Laparoscopic management of acute abdominal emergencies

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Abstract

Laparoscopic management is increasingly recognized as a valuable approach in treating acute abdominal emergencies due to its diagnostic accuracy, minimally invasive approach and therapeutic advantages. It serves as an effective diagnostic tool in unclear abdominal cases, reducing the need for exploratory laparotomies. Key insights from recent literature include the following: Laparoscopic appendicectomy (LA) has been shown to lower wound infection rates and hospital stays compared to open appendicectomy, though the incidence of intra-abdominal abscesses may be slightly higher with LA. Laparoscopy is a safe method for managing acute abdominal pain during pregnancy, especially in cases of appendicitis or cholecystitis, as it minimizes fetal risks and avoids the use of ionizing radiation. Early laparoscopic cholecystectomy, preferably within 72 hours of onset of cholecystitis symptoms, is recommended for quicker recovery and fewer complications. Laparoscopy can be applied in certain trauma cases, although its use is contingent on the surgeon's skill and the patient's stability. It is particularly beneficial in diagnosing gynaecological emergencies such as ectopic pregnancy or ovarian torsion, where rapid diagnosis and treatment can improve outcomes. The success of laparoscopic surgery is highly dependent on the surgeon's expertise. In conditions such as adhesional bowel obstruction or mesenteric ischemia, the evidence is less conclusive, and further clinical trials are needed. In resource-limited settings, the availability of equipment and costs may limit the widespread use of laparoscopic techniques.

Keywords Abdominal emergencies; appendicitis; cholecystitis; diverticulitis; keyhole surgery; laparoscopy; obstruction; pain; peptic ulcer; trauma

Introduction

Over the past three decades, minimally invasive surgery has advanced considerably, with elective procedures such as laparoscopic cholecystectomy and colorectal resections now standard practice. Adoption for emergency cases has been slower due to concerns regarding extended setup time, longer operations, and risks of injury in unstable patients. However, improved training, standardized protocols, and extensive research have demonstrated its value in the emergency setting, enabling safe and effective management of complex cases. This article reviews evidence, controversies, risks, and techniques in laparoscopic emergency surgery.

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Diagnostic laparoscopy in abdominal pain

Diagnostic laparoscopy is a minimally invasive procedure used to identify intra-abdominal conditions, particularly when standard tests and imaging are unable to determine the cause of abdominal pain. It helps minimize treatment delays and often eliminates the need for laparotomy. This technique allows direct visualization of abdominal organs, facilitates biopsies, and enables therapeutic interventions including lavage and drainage. It is highly accurate in diagnosis, with a success rate of up to 99% and has a low complication rate. A thorough exploration of all abdominal structures is crucial, and "re-look laparoscopy" is increasingly used after surgery to evaluate potential complications, offering lower morbidity compared to laparotomy. An absolute contraindication to diagnostic laparoscopy in abdominal pain is where a patient is haemodynamically unstable.

Appendicitis

Appendicectomy has been a fundamental surgical procedure for many years, with laparoscopic techniques gaining significant popularity since the 1990s. Appendicitis can be classified as either perforated or non-perforated. Laparoscopic surgery has increasingly replaced the open approach, even for perforated appendicitis, due to advancements in skillset and equipment.

Laparoscopy offers numerous advantages. Diagnosing appendicitis can be challenging, with the rate of negative appendicectomies in the UK reaching up to 20%. An open surgical approach limits the ability to examine other abdominal organs if the appendix appears normal. Laparoscopy, however, allows a comprehensive diagnostic evaluation, which is particularly beneficial for female patients where gynecological conditions may mimic appendicitis. Other benefits of minimally invasive surgery include reduced postoperative pain, lower rates of wound infections, and faster recovery times.

A 2018 Cochrane review of 85 studies involving nearly 10,000 patients revealed that adults undergoing laparoscopic appendicectomy experienced better pain relief, fewer wound infections, shorter hospital stays (by one day), and returned to normal activities five days sooner than open surgery patients. Although the differences were less significant in children, they also experienced shorter hospital stays and reduced pain levels. However, the review found a higher incidence of intra-abdominal abscesses in adults after laparoscopic appendicectomy, though this was not the case in children.[1]

Another area of discussion is the use of drains for complicated appendicitis after surgery. A 2021 Cochrane review that examined six studies with over 500 patients, found that patients with drains had higher complication rates and longer hospital stays.[2]

Laparoscopic appendicectomy should be considered first-line management whenever possible and when there are no contraindications.

Operative technique

Classical laparoscopic appendicectomy typically involves the use of at least one 10- or 12-mm port, along with two additional ports, which may consist of either two 5-mm ports or one 10-mm and one 5-mm port. The appendix is separated from the surrounding structures through blunt dissection, and if it is positioned retrocaecally, mobilization of the right colon may be required.

The mesoappendix is then dissected, and the appendiceal artery is secured. This can be done using one of two approaches: a "top-down" method, where the mesoappendix is separated from the appendix, or by dissecting the mesoappendix at its base and securing the artery. Both methods are shown in Figure 1a and b.

