Evaluation of abdominal pain in children

The right clinical information, right where it's needed
# Table of Contents

Summary 3

Overview 4

   Etiology 4

Emergencies 12

   Urgent considerations 12

Diagnosis 15

   Step-by-step diagnostic approach 15
   Differential diagnosis overview 22
   Differential diagnosis 24

Evidence scores 62

References 63

Images 68

Disclaimer 72
Pediatric abdominal pain is often a diagnostic dilemma. It is a common problem and, although the vast majority of these episodes are benign and self-limiting, persistent abdominal pain may signify an underlying pathology requiring urgent intervention. Timely evaluation and intervention are critical in preventing untoward sequelae in children presenting with abdominal pain. Because of the spectrum of etiologies that manifest as abdominal pain, the differential remains broad and diagnosis can be challenging. In most cases, a thorough history and physical exam can narrow the broad differential. However, depending on the age of the child, additional investigations may be required to delineate diseases that present with similar symptoms. Furthermore, even with the assistance of parents or guardians, a comprehensive history is often difficult to obtain, and diagnosis therefore relies heavily on the clinical acumen of the practitioner.
Evaluation of abdominal pain in children

Overview

Etiology

The differential diagnoses for pediatric abdominal pain are broad and encompass almost every organ system. In addition, distinguishing acute from chronic abdominal pain may be particularly difficult in children. Although the most common etiologies are not immediately life threatening, the ability to diagnose urgent pathology remains paramount. A thorough history and physical exam are required to narrow the differential diagnosis, as well as an understanding of the more common diseases affecting the age group of the child in question.

Gastrointestinal

GI sources are the most common etiology, encompassing infectious, congenital, and mechanical causes.

Constipation

- Childhood constipation is typically characterized by infrequent bowel evacuations, large stools, and difficult or painful defecation.
- Symptoms usually result from low-fiber, poor-nutrient intake, and too little water, which leads to high levels of colonic reabsorption of water and hardening of the stool. Additional risk factors include genetic predisposition, infection, stress, obesity, low birth weight, cerebral palsy, spina bifida, and mental retardation. Constipation starts as an acute problem but can progress to fecal impaction and chronic constipation.
- It tends to develop during 3 stages of childhood: weaning (infants), toilet training (toddlers), starting school (older children).

Appendicitis

- Develops when the appendiceal lumen becomes obstructed by stool, barium, food, or parasites.
- Can occur in all age groups, but is rare in infants.
- If left untreated, acute appendicitis progresses to ischemia, necrosis, and eventually perforation. The overall rate of perforation varies from 15.5% to 47%.[1]

Gastroenteritis

- May be due to acute or chronic viral (especially rotavirus), bacterial, or parasitic GI infection.
- Eosinophilic gastroenteritis, defined as a condition affecting the GI tract with eosinophil-rich inflammation without a known cause for the eosinophilia, can result in significant abdominal pain.[2]
- Hemolytic uremic syndrome, characterized by microangiopathic hemolytic anemia, thrombocytopenia, and nephropathy, can occur as a complication of gastroenteritis caused by verotoxin-producing Escherichia coli. Abdominal pain is a common presenting symptom.[3]

Intussusception

- Occurs when a proximal segment of the intestine telescopes into the lumen of an immediately distal segment.
- Most commonly seen in infants between 3 and 18 months of age; reported by some to be the most common cause of intestinal obstruction in infants and children between 3 months and 6 years of age, and the second most common cause of acute abdomen in this age group.[4]
Evaluation of abdominal pain in children

Overview

• In most cases, the intussusception is in the ileocecal area.
• In infants <2 years of age, episodes of intussusception are most likely caused by mesenteric lymphadenopathy secondary to an associated illness (e.g., viral gastroenteritis). In older children, mesenteric lymphadenopathy is still the most likely cause, but other etiologies should be considered (e.g., intestinal lymphomas, Meckel diverticulum). Therefore, children ≥6 years or with jejunojejunal or ileoileal intussusception should be evaluated for a malignant lead point.
• Ileoileal intussusception may also be indicative of Henoch-Schonlein purpura (HSP). HSP is a vasculitis that affects small veins and primarily occurs in children <11 years of age.

Intussusception: blood vessels become trapped between layers of intestine, leading to reduced blood supply, edema, strangulation of bowel and gangrene. Sepsis, shock, and death may eventually occur

Created by the BMJ Knowledge Centre

Meckel diverticulum

• A finger-like projection located in the distal ileum arising from the antimesenteric border; usually 40 to 60 cm from the ileocecal valve, measuring 1 to 10 cm long and 2 cm wide.  
[Fig-4]
• The majority of symptomatic patients present before the age of 2 years.
• The prevalence is estimated to be 2% to 3%.[5]
• Intestinal obstruction is a known complication and may be observed in as many as 40% of all symptomatic Meckel diverticula (according to some series).[6]

Mesenteric adenitis

• Refers to inflammation of the mesenteric lymph nodes. This process may be acute or chronic. It is often mistaken for other diagnoses, such as appendicitis; up to 20% of patients undergoing negative appendectomy have been found to have nonspecific mesenteric adenitis.[7]

Hirschsprung disease

• Most commonly diagnosed in the first year of life, but can present later in childhood; slightly higher male preponderance.
• Congenital condition characterized by partial or complete colonic obstruction associated with the absence of intramural ganglion cells. Because of the aganglionosis, the lumen is tonically contracted, causing a functional obstruction. The aganglionic portion of the colon is always located distally, but the length of the segment varies.  
[Fig-5]
• May be associated with Down syndrome and multiple endocrine neoplasia type IIA.

Intestinal obstruction

• Small or large bowel obstruction may be the result of various etiologies and can occur at any age. Abdominal pain may not occur until the obstruction has progressed to include extensive abdominal distension or intestinal ischemia. Intestinal obstruction may mimic intestinal ileus, which usually does not require surgical intervention.
• The etiology of intestinal obstruction can be congenital or acquired. Congenital causes include atresias or stenosis, which present in the newborn period.
Evaluation of abdominal pain in children

Overview

• Duodenal atresia or stenosis may cause complete or partial obstruction of the duodenum as a result of failed recanalization during development. This results in either stenosis with incomplete obstruction of the duodenal lumen (allowing some but not all gas and liquid to pass) or an atresia where the duodenum ends blindly causing a true complete obstruction.

• Jejunoileal atresia or stenosis is a complete or partial obstruction of any part of the jejunum or ileum. Although uncertain, it is believed to result from a vascular accident during development. Jejunal stenosis may still have bowel lumen continuity with a narrowed lumen and thickened muscular layer. There are 4 types of atretic bowel, and all result in a complete obstruction due to a blind-ending lumen.

• Colonic atresia is an extremely rare complete obstruction of any part of the colon, although it usually occurs near the splenic flexure. Like jejunoileal atresia, it is thought to occur as a result of a vascular event.

[Fig-6]

• Acquired causes of intestinal obstruction include small bowel adhesions, incarcerated or strangulated hernias, or tumors. These can occur at any age. Tumors may be intraluminal or extra-intestinal. Hernias may be internal or external and congenital or acquired. A history of previous intra-abdominal surgery or inflammation (such as necrotizing enterocolitis should prompt concern for adhesive small bowel obstruction.

• Omental cysts, although rare, can present with intestinal obstruction; may be confused with ovarian cysts on ultrasound.

• Meconium ileus is an important cause of intestinal obstruction in the neonatal period; cystic fibrosis should be suspected as an associated disease. There may also be associated pancreatic abnormalities.

• Duplication cysts occur most commonly in the small intestine; they may serve as a lead point for volvulus and intussusception and can also result in obstruction. With duodenal duplication cysts, peptic ulcer disease, hemorrhage, or perforation may result secondary to ectopic gastric mucosa.

• In patients with cystic fibrosis, partial bowel obstruction may sometimes be referred to as distal intestinal obstruction syndrome (DIOS) or meconium ileus-equivalent syndrome. This entity is not related to meconium. This refers to a distal small bowel obstruction caused by impacted bowel contents; it typically occurs in adolescents and adults with cystic fibrosis.

[Fig-7]

Volvulus

• This can occur in any age group, but is most common in children <1 year old; 60% of children present before 1 month of age.[8] [9] Midgut volvulus is the most common type. Sigmoid volvulus can also occur.

• Intestinal malrotation is a term used to encompass the entire spectrum of anatomic arrangements that result from incomplete rotation of the gut during embryonic development. Volvulus of the entire small bowel and part of the colon is only possible when malrotation exists.

• In malrotation, the most significant pathologic concerns are a lack of gut fixation to the retroperitoneum and narrow midgut mesenteric base that predisposes patients to midgut volvulus, which occurs when the duodenum or colon twist around this mesenteric base.

Necrotizing enterocolitis
Evaluation of abdominal pain in children

Overview

• A disease primarily of premature infants, particularly those weighing less than 1500 g. The pathogenesis is multifactorial and not well understood, although ischemia, reperfusion injury, and infectious pathogens may play a role.

Peptic ulcer disease

• Gastric and duodenal ulcers are uncommon among the pediatric population (5/2500 hospitalizations).[10] When they occur, they are classified as primary or secondary peptic ulcers.
• Primary ulcers occur without predisposing factors and are most commonly located in the duodenum or pyloric channel. They manifest most often in older children and adolescents with a positive family history. Rarely, primary peptic ulcers can occur in the first month of life, presenting with bleeding and possible perforation. Most are located in the stomach. Primary ulcers may be associated with Helicobacter pylori.
• Secondary ulcers are usually associated with stress, burns, trauma, infection, neonatal hypoxia, chronic illness, and ulcerogenic medications or lifestyle habits (e.g., NSAIDs, salicylates, corticosteroids, smoking, intake of caffeine, nicotine, or alcohol). It is important to treat the predisposing condition. Exacerbations and remissions can last for weeks to months.

Inflammatory bowel disease

• This category includes ulcerative colitis (UC) and Crohn disease (CD).
• UC affects the rectum and extends proximally, and is characterized by diffuse inflammation of the colonic mucosa and a relapsing, remitting course. UC is uncommon in people younger than 10 years old.
• CD may involve any or all parts of the entire GI tract from mouth to perianal area. Unlike UC, CD is characterized by skip lesions. The transmural inflammation often leads to fibrosis, causing intestinal obstruction. The inflammation can also result in sinus tracts that burrow through and penetrate the serosa, thereafter giving rise to perforations and fistulas. The peak age of onset is between 15 and 40 years.

Cholelithiasis/cholecystitis

• Cholelithiasis describes the entity of stones in the gallbladder (usually asymptomatic or an incidental finding). Biliary colic refers to the classic description of intermittent, recurrent, RUQ pain that resolves without intervention. This is usually caused by intermittent obstruction of the cystic duct due to cholelithiasis and contraction of a distended gallbladder.
• Cholecystitis refers to inflammation of the gallbladder precipitated by obstruction of bile through the cystic duct. Symptoms do not usually resolve spontaneously, and there are specific findings on diagnostic imaging. Cholecystitis may be acalculous (without stones) or calculous (with stones). Choledocholithiasis is the term describing a gallstone(s) in the common bile duct.
• Budd-Chiari syndrome (obstruction of hepatic veins) may present very similarly to acute cholecystitis with RUQ pain, and when it occurs it is generally related to hypercoaguable states, prolonged total parental nutrition, tumor, infection (e.g., tuberculosis, aspergillosis, filariasis, and echinococcus), or other mechanical causes. It is therefore important to keep in mind as a rare cause of RUQ pain in the correct clinical scenario.

Viral hepatitis
• The viral hepatitides include A, B, C, D, and E.
• Hepatitis A virus remains a significant etiology of acute viral hepatitis and jaundice, particularly in developing countries, in travelers to those countries, and in sporadic food-borne outbreaks in the Western world.
• Hepatitis B virus (HBV) frequently causes acute hepatitis and is the most common cause of chronic hepatitis in Africa and the Far East.
• Hepatitis C virus (HCV) represents the leading cause of chronic viral hepatitis in the Western world.
• Hepatitis D virus is a defective virus that needs the presence of hepatitis B to cause clinically recognizable disease.
• Hepatitis E virus represents a major cause of mortality in developing countries, especially among pregnant females.

Biliary dyskinesia

• Characterized by symptoms of biliary colic (intermittent, recurrent RUQ pain that resolves without intervention) in the absence of documented stones in the gallbladder; the diagnosis should be considered in those with symptoms suggestive of biliary colic but with negative laboratory tests and ultrasound in their workup for symptomatic choledolithiasis.
• Caused by abnormal or altered contraction of the gallbladder resulting in biliary colic. Patients frequently have gone through a comprehensive workup prior to being diagnosed with this entity; increasing recognition and testing for the disease has led to more frequent diagnosis in children.

Acute pancreatitis

• Refers to inflammation of the pancreas; it does not necessarily imply that infection is present.
• Excessive alcohol and gallstones are the most common causes of pancreatitis in adults; these causes are relatively less common in children, although they may still occur.

There are numerous other etiologies of pancreatitis in children, which can be categorized as follows:

Obstructive causes:

• Choledochal cyst causing abnormal pancreas and bile drainage; pancreas divisum (congenital)
• Gallstones
• Strictures
• Parasites (Ascaris lumbricoides)
• Tumors (intrinsic or external).

Nonobstructive causes:

• Trauma (blunt or sharp)
• Drug induced (e.g., corticosteroids, adrenocorticotropic hormones, estrogens including contraceptives, azathioprine, asparaginase, tetracycline, chlorothiazides, valproic acid)
• Hereditary pancreatitis
• End-stage renal disease
• Metabolic disorders (e.g., aminoaciduria, hyperlipoproteinemia types 1 and 5, hypercalcemia, porphyria).

Inflammatory causes:
Evaluation of abdominal pain in children

Overview

- Mumps
- UC
- Infectious mononucleosis
- Cystic fibrosis
- Scorpion venom
- Collagen vascular diseases
- Polyarteritis nodosa
- Systemic lupus erythematosus
- Idiopathic.

