# Tutorial 11: Radiological Approach to the Acute Abdomen

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## Aims and Guidance for Tutors

The aim of this chapter is to familiarize students with the role of imaging in patients presenting with an "acute abdomen". It is important that students understand the various imaging modalities used in the assessment of patients with acute abdominal pain—the indications, advantages and disadvantages of each. They should also, on completion of this tutorial, be able to recognise the most commonly-encountered and most important acute abdominal pathologies on CT, US and plain radiography.

## Introduction

- The "acute abdomen" is a term used to describe sudden-onset, severe abdominal pain, often with associated abdominal tenderness and rigidity.
- There are many causes of acute abdominal pain—from benign, self-limiting conditions that can be managed conservatively to life-threatening conditions, that require urgent intervention.
- History taking, physical examination and laboratory tests are important in establishing a differential diagnosis, however, imaging is often required for definitive diagnosis and to guide management.
- CT is the most important imaging modality in the work-up of patients with acute abdominal pain.

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## Radiological Modalities Utilised

### Computed Tomography

- The most important imaging modality in the work-up of patients with acute abdominal pain.
- CT abdomen/pelvis takes seconds to perform, is accurate, and widely-available.
- CT involves exposure to ionizing radiation, thus alternative imaging should be considered in pregnant women, children.
- The CT protocol should be tailored to the suspected pathology.
- The standard CT abdomen/pelvis is acquired 70 seconds after intravenous (IV) injection of iodinated contrast material—so-called portal venous phase imaging.
- Caution should be taken with IV contrast in patients at risk of contrast-induced nephropathy.
- Iodinated contrast ingested orally is sometimes given in conjunction with IV contrast; by opacifying small bowel, oral contrast can help to differentiate fluid-filled bowel loops from fluid collections but it takes about 2 hours for oral contrast to reach the caecum, so this can delay treatment.
- Additional phases of imaging should be considered in selected patients.
- Non-contrast CT can detect renal/ureteric calculi and intramural haematoma in patients with ruptured abdominal aortic aneurysm/mesenteric ischaemia.
- Arterial phase imaging (triggered when IV contrast reaches the aorta at the level of the renal arteries) is useful in detecting active arterial bleeding and may identify arterial thromboembolism in mesenteric ischaemia.
- Delayed imaging (3 or 5 minute delay) is useful in identifying contrast pooling in patients with active bleeding.

### Ultrasound

- First line in patients with suspected acute cholecystitis.
- As US does not involve exposure to ionizing radiation, it should be considered the initial imaging modality in women of childbearing age presenting with acute lower abdominal pain.
- It is safe for use in pregnant women and children.
- Reasonably fast, inexpensive, widely-available, dynamic, can be performed at the bedside in critically-ill patients.

### Magnetic Resonance Imaging

- Excellent at detecting common bile duct stones, can also diagnose acute appendicitis, acute diverticulitis, acute cholecystitis, and acute pancreatitis.
- Does not involve exposure to ionizing radiation, thus useful in pregnant patients, especially when US inconclusive.

- However, MRI involves long scan times, is expensive, not readily available outside of standard working hours, some patients are unsuitable for MRI due to cla ustrophobia/contraindications to MRI, children often require sedation.

**Conventional radiography**

- Erect chest radiography may identify subdiaphragmatic free air in patients with hollow viscus perforation.
- Abdominal radiography should be limited to patients with suspected bowel obstruction and renal/ureteric calculi.
- Fast, cheap, widely-available, low radiation dose.
- Further imaging is often required.

## Indications for Imaging

- History, physical examination and laboratory results determine which patients with acute abdominal pain require imaging and which do not.
- For example, young men with a classic presentation for acute appendicitis may go straight to theatre for appendicectomy, without the need for imaging.
- Similarly, haemodynamically-unstable patients with suspected abdominal aortic aneurysm rupture often go straight to theatre without any imaging, so that treatment is not delayed.
- However, in most patients with acute abdominal pain, some form of imaging is required in order to establish a definitive diagnosis and determine management.

## Review of Relevant Anatomy: CT Abdomen/Pelvis

Figures 1, 2, 3, and 4.

**Normal bowel diameter**:

- Normal small bowel diameter is 2.5–3 cm.
- The colon measures up to 6 cm and the caecum up to 9 cm.

**Arterial supply to the bowel**:

- The coeliac artery supplies the foregut from the distal oesophagus to the second part of the duodenum.
- The superior mesenteric artery supplies the midgut from the second part of the duodenum to the junction between the middle and distal thirds of the transverse colon.

