An acute abdomen is any problem in which the patient’s pain or other physical findings originates from an abdominal lesion resulting in serious morbidity or mortality without appropriate therapy. As sicker patients are admitted to our intensive care units (ICUs), the challenge of diagnosis and treatment of the acute abdomen becomes more important. Patients who are immuno-compromised from diseases such as HIV, posttransplant, or chemotherapy frequently present with a nonclassic sign of pain and inflammation. Patients who are post-cardiac surgery have a well-recognized constellation of intra-abdominal catastrophes. Bariatric surgery presents ICU physicians with a whole new set of intra-abdominal problems, which if not recognized early, can lead to death or significant morbidity.

Patients admitted to respiratory care units are subject to various acute abdominal problems. Aranha and Goldberg reported that 32 of 175 (18%) patients on ventilators had acute abdominal problems. Aranha and Goldberg rephrased. Bariatric surgery presents ICU physicians with a whole new set of intra-abdominal problems, which if not recognized early, can lead to death or significant morbidity. Acute abdominal problems are frequent sources of admission and complications in ICUs (2).

Therefore, knowledge of common abdominal problems and appropriate diagnostic modalities are essential parts of the armamentarium of all ICU physicians. A high index of suspicion that an abdominal problem is causing a patient’s critical illness is important to stimulate the necessary diagnostic and therapeutic responses.

Searching for a cause of abdominal signs and symptoms is difficult in the critically ill patient. The patient may not be able to give a lucid history, especially if intubated or sedated. Physical findings may be masked by narcotics, steroids, and other therapy administered.

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- Gastrointestinal bleeding, ileus, bowel obstruction, and peritonitis that required operation.
- Acute abdominal problems are frequent sources of admission and complications in ICUs (2).

Early recognition of the acute abdomen and initiation of definitive surgical or medical therapy often determines the outcome. Therefore, knowledge of common abdominal problems and appropriate diagnostic modalities are essential parts of the armamentarium of all ICU physicians. A high index of suspicion that an abdominal problem is causing a patient’s critical illness is important to stimulate the necessary diagnostic and therapeutic responses.

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ANATOMY

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in critically ill patients. Deep visceral pain is transmitted via autonomic nerves, both sympathetic and parasympathetic. Visceral pain is poorly localized as pain receptors are much sparser than somatic receptors. The pain is typically unpleasant and is associated with autonomic symptoms such as tachycardia, bradycardia, and diaphoresis. The primary stimulus to visceral pain is stretching of hollow visera or solid organ capsules. Visceral pain signals share common pathways with somatic pain in the spinalthalamatic tracts. Visceral pain signals are received in areas of the sensory cortex where somatic structures that originated from the same embryonic segment are represented. This is the reason why visceral pain tends to be referred to remote dermatomes, e.g., should pain caused by diaphragmatic irritation. Abdominal pain becomes more localized when the parietal peritoneum is affected by the underlying inflammatory process. The parietal peritoneum has a rich somatic sensory supply.

Knowledge of the blood supply of the abdomen is also important given the extensive diagnostic and therapeutic applications of angiography in acute abdominal pathology. The foregut (esophagus to duodenum) is supplied by branches of the celiac trunk, the midgut (duodenum to distal transverse colon) is supplied by branches of the superior mesenteric artery (SMA), and the hindgut (descending colon and rectum) is supplied by branches of the inferior mesenteric artery (IMA). The right hepatic artery is replaced (arises from the SMA) in about 10% of the population. An embolus tends to lodge distal to the origins of the most proximal branches of the SMA, namely, the inferior pancreaticoduodenal, the middle colic, and the proximal jejunal branches. The proximal jejunal and transverse colon are typically spared in acute ischemia due to SMA embolism compared to thrombosis. Collateral circulation exists between branches of the three mesenteric vessels. The marginal artery of Drummond is formed by the anastomosing branches of the SMA and IMA along the mesenteric border of the colon. The arc of Riolan connects the middle colic artery with the ascending branch of the ileocolic artery. The internal iliac artery contributes to colonic circulation through the anastomosis between the middle and superior rectal arteries.

### Chapter 76: Evaluating the Acute Abdomen

A careful evaluation of the characteristics of abdominal pain is essential. Its nature, onset, associated symptoms, radiation, and other characteristics are useful in localizing and delineating the cause. Abdominal symptoms can be masked by other disease processes. A diabetic patient who presents with diabetic ketoacidosis may have an underlying abdominal catastrophe as a precipitating factor. Syncope is a symptom that can be caused by ruptured aneurysm, a ruptured spleen, an ectopic pregnancy, or any severe abdominal catastrophe, as well as by neurologic and metabolic problems.