- Pediatric pancreatitis is rare, but the growing population of children with gallstones will likely increase future incidence.

Splenic infarction and cysts

- Cysts are classified as either primary or secondary (acquired). Primary cysts are usually congenital and have a true epithelial lining. Eighty percent of splenic cysts are pseudocysts related to infection, infarction, or trauma.[11] Most cysts are incidental diagnoses, although some patients may present with dull, left-sided abdominal pain. In pediatric patients, the most common splenic masses are congenital and/or acquired cysts.[12]

Abdominal trauma

- The third leading cause of death in pediatric trauma patients.[13] It is generally classified as penetrating or blunt. Occult blunt abdominal trauma should always be considered in the setting of vague or inconsistent history. Additionally, it is important to consider child abuse/nonaccidental trauma in this patient population (e.g., a kick to the abdomen). The liver, spleen, and kidneys are the most commonly injured intra-abdominal organs in blunt trauma. Most cases of blunt injury to the liver and spleen are managed nonoperatively.

- It is important to exclude duodenal and/or pancreatic injuries with bicycle handlebar injuries and/or direct blows to the abdomen. Hollow viscus injuries (e.g., stomach and intestines) are more common with penetrating trauma.

Genitourinary

Urinary tract infection (UTI)

- Infection may arise along any part of the urinary tract including the urethra, bladder, ureter, and kidney. Diagnosis and treatment is paramount to prevent potential long-term side effects, including renal or urinary tract scarring and hypertension.

- Estimates of the true incidence of UTI depend on rates of diagnosis and investigation. At least 8% of girls and 2% of boys will have had a UTI by the age of 7 years.[14] [15]

- Bacterial infections are the most common cause, particularly *Escherichia coli* infection.
Primary dysmenorrhea

- Dysmenorrhea, or painful menstruation, is one of the most common gynecologic conditions affecting females of reproductive age.[16]
- Primary dysmenorrhea is characterized by menstrual pain in the absence of pelvic pathology.

Nephrolithiasis

- Refers to stones that may be located anywhere in the genitourinary tract; the majority of stones are noted in the kidneys, followed by the bladder and ureter.
- Most patients have a predisposing factor, such as a family history of nephrolithiasis, high-risk diet (e.g., high oxalate intake), chronic disease (e.g., renal tubular acidosis), to name but a few.
- Stones less than 5 mm in diameter will generally pass spontaneously.

Testicular torsion

- Considered a urologic emergency caused by the twisting of the testicle on the spermatic cord, leading to constriction of the vascular supply and time-sensitive ischemia and/or necrosis of testicular tissue.[17]

Ruptured ovarian cyst

- Ovarian cyst rupture is rare and may occur in conjunction with torsion.
- Symptoms usually occur prior to the expected time of ovulation and may mimic ruptured ectopic pregnancy. Pain arises from local peritonitis secondary to hemorrhage.[18] [19] [20]

Ovarian torsion

- Although it can affect females of any age it most commonly occurs in the early reproductive years.
- In children, torsion of the ovary is often associated with the presence of an ovarian tumor, most commonly a teratoma.
- Twisting or torsion of the ovary compromises the arterial inflow and venous outflow, producing ischemia, which, if not relieved promptly, can affect the viability of the ovary.

Pelvic inflammatory disease (PID)

- Represents a spectrum of upper genital tract infections that includes any combination of endometritis, salpingitis, pyosalpinx, tubo-ovarian abscess, and pelvic peritonitis; usually caused by *Neisseria gonorrhoeae* or *Chlamydia trachomatis* and less commonly by normal vaginal flora including streptococci, anaerobes, and enteric gram-negative rods.
- Adolescents are at higher risk of developing PID compared with older women.[21] STDs are a key risk factor.
• PID in a young child should prompt workup for possible sexual abuse, as it is extremely rare for PID to occur in the absence of sexual activity.

Pregnancy complications

• Miscarriage and ectopic pregnancy should be a concern in any female of reproductive age presenting with lower abdominal pain, amenorrhea, and vaginal bleeding.
• Miscarriage is defined as an involuntary, spontaneous loss of a pregnancy before 22 completed weeks.[22] The majority of spontaneous miscarriages occur in the first trimester with less than 3% occurring in the second trimester.[23] The etiology can be divided into embryonic and/or maternal factors, although it is more likely to be multifactorial.
• Ectopic pregnancy is defined as a fertilized ovum implanting and maturing outside of the uterine endometrial cavity, with the most common site being the fallopian tube (97%), followed by the ovary (3.2%), and the abdomen (1.3%).[24] Age <18 years at first sexual encounter is associated with higher rates of ectopic pregnancy.[25] Mortality from ectopic pregnancy has declined, but still remains a danger.

Pulmonary

Primary respiratory illnesses such as pneumonia or empyema may present as abdominal pain in the pediatric population. Recurrent pneumonia in children is usually the result of a particular susceptibility, such as disorders of immunity and leukocyte function, ciliary function, anatomic abnormalities, or specific genetic disorders such as cystic fibrosis.[26]

Other

Functional abdominal pain

• Also referred to as nonspecific abdominal pain; pain is usually chronic or recurrent. Functional abdominal pain disorders are classified according to Rome IV criteria, which describe functional dyspepsia, irritable bowel syndrome, abdominal migraine, and functional abdominal pain—not otherwise specified.[27] [28]
• Typically affects children between 5 and 14 years of age.
• Family history of functional disorder common (irritable bowel syndrome, mental illness, migraine, anxiety).
Urgent considerations

(See Differential diagnosis for more details)

Although the causes of abdominal pain in children are frequently benign (e.g., constipation), there is always the potential for life- or organ-threatening conditions, which require urgent intervention.

GI emergencies

Acute appendicitis resulting in perforation

- Untreated acute appendicitis may progresses to ischemia, necrosis, and eventually perforation. The clinician may encounter a range of presentations. Patients often complain of abdominal pain localized to the RLQ; in more severe cases the pain may be diffuse (e.g., if a large perforation results in generalized peritonitis). Perforation should be considered when a patient presents with a long duration of symptoms and/or suspected appendicitis with marked systemic signs of illness (e.g., high fever [>101°F, 38.3°C], tachycardia, and anorexia).1[A]Evidence A CT scan of the abdomen may be useful in determining the extent of the inflammatory response as well as the presence of any collections that may be amenable to percutaneous drainage. Appendectomy is commonly performed for perforated appendicitis, although nonoperative management is also practiced in some centers. The procedure can be done with an open approach or laparoscopically. Referral to a children’s hospital or a pediatric surgeon should be considered for children younger than 5 years of age.30

Intestinal obstruction

- Urgency of intervention is dependent on the clinical severity of the obstruction. Nonstrangulated obstructions involve a loop of bowel that is partially or completely obstructed, but has adequate blood supply and is not necrotic. This type of obstruction is usually not associated with peritonitis, fever, or leukocytosis, but may be associated with abdominal distension, nausea, and vomiting. Although surgical intervention may be necessary, it is usually not urgent. However, prolonged delay may progress to strangulation. Strangulated obstructions are usually complete obstructions in which the blood supply to the bowel is cut off as a result of edema, twisting of the bowel, or adhesions. These usually demonstrate diffuse or local peritonitis, fever, and leukocytosis. Untreated, they progress to intestinal necrosis and/or perforation. Urgent surgical treatment is mandatory.

Intussusception

- May lead to venous obstruction and bowel-wall edema and can progress, if untreated, to bowel necrosis, perforation, and, rarely, death.31 32 Treatment should be initiated at the time of diagnosis. The goal is correction of hypovolemia and electrolyte abnormalities, and antibiotic administration, followed by urgent reduction. Reduction can be accomplished with contrast enema (air or contrast reagent) or by surgery.

Volvulus

- Malrotation with midgut volvulus is a surgical emergency, and bilious vomiting in any child should prompt concern for this condition until confirmed otherwise. With a corresponding history and physical
Evaluation of abdominal pain in children

Emergencies

Exam (bilious vomiting and feeding difficulty, especially in infants during the first month of life), no further diagnostic intervention is necessary and prompt surgical exploration is recommended. Ambiguous cases may proceed to an upper GI contrast study or abdominal CT scan. However, this should not preclude surgical intervention if clinical suspicion is high.

Fig-19

Incarcerated hernia

- Prompt attention should be paid to an incarcerated inguinal or umbilical hernia due to the danger of bowel strangulation (compromise of blood flow to the bowel with consequent bowel ischemia and gangrene). Incarceration, with or without strangulation, occurs if intra-abdominal contents become trapped in the protruding hernia sac. Clinically, the hernia is irreducible and tender. Associated symptoms may include nausea, vomiting, and generalized abdominal pain. In severe cases, fever, abdominal distension, and skin changes may be present. If strangulation is evident, surgery is required urgently to resect the gangrenous segment of bowel.

Fig-7

Necrotizing enterocolitis

- The most common medical/surgical emergency affecting neonates, particularly premature infants, especially those weighing less than 1500 g. Early intervention is mandatory to prevent morbidity and mortality due to multiple organ impairment. Signs and symptoms include feeding intolerance, apnea, lethargy, bloody stools, abdominal distension, tenderness, abdominal wall erythema, and bradycardia. Treatment may be medical or surgical, and is determined by severity of the clinical presentation.

Abdominal trauma

- The third leading cause of death in pediatric trauma patients. It is generally classified as penetrating or blunt. Most cases of blunt injury to the liver and spleen are managed nonoperatively. Indications for urgent surgery include hemodynamic instability despite adequate resuscitation, free air in the abdomen, penetrating injuries with fascial penetration, and peritonitis.

Genitourinary emergencies

Ruptured ectopic pregnancy

- If undiagnosed or incorrectly managed, a ruptured ectopic pregnancy may lead to maternal death due to rupture of the implantation site and intraperitoneal hemorrhage. The classic presentation includes lower abdominal pain, amenorrhea, and vaginal bleeding. Patients with a positive urine pregnancy test and the absence of an intrauterine pregnancy on transvaginal ultrasound are considered to have an ectopic pregnancy until confirmed otherwise. It is important not to delay care while waiting for an ultrasound. A quick and focused ultrasonographic exam to assess for the presence of free fluid or blood may be helpful when this diagnosis is suspected. Urgent laparoscopy with salpingectomy or salpingostomy is performed for a ruptured ectopic pregnancy.

Ovarian torsion

- Twisting or torsion of the ovary compromises the arterial inflow and venous outflow, producing ischemia, which, if not relieved, can affect the viability of the ovary. It presents with acute-onset lower abdominal pain and, frequently, nausea and vomiting. Symptoms may be intermittent and fluctuate in severity. It is not known how long an ovary can withstand ischemia without permanent damage (it may
be up to 72 hours or even longer, but definitive operative intervention should be undertaken as soon as possible.[34] [35]

Testicular torsion

- Should be ruled out in any male child presenting with abdominal pain.[17] [36] The twisting of the testis and spermatic cord causes obstruction of arterial inflow and venous drainage from the testis. It typically presents with sudden-onset testicular pain; however, younger boys may only complain of abdominal tenderness, nausea, and/or vomiting. Physical findings suggestive of testicular torsion include loss of the cremasteric reflex, diffuse testicular tenderness, elevated testes, and a horizontal rather than vertical position of the testes. Prompt recognition and early surgical intervention are necessary to prevent testicular loss. Manual detorsion may be attempted while preparations for surgery are being made. Diagnostic studies should not preclude operative intervention.
Step-by-step diagnostic approach

Evaluation of pediatric abdominal pain can prove a diagnostic challenge. Children may be limited in their ability to give an accurate history. Parents or guardians may also have difficulty interpreting the complaints of small children. In many cases, the causes are benign with few long-term sequela. However, some require rapid diagnosis and treatment in order to prevent significant morbidity or mortality. Consideration of the child’s age helps narrow the differential diagnoses to include pediatric-specific conditions.[37]

History

The clinician should determine early on whether the abdominal pain is acute or chronic in nature, as this will help indicate the urgency of treatment. Acute abdominal pain is usually a single episode that typically lasts from hours to days. The pain may vary in severity over time and is often localized and described as sharp and/or stabbing in nature. Conversely, chronic abdominal pain typically lasts days to weeks to months, and is usually dull, diffuse, and poorly localized. There may be pain-free intervals of variable duration, and when it recurs the pain may vary in intensity. In addition, the history should cover the following:

- Onset, frequency, duration, and time of day that the abdominal pain occurs: gastroenteritis lasting >10 days suggests parasitic or noninfectious cause; the onset and progression of mesenteric adenitis may be insidious or dramatic; recurrent, self-resolving episodes of pain are characteristic of biliary colic, whereas pain that is constant over 24 hours or more is suggestive of acute cholecystitis; sudden-onset flank pain can indicate nephrolithiasis or pyelonephritis
- Whether the pain is localized or diffuse: RLQ pain suggests appendicitis; evidence epigastric pain suggests peptic ulcer disease; diffuse pain may indicate perforation or peritonitis
- Whether the pain radiates or migrates between areas of the abdomen: abdominal pain radiating to the back is suggestive of cholecystitis or pancreatitis
- Any factors that make the pain better or worse, such as movement, food, or medication: in cholelithiasis/cholecystitis pain often occurs after eating (particularly fatty foods); epigastric pain due to peptic ulcer disease is usually related to eating meals
- The character of the pain: pain associated with peptic ulcer disease is dull rather than burning in nature; sharp or stabbing pain is typical of appendicitis
- The presence and severity of any associated symptoms such as: fever, nausea, vomiting, anorexia, diarrhea (gastroenteritis); fatigue, jaundice (viral hepatitis); lethargy, headache, cough, shortness of breath (pneumonia or empyema); pain elsewhere (e.g., sudden onset testicular pain suggests testicular torsion); blood in stool (ulcerative colitis, necrotizing enterocolitis, dysentery), and blood or bile in vomitus (small bowel obstruction)
- The presence of genitourinary symptoms: dysuria, frequency of micturition, and hematuria suggest a UTI; vaginal discharge is suggestive of pelvic inflammatory disease (PID); current menstruation may be indicative of dysmenorrhea
- History of trauma: whether blunt or penetrating, accidental or nonaccidental
- Travel history: travel to a developing country increases risk of viral hepatitis infection and infectious gastroenteritis
- Past medical history focusing on previous operations, medication use, immunizations, allergies, and current comorbidities: patients with sickle cell disease or cystic fibrosis are at higher risk of developing gallstones; patients with spina bifida, mental retardation, and cerebral palsy are prone to constipation; splenic infarction may be a consequence of sickle cell disease; recent or current upper respiratory tract infection is suggestive of mesenteric adenitis or pulmonary cause[38]
Evaluation of abdominal pain in children

Diagnosis

- Stooling patterns: infrequent bowel action or fecal incontinence is suggestive of constipation
- Dietary history: helpful when evaluating constipation; new or unusual food intake may support the diagnosis of gastroenteritis
- Family history: positive FHx is a risk factor for inflammatory bowel disease as well as nephrolithiasis
- Social and psychiatric history including family dynamics: may help determine if pain is functional or due to organic cause; psychological factors (e.g., depression, abuse, attention deficit disorder, oppositional disorder), weaning, toilet training, start of schooling, or other causes of stress may play a role in constipation
- Sexual history in females of reproductive age: adolescents may avoid answering sensitive questions regarding sexual history and drug use truthfully in the presence of parents or guardians; therefore, it may be appropriate to conduct some parts of the history with the adolescent alone.

