Evaluation and Management of Common Intraoperative and Postoperative Complications in Gynecologic Endoscopy

Brittany Lees, MD*, Jubilee Brown, MD

KEYWORDS

• Complications • Injury • Laparoscopy

KEY POINTS

- Safe trocar placement is essential to avoid injury, and immediate recognition of trocar injury is essential.
- Urologic injury can involve the bladder or ureters and must be recognized and repaired immediately to avoid more complex repairs or urinoma or fistula formation.
- Bowel injury may be subtle, and delayed presentation is common. Vigilance in the postoperative setting is necessary to diagnose injury and allow timely repair.

INTRODUCTION

Laparoscopy was first pioneered by Jacobaeus in the early 1900s, and it has evolved to include a variety of specialized platforms and techniques, including conventional laparoscopy, single-incision laparoscopy, and robotics.[1] A recent review article reported complication rates using a variety of definitions and concluded that adverse events are reported to occur between 0.2% and 18% of conventional gynecologic laparoscopy and 3% and 15% of robot-assisted gynecologic procedures. Although major complication rates were similar between laparotomy and laparoscopy, there was a lower incidence of minor complications at 15.2% versus 4.3% to 8.9%, respectively.[2] The relatively low complication rates make some details difficult to study. This article seeks to highlight the most current complication rates, outline steps toward prevention of complications, and detail management of key complications related to minimally invasive surgery (MIS) in gynecology.

Division of Gynecologic Oncology, Levine Cancer Institute at Atrium Health, 1021 Morehead Medical Drive, Suite 2100, Charlotte, NC 28204, USA
* Corresponding author.
E-mail address: brittany.lees@atriumhealth.org

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LAPAROSCOPIC ENTRY

A majority of laparoscopic complications occur at the time of intraabdominal entry. Complications include injury to structures, such as the bowel, bladder, or liver; preperitoneal insufflation; failure to achieve pneumoperitoneum; and puncture of the pregnant uterus.[3–6] The risk of vascular injury at the time of entry is approximately 3 per 1000 surgical case.[7] Bowel injury incidence ranges between 0.13% and 0.54%, with 37.3% to 55% occurring during entry. Although 75% of injuries are to the small bowel, colonic injury or gastric perforation also can occur.[8]

Techniques for abdominal entry include Veress needle placement, direct optical entry, and the open or Hasson technique. Each of these entry techniques can be utilized in the umbilical, supraumbilical, or left-upper quadrant (Palmer point) areas, and the location typically is chosen based on avoiding areas of prior surgery or avoiding the area of a large adnexal or uterine mass. Each technique and location have individual pros and cons that require careful review of patient anatomy and prior surgical history.

The Veress needle has an external diameter of 2 mm and, therefore, is smaller compared with 5 mm to 12 mm for other trocars. Thus, any resultant injury is smaller than with other entry techniques.[9] Direct visualization and open (or Hasson) entry techniques have overall low rates of reported complications and theoretically seem safer by avoiding blind entry. Despite the purported advantages of individual techniques, a 2019 Cochrane Review reported insufficient evidence to demonstrate differences in the rates of failed entry, vascular injury, visceral injury, or other major complications between open-entry and closed-entry techniques.[10] There also was insufficient evidence to demonstrate differences in the rates of vascular or visceral injury between direct vision entry and Veress needle entry. The reviewers noted moderate evidence for a reduction in risk of failed entry with direct trocar insertion compared with Veress needle access, but the data were not limited to gynecologic cases, and many of the studies included in the review excluded patients with a high body mass index (BMI) and previous abdominal surgery[9] (**Table 1**).

Abdominal Wall Injuries

Abdominal wall injuries at the time of trocar insertion include vascular injury to the inferior epigastric artery and neuropathy secondary to injury to the iliohypogastric and ilioinguinal nerves. A thorough understanding of anatomy is important to avoid either complication.