### PHYSICAL EXAMINATION

Abdominal examination in the critically ill patient can be challenging as many patients will be unconscious or intubated. Examination of the abdomen in the critically ill patient who may be combative, comatose, narcotized, or paralyzed is difficult. The standard routine of inspection, palpation, percussion, and auscultation should be followed. Vital signs, including blood pressure (with the patient sitting if possible), pulse, respiratory rate, and rectal or core temperature, should be taken. Too often, oral or axillary temperatures are normal because of peripheral cooling, nasal oxygen administration, or nasogastric (NG) tubes.

Inspection of the abdomen can give many clues. The Gray-Turner sign, flank ecchymosis, was initially described with hemorrhagic pancreatitis but can occur with other causes of retroperitoneal bleeding. The Sister Mary Joseph nodule indicates abdominal or breast malignancy that spread along the round ligament to the umbilicus. Dilated abdominal wall veins indicated advanced portal hypertension. A large abdominal aortic aneurysm may be discerned as a pulsating upper abdominal mass in a thin patient. Absent or hypovascular bowel sounds is a nonspecific sign as many patients will have ileus associated with their critical illness. Bowel sounds are frequently absent in paralyzed patients, despite the fact that muscular paralysis should not eliminate autonomic bowel function. Hyperactive sounds or “rusher” sounds are most common with small bowel obstruction. The presence of bowel sounds, however, does not always correlate with normal bowel function.

The presence of guarding or rigidity indicates peritoneal irritation. Rebound may not be present in a postoperative patient with significant abdominal pathology. It is important to note, however, that patients’ response to the presence of blood in the
peritoneal cavity is variable. Some patients will have guarding or rigidity whereas others will have a soft abdomen. Assessment of obese patients for abdominal wall rigidity is also unreliable. Obese patients may also have groin or incisional hernias that are not easily discerned. Patients with mesenteric ischemia have pain that is out of proportion to the findings of the physical exam. Rectal and pelvic examinations are frequently avoided in the ICU; however, they are mandatory to discover low pelvic abscesses and masses, prostatic infection, and bloody stools.

The physical examination of the acute abdomen should be performed by an experienced physician on a regular basis. Serial examinations are essential to carefully document any progression of tenderness, muscular rigidity, and the overall trend toward improvement or deterioration. An isolated examination is not nearly as useful as sequential examinations by the same observer. The physician who will ultimately make the decision whether surgical intervention is required should be involved as early as possible.

The presence of abdominal distention in the setting of decreased urine output and increased ventilator pressures should lead to a possible diagnosis of abdominal compartment syndrome and immediately to a measurement of intra-abdominal pressures using bladder pressure manometry.

LABORATORY EVALUATION

Laboratory tests should be viewed as adjuncts in the evaluation of patients. They often provide useful information but are rarely diagnostic. Depending exclusively on laboratory findings is costly and occasionally misleading. A complete hemogram, including hematocrit, hemoglobin, and complete white blood cell (WBC) count, is routine. A decreasing WBC count may give a false sense of improvement, because severe sepsis can cause a leukopenia with a shift to the left that will be missed without a differential count. Urinalysis, including specific gravity and analysis for bacteria, bile, and reducing substances, should be performed. Patients with indwelling Foley catheters often have asymptomatic bacteriuria and mild hematuria. A full workup of “benign bacteriuria” may delay the diagnosis of the true cause of sepsis. The serum amylase concentration, especially fractionated into isoenzymes, is helpful in diagnosing intra-abdominal catastrophe when it is elevated but is not specific. Amylase may be increased in ischemic bowel disease, fascial trauma, perforated ulcer, and pancreatitis, or without apparent cause (3). The serum lipase is a more specific marker of acute pancreatitis than amylase and is less influenced by other intra-abdominal problems. Calcium and phosphorus values are also helpful in determining the severity of pancreatitis.

An elevated serum bilirubin level is associated with sepsis, resolving hematoma, hemolysis, and hepatobiliary disease. Likewise, the lactate dehydrogenase concentration may be elevated in numerous disease processes. Liver enzymes, such as serum glutamate oxaloacetic transaminase, serum glutamic pyruvic transaminase, and alkaline phosphatase 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. Persistent acidosis and arterial hypoxemia suggest severe metabolic problems that may be a reflection of unresolved third-space losses from untreated abdominal sepsis or ischemia. These causes are frequently overlooked in the early workup of these problems.

