

ABDOMINAL PAIN

“The general rule can be laid down that the majority of severe abdominal pains which ensue in patients who have been previously fairly well, and which last as long as 6 hours, are caused by conditions of surgical import.”

Sir Zachary Cope (1881-1974)

Abdominal pain is one of the most common conditions for which patients seek medical care. The differential diagnosis of abdominal pain is vast, and determining when emergent intervention is required is essential. Appropriate diagnosis and subsequent treatment can be challenging. The evaluation of a patient with abdominal pain begins with two important principles: first, an understanding of the anatomy and physiology of the abdominal viscera including blood supply and three-dimensional relationships; second, the ability to take a thorough history and focused abdominal exam.

Anatomy

The abdominal cavity is the largest hollow space in the body and an in-depth understanding of anatomy is critical. The abdominal cavity is bound superiorly by the diaphragm, which separates the abdomen from the chest. The inferior boundary is the upper plane of the pelvic cavity. Vertically the abdomen is enclosed posteriorly by the vertebral column and posterior musculature and anteriorly by the abdominal wall muscles. The abdominal cavity contains the majority of the digestive tract, liver, pancreas, spleen, and kidneys. Several major blood vessels are contained within the abdomen including the aorta, inferior vena cava, and mesenteric vessels.

The abdominal cavity is lined by a thin membrane called the peritoneum that covers the walls of the cavity (parietal peritoneum) and every organ or structure (visceral peritoneum). The space between the visceral and parietal peritoneum, commonly referred to as the peritoneal cavity, normally contains a small amount of fluid that acts a lubricant and permits free movement of the intraperitoneal viscera, particularly the gastrointestinal tract. Attachments of the peritoneum to the body wall divide the abdominal cavity into several compartments. Abdominal structures are further classified as intra-, retro-, or infraperitoneal depending on their relationship to the peritoneal lining (*Table 1*).

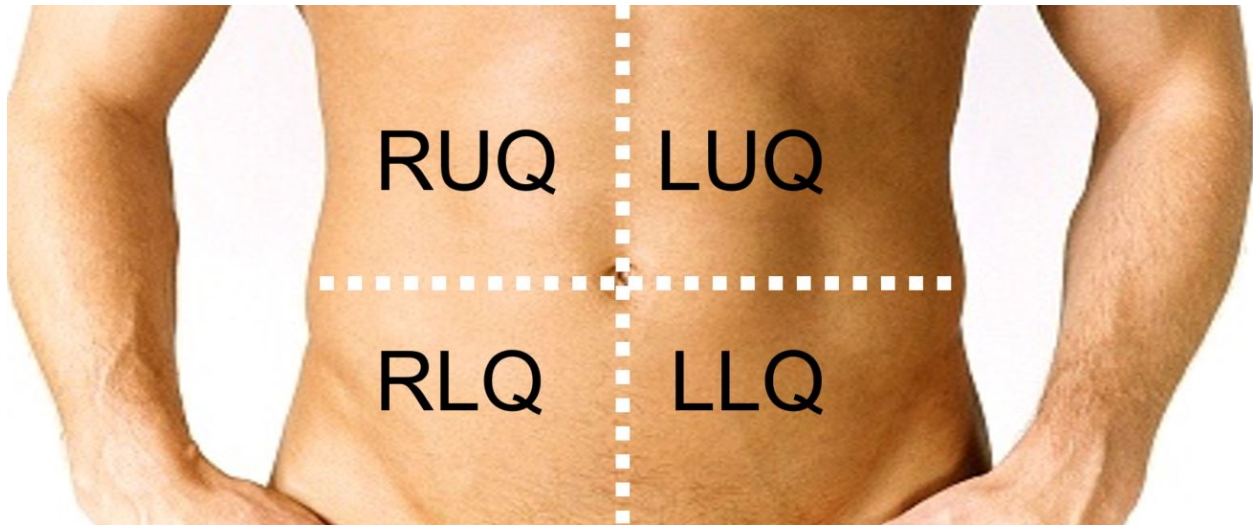
Table 1: Intra and retroperitoneal structures

Intraperitoneal structures	Retroperitoneal structures	Infraperitoneal structures
stomach	second and third portions of duodenum	lower third of rectum
omentum	ascending and descending colon	bladder
first and fourth portions of duodenum	middle third of the rectum	
jejunum	pancreas	

Intraperitoneal structures	Retroperitoneal structures
ileum	kidneys
cecum and appendix	adrenal glands
transverse and sigmoid colon	ureters
proximal third of rectum	inferior vena cava
liver	aorta
spleen	iliac and renal vessels
uterus, fallopian tubes, ovaries	

The abdomen is commonly divided into four quadrants (*Figure 1*): left upper quadrant (LUQ), right upper quadrant (RUQ), left lower quadrant (LLQ), and right lower quadrant (RLQ). Many pathologies classically present with symptoms found in a specific quadrant and the location of symptoms can assist in developing a differential diagnosis and guiding further testing and treatment. Variation and overlap can exist, but a general understanding of the underlying structures of each quadrant aids initial assessment.

Figure 1: Abdominal quadrants



Definitions

Acute abdomen refers to a sudden, severe abdominal pain that may indicate an emergency and urgent surgical intervention.

Peritoneum is the membrane that forms the lining of the abdominal cavity and covers most of the intraabdominal organs to provide support and act as a conduit for blood vessels, lymphatics, and nerves. Abdominal structures are classified as intraperitoneal, retroperitoneal, or infraperitoneal depending on location and relationship to the peritoneum.

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Peritonitis is inflammation of the peritoneum that is usually due to infection, perforation of an abdominal organ, or as a complication of other medical conditions. Peritonitis is a surgical emergency.

Greater omentum is a large apron-like fold of fatty visceral peritoneum that hangs down from the greater curvature of the stomach. It doubles back to the transverse colon before reaching to the posterior abdominal wall.

Greater sac (peritoneal cavity) is the potential space between the parietal and visceral peritoneum. It normally contains a thin film of fluid that acts as a lubricant allowing free movement of the abdominal organs.

Lesser sac (omental bursa) lies posterior to the stomach and lesser omentum. It allows the stomach to move freely against the retroperitoneal structures posterior and inferior to it. The lesser sac is connected to the greater sac through a communication posterior to the portal triad — the epiploic foramen (of Winslow).

Mesentery is a set of tissues that attach the bowel to the posterior abdominal wall, formed by a double fold of peritoneum. Blood vessels, nerves, and lymphatics branch through the mesentery to supply the gastrointestinal tract.

History and Physical Examination

A thorough history and physical examination will lead to an appropriate differential diagnosis and guide further evaluation with laboratory testing and/or imaging. A tremendous amount of information is obtained through a careful history even before performing the exam. Especially important is the recognition of patterns such as determining the chronicity of pain — whether the pain is acute or chronic, pain character, and associated symptoms. The relative sensitivity and specificity of a history and physical examination are low, but are critical in identifying emergent conditions early and guiding treatment decisions.

Clinical judgment must be exercised to determine whether the history represents a rapid onset of symptoms or one that is more chronic. There is no strict time cutoff for acute versus chronic symptoms. Pain that has started less than a day prior to presentation is clearly acute, while pain that has persisted for months or years can be safely classified as chronic. Pain is characterized according to location, severity, aggravating and alleviating factors, and associated symptoms. Location can assist in narrowing the differential diagnosis as different pain syndromes typically have characteristic locations (*Table 2*). For example, RUQ pain generally points to a liver or biliary source while RLQ pain is a typical hallmark of acute appendicitis. Radiation of pain may also point to the source as is classically found with pancreatitis demonstrating pain that radiates to the back.

Table 2. Causes of abdominal pain by location

Location	Clinical Features
LUQ splenomegaly splenic infarct splenic abscess splenic rupture	pain or discomfort, left shoulder pain, early satiety severe pain fever, LUQ tenderness left shoulder pain, hypotension, trauma
RUQ biliary colic acute cholecystitis choledocholithiasis ascending cholangitis biliary dyskinesia acute hepatitis perihepatitis (Fitz-Hugh-Curtis) hepatic abscess Budd-Chiari syndrome portal vein thrombosis	intense, dull pain, postprandial, plateaus with gradual improvement, nontender exam prolonged pain (>6hrs), tender to palpation, Murphy's sign elevated bilirubin, dilated bile duct fever, jaundice, RUQ pain dysfunctional contraction of gallbladder fatigue, malaise, jaundice, dark urine increased pain with inspiration, right shoulder fever, tenderness fever, distention (ascites), peripheral edema, GI bleeding, encephalopathy dyspepsia, GI bleeding
Epigastric acute myocardial infarction acute pancreatitis chronic pancreatitis peptic ulcer disease gastritis gastroparesis	shortness of breath, diaphoresis, exertional symptoms radiation to the back radiation to the back, longer duration severe pain heartburn, nausea, hematemesis postprandial fullness, nausea, vomiting, bloating
LLQ diverticulitis PID/tubo-ovarian abscess hernia constipation	fever, distention (ileus), change in bowel habits, melena bilateral pain, purulent vaginal discharge, fever, malaise palpable bulge
RLQ acute appendicitis Meckel's diverticulum PID/tubo-ovarian abscess hernia	migrating periumbilical pain, fever, anorexia, nausea currant jelly stool bilateral pain, purulent vaginal discharge, fever, malaise palpable bulge

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The onset, frequency, and duration of the pain are helpful features. The pain of biliary colic is often dull and precipitated by fatty meals, while peritonitis from a perforated peptic ulcer is sudden and severe. Gynecologic sources must be considered in women reporting abdominal pain and premenopausal women should be asked about their menstrual history and use of contraception.

Physical examination begins with vital signs. Unstable patients warrant expedited evaluation and prompt interventions. A complete abdominal examination includes inspection, auscultation, percussion, and palpation. General appearance and comfort or distress level are noted during inspection with careful attention to the patient's positioning and mobility. Intolerance to movement or repositioning is typical of peritonitis, while patients with mesenteric ischemia may writhe in extreme pain despite the absence of tenderness to palpation.

Historically, auscultation of the abdomen for bowel sounds was encouraged. The clinical value of absent or present bowel sounds has been debated and recent studies show that neither quantity nor quality of bowel sounds are predictive of small bowel obstructions [1]. The low sensitivity and positive predictive value of bowel sounds together with examiner variability do not support utilizing bowel sounds in clinical decision making [1-3]. An abdominal bruit, however, is associated with renal artery stenosis, particularly if heard during diastole.

Gentle percussion can test for peritonitis and identify ascites and hepatomegaly. Tympany signifies distended bowel, analogous to a hollow drum, while dullness may signify a solid structure such as organomegaly or a mass (*see Abdominal Mass module*).

Palpation is the most effective way to evaluate tenderness. Examination should begin in the quadrant with the least amount of pain and systematically proceed to the area of maximum tenderness. Guarding is rigidity of the abdominal muscles and is an important finding. It can be voluntary or involuntary, with the latter being a much more ominous finding suggesting peritonitis. Rebound tenderness is pain elicited upon rapid removal of pressure causing agitation of the parietal peritoneum.

All patients with complaints of abdominal pain should be examined for hernias (*see Abdominal Wall and Groin Mass module*). Abdominal wall pathology may be found by palpation or by noting appearance when using the abdominal wall muscles. Both ventral and groin hernias can cause bowel obstruction and strangulation leading to perforation and sepsis.

Most patients with abdominal pain should have a rectal examination [4]. Fecal impaction might explain symptoms of obstruction in older adults (*see Vomiting, Diarrhea, and Constipation module*). Some patients with localized upper abdominal pain (e.g., right upper quadrant pain without suspicion of upper GI bleeding) or abdominal pain that is likely from a non-gastrointestinal cause (e.g., suspected cystitis) may not require a rectal examination. If a rectal examination is performed, stool should be inspected for gross and occult blood.

The location of symptoms of abdominal disease processes can be categorized into foregut, mid-gut, and hind-gut. The foregut includes those structures fed by the celiac trunk (stomach, spleen, liver, etc.), the mid-gut are those structures fed by the superior mesenteric artery (small bowel, appendix, right colon, etc.), and the hind-gut are those structures fed by the inferior

mesenteric artery (left colon, sigmoid colon, proximal rectum). Certainly, there are disease entities that overlap, i.e., inflammatory bowel disease, but we will place them in the most common region affected. We will list the most common core disease states under these categories for simplicity.

FOREGUT

Gastroesophageal Reflux

Most people experience gastroesophageal reflux intermittently, particularly after a large meal. Gastroesophageal reflux disease (GERD) occurs when the reflux amount is excessive to the point of causing symptoms or esophageal mucosal injury. Survey data estimate that 25-40% of Americans experience symptomatic GERD at least once a month and 7-10% of adults report daily symptoms [19]. Patients with GERD exhibit various symptoms, both typical and atypical. Typical symptoms include heartburn, regurgitation, and dysphagia. Atypical symptoms include noncardiac chest pain, asthma, pneumonia, hoarseness, and aspiration.

Esophageal manometry and 24-hour pH monitoring are essential for diagnosis and planning an antireflux operation. The most reliable way to determine the presence of abnormal reflux is through pH monitoring or impedance testing. Manometry is used to determine the lower esophageal sphincter (LES) pressure and identify motility disorders. Achalasia can present with symptoms similar to GERD, but the treatment is very different. An upper endoscopy or EGD (esophagogastroduodenoscopy) confirms the diagnosis by demonstrating anatomic and histologic changes such as esophagitis, strictures, Barrett esophagus, or hiatal hernias.

Treatment of GERD is approached in a stepwise fashion, beginning with lifestyle modifications and acid-reducing medications such as proton pump inhibitors (PPI) to limit symptoms [20, 21]. Medical therapy is effective in the majority of patients. Surgical therapy is usually reserved for patients refractory to medical therapy or where medications are not tolerated and definitive therapy is desired. The presence of Barrett esophagus is also an indication for surgery due to malignant transformation potential. Surgical options include partial (anterior or posterior) and circumferential laparoscopic fundoplication. Nissen fundoplication is the most commonly performed antireflux operation today in both children and adults, and is a 360° wrap of the fundus around the gastroesophageal junction [22]. Long-term results of fundoplication are good as nearly all patients maintain symptomatic relief though a minority may require continued medication [23, 24]. Gastric bypass surgery provides durable treatment for GERD patients with obesity and magnetic sphincter augmentation is a novel technique that is gaining popularity and may have potential in select patients [25].

Refer to Gastroesophageal Reflux Disease module for additional information.

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Gastritis and Duodenitis

Gastritis and duodenitis are broad terms covering multiple conditions related to inflammatory changes in the gastric and duodenal mucosa. The inflammation may involve the entire stomach or be limited to a region such as the antrum. Acute gastritis and duodenitis can be separated into two main categories: erosive and nonerosive (generally caused by *H pylori*). Patients often present with an array of symptoms, the most common being nondescript epigastric discomfort. Other symptoms include nausea, vomiting, loss of appetite, belching, and bloating.

Exposure to noxious drugs or chemical agents such as aspirin or NSAIDs decrease endogenous protection and increase risk for mucosal injury. Physical examination findings are typically nonspecific and with occasional mild epigastric tenderness.

Upper endoscopy reveals a thickened, edematous gastric wall with erosions and reddened folds. In more severe cases, ulcers and frank bleeding might be present and biopsies should be obtained to test for *H pylori*.

No specific medical therapy exists for acute gastritis, except for cases caused by *H pylori* where triple therapy with a PPI and dual antibiotics is warranted [14, 15]. Surgical intervention is rarely necessary, except in cases of perforated ulcer disease (see *Peptic Ulcer Disease section*) or necrosis seen with phlegmonous gastritis where resection of the affected area may be the most effective form of treatment.

Refer to Gastritis/Duodenitis and Gastropathy module for additional information.

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Peptic Ulcer Disease

Epigastric pain is the most common symptom of peptic ulcer disease (PUD), often characterized by a gnawing or burning sensation and frequently occurs after meals — classically, shortly after meals with gastric ulcers and delayed with duodenal ulcers. “Alarm features” that warrant prompt referral include bleeding, anemia, early satiety, weight loss, dysphagia, and family history of gastrointestinal cancer.

Obtaining a medical history, especially for previous peptic ulcers, *H pylori* infection, nonsteroidal anti-inflammatory drug (NSAID) use, or smoking, is essential. Food or antacids may relieve the pain of duodenal ulcers but provide minimal relief in gastric ulcers. Patients may develop gastric outlet obstruction from chronic duodenal ulcers and report fullness and bloating associated with nausea and vomiting after eating. Patients with perforated PUD present with a sudden onset of severe, sharp abdominal pain and peritonitis.

Physical exam findings are nonspecific and may include epigastric tenderness and guaiac positive stool. Perforated PUD demonstrate signs of peritonitis and severe epigastric pain. These patients may also demonstrate signs of shock, such as tachycardia, hypotension, and anuria. Recognition of these finding is important for treatment and surgical consultation.

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In most cases of uncomplicated PUD, routine laboratory tests are not particularly helpful. PUD diagnosis largely depends on radiographic and endoscopic confirmation with testing for *H pylori* infection. Upper GI endoscopy (EGD) is the preferred diagnostic evaluation. EGD provides an opportunity to visualize the ulcer, determine the presence and degree of active bleeding, and attempt hemostasis by direct measures. Biopsies for *H pylori* testing and pathology should be obtained.

