

The Management of Gynecological Laparoscopy Complications: Review

Jinekolojik Laparoskopik Komplikasyonlarında Yönetim

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ABSTRACT Laparoscopy has a good safety profile, with advantages over more invasive surgeries such as reduced operative procedure time, reduced complications, decreased hospital stay and improved recovery time. However, complications can arise, including vessel injuries, gastrointestinal and genitourinary injury, gas embolism, incisional hernia, port site metastases, subcutaneous emphysema, wound site infection, intraperitoneal adhesions and anaesthesia related complications. Training and supervision of new surgeons, familiarity with equipment and instruments, development of excellent surgical skills and awareness of potential complications are key to management of complications in gynaecological endoscopic procedures. Importantly, there are many ways in which the risk of complications can be minimised. Laparoscopic camera control systems and robotically assisted endoscopic surgeries are some recently developed technological innovations. The use of laparo-endoscopic single-site surgery for procedures including balloon vaginoplasty should theoretically also help reduce complications. There is also a trend towards natural orifice transluminal endoscopic surgery, for example, transvaginal natural orifice transluminal endoscopic hysterectomy, which has the advantages of not being limited by uterine volume or the need for abdominal incision. Thus, surgeons can incorporate innovative techniques and technologies into management and minimisation of complications in gynaecological endoscopic procedures. This article reviews measures can be taken to minimize and management of gynecological laparoscopic complications.

Keywords: Laparoscopy; complications; case management

ÖZET Laparoskopik daha invaziv cerrahiler üzerine, daha kısa operasyon süresi, azalan komplikasyonlar, daha kısa hastanede kalış süresi, daha hızlı iyileşme gibi avantajlarıyla iyi bir güvenlik profiline sahiptir. Ancak damar yaralanmaları, gastrointestinal ve genitoüriner yaralanmalar, gaz embolisi, insizyonel herni, port yeri metastazi, subkutanöz anfizem, yara yeri enfeksiyonu, intraperitoneal adezyonlar ve anestezi ile ilişkili istenmeyen olaylar gibi komplikasyonlar meydana gelebilmektedir. Yeni cerrahların eğitilmesi ve denetlenmesi, araç gereçleri tanımları, kusursuz cerrahi yetenekler geliştirmeleri ve potansiyel komplikasyonlara dair bilince sahip olmaları jinekolojik endoskopik yöntemlerde komplikasyon yönetiminin anahtarlarıdır. Daha da önemlisi, komplikasyon riskini minimize edebilmenin birçok yolu bulunmaktadır. Laparoskopik kamera kontrol sistemleri ve robotik yardımcı endoskopik ameliyatlarda geliştirilen güncel teknolojik yeniliklerden bazılarıdır. Balon vajinoplasti gibi yöntemler için laparo-endoskopik tek taraflı cerrahi uygulaması da teorik olarak komplikasyonların azaltılmasına yardımcı olur. Aynı zamanda, örneğin vajinal histerektomi gibi uterus hacminin sınırlandırıcı etkisinin olmaması veya abdominal kesi gerektirmeme gibi avantajlara sahip olması nedeniyle transluminal endoskopik cerrahiye doğru da bir eğilim vardır. Böylelikle cerrahlar, jinekolojik endoskopik yöntemlerde yenilikçi teknikleri ve teknolojileri komplikasyonların yönetimine ve minimize edilmesine dahil edebilmektedir. Bu makale jinekolojik laparoskopik komplikasyonları en aza indirmek için alınabilecek tedbirleri ve komplikasyonlarda yönetimi incelemektedir.

Anahtar Kelimeler: Laparoskopik; komplikasyonlar; vaka yönetimi

Laparoscopy has revolutionised gynaecological surgery, allowing procedures such as hysterectomies and oophorectomies to be carried out in a minimally invasive manner when clinical circumstances are appropriate.¹⁻³ Gynaecological laparoscopy developed both diagnostically and therapeutically throughout the middle to late twentieth century due to the work of gynaecologists including Palmer, who worked on treatment of bleeding sites, ovarian cysts and pelvic adhesions and Semm, who invented the automatic insufflator among many other laparoscopic instruments.^{4,5} The work of Nehzat during the 1970s and 1980s on use of video cameras during laparoscopy was groundbreaking.⁶ Video laparoscopy became standard by the end of the 1980s and today operative laparoscopy is considered a safe and effective approach to many types of gynaecological surgery.