Haemostasis is achieved using techniques such as diathermy, energy devices, or laparoscopic clips. The base of the appendix is identified and secured with two Roeder knots, Endoloops, or polymeric clips. A 2024 meta-analysis found that using polymeric clips to secure the appendix base leads to shorter operative times and a lower incidence of postoperative intra-abdominal abscesses compared to Endoloops.[3]

It is recommended to remove the appendix using a laparoscopic retrieval bag to avoid contamination. If complications arise, such as bleeding, patient instability, failure to advance the procedure, or accidental injury to surrounding organs, conversion to open surgery should be considered.

Perforated peptic ulcer

Laparoscopic repair of a peptic ulcer perforation (PUP) was first described in 1990 and has become one of the most suitable emergency conditions to address using minimally invasive techniques. Contamination from the upper gastrointestinal tract, which is typically bilious, is more easily managed laparoscopically than faecal contamination. The defects are usually small, making laparoscopic suturing appropriate, and resection of any affected viscera is rarely necessary, eliminating the need for an extraction site. The 2020 World Society of Emergency Surgery (WSES) guidelines recommend laparoscopic surgery as first-line treatment for peptic ulcer perforation, provided the surgeon is skilled in the technique.

The benefits, safety, and feasibility of laparoscopic versus open approaches have been extensively researched, with four meta-analyses conducted on the topic, yielding somewhat contradictory results. Two of the meta-analyses found short-term benefits, such as lower postoperative pain and wound morbidity.[4,5] However, one of these studies also reported longer operation times and a higher rate of suture line leakage.[4] Another meta-analysis found no significant difference between the two approaches.[6] The most recent meta-analysis, published in the *Annals of The Royal College of Surgeons of England*, found that laparoscopic repair of PUP is associated with significantly lower mortality and morbidity, as well as a shorter length of stay compared to the open approach.[7]

Another analysis of 29 studies also found that laparoscopic repair was associated with fewer overall complications and a lower risk of mortality compared to open repair in patients with PUP.[8] A systematic review and meta-analysis of 29 studies involving 5311 patients, published in the *American Journal of Trauma and Acute Care Surgery*, concluded that laparoscopic omental patch repair results in lower mortality, overall morbidity, length of stay, intraoperative blood loss, and postoperative pain compared to open repair. Most laparoscopic procedures were performed by consultants, while open repairs were conducted by residents.[9]

Operative technique

Whether performed open or laparoscopically, the procedure involves a thorough lavage of the peritoneal cavity, closure of the ulcer with sutures, and placement of an omental patch (or both) as shown in Figure 2. If there is a risk of suture line leakage, an

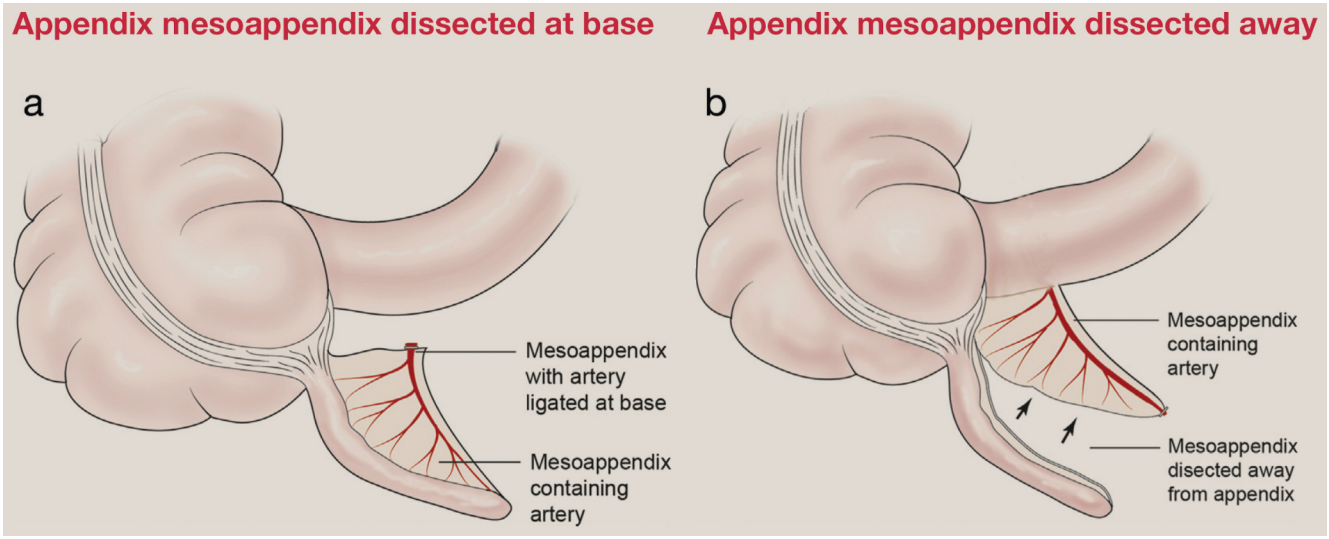

Figure 1 Different methods of dissecting mesoappendix.