RADIOGRAPHIC STUDIES

Although plain portable radiographs of the abdomen are obtained on most patients with suspicious abdominal findings, their yield is relatively low and their quality is frequently suboptimal. They are most useful to determine the position of intra-abdominal tubes such as NG and drains. Plain abdominal films are useful to examine abnormal gas patterns intraluminally and extraluminally. The absence of gas may be found with ischemic bowel, whereas small bowel obstruction and colonic volvulus present with massive gaseous distention. An upright abdominal film is desirable; however, many patients in an ICU cannot tolerate this procedure, and therefore, a left lateral decubitus film to discover air-fluid levels and free air above the liver should be obtained. Free air from perforated viscus is best seen in an upright chest radiograph, which is usually possible to obtain in the critically ill patient by sitting the patient up in bed and elevating the head of the bed 75 to 90 degrees.

A retrospective study of 1,000 patients presenting to the emergency room (ER) with acute abdominal pain compared the use of plain films to computed tomography (CT) scans. The majority, 588 of 871 (68%), of abdominal radiographs were interpreted as nonspecific, whereas 83 demonstrated specific diagnostic abnormalities, including bowel obstruction (4%), urolithiasis (2%), diarrhea (2%), and abnormal foreign bodies (1%) (4). No free air was found. Films were most sensitive for foreign bodies (90%) and bowel obstruction (49%). Only 38 of 188 CT scans were normal. Of these, 120 of 188 had undergone plain films. CT was predictive of bowel obstruction in 75% and pancreatitis in 60%. Of the 120 patients who had both exams, abdominal films were negative in 20%, nonspecific in 75%, and pancreatitis in 60%. Of the 120 patients who had both exams, abdominal films were negative in 20%, nonspecific in 75%, and abnormal in 4%. These data could be extrapolated to ICU patients although there are no studies to confirm similar findings.

Ultrasonography has emerged as a dependable adjunctive diagnostic tool. It can be brought to the bedside and give data on acalculous cholecystitis, fluid collection, and blood flow. Ultrasonography is also useful in demonstrating intra-abdominal blood or fluid and to perform percutaneous abscess drainage. It is less invasive and less expensive than CAT scan and does not require transporting patients. However, in patients who have been in an ICU for extended periods, the gallbladder can be expected to be distended with poor contractility, and the ultrasound is not specific for acalculous cholecystitis unless a radionuclide study using a HIDA (hepato-biliary iminodiacetic acid) scan confirms abnormal gallbladder filling. Ultrasound can also be used as a therapeutic tool to help perform procedures such as percutaneous cholecystostomy (Fig. 76.1).

The CT scan has become the most widely used tool to examine the abdomen for abnormalities, and CT scanning is more accurate for diagnosing intra-abdominal fluid collections than any other modality. It is especially useful in liver, splenic, renal, and retroperitoneal abscesses but may not be as useful as ultrasound in the diagnosis of right upper quadrant and pelvic masses.
The treatment of intra-abdominal problems in the acutely ill frequently requires surgical intervention. Surgical consultation should be obtained early in the evaluation. In the preoperative patient, adequate volume resuscitation and electrolyte correction are vital to prepare the patient for surgical repair of the underlying problem. Most fluid losses in preoperative surgical patients are isotonic. Patients who are volume contracted may be hypotensive, hypochloremic, hypokalemic, and alkalotic because of vomiting, nasogastric suctioning, and third-space losses. These patients require normal saline resuscitation to prevent anesthetic disaster. Only after volume and salt repletion will their chloride-dependent alkalosis resolve. Although hypokalemia may exist, potassium should be administered cautiously until oliguria is resolved.

Acute abdominal catastrophe may be the first event in the precipitous cascade of multiple organ system failure (MOSF). Unrecognized abdominal sepsis is associated with MOSF in 44% of cases (8,9). Early aggressive surgical therapy, vigorous fluid replacement, and appropriate antibiotic regimens are necessary.

The specific management of disease entities should be based on well-established surgical principles. However, the explosion of minimally invasive surgery has lead to a new era in surgical intervention. Many acute abdominal procedures can now be performed either via an open or laparoscopic technique. Most acute cholecystitis can be treated conservatively for 24 to 48 hours. If the signs and symptoms do not improve within 48 hours or if cholangitis appears, an endoscopic retrograde cholangiopancreatography (ERCP) can be performed to drain the common duct. A percutaneous cholecystostomy or a laparoscopic cholecystectomy can then be performed in most patients. A Gastrografin swallow is still an excellent tool to differentiate abdominal collections from intra-abdominal abscesses instead of surgical or radiologic drainage and antibiotics in acute abdominal problems is usually adjunctive to prevent systemic sepsis. The prolonged use of antibiotics for localized abscesses instead of surgical or radiologic drainage can lead to morbidity and increased mortality.
In patients with diffuse peritonitis or necrotizing infected pancreatitis, conversion from a closed abdomen into an open abdomen may be necessary to control the process (19).

### Specific Disease States

Any stable patient in an ICU developing sudden shock or sepsis must be examined closely for an intra-abdominal cause. Several conditions that are common causes of abdominal symptoms in critically ill patients are presented in the following sections.