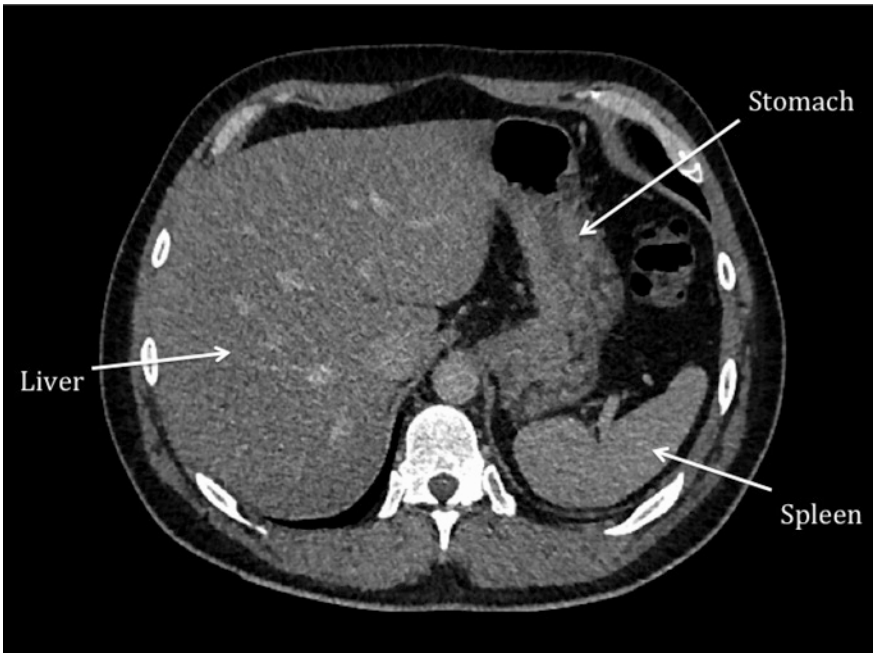


**Fig. 1** Axial slice from contrast-enhanced CT abdomen/pelvis demonstrating normal anatomy

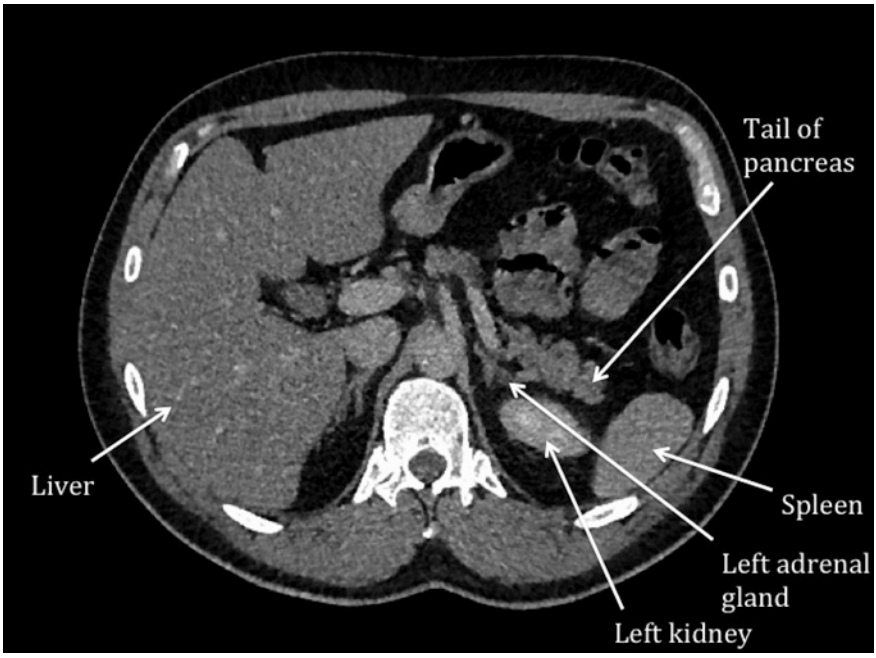


**Fig. 2** Axial slice from contrast-enhanced CT abdomen/pelvis demonstrating normal anatomy

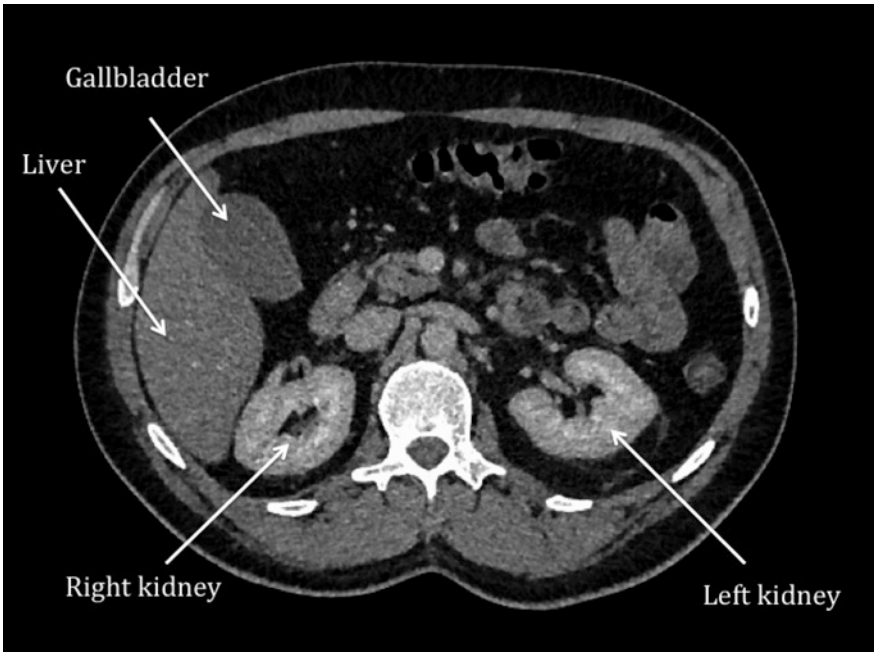


**Fig. 3** Axial slice from contrast-enhanced CT abdomen/pelvis demonstrating normal anatomy

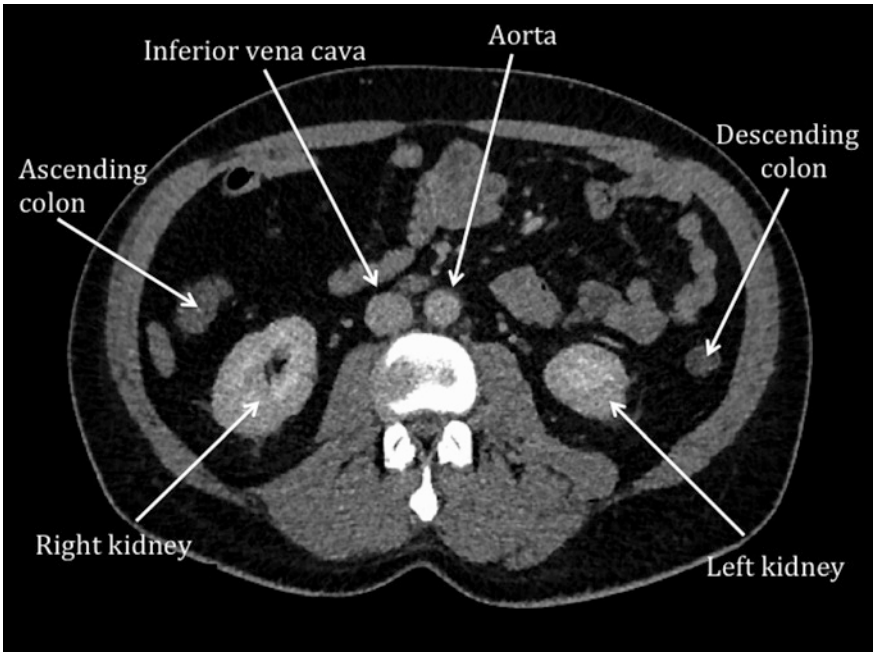


**Fig. 4** Axial slice from contrast-enhanced CT abdomen/pelvis demonstrating normal anatomy

- The inferior mesenteric artery supplies the hindgut from the splenic flexure to the upper two-thirds of the rectum.

## Differential Diagnosis for Acute Abdominal Pain

- There is a very broad differential diagnosis for acute abdominal pain.
- Some of the differential diagnoses, by quadrant, are listed below.
- Small and large bowel obstruction, bowel ischaemia and abdominal aortic aneurysm rupture typically present with *generalized* abdominal pain (Fig. 5).