Laparoscopy involves making a small incision in the abdomen to allow endoscopic examination of the abdominal or pelvic organs. There is ample evidence to suggest that when they are feasible, gynaecological endoscopic procedures, offer advantages such as decreased hospital stay, reduced operative and post-operative complications, reduced operative procedure time and improved recovery time.⁷ For example, in the case of endometrial cancer treatment, when compared to conventional abdominal surgery, reductions in peri-operative complications, blood loss, transfusion rates and hospital stays have been reported for laparoscopically assisted vaginal hysterectomy (LAVH) or laparoscopic radical hysterectomy, along with better quality of life.⁸ When compared to total abdominal hysterectomy, total laparoscopic hysterectomy (TLH) has also been associated with less blood loss and shorter hospital stay for women with uterine neoplasia.⁹ For benign ovarian tumours, laparoscopy is associated with fewer adverse events, reduced postoperative pain and fewer days in hospital than with laparotomy.³ Reduced long-term costs are also associated with endoscopically assisted gynecological procedures.^{3,8,10-12} Minimally invasive surgical techniques also appear to be effective and efficient when used in more complex procedures such as complex hysterectomies.¹ For

some higher risk patients with co-morbidities such as obesity, the indications for minimally invasive surgery are even more striking in terms of greater safety, once anatomical limitations and other factors such as nulliparity are taken into account.^{8,9} However, complications do occur, including vascular injuries, bowel, bladder and ureteral injuries, intraperitoneal adhesions. These complications and the techniques and innovations that are used or are being developed to minimise and manage them are discussed in this literature review.

LAPAROSCOPIC COMPLICATIONS AND MANAGEMENT

The most common major complications in laparoscopic gynaecological surgery involve vascular injuries and injuries to the gastrointestinal and genitourinary systems.¹³ Vascular injuries can occur at both great vessels (vena cava, aorta, iliac vessels) or at abdominal wall vessels, particularly the inferior epigastric artery and vein.¹³ More rarely, stomach injury can result during Veress needle or first trocar entry in laparoscopic procedures. Other complications include blood loss, gas embolism and incisional hernias.

VESSEL INJURIES

The incidence of vessel injuries in gynaecological laparoscopic surgery has been estimated to lie between 0.04 to 0.5%.¹⁴ It is one of the most serious potential complications of this type of surgery as it can result in catastrophic haemorrhage or gas embolism. Estimates of mortality rate varies between studies. In one study on 408 trocar-related major vascular injuries notified by the medical devices industry to the United States Food and Drug Administration, a mortality rate of 6.4% was reported.¹⁵ In another smaller series examining complications associated with optical-access laparoscopic trocars, a mortality rate of 10.8% due to vascular injury was reported.¹⁶ However, in another study a higher mortality rate of 20.8% was reported.¹⁷

Injury usually occurs during the entry stage of the surgery, when the pneumoperitoneum is being created with insertion of the trocar or insufflation needle (Veress needle).^{13,14,18} According to Royal

College of Obstetricians and Gynaecologists (RCOG) guidelines, to reduce the possibility of vessel injuries the patient should be placed in the completely horizontal position, not Trendelenburg, and the operating table should be in the horizontal position at the start of the procedure.¹⁹ The abdomen should also be palpated to check for the position of the aorta. However, in many cases, particularly in obese patients, use of the Trendelenburg position is necessary for adequate access. The association of vessel injury with the set-up stage has led to abdominal entry strategies being suggested as opposed to blind entry with use of Veress needle. This involves creation of the pneumoperitoneum after a 'mini-laparotomy', with incision of the skin, rectus, sheath and peritoneum under direct visualisation and with use of a blunt cannula and trocar.^{13,14} However, there is some debate as to whether this approach is preferable to blind entry in avoidance of vessel injury, with studies indicating no statistical difference in complication rates and visceral complications can still occur.^{14,20,21} Optical access trocars are an innovation that allows the surgeon to directly visualise tissue planes as the needle is being placed, and they are associated with a low complication rate.^{13,16} However their effectiveness in terms of vessel injury avoidance is questionable. For example, in a review of FDA-maintained databases including the Medical Device Reporting (MDR) and Manufacturer and User Facility Device Experience (MAUDE) databases, vascular injury emerged as the most common complication for laparoscopic surgery carried out using optical access trocars; of 79 serious complications reported in MAUDE, 37 were major vascular injuries involving aorta, vena cava, or iliac vessels.¹⁶ Another factor for surgeons to consider in avoiding vessel injury in gynaecological laparoscopic procedures is the laparoscopic entry site. The umbilicus is the thinnest part of the abdominal anterior wall and the most common entry site, however issues associated with prior abdominal or pelvic surgery should be considered when choosing the entry site, with the left upper quadrant indicated.¹³ Other Veress needle entry points to consider when creating the pneumoperitoneum is via the posterior

