suction probe tip or a kitner can then be used to bluntly reflect the colon medially while using the ultrasonic dissector to free any remaining diaphanous attachments.

Once the kidney is exposed, dissection should be performed at the level of the renal capsule, if possible. In cases where inflammation is present, one must keep in mind that it will often be impossible to define planes within Gerota's fascia because of peri-renal fibrosis; therefore, dissection will need to progress outside of this plane as would be done in a radical nephrectomy. It is important to carefully dissect from points of known anatomy to points of unknown anatomy. Use of a Maryland dissector in combination with a right-angle hook electrode may allow finer dissection and should be considered if difficulty is encountered.

Step 5: Renal Dissection

One should avoid dissecting along the lateral border of the kidney initially, as early division of these attachments allows the kidney to drop medially, which can hinder hilar dissection.

Right Kidney. In cases where the perinephric fat is easily dissected, it should be cleared away to expose the renal capsule. When significant inflammation is present, work should begin at the level of Gerota's fascia. Dissection proceeds medially, where the duodenum is located and lies anterior to the vena cava and hilar vessels.

The surgeon should then define the duodenum, the lateral border of which must be carefully dissected and mobilized medially (Kocher maneuver). The duodenum is then reflected, exposing the underlying vena cava. As one progresses superiorly along the vena cava, the renal vein is located. Further inferiorly, it is important to find the origin of the gonadal vein for two reasons. First, one can clip and divide the vein early to prevent hemorrhage from this structure, which is commonly very fragile at this site. In addition, by identifying the gonadal vein, the surgeon has a landmark that can then be used to locate the ureter, which usually runs in close proximity.

If difficulty is encountered in initial dissection over the hilar region of the kidney, then one should opt to begin defining the lower pole region of the kidney and isolate the ureter if possible (*see* Step 7). This allows the surgeon to approach the hilum by progressing superiorly along the ureter or the gonadal vessel after retracting the lower pole of the kidney off the psoas muscle, facilitating dissection.

Left Kidney. Dissection can begin medially over the hilar region; however, the surgeon must keep in mind that the long renal vein on this side travels over the aorta and will be the most anterior structure in this area, so that care must be taken to avoid entering this structure inadvertently.

If significant fibrosis or inflammatory change prevents safe dissection over the hilar region, it is probably best to begin toward the lower pole of the kidney (*see* Step 7) and define the ureter and/or gonadal vein. One can then proceed along these landmarks superiorly and define the hilar vessels from this approach.

Once the renal vein is defined, the renal artery can then be isolated. Dissection of the periarterial tissue should begin bluntly, while looking for pulsations indicative of the location of the artery.

Step 6: Isolation of the Upper Pole

Left Kidney. On the left side, the lienorenal and phrenicocolic ligaments are located and divided, in order to allow mobilization of the splenic flexure of the colon and medial displacement of the spleen. One must incise the peritoneal reflection along the upper pole of the kidney in order to be able to define the plane between the adrenal and kidney.

Right Kidney. On the right side, attachments to the inferior border of the right lobe of the liver are freed in order to allow cephalad retraction of this structure. At times, the right triangular ligament may also need to be partially divided to improve mobility of the right lobe. Again, the peritoneal reflection along the upper pole of the kidney should be incised in order to commence dissection at the level of the renal capsule between the adrenal gland and the kidney.

As dissection proceeds along the upper pole of the kidney, the liver or spleen may hinder access to this area. In order to retract these organs cephalad to improve exposure, 5-mm locking graspers with teeth can be inserted through the subxiphoid port. The grasper shaft is used to retract the underside of the organ, and the lateral abdominal wall is engaged with the jaws of the grasper. The surgeon must take great care during positioning of the grasper to avoid traumatizing the liver or spleen with the tip of the instrument, which can result in troublesome bleeding. In addition, one must also avoid injuring the diaphragm with the graspers, as this may lead to a pneumothorax should the pleura be inadvertently punctured. A diaphragmatic tear with pneumothorax should be suspected if the patient develops consistently high-end tidal CO_2 levels and end inspiratory pressures *(17)*. The diaphragmatic injury can be repaired using intracorporeal suturing with needle drivers or the Endostitch device (U.S. Surgical Corporation, Norwalk, CT). The pneumothorax can be aspirated without further intervention as long as the lung is unharmed.

Once the peritoneal reflection along the upper pole of the kidney has been incised, dissection should proceed with the goal of finding the plane between the adrenal and the upper pole of the kidney. Use of an ultrasonic dissector or bipolar coagulator in this situation is useful, as the lower border of the adrenal can be coagulated during dissection to minimize the probability of troublesome hemorrhage. If significant bleeding or abundant, inflamed fatty tissue is encountered, another option is to use a GIA stapler to manage the plane between the adrenal and kidney.

Step 7: Isolation of the Lower Pole

Attention is then turned toward the lower pole of the kidney, where the process of dissection is similar for both sides. Once the lower pole is defined, location and isolation of the ureter further medially is a key maneuver. This major anatomic landmark can be used not only as a traction point to assist in dissection toward the hilum, but also as a guide to other more medial structures such as the aorta on the left and the vena cava on the right. As a result, it is important not to clip and divide the ureter too early in the procedure. This can be done once the hilar vessels are completely isolated and divided.

During ureteral dissection, the colon is retracted medially to improve exposure. Dissection continues from the level of the psoas muscle to the lower pole of the kidney. Once the lower pole and ureter have been defined, the ureter should be tented laterally, and dissection should continue to completely free the posterior portion of the lower pole from the psoas muscle. This creates a window through which the lower pole and ureter can be elevated on traction while dissection continues superiorly toward the hilum.

Step 8: Completion of Hilar Dissection

The surgeon should attempt to completely dissect the hilar vessels free from any surrounding tissue if possible. By isolating the vessels from one another, precise and safe division of the vessels can be achieved. A helpful maneuver during hilar dissection is having an assistant place a kitner through the 5-mm mid-axillary port to retract the kidney laterally.

Left Kidney. On the left side, numerous branches (adrenal, lumbar, gonadal) are derived from the left renal vein, which complicates dissection as a result. Each of these branches must be carefully dissected free, controlled with clips (two on the patient side, one on the specimen side), and divided before proceeding with dissection of the renal artery. The surgeon must be cognizant that the 5 mm clips used to control the renal vein branches can interfere with the engagement of an endovascular GIA staple load on the renal vein itself, leading to potentially catastrophic bleeding. Chan et al. found in a retrospective review that five of seven preventable causes of GIA stapler malfunction were caused by deployment of the stapler over unrecognized clips *(18)*. It is important to suspect stapler problems early, before disengaging the device, as one can place clips or another staple load further medially to ensure control of the vein. A more recent technique employs bipolar electrocautery to cauterize the renal vein branches, which can then be divided without clips. Schuster et al. employed this technique in 20 laparoscopic donor nephrectomies without complications *(19)*.

Right Kidney. Similar retraction and dissection maneuvers are employed during a right-sided procedure. The kidney needs to be retracted laterally to provide the best exposure to the hilar vessels; however, it is important to first detach the adrenal gland from the upper pole of the kidney to prevent inadvertent injury to the right adrenal vein. In addition, the short renal vein can make isolation of the renal artery a challenging task. If one is experiencing difficulty in dissecting the renal artery, the right ureter may need to be divided to allow cephalad and medial rotation of the lower pole.

Once the renal artery and vein are circumferentially dissected, the artery is clipped first. The artery can be controlled by placing three 10-mm clips on the patient side and another clip on the specimen side prior to sharp division with endoscopic scissors. We have found that Weck hemoclips (Weck Closure Systems, Research Triangle Park, NC) also work well in controlling the artery, while providing the additional security of a locking mechanism that ensures that the clip cannot be dislodged once engaged. If one is using the hemoclip, the vessel must be completely skeletonized, as any remaining periadventitial tissue may become lodged within the locking mechanism and prevent clip engagement or worse, a delayed release.

Once the artery is divided, flattening of the renal vein should be observed. If the vein remains full, careful examination for an accessory renal artery should be performed. When the surgeon is satisfied that arterial control has been achieved, the renal vein is then ligated and cut using an endovascular GIA stapler (2.5-mm load).

Should difficulty be encountered in isolating each of the renal vessels because of severe inflammatory changes, a renal pedicle isolation technique using a penrose drain can be implemented. Sufficient dissection anterior and posterior to the hilum must be performed in order to free the pedicle. At this point, the drain is placed around the pedicle such that lateral traction can be utilized to optimize exposure. An endovascular GIA staple load can then be used to cut and ligate the vessels enblock. In this case, a wider staple load (3.5-mm) should be used. In their series examining the transperitoneal laparoscopic approach for inflammatory renal conditions, Shekarriz et al. managed five patients with this technique, with no subsequent development of an arteriovenous fistula after 2 yr of follow-up *(20)*.

Step 9: Removal of Specimen

When the kidney is completely dissected, there are a number of options for specimen retrieval. The first is morcellation of the kidney. This process is facilitated by incorporating the kidney within an Endocatch bag (U.S. Surgical Corporation). To do this, the surgeon must maneuver the kidney over the liver after a right-sided nephrectomy or the spleen after a left-sided procedure to make room for the sack. The 10-mm Endocatch bag is then placed into the lateral 12-mm port, or a 15-mm bag can be placed after removal of the 12-mm trocar and enlargement of the skin incision. The bag is then deployed inferior to the kidney. The kidney is then grasped by the ureter and moved into the bag under direct vision. The drawstring is then pulled tight to cinch the edges of the bag closed, and the edges pulled out of the port.

We prefer to manually morcellate the specimen using finger dissection within the bag and blunt instruments such as ring forceps. Morcellation with mechanical devices often takes longer in simple nephrectomy cases, as inflammatory changes make the tissue very fibrous and scarred.

If the specimen is large, as in cases of ADPKD, manual morcellation becomes less efficient. In these cases, a commercial morcellator can be used in concert with a Lapsac device (Cook Urological, Incorporated, Spencer, IN), which tends to be sturdier than the Endocatch bag. The process should be done under direct vision to ensure that the morcellator does not penetrate the sack and injure other intraabdominal structures *(21)*. A newer device, the WISAP morcellator (WISAP America, Lenexa, KS), allows efficient intracorporeal morcellation of specimens under direct vision, without the use of a laparoscopic bag. To utilize this approach, a 2-cm subumbilical incision is made and the 20-mm WISAP trocar placed with visual guidance. A serrated rotary sheath, along with grasping forceps, is placed within the trocar to perform morcellation. The specimen is grasped and pulled into the rotary sheath, which morcellates in a coring fashion. It is important to lift the specimen up and away from the bowel when engaging the kidney into the morcellator and to visualize the process carefully to prevent inadvertent injuries.

The last option, which is used for unusually large specimens, is open extraction. This can be performed using a standard Pfannenstiel incision, through which the surgeon's arm is inserted and the specimen removed. The rectus fascia is then closed with 0 polydioxanone suture.

Step 10: Port Closure and Procedure Completion

After the specimen retrieval is finished, a fingertip can be placed into the port through which the Endocatch device was removed. Pneumoperitoneum is reestablished, and a final inspection of the intra-abdominal contents performed. One must remember to decrease the intra-abdominal pressure to 4 mmHg to confirm hemostasis prior to exiting the abdomen. The 5-mm ports are then removed under direct vision, and the remaining 12-mm port withdrawn with the laparoscope within it to observe the edges of the port during removal.

All 12-mm ports should have fascial closure with 0 polyglactin suture. We prefer the Carter-Thomason device (Inlet Medical Incorporated, Minneapolis, MN), which allows efficient suture placement. We are evaluating the safety of leaving the fascia of 12-mm port sites created with the Optiview device unclosed. When the port access tract is created by blunt dissection, the tissue planes tend to overlap upon removal of the trocar. At present, 70 transperitoneal laparoscopic live donor nephrectomies have had nonclosure of 12-mm Optiview trocar sites, with no cases of clinical port herniation to date *(22)*. Further long-term evaluation of this method must be performed.

The skin of the 12-mm port sites are typically closed with a subcuticular suture (4-0 polyglecaprone or polyglactin) and steri-stripped. Five-mm port sites are closed with steri-strips alone.

Key Maneuvers

1. After incising the line of Toldt and reflecting the colon medially, initial renal dissection should not begin at the postero-lateral aspect of the kidney. If this is done too early, the kidney will tend to drop medially and making hilar dissection more difficult.
2. On the right side, careful dissection medially to identify and mobilize first the duodenum and then the vena cava allows the surgeon to dissect along the vena cava to identify key vascular structures such as the gonadal vein, renal vein, and adrenal vein.
3. If difficulty is encountered during dissection of the renal artery, attempt to free the lower pole of the kidney first and isolate the ureter. This allows the creation of a window between the hilum and ureter, which facilitates upward traction on the kidney and provides better arterial exposure.
4. When using an endovascular GIA stapler to divide the renal vein, the surgeon must ensure that no clips are included within the staple jaws (e.g., clips on the stumps of the renal artery or left renal vein branches), as these can cause the stapler to misfire.

Retroperitoneal Laparoscopic Simple Nephrectomy

The retroperitoneal approach for laparoscopic nephrectomy was initially assessed by Clayman et al. *(23)*. However, multiple technical difficulties were encountered, the most significant of which was the lack of working space within the retroperitoneum. As a result, most laparoscopic nephrectomies continued to be performed through the transperitoneal approach. It was not until Gaur described a technique of expanding the retroperitoneal space with a self-made balloon expander that this approach became more widely implemented *(24)*. Gaur went on to perform the first laparoscopic retroperitoneal nephrectomy in 1993 *(25)*.

There are a number of advantages of the retroperitoneal route as compared to the more traditional transperitoneal approach. First, the renal artery can be identified much more readily, as the kidney is approached from a posterior plane. In addition, there is a lower risk of intra-abdominal organ injury, because mobilization and retraction of structures such as the liver, spleen, and colon are unnecessary. Because the bowel undergoes little manipulation or direct exposure to CO_2 and fluid collections (hematoma, urinoma) are contained within the retroperitoneal space, the likelihood of postoperative ileus is minimized. The main disadvantages when compared to the transperitoneal approach include the lack of anatomic landmarks, a steeper learning curve, and a tighter working space. Because trocars need to be spaced closer together, specimen entrapment after completion of dissection can also present a challenge.

In general, a retroperitoneal simple nephrectomy can be performed for any indication for which a transperitoneal approach is contemplated. However, larger kidneys will often cause problems in a retroperitoneal approach, secondary to more limited hilar access and difficulty in specimen entrapment *(26)*. In addition, a known history of retroperitoneal inflammation (XGP, tuberculosis) can also limit this approach.

Procedure

Equipment list for laparoscopic retroperitoneal simple nephrectomy is as follows:

- 15 blade scalpel
- 0° 10-mm scope
- 30° 10-mm scope
- 0° 5-mm scope
- 30° 5-mm scope
- 14-gauge Veress needle

- 12-mm Optiview trocar (Ethicon Endo-Surgery)
- Balloon trocar (800 cc, kidney shaped) (General Surgical Innovations)
- 12-mm Bluntip trocar (U.S. Surgical Corporation)
- Two 5-mm trocars
- 5-mm ultrasonic dissector
- 5-mm hook electrode (right angle)
- 5-mm Maryland dissector
- 5-mm suction/irrigation probe
- Three 5-mm Kitner retractors
- 5-mm grasper
- 5-mm locking grasper with teeth
- 5-mm bipolar grasper
- 5- and 10-mm straight clip applier
- Endovascular GIA stapler
- 10-mm and 15-mm Endocatch bags (U.S. Surgical Corporation)
- Endoscopic scissors
- Open laparotomy tray

Step 1: Initial Positioning

If one anticipates a difficult dissection secondary to perirenal inflammation, a ureteral catheter should be placed prior to final positioning. The patient undergoes the same positioning steps as in the transperitoneal approach, along with placement of an axillary roll, Foley catheter, and nasogastric tube.

A key difference, however, is that a full lateral decubitus position is utilized. Chiu et al. performed detailed CT studies of patients, looking specifically at differences in the antero-posterior distances between the quadratus lumborum and colon when patient positioning was changed. A significant increase in the distance between these structures was found with patients in lateral decubitus positions *(27)*. As a result, the patient should lie perpendicular to the table, with the kidney rest between the anterior superior iliac spine and the costal margin, prior to elevation of the kidney rest and table flexion. Proper positioning of the patient is essential to also maximize the distance between the costal margin and the anterior superior iliac spine, to allow for optimal trocar placement (Fig. 3).

The spine, anterior superior iliac spine, costal margin, and umbilicus should be left exposed within the operative field to serve as anatomic landmarks. Leg positioning, padding of pressure points, and securing of the patient is then performed in the same fashion as described for the transperitoneal approach. In the retroperitoneal approach, the surgeon will stand facing the patient's back, with the video tower on the opposite side.

Step 2: Establishment of Pneumoperitoneum

At our institutions, we utilize the retroperitoneal approach described previously by the Cleveland Clinic *(28,29)*. However, for initial access we prefer to use the blunt Optiview trocar with a 10-mm 0° laparoscope for direct visualization of the tissue layers, as opposed to the blunt separation technique using S retractors as described by Gill et al *(30)*.

The anatomic landmarks consist of the 12th rib and the angle between the 12th rib and paraspinous musculature (Fig. 4). Initial access is achieved approximately one fingerbreadth inferior to the tip of the 12th rib. A 15 blade is used to make a 1.5-cm transverse skin incision at this point. The Optiview trocar is then placed into the incision under direct vision, using the 10-mm 0° laparoscope. With the trocar pointed

Fig. 3. Positioning for laparoscopic retroperitoneal nephrectomy (antero-posterior distance maximized).

Fig. 4. Anatomic landmarks (12th rib, paraspinous muscles, iliac crest) for lap retroperitoneal nephrectomy.

to the level of the umbilicus, 20° anteriorly, a twisting motion is applied until the retroperitoneum is entered through the intervening muscle layers and the lumbodorsal fascia. Next, the surgeon's index finger is placed through the established tract to bluntly define the retroperitoneal space. It is important to begin the dissection by sweeping the finger under the tip of the 12th rib anteriorly, to ensure that the correct plane into the retroperitoneum is entered. The goal is for the surgeon's finger to be between the

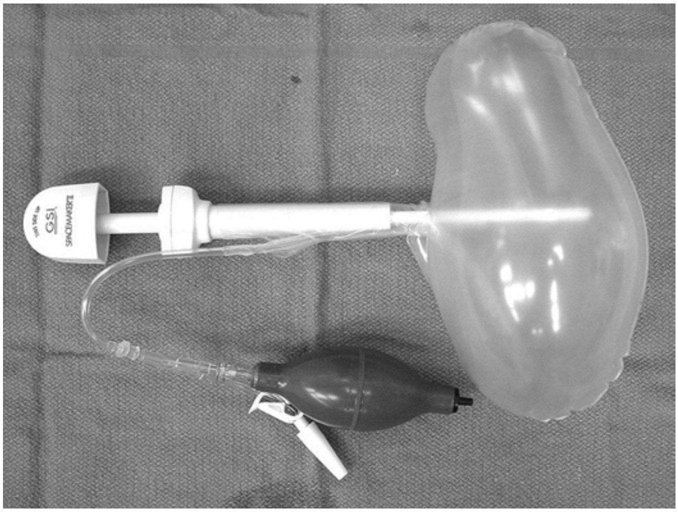

Fig. 5. Balloon dilator for active expansion of retroperitoneal space.

internal surface of the transversalis fascia and the retroperitoneal fat at all times. As the space develops, blunt dissection continues posteriorly. The psoas and paraspinous muscles should be palpated with the tip of the index finger at this point, confirming that the correct plane outside of Gerota's fascia has been maintained. Lastly, the surgeon will sweep the finger further anteriorly to free any remaining attachments, with care taken to avoid inadvertent entry into the peritoneum.

Once the initial development of the retroperitoneal space is completed, the surgeon should be able to sweep the entire index finger in all directions without resistance. A balloon trocar is then placed into the tract and a 0° 10-mm laparoscope inserted into it, to allow direct visualization of the retroperitoneum during balloon expansion. We prefer the GSI Spacemaker II dilator (General Surgical Innovations), because the balloon is "kidney-shaped" and expands the retroperitoneum in an antero-posterior axis as well as a medio-lateral fashion (Fig. 5). Approximately 800–1000 cc of air is required to fill the balloon in the adult patient *(29,31)*. Once the balloon has been fully expanded, the wrinkles along the midline seam of the balloon should no longer be visible. The balloon is then deflated, and the entire trocar removed.

Other groups advocate use of the Veress needle to insufflate the retroperitoneum, creating an initial potential space before active balloon dilation is performed. The initial puncture point should be within Petit's triangle, which is formed by the medial border of the latissimus dorsi muscle, the lateral border of the external oblique muscle, and the superior border of the iliac crest *(23)*. Cadaveric and radiologic studies by Capelouto et al. further refined the access site within Petit's triangle *(32)*. Their report demonstrated that placement of the Veress needle approximately 1 cm above the iliac crest at the level of the *posterior* axillary line while angling the needle tip 10° anteriorly allows safe initial retroperitoneal entry. Once the retroperitoneum has been insufflated, an appropriately sized skin incision is made at the tip of the 12th rib to allow insertion of a balloon dilator, along with a 10-mm 0° laparoscope. After the retroperitoneal space is fully developed under direct vision, accessory ports are then placed as described in step 3.

Fig. 6. Port placement sites for laparoscopic retroperitoneal nephrectomy.

Fig. 7. Placement of trocars in retroperitoneal configuration.

Step 3: Completion of Port Placement

With our method, two additional working trocars are placed with initial tactile guidance, using an index finger inserted into the initial port site. If possible, the trocars should be spaced at least 6–8 cm apart from one another in the subsequently described configuration (Figs. 6–8) *(31)*.

The first port, which is furthest anterior, should be placed approx 3–5 cm above the iliac crest along the anterior axillary line. The proposed insertion site is palpated from within the 1.5-cm port site to ensure that no intervening structures are present. It is

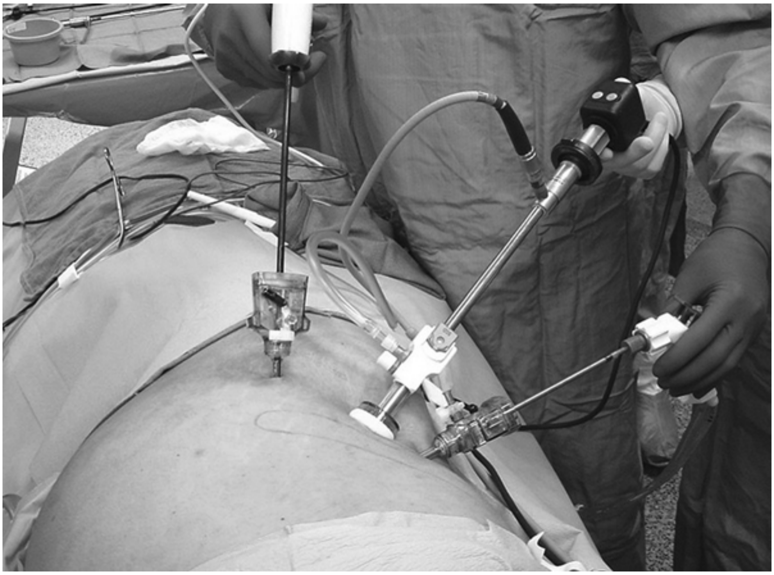

Fig. 8. Final appearance of trocar placement for laparoscopic retroperitoneal nephrectomy (anesthesiologist's view).

crucial to ensure that the border of the peritoneum has been swept as far medially as possible (both manually and by balloon dilation) to avoid puncture during insertion of this trocar. A defect in the peritoneum can cause CO_2 pressure equilibration with the peritoneal cavity, reducing an already limited working space. A 15 blade is used to make a 12-mm skin incision at this site, and a 12-mm trocar is then inserted under tactile guidance. If the surgeon anticipates that an endovascular GIA stapler will not be required for renal vein division (i.e., atrophic kidney), a 5-mm trocar may be used at this site instead. Care should be taken not to inadvertently injure the index finger during trocar insertion. Although the surgeon may choose to wear a thimble to protect the fingertip, we have found that movement of the finger slightly laterally from the intended trocar path is sufficient to prevent injury during insertion.

The second working port consists of a 5-mm trocar placed at the angle formed by the junction between the 12th rib and the paraspinous musculature. The surgeon, with the index finger placed in the initial port site to provide tactile guidance, places the trocar at the junction point approximately 1 cm below the 12th rib and 1 cm lateral to the paraspinous muscles.

Finally, a 12-mm Bluntip trocar (U. S. Surgical Corporation) is placed into the initial port site at the tip of the 12th rib. The advantage of this trocar as opposed to a traditional one is that it contains both a 20-cc balloon, which seats against the transversalis fascia of the abdominal wall, and an adjustable foam cuff at the skin level that prevents loss of pneumoperitoneum through the 1.5-cm skin incision (Fig. 9). A pneumoperitoneum is then established through the Bluntip trocar with CO_2 at 14 mmHg pressure.

Step 4: Dissection of the Kidney

Dissection is begun by inserting either the 0° or 30° 10-mm laparoscope into the Bluntip trocar, and the ultrasonic dissector and blunt-tipped suction/irrigation probe into the working ports. Initial orientation in the retroperitoneum is often difficult. The psoas muscle is often the only visible structure in the lower half of the visual field, with the

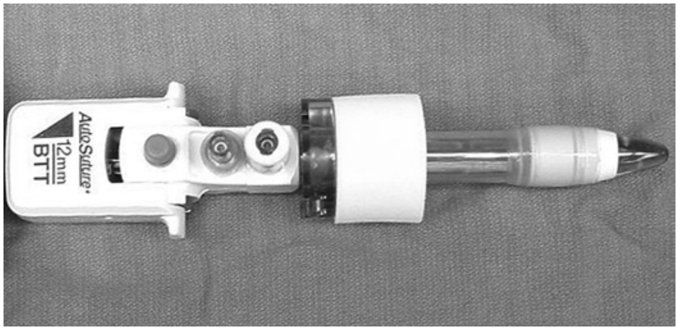

Fig. 9. Bluntip trocar (with cuff).

ureter occasionally visible in this area as well. Gerota's fascia (anteriorly and medially) comprises the rest of the field. On the right side, the vena cava may be seen. With a left approach, the aorta can usually be identified quite easily *(29)*.

It is often easiest to begin dissection toward the posterior surface of the kidney, which allows eventual access to the renal artery. Use of the suction/irrigation probe as a blunt dissector will allow the surgeon to define the plane between Gerota's fascia and the renal capsule. Any remaining perinephric fat can then be dissected away efficiently with the ultrasonic dissector, to expose the kidney. If significant inflammation is present, the goal of dissection should be to define Gerota's fascia around the kidney; only if that fails should one attempt to define the renal capsule.

Proceeding inferiorly, the lower pole should be freed and the ureter identifed if possible. Once it is freed, the ureter should be grasped and torqued in an anterolateral vector to provide traction for hilar exposure. Dissection should then proceed toward the hilum.

As hilar dissection progresses, the surgeon should work both superiorly and inferiorly to the hilum to disengage as much perinephric fat as possible. When sufficient investing fat is freed, the kidney can be also be elevated anteriorly with the suction/irrigation probe or a kitner dissector to provide even further hilar exposure. Dissection should not progress to the anterior surface of the kidney until the artery and vein have been controlled, as the kidney will drop posteriorly and block access to the hilum.

Vascular Control.

Right Side. The renal artery will be the first major vascular structure encountered. It is important to watch for pulsations indicative of proximity to the artery. After the artery has been isolated, the renal vein is found anterior and likely inferior to the artery. One must remember that the structure immediately anterior and medial to the renal artery is likely the vena cava, not the duodenum, and avoid rough retraction, grasping, and dissection of this area. It is common for the vena cava to collapse under the pressure of the CO_2 pneumoperitoneum, making this structure difficult to distinguish from bowel, a gonadal vein, or a ureter.

Left Side. Branches of the left renal vein will complicate hilar dissection. The surgeon must be aware of the lumbar vein originating from the renal vein, which is often encountered prior to reaching the renal artery. This lumbar branch should be isolated, clipped (two on stay side, one on specimen side), and the branch divided.

The renal artery is isolated next. Once the renal artery is circumferentially exposed with no intervening neurolymphatic tissue present, the artery can be clipped. A total of three 10-mm clips should be placed on the patient side of the artery, with one clip placed on the specimen side. The artery is then sharply divided with endoscopic scissors.

Finally, the renal vein is identified; care must be taken to dissect out, clip, and divide the gonadal and adrenal branches, which are located inferior and superior to the renal vein, respectively. As an alternative to clipping the branches of the renal vein, bipolar graspers may be used to cauterize the branches thoroughly prior to division. If the renal vein is divided very close to the kidney, the gonadal and adrenal branches may be left intact. The vein is then engaged and cut with the roticulating Auto Suture endovascular GIA stapler (U.S. Surgical Corporation). This particular stapler has the advantage of adjustable angling of its jaws to optimize positioning.

If hilar dissection is difficult, the ureter can be isolated, clipped, and divided, as it can block mobilization of the lower pole from a retroperitoneal direction. Following this, the lower pole is dissected and freed, allowing retraction of this area superiorly to improve access to the hilum.

Step 5: Completion of Renal Dissection

The ureter is then divided between two 10-mm clips. Completion of the dissection involves careful division of the anterior and superior attachments of the kidney. This portion of the dissection poses the greatest risk of bowel injury, particularly when dense adhesions are present between the anterior aspect of the kidney and the peritoneal cavity. The superior dissection takes place in the plane between the kidney and adrenal, as the adrenal is left behind. Intermittent retraction of the kidney caudally, laterally, and medially will facilitate this process.

Step 6: Removal of Specimen

At this point, a 30° 5-mm laparoscope is placed through the posterior port. A 10-mm Endocatch bag is inserted through the 12-mm Bluntip port and deployed. Grasping forceps are then used through the anterior working port to maneuver the specimen into the bag. Unfortunately, the limited space within the retroperitoneum makes this step rather challenging. It is best to position the Endocatch bag directly inferior to the specimen and attempt to guide the kidney into the enclosure device using graspers.

Once the bag has been drawn around the specimen, the edges are pulled out of the 12-mm Bluntip port. Morcellation of the kidney is then performed.

Step 7: Port Closure and Completion of Procedure

When morcellation is complete and the Endocatch bag has been removed, a fingertip can be inserted into the 12-mm Bluntip port site and insufflation restarted to allow a final inspection of the retroperitoneum. The retroperitoneal pressure should be reduced to 4 mmHg to confirm hemostasis prior to exiting the space. The anterior trocar is first removed under direct vision. The posterior 5-mm trocar is then slipped out over the shaft of the laparoscope, leaving the 5-mm scope within the retroperitoneum. The laparoscope is then withdrawn slowly, allowing visualization of the access tract to confirm hemostasis.

If the peritoneum is intact, there is no need to close the fascia of the 12-mm port sites, as there is no retroperitoneal structure that is predisposed to herniation. If preferred, fascial closure is done under direct vision from the posterior port site with the Carter-Thomason device. The skin of the 12-mm port sites is typically closed with a subcuticular absorbable suture (4-0 polyglecaprone or polyglactin) and steri-stripped. 5-mm port sites can be closed with steri-strips alone.

Key Maneuvers

1. Ensure that initial finger dissection of the retroperitoneum (at initial port site at tip of 12th rib) is done in the right plane. Always begin by palpating under the 12th rib from within the retroperitoneum.
2. Trocars should be spaced as far apart as possible to avoid clashing of instruments. The maximum distance between ports that will be achieved is likely only 6–8 cm.
3. Extreme care must be used when placing the anterior and posterior working trocars, as insertion is done under tactile guidance. The surgeon may use a thimble, but moving the finger slightly away from the entry point will prevent injury.
4. Initial orientation within the retroperitoneum can be difficult. The key structures to identify are the ureter, psoas muscle posteriorly, the aorta on the left, and the vena cava on the right. On the left, try to look for arterial pulsations (renal artery or aorta) if structures are not immediately obvious.
5. When using the endovascular GIA stapler to divide the renal vein, the surgeon must ensure that no clips are in the staple path (e.g., clips on the stumps of the renal artery), as these can cause the stapler to misfire and cause renal vein bleeding.

TIPS FOR SPECIFIC PATHOLOGIC ENTITIES AFFECTING THE KIDNEY

Xanthogranulomatous Pyelonephritis

Xanthogranulomatous pyelonephritis (XGP) is a process that occurs mainly in middle-aged females in the setting of chronic infection (most often with *Proteus mirabilis* or *Esherichia coli*) and obstruction *(33–37)*. Calculi are associated with 22–83% of involved kidneys in various XGP series in the literature *(34,35,38,39)*. The most common symptoms and signs that accompany the process are flank/abdominal pain, palpable mass, fever, anemia, leukocytosis, and weight loss *(36,39,40)*.

The extensive inflammation that accompanies the process causes a severe reaction that involves contiguous structures such as the liver, spleen, colon, and psoas muscle. Patients may also develop fistulous tracts to the skin or colon *(35,36)*. As a result, an abdominal/pelvic CT scan should be a mandatory part of the preoperative work-up for a suspected case of XGP *(41)*. Eastham et al. reviewed the results of 27 patients with a pathologic diagnosis of XGP *(36)*. In 23 of the patients, a CT scan had been performed. Overall, CT scan findings were sufficient to allow diagnosis of XGP in 20 of the 23 patients (87%). In addition, CT accurately revealed the presence of disease extension into the psoas and/or quadratus lumborum muscles in eight patients, into the descending colon in one patient, and involvement of the great vessels in five others.

There is no question that the inflammatory nature of XGP predisposes the patient to a higher risk of complications. Keeley et al. reviewed their first 100 laparoscopic nephrectomies and found that 87% of the patients without inflammatory conditions had no complications or open conversions, as compared to only 69% of patients with existing perirenal inflammation *(9)*. Notably, of the two patients undergoing laparoscopic nephrectomy for XGP, one had to undergo open conversion for lack of progression. In another recent series, one of three patients with XGP required open conversion for dense fibrosis *(20)*.

Bercowsky et al. performed a retrospective review comparing the results of a cohort of five patients undergoing laparoscopic nephrectomy for XGP (three transperitoneal approach, two retroperitoneal approach) with four others treated with the traditional open approach *(42)*. Overall, mean operating time was 360 min, with an average blood loss of 260 cc in the laparoscopic group, compared to 154 min and 438 cc in the open group, respectively. Of note, complications occurred in 60% of the laparoscopic group, as compared to 0% of the open patients. One of the laparoscopic patients that underwent a nephrectomy via a retroperitoneal approach required conversion to a transperitoneal laparoscopic approach. The authors concluded that the benefits of minimally invasive surgery might not apply to this specific group of patients.

Preoperatively, the patient should be counseled carefully about the increased complication rates associated with the laparoscopic treatment of XGP. In addition, there should be a clear understanding that the chance for open conversion approaches 50%.

Once the laparoscopic approach has been chosen and the procedure initiated, it is common to encounter instances where dissection simply cannot proceed because of the inability to identify anatomic landmarks. It is important to attempt dissection in multiple areas, because freeing specific portions of the kidney can improve the overall exposure. Other helpful maneuvers include changes in patient position (i.e., medial or lateral rotation) or the addition of more ports for retraction purposes.

The surgeon should always have a conversion point in mind when undertaking an attempted laparoscopic dissection of an XGP kidney. If no significant progress has been made after 30 min once the aforementioned maneuvers have been used, it is our policy to proceed with open conversion to complete the case.

In summary, the laparoscopic approach to the XGP kidney can be fraught with difficulty and should be attempted only by very experienced laparoscopists. The XGP patient should be made aware of the increased risks involved with the laparoscopic approach. The surgeon should then obtain a preoperative CT scan to assess the degree of inflammation present and involvement of any adjacent structures. The transperitoneal approach should be used because it provides a large working space and helpful landmarks. Finally, early conversion should always be considered, to facilitate completion of the nephrectomy.

Tuberculous Kidney

Involvement of the kidney by tubercular pyelonephritis results in dense perinephric adhesions that complicate surgical dissection *(43)*. However, surgical management of renal tuberculosis is necessary to eradicate a source of infection and prevent late complications such as hypertension and abcess formation *(44)*. Unfortunately, spillage of infectious caseous material is common during attempted laparoscopic dissection of the involved kidney *(43,45)*. Therefore, it is important to have initiated medical treatment well in advance of the surgery.

As with XGP kidneys, laparoscopic dissection can be very difficult. In a review of 482 laparoscopic nephrectomies, Rassweiler et al. found that four of five cases of renal tuberculosis that underwent attempted laparoscopic treatment required open conversion *(46)*. A more recent study of 13 renal tuberculosis patients undergoing laparoscopic nephrectomy (9 transperitoneal, 4 retroperitoneal) showed that 12 were successfully completed, with only one open conversion. However, the authors noted that subcapsular dissection was required in some instances as a result of the intense adhesions to surrounding tissue *(45)*.

Theoretically, a retroperitoneal approach would limit contamination resulting from spillage from the infected kidney and should be attempted if possible. A CT scan is very helpful in assessing the degree of inflammation that is present and can assist the surgeon in determining the appropriate laparoscopic approach. Again, there should be a low threshold for open conversion if lack of progression is experienced.

If gross spillage occurs, the patient should be placed on an antituberculosis regimen during the immediate postoperative period. These regimens should consist of multiple agents, most commonly isoniazid, rifampin, ethambutol, and pyrazinamide *(45)*.

Adult Dominant Polycystic Kidney Disease (ADPKD)

ADPKD is an entity with an incidence of 1:400 to 1:1000 *(47)*. By definition, it is inherited in an autosomal dominant fashion caused by mutations in the PKD1 or PKD2 genes, which are responsible for proper encoding of Polycystin and other vital cellular membrane proteins *(48)*. Patients with the disease develop multiple, bilateral renal cysts, which progressively enlarge and eventually destroy remaining areas of renal parenchyma *(47)*. The cysts are thought to derive from an abnormal proliferation of renal tubular cells *(48)*.

Co-morbidities associated with ADPKD can be numerous. Up to 50% of patients with ADPKD develop end-stage renal disease that necessitates hemodialysis or renal transplantation by the age of 60 *(49)*. In addition, hypertension can develop in up to 50–70% of patients *(50,51)*. The pathogenesis of hypertension in ADPKD patients is complex, but is thought to be derived from progressive intrarenal ischemia through physical compression by enlarging cysts, thus activating the renin-angiotensin-aldosterone pathway *(48)*. Up to 60% of patients also have significant, chronic flank discomfort *(52)*. The etiology of the pain is thought to derive from progressively increased tension on the sensory nerves of the renal capsule as cysts enlarge over time *(53)*. Other potential causes of pain are cyst infection and hemorrhage, as well as nephrolithiasis *(54)*.

In general, nephrectomy in a case of ADPKD is reserved for patients with end-stage renal disease and chronic pain that is refractory to medical therapy. Past studies have documented significant morbidity and mortality rates associated with conventional open nephrectomies for ADPKD *(55,56)*. However, the laparoscopic approach is well-suited for the ADPKD kidney, because it results in much less morbidity for these patients *(57)*.

Early experiences with laparoscopic nephrectomy for ADPKD utilized the transperitoneal approach with intact specimen removal through the flank *(54)*. Because a large incision was required to removed the enlarged specimens, it was soon discovered that patients were prone to develop incisional hernias when a flank muscle cutting incision was used *(58)*. Current approaches for the laparoscopic treatment of ADPKD kidneys attempt to minimize the overall size of the specimen during dissection and limit the size of extraction incisions.

We prefer the transperitoneal route in these cases because of the optimal working space. When approaching an ADPKD kidney transperitoneally, initial port placement should be at an umbilical location (umbilical base), to avoid injury to the enlarged kidney, which may cross the midline *(57,59)*.

Cyst decortication and drainage of fluid is a mandatory step prior to dissection of the kidney, in order to reduce its overall size so that mobilization and exposure of the hilum is facilitated. Sequential cyst puncture with the active blade of the ultrasonic dissector and removal of the cyst fluid using a suction probe is an efficient method of completing this task.

Once dissection of the specimen is completed, we recommend *in situ* morcellation (using the WISAP morcellator) if possible, to minimize the possibility of a postoperative hernia. If an incision must be made to remove the specimen, a minimal lower midline incision is preferred.

A recent review of the laparoscopic transperitoneal approach for ADPKD kidneys compared a cohort of 10 laparoscopically removed kidneys (all morcellated) to 10 specimens removed through open nephrectomy *(59)*. Although the mean operative time for the laparoscopic group was significantly longer than for the open group (247 vs 205 min), the mean hospital stay was much shorter for the laparscopic group (2.6 vs 6.6 d). No intraoperative complications occurred in the laparoscopic group, although one open conversion was necessary secondary to adhesions to the spleen and colon in that patient.

CONCLUSIONS

The laparoscopic approach to simple nephrectomy is applicable to many forms of benign pathology, with significant patient benefits such as superior cosmesis, reduced analgesia requirements, shortened hospital stays, and decreased convalescent times. As with any surgical procedure, however, careful preoperative patient evaluation is necessary to plan the proper approach and maximize the chances for success. The surgeon should always keep in mind the limitations of laparoscopy and apply the approach judiciously when faced with a situation where significant inflammation may be involved.

TAKE HOME MESSAGES

1. If progression is hindered during a laparoscopic simple nephrectomy (transperitoneal or retroperitoneal), early open conversion is warranted.
2. When dealing with very large kidneys (e.g., ADPKD) or marked perirenal inflammation, the transperitoneal approach is preferred to maximize the available working space and improve orientation.
3. Always be aware of clips that may impede engagement of the GIA stapler when taking the renal vein, causing it to misfire and forcing an open conversion.
4. The ultrasonic dissector can be used for almost all points of dissection during a laparoscopic nephrectomy. If difficulty is encountered or finer dissection is needed, switching to a right-angle hook electrode and grasping structures with a Maryland dissector can facilitate the process.

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7 Laparoscopic Radical Nephrectomy

Retroperitoneal Approach

Sidney Castro de Abreu, MD,
and Inderbir S. Gill, MD, MCh

CONTENTS

INTRODUCTION

At specialized centers worldwide, laparoscopic radical nephrectomy is now routine practice for management of indicated patients with localized renal cell carcinoma. Compared to open radical nephrectomy, the laparoscopic approach is associated with comparable operative time, decreased blood loss, superior recovery, improved cosmesis, and equivalent cancer control over an intermediate-term follow-up *(1–4)*.

Laparoscopic radical nephrectomy is commonly performed by the transperitoneal approach, primarily because the transperitoneal route offers a larger working space. However, because the kidney is a retroperitoneal organ, a direct "retroperitoneoscopic" approach duplicates the established open surgical techniques, and has considerable appeal.

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
Edited by: S. Y. Nakada © Humana Press Inc., Totowa, NJ

At the Cleveland Clinic, laparoscopic radical nephrectomy is preferentially performed by the retroperitoneal technique. Concerns about the smaller retroperitoneal working space notwithstanding, our learning curve has allowed us to readily overcome this technical difficulty. Furthermore, retroperitoneoscopy offers several unique advantages, including expeditious access to renal artery and vein allowing early ligation, extra fascial mobilization of the kidney, and *en bloc* removal of the adrenal gland, recapitulating the principles of open surgery *(5)*. In fact, it is the senior author's impression that graduating fellows from our institution are equally confortable and adept at either the transperitoneal and the retroperitoneal laparoscopic approach to radical nephrectomy.

PREOPERATIVE ASSESSMENT

Attention to the patient's cardiorespiratory status, coagulation profile, history of prior operations, and bone or spinal abnormalities is imperative.

Our preoperative bowel preparation comprises two bottles of magnesium citrate administered the evening before the surgery. The patient reports to the hospital on the morning of surgery. Broad-spectrum antibiotics are administered intravenously 2 h preoperatively and intermittent compression stockings are placed bilaterally.

NECESSARY INSTRUMENTATION

- One 10-mm 30° laparoscope
- One 10-mm trocar-mounted balloon dissection device (U.S. Surgical, Norwalk, CT)
- One 10-mm Bluntip trocar (U.S. Surgical)
- Two 10–12-mm trocars
- One 5-mm electrosurgical monopolar scissors
- One 5-mm electrosurgical hook
- One 5-mm atraumatic grasping forceps (small bowel clamp)
- One 10-mm right-angle dissector
- One 10-mm three-pronged reusable metal retractor (fan-type)
- One 11-mm Endoclip applier
- One 12-mm articulated endo-GIA vascular stapler (U.S. Surgical)
- One 5-mm irrigator/aspirator
- One 15-mm Endocatch II bag (U.S. Surgical)
- One Weck clip applicator with disposable clip cartridges (Weck Systems)

PATIENT POSITION

Following general anesthesia and Foley catheter placement, the patient is firmly secured to the operating table in a 90° full flank position. All bony prominences are meticulously padded and extremities carefully placed in neutral position to minimize postoperative neuromuscular sequelae. The kidney bridge is elevated moderately, and the operating table is flexed somewhat to increase the space between the lowermost rib and the iliac crest. To guard against development of neuromuscular spinal problems, we make every attempt to minimize the time period for which the patient is placed in the lateral decubitus flexed position.

OPERATION ROOM SET-UP

The surgeon and the camera operator (assistant) stand facing the patient's back. The surgeon stands towards the patient's feet, while the assistant stands toward the patient's

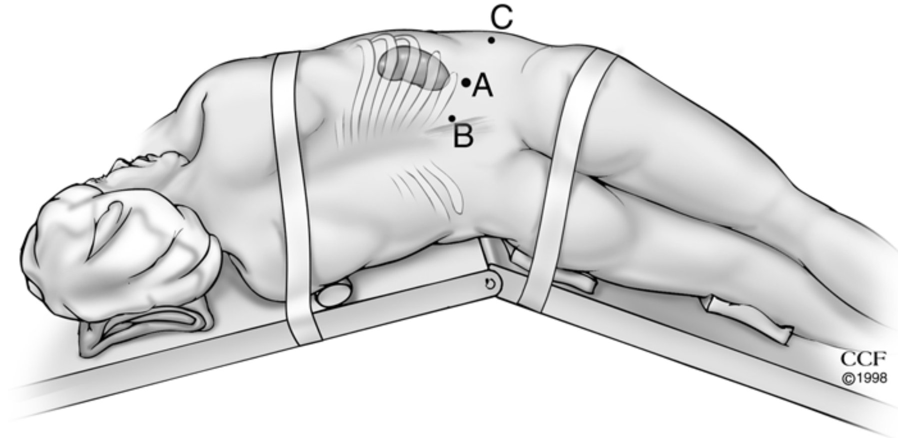

Fig. 1. Port placement during right retroperitoneoscopy radical nephrectomy. **(A)** primary 10-mm port is placed at the tip of 12th rib. **(B)** 10-/12-mm port is placed at junction of lateral border of the erector spinae muscle with underside of 12th rib. **(C)** 10-/12-mm port is placed three fingerbreadths cephalad to iliac crest, between mid and anterior axillary lines.

head. The cart holding the primary video monitor, CO_2 insufflator, light source, and recorder is placed on the side of the table contralateral to the surgeon. The scrub nurse is positioned toward the foot end of the operative table.

PORT PLACEMENT

During radical retroperitoneoscopic nephrectomy, three trocars are placed. The laparoscope is positioned in the primary port at the tip of the 12th rib. The surgeon works through the posterior and anterior secondary ports (Fig. 1).

Primary Port

The open (Hasson cannula) technique is ideal for obtaining initial access. A horizontal 1.5-cm skin incision is made just below the tip of the 12th rib. Using S-shaped retractors, the flank muscle fibers are bluntly separated. Entry is gained into the retroperitoneal space by gently piercing the anterior thoracolombar fascia with the fingertip or hemostat. Limited finger dissection of the retroperitoneum is performed in a cephalad direction, remaining immediately anterior to the psoas muscle and fascia, and posterior to the Gerota's fascia to create a space for placement of the balloon dilator *(6)*. At this juncture the tip of the lower pole of the kidney can often be palpated by the finger. We insert a trocar-mounted balloon dissection device (Origin Medsystems, Menlo Park, CA) for rapidly and atraumatically creating a working space in the retroperitoneum in a standardized manner (Fig. 2). The volume of air instilled into the balloon is typically 800–1000 mL in adults (40 pumps of the sphygmomanometer bulb). The balloon dilatation outside Gerota's fascia (i.e., in the pararenal space between the psoas muscle posteriorly and Gerota's fascia anteriorly) effectively displaces the Gerota's fascia covered kidney anteromedially, allowing direct access to the posterior aspect of the renal hilum (Fig. 3). Laparoscopic examination from within the transparent balloon confirms adequate expansion of the retroperitoneum. Secondary cephalad or caudad balloon dilatation, as required by the clinical situation, further enlarges the retroperitoneal working space. For example, during a retroperitoneoscopic

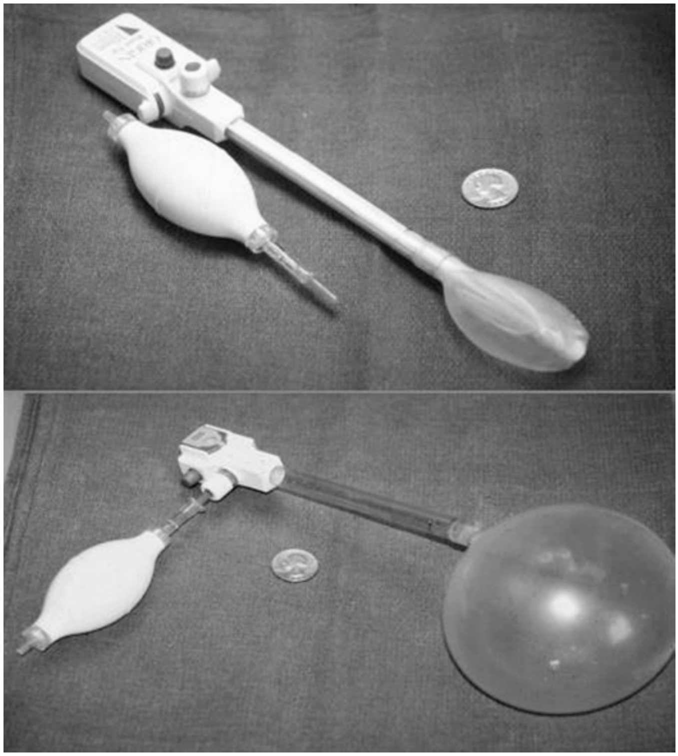

Fig. 2. Trocar-mounted preperitoneal dilator balloon (uninflated and inflated) device (Origin Medsystems).

adrenalectomy the balloon is deflated and reinflated in a more cephalad location along the undersurface of the diaphragm to create a working space in the immediate vicinity of the adrenal gland. Similarly, during a retroperitoneoscopic nephroureterectomy, secondary balloon dilation is performed caudally to expose the distal ureter.

Following balloon dilatation and removal, a 10-mm Bluntip trocar (Origin Medsystems) is placed as the primary port (Fig. 4). This trocar has an internal fixed fascial retention balloon and an external adjustable foam cuff, which combine to eliminate air leakage at the primary port site. The internal fascial retention balloon of the cannula is inflated with 30 cc of air, and the external adjustable foam cuff is cinched down to secure the primary port in an airtight manner *(7)*. In the author's experience, such an airtight seal has been more difficult to achieve with a standard Hasson cannula. Pneumoretroperitoneum is established to 15 mmHg, and a 10-mm, 30° laparoscope is inserted. The psoas muscle and Gerota's fascia are identified immediately. In our experience *(8)*, one or more of these landmarks are identifiable in the following frequency: lateral peritoneal reflection (83%), ureter and/or gonadal vein (61%), pulsations of the fat-covered renal artery (56%), aortic pulsations of the left side (90%), and the compressed, ribbon-like inferior vena cava on the right side (25%).

Secondary Ports

Two secondary ports are placed under 30° laparoscopic visualization. The immediately adjacent undersurface of the flank abdominal wall is visualized endoscopically.

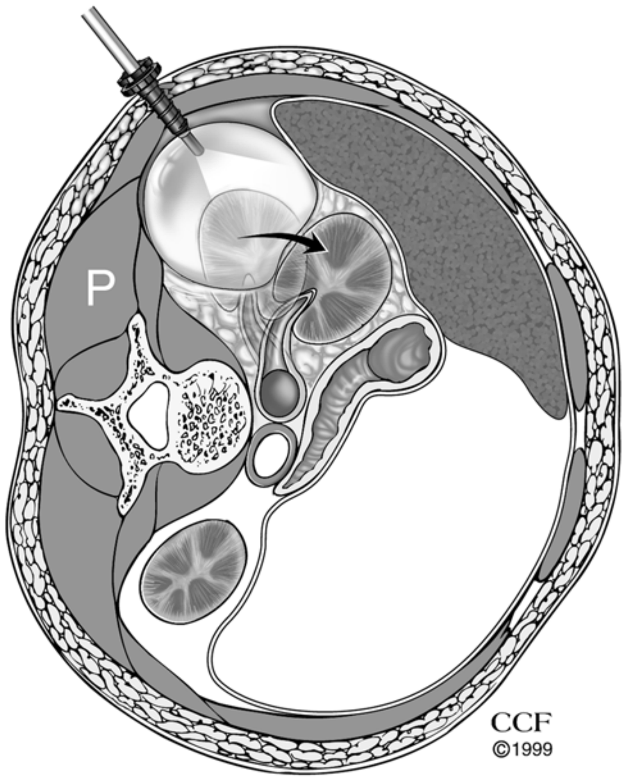

Fig. 3. Balloon dilator positioned between psoas fascia posteriorly and Gerota's fascia anteriorly. The distended balloon (800 cc) displaces Gerota's fascia/kidney antero-medially allowing access to renal vessels.

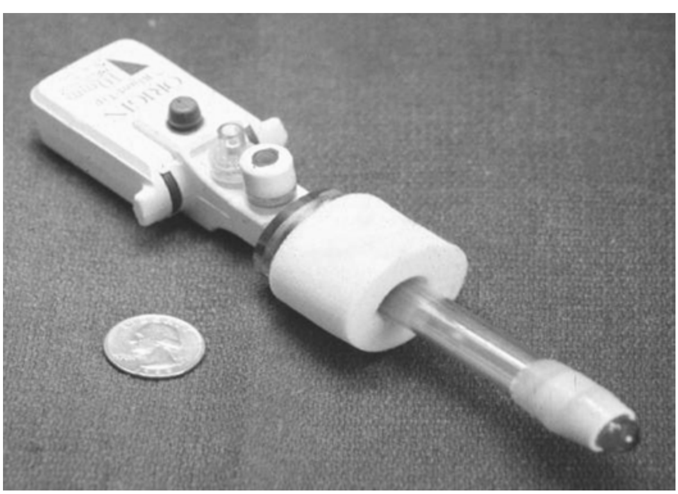

Fig. 4. A Bluntip trocar (Origin Medsystems) is employed to achieve an airtight seal for the primary port.

A 10-/12-mm port is placed 3 fingerbreadths cephalad to the iliac crest, between the mid and anterior axillary lines. A second 10-/12-mm port is placed at the lateral border of the erector spinae muscle just below the 12th rib *(9)*. Frustrating "clashing of swords" occurs if the trocars, and therefore the laparoscopic instruments, are located in close proximity. Thus, the port placed between mid and anterior axillary lines can be positioned even more anteriorly to the anterior axillary line; however, the lateral peritoneal reflection must be clearly visualized laparoscopically and avoided before the port is inserted. If necessary, the lateral peritoneal reflection can be bluntly mobilized further anteriormedially from the undersurface of the flank abdominal wall using the laparoscope's tip.

STEP-BY-STEP SURGICAL APPROACH

Renal Hilum Control

The kidney is retracted anterolaterally with a laparoscopic small bowel clamp or the fan retractor in the nondominant hand of the surgeon placing the renal hilum on traction. Gerota's fascia is incised longitudinally in the general area of the renal hilum, parallel and 1- to 2-cm anterior to the psoas muscle. Care must be taken to avoid dissection close by the psoas muscle, which may lead the surgeon to reach the retrocaval or the retroaortic space. The longitudnal incision of the Gerota's fascia opens the retroperitoneal space, thereby adding to the effect of the carbon dioxide insufflation, and exposing the renal hilum. Blunt and sharp dissection in this avascular area of loose areolar fatty tissue is performed to identify renal arterial pulsations. Visualization of the vertically oriented, distinct arterial pulsations indicates the location of the renal artery, which is circumferentially mobilized, clip-ligated (11-mm titanium clips; three on the "stay side" and two on the "go side") and divided. Subsequentially, the renal vein, is stapled and divided with an Endo-GIA stapler (U.S. Surgical) (Fig. 5). Usually after division of the renal vein, some flimsy hilar attachments remain between the kidney and the great vessels. In order to avoid traction injury, which may lead to venous tear and bleeding, these remaining attachments should be precisely clipped and transected.

Intraoperative Trouble-Shooting

Problems with Orientation in the Retroperitoneum

To avoid problems with orientation in the retroperitoneum, the camera should be oriented such that the psoas muscle is always absolutely horizontal on the video monitor *(5)*. However, the retroperitoneal space is relatively small at this stage of the procedure, anteromedial retraction of the kidney serves to increase the retroperitoneal space, exposing the psoas muscle that can be identified most easily caudal to the kidney.

Difficulty in Finding the Renal Hilum

If the renal hilum cannot be located, the surgeon should reinsert the laparoscope slowly and identify the psoas muscle. The psoas muscle should then be crossed from lataral-to-medial in a cephalad direction and a search conducted for arterial pulsation near its medial border. Pulsations of the fat-covered renal artery or aorta are usually identifiable. Gentle dissection with the tip of the suction device or hook is performed directly toward the pulsations. The renal artery is identified and traced directly to the renal hilum. One must always be mindful of aberrant major vessels, such as the superior mesenteric artery, which arises from the aorta more medially and superiorly than the

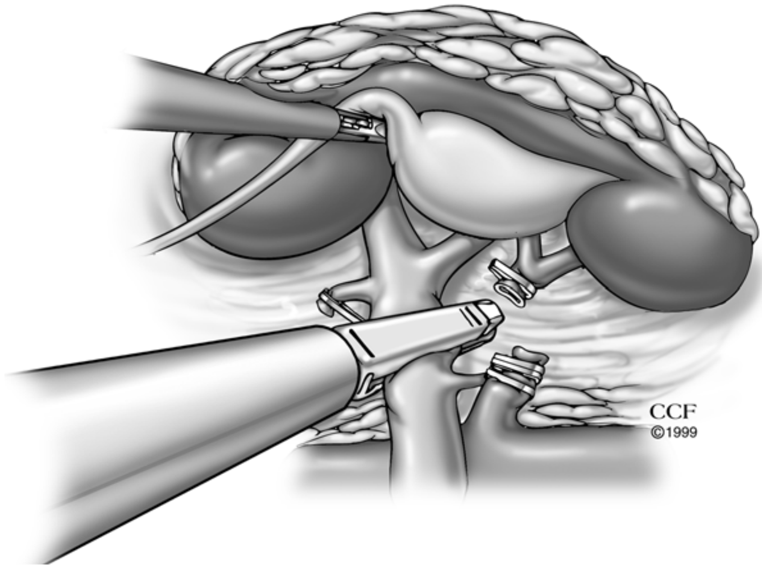

Fig. 5. Renal artery has been clip-ligated and divided. Renal vein is circumferentially mobilized and controlled with a gastrointestinal anastomosis stapler.

left renal artery. Alternatively, the ureter can be identified and followed cephalad to the hilum. Dissection through the perirenal fat may identify the surface of the kidney, which can then be dissected toward its hilum.

Persistent Renal Hilar Bleeding After Division of the Renal Artery and Vein

Persistent renal hilar bleeding generally indicates the presence of an overlooked, accessory renal artery. After flow is controlled from the main renal artery, the renal vein should appear flat and devoid of blood. A normally distended renal vein at this juncture indicates continued arterial inflow through an accessory renal artery. In this circumstance, division of the distended renal vein with an Endo-GIA stapler (U.S. Surgical) interrupts renal outflow, with a resultant increase in intrarenal venous back pressure. This causes persistent oozing during the remainder of the dissection. One should search for an accessory renal artery in this situation.

Endo GIA Malfunction

The GIA stapler is standard for control of renal hilar vessels. However, failure of the device can be associated with severe consequences, including emergency conversion to open procedure.

The most common cause of GIA failure is inadvertent placement of the device over a previously placed surgical clip *(10)*. In order to avoid this situation, extreme care must be taken when positioning and firing the Endo GIA stapler in the presence of surgical clips in the area of renal hilum.

CIRCUMFERENTIAL EXTRAFASCIAL MOBILIZATION OF THE EN BLOC SPECIMEN

Suprahilar dissection is performed along the medial aspect of the upper pole of the kidney and the adrenal vessels, including the main adrenal vein, are precisely controlled with clip-ligation. Dissection is next redirected towards the supralateral aspect of the specimen, including *en bloc* adrenal gland, which is readily mobilized from the underside of the diaphragm. In the avascular flimsy areolar tissue in this location, inferior phrenic vessels to the adrenal gland are often encountered and controlled. The anterior aspect of the specimen is mobilized from the underside of the peritoneum envelope. During this dissection, use of electrocautery must be avoided in order to avoid transmural thermal damage to the bowel located just beside the thin peritoneal membrane. The ureter, with or without the gonadal vein, is secured, and the specimen is completely freed by mobilization of the lower pole of the kidney. The entire dissection is performed outside Gerota's fascia, mirroring established oncologic principles of open surgery.

INTRAOPERATIVE TROUBLE-SHOOTING

Inadverted Peritoneotomy

A peritoneotomy does not necessarily mandate conversion to transperitoneal laparoscopy. Usually, a peritoneal rent does not cause significant problems, and the procedure can be completed retroperitoneoscopically. However, if operative exposure is compromised, a fourth port can be inserted to provide additional retraction of the billowing peritoneal membrane.

Also, intra-abdominal viscera must be thoroughly inspected by inserting the laparoscope trough the peritoneotomy to rule out iatrogenic injury.

SPECIMEN ENTRAPMENT

Organ entrapment is rapidly performed by using an Endocatch bag (U.S Surgical). This bag is an impermeable plastic and nylon sac designed to prevent tumor spillage during intact specimen removal. This bag should never be employed during tissue morcellation *(11)*. The specimen is tented up by the nondominant hand. The bag is introduced through the anterior port, the spring-loaded mouth of the sac is opened in the retroperitoneun, and the specimen placed within. After specimen entrapment, the mouth of the bag is detached from the metallic ring and closed (under laparoscopic visualization) by tightening the drawstring (Fig. 6).

Entrapment of Larger Specimens

An intentional peritoniotomy is occasionally created, strictly for entrapment of large specimens. The large specimen is inserted within the peritoneal cavity where it is entrapped within the 15-mm Endocatch II bag (U.S. Surgical).

SPECIMEN EXTRACTION

Currently our routine practice for specimen extraction aims to achieve a superior cosmetic result while providing an intact specimen for precise pathologic staging. In this manner, we employ for the male patient a low muscle-splitting Pfanensteil incision *(12)* and for the appropriate female patient a vaginal extraction *(13)* of the specimen.

Specimen Extraction in Males

A Pfannensteil skin incision (slightly lateralized towards the nephrectomy side) is made at or just below the level of the pubic hairline. Subsequently the anterior rectus

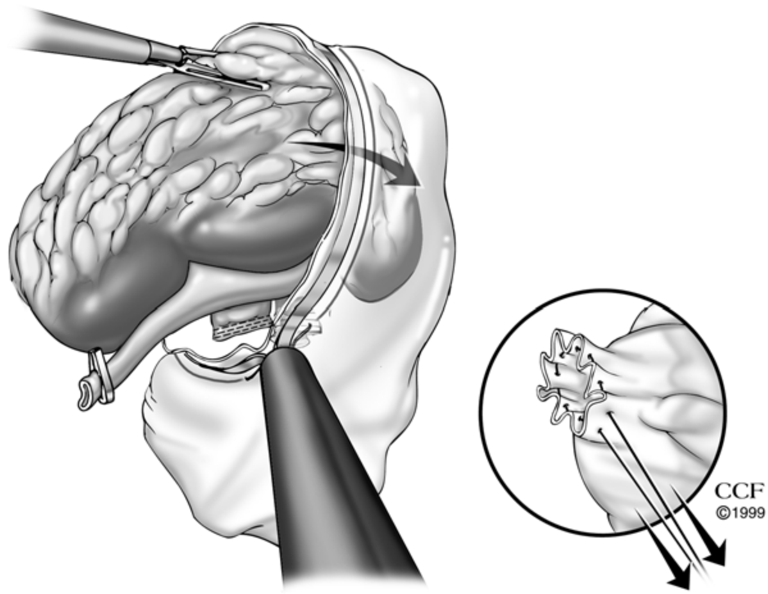

Fig. 6. After specimen entrapment, mouth of bag is detached from metallic ring and closed by pulling on built-in drawstring.

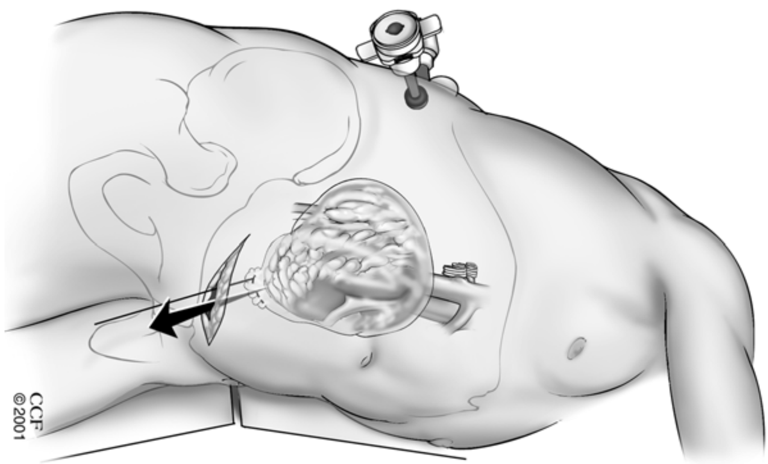

Fig. 7. A Pfanensteil skin incision (at or just below the level of the pubic hairline) is used to retrieve the intact specimen entrapped in a bag.

fascia is incised obliquely, rectus muscle fibers are retracted medially, posterior rectus fascia is incised, the peritoneal membrane is reflected cephalad using finger dissection, and extraperitoneal access is gained to the retroperitoneal space, to extracted the intact entrapped specimen (Fig. 7).

Specimen Extraction in Females

After the specimen is entrapped in an Endocatch II bag, a generous longitudinal peritoneotomy is intentionally created along the undersurface of the anterior abdominal wall. The operating table is placed in a steep Trendelenburg position, and rotated such that the flank position is decreased to 60°. Bowel loops are retracted cephalad.