Injury to the inferior epigastric artery has an incidence of approximately 3 per 1000 surgical cases.[7] Prevention of injury involves vascular identification and avoiding trocar placement along its expected route. Cadaveric studies have demonstrated many potential origins of the inferior epigastric artery; it typically arises from the external iliac artery but also can arise from the femoral or obturator artery.[11] The first key step to avoiding injury is identification of the inferior epigastric vessels through direct laparoscopic inspection of the anterior abdominal wall after initial port placement, but this may not be possible in the setting of high BMI.[7,12] In general, placement of lateral trocars greater than 7 cm from the midline helps to avoid injury. Care should be taken to not track medially on the fascia at the time of entry (see **Table 1**). Techniques to manage incidental inferior epigastric arterial injury include direct bipolar coagulation or sealing of the vessel, tension with a balloon trocar, placement of a foley catheter balloon with pressure to tamponade, cut-down below the rectus muscle to achieve direct ligation of the vessel superior and inferior to the injury, and laparoscopic suture ligation of the vessel superior and inferior to the injury, either with a laparoscopic straight ligature carrier, laparoscopic ligation, or temporary mattress suture placement[13] (**Table 2**).

Table 1
Techniques to avoid complications

Category of Injury	Strategy to Avoid Injury
Trocar insertion	Direct entry has decrease in failure rate compared with Veress entry No other comparative advantage for any specific technique
Inferior epigastric vessels	Transillumination Direct inspection Placement of trocar >7 cm lateral to midline
Ilioinguinal or iliohypogastric nerve	Placement of lateral trocars ≥2 cm above and medial to ASIS
Vascular injury (aorta/vena cava)	Initial trocar insertion at an angle appropriate for the patient's BMI Initial trocar insertion with the operating table flat
Bowel injury	Insert trocars at a relaxed, level position Thorough understanding of anatomy and surgical history Review prior operative reports prior to deciding on entry site Consider access in right upper quadrant with orogastric tube in place for any patient with prior midline or periumbilical surgery
Trocar site hernia	Close fascia at any port site ≥10 mm
Bladder injury	Backfill bladder when necessary to define location Lateral approach to dissection when significant scarring
Ureteral injury	Careful anatomic dissection and identification Cephalad displacement of the uterine manipulator Maintain surgical dissection fundal to the manipulator ring Consider stents or lighted stents in select cases
Neurologic injury	Careful positioning, padding, avoid extreme extension/flexion Clear identification of obturator nerve in obturator space
VCD	Laparoscopic closure has lower risk than vaginal closure Minimize cautery artifact Sutures should be ≥5 mm deep and ≤5 mm apart
Port site metastasis	Avoid repeated removal and replacement of trocars Use containment systems for cancer-containing specimens

Rates of injury to the ilioinguinal and iliohypogastric nerves are not well documented, and overall neurologic injury is cited at less than 2%, but one study showed injury to these nerves as high as 4.9% when fascial closure is required in lateral port sites.[14,15] Preventing injury is challenging because the nerves cannot be visualized directly, so knowledge of anatomy is essential to prevent injury to these nerves. A study of cadavers identified the ilioinguinal nerve to be located an average of 3.1 cm medial and 3.7 cm inferior to the anterior superior iliac spine (ASIS). The iliohypogastric nerve was located within 2.1 cm medial and 0.9 cm inferior to the ASIS.[16] Therefore, placement of the lateral tracers at least 2 cm above and medial to the ASIS should avoid incidental nerve injury (see **Table 1**). Injury to these nerves typically

Table 2
Management of laparoscopic complications

Category of Injury	Management Strategy
Inferior epigastric vessels	Direct bipolar coagulation or sealing of the vessel Tamponade with a balloon trocar or Foley catheter Laparoscopic suture placement proximal and distal to the injury Direct ligation with cut-down
Ilioinguinal or iliohypogastric nerve	Supportive care Release of surrounding sutures Trigger point injections
Vascular injury (aorta/vena cava)	Emergent laparotomy (in most cases)
Bowel injury	Immediate repair with possible resection and reanastomosis Observation in some cases of injury <2 mm with a Veress needle
Trocar site hernia	Reduce hernia and surgically repair fascia
Bladder injury	Double-layer watertight closure with absorbable suture Postoperative Foley catheter placement No antibiotics indicated
Ureteral injury	Dependent on type and location of injury
Neurologic injury	Supportive care, physical therapy, analgesics Direct repair for transections (eg, obturator nerve)
VCD	Immediate repair, typically through vaginal approach Consider laparoscopic or abdominal evaluation in select cases

manifests as a burning or sharp pain in the location of the port site that is not responsive to narcotic therapy. Management depends on the degree of discomfort and suspected cause of injury. Typically, medical management with neuropathic pain medications or lidocaine, and time improves symptoms. If no improvement and a fascial stitch is suspected as the source, however, surgical intervention for stitch removal should be considered[15] (see **Table 2**).