Although appendicitis is the most common abdominal condition requiring surgery, it is rarely seen in the ICU. Pancreatitis and acalculous cholecystitis are more common, especially after open heart surgery. Abdominal distention in elderly patients after orthopedic procedures is frequently caused by ileus and colonic pseudo- obstruction. Patients receiving mechanical ventilation are at high risk for gastrointestinal bleeding, ileus, and unrecognised perforation (2). Stress ulcer perforation and ileus are insidious causes of respiratory failure and sepsis in any patient with a spinal injury (20).

### Acquired Immunodeficiency Syndrome (AIDS)

Immunocompromised hosts require special attention when presenting either with abdominal pain or sepsis of unknown origin. Since the advent of antiretroviral medication therapy, the incidence of severe abdominal problems in HIV-positive patients has decreased. Patients presenting with overt AIDS have a constellation of problems that are unique to this population. The frequency of pulmonary, cardiac, gastrointestinal, and renal disease that is not directly related to the underlying HIV infection has increased (21).

Acute abdominal pain is a complaint in 12% to 45% of patients with HIV infection presenting to the emergency room (22). Earlier studies have noted that cytomegalovirus (CMV), gastroenteritis, followed by lymphoma, Kaposi sarcoma, and mycobacterial disease were frequent causes of abdominal pain in HIV patients. There has been a significant reduction in these opportunistic infections, especially peritonitis secondary to atypical mycobacterium and fungi (23, 24).

The clinician must be aware that the HIV patient continues to present with non-HIV-related problems, such as appendicitis, diverticulitis, and pancreatitis. Only 11% of acute abdominal pain in HIV patients is caused by HIV/AIDS, whereas opportunistic infection results in surgery in only 0.9% of patients (25). Surgery should be considered early because of the difficulty in interpreting findings in these patients and the importance of differentiating true surgical from nonsurgical abdominal problems. Earlier studies reported increased morbidity and mortality in patients with AIDS (26); whereas recent data yield 10% to 19% operative mortality for emergency surgery (24).

Fever and non-specific abdominal pain are frequently noted although peritoneal signs may be lacking in severely immunocompromised patients (27). Prognosis of patients is somewhat dependent on the CD4 count and viral loads. CD4 counts less than 200 cells/mm³, total lymphocyte count less than 1,000 cells/mm³, and viral loads greater than 75,000 RNA copies/mL are associated with higher morbidity and mortality (24).

Plain films have a low yield compared to CT scan in the diagnoses of processes such as pneumatisis intestinalis. This finding on CT is very suggestive of bowel necrosis. Intrapertoneal collections associated with opportunistic infections can be aspirated under CT guidance (4, 28).

Acute appendicitis in AIDS patients may be routine or secondary to opportunistic organisms. Although fever and pain are frequent, white blood cell count may be low or normal (29).

There has been a decrease in bowel perforation secondary to CMV or Kaposi sarcoma since the advent of antiretroviral therapy. However, diligence is required to ensure perforation has not occurred. Recent data point to lymphoma and disseminated mycobacterial disease as causes for perforation (25). CMV perforations are more common in the duodenum and colon secondary to ischemic lesions, which require aggressive surgical therapy and diversion of the fecal stream (23). Acute bowel obstruction suggests disseminated disease and has a poor prognosis if the cause is age related.

Colonic disease, especially toxic megacolon, has been seen with Clostridium difficile colitis, especially in patients with CMV infection. Megacolon can be a significant prognostic indicator in advanced age and may best be treated with colonoscopy for short-term management of the severely ill (30).

Acute hepatobiliary disease secondary to opportunistic disease can present difficult diagnostic problems in patients with CD4 counts less than 100 cells/mm³. Acalculous cholecystitis is more common in HIV/AIDS patients than in the normal population (31–33).

Neutropenic patients with cancer also present a diagnosis and therapeutic challenge. In patients who underwent emergency celiotomy for suspected intra-abdominal disease, the most common disease has been reported to be neutropenic enteropathy (61%) with postoperative mortality up to 32% (34).

### Biliary Disease

Primary biliary tract disease in critically ill patients appears as calculous or acalculous cholecystitis. Calculous disease may present as acute cholecystitis, cholangitis, or pancreatitis. Acute acalculous biliary disease is a concomitant of critical illness and has been reported in 1% of surgical patients and 0.2% of postoperative cardiac patients (35).