Most patients with uncomplicated PUD are treated successfully with acid suppressive medications, eradication *H pylori* infection, and avoidance of NSAIDs. The recommended treatment for *H pylori* infection is triple therapy with a proton pump inhibitor (PPI) and dual antibiotic course [14, 15]. The indications for urgent surgery include failure to achieve hemostasis endoscopically or recurrent bleeding despite endoscopic attempts (see *Gastrointestinal Bleeding module*), or perforation. Overall, the number of emergent operations for perforated ulcers has decreased because of the success of medical therapy. However, perforated PUD remains a serious diagnosis and requires urgent intervention. Most duodenal and distal gastric perforations are treated successfully with a patch of omentum sutured over the perforation (Graham Patch). Gastric ulcers require biopsies to rule out a malignancy. Definitive ulcer procedures such as vagotomy with antrectomy are rarely performed during the initial operation unless the patient is hemodynamically stable, failed previous medical therapy, or had multiple recurrent PUD episodes. Laparoscopy for PUD treatment has been demonstrated to be as safe as and with comparable outcomes compared to laparotomy. Patient stability, comorbidities, and surgeon skill and experience guide the surgical approach [16].

Refer to Gastritis/Duodenitis and Gastropathy module for additional information.

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Gallbladder Pathology

Biliary colic and cholecystitis are part of a spectrum of biliary tract disease that ranges from asymptomatic gallstones on one end, to ascending cholangitis on the other [9]. Most patients with gallstones are asymptomatic, but stones may temporarily obstruct the cystic duct or pass through into the common bile duct, leading to biliary colic. In some cases, biliary colic can progress to acute cholecystitis when obstruction at the cystic duct is prolonged (usually >6 hours) [10]. Choledocholithiasis occurs when stones pass into the common bile duct, with the potential sequelae of obstruction and ascending cholangitis.

Typical biliary colic consists of 1-5 hours of RUQ pain that may radiate to the epigastrium or right shoulder. The onset of pain often develops after a meal, occurs frequently at night, and can be severe enough to waken the patient from sleep. Common associated symptoms include nausea and vomiting.

Acute cholecystitis presents similar to biliary colic, except that symptoms usually occur for more than six hours. Fever is more commonly associated with cholecystitis and the majority of patients report having experienced similar episodes in the past. Elevated bilirubin and dilated bile ducts suggest choledocholithiasis and obstruction. Ascending cholangitis is the most

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serious infectious biliary condition. The triad of RUQ pain, fever, and jaundice (Charcot's triad) must raise suspicion and demands immediate intervention. Reynolds pentad adds the findings of shock (i.e., hypotension) and altered mental status and is indicative of a deteriorating condition.

Vital signs parallel the degree of illness. Patients with biliary colic have relatively normal vital signs while patients with cholangitis can have fever, tachycardia, and hypotension. Abdominal examination is remarkable for epigastric or right upper quadrant tenderness and abdominal guarding. A halt in inspiration with palpation of the right upper quadrant (Murphy's sign) is both a sensitive and predictive test for acute cholecystitis, but less so in diabetic and elderly patients [11]. A palpable fullness in the RUQ may be appreciated (Courvoisier's sign - associated with cholangiocarcinoma), but is rarely present in the early clinical course.

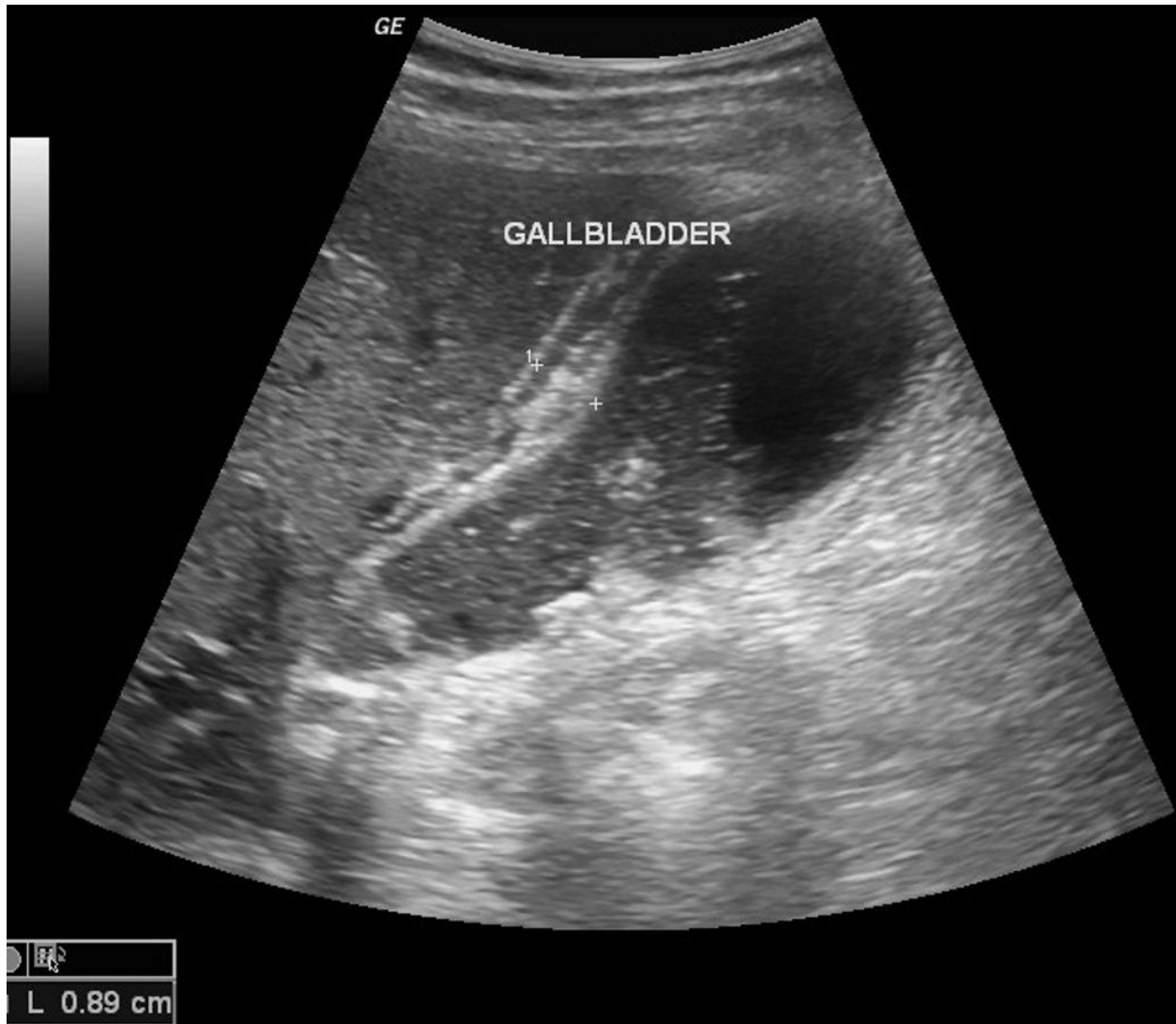
Workup includes comprehensive laboratory studies, which may be normal in cases of simple symptomatic cholelithiasis and biliary colic. Elevated white blood cell (WBC) counts and hepatic profiles are common. Elevated bilirubin should prompt attention to the common bile duct and pancreatic region.

Ultrasonography is the best initial imaging modality for the diagnosis of both cholelithiasis and cholecystitis. The presence of stones, gallbladder wall thickening, and fluid around the gallbladder (pericholecystic fluid) support a diagnosis of acute cholecystitis (*Figure 2*). Air in the gallbladder often indicates gangrenous progression and is an ominous sign. Advanced imaging such as hepatobiliary scintigraphy (HIDA) and magnetic resonance cholangiopancreatography (MRCP) have utility in patients in whom the diagnosis is unclear or need further assessment of the biliary tree. CT scans are less sensitive as the majority of gallstones are of the same density of bile and are not visualized. Gallbladder wall thickening and pericholecystic fluid can be seen on CT in addition to information about other abdominal structures such as the stomach, pancreas, and bowel.

Elective surgery is indicated in patients with biliary colic and symptomatic cholelithiasis. Laparoscopic cholecystectomy is effective and has few complications. Urgent laparoscopic cholecystectomy should be performed within 72 hours of admission in cases of acute cholecystitis. Unstable patients may need more urgent intervention with endoscopic retrograde cholangiopancreatography (ERCP) for choledocholithiasis or percutaneous drainage of the gall bladder. Patients with choledocholithiasis should undergo ERCP to clear the common bile duct prior to definitive surgery.

Acalculous cholecystitis (cholecystitis in the absence of gallstones) is more common in the critically ill, burns or sepsis, and trauma patients. Due to their critical illness, most are managed with percutaneous cholecystostomy drainage and interval cholecystectomy once the critical illness has resolved.

Figure 2. Gallbladder ultrasound



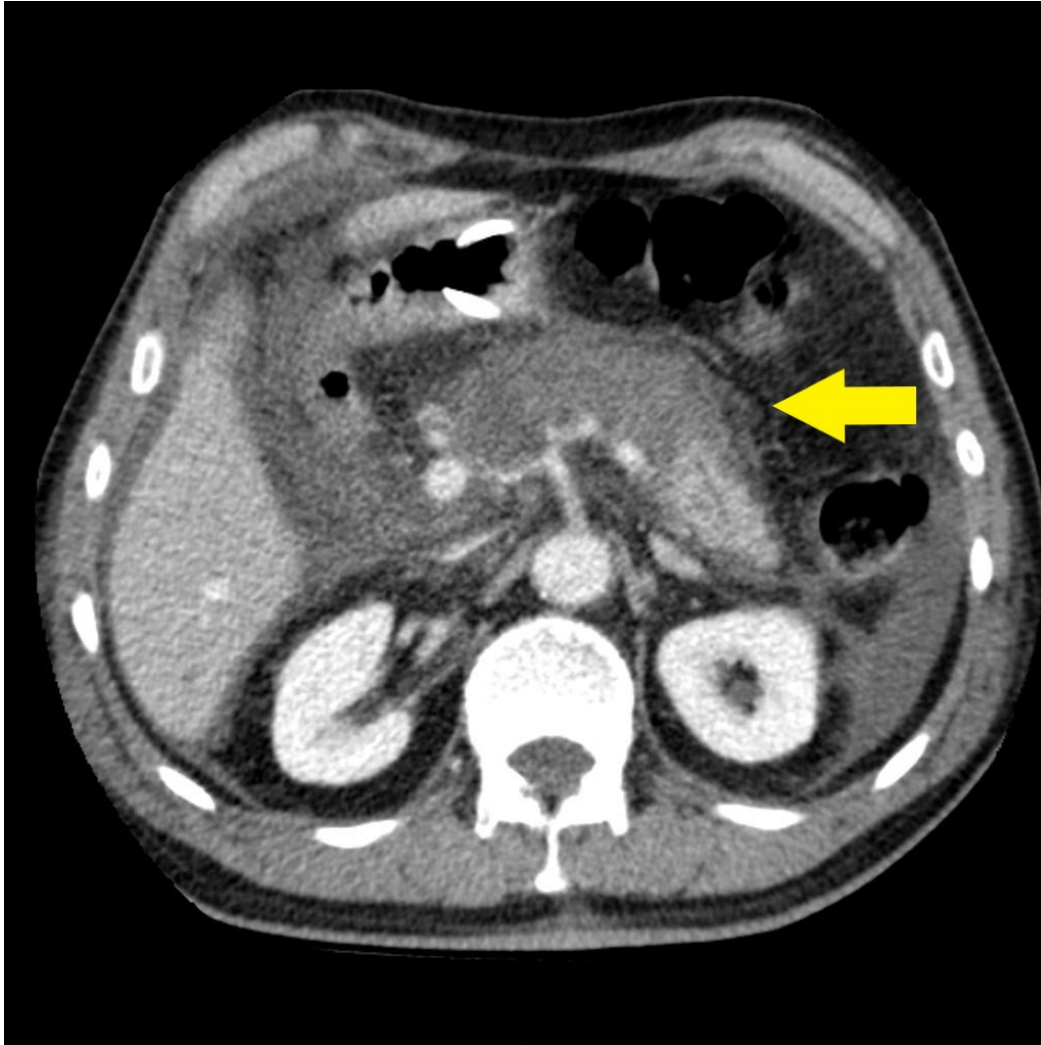
Ultrasound demonstrating findings of acute cholecystitis including, wall thickening, pericholecystic fluid, and sludge. Case courtesy of Dr. Maulik S Patel, Radiopaedia.org, rID: 20542.

Pancreatitis

Acute pancreatitis is a common cause of inpatient admissions. Alcohol consumption and biliary stones are the most common causes. Trauma, medications, and invasive procedures are other causes. In 10-30% of cases, the cause is unknown. Sudden dull epigastric pain with radiation to the back is most common. Fever and tachycardia are common abnormal vital signs. Hypotension indicates increased severity and urgency. Exam findings include abdominal tenderness, guarding, and distention. Lung sounds may be diminished along the bases indicating pleural effusions.

Laboratory tests are obtained to support the working diagnosis of acute pancreatitis and are helpful in determining the precipitating cause. CT imaging with intravenous contrast is often performed and the inflammatory changes within the pancreas are helpful in determining the presence and extent of pancreatic necrosis (*Figure 3*). Scans obtained in the early stages of the episode are less sensitive as the inflammatory changes may not be present until days after onset of symptom. Multiple scoring systems have been developed to predict the severity of pancreatitis and direct treatment plans.

Figure 3. CT scan of acute pancreatitis

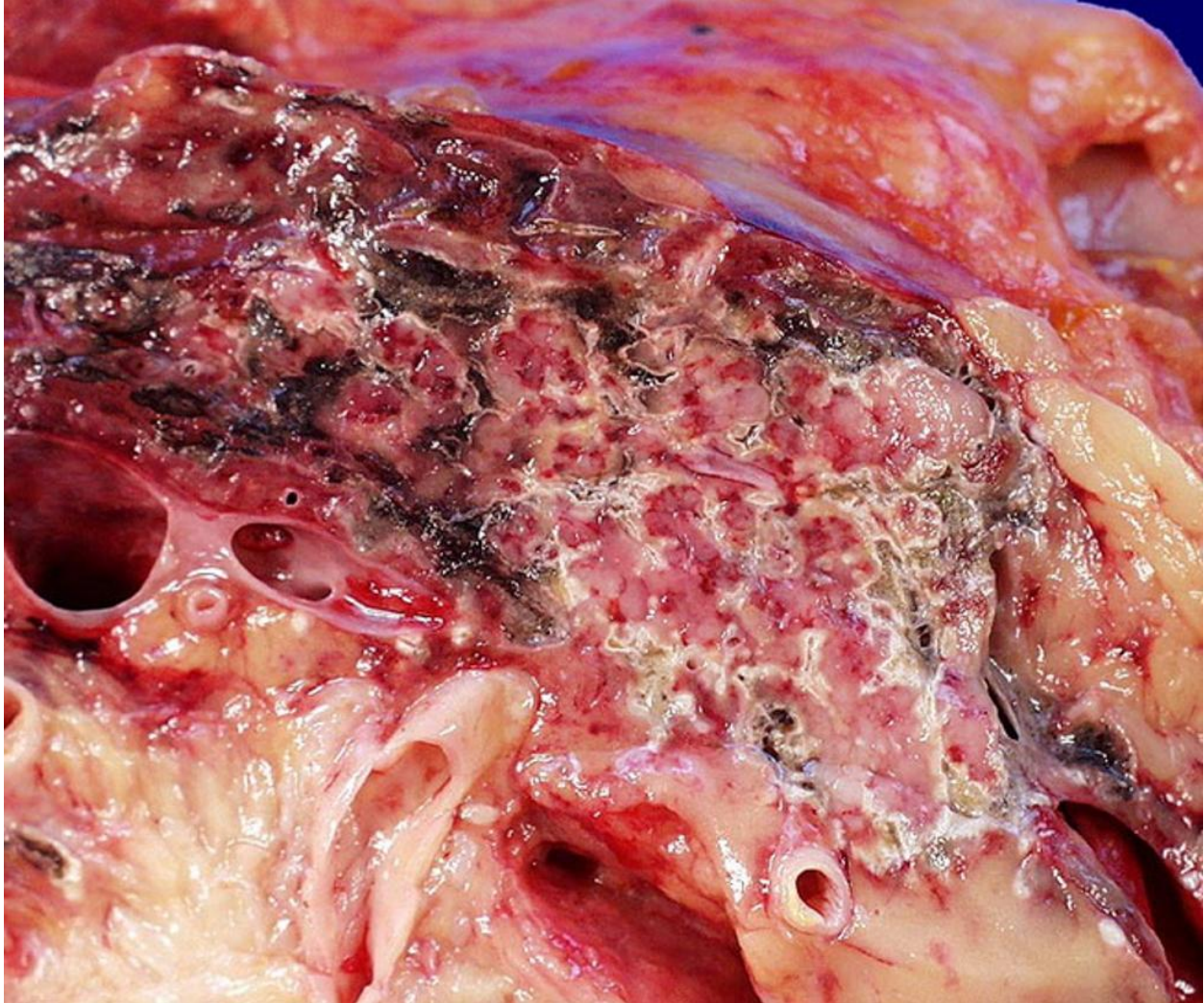


Acute pancreatitis with peripancreatic inflammation and lack of parenchymal enhancement indicating necrosis (arrow). Case courtesy of Dr. David Cuete, Radiopaedia.org, rID: 23302.

