Evaluation of abdominal pain in children

The right clinical information, right where it's needed
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Pediatric abdominal pain is a common problem that often poses a diagnostic dilemma. The vast majority of episodes are benign and self-limiting, but persistent abdominal pain may signify an underlying pathology requiring urgent intervention. Acute abdominal pain can also be caused by a wide range of conditions, some of which are emergencies (e.g., acute appendicitis). Timely evaluation and intervention are critical in children presenting with abdominal pain.

A broad spectrum of etiologies can cause abdominal pain, and diagnosis can be challenging. In most cases, a thorough history and physical exam can narrow the differential diagnoses. Additional investigations may be required to confirm the diagnosis.

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.
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, and an understanding of the more common diseases affecting the child’s age group, are essential.

Gastrointestinal

Gastrointestinal (GI) sources are the most common etiology of abdominal pain in children, encompassing infectious, congenital, functional, and mechanical causes.

Constipation

• A common condition, with a reported pooled prevalence of 9.5%.[1]
• Childhood constipation is typically characterized by infrequent bowel evacuations, large stools, and difficult or painful defecation.[2]
• 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 learning difficulties.
• Constipation starts as an acute problem but can progress to fecal impaction and chronic constipation.
• It tends to develop during three 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. A cohort study in Sweden found that 2.5% of children had had appendicitis by age 18 years.[3]
• If left untreated, acute appendicitis progresses to ischemia, necrosis, and eventually perforation. The overall rate of perforation is about 30%.[4] Risk of perforation increases if appendectomy is delayed.[5]

Gastroenteritis

• May be due to acute or chronic viral infection (especially rotavirus), or bacterial or parasitic infection.
• Causes vague, cramping abdominal pain in association with fever, vomiting, and diarrhea.
• 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.[6]
• 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.[7]

Intussusception

• Occurs when a proximal segment of the intestine telescopes into the lumen of an immediately distal segment. In most cases, the intussusception is in the ileocecal area.
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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.

- Usually occurs in infants between 3 and 12 months of age. Peak incidence is 5 to 7 months of age.[8]
- Intussusception should be suspected in an infant in this age group presenting with colicky abdominal pain, flexing of the legs, fever, lethargy, and vomiting.
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• 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-Schönlein purpura (HSP). HSP is a vasculitis that affects small veins and primarily occurs in children <11 years of age.

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 up to 3%.[9]
• Intestinal obstruction is a known complication and may be observed in as many as 40% of all symptomatic Meckel diverticula (according to some series).[10] [11]

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 23% of patients undergoing negative appendectomy have been found to have nonspecific mesenteric adenitis.[12]
• One retrospective study reported that, compared with children who have appendicitis, patients who have mesenteric adenitis are more likely to have high fever (above 102.2°F [39°C]) and dysuria, and are less likely to have migratory pain, vomiting, or typical abdominal signs of appendicitis on examination.[13]

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. Acquired causes include small bowel adhesions, strangulated or incarcerated hernias, and tumors.
• Congenital causes:
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- 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 four types of atretic bowel, and all result in a complete obstruction due to a blind-ending lumen.
- Hernias may be internal or external and congenital or acquired.
- 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.

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.

- Acquired causes:
  - May 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.
- 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.

Volvulus

- This can occur in any age group, but is most common in children <1 year old; at least 60% of children present before 1 month of age.[14] Midgut volvulus is the most common type. Sigmoid volvulus can also occur.
- Green (bilious) vomiting is a cardinal symptom of duodenal obstruction secondary to midgut volvulus.[14]
- 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

• 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.
• Typical symptoms are feed intolerance, abdominal distension, and bloody diarrhea at 8 to 10 days of age.[15] Other signs and symptoms include apnea, lethargy, abdominal tenderness, abdominal wall erythema, and bradycardia.

Peptic ulcer disease

• Gastric and duodenal ulcers are uncommon among the pediatric population.[16] 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 and Crohn disease.
• Ulcerative colitis affects the rectum and extends proximally, and is characterized by diffuse inflammation of the colonic mucosa and a relapsing, remitting course. Ulcerative colitis is uncommon in people younger than 10 years old.
• Crohn disease may involve any or all parts of the entire GI tract from mouth to perianal area. Unlike ulcerative colitis, Crohn disease 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.
• Ulcerative colitis often presents with bloody diarrhea, whereas this is an unusual presentation in Crohn disease. Both conditions cause cramping abdominal pain, anorexia, and weight loss when they present late in the course of the disease. Depending on the intestinal location of Crohn disease, it may mimic other disease processes such as acute appendicitis.

Celiac disease

• Systemic autoimmune disease triggered by dietary gluten peptides found in wheat, rye, barley, and related grains.
• Immune activation in the small intestine leads to villous atrophy, hypertrophy of the intestinal crypts, and increased numbers of lymphocytes in the epithelium and lamina propria. Locally these changes lead to GI symptoms and malabsorption.
Celiac disease is a common disorder in the US and in Europe. A relatively uniform prevalence has been found in many countries, with pooled global seroprevalence and biopsy-confirmed prevalence of 1.4% and 0.7%, respectively.\[17\]

Patients may present with recurrent abdominal pain, cramping, or distension.\[18\] Other common symptoms include bloating and diarrhea. Dermatitis herpetiformis, an intensely pruritic papulovesicular rash that affects the extensor limb surfaces, almost universally occurs in association with celiac disease.

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 right upper quadrant (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.

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 cholelithiasis.

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.

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 developed countries.

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 developed countries.

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.

Acute pancreatitis

Refers to inflammation of the pancreas; it does not necessarily imply that infection is present.

Pancreatitis in children is often due to drugs, infection, anatomic abnormalities, or trauma.\[19\] Corticosteroids, adrenocorticotropic hormones, estrogens including contraceptives, azathioprine,
asparaginase, tetracycline, chlorothiazides, and valproic acid may induce pancreatitis. Congenital causes include choledochal cyst causing abnormal pancreas and bile drainage and pancreas divisum. Infectious causes include mumps and infectious mononucleosis.

- 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. 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.[20] 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.[21]

- Splenic infarction occurs when there is occlusion of the splenic blood supply. It may affect the whole organ or only a portion of the spleen, depending on the blood vessels involved. The incidence of splenic infarction is difficult to assess.

Abdominal trauma

- A multicenter prospective study found that abdominal trauma accounted for 3% of admissions to pediatric trauma units.[22]
- Generally classified as penetrating or blunt. Occult blunt abdominal trauma should always be considered in the setting of vague or inconsistent history. 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.
- It is essential to consider child abuse/nonaccidental trauma in this patient population (e.g., a kick to the abdomen).

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. UTI is more common in girls. UTIs affect approximately 4% and 10% of children by ages 1 year and 6 years, respectively.[23]
- Bacterial infections are the most common cause, particularly *Escherichia coli* infection.

Primary dysmenorrhea
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• Dysmenorrhea, or painful menstruation, is one of the most common gynecologic conditions affecting females of reproductive age.

• 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), or chronic disease (e.g., renal tubular acidosis).

• Stones less than 5 mm in diameter will generally pass spontaneously.

Testicular torsion

• 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.

• Has a bimodal distribution, with extravaginal torsion affecting neonates in the perinatal period, and intravaginal torsion affecting males of any age but most commonly adolescent boys.

• Pain from torsion of a testicular appendage 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.

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.

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. Sexually transmitted infections are a key risk factor.
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Overview

• 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.[31] The majority of spontaneous miscarriages occur in the first trimester.[32]

• Ectopic pregnancy occurs when a fertilized ovum implants and matures outside the uterine endometrial cavity, with the most common sites being the fallopian tube (97%), the ovary (3.2%), and the abdomen (1.3%).[33] Use of oral contraceptives before age 16 years is associated with increased risk of ectopic pregnancy.[34] The classic presentation includes lower abdominal pain, amenorrhea, and vaginal bleeding. Hemorrhage from a ruptured ectopic pregnancy can be fatal.

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.[35]

Functional abdominal pain

Functional abdominal pain is also referred to as nonspecific abdominal pain; pain is usually chronic or recurrent. Visceral hyperalgesia is the final outcome of sensitizing medical and psychosocial events, on a background of genetic predisposition.[36] 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.[36] [37]

• Typically affects children between 5 and 14 years of age.

• Prevalence estimates vary from 10% to 30% in samples of school students, to 87% in some gastroenterology clinics.[38]

• Family history of functional disorder common (irritable bowel syndrome, mental illness, migraine, anxiety).

• Clarifying the type of functional disorder is important to determine which treatments are most likely to improve symptoms.

