Chapter 16
Diagnostic and Operative Laparoscopy

Howard T. Sharp

Marisa R. Adelman

DEFINITIONS

Aqua dissection—The use of fluid, most often sterile water or saline, under force, to separate one anatomical plane from another. Laparoscopic suction-irrigators are an excellent tool for performing aqua dissection.

Chromopertubation—A procedure in which a colored dye is passed through the fallopian tubes to confirm patency.

Colpotomy—A surgical incision in the vagina. The *-tomy* part of the word is from the Greek word *tome,* meaning cutting.

High definition—A term initially introduced in the 1930s to define the then-new technology that replaced the experimental systems ranging from 15 lines to about 220 lines of resolution. High-definition television is now defined as resolution 1,080 or 720 lines. HD is broadcast digitally and consequently produces a more vivid and realistic picture.

Morcellate—To divide into small portions.

Reposable—A trocar/sleeve kit in which disposable trocars are used with reusable sleeves in an effort to reduce the cost of disposable products while ensuring sharp, undamaged instruments more commonly found in the disposable kits.

Veres needle—A spring-loaded needle designed to allow entry into body cavities without trauma to underlying organs during laparoscopy.

Laparoscopic surgical advances have accelerated remarkably over the past decades. What was initially a primitive tool for diagnostic purposes and simple procedures such as tubal sterilization has evolved into a more coordinated system for the repair or removal of diseased abdominal and pelvic organs. As operative laparoscopy has become more complex and technology has continued to advance, new challenges and complications have been recognized. The proper use of equipment and techniques can greatly add to patient safety and satisfaction. To this end, the purpose of the chapter is to review contemporary equipment, commonly used surgical techniques, and strategies to avoid and manage complications associated with laparoscopic surgery.

HISTORY

The first description of endoscopy is attributed to Phillip Bozzini in 1805, as he attempted to view the urethral mucosa with a simple tube and candlelight. Hysteroscopy was the first gynecologic endoscopic procedure performed when Pantaleoni used a cystoscope to identify uterine polyps in 1869. Laparoscopy was first performed by Jacobaeus of Sweden in 1910, wherein a Nitze cystoscope, composed of a candle and a hollow tube, was used to illuminate the peritoneal cavity. Kalk of Germany was instrumental in developing laparoscopy into a diagnostic and surgical procedure in the early 1930s. By the end of the 1930s, laparoscopy was being used in the diagnosis of ectopic pregnancy and the performance of tubal sterilization. Raoul Palmer of France reported the use of gaseous distention with lithotomy-Trendelenburg positioning in 1947. The use of "cold light" and fiberoptics were landmark innovations credited to Fourestier, Gladu, Valmiere, and Kampany and Hopkins, respectively. Monopolar electrosurgery for tubal sterilization was popularized in the 1960s. Semm of Germany reported advanced operative laparoscopic procedures such as salpingectomy, myomectomy, oophorectomy, ovarian cystectomy, and salpingostomy in the 1970s. These pioneers of endoscopic surgery and many others have laid the crucial groundwork that has enabled modern gynecologic surgeons to perform advanced operative laparoscopy on a routine basis, with a variety of energy systems under increasingly ergonomic and efficient conditions.

INDICATIONS FOR LAPAROSCOPY

Diagnostic Laparoscopy

Laparoscopy can provide valuable clinical information in a number of circumstances. It can aid in the evaluation of patients with acute pelvic and abdominal pain, including ovarian torsion, ovarian cyst rupture, ectopic pregnancy, appendicitis, and pelvic inflammatory disease. In the evaluation of less emergent conditions, such as chronic pelvic pain and infertility, it is useful to identify pelvic adhesions, endometriosis, hernias, uterine fibroids, and adnexal masses. Before performing diagnostic laparoscopy, a thorough history, detailed physical examination, and appropriate imaging studies should be completed.

Operative Laparoscopy

Most surgeries traditionally performed by the abdominal or vaginal approach can now be performed laparoscopically. Studies are still needed to better define which advanced procedures are most appropriate to perform laparoscopically from an economic and safety vantage point. Operator experience is a critical factor that must be considered. Commonly performed laparoscopic procedures include adhesiolysis, treatment of endometriosis, tubal sterilization, ovarian cystectomy, oophorectomy, salpingectomy, salpingostomy, and hysterectomy. More advanced procedures include repair of pelvic organ prolapse, tubal reanastomosis, myomectomy, radical hysterectomy, and lymphadenectomy.

EQUIPMENT

Contemporary laparoscopy equipment consists of an imaging system comprising a telescope (laparoscope) and video camera system, an insufflation or abdominal wall lift system, and specialized surgical instruments. Digitization and robotics are areas that continue to evolve.

Imaging Systems

Imaging systems consist of a laparoscope, light source, fiberoptic cord, camera unit, and monitors. High-definition digital cameras are compatible with the increased resolution capabilities of high-definition flat screen monitors. Most imaging systems are also equipped with a printer, video recorder, or DVD recorder for documentation.

The laparoscope in its basic form is a telescope. Laparoscopes range from 1.8 to 12 mm in diameter, with a distal end (objective) available in varying viewing angles (Fig. 16.1). The 0-degree deflection-angle telescope is most commonly used and provides a straightforward view, whereas a 30-degree foroblique lens allows for visualization in a large frontal view but must be continuously directed to maintain field orientation. Operative laparoscopes are equipped with a central channel that allows laser, electrosurgical, or mechanical instruments to be introduced into the abdomen. Light is introduced through the laparoscope with a fiberoptic cable powered by a light source. It is important that the light source has sufficient power to deliver adequate light through the fiberoptic cable. Ideally, high-intensity light sources that use xenon or halogen are used. Though a significant amount of original light is lost from the original hot light source, the fiberoptic cable is able to transmit enough heat to burn paper drapes as well as patient's skin; therefore, caution should be used to avoid inadvertent contact with drapes or the patient.

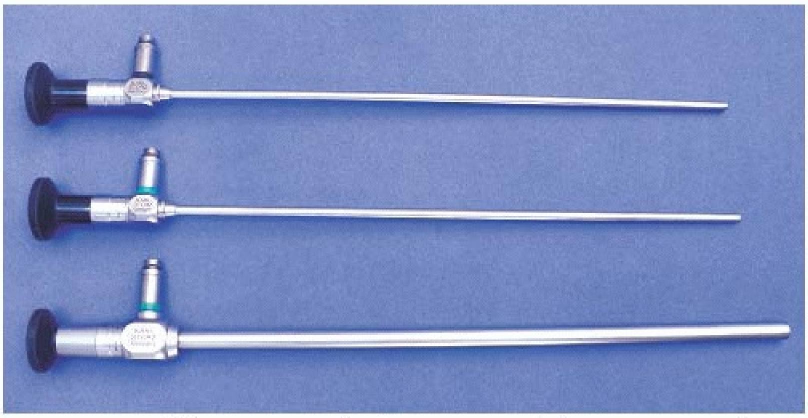

FIGURE 16.1 Telescopes used in laparoscopy. **Top**: 5-mm, 45-degree viewing angle laparoscope. **Middle**: 5-mm, 0-degree viewing angle laparoscope. **Bottom**: 10-mm, 0-degree viewing angle laparoscope.

The camera unit consists of a camera head, cable, and camera control. The camera head attaches to the eyepiece of the laparoscope and captures images transmitted by the laparoscope. Camera/laparoscopes are now available as combined, fused units that are fully autoclavable, with push-button zoom and autofocus features. The basis of laparoscopic cameras is the solid-state silicon computer chip or charge-coupled device (CCD). This is composed of silicon elements, which emit an electric charge when exposed to light. Each silicon element contributes one pixel unit to the image produced. The image resolution is dependent on the number of pixels on the chip. CCDs are housed within the camera head of rigid scopes, in comparison to complementary metal oxide semiconductors, which are located at the tip of flexible scopes. Most laparoscopic cameras have 250,000 to 2,073,600 pixels. Three-chip CCDs provide better image quality but are more expensive, as they have a separate chip for each primary color, as opposed to the single-chip CCD. High-definition displays, with 1,080 lines, are needed to provide optimal visualization. Newer developments include the use of wireless systems, designed to provide central control over operating room devices, using either a microphone or a movable touch-pad screen.

Abdominal Lifting Systems

Insufflation systems allow gas to fill the abdominopelvic cavity to optimize visualization. Insufflators are designed to deliver gas at low rates during initial Veres needle insertion, but are also able to provide high flow rates when gas is lost to maintain a relatively constant, set intra-abdominal pressure during surgery. Insufflation may be achieved with a Veres needle or the Hassan trocar, filtered tubing, an insufflator, and gas tanks. Insufflation tubing with a 0.3-micron filter is recommended to prevent intraperitoneal contamination with bacteria, microparticles, and debris from the insufflator and gas tank. A Veres needle is often used to create a pneumoperitoneum, although other methods, such as direct trocar insertion and open laparoscopy, will be discussed. The Veres needle is available in reusable or disposable

P.267

models containing a spring-loaded tip that retracts as it pierces the abdominal wall, allowing a blunt tip to engage on entry to the peritoneal cavity (Fig. 16.2). This is designed to avoid damaging the bowel or other intra-abdominal organs. Though filtered room air has been used, carbon dioxide is most commonly used today. Carbon dioxide has the advantage of being rapidly absorbed by blood. However, it is converted to carbonic acid on moist peritoneal surfaces, which can cause pain. For this reason, nitrous oxide or helium is preferred by some, especially in cases using local anesthesia or conscious sedation. Some have advocated the use of heated or hydrated gas to prevent hypothermia during laparoscopy. A Cochrane review concluded that during laparoscopic abdominal surgery, heated gas insufflation, with or without humidification, had minimal benefit on patient outcomes. Specifically, there was no effect on postoperative pain, changes in core temperature, or length of hospitalization observed. This is partly because insufflators that contain a heating unit will ultimately have little or no effect on temperature by the time the gas has traveled 50 to 100 cm in tubing. In longer surgeries, prevention of hypothermia is better achieved by using a heated body surface blanket or a device that delivers heated and hydrated gas. Gasless laparoscopy can also be performed with the use of a mechanical lifting arm that attaches to a fanlike retractor along the peritoneal surface of the abdominal wall, obviating the need for gas distension. Some favor this approach in patients with cardiopulmonary risk factors.

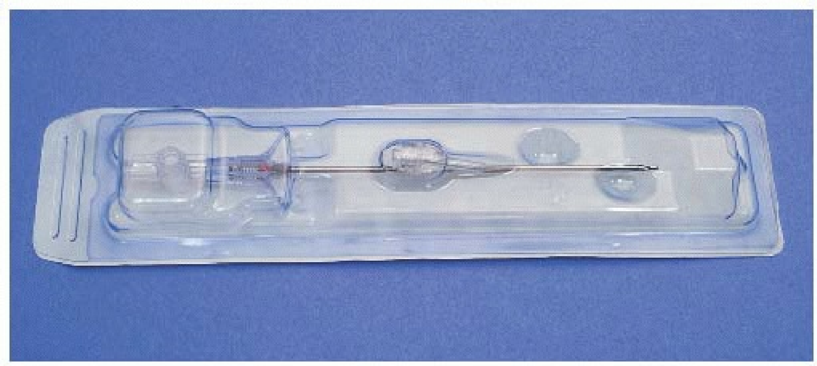

FIGURE 16.2 Disposable Veres needle.

Surgical Instrumentation

Trocars and sleeves are used to pierce the abdominal wall for placement of the laparoscope and surgical instruments (Fig. 16.3). Trocar sleeves range from 3 to 15 mm in diameter and are available as reusable, disposable, and reposable systems. Disposable systems consist of completely disposable trocars and sleeves. They offer the advantage of consistent sharpness but are more expensive. Reusable trocars offer the advantage of being the most cost effective, but they must be maintained for sharpness. Reposable systems are composed of a disposable bladed or nonbladed trocar with a reusable sleeve. All are acceptable for use. Most sleeves contain a Luer-Lok port that attaches to insufflation tubing. Trocar tips may be pyramidal, conical (reusable), bladed, or blunt tipped or have optical access (disposable). Conical and blunt-tipped trocars have the advantage of making smaller fascial defects but require greater force to place. Optical access trocars enable the surgeon to visualize the layers of the abdominal wall during placement. Expandable trocar sheaths are available that are initially placed through the abdominal wall with a Veres needle and then expand to accept a 5- to 12-mm port. These offer the advantage of creating smaller abdominal wall defects and thereby reducing the risk of hernia formation and injury to the inferior epigastric vessels.

FIGURE 16.3 Trocars and sleeves. Shown from left to right: 12-mm blunt optical tip, 12-mm Hasson blunt tip, 12-mm shielded tip, 5-mm pyramidal tip, and 5-mm bladeless tip. (Courtesy of Genicon.)

Ancillary instruments may be placed through secondary trocar sleeves to aid in diagnostic and operative laparoscopy (**Figs. 16.4** and **16.5A, B**). These include blunt probes; a variety of graspers, including toothed and atraumatic graspers; scissors; needle drivers; knot pushers; biopsy forceps; suction-irrigators; energy delivery tools; specimen retrieval bags; and tissue morcellators. A uterine manipulator may be used to improve access to the uterus, fallopian tubes, ovaries, and the posterior and anterior cul-de-sacs. These are available in reusable and disposable models (**Fig. 16.6A-C**). Some manipulators are inserted in a fixed position and allow limited uterine mobility, whereas others are hinged and allow the uterus to be moved anteriorly, posteriorly, and laterally. Many of these also offer the ability to perform chromotubation for evaluation of fallopian tube patency. Colpotomizer cups are included, or can be attached to most uterine manipulators, and engulf the cervix, allowing the surgeon to cut against it when resecting the uterus and cervix from the vagina during laparoscopic hysterectomy. The colpotomizer delineates the vaginal fornices, allowing for maximal preservation of vaginal length, and optimizes separation of the ureters from the uterine arteries, in order to avoid injury. At least one of the current cups on the market utilizes light, in order to better identify the cervicovaginal junction. The same device may also include a balloon that is inflated to prevent the pneumoperitoneum from escaping through the

vagina (pneumooccluder) once the colpotomy has been made. Though these instruments can significantly facilitate the hysterectomy, they are more expensive than other manipulators, and the time required to insert them can potentially contribute to the overall anesthesia time. An alternative to a colpotomizing cup is a sponge-stick or EEA sizer.

FIGURE 16.4 Ancillary instruments for laparoscopic surgery. Shown from *left* to *right:* Maryland dissector, atraumatic forceps, biopsy forceps, and bowel grasper.

