BMJ Best Practice

Assessment of abdominal pain in children

Straight to the point of care

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Summary

Paediatric 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 assessment and intervention are critical in children presenting with abdominal pain.

A broad spectrum of aetiologies can cause abdominal pain, and diagnosis can be challenging. In most cases, a thorough history and physical examination 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.

THEORY

Aetiology

The differential diagnoses for paediatric 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 aetiologies are not immediately life-threatening, the ability to diagnose urgent pathology remains paramount. A thorough history and physical examination, and an understanding of the more common diseases affecting the child's age group, are essential.

Gastrointestinal

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

Constipation

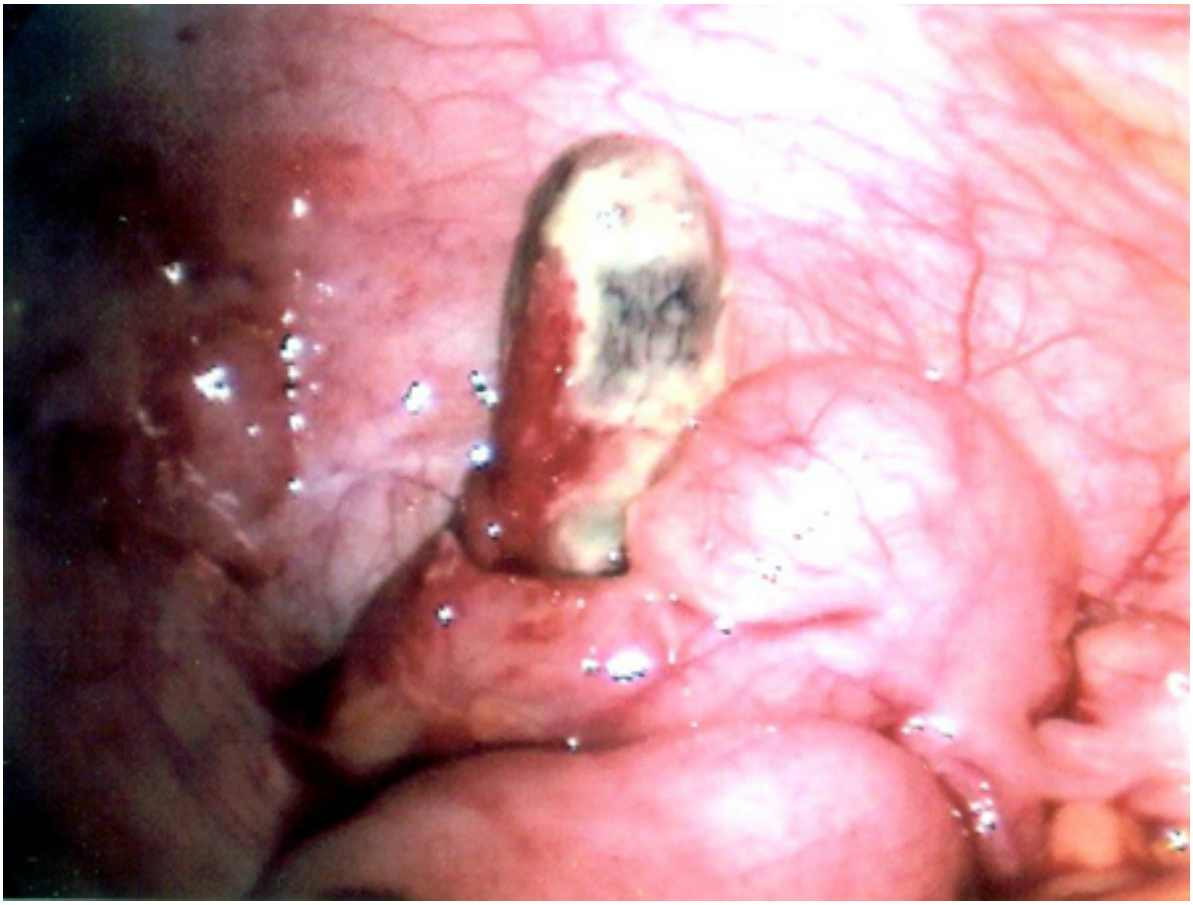
- A common condition, with a reported pooled prevalence of 9.5%.[1]
- Childhood constipation is typically characterised by infrequent bowel evacuations, large stools, and difficult or painful defecation.[2] [3]
- Symptoms usually result from low-fibre, poor-nutrient intake, and too little water, which 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 faecal impaction and chronic constipation.
- It tends to develop during three stages of childhood: weaning (infants), toilet training (toddlers), starting school (older children).

Infantile colic

- Characterised by paroxysms of uncontrollable crying in an otherwise healthy and well-fed infant aged <5 months. The duration of crying is >3 hours per day, and >3 days per week, for at least 3 weeks.[4]
- The crying typically starts in the first weeks of life and ends by 4-5 months of age.
- Food allergy may play a role in the pathogenesis.
- Colic occurs equally in both male and female infants.[5] Infants with colic tend to have siblings who also have this condition.

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.[6]
- If left untreated, acute appendicitis may progress to ischaemia, necrosis, and eventually perforation. The overall rate of perforation is about 30%.[7]
- Validated paediatric clinical prediction rules may help to quantify risk for appendicitis, but guidelines recommend against making a diagnosis of appendicitis in children based on clinical scores alone.[8] [9] [10] [11] [12] [13]
- Although the risk of perforation increases if appendectomy is substantially delayed, surgery within 24 hours does not increase the risk of perforation for children with uncomplicated acute appendicitis.[13] [14] [15]



Necrotic appendix

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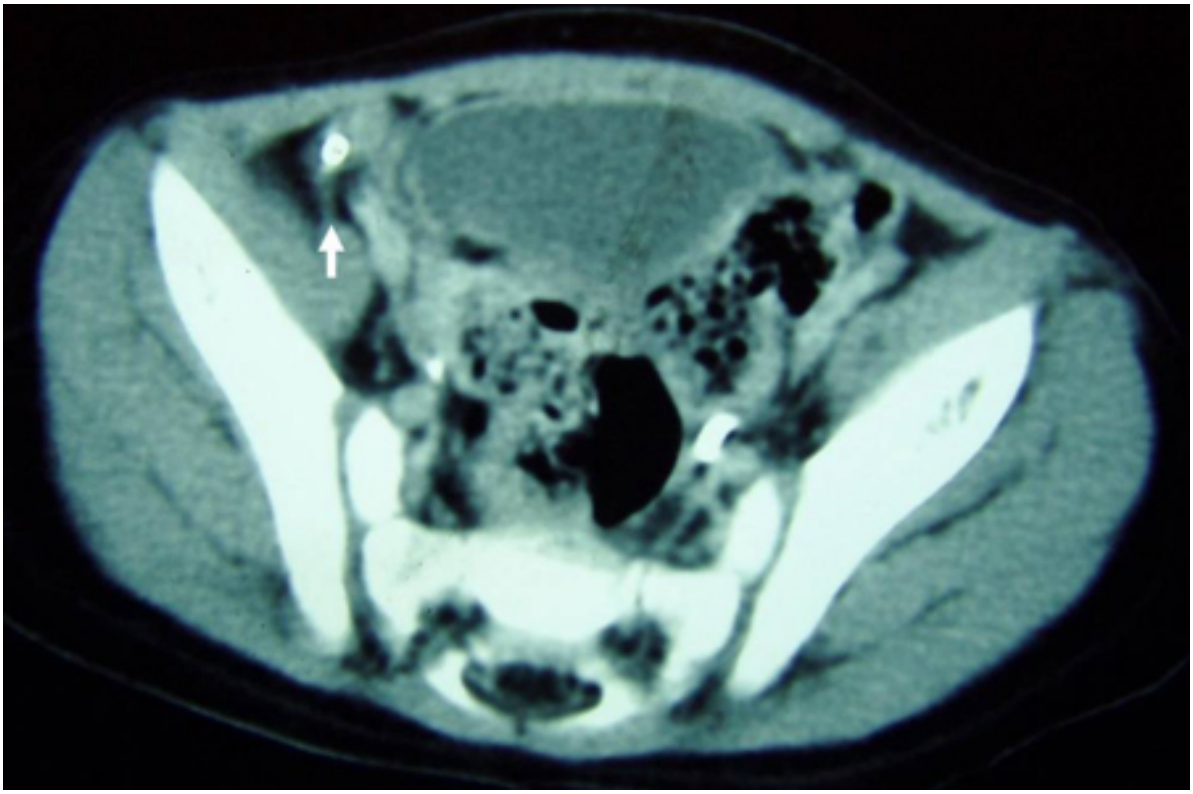

CT scan demonstrating faecalith (white arrow) outside the lumen of the appendix consistent with perforated appendix

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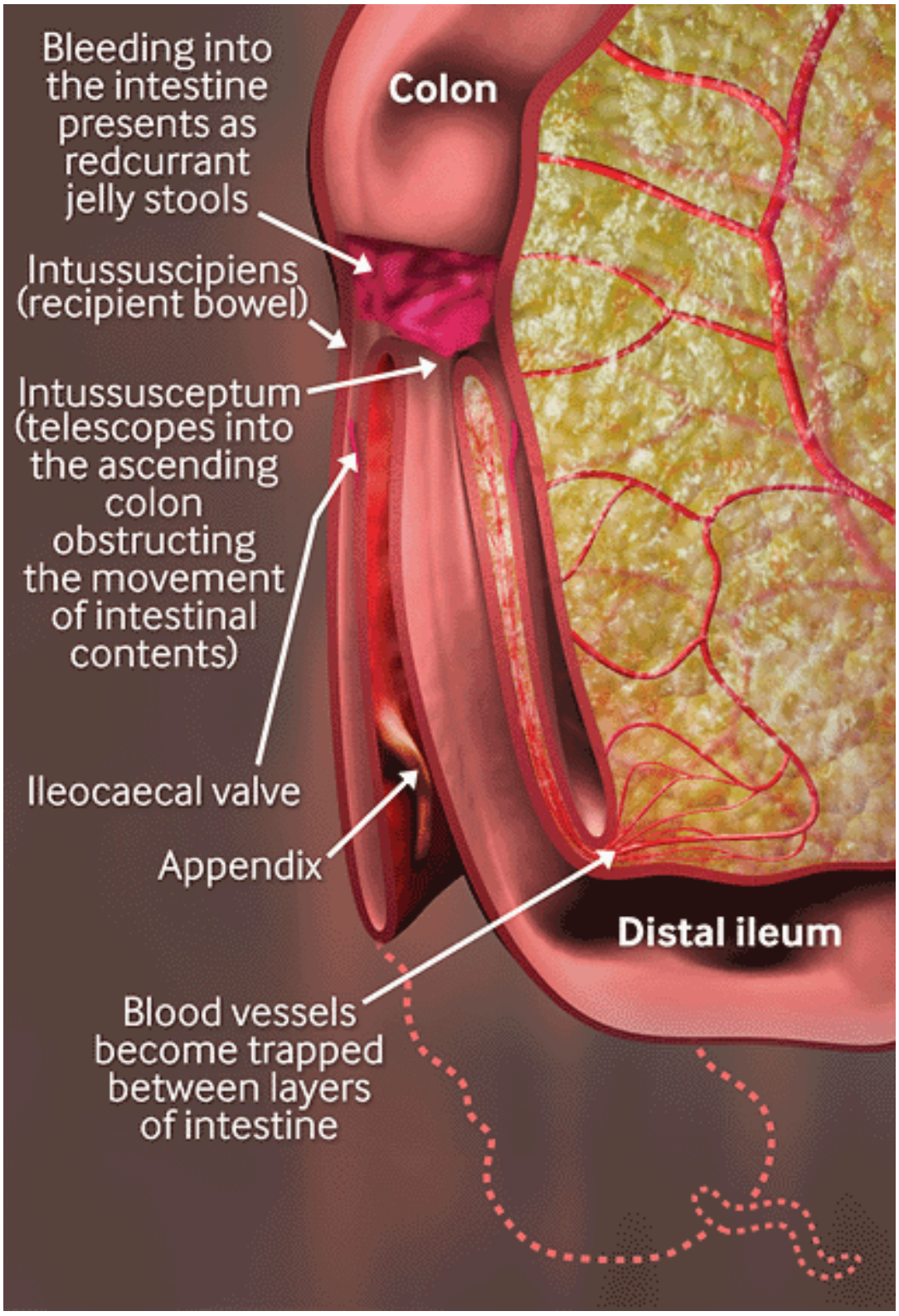
- Stump appendicitis may occur after an appendectomy when the residual stump is >0.5 cm. It can occur after both open and laparoscopic surgery.[16]

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 diarrhoea.
- 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.[17]
- Haemolytic uraemic syndrome, characterised by microangiopathic haemolytic anaemia, thrombocytopenia, and nephropathy, can occur as a complication of gastroenteritis caused by verotoxin-producing *Escherichia coli* . Abdominal pain is a common presenting symptom.[18]

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 ileocaecal area.



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

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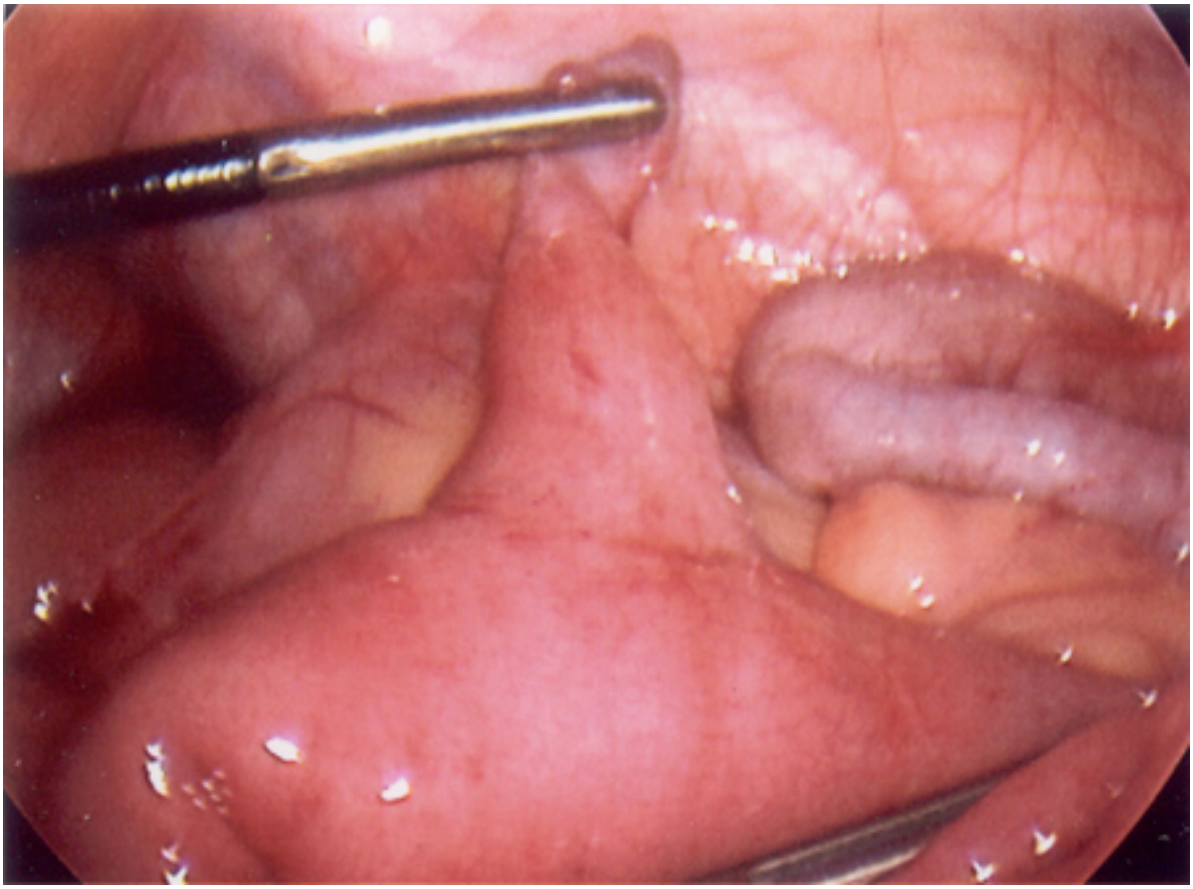
- Usually occurs in infants between 3 and 12 months of age. Peak incidence is 5-7 months of age.[19]
- Intussusception should be suspected in an infant in this age group presenting with colicky abdominal pain, flexing of the legs, fever, lethargy, and vomiting.

- In infants <2 years of age, episodes of intussusception are most likely to be 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 aetiologies should be considered (e.g., intestinal lymphomas, Meckel's diverticulum). Therefore, children ≥6 years or with jejuno-jejunal or ileo-ileal intussusception should be assessed for a pathological lead point.
- Ileo-ileal intussusception may also be indicative of Henoch-Schonlein purpura (HSP).[20] [21] HSP is a vasculitis that affects small veins and primarily occurs in children <11 years of age.[22]
- Occasionally, an ultrasound examination will show small-bowel to small-bowel intussusception. If there are no obstructive symptoms, and the wall of the bowel is normal, with length <3.5 cm, and normal vascularity with no colonic involvement, then these findings are usually transient and require no further intervention.[23]

Meckel's diverticulum

- A finger-like projection located in the distal ileum arising from the anti-mesenteric border; usually 40-60 cm from the ileocaecal valve, measuring 1-10 cm long and 2 cm wide.



Intraoperative photo of Meckel's diverticulum

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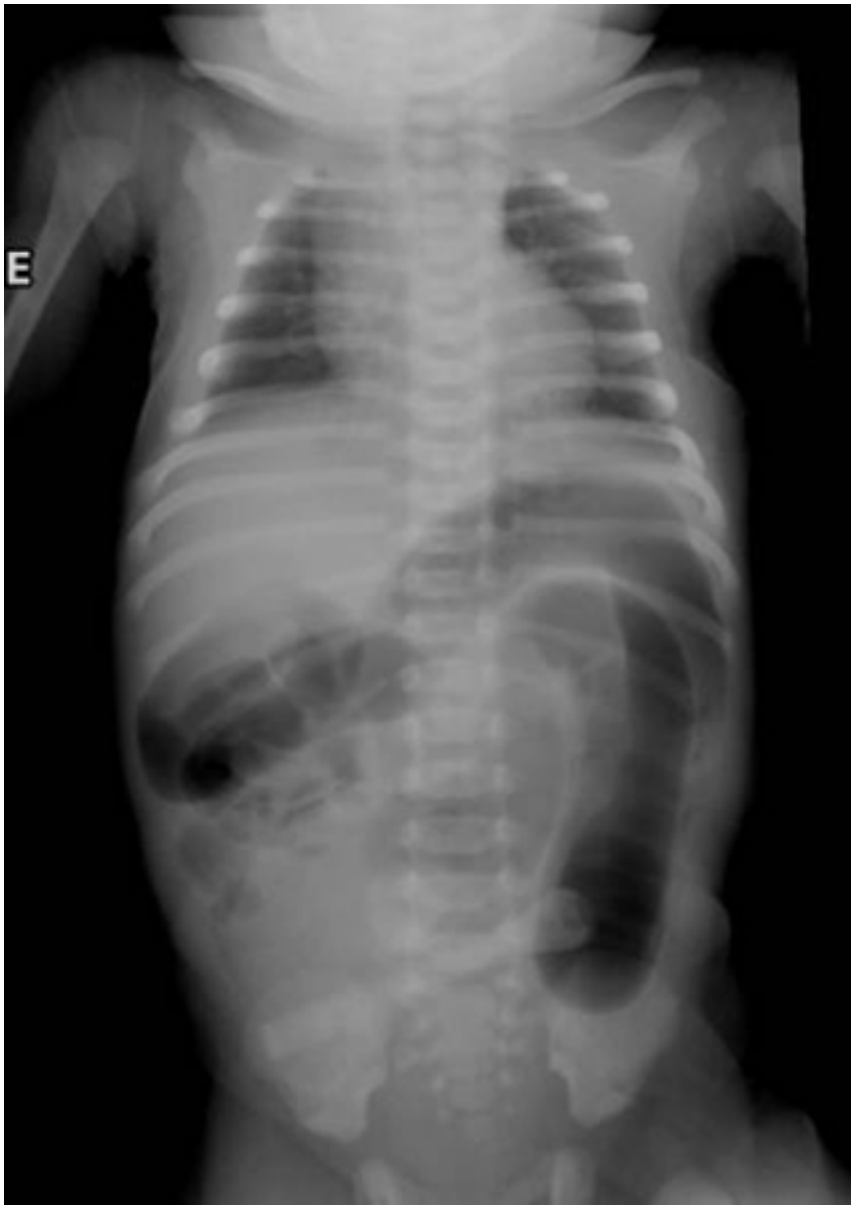
- The majority of symptomatic patients present before the age of 2 years.
- Meckel's diverticulum is a common cause of paediatric gastrointestinal bleeding and should be considered if there is painless rectal bleeding.
- The prevalence is estimated to be up to 3%.[24]
- Intestinal obstruction is a known complication and may be observed in as many as 40% of all symptomatic Meckel's diverticula (according to some series).[25] [26]

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 non-specific mesenteric adenitis.[27]
- One retrospective study reported that, compared with children who have appendicitis, patients who have mesenteric adenitis are more likely to have high fever (above 39°C) and dysuria, and are less likely to have migratory pain, vomiting, or typical abdominal signs of appendicitis on examination.[28]

Hirschsprung's disease

- Most commonly diagnosed in the first year of life but can present later in childhood; higher male preponderance in the most common anatomical variant (rectosigmoid disease).[29]
- Congenital condition characterised 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.



Abdominal x-ray of a neonate with abnormal stooling pattern and constipation. The dilated transverse and descending colon is suggestive of Hirschsprung's disease

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- Hirschprung-associated enterocolitis is the main cause of serious morbidity and death in patients with Hirschprung's disease if not recognised and treated promptly.[30] The classic presenting features include abdominal distention, fever, and diarrhoea; however, other signs or symptoms may include vomiting, rectal bleeding, lethargy, loose stools, and obstipation.[30] [31]
- 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 aetiologies and can occur at any age. Abdominal pain may not occur until the obstruction has progressed to include extensive abdominal distension or intestinal ischaemia. Intestinal obstruction may mimic intestinal ileus, which usually does not require surgical intervention.
- Intestinal obstruction in a child without a history of prior surgery is traditionally considered an indication for surgery.

- The aetiology 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 tumours.
- Congenital causes:
    - Duodenal atresia or stenosis may cause complete or partial obstruction of the duodenum as a result of failed re-canalisation 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.
    - Jejuno-ileal 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: type I, an obstructing web or septum with intact bowel wall and mesentery; type II, an atretic cord of remnant bowel with an intact mesentery; type IIIa, a missing atretic segment with a mesenteric defect; type IIIb, atresia with the distal bowel coiled ('apple peel') around a distal mesenteric vessel; and type IV, multiple segmental atresias ('sausage-links').
    - Hernias may be internal or external and congenital (most commonly in children) or acquired.
    - Colonic atresia is a rare complete obstruction of any part of the colon, although it usually occurs near the splenic flexure. Like jejuno-ileal atresia, it is thought to occur as a result of a vascular event.

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

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- Meconium ileus is an important cause of intestinal obstruction in the neonatal period; cystic fibrosis should be suspected as an associated disease. There may 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. In the presence of duodenal duplication cysts, peptic ulcer disease, haemorrhage, or perforation may result secondary to ectopic gastric mucosa.

- Acquired causes:
  - May occur at any age.
  - Tumours may be intraluminal or extra-intestinal.
  - Hernias may be internal or external and congenital or acquired (e.g., prior operation, incisional, traumatic).

Infant with right groin bulge consistent with incarcerated inguinal hernia. The lack of overlying skin oedema and erythema does not rule out strangulation of the small intestine

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- A history of previous intra-abdominal surgery or inflammation (such as necrotising enterocolitis) should prompt concern for adhesive small bowel obstruction.
- Bowel obstruction without previous surgical or inflammatory history in the paediatric population should raise concern for aetiologies such as a mass or cyst that requires intervention.
- 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, formerly known as meconium ileus-equivalent syndrome). DIOS is not related to meconium. It refers to a distal small bowel obstruction caused by impacted bowel contents that 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.[32] Mid-gut volvulus is the most common type.
- Green (bilious) vomiting is a cardinal symptom of duodenal obstruction secondary to mid-gut volvulus.[32]
- Intestinal malrotation is a term used to encompass the entire spectrum of anatomical 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, unless in extremely preterm infants, when malrotation exists.[33]
- In malrotation, the most significant pathological concerns are a lack of gut fixation to the retroperitoneum and narrow mid-gut mesenteric base that predisposes patients to mid-gut volvulus, which occurs when the duodenum or colon twist around this mesenteric base.
- Colonic volvulus (sigmoid or caecal) is rare.[34] It usually occurs in children with a history of chronic constipation, in dysmotility disorders, or in patients who have cognitive deficits with limited mobility.

