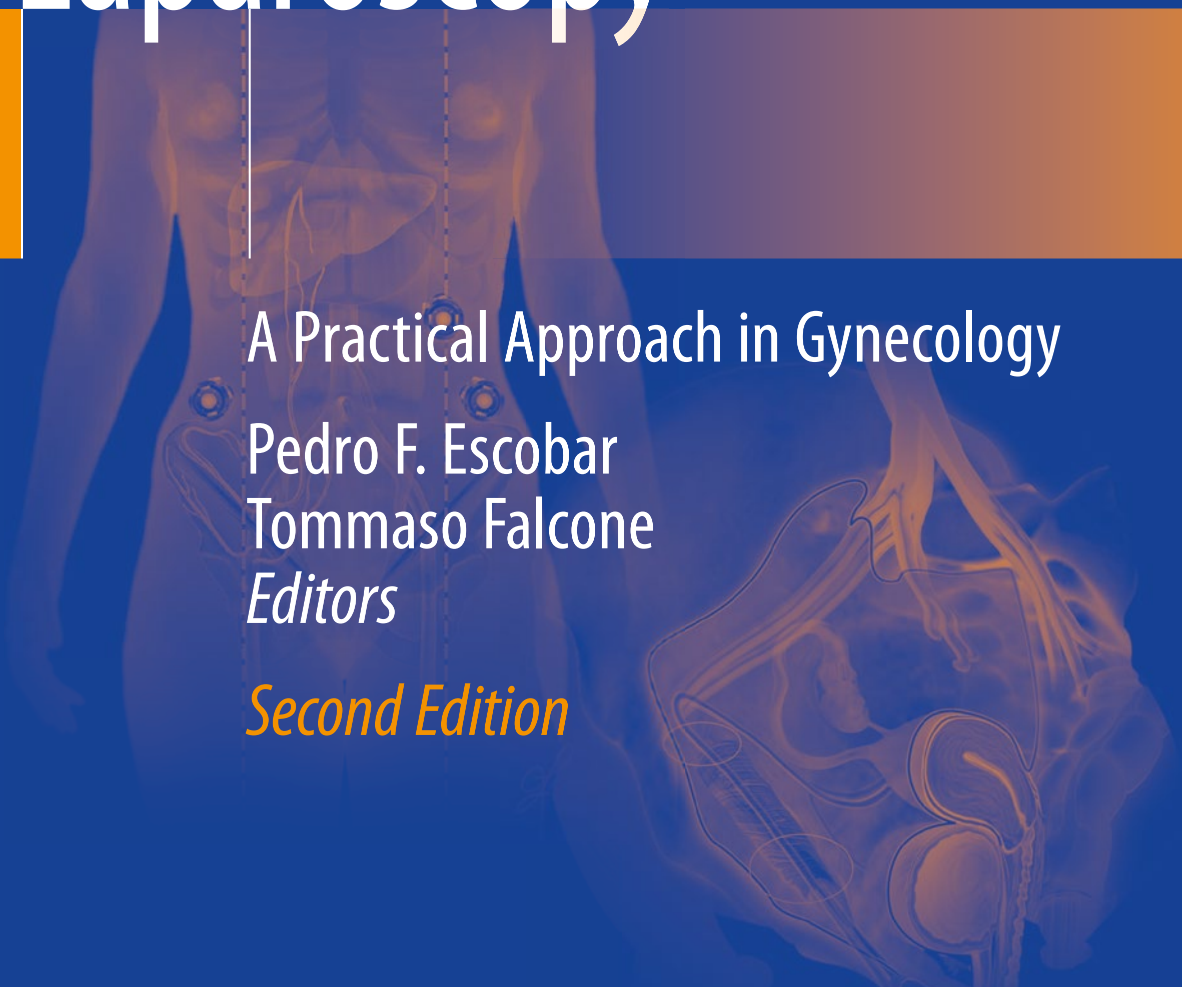
Atlas of Robotic, Conventional, and Single-Port Laparoscopy



A Practical Approach in Gynecology

Pedro F. Escobar
Tommaso Falcone
Editors

Second Edition

Springer

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Preface to the First Edition

Over the years, minimally invasive surgery, namely operative laparoscopy, has emerged as the standard treatment for many gynecologic conditions. Innovations in minimally invasive surgical technology—such as multichannel ports, articulating instruments, and flexible high-definition endoscopes—have allowed laparoscopic surgeons to perform increasingly complex surgeries through smaller incisions utilizing robotic and single-site technology. The collaborative efforts that we, the editors, have had together from novel surgical instrumentation development and working together on multiple national and international events have resulted in this surgical atlas.

We are honored to have a group of world experts in conventional laparoscopic, robotic, and single-site gynecologic surgery contribute to our surgical atlas. This atlas is unique in that it includes illustrative pictures, drawings, and images that cover all contemporary minimally invasive techniques in gynecology.

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Preface to the Second Edition

This is the second edition of a surgical atlas conceived in 2012 in the OB/GYN & Women's Health Institute at The Cleveland Clinic and first published in 2013. Since then, the world of minimally invasive gynecologic surgery has changed dramatically. Nevertheless, our purpose has not changed: we have sought to provide medical students, residents, fellows, and staff with the most up-to-date techniques, images, and illustrative pictures in minimally invasive gynecologic surgery to better serve our patients.

In this second edition, we have added new procedures and expanded on previous work. There is a dedicated chapter on robotic-assisted surgical management of endometriosis and a new chapter in novel technology in robotic surgery. The title of this atlas, *Atlas of Robotic, Conventional, and Single-Port Laparoscopy: A Practical Approach in Gynecology,* raises important questions: Why are we interested in reduced-port laparoscopy/robotics? And will the rapid pace of surgical/technological innovation continue?

Augmented reality (AR), virtual reality (VR) technologies, and artificial intelligence (AI) integration into novel robotic and laparoscopic platforms are providing surgeons with new ways of interacting in "real time" with medical imaging technologies and opening up great possibilities in the field. The reduction of the "footprint" in the operating room, and the number of ports of these new platforms is inevitable, and perhaps a natural transition into the newest developments in minimally invasive surgery education, technologies, and applications.

Once again, we are honored and grateful to have a group of world experts in conventional laparoscopic, robotic, and reduced-port gynecologic surgery contribute to our surgical atlas. This atlas is unique in that it includes illustrative pictures, drawings, and images that cover all contemporary minimally invasive techniques in gynecology. It is our belief that, as the field continues to evolve, the education of trainees becomes a far more important subject than ever before.

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Part I

Conventional and Reduced-Port Laparoscopy

1 Basic Principles and Anatomy for the Laparoscopic Surgeon

Amal Saad, M. Jean Uy-Kroh, and Tommaso Falcone

As we push the barriers of minimally invasive surgery and incorporate new platforms, the gynecologic surgeon must utilize steadfast surgical and anatomic principles to optimize outcomes and reduce complications. In this chapter, we review laparoscopic principles and practical anatomy that allow one to safely operate in even the most challenging surgical landscapes. There is an emphasis on clearly labeled anatomy and illustration of critical anatomic relationships. We include a thorough discussion and demonstration of the anterior abdominal wall, vasculature, and innervations of the abdomen and pelvis, peritoneal landmarks, pelvic viscera, and the pelvic diaphragm.

The common objective of single-port, laparoscopic, and robotic gynecologic surgery is to treat conditions using techniques that safely maximize operative exposure and minimize patient recovery time and pain. No matter what approach is used, the surgeon requires an intimate knowledge of abdominal and pelvic anatomy to achieve optimal outcomes and reduce complications. This chapter reviews basic principles and practical surgical anatomy encountered by the laparoscopic, gynecologic surgeon.

Surface Landmarks

Surface anatomy and osseous structures are important markers for surgeons. Once identified, they can be used to avoid underlying vasculature and plan safe surgical points of entry. A surgeon should always begin with a brief survey of the supine patient. The osseous landmarks of the anterior abdominal wall are fixed (Table 1.1) and

Table 1.1 Anterior landmarks and vertebral levels

Landmark	Vertebral level
Xyphoid process	T9
Tenth costal cartilage inferior margin	L2/L3
Umbilicus	Variable
Ideal body weight	Intervertebral disc between L3/L4
Anterior superior iliac spine (ASIS)	Sacral promontory
Inguinal ligament	
Pubic symphysis	

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frame the clinical decisions that are made prior to surgery, such as trocar placement. The osseous landmarks include the xyphoid process, the inferior margins of the tenth costal cartilages, the anterior superior iliac spines (ASIS), and the pubic symphysis (Fig. 1.1).

The nonosseous landmarks are in variable relationship to each other and the bony landmarks. Their anatomic positions are influenced by patient habitus, skin laxity, and patient positioning (i.e., supine versus Trendelenburg).

The umbilicus is an important nonosseous landmark that is a common point of surgical entry. It has a variable position and is influenced by patient habitus. Owing to its relationship to the adjacent vasculature, the angle of trocar entry must be planned. The umbilicus lies in close proximity to the aorta and its bifurcation into the right and left common iliac arteries [1, 2]. While the patient is supine, the aortic bifurcation is located superior to the umbilicus in almost 90% of patients. In contrast, when the patient is in the Trendelenburg position, the aortic bifurcation is located superior to the umbilicus in only 70% of patients. When the bifurcation lies inferior to the umbi-

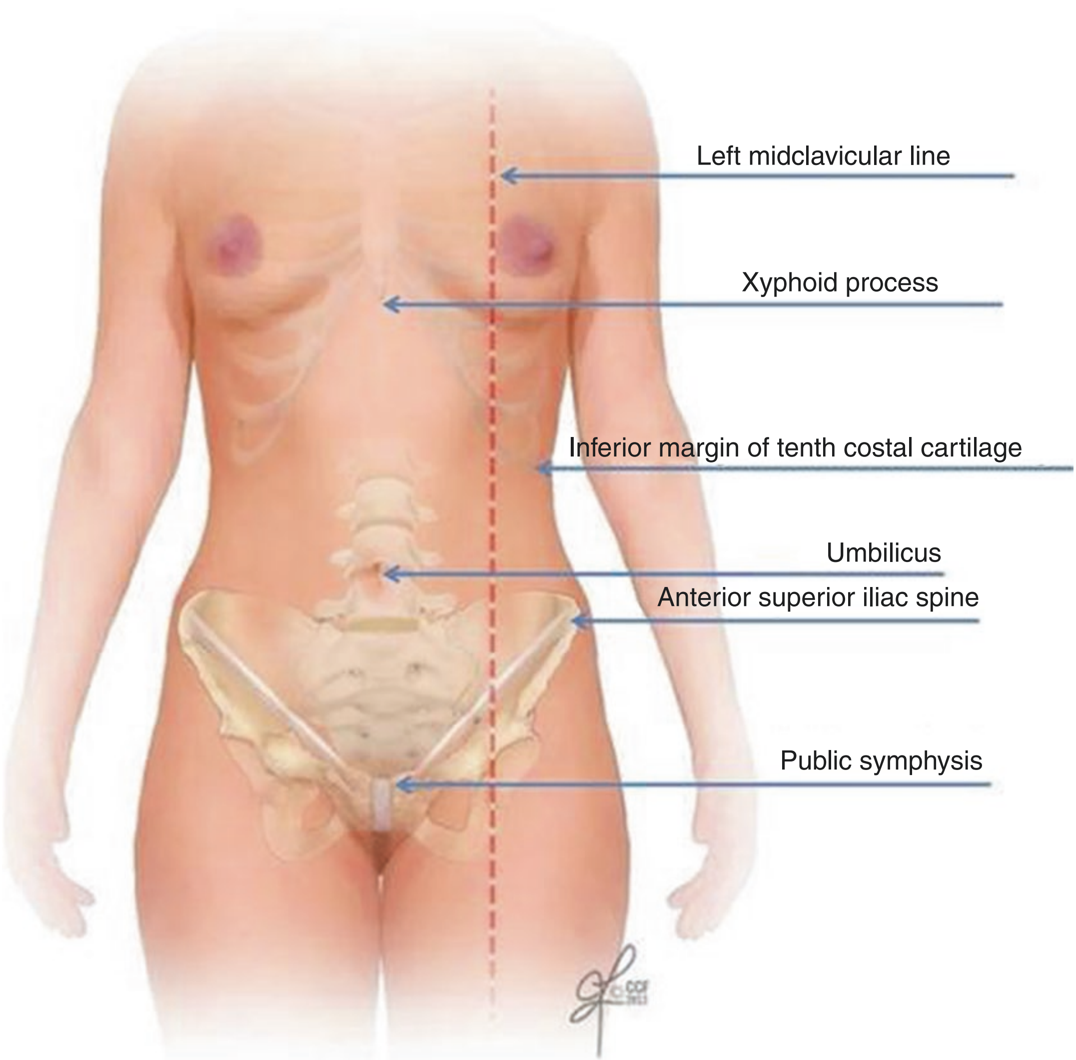


Fig. 1.1 Supine abdomen with osseus and nonosseous landmarks

licus, the iliac vessels, in particular the left common iliac vein, are more susceptible to trocar injury. Patients are therefore usually placed in the supine position in order to minimize vessel injury during initial surgical entry at the umbilicus.

Several studies have confirmed the effect of obesity on the position of the umbilicus, trocar angle, and distance to the retroperitoneal structures during initial umbilical entry. For patients of ideal body weight (body mass index [BMI] <25 kg/m²), the umbilicus is often at the level of the intervertebral disc between the L3 and L4 vertebrae. For these patients, the trocar or Veress needle should be introduced at a 45-degree angle to protect the retroperitoneal vessels, since these vessels can be as close as 4 cm from the skin. In contrast, for obese patients an almost 90-degree trocar entry may be necessary to traverse the increased width of the abdominal wall (Fig. 1.2) [3].

Large pelvic masses and bulky or gravid uterus may require supraumbilical primary trocar placement. Supraumbilical trocars located 3 and 5 cm superior to the umbilicus and introduced at a 45 degree angle actually had greater distances to retroperitoneal vessels compared to umbilical trocars introduced at a 45-degree angle [4].

The inguinal ligament, formed by the aponeurosis of the external oblique, marks the anatomic boundary between the abdomen and the thigh. The midline abdominal wall is the area between the xyphoid and the pubic symphysis. The left midclavicular line refers to a line drawn from the middle of the left clavicle to the middle of the left inguinal ligament.

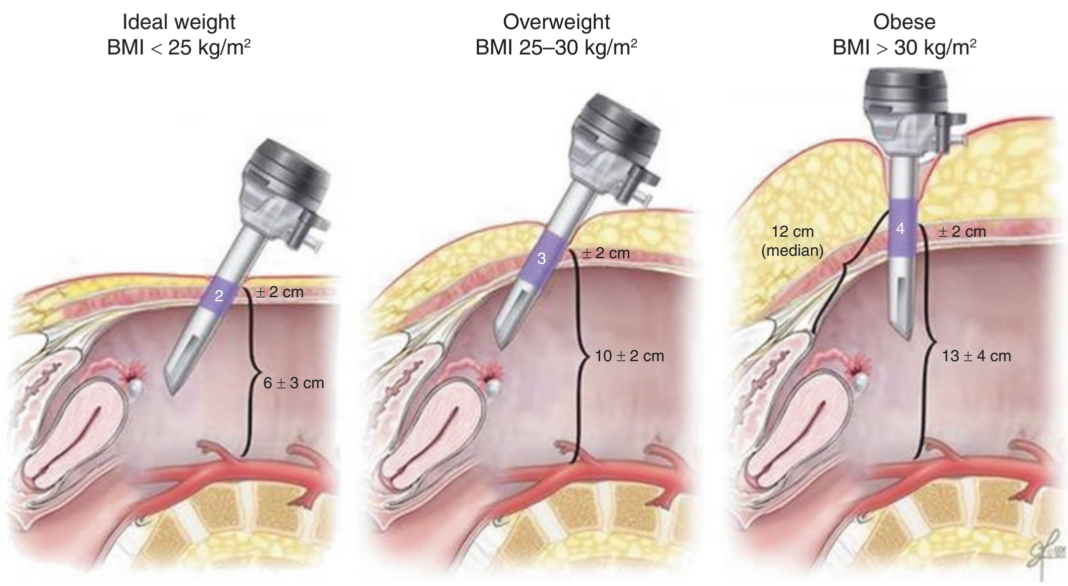


Fig. 1.2 The effect of increasing weight on anterior abdominal wall anatomy. These sagittal views illustrate that as a patient's body mass index increases, the distance from the base of the umbilicus to the peritoneum and the distance from the base of the umbilicus to retroperitoneal structures increase. To accommodate for these increased distances, the trocar angle must move from a 45-degree angle in an ideal weight patient to almost a 90-degree angle in an obese patient in order to traverse the abdominal wall. The purple trocar area denotes the distance from the base of the umbilicus to the peritoneum at a 45-degree angle in ideal and overweight patients. In the obese patient, this distance is measured at a 90-degree angle, to mimic the recommended trocar trajectory. Furthermore, if one were to utilize a standard 45-degree trocar for insertion in the obese patient, the median distance from the base of the umbilicus to the peritoneum is 12 cm [3]

Anterior Abdominal Wall

The abdominal wall from superficial to deep includes the skin, subcutaneous tissue/superficial fascia, rectus sheath and muscles, transversalis fascia, extraperitoneal fascia, and parietal peritoneum. Several important nerves and blood vessels course through these layers.

Subcutaneous Tissue

Camper's fascia is the superficial fatty layer and Scarpa's fascia is the deeper, thin fibrous layer; collectively they represent the "superficial fascia" or subcutaneous tissue. Superficial abdominal wall vessels course through the fascia. This tissue layer tends to be deceptively prominent in obese patients.

Muscles and Fascia

The abdominal wall is composed of five pairs of interconnected muscles. There are two midline muscles (the rectus abdominis and pyramidalis) and three sets of lateral muscles (the external and internal obliques and the transversus abdominis). In the midline, the rectus abdominis originates from the xyphoid process and costal cartilages of the fifth to seventh ribs and extends to the pubic symphysis. This broad strap muscle is encased within the anterior and posterior rectus sheath. The aponeuroses of the rectus muscles fuse in the midline as the linea alba and fuse laterally as the linea semilunaris.

The pyramidalis muscle is a small triangular muscle that lies in the rectus sheath, anterior to the inferior aspect of the rectus abdominis. Occasionally this muscle is absent on one or both sides. When it is present, it arises from the pubis and inserts into the lower linea alba.

The three lateral muscles, found bilaterally, are also referred to as flat muscles. The most superficial of these is the external oblique. It arises from the lower eighth rib, where its fibers interdigitate with the serratus anterior muscle and extend inferiorly to the linea alba and pubic tubercle, creating a broad fibrous aponeurosis.

Aponeuroses are tendon-like membranes that bind muscles to each other or to bones. Posterior to the external oblique lies the internal oblique muscle, whose fibers arise from the lumbar fascia, the iliac crest, and the lateral two-thirds of the inguinal ligament. The internal oblique fibers are at right angles to the external oblique fibers. The anterior and posterior layers of the internal oblique separate into the anterior and posterior rectus sheath and are responsible for creating the arcuate line landmark. The deepest lateral muscle is the transversus abdominis. Its muscle fibers run in a transverse fashion across the abdomen. The fibers arise from the costal cartilages of the sixth to eighth ribs, interlocking with the diaphragm, the lumbodorsal fascia, the lateral third of the inguinal ligament, and from the anterior three-fourths of the iliac crest and terminate anteriorly as an aponeurosis. The transversalis fascia lies deep to the transversus abdominis and is a continuous layer that lines the abdominal and pelvic cavity (Fig. 1.3).

The arcuate line is a transverse line located midway between the umbilicus and the pubic symphysis. Superior to the arcuate line, the rectus abdominis muscles possess both anterior and posterior sheaths formed by the aponeuroses of

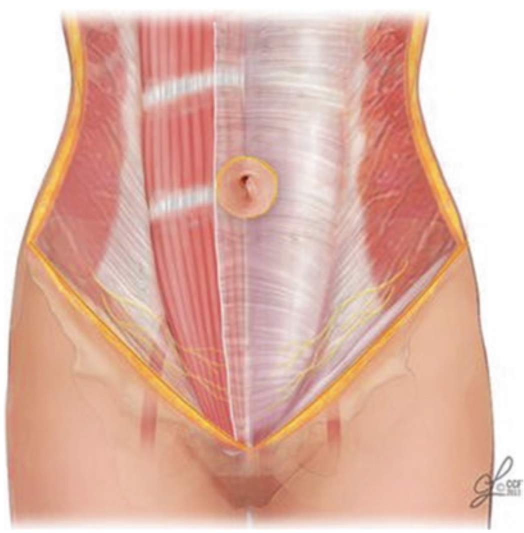


Fig. 1.3 Anterior abdominal wall muscles

the midline and lateral muscles. Inferior to the arcuate line, all layers of the sheaths course anterior to the rectus abdominis muscles.

The extraperitoneal fascia is the layer of connective tissue that separates the transversalis fascia from the parietal peritoneum. It contains a varying amount of adipose tissue and lines the abdominal and pelvic cavities. Viscera in the extraperitoneal fascia are referred to as retroperitoneal. Last, the parietal peritoneum lines the abdominal cavity. Remarkably, it is only one cell layer thick. Inward reflections of this peritoneum form a double cell layer known as mesentery.

The inguinal ligament is formed by the aponeuroses of the external oblique. It arises from the ASIS and inserts into the pubic tubercle. The inguinal canal runs parallel to the inguinal ligament. The inguinal canal is classically described by its four walls. Its anterior wall is formed by the aponeurosis of the external oblique, the inferior wall (floor) is formed by the inguinal ligament, the superior wall (roof) is formed by arching fibers of the internal oblique and transversus abdominis muscles, and the posterior wall is formed by the transversalis fascia.

The deep internal inguinal ring is the tubular evagination of the transversalis fascia, located halfway between the ASIS and the pubic symphysis. The inferior epigastric vessels lie medial to the deep internal inguinal ring. The round ligament dives through this deep internal ring, enters the inguinal canal, exits through the superficial external inguinal ring, and terminates at the labia majora. In addition, the terminal aspect of the ilioinguinal nerve and the genital branch of the genitofemoral nerve exit the inguinal canal via the superficial external inguinal ring. The superficial external inguinal ring is created by the opening of the external oblique aponeurosis and is located superior and lateral to the pubic tubercle (Fig. 1.4).

Nerves

The clinically relevant superior and inferior anterior abdominal wall nerves contain both motor

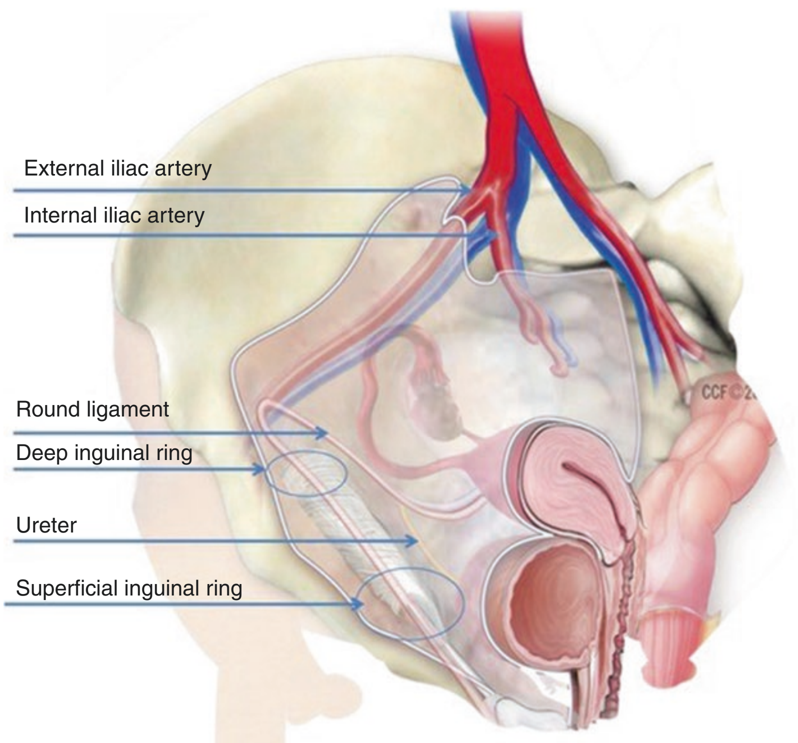


Fig. 1.4 The peritoneum drapes over the ureters, vital blood vessels, and large organs within the pelvis. The round ligament is seen entering the deep inguinal ring and exiting the superficial inguinal ring

and sensory fibers. The thoracoabdominal and subcostal nerves originate from T7 to T11 and T12, respectively. Their distributions are summarized in Table 1.2.

The iliohypogastric nerve and ilioinguinal nerve originate from L1 and accompany the thoracoabdominal and subcostal nerves as they course between the internal oblique and transversus abdominis muscles. At the ASIS, they traverse the internal oblique and run between the internal and external oblique muscles. The iliohypogastric nerves innervate the lateral abdominal wall, inferior to the umbilicus. The ilioinguinal nerve runs within the inguinal canal and emerges from the superficial, or external, inguinal ring to provide sensory innervation to the labia majora, inner thigh, and groin.

During laparoscopic and robotic surgery, the iliohypogastric and ilioinguinal nerves are particularly susceptible to injury because of their proximity to traditional, lower quadrant trocar sites. Nerve damage may result from trocar placement or nerve entrapment secondary to lateral closure of transverse incisions or scar tissue (Table 1.3). The nerve injury usually results in chronic neuropathic pain (Fig. 1.5) [5].

Postoperative nerve damage should be suspected if the patient reports a burning or searing pain in the lower abdominal, pelvic, or medial thigh areas. The pain may be worsened by the Valsalva

Table 1.2 Anterior abdominal wall innervations

Thoracoabdominal n. T7–T9 superior to the umbilicus T10 – at level of umbilicus T11 – inferior to umbilicus
Subcostal n. (anterior and lateral branches) T12 – inferior to the umbilicus
Iliohypogastric n. L1 lateral and inferior to the umbilicus
Ilioinguinal n. L1 labia majora, inner thigh, and groin

Table 1.3 Decrease neuropathy risk

Reduce the risk of iliohypogastric and ilioinguinal nerve damage by utilizing transverse skin incisions and small trocars
If possible, place laparoscopic trocars at or above the level of the ASIS [6]
If necessary, place lower abdominal trocars 2 cm medial and superior to the ASIS

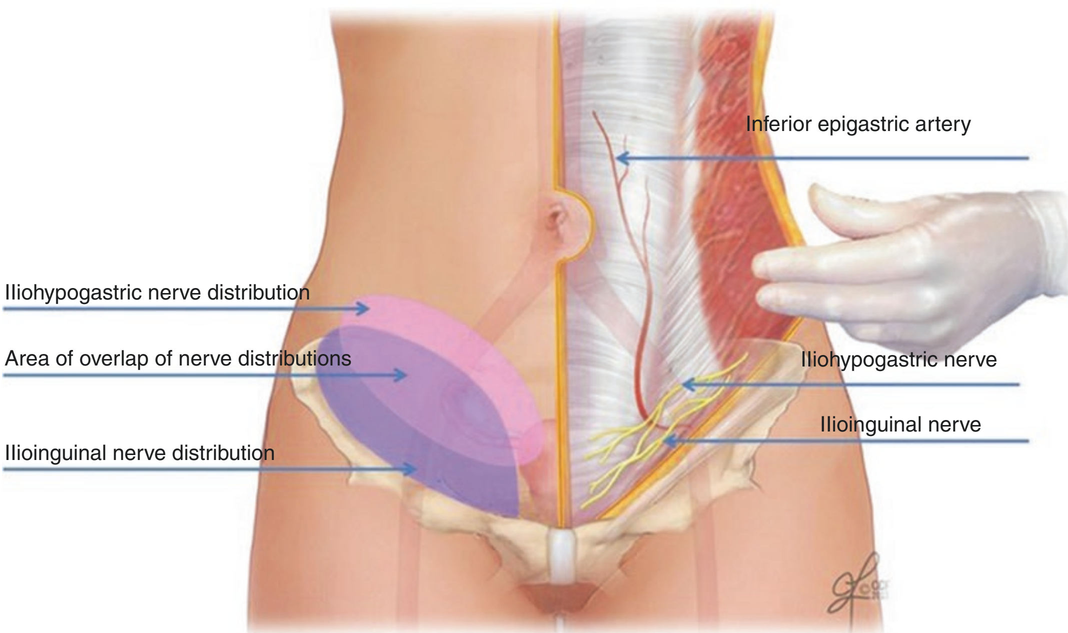


Fig. 1.5 Laparoscopic trocar placement two fingerbreadths superior and medial to the anterior superior iliac spine usually avoids ilioinguinal and iliohypogastric nerves and the inferior epigastric vessels

maneuver and is often relieved by hip and trunk flexion. A diagnostic and therapeutic injection of local anesthetic at the origin of the affected nerves, 3 cm medial to the ASIS, may provide relief.

Blood Vessels

The most notable anterior abdominal wall arteries are the epigastric vessels and the circumflex iliac vessels. Both pairs of vessels can be further classified into superficial and deep vessels. The deep epigastric vessels include the superior and inferior epigastric arteries and veins. The superior epigastric artery originates from the internal mammary artery and descends through the thorax into the rectus muscle, where it anastomoses with the inferior epigastric artery. The superior epigastric artery is accompanied by two superior epigastric veins. The deep inferior epigastric artery arises from the external iliac artery, just above the inguinal ligament. The inferior epigastric artery and vein travel in a medial and oblique fashion along the peritoneum to pierce the transversalis fascia and the rectus muscle. Owing to the absence of the posterior rectus sheath below the arcuate line, the inferior epigastric vessels can be seen within the lateral umbilical fold (Table 1.4) [7]. Accidental laceration of these deep vessels may result in hemorrhage that must be swiftly occluded using electrosurgery or sutures (Fig. 1.6) [8].

Table 1.4 Decrease vascular injury risk

Always identify the deep, inferior epigastric vessels as they course along the parietal peritoneum. The deep vessels are located lateral to the medial umbilical folds but medial to the deep inguinal ring. Identify the deep inguinal ring by locating where the round ligament enters the inguinal canal and continues into the deep inguinal ring
If the deep epigastric vessels are obscured by excess tissue and cannot be easily identified, one of two strategies may be employed: Place the trocars approximately 8 cm lateral to the midline and 5 cm above the pubic symphysis [7]. These right and left anterior abdominal areas approximate "McBurney's point" and "Hurd's point," respectively Or Place the trocar medial to the medial umbilical fold, as the inferior epigastrics are consistently lateral to these. One problem with positioning the trocar this medially, however, is poor access to the adnexa

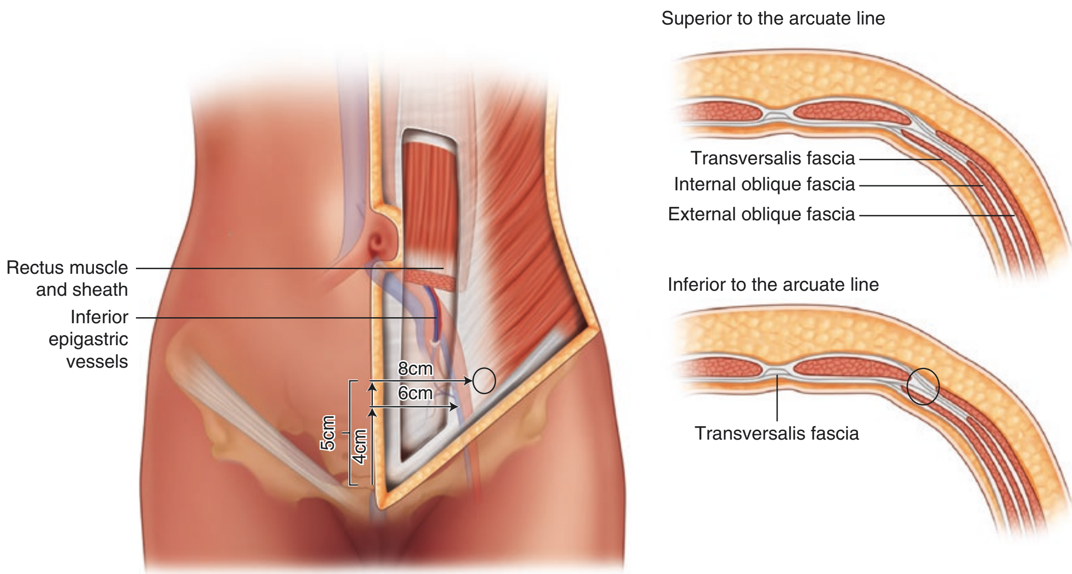


Fig. 1.6 Lower abdominal trocars should be placed lateral to the inferior epigastric vessels. These vessels travel medially from their origin off the external iliac artery and course toward the umbilicus. The vessels penetrate the transversus abdominis fascia and muscle approximately 4 cm superior and 6–7 cm lateral from the pubic symphysis. They then continue to run obliquely for an additional 7 cm and enter the posterior rectus sheath. Given these landmarks, a safe area for trocar entry is 5 cm superior and 8 cm lateral to the pubic symphysis. (Modified from Park and Barber [8])

In contrast, the superficial epigastric artery originates from the femoral artery and courses through the superficial fascia toward the umbilicus. Prior to placing secondary laparoscopic trocars, the superficial epigastric vessels are often identified by intra-abdominal transillumination in order to avoid vessel injuries (Table 1.5) [9].

Vascular trauma to the superficial epigastric vessels may result in a hematoma or abscess and, in rare cases, may even expand to the labia majora [10].

The circumflex iliac arteries consist of the deep and superficial circumflex iliac arteries. They arise from the femoral and external iliac arteries, respectively.

Peritoneal Landmarks

Distorted anatomy and severe surgical scarring challenge even experienced laparoscopic surgeons. When difficult situations are encountered, it is imperative to identify key structures that facilitate safe surgical dissection and avoid injury to retroperitoneal vessels and viscera (Table 1.6). In the midline, there are two peritoneal folds. In the upper abdomen, the falciform ligament extends from the umbilicus to the liver and includes the obliterated umbilical vein. It is a remnant of the ventral mesentery. In the pelvis, the median umbilical fold extends from the umbilicus to the apex of the bladder and encases the urachus. Occasionally, the urachus fails to close after birth and continues to communicate with the bladder. Therefore, one should avoid this fibrous fold during laparoscopic trocar placement. In addition, a pair of bilateral, medial folds encases the obliterated umbilical arteries, sometimes referred to as the obliterated fetal hypogastric arteries, which are an extension of the internal iliac arteries. Finally, the bilateral, lateral umbilical folds contain the inferior epigastric vessels (Figs. 1.7 and 1.8).

Table 1.5 Identify vasculature

To avoid vessel injury, transilluminate the superficial epigastric and circumflex vessels, and identify their course prior to placing secondary trocars

There are two naturally occurring peritoneal pouches within the pelvis. Located anteriorly, the vesicouterine pouch is found between the uterus and the bladder. In a pristine pelvis, the anterior aspect of the bladder may be seen behind the anterior abdominal wall peritoneum. However, after cesarean sections, myomectomies, and previous abdominal surgery, this area may be scarred, and the anterior bladder margin may be pulled superiorly. Similarly, the posterior bladder margin usually lies on the anteroinferior surface of the uterus. It is an important landmark for avascular dissection, but after pelvic surgery it may be adherent and require meticulous dissection (Table 1.7).

Located posteriorly, the rectouterine pouch, or the pouch of Douglas, lies posterior to the vagina, cervix, uterus, and anterior to the rectum. This pocket can be obliterated with advanced endometriosis. The scarring may extend inferiorly to the posterior wall of the vagina and the anterior wall of the rectum. This area is an extraperitoneal fascial plane known as the rectovaginal septum. On pelvic examination, endometriosis can be appreciated as palpable nodularity along this fascial plane that runs from the rectouterine pouch to the perineal body (Fig. 1.9).

Table 1.6 Peritoneal landmarks: location and clinical significance

Peritoneal landmark	Anatomic location	Clinical significance
Median umbilical fold	Midline From umbilicus to bladder apex	Contains the fibrous and potentially patent urachus
Medial umbilical fold	Bilateral From umbilicus to the anterior division of the internal iliac artery	Forms the boundaries of the bladder dome Contains the obliterated fetal umbilical artery Also known as the obliterated fetal hypogastric artery
Lateral umbilical fold	Bilateral From arcuate line to inguinal ring	Lie lateral to the medial folds but medial to the deep inguinal ring Contains the deep inferior epigastric vessels

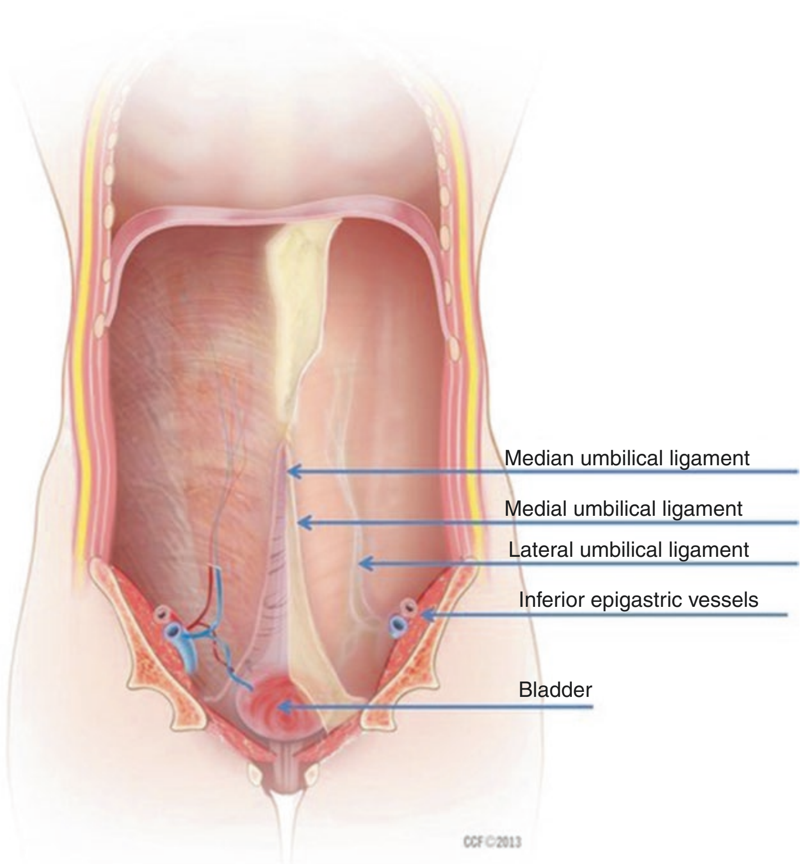


Fig. 1.7 The non-midline peritoneal folds aid in identifying vasculature. The medial umbilical folds extend from the umbilicus to the anterior division of the internal iliac artery. The medial folds contain the obliterated umbilical arteries and form the boundaries of the bladder dome. The lateral umbilical folds extend from the arcuate line to the inguinal ring and contain the inferior epigastric vessels

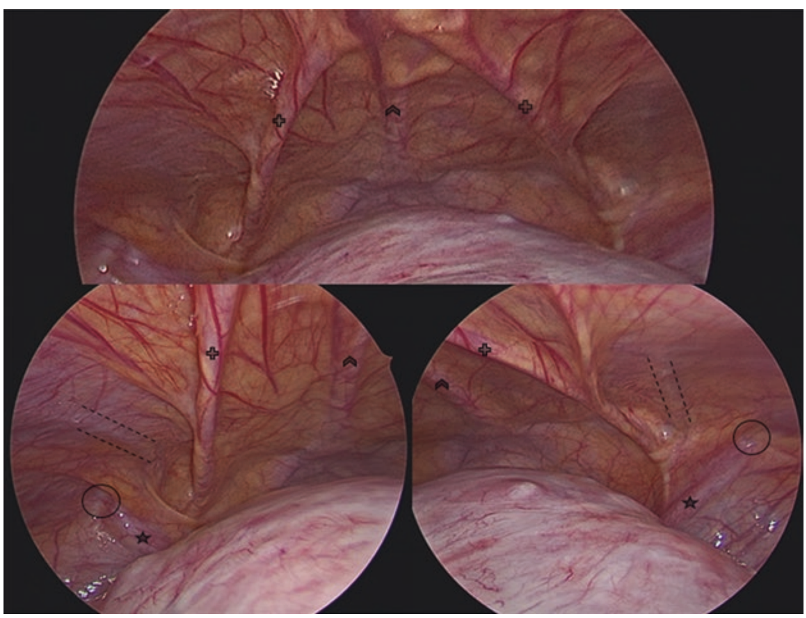


Fig. 1.8 Laparoscopic view of the anterior abdominal. The midline median umbilical fold (^), medial umbilical fold (+), lateral umbilical fold (--), and round ligaments (*) provide peritoneal landmarks. Note that the round ligaments insert into the deep inguinal rings (O), lateral to the deep inferior epigastric vessels contained within the lateral umbilical folds

Table 1.7 Avoid vesical injury

To decrease bladder injury, incise the peritoneum laterally, and work medially. Keep in mind that the bladder apex is most superior at the midline and is triangular in shape. The medial umbilical ligaments mark the bladder dome boundaries and are contiguous with the parietal peritoneum

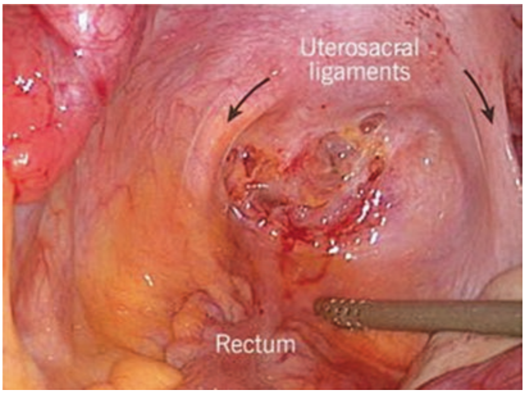


Fig. 1.9 The rectouterine pouch is shown after endometriosis resection. Bilateral uterosacral ligaments (*black arrows*) as well as the rectum are visible

Upper Abdomen

Historically, laparoscopists only utilized the left upper quadrant as the initial entry point in patients with previous surgeries, suspected umbilical adhesions, or a large pelvic mass. However, today the left upper quadrant and other upper abdominal sites are routinely used in laparoscopic and robotic surgery. To perform a left upper quadrant entry, a Veress needle or trocar is introduced at Palmer's point, located in the midclavicular line just below the left subcostal margin. Anatomic structures at the greatest risk of injury are the stomach, left lobe of the liver, and the splenic flexure of the colon [11, 12]. Hence, prior to attempting this entry, the patient should be placed in the supine position and the stomach decompressed. Although the upper abdomen has become a more familiar landscape in recent years, caution should be exercised when using this entry in patients with relative contraindications such as hepatosplenomegaly, portal hypertension, and gastric or pancreatic masses (Fig. 1.10).

Posterior Abdominal Wall and Pelvic Side Walls

Thorough knowledge of the posterior abdominal wall and the pelvic side wall structures is necessary for safe retroperitoneal dissection and effective management of surgical complications.

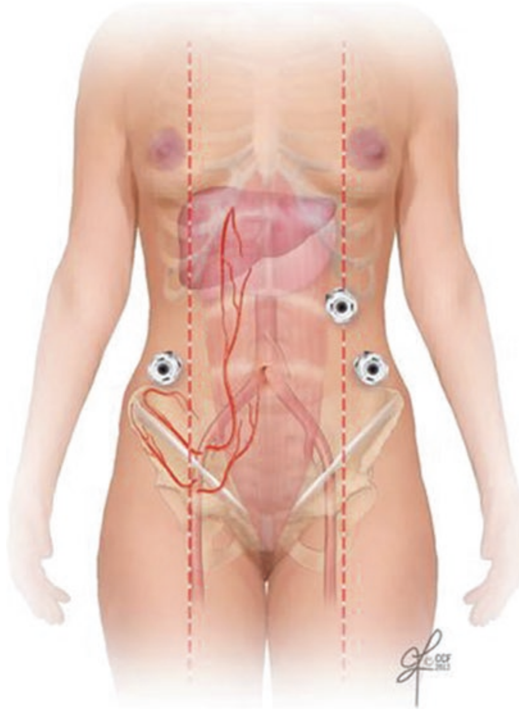


Fig. 1.10 The relationship of standard lower and upper abdominal trocar sites to important vascular landmarks and organs

Blood Vessels

The aorta descends from the thorax into the abdominal cavity slightly left of the midline. It bifurcates at the level of L4–L5, into the left and right common iliac arteries and also gives rise to the much smaller, middle sacral artery (Fig. 1.11). The inferior vena cava (IVC) lies to the right of the aorta. In the abdomen, the IVC is anterior to the aorta at the level of the renal veins. It then runs posterior to the aorta by the level of the aortic bifurcation and divides into the left and right common iliac veins (Table 1.8).

The common iliac artery courses anterior and lateral to the common iliac vein before dividing into the external and internal iliac arteries (Fig. 1.12). The external iliac artery is medial to the psoas muscle and gives rise to two vessels: the inferior epigastric artery and the deep circumflex iliac artery. Once the external iliac artery passes under the inguinal ligament, it becomes

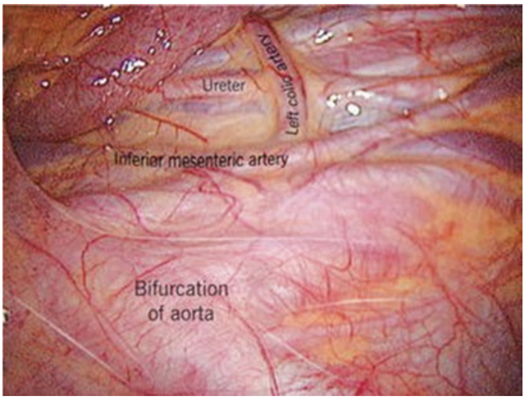


Fig. 1.11 Vessels of the abdomen and pelvis. The aorta bifurcates into the iliac vessels. The left colic artery and inferior mesenteric artery are visible lateral to the bifurcation

Table 1.8 Considerations prior to umbilical trocar insertion

The left common iliac vein lies in the midline, just inferior to the aortic bifurcation and the umbilicus (see Fig. 1.12). Increased patient weight impacts anterior abdominal wall anatomy

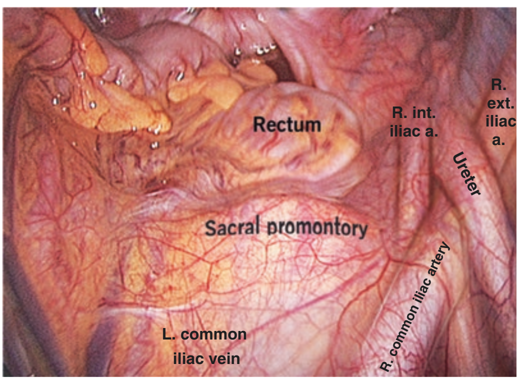


Fig. 1.12 A laparoscopic view of vessels posterior to the umbilicus. The left and right iliac vessels are seen in relationship to the sacral promontory, rectum, and ureter. Appreciation of this proximity and control of the trocar speed, angle, and depth are necessary to avoid serious complications

the femoral artery. Of note, its venous counterpart, the external iliac vein, is a much larger vessel, and it is situated posterior and medial to the artery, over the obturator fossa.

The internal iliac artery is the predominant artery within the pelvis. In addition to supplying the pelvic viscera, its smaller branches veer in and out of the greater and lesser sciatic foramina to perfuse the gluteal muscles and the perineum.

The internal iliac arteries split into anterior and posterior divisions that are readily seen with a retroperitoneal dissection. The anterior division of the internal iliac artery has several branches of clinical relevance. The obturator artery branches anterolaterally and dives into the obturator canal, posterior to the obturator nerve. The obliterated umbilical artery and uterine artery emerge from a common trunk and then diverge along their distinct paths. The distal portion of the obliterated umbilical artery is contained within the medial umbilical fold and serves as a peritoneal landmark. The superior vesical artery arises from the same internal iliac trunk and courses inferiorly and medially to supply the superior portion of the bladder and the distal ureter. Knowledge of these anatomic relationships is particularly useful when dealing with distorted anatomy (Table 1.9).

The uterine artery supplies the uterus and the adnexa and is of great clinical importance. In the retroperitoneum, the proximal uterine artery travels lateral and parallel to the ureter. As the uterine artery descends into the pelvis, it crosses over the ureter in a medial and anterior fashion at the level of the cervix (Fig. 1.13). The most distal aspect of the uterine artery is usually identified within the cardinal ligament, at the level of the internal os, as it propagates into smaller spiral arteries that form a network toward the uterine corpus and cervix.

The vaginal artery usually originates from the uterine artery, but it may arise directly from the internal iliac artery.

Table 1.9 Utilize peritoneal landmarks for orientation

Identification of the ureters and major vessels is critical before any ligation or cauterization is performed. When distorted anatomy poses a challenge, first identify a medial umbilical fold as a fibrous band on the anterior abdominal wall. Then apply gentle traction on this fold (and the encased obliterated umbilical artery), and follow it to its origin, the internal iliac artery. In this vicinity, the superior vesical artery and uterine artery can be identified and followed toward their terminal organs

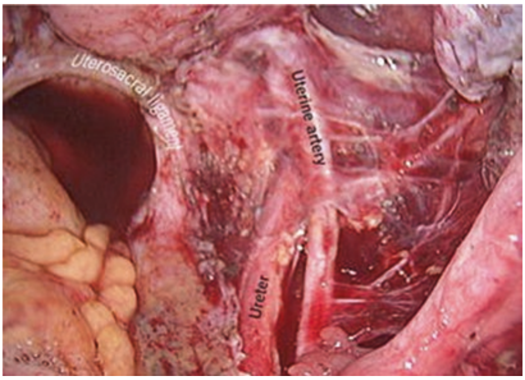


Fig. 1.13 Uterine artery crossing over the ureter

Other important branches of the anterior trunk of the internal iliac artery are the middle rectal, internal pudendal, and inferior gluteal arteries. The inferior gluteal artery is the largest branch of the anterior trunk.

The posterior division travels toward the ischial spine and gives rise to the iliolumbar, lateral sacral, and superior gluteal arteries. The superior gluteal artery is the largest branch of the internal iliac artery as it supplies the skin and muscles of the gluteal region. During uterine fibroid embolization, accidental occlusion of the superior gluteal artery can result in necrosis of the gluteal region.

The uterus and the adnexa are perfused by the uterine, vaginal, and ovarian arteries and their anastomoses with each other.

The ovarian arteries originate directly from the abdominal aorta. They descend over the pelvic brim, lateral to the ureters, and then course within the infundibular pelvic ligaments. The right ovarian vein drains directly into the IVC, while the left ovarian vein drains to the left renal vein.

Ureters

The ureters measure approximately 25–30 cm from the renal pelvis to the bladder. They are located in the retroperitoneum and are occasionally duplicated on one or both sides. In the abdomen, the ureters descend on the medial aspect of the psoas major muscle. Due to the anatomic deviation of the aorta to the left, at the pelvic brim, the right ureter commonly crosses the right external iliac artery, whereas the left ureter tends to cross the left common iliac artery (Fig. 1.14).

In the pelvis, the ureters lie in close proximity to the ovarian vessels. The ureter is located medial to the internal iliac and its anterior division (Fig. 1.15). The ureter is usually found medial to the infundibulopelvic ligament. Broad ligament dissection may be necessary to identify the ureter and to ensure the safe ligation of the ovarian vessels during a salpingo-oophorectomy (Fig. 1.16).

The ureter then dives deep into the parametrium and travels under the uterine artery. This anatomic relationship is classically referred to as "water under the bridge." It traverses the cardinal

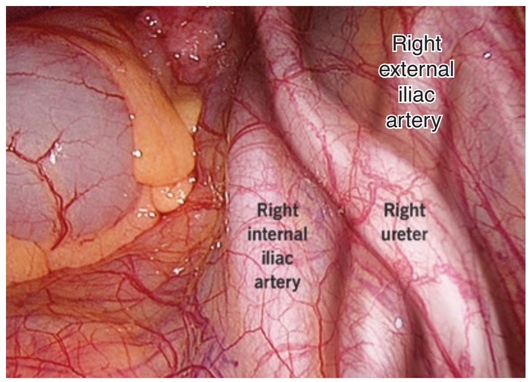


Fig. 1.14 A view of the ureter and iliac vessels from the pelvic brim

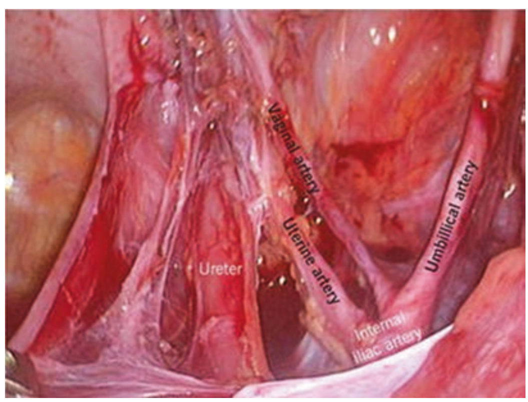


Fig. 1.15 A more inferior view of the internal iliac artery and its anterior division. Here the uterine, vaginal, and umbilical arteries are seen in relationship to the ureter. Note how the ureter moves from lateral (in Fig. 1.14) to medial in relation to the internal iliac artery as it courses from the pelvic brim to deep within the pelvis

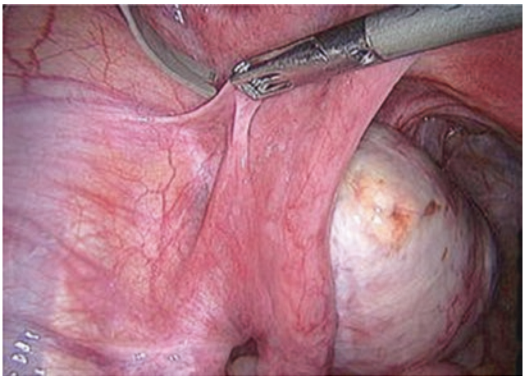


Fig. 1.16 The left broad ligament is incised to facilitate ureter identification. Retroperitoneal dissection may begin at the pelvic brim and carried inferiorly to follow the course of the ureter. Alternatively, for a salpingo-oophorectomy, the broad ligament may be incised between the round ligament and the infundibular pelvic ligament to access the retroperitoneum prior to securing the vascular ovarian pedicle. The ureter is located on the medial leaf of the broad ligament

ligament, then crosses over the vaginal fornix, and finally inserts into the bladder trigone.

The average distance between the ureter and cervix is more than 2 cm. However, this distance can be less than 0.5 cm in about 10% of women [13]. This variable distance partially explains the relatively common occurrence of ureteral injury during hysterectomy.

Muscles

There are six clinically relevant muscles of the posterior abdominal wall and pelvic side wall. Beginning superiorly, the diaphragm is a dome-shaped muscle that separates the thorax from the abdomen. The psoas major muscle originates from the transverse processes of the lumbar vertebrae and runs longitudinally to insert onto the lesser trochanter of the femur. The psoas major muscle constitutes a substantial portion of the posterior and medial walls. The psoas minor muscle lies anterior to the psoas major, and its tendon is seen during dissection near the external iliac vessels. The quadratus lumborum muscle is located lateral and posterior to the psoas major. It spans the transverse process of lumbar vertebrae and ribs to the iliac crest. The iliacus muscle is a flat, triangular muscle that fills the iliac fossa and joins the psoas major to form the iliopsoas muscle. Ending inferiorly, the piriformis muscle lies immediately posterior to the internal iliac vessels. It originates from the anterior sacrum, passes through the greater sciatic foramen, and inserts into the greater trochanter of the femur.

Nerves

There are many nerves that innervate and course along the pelvic sidewall (Fig. 1.17) [14].

Deep nerves, such as the superior and inferior gluteal nerves, supply the pelvic muscles but are not visible during reproductive surgery. The obturator nerve, however, can easily be identified during pelvic side wall dissections. It provides sensory innervation to the medial thigh and is responsible for thigh adduction (Fig. 1.18).

The genitofemoral nerve (from spinal cord levels L1 and L2) lies on the anterior surface of the psoas major muscle, and as its name implies, it divides into two branches: the femoral and the genital nerves (Fig. 1.19). The genitofemoral nerve provides sensory innervation over the mons pubis and anterior and medial surface of the thigh.

The lateral femoral cutaneous nerve (from spinal cord levels L2 and L3) is located 2–3 cm superior to the genitofemoral nerve. It emerges from the lateral edge of the psoas major muscle, crosses over the iliacus muscle toward the inguinal ligaments, and supplies the sensory fibers to the lateral thigh.

The femoral nerve (spinal cord levels L2–L4) is usually not seen during pelvic surgery, but it may be injured during laparotomy. The femoral nerve is a branch of the lumbar plexus. It dives into the psoas major muscle and then emerges at its lower lateral border. The nerve courses between the psoas and iliacus muscles and then passes posterior to the inguinal ligament to supply the motor and sensory nerves of the anterior thigh. Prolonged pressure on the psoas major muscle may cause temporary or permanent damage to the femoral nerve, the lateral femoral cuta-

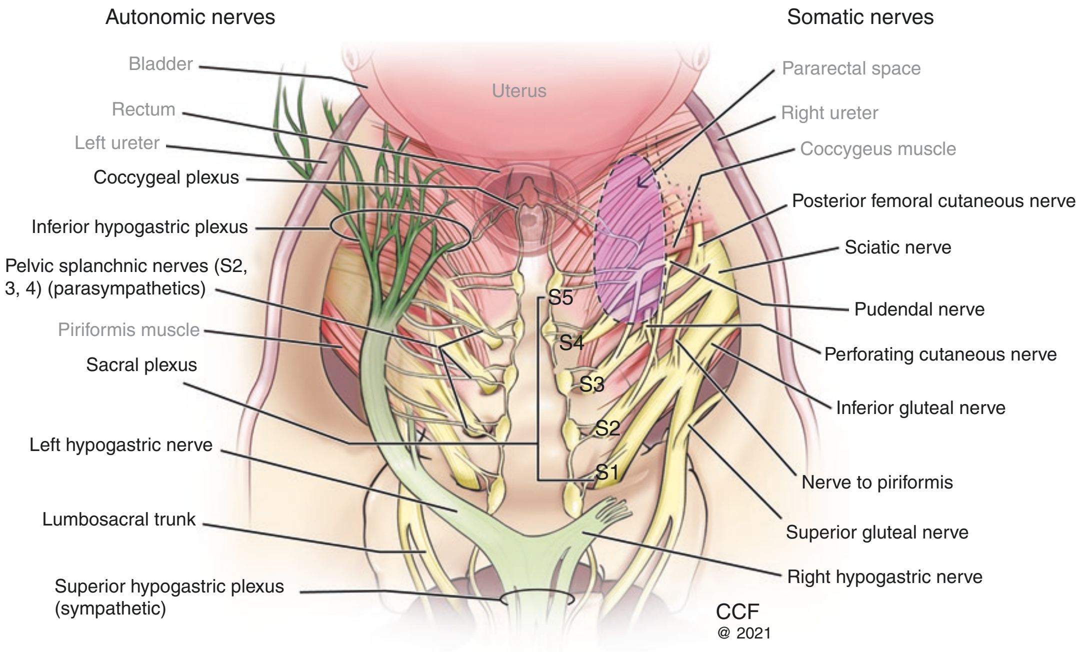


Fig. 1.17 Pelvic nerves. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography ©2021. All Rights Reserved)

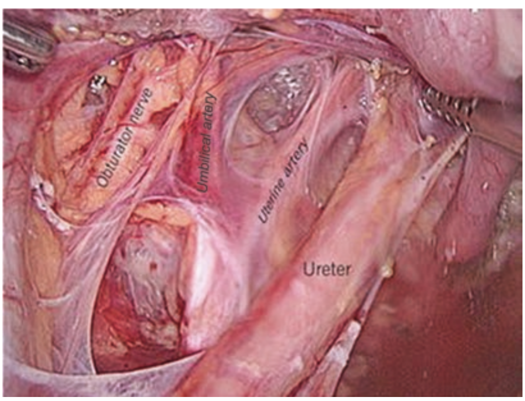


Fig. 1.18 The obturator nerve originates at spinal cord levels L2–L4 and descends through the psoas major muscle and emerges medially to course over the obturator internus muscle. The obturator nerve remains lateral to the anterior division of the internal iliac artery and ureter and then enters the thigh through the obturator canal

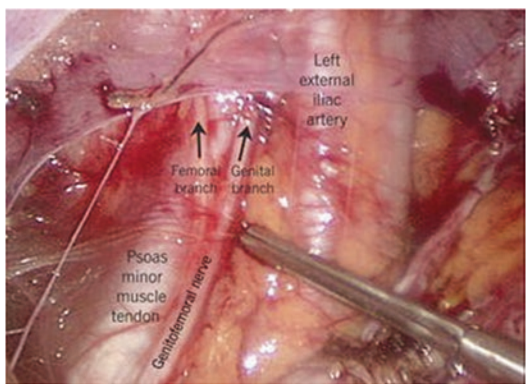


Fig. 1.19 The genitofemoral nerve lies lateral to the external iliac artery. The femoral branch enters the thigh under the inguinal ligament, and the genital branch enters the inguinal canal. The genitofemoral nerve is at risk when the peritoneal fold between the sigmoid colon and the psoas major muscle is incised

neous nerve, and the genitofemoral nerve. Therefore, it is imperative to ensure that the lateral blades of a self-retaining retractor do not exert excessive pressure on the pelvic side walls.

The ilioinguinal nerve (from spinal cord level L1) is located 2–3 cm superior to the lateral femoral cutaneous nerve. It arises from the lateral edge of the psoas major muscle and obliquely crosses the iliacus muscle and quadratus lumborum and then exits the superficial inguinal ring. The nerve is composed of motor and sensory fibers to the transversus abdominis and internal obliques and sensory fibers to the anteromedial thigh and labia majora.

The sacral and coccygeal nerve plexuses are located anterior to the piriformis muscle. The sciatic and pudendal nerves are the largest nerves in this area. The sciatic nerve (from spinal cord levels L4–S3) lies anterior to the piriformis muscle and exits the pelvis through the greater sciatic foramen; it is the largest nerve in the body. The pudendal nerve (from spinal cord levels S2–S4) also lies anterior to the piriformis muscle and exits the pelvis through the greater sciatic foramen. It then courses around the sacrospinous ligament and ischial spine, through the lesser sciatic foramen, and continues into the perineum. At this level, endometriosis may involve the sciatic nerve and cause pain related to its course. The posterior femoral cutaneous nerve (from spinal cord levels S2 and S3) innervates the skin of the perineum and the posterior thigh.

Pelvic autonomic nerves with sympathetic and parasympathetic origins innervate pelvic viscera and control their functions (Table 1.10). Parasympathetic stimulation increases peristalsis and facilitates urination and defecation. Sympathetic stimulation enables bladder capacity or accommodation and inhibits parasympathetic micturition. Sympathetic stimulation also mediates genital vascular dilation, secretions, and somatic pelvic muscle contraction during orgasm.

Lateral sigmoid retraction and retroperitoneal dissection at the sacral promontory reveals the superior hypogastric plexus. The superior hypogastric plexus (SHP) lies anterior to the sacrum and posterior to the rectum. Approximately 75% of patients have major SHP trunks to the left of midline and include extension into the alveolar tissue of the left common iliac vein [15]. Interruption and excision of the SHP is the neuroanatomic goal of presacral neurectomy performed for midline chronic pain. The SHP contains sympathetic fibers derived from the aortic plexus and divides into the right and left hypogastric nerve (Fig. 1.20). The sympathetic hypogastric nerves descend into the pelvis to join the parasympathetic pelvic splanchnic nerves (from spinal cord levels S2–S4) to create the inferior hypogastric plexus (IHP). The IHP exists bilaterally and course lateral to the rectum and vagina and along the bladder base. The IHP concludes in three terminal branches: the vesical, uterine, and rectal plexuses.

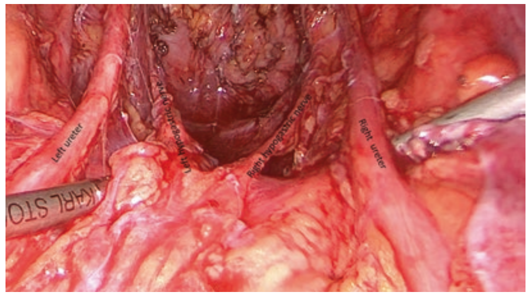


Fig. 1.20 The sympathetic superior hypogastric plexus (SHP) bifurcates at the promontory into the right hypogastric nerve (RHN) and left hypogastric nerve (LHN). The hypogastric nerves course 2–3 cm inferior and medial to the ureters but lateral to the uterosacral ligaments and descend into the pelvis to join the inferior hypogastric plexuses

The pelvic splanchnic nerves (from spinal cord levels S2–S4) carry sensory nerve fibers from pelvic organs also known as visceral afferent fibers. Autonomic nerve preservation during pelvic surgery improves patient's quality of life by decreasing postoperative bladder, bowel, and sexual dysfunction [14]. Meticulous dissection of retroperitoneal pelvic spaces and accompanying nerves is required to prevent nerve injury (Table 1.11).

Table 1.10 Pelvic autonomic nerves

Sympathetic
Superior hypogastric plexus
Hypogastric nerves
Parasympathetic
Pelvic splanchnic nerves
Sympathetic and parasympathetic
Inferior hypogastric plexus

Pelvic Fasciae and Ligaments

The pelvic viscera are attached to the pelvic side walls by (1) peritoneal folds, (2) condensations of pelvic fascia, and (3) remnants of embryonic structures. Historically, these structures were called ligaments because it was believed that they

Table 1.11 Pelvic nerve injuries

Injured nerve	Clinical implication	Common procedure
Hypogastric nerve	Increased bladder tone, dyspareunia	Rectovaginal ligament incision Lateral uterosacral ligament incision
Pelvic splanchnic nerve	Urinary retention and impaired vaginal lubrication	Deep uterine vein/cardinal ligament transection
Vesical branch of the inferior hypogastric plexus	Urinary retention Increased post void residual	Paracolpium transection
Lateral femoral cutaneous nerve	Paresthesia/hyperesthesia of lateral thigh	Excessive or prolonged compression of psoas major muscle by retractor
Genitofemoral nerve	Paresthesia/hyperesthesia of mons pubis, labia and medial thigh	Peritoneal incision between sigmoid colon and psoas major muscle Excessive or prolonged compression of psoas major muscle by retractor
Ilioinguinal nerve	Paresthesia/hyperesthesia of the lower abdominal wall and labia Motor weakness: transverse abdominis and internal oblique muscles	Lateral trocar placement
Obturator nerve	Paresthesia/hyperesthesia of anteromedial thigh Motor weakness: thigh adduction and external rotation	Inguinal lymphadenectomy
Sciatic nerve	Paresthesia/hyperesthesia of posterior leg Motor weakness: hip extension, knee flexion	Endometriosis resection Radical pelvic surgery
Pudendal nerve	Paresthesia/hyperesthesia of perineum, labia minora and majora. Motor weakness: external urethral sphincter and external anal sphincter	Endometriosis resection Radical pelvic surgery

supported the uterus and prevented genital prolapse. However, it has become clear that they do not provide significant support for the pelvic viscera in the presence of pelvic floor defects.

Peritoneal Folds and Gubernacular Ligaments

The broad ligament is a double-layered transverse fold of peritoneum that drapes the uterus, fallopian tubes, lateral pelvic side walls, and pelvic floor. On the lateral aspects of the uterus, the mesometrium encloses the uterine vessels and the ureters. Posteriorly, the mesovarium attaches the ovary to the broad ligament, while the mesosalpinx connects the fallopian tube near the base of the mesovarium.

The suspensory ligament of the ovary, or the infundibulopelvic ligament, is a lateral continuation of the broad ligament beyond the fallopian tube that connects the ovary to the pelvic brim and contains the ovarian vessels. The ureter crosses these vessels posteriorly near the ligament's insertion into the pelvic sidewall (Fig. 1.21).

The ovarian ligament runs within the broad ligament and attaches the medial pole of the ovary to the posterolateral uterine surface, inferior to the fallopian tube. The round ligament is a fibromuscular structure that runs from the anterolateral surface of the uterus and continues through the deep, external, inguinal ring and terminates in the connective tissue of the labium majora.

Fascial Ligaments

Together, the cardinal and uterosacral ligaments provide Level 1 support for the uterus, cervix, and upper vagina [16].

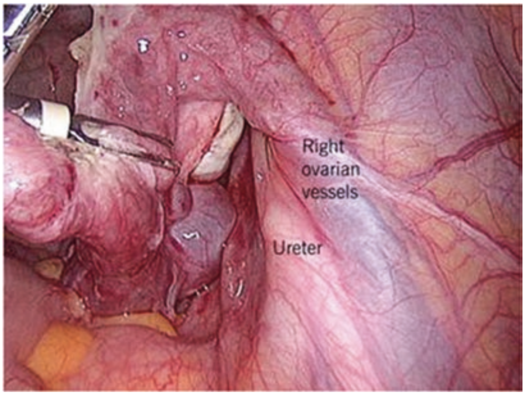


Fig. 1.21 Proximity of the ureter to the ovarian vessel. In order to minimize ureteral injury, a surgeon may perform ureterolysis or create a clear window between the ovarian vessels and the ureter prior to ligation and incision of the blood vessels. Damage to the ureter most commonly occurs at the following locations: at the pelvic brim while securing the ovarian vessels, at the level of the cardinal ligament (in this area the ureter dives under the uterine artery), at the level of the uterosacral ligaments along the pelvic sidewall, and at the level of the vaginal cuff while securing the angles for hemostasis

The cardinal ligament is the dense connective tissue located lateral to the cervix. It is abutted by the broad ligament anteriorly, posteriorly, and inferiorly by the pelvic floor. It is continuous with the paracervix, a thick fibrous sheath around the lower cervix and the upper vagina. It is attached to the pelvic walls laterally and contains major branches of the uterine vessels and the ureter as it traverses into the bladder.

The uterosacral ligaments are bands of connective tissue and smooth muscle that stretch from the posterior paracervix to the sacrum and rectum.

Pelvic Spaces

Pelvic spaces can be described as cavities lined by folds of peritoneum not occupied by pelvic viscera. They are avascular, retroperitoneal potential spaces that extend to the levator ani muscles. There are ten in total: the bilateral paravesical, pararectal, and paravaginal spaces and the midline prevesical, vesicovaginal, rectovaginal, and presacral spaces (Fig. 1.22) [17].

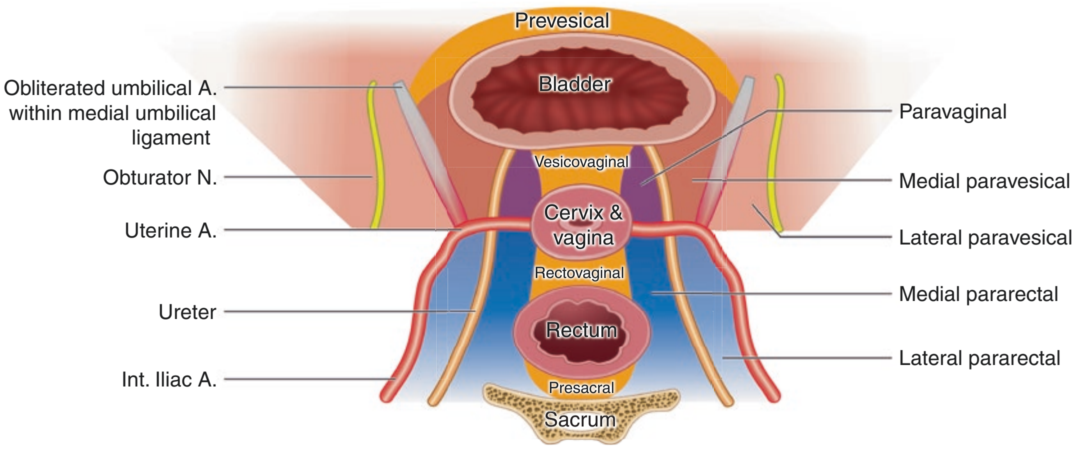
The bilateral spaces can be developed by identifying the ureter at the pelvic brim and following it inferiorly to the parametrium where it crosses under the uterine artery. At this level, the paravesical and pararectal spaces are separated by the uterine artery.

The paravesical space is enclosed medially by the bladder, laterally by the pelvic wall, and posteriorly by the uterine artery. Further subdivision into medial and lateral paravesical spaces is delineated by the obliterated umbilical artery within the medial umbilical fold (Fig. 1.23). Inguinal lymphadenectomy occurs in the lateral paravesical (LPV) space and concludes just superior to the obturator nerve. The medial paravesical (MPV) space is often dissected to avoid ureteral or bladder injury secondary to distorted anatomy or dense adhesions.

The pararectal space is enclosed medially by the rectum, laterally by the internal iliac artery, anteriorly by the uterine artery. The medial and lateral pararectal space is divided by the ureter. The medial pararectal (MPR) space, or Okabayashi space, contains the middle rectal artery, the parasympathetic pelvic splanchnic nerve roots, and the inferior hypogastric plexus. The lateral pararectal (LPR) space, or Latzko's space, is commonly developed before uterine artery transection at its origin from the internal iliac during radical hysterectomy and for internal iliac artery ligation to control pelvic hemorrhage (Fig. 1.24) [18].

A "fourth space" of Yabuki is the term used to describe a small retroperitoneal, triangle shaped paravaginal space that contains parasympathetic nerves traveling to the bladder. It is enclosed medially by the bladder pillars, laterally by the ureter, and posteriorly by the cervix and vagina. The space is created by careful dissection of the cervicovesical fascia. The anterior cervicovesical fascia enfolds the ureter and continues as bladder pillars. The posterior cervicovesical fascia is contiguous with the levator ani endopelvic fascia.

The prevesical space lies between the bladder and pubic symphysis and is enclosed laterally by the medial umbilical folds. This space is often developed to expose the bladder neck and urethra for stress urinary incontinence procedures.



Bilateral	**Midline/unilateral**
Paravesical	Prevesical
Medial paravesical	Vesicovaginal
Divided by the obliterated umbilical artery	Rectovaginal
Lateral paravesical	Presacral
Paravaginal	
Fourth space of Yabuki	
Pararectal	
Medial pararectal (Okabayashi space)	
divided by the ureter	
Lateral pararectal (Latzko space)	

Fig. 1.22 Avascular retroperitoneal pelvic spaces. Medial paravesical (MPV), lateral paravesical (LPV), medial pararectal (MPR), lateral pararectal (LPR)

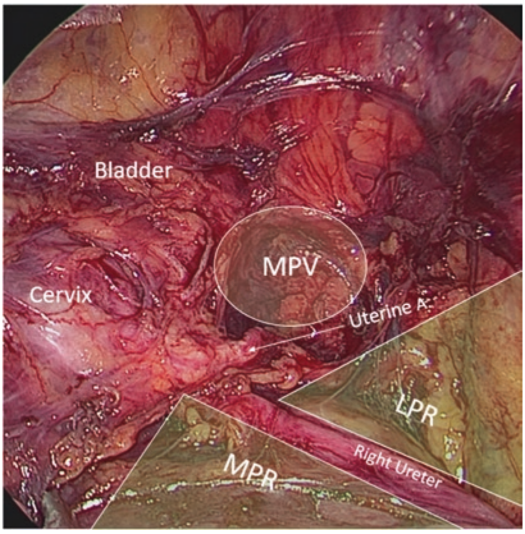


Fig. 1.23 The paravesical space is enclosed medially by the bladder, laterally by the pelvic wall, and posteriorly by the uterine artery. The medial paravesical (MPV) space is delineated from the lateral paravesical space by the obliterated umbilical artery. The right medial and lateral pararectal (MPR, LPR) spaces are also visible

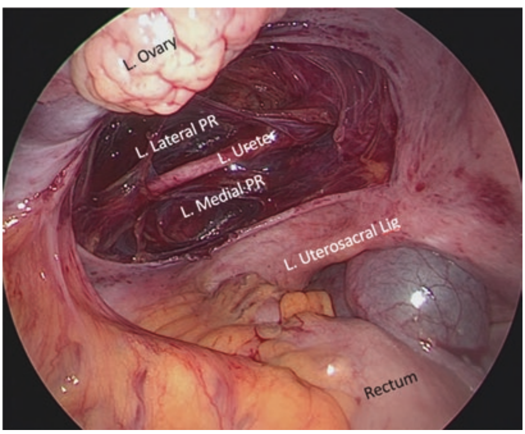


Fig. 1.24 The pararectal space is enclosed medially by the rectum, laterally by the internal iliac artery, anteriorly by the uterine artery. The medial and lateral pararectal spaces are divided by the ureter

The vesicovaginal space lies between the posterior bladder wall and anterior vaginal wall and is enclosed laterally by the bladder pillars (vesicouterine ligaments). This space is dissected to release the bladder from the inferior uterus and cervix during hysterectomy, cerclage, isthmocele, and ectopic cesarean scar pregnancy procedures.

The rectovaginal space lies between the posterior vaginal wall and the rectum and enclosed laterally by the uterosacral ligaments. Advanced endometriosis commonly infiltrates this area, and the space is developed during deep endometriosis resection, rectovaginal fistula repair, and rectocele procedures.

The presacral space lies between the rectum and the sacrum. There are three fascial layers of the presacral area: presacral fascia, mesorectal fascia, and rectosacral fascia or Waldeyer's fascia. The presacral fascia contains the SHG plexus, hypogastric nerves, and middle sacral vessels. The middle, or median, sacral vessels originate from the aorta and descend in the midline into the presacral area. Vascular injury in this confined, deep space is problematic at minimum and sometimes life-threatening. Sacrocolpopexy and para-aortic lymphadenectomy are performed in this space [18].

Pelvic Viscera

The pelvic viscera include the rectum, urinary organs, the vagina, uterus, uterine tubes, and ovaries.

The Rectum

The rectum is approximately 12–15 cm in length. It begins at the rectosigmoid junction at the level of S3 and ends at the level of the coccyx. It is distinguished from the colon by its lack of taenia coli, haustra, and omental appendices.

The proximal one-third of the rectum projects into the peritoneal cavity. At its midpoint, the rectouterine pouch is formed by the extension of the rectum's anterior peritoneum onto the vaginal fornix. The distal one-third of the rectum is located in the retroperitoneum.

The blood supply to the rectum includes the superior rectal artery, a branch from the inferior mesenteric artery, the middle rectal artery, a branch from the internal iliac artery and the inferior rectal artery, and a branch from the internal pudendal artery. Sympathetic fibers from the inferior hypogastric plexus, parasympathetic fibers from S2 to S4, and sensory fibers from the rectum all join the inferior hypogastric plexus to innervate the rectum.

Vagina

The vagina is a muscular membranous cylinder that extends anteroinferiorly from the uterine cervix to the vestibule and is approximately 7–9 cm in length. The vagina is separated from the bladder and rectum by the vesicouterine and rectouterine pouch. The vagina receives its blood supply from the uterine, vaginal, and middle rectal arteries. The inferior hypogastric plexus and pelvic splanchnic nerves innervate the vagina.

Uterus

The uterus is a dynamic, fibromuscular organ that varies in size and weight according to life stage and parity. The uterus is composed of a body (corpus) and a cervix. The fundus is the superior portion of the uterine body. The uterine cavity is triangular in shape. The length of the uterine cavity changes according to life stage owing to the profound effect of hormones on uterine size. In premenarchal females the uterine length from the external os to the fundus is 1–3 cm. During the reproductive years, this increases to 6–7 cm, and in postmenopausal women the uterus decreases to 3–5 cm in length. Similarly, the inner lining of the uterus is hormonally active and varies throughout a woman's life cycle. The endometrium varies from 5 to 15 mm during a single menstrual cycle during the reproductive years and should measure less than 5 mm in thickness after menopause.

The myometrium is thickest in the midportion of the corpus and thinnest in the cornua. The outer and innermost layers are composed mostly of longitudinal fibers in contrast to the middle layer, which consists of circular and oblique fibers that enwrap blood vessels and loose connective tissue.

The majority of the uterine blood supply is from the uterine artery, a branch of the internal iliac artery. Uterine arteries run along the lateral borders of the uterus and form anastomoses with the ovarian and vaginal arteries. The anterior and posterior arcuate arteries branch off the uterine arteries and run circumferentially around the uterine corpus and anastomose in the midline. Interestingly, no large blood vessels are found in the uterine midline. Radial arteries develop from the arcuate arteries and deeply penetrate the myometrium to reach the endometrium. The spiral arteries, which arise from the radial arteries, supply the endometrium and are the terminal blood vessels of the uterus.

Uterine Tubes

The uterine tubes are enshrouded within the superior aspect of the broad ligament and measure about 10–12 cm. Each tube is divided into four anatomic segments: intramural (or interstitial), isthmic, ampullary, and infundibulum.

The intramural portion is usually 1.5 cm long and less than 1 mm in diameter and may be tortuous. The isthmic portion is often the segment excised or ligated during tubal ligation and therefore is also the site of tubal anastomosis. The lumen is approximately 0.5 mm. Subsequent pregnancy rates are highest for procedures done in this area.

The ampulla comprises two-thirds of the length of the tube and is characterized by 4–5 longitudinal ridges. It is the site of fertilization. Not surprisingly, it is also the most common site of ectopic pregnancy. Tubal ligations are often performed at this more distal site. Pregnancy rates after anastomosis are lower in this segment despite the larger lumen.

The infundibulum is the most distal section of the tube. It is open to the peritoneal cavity and is readily identified by its fimbriae. The lumen diameter may reach 10 mm.

The tubal wall is made up of three layers: mucosa, muscularis, and serosa. The muscular layer possesses an external longitudinal layer and an inner circular layer of smooth muscle. Branches of the uterine and ovarian arteries course through the mesosalpinx and provide the blood supply for the fallopian tube.

Ovaries

The ovaries are hormonally dynamic ovoid structures suspended from the posterior aspect of the broad ligament by the mesovarium. This fold of peritoneum contains a complex of blood vessels. The ovarian ligament enters the ovary along its inferior pole, and the suspensory ligament of the ovary, or infundibulopelvic ligament, enters the ovary along its superior pole. The infundibulopelvic ligament carries the ovarian vessels, lymphatics, and nerves from the pelvic side wall and lies in close proximity to the ureter at the pelvic brim. The ovary is attached to the broad ligament by the well-vascularized mesovarium. The highly coiled, cascading anastamoses of uterine and ovarian vessels are prominent in the gravid uterus or a uterus laden with leiomyomata.

Muscles of the Pelvic Floor

The pelvic floor contains a series of muscles and endopelvic fascia that provide pelvic support to the uterus, vagina, bladder, and rectum. Disruption of these varying levels of pelvic support, described as Levels 1, 2, and 3, results in pelvic organ prolapse, paravaginal defects, and voiding and defecatory dysfunction. Pelvic floor relaxation occurs with increasing age but may be hastened by stressors such as the physiologic rigors of pregnancy, increasing parity, obesity, and birth trauma [19].

Pelvic Diaphragm

The pelvic diaphragm refers to the levator ani muscle complex and the coccygeus muscle. The levator ani consists of the puborectalis, pubococcygeus, and the iliococcygeus muscles (Fig. 1.25).

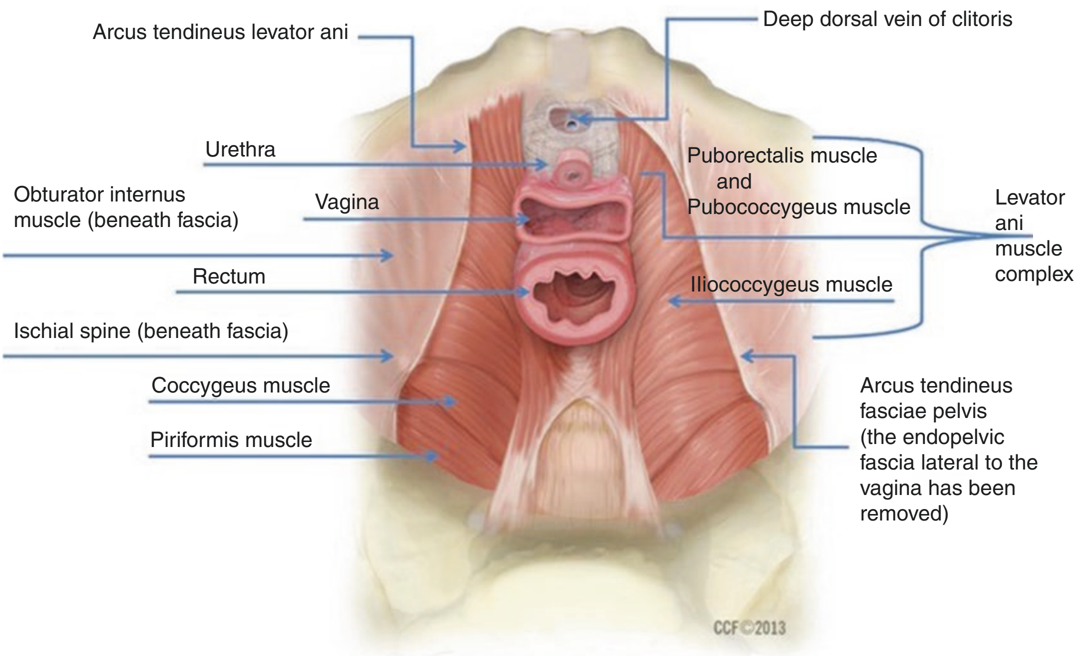


Fig. 1.25 Components of the pelvic diaphragm. The puborectalis muscle encircles the rectum and is attached to the pubic symphysis. The pubococcygeus muscle stretches in an anteroposterior fashion, from the pubis to the coccyx, and is attached to the obturator internus muscle by a dense band of connective tissue known as the arcus tendineus fascia pelvis (ATFP). The ATFP runs from the ischial spine and inserts on the pubic symphysis, and its posterior support is mirrored by the arcus tendineus rectovaginalis. The lateral iliococcygeus muscle extends from the ATFP and ischial spine to the coccyx. The coccygeus muscle is the most posterolateral component and spans from the ischial spine to the coccyx and sacrum

The thick anterior and posterior condensations of white fascia that surround the vagina are known as the arcus tendineus fascia pelvis (ATFP) and the arcus tendineus rectovaginalis (ATRV). These fasciae, together with the levator ani muscles, attach the midvagina to the pelvic side walls and support the bladder and rectum. Note the almost perpendicular axis of the puborectalis and pubococcygeus muscles to the vagina and rectum in a standing woman. Defects of Level 2 support result in cystoceles and rectoceles (Fig. 1.26) [16].

Deep and Superficial Perineal Pouches and the Perineal Membrane

The deep perineal pouch is somewhat of a misnomer as there is no true pouch. It refers to the area superior to the perineal membrane located between the inferior pubic rami and the perineal body. The connective tissues in this region provide the most distal level of pelvic organ support. Anteriorly, the ATFP unifies the vagina to the contiguous striated muscles of the urethra. Posteriorly, the ATRV merges the vagina to the deep transverse perineal muscles, perineal membrane, and the perineal body. And laterally, the connective fibers attach the vagina to the levator ani muscles. Defects of this Level 3 support result in perineal body descent and can cause urethral hypermobility, stress incontinence, and defecatory dysfunction [16].

The perineal membrane is a fascial layer that separates the deep and superficial perineal pouches but still allows passage of the vagina and urethra to the pelvic outlet.

The superficial perineal pouch includes the greater vestibular glands (Bartholin glands) and the ischiocavernosus, bulbospongiosus, and superficial transverse perineal muscles.

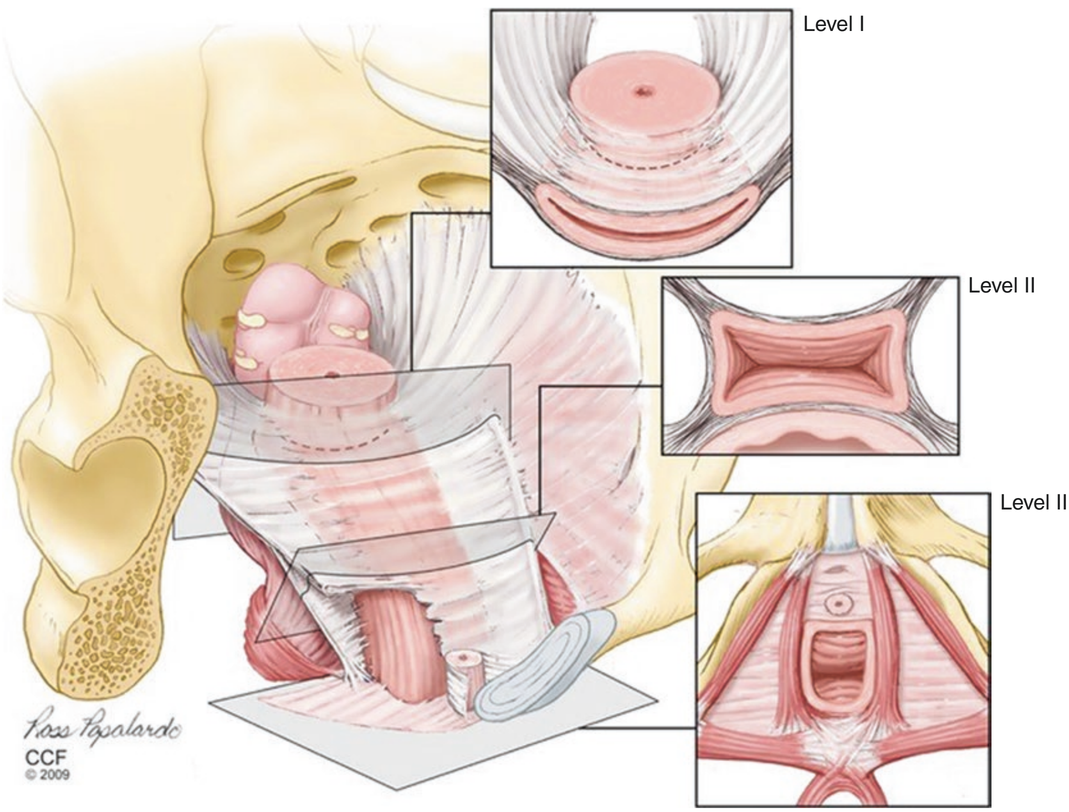


Fig. 1.26 Three integrated levels of uterine and vaginal support in a standing woman. *Level 1* support relies on the uterosacral and cardinal ligament complex to suspend the uterus, cervix, and upper vagina vertically and posteriorly toward the sacrum. *Level 2* utilizes the arcus tendineus fascia pelvis and arcus tendineus rectovaginalis to provide lateral support to the midportion of the vagina. *Level 3* support is provided by the network of connective tissue surrounding the vagina. These connective tissues bind the vagina to the urethra, perineum, and levator ani muscles

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Laparoscopic Myomectomy

2

Megan S. Orlando and Rosanne M. Kho

Introduction

With an estimated prevalence up to 70%, uterine leiomyomas—or fibroids—are the most common uterine neoplasm [1]. They consist of benign proliferations of smooth muscle cells and fibroblasts. Approximately 25% of women experience symptoms that are severe enough to prompt medical care, including abnormal uterine bleeding; bulk symptoms such as pelvic pressure, urinary frequency, and constipation; and adverse reproductive outcomes. Fibroids may significantly impair patients' quality of life, particularly related to domains of self-image, relationships, sexuality, and work productivity [2]. Uterine fibroids are the most common indication for hysterectomy and account for 40% of procedures performed in the United States [3]. There are marked disparities by race, with Black women often presenting at earlier ages with more severe symptoms and disease burden compared to White women [4, 5].

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Preoperative Considerations

Patient Selection

Although various medical treatments are available for managing the sequelae of leiomyomas, procedural interventions are the most effective at addressing bulk symptoms secondary to uterine enlargement. Myomectomy is a uterine-sparing surgery during which fibroids are excised through hysteroscopic or abdominal approaches. Abdominal myomectomy may involve laparotomic or laparoscopy routes with or without the incorporation of robot assistance.