Physical exam

This should be performed in a comfortable and nonthreatening manner. Children may need to be distracted by parents or guardians in order to obtain an accurate exam. In younger children, localization of the abdominal pain may be difficult. Consideration of vital signs should be based on age-appropriate normal values. Because pediatric abdominal pain may originate from other areas of the body (e.g., genitals or lungs), a comprehensive physical exam is necessary, including performing a rectal exam and checking stool for occult blood (guaiac test). Pelvic exam is not routinely performed; history is usually a guide and digital exam should be reserved for adolescents who are sexually active.

All ages

- A diagnosis of constipation should be considered when an otherwise well child has mild abdominal tenderness, and stool in the rectum on digital rectal exam. In severe cases abdominal distension may be present with a palpable fecal mass per abdomen or rectum. The presence of an anal fissure and/or hemorrhoids (rare in children; may be mistaken for skin tags from Crohn disease [CD]), imperforate anus or anal stenosis (particularly in a neonate or infant) may provide further diagnostic clues. Children with spina bifida, mental retardation, and cerebral palsy are also prone to constipation, and features of these conditions may be obvious on exam (e.g., sacral dimples or pits and/or tags/tufts indicative of abnormality of spinal cord). Psychological assessment may explain why symptoms are intractable in the absence of a severe physiologic predisposition.

[Fig-20]

- Patients presenting with central abdominal pain, with or without guarding and rigidity, that settles in the RLQ should arouse suspicion of appendicitis.1(A)Evidence Acute mesenteric adenitis often resembles acute appendicitis; however, pain in the abdomen is usually diffuse with tenderness not localized to the RLQ. Guarding may be present but rigidity is usually absent. Generalized lymphadenopathy is common and signs of an upper respiratory tract infection may be present (e.g., hyperemic pharynx or oropharynx suggesting pharyngitis).
- Patients with gastroenteritis usually exhibit diffuse abdominal pain without evidence of peritonitis (no guarding or rebound tenderness). Abdominal distension and hyperactive bowel sounds are a common finding. It is important to determine whether signs of volume depletion are present (tachycardia, hypotension, dry mucous membranes, poor capillary refill, sunken fontanelle in infants). The presence of mucus in the stool suggests a bacterial or parasitic etiology. Blood in the stool is indicative of dysentery or hemolytic uremic syndrome.
- Intussusception should be suspected in an infant between 3 and 12 months of age presenting with colicky abdominal pain, flexing of the legs, fever, lethargy, and vomiting. Henoch-Schonlein purpura
(HSP) may be the initiating factor in an older child (usually <11 years of age), and therefore signs of HSP should be sought (rash of palpable purpura, blood in the stools).

• The presence of abdominal distension and tenderness associated with decreased or absent bowel sounds is strongly suggestive of large bowel obstruction. The presence of bilious vomiting (partial obstruction) or without (complete obstruction) the passage of stool/flatus suggests small bowel obstruction.

• The clinical presentation of peptic ulcer disease in children >6 years of age mimics adults and should be suspected in a child presenting with epigastric pain with or without acute or chronic blood loss (pallor on exam).

• Ulcerative colitis often presents with bloody diarrhea, whereas this is an unusual presentation in CD. Both conditions cause cramping abdominal pain, anorexia, and weight loss when they present late in the course of the disease. Extraintestinal manifestations of inflammatory bowel disease may be evident (e.g., iritis, arthritis, sacroiliitis, erythema nodosum, pyoderma gangrenosum). Depending on the intestinal location of CD, it may mimic other disease processes such as acute appendicitis.

• Fever may be the only presenting sign of a UTI, especially in the younger age group, and UTI should therefore be a top differential in children between 2 months and 2 years of age with fever. Abdominal or flank pain is a more common finding in older children. High fever is suggestive of pyelonephritis; it is estimated that in children presenting with suspected UTI, up to two-thirds have concurrent pyelonephritis.[39] [40]

• Cholecystitis is often associated with fever. Jaundice is rare with cholelithiasis or acute cholecystitis and, if present, suggests an obstruction of the common bile duct. Tenderness in the RUQ is a classic sign of gallbladder disease, as is Murphy sign (cessation of inspiration during concurrent deep RUQ palpation).

• Patients with biliary dyskinesia usually present in a similar fashion to those with cholelithiasis and cholecystitis and may have RUQ tenderness on palpation. Physical exam findings can be equivocal.

• Patients with splenic infarction typically present with fever as well as left-sided abdominal pain; occasionally patients may be asymptomatic. Pain may also be reported in the left side of the chest or the left shoulder. Those with a splenic cyst are either asymptomatic or present with dull left-sided abdominal pain in the absence of fever.[41]

• Tenderness in the epigastric or upper abdominal quadrants of the abdomen is typical of pancreatitis. With more severe disease systemic signs such as fever, tachycardia, and hypotension are usually present. Patients may lie with their knees and hips flexed and avoid moving. It is important to note that, in younger patients with pancreatitis (<3 years of age), abdominal tenderness may not be the main finding; these patients may demonstrate increased irritability and abdominal distension. With hemorrhagic pancreatitis, discoloration may be noted around the umbilical area (Cullen sign) or in the flanks (Grey-Turner sign) due to blood tracking along defined fascial planes.

• Abdominal tenderness and/or renal angle tenderness associated with gross or macroscopic hematuria usually indicate underlying nephrolithiasis.

• The presence of cyanosis, tachypnea, decreased breath sounds on auscultation, dullness on percussion (indicates consolidation), and abdominal tenderness and distension without guarding or rebound, should arouse suspicion of a pulmonary cause such as pneumonia or empyema.

• Testicular torsion is likely in any male child with abdominal tenderness plus loss of the cremasteric reflex, diffuse testicular tenderness, elevated testes, and a horizontal rather than vertical position of the testes on exam. Torsion of a testicular appendage may be confused with testicular torsion; however,
Evaluation of abdominal pain in children

Diagnosis

it does not compromise the viability of the testes and frequently requires only supportive care. Pain may develop more gradually (over days to weeks) and frequently is pinpoint (superior pole of testes). In addition, systemic symptoms such as nausea and vomiting are not usually present.

[Fig-13]

[Fig-14]

[Fig-15]

• The presence on physical exam of jaundice associated with abdominal tenderness, hepatomegaly (splenomegaly may also be present), and lymphadenopathy, particularly in a child of school age, should arouse suspicion of viral hepatitis (commonly hepatitis A).

• Abdominal trauma should be considered when abdominal pain is out of proportion to physical exam findings. Signs of accidental (e.g., seatbelt mark suggesting a motor vehicle accident) and nonaccidental injury (particularly if history is suspicious) should be sought (e.g., cigarette burns, subdural hemorrhages in an infant/young toddler). Blood at the urethral meatus, or hematuria, may suggest urinary tract or kidney injury.

• If clinical findings are minimal and the child appears well, a diagnosis of functional abdominal pain should be considered. Diagnostic criteria for functional abdominal pain are symptom based, not physical exam or laboratory based.[27]

Infants and toddlers

• In a neonate, the triad of abdominal distension, delayed passage of meconium (not occurring in the first 36 hours of life), and vomiting is highly suggestive of Hirschsprung disease. Necrotizing enterocolitis should be considered in a premature neonate weighing less than 1500 g. Early signs may include inability to tolerate feeds, abdominal distension and tenderness, blood in the stool, and abdominal wall erythema. In severe cases, systemic signs of sepsis may be present. A neonate presenting with bilious vomiting, with (partial obstruction) or without (complete obstruction) the passage of meconium, is highly suggestive of small bowel obstruction. Causes such as meconium ileus, intestinal atresia, and midgut volvulus should be excluded with further investigations.

• Meckel diverticulum should be considered in a child <2 years old with abdominal tenderness (Meckel diverticulitis); hematochezia, typically dark red, maroon, or “red currant jelly” stools (indicates intestinal bleeding as they contain heterotopic gastric tissue); or signs of obstruction such as nausea, vomiting, and obstipation (intussusception, volvulus, or herniation can result).

Reproductive age

• Ectopic pregnancy and miscarriage should be suspected in any female of reproductive age presenting with lower abdominal pain, amenorrhea, and vaginal bleeding. Pelvic exam may reveal a mass, eliciting cervical motion tenderness if hemoperitoneum is present; tubal rupture can cause hemodynamic instability. Clinical features of a ruptured ovarian cyst usually occur prior to the expected time of ovulation and may mimic ectopic pregnancy. Pain arises from local peritonitis secondary to hemorrhage.[18] [19] [20] Peritonism may be present in lower abdomen and pelvis; adnexal size is unremarkable due to collapsed cyst. The presence of a tender pelvic mass associated with nausea and vomiting may suggest ovarian torsion. In addition, in patients old enough to undergo pelvic exam, cervical motion tenderness may be elicited; typically no vaginal discharge is present, but there may be some mild to moderate vaginal bleeding.

• Physical findings of PID vary widely and may include lower abdominal tenderness, adnexal tenderness, and cervical motion tenderness. Fever and cervical or vaginal discharge may also be
Evaluation of abdominal pain in children

**Diagnosis**

If suspected in a young child, signs of sexual abuse should be sought. Patients with PID may also present with RUQ pain resulting from inflammation of the liver capsule or diaphragm, referred to as Fitz-Hugh-Curtis syndrome. This is secondary to an ascending infection. Referred pain to the right shoulder may result from irritation of the diaphragm.[21] [42] [43] Primary dysmenorrhea should be considered if lower abdominal tenderness is associated with current menstruation.

**Laboratory tests**

Challenges in the clinical evaluation of abdominal pain in the pediatric patient mean laboratory and imaging studies can play an important role.

Initial tests should include a CBC (useful in evaluating infection and inflammation) and complete chemistry panel (electrolyte disturbances associated with GI causes are common). Urinalysis is essential to exclude underlying UTI or hematuria (associated with nephrolithiasis, UTI, hemolytic uremic syndrome, urinary tract or kidney injury) and should be performed in children of all ages presenting with abdominal pain. For females of reproductive age a urine pregnancy test and/or serum beta-hCG is necessary to exclude miscarriage and ectopic pregnancy. Type and screen is essential when a ruptured ectopic pregnancy is suspected, as the rhesus status of the mother determines the need for RhoGAM administration. LFTs are helpful baseline investigations, when considering a hepatobiliary or pancreatic cause (e.g., viral hepatitis, cholecystitis, pancreatitis). Serum amylase and lipase is indicated if pancreatitis is suspected. Although nonspecific, ESR and CRP may suggest underlying infection or inflammation. Furthermore, these inflammatory markers correlate closely with disease activity in cases of inflammatory bowel disease.

Stool microscopy and culture may be helpful in determining an infectious etiology of gastroenteritis. Risk factors and features of the clinical presentation help guide the choice of tests for specific pathogens. The 2017 Infectious Disease Society of America (IDSA) guideline on infectious diarrhea recommends that when there is fever or bloody diarrhea, investigations for enteropathogens for which antimicrobial agents may confer clinical benefit (including *Salmonella enterica* subspecies, *Shigella*, and *Campylobacter*) should be done.[44] Blood cultures are indicated when sepsis is a concern. The IDSA guideline also recommends blood cultures: in children with infectious diarrhea who are <3 months of age or who are immunocompromised; when enteric fever is suspected (including travel to enteric fever-endemic area, or contact with travelers from enteric fever-endemic areas who have a febrile illness of unknown etiology); when there are systemic manifestations of infection; and with high-risk conditions such as hemolytic anemia.[44] Urine culture is necessary if urinalysis is suggestive of a UTI. Sputum culture is usually reserved for those patients with suspected pneumonia. Aspiration of frank pus on thoracentesis is diagnostic of empyema. In cases of patients with suspected peptic ulcer disease, *Helicobacter pylori* breath test or stool antigen test may be helpful. Serologic markers (perinuclear antineutrophil cytoplasmic antibody and antiasaccharomyces cerevisiae antibody) may be particularly useful for differentiating between CD and ulcerative colitis in the pediatric population. Polymorphonuclear leukocytes (PMNs) seen on wet mount of vaginal secretions confirms vaginal infection in cases of PID. In all patients with PID, it is important to screen for other STDs. Therefore, HIV serology, syphilis serology, hepatitis studies, and genetic probe or culture of vaginal secretions for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* are indicated. In patients with suspected exposure to or symptoms of hepatitis A, B, C, D, and E, the following laboratory tests are warranted: hepatitis A antibody IgM, hepatitis B serology or viral load, hepatitis C serology or viral load, hepatitis D and E serologies. A coagulation profile, including PT and INR, is usually necessary in cases of suspected viral hepatitis to measure liver synthetic function.
Imaging and other investigations

Imaging studies are guided by history and physical exam findings. Plain abdominal x-rays are often nonspecific but may suggest the presence of an obstruction; fecal impaction can be detected on x-ray, as well as duodenal atresia. In addition, if sufficiently radio-opaque, it may be possible to identify gallstones or urinary stones on a plain abdominal film. This is often the initial test, as it can be performed quickly. Supine and upright films are usually requested. Free air under the diaphragm suggests perforation and requires immediate surgical evaluation. Chest x-ray should be ordered if perforation is suspected or a respiratory cause such as pneumonia or empyema is likely.