Necrotising enterocolitis

- A disease primarily of premature infants, particularly those weighing less than 1500 g.[35] The pathogenesis is multifactorial and not well understood, although ischaemia, reperfusion injury, microbiome changes, and infectious pathogens may play a role.
- Typical symptoms are feeding intolerance, abdominal distension, and bloody diarrhoea at approximately 1-2 weeks of age.[36] Other signs and symptoms include apnoea, lethargy, abdominal tenderness, abdominal wall erythema, and bradycardia.

Peptic ulcer disease

- Gastric and duodenal ulcers are uncommon among the paediatric population.[37] 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., non-steroidal anti-inflammatory drugs [NSAIDs], salicylates, corticosteroids, smoking, or intake of caffeine, nicotine, or alcohol).[37] It is important to treat the predisposing condition. Exacerbations and remissions can last for weeks to months.

Inflammatory bowel disease (IBD)

- This category includes ulcerative colitis, Crohn's disease, and indeterminate colitis (up to 30% of paediatric cases of IBD in retrospective cohorts, but initial diagnosis may be reclassified during follow-up).[38] [39]
- Ulcerative colitis affects the rectum and extends proximally; it is characterised by diffuse inflammation of the colonic mucosa and a relapsing, remitting course. Ulcerative colitis is uncommon in children, but prevalence is increasing.[40]
- Crohn's disease may involve any or all parts of the entire GI tract from mouth to perianal area. Unlike ulcerative colitis, Crohn's disease is characterised 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, giving rise to perforations and fistulas. Onset of Crohn's disease typically occurs in the second to fourth decade of life.[41] [42] [43]

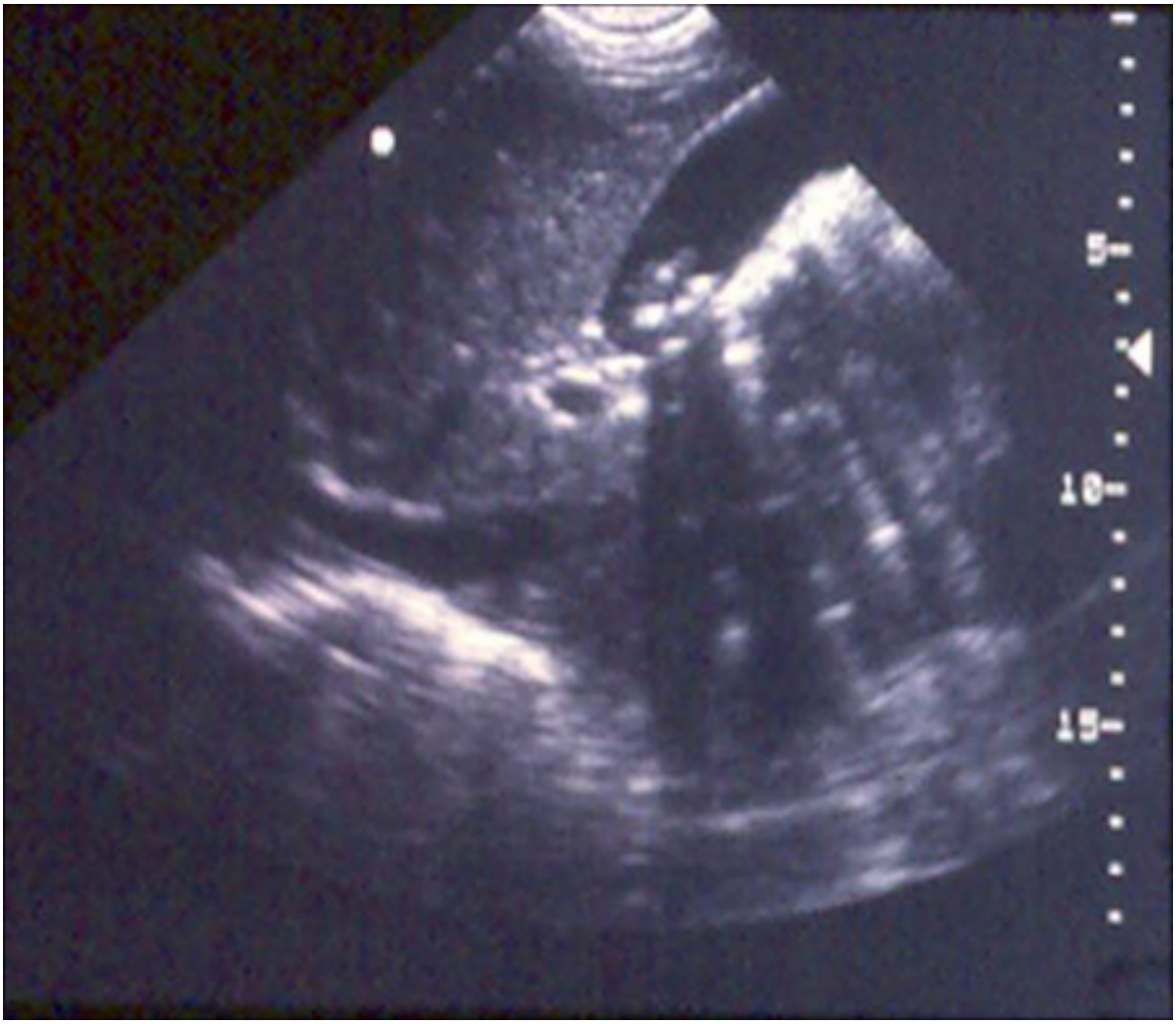
- Ulcerative colitis often presents with bloody diarrhoea, whereas this is an unusual presentation in Crohn's disease. Both conditions cause cramping abdominal pain, anorexia, and weight loss when they present late in the course of the disease. Depending on the intestinal location of Crohn's disease, it may mimic other disease processes such as acute appendicitis.
- IBD in the paediatric population can start with very subtle signs that are difficult to interpret. IBD should be considered for any vague, ongoing chronic abdominal pain combined with a slowing of the patient's normal growth curve.

Coeliac 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.
- Coeliac 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.[44]
- Patients may present with recurrent abdominal pain, cramping, or distension.[45] Other common symptoms include bloating, weight loss, vomiting and diarrhoea.[46] Dermatitis herpetiformis, an intensely pruritic papulovesicular rash that affects the extensor limb surfaces, almost universally occurs in association with coeliac disease.[46]

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.



Gallbladder ultrasound demonstrating cholelithiasis with characteristic shadowing

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Abdominal x-ray with opacities in the RUQ consistent with gallstones

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- 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

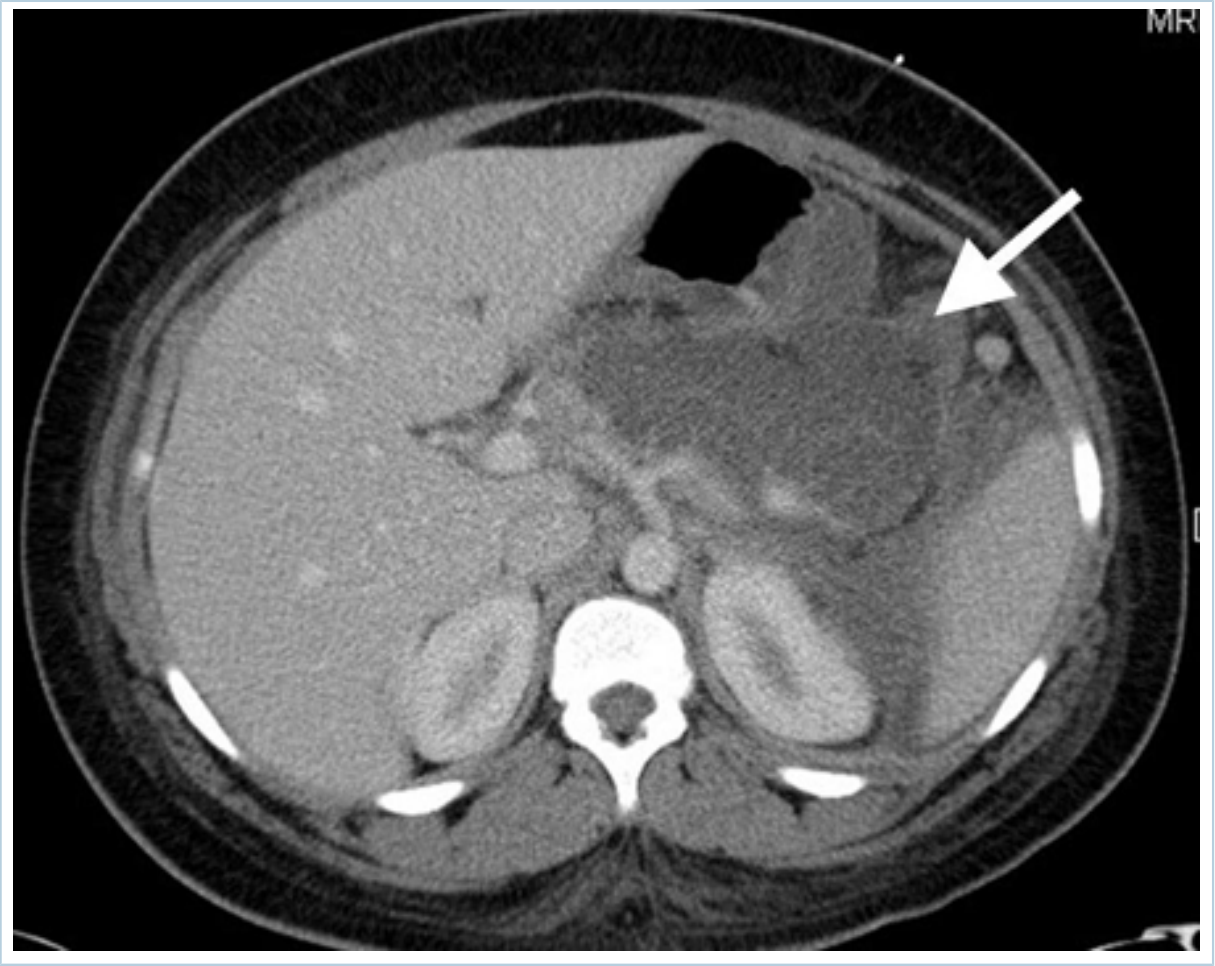
- Characterised by symptoms of biliary colic (intermittent, recurrent RUQ pain that resolves without intervention) in the absence of documented stones in the gallbladder; the diagnosis should be considered in those with symptoms suggestive of biliary colic but with negative laboratory tests and ultrasound in their work-up for symptomatic cholelithiasis.
- Caused by abnormal or altered contraction of the gallbladder resulting in biliary colic. Patients have frequently gone through a comprehensive work-up prior to being diagnosed with this entity; increasing recognition and testing for the disease has led to more frequent diagnosis in children.[47]

Viral hepatitis

- The viral hepatitides include A, B, C, D, and E.
- Hepatitis A virus remains a significant cause of acute viral hepatitis and jaundice, particularly in developing countries, in travellers 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 recognisable 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.
- Paediatric acute pancreatitis is classified into mild, moderately severe and severe.[48]
- Pancreatitis in children is often due to drugs, infection, anatomical abnormalities, or trauma.[49] Corticosteroids, adrenocorticotrophic hormones, oestrogens 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. Paediatric pancreatitis is rare, but the growing population of children with gallstones is likely to increase future incidence.



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

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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.[50] Most cysts are incidental diagnoses, although some patients may present with dull, left-sided abdominal pain. In paediatric patients, the most common splenic masses are congenital and/or acquired cysts.[51]

CT scan demonstrating fluid-filled cyst within the spleen

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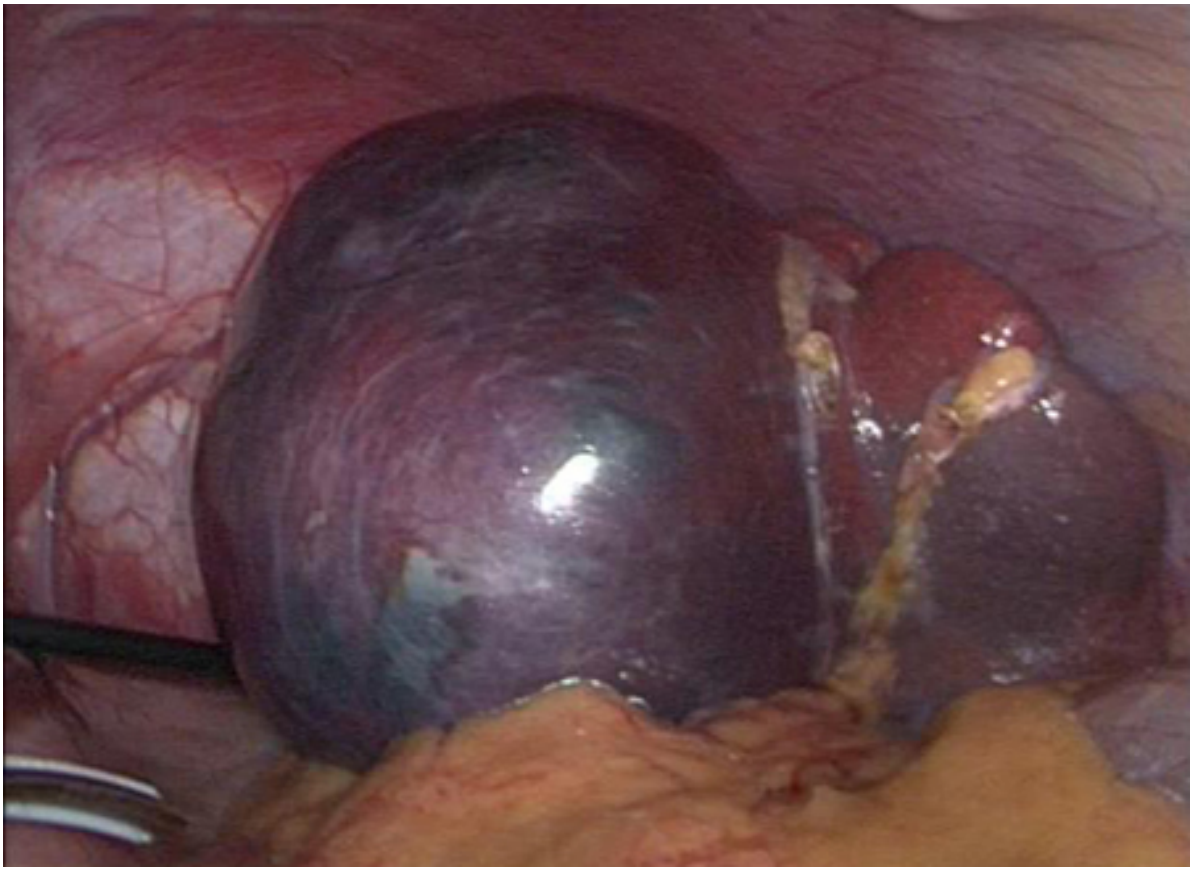

Intraoperative photo of large splenic cyst

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- 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 multi-centre prospective study found that abdominal trauma accounted for 3% of admissions to paediatric trauma units.[52]
- 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 non-operatively.
- 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/non-accidental trauma in this patient population.

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 adverse 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.[53]
- Bacterial infections are the most common cause, particularly *Escherichia coli* infection.

Primary dysmenorrhoea

- Dysmenorrhoea, or painful menstruation, is one of the most common gynaecological conditions affecting females of reproductive age.[54]
- Primary dysmenorrhoea is characterised 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 urological emergency caused by the twisting of the testicle on the spermatic cord, leading to constriction of the vascular supply and time-sensitive ischaemia and/or necrosis of testicular tissue.

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

Torsion of an appendix testis resulting in acute infarction

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- Has a bimodal distribution, with extravaginal testicular torsion affecting neonates in the perinatal period, and intravaginal testicular torsion affecting males of any age but most commonly adolescent boys.[55]
- Systemic symptoms such as nausea and vomiting are not usually present. The thin skin of the scrotum sometimes allows visualisation of the torsed appendage ('blue dot or black dot sign').
- The differential diagnosis includes pain from torsion of a testicular appendage; this may develop more gradually (over days to weeks) and frequently is pinpoint (superior pole of testes).
- Epididymitis can also mimic testicular torsion, but it is more gradual in onset with less severe symptoms.

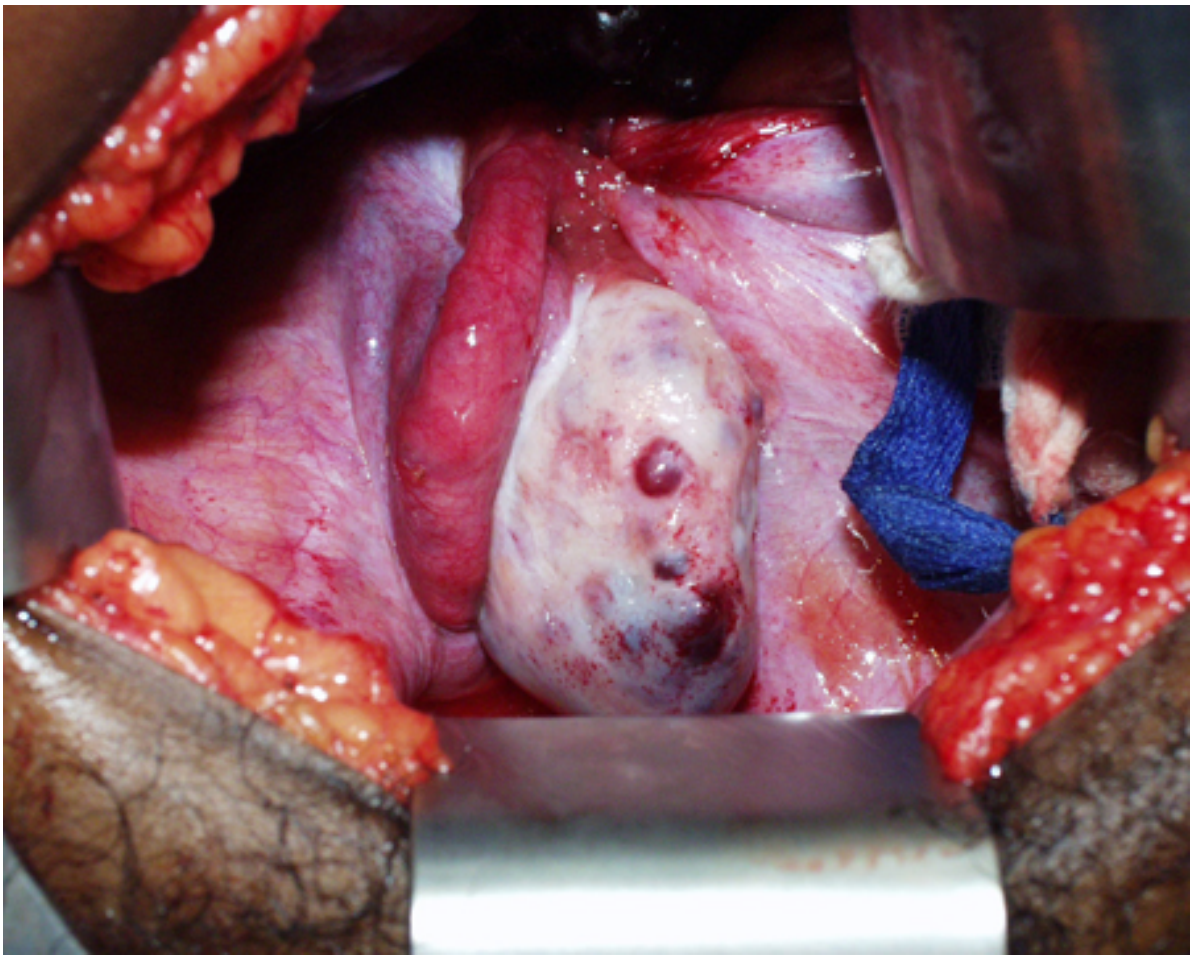
Ruptured ovarian cyst

- 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 haemorrhage.[56] [57] [58]

Ovarian torsion

- Although it can affect females of any age, it most commonly occurs in the early reproductive years.[59]
- In children, torsion of the ovary is often associated with the presence of an ovarian tumour, most commonly a teratoma.

- Twisting or torsion of the ovary compromises the arterial inflow and venous outflow, producing ischaemia, which, if not relieved promptly, can affect the viability of the ovary.
- Oophorectomy is infrequently indicated and most ovaries can be preserved.[60]



Intraoperative photo of ovarian mass that presented as ovarian torsion

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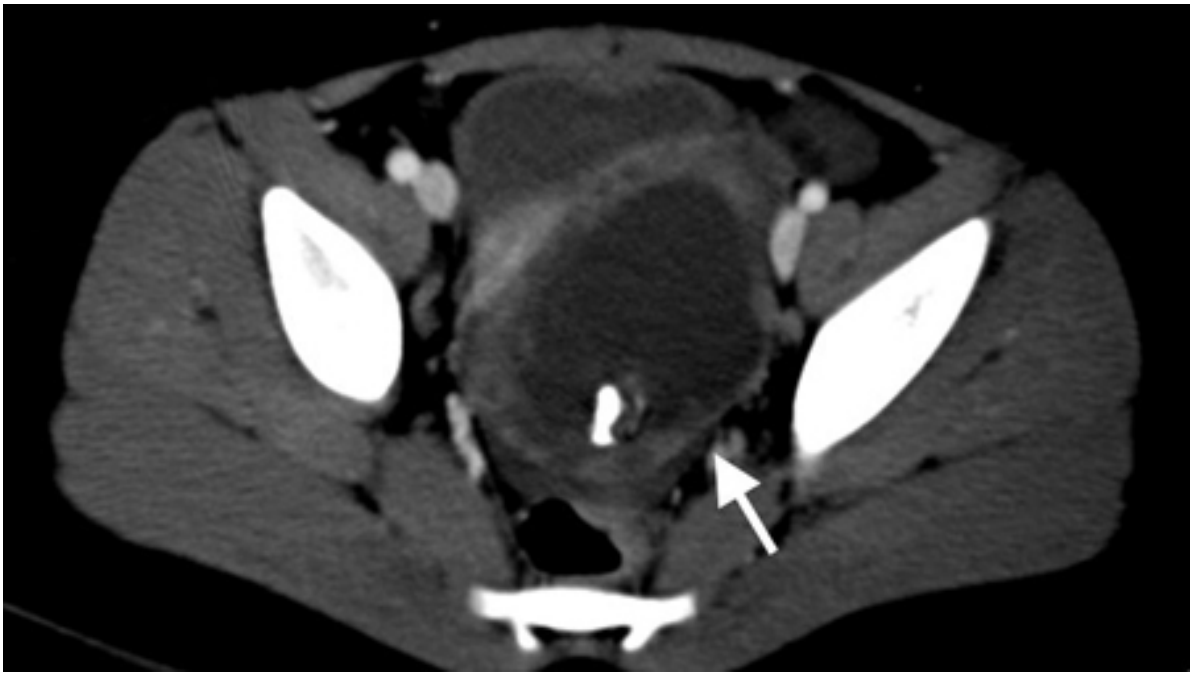

CT scan of a young girl presenting with ovarian torsion. The large pelvic cystic lesion contains calcifications (white arrow) consistent with a teratoma or dermoid cyst

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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.[61] Sexually transmitted infections (chlamydia and gonorrhoea) are a key risk factor.[62]
- PID is rare in the absence of sexual activity; PID in a young child should prompt work-up for possible sexual abuse.

Pregnancy complications

- Miscarriage and ectopic pregnancy should be a concern in any female of reproductive age presenting with lower abdominal pain, amenorrhoea, and vaginal bleeding.
- Miscarriage is an involuntary, spontaneous loss of a pregnancy before 20-24 completed weeks. The gestational threshold for the definition varies between countries: in the US it is usually 20 weeks (but may vary in different states), whereas in the UK, the Royal College of Obstetricians and Gynaecologists defines it as 24 weeks.[63] [64] The majority of spontaneous miscarriages occur in the first trimester.[65]
- Ectopic pregnancy occurs when a fertilised 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%).[66] Use of oral contraceptives before age 16 years is associated with increased risk of ectopic pregnancy.[67] The classic presentation includes lower abdominal pain, amenorrhoea, and vaginal bleeding. Haemorrhage from a ruptured ectopic pregnancy can be fatal.

Pulmonary

Primary respiratory illnesses such as pneumonia or empyema may present as abdominal pain in the paediatric population.[68] Ileus following a thoracic procedure can lead to abdominal distension, GI symptoms, and discomfort.

