

# Acute abdomen: peritonitis

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## Abstract

Peritonitis is inflammation of the peritoneum and represents an important cause of surgical morbidity and mortality. It may be localized or generalized, and is thought to pass through three phases: firstly, a phase of rapid removal of contaminants from the peritoneal cavity into the systemic circulation; secondly, a phase of synergistic interactions between aerobes and anaerobes; and thirdly, an attempt by host defences to localize infection. Peritonitis is commonly caused by bacteria, but can be chemical (aseptic), biliary, tuberculous, chlamydial, drug-induced or induced by other, rarer causes. Bacterial peritonitis is subclassified into primary or secondary on the basis of whether or not the integrity of the gastrointestinal tract has been compromised. Typically, the patient with peritonitis complains of severe abdominal pain and may exhibit the characteristic Hippocratic facies. Abdominal palpation demonstrates tenderness, guarding and rebound tenderness. Initial laboratory investigations should include urea and electrolytes, full blood count and blood gases. An erect radiograph of the chest demonstrates pneumoperitoneum in about 70–80% of visceral perforations. CT often plays a role in confirming specific diagnoses (e.g. subphrenic abscess). Immediate management should include fluid resuscitation, high-flow oxygen, appropriate antibiotics (i.v.) and analgesia. Definitive management is surgical except for a small group of patients in whom conservative management with fluids (i.v.) and antibiotics (i.v.) is indicated. Surgical management can be via a laparotomy or, in some conditions, laparoscopy. Control of the primary site of sepsis is the main determinant of outcome. Most patients recover quickly. However, major generalized peritonitis is associated with organ dysfunction/failure, and mortality can up to 20–40% in the UK.

**Keywords** antibiotics; bacterial; conservative therapy; emergency surgery; guarding; inflammation; laparotomy; mesothelium; peritonitis; rebound tenderness; relaparotomy; sepsis

Peritonitis is inflammation of the peritoneum and may be localized or generalized.

## Pathophysiology

Peritonitis is thought to pass through three phases.<sup>1</sup>

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**Phase I** involves the rapid removal of contaminants from the peritoneal cavity into the systemic circulation. It occurs because contaminated peritoneal fluid moves cephalad in response to pressure gradients generated by the diaphragm. The fluid passes through stomata in the diaphragmatic peritoneum and is absorbed into lymphatic lacunae. The lymph flows into the main lymphatic ducts via the substernal nodes. The resultant septicaemia predominantly involves Gram-negative facultative anaerobes and is associated with high morbidity.

**Phase II** involves synergistic interactions between aerobes and anaerobes as they encounter host complement and phagocytes. The activation of complement is a first-line event in peritonitis and involves innate and acquired immunity; activation occurs mainly by the classical pathway, with the alternative and lectin pathways in support. Phospholipid surfactants produced by the peritoneal mesothelial cells work synergistically with complement to increase opsonization and phagocytosis. Peritoneal mesothelial cells are also potent secretors of pro-inflammatory mediators, including interleukin-6, and -8, monocyte chemoattractant protein-1, macrophage inflammatory protein-1 $\alpha$  and tumour necrosis factor- $\alpha$ .<sup>2</sup> Therefore, peritoneal mesothelial cells play a central role in the cell-signalling pathways leading to the recruitment of phagocytes to the peritoneal cavity and the upregulation of mast cells and fibroblasts in the submesothelium.

**Phase III** is an attempt by host defences to localize infection (Table 1), mainly via production of a fibrinous exudate that traps microbes within its matrix and promotes local phagocytic effector mechanisms. It also serves to promote the development of abscesses. Regulation of the formation and degradation of fibrin is vital to this process. The plasminogen-activating activity generated by peritoneal mesothelial cells determines whether the fibrin that forms after peritoneal injury is lysed or organized into fibrous adhesions. In particular, tumour necrosis factor- $\alpha$  stimulates the production of plasminogen activator-inhibitor-1 by peritoneal mesothelial cells, which inhibits degradation of fibrin.

**The clinical manifestations** of peritonitis are fluid shifts and metabolic disturbance. The heart rate and respiratory rate initially increase as a result of volumetric, intestinal, diaphragmatic and pain reflexes. Metabolic acidosis and the increased secretion of aldosterone, antidiuretic hormone and catecholamines subsequently alter cardiac output and respiration. Protein is broken

## Factors favouring localization or generalization of peritonitis

### Localization

Fibrinous exudate  
Anatomical compartmentalization of peritoneum  
Greater omentum (adheres to inflamed structures)

### Generalization

Sudden visceral perforation  
Violent peristalsis  
Virulent infecting organism  
Injudicious handling of localized collections  
Immunocompromise

**Table 1**

down and hepatic glycogen is mobilized as the body enters a highly catabolic state. Paralytic ileus develops, leading to profound sequestration of fluid and loss of electrolytes and protein-rich exudate. Gross abdominal distension causes diaphragmatic elevation, with resultant atelectasis and pneumonia. Multiple-organ failure, coma and death will follow if peritonitis persists and fails to localize.