Ultrasound scans avoid radiation exposure and are typically better tolerated than other imaging modalities such as CT scan. An experienced pediatric radiologist may be able to utilize ultrasound in all regions of the body (abdomen, chest, testicles). Ultrasound scans are considered particularly useful in evaluating pain in the RUQ (i.e., gallbladder disease), and lower abdominal pain (pelvic pain) in females. Color Doppler may be helpful in determining ovarian blood flow in cases of suspected ovarian torsion. Testicular ultrasound (using power Doppler ultrasound and/or gray-scale ultrasound) should be able to diagnose testicular torsion and provide information on the vascular integrity of the testis. Ultrasound of the urinary tract (including kidneys) is of benefit when wanting to exclude anatomic abnormalities (e.g., when UTI is present) or nephrolithiasis and associated complications such as hydronephrosis.

Focused abdominal sonography for trauma (FAST) may be useful in children with blunt abdominal trauma who are hemodynamically unstable.[45] The presence of large amounts of free fluid indicates a need for immediate operative intervention. FAST in hemodynamically stable patients has a less certain impact, as a negative scan does not preclude injury. A large multi-institutional study at pediatric trauma centers demonstrated poor FAST sensitivity (28.6%) in normotensive patients.[46] Though specificity was high (91.1%), results of FAST rarely changed management. A randomized trial comparing FAST with standard care in hemodynamically stable children and adolescents with blunt torso trauma also found no significant difference in the proportion of abdominal CT scans, missed intra-abdominal injuries, length of stay in the emergency department, and median hospital costs.[47] Abdominal CT scan with intravenous contrast is the diagnostic test of choice for the identification of solid organ injuries, especially to the liver, kidney, and/or spleen. Oral contrast is usually not necessary when scanning a patient for trauma.

Ultrasound is recommended as the first imaging test for suspected appendicitis.[48] CT with contrast may be appropriate after nondiagnostic ultrasound; however, radiation exposure with its risk of malignancy should be considered. MRI avoids ionizing radiation and has similar or better sensitivity and specificity than CT, though availability and longer scan times may limit its utility.[49]

In general, for investigation of abdominal pain in children, CT scan of the abdomen and pelvis, with or without contrast, may provide a high yield of information, but radiation exposure should be considered.[50] Sedation or general anesthesia may be required in some children.

GI contrast studies (upper-GI or barium enema studies) are routinely used in place of CT scans, especially in infants. In evaluation of intestinal obstruction, clinical suspicion should direct which contrast study should be performed first and will be most informative.

Endoscopy (esophagogastroduodenoscopy or colonoscopy) with biopsy may be required to evaluate mucosa-based diseases, such as peptic ulcer disease and inflammatory bowel disease. Rectal biopsy and anorectal manometry help confirm the diagnosis of Hirschsprung disease. These procedures may be particularly challenging when performed in a newborn.
Diagnosis of biliary dyskinesia is confirmed by hepatobiliary iminodiacetic acid (HIDA) scan with an ejection fraction <35%. It is important to note that the cutoff of <35% is not universally accepted; some consider an ejection fraction <15% to be more predictive of success of surgical treatment (i.e., cholecystectomy).[51] HIDA scan is also considered a useful adjunct in the diagnosis of cholecystitis. Technetium-99m pertechnetate scan is considered the most useful method to diagnose a suspected Meckel diverticulum; this scan identifies ectopic gastric mucosa as tracer is taken up by parietal cells.

The American Academy of Pediatrics (AAP) recommend that a voiding cystourethrogram is indicated in children between 2 and 24 months of age following an initial UTI if renal and bladder ultrasonography reveals hydronephrosis, scarring, or other findings that would suggest either high-grade vesicoureteral reflux or obstructive uropathy, as well as in other atypical or complex clinical circumstances. Further evaluation should be conducted if there is a recurrence of febrile UTI.[52] Other guidelines have slightly different recommendations.[53] [54]

Full skeletal x-rays (skeletal survey) identify previous skeletal injuries and should be obtained if there is a high suspicion of nonaccidental trauma. This should only be performed to provide adjunctive diagnoses to support an initial injury and suspicion of abuse.

Diagnostic laparoscopy may be necessary to confirm diagnosis of PID as it allows direct visualization of the gynecologic and abdominal structures.

[VIDEO: Peripheral venous cannulation: animated demonstration ]

[VIDEO: Venepuncture and phlebotomy: animated demonstration ]

[Fig-5]

[Fig-6]

[Fig-9]

[Fig-8]

[Fig-2]

[Fig-21]

[Fig-10]
## Differential diagnosis overview

### Common
- Constipation
- Acute appendicitis
- Gastroenteritis
- Urinary tract infection
- Abdominal trauma (blunt or penetrating)
- Cholelithiasis/cholecystitis
- Primary dysmenorrhea
- Pneumonia
- Functional abdominal pain

### Uncommon
- Intussusception
- Meckel diverticulum
- Mesenteric adenitis
- Hirschsprung disease
- Ulcerative colitis
- Crohn disease
- Small bowel obstruction
- Volvulus
- Large bowel obstruction
- Necrotizing enterocolitis
- Peptic ulcer disease
## Uncommon

<table>
<thead>
<tr>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral hepatitis</td>
</tr>
<tr>
<td>Biliary dyskinesia</td>
</tr>
<tr>
<td>Acute pancreatitis</td>
</tr>
<tr>
<td>Splenic infarction/cysts</td>
</tr>
<tr>
<td>Nephrolithiasis</td>
</tr>
<tr>
<td>Testicular torsion</td>
</tr>
<tr>
<td>Ovarian torsion</td>
</tr>
<tr>
<td>Ruptured ovarian cyst</td>
</tr>
<tr>
<td>Pelvic inflammatory disease</td>
</tr>
<tr>
<td>Pregnancy complications</td>
</tr>
<tr>
<td>Empyema</td>
</tr>
</tbody>
</table>
## Differential diagnosis

### Common

#### ◊ Constipation

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>poor diet and fluid intake; hx of cerebral palsy, mental retardation, or spinal cord problems; psychological factors (e.g., depression, abuse, ADHD, autism, oppositional disorder), weaning, toilet training, start of schooling or other causes of stress may be present; vague abdominal pain, painful defecation (infants may extend their legs and squeeze anal and buttock muscles to prevent stooling; toddlers often rise up on their toes, shift back and forth, and stiffen their legs and buttocks), fecal incontinence; medication with known constipating agents (e.g., iron supplements); obesity, low birth weight</td>
<td>exam findings may be minimal (mild abdominal tenderness, stool in rectum); abdominal distension in severe cases or in small children; fecal mass palpable on abdominal or rectal exam; absence of peritonitis (guarding or rebound tenderness); sacral dimples or pits and/or tags/tufts indicative of spinal cord abnormality (i.e., spina bifida); anal fissure, hemorrhoids (rare in children; may be mistaken for skin tags from Crohn disease); imperforate anus or anal stenosis; evidence of depression, abuse, autism, ADHD, or oppositional disorder</td>
<td><strong>abdominal x-ray:</strong> stool visible throughout colon Stool throughout the colon does not rule out other etiologies of abdominal pain. [Fig-20]</td>
<td><strong>CT scan abdomen:</strong> stool throughout colon; absence of other etiologies of abdominal pain</td>
</tr>
</tbody>
</table>

### ≈ Acute appendicitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx of sharp or stabbing periumbilical pain that migrates to the RLQ; anorexia, fever, vomiting, and/or diarrhea may be present; occurs in all age groups but is rare in infants</td>
<td>patient lies still, tries not to move (especially in severe cases with significant peritoneal irritation); positive McBurney sign (RLQ pain and tenderness to palpation at a point two-thirds along a line from the umbilicus to the anterior superior iliac spine); positive Rovsing sign (pain in the RLQ in</td>
<td>✶<strong>CBC:</strong> normal or elevated WBC WBC may be &gt;15,000 cells/mm³³. May see leukocytosis with neutrophilia. However, a normal WBC count does not exclude appendicitis.</td>
<td>✶<strong>abdominal ultrasound:</strong> dilated appendix, free fluid; appendicolith may be present Ultrasound is the preferred method of assessment.[48] [56] However, a negative ultrasound does not necessarily rule out</td>
</tr>
</tbody>
</table>
## Acute appendicitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>response to left-sided palpation, suggesting peritoneal irritation; positive psoas sign (pain in the RLQ when child placed on left side and right hip gently hyperextended, suggesting irritation to the psoas fascia and muscle); positive obturator sign (RLQ pain on internal rotation of the flexed right thigh); rectal tenderness and/or palpable abscess in RLQ</td>
<td><strong>urinalysis</strong>: normal If positive for red cells, white cells, or nitrates an alternative diagnosis such as renal colic or UTI should be considered. The specific gravity of urine can sometimes suggest volume status.</td>
<td>appendicitis as a cause of abdominal pain.[57] In children, specificity of ultrasound is similar to that of CT (0.91 vs. 0.92).[58] It may elicit a sonographic McBurney sign (pain on compression of the appendix that is visualized on ultrasound).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>CT scan abdomen and pelvis</strong>: dilated appendix, free fluid, mesenteric stranding, or appendicolith; abscess or phlegmon consistent with perforated appendicitis Useful when body habitus of patient makes ultrasound difficult or when ultrasound and/or clinical evaluation are inconclusive. CT has greater sensitivity than ultrasound (0.96 vs. 0.89).[58] Radiation exposure should be considered.[50]</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>urine pregnancy test</strong>: negative In adolescent girls, a pregnancy test should be performed to exclude ectopic pregnancy.</td>
<td></td>
</tr>
</tbody>
</table>
## Common

### Acute appendicitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>vague abdominal pain with nausea and vomiting; diarrhea with or without mucus in stool; recent travel or contact with sick individual(s) or ingestion of suspected food and drink; &gt;10 days suggests parasitic or noninfectious cause; fever, chills, myalgia, rhinorrhea, upper respiratory symptoms</td>
<td>diffuse abdominal pain without evidence of peritonitis (no guarding or rebound tenderness); abdominal distension; hyperactive bowel sounds; mucus in stool (bacterial or parasitic); signs of volume depletion (tachycardia, hypotension, dry mucous membranes, poor capillary refill, sunken fontanelle in infants); low-grade fever, lethargy and/ or irritability, reduced response to noxious stimuli, abnormal</td>
<td>»serum electrolytes: normal or low sodium and potassium</td>
<td>contrast is typically not necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>»stool microscopy and culture: fecal leukocytes; ova or parasites; culture positive for infectious agent in bacterial gastroenteritis</td>
<td>»MRI scan abdomen and pelvis: dilated appendix; hyperintensity of the luminal contents of the appendix, periappendiceal tissue and thickened wall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fecal leukocytes and stool culture may be helpful in children presenting with dysentery and to demonstrate invasive pathogens such as</td>
<td>In children, MRI has excellent sensitivity (0.97) and specificity (0.96); however, there are fewer studies evaluating its test characteristics. [58] It is increasingly used due to the potential hazards of ionizing radiation from CT.</td>
</tr>
</tbody>
</table>

### Gastroenteritis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>vague abdominal pain with nausea and vomiting; diarrhea with or without mucus in stool; recent travel or contact with sick individual(s) or ingestion of suspected food and drink; &gt;10 days suggests parasitic or noninfectious cause; fever, chills, myalgia, rhinorrhea, upper respiratory symptoms</td>
<td>diffuse abdominal pain without evidence of peritonitis (no guarding or rebound tenderness); abdominal distension; hyperactive bowel sounds; mucus in stool (bacterial or parasitic); signs of volume depletion (tachycardia, hypotension, dry mucous membranes, poor capillary refill, sunken fontanelle in infants); low-grade fever, lethargy and/ or irritability, reduced response to noxious stimuli, abnormal</td>
<td>»serum electrolytes: normal or low sodium and potassium</td>
<td>»BUN and creatinine: normal; may have evidence of renal failure in patients with hemolytic uremic syndrome</td>
</tr>
<tr>
<td></td>
<td></td>
<td>»stool microscopy and culture: fecal leukocytes; ova or parasites; culture positive for infectious agent in bacterial gastroenteritis</td>
<td>»urine dipstick: may detect presence of albumin or blood in hemolytic uremic syndrome</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fecal leukocytes and stool culture may be helpful in children presenting with dysentery and to demonstrate invasive pathogens such as</td>
<td>»CBC: variable Eosinophilia with viral or parasitic etiology, peripheral eosinophilia suggests eosinophilic gastroenteritis;</td>
</tr>
</tbody>
</table>
## Common

### Gastroenteritis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>temperature (elevated or low)</td>
<td></td>
<td><em>Clostridium difficile</em></td>
<td>bandemia with bacterial etiology; anemia and/or thrombocytopenia if hemolytic uremic syndrome.</td>
</tr>
<tr>
<td>Ova and parasite studies are useful if history suggests camping, travel to other countries, or long-term disease.</td>
<td></td>
<td></td>
<td>Routinely ordered to help differentiate alternative disease processes. However, in true gastroenteritis, only indicated in patient with systemic infection.</td>
</tr>
<tr>
<td>In patients who have taken previous antibiotics or have contact with an individual with <em>C difficile</em> diarrhea, it is important to test for <em>C difficile</em> toxin. Untreated <em>C difficile</em>-related diarrhea can have serious consequences (e.g., toxic megacolon).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Blood culture:** may be positive for infectious agent in presence of sepsis Important to order if concern for sepsis. The 2017 Infectious Disease Society of America also recommends blood cultures: in children with infectious diarrhea who are <3 months of age or who are immunocompromised; when enteric fever is suspected (including travel to an enteric fever-endemic area, or contact with travelers from enteric fever-endemic areas who have a febrile illness of unknown etiology); when there are systemic manifestations of infection; and with high-risk conditions.
## Diagnosis