Recurrent pneumonia in children is usually the result of a particular susceptibility, such as disorders of immunity and leukocyte function, disorders of ciliary function, anatomical abnormalities, or specific genetic disorders such as cystic fibrosis.[69]

Functional abdominal pain

Functional abdominal pain is also referred to as non-specific abdominal pain; pain is usually chronic or recurrent. Visceral hyperalgesia is the final outcome of sensitising medical and psychosocial events, on a background of genetic predisposition.[70]

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.[70] [71] [72]

- 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.[73]
- 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.[70]

Irritable bowel syndrome

Three criteria must be fulfilled for 2 months prior to diagnosis:[70]

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:[70]

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:[70]

1. Episodic or continuous abdominal pain that does not occur solely during physiological 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:[70] [74] [75]

- Family history of inflammatory bowel disease, coeliac disease, or peptic ulcer disease
- Persistent right upper or right lower quadrant pain
- Dysphagia
- Odynophagia
- Persistent vomiting
- Gastrointestinal bleeding
- Nocturnal diarrhoea
- Arthritis
- Peri-rectal disease
- Involuntary weight loss
- Deceleration of linear growth
- Delayed puberty
- Unexplained fever.

Urgent considerations

(See **Differentials** 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 diarrhoea or occult blood in stool, fever (≥38.0°C [≥100.4°F]), rebound tenderness, rigidity, and guarding indicate a possible need for surgery.

Gastrointestinal (GI) emergencies

Acute appendicitis resulting in perforation

- Untreated acute appendicitis may progress to ischaemia, necrosis, and eventually perforation. The clinician may encounter a range of presentations. Patients often complain of abdominal pain localised to the right lower quadrant; in more severe cases the pain may be diffuse (e.g., if perforation results in generalised peritonitis).
- Perforation should be considered when a patient presents with a longer duration of symptoms and/or suspected appendicitis with marked systemic signs of illness (e.g., high fever [>38.3°C, >101°F]), tachycardia, and anorexia), localised or generalised peritonitis with guarding, distended abdomen with absent bowel sounds. There may be a palpable mass if a peri-appendiceal abscess is present due to perforation.
- Refer all children with suspected appendicitis to the paediatric surgery team on call, if available. Where no paediatric surgery team is available, joint care should be managed between paediatrics and surgical teams.
- Ultrasound (US) is usually the preferred initial diagnostic study (due to low cost and lack of radiation exposure).[76] [77] [78] In children, specificity and sensitivity of ultrasound is similar to that of computed tomography (CT) (specificity 92.0% vs. 94.2%; sensitivity 90.3% vs. 93.0%); for MRI the specificity is 96.5% and sensitivity 96.9%.[78] However, all imaging modalities have limitations in differentiating perforated from non-perforated appendicitis.[76] [78][79]
- Treatment (antibiotics and possibly surgery) of acute or perforated appendicitis should be instituted promptly, but the condition is more urgent than emergent. Once antibiotics are administered, appendectomy for out-of-hours cases selected for operative management can be safely deferred until the following day.[13] [14]
- Appendectomy can be done with an open approach or laparoscopically. Laparoscopic appendectomy is associated with lower postoperative pain, lower incidence of surgical site infection, and higher quality of life in children.[13] Referral to a children's hospital or a paediatric surgeon should be considered for children younger than 5 years of age.[80]

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 oedema, 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.
- Non-strangulated obstructions involve a loop of bowel that is partially or completely obstructed but has an 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 oedema and can progress, if untreated, to bowel necrosis, perforation, and, rarely, death.[81] [82] Treatment should be initiated at the time of diagnosis. The goal is correction of hypovolaemia and electrolyte abnormalities, and antibiotic administration, followed by urgent reduction.
- Reduction can be accomplished with a radiographic enema study (air is preferred over contrast reagent) or by surgery.[83]
- There is a risk of recurrence of intussusception after reduction, especially within the first 48 hours, so prompt re-evaluation is necessary if symptoms recur.[84]

Volvulus

- Malrotation with mid-gut 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 examination (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 (the gold standard test). 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 ischaemia 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 generalised abdominal pain. In severe cases, fever, abdominal distension, and skin changes may be present.
- Peritonitis is a contraindication to attempted non-operative reduction.
- If strangulation is evident, surgery is required urgently to resect the gangrenous segment of bowel.

Necrotising enterocolitis

- The most common medical/surgical emergency affecting neonates, particularly premature infants, especially those weighing less than 1500 g.[35]
- Signs and symptoms include feeding intolerance, apnoea, 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 non-operatively.
- Indications for urgent surgery include haemodynamic instability despite adequate resuscitation, free air in the abdomen, penetrating injuries with fascial penetration, and peritonitis.[85] [86]

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 haemorrhage.
- The classic presentation includes lower abdominal pain, amenorrhoea, 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 examination to assess for the presence of free fluid or blood may be helpful when this diagnosis is suspected, but this should not delay other care.
- Haemodynamic instability associated with a ruptured ectopic pregnancy results from severe hypovolaemia secondary to blood loss. As such, the management of these patients involves stabilisation with emergency fluid resuscitation and immediate transfer to theatre. Rapid volume repletion with isotonic solution and blood products is of paramount importance to avoid ischaemic 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 ischaemia, 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.
- Doppler ultrasound is of only variable reliability in the diagnosis of ovarian torsion.[87] [88]
- It is not known how long an ovary can withstand ischaemia without permanent damage (it may be up to 72 hours or even longer), but definitive operative intervention should be undertaken as soon as possible.[89] [90] A delay in the timing of surgery is associated with a reduction in the possibility of ovarian salvage.[91]
- Conservative management with detorsion is highly recommended regardless of appearance of ovary.[60] [92] [93]

Testicular torsion

- Should be ruled out in any male child presenting with abdominal pain. 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, raised 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.
- Duplex Doppler ultrasound is the definitive test for testicular torsion and should be obtained unless the test would unnecessarily delay intervention in a child for whom there is a high index of suspicion.[94] [95]

Sepsis

Sepsis and septic shock

- Patients with intra-abdominal sepsis may present with abdominal pain.[96]
- Sepsis is a spectrum of disease where there is a systemic and dysregulated host response to an infection.[97]
- Presentation ranges from subtle, non-specific symptoms (e.g., feeling unwell with a normal temperature) to severe symptoms with evidence of multi-organ dysfunction and septic shock. Patients may have signs of tachycardia, tachypnoea, hypotension, fever or hypothermia, poor capillary refill, mottled or ashen skin, cyanosis, newly altered mental state, or reduced urine output.[98]
- Sepsis and septic shock are medical emergencies.
- In children, risk factors for sepsis include: age under 1 year, impaired immunity (due to illness or drugs), recent surgery or other invasive procedures, any breach of skin integrity (e.g., cuts, burns), and indwelling lines or catheters.[98]
- Early recognition of sepsis is essential because early treatment improves outcomes.[98] [99] [Evidence C] However, detection can be challenging because the clinical presentation of sepsis can be subtle and non-specific. A low threshold for suspecting sepsis is therefore important.
- The key to early recognition is the systematic identification of any patient who has signs or symptoms suggestive of infection and is at risk of deterioration due to organ dysfunction. Criteria to identify sepsis and septic shock in children and young people under the age of 18 years have been developed.[100] Several other risk stratification approaches exist. All rely on a structured clinical assessment and recording of the patient's vital signs.[98] [100][101] [102][103] It is important to check local guidance for information on which approach your institution recommends.
- The timeline of ensuing investigations and treatment should be guided by this early assessment.[103]
- Treatment guidelines have been produced by the Surviving Sepsis Campaign and remain the most widely accepted standards.[99] Within the first hour:[99]
    - Follow institutional protocols for management of sepsis/septic shock in children; these improve the speed and reliability of care.
    - Obtain blood cultures before administering antibiotics (provided this does not substantially delay antibiotic administration).
    - Administer broad-spectrum antibiotics.
    - Administer crystalloid fluids titrated to clinical signs of cardiac output and stopped if there is evidence of volume overload. Consult local protocols.
    - Use trends in blood lactate levels to guide resuscitation. If the child's hypotension is refractory to fluid resuscitation, consider use of vasopressors.

For more information on sepsis, please see our topic Sepsis in children .

Approach

Assessment of paediatric 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.[75]

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 localised 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 localised. 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:[19] [104]

- Neonates, infants, and toddlers: may present with abdominal pain caused by congenital causes or diseases linked to prematurity, such as necrotising enterocolitis, Meckel's diverticulum, Hirschsprung's 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 school-age children.
- 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

- Useful mnemonics for abdominal pain are 'CLAIR PRADER': Characteristics, Location, Aggravating factors, Intensity, Relieving factors, Periodicity, Rhythmicity, Associations, Duration, Exacerbating factors, and Radiation; or ‘SOCRATES’: Site, Onset, Character, Radiation, Associated Symptoms, Time course, Exacerbating or relieving factors, Severity.
- Onset, frequency, timing, and duration of the pain episode.
- Whether the pain is localised or diffuse: right lower quadrant (RLQ) pain suggests appendicitis; epigastric pain suggests peptic ulcer disease; diffuse pain may indicate perforation or peritonitis. Poorly localised pain that improves with movement is likely to be visceral pain from hollow organs. Well localised pain that worsens with movement is likely to arise from parietal peritoneum, parietal muscle, or skin.[105]
- 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.
- An acute exacerbation with a history of chronic pain can confound the diagnosis. It is important to determine if the nature of the acute pain is different (in character, location, or other factors) from the background, chronic pain. It is easy to miss or overlook an unrelated acute pathology in a patient with a chronic pain history of any sort (e.g., acute appendicitis in children with long-standing functional bowel complaints). The clinician must be wary of this trap, and there is no substitute for experience.

Associated symptoms

The clinician should enquire about the presence and severity of:

- Fever, nausea, vomiting, anorexia (gastroenteritis, mesenteric adenitis)
- Diarrhoea (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, necrotising enterocolitis, dysentery, haemolytic uraemic 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 haematuria suggest a urinary tract infection (UTI); vaginal discharge is suggestive of pelvic inflammatory disease; current menstruation may be indicative of dysmenorrhoea.

Trauma history

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

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 faecal 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.
- In addition to daily stooling pattern, evaluation of constipation includes pertinent medical history, onset of constipation symptoms, severity, and any previous treatments. Dietary history, paying attention to fibre and fluid intake, is helpful.
- 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, immunisations, 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
- Failure to pass meconium in the first 36 hours of life is strongly suggestive of Hirschsprung's disease
- Hirschsprung's disease can be associated with Down syndrome
- Necrotising enterocolitis should be considered in a premature neonate weighing less than 1500 g.

Drug history

- Some medications, such as iron supplements, can cause constipation. Corticosteroids, adrenocorticotrophic hormones, oestrogens including contraceptives, azathioprine, asparaginase, tetracycline, chlorothiazides, and valproic acid may induce pancreatitis. Non-steroidal 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 examination

This should be performed in a comfortable and non-threatening manner. Children may need to be distracted by parents or guardians in order to obtain an accurate examination. In younger children, localisation of the abdominal pain may be difficult.

Because paediatric abdominal pain may originate from other areas of the body (e.g., genitals or lungs), a comprehensive physical examination is necessary. Digital rectal examination is not routinely performed and is not needed to diagnose functional constipation.[106] UK guidelines recommend that digital rectal examination should only be performed by clinicians able to interpret features of anatomical abnormalities or

Hirschsprung's disease.[107] Pelvic examination is not routinely performed; history is usually a guide and digital examination 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 fontanelle 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.[108] High fever is suggestive of pyelonephritis.[108] [109]
- 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°C (1.8°F).
- Children with constipation are usually well with normal vital signs.

Abdominal examination:

- Patients presenting with central abdominal pain, with or without guarding and rigidity, that settles in the RLQ should arouse suspicion of appendicitis. Classic abdominal signs of appendicitis are RLQ abdominal tenderness (McBurney's sign) and localised rebound tenderness, if the appendix is anterior. Compressing the left lower quadrant (LLQ) may elicit pain in the RLQ (Rovsing's sign). Patients with appendicitis may lie still and try not to move, particularly in severe cases with significant peritoneal irritation.
- Acute mesenteric adenitis often resembles acute appendicitis; however, pain in the abdomen is usually diffuse with tenderness not localised 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 39°C) and dysuria, and are less likely to have migratory pain, vomiting, or typical abdominal signs of appendicitis on examination.[28]
- 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 faecal mass per abdomen or rectum.
- Flank pain or costovertebral 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 haemorrhagic pancreatitis, discoloration may be noted around the umbilical area (Cullen's sign) or in the flanks (Grey-Turner's sign) due to blood tracking along defined fascial planes.
- Tenderness in the right upper quadrant (RUQ) is a classical sign of gallbladder disease, as is Murphy's 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 and fevers. 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.[110]
- In trauma patients, signs of accidental (e.g., seat belt mark suggesting a motor vehicle accident) and non-accidental injury (particularly if history is suspicious) should be sought (e.g., cigarette burns, subdural haemorrhages 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.[111]
- 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 examination or laboratory based.[71]
- Signs of peritonitis, such as absent bowel sounds, bilious vomiting, bloody diarrhoea or occult blood in stool, fever (≥38°C [≥100.4°F]), rebound tenderness, rigidity, and guarding indicate a possible need for surgery.

External genital and perineal examination:

- A neonatal examination must evaluate for the presence of an anus along with the proper location within the sphincter complex.
- Testicular torsion is likely in any male child with abdominal tenderness plus loss of the cremasteric reflex, diffuse testicular tenderness, raised testes, and a horizontal rather than vertical position of the testes on exam.
- Blood at the urethral meatus, or haematuria, after trauma may suggest urinary tract or kidney injury.
- The presence of an anal fissure and/or haemorrhoids (rare in children; may be mistaken for skin tags from Crohn's disease), imperforate anus, or anal stenosis (particularly in a neonate or infant) on inspection of the perianal skin may provide further diagnostic clues.

General examination:

- Generalised lymphadenopathy is common and signs of an upper respiratory tract infection may be present in children with mesenteric adenitis (e.g., hyperaemic pharynx or oropharynx suggesting pharyngitis).
- Jaundice is rare with cholelithiasis 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 examination (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 with abdominal pain (usually <11 years of age), and therefore signs of HSP should be sought (rash of palpable purpura, blood in the stools).
- Extra-intestinal manifestations of inflammatory bowel disease may be evident (e.g., iritis, arthritis, sacroiliitis, erythema nodosum, pyoderma gangrenosum).
- The presence of cyanosis, tachypnoea, 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's disease.
- Necrotising 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 mid-gut volvulus should be excluded with further investigations.
- Any abdominal examination of an infant and toddler must include a check for inguinal hernias; if a nappy is worn, remove it, as otherwise a hernia may be missed.
- Meckel's diverticulum should be considered in a child <2 years old with abdominal tenderness (Meckel's diverticulitis); haematochezia, typically dark red, maroon, or red-brick-coloured jelly-like 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

- Ectopic pregnancy and miscarriage should be suspected in any female of reproductive age presenting with lower abdominal pain, amenorrhoea, and vaginal bleeding. Pelvic examination may reveal a mass, eliciting cervical motion tenderness if haemoperitoneum is present; tubal rupture can cause haemodynamic 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 haemorrhage.[56] [57] [58] Signs of peritonitis 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 examination, 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.[62] Fever and cervical or vaginal discharge may also be present. PID is rare in the absence of sexual activity; PID in a young child should prompt work-up for possible sexual abuse.
- 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.[112]
- Primary dysmenorrhoea should be considered if lower abdominal tenderness is associated with current menstruation.

Laboratory tests

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

Urinalysis is essential to exclude underlying UTI or haematuria (associated with nephrolithiasis, UTI, haemolytic uraemic 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 human chorionic gonadotrophin (beta-hCG) is necessary to exclude miscarriage and ectopic pregnancy.

Initial blood and stool tests may include:

- FBC, recommended in all patients (useful in assessing 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 function tests (LFTs) are helpful baseline investigations when considering a hepatobiliary or pancreatic cause. In abdominal trauma, results from one retrospective study suggest that LFTs may be used as a screening tool to determine need for computed tomography (CT) scan; in a haemodynamically normal patient with normal AST/ALT, it may be possible to avoid CT scan.[113]
- Serum lipase, or amylase if lipase is unavailable, is indicated if pancreatitis is suspected.[114]
- Inflammatory markers. Although non-specific, erythrocyte sedimentation rate and C-reactive protein may suggest underlying infection or inflammation. Furthermore, these inflammatory markers correlate closely with disease activity in cases of inflammatory bowel disease.
- A positive faecal occult blood test can support a suspicion of intussusception. However, a negative test cannot reliably rule out the diagnosis.[115]
- Faecal calprotectin is used in the diagnosis and monitoring of inflammatory bowel disease and to distinguish it from functional gastrointestinal disorders.[116]
- A coagulation profile, including prothrombin time and international normalised ratio (INR), is usually necessary in cases of suspected viral hepatitis to measure liver synthetic function.

Microbiological investigations

- Stool microscopy and culture may be helpful in determining an infectious aetiology of gastroenteritis. Risk factors and features of the clinical presentation help guide the choice of tests for specific pathogens. Guidelines recommend that when there is fever or bloody diarrhoea, investigations for enteropathogens for which antimicrobial agents may confer clinical benefit (including *Salmonella enterica* subspecies, *Shigella* , and *Campylobacter*) should be done.[117]
- Blood cultures are indicated when sepsis is a concern. Blood cultures are recommended: in children with infectious diarrhoea who are <3 months of age or who are immunocompromised; when enteric fever is suspected (including travel to enteric fever-endemic areas, or contact with travellers from enteric fever-endemic areas who have a febrile illness of unknown aetiology); when there are systemic manifestations of infection; and with high-risk conditions such as haemolytic anaemia.[117] [118]
- 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.[119] [120]
- Serological markers (perinuclear anti-neutrophil cytoplasmic antibody and anti-saccharomyces cerevisiae antibody) may be particularly useful for differentiating between Crohn's disease and ulcerative colitis in the paediatric population.[121] [122]
- Polymorphonuclear leukocytes (PMNs) seen on wet mount of vaginal secretions confirms vaginal infection in cases of PID. All women who receive a diagnosis of PID should be tested for gonorrhoea, chlamydia, HIV, and syphilis.[62] Hepatitis studies may be considered.
- 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 examination findings.

Abdominal and chest x-ray

Plain abdominal x-rays are often non-specific but may suggest the presence of an obstruction; faecal impaction and duodenal atresia can be detected on x-ray. In addition, if sufficiently radiopaque, 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 assessment. 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 paediatric radiologist may be able to utilise ultrasound in all regions of the body (abdomen, chest, testicles). Abnormalities detected by ultrasound may not be causally related to the patient's abdominal pain.[74]

Ultrasound is usually recommended as the first imaging test for suspected appendicitis.[76] [78] Ultrasound scans are considered particularly useful in assessing pain in the RUQ (i.e., gallbladder disease), and lower abdominal pain (pelvic pain) in females.

Colour Doppler may be helpful in determining ovarian blood flow in cases of suspected ovarian torsion, but is of only variable reliability in the diagnosis.[87] [88] 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 anatomical abnormalities (e.g., when UTI is present) or nephrolithiasis and associated complications such as hydronephrosis.

Point-of-care ultrasound may be useful for detecting intussusception at an early stage.[123] [124]

Focused abdominal sonography for trauma (FAST) may be useful in children with blunt abdominal trauma who are haemodynamically unstable.[125] The presence of large amounts of free fluid indicates a need for immediate operative intervention. FAST in haemodynamically stable patients has a less certain impact, as a negative scan does not preclude injury. A large multi-institutional study at paediatric trauma centres demonstrated poor FAST sensitivity (28.6%) in normotensive patients.[126] Though specificity was high (91.1%), results of FAST rarely changed management. A randomised trial comparing FAST with standard care in haemodynamically 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 accident and emergency department, and median hospital costs.[127]

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 non-diagnostic; however, radiation exposure with its risk of malignancy should be considered.[78] [128] [129] MRI avoids

ionising radiation and has similar or better sensitivity and specificity than CT, though availability and longer scan times may limit its utility.[78] [130] [131] Increasingly, MR enterography (MRE) is being used to evaluate paediatric Crohn's disease patients. This tool can evaluate extraluminal and extra-intestinal manifestations of Crohn's disease as well as the status of the bowel wall and presence of possible stricture formation.[132]

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.[133] Sedation or general anaesthesia 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 assessment of intestinal obstruction, clinical suspicion should direct which contrast study should be performed first and will be most informative.

Endoscopy

Endoscopy (oesophagogastroduodenoscopy or colonoscopy) with biopsy may be required to assess mucosa-based diseases, such as peptic ulcer disease and inflammatory bowel disease. Rectal biopsy and anorectal manometry help confirm the diagnosis of Hirschsprung's 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 cut-off of <35% is not universally accepted; some consider an ejection fraction <15% to be more predictive of success of surgical treatment (i.e., cholecystectomy).[134] Hyperkinetic results (very high ejection fractions) are sometimes considered an indication for cholecystectomy, as are normal scans (at some institutions). Outcomes vary widely among paediatric biliary dyskinesia patients. In retrospective studies, overall rates of symptom resolution post operation ranged from 34% to 100%.[135] [136] The absence of reliable factors to predict which patients will benefit is a source of frustration to patients, families, and physicians. HIDA scan is considered a useful adjunct in the diagnosis of cholecystitis.

Technetium-99m pertechnetate scan is considered the most useful method to diagnose a suspected Meckel's diverticulum; this scan identifies ectopic gastric mucosa as tracer is taken up by gastric mucin-producing cells.

Voiding cystourethrogram

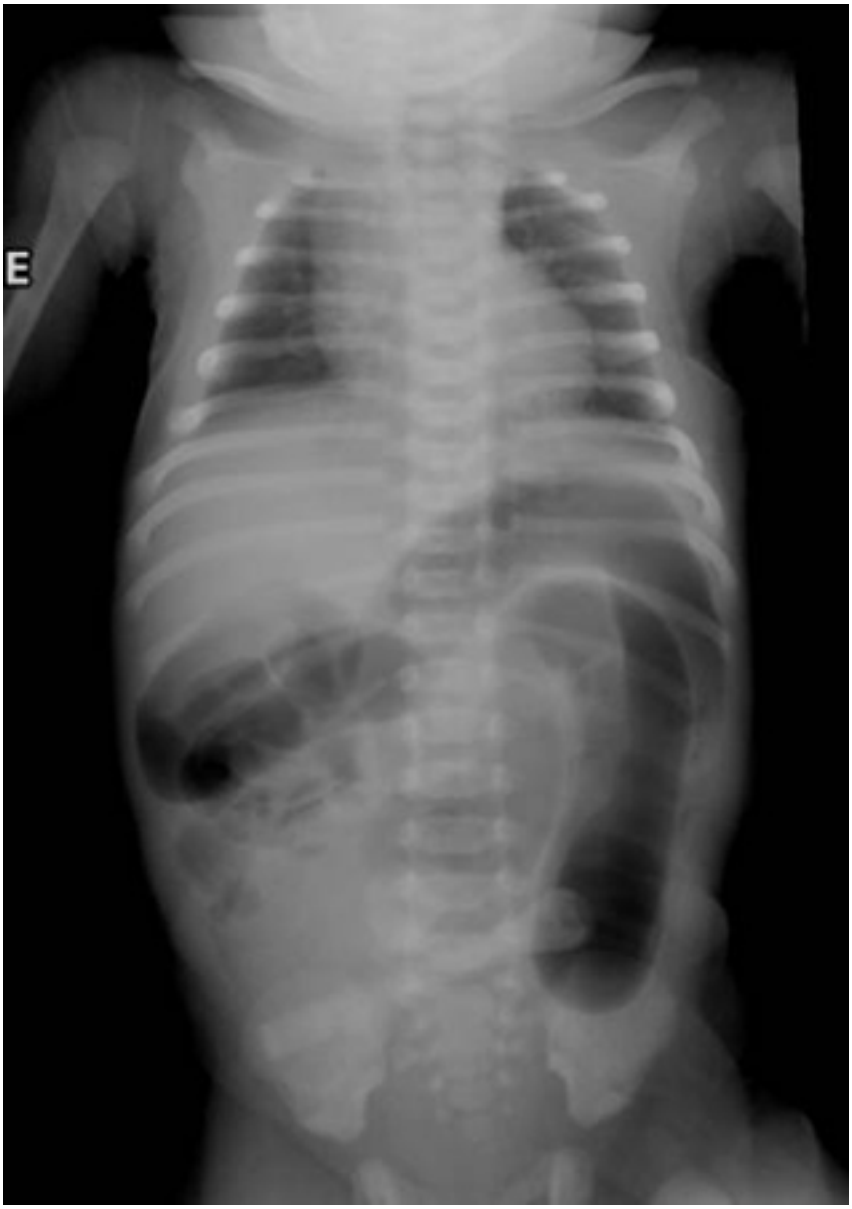
The American Academy of Pediatrics (AAP) recommends that a voiding cystourethrogram (VCUG) is indicated in children between 2 and 24 months of age following an initial UTI if renal and bladder ultrasonography reveals hydronephrosis, scarring, or other findings that would suggest either high-grade vesicoureteral reflux or obstructive uropathy, as well as in other atypical or complex clinical circumstances.[137] Further evaluation is required if there is a recurrence of febrile UTI.[137] [138][139]

Full skeletal x-rays

Skeletal survey identifies previous skeletal injuries and should be obtained if there is a high suspicion of non-accidental trauma. This should only be performed to provide adjunctive diagnoses to support an initial injury and suspicion of abuse.