### Aetiology

**Bacterial peritonitis** is classified as primary or secondary.

- Primary peritonitis is diffuse bacterial infection without loss of integrity of the gastrointestinal tract. It is rare, but occurs in adolescent females and *Streptococcus pneumoniae* is usually the causative organism.
- Secondary peritonitis is acute peritoneal infection resulting from loss of integrity of the gastrointestinal tract or infected pancreatic necrosis. Aerobes and anaerobes are often involved, the most common of which are *Escherichia coli* and *Bacteroides fragilis*.

**Bacterial invasion** – bacteria may invade the peritoneal cavity via four paths.

- **Direct invasion from the external environment** (e.g. penetrating abdominal wound, infection at laparotomy).
- **Translocation from damaged intra-abdominal viscera** (e.g. perforation of a viscus (e.g. perforated duodenal ulcer), gangrene of a viscus (e.g. appendicitis), trauma, iatrogenic (e.g. anastomotic leak)).
- **Via the circulation and/or gut translocation:** primary peritonitis may occur without an obvious source of infection being apparent (e.g. primary  $\beta$ -haemolytic streptococcal peritonitis in children and post-splenectomy patients, spontaneous bacterial peritonitis in patients with hepatic failure and ascites).
- **Via the female genital tract** (e.g. direct extension from external environment, primary pneumococcal peritonitis, acute salpingitis, perforation of uterus by intrauterine device).

**Chemical (aseptic) peritonitis** accounts for about 20% of all cases of peritonitis in the UK, and is usually secondary to a perforated duodenal or gastric ulcer. Sterile peritonitis will progress to bacterial peritonitis within a few hours following transmigration of micro-organisms (e.g. from bowel).

**Biliary peritonitis** is a relatively rare form of sterile peritonitis and can result from a number of causes:

- iatrogenic (e.g. slippage of cystic duct ligature following cholecystectomy)
- acute cholecystitis
- trauma
- idiopathic.

**Other forms of sterile peritonitis: there are four forms.**

**Pancreatic juices** – e.g. due to acute pancreatitis, trauma. Pancreatitis may be the cause of a diagnostic (but unnecessary) laparotomy in patients who do not exhibit a raised concentration of amylase in serum.

**Blood** – e.g. ruptured ovarian cysts, leaking aortic aneurysm.

**Urine** – e.g. intraperitoneal rupture of the bladder.

**Meconium** is a sterile mixture of epithelial cells, mucin, salts, fats and bile which is formed when the fetus begins to swallow

amniotic fluid. Meconium peritonitis develops late in intrauterine life or in the perinatal period when meconium enters the peritoneal cavity through an intestinal perforation. The perforation is secondary to some form of neonatal intestinal obstruction in >50% of cases in the UK.

**Tuberculous peritonitis** is rare in the UK, but may still be encountered in immigrants or immunocompromised patients. Spread to the peritoneum occurs:

- directly from mesenteric lymph nodes, the ileocaecal region or a tuberculous pyosalpinx
- via blood-borne infection originating from pulmonary tuberculosis.

Presentation may be acute (onset resembles bacterial peritonitis) or chronic (onset is more insidious, with abdominal pain, fever, loss of weight, ascites, night sweats, abdominal masses). Macroscopically, there are four forms of the disease: ascitic, encysted, plastic or purulent. Treatment is based on anti-tuberculous chemotherapy, in conjunction with laparotomy (if indicated) for intra-abdominal complications.

**Chlamydial peritonitis:** Fitz-Hugh–Curtis syndrome can occur following pelvic inflammatory disease and is characterized by right hypochondrial pain, pyrexia and a hepatic rub.

**Drugs and foreign bodies:** the use of isoniazid, practolol (now withdrawn from use in the UK), and intraperitoneal chemotherapy have been associated with clinical symptoms similar to acute peritonitis. Talc and starch may stimulate the development of foreign body granulomata if they are introduced into the peritoneal cavity (e.g. via surgical gloves).

**Other causes** include lead toxicity, hyperlipidaemia, acute intermittent porphyria, amoebic infections and familial Mediterranean fever.