fornix and hence to the cul de sac of Douglas or the uterine fundus.^{13,22} These are not used for trocar placement but have the advantage of limiting the blind placement to only one instrument rather than both the trocar and Veress needle, thus potentially limiting vessel injury. Use of blunt-tipped instruments in place of the commonly used external cannula and removable sharp pyramidal trocar, should be considered in reducing vessel injury.¹⁴ If vessel injury does occur, it is important to recognise this and intervene quickly and calmly. Injury to major vessels can be initially brought under control by tamponade or pressure and if laparoscopic repair is not feasible the anaesthesiologist should be notified to insert a central line and the patient should be opened up for conversion to laparotomy and a vascular surgeon brought in for repair of the injury.^{23,24} Injury to more minor vessels, such as epigastric vessels can be addressed by techniques such as application of direct pressure with the operating port, suture ligation (open or laparoscopic) or Foley catheter insertion to the peritoneal cavity for tamponade.²⁵

GASTROINTESTINAL INJURIES

Retrospective case reviews suggest that like vessel injuries, gastrointestinal (GI) injuries most commonly occur during entry phase, for example secondary to umbilical trocar introduction or to pneumoperitoneum creation, but also occur during the operative procedure, for example secondary electrosurgery use.^{13,26} However, complications may not arise or may not become apparent until the post-operative phase. Complications are more common in cases where there has been previous surgery or fixation of the bowel due to prior infections, or in obese women, so the surgical team needs to be aware of such possible risk factors in advance. Assessment of the incidence of GI injuries as a result of gynaecological laparoscopy varies. A retrospective, comparative study based on medical record reviewing of 4307 operative gynecologic laparoscopies estimated the rate of bowel injuries at 0.16%, while a retrospective evaluation of surveys and databases estimated it at 0.08% risk of bowel injury for diagnostic and

minor operative laparoscopy, rising to 0.33% in major operative laparoscopy.^{27,28} Meta-analysis of 28 Pubmed listed articles covering 329 935 laparoscopic procedures estimated the rate of laparoscopy-induced GI injury at 0.13%, involving most commonly the small bowel, then the large intestine, with the stomach being less common.²⁹ From these studies, data from 29 532 procedures could be used to determine the extent of bowel injury; incidence of bowel perforation was 0.22% in this series.²⁹ One recent retrospective cohort study of 41 surgeries suggested that laparoscopy is significantly more likely than laparotomy to result in deserosalization, however it was associated with fewer post-operative complications.³⁰ Injuries are most likely during adhesiolysis or in procedures involving entry into the peritoneal cavity; extremely rarely, they can occur as a result of uterine perforation.³¹ Preparation of the bowel in advance by mechanical cleansing and antibiotic administration can be particularly helpful in cases of pelvic mass, endometriosis or malignancy, or in cases where difficult dissection is likely, in order to reduce likelihood of infectious complication or anastomotic leakage.³¹ Access injuries involving the trocar or insufflation needle account for approximately 40% of cases, for example injury to an adherent loop of bowel.³¹ Signs for the surgical team to be aware of include foul-smelling gas, bowel content return, high insufflation pressure and non-symmetric distension. There are simple ways to ensure diagnosis is not delayed, for example viewing the initial trocar site via different ports if there is any suspicion or concern about adhesions. Use of the optical trocar is recommended in avoiding access injuries.³¹ Insertion of a nasogastric tube by anaesthetists at the beginning of the procedure also facilitates stomach and bowel decompression, reducing injury risk.³¹ Intraoperative injury also occurs, for example grasping injuries caused by forceps or scissors but more commonly thermal injuries due to coagulating instruments or lasers.²⁹ Incidence of thermal injury can be reduced by switching from use of unipolar cautery to either bipolar cautery, electrothermal bipolar vessel sealers or ultrasonic co-

