

Complications of Laparoscopy in Benign and Oncologic Gynecological Surgery

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The evolution of laparoscopy from a diagnostic tool to a modality for major surgical procedures has been rapid and represents one of the most important surgical advancements in the past 30 years. Laparoscopy holds many advantages over laparotomy, including smaller surgical scars, faster recovery from surgery, and decreased time for return of bowel function. However, an appreciation of its potential complications is vital to patient care.

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The evolution of laparoscopy from a diagnostic tool to a modality for major surgical procedures has been rapid and represents one of the most important surgical advancements in the past 30 years. Laparoscopy holds many advantages over laparotomy, including smaller surgical scars, faster recovery from surgery due to a decreased analgesic requirement, and decreased time for return of bowel function. As laparoscopic utilization has expanded among many different specialties, a greater awareness and appreciation has been gained for the nature, frequency, and management of potential complications. For patients with gynecologic malignancies, the most common complications of laparoscopic surgery include vascular injuries, bowel injuries, genitourinary injuries, and

incisional hernias. Other less common complications include port-site metastases and gas embolism.

Vascular Injuries

Vascular injuries are among the most dangerous and serious complications of laparoscopic surgery. The incidence of major vascular injuries has been estimated to range from 0.04% to 0.5%.¹ The vast majority of these injuries occur during the initial setup

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phase of the surgery with the creation of the pneumoperitoneum or the placement of the umbilical trocar. In a review of the register of complications maintained by the French Society of Gynecologic Endoscopy, Chapron and colleagues reported a total of 17 vascular injuries. Of these complications, 13 (76.5%) occurred during the setup phase. Of note, no attempt was made to determine the total number of laparoscopies performed during this case review, nor was the time range of the review stated.²

Particular care must be taken both in very thin and obese patients. In the former, the distance separating the abdominal wall and the great vessels located in the retroperitoneum can be as little as 2 cm. In the latter, the anatomic relationship between the umbilicus and the aortic bifurcation may be modified. The vessels most often affected include the aorta, vena cava, and the common internal and external iliac arteries and veins. Injury to any of these vessels with the sharp tip or edge of a laparoscopic trocar or insufflation needle can result in catastrophic hemorrhage. If the bleeding is massive or the diagnosis is

delayed, serious morbidity or mortality can occur.

With the vast majority of complications occurring during the entry phase of laparoscopy, a number of abdominal entry approaches have been proposed. Proponents for the open technique argue its superiority in comparison with blind entry with the insufflation needle (Veres needle). During the open technique, a mini-laparotomy is created. The skin, rectus

sheath, and peritoneum are all incised under direct visualization and a blunt trocar and cannula are inserted, with subsequent creation of pneumoperitoneum. This approach has gained particular favor with general surgeons and data from prospective trials suggest that open entry may be safer. However, there is insufficient evidence to conclude that one technique is superior to another (Figure 1).³ In fact, in a survey conducted by Jansen and colleagues,⁴ no statistical difference was noted between open and closed entry with respect to vascular injuries. A randomized study comparing blind Veres needle insertion and the open technique reported longer insufflation time with the Veres needle and longer preparation time with the open technique. However, no difference in complication rates was observed.⁵

In an effort to minimize entry-phase injuries, optical access trocars have been developed that allow the surgeon direct visualization of tissue planes during placement. String and colleagues studied 650 patients undergoing various laparoscopic procedures using optical trocars and reported a complication rate of 0.3%.

This included an injury to the bowel and to the gallbladder.⁶ Very few complications have been recorded in the medical literature, but many more have been documented by the US Food and Drug Administration (FDA). The FDA maintains databases designed for the reporting of adverse outcomes associated with medical devices. These include the Medical Device Reporting (MDR) and Manufacturer and User Facility Device Experience (MAUDE) databases. A review of these databases between 1994 and 2000 revealed 79 cases involving complications with trocar insertions. Vascular injury was the most frequently reported complication, occurring in 57 patients and resulting in 4 deaths.⁷ Although these data do not allow for accurate comparison of injuries, it is clear that optical trocars do not preclude serious injury to intra-abdominal structures. Further studies will be necessary to evaluate the true safety of these techniques.