Diagnostic laparoscopy

Laparoscopy may be necessary to confirm diagnosis of pelvic inflammatory disease as it allows direct visualisation of the gynaecological and abdominal structures.



Abdominal x-ray of a neonate with abnormal stooling pattern and constipation. The dilated transverse and descending colon is suggestive of Hirschsprung's disease

From the collection of Dr KuoJen Tsao; used with permission

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

From the collection of Dr KuoJen Tsao; used with permission

Abdominal x-ray with opacities in the RUQ consistent with gallstones

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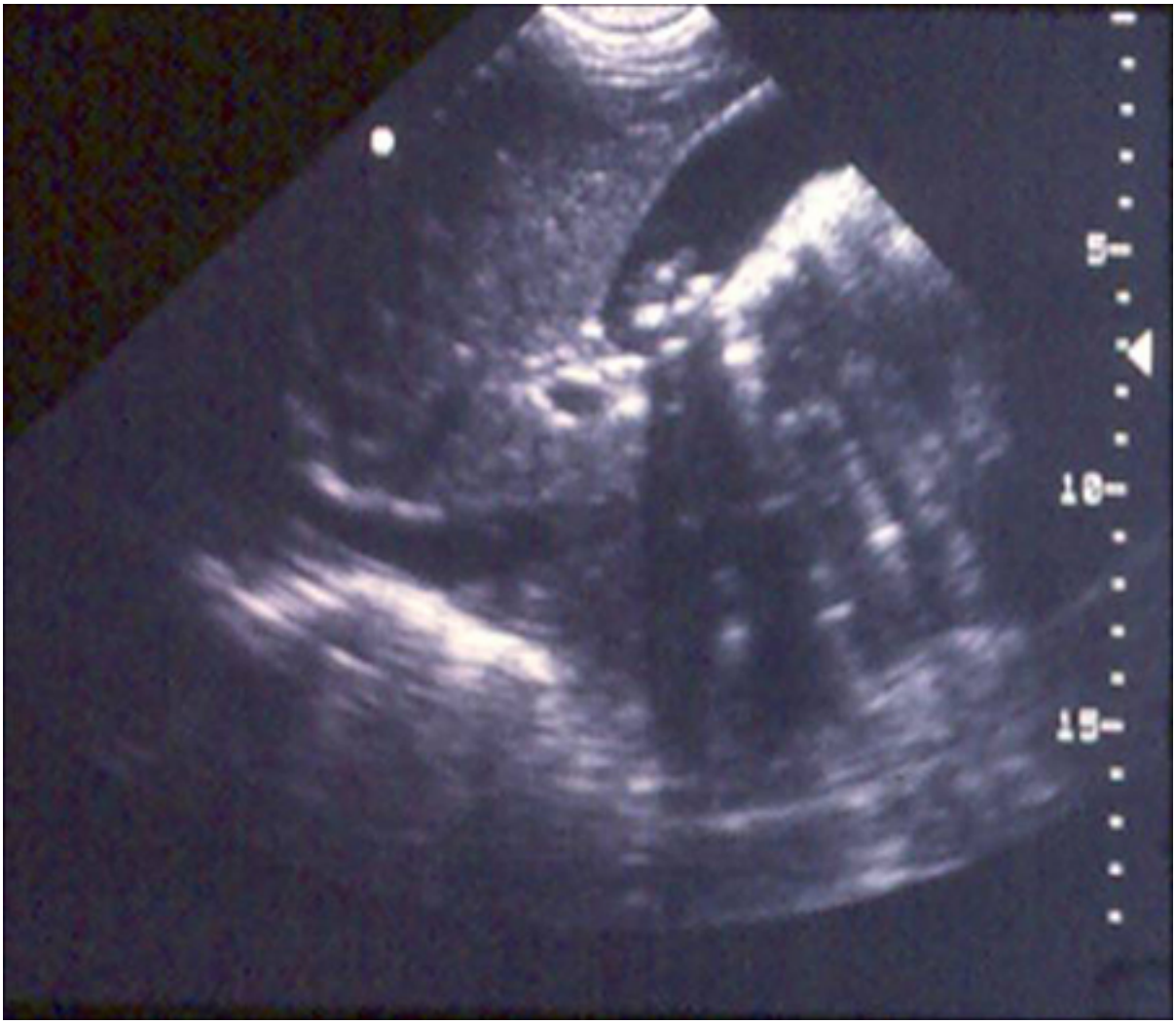
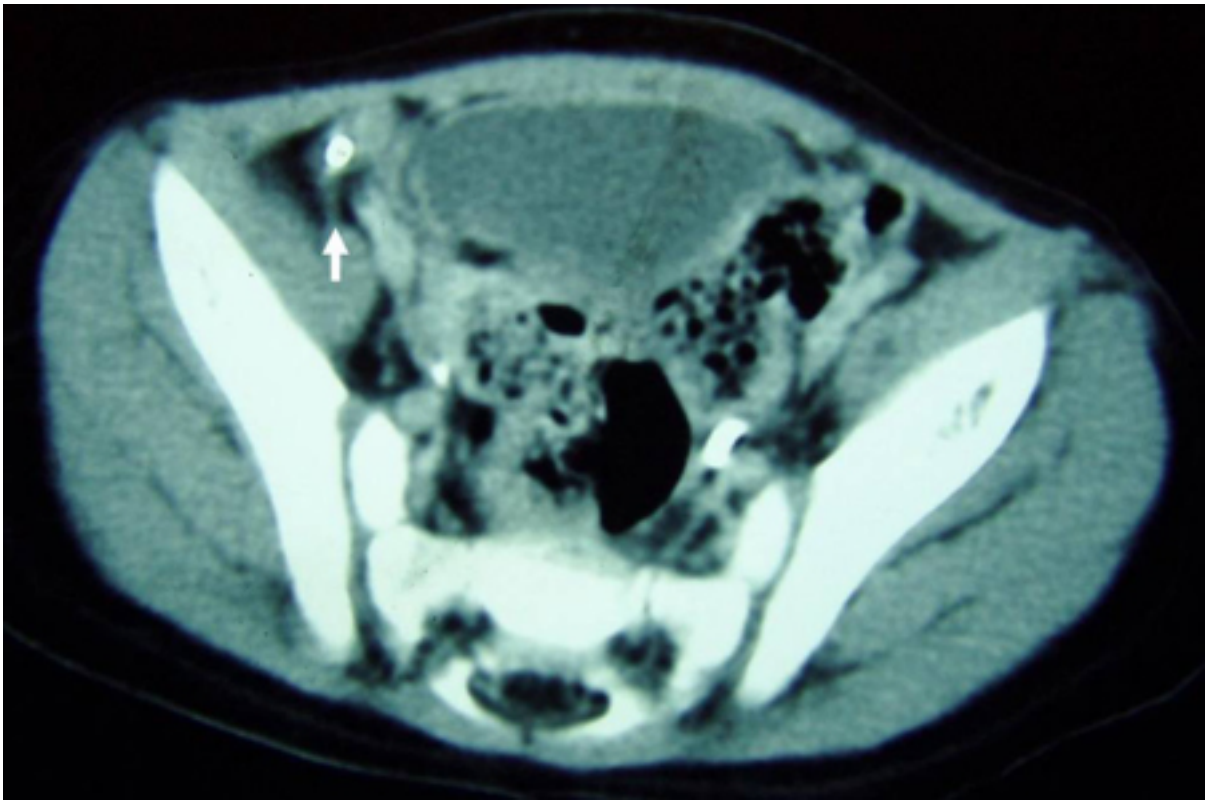


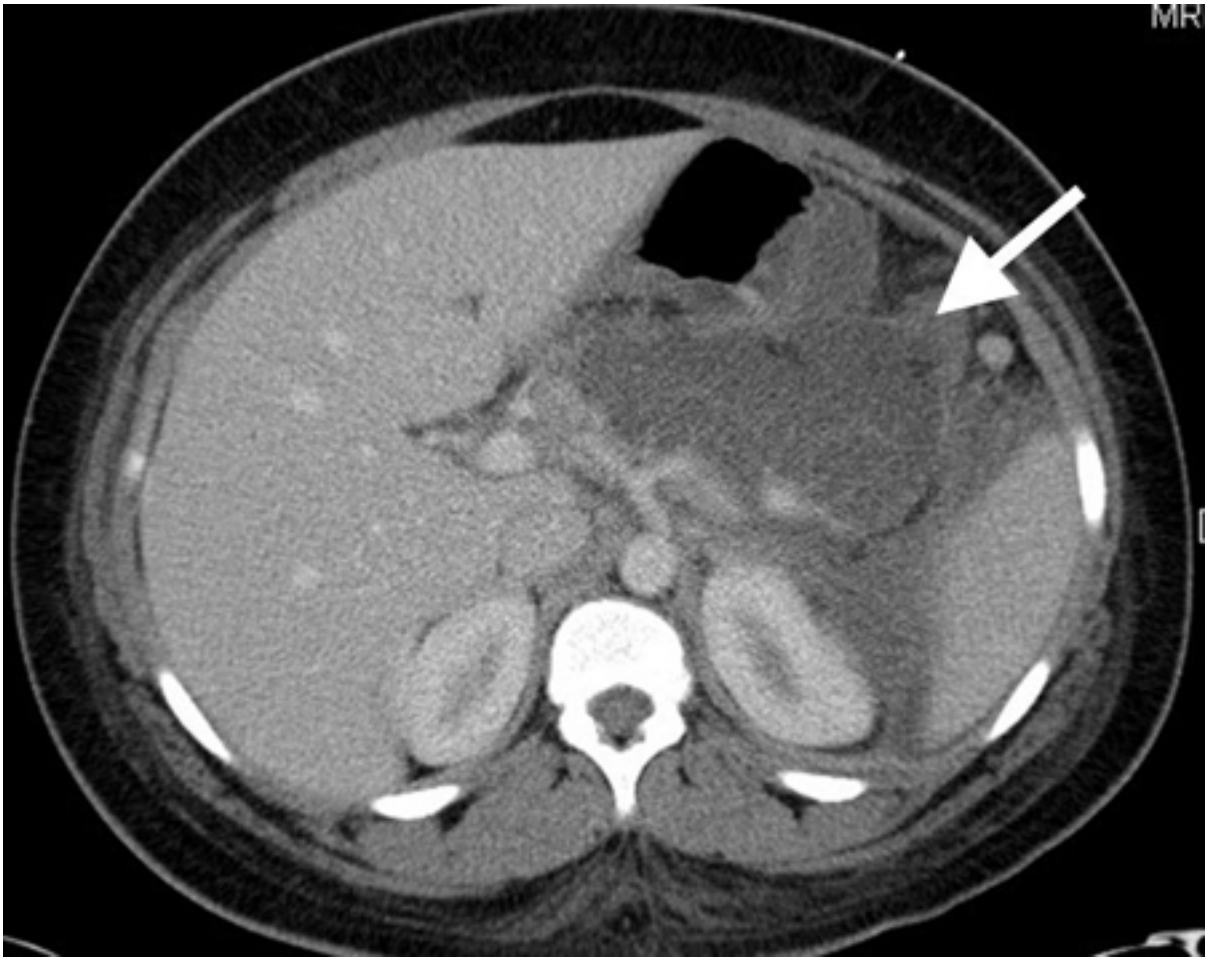
Gallbladder ultrasound demonstrating cholelithiasis with characteristic shadowing

From the collection of Dr KuoJen Tsao; used with permission



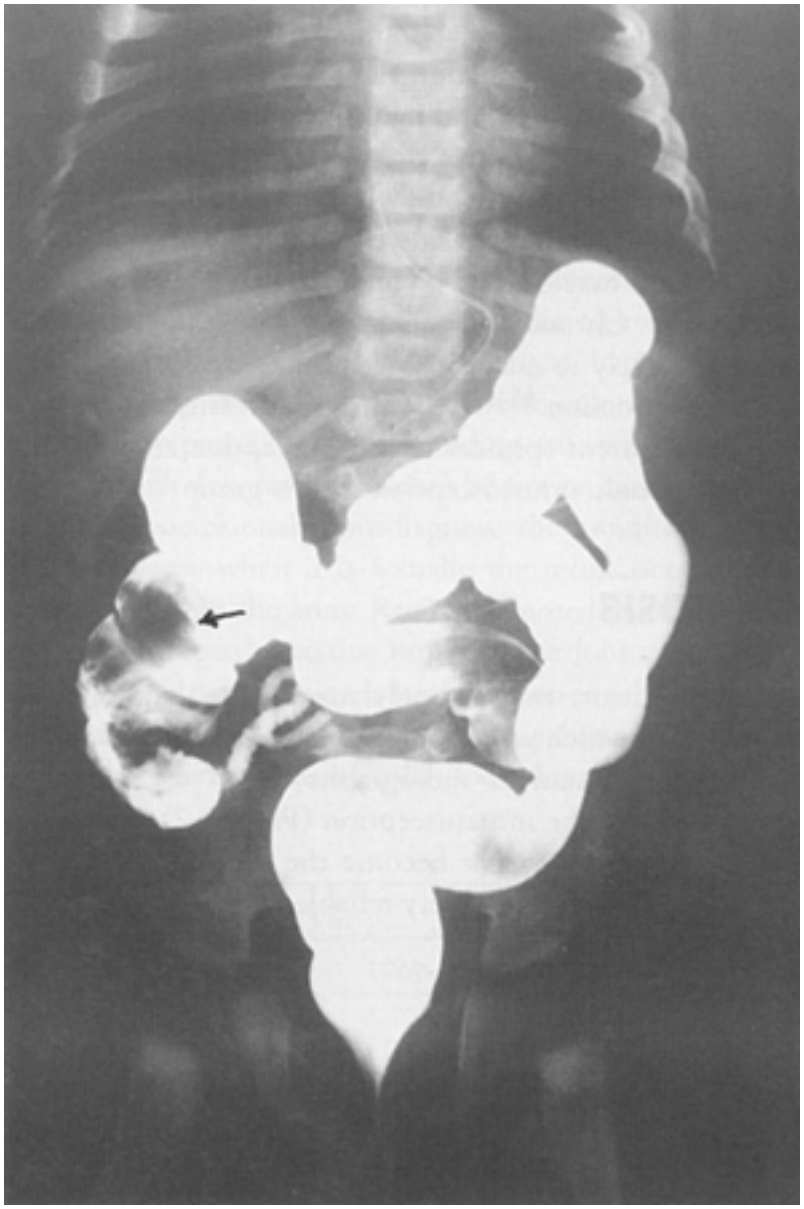
CT scan demonstrating faecalith (white arrow) outside the lumen of the appendix consistent with perforated appendix

From the collection of Dr KuoJen Tsao; used with permission



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



Contrast enema demonstrating ileocolic intussusception (black arrow)

From the collection of Dr KuoJen Tsao; used with permission

Differentials overview

Common
Constipation
Acute appendicitis
Gastroenteritis
Urinary tract infection
Abdominal trauma (blunt or penetrating)
Cholelithiasis/cholecystitis
Primary dysmenorrhoea
Pneumonia
Functional abdominal pain
Infantile colic

Uncommon
Intussusception
Meckel's diverticulum
Mesenteric adenitis
Hirschsprung's disease
Ulcerative colitis
Crohn's disease
Small bowel obstruction
Volvulus
Large bowel obstruction
Necrotising enterocolitis

Uncommon
Peptic ulcer disease
Coeliac disease
Viral hepatitis
Biliary dyskinesia
Acute pancreatitis
Splenic infarction/cysts
Nephrolithiasis
Sepsis
Testicular torsion
Ovarian torsion
Ruptured ovarian cyst
Pelvic inflammatory disease (PID)
Pregnancy complications
Empyema

Differentials

Common

◊ Constipation

History	Exam	1st Test	Other tests
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), faecal incontinence; medication with known constipating agents (e.g., iron supplements); obesity, low birth weight	examination findings may be minimal (mild abdominal tenderness, stool in rectum); abdominal distension in severe cases or in small children; faecal mass palpable on abdominal examination; 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, haemorrhoids (rare in children; may be mistaken for skin tags from Crohn's disease); imperforate anus or anal stenosis	»**none:** clinical diagnosis Characteristic history and examination findings are often sufficient to diagnose the condition.	»**abdominal x-ray:** stool visible throughout colon Stool throughout the colon does not rule out other aetiologies of abdominal pain.  *Abdominal x-ray of a young boy with acute, severe abdominal pain, demonstrating stool throughout the colon and rectum* *From the collection of Dr KuoJen Tsao; used with permission* »**radiopaque marker colonic transit study:** slow colonic transit, as measured by delay in marker movement, confirms constipation

DIAGNOSIS

Common

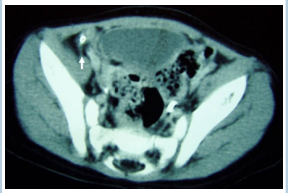
Acute appendicitis

History	Exam	1st Test	Other tests
history of sharp or stabbing periumbilical pain that migrates to the right lower quadrant (RLQ); anorexia, fever, vomiting, and/or diarrhoea may be present; occurs in all age groups but is rare in infants	patient lies still, tries not to move (especially in severe cases with significant peritoneal irritation); positive McBurney's sign (RLQ pain and tenderness to palpation at a point two-thirds along a line from the umbilicus to the anterior superior iliac spine); positive Rovsing's 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	»**FBC:** normal or raised WBC May see leukocytosis with neutrophilia. However, a normal WBC count does not exclude appendicitis. »**C-reactive protein (CRP):** likely to be raised CRP ≥10 mg/L (≥1 mg/dL) is a strong predictor of acute appendicitis in children <6 years old.[142] »**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.	»**abdominal ultrasound:** dilated appendix, free fluid; appendicolith may be present Ultrasound is the preferred method of assessment.[76] In children, specificity of ultrasound is similar to that of CT (0.92 vs. 0.94).[78] It may elicit a sonographic McBurney's sign (pain on compression of the appendix that is visualised on ultrasound). A negative ultrasound does not necessarily rule out appendicitis as a cause of abdominal pain. Subsequent investigations for paediatric patients with an equivocal ultrasound include CT or MRI.[78] [129] »**CT scan abdomen and pelvis:** dilated appendix, free fluid, mesenteric stranding, or appendicolith; abscess or phlegmon consistent with perforated appendicitis Useful when body habitus of patient makes ultrasound difficult or when ultrasound and/or clinical assessment

Common

Acute appendicitis

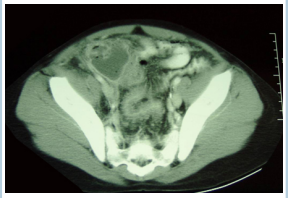
History	Exam	1st Test	Other tests
			are inconclusive. CT has greater sensitivity than ultrasound (0.93 vs. 0.90).[78] Radiation exposure and contrast burden should be considered.[128] [133] However, use of IV contrast, when feasible, is recommended for patients undergoing CT scan.[129] Sedation or general anaesthesia may be required in some children.



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

Common

Acute appendicitis

History	Exam	1st Test	Other tests
			 *CT scan demonstrating intra-abdominal abscess consistent with perforated appendix* *From the collection of Dr KuoJen Tsao; used with permission* »**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 and specificity (0.97); however, there are fewer studies evaluating its test characteristics.[78][131][143] It is increasingly used due to the potential hazards of ionising radiation from CT.

◊ Gastroenteritis

History	Exam	1st Test	Other tests
vague abdominal pain with nausea and vomiting; diarrhoea	diffuse abdominal pain without evidence of peritonitis (no	»**none:** clinical diagnosis	»**serum electrolytes:** normal or low sodium and potassium

Common

◊ Gastroenteritis

History	Exam	1st Test	Other tests
with or without mucus in stool; recent travel or contact with sick individual(s) or ingestion of suspected food and drink; >10 days suggests parasitic or non-infectious cause; fever, chills, myalgia, rhinorrhoea, upper respiratory symptoms	guarding or rebound tenderness); abdominal distension; hyperactive bowel sounds; mucus in stool (bacterial or parasitic); signs of volume depletion (tachycardia, hypotension, dry mucous membranes, poor capillary refill, sunken fontanelle in infants); low-grade fever, lethargy and/or irritability, reduced response to noxious stimuli, abnormal temperature (raised or low)		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. »**urea and creatinine:** normal; may have evidence of renal failure in patients with haemolytic uraemic 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:** faecal leukocytes; ova or parasites; culture positive for infectious agent in bacterial gastroenteritis

Common

◊ Gastroenteritis

History	Exam	1st Test	Other tests
			Faecal leukocytes and stool culture may be helpful in children presenting with dysentery and to demonstrate invasive pathogens such as *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 *C difficile* diarrhoea, it is important to test for *C difficile* toxin. Untreated *C difficile*-related diarrhoea can have serious consequences (e.g., toxic megacolon). »**urine dipstick:** may detect presence of albumin or blood in haemolytic uraemic syndrome »**FBC:** variable Eosinophilia with viral or parasitic aetiology, peripheral eosinophilia suggests eosinophilic gastroenteritis; bandaemia with bacterial aetiology; anaemia and/or thrombocytopenia if

Common

◊ Gastroenteritis

History	Exam	1st Test	Other tests
			haemolytic uraemic syndrome. Ordered to help differentiate alternative disease processes. However, in true gastroenteritis, only indicated in patients with systemic infection. »**blood culture:** may be positive for infectious agent in presence of sepsis Important to order if concern for sepsis. Guidelines recommend blood cultures: in children with infectious diarrhoea who are <3 months of age or who are immunocompromised; when enteric fever is suspected (including travel to enteric fever-endemic areas, or contact with travellers from enteric fever-endemic areas who have a febrile illness of unknown aetiology); when there are systemic manifestations of infection; and with high-risk conditions such as haemolytic anaemia.[117] [118] »**endoscopy with biopsy:** variable

Common

◊ Gastroenteritis

History	Exam	1st Test	Other tests
			Indicated only when eosinophilic gastroenteritis is a concern (condition affecting the gastrointestinal tract with eosinophil-rich inflammation without a known cause of the eosinophilia).[17]

Urinary tract infection

History	Exam	1st Test	Other tests
neonates and infants: fever, vomiting, lethargy, irritability, and poor feeding; older children: dysuria, urinary frequency and urgency, back pain if pyelonephritis	variable; fever >39°C (>102.2°F); suprapubic and/or costovertebral angle tenderness; irritability; foul-smelling urine; gross haematuria	»**urine dipstick:** positive leukocyte esterase and/or positive nitrite Urinalysis should be performed within 1-2 hours of obtaining specimen.[144] 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.[145] [146] Positive nitrite alone: sensitivity 58%, specificity 99%, LR+ 15:9, LR- 0:51.[145] [146] This test has a high positive predictive value.	»**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 colour Doppler; perinephric abscess: hypoechoic fluid Initially performed to look for any anatomical 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**

Common

Urinary tract infection

History	Exam	1st Test	Other tests
		Positive for either leukocyte esterase or nitrite: sensitivity 92%, LR- 0:2.[145] [146] This test is best at ruling out disease. Positive for leukocyte esterase and nitrite: LR+ 28:2.[146] This test is best at ruling in disease. »**urine microscopy:** >4 WBC per high-power field or any bacteria Microscopic analysis is more accurate; however, a urine dipstick analysis may suffice. UK guidelines recommend sending a sample for urine microscopy from all infants under 3 months, before antibiotics are given.[147] Pyuria (the presence of WBC): sensitivity 78%, specificity 87%; LR- 0:27.[145] [146] Bacteriuria: sensitivity 88%, specificity 93% LR+ 14:7, LR- 0:19.[145] [146] Centrifugation reduces the specificity of these tests. »**urine culture:** suprapubic aspirate:	**(VCUG):** if vesicoureteral reflux is present: contrast seen ascending out of the bladder into the upper urinary tract The American Academy of Pediatrics (AAP) recommends a VCUG 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.[137] Further evaluation is required if there is a recurrence of febrile UTI.[137][138] [139]

Common

Urinary tract infection

History	Exam	1st Test	Other tests
		>1000 colony-forming units (CFU)/mL; catheter: >10,000 CFU/mL; clean-catch midstream: >100,000 CFU/mL Urine collected from urinary bags is likely to be contaminated.	