agulating shears.^{13,31} Adhesiolysis of bowel loops adhering to pelvic structures should be carried out using a gentle, controlled traction and counter traction in order to avoid injury.³² The rate of bowel injuries declines with experience of the surgeon and supervision by an experienced surgeon is essential for those learning techniques of diagnosis and repair of GI injuries such as adhesiolysis and bowel perforation during laparoscopic surgery.^{31,32} Early diagnosis is desirable to reduce patient morbidity and mortality; results of one retrospective evaluation of surveys and databases suggested that bowel injury risk during gynecologic laparoscopy tends to be underestimated and that as many as one in five cases of delayed diagnosis result in death.²⁸ While this estimate seems high, there is evidence from, for example, studies of injury-based reporting systems to support the suggestion that late diagnosis of GI injury contributes significantly to mortality risk.³³ Diagnosis during the procedure, with immediate repair by laparoscopy or laparotomy, reduces the chances of severe complications occurring. Estimates of levels of intraoperative diagnosis of bowel injuries varies between studies. In one retrospective case review study of 56 patients with 62 gastrointestinal injuries, diagnosis was delayed by a mean of 4.0 ± 5.4 days and was diagnosed intraoperatively in 35.7% of cases.²⁶ By contrast, meta-analysis of studies including 329935 laparoscopic procedures suggested 66.8% of bowel injuries were diagnosed during laparoscopy but that there was nonetheless a 3.6% mortality rate associated with laparoscopy-induced bowel injury.²⁹ Late diagnosis may contribute to increased mortality due to, for example, the increased likelihood of sepsis or peritonitis.^{33,34} After surgery, the bowel and colon should be examined in their entirety. Superficial thermal injuries can be repaired by laparoscopically-guided purse string suturing and small perforations repaired in two layers, with suture line perpendicular to the bowel's long axis.^{13,31} Larger perforations, in the absence of direct visualisation of the injury site, should be repaired by laparotomy, with resection and anastomosis; a general surgery consult may be needed.^{13,31} Patients should also be moni-

tored for possible GI injuries in the weeks following their surgery.

GENITOURINARY INJURIES

Reported incidence of bladder or ureter injury during laparoscopic, gynaecological surgery varies but has become more common as the types of surgery carried out become more complicated.¹³ One series of 1501 laparoscopic hysterectomy procedures indicated a rate of bladder injuries of 1% over 14.5 years.³⁵ Risk factors included previous Caesarean section, or laparotomy and risk declined with the level of surgeon's experience, plateauing at 0.4% after performance of 100 procedures.³⁵ Other studies have reported incidence of bladder injuries in laparoscopic, gynaecological surgeries varying from 0.02% to 8.3%.³⁶ The rate of ureteral injury is lower but also varies between studies; values for ureteral injury or obstruction can vary from 0.025% to 3.4% depending on the study.^{13,37} For both bladder and ureteral injury, the laparoscopic procedure most commonly implicated is LAVH, although it can occur in other procedures.¹³ For bladder injury, it is most commonly caused by use of sharp, electro-surgical dissection, although it has also been reported for blunt dissection, laparoscopic scissors and trocar.³⁶ Bladder injuries are commonly detected intraoperatively and can be repaired laparoscopically.^{4,38} For example, in a prospective study of 5279 hysterectomies, comparing laparoscopic hysterectomy (LH; n=1679), vaginal hysterectomy (VH; n=2345) and abdominal hysterectomy (AH; n=1255) in 53 Finnish hospitals, rate of bladder or ureteral injury for LH was comparable to the other hysterectomy techniques and most bladder and bowel injuries (88 and 83%) were recognized intraoperatively.³⁸ Laparoscopic bladder injury repair should be carried out using suturing with three-layer closure, single-layer closure or laparoscopic stapler.¹³ While ureter injury rate is low and is often a result of coagulation injury; the situation is complicated by the fact that it is not often detected intraoperatively. For example, in the Finnish study, while the rate of ureteral injury was 0.3%, only 10% of these were detected during the procedure.³⁸ A possible intervention to assist documentation of