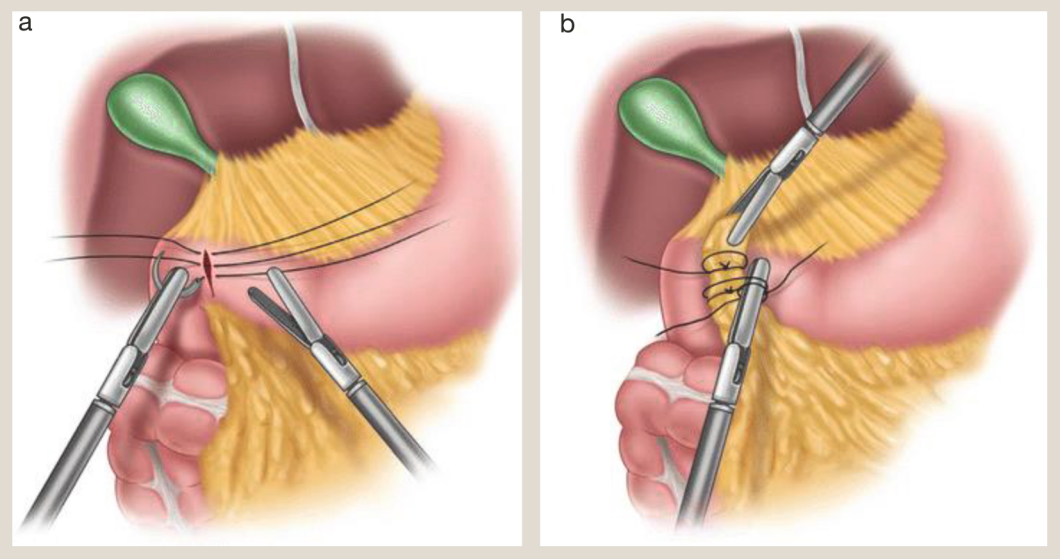

Figure 2 Suture repair of perforated peptic ulcer with omental patch.

appropriately sized drain is inserted. For gastric ulcers, a biopsy is necessary due to the increased risk of malignancy. In rare cases, very large defects may be present that cannot be repaired with simple sutures or an omental patch. In these instances, a specialist in upper gastrointestinal surgery should be consulted for further evaluation and management.

Suggested port placements are shown in Figure 3.

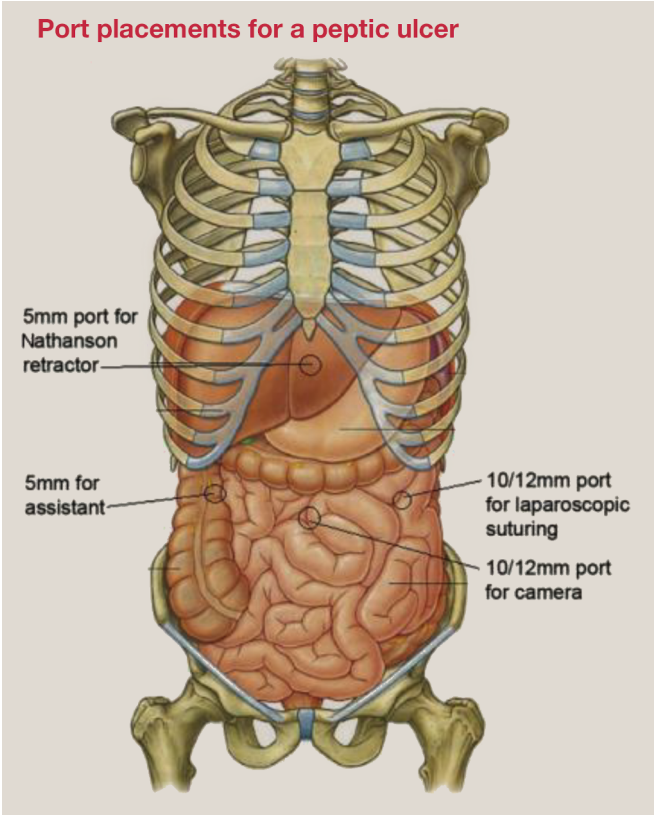

Figure 3 Laparoscopic ports placement sites for peptic ulcer repair.

Cholecystitis

Laparoscopic cholecystectomy is the gold standard technique for gallbladder removal. A recent meta-analysis of 32 trials comparing laparoscopic, robotic, and open cholecystectomy found that robotic surgery is associated with longer operative times. However, both laparoscopic and robotic techniques provided similar safety and better perioperative outcomes compared to the open procedure.[10]

Emergency cholecystectomy is critical in cases of complicated acute cholecystitis, such as those involving gangrene or perforation, since these conditions can be fatal if untreated. CT scans are effective in detecting perforation, but gangrene is more difficult to diagnose and may be indicated by worsening clinical or biochemical markers.

Traditionally, patients with milder cholecystitis were treated initially with antibiotics and underwent cholecystectomy after several weeks. However, laparoscopic cholecystectomy is now increasingly being performed during the acute phase of the illness. Surgery is usually postponed only for highly complex cases or patients with significant comorbidities. Ideally, surgery for acute cholecystitis in otherwise healthy patients should be performed as soon as possible, within 7 days of symptom onset. Delaying surgery beyond 72 hours increases the risk of bleeding and complicates the procedure due to the formation of local inflammation and adhesions.