### Common

#### Gastroenteritis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>such as hemolytic anemia.[44]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>» endoscopy with biopsy: variable Indicated only when eosinophilic gastroenteritis a concern (condition affecting the GI tract with eosinophil-rich inflammation without a known cause of the eosinophilia). [2]</td>
</tr>
</tbody>
</table>

### Urinary tract infection

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>neonates and infants: fever, vomiting, lethargy, irritability, and poor feeding; older children: dysuria, urinary frequency and urgency, back pain if pyelonephritis</td>
<td>variable; fever &gt;102.2°F (39°C); suprapubic and/or costovertebral angle tenderness; irritability; foul-smelling urine; gross hematuria</td>
<td>» urine dipstick: positive leukocyte esterase and/or positive nitrite Urinalysis should be performed within 30 minutes of obtaining specimen. First morning voids may be best for yielding a positive nitrite test. Positive leukocyte esterase alone: sensitivity 84%, specificity 77%, likelihood ratio (LR)+ 5:5, LR- 0:26.[59] [60] Positive nitrite alone: sensitivity 58%, specificity 99%, LR + 15:9, LR- 0:51.[59] [60] This test has a</td>
<td>» renal ultrasound: abnormalities may be present such as dilatation of the renal pelvis or ureters, or distension of thick-walled bladder; renal abscess: area of radiolucency to the renal parenchyma with local hypoperfusion on color Doppler; perinephric abscess: hypoechoic fluid Initially performed to look for any anatomic abnormalities of the urinary tract. Also may be performed to look for evidence of a renal or perinephric abscess when the urinalysis and culture are negative but</td>
</tr>
</tbody>
</table>
### Common

#### Urinary tract infection

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>high positive predictive value.</td>
<td>abdominal pain and fever persist.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive for either leukocyte esterase or nitrite: sensitivity 92%, LR- 0:2. [59] [60] This test is best at ruling out disease.</td>
<td>voiding cystourethrogram (VCUG): if vesicoureteral reflux is present: contrast seen ascending out of the bladder into the upper urinary tract. The American Academy of Pediatrics (AAP) recommend that a VCUG is indicated in children between 2 and 24 months of age following an initial UTI if renal and bladder ultrasonography reveals hydronephrosis, scarring, or other findings that would suggest either high-grade vesicoureteral reflux or obstructive uropathy, as well as in other atypical or complex clinical circumstances. Further evaluation should be conducted if there is a recurrence of febrile UTI. [52] Other guidelines have slightly different recommendations. [54] [53]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positive for leukocyte esterase and nitrite: LR+ 28:2. [60] This test is best at ruling in disease.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>urine microscopy:</strong> &gt;4 WBC per high-power field or any bacteria Microscopic analysis is more accurate; however, a urine dipstick analysis may suffice.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pyuria (the presence of WBC): sensitivity 78%, specificity 87%; LR- 0:27. [59] [60] Bacteriuria: sensitivity 88%, specificity 93% LR+ 14:7, LR- 0:19. [59] [60]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Centrifugation reduces the specificity of these tests.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>urine culture:</strong> suprapubic aspirate: &gt;1000 colony-forming units (CFU)/mL; catheter: &gt;10,000 CFU/mL; clean-catch</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are 5 grades of vesicoureteral reflux, based on the extent of reflux and changes in
## Common

<table>
<thead>
<tr>
<th>Urinary tract infection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Exam</strong></td>
</tr>
<tr>
<td>1st Test</td>
</tr>
<tr>
<td>Other tests</td>
</tr>
</tbody>
</table>

### Urinary tract infection

**History**

- hx of trauma; abdominal pain may be out of proportion to exam findings; may have multiple complaints; hx may suggest child abuse or nonaccidental trauma (e.g., inconsistent or changing history)

**Exam**

- abdominal tenderness; skin marks reflecting mechanism of injury (e.g., seatbelt mark); referred left shoulder pain (due to splenic injury); blood at the urethral meatus, or hematuria (indicate urinary tract or kidney injury); signs of nonaccidental trauma may be present (e.g., cigarette burns, subdural hemorrhages

**1st Test**

- midstream: >100,000 CFU/mL
- Suprapubic puncture of the bladder is considered by some to be the ideal way to collect an uncontaminated specimen. Considered safe in children ≤2 years old (at this age the bladder is primarily intra-abdominal). However, this is unnecessary in routine evaluations.

**Other tests**

- catheterization may be necessary to get a clean-catch urine sample.
- Urine collected from urinary bags is likely to be contaminated.
- ureteral dilatation and tortuosity.
- Vesicoureteral reflux correlates with subsequent scar formation in the kidneys, with later renal morbidity.

**Abdominal trauma (blunt or penetrating)**

<table>
<thead>
<tr>
<th>History</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Exam</strong></td>
</tr>
<tr>
<td><strong>1st Test</strong></td>
</tr>
<tr>
<td><strong>Other tests</strong></td>
</tr>
</tbody>
</table>

### Abdominal trauma (blunt or penetrating)

**History**

- hx of trauma; abdominal pain may be out of proportion to exam findings; may have multiple complaints; hx may suggest child abuse or nonaccidental trauma (e.g., inconsistent or changing history)

**Exam**

- abdominal tenderness; skin marks reflecting mechanism of injury (e.g., seatbelt mark); referred left shoulder pain (due to splenic injury); blood at the urethral meatus, or hematuria (indicate urinary tract or kidney injury); signs of nonaccidental trauma may be present (e.g., cigarette burns, subdural hemorrhages

**1st Test**

- CBC: may be normal or show decreased hematocrit and hemoglobin
- Patients with acute-onset hemorrhage may have normal hematocrit and hemoglobin values.

**Other tests**

- chest x-ray: may be normal or show compatible thoracic injury (e.g., pulmonary contusion, pneumothorax); free air under diaphragm (suggests perforation)
- abdominal ultrasound: variable; may show free fluid in abdominal cavity
- Focused abdominal sonography for trauma
# Common

## Abdominal trauma (blunt or penetrating)

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>in an infant/young toddler</td>
<td>This is the diagnostic test of choice for the identification of solid organ injuries, especially to liver, kidney, and/or spleen. Oral contrast is usually not necessary when scanning a patient for trauma.</td>
<td>(FAST) may be useful in patients with blunt abdominal trauma who are hemodynamically unstable.[45] Presence of large amounts of free fluid indicates need for immediate operative intervention. FAST in hemodynamically stable patients with blunt abdominal trauma has a less certain impact as a negative scan does not preclude injury.[46]</td>
<td></td>
</tr>
</tbody>
</table>

» **full skeletal x-rays:** variable
Skeletal survey identifies previous skeletal injuries and should be obtained if there is a high suspicion of nonaccidental trauma. This should only be performed to provide adjunctive diagnoses to support an initial injury and suspicion of abuse.

## Cholelithiasis/cholecystitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>recurrent, episodic RUQ pain, may radiate to the back and is classically colicky in nature; often occurs after eating, particularly fatty foods; nausea, right subcostal region tenderness; positive Murphy sign (during palpation, deep inspiration causes pain to suddenly become worse and produces</td>
<td><strong>RUQ ultrasound:</strong> gall stones; thickened gallbladder wall (&gt;4 mm); pericholecystic fluid; may also see ultrasonographic Murphy sign</td>
<td><strong>abdominal x-ray:</strong> opacities in RUQ consistent with gallstones If sufficiently radio-opaque, it may be</td>
<td></td>
</tr>
</tbody>
</table>
## Evaluation of abdominal pain in children

### Diagnosis

#### Common

<table>
<thead>
<tr>
<th>Cholelithiasis/cholecystitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td>vomiting, and anorexia may be present; persistent pain and fever may signify acute cholecystitis; referred pain to right shoulder can occur; presence of risk factors (e.g., sickle cell disease, cystic fibrosis)</td>
</tr>
<tr>
<td><strong>Exam</strong></td>
</tr>
<tr>
<td>inspiratory arrest); palpable distended, tender gallbladder; fever suggests acute cholecystitis; jaundice rare</td>
</tr>
<tr>
<td><strong>1st Test</strong></td>
</tr>
<tr>
<td>Definitive test for imaging the gallbladder.</td>
</tr>
<tr>
<td>Certain features are important to note when evaluating a patient with suspected cholecystitis including the presence or absence of gallstones and/or sludge;</td>
</tr>
<tr>
<td>[Fig-8]</td>
</tr>
<tr>
<td>the absence of gallstones in a patient with a history suggestive of cholecystitis may be indicative of biliary dyskinesia. In addition, gallbladder wall thickness: thickened gallbladder wall is suggestive of inflammation. Pericholecystic fluid refers to the presence of fluid around the gallbladder and is suggestive of acute inflammation. The absence of fluid in the presence of gallstones and/or gallbladder wall thickening is suggestive of chronic cholecystitis or biliary colic. Sonographic Murphy sign refers to the presence of Murphy sign with sonographic compression of the</td>
</tr>
<tr>
<td><strong>Other tests</strong></td>
</tr>
<tr>
<td>possible to identify gallstones on a plain abdominal film.</td>
</tr>
<tr>
<td>[Fig-9]</td>
</tr>
<tr>
<td><strong>hepatobiliary iminodiacetic acid (HIDA) scan:</strong> nonfilling gallbladder Considered a useful adjunct in the diagnosis of cholecystitis. The classic finding is nonfilling of the gallbladder. Prolonged fasting may result in a false-positive test.</td>
</tr>
</tbody>
</table>
## Common

### Cholelithiasis/cholecystitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>gallbladder and is suggestive of acute inflammation of the gallbladder.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>» <strong>LFTs:</strong> may see elevated alk phos, bilirubin and aminotransferase</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>May be normal or marginally increased; if significantly elevated, other etiologies (such as hepatitis, choledochochololithiasis, or cholangitis) may be present.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is important to note the direct bilirubin concentration, which is the fraction that is elevated with common duct obstruction.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>» <strong>CBC:</strong> normal WBC (suggests cholelithiasis) or leukocytosis (suggests acute cholecystitis)</td>
<td></td>
</tr>
</tbody>
</table>

### Primary dysmenorrhea

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx of recurrent crampy abdominal pain associated with menstruation</td>
<td>lower abdominal tenderness; normal pelvic exam</td>
<td><strong>none:</strong> diagnosis is clinical</td>
<td><strong>CT scan abdomen/pelvis:</strong> normal; however, useful to rule out other diagnoses</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>abdominal/pelvic ultrasound:</strong> normal; however, useful to rule out other diagnoses</td>
</tr>
</tbody>
</table>
### Common

#### Pneumonia

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>cough; purulent sputum production; upper respiratory tract symptoms (rhinorrhea, sore throat, nasal congestion), shortness of breath, fever, and chills; splinting secondary to pain; vomiting, diarrhea, anorexia</td>
<td>tachypnea, cyanosis, decreased breath sounds, crackles/rales on auscultation, dullness on percussion; abdominal tenderness and distension without guarding or rebound</td>
<td>»CBC: variable In patients with viral pneumonia, WBC count may be normal or decreased. »chest x-ray: infiltration, consolidation, effusion »sputum culture: growth of infecting organism</td>
<td>»chest ultrasound: localized fluid collection May consider before proceeding to CT scan due to the lack of radiation exposure. »CT scan chest with intravenous contrast: consolidation of lung parenchyma; extraparenchymal fluid with loculations suggests empyema CT scan may better differentiate between empyema and simple effusion.</td>
</tr>
</tbody>
</table>

#### Functional abdominal pain

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx may be acute, chronic, or cyclic (frequently girls ages 8-12 years), complaint of vague, persistent, central abdominal pain common, may be associated nausea and vomiting, particularly in chronic cases; FHx of functional disorders common (e.g., irritable bowel syndrome, anxiety, psychiatric disorders, and migraine); Rome IV criteria use symptoms for diagnosis[27]</td>
<td>periumbilical tenderness, abdomen is soft, undistended, no guarding or rebound tenderness; exam of other systems normal</td>
<td>»none: diagnosis is clinical after exclusion of possible organic causes</td>
<td>»CBC: normal »ESR: normal »urinalysis: normal »stool microscopy: normal</td>
</tr>
</tbody>
</table>
Evaluation of abdominal pain in children

Uncommon

Intussusception

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>usually infant between 3 and 12 months of age presenting with colicky abdominal pain, flexing of the legs, fever, lethargy, and vomiting; Henoch-Schonlein purpura (HSP) may be initiating factor in an older child (usually &lt;11 years of age); vague abdominal complaints; severe, cramp-like abdominal pain; child may be inconsolable</td>
<td>may see gross or occult blood that may be mixed with mucus and have &quot;redcurrant jelly&quot; appearance, abdominal tenderness, and palpable abdominal mass; signs of HSP may be present in older child (rash of palpable purpura, blood in the stools)</td>
<td>»barium enema: filling defect or cupping in the head of contrast as it advances to the site of the intussusception Air or hydrostatic enema can be used to reduce intussusception in 60% to 80% of childhood cases.[61] Preferred initial test for children. [Fig-21]</td>
<td>»CT scan abdomen and pelvis: target lesion: intraluminal soft-tissue density mass with an eccentrically placed fatty area; reniform mass: high attenuation peripherally and lower attenuation centrally; sausage-shaped mass: alternating areas of low and high attenuation representing closely spaced bowel wall, mesenteric fat and/or intestinal fluid and gas CT scan should include intravenous and oral contrast for best yield and be performed only in cases in which peritonitis is not present.</td>
</tr>
</tbody>
</table>