Overall, minimally invasive surgical techniques are associated with numerous clinical benefits, including reductions in length of hospital stay, perioperative complications, and mortality rates compared to open surgery [6]. Laparoscopic myomectomy, in particular, is associated with less pain and faster postoperative recovery [7, 8]. However, the appropriate surgical route for myomectomy also depends on fibroid characteristics: number, size, and location relative to the endometrial cavity classified according to the International Federation of Gynecology and Obstetrics (Fig. 2.1) [9]. Candidates for laparoscopic myomectomy traditionally include individuals with type 2 through type 8 myomas [10]. Although generally more

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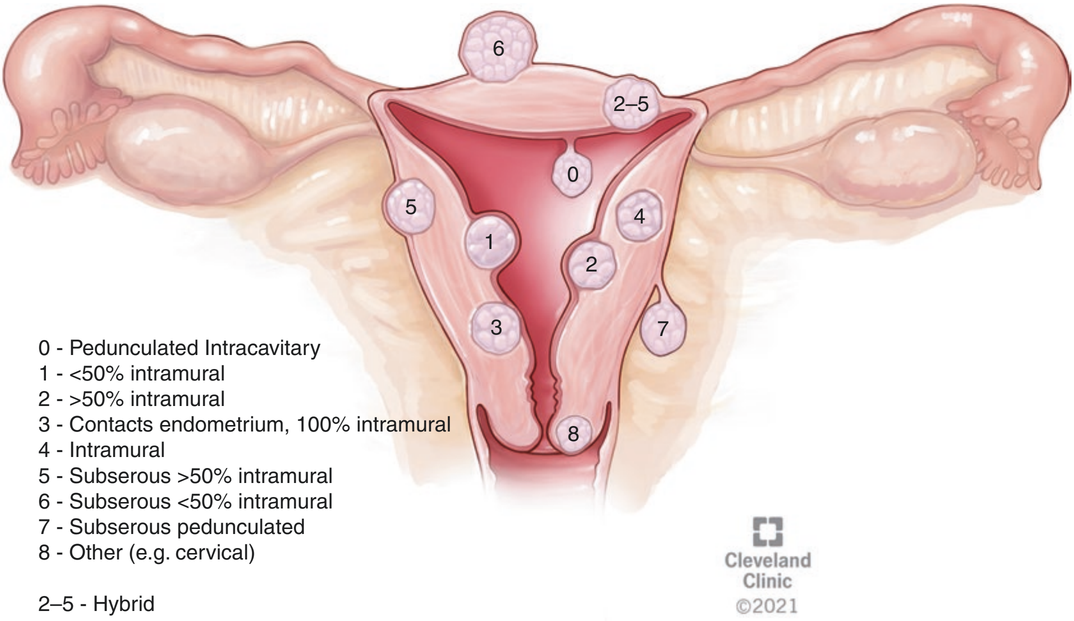

Fig. 2.1 FIGO fibroid classification system based on myoma location relative to the endometrial cavity and uterine serosa

effectively accessed through hysteroscopic myomectomy, type 0 and type 1 myomas can also be excised via transmural myometrial incisions in patients undergoing laparoscopic myomectomy for multiple fibroids.

The decision to pursue myomectomy is often impacted by desires for future fertility. Indications for surgery include fibroid symptoms that limit quality of life and adverse reproductive outcomes such as infertility and recurrent pregnancy loss [7]. Consideration of myomectomy via abdominal routes is recommended in cases of cavity-distorting intramural myomas [11]. Other patients most likely to benefit from myomectomy in terms of postoperative reproductive outcomes include those who are younger at the time of surgery and have fewer myomas [12]. For example, patients who require removal of a high fibroid burden at the time of myomectomy are less likely to become pregnancy and more likely to require assisted reproductive treatments after surgery [13]. Myomectomy can also be considered in patients who have completed childbearing and desire uterine preservation.

Role of Preoperative Imaging and Endometrial Sampling

Variations in fibroid size, location, and number occur among patients. Imaging to map and characterize myomas can be helpful to guide treatment decisions and surgical planning. Ultrasound is traditionally utilized as first-line imaging for diagnosis and monitoring of fibroids because of its accessibility and low cost. However, magnetic resonance imaging (MRI) may provide more specific findings that highlight the contrast between pelvic structures, thereby allowing for improved preoperative planning (Fig. 2.2) [14, 15].

Leiomyosarcoma (LMS) is a rare and aggressive uterine tumor that is difficult to differentiate from benign leiomyomas. Known risk factors for leiomyosarcoma include older patients (above 60 years), Black race, more than 5 years of tamoxifen use, a history of pelvic radiation, hereditary leiomyomatosis and renal cell carcinoma, and childhood retinoblastoma [16, 17]. The risk of unexpected LMS ranges from <1 in 10,000 to 1 in 770 surgeries [18]. Survival time

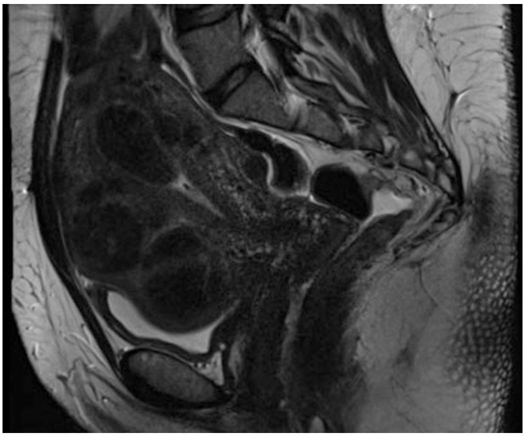

Fig. 2.2 Magnetic resonance image from a patient with multiple submucosal and intramural myomas all with typical or benign imaging features

for LMS appears to be worsened with inadvertent power morcellation. The 5-year survival after LMS diagnosis was 30% with power morcellation (95% Bayesian credible interval (BCI: 13–61%), 59% with scalpel morcellation (BCI: 33–84%), and 60% with intact removal (BCI: 24–98%)). Although confidence intervals are wide and overlap greatly, effort should be made to distinguish benign myomas from LMS in order to avoid inadvertent dissemination of disease and worsening of survival.

Features of LMS on MRI with intravenous contrast and diffusion-weighted imaging have been identified and include a combination of intermediate to hyper-T2 intensity, irregular margin, low apparent diffusion coefficient value, hemorrhage, necrosis, and avid enhancement (Fig. 2.3) [19–21]. We recommend close collaboration with imaging experts to evaluate for atypical fibroid features on MRI image.

Endometrial sampling was able to detect LMS preoperatively in 35.3–66.7% of patients with LMS, and detection rate is improved by threefold when hysteroscopy is used during endometrial sampling [22]. While there is currently NO combination of imaging and evaluation tools to accurately identify LMS prior to surgery, careful history and thorough use of preoperative imaging and biopsy should be taken to evaluate for malignant involvement.

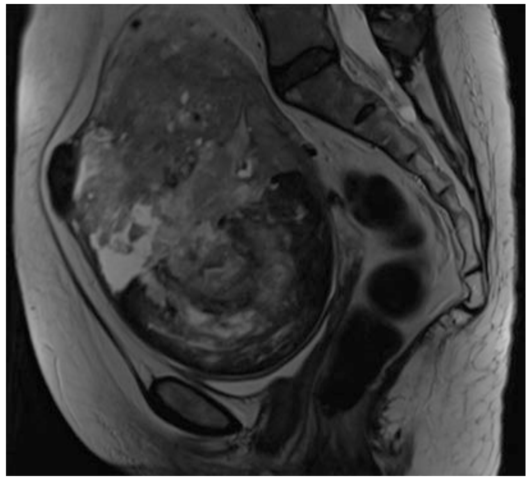

Fig. 2.3 Magnetic resonance image from a patient with leiomyosarcoma. The image displays a dominant heterogeneous uterine mass with hemorrhagic and cystic elements, post-contrast enhancement and restricted diffusion

Use of GnRH Analogues

Gonadotropin-releasing hormone (GnRH) agonists may be offered as a treatment strategy to bridge patients to myomectomy and also to aid in optimization of preoperative anemia. GnRH analogues induce a hypoestrogenic state by downregulating the production of gonadotropins and ovarian steroid hormones. Their effects are reversible, likely within approximately 3–9 months following cessation of therapy [18]. A 2017 Cochrane review demonstrated that the use of GnRH agonists prior to myomectomy was associated with 0.88 g/dL increased preoperative hemoglobin concentration and 22–157 mL decreased intraoperative blood loss compared to placebo. Nevertheless, this did not correlate with clinically meaningful changes in rate of blood transfusion or postoperative complications [23].

From the surgeon's perspective, there are differing views surrounding the utility of GnRH analogues prior to laparoscopic myomectomy. Three months represents the typical duration of pretreatment and is associated with reductions in uterine and fibroid volume at the time of surgery [23]. This may allow for the conversion of certain procedures from laparotomic to minimally invasive approaches, with concomitant benefits in perioperative outcomes and postoperative recovery. However, changes in myoma tissue consistency may negatively impact intraoperative delineation between fibroid pseudocapsule and surrounding myometrium. As such, many surgeons cite impeded fibroid enucleation as their primary reason for not using GnRH pretreatment. Of note, this disadvantage has not been demonstrated in clinical trials. Another concern related to GnRH pretreatment is possible increased persistence or recurrence of leiomyomas too small to be removed at the time of myomectomy. This concern was supported by a retrospective review that revealed higher proportions of GnRH agonist pretreatment among patients with symptomatic fibroid recurrence or reoperation after robot-assisted laparoscopic myomectomy [24]. Given the mixed evidence and multiple considerations involved in the use of GnRH analogues before surgery, shared decision-making should be performed between patients and their providers.

Other Preoperative Considerations

Other important strategies for surgical optimization prior to laparoscopic myomectomy overlap with evidence-based practices from Enhanced Recovery After Surgery protocols for minimally invasive gynecologic surgery. These include correction of anemia with oral iron supplementation or iron infusions and maintenance of perioperative euglycemia to limit infectious morbidity [25].

Laparoscopic Myomectomy Surgical Techniques

Patient Positioning and Laparoscopic Port Placement

After induction of general anesthesia, the patient is repositioned in dorsal lithotomy to allow for placement of a uterine manipulator. Although numerous uterine manipulators are available, some surgeons prefer to use a device with an open channel or insert that allows for injection of dye (frequently methylene blue or indigo carmine) to color the endometrial cavity for easier identification.

Laparoscopic myomectomy is classified as a clean procedure given that no connection is created between the peritoneal cavity and vagina during surgery. The American College of Obstetricians and Gynecologists (ACOG) does not recommend administration of prophylactic antibiotics for laparoscopic procedures without entry into the bowel or vagina. However, ACOG suggests that surgeons should consider administration of cefazolin for similar clean laparotomy procedures [26]. In addition, certain laparoscopic myomectomies involve entry into the endometrial cavity to remove transmural myomas. Many surgeons administer prophylactic antibiotics at the start of a myomectomy procedure in which endometrial cavity disruption is anticipated.

Initial port placement should be chosen to optimize safety and visualization. Most gynecologic surgeons choose to enter the peritoneum at the umbilicus or left upper quadrant at or near Palmer's point. In cases with uterine pathology that extends above the umbilicus or for patients with elevated risk of adhesive disease, a left upper quadrant approach is preferred to maximize visualization and decrease risk of bleeding during peritoneal entry. If the umbilicus is chosen as the site of initial entry, many surgeons prefer to use a 10–12 mm rather than 5 mm port given the frequent need to extend this incision for tissue extraction and the ability to introduce standard needles through a larger port. The midline port may be moved cephalad to the umbilicus to allow for triangulation of large myomas.

Accessory ports should be placed to maximize ease of fibroid enucleation and laparoscopic suturing. Most surgeons choose to use three additional ports, generally 5 mm in size. These should be placed at least 8–10 cm apart to limit intraoperative instrument collisions. Surgeon preference for suturing laparoscopically using an ipsilateral, contralateral, or suprapubic port configuration will guide trocar placement (Fig. 2.4).

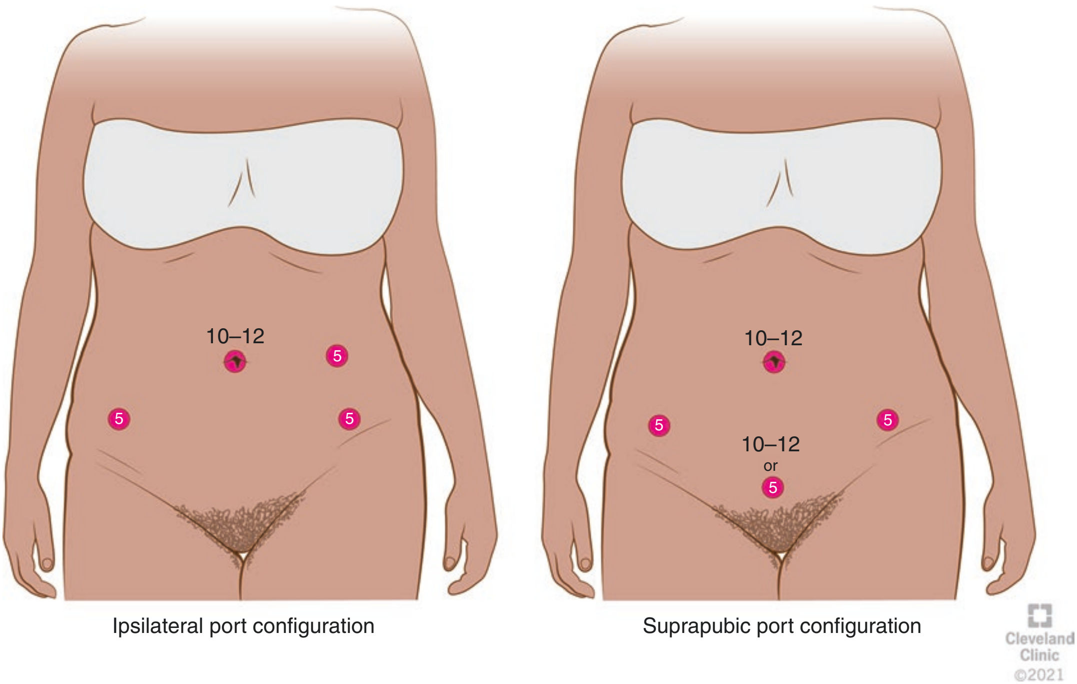

Fig. 2.4 Popular configuration for laparoscopic ports during myomectomy, which allow for visual triangulation and laparoscopic suturing

Intraoperative Interventions to Minimize Blood Loss

Uterine fibroids contain collateral blood vessels that stimulate extensive smooth muscle proliferation. As such, excessive blood loss during myomectomy is one of the most common complications of the procedure and generally correlates directly with myoma number, size, and location. Numerous medical and surgical techniques have been investigated to reduce intraoperative blood loss. However, many studies are limited by the use of estimated blood loss as principal outcome rather than more clinically meaningful outcomes such as need for blood transfusion or unplanned hysterectomy.

A 2014 Cochrane review included data from eight studies that examined interventions to reduce blood loss during laparoscopic myomectomy specifically. The authors concluded that injection of intramyometrial vasopressin was superior to placebo at limiting blood loss in multiple randomized trials. A 2016 randomized controlled trial showed no difference in estimated blood loss or postoperative hematocrit levels among groups that received concentrated (20 units in 60 mL normal saline) vs. dilute (20 units in 400 mL normal saline) solutions of intramyometrial vasopressin [27]. The above Cochrane review also found one trial that investigated bupivacaine plus epinephrine with positive results. Of the uterotonic medications, misoprostol 400mcg administered 1 hour before surgery and oxytocin infusion appeared to reduce intraoperative hemorrhage during laparoscopic myomectomy [28].

Although previous studies have demonstrated an association between intravenous tranexamic acid administration and decreased blood loss during myomectomy via laparotomy, these benefits may not extend to laparoscopic myomectomy [28]. A 2020 randomized controlled trial revealed no significant difference in estimated blood loss following a single bolus of tranexamic acid 15 mg/kg given 20 minutes before surgical start time [29]. Of note, prior studies have used a combination of tranexamic acid bolus followed by continuous infusion, which suggests that further study into dosing modifications may reveal a positive effect of tranexamic acid during laparoscopic myomectomy [30].

Regarding surgical strategies to minimize blood loss, multiple cohort and controlled intervention trials have demonstrated that temporary or permanent bilateral uterine artery occlusion improves hemostasis without compromising postoperative fertility [31–33]. Uterine artery occlusion can be performed intraoperatively by applying removable clamps such as bulldog clamps to the vessels or performing more permanent electrosurgical or suture ligation (Fig. 2.5). Peri-cervical tourniquet is also associated with reduced intraoperative blood loss during myomectomy via laparotomy, though few studies have trialed tourniquet placement during laparoscopic myomectomy [28]. Many surgeons find it challenging to achieve adequate tourniquet tensioning with the laparoscopic approach. The use of barbed suture for hysterotomy closure is another surgical method that allows for shorter operative times and improved tissue tension on the myoma bed with resultant decreases in blood loss [30, 34].

It is also crucial to note the role of meticulous surgical technique in minimizing intraoperative bleeding. A structure known as the myoma pseudocapsule separates fibroids from surrounding myometrium. Identification of the correct tissue plane and fibroid enucleation with maintenance of the pseudocapsule aids in limiting blood loss. Along with the use of barbed suture, efficiency in the surgical steps of myoma enucleation and hysterotomy closure impact intraoperative time and hemostasis. Surgeons with access to the technology can also consider the use of intraoperative cell salvage in cases with elevated anticipated blood loss. Cell salvage should be initiated at the start of surgery to maximize blood available for autologous blood transfusion.

Overall, most surgeons utilize a variety of pharmacologic and procedural methods to limit blood loss during laparoscopic myomectomy. While few studies have examined the additive effects of multiple of the above interventions before and during surgery, this has become common practice at many institutions.

Fibroid Enucleation and Uterine Closure

The process of fibroid enucleation begins with hysterotomy creation. Most surgeons perform this step immediately following injection of vasopressin solution into the surrounding myometrium (Fig. 2.6). Given that the half-life of vasopressin is approximately 20 minutes, this may be readministered during the procedure after sufficient time has passed to limit the risk of adverse effects such as hypertension and

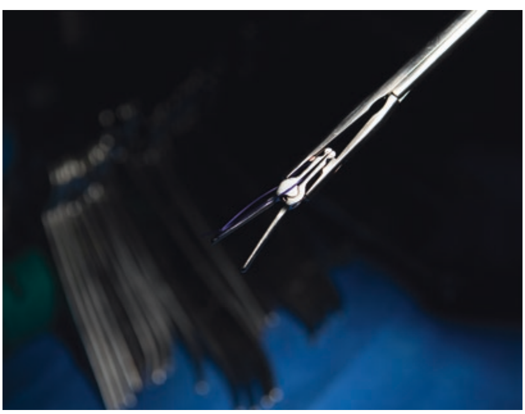

Fig. 2.5 Bulldog clamps can be applied to the uterine arteries bilaterally to perform temporary uterine artery occlusion

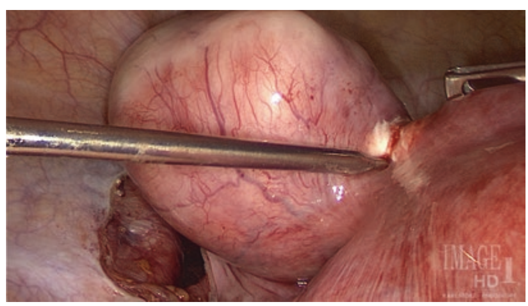

Fig. 2.6 Injection of intramyometrial vasopressin can be performed through a port site with a laparoscopic needle, as pictured, or directly through the abdominal wall using a spinal needle or a laparoscopic needle

cardiotoxicity. A transverse uterine incision over the myoma is often utilized for ease of laparoscopic suturing during hysterotomy closure. Care should be taken to avoid hysterotomy extension into lateral structures, including the round ligaments, fallopian tubes, and utero-ovarian ligaments with their corresponding blood supply.

It is imperative to dissect down to the correct tissue depth in order to identify the fibroid pseudocapsule and separate it from the surrounding myometrium. Enucleation is performed by placing traction on the fibroid specimen—often with the use of a laparoscopic tenaculum or myoma screw—and dissecting away myometrial fibers with countertraction and sparse use of ultrasonic or electrosurgical energy. A 2010 randomized controlled trial that compared the use of ultrasonic and electrosurgical devices during laparoscopic myomectomy found that ultrasonic energy was associated with reduced operative time, estimated blood loss, and postoperative pain [35]. Nevertheless, surgeon experience plays an important role in instrument choice during this procedure with the goals of expediting fibroid enucleation to limit intraoperative blood loss.

Hysterotomy closure serves to expedite time to achieve hemostasis and promote wound healing. Delayed absorbable barbed suture is often used as it presents multiple advantages over traditional polyglactin or polydioxanone sutures. These include obviating the need for knot tying and the ability to maintain tissue tension during hysterotomy closure. Barbed suture also reduces the time to uterine closure, which is an important component in limiting blood loss [36]. Most surgeons perform multilayer closure of the myometrium with a separate serosal layer. This limits space available for hematoma formation and promotes tissue integrity to reduce the risk of future uterine rupture.

Tissue Extraction

Containment and extraction of uterine fibroids is an area of ongoing research and development. In 2014, the US Food and Drug Administration (FDA) released a safety communication discouraging the use of power morcellation during laparoscopic myomectomy or hysterectomy given the risks of spreading occult leiomyosarcoma throughout the abdomen and lack of reliable methods for accurate preoperative diagnosis. Prior to this recommendation, laparoscopic power morcellation was a widespread method of performing expeditious and uncontained tissue extraction of uterine fibroids. While the FDA safety recommendation prompted some surgeons to transition to performing laparotomic rather than laparoscopic myomectomy [37], it also ushered in a wave of innovation surrounding methods for contained and manual morcellation.

Extraction of uterine fibroids typically necessitates extension of a port site or creation of a new incision (mini-laparotomy) at least 2–3 cm in size (Fig. 2.7). This can be performed at the umbilical port, which many find to be cosmetic given the ability to hide the incision within the umbilicus itself. Another common location for mini-laparotomy is a low transverse or suprapubic incision, which can be created by extending a suprapubic port site if already present. A 2018 cohort study comparing these two strategies for tissue extraction found that mini-laparotomies were generally longer in the low transverse group and accommodated larger specimen weights. There were no significant differences between mini-laparotomy incisional symptoms or complications based on location, though there was a nonsignificant trend toward increased hernia rates among women who underwent tissue extraction at the umbilicus [38]. Unlike total hysterectomy, myomectomy does not involve colpotomy creation. However, vaginal tissue extraction can be performed through a posterior colpotomy, which allows for the creation of a larger incision without concomitant elevation in abdominal hernia risk. Vaginal extraction may be particularly desirable in patients who are parous or with an accessible vaginal canal. In some cases, surgeons may choose to create the mini-laparotomy incision at the start of the case and use this as an operative port with a gel cap to maintain pneumoperitoneum (Fig. 2.8).

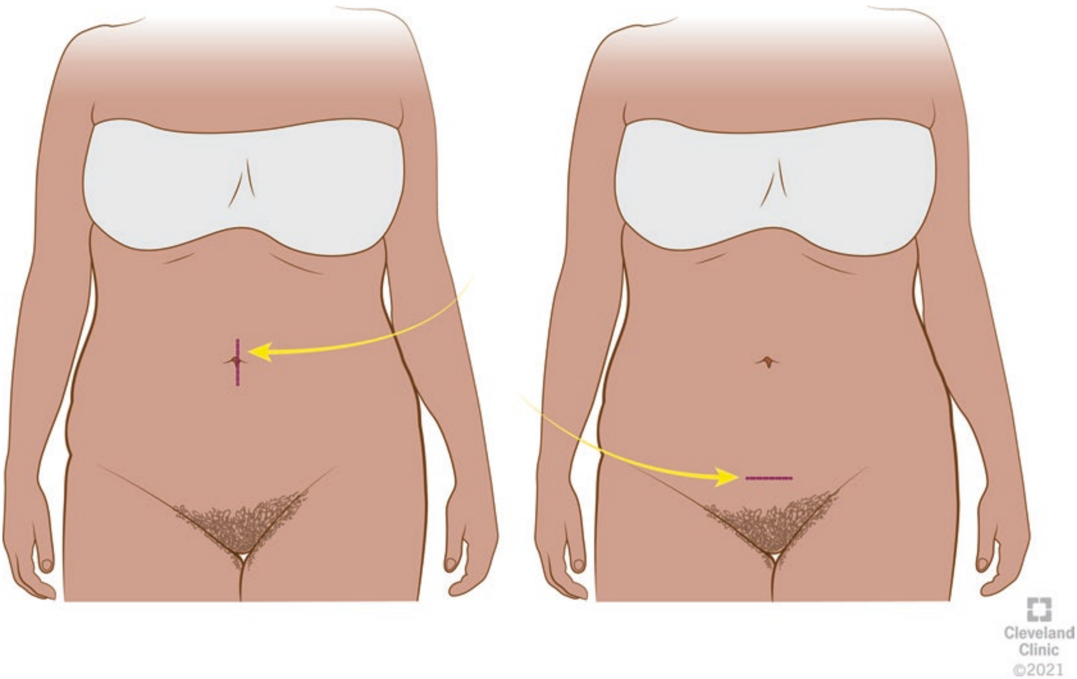

Fig. 2.7 Common locations for mini-laparotomy for tissue extraction during laparoscopic myomectomy: umbilical and low transverse incisions

Fig. 2.8 The umbilical incision is extended at the start of the case, and a self-retaining retractor is placed to allow multiple instruments to be inserted through the umbilical port

Fig. 2.9 Ringed bag with semirigid ring at opening, which can be inserted through the mini-laparotomy incision for specimen retrieval

Various specimen containment bags have been developed to accommodate gynecologic tissue extraction. These frequently involve a flexible ring at the bag opening that allows for easier manipulation in cases of large specimens. After mini-laparotomy or colpotomy creation, the specimen containment bag is placed through the incision (Fig. 2.9). Once the specimen is positioned within the bag, the edges of the bag are brought out through the incision so that fibroids are fully contained and separated from the peritoneal cavity.

Extracorporeal manual morcellation refers to the process by which fibroid and uterine specimens are fractionated by hand to allow for efficient removal though small incisions. This is most commonly performed in a contained fashion as above. The specimen is grasped and traction is applied. Using a scalpel (often #10 or #11 blade), the myoma is incised in a C shape and rolled to create a long thin strip of specimen excised (Fig. 2.10) [39, 40]. A recent systematic review evaluated 184 studies related to the safety of minimally invasive tissue extraction during myomectomy or hysterectomy. Overall, the review found that safety data was limited by low quality studies, non-standardized morcellation techniques, and challenges reporting accurate complication rates given unknown at-risk populations [41].

The FDA modified their 2014 safety communication in February 2020 to recommend that laparoscopic power morcellation only be performed with the use of an approved tissue containment system. The updated ACOG Committee Opinion related to uterine morcellation was released in March 2021. The Committee Opinion notes that tissue containment systems still present risks of leak or perforation and that no method of tissue extraction completely eliminates the risk of spread of occult malignancy [42]. These risks should be weighed against increased morbidity conferred by laparotomic surgical approaches and shared decision-making performed between patient and provider.

Fig. 2.10 Extracorporeal manual morcellation is performed at the umbilicus with the use of a self-retaining retractor and 11-blade scalpel

Adhesion Prevention

Adhesions consist of pathologic connections between abdominopelvic organs that often develop after peritoneal or tissue disruption during surgery. An estimated 30–50% of patients exhibit adhesions on second-look laparoscopy following laparoscopic myomectomy [43, 44]. Adhesions are associated with risks of complications such as small bowel obstruction, chronic abdominopelvic pain, and infertility. Numerous adhesion barrier products have been developed for intraoperative application. A 2020 systematic review demonstrated a significantly lower incidence of adhesions among patients who received a cellulose absorbable barrier during laparoscopic myomectomy compared to no treatment [43]. Emerging evidence suggests that some adhesion barriers such as hyaluronic acid and polyethylene glycol with glycerol are associated with improved postoperative pregnancy rates after myomectomy [12]. In addition, certain fibroid characteristics are related to adhesion formation, including fibroid number and diameter of the largest myoma [44]. These factors likely contribute to an increased probability of large, numerous, and discontinuous wounds at the end of hysterotomy closure. Surgical techniques that promote hemostasis and careful myometrial approximation should be performed during laparoscopic myomectomy.

Mini-Laparotomy Myomectomy

Patient Selection

Multiple variations on the traditional laparoscopic technique have been proposed to address challenges inherent to myomectomy, such as laparoscopic suturing and prolonged operative times, while retaining the benefits of a minimally invasive surgical approach. Acknowledging the frequent need to extend an umbilical or suprapubic laparoscopic incision for tissue extraction, the mini-laparotomy represents a middle ground between techniques. Although there is no strict definition, a mini-laparotomy is generally considered to be an abdominal incision 2–6 cm in length, most often placed in the suprapubic location [45, 46]. The mini-laparotomy may be used for tissue extraction, in combination with laparoscopy for fibroid enucleation and wound closure, or as the predominant surgical site for the procedure. A recent cohort study demonstrated that compared with the traditional laparoscopic technique, mini-laparotomy myomectomy is associated with shorter operative time and longer hospital length of stay [45].

Although choice of surgical approach is often influenced by physician preference and experience, certain fibroid types are more amenable to removal through the mini-laparotomy approach. In particular, these include anterior intramural, subserosal, and pedunculated myomas (Fig. 2.11). Posterior fibroids can be accessed with the use of a uterine manipulator or laparoscopic assistance, though this may present a challenge during hysterotomy closure. In addition, the mini-laparotomy technique can be helpful for patients with numerous fibroids who are often advised against undergoing traditional

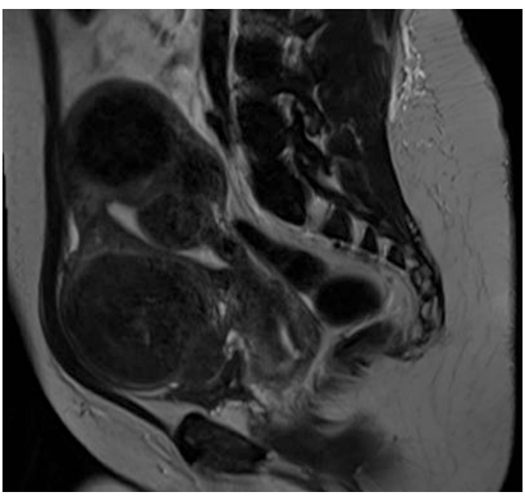

Fig. 2.11 Magnetic resonance image from a patient with considerable anterior and fundal fibroid burden who is likely a good candidate for mini-laparotomy myomectomy

laparoscopic myomectomy due to time required for enucleation and wound closure. Submucosal and intracavitary myomas may be removed through the mini-laparotomy technique, though this requires a transmyometrial incision. In some cases, the procedure may be combined with hysteroscopic myomectomy for complete fibroid excision.

Mini-Laparotomy Myomectomy Technique

If a combination approach is utilized, many surgeons choose to begin the mini-laparotomy myomectomy procedure by obtaining laparoscopic access to the abdomen. Initial port placement is performed at the umbilicus or left upper quadrant. This allows for visual fibroid mapping and evaluation of adnexal structures and other abdominopelvic pathology. Additional laparoscopic ports can be placed as desired and may be used to treat intra-abdominal adhesions before proceeding with myomectomy.

A mini-laparotomy is usually created as a transverse suprapubic incision located 2–3 cm above the pubic bone. After making a 2–4 cm skin incision, the fascia may be extended laterally to allow for improved visualization. Some surgeons advocate for more cephalad placement of the fascial incision to access large or fundal myomas. If using a combination laparoscopic approach, maintaining intra-abdominal insufflation may aid in ease of peritoneal entry. A self-retaining wound retractor is placed once the peritoneal cavity is entered. Fibroids and adnexal structures should be mapped prior to initiating enucleation of the myomas.

Many intraoperative principles apply to both traditional laparoscopic and mini-laparotomy myomectomy. These include techniques to limit blood loss, such as intramyometrial injection of dilute vasopressin and administration of uterotonic medications as desired. Most surgeons who use the mini-laparotomy as their predominant surgical site for the procedure recommend using monopolar electrosurgery for hysterotomy creation. Crile or other small retractors can be placed within the myometrial incision to aid in reaching the fibroid pseudocapsule and recognizing the appropriate plane for enucleation. Specimens are grasped with Lahey or other locking clamps, and a combination of blunt and sharp dissection is used to separate the myoma from the underlying myometrium.

During mini-laparotomy myomectomy, methods for tissue fractionation often vary slightly from the laparoscopic approach. For myomas that are larger than the mini-laparotomy incision, in situ tissue fractionation can be performed. This involves enucleation of the fibroid from the surrounding myometrium and a rolling technique to allow extracorporeal manual morcellation to be performed sequentially along the circumference of the specimen (Fig. 2.12). As a large portion of the fibroid remains attached to the uterus during tissue extraction, a specimen retrieval bag is not used with this technique.

Unlike laparotomic myomectomy, which traditionally involves the use of polyglactin or polydioxanone sutures for hysterotomy closure, many surgeons advocate for the use of barbed suture for mini-laparotomy myomectomy (Fig. 2.13). Similar to the laparoscopic approach, this allows for maintenance of tissue tension throughout hysterotomy closure and also brings the myometrium closer to the incision. Of note, a uterine manipulator or handheld retractors can be useful in exposing posterior or deep hysterotomies for closure.

Postoperative Management and Complications

Immediate Postoperative Period

Patients who undergo laparoscopic myomectomy with or without mini-laparotomy are often candidates for same-day discharge. Enhanced Recovery After Surgery (ERAS) protocols outline strategies for maximizing same-day surgery success following minimally invasive gynecologic surgery. These include comprehensive preoperative counseling, provision of perioperative medications to address pain and limit postoperative nausea, liberal oral intake, early ambulation, and standard-

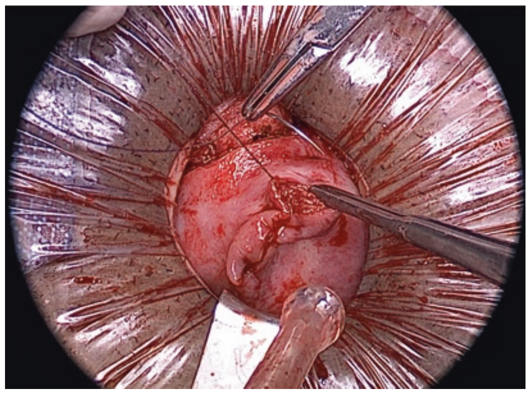

Fig. 2.13 Hysterotomy closure during mini-laparotomy myomectomy can be accomplished with the use of barbed suture to allow for adequate tissue tension. (Image courtesy of Dr. Miguel Luna Russo and Dr. Cara King)

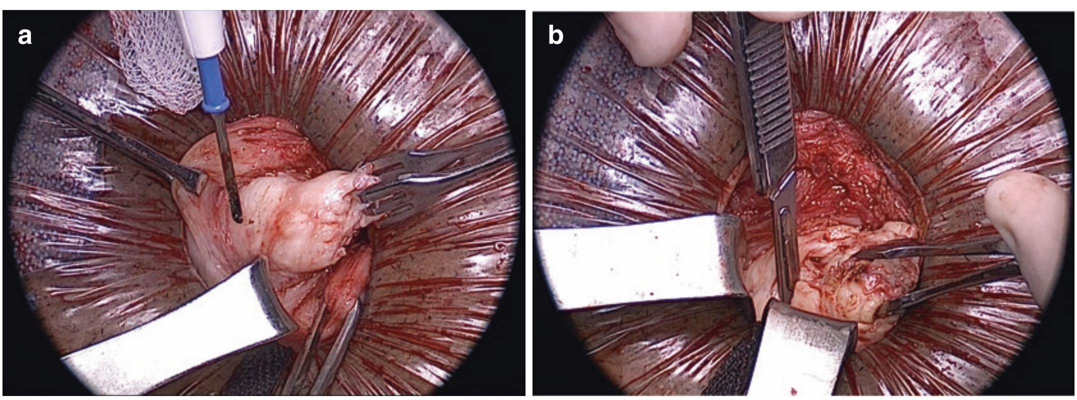

Fig. 2.12 (**a**, **b**) Tissue extraction during mini-laparotomy myomectomy involves a rolling technique that focuses on enucleating the edges of the fibroid specimen from the surrounding myometrium. (Image courtesy of Dr. Miguel Luna Russo and Dr. Cara King)

ized discharge medications [23]. Increased rates of same-day discharge following implementation of ERAS protocols for gynecologic surgery were associated with decreased narcotic medication usage with no change in complication or postoperative readmission rates [47].

Complications and Outcomes

A 2007 Italian prospective cohort study of 2050 laparoscopic myomectomy procedures provides some of the most robust data related to complications rates after laparoscopic myomectomy. The most frequent complications were fever (5.1%, defined as temperature above 38 °C) and cystitis (3.4%) [48]. While multiple studies show that fever occurs less commonly following laparoscopic rather than laparotomic myomectomy, fevers likely relate to release of local inflammatory factors or hematomas at the bed of extracted myomas [36]. Intraoperative bleeding occurred in 0.7% of cases, with blood transfusion required in 0.14% of all procedures. Overall, the probability of developing a major complication was directly related to myoma size, number of fibroids removed, and operative time, which can be considered as proxies for increased surgical complexity [48]. Over half of 86 patients surveyed regarding their postoperative experiences reported full return of quality of life by 2 weeks after laparoscopic myomectomy [49].

In the longer term, laparoscopic myomectomy provides patients with sustained improvements in symptom control and quality of life. A 2020 nationwide prospective study surveyed 519 women 6–12 weeks after laparoscopic myomectomy and found substantial improvements in all health-related quality of life measures, bleeding, and bulk symptoms [50]. At 1 year, myomectomy remains associated with clinically meaningful improvements in quality of life [51]. Nevertheless, rates of myoma recurrence on imaging or subsequent surgery appears to increase with time, reaching almost 53% 5 years after laparoscopic myomectomy [52].

Postoperative Pregnancy Planning

Given that many myomectomies are performed for women desiring future fertility, postoperative pregnancy planning is critically important. Based on limited imaging studies and estimates of myometrial stability, many experts recommend waiting at least 3 months after surgery before trying to conceive [53]. Some specialists extend this interval to 6 months to allow for adequate myometrial healing.

Clinical pregnancy rates following laparoscopic myomectomy vary markedly among published studies, though a 2015 systematic review estimates approximately 50% [36]. A recent systematic review examining fertility outcomes following non-hysteroscopic myomectomy concluded that route of myomectomy is unlikely to impact future pregnancy rates or the likelihood of successful vaginal delivery [12].

Uterine rupture is one of the most severe postoperative delivery complications and is likely more common in cases requiring transmyometrial incision or enucleation of deep intramural or submucosal myomas. Uterine rupture is estimated to occur in 0.93% of pregnancies after myomectomy with a decreased risk of 0.47% among women undergoing trial of labor [54]. This discrepancy is likely related to the frequent recommendation for scheduled cesarean section rather than trial of labor among patients with a history of extensive myomectomy procedures. There is limited data regarding intraoperative techniques for preventing uterine rupture. However, many surgeons advocate for multilayer myometrial closure and avoidance of significant application of electrosurgery to the myometrium to promote wound healing [36].

Conclusions

Fibroids are highly prevalent benign uterine neoplasms, and myomectomy represents an effective uterine-sparing approach to treating symptoms such as heavy bleeding and pelvic pressure. In particular, laparoscopic myomectomy is a safe and feasible minimally invasive treatment modality. Patient selection is critical to enable successful completion of surgery and limit risks of intraoperative bleeding and intra-abdominal spread of disease. Mini-laparotomy myomectomy is a variation on the traditional laparoscopic technique, which may obviate challenges of laparoscopic suturing and prolonged operative times. Overall, laparoscopic myomectomy provides many patients with long-term symptom control and improved quality of life.

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Laparoscopic Adnexal Surgery

3

Anna Fagotti, Cristiano Rossitto, Sara Pizzacalla, and Giovanni Scambia

Any surgical technique uses specific tools. A well-trained and adequately equipped operating room is the basis for a secure and effective surgery. The availability of advanced technology makes procedures safer.

Placement of the Patient

The patient is placed flat on the table with her legs wide apart and thighs bent over the basin. For this purpose, leg stirrups are used (Allen Stirrups; Allen Medical Systems, Ashby Park, UK), which facilitate variations of approach at any time of the intervention and protect the sterile area. The buttocks are placed on the edge of the table and must be positioned to leave sufficient free space for the mobilization of the uterus, if needed. The arms are fixed along the body to reduce the risk of compression of the brachial plexus and at the same time to enhance and provide flexibility to the movements of the surgeon and assistant. The patient must rest in a horizontal position until the positioning of all trocars is completed, because the Trendelenburg position accentuates the lumbar lordosis, bringing the great vessels close to the navel and increasing the risk of vascular lesions. Before each gynecologic laparoscopic surgery, it is essential to insert a Foley catheter to empty the bladder.

Placement of the Surgeons

Two surgeons are needed for this type of surgery. The first surgeon stands to the left of the patient, raised above on a platform for proper ergonomics to reduce arm muscle fatigue (Fig. 3.1). The nurse stands at the side or in front of the first surgeon to allow for the proper exchange of instruments without hindering the field of view of the surgeons. The second surgeon stands to the right of the patient. In some difficult cases (e.g., deep endometriosis), a third assistant may sit between the legs of the patient to manage the uterine manipulator.

Placement of the Trocars

Usually, the first trocar is placed through the umbilicus, but other locations may be used according to the largest diameter of the adnexa or previous surgeries. Different techniques may also be adopted for the insertion of the first trocar, such as the Veress needle, optic trocars, direct trocar, or

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Fig. 3.1 The first surgeon stands to the left of the patient, raised above a platform for proper ergonomics in order to reduce arm muscle fatigue

open access. The diameter of the first trocar may vary between 5 and 10 mm; this is related both to the diameter of the optic and the need to use an endobag large enough to remove the adnexal cyst or adnexa. Regarding ancillary trocars, we prefer to use three 5-mm trocars because the main instruments for all laparoscopic procedures are frequently 5 mm. Whatever the diameter, the positioning of these trocars at the lateral side of the pelvis and the suprapubic position must always be checked. Indeed, at time of accessory trocar placement, bleeding for the injury of the inferior epigastric vessels can occur. These deep vessels of large diameter cannot be identified through the transillumination of the abdominal wall in obese women, showing the superficial epigastric vessels only. Palpation of the wall exposing the edge of the rectus abdominis muscle and the laparoscopic visualization of this area allow the surgeon to choose the exact point for good trocar placement. The trocar should be introduced vertically to the wall under visual control. The third trocar is introduced at the midline height of the two lateral trocar instruments.

Placement of Laparoscopic Instruments

There is a wide range of existing instruments for laparoscopic adnexal surgery. It is our opinion that only a few are needed. It is preferable to use an instrument with a handle and no clamping system in order to make the most dynamic movements.

The essential instruments to perform laparoscopic adnexal surgery include:

- Grippers: there are different types of grippers; those with a strong hold on the tip are preferable in the event of enucleation (stripping) of the cyst.
- Bipolar forceps: the latest generation of bipolar forceps combines hemostatic energy and adequate traction. The ideal bipolar grasp can be used during the whole operation without the need for replacement and can be used to coagulate either the ovarian vessels or the bed of the cyst.
- Forceps: any type of scissors can be used if they ensure continued reliable cutting.
- Suction/irrigation system: any model can be used that provides adequate visualization of the surgical field.

Many other new generation instruments are available for both coagulating, cutting, and handling. The choice depends on the surgeon, the type of surgery, and financial capabilities.

Most recently, the use of percutaneous instruments has further reduced the impact of surgical invasiveness and improved cosmetic outcomes, even if the lack of suitability of bipolar energy requires the use of multifunctional instruments, which may increase the costs of the procedure [1, 2].

Preoperative Work-Up

A correct clinical evaluation, by means of physical examination, laboratory testing, and imaging techniques, is a primary goal in order to choose the best treatment (surgery vs attendance, radical vs conservative surgery), when facing adnexal disease. Once that a surgical indication is decided by the clinician, clear and complete information about surgical options, fertility and hormonal implications, and possible complications must be discussed with the patient.

Laboratory Testing and Imaging in Gynecological Adnexal Disease

Differential diagnosis between benign and malignant adnexal diseases is of outmost importance. In fact, when a malignant lesion is suspected, patients should be referred to a gynecologic oncologist, who guarantees appropriate staging and treatment. On the other hand, for patients with benign lesions, a fertility sparing treatment with a minimally invasive surgery approach represents the gold standard. A proper physical examination is mandatory to seek for signs and symptoms of the major gynecological diseases (i.e., presence of pain uni-/bilaterally, peritoneal reaction, solid masses, ascites).

Laboratory testing might be helpful: in premenopausal women human-beta HCG should be tested to indicate a intra or extra uterine pregnancy.

A complete blood count may help to differentiate a tubo-ovarian abscess and a pelvic inflammatory disease especially when white blood cells count is higher than normal [3].

Ca 125 serum levels might be helpful when a malignancy is suspected, but should not be used as a screening tool since it may be elevated in many benign gynecological conditions (endometriosis, large uterine fibroids, menstruation, ovarian fibroma, pelvic inflammatory disease, previous hysterectomy) and non-gynecological conditions (caffeine use, liver cirrhosis, obesity, lung disease, tuberculosis) beside non-gynecological malignancies (breast cancer or peritoneal implants of non-ovarian cancers) [3].

Ultrasound-based algorithm has shown high sensitivity and specificity in discriminating adnexal masses, so that transvaginal ultrasound is the first choice for imaging of adnexal diseases. Ultrasound should also be used to characterize an adnexal mass that is incidentally found with a TC scan. In particular, the IOTA (International Ovarian Tumor Analysis) group has been working to identify a standardized system of terms and definitions to describe adnexal masses [4]. Secondly using the "easy descriptors" has identified a range of ultrasonographic parameters shared by most (i.e., 43%) of adnexal masses allowing the clinicians to identify their nature with high positive (about 93%) and negative (99%) predictive value [4]. Furthermore the so-called simple rules, represent an easy-to-use method to discriminate between malignant and benign masses in premenopausal women, as stated by the Royal College of Obstetrician and Gynecologist (RCOG) 2011 green-top guidelines. Most recently the ADNEX (Assessment of Different Neoplasias in the adnexa) model was created by means of a logistic regression model. This is the first multiclass prediction model for adnexal masses. It allows to establish the risk of malignancy, the likelihood of borderline nature, stage I to IV of ovarian cancer, and likelihood of metastasis in the ovary from another cancer. This model integrates three clinical predictors (CA 125 serum levels, age, and type of center: oncology vs another hospital) with six ultrasonographic parameters (maximum diameter of the lesion, proportion of solid tissue, presence of >10 loculi, number of papillary projections, acoustic shadows, and ascites) [4]. CA 125 serum levels are relevant in discriminating between late stage of ovarian cancer vs other types of cancer rather than the malignancy of adnexal masses themselves. The role of magnetic resonance is to help characterizing pelvic disease when ultrasound is not clear or to assess extra-pelvic disease in case of malignancy. In this latter case TC scan might also be indicated [3].

Adnexal Surgery and Informed Consent

Age, body mass index, previous surgery, and comorbidities are risk factors for perioperative complications and need to conversion to laparotomy. The most common complications of laparoscopic surgery include vascular, bowel, genitourinary injuries, and incisional hernias. Less common complications include gas embolism [5]. When facing adnexal surgery, patients should also be informed about the specific consequences. When tubal surgery is performed, women should be aware of the risk of interstitial or extrauterine pregnancy (more relevant when the tubal excision is not complete) [6]. Salpingectomy after extrauterine pregnancy doesn't seem to affect ovarian function, and the spontaneous or after in vitro fertilization pregnancy rate seems to be related rather to indication for surgery [7]. A relevant issue is the reduction of ovarian reserve after ovarian cyst excision or adnexal surgery. Literature data show a deep decline in ovarian reserve independently from the histological type and diameter of the cyst [8]. The stripping technique, though, seems to be a tissue sparing procedure, and in some studies, surgical removal of endometriomas showed more favorable outcomes rather than drainage or ablation [9, 10]. Remarkably a consistent damage is also given by the reduction in blood flow to the ovaries, which is associated also to tubal surgery since blood supply is close to the fallopian tube [8]. All patients undergoing repeated adnexal surgery should be counseled preoperatively regarding their fertility. Pre- and perimenopausal women undergoing bilateral salpingo-oophorectomy should be informed of the consequent menopause and eventually of the hormone replacement therapy.

Surgical Technique

The first steps in laparoscopy consist of pneumoperitoneum and trocars' placement. When done properly, this greatly facilitates the smooth running of the surgery. After trocars are placed, an assessment of the pelvis, abdomen, and external surface of the cyst is performed for possible evidence of malignancy. Peritoneal fluid or washing is collected for cytologic examination. If needed, lysis of adhesions is performed to free the adnexa. Once surgery and bleeding control have been completed, the abdomen is deflated, the ports can be removed, and the incisions can be closed.

Fallopian Tube Surgery

Anatomy

The fallopian tubes are paired and symmetric tubular organs, connecting the body of the uterus with the ovaries and providing a wide area for ovum catch. They can measure from 7 to 12 cm in length and up to 3 mm in thickness. These organs are covered by two layers of peritoneum, the mesosalpinx. Each tube can be divided into four portions going from the body of the uterus to the peritoneal cavity: the interstitial, the isthmic, the ampullary, and the fimbriated portions. The tubal branches of the uterine and ovarian arteries anastomose in the round ligament provide branches for the different portions of the tubes passing through the mesosalpinx. The venous and lymphatic drainage follows the uterine and ovarian vessels. Currently, laparoscopy is the gold standard for tubal surgery.

Laparoscopic Salpingectomy

Indications

Monolateral salpingectomy is generally indicated in ectopic pregnancy and for salpingo-ovarian abscess. Bilateral salpingectomy is usually indicated in sterilization and in the prevention of ovarian cancer in high-risk patients. Monolateral and bilateral salpingectomy should also be considered in women with fallopian tube endometriosis, who are planning an in vitro fertilization procedure, although it is still debated whether fallopian tube endometriosis has an impact over fertility and chronic pelvic pain [11].

Surgical Procedure

Once the tube has been identified, it must be lifted and gently held with atraumatic graspers, without injuring vessels and other adjacent structures. In order to minimize blood loss, all vessels in the mesosalpinx need to be coagulated. Using a bipolar grasp, it is possible to coagulate the distal portion until no bleeding is noted. Scissors can be used to cut the coagulated portion. This process needs to be repeated serially in order to move from the distal to the proximal portion of the mesosalpinx. In the case of ectopic pregnancy, an endoscopic loop ligation can be performed, followed by cutting the distal tube to the looped portion. Once the distal portion is cut, the tube is freed and can be removed. Instead, it is also possible to use only monopolar scissors, thus coagulating and then cutting the tube. If available, multifunctional devices can be used to reduce operative time.

Laparoscopic Salpingostomy

Indications

Monolateral salpingostomy is mainly employed in the surgical conservative management of ectopic pregnancy. Patients need to be informed of the approximate 8% risk of persistent trophoblastic tissue after the procedure and of possible permanent damage to the Fallopian tube. Chances of these adverse outcomes are increased in case of high levels of beta-human chorionic gonadotropin (usually more than 6.000 IU/L) or large masses (>3.5–4 cm). Only patients with a strong desire for fertility and/or acceptance of only one functioning tube should undergo this type of procedure. Intrauterine pregnancy rate after this procedure might reach up 70% in case of mild adhesions, depending extensively on the condition of the tube (i.e., presence of mucosal damage), and this surgery must be reserved to selected cases [6].

Surgical Procedure

For the removal of an ectopic pregnancy, a solution of vasopressin should be injected into the mesosalpinx of the tubal wall (5 IU in 20 ml of saline solution) [12]. A 1- to 2-cm longitudinal incision at the level of the tube along the mesosalpinx is then performed using scissors, bipolar or monopolar, or a carbon dioxide laser. Widening the margins of the incisions, the pregnancy can be removed either with suction irrigation followed by hydrodissection or with smooth grasping forceps. Any specimen must be extracted, preferably through an endobag. Hemostasis should be accurately checked. Irrigation and suction of free blood and tissue debris are recommended in order to prevent the risk of persistent trophoblastic tissue.

Ovarian Surgery

Anatomy

The ovaries are paired endocrine pelvic organs, lying on either side of the uterus behind the broad ligament. They are attached to the posterior aspect of the broad ligament by the mesovarium, to the ipsilateral uterine cornus by the utero-ovarian ligament, and to the lateral pelvic wall by the infundibulopelvic ligament. The ovarian artery, a branch of the aorta, runs in the infundibulopelvic ligament and anastomoses with the ovarian branch of the uterine artery at the level of the meso-ovarian border. Here, approximately ten arterial branches originate, penetrating the ovarian hilus and forming a plexus at the corticomedullary junction. Arterioles penetrate the cortex in a radial fashion perpendicular to the ovarian surface. The veins within the ovaries accompany the arteries. The left and right ovarian veins drain into the left renal vein and the inferior vena cava, respectively. Three zones are visible on the sectioned surface: an outer cortex, an inner medulla, and the hilus. The current gold standard for benign ovarian surgery is laparoscopy.

Laparoscopic Adnexectomy

Indications

Laparoscopic adnexectomy is indicated when no residual ovarian parenchyma is thought to remain as a result of multilocular endometriotic cysts or large dermoids reaching the hilus vessels, or during the menopausal period, or for prophylactic purposes.

Surgical Procedure
To perform adnexectomy, bipolar grasping forceps and scissors are used. The technique consists of opening the wide ligament back to the round ligament, visualizing the ureter, and opening a window between the ovarian vessels and the ureter. In this way, a safe coagulation and cut of the ovarian vessels are possible without any injury to the ureter. Then, the utero-ovarian, mesosalpinx, and mesovarium are resected, and the adnexa can be removed within an endobag to avoid spillage. The bag may be inserted through a 10-mm trocar in the umbilicus to avoid any additional scarring. In the case of large cysts without any preoperative oncologic risk factors, suction of the cyst may be performed to reduce the volume (Figs. 3.2, 3.3, 3.4, 3.5, and 3.6).

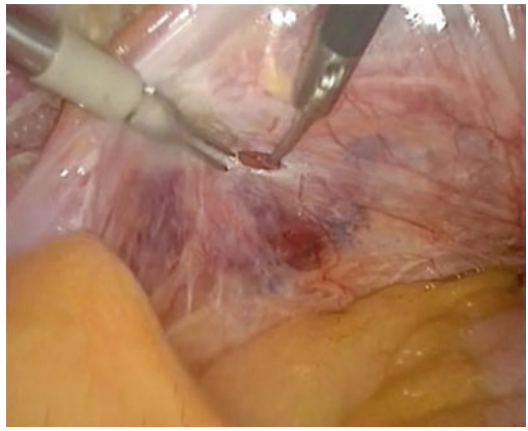

Fig. 3.3 Sequence for adnexectomy. Fenestration of the broad ligament

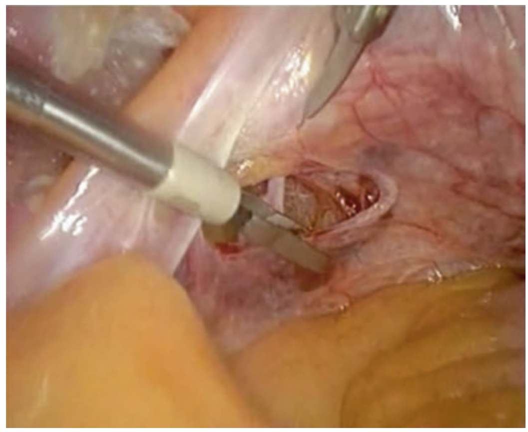

Fig. 3.4 Sequence for adnexectomy. Extension of the fenestration of the broad ligament

Laparoscopic Cystectomy

Indications
Any type of ovarian cyst has the potential to be removed by laparoscopy. A clear and open discussion between patient and surgeon still remains the key to a successful procedure.

Surgical Procedure
When possible, the cyst is removed intact, without spillage. If this is not possible, the cyst is opened and drained, and the internal wall is

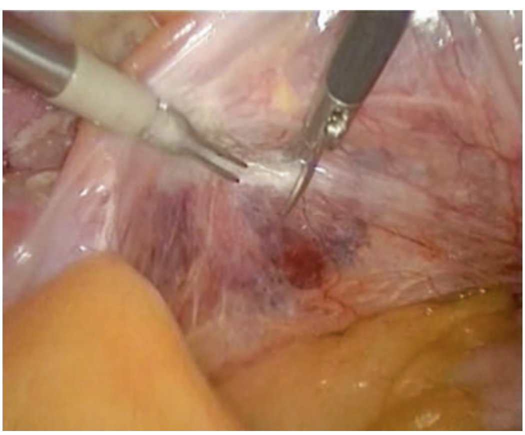

Fig. 3.2 Sequence for adnexectomy. Coagulation of the broad ligament

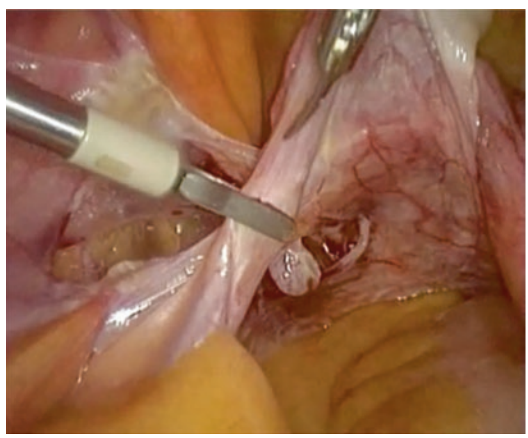

Fig. 3.5 Sequence for adnexectomy. Coagulation of the infundibulopelvic ligament

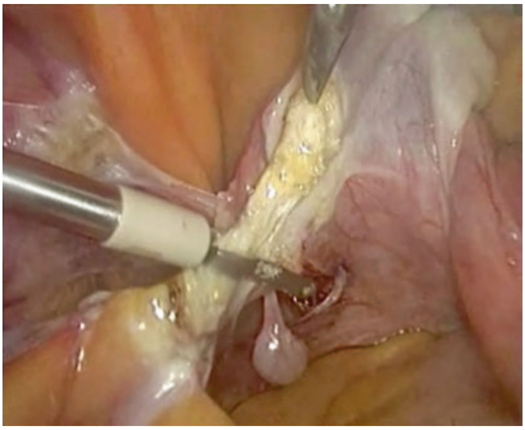

Fig. 3.6 Sequence for adnexectomy. Cut of the infundibulopelvic ligament

Fig. 3.7 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Mobilization of the adnexa and identification of the cyst

inspected for papillae or irregular thickening. In the case in which an unexpected endocystic lesion is identified, the cyst is entirely excised (or the adnexa is completely removed) and sent for frozen section examination.

The stripping technique is performed, utilizing at least three atraumatic grasping forceps (one for the assistant and two for the first surgeon) after having mobilized the adnexa and identified the correct plane of cleavage by cold scissors. Then the cyst capsule is separated from the ovarian tissue by means of repeated diverging [13, 14]. The cystic bed is then coagulated where needed. Usually, there is no need for suturing the remaining ovarian parenchyma (Figs. 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, 3.14, and 3.15).

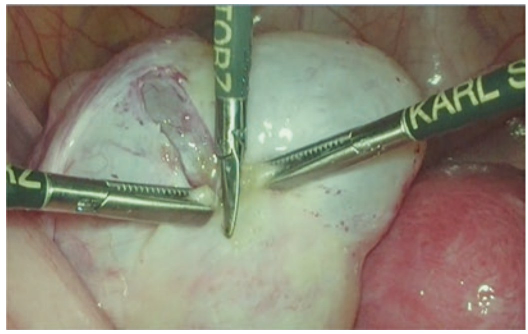

Fig. 3.8 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Cutting ovarian parenchyma surrounding the cyst

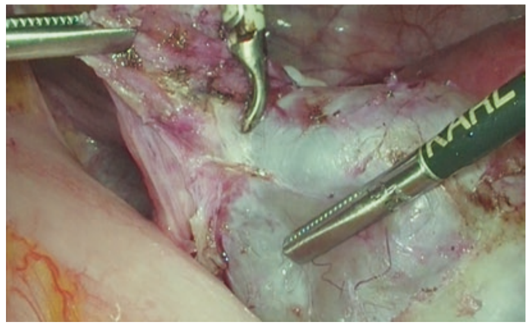

Fig. 3.9 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Location of the plane of the cleavage

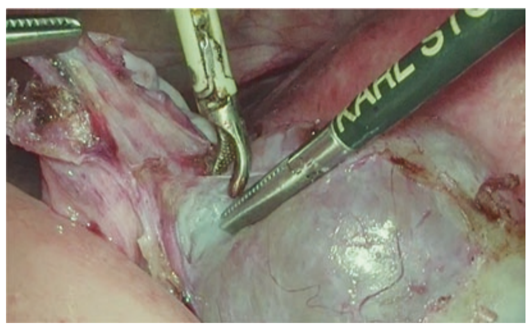

Fig. 3.10 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Separation of the cyst capsule from the ovarian tissue (part 1)

Ovarian Transposition

Indications

Ovarian transposition is a surgical procedure that allows the mobilization of the ovaries from the radiation field to a radiation therapy-free

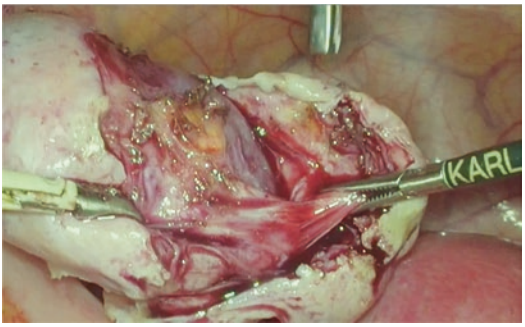

Fig. 3.11 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Separation of the cyst capsule from the ovarian tissue (part 2)

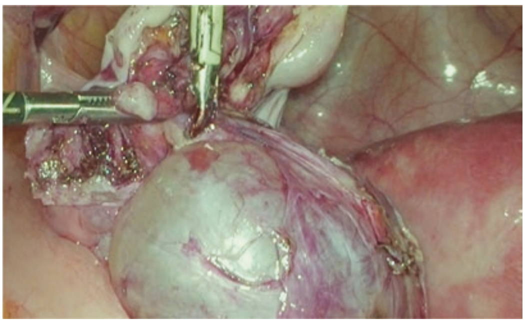

Fig. 3.12 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Complete mobilization of the cyst

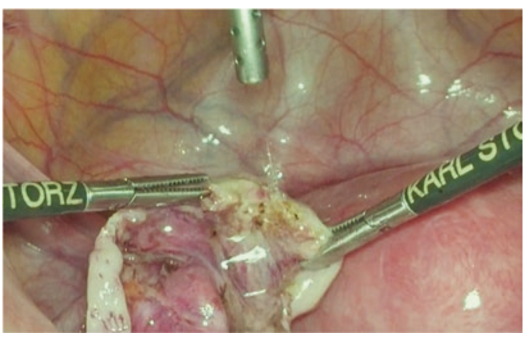

Fig. 3.13 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Irrigation of the cystic bed to improve blood flow visualization

place. It should be offered to all premenopausal women who are going to receive abdominal or pelvic radiation therapy for gynecological and non-gynecological cancers in particular to all women with fertility desire especially in pediatric population [15].

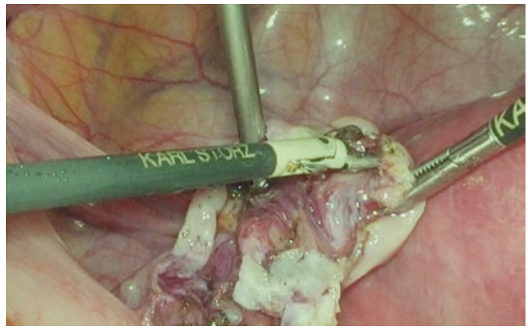

Fig. 3.14 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Cystic bed coagulation

Fig. 3.15 Ovarian cystectomy: sequence for enucleating an ovarian cyst. Cyst extraction

Surgical Technique

The main issue when performing ovarian transposition is to place one or both ovaries in to an anatomically safe position preserving ovarian vascularization and avoiding ischemia.

Minimally invasive surgery is feasible and safe, reducing intraoperative bleeding and hospitalization, and allows a better visualization rather than the open technique. The laparoscopic ovarian transposition has a reported effectiveness of 88.6%, for preservation of ovarian function [16]. The ovary can be transposed as single unit or together with the tube. Argument in favor of ovarian transposition only is the potential risk of developing an HGSOC from the tube, whereas the presence of the mesosalpinx guarantees a better vascularization. The ovary needs to be isolated from the uterus by cutting the utero-ovarian ligament. The ovarian pedicle is then isolated by opening the peritoneum medially and laterally to the infundibulopelvic (IP) ligament. The IP ligament is separated from the ureter. At this point, a pouch can be developed in the retroperitoneum of the paracolic gutters up to the upper limit of the kidney, usually the level where the ovary is located. Here a peritoneal incision is performed. Then, the ovary can be gently grasped through the retroperitoneum superiorly to the brim at the level of the peritoneal incision. This latter step should maintain the ovarian vessels in the retroperitoneum preserving ovarian blood supply. Lastly the ovary can be sutured to the parietal peritoneum to avoid it from slipping to the pelvic or abdominal cavity. The ovaries are marked with titanium clips to identify their position during the follow-up. The median hospitalization is 24–48 hours.

Conclusions

Laparoscopic adnexal surgery represents the basis of laparoscopic surgery, and in the robotic era, it still remains relevant to minimize costs and provide clinical benefits.

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4 Laparoscopic Total and Supracervical Hysterectomy

George Thomas and Michael L. Sprague

Hysterectomy is among the most performed surgical procedures in the United States with the most frequently cited indications being abnormal uterine bleeding, symptomatic leiomyomas, endometriosis, and pelvic organ prolapse [1]. Refinements in laparoscopic technique and instrumentation drove the evolution from conventional laparotomy to a laparoscopic approach for hysterectomy, with observed outcomes including as less surgical blood loss, reduction of perioperative infection, decreased pain, and expedited time to recovery [2]. Reproducible outcomes with laparoscopic hysterectomy are achieved through a systematic approach for comprehensive patient counseling, perioperative patient care, and completion of the surgical procedure. Mastery of laparoscopic hysterectomy requires ongoing development of laparoscopic skills and refinement of surgical mechanics.

Preoperative Preparation

Informed Consent

Patients should be adequately counseled regarding the specific procedure that is being proposed and appropriate alternatives. Decision aids such as models, diagrams, and videos may increase patient comprehensive of the surgery. Patients must understand that the procedure requires general anesthesia, is irreversible, and precludes future childbearing [3]. Patients should be informed of the risks of laparoscopic hysterectomy and the need for conversion to laparotomy (Table 4.1).

Laboratory Testing

Patients undergoing evaluation for laparoscopic hysterectomy minimally require:

- Complete blood count
- Serum electrolytes
- Renal and hepatic function
- Cervical cancer screening
- Blood type and antibody testing
- Endometrial biopsy, if indicated [4]

Table 4.1 List of complications of laparoscopic hysterectomy with associated risk of occurrence

Complication	Risk (%)
Injury to urinary tract [2]	0.024
Bowel injury [2]	0.001
Vascular injury [2]	0.016
Significant perioperative bleeding [2]	0.006
Conversion to laparotomy [3]	3.93
Vaginal cuff dehiscence [4]	0.64–1.35

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Instrumentation

Basic laparoscopic equipment is required for the performance of laparoscopic hysterectomy. An angled laparoscope allows for optimal visualization of large or complex pathology. Non-disposable laparoscopic instruments are cost-effective and decrease operating room waste. Laparoscopic needle drivers facilitate efficient vaginal cuff closure. A uterine manipulator with pericervical cup promotes surgical exposure, efficiency, and safety [5]. The use of conventional laparoscopic electrosurgical instruments versus advanced electrosurgical/electromechanical devices is a matter of surgeon preference. Universal cystoscopy allows for confirmation of bladder integrity and ureteral patency following laparoscopic hysterectomy (Table 4.2) [5].

Surgical Preparation

Optimization of recovery from laparoscopic hysterectomy begins before the surgery. It is recommended for patients to partake in a carbohydrate rich clear liquid beverage up to 2 hours before surgery, undergo administration of antiemetic agents in the preoperative area, and receive multimodal non-opioid analgesia prior to surgery [6].

Appropriate antimicrobial prophylaxis is administered within 60 minutes prior to procedure [7]. Sequential compression devices are initiated for mechanical venous thromboembolism prophylaxis prior to induction of general anesthesia. A drawsheet is employed to safely secure the patient's arms at their side with care not to compromise circulation. The patient is placed in dorsal lithotomy position with their buttocks at the edge of the surgical table as to facilitate access to the urinary, reproductive, and gastrointestinal tracts. Appropriate positioning of the stirrups and adequate padding potential pressure points minimize the risk for perioperative nerve injuries. Outfitting the surgical table with slide resistant materials prevents shifting when patient placed in Trendelenburg position. The patient's abdomen is prepared with chlorhexidine alcohol solution and their vagina cleansed with 4% chlorhexidine gluconate or povidone-iodine [7]. The patient is draped in sterile fashion and a Foley catheter is placed to bedside drainage.

Optimal positioning of surgeon and surgical equipment in relation to the patient enhances surgeon ergonomics and decreases surgeon fatigue. The surgeon stands to the patient's side with their primary assistant on the contralateral side of the table and their second assistant at the patient's perineum. Video screens are positioned to allow for each team member to comfortably observe the video feed from the laparoscopic camera.

Table 4.2 List of recommended equipment to perform a laparoscopic hysterectomy

Recommended equipment for laparoscopic hysterectomy
Video system
Endoscopic camera with light source
Laparoscope 0 degree 30 degree
Insufflator
Basic laparoscopic instrument set
Laparoscopic needle drivers
Uterine manipulator
Electromechanical and/or electrosurgical device(s)
Cystoscope 30 degree 70 degree

Surgical Technique

Uterine Manipulator Placement

A uterine manipulator with pericervical cup promotes efficient laparoscopic hysterectomy by facilitating uterine movement, providing clear delineation of the vaginal fornices, aiding in the mobilization of the bladder, and displaces the cervicovaginal junction away from the ureters. Common features to an appropriate uterine manipulator includes an ergonomic handle, a pneumo-occluding mechanism, a pericervical cup, and intrauterine probe. Multiple disposable and reusable uterine manipulators are available commercially (Fig. 4.1).

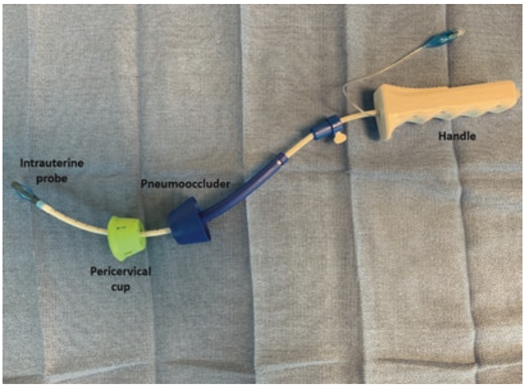

Fig. 4.1 V-care manipulator with components labeled

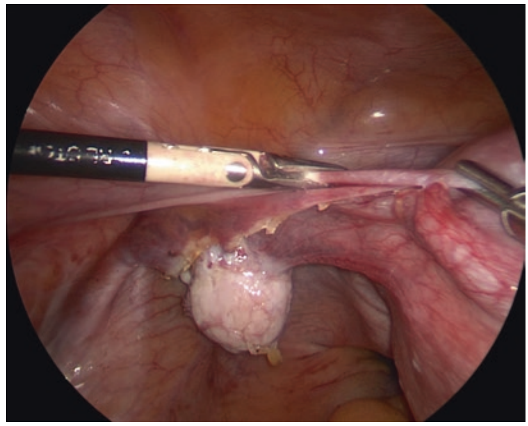

Fig. 4.2 Desiccation of round ligament

Port Placement

Optimal port placement is key for successful completion of laparoscopic hysterectomy. Port placement must allow for adequate visualization of the pelvic anatomy and efficient access to the uterus and surrounding structures.

The umbilicus is a common site for primary port placement and introduction of laparoscope for primary survey of the abdomen and pelvis. Large or complex pathology may require that the camera port be placed cephalad to the umbilicus to allow for adequate visualization. Additional accessory ports are placed under direct visualization to avoid trauma to vascular and visceral structures based on the patient's unique anatomy and pathology. The preferred final port configuration is surgeon-dependent but should grant ergonomic instrument triangulation within the pelvis.

Round Ligament

The round ligament runs from the uterine fundus through the deep inguinal ring to the ipsilateral labia majora. Sampson's artery is an anastomosis of the ovarian and uterine arteries and runs inferior to the round ligament.

The optimal site for division of the round ligament balances the risk of vascular injury to the uterine artery medially and the external iliac vasculature laterally with the ability to appropriately address pathologies such as fundal fibroids or endometriosis. Most often, the round ligament can be safely divided at the midpoint between the uterine fundus and the deep inguinal ring. Identifying the midpoint between the uterine fundus and the deep inguinal ring is facilitated by movement of the uterine fundus toward the contralateral shoulder. Care must be taken to adequately desiccate Sampson's artery prior to division of the round ligament (Fig. 4.2).

Adnexa

Salpingectomy

Patients for which ovarian conservation is appropriate may elect to undergo opportunistic salpingectomy. The surgical objective is to excise both fallopian tubes entirely to confer a 65% risk reduction for developing epithelial ovarian cancers [8].

The infundibular and fimbriated portions of the fallopian tube are grasped, the tube elevated away from neighboring tissues, and traction/countertraction applied to optimize exposure of the mesosalpinx. The mesosalpinx is then desiccated and divided near the fallopian tube using preferred energy device. The fallopian tube may remain attached to the uterus and be removed once hysterectomy is complete. Alternatively, the fallopian tube can be transected near the uterine cornua and removed through a laparoscopic port at this time to help optimize exposure of the cul-de-sac. The utero-ovarian ligament is desiccated and divided to completely mobilize the ovary from the uterus (Figs. 4.3 and 4.4).

Oophorectomy

The ovaries are located within the ovarian fossae, which is bordered by the external iliac vessels, the ureter, and the obliterated umbilical artery.

Following division of the round ligament, the medial infundibulopelvic ligament is grasped and contralateral traction applied. The peritoneum lateral and parallel to the infundibulopelvic ligament is divided to the level of the pelvic inlet and the external iliac vessels exposed. The ureter is identified either transperitoneally or within the retroperitoneum. The peritoneum medial to the infundibulopelvic ligament is incised and the ovarian vasculature isolated. The ovarian vessels are then safely desiccated and divided. Care must be taken to adequately desiccate the ovarian vessels as they will oftentimes retract into the pelvic sidewall following division. The ovary may be left attached to the uterus and extracted following hysterectomy. If the ovary is enlarged or impedes visualization of the cul-de-sac, the ovary's medial investments may

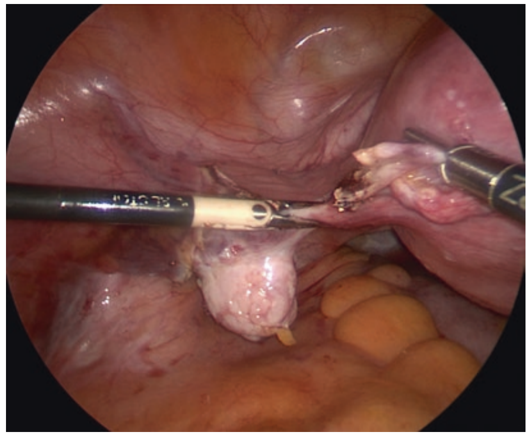

Fig. 4.4 Desiccation of utero-ovarian ligament

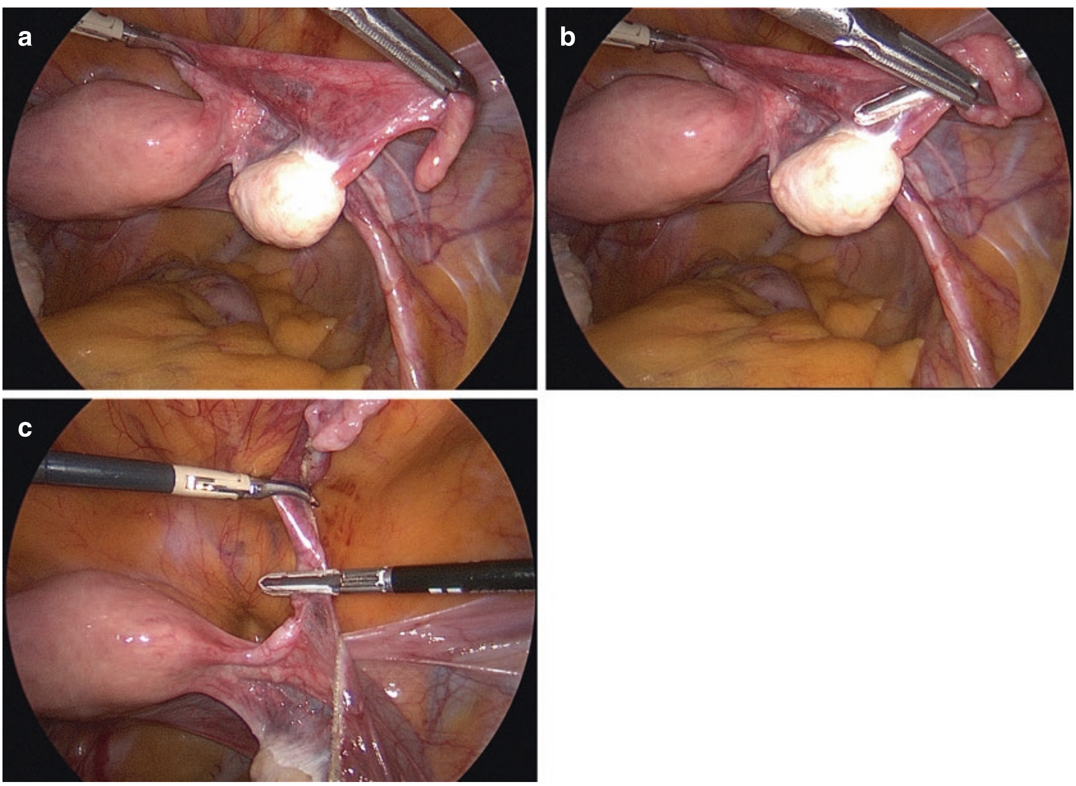

Fig. 4.3 Fallopian tube. (**a**) Fallopian tube grasped at fimbriated and cornual ends and placed on traction. (**b**) Mesosalpinx tube desiccated. (**c**) Fallopian tube transected at cornual end

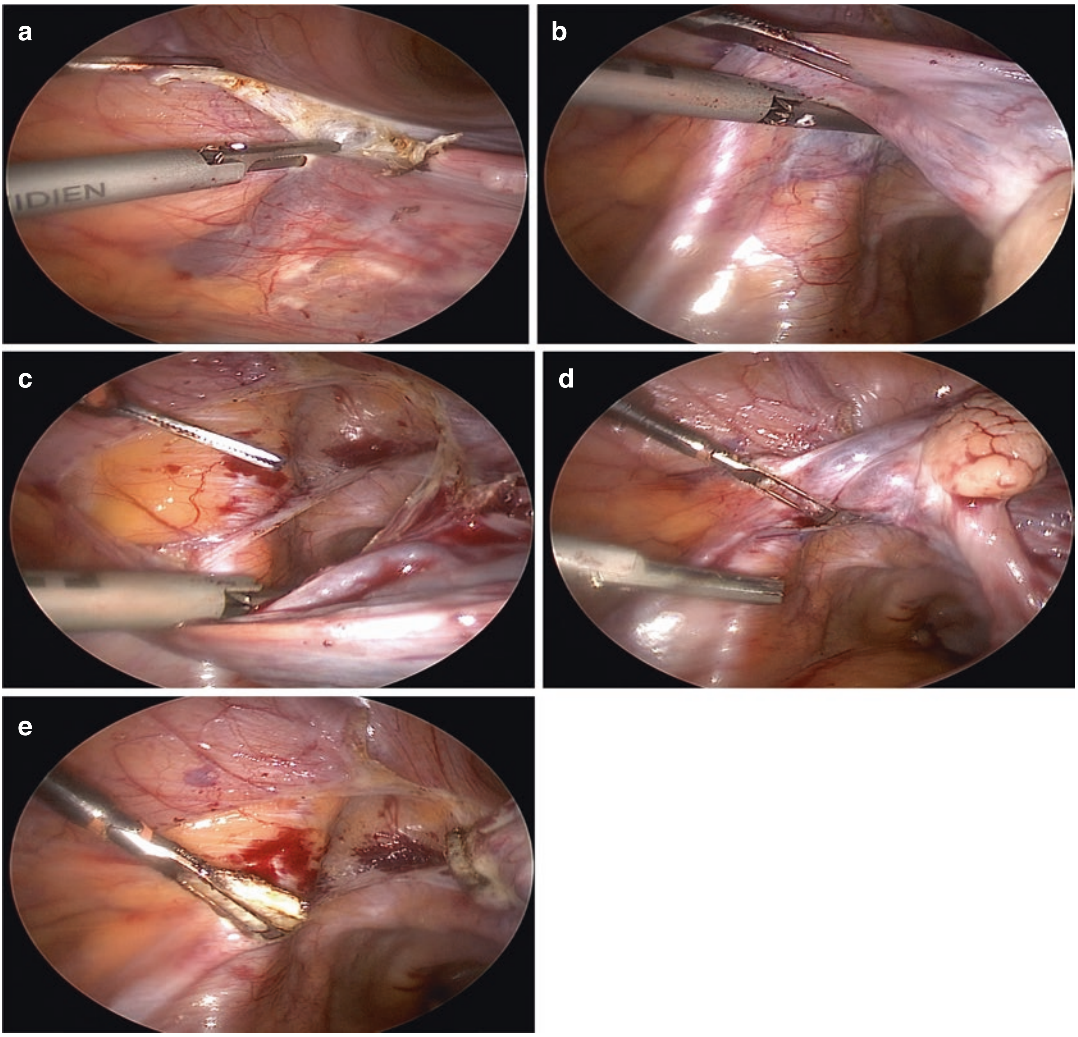

Fig. 4.5 Oophorectomy. (**a**) Division of posterior broad ligament. (**b**) Identification of external iliac and ureter. (**c**) Creation of window in the peritoneum under the IP ligament. (**d**) Desiccation of the IP ligament. (**e**) View of pedicle after division of IP ligament

be divided, and the ovary is placed in the pelvis for later retrieval (Fig. 4.5).

Broad Ligament

Division of the round ligament facilitates the separation of the anterior and posterior leaflets of the broad ligament. The uterine manipulator is adjusted as to move the uterus toward the contralateral shoulder. The anterior and posterior leaflets of the broad ligament are divided to the level of the pericervical cup using preferred energy device. Care must be taken to not injure the uterine vessels that course superiorly over the pericervical cup along the lateral aspect of the uterus (Fig. 4.6).

Bladder Reflection

The vesicouterine peritoneum is grasped, placed on traction, and incised using preferred energy device. The bladder is reflected caudad over the perimeter of the pericervical cup using combination of energy device and blunt dissection technique (Fig. 4.7).

Uterine Vessel Division

The uterine vessels are identified as they course over the perimeter of the pericervical cup toward the cervical isthmus. The uterine vasculature is skeletonized to facilitate efficient desiccation. The uterine vessels are desiccated between the perimeter of the pericervical cup and the cervical isthmus using bipolar electrosurgical instrument and are then divided. The uterine vessels are reflected laterally toward the perimeter of the pericervical cup (Fig. 4.8).

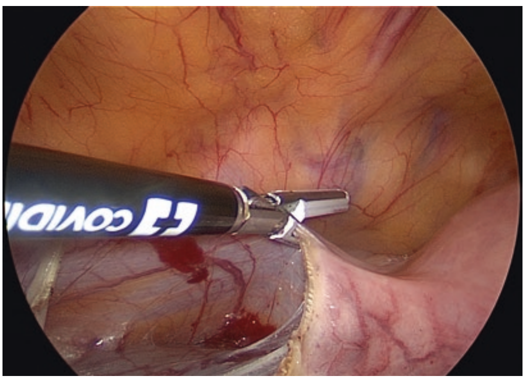

Fig. 4.6 Dissection of anterior broad ligament

Sections "Round Ligament," "Adnexa," "Broad Ligament," "Bladder Reflection," and "Uterine Vessel Division" are performed on the patient's contralateral side.

Hysterectomy

Total Laparoscopic Hysterectomy

Colpotomy

The uterine manipulator is advanced cephalad to define the vaginal fornices and the pericervical cup visualized. The vagina is incised along the pericervical cup with care to minimize thermal spread and unintended thermal injury to the vaginal tissues and nearby anatomy. Pure cut waveform is employed for colpotomy when electrosurgical devices are used. Maximum blade excursion is preferred when ultrasonic scalpel is used for colpotomy. The uterus is removed transvaginally. Contained tissue extraction may be required for large specimens (Figs. 4.9, 4.10, and 4.11).

Vaginal Cuff Closure

Vaginal cuff closure is completed in running or interrupted fashion using delayed absorbable suture via a laparoscopic or transvaginal approach. The objective of cuff closure is to restore the tissues comprising the pericervical

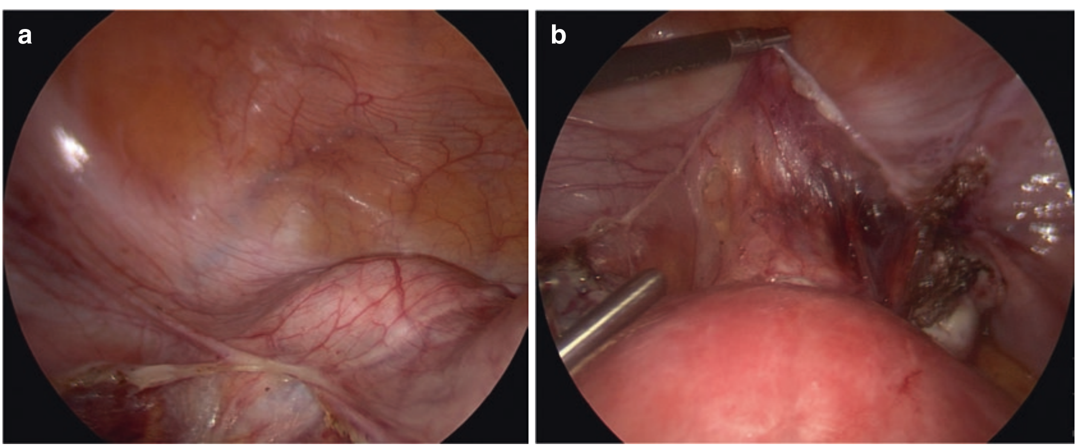

Fig. 4.7 Bladder reflection. (**a**) Vesicouterine peritoneum visualized prior to creation of reflection. (**b**) Peritoneum of bladder reflection lifted off pericervical cup

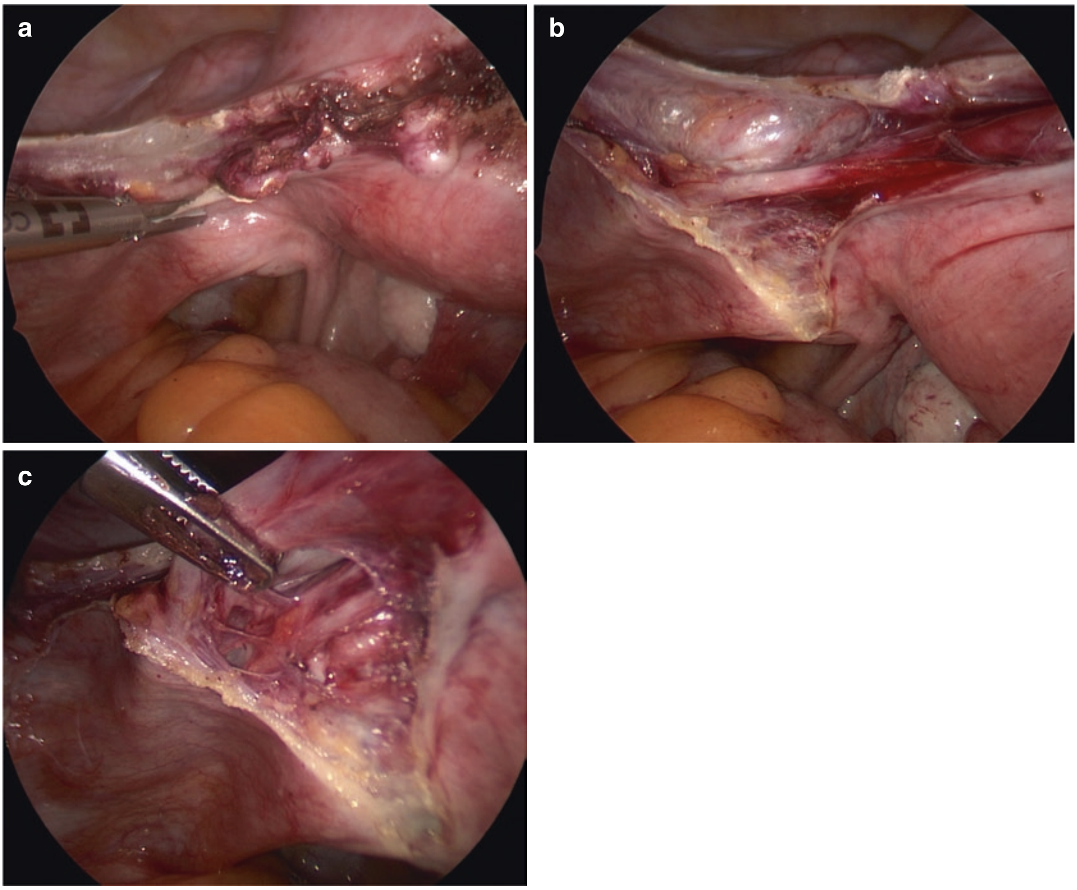

Fig. 4.8 Uterine artery. (**a**) Skeletonization of uterine artery. (**b**) Completely skeletonized uterine artery. (**c**) Desiccation of uterine artery

ring and suspend the vaginal apex to the level of the ischial spines. Care is taken to reapproximate the cardino-uterosacral ligament complex, the anterior and posterior vaginal muscularis, and the vaginal epithelium as to promote durable wound healing and minimize vaginal cuff complications. The use of barbed suture [9] and multilayer closure [10] are techniques associated with reduced cuff complications. Reduced risk of dehiscence is observed with laparoscopic as opposed to transvaginal approach for vaginal cuff closure (Fig. 4.12) [11].

Cystoscopy

Universal cystoscopy following benign hysterectomy decreases the incidence of delayed postoperative urologic complications [5] and is performed after completion of vaginal cuff closure and assuring adequate hemostasis. The urothelium is carefully inspected for incorporated suture, evidence of cystostomy, and abnormal pathology. Observation of brisk ureteral jets from each ureteric orifice to confirms ureteral patency and integrity. Agents such as intravenous methylene blue, intravenous fluorescein, oral phenazopyridine, and intravesicular dextrose 10% solution have been employed to facilitate visualization of ureteral jets (Fig. 4.13).

Laparoscopic Supracervical Hysterectomy

Cervical Amputation

The uterine manipulator is advanced cephalad, the cervical isthmus identified, and cervical

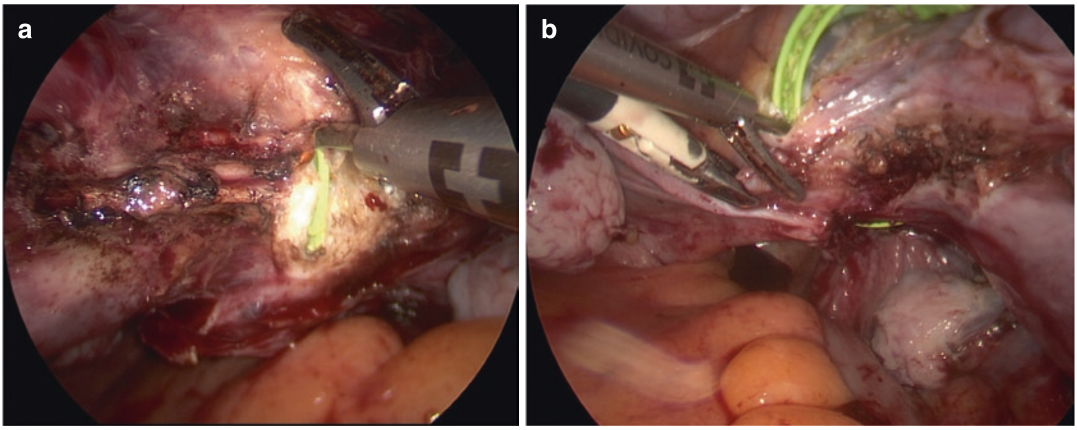

Fig. 4.9 Colpotomy with ultrasonic scalpel. (**a**) Creation of colpotomy on right aspect of cervix with green pericervical cup identified behind vaginal tissue. (**b**) Completion of colpotomy on left aspect of cervix

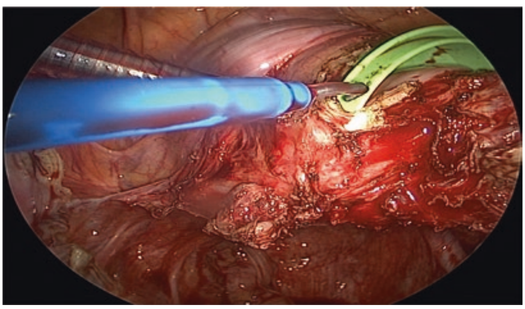

Fig. 4.10 Colpotomy with monopolar "L hook"

amputation completed. Cervical amputation may be performed using electrosurgical electrode, electrosurgical loop, or ultrasonic scalpel. Contained tissue extraction is then performed (Fig. 4.14).

Contained Tissue Extraction

Tissue morcellation is required following laparoscopic supracervical hysterectomy or total laparoscopic hysterectomy when the specimen is too large to remove intact transvaginally. The practice of uncontained morcellation decreased significantly after the issuance of an FDA boxed warning following a report of intraperitoneal dissemination of uterine leiomyosarcoma due electromechanical morcellator use [12]. Techniques for contained tissue morcellation were subsequently developed and can be completed either manually with conventional instruments or electromechanically using commercial devices [13].

