



Small Bowel Perforation

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74.1 Introduction

Learning Goals

- Summarize causes of small bowel perforation.
- Analyse the pathophysiology of different mechanisms of small bowel perforation.
- Discuss diagnosis and treatment options.

74.1.1 Epidemiology

Small bowel perforation can be initially differentiated into traumatic and non-traumatic.

In blunt trauma, small bowel injury is mainly associated with the seatbelt sign [1] and is the third most common injury associated with blunt abdominal trauma [2]. Due to its location in the abdomen the small bowel is the organ most commonly injured in penetrating trauma (30–83%). In stab wounds in particular, a higher body mass index (BMI) seems to be a protective factor [3].

Iatrogenic injuries are a less common cause of traumatic perforation.

Non-traumatic small bowel perforation is a common cause of peritonitis in Western countries, where it is mainly related to ischaemia of the bowel from obstruction due to adhesions and hernias. *It has a significant peri-operative and long-term mortality, which can be as high as 32.8% at 3 years, as recently demonstrated in the National Emergency Laparotomy Audit (an ongoing quality improvement project in the United Kingdom, www.nela.org.uk).* In low- and middle-income countries (LMICs), small bowel perforations caused by infectious conditions are more common and a major challenge for local health care systems, with a mortality rate of up to 60% [4].

74.1.2 Aetiology

The causes of small bowel perforation are summarized in Table 74.1. We will focus our chapter on the general management of small bowel perforation.

74.1.3 Classification

Small bowel perforations can be classified according to anatomy (duodenal/jejunal/ileal), aetiology (traumatic versus non-traumatic) and

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Table 74.1 Causes of small bowel perforation

Causes of small bowel perforation	
Traumatic	Blunt trauma Penetrating trauma Iatrogenic injuries Foreign bodies
Non-traumatic	Ischaemia (obstruction due to adhesions and hernias, vascular occlusion from atherosclerosis or autoimmune disorders affecting the vasculature of the small bowel) Inflammatory (Crohn's disease, celiac disease, collagenous sprue) Infectious (<i>Salmonella paratyphi</i> , <i>Mycobacterium tuberculosis</i> , cytomegalovirus [CMV], <i>Entamoeba histolytica</i> , <i>Ascaris lumbricoides</i>) Meckel's diverticulum/jejunal and ileal duplications Drugs (non-steroidal anti-inflammatory drugs [NSAIDs], chemotherapy ± radiotherapy, monoclonal antibodies, potassium chloride) Neoplasms (either primary or secondary)

type of perforation (free vs. contained). A very proximal position of the perforation has implications regarding the ability to perform diversion in case of patients in extremis, due to inevitably high gastrointestinal (GI) losses. Certain aetiologies can have even poorer prognosis than the already significant mortality related to peritonitis (perforated malignancy, patients on chemotherapy/radiotherapy, typhoid perforations in LMICs). Contained perforations of the small bowel are uncommon, due to the organ's predominantly intraperitoneal anatomy, with the exception of the retroperitoneal duodenum, which is covered in another chapter.

74.1.4 Pathophysiology

The mechanisms behind the perforation are inherently related to the aetiology. In trauma, they usually are related to direct penetrating injury, crush injury between internal and external structures, acceleration/deceleration injuries and low perfusion state from haemorrhagic shock or direct vascular trauma. Small bowel obstruction due to adhesions or hernias, which is not relieved, will lead to proximal bowel dilation, venous out-

flow obstruction and eventually bowel wall ischaemia and perforation. The progressive transmural inflammatory process related to Crohn's disease and its complications (abscess and fistulas in this case) is responsible for spontaneous bowel perforations. Other autoimmune processes, like celiac disease and celiac disease related lymphoma, create histopathologic bowel changes that predispose to ulcerations [5]. In typhoid perforations, the mechanism is hyperplasia and necrosis of Peyer's patches of the terminal ileum [6]. Drug-related direct mucosal injury seems to be the insult leading to full-thickness defects of the bowel [7] on a lot of cases, but also chemotherapy and radiotherapy can cause enterocolitis leading to a perforation [8]. T- and B-cell lymphomas have been reported to have perforation as the first presentation leading to their diagnosis, with a rate that can reach 34% [9–11].