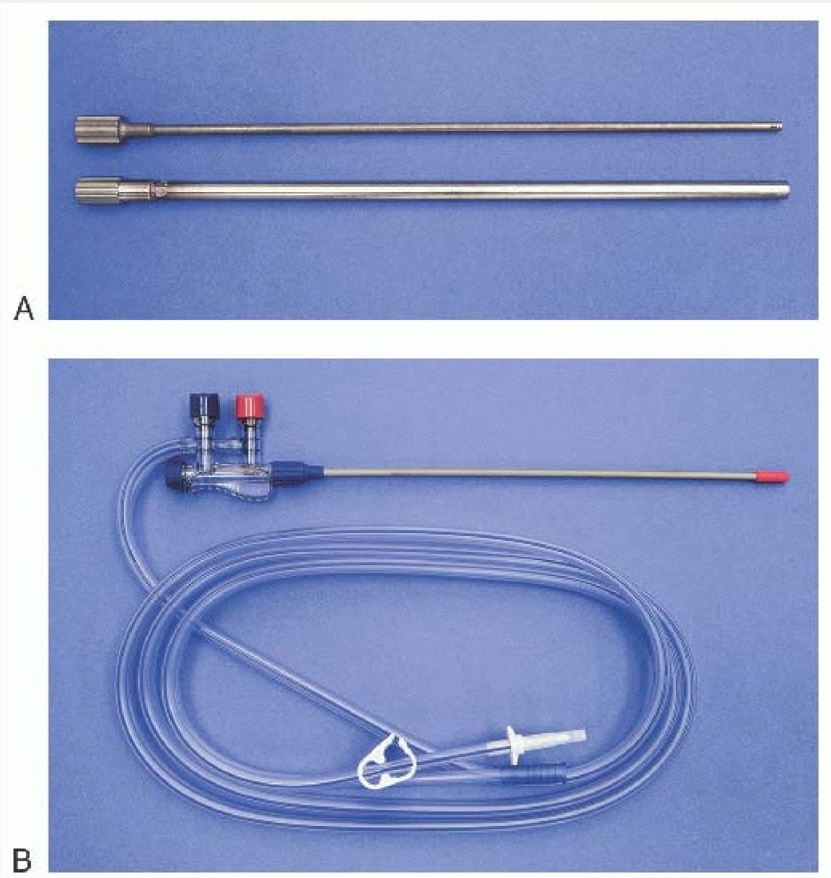

FIGURE 16.5 A: Reusable suction tips. **B:** Disposable suction irrigator. (Courtesy of Genicon.)

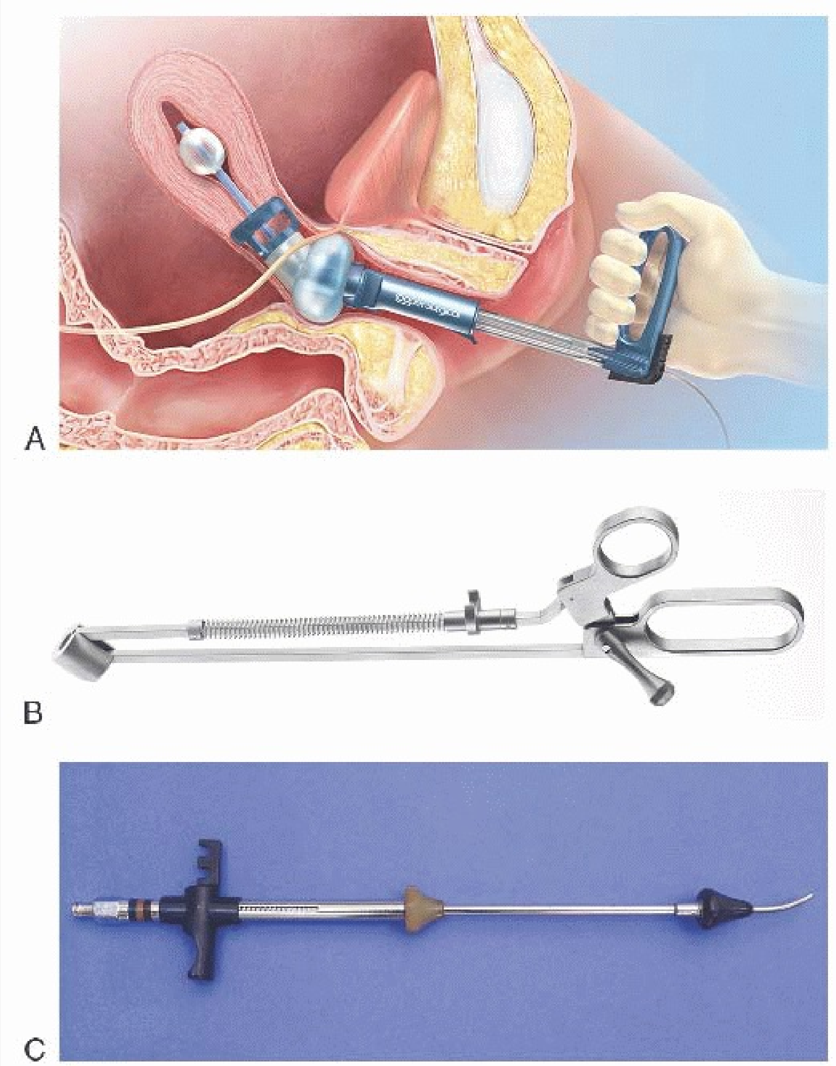

FIGURE 16.6 Uterine manipulators. **A:** Rumi. (CooperSurgical.) **B:** Pelosi. (CooperSurgical.) **C:** Acorn.

Energy and Hemostasis

The application of energy systems to laparoscopy has expanded laparoscopic surgeons' ability to perform complex surgeries with the capability to rapidly divide tissues and maintain hemostasis. This technology has also introduced a new set of complications, such as unrecognized bowel burns from inadvertent direct and capacitative coupling. In an effort to reduce risks associated with monopolar electrosurgical devices, several options are available. One is the use of endomechanical energy; a second is the use of bipolar electrosurgery, laser, or ultrasonic energy; and a third is the gaining of a better understanding of electrosurgical principles. Though our understanding of laparoscopically applied electrophysics has improved, gynecologic surgeons often have no formal electrosurgical training or credentialing, in contrast to the once-common laser safety courses.

Endomechanical Energy

Endomechanical energy can be used for tissue division and hemostasis in a number of ways, including suturing, stapling, and the application of vascular clips.

Suture

The simplest laparoscopic ligature to apply is the pretied loop, available as a slip knot on a push rod that is used to push a suture loop around a tissue pedicle for hemostasis. The Roeder loop, which was modified by Kurt Semm for laparoscopic use, can also be tied in the operating room using standard suture. Laparoscopic suturing can be performed using stock suture, ideally 36 to 48 inches in length (Fig. 16.7). Needle drivers are used to drive needles through tissue, and knots may be tied outside the laparoscopic port (extracorporeal knot) or within the body (intracorporeal knot). Extracorporeal knots are usually performed as sliding square knots, pushed through the trocar sleeve to the tissue by multiple passes of a knot pusher, which serves as the surgeon's finger (**Fig. 16.8**). Intracorporeal knots are tied within the abdomen by looping the suture material around the laparoscopic needle holders using the same technique as an "instrument tie" (**Fig. 16.9**). Laparoscopic suturing requires considerable practice to confidently load the needle into the needle driver and place sutures accurately. To this end, the Endo Stitch (Covidien) was developed, wherein the needle is preloaded and the suture is passed through tissue up to 2 cm thick by closing a handle and a toggle switch. Interrupted or continuous suturing can be accomplished. The Endo Stitch is a 10-mm disposable instrument, which uses device-specific suture cartridges. There are several other automatic suturing devices, both disposable and reusable, some of which are able to articulate. Both absorbable clips and titanium knots are available to secure the ends of suture, obviating the need for knots. In an effort to accommodate surgeons desiring to use the laparoscopic needle driver and suture, self-righting needle drivers were designed, which automatically fix the needle at a perpendicular or oblique position to the needle driver. Such devices can facilitate suturing laparoscopically.

Staplers

The Endo GIA, originally designed for gastrointestinal anastomosis, can be used in gynecologic laparoscopy as a stapling device for securing and dividing tissue. After placing and firing the preloaded device, six staggered rows of staples, 3 cm in length and 1 cm in width, are left behind. A knife blade simultaneously divides the tissue, leaving three rows of staples on each side of the incision.

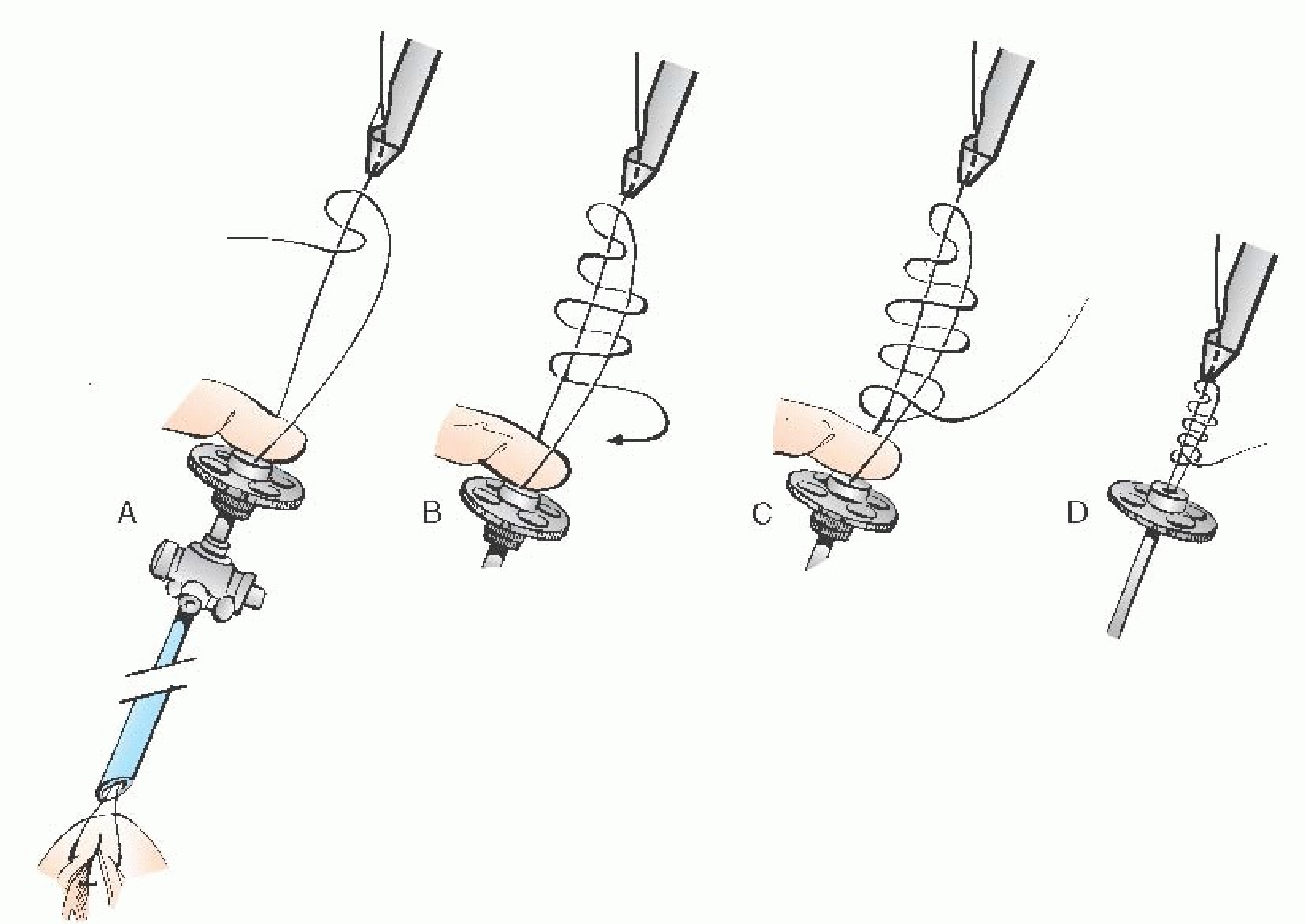

FIGURE 16.7 Extracorporeal knot tying with slip knot. **A:** With both suture ends outside the body, the suture is cut below the needle. A single throw is made. **B:** With the free end of the suture, three revolutions are made around both suture strands. **C:** The tail of the suture is inserted through the lowest loop. **D:** The tail is pulled to tighten the knot, the suture is cut above the knot, and the slip knot is pushed with a closed-nose

knot pusher to the desired position. (Modified from Murphy AA. Operative laparoscopy. *Fertil Steril* 1987;47:1, with permission. Copyright © 1987 Elsevier.)

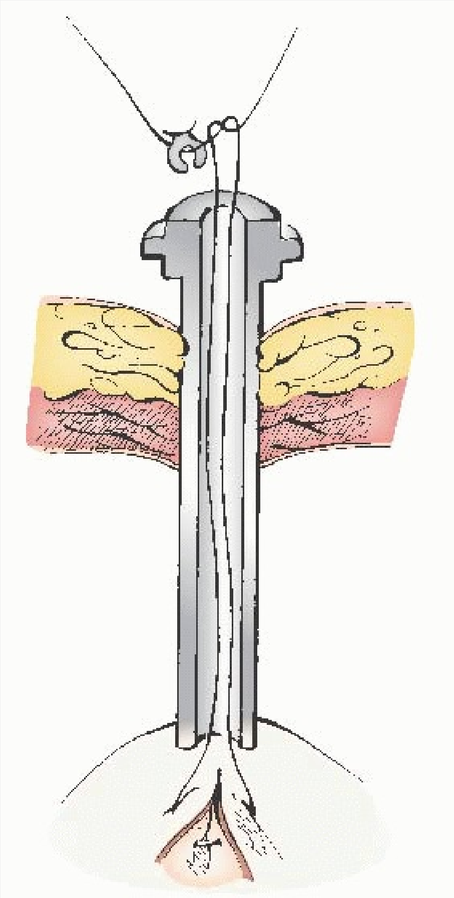

FIGURE 16.8 Extracorporeal knot tying with the Clarke knot pusher. (Modified from Hulka JF, Reich H. *Textbook of laparoscopy,* 2nd ed. Philadelphia, PA: WB Saunders, 1994:202, with permission. Copyright © 1987 Elsevier.)