Contained tissue extraction with manual morcellation requires the introduction of an approved containment system through a 4-cm transumbilical or suprapubic minilaparotomy incision into the abdomen. The uterus is placed within the containment system under laparoscopic guidance and the opening of the system exteriorized through the minilaparotomy incision. Placement of a self-retaining retractor within the containment system can aid in visualization. The uterine tissue is morcellated using a scalpel with care not to damage the containment system. The integrity of the containment system is confirmed following complete tissue removal. This technique can be adapted for transvaginal contained tissue extraction following total laparoscopic hysterectomy (Fig. 4.15).

Postoperative Care

The Foley catheter is removed in the operating room prior to extubation unless contraindicated.

Enhanced recovery protocols such as maintaining euvolemia, scheduled administration of non-opioid analgesics, and early ambulation are initiated to optimize the patient's recovery [6]. A voiding trial is completed during in the recovery area to exclude postoperative urinary retention

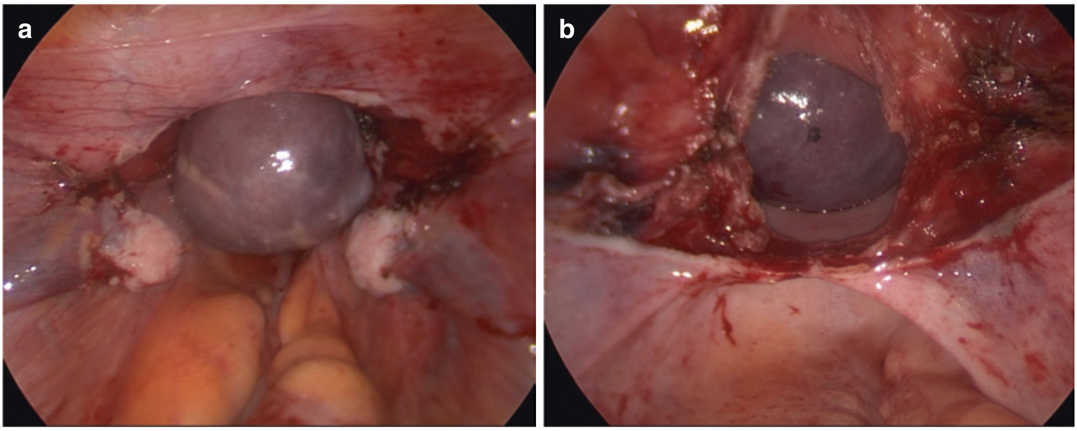

Fig. 4.11 Transvaginal extraction of uterus. (**a**) Uterus brought down through colpotomy into the vagina with the fundus seen at the level of the colpotomy. (**b**) Extraction of uterus through the vagina being completed, with the fundus seen within the vaginal canal

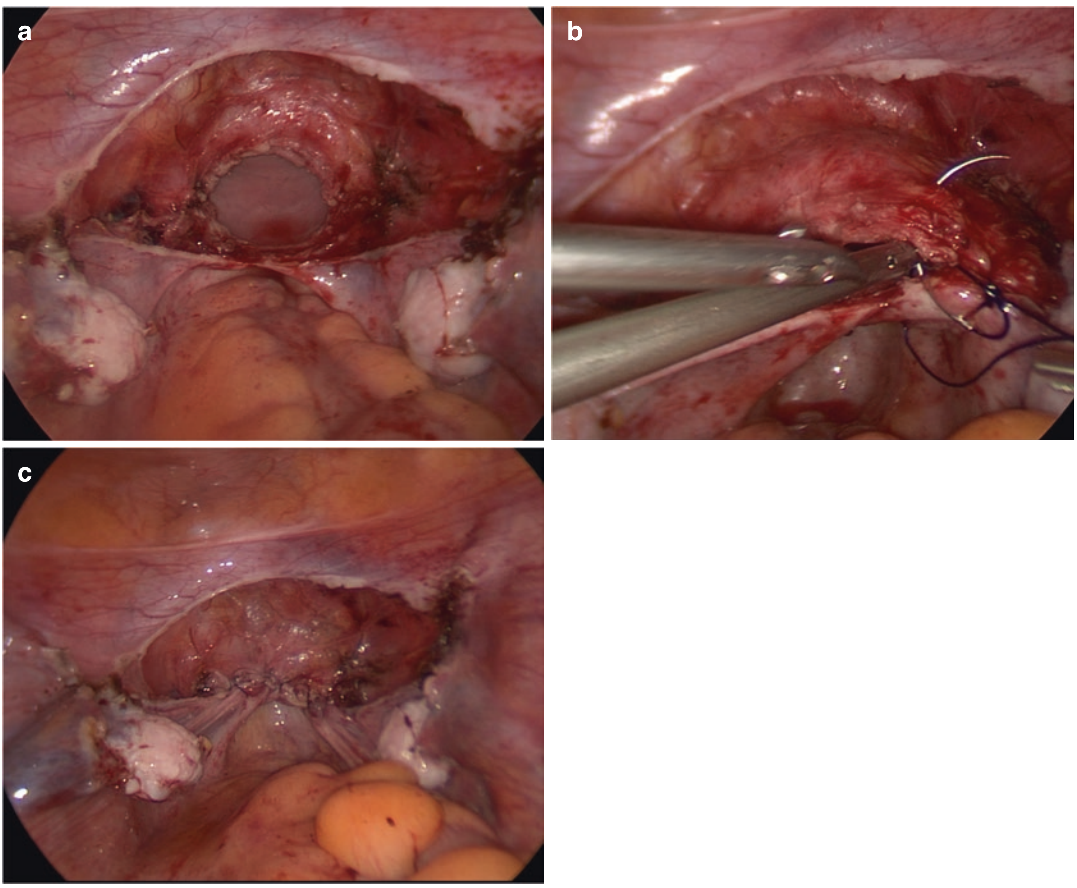

Fig. 4.12 Vaginal cuff closure. (**a**) View of colpotomy after removal of specimen. (**b**) Closure of first layer of vaginal cuff. (**c**) Completed two-layer closure for vaginal cuff

[14]. The patient is discharged from the postanesthesia care unit after they have adequate pain control and are ambulating independently and tolerating oral intake.

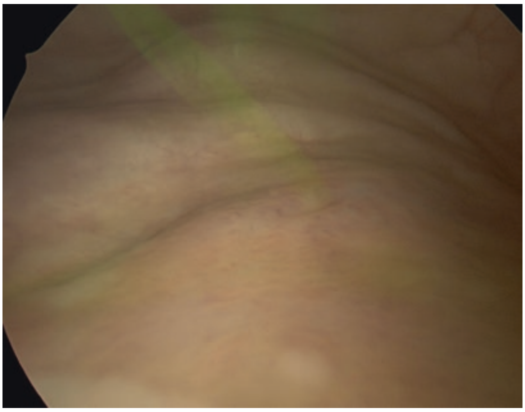

Fig. 4.13 Ureteral jet, colored by fluorescein, visualized from ureteral orifice

Home pain regimen consists of scheduled non-opioid analgesics such as acetaminophen and nonsteroidal anti-inflammatory drugs along with a limited quantity of opioid analgesics for breakthrough pain. A scheduled bowel regimen is prescribed to facilitate return of bowel function. A large part of a successful transition from the outpatient unit to home is preoperative management of expectations: the patient and the family know that the patient is being discharged on the same day and what her limitations might be.

Patients are advised to limit strenuous activity and maintain pelvic rest for 6 weeks. The patient will be scheduled for periodic postoperative visits to track their recovery. They are counseled to continue routine gynecologic care.

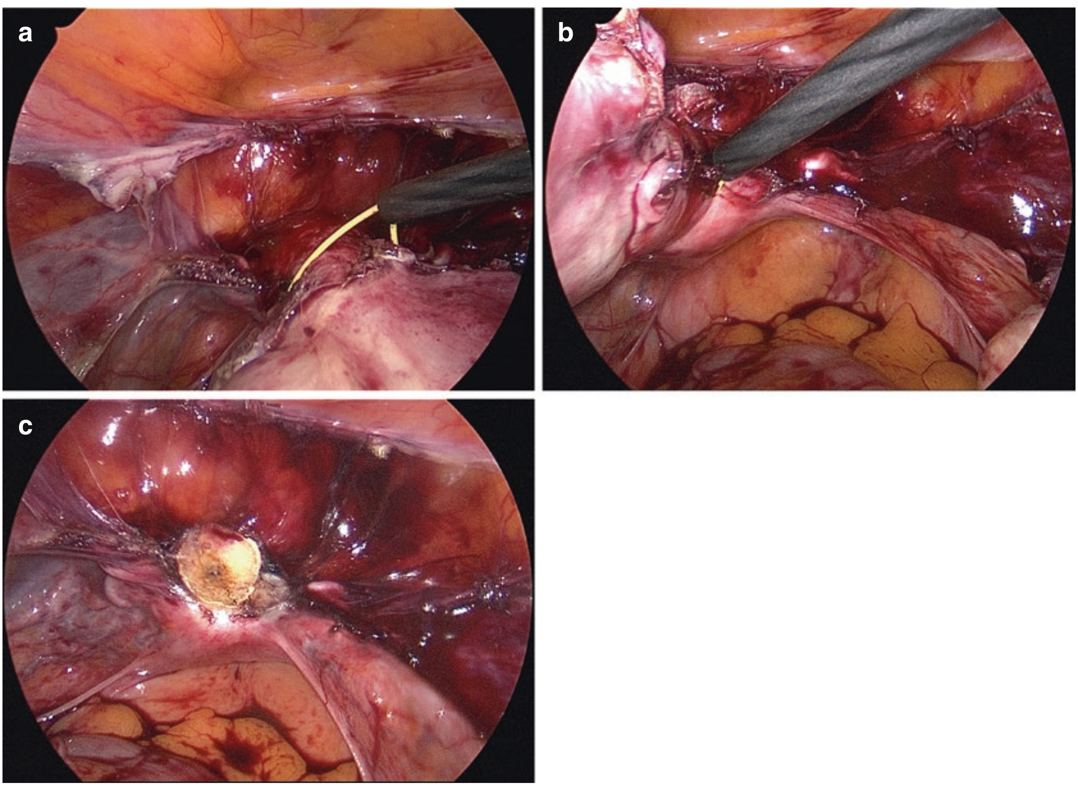

Fig. 4.14 Supracervical hysterectomy completed with LiNA loop. (**a**) Device looped around uterus and positioned at the level of the cervical isthmus. (**b**) Loop tightened in preparation to transect cervix. (**c**) Cervical stump visualized after completion of transection

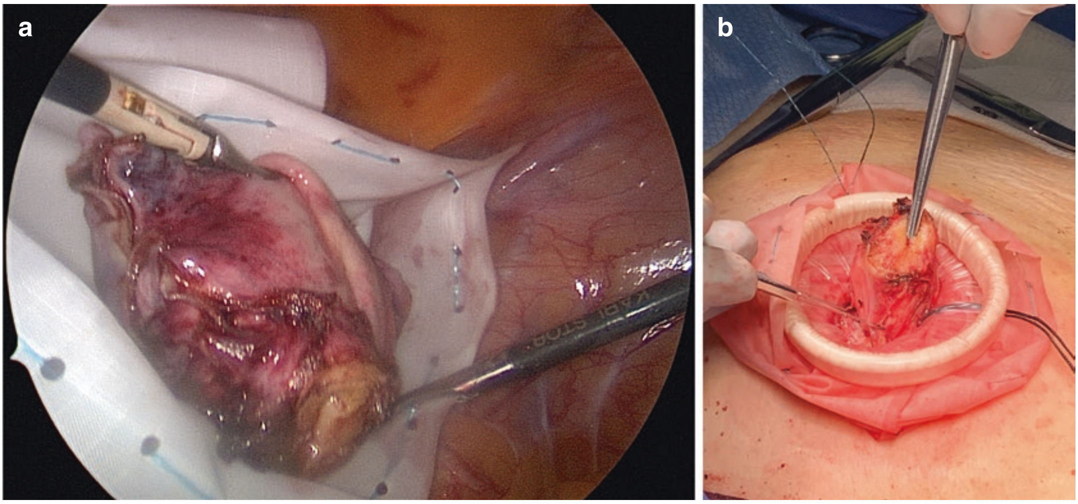

Fig. 4.15 Contained tissue extraction. (**a**) Specimen placed in bag using laparoscopic technique. (**b**) Specimen morcellated transabdominally in contained fashion with scalpel

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5 Laparoscopic Excision of Endometriosis

Angelina Carey-Love, Miguel Luna-Russo, and Cara R. King

Introduction

Endometriosis is a gynecologic disease that affects approximately 10% of reproductive age women worldwide, with the rate of diagnosis highest in Caucasian and Asian women compared with Black and Hispanic women [1, 2]. The disease is defined as the presence of endometrial-like tissue outside of the uterine cavity, and while lesions are primarily located within the pelvis, they can be found at distant sites including the diaphragm, pleural cavity, and central nervous system. The inflammatory effects and associated fibrosis of ectopic endometrial tissue can lead to significant symptomatology in women, including pelvic pain, dysmenorrhea, dysuria, dyschezia, and infertility. The majority of women with endometriosis will experience chronic pelvic pain and up to 50% of women experience infertility [3]. Symptoms can be vague and are often inappropriately normalized with the average time from presentation to diagnosis being delayed at 7–10 years [4–6]. Clinical management should involve a multidisciplinary approach and may involve pharmacologic and surgical intervention. This chapter focuses on the surgical approach and techniques involved in diagnosing and treating endometriosis.

Clinical Aspects

Pathogenesis

There are multiple theories regarding the pathophysiology of this disease, including Sampson's theory of retrograde menstruation, coelomic metaplasia, Mullerianosis, and lymphatic and hematogenous spread. No single theory explains all presentations, and all theories likely contribute to the global etiology with some patients encompassing multiple phenotypes [7].

There are different phenotypes of endometriosis, which are largely categorized by location and depth of the disease, specifically, superficial, ovarian, and deep infiltrating lesions [8]. Superficial endometriosis, primarily located on the peritoneum, is defined as lesions that are <5 mm deep. Techniques for surgical management of superficial lesions include excision and ablation. Although studies comparing the two techniques are limited, excision of superficial implants has been shown to be more efficacious at improving patient symptoms postoperatively

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than ablation [9]. Endometriomas occur when ectopic endometrial tissue grows on the ovary leading to a cyst filled with chocolate-colored fluid. This type of endometriosis can be treated with ablation techniques, cystectomy, or the more definitive option of oophorectomy. Decision on technique must include consideration for the patient's desire for future fertility as ovarian sparing techniques can cause trauma to healthy ovarian cortex and follicles, which can negatively affect ovarian reserve [10]. Ablation of endometriomas has been shown to cause less ovarian damage than cystectomy; however, recurrence rates are thought to be lower with cyst excision [10]. Deep infiltrating endometriosis (DIE) occurs when lesions extend greater than 5 mm beyond the peritoneal surface and can involve both gyn and non-gyn organs, particularly bowel and bladder. Surgical management of DIE of the bowel depends on the size and extent of the disease and includes shaving, discoid excision, and segmental bowel resection.

Diagnosis

Traditionally the diagnosis of endometriosis has required histologic confirmation. This gold standard of diagnosis requires laparoscopy and tissue resection, essentially requiring a surgical intervention to provide a diagnosis. Clinical diagnosis of endometriosis has been proposed, with the use of clinical history aided by physical examination shown to be highly specific [4, 11].

Gynecologic pelvic ultrasound and magnetic resonance imaging have been shown to be useful in the preoperative diagnosis of deep infiltrating endometriosis (Fig. 5.1). Both imaging modalities have similar accuracy in the diagnosis of deep endometriosis of the anterior, middle, and posterior pelvic compartments with a sensitivity of >85% and specificity >95% [12]. The use of structured imagining reports has proved to be a useful tool for preoperative counseling and coordination of multidisciplinary surgical care [13].

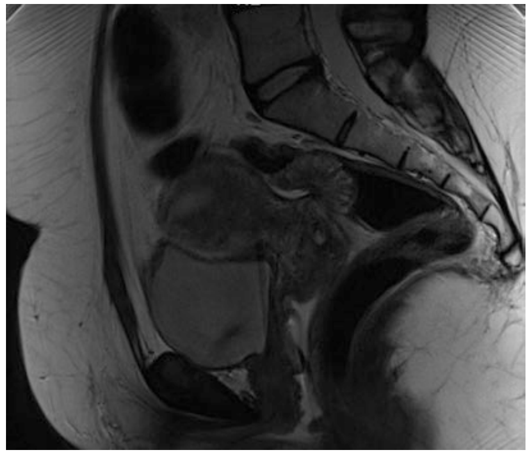

Fig. 5.1 Magnetic resonance imaging with deeply infiltrating endometriosis infiltrating the rectosigmoid colon

Treatment

Treatment strategies for endometriosis depend on a multitude of factors and should be individualized for each patient. Clinical presentation, severity of symptoms, location and extent of lesions, patient age, and future fertility desires should all be considered when determining a treatment plan. The goal of therapy should be to avoid multiple surgeries and maximize medical treatment when appropriate [14]. Pharmacologic therapies typically include hormonal drugs that suppress ovulation and menstruation, which may include combined estrogen-progesterone medications, progesterone-only methods, GnRH agonists and antagonists, danazol, or aromatase inhibitors. Surgical intervention is often recommended when medical treatment is contraindicated or fails to control symptoms or to aid in assisted reproduction.

Surgical Management of Endometriosis

The benefits of laparoscopic surgery over an open approach are clear including improved postoperative pain, shorter hospital stay, decreased wound infection, enhanced visualization, and faster patient recovery [15, 16]. Operative time, intraoperative and postoperative complications, and quality-of-life scores are similar between conventional laparoscopy and robotic approaches [17].

The ultimate goal of surgery remains performing the correct procedure on the first laparoscopy with subsequent pain relief, fertility optimization, and improvement in quality of life. Multiple surgeries should be avoided with a thorough preoperative workup, inclusion of a multidisciplinary team when appropriate, and dedicated preoperative counseling being paramount to reach this goal. Surgical approaches include ablative or excisional techniques, with full excision typically being preferred to allow for pathologic diagnosis and confirmation of full removal over delicate structures such as bladder, bowel, or ureters.

Indications

When surgery is indicated, the extent of excision of deeply infiltrative endometriosis should be based on the patient's symptoms and goals. In patients who desire immediate fertility, the most comprehensive surgery should be performed whilst preserving the integrity of the uterine tubes and ovaries. In those who do not desire future childbearing, hysterectomy with or without oophorectomy can be considered. When surgery is planned, preoperative imaging is essential for evaluation of deeply infiltrating lesions. If deep lesions are suspected on the bladder, bowel, ureters, or diaphragm, collaboration with a multidisciplinary team may be indicated depending on the surgical skill and comfort of the gynecologic surgeon. Expert knowledge of pelvic anatomy and advanced skills in laparoscopy are essential for safe excision of endometriosis, given the complexity of these surgeries and often times significantly distorted anatomy.

Laparoscopic Techniques

Sound surgical technique begins with careful attention to patient positioning. The patient should be placed atop a nonslip table pad in the dorsal lithotomy position, with arms tucked at the side and careful attention to pressure points. Consideration of ureteral stent placement should be given if deep intrinsic or extrinsic ureteral disease is suspected. A uterine manipulator may be considered to aid in visual exposure of the pelvic compartments. A cervical cup can be helpful in identifying the rectovaginal space in patients with an obliterated posterior cul-de-sac and assist with colpotomy for upper vaginectomy when indicated. Abdominal entry classically occurs at the umbilicus, and technique (Veress, open Hasson, direct optical) should be selected by the surgeon based on skill set [18]. Accessory 5 mm ports are then inserted with attention placed on optimization of triangulation between ports.

Endometriotic lesions can have various appearances, including classic red-brown, black, or dark bluish lesions. Less obvious lesions may appear as clear or opaque, fibrotic plaques, or defects in the peritoneum known as Allen-Master windows (Fig. 5.2a–d) [19–21].

The abdominopelvic survey should be detailed and systematic, ensuring complete visualization of the uterus, bilateral ovaries and uterine tubes, anterior and posterior pelvic compartments, bilateral ovarian fossae, uterine ligaments, sigmoid, rectum, cecum, appendix, terminal ileum, and diaphragmatic peritoneum. The surgeon may consider verbally listing the sites affected with endometriosis while performing the survey. This allows the surgical team to understand the extent of the anticipated procedure and ensure all areas described are addressed.

Treatment of Superficial Endometriosis

Superficial endometriosis can be surgically managed with either ablative or excisional techniques. Ablation causes destruction of lesions by the use of electrosurgery down to the level of normal tissue. Excision of endometriotic implants is performed with electrosurgery or sharp dissection and typically requires development of retroperitoneal spaces to protect underlying vital structures. It should be noted that many endometriotic

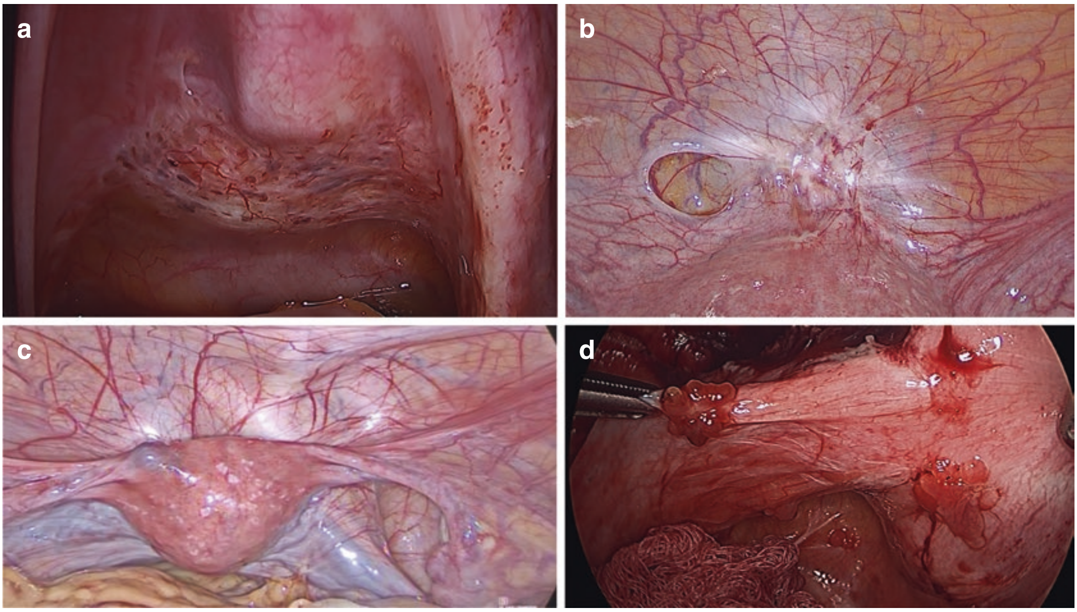

Fig. 5.2 Various appearance of endometriosis. (**a**) Red brown lesions. (**b**) Allen master window and white stellate lesion. (**c**) White lesions. (**d**) Red papillary lesions

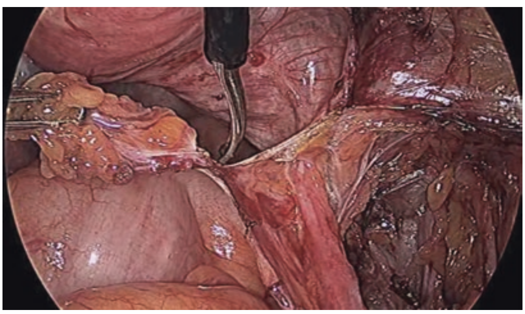

Fig. 5.3 Excision of deeply infiltrating endometriosis lesion adjacent to the right ureter

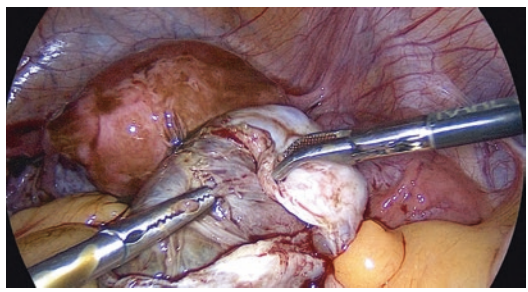

Fig. 5.4 Excision of right ovarian endometrioma cyst wall

lesions have an "iceberg" effect with the deepest margin of the lesion being difficult to identify without full excision (Fig. 5.3). Ablation of deep endometriosis lesions should be avoided as deeply infiltrating lesions are often deeper than they appear. Ablating over structures such as the bladder, bowel, and ureters may lead to thermal damage that manifest in the postoperative period.

Treatment of Ovarian Endometrioma

There are different techniques to surgically manage ovarian endometriomas, which include cyst drainage, coagulation, and complete excision of the cyst wall. When determining which method to utilize, factors such as size, symptoms, patient age, and fertility desires should be considered. Impact of ovarian reserve and recurrence rates are lower when the cyst wall is excised, and women who undergo this method of excision achieve conception at higher rates [15]. Complete cystectomy is typically the preferred approach (Fig. 5.4). Care should be taken to restore anatomy prior to ovarian cystectomy to decrease the risk of damage to the ovarian blood supply. Inadvertent rupture of the cyst and its chocolate-colored hemorrhagic material is common, as endometriomas do not have a true cyst wall [22]. Injection of vasopressin

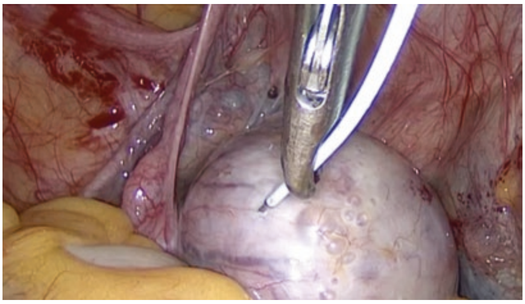

Fig. 5.5 Injection of vasopressin solution below ovarian cortex of right endometrioma

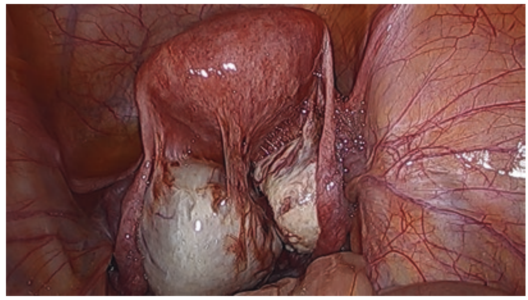

Fig. 5.6 Obliteration of posterior cul-de-sac secondary to stage IV endometriosis

solution between the ovarian cortex and ovarian stroma with a butterfly needle or Williams cystoscopic needle can be beneficial in assisting with hemostasis and hydrodissection (Fig. 5.5). Once the cystectomy is complete, bleeding from the ovary can be controlled with sutures or hemostatic agents, which are preferred over the use of electrosurgery which can cause damage to the normal ovarian tissue [23].

Excision of Deeply Infiltrating Endometriosis

Deeply infiltrating endometriosis can cause significant scarring of the pelvic structures and lead to a complete obliteration of the posterior cul-de-sac, also known as a "frozen pelvis" (Fig. 5.6). Distortion of the pelvic anatomy is common in endometriosis, and when this occurs, it is critical that the surgeon carefully re-establishes the normal anatomical landmarks. A thoughtful and deliberate approach is critical to optimize efficiency and decrease complications. It is essential to master retroperitoneal anatomy including the pararectal, paravesical, vesicovaginal, rectovaginal, and presacral spaces to maximize safety. Surgical principles include identification of vital structures including major vasculature, ureters, pelvic nerves, bladder, and bowel before proceeding with excision. Identifying normal anatomy first and moving into areas of anatomical distortion and fibrosis maximizes safety and efficiency. With an obliterated posterior cul-de-sac, the dissection is typically started high on the pelvic brim or presacral space where anatomy is commonly preserved. Maximizing visualization with oophoropexy or bowel pexy can be beneficial in maximizing working instruments and freeing an assistant hand (Fig. 5.7). Care should be made to preserve pelvic nerves to optimize postoperative bowel and bladder function (Fig. 5.8) [24]. A colpotomy cup can be helpful in delineating the borders between the posterior vaginal fornix and the rectum, and an EEA sizer can help accentuate the borders of the rectum.

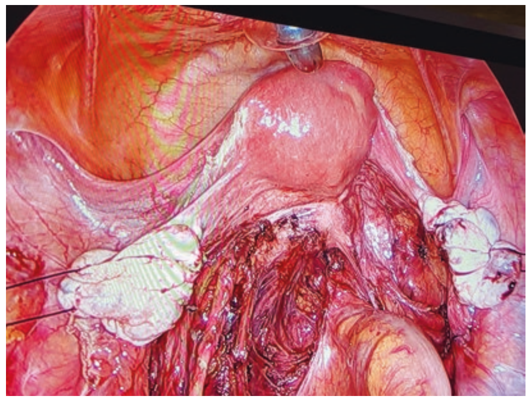

Fig. 5.7 Bilateral temporary oophoropexy to optimize visualization during stage IV endometriosis excision

Resection of Bowel Endometriosis

Bowel involvement is estimated to occur in 8–12% of patients with endometriosis [25]. These lesions can range from superficial lesions involving the outer serosa to invasive disease involving full-thickness mucosa infiltration.

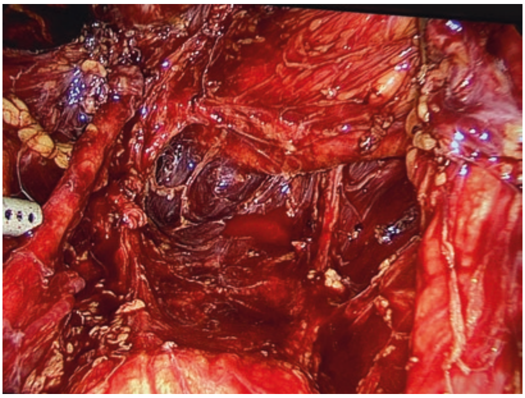

Fig. 5.8 Preservation of bilateral hypogastric nerves during bowel resection for deeply infiltrating endometriosis

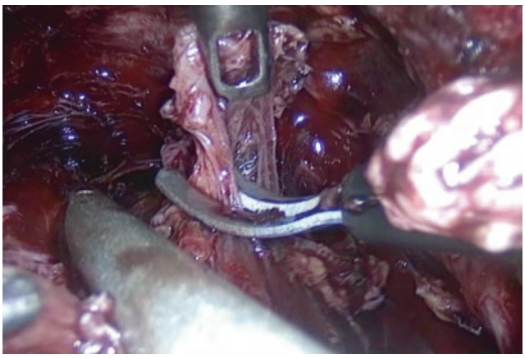

Fig. 5.9 Bowel shave for excision of rectosigmoid endometriosis

Involvement of the bowel can cause substantial gastrointestinal symptoms, including nausea, vomiting, bloating, constipation, dyschezia, dyspareunia, and even bowel obstruction. Surgical techniques for excision depend on size and location of lesions and include shaving, discoid excision, and segmental resection. The colorectal surgery team is often included for invasive bowel disease based on the gynecologic surgeon's comfort with bowel surgery.

Bowel Shaving

The bowel shaving technique is most appropriate for non-skip lesions that are ≤3 cm involving the rectal muscularis. Shaving involves removal of the lesion and surrounding muscular layers without entering the lumen of the bowel (Fig. 5.9). The serosal defect is then closed using an absorbable suture, perpendicular to the longitudinal axis of the bowel to avoid constricting the lumen.

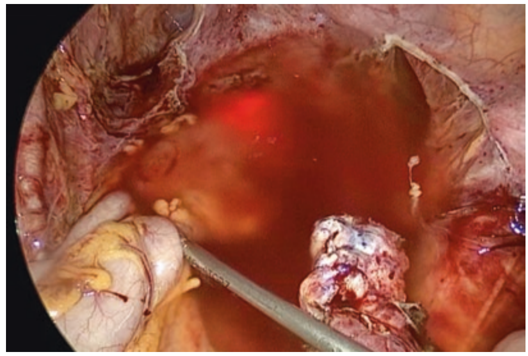

Fig. 5.10 Negative proctoscopy bubble test to confirm bowel integrity

Discoid Excision

Discoid excision can be considered for non-skip lesions that are ≤3 cm involving the entire rectal muscularis. Closure should be performed in two layers with absorbable sutures. An air leak test, or "bubble test," should be performed following closure to ensure a water tight seal (Fig. 5.10). This can be performed by filling the pelvis with saline solution, occluding the proximal sigmoid colon with gentle pressure from a laparoscopic grasper, insufflating the rectum with air, and observing for the emergence of bubbles, which suggests a rectal leak. If this occurs, the defect should be repaired and the bubble test repeated.

Bowel Resection

When bowel lesions are >3 cm, invade the rectal mucosa, or involve >50% of the bowel wall circumference, segmental resection and reanastomosis should be performed (Fig. 5.11a, b). Other indications include multifocal lesions and stenosis of the lumen. The most common location, accounting for >90% of segmental resections, is at the rectum [26]. Once resection and reanastomosis are performed, a bubble test should be performed to ensure proper closure. Strong consideration should be given to performing a diverting stoma for anastomoses that are within 5 cm of the anal verge, as the risk for leakage is significant [27]. When deeply infiltrating endometriosis lesions infiltrate through the vagina, it

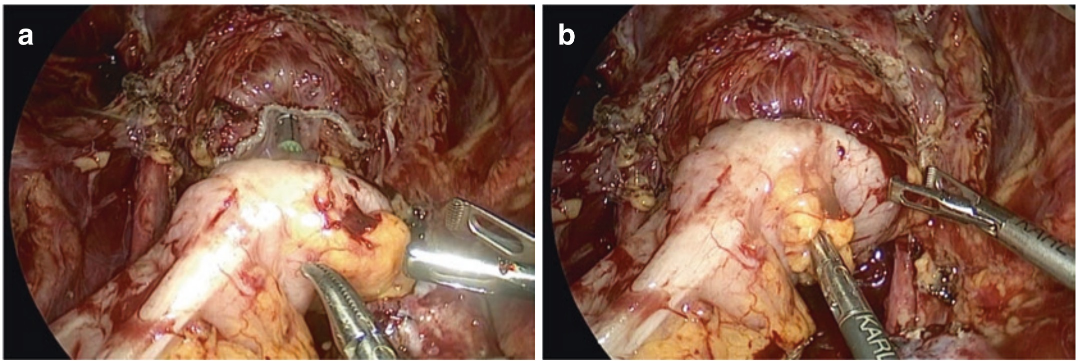

Fig. 5.11 (**a**, **b**) Low anterior bowel resection indicated for deeply infiltrating rectosigmoid endometriosis

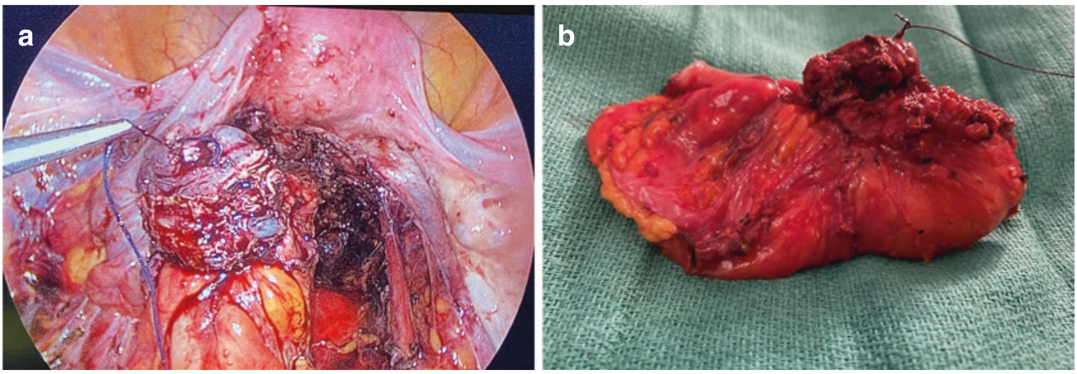

Fig. 5.12 (**a**, **b**) Deeply infiltrating vaginal lesion is removed en bloc with rectosigmoid colon for deeply infiltrating endometriosis. Stitch has been placed through vaginal lesion

can be helpful to place a stitch through the lesion vaginally. Once colpotomy is created laparoscopically, with or without hysterectomy, the stitch can then be pulled into the abdomen to assist with tension and complete removal of the vaginal nodule. In our practice, we often remove the vaginal nodule and rectal nodule en block (Fig. 5.12a, b).

Resection of Bladder Endometriosis

Bladder endometriosis can occur superficially along the serosa, or deep within the detrusor muscle. The most common place for bladder involvement is the posterior bladder adjacent to the uterus. Surgical excision of these lesions should be complete to reduce recurrence and can be performed with a shaving technique for serosal involvement, or full-thickness resection for deeper lesions [28]. In our practice, we typically place a suture through the bladder nodule and maintain a long suture tail to assist in providing traction on the nodule during excision. It is important to evaluate for the location of the ureteral orifices during nodule resection to confirm adequate distance between the resection margin and trigone. Depending on the size of the lesion, the cystotomy should be closed in one to three layers, using 2-0 delayed absorbable monofilament suture. Research has shown that unidirectional barbed suture is also appropriate if desired [29]. After closure, the bladder should be backfilled to confirm a water tight seal. A Foley catheter should be inserted and left in place for 7 days to prevent fistula formation and optimize healing.

Thoracic Endometriosis

Thoracic endometriosis (TE) encompasses lesions involving the diaphragm, parietal pleura, and the lung parenchyma. The majority of patients with TE present with cyclic (catamenial) right upper quadrant pain, pleural effusions, or pneumothorax [30]. When the phrenic nerve is involved, pain is referred to the shoulder or scapula. The incidence of thoracic endometriosis is unknown. In systematic review conducted by Marina P. et al. evaluating all sites of extra pelvic endometriosis, 80% of TE patients presented with isolated right-sided diaphragmatic lesions. In patients with persistent and debilitating symptoms refractory to medical therapy, surgical management is indicated [1]. MRI should be the imaging of choice for the evaluation of TE [31].

Surgical management of diaphragmatic lesions should be a multidisciplinary effort. When full-thickness excision of the diaphragm is required, thoracic surgery and anesthesia should be involved in the patients' preoperative evaluation. A double lumen endotracheal tube should be utilized in to manage a breech into the pleural cavity. Trocar position should allow optimal triangulation for liver retraction, mobilization, and laparoscopic suturing. Intraoperative ultrasound can be helpful in cases of reoperation, and anatomic distortion due to fibrosis is present [32].

Conclusion

Laparoscopy plays an integral role in the diagnosis and treatment of endometriosis. Patients with symptoms not responsive to pharmacotherapies and those with evidence of deeply infiltrating lesions should undergo surgical management. Goals of surgery include obtaining a histologic diagnosis, reducing pain symptoms, and improving fertility outcomes. Given the inflammatory nature of this disease, adhesions and fibrosis are common and can cause significant distortion of the pelvic organs. Surgeons must possess a highly sophisticated understanding of pelvic anatomy as well as laparoscopic skills to maximize surgical safety and efficiency. Preoperative imaging and planning are crucial for optimizing patient counseling and maximizing surgical interventions and outcomes.

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6 Techniques in Gynecologic Oncology

Travis T. Sims and Michael Frumovitz

Introduction

In the 1960s, gynecologists developed laparoscopy as a means to visualize pelvic anatomy and quickly innovated from diagnostic to operative laparoscopy by performing tubal ligations in the 1970s. However, in the 1980s, urologists led the development of the approach for the treatment of cancer, with gynecologic oncologists trailing the uptake with minimal utilization throughout the 1990s. In 2003, a minority of gynecologic oncologists felt that a minimally invasive approach was appropriate for treating any pelvic malignancy [1]. However, less than 5 years later, the majority of gynecologic oncologists recognized the value of patient care and oncologic equivalence in relation to minimally invasive surgery [2]. As frequently happens with new technologies and procedures, widespread adoption into clinical care often occurs based on retrospective studies, clinical judgment, and expert opinion. This, too, has been the case in gynecologic oncology, in which minimally invasive surgery was routinely employed to treat women with uterine, cervical, and ovarian cancers. Widespread adoption before trials were complete ultimately proved safe in the treatment of uterine cancer however may have actually harmed patients with cervical cancer.

For women with uterine cancer, many gynecologic oncologists were performing minimally invasive hysterectomy, and staging long before the data showed it was oncologically equivalent to open surgery. In 2012, however, results from the LAP2 study were published [3]. This randomized study of 2616 women with uterine cancer confirmed what all had assumed: open and minimally invasive approaches to uterine cancer had equivalent disease-free and overall survival rates [4]. Furthermore, women who underwent laparoscopy had better short-term quality of life and shorter hospital stays than those who had laparotomy. Interestingly, long-term (6 months) quality-of-life characteristics were equivalent [4]. In 2017 a second phase III trial, the LACE study confirmed the safety of minimally invasive hysterectomy for women with clinical stage I uterine cancer [5]. This study randomized 760 women to either open or minimally invasive surgery. Recurrence rate, disease-free survival, and overall survival were equivalent between the two groups.

Similar to the treatment of women with uterine cancer, a majority of patients with cervical cancer were being offered a minimally invasive approach for treatment prior to the publication of

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the LACC trial in 2018. Typically, radical hysterectomy and bilateral pelvic lymphadenectomies are performed for stage IA2/IB1 disease as well as for stage IA1 disease with high-risk features such as lymphovascular space invasion. Historically, the oncologic equivalency of this approach in these tumors had been supported by retrospective studies that demonstrate equivalent pathologic parameters and recurrence rates, not survival [6, 7]. But recently minimally invasive laparoscopic radical hysterectomy has come into question. In the prospective, phase III, multicenter, randomized Laparoscopic Approach to Cervical Cancer noninferiority trial, Ramirez et al. [8] reported on 631 women with FIGO 2014 stage IA1 (lymphovascular invasion), IA2, or IB1 cervical cancer, who were randomly assigned to minimally invasive laparoscopic radical hysterectomy (n = 319) or open radical hysterectomy (n = 312). The data and safety monitoring committee made the final recommendation that the trial be permanently and prematurely closed to new patient enrollment because of an imbalance in deaths. The minimally invasive laparoscopic radical hysterectomy DFS at 4.5 years was 86.0% compared with 96.5% for open radical hysterectomy (95% CI, −16.4% to −4.7%) [8]. The disparity persisted after accounting for age, body mass index, stage of disease, LVSI, lymph node involvement, and performance status score. More than 90% of tumors were FIGO 2014 stage IB1, with FIGO stage IA cancers (and lesions <2 cm) underrepresented. Poor mortality rates associated with minimally invasive laparoscopic radical hysterectomy were also reported by Melamed et al. [9] using the SEER and National Cancer Databases. Multi-institutional studies in the USA and Europe have also confirmed worse outcomes for women with early-stage cervical cancer who undergo a minimally invasive approach compared to open surgery [10, 11].

Although the exact mechanism of action to explain the findings is still under investigation, the data are concerning, and open radical hysterectomy is now the recommended route to be performed for FIGO 2018 stage IA1 with LVSI – stage IB2 cervical cancer. The National Comprehensive Cancer Network (NCCN), the European Society of Gynecological Cancer (ESGO), the European Society for Medical Oncology (ESMO), and the International Federation of Gynecology and Obstetrics (FIGO) all now recommend an open approach to radical hysterectomy for cervical cancer. Minimally invasive radical hysterectomy, however, may still be considered for clinical stage II uterine cancer.

Unlike uterine and cervical cancers, the appropriateness of a minimally invasive approach for women with ovarian cancer remains controversial[2] because the goal of surgery for women with ovarian cancer is complete cytoreduction to microscopic disease. For women with stages III and IV disease, we believe strongly that optimal cytoreductive surgery can only be achieved through a laparotomy via a vertical incision, and we do not perform minimally invasive surgery for tumor debulking in these patients. However, some have advocated a diagnostic laparoscopy in patients with obvious metastatic disease to assess for resectability of tumors [12, 13]. This use of minimally invasive surgery may be appropriate in women with widely metastatic disease. For women with clinical stage I disease, a minimally invasive surgery and staging are reasonable. The necessary staging surgery for ovarian cancer, including exploration, peritoneal biopsies, omentectomy, and pelvic and para-aortic lymphadenectomies can be done laparoscopically [14, 15]. For these patients with disease limited to the ovaries, a minimally invasive surgery seems equivalent to a laparotomy [16].

Prior to the development of sentinel lymph node (SLN) mapping, complete lymphadenectomy of the pelvic and para-aortic lymph nodes was the dominant strategy as part of the initial management and staging of endometrial cancer. Evaluation of nodal spread continues to be an important strategy despite the fact that two randomized trials evaluating systematic pelvic lymphadenectomy compared with no lymphadenectomy showed a lack of benefit with respect to recurrence or survival [17, 18], because spread to the pelvic and para-aortic lymph nodes has significant prognostic value, and adjuvant therapy decisions are often made based on nodal involvement [19, 20]. But complete lymphadenectomy is also associated with significant morbidity, including irreversible lymphedema [21, 22], as well as short-term risks that included prolonged surgical times and increased blood loss [23]. Selective lymphadenectomy based upon intraoperative pathology allows restriction of these procedures to a population enriched for increased risk of lymphatic disease but is limited by the sensitivity and specificity of frozen section results and still exposes a large population of women without lymphatic disease to a morbid procedure.

Over the last decade, SLN mapping and biopsies have assumed a dominant role in evaluation of lymphatic spread in women with endometrial cancer [24]. Data emerged showing that lymphatic mapping and sentinel node biopsy may be adequate for women with early-stage cervical cancer (tumors <2 cm) [25–27]. Although no randomized trials have directly compared standard lymphadenectomy verses SLN mapping, multiple single- and multi-institution prospective studies have verified a high sensitivity for detection of metastases, low false-negative rates, and comparable oncologic outcomes when combined with pathologic ultrastaging and use of a sentinel node staging algorithm (indocyanine green dye injection into the cervix, bilateral SLNs are identified and removed, or a side-specific lymphadenectomy is performed if the SLN is not identified) [28–32]. A key component of SLN mapping has been pathologic ultrastaging, which has the ability to detect low-volume disease to the lymph node such as micrometastases and isolated tumor cells (ITCs). The American Joint Committee on Cancer staging classifies the size of the metastasis to the lymph node as ITCs (<0.2 mm), micrometastases (0.2–2 mm), and macrometastases (>2 mm) [33]. Given the increased detection of low-volume disease with SLN mapping, a current challenge is defining appropriate adjuvant treatment of ITCs without overtreatment. Concurrent with the incorporation of SLN biopsy in endometrial cancer staging has been data to support a survival advantage to women treated with systemic chemotherapy who are found to have lymphatic metastases at diagnosis [34, 35].

In this chapter, minimally invasive procedures that are unique to gynecologic oncology are described and include radical hysterectomy, pelvic and para-aortic lymphadenectomy, and omentectomy. Although most associate radical hysterectomy with cervical cancer, para-aortic lymphadenectomy with uterine cancer, and omentectomy with ovarian cancer, these procedures may be used for any gynecologic malignancy. For example, a patient with clinical stage II uterine serous carcinoma may undergo a radical hysterectomy, pelvic and para-aortic lymphadenectomies, and omentectomy.

Total Laparoscopic Radical Hysterectomy

General Considerations

As mentioned, minimally invasive radical hysterectomy should no longer be utilized for the treatment of women with early-stage cervical cancer. Multiple international guidelines and societies recommend open surgery as the "gold standard" for treating women with this disease. This procedure, however, may be considered in treating a subset of women with clinical stage II uterine cancer.

A radical hysterectomy removes not only the uterine fundus and cervix (as in a simple hysterectomy) but also a portion of the upper vagina and parametrium en bloc. Removal of these additional margins is what classifies the procedure as "radical" and what increases the operative morbidity and technical difficulty beyond those of a simple hysterectomy. For women with early-stage cervical cancer, however, this extra dissection is necessary to determine disease status beyond the cervix, since the tumor may have already spread to the vagina or the parametrium by either direct extension or through the lymphatics into the parametrial nodes.

The radicality of the procedure may be tailored to tumor factors such as size and location. The most commonly used classification for radical hysterectomy was originally proposed in 1974 by Piver, Rutledge, and Smith (Table 6.1) [36]. In 2008, Querleu and Morrow proposed an updated classification that considered parasympathetic nerve preservation and paracervical tissue involvement (Table 6.2) [37].

Table 6.1 Piver-Rutledge-Smith classification of radical hysterectomy

Name (type)	Point of uterine vessels transection	Amount of vagina removed	Point of uterosacral ligament transection
Simple (I)	At insertion into cervix (level of the internal os)	Minimal	At insertion into cervix
Modified radical (II)	At level of the ureter	1–2 cm	Midway between cervix and rectum
Radical (III)	At their origin from the internal iliac vessels	Upper half	At their origin
Extended radical (IV)	At their origin from the internal iliac vessels	Upper three-fourths with paravaginal tissue	At their origin
Partial exenteration (V)	At their origin and en bloc with ureters (and possibly bladder)	Entire vagina above levator muscles	At their origin (and possibly en bloc with rectum)

From Piver et al. [36]; with permission

Table 6.2 Querleu-Morrow classification of radical hysterectomy

Type	Extent of resection	Ureter	Comment
Type A	The paracervix is transected medial to the ureter but lateral to the cervix	Ureter palpated or directly visualized without freeing from bed	
	Uterosacral and vesicouterine ligaments are not transected at a distance from the uterus		
	Vaginal resection is minimal without removal of the paracolpos		
Type B1	Paracervix is transected at the level of the ureteral tunnel	Unroofing of ureter	*Type B2*: Type B1 + removal of the lateral lymph nodes
	Partial resection of uterosacral and vesicouterine ligaments	Ureter rolled laterally	
	No resection of caudal (deep) neural component of the paracervix (caudal to the deep uterine vein)		
	Vaginal resection of at least 10 mm of the vagina from the cervix or tumor		
Type C	Transection of paracervix at junction with internal iliac vascular system, uterosacral ligaments at the rectum, and vesicouterine ligaments at the bladder	Ureter completely mobilized	*Type C1*: with autonomic nerve sparing/preservation
	Resection is 15–20 mm of the vagina from the tumor or cervix and corresponding paracolpos		*Type C2*: without autonomic nerve sparing/preservation
Type D1	Resection of the paracervix at the pelvic side with vessels arising from internal iliac system, exposing the roots of the sciatic nerve	Ureter completely mobilized	
Type D2	Resection of the paracervix at the pelvic side, with hypogastric vessels plus adjacent fascial or muscular structures (laterally extended endo-pelvic resection)	Ureter completely mobilized	

From Querleu et al. [37]; with permission

Removal of the ovaries is not necessarily required as part of radical hysterectomy. Performance of salpingo-oophorectomy should be personalized to patients based on age, reproductive history, and tumor histology. If adnexectomy is to be performed, we recommend leaving the infundibulopelvic ligament intact until after complete mobilization of the parametrium because the additional tension created by this ligament greatly assists in the parametrial dissection.

Finally, for a minimally invasive laparoscopic radical hysterectomy, a good uterine manipulator is of utmost importance. A variety of manipulators exist, each with their strengths and weaknesses. For the most part, these devices will improve visualization; create proper counter tension during bladder, ureteral, and parametrial dissections; and delineate the appropriate margins for vaginal colpotomy.

Procedure

What follows is a description of the Piver-Rutledge-Smith type III radical hysterectomy. Once mastered, this procedure can easily be modified for more (type IV) or less (type II) radical procedures. The order of the steps listed may differ slightly from surgeon to surgeon. Although this surgery can be performed with monopolar electrocautery, we recommend using one of the many advanced vessel sealing devices because they tend to have better hemostasis and, more importantly, less lateral thermal spread. The latter is particularly important when dissecting near the ureter.

The surgery begins with a careful exploration of the entire peritoneal cavity for evidence of intraperitoneal spread. This includes inspection of the upper abdomen and all peritoneal surfaces. For women with cervical cancer, if metastatic disease is encountered, the surgery should be terminated and the patient reassigned to chemotherapy and/or radiation.

The round ligament is then divided and the retroperitoneal space is entered. Gentle blunt dissection in this avascular space is performed, and the external iliac vessels, internal iliac artery, and ureter are identified. A careful examination of the pelvic lymph nodes should be made, and any enlarged or abnormal-appearing nodes should be removed and sent for frozen section evaluation. One of the few limitations of the minimally invasive radical hysterectomy is the decreased tactile sensitivity for palpating lymph node basins.

A bladder flap is then created using a combination of the advanced vessel sealing device and blunt dissection. Early in the surgery, only a small bladder flap is necessary. However, throughout the procedure, the surgeon returns to the bladder, further dissecting it from the pubovaginal fascia to achieve the desired vaginal margins.

The pararectal and paravesical spaces are then opened. We favor opening the pararectal space first, although this varies based on the surgeon's preference. The pararectal space is entered by bluntly dissecting between the ureter and internal iliac artery along the curve of the sacrum. This is another avascular space bordered by the internal iliac artery/levator ani laterally, the rectum medially, the sacrum posteriorly, and the cardinal ligament (parametrium) anteriorly.

Once the pararectal space is opened to the pelvic floor, the paravesical space should be opened. With anterior retraction of the proximal portion of the severed round ligament and using the superior vesicle artery as a landmark, this space can be entered either medially or laterally to that vessel (although we favor lateral entry). Again, blunt dissection is used to open this avascular space bordered by the obturator internus muscle laterally, the bladder medially, the pubis symphysis anteriorly, and the cardinal ligament posteriorly. Care must be taken not to create an inadvertent cystotomy. Historically, after opening these spaces, the surgeon would place one finger in each space, palpating the cardinal ligament to rule out tumor infiltration. With a minimally invasive approach, this is not possible. However, opening these two spaces does help identify the uterine artery and its surrounding parametrial tissue (Fig. 6.1).

Once identified, the uterine artery is dissected and ligated at its origin using an advanced vessel sealing device. With gentle traction upward, the surrounding parametrial tissue is taken en bloc with the uterine vessels. As the parametrial tissue

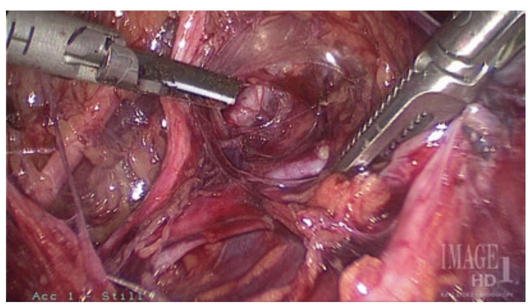


Fig. 6.1 The uterine artery is seen at its origin from the internal iliac (hypogastric) artery

is freed laterally and deeply, the ureter is tunneled from underneath it as the parametrial tissue is brought up over it (Fig. 6.2).

The tunneling of the ureter continues until its insertion into the bladder is reached. Along the way, the ureter is freed from its medial attachments and "rolled" laterally. When dissecting the deep portion of the parametrium, care must be taken not to disrupt the sympathetic nerve fibers innervating the bladder and rectum.

The vesicouterine peritoneal fold is now transected using the advanced vessel sealing device. This often requires further mobilization of the bladder downward. Care must be taken not to perform an inadvertent cystotomy during this portion of the procedure. Backfilling the bladder may assist in helping to decide the best surgical plane to take.

The uterus is now anteflexed, and the rectovaginal space is developed. Another avascular space, this can be entered by retracting the sigmoid colon caudally and posteriorly and incising the fold between the bowel and the posterior cervix (Fig. 6.3).

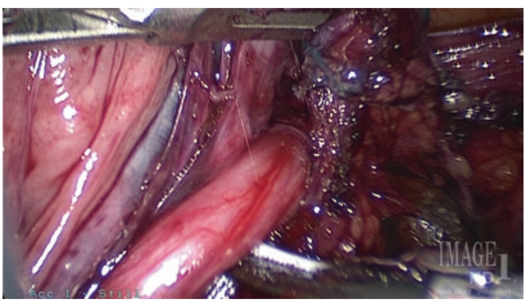


Fig. 6.2 The ureter is untunneled as it courses through the parametrial tissue

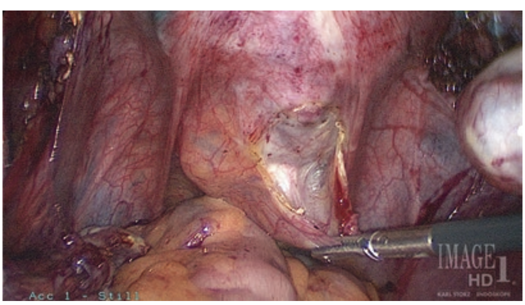


Fig. 6.3 The rectovaginal space is opened, exposing the uterosacral ligaments

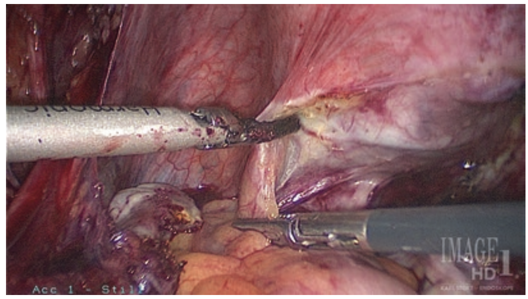


Fig. 6.4 The uterosacral ligaments are transected

This incision is extended laterally, and the rectovaginal space is developed bluntly. This mobilizes the rectum away from the vagina and exposes the uterosacral ligaments. With good visualization of the lateralized ureters, the uterosacral ligaments can now be transected at their origin using an advanced vessel sealing device (Fig. 6.4).

With the bladder, the vesicouterine fold, the parametrium, and the uterosacral ligaments now freely dissected and the ureters mobilized laterally, a circumferential colpotomy incision can be made, taking care to achieve the desired vaginal margins. The radical hysterectomy specimen is removed through the vagina, and the vaginal cuff is closed either vaginally or laparoscopically based on the preference of the surgeon.

Pelvic and Para-aortic Lymphadenectomy

General Considerations

The most important key to safely perform lymphadenectomies for gynecologic malignancies is mastery of the anatomy and careful dissection to identify aberrant vessels and structures. For example, an accessory obturator vein may be present in up to 25% of women and accessory renal arteries in 3%. In addition, the bilateral ureters cross the dissection fields in multiple locations and should always be identified. Transecting tissue and nodal bundles without dissecting and identifying both known anatomic landmarks and unknown anomalies puts the patient at risk for major complications.

For pelvic and para-aortic lymphadenectomies, we favor a four-port diamond configuration with 5-mm trocars in the umbilicus, one in the lateral lower quadrant, and suprapubic locations and a 12-mm trocar in the contralateral lateral lower quadrant. This larger port allows for placement of a specimen bag for removal of nodal bundles.

As previously described, these procedures are best performed with an advanced vessel sealing device (bipolar or ultrasonic). These devices allow for rapid coagulation and transection of tissue and vessels with minimal lateral thermal spread.

Procedures

Pelvic Lymphadenectomy

To begin the pelvic lymphadenectomy, the camera starts in the umbilical port. The tissue overlying the external iliac artery is grasped, and the peritoneal surface is incised just lateral to the vessel. The surgeon can then enter the avascular space between the external iliac artery and the psoas muscle. With medial tension on the nodal bundle and after identification of the genitofemoral nerve as it runs on the medial aspect of the psoas muscle, the incision over the external artery is extended distally (Fig. 6.5).

The assistant grasps the cut round ligament and elevates it toward the anterior abdominal wall to allow for this distal dissection. The dissection continues until the circumflex iliac vein is visualized.

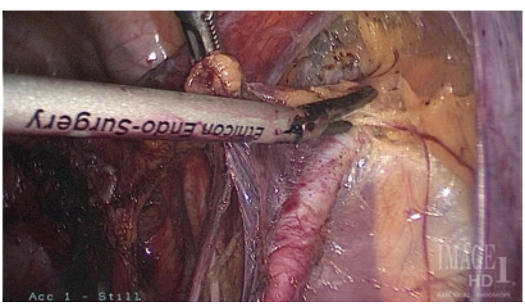


Fig. 6.5 The nodal tissue overlying the external iliac artery is gently retracted medially as the incision over the artery is extended distally

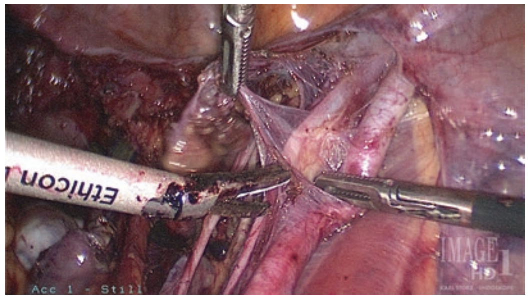


Fig. 6.6 The nodal tissue is carefully dissected from the external iliac vein

The nodal bundle is then freed from the external iliac vein by gently pulling medially on the bundle and bluntly dissecting the avascular space between the vein and the nodes (Fig. 6.6).

In order to avoid tearing the nodal bundle and the subsequent oozing from the nodes, it is important to grasp a large amount of nodal tissue as opposed to a small bite at the edge. Because the vein is much less resilient than the artery, care must be taken to visualize the edge of the vein and avoid any accidental venotomy. During this portion of the procedure, the assistant can use a blunt instrument to retract the vein along its route to aid in visualization and countertraction.

After the nodal bundle is medialized from the external iliac vein, the obturator space is entered bluntly, and the obturator nerve is identified. This structure is the deep margin of the dissection, and care must be taken not to inadvertently transect this nerve. The nodal bundle can typically be released from the nerve by bluntly running an instrument on top of the nerve and in a parallel direction. Minimal bleeding may be encountered, but this typically can be halted by utilizing the nodal bundle for direct pressure. A more hemostatic approach can be performed by creating pedicles above the nerve by spreading with a blunt instrument parallel to the nerve and then using an advanced energy device to coagulate and transect these pedicles.

The internal iliac artery/superior vesicle artery, the medial border of the dissection, is then identified, and the nodal bundle is freed from it either bluntly or with the advanced energy device. This is best achieved with the assistant grasping the vessel and providing countertraction (Fig. 6.7).

Care is taken not to go deep into this vessel because the ureter runs close to it, and this risks injury. This part of the dissection is continued proximally along the internal iliac artery until the bifurcation of the common iliac artery is encountered. At this point the bundle is removed. Remember that the ureter crosses at the bifurcation of the common iliac artery into the internal and external arteries, and visualization of the ureter is important to protect it from transection or thermal injury.

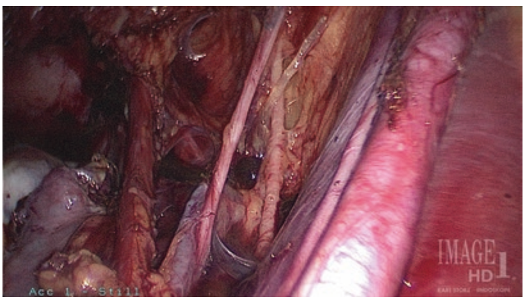


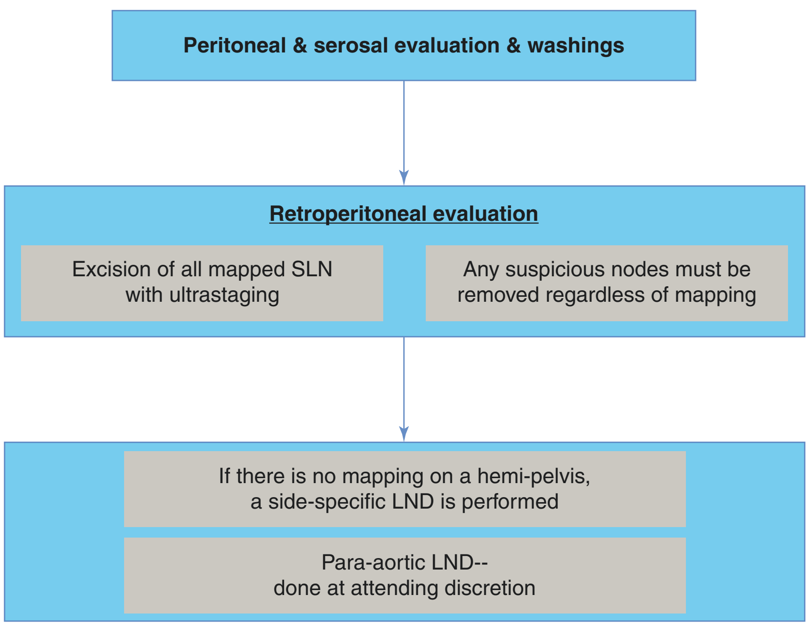
Fig. 6.7 The final aspect of the pelvic lymphadenectomy with the external iliac artery and vein, internal iliac/superior vesicle artery, and obturator nerve cleared of the nodal tissue

Pelvic Sentinel Lymph Node Mapping and Biopsies

Lymphatic mapping may be performed with a variety of mapping substances including patent blue dyes (isosulfan blue or methylene blue), radiocolloids (technecium-99), or indocyanine green. When performing lymphatic mapping and sentinel lymph node biopsy, it is important to adhere strictly to a mapping algorithm (Fig. 6.8) [38]. This algorithm requires a complete side-specific lymphadenectomy if a sentinel node is not found in a hemi-pelvis. Although indocyanine green has higher detection rates than blue dye and/or radiocolloid, the technique has been proven valid for any of the mapping substances. In other words, if the surgeon finds a sentinel node with any of the substances, they can feel confident that the sentinel node is representative of the nodal basin and complete lymphadenectomy is not necessary. When using blue dye and/or radiocolloid instead of indocyanine green, the surgeon will detect fewer sentinel nodes and therefore will be obligated to perform more complete side-specific lymphadenectomies.

With a speculum in the vagina, inject the mapping substance at 6 and 9 o'clock deep and super-

Fig. 6.8 The SLN algorithm for surgical staging of endometrial cancer. (Reprinted from Barlin et al. [38]; with permission)



ficial. The "deep" injection should be in the stroma of the cervix, roughly 1- to 2-cm deep. The "superficial" injection should be just under the dermal layer, and the surgeon should see a bleb rising in the subcutaneous tissue. A tenaculum may be used to manipulate the cervix while injecting. Allow adequate time for the mapping substance to disperse prior to opening the retroperitoneal spaces. For blue dye and indocyanine green, this is typically 10–15 minutes, while for radiocolloid this can take 20–30 minutes. Incise the peritoneum lateral to the infundibular pelvic ligament, and bluntly explore the retroperitoneum with care so that the afferent lymphatic channels are not transected. The afferent lymphatic channel is commonly seen adjacent to the uterine artery near the site where it passes over the ureter. If a channel is visualized and leads directly to a lymph node but the lymph node itself is not colored, it should still be considered sentinel. Following removal of the sentinel node, it should be separated from other non-sentinel nodes and labeled as sentinel so pathology may perform ultrastaging and immunohistochemistry stains on it.

Para-aortic Lymphadenectomy

After the pelvic nodal bundles are removed, the dissection continues proximal along the common iliac artery. Getting proper setup and visualization of the entire nodal basin to be dissected is not only the most difficult part of this procedure but also the most important. If this setup is completed correctly and good visualization of the superior border is achieved first (whether it is the inferior mesenteric artery or the renal vessels), the actual dissection and removal of the nodal basins are somewhat straightforward.

The peritoneum over the common iliac artery is incised and elevated. The underlying nodal tissue is initially left adherent to the vessels as this peritoneal "tent" is raised. With graspers raising this tent, the small bowel may be retracted behind it out of the surgical field. Often visualization of the great vessels owing to the position of the small bowel is the greatest challenge of a laparoscopic para-aortic lymphadenectomy, and as patient body mass index increases, so does the level of difficulty of retracting these organs. Many surgeons maintain the camera in the umbilicus throughout the para-aortic lymphadenectomy; however, we find that switching the camera to the suprapubic port and moving the monitors to the head of the patient often help with visualization and precision in instrument placement. This configuration with the camera held by the assistant using the suprapubic port and the bilateral lower quadrant trocars utilized by the primary surgeon standing between the patient's legs is particularly helpful if the renal vessels are the upper limit of the dissection (as opposed to the inferior mesenteric artery favored by some surgeons). One other technique to assist in visualization is to place a laparoscopic retractor through the umbilical port. We often exchange the 5-mm umbilical port for a 12-mm trocar to allow for placement of a large laparoscopic fan retractor to assist in holding the small bowel in the upper abdomen out of the surgical field (Fig. 6.9).

Finally, if needed a fifth trocar may be introduced in the upper quadrant to allow for another assistant to help with retraction.

Once the peritoneum is open to the superior border of the dissection (inferior mesenteric artery or renal vessels), dissection is begun at the distal portion over the common iliac artery. The avascular plane between the nodal bundle and the artery is entered. The nodal bundle is grasped and elevated gently so as not to tear the inferior vena cava underneath it. The nodal bundle is mobi-

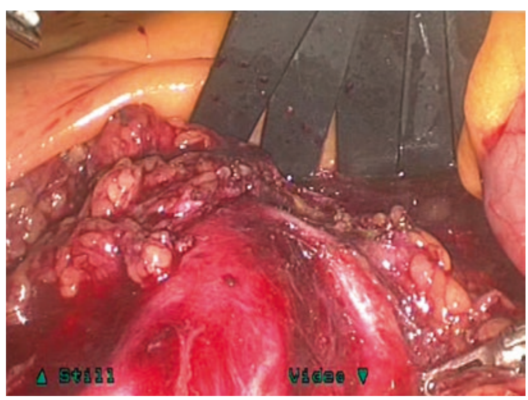


Fig. 6.9 A laparoscopic retractor is used to expose the bifurcation of the aorta

lized along the common iliac artery and over the lower portion of the abdominal aorta. The advanced energy device is used to spread parallel to the vessels, creating pedicles that can then be taken with the device. This technique is particularly important over the vena cava at the level of the aortic bifurcation as this is commonly where the surgeon will encounter the fellow's vein. As the surgeon moves cephalad, the lateral portion of the vena cava should be identified, and the nodal bundle should be separated from its lateral attachments. It is imperative at this point that the right ureter is identified and lateralized away from the dissection. The anatomic borders of this nodal bundle are the common iliac inferiorly and the lateral portion of the vena cava, the aorta, and the inferior mesenteric artery/renal vessels superiorly.

After this portion of the aortocaval nodes is removed, the nodes along the left side of the aorta can be removed. We find this more easily done separately from those nodes overlying the aorta and vena cava described above. When working in this area just lateral to the aorta, care must be taken to identify the left ureter because it courses close to the dissection. In addition, the surgeon should continue to gently create pedicles, since this will help visualize and avoid the lumbar vessel where they originate on the posterior portion of the aorta.

Infracolic Omentectomy

General Considerations

Laparoscopic omentectomy may be performed as part of the staging surgery for presumed early-stage ovarian cancer in addition to certain types of high-risk endometrial cancers. If gross disease is visualized in the omentum or on other upper abdominal organs, we strongly recommend conversion to laparotomy for careful exploration and optimal tumor debulking. For staging of patients without evidence of metastatic disease, most surgeons perform an infracolic omentectomy.

Like all of the procedures described in this chapter, this procedure is best performed with an advanced vessel sealing device (bipolar or ultrasonic). We do not recommend using monopolar electrosurgical instruments because the dissection plane between the omentum and transverse colon can be small, and use of this technology risks a thermal bowel injury.

Procedure

We recommend placing the camera in the suprapubic port and moving the monitors toward the head of the patient. The surgeon stands between the legs of the patient and uses the bilateral lower quadrant trocars to operate. The assistant stands on the side of the patient holding the camera and utilizing the umbilical assistant port.

Utilizing the left lower quadrant and umbilical ports, graspers are used to raise the omentum toward the anterior abdominal wall allowing for visualization of the transverse colon. For a large omentum, this may require grasping the omentum toward its base close to the transverse colon. A fifth trocar may be introduced into the left upper quadrant (Palmer point) for an additional grasper if needed. We do not recommend pulling the omentum down into the pelvis and performing the procedure from above the omentum. This risks damage to both the transverse colon and the small bowel underneath the draping omentum. It is important to ensure visualization of the small bowel and transverse colon throughout the procedure. Slightly reducing the steep Trendelenburg position may help with visualization.

Using an advanced vessel sealing device placed in the right lower quadrant trocar, we start at the hepatic flexure and transect the edge of the omentum heading toward the transverse colon to enter the avascular space between the omentum and colon. We then head across the omentum toward the left side of the patient, mobilizing the omentum from the colon (Fig. 6.10).

During the procedure, it is important to be mindful and avoid the bowel mesentery. As the omentum is released from its connections to the colon, the freed portion is placed into the left upper quadrant and the omentum is regrasped closer to the area still attached to the colon. As

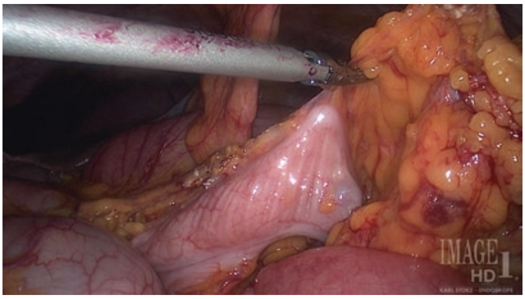


Fig. 6.10 The omentum is dissected from the transverse colon

the splenic flexure is approached, the omentum becomes thicker and bunches up toward the spleen. While remaining in the same trajectory and coming across the base of the omentum, it is completely freed. We typically remove the omentum through the opened vagina.

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7 Laparoscopic Hysterectomy for Oncologic Patients

Stephanie Ricci and Erika J. Lampert

It has been well established that minimally invasive surgery (MIS) offers many benefits compared to laparotomy including decreased blood loss and risk of transfusion, a faster less painful recovery, and a shorter (or no) hospital stay. The application of MIS to the field of gynecologic oncology continues to evolve in response to new research and its effect on cancer specific outcomes. Laparoscopy has long been accepted for the staging, and management of early-stage endometrial cancer and MIS is now largely considered standard of care after the emergence of prospective randomized data to support equivalent oncologic outcomes. Conversely, practice has recently trended away from minimally invasive radical hysterectomy for the management of early-stage cervical cancer based on randomized prospective data demonstrating worse outcomes when compared to laparotomy. Current guidelines also recommend laparotomy for primary treatment of advanced ovarian, fallopian tube, and primary peritoneal malignancy. Recent findings suggest there may be a role for minimally invasive techniques for early-stage ovarian cancer and interval debulking after neoadjuvant chemotherapy in select patients. This chapter highlights the most updated research and clinical guidelines regarding the application of MIS for gynecologic malignancies and describes techniques for laparoscopic hysterectomy and related procedures specific to oncologic patients.

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Uterine Cancer

Indications for Laparoscopic Surgery for Uterine Cancer

Primary management of apparent early-stage endometrial cancer confined to the uterus includes a total hysterectomy, bilateral salpingo-oophorectomy and lymph node assessment including pelvic and para-aortic lymphadenectomy. Based on robust data including prospective clinical trials and systematic reviews, a minimally invasive approach is now the standard of care [1]. In the randomized phase III LAP2 trial comparing laparoscopy to laparotomy for hysterectomy, salpingo-oophorectomy, pelvic cytology, and pelvic and para-aortic lymphadenectomy in patients with clinical stage I to IIA uterine cancer, short-term perioperative results showed that laparoscopic surgical staging is feasible and associated with fewer postoperative complications, a shorter hospital stay, and no statistically significant difference in intraoperative

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complications [2]. There was, however, a 25.8% conversion rate from laparoscopy to laparotomy, with over half of those cases noted to be due to poor exposure and approximately 16% due to extensive disease requiring laparotomy for resection [2]. Interval assessments of the LAP2 trial revealed comparable recurrence and survival rates among the two arms [3], as well as a statistically significant although clinically modest improvement in quality of life 6 weeks after laparoscopy compared to laparotomy, although this did not persist at 6 months post-surgery [4]. Similarly, the Laparoscopic Approach to Cancer of the Endometrium (LACE) trial, which compared total abdominal hysterectomy (TAH) to total laparoscopic hysterectomy (TLH) in patients with stage I endometrial carcinoma, reported improved perioperative outcomes with MIS and no significant difference in recurrence and overall survival rates [5, 6]. A MIS approach is also preferable for the more aggressive uterine tumor types including serous carcinoma, clear cell carcinoma, and carcinosarcomas, whenever technically feasible.

Laparoscopic Versus Robotic Minimally Invasive Surgery in Endometrial Cancer

While the National Comprehensive Cancer Network (NCCN) guidelines recommend a minimally invasive approach for primary management of early-stage endometrial cancer, to date there are no guidelines regarding the decision to pursue this laparoscopically versus robotically. A randomized controlled trial comparing traditional versus robotic-assisted laparoscopic hysterectomy, bilateral salpingo-oophorectomy, and lymphadenectomy among 99 patients with low-grade endometrial carcinoma reported significantly shorter operative times and a lower rate of conversion to laparotomy in the robotic group, while all other surgical outcomes including blood loss, postoperative pain scores, intraoperative, and postoperative complication rates showed no significant difference [7]. Several large retrospective studies and systematic reviews have also compared minimally invasive approaches. One systematic review comparing traditional and robotic-assisted laparoscopic approaches in 10,800 obese patients with endometrial cancer reported similar rates of perioperative complications and conversion to laparotomy. However, the authors suggested a robotic technique may be more feasible in patients with a body mass index (BMI) greater than or equal to 40 kg/m^2 who are more likely to be unable to tolerate steep Trendelenburg and higher intraperitoneal pressures required for laparoscopic surgery [8]. Retrospective studies have similarly shown comparable morbidity and oncologic outcomes associated with robotic versus laparoscopic approaches in endometrial cancer [9, 10]. Presently, the specific route of MIS remains dependent upon surgeon preference and ability, patient selection, and available equipment.

Total Laparoscopic Hysterectomy Technique for Endometrial Cancer

Preparation

Prior to definitive surgical staging, imaging should be obtained to evaluate the extent of disease and possible metastases. This may include a CT chest, abdomen and pelvis, a pelvic MRI to assess for local disease extent, and/or a PET/CT for suspected metastatic disease. Once classified as suitable for primary surgery, the patient should undergo preoperative assessment to optimize for the surgical staging procedure. This includes evaluating medical comorbidities and categorizing potential surgical risk using a scale, such as the American Society of Anesthesiologists (ASA) physical status score, to determine if further labs and testing should be ordered to optimize the patient for surgery. Immediately prior to surgery, a single dose of antibiotic prophylaxis with 2 grams of intravenous cefazolin is recommended (3 grams for patients weighing >120 kilograms). Additionally, 5000 units of subcutaneous heparin is administered 2 hours preoperatively for venous thromboembolism prophylaxis. Once in the operating room, the patient must be properly positioned. A pink pad is placed on the operating table to eliminate patient sliding while in a steep Trendelenburg position. The patient is then placed into dorsal lithotomy position with legs placed into Yellofin or similar stirrups, and both arms are tucked on either side. After sterile preparation, a Foley catheter and uterine manipulator such as the VCare is placed to enhance visualization, aid with countertraction, and demarcate borders for the vaginal colpotomy.

Procedure

Entry into the abdomen is most frequently gained at the umbilicus. We prefer accessing Palmer's point in the left upper quadrant for primary entry, which can be beneficial in patients with a bulky uterus or prior abdominal surgeries. When entering at Palmer's point, the stomach must first be decompressed with an orogastric or nasogastric tube to prevent injury. Primary access can be obtained using the Veress needle or the open Hasson technique or via direct visualization with an optical trocar. After initial port placement, the abdomen is insufflated, a survey of the entire abdomen is performed, and the patient is placed into the Trendelenburg position to displace bowel and optimize pelvic visualization. Additional ports are placed under direct visualization, with careful attention paid to location. Accessory trocars are traditionally placed at the umbilicus and bilateral lower quadrants, approximately 2 centimeters superior and medial to the anterior superior iliac spine (Fig. 7.1). We prefer to place accessory ports slightly higher on the abdomen forming the shape of a shallow arc instead of a diamond, which allows for easier access to larger uteri or pelvic masses and a better vantage point for lymphadenectomy.

The hysterectomy begins with incising either the round ligament or the peritoneum just lateral to the ovarian vessels, thereby opening and separating the anterior and posterior leaves of the broad ligament and developing the retroperitoneal space. The ureter is then identified retroperitoneally on the medial leaf of the broad ligament coursing inferior to the ovarian vessels, and the pararectal space is developed. The infundibulopelvic (IP) ligament is isolated, and the ovarian vessels can then be safely cauterized and divided. The medial leaf of the broad ligament is divided past the utero-ovarian ligament to the uterosacral ligament paying careful attention to the uterine artery and vein. By opening the peritoneum, the anatomic landmarks are more clearly visualized for precise dissection. Next, the anterior leaf of

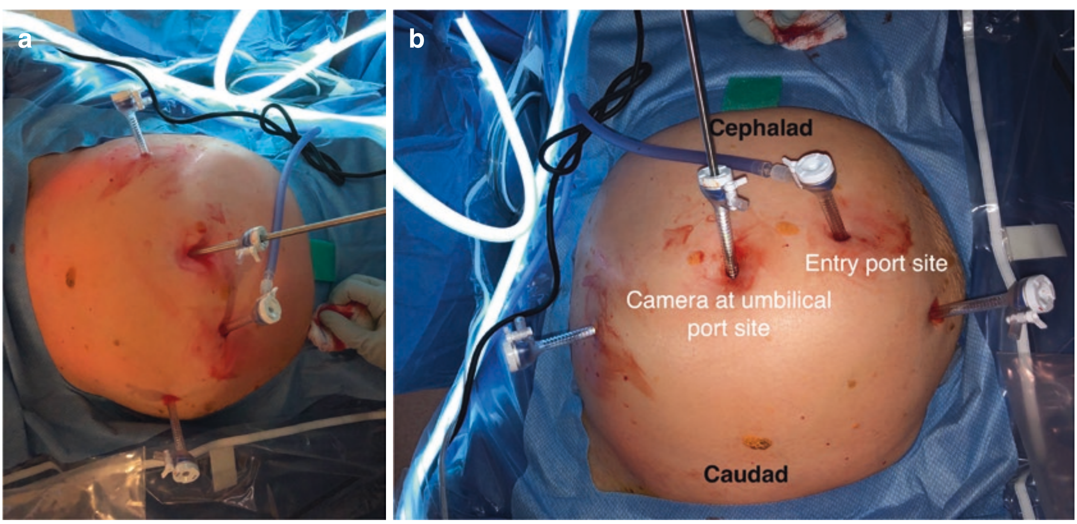

Fig. 7.1 (**a**, **b**) An external view of the laparoscopic port placement technique to ensure access to the pelvis, pelvic sidewall, and upper abdomen if necessary. The camera is placed at the umbilical port after peritoneal access is gained through a modified Palmer's point entry site. This configuration can be used with four ports (as demonstrated) or three omitting the right lateral port site if extra retraction is not necessary

the broad ligament is bluntly dissected toward the level of the cervix, where the bladder flap is carefully created in order to push the bladder away from the cervix in preparation for the colpotomy. When dissecting the overlying peritoneum away from the underlying structures, it is important to first develop potential space with the blunt dissection of a laparoscopic instrument to allow adequate visualization of the uterine vessels and the bladder edge. Once the peritoneum has been transected safely, these important structures will be even better visualized and undamaged. The bladder can often be pushed away from the cervix with careful blunt dissection, however with adhesions formed by prior surgery or inflammation release of denser tissue often referred to as bladder pedicles which may require cautery to transect. The location of the bladder edge must be carefully visualized especially in the presence of adhesions. Techniques to insure the location of the bladder include using the Foley bulb, backfilling the bladder with a dyed liquid or sterile milk and cystoscopy.

The uterine arteries are further skeletonized bilaterally and then cauterized and divided using bipolar energy. By cauterizing and incising the tissue between the uterine artery and the cervix, the uterine artery pedicle is moved away from the path of the colpotomy. We accomplish this by introducing the bipolar instrument from the opposite side of the pelvis in order for it to lie directly parallel to the uterine artery and flush to the cervix. Transection of the cardinal ligaments serves to lateralize the pedicles away from the colpotomy cup. The colpotomy is then performed using a monopolar hook or paddle to circumferentially release the specimen from the vagina with guidance from the intrauterine manipulator to delineate the cervicovaginal junction. We use an extended bovie tip for laparoscopy instead of the traditional monopolar with foot pedal control. This allows for both cut and cautery functions to be used with easy hand control. The specimen should be removed en bloc, avoiding morcellation or fragmentation for optimal oncologic outcomes. Closure of the colpotomy can be performed either laparoscopically or vaginally with absorbable suture in a running fashion or using serial figure-of-eight stitches. Our practice is to close the vaginal cuff laparoscopically with barbed suture in a running fashion, thereby minimizing knot tying and closure time while maximizing suture tensile strength.

Lymphadenectomy Technique for Endometrial Cancer

Sentinel Lymph Node Technique

Complete surgical staging is the most important prognostic factor for endometrial cancer and traditionally included a complete pelvic and para-aortic lymph node dissection. However, based on conclusions from multiple prospective and retrospective studies, sentinel lymph node (SLN) mapping may now be safely considered in patients with suspected uterine-confined disease. The FIRES trial, a prospective cohort study of SLN mapping followed by pelvic lymphadenectomy with or without para-aortic lymphadenectomy, concluded that SLN identification is highly sensitive for detecting endometrial cancer metastases and can safely substitute for systematic lymphadenectomy. Although 3% of patients with node-positive disease are missed by this technique, the study authors concluded that this risk is outweighed by the significant benefits and decreased morbidity gained by avoiding complete lymphadenectomy [11]. A Cochrane review including a total of 2237 women reported a mean SLN detection rate of 86.9% and a sensitivity of 91.8% among detected nodes [12]. To perform SLN identification, tracer dye is injected 1 centimeter deep into the cervix at the 3 o'clock and 9 o'clock positions and travels along the uterine lymphatic trunks to identify the first nodes in the chain to drain from the uterus which are the most likely to contain metastatic disease. While a variety of different types of dyes can be used, we prefer indocyanine green (ICG) due to its easily identified, real-time fluorescence especially in morbidly obese patients (Fig. 7.2). Once identified and resected, ultra-staging of the node is performed, which entails serial sectioning and performing hematoxylin and eosin staining to improve sensitivity for detecting tumor cells (Fig. 7.3).

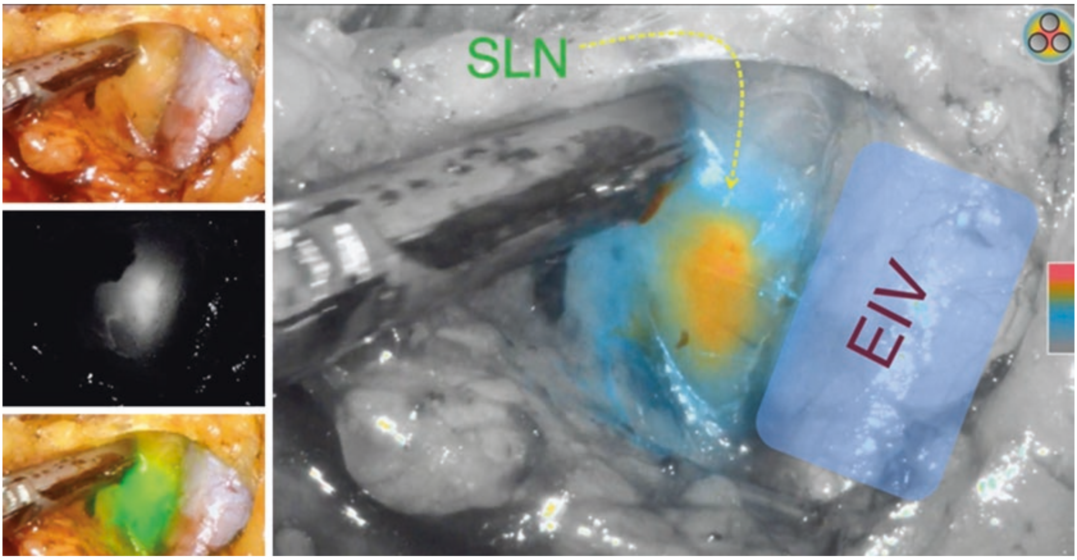

Fig. 7.2 The sentinel lymph node is identified via fluorescence technology highlighted with a green color. In this figure an obturator node has been identified by entering the retroperitoneal pelvic sidewall on the right side. The sentinel lymph node sits directly adjacent to the external iliac vein (EIV)

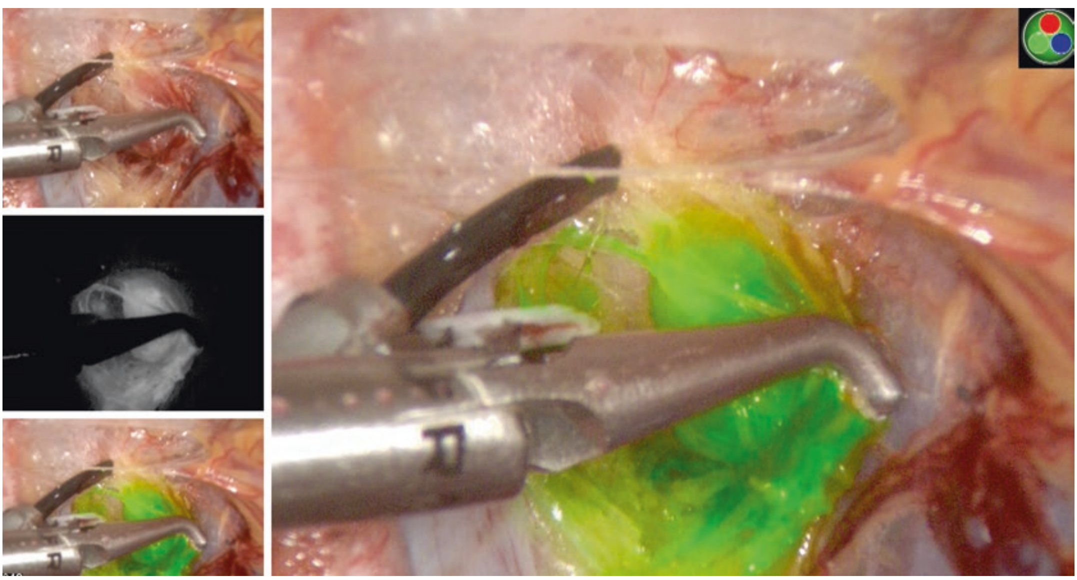

Fig. 7.3 Further dissection toggling between fluorescence and standard camera modes allows for safe isolation and retrieval of the sentinel lymph node

Pelvic Lymphadenectomy

When indicated, a complete pelvic lymphadenectomy is performed and includes removal of obturator and common, external, and internal iliac nodes. Lymphadenectomy can be performed via an extraperitoneal or, more commonly, transperitoneal approach at the time of initial surgery. When performed transperitoneal, the camera is placed in the umbilical port for optimal view of the pelvic sidewall. The pararectal and paravesical spaces are developed. The superior vesical artery is isolated and followed back to its origin from the common iliac artery, where nodal tissue is then dissected off bluntly or using electrosurgery. Next, the obturator space is explored, and the nodal bundle is released only once the obturator nerve is identified and dissected away from the lymph node packet. Finally, the external iliac artery is identified, and the nodal tissue overlying it is dissected, with careful attention paid not to transect the genitofemoral nerve running medially on the psoas muscle. Medial displacement of the ureter, which crosses at the bifurcation of the common iliac artery, is crucial for avoiding ureteral injury during lymphadenectomy.

Para-aortic Lymphadenectomy

For para-aortic lymphadenectomy, we recommend the primary surgeon stand between the patient's legs with the camera placed in the umbilical port turned cephalad. This allows for improved access to the superior border of the para-aortic dissection, the inferior mesenteric artery. To start, the peritoneum is dissected cephalad, and the first bundle of nodes along the lower abdominal aorta is removed. Continuing to move upward, the vena cava is visualized and its nodal bundle is separated. Continuing cephalad, the aortocaval nodes are removed after identification of the ureter to avoid injury.

Cervical Cancer

Indications for Laparoscopic Surgery in Cervical Cancer

Standard-of-care management for early-stage cervical cancer, including stages IA1 (with lymphovascular space invasion [LVSI]), IB1, IB2, and select IB3–IIA1 cervical cancers, involves radical hysterectomy with pelvic lymphadenectomy. In contrast to simple hysterectomy, radical hysterectomy entails removal of 1–2 centimeters of the upper vagina as well as the parametrium, including parts of the cardinal and uterosacral ligaments. While both open and laparoscopic techniques were previously considered acceptable for performing radical hysterectomy in cervical cancer, the most recent 2021 NCCN guidelines recommend laparotomy as the standard approach [13]. This recommendation is based on several retrospective and epidemiologic studies in addition to the phase III, randomized, controlled Laparoscopic Approach to Cervical Cancer (LACC) trial, which showed minimally invasive radical hysterectomy was associated with lower rates of disease-free and overall survival compared to an open abdominal approach [14–17]. As such, the application of laparoscopic hysterectomy is currently limited in patients with cervical cancer and primarily reserved for adenocarcinoma in situ (AIS) and IA1 disease without LVSI.