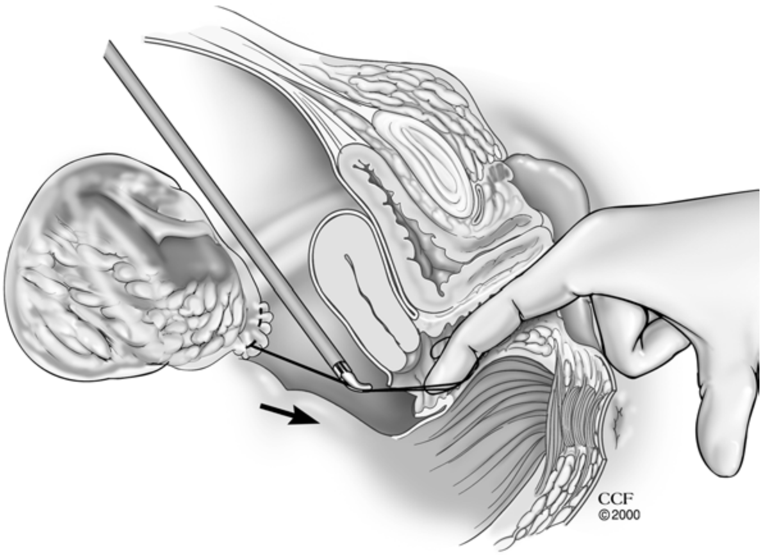

Fig. 8. The drawstring of the closed Endocach II bag, previously grasped by the laparoscopic clamp, is delivered into the vagina.

A sponge-stick is externally inserted into the sterilely prepared vagina and tautly positioned in the posterior fornix. Laparoscopically, a transverse posterior 3-cm colpotomy is created at the apex of the tented-up posterior fornix, and the drawstring of the entrapped specimen is delivered into the vagina (Fig. 8). After laparoscopic exit is completed, the patient is placed in a supine lithotomy position. The specimen is extracted intact per vaginum, and the posterior colpotomy incision repaired transvaginally. This approach is contraindicated in patients with even a mild degree of pelvic or intraperitoneal adhesions from any etiology.

HEMOSTASIS

Hemostasis is confirmed under lowered retropneumoperitoneun (Fig. 9) and ports are removed under laparoscopic visualization. Fascial closure is performed for all 10-mm or larger port sites.

SPECIAL CONSIDERATIONS

Concerns About Tumor Size

Because our initial approach is targeted towards the renal hilum, the size of the renal mass only becomes a significant issue at the time of specimen mobilization. In our series, 33% of the tumors were equal to or larger than 6 cm on CT scan (Fig. 10), including tumors up to 13–14 cm in size with overall specimen weight exceeding 1.5 kg.

Retroperitoneoscopy in Obese Patients

Although the excessive retroperitoneal fat increases the degree of technical difficulty, adherence to a standardized stepwise anatomical approach *(14)* allows retroperitoneoscopy to be performed effectively in markedly obese or morbidly obese patients. In fact, the retroperitoneal flank approach allows the gravitational pull to shift much of the

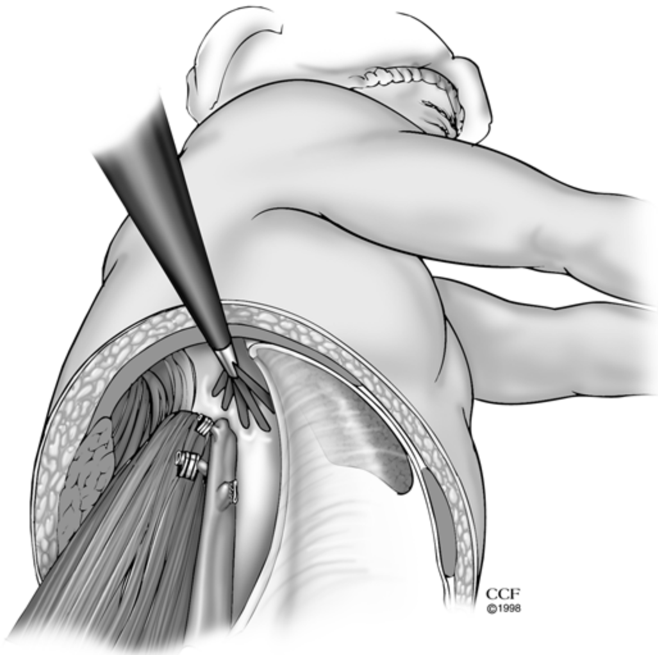

Fig. 9. Hemostasis of the renal bed is confirmed after 5–10 min without CO_2 pressure in the retroperitoneal space. Trocars are removed under laparoscopic visualization.

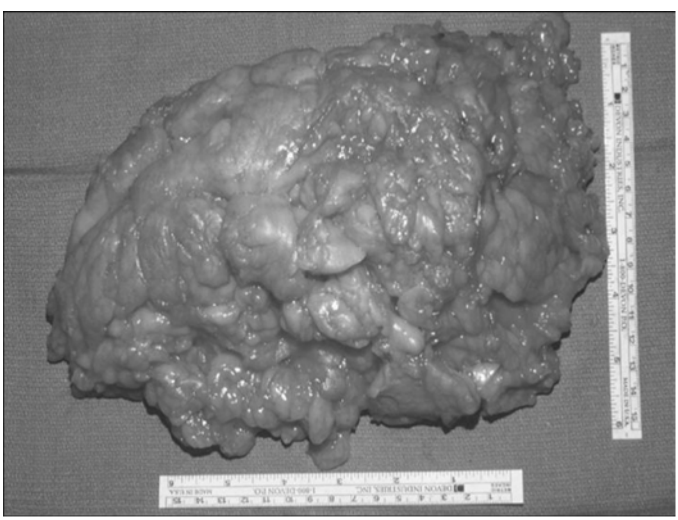

Fig. 10. Retroperitoneoscopic radical nephrectomy. This surgical specimen weighed 1200g.

weight of the pannus anteriorly, away from the ipsilateral flank (Fig. 11). In our series, 35% of the patients had body mass index (BMI) equal or greater than 30. However, the reader should be cautioned that these challenging procedures should be performed by surgeons facile with the laparoscopic technique.

Preservation of the Adrenal Gland (if Necessary)

To preserve the adrenal gland, Gerota's fascia is opened and a well-defined plane between the upper pole of the kidney and the adrenal is dissected using electrosurgical

Fig. 11. With patient in a full-flank position a significant amount of the abdominal pannus falls away from operative side. This patient had a BMI of 47.5.

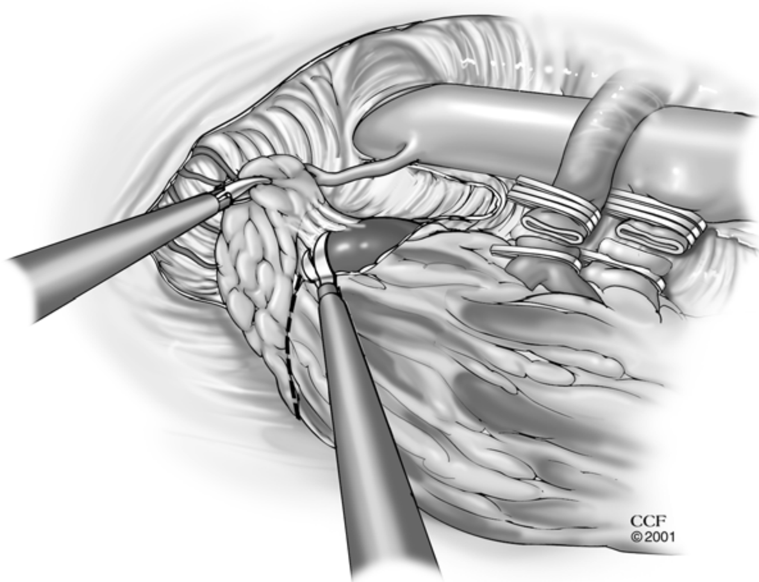

Fig. 12. If necessary, the adrenal gland can be preserved. Gerota's fascia is opened and adrenal is detached from the upper renal pole using electrocautery scisors.

scissor (Fig. 12). In our series, *en bloc* adrenalectomy was not performed in 33 cases (30.5%). These included cases from bilateral radical nephrectomy, previous contralateral adrenalectomy, or elective preservation of the adrenal gland.

Oncologic Efficacy of Retroperitoneoscopy

Laparoscopic retroperitoneal surgery for renal tumor does not result in an increased risk of port site seeding, local recurrences, or metastasis *(15)*. To achieve oncological safety, the classical rules of renal cancer surgery must be respected. Also the surgical specimen must be removed in a hermetic sac to avoid any contact between the abdominal wall. We prefer intact specimen extraction so as to allow precise pathologic staging. If morcelation is employed, care should be taken to guard against rare complications such as sack perforation and tumor spillage *(16,17)*.

TAKE HOME MESSAGES

1. Compared with transperitoneal laparoscopy, retroperitoneoscopy may be associated with a somewhat sharper learning curve.
2. For efficacious performance of retroperitoneoscopic surgery, proper development of the retroperitoneal space and constant orientation with various anatomical landmarks is critical. It is abundantly clear that the retroperitoneal space can be readily developed and enlarged appropriately as the laparoscopic dissection proceeds.
3. Although out of sight, peritoneal organs must never be out of mind, because they are separated only by the peritoneal layer, and therefore are susceptible to injury.
4. Retroperitoneoscopy does offer significant advantages. Foremost is the straightforward and rapid exposure and control of the renal hilum, and nonviolation of the peritoneum, thus minimizing the chances of intraperitoneal organ injury. In our experience, the operating time is shorter, paralytic ileus is minimal, hospital stay is usually overnight, and recovery is rapid *(18)*.

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8 Laparoscopic Radical Nephrectomy

Transperitoneal Approach

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Contents

INTRODUCTION

The radical nephrectomy, described by Robson in 1963 *(1)*, is considered a standard of care in the management of renal tumors. Although highly efficacious, the traditional radical nephrectomy results in significant postoperative pain and a lengthy period of convalescence. Laparoscopic nephrectomy for a renal tumor was introduced by Clayman, Kavoussi, and associates *(2)* in 1990 and in experienced hands has become an accepted alternative to traditional open radical nephrectomy for small- and medium-sized renal masses without evidence of renal vein or inferior vena caval involvement.

The advantages characteristic of minimally invasive procedures have been demonstrated for the laparoscopic radical nephrectomy. McDougall and colleagues compared open and laparoscopic radical nephrectomy *(3)*. They demonstrated that laparoscopic radical nephrectomy was associated with a significantly decreased postoperative analgesic requirement and a more rapid return of oral intake. Additionally, the laparoscopic population had an improved convalescence: a shorter hospital stay and a shorter interval for the return of normal activity and for full recovery. Since their initial report, additional articles have corroborated these findings *(4–9)* (*see* Tables 1 and 2). This chapter describes and illustrates in detail our current technique for standard (i.e., nonhand-assisted) laparoscopic transperitoneal radical nephrectomy with morcellation. We believe that the consistent application of anatomically based templates for right and left laparoscopic radical nephrectomy may improve the efficiency of the procedure while optimizing cancer control and minimizing potential intraoperative complications.

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
Edited by: S. Y. Nakada © Humana Press Inc., Totowa, NJ

Table 1
Laparoscopic Radical Nephrectomy: Worldwide Experience: 2001

Report	*Cases*	*OR time*	*EBL (cc)*	*Spec. wt. (g)*	*Stage*	*Hosp. Stay (d)*	*Recovery (wk)*	*Follow-up (mos)*	*Comp (maj/min)*	*Seeding*
Peschel/Janetschek, 1999 *(4)*	31	2.4	NS	NS	T1/T2	2.9	NS	18	0%/0%	None
Ono/Kinukawa, 1999 *(5)*	91	4.9	300	289	T1/T2	NS	3.0	22	11%	None
Barrett/Fentie, 1998 *(6)*	72	2.9	NS	402	T1/T2	4.4	NS	21	1 death 3%/8%	One
Clayman/McDougall, 2000 *(7)*	61	5.5	172	452	T1/T2/ T3b (r.v.)	3.4	3.6	25	3%/34%	None
Kavoussi/Cadeddu, 1999 *(8)*	50	NS	NS	NS	T1/T2/T3	NS	NS	22	6%/2%	None
Gill, 2000 *(9)*	40	3.1	114	455	NS	1.6	NS	6.5	–/13%	None
Total	345	3.8	195	417	T1/T2 T3a/T3b	3.1	3.2	20	Mort.: 0.3%	0.3%

NS, not stated

Table 2
Laparoscopic vs Open Nephrectomy for Tumors 4.1–10 cm *(7)*

	Laparoscopic radical nephrectomy	*Open radical nephrectomy*	*p-value*
No. pts.	25	25	
Pt. age	62	61	0.73
Body mass index	29.4	29.0	0.85
Operating time (h)	5.9	2.8	<0.001
EBL (mL)	202	493	0.05
Analgesic use (mg morphine sulfate equivalent)	32	86	0.002
Days hospital stay	3.7	5.2	0.02
Wks to normal activity	5.1	7.6	0.11
Wks to feel 100%	10.5	26	0.06

METHOD

Patient Preparation and Positioning

Informed consent must be obtained with discussion of possible complications, including conversion to an open surgical approach owing to failure to progress or vascular injury or bowel injury, postoperative paresthesias (i.e., brachial plexus of downside arm, sciatic stretch injury of upside leg), occult bowel injury, transient shoulder pain associated with the pneumoperitoneum, subcutaneous emphysema, and other potential problems associated with laparoscopy. Also mentioned is the possibility of mortality owing to a gas embolus, although chances of this occurring are in the range of 1 in 10,000. The patient is typed but not cross-matched for blood. Prior to the procedure, a chest radiograph and a computed tomography (CT) scan (with and without contrast) are obtained as part of a metastatic evaluation. The CT scan is scrutinized to rule out the following: liver metastases, lymphadenopathy, renal vein or vena caval involvement; and to assess the adrenal glands. Preoperative blood work includes a serum creatinine, liver function studies, alkaline phosphatase, and calcium levels. If the last two values are elevated or the patient complains of site-specific bone pain, a bone scan is obtained.

Bowel preparation is not routinely performed; but a clear liquid diet is advised for the day prior to the procedure and a Dulcolax suppository is given on the day prior to surgery. One gram of cefazolin (Ancef) is administered preoperatively. In the obese patient or the individual with a history of deep venous thrombosis, 5000 U of heparin are administered subcutaneously 2 h prior to the procedure and continued on a 12-h basis postoperatively. At the outset of the procedure, just prior to any skin incision, 30 mg of ketorolac (Toradol) is given intravenously.

General endotracheal anesthesia is induced and the patient's stomach and bladder are decompressed with an orogastric tube and a Foley catheter, respectively. Pneumatic compression stockings are applied to both legs. The patient is carefully positioned in a 70° flank position with the affected kidney on the upside (Fig. 1). The operating table is fully flexed and the kidney rest is fully raised beneath the iliac crest. The downside leg is flexed at the knee and separated from the extended up-side leg by pillows; the upside leg is placed on a sufficient number of pillows until it is level with the flank, thereby

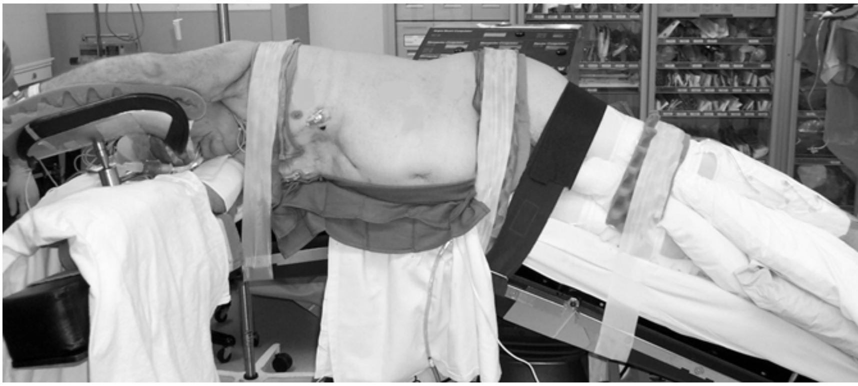

Fig. 1. Photograph of patient in a flank position in preparation for left laparoscopic radical nephrectomy.

precluding any strain on the upside leg when the table is flexed and the kidney rest raised. The downside heel, hip, and knee are cushioned. The downside arm is padded and an axillary roll is carefully positioned. The upside arm is placed on a well-padded arm-board; the arm-board is positioned such that there is no tension on the brachial plexus. Once the patient has been properly positioned, he/she is secured to the operating table by padded safety straps that are passed over the chest, hip, and knee.

Access

Each potential port site is injected with 0.25% bupivacaine (Marcaine) prior to any incision. Under direct vision, bupivacaine (Marcaine) is injected at the skin site selected for placement of the Veress needle and the primary trocar; after placement of the primary trocar, under laparoscopic vision, the peritoneum is infiltrated for all secondary trocar sites.

For right or left renal access (Figs. 2 and 3) a 12-mm incision is made approximately 2 fingerbreadths medial and cranial to the anterior superior iliac spine. The subcutaneous tissue is spread with a Kelly clamp, and the anterior rectus fascia is secured with two Allis clamps. A Veress needle pneumoperitoneum of 25 mmHg is obtained. A 12-mm trocar is placed at this same site (Fig. 2, port site I), and the abdominal pressure is reduced to 15 mmHg. A 10 mm 30° laparoscope is inserted and the underlying bowel is closely inspected for any injury that may have occurred during Veress needle or trocar placement. Subsequently, two additional 12-mm trocars are placed under direct endoscopic vision; 2-cm below the costal margin in the midclavicular line, and immediately lateral to the margin of the rectus abdominus muscle approximately 3–5 fingerbreadths above the umbilicus. Finally, after mobilization of the colon from the abdominal sidewall, a fourth trocar (5-mm) is commonly placed subcostal in the posterior axillary line. For right-sided nephrectomies, a fifth trocar may be placed (optional) to help with liver retraction (Fig. 3).

All smooth surfaced trocars are anchored with a #2 nylon skin suture to prevent inadvertent dislodgement during the procedure; this does not apply if one is using the grooved or radially expanding trocars. All secondary trocars are placed under endoscopic control. Also, as soon as the initial secondary trocar is placed, the laparoscope is passed through it in order to inspect the primary trocar site for any bleeding or injury to underlying organs.

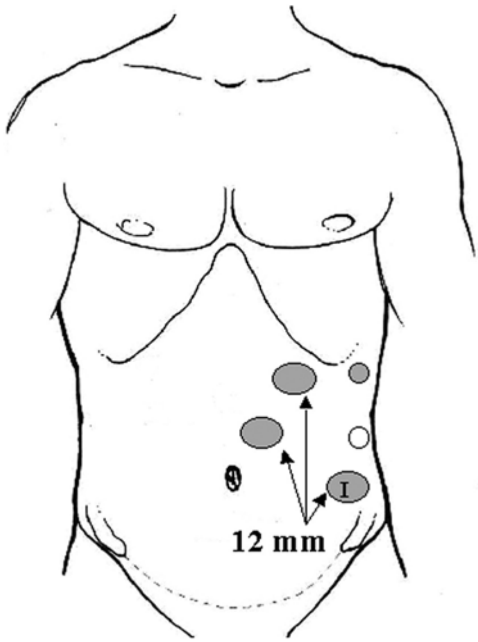

Fig. 2. Diagram demonstrating port sites used for left transperitoneal nephrectomy. I = insufflation port. Large circles represent 12-mm port sites. Small circles represent 5-mm port sites. White circle port site is optional; it is only placed if there is difficulty with specimen entrapment in a LapSac.

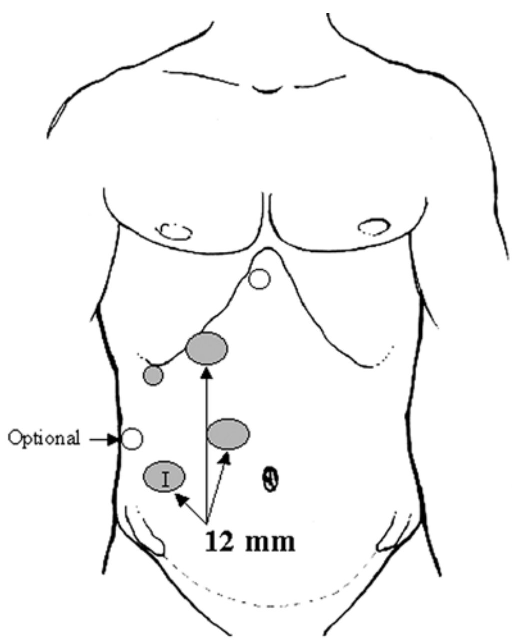

Fig. 3. Diagram demonstrating port sites used for right transperitoneal nephrectomy. I = insufflation port. Large circles represent 12-mm port sites. Small circles represent 5-mm port sites. Optional ports are in white: the upper white port may be used for liver retraction, whereas the lower white port is only used if there is difficulty with specimen entrapment in a LapSac.

Table 3
Laparoscopic Instrumentation for Standard Transperitoneal Radical Nephrectomy (Washington University)

Disposable equipment:
- 5-mm Endoshears (U.S. Surgical)
- 12-mm Multifire EndoGia—Vascular and Tissue staple with reloads available. (U.S. Surgical)
- 10-mm clip appliers with 9-mm and 11-mm clips (U.S. Surgical)
- Three trocars—5-mm and four 12-mm (axially dilating clear ports) (Ethicon)
- 5 × 8 and 8 × 10 inch LapSacs (Cook Urological)
- Veress needles (150 mm) (U.S. Surgical)
- CO_2 insufflation tubing
- 10 sponges (Raytex)
- 5-mm Harmonic scalpel (curved jaws) (Ethicon)

Nondisposable equipment:
- Endoholder (Codman, division of Johnson and Johnson)
- Suction irrigator, extra long, 5-mm (Nezhat system, Storz)
- Laparoscope: 10-mm 0° and a 10-mm 30° lens and a 5-mm 0° lens (Storz)
- Three atraumatic, nonlocking 5-mm smooth-tip (duckbill) grasping forceps (Storz)
- Four traumatic (toothed), locking, 5-mm grasping forceps (Storz)
- LapSac introducer (Cook)
- Electroshield device to attach to electrocautery (Electroscope)
- 5-mm hook electrode (Electroscope)
- 5-mm and 10-mm PEER retractors (Jarit)
- 5-mm needleholders (Jarit and Storz)
- 10-mm soft curved angled forceps (Maryland dissector) (Storz)
- 10-mm right angle dissector (Storz or Jarit)
- Carter-Thomason needle suture grasper and closure cones (Inlet Medical)

Available but Not Opened Equipment:
- Disposable Roticulating Endoshears (U.S. Surgical)
- Endostitch and all types of suture used (0,2-0,4-0, Polysorb, Polydac and Prolene) (U.S. Surgical)
- Disposable Hasson trocar, 12-mm Blunt-Tip (U. S. Surgical)
- 3-0 cardiovascular silk (RB-1 needle) and 0-Vicryl sutures for fascial closure
- Lapra-ty clips and 10-mm Laparo-Ty clip applier (Ethicon)
- Five gauze rolls (Carefree Surgical Specialties)
- 10-mm Satinsky clamp with flexible port (Aesculap)

Instrumentation

Basic instrumentation for laparoscopic nephrectomy includes a standard laparoscopic tower (a carbon dioxide insufflator, light source, camera, monitor and suction-irrigation setup) (Table 3). A 10-mm laparoscope with a 30° lens is used as the angled lens facilitates direct laparoscopic vision during challenging portions of the dissection such as the hilar dissection; with the 30° lens, the surgeon can see almost 270° around a particular structure. For the majority of the blunt and coarse pararenal dissection, we prefer ultrasound energy using a 5-mm curved end-effector (i.e., Harmonic Scalpel, Ethicon Endo-Surgery, Cincinnati, OH). This instrument allows for expeditious

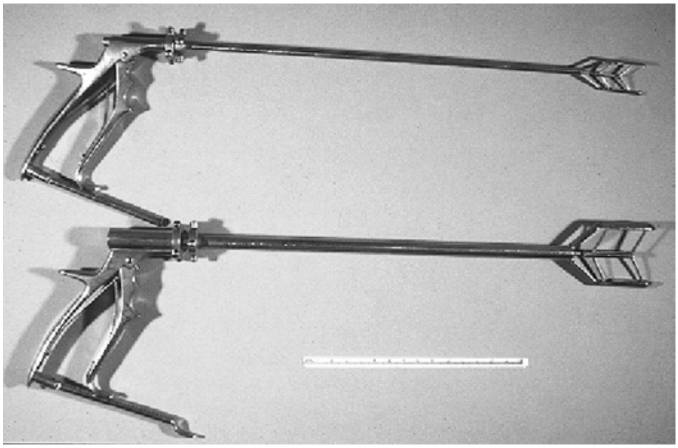

Fig. 4. The PEER retractors: 5-mm (background) and 10-mm (foreground) size. The 5-mm size opens to 2 × 3-cm surface area and the 10-mm size opens to a 4 × 3-cm surface area.

dissection with superb hemostasis. Additionally, monopolar electrosurgical energy with a right-angled hook end-effector is used for delicate dissection of hilar structures. This instrument allows the surgeon to perform safe, fine dissection by engaging and retracting small strands of tissue around vascular structures prior to the application of energy.

For retraction, we have found the PEER Jarit retractor (J. Jamner Surgical Instruments, Inc, Hawthorne, NY) to be useful in a variety of locations. The PEER retractor is placed into the Endoholder (Codman, Raynham, MA), which allows for reliable, safe retraction. These instruments are invaluable because they both allow the surgeon complete control on the amount of retraction on vulnerable structures (i.e., liver and spleen) and avoid the inevitable fatigue of even the most diligent assistant (Figs. 4 and 5).

Control of major arteries and veins is achieved with titanium clips or staples. Typically, the Endoclip clip applier (U.S. Surgical Corporation, Norwalk, CT) is used for clipping the renal artery and the Endo GIA linear stapler with a vascular load (U.S. Surgical) is used for division of the renal vein. Occasionally, a right angled clip applier (Ethicon Endo-Surgery) is useful for smaller structures or for taking a branch of the renal artery.

Choosing a sac for specimen entrapment is dependent on the choice of extraction technique. If morcellation is to be performed, only the LapSac (Cook Urological, Bloomington, IN) can be used for organ entrapment, because no other entrapment sac has proven to be impermeable for high-speed electrical; similarly, we prefer the LapSac for manual morcellation. The plastic sacs have not proven sufficiently durable for manual morcellation; to wit, we have witnessed two bowel injuries associated with attempted morcellation in a plastic entrapment sac. If the specimen is to be extracted intact, use of an entrapment sac is still indicated because the sack prevents potential tumor seeding, which could occur when trying to extract a bare specimen from the incision site. For closure of 12-mm ports, the Carter-Thomason® device is especially useful (Inlet Medical, Eden Prairie, MN).

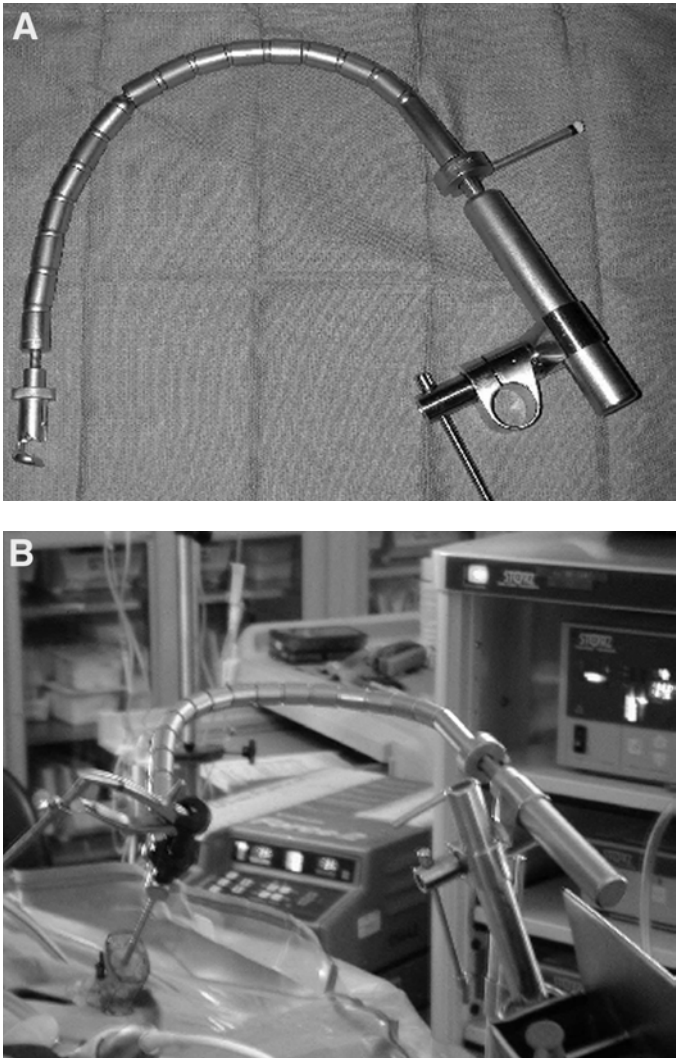

Fig. 5. The Endoholder by Codman. **(A)** The Endoholder before placement. **(B)** The Endoholder holding the PEER retractor during a laparoscopic procedure.

Laparoscopic Radical Nephrectomy

Right Side

The peritoneal cavity is closely inspected. The liver is visualized for mass lesions. The outline of the kidney within Gerota's fascia is commonly visible behind the ascending colon.

Step 1: Peritoneal Incisions and Pararenal Dissection. The key to *en bloc* resection of the kidney within Gerota's fascia lies in defining the borders of the dissection. On the right side, the dissection follows an anatomic template with a "wedge-shaped" configuration (Fig. 6). The apical edge of the wedge is the line of Toldt. The dissection is initiated using a 5-mm curved harmonic scalpel and atraumatic grasping forceps for counter-traction. The harmonic scalpel is preferred for the majority of the dissection because it provides excellent hemostasis with minimal associated peripheral thermal

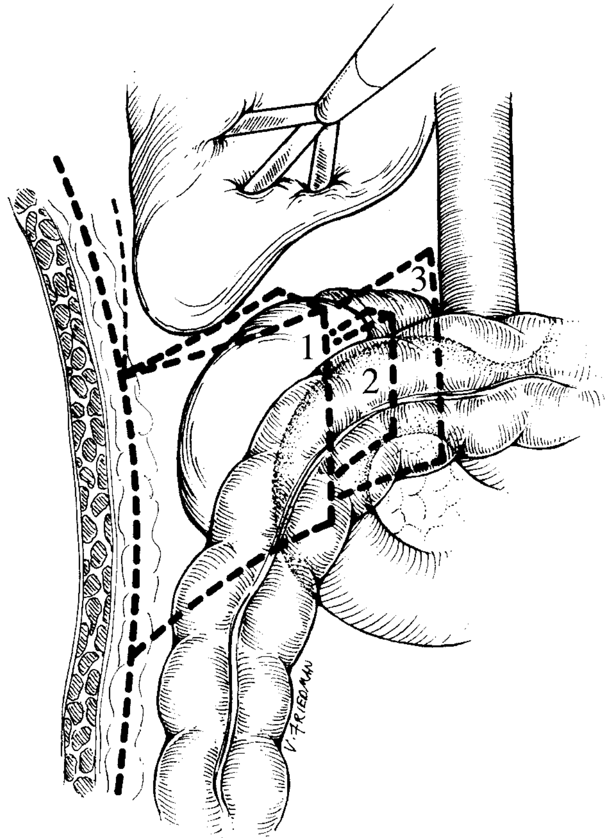

Fig. 6. Diagram of the right-sided nephrectomy demonstrating the wedge shaped configuration. The numbers refer to the three distinct levels of dissection along the medial aspect of the kidney: colon, duodenum, and inferior vena cava. Note that on the right side the line of Toldt paralleling the kidney is left intact; this is done to preclude the kidney from falling medial and obscuring the renal hilum.

injury to surrounding tissues, especially the ascending colon. The line of Toldt is incised beginning at the pelvic brim; this incision is carried upward to the lower pole of the kidney at which point the incision is continued medially staying approximately 2–3 cm away from the ascending colon; in essence the latter half of this incision defines the medial upper border of the broad side of the "wedge." The colon is thus completely mobilized away from the kidney. As such, the lateral border of the kidney and its lateral retroperitoneal attachments are not disturbed; this results in the kidney remaining firmly attached to the abdominal sidewall, thereby facilitating the hilar dissection later in the procedure. The incision in the line of Toldt is continued cephalad from the upper pole of the kidney up to the level of the diaphragm. At this time, the triangular ligament of the liver is also divided up to the diaphragm, thereby mobilizing the lateral aspect of the right lobe of the liver.

The broad side of the wedge comprises three distinct levels of dissection along the medial aspect of the kidney (Fig. 6): 1) the mobilized ascending colon; 2) Kocher maneuver on the duodenum to move it medially (Fig. 7); and 3) dissection of the anterior and lateral surfaces of the inferior vena cava (IVC). The duodenum may appear flattened against the medial aspect of the kidney; it is very important to move slowly

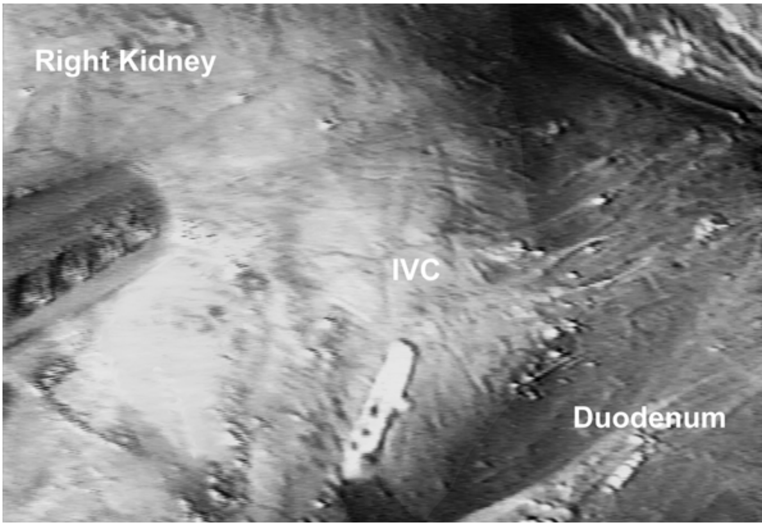

Fig. 7. Laparoscopic view of the duodenum Kocherized. The dissection of the IVC, which is in the center of the figure, is next. At this point the ascending colon and hepatic flexure, which were initially mobilized, lie medial to the duodenum.

during this part of the dissection in order to clearly identify the duodenum. Also, the surgeon should be cognizant that the duodenum MUST always be dissected away from the kidney BEFORE the anterior surface of the vena cava can be identified. To facilitate development of the third and deepest plane of dissection (i.e., the IVC dissection), it is helpful to first define the superior side of the wedge by incising the posterior coronary hepatic ligament from the line of Toldt, laterally, to the level of the IVC, medially; at this cephalad level, the surgeon will come directly onto the lateral and anterior surface of the IVC well above the duodenum and the adrenal gland. This incision in the posterior coronary hepatic ligament provides access to the IVC well above the adrenal gland. At this point, the *en bloc* area of dissection of the specimen has been completely defined, ensuring removal of the kidney within Gerota's fascia, along with the pararenal and perirenal fat, the adrenal gland, and an anterior patch of peritoneum.

Step 2: Securing the Gonadal Vein. The dissection on the IVC is continued caudally until the entry of the gonadal vein is identified. This vein is circumferentially dissected free from surrounding tissue, secured with four 9-mm vascular clips, and divided between the second and third clips. During this portion of the dissection, if one encounters "caval" bleeding, it is more than likely owing to inadvertent injury to the gonadal vein where it enters the IVC. If this occurs, it is often helpful to raise the pneumoperitoneum pressure to 25 mmHg; this maneuver appears to effectively decrease any venous bleeding and facilitate identification of the venous injury. One can then more easily identify the gonadal vein lying laterally to the inferior vena cava and then dissect it cephalad to better define its termination. Clips or sutures can then be safely applied to control bleeding. When using a pneumoperitoneum pressure of 25 mmHg, it is helpful to have the circulating nurse inform the surgeon when 10 min at this pressure has elapsed in order to preclude "forgetting" about the higher pressure and using it for the remainder of the case, thereby risking problems of hypercarbia or difficult ventilation. Usually, the 25 mmHg pressure is sustained for no longer than 10–15 min. Also, in the event of a caval injury, it is important to notify the anesthesiologist of the problem and to request that the patient receive a bolus of intravenous fluid, because studies by O'Sullivan and colleagues have shown that it is important to keep the patient well-hydrated in order to preclude an air embolus *(10)*. Also, we believe that it is important to have access to a laparoscopic Satinsky clamp to control any caval or other vascular injury.

Step 3: Securing the Ureter. The gonadal vein can be traced distally from the vena cava. The right ureter usually lies just posterior and lateral to the right gonadal vein. It is carefully dissected from the retroperitoneal tissues. If the surgeon wishes to further secure the ureter at this time, then a 3-mm Carter-Thomason device, carrying a 0-silk, can then be inserted through a 2-mm incision in the posterior axillary line. Using a right angle dissector, the silk suture is grasped and used to encircle the ureter. The free end of the suture is again grasped by the Carter-Thomason device and pulled out of the abdomen. A hemostat is then placed on both sutures at the skin level in order to retract the ureter and the kidney laterally.

Another approach is to proceed to secure the ureter with four clips and divide it. However, we prefer to divide the ureter at the end of the procedure to provide a good length of ureter to which a grasping forceps can be affixed to facilitate subsequent specimen entrapment. Also, with the ureter on traction, the hilar dissection appears to be facilitated.

At this point, all of the caudal retroperitoneal attachments to Gerota's fascia can be dissected, thereby freeing the specimen inferiorly.

Step 4: Securing the Adrenal Vein. Continued cephalad dissection of the IVC exposes the renal hilum and adrenal vein. The adrenal vein is dissected from the surrounding tissue and secured with three 9-mm clips. The adrenal vein is cut such that two clips remain on the caval side. Alternatively if the supradrenal area just medial to the IVC has been cleanly dissected down to the diaphragm and the lateral border of the supra-adrenal IVC has been identified in this area, then once the inferior border of the adrenal has been cleared of tissue, an Endo-GIA vascular load can be used to secure all of the tissue medial to the adrenal and lateral to the IVC, thereby "taking" the adrenal vein in the 3-cm line of vascular staples.

If one wishes to spare the adrenal gland, then the upper medial border of the kidney needs to be identified. As such, Gerota's fascia in this area is incised. Once the renal parenchyma of the medial and anterior part of the upper pole is seen, an Endo-GIA stapler can be used to further define the margin of dissection from medial (i.e., IVC side) to lateral below the adrenal gland, thereby preserving the adrenal gland and adrenal vein.

Step 5: Securing the Renal Hilum. Attention is then turned to the dissection of the right renal vein from the surrounding tissue. If the IVC has been cleanly dissected, the take off of the renal vein is usually quite evident. The right renal artery is subsequently identified behind the renal vein and dissected circumferentially (Fig. 8). Mobilization of the renal artery must be adequate for comfortable placement of five 9-mm vascular clips; either a linear or right angle clip applier can be used. The artery is then divided between the second and third clips to leave three clips proximally. If the artery appears to be too broad, 11-mm clips can be used or it can be secured with the Endo-GIA stapler (vascular load). The renal vein is then dissected circumferentially and secured with an Endo-GIA vascular stapler (3-cm load) (Fig. 9).

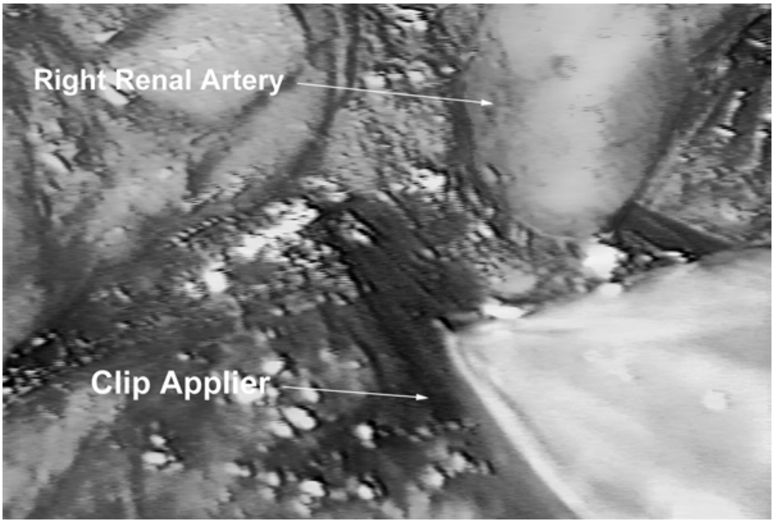

Fig. 8. View of the right renal artery being clipped in preparation for division.

One modification described by Chan and colleagues is to just free the anterior, medial, and lateral borders of the renal artery and then secure it with an Endo-GIA vascular load; however, when doing this it is important for the surgeon to develop the plane of dissection deeply along the upper and lower borders of the renal artery until the muscles of the retroperitoneum can be clearly seen *(11)*.

Occasionally an adequate length of the renal artery cannot be exposed in the presence of the overlying renal vein. In this situation, one or two clips can be applied across the artery to occlude the artery without transection. Now that the main renal artery is occluded, the renal vein is divided with the Endo-GIA stapler. The artery is then further dissected and divided after five clips are applied as previously described.

Rarely the artery cannot be accessed from the anterior approach. It is then necessary to dissect the kidney laterally, flip the entire specimen medially, and approach the artery posteriorly. In this case, the artery is often dissected further medially, where it crosses the posterior surface of the IVC. Great care must be used in dissecting the anterior surface of the renal artery in this location in order not to inadvertently injure the IVC.

Step 6: Freeing the Specimen and Securing the Ureter. The specimen, within Gerota'a fascia, is then freed from the retroperitoneum using electrocautery, the harmonic dissector, and blunt dissection. At this time, the lateral attachments of the kidney to the abdominal sidewall, which were kept intact at the beginning of the procedure, are incised. At the inferior border of the dissection the ureter is secured with four clips; a locking grasping forceps, passed via the 5-mm subcostal posterior axillary line port, is placed on the ureter above the clips followed by division of the ureter between the second and third clips. Using the locking grasping forceps on the ureter, the entire specimen is moved cephalad until it rests on the anterior surface of the liver. Once in this position, the shaft of the grasping forceps is fixed in place by attaching it to the Endoholder.

Step 7: Entrapment for Morcellation. The laparoscope is now moved from the paramedian port to the upper midclavicular line port. An entrapment sac is introduced

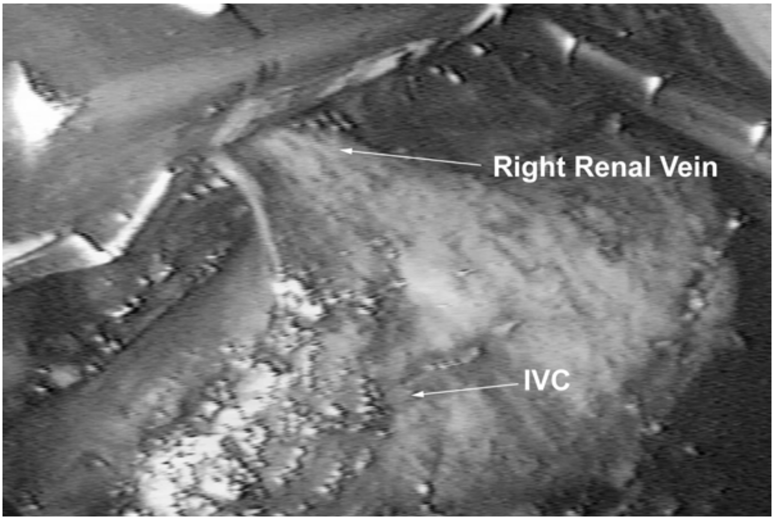

Fig. 9. The right renal vein is stapled and cut with an Endo-GIA stapler containing a vascular load.

via the paramedian port and opened just beneath the lower edge of the liver. If specimen morcellation is planned, a LapSac is used. The 8 × 10 inch LapSac is appropriately sized for the majority of renal specimens (i.e., ≤ 900 grams). On the back table, a glidewire is passed through the holes in the edge of the LapSac such that the two free ends exit the edge of the sac at the same point that the blue nylon drawstring exits the edge of the sac (Fig. 10). The glidewire passed around the edge of the sac greatly facilitates initiation and maintenance of a wide-open entrance to the sac. The LapSac is then loaded on the two-tined introducer; the tines should stay on the outer surface of the sac. Usually the sac is rolled counterclockwise from the bottom upward; the hand on the introducer, the two ends of the glidewire, and the nylon drawstring should all be parallel to one another and on the same side of the sac. Because the 8 × 10 inch LapSac will not pass through a 12-mm trocar, the trocar is removed and the entrapment sac is passed through the 12-mm abdominal incision, deeply into the abdomen and pelvis and then unfurled by twirling the introducer clockwise. Following the removal of the introducer, the 12-mm trocar is replaced and, if necessary, again anchored in position with a skin suture. Using two atraumatic grasping forceps, the LapSac is completely unfolded and flattened within the abdomen. Now two traumatic, locking 5 mm grasping forceps are introduced and the upper and lower tabs on the mouth of the LapSac are grasped. The LapSac is opened broadly such that its inferior edge is pulled just beneath the edge of the liver with the traumatic grasper passed via the midline 12-mm port, while the apex of the sac is pulled anterior via the lower midclavicular line port. The laparoscope can be passed into the LapSac, and with circular motions the entrapment sac is further opened. The specimen is then rolled off of the liver into the mouth of the sac; the forceps on the ureter is directed at the forceps holding the upper tab of the sac. As the specimen enters the sac, the forceps on the inferior edge of the sac's mouth is moved slightly cephalad and anterior to trap and push the specimen deeper into the sac.

The LapSac is essential if one is planning to use a high-speed electrical tissue morcellator (Cook Urological Inc., Spencer, IN) or blunt mechanical morcellation.

Fig. 10. Kidney entrapped in LapSac. Note a glide wire has been inserted through the same holes through which the nylon drawstring passes; the glide wire facilitates opening the sac.

These instruments should not be used with the currently available plastic sacks (vide infra) as these sacks can be easily punctured with resultant injury to bowel or other intra-abdominal organs.

If entrapment using a two-instrument approach is difficult, then a fifth right trocar (5-mm) is placed just above or at Petit's triangle. Now the LapSac is opened using three points of fixation; a traumatic locking grasping forceps is then placed on each of the three tabs. When the sac is opened in this manner, the middle grasper pulls the lip of the sac upward against the underside of the abdominal wall, forming the apex of a tent-like opening in the sac; the medial and lateral 5-mm graspers are used to pull the bottom of the sac in either direction, respectively, while displacing the sac posterior, thereby creating the base of the tent. As such, this triangular opening of the sac results in the base of the triangle running parallel with the edge of the liver while the apex of the triangle lies at the anterior portion of the underside of the abdominal wall. The base of the sac is then positioned further posterior and cephalad until it lies just under the lower edge of the liver. The surgeon now moves the ureteral grasper towards the grasper on the apex of the sac. In doing this, the specimen rolls off of the liver and into the sac; as this occurs, the assistant holding the medial and lateral graspers on the sac moves the base of the sac anterior, thereby pushing the specimen deeper into the sac. Specimen entrapment in this manner requires three people: the surgeon who controls the ureteral grasper and thus guides the specimen into the sac, the camera operator to hold the laparoscope and the middle grasper on the sac (apex of the triangle), and an assistant to hold the medial and lateral graspers (base of the triangle) on the sac (Fig. 11).

Step 8: Entrapment for Intact Removal. If intact removal is planned, then a 15-mm Endocatch II (U. S. Surgical) is introduced and opened just beneath the liver; the self-opening design of this entrapment sac facilitates the entrapment process; however, it should never be used in conjunction with the high-speed electrical tissue morcellator; furthermore, even mechanical morcellation with the plastic sac is strongly

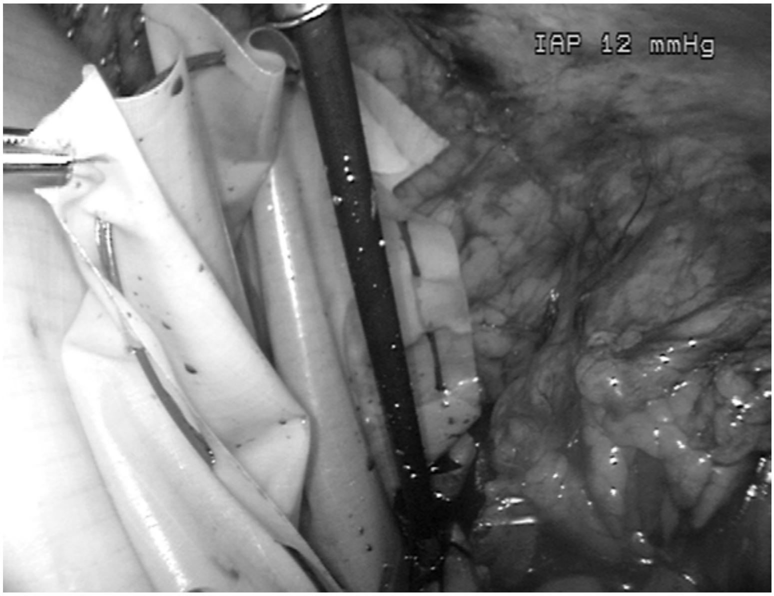

Fig. 11. View of two locking 5-mm grasping forceps introduced grasping the upper and lower tabs on the mouth of the LapSac. The LapSac will be opened broadly such that its inferior edge is pulled just beneath the edge of the liver or spleen depending on side, while the apex of the sac is pulled anteriorly.

discouraged. It is all too easy to perforate the posterior "unseen" section of the plastic sac with even a ring forceps and proceed to "blindly" damage the viscera around the sac. The Endocatch II entrapment sac cannot be passed through a 12-mm trocar. As such, the trocar is removed and the barrel of the 15-mm entrapment sac deployment mechanism is gently passed through the trocar incision site under direct endoscopic vision.

Step 9: Morcellation vs Intact Removal. If morcellation of the specimen is planned, then the neck of the LapSac is delivered through the upper midclavicular line port. The surgical field around the port site is further isolated by the sequential placement over the neck of the sac of a sterile adhesive "10,10" drape, a fenestrated absorbent towel, and a nephrostomy drape; the neck of the sac is passed through a hole in each of these drapes. These precautions are taken to help prevent possible wound contamination with any "spilled" tumor cells.

The specimen can be morcellated with a high-speed electro-mechanical tissue morcellator (Cook Urological). Firm upward traction is constantly maintained on the LapSac to assure that the recessed morcellator blade does not come into contact with folds in the sac; to do this effectively requires two hands. As such, the surgeon holds up on one side of the LapSac while the assistant holds up on the other side; the surgeon then uses the dominant hand to run the morcellator. Suction is maintained on the morcellator during the morcellation process. The entire procedure is continuously monitored with the laparoscope that is operated by an assistant who remains "clean" and works beneath the additional draping. If at any time during the morcellation process, loss of the pneumoperitoneum occurs or the LapSac cannot be clearly seen, the morcellation should be immediately terminated, because it is likely that a hole in the sac has occurred. **Failure to heed this early warning sign may well lead to catastrophic damage to bowel and any other organs lying outside of the sac.**

Alternatively, the 12-mm port site through which the neck of the sac has been delivered can be enlarged to 20 mm. Mechanical morcellation with a ring forceps and a Kelly clamp can then be performed. With the 2-cm opening, the tissue can be fragmented under the direct vision of the surgeon. However, again, it is essential for the camera operator to be vigilant of any loss of pneumoperitoneum implying puncture of the LapSac. If the LapSac is perforated, then the port site incision is immediately enlarged so the remainder of the specimen within the LapSac can be delivered immediately and intact. At Washington University, this has occurred in only two cases during the past 10 years; in both cases the perforation was identified immediately and the leakage from the sac was scant; to date, neither patient has developed a port site or intraperitoneal metastasis.

After completion of morcellation the surgeon and all other members of the surgical team who participated during morcellation should re-gown and re-glove. Using this technique over the past decade, the authors have not experienced a wound seed or peritoneal contamination in any of their renal cell cancer patients, nor have there been any complications associated with morcellation in the LapSac either with the electrical morcellator or with mechanical morcellation.

For intact removal, it is recommended to make a lower midline abdominal or a Pfannenstiel incision. The specimen is then extracted intact within the entrapment sac. One should resist the temptation to connect the medial and lateral upper or lower port sites for extraction purposes. The former will result in a more cephalad and likely more painful incision, whereas the latter is a “weaker” incision and may result in a delayed postoperative hernia.

Left Side

After laparoscopic abdominal inspection, the outline of the left kidney within Gerota’s fascia can commonly be identified beneath the descending colon.

Step 1: Peritoneal Incisions and Pararenal Dissection. The template for anatomic dissection of the left kidney assumes the configuration of an inverted cone (i.e., a water scooper) (Fig. 12). The lateral side of the cone is formed by the line of Toldt that is incised from the pelvic brim, cephalad to the level of the diaphragm. On the left side, the colon appears to cover more of the surface area of the anterior portion of the kidney than on the right side; hence this incision in the line of Toldt is made throughout the length of the retroperitoneum at the outset of the procedure. There are often adhesions from the descending colon at the splenic flexure to the anterior abdominal wall; these attachments need to be sharply released in order to carry the incision in the line of Toldt cephalad alongside the spleen and up to the diaphragm. This cephalad incision serves to release any splenophrenic attachments, thereby mobilizing the spleen from the abdominal sidewall (Fig. 13).

The medial aspect of the cone is then formed by retracting the peritoneal reflection of the descending colon medially and developing the plane between Gerota’s fascia and the colonic mesentery. This natural plane between the mesentery of the descending colon and Gerota’s fascia is most easily identified and entered along the lower pole of the kidney or just inferior to the kidney. The colon is mobilized medially and cephalad up to the spleen.

The anterior upper curve of the cone is formed by the spleno-colic ligament, which is incised in order to fully mobilize the descending colon medially. The posterior upper curve of the cone is formed by the spleno-renal ligament that is incised to

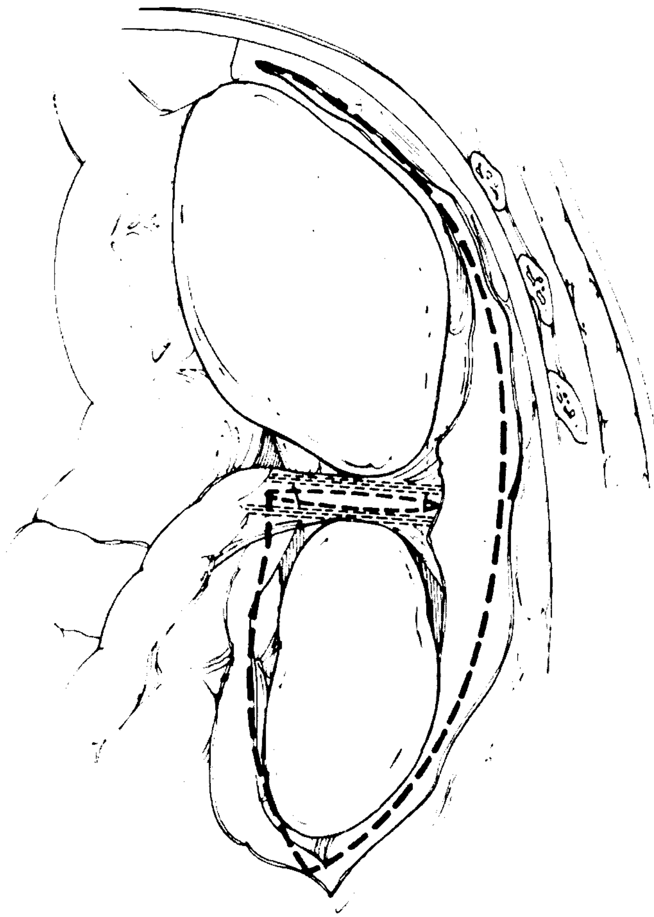

Fig. 12. Diagram demonstrating the inverted cone template for *en bloc* dissection during left radical nephrectomy. Unlike on the right side, the reflection of the colon comes to the lateral sidewall and thus an incision in the line of Toldt parallel to the kidney needs to be made; this incision is not carried deeply in an effort to hold the kidney lateral, which helps somewhat with the hilar dissection.

further release the spleen and thus precludes any inadvertent tearing of the splenic capsule. Incision of the splenorenal ligament may be difficult at this early stage of the procedure and, if need be, can be performed later in the procedure after the renal vessels have been secured.

The dissection then follows the plane between the spleen and the superior portion of Gerota's fascia. At this point, the *en bloc* area of dissection has been defined and incorporates all of Gerota's fascia, the pararenal and perirenal fat, and the adrenal gland.

Step 2: The Gonadal Vein. The left gonadal vein is the most important structure to identify during a left nephrectomy because it reliably leads the surgeon to the renal vein. The gonadal vein can most easily be exposed inferiorly; it is then traced up to its entry into the renal vein (Fig. 14). If necessary, the surgeon can carry the dissection down to the level of the inguinal ring in order to reliably identify the gonadal vein and trace it cephalad; this maneuver is particularly helpful in the morbidly obese patient with a large amount of retroperitoneal fat. Anteriorly along the gonadal vein, there are invariably no tributaries, thereby providing the surgeon with a safe plane of dissection

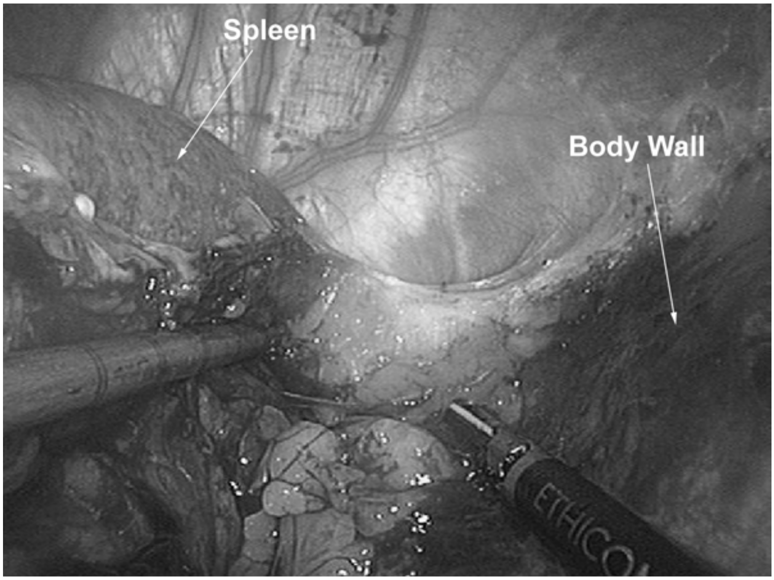

Fig. 13. Dissection of the lateral splenic attachments (splenophrenic attachments).

all the way up to the insertion of the gonadal vein into the main renal vein.

Step 3: Securing the Ureter. The left ureter usually lies just posterior and lateral to the gonadal vein. It is carefully dissected from the retroperitoneal tissues and treated in the same manner as the right ureter was for a right nephrectomy.

Step 4: Securing the Renal Hilum. After tracing the gonadal vein to its junction with the main renal vein, it is secured with four 9-mm vascular clips and divided. Care should be taken to identify the posterior lumbar vein that may enter the renal vein posteriorly in the area of the gonadal vein or may even join the gonadal vein near its insertion into the renal vein. This vein is likewise secured with four clips and incised. The superior border of the renal vein is then freed by dissection of the adrenal vein; this vein usually lies parallel with or just medial to the insertion of the gonadal vein; the adrenal vein is secured with four 9-mm vascular staples and divided. It is important to place the clips on these three renal vein tributaries such that they lie at least 1 cm from the main body of the renal vein; this will facilitate the subsequent safe placement of the Endo-GIA vascular stapler across the renal vein without risking interference of the stapler's function from any of the previously applied clips. If the surgeon inadvertently fires the stapler across a clip, the stapler may freeze-up and then it cannot be properly released *(12)*. In this situation, it may be necessary to convert to an open procedure or proceed to further dissect the renal vein and place a second Endo-GIA stapler across the vein more medial. The decision of which way to proceed is dependent on the surgeon's experience.

If the surgeon tries to identify the left renal hilum by dissecting the area where it "should be," it is not uncommon for the dissection to drift medially. This can become quite problematic and indeed, one may even risk injury to the duodenum, which often lies at the bottom of this "medial hole." Again, the surest way to the renal vein is to trace the left gonadal vein cephalad.

Inferior retraction of the superior border of the renal vein will usually expose the renal artery posterior (Fig. 15). The renal artery is dissected free; five 9-mm vascular

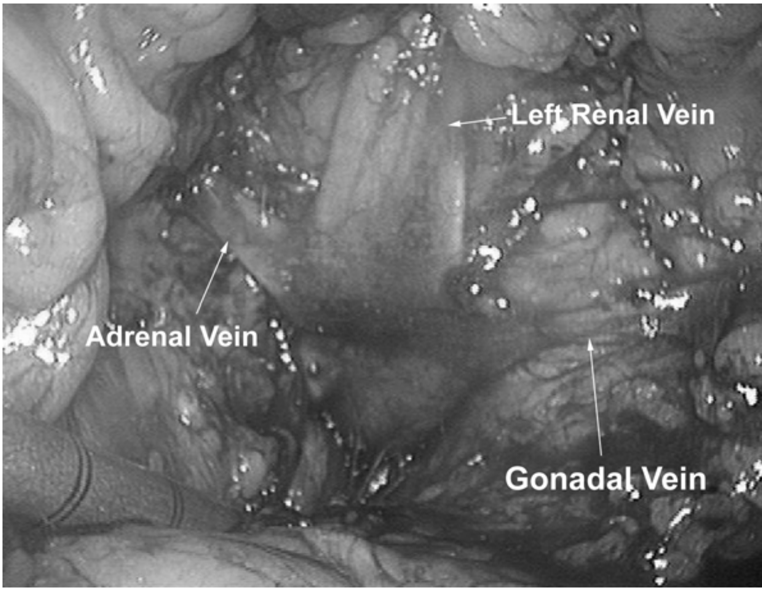

Fig. 14. Laparoscopic view of left renal vein with adrenal and gonadal tributaries. The ascending lumbar vein is not seen; however, it may attach to the posterior surface of the gonadal vein or the renal vein, medial to the renal vein entry of the gonadal and adrenal veins.

clips are applied. The artery is then transected between the second and third vascular clips leaving three clips proximally. The renal vein is then secured with the Endo-GIA vascular stapler. Alternatives to this approach are discussed in Step 5: Securing the Renal Hilum, in the right side (vide supra) section.

Specimen dissection, entrapment, morcellation, or intact removal are all identical to the description for the right side. The only exception is that the left kidney specimen is moved until it rests on the anterior surface of the spleen just prior to entrapment.

Postoperative Care

Patients receive 15 mg of ketorlac (Toradol) IV q6h as requested, for 36 h, as well as an oral narcotic if necessary. Diet is resumed immediately with clear fluids and advanced as tolerated. The patient is ambulated on the first postoperative day. Discharge is routinely planned for the evening of postoperative day 1 or the morning of postoperative day 2. Parenteral antibiotics are stopped on postoperative day 1. The patient is discharged on oral narcotics as needed. Of note, it is not uncommon for these patients to develop some constipation postoperatively; as such, use of a Dulcolax suppository as needed and sending the patient home on a stool softener (e.g., Colace one tablet twice a day) is recommended.

CONCLUSIONS

For small- and medium-sized renal tumors without main renal vein or vena caval involvement, the laparoscopic radical nephrectomy has become an accepted alternative to open radical nephrectomy. Using the anatomic templates and techniques herein described and illustrated, the laparoscopic urologic surgeon can successfully extract the

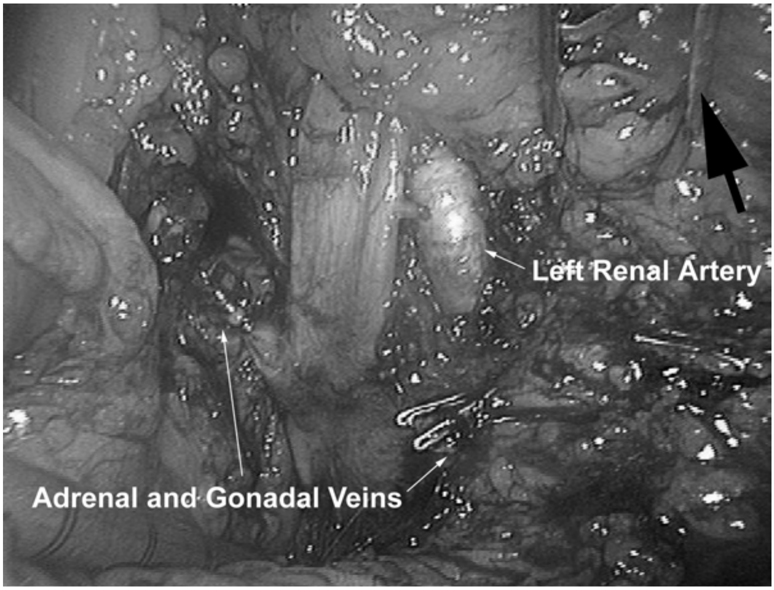

Fig. 15. The left renal artery has been exposed after the ligation and division of the adrenal and gonadal veins. Notice the PEER retractor (black arrow) in the upper right hand corner elevating the kidney thereby placing the renal hilum under gentle stretch. The clips on the gonadal vein have been positioned well away from the main renal vein in order to preclude their interference with the subsequent placement of the EndoGIA stapler.

affected kidney and the ipsilateral adrenal gland within Gerota's fascia while adhering to traditional oncologic principles. The laparoscopic approach meets all oncologic technical criteria while providing the patient with a more comfortable and expeditious recovery. Finally, its long-term effectiveness has now been corroborated by several investigators providing ≥ 5 yr follow-up.

TAKE HOME MESSAGES

1. Think geometrically. Following the described templates facilitates an oncologically complete dissection. For the right remember the wedge; on the left remember the inverted cone.
2. On the left side, the gonadal vein is the key to the renal hilum; cephalad dissection allows discovery of its insertion in the renal vein.
3. On the right side, beware of the duodenum. The Kocher maneuver is essential to identifying the vena cava on the right.
4. When using the morcellator, remember to triple drape the neck of the sac: nephrostomy drape, plastic eye drape, and towel. Avoid any spillage of the specimen over the neck of the sac. Always, have your assistant keep the intra-abdominal portion of the sac in view; always use two hands to hold the sac up taut against the underside of the abdominal wall. If a sudden loss of pneumoperitoneum is encountered, stop immediately!