Abdominal trauma (blunt or penetrating)

History	Exam	1st Test	Other tests
history of trauma; may have multiple complaints; history may suggest child abuse or non-accidental trauma (e.g., inconsistent or changing history, history not consistent with injuries/ examination)	abdominal tenderness; skin marks reflecting mechanism of injury (e.g., seat belt mark); referred left shoulder pain (due to splenic injury); blood at the urethral meatus, or haematuria (indicate urinary tract or kidney injury); signs of non-accidental trauma may be present (e.g., cigarette burns, subdural haemorrhages in an infant/young toddler)	»**FBC:** may be normal or show decreased haematocrit and haemoglobin Patients with acute-onset haemorrhage may have normal haematocrit and haemoglobin 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. In abdominal trauma, results from one retrospective study suggest that LFTs may be used as a screening tool to determine need for CT scan; in a haemodynamically normal patient with normal AST/ALT, it may	»**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 haemodynamically unstable.[125] Presence of large amounts of free fluid indicates need for immediate operative intervention. FAST in haemodynamically stable patients with blunt abdominal trauma has a less certain impact as a negative

Common

Abdominal trauma (blunt or penetrating)

History	Exam	1st Test	Other tests
		be possible to avoid CT scan.[113]	scan does not preclude injury.[126] »**full skeletal x-rays:** variable Skeletal survey identifies previous skeletal injuries and should be obtained if there is a high suspicion of non-accidental trauma. This should only be performed to provide adjunctive diagnoses to support an initial injury and suspicion of abuse.

◊ Cholelithiasis/cholecystitis

History	Exam	1st Test	Other tests
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)	right subcostal region tenderness; positive Murphy's sign (during palpation, deep inspiration causes pain to suddenly become worse and produces inspiratory arrest); palpable distended, tender gallbladder; fever suggests acute cholecystitis; jaundice rare and suggests common bile duct obstruction	»**RUQ ultrasound:** gallstones; ductal dilation, thickened gallbladder wall (>4 mm); pericholecystic fluid; may also see ultrasonographic Murphy's sign »**liver tests:** may see raised alk phos, bilirubin, and aminotransferase May be normal or marginally increased; if significantly raised, other aetiologies (such as hepatitis, choledocholithiasis,	»**abdominal x-ray:** opacities in RUQ consistent with gallstones If sufficiently radiopaque, it may be possible to identify gallstones on a plain abdominal film.

DIAGNOSIS

Common

◊ Cholelithiasis/cholecystitis

History	Exam	1st Test	Other tests
		or cholangitis) may be present. It is important to note the direct bilirubin concentration, which is the fraction that is raised with common duct obstruction. »**FBC:** normal WBC (suggests cholelithiasis) or leukocytosis (suggests acute cholecystitis) »**C-reactive protein:** normal (suggests cholelithiasis) or raised (suggests acute cholecystitis)	 *Abdominal x-ray with opacities in the RUQ consistent with gallstones* *From the collection of Dr KuoJen Tsao; used with permission* »**hepatobiliary iminodiacetic acid (HIDA) scan:** non-filling gallbladder Considered a useful adjunct in the diagnosis of cholecystitis. The classical finding is non-filling of the gallbladder. Prolonged fasting may result in a false-positive test.

◊ Primary dysmenorrhoea

History	Exam	1st Test	Other tests
history of recurrent crampy abdominal pain associated with menstruation	lower abdominal tenderness; normal pelvic examination	»**none:** diagnosis is clinical	»**abdominal/pelvic ultrasound:** normal; however, useful to rule out other diagnoses

Common

◊ Pneumonia

History	Exam	1st Test	Other tests
cough; purulent sputum production; upper respiratory tract symptoms (rhinorrhoea, sore throat, nasal congestion), shortness of breath, fever, and chills; splinting secondary to pain; vomiting, diarrhoea, anorexia	tachypnoea, cyanosis, decreased breath sounds, crackles/ rales on auscultation, dullness on percussion; abdominal tenderness and distension without guarding or rebound	»**FBC:** variable In patients with viral pneumonia, WBC count may be normal or decreased. »**chest x-ray:** infiltration, consolidation, effusion »**sputum culture:** growth of infecting organism	»**chest ultrasound:** localised 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 anaesthesia may be required in some children.

◊ Functional abdominal pain

History	Exam	1st Test	Other tests
history may be acute, chronic, or cyclic (frequently girls aged 8-12 years), complaint of vague, persistent, central abdominal pain common, may be associated nausea and 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	periumbilical tenderness, abdomen is soft, non-distended, no guarding or rebound tenderness; examination of other systems normal	»**none:** diagnosis is clinical after exclusion of possible organic causes	»**FBC:** normal »**erythrocyte sedimentation rate:** normal »**urinalysis:** normal »**stool microscopy:** normal

Common

◊ Infantile colic

History	Exam	1st Test	Other tests
paroxysms of uncontrollable crying in otherwise healthy and well-fed infant aged <5 months; duration of crying is >3 hours per day, and >3 days per week, for at least 3 weeks; sibling(s) may have history of infantile colic	examination findings may be minimal; infant typically well and thriving	»**none:** clinical diagnosis Characteristic history and examination findings are often sufficient to diagnose the condition.	»**urinalysis:** normal Rarely required. Ordered only when the diagnosis is in doubt and urinary tract infection is suspected, when it may show pyuria and bacteriuria. »**urine culture:** normal Rarely required. Ordered only when the diagnosis is in doubt and urinary tract infection is suspected, when it may be positive.

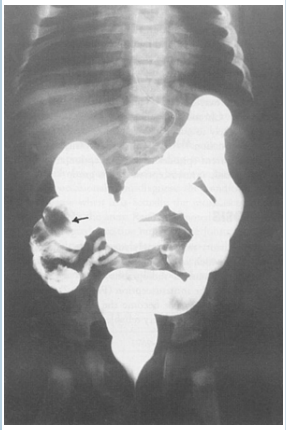
Uncommon

Intussusception

History	Exam	1st Test	Other tests
usually infant between 3 months 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 <11 years of age); vague abdominal complaints; severe, cramp-like abdominal pain; child may be inconsolable	may see gross or occult blood that may be mixed with mucus and have red-brick-coloured jelly-like appearance, abdominal tenderness, and palpable abdominal mass; signs of HSP may be present in older child (rash of palpable purpura, blood in the stools)	»**abdominal ultrasound:** tubular mass in longitudinal view; and a doughnut or target lesion in transverse view Point-of-care ultrasound may be useful for detecting intussusception at an early stage.[123] [124] Ultrasound can also be used to monitor success of treatment with enema, or if recurrence suspected after reduction.	»**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

Uncommon

Intussusception

History	Exam	1st Test	Other tests
		»**diagnostic#enema:** meniscus sign; coiled spring sign Contraindicated if peritonitis, shock, perforation, or an unstable clinical condition is present. Should perforation ensue, the use of barium would lead to barium peritonitis; therefore, it would be problematic. Contrast enema (air or contrast reagent) is the long-standing most specific and sensitive diagnostic test.  *Contrast enema demonstrating ileocolic intussusception (black arrow)* *From the collection of Dr KuoJen Tsao; used with permission*	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, may provide a high yield of information, but radiation exposure should be considered.[133] Sedation or general anaesthesia may be required in some children. »**FBC:** may show raised WBC (suggests intestinal ischaemia) »**faecal occult blood test:** positive test can support suspicion of intussusception Negative test cannot reliably rule out the diagnosis.[115]

Uncommon

◊ Meckel's diverticulum

History	Exam	1st Test	Other tests
typically aged <2 years; may present with abdominal pain (may be intermittent or mimic acute appendicitis), and/or painless passage of bright red blood per rectum (haematochezia); often asymptomatic	painless dark red, maroon, or red-brick-coloured jelly-like stools; abdominal tenderness with guarding and rebound (may suggest diverticulitis); palpable abdominal mass (may suggest intussusception)	»**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. Point-of-care ultrasound may be useful for detecting intussusception at an early stage.[123] Sensitivity is user-dependent. »**technetium-99m pertechnetate scan:** positive Identifies ectopic gastric mucosa as tracer is taken up by mucin-secreting cells. A positive scan shows immediate tracer localisation in the stomach and in the right lower quadrant; an area of 1.8 cm^2 of ectopic gastric mucosa in a Meckel's diverticulum is required to produce a positive result. In the paediatric population, the specificity has been reported to be 95%, with an accuracy of 90%.[148]	»**CT scan abdomen and pelvis:** may show intussusception, Meckel's diverticulitis, and/or dilated bowel consistent with bowel obstruction Not routinely ordered unless concerned for alternative disease process or assessing for complications. May be considered if technetium-99m pertechnetate scan negative, but clinical suspicion remains.

Uncommon

◊ Mesenteric adenitis

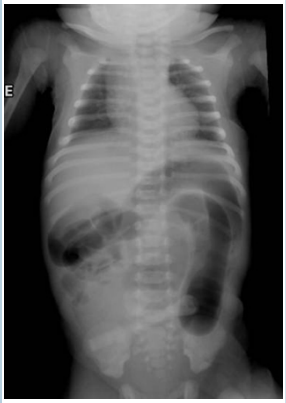
History	Exam	1st Test	Other tests
diffuse abdominal pain; history of recent or current upper respiratory tract infection	fever, abdominal tenderness not localised to right lower quadrant, rhinorrhoea, hyperaemic pharynx or oropharynx (pharyngitis), and/or associated extramesenteric lymphadenopathy (usually cervical)	»**abdominal ultrasound:** enlarged mesenteric lymph nodes Can also show mural and mesenteric thickening suggestive of enteritis. Usually first-line test because it is inexpensive, reproducible, and carries no radiation risk.	»**CT scan abdomen and pelvis:** enlarged mesenteric lymph nodes Demonstrates number and size of mesenteric lymph nodes. Can assess 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 yield of information, but radiation exposure should be considered.[133] Sedation or general anaesthesia may be required in some children.

◊ Hirschsprung's disease

History	Exam	1st Test	Other tests
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; increased incidence in Down syndrome	abdominal distension, fullness in left lower quadrant; palpable faecal mass on abdomen examination; absence of peritonitis (no guarding or rebound tenderness); small rectum and absence of stool on rectal examination (should be performed by clinician able to interpret features of Hirschsprung's	»**abdominal x-ray:** stool visible throughout colon, decreased air in rectum; air-fluid levels may be present Stool throughout the colon does not rule out other aetiologies of abdominal pain.	»**rectal biopsy:** required for a definitive diagnosis; absence of ganglion cells and the presence of an excess of non-myelinated nerves; presence of increased acetylcholinesterase The specimen must be taken at least 1.5 cm above the pectinate line. Suction biopsy has gained wide

Uncommon

◊ Hirschsprung's disease

History	Exam	1st Test	Other tests
	disease); dysmorphic features of Down syndrome may be present	 *Abdominal x-ray of a neonate with abnormal stooling pattern and constipation. The dilated transverse and descending colon is suggestive of Hirschsprung's disease* *From the collection of Dr KuoJen Tsao; used with permission* It is very difficult to differentiate between a distended colon and the small bowel; it is a non-specific investigation. »**contrast enema:** proximal dilation with narrowing of the distal colon, with a funnel-shaped transition zone Considered a classical finding. However, in children less than 1 month of age, the findings may be difficult to interpret.	acceptance, as it is easily performed, is associated with virtually no risk of perforation, and does not require an anaesthetic. »**anorectal manometry:** 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 in patients with aganglionosis. This is the most sensitive and specific test. However, the test has several limitations including the technical difficulty of assessing the newborn.

Uncommon

◊ Hirschsprung's disease

History	Exam	1st Test	Other tests
		Performed with water-soluble contrast material. No bowel preparation required. The infant is placed in a lateral position, and a rectal tube is introduced to barely above the anal canal.	

◊ Ulcerative colitis

History	Exam	1st Test	Other tests
positive family history, bloody diarrhoea, cramping abdominal pain, anorexia, weight loss, fever, rash	evidence of weight loss, pallor, abdominal tenderness, abdominal mass, iritis (inflamed irritated eyes), arthritis, sacroiliitis, erythema nodosum, pyoderma gangrenosum	»**faecal calprotectin:** raised Increasingly used to distinguish between inflammatory bowel disease and non-inflammatory bowel disease, with a sensitivity of up to 90% and a specificity of up to 80%.[116] [149] »**FBC:** leukocytosis, anaemia, thrombocytosis Iron deficiency anaemia 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. »**colonoscopy with biopsy:** continuous uniform rectal	»**plain abdominal x-rays:** 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 faeces. Easy, inexpensive, and widely available; ordered when initial presentation or subsequent relapses are associated with signs and symptoms of an acute abdomen. »**CT scan abdomen:** thickened inflamed bowel mucosa, thumbprinting, intestinal dilation or evidence of stricture; inflamed

Uncommon

◊ Ulcerative colitis

History	Exam	1st Test	Other tests
		involvement, loss of vascular marking, diffuse erythema, mucosal granularity and friability, mucosal oedema 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. 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's disease. »**erythrocyte sedimentation rate:** raised Inflammatory markers correlate closely with disease activity. »**C-reactive protein:** raised Inflammatory markers correlate closely with disease activity.	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.[133] Sedation or general anaesthesia may be required in some children. »**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's disease and ulcerative colitis in the paediatric population; about 70% of patients with ulcerative colitis have positive pANCA; about 70% of patients with

Uncommon

◊ Ulcerative colitis

History	Exam	1st Test	Other tests
			Crohn's disease have positive ASCA.[122]

◊ Crohn's disease

History	Exam	1st Test	Other tests
crampy abdominal pain, intermittent diarrhoea, bloody diarrhoea if colitis a feature (blood less common in Crohn's disease than in ulcerative colitis), weight loss, fatigue, family history of inflammatory bowel disease	aphthous 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	»**faecal calprotectin:** may be raised Increasingly used to distinguish between inflammatory bowel disease and non-inflammatory bowel disease, with a sensitivity of up to 90% and a specificity of up to 80%.[116] [149] »**FBC:** leukocytosis, anaemia, thrombocytosis Iron deficiency anaemia 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. »**C-reactive protein:** raised Inflammatory markers correlate closely with disease activity. »**erythrocyte sedimentation rate:** raised	»**plain abdominal x-rays:** small bowel or colonic dilation; calcification; intra-abdominal abscesses Suggestive of the diagnosis of Crohn's disease and useful to assess severity. »**upper gastrointestinal series with small bowel follow-through:** oedema and ulceration of the mucosa with luminal narrowing and strictures Demonstrates features suggestive of Crohn's disease and aids in defining its distribution and severity. »**CT scan abdomen and pelvis:** skip lesions, bowel wall thickening, surrounding inflammation, abscess, fistulas 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,

Uncommon

◊ Crohn's disease

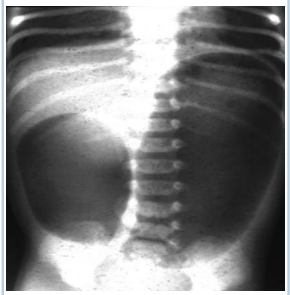
History	Exam	1st Test	Other tests
		Inflammatory markers correlate closely with disease activity. »**colonoscopy with biopsy:** may demonstrate inflammation, friability, ulcer formation, and oedema Biopsy of mucosa should be performed in multiple segments of the bowel. Endoscopic findings may be highly suggestive of inflammatory bowel disease but the characteristics of the mucosa (including ulcers) cannot be used to distinguish between ulcerative colitis and Crohn's disease. »**MR enterography:** skip lesions, bowel wall thickening, surrounding inflammation, abscess, fistulas	with or without contrast, may provide a high yield of information, but radiation exposure should be considered.[133] Sedation or general anaesthesia may be required in some children. »**serological 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's disease and ulcerative colitis in the paediatric population; about 70% of patients with ulcerative colitis have positive pANCA; about 70% of patients with Crohn's disease have positive ASCA.[122]

Small bowel obstruction

History	Exam	1st Test	Other tests
intolerant of feeding, with nausea and/ or bilious vomiting; abdominal pain may or	limited abdominal distension (with proximal obstructions in the duodenum or early	»**abdominal x-ray:** dilated small bowel loops, air-fluid levels throughout abdomen	»**abdominal ultrasound:** may demonstrate focal area causing obstruction

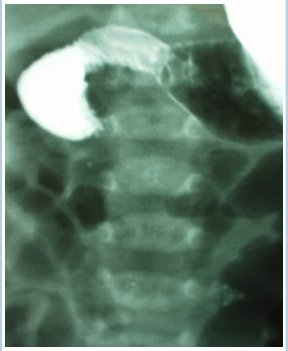
Uncommon

Small bowel obstruction

History	Exam	1st Test	Other tests
may not be a feature; history of previous abdominal surgery; history of cystic fibrosis may be present	jejunum); abdominal tenderness may or may not be present; rebound tenderness and guarding may occur if perforation, ischaemia, and peritonitis; hyperactive bowel sounds (early finding), hypoactive or absent bowel sounds (late finding); incarcerated femoral, obturator, umbilical or ventral hernia may be present	Supine and upright films may reveal characteristic pattern of gas in bowel. In duodenal atresia may see double bubble sign.  *Abdominal x-ray demonstrating double bubble gas pattern consistent with duodenal atresia* *From the collection of Dr KuoJen Tsao; used with permission* Jejunal atresia shows dilated proximal small bowel with decompressed non-air-filled bowel distally.	Can be used to diagnose intussusception; may be of particular value when diagnosing intussusception secondary to Henoch-Schonlein purpura, as it is typically ileo-ileal instead of ileocolic.[22] Point-of-care ultrasound may be useful for detecting intussusception at an early stage.[123] Ultrasound with Doppler blood flow assessment may assist in the diagnosis of mid-gut volvulus associated with malrotation. In addition, it may be useful in the diagnosis of omental and duplication cysts. »**upper gastrointestinal contrast study:** dilated small intestine; may demonstrate a transition zone of obstruction Critical to rule out acute mid-gut volvulus and/or malrotation; water-soluble contrast challenge can be both diagnostic and therapeutic.[150]

Uncommon

Small bowel obstruction

History	Exam	1st Test	Other tests
			 *Upper GI contrast study demonstrating malrotation with volvulus. The duodenum fails to develop the normal anatomical C-loop. There is failure of contrast to pass, resulting in a characteristic bird beak consistent with acute mid-gut volvulus* *From the collection of Dr KuoJen Tsao; used with permission* »**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 be helpful for clearing meconium.

Uncommon

Small bowel obstruction

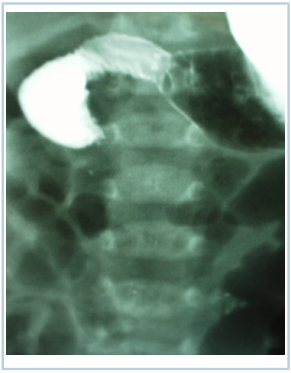
History	Exam	1st Test	Other tests
			»**CT scan abdomen:** dilated small intestine; may demonstrate a transition zone of obstruction, mass, tumour, abscess Helps to determine diagnosis of underlying cause, extent, and location of the obstruction when x-rays are inconclusive.[151] CT scan should include intravenous and oral contrast for best yield and be performed only in cases in which peritonitis is not present.

Volvulus

History	Exam	1st Test	Other tests
infant age group; history of bilious vomiting; pain usually manifests as notable transition to an inconsolable state	often diffuse abdominal distension and tenderness; faint or no bowel sounds, rigid abdomen, guarding, rebound tenderness, fever, or haematochezia	»**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. Not necessary if diagnosis is strongly indicated from plain x-rays or there is	»**CT scan abdomen:** bowel obstruction with whirl pattern of mesentery Usually not necessary to make diagnosis.

Uncommon

Volvulus

History	Exam	1st Test	Other tests
		evidence of bowel necrosis.  *Upper GI contrast study demonstrating malrotation with volvulus. The duodenum fails to develop the normal anatomical C-loop. There is failure of contrast to pass, resulting in a characteristic bird beak consistent with acute mid-gut volvulus* *From the collection of Dr KuoJen Tsao; used with permission* »**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.	

Uncommon

Volvulus

History	Exam	1st Test	Other tests
		»**FBC:** raised WBC (suggests intestinal ischaemia)	

Large bowel obstruction

History	Exam	1st Test	Other tests
history of risk factors: neurodevelopmental problems, inflammatory bowel disease, diabetes, poor diet, previous colorectal resection, laxative misuse, megacolon, or previous abdominal surgery; change in bowel habit with partial or complete obstruction, or change in calibre of stool; colicky abdominal pain becoming more constant and worse with movement, coughing or deep breathing as bowel approaches perforation; intolerant of feeding, with nausea or vomiting	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	»**abdominal x-ray:** gaseous distension of large bowel; volvulus suggested by kidney-bean-shape bowel loop Diagnosis confirmed by colonic dilation. Level of obstruction may be determined by a cut-off beyond which the colon or rectum is empty of gas. Intramural gas (pneumatosis) may suggest colonic ischaemia.	»**abdominal ultrasound:** may demonstrate focal area causing obstruction (e.g., intussusception) Point-of-care ultrasound may be useful for detecting intussusception at an early stage.[123] »**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. Hypertonic contrast medium may be helpful for clearing meconium. »**CT scan abdomen and pelvis:** gaseous distension of large bowel; may demonstrate a transition zone of obstruction May also reveal underlying cause and provide more

Uncommon

Large bowel obstruction

History	Exam	1st Test	Other tests
			diagnostic information than contrast enema. Intravenous and oral contrast should be used for best diagnostic yield. Radiation exposure should be considered.[133] Sedation or general anaesthesia may be required in some children. »**flexible/rigid sigmoidoscopy:** flood of stool and mucus upon passing and decompressing apex of volvulus Useful if sigmoid volvulus is suspected, as sigmoidoscopy may be potentially therapeutic. Must exercise extreme caution if ischaemia is suspected, as there is an increased chance of perforation.

Necrotising enterocolitis

History	Exam	1st Test	Other tests
premature neonate weighing less than 1500 g; feeding intolerance, apnoea, lethargy, bloody stools	abdominal distension, tenderness, abdominal wall erythema, haematochezia, bradycardia	»**FBC:** leukocytosis or leukopenia, anaemia, thrombocytopenia Decreased WBC count may be more ominous than leukocytosis. Thrombocytopenia develops in 50% to	»**abdominal ultrasound:** fluid collections, ascites Useful for diagnosing fluid collections that may represent perforation or abscess. A few centres use

Uncommon

Necrotising enterocolitis

History	Exam	1st Test	Other tests
		95% of all infants with necrotising enterocolitis within 24-72 hours of receiving the diagnosis.[152] Anaemia may result with significant haematochezia. »**blood culture:** negative Bacterial sepsis should be excluded. »**serum electrolyte panel:** hyponatraemia »**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 for early diagnosis and serial follow-up; very sensitive but still not widely used.[153]

Peptic ulcer disease

History	Exam	1st Test	Other tests
non-steroidal anti-inflammatory drug use; 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; melaena and/or haematemesis	unremarkable or epigastric tenderness, melaena, or occult bleeding on stool haemoccult test	»**FBC:** normal or leukocytosis; anaemia present if sustained blood loss »**erect chest x-ray:** usually normal Ordered to rule out gastric or duodenal perforation (demonstrated by free air under the diaphragm).	»**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 readily available, and

Uncommon

Peptic ulcer disease

History	Exam	1st Test	Other tests
if erosion into blood vessel		»**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 visualised 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 haemorrhage Endoscopy should be performed urgently if bleeding is suspected (prior to any contrast radiological studies). Contrast may interfere with the assessment of the mucosa. Biopsies and testing for *Helicobacter pylori* may be performed.	peptic ulcer disease is suspected, *H pylori* breath test or stool antigen test may be helpful, and may also be performed 4 weeks after starting treatment, to assess treatment success.[119] [120] A blood test for *H pylori* is not useful in children.