Functional dyspepsia

• Defined as one or more of the following bothersome symptoms on at least 4 days per month: postprandial fullness, early satiation, epigastric pain, or burning not associated with defecation. After appropriate evaluation the symptoms cannot be fully explained by another medical condition.[36]

Irritable bowel syndrome

Three criteria must be fulfilled for 2 months prior to diagnosis:[36]

1. Abdominal pain at least 4 days per month associated with one or more of:

   • Related to defecation
• Change in stool frequency
• Change in stool form.

2. In children with constipation, the pain does not resolve with resolution of constipation.
3. After appropriate evaluation the symptoms cannot be fully explained by another medical condition.

Abdominal migraine

All of the following criteria must be fulfilled for at least 6 months prior to diagnosis and on at least two occasions:[36]

1. Paroxysmal episodes of intense, acute periumbilical, midline, or diffuse abdominal pain lasting at least 1 hour. The abdominal pain must be the most severe and distressing symptom.
2. Episodes separated by weeks or months.
3. Pain is incapacitating and interferes with normal activities.
4. Stereotypical pattern and symptoms in the individual.
5. Pain associated with 2 or more of:
   • Anorexia
   • Nausea
   • Vomiting
   • Headache
   • Photophobia
   • Pallor.
6. After appropriate evaluation the symptoms cannot be fully explained by another medical condition.

Functional abdominal pain - not otherwise specified

Three diagnostic criteria must be fulfilled at least four times per month, for 2 months prior to diagnosis:[36]

1. Episodic or continuous abdominal pain that does not occur solely during physiologic events (e.g., eating, menstruation)
2. Insufficient criteria for irritable bowel syndrome, functional dyspepsia, or abdominal migraine diagnosis
3. After appropriate evaluation the symptoms cannot be fully explained by another medical condition.

Alarm features in children with chronic abdominal pain, which may indicate an organic or motility-related rather than a functional cause, include:[36]

• Family history of inflammatory bowel disease, celiac disease, or peptic ulcer disease
• Persistent right upper or right lower quadrant pain
• Dysphagia
• Odynophagia
• Persistent vomiting
• Gastrointestinal bleeding
• Nocturnal diarrhea
• Arthritis
• Perirectal disease
• Involuntary weight loss
• Deceleration of linear growth
• Delayed puberty
• Unexplained fever.
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.

Absent bowel sounds, bilious vomiting, bloody diarrhea or occult blood in stool, fever (≥100.4°F [≥38.0°C]), rebound tenderness, rigidity, and voluntary guarding indicate a possible need for surgery.[39]

Gastrointestinal (GI) emergencies

Acute appendicitis resulting in perforation

- Untreated acute appendicitis may progress to ischemia, necrosis, and eventually perforation. The clinician may encounter a range of presentations. Patients often complain of abdominal pain localized to the right lower quadrant; 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).
- A computed tomography (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.[41]
- 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.[42]

Intestinal obstruction

- Urgency of intervention is dependent on the clinical severity of the obstruction.
- 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.
- 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.

Intussusception

- May lead to venous obstruction and bowel-wall edema and can progress, if untreated, to bowel necrosis, perforation, and, rarely, death.[43] [44] 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 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.

**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.

**Necrotizing enterocolitis**

• The most common medical/surgical emergency affecting neonates, particularly premature infants, especially those weighing less than 1500 g.

• Signs and symptoms include feeding intolerance, apnea, lethargy, bloody stools, abdominal distension, tenderness, abdominal wall erythema, and bradycardia.

• Early intervention is mandatory to prevent morbidity and mortality due to multiple organ impairment. Treatment may be medical or surgical, and is determined by severity of the clinical presentation.

**Abdominal trauma**

• 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.[45][46]

**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.

• A quick and focused ultrasonographic exam to assess for the presence of free fluid or blood may be helpful when this diagnosis is suspected, but should not delay other care.

• Hemodynamic instability associated with a ruptured ectopic pregnancy results from severe hypovolemia secondary to blood loss. As such, the management of these patients involves stabilization with emergency fluid resuscitation and immediate transfer to the operating room. Rapid volume repletion with isotonic solution and blood products is of paramount importance to avoid ischemic injury and multi-organ damage.
• 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.[47] [48]

Testicular torsion

• Should be ruled out in any male child presenting with abdominal pain.[25] 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.
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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 sequelae. 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.[39]

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:

Age of the child

The age of the child affects some of the likely differential diagnoses:[39]

- Neonates, infants, and toddlers: may present with abdominal pain caused by congenital causes or diseases linked to prematurity, such as necrotizing enterocolitis, Meckel diverticulum, Hirschsprung disease, volvulus, intestinal obstruction caused by congenital atresia, or stenosis. Intussusception is also common in this age group.
- School-age children: idiopathic constipation and infectious causes of pain are most common in this age group. Functional abdominal pain and abdominal migraine may also present in this age group.
- Adolescents: conditions related to menstruation, sexually transmitted infections, and pregnancy should be considered. Testicular torsion, ovarian torsion, irritable bowel syndrome, and inflammatory bowel disease are more common in this age group.

Pain history

- Onset, frequency, timing, and duration of the pain episode.
- Whether the pain is localized or diffuse: right lower quadrant (RLQ) pain suggests appendicitis; epigastric pain suggests peptic ulcer disease; diffuse pain may indicate perforation or peritonitis. Poorly localized pain that improves with movement is likely to be visceral pain from hollow organs, whereas well localized pain that worsens with movement is likely to arise from parietal peritoneum, parietal muscle, or skin.[39]
- Whether the pain radiates or migrates between areas of the abdomen: abdominal pain radiating to the back is suggestive of cholecystitis or pancreatitis. Pain that begins centrally and migrates to the RLQ is typical of appendicitis.
- Any factors that make the pain better or worse, such as movement, defecation, 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; painful defecation may indicate constipation.
- 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.
Associated symptoms

The clinician should enquire about the presence and severity of:

- Fever, nausea, vomiting, anorexia (gastroenteritis, mesenteric adenitis)
- Diarrhea (gastroenteritis)
- Fatigue or jaundice (viral hepatitis)
- Lethargy, headache, photophobia (abdominal migraine)
- 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, hemolytic uremic syndrome) or mucus in stool (suggests bacterial or parasitic infection)
- Blood or bile in vomitus (small bowel obstruction)
- Genitourinary symptoms: dysuria, frequency of micturition, and hematuria suggest a urinary tract infection (UTI); vaginal discharge is suggestive of pelvic inflammatory disease; current menstruation may be indicative of dysmenorrhea.

Trauma history

- If there is a history of trauma, ascertain whether it is blunt or penetrating, and accidental or nonaccidental.

Travel history

- Travel to a developing country increases risk of viral hepatitis infection and infectious gastroenteritis.

Stooling patterns and dietary history

- The presence of bilious vomiting without passage of stool/flatus suggests complete small bowel obstruction. Bilious vomiting with passage of stool or flatus suggests partial small bowel obstruction.
- Infrequent bowel action or fecal incontinence is suggestive of constipation. 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. Dietary history, paying attention to fiber and fluid intake, is helpful when evaluating constipation; new or unusual food intake may support the diagnosis of gastroenteritis.

Past medical history (including birth and development)

This should focus on previous operations, medication use, immunizations, allergies, and current comorbidities, for example:

- Patients with sickle cell disease or cystic fibrosis are at higher risk of developing gallstones
- Patients with spina bifida, learning difficulties, or 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
- Hirschsprung disease is associated with Down syndrome
- Failure to pass meconium in the first 36 hours of life is strongly suggestive of Hirschsprung disease
- Necrotizing enterocolitis should be considered in a premature neonate weighing less than 1500 g.

Drug history
• Some medication, such as iron supplements, can cause constipation. Corticosteroids, adrenocorticotropic hormones, estrogens including contraceptives, azathioprine, asparaginase, tetracycline, chlorothiazides, and valproic acid may induce pancreatitis. Nonsteroidal anti-inflammatory drugs (NSAIDs), salicylates, and corticosteroids are associated with peptic ulcer development.

Family history

• Positive family history is a risk factor for inflammatory bowel disease, nephrolithiasis, and functional abdominal pain.

Social and psychiatric history

• This should include a discussion of family dynamics and 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.
• History of nicotine, caffeine, or alcohol consumption may suggest peptic ulcer; excess alcohol consumption is a risk factor for pancreatitis.

Sexual history (in adolescents)

• 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.