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9 Laparoscopic Radical Nephrectomy

Hand-Assisted

Brian D. Kessler, MD,
and Steven J. Shichman, MD

CONTENTS

INTRODUCTION

Over the last decade, the use of laparoscopy by urologists has grown exponentially. From its initial use in pelvic lymph node dissections to contemporary use in radical prostatectomies, laparoscopy is quickly becoming a staple in the armament of modern urologic surgery. Because of its technical challenge and steep learning curve, laparoscopy tends to be limited to younger, fellowship-trained surgeons. In addition, standard laparoscopic techniques even in the most skilled hands are not routinely used for removal of kidneys with large tumors. By developing hand-assisted techniques, we have been able to extend the use of laparoscopy to overcome immense technical challenges, to shorten operative time and hospital stay, to decrease morbidity, and to improve patient quality of life.

Sosa and Shichman first reported the use of a finger inserted through a port site to aid in palpation and dissection in 1992 *(1)*. Rassweiler described inserting a gloved hand into the abdomen *(2)*. In 1995, Cuschieri described the use of hand-assistance in laparoscopy via an "extra-corporeal pneumoperitoneum access bubble" *(3)*. The first hand-assisted laparascopic nephrectomy (HALN) performed in the porcine model was reported in 1996 by Bannenberg. One year later, Nakada and colleagues reported hand-assisted laparoscopic radical nephrectomy in a human *(4,5)*.

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Hand-assisted laparoscopy utilizes all the principles of standard transperitoneal laparoscopy. A pneumoperitoneum is created to insufflate the abdomen, increasing the working space. A 30° laparoscope is used to provide magnified visualization of the operative field. Standard laparoscopic instruments are utilized to perform the surgery, in addition to the surgeon's nondominant hand, which is inserted through a small incision. A surgeon with size 7.5 gloves generally requires a 7.5-cm incision. This incision allows the procedure to be performed rapidly and safely with intact specimen removal. Standard laparoscopic radical nephrectomy is usually more time consuming and still requires a 5–6-cm incision for removal of a normal-sized specimen.

The hand-assisted technique allows the laparoscopist to maintain use of the most versatile instrument currently available, the surgeon's own hand. The nondominant hand is placed through the hand incision and the dominant hand performs fine dissection using laparoscopic instruments. The hand is primarily used for dissection, retraction, counter traction, palpation, and maintaining hemostasis. If necessary, the hand may assist in more advanced laparoscopic techniques including intracorporeal suturing and knot tying. By maintaining tactile sense, the surgeon is better able to palpate vessels and adjacent organs, minimizing the chance of injury to vital structures, particularly during difficult laparoscopic dissections. If bleeding occurs, the hand helps the surgeon quickly locate the source and apply hemostasis. In essence, HALN combines the advantages of laparoscopic and open surgery. As has been said by Dr. R.V. Clayman, "one hand is worth a thousand trocars" *(6)*.

Pure laparoscopic radical nephrectomy has inherent limitations. When operating on large, bulky tumors, it may be difficult to adhere to principles of oncologic surgery using standard laparoscopy as compared to open surgical techniques. In addition, removal of an intact specimen requires an incision usually as large or larger than a "hand-access" incision. Hand assistance helps the urologist maintain standard principles of oncologic surgery while employing a minimally invasive approach. In addition, the operative time can usually be shortened as compared to pure laparascopic surgical techniques. Finally, if an incision is going to be utilized to remove the intact kidney, there is a clear benefit in making this incision early on in the operative procedure and using the hand to facilitate the entire procedure.

INDICATIONS AND PREOPERATIVE ASSESSMENT

The indications for HALN can include any scenario in which an open radical nephrectomy is warranted. The most common indications include nephrectomy for functional renal masses (renal cell carcinoma being the most common pathology), nonfunctioning kidneys, and renovascular hypertension. Hand-assisted techniques can also be applied to nephroureterectomy for live donor renal transplants and upper tract transitional cell carcinoma.

Care must be taken in evaluating whether a patient is appropriate for HALN (Table 1). The most favorable patients, especially during the initial learning phase, include those who are relatively thin and have left-sided tumors. Patients with virgin abdominal cavities and small, lower pole tumors located away from the renal hilum are ideal candidates.

Several conditions make a patient less than ideal for initial attempts at hand-assisted cases. Obese patients can be a significant challenge because excessive adipose tissue can make dissection tedious and difficult. Multiple prior abdominal surgeries predispose to intraperitoneal adhesions that are time-consuming to lyse and increase the risk

Table 1
Favorable Aspects, Relative Contraindications, and Absolute Contraindications to Performing Hand-Assisted Laparoscopic Nephrectomy

Favorable aspects	*Relative contraindications*	*Absolute contraindications*
Thin body habitus	Morbid obesity	Caval thrombus extending above hepatic veins
Small tumors	Severe intraperitoneal adhesions	Direct extension of tumor into body wall or adjacent viscera
Left-sided tumors	Severe perirenal and perihilar adhesions	Uncorrectable bleeding disorder
Lower pole tumors	Muscular abdominal wall	
Tumors located away from the renal hilum	Extremely large tumors (>15 cm)	
Minimal or no previous abdominal surgery	Extensive renal vein or IVC thrombus	
	Ipsilateral abdominal wall stoma	
	Pregnancy	

of visceral injury. Patients with extremely muscular abdominal walls have reduced abdominal wall compliance that reduces the working space, restricting the use of the hand. Relative contraindications to hand-assisted techniques also include extremely large tumors, extensive renal vein or inferior vena cava (IVC) thrombus, history of severe perirenal and/or intra-abdominal inflammatory conditions, ipsilateral abdominal wall stomas, and pregnancy. As the surgeon's experience grows, patients with relative contraindications become more amenable to the hand-assisted technique. Absolute contraindications include caval thrombus extending above the hepatic veins, large tumors with direct extension into the body wall or adjacent viscera, and uncorrectable bleeding disorders.

The preoperative assessment of a patient for HALN is the same as for an open nephrectomy. A computed tomography (CT) scan will adequately define the anatomic details necessary for hand-assisted techniques. If renal vein or caval thrombus is suspected, magnetic resonance imaging (MRI) or venogram will further assist preoperative planning.

PATIENT PREPARATION

Preoperative discussions should always include the caveat that conversion to an open nephrectomy is possible. Consent must include permission for open nephrectomy. A type and screen should be obtained. Patients are instructed to take a clear liquid diet starting the day prior to surgery. Because an empty bowel helps maximize working space and allows for more comfortable dissection, a mechanical bowel prep is suggested. We use an 8-ounce bottle of magnesium citrate the afternoon before surgery followed by a Fleets enema in the evening. The patient should have nothing to eat or drink by mouth after midnight except for a sip of water with medications the morning of surgery.

Prior to induction of general anesthesia and endotracheal intubation, pneumatic antiembolic stockings are applied. A nasogastric or orogastric tube and a Foley catheter are used in order to keep the stomach and bladder decompressed. Prophylactic antibiotics are administered. The patient is then positioned in a modified lateral decubitus position at a 45° angle, using either gel pads or a sandbag (Fig. 1). The umbilicus should overlie the kidney rest, but the kidney rest is rarely elevated. A padded neuro armrest is used to support the upper arm and, if needed, an axillary roll is used to pad the dependent axilla. The lower leg is flexed and the upper leg extended with pillows

Fig. 1. Patient positioning for a hand-assisted left radical nephrectomy.

placed in between. The table may be gently flexed. In order to allow the patient to be rolled intraoperatively from a near supine position to the full flank position, three inch cloth tape is wrapped over the patient and passed under the operating room (OR) table several times to secure the patient's shoulders, chest, hips, and legs. Upper and lower body warming blankets are used to maintain core body temperature throughout the case. The surgical field from nipples to pubis and laterally to the mid axillary line should be shaved. After the patient is positioned, it is important to widely prep and drape in order to accommodate placement of the hand-assist device and trocars.

EQUIPMENT AND HAND-ASSIST DEVICES

The operating room is assembled in a manner similar to that for any laparascopic procedure (Fig. 2A,B). Equipment used in hand-assisted cases vs pure laparascopic cases is similar as well. Table 2 outlines the most important equipment we use in hand-assisted surgery. Two important instruments exclusive to hand-assisted surgery include a ringless laparotomy pad and the hand-assist device.

A clean, rolled up laparotomy pad with the ring removed is placed into the abdomen through the hand incision. Use the laparotomy pad to help retract and dry tissues. Drier tissues are easier to grasp and dissect, and tissue planes are easier to identify. It also saves time by not having to stop and insert a suction/irrigating instrument. If the laparotomy pad becomes excessively bloody, it can absorb a significant amount of light, which can darken the video image. Replacing a blood-soaked laparotomy pad with a clean one can dramatically brighten the video image.

Hand-assist devices allow the hand to be introduced into an insufflated abdominal cavity while maintaining the pneumoperitoneum. Technology is evolving quickly as new devices and modifications are introduced frequently. Some devices have a mechanism to protect the abdominal incision, often called a wound retractor or protractor. Devices vary in the way in which they are affixed to the abdomen and in how the pneumoperitoneum is maintained. Early devices used an adhesive applied directly to the patient's abdomen to secure the device. As technology evolves, adhesive is being replaced with self-retaining devices that both secure the device to the abdomen

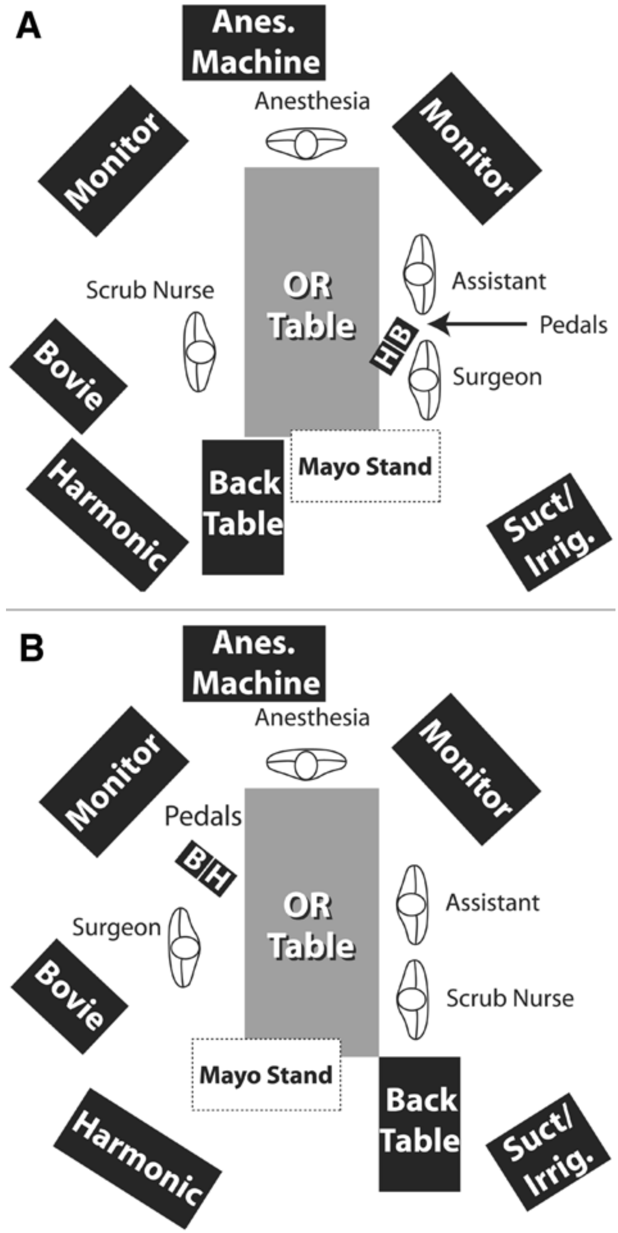

Fig. 2. Schematic drawing of the OR set-up for a hand-assisted **(A)** right and **(B)** left laparoscopic nephrectomy. H, harmonic scalpel foot pedal; B, electrocautery foot pedal.

and protect/retract the incision at the same time. The first device, introduced in 1997, was the PneumoSleeve® (Dexterity, Atlanta, GA). Because the PneumoSleeve was the first device available, it has had the most extensive use among surgeons. The most popular devices in use include the GelPort™ (Applied Medical, Rancho Santa Margarita, CA), the HandPort® (Smith Nephew, Laguna, CA), the Omniport™ (Advanced Surgical Concepts, County Wicklow, Ireland), and the Lap Disc (Ethicon Endo-Surgery, Cincinnati, OH). All of the hand-assist devices are effective, and

Table 2
Essential Equipment for Hand-Assisted Laparoscopic Nephrectomy

Hand-assist device
30° camera
Harmonic scalpel unit
Electrocautery unit
Weck Hem-o-lock clips and applier
Endoscopic linear stapler with vascular cartridges
Right-angle dissector
Maryland dissector
Endoshears
Laparoscopic needleholder
Ringless laparotomy pads
Trocars (5-mm, 10-/12-mm)
Liver retractor
Neuro armrest
2-inch cloth tape (3 rolls)
Pillows and gel pads
Upper and lower body warming blankets
Pneumatic anti-embolic stockings

selection depends on surgeon preference, location of hand incision, body habitus, and patient's history of prior abdominal surgery.

TROCAR AND HAND-PORT CONFIGURATION

We have used the following hand incision and trocar configurations successfully in more than 300 cases with little modification necessary. Numerous factors must be considered when determining the optimal positioning of trocars and the hand incision. These factors include the specific operation being performed, the patient's anatomy, the surgeon's experience, and the surgeon's hand and forearm size.

Although the operation is performed in the flank postion, at the start of the case the table is rolled so that the patient is in a near supine position. Placement of the hand incision and trocars is made with the patient in this position because this allows for easier access to the peritoneal cavity and ensures better cosmetic results.

The midline should always be marked, which aids in trocar placement as well as providing a quick and accurate guide if emergent laparotomy is necessary. The use of 12-mm trocars in all port sites enables the camera and endoscopic stapler to be placed through any trocar to allow maximum flexibility. For a right-sided nephrectomy, a 5-mm trocar is used in the right upper quadrant for placement of a liver retractor, since a camera or stapler would never be used at this site.

The length of the hand incision in centimeters is usually equal to the surgeon's glove size. Once the incision is made and the peritoneal cavity is entered, test the size and length of the incision for comfort. If the incision is too small, parasthesias and cramping of the surgeon's hand can result, which will make the operation more difficult. Too large of an incision may result in the hand device dislodging and loss of the pneumoperitoneum.

The renal hilum is approximately 8–12 cm superior to the umbilicus, but this distance can vary widely based on patient body habitus and vascular anatomy. Examine the patient's CT scan and calculate this distance by counting the number of tomographic images between the renal hilum and the umbilicus. If the distance is greater than 12 cm, if the surgeon has short arms, if the patient is obese, or if the girth of the abdominal cavity is larger than normal, consider moving the hand incision cephalad. This will allow improved access to the renal hilum.

The hand incision should be at a distance from the operative target to allow insertion of the entire hand and wrist into the peritoneal cavity. The surgeon's wrist should have free range of motion and the fingertips should comfortably reach the renal hilum (the most important part of the dissection). If the hand incision is placed too close to the kidney, the hand will not be able to be completely inserted into the abdominal cavity, losing maneuverability of the wrist and fingers. The hand will act more as a retractor and less optimally as a dissector.

For patient comfort, try to place the hand incision as low as possible on the abdominal cavity as this will result in decreased postoperative discomfort and respiratory compromise. Additionally, always try to avoid cutting muscle fibers as this will reduce postoperative morbidity and reduce the risk of incisional hernias. We use a low midline hand incision for a left nephrectomy and a muscle splitting right lower quadrant incision for a right nephrectomy.

For a right nephrectomy (*see* Fig. 3A), the hand incision is placed in the right lower quadrant lateral to the rectus muscle, just below the level of the umbilicus. The skin is incised in line with the external oblique fascial fibers and the abdominal wall musculature is split. After insertion of the hand-assist device, the working instrument port is placed in the infraumbilical midline and the camera port is placed in the supraumbilical midline approximately 6–8 cm cephalad to the working trocar. The camera and working instruments may be switched at any time to facilitate the dissection. A third port is placed in the right midclavicular line at the costal margin that allows placement of a liver retractor.

For a left nephrectomy (*see* Fig. 3B), the hand port is placed midline in the infraumbilical or periumbilical region. The camera port is placed in the anterior axillary line at the level of the umbilicus while the working instrument port is placed in the midclavicular line, just below the level of the umbilicus. For very large upper pole tumors, an additional superior midclavicular working port may be used for the most cephalad part of the dissection.

Trocars must not be placed too close to the hand-assist device because they may impede maneuverability of the nondominant hand inserted through the hand-assist device and instruments inserted through the trocars. In some cases with obese patients, we shift the entire template lateral and cephalad to assure that instruments will reach the operative bed.

In the majority of cases, the hand incision is made initially, the hand device is inserted and trocars are placed prior to establishing a pneumoperitoneum. In cases where there is a high index of suspicion for significant adhesions, we prefer to enter the peritoneal cavity initially via the hand incision, which allows direct visualization of the abdominal cavity and open surgical lysis of adhesions. Taking down extensive intra-abdominal adhesions through the hand incision can save a significant amount of time as compared to using a purely laparoscopic technique.

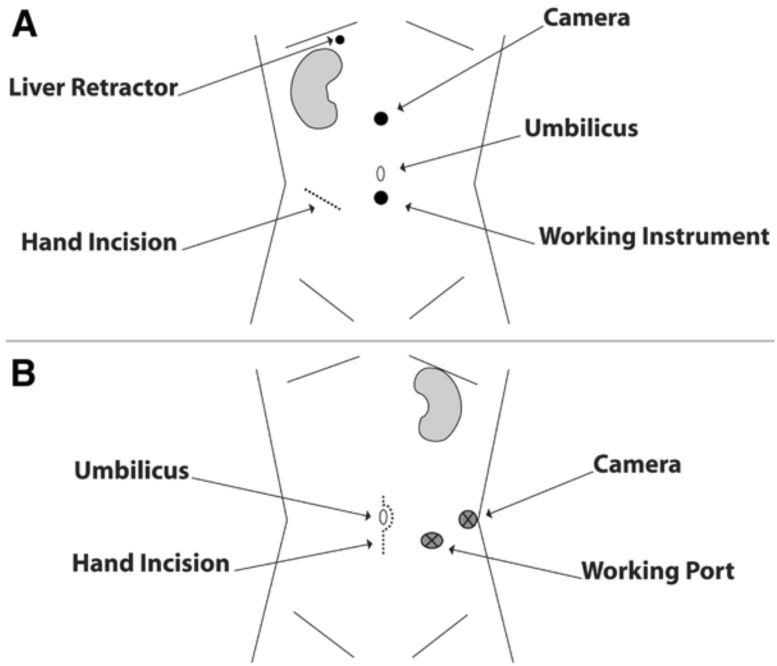

Fig. 3. Schematic drawing depicting placement of hand incision and trocars for hand-assisted **(A)** right and **(B)** left laparoscopic nephrectomy.

Another option is to initially establish the pneumoperitoneum using a Hasson trocar or Veress needle and inspect the peritoneal cavity using the laparoscope. This allows the surgeon to identify adhesions and appreciate variations of anatomy that may alter the positioning of the hand-assist device and/or trocars. We stopped using this technique after our first 100 cases as we found that the placement of our hand incision and trocar placement was rarely modified. A pneumoperitoneum is established and maintained at a pressure of 12–15 mmHg as per standard laparoscopy.

LEFT RADICAL NEPHRECTOMY

To begin, the table is rolled to place the patient in the near flank position. Release the colon from the lateral sidewall by incising the white line of Toldt. Dissection is carried out from the splenic flexure to the iliac vessels. The colon is reflected medially using the back of the hand, while the fingertips help dissect the mesocolon off of the anterior aspect of Gerota's fascia. Dissection is continued in the cephalad direction, freeing the splenic flexure and releasing the spleno-renal ligaments. The lateral attachments from the body sidewall to the spleen are now released up to the level of the gastric fundus, which allows the entire spleen and splenic flexure to fall medially. Do not release the lateral attachments of the kidney to the body sidewall, as these attachments are used for counter traction, which aids in medial dissection of the renal hilum. The plane between the tail of the pancreas and the anterior aspect of Gerota's fascia is then developed, which allows the tail of the pancreas to rotate medially with the spleen. The back of the hand is used as an atraumatic retractor on the spleen and the pancreas while the fingertips aid in dissection. Care is taken to leave the entire anterior aspect of Gerota's fascia intact. The colon and mesocolon are mobilized medially to allow identification of the aorta and renal hilum. The investing tissue overlying the hilar vessels is grasped with the fingertips, retracted anteriorly, and a plane between these tissues and renal vein is developed using the Harmonic scalpel or scissors. Once the anterior wall of the renal vein is exposed, meticulous dissection allows identification of both the gonadal vein and left adrenal vein entering the renal vein. These veins are dissected free of their surrounding tissues and doubly clipped both proximally and distally.

In some cases we choose not to clip and divide the gonadal and adrenal vessels at this point in the case. We do not want to have clips potentially interfere with the subsequent firing of the linear stapling device across the renal vein later in the case. In other cases the anatomy may be favorable for dividing the renal vein proximal to the adrenal vein, obviating the need for division of the adrenal and gonadal veins as long as the surgeon plans on removal of the adrenal gland with the kidney.

At this point, the surgeon must not be tempted to continue dissection of the renal vasculature from the anterior approach. The key to success of the hand-assisted laparoscopic nephrectomy is obtaining vascular control from a posterior approach, which allows the fingertips to surround the renal hilum, helping with palpation, dissection, and control of the renal artery and vein. In a very rare case, the main renal artery will be easily accessible anteriorly and should obviously be ligated and divided at this point in the procedure.

Dissection now continues at the most inferior lateral portion of Gerota's fascia, identifying the body sidewall and psoas muscle. The fingertips and the dissecting instrument of choice, either electrocautery scissors or Harmonic scalpel, are used to reflect the perinephric fat in a medial and anterior direction off the psoas muscle. The surgeon works from a lateral to medial direction, coming across the gonadal vein, which is doubly clipped proximally and distally and divided. If a radical nephrectomy is performed, the ureter is also identified, clipped, and transected. Obviously, during a nephroureterectomy the ureter is left intact. If a donor nephrectomy is being performed, the periureteral tissue is left intact adjacent to the ureter as well as leaving the ureter intact and dissection of the ureter with all of its surrounding tissue is continued into the true pelvis below the iliac vessels.

The surgeon continues reflecting the inferior pole of the kidney, adjacent perinephric fat, and overlying Gerota's fascia anteriorly and medially, releasing the posterior and lateral attachments to the body sidewall and posterior wall. All lateral attachments are now released up to the level of the adrenal gland as the kidney is reflected anteriorly and medially with the back of the hand. Care must be taken not to enter Gerota's fascia. As the lateral attachments to the inferior aspect of the diaphragm are encountered, the surgeon must be careful not to perforate through the diaphragm. If perforation occurs, rapid loss of pneumoperitoneum will occur, resulting in a tension pneumothorax. Perforations can be closed using hand-assisted laparoscopic suturing techniques; conversion to open nephrectomy may be necessary.

After releasing all lateral and posterior attachments, the kidney can be rolled anteriorly and medially, exposing the posterior aspect of the renal pedicle. The kidney should then be rolled back to its normal position and the tips of the second and third finger are placed just above the exposed anterior aspect of the renal vein. Using the thumb and dissecting instrument, the kidney is now rolled anteriorly and medially and the thumb is placed on the posterior aspect of the renal vessels (Fig. 4). This maneuver helps identify the renal artery by direct palpation and allows for presentation of the artery to the dissecting instruments. Additionally, if bleeding is encountered, the fingers

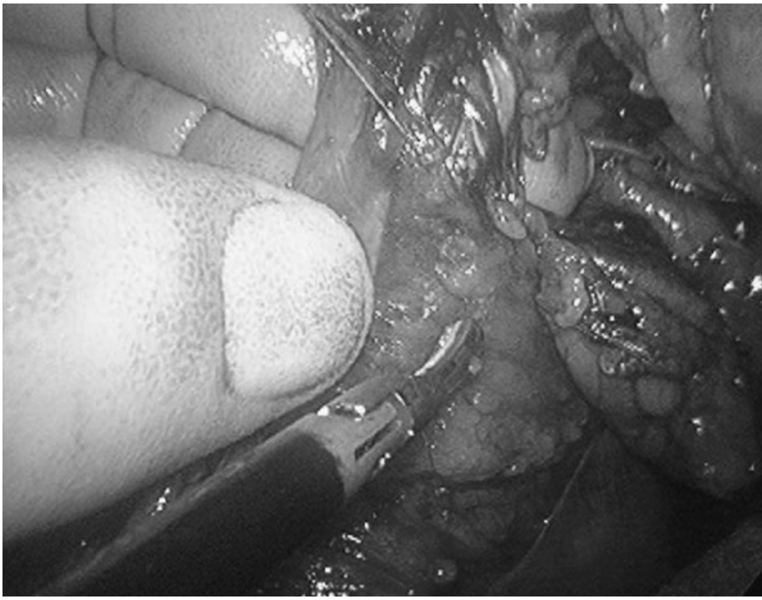

Fig. 4. The posterior approach to the left renal hilum.

can compress the pedicle achieving rapid hemostasis. Using curved electrocautery shears, a Maryland dissector, or a Harmonic scalpel to dissect the surrounding lymphatic tissue, the posterior and inferior aspects of the renal artery are exposed. Often, a lumbar vein is seen coursing across the posterior aspect of the proximal renal artery. This lumbar vein can complicate exposure and dissection of the renal hilum because it may tether the renal vein or obscure the renal artery. In these situations, the lumbar vein must be clipped and divided. Following this, a right angle dissector is passed around the renal artery, completely freeing the vessel from all remaining attachments. The artery can be controlled using either three locking clips, two proximally and one distally, or by using an endoscopic linear stapling device.

After the renal artery is divided, the renal vein is freed of all surrounding lymphatic and connective tissues, and controlled using an endoscopic linear stapling device or large hemoclips. When the endoscopic stapler is used, great care must be taken not engage any previously placed clips in between the jaws of the stapler. Both visual inspection and palpation with the hand assures that the stapler has not engaged any extraneous tissue or clips. Engaging clips in the jaws of the stapler will cause the device to misfire, resulting in a disruption of the staple line and significant bleeding.

If the adrenal gland needs to be removed with the left kidney, attention is now directed to the most superior phrenic attachments. With the spleen completely mobilized medially, diaphragmatic attachments are identified and controlled using hemoclips or the Harmonic scalpel. There is usually a single artery originating from the diaphragmatic attachment, which must be clipped for adequate control. The remaining vessels can usually be divided using the Harmonic scalpel. Care must be taken to identify any accessory phrenic veins that may exist, coursing from the diaphragm along the medial aspect of the adrenal gland toward the renal vein. These structures can be easily mistaken for the adrenal vein when dissecting in the region of the superior aspect of the renal vein. The superolateral attachments from the adrenal gland to the body sidewall are left intact and the medial attachments to the aorta are divided using the Harmonic scalpel and clips when necessary. The remaining superolateral attachments and posterior attachments are now divided using the Harmonic scalpel or electrocautery scissors and the specimen is completely freed.

If the adrenal gland is to be left intact, use visual inspection and palpation with the fingertips to locate the groove separating the adrenal gland from the kidney. The attachments between the adrenal gland and the superior aspect of the kidney are divided using the Harmonic scalpel. If the adrenal vein has not already been divided, it should be doubly clipped proximally and distally, and sharply transected. Usually a single large arterial branch originating from the renal artery feeds the most inferolateral aspect of the adrenal gland. Hemoclips can be used on this vessel for adequate hemostasis.

Once dissection is complete, the kidney is removed through the hand incision. Oncologic principles are no different in the hand-assisted technique than that of open surgery. The specimen is delivered intact, without the need for morcellation, preserving the pathologic integrity of the specimen. The hand is placed back into the abdomen and pneumoperitoneum is re-established. Adequate hemostasis should be ensured at lower insufflation pressures (5–8 mmHg), confirming vascular control of all arterial and venous structures. Renal hilar vascular stumps are re-examined and any bleeding staple lines or vascular stumps can be controlled with laparoscopic suture ligation.

RIGHT RADICAL NEPHRECTOMY

After insertion of the hand device and trocars as previously described, the liver retractor is inserted and the liver is retracted medially. The right lobe of the liver is released from the body sidewall by incising the triangular ligament and if necessary, the anterior and posterior divisions of the coronary ligaments. There may also be significant attachments between the undersurface of the right lobe of the liver to the anterior/superior aspect of Gerota's fascia that must be released using the Harmonic scalpel.

With the liver adequately mobilized medially, the attachments of the hepatic flexure to the overlying Gerota's fascia are released using the fingertips to develop pedicles, which are transected using the Harmonic scalpel. The duodenum is now identified. If the duodenum at the level of the renal hilum covers the vena cava, a standard Kocher maneuver is performed using sharp dissection, mobilizing the duodenum medially off of the underlying renal hilum and vena cava. Investing tissue over the vena cava and renal vein is released and the anterior wall of the renal vein is skeletonized. The tendency will be to continue dissection on the renal hilum and vasculature at this time, but the surgeon should remember that it is imperative to obtain vascular control from the posterior approach.

Posterior exposure of the renal hilum is obtained by releasing all attachments of Gerota's fascia and perinephric fat to the body wall and rotating the kidney anteriorly and medially. We start this part of the dissection by directing our attention to the perinephric fat inferior to the lower pole of the kidney. Using fingertip dissection, the psoas muscle is identified and the fingers are passed lateral to medial, raising the most caudal attachments of the kidney off the psoas muscle. This large pedicle of tissue may include the right gonadal vein and ureter. The entire pedicle can be divided using an endoscopic linear stapling device. Alternatively, individual pedicles of fat can be divided using the Harmonic scalpel while the gonadal vein and ureter are individually clipped and sharply divided. In some cases the gonadal vein can be gently retracted medially and division of the vein is unnecessary. Attachments of Gerota's fascia

Fig. 5. The posterior approach to the right renal hilum.

and perinephric fat to the lateral and posterior body sidewall are released using the Harmonic scalpel or electrocautery shears.

With the hand placed posterior to the kidney, the kidney is elevated. Any remaining inferior medial attachments to the vena cava or lower pole accessory veins are identified and secured using clips or the Harmonic scalpel. The second and third fingers are now curled behind the renal pedicle, allowing identification of the renal artery (Fig. 5). Using gentle traction with the index finger, the artery can be pulled inferiorly and dissected free of surrounding lymphatic tissue using the Harmonic scalpel, Maryland dissector, or right-angle dissector. The artery can be controlled using locking clips or an endoscopic stapling device with a vascular cartridge. The renal vein is dissected free from surrounding lymphatic and investing tissues and transected using the endoscopic stapling device.

If the adrenal gland needs to be removed with the kidney, the liver must be aggressively mobilized medially. The most superior phrenic attachments and vessels feeding the adrenal gland should now be controlled and ligated with clips or the Harmonic scalpel. The superolateral attachments should be left intact and dissection should continue along the vena cava, releasing medial attachments. The adrenal vein will now be easily identified and should be ligated using large hemoclips and sharply divided. The remaining posterior and lateral attachments can easily be transected using the Harmonic scalpel.

If the adrenal gland does not need to be removed, use visual inspection and palpation with the fingertips to locate the groove separating the adrenal gland from the kidney. The attachments are divided using the Harmonic scalpel.

RESULTS

From March 1998 to January 2002, we performed 305 hand-assisted laparoscopic renal procedures including 174 radical nephrectomies. Operative times averaged 167

Table 3
HALN vs Open Renal Surgery

	Operative time (min)	*Estimated blood loss (cc)*	*Parenteral narcotics (mg MSO_4)*	*Oral narcotics (tablets)*	*Length of stay (d)*	*Comp (%)*	*Convalescence (wk)*
HALN ($n = 74$)	198 ± 77	131 ± 66[a]	32.8 ± 24.6	4.6 ± 3.3	3.7 ± 1.3	6 (8%)	<4 wk
Open ($n = 20$)	196 ± 37	372 ± 68	208.5 ± 73[ab]	8.8 ± 4.5[a]	5.2 ± 1.4[a]	2 (10%)	NR

[a] $p < 0.05$.
[b] OPEN patients required epidural for average 2.7 d; no patient received epidural in HALN group).
NR, not reported.

min, while estimated blood loss was 182 cc. Only two cases required conversion to an open approach. On average oral intake was started on postoperative day 1, average parenteral narcotic requirements were 41 mg equivalents of morphine sulfate, while length of stay averaged 3.6 d. Major and minor complication rates were 11 and 4%, respectively.

Early in our experience, we compared our HALN outcomes to a contemporary group of patients that underwent nephrectomy using the traditional open technique (Table 3). Estimated blood loss, parenteral narcotic requirements, oral narcotic requirements, length of stay, and time of convalescence are all statistically less in the HALN group compared to the open group ($p < 0.05$). No statistical difference was shown between operative time and complication rate. Nakada et al. have also compared their HALN experience with the traditional open technique, confirming these findings *(7)*.

TAKE HOME MESSAGES

1. With the proper training, hand-assisted laparoscopic radical nephrectomy is a safe, reproducible, minimally invasive technique for performing extirpative renal surgery.
2. When performing extirpative laparoscopic renal surgery, making the hand incision at the beginning of the procedure will enable the surgeon to use the hand to operate quickly and safely, minimize blood loss, and allow intact specimen removal.
3. Hand-assisted laparoscopy is easier to learn and is applicable to larger tumors and more complex cases as compared to standard laparoscopy.
4. Vascular control of the renal hilum should be achieved from the posterior approach.
5. Data has shown decreased blood loss, narcotic use, length of hospital stay, and time to convalescence as compared to open techniques.

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10 Laparoscopic Partial Nephrectomy

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CONTENTS

INTRODUCTION

Historically, renal cell carcinoma has been managed by an open surgical radical nephrectomy. Renal masses are becoming more common, in part owing to the increased early detection of renal masses by computed tomography (CT) and ultrasound *(1)*. With improved operative techniques and better postoperative care, nephron-sparing surgery (NSS) is being increasingly used to manage small renal masses *(2)*. NSS is an acceptable management option because a nephron-sparing approach has yielded similar long-term results compared to an open surgical radical nephrectomy for small tumors *(3–5)*.

Laparoscopy in urology has been steadily expanding over the past decade. It was only 2 yr following the first laparoscopic radical nephrectomy *(6)* that the first laparoscopic partial nephrectomies were successfully reported in a child *(7)* and an adult *(8)*. Because of the success of open NSS for small renal masses along with the increased use of laparoscopy in urology, it was only 1 year later in 1994 that the first report of laparoscopic NSS for renal cell carcinoma was performed *(9)*. Although laparoscopic radical nephrectomy has become much more commonplace, laparoscopic partial nephrectomy has lagged behind. This is predominantly owing to the technical challenges of controlling parenchymal hemostasis and repairing collecting system injuries laparoscopically. Even so, several small series of laparoscopic partial nephrectomies

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have been reported, including both transperitoneal and retroperitoneal approaches *(10–16)*. Herein we describe the indications for laparoscopic NSS, the operative technique, potential pitfalls, and results.

INDICATIONS

Indications for a laparoscopic partial nephrectomy are similar to those for an open surgical approach. Most cases are performed for masses suspicious for renal cell carcinoma. Solitary, enhancing, exophytic masses less than 4 cm are ideal for a laparoscopic approach. NSS is considered essential for patients that have either a solitary kidney, either anatomically or functionally, or have bilateral renal masses. NSS has relative indications as well. A relative indication occurs in the setting of patients with a disease process that may impair the contralateral kidney. Such diseases include hypertension, diabetes mellitus, renal calculi, and renal artery stenosis. Patients with von Hippel-Lindau disease would benefit from NSS because of the high likelihood of multiple tumors. Finally, NSS is also performed electively for small (less than 4 cm) masses suspicious for renal cell carcinoma with a normal contralateral kidney.

Laparoscopic NSS can also be used for benign diseases as well. Indications include duplicated collecting systems with poorly functioning segments, renal cystic disease (including Bosniak class II or III cysts), benign masses (angiomyolipoma), and calculi associated with cortical atrophy.

Laparoscopic partial nephrectomy is most technically difficult for large, centrally located tumors. In these instances, reconstruction of the collecting system is very challenging with current laparoscopic techniques. Moreover, in such cases, renal ischemia by renal vessel clamping is required. Renal hypothermia has not yet been shown to be reliably attained in the laparoscopic environment, although there are reports of laparoscopic partial nephrectomies with brief periods of vessel clamping and warm ischemia *(11,12,17,18)*. General contraindications are similar to all other laparoscopic procedures: severe obstructive airway disease, coagulopathy, peritonitis, and severely dilated intestines *(19)*. Prior abdominal surgery and morbid obesity are relative contraindications for a transperitoneal approach.

INSTRUMENTS

The instruments needed for a laparoscopic partial nephrectomy include a standard laparoscopic instrument set, containing a Maryland dissector, laparoscopic scissors, grasper, suction and irrigation tip, fan retractor or a Padron endoscopic exposing retractor (P.E.E.R., Jarit, Inc., Hawthorne, NY), and a biopsy forceps.

Depending on the technique of excising the tumor, various other supplies are needed. If using hand assistance, also used are a gelatin sponge, fibrin glue, laparoscopic needle for application of thrombin, argon-beam coagulator, and—depending on whether or not the renal vessels will be clamped—a handheld vascular ("bulldog") clamp or a bipolar forceps.

If using standard laparoscopy, bipolar forceps, a laparoscopic Satinsky clamp, fibrin glue and laparoscopic applicator, and, if suturing, laparoscopic needle drivers.

Other alternatives include a Harmonic scalpel, oxidized cellulose gauze, and radiofrequency probes.

PREOPERATIVE PREPARATION

The imaging studies of the renal lesion must be reviewed. Particular attention should be directed toward the location of the lesion and the depth of penetration into the renal parenchyma. The potential for a collecting system injury should be assessed. This applies to all surgical procedures, but for laparoscopy, in particular, preoperative planning is essential. The laparoscopic approach should be decided (transperitoneal or retroperitoneal) and, if transperitoneal, whether or not hand assistance will be employed. Transperitoneal surgery provides the benefit of a familiar anatomic orientation, a larger working space, and the ability to use (or convert to) hand assistance. Disadvantages occur in the previously operated abdomen with the potential for bowel injury and the time-consuming task of dividing adhesions. Furthermore, the colon needs to be mobilized. A retroperitoneoscopic approach allows the renal hilum to be more readily accessible. In addition, postoperative ileus is less likely, the risk of bacterial seeding of the peritoneum is reduced, and any extravasated urine or blood can only spread into a limited area *(20)*. The main disadvantage of the retroperitoneoscopic approach is that the orientation of the anatomy is unfamiliar, thereby making this technique more difficult to learn. Furthermore, the working space is much less than with a transperitoneal approach, especially if an incidental rent in the peritoneum occurs. Our approach at the University of Michigan entails hand assistance through a transperitoneal route for larger masses with deeper penetration into the parenchyma. If the tumor appears to have shallow (approx 0.5 cm or less) penetration into the parenchyma, then wedge resection is performed. The approach is chosen based on the location of the mass (retroperitoneal for posterior lesions, transperitoneal for others).

The day prior to the scheduled date of surgery, the patient scheduled for a transperitoneal laparoscopic approach should drink only clear liquids and receive a mild bowel preparation (i.e., magnesium citrate). The goal is to reduce the volume of the intestines and to minimize contamination if a bowel injury does occur. Bowel preparation is not needed for retroperitoneoscopy. After adequate anesthesia, a urethral catheter is placed to prevent a bladder injury owing to "blind" access techniques, as well as to monitor urine output during the procedure. An orogastric tube is also placed to decompress the stomach. Nitrous oxide should be avoided to minimize bowel distention.

TRANSPERITONEAL LAPAROSCOPIC NSS

The patient is placed in the lateral decubitus position, allowing the torso to fall back to a 45° angle from the horizontal. Flexion of the table is not necessary. If hand-assistance is being used, the intended site for the hand-assistance device should be noted prior to any incision. The device is used through a peri-umbilical/upper midline incision. The HandPort (Smith & Nephew, Andover, MA) Gelport (Applied Medical, Rancho San Marita, CA), Lap-Disc (Ethicon Endosurgery, Cincinnati, OH), and the Omni Port (Advanced Surgical Concepts, Wicklow, Ireland) are best placed prior to insufflating the abdomen. Therefore, the midline incision is performed and the peritoneal cavity is entered. The device is placed and then the laparoscopic ports are placed as described below. The Pneumo Sleeve (Dexterity Surgical, Roswell, GA) is best placed on the insufflated abdomen; therefore, the laparoscopic ports are placed first.

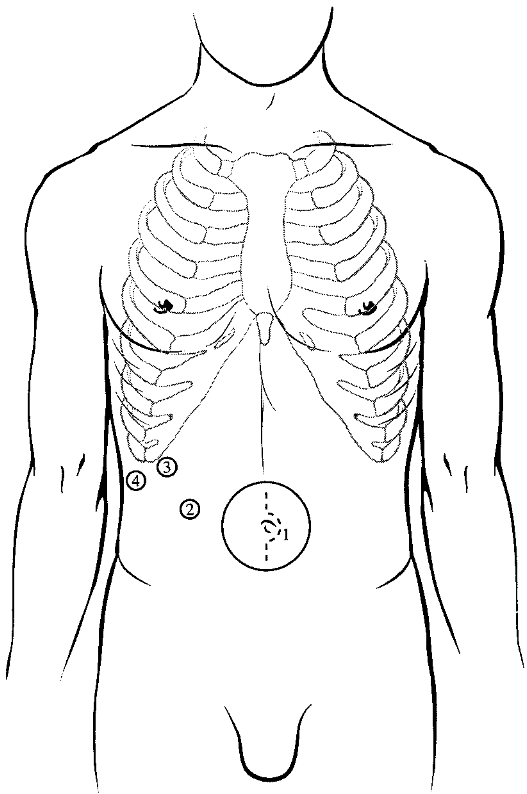

Fig. 1. Laparoscopic port placement. Dashed line (1) represents midline incision for hand-assistance; the circle representing the area covered by the base of the hand-assistance device. 2 depicts a 10 mm port site used for the videolaparoscope. 3 represents a 10 or 12 mm port site that is the primary working port. 4 is a 5 mm port site that is placed directly over the tumor and can be variable in its location.

Transperitoneal access can be obtained with a Veress needle (or other similar method). The primary videolaparoscope port is located at the lateral border of the rectus muscle at the approximate level of the umbilicus. This port, as well as the primary working port, are both 10- or 12-mm. The primary working port is placed in the anterior axillary line, a few fingerbreadths subcostal (Fig. 1). If hand assistance is not being used, a third 5-mm port is placed in the anterior axillary line above the iliac crest. A final 5-mm working port is inserted later in the case directly overlying the tumor once its location relative to the abdominal wall has been verified.

The line of Toldt is incised and the colon is reflected medially to expose the entire kidney. In general, the descending colon needs to be mobilized to the aorta and the ascending colon to the duodenum. At this point, Gerota's fascia is incised distant from the tumor. Gerota's fascia and the perinephric fat are reflected to generously expose the lesion (Fig. 2). The renal hilum is dissected only if vascular clamps might be needed. A patch of perinephric adipose tissue is left on the tumor during renal mobilization. The fat overlying the mass is then resected as a separate specimen.

The kidney and the tumor are then assessed with a laparoscopic ultrasound probe. The location and depth of the primary tumor is readily established. The entire kidney is examined for any satellite lesions. Particular attention is paid to the surrounding vasculature and location of the adjacent renal calyx.

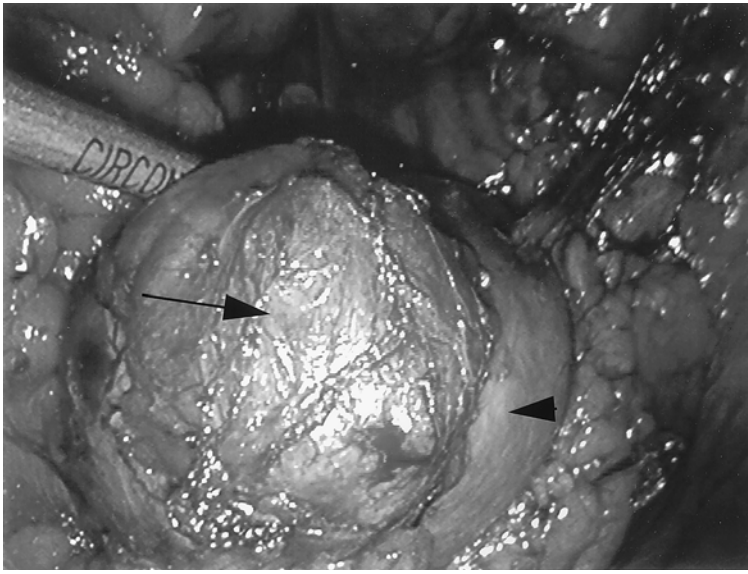

Fig. 2. The perinephric fat has been removed to expose the renal mass (arrow). Arrowhead shows normal renal parenchyma.

If the lesion is deep enough that hand assistance has been chosen, then additional preparations for hemostasis are made. A gelatin sponge (Gelfoam, Pharmacia and Upjohn, Kalamazoo, MI) that is soaked with the fibrinogen component of fibrin glue (Tisseel, Baxter, Deerfield, IL) is placed into the peritonal cavity protected by 2 section of a cut sterile glove (i.e., on the liver for right-sided lesions or spleen for left-sided lesions). This will be used for hemostasis after the tumor is removed.

Electrocautery is used via a right angle probe to incise the renal capsule 2-mm around the edge of the tumor (Fig. 3). A cutting instrument is then used to resect the tumor. We have used a variety of cutting instruments in an effort to find the one that maximizes coagulation (hemostasis), including: monopolar electrocautery scissors, contact tip neodymium:yttrium-aluminum-garnet (Nd:YAG) laser, ultrasonic shears (Ethicon Endosurgery, Cincinnati, OH), and bipolar cautery forceps with and without impedance control. No cutting instrument provides complete hemostasis for lesions penetrating more than 1-cm into the parenchyma, but we are currently using impedance-controlled bipolar electrocautery forceps (Gyrus, Maple Grove, MN). Others have described radiofrequency ablation *(21)* or microwave tissue coagulation *(22)* of the mass, followed by resection of the coagulated mass. This technique maximizes hemostasis for selected lesions. The dissection is performed maintaining a 2-mm rim of normal parenchyma. If hand assistance is being used, direct palpation helps direct the dissection (Fig. 4) and can also be used to compress the kidney to decrease blood loss. Gentle irrigation and aspiration through the overlying 5-mm port is helpful for both visualization and counter-traction on the mass.

After the mass is resected, hemostasis is attained. Direct compression can be used if employing hand assistance. The gelatin sponge previously placed in the abdomen is then placed onto the resection bed and sprayed with the thrombin component of the fibrin glue *in situ* using a cholecystotomy needle. A finger or blunt dissection forceps is then used to compress the sponge on the defect for up to 10 min to ensure adequate

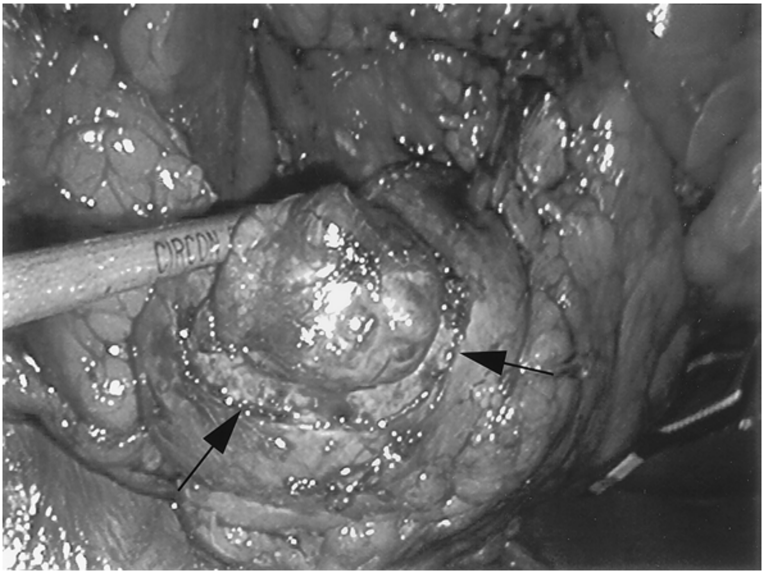

Fig. 3. The renal capsule is incised around the tumor with 2 mm margins. Arrows point to the edge of the renal capsule.

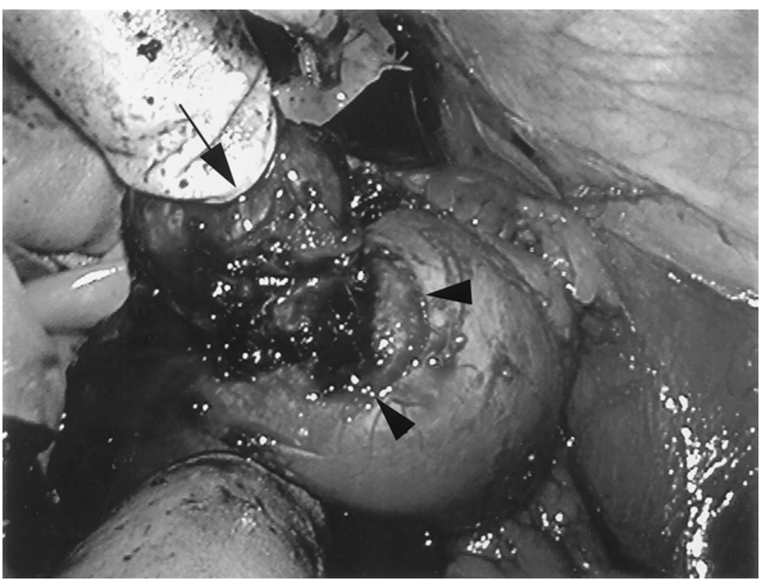

Fig. 4. Direct palpation helps direct the dissection of the tumor (arrow) off of the kidney. Arrowheads point to the edge of the renal capsule.

hemostasis. The sponge is left in place (Fig. 5). An argon beam coagulator is then used to seal along the edges of the gelatin sponge to complete hemostasis. For resection without hand assistance, the argon-beam coagulator is used as the lesion is being resected to staunch any bleeding that occurs. In these cases, a gelatin sponge or another material is placed into the defect and covered with fibrin glue. Surgeons who routinely use vessel clamping and renal ischemia have reported closing the renal defect with sutures and bolsters *(11)*.

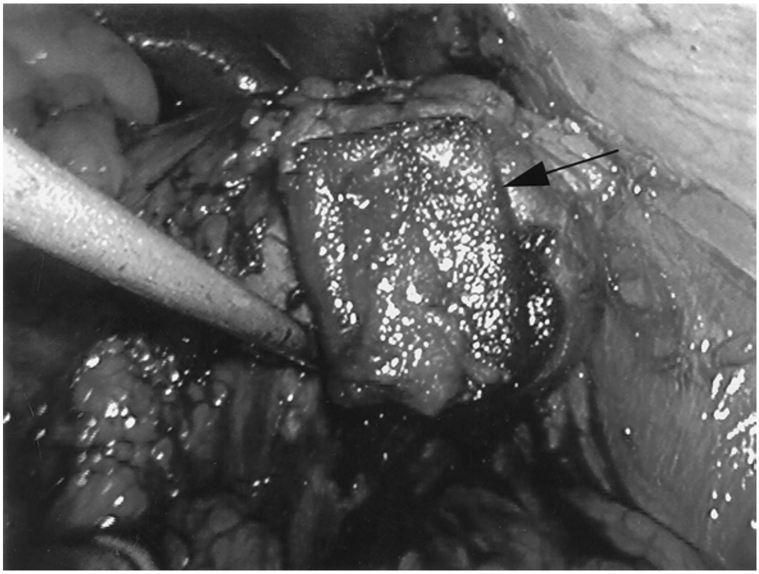

Fig. 5. The gelatin sponge (arrow) used for hemostasis is left in the renal defect.

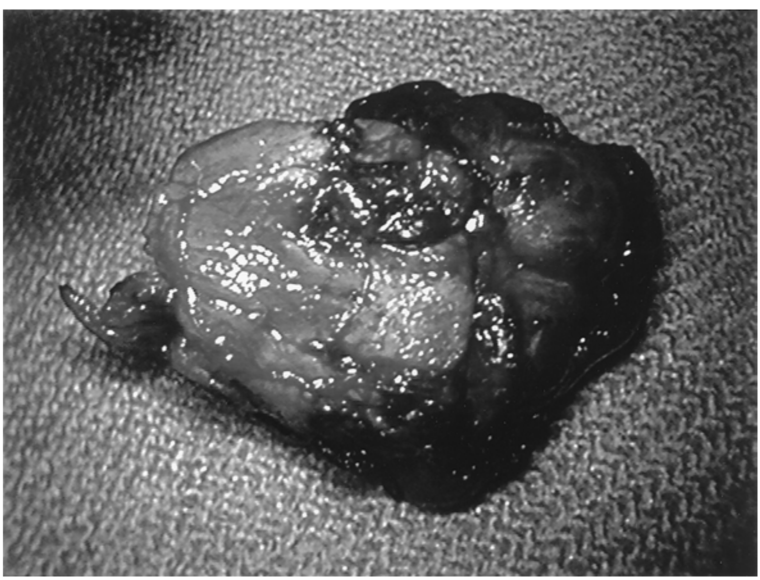

Fig. 6. The resected renal mass with a 2-mm rim of normal parenchyma.

The tumor is placed into an endoscopic bag collection device (as large as necessary) and is removed either via the hand-assistance incision or through a 10- or 12-mm port site (Fig. 6). The intra-abdominal pressure is reduced to 5 mmHg in order to assess completely for hemostasis. The operative bed, port sites, and surrounding viscera are inspected. Once adequate hemostasis is achieved, the intra-abdominal pressure is returned to 15 mmHg. If there are concerns regarding the integrity of the collecting system, a closed suction drain is placed through a 5-mm port site. Any 10- or 12-mm trocar site should have the fascial defect closed (the hand-assistance site as well). The pneumoperitoneum is evacuated prior to closing the last fascial defect. The skin edges are then re-approximated in a subcuticular fashion.

RETROPERITONEAL APPROACH

The patient is positioned in the full lateral decubitus position with the table flexed and the kidney rest elevated to allow for a larger working space in the retroperitoneum. Primary access is obtained through a 2-cm incision below the tip of the 12th rib in the posterior axillary line. Using a hemostat, the tissue is bluntly spread away until the anterior thoracoabdominal fascia is exposed. A finger or hemostat is used to penetrate through this fascial layer as well as the lumbodorsal fascia to enter the retroperitoneum. A finger inserted into this space can often feel the lower pole of the kidney and the psoas muscle. The peritoneum can be bluntly moved anteriorly. The retroperitoneum is then expanded with approximately 800 cc of air using a balloon dilator. It is imperative to position the dilator posterior to the kidney; this facilitates the dissection and makes the anatomy more easily identified.

After the balloon dilation, a self-retaining 12-mm port is inserted through the 2-cm incision. Pneumoperitoneum is established to 15 mmHg and the other ports are placed under direct vision. A 5-mm working port is placed anterior to the paraspinous muscles several centimeters posterior to the initial port placement, underneath the ribs. A third 5-mm working port is placed in the anterior axillary line in the same line as the other two ports. This port needs to be placed well above the iliac crest to ensure that the port can be used optimally. A fourth 5-mm port can be placed later to retract the kidney, usually in front of the tip of the 10th or 11th rib. If needed, any of these 5-mm ports can be dilated to a larger size as dictated by the operation (please reference retroperitoneal nephrectomy chapter for port placement photo).

The most easily identified structures upon initial visualization are the psoas muscle and the ureter. With anterior displacement of the kidney and dissection along the ureter cephalad, if necessary, the renal hilum can be identified. The renal artery is often recognized by its pulsations. Gerota's fascia can then be incised and the perinephric fat dissected off of the kidney to the region of interest. As described earlier, a laparoscopic ultrasound probe assists in defining the extent of the lesion, the location of the collecting system, and the presence of surrounding vasculature. The resection is then performed as described earlier for a transperitoneal procedure without hand assistance.

The retroperitoneal pressure is reduced to 5 mmHg in order to assess for adequate hemostasis. The resection bed and trocar sites are examined. Once hemostasis is achieved, the trocars are removed. All carbon dioxide is evacuated and fascial defects corresponding to 10- and 12-mm port sites are closed. If entry into the collecting occurred or is suspected, a closed suction drain is placed through a 5-mm port site. The skin edges are then re-approximated using a subcuticular technique.

POTENTIAL PITFALLS

Bleeding

Management of parenchymal bleeding during NSS is perhaps the greatest challenge of the laparoscopic technique. As laparoscopy has become more commonplace, novel instruments and techniques have been developed to achieve hemostasis more readily. These techniques fall into three categories based on the timing of the technique: before resecting the tumor, while resecting the tumor, and after resecting the tumor.

Prior to resecting the renal mass, one option is to clamp the renal hilum. The renal hilum can be dissected free in order for a laparoscopic vascular clamp to be placed around it or, in the case of hand assistance, a regular bulldog clamp can be carried into the abdomen. After resecting the tumor in a bloodless field, vessels can be identified and sutured intra-corporeally, thus replicating the open approach. The major problem with this technique is that renal hypothermia is not obtained. This may cause functional damage to the parenchyma, which is in contradistinction to the goal of NSS. Authors have reported success with this technique citing overall renal function not being altered *(17,18)*. In a recent series, one patient did have hypothermia attempted by placing the kidney in an endoscopic bag and slush placed into it through a port site *(11)*. Although all published data claim successful results, differential renal function has not been reported. Hence, the true amount of functioning renal parenchyma preserved is unknown as the contralateral kidney may be preserving the overall stable function.

Another method to control hemostasis prior to resecting the mass is using a microwave tissue coagulator. The most recent series comprises six patients with tumors ranging in size from 11–25 mm *(22)*. Blood loss was minimal for all six cases. There was one postoperative hematoma after the patient was heparinized. The pathologic diagnosis was able to be determined after using the microwave tissue coagulator. Longer follow-up and more experience will determine the long-term use of this method.

A final pre-resection technique involves the use of radiofrequency coagulation *(21)*. Prior to excising the lesion, a radiofrequency probe is inserted into the lesion and deployed to coagulate the lesion as well as a rim of surrounding parenchyma. Median blood loss after removing the tumor was 125 cc. Renal architecture was preserved in all 10 patients, allowing for a pathologic diagnosis. This is a promising technique that is presently in its infancy. Expertise with radiofrequency is only available at a few institutions, thereby hindering its widespread application.

Many laparoscopic instruments have been developed to provide hemostasis during resection of the renal tumor. Options include the argon-beam coagulator *(8,10,23)*, ultrasonic scalpel/shears *(12,14)*, the Nd:YAG laser *(10,23,24)*, and bipolar electocautery *(13)*. The argon-beam coagulator has been cited most often, though many instruments are used together. Unfortunately, none of these instruments alone, nor in combination, reliably provide adequate hemostasis without additional maneuvers.

Once the mass has been removed, either sutures or topical sealants can be used. Gill et al. *(11)* has the largest series of partial nephrectomies to date with 50 patients. Using a combination of renal hilum clamping and intra-corporeal suturing, the average blood loss was 270 cc, but two patients had bleeding complications (one intra-operative hemorrhage and one delayed postoperative hemorrhage).

Though several topical sealants have been used, the two largest series describing sealant use involve the use of fibrin glue *(10)* and gelatin resorcinol formaldehyde glue *(12)*. As described earlier, we currently use a gelatin sponge soaked with fibrin glue onto the resected renal bed. Through October 2001, 35 patients have undergone a laparoscopic partial nephrectomy with this technique. The rapidity and completeness of hemostasis is impressive with the fibrin glue soaked gelatin sponge. To date, there has been only one bleeding complication (a delayed hemorrhage on postoperative day 2).

Hoznek et al. *(12)* employ a gelatin resorcinol formaldehyde glue onto the resected renal parenchyma. Of their 12 patients, the average estimated blood loss was 189 cc. The renal artery was clamped for six of the procedures. There were no bleeding complications noted in their series.

Stifelman et al. *(23)* use a variety of techniques, including topical sealants, the Harmonic scalpel, and the argon-beam coagulator. Even with these all of these tools, pledget reinforced sutures in the renal capsule were still needed to aid with hemostasis in several cases. Their series underscores the fact that many techniques need to be available to the laparoscopic surgeon and more than one may be necessary to achieve hemostasis.

Entry into the Collecting System

Urinary fistula is the most common complication after a partial nephrectomy *(2)*. The postoperative management (urinary diversion with a ureteral stent) is similar whether or not the patient underwent a laparoscopic or an open surgical procedure. The best way to avoid a urinary fistula is to not enter the collecting system. The emphasis of preoperative planning and patient selection is paramount. Large, centrally located tumors may not be best managed laparoscopically (let alone by NSS), especially if the renal hilum will not be clamped. In addition, intra-operative ultrasound can help to identify the location of the collecting system, thereby helping to prevent injury to it.

Nevertheless, violations of the collecting system do occur. It is important to recognize these injuries intra-operatively so that they can be repaired. Gill et al. *(11)* place a ureteral access catheter prior to performing the partial nephrectomy. Methylene blue (or indigo carmine) can then be instilled into the collecting system to assess for collecting system injury. If present, chromic sutures are placed in a figure-eight fashion to close the defect. With this technique, one (2%) urinary fistula occurred *(11)*.

For those surgeons who elect not to clamp the renal hilum, entries into the collecting system can be sealed with topical sealants. In our experience of using the gelatin sponge soaked with fibrin glue, 1 of 35 patients (3%) developed a urine leak that required ureteral stenting and percutaneous drain placement. This technique appears to be adequate to seal small, peripheral transgressions into the collecting system, although we have yet to enter the central collecting system. Of note, we do not place a ureteral stent postoperatively; a closed suction drain should be placed into the abdominal cavity if there is concern for an entry into the collecting system.

Hoznek et al. *(12)*, as stated earlier, use gelatin resorcinol formaldehyde glue for hemostasis as well as to seal the collecting system. Two patients (16.7%) developed urinary leaks despite placement of a ureteral stent. This suggests that gelatin resorcinol formaldehyde glue does not ensure a watertight closure of the collecting system and may not be the ideal sealant.

RESULTS

There are two major issues regarding laparoscopic partial nephrectomy. The first is the routine feasibility of the operation, and the second is cancer control. Tables 1 and 2 summarize the results of published series of nine or more patients that had renal mass as the indication for surgery.

Laparoscopic partial nephrectomy is feasible in experienced hands. All three approaches to the kidney (hand assistance, transperitoneal, and retroperitoneal) can be completed with success using a wide variety of hemostatic maneuvers (Table 1). Some authors also choose their route based on the location of the tumor; posterior tumors are better-suited to a retroperitoneal approach and anterior tumors and better-

Table 1
Summary of Operative Techniques for Laparoscopic Partial Nephrectomy for a Renal Mass Suspicious for Renal Cell Carcinoma (Minimum Nine Patients)

Reference	*No. patients*	*Route (n)*	*Operative time (min)*	*Method of hemostasis*
Wolf et al. *(10)*	10	HALS (8) Transperitoneal (2)	199	Argon beam coagulator Gelatin sponge with fibrin glue
Harmon et al. *(14)*	15	Transperitoneal (15)	170	Argon beam coagulator Oxidized cellulose guaze
Rassweiler et al. *(13)*	53	Transperitoneal (15) Retroperitoneal (28)	191	Argon beam coagulator Fibrin coated hemostyptic gauze Gelatin resorcinol formaldehyde glue
Stifelman et al. *(23)*	9	HALS (9)	274	Harmonic scalpel Argon beam coagulator Laparoscopic suturing Fibrin glue Oxidized cellulose gauze
Gettman et al. *(21)*	10	Transperitoneal (9) Retroperitoneal (1)	170	Radiofrequency coagulation
Gill et al. *(11)*	50	Transperitoneal (28) Retroperitoneal (22)	180	Renal artery occlusion Laparoscopic suturing

HALS, hand-assisted laparoscopic surgery.

suited to a transperitoneal approach *(11,13)*. The route of choice ultimately depends on the surgeon's experience and comfort with standard laparoscopy (vs hand assistance) as well as the anatomical orientation in retroperitoneoscopy.

The benefits of laparoscopy are decreased morbidity, decreased hospital length of stay, and improved convalescence as compared to an open surgical approach *(10)*. Parenteral narcotic use was 62% less for patients who underwent a laparoscopic vs an open surgical partial nephrectomy. Furthermore, patients who underwent a laparoscopic approach rather than an open surgical one returned to normal, nonstrenuous activity sooner (8.2 vs 22.8 d, respectively) and had better pain and physical health scores at 2 and 6 wk after their operation *(10)*. Length of stay for the references cited in Table 2 are all under 4 d except one. Complications were noted in the three largest series with urine leak being the most common (Table 2). Even so, urinary fistula rates of 1.4–17% have been reported in open surgical approaches *(25,26)*. The laparoscopic technique does not appear to have a higher rate of postoperative complications. Most

Table 2
Complication Rates, Length of Stay and Local Recurrence Rates of Laparoscopic Partial Nephrectomies for a Suspicious Renal Mass (Minimum Nine Patients)

Reference	*Major complications (n)*	*Length of hospital stay (d)*	*Mean follow-up (mo)*	*Local recurrence*
Wolf et al. *(10)*	None (0/10)	2.0	7.0	0
Harmon et al. *(14)*	None (0/15)	2.6	8	0
Rassweiler et al. *(13)*	Pneumothorax (1/53) Urine leak (5/53) Intra-operative hemorrhage (4/53) Delayed hemorrhage (1/53)	5.4	24	0
Stifelman et al. *(23)*	None (0/9)	3.3	8	0
Gettman et al. *(21)*	None (0/10)	–		0
Gill et al. *(11)*	Intra-operative hemorrhage (1/50) Delayed hemorrhage (1/50) Urine leak (1/50)	2.2	7.2	0

urine leaks can be managed with percutaneous drain placement and ureteral stenting. Nephrectomy is not likely to be necessary.

Though local recurrences have yet to be reported after a laparoscopic partial nephrectomy, the mean follow-up is short (Table 2). After an open surgical partial nephrectomy, the mean time to local recurrence is 50 mo *(4)*. Because laparoscopic nephron-sparing surgery is still in its early years (longest mean follow-up among series is Table 2 is 24 mo), the long-term oncologic efficacy of the procedure is yet to be determined.