Medical management of mild acute pancreatitis is relatively straightforward. The patient is kept NPO and intravenous fluid hydration is provided. Analgesics are administered for pain relief. Antibiotics are generally not indicated [12]. If gallstones are present and the suspected cause of pancreatitis is thought to be related to them, a cholecystectomy should be performed during the same hospital admission. Patients with severe pancreatitis require intensive care and often volume and pressor support. Image-guided aspiration may be useful for differentiating infected from sterile necrosis and for draining fluid collections after first two weeks. Carbapenem antibiotics are used in cases complicated by infected pancreatic necrosis (*Figure 4*). Surgical techniques have evolved from extensive open operations to a stepwise video-assisted retroperitoneal debridement in conjunction with percutaneous drains [13]. The principles of surgical management remain unchanged — source control to limit sepsis, or hemorrhage

control. Patients often develop peripancreatic fluid collections, referred to as pseudocysts that may require an additional drainage procedure if symptomatic.

Figure 4. Necrotizing pancreatitis



Macroscopic appearance of pancreatic necrosis. Case courtesy of Dr. Henry Knipe, Radiopaedia.org, rID: 27638.

Splenomegaly

The spleen is a functionally diverse organ with active roles in immunity and hematopoiesis. It is located in the LUQ adjacent to several structures including the stomach, left kidney, colon, and tail of the pancreas. A normal spleen weighs 150 g and is around 10-12 cm and usually not palpable. Splenomegaly is defined as enlargement with dimensions of 11-20 cm classified as moderate, and severe if greater than 20 cm [40].

Although a wide variety of diseases are associated with enlargement of the spleen, common primary causes include immune response hypertrophy (infectious mononucleosis), erythrocyte destruction hypertrophy (hereditary spherocytosis or thalassemia major), and congestive (splenic vein thrombosis and portal hypertension). Other causes include trauma, cysts, hemangiomas, metastasis, abscess, and medications.

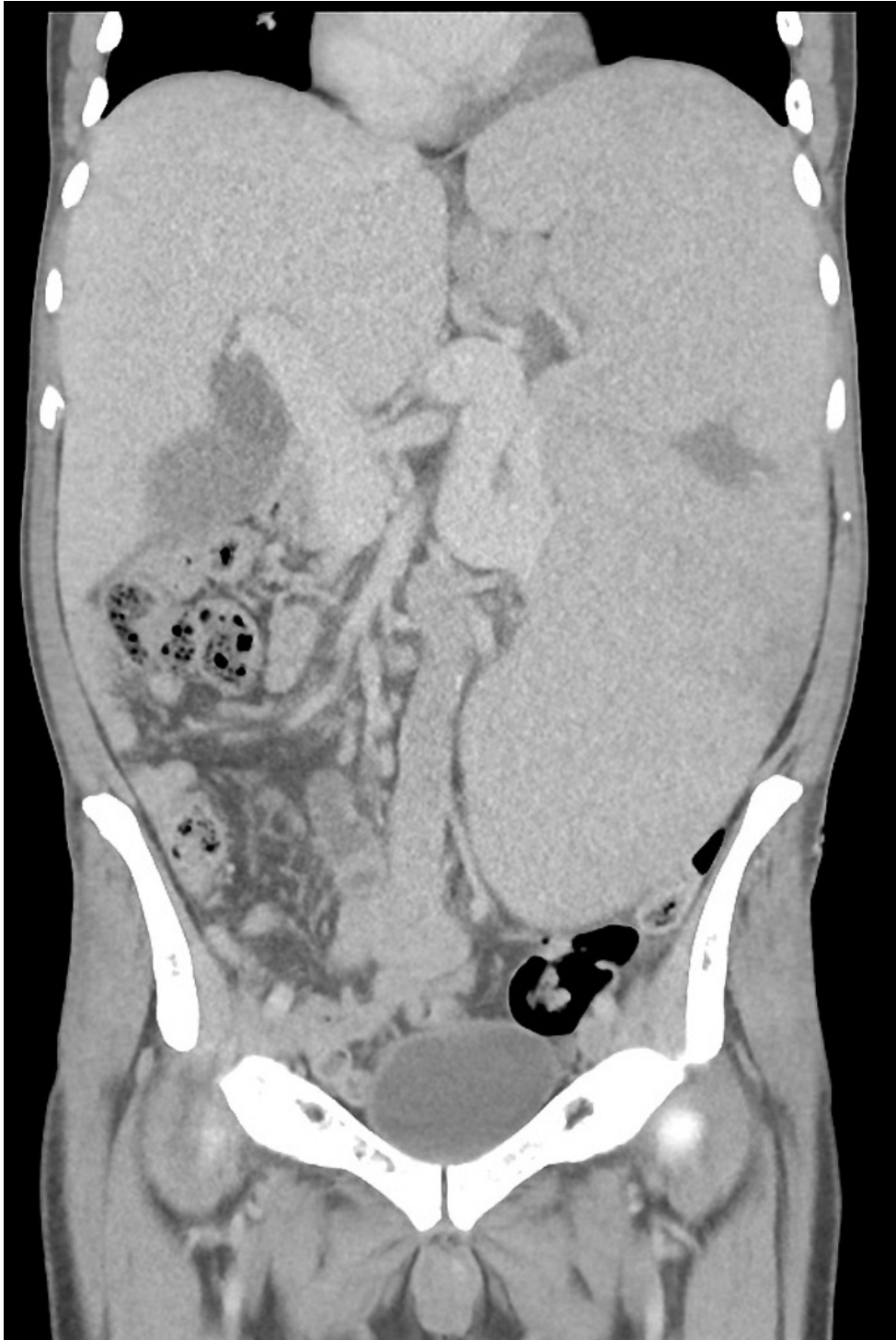
Patients with splenomegaly may complain of mild, vague, abdominal discomfort. Some may also report LUQ pain or referred pain to the left shoulder. Enlarged abdominal girth is uncommon, but early satiety from gastric compression is not. Proper physical examination should include palpation with the patient in the supine and right lateral decubitus positions. In extreme splenomegaly, the lower splenic pole may extend into the pelvis or cross the abdominal midline (*see Abdominal Mass module*).

Splenomegaly workup depends on the suspected etiology. A complete blood count with differential, platelet count, and peripheral blood smear are appropriate. CT scanning is the imaging study of choice for assessing size and is sensitive in detecting mass lesions, calcifications, infarcts, and cysts (*Figure 5*). CT remains the most useful preoperative investigation to measure splenic volume, assess lymph nodes at the splenic hilum, detect accessory spleens, and splenic abscesses. Non-traumatic splenic rupture is a rare but life-threatening condition. Abdominal CT scan is often essential, especially if the clinical diagnosis is unclear, and there should be a low threshold for laparotomy if the patient remains hemodynamically unstable despite resuscitation [41].

Medical treatment of the primary disorder can lead to regression without the need for surgery. Splenectomy may be indicated to help control or stage the underlying disease in cases of splenomegaly such as immune thrombocytopenia (ITP) or autoimmune hemolysis. The vast majority of elective splenectomies are performed using laparoscopic techniques. Laparoscopic splenectomy is safe and associated with reduced hospital stay compared to an open approach. Laparoscopic resection can be safely performed on individuals with massive splenomegaly.

Vaccines for encapsulated organisms (*pneumococcus*, *N. meningitidis*, *H. influenza*) should be administered at least two weeks prior to surgery or two weeks after if preoperative vaccination is not possible.

Figure 5. Massive splenomegaly



Massive splenomegaly from myelofibrosis with multiple infarcts. Concurrent hepatomegaly. Prominent mesenteric vessels likely from venous engorgement given the dilated splenic and portal veins. Case courtesy of Dr. Wael Nemattalla, Radiopaedia.org, rID: 10633.

MID GUT

Acute Appendicitis

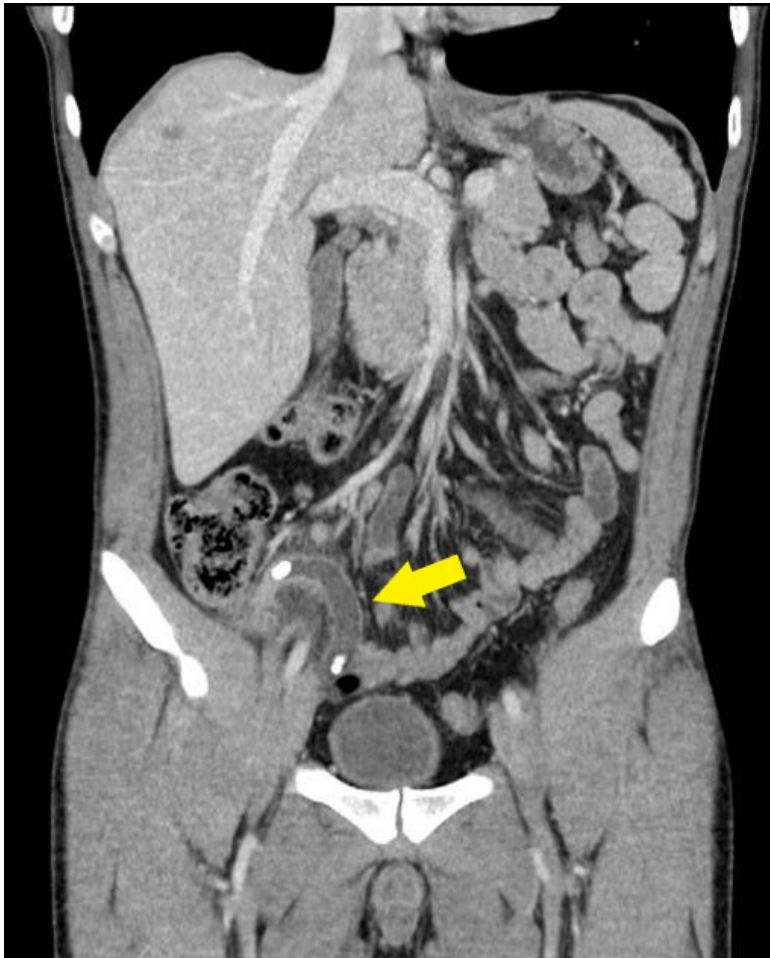
Acute appendicitis is the most common time-sensitive surgical condition in the United States [5]. It is thought to be the result of obstruction to the appendiceal lumen leading to increased intraluminal pressure and possible bacterial overgrowth [6]. The classic symptoms are pain migrating to the RLQ, nausea, and anorexia. Other pathology may present with a similar pattern, requiring clinicians to consider a broad differential diagnosis, including gastrointestinal, urologic, and gynecologic pathology.

A full history and physical exam is performed, including questions about inflammatory bowel disease and a complete menstrual and pregnancy history in women. Pain over McBurney's point (one-third the distance from the anterior superior iliac spine to the umbilicus) is a classic presenting sign of acute appendicitis. Additional findings include Rovsing's sign (pain in the RLQ when pressure is applied to the LLQ and released quickly), obturator sign (pain with passive rotation of the flexed right hip), and psoas sign (pain on extension) of the right hip suggesting a retrocecal appendix in contact with the iliopsoas muscle.

Laboratory findings will typically reveal a leukocytosis. Other tests that should be ordered include a basic metabolic panel, coagulation profile, pregnancy test in women of childbearing age, and a urinalysis. The diagnosis can often be made clinically without imaging, but imaging studies are helpful and have become standard. The two most common imaging modalities are ultrasound and computed tomography (CT). CT has significantly higher sensitivity and specificity, but carries risks of ionizing radiation, especially in children. A dilated, thickened appendix with surrounding inflammatory changes is consistent with acute appendicitis (*Figure 6*). Perforation and evolving phlegmon or abscess formation are found in 15-30% of patients, and more commonly seen with delayed presentations [7]. Ultrasound is operator dependent and often limited by overlying gas-filled bowel obscuring the view of the appendix.

Surgery is the standard treatment with a laparoscopic appendectomy for uncomplicated appendicitis without perforation [8]. Initial management of perforated appendicitis with abscess is debated and most do well with antibiotics and percutaneous drainage [7].

Figure 6. CT scan of acute appendicitis



Axial and coronal images demonstrating radiographic findings of acute appendicitis. Enlarged fluid-filled appendix (yellow arrow) with appendicoliths. Case courtesy of Dr. David Cuete, Radiopaedia.org, rID: 27049.

Enterocolitis

Enterocolitis is inflammation in the digestive tract specifically affecting both the small intestine and the colon, and is typically limited to the mucosa. There are several different types of enterocolitis, each with their distinct symptoms and etiology. Neutropenic enterocolitis, also known as typhilitis, is acute transmural inflammation often limited to the cecum and ascending colon in patients who are severely immunosuppressed [28]. Its exact pathogenesis is not completely understood but thought to be related to invasion of the bowel wall from impaired host protection. Clinical presentation can be dramatic, and the outcome may be devastating. Symptoms often mimic acute appendicitis with RLQ pain and tenderness. Medical treatment includes bowel rest, broad-spectrum antibiotics, and withholding further chemotherapy until complete recovery. Surgery is indicated in patients with peritonitis or signs of perforation.

Necrotizing enterocolitis (NEC) occurs when the inflammation is accompanied by the death of tissues in the lining of the intestine. The problem is most common in premature, formula-fed infants and is the most common gastrointestinal emergency in neonates. The cause remains unknown. Research suggests a multifactorial cascade of ischemia exacerbated by activation of proinflammatory intracellular processes. Clinical findings include increased residual gastric volumes, bilious vomiting, abdominal distention, bloody stools, lethargy, and poor skin perfusion. When intestinal perforation occurs, guarding may be found on abdominal examination, but may not be apparent in weak premature infants. Plain film radiographs may show small bowel distention or pneumatosis intestinalis (gas in the bowel wall). Treatment starts with stopping oral feedings, orogastric suction, systemic antibiotics, and correction of metabolic and electrolyte abnormalities.

The only absolute indication for surgical intervention is pneumoperitoneum. Necrotic bowel is resected and the proximal bowel is made into a stoma. Severe disease may require extensive bowel resection, resulting in short bowel syndrome. An alternative treatment option in select situations is bedside drainage of the peritoneal cavity in the right lower quadrant using local anesthesia. NEC resolves in one-third of cases without further treatment and the overall survival rate is more than 50%. Intestinal strictures are a common late complication and may require additional intervention.

Clostridium difficile colitis results from a disturbance of the normal bacterial flora of the colon, usually after antibiotic use, leading to bacterial overgrowth. *C difficile* is a gram-positive, anaerobic, spore-forming bacteria. *C difficile* colitis commonly presents with mild to moderate diarrhea and abdominal cramping. In severe cases, patients with *C difficile* colitis can develop peritonitis and fulminant life-threatening colitis. Leukocytosis is common and pronounced levels correlate with a worse prognosis [29]. Stool cultures are the most sensitive tests for detecting *C difficile*, but have a long turnaround time. Enzyme immunoassays and real-time PCR are more practical and commonly used. Mild to moderate disease can be treated with oral metronidazole, with oral vancomycin reserved for severe or complicated cases. Patients with colonic perforation or a deteriorating clinical condition need surgical intervention with either total abdominal colectomy or diverting loop ileostomy combined with colonic lavage in select settings [30].

Refer to Enterocolitis and Genito-Urinary Etiologies module for additional information.

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Small Bowel Obstruction

In the United States, 15% of admissions for abdominal pain are due to small bowel obstructions (SBO), with over 300,000 admissions annually [31]. The most common cause of SBO in developed countries is intraabdominal adhesions, followed by hernias, Crohn disease, malignancy, and volvulus [32]. In developing countries, the distribution is more diverse with 30-40% caused by hernias followed by adhesions, and tuberculosis, and parasitic infections [33].

The classic symptoms of nausea, vomiting, abdominal pain, and constipation are rarely present in all cases of SBO, but abdominal pain is often described as cramping and intermittent. Without treatment, the pain can increase and progress to perforation and ischemia in high grade or closed loop obstructions. High clinical suspicion is paramount for early identification and intervention. Constipation and failure to pass flatus are common presenting symptoms, with abdominal discomfort and distention the most frequent physical examination findings [34].

Physical examination should include careful evaluation for incarcerated hernias — ventral and groin — and evaluation for signs suggesting intestinal ischemia (fever, tachycardia, and peritoneal signs). No physical examination method exists to differentiate simple partial obstruction from early strangulated obstruction, and serial abdominal examinations are important to detect changes early.

Plain radiographs with an abdominal series are a common first step for suspected SBO (*Figure 7*). Upright films may help with the diagnosis if air-fluid levels are present or if a paucity of distal bowel gas is observed. CT imaging has been shown to be a particularly effective tool capable of detecting complications of SBO including ischemia, perforation, mesenteric edema, and pneumatosis, which should prompt surgical attention (*Figure 8*).

Laboratory testing is needed as electrolyte abnormalities may be present related to vomiting and dehydration (*see Vomiting, Diarrhea, and Constipation module*). Elevated white blood cell count or a left shift may suggest strangulation or perforation. Serum lactate levels may also be increased from dehydration or tissue underperfusion, however, a normal lactate level does not exclude ischemia.