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

Vital signs:

• Consideration of vital signs should be based on age-appropriate normal values.
• It is important to determine whether signs of volume depletion are present (tachycardia, hypotension, dry mucous membranes, poor capillary refill, sunken fontanel in infants). Children with gastroenteritis may quickly become volume depleted.
• 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. High fever is suggestive of pyelonephritis.[49]
• Cholecystitis, pancreatitis, and splenic infarction typically cause fever.
• Patients with appendicitis do not usually have significant changes in vital signs. Body temperature may be increased by 1.8°F (1°C).
• Children with constipation are usually well with normal vital signs.

Abdominal exam:

• Patients presenting with central abdominal pain, with or without guarding and rigidity, that settles in the RLQ should arouse suspicion of appendicitis. 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. One retrospective study found that, compared with children who have appendicitis, patients who have mesenteric adenitis are more likely to have high fever (above 102.2°F [39°C]) and dysuria, and are less likely to have migratory pain, vomiting, or typical abdominal signs of appendicitis on examination.[13] Classic abdominal signs of appendicitis are RLQ abdominal tenderness (McBurney sign) and localized rebound tenderness, if the appendix is anterior. Compressing the left lower quadrant (LLQ) may elicit pain in the RLQ (Rovsing sign). Patients with appendicitis may lie still and try not to move, particularly in severe cases with significant peritoneal irritation.

• Patients with gastroenteritis usually exhibit diffuse abdominal pain without evidence of peritonitis (no guarding or rebound tenderness). Abdominal distension and hyperactive bowel sounds are common findings.

• The presence of abdominal distension and tenderness associated with decreased or absent bowel sounds is strongly suggestive of large bowel obstruction. In severe cases of constipation, abdominal distension may be present with a palpable fecal mass per abdomen or rectum.

• Flank pain or renal angle tenderness may indicate pyelonephritis or nephrolithiasis.

• Epigastric pain may indicate peptic ulcer disease or pancreatitis. Patients with pancreatitis 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.

• Tenderness in the right upper quadrant (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.

• Patients with splenic infarction typically present with left-sided abdominal pain. 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.[50]

• 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). The presence of seat belt marks increases the likelihood that intra-abdominal injuries are present, particularly in the presence of lumbar fracture or persistent tachycardia.[51]

• 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.[37]

• Absent bowel sounds, bilious vomiting, bloody diarrhea or occult blood in stool, fever (≥100.4°F [≥38°C]), rebound tenderness, rigidity, and voluntary guarding indicate a possible need for surgery.[39]

Digital rectal exam:
There may be palpable stool in the rectum in constipation.

The presence of an anal fissure and/or hemorrhoids (rare in children; may be mistaken for skin tags from Crohn disease), imperforate anus, or anal stenosis (particularly in a neonate or infant) may provide further diagnostic clues.

External genital exam:

- 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.
- Blood at the urethral meatus, or hematuria, after trauma may suggest urinary tract or kidney injury.

General examination:

- Generalized lymphadenopathy is common and signs of an upper respiratory tract infection may be present in children with mesenteric adenitis (e.g., hyperemic pharynx or oropharynx suggesting pharyngitis).
- Jaundice is rare with cholelitiasis or acute cholecystitis and, if present, suggests an obstruction of the common bile duct. 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).
- Children with spina bifida, learning difficulties, and cerebral palsy are 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).
- 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).
- Extraintestinal manifestations of inflammatory bowel disease may be evident (e.g., iritis, arthritis, sacroiliitis, erythema nodosum, pyoderma gangrenosum).
- 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.

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 constipation (intussusception, volvulus, or herniation can result).

Reproductive age
Evaluation of abdominal pain in children

Diagnosis

- 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. Peritonism may be present in the 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 pelvic inflammatory disease (PID) vary widely and may include lower abdominal tenderness, adnexal tenderness, and cervical motion tenderness. Fever and cervical or vaginal discharge may also be present. 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.

- 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.

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.

Initial blood tests may include:

- CBC, recommended in all patients (useful in evaluating infection and inflammation).
- Complete chemistry panel, recommended in all patients (electrolyte disturbances associated with GI causes are common).
- Blood type and screen and rhesus status when ectopic pregnancy is suspected.
- Liver tests are helpful baseline investigations, when considering a hepatobiliary or pancreatic cause.
- Serum amylase and lipase is indicated if pancreatitis is suspected.
- Inflammatory markers. Although nonspecific, erythrocyte sedimentation rate and CRP may suggest underlying infection or inflammation. Furthermore, these inflammatory markers correlate closely with disease activity in cases of inflammatory bowel disease.
- A coagulation profile, including prothrombin time and INR, is usually necessary in cases of suspected viral hepatitis to measure liver synthetic function.

Microbiologic investigations

- 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.[53]

- 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.[53]
- Urine culture is necessary if urinalysis is suggestive of a UTI.
- Sputum culture is indicated in 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 antisaccharomyces cerevisiae antibody) may be particularly useful for differentiating between Crohn disease and ulcerative colitis in the pediatric population.[54][55]
- 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 sexually transmitted infections. Therefore, HIV serology, syphilis serology, hepatitis studies, and nucleic acid amplification testing 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 surface, core, and e antigen or viral load, hepatitis C serology or viral load, hepatitis D and E serologies.

**Imaging and other investigations**

Imaging studies are guided by history and physical exam findings.

**Abdominal and chest x-ray**

Plain abdominal x-rays are often nonspecific but may suggest the presence of an obstruction; fecal impaction and duodenal atresia can be detected on x-ray. 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**

Ultrasound scans avoid radiation exposure and are typically better tolerated than other imaging modalities such as computed tomography (CT) scan. An experienced pediatric radiologist may be able to utilize ultrasound in all regions of the body (abdomen, chest, testicles).

Ultrasound is recommended as the first imaging test for suspected appendicitis.[41] 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 duplex Doppler 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.[56] 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.[57] 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.[58] 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.

CT and magnetic resonance imaging (MRI)

CT with contrast may be appropriate in investigating suspected appendicitis if ultrasound is nondiagnostic;
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.[59]

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.[60] 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

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.

Nuclear medicine scans

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).[61]
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.
#### Voiding cystourethrogram

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.[62] Other guidelines have slightly different recommendations.[49] [63]

#### Full skeletal x-rays

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

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

[Fig-5]
[Fig-6]
[Fig-9]
[Fig-8]
[Fig-2]
[Fig-18]
[Fig-10]

[VIDEO: Peripheral venous cannulation: animated demonstration ]

[VIDEO: Venepuncture and phlebotomy: animated demonstration ]
# 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

- Celiac disease
- Viral hepatitis
- Biliary dyskinesia
- Acute pancreatitis
- Splenic infarction/cysts
- Nephrolithiasis
- Testicular torsion
- Ovarian torsion
- Ruptured ovarian cyst
- Pelvic inflammatory disease (PID)
- Pregnancy complications
- Empyema
Differential diagnosis

**Common**

◊ **Constipation**

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
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<tbody>
<tr>
<td>poor diet and fluid intake; history of cerebral palsy, learning difficulties, 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</td>
<td>»<strong>none</strong>: clinical diagnosis&lt;br&gt;Characteristic history and examination findings are often sufficient to diagnose the condition.</td>
<td>»<strong>abdominal x-ray</strong>: stool visible throughout colon.&lt;br&gt;Stool throughout the colon does not rule out other etiologies of abdominal pain.&lt;br&gt;[Fig-19]</td>
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**Acute appendicitis**

<table>
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<td>history of sharp or stabbing periumbilical pain that migrates to the right lower quadrant (RLQ); anorexia, fever, vomiting, and/or diarrhea may be</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</td>
<td>»<strong>CBC</strong>: normal or elevated WBC&lt;br&gt;May see leukocytosis with neutrophilia.&lt;br&gt;However, a normal</td>
<td>»<strong>abdominal ultrasound</strong>: dilated appendix, free fluid; appendicolith may be present&lt;br&gt;Ultrasound is the preferred method</td>
</tr>
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</table>

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.[60] Sedation or general anesthesia may be required in some children.
## Acute appendicitis

### History

Present; occurs in all age groups but is rare in infants

### Exam

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 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

### 1st Test

WBC count does not exclude appendicitis.

**Urinalysis:** normal
If positive for red cells, white cells, or nitrates an alternative diagnosis such as renal colic or urinary tract infection should be considered.

The specific gravity of urine can sometimes suggest volume status.

**Urine pregnancy test:** negative
In adolescent girls, a pregnancy test should be performed to exclude ectopic pregnancy.

### Other tests

of assessment.[41]
However, a negative ultrasound does not necessarily rule out appendicitis as a cause of abdominal pain.[65]
In children, specificity of ultrasound is similar to that of CT (0.91 vs. 0.92).[66] It may elicit a sonographic McBurney sign (pain on compression of the appendix that is visualized on ultrasound).

