INTRODUCTION
The physician caring for surgical patients is often challenged by a variety of problems in the assessment and evaluation of the acute abdomen in critically ill patients. Acute abdominal problems are frequent sources of admission and complications in intensive care units (ICUs) (1). Early diagnosis of the acute abdomen and initiation of resuscitative efforts and surgical therapy often determine outcome. Knowledge of common abdominal problems and having a clinical approach for management are essential to all ICU physicians.

Any surgical procedure carries the risk of postoperative complications and difficult therapeutic management. The difficult postoperative abdomen presents many challenging issues for the ICU physician. Routine surgery may lead to the formation of adhesions leading to recurrent episodes of abdominal pain and partial or complete bowel obstruction. Enterocutaneous, intra-abdominal, or pancreatic fistulas may result from the natural progression of intra-abdominal pathology or the result of invasive procedures. Abdominal catastrophes may result in compartment syndrome leading to temporary abdominal closures and planned ventral hernias.

Herein, we will discuss the evaluation of the acute abdomen and the management of intra-abdominal problems commonly seen in the ICU. Further discussion will also include management of difficult postoperative issues. Considerations will be devoted to a review of etiology, diagnosis, and therapeutic approaches. The core principles of careful surgical technique and meticulous patient management, including wound care, nutritional management, and timing of recurrent interventions, are key in treating these problems.

EVALUATION OF THE ACUTE ABDOMEN

History
Evaluation of the acute abdomen and management of the difficult postoperative abdomen require a careful evaluation of the presenting illness. A detailed history of presenting illness should be obtained from either the patient or a family member. A focused abdominal history should include a review of previous abdominal surgeries and interventions, anesthetic exposure, and family history. The history should also include a review of medications, allergies, immunosuppressive therapies, and the use of drugs, tobacco, and alcohol. Symptomatic complaints should be identified in detail such as nausea and vomiting, hematemesis, hematochezia, diarrhea, and constipation. Characterization of abdominal pain is essential to establish an appropriate differential diagnosis. Location, nature, onset, and radiation of pain are useful in delineating the cause. These details are necessary to help focus diagnostic and therapeutic interventions. Symptoms of biliary disease, especially pain, and jaundice should be noted.

Physical Examination
Physical examination of a critically ill patient is often challenging given they may be sedated, intubated, combative, comatose, or paralyzed. However, thorough examination by inspection, palpation, percussion, and auscultation will usually provide good direction for both definite diagnosis and for appropriate advanced diagnostic investigations. Present and trended vital signs should be carefully evaluated in addition to the intravascular volume status and hemodynamics of a patient. Assessment of end-organ perfusion in critically ill patients is needed to help guide appropriate fluid resuscitation.

A focused examination of the abdomen can also give important clues to underlying pathology. Dilated abdominal wall veins indicate advanced portal hypertension. A pulsating upper abdominal mass in a thin patient may suggest a large abdominal aortic aneurysm. Absent or hypoactive bowel sounds is a nonspecific sign of an ileus. Hyperactive sounds or “rushes” are most common with small bowel obstruction. The presence of bowel sounds, however, does not always correlate with normal bowel function. Guarding or rigidity may indicate peritoneal irritation. Assessment of obese patients is often difficult as the assessment for abdominal wall rigidity is unreliable and specific pathologies such as groin or incisional hernias are difficult to identify. Patients with mesenteric ischemia have pain that is out of proportion to the findings of the physical examination. Serial examination is a useful technique to evaluate for the progression of tenderness, and the overall trend toward improvement or deterioration.

Laboratory Investigations
Laboratory investigations provide useful information in the diagnostic work of a patient. A complete blood count (CBC) including hematocrit, hemoglobin, platelets, and complete white blood cell count is routine, and provides valuable information about bone marrow function, transfusion requirements, and evaluation of infection. Urinalysis, including specific gravity and analysis for bacteria, bile, and reducing substances, should be performed. The serum amylase level is helpful in diagnosing intra-abdominal catastrophe when it is elevated but is not specific. In addition to its elevation in pancreatitis, serum amylase may be increased in ischemic bowel disease, facial trauma, perforated ulcer, or without apparent cause (2). Serum lipase is a specific marker of acute pancreatitis.
Saponification of retroperitoneal fat resulting in hypocalcemia is a helpful marker of severity in pancreatitis. An elevated serum bilirubin level is associated with sepsis, resolving hematomata, hemolysis, and hepatobiliary disease. Likewise, the lactate dehydrogenase (LDH) concentration may be elevated in numerous disease processes. Liver enzymes, including serum glutamate oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), and alkaline phosphatase (ALP) may be helpful, but are rarely diagnostic by themselves. Laboratory data are most useful in the management and correction of fluids, electrolytes, and acid–base derangements.

**Diagnostic Imaging**

Modern diagnostic imaging techniques have become an essential tool in the diagnostic evaluation of critical ill patients. The most common modalities used are plain x-ray, computed tomography (CT) scan, and ultrasound. Each modality has specific applications where it is most useful. Standard x-rays have the benefit of being portable and available at the patient’s bedside. Abdominal x-rays are most commonly used to determine the position of intra-abdominal tubes and to evaluate abnormal intra-abdominal gas patterns. The presence of air–fluid levels and bowel distention suggests bowel obstruction, while the absence of gas may be found with ischemic bowel. Free air from a perforated viscus is best seen in an upright chest radiograph.

The CT scan has become the most widely used tool to examine the abdomen for abnormalities. CT can provide greater detail of intra-abdominal organs and pathology than standard abdominal x-rays. In critical ill patients, CT is useful in determining specific diagnostic abnormalities. The utilization of intravenous contrast can help delineate vascular structures and enhancement of intra-abdominal anatomy. However, caution must be utilized in patients with renal dysfunction. In addition, oral and rectally administered contrast can greatly enhance the identification of bowel pathology; a limitation of oral contract is the risk of aspiration. The use of CT also requires transporting the patient to the scanner resulting in logistical challenges and patient safety risk.