Vascular Injuries

Deeper vessels also can be injured with laparoscopic entry but are rare, with a rate of 0.2/1000 procedures.[17] Any periumbilical entry technique requires consideration of the varying anatomic layout of the bifurcation of the aorta and vena cava, depending on body habitus. The bifurcation of the aorta in thin patients often is just deep to the umbilicus, whereas in obese patients the bifurcation often is cephalad to the umbilicus.[18] Therefore, the operating table should be flat (no Trendelenburg), and insertion of the Veress needle or optical trocar must be at a 30º angle in patients with a normal BMI and must be vertical in obese patients to avoid injury to the great vessels (see **Table 1**). If the great vessels are pierced with either the Veress needle or a trocar, emergent laparotomy is indicated for immediate repair, because this situation can be catastrophic (see **Table 2**). It is imperative to alert the anesthesia team and operating room staff, obtain blood products, begin fluid resuscitation, hold compression to minimize further volume depletion, and engage in primary repair or consult vascular surgery, depending on the surgeon's skills.

Mesenteric or omental vascular injury also can occur at time of trocar placement. Such injuries can be prevented through meticulous technique with appropriate pressure upon entry, avoiding areas of prior surgical incisions, and using an upper abdominal entry site. Management may include observation once additional ports are placed, coagulation with a sealing device, or suture ligation of the injured vessel, but care should be taken to avoid bowel injury during repair. Hemostasis must be confirmed under low or no pressure before the case is completed.[17]

Bowel Injuries

The incidence of bowel injury is 0.13% to 0.54%, and one-third to one-half of these injuries occur at the time of laparoscopic entry. Although 75% of injuries are to the small bowel, colonic injury or gastric perforation also can occur. The mortality rate from gastrointestinal injury is as high as 3.6%.[19] Regardless of entry technique, having the patient in the appropriate relaxed, level position and a thorough understanding of anatomy and surgical history should be considered prior to proceeding with entry. Consideration should be given to access in the right upper quadrant for any patient with prior midline or periumbilical surgery. Previous operative reports should be reviewed prior to a decision on initial port site placement (see **Table 1**).

The most important part of minimizing morbidity and mortality from bowel injury is intraoperative recognition. Unfortunately, 41% of bowel injuries are identified in a delayed manner.[19] In order to help ensure recognition, the camera should look directly at the bowel in the vector of entry to ensure no injury, and, prior to exiting the case, the camera should be inserted through a secondary port and the site of entry should be inspected. If an injury is identified or the entry is difficulty, the surgeon should ensure there has not been a through and through perforation across both sides of the bowel lumen. Injury from Veress insertion may be indicated by foul smelling gas through the needle, reflux of bowel contents through the Veress needle, high insufflation pressures, or asymmetrical abdominal distension.[20] A small 2 mm Veress perforation may not require repair.[21,22] Trocar injuries which are larger in caliber, have irregular borders, or are leaking bowel contents require immediate repair or resection with reanastamosis (see **Table 2**). The decision to proceed with laparoscopic versus open repair is dependent on surgeon preference and expertise. Specific surgical repair techniques are beyond the scope of this review.

An additional trocar-related gastrointestinal injury is postoperative port site hernia formation, which has an incidence of 0.17% to 1.5%.[23,24] Hernias rarely occur in ports that are smaller than 10 mm and usually are limited to port sites with a diameter of at least 10 mm. Therefore, prevention of port site hernias requires fascial closure of any port site greater than or equal to 10 mm at the completion of the case.[25–28] Although recommended, such fascial closure does not negate the possibility of port site herniation.[24] Single-incision laparoscopic techniques, also employed in gynecologic surgery, require a larger midline incision and have a higher rate of incisional hernia.[29] The use of bladeless trocars also protects against hernia formation, as a systematic review demonstrated lower rates of port site herniation with bladeless trocars24 (see **Table 1**). Diagnosis of a port site hernia is suggested by pain at the site, nausea or vomiting, tenderness, and a bulge on physical examination. Presentation can mirror that of a partial small bowel obstruction or ileus. Computerized tomography (CT) scan findings can confirm clinical suspicion. Management requires surgical reduction of the hernia and fascial repair; bowel resection is limited to cases in which the bowel has been strangulated or devascularized with compromised viability.[30] Incarcerated hernias require emergent surgery (see **Table 2**).