**CT scan abdomen and pelvis:** dilated appendix, free fluid, mesenteric stranding, or appendicolith; abscess or phlegmon consistent with perforated appendicitis Useul 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).[66] Radiation exposure should be considered.[60]

Oral/IV contrast burden and radiation have to be considered.
### Common

#### Acute appendicitis

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<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;</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,</td>
<td>none: clinical diagnosis</td>
<td>However, use of oral/IV contrast increases sensitivity of CT scan. Rectal contrast is typically not necessary. Sedation or general anesthesia may be required in some children. MRI scan abdomen and pelvis: dilated appendix; hyperintensity of the luminal contents of the appendix, periappendiceal tissue and thickened wall. In children, MRI has excellent sensitivity (0.97) and specificity (0.96); however, there are fewer studies evaluating its test characteristics. It is increasingly used due to the potential hazards of ionizing radiation from CT.</td>
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#### Gastroenteritis

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<td>none: clinical diagnosis</td>
<td>serum electrolytes: normal or low sodium and potassium. Measurements of serum electrolytes, urea, and creatinine are usually not necessary to assess children with acute gastroenteritis,</td>
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**Common**

◊ **Gastroenteritis**

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<td>fever, chills, myalgia, rhinorrhea, upper respiratory symptoms</td>
<td>hypotension, dry mucous membranes, poor capillary refill, sunken fontanelle in infants; low-grade fever, lethargy and/or irritability, reduced response to noxious stimuli, abnormal temperature (elevated or low)</td>
<td>as the results do not change the therapeutic strategy. These tests should only be considered in a subset of patients with severe dehydration receiving intravenous therapy.</td>
<td></td>
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</table>

» **BUN and creatinine:** normal; may have evidence of renal failure in patients with hemolytic uremic syndrome

Measurements of serum electrolytes, urea, and creatinine are usually not necessary to assess children with acute gastroenteritis, as the results do not change the therapeutic strategy. These tests should only be considered in a subset of patients with severe dehydration receiving intravenous therapy.

» **stool microscopy and culture:** fecal leukocytes; ova or parasites; culture positive for infectious agent in bacterial gastroenteritis

Fecal leukocytes and stool culture may be helpful in children presenting with dysentery and to demonstrate invasive pathogens such as

» **stool microscopy and culture:** fecal leukocytes; ova or parasites; culture positive for infectious agent in bacterial gastroenteritis

Fecal leukocytes and stool culture may be helpful in children presenting with dysentery and to demonstrate invasive pathogens such as
## Evaluation of abdominal pain in children

### Diagnosis

#### Common

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

- **Clostridium difficile**
  - Ova and parasite studies are useful if history suggests camping, travel to other countries, or long-term disease.

  In patients who have taken previous antibiotics or have contact with an individual with *Clostridium difficile* diarrhea, it is important to test for *Clostridium difficile* toxin. Untreated *Clostridium difficile*-related diarrhea can have serious consequences (e.g., toxic megacolon).

- **Urine dipstick**: may detect presence of albumin or blood in hemolytic uremic syndrome

- **CBC**: variable
  - Eosinophilia with viral or parasitic etiology, peripheral eosinophilia suggests eosinophilic gastroenteritis;
  - Bandemia with bacterial etiology; anemia and/or thrombocytopenia if hemolytic uremic syndrome.

  Ordered to help differentiate alternative disease processes. However, in true gastroenteritis, only
## Diagnosis

### Common

<table>
<thead>
<tr>
<th>◊ Gastroenteritis</th>
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</thead>
</table>

#### History

#### Exam

#### 1st Test

#### Other tests

- **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 such as hemolytic anemia.[53]

- **endoscopy with biopsy:** variable. Indicated only when eosinophilic gastroenteritis is a concern (condition affecting the gastrointestinal tract with eosinophil-rich
## Evaluation of abdominal pain in children

### Diagnosis

#### Common

**◊ Gastroenteritis**

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</table>
| neonates and infants: fever, vomiting, lethargy, irritability, and poor feeding; older children: dysuria, urinary frequency and urgency, back pain if pyelonephritis | variable; fever >102.2°F (>39°C); suprapubic and/or costovertebral angle tenderness; irritability; foul-smelling urine; gross hematuria | urine dipstick: positive leukocyte esterase and/or positive nitrite | inflammation without a known cause of the eosinophilia) | urinary tract infection

#### Urinary tract infection

<table>
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<tr>
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<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 (&gt;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</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: hypoechocic fluid</td>
</tr>
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</table>

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.[68] [69]

Positive nitrite alone: sensitivity 58%, specificity 99%, LR + 15.9, LR- 0.51.[68] [69] This test has a high positive predictive value.

Positive for either leukocyte esterase or nitrite: sensitivity 92%, LR- 0.2.[68] [69] This test is best at ruling out disease.

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: hypoechocic 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 abdominal pain and fever persist.

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
# Diagnosis

## Urinary tract infection

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<td>Positive for leukocyte esterase and nitrate: LR+ 28:2.[69] This test is best at ruling in disease.</td>
<td></td>
<td></td>
<td>(AAP) recommend that a VCUG is indicated in children between 2 and 24 months of age following an initial urinary tract infection (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.[62] Other guidelines have slightly different recommendations.[49][63]</td>
</tr>
<tr>
<td>» urine microscopy: &gt;4 WBC per high-power field or any bacteria Microscopic analysis is more accurate; however, a urine dipstick analysis may suffice.</td>
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<tr>
<td>Pyuria (the presence of WBC): sensitivity 78%, specificity 87%; LR- 0:27.[68][69] Bacteriuria: sensitivity 88%, specificity 93% LR+ 14:7, LR- 0:19.[68][69]</td>
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<td>Centrifugation reduces the specificity of these tests.</td>
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<tr>
<td>» urine culture: suprapubic aspirate: &gt;1000 colony-forming units (CFU)/mL; catheter: &gt;10,000 CFU/mL; clean-catch midstream: &gt;100,000 CFU/mL</td>
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<tr>
<td>Urine collected from urinary bags is likely to be contaminated.</td>
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AAP = American Academy of Pediatrics; WBC = white blood cell; UTI = urinary tract infection; VCUG = voiding cystourethrogram.
# Abdominal trauma (blunt or penetrating)

<table>
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</tr>
</thead>
</table>
| history of trauma; abdominal pain may be out of proportion to exam findings; may have multiple complaints; history may suggest child abuse or nonaccidental trauma (e.g., inconsistent or changing history) | 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 in an infant/young toddler) | »CBC: may be normal or show decreased hematocrit and hemoglobin Patients with acute-onset hemorrhage may have normal hematocrit and hemoglobin values.  
»abdominal CT scan with intravenous contrast: variable  
This is the diagnostic test of choice for the identification of solid organ injuries, especially to liver, kidney, and/or spleen.  
»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 (FAST) may be useful in patients with blunt abdominal trauma who are hemodynamically unstable.[56] 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.[57]  
»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 | |
### Common

<table>
<thead>
<tr>
<th>Abdominal trauma (blunt or penetrating)</th>
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<tbody>
<tr>
<td><strong>History</strong></td>
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<tr>
<td>recurrent, episodic right upper quadrant (RUQ) pain, may radiate to the back and is classically colicky in nature; often occurs after eating, particularly fatty foods; nausea, 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>
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<tr>
<th>Cholelithiasis/cholecystitis</th>
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### Common

#### ◊ Primary dysmenorrhea

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<th>Other tests</th>
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</thead>
<tbody>
<tr>
<td>history of recurrent crampy abdominal pain associated with menstruation</td>
<td>lower abdominal tenderness; normal pelvic exam</td>
<td>none: diagnosis is clinical</td>
<td>abdominal/pelvic ultrasound: normal; however, useful to rule out other diagnoses</td>
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</table>

#### ◊ Pneumonia

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<tr>
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</thead>
</table>
| 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 | tachypnea, cyanosis, decreased breath sounds, crackles/rales on auscultation, dullness on percussion; abdominal tenderness and distension without guarding or rebound | CBC: variable In patients with viral pneumonia, WBC count may be normal or decreased. | 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. Radiation exposure should be considered. Sedation or general anesthesia may be required in some children. |

#### ◊ Functional abdominal pain

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</table>
| history 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 vomitings are common and weight loss uncommon | periumbilical tenderness, abdomen is soft, undistended, no guarding or rebound tenderness; exam of other systems normal | none: diagnosis is clinical after exclusion of possible organic causes | CBC: normal 
erythrocyte sedimentation rate: normal 
urinalysis: normal |
Diagnosis