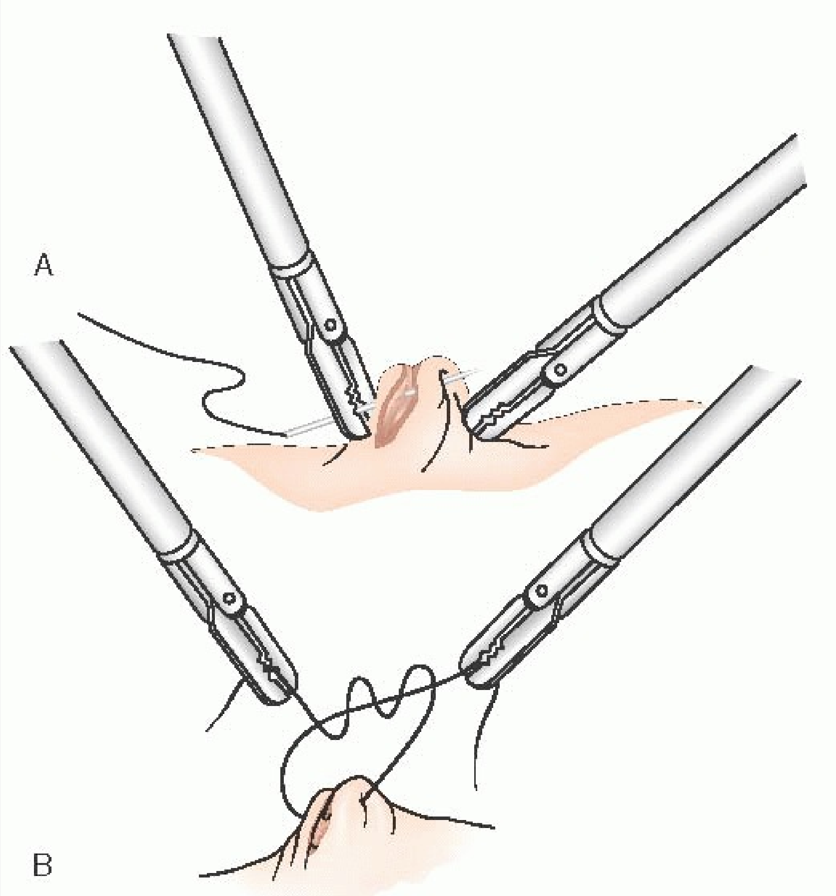

FIGURE 16.9 Intracorporeal knot tying. **A:** The needle is passed through the tissue. **B:** A surgeon's knot is made with the instruments and pulled tight.

Vascular Clips

Endoscopic vascular clips may be used to achieve hemostasis for bleeding vessels or pedicles. These offer the advantage of being used near vital structures, where the use of other forms of energy may otherwise result in lateral thermal damage.

Laser Energy

The term *laser* is an acronym for *l*ight *a*mplification by *s*pontaneous *e*mission of *r*adiation. Surgical lasers available for gynecologic use include CO_2, argon, potassium titanyl phosphate, and neodymium:yttrium-aluminum-garnet. These have the ability to vaporize, cut, and, to varying degrees, coagulate tissue (see Chapter 15).

Ultrasonic Energy

The HARMONIC ACE Scalpel (Ethicon) uses vibration at a rate of 55,000 cycles per second, as an energy source to break hydrogen bonds in tissue, resulting in cutting or coaptation of vessels. The Harmonic devices are available for use in vaginal, abdominal, and laparoscopic procedures. The laparoscopic device, termed the Harmonic Ace (**Fig. 16.10**), is approved for sealing vessels up to 5 mm in diameter. It can be used to grasp, seal, and incise structures, or the active blade can be used alone for dissection and transection of tissue. This modality results in minimal lateral thermal spread of energy, and there is no risk of electrical injury.

Electrosurgery

Monopolar and bipolar electrosurgical instruments are frequently used to perform tubal sterilization and to obtain hemostasis. Monopolar instruments use current that flows from an active electrode through a patient's tissue, and exits by way of a return electrode plate (usually placed on the patient's thigh), to the electrosurgical unit (ESU). Needlepoint electrodes, L-hooks, and most endoscopic scissors are examples of monopolar electrosurgical instruments. Bipolar instruments, such as the Kleppinger forceps and the newer impedancecontrolled bipolar systems, use current that flows from an active electrode through tissue and returns back to the ESU through a return electrode within the same instrument. With bipolar energy, a return electrode plate is not necessary. Both monopolar and bipolar electrosurgery can be used for cutting or coagulating (see Chapter 15).

Electrosurgical instruments conduct high-frequency alternating current (AC), which forces electrons through the tissue and accomplishes resistive heating. With AC, electrons flow back and forth between positive and negative poles, as compared with direct current, in which electrons only flow in one direction. Household electrical outlets conduct low-frequency AC, at 60 cycles per second (Hz). Electrosurgical generators convert low-frequency AC to high-frequency AC, in the range of radiofrequency (300 to 600 kHz). The waveform of radiofrequency current is continuous and sinusoidal. The waveform can thus be interrupted to produce different effects (**Fig. 16.11**).

FIGURE 16.10 HARMONIC ACE. (Courtesy of Ethicon.)

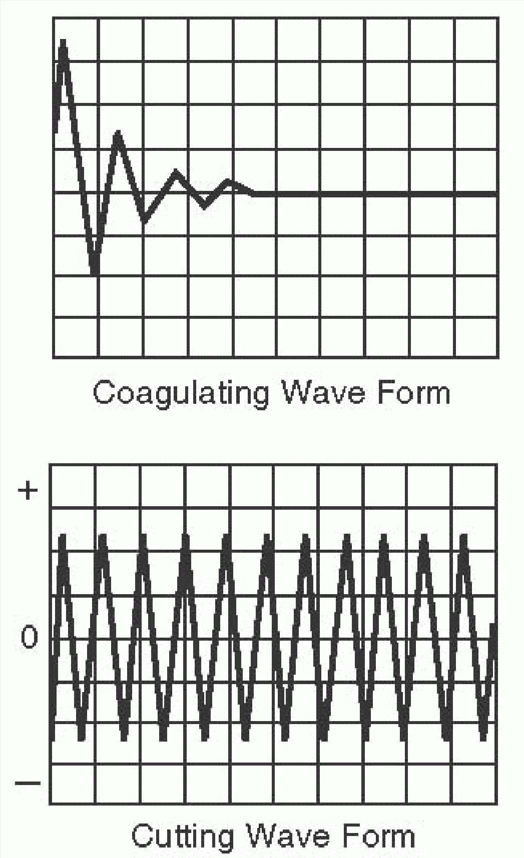

FIGURE 16.11 Coagulating and cutting waveforms.

Cutting mode utilizes continuous uninterrupted low-voltage energy, inducing resistive heating and causing cells to vaporize at their boiling point of 100°C. There is very little elevation in surrounding tissue temperature, therefore minimizing the amount of lateral thermal damage. Modifications in the waveform refer to blend 1 (80% on, 20% off), blend 2 (60% on, 40% off), blend 3 (50% on, 50% off), and coagulation (6% on, 94% off). Electrosurgical generators will maintain a constant power output; therefore, when the highly interrupted waveform of *coagulation mode* is utilized, and current is reduced, a higher output voltage will be generated (watts = voltage × current). These "bursts" of high voltage increase the temperature of surrounding tissues, resulting in denaturation and charring, giving the effect of coagulation and hemostasis, rather than cutting. Understanding the concepts of cutting and coagulation is clinically relevant when bleeding is encountered. For example, when there is surface oozing, fulguration is used to achieve enough superficial lateral thermal spread to cause hemostasis. Fulguration is superficial coagulation, which uses the coagulation mode to achieve high-voltage sparking. The highly interrupted, high-voltage current causes random sparks to arc between the electrode and tissue, rapidly elevating superficial tissue temperatures, in order to achieve hemostasis. Vessels up to 2 mm in diameter can be controlled in this manner, although it is ineffective in wet surgical fields, as the current is conducted and the energy is widely disbursed. Conversely, in the case of a larger bleeding vessel or pedicle, it is best to desiccate the tissue by applying pressure (coaptation) and cutting current. This causes fibrous bonding of the dehydrated cells of the endothelium without significant lateral thermal spread. It also decreases the risk of thermal bowel injury from capacitive coupling (see Chapter 15), as lower voltage is used. Conversely, when the coagulation waveform is used in this scenario, instead of causing bonding inside the vessel, superficial lateral thermal spread is more likely to occur along the tissue surface, resulting in eschar formation and subsequent bleeding.

Current density refers to the amount of current flow per cross-sectional area, described in amps per meters squared.

This concept has several direct applications to the use of electrosurgical energy in laparoscopy and is used to safely return current from the patient to the ESU. Because current density is described in terms of current per meter squared, applying energy to a small area of bleeding or to a bleeding tissue pedicle will result in an intended thermal effect, inversely related to the electrode size. For example, the use of a needlepoint electrode will have high-current density, compared with a much larger spatula tip, resulting in greater energy applied to a small surface in the former. The current density principle is used to allow current to exit the body without causing injury, as it exits through a relatively large surface area of the return electrode, usually placed on the patient's thigh. This does not cause an exit site burn because of low current density. Exit site burns have typically occurred when part of the return electrode has peeled away from the patient, resulting in a smaller area of surface contact, thus creating high current density at the exit site. Newer systems have a built-in fault, whereby the active electrode will not deliver current if the pad is no longer in complete contact with the patient.

Bipolar instruments have undergone significant transformation in recent years. Simple bipolar systems, such as the ESU with a Kleppinger forceps, have evolved to devices that provide bipolar energy that senses tissue impedance to perform controlled energy delivery. The LigaSure Vessel Sealing Device (Covidien) (**Fig. 16.12A**) applies high coaptive pressure at temperatures below 100°C, to denature and reform hydrogen cross-links, forming a vascular seal. Tissue fusion and vessel sealing use the body's own collagen and elastin to create a permanent fusion zone. Hemostasis is achieved by reforming the collagen and elastin in vessel walls to form an autologous seal. Tissue impedance is monitored 3,333 times a second, in order to provide real-time adjustment of energy output. The EnSeal Laparoscopic Vessel Fusion System (Ethicon) (**Fig. 16.12B**) is also able to produce high-coaptive pressures and does so uniformly across the length of the jaw, as a mechanical blade is advanced. The plastic jaws are thermoelastic and contain conductive carbon spheres. When the temperature exceeds 100°C, the polymer of the jaws expands, and the spheres are separated such that they cannot conduct current. Tight temperature regulation is thus maintained, avoiding elevation in temperature of surrounding tissue. Additionally, the offset electrode configuration, whereby the positive electrode is located within the nonhinged lower jaw and all jaw components serve as the negative electrode, is designed to minimize thermal spread. The combination of coaptive pressure and heat results in a tissue seal. PlasmaKinetic technology (Gyrus ACMI, a division of Olympus) makes two laparoscopic instruments, both of which deliver pulsed, ultra-low-voltage, high-current radiofrequency energy and utilize continuous impedance feedback. The HALO PKS Cutting Forceps (**Fig. 16.12C**) uses a mechanical blade, while the PKS Omni delivers both bipolar coagulation and cutting. The newest device on the market, the ThunderBeat (Olympus) (**Fig. 16.12D**), combines bipolar and ultrasonic energy. Sealing can be achieved alone by applying bipolar energy, or sealing and cutting can occur simultaneously with a combination of bipolar and ultrasonic energy. Bipolar energy is applied laterally, while ultrasonic energy is applied centrally. All of these devices are approved to seal vessels up to 7 mm in diameter.

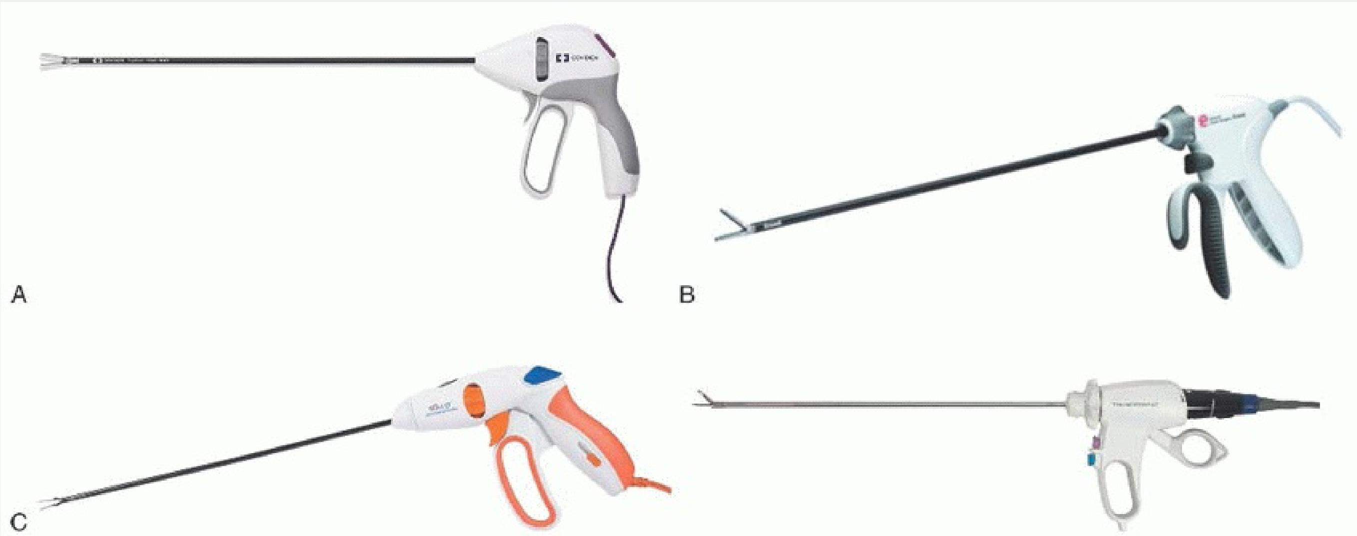

FIGURE 16.12 Bipolar energy devices. **A:** LigaSure. (Copyright © 2012 Covidien. All rights reserved. Used with permission of Covidien.) **B:** EnSeal. (Courtesy of Ethicon.) **C:** HALO PKS Cutting Forceps. (Courtesy of Gyrus.) **D:** ThunderBeat. (Courtesy of Olympus.)

In several comparative studies between the HARMONIC ACE, LigaSure, and EnSeal, failure rates and mean burst pressure tended to increase for all instruments with increasing vessel diameter, but the lowest burst pressures measured were still three times higher than that of normal systolic pressure. EnSeal and LigaSure had less radial adventitial collagen denaturation than the Harmonic ACE. Representative histologic samples were found to have less than 3 mm of coagulative necrosis for all instruments; therefore, 5 mm is likely a safe margin of distance from an instrument, in order to avoid histologic damage. When change in temperature was measured at varying distances, no changes were recorded at distances greater than 1 cm from the tips of monopolar, bipolar, Harmonic, and LigaSure devices in a porcine model. It is worth noting that the maximum temperature during and after activation is approximately 200°C for ThunderBeat and Harmonic, and that those devices require almost twice the time to cool to less than 60°C, as compared to LigaSure. The maximum temperature during and after activation therefore requires some caution, in order to avoid inadvertent thermal damage to surrounding structures.

Energy systems are commonly used for making the colpotomy, although there are reports of introducing a scalpel laparoscopically. Monopolar hooks, bipolar hooks, spatulas, lasers, and the active ultrasonic blades of the Harmonic and ThunderBeat devices run the gamut of what is available

and typically used. Several companies manufacture monopolar loops for assisting in performance of supracervical hysterectomy. They typically operate at high wattages (100 to 130 watts), using moderately interrupted current (20% coagulation, 80% cut), and can transect the uterine corpus from the cervix in approximately 5 seconds. The loops may also assist in transection of broad-based pedunculated myomas, especially when visualization of the stalk is obscured. It is important when using a monopolar loop, however, to ensure that no viscera are entrapped prior to activation. Many other monopolar, bipolar, and ultrasonic devices can accomplish the same tasks, but not with the same degree of efficiency. The time saved in the operating room must be balanced by the cost of additional instrumentation.