Ovarian Cancer

Indications for Laparoscopic Surgery in Ovarian Cancer

The application of laparoscopy for the management of ovarian cancer is currently controversial. Based on the 2021 NCCN guidelines, open laparotomy remains the recommended approach for the majority of ovarian cancer patients undergoing surgical staging, primary or interval debulking, and secondary cytoreductive surgery [18]. That said, results from a large, multicenter retrospective study suggested laparoscopy may be safely applied for the staging and management of early-stage disease. Specifically, among 300 patients who underwent either immediate or delayed laparoscopic staging surgery for presumed early-stage ovarian cancer, the disease-free survival, overall survival, and recurrence rates were comparable to those reported in the literature for laparotomy [19]. A direct comparison between both surgical approaches has not yet been made.

In the absence of prospective clinical trials directly comparing minimally invasive versus open techniques in ovarian cancer, the application of laparoscopy for ovarian cancer remains limited. Specific concerns regarding a laparoscopic approach to ovarian cancer management include an inadequate survey of the abdominal cavity, loss of tactile sensation important for the detection of sites of metastatic disease, and risk of tumor dissemination, among several others. The Minimally Invasive Interval Debulking Surgery in Ovarian Neoplasm (MISSION) trial studied laparoscopic cytoreduction for interval debulking surgery in patients after a clinically complete response to neoadjuvant chemotherapy [20]. The findings suggest that a minimally invasive technique for performing interval total hysterectomy, bilateral salpingo-oophorectomy, omentectomy, and pelvic or upper peritonectomy, with or without bowel resection as indicated, is safe and feasible in select patients, although survival data has not yet fully matured for interpretation. Further research and particularly prospective trials assessing the application of minimally invasive surgery in ovarian cancer are needed. Current data suggests there may be a role for laparoscopy in appropriately selected patients.

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8 Techniques in Urogynecology and Pelvic Reconstructive Surgery

Cecile A. Ferrando and Beri Ridgeway

Introduction

Pelvic organ prolapse and urinary incontinence are common problems in women that can cause substantial morbidity and negatively affect quality of life. The management of pelvic organ prolapse and incontinence can be challenging, as several support defects often coexist. To achieve the goals of pelvic reconstruction, the surgeon must understand normal anatomic support as well as physiologic function of the organs involved. The goals of surgery are to reconstruct anatomy, maintain or restore normal bowel and bladder function, and preserve vaginal length.

Three modes of surgery exist in pelvic reconstructive surgery: vaginal, open abdominal, and laparoscopic (conventional and robot-assisted). Advances in minimally invasive surgery have led to the widespread adoption of laparoscopic techniques in pelvic reconstruction. Laparoscopy has many practical and economic advantages compared with traditional open procedures. These advantages include improved visualization of pelvic anatomy, decreased postoperative pain, less operative blood loss, shortened hospital stay, rapid recovery rate and return to daily activities by patients [1].

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Perioperative Considerations

Selecting appropriate patients for laparoscopic procedures is very important. The pneumoperitoneum needed during these cases causes important systemic changes in the body, including decreased venous return, increased systemic and pulmonary vascular pressures, and increased ventilation pressures [2]. These changes are amplified in the setting of the Trendelenburg position, which is often used in gynecologic procedures. These physiologic changes are not tolerated by patients with preexisting cardiopulmonary disease. Therefore, appropriate preoperative tests, such as chest X-ray, pulmonary function tests, electrocardiogram, and echocardiogram, may be necessary in patients with suspected cardiac and pulmonary comorbidities. These procedures should be avoided in patients with known severe disease.

Visualization of all pelvic structures up to the level of the sacrum is very important for urogynecologic procedures, and therefore proper patient positioning before commencing surgery is essential. The patient should be positioned in the low lithotomy position using Allen stirrups with care to avoid hyperflexion or extension at the level of the hips and knees. All bony prominences should be padded. Placing an anti-slip device such as an egg crate underneath the patient to limit movement when the operating table is moved is very helpful. Additionally, positioning the patient so that the buttocks are slightly beyond the end of

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the table will help facilitate placement of vaginal and rectal manipulators. The arms should be tucked and padded adequately to relieve any pressure on the elbows, and the hands should be left in the proper anatomic position.

Patients should receive intravenous prophylactic antibiotics within 60 min of incision to reduce the risk of perioperative infection. The antibiotic of choice in all gynecologic surgery is a first-generation cephalosporin, usually cefazolin, or an alternative combination regimen such as clindamycin plus gentamicin if a patient has a documented contraindication to cephalosporins [3].

All patients undergoing prolapse and/or incontinence surgery are at moderate risk for venous thromboembolic events (VTE) and require perioperative prophylaxis. A systematic review of VTE prophylaxis in gynecologic surgery concluded that application of intermittent pneumatic compression devices to the lower extremities before induction of anesthesia is sufficient for VTE prophylaxis [4]. Patients at higher risk for VTE (those with significant comorbidities, cancer history, morbid obesity, or history of prior VTE) should have intermittent pneumatic compression devices and low-dose unfractionated heparin or low-molecular-weight heparin administered before surgery [5].

The value of a mechanical bowel preparation for prevention of infectious complications or an intraoperative bowel leak or for reducing the rates of anastomotic leak if bowel surgery is performed was challenged in a meta-analysis published in 2011 [6]. Based on this review, it does not seem necessary to complete bowel preparation for all patients undergoing operations to treat prolapse or incontinence.

Trocar placement plays a key role in facilitating laparoscopic procedures performed for pelvic prolapse and incontinence (Fig. 8.1). Proper positioning of each trocar allows reach of the laparoscopic instruments from the deep pelvis up to the level of the sacrum as well as adequate articulation for suturing and knot-tying. Sufficient distance between trocars is necessary to prevent instrument crossing. For surgeries such as laparoscopic sacrocolpopexy, which involves dissection over the sacrum and lower pelvis as well as extensive suturing of graft material to both regions, placement of at least four ports is usually necessary. Multiple port configurations are described in the literature. Placement of a 5-mm trocar is recommended in the umbilicus for the

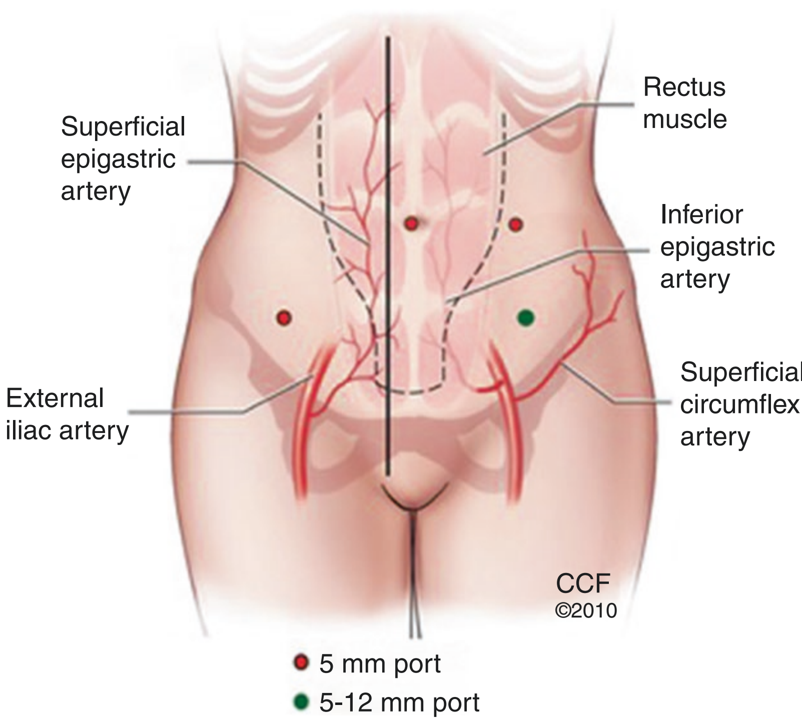

Fig. 8.1 Laparoscopic trocar placement. (From Cleveland Clinic Center for Medical Art & Photography. Copyright © 2010–2013, with permission)

laparoscope, two ports placed 2 cm superior and medial to the anterior iliac spine on each side (typically a 10-mm port on the left and a 5-mm port on the right), and a 5-mm port placed in the midclavicular line at the level of the umbilicus on the side from which the surgeon will suture. The inferior epigastric vessels are the most commonly injured vessels at the time of lateral trocar placement [2]. Although these vessels are not easily visualized, placing the ports lateral to the rectus abdominis muscles usually ensures their avoidance. All trocars should be placed under direct visualization to avoid injury to the internal vasculature and surrounding soft tissues. When placing the initial port through the umbilicus, the table should be level to avoid injury to the greater vessels, and entry should be gained in the manner with which the surgeon is most comfortable. If the patient has a history of midline laparotomy or adhesions are expected, a left upper quadrant approach is recommended. After the entry site is inspected and the upper abdomen is surveyed, the patient should be placed in a steep Trendelenburg position to move the bowels cephalad for good visualization of the pelvis and for placement of the subsequent trocars [6].

Vaginal Apex Prolapse Procedures

Uterosacral ligament suspension is a procedure that is commonly performed at the time of hysterectomy for treatment of vaginal vault prolapse (Fig. 8.2). The procedure involves attaching the vaginal vault to the midportion of the uterosacral ligament, which serves to restore the apical support of the vagina. When compared with the transvaginal approach, this type of suspension

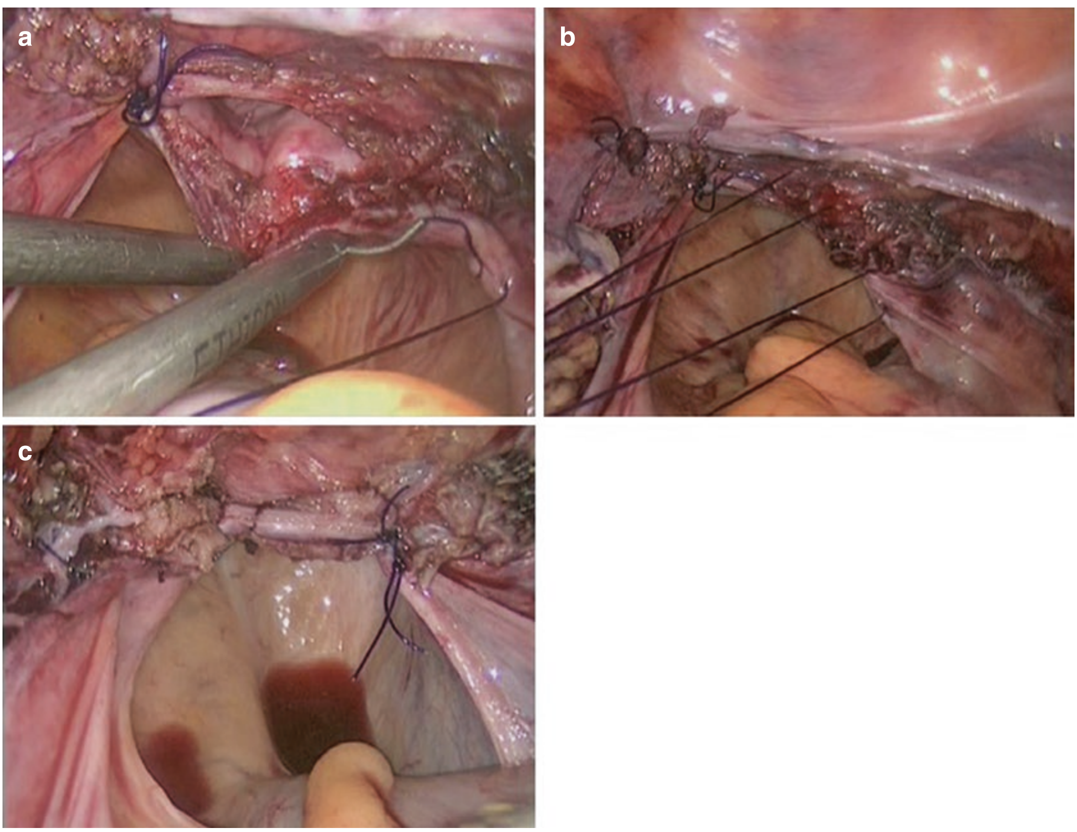

Fig. 8.2 Laparoscopic uterosacral ligament vaginal vault suspension. (**a**) A permanent or delayed absorbable suture is placed through the midportion of the uterosacral ligament (at the level of the ischial spine) with lateral to medial needle placement and then secured to the ipsilateral posterior and anterior vaginal cuffs. (**b**) One or two sutures can be placed on each side of the vagina, extracorporeal or intracorporeal knot-tying technique can be employed to suspend the vagina, (**c**) and the cuff is closed in an interrupted fashion

may decrease the risk of rectal and ureteral injury at the time of placement of the suspension sutures because these structures are easily identified in laparoscopic surgery [7]. Although laparoscopic uterosacral suspension after transvaginal hysterectomy is not very common, these benefits should be considered, especially if concomitant laparoscopic procedures are necessary. A laparoscopic approach can be taken at the time of laparoscopic hysterectomy, especially if no further vaginal reconstruction is needed at the end of the procedure. An Allis clamp can be used to elevate the vaginal cuff to delineate the uterosacral ligaments. Alternatively, a vaginal probe can be used to elevate the vagina, demarcating the uterosacral ligaments. Care is taken to avoid tenting the peritoneum close to the ureter on the ipsilateral side so as to not obstruct the ureter when the suspension sutures are tied down. A relaxing peritoneal incision between the ligament and the ureter can be made in order to reduce peritoneal tension and subsequent ureteral kinking from suture placement.

Vaginal apex prolapse can manifest itself as either uterovaginal prolapse or post-hysterectomy vaginal prolapse. Two laparoscopic options exist for patients who desire concurrent hysterectomy with their prolapse repair, or in whom hysterectomy has already been performed. These options include laparoscopic uterosacral suspension or laparoscopic sacrocolpopexy.

While there is sparse literature on outcomes from laparoscopic uterosacral ligament suspension because most studies do not follow patients beyond 2 years, the reported cure rate ranges from 76% to 90% [8, 9]. Additionally, the laparoscopic approach has also been shown to have a lower risk of ureteral injury than transvaginal uterosacral suspension [7] and therefore may be a safe alternative to transvaginal surgery.

In a recent study published by Houlihan et al. [10], the authors compared vaginal and laparoscopic uterosacral suspension at the time of hysterectomy. The authors found that outcomes and complications did not differ between the groups, but they reported that the rate of completion of adnexal surgery was significantly higher in the laparoscopic group, which points to an added benefit of choosing this mode of prolapse repair for certain patients.

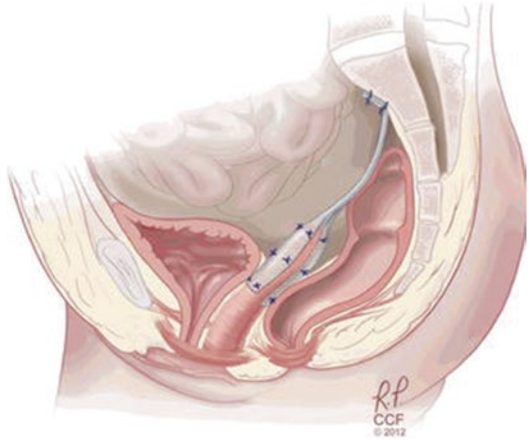

Fig. 8.3 Laparoscopic sacrocolpopexy. (From Cleveland Clinic Center for Medical Art & Photography. Copyright © 2012–2013, with permission)

Sacrocolpopexy is considered the gold standard for vault prolapse and has demonstrated superior anatomic outcomes compared to transvaginal suspension procedures (Fig. 8.3) [11]; however, the operation is associated with a higher complication rate. A laparoscopic approach aims at bridging the gap between the advantages of vaginal surgery, namely, decreased morbidity and faster patient recovery, and the surgical success rates of abdominal sacrocolpopexy [11]. For women who are sexually active with symptomatic pelvic organ prolapse, reconstruction with a sacrocolpopexy procedure is beneficial because the success rates are high as the procedure adequately restores normal pelvic anatomy and maintains vaginal length [12]. Laparoscopic sacrocolpopexy involves suspension of the vagina to the sacral promontory using a bridging graft that can be made of biologic or synthetic materials. The graft is sutured to the anterior as well as the posterior vagina and then to the anterior longitudinal ligament of the sacrum. We strongly believe that the minimally invasive approach to sacrocolpopexy should not have alterations from the open approach. The exact same steps, suture type and number, and graft should be used with open or laparoscopic surgery (Table 8.1).

Table 8.1 Tips for performing minimally invasive sacrocolpopexy [11]

Patient positioning is critical
Place egg crate or other anti-slip device directly below patient to prevent movement during operation
Position buttocks slightly beyond end of table so that vaginal manipulation is possible
Tuck and protect both arms
Once intra-abdominal access is gained, steep Trendelenburg positioning helps move the small bowel into the upper abdomen
Two knowledgeable assistants are necessary
One works intra-abdominally and helps with retraction
One works vaginally and manipulates the vagina and rectum to optimize visualization
Placement of ports is integral to procedure success
If the colon is redundant, an epiploica can be sutured temporarily to the left anterior abdominal wall to improve visualization
If hysterectomy is planned, a supracervical hysterectomy should be considered because the cervix may help to decrease future mesh erosions. Alternatively, a vaginal hysterectomy can be performed prior to a laparoscopic repair
Care should be taken to avoid the intervertebral disc while placing the sacral sutures. Deep stitches through the disc and periosteum should be avoided because cases of osteomyelitis have been reported after robotic sacrocolpopexy
Convert to laparotomy when necessary. Patient safety is of utmost importance

From Walters and Ridgeway [12]; with permission

The most commonly used material is a large-pore polypropylene mesh, which has proven to have fewer complications because of its favorable synthetic properties [12]. The technique of laparoscopic sacrocolpopexy using graft placement begins with proper positioning of the patient in the low lithotomy position using Allen stirrups so that there is access to the vagina during the operation. An end-to-end anastomosis (EEA) sizer should be placed in the vagina for manipulation of the apex. A Foley catheter is placed in the bladder for continuous drainage throughout the operation. After intraperitoneal access is gained and laparoscopic trocars are placed, the small bowel should be gently placed into the upper abdomen and the sigmoid colon deviated to the left pelvis as much as possible. If manual retraction of the sigmoid colon is not adequate, a temporary suture can be placed through the epiploica of the colon, passed lateral to a trocar on the left side of the patient, and clamped to the drapes, with removal of the suture at the end of the procedure. The ureters are identified bilaterally; it is important to note their location throughout the duration of the case. Attention is then turned to the sacrum, and the sacral promontory is identified so that the presacral space may be entered.

The important landmarks of the presacral space include the aortic bifurcation, the common and internal iliac vessels, the sigmoid colon, and the right ureter (Fig. 8.4a). Notably, the left common iliac vessel is located medial to the iliac artery and is particularly vulnerable to injury during this procedure, as are the internal iliac vessels, the right ureter, and the middle sacral artery. Once all structures are identified, a longitudinal peritoneal incision is made over the sacral promontory. Dissection is done carefully to reveal the bony promontory as well as the anterior longitudinal ligament, which will later serve as the attachment point for the graft. Approximately 4 cm of exposure is necessary, and this is achieved by using blunt dissection or electrocauterization of the subperitoneal fat. Caution should be taken to avoid the presacral venous plexus as well as the middle sacral vein and artery, which are often encountered during this dissection. Dissection caudally through the peritoneum and subperitoneal fat is carried down to the level of the posterior cul-de-sac. The rectum and right ureter are visualized at all times during this part of the procedure as the course of the dissection is located between these two structures.

The vagina is elevated cephalad using a sponge stick or EEA sizer, the peritoneum overlying the anterior vaginal apex is incised transversely, and the bladder is dissected off the anterior vagina using sharp dissection, creating a 4- to 5-cm pocket (Fig. 8.4b). If this plane is difficult to establish, the bladder can be filled in a retrograde fashion to find the correct dissection plane. Similarly, the peritoneum overlying the posterior vagina is incised, and dissection is done overlying the vagina and extending into the posterior cul-de-sac, creating a 4- to 5-cm pocket. Care must be taken to avoid injury to the rectum during this part of the surgery. If the rec-

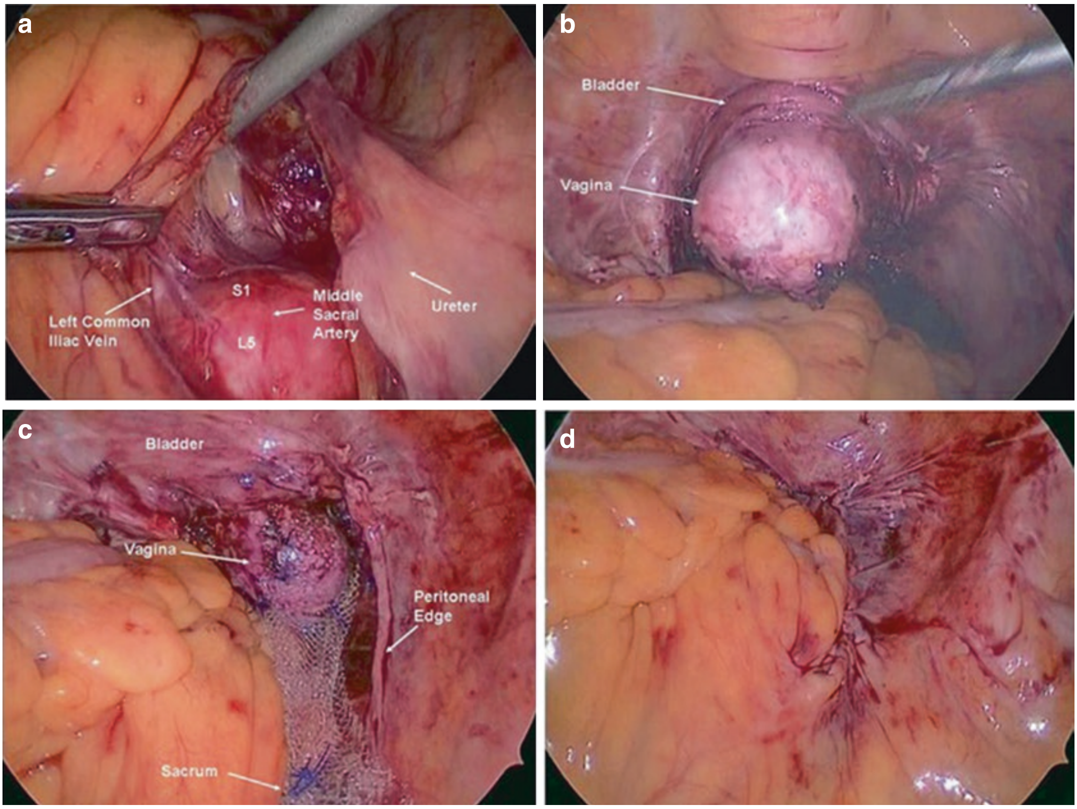

Fig. 8.4 (**a**) The important landmarks of the presacral space include the aortic bifurcation, the common and internal iliac vessels, the sigmoid colon, and the right ureter. (**b**) The vagina is elevated cephalad using a sponge stick or EEA sizer, the peritoneum overlying the anterior vaginal apex is incised transversely, and the bladder is dissected off the anterior vagina using sharp dissection, creating a 4- to 5-cm pocket. (**c**) The graft extends approximately halfway down the posterior vaginal wall. The second arm of the graft is then attached to the anterior vaginal wall in a similar fashion. (**d**) The peritoneum is then closed over the exposed graft with absorbable suture

tum is hard to delineate, a second EEA sizer should be introduced into the rectum, and with manipulation of the vaginal and rectal EEA sizers, the correct dissection plane is identified. If the patient has concomitant defecatory dysfunction and/or rectal prolapse, the posterior dissection is sometimes carried down to the level of the perineal body. In most cases, however, the 4- to 5-cm pocket is sufficient. Once dissection is complete, the graft is prepared. A lightweight polypropylene mesh is currently most commonly used. The mesh is fashioned into two arms that are approximately 4 × 15 cm in size. Alternately, a prefabricated Y-mesh can be used. The graft is first attached to the posterior vaginal wall using 4–6 monofilament permanent or delayed absorbable No. 0 or 2-0 sutures in an interrupted fashion, 1–2 cm apart from each other. Sutures are placed through the fibromuscular tissue of the vagina but not through the underlying epithelium.

The graft extends approximately halfway down the posterior vaginal wall (Fig. 8.4c). The second arm of the graft is then attached to the anterior vaginal wall in a similar fashion. Delayed absorbable sutures should be used for the most distal stitches close to the bladder to avoid suture erosion and fistulization. The vagina is then elevated with the sponge stick or EEA sizer toward the sacral promontory. The graft is trimmed to the appropriate length and then sutured to the anterior longitudinal ligament using a stiff but small half-curved tapered needle with two to three permanent No. 0 monofilament sutures.

The peritoneum is then closed over the exposed graft with absorbable suture (Fig. 8.4d). After cystoscopy, a vaginal examination is performed, and a posterior colporrhaphy and perineorrhaphy are performed if needed.

A review of abdominal sacrocolpopexy reported the success rate when defined as lack of apical vaginal prolapse postoperatively from 78% to 100% [13]. The median reoperation rates for pelvic organ prolapse and for stress urinary incontinence in the studies that reported these outcomes were 4.4% (range, 0–18.2%) and 4.9% (range, 1.2–30.9%), respectively. A randomized, controlled trial of sacrocolpopexy with and without concomitant Burch colposuspension at 2-year follow-up had reassuring anatomic outcomes, with 95% of subjects having excellent objective outcomes for the vaginal apex (within 2 cm of total vaginal length), with 2% of subjects demonstrating stage III prolapse, and 3% of subjects undergoing reoperation for prolapse [14]. These subjects also demonstrated improved urinary, defecatory, and sexual function based on validated questionnaires. Historically, most of the literature has focused on abdominal sacrocolpopexy, but in the past 10 years, there has been emerging data on the laparoscopic approach. A comprehensive review looking at over 1000 patients in 11 series who underwent laparoscopic sacrocolpopexy revealed that the conversion rates and operative times had decreased substantially with increased experience in performing this procedure [11]. The mean follow-up for these series was 24.6 months with an average patient satisfaction rate of 94.4% and a 6.2% prolapse reoperation rate [11]. From this review, the authors concluded that a laparoscopic approach to sacrocolpopexy upholds the outcomes of the gold standard of abdominal sacrocolpopexy and is a very good minimally invasive option for patients with vaginal vault prolapse [11].

In another more recent randomized clinical trial, Coolen et al. [15] compared laparoscopic sacrocolpopexy to open abdominal sacrocolpopexy and found that the laparoscopic approach was associated with less blood loss, a shorter hospital stay but with similar anatomic and functional outcomes, thus further supporting the use of laparoscopy to perform this surgery.

Uterine-Preserving Laparoscopic Procedures

Hysterectomy is often done at the time of surgical repair for uterine and uterovaginal prolapse. Uterine preservation techniques have largely been employed in women with uterovaginal prolapse desiring future fertility. However, there has been a small shift in this practice as more women are requesting uterine preservation for other important reasons, including issues of sexuality, body image, cultural preferences, and the concern for earlier-onset menopause after hysterectomy [12]. The risk of unanticipated pathology in asymptomatic women remains low [16]; however, it is important to determine which patients are appropriate candidates for uterine-preserving surgery. Uterine-preserving surgery is contraindicated in women with a history of cervical dysplasia, dysfunctional uterine bleeding, postmenopausal bleeding, and risk factors for endometrial carcinoma. Additionally, women who choose to undergo hysteropexy should be counseled about the need for continued cancer surveillance and potential risks associated with future pregnancies [17].

Most procedures that aim to suspend the vaginal apex are performed in a similar fashion to those performed with hysterectomy, with some necessary modifications [12]. The minimally invasive abdominal procedures most commonly described in the literature include laparoscopic uterosacral ligament suspension and laparoscopic sacrohysteropexy. Laparoscopic uterosacral ligament suspension is performed similarly to vaginal vault suspension to the uterosacral ligaments. The uterus is suspended to a portion of the ligament on each side, preferably using permanent suture. Additionally, the uterosacral ligaments can be shortened with sutures, providing additional support. This procedure is favorable because it restores normal anatomy while preserving the uterus. Furthermore, it carries little risk for subsequent pregnancy and labor. Few comparative studies exist, but one study looking at laparoscopic hysteropexy via uterosacral ligament suspension and vaginal hysterectomy with subsequent vaginal vault suspension was compared in a retrospective cohort study of 50 patients [18]. The authors found that hysteropexy patients had better vault suspension as measured by the Pelvic Organ Prolapse Quantification examination postoperatively and experienced fewer failures as measured by reoperation rates when compared to the vaginal vault suspension group [18].

Sacrohysteropexy involves mesh attachment to the vagina and cervix with the uterus in situ with subsequent suspension of the mesh to the anterior longitudinal ligament of the sacrum. Few long-term randomized trials exist comparing this procedure to other types of prolapse surgery. When compared to vaginal hysterectomy with uterosacral suspension, 2-year outcomes were similar [19]. Similarly, when compared to vaginal sacrospinous hysteropexy, mesh-augmented sacrohysteropexy was found to be non-inferior with regard to repair of the apical compartment [20].

Laparoscopic Sacrohysteropexy

Laparoscopic sacrohysteropexy can be done using different techniques but is similar to the technique used during sacrocolpopexy. Graft material can be sutured anteriorly and/or posteriorly, usually on the lower uterine segment, but can also be sutured to a portion of the proximal vagina. The graft is then suspended to the anterior longitudinal ligament of the sacrum using permanent sutures. If anterior mesh is applied, windows are created through the broad ligament to allow the graft to pass through for attachment to the sacrum (Fig. 8.5a–b). A posterior cervical graft has been placed, and this also has been sutured to the sacral promontory, thus suspending the uterus, cervix, and vagina to the sacrum (Fig. 8.5c–d). While outcomes data are sparse for laparoscopic sacrohysteropexy, results from abdominal sacrohysteropexy studies have shown similar high success rates when compared to open abdominal hysterectomy with subsequent sacrocolpopexy [21]. This procedure remains a viable option for patients with uterovaginal prolapse who desire uterine preservation. However, sacrohysteropexy with anterior mesh should not be offered to patients who desire future fertility. In these patients, placing a solitary posterior mesh can be considered.

Laparoscopic Enterocele Repair

An enterocele is a true hernia of the peritoneal pouch of Douglas and most often occurs in conjunction with additional uterovaginal prolapse or develops following vaginal or abdominal hysterectomy. The repair of an enterocele is traditionally done transvaginally or abdominally for larger enteroceles. However, there are times when laparoscopic repair is indicated, such as during concomitant surgery for other uterovaginal prolapse [22]. Two different laparoscopic techniques have been described to repair an enterocele: the Moschcowitz and Halban procedures. In both operations, a transvaginal manipulator or digital manipulation is necessary to apply transvaginal pressure for easy identification of the posterior vagina, rectum, and hernia sac.

In the Moschcowitz procedure, the enterocele sac is obliterated by reapproximating the pelvic peritoneum between the rectum and vagina, incorporating the uterosacral ligaments with a permanent No. 0 suture in a purse-string fashion (Fig. 8.6a).

The Halban culdoplasty is similar but involves placing permanent No. 0 sutures in an interrupted fashion, starting at the posterior vagina and proceeding longitudinally over the cul-de-sac peritoneum and then over the inferior sigmoid serosa; the sutures are tied as they are placed and should be approximately 1 cm apart (Fig. 8.6b) [23].

Visualization of the ureters is important during both of these procedures to ensure that there is no obstruction or kinking of the overlying peritoneum when the cul-de-sac is closed.

Incontinence Procedures

Laparoscopic Burch Colposuspension

Surgery for stress incontinence is recommended when conservative treatments fail. The open

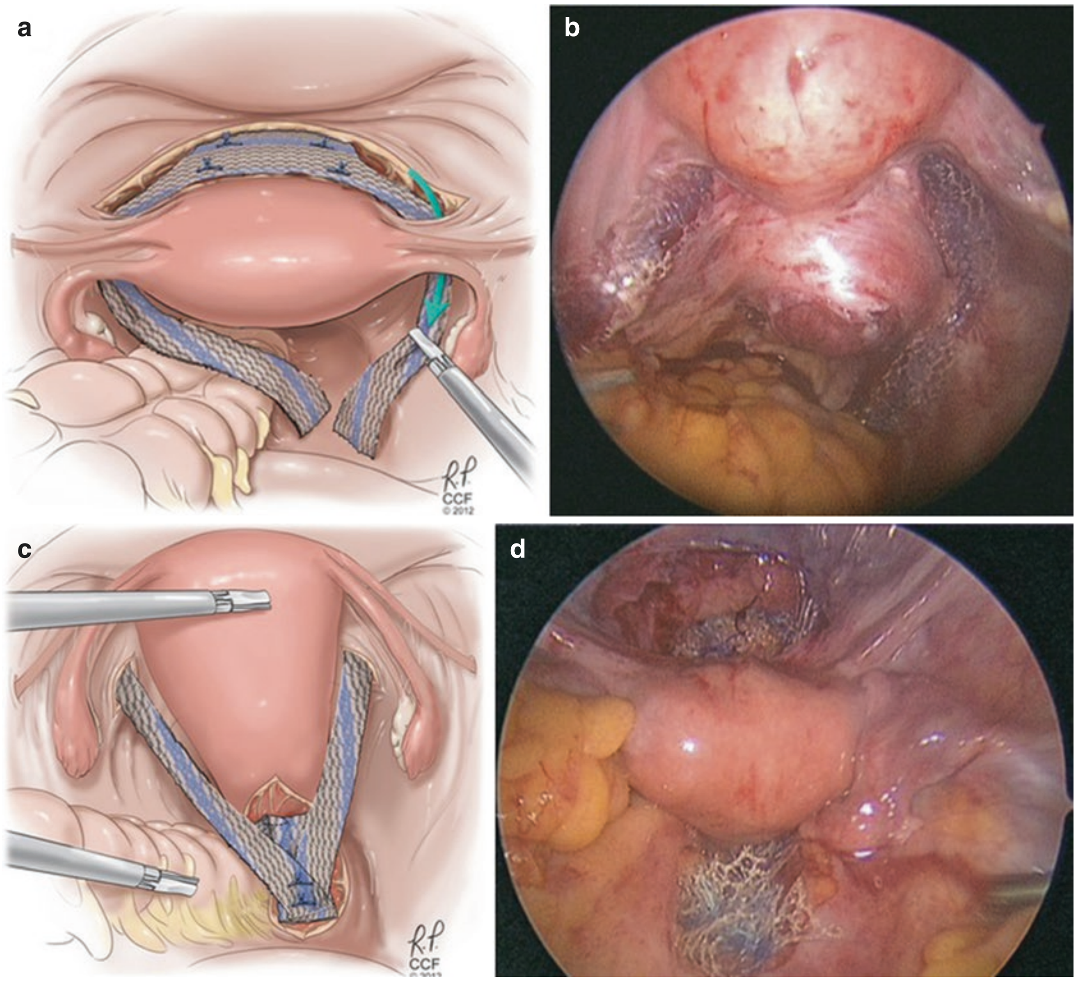

Fig. 8.5 Laparoscopic sacrohysteropexy. (**a**–**b**) If anterior mesh is applied, windows are created through the broad ligament to allow the graft to pass through for attachment to the sacrum. (**c**–**d**) A posterior cervical graft has been placed, and this also has been sutured to the sacral promontory, thus suspending the uterus, cervix, and vagina to the sacrum. (**a** and **c** from Cleveland Clinic Center for Medical Art & Photography. Copyright © 2012–2013, with permission)

Burch colposuspension has been referred to as the gold standard for surgical management of urinary stress incontinence, with a reported cure rate higher than 80% [24]. In the past decade, the midurethral sling has become the most common method of surgical management of stress urinary incontinence owing to its minimally invasive approach and evidence that it has similar long-term efficacy to the Burch procedure [25]. However, the Burch colposuspension remains an important technique for management of stress urinary incontinence in patients who have failed treatment with the midurethral sling, who decline synthetic mesh placement, or who are undergoing concomitant laparoscopic prolapse repair surgery and would prefer to have an abdominal approach for their incontinence procedure.

The laparoscopic Burch colposuspension was first described in the 1990s and, while similar in technique to the open approach, has the same advantages as conventional laparoscopic surgery [24]. Miklos and Kohli provide a good description of how this procedure is performed [26]. The bladder is first filled in retrograde fashion to visu-

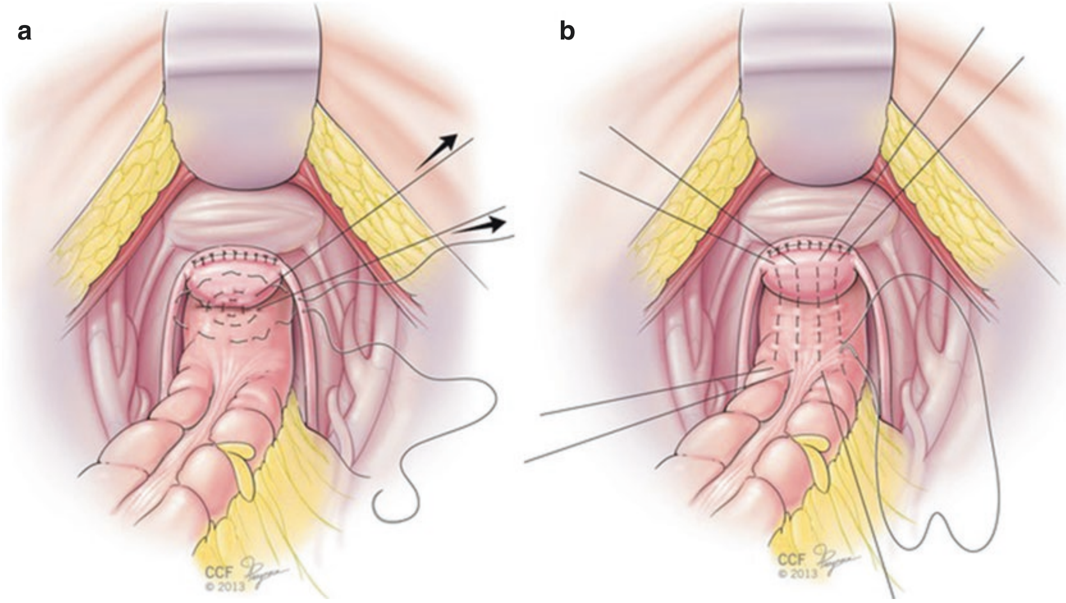

Fig. 8.6 Laparoscopic enterocele repair. (**a**) In the Moschcowitz procedure, the enterocele sac is obliterated by reapproximating the pelvic peritoneum between the rectum and vagina, incorporating the uterosacral ligaments with a permanent No. 0 suture in a purse-string fashion (*arrows*). (**b**) The Halban culdoplasty is similar but involves placing permanent No. 0 sutures in an interrupted fashion, starting at the posterior vagina and proceeding longitudinally over the cul-de-sac peritoneum and then over the inferior sigmoid serosa; the sutures are tied as they are placed and should be approximately 1 cm apart. (From Cleveland Clinic Center for Medical Art & Photography. Copyright © 2013, with permission)

alize the superior border of the bladder edge (Fig. 8.7). The space of Retzius can be entered by creating a peritoneal incision above the bladder reflection, starting along the medial border of the right obliterated umbilical ligament. Confirmation of entry into the proper plane is made when the underlying loose alveolar tissue is encountered and the pubic rami are identified. The bladder is then drained, and blunt dissection opens the space of Retzius until the bladder neck is identified. Important anatomic landmarks of this dissection include the pubic symphysis, Cooper's ligaments, and the arcus tendineus fascia pelvis. Once the bladder neck and midurethra are visualized, careful dissection exposes the underlying endopelvic fascia. A vaginal manipulator or digital manipulation elevates the vagina during placement of the sutures. Permanent No. 0 or 2-0 sutures are used, first placed lateral to and at the level of the midurethra, through the fibromuscular tissue of the vagina, with care not to incorporate the underlying epithelium. The suture is then passed through the Cooper's ligament on the ipsilateral side. A

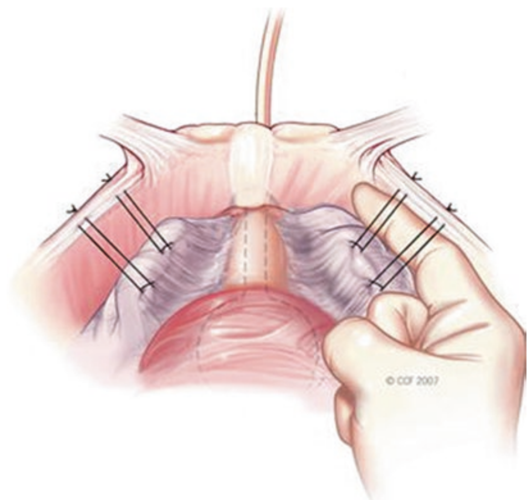

Fig. 8.7 In Burch colposuspension, two sutures are placed in the fibromuscular layer of the vagina and through Cooper's ligaments on each side in order to support the midurethra and bladder neck

second suture is then placed at the level of the urethrovesical junction and again through the Cooper's ligament on the same side. The sutures are tied in an extracorporeal or intracorporeal fashion. The same procedure is repeated on the contralateral side. While the literature shows that midurethral sling procedures appear to offer greater benefits with better objective outcomes in the short term and similar subjective outcomes long term [27], the laparoscopic Burch procedure is still an important operation in pelvic reconstructive surgery and is appropriate for certain patients. Some studies have shown that that laparoscopic colposuspension is as efficacious as open colposuspension [28]; however, the 2010 Cochrane review on laparoscopic Burch colposuspension revealed that while women's subjective impression of cure was similar for both procedures, there was some evidence of poorer results for laparoscopic colposuspension on objective outcomes [27]. Additionally, while there were fewer postoperative complications and shorter hospital stays with laparoscopic Burch procedures when compared to open colposuspension, the laparoscopic approach was more costly.

Laparoscopic Paravaginal Defect Repair

Lateral vaginal wall support defects may contribute to the development of stress urinary incontinence, and for this reason the paravaginal defect repair was once routine at the time of Burch colposuspension for treatment of stress urinary incontinence [26]. However, the rate of Burch colposuspension procedures continues to decrease with the increasing use of the midurethral sling. Additionally, the presence and degree of severity of paravaginal defects is challenging to diagnose as there is evidence that the clinical examination of these support defects displays poor interexaminer and intraexaminer agreement [28]. For these reasons, paravaginal defect repairs are performed much less frequently than in the past. However, a Cochrane review evaluating laparoscopic Burch colposuspension reported that paravaginal repair at the time of the Burch procedure appears to be beneficial with regard to postoperative outcomes. Therefore, understanding the steps of this procedure continues to be important [27].

These defects are identified when the space of Retzius is opened; the lateral attachments of the pubocervical fascia are detached from the side wall of the pelvis at the level of the arcus tendineus fascia pelvis (Fig. 8.8). To repair these defects laparoscopically, a nonabsorbable suture can be used and passed through the fibromuscular layer of the vagina and then through the obturator internus muscle and its fascia around the arcus tendineus at its origin, approximately 2 cm from the ischial spine [26]. Several sutures are

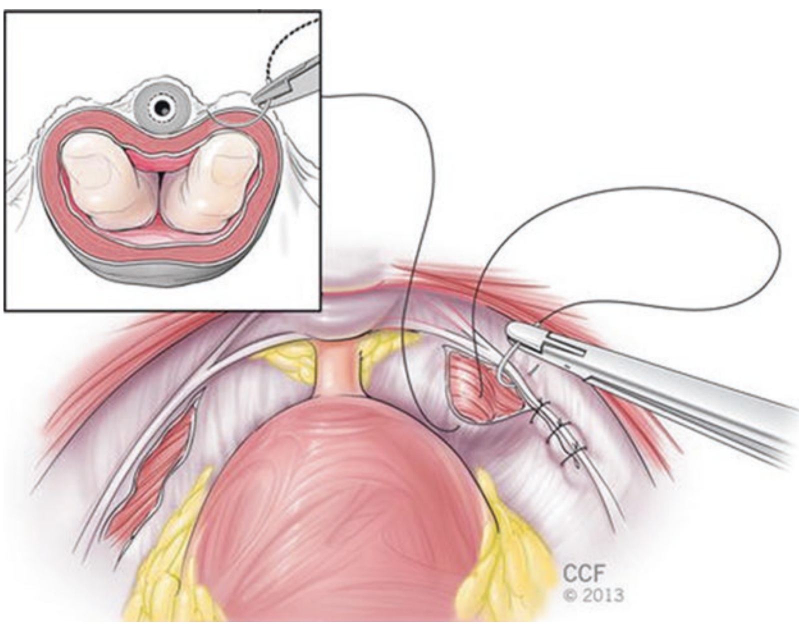

Fig. 8.8 In paravaginal defect repair, a suture is passed through the fibromuscular layer of the vagina and then through the obturator internus muscle and its fascia around the arcus tendineus at its origin on each side in order to support the lateral vagina and repair the defect

placed in an interrupted fashion from the ischial spine to the proximal portion of the vesicourethral junction until there is good restoration of vaginal anatomy. The procedure can be done unilaterally or bilaterally, depending on the nature of the defect.

The Burch colposuspension procedure remains an important technique for management of stress urinary incontinence in patients who have failed treatment with the midurethral sling, who decline synthetic mesh placement, or who are undergoing concomitant laparoscopic prolapse repair surgery and would prefer to have an abdominal approach for their incontinence procedure. Additionally, the paravaginal defect repair was once a routine procedure at the time of Burch colposuspension for treatment of stress urinary incontinence. While this procedure is no longer routinely performed, it remains indicated in certain patients.

Complications

The overall complication rate of gynecologic laparoscopic procedures has been reported to be approximately 0.46% with a mortality rate of 3.3 per 100,000 laparoscopies [29]. As procedures become more complex, the risk of complication increases. Up to one-third of complications can be attributed to trocar entry or placement [2]. Vascular injuries, while rare, are associated with the highest rate of mortality from a laparoscopic injury. The reported incidence of laparoscopic vascular injury ranges from 0.01% to 0.64% [29]. Morbidity from a vascular injury varies and is dependent on the vessel that is injured and the time of recognition. The vessels most commonly injured during operative laparoscopy are the aorta, inferior vena cava, and iliac vessels [2]. Laparoscopic sacrocolpopexy adds additional risk to the vasculature of the presacral space, including the left common iliac vein, middle sacral artery, and sacral venous plexus [12].

Bowel injuries can account for almost one-third of laparoscopic complications during gynecologic procedures [29]. Injuries that occur at entry are usually associated with small bowel injuries and are the most common. Once entry has been achieved, injury to the rectosigmoid colon is the second most common type of injury [2]. Operative injuries with laparoscopic instruments, especially those using electrocautery, can also occur and can be very severe, as recognition of the injury can be delayed in these cases. Factors that increase the rate of bowel injury include complexity of the case, the presence of intra-abdominal adhesions, and the experience of the operating surgeon. A study by Warner and colleagues reported on the intraoperative and postoperative gastrointestinal complications specific to laparoscopic sacrocolpopexy [30]. Their intraoperative bowel injury rate was 1.3%, and injury was not found to be associated with prior abdominal surgery, age, or body mass index. Their postoperative gastrointestinal complications included ileus and small bowel obstruction with a reported rate of 1% in their patient population.

The incidence of ureteral injury (including transection, obstruction, fistula formation, and necrosis from thermal injury) during gynecologic laparoscopy ranges from less than 1–2% [31]. The bladder is at risk of injury during its dissection at the time of hysterectomy and also during sacrocolpopexy. Injuries to the ureter occur most commonly at the level of the infundibulopelvic ligament and at the cardinal ligament, where the ureter passes underneath the uterine artery. Ureteral injury can also occur at the time of suspension suture placement during uterosacral ligament suspension if the sutures are placed in such a way that the peritoneum overlying the ureter receives too much tension or if the ureter itself is incorporated into the suspension. Cystoscopy should always be performed after laparoscopic reconstructive pelvic surgery because studies show that there is a higher injury detection rate seen when intraoperative cystoscopy is done [31].

A large retrospective cohort study of 406 women undergoing minimally invasive abdominal sacrocolpopexy further confirmed that peri- and postoperative outcomes following laparoscopic sacrocolpopexy are favorable with few patients experiencing adverse events. In this series, the rates of bladder injury, ureteral injury, bowel injury, and vascular injury were 0.4, 0, 1.2, and 0.8%, respectively. Postoperative complications were similarly low [32].

Postoperative infection is rare after laparoscopic surgery. Spondylodiscitis of the L5 to S1 disc space is the most morbid infection associated with sacrocolpopexy and is very rare; only case reports have been written about this complication. *Staphylococcus aureus* is the most commonly reported organism, and cases were most commonly associated with concomitant hysterectomy at the time of prolapse repair [33]. When sacrocolpopexy is being performed, care should be taken to avoid the intervertebral disc space while placing the sacral sutures because deep stitches through the disc and periosteum may be the precipitating factors in the development of osteomyelitis. Patients with these infections require aggressive therapy with intravenous antibiotics and often reoperation for pelvic washout and removal of the infected graft.

Mesh exposure is also a complication related to laparoscopic sacrocolpopexy. A randomized clinical trial evaluating the outcomes of abdominal sacrocolpopexy with and without Burch colposuspension also looked at the risk of mesh and suture exposure following abdominal sacrocolpopexy and found the exposure rate to be 6% in 322 study participants [34]. More recent data show that the rate of erosion may actually be lower with the development of lighter polypropylene mesh, which has become the standard of care for this procedure. In a recently published retrospective study of 660 patients, Baines et al. [35] reported a vaginal mesh erosion incidence of 0.7%, showing that laparoscopic sacrocolpopexy might confer a low risk of mesh exposure, lower than previously reported.

Results from a retrospective study of 188 subjects demonstrated a higher rate of mesh exposure in patients who had undergone concurrent total laparoscopic hysterectomy compared to those who were post-hysterectomy or underwent supracervical hysterectomy at the time of surgery, with rates of 23, 5, and 5%, respectively [36]. Performing a supracervical hysterectomy at the time of prolapse surgery rather than a total vaginal hysterectomy prior to sacrocolpopexy has become more common, and patients should be counseled regarding the risks and benefits of both options.

Conclusions

Currently, our fastest-growing population is the elderly, and the incidence and prevalence of uterovaginal prolapse and urinary incontinence increase with age. Current data show that 23.7% of women suffer from at least one pelvic floor disorder [37] and that the overall prevalence of these disorders is projected to increase by 56% by 2050 [38]. While there are multiple approaches to surgery that exist for pelvic floor disorders, in this chapter we focus on the laparoscopic procedures that are used to treat prolapse and incontinence. There are many advantages to performing these surgeries in a minimally invasive fashion; however, the burden of postoperative complications remains. For this reason, it is imperative that the appropriate surgical candidates undergo the correct procedures for their surgical needs and that important perioperative precautions are taken. Surgical management of pelvic organ prolapse and incontinence remains complex. The principles for management of these disorders are not new, and the difference lies in the route by which the surgery is performed. Adequate training is necessary to perform these procedures laparoscopically; however, pelvic floor surgeons should strive to learn these techniques as the benefits of improved visualization of pelvic anatomy and faster recovery for patients remain very desirable.

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Techniques in Reproductive Surgery

9

Nisha Garg, Elizabeth W. Patton, and Magdy P. Milad

Advances in gynecologic minimally invasive surgical techniques coupled with basic and translational research have led to the development of multiple laparoscopic surgical applications for fertility preservation. Procedures discussed in this chapter include salpingolysis and fimbrioplasty for tubal occlusion, reversal of tubal ligation and tubal reanastomosis, treatment of hydrosalpinx or salpingectomy to improve in vitro fertility rates, and removal of hysteroscopic sterilization devices. In addition, laparoscopic approaches for oophoropexy and ovarian transposition to prevent recurrent torsion or to avoid damage secondary to radiation treatment are reviewed.

Each procedure is described and includes patient selection and preparation as well as surgical approach and technique. Narrative descriptions are supplemented by multiple intraoperative images as well as figure drawings to illustrate the various techniques.

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Introduction

As the field of gynecologic laparoscopy has become increasingly sophisticated, techniques and procedures related to fertility preservation, treatment, and enhancement have likewise been refined. Basic and translational research has also shaped the practice of gynecologic minimally invasive surgery. For example, as techniques of in vitro fertilization have become progressively successful, the role of tubal surgery for tubal repair or reanastomosis has become more limited, although it retains a role for select patients when performed by skilled providers. Robotic access may also improve the availability of these procedures by trained providers that previously did not have the requisite psychomotor skills. Additionally, ovarian preservation surgery remains an important area of gynecologic laparoscopy, particularly for younger patients facing radiation treatment for malignancy or those with recurrent ovarian torsion requiring repeated urgent surgeries. Surgical procedures such as oophoropexy to prevent recurrent torsion or transposition to attempt to preserve fertility by moving the ovaries outside of a proposed radiation field for treatment of malignancy should be offered to appropriate patients during physician-patient counseling on surgical management.

In this chapter, the techniques of tubal repair and reanastomosis, oophoropexy and ovarian transposition, and removal of previously

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hysteroscopically placed sterilization devices will be reviewed, along with illustrative intraoperative images and figure drawings. Each section in the chapter will review the technique, the patients for whom it is appropriate, and any particular preoperative and perioperative considerations accompanied by the images. In some cases, such as tubal repair and reanastomosis, the procedure requires highly specialized laparoscopic skills, which may necessitate referral to a specialist trained in these techniques.

Laparoscopic Tubal Surgery for Fertility Indications

Laparoscopic Tubal Repair and Reanastomosis and Removal of Previously Placed Tubal Occlusion Devices

Tubal disease plays a significant role in female-factor infertility, with rates ranging from 25% to 35% [1]. Besides the significant role of salpingitis and other contributors to tubal factor infertility, 20–30% of women regret having pursued a tubal ligation [2]. Thus, there are many potential patients for whom a tubal repair or tubal reanastomosis surgery might be appropriate. However, in an era in which in vitro fertilization (IVF) treatments are becoming ubiquitous and effective, careful consideration must be given to patient counseling and selection. Bypassing the fallopian tubes entirely with IVF has further advantages for those affected by infertility. It is less surgically invasive, enables treatment of other infertility factors (e.g., male factor), and allows for frozen embryos that can be used years later when diminished ovarian reserve may have ensued. Additionally, tubal repair or reanastomosis requires a surgeon of sophisticated skill; such a surgeon may not be readily accessible.

Tubal repair/reanastomosis does have its own advantages. It is a minimally invasive outpatient surgery and avoids the IVF concerns gonadotropin injections, multifetal gestation, and ovarian hyperstimulation syndrome. For patients whose location, socioeconomic status, or insurance does not afford them access to IVF treatment, tubal repair may be their only option for treatment of tubal factor infertility including tuboplasty and tubal anastomosis. Finally, with severely diminished ovarian reserve, IVF may be associated with a dismal cycle-specific pregnancy rate, in which case tubal repair with its associated cumulative success may be warranted.

Tubal repair surgery or reanastomosis surgery may be appropriate for young healthy patients who do not have other known contributing factors to infertility except for the identified tubal factor or a prior tubal ligation. Surgery has low risks of infection, bleeding, damage to adjacent structures, ectopic pregnancy, and the possibility that even a technically successful surgery may not result in pregnancy.

Once a patient has been thoroughly advised regarding her options and has, through collaborative discussion with her physician, opted for laparoscopic tubal repair surgery, the location of the tubal blockage of disease will determine the surgical approach and technique.

Proximal Tubal Occlusion

Proximal tubal blockage accounts for 10–25% of tubal disease and may be due to mucus plugs, debris, tubal spasm, or a true anatomic blockage due to fibrosis [1, 3]. Appropriate candidates for tubal repair surgery to correct proximal tubal blockage are those who are young, without other obvious causes of female or male factor infertility, and those a confirmatory preoperative hysterosalpingogram (HSG), without evidence of salpingitis isthmica nodosa or predisposing risk factors for concomitant distal disease.

Diagnosis of proximal tubal blockage can occur via fluoroscopy or by hysteroscopy with laparoscopic confirmation. An outer catheter is inserted in the ostia and a hysterosalpingogram is performed (Fig. 9.1). If blockage is confirmed, an inner catheter with guidewire is advanced gently through the proximal tube, under fluoroscopic or hysteroscopic/laparoscopic guidance. If the catheter cannot be threaded with gentle pressure, a true anatomic occlusion is considered confirmed, and the procedure is terminated. In these cases, IVF is preferred over resection and anastomosis

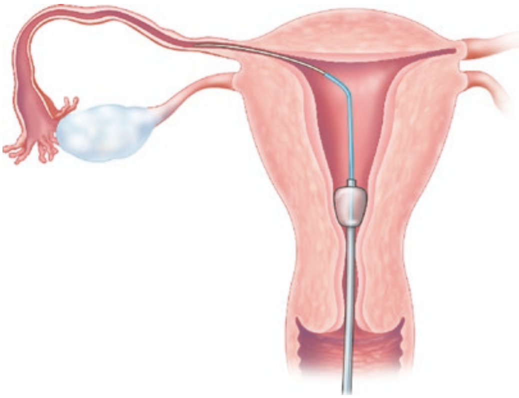

Fig. 9.1 Transcervical tubal cannulation to assess for tubal patency

Fig. 9.2 Peritubal adhesions. Intraoperative laparoscopic image of peritubal adhesions. (Courtesy of M. Milad)

[1]. However, if IVF is not an option for the patient, microsurgery can be considered if performed by a surgeon with appropriate training and recent experience. A meta-analysis on tubal cannulation in patients with both unilateral and bilateral obstruction showed cumulative clinical pregnancy rates were approximately 22% at 6 months and increased slowly over time to approximately 28% at 48 months [4]. Given these findings, it is reasonable to pursue alternative interventions if spontaneous pregnancy is not achieved within 6–12 months after successful cannulation [1].

Distal Tubal Occlusion

If preoperative HSG has confirmed a more distal tubal occlusion, laparoscopy is a common next step even if patients proceeding directly to IVF. Prior to these procedures, patients should be counseled on both tubal repair as well as salpingectomy, since severe hydrosalpinges have been demonstrated to negatively affect IVF success [5]. Patients with the best chance of success for tubal repair are those with small amounts of filmy adhesions and mild dilation of the fallopian tube (Fig. 9.2).

Salpingolysis and Fimbrioplasty. Once laparoscopic access is established, the fallopian tube is identified. The mesosalpinx can be injected with dilute vasopressin (5 international units per 20 mL of normal saline) to improve hemostasis. The tube is gently elevated with an atraumatic grasper, and adhesions are either lysed or excised. Avoiding thermal injury likely improves long-term tubal function.

A straight dissector can be used to resolve fimbrial agglutination or prefimbrial phimosis. If a hydrosalpinx is present, an incision is made using a laparoscopic scissors with harmonic, monopolar electrosurgery employed sparingly. This incision allows drainage of the hydrosalpinx fluid and promotes the ability to assess the intratubal architecture assessing whether there is retention of the normal mucosal folds and cilia.

If the hydrosalpinx is large or the adhesions are extensive, salpingectomy should be undertaken and followed by IVF because a large hydrosalpinx (greater than 3 cm) has a poor response to neosalpingostomy. A scored blunt probe can be very useful in truly quantifying the diameter of a hydrosalpinx (Fig. 9.3).

Salpingectomy is performed by dividing the proximal tube at the cornua using an electrosurgical coagulation and cutting device. The same device is then used to coagulate and cut the mesosalpinx close to the tube along its length serially. Electrosurgery should be used sparingly, given the theoretical concern for thermal injury to the ovarian vessels and the potential for fewer oocytes retrieved at egg aspiration. To avoid any electrosurgery at the infundibulopelvic ligaments, sutures or an endoloop may be employed (Fig. 9.4).

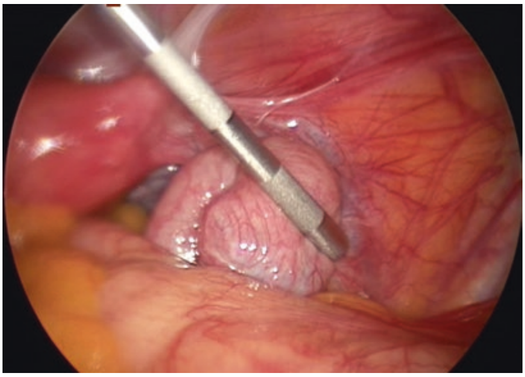

Fig. 9.3 Utilizing a blunt probe to assess the size of a hydrosalpinx. (Courtesy of M. Milad)

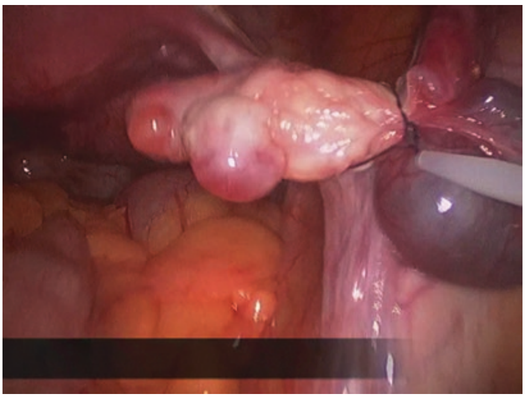

Fig. 9.4 Use of an endoloop to ligate the infundibulopelvic ligament as part of a salpingectomy, enabling minimal use of the electrocautery and maximal sparing of the ovarian blood supply. (Courtesy of M. Milad)

Neosalpingostomy. If the fimbria has become adhered in such a way that the tubal opening is obliterated and no retention of normal fimbria, a more complex tubal repair may be warranted. After placement of dilute vasopressin and salpingolysis, a stellate or cruciate incision is made at the distal end of the hydrosalpinx using a needle, harmonic shears, or scissors. Electrosurgery should be used sparingly to avoid tubal damage. The distal end "fimbriae" are then everted, and interrupted sutures are placed to maintain the increased size of the opening (see Fig. 9.5a, b). Owing to the technically difficult nature of placing these sutures in friable and delicate tubal tissue, this procedure should only be undertaken by laparoscopic surgeons who are very comfortable with the laparoscopic microsuturing technique and the use of 6–0 suture or finer. Alternatively, desiccation using electrosurgery or laser immediately behind the distal end may help facilitate retention of patency after the stellate or cruciate incision has been made (see Fig. 9.6).

Success rates for these procedures range widely. Patients with only mild hydrosalpinx have had intrauterine pregnancy rates ranging from 58 to 77% after the procedure, with an ectopic pregnancy rate of 2–8% [6].

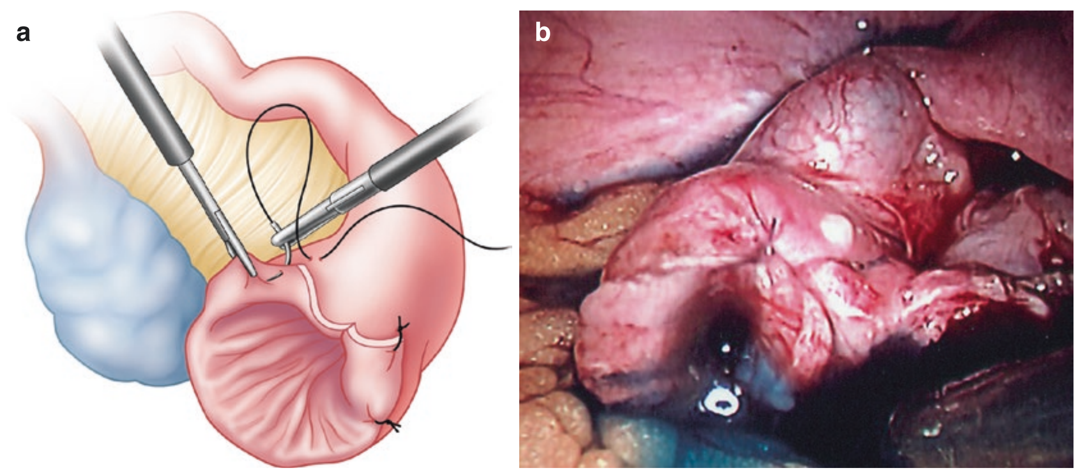

Fig. 9.5 Neosalpingostomy. (**a**) Line drawing of neosalpingostomy technique illustrating suturing of divided tubal edge to proximal tube to create a new tubal opening. (**b**) Intraoperative photograph demonstrating the resulting tubal opening after completion of the neosalpingostomy

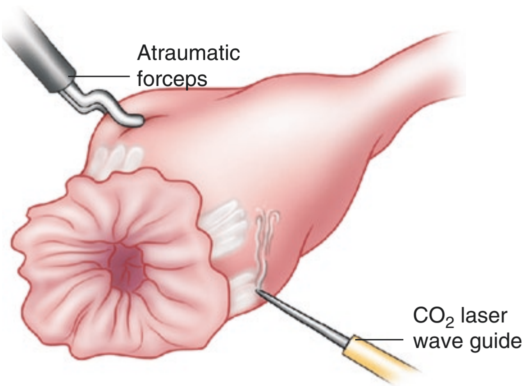

Fig. 9.6 Bruhat technique using carbon dioxide laser just behind the distal tubal edge to attempt to maintain tubal patency after lysis of adhesions of a blocked tubal opening

Reversal of Prior Tubal Ligation

Patients undergoing reversal of prior tubal ligation should be counseled about the alternate option of IVF. Most patients with tubal ligation have excellent IVF cycle-specific success rates. This population also generally has better success rates after surgery than patients with tubal pathology. If tubal reversal is warranted, it should be undertaken by an expert reproductive surgeon experienced with handling of fine suture and delicate tissue. Prior to surgery, it is critical to understand how the tubal ligation was performed (i.e., clip, Pomeroy, bipolar) typically by obtaining the operative report, confirm the length of the proximal portion (e.g., hysterosalpingogram), and, if partnered, rule out severe male factor infertility.

Laparotomy for this procedure has largely been replaced by minimally invasive techniques including minilaparotomy microsurgery, traditional laparoscopy, and robotic surgery. These approaches are preferred because outcomes are the same as with laparotomy [7].

The previously ligated tubes are identified, and the two occluded ends of the distal and proximal ends are located. Vasopressin can be injected into the mesosalpinx prior to operating on the tube. If a clip or ring was used, the affected tubal segment is resected typically in a perpendicular fashion to the lumen. Using monopolar energy, the serosal covering of the proximal and distal anastomosis site is incised. Then, scissors are used to cut the muscularis-mucosal portion of the tube to open each end. A stent may be placed hysteroscopically and inserted through the proximal end into the distal end to ensure patency throughout the length of the tube. A retention suture is often placed in the mesosalpinx under the distal and proximal ends to ensure that the ends remain in close proximity and tension-free while the approximating sutures are placed. The proximal and distal ends are reanastomosed using interrupted nonreactive sutures placed circumferentially at the cardinal angles. Anastomoses are typically done in two layers: interrupted sutures in the muscularis, followed by reapproximation of the serosa. A single suture along the antimesosalpingeal corner has been suggested as an alternative but has not been well studied. The stent is withdrawn. Reanastomosis requires surgeons skilled in microsurgical laparoscopic technique (Fig. 9.7) [1, 8, 9].

Removal of Previously Placed Hysteroscopic Sterilization Device

The advent of hysteroscopic sterilization with coil devices has resulted in a new group of patients pursuing surgery for fertility indications—those with such previously placed devices who desire their removal for pursuit of fertility or owing to chronic post-placement pain. Like patients with second thoughts regarding a previous tubal ligation, patients with prior hysteroscopic sterilization should also be counseled about the option of IVF if fertility is their goal.

Once laparoscopic access to the abdomen has been achieved, the location of the microinsert within the tube is identified. Dilute vasopressin can be injected in the mesosalpinx; however, direct injection into the tube prior to salpingostomy is not recommended as this may obscure visualization of the sterilization device [10]. Needlepoint monopolar electrosurgery is used to incise over the isthmic portion of the microinsert, and then graspers are used to gently remove the interstitial end of the microinsert from the surrounding tissue [10, 11]. If fertility is

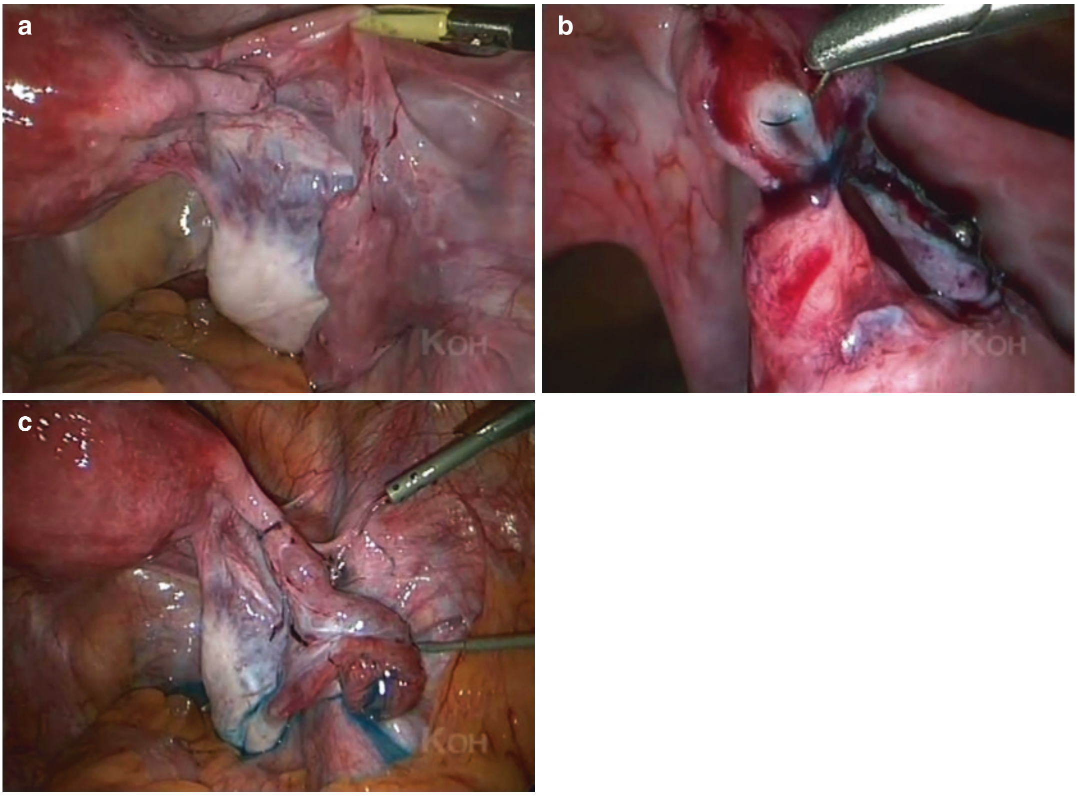

Fig. 9.7 (**a**) Intraoperative image demonstrating the appearance of a fallopian tube in a patient with a history of prior tubal ligation; (**b**) laparoscopically suturing the uterine tubal stump to the tubal stump at the fimbriated end of the fallopian tube; (**c**) appearance after suturing is complete; chromopertubation with spillage of blue dye at fimbriated end confirming patency of the fallopian tube after reanastamosis. (Courtesy of Charles Koh, MD, Co-Director, Milwaukee Institute of Minimally Invasive Surgery)

desired, the procedure is terminated. If the goal of the procedure was to reduce pain and the patient does not desire fertility, a laparoscopic salpingectomy is performed at this time.

If the goal of the procedure was to reduce pain and the patient does not desire fertility, it is easier at this point to leave the remainder of the microinsert within the fallopian tube while performing a laparoscopic salpingectomy. If fertility is desired and patient desires salpingostomy, then the incision can be extended along the fallopian tube and a grasper used to carefully remove the remainder of the microinsert [10] . The pregnancy rate after insert removal is expected to be quite low.

All efforts should be made to avoid stretching or desiccating the microinsert in order to reduce the risk of fracturing the coils. It is important to assess for complete removal of the inserts at the end of the procedure. If there is any suspicion for retained coils, X-ray can be performed intra- or postoperatively to ensure complete removal (Fig. 9.8) [12].

Laparoscopic Ovarian Surgery for Fertility Indications

While most gynecologic surgeons are familiar with ovarian surgery for removal of ovarian masses and cysts, ovarian surgery for fertility indications is less widely performed. However, for the appropriate patient, these procedures may provide benefit. This section will review the reasons for and the techniques of oophoropexy.

Oophoropexy can principally benefit two groups of patients: those younger women undergoing radiation for various malignancies before completing childbearing and desiring ovarian

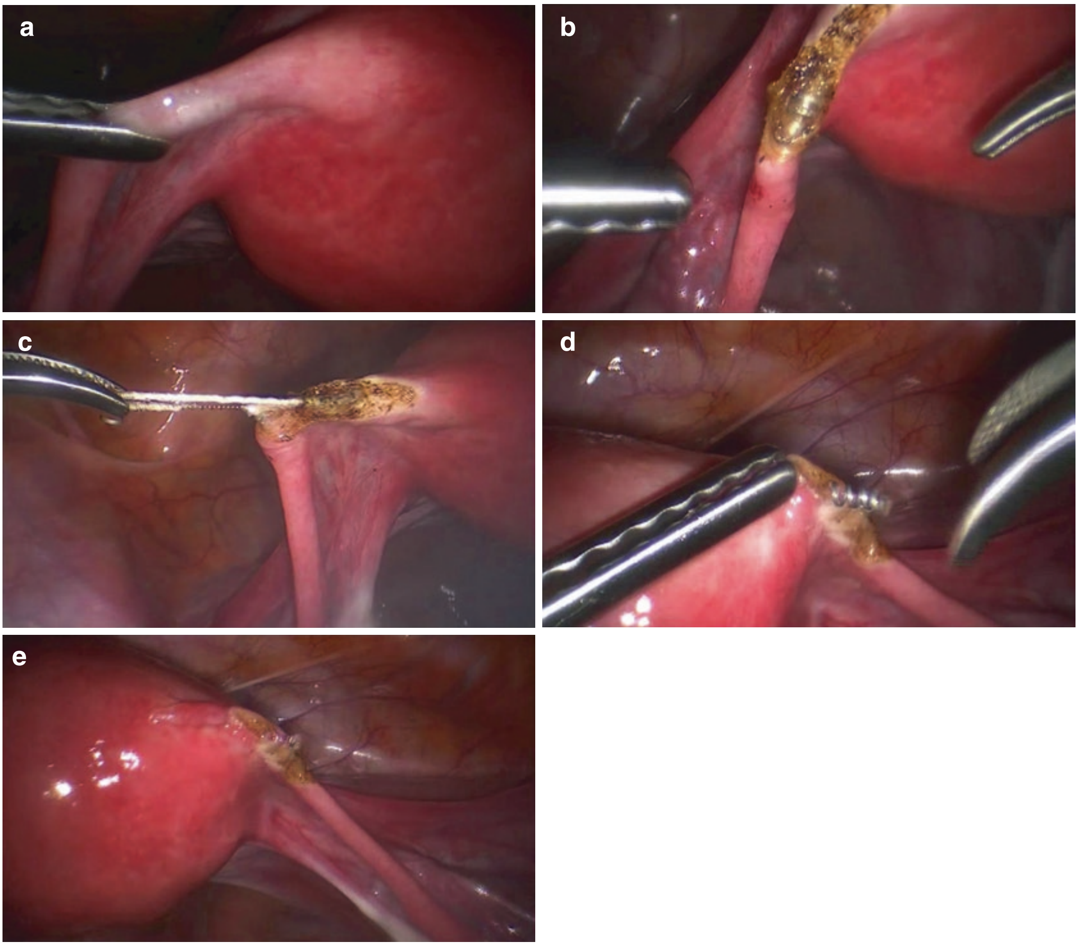

Fig. 9.8 (**a**–**e**) Removal of hysteroscopic sterilization device. (**a**) Elevation of tube with laparoscopic grasper to locate the end of the hysteroscopic sterilization device within the tube. (**b**) Incision using monopolar needle electrosurgery along the length of the tube parallel to the hysteroscopic sterilization device to expose the end of the device. (**c**) Laparoscopic graspers such as a Maryland grasper are used to grasp the end of the device and withdraw it from the tube. (**d**) Any remaining portion of the coil that did not emerge with the initial portion of the device may be grasped similarly and withdrawn from the tube. (**e**) Excellent hemostasis noted after removal of the device. If the procedure was pursued to relieve pain symptoms and the patient desires tubal ligation, it may be done at this time. (Courtesy of Dr. Amanda Yunker, DO, MSCR, Assistant Professor, Vanderbilt Medical Center)

preservation and those women with recurrent ovarian torsion of normal-sized adnexa. Although data are limited regarding these techniques and outcomes, it seems that the best approach to oophoropexy in the setting of planned radiation treatment is fixation of the ovary to the anterolateral pelvic side wall at or above the level of the pelvic brim [13]. In the setting of recurrent torsion of the adnexa, an alternate technique involves plication of the utero-ovarian ligament rather than oophoropexy [14].

Ovarian Transposition and Oophoropexy

Once laparoscopic access to the abdomen has been achieved, the ovaries and the utero-ovarian ligament are identified. To facilitate transposition, the utero-ovarian ligament is divided close to the uterine cornua. The tube may be left intact. The ovary is then transposed lateral and anterior, at or above the level of the anterior superior iliac spine based on the recommendations of the radiation oncologist. It is securely sutured in place with permanent suture to the peritoneum. The lower border of the ovary can be marked with titanium clips for later identification. Prior to surgery, the field of planned radiation can be outlined to ensure that the ovaries are placed lateral and superior to the field [9].

Plication of the Utero-Ovarian Ligament

The utero-ovarian ligament and ovary are identified. Suture is brought into the pelvis and inserted with the needle parallel to the ligament. The needle enters into the ligament from the lateral end, and several stitches are placed along the length of the ligament running toward the cornua to plicate the extra length of the ligament. The suture is tied once the ligament is felt to be sufficiently shortened. The process can be repeated on the opposite site. The ovary and fallopian tube are not disturbed by this technique nor is undue tension placed on the ligament (Fig. 9.9).

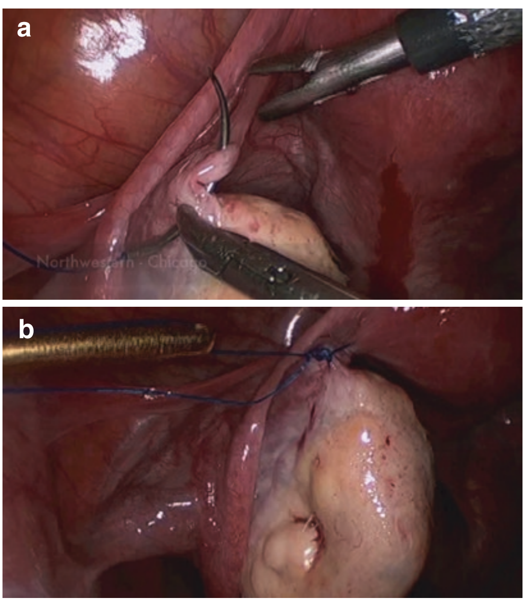

Fig. 9.9 (**a**, **b**) Intraoperative image demonstrating suture plication of the utero-ovarian ligament to prevent recurrent torsion. (Courtesy of M. Milad)

Conclusion

The laparoscopic techniques in this chapter range from the relatively straightforward (plication of the utero-ovarian ligament, salpingectomy in the case of large hydrosalpinges to promote improved IVF success rates) to those requiring exquisite laparoscopic surgical skill (e.g., tubal reanastomosis). All illustrate the multiple applications of laparoscopic gynecologic surgery in the arena of fertility, a trend that is likely to continue with further developments in minimally invasive techniques and ever more sophisticated equipment.

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10

Surgical Repair of the Symptomatic Isthmocele

Charles E. Miller and Kirsten J. Sasaki

According to the CDC, evaluating birth data from 2016 to 2019, between 31.7% (2019) and 32% (2017) of deliveries in the United States were via cesarean section [1]. The isthmocele, as it is referred to in North America, or niche in Europe, is a diverticulum in the lower uterine segment, isthmus of the cervix, or endocervical canal at the site of a previous cesarean section scar. It was initially described by Morris in 1995, who reviewed 51 hysterectomy specimens with a history of cesarean section [2]. Hysterectomy was performed for menorrhagia (72%), dyspareunia, dysmenorrhea, or low abdominal pain refracting to medical management. In 75% of cases, distortion and widening of the lower uterine segment were noted along with "free" red blood cells in the endometrial stroma of the scar (59%), fragmentation and breakdown of the endometrium of the scar (37%), and iatrogenic adenomyosis (28%).

Diagnosis

The diagnosis of isthmocele is made via radiologic imaging – transvaginal ultrasound, saline-infused sonogram, hysterosalpingogram, MRI, or directly via hysteroscopy (Fig. 10.1). In a study by Osser, published in 2010, 108 women with a history of one or more cesarean section and no other uterine surgeries were evaluated by ultrasound followed by saline-infused sonogram. An isthmocele was defined as any indentation at the site of the cesarean section. As can be seen in Table 10.1, not surprisingly as the saline distends the cesarean section defect, more isthmoceles were identified by saline-infused sonogram [3].

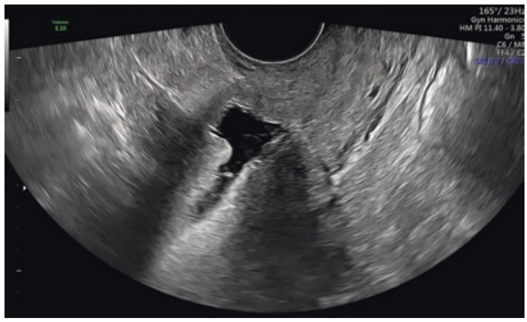

Fig. 10.1 Isthmocele visualized saline-infused sonogram prior to surgical repair

In 2008, Surapaneni reported on 148 women undergoing hysterosalpingogram with a history of previous cesarean section and secondary infer-

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Table 10.1 More scar defects were identified on SIS vs. TVUS [3]

	TVUS	SIS
One CS (*N* = 68)	42 (62%)	53 (78%)
Two CS (*N* = 32)	28 (88%)	31 (97%)
Three CS (*N* = 8)	8 (100%)	8 (100%)

tility. Eighty-nine patients (60%) were noted to have an isthmocele. In 31 patients (35%), the defect was described as linear, while 58 patients (65%) had a bulbous appearing defect [4].

At time of hysteroscopy, the isthmocele is noted as a dome, bulging pouch or wedge. In 2011, El-Mazny published the results of an observational cross-sectional study comparing saline-infused sonogram and hysteroscopy, including 75 women with a history of prior cesarean section, complaining of menstrual disorders (33.3%), infertility (49.3%), or recurrent pregnancy loss (17.3%). Twenty cases of isthmocele were diagnosed by saline-infused sonogram, while 22 cases were noted at hysteroscopy [5].

Risk Factors

In 2018, Antila-Långsjö published a prospective observational cohort study in 401 nonpregnant women, recruited within 3 days of cesarean section. In 371 patients undergoing saline-infused sonogram, 45.6% were noted to have an isthmocele. Interestingly, there was no difference in isthmocele risk when comparing elective vs. emergent delivery. Evaluated by multivariate logistic regression, risk factors were previous cesarean section, gestational diabetes, BMI, and uterine position. In the subcohort of emergent cases, risk factors included previous cesarean section delivery, gestational diabetes, intrapartum or postoperative infection, and duration of labor. Single-layer versus two-layer closure could not be evaluated, as only one patient in the study had a single-layer closure [6].

In 2017, Di Spiezio Sardo published a systematic review and meta-analysis of randomized controlled studies, evaluating the risk of cesarean scar defect following single- versus double-layer closure. Though the authors concluded that single- and double-layer closures were associated with a similar incidence of isthmocele, as well as uterine dehiscence and rupture in a subsequent pregnancy, the quality of the summary estimate was low. Therefore, the true effect is unknown [7].

Symptoms

Isthmocele can be associated with abnormal uterine bleeding and pelvic pain, including dysmenorrhea and dyspareunia, as well as secondary infertility. Other complications include abscess, ectopic pregnancy at the isthmocele site, and uterine desinence. Often times, postmenstrual bleeding for several days to weeks postmenses occur. In 2001, Monteagud noted 75% of women in a prospective cohort study had abnormal bleeding, while in 2003, Fabres noted 82% of women with an isthmocele in a retrospective cohort study had abnormal uterine bleeding [8, 9].

In 2011, Bij de Vaate noted significantly greater postmenstrual spotting in women with an isthmocele (33.6% vs. 15.2%) in a prospective cohort study [10]. Also, in yet another prospective cohort in 2014, van der Voet noted similar results (28.9% vs. 6.9%) [11]. This is secondary to menstrual blood accumulating in the cesarean section defect. Due to lack of coordinated muscle contraction, there is continued accumulation of blood and menstrual debris. Furthermore, blood can be produced in situ in the outpouching. The degree of symptoms may be related to the volume of the defect. This was seen in the 2011 study by Bij de Vaate.

In a 2009 cross-sectional study of 207 patients, Wang compared symptoms based on width, depth, and residual thickness of the isthmocele. Fifty-three percent complained of dysmenorrhea and 40% presented with chronic pelvic pain. Only defect width correlated with presence or absence of dysmenorrhea, chronic pelvic pain, or dyspareunia [12].

Secondary infertility can be caused by accumulation of blood and mucus. This can negatively impact cervical mucus, obstruct sperm transport, and interfere with embryo implantation. Another potential concern is chronic inflammation at the isthmocele site. Moreover, there is evidence which shows improved fertility post-isthmocele correction.

Surgical Repair

At present, there is no general agreement regarding the best surgical approach to the symptomatic isthmocele. There are three surgical approaches to the symptomatic isthmocele – hysteroscopic, transvaginal, and laparoscopic.

The hysteroscopic approach involves shaving down the caudal portion of the isthmocele and desiccating or superficially resecting the base using a monopolar or bipolar resectoscope. This allows fluid to drain into the vagina, as opposed to collecting in the endometrium. Some physicians, including the author, prefer to also shave the cephalad border as well.

The transvaginal approach to isthmocele is most commonly performed in Asia. Initially, a vasoconstrictive agent is injected into the vesicocervical space. The vaginal wall mucosa is incised to open the vesicocervical space. The bladder is then mobilized off the uterus. The isthmocele is then identified with a uterine sound. Next, the isthmocele is excised. The uterus is then closed in two layers of absorbable suture; generally, the first layer is interrupted. A third layer is used to close the peritoneum.

Finally, the laparoscopic approach can be performed via conventional laparoscopy or with robotic assistance. The bladder is initially mobilized off the uterus and cervix. Next, a vasoconstrictive agent can be injected into the uterus. The isthmocele is next identified by placing the tip of the hysteroscope. The isthmocele is then excised utilizing the CO_2 laser or monopolar scissors or with ultrasonic energy. Once again, the uterus is repaired in two layers utilizing interrupted or running absorbable suture. Finally, the area is reperitonealized again, using absorbable suture. Perhaps, an advantage to the laparoscopic approach to the symptomatic isthmocele is the ability to suspend the uterus.

In review of literature by Tulandi in 2016, successful treatment of isthmocele-related abnormal uterine bleeding was noted to be 59% to 100% in treatment of women undergoing a hysteroscopic approach, 89% to 93.5% of patients treated via vaginal isthmocele excision and repair, and 86% when laparoscopic treatment was undertaken [13]. Pregnancy rates following isthmocele repair were noted in 77.8% to 100% of hysteroscopic cases and 86% of patients treated laparoscopically. In Table 10.2, the treatment of abnormal uterine bleeding secondary to isthmocele repair via a hysteroscopic, vaginal, or laparoscopic route is demonstrated. In Table 10.3, fertility post-isthmocele surgery is presented [14–32].

In 2016, the author's first 21 cases of robotic and conventional laparoscopic isthmocele resection and repair were presented [32]. Nine patients presented with secondary infertility alone, four with infertility and abnormal uterine bleeding, and one with pelvic pain and infertility. Ultrasonic energy was utilized in the conventional laparoscopic cases, and monopolar scissors were used in the robotic-assisted cases. Closure of the defect was performed in two layers. The first layer was closed via 3–4 mattress style sutures using 3–0 polydioxanone, while the second layer consisted of an imbricating, running, 3–0 knotless unidirectional barbed monofilament absorbable suture. If possible, the peritoneum was approximated with a running, 3–0 knotless unidirectional barbed monofilament absorbable suture or 3–0 polydioxanone placed in a purse-string fashion. If the uterus was retroflexed or retroverted, a uterine suspension was performed.

There were no intraoperative or postoperative complications. Post-3-month avoidance of pregnancy, 12 of 15 women attempting pregnancy became pregnant; 8 had ongoing pregnancies or delivered. Of interest, five patients previously unable to undergo IVF because of fluid in the endometrial cavity, subsequent to isthmocele resection and repair, became pregnant spontaneously.

Our minimally invasive gynecologic surgery team, located in Metropolitan Chicago, continues to evaluate patient outcomes post robotic-assisted and conventional laparoscopic repair of symptomatic isthmocele via a prospectively maintained data base. The indication for surgery for virtually all patients has been secondary infertility.

Table 10.2 Surgical treatment of symptomatic isthmocele causing abnormal uterine bleeding

Author/year	Study type	Patients	Approach	Technique	Success
Fabres 2005 [14]	Retrospective	24	Hysteroscopic	Shave caudal border Desiccate base (60 W monopolar)	84%
Gubbini 2008 [15]	Prospective	26	Hysteroscopic	Shave cephalad border Pure monopolar cut Roller ball desiccation of base	100%
Chang 2009 [16]	Prospective	22	Hysteroscopic	Shave caudal border (80 W monopolar) Desiccate base (50 W monopolar)	63.3%
Florio 2011 [17]	Retrospective	39	19 Hysteroscopic 20 Hormonal	Shave caudal and cephalad border Monopolar loop Roller ball desiccation of base	Hysteroscopic 100%
Feng 2012 [18]	Retrospective	57	Hysteroscopic	Resection of flap or shaving, if no flap	66.7%
Raimondo 2015 [19]	Prospective	118	Hysteroscopic	Shave caudal border Desiccate base – monopolar loop	84%
Vegas Carrillo de Albornoz 2019 [20]	Prospective	38	Hysteroscopic	Shave caudal border Desiccate base	96.8%
Luo 2012 [21]	Retrospective	42	Vaginal	Incise vaginal wall mucosa Open vesicocervical space Mobilize bladder Identify isthmocele with uterine sound Excise isthmocele Closure: Layer one – 3-4 interrupted polydioxanone "0" Second layer – continuous or interrupted Resound uterus Approximate bladder peritoneum Approximate cervix and vagina	93%
Xie 2014 [22]	Retrospective	77	Hysteroscopic vs. Vaginal	Vaginal surgery – 55 mins Hysteroscopic surgery – 25 mins ($p < 0.001$) Vaginal surgery blood loss – 50 cc Hysteroscopic surgery blood loss – 10 cc ($p < 0.001$)	93.5% Vaginal 64.5% Hysteroscopic

Donnez 2008 [23]	Retrospective	3	Laparoscopic	CO_2 laser Four-layer closure – polyglactin 910 (2/0, 3/0) Peritoneum closed Three-month convalescence	100% Pre-op myometrium 2.1 mm or less Post-op myometrium 9.4–11 mm
Yalcinkaya 2011 [24]	Retrospective	2	Robotic-assisted	Hook electrode Two-layer closure – polyglactin 910 (2/0 then 3/0) Repair peritoneum	100% Myometrium less than 3 mm post-repair
Marotta 2013 [25]	Retrospective	4	Laparoscopic	CO_2 laser Two-layer closure – polyglactin 910 (2/0) Peritoneum running closure – poliglecaprone 25	100% Pre-op myometrium 1.7 ± 0.69 mm Post-op myometrium 9.8 ± 1.04 mm
Li 2014 [26]	Retrospective	15	Laparoscopic	Ultrasonic energy Single-layer closure – polyglactin 910 (1/0) Peritoneum repaired	93.3%
Donnez 2017 [27]	Prospective	38 58.1% Intermenstrual bleeding 48.3% Dysmenorrhea 41.9% Chronic pelvic pain 25.8% Deep dyspareunia	Laparoscopic	CO_2 laser Two-layer closure – polyglactin 910 (2/0, 3/0)	91% Pain and bleeding MRI Pre-op myometrium 1.4 ± 0.7 mm Post-op myometrium 9.6 ± 1.8 mm
Zhang 2016 [28]	Retrospective	124	65 Transvaginal 59 Laparoscopic	*Similar technique to Luo 2012* Transvaginal Interrupted figure-of-8 sutures and then mattress absorbable suture Laparoscopic Ultrasonic knife using hysteroscopic guidance Three-layer repair – continuous absorbable suture Layer one – full thickness Layer two – imbricating Layer three – repair peritoneum	89% Transvaginal 86% Laparoscopic
He 2020 [29]	Meta-analysis 4 Randomized controlled 6 Observational	858	Hysteroscopic Vaginal Laparoscopic	Laparoscopic Hysteroscopic Laparoscopic/hysteroscopic Vaginal	Laparoscopic approach superior to: Hysteroscopic approach ($p = 0.007$) Transvaginal approach ($p = <0.0001$)

Table 10.3 Surgical management of isthmocele causing infertility

Author/year	Study type	Patients	Approach	Technique	Success
Fabres 2005 [14]	Retrospective	11	Hysteroscopic	Shave caudal border (80 W monopolar) Desiccate base (50 W monopolar)	82%
Gubbini 2008 [15]	Prospective	9	Hysteroscopic	Shave caudal and cephalad borders Ultra-monopolar loop Roller ball desiccation of base	72.8%
Gubbini 2011 [30]	Prospective	41	Hysteroscopic	Shave caudal and cephalad borders Ultra-monopolar loop Roller ball desiccation of base	100%
Vegas Carrillo de Albornoz 2019 [20]	Prospective	7	Hysteroscopic	Shave lower wall Desiccate base	42.8%
Donnez 2008 [23]	Retrospective	3	Laparoscopic	CO_2 laser Four-layer closure – polyglactin 910 (2/0, 3/0)	33.3%
Marotta 2013 [25]	Retrospective	13	Laparoscopic	CO_2 laser Two-layer closure – polyglactin 910 (2/0) Peritoneum running closure Poliglecaprone 25	Four patients spontaneously pregnant after 3 months abstinence
Li 2014 [26]	Retrospective	17	Laparoscopic	Ultrasonic energy Single-layer closure – polyglactin 910 (1/0) Peritoneum repaired separately	After 6 months of abstinence, four patients achieved pregnancy
Tanimura 2015 [31]	Prospective	22	Hysteroscopic if myometrial thickness ≥ 2.5 mm with a mid or anteflexed uterus Otherwise, laparoscopic	Not stated	4/4 Patients pregnant in the hysteroscopic group 10/18 Patients pregnant in the laparoscopic group
Miller 2016 [32]	Retrospective	15	Robotic-assisted Laparoscopic	Robotic-assisted – monopolar scissors Laparoscopic – ultrasonic energy Layer one – 3-4 mattress sutures 3–0 polydioxanone Layer two – Imbricating, running, 3–0 knotless barbed suture Layer 3 – 3-0 barbed suture on peritoneum	80% Pregnant 53% Delivered/ongoing

Table 10.3 (continued)

Author/year	Study type	Patients	Approach	Technique	Success
Donnez 2017 [27]	Prospective	18/38	Laparoscopic	CO_2 laser Two-layer closure – Interrupted polyglactin 910 Peritoneum repaired – poliglecaprone 25 suture Round ligament shortening, if uterus retroflexed Hysteroscopic evaluation post-repair	50% Delivered or ongoing

To date, since December 2014, a total of 125 patients have undergone conventional or robotic-assisted isthmocele resection and multilayer repair. Because of a change in record keeping, five patients' records could not be retrieved; moreover, an additional 19 patients were lost to follow-up. Of the remaining 101 patients, ongoing pregnancy or successful delivery has been achieved in 47 patients, while 21 patients have attempted pregnancy, but not yet been successful; 9 patients did not attempt pregnancy post-surgery; and 15 patients have either not been cleared to attempt pregnancy or have been attempting less than 1 year. Therefore, of the women attempting pregnancy for at least 1 year post-minimally invasive isthmocele resection or repair, 69.1% either delivered or have an ongoing pregnancy.