A 2023 systematic review and meta-analysis of 34 studies by Wu et al., published in *Frontiers in Medicine*, found that early laparoscopic cholecystectomy (within 7 days of symptom onset) was associated with a lower conversion rate to open surgery, fewer postoperative complications, and shorter hospital stays.[11]

A significant proportion of patients with acute cholecystitis also present with common bile duct stones, which may be detected through preoperative imaging or intraoperative cholangiography. These stones can be removed through bile duct exploration, often laparoscopically, or through endoscopic retrograde cholangiopancreatography (ERCP) before or after surgery. If surgery cannot be performed within 10 days, it is

typically delayed for 6 weeks to allow inflammation to subside, unless the patient's condition deteriorates.

Intraoperative indocyanine green (ICG) fluorescence imaging can assist in identifying biliary anatomy during surgery. While its use in emergency cholecystectomy has been studied, large-scale evaluations are still lacking. A 2023 meta-analysis concluded that the critical view of safety (CVS) should be documented using imaging, in addition to being noted in the operative records. When CVS cannot be safely established, the threshold for using alternative imaging or bailout strategies should be low.[12]

Early cholecystectomy offers advantages such as preventing complications like recurrent cholecystitis or pancreatitis. For patients with gallstone pancreatitis, performing laparoscopic cholecystectomy during the initial hospital admission has become the standard of care.

For patients with significant comorbidities where surgery poses a high risk, conservative management is often preferred over acute cholecystectomy. Techniques such as percutaneous cholecystostomy can be used to manage complications, although they are beyond the scope of this review.

Operative technique

Following the creation of pneumoperitoneum the patient is typically positioned in a supine "head-up" position with the left side tilted downward. This positioning helps optimize access to the gallbladder and the operative field. A common port placement involves inserting one 10-mm port at the umbilicus for the camera and three 5-mm ports in the epigastrium just beneath the right costal margin, though the epigastric port may be converted to a 10-mm port to facilitate the use of instruments such as gold Hem-o-loks for securing vessels.

Once the ports are placed, the assistant's role is to retract the gallbladder superolaterally, exposing the porta hepatis. In cases of acute cholecystitis, where the gallbladder may be inflamed or distended, it can be challenging to securely grip the gallbladder. In such instances, aspirating the gallbladder with a sharp-tipped suction device can be useful to reduce distension and facilitate easier manipulation.

Adhesions to nearby structures such as the duodenum, omentum, and colon are commonly encountered and must be carefully dissected to prevent injury to these tissues.

The crucial step in the procedure is achieving the CVS, which is imperative for safe dissection of the cystic duct and artery. The CVS is defined by the inferior edge of the liver, the cystic duct, and the common hepatic duct. To obtain the CVS, the surgeon first creates a large posterior window behind the gallbladder. This allows for better access and visualization before carefully dissecting the cystic artery and cystic duct.

Once the anatomy is clearly identified, secure clips are placed on both the cystic duct and cystic artery to ensure proper hemostasis before these structures are divided. At this point, the gallbladder is separated from its bed. If an on-table cholangiogram is planned to assess for any bile duct stones or other abnormalities, it is performed after placing the first distal clip on the cystic duct to ensure proper visualization.

In situations where extensive inflammation prevents a clear view of Calot's triangle (the critical area where the cystic duct and artery meet), a subtotal cholecystectomy may be necessary. This involves removing the gallbladder while leaving part of the gallbladder bed to minimize the risk of injury to surrounding structures, especially the bile duct.

The laparoscopic approach, when executed carefully and with attention to these anatomical landmarks, allows for a safe and effective cholecystectomy, with reduced postoperative recovery times compared to open surgery.

Suggested port placements and an operative diagram of critical view of safety are shown in Figure 4.

Diverticulitis

The advent of laparoscopy, improved access to CT scanning, and interventional radiology have significantly altered treatment algorithms. However, Hartmann's procedure remains a safe and accepted treatment option. Traditionally, diverticulitis was assessed using the Hinchey classification, but given that many of the findings were based on operative assessments, more modern CT-based classification systems have been developed. Both classifications are summarized in Table 1 and illustrated in Figure 5. For localized abscesses of sufficient size (Hinchey 1b, Sartelli 2A), percutaneous radiological drainage is often an appropriate management strategy. However, clinicians should be aware of high recurrence rates, and if this approach fails, surgery may be necessary.