Robotics

In 1994, the first U.S. Food and Drug Administration-approved robotic surgical device called AESOP (Automated Endoscopic System for Optimal Positioning, Computer Motion, Inc.) was introduced. With this system, the surgeon could control the orientation of the laparoscope through voice commands. The da Vinci Robotic Surgical System (Intuitive Surgical) and Zeus Robotic Surgical System (Computer Motion) allow the surgeon to operate from a remote station with hand controls that can provide increased dexterity and minimize fatigue, tremors, or incidental hand movement (see Chapter 17).

POSITIONING THE PATIENT FOR LAPAROSCOPIC SURGERY

The patient should be placed on the operating table in the low lithotomy position with the buttocks at or slightly over the table's edge to allow placement and use of an intrauterine manipulator and to have access to the perineum if needed during surgery. The patient's thighs should be in the same plane as the abdomen to allow freedom of motion for laparoscopic instrumentation. When the knees are bent and elevated above the plane of the abdominal wall, it is difficult to gain access to the upper abdomen and pelvic brim without bumping into the legs because of the fulcrum effect of instruments placed into lower ports. Stirrups should have ample padding to support the lower leg without creating pressure points. Particular attention should be given to preventing injury to the peroneal nerve, which is especially vulnerable to compression injury. It is preferable to use a stirrup that can be elevated without undraping the patient so that a high lithotomy position can be used for easier vaginal access if needed. To avoid stretch injury to the femoral, sciatic, or obturator nerves, the thigh should be flexed no more than 90 degrees, and the hips should be abducted no more than 45 degrees. External rotation should be avoided.

Systems to prevent slippage while in steep Trendelenburg include nonslip pads, beanbags, and shoulder braces. Nearly all of these setups require that the arms be tucked to the side. Caution should be exercised when using shoulder braces, as brachial plexus injuries can result when placed too medially.

Surgical Suite

Efficient orientation of the surgical suite is critical for efficient laparoscopic surgery. In general, a right-handed surgeon stands on the patient's left side with the surgical assistant on the patient's right; however, some surgeons prefer the patient's right side. The monitor is usually placed between the patient's legs if only one is available. In the case of two monitors, these are usually placed near the patient's lower legs in the direct line of vision of the surgeons. Newer surgical suites have done away with towers and have ceiling-mounted, movable flat screens, which are highly ergonomic (**Fig. 16.13**). The insufflation monitor is usually placed across from the surgeon so intra-abdominal pressure can be viewed. Insufflation tubing, light cords, electrosurgical cords, and suction-irrigation tubing should be out of the surgeon's path if perineal access is necessary. Knowledgeable operating room personnel are likewise critical to the laparoscopic mission. The scrub technician usually stands caudad to the surgical assistant. A circulating technician assists in troubleshooting equipment and obtaining supplies and equipment.

FIGURE 16.13 Ergonomic surgical suite with ceiling-mounted, movable flat screens.

ENTERING THE ABDOMINAL CAVITY

The abdominal cavity may be initially entered at the umbilicus or alternative sites by Veres needle, open laparoscopy, or direct trocar insertion.

Umbilical Site Veres Needle Technique

When the umbilical site and Veres needle technique is used, the Veres needle is first placed into the abdominal cavity to establish a pneumoperitoneum, and a trocar is subsequently placed into the pneumoperitoneum. A meta-analysis of methods used to establish pneumoperitoneum compared open access (Hasson type) with closed access (needle/trocar) and two types of closed access techniques (direct trocar versus needle/trocar). It was noted that deaths were only reported in the needle/trocar group. However, because of the rarity of death as an outcome, the statistical risk could not be compared meaningfully. The meta-analysis was underpowered to adequately compare the two closed techniques. Therefore, the question of which technique for initial port placement is safest has not been definitively answered to date.

A scalpel is used to make a small skin incision in accordance with the size of the trocar to be placed at the umbilicus or in the left upper quadrant (discussed later in Alternatives to Umbilical Entry). The skin should be elevated in the case of umbilical entry, and the scalpel should be held parallel to the long axis of the patient, to avoid incidentally lacerating the great vessels, which lie in close proximity to the umbilicus. Having the anesthesiologist decompress the stomach with a nasogastric tube will decrease the risk of inserting the Veres

needle or trocar into an overdistended stomach, especially in the case of a left upper quadrant entry. The patient's abdomen should be relaxed by neuromuscular blockade if general anesthesia is being used to allow adequate elevation for Veres needle and trocar insertion. The patient should be lying in a flat or neutral position on the operating table, because the use of Trendelenburg positioning may cause the trajectory of the Veres needle or trocar to be closer to the great vessels rather than the pelvic cavity. In the thin patient, the Veres needle or trocar should be directed toward the hollow of the sacrum to avoid the great vessels (**Fig. 16.14**). In the obese patient, the aorta is typically above the level of the umbilicus; therefore, the Veres needle or trocar may be inserted vertically (90 degrees to the long axis of the patient), as long as the abdominal wall has been elevated adequately (**Fig. 16.15**). Placing the Veres needle close to the base of the umbilicus takes advantage of the thin natural confluence of tissue planes at the umbilicus. Separate clicks can be heard or felt as the needle traverses the fused fascia of the rectus muscles and then peritoneum.

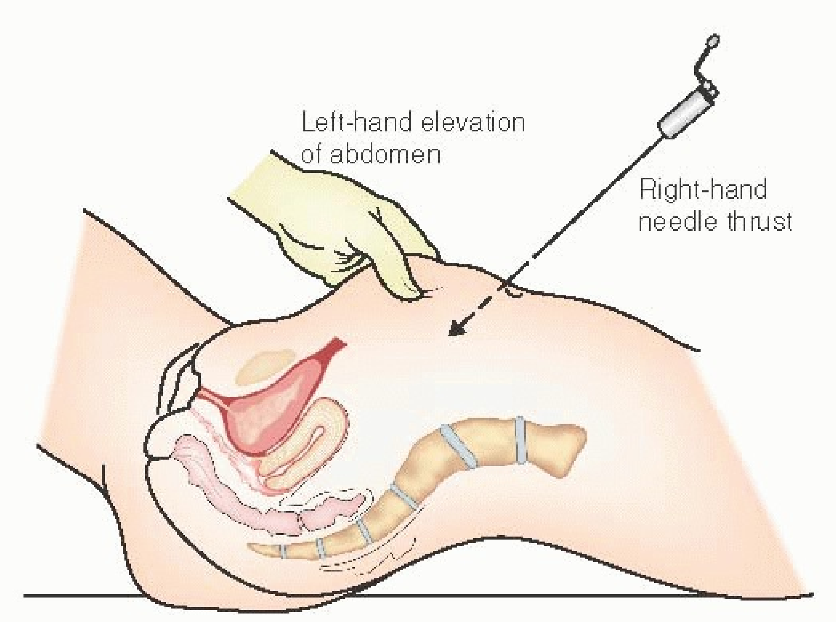

FIGURE 16.14 Insertion of the Veres needle.

Correct placement of the Veres needle into the abdominal cavity can be assessed by several techniques. The hanging drop technique is used by placing a small amount of sterile saline in the top of the Veres needle to verify a negative intraabdominal pressure as it descends into the abdominal cavity. Alternatively, the syringe barrel test can be performed by watching the column of saline descend the barrel of a syringe attached to the Veres needle. Aspiration of a syringe attached to the Veres needle can test for blood or gastrointestinal contents. Low-flow insufflation should be performed at a flow rate of approximately 1 L/min, until further signs of intra-abdominal needle placement are confirmed, such as low intra-abdominal pressure (<10 mm Hg) or loss of dullness to percussion over the right upper quadrant. If the “intraabdominal” pressure reading is higher than 10 mm Hg, the probability of extraperitoneal insufflation is high, and the approach should be reassessed. A prospective, observational study of four tests to ascertain Veres needle placement compared the double click test, the hanging drop test, the aspiration test, and the initial five insufflation pressures in 345 women. High insufflation pressures were the most sensitive for preperitoneal insufflation. Occasionally, high insufflation pressures may be encountered with correct intra-abdominal entry, such as in the case of morbid obesity or when the omentum is in close proximity. Often, the abdominal wall can be lifted, allowing the omentum to dislodge from the Veres, and an appropriate opening pressure will be observed. If elevating the abdomen does not result in a more appropriate pressure within several seconds, it must be assumed that the Veres needle is in the incorrect space and must be reinserted. High-flow insufflation may occasionally be used in the presence of reassuring signs of correct needle placement. During insufflation, intra-abdominal pressures should not exceed 20 to 25 mm Hg to avoid interfering with diaphragmatic excursion and central venous return from caval compression. After an adequate pneumoperitoneum has been established, ranging from 1 to 5 L depending on body habitus, a trocar is inserted at the umbilicus, paying attention to the angle of insertion based on body habitus, as discussed. Once the trocar is placed, the bladed or central portion is removed, and the laparoscope is placed through the trocar sleeve to ensure correct placement before attaching the insufflation tubing to the trocar sleeve.

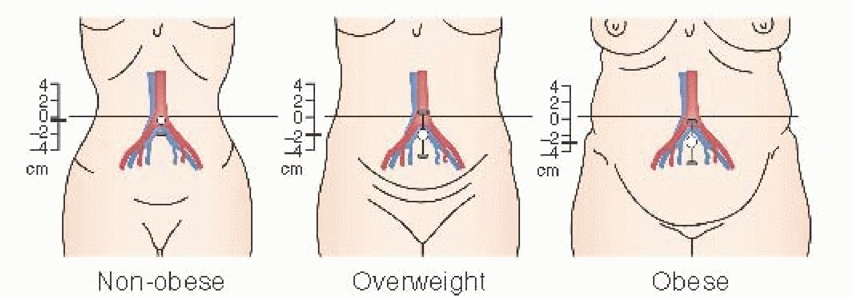

FIGURE 16.15 The location of the umbilicus in relationship to the major vessels in nonobese, overweight, and obese patients. (Modified from Hurd WW, Bude RO, DeLancey JO, et al. The relationship of the umbilicus to the aortic bifurcation: implications for laparoscopic technique. *Obstet Gynecol* 1992;80:48, with permission. Copyright © 1992, The American Congress of Obstetricians and Gynecologists.)

Alternates to Umbilical Entry

When Veres needle insufflation is not successful, or in patients who are at risk for adhesions near the umbilicus, placing the Veres needle at a site other than the umbilicus is usually successful. Two commonly used sites are Palmer point and the left ninth intercostal space. Palmer point is located 3 cm from the midline and 3 cm below the left rib cage. The needle is directed 15 degrees cephalad after the skin has been stretched caudally. This will help direct the Veres needle at a 90-degree angle to the peritoneum, facilitating entry. If the ninth intercostal space is used, the Veres needle should be placed between the ninth and tenth rib, grazing the top of the tenth rib. This grazing minimizes the risk of damaging the intercostal neurovascular bundle. The rib cage provides a natural elevation of a space devoid of bowel regardless of patient weight. There is a remote chance of pneumothorax with this technique. Before performing either of these techniques, palpation for splenomegaly should be performed. After Veres needle placement, a 5-mm trocar is usually placed at Palmer point.

Open Laparoscopy

Hasson described the technique of open laparoscopy in 1971 as a way of avoiding blind trocar placement. A small incision is made at the umbilicus. Allis clamps are used to grasp the fascia, which is incised, and the peritoneum is entered directly. A Hasson-type cannula is used that can be anchored to sutures in the rectus fascia. In a review of more than 5,000 cases over nearly three decades, this technique has been shown to be associated with a low complication rate.

Direct Trocar Insertion

Direct trocar placement has also been described by placing the trocar through the umbilicus initially, rather than using the Veres needle.

SECONDARY TROCAR PLACEMENT

One or two secondary ports are usually adequate for most laparoscopic procedures. More complicated surgeries may require up to five. These may be placed lateral to the inferior epigastric artery or in the midline above the bladder. The size and number of trocars will depend on the procedure and equipment to be used. A 3- to 5-mm trocar may be used for diagnostic laparoscopy to maneuver pelvic organs for adequate visualization. Most instruments for tissue manipulation will fit through a 5-mm port. Some energy delivery systems and tissue retrieval systems require the use of larger ports (8 to 15 mm). Anticipating the need for larger ports can lead to significant cost savings when disposable trocars are used.

The placement of lateral trocars can be associated with injury to the inferior epigastric vessels. Before lateral trocar placement, these vessels can usually be seen along the anterior abdominal wall, as they branch off the external iliac vessels. They can also be found in the anterior abdominal wall triangle, delineated medially by the medial umbilical ligament and laterally by the insertion of the round ligament (**Fig. 16.16**). Laparoscopic visualization of the inferior epigastric vessels has been shown to be successful in 88% of normal weight women, decreasing to 63% in obese women. The ability to visualize the superficial epigastric vessels with transillumination, however, is much more dependent upon weight, with 84% identified in normal weight women and only 23% identified in obese women. Insertion of a spinal needle through the anterior abdominal wall at the intended site of trocar insertion can help find a safe trajectory away from the inferior epigastric vessels. If the vessels cannot be seen, a safe location can usually be found by measuring 5 cm superior to the pubic symphysis and 8 cm lateral. In a study in which ultrasonography was used to measure the distance between the inferior epigastric artery and the umbilicus, a median of 4.75 cm was observed. Additionally, the distance from the midline at the levels of the umbilicus and the ASIS never exceeded 6 cm. Six centimeters should therefore be considered the minimum safe distance from the midline. Secondary trocars should be inserted in a controlled fashion, under direct vision. Placement of suprapubic secondary trocars should be placed well above the bladder. Two fingerbreadths measured above the pubic symphysis has been standard terminology for midline trocar placement. Because of the significant differences in finger widths among surgeons and considering the increased risk of bladder injury using the suprapubic location, it is also worth placing a spinal needle through the anterior abdominal wall in the midline to ensure that the port is well above the bladder. If the patient has had a prior laparotomy, the bladder may be tented superiorly, and it may be necessary to place the trocar higher.

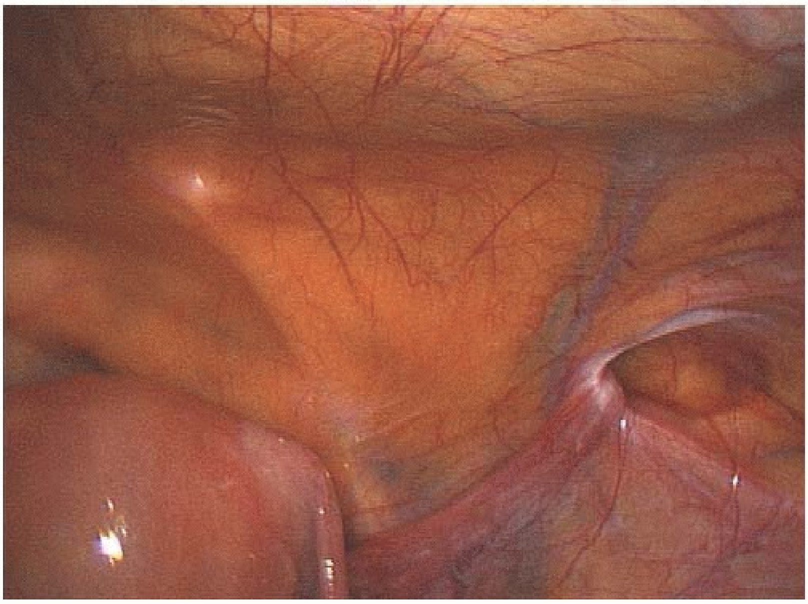

FIGURE 16.16 Note the relationship of the inferior epigastric vessels to the medial umbilical ligament and the insertion of the round ligament.