Ultrasoundography has become an essential adjunctive diagnostic and interventional tool in the emergency department (ED), ICU, and operating room (OR). It can be brought to the bedside and provide diagnostic evaluation of nearly every intra-abdominal organ. It is less invasive and less expensive than CT scan. Ultrasound can also be used as a therapeutic tool to help perform procedures such as percutaneous cholecystostomy.

**TREATMENT**

**Specific Disease States**

There are many potential etiologies of the acute abdomen in critical ill patients. The following outlines a selection of conditions commonly seen in the ICU. These include intra-abdominal sepsis/abscess, pneumoperitoneum, biliary disease, pseudoobstruction of the colon, and acute mesenteric ischemia.

**Intra-abdominal Sepsis or Abscess**

Intra-abdominal sepsis arises from a variety of sources but is mostly commonly associated with perforated viscous, ischemic bowel, anastomotic failure, or biliary leakage. Intra-abdominal infection should be suspected in any patient deteriorating following abdominal surgery. Peritonitis can develop early or late in the postoperative course. Infected fluid collections typically wall-off to form an abscess after 5 to 7 postoperative days. Peritonitis and abscess formation typically occur as complications of anastomotic leakage from colonic surgery (3). Abscess formation also commonly develops with diverticular disease, appendicitis, inflammatory bowel disease, and malignancy. Initial management of patients with intra-abdominal sepsis is outlined in Figure 58.1 (4).

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**FIGURE 58.1 Initial management of suspected or confirmed intra-abdominal infections. (Adapted from IDSA–Complicated Intra-abdominal Infection—In Adults. http://www.idsociety.org.)**
The clinical presentation of an intra-abdominal abscess often requires a high index of suspicion, as the clinical presentation can be subtle. Non-specific manifestations including leukocytosis, fever, dysuria or urinary retention, unexplained pleural effusion, and change in bowel function (diarrhea) should alert the physician to investigate for an intra-abdominal infection. Investigation should include a CT scan of the abdomen and pelvis with oral and intravenous contrast. Once an abscess is identified, early antibiotic coverage and source control with either surgical or percutaneous drainage are mandated. Clinical factors predicting the failure of source control for intra-abdominal infections are outlined in Table 58.1 (4).

The microbiology of abscesses is dependent on the organ involved and duration of critical illness. Figure 58.2 outlines the antibiotic management guidelines of patients with community-acquired intra-abdominal infections (4). The stomach and duodenum normally have sparse bacterial colonization due to the acid concentration in these segments. The flora is mainly composed of swallowed oral organisms such as microaerophilic streptococci and Streptococcus viridans, lactobacillus, fusiform bacteria, and Candida. The concentration of organisms may be altered and significantly increased in patients with acid-suppressive treatment, gastric obstruction, and achlorhydria. The concentration of small bowel flora is variable throughout its length, with greater concentration distally. The normal flora consists primarily of the Enterobacteriaceae, Enterococcus, and anaerobic species. The colon contains a combination of both aerobic and anaerobic bacteria with anaerobes constituting 90% of the bacterial load. Aerobic bacteria are primarily gram-negative rods consisting of the Enterobacteriaceae (Escherichia coli, Klebsiella spp., Enterobacter spp., and Proteus spp.), Pseudomonas, and gram-positive Enterococci. Anaerobic bacteria include

**TABLE 58.1 Clinical Factors Predicting Failure of Source Control for Intra-abdominal Infection**

| Delay in the initial intervention (>24 hr) |
| High severity of illness (APACHE II score >5) |
| Advanced age |
| Comorbidity and degree of organ dysfunction |
| Low albumin level |
| Poor nutritional status |
| Degree of peritoneal involvement or diffuse peritonitis |
| Inability to achieve adequate debridement or control of drainage |
| Presence of malignancy |


Patients with generalized peritonitis or hemodynamic instability with suspected intra-abdominal infection require emergent surgical exploration to identify the cause. The primary source of the infection is controlled by repair or resection followed by a thorough washout of the abdominal cavity with warm saline. In some patients with either hemodynamic instability or severe contamination, the abdominal wall may be temporarily left open for additional washout in 24 to 48 hours. Management of the open abdomen is discussed later.

Stable patients with localized peritonitis or suspected intra-abdominal sepsis should undergo a CT scan to identify any abnormal pathology; if a defined abscess or fluid collection is seen on the CT scan, percutaneous drainage is possible using CT or ultrasound image guidance. This technique is well established (5–7) and minimally invasive; re-exploration of the abdomen may be fraught with difficulty (8).

Antibiotic therapy is based on empiric coverage of bacteria normally present within the gut. Antibiotic coverage should include gram-positive, gram-negative, and anaerobic bacteria; therapy can be focused when culture and sensitivities testing is complete. However, due to problems with anaerobic culturing and identification, most patients should receive anaerobic coverage for gut-associated infection, even when anaerobes are not identified. Antifungal agents are not given even if fungi are seen on cultures, unless the patient is immunosuppressed or has recurrent intra-abdominal infection. Guidelines are published elsewhere (4).

Mortality from intra-abdominal sepsis depends on severity and ranges from 7.5% to 43% (9). Mortality correlates with acute physiology score, malnutrition, age, and shock. Early goal-directed therapy targeted at prompt recognition of abdominal sepsis, broad-spectrum antibiotics, and source control will maximize outcomes.

**Pneumoperitoneum**

The presence of pneumoperitoneum on x-ray is a finding of a perforated viscous until proven otherwise. The exception is the presence of free air less than 48 hours after laparotomy or laparoscopy; pneumoperitoneum greater than 48 hours postoperation is considered pathologic and requires investigation.