GASTROINTESTINAL INJURIES

The incidence of bowel injury during MIS is 0.13% to 0.54%,[19] with most injuries occurring to the small bowel. In addition to injury during abdominal entry or trocar placement, bowel injuries can occur during dissection. Risk factors include the presence of adhesions, prior surgeries with resultant distorted anatomy, and tumor or endometriotic implants involving the bowel.

The key to prevention is the use of meticulous sharp dissection without cautery when operating near the small or large bowel. Thermal injury can occur even without adhesive disease or direct dissection due to lateral thermal spread of energy devices or incidental contact with a hot instrument.

It is imperative to have a high level of suspicion for bowel injury, particularly when significant enterolysis is performed. An intraoperative bubble test can be performed to exclude either small or large bowel injury. To evaluate the rectosigmoid, saline is instilled into the pelvis, and the large bowel is occluded gently with pressure cephalad to the area of presumed injury; air is instilled into the rectum with a proctoscope or bulb suction; and the pool of saline is inspected for air bubbles as the colon expands with insufflation. A lack of bubbles is reassuring but does not guarantee the lack of a thermal injury or deserosalization. To evaluate the small bowel, saline is instilled into the abdomen or pelvis; the area of bowel with the suspected injury is submerged in the saline pool with bowel graspers. Small bowel contents are pushed across the area and the pool of saline is inspected for air bubbles or succus.

Bowel injuries less than 1 cm typically can be repaired with interrupted, delayed, absorbable sutures placed perpendicular to the axis of the bowel to avoid stricture. Full-thickness injuries require a double-layer closure. Larger injuries and most thermal injuries require resection with reanastamosis. Repair can be performed laparoscopically or the patient can be converted to a small mini-laparotomy or a larger laparotomy depending on the surgeon's expertise, location of the injury, and mobility of the affected area of the bowel.[31]

Bowel injury potentially can be catastrophic when not recognized intraoperatively.[31] Postoperatively, patients present with nausea, vomiting, pain, fever, abdominal pain or distention, and/or leukocytosis. It is imperative that any concerning symptoms be investigated with CT of the abdomen and pelvis with oral and IV contrast. If a perforation is identified, immediate surgical exploration usually is indicated with a washout and repair of the affected area. Colostomy or protective ileostomy may be indicated, depending on the type and location of injury[31] (see **Table 2**).

UROLOGIC INJURIES

The anatomic locations of the ureter and bladder in the pelvis lead to a higher risk of injury in gynecologic surgery compared with other types of surgery. The risk of urinary tract injury is estimated at 0.33% for all benign gynecologic conditions and up to 1% with laparoscopic hysterectomy.[32–34] Bladder injuries are slightly more common than ureteral injuries, with a rate estimated at 0.24% (range, 0.05%–1.8%) for all benign gynecologic conditions and 0.66% with laparoscopic hysterectomy (range, 0.05%–1.8%).[21,22] Ureteral injuries are estimated to occur in 0.02% to 1.5% of laparoscopic gynecologic procedures.[22,32,35–37]

Bladder Injury

Because the urinary bladder sits anterior to the uterus and cervix, injuries typically occur following extensive lysis of adhesions, such as in women with multiple prior cesarean or other pelvic surgeries.[38] Risk factors also include endometriosis, urinary

tract anomalies, prior pelvic irradiation, uterine size over 250 g, and obesity. Certain indications for surgery also increase the risk of injury, including prolapse, urinary incontinence, leiomyomata, or a large pelvic mass.[35,38] It is controversial whether cancer surgery is an independent risk factor for urologic injury.[35]

Cystotomies typically are recognized intraoperatively and occur most often at the dome of the bladder. Strategies for prevention focus on intraoperative identification of the bladder. This can be performed by filling the bladder with saline or carbon dioxide in order to distend it and better identify its borders. In the setting of significant fibrosis, a lateral approach to dissection can help identify a clear plane for dissection that is not embedded in scar tissue (see **Table 1**). Bladder injury can be obvious when there is large cystotomy with visualization of Foley balloon. Occult bladder injury can present with hematuria, distended Foley bag, or extravasation of urine in the surgical field.[39] Concern for bladder injury should be investigated intraoperatively by backfilling the bladder through the Foley catheter with 300 mL of methylene blue or indigo carmine diluted with saline. Sterile milk also may be used. Cystoscopy may help identify a smaller perforation, bleeding, or suture within the bladder.[39]