The umbilicus offers the thinnest portion of the anterior abdominal wall and is thus the most common site for laparoscopic entry. However, given the aforementioned risks of visceral and bowel injuries associated with prior abdominal and pelvic surgery, entry may be achieved safely in the left upper quadrant (Figure 2). Placement usually occurs in the mid-clavicular line just below the costal margin.⁸ In addition to this location, the Veres needle may also be inserted through the posterior fornix and into the cul de sac of Douglas or through the uterine fundus to create the pneumoperitoneum.^{9,10} Although these sites are not used for trocar placement, they do limit blind insertion to a single instrument as opposed to the trocar and Veres needle.

Bowel Injuries

Similar to vascular injuries, gastrointestinal trauma may occur during the

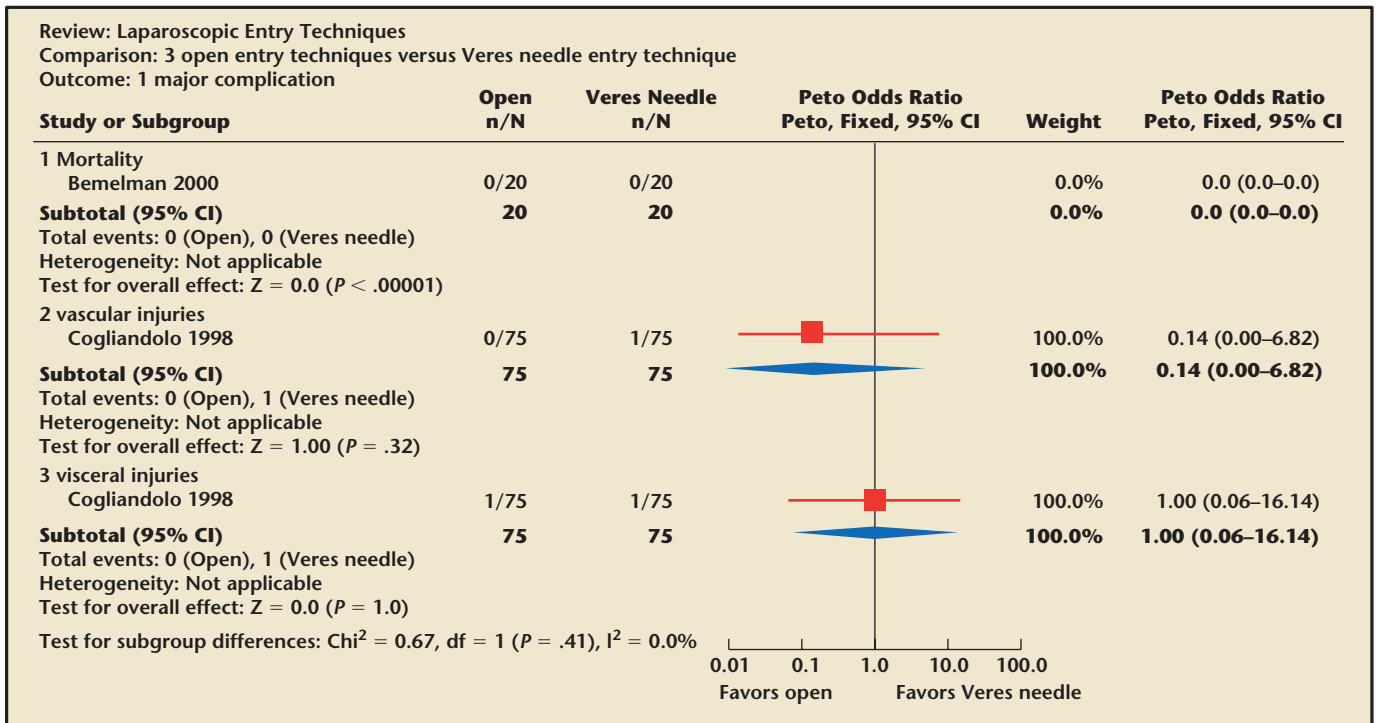


Figure 1. Open versus Veres needle entry technique: major complications. Reprinted with permission from Ahmad G et al.³