Initial treatment of SBO depends on patient condition and exam findings. Peritoneal signs, sepsis, or clinical suspicion for strangulation or perforation should prompt urgent surgical intervention. Patients without concerning findings can be safely managed with nonoperative management with nasogastric tube decompression and bowel rest [35]. Many protocols exist including the use of water-soluble oral contrast for both diagnostic and therapeutic purposes [36]. Surgery is recommended after an established period, usually 24-72 hours, of nonoperative management without resolution. Open surgery is frequently required as laparoscopic approaches may be limited by the distended bowel and an increased risk for bowel injury.

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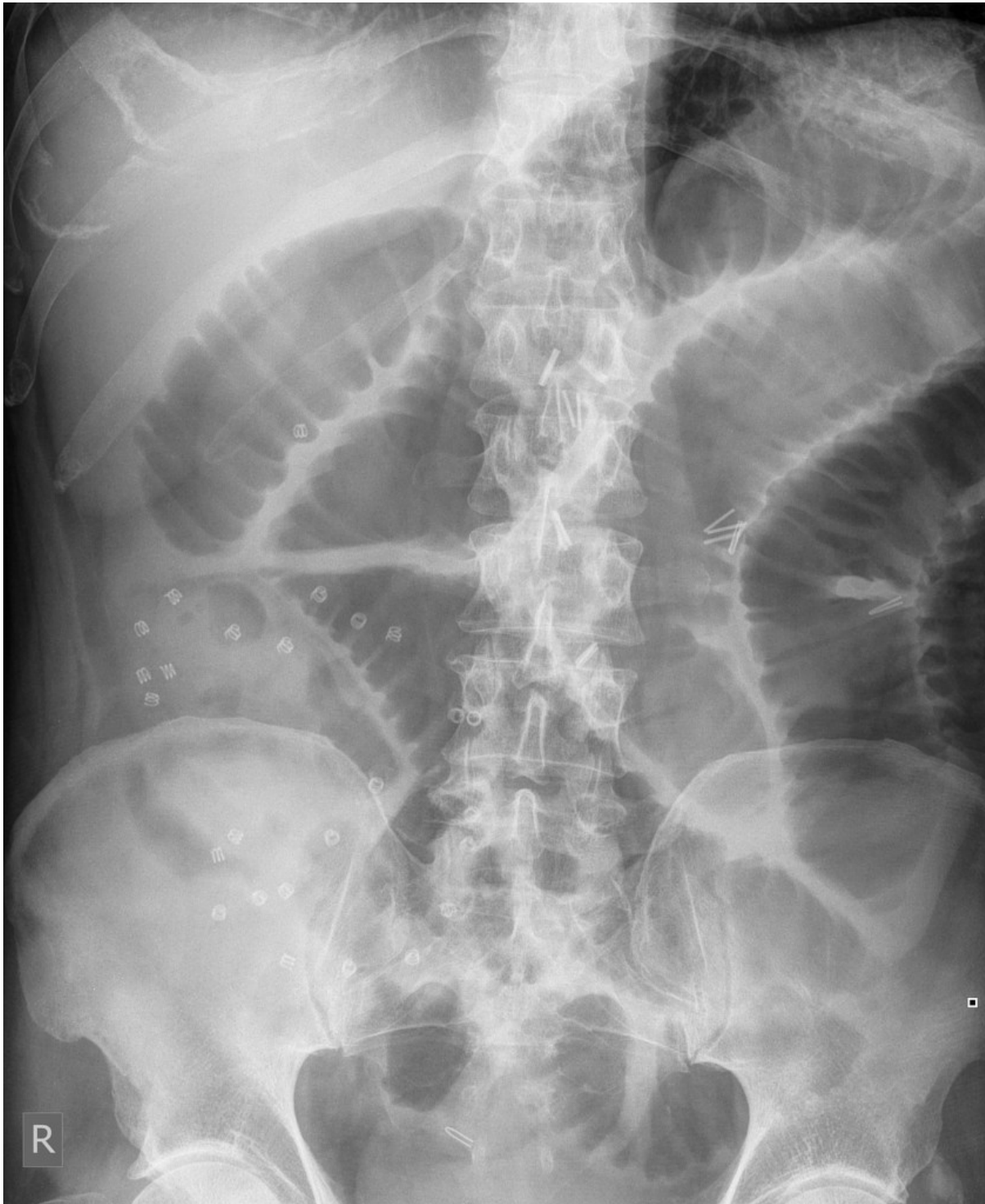
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Surgical intervention is centered on identifying the source of obstruction and assessing bowel viability. Necrotic bowel requires resection with primary anastomosis.

Less common causes of SBO are usually apparent on inspection of the small bowel. Volvulus can be reduced by untwisting the mesentery and intussusception can be reduced by gently milking the proximal intussusceptum out of the distal intussusciens. Masses can be resected and in all situations, bowel viability must be assessed. Hernias can be approached through an incision over the hernia (umbilical, inguinal) with low threshold for conversion to open laparotomy if there is concern for bowel strangulation. For hernias where strangulated bowel is suspected, one should not attempt reduction of the hernia until operative intervention to allow inspection of the involved loop of bowel.

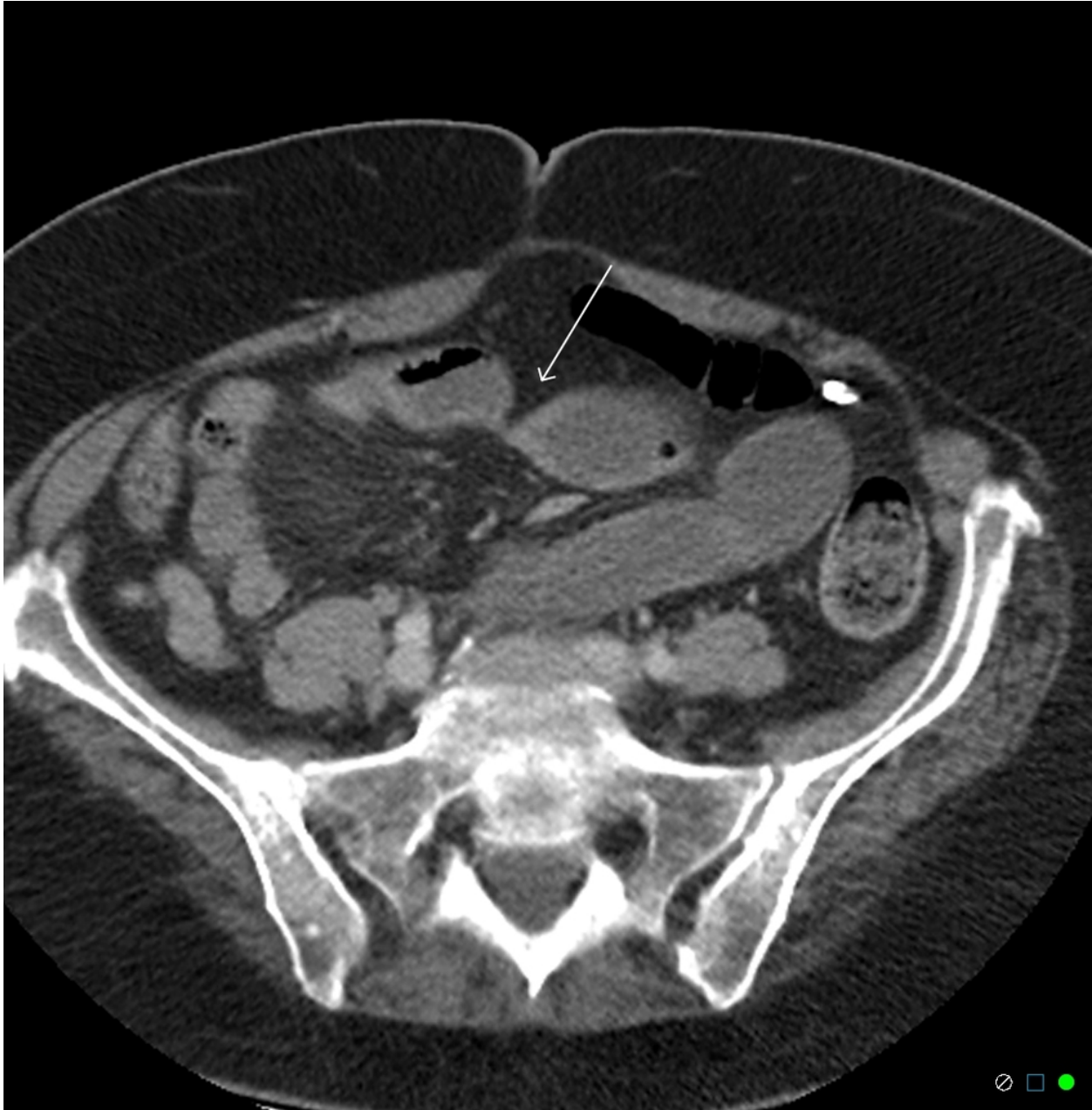
Postoperatively, the nasogastric tube should be continued until there is return of bowel function as many patients will develop an ileus. Care should be taken to maintain the patient's volume status and replenish all electrolyte abnormalities. Nutritional status is important to prevent complications including wound infection and dehiscence.

Figure 7. Small bowel obstruction



Plan abdominal X-ray demonstrating multiple dilated loops of small bowel. Note the multiple surgical clips and tacks indicating prior surgery. Case courtesy of Dr. Ian Bickle, Radiopaedia.org, rID: 34633.

Figure 8. CT small bowel obstruction



Dilated fluid-filled small bowel loops with abrupt transition to collapsed small bowel associated with a focal kink and narrowing of the lumen (arrow). Case courtesy of Dr. Chris O'Donnell, Radiopaedia.org, rID: 31252

HIND GUT

Diverticulitis

Diverticular disease (diverticulosis, diverticulitis) describes the presence of diverticula, small pouches in the wall of the colon, that arise when the inner layers of the colon push through weaknesses in the outer muscular layers. Diverticula can occur anywhere in the colon, but are most common in the descending and sigmoid colon. Diverticulitis arises when diverticula become inflamed or infected. The usual initial symptoms include abdominal pain (most commonly in the LLQ), nausea, vomiting, constipation, fever, and bloating. Common exam findings include localized tenderness, distention, rebound tenderness and guarding. Other less common findings are suprapubic, flank, or costovertebral tenderness, pneumaturia, fecaluria, purulent vaginal discharge indicating the presence of a colovesicular or colovaginal fistula respectively.

Laboratory findings may show a leukocytosis. Other basic labs are helpful in identifying metabolic derangements. A urine culture may distinguish sterile pyuria due to inflammation from polymicrobial infection related to a fistula. Pregnancy tests should be obtained in any female of childbearing age.

CT scan of the abdomen and pelvis is considered the best imaging method to confirm the diagnosis. Colonic wall thickening or pericolic fat stranding indicate inflammation and extraluminal air can confirm perforation. A phlegmon or abscess may also be present. The Hinchey system (*Table 3*) is often used to grade the severity of diverticulitis and guide management recommendations [17].

Table 3. Hinchey classification and modified Hinchey classification for diverticulitis

Hinchey classification		Modified Hinchey by Sher et al.	
I	Pericolic abscess or phlegmon	I	Pericolic abscess
II	Pelvic, intraabdominal, or retroperitoneal abscess	IIa	Distant abscess amenable to percutaneous drainage
		IIb	Complex abscess associated with fistula
III	Generalized purulent peritonitis	III	Generalized purulent peritonitis
IV	Generalized fecal peritonitis	IV	Fecal peritonitis

Uncomplicated diverticulitis can be managed medically with antibiotics. Complicated disease requires a more aggressive approach that can often require urgent or elective surgery and/or abscess drainage [18].

The modified Hinchey classification is used to categorize diverticulitis, as well as guide interventions. Patients with clinically mild diverticulitis, typically with Hinchey I disease, can be treated as an outpatient with a course of ciprofloxacin/levofloxacin and metronidazole. Contained abscesses may be amenable to percutaneous drainage. More advanced grades or where evidence of peritonitis exist, require hospitalization and often urgent surgical consultation. Emergent resection of the diseased portion of the colon with colostomy is required in about 20%

of patients admitted for acute diverticulitis. Elective resection after colonoscopy to rule out underlying malignancy can be offered to patients after uncomplicated diverticulitis and impaired quality of life. The timing and number of recurrent episodes required before elective resection remains a topic of ongoing debate.

Refer to Enterocolitis and Genito-Urinary Etiologies module for additional information.

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Inflammatory Bowel Disease

Inflammatory bowel disease (IBD) is an idiopathic disease caused by autoimmune dysregulation. The two major types of inflammatory bowel disease are ulcerative colitis (UC) and Crohn disease (CD). UC is limited to the colonic mucosa, while CD can affect any portion of the gastrointestinal tract from the mouth to the anus. Other key differences are described in Table 4.

Table 4. Differentiating features of inflammatory bowel disease

	Ulcerative Colitis	Crohn Disease
Site of origin	rectum	terminal ileum
Pattern of progression	moves proximally, continuous	skip lesions
Distribution	colon only	entire GI tract
Thickness	mucosa and submucosa	transmural
Symptoms	bloody diarrhea, weight loss	abdominal pain
Complications	hemorrhage, toxic megacolon	fistula, abscess, obstruction, arthritis, skin ulcers
Risk of colon cancer	marked increase	mild increase
Surgery	potentially curative	limited to complications (strictures)

Symptoms of IBD generally depend on the area of the intestinal tract involved and commonly include abdominal pain, cramping, and diarrhea. Fever, tachycardia, dehydration, and toxicity may be present in more severe flares. Toxic megacolon is a severe complication of IBD and is a surgical emergency. Patients often appear septic with high fever, tachycardia, and severe abdominal pain with distention.

Evaluation of IBD relies on determining the extent and location of involved bowel and obtaining tissue for diagnosis. In the acute setting, CT of the abdomen and pelvis with contrast is a good choice to look for acute complications such as abscess, obstruction, or perforation and also to eliminate other causes of an acute abdomen. Endoscopy is essential in workup, surveillance, and management. Both colonoscopy and EGD are required for demonstrating mucosal inflammation and obtaining tissue for diagnosis. However, the risk of perforation from endoscopy in an acute flare is high and is to be avoided in the acute setting.

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UC is a surgically curable disease. However, surgical management of CD is much more nuanced as resection is not curative and recurrence is the norm. Repeated bowel resections may result in short gut syndrome and dependence on parenteral nutrition. Medical therapy is the most appropriate initial approach in treating IBD flares. Medication frequently used includes immunosuppressants and antibiotics [26]. Few patients will require surgery at the initial disease presentation and is usually reserved for complications such as bowel obstruction from strictures or for fistulae. Patients with obstructive symptoms can typically be managed with bowel rest and nasogastric tube decompression. Surgery can then be delayed and performed in an elective setting when inflammation has resolved to reduce bleeding risks and to preserve bowel length.

Surgical intervention for UC patients is indicated when medical therapy fails, disease duration lasts longer than ten years, those with colonic dysplasia or malignancy, toxic megacolon, or perforation [27]. The two most common operations are total proctocolectomy with end ileostomy and total proctocolectomy with ileoanal anastomosis. Primary anastomoses should be avoided in the setting of acute inflammation due to leak risk.

Refer to Inflammatory Bowel Disease module for additional information.

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Colon Obstruction

Large-bowel obstruction is a surgical emergency that requires early identification and intervention. The most common causes are colon carcinoma and volvulus [37]. Other causes include inflammatory processes (diverticulitis), strictures, or fecal impaction. Colonic obstruction is more common in elderly individuals as a consequence of the higher incidence of neoplasms and other causative diseases [38]. In neonates, colonic obstruction may be caused by an imperforate anus or other anatomic abnormalities such as Hirschsprung disease (*see Pediatric Considerations section*).

Volvulus occurs when a part of the colon twists on its mesentery resulting in obstruction and ischemia. The two main types of colonic volvulus are sigmoid and cecal. Chronic constipation leads to an overloaded sigmoid colon that is prone to torsion along the axis of an elongated mesentery. Alternatively, incomplete cecal and ascending colonic embryologic fixation predisposes torsion of the cecum, terminal ileum, and ascending colon.

Patients with volvulus are usually elderly, debilitated, and bedridden and often have a history of dementia or psychiatric impairment. The majority present with acute and less commonly with subacute or chronic symptoms. A history of chronic constipation is common. Presentation is similar regardless of the anatomic site, usually with abdominal pain, distention, obstipation, and constipation (*see Vomiting, Diarrhea, and Constipation module*).

Abdominal distention can be striking and characteristically tympanitic over the gas-filled, thin-walled colon. Rebound tenderness raises the concern of peritonitis. Depending on the presence and extent of bowel ischemia or peritonitis, signs of systemic toxicity may be apparent. Respiratory and cardiovascular compromise can result from the massive abdominal distention.

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Distention of the sigmoid colon loop arising from the pelvis and extending to the diaphragm is a typical finding of sigmoid volvulus on plain abdominal radiography. The walls of the loop may be evident as lines converging in the described as a “coffee bean sign” or “bent inner tube sign” (*Figure 9*). CT for sigmoid volvulus is often unnecessary, as plain radiographic findings are usually sufficient. Radiographic findings for cecal volvulus may be less evident and CT is helpful to better identify the location of the torsion and assess for evidence of ischemia.

Figure 9. Sigmoid volvulus



Markedly dilated loop of colon with a coffee-bean sign pointing to the RUQ. Case courtesy of Dr. Wael Nemattalla, Radiopaedia.org, rID: 10633.

