Typical and atypical imaging findings of acute appendicitis

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Learning objectives

1. To review the pathogenesis and variable clinical features of acute appendicitis.

2. To illustrate and describe both typical and atypical imaging features of acute appendicitis, including stump appendicitis and tip appendicitis, particularly highlighting the role of ultrasound and computed tomography.

3. To illustrate and describe complications of acute appendicitis, including gangrene, perforation, local abscess formation, peritonitis, pyelothrombosis, hepatic abscess formation, urinary tract obstruction and bowel obstruction.

4. To illustrate and describe other appendiceal pathology that may mimic acute appendicitis in its clinical presentation, namely appendiceal neoplasms.
Background

Appendicectomy for suspected acute appendicitis is the most commonly performed emergency general surgical procedure in the world.[1] Despite the high incidence of acute appendicitis, it can still present a diagnostic challenge with up to one-third of cases having atypical features.[2] Other gastrointestinal and genitourinary pathology can also mimic its presentation.

Untreated acute appendicitis may lead to complications such as appendiceal perforation, abscess formation, peritonitis, pyelophlebitis, pyelothrombosis as well as urinary tract and bowel obstruction. A delay in diagnosis increases the likelihood of complications and carries a significantly increased risk of patient morbidity and mortality. Consequently, radiologists can play an important role in ensuring timely delivery of appropriate treatment by promptly recognising the typical and atypical imaging appearances of acute appendicitis, its complications and mimics.
Imaging findings OR Procedure details

**Acute Appendicitis**

Acute appendicitis refers to acute inflammation of the appendiceal wall. It is most common in adolescents and young adults but may occur at any age. The presentation is more likely to be atypical in the very young and very old, with the diagnosis made more difficult due to the increased likelihood of alternate diagnoses in these age-groups. The lifetime risk of appendicitis is approximately 7%. Most commonly, the inflammed appendix is positioned retrocaecally.[3]

**Pathogenesis**

Acute appendicitis is thought to be caused by increasing intraluminal pressure compromising venous outflow, leading to ischaemic injury, bacterial perforation and neutrophilic infiltration.[4] Approximately 50-80% of cases are associated with overt luminal obstruction, usually by a small stone-like mass of stool (“appendicolith”), and less commonly a gallstone, tumour or parasite (oxyuriasis vermicularis).[4]

**Typical Clinical Features**

- Periumbilical pain that later localises to the right lower quadrant.
- Nausea, vomiting, fever
- Elevated WBC
- Peritonitic tenderness at McBurney’s point (*McBurney’s sign*)

Up to a third of patients have atypical findings that may warrant radiological assessment.[2]

**Secondary Appendicitis**

Secondary appendicitis is caused by an adjacent inflammatory or infective process. This may be due to causes such as caecal diverticulitis, terminal ileitis, active Crohn disease, colitis or pelvic inflammatory disease.[5] CT findings may include a normal diameter appendix with adjacent fat stranding and possible appendiceal wall thickening.[6] Given the non-obstructive nature of such causes, oral contrast may be used to demonstrate patency of the appendiceal lumen. Correct prospective identification of the cause of the secondary appendicitis is crucial to avoid unnecessary appendicectomy, as treatment is usually medical.[6]

**TYPICAL ACUTE APPENDICITIS**
**Ultrasound**

US is a fast, safe and cost-effective modality for evaluation of the appendix and is the most commonly used imaging modality to assess for appendicitis (Fig. 1 on page 10, Fig. 2 on page 10).[7] Ultrasound carries a sensitivity and specificity for detecting acute appendicitis of 71-97%.[8] Limitations of ultrasound include inter-operator variability and difficulty visualising the appendix due to high body-mass-index, anatomical variation, severe pain or overlaying bowel gas.[7] Ultrasound is the preferred imaging modality in paediatric, pregnant and breast-feeding patients owing to its lack of ionising radiation.

US features in acute appendicitis may include:[9]

- Appendiceal diameter >6mm
- Appendiceal mural thickening
- Appendiceal wall hyperaemia on colour Doppler
- Intact echogenic submucosal layer (uncomplicated appendicitis)
- Presence of an appendicolith
- Adjacent hyperechoic fat
- Adjacent mesenteric lymphadenopathy

**Computed Tomography**

CT carries a sensitivity and specificity for diagnosing appendicitis of 83-98%.[7] Since the introduction of CT, negative appendicectomy rates have decreased to <10%, previously 21.5% in the pre-CT era.[7] Limitations of CT include cost, ionising radiation and contrast reactions. Relatively recent studies have shown comparable negative appendicectomy rates and perforation rates between low-dose CT protocols and standard CT protocols.[10]

CT features of acute appendicitis (Fig. 3 on page 11, Fig. 4 on page 12) may include:[11]