ureteral injury during, for example, LH, is use of intraoperative cystoscopy.³⁷ In a series of 118 patients undergoing LH, this technique enabled all ureteral injury complications to be fixed immediately, without postoperative ureteral problems.³⁷ Intraoperative detection of ureteral injury is much more likely to result in laparoscopic repair rather than laparotomy and other methods for detection of such injury include retrograde injection of dye, intraoperative catheterisation of the ureter and ureteral dissection.¹³ While the most common site for ureteral injury during laparoscopy is at or above the pelvic brim, this is in practice, not well defined and should be checked for at any point in the ureter. The repair method would depend on the extent of the injury, for example, small focal injuries could be repaired with use of a small double-J-shaped catheter in the ureter while more extensive injuries may require laparotomy with anastomosis or ureteral reimplantation.¹³

BLOOD LOSS

In general, laparoscopic surgery would not be more associated with greater blood loss than other types of gynaecological surgery. For example, in a review of 27 randomised trials comprising 3643 participants in which AH, VH and LH were compared, LH was found to result in lower intraoperative blood loss than AH and similar to VH.³⁹ In another recent series of 1654 diagnostic laparoscopies, conversion to open laparotomy due to haemorrhage occurred only twice, at a time when the clinicians were still relatively inexperienced.⁴⁰ Nevertheless, blood loss can occur, and it is important to try to minimise this complication. One study of 350 women who underwent TLH indicated that performing uterine artery ligation at the beginning of TLH, rather than after cornuary pedicles as is normally the case, reduced both total blood loss and the operation time.⁴¹ Other possible innovations include the use of vasopressin. For example, in one recent small retrospective study on five women with caesarean scar pregnancies (CSPs), the efficacy of using vasopressin injection into the myometrium to help control haemorrhage during laparoscopy, with temporary bilateral uterine artery occlusion with

titanium clips at the start of the procedure, was investigated.⁴² In this study, no cases had to be converted to laparotomy, nor were there any blood transfusions or complications, suggesting the effectiveness of the combination of laparoscopy with vasopressin and titanium clip occlusion as a minimally invasive procedure for uterus preservation in CSP.

GAS EMBOLISM

Gas embolism is a rare complication of laparoscopic surgery which is caused when CO₂ is introduced into the large veins via Veress needle. Although rare, with a reported incidence of 0.013%, it is fatal if not detected and treated; a mortality rate as high as 28.5% has been reported.^{13,43,44} Cardiovascular mechanisms associated with gas embolism include raised pulmonary arterial pressure and resistance to right ventricular outflow, with reduction in pulmonary venous return.⁴⁵ This results in left ventricular preload and diminished CO, with systemic cardiovascular collapse. Change pulmonary vessel resistance with VQ mismatch can also result in arterial hypoxia and hypercapnia. The first sign is a fall in end-tidal CO₂ concentration caused by reduced blood flow to the lungs. Features for the surgical team to be aware of include sudden circulatory collapse, cyanosis, and raised jugular venous pressure. Any sign of blood from the Veress is a danger sign; the needle should be left in situ.⁴⁶ To manage this condition, the pneumoperitoneum must be released and insufflation stopped. The patient should be placed on the left, lateral decubital with steep head-down positioning, to encourage the embolism to move away from the obstructed outlet towards the apex of the heart.¹³ Aspiration of intracardiac gas may be attempted by insertion of central venous catheter, or aggressive volume expansion may be attempted to try to prevent any further influx of gas.¹³ If the patient remains unstable, emergency thoracotomy needs to be considered.