Meckel diverticulum

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>typically aged &lt;2 years; may present with abdominal pain (may be intermittent or mimic dark red, maroon, or &quot;red currant jelly&quot; stools; abdominal tenderness with</td>
<td>dark red, maroon, or &quot;red currant jelly&quot; stools; abdominal tenderness with</td>
<td>»abdominal ultrasound: tubular mass in longitudinal view; target lesion in transverse view Can be used to monitor success of treatment with enema.</td>
<td>»CT scan abdomen and pelvis: may show intussusception, Meckel diverticulitis, and/or</td>
</tr>
</tbody>
</table>
Evaluation of abdominal pain in children

### Uncommon

◊ **Meckel diverticulum**

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
</table>
| acute appendicitis, and/or painless passage of bright red blood per rectum (hematochezia); often asymptomatic | guarding and rebound (may suggest diverticulitis); palpable abdominal mass (may suggest intussusception) | or target appearance in transverse views suggests intussusception Good initial test if there is concern for intussusception. Sensitivity is user-dependent. *technetium-99m pertechnetate scan:* positive Identifies ectopic gastric mucosa as tracer is taken up by parietal cells. A positive scan shows immediate tracer localization in the stomach and in the RLQ; an area of 1.8 cm² of ectopic gastric mucosa in a Meckel diverticulum is required to produce a positive result. Accuracy of the scan may be improved with the use of pentagastrin and glucagons, and/or cimetidine or ranitidine, which increase the uptake of technetium-99m pertechnetate by parietal cells. Barium absorbs pertechnetate and its use should never precede a technetium-99m pertechnetate scan, as dilated bowel consistent with bowel obstruction Not routinely ordered unless concerned for alternative disease process or evaluating for complications. May be considered if technetium-99m pertechnetate scan negative, but clinical suspicion remains.
**Evaluation of abdominal pain in children**

### Diagnosis

#### Uncommon

<table>
<thead>
<tr>
<th>Diamond</th>
<th>Meckel diverticulum</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>Exam</td>
</tr>
<tr>
<td>diffuse abdominal pain; hx of recent or current upper respiratory tract infection</td>
<td>fever, abdominal tenderness not localized to RLQ, rhinorrhea, hyperemetic pharynx or oropharynx (pharyngitis), and/or associated extramesenteric lymphadenopathy (usually cervical)</td>
</tr>
</tbody>
</table>

#### Mesenteric adenitis

<table>
<thead>
<tr>
<th>Diamond</th>
<th>Mesenteric adenitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>Exam</td>
</tr>
<tr>
<td>diffuse abdominal pain; hx of recent or current upper respiratory tract infection</td>
<td>fever, abdominal tenderness not localized to RLQ, rhinorrhea, hyperemetic pharynx or oropharynx (pharyngitis), and/or associated extramesenteric lymphadenopathy (usually cervical)</td>
</tr>
</tbody>
</table>

#### Hirschsprung disease

<table>
<thead>
<tr>
<th>Diamond</th>
<th>Hirschsprung disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>Exam</td>
</tr>
<tr>
<td>males affected more commonly, mainly presents in early infancy (prior to 6 months); failure to pass meconium in first 36</td>
<td>abdominal distension, fullness in LLQ; palpable fecal mass on abdomen exam; absence of peritonitis (no guarding or rebound tenderness); small rectum and</td>
</tr>
</tbody>
</table>
## Uncommon

### Hirschsprung disease

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hours of life strongly suggestive</td>
<td>absence of stool on rectal exam; dysmorphic features of Down syndrome may be present</td>
<td>out other etiologies of abdominal pain. [Fig-5]</td>
<td>The specimen must be taken at least 1.5 cm above the pectinate line.</td>
</tr>
</tbody>
</table>

It is very difficult to differentiate between a distended colon and the small bowel; it is a nonspecific investigation.

- **[Fig-5]**

  > contrast barium enema: proximal dilation with narrowing of the distal colon
  
  Considered a classic finding. However, in children less than 1 month of age, the findings may be difficult to interpret.

  - **Contrast barium enema**: proximal dilation with narrowing of the distal colon.

  Considered a classic finding. However, in children less than 1 month of age, the findings may be difficult to interpret. The specimen usually measures 1 x 3 mm and should include mucosa and submucosa. The presence of large amounts of acetylcholinesterase in the mucosa and submucosa is also diagnostic.

- **Anorectal manometry**: absent reflex

  Normally, when the rectum is distended with a balloon, pressure in the anal canal falls because of internal...
### Uncommon

<table>
<thead>
<tr>
<th>Hirschsprung disease</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td>—</td>
</tr>
<tr>
<td>—</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ulcerative colitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td>positive FHx, bloody diarrhea, cramping abdominal pain, anorexia, weight loss, fever, rash</td>
</tr>
<tr>
<td>—</td>
</tr>
</tbody>
</table>
## Uncommon

### Ulcerative colitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncommon</td>
<td>in multiple segments of the colon.</td>
<td><strong>ESR:</strong> elevated Inflammatory markers correlate closely with disease activity.</td>
<td>thumbprinting, intestinal dilatation or evidence of stricture; inflamed mesentery; intra-abdominal abscesses Ordered when complications or other diagnoses are being considered.</td>
</tr>
<tr>
<td>◊ Ulcerative colitis</td>
<td>Endoscopic findings may be highly suggestive of inflammatory bowel disease but the characteristics of the mucosa (including ulcers) cannot be used to distinguish between ulcerative colitis and Crohn disease (CD).</td>
<td><strong>CRP:</strong> elevated Inflammatory markers correlate closely with disease activity.</td>
<td>»serologic markers: perinuclear antineutrophil cytoplasmic antibody (pANCA) and anti-Saccharomyces cerevisiae antibody (ASCA): positive pANCA Require special laboratories and are expensive, but may be particularly useful for differentiating between CD and UC in the pediatric population; about 70% of patients with UC have positive pANCA; about 70% of patients with CD have positive ASCA.[63]</td>
</tr>
</tbody>
</table>

### Crohn disease

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Crohn disease</td>
<td>aphanous ulcers, evidence of weight loss, pallor, abdominal tenderness, abdominal mass, perianal fistula, perirectal abscess, anal fissure, perianal skin tags; extraintestinal manifestations</td>
<td><strong>CBC:</strong> leukocytosis, anemia, thrombocytosis Iron deficiency anemia may be present, especially in those with chronic disease. Leukocytosis may also be caused by certain</td>
<td>»plain abdominal x-rays: small bowel or colonic dilatation; calcification; intra-abdominal abscesses Suggestive of the diagnosis of CD and</td>
</tr>
</tbody>
</table>
### Uncommon

**◊ Crohn disease**

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>including iritis, arthritis, sacroiliitis, erythema nodosum, pyoderma gangrenosum</td>
<td>medications used to treat inflammatory bowel disease, such as corticosteroids.</td>
<td>useful to assess severity.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>» CRP:</strong> elevated Inflammatory markers correlate closely with disease activity.</td>
<td><strong>» upper GI series with small bowel follow-through:</strong> edema and ulceration of the mucosa with luminal narrowing and strictures Demonstrates features suggestive of CD and aids in defining its distribution and severity.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>» ESR:</strong> elevated Inflammatory markers correlate closely with disease activity.</td>
<td><strong>» CT scan abdomen and pelvis:</strong> skip lesions, bowel wall thickening, surrounding inflammation, abscess, fistulas Ordered when complications or other diagnoses are being considered.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>» colonoscopy with biopsy:</strong> may demonstrate inflammation, friability, ulcer formation, and edema Biopsy of mucosa should be performed in multiple segments of the bowel.</td>
<td><strong>» serologic markers:</strong> perinuclear antineutrophil cytoplasmic antibody (pANCA) and anti-Saccharomyces cerevisiae antibody (ASCA): positive ASCA Require special laboratories and are expensive, but may be particularly useful for differentiating between CD and UC in the pediatric population; about 70% of patients with UC have positive pANCA; about 70% of</td>
<td></td>
</tr>
</tbody>
</table>
### Uncommon

**◊ Crohn disease**

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>patients with CD have positive ASCA. [63]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Small bowel obstruction**

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>limited abdominal distension (with proximal obstructions in the duodenum or early jejunum); abdominal tenderness may or may not be present; rebound tenderness and guarding may occur if perforation, ischemia, and peritonitis; hyperactive bowel sounds (early finding), hypoactive or absent bowel sounds (late finding); incarcerated femoral, obturator, umbilical or ventral hernia may be present</td>
<td>abdominal x-ray: dilated small bowel loops, air-fluid levels throughout abdomen Supine and upright films may reveal characteristic pattern of gas in bowel. In duodenal atresia may see double bubble sign. [Fig-6] Jejunal atresia shows dilated proximal small bowel with decompressed nonair-filled bowel distally.</td>
<td>abdominal ultrasound: may demonstrate focal area causing obstruction Can be used to diagnose intussusception; may be of particular value when diagnosing intussusception secondary to Henoch-Schonlein purpura, as it is typically ileoileal instead of ileocolic. Ultrasound with Doppler blood flow evaluation may assist in the diagnosis of midgut volvulus associated with malrotation. In addition, it may be useful in the diagnosis of omental and duplication cysts. upper GI contrast study: dilated small intestine; may demonstrate a transition zone of obstruction Critical to rule out acute midgut volvulus and/or malrotation. [Fig-19]</td>
<td></td>
</tr>
</tbody>
</table>
### Evaluation of abdominal pain in children

#### Diagnosis

#### Uncommon

<table>
<thead>
<tr>
<th>Small bowel obstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volvulus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td>infant age group; hx of bilious vomiting; pain usually manifests as notable transition to an inconsolable state</td>
</tr>
</tbody>
</table>
### Uncommon

#### Volvulus

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx of risk factors: mental illness, inflammatory bowel disease, diabetes, poor diet, previous colorectal resection, laxative abuse, megacolon, or previous abdominal surgery; change in bowel habit with partial or complete obstruction, or change in caliber of stool; colicky abdominal pain becoming more constant and worse with movement, coughing or deep breathing as bowel approaches perforation; intolerant of feeding, with nausea or vomiting</td>
<td>tympanic, distended abdomen; hyperactive bowel sounds that become absent in advanced stages; abdominal rebound, guarding, and/or rigidity if perforation or close to perforation; empty rectum; incarcerated femoral, obturator, umbilical, or ventral hernia may be present</td>
<td>(erect) position are taken. »<strong>CBC</strong>: elevated WBC (suggests intestinal ischemia)</td>
<td>x-rays or there is evidence of bowel necrosis. [Fig-19] »<strong>CT scan abdomen</strong>: bowel obstruction with whirl pattern of mesentery Usually not necessary to make diagnosis.</td>
</tr>
</tbody>
</table>

#### Large bowel obstruction

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx of risk factors: mental illness, inflammatory bowel disease, diabetes, poor diet, previous colorectal resection, laxative abuse, megacolon, or previous abdominal surgery; change in bowel habit with partial or complete obstruction, or change in caliber of stool; colicky abdominal pain becoming more constant and worse with movement, coughing or deep breathing as bowel approaches perforation; intolerant of feeding, with nausea or vomiting</td>
<td>tympanic, distended abdomen; hyperactive bowel sounds that become absent in advanced stages; abdominal rebound, guarding, and/or rigidity if perforation or close to perforation; empty rectum; incarcerated femoral, obturator, umbilical, or ventral hernia may be present</td>
<td><strong>abdominal x-ray</strong>: gaseous distension of large bowel; volvulus suggested by kidney-bean-shape bowel loop Diagnosis confirmed by colonic dilatation. Level of obstruction may be determined by a cutoff beyond which the colon or rectum is empty of gas. Intramural gas ominously suggests colonic ischemia.</td>
<td><strong>abdominal ultrasound</strong>: may demonstrate focal area causing obstruction (e.g., intussusception) »<strong>lower GI contrast study</strong>: may indicate site of obstruction Used to diagnose meconium disease or other cause of lower GI intestinal obstruction such as intussusception. Hypertonic contrast medium may be helpful for clearing meconium. »<strong>CT scan abdomen and pelvis</strong>: gaseous distension of large bowel; may demonstrate a transition zone of obstruction May also reveal underlying cause and provide more...</td>
</tr>
</tbody>
</table>
### Uncommon

#### Large bowel obstruction

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>diagnostic information than contrast enema.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Intravenous and oral contrast should be used for best diagnostic yield.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>flexible/rigid sigmoidoscopy</strong>: flood of stool and mucus upon passing and decompressing apex of volvulus. Useful if sigmoid volvulus is suspected, as sigmoidoscopy may be potentially therapeutic. Must exercise extreme caution if ischemia is suspected as there is an increased chance of perforation.</td>
</tr>
</tbody>
</table>

#### Necrotizing enterocolitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>premature neonate weighing less than 1500 g; feeding intolerance, apnea, lethargy, bloody stools</td>
<td>abdominal distension, tenderness, abdominal wall erythema, hematochezia, bradycardia</td>
<td><strong>CBC</strong>: leukocytosis or leukopenia, anemia, thrombocytopenia Decreased WBC count may be more ominous than leukocytosis. Anemia may result with significant hematochezia. <strong>blood culture</strong>: negative Bacterial sepsis should be excluded.</td>
<td><strong>abdominal ultrasound</strong>: fluid collections, ascites Useful for diagnosing fluid collections that may represent perforation or abscess.</td>
</tr>
</tbody>
</table>
### Uncommon

#### Necrotizing enterocolitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
</table>
| FHx of peptic ulcer disease; weight loss, vomiting, anorexia, and intermittent epigastric pain, usually related to eating meals; pain often nocturnal and usually relieved by antacids; melena and/or hematemesis if blood vessel perforated | unremarkable or epigastric tenderness; melena may be present on rectal exam or occult bleeding on stool hemoccult test | »serum electrolyte panel: hyponatremia  
»abdominal x-ray: dilated loops of bowel, pneumatosis intestinalis, portal venous gas, free air, fixed loop of bowel, lack of normal intestinal gas pattern  
Important to obtain both AP and left lateral decubitus views. | |