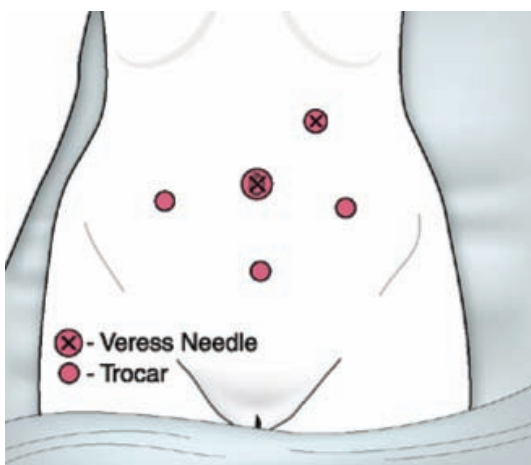


Figure 2. Given the risks of visceral and bowel injuries associated with prior abdominal and pelvic surgery, entry may be achieved safely in the upper left quadrant of the abdomen. Reproduced with permission from Pasic RP, Smith RC. Less invasive is best. *Frontiers in Reproductive Medicine*. http://www.obgyn.net/Frontiers_in_Reproductive_Medicine/Less_Invasive_is_Best_Smith-Pasic.asp. Last updated November 2006. Accessed August 14, 2009.

creation of the pneumoperitoneum or during the operative portion of laparoscopy. Both types of injuries are more frequent in the face of previous surgery or prior infection that has resulted in the fixation of the bowel to other structures, particularly to the anterior abdominal wall. Approximately 40% of bowel injuries are

access related and occur with the insufflation needle or with a trocar.¹¹

The incidence of laparoscopically induced gastrointestinal injury has been reported to be 0.13% by van der Voort and colleagues.¹¹ In their review, the most common location of injury was the small bowel (55.8%), followed by the large intestine

(38.6%), and, less commonly, the stomach (3.9%). Common signs that a bowel injury has occurred include foul-smelling gas, return of bowel contents, high insufflation pressures, and asymmetric distension. Early diagnosis is critical because the morbidity and mortality associated with bowel injuries appear significantly affected by the time at which the insult is identified. One simple step to preclude delay in diagnosis is to view the initial trocar site through an alternative port if there is concern about anterior wall adhesions.

Injury to the gastrointestinal tract may occur during the operative portion of the surgery as well. In the review by van der Voort and colleagues of 273 bowel injuries, 3 (1.1%) and 2 (0.7%) occurred with the grasping forceps and scissors, respectively. In contrast, 70 (25.6%) thermal injuries were reported and occurred with either a coagulating instrument or the

laser.¹¹ In addition, both electrothermal bipolar vessel sealers and ultrasonic coagulating shears appear to be superior in achieving hemostasis when compared with older monopolar and bipolar electrocoagulation devices. They also appear to be safer, in that lateral thermal injury is more common in monopolar and bipolar instruments. However, lateral thermal injury is possible with any method of coagulation.¹²

Tulikangas and colleagues assessed the gross and histologic characteristics of laparoscopic injuries with several coagulating instruments and documented an average length of injury for the monopolar cautery to be 0.6 ± 0.2 cm for the ureter, 2.1 ± 0.4 cm for the bladder, and 1.8 ± 0.3 cm for the rectum. The average length of injury for the bipolar cautery was 0.4 ± 0.2 cm for the ureter, 1.3 ± 0.2 cm for the bladder, and 1.3 ± 0.2 cm for the rectum. The ultrasonic coagulating shears were associated with an average length of injury of 0.5 ± 0.2 cm for the ureter, 0.9 ± 0.2 cm for the bladder, and 0.7 ± 0.2 cm for the rectum.¹³ In addition, previous publications have documented a lateral thermal spread limited to an area less than 1.5 mm and 1.6 mm beyond the tissue bundle for electrothermal bipolar vessel sealers and ultrasonic coagulating shears, respectively.^{14,15}