INCISIONAL HERNIA

Incisional hernia of the bowel is a preventable complication of laparoscopic gynaecological procedures associated with procedures requiring multi-

ple ancillary ports or procedures and instruments requiring large ports.¹³ Laparoscopy has also been associated with longer operating times, for example, when comparing LH to VH, which can result in increased manipulation of ports and hence fascial defect stretching.^{13,39} Studies indicate that using a 10 mm trocar site as opposed to 12 mm can greatly reduce the risk of herniation during operative laparoscopy.^{47,48} Typically, it is accepted that fascial puncture sites of ≥ 10 mm should undergo fascial suturing for prevention of incisional hernia. However, reports exist of 5 mm trocar sites being associated with development of hernia.⁴⁹ Results of one case review study of 5300 operative laparoscopy surgeries suggested fascial suturing should be carried out not only when using trocars ≥ 10 mm but also if extensive manipulation is carried out via a 5-mm trocar port, resulting in incision extension.⁵⁰ Also, monitoring of patients after discharge is indicated, with special attention paid to any incidents of vomiting, nausea and trocar site protrusion.¹³ Depending on whether or not the hernia site is known, it can be corrected by laparoscopy or laparotomy respectively.

PORT SITE METASTASES

Postoperative tumour growth at puncture sites associated with placement of the trocar is a recognised complication of laparoscopic surgery on gynaecological tumours including ovarian, cervical, endometrial, Fallopian tube and vaginal cancer.⁵¹⁻⁵⁶ Incidence of this complication has been variably reported as 1.4%, 9% or 16% per procedure for a laparoscopic procedure for ovarian cancer and 2.3% for gynaecological malignancies overall.⁵⁵ Presence of advanced disease and recurrence of ovarian or primary peritoneal malignancies and presence of ascites are risk factors for development of port site metastases.^{13,55} The causes are poorly understood, but methods of attempted prevention include lavage of the port site with cytotoxic and chemotherapeutic agents.¹³

OTHER COMPLICATIONS

Other potential complications to be aware of in gynaecological laparoscopy include complications of

anaesthesia, subcutaneous emphysema and wound site infection.

ANAESTHESIA

The use of abdominal insufflation in gynaecological laparoscopy, with its associated discomfort, pain and risk usually necessitates use of general anaesthetic for this type of surgery. Local or regional anaesthesia should only be considered in carefully selected patients. Potential complications arising include acidosis associated with transperitoneal absorption of carbon dioxide commonly used in insufflation, which can increase cardiac arrhythmia risk in susceptible patients.^{57,58} Increasing ventilation can be used for correction of acidosis. Another significant risk associated with abdominal insufflation is passive regurgitation of gastric contents due to pressure on abdominal structures.⁵⁸ Endotracheal intubation is therefore recommended in conjunction with general anaesthesia to reduce the risk of aspiration. The abdominal pressure can also directly impact the thorax, which in patients under general anaesthesia, can result in atelectasis and functional pulmonary shunt, and consequently hypercarbia and a respiratory acidosis.⁵⁸ Direct effects on the cardiac system are also a risk of increased abdominal pressure.⁵⁸ Use of the Trendelenburg position, which is often necessary to an extreme extent for example in obese patients, exacerbates both discomfort and aspiration risk. Reduction of intra-abdominal pressure to the minimum possible to achieve insufflation (<14 mm Hg) along with minimisation of the Trendelenburg position can help with reduction of both discomfort and aspiration risk, allowing use of local or regional anaesthesia in some non-obese, pain-tolerant patients who do not require major abdominal surgery. However, for many patients, such as obese individuals, general anaesthesia is usually indicated.⁵⁸ Use of gasless laparoscopy with subcutaneous lifting of the abdominal wall, for example for treatment of ovarian cysts, can reduce the anaesthesia risks associated with insufflation in laparoscopy.^{59,60} For example, in a case study of an obese woman of small stature undergoing a laparoscopic hysterectomy, hypercapnia complications arose during in-

sufflation at 14 mm Hg and Trendelenburg position.⁶⁰ After consulting with anaesthesia, a hybrid approach involving both gasless retractor-based laparoscopy with additional mild insufflation at 8 mm Hg, to allow moderate pneumoperitoneum and adequate field exposure, was employed. These conditions allowed adequate ventilation to be maintained. These gasless procedures may be of particular use in benign gynaecological conditions and are easier to master than insufflation-based techniques, making them an attractive option in, for example, less developed areas.⁶¹ The potential to carry out the procedure under regional anaesthesia and the avoidance of hypercarbia and increased abdominal pressure due to CO₂ insufflation also make this technique particularly suitable during pregnancy.⁶²