Patients without evidence of peritonitis or bowel ischemia can be initially treated with resuscitation and detorsion with sigmoidoscopy or colonoscopy and rectal tube placement. The patient can then be fully prepped for sigmoidectomy during the same admission as recurrence can be as high as 50%. If the patient has evidence of peritonitis or ischemic bowel, emergency surgery for resection is needed.

Obstructions caused by tumors tend to have a gradual onset and result from tumor growth narrowing the colonic lumen. Right-sided colon lesions can become large before obstruction occurs because of the larger capacity of the right colon and soft stool consistency. Sigmoid and rectal tumors cause obstruction much earlier as the colon is narrower and the stool is harder. Changes in stool caliber strongly suggest carcinoma especially when associated with weight loss.

Endoscopic dilation and stenting is helpful in selected cases and may be palliative with unresectable tumors or temporarily alleviate symptoms until more definitive surgery can be performed [39]. In most cases, masses can be effectively treated with a partial colectomy with lymphadenectomy after proper staging workup can be completed.

ABDOMINAL VASCULAR DISEASE

Mesenteric Ischemia

Acute mesenteric ischemia (AMI) is a life-threatening condition if not diagnosed promptly and treated appropriately. Morbidity and mortality associated with AMI is unfavorable and a high index of suspicion is essential as the clinical presentation is often nonspecific [42]. AMI results from four main processes: arterial embolism (50%) typically associated with previous myocardial infarction or atrial fibrillation, acute arterial thrombosis (25%) from diffuse atherosclerosis, nonocclusive mesenteric ischemia (20%) from hypovolemia or reduced cardiac output, and rarely venous thrombosis (5%) associated with portal hypertension, abdominal sepsis, and hypercoagulable states.

Patients with arterial embolism initially present with severe sudden-onset diffuse abdominal pain that is out of proportion to the examination. As the ischemia worsens, patients may develop nausea and vomiting, bloody diarrhea, and eventually peritonitis. Patients with acute thrombotic mesenteric occlusion may present with similar symptoms, but usually have a history of chronic postprandial pain (intestinal angina) accompanied by weight loss and food fear. Nonocclusive mesenteric ischemia is typical consequence of cardiogenic or hypovolemic shock, as blood is shunted away from the mesenteric circulation without an acute occlusion of the vessels. Pain is usually not as sudden as compared to embolic or thrombotic occlusion and many of these patients are already hospitalized for life-threatening conditions.

White blood cell count and lactic acid are often elevated and a significant metabolic acidosis can be present. Abdominal radiographs are of little utility and may only reveal late signs consistent with bowel ischemia, such as intestinal pneumatosis or free air. Ultrasonography is often limited by gas-filled loops of bowel obscuring visualization of the mesenteric vessels. Fluoroscopic angiography is considered the gold standard with views of the celiac, the superior mesenteric

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(SMA) and the inferior mesenteric (IMA) arteries. Angiography is rarely performed due to invasiveness and lack of immediate availability that can delay needed surgery.

CT angiography (CTA) has become the imaging modality of choice due to rapid evaluation of the aorta and mesenteric vessels, small bowel wall, and other potential causes of abdominal pain (*Figure 10*). Findings highly suggestive of AMI include SMA or SMV filling defects, intestinal pneumatosis, portal venous gas, and lack of bowel-wall enhancement [43].

Figure 10. Acute SMA obstruction



Central filling defect in the superior mesenteric artery distal to the middle colic artery takeoff (arrow). Multiple small bowel loops show wall edema / thickening and hypo-enhancement suggesting ischemia. Case courtesy of Dr. Abdallah Al Khateeb, Radiopaedia.org, rID: 43593.

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Patients with suspected bowel ischemia should be started on broad-spectrum antibiotics and anticoagulation before surgery. The primary goals of surgery are to restore blood flow and resect the segments of nonviable bowel (*Figure 11*). Ischemic bowel may recover dramatically after restoring blood flow and should be observed after reperfusion before any decision for resection is undertaken. Acute SMA embolism is approached with laparotomy and embolectomy to remove the offending clot. Surgical treatment of acute thrombotic mesenteric occlusion typically consists of a bypass of the affected vessel because a simple thrombectomy usually leads to recurrent occlusion. Treatment of venous thrombosis is nonsurgical with anticoagulation to reverse the hypercoagulable state. Careful monitoring is needed with full anticoagulation due to risks of gastrointestinal bleeding.

Figure 11. Ischemic bowel



Visual characteristics of ischemic bowel with clear demarcation to healthy perfused segments. Case courtesy of Dr. Ian Bickle, Radiopaedia.org, rID: 52750.

Abdominal Aortic Aneurysm

Abdominal aortic aneurysms (AAA) are found in 2% of the elderly male population, and even higher in those with coronary artery disease and femoral or popliteal aneurysms. Men are four times as likely to be affected as women. Ruptured aortic aneurysms are a significant cause of death of men over the age of 65 years in the United States [44]. An aneurysm is defined as dilation of an artery to at least 1.5 times its normal diameter. The majority of AAAs are true aneurysms involving all three layers of the vessel wall (intima, media, and adventitia).

Many mechanisms that decrease the structural integrity and compliance of the arterial wall have been found to contribute to the development of AAAs including genetic and environmental factors such as smoking. 90% of AAAs occur between the renal arteries and the aortic bifurcation. Rupture with subsequent exsanguination is the most dreaded complication of AAA and most aneurysms cause no symptoms prior to rupture.

The vast majority of AAAs are asymptomatic, yet classically patients may report back pain, hypotension, and a pulsatile abdominal mass (*see Abdominal Mass module*). However, this triad is present in a minority of patients [45, 46]. Most AAAs 5 cm or larger are palpable as a pulsatile abdominal mass in the mid-abdomen. The aneurysm may be slightly tender to palpation and more severe tenderness should raise concern of an inflammatory process, and demands urgent surgical evaluation. The average patient with an AAA less than 5.5 cm in diameter can be observed unless rapid expansion is noted.

Ultrasound is the least expensive method for measuring AAAs and is cost effective for serial observations [47]. However, ultrasound examinations do not delineate adjacent structures as well as CT or MR and are less reliable in obese patients. CT and MR are susceptible to evaluator variability in size determinations especially when the course of aorta is oblique resulting in cross-sectional measures that overestimate the diameter.

Treatment primarily consists of surgical repair. Intact aneurysms can undergo elective surgical repair while ruptured aneurysms require emergency repair with a mortality rate of nearly 90% [48]. Permissive hypotension by withholding aggressive fluid resuscitation so as not to worsen bleeding should be implemented. Systolic pressures of 100-120 mm Hg or to the lowest level while still maintaining adequate vital organ perfusion should be targeted with beta blocker administration.

Open repair requires direct access to the aorta via an abdominal or retroperitoneal approach to replace the aneurysmal segment with a synthetic fabric graft. Endovascular repair using a synthetic graft has been advocated for patients that meet criteria with adequate vascular access to will allow insertion of device catheters, appropriate aortic diameter, angulation, and length [49]. Long-term results of both endovascular open repairs are good in the elective setting with endovascular repair favored due to lower morbidity. Emergent repair in ruptured AAA carries a much higher morbidity and mortality profile with both open and endovascular techniques.

Volume status and renal function should be closely monitored and managed in the postoperative period. Ischemia of the left colon can occur following AAA repair regardless of

IMA reimplantation, and is more common following emergent repairs. Colon resection may be required if ischemia progresses to necrosis or perforation.

GYNECOLOGIC/GENITOURINARY CONCERNS

Gynecologic etiologies

Gynecologic pathology must be considered in female patients presenting with abdominal pain. Several processes contain significant overlap in signs and symptoms with gastrointestinal etiologies. Ruptured ovarian cysts or ovarian torsion can present with RLQ pain similar to acute appendicitis. Ruptured ectopic pregnancy is an emergency due to hemorrhage and patients frequently present with lower abdominal pain and signs of shock. Patients may report amenorrhea or a known diagnosis of pregnancy. A negative pregnancy test effectively rules out ectopic pregnancy and transvaginal ultrasound is highly sensitive in confirming intrauterine pregnancy [50]. The absence of an intrauterine pregnancy in the setting of a positive pregnancy test is highly suggestive of an ectopic pregnancy if the β -hCG value is elevated and transvaginal ultrasound does not show intrauterine pregnancy, typically after about six weeks from the last menstrual period.

Ultrasound is also an important tool to evaluate the ovaries. Ultrasound will identify a mass or cyst if present, and can make the diagnosis of ovarian torsion if blood flow is not reliably identified. Both ectopic pregnancy and ovarian torsion are surgical emergencies [51]. Gynecologic consultation should be obtained immediately if either diagnosis is suspected. A delay in surgical intervention can result in loss of the ovary or death. Ruptured ovarian cyst without torsion can often be managed without surgery using pain medication. Occasionally large cysts require removal if the pain continues, if torsion cannot be ruled out, or if tumor is suspected [52].

Other gynecological causes of lower abdominal pain include pelvic inflammatory disease (PID), salpingitis, and endometriosis. Laparoscopy is the current gold standard for the diagnosis of PID and endometriosis as no specific laboratory test exists. CT and ultrasound may be helpful in unclear cases but often are not specific. Most patients with PID are treated with empirical antimicrobial medications effective against *C trachomatis* and *N gonorrhoeae*. Hormonal therapy is the mainstay for medical treatment of endometriosis with surgical interventions reserved for severe cases or in those where fertility is no longer desired.

Refer to Enterocolitis and Genito-Urinary Etiologies module for additional information.

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Genitourinary etiologies (UTI, pyelonephritis, testicular torsion, ureterolithiasis)

Genitourinary pathology is a common cause of abdominal or flank pain and should be considered in patients presenting with those symptoms. Urinary tract infections (UTI) are among the most common types of infections and can be caused by a variety of microorganisms with *E coli* as the most common. Patients often present with abdominal pain and dysuria. Organisms

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can ascend from the bladder to the kidney resulting in pyelonephritis often manifested with costovertebral angle tenderness. Fever and chills are common and severe infections may rapidly progress to sepsis. Antibiotic therapy is tailored to cultures after identification and sensitivity is determined. Prognosis is favorable with adequate treatment of both the infection and underlying cause.

Nephrolithiasis (kidney stone) is a common reason for emergency departments visits with patients reporting moderate to severe abdominal and flank pain similar to diverticulitis, appendicitis, or cholecystitis [53]. As the stone advances through the ureter, the pain may radiate to the groin. Many patients have a history of previous stones. CT without contrast is preferred to better detect radiopaque stone in the urinary tract. Most stones smaller than 5 mm will pass without intervention. Oral analgesia may be required for symptomatic relief. Patients with large stones, UTI, intractable pain, or obstruction should be evaluated by an urologist for possible surgical intervention.

Testicular torsion refers to twisting of the spermatic cord structures and subsequent loss of the blood supply to the affected testicle. This is a urological emergency and early diagnosis and treatment are vital to saving the testicle and preserving future fertility [54]. Testicular torsion is more common in adolescents and neonates, but may occasionally occur in older men. Patients typically present with a sudden onset of severe unilateral scrotal pain followed by inguinal and/or scrotal swelling. The pain may decrease as necrosis sets in. Many patients also present with gastrointestinal symptoms, nausea, and vomiting, thus overlapping with many intraabdominal processes. When the diagnosis is suspected, routine imaging studies are not necessary and may delay valuable time for definitive diagnosis. Ultrasonography with Color Doppler may be useful when a low suspicion exists to evaluate blood flow and rule out ischemia. Treatment of testicular torsion varies according to patient age and requires urologic expertise.

Refer to Enterocolitis and Genito-Urinary Etiologies module for additional information.

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PEDIATRIC CONSIDERATIONS

Pediatric patients require specialized treatment as the surgical care of children differs from adults in many respects. Pediatric surgical pathology varies according to age and development. Infants and children may suffer from congenital abnormalities and diseases not seen in adults, and management requires an experienced understanding.

Malrotation and Midgut Volvulus

During normal fetal abdominal development, the GI tract herniates out from the abdominal cavity and rotates 270 degrees counterclockwise around the superior mesenteric vessels. The bowels then return to the abdominal cavity, with fixation of the duodenojejunal loop to the left of the midline and the cecum in the right lower quadrant. Intestinal malrotation refers to any variation in this rotation and fixation and can occur at a wide range of locations leading to

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various acute and chronic presentations. The most common type is incomplete rotation predisposing to midgut volvulus requiring emergent operative intervention [55].

Acute midgut volvulus typically presents during the first year of life with sudden bilious emesis. Physical findings may vary depending on the degree of malrotation, but are usually associated with abdominal distention with tenderness. Intestinal ischemia can lead to signs of shock including lethargy, hypotension, and decreased urine output.

Upper GI series is the gold standard to diagnose intestinal malrotation, but should only be obtained in patients who are hemodynamically stable and not actively vomiting. Normal rotation is confirmed if the duodenal C-loop crosses the midline and places the duodenojejunal junction to the left of the spine at a level equal or superior to the pylorus (*Figure 12*). Water-soluble agents should be used if the study is to be obtained prior to emergent operative intervention.

Immediate care should be directed toward resuscitation and stabilizing the patient and pediatric surgical consultation. The Ladd procedure remains the cornerstone of surgical treatment for malrotation, classically described as reduction of the volvulus (typically accomplished by twisting counterclockwise), division of mesenteric bands, placement of small bowel on the right and large bowel on the left of the abdomen, and appendectomy. After the blood supply has been restored by detorsion, the bowel must be assessed for viability as nonviable segments must be resected. If multiple areas of questionable viability are present, the bowel may be left in discontinuity for a second-look operation to preserve bowel length before committing to resection of potentially recoverable bowel.

Figure 12. Intestinal malrotation



Upper GI with small bowel follow through. The distal duodenum, duodenojejunal flexure, and proximal jejunum do not cross the midline. The remainder of the small bowel lies to the right of the spine. The ascending colon is to the left of spine. Case courtesy of Dr. Aditya Shetty, Radiopaedia.org, rID: 27934

Hernia

Inguinal hernia repair is one of the most common pediatric operations performed. Most inguinal hernias in children are indirect inguinal hernias (*see Abdominal Wall and Groin Mass module*). Other less common types of ventral hernias include umbilical and epigastric hernias. All pediatric inguinal hernias require operative treatment to prevent the development of complications, such as incarceration or strangulation. Umbilical hernias typically do not cause any symptoms and do not require surgical repair until approximately 5 years old and may be managed by simple observation [56].

Hirschsprung Disease

Hirschsprung disease results from the absence of enteric neurons within the myenteric and submucosal plexus of the rectum and colon. Early recognition and surgical correction of Hirschsprung disease protects affected infants from enterocolitis and debilitating constipation. Hirschsprung disease is relatively rare and occurs in approximately 1 per 5000 live births and is four times more common in males [57].

Most affected children present by two years of age with distention, failure to pass meconium within the first 48 hours of life, and poor nutritional status. Older children may present with chronic constipation that is refractory to treatment. Hirschsprung enterocolitis can be a fatal complication that can progress to sepsis, transmural intestinal necrosis, and perforation. Diagnosis is made by rectal biopsy, either with suction rectal biopsy or transanal wedge resection, 2-2.5 cm above the dentate line on the posterior wall to minimize the risk of perforation. Histologic examination is performed to assess for the presence or absence of ganglion cells.

The surgical options vary and include colostomy at the level of normal bowel, staged procedure with colostomy followed by a pull-through procedure, or a single-stage pull-through procedure. Depending on the setting, these operations can be performed at the time of diagnosis or after the child has had rectal irrigations. Colostomy followed by pull-through is generally reserved for those patients who present with sepsis due to enterocolitis or massive distention as most patients can be treated in a single-stage.

Pyloric stenosis

Pyloric stenosis is the most common cause of intestinal obstruction in infancy and occurs secondary to hypertrophy and hyperplasia of the muscular layers of the pylorus, resulting in a functional gastric outlet obstruction. Classically infants present with nonbilious projectile vomiting and is more common in males. As the obstruction becomes more severe, the infant may show signs of dehydration and malnutrition.

A firm, mobile, nontender “olive” mass can be palpated in the RUQ in as many as 60-80% of patients and is nearly pathognomonic for pyloric stenosis [58]. Ultrasound is the most sensitive and specific imaging modality. The diagnosis can be confirmed when the muscle thickness is

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greater than 4 mm and the length of the pylorus is greater than 16 mm. Hypochloremic-hypokalemic metabolic alkalosis is the classic electrolyte and acid-base imbalance found in pyloric stenosis. Prolonged vomiting leads to loss of hydrogen and chloride ions. As progressive volume is lost, the kidneys attempt to maintain extracellular volume by resorbing sodium, which in turn results in paradoxical aciduria as hydrogen and potassium ions are excreted (*see Fluid & Electrolytes module for additional information*).

Immediate treatment requires fluid resuscitation and repletion of electrolytes starting with isotonic crystalloid solutions and transitioning to 5% dextrose in 0.45% normal saline with supplemental potassium. Once electrolyte and acid-base abnormalities are corrected, surgery may be performed. Pyloromyotomy is the current procedure of choice, which involves dividing the underlying pyloric muscle fibers and leaving the mucosal layer intact. Traditionally, the pyloromyotomy was performed through an open approach; however, studies have shown laparoscopic pyloromyotomy to have fewer complications, reduced time to full feeds and hospital length [59, 60].