Laparoscopic washout and drainage for pelvic abscesses, intra-abdominal abscesses, and generalized purulent peritonitis have many supporters, as it avoids the significant risks and lifestyle changes associated with a Hartmann's procedure. However, opponents argue that it may be difficult to rule out persistent colon perforations and the potential for missed malignancy. The data available on laparoscopic lavage is controversial and mixed at best. Three trials compared this technique with sigmoid resection (with or without a stoma):

- The SCANDIV trial compared 199 patients and found similar mortality and morbidity rates between the two methods but noted that patients in the lavage group required more re-operations and had a higher incidence of missed cancers.[13]
- The LOLA trial, which compared 90 patients, was halted early due to significantly higher 30-day morbidity and re-operation rates in the lavage group.[14]
- The DILALA trial compared 83 patients and found similar 30-day morbidity and re-operation rates. However, the trial also found a higher re-operation rate after one year in the Hartmann's group, though this was mostly attributed to the reversal of Hartmann's operations rather than severe morbidity. Given the conflicting nature of the data, laparoscopic lavage should be approached with caution and with input from senior clinicians.[15]

Regarding resectional surgery in the acute setting (such as sigmoid colectomy with or without a defunctioning ileostomy, or a Hartmann's procedure), numerous studies have demonstrated that this can be safely performed with minimal invasiveness without increasing patient risk. A 2017 Cochrane review of three randomized controlled trials found no significant difference between the approaches, though it called for more research in this

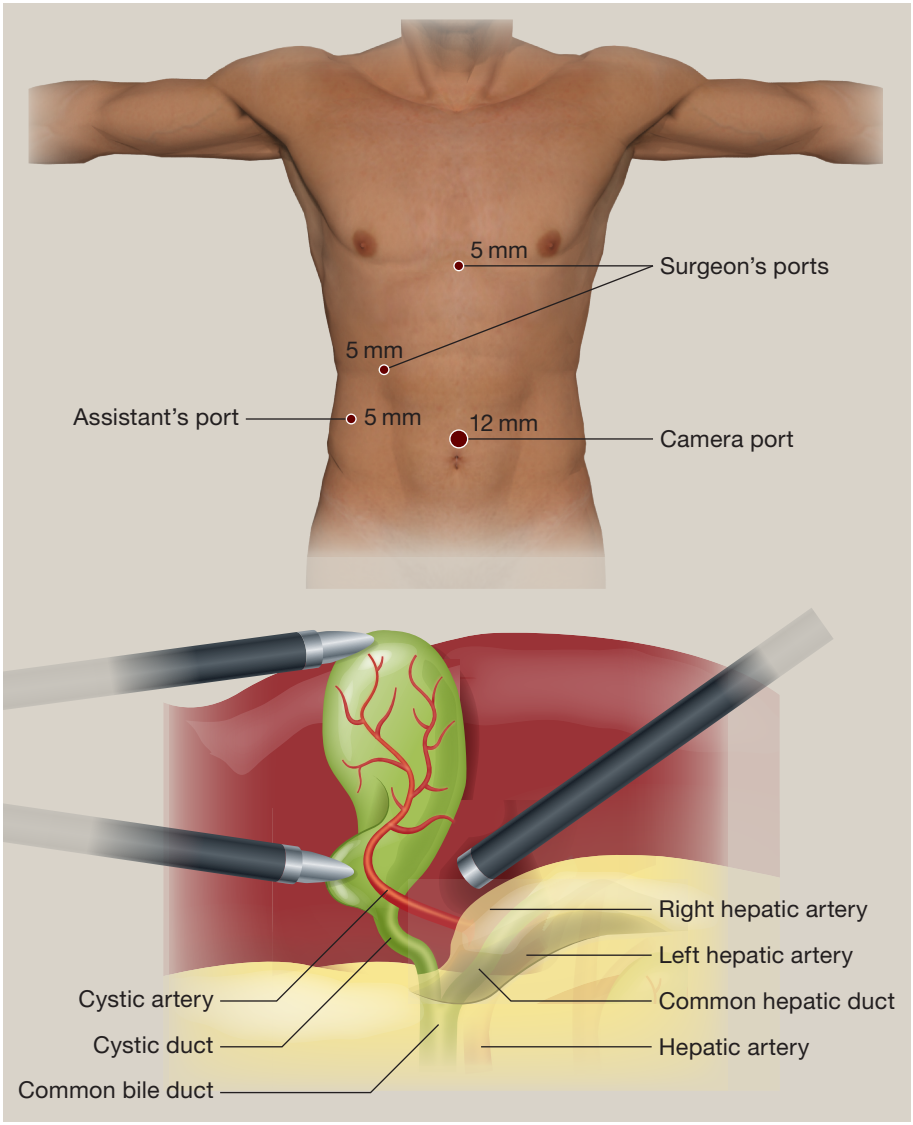

Figure 4 Laparoscopic ports placement sites for laparoscopic cholecystectomy and critical view of safety (Calot's triangle).

area.[16] Other studies have compared Hartmann's procedure with primary anastomosis and diverting loop ileostomy for Hinchey III and IV patients, including those performed laparoscopically. Systematic reviews and meta-analyses from 2018 to 2019 concluded that both procedures were acceptable, with similar major complication and mortality rates. No consensus exists regarding the use of a covering stoma, leaving the decision to the surgeon's discretion.[17]