SUBCUTANEOUS EMPHYSEMA

Subcutaneous emphysema is generally a more minor complication associated with gynaecological laparoscopy, due to subcutaneous CO₂ presence. Its incidence has been estimated at 2.3% in a review of 968 laparoscopic cases.⁶³ Mild subcutaneous emphysema does not usually have a significant clinical outcome and resolves spontaneously. However, if it becomes extensive, it can be coincident with hypercapnia and cardiovascular collapse. One prospective randomised study of 200 patients who underwent gynaecologic laparoscopy for benign gynaecologic disease or cervical intraepithelial neoplasia showed that incidence of subcutaneous emphysema increased with higher intra-abdominal pressure.⁶⁴ Other studies have also implicated high CO₂ pressure and steep Trendelenburg positioning, as well as operative time greater than 200 minutes and use of six or more surgical ports.⁶³ If intervention is necessary, intra-operatively, subcutaneous emphysema can be treated using positive end-expiratory pressure (PEEP), decrease of the abdominal pressure gradient or splinting/sealing of the defect. Post-operatively, subcutaneous CO₂ can diffuse out by treatment with 100% oxygen and positioning of the patient in an upright position with adequate ventilation.⁴⁵

WOUND SITE INFECTION

Wound site infection is a relatively common complication of obstetric and gynaecological surgeries. In some types of surgery, antibiotic prophylaxis is indicated but this is not usually necessary in laparoscopy.^{65,66} In fact laparoscopy has been associated with a lower wound site infection rate than laparotomy. For example in a study of 367 women undergoing laparoscopy or laparotomy for endometrial cancer treatment, the open wound infection rate was 2% versus 9% respectively.⁶⁷ Use of direct trocar insertion and open technique may result in a lower rate of wound site infection than Veress needle entry, according to the results of a randomised control trial on 595 consecutive laparoscopic procedures.⁶⁸ In terms of hysterectomies, transumbilical single-port laparoscopic hysterectomy (TSPLH) appears to be associated with a lower rate of port site infection than traditional four-port laparoscopic hysterectomy.⁶⁹

TECHNOLOGICAL AND SURGICAL INNOVATIONS

There are various innovations coming to the fore in this field which should prove effective in improving even further the safety of these types of procedures and helping to manage complications when they arise. Excellent surgical technique, appropriate training of surgeons and their clinical support teams and familiarity with equipment and instruments used are paramount in avoiding complications in the first place and in taking appropriate steps to manage them.

A promising surgical innovation, to be considered, is the use of camera control systems such as SOLOASSIST™ or Einstein Vision™ for endoscopic surgery.⁷⁰ A recent study addressed use of two of these surgeon-controlled endoscope leading assistance systems in 104 women undergoing laparoscopic surgery.⁷⁰ After about twenty operations, a significant learning curve had been achieved in setting up the systems and surgeons reported their overall comfort in using the systems as 'good'. No complications were encountered among the patients and during long, complex procedures there was a reduction in picture blur. The systems also facilitated solo operations even in

complex procedures. Operation times were either comparable or shorter than reported in the literature, for example, the time needed for LAVH was considerably reduced.⁷⁰

Other surgical innovations, to be considered, include use of robotically-assisted endoscopic surgery, such as with the Zeus or da Vinci robotic systems.⁵⁸ While advantages have been reported including three-dimensional view and tremor-free suturing, there are many barriers to implementation of this type of technology including very high financial cost and feasibility of training for surgeons, for example at company headquarters.⁷¹ It also entails a new learning curve for surgeons. Less cumbersome equipment and reduced costs may result as the technology develops. Also, while robotic surgery has been reported to improve surgeon dexterity and ergonomics, it has also increased the number and size of ports required, which can contribute to complications.⁷² Thus research is ongoing in development of robotically-assisted single-port laparoscopy, or Laparo-Endoscopic Single Site (LESS) surgery.⁷²

In fact, movement towards LESS, which is minimally invasive, should be a consideration for surgeons concerned with reducing and managing complications in endoscopic gynaecological surgery, as it should in theory further reduce complications.^{73,74} A recent study on six women undergoing the LESS technique for balloon vaginoplasty (BV) showed that the procedure worked successfully in all patients and suggested that in considering management of such cases, there should be a prospective comparison of surgical outcomes to conventional laparoscopic BV.⁷³ Results of another study on 40 women treated for benign gynaecological conditions using the LESS technique suggested that it had a favourable impact on operating times and a very low complication rate.⁷⁴ The study authors suggested that LESS may become the method of choice in many simple gynaecological procedures. Surgeons should consider use of these types of techniques where feasible in order to minimise and manage complications.