TISSUE REMOVAL

Small tissue fragments, such as peritoneal biopsy specimens, may be removed through 5-mm trocar sleeves. Large, dense specimens, such as leiomyoma fragments, require larger ports (10 to 15 mm). Fluid-filled specimens, such as ovarian cysts, may be placed in a plastic specimen removal bag (**Fig. 16.17**) and drained while in the bag to avoid spillage. A posterior colpotomy can also be performed for specimen removal. Colpotomy may be performed vaginally, as one would when performing vaginal hysterectomy, or laparoscopically. Laparoscopic colpotomy is performed by first inserting a lubricated sponge stick into the posterior vaginal fornix for cul-de-sac elevation. An incision is then made between the uterosacral ligaments into the posterior vaginal fornix, using the sponge stick as a backstop. Laser, unipolar scissors, or the Harmonic Scalpel may be used as an energy source. An endoscopic specimen bag may be removed through the colpotomy incision. A wet lap pad may be placed vaginally to allow optimal pneumoperitoneum for laparoscopic closure of the colpotomy, or the colpotomy may be closed vaginally. Alternatively, morcellation may be performed with an electromechanical or bipolar morcellator (**Fig. 16.18A-D**). There are several electromechanical morcellators, both disposable and reusable, which either are battery powered or utilize a generator. They range 12 to 15 mm in diameter, although the disposable units are typically only available in a 15-mm diameter. The blades are single use and can be retracted during specimen retrieval, when the morcellator function is not needed. A bladeless morcellator is now available, which uses bipolar energy, and a product line-specific generator. For safety reasons, it is important that the tip of the morcellator be in view at all times. Keeping the cutting tip elevated and parallel with the abdominal wall adds to visualization and decreases the risk of inadvertently injuring bowel and other vital structures, as severe injuries have been reported, including injury to the pancreas. The specimen should be drawn up into the morcellator rather than pushing the morcellator into the specimen.

FIGURE 16.17 Specimen retrieval bag. (Courtesy of Genicon.)

FIGURE 16.18 Tissue morcellators. **A:** Rotocut. (© 2013 Photo Courtesy of KARL STORZ Endoscopy-America, Inc.) **B:** Morcellex. (Courtesy of Gynecare.) **C:** LiNA Xcise. (Courtesy of LiNA Medical.) **D:** PKS PlasmaSORD. (Courtesy of Olympus.)

FASCIAL CLOSURE

Fascial defects should be closed when measuring 10 mm or greater. This can be done directly, by visualizing the fascia, and securing it in an interrupted or figure-of-eight fashion, utilizing a UR6 needle. Alternatively, a fascial closure device can be used and is especially helpful in patients with a thick anterior abdominal wall, when the fascia is difficult to visualize (**Fig. 16.19A-D**). These closure devices are used under direct laparoscopic visualization. Some designs require the retrieval of a suture loop, while others are designed to autoretrieve the end of the suture. Additionally, certain designs will allow for any width of fascial closure, while others secure a predetermined width of fascia. Whether performed abdominally or laparoscopically, it is important to secure an appropriate width of fascia to avoid tearing and subsequent herniation.

DIAGNOSTIC LAPAROSCOPY

A systematic approach to diagnostic laparoscopy, like checklists for pilots, can help ensure thoroughness in what is regarded as a routine surgery. After insertion of the laparoscope, the abdomen should be carefully examined, particularly the area in the trajectory of the Veres needle or trocar, to ensure that inadvertent bowel or vascular damage was not caused. Trendelenburg positioning should then be used to view the pelvic cavity and organs.

With the assistance of a uterine manipulator, the uterus can be anteverted to visualize the posterior aspect of the uterus, from the fundus to the posterior cul-de-sac. This should begin with a panoramic view and proceed with a close-up magnification view to detect subtle findings, such as atypical manifestations of endometriosis. The presence of peritoneal windows or defects in the posterior cul-de-sac should be noted if present.

The posterior cul-de-sac should also be probed with an instrument such as a blunt probe or atraumatic grasper to palpate any hidden endometriotic nodules that may be imbedded within the rectovaginal septum. Anytime a shallow posterior cul-de-sac is noted, this should be considered, as an obliterated endometriotic posterior cul-de-sac can have a deceivingly normal-appearing peritoneal surface. The uterosacral ligaments should have the appearance of a "V" with the apex at the cervix. If peritoneal fluid is obscuring the posterior cul-de-sac, the fluid should be removed by suction. The broad ligaments should be inspected for the presence of endometriosis, adhesions, or fibroids.

FIGURE 16.19 Fascial closure devices. **A:** Endo Close. (Courtesy of Covidien.) **B:** Weck EFx. (Courtesy of Teleflex.) **C:** Carter-Thomason. (Courtesy of CooperSurgical.) **D:** Carter-Thomason II. (courtesy of CooperSurgical.)

The ovaries should be viewed globally. This can be accomplished by simply flipping the ovary superiorly with a probe or other blunt instrument, or the utero-ovarian ligament can be grasped with an atraumatic grasper from the contralateral port and rotated by twisting the grasper clockwise for the left ovary and counterclockwise for the right ovary. This provides an excellent view of the undersurface of the ovary that can be easily held in place for inspection of the ovarian fossa and pelvic sidewall. With the ovary lifted up away from the sidewall, the transperitoneal course of the ureter can usually be seen. The ureter is optimally visualized by looking for peristalsis as it

crosses the common iliac artery at the pelvic brim. One advantage of identifying the ureter early during surgery is that the peritoneal surface can become edematous as the case proceeds, likely from prolonged carbon dioxide exposure and manipulative contact. The fallopian tube should be handled with care. Fallopian tube forceps are available that allow the tube to be grasped at the mesosalpinx while surrounding the tube. The proximal portion of the tube should be examined for nodules, which may be indicative of salpingitis isthmica nodosa. The fimbria should be examined delicately, looking for any sign of phimosis. Anterior to the fallopian tubes, the round ligaments should be viewed and traced laterally to identify the presence of hernia. The anterior cul-de-sac is best seen by using the uterine manipulator to place the uterus in a retroverted position. In this position, the anterior surface of the uterus and the bladder parietal peritoneum can be seen well. The anterior abdominal wall should be viewed for the presence of endometriosis or hernia.

The appendix should be viewed for any sign of inflammation, endometriosis, or fecalith. This is best performed by using an atraumatic bowel grasper. The upper abdomen should also be inspected, taking note of the liver, gallbladder, and diaphragmatic surfaces. If needed, the large and small intestine can also be inspected by “running” the bowel with two atraumatic bowel graspers. A panoramic, 360-degree evaluation is helpful to ensure that no upper abdominal adhesions have been missed that may have caused the intestine to be adherent to the anterior abdominal wall. It is possible in the presence of such adhesions to place a trocar through and through the intestine unknowingly. This condition can be ruled out by placing the laparoscope through one of the lower ports for visualization of the umbilical port. Chromopertubation may be performed by instilling a diluted indigo carmine solution through the uterine manipulator. Lack of spill may be due to obstruction, tubal spasm, or leakage from the cervix. It is therefore important to have a tight uterine cannula seal at the cervix.

OPERATIVE LAPAROSCOPIC PROCEDURES

Adhesiolysis

Pelvic adhesions have been associated with infertility and chronic pelvic pain. It should be recognized that chronic pelvic pain is often a complex condition, and in the absence of gastrointestinal obstructive symptoms, adhesiolysis is usually often not curative of pain. To better understand the nature of symptomatic adhesion, pain mapping under conscious sedation may be a useful technique. In performing adhesiolysis, optimal results depend on the use of microsurgical technique, gentle tissue handling, and meticulous hemostasis with minimal tissue fulguration. Adhesiolysis can be performed by a number of techniques, including blunt and sharp dissection, electrodissection, aquadissection, and laser dissection.

Blunt dissection is the most rudimentary form of adhesiolysis. Although not recommended, this technique is usually used in treating thin, avascular adhesions. Virtually any type of laparoscopic instrument can be used to place traction on an adhesion to cause separation. If bleeding or significant resistance is encountered, this technique should be abandoned.

Sharp dissection is the preferred method for dealing with all adhesions, especially thick avascular adhesions. The advantage of sharp dissection over electrodissection is the decreased risk of inadvertent electrosurgical injury. This is performed in a similar fashion to laparotomy. The adhesion is held on tension with an atraumatic grasper, and scissors are used to lyse the adhesive band. It is important to turn the tip of the scissors toward the optical viewing angle to avoid vascular or bowel injury.

Aqua dissection can be used to free adhesions from the pelvic sidewall to avoid injury to ureter or the great vessels. It is also a useful technique in removing endometriotic nodules. With this technique, the peritoneum is grasped, and an incision is made large enough to place the tip of a powered suction-irrigation device. Irrigation is used to force fluid under the peritoneum, causing it to balloon out from deeper tissues. The adhesion or peritoneum can then be dissected free.

Monopolar energy and *bipolar energy* are frequently used to lyse thicker vascular adhesions. When using electrosurgery, care must be used to avoid injury to bowel. It is always best to start from known to unknown. As known areas are freed from adhesions, unknown areas become recognizable. Monopolar instruments, like scissors and needlepoint electrodes, are ideal for these adhesions. Bipolar instruments, such as Kleppinger forceps, bipolar scissors, or newer tissue-controlled bipolar energy instruments that seal vessels, can be used.

Laser dissection has been used in laparoscopy with great success as a result of minimal lateral thermal spread, as compared with most forms of electrosurgery. However, it should be noted that this form of energy is indeed still an energy source and obtains hemostasis through lateral thermal spread. The small spot size of laser makes this a useful tool for precision adhesiolysis. The CO_2 laser has a depth of penetration of 0.1 mm and is excellent for cutting. With the adhesion on tension, the CO_2 laser is introduced through the operating channel of the laparoscope or through a secondary port.

The Harmonic Scalpel is used with a technique similar to both bipolar and monopolar dissection, depending whether tissue is grasped or the active blade is used alone. This technique does not use electrosurgery. Ultrasonic energy has the advantage of limited lateral thermal spread, similar to the newer bipolar electrosurgical instruments.

Sidewall and Retroperitoneal Space Dissection

It is often necessary to identify the course of ureter and iliac vessel in cases of pelvic sidewall adhesions or endometriosis. If the ureter is able to be identified at the pelvic brim but then is obscured by adhesions, endometriosis, or an ovarian mass along its caudad course, the peritoneum overlying the sidewall can be grasped and opened with scissors (**Fig. 16.20**). A Maryland dissector can be used to gently

spread the peritoneum to view the ureter. If the anatomy is distorted, it may be necessary to start the dissection at the pelvic brim or by opening the round ligament. If the round ligament is to be opened, it should be divided with an energy source as lateral as possible, and a blunt grasper can be used to dissect the retroperitoneal space, watching for the ureter on the medial leaf of the broad ligament and avoiding the iliac vessels. Developing the pararectal space can help to define anatomic landmarks to avoid inadvertent vascular or ureteral injury. Once the ureter and uterine artery are located, adhesions can be lysed with an energy system of the surgeon's choice.

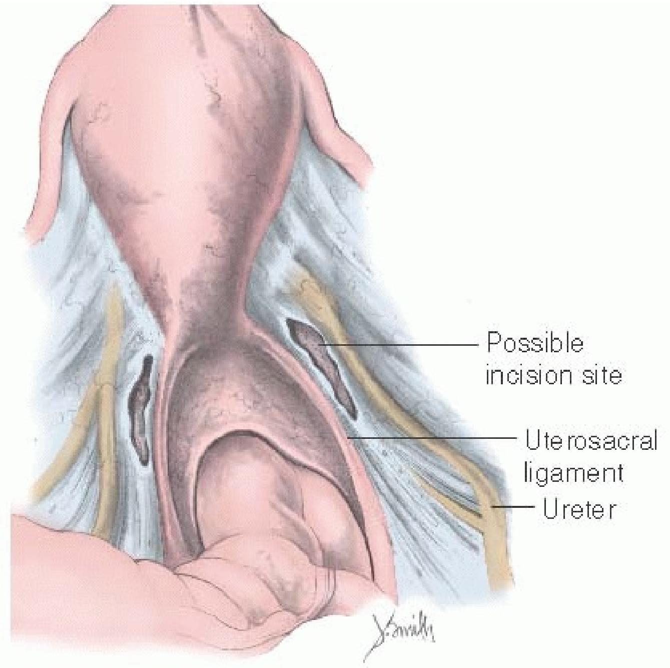

FIGURE 16.20 Pelvic sidewall dissection. The peritoneum has been incised so that the retroperitoneal structures can be visualized.

Posterior Cul-De-Sac Dissection

When endometriosis or pelvic adhesions partially or completely obliterate the posterior cul-de-sac and are associated with pelvic pain or infertility, a surgical approach is usually indicated. Cul-de-sac obliteration secondary to endometriosis often involves deep fibrotic endometriosis that may involve the rectum, rectovaginal septum, or uterosacral ligaments. Dissection of the posterior cul-de-sac may be necessary and can be performed laparoscopically by skilled surgeons. The goal is to lyse adhesions, excise large or deep endometriotic lesions, and resect or vaporize small superficial lesions.

The patient should undergo a bowel prep before surgery. A uterine manipulator is used to antevert the uterus, and a rectal probe is placed in the rectum to delineate and retract the rectum posteriorly. A sponge stick placed in the vagina can further delineate the rectum from the vagina (Fig. 16.21). The anterior rectum is carefully dissected from the posterior aspect of the uterus or vagina with scissors, laser, Harmonic Scalpel, or tissue-controlled bipolar energy system. The use of monopolar and traditional bipolar energy can result in significant thermal injury to the rectum. Aquadissection may also be useful. Dissection should continue until the loose areolar tissue of the rectovaginal space is reached. If a ureter is near the site of dissection, the position of the ureter should be confirmed before any dissection takes place. The fibrotic endometriosis can then be excised from the posterior vagina or uterosacral ligaments. If endometriosis extends to the vaginal mucosa, this is excised, and the posterior vagina is closed vaginally or laparoscopically. Palpation of the endometriotic nodule before and after removal is helpful to ensure complete excision.