Early perforation develops during or directly after surgery, whereas late perforations may manifest several days to weeks following the surgery. If the diagnosis of a full-thickness perforation is delayed, sepsis, multi-organ failure, and even death may occur. Superficial thermal injuries to the bowel can often be repaired by a laparoscopic guided purse-string suture placed beyond the thermally affected tissues. In the event of complete perforation, unless there was direct visualization of the site of injury, the surgeon should proceed with

laparotomy to explore adequately and make sure that a second perforation was not missed.

Genitourinary Injuries

With respect to classic gynecologic surgery, the bladder remains the most common site of injury. Injury to the bladder and/or ureter during laparoscopic surgery has previously been a rare event. However, as laparoscopy

surgery varies considerably within the literature. In 1996, Saidi and colleagues published a review of 452 cases of laparoscopic surgery and reported a rate of 0.44%.²⁰ However, a similar review conducted by Härkki-Sirén and Kurki noted 18 ureteral injuries in 70,607 (0.025%) laparoscopic gynecologic procedures.²¹ Just as with injuries to the bladder, ureteral injuries have been

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has expanded to include more complicated procedures, injuries involving the genitourinary system have also increased. Studies have revealed an incidence of bladder injury during laparoscopy between 0.02% and 8.3%. This most often involves the dome of the bladder. The most common laparoscopic procedure associated with bladder injury is laparoscopic-assisted vaginal hysterectomy and most frequently occurs while conducting sharp, electrosurgical dissection. However, injuries have been reported with blunt dissection, laser utilization, laparoscopic scissors, and trocars.¹⁶

As in laparotomy, factors such as bladder pathology, adhesions, previous surgery, inflammation, or endometriosis may increase the risk of bladder injury. When an injury does occur, classic gynecologic techniques can be modified to repair the trauma laparoscopically. Various authors have reported their techniques for laparoscopic repair of the bladder and include laparoscopic suturing in a single layer closure,¹⁷ 3-layer closure,¹⁸ and a laparoscopic stapler.¹⁹

Similar to bladder injury, the rate of ureteral injury during laparoscopic

most commonly associated with laparoscopically assisted vaginal hysterectomy, but have also been reported during oophorectomy, pelvic lymphadenectomy, sterilization, and excision of endometriosis.

The location at which ureteral injury occurs most frequently during laparoscopy is at or above the pelvic brim. However, the site of injury is infrequently specified in the literature and can occur anywhere along the ureter's path to the bladder. The ideal method of repair varies based on the extent of ureteral trauma. Small, focal injuries to the ureter can be treated using a double-J-shaped catheter passed into the ureter. This intervention precludes further leakage of urine and allows spontaneous healing while providing support for the ureter. More extensive injuries may require laparotomy to perform an end-to-end anastomosis or ureteral reimplantation.

A review of the literature reveals a trend in which injuries diagnosed postoperatively are most often repaired using laparotomy, whereas the likelihood of a laparoscopic repair increases if the diagnosis is made intraoperatively. Efforts to diagnose a

ureteral injury include retrograde ureteral dye injection, intravenous dye injection, intraoperative ureteral catheterization, and dissection of the ureter. If the diagnosis is still left unknown, intraoperative urologic consultation may serve to decrease delay in diagnosis.