Diverticulitis classifications

Score/stage (Hinchey/Sartelli)	Modified Hinchey classification	CT-based scoring system (Sartelli)
0	Mild clinical diverticulitis	N/A
Ia/1A	Localized pericolic inflammation or phlegmon	Pericolic air bubbles/fluid without abscess
Ib/1B	Pericolic/mesenteric abscess	Abscess <4 cm
II/2A	Pelvic, intra-abdominal or retroperitoneal abscess	Abscess >4 cm
2B	N/A	Distant air (>5 cm from inflamed bowel segment)
III/3	Generalized purulent peritonitis	Diffuse fluid but no free air (no ongoing hole in colon)
IV/4	Generalized faecal peritonitis	Diffuse fluid with distant free air (persistent hole)

Table 1

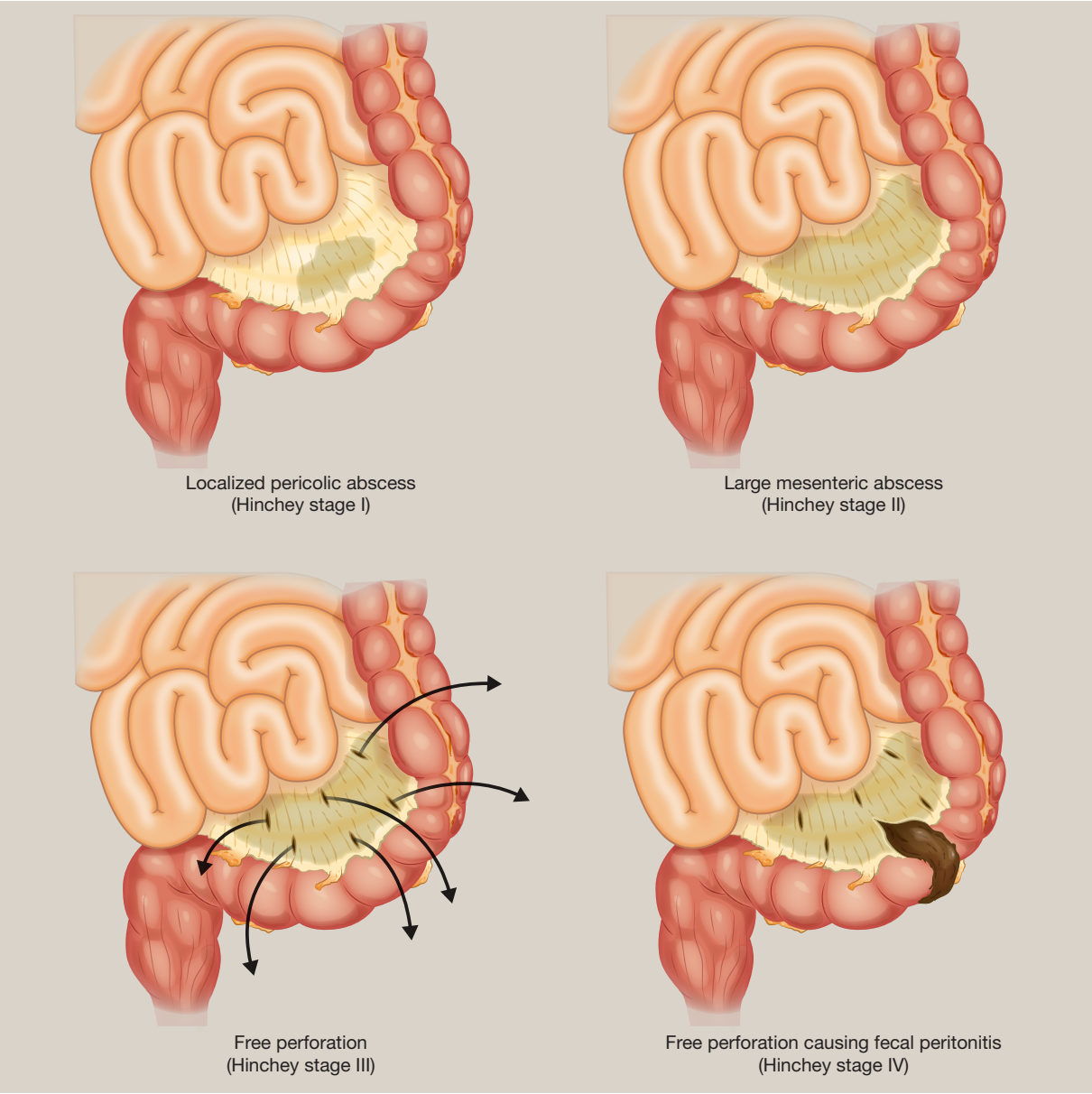

Figure 5 Diverticulitis classification

A growing trend has emerged toward performing laparoscopic Hartmann's procedures in recent years. A meta-analysis by Tiong et al. compared short-term outcomes after laparoscopic lavage versus colonic resection in Hinchey III patients. It found that laparoscopic lavage was associated with lower rates of wound infection, stoma formation, and shorter hospital stays, but it also had an increased rate of re-operations. The analysis emphasized the consideration of elective resection following lavage.[18]

Small bowel obstruction

Small bowel obstruction (SBO) is a common cause of surgical admissions, often resulting from adhesions due to previous surgeries. Around 25% of patients require surgical treatment, and laparoscopic approaches are becoming increasingly common. Although abdominal distension and a history of extensive prior surgeries are considered relative contraindications for laparoscopy, minimally invasive surgery is frequently attempted. In many cases, a single adhesional band is found, which can be safely accessed and divided with minimal incisions, allowing patients to benefit from the advantages of laparoscopic surgery.