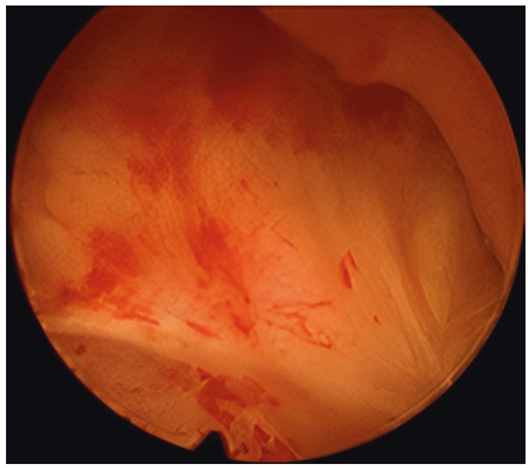

Fig. 10.2 Identify the isthmocele via hysteroscopy

Isthmocele Repair "Chicago Style"

Hysteroscopic treatment:

- Step 1 – identify the isthmocele via hysteroscopy (Fig. 10.2).
- Step 2 – use bipolar resectoscope with loop electrode on cutting setting to shave caudal and cephalad border of isthmocele; essentially, flatten out the defect edges (Fig. 10.3).
- Step 3 – use bipolar resectoscope with loop electrode on desiccation setting to desiccate top of isthmocele (Fig. 10.4).
  - Note: if myometrium is thick, this area can be resected on the cutting setting.

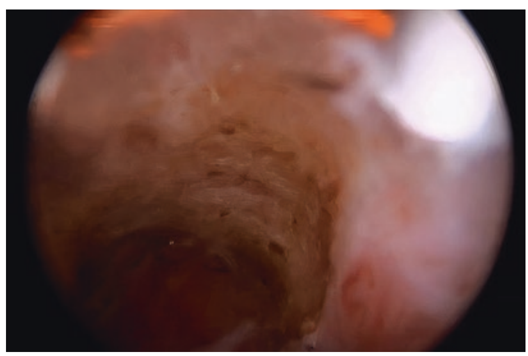

Fig. 10.3 Use bipolar resectoscope with loop electrode on cutting setting to shave caudal and cephalad border of isthmocele; essentially, flatten out the defect edges

Fig. 10.4 Use bipolar resectoscope with loop electrode on desiccation setting to desiccate top of isthmocele

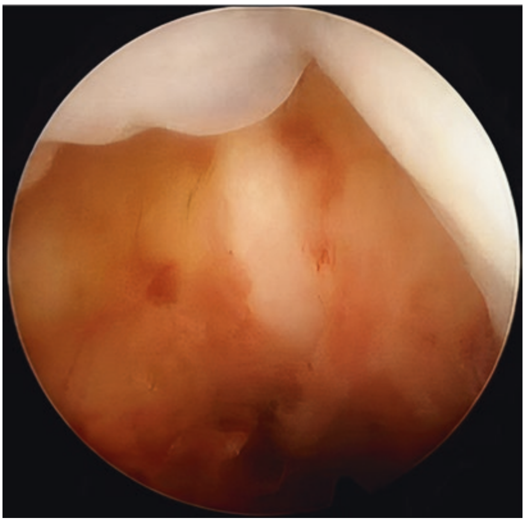

Fig. 10.5 Perform hysteroscopy to verify isthmocele

Laparoscopic treatment:

- Step 1 – can be performed via conventional laparoscopy or with robotic assistance.
- Step 2 – perform hysteroscopy to verify isthmocele (Fig. 10.5).
- Step 3 – place cannula inside cervix/uterus.
- Step 4 – mobilize bladder off lower uterine segment and cervix (may require back filling of bladder) (Fig. 10.6).
- Step 5 – dissect laterally to just above uterine vessels (Fig. 10.7).
- Step 6 – proceed back to hysteroscopy to identify isthmocele defect.
  – Will often times see retracted scar laparoscopically as well.

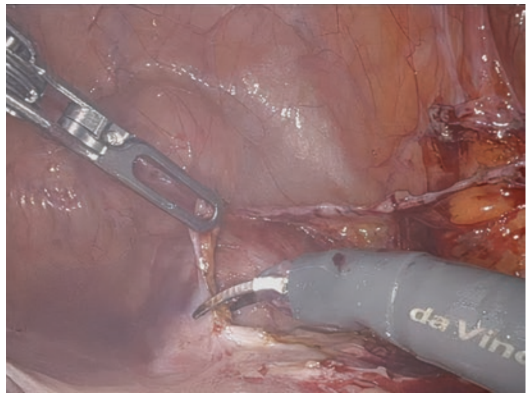

Fig. 10.6 Mobilize bladder off lower uterine segment and cervix

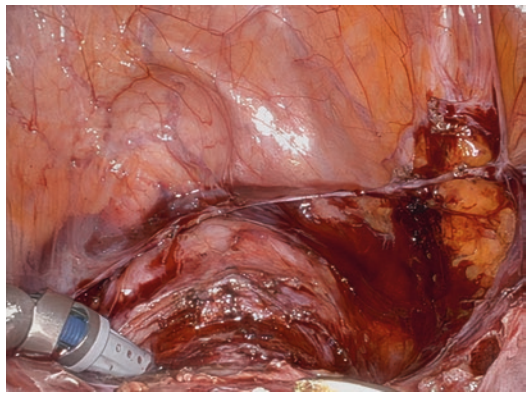

Fig. 10.7 Dissect laterally to just above uterine vessels

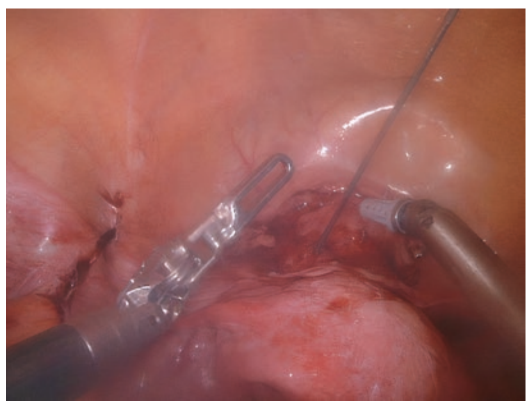

Fig. 10.8 Inject dilute vasopressin into uterus to aid in hemostasis

- Step 7 – inject dilute vasopressin into uterus to aid in hemostasis (Fig. 10.8).
- Step 8 – make initial incision laparoscopically over hysteroscopic light (Fig. 10.9).

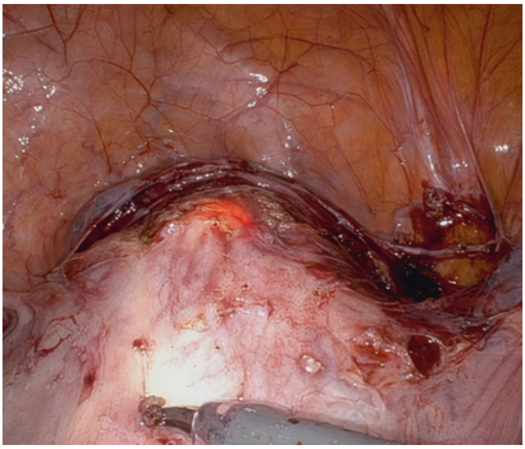

Fig. 10.9 Make initial incision laparoscopically over hysteroscopic light

Fig. 10.10 When saline emits from incision site, replace cannula, only into cervix, and excise isthmocele

- Step 9 – when saline emits from incision site, replace cannula, only into cervix, and excise isthmocele (conventional laparoscopy – ultrasonic energy; robotic assistance – monopolar scissors) (Fig. 10.10).
- Step 10 – repair in layers.
- Step 11 – layer one: 3–4 mattress sutures – placed first at angles – 0 polydioxanone (PDS®, Ethicon, Somerville, NJ) (Fig. 10.11).
- Step 12 – once completed, repeat hysteroscopy to verify that there is no stenosis and repair is adequate (Fig. 10.12).
- Step 13 – layer two: imbricating running 0 knotless unidirectional barbed monofilament absorbable sutures (V-Loc) (Fig. 10.13).

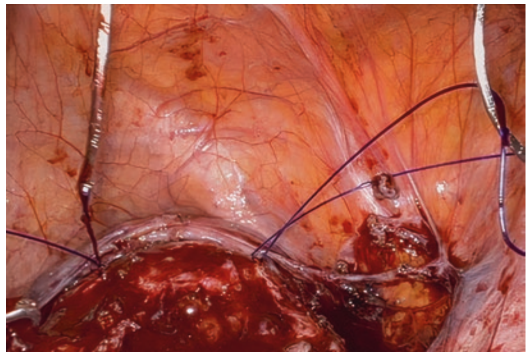

Fig. 10.11 Layer one: 3–4 mattress sutures

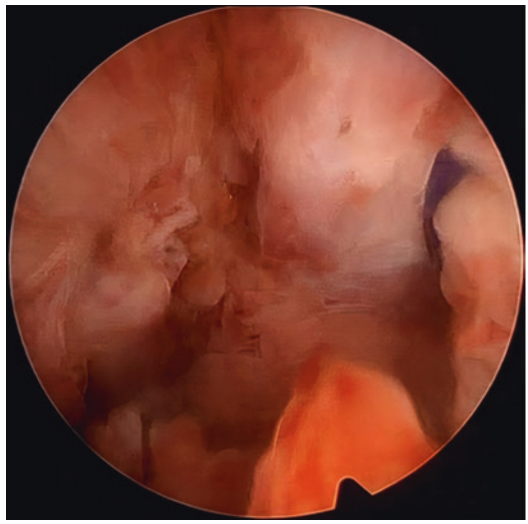

Fig. 10.12 Repeat hysteroscopy to verify that there is no stenosis and repair is adequate

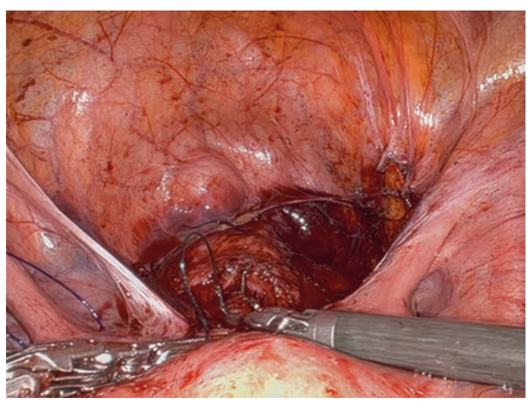

Fig. 10.13 Layer two: imbricating running 0 knotless unidirectional barbed monofilament absorbable sutures

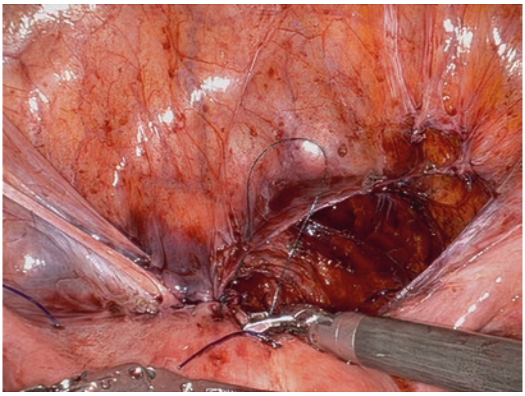

Fig. 10.14 Close peritoneum if possible, utilizing 3–0 V-Loc running suture versus 3–0 polydioxanone

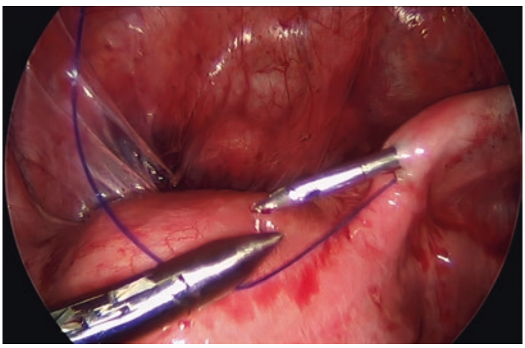

Fig. 10.15 Perform uterine uplift if uterus retroflexed or retroverted

- Step 14 – close peritoneum if possible, utilizing 3–0 V-Loc running suture versus 3–0 polydioxanone (PDS®, Ethicon, Somerville, NJ) purse-string suture (Fig. 10.14).
- Step 15 – perform uterine uplift if uterus retroflexed or retroverted. A small incision is made above and lateral to the lateral insertion of the round ligament. A suture of 0 polypropylene monofilament is passed along the length of the round ligament and then back to the incision site. A fascial bridge is formed, and when tied down, the round ligament is shortened and the uterus rocked forward (Fig. 10.15).

Management of Isthmocele

Based on prevailing literature, the author outlines his current recommendation for the treatment of isthmocele (Fig. 10.16). Asymptomatic patients need not be treated. Bleeding, in a patient, not interested in pursuing pregnancy, may respond to medical therapy. If surgical management is desired, a hysteroscopic approach may be considered if myometrium above the isthmocele (base) is greater than 3 mm in thickness.

If pregnancy is desired, again, observation can be considered if asymptomatic. However, patients

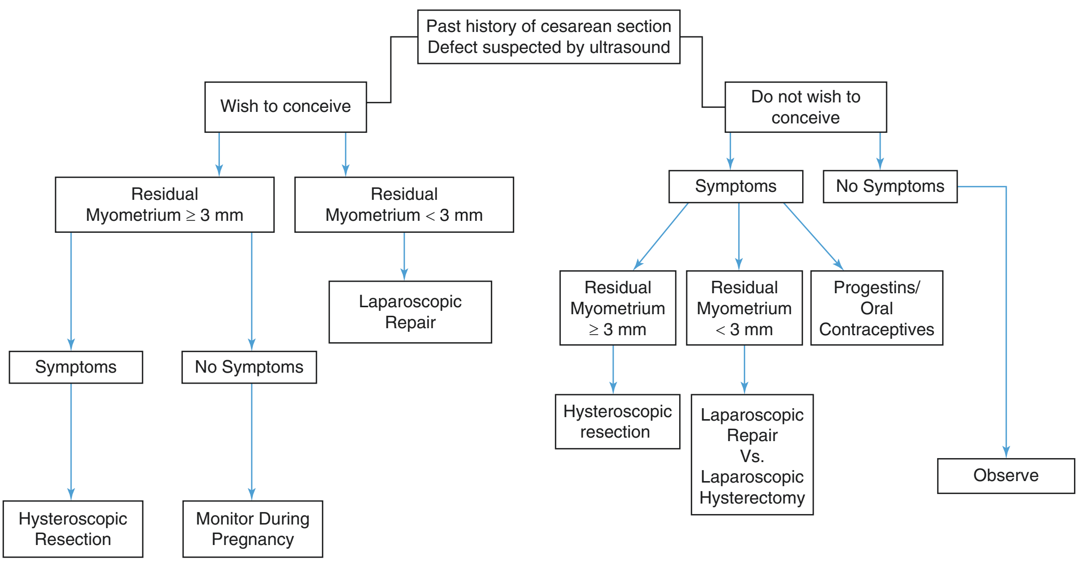

Fig. 10.16 Author's current recommendation for the treatment of isthmocele

must be counseled as to the 6% risk of cesarean scar ectopic [14]. Particularly, if fluid is noted in the endometrium, bleeding or staining is noted mid-cycle, or endometritis is of concern, surgery, either hysteroscopic or laparoscopic, is recommended. Again, if myometrium covering the defect is less than or equal to 3 mm, laparoscopic resection and repair is optimal.

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11 Laparoscopic Trachelectomy

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Introduction

Minimally invasive surgery (MIS) is one of the newest and most exciting areas of development in procedural medicine. This field shows tremendous potential to increase therapeutic benefit while minimizing some of the painful or dangerous side effects of surgical interventions. Minimally invasive surgery has strong historic ties to the field of gynecology [1]. During the 1990s there was an increased interest in procedures such as "supracervical hysterectomy." Researchers hypothesized a benefit for patients by keeping the cervix suggesting it would potentially improve pelvic support and maintain sexual function/satisfaction. Later studies failed to demonstrate any benefits from retention of the cervix at the time of hysterectomy [2, 3]. Furthermore, in some patients, persistent pelvic pain and vaginal bleeding after supracervical hysterectomy eventually required removal of the residual cervical tissue.

Cervical cancer is the fourth most common type of cancer affecting women. The American Cancer Society estimates about 14,480 new cases of invasive cervical cancer will be diagnosed in 2021 and about 4290 women will die from the disease [4]. Approximately 15% of all cervical cancers are diagnosed in women under the age of 40 who still wish to preserve fertility [5].

Throughout history, surgeons have searched for ways to preserve fertility in those who are candidates while attempting to remove the malignancy. Radical trachelectomy, first described by Dr. Dargent, is a procedure that intends to preserve the possibility of future pregnancy while removing the cancerous tissue in patients with cervical cancer stage IA–IBI. It was first described as a combination of laparoscopic and transvaginal approaches in 1994 with results indicating trachelectomy did not appear to increase the rate of recurrence as compared with more invasive procedures [6]. Furthermore, radical trachelectomy is considered the standard of care in patients with early-stage cervical cancer interested in future fertility. Trachelectomy (simple and radical) via laparoscopy has gained wide acceptance secondary to the implied advantages of MIS such as reduced blood loss, shorter hospital stay, earlier return to normal activity and diet, and decreased postoperative analgesic requirements. To improve surgical outcomes and

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decrease morbidity for patients, in this chapter we will review current indications for trachelectomy, critical surgical anatomy for the pelvic surgeon, and key surgical aspects/techniques.

Risk Factors for Trachelectomy

There is a paucity of data with regards to the incidence and risk factors for trachelectomy following a supracervical hysterectomy for benign disease. The overall incidence of trachelectomy for benign disease varies significantly from a high incidence of 23% reported by Okaro et al. to a lower incidence of 2–3% [7, 8]. Patients with persistent pelvic pain and vaginal bleeding after supracervical hysterectomy who eventually require removal of the residual cervical tissue have several factors in common. Most of them, up to 80% have been treated for endometriosis before the hysterectomy procedure. Furthermore, in almost 50% of the cases requiring a trachelectomy, the indication was endometriosis. Overall, the literature provides significant evidence supporting that age of under 40 years and endometriosis are significant risk factors for trachelectomy following supracervical hysterectomy [9].

Indications for Radical Trachelectomy

Candidates for radical trachelectomy must meet a series of criteria to ensure patient safety and decrease the rate of recurrence. These include:

- Reproductive age women, typically less than 40–45 years of age
- Pathology results with evidence of squamous cell carcinoma or adenocarcinoma histology. Patients with high-risk histologic findings including small-cell neuroendocrine, gastric type adenocarcinoma, and adenoma malignum, or evidence of lymphovascular invasion are excluded
- Early-stage cervical cancer including stages IA1 with lymphovascular space invasion, IA3 or IB1
- Tumor size 2 cm or less
- No evidence of lymph node spread or invasion
- No history of fertility impairment
- Strong desire to preserve fertility
- Imaging to rule out upper endocervical involvement

Preoperative imaging is crucial in the assessment of tumor size and location concerning its distance from the internal os, as well as assessing the presence of distant metastases. Magnetic resonance imaging (MRI) plays a vital role in the preoperative assessment of potential candidates for radical trachelectomy as it allows determination of tumor size, extension into the endocervical canal, and the length of the canal (Figs. 11.1 and 11.2) [10].

Pelvic Anatomy

Anterior Abdominal Wall Landmarks: Port Placement

Sagacious pelvic surgeons have remarkable knowledge with regard to pelvic anatomy from surface landmarks to key deep pelvic anatomical structures. This is imperative for the MIS surgeon, particularly for laparoscopic trachelectomy for both benign and malignant indications. Distorted anatomy and severe surgical scarring

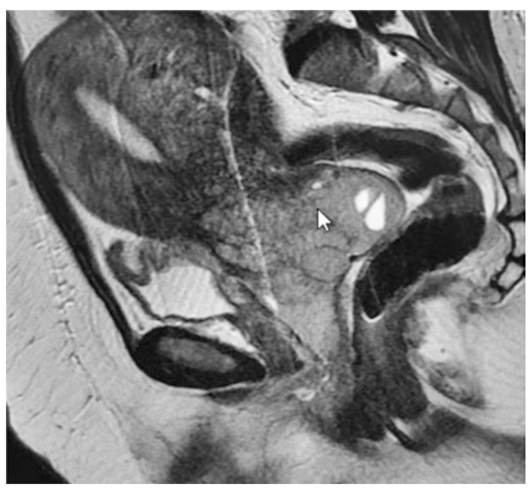

Fig. 11.1 Pelvic MRI (T1 image) demonstrating cervical tumor invading endocervix (yellow arrows)

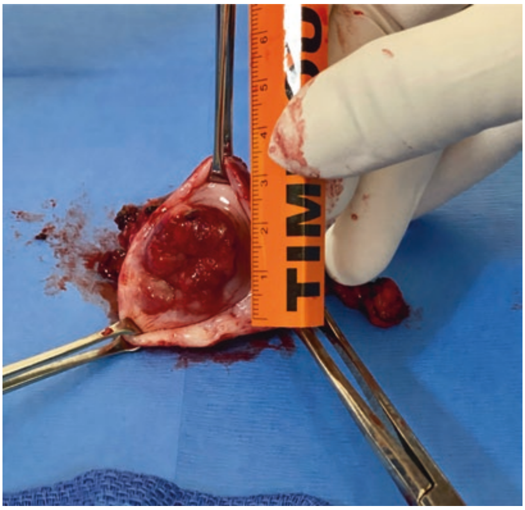

Fig. 11.2 Radical trachelectomy-upper vaginectomy specimen

from prior surgery, radiation, or endometriosis can present a formidable challenge even for experienced laparoscopic surgeons. Port placement is essential for complex cases. This would not only prevent vascular or visceral injuries when establishing the pneumoperitoneum but also makes a great difference for a successful case.

The likelihood of adhesions, either from small bowel (SB), omentum, or colon to the anterior abdominal wall and/or cervical stump after a supracervical hysterectomy, is high. We suggest Palmer's point approach (located in the midclavicular line just below the left subcostal margin) to establish the pneumoperitoneum with a 5 mm optical trocar and a 30 degrees scope. The camera port can be placed above the umbilicus after careful dissection of adhesions if needed. Abdominal trocars should be placed lateral to the inferior and superior epigastric vessels to avoid perforation and bleeding.

In the lower aspect of the abdomen, these vessels travel medially from their origin of the external iliac artery and course toward the umbilicus. Before placing secondary laparoscopic trocars, the superficial epigastric vessels are often identified by transillumination to avoid vessel injuries. Lower abdominal and pelvic trocars are avoided as they usually can impair rather than assist. Furthermore, if needed, they should be placed 2–3 cm lateral and superior to the anterior superior iliac spine (ASIS). This will avoid damage to the iliohypogastric and ilioinguinal nerves as they course between the internal oblique and transversus abdominis muscles (Fig. 11.3).

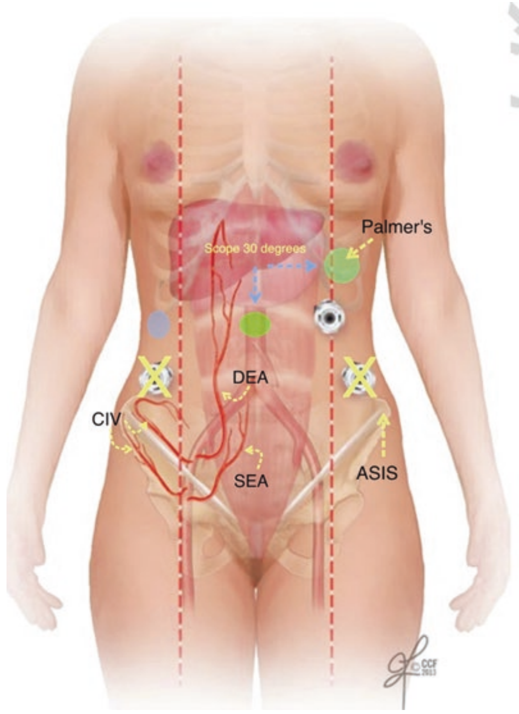

Fig. 11.3 Surface landmarks anatomy and trocar placement. ASIS, anterior superior iliac spine; SEA, superficial inferior epigastric artery; DEA, deep inferior epigastric artery; CIV, superficial circumflex iliac artery and vein

Peritoneal and Retroperitoneal Anatomy

Excellent knowledge of peritoneal and retroperitoneal anatomy and its relevance for a successful trachelectomy particularly via MIA (minimally invasive surgery) cannot be overstated. Careful identification and dissection of vascular, nervous, and genitourinary (bladder/ureter) structures are imperative, not an optional step for a laparoscopic trachelectomy. A survey of the pelvis to identify adhesions from the omentum, SB, bladder, and/or colon to the cervical stump should be established promptly, and a surgical strategy should be established.

The retroperitoneum is "your ally not your foe"; it should be developed meticulously by identifying avascular spaces, nerves, and critical structures. The medial and lateral paravesical spaces, as well as the para-rectal space, should be developed, and the ureters must be identified and carefully dissected. This can be a daunting task depending on the pathology, prior surgery, radiation, infection, or endometriosis. Irrespective of the individual indication for surgery, a nerve-sparing approach, either oncologic or endometriotic, should always be utilized for the resection of the cervix.

Each ureter further divides the para-rectal spaces into medial and lateral para-rectal spaces. These spaces, the medial para-rectal space (Okabayashi space) and the lateral para-rectal space (Latzko space), are anatomical and physiologically relevant. Autonomic and superior hypogastric nerves are within the Okabayashi space and should be spared. The Okabayashi space is named after the famous Japanese surgeon Hidekazu Okabayashi who demonstrated the first nerve-sparing radical hysterectomy in Kyoto Imperial Hospital in 1921 (Figs. 11.4 and 11.5) [11].

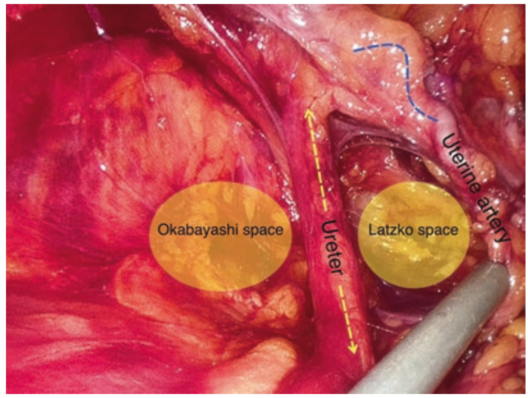

Fig. 11.4 Ureter divides the para-rectal space (Okabayashi and Latzko spaces)

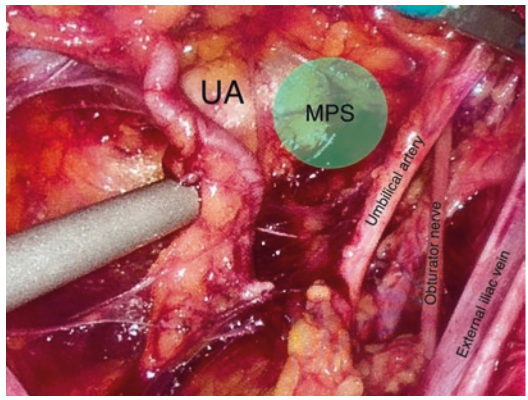

Fig. 11.5 Uterine artery and medial paravesical space (MPS)

Surgical Considerations

Endometriotic Approach (Medial Approach)

In the medial approach, the incision on the peritoneum is made medial to the infundibulopelvic ligament. This approach to the retroperitoneum is often utilized by colorectal, pelvic, and urologic surgeons. The ureter is the first structure identified; it is then carefully dissected with a laparoscopic dissector or right angle. The Okabayashi and Latzko spaces are then developed.

Further dissection of the ureter caudally toward the apex of the uterosacral ligament is performed. This allows the surgeon to identify the uterine artery branching from the internal iliac artery. The first branch of the internal iliac artery is the uterine artery, followed by the superior vesical artery, after which it forms the median obliterated hypogastric artery or median umbilical ligament. It can be argued that endometriosis is a heterogeneous disease. The disturbed anatomy seen in some patients with deep infiltrating endometriosis (DIE) is not homogenous. It can be quite different not only from other patients presenting with DIE but also from peritoneal, vaginal, or ovarian manifestations of the same disease (Figs. 11.6, 11.7, and 11.8).

Oncologic Approach (Lateral Approach)

In the lateral approach, the incision on the peritoneum is made lateral to the infundibulopelvic ligament. Care is taken to preserve the infundibulopelvic and utero-ovarian vessels as this is the

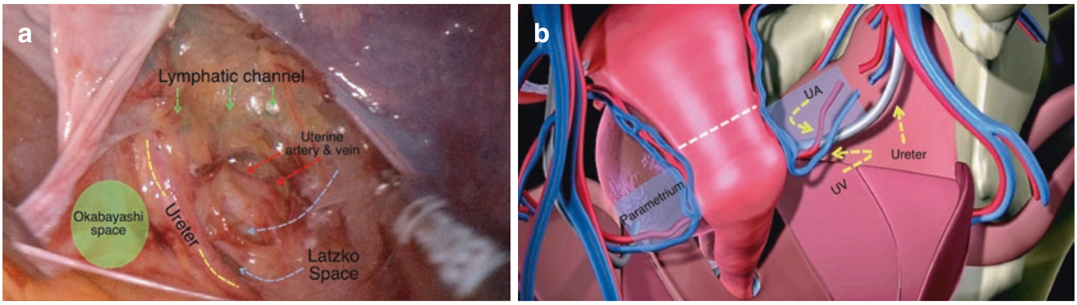

Fig. 11.6 Endometriotic approach (medial to lateral approach). Figure (a) shows the pararectal space divided by the ureter into the medial and lateral pararectal spaces (Okabayashi and Latzko space). Figure (b) shows medial approach utilized for endometriosis cases to the pararectal space

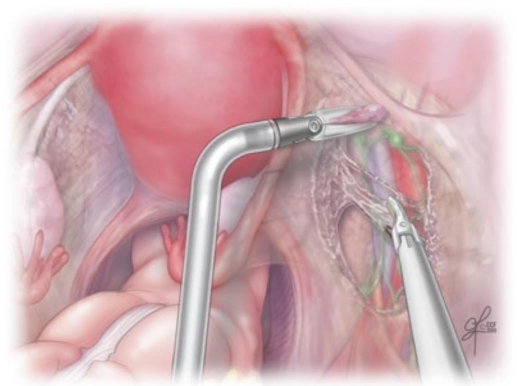

Fig. 11.7 Medial approach (endometriosis with ureter over the iliac vessels)

main blood supply for the remaining uterus. Laparoscopic pelvic lymphadenectomy is first performed, as in all approaches, consisting of the removal of the lymph node-bearing tissue between the distal one-half of each common iliac artery, the anterior and medial aspect of the proximal half of the external iliac artery and vein, and the distal half of the obturator fat pad anterior to the obturator nerve. The pelvic lymph nodes may be assessed with a complete lymphadenectomy or via sentinel lymph node mapping.

Once a complete ureterolysis is performed to the tunnel of Wertheim, the uterine vessels are divided at their origin from the hypogastric vessels. The parametria and paracolpos are mobilized with the trachelectomy specimen. The vagina is then incised to perform an anterior colpotomy, 1–2 cm distal to the external cervical os. This is then carried circumferentially until the specimen is completely separated from the vagina. This step may be facilitated with the use

Fig. 11.8 Trachelectomy with ovarian endometriosis (after a supracervical hysterectomy)

of a vaginal delineator, such as a McCartney TubeTM or other vaginal cylinder. It is our preference to perform the final excision of the cervix vaginally with a knife approximately 5 mm below the internal os. As in the vaginal approach, patency of the remaining cervical canal may be achieved with the use of a pediatric Foley catheter, Smit sleeve, or Malecot catheter followed by the placement of an endocervical cerclage. The lower uterine segment is then sutured to the vaginal mucosa via interrupted or continuous sutures (Figs. 11.9, 11.10, and 11.11) [10].

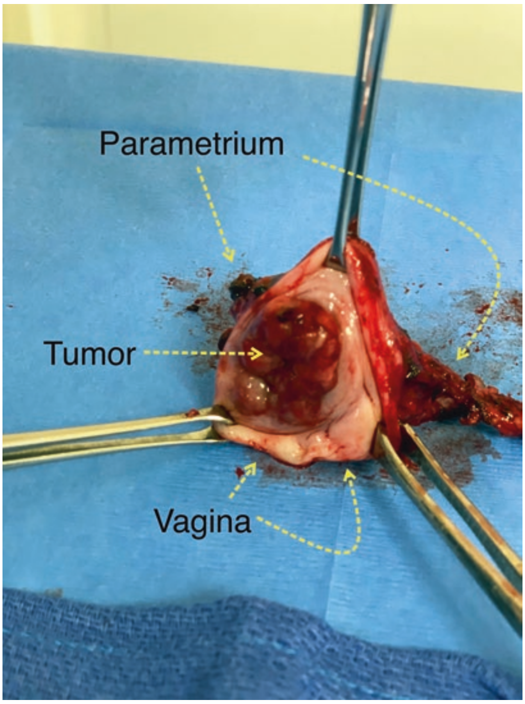

Fig. 11.9 Radical trachelectomy specimen

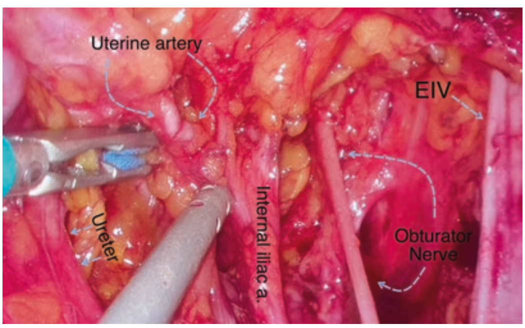

Fig. 11.10 Oncologic approach (lateral approach). EIV, external iliac vein

Cervical Stenosis, Uterine Cannula, and Cerclage

Some experts have posed the idea of placing a Foley catheter, an intrauterine device, or a Smit sleeve in the remaining uterine canal to reduce future cervical stenosis. Cervical stenosis is the most common postoperative complication affecting fertility. A systematic review demonstrated an incidence of 0–73.3% with an average of 10.5 of cervical stenosis in patients with a radical trachelectomy [12]. In this review, the incidence of cervical stenosis with cerclage placement was 8.6%, while the incidence in those with no cerclage placement was 3.0%. The use of anti-stenosis tools could effectively reduce the occurrence of cervical stenosis; however, no guidelines exist regarding preferred tools. There is no consensus on the amount of time a catheter should be left in place as some studies demonstrate the desired effects after 3–5 days and others like the IUD, after 3–8 weeks. Patients with cervical stenosis are typically asymptomatic but can present with a variety of complications affecting the menstrual cycle such as regular but decreased menstrual flow, prolonged or irregular menses, newly developed dysmenorrhea, or amenorrhea. This can also lead to more serious complications affecting the quality of life such as secondary endometriosis due to hematometra and dyspareunia that may lead to anxiety and subfertility. The use of permanent cerclage has also been related to the contribution of cervical stenosis if placement and tension are not adequate. Cerclage placement with the permanent suture is also a debatable topic. Some authors believe that cerclage placement can increase erosion and infection and provoke cervical stenosis. If surgeons choose to place cerclage, it is preferrable to place at the end of the first trimester once the patient becomes pregnant rather than during the trachelectomy procedure. If cervical stenosis occurs, dilatation of the remaining cervical os is a good method stenosis for improving outcomes. It is important to ensure that the knot of the cerclage suture is placed on the posterior aspect of the uterus to avoid possible erosion into the bladder through the anterior wall (Fig. 11.13) [11].

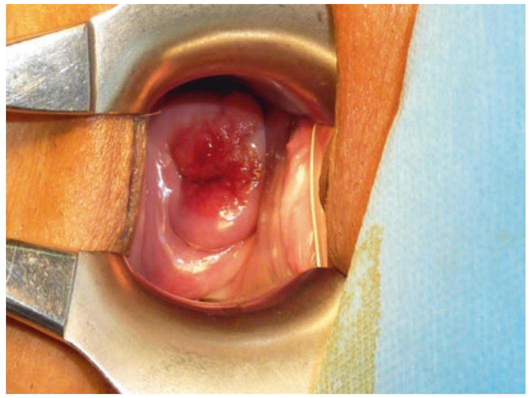

Fig. 11.11 FIGO stage IB2 lesion (tumor measures >2 cm and <4 cm in greater dimension

Preserving Fertility

Trachelectomy is now becoming a desired procedure by females who want to preserve fertility. The actuarial conception rate at 12 months is 37%. There are several complications affecting pregnancy that must be considered when choosing radical trachelectomy. There are potential fertility complications including difficulties in conception, second-trimester losses, preterm premature rupture of membranes, and preterm deliveries. Decreased conception rates could be attributed to a lack of cervical mucus or isthmic stenosis that can occur after surgery. The preterm birth rate after laparoscopic radical trachelectomy was approximately 24% in several published studies which are higher than that of the general population which is 10%. This could be the result of cervical incompetence or increased rates of infection due to the suture used for the cerclage or by the absence of the cervical mucus plug [13]. The cervical shortening that occurs as a result of the trachelectomy increases the risk of infection and can lead to cervical incompetence. There are no definite guidelines in the management of pregnancy after trachelectomy, but experts have suggested some recommendations that should be individualized to each patient. These recommendations include routine placement of cerclage, oral antibiotic in high-risk women for preterm birth, prophylactic routine administration of a single dose of corticosteroids according to recommendations, routine measurement of cervical length with ultrasound, reduced digital examinations, cessation of coitus starting at 20 weeks, and regular gram stains every 2 weeks for determination of bacterial vaginosis [14].

Uterine Artery Preservation

A commonly debated topic in trachelectomy is whether or not the preservation of the uterine vessels has an impact on future obstetric results. It has been proposed that preservation of the ascending branch of the uterine artery may provide improved blood perfusion when a woman is pregnant [15]. To date, Tang et al. and Makino et al. have addressed this issue demonstrating no differences in uterine enhancement rate when uterine arteries were not spared. More recently Escobar et al. [16] measured and analyzed uterine perfusion utilizing laser angiography with ICG (indocyanine green) during uterine artery-sparing and non-sparing radical trachelectomy. The investigators found that the ovarian vessels are likely the primary source of vascularization to maintain uterine viability.

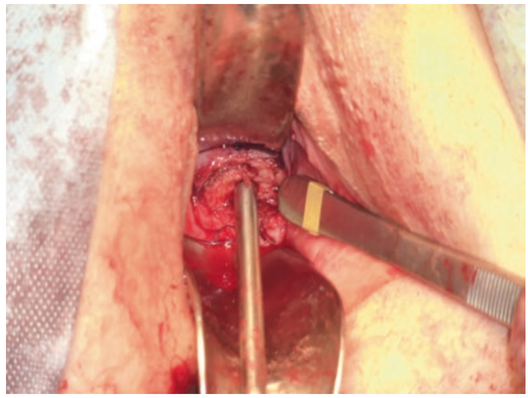

Fig. 11.12 Patency of the remaining cervical canal/lower uterine segment

Based on real-time intraoperative angiography observations, the authors concluded that there is no need to preserve the uterine artery during radical trachelectomy to maintain uterine viability (Fig. 11.12).

Complications

Complications of trachelectomy include ureteral injuries, bowel injuries, bleeding, infections, blood vessel injury, and transection of nerves among others. Postoperative complications include pelvic infection, pelvic lymphocele, intrauterine infection, abnormal menstruation, urinary tract infection, hydronephrosis, intestinal obstruction, chronic pelvic pain, varices at the site of uterovaginal anastomosis, and fistula formation. Delayed postoperative complications include vaginal prolapse and lymphedema [17]. Although all these risks exist, it has been proposed that laparoscopic trachelectomy is associated with significantly reduced blood loss, time to normal urination, and postoperative stay when comparing it to radical hysterectomy [4]. In a retrospective

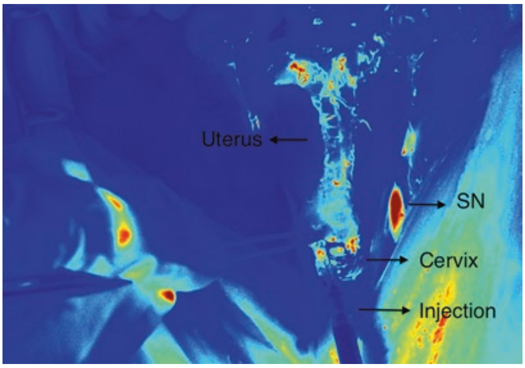

Fig. 11.13 Laser angiography with ICG (indocyanine green) during uterine artery sparing and non-sparing radical trachelectomy – animal model

review of 100 patients (58 underwent open radical trachelectomy, and 42 underwent minimally invasive surgery [MIS]), patients undergoing MIS radical trachelectomy had significantly lower median loss than patients undergoing open surgery (50 mL vs 300 mL). Although all surgical procedures carry the possibility of complications, laparoscopic radical trachelectomy has proven to decrease the possibility when compared to other methods of radical trachelectomy.

Oncologic Outcome

In a study published by Park et al., 79 patients who completed laparoscopic radical trachelectomy were analyzed. The median age of patients in the study was 31 years, and the pathology was squamous cell carcinoma or adenocarcinoma of the cervix. After a median follow-up time of 44 months, nine patients (11%) had recurrent disease, and one patient (1.3%) died of disease [5]. The median time interval to recurrence was 8 months. The 5-year disease-free survival rate and overall survival rate were 84% and 98%, respectively. The recurrence rate of patients after vaginal radical trachelectomy with tumor size less than 2 cm was 2.9%, and the recurrence rate for abdominal radical trachelectomy was 2.4%, and in laparoscopic radical trachelectomy (LRT), the recurrence rate was 6%. This report indicates that LRT is feasible and safe fertility-sparing surgery with early-stage cervical cancer if the tumor is <2 cm. High-risk factors for recurrence include a tumor greater than 2 cm and a depth of stromal invasion greater than 50%, resection margin involvement, parametrial involvement, and lymph node metastasis which can include micrometastasis not detected in frozen section [18]. Maintaining appropriate patient selection is of paramount importance for the outcome of these patients.

Conclusion

Trachelectomy is an innovative surgical procedure that provides women with carcinoma of the cervix with specific criteria the opportunity of a fertility-sparing procedure as a treatment for squamous cell carcinoma of the cervix and a minimally invasive treatment for benign diseases. Physicians should discuss the option of MIS (laparoscopic or robotic) trachelectomy with their patients to offer them options that can appeal to a population that wishes to preserve their fertility whether it is due to a benign or malignant condition. It is documented that when there is proper patient selection, oncologic outcomes are comparable to radical hysterectomy. Furthermore, there is no difference in the rate of recurrence after a trachelectomy when compared to a radical hysterectomy or radiation therapy. Laparoscopic trachelectomy has proven advantages over the other radical trachelectomy surgical procedures with earlier return to normal activity and diet, decreased intraoperative complications, and rapid recovery. Exceptional pelvic anatomy knowledge and advanced laparoscopic skills are imperative for the MIS surgeon, particularly for the challenging procedure of laparoscopic trachelectomy for both benign and malignant indications.

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12 Single-Port Laparoscopic Adnexal Surgery

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Laparoscopic management of the adnexa in gynecology dates back to the initial descriptions of diagnostic laparoscopy and laparoscopic tubal surgery in the early 1900s. In 1910 A Swedish physician named Jacobeaus is credited with coining the term laparoscopy when he performed the first intraperitoneal "scope" using a cystoscope. Despite the discovery of this novel technique to see inside the abdomen with only a small incision, laparoscopy got off to a slow start in the United States. In the late 1940s, TeLinde described the use of a rigid scope placed though the vagina for evaluation of the adnexa. He termed this culdoscopy and used this in the work-up of fertility patients as well as to assess for ectopic pregnancy before laparotomy [1]. The visualization of the pelvic abdominal cavities via a transvaginal approach was one of the foundations for natural orifice surgery [2]. Transabdominal laparoscopic visualization of peritoneal cavity took a little longer to catch on in the United States. It was not until the late 1960s when descriptions of laparoscopic tubal cauterization using a single-channel operative laparoscope with a mirrored lens began to surface that operative laparoscopy gained more interest [3]. Since that time, innovations in technology have greatly improved optics and safety of laparoscopic equipment, while technical innovations and the forward-thinking surgeons have identified new potential applications for operative laparoscopy. This has led to a recent surge in publications on standard laparoscopic, robotic-assisted laparoscopic, and, more recently, single-port laparoscopic management of benign and malignant adnexal conditions. This chapter will focus on single-port laparoscopic management of the adnexa in gynecologic surgery.

Patient Selection and Indications

Indications and patient selection for single-port laparoscopic adnexal surgery are similar to indications for standard laparoscopic procedures, with the possible exception of patient obesity. There is a 1.9% risk of port-site hernia formation following robotic laparoscopic hysterectomy, compared to a 4–5.5% rate in single-port laparoscopy [4, 5]. Higher body mass index (BMI) has consistently been associated with a higher risk of

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hernia formation [6]. The choice of who to offer laparoscopy for management of pelvic pathology should be based on sound clinical judgment and skills of the surgeon. A highly suspicious malignant-appearing mass on ultrasound with a CA125 of 300 may not be the best candidate for single-port, or even standard laparoscopic management. On the other hand, a mostly simple but enlarging 8 cm ovarian cyst with a thin septation and a normal CA125 would be a perfect candidate for trial of single-port laparoscopy. Mass size has been used in the past for patient selection both for surgery as well as for selecting candidates for laparoscopy. Ghezzi et al. [7] found that women with adnexal masses >10 cm and no evidence of ascites or metastases had an 8.6% risk of ovarian cancer, 4.3% risk of low malignant potential tumors, and 0.5% risk of metastatic tumors in the ovary. This means that more than 85% of tumors >10 cm were benign and could safely be managed by laparoscopy. At our institution, in a population of patients referred to gynecology oncology, we found a 7.4% rate of malignancy and 5.2% rate of borderline pathology in patients undergoing single-port laparoscopic management of adnexal pathology [4].

Potential Benefits and Risks

One of the most important benefits of single-port laparoscopy is the slightly larger size of the incision, approximately twice that of a standard 12 mm laparoscopic port, but small enough to hide within the umbilicus in most patients (Fig. 12.1). This extra length of the incision allows for more flexibility in surgery with easier extraction of the mass despite the persistent requirement of draining larger cystic masses or morcellating more solid masses, both of which should be carried out within a laparoscopic specimen retrieval bag. Use of the umbilical incision, which may be enlarged as needed, avoids the need to "stretch" or extend lateral 12 mm port incisions to help with specimen retrieval that can increase postoperative pain and hernia formation. Smaller ovaries can often be removed intact and sometimes do not require a specimen retrieval bag at all, especially if the single-port device has a transabdominal wall sleeve such as seen with the Applied Medical Gel Point™ or Olympus TriPort™/Quadport™. That said, there are several challenges with single-port laparoscopic surgery in gynecology that have been well documented (Table 12.1). The most common themes listed are instrument collision (both inside and outside of the peritoneal cavity), lack of triangulation of instrumentation, and loss of depth perception when the instruments are in-line with the laparoscope. Some of these limitations have been overcome by novel instrumentation including articulating laparoscopes, articulating instruments, and improved camera optics. However, there is still a small learning curve that is present even when advanced laparoscopic surgeons switch to a single-port laparoscopic approach. This has been documented by several studies looking at operative time and proficiency in single-port procedures. Fader et al. studied all laparoendoscopic single-site surgeries (LESS) by gynecologic oncologists with advanced laparoscopic skills at 3 institutions and showed that

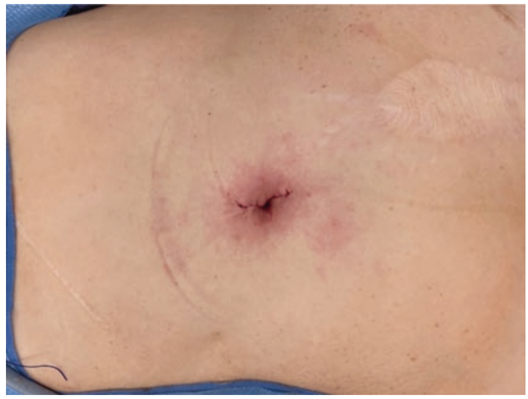

Fig. 12.1 Single-port laparoscopic umbilical incision after closure

Table 12.1 Potential benefits and challenges of single-port laparoscopy for adnexal masses

Potential benefits	Potential challenges
Easier specimen extraction	Increased rupture risk during manipulation
Flexibility of incision	Increased hernia risk in select patients
Better cosmesis	Instrument clashing

Table 12.2 Potential etiologies of adnexal masses

Benign etiologies	Malignant etiologies
Ovarian cysts	Ovarian malignancy
Ovarian torsion	Epithelial carcinoma
Hemorrhagic cyst	Germ cell tumors
Theca lutein cyst	Sex cord/stromal tumors
Benign ovarian neoplasms	Sarcomas
Epithelial	Fallopian tube carcinoma
Germ cell	Low malignant potential tumors
Sex cord/stromal	Metastatic lesions of adnexa
Infectious/inflammatory	Carcinomas
Tubo-ovarian abscess	Gastrointestinal
Appendiceal abscess	Breast
Diverticular abscess	Pancreatic
Endometrioma	Pseudomyxoma/appendiceal tumors
Fallopian tube lesions	Sarcomas
Hydrosalpinx	
Paratubal cyst	
Ectopic pregnancy	
Other masses	
Peritoneal inclusion cyst	
Leiomyomas	

both port placement and operative times markedly decreased between the first 10 cases and the 11–20th cases. Moreover, operative times stabilized after the first 20 cases [8]. A single center retrospective study examining patients undergoing single-port laparoscopy for full staging of endometrial cancer found notable improvement in surgical time after approximately 20 cases [9]. Similarly, a prospective observational study examining the transition to single-port laparoscopy in hysterectomy found approximately 20 patients were needed to reach technical competency [10]. In myomectomy cases, proficiency was documented after approximately 45 cases [11]. These studies demonstrate that although a learning curve exists, it is easily surmountable by a skilled gynecological surgeon.

Selection of surgical candidates for single-port laparoscopic excision of adnexal masses is no different than selection for standard laparoscopy. Etiologies of adnexal masses vary and can sometimes be identified preoperatively (Table 12.2). Ovarian masses can be segregated into high- and low-risk type based on patient age, family history, symptoms, ultrasound findings, and tumor markers. Tumor markers are widely utilized for the differential diagnosis of ovarian masses. Serum samples of patients with both ovarian and endometrial cancers have shown increased expression of human epididymis protein 4 (HE4) and cancer antigen 125 (CA125) [12]. The Risk of Ovarian Malignancy Algorithm, or ROMA, utilizes both HE4 and CA125 in conjunction with a patient's menopausal status to categorize patients into low and high risk for epithelial ovarian cancers [13]. Prospective studies have examined and compared these various diagnostic tools, and some have found the ROMA score has a high specificity for identifying malignancy (Table 12.3) [14]. The International

Table 12.3 Risk of Ovarian Malignancy Algorithm (ROMA)

Menopausal status	Equation (predictive index)	ROMA score cutoff
Premenopausal	$-12.0 + 2.38 * \text{LN(HE4)} + 0.0626 * \text{LN(CA125)}$	≥ 13.1
Postmenopausal	$-8.09 + 1.04 * \text{LN(HE4)} + 0.732 * \text{LN(CA125)}$	≥ 27.7

A predictive index calculated from an equation using HE4 and CA125 values and stratifies women into high or low risk of malignancy. *LN* natural log

Table 12.4 SGO/ACOG guidelines for referral to gynecologic oncologist

Characteristic
Elevated CA125 [a]
Ascites
Nodular or fixed pelvic mass
Evidence of metastasis
Elevated score on formal risk assessment tool (ROMA, RMI, IOTA)
Family history of one or more first-degree relatives with ovarian or breast cancer

From ACOG Practice Bulletin Number 174 [34]*; with permission*

[a] There is no established value above which this value indicates a higher risk of malignancy in premenopausal women, but the value can contribute to level of suspicion depending on the presence of other concerning features

Ovarian Tumor Analysis (IOTA) group has sought to standardize terms and procedures utilized in gynecological sonography with a goal to facilitate ultrasound analysis and aid in better triage of adnexal pathology to the appropriate surgeon [15]. Our institution prefers stratification by ultrasonographic features in combination with CA125. The ROMA score, however, is a great tool in the nonacademic setting where there may be fewer advanced gynecologic sonographers. These criteria can also be used to identify which patients should be referred to a gynecologic oncologist (Table 12.4) [16]. CEA and CA19–9 are tumor markers that can be utilized in the diagnosis of ovarian malignancy; however, these markers can also be elevated in intra-abdominal or mucinous malignancies from other primary sites.

There is no absolute contraindication for use of single-port laparoscopy compared with standard laparoscopy. However, several studies on single-port adnexal mass management have used various exclusion criteria including suspicion of malignant tumor, emergent surgery, coexistence of other surgeries, tumor >7 cm, age >70, and previous abdominal surgery for malignancy [17, 18]. We have found that most gynecologic procedures can be adapted to the single-port approach with relatively few true contraindications. Even patients with one or more prior abdominal surgeries may be considered for the single-port laparoscopic approach given that entry is via an open technique with a slightly larger incision. We have found that we are able to take down adhesions around the entry site enough that the single-port system can be placed and additional adhesiolysis can be performed laparoscopically. However, clinical judgment should dictate how much each individual surgeon is comfortable doing with laparoscopy over laparotomy.

Procedure

The steps for single-port laparoscopic management of adnexal masses are listed in Table 12.5. Most adnexal surgery will be best performed via a transumbilical single-port approach. Entry into the peritoneal cavity should be carried out using the technique described by Hasson [10]. Occasionally we have chosen an alternate site of entry, usually due to large uteri or a large adnexal mass where we make our incision in a supraumbilical location. Our preferred method of entry is to anesthetize the periumbilical region with bupivacaine. The edges of the umbilicus are grasped at 3 and 9 o'clock with Allis clamps, and

Table 12.5 Steps for single-port laparoscopic excision of an adnexal mass

1. Perform an examination under anesthesia
2. Umbilical/abdominal entry via Hasson technique
3. Place single-port device and insufflate abdomen
4. Inspect the mass, peritoneal surfaces, and diaphragm (easier with 30° or flexible-tip laparoscope)
5. Obtain pelvic and abdominal washings
6. Biopsy sites suspicious for metastasis and get frozen section (proceed as indicated based on results and your scope of practice)
7. Excise the adnexal mass (cystectomy, oophorectomy, or salpingectomy) (a) Identify ureter prior to dissection (b) Identify and ligate the gonadal vessels for oophorectomy (c) If performing a prophylactic bilateral salpingo-oophorectomy, ensure *all* ovarian tissue is remove (including adhesions), and ligate the infundibulopelvic ligament 2–3 cm proximal to the ovary
8. Place mass in laparoscopic specimen retrieval bag and remove
9. Send specimen for frozen section
10. Inspect for hemostasis, irrigate, and close

we incise through the base of the umbilicus in the midline to make a 1.5–2.5 cm incision. The fascial incision is extended, the peritoneum grasped and entered, and a finger is swept into the peritoneal cavity to assess for adhesions. We then place an s-retractor into the peritoneal cavity at the inferior portion of the incision. The single-port system is then inserted into the peritoneal cavity, fixed in place, and the abdomen is insufflated (Fig. 12.2). Once the camera is inserted into the peritoneal cavity, we use articulation of the flexible camera to evaluate the anterior abdominal wall around the port site and to evaluate the peritoneal cavity for ascites, carcinomatosis, and other pathology. The operative procedure itself can be carried out using standard straight laparoscopic instruments. There are an increasing number of articulating instruments that are available in an attempt to decrease instrument clashing. In the robotic setting, the "chopstick configuration" has been utilized to avoid instrument collision. This arrangement crosses the instruments at the abdominal wall with the right instrument on the left side of the target and the left instrument on the right side (Figs. 12.3 and 12.4) [19].

The development of multifunctional instruments that enable us to dissect, seal vessels, and cut tissue without instrument exchanges has been a key to efficient single-port (and standard) laparoscopic procedures. An Endo Catch bag, or a specimen retrieval pouch, is utilized to retrieve

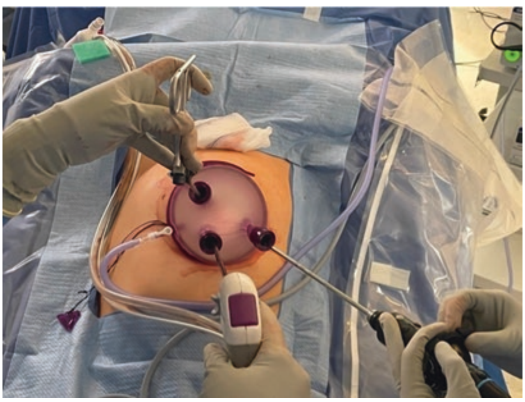

Fig. 12.2 Top view of hand positions in single-port laparoscopy with straight instruments. Camera is in the right caudal port

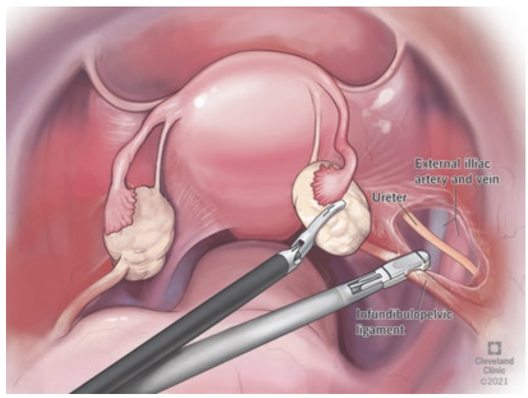

Fig. 12.3 Illustration of arrangement of laparoscopic instruments during SPL demonstrating a blunt grasper on the right ovary and a vessel sealing device on the infundibulopelvic ligament "crossing over" from single-port entry

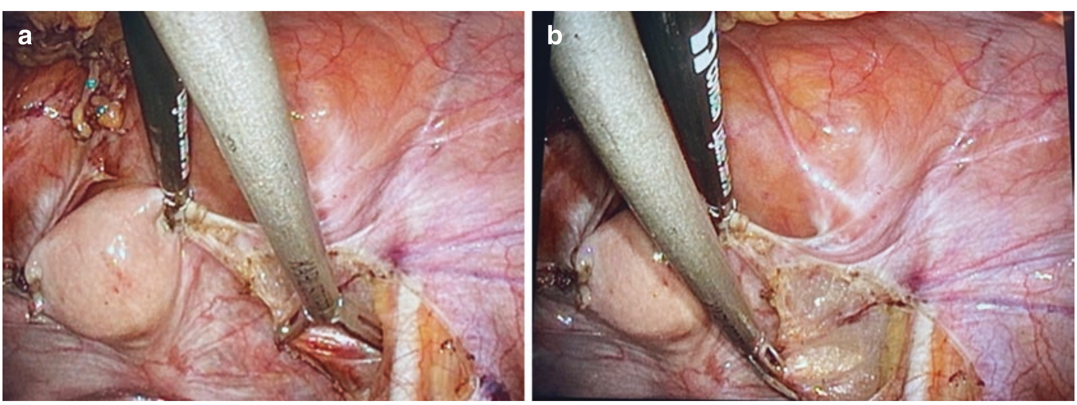

Fig. 12.4 Opening of the retroperitoneal space demonstrating the "crossing technique" of the instruments. (**a**) Retroperitoneal blunt dissection of the avascular space. (**b**) Identification of the ureter on the medial leaf of the broad ligament

specimens during both multiport and single-port laparoscopy (Fig. 12.5). Once the procedure is complete, we typically close the fascia with 0 delayed-absorbable suture in a running fashion. If there was a previous umbilical hernia, we often use interrupted nonabsorbable sutures. Skin is closed with a running subcuticular 4–0 absorbable suture.

Single-Port Laparoscopic Adnexal Surgery in Gynecology

Tubal Sterilization

One of the first reports on the use of single-port laparoscopy was for tubal sterilization. Wheeless reported on 2600 women who underwent tubal sterilization via a one-incision periumbilical technique utilizing either one burn or three burns using electrocautery through an operative laparoscope with an eyepiece at Johns Hopkins between 1968 and 1972. This was also compared to a 2-incision technique for sterilization in an additional 1000 patients [3]. Out of a total of 3600 patients, there were 24 pregnancies following the sterilization procedure. Eleven women had injury of the intestinal tract from electrocautery. Miller described single puncture sterilization in an office setting using a single puncture laparoscope as well as intravenous conscious sedation along with local anesthesia in over 1100 women [11]. Ismail described a single puncture tubal sterilization technique using Filschie clips in 42 women [12]. More recently Sewta published single-port laparoscopic sterilization using fallopian tube rings in 2011 patients in India. There were no sterilization failures and no major complications [13].

Management of Ectopic Pregnancy and Tubal Pathology

Bedaiwy et al. [14] described management of 11 hemodynamically stable women with isthmic and ampullary ectopic pregnancies using laparo-endoscopic single-site salpingectomy using a commercially available single-port device. In this study the tubal mass measured 1 to 6.5 cm, and there was fetal cardiac activity present in 6 of the 11 patients. The median operative time and blood loss were was 35 minutes and 30 mL, respectively. They reported no conversions and no intraoperative or postoperative complications. Yoon et al. described their experience with 20 women with ectopic pregnancy treated by single-port salpingectomy using a homemade "glove port" [15]. Outcomes in this series were similar with no conversions in their series. A retrospective evaluation of patients treated for tubal pregnancies with either single-port laparoscopy or conventional multiport laparoscopy found no statistically significant difference in operative times and improvement in the postoperative visual analog scale for pain scores [20]. Additionally, a small prospective study examined the utilization of single-port laparoscopic technique in the treatment of hydrosalpinx and found this to be a feasible approach [21].

Risk-Reducing Salpingo-Oophorectomy

Risk-reducing salpingo-oophorectomy (RRSO) is easily amendable to laparoscopic management. Escobar et al. described their initial experience and found short operative times and no major complication in the RRSO group [22]. Single-port laparoscopic RRSO has been shown to be

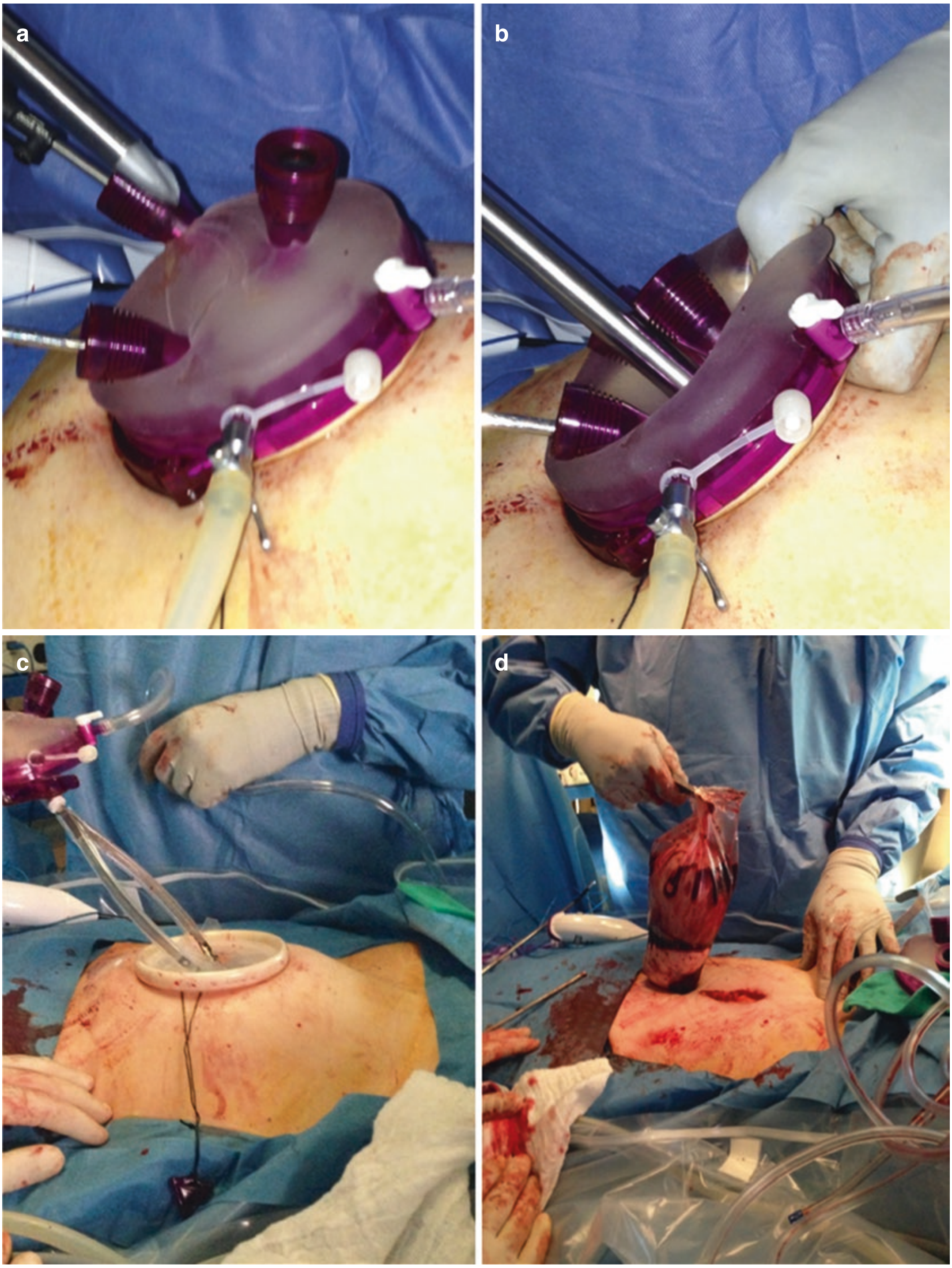

Fig. 12.5 Direct insertion of a large Endo Catch bag through the Applied Medical Gel Point™. (**a**) The tip of the metal ring is advanced. (**b**) Bag is inserted directly through gel. (**c**) Bag is cinched and metallic ring withdrawn. (**d**) String is cut, gel cap removed, and specimen retrieved from the abdomen within the bag. Note the incision in this case was extended to retrieve a very large solid mass

safe and feasible for patients with breast cancer or a BRCA mutation [23]. Experience from our institution found a low incidence of adverse outcomes in patients undergoing single-port laparoscopic risk-reducing procedures. In this study, conversion to laparotomy was 1.6%, intraoperative injury 1.6%, deep vein thrombosis 0.5%, urinary tract infection 2.7%, and incisional cellulitis 4.3% [24].

Management of the Adnexal Mass

Increasing data have shown utility of a variety of single-port laparoscopic techniques in the management of adnexal masses and other pathology. Kim et al. described single-port access transumbilical laparoscopic-assisted adnexal surgery (SPATULAAS) for benign-appearing adnexal masses greater than 8 cm using a homemade glove port [17]. Single-port access hand-assisted laparoscopic surgery (SPA-HALS) was developed for the management of large adnexal tumors. Rho et al. compared 43 patients with large adnexal tumors managed by SPA-HALS with 96 patients managed by standard single-port laparoscopic surgery [18]. Despite a larger median mass size in the SPA-HALS group (10.9 vs. 6.3 cm), they noted a significant reduction in tumor spillage (10.3% vs. 31.3%) and more frequent adnexa-conserving procedures (76.7% vs. 43.8%) in the SPA-HALS group compared to standard single-port laparoscopic surgery group.

Comparison of single-port laparoscopic surgery and conventional multiport laparoscopy in the removal of benign adnexal masses has found comparable surgical outcomes, including mean operative time, hospital time, and estimated blood loss (EBL) [25]. A retrospective study at our institution examined the utilization of single-port laparoscopy in the removal of adnexal masses. This study specifically addressed the rate of adverse outcomes within 30 days of surgery and found the following: reoperation (0.0%), intraoperative injury (1.5%), venous thromboembolism (0.3%), and transfusion (0.6%) [4]. The incredibly low risk of adverse outcomes in this population adds to the accumulating data that single-port laparoscopic surgery is not only useful but a safe tool in the extraction of adnexal masses (Fig. 12.6: excision of adnexal mass; Fig. 12.7: excision of leiomyoma).

Although culdoscopy enjoyed popularity in the 1950s–1960s, its use has become more limited today. However, there are still papers published detailing transvaginal management of a variety of adnexal and uterine pathology. Tsin and colleagues described a variety of surgical procedures performed via transvaginal laparoscopy including ovarian cystectomy, oophorectomy, myomectomy, appendectomy, and cholecystectomy [26]. There were no major complications in their series. However, reported bowel injury rates for a transvaginal approach range from 0.25% to 0.65% [27]. In their retrospective review, 22 of 24 injuries resolved with conservative management consisting of hospital observation and antibiotics. A more recent randomized controlled trial compared vaginal natural orifice transluminal endoscopic surgery (vNOTES) with standard laparoscopy for the management of 67 women with adnexal masses and showed shorter operative time and less pain but a higher risk of complications with v-NOTES adnexectomy (15% vs. 3% for standard laparoscopy) [28].

Complications

Expected complications are similar to those for standard laparoscopy such as visceral injury, port-site hernia, and tumor rupture [29]. However, the risk of umbilical (port site) hernia has been a major concern with increasing the size of the umbilical access site. Standard laparoscopic approaches have noted increasing umbilical hernias with increased size of the umbilical port size. Given that most standard laparoscopic procedures would use a port size of up to 10–12 mm with typical umbilical hernia rate of 1–3%, concern has been that increasing the umbilical incision to 20–25 mm may increase hernia risk [30,

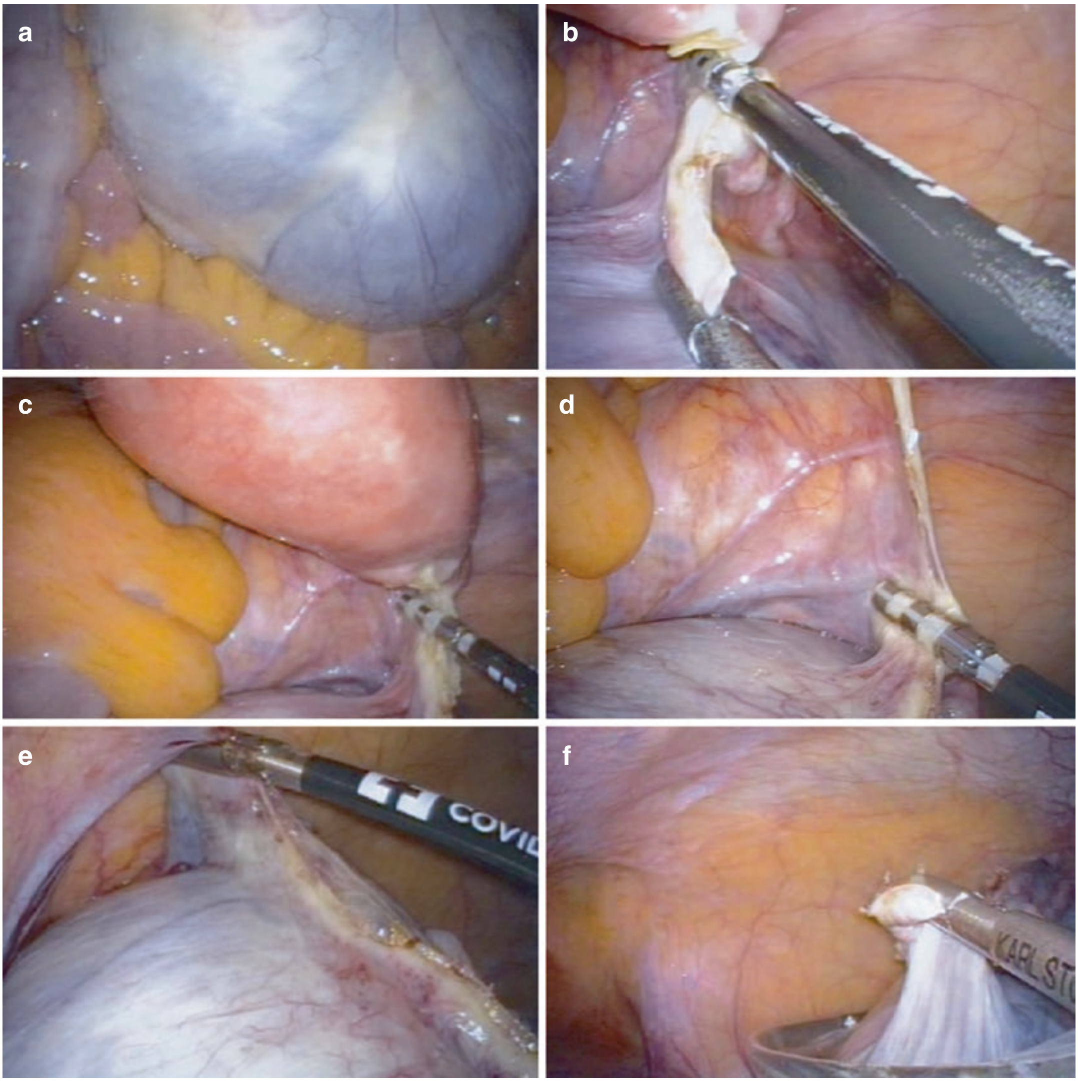

Fig. 12.6 Retrograde excision of 15 cm right ovarian mass. (**a**) 15 cm mass in situ. (**b**) Transection of proximal tube. (**c**) Transection of utero-ovarian ligament. (**d**) Transection of upper broad ligament. (**e**) Transection of infundibulopelvic ligament. (**f**) Placement of specimen into 15 mm specimen retrieval bag

31]. Most single-port laparoscopy studies in the GYN literature have noted umbilical hernia risk from 0% to 2.4% (Table 12.6) [32, 33]; however, our institution found a rate of 4–5.5%, and we are currently evaluating if different closure methods will reduce this rate [4, 5]. Based on early data, the visceral injury and blood loss rates do not appear to be any more frequent with single-port laparoscopy. Cyst rupture varies between studies and also varies by definition of rupture as some authors perceive gross leakage of cyst fluid as spill, while others feel that any breach in the cyst wall would count. Overall rates appear to be around 20% with laparoscopy but do vary widely based on definitions. Moreover, it appears that rupture risk is increased with cystectomy vs. oophorectomy and increases with size of the mass [27].

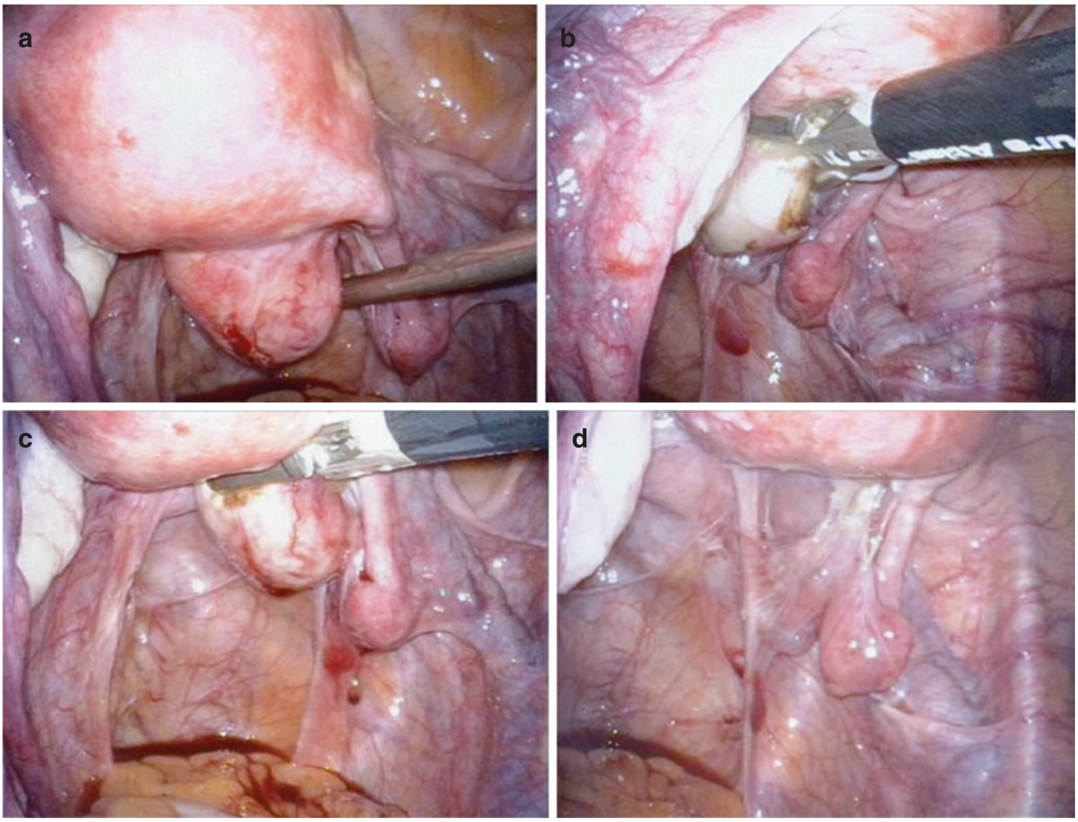

Fig. 12.7 Excision of pedunculated leiomyoma. (**a**) Pedunculated leiomyoma. (**b**) 10 mm LigaSure used with slow closure of jaws on several cauterization cycles. (**c**) Transection of last pedicle. (**d**) Leiomyoma completely excised

Table 12.6 Literature review of single-port laparoscopy: adnexal surgery and hysterectomy

Operative characteristics	Range reported	Studies
Adnexal procedure		
Mean mass size (cm)	4.9–11.9	[17, 18, 25, 35–41]
Operative time (min)	42–90	[4, 17, 18, 25, 35–44]
EBL (mL)	5–100	[4, 17, 18, 25, 35–42, 44]
Hysterectomy		
Operative time (min)	80–170	[4, 5, 45–48]
EBL (mL)	65–197	[4, 5, 47, 48]
Complications	**Rate (percentage)**	**Studies**
Cyst rupture	9.1–31.3	[17, 18, 35]
Hernia	0–5.5	[4, 5, 17, 18, 35–40, 42, 48]
Cellulitis	0–6.2	[4–6, 17, 18, 35–40, 42]
Intraoperative injury	0–1.5	[4, 5, 17, 18, 35–40]

Conclusions

Single-port laparoscopic management of the adnexa in gynecology is safe and feasible. With continued advances in technology, the instrumentation will become easier to use, and increasing dissemination of this knowledge and equipment will allow single-port laparoscopy to become more readily available to a larger number of gynecologic surgeons. In benign gynecology, a large number of cases should be amenable to minimally invasive approaches, whether it be single-port or conventional laparoscopy. However, increased availability of novel technologies should not replace sound clinical judgment and a physician's comfort in deciding which patients should undergo single-port laparoscopic procedures. A focused approach to increasing the number of minimally invasive cases in one's practice can lead to successful decline in the number of open procedures performed and subsequently decrease postoperative complications. Certainly, many adnexal masses should be amenable to laparoscopic excision, and further data should help clarify if single-port laparoscopic cystectomy and oophorectomy have any higher risk of tumor rupture and whether or not this further impacts outcomes in women found to have ovarian cancer.

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13 Single-Port Laparoscopic Hysterectomy

Kevin J. E. Stepp and Anjana R. Nair

Introduction

Since the late 1980s and early 1990s, surgeons have been vigorously exploring minimally invasive techniques to decrease the complication rates of traditional hysterectomy when vaginal hysterectomy is not an option, and this led to the development and advancement of conventional laparoscopic hysterectomy. For the past 10–15 years, access and instrumentation for laparoscopic hysterectomy has improved, but the techniques have been relatively unchanged. Although still minimally invasive options, the conventional laparoscopic and robotic hysterectomy techniques typically require 3–5 small incisions in the abdominal wall. Each additional port contributes a small but not negligible risk for port site complications [1]. Besides, every surgical incision carries an inherent risk of infection, bleeding, or potential for visceral injury as well as an effect on cosmetic results. In an effort to minimize risks including postoperative pain and improve cosmesis, alternatives to traditional laparoscopic surgery are being explored. Several centers are investigating techniques that gain access to the peritoneal cavity via natural orifices using a specialized endoscope and therefore do not require any abdominal wall incisions. Natural orifice transluminal endoscopic surgery (NOTES) has been described in animal models and in humans [2, 3]. A less dramatic and perhaps less risky approach is to perform laparoscopic surgery through a single port in the abdominal wall. The advent of multichannel ports for laparoscopy has enabled surgeons to complete laparoscopic surgeries through a single small incision that can be hidden in the base of the umbilicus. Other technological advances have been the development of articulating cameras and articulating surgical instruments.

Several retrospective studies suggest the potential for decreased pain with single-port laparoscopy; however, two randomized controlled trials have conflicting results [4, 5]. Fagotti et al. showed lower postoperative pain in patients undergoing single-port procedures, while Jung et al. found no evidence of reduction in postoperative pain. Pontis et al. [6] conducted a meta-analysis of RCTs that compared single-site to multi-port gynecologic surgeries. They reported that single-port approach did not offer the expected advantages in postoperative pain or cosmetic results. In a systematic review and meta-analysis in 2017, Sandberg et al. [7] found that

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compared to conventional multi-port laparoscopic hysterectomy, the single-port technique is feasible, effective, and safe for performing benign hysterectomy. The authors did not identify any clinically relevant advantages and concluded that there is no reason to recommend wide implementation of single-port hysterectomy. Nevertheless, the technique continues to be offered as an alternative access technique for hysterectomy and benign gynecologic surgery. Since its first description, several authors around the world have used multiple terms to describe laparoscopy carried out via a single incision. A multispecialty international consortium has recommended the name Laparo-Endoscopic Single-Site Surgery (LESS) [1, 8]. Nevertheless, a list of the multiple terms still being used is listed Table 13.1.

Potential drawbacks of LESS include a larger umbilical incision with higher risk of port site herniation, lack of triangulation of operative instruments, technical challenges due to inherent proximity/crowding of instruments leading to internal and external clashing, and increase in operative time during the learning curve. In addition, it is not clear if LESS is cost-effective as there may be costs involved in implementing a new technology with the need to purchase new supplies (camera, instruments, and ports) [7]. Although not common, it is reported that in 3.5% of LESS hysterectomies, an additional port is required counting as a "failure of the single-site approach" [7]. The first LESS procedure was reported in 1969 with the first LESS hysterectomy performed by Pelosi et al. in 1991 [9, 10]. There are no national data on the proportion of hysterectomies performed using a LESS technique [7].

The objective of this chapter is to illustrate an effective, efficient, and reproducible technique to perform LESS for hysterectomy. The basic concepts illustrated here can be further utilized in any pelvic surgery. This technique is easily understood, replicated, and useful in learning the LESS technique for hysterectomy. Escobar et al. examined the learning curve for LESS and found similar results when compared to published conventional laparoscopy learning curves [11]. Although many of these techniques work well for complex surgical cases, we strongly recommend surgeons become familiar with the technique first for benign indications and ovary preservation. Complex situations such as endometriosis, large fibroid uteri, malignancy, and significant adhesions are not addressed and are for advanced LESS surgeons. We describe a technique for surgeons who are interested in learning the LESS technique. Understanding the procedure and technique described here will help the surgeon proceed efficiently resulting in minimal instrument exchanges and external and internal clashing and avoiding a frustrating experience.

Table 13.1 Terms and abbreviations used to describe LESS

eNOTES
Embryonic natural orifice transluminal endoscopic surgery
LESS
Laparoendoscopic single-site surgery
NOTUS
Natural orifice transumbilical surgery
OPUS
One-port umbilical surgery
SAS
Single-access site laparoscopic surgery
SILS
Single-incision laparoscopic surgery
SPA
Single-port access laparoscopic surgery
SPLS
Singe-port laparoscopic surgery
SSA
Single-site access laparoscopic surgery
SSL
Single-site laparoscopy
TUES
Transumbilical endoscopic surgery
TULA
Transumbilical laparoscopic assisted surgery
U-LESS
Transumbilical laparoendoscopic single-site surgery

Adapted from Tracy et al. [1]

Instrumentation

There are specialized articulating instruments available. This may be helpful in certain situations; however, there is a learning curve to using those articulating instruments. When learning a new technique, we suggest minimizing the number of learning curves as much as possible. Using the technique described below, the majority of cases can be performed using only conventional straight instrumentation available in all operating rooms.

Camera Options

Most experts agree an articulating camera is preferred and can sometimes facilitate an efficient procedure (Fig. 13.1b). However, bariatric length or longer, 30-degree or 45-degree, laparoscopes can also be successful using the techniques and principles described here. If a non-articulating laparoscope is used, we recommend a 90-degree adaptor be used to minimize interference with the light cord (Fig. 13.1a and inset).

Technical Principles

1. Plan the procedure and chose instrumentation and techniques that minimize the need for instrument exchanges.
2. Always retract in such a way to that the handle of the instrument moves lateral, away from the camera and central area above the umbilicus. This prevents clashing of instruments externally.
3. Use a good uterine manipulator with colpotomizer or ring to delineate the vaginal fornix.
4. If significant difficulty is encountered at any time during the procedure, an additional port can always be considered.

Ports and Gaining Access

Various access devices and techniques have been described for peritoneal access. The skin incision should be created to provide the most cosmetic result possible. The umbilicus itself is a scar and each has unique folds and shape. In some patients, a vertical skin incision may be preferred. In others, a circumferential or "omega" incision may produce a better cosmetic result [12]. General surgeons also use this incision to provide additional space to manipulate multiple laparoscopic instruments while providing ample space for specimen removal and maintaining excellent cosmesis [13, 14]. Some have raised concerns regarding umbilical infections; a retrospective study of 120 patients did not find a difference in rate of infection when comparing vertical to circumferential umbilical incision for LESS [12]. As with all laparoscopy, we advocate thorough attention to the umbilicus during the surgical preparation prior to surgery. Overly limiting the size of the incision may place excess pressure on the incision edges that may result in pressure necrosis at the edge of the incision. Although this condition usually heals

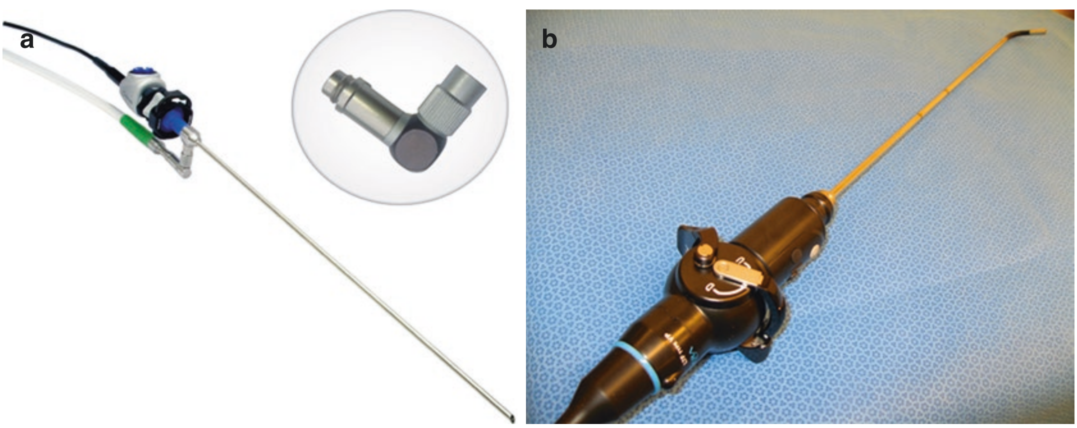

Fig. 13.1 Laparoscope options. (**a**) 30-degree or 45-degree laparoscopes work well for LESS. The longer and more angled the scope, the better to minimize external clashing. A inset: A 90-degree light cord adaptor will minimize interference with the light cord and other instruments. (**b**) An articulating scope provides excellent ability to position the camera away from other instruments. (Pictured, EndoEye™ (Olympus Surgical & Industrial America Inc., Center Valley, PA))

well, this should be considered when making the skin incision and choosing ports for each patient.

There are a number of commercially available ports designed to be placed through a single fascial incision (Fig. 13.2).

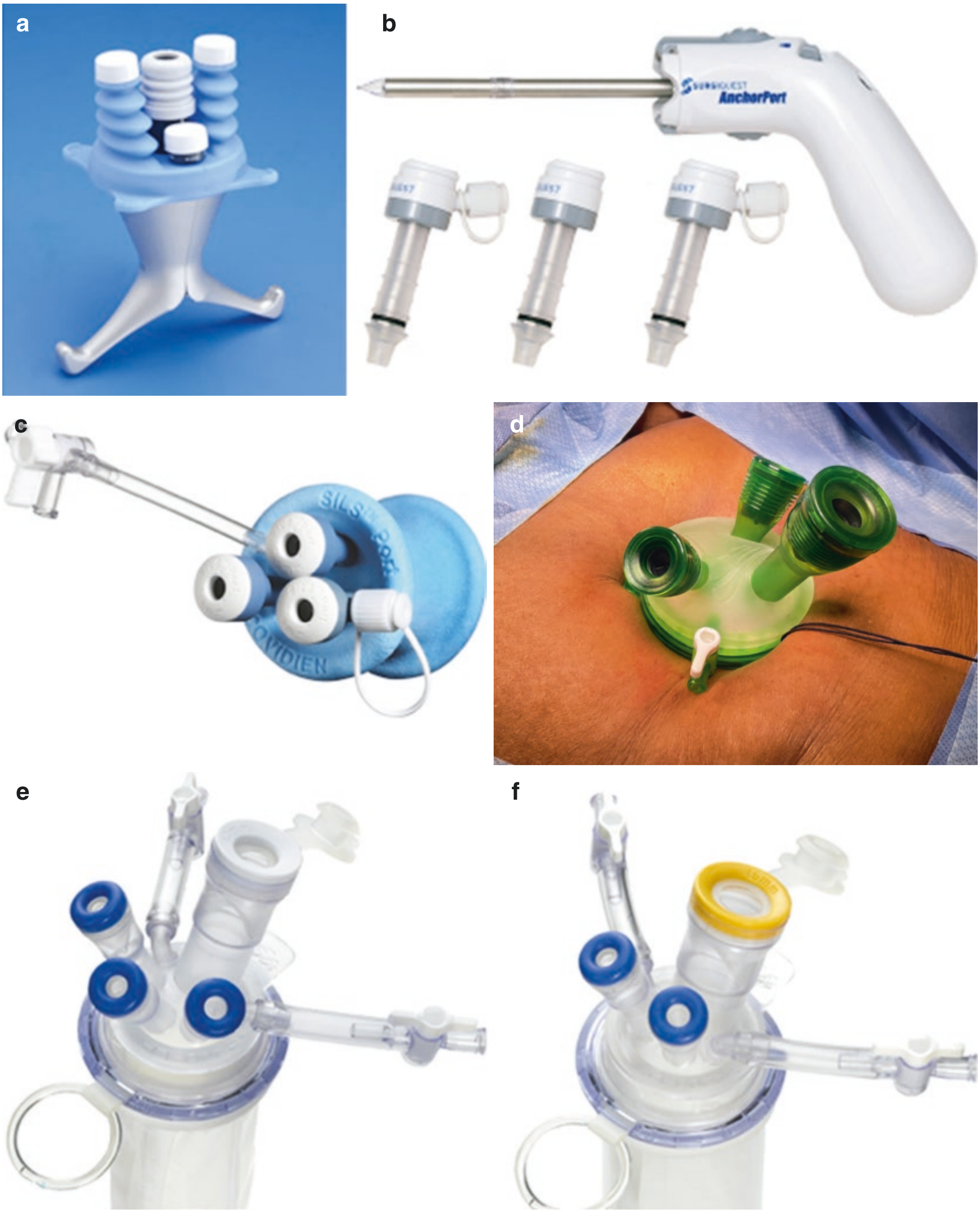

Fig. 13.2 (**a**) The X-CONE™ (Storz Endoscopy, Tuttlingen, Germany). (**b**) AnchorPort ® SIL Kit device (Surgiquest Inc., Orange, CT). (**c**) SILS™ Port (Covidien, Norwalk, CT). (**d**) GelPoint™ (Applied Medical, Rancho Santa Margarita, CA). (**e**) TriPort Plus™ (Advanced Surgical Concepts, Wicklow, Ireland). (**f**) TriPort 15™ (Advanced Surgical Concepts, Wicklow, Ireland)

A. The X-CONE™ (Storz Endoscopy, Tuttlingen, Germany) (three 5-mm valves).
B. AnchorPort ® SIL Kit device (Surgiquest Inc., Orange, CT) (allows 3 or more 5-mm trocars through a 1-in. skin incision).
C. SILS™ Port (Covidien, Norwalk, CT) (three 5-mm cannulas, one of which can be upsized to 15 mm).
D. GelPoint Mini™ (Applied Medical, Rancho Santa Margarita, CA) (includes four 5–12-mm universal cannulas. Additional instruments can be placed as needed).
E. TriPort Plus™ (Advanced Surgical Concepts, Wicklow, Ireland) (three 5-mm and one 10-mm channel).
F. TriPort 15™ (Advanced Surgical Concepts, Wicklow, Ireland) (two 5-mm and one 15-mm channel, respectively).