SUMMARY

Laparoscopic partial nephrectomy is a viable management option for small (less than 4 cm) renal masses. Though long-term local recurrence rates are not yet available, the short-term results are promising. The benefit of the laparoscopic approach over the open surgical one is a briefer and less intense convalescence. Complications from a laparoscopic technique are similar to the open surgical approach and will continue to decrease as more experience is gained. Preoperative planning is of utmost importance in that potential complications can be avoided and the best operative approach can be selected. A successful operation can be performed through a variety of access routes (hand assistance, transperitoneal, and retroperitoneal) using a variety of hemostatic maneuvers (tissue sealants, argon-beam coagulator, renal hilum clamping, etc.). The ideal device that allows for hemostasis, preserves renal architecture for pathologic analysis, and seals the collecting system has yet to be developed. Novel techniques (i.e., radiofrequency ablation, microwave coagulation) and new instrumentation are being explored that, with more experience, may simplify the technical demands of the operation and promote its widespread use.

TAKE HOME MESSAGES

1. Preoperative planning is essential to determine the operative approach.
2. Laparoscopic ultrasound is useful in visualizing the location of the collecting system and vasculature relative to the mass.
3. Multiple instruments/techniques may be necessary for hemostasis, including a gelatin sponge, fibrin glue, and the argon-beam coagulator.
4. Laparoscopic partial nephrectomy has similar complications and oncologic efficacy, with limited follow-up, as compared to an open partial nephrectomy.

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11 Laparoscopic Nephroureterectomy

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Contents

INTRODUCTION

The gold standard for management of patients with upper ureteral or renal transitional cell carcinoma (TCC) who have normal renal function and two kidneys is radical nephroureterectomy including excision of an ipsilateral periureteral cuff of bladder. Although highly efficacious for disease control, the open nephroureterectomy results in significant pain and an extended convalescence. Laparoscopic radical nephroureterectomy was introduced by Clayman, Kavoussi, and colleagues in 1991 *(1)*. Compared to open nephroureterectomy, the laparoscopic approach results in decreased postoperative analgesic requirements, a shorter hospital stay, and improved convalescence *(2–5)*. Despite these advantages to the patient, there are two drawbacks to the laparoscopic approach: lengthy operative time, and the need for significant laparoscopic experience on the part of the surgeon. These disadvantages may be partially offset by the application of hand-assisted technique for nephroureterectomy. Herein, the techniques for transperitoneal laparoscopic nephroureterectomy and hand-assisted nephroureterectomy including bladder cuff management options are reviewed.

TCC of the renal pelvis is responsible for 4.5–9% of all renal tumors and accounts for 5–6% of all urothelial tumors *(6–10)*. Traditionally, the management of upper-tract TCC has involved open nephroureterectomy including an ipsilateral bladder cuff, which is performed with two incisions (a flank or upper abdominal incision and a lower abdominal incision) or via one extended incision. Advances in minimally invasive technologies have provided viable alternative management strategies. Antegrade and retrograde endoscopic excision and ablation of TCC have been described, and are accepted management strategies in selected cases *(11–14)*. However, the majority of patients require nephroureterectomy.

In 1990, the introduction of laparoscopic renal surgery by Clayman, Kavoussi, and colleagues enabled traditional management strategies (i.e., radical ablative surgery) to

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
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be performed in a less invasive manner *(15)*. This same group subsequently described application of laparoscopy for nephroureterectomy *(1)*. The laparoscopic approach for control of upper-tract TCC has afforded the urologic surgeon the opportunity to perform a highly effective form of surgical cancer control, yet minimize postoperative pain and convalescence.

Major series describing results of laparoscopic nephroureterectomy are listed in Tables 1 and 2 *(16,17)*. Table 1 reviews the experience of two trials incorporating 47 patients undergoing laparoscopic or hand-assisted laparoscopic nephroureterectomy. These trials demonstrate that the procedure can be safely performed with limited blood loss and with a relatively expeditious convalescence.

Table 2 reviews results of three comparative trials contrasting open nephroureterectomy and laparoscopic or hand-assisted nephroureterectomy *(18–20)*. Overall, 66 laparoscopic or hand-assisted laparoscopic procedures were compared to 54 open nephroureterectomies. Although operative time favored the open approach by 2 h, hospital stay and postoperative analgesic requirements were significantly decreased in the cohort undergoing laparoscopic nephroureterectomy. It was most striking, however, that full convalescence was expedited by more than 6 wk with laparoscopic or hand-assisted laparoscopic nephroureterectomy (*see* Tables 3 and 4).

Application of hand-assisted laparoscopy to nephroureterectomy may offer the urologic surgeon advantages. First, the technique provides the novice laparoscopist a logical segue into minimally invasive surgery by allowing one hand to remain in the realm of open surgery while the other hand and the surgeon's field of view are in a laparoscopic milieu. Second, the hand-assisted laparoscopic technique affords the laparoscopist the use of tactile sensation, blunt manual dissection, and broad retraction. Thus, hand-assist technique decreases operative time and may allow experienced laparoscopic surgeons to expand the scope of cases performed laparoscopically (i.e., larger and more extensive tumors). Furthermore, the aggressive nature of TCC precludes morcellation, thus intact removal of the kidney, ureter, and bladder cuff are mandatory. Given the mandatory incision for extraction, and the potential advantages of hand-assisted technique, hand-assisted laparoscopic nephroureterectomy is appealing.

A multicenter retrospective comparison of 11 patients undergoing standard laparoscopic and 17 patients undergoing hand-assisted laparoscopic nephroureterectomy for localized TCC was recently completed *(21)*. In this series, the hand-assisted technique decreased operative time by 1 h without significantly affecting blood loss. Patients in both cohorts manifested similar short-term convalescence. Although not achieving statistical significance in this small cohort, the time to return to full activity was expedited by 3 wk in the standard laparoscopic group.

The advantages of laparoscopic and hand-assisted laparoscopic nephroureterectomy over open nephroureterectomy are clear. Herein is described a practical guide to performing these procedures, including equipment suggestions, surgical technique, and alternative surgical management strategies for the distal ureter and bladder cuff.

SURGICAL TECHNIQUE

Patient Preparation and Positioning

Prior to performing laparoscopic or hand-assisted nephroureterectomy, informed consent must be obtained. Patients should be made aware of the risks and benefits of the laparoscopic approach. The discussion should include review of possible complications,

Table 1
Noncomparative Laparoscopic Nephroureterectomy Trials

Series	*Operative approach*	*n*	*OR time (h)*	*EBL (mL)*	*Analgesic ($mgMSO_4$)*	*Hospital stay (d)*	*Complete convalescence (wk)*	*Follow-up (yr)*	*Major complications (%)*
Stifelman, et al. *(17)*	Hand-assist	22	4.5	180	55	4.1	2.7	1.1	5
Jarrett, et al. *(18)*	Laparoscopic	25	5.5	440	NA	4.0	NA	>1	12

NA, Data not available.

Table 2
Comparative Nephroureterectomy Trials
(Laparoscopic and Hand-Assisted Laparoscopic vs Open Trials)

Series	*Operative approach*	*n*	*OR time (h)*	*EBL (mL)*	*Analgesic (mgMSO$_4$)*	*Hospital stay (d)*	*Complete convalescence (wk)*	*Follow-up (yr)*	*Major complications (%)*
Shalhav, et al. *(19)*	Laparoscopic	25	7.7	199	37	3.6	2.8	2.0	8
	Open	17	3.9	441	144	9.6	10	3.6	29
Seifman, et al. *(20)*	Hand-assist	16	5.3	557	48	3.9	2.5	1.5	19
	Open	11	3.3	345	81	5.2	7.5	1.2	27
Keeley and Tolley *(21)*	Laparoscopic	22	2.4	NA	NA	5.5	NA	NA	NA
	Open	26	2.3	NA	NA	10.8	NA	NA	NA
Total	**Laparoscopic**	**66**	**5.1**	**339**	**41.3**	**4.4**	**2.7**		**10**
Total	**Open**	**54**	**3.0**	**403**	**119**	**9.3**	**9.0**		**28**

NA, Data not available.

Table 3
Comparison of Hand-Assisted and Laparoscopic Nephroureterectomy: Operative Parameters *(21)*

Parameter	*Hand-assisted laparoscopy*	*Laparoscopy*	*p-value*
Laparoscopy time (h)	4.4	5.3	0.09
Cystoscopy time (min)	29	46	0.15
Total operative time (h)	4.9	6.1	0.055
Estimated blood loss (mL)	201	190	0.78
Specimen weight (g)	576	335	0.36

Table 4
Comparison of Hand-Assisted and Laparoscopic Nephrouretereco tmy: Convalescence Parameters *(21)*

Parameter	*Hand-assisted laparoscopy*	*Laparoscopy*	*p-value*
Time to oral intake (h)	20	13	0.45
Analgesics (Mg MSO_4)	33.0	29.3	0.83
Hosptial stay (d)	4.5	3.3	0.59
Partial recovery (wk)	3.5	2.4	0.29
Complete recovery (wk)	8.0	5.2	0.27

including conversion to an open surgical approach owing to failure to progress or vascular injury or bowel injury, postoperative paresthesias (i.e., brachial plexus of downside arm, sciatic stretch injury of upside leg), bowel injury with possible need for diversion, and other potential problems associated with laparoscopy (i.e., CO_2 embolism). Until experience has been gained with the procedure, two units of packed red blood cells should be available in the operating room. When the surgeon has become more comfortable with the laparoscopic approach, type and screen is adequate.

Preoperative staging of upper-tract TCC includes a chest radiograph and a computed tomography (CT) scan as part of a metastatic evaluation. The CT scan should be carefully evaluated for the following: liver metastases, lymphadenopathy, and extension into surrounding organs, as well as assessment of the adrenal glands. Depending on the surgeon's level of experience, direct extension of the tumor into surrounding structures may preclude the laparoscopic approach. Cystoscopy should be performed to evaluate the lower urinary tract for TCC. Preoperative blood work includes a serum creatinine, liver-function studies, alkaline phosphatase, and calcium levels. If the last two values are elevated or the patient complains of site-specific bone pain, a bone scan should be obtained.

With the routine availability of small-caliber flexible ureteroscopes, tumor visualization and possible biopsy is recommended to preclude the possibility of alternative benign pathology (i.e., fibroepithelial polyp, sloughed papilla, etc.). Special care must be taken to avoid ureteral injury and potential tumor extravasation. The use of a ureteral access sheath for evaluation and biopsy of renal pelvic tumors is highly recommended,

Fig. 1. Photograph of patient in the modified lateral decubitus position in preparation for left laparoscopic or hand-assisted nephroureterectomy.

because the sheath will protect the ureter from injury during the procedure, and has been shown to decrease renal pelvic pressures during ureteroscopy *(22)*. Tissue biopsy can be facilitated by the application of a nitinol basket to entrap and "avulse" an adequate specimen for histopathologic evaluation. Frequently, a characteristic appearance by endoscopic tumor inspection is adequate for diagnosis if other clinical evidence of malignancy is available (i.e., positive urinary cytology). As such, when there is a high degree of preoperative suspicion for upper-tract TCC, it is possible to perform the ureteroscopic evaluation and the laparoscopic nephroureterectomy under a single anesthetic.

Bowel preparation with a bottle of magnesium citrate and a clear liquid diet for 24 h prior to surgery is advised, and a Dulcolax suppository is administered on the day prior to surgery. If the patient has a previous history of abdominal surgery or radiation, a full antibiotic and mechanical bowel preparation may be indicated. One gram of cefazolin is administered preoperatively. All patients should have pneumatic compression boots placed and activated prior to induction of anesthesia.

General endotracheal anesthesia is induced and the patient's stomach and bladder are decompressed with an orogastric tube and a Foley catheter, respectively. Owing to the prolonged length of the procedure, proper patient positioning and padding are of utmost importance. The patient is carefully positioned in a 70° flank position with the affected kidney on the upside (Fig. 1). If hand-assisted laparoscopy is planned, the prepared surgical area must extended to accommodate the external component of the hand-assist device (i.e., extended past the midline to the patient's right side for left-sided nephroureterectomy). The operating table is fully flexed and the kidney rest is fully raised beneath the iliac crest. The downside leg is flexed at the knee and separated from the extended upside leg by pillows. The upside leg is placed on a sufficient number of pillows until it is level with the flank, thereby precluding any strain on the upside leg when the table is flexed and the kidney rest raised. The downside heel, hip, and knee are cushioned. The downside arm is padded and an axillary roll is carefully positioned. The upside arm is placed on a well-padded arm-board; the arm-board is positioned such that there is no tension on the brachial plexus. Once the patient has been properly positioned, he/she is secured to the operating table by padded safety

Fig. 2. Template for trocar sites used for right transperitoneal laparoscopic nephroureterectomy. Black ovals, 12-mm trocar sites; white ovals, 5-mm trocar sites.

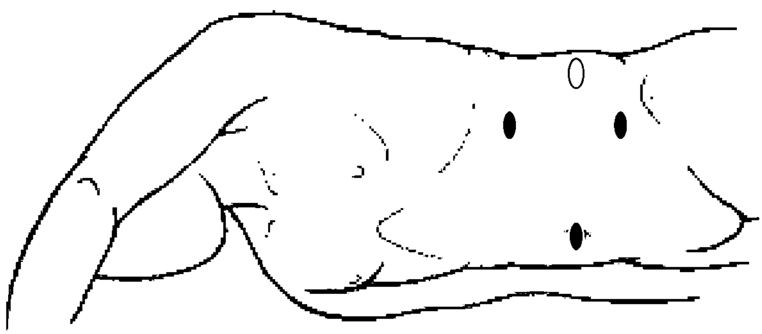

Fig. 3. Template for trocar sites used for left transperitoneal laparoscopic nephroureterectomy. Black ovals, 12-mm trocar sites; white ovals, 5-mm trocar sites.

straps that are passed over the chest, hip, and knee. As patient rotation is sometimes very helpful during laparoscopic procedures, securing the patient to the table is of great importance. After the patient has been secured, the table should be rotated steeply in both directions to assure the patient remains completely immobilized.

Access: Laparoscopic and Hand-Assisted Laparoscopic Nephroureterectomy

Laparoscopic Nephroureterectomy

Laparoscopic access can be obtained via a direct vision (Hasson) or Veress needle technique. Templates for trocar positioning for both right and left renal access are presented in Figs. 2 and 3. In the virgin abdomen, the anterior superior iliac spine trocar site is used for primary access. Alternatively, if there has been prior surgery in the lower abdomen, the subcostal trocar site is suitable for primary access. A 12-mm incision is made approximately 2 fingerbreadths medial and cranial to the anterior superior iliac spine. The subcutaneous tissue is spread with a Kelly clamp and a Veress needle pneumoperitoneum of 25 mmHg is obtained. A 12-mm trocar is placed at this same site, and after access to the abdominal cavity has been obtained, the abdominal pressure is immediately reduced to 12 mmHg. Presently, a dilating trocar (blunt tip for penetrating the fascia) is preferred to a cutting trocar. A number of dilating trocars are commercially available, however, the visual dilating trocar (Ethicon) affords the surgeon the additional advantage of direct vision dilation when desired. Occasionally,

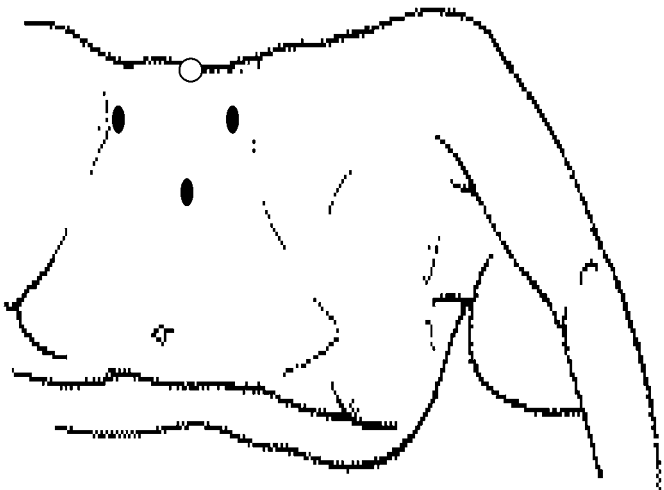

Fig. 4. Modified template for trocar sites for right transperitoneal laparoscopic nephroureterectomy in patient with alternative body habitus. Black ovals, 12-mm trocar sites; white ovals, 5-mm trocar sites.

in the nonvirgin or morbidly obese abdomen, visual dilation can be useful for obtaining access. Dilating trocars may reduce the probability of injury to the abdominal wall vasculature, and do not require closure because they result in smaller fascial defects (the defect is one-half the size of the diameter of the trocar).

A 10-mm 30° laparoscope is inserted and the underlying bowel is closely inspected for any injury that may have occurred during Veress needle or trocar placement. Subsequently, two additional 12-mm trocars are placed under direct endoscopic vision. A second trocar is placed 2-cm below the costal margin in the midclavicular line. The third trocar is placed either at the umbilicus or immediately lateral to the margin of the rectus abdominus muscle approximately 3–5 fingerbreadths above the umbilicus. This medial trocar site is used during the majority of the case for the laparoscope because it is midway between the two “working” trocar sites and thus it provides the surgeon with the most intuitive perspective on the operative field. Lastly, after mobilization of the colon from the abdominal sidewall, a fourth trocar (5 mm) is placed subcostally in the posterior axillary line. When all trocars have been placed, the primary access site is inspected laparoscopically, because this is the only site of “blind” access.

Although trocar placement templates are helpful, the laparoscopic surgeon must tailor trocar placement to the individual patient. Patients with previous surgery should have primary access established away from scar sites to avoid adhesions that may increase the probability of injury to underlying structures. Similarly, patient body habitus may alter trocar positioning. Figure 4 demonstrates movement of the optical trocar site medially, which helps avoid the pannus in the obese patent. In this situation, care should be taken to remain lateral to the rectus abdominus muscle to avoid injury to the inferior epigastric vessels.

Hand-Assisted Nephroureterectomy

Primary access for hand-assisted procedures is gained by creating the hand-assist incision. Figures 5 and 6 demonstrate templates for hand-assist device and trocar

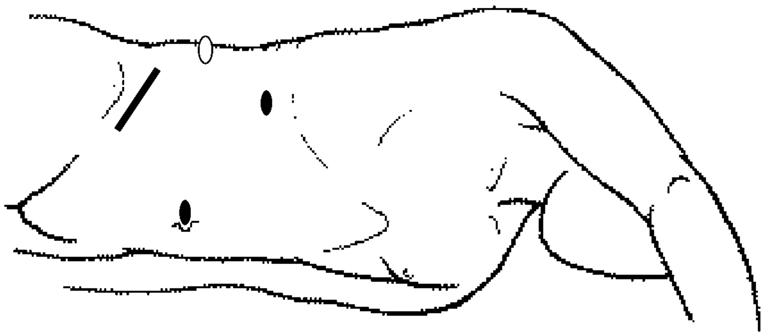

Fig. 5. Template for trocar sites used for right hand-assisted laparoscopic nephroureterectomy. Black ovals, 12-mm trocar sites; white ovals, 5-mm trocar sites.

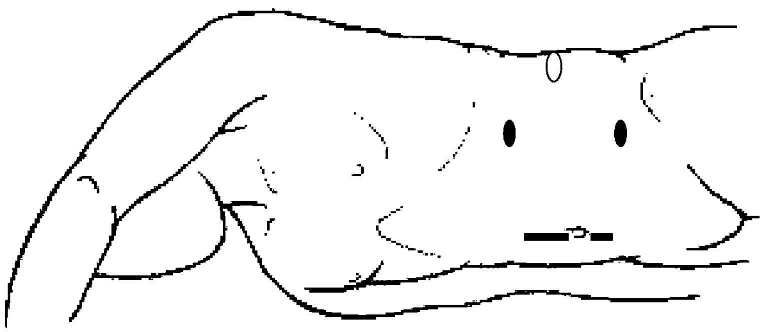

Fig. 6. Template for trocar sites used for left hand-assisted laparoscopic nephroureterectomy. Black ovals, 12-mm trocar sites; white ovals, 5-mm trocar sites.

placement sites for right- and left-sided nephroureterectomy. Prior to positioning for the procedure, the hand-assist incision site is marked, because the location of the skin incision may be difficult to discern with the patient in the lateral decubitus position. The length of the hand-assist incision is equal to the surgeon's glove size in centimeters. Presently, there are a number of hand-assist devices available from different manufacturers. The Gel Port (Applied Medical Resources) utilizes a biocompatible gel for access. This device is easy to place, has a reliable sealing mechanism, minimizes the hand and arm discomfort experienced by the surgeon, and allows the surgeon access to the surgical field using only a gloved hand. If there has been previous surgery at the anticipated site of hand-assist device placement, the surgeon may insufflate the abdomen at a virgin site (i.e., anterior superior iliac spine or subcostal trocar sites). After a primary trocar site has been established, the abdomen may be inspected for adhesions at the hand-assist device site. If present, adhesions may be lysed at the proposed hand-assist device location and prior to device placement.

Instrumentation

Basic instrumentation for laparoscopic nephrectomy includes a standard laparoscopic tower (a carbon dioxide insufflator, light source, camera, monitor, and suction-irrigation setup). A complete list of useful disposable and nondisposable equipment is presented in table 5. A 10-mm laparoscope with a 30° lens can be exclusively used because the angled lens facilitates direct laparoscopic vision during challenging portions of the dissection such as the renal hilum.

Table 5
Laparoscopic Instrumentation for Laparoscopic Nephroureterectomy

Disposable equipment		
	End effectors	
		Endo-GIA stapler (Vascular load)
		Clip appliers (11-mm titanium clips)
		Harmonic scalpel (5 mm curved jaws) (Ethicon)[a]
		Endocatch II (15-mm) entrapment sack (Ethicon)
	Others	
		Trocars (three 12-mm and one 5-mm)
		Veress needles
		Gel Port (Applied Medical Resources)
Nondisposable equipment		
	End effectors	
		Bipolar grasping forceps (Aesculap)[a]
		Suction irrigator, extra-long, 5-mm (Nezhat system; Storz)
		Two 5-mm Maryland grasping forceps
		5-mm Endoshears
		5-mm hook electrode (Electroscope)
		5-mm and 10-mm PEER retractors (Jarit)[a]
		10-mm right angle dissector (Storz or Jarit)
	Others	
		10-mm 30° Laparoscope lens
		Endoholder (Codman)[a]
		Open surgical tray (not open, but available for emergent conversion)

[a]Specialty instruments that greatly facilitate laparoscopic nephroureterectomy.

The majority of dissection during the case can be performed expeditiously and safely with the use of ultrasound and bipolar energy. The surgeon should use ultrasound energy using a 5-mm curved end-effector (i.e., Harmonic scalpel, Ethicon Endo-Surgery, Cincinnati, OH) in the dominant hand. This instrument allows for expeditious dissection with acceptable hemostasis. In the nondominant hand, a 5-mm bipolar grasper (Aesculap, Center Valley, PA) (Fig. 7) serves well for both tissue manipulation (simple grasping) and for control of small- to medium-sized vessels that the Harmonic scalpel does not easily control. The Aesculap bipolar is particularly useful because it is an excellent grasping device, has a well-engineered roticulating mechanism, and is ergonomically designed for the surgeon's hand. The simultaneous application of two energy end effectors facilitates expeditious and safe dissection. Ultrasound and bipolar energy sources are preferred to monopolar energy as the peripheral thermal damage from the Harmonic scalpel (0–1 mm) and bipolar end-effectors (2–6 mm) are known to be limited in comparison with monopolar energy (up to 10-mm) *(23)*. Monopolar electrosurgical energy with a right-angled hook end-effector is occasionally useful, however, for delicate dissection of hilar structures. This instrument allows the surgeon to perform safe, fine dissection by engaging and retracting small strands of tissue around vascular structures prior to the application of energy.

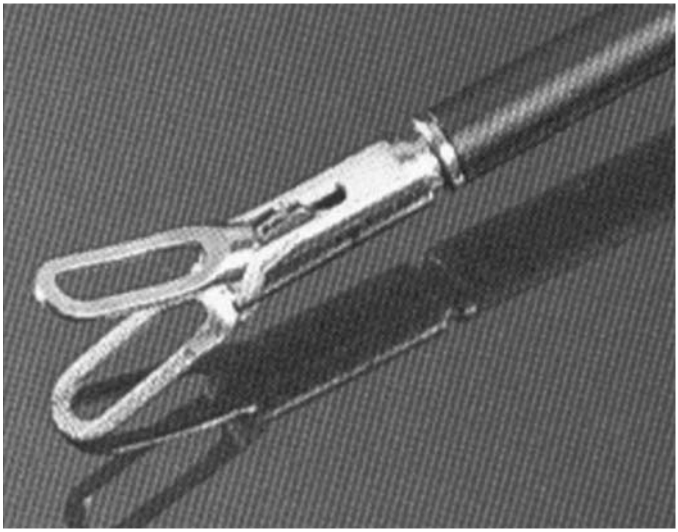

Fig. 7. Bipolar grasping forceps (Aesculap).

Fig. 8. The PEER retractors: 5-mm and 10-mm size. The 5-mm size opens to 2 × 3 cm surface area and the 10-mm size opens to a 4 × 3 cm surface area.

The 5-mm lateral trocar site is particularly important because it facilitates retraction of the specimen or surrounding structures. For retraction, the PEER Jarit retractor (J. Jamner Surgical Instruments) is useful and reliable (Fig. 8). The PEER retractor can be used in conjuction with the Endoholder (Codman) (Fig. 9A and B) that allows consistent safe retraction. These instruments are invaluable because they both allow the surgeon complete control on the amount of retraction on vulnerable structures (i.e., liver and spleen) and avoid the inevitable fatigue of even the most diligent assistant. Application of these instruments for retraction allows the surgeon the use of both hands for dissection and tissue manipulation.

Control of major arteries and veins is achieved with titanium clips or staples. Typically, an 11-mm titanium clip applier is used for clipping the renal artery and the Endo-GIA linear stapler with a vascular load is used for division of the renal vein. The majority of smaller vessels (i.e., the gonadal vein, adrenal vein, and distal lumbar veins) may be controlled with the harmonic scalpel on the variable setting.

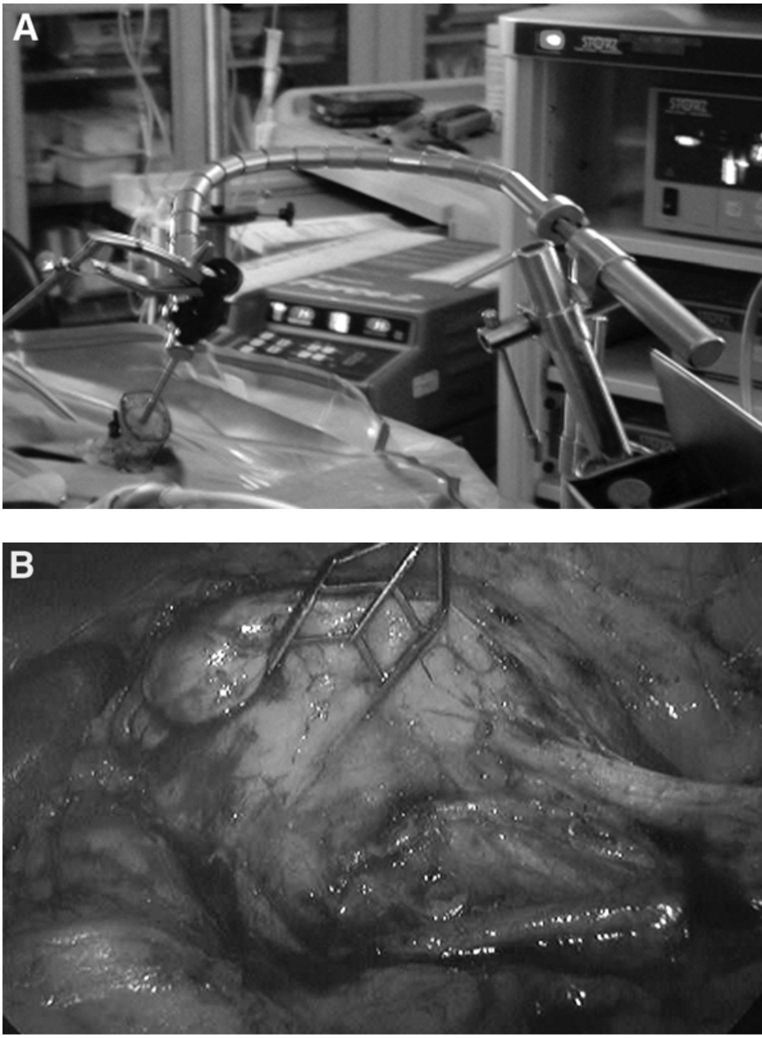

Fig. 9. The Endoholder by Codman. **(A)** The Endoholder holding the PEER retractor during a laparoscopic procedure. **(B)** Laparoscopic retraction of the kidney with the PEER retractor.

Morcellation is contraindicated owing to the biologically aggressive nature of TCC; entrapment of the specimen after mobilization is safely and easily performed with the Endocatch II (15-mm) sac (Ethicon Endosurgery). This sac is large enough for the majority of specimens (up to 1000g) and the device includes a simple deployment mechanism for the bag that allows the surgeon to "scoop-up" the specimen. The sac's deployment mechanism does, however, have a 15-mm diameter requiring trocar extraction and minimal dilation of the fascia. Although easy to use, special care must be taken because the sac may prematurely eject from the deployment mechanism. Additionally, the sac is made of plastic and is easily perforated by excessive tension, sharp edges, or electrosurgery (heating of peripheral structures may melt the plastic). Even with hand-assisted nephroureterectomy, the use of an entrapment sac is recommended because application of the sac avoids contact between the specimen and the incision site. Additionally, the slick surface of the sac may facilitate the extraction and thus help minimize the size of the extraction incision.

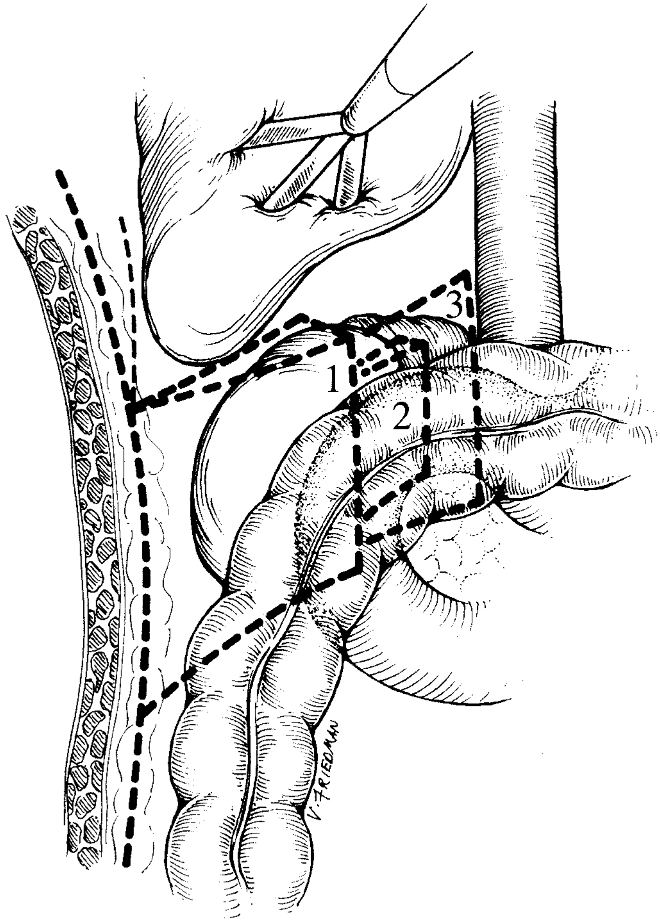

Fig. 10. Diagram of the right-sided nephrectomy demonstrating the wedge-shaped configuration. The numbers refer to the three distinct levels of dissection along the medial aspect of the kidney: colon, duodenum, and IVC.

Surgical Technique: Laparoscopic and Hand-Assisted Laparoscopic Nephroureterectomy

Right Side

After gaining access, the peritoneal cavity is closely inspected, and the liver is visualized for mass lesions. With hand-assisted nephroureterectomy, palpation of abdominal structures is possible. The outline of the kidney within Gerota's fascia is commonly visible behind the ascending colon.

Step 1: Peritoneal Incisions and Pararenal Dissection. The key to *en bloc* resection of the kidney within Gerota's fascia lies in defining the borders of the dissection. On the right side, the dissection follows an anatomic template with a "wedge-shaped" configuration (Fig. 10). Although traditional teaching describes mobilization of the line of Toldt, this line is located quite laterally. Attention should be turned to the thin mesentery extending from the line to Toldt, draped over Gerota's fascia, and attaching medially to the ascending colon. Gentle traction with a laparoscopic grasper will allow the surgeon to laparoscopically visualize this thin mesentery sliding over Gerota's fascia. Meticulous adherence to the plane between this filmy mesentery and Gerota's allows this portion of the procedure to proceed expeditiously and almost bloodlessly. There is a tendency to "wander" medially into the fatty mesenteric tissue that will result in increased bleeding. If the dissection appears to be bloodier than usual, it is likely that the proper plane has been abandoned. Reevaluation of the surgical planes, or attempting to enter this plane in a virgin area will usually allow the colonic mobilization to proceed in a bloodless fashion.

The dissection is initiated using a 5-mm curved Harmonic scalpel and the bipolar grasping forceps for counter-traction. With the hand-assisted technique, placing a gauze pad in the abdominal cavity will provide superior tissue traction as well as assistance with hemostasis. The Harmonic scalpel is preferred for the majority of the dissection. The colon is mobilized medially beginning over the lower pole area of Gerota's fascia where the plane between the colon and specimen is usually most distinct. Care must be taken to stay at least 1-cm from the edge of the colon to prevent thermal or mechanical injury. The colon should be mobilized from the pelvic brim with the incision extending upward above the specimen through the triangular ligament to the diaphragm. This incision defines the medial upper border of the broad side of the "wedge." The colon is thus completely mobilized away from the kidney. The time spent in complete mobilization of the colon is particularly well-invested, because it later defines a broad field for hilar dissection and prevents the surgeon from working "in a hole." The lateral border of the kidney and its lateral retroperitoneal attachments are not disturbed; this results in the kidney remaining firmly attached to the abdominal sidewall, thereby facilitating the hilar dissection later in the procedure.

The broad side of the wedge comprises three distinct levels of dissection along the medial aspect of the kidney: the mobilized ascending colon, Kocher maneuver on the duodenum to move it medially, and dissection of the anterior and lateral surfaces of the inferior vena cava (IVC) (Fig. 11). As the colon is mobilized, special attention should be directed at identification of the duodenum. The duodenum may appear flattened against the medial aspect of the kidney; it is very important to move slowly during this part of the dissection in order to clearly identify the duodenum. The duodenum will always be identified before the anterior surface of the vena cava can be isolated. To facilitate development of the deepest plane of dissection (i.e., the IVC dissection), it is helpful to first define the superior side of the wedge by incising the posterior coronary hepatic ligament from the line of Toldt, laterally, to the level of the IVC, medially; at this cephalad level, the surgeon will come directly onto the lateral and anterior surface of the IVC well above the duodenum and the adrenal gland. This incision in the posterior coronary hepatic ligament provides access to the IVC well above the adrenal gland. This portion of the dissection is facilitated by inferior and lateral traction on the renal specimen with the PEER retractor. If hand-assisted technique is used, the surgeon's nondominant hand can be used to retract the liver superiorly and medially providing excellent exposure. At this point, the *en bloc* area of dissection of the specimen has been completely defined, ensuring removal of the kidney within Gerota's fascia, along with the pararenal and perirenal fat, the adrenal gland, and an anterior patch of peritoneum.

Step 2: Identifying the Proximal Ureter. The dissection on the IVC is continued caudally until the entry of the gonadal vein is identified. The gonadal vein can be traced distally from the vena cava; the right ureter usually lies just posterior and lateral to the right gonadal vein. It is carefully dissected from the retroperitoneal tissues.

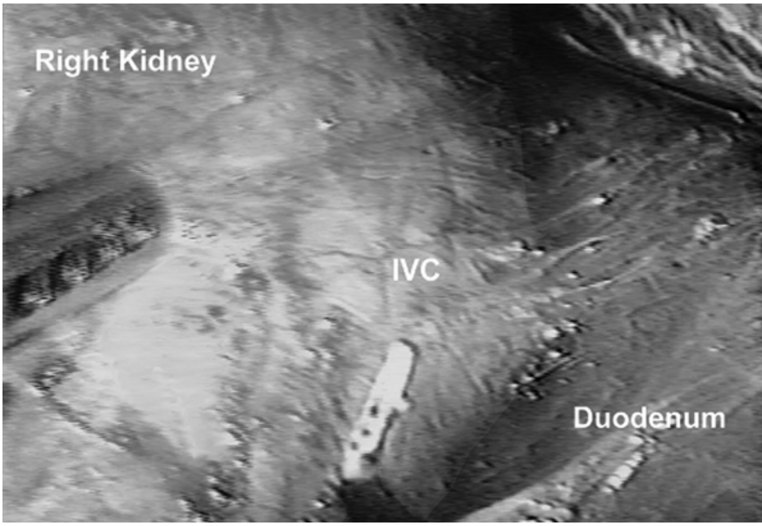

Fig. 11. Laparoscopic view of the duodenum Kocherized. The dissection of the IVC, which is identified in the center of the figure, is next. At this point, the ascending colon and hepatic flexure, which were initially mobilized, lie medial to the duodenum.

Step 3: Securing the Adrenal Vein. Continued cephalad dissection of the IVC exposes the renal hilum and adrenal vein. The adrenal vein is dissected from the surrounding tissue and in most circumstances can be safely secured with the Harmonic scalpel using the variable setting. The adrenal vein may alternatively be controlled with titanium clips. If clips are used, the adrenal vein is cut such that two clips remain on the caval side. Alternatively if the supradrenal area just medial to the IVC has been cleanly dissected, and the lateral border of the supra-adrenal IVC has been clearly identified, then an Endo-GIA vascular load can be used to secure all of the tissue medial to the adrenal and lateral to the IVC. This maneuver will result in the "taking" of the adrenal vein in the 3-cm line of vascular staples.

If preoperative staging suggests that the tumor does not involve the adrenal gland, this structure may be spared. The upper medial border of the kidney is identified by incision of Gerota's fascia in this area. Once the renal parenchyma of the medial and anterior part of the upper pole is seen, an Endo-GIA stapler can be used to further define the margin of dissection from medial (i.e., IVC side) to lateral below the adrenal gland, thereby preserving the adrenal gland and adrenal vein.

Step 4: The Renal Hilum. Attention is then turned to the dissection of the right renal vein from the surrounding tissue. Lateral retraction with the PEER retractor held in position by the endoholder can greatly facilitate hilar dissection by "opening" the operative field. If the IVC has been cleanly dissected, the take off of the renal vein is usually quite evident. Attention is usually turned to circumferential dissection of the renal vein. During laparoscopic nephroureterectomy, the CT scan can be invaluable in helping determine the location of the renal artery. The artery is located posterior to the vein, but may be cephalad, caudad, or directly posterior to this structure. Alternatively, with hand-assisted nephroureterectomy, the artery is localized by digital palpation. Mobilization of the renal artery must be adequate for comfortable placement of five

11-mm vascular clips. The artery is then divided between the second and third clips to leave three clips proximally. If the artery appears to be too broad, the Endo-GIA stapler (vascular load) can be used to control and transect the vessel. The renal vein is then secured with an Endo-GIA vascular stapler (3-cm load).

Occasionally an adequate length of the renal artery cannot be exposed in the presence of the overlying renal vein. In this situation, one or two clips can be applied across the artery to occlude the artery without transection. With the main renal artery occluded, the renal vein is divided with the Endo-GIA stapler. The artery is then further dissected and divided after five clips are applied as previously described. When using the Endo-GIA stapler, it is imperative that the device not be deployed over titanium clips. Deploying the device on clips will cause it to "jam" so that it cannot be opened *(24)*. If the Endo-GIA stapler should jam in this manner, the surgeon must fight the urge to pull the stapler as this will avulse the vessel within the jaws. The stapler can only be released by proximal dissection and application of another stapler. Alternatively, if proximal dissection in not possible, the patient should be converted to open surgery. Once the hilar vasculature has been controlled, the PEER retractor can be readjusted to further pull the specimen laterally, and the dissection should proceed medially to the specimen to identify the psoas muscle and the back wall of the abdomen. This maneuver facilitates clear separation and distinction between the specimen and the remaining stumps of the artery and vein, and prevents subsequent dissection from inadvertently involving these structures.

Step 5: Distal Ureteral Dissection. The specimen, within Gerota'a fascia, is then freed from the retroperitoneum using the Harmonic scalpel and blunt dissection. At this time, the lateral attachments of the kidney to the abdominal sidewall, which were kept intact at the beginning of the procedure, are incised, freeing the renal specimen. The patient can be placed in the Trendelenberg position to allow gravity to facilitate the deep pelvic dissection. The ureter is grasped and gentle cephalad traction placed while the Harmonic scalpel is used to dissect this structure from surrounding tissues. With hand-assisted technique, this portion of the procedure is expedited by blunt finger dissection. The dissection proceeds caudally over the iliac and superior vesical vessels that should be identified to avert injury. There are several techniques for distal ureteral management, which are reviewed in subsequent sections. Currently at Washington University, the preferred technique involves fine dissection of the distal ureter, which will frequently allow some of the intramural ureter to be mobilized. An Endo-GIA stapler (tissue load) is then applied to the distal ureter/bladder cuff to free the specimen. This technique can be facilitated by application of the Endo-GIA staplers with a roticulating head (U.S. Surgical). The reticulating stapler may improve staple deployment and simplify subsequent ureteral unroofing.

Step 6: Specimen Entrapment and Intact Extraction. The specimen is most easily controlled by grasping the ureter using the subcostal 12-mm trocar site. The patient is maintained in the Trendelenberg position and the kidney placed over the edge of the liver. The inferior trocar is then removed, and a 15-mm Endocatch II (U.S. Surgical Inc.) is introduced and opened just beneath the liver; the self-opening design of this entrapment sac facilitates the entrapment process. The Endocatch II entrapment sack deployment mechanism has a 15-mm diameter and cannot be passed through a 12-mm trocar. As such, the trocar is removed and the barrel of the 15-mm entrapment sac deployment mechanism is gently passed through the trocar incision site under direct endoscopic vision.

For intact specimen removal, the surgeon should fight the urge to "connect the dots" by extending or connecting existing trocar incisions. It is recommended to make a lower midline abdominal, Gibson, or Pfannenstiel incision. The specimen is then extracted intact within the entrapment sac. Although all attempts are made to minimize the extraction incision, only gentle traction should be placed on the specimen to avoid rupturing the entrapment sac. Once the specimen is extracted, the entire operative field is inspected for hemostasis. Because the pneumoperitoneum is an effective form of venous tamponade, the insufflation pressure is reduced to 5 mmHg and the entire operative field inspected once again prior to closure of the abdominal incisions. If dilating trocars are used, fascial closure of these sites is not required. With hand-assisted technique, the incision is closed in a traditional fashion as per surgeon preference. All skin incisions are closed with subcuticular sutures or with Dermabond (Ethicon Endosurgery, Cincinnati, OH).

Step 7: Cystoscopic Management of the Distal Ureter/Bladder Cuff. After wound closure, the patient is re-positioned into the cystolithotomy position and rigid cystoscopy is performed. If staples are visualized in the bladder, the procedure can be terminated. More commonly, the ureteral orafice is visualized and a ureteral catheter is gently placed into the remaining short intramural ureteral segment (Fig. 12A,B). An Orandi knife or alternatively a 1000μ holmium laser fiber is then used to "unroof" the intramural ureter over the ureteral catheter (Fig. 13A,B). Unroofing proceeds until the staples are identified. After staple identification, a resectoscope with a rollerball electrode is introduced and the ureteral tunnel and surrounding urothelium are fulgurated for a radius of 1-cm around the site of unroofing (Fig. 14A,B). A Foley catheter is left to drain the bladder for 48 h.

Left Side

After laparoscopic abdominal inspection, the outline of the left kidney within Gerota's fascia can commonly be identified beneath the descending colon.

Step 1: Peritoneal Incisions and Pararenal Dissection. The template for anatomic dissection of the left kidney assumes the configuration of an inverted cone (Fig. 15). The lateral side of the cone is formed by the line of Toldt that is incised from the pelvic brim, cephalad to the level of the diaphragm. On the left side, the colon should be mobilized from the iliac vessels to the diaphragm as previously described. However, even in the virgin abdomen, there are usually adhesions from the splenic flexure of the descending colon to the anterior abdominal wall; these attachments need to be released with the Harmonic scalpel in order to carry the incision in the line of Toldt cephalad alongside the spleen and up to the diaphragm. This cephalad incision serves to release any splenophrenic attachments, thereby mobilizing the spleen from the abdominal sidewall (Fig. 16). The spleen should be mobilized such that it rotates medially by gravity away from the operative field. Adequate splenic mobilization early in the procedure opens the area of the renal hilum, facilitating this dissection, and helps prevent inadvertent splenic injury. During this portion of the dissection, excellent exposure can be gained by medial and inferior traction on the specimen with the PEER retractor. If hand-assisted technique is employed, the surgeon's hand can gently retract the spleen superiorly and medially to further delineate the proper plane of dissection.

The medial aspect of the cone is then formed by retracting the peritoneal reflection of the descending colon medially and developing the plane between Gerota's fascia and the colonic mesentery. As with the right-sided dissection, this natural plane between

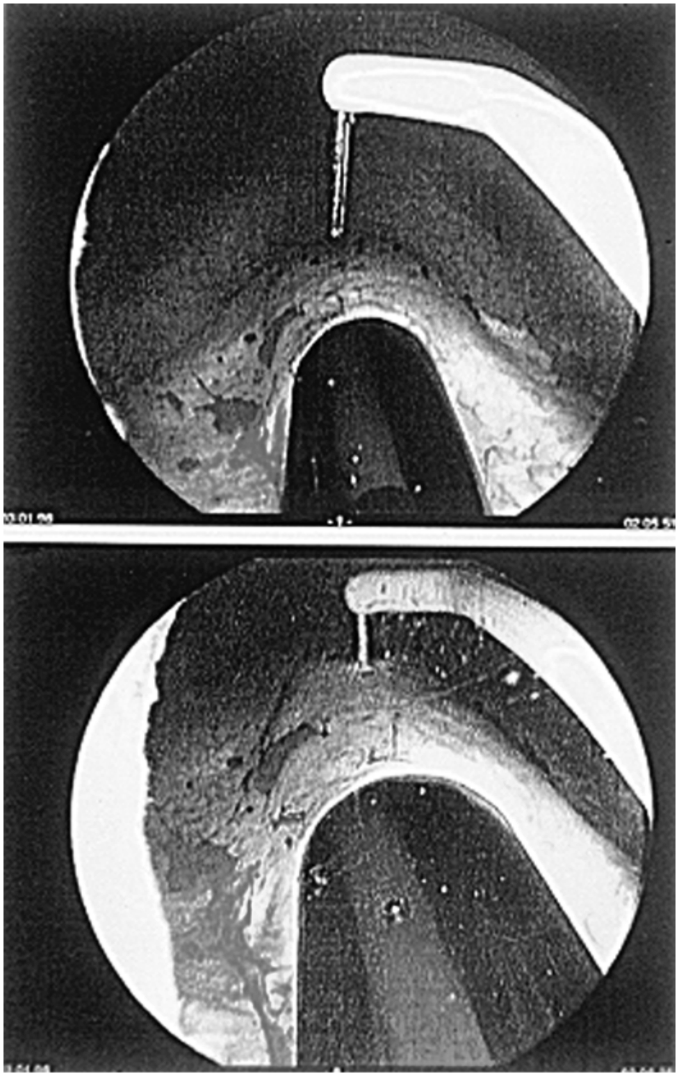

Fig. 12. (Top Panel) Remaining intramural ureteral tunnel with (Bottom Panel) ureteral catheter in position.

the mesentery of the descending colon and Gerota's fascia is most easily identified and entered along the lower pole of the kidney or just inferior to the kidney.

The anterior upper curve of the cone is formed by the spleno-colic ligament, which is incised in order to fully mobilize the descending colon medially. The posterior upper curve of the cone is formed by the spleno-renal ligament that is incised to further release the spleen, and thus precludes any inadvertent tearing of the splenic capsule. Incision of the splenorenal ligament may be difficult at this early stage of the procedure and, if need be, can be performed later in the procedure after the renal vessels have been secured. The dissection then follows the plane between the spleen and the superior portion of Gerota's fascia. At this point, the *en bloc* area of dissection has been defined and incorporates all of Gerota's fascia, the pararenal and perirenal fat, and the adrenal gland.

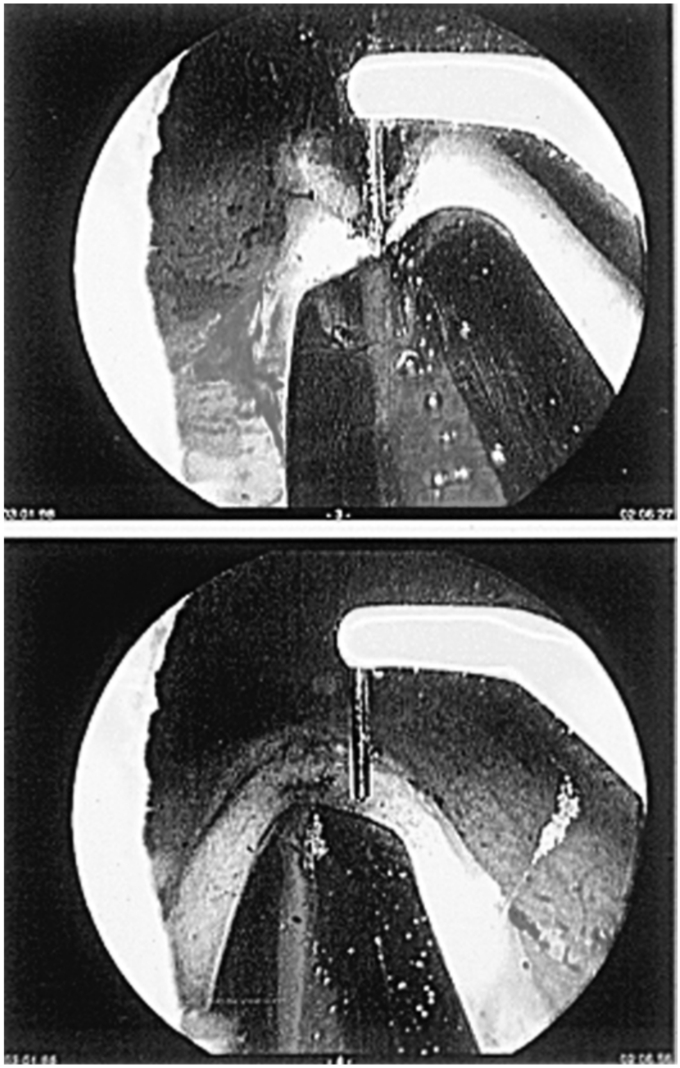

Fig. 13. The Orandi knife is used to "unroof" the ureteral tunnel (Top Panel) until staples from the Endo-GIA stapler used to transect the distal ureter are identified (Bottom Panel).

Step 2: The Gonadal Vein. Identification and isolation of the left gonadal vein is useful because it reliably leads the surgeon to the renal vein. The gonadal vein can most easily be exposed inferiorly; it is then traced up to its entry into the renal vein (Fig. 17). Anteriorly along the gonadal vein there are no tributaries, thereby providing the surgeon with a safe plane of dissection all the way up to the insertion of the gonadal vein into the main renal vein.

Step 3: Identifying the Proximal Ureter. The left ureter usually lies just posterior and lateral to the gonadal vein. It is carefully dissected from the retroperitoneal tissues and treated in the same manner as the right ureter for a right nephroureterectomy.

Step 4: Securing the Renal Hilum. After tracing the gonadal vein to its junction with the main renal vein, it is secured using the Harmonic scalpel on the variable setting. Alternatively, if the vessel is robust (>5 mm), it can be secured with four

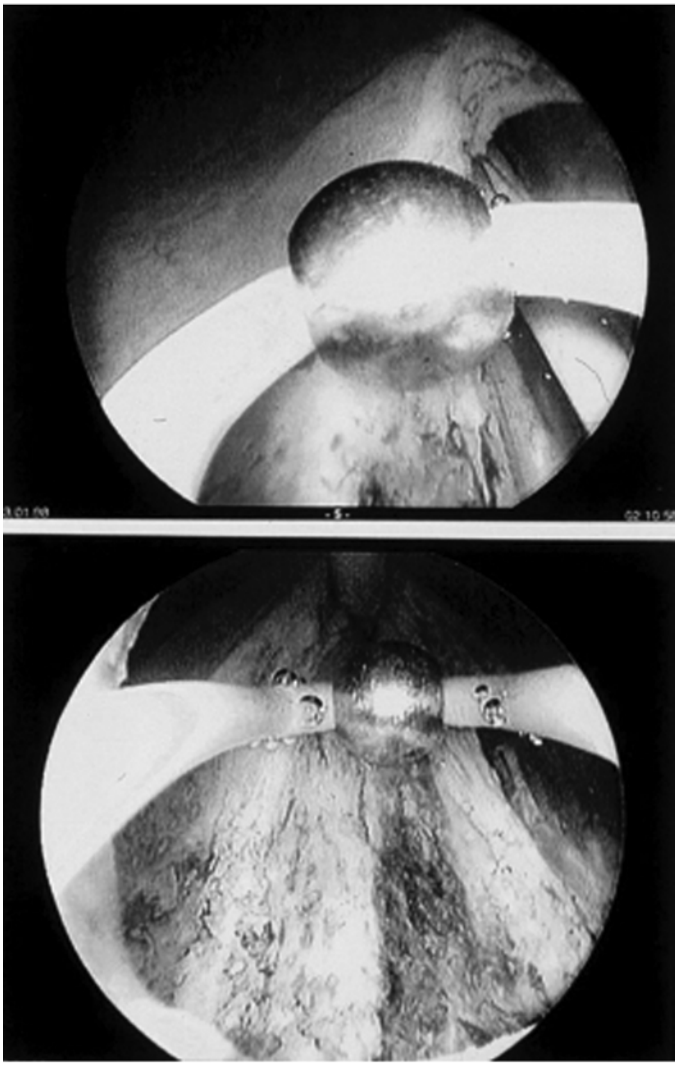

Fig. 14. After staples have been identified, a roller-ball electrode is used to fulgurate the area around the ureteral orifice.

vascular clips and divided. Care should be taken to identify the posterior lumbar vein that may enter the renal vein posteriorly in the area of the gonadal vein or may even join the gonadal vein near its insertion into the renal vein. Thoughtful utilization of the 30° lens during renal vein dissection will allow the surgeon to visualize the area behind the renal vein. Thus, optical identification of lumber veins during the posterior dissection of the renal vein is possible. This maneuver helps avoid the bleeding associated with blind dissection behind the renal vein. Lumbar veins can similarly be secured with the Harmonic scalpel or with four clips and incised. The advantage of vascular control of small vessels with the Harmonic scalpel is that there is no concern of clip entrapment with the Endo-GIA during hilar transection.

The superior border of the renal vein is then dissected from surrounding tissue. The adrenal vein is identified during this dissection, usually lying medial to the insertion of the gonadal vein on the renal vein. The adrenal vein is secured with the Harmonic

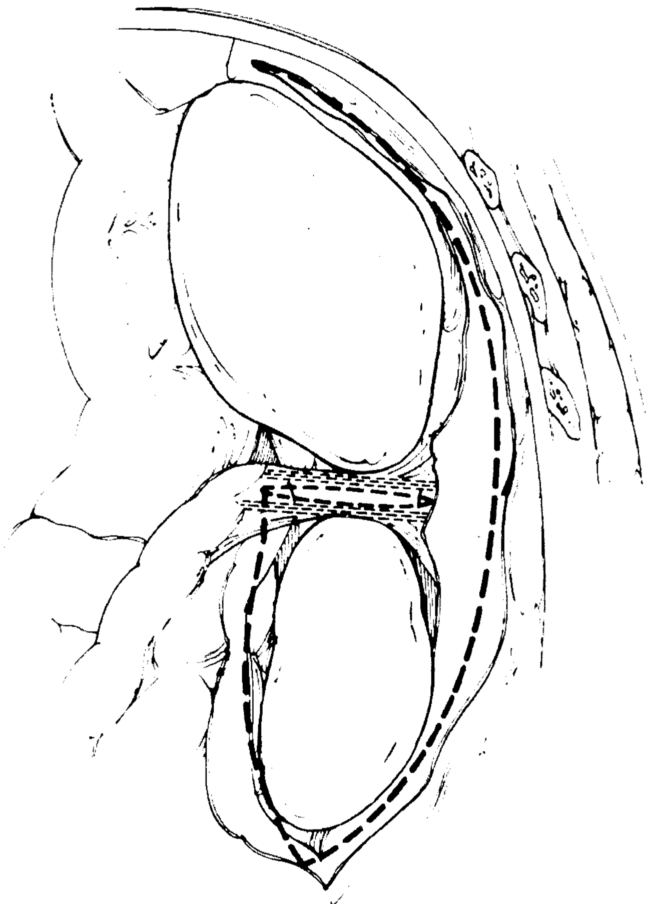

Fig. 15. Diagram demonstrating the inverted cone template for *en bloc* dissection during left laparoscopic nephroureterectomy. Unlike on the right side, the reflection of the colon comes to the lateral sidewall and thus an incision in the line of Toldt parallel to the kidney needs to be made; this incision is not carried deeply in an effort to hold the kidney lateral, which helps somewhat with the hilar dissection.

scalpel or with four vascular clips and divided. If clips are applied, the clips should be placed with consideration of subsequent safe placement of the Endo-GIA vascular stapler across the renal vein.

Although the location of the renal artery usually becomes evident during the renal vein dissection, careful review of preoperative imaging (CT scan or magnetic resonance imaging [MRI]) will suggest the location of the renal artery when it is not immediately evident (i.e., cephalad or caudad to the vein). With hand-assisted technique, localization of the renal artery is simplified by digital palpation. The renal artery is dissected free, and five 11-mm titanium clips are applied. The artery is then transected between the second and third vascular clips, leaving three clips proximally. Occasionally, the hilar dissection may seem simplified by the presence of a renal artery that is parallel or anterior to the renal vein. In this situation, extreme caution should be exercised because the superior mesenteric artery can easily be mistaken for the renal artery. If the “presumed” renal artery is not behind the renal vein, additional dissection of the

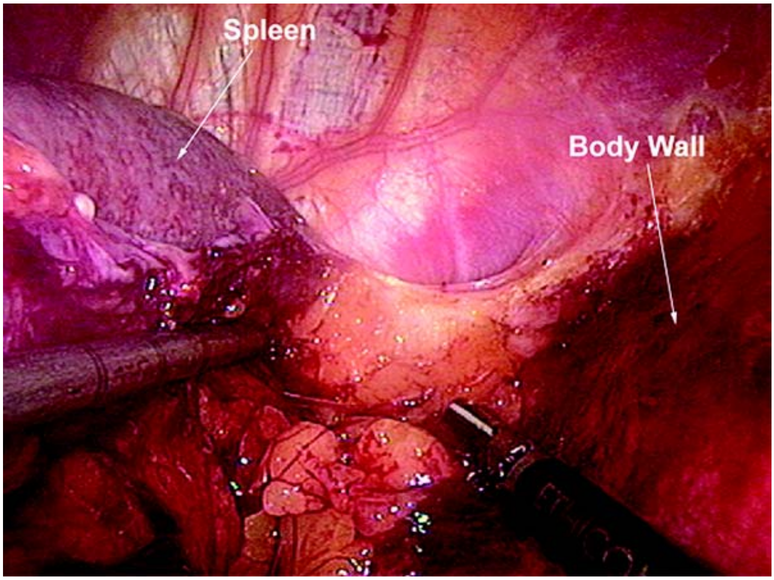

Fig. 16. Dissection of the lateral splenic attachments (splenophrenic attachments).

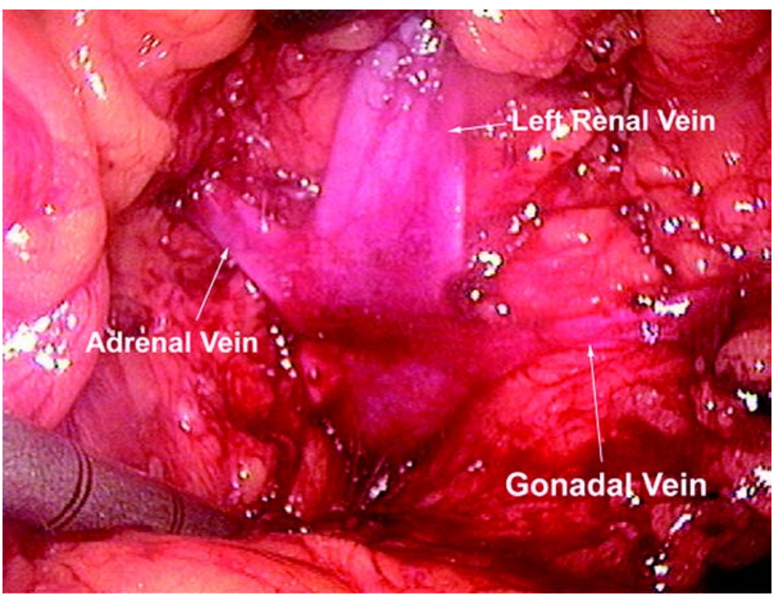

Fig. 17. Laparoscopic view of left renal vein with adrenal and gonadal tributaries. The ascending lumbar vein is not seen; however, it may attach to the posterior surface of the gonadal vein or the renal vein, medial to the renal vein entry of the gonadal and adrenal veins.

vessel should be performed to clearly delineate the anatomy before vessel transection is performed.

Distal ureteral dissection, entrapment, specimen extraction, and cystoscopic management of the intramural ureteral tunnel are all identical to the description for the right side. The only exception is that the left kidney specimen is moved such that it rests on the anterior surface of the spleen just prior to entrapment.

Alternative Management Strategies for the Distal Ureter

Pluck Technique

Transurethral ureteral resection ("pluck" ureterectomy) is performed cystoscopically prior to the laparoscopic component of the procedure with the patient in a dorsal lithotomy position. The ureteral orifice, tunnel, and ureterovesical junction are transurethrally resected out to the perivesical fat. The ureter is thereby released from the bladder. Hemostasis is obtained and a urethral catheter is placed. Early in the laparoscopic portion of the procedure, the ureter is clipped to prevent further leakage of urine into the retroperitoneum. After laparoscopic dissection of the kidney, the surgeon can "pluck" the ureter cephalad, thereby precluding any pelvic dissection of the ureter. The major drawback of this approach is concern about leakage of malignant cell-laden urine into the retroperitoneum until the ureter is laparoscopically occluded. Indeed, instances of seeding after an open "pluck" procedure have now been reported by several urologists *(25–27)*.

Needlescopic (Cleveland Clinic) Technique

Application of a needlescopic technique for management of the distal ureter was described by Gill and colleagues in 1999 *(28)*. The patient first undergoes cystoscopy to rule out a concomitant bladder tumor and to insure adequate bladder capacity. Diminished bladder capacity (less than 200 mL) increases the technical difficulty owing to limited working space. Cystosopy is performed with the patient in 30° Trendelenburg position. Two needlescopic trocars (2-mm) are inserted suprapubically into the bladder under cystoscopic vision. A 2-mm Endoloop is inserted through the needlescopic trocar. A 6F ureteral catheter is passed through the loop and into the affected ureter with the assistance of a guidewire. A 24F continuous flow resectoscope is then passed into the bladder alongside the ureteral catheter. A Collings' knife is used to electrosurgically score circumferentially the urothelium around the intramural ureter, such that a 2- to 3-cm cuff is outlined.

Using a 2-mm grasper, the ureteral orifice and hemitrigone are retracted anteriorly and a full-thickness incision is made with the Collings' knife. In this manner approximately 3- to 4-cm of ureter may be dissected free from surrounding tissues. The previously placed Endoloop is then positioned over the ureter and closed tightly, occluding the lumen as the ureteral catheter is withdrawn. The tail of the Endoloop is then cut with 2-mm laparoscopic scissors. The bladder edges about the excised ureter are then coagulated. All instruments are removed from the bladder and a Foley catheter is left indwelling. The laparoscopic nephrectomy component of the procedure is then performed and the ureter is pulled up with the specimen via a 7–10-cm incision.

Postoperative Care

Patients receive 15 mg of ketorlac (Toradol) IV q6h as requested, for 36 h. Typically patients will require supplemental analgesic control with an oral narcotic. Diet is resumed immediately with clear fluids and advanced as tolerated. Pneumatic compression boots remain on the patient and activated until the patient is ambulating well. Typically, the patient is ambulated on the first postoperative day. At Washington University, mean hospital stay for laparoscopic nephroureterectomy has been 3.3 and 4.5 d for laparoscopic and hand-assisted laparoscopic nephroureterectomy, respectively. The patient is discharged on oral narcotics as needed.

SUMMARY

For localized TCC, laparoscopic and hand-assisted laparoscopic nephroureterectomy have become accepted alternatives to open nephroureterectomy. Application of laparoscopic technique provides excellent oncologic control and minimizes the patient's postoperative discomfort and convalescence. Using the anatomic templates and techniques described and illustrated in this chapter, the laparoscopic urologic surgeon can successfully extract the kidney and adrenal within Gerota's fascia as well as the ureter and a cuff of bladder.

TAKE HOME MESSAGES

1. Anatomic dissection following the described templates for the right and left nephrectomy component of the procedure will facilitate a safe dissection that is oncologically sound.
2. On the right side, the surgeon should actively seek out the duodenum to identify and protect this structure during medial dissection of the renal specimen.
3. On the left side, identification of the gonadal vein helps expedite hilar dissection. The surgeon must remember the superior mesenteric artery if the "renal artery" is located anterior or parallel to the renal vein.
4. Preliminary data has demonstrated that the hand-assisted laparoscopic technique will expedite nephroureterectomy, and will likely have only a small impact on postoperative analgesic requirements and convalescence.

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12 Laparoscopic Adrenalectomy

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Contents

INTRODUCTION

Laparoscopic techniques have become widespread within many surgical specialties and are now the standard of care for many procedures. This is especially true when considering the realm of surgical adrenal disorders. Since the report of the first series of laparoscopic adrenalectomy for Cushing's syndrome and pheochromocytoma in 1992 *(1)*, this technique has become widely disseminated and is now accepted as the technique of choice for many adrenal lesions. Recovery times have clearly improved with these approaches and patients can now enjoy earlier discharge from the hospital and a much faster return to normal activity.

In addition to being efficacious, this procedure has also been proven to be safe. The learning curve with technique is reasonable, although previous laparoscopic experience greatly facilitates a safe and timely operation and avoids unnecessary conversions to open surgery.