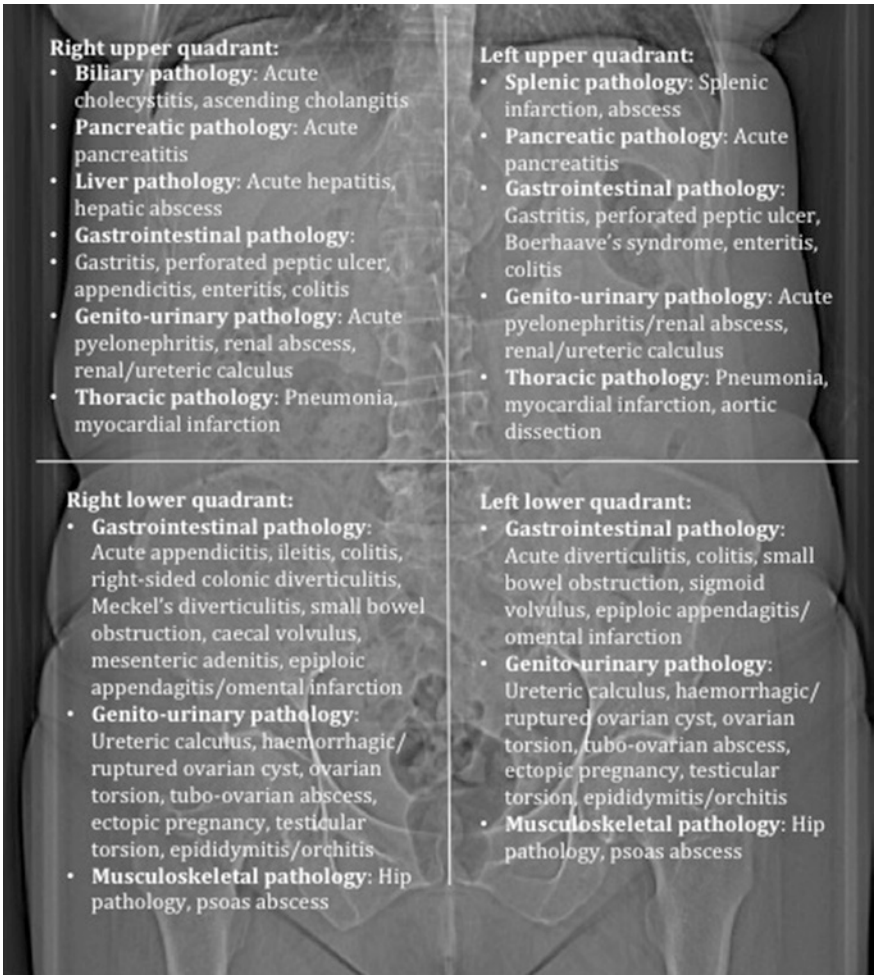


**Fig. 5** Quadrant-based approach to differential diagnosis

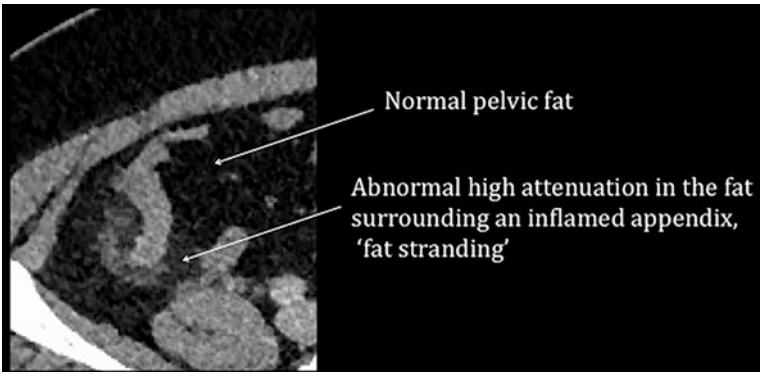


**Fig. 6** Example of inflammatory fat stranding

**Radiologist's tips: Fat stranding on CT**

- Fat standing on CT refers to abnormal high attenuation within abdominal/pelvic fat due to oedema and engorged lymphatics
- It is a non-specific sign
- Commonly infectious and inflammatory conditions cause fat standing, however it can also be seen in the setting of malignancy and trauma

## Acute Cholecystitis

- Obstruction of the cystic duct, typically by gallstones, leads to acute inflammation of the gallbladder.
- US is the imaging investigation of choice in patients with suspected acute cholecystitis.
- CT can also identify acute cholecystitis and its complications.
- Magnetic resonance cholangiopancreatography (MRCP) excels in detecting calculi in the cystic and common bile ducts.
- Cholecystectomy is the definitive treatment for patients with acute cholecystitis, however, US/CT-guided percutaneous drainage may be considered in patients with severe acute cholecystitis and sepsis/organ failure.

**Clinical features**:

- Classic presentation is of right upper quadrant pain, fever and raised white cell count (WCC).
- A distended gallbladder may be palpable.

- Positive Murphy's sign: Pain and inspiratory arrest on palpation of the right upper quadrant.

**Key imaging appearances**:

- US:
  - Gallstones—typically hyperechoic with posterior acoustic shadowing.
  - Thickened gallbladder wall >3 mm.
  - Pericholecystic fluid.
  - Distended, non-compressible gallbladder.
  - Positive sonographic Murphy's sign—pain on inspiration when US probe placed over gallbladder (Fig. 7).
- CT:
  - Findings as on US.
  - In addition, mucosal hyperenhancement and pericholecystic inflammatory fat stranding can be seen.
  - Superior to US in detecting complications of acute cholecystitis, i.e. perforation, abscess formation (Fig. 8).

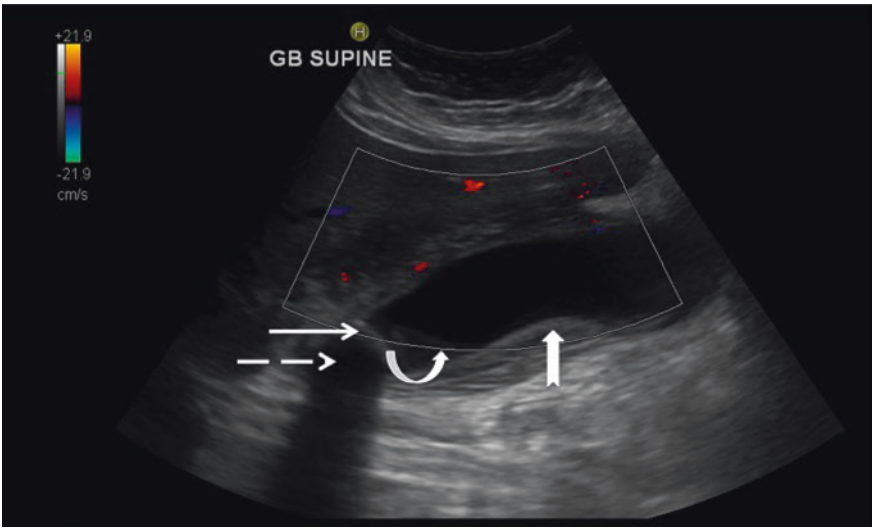


**Fig. 7** A 54-year-old woman with known gallstones presents with right upper quadrant pain, tenderness and raised inflammatory markers. Ultrasound demonstrates a distended gallbladder full of hypoechoic bile, a hyperechoic calculus (solid arrow) with posterior acoustic shadowing (dashed arrow), sludge (curved arrow) and a thickened gallbladder wall (notched arrow). Findings are in keeping with acute cholecystitis. The patient was sonographically Murphy's positive