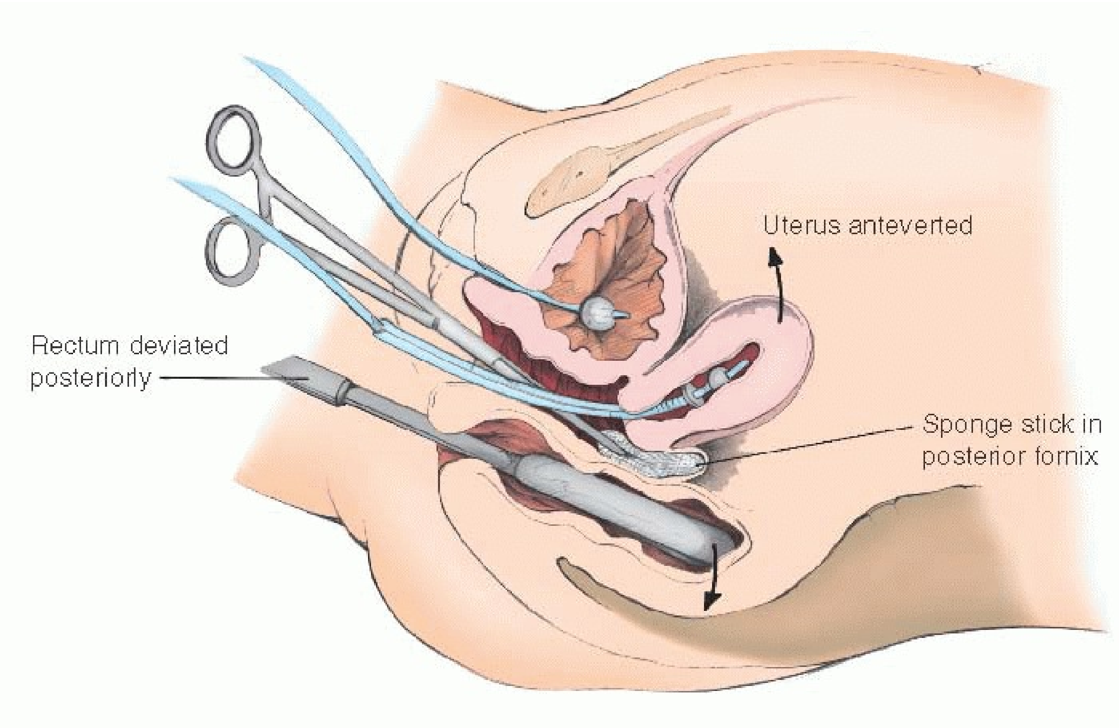

FIGURE 16.21 Dissection of the posterior culde-sac. Instruments in the uterus, posterior fornix of the vagina, and rectum help define the anatomy.

Oophorectomy and Salpingo-Oophorectomy

STEPS IN THE PROCEDURE

Salpingo-Oophorectomy

- Ensure that the tube and ovary are free of all adhesions.
- Identify the ureter. If it is not possible to visualize the ureter through the peritoneum, incise the peritoneum, and identify the ureter by dissecting the pararectal space.
- The infundibulopelvic ligament is isolated and sealed with either bipolar or ultrasonic energy and transected. The utero-ovarian ligament is sealed and transected.
- The intervening mesosalpinx is incised parallel to the round ligament.
- All pedicles are inspected for hemostasis.

Several techniques for laparoscopic oophorectomy or salpingo-oophorectomy have been described. One procedure involves the placement of three loop ligatures around the ovary and adnexa. Before placement of the loops, the structures must be free of adhesions. Incisions in the mesosalpinx are sometimes necessary to facilitate placement. The ovary or adnexa is cut distal to the three loops. Small bleeding points can be coagulated on the stump, but care must be taken not to coagulate the suture.

Alternatively, the peritoneum is opened, and the ureter is identified by dissecting the pararectal space (**Fig. 16.22A**, **B**). Lactated Ringer solution or saline can be injected into the retroperitoneal space to push the ureter away from the site of coagulation and increase the margin of safety. The uteroovarian ligament is coagulated or sealed with bipolar energy or ultrasonic energy and transected, and the infundibulopelvic ligament is then coagulated or sealed and transected. If the fallopian tube is to be removed with the ovary, the proximal fallopian tube and utero-ovarian ligament are coagulated or sealed before transection (**Fig. 16.23A-C**). The intervening mesosalpinx is similarly transected. Pedicles are examined for hemostasis, and the ovary is removed by one of the described methods of tissue removal. Laparoscopic stapling devices can also be used on the pedicles, but care must be used to avoid the ureter.

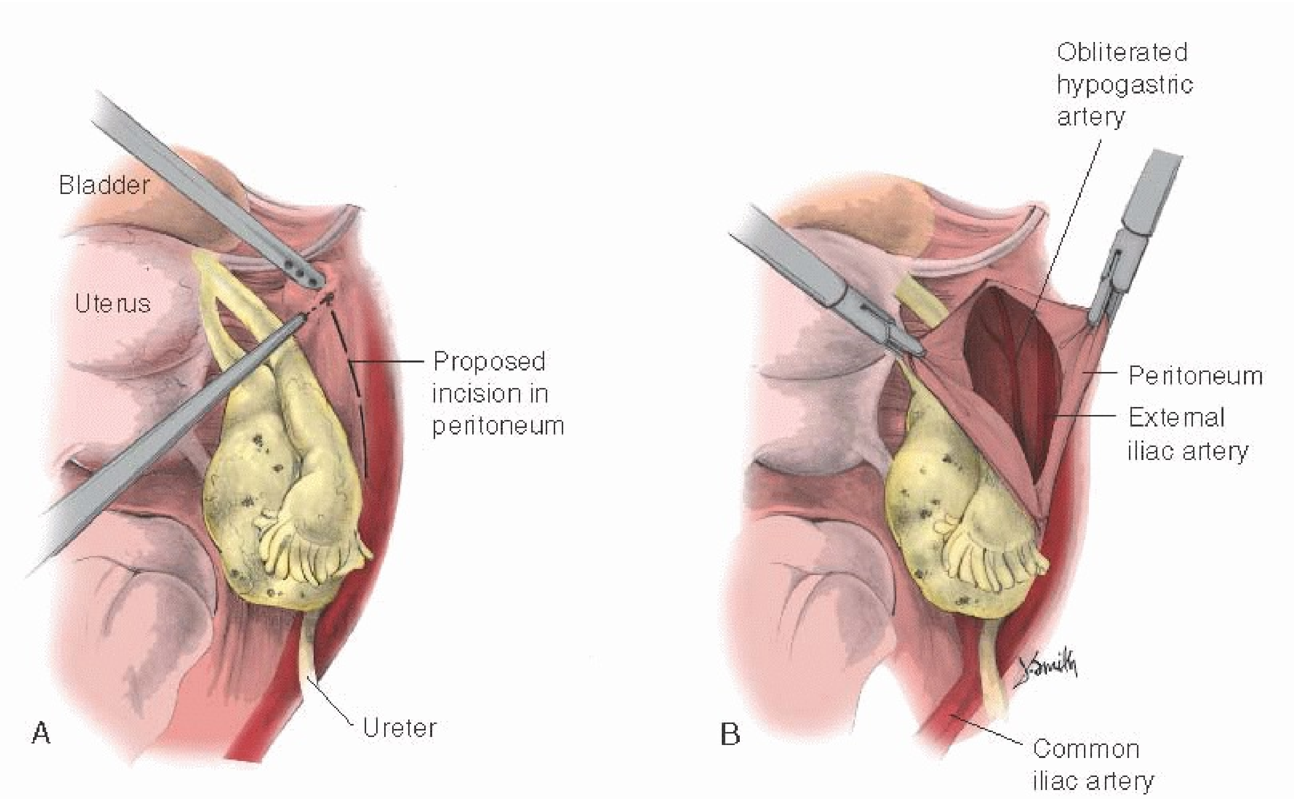

FIGURE 16.22 Dissecting the retroperitoneal space. **A:** The peritoneum overlying the pelvic sidewall is incised. **B:** The peritoneum is opened, and the ureter and vessels are identified.

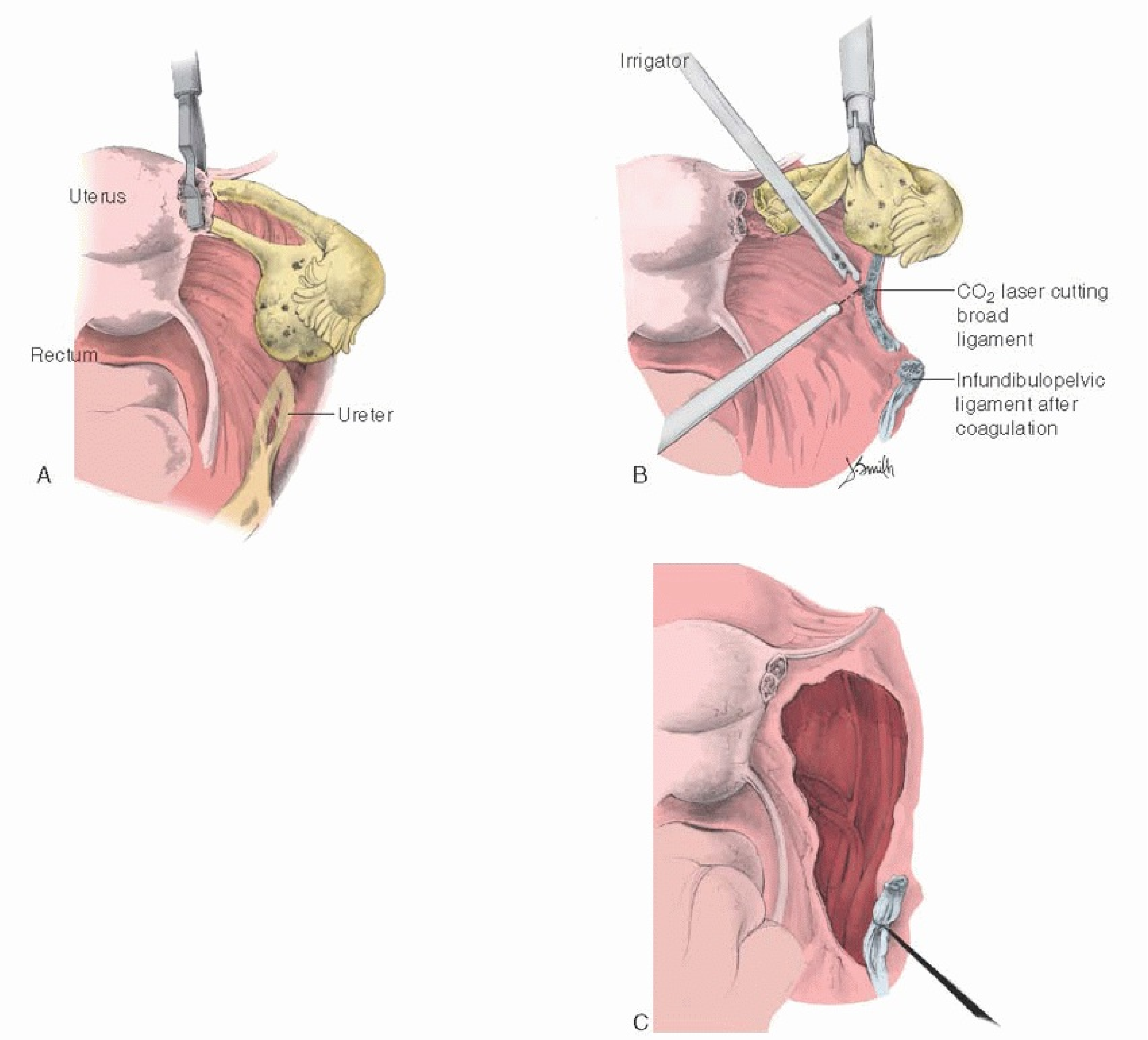

FIGURE 16.23 Oophorectomy with the use of bipolar coagulation. **A:** The utero-ovarian ligament is coagulated and then transected. **B:** The infundibulopelvic ligament is coagulated with bipolar forceps and then cut. **C:** An Endoloop may be placed on the infundibulopelvic ligament after transaction for added hemostasis.

LAPAROSCOPIC MYOMECTOMY

STEPS IN THE PROCEDURE

Myomectomy

- A hemostatic agent, such as dilute vasopressin, is injected into the myometrium, either through a port or transabdominally.
- The uterine serosa is incised with a laser, needle electrode, or ultrasonic energy.
- A myoma screw is introduced into the fibroid, or a tenaculum is used to grasp the fibroid.
- The fibroid is enucleated with a combination of traction and countertraction, as well as electrosurgery where indicated.
- The defect is closed in two to three layers.

Laparoscopic myomectomy is a heterogeneous procedure that can range from a simple procedure to one of the more difficult laparoscopic surgeries requiring expert laparoscopic suturing skills. For example, large pedunculated fibroids (8 to 10 cm) can be detached in a few minutes. Large intramural fibroids may take several hours to remove and repair in the hands of expert laparoscopic surgeons. Two case-control studies comparing open with laparoscopic myomectomy have both demonstrated significantly longer mean operating room time and shorter hospital stays with the laparoscopic group. The use of a preoperative gonadotropin-releasing hormone (GnRH) agonist may be considered in patients who are anemic. A prospective randomized study using leuprolide acetate in patients undergoing laparoscopic myomectomy also demonstrated significantly lower blood loss and operative times in the treatment group. The authors of this study noted increased operative time in the subset of markedly hypoechoic fibroids because of increased fibroid softness. Other studies have shown longer operative times and a higher conversion to laparotomy rate associated with the use of GnRH agonists in laparoscopic myomectomy because of difficult cleavage planes.

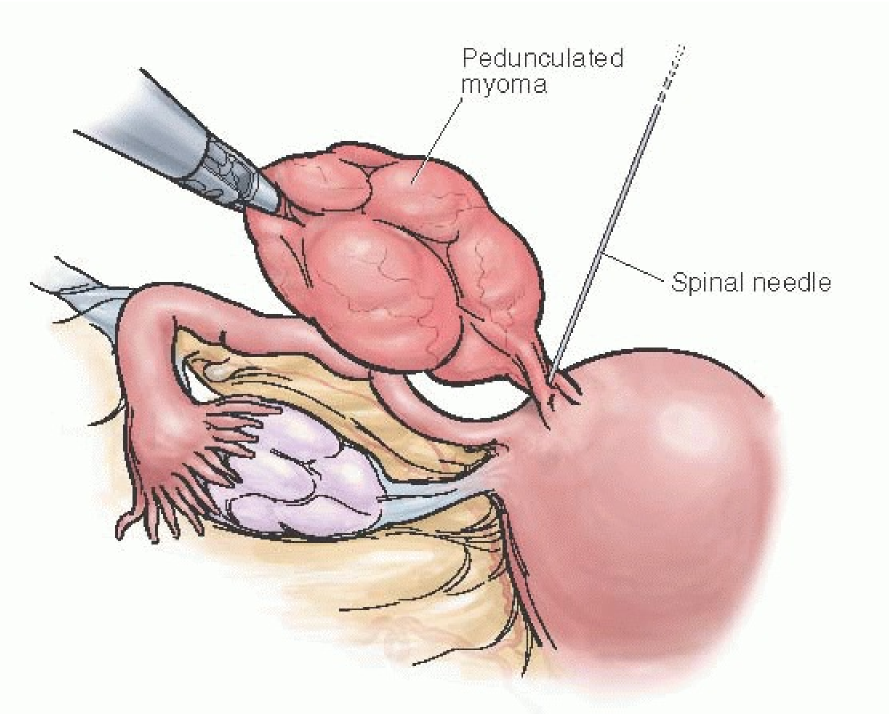

FIGURE 16.24 Excision of a pedunculated myoma. The base is thoroughly coagulated and cut.