The most common cause of pneumoperitoneum is perforation of the stomach or duodenum from peptic ulcer disease. Free air is also seen in patients with perforation of the colon due to diverticular disease or iatrogenic from endoscopy. Barotrauma to the lung from high-pressure mechanical ventilation can result in pneumoperitoneum (10). The mechanism is thought to be related to the tracking of air from ruptured or distended alveoli toward the mediastinum then dissecting toward the peritoneal cavity. Patients with severe chest trauma resulting in a pneumothorax and pneumomediastinum can also have pneumoperitoneum. Lastly, in females, the peritoneal cavity communicates with the genital tract through the fallopian tubes. Although rare, this provides a potential pathway for communication of air into the peritoneal cavity.

The presence of pneumoperitoneum requires careful evaluation of the patient as not all conditions require operative intervention. In the ICU, a sedated septic patient with no obvious source of sepsis, in the presence of pneumoperitoneum, should nearly always prompt an exploratory laparotomy.

**Biliary Disease**

Pathology related to the biliary system is common in critically ill patients and is typically associated with either calculous or acalculous cholecystitis. Patients with pre-existing calculous disease may present with acute cholecystitis, cholangitis, or pancreatitis. Clinically patients may present with a positive Murphy sign, fever, and increased WBC; local peritonitis is found in only 24% of patients (11). On further investigation, laboratory findings include leukocytosis, elevated bilirubin (65%), and elevated liver enzymes in less than 50% (12). Ultrasound is the most favorable imaging modality of the biliary system. Ultrasonographic findings of acute cholecystitis include dilated gall bladder, gall bladder wall thickening, the presence of gall stones, and evidence of pericholecystic fluid. Acute acalculous cholecystitis is more commonly associated with critically ill surgical and medical patients in the ICU. The development of acalculous cholecystitis is associated with narcotic use, gastric suctioning, prolonged ileus, prolonged mechanical ventilation, intravenous hyperalimentation, and massive transfusion (12,13). Acalculous cholecystitis in critically ill patients carries a 40% mortality rate (11,14).

Drainage of the biliary tree and antibiotics are the mainstay of treatment. Drainage can be achieved by surgically placed cholecystostomy tube or a percutaneous cholecystostomy tube.

**Pseudo-obstruction of the Colon**

An ileus of the colon without mechanical obstruction is referred to as pseudo-obstruction or Ogilvie syndrome (15). This condition is typically seen in elderly patients with prolonged immobility, electrolyte imbalance (hyponatremia and hypokalemia), narcotic use, and mechanical ventilation. Other risk factors include multiple trauma, abdominal and pelvic operations, orthopedic operations, and spinal cord injuries (15,16). On physical examination, the abdomen appears distended and tympanic. Abdominal x-ray demonstrates a distend colon. As the colon distends, the wall tension increases leading to local wall ischemia, necrosis, and perforation. The highest risk is when the colon diameter exceeds 12 cm. Mechanical causes of distal obstruction should be ruled out using a contrast enema or colonoscopy.

Management of colonic pseudo-obstruction is based on nonoperative and operative interventions. Initial management should include gastrointestinal decompression with placement of a gastric sump drain and a rectal tube. Correction of electrolysis, minimization of narcotics, and ambulation are further management adjuncts. If there is no improvement with these interventions, neostigmine should be administered to stimulate colonic motility in the absence of distal obstruction (17). Neostigmine is a parasympathomimetic and is given as 1 to 2 mg i.v. Bradycardia is a significant side effect of neostigmine; therefore, patients should be in a monitored location. Neostigmine should be avoided in patients with baseline bradycardia, hypotension, heart block, or bronchospasm. If a patient is unable to take neostigmine, or previous measures are unsuccessful, cautious colonoscopic decompression can be attempted. Colonoscopy can evaluate for mechanical obstruction, provide colonic decompression, and guide placement of a rectal tube. Surgery is offered to patients who fail conservative management, have complications, or impending colonic rupture. Depending on the extent of colonic abnormality, the suggested operation is typically a total abdominal colectomy.
in which case an ileostomy with mucus fistula should be performed.

**Acute Mesenteric Ischemia**

Acute mesenteric ischemia is an uncommon condition and often results in significant morbidity and mortality (70% to 80%) (18,19). The etiology of acute mesenteric ischemia is either from arterial or venous pathology. Arterial causes are classified as nonocclusive mesenteric ischemia and occlusive mesenteric arterial ischemia. Occlusive disease is further classified as acute mesenteric arterial embolism and acute mesenteric arterial thrombosis. Acute mesenteric ischemia can also be caused by mesenteric venous thrombosis (20–22). Early clinical recognition, workup, and intervention are needed to improve outcome (19). Death occurs from MOF secondary to ischemic bowel (65%), sepsis (25%), pulmonary failure (8%), and stroke (2%) (23).

The classic presentation of acute mesenteric ischemia is a patient’s complaint of pain out of proportion to physical examination findings. Pain is identified in patients 75% to 90% of the time; nausea, vomiting, and abdominal distention are commonly seen. Leukocytosis (WBC count of 20,000 cells/mm$^3$) is seen in less than half of patients. As the degree of bowel ischemia progresses toward gangrene, patients will have a worsening clinical presentation. Peritoneal irritation, leukocytosis, elevated hematocrit, unexplained acidosis, and blood-tinged fluid on peritoneal lavage are all signs of advancing intestinal necrosis (24) and are associated with significant mortality.

Early management should include aggressive fluid resuscitation to maintain adequate blood flow in the mesenteric vessels. Gastric decompression with a nasogastric tube and continuous hemodynamic monitoring is required. Heparinization should be used if immediate surgery is not undertaken.