Incisional Hernias

Several factors contribute to the development of incisional bowel herniations. These include the use of mul-

scopies. In addition, this review revealed that the risk of herniation through a 12-mm trocar site was 3.1%, whereas at a 10-mm trocar site the risk was 0.23%.²³ Given that many patients undergoing laparoscopic surgery are discharged early from the hospital, early evaluation during the postoperative period (1-2 weeks) is warranted. Patients should also be instructed to report issues with nausea, vomiting, and/or protrusion at trocar sites. An incisional her-

compared with the rate of wound-site metastasis in patients undergoing laparotomy or percutaneous needle aspiration for malignant disease, the rate is similar. Several etiologic factors have been proposed for the occurrence of port-site metastasis and include direct wound contamination with viable tumor cells, effects of pneumoperitoneum, effects of specific gases, the "chimney effect," and surgical techniques.

The *chimney effect* refers to the high efflux of gas from the abdominal cavity through the space around the trocars and, upon deflation of the abdomen, through the trocar incision site. This concept remains controversial in that although some investigators have been able to isolate tumor cells escaping from the port sites, other groups were not able to show aerosolization of viable tumor cells in either in vivo or in vitro experiments.³¹⁻³³

Several efforts have been suggested in an attempt to prevent port-site metastasis. Port-site lavage with cytotoxic agents has been recommended by some authors. Solutions such as heparin, taurolidine, combination heparin and taurolidine,³⁴ 5-fluorouracil,³⁵ doxorubicin,³⁶ povidine-iodine solution, and methotrexate have been implemented.³⁷

The utility of laparoscopic surgery in the setting of advanced ovarian cancer remains a topic of debate. However, the majority of patients diagnosed with an ovarian malignancy and subsequently found to develop a port-site metastasis are diagnosed with advanced disease. A large percentage of these patients have evidence of ascites and carcinomatosis at the time of surgery. Kindermann and colleagues proposed that the laparoscopic management of ovarian malignancies and borderline tumors be abandoned based on a high rate of port-site metastases. However, 92% of

Several factors contribute to the development of incisional bowel herniations. These include the use of multiple ancillary ports, extirpative procedures such as oophorectomy or lymphadenectomy requiring larger ports for specimen removal, the use of instruments such as clip applicators and linear staplers requiring 10- and 12-mm ports, increased operative times with more port manipulation causing stretching of the fascial defect, the use of port anchoring devices that may add an extra 1 to 2 mm to the fascial defect, and failure to close the fascial defect.

multiple ancillary ports, extirpative procedures such as oophorectomy or lymphadenectomy requiring larger ports for specimen removal, the use of instruments such as clip applicators and linear staplers requiring 10- and 12-mm ports, increased operative times with more port manipulation causing stretching of the fascial defect, the use of port anchoring devices that may add an extra 1 to 2 mm to the fascial defect, and failure to close the fascial defect. In 1995, Boike and colleagues reported 19 patients with bowel herniation among 11 participating institutions. Of the 21 herniations, 12 (57%) occurred at 12-mm port sites, 8 (38%) at 10-mm port sites, and 1 at an 11-mm port site. Umbilical herniations occurred in 36% of cases, whereas extraumbilical sites were involved in the remaining 64%. In addition, 2 (9.5%) patients required small bowel resection.²² Similar findings were recorded in a multicenter report of 3560 operative laparo-

nia may be repaired laparoscopically if the involved site is known. However, if the involved site is not obvious, laparotomy is often indicated to repair the defect.

Port-Site Metastases

In 1978, Döbrönte and colleagues documented the first case of port-site metastasis in a patient with ovarian carcinoma.²⁴ Since then, a number of similar cases involving patients with gynecologic malignancies have been recorded in the literature. In addition, port-site metastasis complicating cancer of the pancreas,²⁵ esophagus,²⁶ stomach,²⁷ liver,²⁸ and colon²⁹ has also been reported.