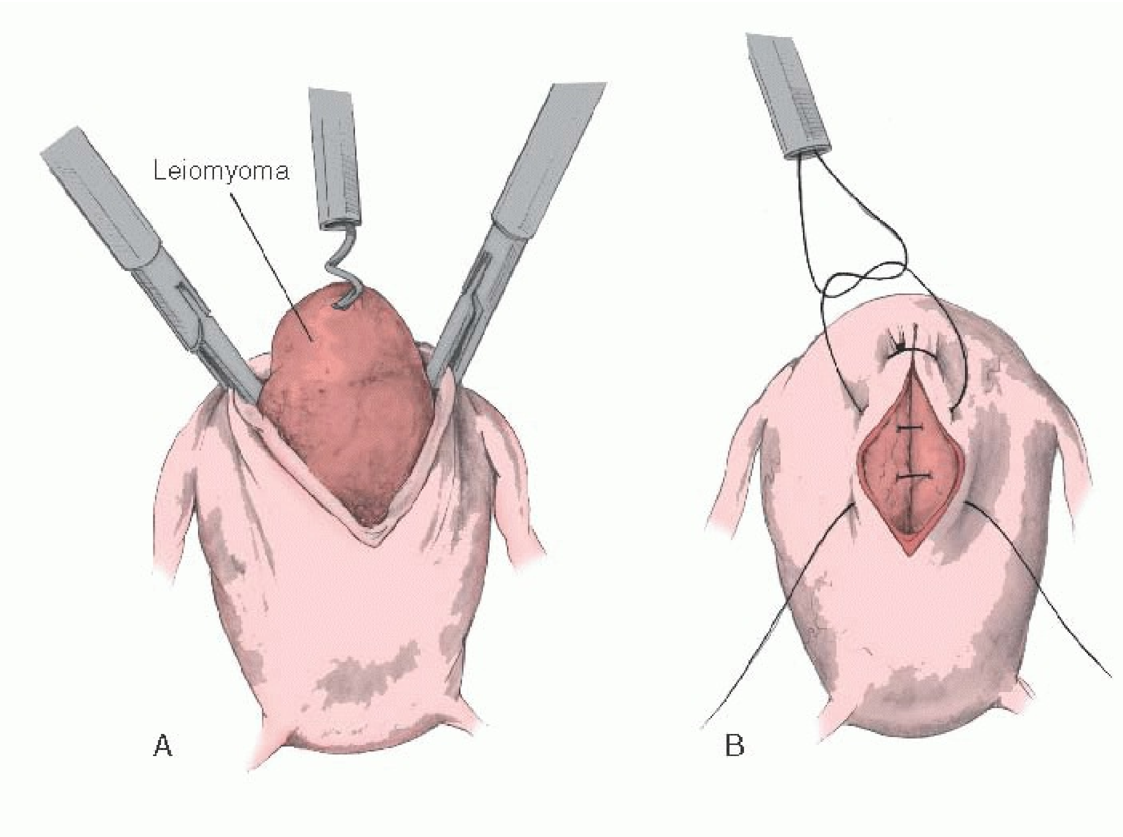

FIGURE 16.25 Myomectomy. **A:** The leiomyoma is grasped with forceps or a corkscrew and is dissected from the myometrium with careful blunt and sharp dissection. **B:** The defect, if large, is closed with sutures in two layers.

Pedunculated myomas can be resected by coagulating and transecting the base, and the defect does not typically require suturing (**Fig. 16.24**). Intramural and subserosal fibroids require an incision to be made with scissors, laser, needle electrode, or Harmonic Scalpel. Before incising the uterine serosa, it is advisable to inject hemostatic agents into the serosa and myoma. A dilute vasopressin solution or bupivacaine plus epinephrine may be injected transabdominally into the myometrium through a spinal needle. A randomized placebo-controlled trial demonstrated significantly lower blood loss, total operative and enucleation time, and degree of surgical difficulty associated with bupivacaine plus epinephrine compared with saline. When the whorled white appearance of the myoma is seen, the edges of the uterine serosa are held open with atraumatic graspers, and a corkscrew retractor is screwed into the myoma. Using upward traction with the corkscrew retractor, the myoma is peeled away from the uterine corpus (**Fig. 16.25**). Hemostasis is

achieved with electrosurgery or Harmonic Scalpel. The defect is sutured closed in two or three layers, depending on the depth of the defect, using a delayed absorbable suture as described previously. In order to close a defect under tension, an intracorporeal cinch knot, an extracorporeal sliding knot, or a barbed suture can be used. Another option is to perform uterine closure through a minilaparotomy if the fundus or area to be sutured can be delivered through a small incision. Morcellation can be performed, or smaller specimens can be delivered through a posterior colpotomy. It is best to avoid losing myoma pieces that become detached, as there have been reports of specimens becoming infected, parasitic, or continuing to grow at the trocar incision site. Loss of tissue, however, is not necessarily an indication for laparotomy, as a case series of 12 retained specimens, three of which were myomas, resulted in no sequelae with 2-year follow-up. Uterine rupture has been reported in patients undergoing laparoscopic myomectomy, and pregnancy should be monitored with the same caution given to patients who have undergone abdominal myomectomy. It is not known whether laparoscopic repairs are equivalent to repair by laparotomy, although healing time is certainly improved.

FIGURE 16.26 Acessa System. (Courtesy of Halt Medical.)

A radiofrequency ablation system, which utilizes an electrode array to accommodate fibroids of varying size, can now be delivered laparoscopically. The Acessa System (Halt Medical) (**Fig. 16.26**) uses monopolar radiofrequency, with real-time temperature feedback control, to achieve a target temperature of 100°C. The electrosurgical probe contains a needle electrode array, consisting of seven straight electrodes, which is inserted percutaneously through a 2-mm skin incision. The procedure is performed in conjunction with real-time laparoscopic ultrasound. In a 12-month prospective follow-up study, mean uterine volume decreased by 25.1%, mean fibroid volume decreased by 44.3%, and a clinically significant reduction in menstrual bleeding was observed in 68.8% of subjects. A median of 5 days was missed from work, return to normal activities occurred at a mean of 9 days, and 95% of patients reported being satisfied with the treatment at 12 months. A total of 674 fibroids were treated, with a mean of five fibroids per patient. There were four device-related adverse events and one surgical reintervention.

LAPAROSCOPY USING LOCAL ANESTHESIA OR CONSCIOUS SEDATION

Laparoscopy can be performed under conscious sedation in the operating room or in a nonhospital environment, such as physician's office. Microlaparoscopy is often used with 2- or 3-mm instrumentation. Local anesthesia and conscious sedation has long been used to perform tubal ligation. The use of microlaparoscopic instrumentation has assisted in performing laparoscopy under conscious sedation in the office setting for pain mapping in chronic pelvic pain patients. Pain mapping may be useful in patients with chronic pelvic pain of uncertain etiology, as this enables the patient to participate in the evaluation of the pelvis, and to decipher between incidental versus painful adhesions and endometriosis. If conscious sedation is to be performed in the office without the presence of an anesthesiologist, it is important to follow state guidelines. The American College of Surgeons has developed guidelines that have been endorsed by the American Congress of Obstetricians and Gynecologists, which detail requirements for an optimally safe environment and resuscitation.

Laparoscopy under conscious sedation is usually performed by combining local anesthesia with intravenous sedation. Proper patient selection is important, as patients must be able to withstand lifting the abdomen at the umbilicus for trocar insertion and tolerate local infiltration at the umbilicus. The umbilicus is infiltrated at the skin and then down through the fascia with a 25-gauge needle, using approximately 10 mL of 1% lidocaine or 0.25% bupivacaine. If conscious sedation is used, short-acting narcotics, such as remifentanil, are ideal if pain mapping is to be performed, so that the patient is able to respond to intraperitoneal stimuli. If tubal sterilization is to be performed, an anxiolytic drug such as midazolam is useful.

COMPLICATIONS

Nerve Injury

Most nerve injuries occurring during laparoscopic surgery are neurapraxia or nerve contusion and will usually resolve within 6 weeks. Neurotmesis, or complete division of the nerve, is the most severe form of nerve injury, often resulting in permanent disability. Proper preoperative and intraoperative patient positioning—as well as knowledge of known risk factors associated with mononeuropathies—is an important part of providing a safe environment for laparoscopic surgery. Femoral neuropathy occurring during laparoscopy can be associated with excessive hip flexion or abduction or long operating times. When the lithotomy position is used in patients undergoing vaginal or laparoscopic surgery, the thigh should be flexed no greater than 90 degrees and abducted no greater than 45 degrees. If a patient's position is changed intraoperatively from low lithotomy to high lithotomy, these relationships should be maintained. Obturator neuropathy is most commonly associated with direct injury during radical pelvic surgery or lymphadenectomy, but can also occur as a result of excessive hip flexion. As the obturator nerve leaves the obturator foramen, it lies directly against bone and can become acutely angulated and deformed if the hips are excessively flexed, particularly during prolonged surgery. The obturator neurovascular bundle is also vulnerable during laparoscopic retropubic dissection, particularly during the paravaginal repair of lateral defects of the anterior vaginal wall. Surgeons who operate in these spaces should be well versed in the anatomy of the obturator nerve.

The iliohypogastric and ilioinguinal nerves can be injured from lateral trocars with subsequent suture ligature and fibrotic entrapment. Care should be taken to avoid extreme lateral trocar placement; however, there is considerable anatomic variation in the course of these nerves, and injury cannot always be avoided. Mapping of nerves in fresh frozen cadavers revealed that the ilioinguinal nerve enters the abdominal

wall with an average of 3.1 cm medial and 3.7 cm inferior to the ASIS and that the iliohypogastric nerve enters the abdominal wall with an average of 2.1 cm medial and 0.9 cm inferior to the ASIS. Placement of trocar sites 2 cm above the level of the ASIS, at any point medially, would avoid almost all of the ilioinguinal and iliohypogastric nerves identified in the study, although such placement may not always be practical.

Sciatic neuropathy during laparoscopic surgery can be a result of nerve stretching. Injury to the sciatic nerve has been reported in procedures lasting as short as 35 minutes in freehanging stirrups. The peroneal division of the sciatic nerve is under the least amount of tension when the knee and hip are flexed, as the nerve is fixed at the sciatic notch and the fibular head. Tension along the nerve is increased with hip flexion when the knee joint becomes straightened or externally rotated. Patients at increased risk of sustaining sciatic nerve injury are long legged, obese, or short in stature. In hangingtype stirrups, long-legged or obese patients have a tendency for external hip rotation, and shorter patients have less flexion at the knee. In such cases, stirrups that support the ankle and calf may be more appropriate.

In a large retrospective study, at a single institution, a total of 19,461 cases were reviewed, encompassing 56 surgical procedures performed in the lithotomy position. Fifty-five patients were found to have persistent neuropathy of the lower extremity, defined as a motor deficit if at least 3 months' duration. The majority were neuropathies of the common peroneal nerve, of which there were 43. The remaining neuropathies included eight sciatic and four femoral. At 12 months, approximately 50% of patients with common peroneal and femoral neuropathies had regained complete motor function, while none of the patients with sciatic neuropathies had regained complete motor function. The most important risk factor, found to have a relative risk of 100, was each hour spent in lithotomy. Decreasing the amount of time spent in the lithotomy position should therefore be the primary preventative strategy.

The incidence of brachial plexus injuries is 0.16% and can be particularly devastating, especially when bilateral. The brachial plexus arises from the anterior nerve roots of C5-T1; passes behind the clavicle, over the first rib; and is partially fixed to the fascia of the upper arm. The upper roots can be stretched when a patient is positioned in steep Trendelenburg, and the body slides relative to outstretched arms, or when shoulder braces are positioned too medially. This results in weakness of the upper arm and a constellation of sequelae termed Erb palsy. The lower roots can be compressed between the clavicle and first rib when the arms are abducted greater than 90 degrees. This results in weakness of the distal forearm and hand and a constellation of sequelae termed Klumpke paralysis.

Vascular Injuries

Of all the injuries associated with laparoscopy, vascular injuries are the most acutely life threatening, particularly in the case of injury to the aorta, vena cava, or iliac vessels. Injury can occur during Veres needle placement, during trocar insertion, or during tissue dissection. Injury to the great vessels requires immediate laparotomy, manual compression, repair, and usually transfusion. Injury to smaller vessels can usually be rendered hemostatic with the use of bipolar electrosurgery, hemostatic clips, or laparoscopic suturing techniques. Injury to the inferior epigastric vessels can occur during placement of the lateral trocar. The inferior epigastric artery can usually be seen as it branches off the external iliac artery running cephalad along the abdominal wall peritoneum. If it is injured, a bipolar forceps can be placed through the contralateral port in an attempt to coagulate. Alternatively, endoscopic fascial closure devices can be used to place suture on either side of the vessel for vascular occlusion. Hemostasis can usually be immediately achieved by placing a 30-mL Foley catheter through the trocar site and inflating the balloon for tamponade. The Foley catheter can then be secured with an 8-inch clamp. This injury can also be managed by enlarging the trocar site to visualize, clamp, and ligate the bleeding vessel.

Gastrointestinal Injury

Gastrointestinal injury is the most lethal injury associated with laparoscopy, with a mortality rate reported as high as 3.6%. Injury may occur from Veres needle placement, trocar insertion, adhesiolysis, tissue dissection, devascularization injury, or thermal injury. As a general rule, Veres needle injuries need no repair as long as the puncture is not associated with bleeding or a subsequent rent from additional tissue manipulation. In the case of colonic puncture without tearing, nonoperative management with antibiotics, copious irrigation, and suction has been suggested. There has been little evidence-based literature published about stomach injury during laparoscopy, but it is estimated that gastric perforation occurs in approximately 1 in 3,000 cases. Risk factors for stomach injury include a history of upper abdominal surgery and difficult induction of anesthesia, as a gas-distended stomach can distend to below the level of the umbilicus. Orogastric or nasogastric suction before Veres needle or trocar placement can help lower this risk. Trocar injury to the stomach requires repair by laparoscopy or laparotomy. The defect may be oversewn with a delayed absorbable suture in layers, and the abdominal cavity should be irrigated and suctioned, being sure to remove any food particles as well as gastric juices. Nasogastric suction is usually maintained postoperatively until normal bowel peristalsis occurs.