74.2 Diagnosis

74.2.1 Clinical Presentation

The clinical presentation of small bowel perforation is largely associated with the underlying aetiology, as outlined above.

In the majority of cases, patients will present with pain, peritonism and sepsis in the later stages. Further symptoms will be related to underlying causes:

- Obstruction—vomiting, reduced bowel movements, abdominal distension
- Ischaemia—significant abdominal pain, atrial fibrillation or coagulopathy
- IBD—may be known Crohn's, or new presentation with loose stools with blood and mucous
- Infection—diarrhoea
- Meckel's—pain, bleeding
- Neoplasms—weight loss, fatigue, night sweats
- Coeliac disease—known Coeliac, bloating, iron-deficiency anaemia
- Iatrogenic—recent procedure, for example, ERCP, laparoscopic surgery
- Foreign body—recent ingestion

For those presenting following abdominal trauma, concerning features in blunt injuries are widespread peritonism and significant bruising. Following penetrating trauma, any pain or peritonism distant from the site of injury warrants further investigation.

74.2.2 Tests

As with all patients, a thorough history and clinical examination are essential parts of the assessment process.

All patients presenting with suspected small bowel perforation should have a routine blood screen performed, including inflammatory markers, albumin and clotting. Arterial blood gas analysis is useful in those who are unwell on presentation, or in those where ischemic bowel is suspected as an underlying cause.

Erect chest X-ray may show presence of sub-diaphragmatic free air. Abdominal X-ray can show non-specific signs such as Rigler's or the football sign.

Urinalysis may be useful to exclude underlying urinary tract infection. Urinary beta-HCG should be performed in all females of child-bearing age.

The mainstay of investigation in most sites is the abdominal computed tomography (CT), with intravenous contrast. Oral contrast may be used and can be helpful in assessing more proximal perforations. In the United Kingdom, the majority of patients will undergo CT scanning prior to ongoing management.

Where the underlying aetiology is small bowel obstruction, CT may show hyperaemic small bowel wall with or without pneumatosis. While a small volume of extraluminal fluid may be the only sign of perforation, extraluminal gas is more diagnostic [12]. Walled-off collections may be present, particularly in those with underlying inflammatory conditions such as Crohn's disease.

For those in whom small bowel perforation is suspected, but CT is non-diagnostic, a diagnostic laparoscopy is the next step. The same follows for victims of both blunt and penetrating trauma.

Differential Diagnosis

Differential diagnoses for small bowel perforation include other sites of perforation:

- Gastric
- Duodenal
- Colonic

Abdominal aortic aneurysm (AAA) rupture may cause significant and widespread peritonism, along with cardiovascular instability and collapse. Any concern of AAA rupture should prompt immediate investigation.

Similarly, ruptured ectopic pregnancies can cause significant pain and collapse. Pregnancy should be excluded in all females of child-bearing age presenting with abdominal pain.

Significant and widespread peritonism may also be present in acute pancreatitis. Other causes of intra-abdominal sepsis should also be considered:

- Cholangitis
- Cholecystitis
- Appendicitis
- Diverticulitis
- Tubo-ovarian pathology

74.3 Treatment

74.3.1 Medical Treatment

The mainstay of treatment for small bowel perforation is surgical. In a small group of patients where the perforation has been contained by surrounding structures and signs of generalized peritonism are absent, a non-operative approach may be appropriate. This is more common in duodenal perforation (which is covered in another chapter) but rare in small bowel perforation.

Key management steps for small bowel perforation are

- Timely diagnosis
- Resuscitation
- Initiation of broad-spectrum antibiotics
- Early and definitive source control

The investigation and diagnosis of small bowel perforation has been discussed. Initial medical management involves resuscitation and treatment of sepsis. Broad spectrum antibiotic therapy (which should cover both aerobic and anaerobic organisms) should be initiated promptly. Resuscitation with intravenous fluids is also critical in patients with intra-abdominal sepsis. The Surviving Sepsis Campaign (SSC) has led to the development of guidelines for the management of patients with sepsis [13] with specific bundles of care which should be implemented.