With improved resolution of modern CT scanners, the diagnosis of acute intestinal ischemia can often be made. Multidetector CT angiography can differentiate occlusive from nonocclusive disease. Despite this, selective arteriography remains the gold standard in the diagnostic and therapeutic approach to acute mesenteric ischemia. Acute occlusion is best treated by immediate surgical management with an embolectomy or aorto-superior mesenteric artery bypass. The bowel should be evaluated for ischemia with nonviable segments resected. Segments with questionable viability should be re-evaluated after allowing time for reperfusion. Although second-look operations are frequently used at 24 to 48 hours to determine the viability of remaining bowel, survival is not necessarily improved by this technique (25).

In patients with nonocclusive mesenteric ischemia, an angiogram will demonstrate mesenteric vasoconstriction. Interpretation of the angiogram may be difficult if the patient is in shock and on vasopressors (26). Traditionally, treatment included the administration of papaverine (30 to 60 mg/hr) through a catheter placed selectively in the superior mesenteric artery (SMA) (27). Papaverine is continued until repeat arteriogram after 24 hours. Currently, however, there is a worldwide shortage of papaverine. Therefore, alternative treatment such as nitroglycerin, combined with verapamil, is becoming more commonly used. The presence of peritoneal signs mandates surgical exploration to assess bowel viability. Antibiotics are indicated because of the high incidence of positive blood cultures resulting from compromised bowel.

**The Difficult Postoperative Abdomen**

The practice of surgery carries risk of postoperative complications and often difficult therapeutic choices to manage these complications. Intra-abdominal surgery will inevitably result in adhesion formation, which may lead to recurrent episodes of abdominal pain and partial or complete bowel obstruction. Fistulae may result from the natural progression of intra-abdominal pathology or from iatrogenic injury. Abdominal catastrophes may result in abdominal compartment syndrome (ACS) and the risk of temporary abdominal closures and planned ventral hernias. Less commonly seen are complications of radiation enteritis and short bowel syndrome. The following sections will review many of these difficult postoperative issues with descriptions of etiology, diagnosis, and therapeutic approaches.

**Adhesions**

Intra-abdominal surgery will inevitably result in the unavoidable consequence of adhesions. Adhesion formation is a normal physiologic response in postoperative healing. Formation of adhesive tissue protects an anastomosis and prevents leaks, in addition to assisting in the body’s attempt to isolate intra-abdominal catastrophes. When adhesive bands become too dense, kink, or encompass loops of bowel, they may result in negative consequences such as bowel obstruction and persistent abdominal pain. Intra-abdominal adhesions are the primary cause for postoperative bowel obstruction, accounting for approximately 75% of cases (28).

The majority (94% to 98%) of abdominal adhesions are acquired from either operative therapy or inflammatory processes. The remaining 2% to 6% of adhesions are congenital. In the reoperative abdomen, adhesions are present in 30% to 40% of patients. The most frequent morbidity in those with postoperative adhesions is small bowel obstruction, which accounts for 12% to 17% of hospital admissions following previous abdominal surgery (29). The degree of morbidity related to adhesion formation is related to the type of surgery performed. Laparoscopic surgeries have a 15% adhesion rate as opposed to open laparotomies, in which 50% result in adhesion formation. Adhesions form more commonly following surgery to the small and large bowels and uterus than with other intra-abdominal organs, especially in surgeries involving bowel distal to the transverse colon or involving gynecologic organs (28). The areas most frequently affected are the undersurface of the midline incision and the operative site. The omentum is the most frequently involved organ (57%). Small and large bowel adhesions continue to result in the highest morbidity (30). Adhesions may result in mechanical fixation points where the bowel may kink, wrap around, or become strangulated, thereby compromising enteric flow and blood supply. Patients with high-grade bowel obstructions require an emergency operation to relieve the obstruction before the adverse sequelae of bowel ischemia.

Given the prevalence and morbidity associated with adhesions extensive research have focused on identifying methods to avoid adhesion formation. Adhesions result from trauma to tissues, tissue ischemia, infection within the abdominal cavity, inflammatory processes, or by the presence of foreign bodies such as suture, t alc from gloves, and lint from sponges. To minimize adhesions, gentle tissue handling with strict hemostasis and minimization of intraperitoneal trauma are core...
principles. In addition, frequent irrigation to dilute or to remove contaminants and the use of small, nonreactive suture material will diminish the contribution to adhesiogenesis. Perhaps the most effective method of preventing serious adhesions is via the use of the omentum. The omentum may be used to wrap anastomoses or to protect abdominal contents from a healing midline incision. Despite the adverse effects of adhesion formation, adhesions are an important part of the wound healing and without adhesions most anastomoses would likely fail.

**Fistulae**

A fistula is an abnormal communication between two epithelialized surfaces. A variety of fistulas can exist within the abdomen, including pancreatic and biliary fistulae, fistulae between two intra-abdominal organs, and enterocutaneous and enterosomatic fistulae. The majority of GI fistulae occur as complications of abdominal surgery. The incidence of spontaneous fistula formation is rare and is usually the result of intra-abdominal infection or inflammation. The natural history of a fistula begins as a bowel leak. The type of fistula depends on whether the leak is uncontrolled, partially controlled, or well controlled (31). An uncontrolled leak will result in peritonitis and require surgical exploration for correction of the underlying pathology. A partially controlled leak may result in an intra-abdominal abscess, which will require definitive therapy such as open or percutaneous drainage. Controlled leaks result in fistulae. Management of fistulae can be a long-term challenge for surgeon and patient. An enterocutaneous fistula is an abnormal communication between the bowel and the skin surface. The majority of these fistulae (71% to 90%) are the result of postoperative iatrogenic complications (29,32). Spontaneous causes of fistulae are uncommon but may include malignancy, inflammatory processes, mechanical obstruction, or vascular insufficiency. Iatrogenic fistulae may result from inadvertent enterotomies, intra-abdominal infections, direct injury or bowel desiccation in the open abdomen, misplaced stitches, or anastomotic breakdown. Impaired tissue perfusion from hypotension or vascular disease may predispose to this complication, as will infections, steroids, and malnutrition. Characterization of the fistula tract and surrounding anatomy is essential, best done with a fistulogram. This is done by injecting gastrografin into the tract and using fluoroscopy to follow the progress of the contrast. A fistulogram is useful to define the length of the tract, tortuosity, tract diameter, and which segment of the gastrointestinal tract is involved. A CT scan is helpful in defining surrounding anatomy such as intra-abdominal abscesses, malignancy, and hernias (33).