When injuries involve the dome of the bladder, the size of the defect dictates management. Defects less than 2 mm can be managed expectantly. Defects between 2 mm and 10 mm can be managed with repair or with catheter drainage for 5 days to 7 days. Defects over 1 cm require repair. Repair typically can be performed laparoscopically by experienced surgeons, as long as there is adequate visualization and there is no involvement of the trigone or bladder neck. Repair is performed with 2 layers of absorbable suture (3-0 then 2-0 Vicryl or Monocryl) placed full thickness to incorporate the bladder mucosa. This double-layer closure incorporates the mucosa in the first layer and an imbricating suture of the muscularis over the second layer. Sutures can be either interrupted or running, and barbed suture also is acceptable. The repair should be watertight and tested for integrity with retrograde fill of the bladder prior to completion of the laparoscopic portion of the procedure. A Foley catheter should remain postoperatively for 5 days to 14 days, depending on the size and location of the injury, because re-epithelialization occurs in 3 days to 4 days and normal strength is regained by 21 days[40] (see **Table 2**). Limited data support the use of postoperative antibiotic use.[41,42] Prior to catheter removal, a CT cystogram and a voiding trial may be performed.

Ureteral Injury

Ureteral injuries, although less common than bladder injuries, are diagnosed more frequently postoperatively and often are the result of thermal injury or suture entrapment.[33] The three most common locations of ureteral injury are the pelvic brim during transection of the infundibulopelvic ligament and ligation of the gonadal (ovarian) vessels, the cardinal ligament near the uterine vessels during dissection or coagulation of the uterine vessels, and the ureterovesical junction during bladder dissection or vaginal cuff closure. Ureters also can be devascularized during extensive ureterolysis.

Transperitoneal visualization and/or retroperitoneal dissection and identification of the ureter throughout its course during surgery are the keys to prevention of ureteral injury during gynecologic surgery. When ligating the gonadal vessels, often a retroperitoneal approach with a window made between the gonadal vessels, and the ureter allows the surgeon to cauterize the vessels with adequate space from the ureter to avoid injury. Although the ureter is typically approximately 2 cm anterolateral to the cervix, it can be as close as 0.5 cm in some women.[43] Vermiculation must be visualized to ensure that the ureter is identified accurately. The surgeon must take care to stay above the level of the cervicovaginal junction, a location that corresponds to

the delineation of the Koh ring or cup, and the assistant should continually exert cephalad pressure on the uterine manipulator to maximize the distance from the cervix to the ureter. The surgeon should be aware of thermal spread associated with sealing devices, which range from 0 mm to 22 mm, depending on the device, activation time, and settings.[44] The bladder also should be adequately dissected away from the upper vagina to allow appropriate closure without injury. Placement of preoperative ureteral stents may be useful to identify the ureters in selected cases, but data do not show a consistent advantage to this strategy[45–47] (see **Table 1**).

Identification of many ureteral injuries can be accomplished by intravenous (IV) instillation of indigo carmine or preoperative oral phenazopyridine.[39] If colored fluid is seen to pool in the pelvis, a bladder or ureteral transection is noted and the location must be identified in order to effect repair. Thermal and devascularization injuries can be more challenging to identify intraoperatively. Recent data support the use of near infrared imaging with indocyanine green to identify devascularization injuries.[48] Cystoscopy also may be performed at the completion of the procedure in order to identify brisk bilateral ureteral jets; a single dose of preoperative oral Pyridium (100–200 mg), 1 mL of diluted IV sodium fluorescein (1 mL of 10% fluorescein diluted in 9 mL saline), IV indigo carmine, or IV or intravesical methylene blue may be utilized, but this not always is necessary because the urine jets may be visualized without any additional dye. If bilateral jets are not identified initially, additional time may be allocated, the patient may be given additional fluid or furosemide or placed into reverse Trendelenburg position or a temporary ureteral stent may be placed to ensure patency.[39] If an injury is still suspected, an intraoperative IV pyelogram or retrograde cystogram may be performed.[39] Early detection decreases the risk of requiring reimplantation by tenfold.[49]