However, concerns exist regarding limited visibility due to bowel distension, which may increase the risk of unintentional small bowel injury. Currently, no surgical organizations officially recommend laparoscopy for SBO, and studies supporting its feasibility suggest it should only be performed by experienced surgeons.

A systematic review and meta-analysis by Krielen et al. evaluated 14 studies and concluded that laparoscopic surgery is safe and feasible for adhesional SBO. No significant differences were observed between open and laparoscopic approaches regarding postoperative mortality, bowel perforations, length of

hospital stay, complications, or early readmissions, although laparoscopic surgery appeared to offer advantages in these areas.[19]

A 2024 study published in *Heliyon* concluded that appropriate patient selection, such as no contraindications to pneumoperitoneum, fewer than two previous abdominal surgeries, no pregnancy, less than 4 cm of intestinal dilation, simple adhesions, and no intestinal strangulation or necrosis resulted in fewer postoperative complications and lower re-operation rates for laparoscopic adhesiolysis.[20]

Internal hernias, especially following gastric bypass, are another common cause of SBO and are considered a surgical emergency. They can be effectively managed with laparoscopic surgery. Clinicians should have a low threshold for diagnostic laparoscopy if there is a high clinical suspicion of internal hernia, as CT imaging has only an 80% sensitivity for diagnosis.[21]

Despite the potential benefits of laparoscopic surgery, the risk of inadvertent injury to abdominal structures must be carefully weighed when deciding on a minimally invasive approach. The role of laparoscopy in managing small bowel obstruction remains uncertain, and further research is needed to establish clear guidelines for patient selection and minimize intraoperative and postoperative risks.

Diagnostic laparoscopic in trauma

Diagnostic laparoscopy has become an increasingly valuable tool in the management of abdominal trauma, offering the potential to avoid unnecessary laparotomies, especially in patients who may have a low likelihood of needing an extensive open procedure. The key advantage of diagnostic laparoscopy lies in its ability to provide a clear, real-time view of the abdominal cavity, allowing for assessment of injuries with minimal invasiveness. However, its use must be carefully considered based on patient stability and the nature of the injuries.

In trauma patients, particularly those with blunt or penetrating abdominal trauma, diagnostic laparoscopy can be extremely helpful when CT scans or clinical examination are inconclusive. It is particularly valuable in situations where there is suspicion of a peritoneal breach from penetrating trauma or when diaphragmatic injuries are suspected in thoraco-abdominal trauma but radiological findings are normal. However, in critically unstable patients, especially those with suspected major vascular injuries, laparoscopy is contraindicated due to the risk of further complications like tension pneumothorax, gas embolism, or exacerbating hemodynamic instability.

While diagnostic laparoscopy has shown diagnostic accuracy rates exceeding 90%, it is crucial for the trauma team to recognize when conversion to laparotomy is necessary. Indications for conversion include persistent intra-abdominal bleeding, complex injuries that require more extensive repair, haemodynamic instability, or poor intraoperative visualization during laparoscopy. For example, if a small bowel injury is identified, it can often be repaired laparoscopically, and drains can be placed if necessary, making the procedure not only diagnostic but also therapeutic in some cases.

Nonetheless, close monitoring after the procedure is essential, with a high index of suspicion for missed injuries, especially in cases where the findings are ambiguous or where a full inspection may not have been possible. This ensures that any injuries that may have been overlooked or not adequately treated during laparoscopy are promptly addressed.

A recent meta-analysis published in *Frontiers in Surgery* (2022) by Wang et al. confirmed that there was no significant difference in the rates of missed injuries or mortality between patients undergoing diagnostic laparoscopy and those who had laparotomy for abdominal trauma. This highlights the utility of laparoscopy as a safe and effective option in the appropriate clinical context, though its use still requires careful patient selection and a readiness to convert to open surgery if necessary.[22]

In summary, diagnostic laparoscopy can be an excellent tool in trauma surgery when used appropriately, offering diagnostic precision with reduced invasiveness, but it should always be performed with caution, especially in patients with complex or unstable conditions.

Herniae

Laparoscopic management of acutely strangulated or incarcerated abdominal wall hernias has become increasingly feasible and successful, particularly for femoral or obturator hernias. In these cases, after establishing pneumoperitoneum, the hernia is reduced, and the contents are assessed to determine if any bowel resection is required. The sac is then reduced, and mesh is placed to prevent recurrence. Although laparoscopic surgery offers the advantage of minimally invasive techniques, it carries risks similar to those seen in open hernia repairs.

In cases of acutely obstructed hernias, open surgery remains the preferred approach, primarily because the surgeon can directly assess the bowel for signs of ischemia or necrosis. The decision to perform a laparoscopic approach must be made carefully, with particular attention to ensuring that the bowel is not severely compromised, as this could increase the risk of contamination and subsequent complications.

