Appendicitis

A DECLASSIFIED GUIDE TO IMAGING

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Describe the normal anatomy and imaging appearance of the appendix.

Discuss the clinical presentation of appendicitis and the role of diagnostic imaging in establishing a diagnosis.

Recognize the key imaging features of acute appendicitis and its complications across US, CT and MRI.
What is Acute Appendicitis?

The **vermiform appendix** is a hollow cul de sac pouch located at the base of the cecum, 2cm below the ileocecal valve. It is typically 9 cm long and has a base, a body and a tip.

While the location of the base of the appendix is constant (posteromedial end of the cecum), the location of its tip can vary across individuals!

**Acute Appendicitis** is the inflammation of the vermiform appendix. It is caused by the mechanical obstruction of the appendiceal lumen, most commonly due to the presence of fecalith or lymphoid hyperplasia.

Acute Appendicitis is the most common time sensitive surgical condition. It is most common in individuals between the ages of 10 and 19 but can develop at any age!
Clinical Presentation

The classic clinical presentation of appendicitis is characterized by the following:

**Symptoms:**
- Migratory RLQ pain
- Anorexia
- Mild fever
- Nausea & vomiting

**Physical Exam Findings:**
- Tenderness at McBurney's point
- Rovsing’s sign
- Psoas sign (retrocecal appendix)
- Obturator sign (pelvic appendix)

**Laboratory Parameters:**
- Neutrophil-predominant leukocytosis
- Elevated CRP

**However, up to 40% of patients present with atypical symptoms!**

This is attributable to anatomical variations, concomitant comorbidities (diabetes, immunocompromised states), as well as the development of complications.
Role of Imaging in Diagnosing Appendicitis

In diagnosing appendicitis, physicians often rely on clinical risk assessment scores like the Alvarado score. These scores help physicians gauge the likelihood of appendicitis based on the presentation of patients. However, said scoring systems are associated with up to a 25% false appendectomy rate. The use of imaging as an adjunct to these clinical scores improves diagnostic accuracy and minimizes the risk of unnecessary surgeries.

Imaging is a mainstay in the diagnostic workup of patients with suspected appendicitis, especially in patients that present with atypical symptoms.

Imaging is essential in excluding the differential diagnoses of appendicitis, some of which require urgent surgical management and may have grave consequences if overlooked.

Imaging can help with the timely detection of complications, thereby improving patient care and clinical outcomes.
The role of abdominal radiographs in diagnosing appendicitis is very limited. X-ray signs associated with appendicitis are neither sensitive nor specific. However, X-rays are traditionally used in the evaluation of acute abdomen and may reveal signs that increase suspicion for appendicitis, thereby guiding clinicians towards more sensitive and specific diagnostic modalities.

Localized paralytic ileus and dilated bowel loops are sometimes seen and indicate the presence of local inflammation. Calcified appendicoliths may be seen on X-ray and when present increase the likelihood of appendicitis in the appropriate clinical setting. Pneumoperitoneum, visualized as subphrenic air on X-ray, is a definitive sign of perforation and may be seen in perforated appendicitis. An appendiceal abscess may appear as a soft tissue mass distorting cecal air and displacing adjacent bowel loops.

X rays are not very informative in non-perforated appendicitis. Their relevance is more prominent in the setting of perforation.
Graded compression US is the first line imaging modality in the diagnosis of acute appendicitis. This is due to its’ cost effectiveness, non invasiveness, and widespread availability. It is the preferred modality for young patients and women due to lack of ionizing radiation. It’s generally reliable in identifying abnormal appendices but is less consistent in identifying normal ones. It is highly operator dependent and is limited by body habitus.

The normal appendix is a non peristaltic, compressible, blind ended structure with a diameter <6mm and a wall <3mm in thickness.

Its lumen is either empty or filled with gas or fecal material.

The wall of a normal non inflamed appendix is made up of 5 concentric layers of alternating echogenecity (this is commonly known as the gut signature sign).

Image: Case courtesy of Bruno Di Muzio, rid: 60308
Ultrasound

Appendiceal Changes

- Dilated appendix (outer diameter > 6 mm)
- Thickened appendiceal wall (wall thickness > 3mm)
- Non-compressibility using graded compression US
- Hyperechoic surrounding inflamed fat

The sonographic appearance of appendicitis may be misleading and may yield false negatives in retrocecal appendicitis, early stages of disease, as well as in the late complicated stages!