### Diagnosis

#### Presentation

**Pain** is the most common symptom and may be localized or diffuse; it is usually constant and of a sharp, pricking character. A visceral perforation causes a sudden, severe pain that is usually first appreciated in the area of the perforation, but may become more generalized as peritoneal contamination spreads. The pain will be referred to the ipsilateral shoulder tip if the diaphragmatic peritoneum is involved. Anorexia, malaise, nausea and vomiting are common associated features. Constipation is usually present, unless a pelvic abscess develops (which can cause diarrhoea).

#### Examination

**General:** a patient with peritonitis is pale, drawn and anxious; the eyes are sunken because of dehydration. Regular observations will show signs of systemic inflammatory response syndrome or, at worst, septic shock, hypovolaemic shock or multiple-organ failure.

**Abdomen:** the patient will lie supine and relatively motionless with shallow respiratory excursions. The knees are flexed and drawn up in order to reduce tension in the abdominal wall. In diffuse

peritonitis, spasm of the abdominal musculature will result in board-like rigidity and failure of the abdomen to move with respiration.

Abdominal palpation exacerbates the pain and therefore should be undertaken carefully and gently. It will show tenderness, guarding and rebound tenderness; the site of maximum tenderness is usually related to the site of pathology. Guarding will initially be voluntary, before becoming an involuntary reflex as inflammation progresses. Specific pathognomonic signs of disease may be clinically evident (e.g. Rovsing's sign in acute appendicitis). Digital rectal examination will elicit anterior tenderness in pelvic peritonitis. Auscultation will confirm increasing ileus as bowel sounds diminish and eventually cease.

### Investigations

Peritonitis is mainly a clinical diagnosis and urgent laparotomy should not be delayed for unnecessary investigations.

### Blood tests are discussed below

**Full blood count** will demonstrate a leukocytosis.

**Urea and electrolytes** will confirm dehydration and acute renal failure; results are used to guide replacement of fluid and electrolytes.

**Liver function tests and serum amylase** – a high concentration of amylase in serum is diagnostic of acute pancreatitis, but a moderately elevated concentration can be caused by other intra-abdominal catastrophes (e.g. perforated duodenal ulcer).

**Arterial blood gas** reflects a metabolic acidosis, often preceded by a low arterial carbon dioxide tension caused by hyperventilation.

**Group and save** – laparotomy may be indicated and therefore crossmatched blood will be required.

### Imaging

**Erect radiograph of the chest** will show pneumoperitoneum in about 70–80% of visceral perforations. A left lateral decubitus radiograph of the abdomen is an alternative in those who are unable to sit up. A supine radiograph of the abdomen is less informative, but has a 'ground glass' appearance in cases of diffuse peritonitis.

**Ultrasound** may play a role in confirming or excluding specific diagnoses (e.g. subphrenic abscess).

**Computerized Tomography (CT)** is far more accurate in negative prediction than ultrasound, and has largely replaced blind, diagnostic laparotomy in the search for occult sepsis. The diagnostic accuracy of both ultrasound and CT has also been affirmed in clinically equivocal cases of acute appendicitis.

### Differential diagnosis

Basal pneumonia, myocardial infarction, gastroenteritis, hepatitis and urinary tract infection may be misdiagnosed as peritonitis. Other causes of severe abdominal pain (e.g. intestinal obstruction, ureteric or biliary colic) tend to cause restlessness.

## Management

### Conservative

Medical treatment is indicated if the:

- infection has localized (e.g. appendix mass)

- cause of peritonitis does not require surgery (e.g. acute pancreatitis)
- patient is not fit for general anaesthesia (e.g. elderly, moribund patient with severe comorbidity)
- medical facilities are unable to support safe surgical management.

The principal elements of medical treatment are fluid hydration (i.v.) and broad-spectrum antibiotics. Supportive care should include early enteral feeding (in preference to total parenteral nutrition) for patients with complex abdominal sepsis in the ICU.

### Immediate

**High-flow oxygen** is vital for all shocked patients. Hypoxia can be monitored by pulse oximetry or measurement of arterial blood gases.

**Fluid resuscitation** is initially with crystalloids (i.v.), the volume being dependent on the degree of shock and dehydration. Electrolyte (especially potassium) replacement may be required. The patient should be catheterized in order to monitor the hourly output of urine. Monitoring of central venous pressure and the use of inotropes may be appropriate in severe sepsis or in patients with comorbidity.

**Analgesia** – opiate analgesia (i.v.) and an appropriate anti-emetic will be required.

**Antibiotics** should be broad-spectrum, cover aerobes and anaerobes, and given intravenously. A third-generation cephalosporin and metronidazole is a common primary strategy. For patients who acquire peritonitis in hospital (e.g. anastomotic leak) or who require intensive care, second-line therapy with meropenem or a combination of piperacillin and tazobactam is advised. Antifungal therapy should also be considered to cover possible *Candida* species. Early and appropriate use of antibiotics is a key to reducing mortality in patients with septic shock associated with peritonitis.