Most commercially available ports have two attachments that can be used for insufflation, outflow, smoke evacuation, or an additional insufflation port as necessary.

Ports that make use of a single open fascial incision maximize space for additional instruments. However, ports that have multiple channels/cannulas minimize instrument friction and unintended crossing at the level of the fascia at the expense of needing a slightly larger fascial incision.

When necessary, an additional port can always be placed at an alternate location to facilitate the procedure. Conversion to two-port or multiport conventional laparoscopy should not be considered a complication.

Technique

What follows is a step-by-step outline for an efficient procedure. The temptation will be to skip steps or alter the order. We cannot stress enough the importance of completing the first step before moving on to the next. This will eliminate extraneous or duplicative movements. It also will ensure that instruments are positioned away from each other and avoid clashing – both internally and externally.

Step 1: Initial Port Placement and Orientation

The surgeon should choose the port based on the individual characteristics of the patient, the case, surgeon preference and experience, and the advantages and disadvantages to the specific ports. The ports should be placed in accordance with the manufacturer's instructions for use. Once securely placed in the peritoneal cavity, the port should be oriented as in Fig. 13.3. The chan-

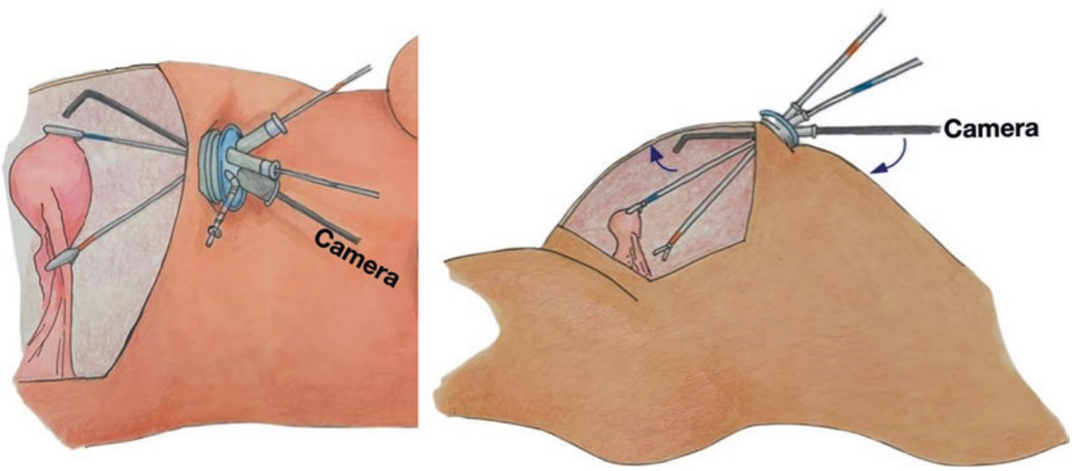

Fig. 13.3 Port orientation and camera placement. Port should be oriented so that the laparoscope may be placed through the most cephalad channel, valve, or cannula

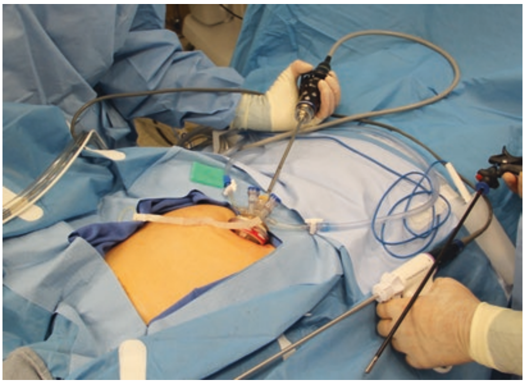

Fig. 13.4 Camera placement. The camera should be placed first prior to any additional instruments. The camera should be placed close to the chest and deviated lateral to maximize space for additional instruments

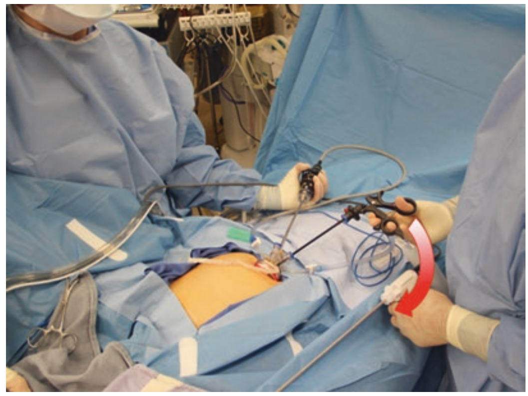

Fig. 13.5 Insert the assistant grasper. Retraction should always be in the direction such that the handle moves lateral, away from the midline

nels or valves should be oriented so that the laparoscope can be placed through the most cephalad channel. The laparoscope should be positioned so that externally, the camera will be placed as close to the chest as possible. Then position the camera laterally as much as practical (Fig. 13.4). This places the camera low and lateral maximizing space for other instruments and the primary surgeon's hands directly above the port. With the hands and camera close to the chest, this will elevate the internal end of the laparoscope toward the anterior abdominal wall. Internally, this positions the laparoscope anterior and out of the way for additional instruments within the pelvis. The greater the angle of the scope (30-degree, 45-degree, or flexible), the easier it is to get the laparoscope and camera away from the operative field and avoid clashing.

Step 2: Insert the Assistant Instrument/Grasper

Here we assume the primary surgeon is on the patient's left side and will begin the hysterectomy on the patient's left. (This process could be reversed if standing on the opposite side.) An assistant grasper instrument is inserted through the *left* channel and controlled with the surgeon's left hand (Fig. 13.5). The technical principle should be maintained: the direction of traction should always be to move the instrument handle away from midline externally. Retract or manipulate the tissue internally so the handle falls lateral and away from the camera. This maximizes room for the laparoscope and instrument handles externally. A good uterine manipulator will be able to adequately elevate and position the uterus toward the right shoulder. The assistant grasper can be used to augment and maximize this positioning to present the left uteroovarian and broad ligaments for the electrosurgical device (Fig. 13.6).

Step 3: Insert the Operating Electrosurgical Instrument

The operating instrument will be inserted through the *right* channel (Fig. 13.7). It will enter the internal operative field through the center and usually be directed straight toward the uteroovarian ligament. It is often easier to begin by sealing and transecting the uteroovarian ligament leaving the ovaries until after the hysterectomy is completed (Fig. 13.6). This allows the ovaries to remain on the pelvic sidewall, away from the uterus, and out of the way. After the hysterectomy is completed, the ovaries can be simply removed if desired. In the event the instrument handles interfere with each other or the camera, the handles should be positioned opposite of each other (Fig. 13.8).

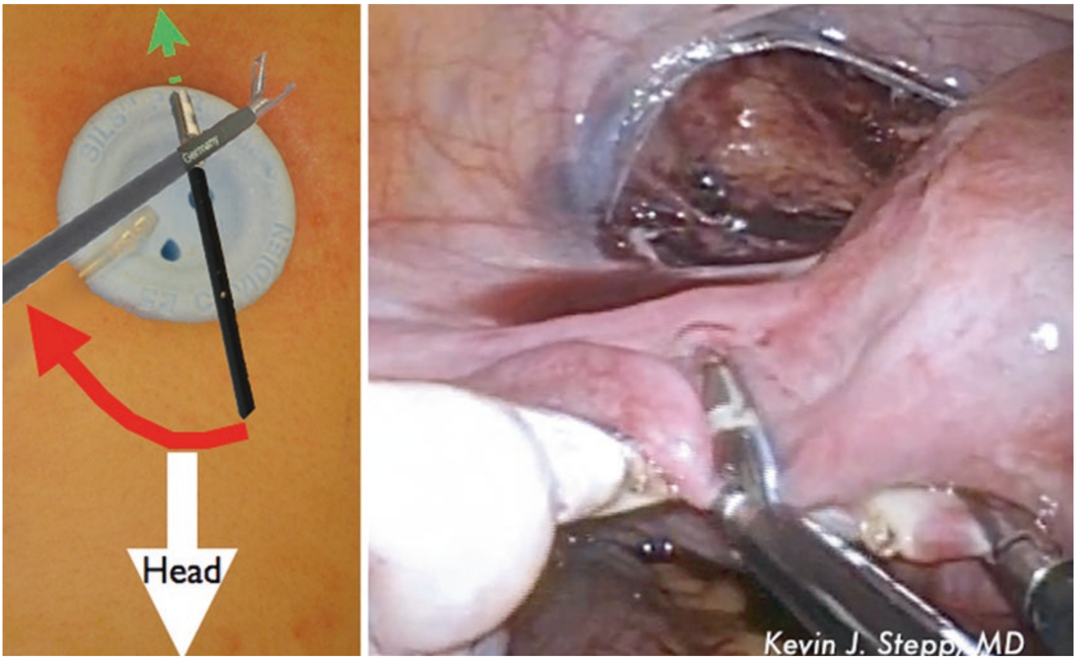

Fig. 13.6 Begin the left side of the hysterectomy. The assistant grasper and uterine manipulator deviate the uterus to the contralateral side providing excellent position for the bipolar device to begin the hysterectomy

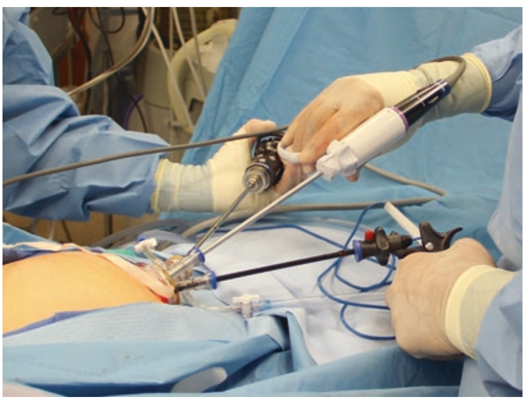

Fig. 13.7 External view showing set-up and instrument positions without clashing. Note the handles of the bipolar device and assistant grasper are facing opposite directions

Fig. 13.8 External view showing camera low and a comfortable surgeon position with handles of instruments facing outward

Step 4: Perform the Left Side of the Hysterectomy

Grasp and seal the utero-ovarian ligament with the electrosurgical device. Continue to seal and transect the broad ligament until beyond the round ligament. Separate the broad ligament to begin to expose the uterine vessels (Fig. 13.9). Separating the anterior and posterior leaves of the broad ligament too soon will cause bleeding from the round ligament. Upward traction on the uterine manipulator exposes the uterine vasculature and increases the distance to the ureters. If the uterine vessels are clearly visible, they may be sealed at this time; inside the ring/cup of the uterine manipulator will provide a safe distance from the ureters to avoid lateral electrosurgery injury (Fig. 13.10).

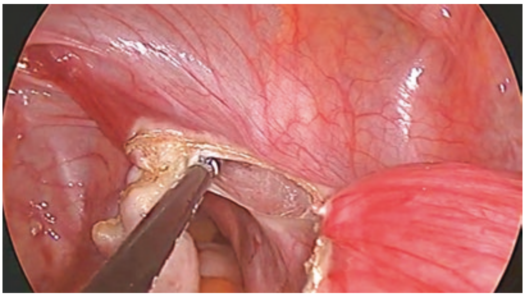

Fig. 13.9 Once the round ligament is completely sealed, begin to separate the anterior and posterior broad ligament to expose the uterine vasculature and begin the bladder flap

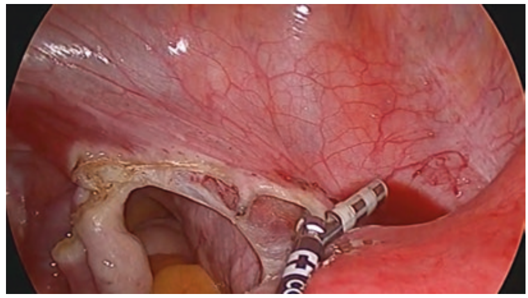

Fig. 13.11 Creating the bladder flap. Often the bladder flap is created with the bipolar instrument. Opening the jaws and rotating will help get around the front of the uterus

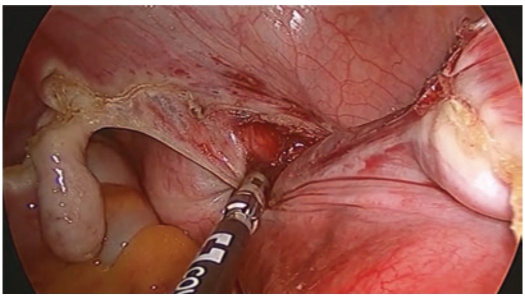

Fig. 13.10 The uterine vasculature is sealed, while upward traction is placed on the uterine manipulator. The bipolar device should stay inside the colpotomizer ring/cup of the uterine manipulator to minimize risk of ureter injury

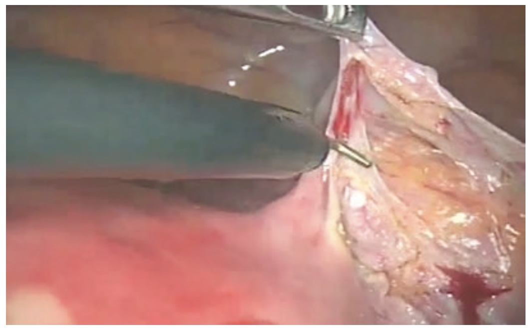

Fig. 13.12 Creating the bladder flap. An alternate method involves elevation of the anterior bladder peritoneum in the midline while incising the peritoneum to expose the vaginal cuff and fornix

Step 5: Create the Bladder Flap

The assistant grasper now can be moved inferiorly on the uterus if necessary. Alternatively, the assistant grasper may elevate the bladder peritoneum cephalad and upward toward the anterior wall. Ideally, the assistant grasper will also be used to elevate the bladder peritoneum thus minimizing instrument exchanges. If necessary, rotation of the open jaws of the energy device will provide an additional few millimeters toward the right side (Fig. 13.11).

Variation: If necessary, the operative instrument/energy device can be exchanged with a monopolar/bipolar hook or spatula to create the bladder flap (Fig. 13.12). Remove the hook or spatula when the bladder flap is complete.

Step 6: Perform the Right Side of the Hysterectomy

Early in one's learning curve, we believe the simplest option for the right side is to remove both the assistant grasper and the operative instrument/energy device. The primary surgeon can move to the patient's contralateral side (Fig. 13.14) or remain on the patient's left side (Fig. 13.15). The uterus should be repositioned toward the left with the manipulator. Then steps 2–5 should be performed from the right side/opposite directions.

Reinsert the assistant grasper from the *right* channel and retract lateral (Fig. 13.13) while deviating the uterus toward the left shoulder. Insert the electrosurgical instrument through the

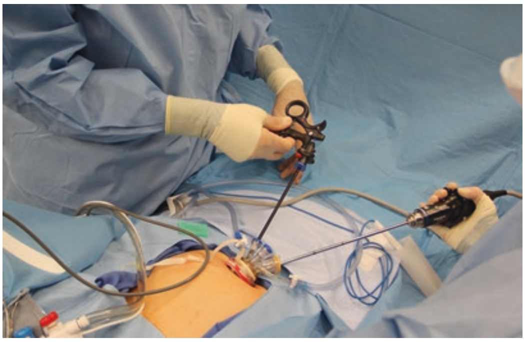

Fig. 13.13 Performing the right side of the hysterectomy. In this view, the primary surgeon has switched sides and is now on the patient's right side. The camera is positioned on the contralateral side. All instruments are removed to set up the operative technique again. The assistant grasper is placed through the *right* channel and the handle retracted laterally

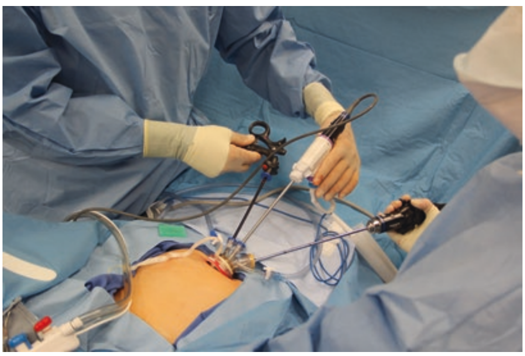

Fig. 13.14 Insert the bipolar device to perform the right side of the hysterectomy. Note the handles are not clashing with each other or the camera

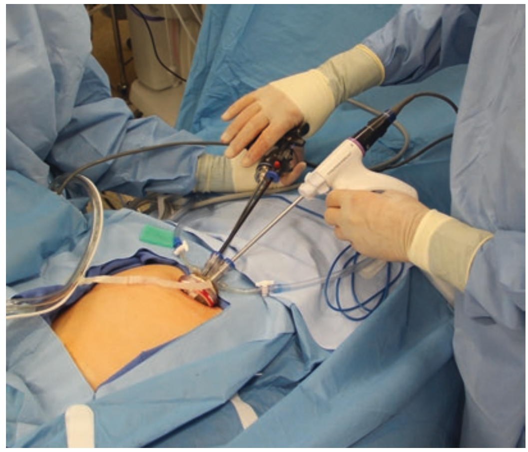

Fig. 13.15 Performing the right side of the hysterectomy without switching sides. The instruments are still switched as in Fig. 13.14. However, the primary surgeon remains on the patient's left side. To maintain a comfortable position requires the surgeon to place the bipolar device in his/her left hand

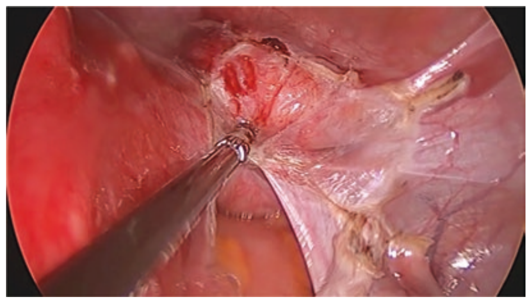

Fig. 13.16 Sealing the right uterine vasculature with upward traction on the uterine manipulator. The bladder flap is completed if necessary

left channel (Figs. 13.14 and 13.15). Seal and transect the uteroovarian ligament, round ligament, and broad ligament. Complete the bladder flap from the right side. Expose and seal the right uterine vessels (Fig. 13.16).

Step 7 (Supracervical Hysterectomy): Amputate the Fundus

Position the uterus toward the right shoulder with the uterine manipulator. Remove the assistant grasper and operative instrument. Move the assistant grasper to the contralateral channel on the *left* and insert. Grasp the uterine fundus or place posteriorly behind cervix to elevate the uterus toward the right shoulder and away from bowel. The instrument handle will fall laterally to the left and down away from the camera. Insert a monopolar/bipolar hook or spatula through the contralateral (*right*) channel for amputation (Fig. 13.17). The instrument should appear midline as it approaches the lower uterus (Fig. 13.18).

Complete 50% of the amputation from the left side (Fig. 13.19). Continued and increasing upward traction on the uterus with the assistant grasper will create a reverse cone ensuring maximal resection of the internal cervical os. To complete the amputation from the right side, reposition the uterus to the right with the uterine manipulator, and repeat the steps from the contralateral side: Remove the assistant grasper and operative instrument. Place the assistant grasper now through the *right* channel and create the upward traction by grasping the uterine fundus or by placing the instrument posteriorly behind the cervix. Elevate the uterus toward the left shoulder and away from bowel by placing handle laterally to the right and down away from camera. Reinsert the monopolar/bipolar hook or spatula via the *left* channel to complete the amputation. Coagulate the endocervix.

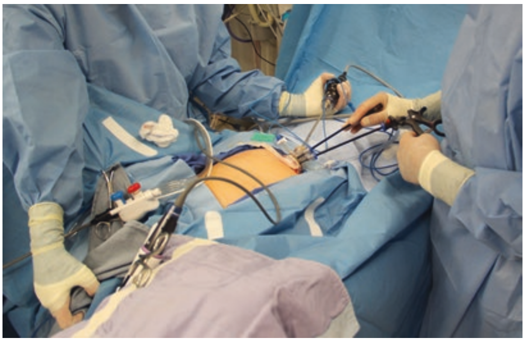

Fig. 13.17 Set-up for supracervical amputation or colpotomy. The assistant grasper handle is retracted laterally providing space for the hook or spatula without clashing or touching other instruments. The assistant can comfortably manipulate the uterus and the camera for exposure

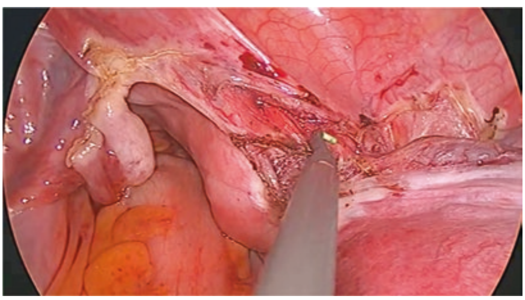

Fig. 13.18 Internal view of a monopolar hook beginning the supracervical amputation on the left

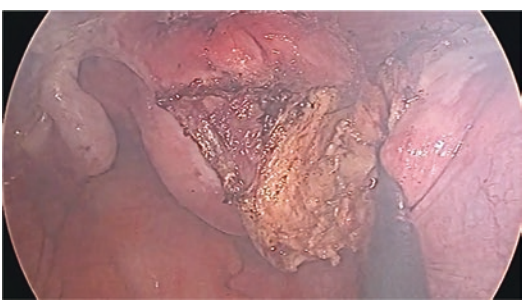

Fig. 13.19 Internal view of amputation. The left side is completely amputated before proceeding to the contralateral side to minimize going back and forth

Step 7 (Total Laparoscopic Hysterectomy): Perform the Colpotomy

This procedure is very similar to the supracervical amputation technique. Careful positioning of the uterus to expose the cervicovaginal junction will allow efficient creation of the colpotomy with limited instrument exchanges.

The external position of the instruments and hands are similar to supracervical amputation (Fig. 13.17).

With the uterus positioned to the right with the uterine manipulator, place the assistant grasper now through the *left* lateral channel, and grasp the uterine fundus or place posteriorly behind cervix to elevate the uterus toward the right shoulder and away from bowel. Insert a monopolar/bipolar hook or spatula through the contralateral channel to start the colpotomy (Fig. 13.20). Complete 50% of the amputation from the left side.

Fig. 13.20 Internal view of the colpotomy. Upward traction will increase the distance from the ureters laterally and help identify the colpotomizer ring/cup of the uterine manipulator. Begin the colpotomy anteriorly and proceed laterally and posteriorly as much as possible before proceeding to the contralateral side

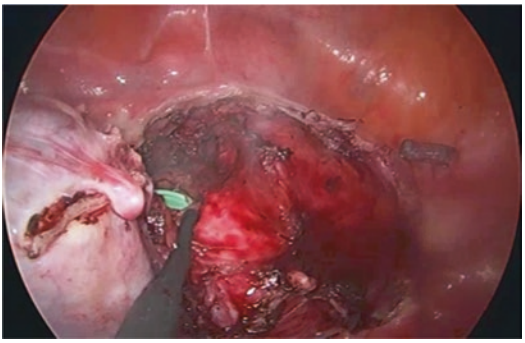

Fig. 13.21 The colpotomy is then completed on the right side staying medial to the sealed uterine vessels

To complete the amputation from the right side, reposition the uterus to the left with the uterine manipulator and repeat the process from the contralateral side (Fig. 13.21). Occasionally it may be necessary to reposition the uterus anteriorly to complete the colpotomy in the posterior midline.

Step 8 (Total Laparoscopic Hysterectomy): Vaginal Cuff Closure

In the case of total hysterectomy, the authors suggest closing the vaginal cuff from a vaginal approach. Laparoscopic suturing is the most complicated task to perform with LESS. We recommend traditional suturing be considered only by those well experienced with LESS. If laparoscopic closure is attempted, we suggest utilizing suture-assisting devices such as Endostitch (Covidien, Norwalk, CT), barbed suture, and Laparo-Ty (Ethicon EndoSurgery, INC. Cincinnati, OH).

Risks Specific to LESS

As with any laparoscopy, it is imperative that surgeons have thorough knowledge of electrosurgery to avoid electrosurgical complications. Surgeons should be aware of the different types of electrosurgical complications. There may be a theoretical increased risk of capacitive coupling when performing LESS. Working with instruments in close quarters may predispose them to insulation damage. Therefore, we recommend meticulous inspection of the instruments. Disposable electrosurgical instruments may have decreased risk of insulation damage and thus lower risk of direct coupling. We believe good technique should mitigate these risks. LESS is a feasible and safe alternative to traditional multiport conventional laparoscopy in selected patients.

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Part II

Robotic Surgery

Robotic-Assisted Total Laparoscopic Hysterectomy

14

Danielle B. Chau and Peter G. Rose

Robotic-assisted total laparoscopic hysterectomy is a minimally invasive approach that has gained increasing popularity over the past two decades. Articulating instruments and high-definition binocular vision have allowed for increased surgical complexity through a minimally invasive approach [1]. Similarly, the prioritization of ergonomics has resulted in a console designed to optimize physician posture, reduce tremor and muscle strain, and create the opportunity for increased longevity of practice for minimally invasive surgeons [2]. This chapter will discuss evaluating patients for candidacy for robotic hysterectomy and considerations for benign and malignant indications.

Introduction

The American College of Obstetricians and Gynecologists (ACOG) recommends that minimally invasive approaches to hysterectomy should be performed whenever feasible based on their well-documented advantages over abdominal hysterectomy [3]. As such, robotic-assisted technology has gained increasing popularity over the past two decades as a minimally invasive option for hysterectomy since its FDA approval for gynecologic indications in 2005 [1]. In fact, the minimally invasive approach with the great increase in overall use has been robotic-assisted hysterectomy, ranging from 0.9% of all hysterectomies performed in the USA in 2008 to 8.2% in 2010 [4] with some recent contemporary studies citing an increase to 19–25% for benign disease [5, 6]. This is in direct contrast to vaginal hysterectomies, whose frequency has continued to decrease over time despite this approach remaining the recommended route for benign hysterectomy.

The increasing popularity of this approach is likely the result of many features robotic-assisted technology has to offer when approaching surgically complex minimally invasive cases, as well as the ability to reduce surgeon fatigue through ergonomic design. This chapter will discuss candidacy for robotic hysterectomy and considerations for benign and malignant indications.

Candidacy and Comparison to Alternative Approaches

While vaginal hysterectomy is the preferred gold standard, there are several anatomical risk factors that may preclude this approach including large adnexal masses, severe adhesions, endometriosis, or a significantly enlarged uterus. Furthermore, patients who require a peritoneal disease assessment, lymphadenectomy, or grossly negative

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tissue margins will need an abdominal survey not feasible through a vaginal approach (i.e., a new cancer diagnosis or prophylactic surgery for hereditary gynecologic cancer syndromes).

Patients who are candidates for conventional laparoscopy may also be offered a robotic-assisted surgery. Anesthetic considerations include the ability to tolerate Trendelenburg positioning which may make ventilation challenging in patients with higher BMIs. Anatomical factors include uterine mobility and the ability to affectively reach the level of colpotomy.

Both minimally invasive approaches offer the benefit of small incisions, decreased blood loss, shortened hospital stays, and even same-day discharge [3]. While robotic consoles do offer several advantages, there has yet to be a randomized control study demonstrating superiority of robotic gynecologic surgery to a laparoscopic approach. In some studies, this is attributed to the longer operative time that docking a robotic setup requires [7, 8]. Similarly, the cost of maintaining a robotic surgical system, equipment, and specialized OR staff, as well as the cost of increased time under anesthesia, must be balanced against the benefit of wristed instruments and stereoscopic vision when selecting candidates for robotic surgery over conventional laparoscopy. Therefore, a large Cochrane meta-analysis concluded that there was no significant benefit to robotic-assisted total laparoscopic hysterectomy when compared to conventional laparoscopy [9].

ACOG and the Society of Gynecologic Surgeons (SGS) recommend that robotic-assisted cases should be selected based on the likelihood of improved outcomes compared with other surgical approaches due to the complexity of the case or patient factors [1]. While the overarching conclusions of direct robotic to laparoscopic comparisons demonstrate no clear benefit, several of these cohorts suggest patient factors with which a robotic approach would be more advantageous. For example, a review by Lim et al. in 2016 evaluated the cumulative experience of 7 surgeons. While there was no difference in perioperative complications or conversion rate to an open procedure between robotic and laparoscopic approaches, the patients in the robotic cohort were older, had higher rates of adhesive disease, and had higher rates of large uteri, suggesting that increased case complexity can be achieved with robotic assistance without increasing complication rates [10].

Articulating robotic instruments allow robotic surgeons to overcome anatomical challenges not amenable to conventional laparoscopic instruments, such as lower uterine fibroids that may preclude a straight approach to the colpotomy site. Additionally, manipulation of conventional laparoscopic instruments may be more challenging in patients with higher BMIs as the fulcrum point of each port shifts higher in the subcutaneous layer with increased abdominal wall thickness, creating a challenge for trocar manipulation during finer dissections. This is overcome by the robotic surgical system with ports that have a fixed fulcrum point as well as the guarded strength offered by the robot. Patients with a larger BMI that are deemed difficult conventional laparoscopic candidates secondary to the above indications can still be offered a robotic-assisted hysterectomy and benefit from the lower rate of surgical site infections, venous thromboembolism risk, and wound complications provided by a minimally invasive approach [3]. In fact, in a recent large database study from Sweden including more than 12,000 women with BMI $\geq$ 30, conversion rate to abdominal hysterectomy was noted to be significantly lower in robotic hysterectomy patients compared to conventional laparoscopy (aOR 28.2; 95% CI, 6.4–124.7), suggesting that the success rate of minimally invasive hysterectomy is improved by a robotic approach [11].

Risks for robotic surgery are similar to those for traditional laparoscopy, and the same preoperative counseling should be reviewed with these patients. General risks to hysterectomy by any route include injury to surrounding tissues/organs, bleeding, infection, and adhesion formation. Risks specific to minimally invasive surgery, including robotic-assisted and laparoscopic approaches, include temporary pain/nerve injury associated with positioning, a longer operative time, the need to convert to an open approach, or the need for additional or larger incision sites.

Table 14.1 Risks associated with robotic hysterectomy, adapted from da Vinci® website

Risks associated with robotic-assisted total laparoscopic hysterectomy
Risks specific to hysterectomy: Urinary tract injury Voiding dysfunction Vaginal cuff issue (separation, adhesions, granulation tissue, infection, cellulitis, hematoma) Bowel injury Vaginal tear or laceration Vaginal shortening Fistula formation: Vesicovaginal, rectovaginal
Risks specific to minimally invasive surgery, including robotic surgery: Temporary pain or nerve injury associated with positioning A longer operative time The need to convert the procedure to an open approach
Risks associated with all types of surgery: Potential for human error Potential for equipment failure Potential for anesthesia complications
Serious and life-threatening complications for all types of major surgery, which may require prolonged and/or unexpected hospitalization and/or reoperation: Injury to tissues and/or organs Bleeding Infection Internal scarring that can cause long-lasting dysfunction or pain

Patients should also be aware that converting the procedure could result in a longer operative time, a longer time under anesthesia, and could lead to increased complications (Table 14.1) [12].

Robotic Hysterectomy for Benign Indications

Robotic-assisted total laparoscopic hysterectomy is a safe and feasible option for patients undergoing surgery for benign indications. The learning curve for robotic versus laparoscopic approach to hysterectomy is significantly faster, allowing for increased and efficient uptake of robotic hysterectomy [13]. Additionally, there is data to suggest that even among high-volume surgeons, the odds of conversion were lower with robotic hysterectomy (7.54% compared with 1.46%, $P < 0.001$; adjusted OR 0.13, 95% CI 0.06–0.27), even when controlling for other factors including uterine weight and adhesive disease [14]. The ability to switch between multiple arms is useful in manipulation of the uterus and adnexa, especially with the initial approach to hysterectomy (Fig. 14.1). Hysterectomy for benign indications may be performed with concurrent oophorectomy or without (Fig. 14.2).

At the Cleveland Clinic Foundation, a uterine manipulator with an intrauterine component (i.e., Vcare®, RUMI®, Advincula Delineator™) is generally used for hysterectomy for benign indications. In patients with significant cervical stenosis, an EEA sizer, sponge stick, or colpotomy tube such as the McCartney Tube™ can be utilized to delineate the cervicovaginal junction.

In patients with low suspicion for malignancy, contained morcellation at an extended port site can be performed. Placement of an Alexis® wound retractor may be helpful to improved visualization through small incisions. Contained morcellation may also be performed vaginally (Fig. 14.3).

Large Fibroid Uterus

Hysterectomy candidates with large fibroid uteri may benefit from a robotic approach. Often the distorted anatomy of a fibroid uterus requires a higher complexity of dissection which is facilitated by the articulation of robotic arms. Similarly, this provides easier access to the colpotomy site by allowing instruments to work around lower uterine segment fibroids. Aberrant vasculature may be present in the setting of fibroids which may be easier to identify with the high magnification afforded by a robotic console (Fig. 14.4).

Adhesive Disease and Endometriosis

Patients undergoing hysterectomy for endometriosis may have significant adhesions or obliterated planes secondary to diffuse endometrial implants or large endometriomas. In these cases, restoring normal anatomy is key to proceeding

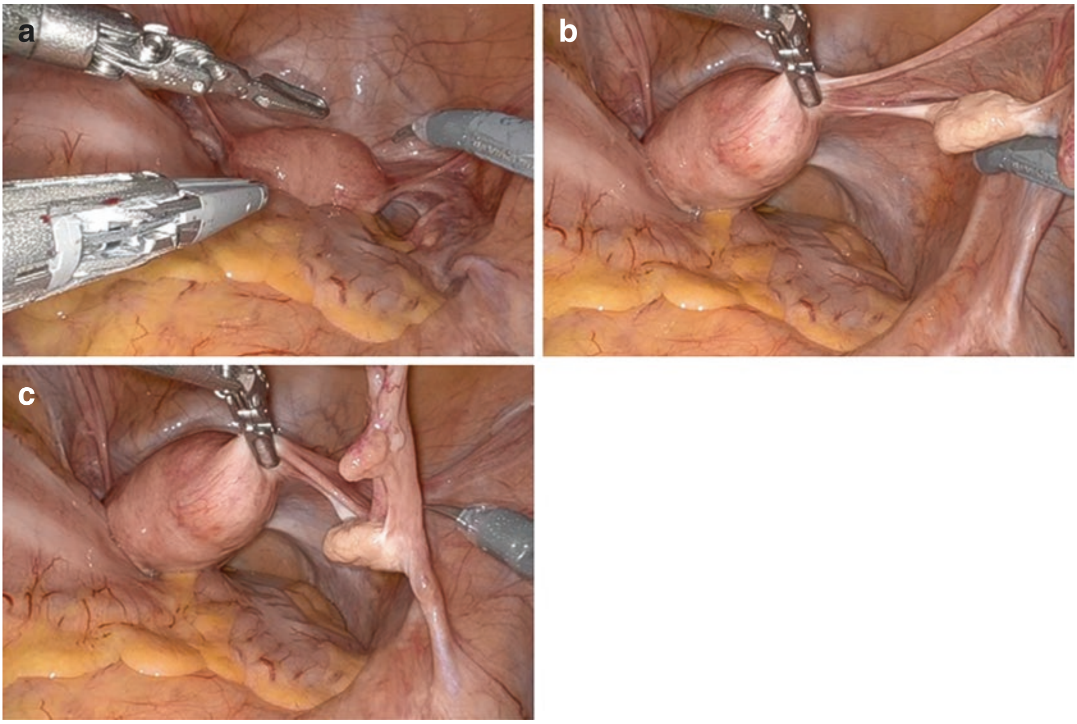

Fig. 14.1 Initial approach to robotic-assisted total laparoscopic hysterectomy with three operative ports using monopolar shears, Prograsp, and Vessel Sealer (**a**). Toggling between two robotic arm options allows the surgeon to assist themselves, both for hysterectomies involving an oophorectomy (**b**), and for hysterectomies that leave the ovaries in situ (**c**). In this figure, the ureter is identified transperitoneally prior to proceeding with the adnexal portion of the hysterectomy

with hysterectomy safely. The wristed instruments and 3-D optics provided by robotic technologic as well as the ability to toggle between multiple operative arms allow for easy transition between the instruments that may be utilized for this dissection (Fig. 14.5).

Identification of the Ureter

In patients with a history of prior pelvic or retroperitoneal surgery, identification of the ureter transperitoneally may be difficult secondary to scar tissue. A retroperitoneal approach can be utilized by incising the peritoneum lateral to the IP ligament with care to avoid underlying iliac vessels. This may also be achieved by incising the peritoneum medial to the IP ligament (Fig. 14.6). If this plane is adherent from previous surgery, ureterolysis may be required to ensure that the ureter is safely away from the operative field.

Robotic Hysterectomy for Malignant Indications

In 2012, the Society of Gynecologic Oncology (SGO) issued a consensus statement supporting the equivalence of robotic surgery and laparoscopy for perioperative outcomes in cancer patients and recommended standardized training in both robotic surgery and traditional laparoscopy for gynecologic oncology fellowship programs [15]. While there is no randomized data to demonstrate a significant benefit of robotic versus conventional laparoscopic approaches to malignant hysterectomy, there are several advantages to a robotic approach to gynecologic malignancies.

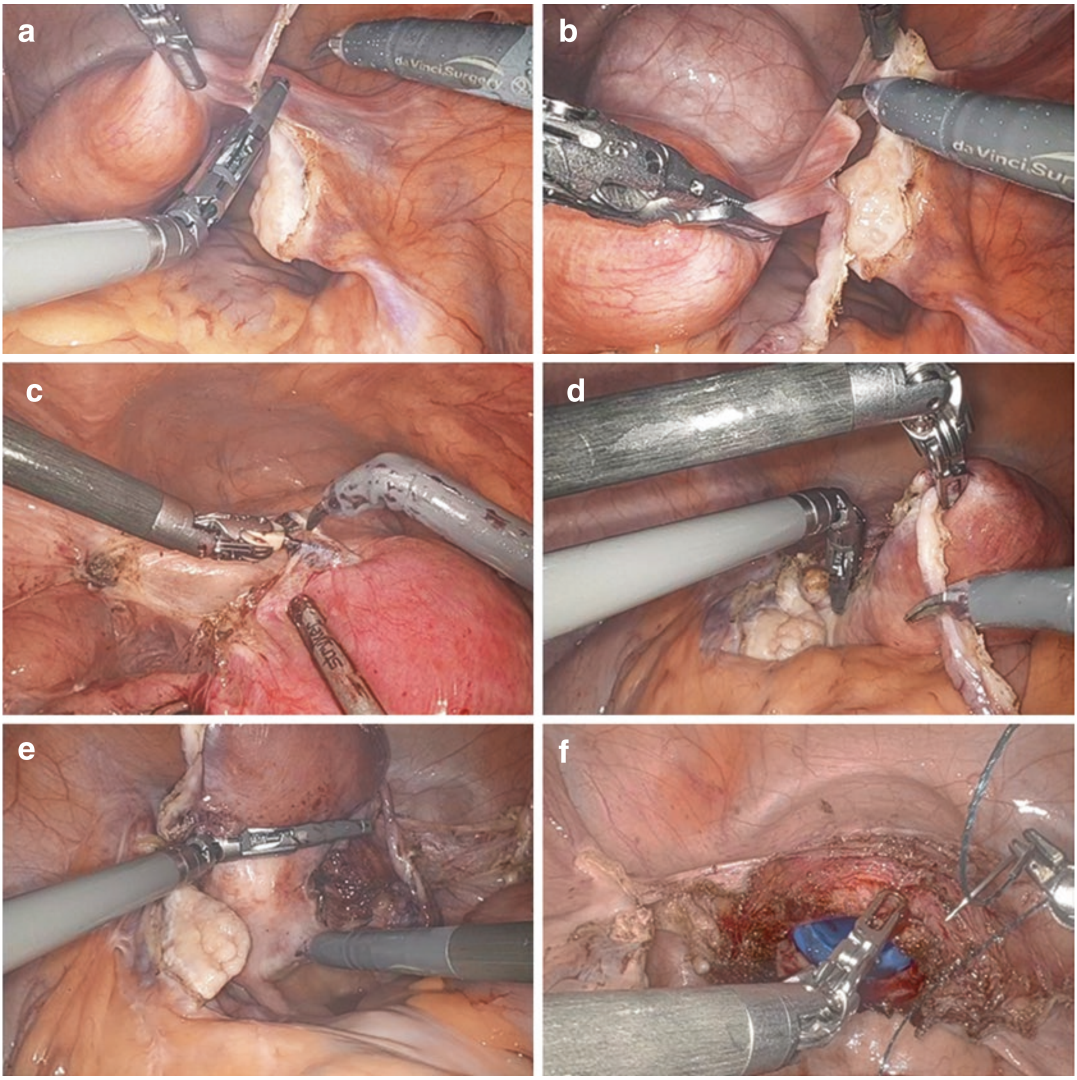

Fig. 14.2 Initial approach to robotic-assisted total laparoscopic hysterectomy with salpingectomy. After transection of the fallopian tube, the utero-ovarian ligament is divided using the Vessel Sealer or bipolar cautery and the monopolar shears (**a**). The round ligament is then cauterized and transected (**b**), to open the anterior broad ligament, and the bladder flap is created (**c**). The uterine vessels are skeletonized and sealed (**d**). Colpotomy is performed, often starting with a posterior approach given that this area is hard to access once the uterus becomes mobile (**e**). The vaginal cuff can then be closed using a robotic needle driver and V-Loc™ suture (**f**)

Robotic Hysterectomy for Uterine Cancer

In the USA, robotic-assisted total laparoscopic hysterectomy in conjunction with full or sentinel lymph node dissection is currently being used for early-stage endometrial cancers. The validity of a minimally invasive approach for endometrial cancer staging was demonstrated in a randomized control trial by the Gynecologic Oncology Group in 2009, which showed superiority of a minimally invasive approach regarding short-term safety and length of stay as well as a non-inferiority of recurrence-free interval when compared to staging by laparotomy [16].

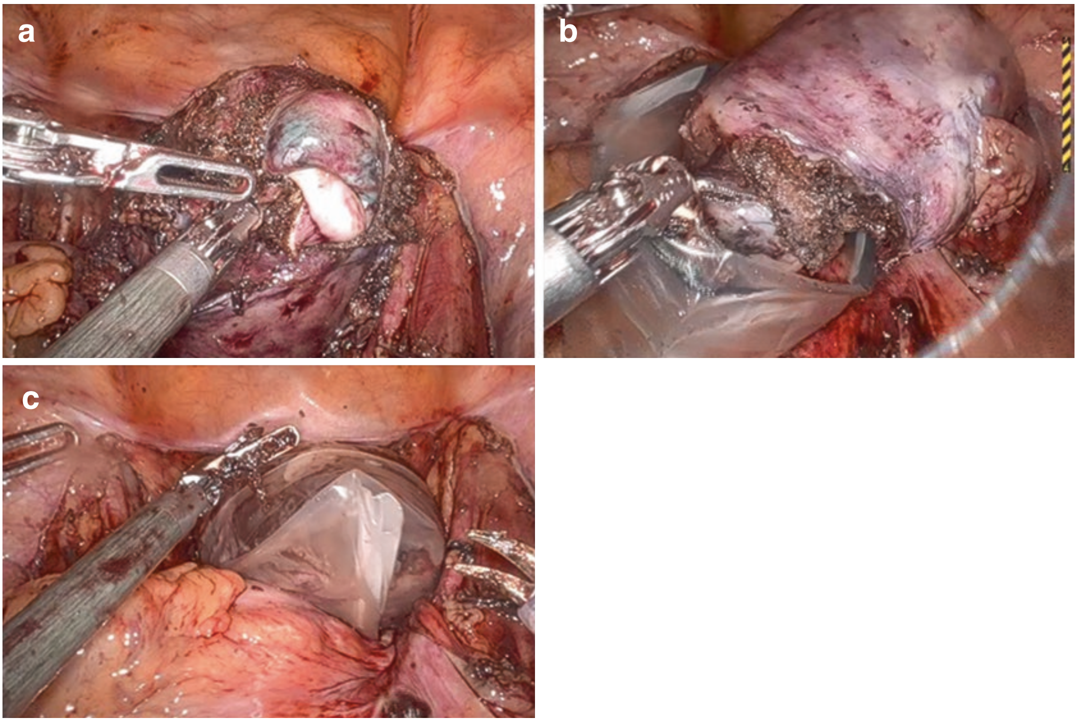

Fig. 14.3 Removal of the hysterectomy specimen vaginally contained within a sterile bag. The specimen is grabbed at the level of the cervix (**a**), and placed into the endocatch bag cervix first (**b**), to ensure that the smallest diameter of the specimen will be removed initially. The bag is then closed and removed vaginally (**c**). Large specimens can then be bi-valved or morcellated within the bag. Other options for contained removal include removal through an abdominal port site with morcellation within the bag or intact removal through a minilaparotomy site

At the Cleveland Clinic Foundation, a uterine manipulator with an intrauterine component is typically avoided due to retrospective data demonstrating an increased recurrence rate [17]. In the setting of uterine malignancy, a McCartney Tube™ is utilized (Fig. 14.7).

In the setting of malignant hysterectomy, morcellation, even contained morcellation is avoided in order to provide pathology with an intact specimen for staging purposes. Therefore, if vaginal extraction is not feasible, a mini-laparotomy for removal of an intact specimen is preferred.

Furthermore, the learning curve for robotic-assisted hysterectomy with lymph node dissection seems to be easier compared with that for laparoscopic hysterectomy with lymph node dissection for surgical management of endometrial cancer. In a large study by Lim et al., robotic-assisted total laparoscopic hysterectomy with lymph node dissection patients experienced significantly better clinical outcomes compared to conventional laparoscopy and open abdominal patients with regard to shorter average length of stay, lower average estimated blood loss, and low intraoperative complication rate. Most notably, there was a lower conversion rate for robotic-assisted patients (1.7%) compared to the conversion rate for conventional laparoscopic patients (7.1%) [18].

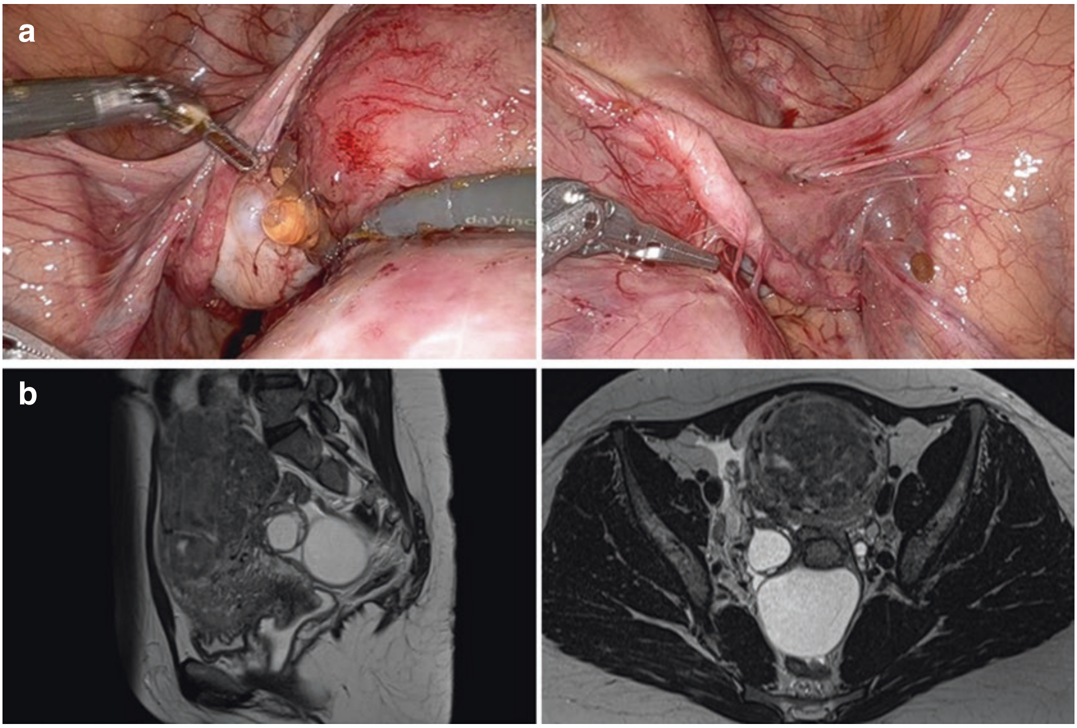

Fig. 14.4 Robotic (**a**) and MRI (**b**) imaging of a large fibroid uterus with a concurrent adnexal mass. The large posterior fibroid obscures direct access to the posterior cul-de-sac and lower pelvic sidewalls, and therefore the wristed articulation of the robotic arms is particularly useful in this circumstance

Approaches to sentinel and full lymph node dissection at the time of robotic hysterectomy are similar to conventional laparoscopy and start with opening the retroperitoneal space. Indocyanine green (ICG) fluorescence is used to identify the sentinel lymph node once the pararectal and paravesical spaces are opened (Fig. 14.8). Our approach to full pelvic lymph node dissection differs slighting in that ureterolysis is performed to mobilize the ureter medially to gain broader access to the pelvic side wall. To achieve this, we use a vessel loop placed percutaneously (Figs. 14.9 and 14.10).

Robotic Hysterectomy for Other Gynecologic Malignancies

While robotic-assisted radical hysterectomies were formerly a popular approach for management of early-stage cervical cancers, recent randomized data has demonstrated inferiority of this approach to laparotomy for overall survival [19]. Therefore, radical hysterectomy through a minimally invasive approach is no longer recommended for cervical cancer patients. Robotic-assisted technology can also be utilized to performed radical hysterectomies for other indications – including lower uterine segment or cervical fibroids – and some endometrial cancer cases.

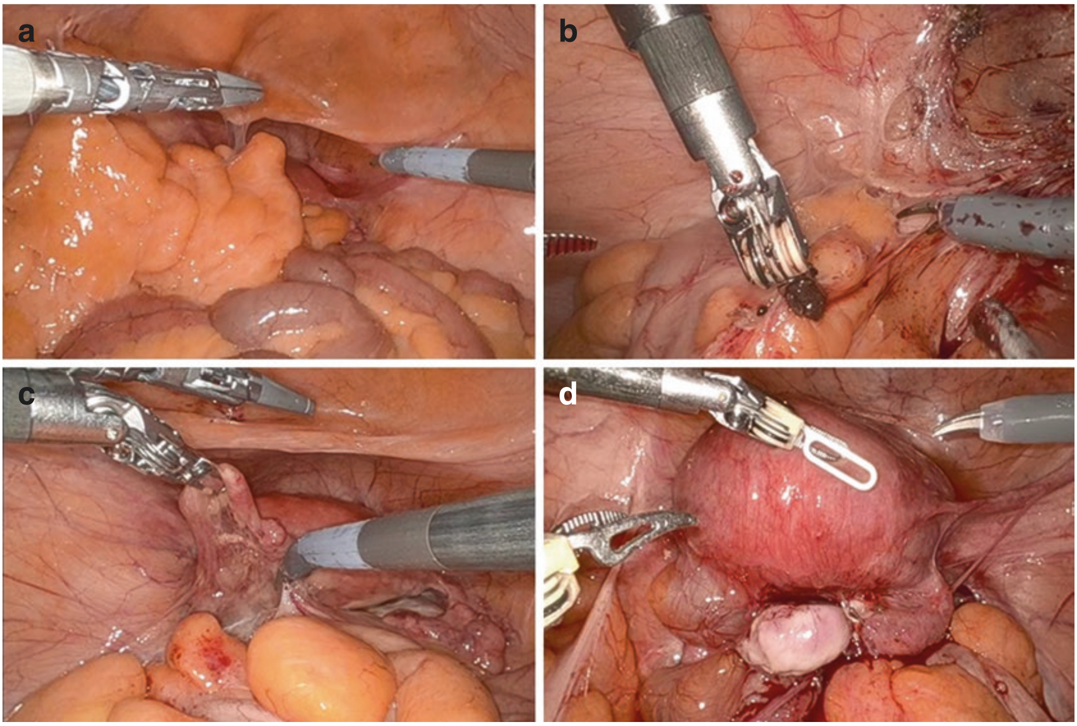

Fig. 14.5 Examples of simple adhesions (**a**), physiologic bowel adhesions (**b**), and adhesive disease secondary to endometriosis involving the adnexa and large bowel unilaterally (**c**), and bilaterally (**d**)

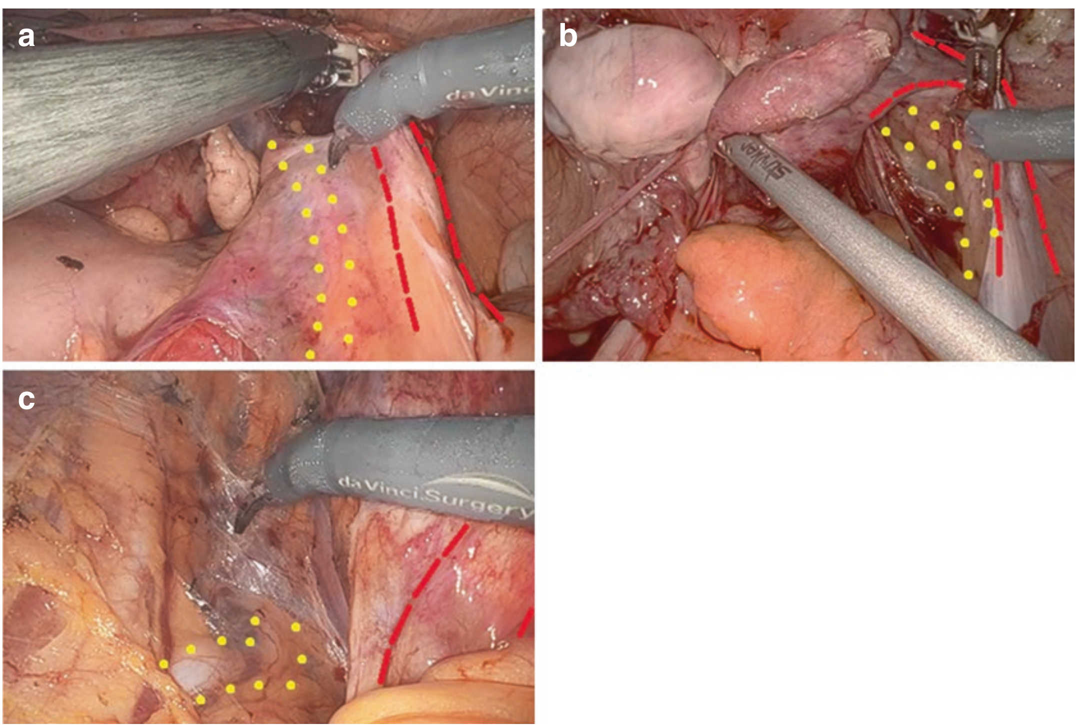

Fig. 14.6 Identification of the ureter (demarcated in yellow) transperitoneally (**a**), and retroperitoneally (**b**, **c**). In **b**, an incision is made along the peritoneum medial and parallel to the IP ligament (demarcated in red). In **c**, an incision is made along the peritoneum lateral and parallel to the IP ligament

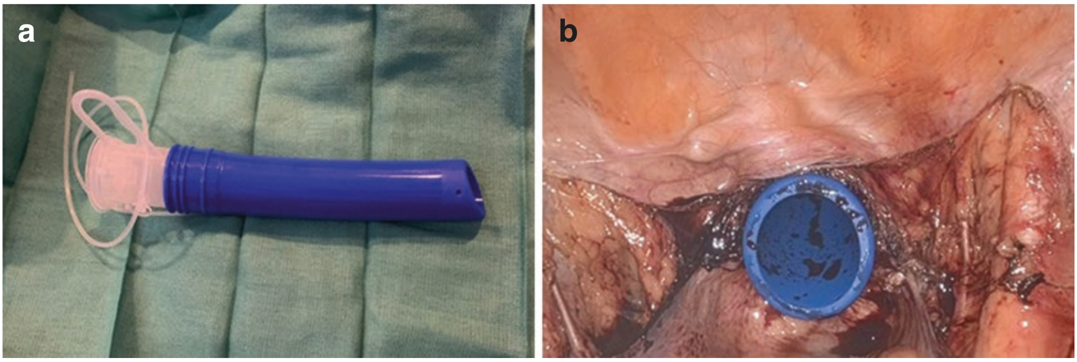

Fig. 14.7 (**a**) The McCartney Tube™ includes an orientation handle, suction port (that can also be used to pass traditional laparoscopic instruments), and a silicon tie for securing the tube to the sterile drape. (**b**) It can additionally be used as a vaginal occluder to maintain pneumoperitoneum during vaginal cuff closure as well as a passage to remove small specimens from the abdomen (i.e., omental biopsies, lymph nodes)

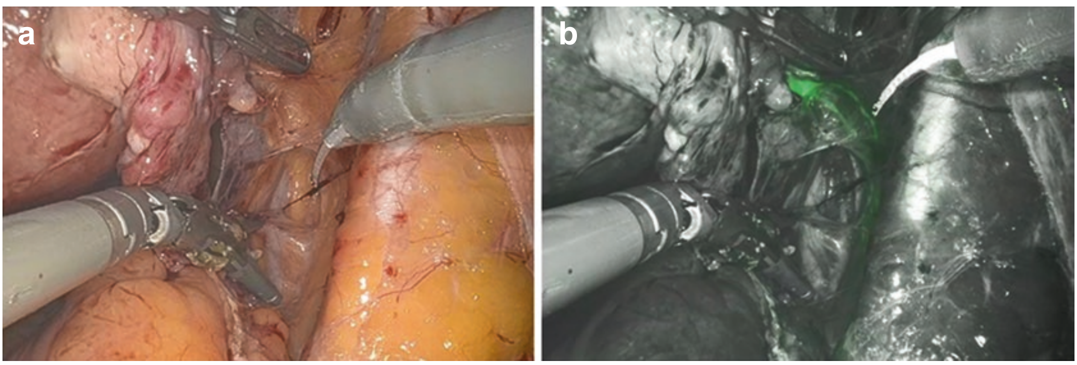

Fig. 14.8 After injection of ICG into the cervix, the retroperitoneal space is opened to expose the pararectal and paravesical spaces (**a**), and the ICG-illuminated lymph node channels are traced to the sentinel lymph node (**b**)

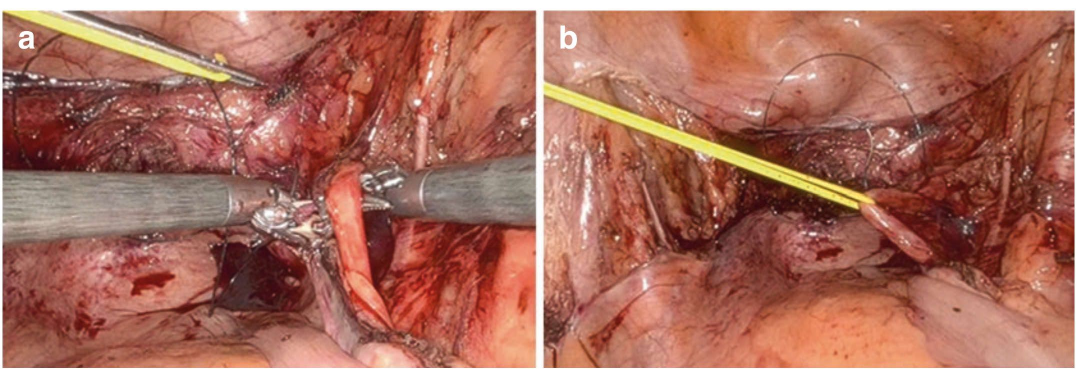

Fig. 14.9 Initial approach to full pelvic lymphadenectomy. The retroperitoneum is opened and the ureter is identified. A vessel loop is introduced directly into the abdomen using a Carter-Thomason® device (**a**), and the ureter is retracted medially by pulling the vessel loop back out of the abdomen and securing it with a small clamp (**b**)

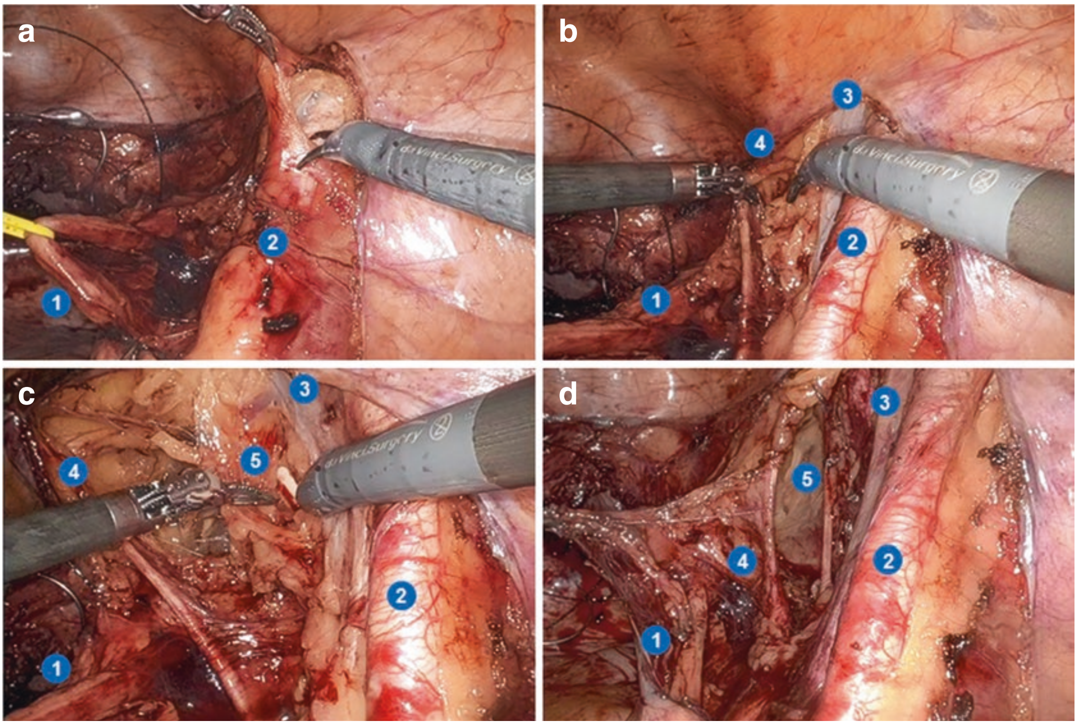

Fig. 14.10 Approach to pelvic lymphadenectomy, continued. (**a**) After the ureter (1) is retracted, the external iliac artery (2) is exposed by dissecting the retroperitoneal tissue medially, in this case starting distally and working proximally to the level of the bifurcation of the common iliac artery. (**b**) The retroperitoneal lymph node packet and associated connective tissue is further dissected from the external iliac vein (3). (**c**) The paravesical space is identified by retracting the obliterated umbilical artery (4) medially; this space is further divided until the obturator nerve is identified (5). The remainder of the pelvic lymph node packet is then removed by working cephalad towards the common iliac bifurcation. (**d**) Removal of this tissue results in a clear view of the retroperitoneal anatomy and pelvic lymphadenectomy borders

Conclusion

Robotic-assisted total laparoscopic hysterectomy is a minimally invasive approach with a short learning curve and several applications useful for complex surgical cases, including large fibroid uteri, intra-abdominal adhesions, endometriosis, and malignant disease. It is a useful surgical technique that allows for reduced surgeon fatigue, creating the potential for improved longevity of practice for minimally invasive surgeons.

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15 Principles of Robotic Myomectomy

Antonio R. Gargiulo

Myomectomy, the quintessential fertility-sparing surgery, is no longer the heroic alternative to hysterectomy, but it is a common operation with an excellent safety record [1]. So much so, it can be offered as an organ-sparing alternative to hysterectomy to some premenopausal patients who have completed their reproductive endeavor. Myomectomy is a microsurgical operation, based on the following requirements: (1) myometrial, endometrial, and tubal preservation, (2) thorough hemostasis with minimal use of cautery, (3) precise tissue apposition through reconstruction in layers, and (4) absence of exposed suture and minimal serosal disruption. Surgeons are held to these operative standards whether they opt to open the abdominal wall or choose the minimally invasive route. For a patient, myomectomy is myomectomy: it is up to the surgeon to live up to this expectation.

It is well established that minimally invasive myomectomy offers clinically superior results compared to open myomectomy [2]. Despite this, there are good reasons why many surgeons continue to offer open myomectomy as their primary operative modality [3]. First, open myomectomy is easier to perform compared to its minimally invasive counterpart. In fact, the technical challenges of minimally invasive myomectomy have been recently compounded by the widespread demise of electromechanical uterine tissue morcellation, following the American Food and Drug Administration (FDA) black box warning of 2015. Secondly, open myomectomy objectively remains the only technically feasible option in some patients. Any myomectomy approach, provided it follows the tenets of microsurgery, remains an ethical professional choice.

Few may recall that robotic myomectomy was already in the works in the United States two full decades ago. The first clinical series was published in 2004, and since that time, the safety and efficacy of robotic myomectomy has been clearly established [4–8]. Similarly to what has been observed for conventional laparoscopic myomectomy, case-matched comparisons between patients undergoing open and robotic myomectomy have shown lower blood loss, fewer complications, and shorter hospital stay for this minimally invasive procedure [9, 10].

Robotic myomectomy is primarily about the standardization of suturing and its positive impact on adhesion formation and reproductive outcomes [11]. Regrettably, single-layer closure of uterine incisions is still common in conventional laparoscopic myomectomy (in contrast to the higher prevalence of two- and three-layer closure prevalence in robotic myomectomy), with a consequent higher incidence of healing by

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secondary intention, and increased chance of postoperative adhesions because of wound protrusion [12, 13].

Platform-Agnostic Principles of Robotic Myomectomy

Multiple robotic platforms have been approved for clinical use since the first edition of this Atlas, and many more will emerge in the next few years, at an accelerated pace. However, it is reasonable to expect that the general flow of the myomectomy operation will remain unchanged until robotic automation will be introduced (which is not expected to occur for many more years). I will break up robotic myomectomy into basic steps and explain the possible advantages provided by any robotic platform endowed with the appropriate mechanical tools.

The use of high-quality imaging to provide adequate case selection is germane to a surgical atlas and should be discussed. Minimally invasive myomectomy removes the ability to locate fibroids by palpation. Some robotic platforms do provide simulated haptic feedback [14]. However, feedback obtained through the tip of a laparoscopic instrument is not comparable to that obtained by palpation. Therefore, all minimally invasive myomectomy will require high-quality preoperative imaging. Magnetic resonance imaging (MRI)'s ability to locate smaller fibroids is superior to ultrasound, and so is its accuracy in ruling out adenomyosis [15, 16]. Even palpation, allowed only by open myomectomy, cannot compete with imaging techniques in terms of the ability to detect smaller intramural myomas [17, 18]. Therefore, the relevance of haptic feedback in myomectomy is overrated, and robotic platforms with simulated haptic feedback will not provide a definite advantage in this operation. We consider MRI to be an essential preoperative imaging requirement for robotic myomectomy: real-time image fusion of preoperative MRI is expected to become a feature of robotic platforms soon.

A myomectomy in a patient who has not been prepared pharmacologically is an unnecessarily risky operation that should only be considered in an emergency. Pharmacological preparation of the patient and of the uterus includes long-term and short-term interventions: all of which are extremely important. Although their discussion is beyond the scope of this Atlas, their importance is paramount.

To optimize visualization in minimally invasive myomectomy, we make sure that the camera port is about 10 cm above the level of a palpable fundus. In the case of very large uterine pathology, the trocar may transfix the falciform ligament of the liver [19]. No complications from laceration of this ligament have been reported in the literature.

Robotic instrument ports for myomectomy can be two or three. These ports are also placed in the upper abdomen: usually at the same height of the umbilicus and at 8-cm distance minimum from each other (Fig. 15.1).

Safe suture exchanges are accomplished by placing the assistant port in a lower quadrant location. There are many good reasons for a lower quadrant assistant port in minimally invasive myomectomy: (1) losing a needle because the assistant port is placed beyond the visual range of the laparoscope is never excusable, (2) the lower quadrant entry can be used as a point of extraction for the specimen, (3) a bedside assistant working through a lower quadrant port can reach the uterine manipulator, and (4) conventional laparoscopic steps are performed more easily with two lateral access ports in a sagittal plane.

Myomectomy involves three main steps:

1. Hysterotomy
2. Enucleation
3. Reconstruction in layers

On current robotic platforms, hysterotomy is usually carried out with monopolar cautery instruments (scissors, hooks, and spatulas). This energy is associated with the highest possible level of collateral thermal tissue damage: all reported uterine ruptures following laparoscopic and robotic myomectomy have occurred following the use of monopolar or bipolar electrocautery [11, 20]. These electrosurgical tools are

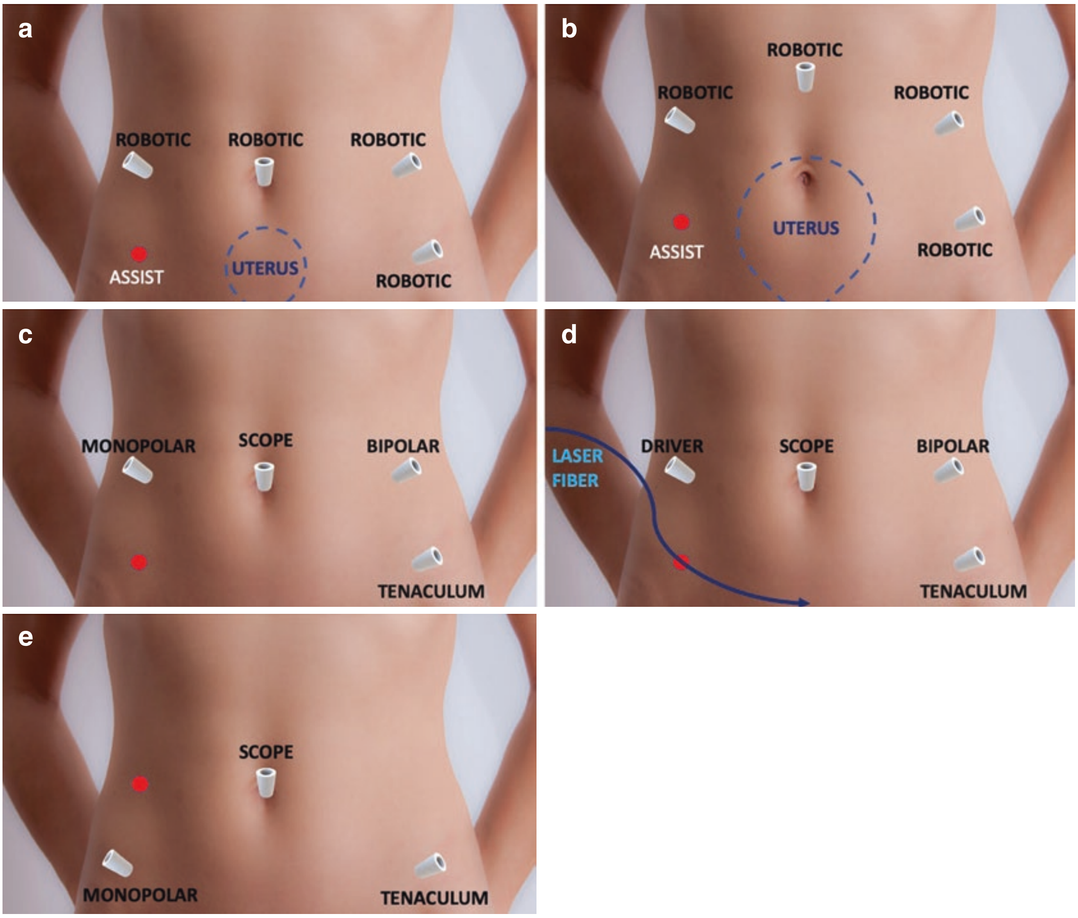

Fig. 15.1 Recommended robotic and assistant port placement for robotic myomectomy. The assistant port (red circle) is a 12-mm standard disposable port placed in the right lower quadrant, which allows rapid exchange of multiple sizable (CT-1 and CT-2) suture needles and easily converts to a uterine tissue extraction point at the end of the operation. (**a**) Standard setup. (**b**) Setup for large pathology: in myomectomy, the camera port should be placed about 10 cm above the uterine fundus, when possible. The other ports rise cephalad as needed. (**c**) Standard instrument choice, with cutting monopolar instrument, bipolar grasper for focused hemostasis and tissue manipulation and tenaculum for tumor immobilization and traction. (**d**) Adaptation for effective use of a flexible carbon dioxide laser fiber as the cutting tool; a needle driver is used to grasp and maneuver the tip of the laser fiber guide, which is introduced through the assistant port. (**e**) Setup for small uterine fibroids. The robotic ports in this case are three (camera plus two instruments) and are placed in a particularly cosmetically conscious manner, with instrument arms medial to the anterior superior iliac spines. The assistant port is a 5-mm port and is placed laterally in the upper abdomen or in a suprapubic location: this port can be omitted completely for small tumors, and the laser guide can be inserted through the umbilical incision, to the side of the scope port

therefore less than ideal and should never be used in "coagulation" modality (intermittent waveform), but in pure "cutting" modality (constant waveform). Energy instruments with significantly decreased collateral thermal tissue damage, such as the ultrasonic scalpel and the carbon dioxide laser, are not currently optimized for use with any robotic surgical platform: this limits their acceptance and popularity, despite the demonstrated advantages [21–23].

The key to successful enucleation of a myoma is the prompt recognition of entry into the space between the tumor and its pseudo-capsule: the correct myomectomy is always intracapsular [24]. Robotic myomectomy allows magnified high-definition three-dimensional view of the uterine wall layers. When the correct cleavage plane has been established, the myoma is grasped with a tenaculum and immobilized under traction. Correct traction is away from the core of the uterus and through the incision: here too, robotic technology comes to help by facilitating instrument triangulation on the target tissue. The surrounding myometrium is detached from the immobilized myoma. A three-instrument arm setup can be advantageous at this point, allowing two instruments to work on detaching the myometrium while another one keeps the myoma in traction. Consequently, robotic platforms that do not allow the concomitant use of three-instrument arms severely limit the applicability of robotics to myomectomy.

Hemostasis is achieved by enucleating and suturing with speed and precision: thermal energy as a means to achieve hemostasis in myomectomy is a mistake with potentially fatal consequences (uterine rupture) that must be avoided at all costs. Speed of execution is dramatically aided by robotic assistance. The ability to suture from any angle also allows true choice of hysterotomy location (therefore allowing best access to the tumors through least myometrial depth and avoidance of reproductive tissue damage). Because of the above, robotic platforms that allow operation with fully wristed instruments will always be superior for this operation. Fixed-tip instruments and snake-wrist instruments are not comparable in terms of the dexterity that they allow. The mechanics of suturing with a fully wristed instrument, including nondominant hand suturing and backhand suturing, are very different from those employed in conventional laparoscopy and must be perfected on a virtual reality simulator: robotic suturing is a specific skill that is perfected before surgery, not during surgery. Barbed sutures on CT-1- and CT-2-type needles are our suture of choice for myomectomy. We recommend using two proper robotic needle drivers for myomectomy: this is not a quick vaginal cuff repair and should not be carried out with any tissue grasper. Uterine manipulation by an expert bedside assistant is useful during suturing but offers limited support in the case of a large uterus: in those cases, we use a robotic tenaculum for uterine manipulation. If an endometrial cavity breach is noted, the myometrium above the breach is carefully reapproximated before reconstructing the rest of the uterine wall. Running sutures are used to close deep myometrial layers. The most superficial layer is closed with a subserosal or an imbricating ("baseball") stitch. We apply oxidized regenerated cellulose to all uterine incisions following myomectomy (Fig. 15.2).

Once closure of hysterotomy is completed and hemostasis is confirmed with low-pressure test, the surgical specimen needs to come out of the patient. Tissue extraction is not currently aided by surgical robots. Our hospital has developed sophisticated extraction techniques to be employed, while electromechanical morcellation is not available [25, 26]. We employ endoscopic specimen extraction bags through a 2.5-cm umbilical incision or through a 2.5-cm incision performed in either lower quadrant (the ones we use for bedside assistance). Tissue extraction is accomplished using a #10 blade in a semicircular motion while applying direct traction of tissue with standard towel clips. The cosmetic impact of these incisions is very well accepted by our patients (Fig. 15.3).

Special Scenarios

Robotic Myomectomy for Very Large Myomas (>10 cm in Diameter)

Robotic platforms are not currently optimized for large myomectomies. A robotic myomectomy where the uterine fundus surpasses the umbilicus is a four-quadrant operation, and cantilever-based robotic platforms (and even multiunit platforms) are two-quadrant operators. Moreover, available tenacula are delicate instruments designed for smaller and light tumors. Consequently, we often plan our largest cases as hybrid procedures: conventional laparoscopic enucleation with ultrasonic scalpel, followed by docking of the robot for microsurgical uterine reconstruction. Conventional laparoscopy provides a more substantial tenaculum and unlimited four-quadrant action, while the robot provides better suturing ability for a pristine reconstruction in layers [21].

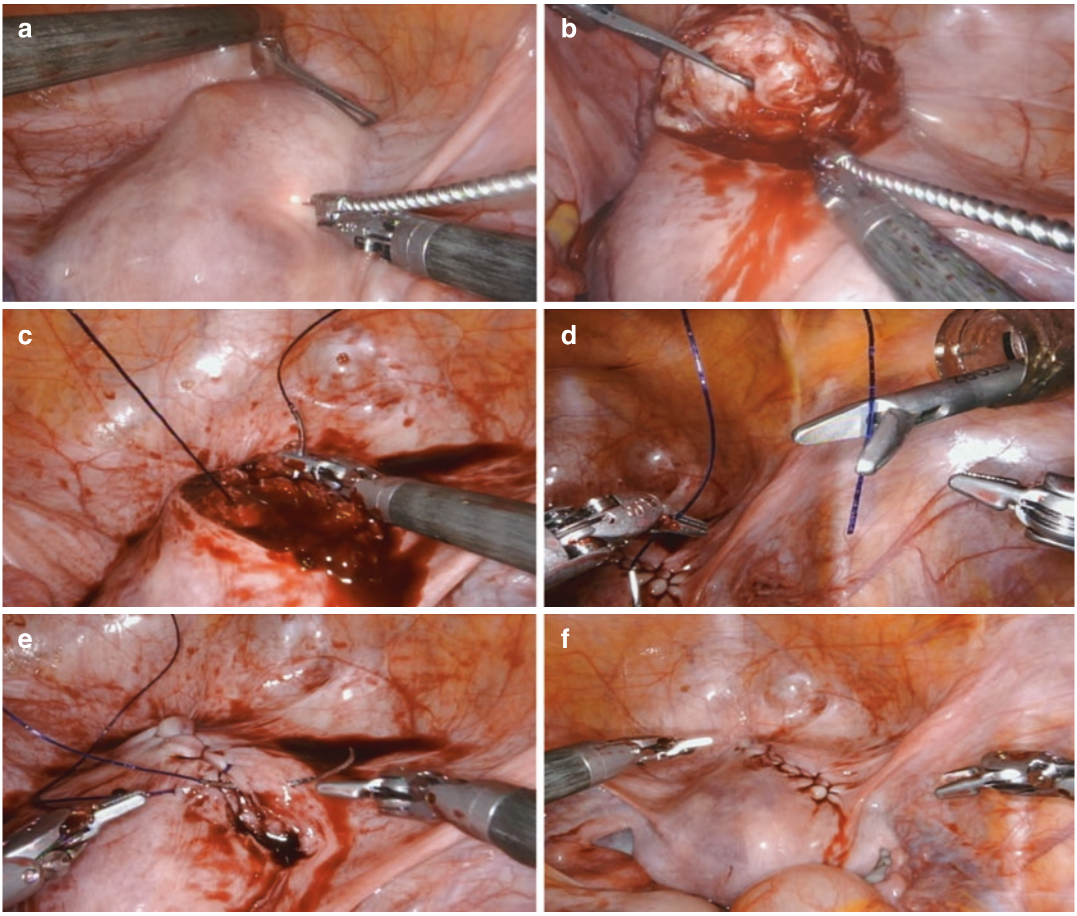

Fig. 15.2 Basic steps of myoma enucleation and repair are not different in robotic surgery that in open or conventional laparoscopic surgery. Anatomically correct, intracapsular, myomectomy has been compared to the technique employed in nerve-sparing robotic radical prostatectomy: it involves the gentle detachment of the mass from its pseudo-capsule and its associated neurovascular bundle. A tenaculum is used to steady the tumor, and one or two blunt instruments are used to push the myometrium away from the immobilized myoma. Hemostasis is achieved solely by chemical (vasoconstriction) and mechanical means. Barbed suture should be used to close all uterine wall layers. (**a**) Standard setup for a small anterior lower segment myoma, with two robotic instruments (tenaculum and needle driver) and an assistant port through which a carbon dioxide fiber is introduced. A tenaculum is in the left arm. (**b**) The tenaculum immobilizes the tumor and the tip of the laser fiber guide acts at the dissector. Note the healthy myometrium at the site of hysterotomy, with no sign of thermal effect. (**c**) Running 2.0 PDS barbed suture closes the intracapsular space in a running fashion; myometrial layers are closed in the same fashion. (**d**) Needle exchanges occur in front of the laparoscope, due to the location of the assistant port just medial to the right anterior superior iliac spine. (**e**, **f**) The serosal layer is closed with a "baseball stitch," so as to bury all barbed suture

Robotic Myomectomy for Small Myomas

In these cases, we strive to provide an operation with minimal cosmetic impact [22, 26, 27]. Our team has described the original single-site robotic myomectomy. This remains a technique with limited applicability in terms of myoma size and number and involves the use of special equipment. This technique can spare the patient three extra laparoscopic entry points while assuring a favorable cosmetic outcome (provided that the patient can accommodate a 2.5-cm incision within the umbilicus). Excellent cosmetically

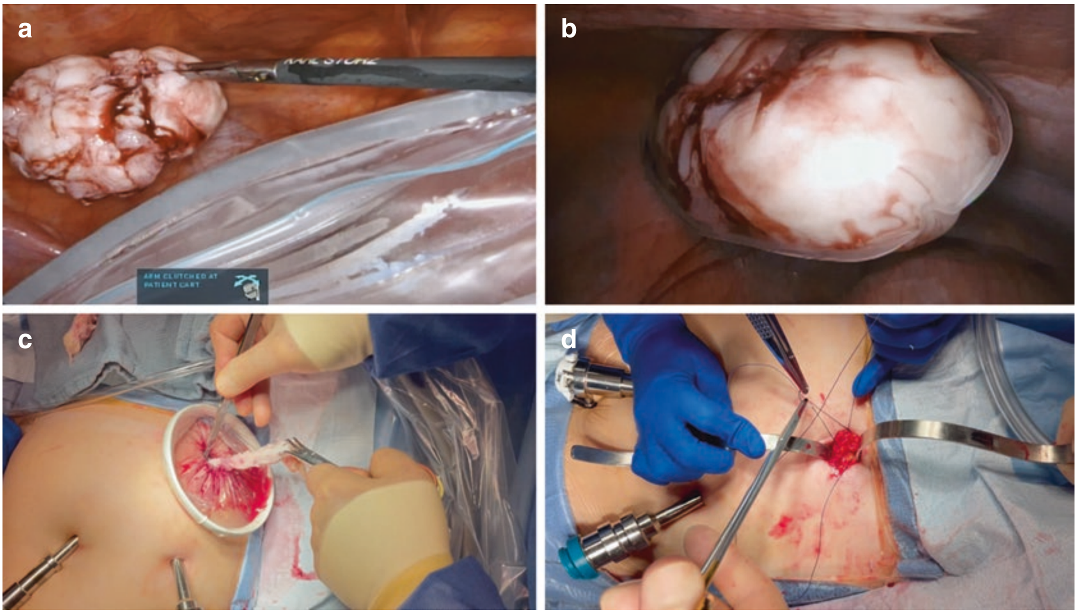

Fig. 15.3 Minilaparotomy for contained tissue extraction is never needed in robotic myomectomy, and its use should be avoided. We are consistently able to extract uterine tumors in endoscopic specimen bags through a 2.5-cm open laparoscopy umbilical incision or a 2.5-cm incision in either lower quadrant. (**a**, **b**) The uterine tumor is placed in an endoscopic bag and brought to the anterior abdominal wall. (**c**) The assistant port is increased in size from 12 to 25 mm, and the opening is placed on stretch by use of a radial retractor. Tissue extraction is performed with careful semicircular movements with a surgical knife while the tumor is pulled with a grasper. (**d**) Fascial incision is closed with running 0 Vicryl

conscious multi-port alternatives exist for small myomectomy. In those, two robotic instrument cannulas are placed just medial and slightly cephalad to the left and right anterior superior iliac spines. A 5-mm bedside assistant port can be placed in the suprapubic area or avoided altogether (*see* Fig. 15.1).

Cervical and Retroperitoneal Myomas

The main challenge in retroperitoneal myomectomy is to excise tumors without avulsing a ureter or a sizable pelvic vessel. Hemostatic agents (thrombin and fibrin products) should be used liberally in these cases. For very large cervical myomas, we plan transient uterine artery embolization by the interventional radiology team before robotic myomectomy [28, 29] with excellent results. The main contribution of robotic technology approach in this specific operation resides in its ability to provide a high-quality, steady image in the distorted retroperitoneal spaces where a safe plane can be developed between the tumor and its surroundings and to allow the surgeon to concentrate on the complex anatomy and the surgical strategy, rather than on the added mechanical challenges of laparoscopy.

Acknowledgments This chapter is dedicated to the memory of our dear colleague Micheal C. Pitter, MD, master robotic surgeon and innovator, who contributed greatly to the standardization and diffusion of the original robotic myomectomy technique.

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Robotic-Assisted Surgical Management of Endometriosis

16

Katherine de Souza and Lindsey N. Valentine

Endometriosis is a common disorder defined by the presence of ectopic endometrial glands and stroma. Clinical manifestations include pain, infertility, and decreased quality of life. Surgery is considered for women with symptoms refractory to conservative management and has both diagnostic and therapeutic benefits. Endometriosis can lead to a variety of surgical findings including severe adhesive disease as well as disease on the bowel and bladder. Due to the complex nature of endometriosis, advanced surgical skills are required for laparoscopy. The introduction of robotic-assisted laparoscopy in gynecology has created an alternative surgical approach. Robotic-assisted laparoscopy shares the benefits of conventional laparoscopy, with additional advantages afforded by robotic technology. Current data comparing robotic-assisted laparoscopy to conventional laparoscopy for endometriosis is limited, but it suggests outcomes are non-inferior and approach should be chosen by surgeon preference and experience.

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Background

Endometriosis is a chronic inflammatory condition affecting up to 10% of reproductive-aged women [1]. Common presentations include pelvic pain, dysmenorrhea, subfertility, and adnexal masses. Management is complex and multimodal including medical and surgical options. Medical suppression with hormonal agents or gonadotropin-releasing hormone agonists/antagonists is typically considered first-line for appropriate candidates. Surgery is recommended for patients with continued symptoms despite medical treatment, medication contraindication/intolerance, adnexal masses, or infertility. Surgery also confirms diagnosis, although treatment should be initiated based on clinical suspicion and not reliant on pathology-proven disease. Goals of surgical treatment include excision of visible disease and restoration of anatomy.

Laparoscopy has been established as the standard of care for surgical management of endometriosis. Compared to laparotomy, laparoscopy is associated with shorter hospital stays, reduced postoperative pain, improved cosmesis, and decreased perioperative complications. More recently, robotic-assisted laparoscopy and laparoendoscopic single-site surgery (LESS) have expanded the available surgical options while still maintaining the benefits of a minimally invasive approach.

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The da Vinci robotic surgical system (Intuitive Surgical Inc.; Sunnyvale, CA) received US Food and Drug Administration approval for gynecologic use in 2005. Robotic-assisted laparoscopy has many technical advantages including 3D imaging with enhanced depth perception, wristed articulating instruments, decreased tremor, and autonomous surgeon control. Surgeons have also suggested improved surgeon ergonomics and decreased fatigue with a robotic approach.

Endometriosis can be superficial, deep infiltrating, ovarian, or extrapelvic in nature and is often associated with significant adhesions disrupting normal anatomic planes. The varied disease presentation, disruption of anatomic planes, and proximity to other critical organs make resection complex and technically challenging. As such, procedures may benefit from the advantages of a robotic approach.

Robotic Approach for Endometriosis Surgery

Through laparoscopy, a minimally invasive approach has been established as the preferred approach for endometriosis. With the advent of robotic-assisted laparoscopy in gynecology, many have applied this technology to endometriosis procedures. When compared to laparotomy, robotic-assisted laparoscopy shares the benefits of conventional laparoscopy. Laparoscopic views enhanced by zoom and angled camera lenses allow close examination of peritoneal surfaces and improved visualization deep in the pelvis. Similar views are difficult to achieve with laparotomy. Small incisions lead to shorter hospital stays, faster recovery, reduced postoperative pain, and fewer perioperative complications.

While minimally invasive surgery boasts obvious advantages over laparotomy, the choice between robotics and laparoscopy is less clear. However, robotic surgery provides additional gains in advanced technology compared to traditional laparoscopy which should be carefully considered when choosing a surgical approach for managing endometriosis. Robotic instruments have 7 degrees of motion including wrist articulation, increasing surgical dexterity. Binocular optics are utilized to create a three-dimensional view of the operating field with improved depth perception and magnification. Motion scaling diminishes tremor. The surgeon can control two to three instruments in addition to the camera from the robotic console. This autonomous control may be more intuitive for the surgeon and reduces dependence on available skilled surgical assistants. Although data is limited, many surgeons believe robotic-assisted laparoscopy improves operator ergonomics and decreases fatigue when compared to conventional laparoscopy or laparotomy. This is especially advantageous for long, meticulous dissections as is often encountered with advanced endometriosis. These factors enhance visualization of disease and facilitate precise excision of lesions, leading to preservation of healthy tissue and reduced risk of injury to nearby structures. Given the complexity of surgical cases, advanced endometriosis is an excellent indication for robotic surgery.

Despite notable advantages, robotic surgery is not without limitations. A significant disadvantage is the absence of tactile feedback for the console surgeon during robotic procedures. Experienced robotic surgeons can learn to compensate for this limitation with improved appreciation of visible cues. Increased operating room time is another frequently cited disadvantage. Multiple studies in gynecology have shown longer operating room times for robotic cases, most often attributed to time required for docking. Additional delays can occur with room and instrument setup, including sterile draping of the patient cart. Trained staff, dedicated robotic teams, and experienced robotic surgeons can help minimize this time. Another major criticism of robotic technology is the increased financial cost of the system and associated instrumentation. However, instrument cost can be decreased with conservative use of instruments by surgeons.

Studies comparing robotic surgery to laparoscopy for endometriosis are sparse and limited by retrospective, non-randomized design. Existing data reveals robotic surgery is non-inferior for all stages of endometriosis and shows no significant difference in complications, conversion to laparotomy, or blood loss. Conclusions are maintained when stratified for severe disease [2]. To date, only one randomized control trial has examined robotic-assisted versus conventional laparoscopic surgical approach for endometriosis [3]. Similar to other studies, there were no differences observed in perioperative outcomes. Long-term quality of life or pain outcomes have not been consistently reported in comparative trials.