A postoperative enterocutaneous fistula typically presents as discolored, watery drainage or frank succus from the midline incision. Palpation along the facial closure suture line will often reveal a local dehiscence. Passage of gas from the midline wound is diagnostic of an enterocutaneous fistula. Patients will usually demonstrate signs of infection characterized by increasing temperature, white blood cell count, and persistent ileus. Some patients may develop profound shock due to electrolyte imbalances and sepsis. In these cases, emergent re-exploration is necessary. However, if the patient presents with drainage or an obvious fistula but is hemodynamically stable, a short-period conservative management is reasonable.

**Conservative Management of the Enterocutaneous Fistula.** Initial management of enterocutaneous fistulas is based on evaluation and control of sepsis, aggressive fluid resuscitation with correction of electrolytes and nutritional deficiencies, and control and characterization of fistula output with protection of surrounding skin surface. Early and aggressive management of these factors will maximize the potential for spontaneous closure. Patients with enterocutaneous fistulae are prone to malnutrition from protein losses, increased metabolic demands, and limited oral intake; early fluid and electrolyte replacement is needed. Parenteral nutrition is often necessary to provide early nutritional repletion, enable management of electrolyte and protein balances, and to decrease volume transit past the fistula in the gastrointestinal tract. Other methods of reducing volume of enteric content past the fistula is the use of narcotics, loperamide, and somatostatin analogs. The use of octreotide or other somatostatin analogs (100 μg intravenously every 8 hours) may decrease gastrointestinal secretions. Somatostatin inhibits the secretion of most gastrointestinal hormones and enhances fluid and electrolyte absorption, thereby decreasing intraluminal volume and potentially decreasing fistula output. Despite the theoretical benefits of somatostatin use, clinical studies have revealed mixed results on effectiveness. Although some studies have demonstrated a decreased fistula output and higher rate of spontaneous closure, an equivalent literature reveals no statistical difference in output or closure rates (34). As side effects are relatively mild, including gastrointestinal discomfort and increased biliary sludge, we recommend trying a somatostatin analog in conjunction with other conservative therapies while waiting for a fistula to close spontaneously.

Containment and control of fistula output is a significant challenge. Enteric contents are extremely caustic to the skin and surrounding tissues, creating a need to isolate enteric contents from the skin. For a simple enterocutaneous fistula, a stoma appliance is usually sufficient. However, many fistulae present in open wound beds, including on granulating abdomens. These tissue fields are not amenable to the placement of a simple stoma appliance. In these situations, a multidisciplinary approach with the surgeon and wound care nurse/enterostomal therapist is needed to control fistula output. Once initial control is achieved, it may be possible to close fistulae surgically or to skin graft the region.

**Spontaneous Fistula Closure.** Spontaneous fistula closure is the goal of conservative management. Many fistulae close without operative intervention, and will do so in the first 3 to 6 weeks after appearance. The spontaneous closure of a fistula is dependent on its inherent characteristics. Fistulae with long tracts and narrow mouths are more likely to resolve without intervention. Low-output fistulae (less than 500 mL per day) have a higher likelihood of closure than do high-output ones. A fistula with persistent drainage after 3 months is unlikely to close without surgical therapy. In addition, several patient factors are associated with failure of the fistula closure. These include the presence of a foreign body in the fistula tract, close association with an abscess, presence of malignancy, distal bowel obstruction leading to increased pressure and transit through the fistulous tract, and a short neck with wide fistula mouth. Longstanding fistulae with high outputs are unlikely to close spontaneously. To improve the likelihood of spontaneous fistula closure, optimal nutrition for wound healing and
minimization of enteric content should be undertaken. Parenteral nutrition is used to decrease the volume transiting the gastrointestinal tract and through the fistula. A positive nitrogen balance and a transferrin level greater than 200 mg/dL are also associated with successful closure (35).

Surgical Therapy for Enterocutaneous Fistulae. Failure of spontaneous fistula closure is considered after 3 months if the fistula remains open; after this point the likelihood of closure without surgical management is poor. Preoperative management requires characterization of the fistula track and surrounding anatomy, optimization of nutrition, albumin and pre-albumin levels, and wound care. Control of fistula output and maintenance of healthy skin integrity at the time of operation will improve the success of abdominal wall reconstruction (34). With careful planning and delay of operative repair until all criteria are met (nutrition, fistula definition, wound care), the morbidity and mortality may be decreased from 50% mortality and 50% recurrence in early surgeries to 94% successful closure and a 4% mortality rate (29,36).

Surgical management of an enterocutaneous fistula requires a laparotomy. Management of intra-abdominal adhesions from prior surgeries or infection is a challenge. Extensive and dense adhesions may make access to the fistula difficult with the risk of enterotomies. While a common initial impulse is to oversew the fistula primarily, this should be avoided whenever possible as the recurrence rate is high. The preferred method for surgical management remains complete lysis of intra-abdominal adhesions and resection of the involved segment. With this approach, the diseased portion of bowel is removed and the anastomosis is performed between two healthy segments of bowel. The complete lysis of adhesions allows careful inspection of the remaining bowel to rule out downstream obstruction or other pathology. Although time consuming, this approach provides the highest likelihood of recovery without recurrent fistulization.