INDICATIONS AND CONTRAINDICATIONS (TABLE 1)

Laparoscopic techniques for adrenalectomy have now become the standard of care for the majority of surgical lesions. This is especially true for smaller, metabolically active lesions such as mineralocorticoid tumors, corticosteroid producing lesions, and other functional adenomas. In addition, these techniques lend themselves nicely to symptomatic myelolipomas, suspicious adrenal cysts, and other lesions of indeterminate significance found on inadvertent radiographic imaging.

A particular area of benefit is the management of masses larger than 5 cm. These lesions have been shown to have a significant likelihood of harboring malignancy and

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Table 1
Indications/Contraindications for Laparoscopic Adrenalectomy

Indications	
	Cushing's adenoma
	Cushing's syndrome
	Mineralocorticoid tumor (Aldosteronoma)
	Pheochromocytoma
	Solitary adrenal metastasis
	Nonfunctioning adenoma >4–5 cm
	Symptomatic myelolipoma/cyst
Contraindications	
	Large tumor >8–10 cm (relative)
	Significant abdominal adhesions (relative)
	Morbid obesity (relative)
	Local invasion (true)
	Venous involvement (true)

so are often approached surgically *(2)*. A laparoscopic approach can clearly allow for the complete excision of these potential malignancies without subjecting the patient to a much larger and more painful incision.

The use of laparoscopy in the management of larger malignant masses is somewhat controversial. The lack of a true capsule around the adrenal gland greatly increases the risk of local invasion of these highly aggressive tumors. This makes complete excision and adherence to basic oncologic principles a difficult task, even during open surgical approaches. It is not surprising that long-term survival rates for any surgical approach have been poor, especially when coupled with the lack of effective chemotherapeutic agents.

In light of these difficulties, many surgeons advocate an open approach to known adrenal malignancies or for large lesions (greater than 8–10 cm). In spite of these fears, there have been multiple reports of effective and complete laparoscopic surgical excision of malignant masses *(3)*. Prospective, randomized trials are lacking, however, and may be slow in coming owing to the relatively rarity of these tumors (0.3% of all cancers) *(2)*.

Locally advanced tumors with obvious extension to surrounding structures or those with venous involvement are also not candidates for laparoscopic excision and should be approached through open surgery.

Metabolically active pheochromocytomas have been approached laparoscopically with good success and are not a contraindication to this approach. As is true during the open approach, however, it is critical that these patients have undergone successful medical blockade prior to the induction of their procedure. This usually entails the use of alpha-adrenergic blockade with the subsequent addition of beta-blockade in the presence of arrhythmias. This sequence of blockade is very important because primary beta-blockade can lead to severe hypertension from unopposed alpha agonist activity. Some endocrinologists advocate the use of the tyrosine hydroxylase inhibitor metyrosine as preoperative medical blockade, but this regimen can be difficult to tolerate owing to side effects. As always, close intraoperative monitoring of vitals signs through the use of invasive lines is crucial. This includes arterial lines, central lines, and large-bore catheters for rapid fluid infusion. Anesthesiologists should also be prepared for rapid and drastic shifts in blood pressure and should have vasoactive medications drawn and ready for immediate infusion in the event that the preoperative blockade is incomplete.

Despite these risks, most pheochromocytomas can be approached with this technique, perhaps avoiding only those patients with significant endocrine storm and multisystem crisis. The transperitoneal laparoscopic approach can also allow for a complete intraperitoneal survey in the event that the patient is suspected of harboring extra-adrenal sites of this lesion.

Obesity has been suggested to be a relative contraindication of a laparoscopic approach to the adrenal gland. Indeed, early series have shown a higher rate of complications (especially minor) in patients with an elevated body mass index. Although more recent investigators have noted that obesity is associated with longer operating room (OR) times and slight increases in complication rates, most authors feel that obese patients are easily managed as the surgeon gains operative experience and advances along the learning curve *(4)*.

Finally, significant previous abdominal surgery can be a relative contraindication to transperitoneal laparoscopy if adhesions are so dense as to create an unacceptably high risk of inadvertent enterotomy. In this instance, the surgeon can opt for a retroperitoneal approach, either through a standard flank incision or through retroperitoneal laparoscopy.

PREOPERATIVE ASSESSMENT

A complete, step-by-step discussion of the evaluation of a patient with an adrenal lesion is beyond the scope of this book. Clearly, each patient requires an assessment of any lesion from a radiologic perspective as well as a full metabolic evaluation.

A complete endocrinologic assessment will entail measurement of serum electrolytes, serum hormone levels, serum catecholamines, urine studies for catecholamines and their metabolites, and urine levels of steroid hormones and their metabolites. The exact tests ordered will of course depend on observed clinical signs and symptoms and the patient history and physical. In addition, stimulation studies such the low and high-dose dexamethasone suppression tests and plasma renin activity can also be applied as necessary and appropriate.

Adrenal lesions are commonly found serendipitously on imaging studies performed for other complaints, especially on computed tomography (CT) scans. CT imaging using thin cuts, both before and after intravenous contrast, can greatly aid in the assessment of these lesions. Small lesions without enhancement after contrast and Hounsefield measurements of 15 units or less are rarely malignant and do not require further evaluation in the absence of clinical symptoms.

Magnetic resonance imaging (MRI) scans can also provide useful information as some lesions are expected to have specific findings on the various phases of this modality. Pheochromocytomas, for example, have a typical bright "light-bulb" appearance on the T2-weighted images of a MRI scan.

Less commonly, adrenal activity can be assessed with a nuclear medicine scan using radiolabeled iodine. Metaiodobenzylguanidine (MIBG) scans employ a guanethidine analog that is preferentially taken up by adrenergic tissue. These scans have poor spatial resolution and take several days to perform, but can be helpful in localizing small pheochromocytomas. This is especially true for those patients with multiple endocrine neoplasma (MEN) syndromes and a high risk of extra-adrenal lesions.

Provided that the surgical lesion has been evaluated completely, patients will require a recent serum chemistry panel prior to surgery to search for significant electrolyte disturbances. Many surgeons advocate checking a complete blood count as well. In the absence of a history of a significant bleeding or coagulopathy disorder, most patients do not require routine coagulation studies (e.g., bleeding time, PT, PTT). Any patient that is suspected of harboring a malignant mass should be evaluated for occult metastatic lesions using a chest radiograph and measurement of liver enzymes and alkaline phosphatase.

TECHNIQUES

Operating Room Set-Up, Trocar Configuration, and Patient Positioning

Operating room requirements for this procedure are relatively straightforward and require instrumentation and equipment that should already be available at most hospitals. A room large enough to accommodate all of the equipment is essential, however, because the video tower and any additional devices can quickly fill a small room.

A laparoscopy tower complete with color monitor, gas insufflator, camera system and a spare tank of CO_2 gas is essential. A color printer in-line with the camera system allows for the easy capture of intraoperative findings. Ideally, a second tower with just a color monitor should be available to place behind the surgeon to allow the rest of the surgical team to follow the progress of the operation.

Once the patient has been intubated and all appropriate lines and monitors have been placed, the patient is rolled into the true flank position with the lesion in the superior position. We generally elevate the kidney rest slightly and use a modest amount of flex in the OR table to help distract the kidney and adrenal gland from nearby structures. The bottom leg is flexed at the hip and knee while the upper leg remains straight. A beanbag device allows for the stabilization of the patient and is further aided by the use of wide silk tape secured to the rails of the bed. It is important to fully pad all pressure points, including both the top and bottom legs as well as the axilla. The upper arm can be supported with pillows or on a specifically designed holder secured to the bed rail (Fig. 1). This position should be very familiar to most urologic surgeons, as it is the same as for a flank approach for extirpative and reconstructive renal surgery.

Trocars will be placed under the ipsilateral costal margin (Fig. 2). Two 10-/12-mm ports can be used for the center trocars allowing the surgeon to exchange the laparoscope and a large clip-applier in either position depending on the best angle of attack. Five-mm trocars are generally used at either end of the line to allow for a retractor or a grasper. The center trocars are positioned at the anterior axillary line and the midclavicular line, while the outer trocars are placed in the midline and the posterior axillary line. Except for the initial trocar, all should be placed under direct laparoscopic vision.

A needlescopic technique has been developed and advocated by some surgeons *(5,6)*. In this method, one 10-/12-mm trocar is placed at the superior aspect of the umbilicus and allows for the use of a larger 10-mm laparoscope while also serving as the eventual exit site of the specimen. A single 5-mm trocar is placed in a subcostal, midclavicular position and allows for the passage of the main working instruments

Fig. 1. The patient is positioned in a true flank position with all pressure points carefully padded and the patient adequately secured to the OR table (left adrenalectomy).

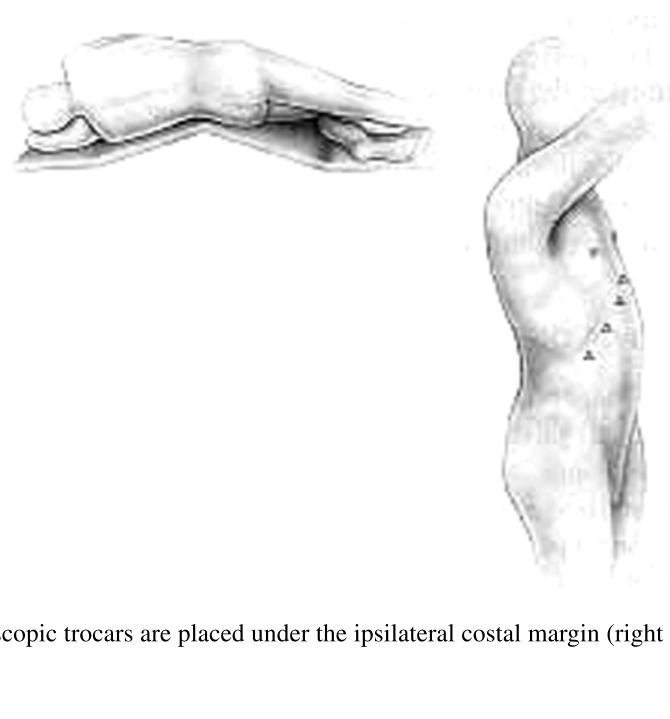

Fig. 2. Laparoscopic trocars are placed under the ipsilateral costal margin (right adrenalectomy).

Table 2
Instrumentation for Laparoscopic Adrenalectomy

Essential

- Video tower (color monitor, CO_2 gas with spare tank, insufflator, video system)
- Camera (preferably three-chip)
- 30° laparoscope
- Curved dissecting scissors (“hot”)
- Atraumatic grasper
- Automatic clip-applier (5- or 10-mm)
- Fan retractor (can be large, blunt grasper)
- Suction/irrigator
- Impervious specimen entrapment device

Helpful

- Harmonic scissors
- Laparoscopic ultrasound
- Laparoscopic stapling device

(clip-applier, suction/irrigator, and scissors). The remaining trocars are placed flanking the center working trocar and are only 2 mm in size. Although these small instruments allow for a very cosmetic result, technical challenges limit them to basic graspers and retractors.

Instrumentation (Table 2)

The instrumentation for this procedure is simple and straightforward. In addition to the basic laparoscopic tower described in the previous section, most surgeons employ an angled laparoscope of 30° or 45°. This endoscope allows the camera holder to look over and around intra-abdominal contents without battling with the working instruments of the surgeon. The use of such an angled endoscope should be simple to master for any urologist because it mimics the techniques used during rigid cystoscopy.

The surgeon typically holds an atraumatic grasper in his or her nondominant hand while the dominant hand controls the working instrument. We frequently employ a curved dissecting scissors that are connected to electrocautery as the main dissecting instrument. Some advocate the use of hook cautery instead of curved scissors, but this is clearly a matter of personal choice and experience. These instruments can be easily changed for a combined suction/irrigator device that is helpful in clearing the surgical field of any oozing blood as well as serving as an atraumatic blunt dissector. An automatic clip-applier is essential and is used to control the adrenal vein, the main adrenal artery, and any other branches of the adrenal vasculature that are too large to control with electrocautery.

Some surgeons advocate the use of high-frequency (Harmonic) instruments to divide the adrenal vessels (except the main adrenal vein) and the surrounding fatty tissue. Although we have not routinely used these devices, they clearly can offer an advantage in those patients with excessive retroperitoneal fat. Small bleeders within this redundant fat can be bothersome and difficult to control during a search for the adrenal gland and its vasculature.

A retractor is also necessary to move the spleen or the liver off the adrenal to allow for the complete dissection. A fan device works well and should be safe on the surrounding organs if used appropriately. Malleable, shepherd's crook retractors are also available and are particularly helpful at raising the liver off of Gerota's fascia and the hepatic flexure of the colon. We frequently employ a large, blunt grasper, which can be used to sweep tissues aside as well as to grasp an edge of exposed peritoneum and thereby lift and retract the offending object or tissues.

Intraoperative ultrasound is occasional helpful when searching for a small lesion to enucleate. Current devices can be passed intra-abdominally, but require a larger trocar. These instruments can be difficult to use and clearly benefit from operator experience.

Finally, a specimen retrieval bag is also necessary once the adrenal gland has been completely mobilized and freed of all attachments. The Endocatch device (U.S. Surgical Corp., Norwalk, CT) is easy to open and has a nice, fixed open mouth into which the specimen is delivered. The LapSac (Cook Corporation, Spencer, IN), however, has been proven to be impervious and is the bag of choice for any lesion that is possibly malignant. This device can be cumbersome and requires skill to keep the mouth of the bag open while passing the specimen into its interior.

Surgical Technique

Patient Preparation

All patients require a full mechanical and antibiotic bowel preparation. This helps decompress the intestines to facilitate exposure during dissection and allows for conservative repair of any inadvertent bowel injury. Patients are given a dose of broad-spectrum antibiotics before the procedure and all patients are typed and cross-matched for two units of blood. Patients undergoing laparoscopic adrenalectomy should have a general endotracheal anesthetic, because controlled ventilation is necessary to ensure adequate oxygenation and to avoid hypocarbia. Nitrous oxide can lead to bowel distention and should be avoided during this procedure. A nasogastric tube is placed to keep the stomach and bowels decompressed and a Foley catheter is positioned to allow drainage of the bladder before initiating the pneumoperitoneum.

Transperitoneal Laparoscopic Adrenalectomy

Left Adrenalectomy. Once the patient has been adequately positioned, prepped, and draped, the operation begins with the creation of the pneumoperitoneum. A Veress needle can be used or an open Hasson technique may be applied depending on surgeon experience and preference. In either case, we have typically placed our first trocar in the anterior axillary line, 2 fingerbreadths below the costal margin.

After adequate insufflation of the abdomen to 15 mmHg, a 10-/12-mm trocar is inserted in the left subcostal area at the level of the anterior axillary line. A 30° angled laparoscope is then inserted through this trocar. One additional 10-/12-mm trocar is inserted under direct vision in the midclavicular line while the flanking 5-mm trocars are placed in the posterior axillary line and the mid-line of the abdomen (Fig. 2). Using endoscopic scissors, the white line of Toldt is divided near the splenic flexure of the colon to open the retroperitoneal space between the colon and the lateral abdominal wall. This incision is continued superiorly to further release the spleen as well. The upper pole of the left kidney is identified and exposed by freeing the posterolateral attachments of the spleen in the direction of the diaphragm. Using a fan or blunt retractor, the spleen is retracted medially and superiorly. This maneuver exposes the adrenal gland and will allow the dissection to begin in the correct plane.

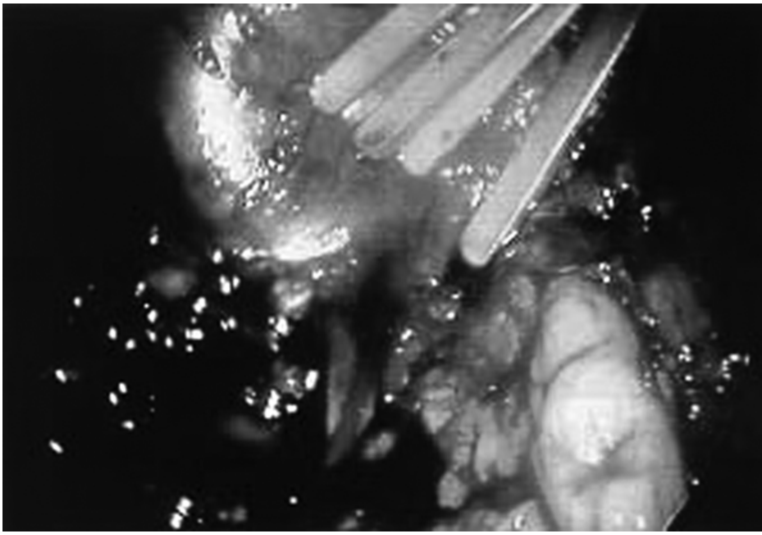

Fig. 3. The left adrenal vein has been carefully dissected free. Note the fan retractor holding back the specimen as well as the neighboring spleen.

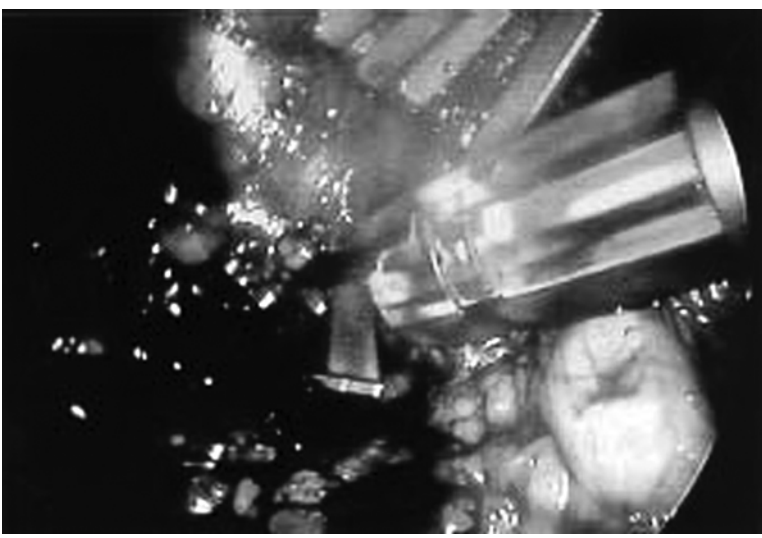

Fig. 4. The left adrenal vein is secured with clips and will be divided next.

After entering Gerota's fascia, the superior aspect of the adrenal gland is exposed first and the dissection is carried medially. The dissection of the inferior portion of the gland should be performed last, because starting here will lead to superior gland retraction and unnecessary bleeding. The inferior phrenic arterial branches are ligated with titanium clips after mobilization of the superior pole of the gland. The left adrenal vein is then visualized, dissected free (Fig. 3), and ligated with two laparoscopic clips (Fig. 4). The inferior portion of the adrenal gland is dissected last and the gland is separated from the surrounding tissue. Hemostasis is obtained by using an irrigation/irrigation device.

A small entrapment sac is then placed through the medial trocar, the bag is opened, and the adrenal gland is placed into the entrapment sac under laparoscopic control

Fig. 5. The specimen has been placed into an entrapment sac and will be removed via one of the larger trocar sites.

(Fig. 5). The bag is removed through the most inferior trocar site with minimal spreading of the oblique muscles using a Kelly clamp. Prior to exiting the abdomen, the insufflation is typically lowered to 5 mmHg and the operative site is searched for bleeding. Persistent bleeding can be addressed with electrocautery or with Surgicell that is introduced through a larger trocar. All trocar sites 10-mm or larger require a facial closure using 2-0 absorbable suture, while the skin is reapproximated using 4-0 suture. A fascial closure device, such as the Puncture Closure Device (ConMed Corp., Utica, NY) can be very helpful and avoids difficult and often blind suturing of the abdominal fascia.

Right Adrenalectomy. After adequate insufflation using a Veress needle, the entire abdomen should be tympanitic after the pneumoperitoneum surrounds the liver. Care must be taken during lateral insufflation to avoid placement of the Veress needle into the liver parenchyma. A 10-/12-mm trocar is inserted in the anterior axillary line and used for passage of the laparoscope. The additional trocars are inserted in the abdominal wall in a similar pattern as described for a left adrenalectomy.

The liver is retracted in a cephalad direction and the posterior peritoneum is then divided close to the liver edge. This incision is carried from the line of Toldt to the inferior vena cava (IVC). The hepatic flexure of the colon does not need aggressive mobilization if this incision is carried far enough laterally. The upper pole of the kidney is identified and the perinephric fat is dissected superiorly and close to the IVC to expose the adrenal gland. The dissection begins at the superior and anterior aspect of the right adrenal gland. Small vessels are secured with laparoscopic clips or electrocautery and a laparoscopic kittner dissector is used to retract the adrenal gland in a lateral direction. Meticulous dissection in this area will prevent tears from the lateral vascular branches of the IVC and to the body of the adrenal gland itself, which can lead to tiresome oozing.

The adrenal vein is identified, isolated, and laparoscopic clips are placed, leaving two clips on the patient side. The vein is then divided between the clips. Extreme care must be taken when mobilizing the right adrenal vein as it is short and has a direct entry into the vena cava (Fig. 6). The inferior pole of the adrenal gland is dissected last and an

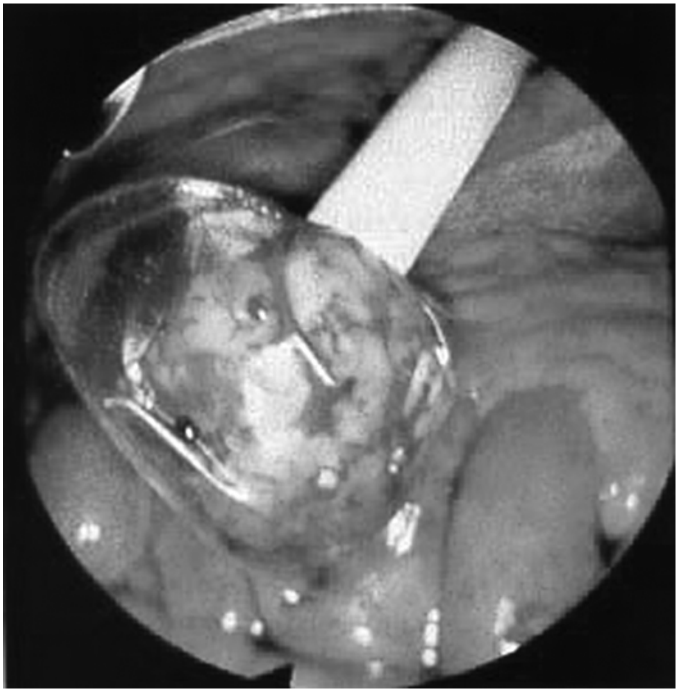

Fig. 6. The right adrenal vein has been dissected free and is being secured with clips. Notice the lack of working space between the specimen and the IVC.

entrapment sac is used to remove the adrenal gland through the anterior axillary line trocar site. A 2-0 absorbable suture is used to close the fascia at all trocar sites larger than 10 mm and the skin edges are reapproximated using 4-0 suture.

Retroperitoneal Laparoscopic Adrenalectomy

A retroperitoneal approach may be able to offer improved patient comfort, but does require a longer learning curve. With the patient positioned and prepared as previously described, a small 1.5-cm incision is made above the iliac crest in the midaxillary line, and the pararenal space is developed using the surgeon's index finger. The retroperitoneal space can be further expanded using a commercially available balloon dilation trocar (i.e., Origin USA, Menlo Park, CA) or the finger of a glove secured to a red rubber catheter. Once this space is developed, the laparoscope is secured within the trocar and the remaining trocars are ready to be placed under direct laparoscopic visualization. For a right-sided lesion, a 5-mm port is placed in the posterior axillary line, just below the costal margin. Using a blunt grasper, any remaining peritoneal attachments are swept medially. A 10-/12-mm trocar is then placed in the anterior axillary line in a subcostal position. These trocars would switched for a left retroperitoneal adrenalectomy. A final 5-mm port can be placed down near the iliac crest as needed for intraoperative retraction.

With the space adequately developed and the trocars in place, the procedure is begun by opening Gerota's fascia widely in a cephalocaudad fashion to avoid inadvertently opening the peritoneal cavity. The periadrenal and perinephric fat is then carefully dissected away from its surrounding attachments. This includes separation away from the psoas muscle, the diaphragm, the peritoneal reflection, and the pancreas or liver. Premature entry into the periadrenal fat in search of the gland itself can produce hemorrhage and ooze, which will obscure visualization in this tight space. Care must be taken to secure and divide any phrenic branches of the adrenal vasculature when separating the gland from the diaphragm.

Once the periadrenal fat has been mobilized, the plane between the adrenal gland and the superior pole of the kidney is dissected free. It is important to avoid tearing the adrenal gland during these maneuvers to avoid another potential source of troublesome hemorrhage. This maneuver should lead the surgeon to the adrenal vein as the dissection proceeds medially. With the vein dissected free, it is secured with clips and then divided with the curved scissors.

The specimen should be captured within an entrapment sac and delivered via the largest trocar site. This incision can be enlarged as needed for larger specimens. The insufflation pressure should be lowered and the surgical field inspected for bleeding. As with a transperitoneal approach, only trocar sites 10 mm or larger are closed with a 2-0 absorbable suture. The skin incisions are closed with a 4-0 suture.

Postoperative Care

The nasogastric tube and Foley catheter may be removed in the recovery room. Sequential stockings are left in place until the patient is ambulatory. All fluids are begun on the day of surgery, if tolerated. A parental, broad-spectrum antibiotic is administered for 24 h following surgery and the patient is kept on an oral antibiotic preparation for 3 d. Oral analgesics are administered as needed, however, postoperative pain requirements are minimal. The need for any significant amounts of analgesic postoperatively should raise the suspicion of a postoperative complication. Patients resume their regular activities as tolerated.

Patients should be warned that they may experience transient shoulder pain owing to the irritating effects of the CO_2 on the diaphragm. The pain is usually described as arthralgic-like discomfort in one or both shoulders. Placing the patient in Trendelenberg and opening the most superior trocar prior to removal will prevent this from occurring. This pain generally responds well to oral analgesics and/or anti-inflammatory medications and often resolves spontaneously within 24–48 h after surgery. Some adrenal conditions will necessitate hormonal support and this is begun in the immediate postoperative period.

PUBLISHED RESULTS

Published results from peer-reviewed journals have consistently shown that laparoscopic adrenalectomy is both efficacious and safe. Furthermore, operative times have begun to rival those of open procedures, as surgeons become more experienced with this technique and with laparoscopy in general.

A review of the recent literature demonstrates mean operative times that range from 94–188 min for the transperitoneal approach and 114–178 min for retroperitoneal laparoscopy. Complication rates in these series have ranged from 2.6–16%, while mortality rates have been reported from 0.0–1.3%. Conversion rates for both approaches have been low: 0.9–7% for transperitoneal laparoscopy and 0.8–5.1% for the retroperitoneal route *(7–14)*. These data are presented in Table 3. It should be noted that most surgeons report all conversions to open surgery occurred early in each series. The majority of authors have not had any open conversions after passing their first 20 cases.

Table 3
Recent Published Results of Laparoscopic Adrenalectomy

Authors	*Number of patients*	*Surgical approach*	*Operative times (min)*	*Complication rate (%)*	*Mortality rate (%)*	*Open conversion rate (%)*
Guazzoni et al. 2001 *(8)*	161	Trans	160	2.8	0	NR
Henry et al. 2000 *(14)*	169	Trans	129	7.5	0	5.0
Porpiglia et al. 2001 *(10)*	72	Trans	130	16	0	4.0
Valeri et al. 2001 *(12)*	78	Trans	94-120	2.6	1.3	2.6
Lezoche et al. 2000 *(13)*	108	Trans	NR	2.8	0.9	0.9
Terachi et al. 2000 *(11)*	311	Trans	NR	8	0	3.2
Terachi et al. 2000 *(11)*	59	Retro	NR	12	0	5.1
Saloman et al. 2001 *(9)*	115	Retro	118	15.5	0	0.8
Bonjer et al. 2000 *(7)*	111	Retro	114	11	0.9	5.0

Table 4
Comparison of Laparoscopic to Open Adrenalectomy

Authors	*Surgical approach*	*Number of patients*	*Operative times (min)*	*Blood Loss (mL)*	*Length of stay (d)*
Gill et al. 1999 *(18)*	Open	100	219	563	7.6
	Laparoscopic	110	189	125	1.9
Winfield et al. 1998 *(16)*	Open	17	140	266	6.2
	Laparoscopic	21	219	183	2.7
Thompson et al. 1997 *(15)*	Open	50	126	NR	5.7
	Laparoscopic	50	168	NR	3.1
Hazzan et al. 2001 *(17)*	Open	28	139	NR	7.5
	Laparoscopic	28	188	NR	4.0

Multiple retrospective comparisons have been made between contemporary laparoscopic series and matched open surgical series *(15–18)*. On average, operative times in these reports have been significantly longer in the laparoscopic groups, although recent series have shown improvements in speed with OR times now approaching older open series. Blood loss has been consistently lower in laparoscopic patients.

Most striking are the patient comfort parameters. Mean analgesic use, length of hospital stay, and time of convalescence are all markedly lower in the laparoscopic groups. Further improvements in these parameters have been noted in several series of Needlescopic patients, although the authors admit that this is more likely related to improving surgeon skill and experience than true superiority of the instrumentation. These retrospective comparisons are presented in Table 4.

Morbid obesity has been associated with increased operative times and with increased blood loss *(4)*. This is not surprising when considering the redundant retroperitoneal fat that is encountered in these patients. All authors stress, however, that these outcomes would have been expected during open surgery as well and should not be taken as an argument against the laparoscopic techniques.

To date, there have been no reports of trocar site seeding of adrenal carcinoma in the literature despite previous reports of renal, gastrointestinal, and gynecologic tumor recurrence within trocar sites. This is, however, an area of great concern because a significant percentage of all procedures are performed for lesions that meet size or other radiographic criteria for an increased risk of harboring a malignancy. There is a least one reported series of pheochromocytosis within the surgical bed of three patients who underwent laparoscopic adrenalectomy for known pheochromocytomas *(19)*. Although the patients are not members of a known MEN syndrome, they all had large lesions ranging from 5.5–6.5 cm. The authors conclude that a more careful handling of the tissues can avoid trauma to the lesion during the procedure and should therefore avoid this significant late complication. However, they also note that long-term follow-up data for this and other lesions are not well-represented in the literature.

TAKE HOME MESSAGES

1. Laparoscopic adrenalectomy has become the standard of care for all small (less than 5 cm), nonmalignant adrenal masses. The use of this technique for larger masses and for malignant tumors is still being debated in the literature.
2. Both the transperitoneal and the retroperitoneal approach have proven safe and efficacious. The choice of approach depends on patient body habitus and surgeon experience.
3. Early control of the adrenal vein is essential in all cases involving a pheochromocytoma and those lesions that may harbor a malignancy. The retroperitoneal approach may facilitate this maneuver.
4. Early entry into Gerota's fascia can facilitate the search for the adrenal gland in those patients with significant obesity and abundant retroperitoneal fat.

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13 Laparoscopic Live Donor Nephrectomy

Li-Ming Su, MD

CONTENTS

INTRODUCTION

Advances in renal transplantation and transplant immunobiology have made tremendous strides in improving the quality of life of individuals suffering from end-stage renal disease (ESRD), offering them a independent lifestyle free from dialysis. Since the 1950s, continued discoveries and implementation of new immunosuppressive regimens have led to an improvement of renal allograft survival as well as overall survival of the renal transplant recipient. Although substantial advances have been made with respect to the treatment and management of the renal transplant recipient, less has occurred with respect to the donor patient until recently.

Prior to 1995, the standard method of organ procurement was open donor nephrectomy performed either through a flank, subcostal, or transabdominal incision. Even for those donors with the very best of intentions, this operation was associated with considerable disincentives to organ donation, including the prospects of undergoing an invasive operation with the possibility of postoperative pain, a long hospital stay and convalescence, lost wages, and a poor cosmetic outcome. The impetus for the development of a less invasive technique for renal allograft procurement was based on two observations. The first observation was the widening gap between the supply and demand for renal allografts as evidenced by statistics compiled by the United Network for Organ Sharing (UNOS) organization *(1)*. In 1995, a total of 10,954 renal transplants (cadaveric plus living) were performed in the United States as compared to 31,149

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
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patients with ESRD who remained on the waiting list, with an additional 1,543 patients dying while awaiting renal transplantation by the end of the year. Although the total number of renal allografts in 1995 had increased by 17% from 1990, the number of individuals on the waiting list increased disproportionately by 74% and the number of patients who died increased by 61%. The second observation was that live renal allografts had significant advantages over those of cadaveric allografts including superior allograft and patient survival rates, shorter waiting periods for transplantation, closer human leukocyte antigen (HLA) matching, shorter cold ischemic times, and overall reduced immunosuppression requirements *(2)*. Despite these advantages, the number of live renal transplants performed in 1995 (i.e., 3,359) accounted for less than one-third of the total number of transplants performed *(1)*. Taken together, live donor kidneys remained a very valuable, but underutilized source of allografts, limited only by the willingness of family members and friends to donate a kidney to a loved one.

In 1995, Ratner and Kavoussi performed the first laparoscopic live donor nephrectomy, an operation that was devised to reduce the disincentives to live kidney donation in hopes of increasing the pool of live donor candidates *(3)*. Since its inception, laparoscopic live donor nephrectomy has made a substantial impact on the treatment and outcome of the donor patient by providing a less invasive alternative to renal donation. This technique has resulted in significantly less postoperative pain, shorter hospital stays, reduced postoperative convalescence, and improved cosmesis without jeopardizing either donor safety or the quality of allograft provided to the recipient *(4–11)*. Herein we describe our current step-by-step technique for laparoscopic live donor nephrectomy.

PREOPERATIVE ASSESSMENT

Patient Selection

All donor candidates require extensive medical and psychological evaluation in accordance with guidelines published by the American Society of Transplant Physicians *(12)*. The transplantation team must carefully evaluate the donor's motivation and emotional stability. In addition, donor candidates must undergo a battery of laboratory studies for histocompatibility testing and to ensure that the patient will be left with normal renal function following unilateral nephrectomy. Standard blood tests include a complete blood count, serum chemistries, coagulation profile, ABO histocompatibility, and HLA crossmatching. Other serologic tests include that for hepatitis B and C, syphilis, human immunodeficiency virus (HIV), cytomegalovirus (CMV), Epstein-Barr virus (EBV), and varicella. Urine tests include a urinalysis, urine culture, and a 24-h urine collection for creatinine clearance and protein.

Radiographic Evaluation

Laparoscopic donor nephrectomy requires accurate preoperative radiographic imaging especially of the renal vasculature. Preoperative mapping of the precise number and location of the main renal vessels as well as the presence of any aberrant vessels is helpful in planning the dissection and minimizing vascular complications. For this purpose, we have used dual-phase spiral computed tomography (CT) with three-dimensional angiography in lieu of standard angiography plus intravenous pyelography. Three-dimensional CT angiography can depict subtleties in renal vascular anatomy and

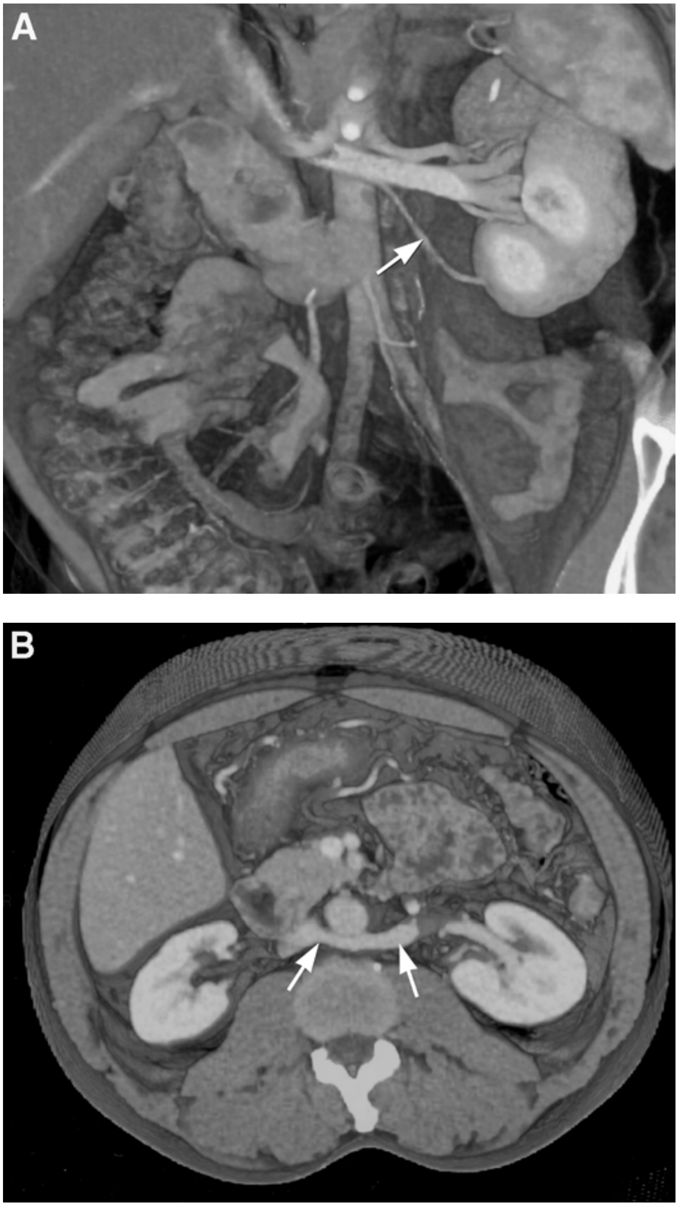

Fig. 1. Three-dimensional CT angiography demonstrating **(A)** a second left lower pole renal artery (white arrow) and **(B)** a retroaortic left renal vein (white arrows) in two separate donor patients.

is valuable in planning both the donor and recipient operation especially when multiple renal arteries or veins are identified (Fig. 1).

Patient Preparation

Patients are advised to remain on a clear liquid diet the entire day prior to surgery. The patient fasts after midnight the evening prior to surgery. No specific bowel preparation is required.

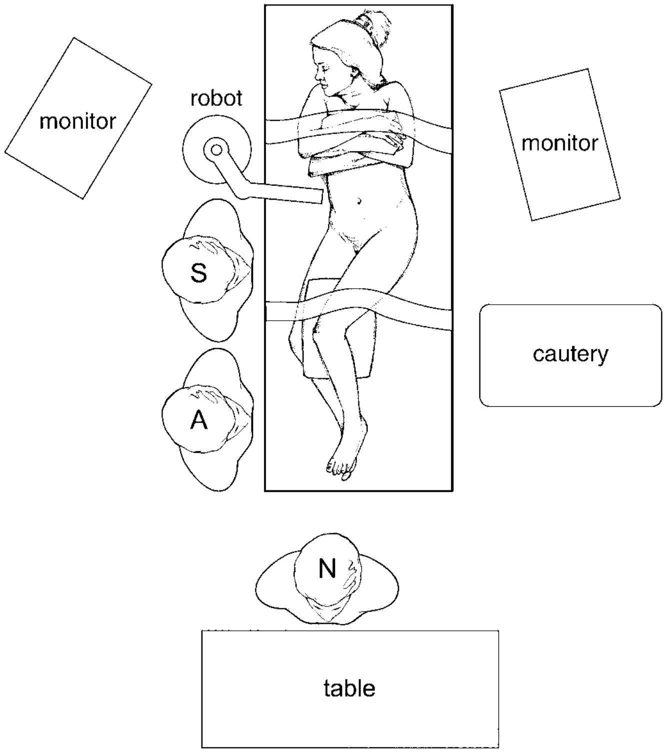

Fig. 2. Patient positioning and operating room configuration for left laparoscopic live donor nephrectomy. S, surgeon; A, assistant; N, scrub nurse/technician.

OPERATING ROOM SET-UP

Personnel and Equipment Configuration

In addition to the operating surgeon, laparoscopic live donor nephrectomy requires the following personnel: surgical assistant, scrub technician, circulating nurse, and anesthesia team. Both the operating surgeon and assistant stand on the abdominal side of the patient, contralateral to the targeted kidney. The scrub nurse and equipment table are situated near the surgical team at the foot of the table. The operating table must be adjustable and allow for lateral rotation. Two towers or cabinets, equipped with a color video monitor mounted at eye level, light source, and carbon dioxide (CO_2) insufflator, are placed on either side near the head of the table to allow the operating surgeon, assistant, and scrub technician to continuously monitor the surgical procedure. A video camera is attached to the laparoscope during the procedure and provides a sharp color image of the surgery, projected on both video monitors. A standard monopolar electrocautery unit is placed either in front or behind the operating surgeon. If the AESOP® (Computer Motion, Inc., Goleta, CA) robotic arm is employed to stabilize and control the laparoscope, it should be attached to the operating table on the side contralateral to the targeted kidney and at the level of the patient's shoulders, taking great care to ensure that it does not come in contact with the patient's hands, arms, or shoulder during maneuvering of the robotic arm. A typical operating room (OR) configuration for a left laparoscopic live donor nephrectomy is shown in Fig. 2.

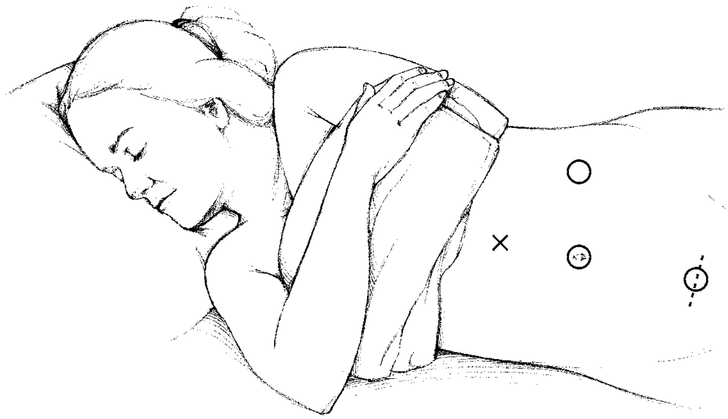

Fig. 3. Trocar configuration for left laparoscopic live donor nephrectomy. X, 5-mm trocar; O, 12-mm trocar. The kidney is delivered through a 5–6 cm Pfannenstiel incision (dotted line).

Patient Positioning

Prior to patient positioning, the entire operating table is padded to reduce the risk of neuromuscular injuries. A 5–6 cm Pfannenstiel incision marking the eventual delivery site of the kidney is drawn with a marking pen across the lower abdomen 2–3 fingerbreadths above the pubic symphysis prior to rotating the patient to ensure symmetry when the incision is later created (Fig. 3). Sequential compression stockings are placed on the lower extremities. After induction of general endotracheal anesthesia, the patient is given one dose of intravenous cephazolin. An orogastric tube and Foley catheter are placed to decompress the stomach and bladder, respectively. The patient is placed in a modified flank position at a 45° angle with the operating table with the ipsilateral flank facing upwards. A sand bag is placed posterior to the ipsilateral flank for support. The arms are crossed over the chest and padded with egg crate padding or pillows (Fig. 3). This is performed to ensure that the patient's hands and arms do not rest on the AESOP robotic arm. Alternatively, if the AESOP robotic arm is not utilized, the arms can be kept outstretched on an arm board with sufficient padding placed between the arms. Neither an axillary roll nor flexion of the table is required. The hips are rolled slightly posterior to allow exposure of the lower abdomen and eventual delivery site (i.e., Pfannenstiel incision) of the renal allograft. The dependent leg is gently flexed at the knee and pillows are placed between the legs. The patient is secured to the operating table with 2-inch heavy cloth tape at the level of the shoulders and thighs. Additional egg crate sponge padding is placed over the shoulder and hips to prevent compression injuries as a result of the cloth tape. The operating room table is rotated to the extreme lateral limits to ensure that the patient is adequately secured to the table.

Trocar Configuration

Our technique of laparoscopic donor nephrectomy requires four trocars (one 5-mm, three 12-mm) as depicted in Fig. 3. The 5-mm trocar is place below the xiphoid process in the abdominal midline, halfway between the umbilicus and xiphoid process. A 12-mm trocar is placed at the level of the umbilicus just lateral to the rectus muscle to avoid injury to the epigastric vessels. These two trocars serve as the main working trocars. A 12-mm trocar placed at the umbilicus is utilized for the laparoscope. A third 12-mm trocar is inserted in the middle of the planned Pfannenstiel incision and is used for retraction of the colon, mesentery, and small bowel. This trocar site is eventually extended transversely on either sided to a total length of 5–6 cm to accommodate extraction of the renal allograft at the end of the operation.

Instrumentation and Medications

In performing laparoscopic live donor nephrectomy, specific instrumentation is required. Table 1 lists necessary laparoscopic instrumentation and medications. Optional equipment is also listed.

OPERATIVE TECHNIQUE

Laparoscopic procurement of the left kidney is preferred owing to the longer renal vein obtained as compared to that of the right kidney and therefore is discussed first in great detail. The technique for right laparoscopic donor nephrectomy and options for maximizing renal vascular length is also described. Finally, the technique of hand-assisted laparoscopic nephrectomy is described.

Left Laparoscopic Live Donor Nephrectomy

Obtaining Access and Insufflating the Abdomen

In order to obtain access to the peritoneal cavity for insufflation of the abdomen, a Veress needle is inserted into the base of the umbilicus. For patients with prior abdominal surgery, other sites of access include the right upper quadrant 2–3 finger-breadths below the costal margin, or the right or left lower quadrant, lateral to the rectus muscles. Great care must be taken to manually stabilize on the anterior abdominal wall during insertion of the Veress needle to prevent injury to intraperitoneal organs, including the bowel, liver, spleen, gallbladder, kidney, inferior vena cava (IVC), aorta, or iliac vessels depending on the site of insertion. The Veress needle should be inserted directly perpendicular to the skin surface in a steady and deliberate manner. Placing the wrist on the abdominal wall for stabilization can minimize any jerk or past pointing of the needle during advancement. To test the position of the needle once inserted, a small amount of sterile saline can be placed into the hub of the Veress needle and should enter the peritoneum without resistance or backpressure. The insufflation tubing is connected to the end of the Veress needle and CO_2 gas is infused initially at a low flow rate (i.e., 1 L/min). If the needle is in proper position, a reading of low intraperitoneal insufflation pressures (usually less than 10 mmHg) should be noted. If a high insufflation pressure is detected, the Veress needle should be immediately removed and the above steps repeated. Once proper positioning of the Veress needle is confirmed, the flow rate on the insufflator is increased to a high setting. If proper technique is used, a four-quadrant pneumoperitoneum is achieved. The peritoneal cavity is insufflated to a target pressure of 15–20 mmHg.

Trocar Placement

A No. 15 scalpel blade is used to create a 1-cm horizontal skin incision in the left lower quadrant, just lateral to the rectus muscle and at the level of the umbilicus. A 10-mm 0° laparoscopic lens is placed into the Visiport device (U.S. Surgical Corporation, Norwalk, CT) with a preloaded 12-mm laparoscopic trocar. The Visiport is inserted into the incision staying perpendicular to the skin surface and access is

Table 1
Laparoscopic Instrumentation and Medications

Instruments
- Veress needle
- Debakey forceps
- Suction/irrigator device and probe
- Electrocautery scissors
- Hand-held electrocautery device
- Visiport device (U.S. Surgical Corporation, Norwalk, CT)
- 5- and 10-mm vascular clip appliers
- 10-mm 0° and 30° laparoscopic lens
- Anti-fog lens solution and/or sterile hot water thermos
- Three 12-mm laparoscopic trocars
- One 5-mm laparoscopic trocar
- 15-mm Endocatch™ bag (U.S. Surgical Corporation, Norwalk, CT)
- 12-mm Endo Paddle retractor (Autosuture, U.S. Surgical Corporation, Norwalk, CT)
- 10-mm Endoscopic GIA stapling device™ (U.S. Surgical Corporation, Norwalk, CT)
- Three–four Endoscopic GIA vascular staple cartridges
- Carter-Thomason® (Inlet Medical, Eden Prairie, MN) fascial closure device
- Four–six 2-0 and 0-polyglactin sutures
- No. 10 and 15 scalpel blades
- 16 French Foley catheter
- 16 French orogastric tube
- Sterile ice slush and container (to cool and transport renal allograft)
- 1 L of ice-cold standard preservation solution (to perfuse harvested renal allograft prior to transplantation)
- Standard open nephrectomy tray and instrumentation with Bookwalter or Omni retractor (in case of open conversion)

Optional equipment
- AESOP Robotic Arm (Computer Motion, Inc., Goleta, CA)
- Electrocautery hook
- Bipolar electrocautery forceps
- Ultrasonic shears

Medications
- Cephazolin (1 gram i.v.)
- Protamine (30 mg i.v.)
- Furosemide (40 mg i.v.)
- Mannitol (12.5 g i.v. × 2 doses)
- Heparin (3000 U i.v.)
- Papavarine (30 mg/mL solution, 10–20 mL total)

gained into the peritoneal cavity under direct laparoscopic view by firing the trigger device, which deploys a small cutting knife at the tip of the Visiport. Steady forward pressure with rotational movement of the Visiport between each firing of the device can help define and incise separate layers of the abdominal wall as well as help to identify and avoid subcutaneous blood vessels. To prevent unnecessary bleeding, great care must be used to avoid transection of these subcutaneous vessels by incising adjacent and parallel to the vessels. Once access is gained into the peritoneum, the insufflation tubing is connected to the 12-mm trocar. The abdomen and its contents are carefully

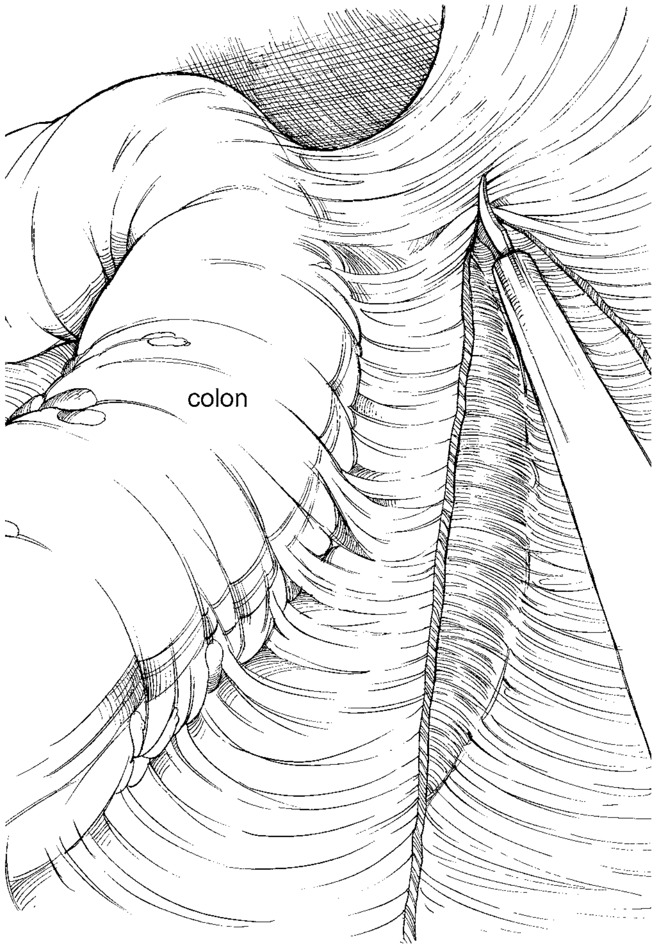

Fig. 4. Incising the line of Toldt along the descending colon.

inspected to identify any adhesions, as well as to confirm atraumatic insertion of the Veress needle. The Veress needle is then removed.

The 0° lens is replaced with a 10-mm 30° lens, which is utilized during the remainder of the operation. A second 12-mm trocar is inserted through the umbilicus and a 5-mm trocar inserted in the midline between the umbilicus and xiphoid process under laparoscopic view. The final 12-mm trocar is inserted through the middle of the planned Pfannenstiel extraction site (*see* Trocar Configuration). Once in place, all trocars are secured to the skin with 0 polyglactin suture on the side *opposite* the kidney to allow for optimum range of motion without placing tension on the skin sutures.

Step 1: Reflecting the Colon

With Debakey forceps in the 5-mm trocar and laparoscopic electrocautery scissors placed in the left lower quadrant 12-mm trocar, the line of Toldt along the descending colon is sharply incised from the splenic flexure down to the pelvic inlet (Fig. 4). Only the peritoneal attachments between the colon and lateral sidewall should be released at this time. Inadvertent release of the deeper lateral attachments of the kidney can result in the kidney dropping medially and obscuring the renal hilum, making dissection of the renal vessels more difficult. Electrocautery should be minimized while reflecting

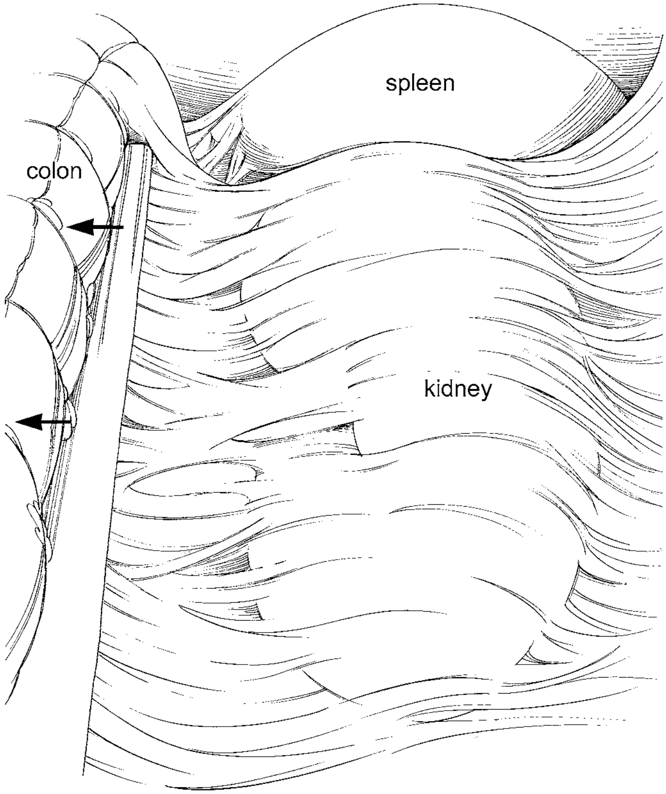

Fig. 5. Medial retraction of the colon and mesentery using a 15-mm Endocatch device (bag closed).

the colon in order to avoid accidental burn injury to the bowel. The operating table is maximally rotated towards the operating surgeon to allow the colon to fall medial and away from the kidney. The colon is bluntly dissected with a suction-irrigator device in a medial direction, exposing Gerota's fascia overlying the kidney. Great care must be taken to develop the precise plane between Gerota's fascia and the mesentery of the colon. Dissecting too close to the colonic mesentery can result in inadvertent injury to the mesenteric vessels or creating a defect in the mesentery. Likewise, entering and dissecting within Gerota's too prematurely will result in excessive bleeding and may compromise exposure of the renal hilum. The mesenteric fat may often times be difficult to distinguish from Gerota's fat but is typically a brighter shade of yellow. If a defect within the mesentery is created, this should be closed laparoscopically with 3-0 polyglactin sutures to minimize the chance of an internal hernia.

A 15-mm Endocatch device may be placed at this time for retraction of the colon and small bowel (Fig. 5). To accomplish this, the 12-mm trocar located along the middle of the Pfannenstiel incision is removed and the tract bluntly dilated with the surgeon's index finger. This allows the 15-mm Endocatch device to fit snugly within the tract without continuous loss of pneumoperitoneum during the remaining steps of the operation. The purpose of the Endocatch device is twofold. First, without deploying the bag (i.e., bag closed), this device is used during the initial steps of the operation as a blunt retractor to facilitate medial reflection of the colon and to provide optimum exposure of the renal hilum. Second, the Endocatch device can be left in place during the remaining steps of the operation until the end of the procedure, at which time the

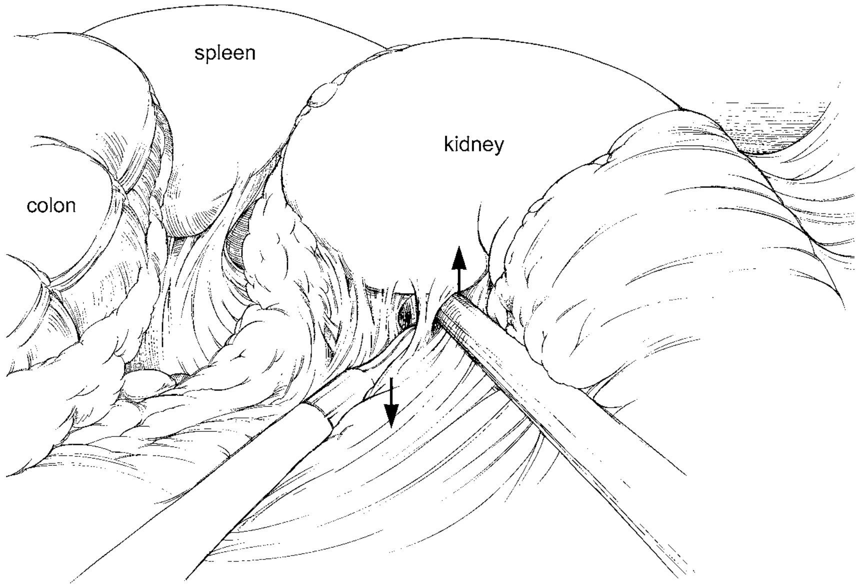

Fig. 6. Dissection of the upper pole of the kidney. As one instrument is used to elevate the upper pole, the second instrument is used to bluntly dissect the posterior attachments.

bag is deployed, thus serving as the device for entrapment and delivery of the kidney. As an alternative to the Endocatch device, a 12-mm Endo Paddle retractor (Autosuture, U.S. Surgical Corporation, Norwalk, CT) may be placed through the 12-mm trocar and used to retract the bowels.

Step 2: Exposing the Upper Pole of the Kidney

Gerota's fascia is incised sharply along the anterior aspect of the upper pole, exposing the renal capsule. With a laparoscopic Debakey forceps in the left hand and a suction/irritation device in the right hand, the upper pole is gradually freed from within Gerota's fascia using mainly blunt dissection. While one instrument is used to elevate the upper pole, the second instrument is used to bluntly dissect the posterior upper pole attachments (Fig. 6). Great care must be taken to avoid injury to any upper pole renal vessels that may course in this location. As mentioned previously, preoperative three-dimensional CT angiography is helpful in identifying the presence of multiple renal arteries and veins. However, despite preoperative imaging, one must maintain vigilance during dissection of the upper pole in identifying and sparing any crossing vessels in this region. By the end of this step, the entire upper pole should be free, allowing it to rest atop the lower edge of the spleen.

Step 3: Dissecting the Ureter

In efforts to avoid skeletonizing the ureter with resultant devascularization, a generous "V"-shaped packet of periureteral tissue (i.e., mesoureter) should be maintained along with the ureter from the lower pole of the kidney down to the pelvic inlet (Fig. 7). Dissection is first carried out *medial* to the gonadal vein, bluntly sweeping this structure and the periureteral tissues in a lateral direction. Similar to the dissection of the upper pole of the kidney, one instrument is placed beneath the ureteral packet, elevating it anteriorly, while the other instrument bluntly dissects the posterior attachments. The

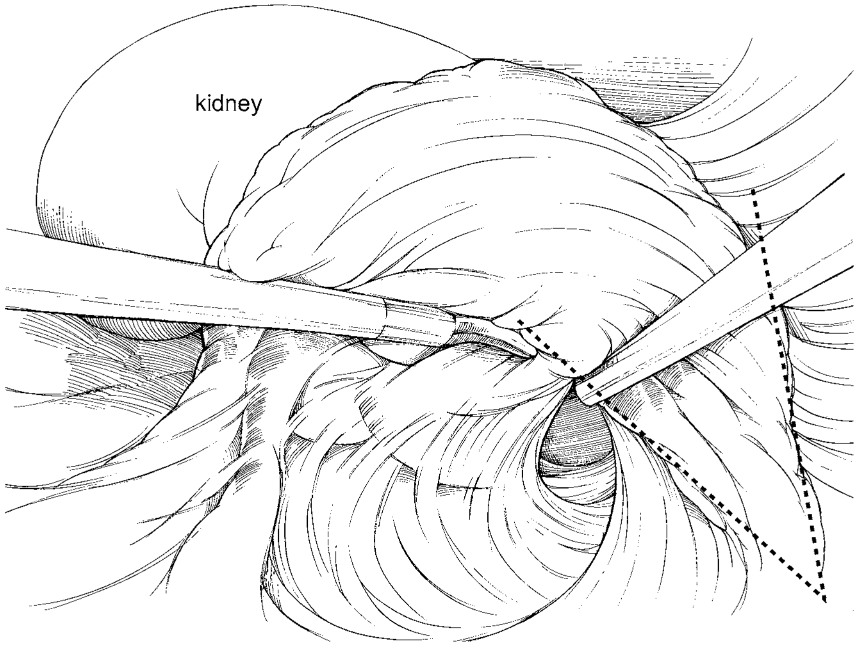

Fig. 7. Dissection of the ureter, maintaining a generous "V"-shaped packet of surrounding mesoureter (dotted line).

fascia overlying the psoas muscle is an important landmark, which defines the posterior margin of the ureteral dissection. The plane between the ureteral packet and psoas fascia is often avascular. Great care must be taken to avoid dissecting beneath the psoas fascia where bleeding from the psoas muscle is often encountered. Once the left abdominal sidewall is reached, this posterior dissection is continued superiorly to the renal hilum and inferiorly to the iliac vessels. Hemostatic clips are applied to small perforating vessels and lymphatics. Electrocautery is used sparingly to prevent transmission of thermal injury to the ureter and its delicate blood supply. A conscious effort should be made to avoid any direct manipulation of the ureter. The ureter should never be cleanly dissected or even visualized until it crosses the iliac vessels. By staying medial to the gonadal vein, this ensures that the dissection is not carried out too close to the ureter, jeopardizing injury to its delicate blood supply. Because the only ureteral blood supply that remains intact arises from the renal artery, dissection between the renal artery and proximal ureter should be avoided. At the end of this step, the ureter is left intact and is not divided until the entire kidney and renal vessels are completely dissected.

Step 4: Dissecting the Renal Vein and Artery

From the start of the operation, the patient should be aggressively hydrated to maintain a high intravascular volume status, optimize renal perfusion, and combat the effects of pneumoperitoneum on renal blood flow. Six to seven liters of crystalloid are routinely administered during the course of this operation. Mannitol (12.5 gm) is administered intravenously prior to dissection of the renal pedicle to stimulate a brisk diuresis. As an indication of adequate hydration, the renal vein should appear plump and full prior to dissection of the renal vessels. At this stage, the lateral, posterior, and inferior attachments to the kidney are still maintained, creating a three-point fixation

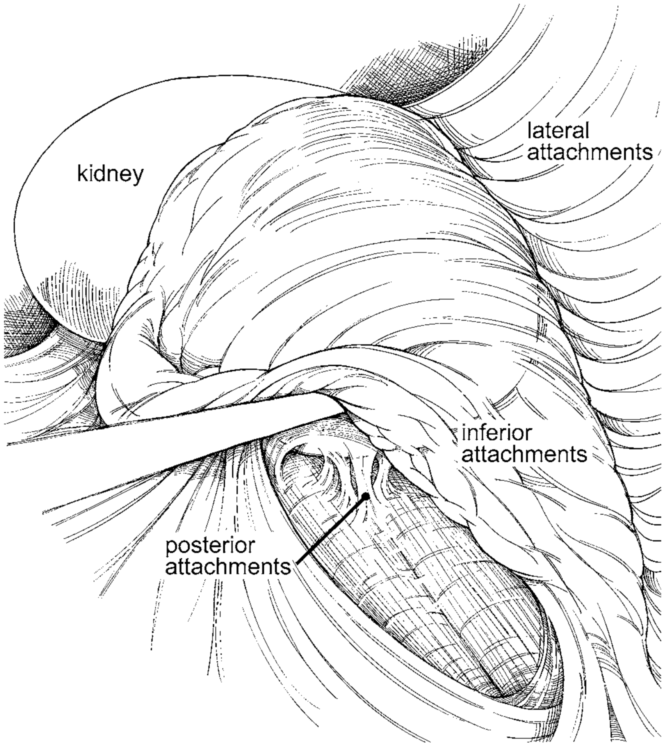

Fig. 8. The inferior, posterior, and lateral attachments of the kidney provide a three-point fixation of the kidney to the retroperitoneum.

(Fig. 8). Leaving these attachments intact during the dissection of the renal hilum limits the mobility of the kidney and prevents the kidney from dropping medially and obscuring the renal hilum. This also prevents inadvertent kinking or torsion of the kidney about its vascular pedicle during the operation.

The renal pedicle is placed on gentle traction by elevating the ureteral packet and lower pole of the kidney, thus facilitating identification and dissection of the renal vein and artery using primarily blunt dissection (Fig. 9). Sharp dissection is used sparingly around the renal pedicle and is performed with great care to minimize the chance of iatrogenic injury to the renal vessels and their branches. Hemostatic clips are applied to the adrenal and any lumbar veins prior to transection. The renal artery is dissected completely to its origin with the aorta and the renal vein dissected as far medial beyond the adrenal vein as possible in order to achieve maximal renal vascular length. For optimal exposure of the renal vessels, the 15-mm Endocatch device or paddle retractor is utilized for medial retraction of the surrounding colon, mesentery, and small bowel. Topical papavarine (30 mg/mL) may be applied to the renal artery periodically to minimize vasospasm. The renal vessels should be skeletonized of all of their surrounding perivascular and lymphatic tissues. The electrocautery hook, bipolar forceps, or ultrasonic scalpel may be used to divide these connective tissues. Hemostatic clips can also be used, but should be avoided especially near the origin of the renal vessels as they may become entrapped within the endoscopic GIA stapler and cause misfiring of this device at the time of transection of the renal vessels. At the end of the dissection of the renal vessels, furosemide (40 mg) and a second dose of mannitol (12.5 gm) are administered intravenously.

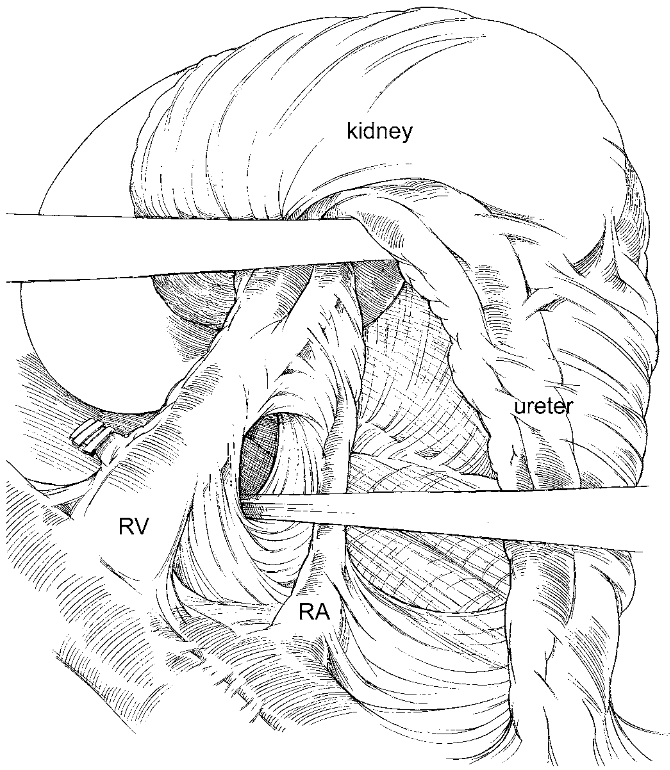

Fig. 9. Dissection of the renal vessels and perivascular connective tissue. RV, renal vein; RA, renal artery. Left adrenal vein stump is seen clipped.