#### Peptic ulcer disease

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
</table>
| FHx of peptic ulcer disease | unremarkable or epigastric tenderness; melena may be present on rectal exam or occult bleeding on stool hemoccult test | »CBC: normal or leukocytosis; anemia present if sustained blood loss  
»erect chest x-ray: usually normal  
Ordered to rule out gastric or duodenal perforation (demonstrated by free air under the diaphragm).  
»upper GI series with water-soluble contrast: mucosal defect(s) consistent with ulcer or free intraperitoneal contrast consistent with perforation  
Gastric and duodenal ulcers can sometimes be visualized with x-ray imaging. Contrasted imaging studies can indicate location and | »Helicobacter pylori breath test or stool antigen test: positive result if H pylori present  
Generally not necessary if endoscopy and biopsy are being performed; however, in places where endoscopy is not readily available, and peptic ulcer disease is suspected, H pylori breath test or stool antigen test may be helpful. A blood test for H pylori is not useful in children. |
Uncommon

Peptic ulcer disease

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>depth of ulcers. This may serve as an initial test prior to the more definitive endoscopy.</td>
<td>upper GI endoscopy: mucosal inflammation, ulceration, and hemorrhage Peptic ulcer disease, generalized gastritis, and hemorrhage can be confirmed with upper GI endoscopy. Endoscopy also enables several techniques to be used to control bleeding vessels. Endoscopy can also provide biopsies if malignancy suspected and for culture of ( H ) pylori.</td>
<td>»serum LFTs: high direct bilirubin, AST, ALT, alk phos and gamma-GT</td>
<td>Endoscopy should be performed urgently if bleeding is suspected (prior to any contrast radiologic studies). Contrast may interfere with the evaluation of the mucosa.</td>
</tr>
</tbody>
</table>

Viral hepatitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>multiple sexual partners, sexual intercourse with infected individuals (hepatitis B and/or C), jaundice; early disease: tender hepatosplenomegaly, lymphadenopathy; late disease: generalized</td>
<td>»CBC: low or normal platelet count A low platelet count is suggestive of portal hypertension.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Viral hepatitis**

<table>
<thead>
<tr>
<th><strong>History</strong></th>
<th><strong>Exam</strong></th>
<th><strong>1st Test</strong></th>
<th><strong>Other tests</strong></th>
</tr>
</thead>
</table>
| travel to developing countries, pregnant (hepatitis E); early disease: malaise, muscle and joint aches, fever, nausea, vomiting, diarrhea, headache, anorexia, dark urine, pale stool, abdominal pain; late disease: weight loss, easy bruising and bleeding tendencies | wasting, cachexia, gynecomastia, ascites, altered sensorium, asterixis, or decreased deep tendon reflexes, caput medusa, ascites, hepatosplenomegaly, congestion secondary to right heart failure | Although transaminases may be elevated, the level is not a good correlate for severity of infection; it indicates liver damage. | » *serum IgM anti-HAV*: positive if acute hepatitis A infection  
» *serum hepatitis B surface antigen (HBsAg)*: positive if hepatitis B infection  
Positive result appears in serum 1 to 10 weeks after an acute exposure and disappears when infection abates.  
» *serum hepatitis B core antigen (HBcAg)*: positive if hepatitis B infection  
An intracellular antigen that is found in infected hepatocytes.  
» *serum hepatitis B e antigen (HBeAg)*: positive if hepatitis B infection  
Patients with a positive result are considered highly infective for hepatitis B.  
» *serum HCV RNA*: positive if hepatitis C infection  
Identifies acute or chronic infection with hepatitis C virus.  
Progression to chronic disease after acute infection is highly |

» *coagulation profile (PT, INR)*: May be elevated or normal  
In cases of severe hepatitis, liver synthetic function as measured by coagulation parameters may be compromised, reflected by increased PT and INR.
### Uncommon

#### Viral hepatitis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx of previous negative workup for cholelithiasis common; recurrent RUQ pain; nausea and vomiting; symptoms may or may not be associated with eating</td>
<td>may be equivocal; RUQ tenderness</td>
<td>likely. Significant risk for hepatocellular carcinoma.</td>
<td>Perform by enzyme-linked or radioimmunoassay. Hepatitis D is a defective virus and can only replicate in the presence of coinfection or superinfection with HBV.</td>
</tr>
</tbody>
</table>

**» serum total (IgM and IgG) anti-HDV antibodies:** positive if hepatitis D infection

**» serum anti-HEV IgM antibodies:** positive if acute hepatitis E infection

#### Biliary dyskinesia

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx of previous negative workup for cholelithiasis common; recurrent RUQ pain; nausea and vomiting; symptoms may or may not be associated with eating</td>
<td>may be equivocal; RUQ tenderness</td>
<td>»LFTs: normal AST, ALT, alk phos, and bilirubin</td>
<td>»hepatobiliary iminodiacetic acid (HIDA) scan: decreased (&lt;35%) gallbladder ejection fraction</td>
</tr>
</tbody>
</table>

**» RUQ ultrasound:** normal

Gallstones should not be demonstrated in patients with biliary dyskinesia.

The ejection fraction of the gallbladder is measured after the administration
### Uncommon

**◊ Biliary dyskinesia**

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nausea, vomiting, epigastric pain radiating to back; acute-onset abdominal pain</td>
<td>Epigastric or upper abdominal tenderness; tachycardia and hypotension in severe cases; discoloration around the umbilicus (positive Cullen sign) or flanks (positive Grey-Turner sign) in cases of hemorrhagic pancreatitis; small children may demonstrate increased irritability and abdominal distension only</td>
<td>Amylase: 3 times upper limit of normal range</td>
<td>Other tests of cholecystokinin (CCK); pain elicited after administration of CCK that mimics the patient's presenting symptoms may equate to a better outcome after cholecystectomy (if a cutoff of &lt;15% is used).</td>
</tr>
</tbody>
</table>

### Acute pancreatitis

**❖ Acute pancreatitis**

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nausea, vomiting, epigastric pain radiating to back; acute-onset abdominal pain</td>
<td>Epigastric or upper abdominal tenderness; tachycardia and hypotension in severe cases; discoloration around the umbilicus (positive Cullen sign) or flanks (positive Grey-Turner sign) in cases of hemorrhagic pancreatitis; small children may demonstrate increased irritability and abdominal distension only</td>
<td>Amylase: 3 times upper limit of normal range</td>
<td>Abdominal ultrasound: may appear normal early in disease course; enlargement of the pancreas; peripancreatic edema; dilated pancreatic duct; may show underlying biliary disease.</td>
</tr>
</tbody>
</table>

Normal range: 35 to 118 units/L. Sensitivity of 75% to 92% and a specificity of 20% to 60% with a positive predictive value approaching 100%.[65]

Levels start rising over the first 2 to 12 hours, peak at 48 hours, and return to normal within 3 to 5 days.

Lipase: can be elevated if amylase normal
Lipase is more sensitive (50% to 60%) than amylase.

CT scan abdomen with intravenous
Uncommon

<table>
<thead>
<tr>
<th>Acute pancreatitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td>99%) and specific (86% to 100%) than amylase; however, the utility is limited in acute pancreatitis due to discrepancies in measurement method, patient selection, and cutoff point. Hence, the determination of lipase is not necessary in a patient with a clinical diagnosis of acute pancreatitis and 3 times the normal value of serum amylase. Its use can be helpful in patients with a clinical presentation suggestive of pancreatitis and normal amylase. Due to additional cost and lack of benefit in the majority of patients, utilizing serum lipase in conjunction with serum amylase is considered inappropriate.[65] [66]</td>
</tr>
<tr>
<td><strong>Levels start rising 4 to 8 hours after the onset of pain, peak at 24 hours, and last for 8 to 14 days. Patients with alcoholic pancreatitis have higher levels of lipase than those with gallstone pancreatitis.</strong>[65]</td>
</tr>
<tr>
<td><strong>bilirubin:</strong> normal or elevated</td>
</tr>
<tr>
<td><strong>contrast:</strong> peripancreatic inflammation (fat stranding); may show gallstones</td>
</tr>
<tr>
<td>Although this involves exposure to radiation, it is an excellent tool in the diagnosis of early pancreatitis. Ordered if patient is not improving with standard treatment or if complicated disease is suspected. Should not be ordered for uncomplicated cases of pancreatitis in which the patient is improving.</td>
</tr>
<tr>
<td>Allows better assessment of potential pancreatic necrosis (which would indicate more serious disease) and peripancreatic inflammation than is achievable with ultrasound.</td>
</tr>
<tr>
<td>[Fig-10]</td>
</tr>
</tbody>
</table>
### Diagnosis

#### Uncommon

<table>
<thead>
<tr>
<th>Acute pancreatitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td>varied: may be hx of trauma; cysts either asymptomatic or dull, left-sided abdominal pain; infarction typically causes fever as well as pain, but occasionally asymptomatic; left-sided shoulder and/or chest pain; presence of risk factors for splenic infarction (sickle cell disease, high altitude)</td>
</tr>
</tbody>
</table>

#### Splenic infarction/cysts

<table>
<thead>
<tr>
<th>Splenic infarction/cysts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td>varied: may be hx of trauma; cysts either asymptomatic or dull, left-sided abdominal pain; infarction typically causes fever as well as pain, but occasionally asymptomatic; left-sided shoulder and/or chest pain; presence of risk factors for splenic infarction (sickle cell disease, high altitude)</td>
</tr>
</tbody>
</table>

#### Nephrolithiasis

<table>
<thead>
<tr>
<th>Nephrolithiasis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
</tr>
<tr>
<td>FHx of nephrolithiasis and/or gout; intermittent, severe, colicky flank and/or abdominal pain; nausea and vomiting; gross or microscopic hematuria; urinary frequency/urgency; atypical presentation</td>
</tr>
</tbody>
</table>
## Uncommon

### Nephrolithiasis

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>common in younger children</td>
<td>provide information on potential complications of obstruction such as hydronephrosis.</td>
<td>urinalysis: may be normal or dipstick-positive for leukocytes, nitrites, blood; microscopic analysis positive for WBCs, RBCs, or bacteria</td>
<td>noncontrast CT scan abdomen and pelvis: calcification seen in renal collecting system or ureter; possible dilated proximal ureter and hydronephrosis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Highly sensitive for detection of nephrolithiasis and evaluation of hydronephrosis. In addition, if stones are not seen, an alternative etiology may be detected; frequently, nephrolithiasis detected on CT scan is a serendipitous finding for the investigation of other etiologies of abdominal pain.</td>
</tr>
</tbody>
</table>

### Testicular torsion

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>acute-onset testicular pain; nausea, and vomiting; hx of recurrent episodes suggests repeated episodes of testicular torsion followed by spontaneous detorsion; hx of trauma may be present</td>
<td>tender, edematous testicle; affected testicle may appear higher than unaffected testicle with horizontal lie; associated scrotal erythema and edema; absent cremasteric reflex; usually no pain relief with elevation of the scrotum</td>
<td>gray-scale ultrasound: presence of fluid and the whirlpool sign (the swirling appearance of the spermatic cord from torsion as the ultrasound probe scans downward perpendicular to the spermatic cord)</td>
<td>power Doppler ultrasound: absent or decreased blood flow in the affected testicle; decreased flow velocity in the intratesticular arteries, increased resistive indices in the intratesticular arteries Can help quantify the strength of intratesticular blood flow.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

53
### Uncommon

#### Testicular torsion

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>if the diagnosis of testicular torsion is highly suggested by history and physical exam.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The real-time whirlpool sign is the most specific sign of partial or complete testicular torsion.[67] [68]</td>
</tr>
</tbody>
</table>
|                                  | Other tests                   | Power Doppler is direction sensitive, making it more likely to pick up blood flow than color Doppler. The amount of flow detected in the normal testicle is usually greater using power Doppler than that detected when using color Doppler. Power Doppler is up to 5 times more sensitive to blood flow than regular color Doppler, and is the mode of choice to pick up slow-moving blood such as is seen in ovaries and testicles.[70]

#### Ovarian torsion

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>acute onset of one-sided lower abdominal or pelvic pain; nausea and vomiting common; hx of frequent, similar episodes; fever rare</td>
<td>tender pelvic mass (adnexal); in patients old enough to undergo pelvic exam, cervical motion tenderness may be elicited; typically no vaginal discharge, but may be some mild to moderate vaginal bleeding</td>
<td>pelvic ultrasound: solid appearance of the ovary, unilateral ovarian enlargement, ovarian peripheral cystic structures, marked stromal edema, fluid in the pouch of Douglas</td>
</tr>
</tbody>
</table>

Other tests

- **pelvic ultrasound**: reduced or absent intraovarian blood flow Suggestive of ovarian torsion. Can help determine whether the flow in the ovary is impaired. However, specificity is poor.
- **color Doppler**: enlarged, edematous ovary with or without vascular enhancement; free fluid in pelvis
- **CT scan abdomen and pelvis**: enlarged, edematous ovary with or without vascular enhancement; free fluid in pelvis
- CT scans can demonstrate adnexal
### Uncommon

#### Ovarian torsion

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>adnexal tenderness; adnexal size unremarkable due to collapsed cyst; peritonism may be present in lower abdomen and pelvis</td>
<td></td>
<td>masses and ischemia of the ovary. Typically, ovarian torsion diagnosed by CT scan is a serendipitous finding during an attempt to identify other sources of abdominal pain. [Fig-17]</td>
</tr>
</tbody>
</table>

#### Ruptured ovarian cyst

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>rupture usually spontaneous, can follow history of trauma or sexual intercourse; mild chronic lower abdominal discomfort may suddenly intensify</td>
<td>adnexal tenderness;</td>
<td><strong>pelvic ultrasound:</strong> complex mass appearance; fluid in the pouch of Douglas</td>
<td></td>
</tr>
</tbody>
</table>

A complex mass appearance suggests a ruptured hemorrhagic cyst surrounded by a hematoma. Fluid in the pouch of Douglas is also indicative of a ruptured cyst.