◊ Coeliac disease

History	Exam	1st Test	Other tests
recurrent abdominal pain, cramping, or distension; bloating and	generalised abdominal pain or bloating; underweight or failing	»**immunoglobulin A-tissue transglutaminase**	»**endomysial antibody (EMA):** raised titre

Uncommon

◊ Coeliac disease

History	Exam	1st Test	Other tests
diarrhoea; dermatitis herpetiformis, an intensely pruritic papulovesicular rash that affects the extensor limb surfaces, almost universally occurs in association with coeliac 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 coeliac disease	to thrive; aphthous stomatitis; dermatitis herpetiformis	**(IgA-tTG):** titre above normal range for laboratory IgA anti-tissue transglutaminase antibody is the preferred single test for detection of coeliac disease in individuals over the age of 2 years.[154] When screening children aged <2 years for coeliac disease, the IgA-tTG test should be combined with deamidated gliadin peptide (IgA and IgG).[154] »**quantitative immunoglobulin A (IgA):** titre normal or below normal range for laboratory In patients with low total IgA concentrations, an IgG-based test (e.g., deamidated gliadin peptide) should be performed.[155] »**FBC:** may show iron deficiency anaemia »**endoscopy and small bowel biopsy:** presence of intra-epithelial lymphocytes, villous atrophy, and crypt hyperplasia Small-bowel histology is essential and the gold-standard test to confirm the diagnosis.	EMA is a more expensive alternative to IgA-tTG with greater specificity but lower sensitivity. Perform initially if IgA-tTG is unavailable. »**human leukocyte antigen (HLA) typing:** positive HLA-DQ2 or HLA-DQ8 This genetic test is useful to rule out coeliac disease in patients already on a gluten-free diet or in patients with an idiopathic coeliac-like enteropathy.[46] Paediatric patients with symptoms consistent with coeliac disease and a high IgA-tTG titre (≥10 times the upper limit of normal) may go on to have confirmatory EMA and HLA-DQ2/-DQ8 testing. If both of these are positive, coeliac disease may be considered confirmed without a small intestinal biopsy.[155] Children with lower IgA-tTG titres (<10 times upper limit of normal) should undergo biopsies to decrease

Uncommon

◊ Coeliac disease

History	Exam	1st Test	Other tests
		Two biopsies of the bulb and at least four biopsies of the distal duodenum should be submitted for histological analysis. Paediatric patients with symptoms consistent with coeliac disease and a high IgA-tTG titre (≥10 times the upper limit of normal) may go on to have confirmatory EMA and HLA-DQ2/-DQ8 testing. If both of these are positive, coeliac disease may be considered confirmed without a small intestinal biopsy.[155] Children with lower IgA-tTG titres (<10 times upper limit of normal) should undergo biopsies to decrease the risk of false positive diagnosis.[155]	the risk of false positive diagnosis.[155]

Viral hepatitis

History	Exam	1st Test	Other tests
birth or residence in endemic area, antenatal exposure, family history of chronic viral hepatitis, multiple sexual partners, sexual intercourse with infected individuals (hepatitis B and/or C), travel to developing	jaundice; early disease: tender hepatosplenomegaly, lymphadenopathy; late disease: generalised wasting, cachexia, gynaecomastia, ascites, altered sensorium, asterixis, or decreased deep	»**serum LFTs:** high direct bilirubin, AST, ALT, alk phos and gamma-GT Although transaminases may be raised, the level is not a good correlate for	»**FBC:** low or normal platelet count A low platelet count is suggestive of portal hypertension. »**coagulation profile (prothrombin time [PT], INR):** May be raised or normal

Uncommon

Viral hepatitis

History	Exam	1st Test	Other tests
countries, pregnant (hepatitis E); early disease: malaise, muscle and joint aches, fever, nausea, vomiting, diarrhoea, headache, anorexia, dark urine, pale stool, abdominal pain; late disease: weight loss, easy bruising and bleeding tendencies	tendon reflexes, caput medusa, ascites, hepatosplenomegaly, congestion secondary to right heart failure	severity of infection; it indicates liver damage. »**serum IgM anti-HAV:** positive if acute hepatitis A infection »**serum hepatitis B surface antigen (HBsAg):** positive if hepatitis B infection Positive result appears in serum 1 to 10 weeks after an acute exposure and disappears when infection abates. »**serum hepatitis B core antigen (HBcAg):** positive if hepatitis B infection An intracellular antigen that is found in infected hepatocytes. »**serum hepatitis B e antigen (HBeAg):** positive if hepatitis B infection Patients with a positive result are considered highly infective for hepatitis B. »**serum HCV RNA:** positive if hepatitis C infection Identifies acute or chronic infection with hepatitis C virus. Progression to chronic disease after acute infection is highly likely. Significant risk for hepatocellular carcinoma.	In cases of severe hepatitis, liver synthetic function as measured by coagulation parameters may be compromised, reflected by increased PT and INR.

Uncommon

Viral hepatitis

History	Exam	1st Test	Other tests
		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 radio-immunoassay. Hepatitis D is a defective virus and can only replicate in the presence of co-infection or superinfection with HBV. »**serum anti-HEV IgM antibodies:** positive if acute hepatitis E infection	

◊ Biliary dyskinesia

History	Exam	1st Test	Other tests
history of previous negative work-up for cholelithiasis common; recurrent right upper quadrant (RUQ) pain; nausea and vomiting; symptoms may or may not be associated with eating	may be equivocal; RUQ tenderness	»**LFTs:** normal aspartate aminotransferase, alanine aminotransferase, alk phos, and bilirubin »**RUQ ultrasound:** normal Gallstones should not be demonstrated in patients with biliary dyskinesia.	»**hepatobiliary iminodiacetic acid (HIDA) scan:** decreased (<35%) gallbladder ejection fraction Considered the diagnostic test of choice. The ejection fraction (EF) of the gallbladder is measured after the administration of cholecystokinin (CCK); definition of dyskinesia widened at some centres to include

Uncommon

◊ Biliary dyskinesia

History	Exam	1st Test	Other tests
			high EFs (85% to 90% +) and even normal results. No consistent predictive factors for subset of children that will have medium- to long-term relief of symptoms following cholecystectomy.

Acute pancreatitis

History	Exam	1st Test	Other tests
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's sign) or flanks (positive Grey-Turner's sign) in cases of haemorrhagic pancreatitis; small children may demonstrate increased irritability and abdominal distension only	»**lipase:** at least 3 times upper limit of normal range; can be raised if amylase normal Use serum lipase in preference to serum amylase, if available.[114] Serum lipase levels remain raised 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.[156] »**amylase:** at least 3 times upper limit of normal range Use serum lipase in preference to serum amylase, if available.[114] Serum lipase levels remain raised for longer	»**abdominal ultrasound:** may appear normal early in disease course; enlargement of the pancreas; peripancreatic oedema; 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 assessment of the biliary system for cholelithiasis and/or choledocholithiasis that may be the underlying cause of pancreatitis. »**CT scan abdomen with intravenous contrast:**

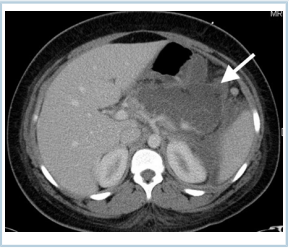
Uncommon

Acute pancreatitis

History	Exam	1st Test	Other tests
		(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.[156] »**bilirubin:** normal or raised An raised bilirubin (specifically direct bilirubin) is suggestive of gallstone-induced pancreatitis. In addition, choledochal cysts are an important cause of pancreatitis in children.	peripancreatic inflammation (fat stranding); may show gallstones 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. Allows better assessment of potential pancreatic necrosis (which would indicate more serious disease) and peripancreatic inflammation than is achievable with ultrasound.

Uncommon

Acute pancreatitis

History	Exam	1st Test	Other tests
			 *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*

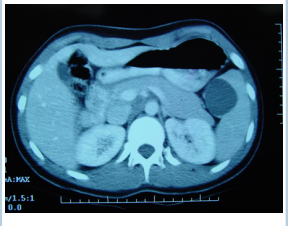
Splenic infarction/cysts

History	Exam	1st Test	Other tests
varied; may be history of trauma; cysts either asymptomatic or dull, left-sided abdominal pain; infarction typically causes fever as well as pain, but occasionally asymptomatic; left-sided shoulder and/or chest pain; presence of risk factors for splenic infarction (sickle cell disease, high altitude)	may be vague left upper quadrant tenderness	»**Doppler ultrasound:** infarction or cyst on spleen Splenic infarcts appear as wedge-shaped defects. Blood flow is absent, with absence of Doppler signal. Cysts appear anechoic.	»**CT scan abdomen with intravenous 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.

DIAGNOSIS

Uncommon

Splenic infarction/cysts

History	Exam	1st Test	Other tests
			Splenic cysts may also be visualised.  *CT scan demonstrating fluid-filled cyst within the spleen* *From the collection of Dr KuoJen Tsao; used with permission*

◊ Nephrolithiasis

History	Exam	1st Test	Other tests
family history of nephrolithiasis and/or gout; intermittent, severe, colicky flank and/or abdominal pain; nausea and vomiting; gross or microscopic haematuria; urinary frequency/urgency; atypical presentation common in younger children	ipsilateral costovertebral angle and flank tenderness; tachycardia and hypotension in pain-controlled patient may suggest concurrent urosepsis	»**ultrasound of the urinary tract:** calcification seen within urinary tract; possible dilated proximal ureter and hydronephrosis Ultrasound should be the first modality. As well as diagnosing nephrolithiasis, it can provide information on potential complications of obstruction such as hydronephrosis. »**urinalysis:** may be normal or dipstick-positive for leukocytes, nitrites, blood; microscopic analysis positive for WBCs, red blood cells, or bacteria	»**abdominal x-ray:** radiopaque stones If sufficiently radiopaque, urinary stones may be visible on plain x-rays. Calcium oxalate and calcium phosphate stones are radiopaque, whereas pure uric acid and indinavir stones are radiolucent and cystine stones are partially radiolucent. »**non-contrast CT scan abdomen and pelvis:** calcification seen in renal collecting system or ureter; possible dilated proximal ureter and hydronephrosis

Uncommon

◊ Nephrolithiasis

History	Exam	1st Test	Other tests
		Patients with nephrolithiasis typically have blood in the urine. It is important to pay attention to other elements of the urine analysis, as the presence of white blood cells, leukocyte esterase, and nitrites may signify a concurrent urinary tract infection.	Highly sensitive for detection of nephrolithiasis and assessment of hydronephrosis. In addition, if stones are not seen, an alternative aetiology may be detected; frequently, nephrolithiasis detected on CT scan is a serendipitous finding for the investigation of other aetiologies of abdominal pain.

Sepsis

History	Exam	1st Test	Other tests
may be history of decreased activity, carer concern that child is not behaving as normal; may not wake or may be difficult to rouse	fever may be present (although core temperature may also be normal or low), tachycardia, raised respiratory rate, may be delayed capillary refill time, oxygen saturations may be <92% in air, altered mental state, petechiae or purpura may be present	»**FBC:** WBC variable; may be thrombocytopenia Abnormal WBC count (i.e., above or below normal range for age or >10% immature white cells) is one of the core diagnostic criteria for systemic inflammatory response syndrome.[157] However, raised or depressed WBC count is not specific for the diagnosis of sepsis. »**blood glucose:** may be hypo- or hyperglycaemia »**serum electrolytes:** deranged	»**lumbar puncture:** positive culture may reveal bacterial meningitis as infective source »**procalcitonin:** raised Raised procalcitonin levels may be better than traditional laboratory screening tests for detecting serious bacterial infections in febrile infants and young children without obvious sources of infection.[158] [159] [160] »**CT scan of the chest and/or abdomen and pelvis:**

Uncommon

Sepsis

History	Exam	1st Test	Other tests
		»**blood lactate:** raised May be possible to measure lactate using the arterial blood gas sample. »**arterial blood gas:** hypoxaemia and/or hypercarbia; large base deficit »**coagulation studies:** may be abnormal »**LFTs:** may be abnormal »**blood culture:** may be growth of bacteria identifying pathogen »**chest x-ray:** may reveal evidence of pneumonia »**urinalysis:** may be positive for nitrites and leukocytes if urinary tract infection present »**urine culture:** may be positive if urinary tract infection present	may reveal focus of infection CT may play an important role in the evaluation of patients with suspected sepsis. The increased exposure to radiation with this investigation should be considered. CT scan can help to identify a hidden collection (e.g., an intra-peritoneal abscess or effusion) which may not be readily apparent on ultrasound or chest x-ray. CT can also be used to identify free air (perforation). »**abdominal ultrasound scan:** may reveal focus of infection Useful if an abdominal source of infection is suspected, or where the source of infection is not clear after the initial clinical examination and tests. Ultrasound has a reasonable false-negative rate; absence of positive findings on ultrasound does not rule out any given infection source.

Uncommon

Testicular torsion

History	Exam	1st Test	Other tests
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	tender, oedematous testicle; affected testicle may appear higher than unaffected testicle with horizontal lie; associated scrotal erythema and oedema; absent cremasteric reflex; usually no pain relief with elevation of the scrotum; thin skin of the scrotum sometimes allows visualisation of the torsed appendage ('blue dot or black dot sign')	»**Testicular Workup for Ischemia and Suspected Torsion (TWIST) score:** low risk (score 0 to 2), intermediate risk (3 to 4), or high risk (5 to 7) Sensitivity 98.4% in low-risk patients and specificity 97.5% in high-risk patients.[161] »**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 downwards 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 Definitive test for torsion and should be obtained unless the test would unnecessarily delay intervention in a child for whom there is a high index of suspicion. Diagnostic studies should not preclude operative intervention.[94] [95] Duplex Doppler ultrasound includes grey scale, colour	»**urinalysis:** usually normal, but can be abnormal in some cases If abnormal, usually suggests alternate diagnosis (e.g., epididymitis or orchitis). However, it is important to note that the urinalysis may be negative in cases of epididymitis or orchitis and positive in the setting of testicular torsion.

DIAGNOSIS

Uncommon

Testicular torsion

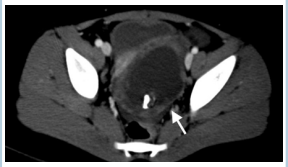
History	Exam	1st Test	Other tests
		Doppler, and spectral Doppler ultrasound. Power Doppler can be used as well as or instead of colour Doppler. Power Doppler is more sensitive for evaluating areas of low blood flow such as the prepubertal testis.[162]	

Ovarian torsion

History	Exam	1st Test	Other tests
acute onset of one-sided lower abdominal or pelvic pain; nausea and vomiting common; history of frequent, similar episodes; fever rare	tender pelvic mass (adnexal); in patients old enough to undergo pelvic examination, cervical motion tenderness may be elicited; typically no vaginal discharge, but may be some mild to moderate vaginal bleeding	»**pelvic ultrasound:** solid appearance of the ovary, unilateral ovarian enlargement, ovarian peripheral cystic structures, marked stromal oedema, fluid in the pouch of Douglas	»**colour Doppler ultrasound:** reduced or absent intraovarian blood flow Suggestive of ovarian torsion. Can help determine whether the flow in the ovary is impaired. Doppler ultrasound is of only variable reliability in the diagnosis of ovarian torsion.[87] [88] »**CT scan abdomen and pelvis:** enlarged, oedematous ovary with or without vascular enhancement; free fluid in pelvis CT scans can demonstrate adnexal masses and ischaemia of the ovary. Typically, ovarian torsion diagnosed by CT scan is a serendipitous finding during an

Uncommon

Ovarian torsion

History	Exam	1st Test	Other tests
			attempt to identify other sources of abdominal pain.  *CT scan of a young girl presenting with ovarian torsion. The large pelvic cystic lesion contains calcifications (white arrow) consistent with a teratoma or dermoid cyst* *From the collection of Dr KuoJen Tsao; used with permission* 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.[133] Sedation or general anaesthesia may be required in some children.

Uncommon

◊ Ruptured ovarian cyst

History	Exam	1st Test	Other tests
rupture usually spontaneous, can follow history of trauma or sexual intercourse; mild chronic lower abdominal discomfort may suddenly intensify; may occur in conjunction with torsion	adnexal tenderness; adnexal size unremarkable due to collapsed cyst; peritonism may be present in lower abdomen and pelvis	»**pelvic ultrasound:** complex mass appearance; fluid in the pouch of Douglas A complex mass appearance suggests a ruptured haemorrhagic cyst surrounded by a haematoma. Fluid in the pouch of Douglas is also indicative of a ruptured cyst.	

◊ Pelvic inflammatory disease (PID)

History	Exam	1st Test	Other tests
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	temperature >38.3°C (101°F); cervical motion tenderness, adnexal or uterine tenderness, vaginal or cervical mucopurulent discharge	»**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 organism Supports a diagnosis of PID. Specimens obtained from vaginal	»**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 work-up for PID, including HIV infection.

Uncommon

◊ Pelvic inflammatory disease (PID)

History	Exam	1st Test	Other tests
		examination can be sent for testing. Urine tests should not be the initial test ordered but may be necessary if a pelvic examination is not feasible (e.g., due to age of child).	»**hepatitis studies:** positive or negative Testing for hepatitis B and C may be considered during work-up for PID. »**rapid plasma reagin (RPR):** positive or negative It is important to test for other sexually transmitted diseases during a work-up for PID, including syphilis. »**FBC:** leukocytosis Result is not specific but may increase index of suspicion for PID. »**C-reactive protein or erythrocyte sedimentation rate:** raised Non-specific test for inflammatory process. »**laparoscopy:** normal or may demonstrate endometritis, hydrosalpinx, pyosalpinx, tubo-ovarian abscess Laparoscopy is the preferred invasive method of diagnosis allowing direct visualisation of the gynaecological and abdominal structures. In addition, it may aid the diagnosis of Fitz-Hugh-Curtis syndrome.

Uncommon

Pregnancy complications

History	Exam	1st Test	Other tests
history of previous ectopic pregnancy or miscarriage, fallopian tube or pelvic surgery, pelvic inflammatory disease; lower abdominal pain, amenorrhoea, and vaginal bleeding	minimal abdominal tenderness and/or vaginal bleeding; pelvic examination may reveal a mass, eliciting cervical motion tenderness if haemoperitoneum is present; tubal rupture can cause haemodynamic instability	»**urine pregnancy test:** positive Confirms pregnancy; although false-negative tests, depending on kit used, are known. »**quantitative serum beta-hCG:** positive A normal intrauterine pregnancy is typically visualised at serum human chorionic gonadotrophin (beta-hCG) levels between 1500 and 2500 IU/L (1500 and 2500 mIU/mL). If not, the likely differential diagnosis is ectopic pregnancy or miscarriage. Serial beta-hCG measurement is usually used when the ultrasound is inconclusive and the initial beta-hCG is below the discriminatory zone (1500-2000 IU/L [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 <66% is suggestive of an ectopic pregnancy. A rapid and steady	»**blood type and screen:** variable Necessary to assess the rhesus status of the mother if not yet known. If Rh-negative, should receive anti-D immunoglobulin to prevent rhesus isoimmunisation, which may affect subsequent pregnancy outcomes.

Uncommon

Pregnancy complications

History	Exam	1st Test	Other tests
		decline is indicative of a miscarriage. A single serum measurement cannot exclude ectopic pregnancy or predict the risk of rupture unless it is <5 IU/L (<5 mIU/mL). »**pelvic ultrasound:** demonstrates free fluid in the pelvis and/or a periovarian mass With trained personnel, bedside pelvic ultrasound is a fast, reliable method to assess for ectopic pregnancy. Transvaginal ultrasound may be used to assess for intrauterine pregnancy. An ectopic pregnancy may be characterised by an echogenic, cyst-like structure outside the uterus. Several ultrasound findings may be associated with early ectopic pregnancy such as tubal ring, extrauterine mass, extrauterine empty gestational sac, and haemosalpinx. In an unstable patient, it is important not to delay treatment while waiting	

Uncommon

Pregnancy complications

History	Exam	1st Test	Other tests
		for an ultrasound. A quick and focused bedside ultrasound examination to assess for the presence of free fluid or blood may be helpful when ruptured ectopic pregnancy is suspected. »**transvaginal ultrasound:** presence or absence of intrauterine pregnancy Differentiates between different stages and types of miscarriage. Specific, fairly prognostic and would exclude other differential diagnoses of miscarriage. 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.	

Empyema

History	Exam	1st Test	Other tests
recent pneumonia, fever, cough, chest pain; malaise, anorexia, weight loss, or fatigue may occur; presence of risk factors	febrile, toxic patient, dullness on percussion, absence of breath sounds over affected area; abdominal tenderness and	»**FBC:** raised WBC count »**chest x-ray:** blunting of costophrenic angle or effusion on	»**blood culture:** positive for specific pathogens Blood cultures may be positive even if the

Uncommon

Empyema

History	Exam	1st Test	Other tests
(immunocompromise, comorbidities predisposing to the development of pneumonia, pre-existing lung disease, iatrogenic interventions in the pleural space, male sex)	distension without guarding or rebound	affected side, possible consolidation, pleurally based 'D' shape in empyema The presence of a loculated effusion suggests an empyema. There may be associated pulmonary consolidation due to pneumonia. »**thoracentesis:** frank pus in empyema, serous or cloudy in complicated parapneumonic effusions Aspiration of frank pus is diagnostic of empyema, and no other investigations are required to establish the diagnosis.	pleural fluid culture is negative. Should be taken before the initiation of antibiotics if the clinical state of the patient permits. »**chest ultrasound:** localised 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.

Guidelines

Europe

Rome IV: functional gastrointestinal disorders - disorders of gut-brain interaction. 4th ed. (https://theromefoundation.org/rome-iv)

Published by: Rome Foundation
Last published: 2016

International

Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines (https://www.wses.org.uk/guidelines)

Published by: World Society of Emergency Surgery
Last published: 2020

The management of intra-abdominal infections from a global perspective (https://www.wses.org.uk/guidelines)

Published by: World Society of Emergency Surgery
Last published: 2017

North America

SAGES guideline for the diagnosis and treatment of appendicitis (https://www.sages.org/publications/guidelines)

Published by: Society of American Gastrointestinal and Endoscopic Surgeons
Last published: 2024

Clinical policy: critical issues in the evaluation and management of emergency department patients with suspected appendicitis (https://www.acep.org/patient-care/clinical-policies)

Published by: American College of Emergency Physicians
Last published: 2023

ACR appropriateness criteria: acute nonlocalized abdominal pain (https://www.acr.org/Clinical-Resources/ACR-Appropriateness-Criteria)

Published by: American College of Radiology
Last published: 2018

North America

ACR appropriateness criteria: suspected appendicitis - child (https://www.acr.org/Clinical-Resources/ACR-Appropriateness-Criteria)

Published by: American College of Radiology
Last published: 2018

ACR appropriateness criteria: fever without source or unknown origin - child (https://www.acr.org/Clinical-Resources/ACR-Appropriateness-Criteria)

Published by: American College of Radiology
Last published: 2015

Evidence tables

What are the effects of early versus late initiation of empiric antimicrobial treatment in children with or at risk of developing sepsis or severe sepsis?

This table is a summary of the analysis reported in a guideline (underpinned by a systematic review) that focuses on the above important clinical question.

View the full source guideline (https://www.nice.org.uk/guidance/ng51/evidence)

Evidence C *	Confidence in the evidence is very low or low where GRADE has been performed and the intervention may be more effective/beneficial than the comparison for key outcomes. However, this is uncertain and new evidence could change this in the future.

Population: Children with or at risk of developing sepsis or severe sepsis
Intervention: Early initiation of empiric antimicrobial treatment
Comparison: Late initiation of empiric antimicrobial treatment

Outcome	Effectiveness (BMJ rating)†	Confidence in evidence (GRADE)‡
<1 hour versus >1 hour [a]		
Paediatric Intensive Care Unit (PICU) mortality	No statistically significant difference	Very Low
<2 hours versus >2 hours [a]		
PICU mortality	No statistically significant difference	Very Low
<3 hours versus >3 hours [a]		
PICU mortality	Favours intervention	Very Low
<4 hours versus >4 hours [a]		
PICU mortality	Favours intervention	Very Low

Recommendations as stated in the source guideline
For children aged 5–11 years who have suspected sepsis and one or more high-risk criteria, give a broad-spectrum antimicrobial [b] at the maximum recommended dose without delay (within one hour of identifying that they meet any high-risk criteria in an acute hospital setting).

Note
The guideline group noted that the direct evidence in children came from one small (n=130), single-centre retrospective study of children in PICU with severe sepsis and septic shock. Therefore, they also

extrapolated from the indirect evidence in adults to make the same recommendation for all age groups (including children aged under 5 years and 5-11 years).

[a] Time from sepsis recognition to initial treatment and first appropriate treatment.

[b] See full guideline for more information.

* Evidence levels

The Evidence level is an internal rating applied by BMJ Best Practice. See the EBM Toolkit (https://bestpractice.bmj.com/info/evidence-tables/) for details.

Confidence in evidence

A - High or moderate to high

B - Moderate or low to moderate

C - Very low or low

† Effectiveness (BMJ rating)

Based on statistical significance, which demonstrates that the results are unlikely to be due to chance, but which does not necessarily translate to a clinical significance.