74.3.2 Surgical Treatment

The goals of surgical treatment are to correct the underlying anatomic problem, remove the source of contamination and prevent persistent or recurrent infection. In most cases this will be achieved through a laparotomy.

Some debate exists regarding the benefit of peritoneal lavage at time of laparotomy. While the need to remove obvious contamination is not questioned, there is some debate about the role of more aggressive intra-abdominal lavage in peritonitis with limited clinical evidence to support this [14]. Indeed, it has been shown that routine use of intra-operative irrigation for appendicectomies does not prevent abscess formation [15]. However, in cases of small bowel perforation there is often significant contamination and lavage of the abdominal cavity removing all enteric content and pus should be performed, with careful attention to common sites of intra-abdominal abscess including the pelvis, paracolic gutters and subphrenic space. There is no evidence to support lavage solutions containing antibiotics in patients who are already receiving systemic antibiotics [14].

Operative strategy for control of the bowel depends on the underlying aetiology and the clinical state of the patient. For stable patients with limited contamination primary small bowel repair or resection and anastomosis is recommended

[16]. However in those who are clinically unstable or with delayed presentations where the bowel is significantly inflamed and oedematous, proximal diversion/ileostomy should be considered. This scenario is more challenging and more consideration is given when the perforation is very proximal to the ligament of Treitz, as a proximal stoma will result in significant gastrointestinal losses and electrolyte disturbances.

The aetiology, size of defect and presence of associated mesenteric injury will determine whether the defect can be primarily closed or a small bowel resection is required. Primary repair is associated with lower complication rates [17], which likely reflects smaller injuries with less tissue damage. Those with large perforations (involving more than 50% circumference of the bowel), multiple contiguous perforations, malignancy, ischaemia, or mesenteric disruption should undergo a small bowel resection.

Standard principles of bowel resection and anastomosis are important; excising the entire diseased segment, ensuring adequate blood supply, lack of tension and approximation of the resected ends with meticulous technique.

Studies have suggested a higher rate of anastomotic leak with stapled compared to hand sewn anastomosis in the trauma setting [18]. However, a systematic review and meta-analysis [19] found no evidence to favour hand sewn over stapled technique in emergency laparotomy. The choice of anastomotic technique is therefore determined by surgeon's preference.

While laparoscopy has gained acceptance in the management of perforated appendicitis and diverticulitis, there are no studies comparing outcomes for laparoscopic and open surgery for small bowel perforation. Reports suggest that laparoscopic techniques can be used safely with low post-operative wound infection rates [20] but should be used selectively in centres with experienced surgeons.

Where there is severe contamination and inflammation, haemodynamic instability, or concern regarding viability of the bowel, anastomosis should not be performed. Options are formation of a stoma or planned re-laparotomy with deferred primary anastomosis [21]. This latter approach is in keeping with the principles of damage control surgery, which are now established for trauma

management, and allows anastomosis to be created when the patient's physiology and local conditions are more favourable.

74.3.3 Prognosis

Prognosis following small bowel perforation is variable depending on the clinical situation and underlying aetiology. The morbidity and mortality rates are probably less affected by surgical technique than general condition of the patient, nature of underlying disease and duration of perforation prior to surgical intervention (Table 74.2).

Table 74.2 Complications of small bowel perforation

Early complications	Late complications
Sepsis	Delayed wound healing
Multi-organ failure	Fistula formation
Wound infection	Adhesions
Anastomotic leak	Hernia
Intra-abdominal abscess	

Dos and Don'ts

- **Do** initiate antibiotic therapy and fluid resuscitation promptly.
- **Do** involve critical care team early.
- **Don't** delay theatre. Small bowel perforations require surgical management.
- **Don't** perform primary closure or anastomosis in if any concerns about patient stability or bowel viability—either plan for relook laparotomy with delayed anastomosis or stoma formation.