Enterocutaneous fistulae communicate with an open granulating abdomen and represent a complex management problem. In particular, managing the fistula drainage on a granulating surface makes it difficult to control contamination. Often a multidisciplinary approach with an enterostomal therapist is necessary to identify a functional solution using a variety of stoma appliance options. A split-thickness skin graft is a favorable option for patients with a fistula in the face of the granulating, open abdomen. The skin graft will decrease the metabolic demands of a granulating abdomen and provides a good base for control of fistula output. At the time of skin grafting, the fistula track should be cannulated with a catheter to allow for preferential drainage of enteric content and to avoid contamination of the skin graft site. Contamination of the graft site often complicated with high rate of graft failure. A vacuum assisted closure (VAC) appliance should be applied to the skin graft site with a specialized porous VAC sponge surrounding the fistula opening to prevent injury to the bowel surface; this should be changed every 2 to 3 days.

The Pancreatic Fistula

The majority of pancreatic fistulae result from trauma or pancreatic resection, with only a small percentage resulting from primary pancreatic diseases. The principles of management are diagnosis of the fistula and wide drainage. Evaluation with a CT scan will provide important information about the pancreatic anatomy, degree of inflammation, and peripancreatic fluid collections. Pancreatic fluid contains a large amount of bicarbonate (70 to 90 mEq/L), and inadequate replacement of bicarbonate may lead to nonanion gap metabolic acidosis. Pancreatic fistulae typically drain between 100 and 1,000 mL of fluid/d. Classification of pancreatic fistulae is outlined in Table 58.2 (37). Pancreatic injury may result in accumulation of pancreatic ascites, resulting in abdominal pain, fever, ileus, and abscess formation. There exists a spectrum of patient clinical presentation from a pancreatic leak; some patients may present in profound shock while others may tolerate large-output pancreatic fistulae with a benign clinical presentation. The source of this variability in clinical presentation is poorly understood but is likely due to the degree of enzymatic activation of the leaking fluid.

For most patients, the initial treatment for a pancreatic fistula is percutaneous drainage. Intraoperative concern for a postoperative pancreatic leak should prompt the surgeon to prove wide drainage with a closed-system drain before closing the patient’s abdomen. Wide drainage of pancreatic secretions should allow time for the patient to stabilize and prevent damage to other abdominal organs. Long-term drainage is often needed to enable spontaneous closure of the pancreatic fistula. This conservative approach with drains is generally pursued for up to 6 months and has a success rate of up to 97% in some studies (38). Pancreatic fistulae with persistent drainage should undergo imaging studies to define duct anatomy and determine if an obstructive process is maintaining fistula patency. Magnetic resonance cholangiopancreatography

| TABLE 58.2 Criteria for Grading Pancreatic Fistula: ISGPF Classification Scheme |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Criteria                        | No Fistula      | Grade A Fistula | Grade B Fistula | Grade C Fistula |
| Drain amylase                   | >3x normal serum amylase | >3x normal serum amylase | >3x normal serum amylase | >3x normal serum amylase |
| Clinical conditions             | Well            | Well            | Often well      | III appearing   |
| Specific treatment              | No              | No              | Yes/no          | Yes             |
| US/CT                           | Negative        | Negative        | Negative/positive | Positive       |
| Persistent drainage (>3 wk)     | No              | No              | Usually yes     | Yes             |
| Signs of Infection              | No              | No              | Yes             | Yes             |
| Readmission                     | No              | No              | Yes/no          | Yes             |
| Sepsis                          | No              | No              | No              | Yes             |
| Reoperation                     | No              | No              | No              | Yes             |
| Death related to fistula        | No              | No              | No              | Yes             |

Abdominal Compartment Syndrome

ACS can be a source of significant patient morbidity and mortality. Since its first description in the 1980s, ACS has become an increasingly recognized clinical entity (40). In current surgical management it is usually seen following a massive fluid resuscitation from trauma, burns, intraoperative resuscitation, pancreatitis, or sepsis. Capillary leak occurs secondary to resuscitation from trauma, burns, intraoperative resuscitation, pancreatitis, or sepsis. Capillary leak occurs secondary to resuscitation from trauma, burns, intraoperative resuscitation, pancreatitis, or sepsis. Capillary leak occurs secondary to resuscitation from trauma, burns, intraoperative resuscitation, pancreatitis, or sepsis. Capillary leak occurs secondary to resuscitation from trauma, burns, intraoperative resuscitation, pancreatitis, or sepsis. Capillary leak occurs secondary to resuscitation from trauma, burns, intraoperative resuscitation, pancreatitis, or sepsis.

Adjunctive therapies including parenteral nutrition and octreotide may be helpful in decreasing secretory stimulation to the pancreas. With a low side-effect profile it is reasonable to pursue this therapy for a short course to improve chances of nonoperative resolution.

The Open Abdomen

The open abdomen is an important tool in a surgeon's armamentarium for management of critical ill patients. There are two important management strategies requiring the open abdomen. First is the recognition of primary and secondary ACS allows surgeons to choose the open abdomen as a management strategy for the short term. Second, "damage control laparotomies" have become increasingly common in treating major abdominal trauma. Although the idea of abbreviated laparotomy was first described by Stone et al. in 1983 (45), the formal nomenclature and increasing popularity are credited to Rotondo et al. in 1993 (46). Damage control laparotomy is aimed at limiting intraoperative times by delaying definitive repair and limiting operative intervention to controlling hemorrhage and contamination. The patient’s abdomen is

![Intra-abdominal pressure monitoring](image-url)
temporary closed with a plan to return when the patient is stable enough to enable definitive repair. Early transfer to the ICU facilitates continued resuscitation and rewarming. Damage control laparotomy remains an aggressive strategy for treatment of patients who develop the deadly triad of coagulopathy, hypothermia, and metabolic acidosis.