Common

◊ Functional abdominal pain

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<td>vomiting, particularly in chronic cases; family history of functional disorders common (e.g., irritable bowel syndrome, anxiety, psychiatric disorders, and migraine); Rome IV criteria use symptoms for diagnosis[37]</td>
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<td>»stool microscopy: normal</td>
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Uncommon

≈ Intussusception

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<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;recurrant 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.[70] Preferred initial test for children. [Fig-18]</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. In general, for investigation of abdominal pain in children, CT scan of the abdomen and pelvis, with or without contrast,</td>
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Uncommon

Intussusception

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<td>may provide a high yield of information, but radiation exposure should be considered.[60] Sedation or general anesthesia may be required in some children.</td>
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<td>» abdominal ultrasound: tubular mass in longitudinal view; target lesion in transverse view Can be used to monitor success of treatment with enema.</td>
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<td>» CBC: may show elevated WBC (suggests intestinal ischemia)</td>
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◊ Meckel diverticulum

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<td>typically aged &lt;2 years; may present with abdominal pain (may be intermittent or mimic acute appendicitis), and/or painless passage of bright red blood per rectum (hematochezia); often asymptomatic</td>
<td>dark red, maroon, or “red currant jelly” stools; abdominal tenderness with guarding and rebound (may suggest diverticulitis); palpable abdominal mass (may suggest intussusception)</td>
<td>» abdominal ultrasound: tubular mass in longitudinal views and a doughnut or target appearance in transverse views suggests intussusception Good initial test if there is concern for intussusception. Sensitivity is user-dependent.</td>
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<td>» CT scan abdomen and pelvis: may show intussusception, Meckel diverticulitis, and/or dilated bowel consistent with bowel obstruction Not routinely ordered unless concerned for alternative disease process or evaluating for complications.</td>
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<td>May be considered if technetium-99m pertechnetate scan positive</td>
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## Uncommon

### Meckel diverticulum

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<td>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 right lower quadrant; an area of 1.8 cm² of ectopic gastric mucosa in a Meckel diverticulum is required to produce a positive result.</td>
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In the pediatric population, the specificity has been reported to be 95%, with an accuracy of 90%.[71]

### Mesenteric adenitis

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<tr>
<td>diffuse abdominal pain; history of recent or current upper respiratory tract infection</td>
<td>fever, abdominal tenderness not localized to right lower quadrant, rhinorrhea, hyperemic pharynx or oropharynx (pharyngitis), and/or associated extramesenteric lymphadenopathy (usually cervical)</td>
<td><strong>abdominal ultrasound</strong>: enlarged mesenteric lymph nodes Can also show mural and mesenteric thickening suggestive of enteritis.</td>
<td><strong>CT scan abdomen and pelvis</strong>: enlarged mesenteric lymph nodes Demonstrates number and size of mesenteric lymph nodes. Can evaluate entire abdomen in a single scan. In general, for investigation of abdominal pain in children, CT scan of the abdomen and pelvis, with or without contrast, may provide a high</td>
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## Evaluation of abdominal pain in children

### Diagnosis

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◊ **Mesenteric adenitis**

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<td>yield of information, but radiation exposure should be considered. [60] Sedation or general anesthesia may be required in some children.</td>
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◊ **Hirschsprung disease**

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<td>males affected more commonly, mainly presents in early infancy (prior to 6 months); failure to pass meconium in first 36 hours of life; strongly suggestive; may be history of Down syndrome</td>
<td>abdominal distension, fullness in left lower quadrant; palpable fecal mass on abdomen exam; absence of peritonitis (no guarding or rebound tenderness); small rectum and absence of stool on rectal exam; dysmorphic features of Down syndrome may be present</td>
<td>&gt; <strong>abdominal x-ray:</strong> stool visible throughout colon, decreased air in rectum; air-fluid levels may be present. Stool throughout the colon does not rule out other etiologies of abdominal pain. [Fig-5] It is very difficult to differentiate between a distended colon and the small bowel; it is a nonspecific investigation. &gt; <strong>contrast barium enema:</strong> 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. &gt; <strong>rectal biopsy:</strong> absence of ganglion cells and the presence of an excess of nonmyelinated nerves; presence of increased acetylcholinesterase. The specimen must be taken at least 1.5 cm above the pectinate line. Suction biopsy has gained wide acceptance, as it is easily performed, is associated with virtually no risk of perforation, and does not require an anesthetic. &gt; <strong>anorectal manometry:</strong> absent reflex Normally, when the rectum is distended with a balloon, pressure in the anal canal falls because of internal sphincter relaxation. This reflex is absent</td>
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### Uncommon

#### Hirschsprung disease

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<td>positive family history, bloody diarrhea, cramping abdominal pain, anorexia, weight loss, fever, rash</td>
<td>evidence of weight loss, pallor, abdominal tenderness, abdominal mass, iritis (inflamed irritated eyes), arthritis, sacroilitis, erythema nodosum, pyoderma gangrenosum</td>
<td>CBC: leukocytosis, anemia, thrombocytosis Iron deficiency anemia may be present, especially in those with chronic disease. Leukocytosis may also be caused by certain medications used to treat inflammatory bowel disease, such as corticosteroids. <strong>colonoscopy with biopsy:</strong> continuous uniform rectal involvement, loss of vascular marking, diffuse erythema, mucosal granularity and friability, mucosal edema ulcers, fistulas (rarely seen), normal terminal ileum (or mild backwash ileitis in pancolitis) Biopsy of mucosa should be performed in multiple segments of the colon.</td>
<td>in patients with aganglionosis. This is the most sensitive and specific test. However, the test has several limitations including the technical difficulty of evaluating the newborn.</td>
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#### Ulcerative colitis

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<td><strong>plain abdominal x-rays:</strong> dilated loops with air-fluid level secondary to ileus; free air is consistent with perforation; in toxic megacolon, the transverse colon is dilated to 6 cm or more in diameter This test gives an approximate estimate of the extent of disease because an ulcerated colon usually contains no solid feces. Easy, inexpensive, and widely available; ordered when initial presentation or subsequent relapses are associated with signs and symptoms of an acute abdomen. <strong>CT scan abdomen:</strong> thickened inflamed bowel mucosa, thumbprinting, intestinal dilation or evidence of stricture; inflamed</td>
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## Uncommon

### Ulcerative colitis

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<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.</td>
<td>mesentery; intra-abdominal abscesses Ordered when complications or other diagnoses are being considered. 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.[60] Sedation or general anesthesia may be required in some children.</td>
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<td>» erythrocyte sedimentation rate: elevated Inflammatory markers correlate closely with disease activity.</td>
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<td>» CRP: elevated Inflammatory markers correlate closely with disease activity.</td>
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<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 Crohn disease and ulcerative colitis in the pediatric population; about 70% of patients with ulcerative colitis have positive pANCA; about 70% of patients with</td>
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### Evaluation of abdominal pain in children

#### Diagnosis

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<tr>
<th>Uncommon</th>
<th>Crohn disease</th>
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<tbody>
<tr>
<td><strong>◊ Ulcerative colitis</strong></td>
<td><a href="#">Diagnosis</a></td>
</tr>
<tr>
<td><strong>History</strong></td>
<td><strong>Exam</strong></td>
</tr>
<tr>
<td>crampy abdominal pain, intermittent diarrhea, bloody diarrhea if colitis a feature (blood less common in Crohn disease than in ulcerative colitis, weight loss, fatigue, family history of inflammatory bowel disease</td>
<td>aphantous ulcers, evidence of weight loss, pallor, abdominal tenderness, abdominal mass, perianal fistula, perirectal abscess, anal fissure, perianal skin tags; extraintestinal manifestations including iritis, arthritis, sacroiliitis, erythema nodosum, pyoderma gangrenosum</td>
</tr>
<tr>
<td><strong>Other tests</strong></td>
<td><strong>CBC</strong></td>
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<td>elevated</td>
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</table>
Evaluation of abdominal pain in children

Diagnosis

◊ Crohn disease

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<th>Exam</th>
<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td>suggestive of inflammatory bowel disease but the characteristics of the mucosa (including ulcers) cannot be used to distinguish between ulcerative colitis and Crohn disease.</td>
<td>with or without contrast, may provide a high yield of information, but radiation exposure should be considered. [60] Sedation or general anesthesia may be required in some children.</td>
</tr>
</tbody>
</table>

» serologic markers: 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 Crohn disease and ulcerative colitis in the pediatric population; about 70% of patients with ulcerative colitis have positive pANCA; about 70% of patients with Crohn disease have positive ASCA. [55]