The differentiation of calculous from acalculous disease can be difficult. Several risk factors are associated with the development of acalculous cholecystitis, including use of narcotics for more than 6 days, gastric suction, prolonged ileus with nothing by mouth, ventilatory support longer than 24 hours, multiple recent operations, more than ten blood transfusions, open wound or abscesses, and intravenous hyperalimentation for more than 3 days. The presence of five of these risk factors in a patient with acute abdominal findings should lead to a search for acalculous biliary disease (35, 36).

The typical presentation of right upper quadrant pain, a positive Murphy sign, and fever may be absent in critically ill patients. Symptoms of right upper quadrant pain were present in only 30% of patients with acalculous disease, although all exhibited fever. Peritonitis was an inconsistent finding and present in only 24%. Persistent fever was the most consistent finding (37).

The laboratory findings of biliary disease are variable. Leukocytosis is common, although nonspecific. Up to 65% of patients with acalculous cholecystitis have elevated bilirubin; however, a control group of patients receiving multiple...
transfusions had similar hyperbilirubinemia. Liver enzymes are elevated in less than 50% (35).

Acute cholecystitis can mimic numerous other disease processes in the abdomen. Conversely, the presence of stones in the gallbladder in patients with nonspecific symptoms is not pathognomonic of acute biliary disease. Improved ultrasonography can be supplemented by radionuclide imaging techniques that can distinguish cystic duct obstruction in acute cholecystitis from other causes of abdominal pain have markedly increased our diagnostic acumen. Derivatives of iminodiacetic acid are rapidly taken up by the hepatocytes and excreted into the bile even in patients with elevations of bilirubin up to 6 g/dL. The test has proved to be 95% accurate in the diagnosis of acute cholecystitis. The presence of fever, mild elevation of bilirubin, sludge on ultrasound, and nonspecificization on HIDA are accurate indications of acute acalculous cholecystitis in critically ill patients. Caution is urged in patients receiving hyperalimentation, which severely limits the usefulness of the test (38,39). Furthermore, HIDA scan requires moving the critically ill patient to the radiology suite for up to 4 hours, and the risk-benefit ratio requires a high degree of clinical suspicion. The treatment of choice has been surgical drainage, either cholecystostomy or cholecystectomy, if the patient is able to tolerate a major procedure. The use of percutaneous cholecystostomy has been reported in severely ill patients. The mortality rate associated with acalculous cholecystitis is as high as 40% secondary to the multiplicity of the patient’s problems (37,40).

**ABSCESS**

Intra-abdominal abscesses develop as a complication of sepsis, either postoperative or perforation of a hollow viscus. They usually occur postoperatively, particularly after colonic resection complicated by anastomotic leak (41). This is followed in frequency by diverticular disease, appendicitis, inflammatory bowel disease, and malignancy. Patients undergoing gastric bypass procedures for obesity are also a potential population to develop abscess accompanied by an anastomotic leak. Abscesses can also develop retroperitoneally. This can be the result of retroperitoneal visceral perforation, e.g., colonic perforation or lymphatic and hematogenous spread of bacteria, e.g., infected pancreatic necrosis. Peritonitis and abscesses should be suspected in any patient deteriorating following abdominal surgery.

Making the diagnosis of intra-abdominal abscess requires a high index of suspicion as the clinical picture can be vague. Peritonitis is rare, and bowel function may be normal. Physical examination is rarely helpful. Abscesses that have the anterior abdominal wall as part of their walls are associated with a palpable tender mass. Nonspecific manifestations such as fever, chills, malaise, and leukocytosis should raise the suspicion. Hiccups, unexplained pleural effusion, and a raised hemidiaphragm on chest radiograph may indicate subphrenic abscess. Diarrhea and urinary retention may indicate a pelvic abscess. CT scanning, preferably with oral and intravenous contrast, is the standard diagnostic modality. Befside ultrasonography may be used in patients who are too unstable to move out of the ICU.

The bacterial flora are related to the organ involved, the host defenses, and the duration of the critical illness. The flora of the normal stomach and duodenum is very sparse and is composed mainly of swallowed oral organisms such as microaerophilic streptococci and *Streptococcus viridans*, lactobacilli, fusiform bacteria, and *Candida* species. The flora grows and changes remarkably if there is gastric outlet obstruction, achlorhydria, or acid-suppressive therapy. Small bowel flora consists mainly of *Enterobacteriaceae, Enterococcus* species, and anaerobic species. The flora becomes gradually more dense distally. Colonic flora is extremely dense; it accounts for one sixth of the dry weight of stools and contains both aerobic and anaerobic bacteria with the former much more abundant than the latter. *Aerobic* bacteria are primarily *Gram*-negative, e.g., *Escherichia coli*, *Klebsiella* species, *Enterococcus* species, and * Proteus* species. Anaerobic bacteria include *Bacteroides fragilis*, *Eubacterium* species, and *Bifidobacterium* species. Intra-abdominal abscesses are typically polymicrobial, but anaerobes are difficult to grow on cultures.