Take-Home Messages

- Small bowel perforation is a surgical emergency.
- The aetiology is varied, but it is useful to classify into traumatic and non-traumatic causes.
- Abdominal CT is the most useful investigation, as this allows localization of the of perforation and can identify the underlying cause.

- The mainstay of treatment, after resuscitation and administration of antibiotics, is surgical.
- Principles of surgical management are removal of enteric contamination, correction of the anatomic problem causing the perforation and restoration of bowel continuity or formation of a stoma.

Multiple Choice Questions

1. Which of the following findings on plain abdominal X-ray raises suspicion of small bowel perforation?
 - A. **Gas outlining both sides of the bowel wall**
 - B. Colonic faecal loading
 - C. Dilated small bowel loops
 - D. A 'lead pipe' featureless colon
2. Which of the following is the most useful investigation for suspected small bowel perforation?
 - A. **Abdominal CT with IV and oral contrast**
 - B. Chest X-ray
 - C. Abdominal X-ray
 - D. Abdominal ultrasound
3. Which of the following does not form part of the mainstay management of small bowel perforation?
 - A. Broad spectrum antibiotics
 - B. Resuscitation with intravenous fluids
 - C. Surgery
 - D. **Watch and wait**
4. Which of the following are not components of the management of sepsis in small bowel perforation?
 - A. Use of sepsis care bundles
 - B. Administration of broad-spectrum antibiotics
 - C. Early source control with removal of pus and enteric content
 - D. **Abdominal lavage with antibiotic containing solutions**

5. Choose the most appropriate management option in the following scenario. An 18-year-old female stabbed in the abdomen. At laparotomy, there is a small (2 cm) defect in the wall of the proximal ileum with limited intra-abdominal contamination.
- Primary small bowel repair**
 - Small bowel resection and anastomosis
 - Small bowel resection and end ileostomy
 - Small bowel resection, re-look laparotomy \pm deferred primary anastomosis
6. Choose the most appropriate management option in the following scenario. A 66-year-old female presents with a strangulated femoral hernia. There is a knuckle of ischemic small bowel with localized perforation within the hernia sac. There is no intra-abdominal contamination and the patient is stable.
- Primary small bowel repair
 - Small bowel resection and primary anastomosis**
 - Small bowel resection and end ileostomy
 - Small bowel resection, re-look laparotomy \pm deferred primary anastomosis
7. A 76-year-old male with multiple comorbidities presents with small bowel perforation secondary to closed loop adhesional obstruction. At laparotomy, there is a 50 cm segment of necrotic distal and terminal ileum with multiple perforations. There is significant intra-abdominal contamination. The patient is in septic and on vasopressors.
- Primary small bowel repair
 - Small bowel resection and anastomosis
 - Small bowel resection and end ileostomy**
 - Small bowel resection, re-look laparotomy \pm deferred primary anastomosis
8. Choose the most appropriate management option in the following scenario. A 29-year-old male has suffered blunt abdominal trauma during a road traffic accident. At laparotomy, he is found to have a small bowel perforation with associated mesenteric injury, as well as other intra-abdominal injuries. After initial resuscitation and control of bleeding he remains acidotic and coagulopathic.
- Primary small bowel repair
 - Small bowel resection and anastomosis
 - Small bowel resection and end ileostomy
 - Small bowel resection, re-look laparotomy \pm deferred primary anastomosis**
9. Choose the most appropriate management option in the following scenario. A 72-year-old lady presents with small bowel perforation secondary to small bowel obstruction, with widespread peritoneal metastases. The primary tumour could not be identified at time of laparotomy.
- Primary small bowel repair
 - Small bowel resection and anastomosis
 - Small bowel resection and end ileostomy**
 - Small bowel resection, re-look laparotomy \pm deferred primary anastomosis
10. Which of the following is not an important operative factor in determining outcome of small bowel anastomosis?
- Adequate blood supply to bowel ends
 - Correct bowel orientation with lack of tension
 - Stapled vs handsewn anastomosis**
 - Good approximation with accommodation for any size discrepancy

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