The open abdomen represents a complex and challenging management problem involving three decision-making stages: initial operative management (28), decision to close primarily versus a planned ventral hernia (29), and definitive closure of the planned ventral hernia (47). At the conclusion of a damage control laparotomy, the abdominal wall is temporarily closed, using a gusset or negative pressure-type closure devices, to achieve rapid closure with protection of intra-abdominal contents. The original temporary abdominal dressing is known as the Bogota bag. It consists of covering the abdominal contents with a sterile saline bag to protect the bowel until re-exploration; current practice of temporary abdominal wall closure is based on a derivation of the Bogota. A plastic drape, such as a sterile cassette cover, is placed over the bowels to prevent them from injury and to allow drainage of fluid. A sponge or blue towel, with two large Jackson–Pratt drains (Cardinal Health, McGaw Park, IL), is then placed over the plastic drape. The entire system is folded under the fascia to contain the abdominal contents. An adhesive drape is placed over the abdomen to maintain sterility and prevent free drainage of fluid. The drains are placed to suction to allow collection of blood and edema fluid. This dressing is then left intact until return to the operating room (48). Alternatively, vacuum-assisted fascial closure may be used. In this method, the bowels are protected with the plastic drape. A drainage sponge with constant suction is then placed, and the abdomen is covered with an adhesive dressing. The sponge suction provides constant medial tension, without disrupting the fascia, to prevent lateral retraction (48,49). These methods allow for control of abdominal edema and are easily applied in the OR (49).

The patient is returned to the operating room after an appropriate resuscitation period, usually 24 to 48 hours. Once definitive operative repair is complete, the decision to close primarily depends on the degree of intra-abdominal edema and the quality of the fascia. Primary closure of fascia is preferable as long as there is no excessive fascial tension. High-tension closures will elevate intra-abdominal pressures leading to compartment syndrome with cardiopulmonary dysfunction, renal impairment, and risk of dehiscence. In the absence of primary closure, return trips to the OR are indicated to facilitate gradual closure. The goal of temporary closure is to prevent lateral retraction of fascia to facilitate delayed primary closure. Vicryl mesh sewn directly to the fascia is a form of temporary abdominal closure. Daily tightening of the abdominal wall with mesh pleating combined with fluid removal will help improve the likelihood of primary abdominal wall closure (41). Management of the patient’s volume status to achieve a net negative balance is important to facilitate re-approximation of the fascia. Achieving a net negative volume balance is often difficult in critically ill trauma patients requiring large-volume resuscitations. Therefore, many of these patients will go on to planned ventral hernias.

**Ventral Hernia Repair**

A giant ventral hernia is the result of the inability to close an open abdomen. Once it is established that primary closure of the abdominal wall is not possible, the patient is managed with a temporary Vicryl mesh secured across the abdominal wall. After 2 to 3 weeks, the abdominal contents should display a healthy bed of granulation tissue. At this point, a split-thickness skin graft is used to close the surface. Application of skin graft too early or late may result in fistula formation. The patient is then observed for 6 to 12 months while undergoing rehabilitation and nutritional optimization (50).

With the absence of a functional abdominal wall, ventral hernias are debilitating and cosmetically displeasing. Most patients are motivated for definitive closure of the hernia. Consideration of abdominal wall reconstruction requires careful evaluation of the patient’s nutritional status, as well as the laxity of the skin graft. Over time, the skin graft and intra-abdominal adhesions will soften, allowing easier graft removal and adhesiolysis. The ideal window for most patients appears to be at 6 to 12 months (51).

The majority of ventral hernias are not amenable to primary closure. As such, the surgeon must decide on the best method of restoring abdominal domain, with options including functional and nonfunctional abdominal wall reconstruction. A functional reconstruction attempts to use the patient’s native tissues through a process of component separation. Nonfunctional repairs rely on the placement of synthetic or porcine mesh across the defect. The use of mesh is not possible if enterotomies are made during the lysis stage or if stoma reversal is necessary. Functional abdominal wall reconstruction is based on a component separation technique, which is a type of rectus abdominis muscle advancement flap. After sharply removing the skin graft, small bowel adhesions are freed from the overlying fascia for a distance of 4 to 6 cm. Skin flaps are raised laterally on both sides extending from the iliac crest to the level of the midaxillary line. The component separation technique involves placement of relaxing incisions in the anterior and posterior rectus fascial layers to allow advancement of the abdominal wall to provide a tension-free repair at the abdominal midline. Aggressive closure under tension may lead to postoperative respiratory compromise and complications associated with ACS. Since the original description of this technique by Ramirez (52) in 1990, there have
Short bowel syndrome is a condition characterized by a short bowel segment and the inability to meet nutritional requirements and dependence on parenteral nutrition. Patients will have significant weight loss, diarrhea, and steatorrhea. Patients often develop gastric emptying abnormalities and rapid transit times due to short intestinal length. Dehydration is a constant problem especially if the colon is absent due to an inability to reabsorb gastrointestinal secretions (approximately 4 L/d). Reduced absorption leads to vitamin deficiencies such as B₁₂ and fat-soluble vitamins and bile salts. Short gut patients are also prone to cholelithiasis and nephrolithiasis due to altered absorption of bile salts and oxalate, peptic ulcers due to increased gastric secretions, line sepsis from deep catheters, and liver dysfunction from parenteral nutrition (55).