Intussusception

Intussusception, described as a telescoping or invagination of the bowel (*Figure 13*), is one of the most common causes of bowel obstruction in infants and toddlers. Obstruction, ischemia, and subsequent perforation are among the primary concerns. Most cases are idiopathic, but there is a correlation with viral infections and hypertrophied Peyer patches. Other mechanical factors that predispose to intussusception include Meckel's diverticulum, polyps, hemangioma, Henoch-Schönlein purpura, and lymphoma. Blood and mucus from the involved bowel combine to form "currant jelly" stool. Characteristic ultrasonographic findings include a target sign. Stable patients without evidence of ischemia, perforation, or sepsis may undergo immediate contrast enema treatment which is successful 60-80% of the time [61]. Immediate surgery is indicated for unstable patients, patients who have peritonitis, and patients with bowel perforation during attempted enema reduction. Elevated temperature and white blood cell counts have also served as relative indicators for surgery. Among patients who undergo operative reduction of intussusception, as many as 10% may require bowel resection.

Figure 13. Intussusception

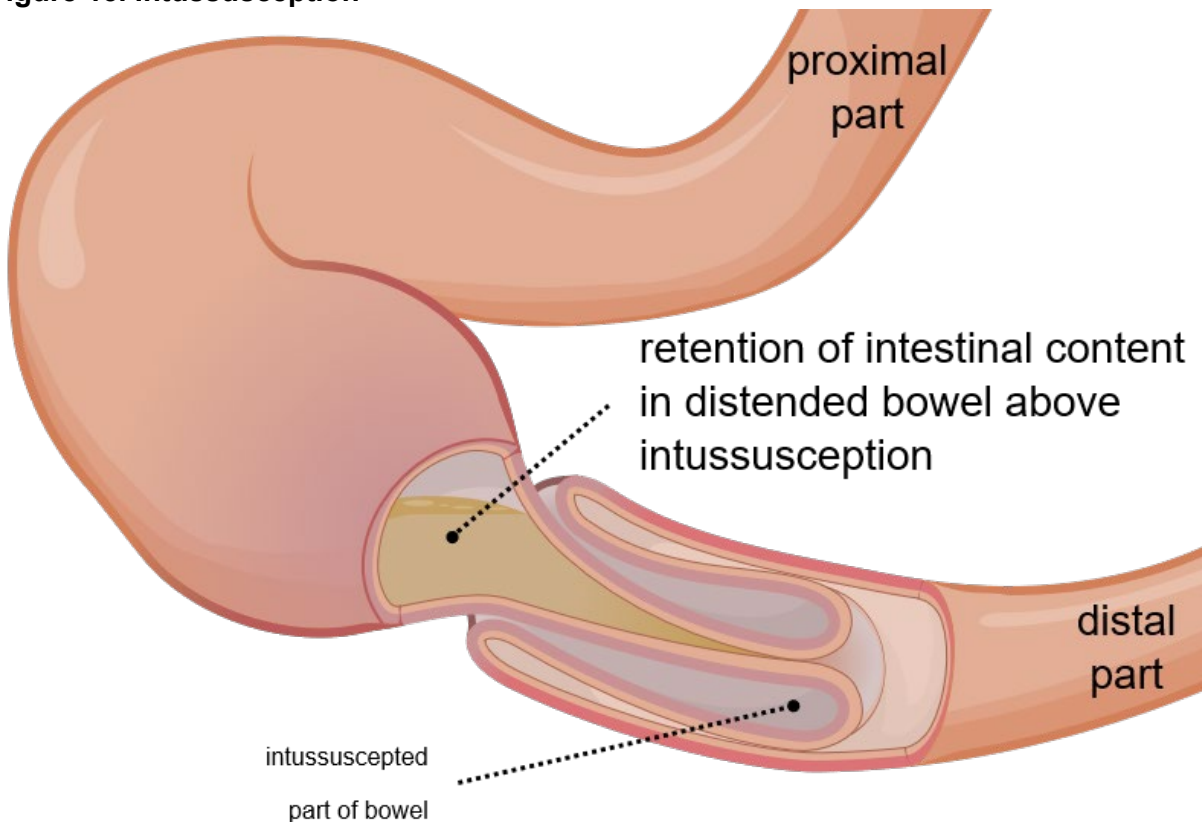


Illustration demonstrating invagination of proximal bowel (intussusceptum) out of the distal bowel (intussusciens) leading to obstruction. Illustration courtesy of Olek Remesz, Wikimedia.org.

Meckel's diverticulitis

Meckel's diverticulum is the most common congenital abnormality of the small intestine. It results as an incomplete obliteration of the vitelline duct (omphalomesenteric duct). Meckel's are usually asymptomatic but may develop complications requiring attention. Ectopic mucosal tissue within the diverticulum can cause GI bleeding and pain. Other complications include obstruction, inflammation, and rarely perforation. In children, the most common presenting symptom is hematochezia [62].

Meckel's diverticula are located on the antimesenteric border of the ileum, 10-90 cm from the ileocecal valve. The Meckel's scan with radiolabeled tracer is the preferred imaging modality as it is noninvasive, requires limited radiation exposure, and is more sensitive than other contrast studies. Heterotopic gastric mucosa will enhance indicating a positive result.

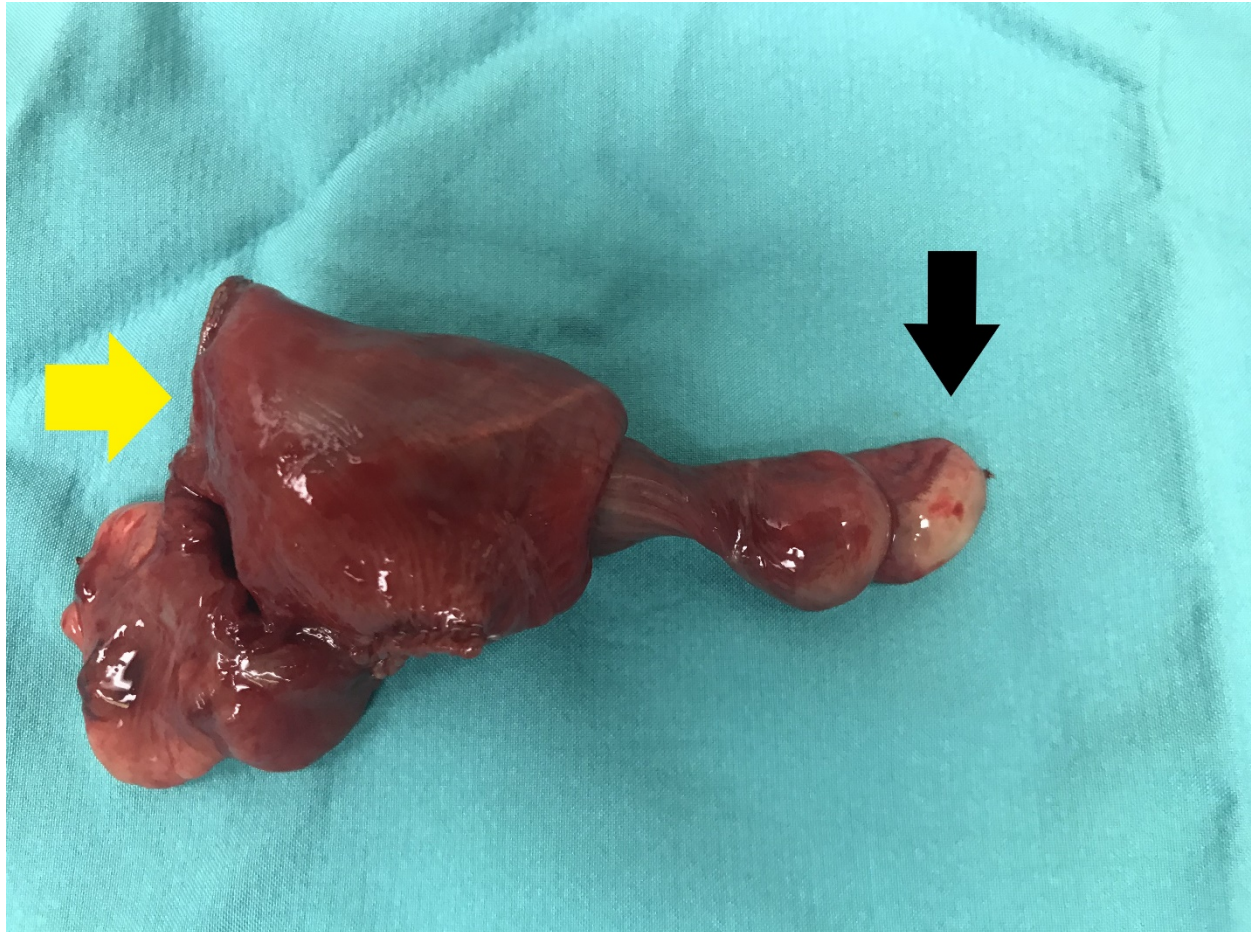
Definitive treatment for symptomatic patients is excision of the diverticulum by performing a wedge resection or segmental resection of the affected bowel with primary anastomosis (*Figure 14*). In those rare instances when the diverticulum is located on the mesenteric border, resection and anastomosis is preferred instead of a wedge resection [63].

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Refer to Meckel's Diverticulum module for additional information.

https://www.facs.org/-/media/files/education/core-curriculum/abdominal_pain_meckels.ashx

Figure 14. Meckel's diverticulum



Ex vivo Meckel's diverticulum (black arrow) after resection. The yellow arrow denotes the stapled proximal bowel. The diverticulum was acting as a lead point for intussusception causing pain. Photo courtesy Dr. L. Kasey Welsh.

Child abuse

Physical child abuse, also referred as nonaccidental trauma (NAT), is any injury inflicted by a parent, guardian, or other supervising adult. It is estimated that 1 million children per year in the United States suffer injuries that qualify as NAT. In most cases, the victim is under 3 years of age with an unstable home environment. A pattern of discrepancy between the history provided and the magnitude of the injury, delayed presentation, frequency of injury, or injuries in an infant less than one year old should raise suspicion. The guardians may be evasive or hostile. To determine whether a child's injury was likely to have been inflicted rather than accidental, the

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clinician must establish the full extent of the injury and must understand the child's developmental level and abilities.

Physical findings that raise concern include injury patterns inconsistent with the history, multiple injuries of various stages of healing, forced immersion burn patterns, bruising beyond bony prominences (ears, facial cheeks, neck, genitals), and patterned markings resembling objects [64]. Photo documentation of injuries, when possible, is often helpful when working with authorities.

Treatment for NAT is complex requiring a multidisciplinary approach and can often be emotionally demanding. The nature of the injuries will determine the level of treatment needed in addition to social services and law enforcement involvement. The American Academy of Pediatrics declares that pediatricians are mandated reporters of suspected abuse, and reports to child protective service agencies are required by law when the physician has a reasonable suspicion of abuse [65]. Child protective services (CPS) agencies are responsible for performing investigations and rely on medical evaluations from physicians. CPS is also responsible in assessing caregiving abilities, environmental safety, risk for repeat abuse, and risk to other siblings. Even if no obvious fracture is present, a full skeletal radiographic survey should be performed to assess for occult injuries and evaluate for evidence of previous trauma. In cases of severe or multisystem trauma, pediatric surgeon involvement may be necessary.

SPECIAL CIRCUMSTANCES

The differential diagnosis of abdominal pain can also vary based on special considerations. These considerations include patients who are pregnant, had recent surgery, are getting chemotherapy, are on steroids or who are immunocompromised. The physician has to take into account these issues and the potential implications on diagnosis, treatment and outcome.

Pregnancy

Pregnant patients may present with atypical abdominal pain depending on the stage of pregnancy. Pregnancy after the 20th week can cause displacement of abdominal organs by the enlarging gravid uterus. For example, a pregnant woman may have more centralized or right mid abdominal pain with appendicitis. The imaging, antibiotics and surgical management of abdominal pain in pregnant women has to be tailored to techniques that are safest for mother and fetus.

Immunocompromised Patients

Patients receiving chemotherapy or who are immunosuppressed or on steroids may also present with atypical abdominal pain. Physical exam findings may be more subtle if the patient's immune system is unable to mount a normal inflammatory response. This can also be reflected in abnormal laboratory values, such as neutropenia in patients receiving chemotherapy, or

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hyperglycemia in patients on steroids. An important disease in the differential of immunocompromised patients receiving chemotherapy with abdominal pain is typhlitis. This inflammation of the ileum and cecum can become transmural and ultimately lead to sepsis and death if untreated. Treatment typically involves antibiotics, bowel rest, and surgical resection (see *Enterocolitis section for additional information*).

Postoperative Patient

Assessing abdominal pain in a postoperative patient can be difficult. Abdominal procedures are expected to cause pain, so learning when pain is out of proportion to the expected pain is essential. New onset of abdominal pain cannot always be attributed to the surgical procedure. For example, a patient with a recent orthopedic procedure who has abdominal pain may have a simple postoperative ileus or a severe colitis from antibiotics administered at the time of surgery.

QUESTIONS

Case #1

A 60-year-old woman with a history of chronic abdominal discomfort presents with the sudden onset of severe generalized abdominal pain. Further history reveals that the patient is a smoker and has had many months of general, centralized abdominal pain. She describes that pain as burning and sometimes causing nausea. She has taken antacid medication on occasion for this chronic pain. The pain she is having now is very different. It is sharp and continuous and started exactly two hours ago. It is not radiating. Movement makes the pain worse. Taking a deep breath makes the pain worse. She has never had pain like this before and has no prior surgery. She denies weight loss, change in bowel habits or change in appetite. On physical exam, the patient is tachycardic and clearly in distress. She is flat in bed and reluctant to change position. She has a low-grade fever and her abdomen is diffusely tender and rigid with peritonitis.

1. What is the likely diagnosis?
 - A. Gastritis
 - B. Gastroesophageal reflux
 - C. Peptic ulcer disease
 - D. Pneumonia with referred pain

2. What further workup is indicated?
 - A. CT scan of the chest and abdomen
 - B. Abdominal X-ray series
 - C. Outpatient surgical consultation for follow up
 - D. All of the above

3. What treatment is required?
 - A. Esophagogastroduodenoscopy (EGD)
 - B. Aggressive antacid therapy
 - C. Surgery for repair of the perforation
 - D. IV antibiotics to prevent infection

Case #2

A 58-year-old man with a history of alcohol abuse presents with worsening generalized abdominal pain, emesis, low grade fever and confusion. He reports battling alcohol addiction for many years. He started having generalized abdominal pain about two days ago, but over the past 24 hours, it has gotten worse. He cannot eat and has had several episodes of bilious emesis. His wife brought him to the emergency room when she found him confused and collapsed on the floor. The pain has been continuous for the past two days and nothing improves his symptoms. He has never had surgery and there have been no other changes in his bowel function. Over the past few months, the patient has lost a little weight, mostly because his drinking has been out of control and he forgets to eat. He is tachycardic, diaphoretic, and is only oriented to person, but not place or time. His blood pressure is 86/40. He recognizes his wife, but is not cooperative with the exam. Examination of the abdomen reveals minimal distension and generalized tenderness to palpation, especially centrally. There are no masses. There is a suggestion of ascites.

1. What is your differential diagnosis?
 - A. Alcohol intoxication
 - B. Liver failure
 - C. Pancreatitis
 - D. Malignancy
 - E. Infection
 - F. All of the above

2. What further workup is indicated?
 - A. Labs (CBC, chemistries, pancreatic enzymes, liver enzymes, coagulation studies)
 - B. CT scan of the abdomen
 - C. Surgical consultation with immediate exploration
 - D. A and B

Case #3

A 40-year-old woman who had a previous open appendectomy as a child presents with generalized abdominal pain, bilious emesis, and anorexia. She was previously healthy until earlier in the day when she began having waves of intermittent, cramping abdominal pain. She has never had pain like this before, but she described the pain as similar to labor pain. Nothing she does makes the pain better. The pain is not exacerbated by anything, but shortly after the pain started, she had two episodes of bilious emesis. She has had no fever or other changes to her bowel function. Her last stool was 12 hours before and was normal. She has two young children and no significant medical history apart from an open appendectomy done at the age of 8 years. On examination, her vital signs are normal. She appears unwell and she complains of intense nausea. Her abdomen is soft but distended and tympanitic to percussion. There is no peritonitis or palpable masses.

1. What is the likely diagnosis?
 - A. Small bowel obstruction
 - B. Colon obstruction
 - C. Ovarian torsion
 - D. Food poisoning

2. What is the best next step?
 - A. Abdominal X-ray series
 - B. MRCP
 - C. Colonoscopy
 - D. Exploratory laparotomy

3. What treatment is required?
 - A. Surgical consultation
 - B. Bowel rest
 - C. NG tube decompression, IV fluid resuscitation
 - D. Laxatives

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- E. A, B and C
- F. All of the above

Case #4

An 80-year-old man with a history of atrial fibrillation presents with severe generalized abdominal pain and confusion. Further history reveals that he has a history of hypertension, chronic pulmonary disease from smoking, and diabetes. Earlier in the day, he began having sudden severe abdominal pain. The pain continues to be severe and relentless and is associated with nausea — described as diffuse and getting worse. Upon arrival to the emergency room, he had a large, foul smelling, dark stool and was becoming more confused. On exam, he is moaning in pain. He is in atrial fibrillation and is becoming hypotensive. He is diaphoretic and only oriented to person and place. His abdomen is soft and not distended. There are no obvious masses or peritonitis.