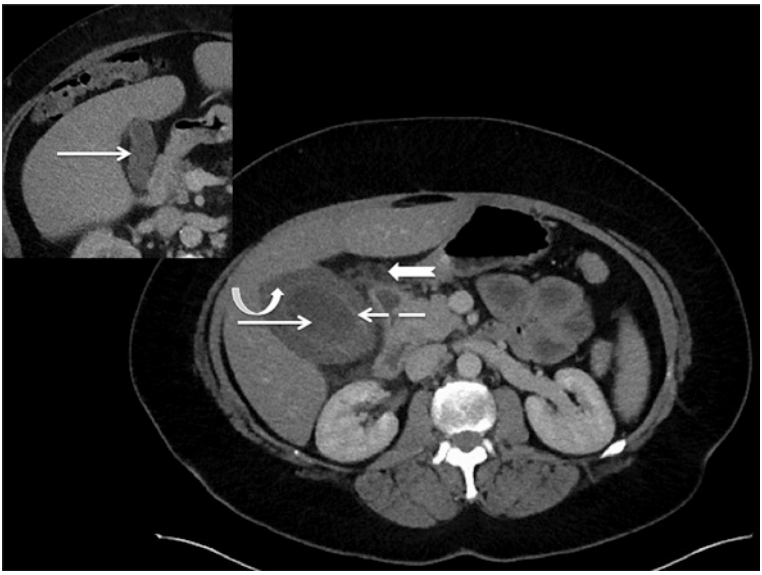

**Fig. 8** A 76-year-old woman with a history of dementia presents with generalized abdominal pain, pyrexia and raised inflammatory markers. Axial contrast-enhanced CT abdomen demonstrates a distended gallbladder (solid arrow), which is of low attenuation due to fluid but which demonstrates a high attenuation/enhancing wall (dashed arrow). There is large volume low attenuation pericholecystic fluid (curved arrow) and high attenuation inflammatory fat stranding (notched arrow). Findings are in keeping with acute cholecystitis. (Inset: See normal gallbladder (solid arrow) for comparison). The patient underwent emergency percutaneous (US-guided) cholecystostomy due to severe sepsis

- MRCP:
  - Cystic/common bile duct calculi are seen as low signal filling defects within the biliary tree on heavily T2-weighted sequences (Fig. 9).

## Acute Pancreatitis

- Acute inflammation of the pancreas, most commonly due to alcohol and gallstones.
- Acute pancreatitis ranges from a mild, self-limiting condition (80–90%) to a severe condition with multiorgan failure and a mortality of up to 25%.
- A diagnosis of acute pancreatitis is usually made on the basis of clinical and laboratory findings alone, without the need for imaging.
- However, CT is important in assessing disease severity in patients with severe acute pancreatitis and in identifying complications.

**Fig. 9** A 63-year-old man with gallstone pancreatitis and deranged liver function tests undergoes MRCP to evaluate for common bile duct stones. Coronal MRCP demonstrates a dilated common bile duct (solid arrow), which contains a low signal filling defect distally (dashed arrow), in keeping with an obstructive calculus

**Clinical features**:

- Severe epigastric pain, radiating through to the back, relieved by sitting up and leaning forward.
- Nausea, vomiting.
- Epigastric/generalized abdominal tenderness, guarding, rigidity.
- Raised WCC, lipase, amylase.

**Key imaging appearances**:

- CT:
  - Focal or diffuse pancreatic enlargement.
  - Indistinct pancreatic margins.
  - Free fluid and inflammatory fat stranding in the peripancreatic/retroperitoneal tissues.
  - Heterogenous enhancement of the pancreatic parenchyma due to oedema, which can progress to lack of enhancement with pancreatic necrosis.
  - Pancreatic or peripancreatic fluid/necrotic collections, which may be sterile or infected.

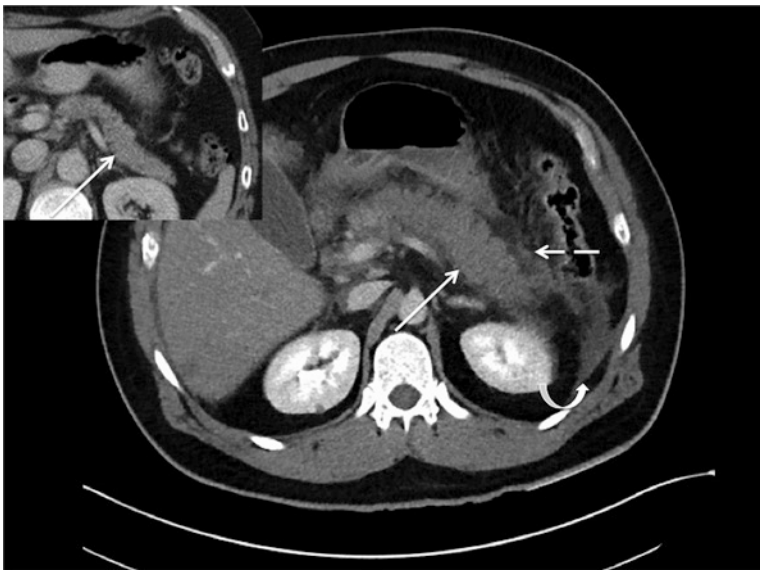

**Fig. 10** A 55-year-old man presents with upper abdominal pain. Axial contrast-enhanced CT abdomen demonstrates an enlarged, oedematous pancreas (solid arrow) with surrounding inflammatory fat stranding (dashed arrow) and small volume upper abdominal free fluid (curved arrow). Findings are in keeping with acute uncomplicated pancreatitis. (Inset: See normal pancreas (solid arrow) for comparison)

  - Pancreatic calcification indicates chronic inflammation (Figs. 10 and 11).
- US:
  - Identifies gallstones as a cause of pancreatitis.

## Acute Appendicitis

- Acute inflammation of the appendix typically occurs due to obstruction of the appendiceal lumen by a faecolith/lymphoid hyperplasia.
- If appendicitis goes unrecognised, there is a risk of perforation and increased mortality, so timely diagnosis is crucial.
- Treatment is with appendicectomy, however select patients with uncomplicated appendicitis may be managed conservatively with IV antibiotics.

**Clinical features**:

- Periumbilical abdominal pain due to inflammation of visceral peritoneum, localizing to the right lower quadrant (RLQ) due to inflammation of parietal peritoneum.
- Nausea, vomiting.

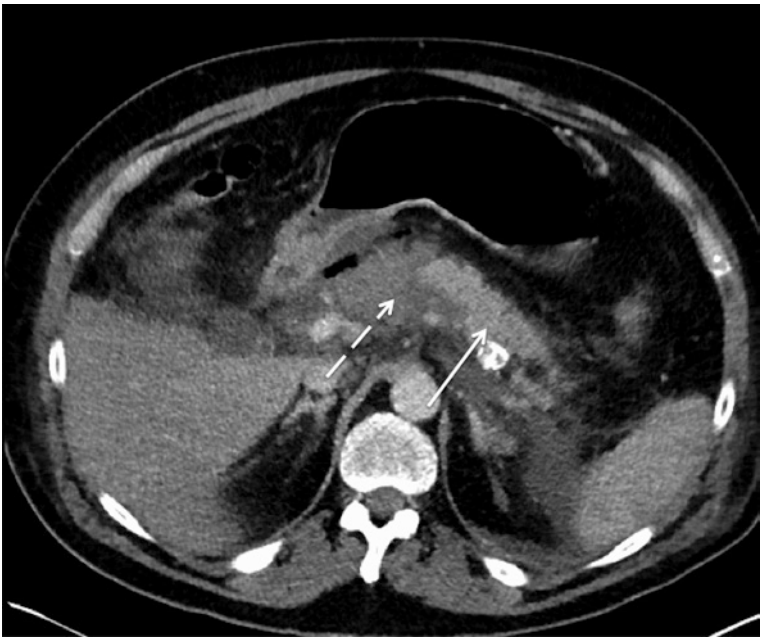

**Fig. 11** A 57-year-old man with known pancreatitis undergoes CT abdomen due to persistently raised inflammatory markers. Axial contrast-enhanced CT demonstrates normal enhancement (high attenuation) of the distal pancreatic body and tail (solid arrow) but lack of enhancement (low attenuation) in the pancreatic head and proximal body (dashed arrow), in keeping with pancreatic necrosis

- Fever.
- Abdominal tenderness—maximal over McBurney's point, guarding, rigidity.
- Raised inflammatory markers.