Small bowel obstruction

<table>
<thead>
<tr>
<th>History</th>
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</tr>
</thead>
<tbody>
<tr>
<td>intolerant of feeding, with nausea and/or bilious vomiting; abdominal pain may or</td>
<td>limited abdominal distension (with proximal obstructions in the duodenum or early</td>
<td>abdominal x-ray: dilated small bowel loops, air-fluid levels throughout abdomen</td>
<td>abdominal ultrasound: may demonstrate focal area causing obstruction</td>
</tr>
</tbody>
</table>
Evaluation of abdominal pain in children

Diagnosis

Small bowel obstruction

<table>
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<tbody>
<tr>
<td>may not be a feature; history of previous abdominal surgery; history of cystic fibrosis may be present</td>
<td>jejenum); 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>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>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.</td>
</tr>
</tbody>
</table>

» upper gastrointestinal contrast study: dilated small intestine; may demonstrate a transition zone of obstruction Critical to rule out acute midgut volvulus and/or malrotation. [Fig-21]

» lower gastrointestinal contrast study: dilated small intestine; may demonstrate a transition zone of obstruction May be helpful in diagnosing meconium disease; hypertonic contrast medium may
### Uncommon

#### Small bowel obstruction

<table>
<thead>
<tr>
<th>History</th>
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<th>1st Test</th>
<th>Other tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>infant age group; history of bilious vomiting; pain usually manifests as notable transition to an inconsolable state</td>
<td>often diffuse abdominal distension and tenderness; faint or no bowel sounds, rigid abdomen, guarding, rebound tenderness, fever, or hematochezia</td>
<td>» upper gastrointestinal contrast study: bird beak sign of stricture at the site of the volvulus Standard diagnostic test for malrotation. Should be performed with anteroposterior and lateral projections if there is any history of bilious vomiting without previous abdominal surgery.</td>
<td>be helpful for clearing meconium. » CT scan abdomen: dilated small intestine; may demonstrate a transition zone of obstruction, mass, tumor, abscess Helps to determine diagnosis of underlying cause, extent, and location of the obstruction when x-rays are inconclusive.[72] 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>
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</table>

#### Volvulus

<table>
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<td>infant age group; history of bilious vomiting; pain usually manifests as notable transition to an inconsolable state</td>
<td>often diffuse abdominal distension and tenderness; faint or no bowel sounds, rigid abdomen, guarding, rebound tenderness, fever, or hematochezia</td>
<td>» upper gastrointestinal contrast study: bird beak sign of stricture at the site of the volvulus Standard diagnostic test for malrotation. Should be performed with anteroposterior and lateral projections if there is any history of bilious vomiting without previous abdominal surgery.</td>
<td>» CT scan abdomen: bowel obstruction with whirl pattern of mesentery Usually not necessary to make diagnosis.</td>
</tr>
</tbody>
</table>
Evaluation of abdominal pain in children

**Uncommon**

**Volvulus**

<table>
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<tr>
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<tbody>
<tr>
<td>Not necessary if diagnosis is strongly indicated from plain x-rays or there is evidence of bowel necrosis. [Fig-21]</td>
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<tr>
<td>- abdominal x-ray: partial or complete obstruction; dilated bowel loops; air-fluid levels; abdominal free air with perforation. Images in both flat (supine) and upright (erect) position are taken.</td>
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<tr>
<td>- CBC: elevated WBC (suggests intestinal ischemia)</td>
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</table>

**Large bowel obstruction**

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<thead>
<tr>
<th>History</th>
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<tr>
<td>history 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;</td>
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<tr>
<th>Exam</th>
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<tr>
<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>
</tr>
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<tr>
<th>1st Test</th>
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<tbody>
<tr>
<td>- abdominal x-ray: 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>
</tr>
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<thead>
<tr>
<th>Other tests</th>
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<tbody>
<tr>
<td>- abdominal ultrasound: may demonstrate focal area causing obstruction (e.g., intussusception)</td>
</tr>
<tr>
<td>- lower gastrointestinal (GI) contrast study: may indicate site of obstruction. Used to diagnose meconium disease or other cause of lower GI intestinal obstruction such as intussusception.</td>
</tr>
</tbody>
</table>
### Uncommon

#### Large bowel obstruction

<table>
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<tbody>
<tr>
<td>intolerant of feeding, with nausea or vomiting</td>
<td></td>
<td></td>
<td>Hypertonic contrast medium may be helpful for clearing meconium.</td>
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<td><strong>CT scan abdomen and pelvis:</strong> gaseous distension of large bowel; may demonstrate a transition zone of obstruction</td>
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<td>May also reveal underlying cause and provide more diagnostic information than contrast enema.</td>
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<td></td>
<td>Intravenous and oral contrast should be used for best diagnostic yield. Radiation exposure should be considered.[60]</td>
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<td>Sedation or general anesthesia may be required in some children.</td>
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<td><strong>Flexible/rigid sigmoidoscopy:</strong> flood of stool and mucus upon passing and decompressing apex of volvulus</td>
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<td>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>
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</tr>
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</table>
| premature neonate weighing less than 1500 g; feeding intolerance, apnea, lethargy, bloody stools | abdominal distension, tenderness, abdominal wall erythema, hematochezia, bradycardia | - **CBC:** leukocytosis or leukopenia, anemia, thrombocytopenia Decreased WBC count may be more ominous than leukocytosis. Anemia may result with significant hematochezia.  
- **blood culture:** negative  
- **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 anteroposterior and left lateral decubitus views. | - **abdominal ultrasound:** fluid collections, ascites Useful for diagnosing fluid collections that may represent perforation or abscess. |

### Peptic ulcer disease

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</tr>
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</table>
| family history 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 | - **CBC:** normal or leukocytosis; anemia present if sustained blood loss  
- **erect chest x-ray:** usually normal  
- **Helicobacter pylori breath test or stool antigen test:** positive result if *Helicobacter pylori* present Generally not necessary if endoscopy and biopsy are being performed; however, in places where endoscopy is not |  |
## Peptic ulcer disease

### History

#### Exam

free air under the diaphragm).

»**upper gastrointestinal 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 depth of ulcers. This may serve as an initial test prior to the more definitive endoscopy.

»**upper gastrointestinal endoscopy:** mucosal inflammation, ulceration, and hemorrhage

Endoscopy should be performed urgently if bleeding is suspected (prior to any contrast radiologic studies). Contrast may interfere with the evaluation of the mucosa. Biopsies and testing for *Helicobacter pylori* may be performed.

### Other tests

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

#### Celiac disease

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<tbody>
<tr>
<td>recurrent abdominal pain, cramping, or distension; bloating and diarrhea; dermatitis herpetiformis, an intensely pruritic papulovesicular rash that affects the extensor limb surfaces, almost universally occurs in association with celiac disease; may be a history of immunoglobulin A deficiency, type 1 diabetes, autoimmune thyroid disease, Down syndrome, Sjogren syndrome, inflammatory bowel disease, or primary biliary cholangitis; may be a family history of celiac disease</td>
<td>generalized abdominal pain or bloating; underweight or failing to thrive; aphthous stomatitis; dermatitis herpetiformis</td>
<td>»CBC: may show iron deficiency anemia&lt;br&gt;»immunoglobulin A-tissue transglutaminase (IgA-tTG): titer above normal range for laboratory&lt;br&gt;»endoscopy and small bowel biopsy: presence of intraepithelial lymphocytes, villous atrophy, and crypt hyperplasia Small-bowel histology is essential and the gold-standard test to confirm the diagnosis.</td>
<td>»endomysial antibody (EMA): elevated titer EMA is a more expensive alternative to IgA-tTG with greater specificity but lower sensitivity. Perform initially if IgA-tTG is unavailable.&lt;br&gt;»human leukocyte antigen (HLA) typing: positive HLA-DQ2 or HLA-DQ8 This genetic test is useful to rule out celiac disease in patients already on a gluten-free diet or in patients with an idiopathic celiac-like enteropathy. Pediatric patients with symptoms consistent with celiac disease and a high IgA-tTG titer (above normal range for laboratory) may go on to have confirmatory EMA and HLA-DQ2/-DQ8 testing. If both of these are positive, celiac disease may be considered confirmed without a small intestinal biopsy.[73]</td>
</tr>
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</table>

Two biopsies of the bulb and at least four biopsies of the distal duodenum should be submitted for histologic analysis.