If bleeding from the renal vessels or their branches occurs, direct pressure should be applied to the point of bleeding when possible using a laparoscopic instrument or 4×8-inch sterile gauze introduced through a 12-mm trocar. In addition, the insufflation pressure can be increased temporarily to help tamponade any ongoing bleeding. Small venous injuries will often subside with these two maneuvers. Larger venous or arterial injuries often require open conversion. Although certain vascular injuries may be managed laparoscopically, the author emphasizes the importance of having a low threshold for open conversion in efforts to both minimize donor morbidity and preserve renal allograft function. If open conversion is deemed necessary, pressure should be maintained at the point of bleeding with laparoscopic control until the necessary equipment is available and the proper incision is made exposing the renal hilum. Standard equipment and instrumentation used in open donor nephrectomy should *always* be kept available in the operating room. Either a standard flank or midline incision can be used for open conversion.

Step 5: Preparing the Kidney Extraction Site

The extraction site of the kidney is prepared at this time by extending the Pfannenstiel incision transversely on either side of the Endocatch device to a total length of approximately 5–6 cm. A generous subcutaneous pocket is created cephalad and caudad just above the level of the anterior rectus fascia to provide sufficient room for extraction of the kidney. The rectus fascia and underlying peritoneum are left intact, thus preserving the pneumoperitoneum.

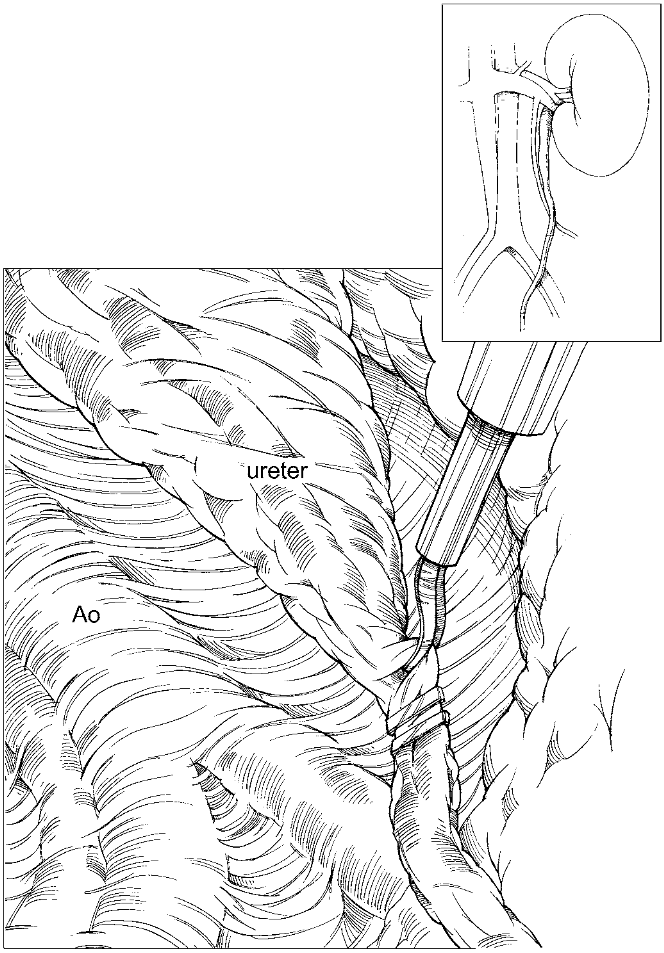

Fig. 10. Hemostatic clips are applied to the distal ureter at the level of the iliac vessels prior to transection. Alternatively, an endoscopic GIA stapling device can be used. Ao, aorta.

Step 6: Transecting the Gonadal Vessels and Ureter

When the transplantation team is prepared to receive the kidney, the gonadal vessels and ureter are transected distally at the level of the iliac vessels using either an endoscopic GIA stapler or hemostatic clips (Fig. 10). In a well-hydrated patient, urine is usually seen emanating from the proximal end of the ureter following transection.

Step 7: Releasing the Inferior, Lateral, and Posterior Renal Attachments

At this point, the remaining inferior, lateral, and posterior attachments to the kidney can be safely released. A combination of sharp and blunt dissection is used to release Gerota's fascia from the lateral and posterior aspect of the kidney down to the renal capsule. The Gerota's fat surrounding the lower pole and proximal ureter is left intact. It is important that the renal artery and vein remain as the *only* attachments to the kidney at the end of this step (Fig. 11).

Step 8: Transecting the Renal Vessels

Prior to transection of the renal artery and vein, the patient is given 3000 U of intravenous heparin sulfate. The laparoscope is moved to the left lower quadrant trocar

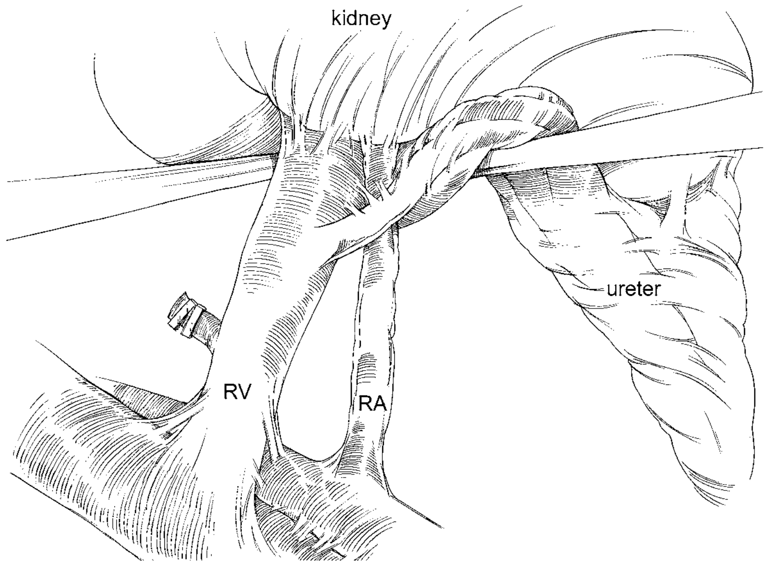

Fig. 11. Complete dissection of the kidney, renal vessels, and ureter. RV, renal vein; RA, renal artery.

to allow the endoscopic GIA stapling device to be placed through the umbilical trocar. This provides the best angle of approach for transection of the renal vessels with the stapling device. With the renal vessels on gentle traction, the endoscopic GIA stapler is applied first to the renal artery (Fig. 12) followed immediately by the renal vein using a second vascular load in the stapling device. The renal artery is divided at its origin with the aorta and the renal vein is transected as far medial beyond the adrenal vein stump as possible to ensure maximum renal vascular length for transplantation. If multiple renal vessels are present, all arteries should be transected prior to transection of the renal vein(s).

Step 9: Entrapping and Delivering the Kidney

To facilitate entrapment, the kidney is placed above the spleen after transection of the renal vessels. The 15-mm Endocatch bag, which should already be placed within the delivery site (Pfannenstiel incision), is now deployed below the spleen and the kidney is gently placed within the bag (Fig. 13). After ensuring that the entire kidney and ureter are within the bag, the ring cord of the Endocatch device is pulled, thus entrapping the kidney. A muscle-splitting longitudinal incision is made in the rectus fascia and underlying peritoneum along the linea alba using heavy scissors. The surgeon's hand is used to protect the intraperitoneal contents, taking great care not to injure either the bladder or bowel during this maneuver. The fascial and skin incisions should be made large enough to allow for atraumatic delivery of the kidney (Fig. 14). Once the kidney is delivered within the bag, it is passed off to the recipient transplantation team for immediate perfusion with ice-cold preservation solution.

Step 10: Inspecting the Renal Bed and Closing Abdominal Incisions

The patient is given 30 mg of intravenous protamine sulfate and the rectus fascia is closed with interrupted, 0-polyglactin suture. The abdomen is reinsufflated and the renal bed is inspected for bleeding under low insufflation pressure (e.g., 5–10 mmHg).

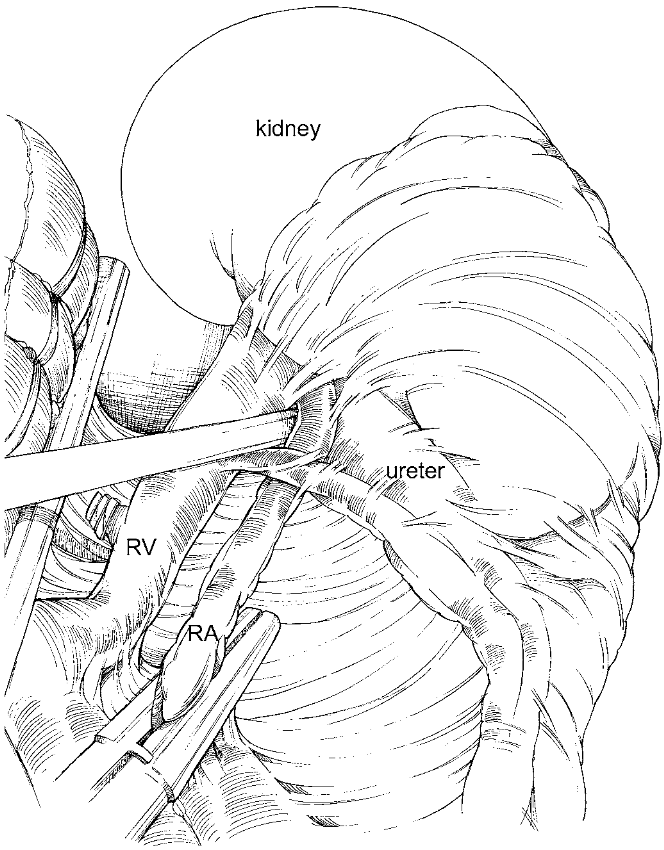

Fig. 12. Transection of the renal artery using an endoscopic GIA stapling device. RV, renal vein; RA, renal artery.

The nephrectomy bed should be copiously irrigated using the suction/irrigation device with meticulous hemostasis achieved using either bipolar forceps or electrocautery scissors. Special attention should be paid to inspecting the stump of the renal vessels. The colon and its associated mesentery, small bowel, spleen, and adrenal bed should be inspected closely for any bleeding or injuries. Once meticulous hemostasis is achieved, the 12-mm trocars are sequentially removed and the fascia closed with 2-0 polyglactin suture using the Carter-Thomason® fascial closure device (Inlet Medical, Eden Prairie, MN) under laparoscopic view. The 5-mm trocar site typically requires no fascial closure. The abdomen is desufflated of all CO_2 gas prior to removal of the last trocar.

Right Laparoscopic Live Donor Nephrectomy

For a right-sided laparoscopic donor nephrectomy, trocar configuration is the mirror image of that used for a left-sided dissection. The steps used for dissecting the kidney are similar to that on the left, however, one of two modifications should be considered in efforts to preserve maximum length of the anatomically shorter right renal vein. In the fist modification, the placement of the endoscopic GIA stapling device is relocated so as to transect the right renal vein in a plane parallel to the IVC. In contrast to procurement of a left kidney where the stapling device is placed in the umbilical trocar

Fig. 13. Entrapment of the renal allograft using a 15-mm Endocatch bag. The kidney is placed above the spleen and lowered down into the bag to facilitate entrapment.

position, with procurement of a right kidney the stapling device is introduced into the right lower quadrant trocar port located lateral to the rectus muscle. This angle of approach allows the stapling device to transect the right renal vein directly at its junction and parallel with the IVC, thus preserving as much length of the right renal vein as possible. The kidney is subsequently delivered through a Pfannenstiel incision.

The second modification involves relocating the extraction site of the renal allograft. After completely dissecting the kidney, renal vessels, and ureter laparoscopically, a 5–6 cm transverse subcostal muscle-splitting incision is made directly overlying the renal hilum. This incision is used for open division of the renal vessels and for delivery of the renal allograft as an alternative to a Pfannenstiel incision. To optimize the length of the right renal vein, a Satinsky clamp may be placed on the IVC, allowing the renal vein to be transected along with a cuff of vena cava. The vena cava is subsequently closed with a nonabsorbable, monofilament suture after delivery of the renal allograft.

Hand-Assisted Laparoscopic Live Donor Nephrectomy

Hand-assisted laparoscopy allows a right-handed operating surgeon to place his or her left hand in the abdomen through a 6–8-cm incision (depending on the size of the surgeon's hand), using a pneumatic sleeve device to preserve the pneumoperitoneum. The surgeon can thus use the left hand inside the abdomen in concert with the right, which controls conventional laparoscopic instrumentation outside of the abdomen.

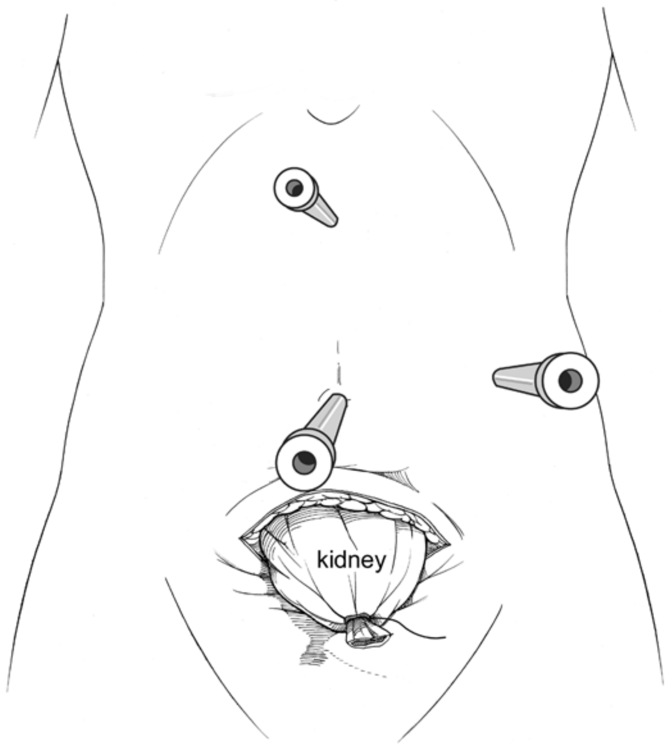

Fig. 14. Delivery of the renal allograft within the Endocatch bag through the Pfannenstiel incision. Three trocars remain in place to allow for inspection of the renal bed after delivery of the kidney.

The intraperitoneal hand can be used to provide tactile sensation, expose, dissect, and retract tissues, as well as secure hemostasis.

In performing hand-assisted laparoscopic donor nephrectomy, any of the commercially available hand-assistance port devices can be utilized. Selection of the proper incision site for placement of the hand-assist device is important. For a left-sided donor nephrectomy, either a periumbilical or infraumbilical midline incision can be used for the hand-assist device. A 30° laparoscopic lens is introduced through a 12-mm trocar placed along the anterior axillary line at the level of the umbilicus. The working trocar is placed lateral to the rectus muscle just below the level of the umbilicus. For a right-sided donor nephrectomy, the incision for the hand-assist device is made in the right lower quadrant along a muscle-splitting incision (i.e., Gibson incision) and the umbilicus serves as the working trocar. The laparoscope is placed in the abdominal midline, halfway between the xiphoid process and umbilicus. For retraction of the liver, a blunt 5-mm laparoscopic instrument can be introduced through a trocar placed either below the xiphoid process or along the anterior axillary line above the hand-assist device.

Dissection of the kidney and renal vessels is carried out in a similar fashion to conventional laparoscopic techniques. Instead of the Endocatch device, the left hand is used to reflect and retract the bowel contents. The intraperitoneal hand is useful in elevating the kidney during transection of the renal vessels, thus optimizing renal vascular length. After transection of the renal vessels, the kidney is delivered directly through the hand-assist port and does not require entrapment within a bag.

RESULTS

Since its inception in 1995, laparoscopic live donor nephrectomy has had a substantial impact on the donor operation by providing a less invasive approach to kidney procurement as compared to open donor nephrectomy. This has resulted in less postoperative pain and shorter hospitalizations and postoperative convalescence for the donor patient while maintaining a high-quality allograft for the recipient *(4–11)*. Donor complications have remained low and comparable to open donor nephrectomy series *(13)*. Ureteral complications have declined with modifications in surgical technique *(14,15)*. Immediate as well as long-term renal allograft function has paralleled that of kidneys procured by open surgical techniques *(5,16)*.

TAKE HOME MESSAGES

The technique of laparoscopic live donor nephrectomy requires substantial technical skill and knowledge of renal vascular anatomy in order to successfully procure a healthy, functioning renal allograft suitable for transplantation. Whether using conventional or hand-assisted laparoscopic techniques, adherence to the following four principles is important.

1. Maintaining the Renal Attachments During Dissection of the Renal Hilum. In order to facilitate identification and dissection of the renal vessels, it is crucial that the lateral, posterior, and inferior renal attachments remain intact until the renal vein and artery are completely dissected to their origin with the inferior vena cava an aorta respectively. These three attachments fix the kidney to the retroperitoneum, minimizing its mobility, and preventing the kidney from dropping medially and obscuring the renal hilum. These attachments also prevent kinking or torsion of the kidney about its renal pedicle.
2. Exposure of the Renal Hilum. Just as in open surgery, proper exposure of the renal hilum for dissection of the renal vessels is crucial. Complete medial reflection of the ipsilateral colon is an important initial step in providing the necessary exposure of the renal hilum. Placement of the Endocatch device early on during the laparoscopic dissection of the kidney provides an excellent blunt retractor for medial retraction of the colon and further exposure of the renal hilum. However, the author cautions that the terminal end of the Endocatch device is not blunt and therefore should be used gently during retraction. In addition, great care must be taken to avoid contacting the Endocatch device when using cautery during the operation, because this device is not insulated and can therefore transmit electrical current to adjacent tissues. Alternatively, an insulated paddle retractor can be used for retraction of the bowels. With the exposure provided by either the Endocatch device or paddle retractor, the renal vessels are easily visualized and dissected back towards their origin with the great vessels. Inadvertent injury to these structures and their branches is thus minimized.
3. Dissection of the Renal Hilum. Minimizing sharp dissection and electrocautery around the renal hilum is important in preventing inadvertent injury to the main renal vessels. Blunt dissection should primarily be used. When dissecting the perivascular tissue, hemostatic clips should be used judiciously. Excessive use of clips especially around the origin of the renal vessels can pose significant problems when transecting the renal vessels. These clips can become lodged within the endoscopic GIA stapling device resulting in incomplete transection of the renal vessels. This can result in

significant bleeding, often requiring emergent open conversion. As an alternative, the electrocautery hook, bipolar electrocautery, or ultrasonic shears can be used instead of clips to transect the often abundant perivascular lymphatic and connective tissues. The renal artery and vein should be skeletonized and dissected back to their origin with the aorta and vena cava, respectively, to optimize renal vascular length.

4. Dissection of the Ureter. The blood supply to the transplant ureter is based solely upon branches of the renal artery. Therefore, maintaining abundant mesoureter and minimizing ureteral dissection especially between the renal artery and proximal ureter are important principles for optimizing the vascular integrity of the ureter and minimizing postoperative ureteral complications. The use of electrocautery around the ureter, as well as, direct manipulation of the ureter itself should be avoided. Blunt dissection is predominately used starting *medial* to the gonadal vein, sweeping this structure along with the ureter and mesoureter in a lateral and anterior direction. Ultimately a "V"-shaped packet of tissue should be maintained surrounding the ureter from the lower pole to the iliac vessels. The ureter should not be directly manipulated or even visualized until it crosses the iliac vessels, where it can be safely clipped and then transected.

ACKNOWLEDGMENT

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14 Laparoscopic Pyeloplasty

Sean P. Hedican, MD

CONTENTS

INTRODUCTION

Laparoscopic pyeloplasty as a treatment option for the obstructed ureteropelvic junction (UPJ) combines the advantage of an open reconstruction under direct magnified vision with the low morbidity of an endoscopic approach. First described as a minimally invasive treatment option by Schuessler and colleagues in 1993 *(1)*, there are now several large published series with extended follow-up confirming long-term patency rates of 96–100% *(2)*. These results parallel the outcomes of the prior gold standard approach (i.e., open pyeloplasty) and exceed what is observed with endoscopic incisional operations. As demonstrated with other minimally invasive operations, patients undergoing laparoscopic pyeloplasty have reduced analgesic requirements, hospital stays, and time until return of full activities compared to their open surgery counterparts *(3)*. Although technically challenging, the low incidence of failure combined with reduced postoperative morbidity has made this an increasingly popular treatment option at institutions offering this approach.

PATIENT SELECTION

As with most laparoscopic procedures, there are few contraindications to laparoscopic pyeloplasty. It has been utilized in the treatment of secondary as well as primary UPJ obstructions. Prior failed treatment approaches in patients with secondary UPJ obstructions undergoing successful laparoscopic pyeloplasty have included incisional and open operations. This technique is particularly advantageous in the reconstruction

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
Edited by: S. Y. Nakada © Humana Press Inc., Totowa, NJ

of the obstructed UPJ owing to anterior crossing vessels because the low-angle, 10–15-fold magnification aids in the delicate dissection around these structures. This procedure has also been successfully performed in patients with additional associated anomalies such as a horseshoe kidney, duplication, or nephroptosis.

The strongest relative contraindications to this approach include prepubertal children, owing to the delicate dimensions of the UPJ, and the presence of a small intrarenal pelvis. This latter condition limits mobility of the pelvis and requires intrahilar dissection, making laparoscopic as well as open reconstruction difficult. In such patients, an incisional procedure may be the preferred treatment option. Preoperative recognition of this condition is best made by careful inspection of the intravenous pyelogram or ultrasound. A retrograde pyelogram is often less helpful in judging the amount of extrarenal pelvis, because it does not outline the location of the parenchyma relative to the collecting system.

OPERATING ROOM SET-UP

The side on which the patient's UPJ obstruction exists determines the variables in the operating room set-up. The patient is placed in a semi-flank position as described here with the affected side up. The operating surgeon and first assistant stand on the contralateral side of the pathology facing the patient's abdomen while the second assistant and scrub nurse (or technician) stand on the opposite side of the table facing the primary surgeon (Fig. 1). This positioning facilitates direct passage of equipment by the scrub personnel across the table to the operating surgeon so that he or she does not have to reach behind, or to the side, to receive instruments. It is valuable to have a second assistant or robotic arm for the later portion of the procedure, especially in larger patients, because the spread of the trocars can lead to shoulder fatigue in the first assistant trying to maintain the camera while operating instruments from the lateral port site. Monitor towers should be positioned at approximately the location of the patient's shoulders and angled slightly toward the feet with screens at a comfortable eye level to the surgeons. The exact angulation and position is ultimately adjusted to the visual preference of the operating surgeon. The tower containing the insufflator, light source, and camera plug-in should be across from the primary surgeon to facilitate visual monitoring of the pressure recordings. The irrigation fluids are hung on one of the anesthetic poles at the head of the operative table. The Harmonic and electrocautery generator units are located near the patient's feet on the same side of the table as the operating surgeon. The nurse places his or her working table directly over the patient's lower legs. The back equipment tables are positioned in an L-configuration just foot-ward of the working table extending toward the scrub nurse to allow easy access to the equipment.

PATIENT PREPARATION AND POSITIONING

It is of great advantage to prepare the patient for this procedure by stenting the patient's obstructed ureter at least 1 wk prior to laparoscopic pyeloplasty. This allows for passive dilation of the UPJ and ureter, which will aid in performing the reconstruction. A stent that is at least one size (2 cm) longer than would normally be inserted based on the patient's height is selected. This additional length reduces the risk of pulling the stent into the distal ureter during its laparoscopic manipulation. A smaller stent caliber (i.e., 6 Fr) is also utilized because it provides a greater amount of space between

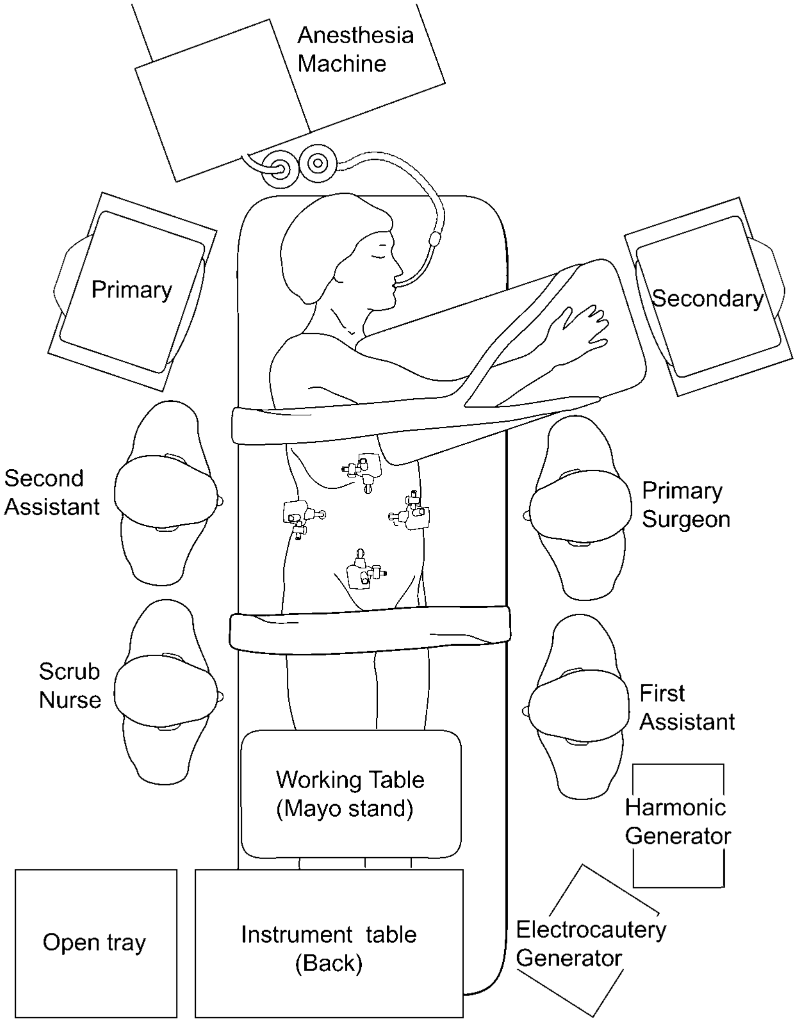


Fig. 1. Schematic representation of the operating room set-up and personnel arrangement for a right laparoscopic pyeloplasty. A mirror-image arrangement is utilized for a left-sided procedure. The first assistant operates the camera while the second assistant manipulates instruments from the lateral-most trocar. Alternatively, a robotic arm can be secured to the table at the position of the first assistant and utilized to hold the camera. The first assistant then takes the position shown for the second assistant, who is no longer required for the procedure.

the stent and the urothelium of the ureteral wall. This facilitates needle placement during suturing and improves urine flow around the stent following completion of the anastomosis.

There are several additional imaging studies that may be of value in the preoperative assessment of a particular patient. Attempts to radiographically demonstrate the presence of crossing lower pole vessels via computed tomography (CT) or magnetic resonance imaging (MRI) with vascular reconstructions are not critical if the laparoscopic approach is pre-ordained. If there is any question regarding the degree of recoverable function within the obstructed renal unit or the degree of obstruction from an asymptomatic narrowing, it is valuable to obtain a nuclear renal scan with diuretic washout. This study helps to identify patients who may be more appropriately treated with a nephrectomy for a poorly functioning kidney, or patients without significant obstruction who may be observed. It also establishes baseline functional and drainage values for the patient against which postoperative studies can be compared. A retrograde pyelogram can be performed at the time of stent placement if a prior contrast study has not adequately defined the anatomy of the UPJ and distal ureter. This information is particularly important in defining the length of the scarred segment following previous failed procedures.

The patient is prepared for transperitoneal laparoscopy utilizing a standard bowel cleansing of magnesium citrate and a clear liquid diet the day prior to the operation. Preparation of the bowels is important because it facilitates visualization by decompressing the colon, reduces the risk of fecal soiling—thus enabling a laparoscopic repair should an intraoperative bowel injury occur—and reduces the severity of postoperative ileus following the operation. At the beginning of the procedure, an oro- or nasogastric tube is placed to decompress the stomach and a Foley catheter is inserted to drain the bladder. Sequential compression devices are applied to the lower extremities to decrease lower extremity venous pooling noted during prolonged laparoscopy and the risk of resultant deep venous thrombosis. A beanbag is placed on the operative table beneath the patient to assist in securing the surgical positioning with a minimum of pressure points.

Once the anesthetic has been induced, the patient is placed in a semi-flank position (angled back approx 15–20° from vertical) with his or her kidney over the break in the table. The table is flexed slightly to increase the space between the rib cage and the iliac crest. Significant elevation of the kidney rest is discouraged because it can lead to myonecrosis or sensory nerve injury owing to the duration of the operation. The down leg is flexed with foam padding placed beneath the knee, ankle, and foot. The upper leg is kept straight and three or more pillows are positioned between the legs at right-angles to the upper leg. Right-angle positioning of the pillows between the legs reduces the chance that the upper leg will roll off the pillows and bring the knees into prolonged contact. A quantity of pillows sufficient to keep all portions of the lower extremities from touching without significant abduction is recommended (Fig. 2).

Two arm boards are positioned side-by-side with slight cephalad elevation at the level of the patient's shoulder on the side opposite the pathology. A soft foam or gel pad axillary roll is positioned perpendicular to the patient 2 fingerbreadths below the down axilla. One pillow is placed beneath the lower arm and three or more pillows are placed between the arms to support the upper extremity. The pillows should be inserted parallel to the arms and the proximal end placed deep into the upper axilla. A sufficient number of pillows should be used to prevent the shoulder from sagging while avoiding elevation of the upper arm above the shoulder. In-line placement of the pillows between the arms is important because perpendicular placement will limit the movements of laparoscopic instruments, especially as the surgeon's hands are brought toward the patient's head (Fig. 2).

The safety strap is moved to the lower portion of the operating table and is brought across the patient's lower legs in the mid-region. A cautery pad is adhesed just above the compressive hose of the patient's upper leg. A towel is placed at the hip just cephalad to the cautery pad and 3-inch cloth tape is brought from table edge to table edge over the towel to secure the patient to the table. A second towel is folded in half, lengthwise, to cover from the patient's elbow to across the shoulder. Two to three strips

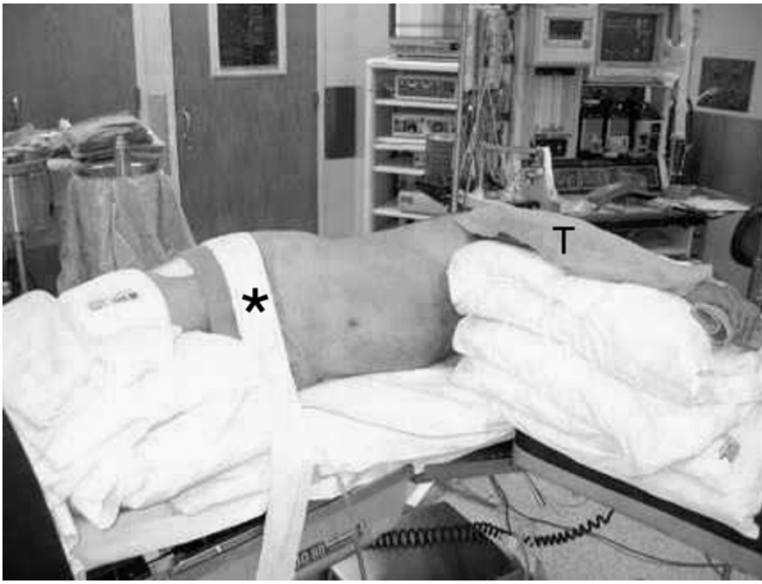


Fig. 2. Semi-flank positioning and padding of a patient undergoing a right laparoscopic pyeloplasty. Note the minimal amount of flexion applied to the operating room table at the level of the kidneys. The beanbag is beneath the patient but is not pushed high on the abdominal side because it can then inhibit downward displacement of the instruments. Pillows are placed perpendicular to the legs to prevent them from rolling off the table, but are aligned parallel to the arms to maximize the amount of room for cephalad movement of the instruments. A quantity of pillows sufficient to prevent shoulder sagging without abduction above the joint is utilized. A folded towel (T) is placed across the shoulder to beyond the elbow and at the hip to protect the skin from the 3-inch wide cloth tape (*) used to secure the patient to the operative table.

of 3-inch cloth tape are passed across this towel securing the patient's torso and upper extremities to the table. The tape is split once it is brought past the elbow and is placed on either side of the arm board. The beanbag is then pushed in around the abdomen and behind the back in a cradling fashion prior to solidifying the position by applying suction to the bag. Care must be taken not to elevate the bag too high on the side of the patient's abdomen as it may inhibit downward movement of the trocars and laparoscopic instruments. Two-inch strips of foam are used to pad between the edge of the beanbag and the lower back because this can form a firm ridge of contact during the procedure. The operating surgeon must be confident that the patient is adequately secured to allow airplaning of the table without shifting of position or padding. A foam ring or gel pad may be required to support the patient's head in a neutral orientation following final positioning.

The anesthesiologist should be encouraged to replace fluid deficits and adequately hydrate the patient prior to creation of the pneumoperitoneum to limit the hemodynamic effects that are enhanced by volume depletion. Nitrous oxide inhalational agents should be avoided to reduce bowel distention. As with many laparoscopic operations, oliguria is common and vigorous fluid bolusing regardless of pressure or heart rate changes is to be avoided. Intravenous lines or monitoring devices (e.g., blood pressure cuff) to which the anesthesiologist wishes to have quick access should be placed on the upper arm. A pneumatic warming device may be adhered to the upper chest down to the

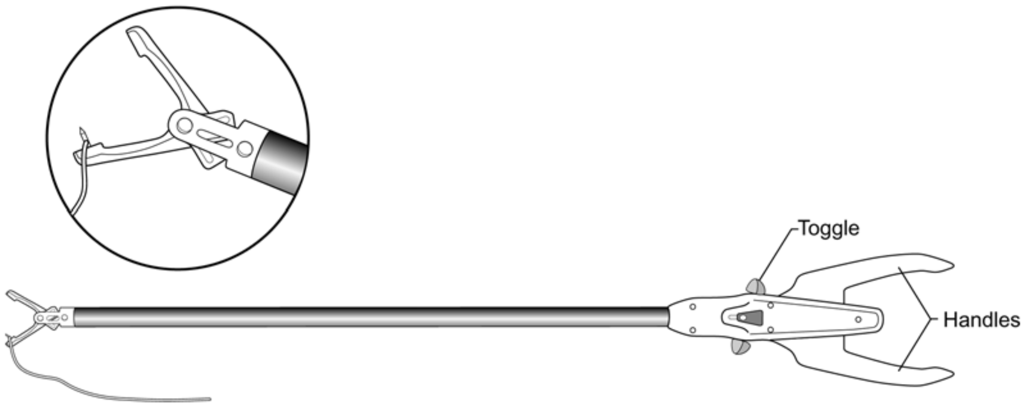


Fig. 3. The Endostitch Autosuturing Device (U.S. Surgical) and a close-up of the jaws with mounted needle (inset). The suture attaches to the mid-portion of the short straight needle, which passes from jaw-to-jaw as the handles of the device are squeezed and the toggle is flipped up or down out of neutral position.

level of the xiphoid process. The entire abdomen and back is shaved if necessary from the midline to the posterior axillary line and from xiphoid to pubis. Providone-iodine (Betadine) or a similar preparation solution is painted onto the abdomen with special care to make certain the umbilicus is adequately prepped.

NECESSARY EQUIPMENT

- 10-mm laparoscope (0 and 30°).
- Laparoscopic needle drivers.
- Maryland dissector.
- Laparoscopic right-angle dissector.
- Dolphin-shaped grasper.
- Right-angle electrocautery hook.
- Diamond Flex Triangle retractor (Genzyme Surgical Products, Tucker, GA).
- Laparoscopic injecting needle.
- Veress needle.
- Three 10-mm nonbladed trocars.
- Two 5-mm nonbladed trocars.
- 10-mm OptiView introducing cannula (Ethicon Endo-Surgery, Inc., Cincinnati, OH).
- Endoshears.
- 5-mm Harmonic Shears (Ethicon Endo-Surgery).
- Endostitch Autosuturing Device (U.S. Surgical Inc., Norwalk, CT) (Fig. 3).
- Fifteen Polysorb 4-0 autosutures (U.S. Surgical).
- Irrigator-aspirator with 5-mm wand.
- Four 2-0 Vicryl sutures.
- 3-0 Nylon suture on Keith straight needle.
- Three 0 Vicryl ties.
- Carter-Thomason fascial closure device (Inlet Medical, Eden Prairie, MN).
- 15 Fr round Davol drain.
- Grenade suction bulb.
- Skin-stapling device to secure the drapes.
- Three 4-0 Monocryl sutures.

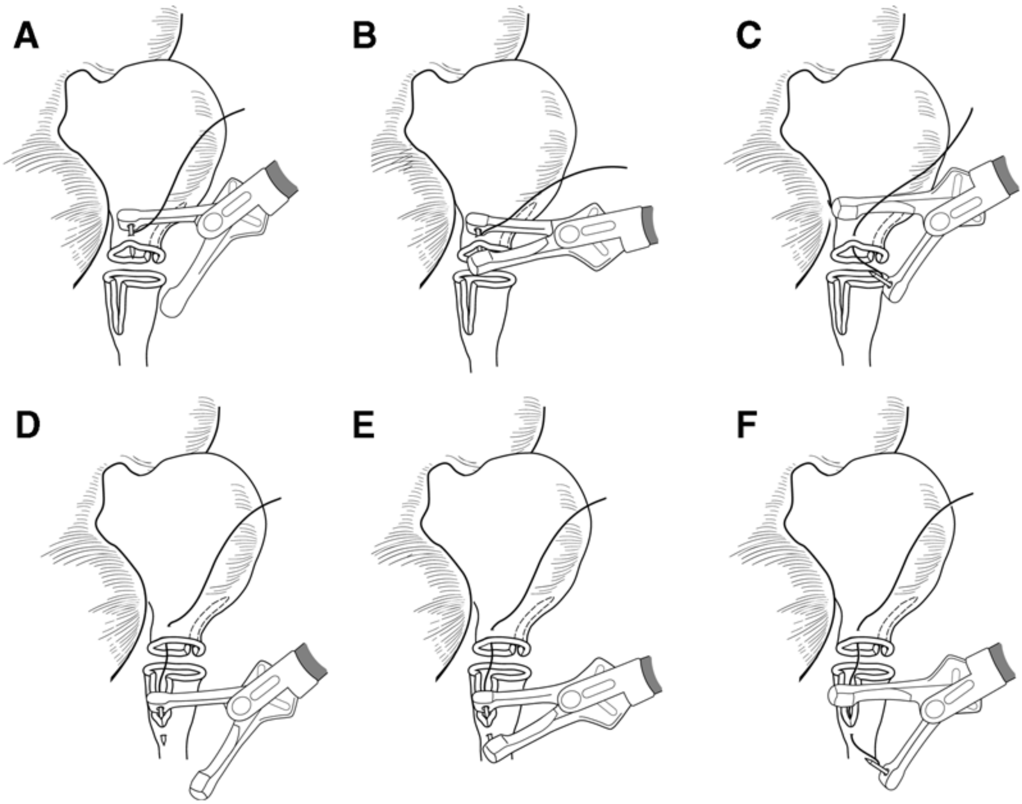


Fig. 4. Intracorporeal placement of the lateral corner stitch during right laparoscopic pyeloplasty utilizing the Endostitch Device. The ureter has been spatulated laterally and the pelvis medially. **(A)** The suture-mounted needle is passed from outside-to-inside on the lateral flap of the pelvis. **(B)** The jaws of the device are closed by squeezing the handle. **(C)** The toggle of the Endostitch is then flipped and the handle is released transferring the needle to the opposite jaw, which is pulled through the tissue of the pelvis along with the suture. **(D)** The needle is then passed from inside-to-outside in the deepest point of the ureteral spatulation taking care to include mucosa. **(E)** The jaws of the Endostitch Device are closed by squeezing the handle. **(F)** The toggle is then flipped and the handle is released transferring the needle to the opposite jaw, which is pulled through the tissue of the ureter. The corner stitch is now ready to be tied.

- Benzoin.
- Steri-strips (1/4-inch).
- Three Band-Aids.
- Standard open tray for flank surgery including preferred retractor.

The Endostitch Autosuturing Device (U.S. Surgical) is an automated instrument that passes a suture attached to a small straight needle from jaw- to-jaw through the tissues (Fig. 3). This was designed to assist with rapid intracorporeal suturing (Fig. 4) and knot-tying *(4)* (Fig. 5). The most delicate suture available for this instrument is the 4-0 Polysorb (U.S. Surgical), which should be utilized when performing pyeloplasties in adult patients. As with all laparoscopic equipment, it is imperative that the operating surgeon understands the technique of loading and unloading the suturing device. Briefly, the suture is placed flat on the table in its plastic loading scaffold and the jaws of the Autosuturing Device are closed over each end of the suture-loaded needle. The

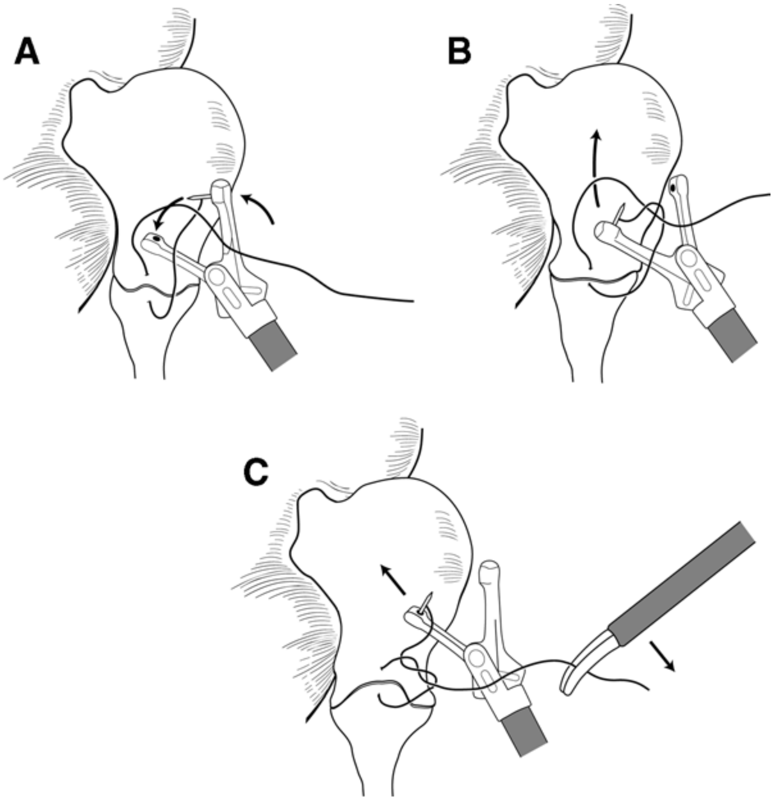


Fig. 5. Rapid intracorporeal knot-tying using the Endostitch Device. **(A)** A square-knot is formed by passing the suture-mounted needle through the internal loop formed by crossing the free end of the suture over the more proximal end that is draped over the lower jaw of the Endostitch. The jaws of the device are then closed and the needle transferred through the loop to the jaw located on the opposite side. **(B)** Once transferred, the needle and attached suture are pulled further through the loop. The first knot of each suture placed during a laparoscopic pyeloplasty should be a surgeon's knot to prevent loosening and separation of the tissues. Passing the needle back through the same loop a second time prior to tightening forms this knot. **(C)** The throw is completed by pulling the two ends in opposite directions while making certain the knot lies down square.

handles are squeezed and both arms of the needle toggle are drawn simultaneously toward the handle. The jaws are kept closed on the needle and the suture material is drawn out and cut to the desired length. The ideal suture length is 12 cm, which enables placement and efficient tying of two intracorporeal sutures. Longer lengths allow for placement of more sutures, however, the additional length is cumbersome and results in inefficient knot-tying and prolonged operative times.

OPERATIVE PROCEDURE

Port Placement

Port placement is identical for right- and left-handed surgeons. An initial 1-cm incision for introduction of the Veress needle and 10-mm camera port is placed midway between the umbilicus and the superior iliac crest just lateral to the rectus muscle. A small curved clamp is used to spread the subcutaneous tissues down to the level of the fascia and the Veress needle is introduced. Typically, the first popping sensation

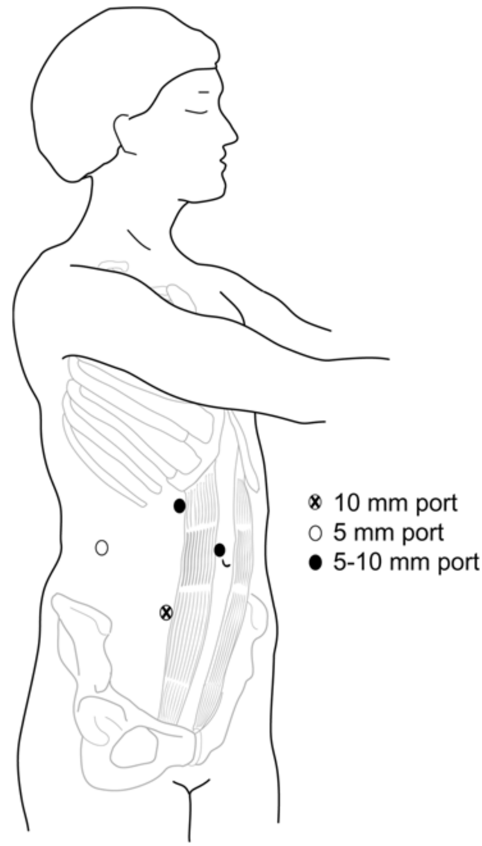


Fig. 6. Standard port arrangement for a right laparoscopic pyeloplasty. A mirror-image distribution is used for a left laparoscopic pyeloplasty. The periumbilical and subcostal trocar can be either a 5- or a 10-mm, depending on the side of the obstruction and the dominant hand of the operating surgeon. In general, the Endostitch Device is held in the surgeon's dominant hand and must be inserted via a 10-mm port while the nondominant hand operates instruments via a 5-mm port.

indicates puncturing of the fascia and the second denotes entry into the peritoneal cavity. Saline injected into the hub of the Veress needle should flow easily into the peritoneal cavity and aspiration should not yield any gas, blood, or bowel contents. The abdomen is insufflated to 15 mmHg pressure and initial pressure readings should be below 10 mmHg pressure to indicate presence within the peritoneal cavity.

All 10-mm ports are introduced using the OptiView nonbladed introducer and the tip should be directed slightly toward the kidney. The nonbladed trocar splits the fascia along the course of the fibers, thereby reducing the risk of postoperative hernia formation. A second 10-mm port is placed at the superior lateral margin of the umbilicus and the third port is placed in a subcostal position, just lateral of the midline, halfway between the xiphoid process and the umbilicus. The second and third trocar can be either a 5- or 10-mm depending on the side and the dominant hand of the operating surgeon (Fig. 6). A 10-mm periumbilical and 5-mm subcostal port are used for a left pyeloplasty by a right-handed surgeon or a right pyeloplasty by a left-handed surgeon. In contrast, a 5-mm periumbilical and 10-mm subcostal port are used for a left pyeloplasty by a left-handed surgeon or a right pyeloplasty by a right-handed surgeon. Care must be taken to angle the subcostal port so that it enters lateral to the

Falciform Ligament to prevent entrapment of the instruments by this structure as they are introduced through the trocar. Internally, the ports are pulled back until they are just far enough in to fully expose the insufflation hole. They are rotated until the stop-cock is furthest away from the kidney. All three trocars are then secured to the abdomen using 2-0 Vicryl suture tied at the skin and around the stop-cock owing to the frequent introduction and withdrawal of instruments, which can result in port dislodgment.

Exposure of the Retroperitoneum

The camera is inserted via the lower quadrant port and held by the assistant surgeon while the operating surgeon manipulates instruments inserted via the subcostal and periumbilical trocars. The Harmonic shears are utilized to rapidly incise the line of Toldt and pericolonic attachments. The extent of the dissection and medial colonic mobilization can be tailored somewhat depending on the position and ease of exposure of the UPJ. It is advantageous to have complete exposure of the pelvis and upper ureter to minimize the interference of bowel and adjacent structures during the suturing process. Unlike the laparoscopic nephrectomy, however, extensive dissection and exposure of the hilar vessels, or cephalad portions of the kidney, are unnecessary. On the left side, it may be adequate to simply release the line of Toldt and carry the dissection around the splenic flexure between the colon and spleen if the colon is mobile and the UPJ lies in a more lateral position. In other cases where the UPJ is located more medially, it may be necessary to completely release the spleen together with the bowel and roll the spleen, bowel, and pancreas medially to expose the retroperitoneum. On the right, the peritoneal incision is carried around the hepatic flexure and the underlying duodenum can be left in situ.

Once the colon is reflected medially, a fourth and final trocar (5 mm) is introduced midway between the tip of the 12th rib and the superior iliac crest. It is usually unnecessary to maintain constant elevation of the liver when performing a right-sided pyeloplasty because the UPJ tends to lie well below the liver edge. If liver elevation is required, the irrigator-aspirator can be inserted via the lateral-most trocar or the Diamond Flex Triangle retractor (Genzyme Surgical Products) can be utilized.

Dissection of the Retroperitoneum

After mobilization of the colon, the next step is to identify the upper extent of the ureter. Opening Gerota's fascia over the lower pole of the kidney facilitates this maneuver. Once this area is fully exposed, a laparoscopic instrument is gently drawn from lateral to medial across the presumed location of the ureter. Owing to the presence of the stent, there is usually enough tactile feedback via the instrument to indicate the presence of a firm band-like structure running in a cranial-caudal direction in the retroperitoneum. The gonadal vein can provide another aid to identification of the ureter, since the ureter usually lies lateral and slightly deep to the gonadal vein when the patient is in a semi-flank position. When a tubular structure is identified and there is a question of whether or not it represents ureter, gentle contact with an instrument will usually produce a peristaltic reaction. Once identified, the ureter is then elevated and traced to the area of the UPJ. Full circumferential dissection is limited to the first 3–4 cm of upper ureter in an effort to preserve as much ureteric vasculature as possible. This maneuver is facilitated by placing the curve of the Maryland dissector (nondominant hand) just below the surface of the ureter, elevating it, and bluntly teasing away the underlying fat using the Harmonic shears to coagulate all small feeding vessels (dominant hand).

As the dissection is carried cephalad toward the renal pelvis, it is important to be cautious in examining the area for the presence of anterior lower pole crossing vessels, which can be present in 57–76% of adult UPJ obstructions *(2)*. If identified, these vessels must be meticulously isolated from the renal pelvis above, UPJ beneath, and upper ureter below. Usually a paired artery and vein are identified in this location, but any combination of vessels can be seen. The right-angle cautery hook is the ideal instrument for gently elevating and separating the tissues between the UPJ and the vessels. The back of the instrument can be used to peel apart the tissues and the tip is ideal for creating planes between the two structures. Obviously, care must be taken to use the lowest effective setting on the cautery and to avoid puncturing the vessels, ureter, or pelvis with the tip of the instrument. Unlike the ureter, the pelvis can be gently grasped during the dissection, as long as care is taken to avoid grasping near the region of the planned reconstruction. A better alternative to assist in elevating and freeing up the pelvis is to pass a 3-0 Nylon mounted on a Keith straight needle through the abdominal wall directly over the region of the hilum, through the renal pelvis, and back out the abdominal wall. The suture ends are then secured with a straight clamp as they exit the abdominal wall and the suture can be raised and lowered as desired. The dissection must be carried out until a right-angle clamp can be passed freely behind the vessels and traction on the pelvis draws the area of the UPJ above the level of the vessels.

In cases of secondary ureteropelvic junction obstruction, or significant prior inflammatory episodes, there may be a thick fibrous rind surrounding the UPJ and pelvis. The pelvis, UPJ, and upper ureter need to be freed from the confines of this tissue as much as possible prior to transecting the UPJ, because the dissection planes often become less distinct once the pelvis is fully decompressed and urine is constantly draining into the operative field.

Incision of the Ureteropelvic Junction

Circumferential incision of the UPJ should be made directly at the juncture of the ureter with the pelvis even in cases where an anterior crossing vessel appears to be the source of the pathology. In the presence of a crossing vessel, this maneuver can be facilitated by gentle downward traction through the underlying window in the periureteric soft tissue using the nondominant hand (Fig. 7). The curved Endoshears are the ideal instrument for making this initial incision and great care should be exercised not to cut the indwelling ureteral stent. Prior to making the incision, it is important to note a surface landmark on the ureter such as a vessel, or attachment of soft tissue, that will help the operating surgeon quickly identify the anterior wall of the ureter after it is transected. It is crucial to maintain correct orientation once it becomes time to spatulate the ureter. The assistant surgeon should utilize the irrigator-aspirator to slowly drip saline on the ureter as it is transected and to aspirate urine and blood from the lumen of the ureter, which obscure visualization of the stent. Once the ureter is opened adequately to expose the underlying stent, the lower jaw of the shears can be inserted into the lumen so the anterior wall lies between the jaws of the shears while the stent is protected beneath the back of the lower jaw. After completing this anterior incision, the upper jaw is passed between the stent and the posterior wall to complete transection of the posterior ureteric wall (Fig. 7). The stent is then grasped just above its exit point

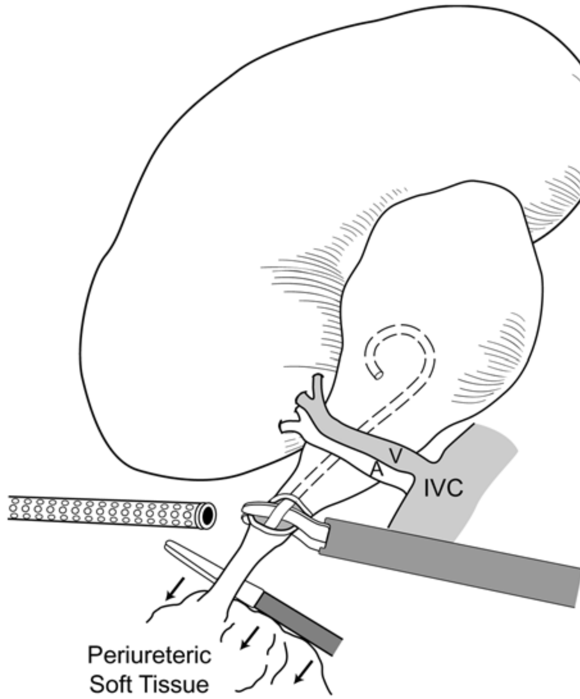


Fig. 7. Transection of the posterior wall of an obstructed UPJ due to lower pole crossing vessels. A Maryland dissector, held in the nondominant hand of the operating surgeon, is placed in the periureteric soft tissue window created by circumferential dissection of the upper portion of the ureter. Downward retraction with the Maryland draws the UPJ below the vessels to allow unimpeded transection. Once the anterior wall is cut, exposing the indwelling stent, the upper jaw is passed beneath the stent to transect the posterior wall. The assistant utilizes the irrigator-aspirator device to help maintain exposure of the stent.

from the ureter as the upper portion is drawn out of the pelvis. It is important to avoid pulling out the portion of the stent contained within the ureter during manipulations because this can result in the distal pigtail being withdrawn through the ureteral orifice into the intravesical tunnel.

Preparation of the Anastomosis

If lower pole crossing vessels are present, the pelvis is elevated cephalad using the stay suture or by gently grasping the upper portion of the pelvis and lifting until it relocates anterior to the vessels. Often additional fibrous attachments to the pelvis remain, which inhibit its tension-free anterior positioning. These must be transected using the Harmonic shears or electrocautery hook. Once tension-free anterior positioning is established, the Endoshears are used to spatulate the ureter laterally. Caution should be exercised to avoid spiraling the incision. The gentle curve of the Endoshears facilitates this lateral-based cut by using only the tips of the shears to cut with the concavity of the shear facing anteriorly. The previously established landmark on the anterior surface of the ureter also assists in maintaining orientation during this maneuver. The length of the spatulation can vary depending on the size of the patient's ureter and whether or not the edges of the spatulated ureter need to be excised. Usually, the spatulation is approximately three-quarters of the length of the metallic jaws on the Endoshears (approx a 12-mm cut). It is important to try to minimize the amount of tissue removed by performing the spatulation first prior to excision. This enables a closer inspection of the health of the mucosa and muscular layer of the ureter. Most often there is sufficient tactile feedback when incising the ureter to gauge the length of the fibrotic ring, if present, that needs to be trimmed off of the ureteral and pelvic side of the anastomosis. The pelvis is spatulated medially and, if it is sufficiently redundant, tissue can be excised regardless of the length of the ureteral spatulation, because the pelvis can be closed to itself to insure a dependent cone-shaped anastomosis. All excised tissue should be sent for pathologic inspection to rule out the possibility of an unsuspected malignancy as the cause of obstruction.

Performing the Anastomosis

The Endostitch device is used to place a corner stitch at each of the spatulations, with care taken to include adequate amounts of muscular wall as well as full thickness mucosa. The knots should be placed on the outside of the anastomosis. It is advisable to pass the lateral corner stitch from outside-to-inside on the renal pelvis side and from inside-to-outside on the ureter side as this insures that an adequate bite of ureter with underlying mucosa is included in the depth of the ureteral spatulation (Fig. 4). The medial corner stitch is performed in a mirror-image fashion passing from outside in on the ureter side and from inside out in the depth of the renal pelvis spatulation. A total of four knots should be placed in each stitch with the first being a surgeon's knot; care is taken to make certain each knot lies down square as it is tied (Fig. 5). The ureteral stent should be kept anterior to the pelvis and between, but not entrapped within, the corner stitches. The ends of the corner sutures are both left long by throwing only one stitch from the entire 12-cm length of suture. This allows the ends to be grasped and passed behind the ureter to expose the posterior edges of the anastomosis.

After placement of the corner stitches, a right-angle grasper is passed lateral-to-medial behind the ureter and is used to grasp the medial corner stitch. This stitch is then pulled lateral (behind the ureter) as the lateral corner stitch is retracted medially (in front of the ureter) to expose the posterior edges of the anastomosis (Fig. 8). On occasion the anatomy of the reconstruction is such that less tension is placed on the anastomosis, and better exposure of the posterior edges is obtained, by pulling the lateral corner stitch behind the ureter medially. This determination can only be made intraoperatively. Regardless of which corner stitch is passed behind the ureter, the first assistant is asked to grasp the lateral-most corner stitch to allow placement of the posterior row of sutures.

It is preferable to use interrupted sutures with each consecutive suture placed to divide the unsutured regions that remain rather than immediately adjacent to one another. Each undivided segment is then further divided working lateral-to-medial. As each suture is placed, the assistant holds the tag of the lateral suture and the operating surgeon holds the medial suture, of the segment being divided, in their nondominant hand as the suture is placed using the dominant hand. A total of two sutures can be obtained from each 12-cm length of Polysorb stitch. Therefore, the first posterior row suture is placed midway between the corner sutures dividing it into two equally long unsutured segments. The next suture divides the more lateral half into two segments (quarters), and the next divides the more lateral quarter into eighths, and so on (Fig. 9). This approach is advantageous because it prevents bunching of the anastomosis with associated narrowing that can occur with a running stitch. It also: 1) facilitates

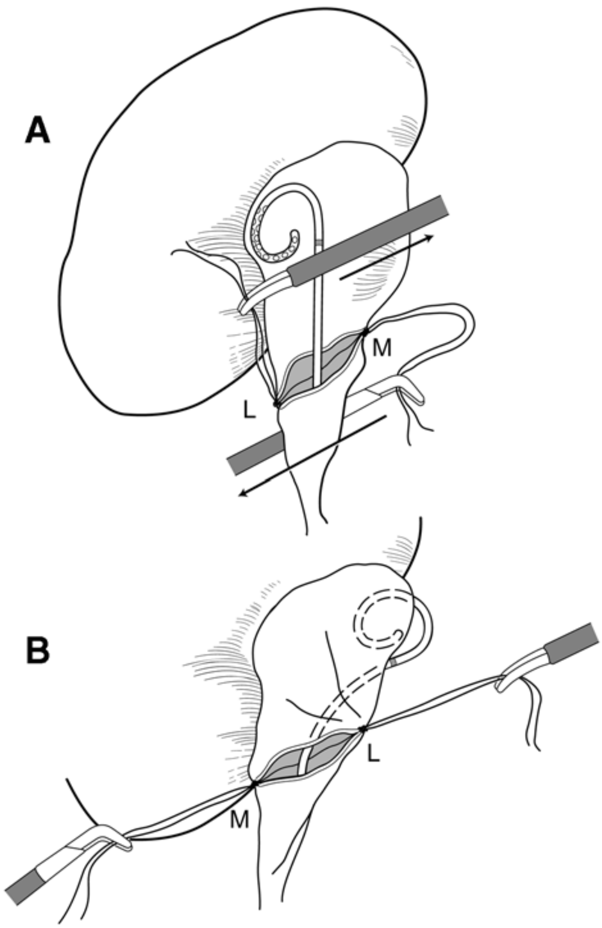


Fig. 8. Exposure of the posterior edges of the anastomosis. **(A)** The right-angle dissector is passed behind the ureter from lateral-to-medial and the medial corner stitch (M) is grasped and pulled behind the ureter laterally. At the same time, the lateral corner stitch (L) is retracted medially over the anterior surface of the UPJ using the Maryland dissector. **(B)** The posterior edges of the anastomosis are exposed anteriorly for suturing and the stent is displaced on the anterior surface of the pelvis, which now faces posteriorly.

visualization of both ureteral and pelvic mucosa during suture placement, 2) prevents undue continued tension on any one section of the anastomosis, and 3) rapidly reapproximates the pelvis and ureter using the minimum number of sutures to achieve a water-tight seal. As the operating surgeon completes the final knot of each stitch, the assistant surgeon exchanges their graspers for the Endoshears and cuts the end of the suture attached to the Endostitch device, leaving the other free end long. This suture end is then grasped to assist in placement of the next stitch. I do not place a specific number of sutures, but tailor the anastomosis based on the length of the spatulations

After completion of the posterior row, all remaining extra lengths of suture are trimmed to appropriate size and the right-angle clamp is passed behind the ureter, directly opposite the way it was passed initially, to replace the corner stitch in its normal position. At this point, the upper pigtail of the stent should be reinserted into the pelvis. This can be a difficult maneuver laparoscopically owing to the memory of

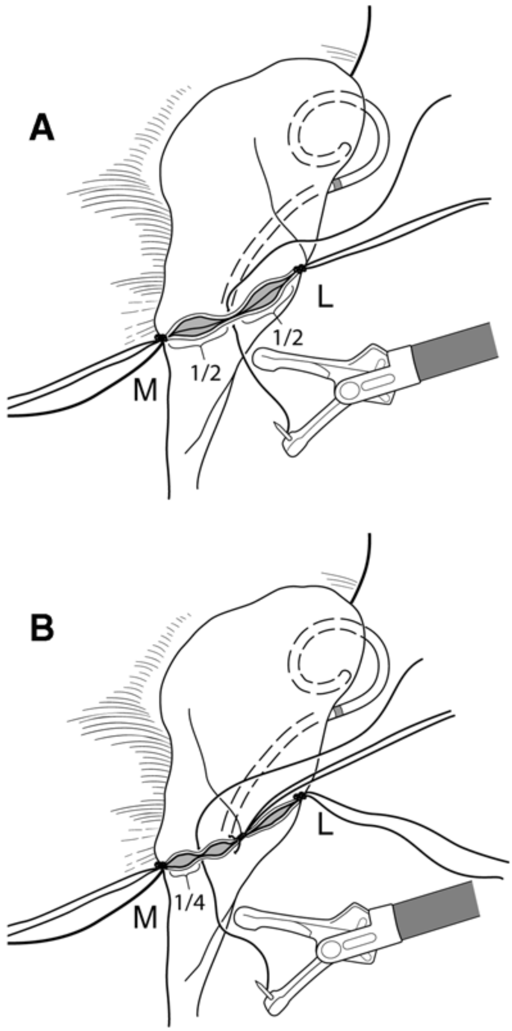


Fig. 9. Closing the posterior row of the anastomosis with each interrupted suture dividing the unsutured segments from lateral-to-medial. The posterior edges of the anastamosis have been exposed by retracting the medial corner stitch (M) behind the ureter laterally, and the lateral corner stitch (L) medially. **(A)** The first stitch is placed midway between the two corner stitches (held on tension) to divide the posterior row into two equal-sized, unsutured half segments. **(B)** The laterally located medial corner stitch (M) and midway stitch are then held on tension and the next suture divides the unsutured lateral half into quarters.

the pigtail and the concern not to pull the stent from the ureter or place tension on the newly completed posterior anastomosis. The most effective way of performing this step is to have the assistant grasp the stent just as it emerges from the ureter. The operating surgeon uses a Maryland dissector in their nondominant hand to grasp midway up the exposed straight length of the stent while a right-angle clamp is used in the dominant hand to grab the stent approximately 0.5 cm back from its tip. The right-angle clamp is then rotated in a counter-clockwise direction on the left, or clockwise direction on the right, to uncoil the pigtail and the end is then inserted as far as the cut edge of the pelvis will allow. The straight portion of the stent is grasped with the Maryland dissector just above the assistant's grasper and the assistant gently releases their grip on the stent as

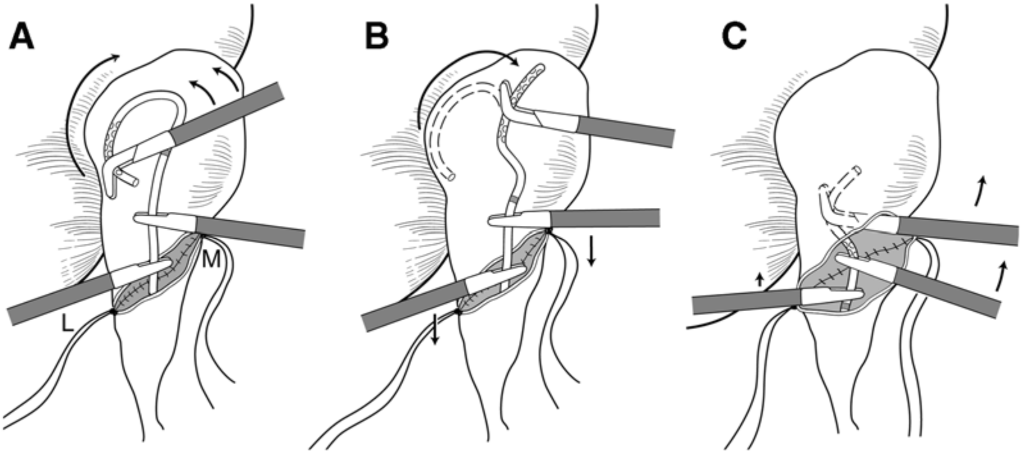


Fig. 10. Reinsertion of the upper pigtail of the stent into the renal pelvis prior to placement of the anterior row of sutures. **(A)** The assistant grasps the stent as it emerges from the ureter to prevent its upward movement. The operating surgeon uses a right-angle dissector to uncoil the pigtail in a clockwise direction while grasping midway up the exposed straight length of the stent. **(B)** After the pigtail is straightened, the stent is advanced down into the ureter to minimize the exposed length. **(C)** The right-angle dissector is utilized to insert the tip of the stent into the renal pelvis as far as the lower edge will allow. The assistant relaxes their grip on the stent while the primary surgeon elevates the stent into the pelvis as the jaws of the right-angle dissector are slowly opened to allow re-formation of the pigtail within the pelvis.

it is elevated into the pelvis with the Maryland dissector. The assistant then re-grips the stent tightly as the primary surgeon then releases their grip on the stent first with the right-angle followed by the Maryland dissector (Fig. 10). It is important to make certain the stent has passed into the pelvis and not through the posterior suture line prior to placing the anterior sutures. The anterior row of interrupted sutures is then placed using the Endostitch device in similar fashion to what was performed on the posterior row with each consecutive suture dividing unsutured segments from lateral-to-medial.