**Key imaging appearances**:

- CT:
  - Dilated, fluid-filled appendix, >6 mm.
  - Thickened, enhancing appendiceal wall.
  - Appendicolith.
  - Periappendiceal free fluid and inflammatory fat stranding.
  - Inflammatory phlegmon, abscess (Figs. 12 and 13).
- US:
  - Non-compressible, blind-ending tubular structure in the RLQ with surrounding fluid.
- MRI:
  - Thickened appendix.
  - Increased signal intensity.
  - Infiltration of surrounding fat.

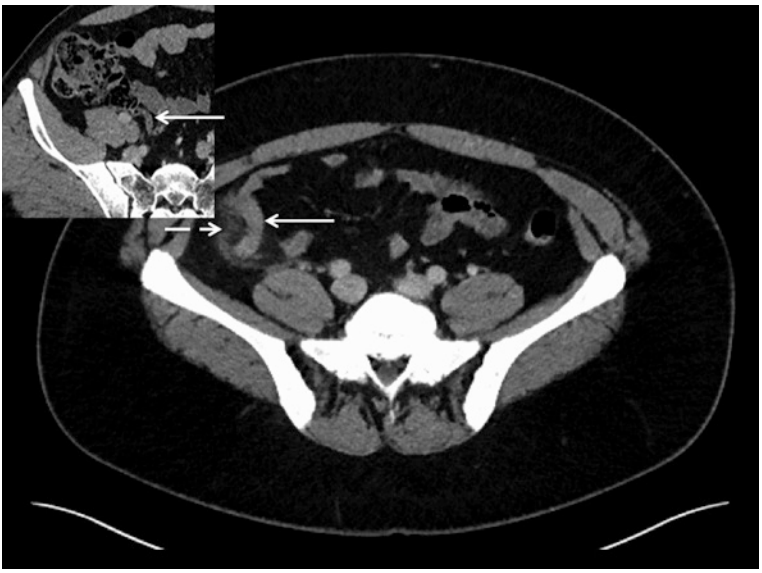

**Fig. 12** A 44-year-old man presents with right iliac fossa pain and raised inflammatory markers. Axial contrast-enhanced CT abdomen/pelvis demonstrates a dilated, fluid-filled appendix (solid arrow) with surrounding inflammatory fat stranding (dashed arrow), in keeping with acute uncomplicated appendicitis. (Inset: See normal appendix (solid arrow) for comparison)

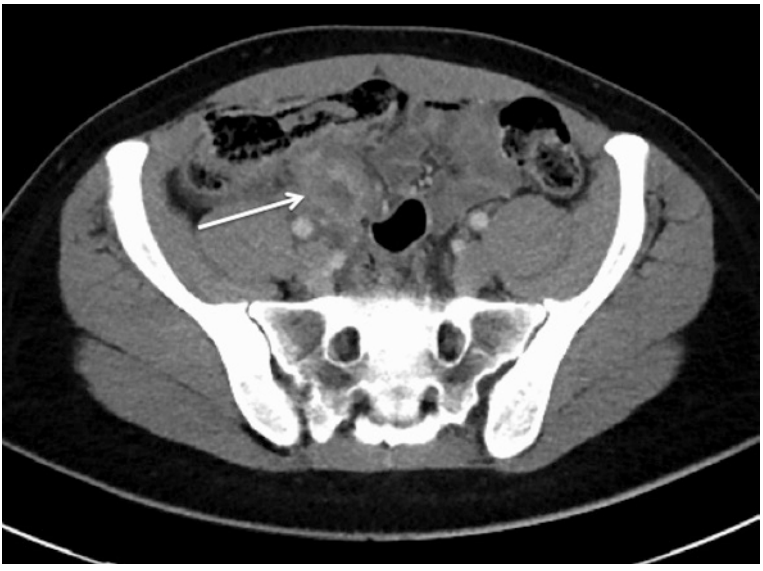

**Fig. 13** A 23-year-old man presents with a four-day history of right iliac fossa pain and is tender and guarding on examination. Axial contrast-enhanced CT abdomen/pelvis demonstrates an inflammatory soft tissue mass in the right iliac fossa, in keeping with acute appendicitis with phlegmon formation

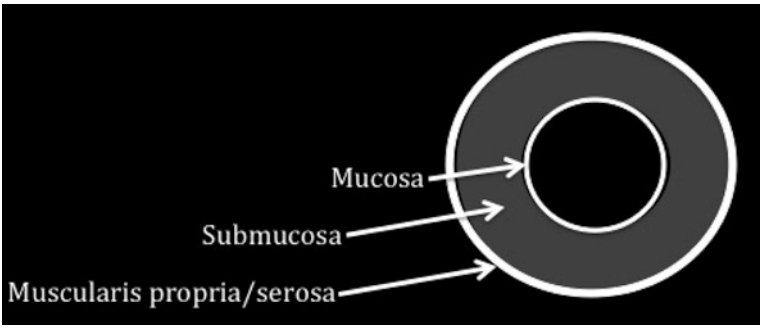


**Fig. 14** Schematic illustration of bowel wall 'target sign'

**Radiologist's tips: The bowel wall 'target sign' on CT**

- The 'target sign' may be seen on contrast-enhanced CT
- It describes a thickened bowel wall with 3 distinct layers—an inner high attenuation layer of enhancing mucosa, a middle low attenuation layer due to oedema in the submucosa and an outer high attenuation layer due to enhancing muscularis propria/serosa
- It is a non-specific sign
- It can be seen in ischaemic bowel, acute inflammatory bowel disease and infectious colitis (including pseudomembranous colitis)

## Acute Enteritis/Ileitis

- Acute inflammation of the small bowel can occur due to a variety of causes: infection (bacterial, protozoal or viral), inflammation (Crohn's disease, chemotherapy or radiotherapy), ischaemia.
- Differentiating between these conditions is important as they are managed differently.
- While stool cultures and endoscopic biopsies are often required, CT can help in identifying the most likely diagnosis due to the distribution of bowel involvement.

**Clinical features**:

- Abdominal pain.
- Diarrhoea.
- Nausea, vomiting.

- Abdominal tenderness.
- Elevated inflammatory markers.

**Key imaging appearances**:

- CT:
  - Thickening of the small bowel wall.
  - Bowel wall thickening is segmental in Crohn's disease but typically involves the terminal ileum.
  - 'Mesenteric comb sign' in Crohn's disease is due to increased blood flow in the mesenteric vessels.
  - Lymphadenopathy (Fig. 15).

## Acute Colitis

- As with enteritis, acute inflammation of the large bowel can occur due to infection, inflammation or ischaemia.
- Patients with acute colitis do not always require imaging, however it is useful in confirming the diagnosis and in detecting complications.
- Clostridium difficile is an important cause of infectious pancolitis (inflammation involving all of the large bowel), as it can result in toxic megacolon and colonic perforation.