1. What is the likely diagnosis?
 - A. Ruptured appendicitis
 - B. Acute mesenteric ischemia
 - C. Ruptured abdominal aortic aneurysm (AAA)
 - D. Myocardial infarction

Case #5

A 41-year-old woman presents with right upper quadrant abdominal pain, nausea and vomiting. She had a baby three weeks ago and had a similar episode during her pregnancy after eating some pizza, but it was short lived and never occurred again. The current pain developed about thirty minutes after eating ice cream. The pain was severe and associated with nausea and a non-bilious emesis. She has had no fever, weight loss, malaise or ill contacts. This attack again began in the right upper quadrant but was much worse than the prior attack. She came to the ER for evaluation, and after about an hour, the pain began to spontaneously get better. Physical exam reveals a moderately obese woman with stable vital signs. Her abdominal exam is normal.

1. What is the likely diagnosis?
 - A. Cholelithiasis
 - B. Choledocholithiasis
 - C. Cholecystitis

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- D. Gallstone pancreatitis
 - E. Cholangitis
2. What workup is indicated?
- A. Liver function, amylase and lipase, bilirubin
 - B. CBC
 - C. Abdominal ultrasound
 - D. All of the above

Case #6

A 16-year-old boy presents with fatigue, sore throat and severe left upper quadrant pain. He has had a sore throat and fever (100.4 F) and been complaining of feeling very tired over the last week. He has no history of recent travel or ill contacts. The left-sided abdominal pain started about a week ago and has gotten worse. Nothing makes the pain better or worse, and the patient has a hard time getting comfortable. The pain is constant and has always been located in the left upper quadrant. The patient has never had surgery before. His bowel function is normal, but he does feel full all the time which makes it hard for him to eat very much. Physical exam reveals a tired appearing patient. Temperature is 100.1 F and other vital signs are normal. There is abdominal fullness in the left upper quadrant with tenderness to palpation. He has enlarged lymph nodes bilaterally in his neck. The remainder of the physical exam is normal.

1. What is the most likely diagnosis?
- A. Acute appendicitis
 - B. Perforated gastric ulcer
 - C. Splenomegaly
 - D. Transverse colon colitis
2. What work up is indicated?
3. What is the treatment?

Case #7

A 14-year-old boy presents with right lower quadrant pain, low grade fever and anorexia. His mother reports that he was perfectly well until 12 hours ago when he began having a vague centralized abdominal pain. He had an episode of non-bilious emesis after dinner, and tried to go to sleep in order to feel better. He awoke in the middle of the night with severe right sided abdominal pain. The patient's mother brought him to the emergency room because he was having a hard time walking. The patient complains of pain with any movement at all. He has no ill contacts, recent travel or other symptoms. He has never had pain like this before. The pain is now constant. Physical exam reveals an otherwise healthy boy. He has a temperature of 100.5 and is lying still on his side with his legs drawn up. His vital signs are normal. With difficulty he is able to lie on his back. Abdominal exam reveals tenderness to palpation of the right lower quadrant with rebound and involuntary guarding.

1. What is the most likely diagnosis?
 - A. Acute appendicitis
 - B. Acute cholecystitis
 - C. Urinary tract infection
 - D. Crohn's ileitis

2. What workup is indicated?
 - A. Ultrasound of the abdomen
 - B. CBC and urinalysis
 - C. Intravenous antibiotics
 - D. Surgical consultation
 - E. All of the above

3. What is the best treatment?
 - A. Laparoscopic cholecystectomy
 - B. Intravenous antibiotics
 - C. Laparoscopic appendectomy
 - D. No treatment indicated

Case #8

A 20 year old woman presents with sudden onset of right lower quadrant pain and emesis.

Discussion:

Further history reveals that the patient was perfectly well until the sudden development of right lower quadrant abdominal pain. The pain is described as constant and getting worse. The patient has had no fever and had one episode of emesis upon arrival to the emergency room. No significant past medical history and the patient has never had surgery. She takes no medication and had her last menstrual cycle two weeks ago. Physical exam reveals a patient in distress from the pain. She is tachycardic, but her other vital signs are normal and there is no fever. It is hard for her to get comfortable for the examination. Abdominal exam reveals discomfort in the bilateral lower quadrants. The remainder of the exam is normal.

1. What is your differential diagnosis?

- A. Acute appendicitis
- B. Ruptured ovarian cyst
- C. Ovarian torsion
- D. Ectopic pregnancy
- E. All of the above
- F. B, C and D

2. What work up is indicated?

- A. Pregnancy test
- B. Ultrasound of the pelvis
- C. CBC
- D. Pelvic examination
- E. All of the above

3. What is the treatment?

Case #9

A 72-year-old woman presents with left lower quadrant abdominal pain, nausea and fever. She reports that the pain started about two weeks ago and is getting worse and is constant. The pain is generalized, but worse in the left lower quadrant of the abdomen. She reports associated nausea and had one episode of non-bilious emesis. She has also noted some changes in her stool frequency, as has felt constipated over this same period despite passing flatus. She feels very bloated and is not interested in eating. The patient has been a smoker for a long time. She takes ibuprofen daily for her chronic knee pain. Her physical exam shows an obese woman who is tachycardic and febrile to 101.5. Her blood pressure is normal and she is oriented to person, place and time. She has left lower quadrant tenderness and appears unwell.

1. What is the likely diagnosis?
 - A. Diverticulitis
 - B. Sigmoid volvulus
 - C. Bladder infection
 - D. Acute appendicitis

2. What initial workup is indicated?
 - A. Colonoscopy
 - B. CBC
 - C. Stool samples
 - D. CT abdomen and pelvis
 - E. B and D

Case #10

A 3-day-old full term baby boy presents with sudden onset of bilious emesis, generalized abdominal pain and fussiness. The mother reports that the child has been perfectly healthy until suddenly developing two episodes of bilious emesis. The baby was born at term and has been passing stools regularly. He is now very fussy and seems to have generalized abdominal pain. He refuses to eat. On physical exam, he is tachycardic and afebrile. He has a large bilious emesis while you are examining him and seems uncomfortable. His abdomen seems soft and not distended. The remainder of the exam is normal.

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1. What is the likely diagnosis?
 - A. Intestinal intussusception
 - B. Formula intolerance
 - C. Pyloric stenosis
 - D. Malrotation with midgut volvulus

2. What work up is indicated?
 - A. UGI
 - B. Barium enema
 - C. Abdominal X-ray
 - D. Abdominal CT scan

3. What is the next step in treatment?
 - A. Upper endoscopy
 - B. Admit to floor for observation
 - C. Emergent exploratory laparotomy
 - D. Percutaneous drain placement

Case #11

A 9-month-old baby presents with an upper respiratory tract infection, abdominal pain, fussiness and bloody stools. He is an otherwise perfectly healthy baby who began having symptoms about six hours ago. He does not want to eat and seems very uncomfortable. He has had an episode of non-bilious emesis. There are periods of time when he screams uncontrollably and draws his legs up. When the pain wave passes, he is lethargic and appears exhausted. Recently he was noted to pass red, gelatinous (currant jelly) stools from below. He has had an upper respiratory tract infection for the past few days, but is otherwise very healthy. Physical exam reveals a well-nourished appearing 9-month-old baby. He is fussy but has normal vital signs. He has some residual nasal secretions but his lungs are clear. The abdominal exam is

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significant for distension, with a palpable right-sided abdominal mass, which is tender to deep palpation. Rectal exam shows bloody, gelatinous stool.

1. What is the likely diagnosis?
 - A. Pyloric stenosis
 - B. Ileocolic intussusception
 - C. Milk protein allergy
 - D. Malrotation with midgut volvulus

2. What is the indicated work up?
 - A. X-ray of the abdomen
 - B. Ultrasound of the abdomen
 - C. Barium or air enema
 - D. Surgery
 - E. All of the above

ANSWERS TO QUESTIONS

Case #1

A 60-year-old woman with a history of chronic abdominal discomfort presents with the sudden onset of severe generalized abdominal pain. Further history reveals that the patient is a smoker and has had many months of general, centralized abdominal pain. She describes that pain as burning and sometimes causing nausea. She has taken antacid medication on occasion for this chronic pain. The pain she is having now is very different. It is sharp and continuous and started exactly two hours ago. It is not radiating. Movement makes the pain worse. Taking a deep breath makes the pain worse. She has never had pain like this before and has no prior surgery. She denies weight loss, change in bowel habits or change in appetite. On physical exam, the patient is tachycardic and clearly in distress. She is flat in bed and reluctant to change position. She has a low-grade fever and her abdomen is diffusely tender and rigid with peritonitis.

1. What is the likely diagnosis?
 - A. Gastritis
 - B. Gastroesophageal reflux
 - C. Peptic ulcer disease**
 - D. Pneumonia with referred pain

The correct answer is C. The chronic abdominal pain suggests peptic ulcer disease. The fact that this attack of pain is sudden (the patient can pinpoint exactly when the pain occurred) and severe, implies that likely there is a perforation of the ulcer. Although gastritis and gastroesophageal reflux can cause chronic abdominal pain, they do not cause peritonitis. One would expect symptoms of respiratory infection (cough, fever, sputum) if pneumonia was the cause of the referred abdominal pain. Additionally, peritonitis is not a typical feature of referred abdominal pain, as the pain is related to diaphragm irritation and not peritoneal irritation.

2. What further workup is indicated?
 - A. CT scan of the chest and abdomen
 - B. Abdominal X-ray series**
 - C. Outpatient surgical consultation for follow up
 - D. All of the above

The correct answer is B. X-rays of the abdomen are the best initial study to obtain. The X-rays should include supine and upright views of the abdomen and a chest X-ray. These studies will demonstrate a large amount of free air and this makes the diagnosis of perforated peptic ulcer disease highly likely. Although a CT scan can also be done, it is expensive, time consuming, and exposes the patient to unnecessary radiation. It is not appropriate to refer for outpatient surgical consultation. This patient requires an urgent surgical consultation.

3. What treatment is required?
 - A. Esophagogastroduodenoscopy (EGD)
 - B. Aggressive antacid therapy
 - C. Surgery for repair of the perforation**
 - D. IV antibiotics to prevent infection

The correct answer is C. In the case of peptic ulcer disease without perforation, it would be appropriate to consider GI consultation and antacid therapy, while scheduling the patient for EGD to look for *H pylori* infection and ulcer disease. However, this patient has a perforation, which is a surgical emergency. Although many peptic ulcers are caused by chronic *H pylori* infection which is treated with antibiotics and acid blockade, IV antibiotics alone are not indicated in this setting. Prompt surgical exploration and repair is the correct choice. Typical surgical repair involves closure of the perforation with an overlay of tissue reinforcement using omentum or falciform ligament. This procedure is commonly known as a Graham patch.

Case #2

A 58-year-old man with a history of alcohol abuse presents with worsening generalized abdominal pain, emesis, low grade fever and confusion. He reports battling alcohol addiction for many years. He started having generalized abdominal pain about two days ago, but over the past 24 hours, it has gotten worse. He cannot eat and has had several episodes of bilious emesis. His wife brought him to the emergency room when she found him confused and collapsed on the floor. The pain has been continuous for the past two days and nothing improves his symptoms. He has never had surgery and there have been no other changes in his bowel function. Over the past few months, the patient has lost a little weight, mostly because his drinking has been out of control and he forgets to eat. He is tachycardic, diaphoretic, and is only oriented to person, but not place or time. His blood pressure is 86/40. He recognizes his wife, but is not cooperative with the exam. Examination of the abdomen reveals minimal distension and generalized tenderness to palpation, especially centrally. There are no masses. There is a suggestion of ascites.

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1. What is your differential diagnosis?

- A. Alcohol intoxication
- B. Liver failure
- C. Pancreatitis
- D. Malignancy
- E. Infection
- F. All of the above**

The correct answer is F. Clearly, this patient is gravely ill. He is tachycardic, diaphoretic, hypotensive and confused. Although there is a strong history of alcohol abuse, it is not appropriate to assume intoxication is the sole cause of the patient's symptoms or confusion. All of the listed diagnoses could be considered.

2. What further workup is indicated?

- A. Labs (CBC, chemistries, pancreatic enzymes, liver enzymes, coagulation studies)
- B. CT scan of the abdomen
- C. Surgical consultation with immediate exploration
- D. A and B**

The correct answer is D. Labs should be drawn at the same time IV access is established. While resuscitating the patient, it would be appropriate to plan for his admission to the intensive care unit (ICU). When the patient's condition stabilizes, it would be appropriate to obtain a CT scan with contrast of the abdomen to evaluate for pancreatitis. While surgical consultation may ultimately be required, surgical management of pancreatitis is ultimately reserved for cases of necrosis and sepsis and would only be considered if imaging suggested pancreatic necrosis. The patient may need to be intubated and have central venous access established upon admission to the ICU. If infection is suspected, the patient may also need antibiotics. CT scan would also be helpful to identify malignancy if it is present.

Case #3

A 40-year-old woman who had a previous open appendectomy as a child presents with generalized abdominal pain, bilious emesis, and anorexia. She was previously healthy until

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earlier in the day when she began having waves of intermittent, cramping abdominal pain. She has never had pain like this before, but she described the pain as similar to labor pain. Nothing she does makes the pain better. The pain is not exacerbated by anything, but shortly after the pain started, she had two episodes of bilious emesis. She has had no fever or other changes to her bowel function. Her last stool was 12 hours before and was normal. She has two young children and no significant medical history apart from an open appendectomy done at the age of 8 years. On examination, her vital signs are normal. She appears unwell and she complains of intense nausea. Her abdomen is soft but distended and tympanitic to percussion. There is no peritonitis or palpable masses.

1. What is the likely diagnosis?

A. Small bowel obstruction

B. Colon obstruction

C. Ovarian torsion

D. Food poisoning

The correct answer is A. Most patients with food poisoning have frequent emesis which gradually becomes bilious and the abdomen is usually not distended. The most likely diagnosis is small bowel obstruction due to adhesions from prior surgery. The patient's symptoms and physical exam suggest obstruction, with distension (which can be absent as well) and the sudden onset of intermittent cramping pain (colic), associated with bilious emesis. Colon obstruction is not caused by adhesions from prior surgery. Although ovarian torsion is possible, the abdomen is not typically distended, and the pain is usually in the lower abdomen.

2. What is the best next step?

A. Abdominal X-ray series

B. MRCP

C. Colonoscopy

D. Exploratory laparotomy

The correct answer is A. Abdominal X-rays are usually the best initial imaging modality. They will likely demonstrate the small bowel obstruction, with proximal dilatation and distal decompression. They are also helpful for identifying free air if it is present. MRCP is helpful in assessing biliary and pancreatic anatomy and not appropriate in this setting. CT imaging is effective in evaluating SBO and associated complications including ischemia, perforation, mesenteric edema, and pneumatosis, which may prompt surgical interventions. There is no role

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for colonoscopy in this setting. Patients with bowel obstructions may require surgery, but more information is required in this scenario.

3. What treatment is required?
 - A. Surgical consultation
 - B. Bowel rest
 - C. NG tube decompression, IV fluid resuscitation
 - D. Laxatives
 - E. A, B and C**
 - F. All of the above

The correct answer is E. The treatment for adhesive small bowel obstruction is bowel rest (NPO), IVF administration and NG decompression. Surgery should be consulted early on when the diagnosis is first being considered. Not all obstructed patients will require exploration. Most are managed with bowel rest and decompression and will resolve without surgical intervention. It is imperative that the surgeon is involved early in the care of any obstructed patient, as signs of obstruction progressing to gangrenous bowel can sometimes be initially subtle. There is no role for laxatives in patients with small bowel obstruction.

Case #4

An 80-year-old man with a history of atrial fibrillation presents with severe generalized abdominal pain and confusion. Further history reveals that he has a history of hypertension, chronic pulmonary disease from smoking, and diabetes. Earlier in the day, he began having sudden severe abdominal pain. The pain continues to be severe and relentless and is associated with nausea — described as diffuse and getting worse. Upon arrival to the emergency room, he had a large, foul smelling, dark stool and was becoming more confused. On exam, he is moaning in pain. He is in atrial fibrillation and is becoming hypotensive. He is diaphoretic and only oriented to person and place. His abdomen is soft and not distended. There are no obvious masses or peritonitis.

1. What is the likely diagnosis?
 - A. Ruptured appendicitis
 - B. Acute mesenteric ischemia**

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- C. Ruptured abdominal aortic aneurysm (AAA)
- D. Myocardial infarction

The correct answer is B. Acute mesenteric ischemia can be due to sudden occlusion of the mesenteric blood vessels, likely sudden occlusion from an arterial thrombus. Atrial fibrillation can cause dislodgement of a clot that originates in the heart that then embolizes to the mesenteric vessels. Impaired blood flow leads to ischemia, necrosis, perforation, and eventual sepsis. The diagnosis has to be suspected immediately. Patients typically have pain out of proportion to physical exam. Because there is no pulsatile abdominal mass, ruptured AAA is not likely. The patient has no history of chest pain or pressure making myocardial infarction unlikely. Ruptured appendicitis typically presents with diffuse peritonitis and fever. Treatment needs to be initiated early and aggressively. Immediate surgical consultation and ICU support along with anticoagulants are necessary. The morbidity of this condition is very high, especially when bowel necrosis, peritonitis, and multisystem organ failure have occurred. A mesenteric angiogram can be done to delineate the occlusion in a chronic pain setting, but the diagnosis should not be delayed.