Laparoscopic repair is becoming more commonly applied in cases of diaphragmatic hernias, even in acute settings. A 2016 NHS study found a significant increase in the use of minimally invasive techniques for strangulated or incarcerated paraoesophageal hernias from less than 1% prior to 2000, to over 30% between 2009 and 2012. The mortality rate during this period remained unchanged, indicating that minimally invasive techniques are safe, although such procedures should be carried out by skilled surgeons, especially in emergency situations.[23]

A review by Clapp et al., in 2022 addressed the outcomes of paraesophageal hernia repairs, noting that when fundoplication was not performed, higher rates of gastrooesophageal reflux disease, hernia recurrence, and reoperation were present. However, there was a lower risk of dysphagia in patients who did not undergo fundoplication, although these differences were not statistically significant. This highlights the importance of considering individual patient factors and surgical preferences when planning these complex procedures.[24]

A suture repair of a hiatus hernia is shown in Figure 6.

Utilizing a laparoscopic approach for the acutely strangulated or incarcerated hernia (including diaphragmatic and abdominal wall) is growing in popularity due to the minimally invasive nature and associated benefits including shorter recovery times.

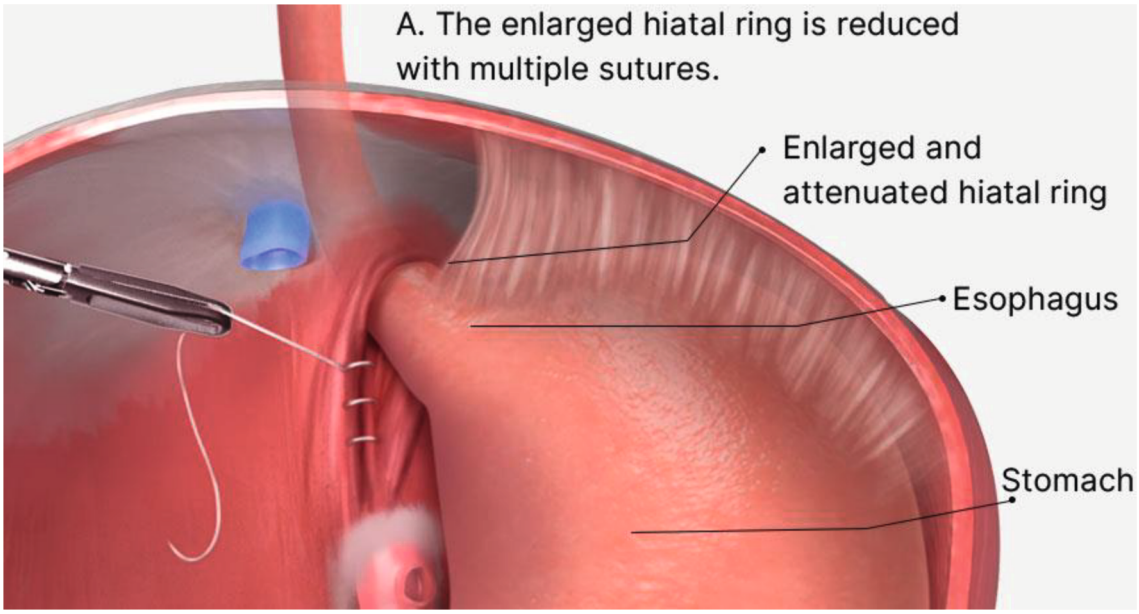

Figure 6 Suture repair of hiatus hernia.

However, these procedures require a high level of surgical expertise, and the decision to perform laparoscopy must be carefully weighed against the risks of bowel compromise and the need for more extensive open surgery.

Conclusion

Minimally invasive surgery has revolutionized patient care, particularly in the elective setting, and its use continues to expand into acute abdominal emergencies. Numerous studies have highlighted the benefit of laparoscopic approaches for conditions such as appendicitis and cholecystitis with reduced postoperative pain, shorter hospital stays, and faster recovery times. The growing body of evidence supports laparoscopic surgery as a safe and effective alternative in many acute settings. However, determining appropriateness and undertaking laparoscopy in such scenarios should involve experienced surgeons, especially in the acutely unwell patient. Similarly, determining when laparoscopic surgery is not appropriate or the need to convert requires careful consideration. ◆

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Practice points

- Laparoscopic techniques for managing acute abdominal surgical emergencies have become more common in recent years
- Minimally invasive surgery typically results in less postoperative pain and shorter hospital stays, and quicker overall recovery compared to traditional open surgery
- Laparoscopy is now considered the preferred treatment for appendicitis and cholecystitis. Growing evidence highlights its significant potential for treating conditions such as diverticulitis, peptic ulcer disease, hernias, and small bowel obstruction
- In trauma cases, laparoscopy has proven beneficial and may significantly reduce the need for an exploratory laparotomy
- The decision to perform laparoscopic surgery for acute abdominal emergencies often depends on the clinical judgment of the surgical team, based on their experience and expertise