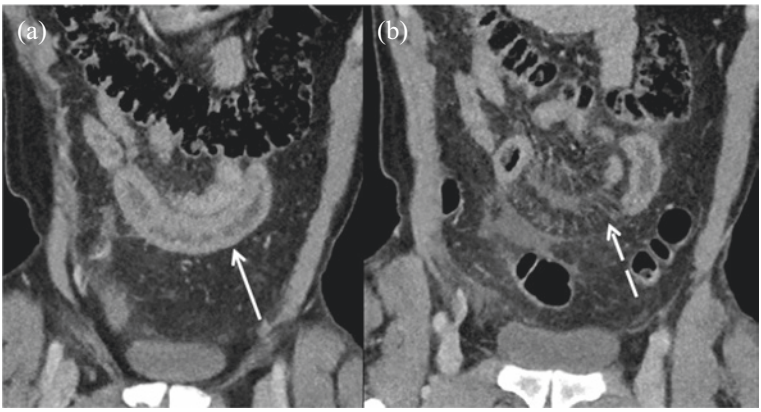


**Fig. 15** A 20 year old man with known Crohn's disease presents with increased frequency of bowel motions, blood and mucous per rectum, pyrexia, tachycardia and raised CRP. Coronal contrast-enhanced CT abdomen/pelvis demonstrates wall thickening in the terminal ileum (image A-solid arrow) and the 'mesenteric comb sign' (image B-dashed arrow). Findings are consistent with active inflammation

**Clinical features**:

- Abdominal pain.
- Diarrhoea, often bloody.
- Nausea, vomiting.
- Fever.
- Abdominal tenderness.
- Elevated inflammatory markers.

**Key imaging appearances**:

- CT:
  - Thickening of the large bowel wall.
  - Enhancement of bowel wall mucosa with submucosal oedema—see 'target sign' above.
  - Bowel wall thickening is continuous in ulcerative colitis, it always involves the rectum and a variable amount of colon.
  - Ischaemic colitis follows a vascular distribution and occurs at "watershed" areas.
  - The 'accordion sign' is quite specific for clostridium difficile infection; it refers to oral contrast interposed between thickened haustral folds.

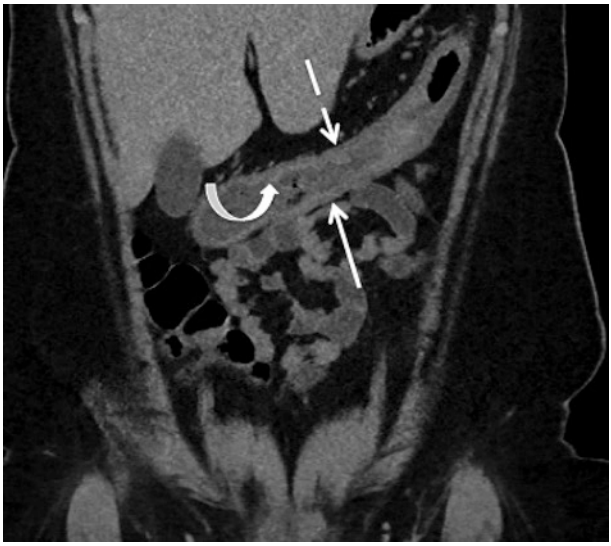

**Fig. 16** A 43-year-old man presents with abdominal pain, diarrhoea and raised inflammatory markers. Coronal contrast-enhanced CT abdomen/pelvis demonstrates thickening of the wall (solid arrow) and haustra (dashed arrow) of the transverse colon with mucosal high attenuation/hyperenhancement (curved arrow). Findings are in keeping with acute colitis

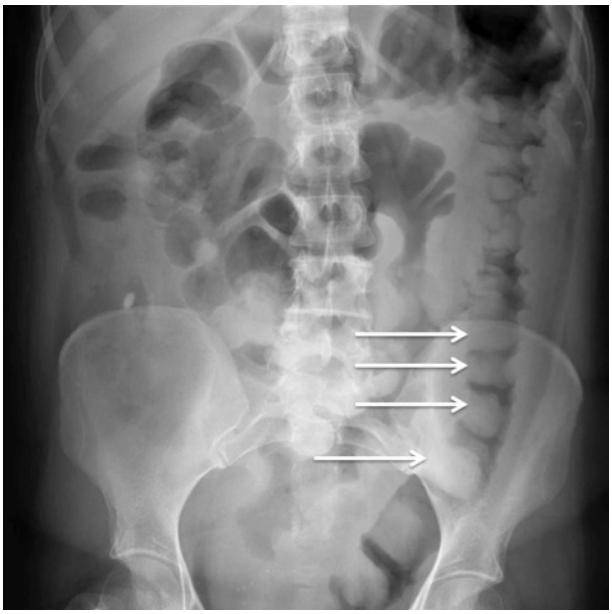

**Fig. 17** Abdominal radiograph demonstrating 'thumbprinting'/thumb-like indentations in the large bowel (solid arrows) due to haustral oedema in a patient with acute colitis

  - Toxic megacolon (usually secondary to pseudomembranous colitis/ulcerative colitis) manifests as dilated large bowel with wall thinning and loss of haustral markings (Fig. 16).

- Abdominal radiography:
  - Thumb-like indentations in the large bowel wall due to haustral oedema, 'thumbprinting' (Fig. 17).

## Acute Diverticulitis

- Diverticula are outpouchings of mucosa and submucosa at weak spots in the bowel wall, where blood vessels and nerves pierce the muscularis.
- Diverticulosis most commonly occurs in the descending/sigmoid colon.
- If one or more diverticula become obstructed, inflammation, infection and perforation can result.
- CT is useful in confirming the diagnosis and in staging the disease.
- Uncomplicated diverticulitis can often be managed conservatively with antibiotics and diet modification.
- Diverticulitis with perforation and abscess formation often requires percutaneous drainage (US/CT-guided).
- Surgery is reserved for those who fail conservative management.

**Clinical features**:

- Abdominal pain, typically in the left lower quadrant (LLQ).
- Altered bowel habit.
- Nausea, vomiting.
- Low-grade fever.
- Tenderness, guarding, rigidity and/or a palpable mass in the LLQ.
- Raised inflammatory markers.

**Key imaging appearances**:

- CT:
  - Diverticulosis.
  - Wall thickening in the affected colon.
  - Significant surrounding inflammatory fat stranding—more than would be expected for the degree of colonic wall thickening.
  - Fascial thickening.
  - Accumulation of fluid in the root of the sigmoid mesentery gives rise to the 'comma sign'.
  - Engorged mesenteric vessels result in the 'centipede sign'.
  - Important in detecting complications, i.e. perforation, abscess formation, fistulae etc. (Fig. 18).

**Radiologist's tips: Small versus large bowel obstruction on xray**

- **Small bowel obstruction**:
  - Dilated, central small bowel loops (>3 cm)
  - Valvulae conniventes traverse the bowel lumen
- **Large bowel obstruction:**
  - Dilated, peripheral large bowel loops (>6 cm/>9 cm for caecum)
  - Haustra partially cross the bowel lumen

## Small Bowel Obstruction

- Small bowel obstruction (SBO) refers to mechanical blockage of the small bowel lumen.
- It is far more common that large bowel obstruction.
- Post-operative adhesions are the most common cause of SBO, followed by hernia(e).