Patient Positioning and Room Setup

Patient Positioning

Patient positioning for robotic-assisted laparoscopy is similar to positioning for conventional laparoscopic gynecologic cases. Positioning follows the same general principles to reduce risk of neuromuscular patient injury and facilitate bedside surgeon access. The patient is placed in dorsal lithotomy with both arms tucked to the sides in a neutral position. Additional measures should be taken to prevent cephalad slide of the patient on the operating table with Trendelenburg position. Progressive slide during the course of the procedure is particularly dangerous with robotic surgery, as the ports and instruments are fixed and will not move with the patient. Various methods have been described including foam pads, gel pads and bean bags for the surface of the table. Many surgeons also employ a chest strap to further secure the patient's position. Placement of foam padding or a head butler protects the patient's face from instruments and robotic arms.

Port Placement

Camera port is placed at the umbilicus. Two or three 8-mm robotic ports are placed lateral to the umbilicus for working instruments. Ports are placed more cephalad and lateral compared to traditional laparoscopy, to accommodate the increased length of the trocar and robotic instrument with respect to the remote center and working distance to target anatomy. Importantly, ports must be placed a minimum of 8–10 cm apart to decrease the risk of extracorporeal arm collisions.

An additional assistant port is typically placed in the left or right upper quadrant. If feasible, it is ideal to place this port on the contralateral side of the planned patient cart location in order to provide the assistant additional working space at the bedside. For right hand dominant assistants, a left upper quadrant assistant port is typically more ergonomic.

A third operating robotic arm may be useful for retraction, particularly for severe disease requiring extensive dissection. This port is often positioned in the left or right upper quadrant (contralateral to the assistant location) while maintaining appropriate distance between ports (Figs. 16.1 and 16.2).

Unique to robotic-assisted laparoscopy, robotic trocars have a remote center demarcated by a thick black line. The remote center should be placed within the abdominal wall and not visible intra-abdominally when positioned correctly.

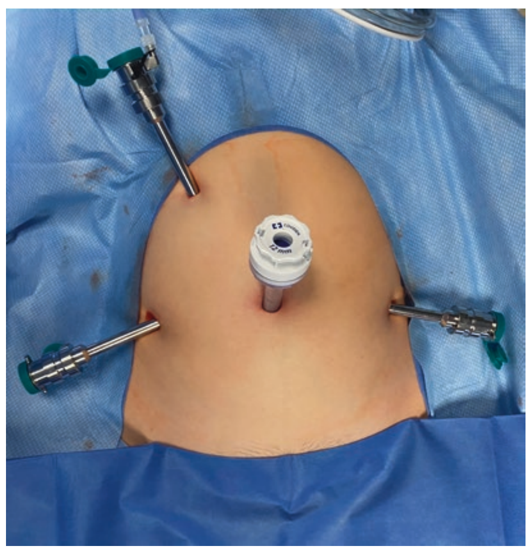

Fig. 16.1 Placement of trocars. Camera port is placed at umbilicus, with two additional robotic trocars. Assistant port is positioned in the right upper quadrant

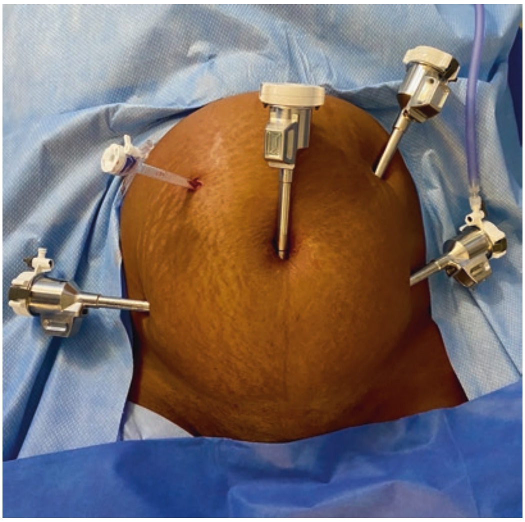

Fig. 16.2 Robotic trocar placement including the third robotic arm. A 5-mm assistant port is positioned in the right upper quadrant

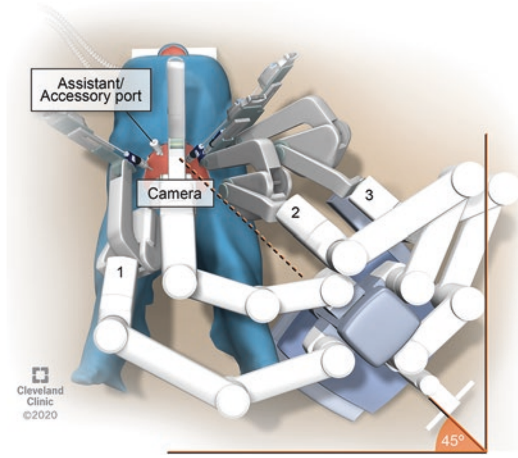

Fig. 16.3 Position of patient cart docked at 45° angle to operating room table. (*Reprinted with permission*, Cleveland Clinic Center for Medical Art & Photography ©2021. *All Rights Reserved*)

Docking and Room Setup

Once the patient is positioned and ports placed, the patient cart is moved into place and robotic arms positioned. Docking configuration is dependent on procedure, room setup, and surgeon preference. Authors typically position the patient cart caudad at approximately a 45° angle to the operating table (Fig. 16.3) near the left or right patient leg. Other variations include parallel docking at 90° to either side of the patient bed or between the patient legs. Placing the patient cart between the patient legs should be avoided as it limits access to the vagina, bladder, and rectum as well as limits uterine manipulation (Fig. 16.4).

After positioning the patient cart, the robotic camera and instruments are introduced. Instruments should include a grasping instrument and an instrument to perform electrosurgery. Authors typically use a fenestrated bipolar forceps and monopolar scissors; however, various instrument options exist. If the third robotic arm is utilized, another grasper is placed for additional tissue manipulation and retraction.

Technique

General Approach

Goals of surgery include diagnosis and description of disease, restoration of anatomy, and excision of visible lesions. Surgery for endometriosis should start with a systematic survey of the abdomen and pelvis. Endometriosis lesions can have various phenotypic appearances including classically described "powder burn" lesions, vesicular papules, and fibrotic plaques, among others (Fig. 16.5). All suspicious lesions should be identified and evaluated in the context of surrounding anatomic structures.

Affected areas are grasped and elevated away from underlying tissue. Lesions are circumscribed and excised using a combination of electrosurgery and sharp and blunt dissection (Figs. 16.6 and 16.7). Additional lysis of adhesions may be required in order to restore normal anatomic planes.

Lesions extending deep into tissue greater than 5 mm are classified as deep infiltrating endometriosis (DIE). Nodules of this type frequently involve the rectovaginal space, uterosacral liga-

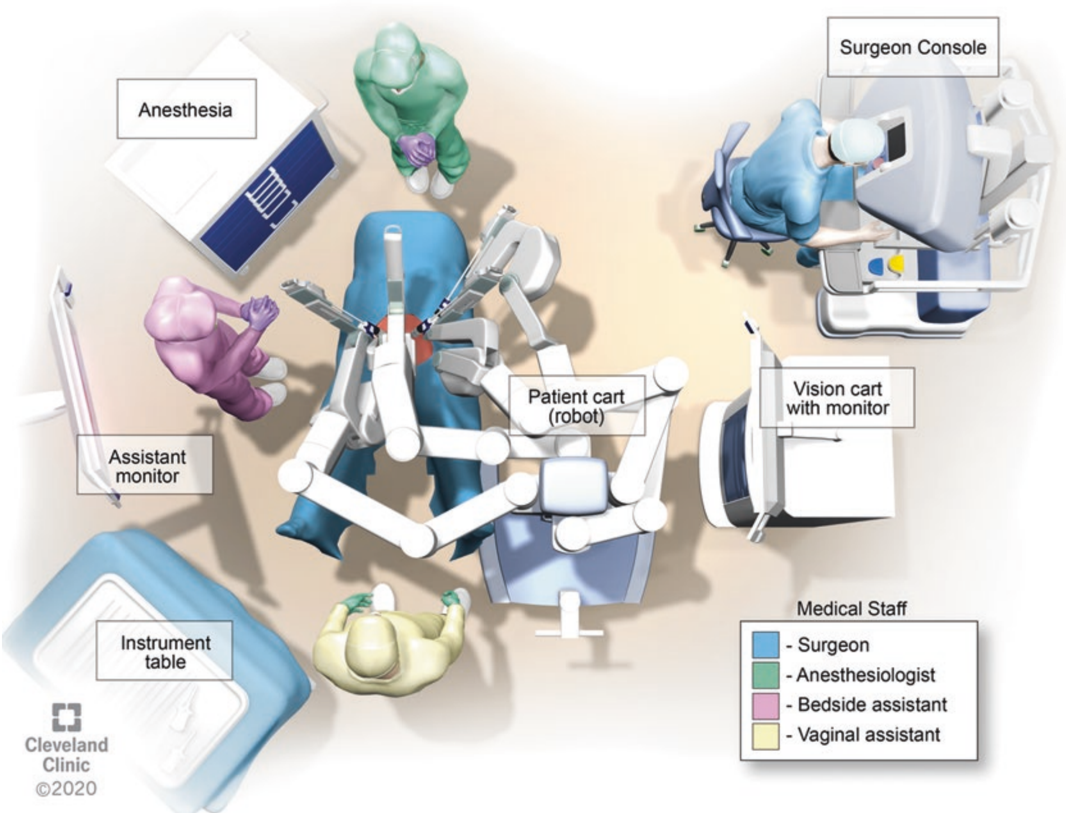

Fig. 16.4 Overview of room setup with patient cart docked. (*Reprinted with permission*, Cleveland Clinic Center for Medical Art & Photography ©2021. *All Rights Reserved*)

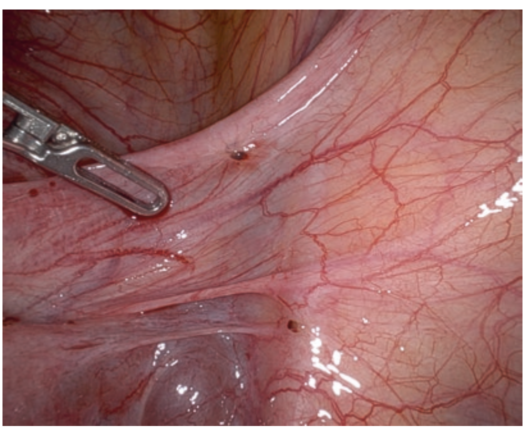

Fig. 16.5 Small endometriotic lesion on right round ligament

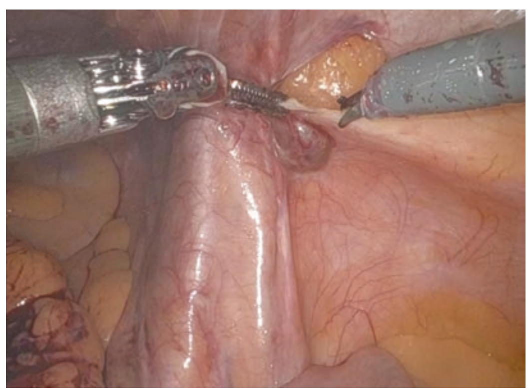

Fig. 16.6 Vesicular lesion is excised

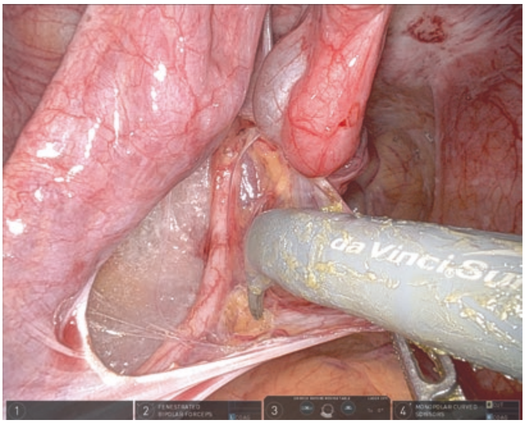

Fig. 16.7 Left ureterolysis prior to excision of affected pelvic peritoneum

ments, bowel, bladder, and/or ureters [2, 4]. While the general approach to DIE follows the same basic principles, resection is more technically challenging due to increased size and depth of nodules as well as proximity or invasion into pelvic structures. For disease involving nongynecologic organ systems, a multidisciplinary approach is advised.

When appropriate, ovaries should be mobilized to an anatomic position. Following adhesiolysis, ovaries may be elevated by an assistant, suture suspension, or third arm. The use of a tissue retraction device or suture fixation to temporarily suspend ovaries from the anterior abdominal wall can free an additional instrument for dissection while optimizing exposure to posterior structures, ovarian fossa, and retroperitoneum (Fig. 16.8).

Endometriomas

Endometriomas are ovarian cysts containing endometriosis (Fig. 16.9). Transvaginal ultrasound has a high sensitivity for endometriomas, with cysts demonstrating a classic ground-glass appearance. When approaching endometriomas, drainage alone is associated with high recurrence risk and thus is not recommended [5]. While complete excision of the cyst wall reduces recurrence risk, it can also result in additional trauma to ovarian stroma. Implications for ovarian

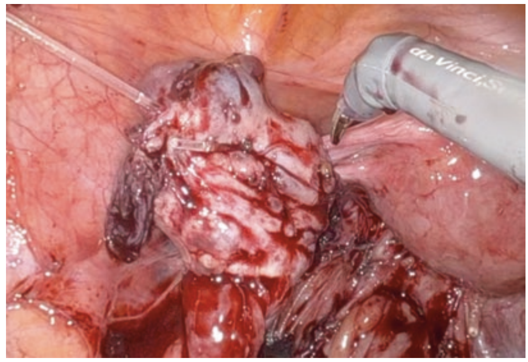

Fig. 16.8 Left ovary is suspended from anterior abdominal wall

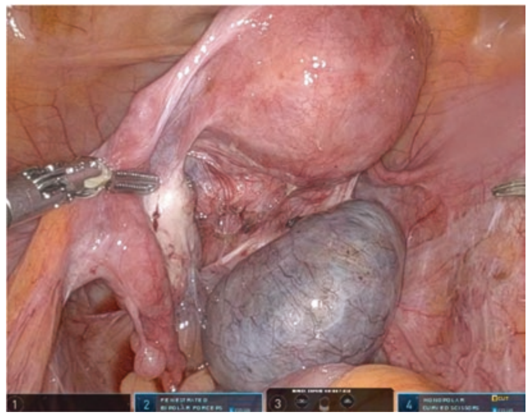

Fig. 16.9 Advanced endometriosis with large right endometrioma, prior to drainage and excision

reserve should be balanced with pain management when choosing technique for patients with desired fertility.

Cystectomy is most efficient with the use of three grasping instruments. One instrument helps stabilize the ovary, allowing for two opposing hands. Ovary is carefully assessed with identification of cyst. A superficial incision is made into the ovarian cortex overlying the cyst, away from the mesenteric surface. Cyst is grasped and a cleavage plane identified. Cysts often rupture with manipulation or can be intentionally drained to facilitate improved visualization and ease of dissection. The cyst wall is separated from the ovarian stroma with opposing traction (Figs. 16.10 and 16.11).

Fig. 16.10 Incision made overlying large endometrioma

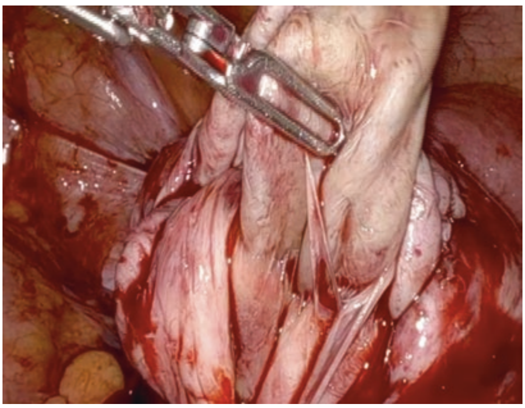

Fig. 16.11 Endometrioma cyst wall is excised with use of opposing graspers

Hemostasis may be obtained with electrosurgery, laser vaporization, or suture of the ovarian cortex. Limited tissue manipulation and energy use may reduce trauma to normal ovarian parenchyma, resulting in better outcomes regarding continued ovarian function and fertility [6].

Bowel Endometriosis

Endometriosis affecting the bowel is a challenging subtype of endometriosis. The estimated incidence of bowel involvement varies widely from approximately 4% to 37% of all women with endometriosis [7–9]. In those affected, the rectosigmoid is the most common location. Following the general principles guiding endometriosis excision, the goal of surgical management is to remove all visible disease while preserving as much healthy tissue as possible. Based on the size, depth, and location of lesions, resection of bowel endometriosis can be accomplished through three recognized techniques: shaving, disc excision, or segmental resection.

Each technique is approached similarly. Dissection typically begins retroperitoneal with identification of the ureter. Pararectal space is then identified and opened with delicate adhesiolysis to isolate the portion of bowel affected by endometriosis. An end-to-end anastomotic (EEA) sizer in the rectum can help delineate bowel margins, particularly in obese patients or those with significant adhesive disease distorting normal anatomy. Depending on the location of the lesion, it is often helpful to develop the rectovaginal plane. Surgical assistant can place a sponge-stick vaginally with gentle anterior pressure in the posterior cul-de-sac while simultaneously pushing the rectal EEA sizer posteriorly, to help accentuate the rectovaginal septum.

Shaving is the most conservative method of excision. The bowel mucosa and at least partial muscularis thickness are kept intact. Lesion is grasped, elevated, and “shaved” off underlying bowel in layers with sharp scissors and sparse monopolar electrosurgery. Following excision, the overlying serosal and/or muscularis defect is reinforced with suture.

For larger or deeper lesions that encompass less than 60% of the bowel circumference, a discoid excision is preferred. The endometriosis nodule is similarly grasped, elevated, and excised including a full-thickness portion of bowel wall. The resulting defect requires closure. This can be accomplished with a two-layer suture repair or stapler, depending on surgeon preference.

Segmental resection is typically required for multifocal lesions, a single nodule greater than 3 cm, or a single nodule encompassing greater than 60% of the bowel circumference [7, 8]. Segmental resection requires an advanced understanding of relevant anatomy and surgical expertise. A multidisciplinary surgical team is strongly recommended. The involved bowel segment is isolated and mobilized. A linear stapler is introduced and utilized to divide the bowel proximal and distal to the nodule, excising the intervening bowel segment. Primary reanastomosis can be performed in a side-to-side or end-to-end technique. A diverting ostomy may be indicated to facilitate tension-free healing and reduce the risk of postoperative anastomotic leak. Following each excisional technique, bowel integrity should be assessed to confirm an airtight repair.

Extrapelvic Disease

Pelvic lesions are the most common presentation of endometriosis. Other sites such as the abdominal wall, diaphragm, and small bowel are less frequently seen. Although extremely rare, disease has also been reported in various other distant anatomic locations including kidneys, liver, pancreas, gallbladder, peripheral nerves, thoracic, and central nervous system [10]. A multidisciplinary team involving both gynecology and other relevant specialists is recommended for surgical treatment of extrapelvic endometriosis. Due to limited range of motion at docked ports, work in the upper abdomen will require re-docking instrument arms and possible reposition of the patient cart if a robotic approach is continued after pelvic dissection. Additional ports may also be necessary to create appropriate triangulation and visualization of extrapelvic target anatomy.

Specimen Extraction

While rare, abdominal wall endometriosis at prior trocar sites is well described in the literature [11]. Small lesions can be removed directly through robotic trocars or the assistant port. However, due to risk of implantation at extraction sites, a specimen retrieval bag is recommended for removal of larger lesions.

Postoperative Care

Similar to laparoscopic excision of endometriosis, the majority of patients undergoing robotic-assisted excision of endometriosis can be discharged home the day of surgery.

Oral acetaminophen and ibuprofen are the mainstays of postoperative pain management. Additional opioid medications for breakthrough pain may also be provided. Patients are typically seen for a postoperative follow-up visit within 4 weeks.

While surgical management often improves quality of life for women with endometriosis, endometriotic lesions and associated symptoms frequently recur. Women with no contraindications who do not desire immediate fertility may benefit from medical suppression [1]. Successful long-term management of chronic pelvic pain including endometriosis includes a multidisciplinary approach.

Summary

Robotic-assisted laparoscopy is a safe and effective approach to surgical excision of endometriosis. Although limited, existing data demonstrates that robotic surgery is non-inferior to conventional laparoscopy. The advantages of the robotic platform include improved optics, instrument dexterity, and surgical precision. Therefore, resection of endometriosis, particularly for women with advanced disease, is a procedure well-suited to employ robotic technology.

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17 Techniques for Robotic Urogynecology and Pelvic Reconstructive Surgery

Heather M. Winn, Megan E. Tarr, and Marie Fidela Paraiso

Laparoscopic urethropexy was introduced in the early 1990s, and the first robot-assisted sacral colpopexy was reported in 2004 [1]. Over the past 15–20 years, laparoscopic and robot-assisted laparoscopic techniques have been applied to many prolapse and incontinence procedures. After the United States Food and Drug Administration approved its use in gynecologic surgery in 2005, the da Vinci Surgical System (Intuitive Surgical, Inc.; Sunnyvale, CA) gave gynecologic surgeons another minimally invasive option for surgeries that had been previously performed by laparotomy, vaginally, or by the traditional laparoscopic technique.

In the field of female pelvic reconstructive surgery, robotic-assisted laparoscopy is most widely used for sacrocolpopexy. Retrospective cohort studies show that robotic-assisted sacrocolpopexy is associated with less intraoperative blood loss, earlier hospital discharge, and better short-term anatomic outcomes when compared with open sacrocolpopexy [2, 3]. Additionally, robotic-assisted laparoscopy may enable surgeons who have not been extensively trained or are not appropriately skilled in traditional laparoscopic techniques to perform complex abdominal surgery by minimally invasive access, as there is some evidence that the learning curve may be shorter [4–6]. Finally, although this has not been widely studied in live surgery, robotic-assisted laparoscopy may offer ergonomic advantages over traditional laparoscopy [7–10].

There are many advantages of robotic sacrocolpopexy when compared with open sacrocolpopexy; however, there are several potential barriers to adopting robotic-assisted laparoscopic technology. Surgeons, surgical assistants, and operating room teams must be comprehensively trained, and patient-centered outcomes of surgical cases should be tracked. Surgeons must be wary of extending patient anesthesia time, especially during the early robotic learning curve. Published surgical proficiency in robotic sacrocolpopexy, as determined by a risk-adjusted cumulative summation (CUSUM) analysis for intraoperative or postoperative complication rates, has been shown to be achieved after approximately 84 cases [11]. In this study by Linder et al., operative time plateaued after the first 60 cases [11]. Other published studies cite that the surgeon's learning curve is approximately 20 [12], 50 [13], or a range of 30–60 procedures [14], depending upon the parameters measured. Finally, instrumentation cost and robotic maintenance fees must be considered in

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the adoption and maintenance of robotic technology at a particular institution.

Robotic technology has expanded the use of minimally invasive prolapse techniques, most especially in sacrocolpopexy. As robotic techniques for female pelvic floor disorders are taught and refined, we must continue to be cognizant of other minimally invasive surgery options, patient and societal costs, and most importantly, patient safety and satisfaction.

Perioperative Considerations

Similar criteria are used to select patients for both laparoscopic and robotic-assisted laparoscopic pelvic reconstructive procedures. Patients should be able to tolerate pneumoperitoneum and the steep Trendelenburg position needed to facilitate cephalad bowel retraction for optimal visualization of pelvic anatomy. Consequently, patients with certain cardiopulmonary conditions may not be optimal candidates for robotic or laparoscopic pelvic floor procedures. In addition, unlike traditional laparoscopic procedures, the use of the surgical robot prohibits use of operative table movement during cases. Consequently, patients are usually placed in the maximally required Trendelenburg position (often 30° from horizontal) and are maintained in this position for the duration of the robotic portion of the case. This position can cause difficulty in ventilating the patient and can contribute to intraoperative hemodynamic changes [15]. Prolonged Trendelenburg position increases chest wall resistance and dead space with a consequent decrease in the alveolar-arterial diffusion of oxygen. Pulmonary compliance and functional residual capacity are reduced; these effects are often more pronounced in obese patients [16–19].

The surgeon also needs to carefully consider the effects of intra-abdominal CO_2 insufflation and its hemodynamic and metabolic effects in patients with chronic obstructive pulmonary, cardiovascular, and chronic renal disease [17, 18, 20, 21]. Be aware of patients with contraindications to increases in intracranial pressure and patients who are potentially hypovolemic preoperatively; a laparoscopic or robotic procedure may be contraindicated in these patients. These concerns are particularly amplified in prolonged minimally invasive cases [22, 23]. Patients with such underlying cardiopulmonary conditions should be preoperatively counseled as to the need for a possible conversion to an open procedure if indicated by intraoperative physiologic parameters.

During the learning curve [11–13] robotic sacrocolpopexy and concomitant procedures frequently take over 3 h to perform; therefore, a patient may be exposed to prolonged general anesthesia and increased risks for thromboembolism, hypothermia, and nerve injury. Because prolongation of surgery is known to be associated with certain degrees of morbidity, a robotic surgeon should be mindful of surgical case progression. We often use time goals whereby a trainee is given a set amount of time to perform a portion of the surgery while at the surgeon console. If the time goal is met, they continue to sit at the console. If not, the attending surgeon assumes the role of the console surgeon. This technique is useful when teaching resident and fellow surgeons portions of a complex surgery.

Operating Room Setup and Patient Positioning

We typically use either the da Vinci Si or Xi Surgical System (Intuitive Surgical, Inc.; Sunnyvale, CA). The Dual Console system is helpful when teaching a resident or fellow surgeon as long as an experienced bedside assistant is present. Our surgical team is typically composed of the robotic surgeon(s) at the surgeon console, a bedside assistant standing on the patient's right near the assistant port, a vaginal assistant who operates the vaginal and rectal sizers, a scrubbed surgical nurse or technician, and a circulating nurse. There is evidence of a learning curve for a robotic team, and familiarity with the robotic technology greatly facilitates surgical case efficiency [14].

Figure 17.1 demonstrates the robotic room setup for sacrocolpopexy and reconstructive pelvic surgery. There is typically one table for

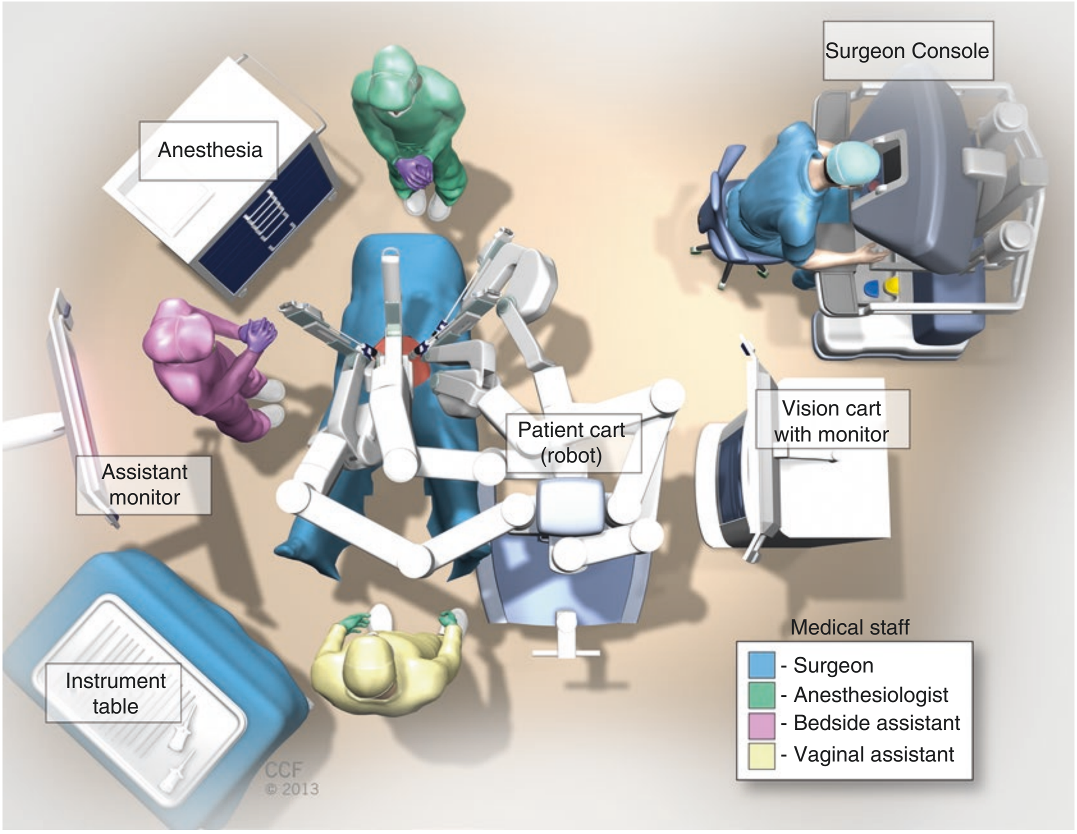

Fig. 17.1 Robotic room setup for sacrocolpopexy and reconstructive pelvic surgery

laparoscopic and robotic abdominal instruments, one table for vaginal instruments and cystoscopy equipment, and a large Mayo stand upon which the robotic endoscopic camera sits (after it has been removed from the warmer) until it is placed into the peritoneal cavity. The Vision cart is usually on the left side of the operating table so that the bedside assistant on the patient's right can have an optimal viewing angle.

Patient positioning for robotic sacrocolpopexy is similar to that for laparoscopic sacrocolpopexy (*see* Chap. 8) in that the patient is placed on an anti-slip pad, foam egg crate pad, or bean bag. After induction of anesthesia and placement of an orogastric tube for stomach decompression, the patient is moved down the operating room table and placed in the dorsal lithotomy position with the buttocks slightly beyond the end of the table to facilitate movement of the vaginal and rectal sizers. The arms are tucked in by the patient's sides, and the hands and all bony prominences are padded for neural safety. We also typically place a padded chest strap at the nipple line to further secure the torso. If following an Enhanced Recovery After Surgery (ERAS) protocol, strict adherence during this phase of the procedure is critical [24]. An active warming device is placed directly overlying the safety strap. After the patient is prepped and draped, a two-way or three-way Foley catheter is placed. We routinely recheck for optimal positioning of the patient during the case.

After intraperitoneal access has been gained, the bed is placed in the maximal Trendelenburg position, and the 8-mm robotic ports and laparoscopic assistant ports are placed (see section below). Once this has been safely accomplished, the bedside assistant temporarily stands on the patient's left and supervises the parallel docking of the robot on the patient's left side.

Prolapse Procedures

Sacrocolpopexy

Robotic sacrocolpopexy is performed using a technique similar to the laparoscopic sacrocolpopexy (*see* Chap. 8). The da Vinci Surgical System is currently the only widely used robotic surgical system in the United States, and the four-armed da Vinci Si or da Vinci Xi systems are currently the most commonly used. The robotic approach to sacrocolpopexy differs from the laparoscopic approach on a few parameters: trocar locations, docking the robotic patient cart, and use of intracorporeal knot tying, although this is also an option for the standard laparoscopic technique.

Figure 17.2b demonstrates robotic trocar placement compared with laparoscopic (Fig. 17.2a) trocar placement. Although there are a few ways in which the robotic and laparoscopic trocars can be positioned, we advocate using five trocars placed in a shallow "W" formation: two of the 8-mm robotic ports are placed bilaterally, 9 cm lateral and inferior from the umbilicus, and the third robotic trocar is placed in the left upper quadrant, 9 cm lateral to the more medial left-sided port. When using the Xi system, one can utilize a sunburst formation for the trocar placement. An 8-mm trocar, when utilizing the da Vinci Xi system, or a 12-mm umbilical trocar when utilizing the Si system, is used for the robotic laparoscope, and a 10- or 8-mm assistant trocar is placed 9 cm lateral or medial to the right-sided robotic trocar. The 8-mm assistant trocar allows for the introduction and removal of suture with the variety of needle types we use during the procedure (SH, GS-21, V-20, TH-26, and CT-2) and does not require fascial closure, minimizing the risk of postoperative pain. The robotic trocars are placed approximately 9–10 cm apart to minimize the risk of robotic arm collision. If a patient has a short torso, a shallow "Z" configuration with the right robot port in the upper quadrant and the right lower quadrant accessory port three finger breaths cephalad and medial to the right anterosuperior iliac spine will decrease arm collision.

The robotic patient cart is then docked with the operating table in a 30-degree Trendelenburg position (Fig. 17.3). After the robotic trocars are safely placed and the patient is placed in the maximal Trendelenburg position (about 30°), the robotic patient cart is docked under the instruction of the bedside surgeon.

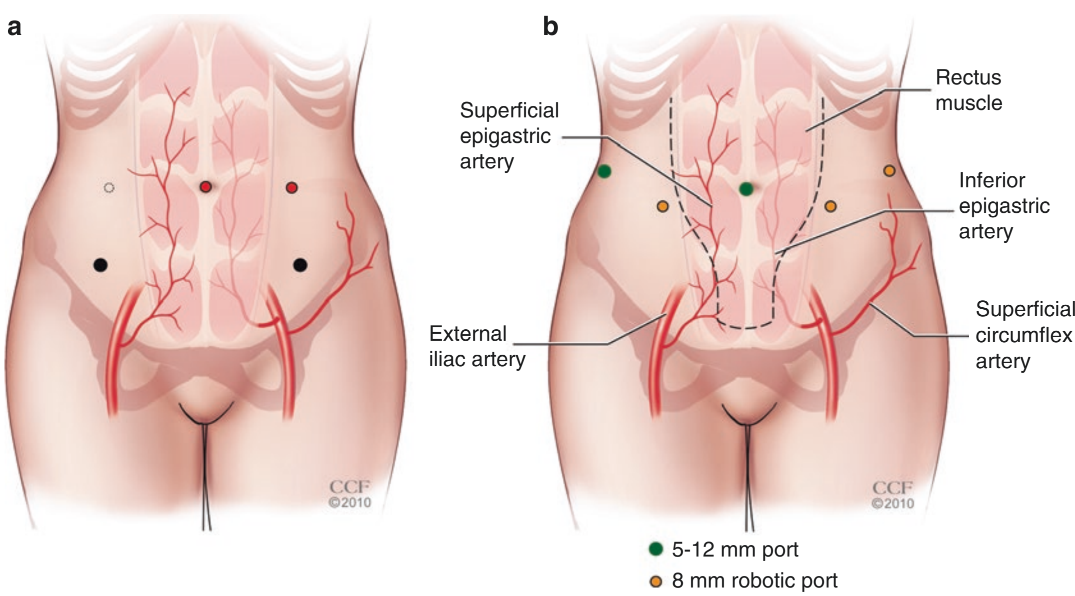

Fig. 17.2 (**a**) Laparoscopic trocar placement compared with (**b**) robotic trocar placement

Although many methods of robotic patient cart docking have been described, we feel that docking the Si patient cart at a 30–45-degree angle to the operative bed on the patient's left side allows easy access for vaginal manipulation during vaginal and rectal dissections in sacrocolpopexy and results in minimal issues with robotic arm collision (Fig. 17.4). Conversely, the Xi patient cart is docked in a perpendicular manner on the patient's left side. In our practice, we routinely have the bedside assistant on the contralateral side of the robotic system with the robotic system on the left and assistant positioned on the right. If the surgeon choses right-sided docking, the assistant would likely be most comfortable on the left side.

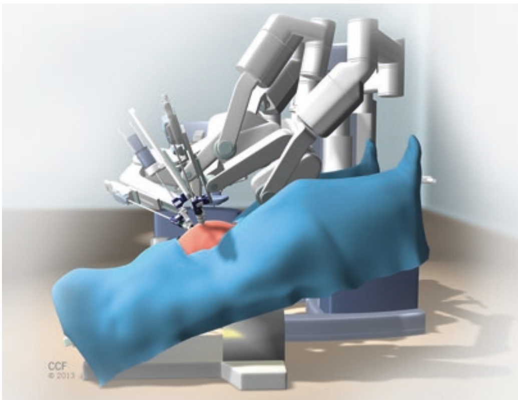

Fig. 17.3 Robotic patient cart docked with operating table in 30° Trendelenburg position

We then place the appropriately calibrated robotic endoscope into the camera trocar. After first affixing the camera arm, the other robotic arms are connected to the robotic trocars with care taken to position them to minimize the risk of collisions (Fig. 17.5). If using the Xi system, the "targeting" feature is employed to maximize arm and instrument spacing. When using the Si

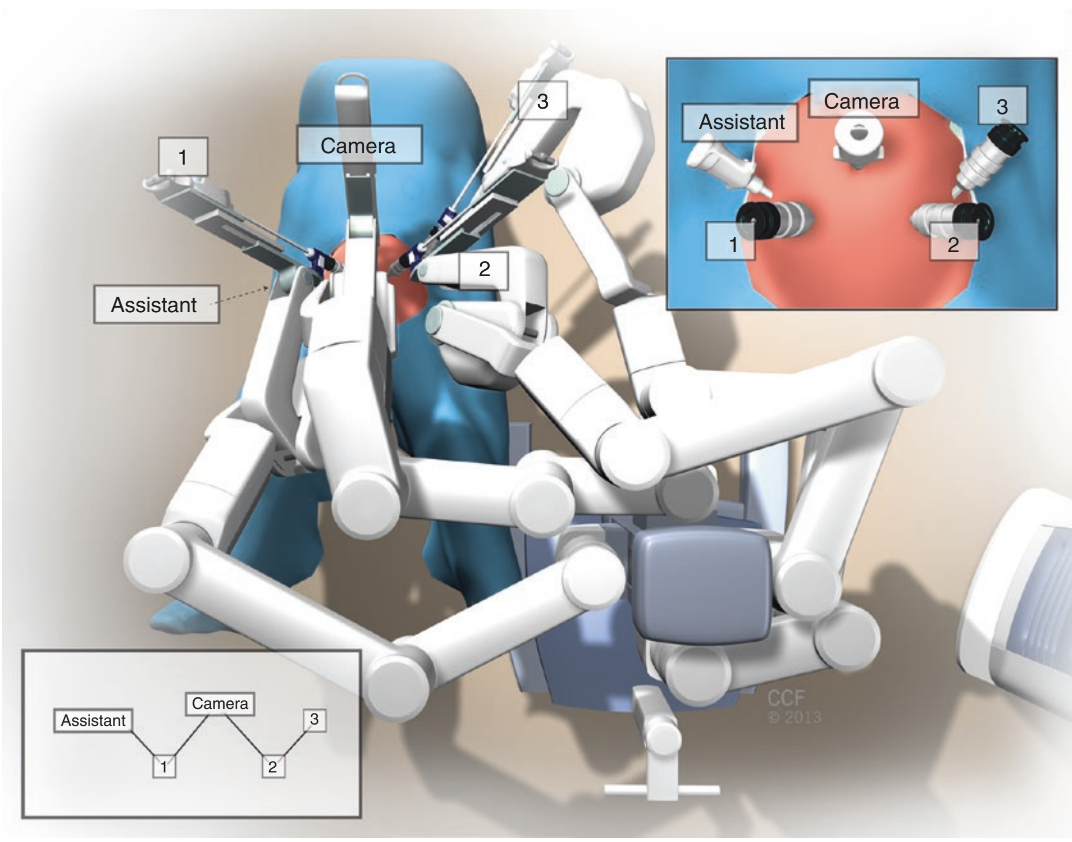

Fig. 17.4 Parallel docking of robotic patient cart

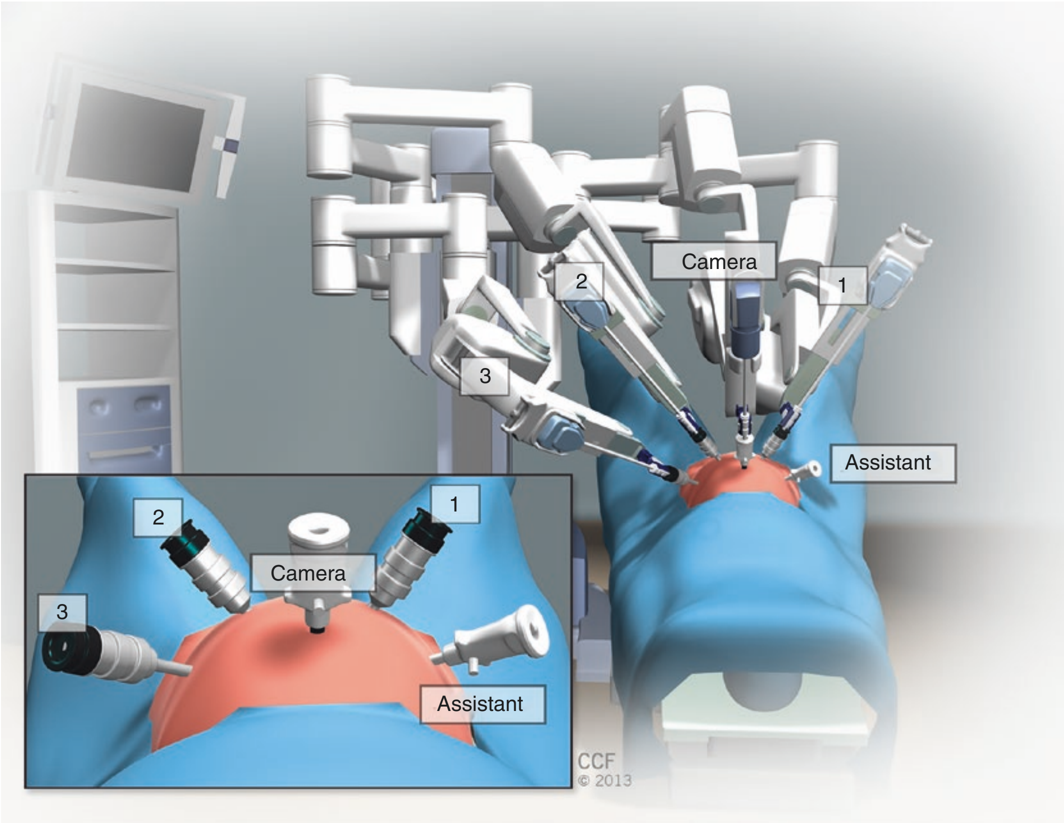

Fig. 17.5 Robotic arms connected to the robotic trocars

system, a 30-degree angle between the instruments' arms and the camera is good, but a 45-degree angle is usually better. Positioning the most lateral left arm at the most left lateral trocar is usually done last because of the need for its almost horizontal docking and, often, its inferior angle to the patient.

We typically use a 30-degree robotic endoscope upon entry. When performing the vesicovaginal and rectovaginal dissection, a 30-degree upward-facing endoscope can aid in the rectovaginal, perineal, and bilateral levator ani dissections and posterior and perineal suture placement. Additionally, a 30-degree upward endoscope scope facilitates vesicovaginal dissection when the bladder wraps around the vaginal apex and extends to the cul-de-sac. A 30-degree downward-facing endoscope can be particularly helpful for the presacral dissection and anterior vaginal suture placement. On the Xi system, camera orientation can be easily changed by the surgeon on the operative console without removing the camera.

For both the Si and Xi systems, we typically place the robotic monopolar scissors on the right most lateral arm, a bipolar instrument (either PK Dissecting Forceps [Gyrus Medical; Maple Grove, MN] or other fenestrated bipolar forceps) in the left medial arm, and a ProGrasp (Intuitive Surgical, Inc.; Sunnyvale, CA) in the left most lateral arm for the initial dissection. Once the initial dissection for the sacrocolpopexy is done (as discussed in Chap. 8), we typically use a SutureCut needle driver (Intuitive Surgical, Inc.; Sunnyvale, CA) in the right lateral arm, a needle driver in the medial left arm, and a ProGrasp in the left lateral arm to suture robotically. Large suture cut needle drivers facilitate intracorporeal knot tying compared to the "mega" needle driver, but the use of needle drivers is based on surgeon

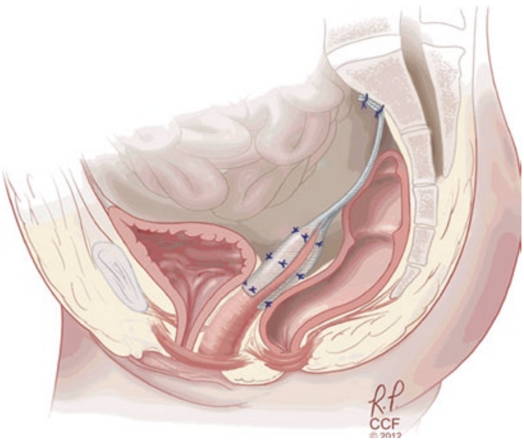

Fig. 17.6 Suture and polypropylene graft placement for sacrocolpopexy

preference. Suture choice is surgeon dependent. A recent prospective randomized control trial by Matthews et al. which compared 2-0 polytetrafluoroethylene (permanent group) to 2-0 polydiozanone (delayed absorbable group) demonstrated suture type for vaginal graft attachment did not influence mesh or suture exposure rates at 12 months follow-up [25]. All knot tying in robotic sacrocolpopexy is performed using an intracorporeal technique. Some centers are exploring the use of absorbable barbed suture as an alternative [26, 27]. More evidence is needed to support one method of graft attachment to the vagina over another. Suture and polypropylene graft placement do not differ between laparoscopic and robotic sacrocolpopexy (Fig. 17.6).

There are a few points of caution for robotic-assisted laparoscopic sacrocolpopexy. The lack of haptic feedback is important to acknowledge when distinguishing robotic from laparoscopic sacrocolpopexy. Consequently, the console surgeon must pay close attention to visual cues when placing tension on tissues or sutures and judging the depth of suture placement. This is particularly important when determining where the sacral promontory is located for the presacral dissection. After identifying the right ureter, aortic bifurcation at the L4–L5 level, common iliac vessels, and retracting the sigmoid laterally, we typically have the bedside assistant palpate the promontory laparoscopically. Caution is also taken when placing sutures in the anterior longitudinal ligament at the level of S1; care must be taken not to penetrate the vertebral periosteum or intravertebral disk with deep suture placement. Finally, we also try to minimize robotic manipulation of the sigmoid and epiploica with the ProGrasp in the left lateral arm by initially retracting the bowel cephalad and laterally with a bowel grasper in the right upper quadrant assistant port. We then use the ProGrasp, with its closed or slightly open tips angled toward the sacrum, to maintain gentle, lateral traction on the sigmoid. Alternatively, suture can also be passed through several sigmoid epiploica and brought through the left lower quadrant lateral to the left upper and lower quadrant port sites with a Carter-Thomason suture carrier (Cooper Surgical; Trumbull, CT). Both suture ends are secured with minimal tension at the skin surface with a hemostat clamp, retracting the sigmoid laterally. Alternatively, the T'LIFT surgical retractor (Peters Surgical, Bobigny, France) can be used in a similar fashion to optimize visualization during this step.

Other points of caution for robotic sacrocolpopexy include the following: (1) If using the Si system, once the robotic system is docked, the patient bed position cannot be changed without first removing instruments and undocking the robotic arms. The Xi system does have the capability to connect to a specialized bed (Trumpf Model 7000dv) to utilize Integrated Table Motion, allowing instruments and robotic arms to stay docked while repositioning the patient. (2) The tip of the robotic endoscopic camera becomes very hot and must be cleaned outside of the peritoneal cavity. (3) The abilities to clutch, exchange instruments, focus the camera, and use monopolar and bipolar energy modalities differ between the different generations of da Vinci Robotic Surgical Systems. Consequently, a surgeon should be comfortable with the features of the particular robotic system prior to its use.

Robotic Sacrocolpopexy Outcomes and Complications

Historically, abdominal sacrocolpopexy, considered the gold standard, was compared with vaginal native tissue apical suspension procedures. It was well established in the Cochrane review of surgical management of pelvic organ prolapse by Maher and coworkers [25] that abdominal sacrocolpopexy had lower rates of recurrent vaginal apex prolapse (3.5% vs. 15%; RR 0.23, 95% CI 0.07–0.77), a reduced grade of residual prolapse (5.7% vs. 20%; RR, 95% CI 0.09–0.97), and less dyspareunia (16% vs. 36%; RR 0.39, 95% CI 0.18–0.86) when compared with vaginal sacrospinous colpopexy. Abdominal sacrocolpopexy, however, was associated with a longer operative time (mean difference [MD] 21 min, 95% CI 12–30) and longer time to recovery (MD 8.3 days; 95% CI 3.9–12.7) and was more expensive (weighted MD USD $1334; 95% CI $1027–$1641) than the non–mesh-augmented vaginal approach. Well- designed randomized trials included in the meta-analysis by Paraiso and colleagues [28], Freeman and colleagues [29], and Maher and associates [30] compared laparoscopic sacrocolpopexy with either robotic [31], open [29], or total vaginal mesh [30].

Despite the marked increase in the minimally invasive approach, only a few well-designed comparative studies for robotic sacrocolpopexy exist, and many have varying objective and subjective outcomes. One single-center, blinded, randomized trial from our institution randomized women with posthysterectomy stages 2–4 vaginal apex prolapse to either laparoscopic or robotic sacrocolpopexy groups [28]. The primary outcome was total operative time from incision to closure, but secondary outcomes included postoperative pain, functional activity, bowel and bladder symptoms, quality of life, anatomic vaginal support, and cost from a healthcare perspective. Total operative time was significantly longer in the robotic group (227 ± 47 vs. 162 ± 47 min, $p < 0.001$), with docking only accounting for an average additional 14 min. In addition, sacrocolpopexy suture tying was longer for the robotic group (98 ± 22 vs. 68 ± 16 min, $p < 0.001$). There were no significant differences in intraoperative and perioperative complications between robotic and laparoscopic sacral colpopexy [28]. The most frequent complication was in the area of urinary tract infections, of which there were three in the laparoscopic and five in the robotic groups (9% vs. 14%, respectively, $p = 0.71$). There were two cystotomies recognized intraoperatively in both groups and one enterotomy in the robotic group. The robotic group had two patients with a mesh erosion (6% vs. 0%, $p = 0.49$) and three with abdominal wall pain necessitating trigger point injections (9% vs. 0%, $p = 0.24$) [28]. Although pain scores were not significantly different on postoperative day 1, the robotic group reported more pain at rest and with normal activities at several points during the 6-week postoperative period. At 6 and 12 months follow-up, anatomic and quality of life outcomes did not differ between the two groups. We believe that increased pain in the robotic group was caused by muscular pain associated with manipulation and fascial closure of the right paracolic gutter accessory port. Hence, one should decrease port size from 10 or 12 mm to 8 mm as previously described due to lower risk of muscular pain and nerve entrapment. Additionally, for adjuvant pain reduction, we perform a laparoscopic guided transverses abdominis plane (TAP) block with liposomal bupivacaine at the beginning of the procedure. The injection is a mixture of 20 cc of 1.3% liposomal bupivacaine, 30 cc of 0.25% bupivacaine, and 50 cc of injectable saline. Emerging evidence supporting the use of this liposomal formulation has been shown to be effective in reducing postoperative opioid consumption and pain scores [32, 33]. Finally, Paraiso and colleagues' findings are further supported by recent work from Illiano et al. in a 2019 prospective randomized trial of 100 patients which found robotic-assisted sacrocolpopexy took significant more time than the laparoscopic approach. The authors also found no difference between groups with regard to intraoperative and postoperative complications [34].

The majority of other studies comparing robotic and laparoscopic sacrocolpopexy with open sacrocolpopexy are retrospective cohorts from either one or two institutions, and the length of follow-up included in these studies ranged from 3 to 44 months. Overall, these studies show that both anatomic and subjective cure rates are comparable between robotic and laparoscopic sacrocolpopexy. Similar to the randomized trial by Paraiso et al. [28], Antosh's retrospective cohort trial comparing robotic and laparoscopic sacrocolpopexy did not show a significant difference in perioperative and postoperative complications [35]. There was no difference in the respective number of cystotomies (three vs. one, $p = 1.0$) or blood transfusions (one vs. two, $p = 0.17$) in either group. There were no conversions to laparotomy in either group. There were also no significant differences in urinary tract infection (nine vs. six cases, $p = 0.20$), fever (one case in both groups, $p = 0.46$), wound infection/abscess (two vs. one case, $p = 1.0$), or mesh erosion (two vs. 0 cases, $p = 1.0$).

A randomized control trial by Anger and colleagues also compared laparoscopic versus robotic approaches. They randomized 78 women, $n = 38$ to laparoscopic procedure and n = 40 to robotic procedure. They concluded the average initial hospital costs were higher for robotics ($19,616 compared with $11,573, $p < 0.001$. After controlling for robot purchase and maintenance fees, the costs were similar (12,586 v. 11,573 $p = 0.160$) suggesting that the primary cost difference was attributable to robotic maintenance and purchase costs. Building on existing data, also concluded longer operative times in the robotic group (202.8 mins v. 178.4 mins, $p = 0.030$). They found no differences in surgical outcomes, rates of adverse events, or patient bother questionnaire data [36].

A 2016 systematic review and meta-analysis which includes the abovementioned studies compared laparoscopic and robotic sacrocolpopexy. The authors confirmed longer robotic operating times (245.9 vs. 205 mins, $p < 0.0001$), with similar estimated blood loss (114.4 mL vs. 160.1 mL) and intraoperative/postoperative complications ($p = 0.84$ vs. $p = 0.92$). Additionally, the three studies which compared the cost of each modality found the robotic approach were significantly higher ($p < 0.001$) [37].

As techniques and products continue to advance, the complications and mesh erosion rates are much lower than originally reported. In 2020, Culligan et al. published a 5-year prospective analysis of 253 consecutive patients who underwent robotic sacrocolpopexy using lightweight Type 1 Y-mesh affixed to the vagina with interrupted polytetrafluoroethylene sutures (CV4 Gore-Tex suture on TH-26 Needles; Gore Medical Products Division, Flagstaff, AZ, USA). They reported an 89.3% surgical success rate with no apical failures, no reported mesh exposures, and reduced operative times (146.54 ± 25 mins) [38].

Sacral Colpoperineopexy

Although we perform traditional laparoscopic sacral colpoperineopexy, we believe that the use of the robotic system may be particularly helpful for dissecting and suturing the most distal aspects of the vagina, perineum, and levator fascia and muscles, particularly when performing this procedure. A 30-degree upward-facing robotic endoscope is particularly helpful when performing this dissection. We typically place the robotic monopolar scissors in right lateral arm, a bipolar instrument (either PK Dissecting Forceps or bipolar forceps) in the left medial arm, and a ProGrasp in the left lateral arm for the initial dissection.

The anatomic landmarks for laparoscopic or robotic rectocele repair, ventral rectopexy, and sacrocolpopexy/colpoperineopexy include the rectovaginal septum, made up of Denonvilliers' fascia and its lateral attachment to the medial aspect of the levator ani muscles. The terms *rectovaginal fascia*, *rectovaginal septum*, and *Denonvilliers' fascia* are synonymous. The posterior dissection for sacral colpoperineopexy is started by opening the rectovaginal septum using a monopolar scissor or harmonic scalpel, facilitated using both vaginally and rectally placed end-to-end anastomosis (EEA) sizers, Breisky-Navratil retractor, or another vaginal manipulator. Blunt dissection, with the aid of hydrodissection or sharp dissection, may be used to open the rectovaginal space down to the perineal body and the levator ani. This should be relatively bloodless if performed correctly along anatomic planes. The rectovaginal septum is the posterior point of attachment of the sacrocolpopexy mesh. In contrast, a posterior T-shaped mesh is attached to the perineum and bilaterally to the levator ani fascia and muscles during sacral colpoperineopexy. Most surgeons prefer rectocele repair by the vaginal route for patients with distal stool trapping. One option is to utilize the sacral colpoperineopexy with attachment of a posterior mesh to the perineum and medial aspect of the pubococcygeus and iliococcygeus fascia and muscles for patients who have perineal descent with outlet dysfunction constipation or for patients who undergo concomitant ventral rectopexy (Fig. 17.7). One may place absorbable plicating stitches into the rectovaginal muscularis in order to repair the rectovaginal defect causing the rectocele.

Some surgeons skilled in minimally invasive sacrocolpopexy, however, routinely perform sacral colpoperineopexy for patients with a rectocele and perineal descent. The original approach for this surgery was a combined vaginal and open abdominal approach, described by Cundiff and coworkers in 1997 [39]. The posterior vaginal mesh was placed in the rectovaginal septum, anchored to the perineal body vaginally, passed through a colpotomy incision, and then affixed to the posterior vagina and anterior longitudinal ligament abdominally. This technique has been used laparoscopically [40]. A retrospective cohort study compared abdominal ($n = 17$) versus vaginal ($n = 51$) introduction of posterior polypropylene mesh overlaid with Pelvicol (Bard; Murray Hill, NJ) with attachment to the perineal body and rectovaginal septum for colpoperineopexy, followed by laparoscopic attachment of a second mesh to the anterior vagina with laparoscopic affixation of both meshes to the anterior longitudinal ligament [40]. At 6 months follow-up, there were no significant differences in perioperative outcomes and objective anatomic cure. Four patients in the abdominal group had symptoms of recurrent prolapse compared with one in the vaginal group ($p = 0.010$). Although there were no patients with mesh erosion in the abdominal group, the vaginal group had four ($p = 0.6$), with one being apical and three noted at the posterior, distal vagina; all required surgical excision. Mesh erosion rates have been estimated to be approximately 6% with sacral colpoperineopexy [41, 42], and there are conflicting data regarding mesh erosion associated with sacral colpoperineopexy and sacral colpoperineopexy with concomitant hysterectomy [41, 43, 44].

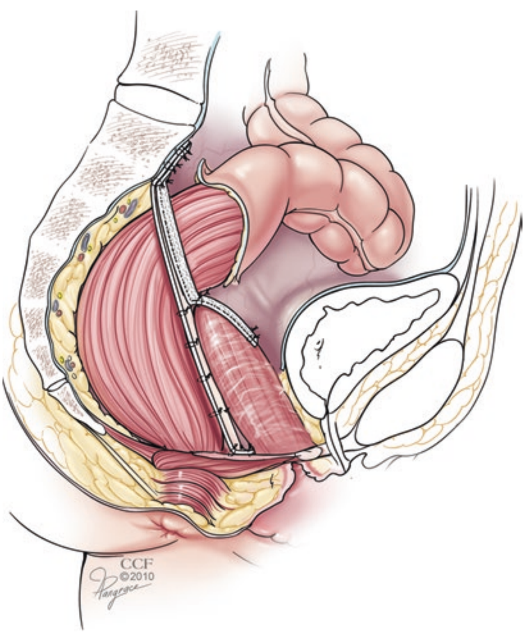

Fig. 17.7 Attachment of posterior mesh to pubococcygeus and iliococcygeus for ventral rectopexy performed in combination with sacrocolpopexy

There are limited data on minimally invasive sacral colpoperineopexy with robotic assistance. Paraiso and colleagues published a case series of ten patients who underwent robotic sacral colpoperineopexy for combined rectal and vaginal prolapse that showed feasibility and minimal operative morbidity with the procedure [45]. A retrospective cohort study by Wehbe et al. compared 56 robot-assisted sacrocolpopexy and 28 sacral colpoperineopexy with a polypropylene mesh introduced transvaginally [46]. They showed comparable apical and posterior anatomic outcomes at a mean of 5 months' follow-up, but anterior recurrent prolapse was higher in the robotic sacral colpoperineopexy group. In addition, there was significantly higher intraoperative blood loss in the sacral colpoperineopexy group when compared with the sacrocolpopexy group (125 [50–1000] vs. 50 [50–400], $p = 0.020$). Vaginal mesh exposure rate was 23 and 7% in the sacrocolpopexy and sacral colpoperineopexy groups, respectively. This high erosion rate was associated with incidental anterior vaginotomy, the surgeon's robotic experience, and the use of Ethibond suture (Ethicon; Somerville, NJ). There are no larger studies with long-term follow-up for robot-assisted sacral colpoperineopexy.

Ventral Rectopexy

Rectal prolapse, full-thickness prolapse of the rectum through the anal muscles (Fig. 17.8), and rectal intussusception, full-thickness descent of the rectum through the anal muscles, can be addressed with a ventral rectopexy during a minimally invasive sacrocolpopexy [47, 48]. The colorectal surgeon can perform his or her dissection either prior to or after the vaginal and presacral dissections for the sacrocolpopexy. If performed laparoscopically, two 5-mm ports are utilized in the right and left lower quadrants with a 12-mm port placed suprapubically to the right of the midline for sigmoid retraction. When performed robotically, we utilize the "W" port configuration, as previously discussed in the sacrocolpopexy section. Other authors report using more of a sunburst configuration, with two robotic ports on the patient's right lower (right lateral arm) and right upper quadrants (left medial arm). The third robotic port is in the left upper quadrant (left lateral arm). One 12-mm assistant port is in the left lower quadrant, and a 5-mm assistant port used for sigmoid retraction is located suprapubically [49]. Another configuration includes all 8-mm ports in a horizontal configuration or flattened "W" or "Z" based on the patient's body habitus.

A steep Trendelenburg position is utilized to retract the bowel cephalad, and the uterus is retracted anteriorly if needed. The presacral and rectovaginal dissections are performed in similar fashion to those for sacral colpopexy. When perineal descent is present and in most ventral rectopexy cases, the dissection is extended caudally to the perineal body and bilateral pubococcygeus muscles. A polypropylene or biologic mesh measuring 8–9 × 15–20 cm is introduced through the 12-mm port, and 2-0 polydiaxone sutures are used to secure the mesh to the pelvic floor muscles laterally (Figs. 17.9 and 17.10). The width and length of the mesh depend on the dimensions of the pelvis and are chosen to ensure that the mesh is not placed on any tension. The senior author measures the distance from pubococcygeus to pubococcygeus with a ruler introduced through the ancillary port. This measurement determines the width of the base of the mesh. Six to 12 or more sutures are then used to secure the mesh to the anterior seromuscular rectum, with caution used to avoid full-thickness rectal bites. The mesh is then secured to the posterior vaginal apex leaving 3 cm between rectal and vaginal attachment and then to the anterior longitudinal ligament of the sacrum with sutures with little to no tension. At

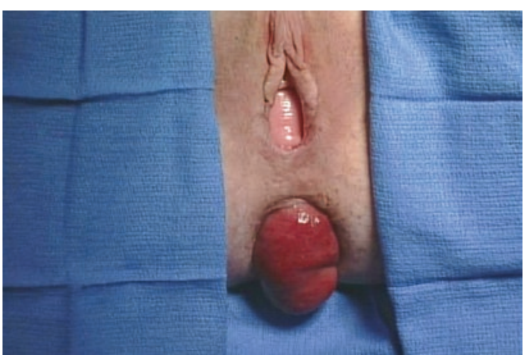

Fig. 17.8 Full-thickness rectal prolapse

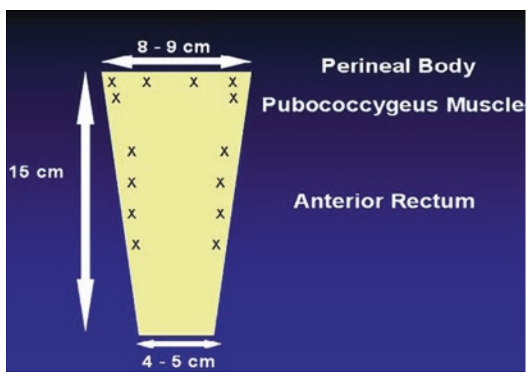

Fig. 17.9 Dimensions of ventral rectopexy mesh and points of attachment

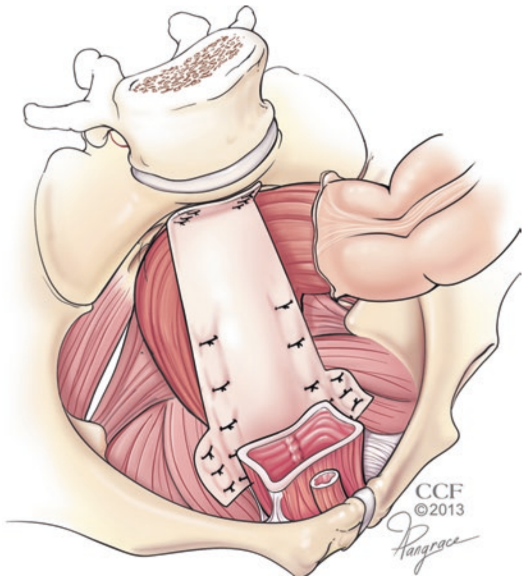

Fig. 17.10 Ventral rectopexy mesh secured to the pelvic floor muscles laterally and anterior seromuscular rectum

the conclusion of the prolapse repair, the peritoneum is closed over both the rectopexy and sacrocolpopexy meshes (Fig. 17.7).

Ventral Rectopexy: Clinical Results and Complications

Several case series discuss the feasibility and safety of combined laparoscopic vaginal and rectal prolapse procedures [50, 51]. Slawik and colleagues reported a case series of 74 patients who underwent laparoscopic ventral rectopexy, posterior colporrhaphy, and sacrocolpopexy [50]. The median operative time was 125 min (range, 50–210 min), with only one conversion to an open procedure. Patients had only minor postoperative complications (three fecal impactions, one port site infection, one urinary tract infection, one chest infection). These women were followed for a median time of 54 months (range, 20–96 months). Although no patient developed recurrent full-thickness rectal prolapse, four had symptoms of postoperative residual hypertrophied rectal mucosal prolapse. Wexner fecal incontinence scores improved in 91% of patients, and obstructed defecation resolved in 80%; three patients, however, reported new-onset minor issues with defecation. Although they did not report objective or subjective outcomes for vaginal prolapse or urinary incontinence, no mesh erosions were reported.

A systematic review of ventral rectopexy for rectal prolapse and rectal intussusception included 12 case series with a total of 728 patients [52]. Weighted mean percentage decrease in fecal incontinence was 45% (95% CI, 35.6–54.1%), and weighted mean decrease in constipation was 24% (95% CI, 6.8–40.9%). Recurrent rates of rectal prolapse ranged from 0% to 15.4% over mean follow-up periods ranging from 3 to 106 months. The most common complications were urinary tract infections ($n = 11$) and port site or incisional hernias ($n = 16$). There were four reported mesh-related complications; there was one mesh erosion and two mesh detachments. One patient died from sepsis attributed to infection of a nylon mesh. Long-term outcome data on minimally invasive ventral rectopexy, however, are limited.

Other studies have compared operative, clinical, and cost results between ventral rectopexy performed laparoscopically and robotically [49, 53, 54]. Overall, small comparative studies report no difference in perioperative complications. One study found similar short-term outcomes for robotic and laparoscopic procedures. Another prospective cohort of 82 patients found recurrent rectal prolapse more frequent after laparoscopic and robotic procedures compared with open rectopexy (27, 20, and 2%, respectively; $p = 0.008$). Two meta-analysis reaffirmed robotic rectopexy takes longer than laparoscopic rectopexy, with a mean weighted difference between 22.8 and 27.9 minutes. Additionally, there was a significantly short length of hospital stay with robotic surgery (mean difference −0.36 days (95% CI -0.66 to −0.07) [55, 56]. Robotic cases cost more to perform ($4910 vs. $4165; $p = 0.012$) [49, 53, 57]. Robot-assisted laparoscopy, however, may help with ease of suturing for those colorectal surgeons who are not accustomed to suturing laparoscopically. Finally, suturing and knot tying deep in the pelvis are facilitated by the robotic platform.

Other Robotic Prolapse Procedures

Robotic uterosacral vault suspension, hysteropexy, sacrohysteropexy, and enterocele repair are all performed in a similar manner to their laparoscopic correlates, as described in detail in Chap. 8. All robotic suture tying, however, is performed with an intracorporeal technique. We utilize the same port placement as described for robotic sacrocolpopexy but move robotic ports into more of a sunburst or arch configuration for larger uteri. Posterior vaginal dissection, however, can be greatly hindered if the robotic ports are too far cephalad.

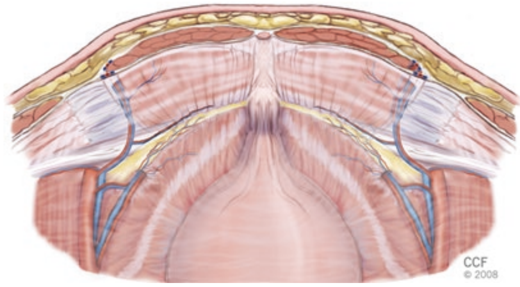

Fig. 17.11 Vascular anatomy of the retropubic space

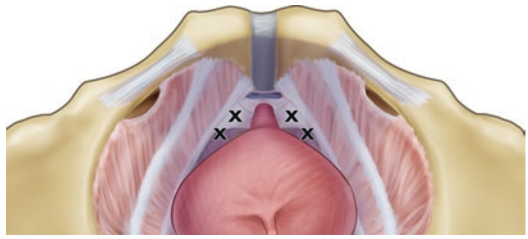

Fig. 17.12 Location of Burch colposuspension sutures

Incontinence Procedures

Burch Colposuspension and Paravaginal Defect Repair

Although robotic and single-port laparoscopic technology have been applied to laparoscopy for prolapse repair, it is not currently widely used for colposuspension; however, we have increased utilization of retropubic procedures in patients who do not prefer vaginally introduced synthetic mesh. When we perform a Burch colposuspension robotically, it is done with an intraperitoneal technique similar to that described for laparoscopic colposuspension in Chap. 8. Owing to the lack of haptic feedback with the robot, careful dissection technique must be used when clearing off Cooper's ligament. Cadaveric studies have shown that the obturator canal is located approximately 5.4 cm (range, 4.5–6.1 cm) lateral to the pubic symphysis and 1.7 cm (range, 1.5–2.6 cm) inferior to the iliopectineal line [58]. Additionally, the external iliac vessels are located approximately 1 cm lateral to the obturator canal and 7.3 cm (range, 6.3–8.5 cm) lateral to the pubic symphysis (Fig. 17.11) [59].

After the space of Retzius is exposed as described in Chap. 8, the vaginal or bedside assistant places two fingers or an end-to-end anastomosis (EEA) sizer in the vagina and identifies the urethrovesical junction with gentle traction on the Foley catheter. With elevation of the periurethral and paravaginal tissues, the vaginal wall lateral to the bladder neck is exposed by using a laparoscopic blunt-tipped dissector held by the bedside assistant. A no. 0 monofilament permanent suture on a CT-2 or SH needle can be placed first through the Cooper's ligament, then through the periurethral endopelvic fascia in a figure-of-eight fashion, again through Cooper's ligament, and finally tied superior to the ligament in an intracorporeal fashion. The surgeon must take care to place stitches in the vaginal wall, excluding the vaginal epithelium at the level of, or just proximal to, the midurethra and bladder neck (Fig. 17.12). We typically place the midurethral sutures first and tie sutures immediately after placement to avoid tangling. A suture bridge of 1.5–2 cm between the paravaginal tissue and Cooper's ligament is common. When a paravaginal defect repair is performed at the same time as Burch colposuspension, the paravaginal sutures are placed prior to the Burch sutures in the same manner as described laparoscopically in order to optimize exposure in the surgical field (*see* Figs. 8.7 and 8.8).

Burch Colposuspension: Clinical Results and Complications

Apart from a small case series that utilized an extracorporeal robotic technique, there is scant literature on robotic-assisted laparoscopic colposuspension [60]. A Cochrane review, updated in 2017, compared laparoscopic Burch colposuspension with open Burch colposuspension [61]. Unfortunately, over the last 10 years, additional data are sparse pertaining to this procedure performed with robotic assistance. Twelve randomized trials were included, with a total of 1260 women studied. Comparison of short-term success was limited by the combined estimates for subjective stress incontinence showing a wide confidence interval, favoring either approach (RR 0.97; 95% CI 0.79–1.18). Only one trial with 64 participants was included in long-term analysis [62]. Although statistical significance was not reached, this seemed to favor laparoscopic Burch (RR 1.89; 95% CI 0.99–3.59). In this trial, however, there was greater than 50% incontinence rate following open Burch, which was much greater than that reported in other trials. Objective clinical data regarding stress incontinence outcomes, both in the short (six trials) and middle (seven trials) term, did not show differences between laparoscopic and open Burch (RR 0.88; 95% CI 0.64–1.21) and (RR 0.92; 95% CI 0.71–1.19), respectively.

A recent large case series of 76 women who underwent robotic-assisted Burch colposuspension reported an 85% treatment success rate [63]. Procedure complications were cystotomy 3% (n = 2), postoperative urinary tract infections 16% (n = 12), and postoperative urinary retention 10% (n = 8). Burch-only operative times were 143 ± 58 min, which are comparable to previously reported laparoscopic times by Paraiso and colleagues [64]. Unfortunately, there are few sources that discuss complications specifically related to robotic Burch as noted above. When comparing laparoscopic to open Burch, there were slight differences in some of the surgical parameters and perioperative complications [61]. The operative time for open Burch was significantly shorter (range, 15–41 min) than for laparoscopic surgery in three of the four trials comparing procedural time [65–68]. Five [66–70] of the seven trials reported a longer hospital stay for open Burch, with two trials showing no difference in length of stay [71, 72]. Four trials showed a higher rate of bladder perforation for the laparoscopic Burch (0.6% vs. 3%; RR 0.22; 95% CI 0.06–0.87) [67, 69, 70, 72]. Six trials showed no significant difference in de novo detrusor overactivity (8% vs. 11%; RR 0.82; 95% CI 0.48–1.38) or voiding difficulties (10% vs. 9%; RR 1.12; 95% CI 0.70–1.79) between laparoscopic and open Burch [62, 66, 68, 71–73]. Two trials reported a total of 39 new or recurrent prolapse events, rate 11% versus 9%, with no significant difference between laparoscopic and open Burch (RR 0.76; 95% CI 0.39–1.52) [71, 72].

Conclusions

Robotic-assisted laparoscopy is a means of less invasive surgical access but should not be considered a unique surgical procedure. We believe that the minimally invasive and open prolapse and incontinence procedures should be identical in operative techniques. The benefits of improved visualization of anatomic structures and the small incisions associated with minimally invasive approaches are desirable, particularly in obese patients. The advantages of less postoperative pain, shorter hospitalization, shorter recovery period, and earlier return to work are very popular with patients, but these advantages are partially offset by increased operating time and, in many cases, increased costs.

Although the quality of surgical trials for minimally invasive prolapse and incontinence procedures has increased over the past 10 years, the field of pelvic reconstructive surgery still needs long-term robotic outcomes from multicenter, prospective, randomized trials. There is an opportunity to expand the literature, specifically including outcomes for obese patients, type of hysterectomy (total vs. supracervical), and suture type for intra-abdominal mesh attachment. Surgical recovery and health-related quality of life indices must be included in further work. These patient-centered outcomes, along with surgical efficiency and cost containment, must be emphasized when training the next generation of minimally invasive pelvic reconstructive surgeons.

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18 Techniques for Robotic Tubal Reanastamosis

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Robotic tubal reanastomosis allows less experienced laparoscopic surgeons to offer a minimally invasive approach to sterilization reversal. Robotic techniques present several advantages for the surgeon: easier dissection of the tubal ends, better visualization of the tubal lumina for reapproximation, more delicate tissue handling, and more precise placement of fine sutures. Data on pregnancy outcomes after robotic tubal reversal appear comparable with those obtained after classic laparotomy with microsurgery. For women desiring childbearing after tubal ligation, robotic tubal reanastomosis should be considered a viable alternative to in vitro fertilization, especially in younger patients.

Introduction

Tubal ligation remains the most common form of contraception in the United States among married women and women over the age of 30 [1]. Although it is a safe and efficacious method, tubal sterilization is associated with a high risk of desire for reversal, and approximately 1–2% of patients seek tubal reversal for further fertility [2]. Young age at the time of sterilization is the most common factor related to feelings of regret [3]. Couples desiring children after tubal ligation can chose between in vitro fertilization (IVF) or surgical tubal reanastomosis.

Traditionally, tubal reanastomosis was performed through a Pfannenstiel laparotomy incision using microsurgical techniques. Success rates for this technique have been quoted to be as high as 85% [4]. However, this technique has the standard limitations of a laparotomy, including longer recovery time, increased postoperative pain, and increased risk of adhesion formation. Typically, patients remain in the hospital overnight and cannot return to work and normal activities for at least 2 weeks. Laparoscopic tubal reversals became more common in the 1990s with the rise of minimally invasive surgery [5]. Unfortunately, this method requires advanced training in complex laparoscopy and experience with laparoscopic suturing using very fine suture material. In addition, two experienced surgeons are often needed to complete a laparoscopic tubal reanastomosis, and the procedure can take from 2 to 4 hours.

As IVF success rates climbed over the past several decades and comfort with complex laparoscopic suturing has diminished, some centers have dismissed the surgical approach to treating infertility after tubal ligation. However, robotic

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tubal reanastomosis is attainable for less experienced laparoscopic surgeons and offers the advantages of improved visualization of the tubal lumina, simpler knot tying, and finer dissection and manipulation of the fallopian tubes. Patients can be discharged home the same day. For patients seeking restoration of fertility, robotic tubal reanastomosis represents a one-time, minimally invasive method of tubal reversal with a high chance of subsequent successful spontaneous conceptions. In comparison with IVF, tubal reversal surgery dramatically reduces the risk of twins and higher-order multiples, along with their attendant concerns of increased cost and medical risks. An additional benefit of tubal reversal is that one procedure can result in more than one subsequent pregnancy.

Preoperative Considerations

The presence of other infertility factors that may affect the success of conception should be considered preoperatively. A semen analysis should be performed for all couples electing this procedure. Patients of advanced maternal age may also be assessed for ovarian reserve. Additionally, other confounding tubal infertility factors, such as pelvic inflammatory disease or endometriosis, that may make tubal surgery more challenging should be considered when counseling patients on tubal surgery versus IVF.

Patient age is the most significant factor associated with successful sterilization reversal; however young age should not be a restriction when assessing for surgical candidacy [5]. It is important to note that the results of tubal surgery and IVF are difficult to directly compare given that surgical success rates are measured as pregnancy rate per patient and IVF success rate is measured by individual cycles. Counseling should be individualized to each patient. If possible, the surgeon should obtain operative and pathology reports from the sterilization procedure to determine the mode of surgery, techniques employed (including length of tube excised), and any additional pathology noted. Patients should be counseled that successful reanastamosis of one or both tubes may not be possible depending on how much suitable tube has been preserved after their sterilization. Preconception counseling can be undertaken at the time of the preoperative visit.

Setup and Positioning

The patient is placed in the lithotomy position. Choosing a uterine manipulator with the capability for chromopertubation is essential. Because the appropriateness of the patient's tubes for surgery cannot be assessed preoperatively, a 5-mm trocar is placed at the umbilicus for the introduction of the 5-mm laparoscope, and pelvic survey is performed before extending the umbilical incision to accommodate a 12-mm trocar for the robotic laparoscope. The tubes must be of adequate length (at least 4 cm) and free of significant adhesions for the procedure to be successfully performed [6]. The 8-mm robotic trocars are then placed at a 10- to 15-degree angle approximately 8–10 cm from the umbilicus on either side. Five-mm robotic trocars and instruments are also now available and can be used for this procedure.

An important aspect of the approach for tubal reanastomosis is the placement of an accessory port low in the abdomen. We place either a 5- or 10-mm accessory port in the right or left lower quadrant to allow the assistant to easily introduce needles under direct visualization into the operator field. The needles for tubal reanastomosis are small and difficult to handle and can be easily lost if not transferred slowly and carefully. Once lost, the chances of finding and retrieving the needle are small.

Docking of the Robot

The column of the robot is located at the patient's side, which allows easy access to the manipulator by an assistant. The camera is placed into the umbilical port, and the two robotic arms are attached to the two lateral robotic trocars. If using second- and third-generation robotic systems, the use of the first and third robotic arms for tubal reanastomosis allows for a wider angle of approach. The final arm can be docked with the placement of an additional 8-mm trocar if needed, but this scenario is rare. The most recent generation of the robotic system offers more flexibility in docking, with decreased bulkiness and extended range of motion; therefore this modification may not be necessary.

Robotic Instrumentation

After the robot has been docked, the robotic instruments are introduced into the pelvis under operator visualization. The instruments needed for the procedure are the EndoWrist monopolar cautery hook or shears (Intuitive Surgical Inc., Sunnyvale, CA) and the EndoWrist PK grasper (Intuitive Surgical Inc., Sunnyvale, CA) with bipolar energy attached. For right-handed surgeons, the EndoWrist PK grasper is loaded into the left port and the monopolar energy source is in the right port. If the final remaining arm is utilized, the EndoWrist Prograsper (Intuitive Surgical Inc., Sunnyvale, CA) can be introduced here. For suturing, we prefer an EndoWrist Black Diamond Micro Forceps (Intuitive Surgical Inc., Sunnyvale, CA) in either hand as the needle driver.

Surgical Procedure

The goal of robotic tubal reanastomosis is to duplicate the steps of the open procedure using robotic instruments and techniques.

Preparation of Proximal and Distal Segments

The serosa is incised, and the stump is exposed. Initially, lysis of tubal adhesions is performed, and any tubal clips or rings are removed. Dilute vasopressin (20 U in 100–200 mL of normal saline) is then injected into the mesosalpinx for hemostasis and to assist with identifying tissue planes. Transcervical injection of indigo carmine dye can then be performed to ensure proximal tubal patency and identify the end of the proximal tube for dissection. The serosa covering the occluded end is then incised using the monopolar cautery, and the serosa is peeled back to expose the proximal stump.

Scissors are used without energy to reveal tubal lumina. The robotic scissors are then used to move across the exposed area, excising the scar and revealing the tubal lumina. Energy is not applied during this step, and minimal cautery is used to coagulate bleeders to minimize subsequent scarring or reocclusion. A similar procedure is performed to expose the distal tubal lumina, and the fimbriated end of the tube can be cannulated to confirm patency by injection of indigo carmine dye.

This step is particularly amenable to a robotic approach. Visualization of the tubal lumina is enhanced by robotic magnification, and tremor reduction allows a more careful dissection of the tubal ends. The display settings should be carefully configured at the beginning of the case. A 4x magnification is recommended (Figs. 18.1 and 18.2).

Reapproximation of Mesosalpinx

Often, the mesosalpinx separates widely after preparation of the tubal ends. To align the tubes

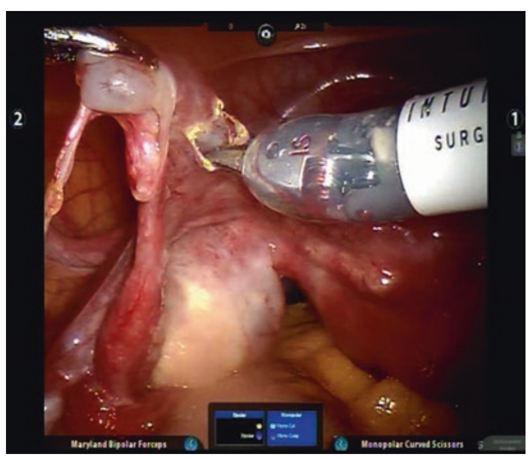

Fig. 18.1 The serosa is incised, and the stump is exposed

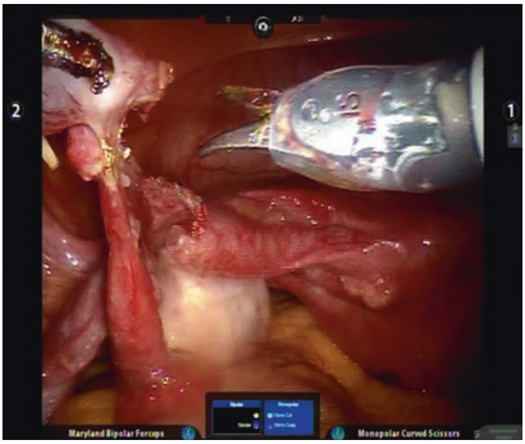

Fig. 18.2 Scissors are used without energy to reveal the tubal lumen

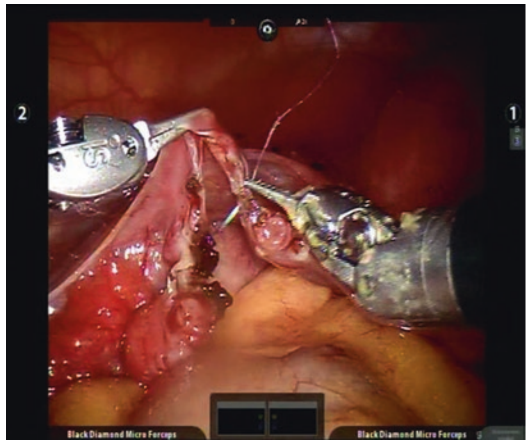

Fig. 18.3 Reapproximated mesosalpinx

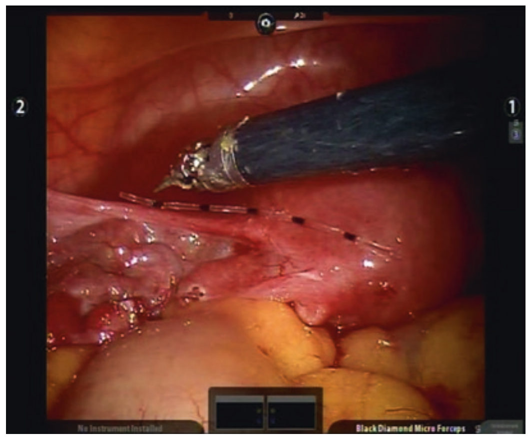

Fig. 18.4 Plastic cannula as tubal stent

and relieve tension on the anastomosis site, one or more 6–0 Vicryl (Ethicon, EndoSurgery Inc., Somerville, NJ) stitches are placed into the mesosalpinx to bring its edges closer together. Care must be taken to use visual cues to approximate but not strangulate the tissue, as the goal is to bring the tubal lumen closer together and avoid tension on the anastomosis site. Also at this time, a catheter is placed into the proximal and distal tubal ends to facilitate suturing of the lumina.

For a tubal stent, we use the inner plastic cannula from the Novy Cornual Cannulation Set (Cook Medical Inc., Bloomington, IN), cut to a 6- to 9-cm length. Other luminal stents and adaptations have been described; an alternative and low-cost stent is a 1-0 Prolene or 0-Vicryl suture cut to 6 cm (Figs. 18.3 and 18.4).

Tubal Reanastomosis

The tubal reanastomosis is performed using interrupted sutures of 8-0 Vicryl in the muscularis followed by reapproximation of the overlaying serosa. To avoid passing a new needle in and out of the operative field, the same suture should be used for as many interrupted stitches as possible. In order, we place sutures at the 6, 3, 9, and 12 o'clock locations and tie them with intracorporeal knot-tying techniques. The suturing should position the knot outside of the tubal lumen. Precise placement of these sutures is another distinct advantage when using the surgical robot. We do not tie down the 3 and 9 o'clock knots until the 12 o'clock stitch is placed; otherwise, it may be difficult to identify the lumina and place the 12 o'clock stitch correctly. Great care must be taken to handle the tissue delicately while suturing and not to avulse either the needle or the tissue.

As with all robotic surgery, visual rather than tactile feedback can be used to provide the appropriate tissue tension. Transcervical injection of indigo carmine dye is again used to confirm tubal patency at the conclusion of this portion of the procedure. Revisions can occur if patency has not been established. Usually, an additional suture placed at an area of dye leakage at the anastomosis site is all that is needed (Figs. 18.5 and 18.6).

Serosal Repair

In a similar fashion to the above, the serosa is repaired with circumferential interrupted stitches of 8-0 Vicryl. Chromopertubation is again performed to ensure that the reanastomosis site has not been kinked or occluded by the placement of serosal sutures. If patency is initially present and then cannot be obtained, suture should be removed, and the reanastomosis can again be attempted (Fig. 18.7).

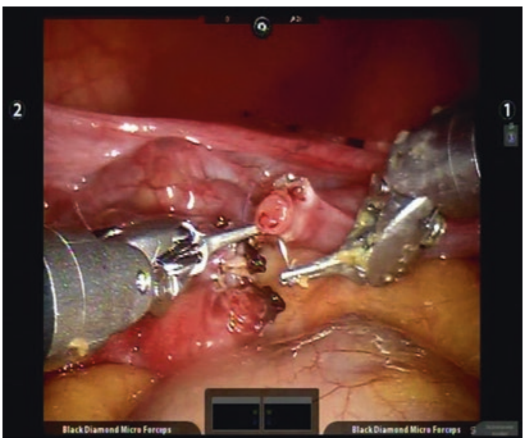

Fig. 18.5 Chromopertubation

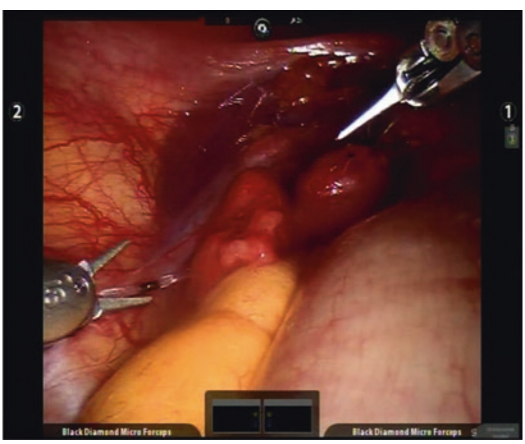

Fig. 18.6 Serosal stitches

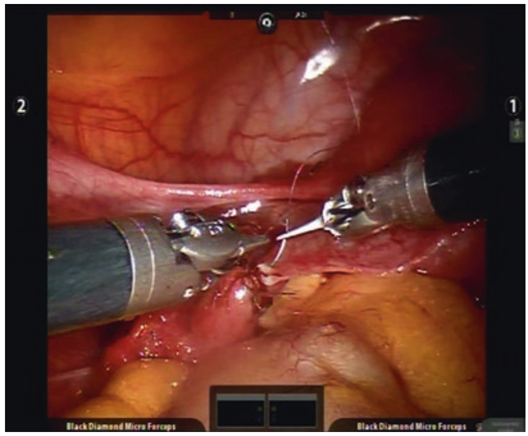

Fig. 18.7 Repair of serosa with circumferential stitches

Postoperative Care

In most cases, patients undergoing robotic tubal reanastomosis can be discharged home the same day with oral pain medications. A follow-up visit should be scheduled within 6 weeks. Patients can initiate attempts to conceive after two menstrual cycles. We recommend a hysterosalpingogram if the patient has not conceived within six cycles.

Discussion

In comparison to standard microsurgical tubal reanastomosis via laparotomy, robotic tubal reversal offers a same-day discharge with the benefits of a minimally invasive recovery. Given that few surgeons possess the skills needed for laparoscopic tubal reanastomosis, robotic reversal should be considered as a first-line alternative to IVF in carefully selected women.

Cumulative pregnancy rates after robotic tubal reanastomosis are largely dependent on the woman's age (below or above 35 years) and range from 60% to 90% [5, 7, 8]. Chances for conception are highest in the first 12 to 18 months after surgery [8]. In a recent large series of robotic tubal reanastomosis, even women between 40 and 42 years old had high pregnancy and birth rates of 50% and 44%, respectively [7]. Ectopic risk after tubal reanastomosis appears to be consistently 2–3% [2, 4, 9, 10]. Other factors related to success of tubal reanastomosis include final tube length (ideally >4–5 cm) and site of anastomosis (isthmic-isthmic reversals can have greater success than ampullary or cornual segments) [8].

Two publications with small sample sizes have compared outcomes of women undergoing robotic tubal reanastomosis with reanastomosis by laparotomy or outpatient minilaparotomy [5, 11]. Pregnancy and ectopic rates were similar, although the robotic approach took longer and was more costly. As expected, hospitalization times and return to normal activities were shorter after robotic surgery than laparotomy. When weighing robotic surgery versus IVF, one must take into consideration the individual success rates of the IVF program versus the surgeon's comfort and ability with the procedure and the patient's prognosis for success. Higher cumulative pregnancy rates and lower cost per delivery have been described for tubal reanastomosis versus IVF in women less than 37 years old [12].

In conclusion, robotic tubal reanastomosis offers an alternative to open surgery or IVF for women seeking sterilization reversal. This type of surgery appears uniquely suited to robotics owing to the need for delicate tissue handling, increased magnification for identification and preparation of the tubal ends, and fine intracorporeal suturing. Technical improvements that facilitate docking, range of motion, and visualization in more recent robotic systems allow for the next generation of surgeons to accomplish this procedure more easily. The limited data available support the efficacy and safety of this approach.

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19 Techniques for Robotic Adnexal Surgery

Kristina A. Butler and Javier F. Magrina

Introduction

Laparoscopy and robotics are preferable to laparotomy for the management of adnexal disease. There are different indications for robotics and laparoscopy. Robotics offers technological advantages over laparoscopy but has disadvantages for uncomplicated adnexal surgery and large ovarian cysts.

Incidence

As many as 5–10% of women in the United States will undergo a surgical procedure for an adnexal mass sometime in their lifetime [1].

Preoperative Management

There are three questions a gynecologist needs to answer for any patient with an ovarian mass: Does it require surgery? Is it benign or malignant? If removal is indicated, what is the best surgical approach?