Pediatric patients with symptoms consistent with celiac disease and a high IgA-tTG titer (above normal range for laboratory) may go on to have confirmatory EMA and HLA-DQ2/-DQ8 testing. If both of these are positive, celiac disease may be considered confirmed without a small intestinal biopsy.[73]
# Uncommon

## Viral hepatitis

### History
- birth or residence in endemic area, prenatal exposure, family history of chronic viral hepatitis, multiple sexual partners, sexual intercourse with infected individuals (hepatitis B and/or C), 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

### Exam
- jaundice; early disease: tender hepatosplenomegaly, lymphadenopathy; late disease: generalized wasting, cachexia, gynecomastia, ascites, altered sensorium, asterixis, or decreased deep tendon reflexes, caput medusa, ascites, hepatosplenomegaly, congestion secondary to right heart failure

### 1st Test
- »serum LFTs: high direct bilirubin, AST, ALT, alk phos and gamma-GT
- 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

### Other tests
- »CBC: low or normal platelet count
A low platelet count is suggestive of portal hypertension.
- »coagulation profile (prothrombin time [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

<table>
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<tr>
<th>Viral hepatitis</th>
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<tbody>
<tr>
<td><strong>History</strong></td>
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<tr>
<td>hepatitis C virus.</td>
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</tbody>
</table>

Patients should be at least 1 year old prior to testing for hepatitis C.

- **serum total (IgM and IgG) anti-HDV antibodies:** positive if hepatitis D infection
- Performed by enzyme-linked or radioimmunoassay.
- Hepatitis D is a defective virus and can only replicate in the presence of coinfection or superinfection with HBV.

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

### Biliary dyskinesia

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<thead>
<tr>
<th><strong>History</strong></th>
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</tr>
</thead>
<tbody>
<tr>
<td>history of previous negative workup for cholelithiasis common; recurrent right upper quadrant (RUQ) pain; nausea and vomiting; symptoms may or may not be associated with eating</td>
<td>may be equivocal; RUQ tenderness</td>
<td><strong>LFTs:</strong> normal aspartate aminotransferase, alanine aminotransferase, alk phos, and bilirubin</td>
<td><strong>hepatobiliary iminodiacetic acid (HIDA) scan:</strong> decreased (&lt;35%) gallbladder ejection fraction</td>
</tr>
</tbody>
</table>

- **RUQ ultrasound:** normal
- Gallstones should not be demonstrated in

- **hepatobiliary iminodiacetic acid (HIDA) scan:** decreased (<35%) gallbladder ejection fraction
- Considered the diagnostic test of choice.
### Uncommon

**◊ Biliary dyskinesia**

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<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>- patients with biliary dyskinesia.</td>
<td>- The ejection fraction of the gallbladder is measured after the administration 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>
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</table>

### Acute pancreatitis

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| - nausea, vomiting, epigastric pain radiating to back; acute-onset abdominal pain | - 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 | - **amylase:** at least 3 times upper limit of normal range  
  - Serum lipase and amylase have similar sensitivity and specificity but lipase levels remain elevated for longer (up to 14 days after symptom onset vs. 5 days for amylase), providing a higher likelihood of picking up the diagnosis in patients with a delayed presentation.[74]  
  - **lipase:** at least 3 times upper limit of normal range; can be elevated if amylase normal | - **abdominal ultrasound:** may appear normal early in disease course; enlargement of the pancreas; peripancreatic edema; dilated pancreatic duct; may show underlying biliary disease  
  - Ultrasound is a useful and commonly employed modality for the diagnosis of pancreatic disease in children, as there is no radiation exposure involved.  
  - Permits concurrent evaluation of the biliary system for cholelithiasis and/or choledocholithiasis that... |
### Acute Pancreatitis

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<td>Serum lipase and amylase have similar sensitivity and specificity but lipase levels remain elevated for longer (up to 14 days after symptom onset vs. 5 days for amylase), providing a higher likelihood of picking up the diagnosis in patients with a delayed presentation. [74]</td>
<td>may be the underlying cause of pancreatitis.</td>
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<tr>
<td>» Bilirubin: normal or elevated</td>
<td>» <strong>CT scan abdomen with intravenous contrast:</strong> peripancreatic inflammation (fat stranding); may show gallstones</td>
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<tr>
<td>An elevated bilirubin (specifically direct bilirubin) is suggestive of gallstone-induced pancreatitis. In addition, choledochal cysts are an important cause of pancreatitis in children.</td>
<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>
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Allows better assessment of potential pancreatic necrosis (which would indicate more serious disease) and peripancreatic inflammation than is achievable with ultrasound. [Fig-10]

### Splenic Infarction/Cysts

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</thead>
<tbody>
<tr>
<td>varied; may be history of trauma; cysts either asymptomatic or dull,</td>
<td>may be vague left upper quadrant tenderness</td>
<td>» <strong>Doppler ultrasound:</strong> infarction or cyst on spleen</td>
<td>» <strong>CT scan abdomen with intravenous contrast:</strong></td>
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</table>

«Fig-10»
### Splenic infarction/cysts

<table>
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<td>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>
<td></td>
<td>Splenic infarcts appear as wedge-shaped defects. Blood flow is absent, with absence of Doppler signal. Cysts appear anechoic.</td>
<td>contrast: infarction or cyst on spleen Splenic infarcts appear as wedge-shaped defects. Blood flow is absent, manifested as lack of contrast enhancement on CT scan. Splenic cysts may also be visualized. [Fig-11]</td>
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### Nephrolithiasis

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<tr>
<td>family history 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 common in younger children</td>
<td>ipsilateral costovertebral angle and flank tenderness; tachycardia and hypotension in pain-controlled patient may suggest concurrent urosepsis</td>
<td>ultrasound of the urinary tract: calcification seen within urinary tract; possible dilated proximal ureter and hydrenephrosis Ultrasound should be the first modality. As well as diagnosing nephrolithiasis, it can provide information on potential complications of obstruction such as hydrenephrosis. urinalysis: may be normal or dipstick-positive for leukocytes, nitrites, blood; microscopic analysis positive for WBCs, RBCs, or bacteria Patients with nephrolithiasis typically have blood in the urine. It is important</td>
<td>abdominal x-ray: radio-opaque stones If sufficiently radio-opaque, urinary stones may be visible on plain x-rays. Up to 85% of stones are visible, although uric acid stones are radiolucent. noncontrast CT scan abdomen and pelvis: calcification seen in renal collecting system or ureter; possible dilated proximal ureter and hydrenephrosis Highly sensitive for detection of nephrolithiasis and evaluation of hydrenephrosis. In addition, if stones are not seen, an alternative etiology may</td>
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### Uncommon

#### Nephrolithiasis

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<tr>
<td>Uncommon</td>
<td>◊ Nephrolithiasis</td>
<td>to pay attention to other elements of the urine analysis, as the presence of white blood cells, leukocyte esterase, and nitrates may signify a concurrent urinary tract infection.</td>
<td>be detected; frequently, nephrolithiasis detected on CT scan is a serendipitous finding for the investigation of other etiologies of abdominal pain.</td>
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</table>

### Testicular torsion

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<tbody>
<tr>
<td>acute-onset testicular pain; nausea, and vomiting; history of recurrent episodes suggests repeated episodes of testicular torsion followed by spontaneous detorsion; history 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>»duplex Doppler ultrasound of scrotum: 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); absent or decreased blood flow in the affected testicle; decreased flow velocity in the intratesticular arteries, increased resistive indices in the intratesticular arteries An ultrasound or other radiologic test should not delay surgical exploration and definitive treatment if the diagnosis of testicular torsion is highly suggested by history and physical exam.</td>
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</table>
### Testicular torsion

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<tbody>
<tr>
<td>acute onset of one-sided lower abdominal or pelvic pain; nausea and vomiting common; history 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>Duplex Doppler ultrasound includes gray scale, color Doppler, and spectral Doppler ultrasound. Power Doppler can be used as well as or instead of color Doppler. Power Doppler is more sensitive for evaluating areas of low blood flow such as the prepubertal testis.[75]</td>
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### Ovarian torsion

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<td>acute onset of one-sided lower abdominal or pelvic pain; nausea and vomiting common; history 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><strong>pelvic ultrasound:</strong> solid appearance of the ovary, unilateral ovarian enlargement, ovarian peripheral cystic structures, marked stromal edema, fluid in the pouch of Douglas</td>
<td><strong>color Doppler:</strong> 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. <strong>CT scan abdomen and pelvis:</strong> enlarged, edematous ovary with or without vascular enhancement; free fluid in pelvis CT scans can demonstrate adnexal masses and ischemia of the ovary. Typically, ovarian torsion diagnosed by CT scan is a serendipitous finding during an attempt to identify other</td>
</tr>
</tbody>
</table>
### Uncommon