Veres needle and trocar injury to the small intestine may not be obvious because of small-bowel redundancy and a tendency for small bowel to fall out of view. Furthermore, a throughand-through trocar injury may be hidden from laparoscopic view. Potential injury should be investigated when multiple anterior abdominal wall adhesions are present. A lower quadrant secondary port can be used to view the umbilical port site. If there are no abdominal wall adhesions but a bowel injury is suspected, the bowel should be run with laparoscopic bowel graspers, or manually by standard laparotomy, until an injury is satisfactorily ruled out. A full-thickness injury to the small bowel of 5 mm or greater should be repaired in two layers with an interrupted layer of 3-0 delayed absorbable suture to approximate the mucosa and muscularis and a serosal layer of 3-0 interrupted silk suture placed perpendicular to the long axis of the intestine to avoid stricture formation. This is usually performed by laparotomy or by minilaparotomy at the umbilical site, where the injured bowel loop is pulled through to the skin surface and repaired. Laparoscopic repair has also been reported as effective by surgeons with advanced gastrointestinal surgical skills. If the laceration to the small bowel exceeds one half of the luminal diameter, segmental resection is recommended.

Trocar injury to the colon is reported to occur with a frequency of approximately 1 per 1,000 cases. Undetected injury to the large intestine can be associated with significant morbidity, compared with injury to the small intestine and stomach, because of the high concentration of coliform bacteria. Therefore, if injury to the colon is suspected, the area should be inspected carefully, using atraumatic bowel graspers, or laparotomy may be performed. The management of large intestinal injuries depends on size, site, and length of time from injury to diagnosis. In general, once the diagnosis of colonic

injury is made, broad-spectrum antibiotics should be administered, and consultation should be sought with a surgeon who has experience with bowel injury. In the case of a small rent with minimal soilage, the defect can be closed in two layers with copious irrigation. When a larger injury has occurred and the bowel has not been prepared with a mechanical or antibiotic regimen, or when the injury involves the intestinal mesentery, a diverting colostomy is usually necessary. In the case of delayed (postoperative) diagnosis, a diverting colostomy should be performed. If injury to the rectosigmoid colon is suspected, filling the posterior cul-de-sac with normal saline, injecting air into the rectum through a catheter-tipped bulb syringe, and looking laparoscopically for bubbles may aid in detection (flat tire test). Alternatively, proctosigmoidoscopy may be performed or used to inject air into the rectum.

Thermal injuries are histologically different from traumatic injuries and therefore must be treated differently. Thermal bowel injuries can be differentiated histologically from traumatic injury by the presence of coagulation necrosis and the absence of capillary ingrowth and white cell infiltrate in the former. Because of this coagulation necrosis, thermal injuries require wide resection, even though the bowel may still have a normal appearance adjacent to the injury, as it may take days for the extent of the injury to become apparent.

Trocar Site Hernia

In a retrospective review of more than 3,500 laparoscopies in 1993, the frequency of incisional hernias was reported to be 0.17%. The fascia should be closed in trocar sites that are 10 mm and larger. Although there are case reports of hernia occurring at 5-mm trocar sites, closing 5-mm trocar sites usually requires enlarging the skin incision, or using laparoscopic fascial closure devices, which may not be warranted in this rare possibility. Closing the fascia may not entirely prevent hernia formation. A survey of more than 3,200 gynecologists noted that 18% of hernias occurred despite fascial closure and appeared to be related to the number of laparoscopies performed, rather than the length of the surgeon's career. Trocar site hernias can present as occult or incarcerated hernias. A defect is usually palpable over the trocar site incision with Valsalva, or a mass can be seen. If the patient presents with signs of bowel obstruction, the bowel must be inspected carefully, and if there is evidence of necrosis or vascular compromise, the bowel should be resected.

Urinary Tract Injury

Bladder injury during laparoscopy is estimated to occur 1 in 300 cases. Higher injury rates have been reported with laparoscopic hysterectomy and bladder neck suspension. Risk factors for bladder injury include a distended bladder during suprapubic trocar insertion; previous surgery with distortion of bladder anatomy, causing it to be pulled cephalad with the parietal peritoneum; and endometriosis obliterating the anterior cul-de-sac. Inserting a Foley catheter into the bladder before trocar placement, and using lateral trocar sites, will lessen the risk of bladder injury. In cases when a midline, suprapubic trocar is used, and the superior aspect of the bladder cannot be deciphered, filling the bladder with 300 mL of water or saline will define the bladder margins. Intraoperative signs of bladder injury include clear fluid in the operative field, visible bladder laceration, and gas distention of the Foley bag. To adequately make the diagnosis, the bladder wall can be inspected directly, or methylene blue or indigo carmine, diluted with 200 to 300 mL of sterile normal saline, may be instilled retrograde through the Foley catheter. Intentional cystotomy or cystoscopy may be performed to inspect the extent of the injury and to ensure that there is no ureteric involvement.

Recommendations for repair of bladder injuries have been reviewed in a consensus statement of the International Society of Urology (Société Internationale d'Urologie). In the acute setting, bladder injuries can be treated with catheter drainage alone if the injury is small, uncomplicated, and isolated. A cystogram should be performed on the 10th day of drainage, when more than 85% of bladder injuries will be healed. A surgical repair should be performed if the Foley catheter is unable to provide adequate drainage because of blood clots or persistent extravasation or if there is concomitant injury to the urethra or ureter. Cystotomy closure should be performed using a watertight, multilayered repair, with absorbable suture. Laparoscopic repair may be performed in the case of a small injury with adequate exposure and surgical expertise, as long as the ureters and bladder neck are not compromised.

According to a nationwide Finnish record linkage study, although the overall complication rates for laparoscopy are decreasing, the rate of ureteral injury has remained steady at 1%, with the greatest risk associated with laparoscopic hysterectomy. A review of the world literature through 2003 concluded that laparoscopically assisted vaginal hysterectomy was the most frequently performed surgery associated with ureteral injury. The usual time to diagnosis in postoperative patients with ureteral injury is typically between 2 and 7 days, but has been reported as late as 33 days after surgery. Patients often present with symptoms of abdominal pain, fever, hematuria, flank pain, or peritonitis. Leukocytosis is a common finding. Management of ureteral injury should be undertaken in collaboration with a surgeon trained in ureteral injury repair. In the majority of cases, percutaneous or cystoscopic stenting techniques can be used. Laparotomy is usually performed for endto-end anastomosis or reimplantation of the ureter into the bladder, but in experienced hands, repair may be performed laparoscopically. The literature is growing in favor of intraoperative diagnostic cystoscopy after complex vaginal, laparoscopic, and abdominal pelvic surgery, in an effort to avoid delayed diagnosis of injuries to the urinary tract. It appears that cases in which the diagnosis is delayed are most likely to result in the greatest morbidity and legal repercussions.

CONCLUSION

Laparoscopy has become a mainstay of gynecologic surgery. Laparoscopic technology continues to evolve, requiring continual education and research. The main benefits of laparoscopic surgery have been shorter hospitalization, improved cosmesis, and, in some cases, improved safety and cost. Evidence-based surgical studies are difficult to perform but will be required to fully understand the role of each laparoscopic procedure in terms of long-term outcomes and cost.

BEST SURGICAL PRACTICES

- A good laparoscopic surgeon should know his or her limitations and not hesitate to call for help.
- Conversion to laparotomy is not considered failure.

- Careful selection of patients is the first key to success in any surgery.
- Preparation is essential in laparoscopic surgery and may include a “pilot's checklist” and/or “dress rehearsal” to avoid being caught with too few inappropriately sized trocars.
- “Shortcuts,” which modify a surgical procedure, “change” the procedure. Once the surgical technique has been

changed, success rates obtained from literature or prior experience cannot be attributed to the new procedure.
- Careful positioning of the patient can help avoid nerve injuries, as can minimizing operative time.
- Traction-countertraction and exposure are important in both open and laparoscopic surgeries. To maximize these, an additional trocar port is often helpful.
- Consider intraoperative cystoscopy with indigo carmine in complex pelvic surgery.
- Understand your energy source.

BIBLIOGRAPHY

Batres F, Barclay DL. Sciatic nerve injury during gynecologic procedures using the lithotomy position. *Obstet Gynecol* 1983;62:92S.

Birch DW, Manouchehri N, Shi X, et al. Heated CO_2 with or without humidification for minimally invasive abdominal surgery. *Cochrane Database Syst Rev* 2011;(1):CD007821. doi: 10.1002/14651858. CD007821.pub2

Brill AI. Electrosurgery: principles and practice to reduce risk and maximize efficacy. *Obstet Gynecol Clin North Am* 2011;38:687.

Chudnoff SG, Levine DJ, Galen DI, et al. Prospective 12-Month Follow Up of Quality-of-Life Improvement Following 135 Consecutive Cases of Laparoscopic and Ultrasound-Guided Radiofrequency Ablation of Fibroids. Data presented at the 41st Global Congress of Minimally Invasive Gynecology.

Gomez RG, Ceballos L, Coburn M, et al. Consensus statement on bladder injuries. *BJU Int* 2004;94:27.

Grainger AH, Soderstrom RM, Schiff SF, et al. Ureteral injuries at laparoscopy: insights into diagnosis, management and prevention. *Obstet Gynecol* 1990;75:839.

Guido RS, Levine DJ, Galen DI, et al. Reduction in Uterine and Fibroid Volumes in 135 Consecutive Subjects following Laparoscopic and Ultrasound-Guided Radiofrequency Ablation of Fibroids: 12-Month Follow-Up. Data presented at the 41st Global Congress of Minimally Invasive Gynecology.

Harkki-Siren P, Sjoberg J, Kurki T. Major complications of laparoscopy: a follow-up Finnish study. *Obstet Gynecol* 1999;94:94.

Hershlag A, Loy RA, Lavy G, et al. Femoral neuropathy after laparoscopy: a case report. *J Reprod Med* 1990;35:575.

Hulka JF, Reich H. Textbook of laparoscopy, 2nd ed. Philadelphia, PA: WB Saunders, 1994:202.

Hurd WW, Bude RO, DeLancey JO, et al. The relationship of the umbilicus to the aortic bifurcation: implications for laparoscopic technique. Obstet Gynecol 1992;80:48.

Hurd WW, Amesse LS, Gruber JS, et al. Visualization of the epigastric vessels and bladder before laparoscopic trocar placement. *Fertil Steril* 2003;80:209.

Irvin W, Andersen W, Taylor P, et al. Minimizing the risk of neurologic injury in gynecologic surgery. *Obstet Gynecol* 2004;103:374.

Kadar N, Reich H, Liu CY, et al. Incisional hernias after major laparoscopic gynecologic procedures. *Am J Obstet Gynecol* 1993;168:1493.

Krebs HB. Intestinal injury in gynecologic surgery: a ten-year experience. *Am J Obstet Gynecol* 1986;155:509.

Leal JG, Leon IH, Saenz LC, et al. Laparoscopic ultrasound-guided radiofrequency volumetric thermal ablation of symptomatic uterine leiomyomas: feasibility study using the halt 2000 ablation system. *J Minim Invasive Gynecol* 2011;18:364.

Levy BS, Soderstrom RM, Dail DH. Bowel injuries during laparoscopy. *J Reprod Med* 1985;30:660.

Loffer F, Pent D. Indications, contraindications and complications of laparoscopy. *Obstet Gynecol Surv* 1975;30:407.

Montz FJ, Holschneider CH, Munro MG. Incisional hernia following laparoscopy: a survey of the American Association of Gynecologic Laparoscopists. *Obstet Gynecol* 1994;84:881.

Murphy AA. Operative laparoscopy. *Fertil Steril* 1987;47:1.

Newcomb WL, Hope WW, Schmelzer TM, et al. Comparison of blood vessel sealing among new electrosurgical and ultrasonic devices. *Surg Endosc* 2009;23:90.

Nezhat C, Nezhat F, Ambrose W, et al. Laparoscopic repair of small bowel and colon: a report of 26 cases. *Surg Endosc* 1993;7:88.

Nezhat C, Seidman D, Nezhat F, et al. The role of intraoperative proctosigmoidoscopy in laparoscopic pelvic surgery. *J Am Assoc Gynecol Laparosc* 2004;11:47.

Nezhat CH, Seidman DS, Nezhat F, et al. Laparoscopic management of intentional and unintentional cystotomy. *J Urol* 1996;156:1400.

Oh BR, Kwon DD, Park KS, et al. Late presentation of ureteral injury after laparoscopic surgery. *Obstet*

Gynecol 2000;95:337.

Ostrzenski A, Radolinski B, Ostrzenska KM. A review of laparoscopic ureteral injury in pelvic surgery. *Obstet Gynecol Surv* 2003;58:794.

Palter SF, Olive DL. Office microlaparoscopy under local anesthesia for chronic pelvic pain. *J Am Assoc Gynecol Laparosc* 1996;3:359.

Pellegrino MJ, Johnson EW. Bilateral obturator nerve injuries during urologic surgery. *Arch Phys Med Rehabil* 1988;69:46.

Person B, Vivas DA, Ruiz D, et al. Comparison of four energy-based sealing and cutting instruments: a porcine model. *Surg Endosc* 2008;22:534.

Seehofer D, Mogl M, Boas-Koop S, et al. Safety and efficacy of new integrated bipolar and ultrasonic scissors compared to conventional laparoscopic 5-mm sealing and cutting instruments. *Surg Endosc* 2012;26:2541.

Spinelli P, Di Felice G, Pizzetti P, et al. Laparoscopic repair of fullthickness stomach injury. *Surg Endosc* 1991;5:156.

Siprasad S, Yu DF, Muir GH, et al. Positional anatomy of vessels that may be damaged at laparoscopy: new access criteria based on CT and ultrasonography to avoid vascular injury. *J Endourol* 2006;20:498.

Sutton PA, Awad S, Perkins AC, et al. Comparison of lateral thermal spread using monopolar and bipolar diathermy, the Harmonic Scalpel and the Ligasure. *Br J Surg* 2010;97:428.

Taylor R, Weakley FL, Sullivan BH. Non-operative management of colonic perforation with pneumoperitoneum. *Gastrointest Endosc* 1978;24:124.

Tulikangas PK, Gill IS, Falcone T. Laparoscopic repair of ureteral injuries. *J Am Assoc Gynecol Laparosc* 2001;8:259.

Van Der Voort M, Heijnsdijk EA, Gouma DJ. Bowel injury as a complication of laparoscopy. *Br J Surg* 2004;91:1253.

Wang PH, Lee WL, Yuan CC, et al. Major complications of operative and diagnostic laparoscopy for gynecologic disease. *J Am Assoc Gynecol Laparosc* 2001;8:68.

Warner MA, Martin JT, Schroeder DR, et al. Lower-extremity motor neuropathy associated with surgery performed on patients in a lithotomy position. *Anesthesiology* 1994;81.

Whiteside JJ, Barber MD, Walters MD, et al. Anatomy of ilioinguinal and iliohypogastric nerves in relation to trocar placement and low transverse incisions. *Am J Obstet Gynecol* 2003;189:1574.

Wu MP, Lin YS, Chou CY. Major complications of operative gynecologic laparoscopy in southern Taiwan. *J Am Assoc Gynecol Laparosc* 2001;8:61.