The type of injury—kinking, ligation, crush, or thermal—and the location of the injury determine the necessary repair strategy. Crush injuries, delayed thermal injuries, and partial obstructions can be difficult to recognize.[43] If the ureter is kinked by a suture, the ureter can be dissected away, or the surgeon can remove the offending suture, assess ureteral integrity, and place a stent if any abnormality in appearance or efflux is noted.[50] If the ureter has been clamped, the surgeon should immediately remove the clamp and inspect the ureter for integrity. Next, a ureteral stent should be placed for 2 weeks to 6 weeks, and given the potential for urine leakage with extensive injury, a drain should be placed to prevent urinoma for at least 7 days to 10 days.[49] For both thermal injuries and crush injuries, if the ureter is viable, then a ureteral stent may be placed, and no further repair is required. If the ureter is not viable, then resection of the necrotic segment is indicated with reattachment either to the ureter or reimplantation in the bladder is indicated (discussed later). Thermal injuries may have associated cellular damage past the visible area of injury, and this may lead to delayed disruption if not recognized intraoperatively. The location of the injury also determines the strategy for repair. In general, an injury below the pelvic brim that requires resection of a segment of the ureter requires reimplantation into the bladder, usually with a lengthening technique, such as the psoas hitch or a Boari flap. Injuries above the pelvic brim may require direct ureteroureterostomy or transureteroureterostomy[50,51] (see **Table 2**). Although the general gynecologist may repair bladder injuries, it is within the scope of practice of a subspecialist or urologist to repair most ureteral injuries.

Delayed diagnosis of a ureteral or bladder injury may present with flank pain, costovertebral tenderness, unexplained fever, persistent ileus, a lower abdominal mass (urinoma), urine leakage from the vagina, decreased urine output, or unexplained hematuria.[52] These findings should prompt cystoscopy, a CT cystogram, renal ultrasound, retrograde pyelogram, and/or CT of the abdomen and pelvis. Once a

ureteral obstruction is identified, retrograde stent placement should be attempted, and, if unable to be passed, antegrade stents may be attempted, although percutaneous nephrostomy tubes may be required. Any infection should be treated, and catheterization of the urinary bladder may be required to stop urine leakage.

The routine use of cystoscopy following laparoscopic hysterectomy has been debated in the gynecologic literature and unfortunately no prospective randomized data exist to determine benefit. Most surgeons would agree that although cystoscopy does not eliminate the potential for a postoperatively identified injury, in complicated dissections or with any suspicion of injury, cystoscopy should be considered and is cost-effective.[53–55]

NEUROLOGIC INJURIES

Neurologic injuries are estimated to occur in less than 2% of gynecologic procedures and are not unique to the laparoscopic approach.[56,57] A vast majority are related to improper positioning and prolonged surgical time and include both upper and lower extremity neuropathies. The most common nerve injuries are the peroneal, femoral, lateral femoral cutaneous, obturator, and ulnar nerves.[14] Prevention includes appropriate positioning and padding to avoid stretch and compression.

Upper extremity nerve injury typically is due to excessive stretch of the brachial plexus from improper positioning, with an incidence of 0.16%.[58] It is vital to ensure that patients' arms are placed in a neutral position at their sides with adequate padding along the ulnar nerve with relaxed hand positioning. Some surgeons, particularly with obese patients, use shoulder straps to minimize cephalad displacement when in steep Trendelenburg. Caution should be used because these can place lateral pressure on the brachial plexus and prevent proper movement of the shoulders should the patient slide cephalad. A crossed-strap approach is recommended to minimize this risk[59] (see **Table 1**). Brachial plexus injuries can present with both motor and sensory deficits, depending on the nerve root distribution injured. Early physical therapy and neurology consultation is recommended, especially when motor deficits occur. Oral analgesics, epileptics, and vitamin B can be prescribed for sensory discomforts[60] (see **Table 2**).