#### Ovarian torsion

<table>
<thead>
<tr>
<th>History</th>
<th>Exam</th>
<th>1st Test</th>
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<tbody>
<tr>
<td>Uncommon</td>
<td>Adnexal tenderness; adnexal size</td>
<td>Pelvic ultrasound:</td>
<td>Sources of abdominal pain. [Fig-17]</td>
</tr>
<tr>
<td>Ovarian torsion</td>
<td>unremarkable due to collapsed cyst;</td>
<td>complex mass appearance; fluid in</td>
<td>In general, for investigation of abdominal pain in children, CT scan of the</td>
</tr>
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<td></td>
<td>peritonism may be present in lower</td>
<td>the pouch of Douglas</td>
<td>abdomen and pelvis, with or without contrast, may provide a high yield of</td>
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<td></td>
<td>abdomen and pelvis</td>
<td></td>
<td>information, but radiation exposure should be considered. [60]</td>
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<td></td>
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<td>Sedation or general anesthesia may be required in some children.</td>
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</table>

#### Ruptured ovarian cyst

<table>
<thead>
<tr>
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<td>Ruptured ovarian cyst</td>
<td>Adnexal tenderness; adnexal size</td>
<td>Pelvic ultrasound:</td>
<td>Sources of abdominal pain. [Fig-17]</td>
</tr>
<tr>
<td>rupture usually spontaneous, can</td>
<td>unremarkable due to collapsed cyst;</td>
<td>complex mass appearance; fluid</td>
<td>In general, for investigation of abdominal pain in children, CT scan of the</td>
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<td>follow history of trauma or sexual</td>
<td>peritonism may be present in lower</td>
<td>in the pouch of Douglas</td>
<td>abdomen and pelvis, with or without contrast, may provide a high yield of</td>
</tr>
<tr>
<td>intercourse; mild chronic lower</td>
<td>abdomen and pelvis</td>
<td>A complex mass appearance</td>
<td>information, but radiation exposure should be considered. [60]</td>
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<td>abdominal discomfort may suddenly</td>
<td></td>
<td>suggests a ruptured hemorrhagic</td>
<td>Sedation or general anesthesia may be required in some children.</td>
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<tr>
<td>intensify</td>
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<td>cyst surrounded by a hematoma.</td>
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<td></td>
<td></td>
<td>Fluid in the pouch of Douglas</td>
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<td></td>
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<td>A complex mass appearance is</td>
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<td>also indicative of a ruptured</td>
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<td></td>
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<td>cyst.</td>
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# Uncommon

◊ **Pelvic inflammatory disease (PID)**

## History

- sexually active; multiple partners; history 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

## Exam

- temperature >101°F (38.3°C); cervical motion tenderness, adnexal or uterine tenderness, vaginal or cervical mucopurulent discharge

## 1st Test

- **wet mount of vaginal secretions:** polymorphonuclear leukocytes (PMNs) seen
  - Presence of vaginal PMNs confirms vaginal infection. High predictive value but not specific for pathogens most likely to cause PID.

- **nucleic acid amplification test or culture of vaginal secretions for Neisseria gonorrhoeae and Chlamydia trachomatis:** positive result indicates presence of organisms
  - Test should be ordered in any patient with suspected PID.

  Specimens obtained from vaginal exam can be sent for testing. 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).

## Other tests

- **pelvic ultrasound:** normal or may demonstrate endometritis, hydrosalpinx, pyosalpinx, tubo-ovarian abscess
  - Test is useful in confirming an uncertain diagnosis. Ultrasound findings can be variable demonstrating any portion of the female reproductive organs.

  Most common findings include pyosalpinx and tubo-ovarian abscess.

- **HIV serology:** positive or negative
  - It is important to test for other sexually transmitted diseases during a workup for PID, including HIV infection.

- **hepatitis studies:** positive or negative
  - It is important to test for other sexually transmitted diseases during a workup for PID, including hepatitis B and C.

- **rapid plasma reagin (RPR):** positive or negative
  - It is important to test for other sexually transmitted diseases during a workup for PID, including syphilis.
## Uncommon

◊ **Pelvic inflammatory disease (PID)**

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### Diagnosis

#### Pelvic inflammatory disease (PID)

- **History**
  - Pelvic inflammatory disease
- **Exam**
  - Pelvic exam
- **1st Test**
  - CBC: leukocytosis
  - CRP or erythrocyte sedimentation rate: elevated
  - Laparoscopy: normal
  - Pregnancy complications

### Pregnancy complications

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- **History**
  - History of previous ectopic pregnancy or miscarriage, fallopian tube or pelvic surgery, pelvic inflammatory disease; lower abdominal pain, amenorrhea, and vaginal bleeding
- **Exam**
  - 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
- **1st Test**
  - Urine pregnancy test: positive
  - Quantitative serum beta-hCG: positive
  - Blood type and screen: variable

- **Other tests**
  - CBC: leukocytosis
  - CRP or erythrocyte sedimentation rate: elevated
  - Laparoscopy: normal
  - Pregnancy complications

**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

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<td>between 1500 and 2500 mIU/mL. If not, the likely differential diagnosis is ectopic pregnancy or miscarriage.</td>
<td>may affect subsequent pregnancy outcomes.</td>
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<td>Serial beta-hCG measurement is usually used when the ultrasound is inconclusive and the initial beta-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.</td>
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<td></td>
<td>A single serum measurement cannot exclude ectopic pregnancy or predict the risk of rupture unless it is &lt;5 mIU/mL.</td>
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<td><strong>pelvic ultrasound:</strong> demonstrates free fluid in the pelvis and/or a periovarian mass. With trained personnel, bedside pelvic ultrasound is a fast,</td>
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## Uncommon

### Pregnancy complications

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<td></td>
<td>reliable method to evaluate for ectopic pregnancy. Transvaginal ultrasound may be used to evaluate for intrauterine pregnancy.</td>
<td>An ectopic pregnancy may be characterized by an echogenic, cyst-like structure outside the uterus. Several ultrasonographic findings may be associated with early ectopic pregnancy such as tubal ring, extraterine mass, extraterine empty gestational sac, and hemosalpinx.</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>
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» **transvaginal ultrasound**: presence or absence of intrauterine pregnancy Differentiates between different
### Uncommon

#### Pregnancy complications

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<tr>
<td>stages and types of miscarriage. Specific, fairly prognostic and would exclude other differential diagnoses of miscarriage. Occasionally directly identifies ectopic pregnancy. Usually used in conjunction with pelvic ultrasound in the setting of positive beta-hCG plus abdominal pain and/or vaginal bleeding.</td>
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#### Empyema

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| recent pneumonia, fever, cough, chest pain; malaise, anorexia, weight loss, or fatigue may occur; presence of risk factors (immunocompromise, comorbidities predisposing to the development of pneumonia, pre-existing lung disease, iatrogenic interventions in the pleural space, male sex) | febrile, toxic patient, dullness on percussion, absence of breath sounds over affected area; abdominal tenderness and distension without guarding or rebound | »**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 | »**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. |
### Uncommon

**Empyema**

<table>
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<td>parapneumonic effusions</td>
<td>CT scan chest with intravenous contrast: consolidation of lung parenchyma; extraparenchymal fluid with loculations suggests empyema.</td>
</tr>
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<td></td>
<td>Aspiration of frank pus is diagnostic of empyema, and no other investigations are required to establish the diagnosis.</td>
<td>CT scan may better differentiate between empyema and simple effusion.</td>
</tr>
</tbody>
</table>
Key articles


References


Evaluation of abdominal pain in children

References


Evaluation of abdominal pain in children


75. American College of Radiology. ACR appropriateness criteria: acute onset of scrotal pain - without trauma, without antecedent mass. 2018 [internet publication]. Full text
Images

Figure 1: Necrotic appendix

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

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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.
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

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Figure 6: Abdominal x-ray demonstrating double bubble gas pattern consistent with duodenal atresia

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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

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Figure 8: Gallbladder ultrasound demonstrating cholelithiasis with characteristic shadowing

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

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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

From the collection of Dr KuoJen Tsao; used with permission
Figure 11: CT scan demonstrating fluid-filled cyst within the spleen

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**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 erythematous as a result of torsion of the appendix testes. The clinical signs and symptoms mimic those of testicular torsion

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Figure 14: Infant boy with swollen, tender, and erythematous left testicle. The testicle is retracted consistent with testicular torsion

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Figure 15: Torsion of an appendix testis resulting in acute infarction

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Figure 16: Intraoperative photo of ovarian mass that presented as ovarian torsion

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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

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Figure 18: Contrast enema demonstrating ileocolic intussusception (black arrow)

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Figure 19: Abdominal x-ray of a young boy with acute, severe abdominal pain, demonstrating stool throughout the colon and rectum

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Figure 20: CT scan demonstrating intra-abdominal abscess consistent with perforated appendix

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Figure 21: 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.

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