- Appendix diameter >6 mm**^**
- Appendiceal mural thickening**
- Appendiceal mural enhancement**
- Peri-appendiceal fat stranding**
- Focal caecal apical thickening
- Presence of an appendicolith
- Intramural air (pneumotosis)
- Extraluminal air
- Phlegmon
- Adjacent mesenteric lymphadenopathy
** Represent the four most useful signs for diagnosing appendicitis on CT.[11]

^ The original cut-off of >6 mm was an early extrapolation from ultrasound findings with application of right lower quadrant compression. Some authors consider an appendiceal diameter on CT of 6-10 mm indeterminate, as there is considerable overlap between the normal and abnormal appendix diameter.[12] Consequently, appendiceal diameter on CT is best interpreted in the context of clinical and other CT findings.[12]

An increase in appendiceal caliber between serial CT examinations with supporting clinical features may signal early-stage acute appendicitis. Oral contrast material within the appendix conflicts with a diagnosis of acute appendicitis and can be used as supporting evidence for a non-obstructed appendix.

**Magnetic Resonance Imaging**

MRI may be utilised in the paediatric or pregnant population, in addition to ultrasound, where the diagnosis remains uncertain. One study demonstrated a sensitivity and specificity of 100% and 99% respectively when using an ultrasound - MRI pathway.[13] Limitations of MRI include cost, availability and long scan times which may not be appropriate in the context of an acute abdomen.[7]

**ATYPICAL ACUTE APPENDICITIS**

**Atypical Location**

An atypical location of the appendix may give rise to an atypical clinical presentation (Fig. 5 on page 13, Fig. 6 on page 15). For example, the appendix may be contained within the inguinal canal (Amyand hernia [Fig. 7 on page 14]) or femoral canal (De Garengeot hernia) or be left-sided in malrotation or situs inversus (Fig. 8 on page 16).[5]

**Stump appendicitis:**

Stump appendicitis represents acute inflammation of an appendiceal remnant following appendicectomy. This is due to inadvertent partial appendicectomy at the time of surgery. Larger appendiceal stumps are associated with an increased risk of subsequent stump appendicitis.[6] CT findings in stump appendicitis involving a long stump remnant are similar to those in typical appendicitis, with an inflammed blind-ended tubular structure associated with the caecum.[14] In the case of a short stump, only secondary findings such as inflammation at the expected location of the appendix and localised caecal wall thickening may be present.[15] Stump appendicitis is associated with a higher likelihood of perforation (59%), compared to primary acute appendicitis (17%), possibly due to
delays in diagnosis given the altered differential diagnosis in the setting of previous appendicectomy.[16]

**Tip appendicitis:**

Tip appendicitis describes an uncommon presentation where the inflammatory process is focally confined to the distal appendiceal tip (Fig. 9 on page 17). In contrast to the imaging appearance of typical appendicitis, the proximal portion of the appendix in tip appendicitis appears normal. The true prevalence of tip appendicitis is unknown but has been cited to be up to 5% of appendicitis cases.[17] There is some evidence that a greater proportion of these cases can be managed conservatively compared to typical appendicitis.[18]

**COMPLICATED ACUTE APPENDICITS**

**Gangrene, Perforation and Abscess Formation**

Delays in diagnosis of uncomplicated appendicitis may lead to the development of complications, including the development of gangrene, perforation (Fig. 10 on page 18) and abscess formation (Fig. 11 on page 19, Fig. 12 on page 20, Fig. 13 on page 21).

Gangrenous appendicitis is the result of arterial and intramural thrombosis.[12] Sonographically, gangrenous appendicitis may be seen as a loss of the usually echogenic submucosal layer and absent colour flow on Doppler ultrasound.[9] CT evidence of gangrenous appendicitis includes pneumatosis, an irregular appendiceal wall and patchy mural enhancement defects.[12]

Sonographic features suggestive of perforation include loculated pericaecal fluid, hyperechoic pericaecal fat and circumferential loss of the submucosal layer.[9] On CT, perforation is suggested by localised periappendiceal inflammation, although this is non-specific.[12] The presence of appendicoliths increased the likelihood of perforation.[19] Horrow et al found the CT finding with highest sensitivity for perforation was a mural enhancement defect.[20]

Abscess formation is the most frequent complication of perforation.[12] Sonographically, this may appear as a loculated fluid collection. CT may demonstrate rim enhancement of the loculated fluid collection. Treatment of large appendiceal abscesses by percutaneous drainage, followed by delayed appendicetomy, is a preferred treatment approach.[21]

**Peritonitis**
Early perforation of the appendix prior to formation of inflammatory adhesions may lead to bacterial peritonitis.[12] Appendicitis complicated by peritonitis tends to be more common in young children.[22] CT features include relatively diffuse free fluid, mesenteric fat stranding, engorged mesenteric vessels and enhancing thickened peritoneal reflections.[12]

**Pyelophlebitis, Pyelothrombosis and Hepatic Abscess**

Haematogenous spread of infection along the draining portal venous system may lead to superior mesenteric and portal vein thrombosis, infection and seeding of the liver with subsequent abscess development.