‡ Grade certainty ratings

High	The authors are very confident that the true effect is similar to the estimated effect.
Moderate	The authors are moderately confident that the true effect is likely to be close to the estimated effect.
Low	The authors have limited confidence in the effect estimate and the true effect may be substantially different.
Very Low	The authors have very little confidence in the effect estimate and the true effect is likely to be substantially different.

BMJ Best Practice EBM Toolkit: What is GRADE? (https://bestpractice.bmj.com/info/toolkit/learn-ebm/what-is-grade/)

Key articles

- Di Lorenzo C, Colletti RB, Lehmann HP, et al; AAP Subcommittee, NASPGHAN Committee on Chronic Abdominal Pain. Chronic abdominal pain in children: a technical report of the American Academy of Pediatrics and the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition. J Pediatr Gastroenterol Nutr. 2005 Mar;40(3):249-61. Full text (https://journals.lww.com/jpgn/Fulltext/2005/03000/Chronic_Abdominal_Pain_In_Children__A_Technical.2.aspx) Abstract

- Di Lorenzo C, Colletti RB, Lehmann HP, et al; American Academy of Pediatrics Subcommittee on Chronic Abdominal Pain; NASPGHAN Committee on Abdominal Pain. Chronic abdominal pain in children: a clinical report of the American Academy of Pediatrics and the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition. J Pediatr Gastroenterol Nutr. 2005 Mar;40(3):245-8. Full text (https://journals.lww.com/jpgn/Fulltext/2005/03000/Chronic_Abdominal_Pain_in_Children__A_Clinical.1.aspx) Abstract

- Tabbers MM, DiLorenzo C, Berger MY, et al; European Society for Pediatric Gastroenterology, Hepatology, and Nutrition; North American Society for Pediatric Gastroenterology. Evaluation and treatment of functional constipation in infants and children: evidence-based recommendations from ESPGHAN and NASPGHAN. J Pediatr Gastroenterol Nutr. 2014 Feb;58(2):258-74. Full text (https://journals.lww.com/jpgn/Fulltext/2014/02000/Evaluation_and_Treatment_of_Functional.24.aspx) Abstract

- Diercks DB, Adkins EJ, Harrison N, et al. American College of Emergency Physicians. Clinical policy: critical issues in the evaluation and management of emergency department patients with suspected appendicitis. Approved by ACEP Board of Directors February 1, 2023. Ann Emerg Med. 2023 Jun;81(6):e115-52. Full text (https://www.annemergmed.com/article/S0196-0644(23)00029-X/fulltext) Abstract

- Dahabreh IJ, Adam GP, Halladay CW, et al. Diagnosis of right lower quadrant pain and suspected acute appendicitis. Dec 2015 [internet publication]. Full text (https://www.ncbi.nlm.nih.gov/books/NBK355441) Abstract

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Images

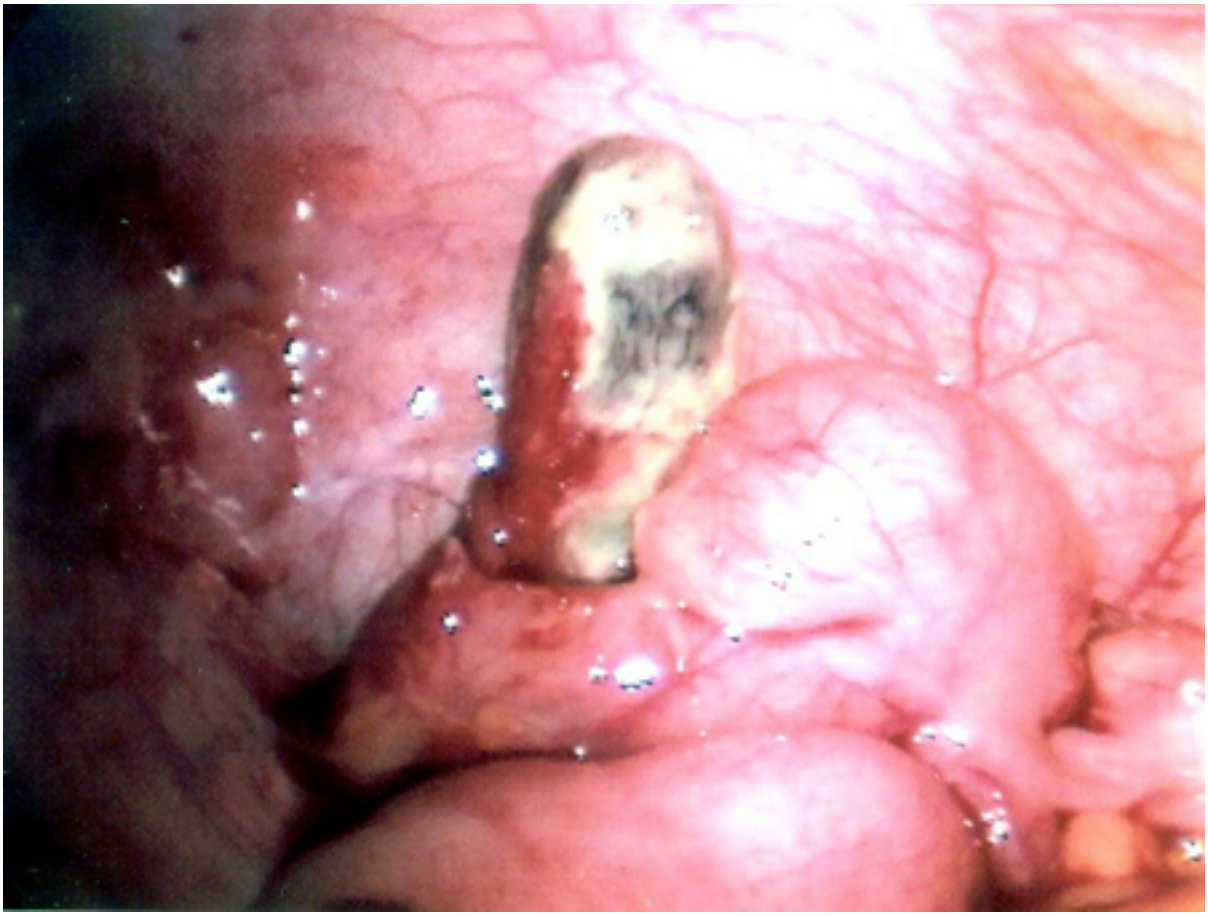

Figure 1: Necrotic appendix

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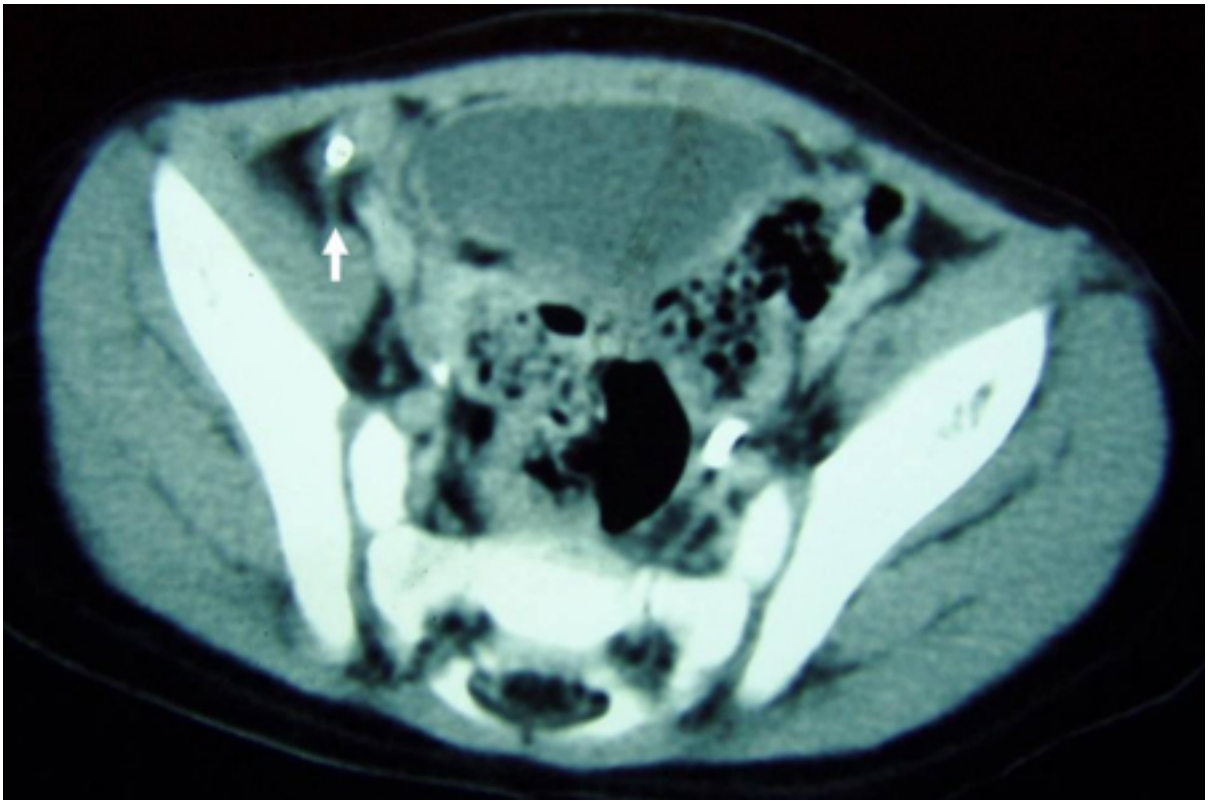

Figure 2: CT scan demonstrating faecalith (white arrow) outside the lumen of the appendix consistent with perforated appendix

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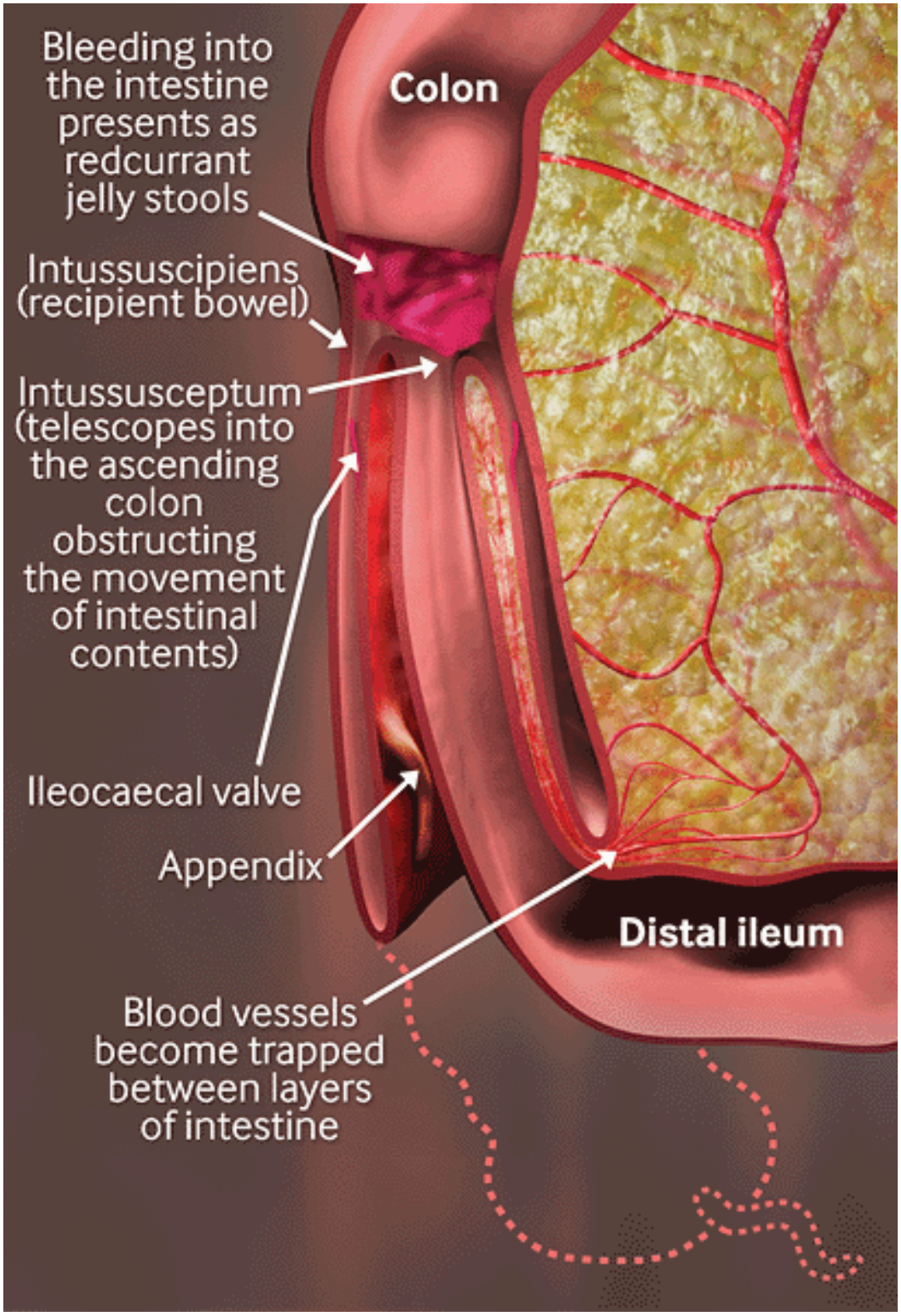

Figure 3: Intussusception: blood vessels become trapped between layers of intestine, leading to reduced blood supply, oedema, strangulation of bowel, and gangrene. Sepsis, shock, and death may eventually occur

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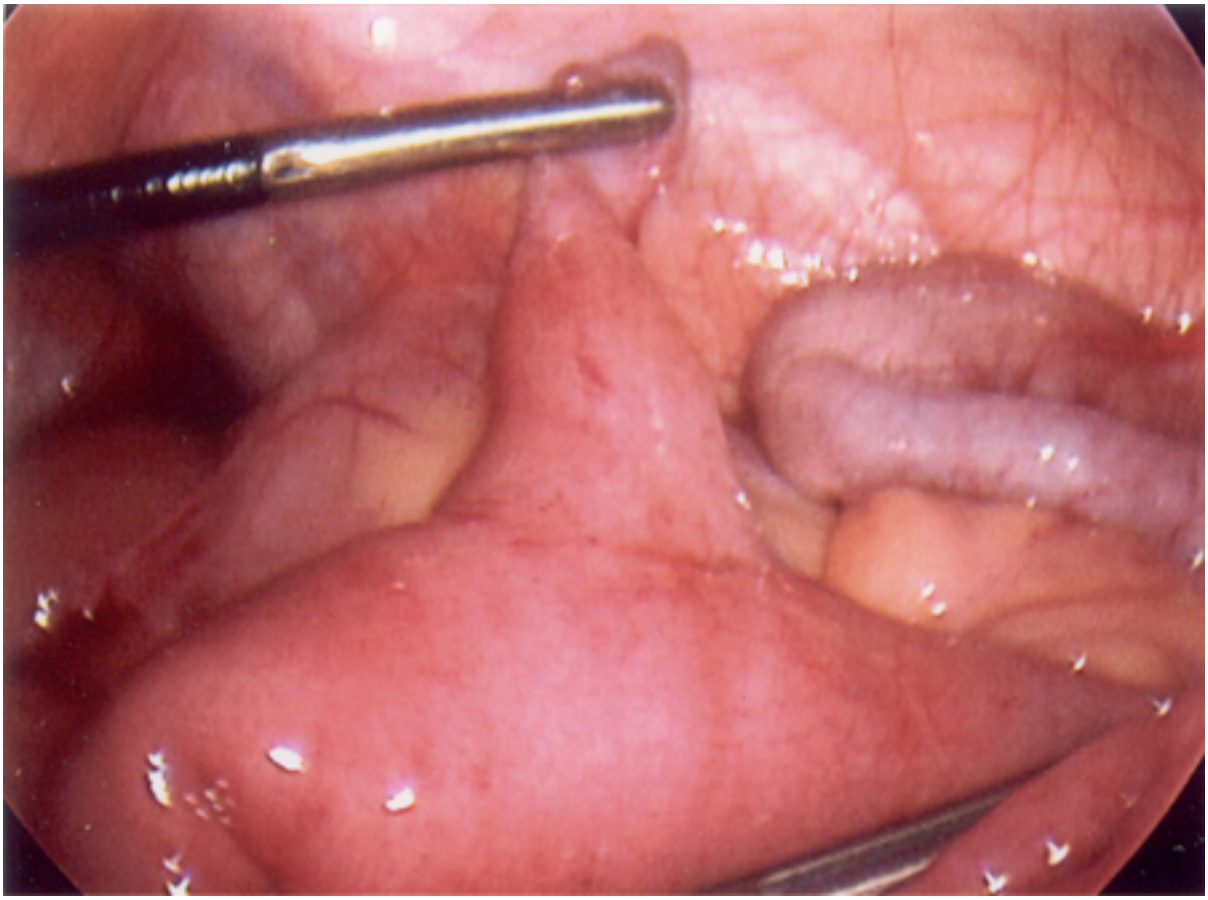

Figure 4: Intraoperative photo of Meckel's diverticulum

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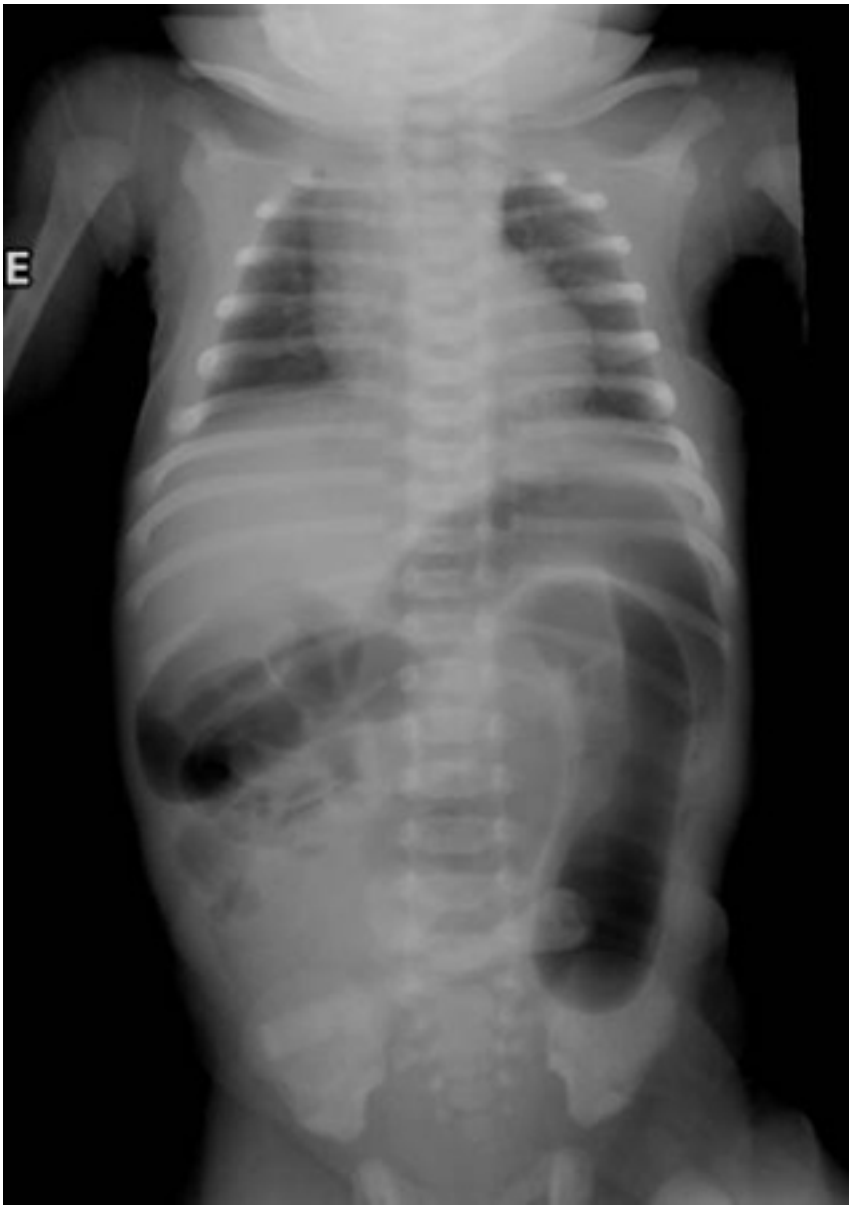

Figure 5: Abdominal x-ray of a neonate with abnormal stooling pattern and constipation. The dilated transverse and descending colon is suggestive of Hirschsprung's disease

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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 oedema and erythema does not rule out strangulation of the small intestine

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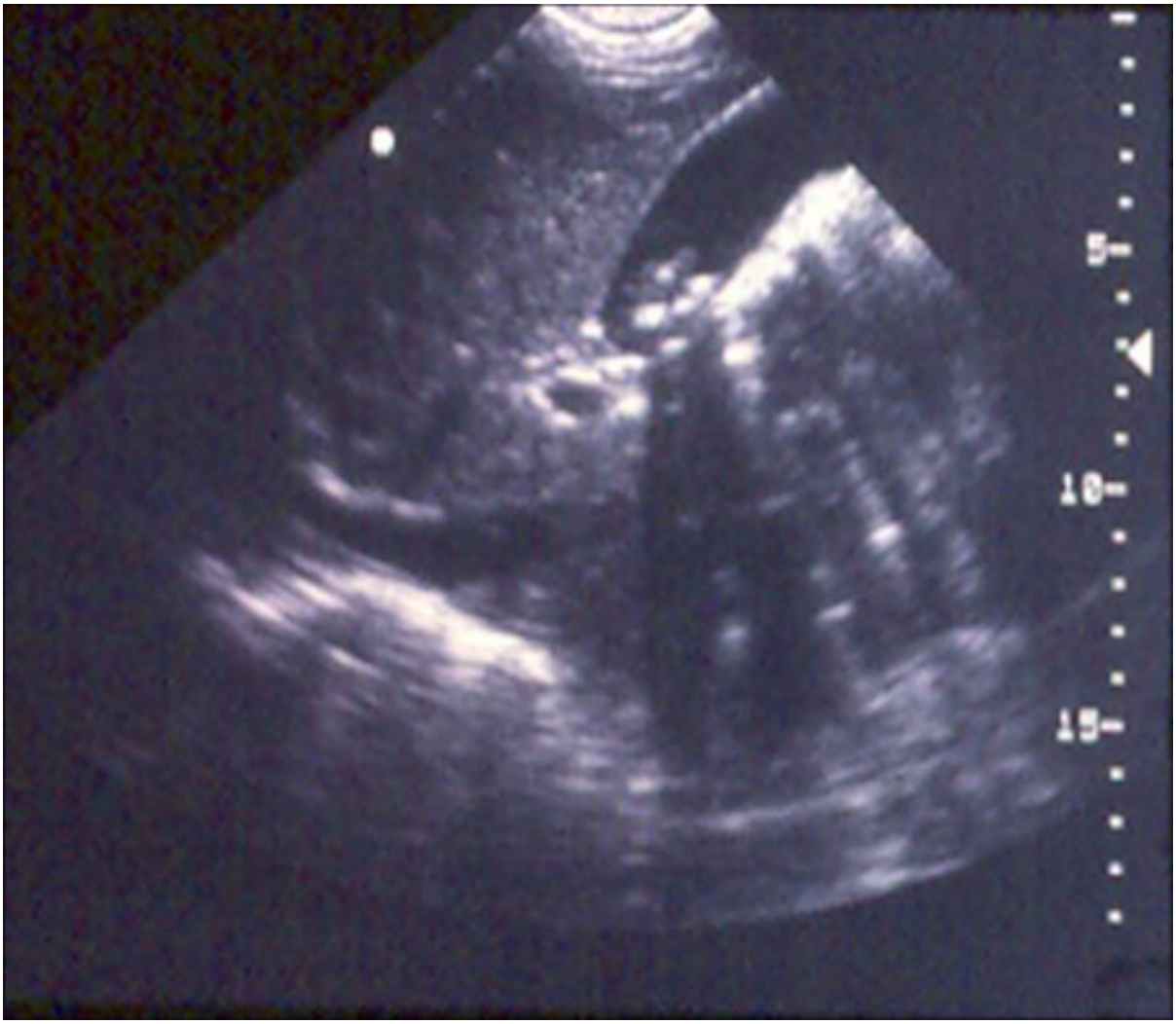

Figure 8: Gallbladder ultrasound demonstrating cholelithiasis with characteristic shadowing