Whenever possible the source of infection should be dealt with surgically, e.g., appendectomy or resection of necrotic or perforated intestine. Open surgical management is not always possible or necessary. Surgical consultation should be obtained, and the decision to operate is based on individual patient conditions. Open surgical drainage does not always entail a celiotomy. Drainage of subphrenic abscess can be performed through the bed of the 12th rib, and extra peritoneal drainage of lower quadrant abscesses may be done. The efficacy of CT-guided percutaneous drainage of intra-abdominal abscesses (Fig. 76.2) has long been established (17,42,43). This minimally invasive technique is quite helpful, particularly when operative intervention carries a high risk of morbidity as in the case of Crohn disease (44). In a retrospective study of 38 patients with intra-abdominal abscesses due to colorectal disease both postoperative and primary, the overall success rate of percutaneous drainage was 89% (45). Antibiotic therapy is based on empiric coverage of bacteria that is normally present within the gut rather than culture results. Antibiotics are adjunctive in treating intra-abdominal sepsis. The antibiotic regimen should cover *Gram*-positive, *Gram*-negative, and anaerobic bacteria. Antifungal agents are not given even if fungi are seen on cultures unless the patient is immunosuppressed or has recurrent intra-abdominal infection. Guidelines for the use of antimicrobial agents are published by several medical societies (46).

Mortality from intra-abdominal sepsis ranges from 7.5% for single abscess to 43% for patients with multiple abscesses and peritonitis (47). Overall mortality from intra-abdominal infection is 24%. Mortality correlates directly with acute physiology score, malnutrition, age, and shock. Only early recognition, appropriate use of antibiotics, and prompt drainage can improve on these data.

**PNEUMOPERITONEUM**

The most common cause of pneumoperitoneum is laparoscopy or laparoscopy. After abdominal surgery, air may persist for weeks, although air from laparoscopy is frequently absent at 48 hours. Pneumoperitoneum in a patient who does not have a recent history of laparotomy or laparoscopy should be presumed to be due to a perforated viscus until proven otherwise. Perforation of the stomach or duodenum due to peptic ulcer disease is more
likely to cause an obvious pneumoperitoneum than perforation of the colon due to diverticular disease. Other conditions that may cause pneumoperitoneum are a recent percutaneous endoscopic gastrostomy and barotrauma to the lung (48,49). The latter, however, occurs much less frequently with today's lung-protective strategies whereby peak airway pressures are not allowed to exceed 40 cm H₂O. Patients who suffer severe chest trauma with pneumothorax and pneumomediastinum can also have pneumoperitoneum.

Pneumoperitoneum has been observed in up to 10% of patients who have demonstrated other evidence of extra alveolar air. Macklin and Macklin (49) postulated that air first ruptures though distended alveoli and dissects toward the mediastinum. From there, it dissects down the mediastinum and ruptures into the peritoneal cavity. The diagnosis of perforated viscus may be difficult in paralyzed, mechanically ventilated patients who cannot complain of tenderness and who will have a soft abdomen and absent bowel sounds.

Pneumoperitoneum should be evaluated in the context of the patient's overall condition. In unconscious or paralyzed septic patients with no obvious source of sepsis, pneumoperitoneum should prompt an exploratory laparotomy. Diagnostic peritoneal lavage may be considered if the risk of operative exploration is too high or the index of suspicion is low. The presence of bacteria, bile, more than 500 WBCs/mm³ can be inferred to indicate an acute abdominal process requiring immediate laparotomy.

**PSEUDO-OBSTRACTION OF THE COLON**

Isolated colonic ileus without mechanical obstruction was first described by Ogilvie (50). Patients at risk are the elderly and those requiring bed rest, prolonged narcotic use, and mechanical ventilation. Massive colonic distention presents a perplexing dilemma in the ICU. The cause is unknown, but the condition typically occurs in patients with associated illness who are bedridden for a long time. The most common risk factors are old age, multiple trauma, abdominal and pelvic operations, orthopedic operations, and spinal cord injuries (50,51). Hypotension and hypokalemia may play a role in the development of this condition. The abdomen is distended and tympanitic without signs of peritonitis, fever, or leukocytosis.

On radiograph the colon appears diffusely distended, including the rectum, and the small bowel is usually not seen. The cecum, being the widest segment of the colon, is at risk for necrosis and perforation if the diameter reaches 12 cm. Mechanical obstruction should be ruled out with a Hypaque enema. This is a hyperosmolar water-soluble enema that helps to cleanse the colon and, unlike barium, does not interfere with a subsequent colonoscopy.