Surgical management of short bowel requires effort to preserve bowel length and the ileocecal valve. In some cases, limited bowel resection with plan for delayed inspection of marginally viable bowel is necessary to preserve as much bowel as possible. Initial postoperative therapy is often supportive with early administration of parenteral nutrition to prevent malnutrition and optimize wound healing. The long-term management of short gut patients then requires a multidisciplinary team involving physicians and nurses, nutritionists, patients, and their families.

Surgical therapy is occasionally required to deal with the sequelae of short gut syndrome. Patients with enteral continuity and increasing oral intake often suffer from rapid transit due to inadequate length for absorption and bowel maladaptation resulting in diarrhea and malnutrition. The initial management should target conservative therapies such as medication and diet modification. Given that surgical therapy for short bowel syndrome is pursued infrequently, patients should be referred to tertiary centers with extensive experience managing these challenging cases.

**Radiation Enteritis**

Intra-abdominal radiation injury from neoadjuvant or adjuvant oncologic therapy can lead to many challenging problems in the perioperative period. Radiation damages mitotically active cells of the mucosal surface epithelium, leading to cellular injury, and causes production of oxygen free radicals, which further damage cellular function. The incidence of injury is dependent on such factors as volume of irradiated small bowel, total dose and time dose delivered, and type of radiation being delivered (56). Radiation-induced cellular injury results in obliterative arteritis with subsequent bowel ischemia. Acute radiation-associated injury results in transient mucosal atrophy, submucosal edema, and inflammation and infiltration of the lamina propria with leukocytes and plasma cells. The chronic ischemia and inflammation in the affected bowel segment may result in stricture formation, perforation, or fistula formation. Radiation exposure also results in the formation of dense local adhesions. Of patients undergoing abdominal and pelvic radiation, 50% to 75% will have some symptoms related to the therapy in the months to years following treatment; these include, commonly, vague abdominal pain, diarrhea, rectal bleeding, and tenesmus. Up to 15% of patient’s symptoms will progress to actual radiation enteritis. Symptoms may occur acutely during therapy or years after treatment. Management of late radiation enteritis should include investigation of recurrence of the initial neoplasm (57,58).
Initial management of radiation enteritis should embrace conservative measures. Sitz baths and stool softeners are effective initial treatments for rectal and anal symptoms. Opiates, antispasmodics, and anticholinergics will prolong transit time if diarrhea is the primary problem. Steroid enemas and sucralfate can diminish irritation of the mucosa, which results in rectal pain and bleeding. If the patient is malnourished, nutritional support may be required, especially if operative intervention is entertained.

**Surgical Management of Radiation Enteritis.** Perioperative management of radiation enteritis involves both prevention and therapy. If radiation is planned as an adjuvant therapy following surgery, intraoperative goals are to minimize radiation injury. Simple nonsurgical methods to diminish radiation injury include patient positioning, multiple-field techniques, and bladder distention (56). Following pelvic surgery, intraoperative management is aimed to decrease the volume of small bowel included in the radiation field postoperatively. Techniques include reperitonealizing the operative field, the use of a mesh sling for exclusion of small bowel from the pelvis, and using omentum to exclude the pelvis. Small bowel displacement systems have had some success in physically excluding up to 50% of small bowel volume from the radiation field (57).

Surgical intervention is sometimes required in the management of complications related to radiation enteritis. The most common indication for surgery is bowel obstruction, but other indications include bleeding, intractable diarrhea, pain, fistulas, and persistent abscess. Surgical intervention should use the least invasive procedure required to address the problem as excessive handling of radiated tissues and lysis of adhesions commonly results in unplanned enterotomies and may interrupt a tenuous blood supply. Recurrent neoplasm is not uncommon and any suspicious-appearing areas should be biopsied. Diseased segments of bowel should be removed and repaired with an anastomosis in nonradiated bowel. A gastrointestional bypass may be required if diseased segments of bowel cannot be safely resected (58).

**SUMMARY**

Acute intra-abdominal pathology is commonly seen in critically ill patients. As such physicians must maintain a high level of suspicion of an abdominal problem in a deteriorating patient. History and physical examination are used to guide further laboratory and diagnostic imaging tests, and surgical consultation should be obtained early in a patient’s course, as treatment frequently requires surgical intervention.

Early goal-directed fluid resuscitation, antibiotic administration, and source control should be the priority for the health care team. Perioperative management of even the most routine abdominal surgery has the potential to be difficult. When the anticipated progress of a postoperative patient deviates from the expected, a high index of suspicion is important for rapid diagnosis and treatment. Careful evaluation of the patient’s operative details, postoperative course, and clinical evaluation will dictate appropriate management. Interventions may vary from the addition of antibiotics to percutaneous drainage of an abscess to surgical re-exploration. The critical care surgeon must be adept in a multitude of complex postoperative issues to provide appropriate therapy.

**Key Points**

- Patients presenting with abdominal pain, fever, evidence of multi-organ failure, unexplained acidosis, or jaundice should be evaluated for an intra-abdominal source of infection.
- Early goal-directed resuscitation, antibiotic administration, and source control is required for patients with acute abdominal problems.
- Common postoperative abdominal problems include abscess, leak from anastomoses or perforated bowel, acalculous cholecystitis, and ileus.
- Abdominal distension in combination with organ dysfunction suggests evaluation of abdominal compartment pressures and surgical consult.
- Routes to provide enteral feedings should be considered at the time of surgery for patients in whom oral intake is not anticipated for some time.
- All tubes and drains must be labeled secured to minimize inadvertent dislodgement. Loss of carefully placed tubes and drains can lead to significant morbidity.
- Carefully assess the patient’s general condition before entering a hostile abdomen. Cardiovascular and pulmonary status, nutritional support, blood sugar control, and coagulation profile should be optimized if possible.

**References**