**Fig. 18** A 64-year-old woman presents with left iliac fossa pain and raised inflammatory markers. Axial contrast-enhanced CT abdomen/pelvis demonstrates diverticula (solid arrow), with wall thickening in the sigmoid colon (dashed arrow), marked pericolonic inflammatory fat stranding (curved arrow) and fascial thickening (notched arrow), in keeping with acute uncomplicated diverticulitis

- Low-grade/partial/incomplete small bowel obstruction can usually be managed conservatively with a "drip and suck" technique (patient kept nil by mouth, nasogastric tube inserted, IV fluids commenced).
- In patients with high-grade/complete small bowel obstruction, surgery is often required due to the risk of bowel ischaemia.
- CT is useful in establishing the site, cause and severity of the obstruction and in detecting complications like ischaemia.

**Clinical features**:

- History of prior abdominal surgery.
- Crampy abdominal pain.
- Abdominal distension.
- Nausea, vomiting.
- Absolute constipation.
- High-pitched bowel sounds.
- Hernia on clinical exam.

**Key imaging appearances**:

- CT:
  - Dilated, fluid-filled small bowel loops proximal and collapsed small bowel loops distal to the point of obstruction—the so-called 'transition point'.
  - Faeces-like material in distended small bowel loops proximal to the transition point—the 'small bowel faeces sign'.
  - Small air locules can become trapped between valvulae conniventes, giving rise to the 'string-of-pearls sign' (may also be seen on abdominal x-ray).
  - Adhesions are invisible on CT.
  - In closed-loop SBO, the small bowel is obstructed at two points, usually due to an internal hernia; closed-loop obstruction is associated with a higher risk of ischaemia and requires urgent surgery (Fig. 19).
- Abdominal radiography:
  - Please refer to Tutorial 10: The Abdominal Radiograph.

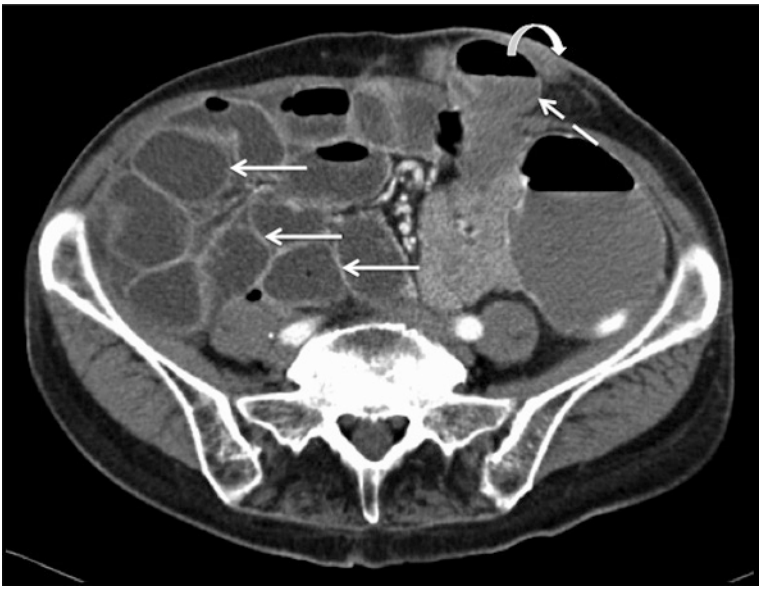

**Fig. 19** A 66-year-old woman with a prior colectomy for colorectal cancer presents with severe abdominal pain, vomiting, no output from her stoma and an irreducible parastomal hernia on exam. Axial contrast-enhanced CT abdomen/pelvis demonstrates dilated, fluid-filled small bowel loops (solid arrows). There is a point of transition from dilated proximal small bowel loops to collapsed distal small bowel loops at the level of a parastomal hernia in the left iliac fossa. Note the dilated small bowel loop in the left anterior abdominal wall (dashed arrow) adjacent to the stoma, which communicates with the skin (curved arrow)

## Large Bowel Obstruction

- Large bowel obstruction (LBO) refers to mechanical blockage of the large bowel lumen.
- It is far less common than small bowel obstruction.
- It is most commonly caused by colorectal cancer, followed by sigmoid volvulus and diverticular disease.
- Sigmoid/caecal volvulus cause closed-loop obstruction.
- As with SBO, CT is useful in identifying the level and cause of obstruction and the presence of complications.

**Clinical features**:

- Crampy abdominal pain.
- Abdominal distension.
- Nausea, vomiting.
- Absolute constipation.
- High-pitched bowel sounds.

**Key imaging appearances**:

- CT:
  - Dilated large bowel loops proximal and collapsed large bowel loops distal to the point of obstruction—the so-called 'transition point'.
  - The proximal colon is filled with faeces, air and fluid.
  - If the ileocaecal valve is competent, the small bowel will not be dilated, however if the ileocaecal valve is incompetent, both the small and large bowel will be dilated (Fig. 20).
- Abdominal radiography:
  - Please refer to Tutorial 10: The Abdominal Radiograph.

## Gastrointestinal Perforation

- There are innumerable (non-traumatic) causes of gastrointestinal perforation, the most common of which are perforated peptic ulcer disease and diverticulitis.
- Often patients with gastrointestinal perforation require urgent surgery.
- CT (+/− erect chest/abdominal x-ray) will demonstrate free intra-abdominal air (pneumoperitoneum).
- CT often demonstrates the site and cause of the perforation.
- However, CT may not be performed if it will delay emergency surgery.

**Fig. 20** A 79-year-old woman presents with abdominal pain and constipation. Coronal contrast-enhanced CT abdomen/pelvis demonstrates dilated proximal sigmoid colon (solid arrow), with an abrupt transition to collapsed distal sigmoid colon (dashed arrow) at the point of volvulus

**Clinical features**:

- Sudden-onset, severe, constant upper abdominal pain.
- Anorexia, nausea, vomiting.
- Patient may lie completely still.
- Abdominal tenderness, involuntary guarding, rigidity.
- Haemodynamic instability—tachycardia/hypotension.

**Key imaging appearances**:

- CT:
  - Can detect small amounts of free intraperitoneal air.
  - Free air, free fluid and inflammatory fat stranding is usually maximal adjacent to the site of hollow viscus perforation.
  - May demonstrate the site of perforation as a focal defect in the stomach/bowel wall.
  - There may be bowel wall thickening at the site of perforation (Fig. 21).