Initial management consists of decompressing the stomach and colon with nasogastric and rectal tubes. Electrolyte abnormalities, especially hypokalemia, should be promptly corrected. If there is no response to these measures, neostigmine, a parasympathomimetic, should be given to stimulate colonic motility (52). Neostigmine is given in a dose of 1 to 2 mg intravenously and can be repeated in 3 hours. This should be done under cardiac monitoring as it may result in severe bradycardia. Neostigmine should not be given if the patient’s baseline heart rate is less than 60 beats per minute, the systolic blood pressure is less than 90 mm Hg, or if there is a significant heart block or bronchospasm. The next step in management, if the previous measures fail, is colonoscopic decompression. This is associated with a higher-than-normal risk of perforation and therefore should be used gently and with the goal of decompression only. It is not necessary to advance the colonoscope all the way to the cecum. Recurrence is seen in up to 40% of patients, and colonoscopy can be repeated. Surgery is reserved for patients who fail all other measures and those with complications or impending cecal rupture, i.e., diameter more than 12 cm. The operation of choice is right hemicolectomy with primary ileocolic anastomosis if there is no evidence of necrosis or perforation, in which case an ileostomy with mucus fistula should be performed.
MANAGEMENT OF THE OPEN ABDOMEN IN THE ICU

The abdominal compartment syndrome (ACS) is a condition in which the intra-abdominal pressure rises to a point that impairs respiratory, renal, and cardiovascular function (53). The condition is described mainly in the trauma population but can occur in any patient who receives a massive resuscitation for a profound shock state. The abdomen is not necessarily the site where the original pathology occurs, e.g., severe burns (54). This is sometimes described as secondary ACS. It is believed that severe edema of the abdominal wall, bowel wall, and the retroperitoneum occurs as a result of massive fluid shifts associated with the severe systemic inflammation that accompanies reperfusion of tissues after shock states. The diagnosis of ACS is made when there is abdominal distention associated with high ventilator pressures, oliguria, and elevated urinary bladder pressures (25–30 cm H2O). Treatment consists of abdominal decompression using a midline celiotomy and keeping the abdomen open using various dressing mechanisms over the bowel. For a detailed discussion of the ACS, see the section on abdominal trauma.

The treatment principles in trauma patients have been extrapolated to general surgery patients. More abdomens are now kept open if fascial closure is expected to increase abdominal pressure. By keeping the abdomen open, renal and pulmonary functions are not compromised and the integrity of fascial edges is preserved. The open abdomen also gives the opportunity for frequent bedside washouts and debridements such as with infected pancreatic necrosis. Once the swelling has resolved, the abdomen can be closed either by primary fascial closure or using one of the commercially available biologic or synthetic grafts. Prolongation of the open abdomen should be closed as soon as possible either by primary fascial closure or using one of the commercially available biologic or synthetic grafts. Prolongation of the open abdomen is associated with increased risk of fistula formation.

BARIATRIC SURGERY

It is estimated that over 130,000 bariatric procedures will be performed in the United States each year (55). Many of these patients have sleep apnea, hypoxemia, or other physiologic abnormalities that require ICU care in the immediate postoperative period. Since anastomotic leaks following gastric bypass and duodenal switch are potentially fatal, rapid recognition, diagnosis, and treatment are necessary to minimize patient risk. Likewise, acute gastric dilatation requires immediate treatment. The hallmarks of dilatation and leak are persistent tachycardia, tachypnea, fever, anxiety, and hiccups, usually accompanied by a mild leukocytosis with or without fever (56). Because this is also found in patients with pulmonary emboli, it is vital that the diagnosis of leak be made early. Abdominal pain is frequently not a major symptom, although shoulder (referred) pain may be present. In the absence of hypoxemia in the first 48 hours, the above symptoms should suggest leak and immediate Gastrografin swallow with adequate volume of contrast should be performed. The presence of a large gastric bubble without leak requires immediate decompression via either a percutaneous or surgical therapy (56).

This will prevent gastric perforation or an anastomotic disruption from pressure. A leak must be addressed immediately with drainage either percutaneously for small and contained leaks, or operative intervention to attempt to repair and drain the area of concern.

ACUTE MESENTERIC ISCHEMIA

Numerous causes exist for acute intestinal ischemia. Embolus (50%–60%) or thrombus (25%–35%) of the superior mesenteric artery (SMA) must be differentiated from nonmesenteric thrombosis (10%–20%) and acute mesenteric venous occlusions (5%) (57–60). Colonic and rectal ischemias have been reported after abdominal aortic aneurysmectomy in which the inferior mesenteric artery was ligated (61).