**Hydronephrosis**

Right sided hydronephrosis secondary to appendicitis which resolves on short-term follow-up imaging is a rare complication, occurring in approximately 3.5% of patients with acute appendicitis.[23] It is associated with a retrocecal location of the appendix and pregnancy.[23] Seventy-one percent of these patients have associated haematuria.[23]

**Bowel obstruction**

Rarely, a peri-appendiceal inflammatory mass from appendicitis may lead to a mechanical obstruction of the terminal ileum.[12] More commonly, post-operative adhesions produce small bowel obstruction as a late complication of appendicectomy. [12] An acutely inflammed appendix may produce a localised ileus of adjacent bowel loops (Fig. 14 on page 22), evident as adynamic bowel on ultrasound, and as prominent loops on abdominal radiographs or CT.

**APPENDICEAL MIMCS OF APPENDICITIS**

**Appendiceal neoplasms**

Acute appendicitis is the most frequent clinical manifestation of appendiceal tumours, occurring in 30-50% of patients [24], however, often the tumours may be overlooked on imaging. Overall, primary and secondary appendiceal neoplasms are found in approximately 1% of appendicectomy specimens.[25] The majority of these tumours consist of primary epithelial neoplasms and neuroendocrine tumours (NETs).

**Primary Epithelial Neoplasms**

Epithelial adenocarcinoma is the most common malignant primary appendiceal tumour (Fig. 15 on page 23). There are mucinous and non-mucinous types (mucin evident
radiologically and pathologically). Epithelial neoplasms tend to be larger than NETs and are more likely to show peritoneal and metastatic spread.

Mucinous epithelial neoplasms:

- May produce a mucocele (Fig. 16 on page 24) (a macroscopic appearance of an appendix abnormally distended by mucin), peri-appendiceal or localised mucinous deposits or peritoneal dissemination causing pseudomyxoma peritonei (Fig. 17 on page 25).
- Extraperitoneal dissemination is uncommon.

Non-mucinous epithelial neoplasms:

- Less common than mucinous type.
- Manifest as focal soft tissue masses, similar to colonic malignancies, with possible regional lymph node involvement and metastases to the peritoneum, liver or lung.[26]

**Neuro-endocrine Tumours**

- Represent 57-80% of appendiceal tumours (combining benign and malignant histological types).[25]
- May not be identifiable on imaging and are more often discovered incidentally on pathological examination post-operatively.
- Tend to be small and non-aggressive. If detected, they are often a small mass localised at the appendiceal tip. Uncommonly they involve regional lymph nodes and rarely do they metastasise.

**Other Tumours**

- Are rare tumours of the appendix.
- Include lymphoma, sarcoma, metastatic disease to the appendix.

**Summary of Modalities for Imaging Appendiceal Neoplasms**

Ultrasound may detect secondary signs of appendiceal neoplasms such as a mucocele, regional lymphadenopathy or ascites. CT offers a sensitivity of up to 95% for detection of appendiceal tumours and is advantageous in its staging capability.[26] MRI is, however, the recommended modality for staging and follow-up of appendiceal carcinoma due to its higher sensitivity and specificity for detecting peritoneal spread.
Fig. 1: Acute Appendicitis on Ultrasound. Oblique ultrasound image taken of the right iliac fossa in a patient with right lower quadrant pain. There is an incompressible blind-ended tubular structure, measuring approximately 9mm in diameter, with increased wall vascularity. Features are consistent with acute appendicitis.

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Fig. 2: Appendiceal Pneumatosis. Transverse ultrasound images of the right iliac fossa performed pre- and post- compression in a patient with right lower quadrant pain. There is an incompressible dilated blind-ended tubular structure with multiple hyperechoic foci contained within its wall. There is also a thin layer of adjacent hypoechoic fluid and increased echogenicity of the adjacent fat. These findings are consistent with acute appendicitis with appendiceal pneumatosis.

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Fig. 3: Acute Appendicitis on CT. Axial CT image in a patient with right lower quadrant pain. Within the right lower quadrant, in continuity with the caecum, there is a dilated, enhancing, blind-ended tubular structure with adjacent mesenteric fat stranding. There is no adjacent free gas or free fluid. Findings are consistent with uncomplicated acute appendicitis.