Case #5

A 41-year-old woman presents with right upper quadrant abdominal pain, nausea and vomiting. She had a baby three weeks ago and had a similar episode during her pregnancy after eating some pizza, but it was short lived and never occurred again. The current pain developed about thirty minutes after eating ice cream. The pain was severe and associated with nausea and a non-bilious emesis. She has had no fever, weight loss, malaise or ill contacts. This attack again began in the right upper quadrant but was much worse than the prior attack. She came to the ER for evaluation, and after about an hour, the pain began to spontaneously get better. Physical exam reveals a moderately obese woman with stable vital signs. Her abdominal exam is normal.

1. What is the likely diagnosis?

- A. Cholelithiasis**
- B. Choledocholithiasis
- C. Cholecystitis
- D. Gallstone pancreatitis
- E. Cholangitis

The correct answer is A. Biliary colic describes the symptoms that develop when gallstones intermittently obstruct the cystic duct. Typically patients present with severe, sudden onset of

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right upper abdominal pain that may radiate to the epigastric area or the back shortly after fatty meals. The symptoms will typically resolve spontaneously. Cholecystitis refers to obstruction of the cystic duct which subsequently causes inflammation of the gallbladder. Sometimes the pain is relentless and the patient may also have right upper quadrant abdominal tenderness (Murphy's sign), fever, nausea and vomiting. Choledocholithiasis refers to gallstones in the common bile duct, and can be considered a complication of cholelithiasis. Patients will usually have right upper quadrant pain, nausea, vomiting, jaundice and elevated liver enzymes. Cholangitis refers to obstruction of the common bile duct and infection within the biliary tree. This can be a life-threatening complication and is an emergency when identified. Gallstone pancreatitis refers to pancreatitis caused by the passage of a gallstone that irritates the ampulla of Vater causing subsequent pancreatitis.

2. What workup is indicated?
 - A. Liver function, amylase and lipase, bilirubin
 - B. CBC
 - C. Abdominal ultrasound
 - D. **All of the above**

The correct answer is D. In addition to physical exam, liver function tests and amylase and lipase levels can rule out obstructing stones. Patients who suffer from biliary colic typically have normal laboratory values, but WBC elevation can be seen in patients with cholecystitis or cholangitis. Those patients with choledocholithiasis or cholangitis can have elevation in liver enzymes and bilirubin. Gallstone pancreatitis will be diagnosed with elevated amylase and lipase levels. Abdominal ultrasound is essential to the diagnosis of all of the aforementioned disease processes.

Case #6

A 16-year-old boy presents with fatigue, sore throat and severe left upper quadrant pain. He has had a sore throat and fever (100.4 F) and been complaining of feeling very tired over the last week. He has no history of recent travel or ill contacts. The left-sided abdominal pain started about a week ago and has gotten worse. Nothing makes the pain better or worse, and the patient has a hard time getting comfortable. The pain is constant and has always been located in the left upper quadrant. The patient has never had surgery before. His bowel function is normal, but he does feel full all the time which makes it hard for him to eat very much. Physical exam reveals a tired appearing patient. Temperature is 100.1 F and other vital signs are normal. There is abdominal fullness in the left upper quadrant with tenderness to palpation. He has enlarged lymph nodes bilaterally in his neck. The remainder of the physical exam is normal.

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1. What is the most likely diagnosis?
 - A. Acute appendicitis
 - B. Perforated gastric ulcer
 - C. Splenomegaly**
 - D. Transverse colon colitis

The correct answer is C. The history and physical exam suggest splenic enlargement, likely related to an infection. Hypersplenism can occur in a number of disease states including lymphoma and many viral illnesses. The patient's symptoms of fever, fatigue, sore throat and splenic enlargement suggest infection with Epstein-Barr virus (infectious mononucleosis). Acute appendicitis is not likely to cause left upper quadrant pain and fullness, and colitis is not very likely given the lack of bowel symptoms. A perforated gastric ulcer would present with peritonitis.

2. What work up is indicated? Do we want to offer answer options here?

Ultrasound of the abdomen can be easily performed to evaluate the enlarged spleen and rule out a mass as a cause of the splenic enlargement. CBC can be performed as well as a Monospot to specifically look for Mononucleosis.

3. What is the treatment? Do we want to offer answer options here?

Patients with splenomegaly should avoid contact sports or heavy lifting for several weeks to avoid the unlikely but life threatening complication of splenic rupture and hemorrhage. Surgical consultation should be obtained for any patient with splenomegaly suspected of rupture (sudden worsening of pain, dizzy, fainting, tachycardia, distension).

Case #7

A 14-year-old boy presents with right lower quadrant pain, low grade fever and anorexia. His mother reports that he was perfectly well until 12 hours ago when he began having a vague centralized abdominal pain. He had an episode of non-bilious emesis after dinner, and tried to go to sleep in order to feel better. He awoke in the middle of the night with severe right sided abdominal pain. The patient's mother brought him to the emergency room because he was having a hard time walking. The patient complains of pain with any movement at all. He has no ill contacts, recent travel or other symptoms. He has never had pain like this before. The pain is now constant. Physical exam reveals an otherwise healthy boy. He has a temperature of 100.5 and is lying still on his side with his legs drawn up. His vital signs are normal. With difficulty he is able to lie on his back. Abdominal exam reveals tenderness to palpation of the right lower quadrant with rebound and involuntary guarding.

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1. What is the most likely diagnosis?

- A. Acute appendicitis**
- B. Acute cholecystitis
- C. Urinary tract infection
- D. Crohn's ileitis

The correct answer is A. This patient was very healthy before the onset of these symptoms. There are no bowel complaints and, therefore, Crohn's disease is very unlikely. Acute appendicitis will typically present with a sequence of signs and symptoms. These include periumbilical pain, which is vague, poorly localized, and visceral in quality. The patient then begins to develop nausea, anorexia and vomiting. The pain then begins to localize to the right lower quadrant and localized tenderness develops. Not all patients present with classic signs and symptoms depending on the location of the appendix. Acute cholecystitis presents with right upper quadrant pain and is rare in children. UTI is a possibility, but less likely in the absence of urinary symptoms.

2. What workup is indicated?

- A. Ultrasound of the abdomen
- B. CBC and urinalysis
- C. Intravenous antibiotics
- D. Surgical consultation
- E. All of the above**

The correct answer is E. All of the listed choices have been utilized in the workup of acute appendicitis. Ultrasound is typically preferred in children to limit ionizing radiation exposure. Ultrasound sensitivity can be limited and operator depended as the appendix may not always be visualized. CT scan is the imaging test of choice in adults. MRI can also be used to confirm the diagnosis but is costly and time consuming. Ultimately, the choice of imaging is dependent on physician preference, hospital resources, and degree of clinical suspicion, pregnancy status, and cost considerations. Usually, a white blood cell count will be obtained and in most patients, it will be elevated. A very high white cell count may suggest gangrenous or perforated appendicitis. Urinalysis will frequently show microscopic hematuria. Intravenous antibiotics should be started when the diagnosis of appendicitis is made. It is important to obtain prompt surgical consultation when the diagnosis is suspected, as further imaging may not be needed if clinical history and physical examination suggest the diagnosis.

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3. What is the best treatment?
 - A. Laparoscopic cholecystectomy
 - B. Intravenous antibiotics
 - C. Laparoscopic appendectomy**
 - D. No treatment indicated

The correct answer is C. Removal of the appendix (usually laparoscopically) remains the treatment of choice for acute appendicitis. Recently, there is literature to suggest that some patients may be successfully treated with antibiotics alone. Treatment of ruptured appendicitis is more complex and can range from simple appendectomy to drainage of an abscess (if present) with antibiotics.

Case #8

A 20 year old woman presents with sudden onset of right lower quadrant pain and emesis.

Discussion:

Further history reveals that the patient was perfectly well until the sudden development of right lower quadrant abdominal pain. The pain is described as constant and getting worse. The patient has had no fever and had one episode of emesis upon arrival to the emergency room. No significant past medical history and the patient has never had surgery. She takes no medication and had her last menstrual cycle two weeks ago. Physical exam reveals a patient in distress from the pain. She is tachycardic, but her other vital signs are normal and there is no fever. It is hard for her to get comfortable for the examination. Abdominal exam reveals discomfort in the bilateral lower quadrants. The remainder of the exam is normal.

1. What is your differential diagnosis?
 - A. Acute appendicitis
 - B. Ruptured ovarian cyst
 - C. Ovarian torsion
 - D. Ectopic pregnancy
 - E. All of the above
 - F. B, C and D**

The correct answer is F. Acute appendicitis is unlikely in this clinical scenario as discussed above. In women, ovarian pathology has to be considered in the differential of abdominal pain. It is possible that a ruptured ovarian cyst or ovarian torsion can present with right lower quadrant pain as described. An ectopic pregnancy can also present this way, although a ruptured ectopic pregnancy is an emergency due to hemorrhage, and patients frequently present with abdomen or pelvic pain with signs of shock.

2. What work up is indicated?

- A. Pregnancy test
- B. Ultrasound of the pelvis
- C. CBC
- D. Pelvic examination
- E. All of the above**

The correct answer is E. A pregnancy test which is negative effectively rules out the risk of ectopic pregnancy. Ultrasound of the pelvis is critically important to obtain. After about six weeks from the last menstrual period in a pregnant woman, the fetus should be visualized in the uterus. If the pregnancy test is positive and no fetus is in the uterus, an ectopic is suspected. Ultrasound is also important to evaluate the ovaries. Ultrasound will identify a mass or cyst if present, and can make the diagnosis of ovarian torsion if no blood flow is reliably identified to the ovary. A CBC can be helpful if bleeding or infection is suspected.

3. What is the treatment?

Both ectopic pregnancy and ovarian torsion are surgical emergencies. Surgical consultation should be obtained immediately if either diagnosis is suspected. A delay in surgical intervention can result in loss of the ovary or death of the patient from exsanguination if rupture of the ectopic occurs. Ruptured ovarian cyst without torsion can often be managed without surgery using pain medication. Sometimes large cysts require removal if pain continues, if torsion cannot be ruled out, or if tumor is suspected.

Case #9

A 72-year-old woman presents with left lower quadrant abdominal pain, nausea and fever. She reports that the pain started about two weeks ago and is getting worse and is constant. The pain is generalized, but worse in the left lower quadrant of the abdomen. She reports associated nausea and had one episode of non-bilious emesis. She has also noted some changes in her

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stool frequency, as has felt constipated over this same period despite passing flatus. She feels very bloated and is not interested in eating. The patient has been a smoker for a long time. She takes ibuprofen daily for her chronic knee pain. Her physical exam shows an obese woman who is tachycardic and febrile to 101.5. Her blood pressure is normal and she is oriented to person, place and time. She has left lower quadrant tenderness and appears unwell.

1. What is the likely diagnosis?

- A. Diverticulitis**
- B. Sigmoid volvulus
- C. Bladder infection
- D. Acute appendicitis

The correct answer is A. Diverticula form in the colon when outpouchings of colon mucosa protrude through the muscular wall. This is very common and the risk increases with age. Obesity, smoking, straining at stools and a sedentary lifestyle are risks for diverticular formation. Diverticular disease is most common in the sigmoid colon. Diverticulitis is inflammation of diverticula that can lead to perforation and peritonitis. Sigmoid volvulus is a large bowel obstruction due to twisting of the sigmoid colon. Patients typically present with abdominal pain, distention, and obstipation. Bladder infection is less likely in this instance as the patient has no dysuria. Acute appendicitis has a similar presentation, but with pain in the right lower quadrant.

2. What initial workup is indicated?

- A. Colonoscopy
- B. CBC
- C. Stool samples
- D. CT abdomen and pelvis
- E. B and D**

The correct answer is E. Colonoscopy is not safe to consider in patients with acute diverticulitis. Insufflation of the colon with air can cause perforation or worsen infection. Stool samples are not useful to direct therapy. A CBC will likely show an elevated WBC, consistent with inflammation/infection. CT of the abdomen and pelvis will make the diagnosis and can give additional information about the severity of the diverticulitis (such as abscess or perforation). Many patients with diverticulitis can be managed non-operatively with antibiotics. For patients that present in shock, or with signs of perforation or abscess on imaging, prompt surgical

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consultation should be obtained. Surgical treatment can range from abscess drainage to colon resection with colostomy (Hartmann operation).

Case #10

A 3-day-old full term baby boy presents with sudden onset of bilious emesis, generalized abdominal pain and fussiness. The mother reports that the child has been perfectly healthy until suddenly developing two episodes of bilious emesis. The baby was born at term and has been passing stools regularly. He is now very fussy and seems to have generalized abdominal pain. He refuses to eat. On physical exam, he is tachycardic and afebrile. He has a large bilious emesis while you are examining him and seems uncomfortable. His abdomen seems soft and not distended. The remainder of the exam is normal.

4. What is the likely diagnosis?

A. Intestinal intussusception

B. Formula intolerance

C. Pyloric stenosis

D. Malrotation with midgut volvulus

The correct answer is D. Although intussusception can cause fussiness and emesis, bilious emesis is a red flag. Malrotation with midgut volvulus is the diagnosis until proven otherwise. Pyloric stenosis is more common in boys, but does not present with bilious emesis. Formula intolerance usually causes fussiness or emesis, but not bilious emesis.

5. What work up is indicated?

A. UGI

B. Barium enema

C. Abdominal X-ray

D. Abdominal CT scan

The correct answer is A. Although abdominal X-rays are frequently done, they are not reliable for making the diagnosis of malrotation with midgut volvulus. The X-rays can appear normal even in the case of obstruction. Barium enema is not indicated in this instance, as it does not make the diagnosis of duodenal malrotation with volvulus. The immediate workup required is an

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UGI, which will show the malrotated duodenum and the associated volvulus. If the patient is also presenting with acidosis and bloody stools, the UGI can be skipped and the baby taken emergently to the operating room. These findings are worrisome for intestinal necrosis.

6. What is the next step in treatment?
 - A. Upper endoscopy
 - B. Admit to floor for observation
 - C. Emergent exploratory laparotomy**
 - D. Percutaneous drain placement

The correct answer is C. Malrotation with midgut volvulus is a true surgical emergency. Surgical consultation needs to be obtained immediately if the diagnosis is being considered. After establishing IV access and placing an NG for decompression, an exploratory laparotomy is performed and the twisted bowel is detorsed and the retroperitoneal bands are released. Failure to quickly treat the volvulus can result in loss of the entire small bowel, which is fatal. This procedure is known as a Ladd's procedure, and also involves removing the appendix at the same time.

Case #11

A 9-month-old baby presents with an upper respiratory tract infection, abdominal pain, fussiness and bloody stools. He is an otherwise perfectly healthy baby who began having symptoms about six hours ago. He does not want to eat and seems very uncomfortable. He has had an episode of non-bilious emesis. There are periods of time when he screams uncontrollably and draws his legs up. When the pain wave passes, he is lethargic and appears exhausted. Recently he was noted to pass red, gelatinous (currant jelly) stools from below. He has had an upper respiratory tract infection for the past few days, but is otherwise very healthy. Physical exam reveals a well-nourished appearing 9-month-old baby. He is fussy but has normal vital signs. He has some residual nasal secretions but his lungs are clear. The abdominal exam is significant for distension, with a palpable right-sided abdominal mass, which is tender to deep palpation. Rectal exam shows bloody, gelatinous stool.

1. What is the likely diagnosis?
 - A. Pyloric stenosis
 - B. Ileocolic intussusception**
 - C. Milk protein allergy
 - D. Malrotation with midgut volvulus

The correct answer is B. The above patient is presenting with classic signs and symptoms of ileocolic intussusception. The colicky pattern of abdominal pain and currant jelly stools in a previously healthy nine-month-old infant makes the diagnosis very likely, especially given the palpable abdominal mass. Milk protein allergy may present with bright blood in the stool and diarrhea but not the symptoms as described.

2. What is the indicated work up?
 - A. X-ray of the abdomen
 - B. Ultrasound of the abdomen
 - C. Barium or air enema
 - D. Surgery
 - E. All of the above**

The correct answer is E. Often X-rays of the abdomen are obtained first. These can be very helpful, especially in the case of this infant with a palpable abdominal mass. Plain films may show paucity of gas in the right abdomen, due to the mass. If plain films strongly suggest intussusception, a contrast enema with attempted reduction can be considered as the next step. In many cases, clinical providers and radiologists will confirm the ileocolic intussusception with an abdominal ultrasound when the diagnosis is in question. If an intussusception is present, it will appear as a target sign on ultrasound. With a palpable mass and an X-ray that is consistent with intussusception, ultrasound is not needed. The definitive diagnostic and therapeutic modality is barium or air enema. Either fluoroscopic technique is used to visualize and attempt to reduce the intussuscepted bowel in a retrograde manner. Those patients who either present with peritonitis or for whom reduction does not work will then need surgery for reduction or resection of the intussusception. Surgical consultation should be promptly obtained prior to enema reduction attempt.

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AUTHOR

Leonard K. Welsh, MD
Duke University, Durham, NC