A characteristic of gut ischemia is the disparity between the patient’s pain and abdominal findings. Pain is found in 75% to 90% of patients. Nausea and vomiting are present in 50% to 60% of patients, whereas upper gastrointestinal bleeding is less common (62,63). Abdominal distention is present in 56% to 80%, peritoneal signs in 60%, jaundice in 50%, and shock and fever in 30% of patients. Leukocytosis (WBC count of 20,000/mm3) is seen in less than 50% of patients. A mild elevation in amylase is common (59,64).

The presence of physical signs indicating peritoneal irritation is extremely important because they portend impending or progressive gangrene and are associated with significant mortality. Leukocytosis out of proportion to the physical findings, elevated hematocrit, unexplained acidosis, and blood-tinted fluid on peritoneal lavage are all signs of advancing intestinal necrosis (62).

Plain radiographs are useful to exclude the other processes that can stimulate the symptoms. Signs of intestinal ischemia on plain radiographs is a grave prognosticator with 90% mortality (62).

Patients at highest risk are those older than 50 years of age with either valvular or atherosclerotic heart disease, congestive heart failure, diabetes, or severe respiratory, renal, or hepatic insufficiency (57–60). Therefore, patients with these risk factors should be observed more closely and be evaluated as early as possible for signs of intestinal ischemia.
The absence of obvious signs and symptoms in an acutely ill patient necessitates a high level of suspicion that an acute abdominal source may exist. In their patients through the multiple perturbations created by medical and surgical therapies, critical care practitioners guide their patients to the multiple perturbations created by medical and surgical therapies. Laboratory tests are usually adjunctive and rarely diagnostic. History and physical examination must be obtained early in a patient’s course, because treatment frequently requires surgical intervention. Only by maintaining constant vigilance can critical care practitioners guide their patients through the multiple perturbations created by acute abdominal problems.

When papaverine is the primary treatment for nonocclusive ischemia, it is continued for 24 hours and an arteriogram is repeated. Heparin may be used concomitantly. Maintaining adequate plasma volume and blood pressure is essential to maintain perfusion of the splanchnic vessels. Occasionally, dextran has been used to expand plasma and to decrease sludging. Digitalis should be used cautiously.

Systemic antibiotics are indicated because of the high incidence of positive blood cultures resulting from compromised bowel. Antibiotics may mask peritoneal signs. Decompression by NG suction can decrease bowel distention.

The mortality rate for acute mesenteric ischemia has remained at 70% to 80% (59,63). Embolus in the SMA is still associated with a 44% to 90% mortality rate whereas nonocclusive ischemia without peritoneal signs has a more favorable outcome. Peritonitis is associated with mortality rates of 60% to 90% (59,62). Logistic regression yields an odds ratio of 22 for peritonitis and 14.9 for hypotension as independent predictors of mortality (59).

The early workup of a suspicion of ischemia followed by aggressive and rapid diagnostic workup seems to be the only method for improving this abysmal mortality rate (63). Death occurs from MSOF secondary to ischemia (65%), sepsis (25%), pulmonary failure (8%), and stroke (2%) (59). Although second-look operations are frequently used at 24 to 48 hours to determine viability of remaining bowel, survival is not necessarily improved by this technique (67).

SUMMARY

Acute abdominal problems are frequent among ICU patients. The physician must maintain a high level of suspicion that an abdominal problem is present when faced with a deteriorating critically ill patient. History and physical examination must be used to guide the use of more invasive and expensive tests. Radiographic procedures, especially ultrasound and CT scans, when appropriately used, can be helpful. Surgical consultation should be obtained early in a patient’s course, because treatment frequently requires surgical intervention. Only by maintaining constant vigilance can critical care practitioners guide their patients through the multiple perturbations created by acute abdominal problems.

PEARLS

- Patients admitted to an ICU with abdominal pain, fever, evidence of multiorgan failure, unexplained acidosis, or jaundice should have an acute abdominal source ruled out early in their course.
- The absence of obvious signs and symptoms in an acutely ill patient does not rule out an acute abdominal problem.
- Resuscitation of acute abdominal problems frequently requires large volumes of isotonic crystalloid fluids and broad-spectrum antibiotics.
- Common postoperative abdominal problems include abscess, leak from anastomoses or perforated bowel, acalculous cholecystitis, and ileus.
Acute abdominal pain in an immunocompromised patient requires a high index of suspicion and rapid diagnosis of uncommon infection causes.

The diagnostic approach to acute abdominal symptoms includes radiologic examinations—ultrasound or CT scan of the abdomen, which should be initiated early in the workup.

Abdominal distension associated with low urine output and high ventilatory pressures should prompt measurement of abdominal compartment pressures and surgical consultation.

Acute mesenteric embolus is the most common cause for intestinal ischemia (50%–60%). It may present as severe pain out of proportion to the physical signs and requires immediate diagnosis and surgical treatment to prevent significant morbidity/mortality.

References