Certain disease states give rise to US signs that mimic those of appendicitis, potentially yielding false positives. Examples include Crohn’s and Meckel’s diverticulum!

BEWARE a compressible appendix is not always a good sign, it may indicate perforation!

Make sure you visualize the entire appendix before excluding appendicitis, inflammation may be focal!
Appendicitis may be associated with the presence of a calcified appendicolith in the appendiceal lumen. This presents as an echogenic structure with posterior acoustic shadowing. Appendicoliths are associated with an increased risk of perforation and a worse overall prognosis.

Normally, Doppler US of the bowel wall shows minimal color flow. An increased color flow signal within the appendiceal wall is indicative of hyperemia and therefore inflammation.

BEWARE a lack of hyperemia may indicate perforation.
Target sign is best visualized on transverse US imaging and is considered one of the earliest sonographic manifestations of appendicitis. It is essentially a distortion of the normal gut signature.

**Target sign:**
- **Hypoechoic** fluid filled lumen
- **Hyperechoic** mucosal/submucosal ring
- **Hypoechoic** muscularis

**Clinical pearl:** Although the target sign is suggestive of appendicitis, it can also be present in other conditions such as intussusception and biliary diseases.
Clinical pearl: Some studies suggest that the visualization of periappendiceal changes is sufficient to make a diagnosis of appendicitis. A small amount of free fluid in young female patients is a normal finding. Moderate to large amounts, however, are considered pathologic and warrant further evaluation!
Ultrasounds are limited in their ability to differentiate between perforated and non-perforated appendicitis. However, certain findings, such as periappendiceal fluid collection and discontinuity of the appendiceal wall may indicate perforation.

**Circumscribed periappendiceal fluid collection (abscess)**

**Discontinuous appendiceal wall**

Case courtesy of Maulik S Patel, rID: 55439

Case courtesy of Maulik S Patel, rID: 16365
Computed Tomography is a highly sensitive & specific imaging modality in the workup of acute appendicitis. It is also the preferred modality in adults due to its low non-visualization rates as well as its usefulness in excluding alternative diagnoses. CT scans provide a detailed evaluation of appendiceal diameter and wall thickness and are highly accurate. Some studies even suggest that the majority of cases of uncomplicated appendicitis can be diagnosed without contrast. However, CT scans are limited by the use of ionizing radiation, which places patients, especially children and women, at risk.

Normal CT anatomy

On CT, the normal appendix exhibits a diameter <6mm with a length ranging from 2 to 20 cm. Its lumen may contain air, fluid or contrast. Normally, the periappendiceal fat appears hypodense and homogenous.

Case courtesy of Ammar Haouimi, rID: 92174
Dilated fluid-filled appendix (diameter >6mm)

The 6 millimeter myth: 42% of the general population have an appendiceal diameter larger than 6 mm, the 6mm criterion is therefore not a reliable standalone diagnostic indicator.

Tip: Utilizing the bone window setting can enhance your ability to visualize calcified appendicoliths.

Case courtesy of David Cuete, rID: 27049

Thickened & enhancing appendiceal wall

Appendicolith

Note the 2 calcified appendicoliths within the lumen of the inflamed appendix.
Computed Tomography

Periappendiceal Changes

Inflammatory appendicular mass/phlegmon

Mesenteric fat stranding and lymphadenopathy

Reactive small bowel wall thickening and edema

Case courtesy of Eid Kakish, rID: 85648
**Arrowhead sign** arises due to the focal thickening of the cecal wall at the appendiceal orifice. It’s caused by the funneling of enteral contrast into the narrowed cecal lumen with the tip of the ‘arrow’ pointing towards the base of the appendix.

**Cecal bar sign** denotes inflammation of soft tissue at the appendiceal base. This creates a division between the appendix & the cecum.

The arrowhead and cecal bar signs can only be visualized when enteral contrast is used. These signs are very specific but poorly sensitive and their absence should not be used to exclude appendicitis.
**Computed Tomography**

**Complications**

**Perforation**

Abscesses are the **most common** complication of perforation. They are mostly found in the right lower quadrant but can also occur between bowel loops, in the pelvic cul-de-sac, or elsewhere in the abdomen. Note the **appendicolith** and the **air bubble** within the abscess.