Final inspection should reveal a dependent anastomosis with no lines of tension observed on the anastomosed pelvis (Fig. 11). No areas of significant urine leakage should be observed. All suture ends are trimmed including the two corner stitches. It is unusual to have significant disparity between the ureteral and pelvic spatulations requiring separate closure of the pelvis unless excess pelvis was initially excised. Any residual pyelotomy can be closed using a running 4-0 Polysorb after completion of the anastomosis. If anterior crossing vessels have been transposed posteriorly, they should not be under tension and the lower pole should appear well-perfused. If duskiness is noted and there is no apparent tension on the transposed vessels, the artery may be in spasm. This can be relieved with the topical application of vasodilators such as papaverine or lidocaine via a laparoscopic injecting needle.

Exiting the Abdomen

The area of dissection is inspected under reduced insufflation pressures of 8 mmHg and all areas of bleeding are controlled using the Harmonic shears or electrocautery. Once adequate hemostasis has been achieved, the pressure is increased and figure-eight fascial closure sutures of 0-Vicryl are placed at each of the 10-mm port sites using a grasping needle device such as the Carter-Thomason. The ports are left in place temporarily to assist in positioning a 15 Fr round Davol drain in the retroperitoneum. The spike is cut from the drain and a clamp is placed across the end to prevent escape of the pneumoperitoneum. The perforated end is then fed into the abdomen via the lateral 5-mm port and placed in the retroperitoneum. It is important to position the drain in the retroperitoneum away from the anastomosis so it does not apply suction directly to the suture line. The port is pulled off of the drain tubing after momentarily releasing the clamp and the drain is secured to the flank using a 3-0 Nylon suture. Each port is removed under vision and the closure suture tied, leaving the lower quadrant port until the end. The pneumoperitoneum is released and the fascial suture is elevated after sliding the final port outside of the abdomen. The laparoscope is drawn out of the abdomen slowly while making sure the peritoneal contents fall away from the fascia as it exits.

After tying down the final fascial suture, the suction on the beanbag is released to remove pressure points on the patient's down flank. The drain is cut to an appropriate length and placed to bulb suction. The port sites are irrigated with antibiotic solution and closed using a running 4-0 Monocryl suture. Benzoin, steri-strips, and a standard Band-aid are applied to each of the port-sites. A dry, sterile gauze dressing is placed at the drain site completing the operation.

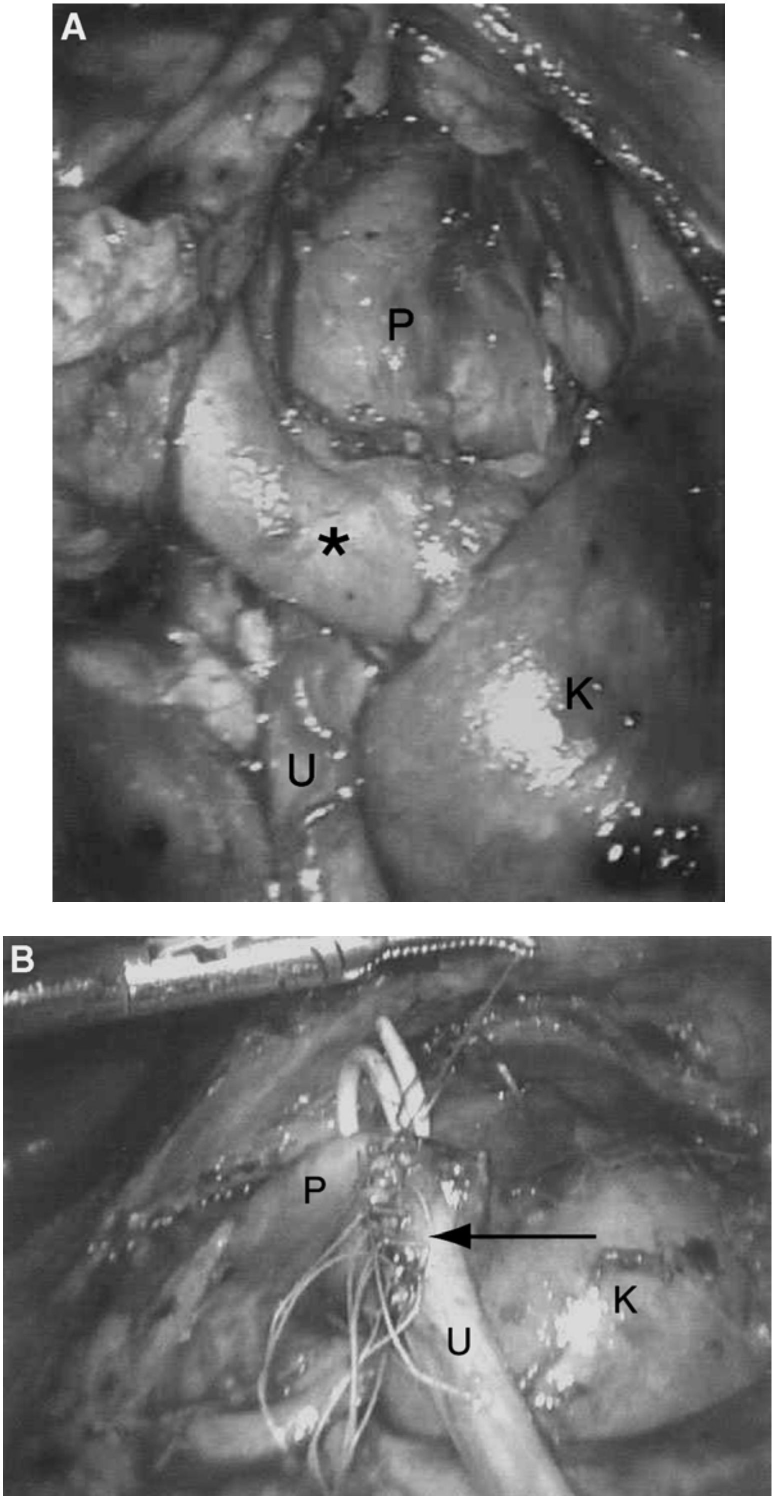
Follow-Up

The patient is sent home on low-dose antibiotic prophylaxis until the stent is removed in the office 6 wk following the operation. I do not perform imaging studies before or at the time of stent removal, because the early appearance of the anastomosis is often difficult to interpret. An intravenous pyelogram is performed 6 wk after stent removal and a diuretic renal scan 6 mo after the operation.

RESULTS

To date, I have performed this procedure in 21 renal units of 20 patients. Three were performed for secondary UPJ obstructions having failed a prior endoscopic approach. All procedures were dismembered reconstructions as outlined earlier. Anterior lower pole crossing vessels were identified in 76% of the renal units. Clinical freedom from episodes of pain and radiographic patency rates have been confirmed in 100% of patients (20/20 renal units) who are at least 3 mo from surgery at the time this manuscript was prepared. Mean clinical and radiographic follow-up is 18 and 17.2 mo, respectively. Minor complications occurred in two patients, one suffering a postoperative ileus and another a mild transient elevation of creatinine.

The Johns Hopkins Hospitals recently published its large single institution series of 100 laparoscopic pyeloplasties performed by their group of surgeons in 99 patients between August 1993 and January 1999 *(2)*. Seventeen patients had secondary UPJ obstructions and 57 patients were found to have crossing lower pole vessels. Dismembered reconstructions were performed in 71 cases, Y-V plasty in 20, Heineke-Mikulicz in 8, and a Davis intubated ureterotomy in 1 case. Mean clinical and radiographic follow-up was 2.7 and 2.2 yr, respectively, with radiographic patency confirmed in 96% of patients. All reported failures occurred within the first year of the patients operation and the overall complication rate was 13%.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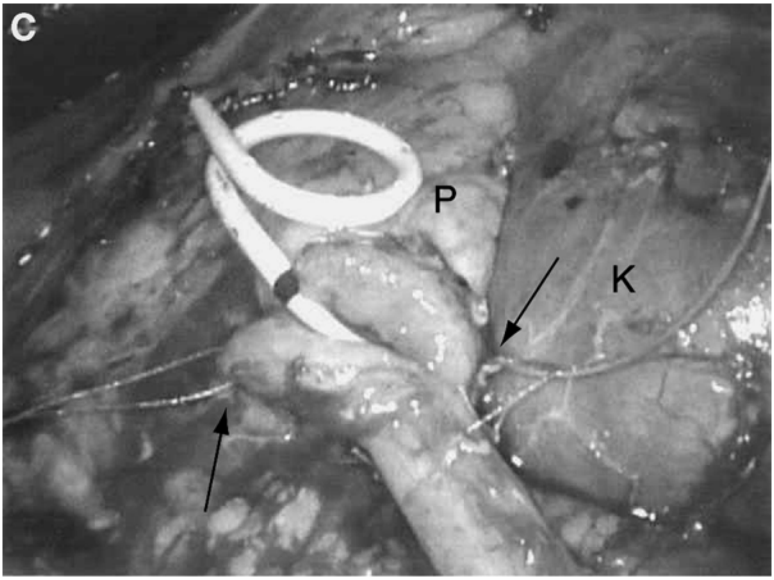

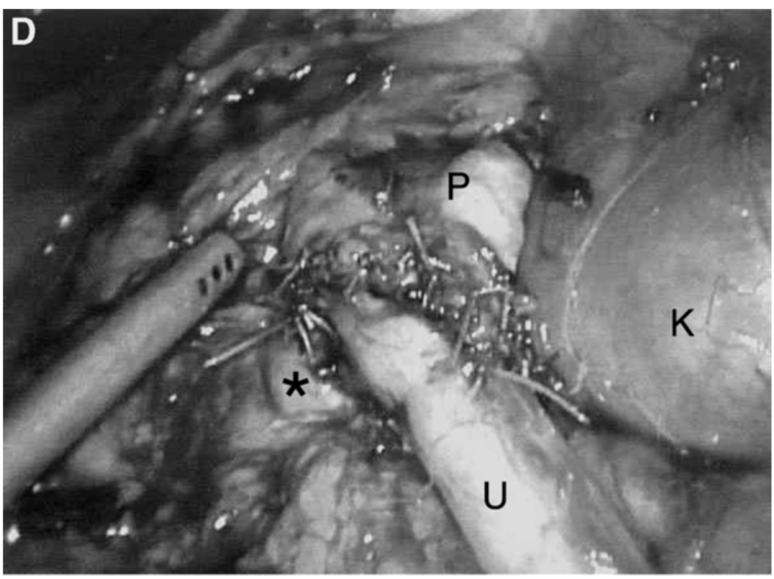

Fig. 11. Left laparoscopic pyeloplasty to reconstruct a UPJ obstructed by lower pole crossing vessels. **(A)** Anterior vessels (*) crossing the area of the UPJ to supply the lower pole of the left kidney (K) with the renal pelvis (P) visible above the vessels and the ureter (U) below. **(B)** After transection, spatulation, and transposition of the UPJ anterior to the vessels, the completed posterior row (arrow) can be easily seen as the medial corner stitch is rolled laterally in the jaws of the Maryland dissector. **(C)** The stent is now ready to be re-inserted into the pelvis following completion of the posterior row of sutures and relocation of the corner stitches (arrows) into their normal location. **(D)** The completed cone-shaped, dependent anastomosis with the lower pole crossing vessels (*) now residing posteriorly.

TAKE HOME MESSAGES

1. Laparoscopic pyeloplasty is an excellent minimally invasive treatment option for the obstructed UPJ with patency rates equivalent to the open approach.
2. All forms of primary and secondary UPJ obstruction can be treated using this technique, including anterior crossing lower pole vessels.
3. The only significant relative contraindication to laparoscopic pyeloplasty is a small intrarenal pelvis.
4. The procedure is technically demanding, but the Endostitch device facilitates the intracorporeal suturing and knot-tying required during this operation.

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15 Laparoscopic Radical Cystectomy and Urinary Diversion

Andrew P. Steinberg, MD,
and Inderbir S. Gill, MD, MCh

Contents

INTRODUCTION

Radical cystectomy remains the most effective form of treatment to date for muscle-invasive bladder cancer. Cystectomy is usually coupled with urinary diversion in the form of urinary conduit (e.g., Bricker ileal conduit), catheterizable continent pouch (e.g., Kock or Indiana pouch) or continent orthotopic neobladder (e.g., Studer or Sigmoid neobladder). Urinary diversion may also be performed for palliation of patients with intractable urinary symptoms, urinary fistula, bladder obstruction, or neurogenic bladder.

Radical cystectomy and urinary diversion is a major abdominal surgery with extended hospital stay, significant morbidity, and a protracted recovery period. In the past decade, laparoscopy has taken an important role in extirpative urological surgery. Because of the associated inherent complexity of the procedures, laparoscopic reconstructive surgery has taken longer to gain widespread use. However, with improvement in both laparoscopic technique and equipment, major advances in laparoscopic reconstructive urology (including urinary diversion) have been made.

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
Edited by: S. Y. Nakada © Humana Press Inc., Totowa, NJ

In 1992, Parra et al. published the initial report of a laparoscopic simple cystectomy for a retained bladder with pyocystis *(1)*. No urinary diversion was performed since the patient had a previous ileal conduit. In the same year, Kozminski and Partamian performed a laparoscopic-assisted ileal conduit in two patients *(2)*. Ureteroileal anastomoses were performed extracorporeally by bringing the ileal loop and ureters outside the abdomen through a stoma site. Since then, several experimental and clinical attempts have utilized varying degrees of laparoscopic assistance to perform cystectomy and urinary diversion. Clinical milestones are listed in Table 1 *(1–9)*. At the Cleveland Clinic, we have successfully completed experimental porcine models of cystectomy and ileal conduit *(10)* and orthotopic neobladder *(11)* in which the entire surgical procedure was performed intracorporeally. Subsequently, we published the first report of laparoscopic radical cystectomy and ileal conduit in humans performed completely intracorporeally *(6)*. Other groups have been simultaneously trying to develop the technique of laparoscopic urinary diversion. Türk et al. performed laparoscopic radical cystectomy with rectal sigmoid pouch (Mainz pouch II) in five patients *(8)*. More recently, we have performed laparoscopic cystectomy with orthotopic ileal neobladder in two patients and continent catheterizable (Indiana) pouch in one patient *(9)*. Again all suturing was done intracorporeally. A detailed step-by-step description of the technique is described.

PATIENT SELECTION

Proper patient selection is crucial in assuring good surgical and oncological outcomes. Therefore, patients need to fulfill two sets of criteria.

Criteria for Cystectomy and Type of Urinary Diversion

This is well-described in the general urological literature and is therefore not reviewed in this chapter.

Criteria for Selection of Laparoscopic Surgery in General

Generally, it is safer to exclude patients with multiple previous abdominal surgeries, acute intraperitoneal infectious process, and uncorrected coagulopathy. Previous abdominal surgery is not an absolute contraindication, but extra care should be taken during trocar insertion and lysis of adhesions may be required. Obesity is not, in itself, a contraindication to the laparoscopic approach, however, difficulty may be encountered while constructing an ileal conduit through the thicker abdominal wall. Obesity will also add difficulty to the pelvic portion of the surgery (cystoprostatectomy). In our initial experience, we have limited the patient selection to non-obese patients with low-volume cancers, which appear to be confined to the bladder, without pelvic lymphadenopathy on abdominopelvic computed tomography (CT) scanning. As we become more comfortable with the technique, our selection criteria will ease accordingly.

PREOPERATIVE ASSESSMENT

The preoperative assessment for patients undergoing laparoscopic cystectomy with urinary diversion is similar to that done for the open procedure. In brief, patients undergo a complete physical exam, routine blood tests (complete blood count, renal panel, alkaline phosphatase, liver function tests, and calcium), and a radiographic

Table 1
Laparoscopic Cystectomy and Urinary Diversion: Clinical Milestones

Study (ref)	*Size (n)*	*Bladder*	*Urinary diversion*	*Intracorporeal suturing (Y/N)*
Parra et al. 1992 *(1)*	1	Laparoscopic simple cystectomy	None performed, patient had preexisting ileal conduit	—
Kozminski et al. 1992 *(2)*	2	—	Lap-assisted ileal conduit	No
Puppo et al. 1995 *(3)*	5	Lap-assisted transvaginal radical cystectomy	Bilateral cutaneous ureterostomy (n = 1), ileal conduit through minilaparotomy (n = 4)	No
Sanchez de Badajoz et al. 1995 *(4)*	1	Laparoscopic radical cystectomy	Ileal conduit through flank incision	No
Denewar et al. 1999 *(5)*	10	Lap-assisted radical cystectomy	Sigmoid pouch through mini-laparotomy	No
Gill et al. 2000 *(6)*	2	Laparoscopic radical cystectomy	Laparoscopic ileal conduit	Yes
Potter et al. 2000 *(7)*	1	Not performed (nonmalignancy)	Laparoscopic ileal conduit	Yes
Türk et al. 2001 *(8)*	5	Laparoscopic radical cystectomy	Laparoscopic rectal sigmoid pouch	Yes
Gill et al. 2001 *(9)*	3	Laparoscopic radical cystectomy	Laparoscopic Indiana pouch (n = 1), laparoscopic orthotopic neobladder (n = 2)	Yes

metastatic work-up (chest X-ray, CT scan of the abdomen and pelvis). Other examinations (magnetic resonance imaging of the abdomen, abdominal ultrasound, bone scan) are done as necessary.

PREOPERATIVE PREPARATION

On the day prior to surgery, full bowel preparation is initiated. A mechanical preparation is undertaken using 4 L of GoLytely. Neomycin and metronidazole are used for the chemical preparation. Broad-spectrum intravenous antibiotics and subcutaneous low molecular-weight heparin (2,500 U) are given prior to surgery.

NECESSARY INSTRUMENTATION

- One 10-mm 0° laparoscope.
- Three 10–12-mm Trocars.
- Three 5-mm Trocars.
- One 5-mm electrosurgical monopolar scissors.
- One 5-mm electrosurgical hook.
- Two 5-mm atraumatic grasping forceps (small bowel clamp).
- One 5-mm right-angle dissector.
- One 10-mm right-angle dissector.
- One 10-mm 3-pronged reusable metal retractor (fan-type).
- One Weck clip applicator with disposable clip cartridges (Weck Systems).
- Two Needle holders.
- One 5-mm Endoshears.
- One 5-mm Maryland grasper.
- Two 11-mm Endoclip applier.
- One 12-mm articulated Endo-GIA vascular stapler (U.S. Surgical) with multiple reloads.
- One 5-mm irrigator/aspirator.
- One 15-mm Endocatch II bag (U.S. Surgical).

PATIENT POSITION

Following general anesthesia, bilateral sequential compression devices are placed. The patient is placed in the supine, modified lithotomy position with thighs abducted to allow simultaneous, intraoperative perineal access. All bone prominences are meticulously padded and the patient is secured to the table with safety straps. After port placement (see below), the patient is placed in a 30° Trendelenberg position.

OPERATING ROOM SET-UP

The surgeon is situated on the left of the patient (Fig. 1). The first assistant is on the right side of the patient and the second assistant is positioned next to the surgeon, in the caudal direction of the patient. Monitors are placed on either side of the patient's pelvis for the cystoprostatectomy part of the operation and on either side of the patient's shoulders when laparoscopic bowel work is being performed.

PORT PLACEMENT

For the laparoscopic cystectomy and urinary diversion, a six-port transperitoneal approach is used (Fig. 2). A primary 10-mm port is placed at the umbilicus for the 0°

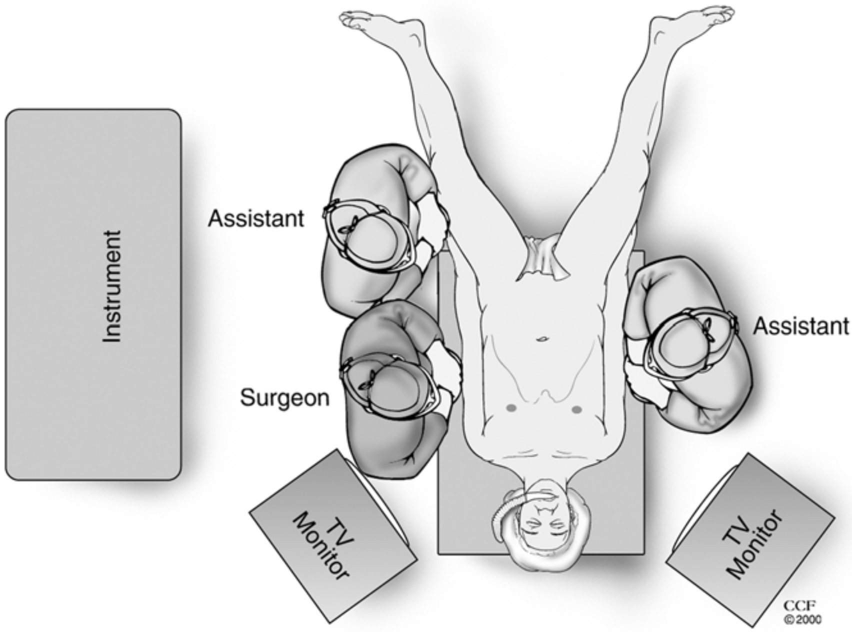

Fig. 1. The surgeon stands on the left side of the patient with one assistant across from him and one to his left.

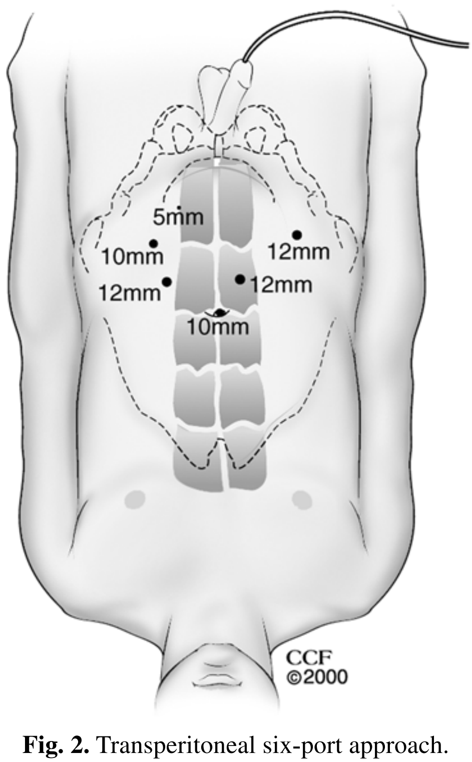

Fig. 2. Transperitoneal six-port approach.

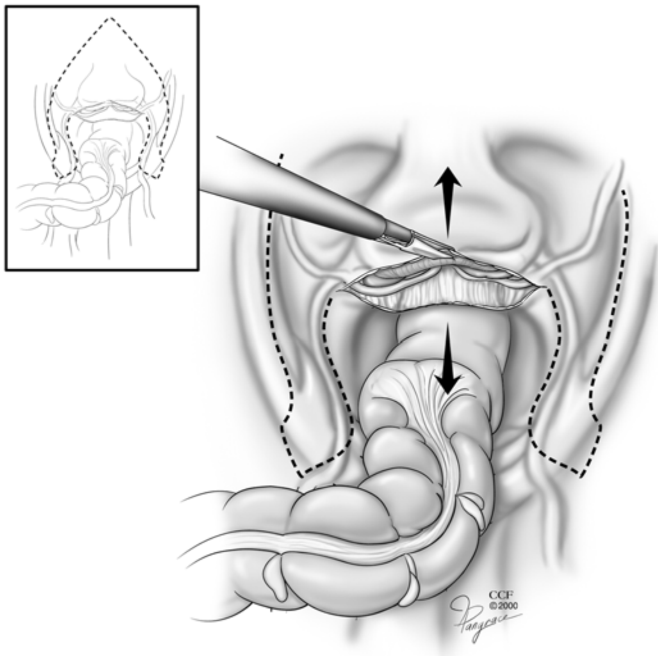

Fig. 3. Initial peritoneal incision is made in the rectovesical pouch. A plane is identified between the bladder and the rectum. Dashed line represents subsequent incision, laterally up to the common iliacs. Inset represents extension of peritoneotomy onto the undersurface of the abdominal wall.

laparoscope. Four secondary ports are placed under visualization: a 12-mm port to the left of the umbilicus, lateral to the rectus muscle, and two 10-mm ports in the left and right lower quadrants, approximately 2 fingerbreadths medial to the ipsilateral anterior superior iliac spines. If the preselected stoma site in the right rectus muscle (in the case of an ileal conduit) is at or below the level of the umbilicus, another 12-mm port is placed at that location. Otherwise a 12-mm port is placed at the lateral border of the rectus muscle approximately 2 fingerbreadths caudal to the umbilicus. As such, the preselected stoma site is left undisturbed. Finally, a 5-mm port is placed in the midline infraumbilical location approximately 2 fingerbreadths cephalad to the symphysis pubis.

LAPAROSCOPIC RADICAL CYSTECTOMY

A Foley catheter is placed in the bladder after the patient is prepped and draped. After port placement, cystoprostatetcomy is initiated by dissecting sigmoid and bowel adhesions from the pelvic side wall. A wide peritoneal incision is made beginning in the midline in the rectovesical pouch (Fig. 3). A plane is identified between the bladder and the rectum. The vasa deferentia are divided and dissection continued along the posterior aspect of the seminal vesicles toward the bladder base (Fig. 4). This plane is then followed distally, by incising Denonvilliers fascia, towards the apex of the prostate.

Upon completion of the posterior dissection, the initial peritoneal incision is carried laterally on either side, up to the common iliac artery at the point of crossing of the ureter (Fig. 3, dashed line). Generous mobilization of the ureters is done bilaterally.

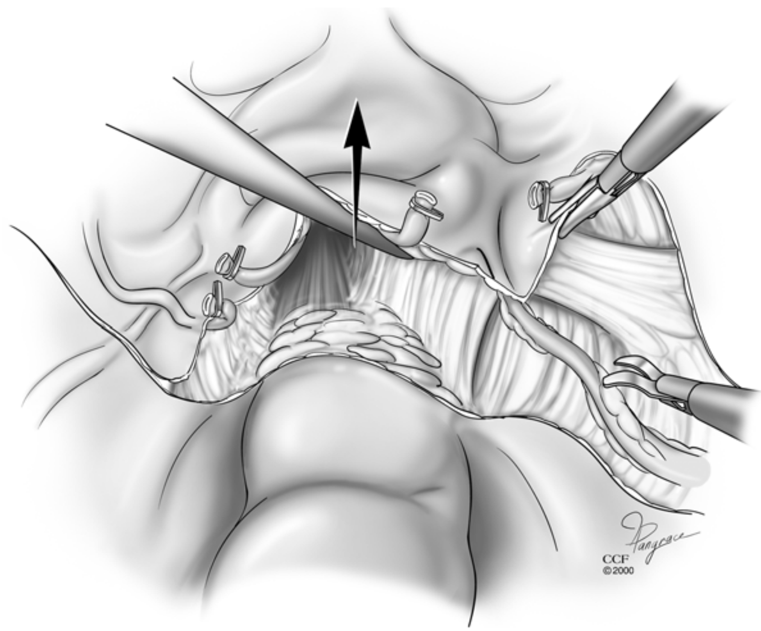

Fig. 4. The vasa deferentia are clipped and divided. Dissection continues along the posterior aspect of the bladder and seminal vesicles.

Distally, the ureters are mobilized down to the bladder wall. Proximally, the right ureter is mobilized for a short distance above the iliac vessels and the left ureter is mobilized even more proximally to allow subsequent tension-free retroperitoneal transfer to the right side for the ureteroileal anastomosis. Ureteral mobilization also facilitates identification of the vesical pedicles.

The space of Retzius is entered by extending the peritoneal incisions onto the undersurface of the abdominal wall, extending lateral to the medial umbilical ligaments towards the umbilicus (Fig. 3, inset). The bladder is distended with 200 mL and an inverted V incision is made in the anterior parietal peritoneum (Fig. 5). The urachus is transected high, close to the umbilicus. Keeping all the extraperitoneal perivesical fat attached to the bladder, the bladder is mobilized from the anterior abdominal wall toward the pelvis.

The lateral vesical pedicles are identified by careful blunt dissection of the of the lateral bladder wall from the pelvic side-wall. The lateral and posterior pedicles are controlled with serial applications of the Endo-GIA stapler (35-mm length, 2.5-mm staple height) (U.S. Surgical) (Fig. 6). Both ureters are clipped close to the bladder and divided. The distal ureteral margin is sent for frozen pathological examination. The clip-occluded ureters are allowed to hydrodistend to allow for easier subsequent uretero-ileal anastomosis.

With the space of Retzius now open, the dissection can proceed to the prostate. As in a prostatectomy, the endopelvic fascia is incised bilaterally and the puboprostatic ligaments are divided, allowing visualization of the prostatic apex. The dorsal venous complex is then controlled with either the Endo-GIA or by applying a suture (2-0 Vicryl suture, CT-1 needle). The Foley catheter is removed and the urethra is transected using the Endoshears. Any remaining attachments between the prostate and the rectum are divided, freeing the cystoprostatectomy specimen. The specimen is placed in a 15-mm

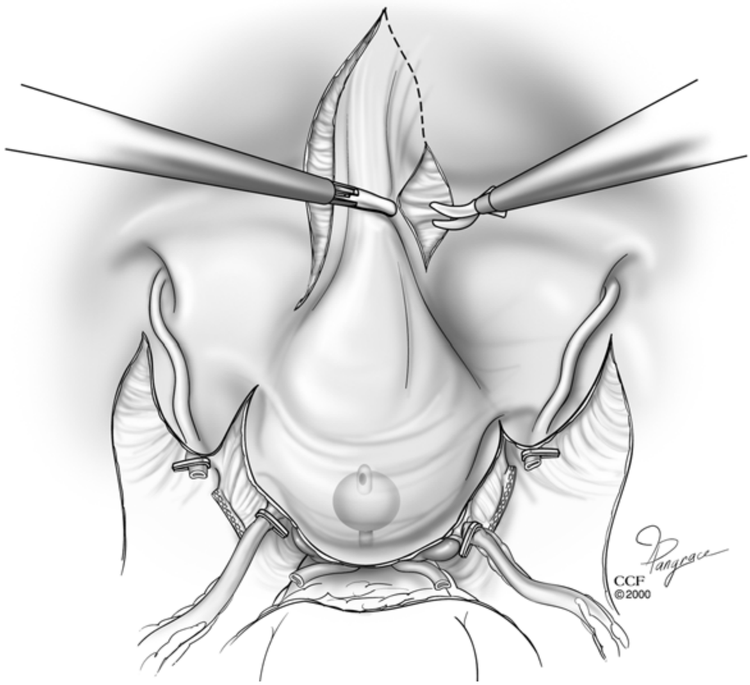

Fig. 5. An inverted "V" incision is made on the anterior parietal peritoneum and the urachus is subsequently transected.

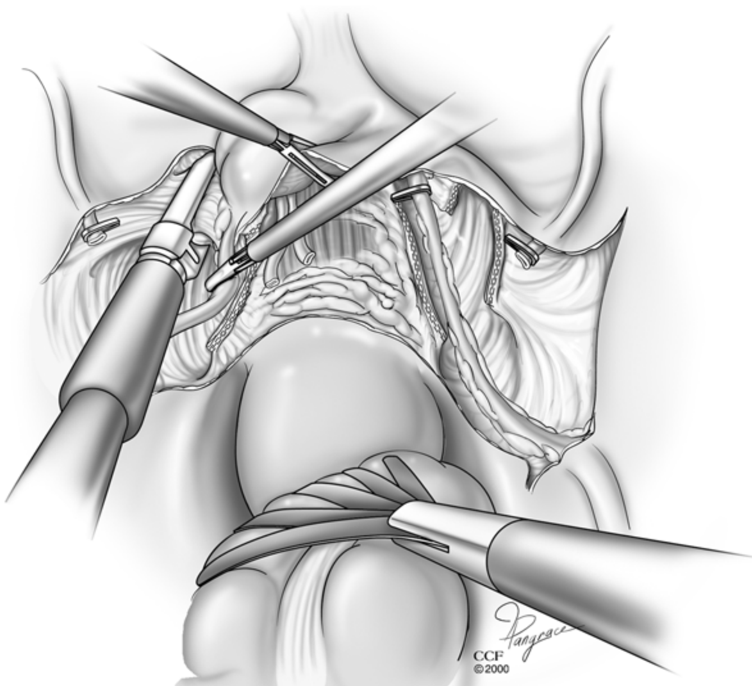

Fig. 6. Generous mobilization of the ureters is done. The lateral and posterior pedicles are secured with an Endo-GIA stapler.

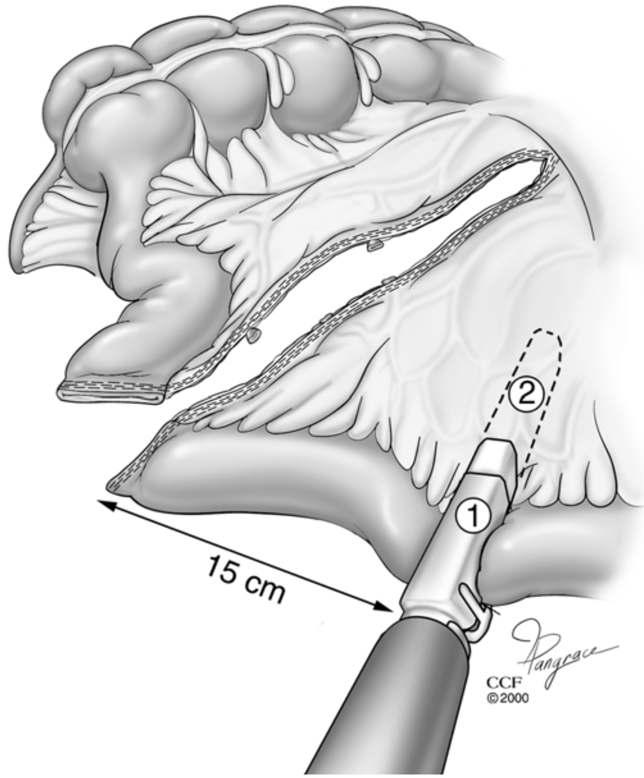

Fig. 7. Division of the isolated bowel segment and mesentery is performed with serial firings of the Endo-GIA stapler.

Endo-catch impermeable bag (U.S. Surgical). Hemostasis is confirmed and bilateral pelvic lymphadenectomy is completed.

LAPAROSCOPIC ILEAL CONDUIT

With the cystoprostatectomy and lymphadenectomy completed, attention is focused on the urinary diversion. In the case of the ileal conduit, a 15–20 cm segment of ileum is identified 15 cm from the ileocecal junction. Division of the isolated segment of bowel and the mesentery is performed using the Endo-GIA stapler (Fig. 7). Staple heights of 3.5 mm are used for the bowel and 2 or 2.5 mm for the mesentery. Two firings are used to complete the distal mesenteric division and one firing is used to complete the proximal division. As in the open procedure, care is taken not to compromise the main mesenteric vessels feeding the conduit. Ileo-ileal continuity is reestablished by creating a generous side-to-side anastomosis with two sequential firings of the Endo-GIA stapler (Fig. 8). The open ileal ends are closed with two transverse firings of the Endo-GIA stapler, and oversewn with 2-0 Vicryl for added security. The mesenteric window is closed with 3-0 silk sutures. The distal end of the conduit is exteriorized through the preselected stoma site at the right rectus muscle (Fig. 9) and an end-ileal stoma is fashioned using conventional techniques.

The left ureter is passed to the right side of the abdomen through a window created in the sigmoid mesentery (Fig. 10). A 90 cm, 7 Fr single-J stent is grasped with a laparoscopic right-angle clamp and inserted into the conduit lumen. It is then used

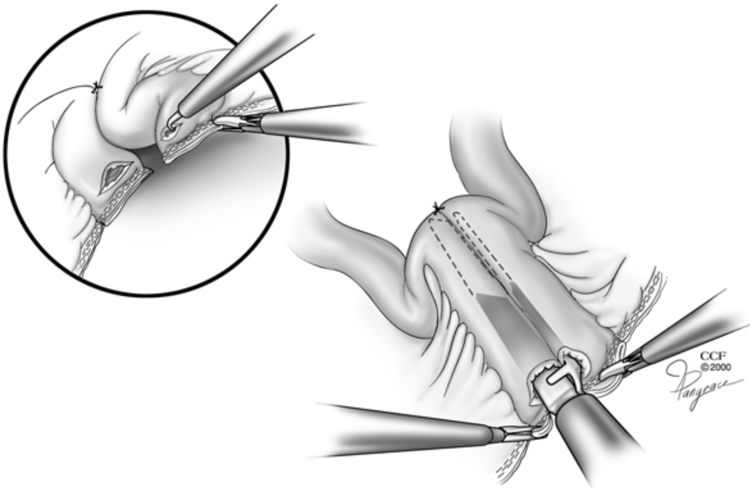

Fig. 8. Ileotomies are made in both ileal stumps (inset) and intestinal continuity is re-established by creating a generous side-to-side ileoileal anastomosis with two sequential firings of the Endo-GIA stapler. The open ends of the bowel are closed with transverse firings of the Endo-GIA stapler.

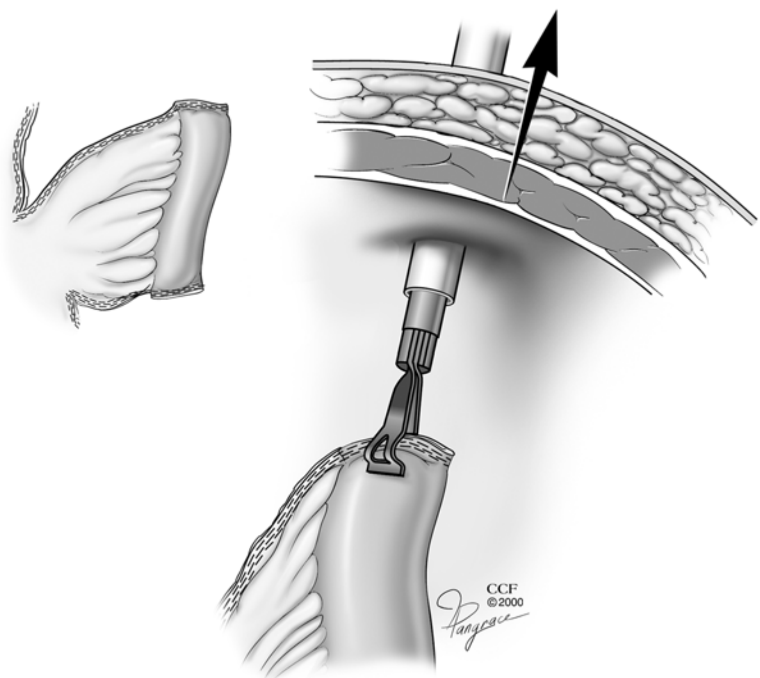

Fig. 9. The distal end of the ileal loop is exteriorized through the preselected stoma site and is secured to the skin using standard technique.

to tent the conduit at the desired site of ureteroileal anastomosis (Fig. 11). Using an electrical J-hook, a small ileotomy is created and the stent is delivered into the abdominal cavity. The right ureteral anastomosis is performed first. The ureter is spatulated. An apical stitch is placed outside-in (Fig. 12) (4-0 Vicryl, RB-1 needle) and is anchored to the desired site of the ileotomy. A running suture is then performed to approximate 80% of the posterior wall and the J-stent is fed into the ureter up to the renal

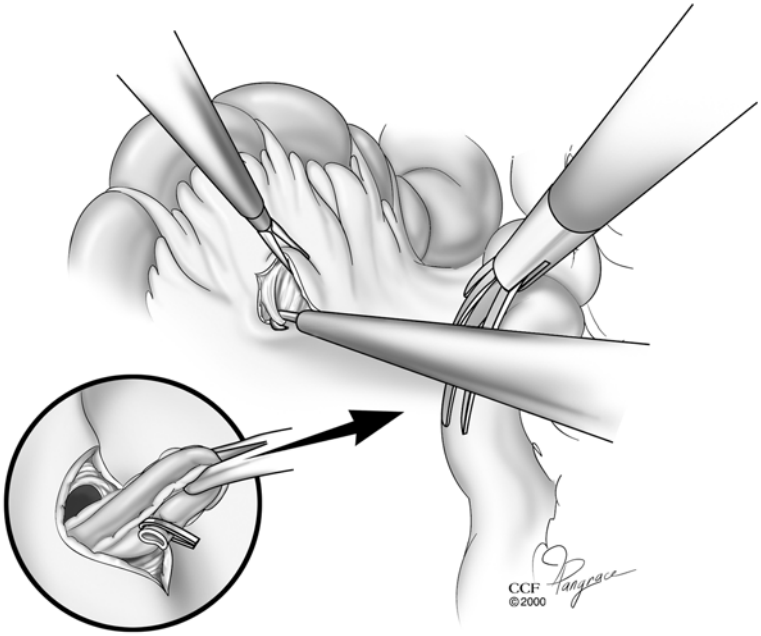

Fig. 10. A window is created in the sigmoid mesentery and the left ureter is passed through it.

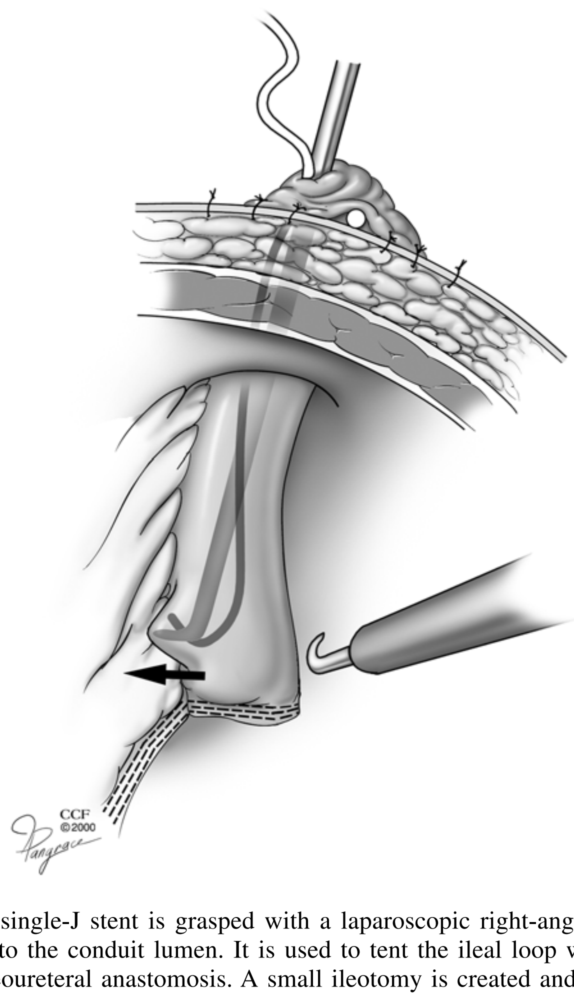

Fig. 11. A 7-French single-J stent is grasped with a laparoscopic right-angle clamp and inserted through the stoma into the conduit lumen. It is used to tent the ileal loop within the abdomen at the desired site of ileoureteral anastomosis. A small ileotomy is created and the stent is delivered into the abdominal cavity.

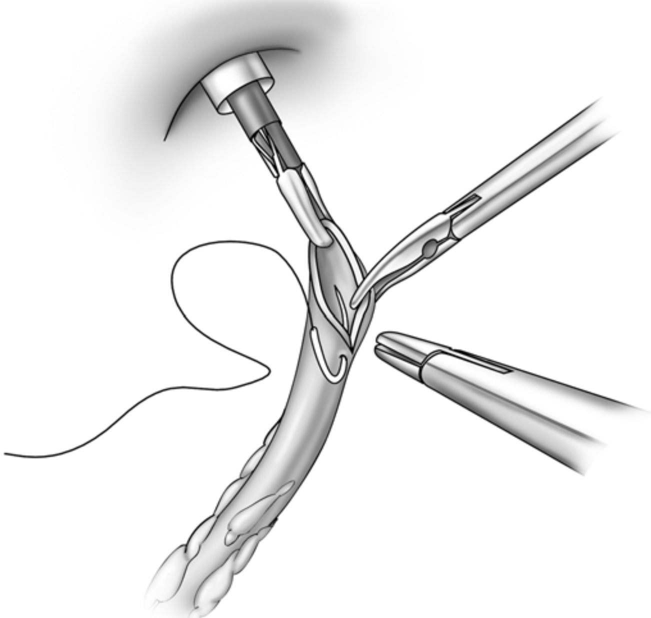

Fig. 12. The ureter is spatulated and an apical stitch is placed.

pelvis (Fig. 13). The remainder of the posterior wall anastomosis is completed. The anterior (near) wall is sutured in a running fashion to complete the right ureteroileal anastomosis. The left ureteroileal anastomosis is completed in a similar manner (Fig. 14). Alternatively, interrupted sutures can be used for the anastomoses.

Two Jackson-Pratt drains are inserted through different port sites and a Foley catheter is inserted into the urethra to be used as a pelvic drain. The entrapped specimen is extracted intact through a 3.5-cm extension of the umbilical port-site incision. In the female patient, the intact specimen is extracted per vaginum. Hemostasis is confirmed and port sites are closed in standard fashion.

LAPAROSCOPIC ORTHOTOPIC NEOBLADDER

Following our developmental study of orthotopic ileal neobladder in 12 survival porcine animals *(11)*, we have begun offering this procedure clinically to select patients. Our procedure, described below, utilizes ileum to create the orthotopic bladder and anti-reflux Studer limb *(9)*.

Following cystectomy and lymphadenectomy, the laparoscope is repositioned in the left lateral port, pointing towards the liver. The surgeon works through the midline infraumbilical and the left pararectal port. A 65-cm ileal segment is selected 15 cm proximal to the ileo-cecal junction. The distal end of the selected segment is transected with an Endo-GIA stapler using the 3.5-mm (blue-colored) cartridge. Division of the mesentery is then performed by two sequential firings of the Endo-GIA stapler using the 2.5-mm gray-colored vascular cartridge. Care is taken not to compromise the primary mesenteric vessels. In a similar manner, the proximal end of the 65-cm ileal segment is transected. The proximal mesentery, however, is transected with only a single firing of the Endo-GIA. The isolated ileal segment is placed posterior to the bowel and a side-to-side ileo-ileal anastomosis is performed anteriorly with two

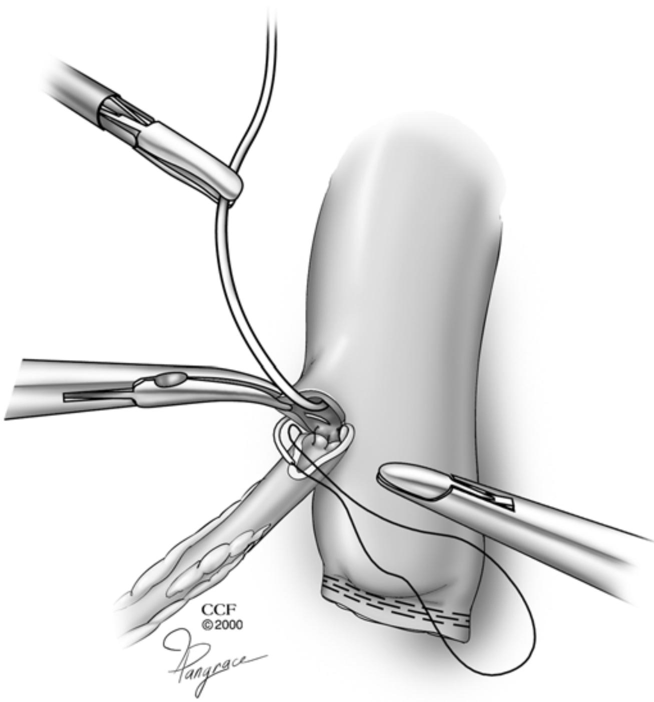

Fig. 13. The ureteroileal anastomis is started with a running suture on the posterior wall. The stent is fed across the anastomosis, up to the renal pelvis, and the anterior wall is sutured in a similar running fashion.

sequential firings of the Endo-GIA stapler (3.5-mm blue-colored cartridge) along the antimesenteric border of the intestinal segments. The open end is closed with two or three transverse firings of the Endo-GIA stapler. This edge is then oversewn with running 2-0 Vicryl suture. The window in the mesentery is closed with two or three interrupted stitches.

The proximal 10–15 cm of the ileal segment is reserved for the isoperistaltic Studer limb of the neobladder. The remaining length of the ileal segment is detubularized along the antimesenteric border using the Endoshears or harmonic scalpel. The posterior wall of the neobladder is created by continuous intracorporeal suturing of adjacent detubularized ileal walls using 2-0 Vicryl suture on a CT-1 needle (Fig. 15). The segment is then brought into the pelvis, avoiding any undue tension or torsion of the mesentery. The most dependent portion is selected for the urethro-ileal (i.e., urethro-vesical) anastomosis. A running circumferential suture is performed using 2-0 Vicryl on a UR-6 needle, similar to that performed during laparoscopic radical prostatectomy. Prior to completing the anastomosis, a 22 French silicone Foley catheter is inserted per urethra. In female patients, two 90-cm single-J ileoureteral stents are inserted via the external urethral meatus alongside the Foley catheter and delivered into the neobladder. In the male, the two ileoureteral stents are inserted through the right lateral port, which is then removed and re-inserted alongside the stents. These stents now exit the abdomen via the port incision outside rather than inside the port itself. The anterior wall of the neobladder is folded forward and the free edges are sutured to achieve a spherical configuration (Fig. 16). Prior to completion of the neobladder suturing, the ileoureteral stents are delivered into the Studer limb and passed into the peritoneal cavity through

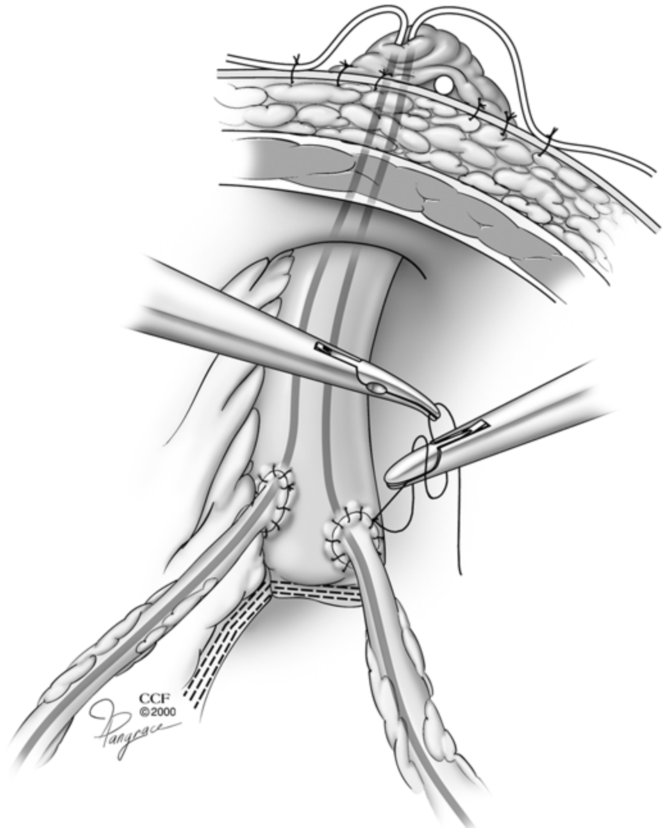

Fig. 14. Stented bilateral ureteroileal anastomosis are completed.

ileotomies created at the site of the future uretero-ileal anastomosis. Bilateral uretero-ileal anastomoses are performed in a continuous manner using two separate 3-0 Vicryl sutures (RB-1 needle) for each ureter. Sutures are used for the posterior and anterior walls, respectively. Prior to completion of the anastomoses, the stents are passed up the ureter and coiled into the renal pelvis. All suturing and knot tying is performed intracorporeally using free-hand laparoscopic technique.

The neobladder is irrigated through the Foley catheter and any obvious sites of leakage are specifically repaired with figure-of-eight stitches. A suprapubic catheter is inserted into the neobladder through the midline port-site incision. Two Jackson-Pratt drains are inserted, one through each lateral port site. The specimen is extracted through a 2–3-cm circumbilical extension of the umbilical port incision. The instruments are removed and port sites closed in standard fashion.

Postoperative Care

In the case of the neobladder, the urethral Foley catheter is irrigated every 4–6 h during the first 2–3 d and every 8 h thereafter. The Jackson-Pratt drains are removed as their drainage decreases appropriately. The ureteral stents are removed at approximately 1–2 wk. A loop-o-gram or cystogram is obtained at 4–6 wk postoperatively to confirm complete healing prior to removal of the Foley catheter (Fig. 17 and 18). An I.V.P. is obtained subsequently to document upper-tract status and drainage (Fig. 19). Abdominopelvic CT scan and chest X-ray are obtained at 6-mo intervals.

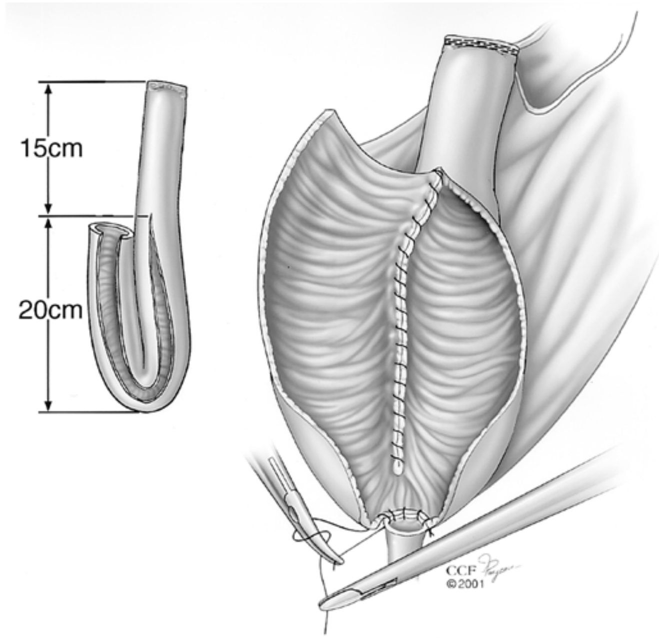

Fig. 15. After isolation of the ileal segment and detubularization of the distal portion, the posterior plate is created with laparoscopic suturing. The urethro-ileal anastomosis is completed using a running suture.

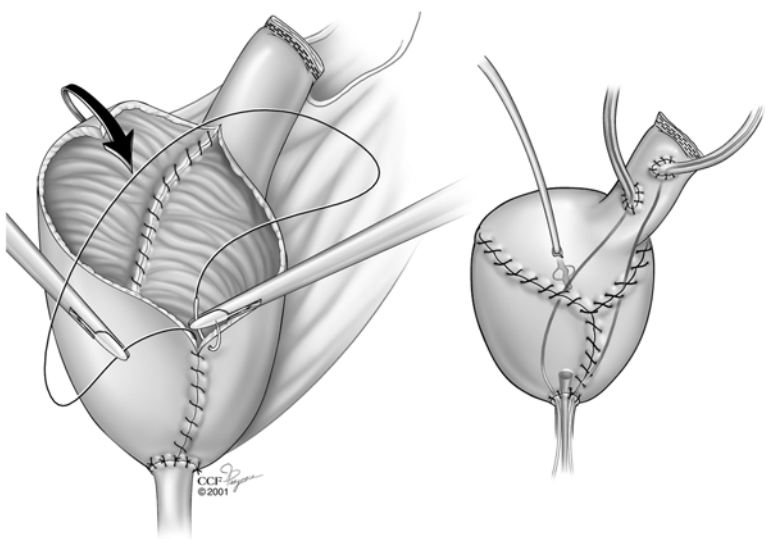

Fig. 16. Completion of the neobladder. Suturing of the anterior wall of the neobladder is completed. Both ureters are anastomosed to the Studer limb. The various drainage tubes (urethral Foley, suprapubic Malecot, bilateral single-J ureteroileal stents) are shown.

RESULTS

Peri-Operative

In the first 11 cases (9 males and 2 females) of laparoscopic radical cystectomy with ileal conduit performed at the Cleveland Clinic, there were no conversions to open surgery *(12)*. Mean surgical time was 8.3 h. The estimated blood loss was only 330 mL

Fig. 17. A loop-o-gram performed at 4–6 wk postoperatively demonstrates no extravasation and free reflux of contrast into the ureters.

Fig. 18. A cystogram demonstrates good volume in the neobladder and studor limb with no reflux into the ureters.

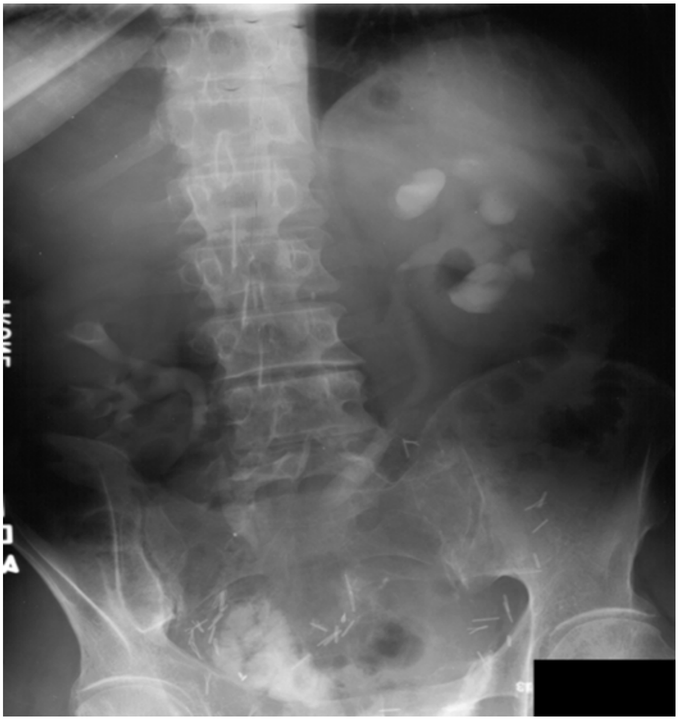

Fig. 19. Postoperative I.V.P. demonstrates adequate drainage of upper tracts into the neobladder.

Fig. 20. Photograph of abdomen reveals excellent cosmetic results.

with no blood transfusions required. A photograph of the abdomen of one of the patients shows excellent cosmetic results (Fig. 20).

Oncological Follow-Up

The first 11 patients undergoing cystectomy had negative surgical margins of the bladder. Five patients have been followed for more than 1.5 yr *(13)*. Of these five, three patients are alive with no evidence of recurrent disease. The remaining two patients died of unrelated causes (septicemia following chest infection in one patient and myocardial infarction 12 mo after surgery in the other). Both of these patients had normal renal function and no evidence of recurrent disease up to the time of death.

TAKE HOME MESSAGES

1. Laparoscopic cystectomy and urinary diversion is an advanced laparoscopic technique. It requires significant intracorporeal suturing and should be attempted only by an experienced laparoscopic team.
2. Choice of urinary diversion include ileal conduit, continent catheterizable pouch, and orthotopic ileal neobladder. Each can be performed laparoscopically with intracorporeal suture techniques.
3. As with any surgical procedure, sound oncological principles must remain in the forefront. Thus, longer follow-up and careful comparisons with the open technique are essential.
4. With the significant morbidity of the open approach to cystectomy and urinary diversion, the potential benefits from the laparoscopic approach are significant.

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16 Laparoscopic Radical Prostatectomy

Transperitoneal Approach

Chandru P. Sundaram, MD, FRCS

CONTENTS

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
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INTRODUCTION

There have been significant advances in laparoscopic skills and instrumentation since Schuessler and colleagues performed the first laparoscopic radical prostatectomy in 1991 *(1)*. Only nine laparoscopic radical prostatectomies (LRPs) were performed between 1991 and 1995. However, the surgery was difficult, with long operating times, and the laparoscopic approach for the treatment of prostate cancer was believed to offer no advantage over open surgery. In 1998, Guillonneau and colleagues reported their initial experience with the surgery with early results of the transperitoneal approach comparable to contemporary series of open radical prostatectomy *(2)*. Since then, several centers have performed the LRP in increasing numbers with early results comparable to open surgery.

OPERATIVE TECHNIQUE

Bertrand Guillonneau and Guy Vallancien in Paris developed the operating technique described in this chapter. Details of the technique have been modified, based on our initial experience. This approach differs from the principles of the open approach in that the dissection of the bladder neck and prostatic pedicles are performed before transection of the dorsal venous complex and the division of urethra. Difficulties faced during our early experience will be mentioned. Bipolar coagulation or the Harmonic Scalpel may be used throughout the operation depending on the surgeon's preference. We use the Harmonic scalpel during most of the prostatic dissection because there is less spread of heat and possibly less damage to the neurovascular bundles.

PREOPERATIVE ASSESSMENT

During a surgeon's initial experience with the LRP, patients may be selected with low-grade, low-stage cancers that do not require laparoscopic pelvic lymph node dissection. This helps limit the operating time, which is likely to be prolonged during the early patients. The first 25 patients we selected had prostate-specific antigen (PSA) less than 10 and a Gleason of 6 or below.

Factors that can adversely affect the prostatic dissection include obesity; a large (>80 g) or small prostate (<20 g); and history of radiotherapy to the prostate, transurethral resection of the prostate, pelvic surgery, laparoscopic inguinal hernia repair, and neoadjuvant hormonal treatment. Nerve-sparing technique is difficult during a surgeon's early experience, and can further add to the operating time. A large median lobe can make bladder neck preservation difficult and would necessitate bladder neck reconstruction. Virtually all patients who are candidates for open surgery can be approached laparoscopically after the surgeon has gained adequate experience.

PREOPERATIVE PREPARATION

Preoperative preparation includes two bottles of magnesium citrate at home the day before surgery as well as a bisacodyl suppository the night before the surgery. Aspirin and other nonsteroidal analgesics are discontinued a week before surgery. The majority of patients do not require blood transfusion. Two units of crossmatched blood are made available. Low-dose subcutaneous heparin may be administered in patients at high risk for deep vein thrombosis. In some centers prophylactic heparin is routinely used. Intravenous cefazolin is administered for antibiotic prophylaxis.

INSTRUMENTATION

- Erbe ICC 350 electrocautery unit set on auto-cut with a 40 watt, max., 50 watts for auto-coagulation and 40 watts for bipolar coagulation. (ERBE USA, Inc., Marietta, GA).
- Five trocars: three 12-mm trocars and two 5-mm trocars.
- A 0° 10-mm laparoscope, 30° 10-mm laparoscope, and 5-mm 30° laparoscope should be available.
- Harmonic scalpel and generator (LCS; Laparoscopic Coagulating Shears, Ethicon Endosurgery, Cincinnati, OH).
- Two 5-mm bipolar electrosurgical forceps: broad-tipped and fine-tipped. (Gyrus Medical, Maple Grove, MN).
- 5-mm locking grasping forceps, Microfrance (Xomed) or Jarit.
- Two 5-mm needle holders (Ethicon Endosurgery). Self-righting needle holders should not be used.
- 5-mm curved electrosurgical scissors.
- Entrapment sack—10-mm Endocatch (U.S. Surgical).
- 5-mm suction/irrigation unit (Karl Stroz Endoscopy—America, Culver City, CA).
- Laparoscopic Kittner (Asten, Grand Rapids, MI).
- Sutures: 0 dyed polyglactin sutures on a #36 needle and 2-0 dyed polyglactin sutures on a #26 needle, SH or RB1 needle (Ethicon, Inc., Somerville, NJ).
- 5-mm cold knife.
- Carter-Thomason suture passer and Pilot 10–12-mm suturing guide, for 12-mm port site closure with O polyglactin suture (Inlet Medical, Inc., Eden Praire, MN).
- 24F curved metal urethral sound.
- 1-inch cervical dilator. May be used as a rectal bougie during early experience.
- 20 F Foley catheter with a 30cc balloon and 18 F Foley with a 5cc balloon.
- 10F Blake drain.
- AESOP 3000 voice activated surgical robot (Computer Motion, Inc., Goleta, CA). Optional to maneuver laparoscope.

PATIENT POSITIONING

Pneumatic compression boots are used as a prophylaxis against deep vein thrombosis. The patient is positioned supine with his legs on spreader bars and the abdomen is prepped from the xiphisternum to the perineum, including the genitals. The patient is secured to the table with adhesive tape, with both arms alongside his body. Adhesive tape over foam strips strap the chest to the table. The thighs and the lower extremities are also secured. Strapping must be secure enough to prevent patient movement with the 30–40° Trendelenberg position during surgery, but breathing should not be impeded. Foam or gel pads are used to pad the patient at all bony prominences to minimize pressure injury. We have discontinued the use of shoulder support owing to risk of pressure injury. A 20 F Foley urethral catheter and an orogastric tube are inserted. The anus is exposed during patient draping for insertion of a rectal bougie. During the early experience, the rectal bougie assists in identification of the Denonvillier's fascia during posterior prostatic dissection.