Another factor to consider in management of complications in endoscopic gynaecological surgery is feasibility of natural orifice transluminal endo-

scopic surgery (NOTES). A recent study on 137 patients undergoing transvaginal natural orifice transluminal endoscopic hysterectomy (tVNOTEH) showed that surgery was successful in 130 patients.⁷ Complications in seven patients were managed successfully by trans abdominal laparoscopy. Thus transvaginal NOTES was an effective technique in performance of hysterectomy and was applicable in procedures that are difficult in conventional vaginal surgery as posterior colpotomy is achievable. Surgeons should be mindful of the potential complications and be ready to manage with trans abdominal laparoscopy but the procedure has the advantages of not being impeded by uterine volume or any requirement for abdominal incision.⁹ Another innovation in the field of NOTES is the use of the single port transdouglass endoscopic device (TED).² The single-port TED is considered to be safe and cost-effective and allows ready access to the peritoneal cavity in women. It may in the future replace many other endoscopic procedures.²

CONCLUSION

Laparoscopy has many advantages in terms of safety and cost effectiveness. Complications are rare, but its effective management depends on surgeon awareness and training and familiarity with techniques, equipment and instruments. Major complications of laparoscopy include vessel injury, gastrointestinal and genitourinary injury, blood loss, gas embolism, incisional hernia and port site metastases. Studies suggest that training and experience results in reduced complication and reoperation rates.^{31,32,35} Preoperative preparation and keen awareness of contraindications and risk factors for different complications improves outcomes by allowing possible complications to be anticipated and steps to be taken to minimise their likelihood. It also maximises the chance that effective action will be taken when complications arise, as inevitably they will for even the most experienced surgeons. Guidelines of professional bodies such as the RCOG on, for example, positioning of patients to minimise complications should be adhered to. In every case, employment of sound surgical techniques, including awareness of different abdominal entry strate-

gies should be followed. This includes use of appropriate instruments such as blunt cannula and trocar and optical access trocars, nasogastric tube at the beginning of procedures to facilitate stomach and bowel decompression, and reduction of thermal injuries by considering use of bipolar cautery, electrothermal bipolar vessel sealers or ultrasonic coagulating shears. Awareness of the possible complications and readiness to react appropriately can minimise the incidence or, when they arise, effectively manage these rare complications. Awareness of signs of complications, for example foul-smelling odour in gastrointestinal injury, increases the chance of early diagnosis and intraoperative repair, reduces the post-operative complications and necessity for further corrective surgery for the patient. Other interventions such as fascial suturing to reduce incisional hernia incidence or lavage of the port site with cytotoxic and chemotherapeutic agents to reduce port site metastases should also be borne in mind. Many innovations are available to potentially assist surgeons in carrying out this type of surgery and minimising potential complications. These include technical developments in camera control systems such as SOLOASSIST™ or Einstein Vision™ and robotically-assisted surgery, such as the Zeus or da Vinci robotic systems, movement to the minimally invasive LESS and to natural orifice surgery.^{2,7,42,70,71,73,74} Added to development of excellent surgical technique and constant mindfulness of the potential complications that can arise, the future appears bright for minimisation and management of complications in endoscopic gynaecological surgery.

Conflict of Interest

Authors declared no conflict of interest or financial support.

Authorship Contributions

The principal investigator, designed the study, assisted in writing the paper and edited it in all its revisions: Ayla Eser; **Collected the data, assisted in writing the paper all its revisions:** İlknur İnegöl Gümüç; **Collected the data:** Nilüfer Akgün; **Collected the data:** Ebru Yüce; **Collected the data:** Müberra Namlı Kalem.

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