Lower extremity injuries from positioning include the femoral, lateral femoral cutaneous, obturator, and sciatic nerves. In general, injury occurs from prolonged dorsal lithotomy position with hip flexion, abduction, or external rotation. Prior to draping, the surgeon should ensure that patients' (1) hips are flexed between 60° and 170°; (2) knees are flexed between 90° and 120°; (3) hips are abducted no more than 90°; and (4) hips are minimally externally rotated.[56] Prolonged operative time has been shown to increase the risk of nerve injury.[61] With cases longer than 2 hours, the surgeon should pause periodically to ensure that appropriate positioning has been maintained. Management of compression or stretch injuries typically involves observation with supportive care, neurology consultation, and physical therapy.

Aside from direct nerve injury at the time of trocar placement or fascial suturing, direct nerve injury or severing of the genitofemoral, obturator, or sciatic nerves can occur with retroperitoneal dissection. Due to their anatomic locations, these nerves are more likely to be injured with retroperitoneal dissections for advanced pathology associated with endometriosis, leiomyoma, and pelvic masses as well as with lymphadenectomies and pelvic floor repairs.[57] During dissection of the obturator space, the obturator nerve always should be identified clearly (see **Table 1**). When transections are identified at the time of surgery, immediate repair should be undertaken. The nerve ends can be reapproximated with 5-0 Prolene to encourage regrowth; this may require

the assistance of a neurosurgeon to ensure proper alignment of the nerve.[62] When noted after surgery and felt to be a crush or compression injury, typically supportive care with early physical therapy and pain control is warranted. Physical therapy is necessary for most patients, and most patients regain function. Most injuries have complete recovery, particularly with early recognition (see **Table 2**).

VAGINAL CUFF DEHISCENCE

Hysterectomy is the most frequently performed major gynecologic surgery and has the unique complication of vaginal cuff dehiscence (VCD). The incidence of VCD is relatively low and occurs in 0.14% to 4.1% of cases, which has made it difficult to study.[63] Laparoscopic procedures have slightly higher rates of VCD compared with laparotomy or vaginal hysterectomy,[64] but robotic and laparoscopic platforms appear similar.[65,66] The type of closure, including suture type, single-layered versus double-layered closure, or vaginal versus laparoscopic approach, all have been examined, and most data are retrospective. A 2015 systematic review and meta-analysis showed no difference between barbed and conventional suture.[67] More recent studies have demonstrated no difference in cuff complications, including dehiscence, related to suture type, including nonabsorbable suture.[68,69] A recent randomized control trial of 1408 patients demonstrated an increased rate of dehiscence with transvaginal as opposed to laparoscopic closure (1% vs 2.7%; odds ratio 2.78; 95%, CI 1.16–6.62; $P = .01$).[70] A 2021 meta-analysis concluded that a laparoscopic approach with barbed suture yielded the least risk for VCD.[66] In terms of best practice for cuff closure to minimize VCD, there exists no randomized controlled trial, although many experts believe minimizing cautery effect and taking sufficient bites at least 5 mm deep and no more than 5 mm apart with peritoneal closure could minimize complications[71] (see **Table 1**). Risk factors from trials do note an increase in dehiscence among premenopausal women and smokers.[70]

Patients with VCD can present at any time after surgery, with studies showing variability from 2 weeks to more than 5 years.[63] Presenting signs and symptoms can include pelvic or abdominal pain, vaginal bleeding or discharge, vaginal mass, or pressure. The surgical urgency and route of repair depends on the size of the defect, clinical status of the patient, extent of bleeding, and bowel involvement. VCD repair typically is performed through a vaginal or laparoscopic approach but also can be done abdominally. No data suggest the superiority of any specific route or repair method. Surgeons should ensure that additional associated problems, including bowel ischemia or intraabdominal abscess, are assessed adequately. The vaginal tissue edges should be trimmed to ensure healthy tissue that is reapproximated with good strength.[63] Infections should be treated, and patients should be counseled regarding any modifiable risk factors and extended pelvic rest (see **Table 2**).

SUMMARY

MIS, through conventional multiport, single-port, or robotic platforms, will continue to become more prevalent in gynecologic surgery, given the significant improvements in perioperative outcomes. It is important for surgeons to be cognizant of potential complications when undertaking any of these techniques. Although a vast majority of surgical complications occur on entry, no specific entry technique currently is recommended over another. Surgeons should be aware of strategies for prevention, diagnosis, and treatment of bowel, vascular, neurologic, and urinary tract injuries.

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