The incidence of port-site metastasis is relatively rare and poorly defined. Childers and colleagues reported on 105 laparoscopic procedures involving patients with documented malignancies and observed a port-site metastasis rate of 1.1% per procedure or 0.3% per puncture site.³⁰ When

the patients in that study had laparoscopic rupture of the tumor capsule and tumor morcellation with intra-abdominal spillage.³⁸

Gas Embolism

With a reported incidence of 15 in 113,253 cases, gas embolism during gynecologic laparoscopy represents a rare event.³⁹ Several theories have

been proposed. A large bolus of gas results in the creation of a “gas lock” within the right atrium, thus impeding the pulmonary outflow. However, smaller gas bubbles most likely enter the pulmonary circulation and manifest as pulmonary hypertension and right ventricular failure. Whereas rapid infusion of carbon dioxide is most likely to result in a gas lock, slower entry leads to

gas embolism with steep head-down positioning. Positioning allows the bubble to migrate toward the apex of the heart and away from the obstructed outlet. Other interventions include insertion of a central venous catheter to attempt aspiration of the bubble and aggressive volume expansion to preclude further gas entry by increasing the central venous pressure. Emergency thoracotomy with internal cardiac massage and aspiration should be considered if the patient continues to be unstable.

Clinical manifestations of gas embolism are entirely dependent upon both the amount of carbon dioxide instilled and its rate of entry. Whereas rapid infusion of carbon dioxide is most likely to result in a gas lock, slower entry leads to gas entrapment within the pulmonary circulation.

sought to explain the manner in which carbon dioxide enters the blood stream. The most obvious route is through direct hepatic puncture with the insufflation needle, with subsequent intravenous injection of gas into the hepatic venous system. Alternatively, if during high-pressure insufflation a vein is ruptured or severed during dissection, carbon dioxide may enter the circulatory system.⁴⁰ Clinical manifestations of gas embolism are entirely dependent upon both the amount of carbon dioxide instilled and its rate of entry. A large

gas embolism results in gas entrapment within the pulmonary circulation.

The definitive diagnosis of gas embolism requires aspiration of carbon dioxide from the right atrium, so the diagnosis is often based on clinical signs. These include a sudden decrease in end-tidal partial pressure of carbon dioxide, a “mill-wheel” murmur, or a rapid drop in blood pressure. Successful management entails release of pneumoperitoneum and cessation of insufflation, ventilation with 100% oxygen, and positioning of the patient in the left, lateral, de-

Conclusion

As surgeons continue to expand their laparoscopic skills and increase the number and type of complex laparoscopic procedures offered to their patients, it is important for them to be familiar with the potential complications that may arise. Emphasis should be placed on prevention of complications by meticulous surgical technique and appropriate patient selection and on management of such complications both intraoperatively and postoperatively. Laparoscopy affords a safe and less invasive modality for both diagnostic and major operative procedures. However, an

Main Points

- The vast majority of vascular injuries occur during the initial setup phase of laparoscopic surgery with the creation of the pneumoperitoneum or the placement of the umbilical trocar. Abdominal entry approaches proposed to limit vascular injury include the open technique and the use of optical access trocars.
- Common signs that a bowel injury has occurred include foul-smelling gas, return of bowel contents, high insufflation pressures, and asymmetrical distension. Early diagnosis is critical because the morbidity and mortality associated with bowel injuries appear significantly affected by the time at which the injury is identified.
- Ureteral injuries have been most commonly associated with laparoscopically assisted vaginal hysterectomy, but have also been reported during oophorectomy, pelvic lymphadenectomy, sterilization, and excision of endometriosis.
- Many patients undergoing laparoscopic surgery are discharged early from the hospital and early evaluation for incisional hernias is warranted. Patients should be instructed to report issues with nausea, vomiting, and/or protrusion at trocar sites.
- Port-site lavage with cytotoxic agents has been recommended in an attempt to prevent port-site metastasis.
- The definitive diagnosis of gas embolism requires aspiration of carbon dioxide from the right atrium, so the diagnosis is often based on clinical signs: sudden decrease in end-tidal partial pressure of carbon dioxide, a “mill-wheel” murmur, or a rapid drop in blood pressure.

appreciation of its potential complications is vital to patient care and further studies will aid in the understanding of the utility and limitations of laparoscopic surgery. ■

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