Case: Sepehr Haghighi rID: 64709

Case courtesy of Tariq Walizai, rID: 183440

*Discontinuity in the enhancing appendiceal wall*

This sign was shown to be the single **most sensitive** CT finding of perforation.
Generalized peritonitis presents with peritoneal thickening, peritoneal enhancement or fluid accumulation. Its presence in the context of acute appendicitis is highly suggestive of perforation.

Extraluminal gas
Note the air foci in the periappendiceal region as well as in the peri- and subhepatic regions.

Extraluminal appendicolith
Appendicoliths may be seen outside of the appendiceal lumen with perforation.
Abdominal MRI

MRIs play an important role in investigating abdominal pain during pregnancy especially when US is inconclusive. MRIs are superior to ultrasounds and have a diagnostic accuracy comparable to that of CTs without the risk of exposure to ionizing radiation. MRIs are also being studied as an alternative to other imaging scans for evaluating appendicitis in pediatric patients. However, they are time-consuming, costly, and in pediatric settings, limited by the need for sedation.

Normal MRI anatomy

The appearance of appendicitis on MRI closely resembles that on CT scans, with similar imaging characteristics and cutoff values.

Acute appendicitis is best seen in T2-weighted sequences as they offer a better visualization of the inflammatory changes associated with appendicitis.

Case courtesy of Vikas Shah, rID: 88003
Abdominal MRI

Case Presentation
Acute appendicitis in pregnancy with rupture into perinephric space

The **appendix** is visualized posterior to the cecum and appears **swollen** and **edematous**.

**Fluid and gas** collections are visualized in the perinephric space suggesting perforation.

An **appendicolith** (dark signal within the appendiceal lumen) is seen.

MRIs provide clinicians with a **clear visualization** of the inflamed appendix and any associated complications. This informs treatment decisions, allowing clinicians to make **better choices** that optimize outcomes and **reduce the risk** of fetal loss and preterm labor.

Case courtesy of Vikas Shah, rID: 63378
Inflammation may be limited to the distal end of the appendix which is why it is very important for operators to visualize the appendix in its full length before arriving at a diagnosis.

Appendicitis can recur post appendectomy in the residual appendiceal tissue! While its a rare entity, stump appendicitis is an important consideration that can easily be missed and overlooked.

Subhepatic appendicitis presents with pain in the right upper quadrant, and is often mistaken for cholecystitis. US & CT are vital for timely diagnosis.

Note the appendicolith in the lumen of the subhepatic appendiceal tip.
Many gastrointestinal, gynecologic, and urologic conditions can mimic appendicitis. Differentiating appendicitis from these other conditions is a key role of imaging and has significant implications for patient care.
Mesenteric Adenitis refers to the inflammation of the mesenteric lymph nodes. Clinically, it presents with right lower quadrant pain and is often mistaken for appendicitis. It often follows a viral or bacterial infection and is a very important consideration in pediatric patients. Mesenteric adenitis is self-limiting and resolves without treatment.

Appendiceal mucocele refers to the accumulation of mucus within the appendix. Mucoceles can either be due to a neoplastic or non-neoplastic process. Preoperative recognition has major implications on treatment and surgical approach.

Appendiceal mucoceles are difficult to distinguish from appendicitis as they present with a dilated appendix. However, unlike acute appendicitis, mucoceles develop gradually over months and are associated with mural calcifications on CT.

On US, mesenteric adenitis is characterized by the presence of 3 or more enlarged mesenteric lymph nodes as well as a normal non-inflamed appendix.

Note the dilated appendix and the mural calcifications.
Mimics of Appendicitis

Crohn’s Disease

Crohn’s Disease is a chronic inflammatory bowel disorder that can affect any part of the gastrointestinal tract. Clinically, it may present with RLQ pain and may be mistaken for appendicitis. Imaging helps exclude appendicitis and reveals imaging features of Crohn’s.

On CT, transmural bowel wall thickening and regional fat stranding, most commonly involving the endpoint ileum, are seen. The appendix may appear normal or abnormal and thickened. The thickening, if present, is usually reactive and associated with ileocecal inflammation and is not indicative of appendicitis.