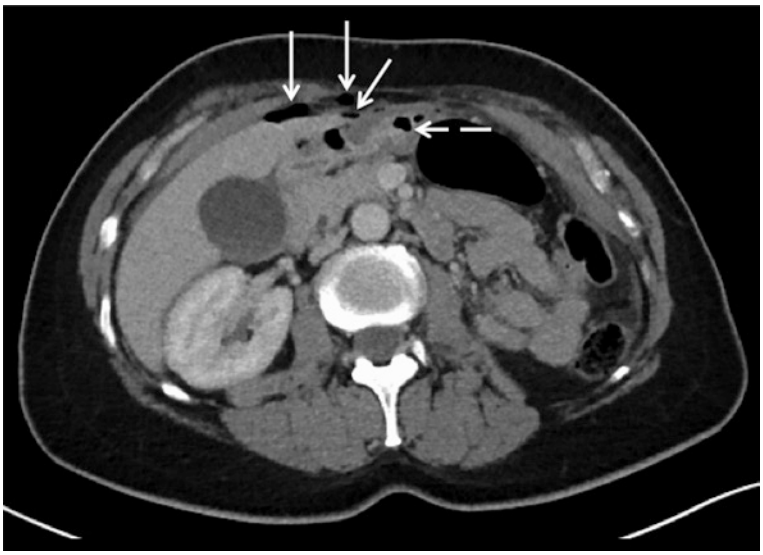

**Fig. 21** A 55-year-old woman presents with sudden-onset upper abdominal pain, peritonism and subdiaphragmatic free air on chest radiograph. Axial contrast-enhanced CT abdomen/pelvis demonstrates locules of free air (solid arrows) in the upper abdomen, adjacent to the liver and the distal stomach (dashed arrow), suggestive of gastroduodenal perforation

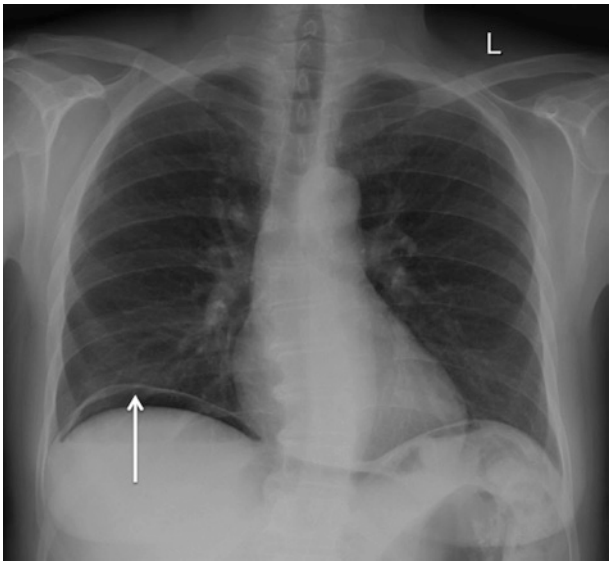


**Fig. 22** Erect chest radiograph demonstrates free intra-abdominal air as a lucent crescent beneath the right hemidiaphragm (solid arrow)

- Erect chest radiography:
  - Free intra-abdominal air is seen as a lucent crescent below the diaphragm (Fig. 22).

## Bowel Ischaemia

- Bowel ischaemia is a life-threatening cause of acute abdominal pain with a mortality of approximately 70%.
- Acute mesenteric ischaemia occurs because of decreased blood flow to the bowel either due to acute arterial or venous occlusion or systemic hypoperfusion.
- CT can identify the cause, location, extent and severity of bowel ischaemia.
- Often, non-contrast, arterial and portal venous phase imaging is performed when bowel ischaemia is suspected.
- Differentiating between arterial and venous bowel ischaemia is important as arterial bowel ischaemia typically requires urgent surgery/radiological intervention, whereas venous bowel ischaemia can often be managed conservatively with anticoagulation.

**Clinical features**:

- History of cardiovascular disease (i.e. atrial fibrillation, atherosclerosis), prior embolic event or risk factors for same, intra-abdominal infection/inflammation/neoplasm.
- Sudden-onset, severe, generalized abdominal pain, classically disproportionate to clinical findings.
- Vomiting, diarrhoea (sometimes bloody).
- As bowel ischaemia progresses to infarction, abdominal distension occurs, peritoneal signs develop and bowel sounds disappear.
- Elevated lactate.

**Key imaging appearances**:

- CT:
  - Filling defect in the lumen of a mesenteric artery on the angiographic phase study indicates thromboembolism.
  - Filling defect in the lumen of a mesenteric vein on portal venous phase imaging indicates thrombosis.
  - Abnormal bowel wall thickness—the bowel wall is often thickened due to oedema, haemorrhage or superimposed infection, however, in occlusive

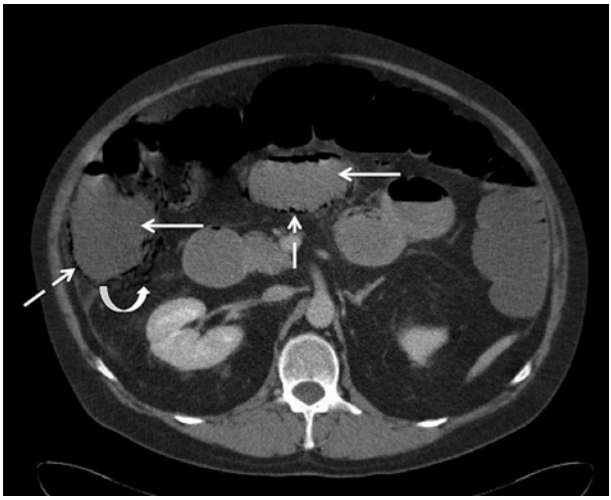

**Fig. 23** A 63-year-old man presents with severe generalized abdominal pain. Contrast-enhanced (portal venous phase) CT abdomen/pelvis demonstrates fluid-filled small and large bowel (solid arrows) with air lying dependently in the small and large bowel wall—pneumatosis intestinalis/coli (dashed arrows) and in pericolonic veins (curved arrow). CT also showed an occlusion of the superior mesenteric artery (not shown)

arterial mesenteric ischaemia/infarction, the bowel wall may become 'paper-thin'.

- Abnormal bowel wall enhancement—there may be bowel wall hyperenhancement due to hyperperfusion (see 'target sign' above) or decreased/absent bowel wall enhancement in the setting of arterial occlusion without reperfusion/infarction.
- Dilated, fluid-filled bowel.
- Pneumatosis intestinalis/coli—air within the small or large bowel wall indicates transmural infarction.
- Pneumatosis portalis—air in mesenteric/portal veins, may extend to the periphery of the liver (Fig. 23).

## Urinary Tract Calculi

- Calculi, most often composed of calcium, can collect in the renal collecting system/ureter(s).
- If obstructing, calculi result in hydronephrosis and hydroureter with distension of the renal collecting system/uretar proximal to the calculus.

**Fig. 24** An 86-year-old man presents with right flank pain and sepsis. Non-contrast CT (KUB) demonstrates an obstructing high attenuation calculus in the proximal right ureter (solid arrow). A further non-obstructing calculus is noted in the lower pole of the right kidney (notched arrow). The patient underwent emergency percutaneous (US-guided) nephrostomy due to urosepsis

- Non-contrast CT (KUB) is the imaging modality of choice for suspected renal/ureteric calculi.
- Small calculi typically pass spontaneously.
- Percutaneous nephrostomy may be required in patients with urosepsis secondary to an obstructing renal/ureteric calculus.

**Clinical features**:

- Severe, colicky flank/loin-to-groin pain.
- Patient can't lie still.
- Haematuria.

**Key imaging appearances**:

- CT:
  - Detects and can accurately measure the size of renal and urinary tract calculi.
  - Hydronephrosis/Hydroureter.
  - Perinephric/Periureteric inflammatory fat stranding.

- US:
  - Variable accuracy in detecting and measuring calculi.
  - Detects hydronephrosis but ureter poorly visualised (Fig. 24).

## Suggested Reading


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