**Nasogastric tube and aspiration** alleviates vomiting and abdominal distension and reduces the risk of aspiration pneumonia.

### Definitive

#### Surgery

**Laparotomy** is usually performed through an upper- or lower-midline incision (depending on the suspected site of pathology). The objectives are to:

- establish the cause of peritonitis
- control the origin of sepsis by removal of the inflamed or ischaemic organ (or closure of the perforated viscus)
- perform effective peritoneal toilet/lavage.<sup>3</sup>

Control of the primary source of sepsis is essential. However, there is a trend towards undertaking primary anastomoses in patients with peritonitis (providing that they are haemodynamically stable and have no other significant risk factors). There is little evidence of clinical benefit for peritoneal irrigation, possibly because of resistance of microbial peritoneal colonies to lavage, or concomitant damage inflicted to mesothelial cells. Rather than robust irrigation of the peritoneal cavity, removal of debris, faecal or purulent material may suffice. Mass closure of the abdomen is undertaken using interrupted or continuous monofilament sutures. Antibiotics are continued for five days postoperatively in cases of generalized or complex peritonitis.

Re-laparotomy has an important role in the treatment of patients with severe secondary peritonitis who, after primary laparotomy, have ongoing or worsening features of sepsis. Re-operations may be performed 'on demand', or in a more aggressive 'planned' strategy at regular intervals. Planned relaparotomy often involves leaving the abdominal wall open with a sheet of synthetic mesh *in situ* to prevent evisceration. Modifications are 'primary open management', and semi-open approaches such as 'staged abdominal repair'. However, recent studies have concluded that in-hospital and long-term survival rates are higher in those patients managed by on-demand relaparotomy than in those with disease of comparable severity treated by planned relaparotomy.<sup>4</sup> Combining clinical data with frequent CT imaging is the key to timely and appropriate selection of patients requiring on demand relaparotomy. However, it should always be remembered that many septic patients do not require relaparotomy but may simply require extended periods of mechanical ventilation, antimicrobials and organ support. Obtaining effective control of sepsis at the first operation is vitally important because each subsequent operation is met with an increasing risk of morbidity and mortality.

**Laparoscopy** – the theoretical risks of malignant hypercapnia and septic shock secondary to absorption of carbon dioxide and endotoxin through an inflamed peritoneum have not been proven. Instead, laparoscopy has proved effective in the management of acute appendicitis and perforated duodenal ulcer. It can be used in cases of colonic perforation, but the conversion rate to laparotomy is higher. Shock or major ileus are contraindications to laparoscopy.

**Drains** tend to be effective if used to drain a localized space, but are generally quickly 'walled off' and fail to drain the entire peritoneal cavity. There is a lack of evidence to support the prophylactic use of drain tubes after laparotomy.

### Predictors of severity and prognosis

There is no single, easily available laboratory test that predicts severity or prognosis in patients with peritonitis. The concentration of intraperitoneal interleukin-18 and fungal culture correlate with poor outcome, but these tests have little clinical applicability.

**Scoring systems** have been advocated as prognostic predictors, but mainly in the context of audit and clinical trials involving large patient groups, for example:

- Acute Physiology and Chronic Health Evaluation Score (APACHE II).
- Simplified Acute Physiology Score.
- Sepsis Severity Score.

The Mannheim Peritonitis Index and the Peritonitis Index Altona II are specific to peritonitis. Treatment selection with respect to re-operation is supported by the Prognostic Peritonitis Model and the Abdominal Re-operation Predictive Index. In contrast, the Ranson and Modified Imrie Scores may be used as scores of disease severity in individual cases of acute pancreatitis.

### Complications

**Septic shock** – patients require treatment in the ICU.

**Intra-abdominal abscess/persistent abdominal sepsis** – in the presence of signs of ongoing sepsis (e.g. pyrexia, raised white cell count), investigations should include CT with luminal contrast (especially if an anastomosis is *in situ*). Re-laparotomy is required if generalized peritonitis is diagnosed. Percutaneous drainage with 'best guess' antibiotics is the treatment of choice if a localized collection is identified. Antibiotic therapy must be adjusted in response to feedback from cultures taken at the time of drainage. Abdominal sepsis carries a mortality of about 30–60%.<sup>3</sup> The outcome is often poor after admission to the ICU. Factors associated with mortality include:

- age
- APACHE II score
- septic shock
- chronic ill-health
- female sex
- sepsis of upper gastrointestinal origin
- failure to clear the source of sepsis.<sup>5</sup>

**Adhesions** may cause intestinal obstruction or volvulus. ◆

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