There are case reports of isolated involvement of the appendix in Crohn’s, which has traditionally been managed conservatively.

Meckel’s Diverticulitis

Meckel’s diverticulum is an embryologic remnant of the omphalomesenteric duct, forming a blind ended pouch arising from the ileum. It is present in 2% of the population and is typically located around 2 feet from the ileocecal valve, in the lower central abdomen or in the right lower quadrant. It may become inflamed and produce a clinical picture that mimics appendicitis.

CT findings include an inflamed diverticulum with mural enhancement and surrounding inflammatory changes, along with a normal appendix. Both Meckel’s diverticulum and the appendix are blind-ending tubular structures, however, the appendix arises from the cecum and Meckel’s from the ileum.

Case courtesy of Hani Makky Al Salam, rID: 12108
Infectious ileocecalitis, caused by Yersinia, Campylobacter, or Salmonella, presents similarly to appendicitis. On CT, mural thickening of the terminal ileum and cecum is seen, and there usually is no fat stranding. The inflamed ileal loop may be confused for the appendix; however, recall the appendix is an aperistaltic structure, whereas the ileum is peristaltic.

Pelvic Inflammatory Disease (PID) is a bacterial infection affecting the upper female reproductive tract. It primarily affects premenopausal women and is considered one of the leading causes of infertility. Clinically, it may mimic appendicitis. The imaging findings in PID vary according to severity. Do not confuse the dilated fallopian tube for the appendix.

Epiploic appendagitis is a benign, self-limiting condition characterized by torsion of an epiploic appendage (small fat-filled pouches protruding from the colon). It can occur anywhere in the colon but can mimic appendicitis if right-sided. On CT, it appears as a pericolic fatty mass with surrounding inflammation. Epiploic appendagitis is difficult to recognize on US because it appears as a fatty mass.
Appendiceal neoplasms, found in 1% of appendectomy specimens, are mostly epithelial and neuroendocrine tumors. They can be asymptomatic or present as acute appendicitis in 40% of cases. Mucinous neoplasms may cause abdominal pain and obstruction due to pseudomyxoma peritonei, while carcinoid syndrome is rare, affecting less than 5% of malignant neuroendocrine tumor cases.

Pseudomyxoma peritonei is a progressive condition characterized by the accumulation of mucinous ascites due to a mucin-secreting neoplasm, most commonly from the appendix. Unlike appendicitis, which presents with acute inflammation and pain, pseudomyxoma peritonei involves chronic, gelatinous fluid buildup in the abdomen and is typically associated with more indolent, long-term symptoms.

On imaging, pseudomyxoma peritonei shows mucinous fluid collections with scalloping of abdominal organs and scattered calcifications. While appendicitis presents as an enlarged, inflamed appendix with periappendiceal fat stranding and fluid, indicating acute localized inflammation.
Clinical suspicion for Acute appendicitis

Consider Appendicitis:
Evaluate likelihood

Perform Imaging:
Confirm diagnosis.

Clinical Presentation:
Assess symptoms

First-line in young/pregnant

US

US +ve for appendicitis
Management
Non-operative
Surgery

US -ve for appendicitis
Consider alternative pathology

Repeat imaging, observe, discharge patient

Normal appendix

Repeat imaging, observe patient
Normal appendix

Inconclusive

Diagnostic surgery
Hospital observation

Other pathology

CT

CT +ve for appendicitis
Surgery

Inconclusive

MRI

MRI +ve for appendicitis
Surgery
Evaluate for alternative diagnosis

MRI -ve for appendicitis

The Algorithm

Pregnant or contraindicated for CT

CT
Take home points

1. Imaging is crucial for diagnosing appendicitis, evaluating patients with atypical symptoms, identifying complications, and excluding alternate pathologies.

2. Choice of imaging modality depends on patient characteristics and the clinical setting. US is considered first line; CT and MRI are reserved for specific situations.

3. Many conditions can mimic appendicitis. A few important ones to consider include:
   - Crohn’s Disease
   - Mesenteric adenitis
   - Appendiceal mucoceles & neoplasms
Radiopedia resources

Acute appendicitis
Appendicitis (summary)
Appendicolith
Subhepatic appendicitis
Appendicular abscess
Appendix
Perforated appendix
Neoplasms of the appendix
Mucinous neoplasms of the appendix
References