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Functional or Neoplastic

Functional cysts do not require surgery unless they cause pain, such as with adhesions, rupture, or torsion. In premenopausal women, about 70–80% of ovarian cysts are functional [1]. In postmenopausal women, 70% of unilocular ovarian cysts resolve spontaneously, while the remaining 30% become complex or persistent, with a malignancy risk <1% [1]. However, the risk of malignancy with a complex adnexal mass is 6–39% [1].

Once a decision is made for surgical removal, the next question is to determine as best as possible whether it is benign or malignant.

Benign or Malignant

A simple rule is to consider patient's age and the size of the cyst. The risk of malignancy increases with patient's age and with cyst size. Among all ovarian masses diagnosed before puberty, 8–12% are malignant [2]. In premenopausal patients <2% are malignant, and in postmenopausal patients, 25–30% are malignant [1]. Most malignant ovarian masses are >5 cm.

Investigations include a physical examination with a rectovaginal exam, a pelvic ultrasound with doppler, and tumor markers. A single investigation is not reliable. In postmenopausal patients, the combination of a negative rectovagi-

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nal exam, a negative pelvic ultrasound including doppler, and a negative serum CA-125 is indicative of no malignancy or a malignancy risk greater than 1:720 (positive predictive value for malignancy = 0 and 95%; confidence interval, 0–7) [3].

The American College of Obstetricians and Gynecologists recommends the combination of clinical examination, pelvic ultrasound, and serological tests such as CA 125 and HE-4 for initial evaluation [4]. Additional serological tests are available and recommended if one or two of the three investigations are positive.

Minimally Invasive Surgery (Laparoscopy, Robotics) Versus Laparotomy

A minimally invasive approach (MIS) is preferable to laparotomy for the excision of adnexal masses because of reduced blood loss, postoperative complications, hospitalization, and time to recovery [5].

Laparoscopy Versus Robotics

The gynecologist must decide the appropriate MIS approach, laparoscopy, or robotics based on the type of adnexal pathology and patient's BMI.

Indications

Robotics

Robotics is preferable for the removal of ovarian masses complicated by adhesions or other pathology, such as ureteral obstruction or endometriosis; for the excision of retroperitoneal ovarian cysts and ovarian remnant; for ovarian masses suspicious for malignancy; for densely adherent hydrosalpinx; and for the performance of ovarian cystectomy (the articulation of the instruments allows a more precise dissection of the thin ovarian tissue over the round spherical surface of an ovarian cyst. In our experience this translates into a lesser risk of cyst rupture). It is also preferable for obese patients because of a similar operating time and lower blood loss as compared to laparoscopy [6].

In case of malignancy, robotics surgical staging is less physically demanding to the surgeon. Postural fatigue is increased with laparoscopic operations over 120 minutes as compared to robotics [7].

Laparoscopy

Laparoscopy is preferable for uncomplicated salpingectomy or salpingo-oophorectomy (SO) without underlying pathology. These are operations which can be performed with 3-mm instrumentation. It is also the preferable approach for large ovarian cysts which require trocar decompression (below) followed by closure of the trocar site entrance into the cyst with an Endoloop. The cyst is then displaced out of the pelvis to divide the adnexal pedicles. Once decompressed, and in the absence of complicating pathology, it is senseless to dock a robotic system for the division of the ovarian vessels and tubo-ovarian ligament.

Results

A retrospective review of 176 patients compared laparoscopy versus robotics for unilateral (14.2%) or bilateral (85.8%) adnexectomy during the years 2003 to 2008 at Mayo Clinic Arizona [6]. Robotic adnexectomy was performed using the da Vinci or da Vinci S system in 85 patients (97% for an adnexal mass and 3% for risk-reducing salpingo-oophorectomy (RRSO)). A laparoscopic approach was used in 91 patients (90% for an adnexal mass and 10% for RRSO).

The robotics operating time was 12 minutes longer (83 vs. 71 min; $p = 0.01$). Potential contributing factors could be the additional time for docking and undocking of the robotic arms, whether the primary surgeon was staff or trainee, and the longer laparoscopic experience of the surgeons as compared to robotics in the beginning of the series. This operating time difference disappeared when comparing robotic and laparoscopy patients with a BMI equal or greater than

30 ($p = 0.43$). There were no differences relative to blood loss (39 vs. 41 ml; $p = 0.65$), intraoperative complications (1 vs. 2; $p = 1.00$), postoperative complications (12 vs. 11; $p = 0.82$), or hospitalization over 2 days (0 vs. 3; $p = 0.25$). When comparing blood loss among patients with a BMI =>30, it was lower for robotic patients (39 vs. 60 ml; $p = 0.02$). There were no conversions to laparotomy and no blood transfusions.

Another retrospective study including 71 patients [8] undergoing ovarian cystectomy or adnexectomy with other procedures such as hysterectomy by robotics (30) or laparoscopy (41) observed similar findings. The robotics operating time was 20 minutes longer (97 vs. 77 min), while there were no differences in blood loss, complications, or length of stay and no conversions to laparotomy.

Fig. 19.1 The da Vinci Xi is docked perpendicular to the patient's mid-abdomen

Fig. 19.2 The da Vinci Si is docked lateral to the patient's right or left knee

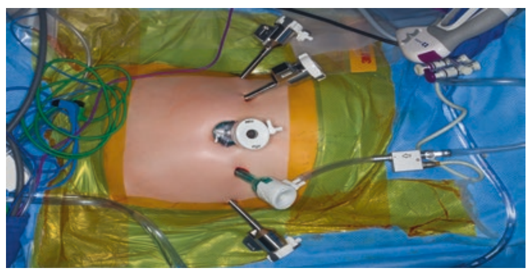

Fig. 19.3 The trocars for the da Vinci System Xi are placed horizontally at the level of the umbilicus

Robotic Technique

Da Vinci Robotic System: Si Versus Xi

The da Vinci Xi is preferable when there is a potential risk for malignancy. The Xi column rotates 180 degrees and allows the performance of upper abdominal staging with the same trocar placement as for pelvic surgery. For the S or Si system, the robotic arms must be undocked, the operating table rotated 180 degrees, and the arms re-docked again.

There is no Food and Drug Administration (FDA) approval of the SP system for gynecological use. Although the column rotates 360 degrees, its surgical field is reduced in size.

The Xi column is positioned perpendicular to the operating table at the level of the patient's mid-abdomen (Fig. 19.1). The Si column is positioned lateral to the patient's either leg at the level of the knee (Fig. 19.2).

Trocar Placement

Four or five trocars are inserted through the abdominal wall. For the da Vinci Xi, they are placed at the same level of the umbilicus (Fig. 19.3), while for the Si system, they are placed in an M distribution when looking cephalad (Fig. 19.4). For the Xi, an 8-mm transumbilical optical trocar is introduced by the open technique, and two robotic trocars (8 mm each) are inserted 10 cm lateral to the right and left of the umbilicus, respectively. An assistant trocar is inserted midway between the optical and the left lateral port. If there is a need for a third robotic instrument, a robotic trocar is inserted midway between the umbilicus and the right lateral trocar.

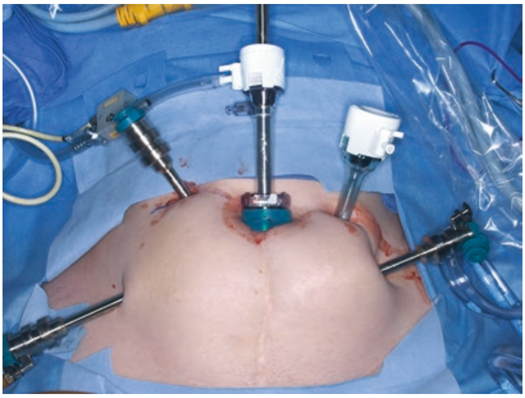

Fig. 19.4 The trocars for the da Vinci System Xi are placed in a M distribution. The lateral trocars are at the umbilical level, while the medial trocars are supra-umbilical

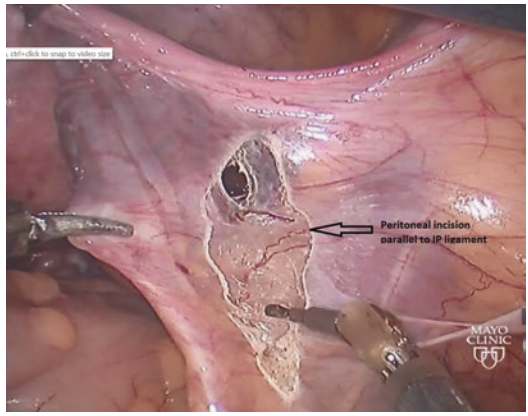

Fig. 19.5 A peritoneal incision lateral to the IP ligament has been made to identify the ureter in the retroperitoneum and create a safety peritoneal window to avoid its injury when transecting the IP ligament

Instruments

A bipolar 8-mm grasper is introduced through the left lateral trocar, and a monopolar 8-mm instrument (spatula or scissors) is inserted through the right lateral trocar. If there is a need for additional retraction, an additional robotic trocar is inserted midway between the umbilicus and the right lateral trocar for a robotic grasper.

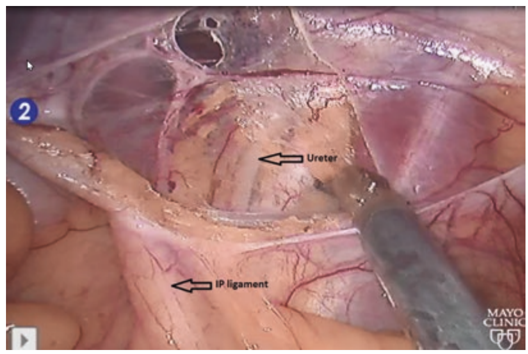

Fig. 19.6 The ureter has been identified medial to the external iliac artery

Surgical Technique

Uni- or Bilateral Salpingo-Oophorectomy (SO)

A peritoneal incision is made lateral and parallel to the ovarian vessels from the round ligament to the pelvic brim (Fig. 19.5). The external iliac vessels and the psoas muscle are easily exposed. The ureter is easier to visualize at the level of the pelvic brim before downturns into the pelvis (Fig. 19.6). Once identified, it is separated from the infundibulopelvic (IP) ligament and traced distal to the ovary. A safety peritoneal window is created with a monopolar instrument between the IP ligament and the ureter (Fig. 19.7). The IP ligament is safely divided at least 2 cm away from the ovary by the assistant using a vessel sealer (Fig. 19.7).

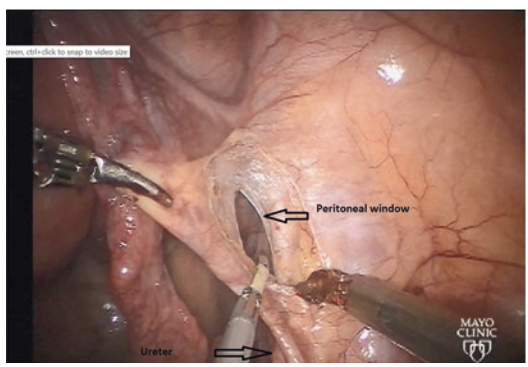

Fig. 19.7 The IP ligament is transected with a vessel sealer through the peritoneal window (ureteral safety) at a distance of at least 2 cm from the ovary to avoid an ovarian remnant

The peritoneal window is then lengthened towards the tubo-ovarian ligament. Lifting the transected IP ligament ventrally facilitates the distal division of the tube and the ovarian ligament by the assistant with a vessel sealer.

If there are adnexal adhesions (Fig. 19.8), they must be excised prior to SO to allow a safe division of the IP ligament and avoid ureteral injury (Fig. 19.9).

Ovarian Cystectomy

Ovarian preservation is the procedure of choice for benign ovarian cysts and for borderline cysts in patients desiring fertility.

A linear incision is made on the stretched ovarian tissue, away from the hilum, using a monopolar instrument (Fig. 19.10). An elliptical incision and removal of an ellipse of the thin ovarian tissue in larger cysts will facilitate the subsequent dissection by reducing the size of the redundant thin ovarian tissue which may impede a safe or expeditious dissection.

With careful, gentle dissection, an avascular plane is created between the ovary and the cyst wall using a monopolar instrument, coagulating small vessels as encountered.

To prevent frustrating breaks of the thin ovarian tissue during the dissection, grab the thin ovarian tissue as close as possible to the edge of the dissection (Fig. 19.10). Once you have dissected a portion of the cyst wall, the redundant thin ovarian cortex makes further dissection difficult. A simple trick consists in folding over the ovarian cortex away from the cyst wall and regrabbing it as close as possible to the edge of the dissection (Fig. 19.11). Another option consists in resecting a portion of the thin ovarian tissue.

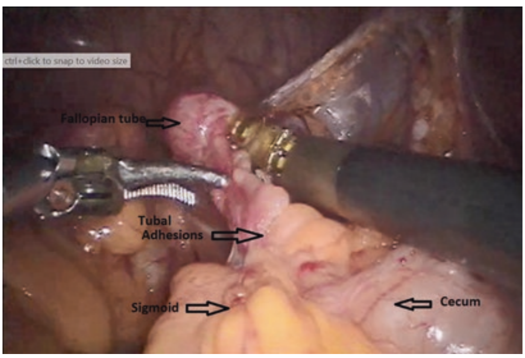

Fig. 19.8 Adnexal adhesions must be excised prior to adnexectomy for a safe exposure of the ureter and IP ligament

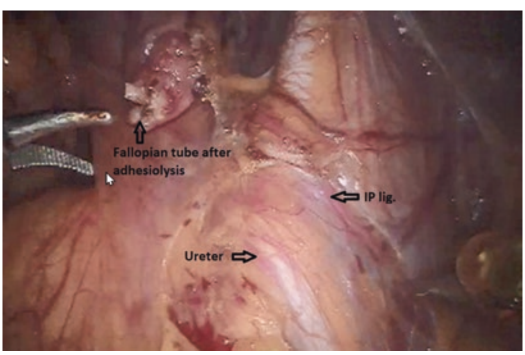

Fig. 19.9 A tubal-cecal-sigmoidal adhesiolysis has been performed, and the ureter and IP ligament are identified with good exposure. A safe division of the IP ligament can now be performed

Fig. 19.10 A linear incision has been made safe from the ovarian hilum, and a safe plane of dissection has been developed. The thin ovarian tissue is grasped as close as possible to the edge of the dissecting plane

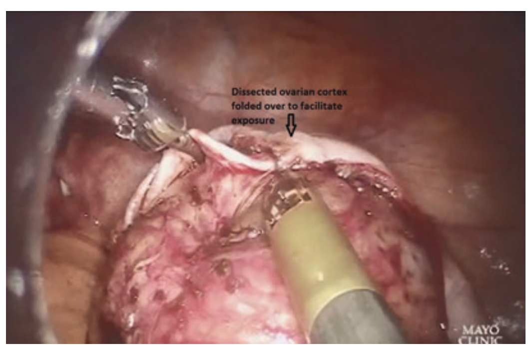

Fig. 19.11 The thin ovarian tissue has been folded over. It is grasped at its junction with the cyst capsule to facilitate dissection and avoid breaks

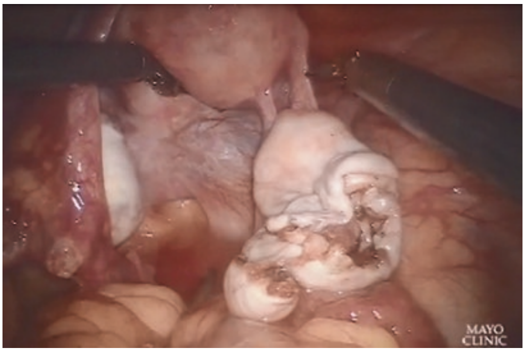

Fig. 19.12 Once gentle hemostasis has been achieved, the remaining healthy ovary is preserved without suturing

Once the cyst has been removed, hemostasis is performed with short, gentle touches of a bipolar instrument to minimize ovarian thermal damage. The ovary is left to heal without using sutures which may increase adhesion formation (Fig. 19.12).

Risk-Reducing Salpingo-Oophorectomy (RRSO)

RRSO is indicated for patients at increased risk of ovarian cancer due to an inherited genetic mutation such as BRCA1 and BRCA2. It is important to remember that the prevalence rate of ovarian, tubal, or peritoneal malignancy in 527 patients undergoing RRSO was 2.3%, and it was 1.7% in totally unsuspected patients [9].

There are five important technical aspects for RRSO:

1. Obtain pelvic cytology at the start.
2. Divide the IP ligament at least 2 cm away from the ovary (*see* Fig. 19.7).
3. Transect the tube at the isthmus.
4. Section the ovarian ligament near the uterus.
5. Ask the pathologist to perform a careful gross inspection of the adnexa and to obtain a frozen section if any anomaly is observed.

The adjacent 2 cm of the IP ligament must be resected with the ovary since 14% of patients

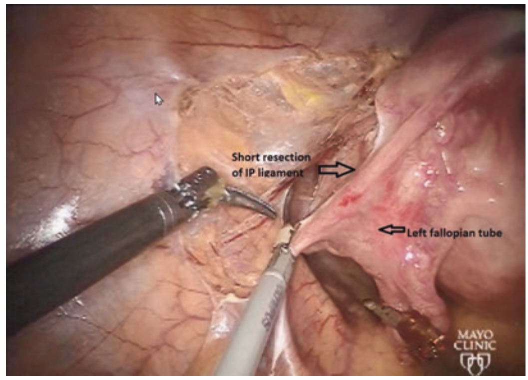

Fig. 19.13 Short resection of the IP ligament. The fimbrial end of the tube, a common site of malignancy, is adjacent to the vessel sealer. This constitutes a risk for residual ovarian tissue in the remaining IP ligament

have microscopic ovarian tissue in the 14 mm of the IP ligament next to the ovary [10]. If an adequate length of the IP is not resected (Fig. 19.13), the patient is at risk for subsequent transformation to malignancy. This may explain why some patients develop a serous malignancy after RRSO. The same length of IP ligament must be resected in all patients undergoing oophorectomy to prevent an ovarian remnant.

In patients with a short IP ligament (Fig. 19.13), the lateral peritoneal incision must be extended cephalad to the pelvic brim to obtain an adequate margin of the IP ligament.

Ovarian Remnant

Prevention

An incomplete oophorectomy creates an ovarian remnant. The risk is increased with adhesions, especially from endometriosis. Most patients give a history of an adnexectomy complicated by adhesions. Adhesions make it difficult to delineate the boundaries of the ovary, and because they may contain microscopic ovarian tissue, it is necessary to remove all the adhesions in conjunction with the ovary (Fig. 19.14).

Another potential cause of ovarian remnant is the division of the IP ligament next to the ovary. Microscopic ovarian tissue has been found in the

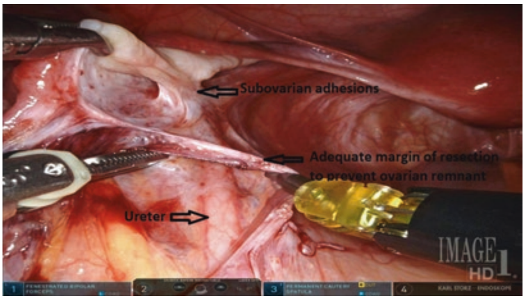

Fig. 19.14 Prevention of ovarian remnant. All the subovarian adhesions must be removed left attached to the ovary with a good margin of resection. The ureter has been identified upstream (near pelvic brim) to the ovary, and an adequate peritoneal margin of resection has been created to prevent an ovarian remnant

14 mm of the IP ligament adjacent to the ovaries (see also RRSO) [10]. This may occur when the oophorectomy is performed intraperitoneally. The ovary or adnexa is pulled medially, and a sealer or stapling device is applied several times to transect the IP and the tubo-ovarian ligaments without entering the retroperitoneum.

Excision

An ovarian remnant always invades the retroperitoneum and is adherent to different retroperitoneal structures depending on its location. It commonly involves the ureter. It generates an intense inflammatory reaction with subsequent dense adhesions and scar tissue, causing severe cyclic or constant pain (Fig. 19.15). Failure to achieve a complete resection of the remnant and surrounding adhesions and scar tissue may result in a subsequent ovarian remnant.

A peritoneal incision is carried out cephalad and lateral to the remnant to identify the IP ligament and the ureter in clearly fresh, uninvolved tissue. The IP ligament, which many times is found intact, is divided and dissected to the remnant (Fig. 19.16). All adherent structures must be dissected free from the remnant by cutting through healthy, fresh tissue circumferentially to the remnant. This is the only assurance to prevent recurrence.

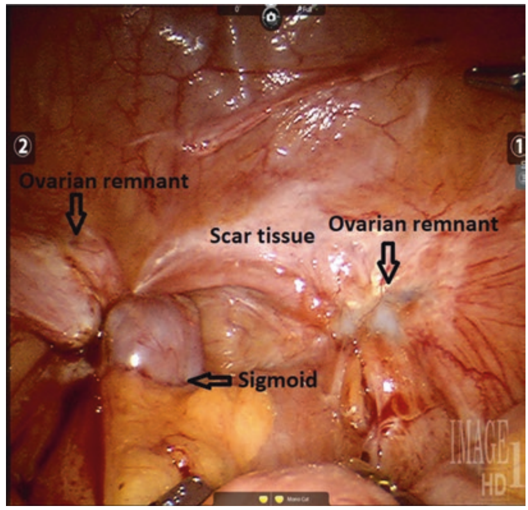

Fig. 19.15 Bilateral ovarian remnants, totally retroperitoneal, involving ureters and the sigmoid on the left remnant. Extensive scar tissue is noted surrounding the remnants, the vaginal cuff, and the bladder peritoneum

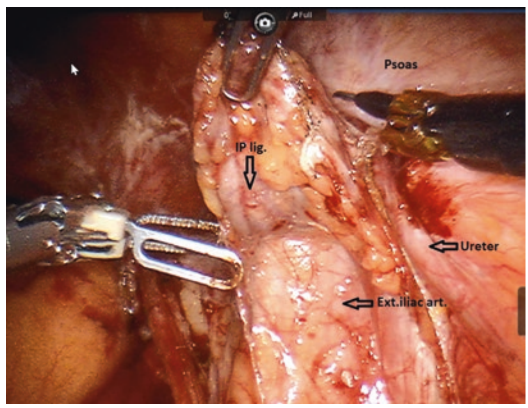

Fig. 19.16 The IP ligament has been transected cephalad to the remnant, and it is followed to the ovarian remnant site. The ureter is in an abnormal position, lateral to the IP ligament

Results

A retrospective comparison of laparotomy (187 patients) with laparoscopy (18 patients) and robotics (17 patients) at Mayo Clinic Arizona showed improved perioperative outcomes for the MIS approach [11].

Among the three groups, laparotomy, laparoscopy, and robotics, there were no differences in the operating times (139, 138, 123 minutes, respectively; $p = 0.34$) or intraoperative complications (8, 5.3, 0%, respectively; $p = 0.24$). The blood loss (378, 87, 65 ml, respectively; $p = <0.01$) and length of stay (9.1, 1.1, 0.8 days, respectively; $p = <0.01$) were lower for the MIS approach. The robotic group had an increased postoperative complication rate (14.4, 15.8, 23.5%, respectively, $p = 0.01$) due to more adhesions and endometriosis compared to the other 2 groups, and the severity of complications was greater in the laparotomy group, with a 12.1% transfusion rate, while there were none in the MIS groups. Reoperation rates were similar among the 3 groups (3.7%, 5.3%, 5.9%, respectively). At a mean follow-up of 21.1 ± 32.4 months, pain improvement was 93.1, 94.4, and 71.4%, respectively, probably for the higher number of patients with adhesions and endometriosis in the robotic group.

The Retroperitoneal Ovarian Cyst or Ovary

The retroperitoneal ovarian cyst requires a surgical excision similar to an ovarian remnant except that in the former an entire cystic ovary (sometimes without a cyst) is present and the IP ligament is always intact. It is a consequence of previous ovarian-preserving surgery/ies in an attempt to save the ovary. Procedures such as ovarian cystectomy, or removal of a tubo-ovarian abscess, or adnexal adhesions, or subovarian endometriosis, may result in adhesion formation burying the ovary in the retroperitoneum (Fig. 19.17). Failure to completely resect a retroperitoneal ovarian cyst will result in a total retroperitoneal ovarian remnant (*see* Fig. 19.15).

A peritoneal incision, similar to the one described for SO, is carried out cephalad to the ovary to identify the IP ligament and the ureter. The IP ligament is divided and followed to the retroperitoneal ovarian cyst. An extensive adhesiolysis from all affected retroperitoneal structures is required, in particular the ureter, if a complete resection is to be accomplished (Fig. 19.17). A spherical dissection of the retroperitoneal ovary or cyst is performed until a plane of dissection with fresh tissue is identified (Fig. 19.18). The dissection is continued through fresh tissue, ensuring all adhesions are removed to minimize the risk of microscopic residual ovarian tissue.

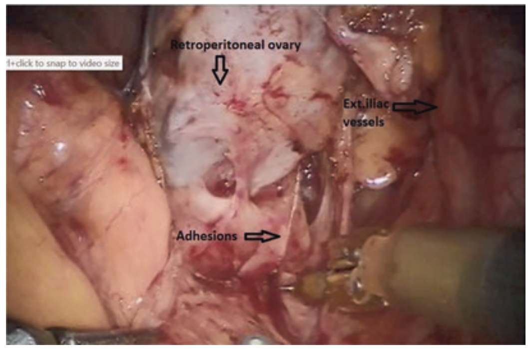

Fig. 19.17 Retroperitoneal ovarian cyst with typical dense adhesions to retroperitoneal structures

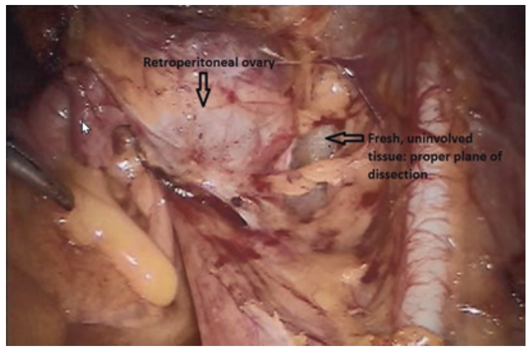

Fig. 19.18 Retroperitoneal ovarian cyst. The dissection is continued until a plane of dissection of uninvolved fresh tissue is identified. This ensures removal of all the ovarian tissue

Malignant Ovarian Cyst

What to Do in Case of Intraoperative Rupture

Contain the spill by reducing Trendelenburg as much as possible and suction the dispersed fluid. Send the fluid for cytology (not all malignant cysts contain malignant cells). Irrigate the pelvis with water. Perform a surgical staging. Prior to closure obtain a third pelvic peritoneal cytology. Compare cytology results before and after rupture and at end of surgery. Irrigate the trocar sites with water prior to their closure.

Consequences of Intraoperative Rupture

Intraoperative Rupture Changes the Stage from IA to IC1

The recent 2014 International Federation of Gynecology and Obstetrics (FIGO) stage IC differentiates between an intraoperative rupture (IC1), a previously ruptured cyst or a cyst with surface excrescences (IC2), or positive ascites or pelvic cytology (IC3). It is therefore necessary to document findings at the start of the surgery in the operative report.

Is Chemotherapy Necessary with an Intraoperative Rupture?

Intraoperative rupture in a patient with a true surgical stage IC1 does not mandate chemotherapy. A recent study comparing observation versus chemotherapy for intraoperative tumor rupture in stage IC1 patients showed no difference in the cause-specific survival for any histological type of ovarian cancer [12].

Why Perform a Surgical Staging If There Is No Visible Metastatic Disease?

A thorough surgical staging is necessary to determine the surgical stage, potential for fertility preservation, and need for chemotherapy.

1. Is fertility preservation possible?
   - Fertility-desiring patients with a surgical stage IA can be treated by unilateral salpingo-oophorectomy (USO). Their survival is similar to patients with hysterectomy and contralateral adnexectomy. In an early series of 52 patients with stage IA and IC (previous FIGO classification) undergoing USO and complete surgical staging, the 5- and 10-year survival rates were 98% and 93%, respectively [13]. These findings have been duplicated in more recent studies [14].
2. Chemotherapy. About one third of patients with an apparent stage I ovarian cancer are upstaged after surgical staging. The finding of a single metastatic implant (Fig. 19.19) eliminates fertility preservation, constitutes a surgical stage III, mandates chemotherapy, and lowers survival.

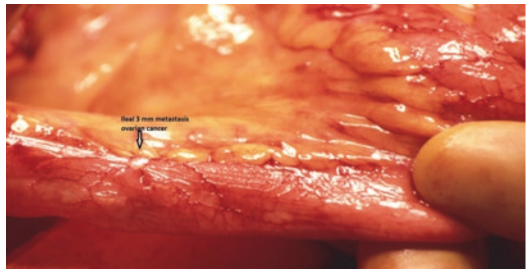

Fig. 19.19 A single abdominal metastasis in ovarian cancer changes the stage from I to III, the chemotherapy, and the prognosis. This is a major benefit of the surgical staging

Delaying Surgical Stage

Delaying the staging or definitive therapy may result in a more advanced stage at reoperation. When the delay is longer than 6 weeks, chemotherapy is indicated for patients with grade 2 and 3 tumors.

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20 Management of Complications

Ghiara A. Lugo Diaz, Mikel Gorostidi Pulgar, and Pedro F. Escobar

Introduction

The use of laparoscopy and the number of physicians trained to perform laparoscopy are in an increasing trend. Laparoscopy-related complications are seen in 0.1–10% of cases, with 50% occurring during abdominal entry [1]. It is estimated that 1:4 of complications are not recognized intraoperatively. A laparoscopic complication is defined as any undesirable result that would have not occurred if the surgery went as desired [1]. In this chapter, we describe the most commonly encountered laparoscopic complications including their diagnosis and treatment.

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Entry-Related Complications

Multiple laparoscopic techniques exist that allow access to the abdominal cavity with no difference in the rate of entry injuries. Laparoscopic entry injuries include hernias, urinary tract, vascular, visceral, and nerve injuries. The majority of entry injuries (50–65%) occur with the insertion of the first trocar. It is essential to avoid premature Trendelenburg positioning during trocar entry since this leads to a distortion of normal anatomy and brings retroperitoneal structures to closer proximity, increasing the probability of bowel or vascular injury [1]. Secondary trocar insertion is associated with 35–50% of injuries.

Abdominal entry techniques are classified as closed or open. The first closed technique or Veress needle involves entering the peritoneal cavity blindly, creating a pneumoperitoneum, and then punctuating the fascia and peritoneum with the trocar. The second closed technique or direct trocar entry involves the insertion of an optical trocar along with a laparoscope before insufflation of the peritoneal cavity. The open or Hasson technique involves identifying and opening the fascia and peritoneum followed by insertion of a blunt trocar under direct visualization. After two failed attempts of Veress needle insertion, or in patients with prior abdominal surgery, a left upper quadrant entry technique or entry at Palmer's point should be attempted (Figs. 20.1 and 20.2) [1].

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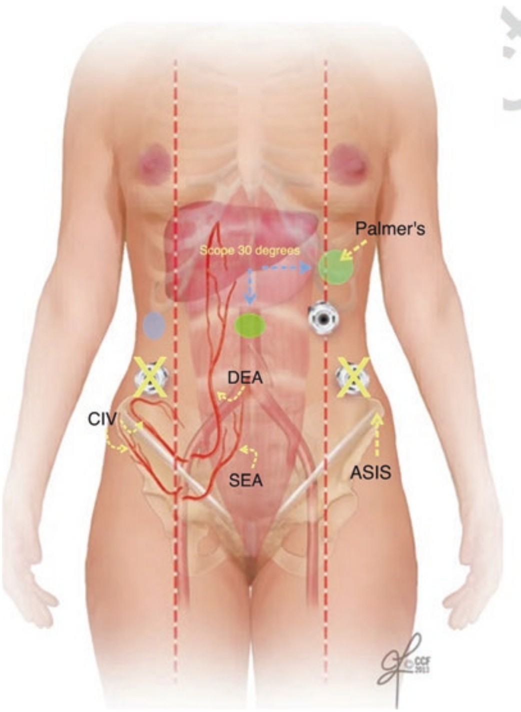

Fig. 20.1 Trendelenburg positioning during trocar entry may lead to a distortion of normal anatomy and brings retroperitoneal structures to closer proximity, increasing the probability of vascular injury

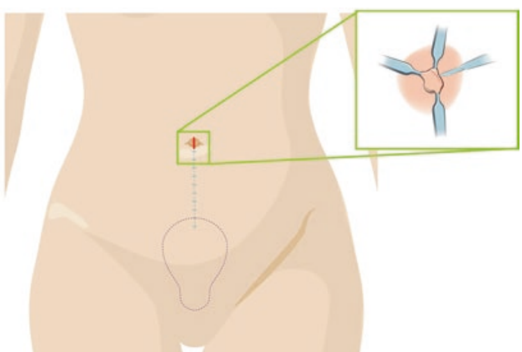

Fig. 20.2 Surface landmarks anatomy and trocar placement. ASIS, anterior superior iliac spine. SEA, superficial inferior epigastric artery. DEA, deep inferior epigastric artery. CIV, superficial circumflex iliac artery and vein

Studies have not demonstrated one entry technique to be superior to the other in terms of preventing bowel or vascular injuries. A recent 2019 Cochrane Database review including 57 randomized control trials and 9865 participants did not find differences in major vascular or visceral complications between different laparoscopic techniques analyzed [2]. However, evidence demonstrates a reduction in failed entry with the use of direct trocar entry techniques in comparison to the Veress needle technique (OR 0.24) [2].

Vascular Complications

Vascular injuries are one of the most serious complications of laparoscopic surgery with an incidence of 0.01–1%. The mortality rate can be up to 15% [3]. They occur most commonly during initial abdominal entry. Recent meta-analyses have not demonstrated differences in the incidence of vascular injuries between different entry techniques [4]. They are divided into major and minor injuries. Injuries to the aorta, inferior vena cava, and iliac vessels compromise the major vascular injuries, while injuries to the abdominal wall and mesentery compromise the minor vessels. Pelvic surgeons should also be aware of vascular malformations and anatomic variations in the pelvis. This can occur in any organ or tissue, including the female pelvis, and can often cause significant morbidity if injured during dissection or entry (Fig. 20.3).

Major Vascular Injuries

Major vascular injuries are rare and may occur due to a loss of perception for the proximity of

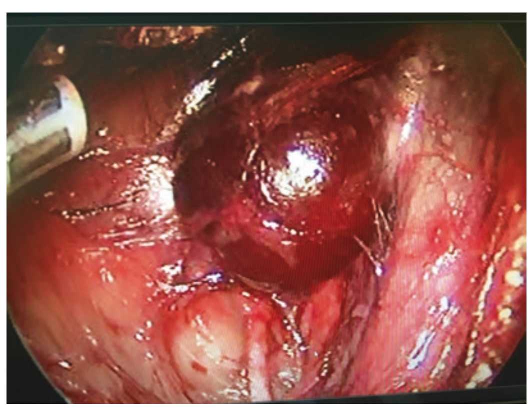

Fig. 20.3 External iliac vein - vascular anomaly

important vascular structures to the anterior abdominal wall. When gaining access to the peritoneal structure, it is important to be aware of the anatomic relationship between the umbilicus and retroperitoneal vessels. The majority of vascular injuries are arterial, with aortic and common iliac artery injuries occurring most commonly. They occur mainly during initial abdominal access using Veress needle or primary trocar placement [3]. It is important to consider the patient's weight before trocar placement. In nonobese women, it is recommended that instruments be inserted through the umbilicus at a 45 angle at which the abdominal wall thickness ranges from 2 to 3 cm to allow successful intraperitoneal trocar placement while minimizing the risk of vessel injury. In obese patients, when trocars are inserted at a 45-degree angle, the abdominal wall thickness is 11 cm, while at 90°, the distance between the umbilicus and the retroperitoneal structures is greater than 13 cm. Thus, it is recommended that instruments be inserted through the umbilicus closer to 90°. It is important to keep the patient in the horizontal position, avoiding the Trendelenburg position during trocar placement to avoid vessel injury. Trendelenburg's position typically elevates the patient's feet 30°; thus, placing a trocar at 45° will result in inserting the instrument at 75° which can result in serious injuries (Fig. 20.4) [5].

Major vascular injuries are typically diagnosed intraoperatively and require rapid recognition and intervention due to their high mortality rate. Injuries involving the Veress needle or trocar may be recognized from the backflow of blood through the needle or trocar sheath. Lacerations to retroperitoneal vessels typically result in brisk bleeding or expanding hematoma. If the patient becomes hemodynamically unstable, the major vascular injury should be considered (Fig. 20.5).

In case of a major vascular injury, the site of injury should be immediately tamponade with a blunt laparoscopic instrument. If the bleeding occurred as a result of trocar placement, resulting in a puncture into a major vessel, the instrument should be left in place. The anesthesia team should be notified promptly for fluid resuscitation and transfusion. Vascular surgery should be notified if available. The laparoscope should remain away from the bleeding source to prevent loss of vision and time [1].

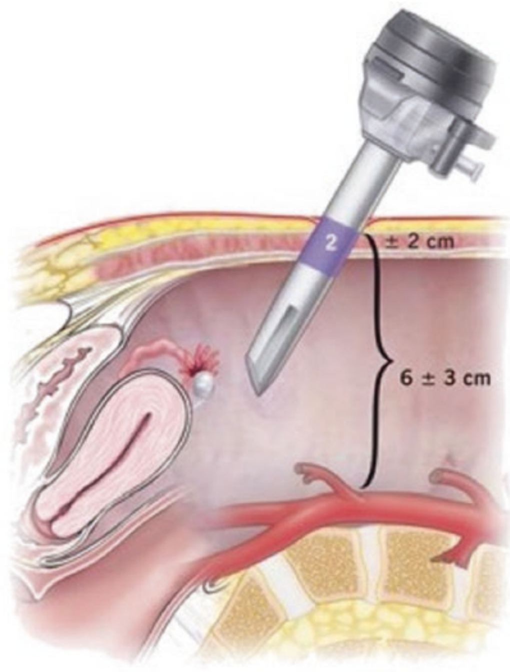

Fig. 20.4 Angle of trocar insertion, body weight and retroperitoneal major vessels

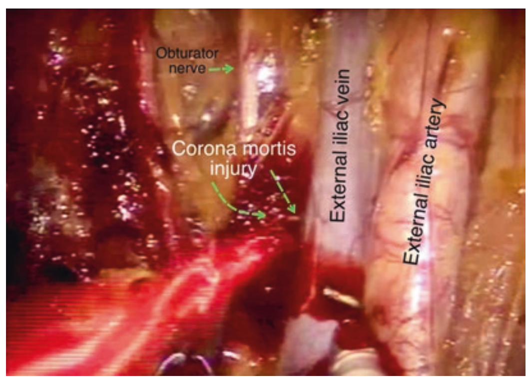

Fig. 20.5 Corona mortis injury – an anatomical variant, an anastomosis between the obturator and the external iliac or inferior epigastric arteries or veins

Injuries of arterial origin are more frequent and easier to visualize. If repair is necessary, it is advised to start with a periarterial or adventitial grasp, preferably passing the needle from the inside out, using a non-absorbable monofilament suture, and giving the points on the direction of the flow from afferent to efferent [1]. Injuries of venous origin are less frequent and difficult to repair. It is important to maintain adequate euvolemic control as a hyper hydrated patient will worsen the bleeding, while a dehydrated patient will have a less venous return, making it easier to suture. Removing the pneumatic compression stockings or transitorily decreasing intraabdominal pressure to 20–25 mmHg will decrease the venous return, aiding to control the bleeding and repair the defect (Fig. 20.6) [1].

Minor Vascular Injuries

Minor vascular injuries typically occur from lateral trocar placement. They occur with an incidence of 0.5%, and it is less frequent with the use of blunt versus sharp cutting trocars [3]. The inferior epigastric artery is the most commonly injured vessel, but omental and mesenteric vessels may also be injured. Secondary trocars should be placed lateral to the rectus sheath to avoid vessel injury.

Damage to the inferior epigastric vessels can be recognized by bleeding from the trocar site into the abdomen or from a local hematoma formation. Identification of the bleeding site is

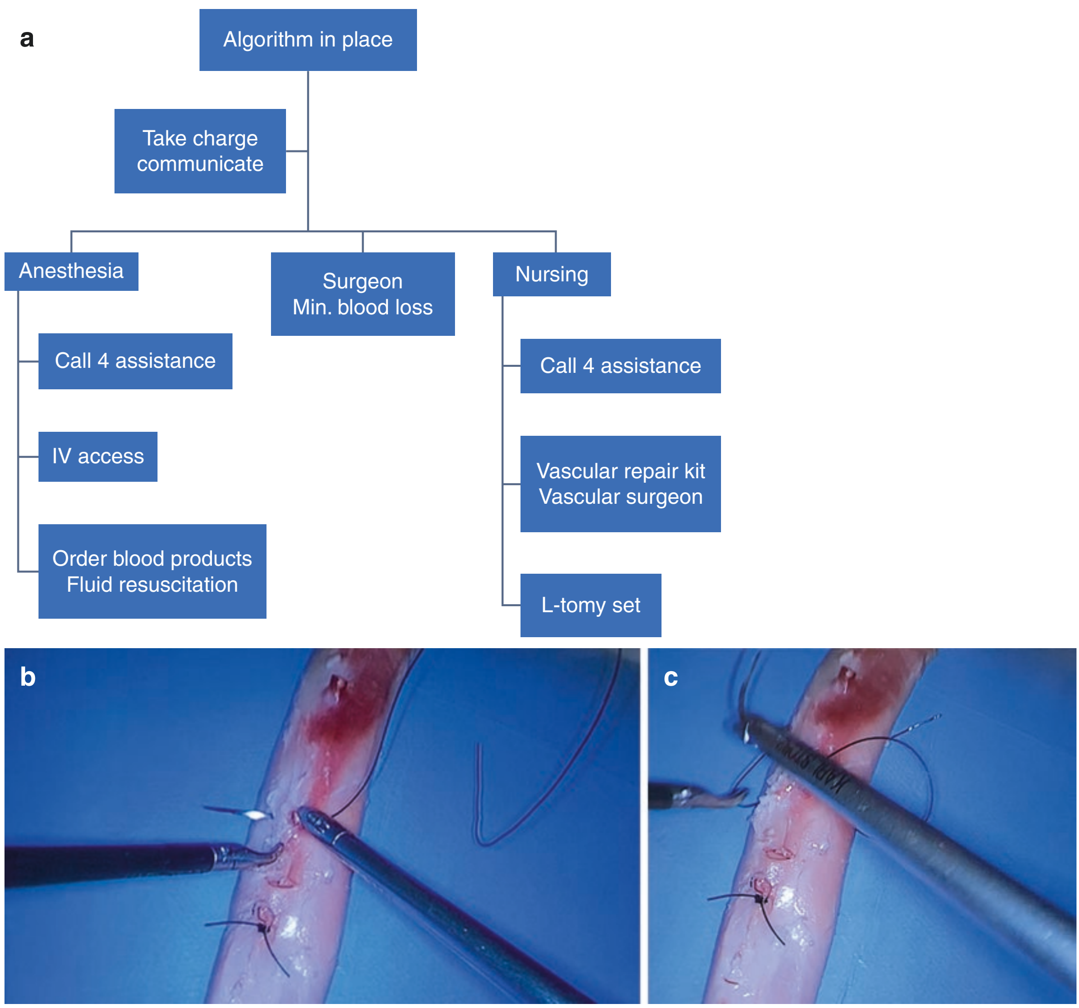

Fig. 20.6 (**a**) Proposed major vascular injury algorithm. (**b**, **c**) Vascular repair simulation swine model – animal lab

essential to coagulate or clip the bleeding vessel. A Foley catheter may also be inserted through the trocar site and the balloon inflated to tamponade the vessel.

In some cases, the injury may not be diagnosed intraoperatively. Patients present postoperatively with severe pain around the trocar site, ecchymosis, and a palpable mass, which may resemble a rectus sheath hematoma. The patient should be followed by a serial CBC to monitor hemoglobin and hematocrit levels. Hemodynamically stable patients can be managed conservatively. Patients who are hemodynamically unstable, present with a decreasing hematocrit level or expanding hematoma, should be taken to the OR for wound exploration and ligation of the bleeding vessels [6].

Urinary Tract Injuries

Bladder Injuries

The most common type of bladder injury is perforation and occurs more commonly during laparoscopic total hysterectomy [7]. Bladder injury can result from Veress needle placement, which typically results in a small puncture, or from trocar insertion that typically leads to larger injuries. Placement of a midline suprapubic trocar can result in significant damage, especially if the bladder was not catheterized or Foley was not placed before surgery. Bladder injuries can also result from thermal injury caused by electrocautery during the separation of the bladder from the lower uterine segment during a hysterectomy. Thus, insertion of a Foley catheter before making an abdominal incision is essential.

Bladder injury can be diagnosed intraoperatively by CO_2 distension of the urinary drainage bag or from bloody urine. It can also be evident if the bulb of the foley is palpated in the surgical field or if extravasation of urine is noticed. If bladder injury is suspected, instillation of indigo carmine, sterile milk, or methylene blue into the bladder may aid in diagnosis and helps delineate the extent of the injury. Thermal injuries may be difficult to detect and may not be apparent until several days after surgery. Delayed diagnosis of bladder injury should be suspected when a patient presents with anuria, abdominal pain, distention, and elevated creatinine levels. In such cases, a cystogram is recommended for diagnosis. Small defects can be treated with bladder decompression leaving a Foley in place, while larger defects may require surgical repair.

Bladder injuries resulting from Veress needle placement typically result in 3–5-mm punctures to the dome and are not repaired as they resolve spontaneously with bladder decompression for 7–10 days. Larger injuries (>1 cm) require repair with one or two running layers of 3-0 absorbable sutures. The first layer is intended to approximate the mucosa and muscularis, while the second layer closes the serosa for reinforcement [1]. Injuries involving the trigone typically require more time to heal. Foley should be left in place 4–14 days, and a cystogram should be performed before removal to ensure adequate epithelization. Urology should be consulted if the surgeon does not have expertise with bladder injuries.

Ureteral Injuries

Ureteral injuries during a laparoscopic hysterectomy can occur at three sites: at its proximity to the uterine artery, during dissection of the infundibulopelvic ligament, or from its proximity to the uterosacral ligament [1, 3]. These lesions occur most commonly at the level of cardinal ligament, where the ureter passes beneath the uterine artery. At this point, the ureter passes usually less than 1 cm away from the uterine artery and 1.5 cm lateral to the cervix. Adequate traction using the uterine manipulator can increase this distance by 1 cm to adequately transect the uterine arteries without damage to the ureters [1]. At the level of the infundibulopelvic ligament, the ureter crosses over the pelvic brim and common iliac vessels and courses into the pelvis along with the medial leaf of the broad ligament.

Ureteral injuries can result from transection, devascularization, crush, or electrothermal damage. Several techniques can aid in preventing ureteral injury. A thorough understanding of pelvic anatomy is a must, and knowledge of the patient's surgical history can aid the surgeon in preparing a surgical plan and being prepared for distorted anatomy. The American Association for Gynecology Laparoscopists cites an 80–90% sensitivity when using intraoperative cystoscopy for the detection of ureteral trauma and recommends that cystoscopy be available when performing laparoscopic hysterectomies.

Instillation of indigo carmine (blue dye) can aid in diagnosis. If no peritoneal extravasation is noted, then a cystoscopy should be performed. This will aid the surgeon identified a crushed, "tied ureters" vs. a complete transection injury. A brisk efflux of dye should be observed from the bilateral ureteral orifices. If a sluggish efflux is seen, this may be suggestive of injury. Ureteral stents can also aid in the diagnosis and/or management of ureteral injuries.

If a ureteral injury is diagnosed during surgery, urology should be consulted. The type of repair depends on the location and extent of the injury. Ureteroureterostomy is performed for injuries that involve the upper third of the ureter, ureteroureterostomy with tension-free is used for lesions involving the middle third, and ureteroneocystostomy is used for lesions close to the bladder. Stenting can be used in the case of partial thermal injuries and partial lacerations [6]. Lesions involving complete ligation, crush injuries, and thermal injuries usually require complete resection of the involved segment [6, 8].

Gastrointestinal Tract Injuries

Visceral injuries are life-threatening complications carrying an incidence of 0.1% and a mortality rate of 3.6%. Many go unrecognized at the time of surgery, with delayed diagnosis increasing its mortality rate to up to 20–25% [1]. The small intestines are the most frequently injured, followed by the colon, rectosigmoid, stomach, and duodenum [1]. In contrast, a recent systematic review by Picerno et al. demonstrated that the overall incidence of bowel injury in robotic-assisted gynecologic surgery is 1 in 160 [9]. When the location of bowel injuries was specified, they most commonly occur in the colon and rectum, and most were managed via a minimally invasive approach (Fig. 20.7).

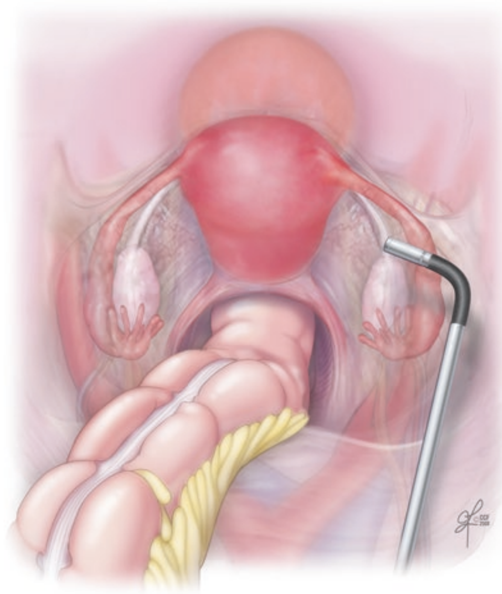

Fig. 20.7 Sigmoid colon and rectum

Injury and Prevention

Most bowel injuries occur upon initial Veress needle or trocar entry; however, other injuries may occur from dissection during lysis of adhesions, from thermal injury when using monopolar or bipolar energy, or from inadequate tissue handling and tension during dissection [10]. Approximately one-third of injuries occur following abdominal entry [3, 11]. Of women that presented with bowel injury, 87% had adhesive disease at the time of surgery, mainly secondary to endometriosis [11]. Risk factors include previous surgical history, radiotherapy, the extent of the current disease, and surgeons' expertise (Figs. 20.8 and 20.9) [1].

In patients with suspected adhesive disease from previous abdominal surgeries, it is recommended to use open entry techniques (Hasson method) or entry by Palmer's point as Veress needle placement can increase the risk of bowel

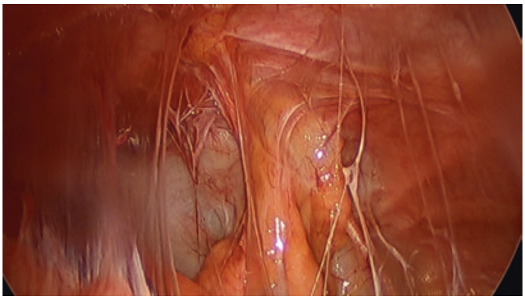

Fig. 20.8 Adhesive disease at the time of surgery, mainly secondary to endometriosis

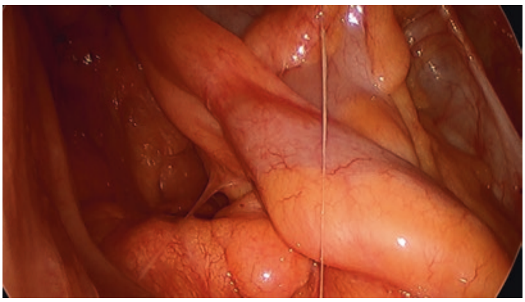

Fig. 20.9 Adhesive disease after radiation

injury. Regardless, no clear strategy has been devised to improve the abdominal entry process, and the literature does not appear to support one entry type (open Hasson vs closed Veress/trocar). What is definitive is that obtaining abdominal access via Veress needle or upon trocar insertion appears to be a relatively high-risk critical step in MIS gynecologic procedures as it accounted for the majority of reported mechanisms [9].

Preoperative surgical imaging is critical for complex cases and unfortunately underutilized. Tu et al. demonstrated that utilization of preoperative abdominal ultrasound readily available in most operating rooms detected the presence and absence of bowel adhesions in patients with previous abdominal operations or infections [12]. This technique may assist in avoiding iatrogenic bowel injury upon establishment of pneumoperitoneum.

Injury to the stomach occurs most commonly during Veress or trocar placement. The risk of stomach injury increases with the use of Palmer's point or with a distended stomach. Placement of an orogastric or nasogastric tube before starting the surgery aids in decompressing the stomach and decreasing stomach injury [6].

Care should be taken to avoid electrosurgical injury. Direct contact of the instrument with the bowel should be avoided as well as prolonged activation of the electrode as it increases the risk of capacitive coupling. The electrode should only be activated when in contact with the target tissue and under direct visualization. Areas to be cauterized should be isolated from surrounding tissue to avoid injury from direct burns or coupling to surrounding organs. Finally, the use of scissors for cutting bowel adhesions should be considered.

Diagnosis and Management

Most bowel injuries go unrecognized at the time of surgery. Prognosis is dependent on prompt recognition, as mortality increases when the diagnosis is delayed >72 hours postoperatively. Signs of visceral injury during Veress needle placement include aspiration of feces, asymmetric abdominal distention, or high initial insufflation pressure (although this can result from insufflation of preperitoneal space). If an injury is suspected, secondary trocars should be placed and a camera directed to the initial trocar site to evaluate for injury. An abdominopelvic survey should follow to assess for bleeding or bowel content leakage.

If a small bowel injury is discovered during surgery, the entire bowel should be run and inspected to rule out other sites of injury. If a rectosigmoid injury is suspected, a bowel integrity test or "flat tire" test should be performed. This test consists of filling the pelvis with sterile water and then injecting air into the rectum using a 60 mL bulb syringe. Then the sigmoid should be laparoscopically compressed proximally with a blunt probe to keep the air distal. If the rectosigmoid injury is present, bubbles will be observed in the fluid-filled pelvis. Another diagnostic test consists of filling the rectum with indigo-carmine-stained saline. If blue dye spillage is observed, perforation is confirmed, and immediate reparation should follow.

Penetrating injuries usually present within 24–48 hours, while thermic injuries may not manifest until 4–10 days postoperatively. Initial symptoms are typically nonspecific and include nausea, vomiting, abdominal distention, or severe pain. Low-grade fever, leukopenia, or leukocytosis may be present, and patients can go on to develop peritonitis or septic shock. An abdominal radiograph may not be helpful as pneumoperitoneum can be observed up to 2 weeks following laparoscopy, although an increasing amount of free air can be suggestive of viscus perforation [6]. An abdominopelvic computed tomography with oral contrast may demonstrate leakage of contrast into the peritoneum. If imaging studies are inconclusive but clinical suspicion is high, a diagnostic laparoscopy should be considered as well as a general surgery consult.

Treatment

If a lesion is recognized intraoperatively, it should be repaired immediately; the cavity should be irrigated and antibiotics administered. A puncture from Veress needle can be managed expectantly if no bleeding is noticed. For larger injuries, the type of repair will depend on the extent of the lesion and may include primary repair or resection and anastomosis [1]. Small lesions may be repaired laparoscopically, but larger lesions may require conversion to laparotomy, observed in 52–90% of cases, and consult to general surgeon is recommended [3]. The final repair should be one without tension, with good vascularization and integrity.

Small intestinal injuries are repaired in two layers perpendicular to the long axis of the bowel to avoid stricture formation. The injured bowel can be exteriorized through a laparoscopic incision and repaired extracorporeally. One type of repair includes repairing the mucosa and muscularis with delayed absorbable suture in an interrupted fashion followed by the closure of the serosal layer using silk suture. Bowel resection and anastomosis are recommended if the laceration is found to be greater than one-half the diameter of the small bowel [9].

Thermal injuries can cause major damage as coagulation necrosis and capillary ingrowth may occur in normal-appearing tissue. Repair with broader resection 1–2 cm beyond visible damage should ensure the removal of all potentially necrotized and damaged tissue [10].

Injuries to the stomach, other than those caused by the Veress needle, require repair with two layers of an absorbable suture. The abdominal cavity should be thoroughly irrigated to avoid damage caused by gastric juices, and a nasogastric tube should remain in place after surgery [10].

The presence of gross fecal material in the abdominal cavity should not affect treatment intraoperatively. Studies have not shown an increased risk of infection with gross fecal contamination.

Trocar Site Hernias

Trocar site hernias occur in 1.9–3.2% of cases and are related to improper or no closure of the facia [1]. They have been associated with procedures involving endostaples, single or multiple ports, and ports of greater diameter. Personal risk factors that may contribute to trocar site hernias are obesity, chronic cough, diabetes mellitus, smoking, history of a previous hernia, and prolonged surgery time [1]. Most are Richter-type hernias, which involve the peritoneum alone or the peritoneum and the fascia. Bowel incarceration is a risk factor with trocar site hernias which can lead to necrosis, peritonitis, and ischemia [3]. Patients present with nausea, vomiting, abdominal distention, fever, and acute abdomen. Diagnosis can be confirmed with a CT or ultrasound. The repair can be performed by laparoscopy or laparotomy. If bowel incarceration occurred, the bowel should be run to assess for injury. Risk can be reduced with fascial closure of trocars >10 mm and removal of trocars under direct visualization to ensure no herniation of peritoneal contents occurred [1, 3].

Urinary Tract Fistulas

Fistulas are long-term, postoperative complications. Patients commonly complain of urine in the vagina or incontinence. Fistulas usually arise from urologic or intestinal lesions that go unnoticed during surgery or from thermic injuries causing necrosis [1]. Diagnosis can be made using Pyridium orally or dyed fluids, indigo carmine, or methylene blue, instilled into the bladder followed by placing a tampon into the vagina. When the tampon is removed an hour later, the presence of blue staining is consistent with a vesicovaginal fistula, while orange staining is suggestive of a ureterovaginal fistula. Repair is usually delayed for 2–6 months and consists of identifying and resecting the fistulous tract, obtaining healthy tissue, and suturing in two to three layers while interposing health tissue between both cavities [1].

Nerve Injuries

Nerve injuries result from incorrect patient positioning or shifting during surgery. Risk factors include a steep Trendelenburg position, medial placement of hands, long operative times, obesity, and frequent adjustment of the legs. The brachial plexus and ulnar nerves are commonly injured upper extremity nerves. Brachial plexus neuropathy occurs in 0.16% from the abduction of the arms and shoulder [13]. Injuries are associated with compression, stretching, and inflammation of the cervical branches of the brachial plexus [13]. Symptoms include pain, paresthesia, and weakness of the entire upper extremity. Ulnar nerve injuries result from lateral elbow compression against the arm board. Patients present with numbness and tingling in the fourth and fifth digits, elbow and hand weakness, and atrophy.

The femoral, sciatic, and peroneal nerves are lower extremity nerves that may be injured secondary to patient positioning. Femoral nerve injury can result from hyperflexion of the leg causing compression against the inguinal ligament or from stretching the leg if externally rotated. Patients will complain of weakness of the quadriceps muscle and problems walking and climbing stairs. Decreased patellar reflex will be observed on physical exam. Sciatic nerve injuries occur secondary to leg stretch with high lithotomy position or from nerve compression in prolonged procedures. Common symptoms include posterior leg pain and weakness. Peroneal nerve injury occurs from the compression of the lateral knee against the stirrup where the nerve crosses the head of the fibula. Symptoms include foot drop and weakness and/or numbness of the dorsal foot.

Reevaluating patient positioning periodically during surgery can help reduce nerve injuries. Upper extremity injuries can be prevented by tucking the arms in the military position and padding the elbow, wrist, and hands.

When placing the patient in a lithotomy position, it is essential to maintain the ankle aligned with the knee and far shoulder to avoid lower extremity injuries. In addition, the hip angle should not be more than 170°. The knee should be flexed from 90° to 120°, and the angle between the legs should be less than 90°. Nerve injuries are treated supportively as muscles take 3–4 months to regenerate. Physical therapy is the mainstay of therapy to maintain an adequate range of motion and muscle strength. Neuropathic pain modulators can be used for pain management. The patient should be referred to a neurologist if no improvement is seen (Fig. 20.10).

Colpotomy Dehiscence

Colpotomy dehiscence is a complication of vaginal cuff closure following a hysterectomy. It occurs with an incidence of 0.7% when performed vaginally versus 1.3% when performed using minimally invasive techniques. Studies have not shown differences in the rate of dehiscence when using continuous versus interrupted sutures. Risk factors include advanced age, medical conditions that result in increased intraabdominal pressure, or chemotherapy/radiotherapy. It is recommended to avoid sexual intercourse for

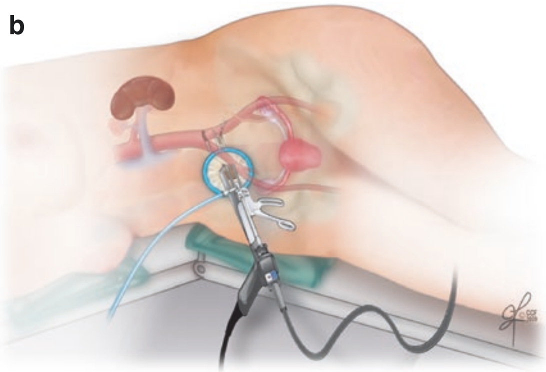

Fig. 20.10 (**a**) Positioning neurovascular injuries are known complications of minimally invasive pelvic surgery. Optimal patient position, padding, "no" pressure points, and a team approach should be implemented in the OR to minimized risk factors. (**b**) Positioning neurovascular injuries are known complications of minimally invasive pelvic surgery. Optimal patient position, padding, "no" pressure points, and a team approach should be implemented in the OR to minimized risk factors

6–8 weeks following a hysterectomy. Patients typically present after surgery with foul-smelling vaginal discharge, vaginal bleeding, pelvic pain, and pressure in the vagina. The small bowel, specifically the distal ileum, is the most common eviscerated organ through the vagina and can lead to necrosis, perforation, peritonitis, and sepsis. The evisceration of bowel content is a surgical emergency. The type of surgery will depend on the viability and type of tissue eviscerated. It consists of reducing the abdominal content that has been eviscerated, assessing its viability, followed by segmental resection if a vascular compromise is present. The vaginal defect is repaired using non-absorbable sutures. If no intestinal lesions present, a vaginal repair of the defect is preferred [1].

Mortality Related to Laparoscopy

Mortality is a rare complication of laparoscopic surgery with a mortality rate of 4.4 per 100,000 laparoscopies [3]. Mortality is mainly associated with the surgical extent of the operative procedure. Surgical complications and risks of anesthesia are the main causes of mortality. Vascular and intestinal complications are the most common complications of surgery associated with mortality.

Conclusion

Complications related to laparoscopic surgery are rare but may occur in increasing frequency due to a rising number of obese women and patients with previous abdominal surgeries. Around 50% of laparoscopic-related complications occur during abdominal entry, and 20–25% may not be recognized until the postoperative period. A thorough understanding of surgical complications is essential in their prevention and management. Proper preoperative management and a thoughtful surgical technique can aid in preventing these complications.

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21 Novel Technology in Robotic Surgery

Mahmoud Abou Zeinab and Jihad Kaouk

Introduction

In 2000, the United States Food and Drug Administration (FDA) approved the use of the first robotic platform in surgical procedures, starting a new era in the minimally invasive surgery world. The da Vinci Surgical System platform (Intuitive Surgical, Inc.; Sunnyvale, CA) has been widely adopted by most surgical fields all around the world. With the three-dimensional (3D) image and articulated instrument arms, this platform overcame many of the limitations of laparoscopic surgery [1]. Single-site robotic surgery was then developed to show potential advantages in terms of the recovery period, postoperative pain, and cosmesis compared to other techniques [2]. Despite these potential advantages, inherent technical challenges such as external clashing between robotic arms and inadequate triangulation limited the use of this approach [2]. Recent innovations has led to the development of the purpose-built single-port (SP) robotic platform, the da Vinci Single-Port (SP) (Intuitive Surgical, Sunnyvale, CA), FDA approved for use in urology patients in 2018 and otolaryngology in 2019. Since its introduction, a wide range of successful urological and other procedures were performed with encouraging outcomes [3]. This chapter introduces the SP platform and focuses on its implications in urological procedures among other specialties.

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SP Platform

Setup

The SP da Vinci® platform consists of three essential components: the patient cart, the surgeon console, and the vision cart (Fig. 21.1). Being the console and vision cart similar to the earlier da Vinci platforms, the patient cart has a unique architecture (Fig. 21.2). Using the same and single 27-mm entry space (single arm), lodge three 6-mm articulating, double-jointed instruments and an 8-mm articulating, double-jointed, flexible camera, mimicking the human elbow and wrist (Fig. 21.3). Each of these instruments occupies a quadrant (12, 3, 6, and 9 o'clock) in that space and can be rotated and switched independently around the clock. Moreover, the single arm with all the instruments can rotate 360° around the surgical field, allowing for various surgical positions and multi-quadrant procedures (Fig. 21.4).

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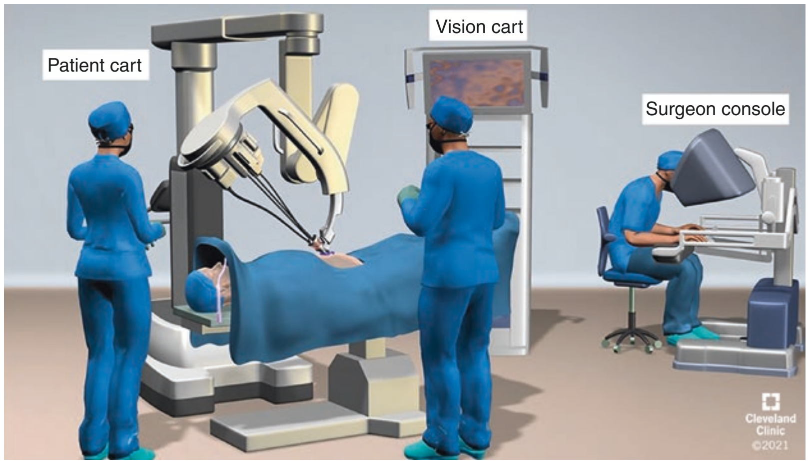

Fig. 21.1 The SP robot setup: the patient cart, vision cart, and surgeon console

Fig. 21.2 The single-arm architecture of the SP robot

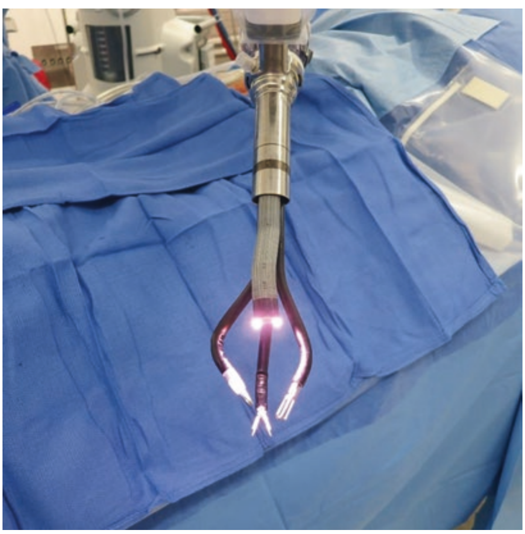

Fig. 21.3 The double joint feature of the SP camera and instruments

Instruments and Toolbox

The instruments compose of Maryland bipolar forceps, monopolar electrosurgery, needle driver, monopolar curved scissors, and medium-large clip applier. The SP® System toolbox consists of a da Vinci SP trocar, 25-mm multichannel cannula, and 12-mm accessory laparoscopic port (Fig. 21.5). We currently use the ROSI (Remotely Operated Suction Irrigation, Vascular Technology Inc., Nashua, NH) suction device in our procedures, it is directly accessed through the access port using the same incision and controlled by the console surgeon.

Access Port and Floating Dock Technique

To further increase the working space and avoid internal clashing of the instruments, we developed the "floating dock technique" [4]. Using the Alexis® wound retractor and a GelPoint Mini (Applied Medical, Rancho Santa Margarita, CA, USA) (Fig. 21.6a), the working space was increased by 390%, a significant improvement, especially in shallow surgical spaces [4]. Intuitive Surgical launched later on a new "bubble port," a built-in floating technique that is currently being used in different SP institutions (Fig. 21.6b).

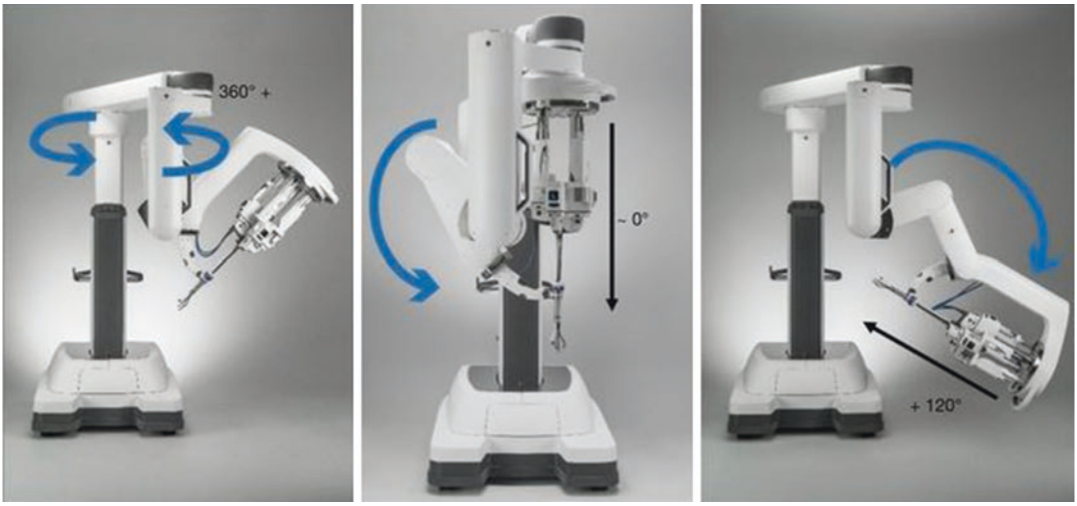

Fig. 21.4 The multi-quadrant feature of the SP robot

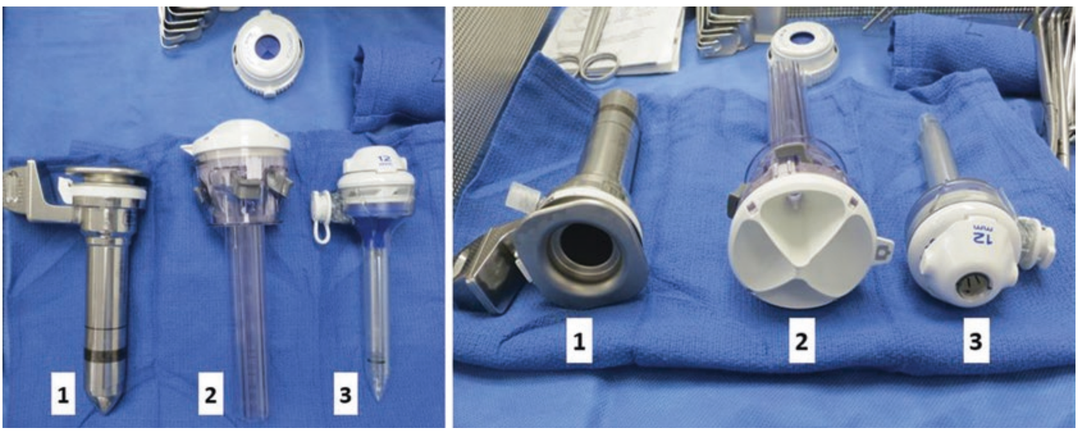

Fig. 21.5 The da Vinci SP toolbox. (1) SP trocar. (2) 25-mm multichannel cannula. (3) 12-mm laparoscopic port

Why SP?

For every innovation to succeed and get adopted, it needs to prove superiority and beneficence to the field it is added to. A new surgical robot must have an added value, a purpose for its use in the surgical field compared to existing surgical platforms. Knowing that the conventional multiport robot (MP) played a major role in the minimally invasive surgery world in terms of decreased morbidity and faster recovery. The single-port robot, a purpose-built robot, was introduced as a key to making minimally invasive surgery even less invasive, with potential decreased morbidity, increased surgeon ergonomics, and faster patient recovery. Moreover, the fact that the SP robot has a single arm, with instruments sharing a single small incision, allows for procedures in narrow surgical fields such as extraperitoneal, retroperitoneal, perineal, vaginal, anal, oral, and axillary approaches [3, 5, 6]. These approaches would be more challenging if performed by the conventional multiport robot.

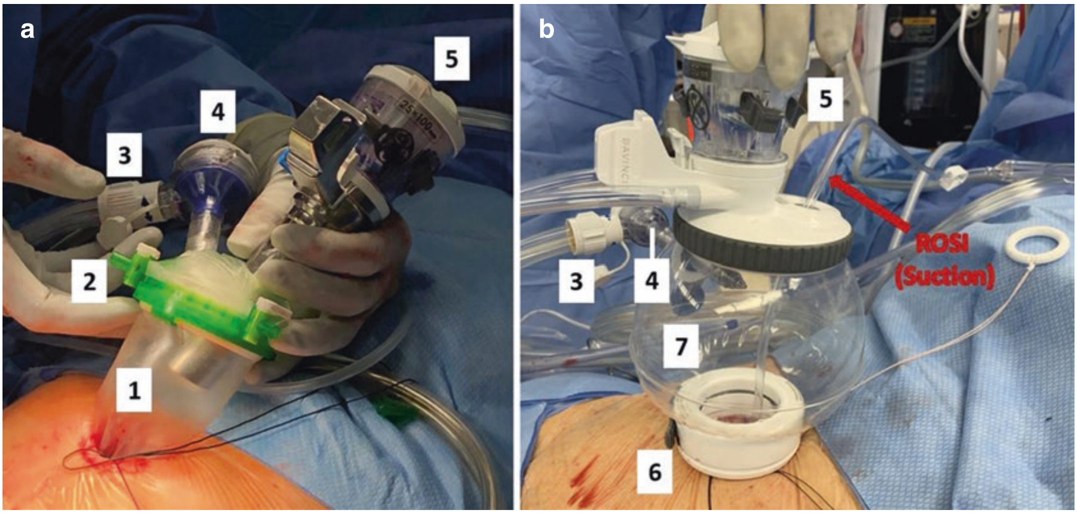

Fig. 21.6 The "floating dock" technique (**a**) vs the new da Vinci Access Port® (**b**). (1) Alexis wound retractor. (2) Gelseal cap. (3) Air seal. (4) 12-mm laparoscopic port. (5) 25-mm multichannel cannula. (6) da Vinci wound retractor. (7) da Vinci Access Port

Preclinical Experience

Before any application of the SP in humans, the system was thoroughly assessed in preclinical setups to determine the feasibility and safety of this platform [5, 7–11].

Clinical Experience

The SP platform became widely used after its FDA approval in 2018. Due to its narrow working space and excellent preclinical and clinical outcomes, this platform was adopted in preclinical and clinical studies by different surgical specialties including urology, otorhinolaryngology, plastic surgery, general and colorectal surgery, gynecology, and thoracic surgery. We focus here on the different applications of SP robot in urological procedures among other specialties, including data outcomes, advantages, and disadvantages.

SP Radical Prostatectomy

Radical prostatectomy is the gold standard treatment approach for clinically localized prostate cancer. In the last decade, robotic-assisted laparoscopic prostatectomy (RARP) has been significantly improved the outcomes of patients with localized prostate cancer (PCa). Using the da Vinci SP robot, different approaches were adopted in RARP, with the hopes of decreasing the perioperative burden of the patients. We discuss here the various surgical approaches used in RARP using the purpose-built SP robot (Fig. 21.7). We also mention the advantages and disadvantages of every approach used.

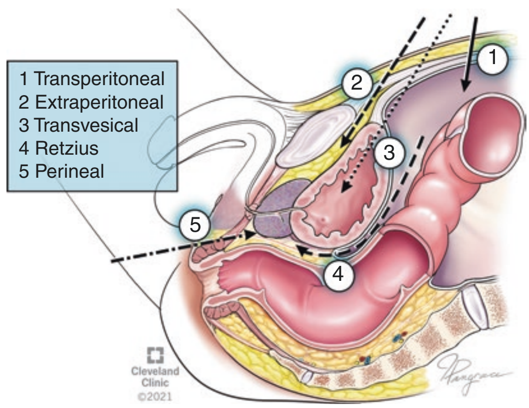

Fig. 21.7 The different possible approaches in RARP

Transperitoneal Approach

This approach is the first to be adopted using the new SP robot. The surgical steps are the same as the multiport platform hence decreasing the burden of the new learning curve [12].

Advantages: Vigneswaran et al. reported no significant differences in surgical or total operating time but a decrease in postoperative pain and hospital stay in the SP RARP compared to the MP RARP [13].

Disadvantages: Patients are in Trendelburg's position during the procedure, and the prostate is accessed using the peritoneal cavity. These challenges are originally faced in the MP RARP and were not resolved using the new SP RARP.

Extraperitoneal Approach

To potentially improve patient outcomes, the SP extraperitoneal RARP using the extraperitoneal space was introduced and became widely used (Figs. 21.8 and 21.9).

Advantages: The advantages of the extraperitoneal approach are significant and well-reported in earlier comparative studies to the standard MP experience [13–17]. By avoiding the peritoneal cavity, the need for a steep Trendelenburg position is not required anymore, resulting in decreased intraoperative, respiratory, or intraocular complications as well as a reduced risk of hernia formation in the postoperative phase. Moreover, a significant decrease in pain score was reported in the SP extraperitoneal patients, with around 50% fewer opioid use compared to the MP RARP. These many benefits sum to a reduction in operative time and hospital stay (from 1–2 days to same-day discharge in 95% of the cases) without any oncological compromise.

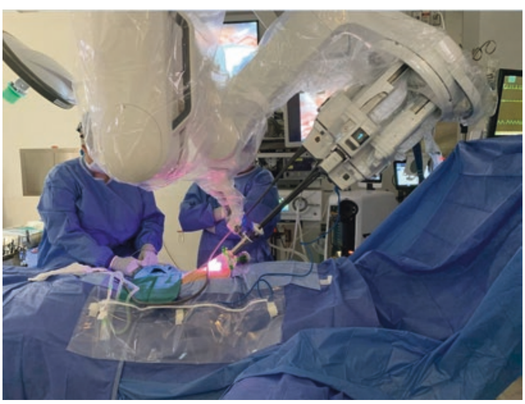

Fig. 21.8 The SP robot docked in extraperitoneal RARP

Disadvantages: The extraperitoneal approach results in greater rates of symptomatic lymphoceles, likely related to the confined space [17]. To avoid such complications, our technique was adjusted to include fenestration of the peritoneum at the end of the procedure, to allow lymphatic fluid resorption, a step that lowered the rate of lymphoceles to zero. Despite the exceedingly favorable early outcomes, the recency of this approach requires a longer follow-up to evaluate future oncologic and functional outcomes.

Transvesical Approach

This is the latest innovative approach using the SP robot. Using a 3.5-cm suprapubic incision, the bladder is directly accessed and the prostate is removed (Fig. 21.10). This approach is used for either simple prostatectomy or radical prostatectomy. Simple prostatectomy is a procedure performed when the prostatic gland is enormously enlarged, nonmalignant, and causing severe lower urinary tract to the patient, nonresponsive otherwise to medical or other surgical treatment [18]. In the simple prostatectomy, the prostatic adenoma is only removed while preserving the prostatic capsule. Transvesical radical prostatectomy, however, is performed for localized PCa, while the capsule is included in the dissection and lymph node dissection is usually performed in indicated cases.

Advantages: The fact that the surgery is performed by direct access to the bladder and avoiding the peritoneal cavity and Retzius space implies numerous advantages. First, patients with a hostile abdomen, with extensive past abdominal surgeries for which transperitoneal or extraperitoneal access is not possible, are candidates for this approach. Second, the patient is in the supine position during the procedure and thus

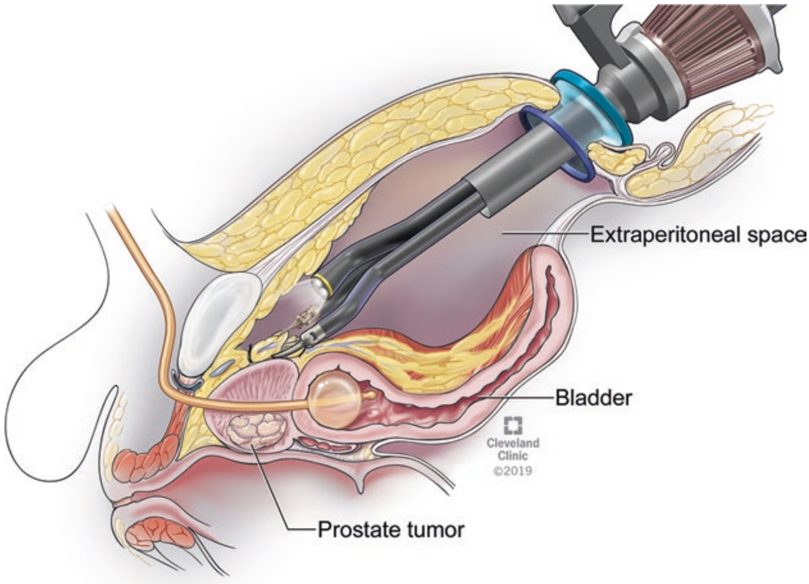

Fig. 21.9 Illustration of the extraperitoneal RARP approach

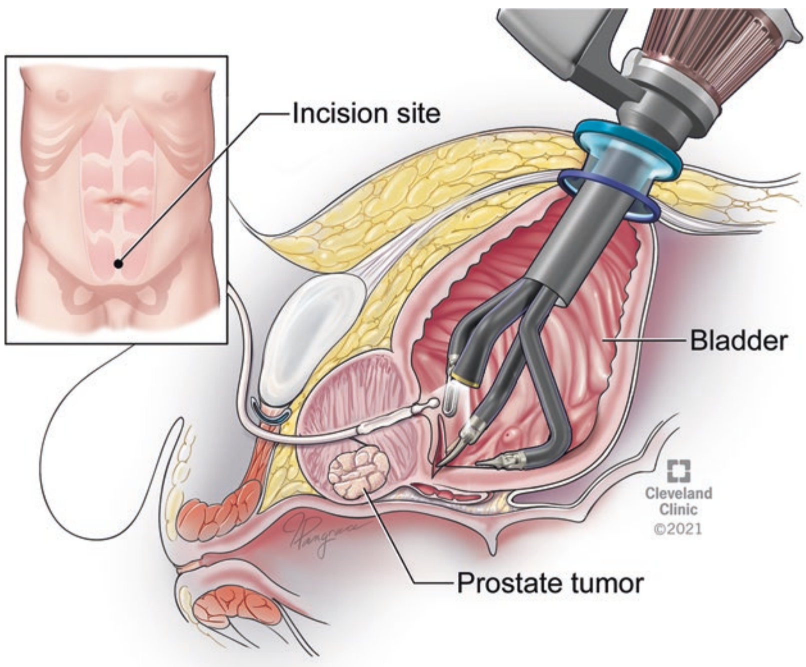

Fig. 21.10 Illustration of the transvesical RARP approach

avoiding the risks of the Trendelenburg position discussed earlier. Third, using this approach allows for minimal intraoperative blood loss, minimal to no pain in the postoperative phase, not requiring any opioid use, and same-day hospital discharge rendering this surgery an outpatient procedure. Fourth, the Foley catheter is removed 3 days after the surgery, with a more than 65% rate of immediate continence, and more than 75% of the patients were fully continent within 7 days after Foley catheter removal [19]. Fifth, limited lymph node dissection is performed in indicated cases, with similar, if not less positive, surgical margins than other surgical

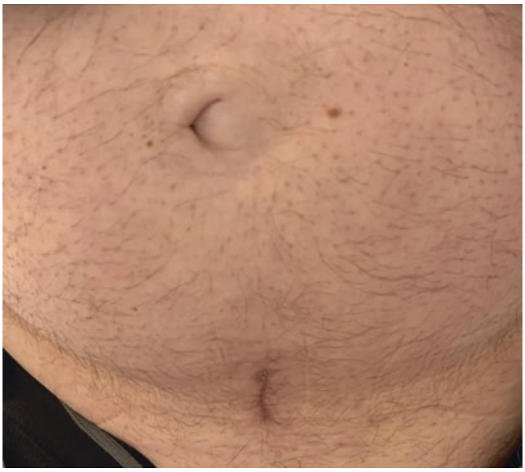

Fig. 21.11 Photograph of the abdomen 6 weeks post-transvesical RARP

approaches. Sixth, in our early series, very few low-grade, easily managed, complications occurred. Finally, patients are very satisfied in terms of functional and cosmetic outcomes (Fig. 21.11).

Disadvantages: Despite the many advantages of this technique, limited sample size and short follow-up data are available in the literature. Future studies with larger samples sizes are needed to validate our results. Also, limited lymph node dissection is feasible in the current setup; thus, we limit the inclusion criteria to patients with a low risk of lymph node metastasis.

Retzius-Sparing Approach

Limited preclinical and clinical work is done on the Retzius space-sparing radical prostatectomy. After incising the posterior peritoneum, the prostate is reached posteriorly and dissected [20, 21].

Advantages: The early experience demonstrated that the SP platform is safe and suitable for the Retzius-sparing approach in terms of access, maneuverability, and early continence results [21].

Disadvantages: Very limited data is published about Retzius-sparing approach. More studies are needed for result validation, reproducibility of this technique, and functional and oncological outcomes.

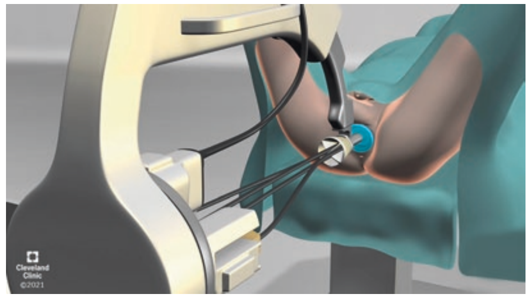

Fig. 21.12 Illustration of the transperineal RARP

Transperineal Approach

The perineal radical prostatectomy was first performed by Hugh Hampton Young in 1904 and considered the preferred surgical approach for PCa. SP perineal RARP is considered an alternative approach for select patients who are not candidates for traditional retropubic approaches, significant surgical adhesions from previous abdominal, or pelvic surgeries for example (Fig. 21.12).

Advantages: The fact of using one single incision and avoiding Trendelenburg position allows for reduced perioperative morbidity, improved oncologic early continence outcomes due to the preservation of the Retzius space, as well as equivalent oncologic outcomes [22, 23]. Moreover, this approach allows for easier pelvic lymph node dissection.

Disadvantages: The SP perineal approach is considered a challenging procedure that necessitates a surgeon's experience and learning curve.

Upper Tract Urological Procedures

The multi-quadrant feature of the SP platform allows to perform a partial nephrectomy using single retroperitoneal access, irrespective of the kidney tumor location. Likewise, a pyeloplasty

Fig. 21.13 SP retroperitoneal robotic partial nephrectomy

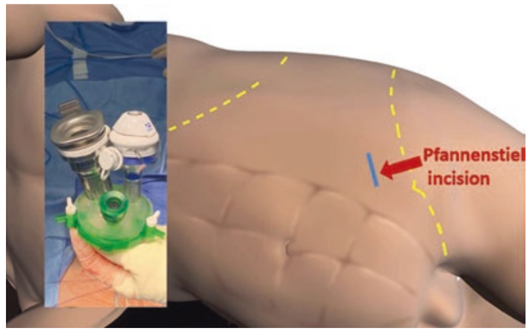

Fig. 21.14 SP pyeloplasty through a Pfannenstiel incision

through a single Pfannenstiel abdominal incision can be performed.

SP Retroperitoneal Robotic Partial Nephrectomy

The patient is placed in a lateral flank position, and the procedure is performed using a 2.5-cm incision above the anterior superior iliac spine, over the anterior axillary line (Fig. 21.13).

Advantages: Using the SP platform allows to approach different tumors (exophytic or endophytic) in various locations (upper, interpolar, or lower pole) [24]. Also, the fact that the instruments have a double articulating design allows for less instruments clashing compared to the multiarm robot [25–27].

Disadvantages: In general SP robot instruments tend to have weaker grasping strength compared to the standard multiport robot, resulting in difficulty loading, applying, or removing the standard robotic bulldog. Moreover, robot SP retroperitoneal partial nephrectomy is a complex procedure that necessitates a surgeon's experience and learning curve.

SP Pyeloplasty Using a Pfannenstiel Abdominal Incision

The patient is placed in a lateral flank position. A 2.5-cm transverse incision over the ipsilateral tubercle is performed, and the robot is docked (Fig. 21.14).

Advantages: Given a small, single incision, patients have minimal to no pain in the postoperative phase, shorter hospital stay, faster recovery, and excellent cosmetic results [28, 29]. Moreover, being a non-bulky, multi-quadrant platform makes it a suitable treatment of choice for the pediatric population.

Disadvantages: The SP pyeloplasty using the Pfannestiel approach is a novel procedure that might be challenging during the early phase of implementation, a fact that entails the surgeon's experience and more comparative studies with other platforms.

SP Robotic-Assisted Kidney Transplantation and Autotransplantation

The implementation of the SP platform at our institution, along with promising results, encouraged us to go even further with this innovation to reach the field of kidney transplantation. SP kidney transplantation is indicated for patients with end-stage renal disease, while SP kidney autotransplantation is performed in patients with chronic renal pain and complex or proximal ureteral stenosis (Fig. 21.15). The patient is in a supine position, with slight lateral rotation and Trendelenburg angulation. Using the extraperitoneal approach, the SP robot is docked through a 5-cm midline periumbilical abdominal incision [30].

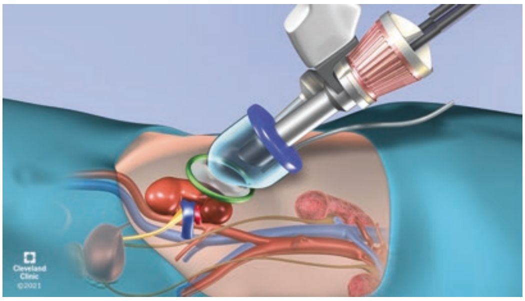

Fig. 21.15 Illustration of the robotic transplantation and autotransplantation

Advantages: SP kidney transplantation and autotransplantation are complex procedures that involve dual, upper tract, and pelvic procedures (kaouk, Transplantation). The low-profile SP platform with its multi-quadrant ability permits to perform this procedure without any need for robot repositioning or undocking, an issue faced in the multiport robotic kidney transplantation. Excellent early results were reported so far in terms of perioperative outcomes, shorter hospital stay, and faster recovery compared to the open or standard multiport approaches [30].

Disadvantages: Very limited data on these procedures are available in the literature. Future larger samples studies, longer follow-up, and comparative studies are needed to validate these results.

Applications in Other Fields and Specialties

After many successful preclinical and clinical work in many urological procedures, the SP da Vinci was adopted by many other fields with excellent and promising outcomes. The first specialty to get FDA approval after urology was otolaryngology for certain transoral procedures such as tonsils and tongue surgeries. Other specialties are still in their preclinical or early clinical stages. We summarize here the different fields where the SP robot is implemented.

Urology

In addition to the procedures described earlier in this chapter, SP robotic-assisted peritoneal flap gender-affirming vaginoplasty (RPGAV) was performed and provides shorter operative time, improved surgeon visualization, and more room for the perineal surgeon to operate [31].

Otolaryngology

Various procedures were achieved using the SP platform including transoral tonsillectomy, tongue tumor resection, hypopharyngectomy, Sialolith removal, thyroidectomy, and preclinical transmaxillary tumor resection [6, 32–34].

Plastic and Reconstructive Surgery

Nipple-sparing mastectomy using the axillary (clinical) or umbilical (preclinical) approach and omentum lymphatic transplant were performed through the SP platform [5, 35].

General and Colorectal Surgery

A case report of SP pediatric splenectomy using Pfannenstiel incision was shown to decrease postoperative pain, eliminate the risk of splenosis, and have superior cosmetic results compared with the traditional open or multiport platforms [36]. Other applications were SP cholecystectomy, hemicolectomy, and transanal resection of rectal tumors, with similar promising outcomes [37–39].

Gynecologic Surgery

In 2000, the first case of robotic surgery in gynecology was reported, a tubal anastomosis [40]. FDA approved the use of the da Vinci® robot for gynecologic surgery in 2005. Many early case series of SP transumbilical hysterectomy were performed lately with excellent results including same-day discharge and minimal to no complications [41, 42].

Thoracic and Cardiovascular Surgery

Preclinical data is available on transcervical esophagectomy successfully performed [43].

Conclusion

Single-port robotic surgery is an emerging and rapidly adopted platform in the urology community, along with many other surgical fields. The SP robot shares unique features that distinguish it from other platforms: a single arm, single incision, double-wristed instruments, and a multi-quadrant feature. This allows for the expansion of the surgical options for poor candidates or patients requiring multi-quadrant surgery compared to other platforms. Likewise, these features allow for excellent and promising outcomes such as shorter hospital stays, minimal pain, no narcotics use, limited complication rate, and faster recovery, without any functional or oncologic compromise. The learning curve with SP robotic surgery may be challenging in the early phases of the implementation of this new system. More clinical trials and comparative studies are required to further assess and validate the outcomes of this innovation.

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