#### Pelvic inflammatory disease

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>sexually active; multiple partners; hx may be suggestive of sexual abuse (particularly if young child); pain worse with sexual intercourse; dull, aching lower abdominal pain with or without dysuria; vaginal discharge, low-grade fever</td>
<td>temperature &gt;101°F (38.3°C); cervical motion tenderness, adnexal or uterine tenderness, vaginal or cervical mucopurulent discharge</td>
<td><strong>wet mount of vaginal secretions:</strong> polymorphonuclear leukocytes (PMNs) seen</td>
<td></td>
</tr>
</tbody>
</table>

Presence of vaginal PMNs confirms vaginal infection. High predictive value but not specific for pathogens.

**genetic probe or culture of vaginal secretions for Neisseria gonorrhoeae and Chlamydia trachomatis:** positive result indicates presence of organisms.
## Uncommon

**◊ Pelvic inflammatory disease**

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>most likely to cause PID.</td>
<td>Test should be ordered in any patient with suspected PID.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>pelvic ultrasound:</strong> normal or may demonstrate endometritis, hydrosalpinx, pyosalpinx, tubo-ovarian abscess</td>
<td>Specimens obtained from vaginal exam can be sent for testing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ultrasound findings can be variable demonstrating any portion of the female reproductive organs.</td>
<td>Urine tests should not be the initial test ordered, but may be necessary if a pelvic exam is not feasible (e.g., due to age of child).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Most common findings include pyosalpinx and tubo-ovarian abscess.</td>
<td><strong>HIV serology:</strong> positive or negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is important to test for other sexually transmitted diseases during a workup for PID, including HIV infection.</td>
<td><strong>hepatitis studies:</strong> positive or negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is important to test for other sexually transmitted diseases during a workup for PID, including hepatitis B and C.</td>
<td><strong>rapid plasma reagin (RPR):</strong> positive or negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is important to test for other sexually transmitted diseases during a workup for PID, including syphilis.</td>
<td><strong>laparoscopy:</strong> normal or may demonstrate endometritis,</td>
</tr>
</tbody>
</table>
## Uncommon

### Pelvic inflammatory disease

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx of previous ectopic pregnancy or miscarriage, fallopian tube or pelvic surgery, pelvic inflammatory disease (PID); lower abdominal pain, amenorrhea, and vaginal bleeding</td>
<td>minimal abdominal tenderness and/or vaginal bleeding; pelvic exam may reveal a mass, eliciting cervical motion tenderness if hemoperitoneum is present; tubal rupture can cause hemodynamic instability</td>
<td>urine pregnancy test: positive</td>
<td>hydrosalpinx, pyosalpinx, tubo-ovarian abscess</td>
</tr>
</tbody>
</table>

Laparoscopy is the preferred invasive method of diagnosis allowing direct visualization of the gynecologic and abdominal structures. In addition, it may aid the diagnosis of Fitz-Hugh-Curtis syndrome.

## Pregnancy complications

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>hx of previous ectopic pregnancy or miscarriage, fallopian tube or pelvic surgery, pelvic inflammatory disease (PID); lower abdominal pain, amenorrhea, and vaginal bleeding</td>
<td>minimal abdominal tenderness and/or vaginal bleeding; pelvic exam may reveal a mass, eliciting cervical motion tenderness if hemoperitoneum is present; tubal rupture can cause hemodynamic instability</td>
<td>urine pregnancy test: positive</td>
<td>type and screen: variable</td>
</tr>
</tbody>
</table>

Confirms pregnancy; although false-negative tests, depending on kit used, are known.

quantitative beta-hCG: positive

A normal intrauterine pregnancy is typically visualized at beta-hCG levels between 1500 and 2500 mIU/mL. If not, the likely differential diagnosis is ectopic pregnancy or miscarriage.

Serial beta-hCG measurement is usually used when the ultrasound is inconclusive and the initial beta-
### Uncommon

#### Pregnancy complications

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>hCG is below the discriminatory zone (1500-2000 mIU/mL). An increase of at least 66% in 2 measurements over 48 hours is suggestive of a viable intrauterine pregnancy. An increase of &lt;66% is suggestive of an ectopic pregnancy. A rapid and steady decline is indicative of a miscarriage. A single serum measurement cannot exclude ectopic pregnancy or predict the risk of rupture unless it is &lt;5 mIU/mL.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pelvic ultrasound: demonstrates free fluid in the pelvis and/or a periovary air mass With trained personnel, bedside pelvic ultrasound is a fast, reliable method to evaluate for ectopic pregnancy. Transvaginal ultrasound may be used to evaluate for intrauterine pregnancy.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>An ectopic pregnancy may be characterized by an echogenic, cyst-like structure outside the uterus. Several</td>
<td></td>
</tr>
</tbody>
</table>
### Uncommon

#### Pregnancy complications

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ultrasonographic findings may be associated with early ectopic pregnancy such as tubal ring, extraterine mass, extraterine empty gestational sac, and hemosalpinx.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>In an unstable patient, it is important not to delay treatment while waiting for an ultrasound. A quick and focused bedside ultrasonographic exam to assess for the presence of free fluid or blood may be helpful when ruptured ectopic pregnancy is suspected.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>transvaginal ultrasound:</em> presence or absence of intrauterine pregnancy Differentiates between different stages and types of miscarriage. Specific, fairly prognostic and would exclude other differential diagnoses of miscarriage.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occasionally directly identifies ectopic pregnancy.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usually used in conjunction with pelvic</td>
<td></td>
</tr>
</tbody>
</table>
### Uncommon

#### Pregnancy complications

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncommon</td>
<td>Ultrasound in the setting of positive beta-hCG plus abdominal pain and/or vaginal bleeding.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Empyema

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncommon</td>
<td>Febrile, toxic patient, dullness on percussion, absence of breath sounds over affected area; abdominal tenderness and distension without guarding or rebound</td>
<td>CBC: elevated WBC count, chest x-ray: blunting of costophrenic angle or effusion on affected side, possible consolidation, pleurally based “D” shape in empyema. The presence of a loculated effusion suggests an empyema. There may be associated pulmonary consolidation due to pneumonia. thoracentesis: frank pus in empyema, serous or cloudy in complicated parapneumonic effusions. An effusion measuring &gt;10 mm on a lateral decubitus chest x-ray, in association with evidence of infection, requires thoracentesis (pleural aspiration).[71] Aspiration of frank pus is diagnostic of empyema, and no other investigations are necessary.</td>
<td>Blood culture: positive for specific pathogens. Blood cultures may be positive even if the pleural fluid culture is negative. Should be taken before the initiation of antibiotics if the clinical state of the patient permits. chest ultrasound: localized fluid collection. May consider before proceeding to CT scan due to the lack of radiation exposure. CT scan chest with intravenous contrast: consolidation of lung parenchyma; extraparenchymal fluid with loculations suggests empyema. CT scan may better differentiate between empyema and simple effusion.</td>
</tr>
</tbody>
</table>
### Evaluation of abdominal pain in children

#### Diagnosis

<table>
<thead>
<tr>
<th>Uncommon</th>
</tr>
</thead>
</table>

| Empyema |

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>required to establish the diagnosis.</td>
<td></td>
</tr>
</tbody>
</table>
Evidence scores

1. Signs and symptoms of appendicitis: there is good-quality evidence to show that children presenting with fever, rebound tenderness, and migrating abdominal pain to the right lower quadrant are likely to have appendicitis.[29]

**Evidence level A**: Systematic reviews (SRs) or randomized controlled trials (RCTs) of >200 participants.
Key articles


References


<table>
<thead>
<tr>
<th>References</th>
</tr>
</thead>
</table>


<table>
<thead>
<tr>
<th>Reference</th>
<th>Title and Details</th>
</tr>
</thead>
</table>


Evaluation of abdominal pain in children

Images

Figure 1: Necrotic appendix
From the collection of Dr KuoJen Tsao; used with permission

Figure 2: CT scan demonstrating fecalith (white arrow) outside the lumen of the appendix consistent with perforated appendix
From the collection of Dr KuoJen Tsao; used with permission

Figure 3: Intussusception: blood vessels become trapped between layers of intestine, leading to reduced blood supply, edema, strangulation of bowel and gangrene. Sepsis, shock, and death may eventually occur
Created by the BMJ Knowledge Centre

Figure 4: Intraoperative photo of Meckel diverticulum
From the collection of Dr KuoJen Tsao; used with permission

Figure 5: Abdominal x-ray of a neonate with abnormal stooling pattern and constipation. The dilated transverse and descending colon is suggestive of Hirschsprung disease
From the collection of Dr KuoJen Tsao; used with permission

Figure 6: Abdominal x-ray demonstrating double bubble gas pattern consistent with duodenal atresia
Figure 7: Infant with right groin bulge consistent with incarcerated inguinal hernia. The lack of overlying skin edema and erythema does not rule out strangulation of the small intestine.

Figure 8: Gallbladder ultrasound demonstrating cholelithiasis with characteristic shadowing.

Figure 9: Abdominal x-ray with opacities in the RUQ consistent with gallstones.

Figure 10: CT scan of teenage girl presenting with mid-epigastric abdominal pain as a result of gallstone pancreatitis. The large fluid collection in the pancreatic bed (white arrow) and lack of pancreatic enhancement suggest liquefactive necrosis of the pancreas.

Figure 11: CT scan demonstrating fluid-filled cyst within the spleen.
Evaluation of abdominal pain in children

Figure 12: Intraoperative photo of large splenic cyst
From the collection of Dr KuoJen Tsao; used with permission

Figure 13: Young boy with right testicular pain. The testicle is swollen, tender, and erythematosus as a result of torsion of the appendix testes. The clinical signs and symptoms mimic those of testicular torsion
From the collection of Dr KuoJen Tsao; used with permission

Figure 14: Infant boy with swollen, tender, and erythematous left testicle. The testicle is retracted consistent with testicular torsion
From the collection of Dr KuoJen Tsao; used with permission

Figure 15: Torsion of an appendix testis resulting in acute infarction
From the collection of Dr KuoJen Tsao; used with permission

Figure 16: Intraoperative photo of ovarian mass that presented as ovarian torsion
From the collection of Dr KuoJen Tsao; used with permission

Figure 17: CT scan of a young girl presenting with ovarian torsion. The large pelvic cystic lesion contains calcifications (white arrow) consistent with a teratoma or dermoid cyst
From the collection of Dr KuoJen Tsao; used with permission
Figure 18: CT scan demonstrating intra-abdominal abscess consistent with perforated appendix

From the collection of Dr KuoJen Tsao; used with permission

Figure 19: Upper GI contrast study demonstrating malrotation with volvulus. The duodenum fails to develop the normal anatomic C-loop. There is failure of contrast to pass, resulting in a characteristic bird beak consistent with acute midgut volvulus

From the collection of Dr KuoJen Tsao; used with permission

Figure 20: Abdominal x-ray of a young boy with acute, severe abdominal pain, demonstrating stool throughout the colon and rectum

From the collection of Dr KuoJen Tsao; used with permission

Figure 21: Contrast enema demonstrating ileocolic intussusception (black arrow)

From the collection of Dr KuoJen Tsao; used with permission
Disclaimer

This content is meant for medical professionals. The BMJ Publishing Group Ltd (“BMJ Group”) tries to ensure that the information provided is accurate and up to date, but we do not warrant that it is. The BMJ Group does not advocate or endorse the use of any drug or therapy contained within nor does it diagnose patients. Medical professionals should use their own professional judgement in using this information and caring for their patients and the information herein should not be considered a substitute for that.

This information is not intended to cover all possible diagnosis methods, treatments, follow up, drugs and any contraindications or side effects. We strongly recommend that users independently verify specified diagnosis, treatments and follow up and ensure it is appropriate for your patient. This information is provided on an “as is” basis and to the fullest extent permitted by law the BMJ Group assumes no responsibility for any aspect of healthcare administered with the aid of this information or any other use of this information.

View our full Website Terms and Conditions.

Contact us

+1 855-458-0579 (toll free from USA)
ussupport@bmj.com

BMJ Americas Office
2 Hudson Place, Suite 300
Hoboken, New Jersey 07030
KuoJen Tsao, MD
Professor
Department of Pediatric Surgery, McGovern Medical School at The University of Texas Health Science Center at Houston, Houston, TX
DISCLOSURES: KT declares that he has no competing interests.

Kathryn Tinsley Anderson, MD
Resident and Pediatric Surgery Research Fellow
Department of Pediatric Surgery, McGovern Medical School at The University of Texas Health Science Center at Houston, Houston, TX
DISCLOSURES: KTA declares that she has no competing interests.

Dr KuoJen Tsao and Dr Kathryn Tinsley Anderson would like to gratefully acknowledge Dr Luke R. Putnam, Dr Shinil K. Shah, Dr Nathan D. Allison, and Dr Peter A. Walker, previous contributors to this monograph. LRP, SKS, NDA, and PAW declare that they have no competing interests.

Ann O. Scheimann, MD, MBA
Associate Professor of Pediatrics
Johns Hopkins School of Medicine, Baltimore, MD
DISCLOSURES: AOS declares that she has no competing interests.

Charles L. Snyder, MD
Professor of Surgery
University of Missouri, Kansas City Children's Mercy Hospital, Kansas City, MO
DISCLOSURES: CLS declares that he has no competing interests.

Karla Au. Yeung, MD
Assistant Professor
Pediatric Gastroenterology and Nutrition, The Johns Hopkins Hospital, Baltimore, MD
DISCLOSURES: KAY declares that she has no competing interests.

Raymond G. Buick, MB BCh, BAO, FRCS (Edin), FRCS (Eng)
Consultant Paediatric Surgeon
Department of Paediatric Surgery, Birmingham Children’s Hospital, Birmingham, UK
DISCLOSURES: RGB declares that he has no competing interests.