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**Fig. 4:** Appendicitis due to Obstructing Caecal Tumour. Sagittal CT image of a patient with right lower quadrant pain and weight loss. The appendix is dilated with adjacent mild mesenteric fat stranding. The caecum demonstrates an enhancing soft-tissue mass at the origin of the appendix. Features are consistent with acute appendicitis secondary to an obstructing caecal mass. Pathology revealed caecal adenocarcinoma.

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Fig. 5: Subhepatic Appendicitis. Coronal CT image in a patient who presented with right upper quadrant pain. A distended appendix with adjacent mesenteric fat stranding is seen in a subhepatic location, consistent with subhepatic acute appendicitis.

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Fig. 7: Appendicitis in Amyand Hernia. Coronal (A) and axial (B) CT images in a patient who presented with right groin pain. There is a distended, enhancing appendix contained within the right inguinal canal, representing an Amyand hernia complicated by acute appendicitis.

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Fig. 6: Appendicitis in Parastomal Hernia Axial. CT image of a patient who presented with increasing pain within a known right-sided parastomal hernia. The appendix is mildly distended with a small amount of adjacent fat stranding suggestive of acute appendicitis.

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Fig. 8: Left-Sided Appendicitis in Malrotation. Coronal CT image in a patient who presented with left lower quadrant pain. There is a distended blind-ending tubular structure containing two high-density foci with adjacent mesenteric fat stranding within the left lower quadrant. The patient has acute appendicitis with midgut malrotation. The high density foci represent appendicoliths.

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**Fig. 9:** Tip Appendicitis. Axial CT image in a patient who presented with right lower quadrant pain. The proximal and mid-portions of the appendix are of normal calibre with normal appearing adjacent mesenteric fat. The distal tip portion of the appendix is dilated with adjacent fat stranding, consistent with tip appendicitis.

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**Fig. 10:** Perforated Appendicitis. Coronal CT image in a patient with severe right lower quadrant pain for several days. The appendix is distended by gas and contains a proximal high density focus. There is adjacent mesenteric fat stranding and several extra-luminal gas locules. The imaging features are consistent with acute appendicitis secondary to an appendicolith with localised perforation.

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Fig. 11: Perforated Appendicitis with Abscess. Oblique ultrasound image in a patient with several days of right lower quadrant pain. There is a dilated blind-ended tubular structure seen within the right iliac fossa with a hypoechoic collection at its distal tip. Features are consistent with acute appendicitis complicated by perforation and abscess formation.

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Fig. 12: Iliopsoas Abscess from Perforated Appendicitis. Axial CT image in a patient with persistent severe right lower quadrant pain. There is a fluid collection with enhancing walls involving the right iliopsoas musculature that extends towards the caecum. The features are consistent with an abscess that was likely secondary to perforated acute appendicitis.

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Fig. 13: Intrahepatic Abscess from Subhepatic Appendicitis. Coronal CT image in a patient with persistent right upper quadrant pain who had previously undergone a cholecystectomy. A mildly dilated enhancing tubular structure is seen abutting the inferior surface of segment 6 of the liver. There is continuity of the internal fluid density material into an intrahepatic subcapsular collection with enhancing walls. The findings represent an intrahepatic abscess secondary to perforated subhepatic acute appendicitis.

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**Fig. 14:** Appendicolith and Ileus in Appendicitis. Supine AP radiograph in a patient with acute abdominal pain reveals a circular density immediately superior to the medial aspect of the right iliac crest and several prominent central gas-filled loops of small bowel. The circular density was found to represent an appendicolith in an acutely inflamed appendix. The prominent loops of small bowel represent adjacent ileus.

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**Fig. 15:** Appendiceal Adenocarcinoma. Axial CT image of a patient with an enhancing thick-walled tubular structure in the right lower quadrant without adjacent fat stranding. A right-sided JJ stent was placed to relieve right ureteric obstruction. Subsequent pathology revealed an appendiceal adenocarcinoma.

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**Fig. 16:** Infected Appendiceal Mucocele. Axial CT image in a patient with acute right lower quadrant pain. There is a large distended blind-ended tubular structure with enhancing walls and mild adjacent mesenteric fat stranding. The distension is greater than that typically seen in acute appendicitis. The features are consistent with an infected appendiceal mucocele.

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Fig. 17: Pseudomyxoma Peritonei from Appendiceal Mucinous Adenocarcinoma. Axial CT image in a patient with generalised abdominal pain, abdominal distension and weight loss demonstrating multiple mesenteric soft tissue nodules and ascites. The patient was found to have primary mucinous adenocarcinoma of the appendix. This appearance represents pseudomyxoma peritonei.

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Conclusion

Acute appendicitis is a common emergency presentation with the potential to cause significant patient morbidity and mortality. This review provides radiology trainees and radiology consultants with an overview of both the typical and atypical imaging features of acute appendicitis and its complications, with various case examples, to aid early and accurate diagnosis.
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References