OPERATING ROOM SET-UP

The voice-activated AESOP 3000 (Computer Motion Inc, Goleta, CA) is a robotic system that holds the laparoscope and helps maneuver the laparoscope as per the surgeon's directions. It is especially useful for the LRP because the field of surgery is

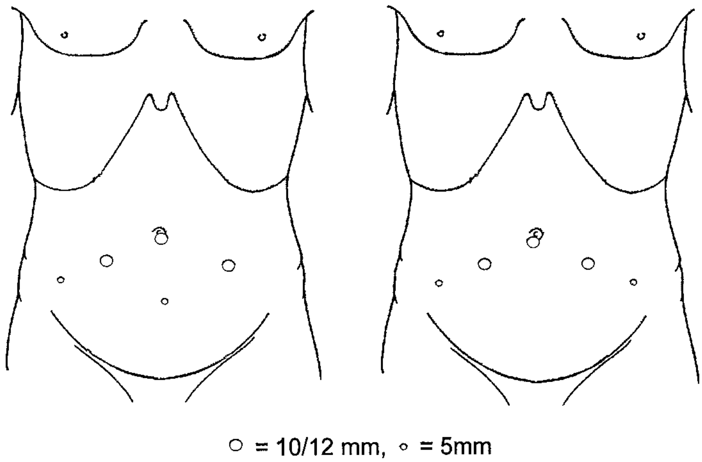

Fig. 1. (Left and right) Diagrams depicting two variations in port placement for LRP.

small and steady images help accurate dissection. AESOP is secured to the operating table adjacent to the right shoulder of the patient. The surgeon stands on an elevated platform adjacent to the left shoulder of the patient facing the pelvis. The assistant's position is on the right of the patient's abdomen. If the robot is not used, a second assistant stands on the patient's right, to the left of the first assistant, to hold the laparoscope. The nurse is positioned beside the left lower extremity of the patient. The video monitor is placed between the patient's feet, at the eye level of the surgeon. We use two ceiling-mounted video monitors placed just above each lower extremity.

TROCAR CONFIGURATION

Five laparoscopic ports are used: three 10-/12-mm ports and two 5-mm ports. Veress needle is used to establish pneumoperitoneum at the umbilicus. A 10-/12-mm port is then inserted at that site. The second 10-/12-mm port is inserted between the umbilicus and the left anterior superior iliac spine. The third 10-/12-mm port is inserted at the lateral border of the right rectus abdominis muscle 2 fingerbreadths below the umbilicus. The third trocar may be 5 mm, but cannot then be used to introduce the needle during anastomosis. The entrapment sac also requires a 10-/12-mm port. The fourth 5-mm port is inserted between the third port and the right anterior superior iliac spine. The fifth 5-mm port is inserted between the umbilicus and the pubic symphysis in the midline (Fig. 1, left). Urachal tissue may need to be held up to the abdominal wall with a gasper during introduction of the last trocar. The surgeon operates through the two ports on either side of the umbilicus. In tall patients, the lateral 10-/12-mm port positions are moved about 3 cm caudally to allow the instruments to reach the urethra and prostatic apex.

The fan configuration is the other alternative for trocar position where two ports are placed on each side between the umbilicus and the anterior superior iliac spine (Fig. 1, right). With port placement in the fan configuration, the surgeon operates through the two ports on the left side and the assistant uses the two right-sided ports.

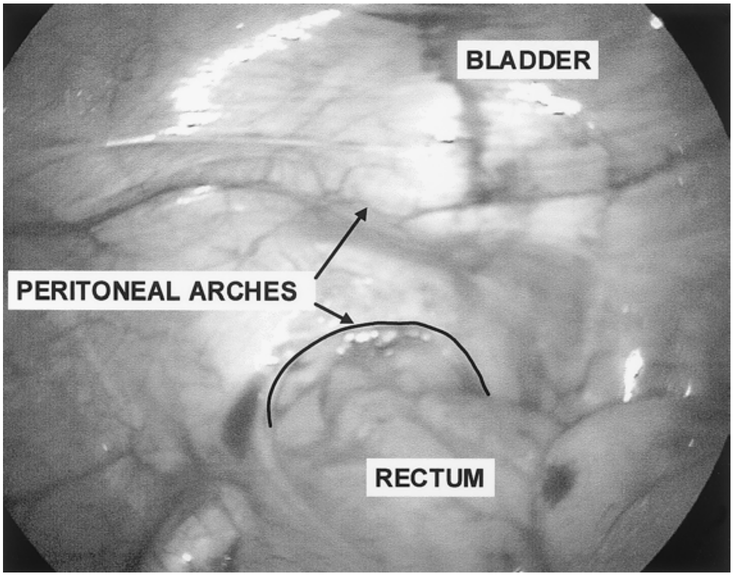

Fig. 2. The peritoneal arches in the retrovesical region are identified after cephalad retraction of the rectosigmoid colon.

SEMINAL VESICLE DISSECTION

The patient is placed in a 30°–40° Trendelenburg position. The assistant via the right lateral port using the suction aspirator or the fan retractor retracts the sigmoid colon superiorly. In some patients a stay suture is placed through the appendix epiploicae of the colon and brought out of the abdominal wall using the Carter-Thomason device, to facilitate retraction of the sigmoid colon. The suction irrigation is used through the lower midline port by the assistant to help with suction during the dissection. There are two peritoneal arches anteriorly in the recto-vesical pouch. The vasa deferentia and seminal vesicles are located deep to the lower peritoneal arch (Fig. 2). The assistant holds up the peritoneum overlying the posterior bladder using a locking grasper to better expose the cul-de-sac. A transverse incision is made at the lower arch to identify and dissect the vas deferens. The vas deferens is coagulated with bipolar coagulation or clipped and divided. The assistant then holds the vasa deferentia anteriorly, exposing the seminal vesicles on either side. The seminal vesicle is dissected circumferentially from the base to the apex, taking care to control the vessels to the seminal vesicle. The contralateral seminal vesicle is also dissected.

If the vas deferens or the seminal vesicle is not readily apparent after incision of the peritoneum in the pouch of Douglas, the vas deferens is identified more laterally along the lateral pelvic wall and followed posteriorly towards the prostate. During the dissection of the seminal vesicles, it is essential to remain close to the seminal vesicles in order to prevent damage to the neurovascular bundles. In some instances, the seminal vesicle dissection may be difficult or time-consuming. The seminal vesicles may then be dissected after the bladder neck dissection is complete, via an anterior approach.

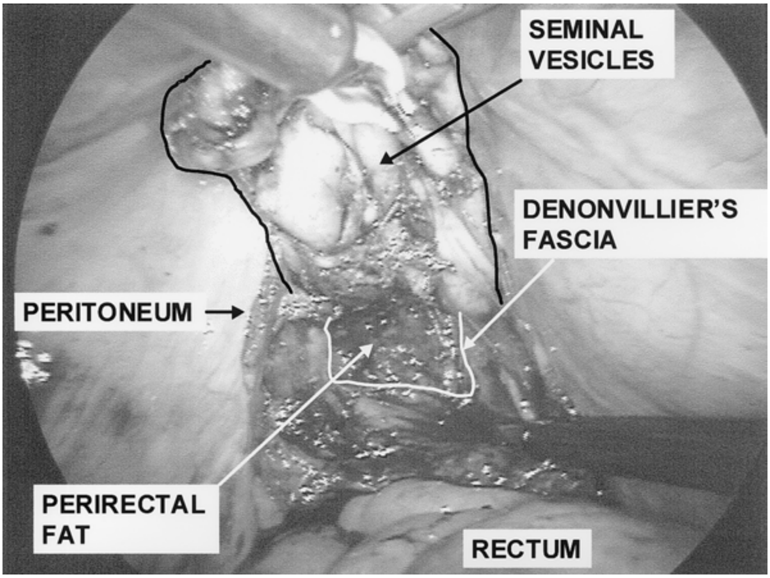

Fig. 3. Dissection of seminal vesicles: the vasa deferentia and seminal vesicles are dissected and held anteriorly. The Denonvillier's fascia is incised to expose the perirectal fat.

INCISION OF THE DENONVILLIER'S FASCIA

The fibers of the Denonvillier's fascia are stretched and identified when the assistant holds the completely dissected seminal vesicles anteriorly. The Denonvillier's fascia is transversely incised in the midline about 3 mm posterior to the base of the seminal vesicles, to visualize perirectal fat (Fig. 3). The complete dissection of the vasa differentia and seminal vesicles are important to enable correct identification of the Denonvillier's fascia. Dissection can then be carried out in perirectal plane towards the prostatic apex.

During the incision of the Denonvilliers fascia, if the plane is not readily apparent, an assistant's finger in the rectum or a rectal bougie would help identify the rectal wall and avoid rectal injury. Should injury to the rectal wall be apparent, it can be primarily closed in two layers after thorough irrigation of the pelvis, provided there is no gross fecal contamination.

RETROPUBIC DISSECTION

One hundred fifty cc of saline is instilled into the bladder via the Foley catheter to help visualize the bladder margins. An inverted U-shaped peritoneal incision is made from one medial umbilical ligament to the other (Fig. 4). The peritoneal incision towards the midline should be as high as possible on the anterior abdominal wall in order to prevent inadvertent injury to the dome of the bladder. Dissection is begun just medial to the medial umbilical ligament on each side until the loose retropubic areolar tissue is identified and the pubic bone is felt. Dissection in this plane is usually bloodless and bleeding could suggest dissection into the bladder wall. This dissection is continued medially until the urachus is encountered (Fig. 5). The urachus is then divided after bipolar coagulation. Occasionally, to improve access to the pelvis the medial umbilical ligament on both sides can be divided after bipolar coagulation.

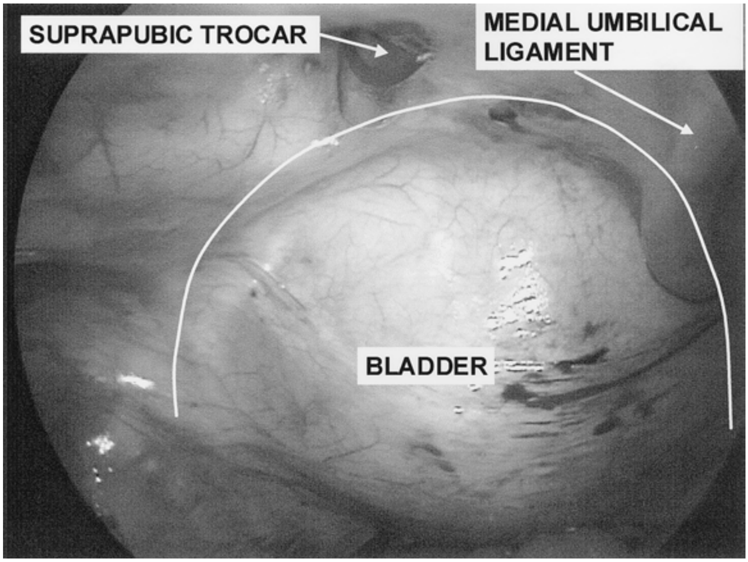

Fig. 4. The contour of the bladder is visible through the overlying peritoneum. The line of the planned incision in the peritoneum is outlined.

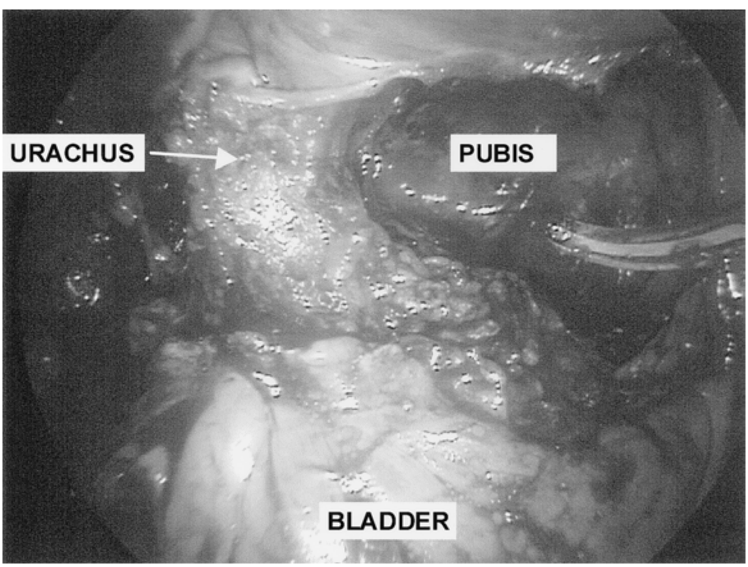

Fig. 5. Retropubic dissection is performed between the right medial umbilical ligament and the urachus. Entry into this avascular plane exposes the pubic bone.

Bladder injury occurred in one patient in our experience and was primarily closed without conversion to the open approach.

DISSECTION OF ENDOPELVIC FASCIA

The bladder is emptied by using the suction irrigator to evacuate the urine within the Foley catheter. The Foley catheter does not adequately drain the bladder by gravity alone, in a steep Trendelenburg position. The endopelvic fascia is exposed after blunt

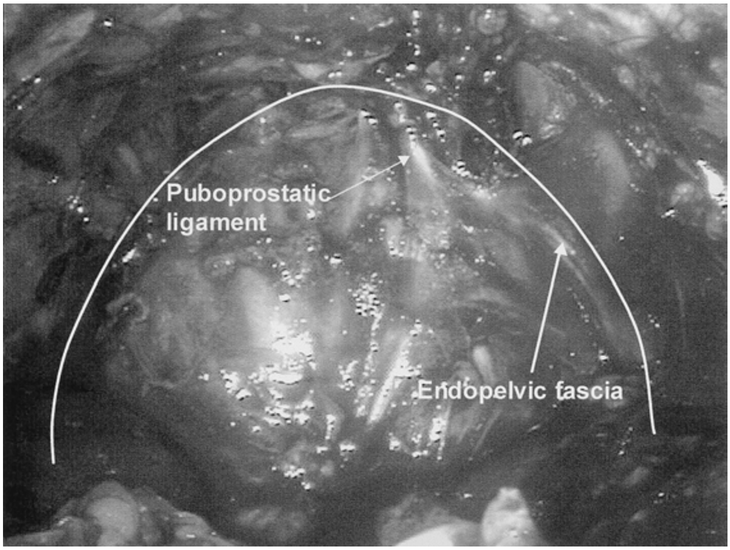

Fig. 6. Blunt dissection exposes the endopelvic fascia and the puboprostatic ligament.

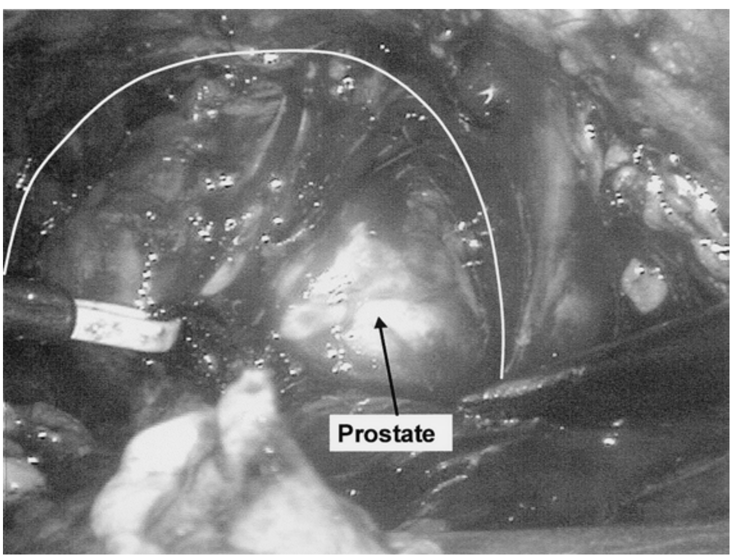

Fig. 7. The endopelvic fascia is incised on the right and the lateral aspect of the prostate exposed.

dissection with a laparoscopic Kittner, to eliminate overlying fat. The superficial dorsal venous complex is coagulated and divided before the puboprostatic ligaments are exposed (Fig. 6). The endopelvic fascia is incised with endoshears just lateral to the prostatic surface along the lateral pelvic wall (Fig. 7). Precise bipolar electrocoagulation assures hemostasis. The lateral surface of the prostate is separated from the levator muscle with a laparoscopic Kittner dissector. The puboprostatic ligaments are divided close to their attachment to the pubic bone. The apex of the prostate is visualized before the dorsal venous complex is ligated.

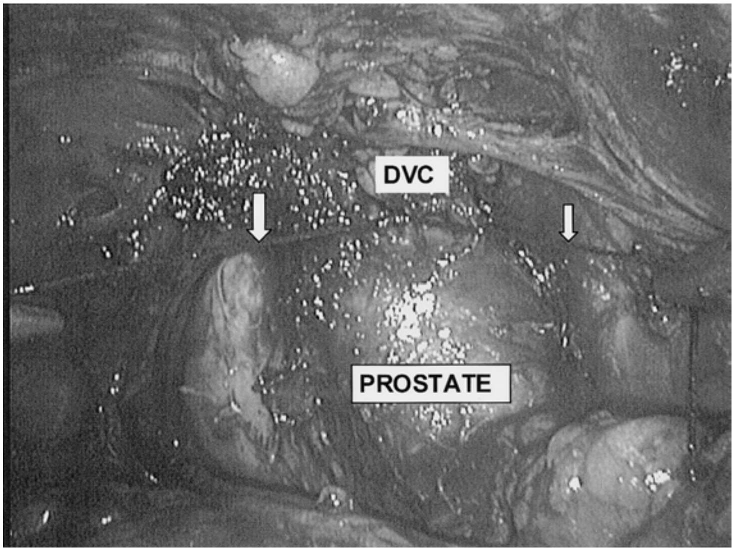

Fig. 8. The deep dorsal venous complex is ligated with 0 Polyglactin (Arrows).

LIGATION OF THE DORSAL VENOUS COMPLEX

The urethral catheter is replaced with a 24-French curved metal bougie. Angulating the tip of the bougie posteriorly, places the dorsal venous complex on stretch. The dorsal venous complex is ligated (Fig. 8) with a figure-of-eight stitch with 0 or 2/0 polyglactin on a 36-mm CT-1 needle (Ethicon Inc., Somerville, NJ). The curve of the needle is made parallel to the curve of the pubic arch and the needle is passed posterior to the dorsal venous complex with the right-handed needle holder. A second back-bleeding stitch can be applied on the anterior surface of the prostate to identify the base of the prostate to help with bladder neck dissection. The author does not typically use the second stitch because the vessels can be controlled during the bladder neck dissection. The dorsal venous complex is not divided until later in the operation.

BLADDER NECK DISSECTION

With experience, the demarcation between the base of prostate and the bladder neck can be accurately determined. The margin of the perivesical fatty tissue helps identify the plane of dissection (Fig. 9). The difference between the floppy bladder wall and the solid prostatic surface can be visualized. Movement of a urethral bougie or a Foley catheter within the bladder can also help. The prostatic base is separated from the bladder neck with blunt and sharp dissection. We use the Harmonic scalpel during this dissection. The dissection is continued posteriorly on either side of the prostatic urethra (Fig. 10). The anterior bladder neck is incised in the midline with endoshears, exposing the metal bougie. Coagulation is not used during this maneuver for the potential for coagulating the urethra in the presence of the urethral metal bougie. After the anterior bladder neck is divided, the metal bougie is brought out through this opening, and the base of prostate is rotated anteriorly. Alternatively, a urethral catheter can be inserted

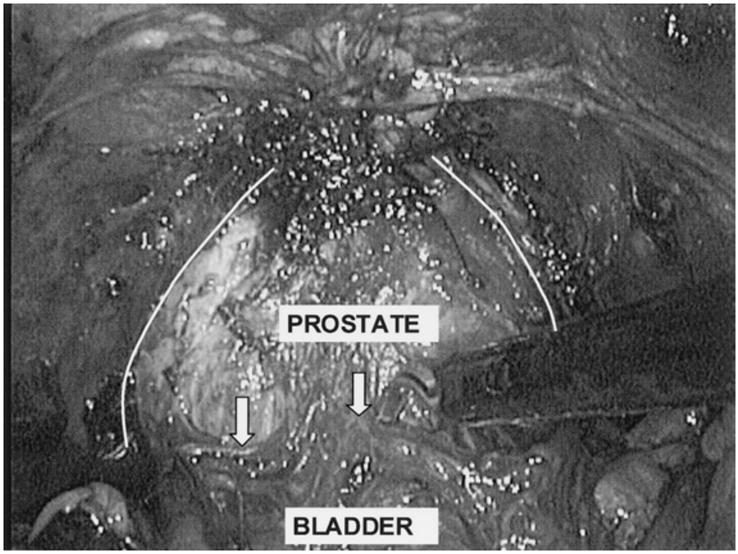

Fig. 9. The demarcation between the prostatic base and the bladder neck is visualized (Arrows), before bladder neck dissection is begun.

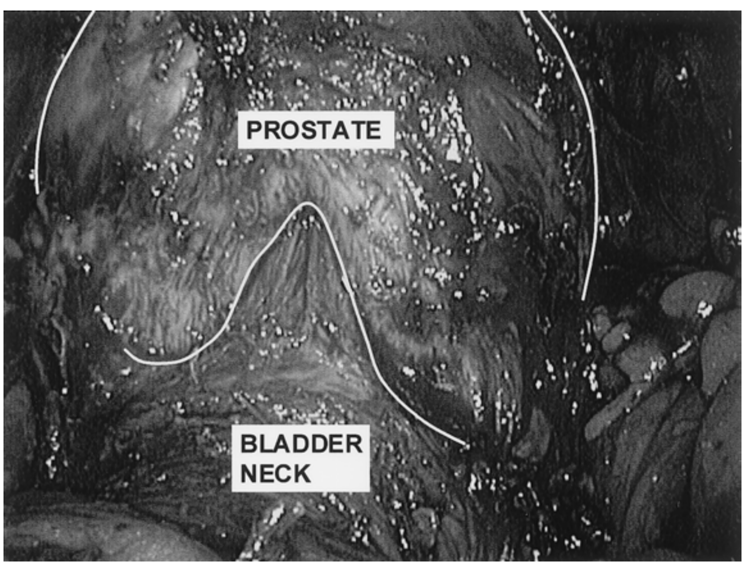

Fig. 10. The anterior bladder neck dissection is completed, exposing the vertical fibers of the bladder neck.

and its tip held up (by the assistant) through the opening in the bladder neck. The posterior wall of the bladder neck is divided and held with a laparoscopic grasper and retracted in a cephalad direction. Vertically directed dissection is performed in the plane between the posterior bladder neck and the base of the prostate. Dissection can inadvertently be intracapsular if the correct plane is missed. The ureteral orifices are at a safe distance from the bladder neck if bladder neck preservation is possible. If not, intravenous indigo carmine can assist identification of the ureteral orifices. In the presence of a large median lobe, the median lobe is retracted anteriorly before

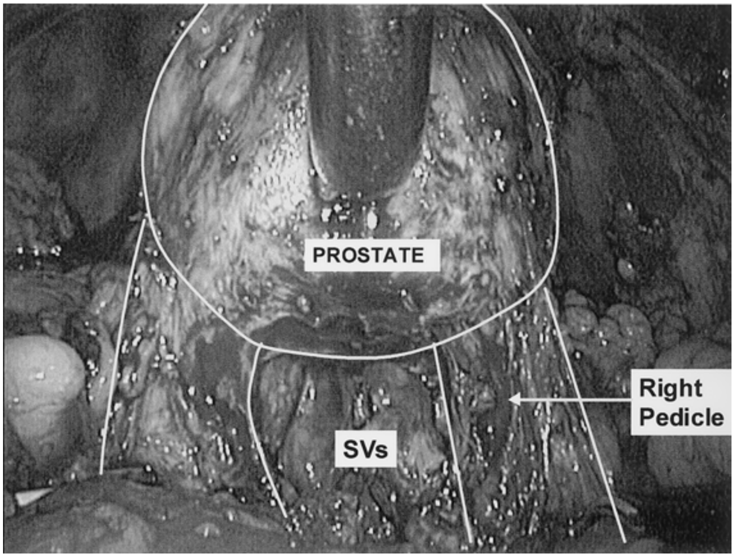

Fig. 11. The posterior bladder neck dissection is completed. The seminal vesicles are visualized through the opening that was previously made in the Denonvillier's fascia.

transection of the posterior bladder neck. Bladder neck preservation may not be possible in the presence of a median lobe.

Completion of the posterior bladder neck dissection exposes the previously dissected seminal vesicles (Fig. 11), because the Denonvillier's fascia was opened during retrovesical dissection. The assistant then holds up the seminal vesicles and the vasa deferentia with locking atraumatic grasper after the metal bougie or catheter is removed.

CONTROL OF PROSTATIC PEDICLES

The prostatic pedicles are exposed by holding the seminal vesicle and vas anteriorly (Fig. 12). We use the Harmonic scalpel for division of the prostatic pedicle, because it has less lateral thermal damage and may be less likely to damage the neurovascular bundles. The periprostatic fascia on the lateral aspect of the prostate is carefully incised and the neurovascular bundle dissected off the prostatic capsule. Completion of the division of the prostatic pedicles is accomplished without injury to the neurovascular bundles by maintaining the dissection close to the prostate. The nerve-sparing transection of the prostatic pedicle on the opposite side is similarly performed before the base of the prostate is free. Remnants of the Denonvilliers fascia are divided to free to posterior aspect of the prostate.

Venous bleeding that occurs during the nerve-sparing technique usually stops spontaneously during the remaining prostatic dissection. The intraperitoneal pressure may be increased to 20 mmHg for a few minutes to assist with hemostasis. Active bleeding can be controlled with accurate bipolar coagulation using fine-tipped forceps. The nerve-sparing technique is not possible during the early experience of a surgeon and can add up to an hour of additional operating time. Guillonneau and associates have used the narrow-tipped bipolar forceps successfully for the nerve-sparing technique. Gill and associates at the Cleveland Clinic have used the articulating, Endo-GIA stapler

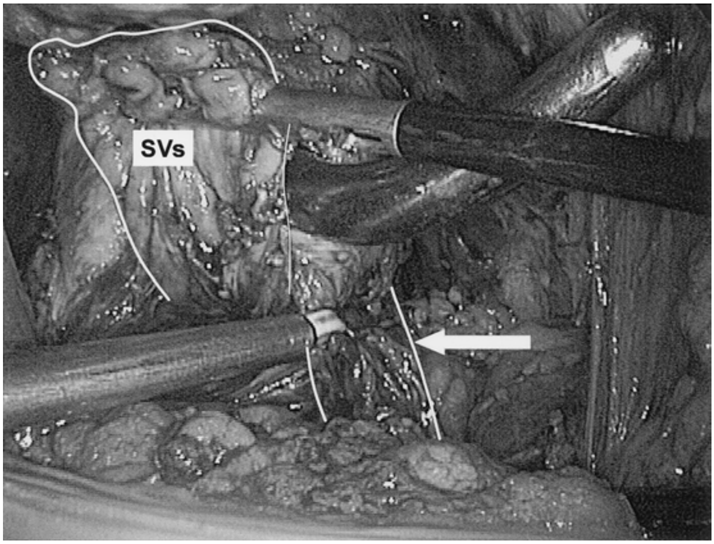

Fig. 12. The seminal vesicles are held up to place the prostatic pedicles (Arrow) on stretch. The pedicles are controlled close to the prostate with bipolar coagulation or Harmonic scalpel without damage to the neurovascular bundles.

(U.S. Surgical) with the 3.5-mm white staple for the pedicle and 2.5-mm gray staple load for the lateral attachments during the non-nerve-sparing technique. For the nerve-sparing procedure, they have described the use of the Hem-o-lok clip (Weck Systems, Research Triangle Park, NC), which is a polymer ligating clip with a locking tip.

DIVISION OF THE DORSAL VENOUS COMPLEX

The deep dorsal venous complex that was previously ligated is divided using endoshears or the Harmonic scalpel. Manipulation of the urethral bougie helps displace the prostate posteriorly and place the dorsal venous complex on stretch. The previously placed stitch may become dislodged during the division of the dorsal venous complex. Bleeding from the complex is controlled with a combination of increasing the intra-abdominal pressure and precise bipolar coagulation of the bleeding vessels. Occasionally a figure-of-eight hemostatic stitch is applied with 2-0 polyglactin on a 36-mm CT-1 needle or 26-mm SH needle (Ethicon Inc., Somerville, NJ).

DIVISION OF THE URETHRA

The prostatic apical dissection is completed to maximize the length of the urethral stump, without violation of the apical tissue. The anterior wall of the urethra is divided with the endoshears or a laparoscopic knife, and the metal bougie within the urethra exposed. The metal bougie is then delivered through this opening, and the posterior urethral wall divided. The rectourethralis muscle is divided, without damage to the neurovascular bundles. The same procedure is repeated on the opposite side. The prostate along with the seminal vesicles is then entirely freed, provided the posterior dissection was previously completed. Occasionally, remnants of the Denonvillier's fascia will need to be divided. Care should be taken during this dissection to avoid injury to the rectum. The prostate is placed in a 10-mm Endocatch bag (Fig. 13), which

Fig. 13. The prostate is placed in the 10-mm Endocatch bag.

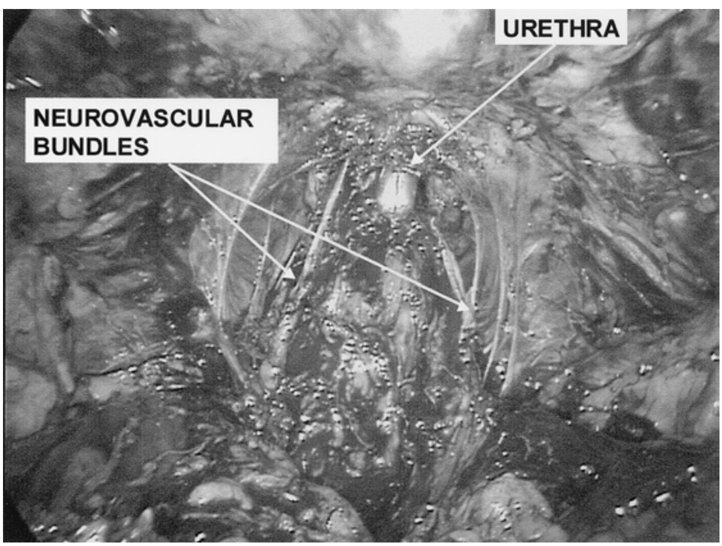

Fig. 14. The neurovascular bundles are visualized on both sides in the prostatic bed.

is closed and left in the abdomen for retrieval at the end of the surgery. The preserved neurovascular bundles can be visualized in the prostatic bed (Fig. 14).

BLADDER NECK RECONSTRUCTION

The size of the lumen of the bladder neck usually corresponds to the lumen of the urethral stump when bladder neck preservation has been successful; bladder neck reconstruction is therefore not required. If bladder neck preservation was not possible or not performed because of surgeon preference, the bladder neck may then be reconstructed with a racquet-handle technique. We reconstruct the bladder anteriorly, rather than posteriorly as is done traditionally with open surgery. Posterior

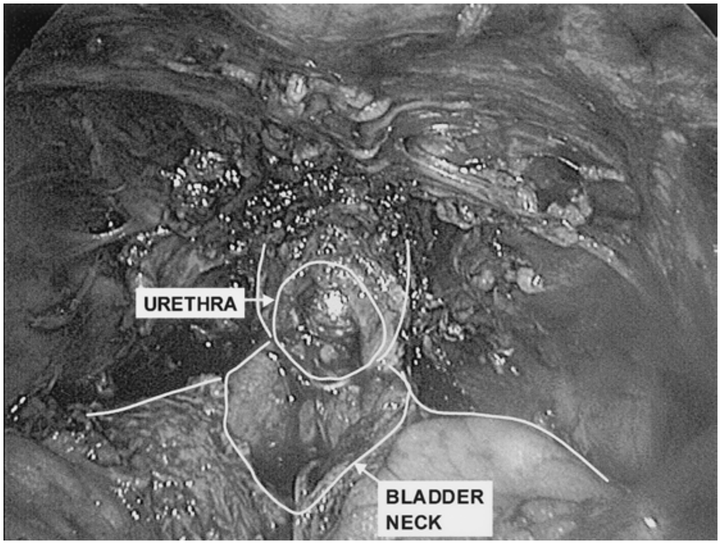

Fig. 15. The posterior layer of the urethrovesical anastomosis is complete. Bladder neck reconstruction is not required since bladder neck preservation was successful.

reconstruction may be required if the ureteric orifices are very close to the bladder neck margin. We do not evert the bladder neck mucosa and rely on mucosal apposition during a watertight urethrovesical anastomosis. Before the anastomosis is begun, the intra-abdominal pressure is decreased to 5 mmHg to confirm that there is no significant bleeding. Bleeding from the prostatic bed after the anastomosis is complete will be difficult to accurately control.

URETHROVESICAL ANASTOMOSIS

Good-quality needle holders are essential during this procedure. We use Ethicon needle holders inserted through two ports on either side of the umbilicus. Self-righting needle holders should not be used because the needle should be held at different angles, depending on the particular anastomotic suture. We use interrupted 2-0 dyed polyglactin sutures on a 26-mm SH needle with intracorporeal knot tying. The 17.45-mm RB1 needle can also be used (Ethicon Inc.). All knots are tied with the intracorporeal technique; the first knot is a surgeon's knot. A total of three knots are tied for each stitch. The suture is 6 inches long for each interrupted stitch. However, as experience is gained, a 9-inch stitch can be used for two or three interrupted stitches. Six to twelve interrupted sutures are placed, depending on the size of the bladder neck and the urethra. The assistant handles the metal bougie within the urethra, which helps guide the needle through the full thickness of the urethra. A perineal sponge stick is occasionally used to exert pressure in the perineum to help visualize the urethral stump clearly.

The first suture, at 5 o'clock position, is placed inside out on the urethra and outside in on the bladder with a right-hand forehand approach. The second stitch at 6 o'clock position is placed right-hand forehand inside out on the urethra and left-hand forehand outside in on the bladder and tied within the lumen. The third stitch is at 7 o'clock position: right-hand forehand inside out on the urethra and left-hand forehand, outside in on the bladder (Fig. 15). These sutures are tied within the lumen of the anastomosis. There have not been problems with calcification owing to intraluminal knots. All other

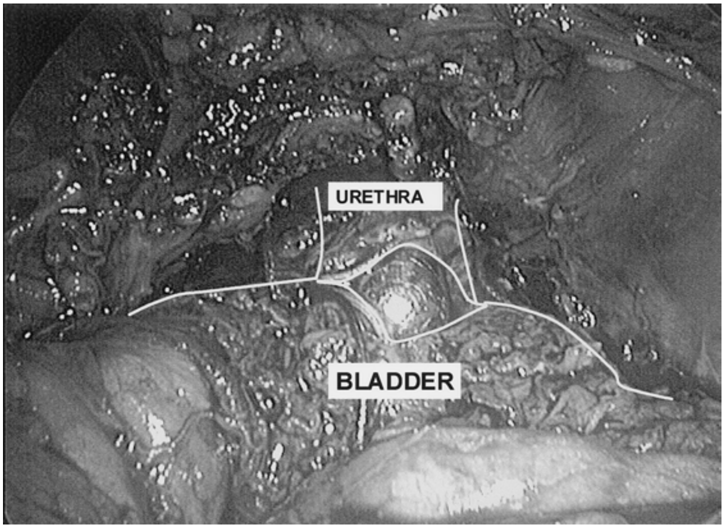

Fig. 16. The urethro-vesical anastomosis is almost complete. The metal bougie is then removed and the anastomosis completed over a catheter.

sutures are placed with extraluminal knot tying. The lateral sutures on both sides are placed: the right-hand forehand outside in on the bladder and left-hand backhand inside out on the urethra on the right side. The left side stitches are placed left-hand forehand outside in on the bladder and right-hand backhand inside out on the urethra (Fig. 16). The anterior stitches are placed at 1 and 11 o'clock positions using similar technique. Right-hand forehand outside in on the urethra and right-hand forehand inside out on the bladder for the 1 o'clock position and 11 o'clock position. The last two stitches are not tied until the 18F Foley catheter is passed into the bladder across the anastomosis. The Foley catheter balloon is inflated with 10 cc of water, and the two last stitches are tied. After the anastomosis is complete, the Foley catheter is irrigated to ensure that the anastomosis is watertight.

During initial experience, the urethrovesical anastomosis is the most time-consuming and challenging part of the operation. However, with experience, suturing is predictable and precise. In our experience, there were four anastomotic leaks in our first eight patients, but all of these were treated conservatively with continued urethral catheter drainage. All patients thereafter did not have an anastomotic leak. The anastomosis has also been done with a continuous suture for the posterior suture line and another continuous suture for the anterior suture line *(4)*.

DRAIN INSERTION PORT SITE CLOSURE AND SPECIMEN EXTRACTION

A 10-French Blake drain is inserted through a right lateral 5-mm port site and placed in the region of the urethrovesical anastomosis. A 0 polyglactin suture is inserted across each 10-/12-mm port site for closure, with a Carter-Thomason suture passer and Pilot 10-/12-mm suturing guide (Inlet Medical). After closure of the 10-/12-mm port sites and removal of the 5-mm trocars under vision, the prostate that was previously placed in an Endocatch bag (U.S. Surgical Corp.; Fig. 15) is extracted through the umbilical

Table 1
Early Results Following Laparoscopic Radical Prostatectomy

Authors	*# of pts.*	*Estimated blood loss (mL)*	*Mean OR time (min)*	*Mean hospital stay time (d)*	*Catheter indwell (d)*	*Positive margins (%)*	*Continence (%)*
Guillonneau et al. *(5)*	240	370	232	5.2 (in last 140 pts)	4.2 (140 pts)	13.75	84 (in 127 pts at 6 mo)
Bollens et al. *(6)*	50	708	330	N/A	7.8	20	85
Abbou et al. *(7)*	43	N/A	255	4.5	4	27.9	84
Tuerk et al. *(8)*	145	185	265	N/A	5.5	23.4	92 at 9 mo
Zippe et al. *(9)*	50	225	324	1.6	9 (in 60% of pts)	20	76 at 6 mo
Rassweiler et al. *(10)*	180	1230	271	10 (Median)	7 (Median)	16	97 at 12 mo

NA, Data not available.

incision after vertical extension of the incision. Care is taken not to exert undue traction on the Endocatch bag because it is not strong and can rupture.

POSTOPERATIVE RECOVERY

Our patients typically are discharged home on the second postoperative day, about 36 h after surgery. The patient is on a clear liquid diet on the first postoperative day and on a regular diet on the second postoperative day. Compression stockings are used during the hospitalization. The Foley catheter is typically removed on the sixth postoperative day at our center. In recent series, with the last 140 patients the catheter has been removed at a mean of 4.2 d. With increasing experience, the integrity of the anastomosis is secure and the duration of catheterization decreases considerably *(5)*.

EXTRAPERITONEAL APPROACH

Preservation of the peritoneal integrity and the elimination of the potential for intraperitoneal injury are obvious benefits of the extraperitoneal approach. There is, however, less operating space than the transperitoneal approach, and the seminal vesicle dissection would need to be done at a later stage of the operation as with the open approach. Early results suggest that this approach may be comparable to the transperitoneal approach *(6)*.

RESULTS (*SEE* TABLE 1)

Learning Curve

Laparoscopic radical prostatectomy is presently being performed by selected surgical teams with advanced laparoscopic skills. The learning curve is long and steep. Since the surgical technique has now been established, the learning curve should become shorter. Furthermore, as urologists at several centers become proficient at the surgery, colleagues and residents will be trained at the procedure. This can be achieved by an experienced surgeon assisting a novice surgeon. During the first 10 patients, the anastomosis can be challenging because no other urologic laparoscopic surgery requires complex intracorporeal suturing. Operating time can be shortened with practice of suturing before surgery on the pelvic trainers. Mean operating time is prolonged during the early experience and was 8.5 h during our first 20 patients and 5.1 h during our last 10 patients in an experience of 42 patients. The average time in the first 50 patients was between 4.2 h and 5.5 h *(6,7,9)*. With even more experience the mean time drops to about 3 h for the transperitoneal approach *(3)*. Complications with 1228 LRPs performed by 13 surgeons in 6 European centers included: conversion to open surgery in 26 (2%), rectal or bowel perforations in 15 (1.2%), ureteral injuries in 12 (1%), anastomotic leak in 69 (5.6%), and thromboembolic complications in 2 patients. Major bleeding from the epigastric artery occurred in three patients. Twenty-three patients (1.9%) were reoperated for portsite hernias in 10, ureteral injuries in 5, bleeding in 5, and anastomotic leak in 3 *(11)*.

ADVANTAGES OF THE LAPAROSCOPIC APPROACH

Blood loss and transfusion rates are significantly less with the laparoscopic approach. The tamponading effect of pneumoperitoneum is one factor that results in decreased bleeding. The antegrade approach to the prostatectomy where the pedicles are controlled early may also be a contributory factor. In most laparoscopic series the estimated blood loss was less than 500 mL compared to an about 1000 mL blood loss after open surgery *(12)*. The urinary continence following surgery appears satisfactory. A recent report studied continence among patients in their experience of 228 patients. At 12 mo the continence rate (with no pads) was 78.3% *(13)*. Erectile function may not completely recover for 1–2 yr following surgery. The efficacy of the nerve-sparing technique in the LRP has therefore not been adequately studied. The potency rates in the published series have not been adequately assessed in all patients owing to the learning curve, and inadequate follow-up. Magnification and better visualization that is provided during laparoscopy may result in more accurate dissection during preservation of the neurovascular bundles.

TAKE HOME MESSAGES

1. LRP can be safely performed with early results comparable to open surgery. However, the procedure requires advanced laparoscopic skills and has a steep learning curve.
2. Decreased blood loss during surgery and possibly a shorter duration of convalescence following surgery are definite advantages to the laparoscopic approach.
3. Intracorporeal suturing skills may be developed and refined in the pelvic trainer, to help decrease operating time during early experience.

ACKNOWLEDGMENT

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17 Postoperative Management and Complications of Laparoscopy

Timothy D. Moon

Contents

INTRODUCTION

As surgeons, we would all like to believe that we never have complications. Unfortunately, this is never the case and, as the saying goes, "the only surgeon who doesn't have complications is the one who doesn't operate." The rate of laparoscopic complications is associated with the surgeon's experience. Prior to the 1990s, laparoscopy in urology essentially did not exist. From that perspective, we have gone a long way in a short time. Unfortunately, when we consider complication rates, we have remained on the learning curve for most of the decade, in that we have been developing new or more difficult procedures throughout this period. As we go forward in the 21st century and develop our techniques further, we must necessarily anticipate new complications being identified.

Complications may occur at any stage of the procedure and therefore are addressed here relative to the various stages of the operation. Consideration of potential complications should lead a surgeon to consider different approaches to avoid problems.

From: *Essential Urologic Laparoscopy: The Complete Clinical Guide*
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PREOPERATIVE PLANNING

This area may be divided into anesthetic considerations, operative field issues, and general considerations.

Anesthetic Consideration

Laparoscopy utilizes carbon dioxide as the insufflationary gas. Naturally some of this is absorbed. Thus patients who have pulmonary airways disease compromising the ability to exhale carbon dioxide might require consideration for surgery via another technique *(1)*. One possibility, however, would be to use helium *(1)*. Unfortunately, helium, because of its lower solubility, is more dangerous than carbon dioxide if a venous gas embolism were to occur *(2)*. When retroperitoneoscopy is performed, CO_2 is absorbed at a faster rate than when performed by the transperitoneal route. Thus, if the procedure could be performed by the retroperitoneal or transperitoneal techniques, and there are questions about hypercarbia, then the transperitoneal route may be considered preferable *(3)*. The pathophysiologic effects of laparoscopy have recently been reviewed *(4)*.

Anesthesiologists commonly use nitrous oxide as an inhalational gas. Unfortunately, nitrous oxide tends to be retained within the bowel, leading to dilation. It is therefore important that the anesthesiologist not use nitrous oxide during laparoscopy.

OPERATIVE FIELD

Previous surgery does not specifically preclude a laparoscopic approach but the potential scarring and associated adhesions from this prior surgery may necessitate altering one's approach. For example, if a patient has had multiple abdominal surgeries and now requires a nephrectomy, then the retroperitoneal approach might be preferred. Conversely, if the patient requires an operation to be performed by the transperitoneal route and the patient has had previous abdominal surgery, then using the Veress needle technique for abdominal insufflation may run the risk of bowel injury. As such it may be preferable to use the Hassan technique to obtain access to the abdomen (*see* Chapter 3).

GENERAL CONSIDERATIONS

When transperitoneal procedures are being performed and the bowel needs to be mobilized (e.g., nephrectomy), we routinely give the patient a mechanical bowel prep with Golytely. This seems to help postoperative recovery and also in decompressing the bowel, which avoids visual obstruction of the operative field by dilated bowel.

Many laparoscopic procedures are fairly long in duration and this is especially true when the surgeon is developing new procedures. The possibility of neuromuscular injury becomes more likely with increasing surgical duration, such that it is extremely important that appropriate attention be paid to patient padding and support. Furthermore, if the patient is likely to be rotated in one direction or another during the case, then this may create new pressure points to the patient that did not exist when the patient was in the original position. These possibilities must be considered with appropriately padded support applied prior to the surgery. For example, when we perform laparoscopic nephrectomy in the flank position, we use a 3-inch mattress pad with foam egg crate padding on top. Our normal operating pad is 2-inch thick. The kidney rest is minimally elevated because elevation may compromise renal blood flow. Table break is limited and

Table 1
Neuromuscular Injuries in Patients: Survey of 15 Centers with 165 Procedures

Injury	*Number of patients (%)*	*Time to evolution (d/mean)*	*Chronic number (%)*
Neuralgia	14 (0.8)	48	1
Sensory deficit	12 (0.7)	83	0
Motor deficit	8 (0.5)	61	1
Shoulder pain	6 (0.4)	12	1
Back sprains	4 (0.2)	55	0
Rhabdomyolysis	2 (0.1)	18	1

an axillary roll is placed. To protect the patient when rolled from side to side, we place a 6-inch gel pad behind their back for support when rolled toward their back.

In a recent review of neuromuscular injuries from a series of 1651 patients from 15 institutions *(5)*, there were 46 injuries in 45 patients (2.7%). Injuries were twice as common with upper abdominal procedures compared with pelvic procedures. These findings are shown in Table 1. Abdominal wall neuralgia occurred in 0.8% of patients, sensory deficits in 0.7%, and motor deficits in 0.7%. Shoulder and back pain occurred in 0.2 and 0.1%, respectively. Rhabdomyolysis occurred in six patients (0.4%). This entity seems to occur in longer procedures and with heavier, more muscular male patients. The lesson to be learned from this report is that patient positioning and protective padding is extremely important and should not be delegated to others, but should at least be reviewed by the surgeon at the start of the procedure.

ENTRY

Transabdominal

The most common method for abdominal insufflation is through the use of the Veress needle technique (*see* Chapter 3). In an effort to prevent abdominal content injury, surgeons will often lift the abdominal wall (Fig. 1B). Unfortunately, in so doing this may release the peritoneum such that its entry may become more difficult and abdominal content injury may even be increased (Fig. 1C). If abdominal entry becomes difficult, perhaps because of inadvertent insufflation of the abdominal wall itself, then reversion to the Hassan technique may be required (*see* Chapter 3). This essentially turns a blind needle puncture into a microlaparotomy. This technique may also be chosen from the outset for patients who have had prior abdominal surgery.

After insufflation the first port is placed. Historically, this has been placed blindly using bladed trocars. These trocars have two problems: first, they are placed blindly with the potential risk to abdominal contents; and second, the cutting blades may cause vascular injury and significant abdominal wall bleeding. In order to avoid these problems, we currently use Optiview trocars (Ethicon, Cincinnati OH). These trocars have blunt plastic "blades" that separate the tissues without cutting them. Additionally, by having a clear plastic tip, the telescope and camera may be placed within the port allowing the surgeon to "look his or her way" into the abdomen.

In the event that the bowel or a major blood vessel is injured at entry, then immediate laparotomy will most likely be required to repair the injury.

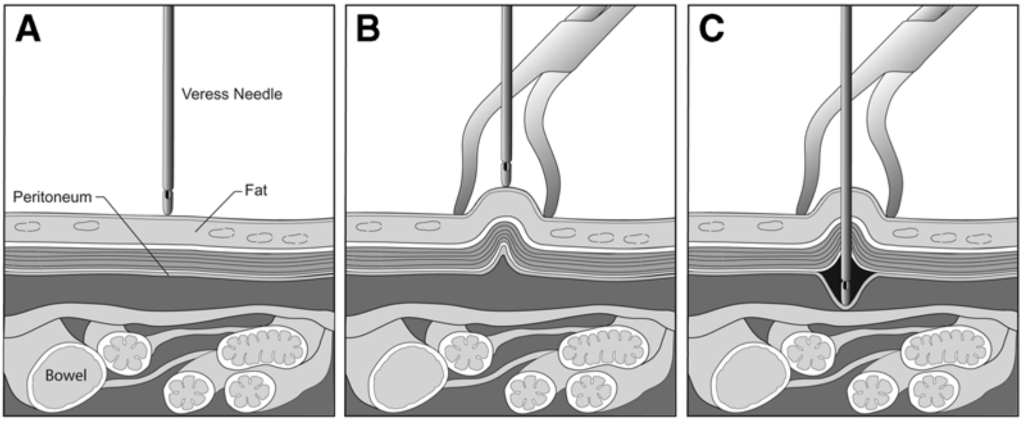

Fig. 1. (A) Veress needle about to penetrate the abdominal wall. Note the bowels close to abdominal wall. **(B)** By lifting the abdominal wall, the peritoneum may be lifted away from the bowels, protecting the bowel from inadvertent puncture. **(C)** With the abdominal wall lifted, this may "release" the peritoneum, making its puncture more difficult, losing everything one gained by elevating the abdominal wall.

A recent review of laparoscopic bowel injuries identified Veress needle injury in 0.04% of cases *(6)*. Although the review did not separate entry injuries from intraoperative injuries, it was noted that 69% of injuries were **not** noted intraoperatively.

Retroperitoneoscopy

The initial port placement for retroperitoneal procedures is off the tip of the 12th rib. This is obtained by use of a small incision. The retroperitoneal space is either dilated with the surgeon's finger/instruments or a dilating balloon. The potential problem with this approach is that of making a peritoneotomy while dilating the retroperitoneal space. If this occurs then the retroperitoneum may not distend because of the pneumoperitoneum. If this becomes a problem, it is possible to place a transabdominal trocar or Veress needle to release the abdominal CO_2.

OPERATIVE COMPLICATIONS

Abdominal Surgery

Operative complications may be recognized immediately, or may be identified later, in which case they will be included as postoperative complications. Two large series of general abdominal laparoscopic procedures have been published and are summarized in Table 2 *(7,8)*. Overall, the intraoperative complication rate was 2.9%. Vascular injuries were the most common at 1.4%. Bowel injuries were the next most common at 0.6% (0.2–0.9). Ureteral injuries were a rare but important complication at 0.3%. The conversion rate was noted in only one paper at 1.1%. The complexity of the cases included in these series was quite varied, ranging from varicocelectomy to adrenalectomy. Likewise, the total complication rates varied from 0% for simple procedures such as varicocelectomy *(8)* to 13.6% for adrenal surgery *(7)*.

Several papers have addressed specific complications. Thiel and associates *(9)* reviewed their incidence of major vascular injuries during 274 consecutive laparoscopic procedures. Six major injuries occurred in five patients, all of them venous. Four of

Table 2
Complications of Abdominal Laparoscopy

Series	*n*	*Complaints (%)*	*Vascular (%)*	*Bowel (%)*	*Ureteral (%)*	*Other (%)*	*Conversion (%)*
Fahlenkamp et al. *(7)*	2407	2.8	1.7	0.2	0.3	0.6	
Soulie et al. *(8)*	350	2.9	1.1	0.9	0.3	0.6	1.1

the injuries were vena cavotomies. The other two injuries were to the gonadal and lumbar veins. All of the injuries except one (gonadal vein avulsion) were repaired endoscopically. The technique used was to grasp the lesion with a right angle dissector and repair the lesion with 3-0 polyglactin sutures.

Pneumothorax has been reported at low but persistent levels (0.3%). The pneumothorax itself may not be recognized surgically but by anesthetic problems such as elevated ventilatory pressures and increased carbon dioxide levels. Potter and associates *(10)* have described a technique for diaphragmatic closure. They utilized interrupted figure-of-eight stitches using the Endostitch device with 2-0 polyglactin. Pneumothoraces are most likely to be associated with upper abdominal laparoscopy. When mobilizing the liver or spleen, appropriate attention must be made to the possibility of creating a penumothorax by diaphragmatic injury.

One of the most devastating complications that can occur is the malfunction of an endovascular-stapling device. Chan and associates *(11)* report on the failure of 10 devices in 565 cases (1.7%). Open conversion was necessary in two cases. The authors concluded that seven of these cases were preventable. Five cases involved stapling over clips, one involved vena caval injury from inclusion in the cutting device, and one involved incomplete transection of the vessel. It is obvious from these data that the implications of clipping a vessel upon the subsequent division of the renal vein be considered. Devices such as the Ligasure device (Valleylab, Boulder, CO) may allow for division of moderate-sized vessels (e.g., adrenal vein) without the need for clips.

Renal Surgery

Renal surgery is perhaps becoming the primary place for laparoscopic urologic surgery. Several series have now been presented *(7,12–14)* and are summarized in Table 3. Overall, intraoperative complications occurred in 2.9–6.0% of cases. Vascular injuries were most common at 1.5–4.6% of cases. Vascular injuries are obviously the most acutely serious and may require emergent conversion to an open operation. However, with the development of laparoscopic vascular clamps, it may be possible to tamponade the injured vessel, obtain vascular control, and suture the lesion. Bowel injuries occurred in 0–1.6%. Pneumothorax occurred in 0–0.5%. The conversion to an open operation occurred in 0–9.4%.

Adrenal Surgery

Two large series of laparoscopic adrenalectomy have been presented Table 4 *(15,16)*. The Italian series *(16)* had no intraoperative complications, although they did have a 2.4% conversion rate.

Table 3
Operative Introabdominal Complications of Renal Surgery

Series	*n*	*Complications (%)*	*Vascular (%)*	*Bowel (%)*	*Pneumothorax (%)*	*Conversion (%)*
Gill et al. *(9)*	185	3	1.5	–	0.5	5
Rassweiler et al. *(8)*	482	6	4.6	0.6	0.2	9.4
Fahlenkamp et al. *(3)*	2407	2.9	–	–	–	–
Hedican et al. *(10)*	196	6	1.6	1.6	–	–

Table 4
Complications of Adrenalectomy

Series	*n*	*Transabdominal Retroperitoneal*	*Overall (%)*	*Vascular (%)*	*Other organs (%)*	*Pneumothorax (%)*	*Conversions (%)*
Yoshida et al. *(11)*	369	Both	8.7	5	3	0.3	3.8
Guazzoni et al. *(12)*	161	Transabdominal	0	0	0	0	2.4

Retroperitoneoscopy

The retroperitoneum has also been used for access primarily to the kidney and adrenal. Because the available working space is much smaller than in the abdomen, this approach has not been utilized as much as the transperitoneal route. Several series of retroperitoneoscopy have been published (Table 5) *(17–19)*. Most of the surgeries have been nephrectomy, though nephrectomy only accounted for 39% in the paper by Rassweiler et al. *(17)*. Overall, complications involved 4–6.8% of patients. As with other techniques, vascular injuries were the most common at 2–4.5%. Despite the limited working area, conversion to open surgery was similar to trans abdominal routes at 3.3–7.5%.

EXITING THE FIELD

As with all surgery, "drying up" before closure is an important part of the operation, and without which complications may occur. Laparoscopic procedures also require this process but with a slightly different technique from open procedures. If vascular staples/clips have been used to divide vessels, then the stumps should be inspected. Because the pneumoperitoneum itself may compress veins, it is important to lower the pressure to 5 mmHg during the several minutes of wound inspection.

Port-site closure requires special attention. The original port devices all had cutting blades to penetrate the abdominal wall. This has the potential for two problems. First, it is possible to injure abdominal wall blood vessels, and second, the division of muscular fibers increases the risk for port-site hernias. More recently, port trocars have been introduced with plastic blades (Ethicon), which are designed to separate the tissues rather than divide them. In their original marketing, it was suggested that formal fascial closure was not necessary. However, we have had one port-site hernia in more than

Table 5
Complications of Retroperitoneoscopy

Series	*n*	*Overall (%)*	*Vascular (%)*	*Bowel injury (%)*	*Organ injury (%)*	*Conversion (%)*
Rassweiler et al. *(8)*	200	4.5	4.5	–	–	7.5
Abbou et al. *(14)*	29	6.8	3.3	3.8	–	3.3
Gill et al. *(15)*	53	4	2	–	2	4

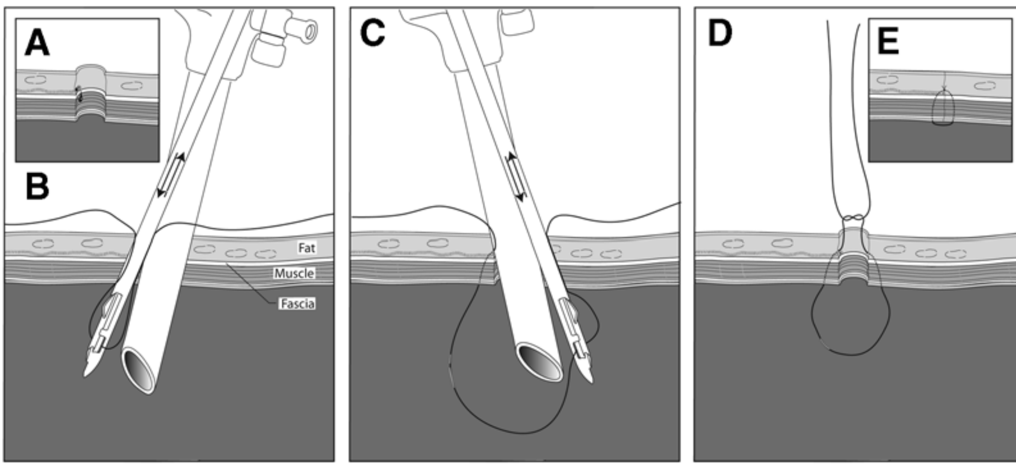

Fig. 2. (A) Port site showing injured blood vessel. **(B)** Placement of suture through fascia and including injured blood vessel. **(C)** Tying of knot closes port site and also legates blood vessel.

70 procedures using this device. As a result of this, and the experience of others, we recommend that all 10-mm port sites have a facial closure. To do this, we place a fascial stitch under laparoscopic guidance using one of the available closure devices (Fig. 2). After placing the stitches, the field is emptied of CO_2 and the skin closed. If incisions have been made for hand assistance or specimen removal, they are closed using a standard open surgical approach.

POSTOPERATIVE COMPLICATIONS

Table 6 identifies reported postoperative complications. A review of the table demonstrates marked differences in complication rates from series to series. It is clear that some of this variation is predicated upon what is, or is not, included under the heading of complications. For example, some authors will include postoperative urinary retention, whereas others do not. The more complicated the procedure, the greater the likelihood of complications. The large series reported by Fahlenkamp et al. *(7)* specifically identified that complication rates were directly linked to the complexity of the case. Simple cases like varicocelectomy had 0.8–1.3% complication rates, whereas complex cases such as adrenalectomy and nephrectomy had complication rates of 8.2–13.6%. Likewise, reintervention rates for these groups ranged from 0–2.7%.

Overall, the postoperative complication rates ranged from 1.7–26.1%. Interestingly, the highest rate recorded was for the hand-assisted laparoscopic group. However, this

Table 6
Postoperative Complications

Series	*n*	*Procedure*	*Port-site hernia (%)*	*Nerve injury (%)*	*Fever/ infection (%)*	*Hematoma (%)*	*Pulmonary embolism (%)*	*Reintervention (%)*	*Total (%)*
Falhenamp et al. *(3)*	2407	Abdominal	0.2		0.4		0.1	0.8	1.7
Soulie et al. *(4)*	350	Abdominal			0.6	0.9	0.9	0.6	3.3
Gill et al. *(4)*	185	Renal	1	1	1.5		0.5		14
Rassweiler et al. *(8)*	482	Renal	0.2		0.8	1.4	0.2	3.1	3.1
Hedican et al. *(10)*	196	Hand-assisted	0.5						26.1
Yoshida et al. *(11)*	369	Adrenal		0.2	1	0.5			6.5
Guazzoni et al. *(12)*	161	Adrenal			1	2			3

group of authors included many items that would not be included in the complication list of other authors. Re-operation rates varied from 0.6–3.1%. The group reporting a 3.1% re-operation rate did not report any other postoperative complications. Postoperative bleeding is a rare but persistent problem being reported, ranging from 0.5–2%. This complication emphasizes the importance of evaluating the operative field at low pressure prior to exiting the wound. Wound infections are in line with open surgery, being reported between 0.4 and 1.5%. Nerve injuries are uncommon at up to 1%, but serve to demonstrate the importance of patient positioning and padding prior to initiating the procedure. Port-site hernias have been reported at up to 1% of cases. It is likely that this rate will decrease in the future with a greater recognition of the problem and the routine closure of 10-mm port sites (Fig. 2). Additionally, the use of noncutting trocars will aid in reducing this problem.

POSTOPERATIVE MANAGEMENT

Over the past decade, there has been a major decrease in the postoperative hospital admission length of stay for both open and laparoscopic procedures. The major driving force for these changes has been the cost of healthcare delivery. For most of the last decade, the hospital charges associated with laparoscopy have been markedly in excess of those for open surgery. However, it has now been reported that laparoscopic nephrectomy may be more cost-effective than open nephrectomy *(20)*. A major part of this cost reduction has been the reduction in postoperative hospitalization. Many patients are now being hospitalized on the "23-h admission" basis. This is especially true for retroperitoneal procedures *(19)* where postoperative discomfort is clearly less than for transabdominal procedures. Thus, most patients are being mobilized soon after surgery; and pain is being effectively controlled with oral analgesia. Postoperative pain is greatest after upper abdominal procedures, and least with retroperitoneal procedures.

Recovery times from laparoscopic surgery are also shorter than for open surgery. In a recent study of hand-assisted laparoscopic radical nephrectomy compared with open radial nephrectomy, the median time to return to work for the laparoscopic group was 26.8 d, compared with 52.2 d for the open radial nephrectomy group. Finally, because the incisions for laparoscopic procedures are either nonmuscle cutting (e.g., Pfannenstiel), muscle splitting, or very small muscle cutting (5–6 cm), patients may increase their physical activities much more rapidly after these surgeries than for those open procedures with large muscle-cutting incisions.

COMPLICATIONS FOR THE SURGEON

Articles on the subject of complications have hitherto dealt only with potential problems for the patient. However, laparoscopy has brought with it many issues that are adversely affecting the physical health of the surgeon, and as such should be given recognition in this chapter. When laparoscopy started, the various pieces of equipment were assembled in the simplest manner. For example, the "obvious" place for the television monitor was on the cart holding the insufflation and camera equipment. Unfortunately, this positioning will be at an appropriate height for only a few surgeons and very unlikely to be acceptable for all the surgical participants. Likewise, the laparoscopic instrumentation works with the surgeon's hands in a variety of positions, from shank handle to rod handle *(21)*. Worse still, the requirements for placing the port

Table 7
Neuromuscular Problems of Surgeons (n = 18)

Problem	*Frequency (%)*
Occasional hand/wrist pain	67
Occasional back pain	33
Frequent neck pain	28
Frequent shoulder pain	17
Occasional elbow pain	11

site in the operative field may exaggerate any problems encountered with ergonomic difficulties of any specific piece of equipment. For example, with flank procedures it is usual for the two working ports to be at different heights above the floor. These problems may lead to neuromuscular stresses on the surgeon, creating a new form of repetitive stress injury.

One paper has been published reporting the neuromuscular injuries encountered by 18 urologists (Table 7) *(5)*. Sixty-seven percent of the surgeons reported hand/wrist pain. This authors' conclusion on this and all the complications is that they result, at least in part, on poor ergonomic considerations in the design and installation of the equipment. Thirty-three percent of the surgeons reported back pain and 28% reported frequent neck pain. The conclusion for this problem is that it occurs as a result of poor monitor placement, necessitating the surgeon to hold his head in unusual positions to view the monitor. It is thus gratifying to observe that in the last few years the equipment manufacturers have developed monitors that may be suspended from the ceiling and placed more conveniently for the surgeon's viewpoint. Unfortunately, installation of such equipment is not only expensive but also requires appropriate access to the operating room ceiling for placement of such monitor mounting devices.

Shoulder and elbow pain was observed in 17 and 11% of surgeons, respectively. Poor ergonomic equipment design might reasonably be held accountable for these problems.

TAKE HOME MESSAGES

Complication rates may be minimized by:

1. Evaluating the patient carefully for appropriateness for a laparoscopic procedure.
2. Paying appropriate attention to patient positioning and padding.
3. Being aware of potential complications so that they will be recognized early (e.g., pneumothorax).
4. Paying careful attention to evaluating the operative field at the end of the procedure for hemostasis; and formally closing all 10-mm port sites.

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Essential Urologic Laparoscopy

The Complete Clinical Guide

Edited by

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Urologic laparoscopy is in the midst of a clinical resurgence that has prompted many urologists to seek new training in the technique. In *Essential Urologic Laparoscopy: The Complete Clinical Guide,* a panel of urologists and physicians distinguished by their clinical expertise in procedural laparoscopy detail how to perform the major urologic laparoscopic procedures. The authors offer clear, concise chapters focusing on getting started, laparoscopic instrumentation, and step-by-step procedural adult laparoscopy. Each chapter is organized so that the reader can easily identify the key points and pitfalls, with the instrumentation chapter completely cross-referenced so that operating room and hospital personnel can use the book as a comprehensive reference guide for most laparoscopic procedures. The procedures detailed range from the simple (renal cyst decortication, pelvic lymph node dissection, and simple nephrectomy) to the advanced (adrenalectomy, partial nephrectomy, radical nephroureterectomy, live donor nephrectomy, and pyeloplasty). The transperitoneal, retroperitoneal, and hand-assisted approaches to laparoscopic radical nephrectomy—the gold standard for most renal pathology—are fully described by those pioneers who have championed them. In addition, the latest cutting-edge procedures such as laparoscopic radical prostatectomy and laparoscopic cystectomy with urinary diversion are detailed.

Easy-to-use and highly practical, *Essential Urologic Laparoscopy: The Complete Clinical Guide* provides a comprehensive guide to performing effective and cutting-edge urologic laparoscopy—the key to creating, maintaining, and expanding a successful practice in minimally invasive urologic surgery today.

- **Detailed instructions on performing urologic laparoscopy in the adult patient**
- **Three approaches to laparoscopic radical nephrectomy by their pioneer inventors**
- **Laparoscopic cystectomy with urinary diversion and radical laparoscopic prostatectomy**
- **Adrenalectomy, partial nephrectomy, and radical nephroureterectomy**
- **Excellent reference guide to all aspects of laparoscopic operations**
- **Highlighting of key points, pitfalls, and take-home points**

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