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

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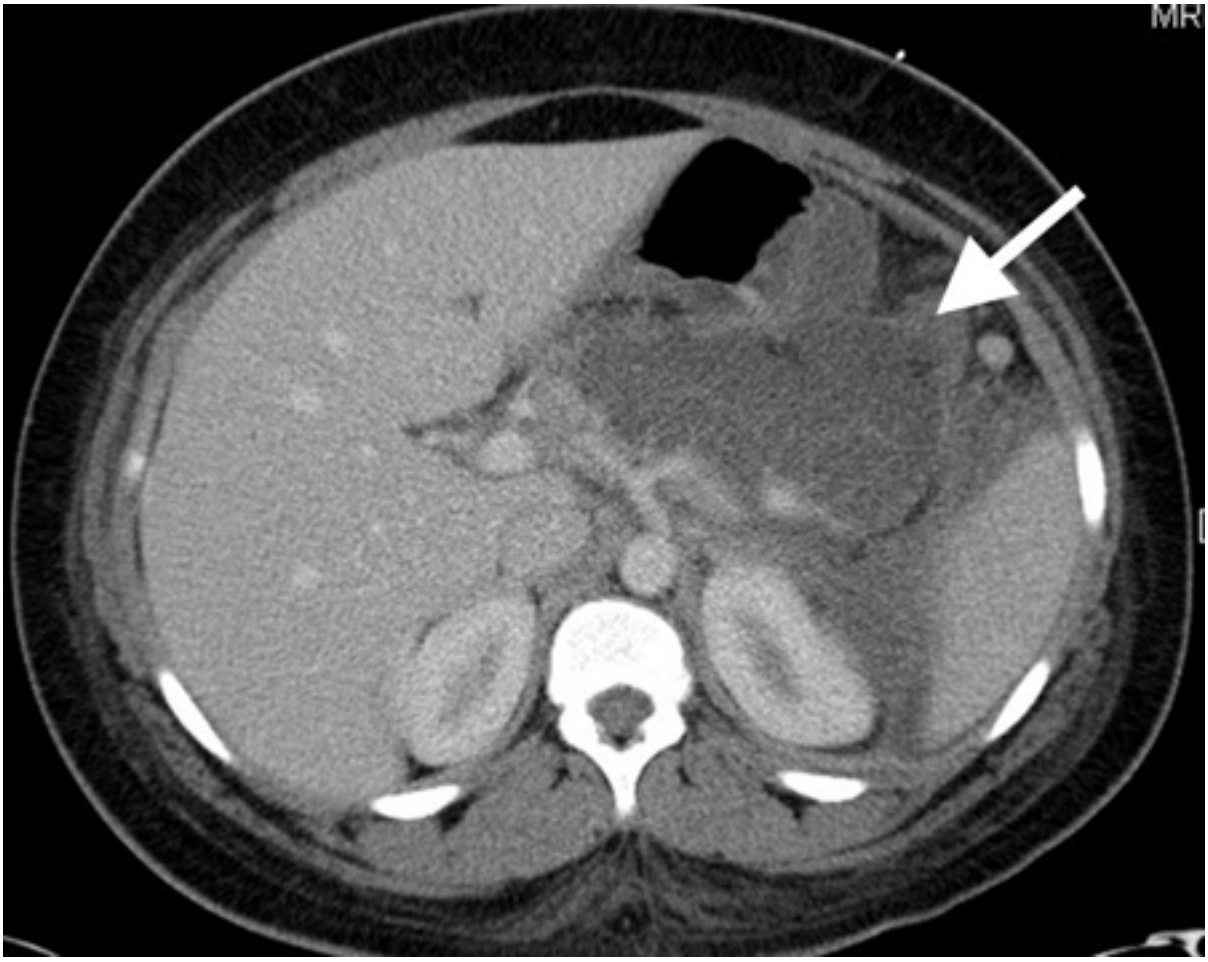

Figure 10: CT scan of teenage girl presenting with mid-epigastric abdominal pain as a result of gallstone pancreatitis. The large fluid collection in the pancreatic bed (white arrow) and lack of pancreatic enhancement suggest liquefactive necrosis of the pancreas

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Figure 11: CT scan demonstrating fluid-filled cyst within the spleen

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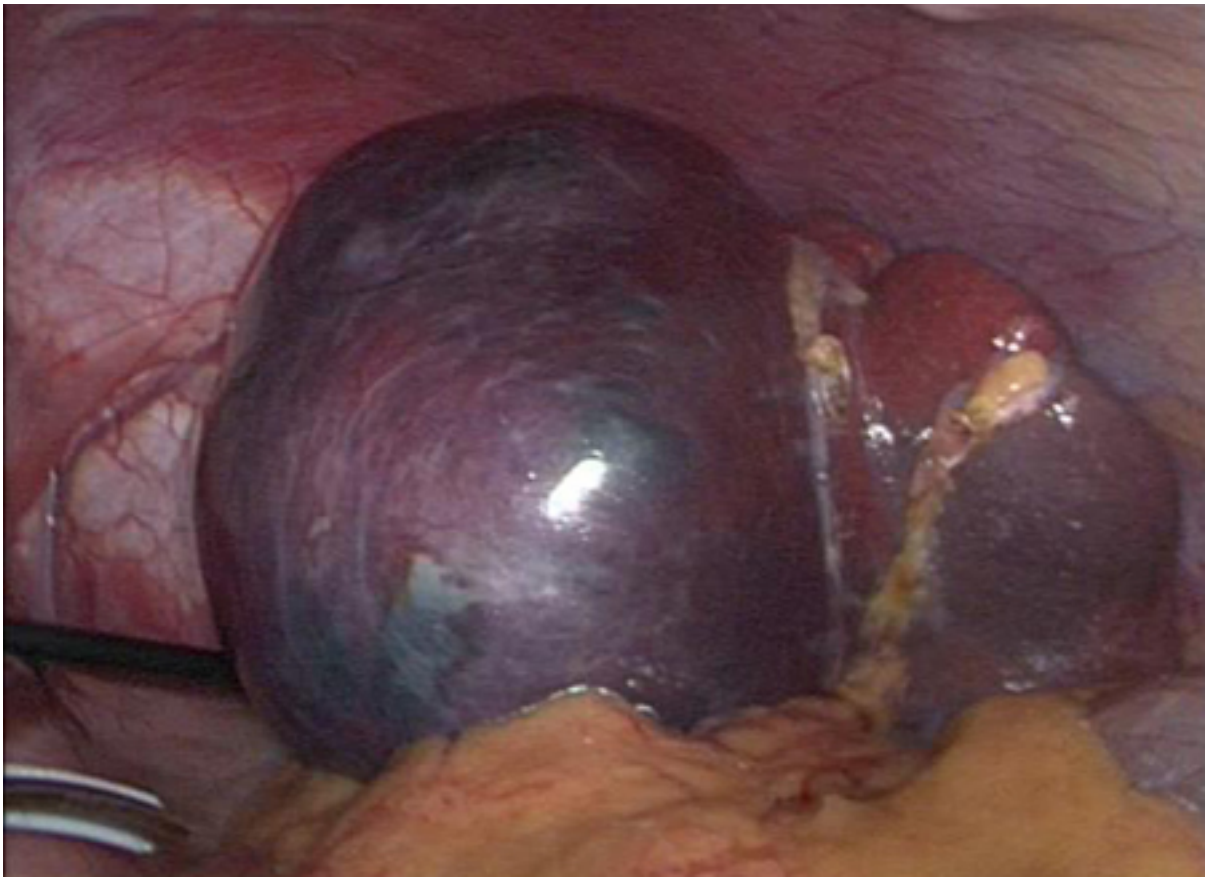

Figure 12: Intraoperative photo of large splenic cyst

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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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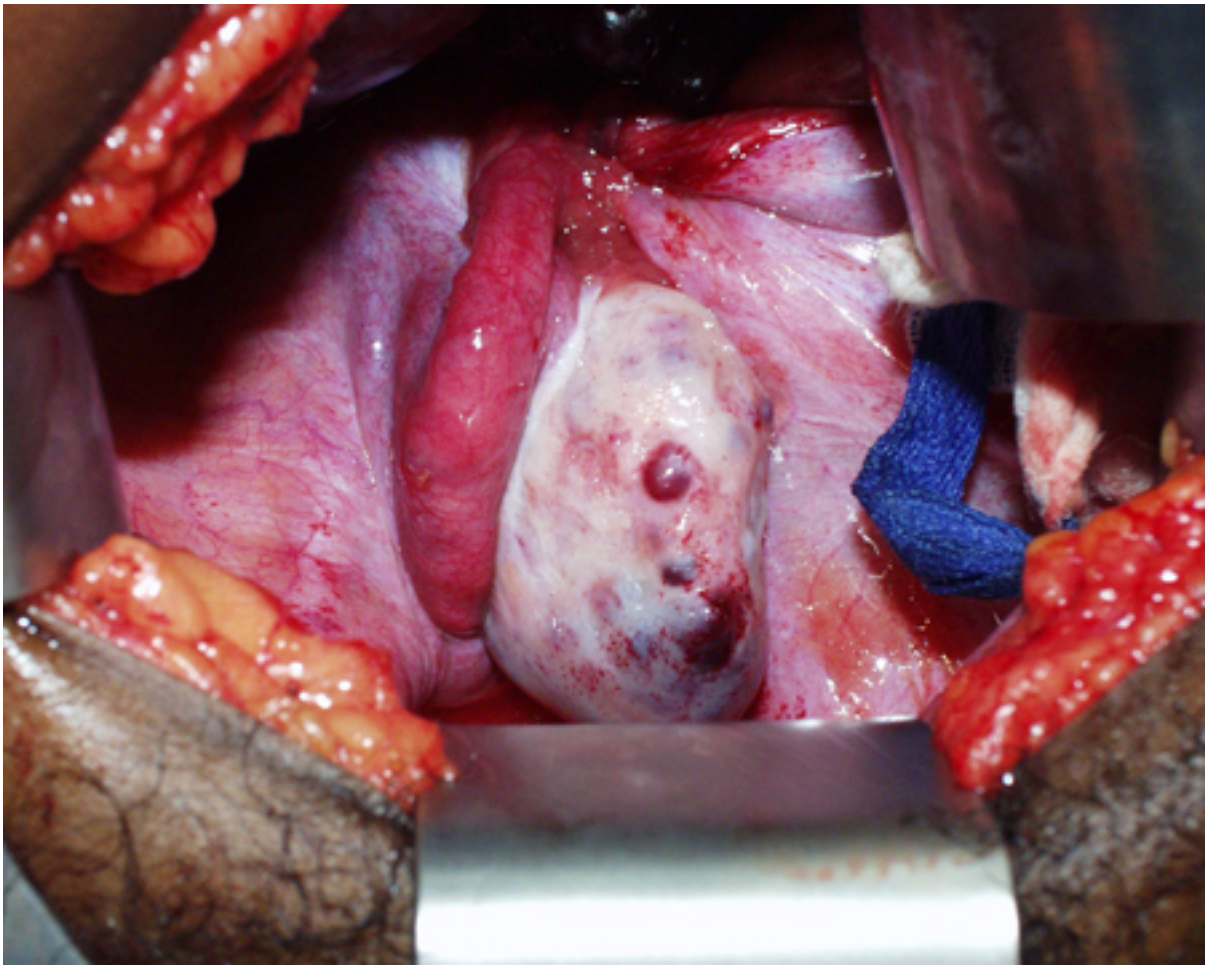

Figure 16: Intraoperative photo of ovarian mass that presented as ovarian torsion

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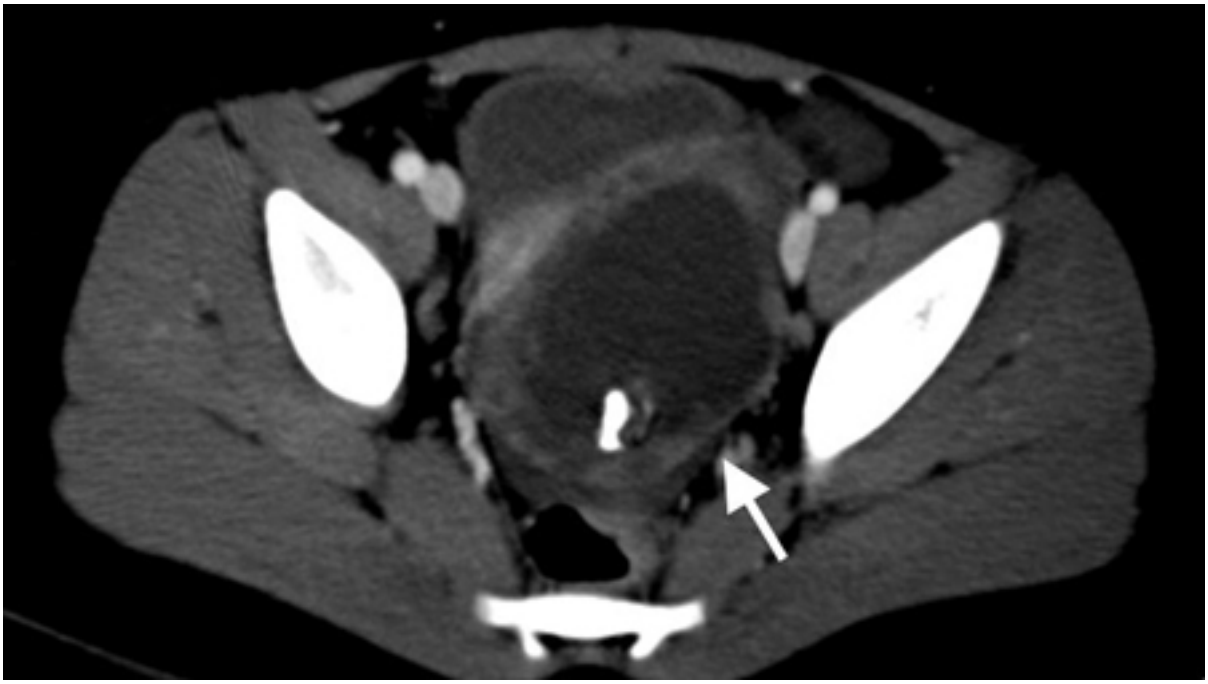

Figure 17: CT scan of a young girl presenting with ovarian torsion. The large pelvic cystic lesion contains calcifications (white arrow) consistent with a teratoma or dermoid cyst

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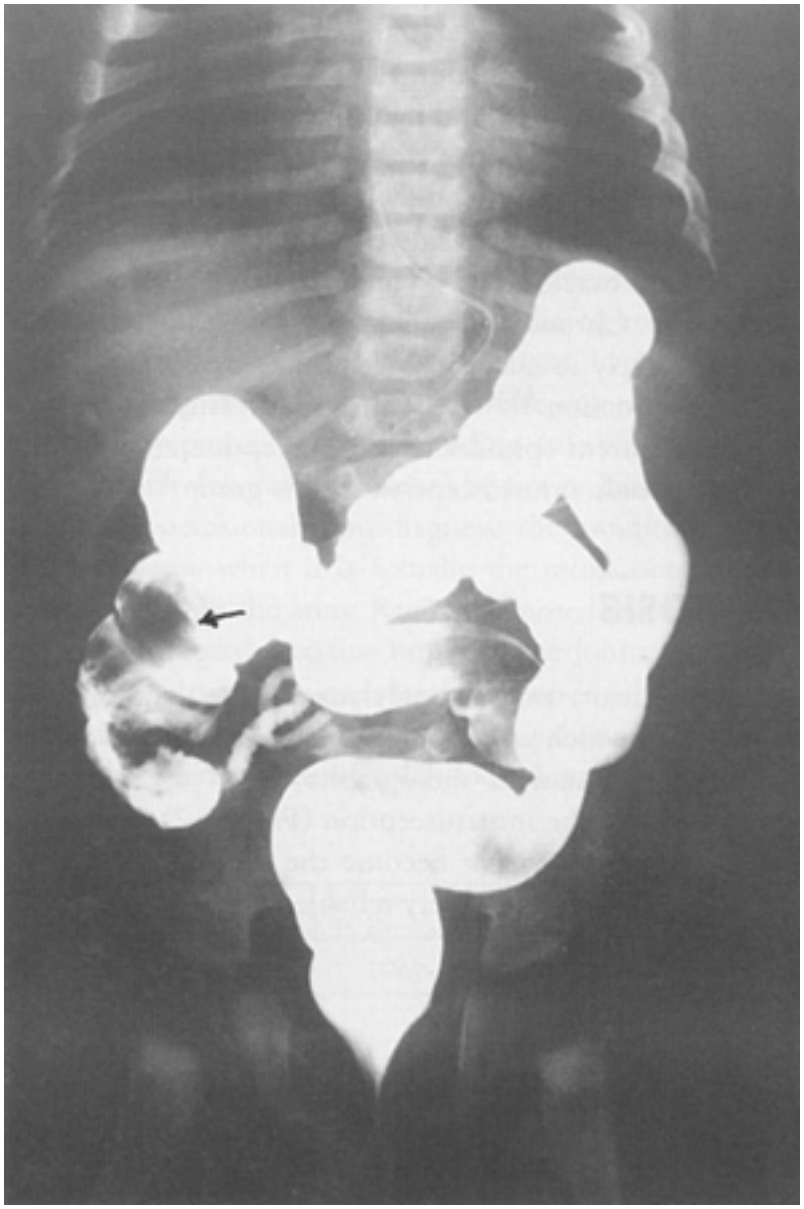

Figure 18: Contrast enema demonstrating ileocolic intussusception (black arrow)

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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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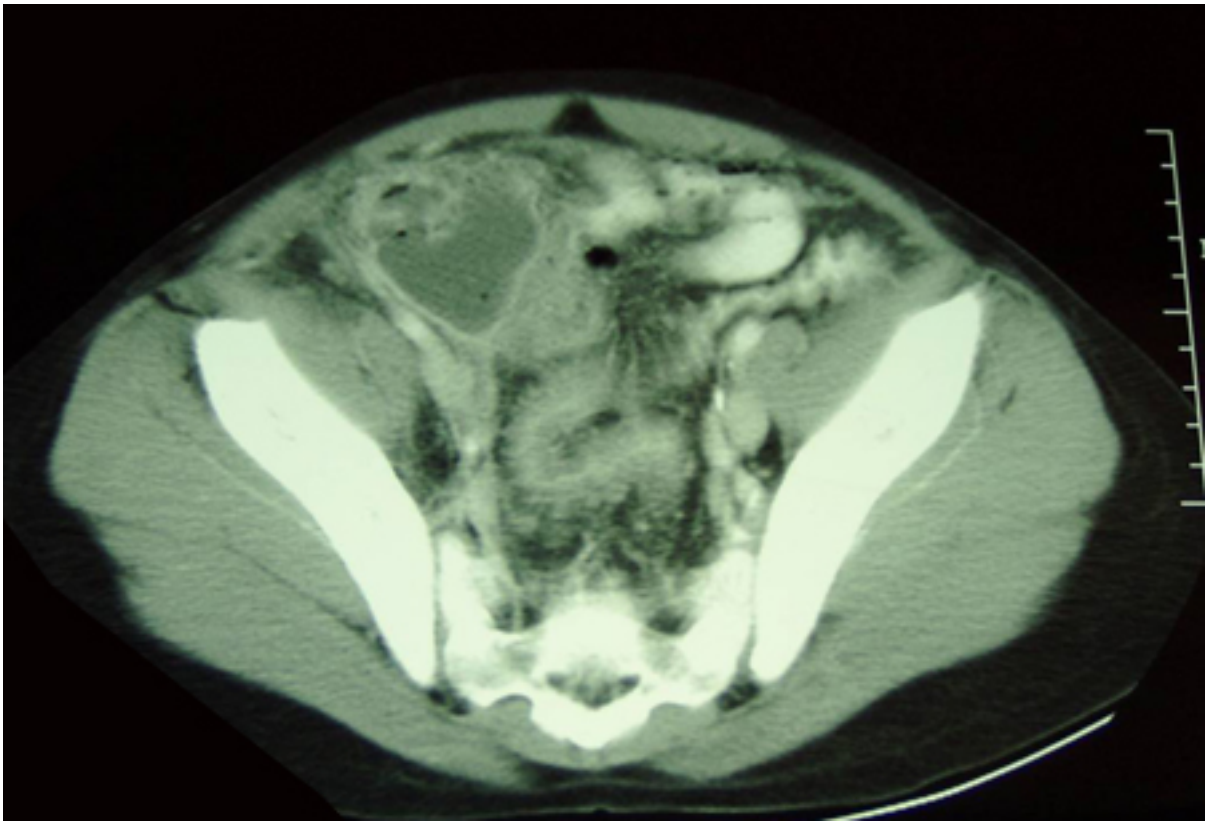

Figure 20: CT scan demonstrating intra-abdominal abscess consistent with perforated appendix

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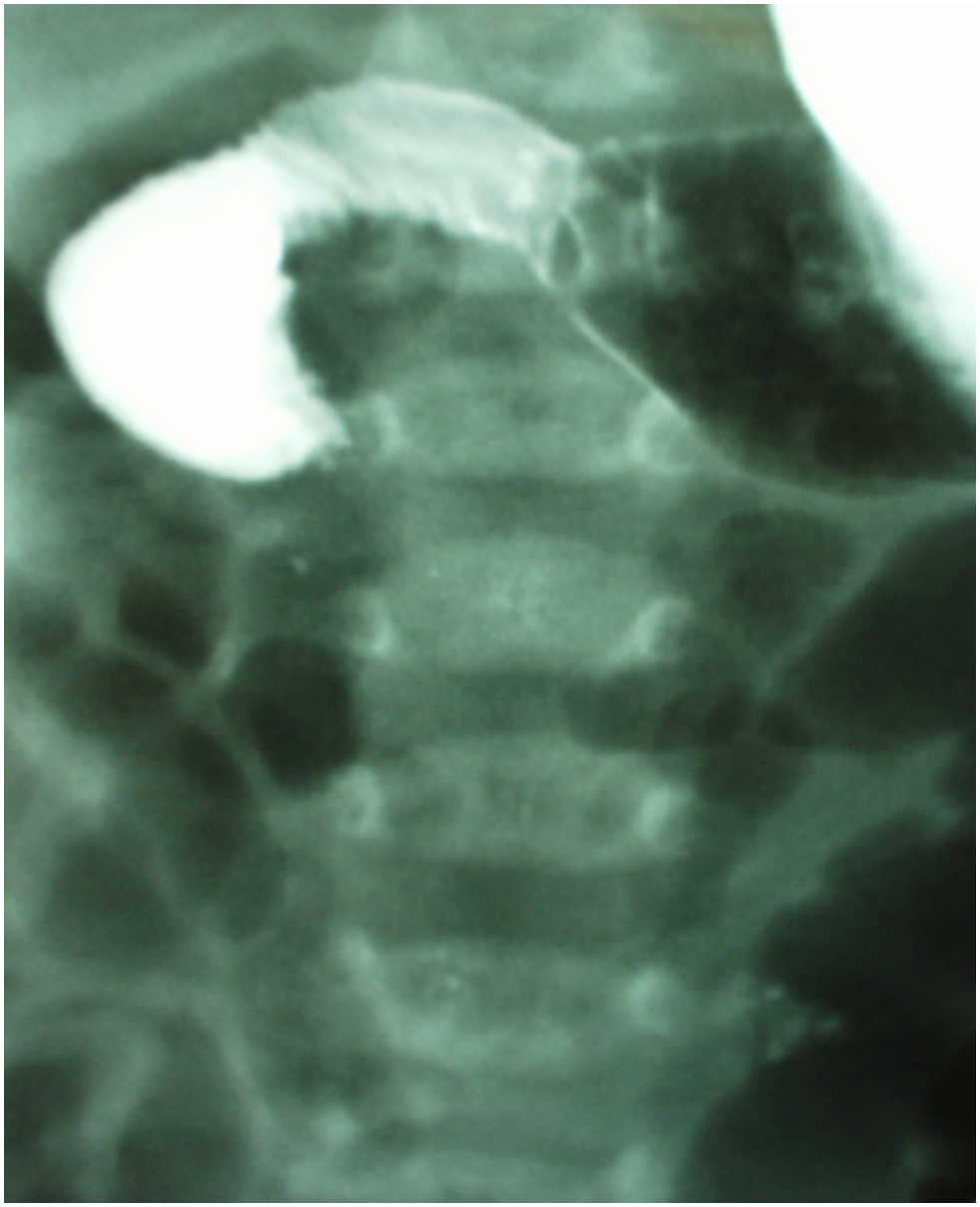

Figure 21: Upper GI contrast study demonstrating malrotation with volvulus. The duodenum fails to develop the normal anatomical C-loop. There is failure of contrast to pass, resulting in a characteristic bird beak consistent with acute mid-gut volvulus

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This approach is in line with the guidance of the International Bureau of Weights and Measures Service.

Figure 1 – BMJ Best Practice Numeral Style

5-digit numerals: 10,000

4-digit numerals: 1000

numerals < 1: 0.25

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