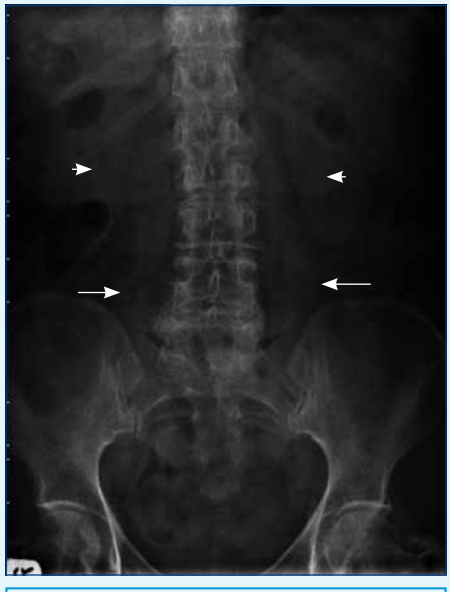
Radiology of the acute abdomen

Introduction

Within the abdomen there are multiple organs that can cause acute pain. It is often difficult to determine the cause of acute abdomen clinically but it is usually the result of a non-traumatic pathology; in these instances plain film radiology is usually the initial investigation to determine serious pathology that may require surgical intervention. The second-line investigations are ultrasound and computed tomography. In trauma cases a FAST (focussed assessment for the sonographic examination of the trauma patient) ultrasound scan to look for the presence of intra-abdominal free fluid is often performed in the emergency department. Computed tomography is the best examination to investigate abdominal trauma because of its superior three-dimensional reconstruction capability but it involves a significant radiation dose.

Figure 1. Normal abdominal radiograph with an unremarkable bowel gas pattern. There is no evidence of free gas. Normal soft tissue structures such as the kidneys (arrowheads) and psoas shadows (arrows) are well demonstrated and there are no abnormal calcifications.



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Approach to evaluating abdominal radiographs

The abdominal radiograph is taken as a supine anterior-posterior film (*Figure 1*) and is the first-line investigation for bowel obstruction. To interpret the abdominal radiograph it is important to systematically check the following:

1. Assess for free intra-peritoneal gas (characteristic of a bowel perforation) or gas in an unusual place such as an organ, e.g. pneumobilia or gas in the portal veins of the liver
2. Assess the bowel gas pattern looking for evidence of bowel obstruction. Normal small bowel measures up to 3 cm in diameter and normal large bowel measures up to 5 cm in diameter. If the bowel measures more than this there is likely to be bowel obstruction although this is not always the case
3. Assess the soft tissue structures that are visible, such as kidneys, liver and spleen. Also assess for calcifications in the soft tissue structures, i.e. kidneys indicating renal calculus, pancreas suggesting chronic pancreatitis or aortic calcification in aortic aneurysm
4. Assess the visible bones. Traumatic rib fractures suggest underlying visceral injury (left lower ribs = splenic injury, right lower ribs = liver injury, pelvic fractures = bladder or bowel injury).

Radiological assessment and classical signs

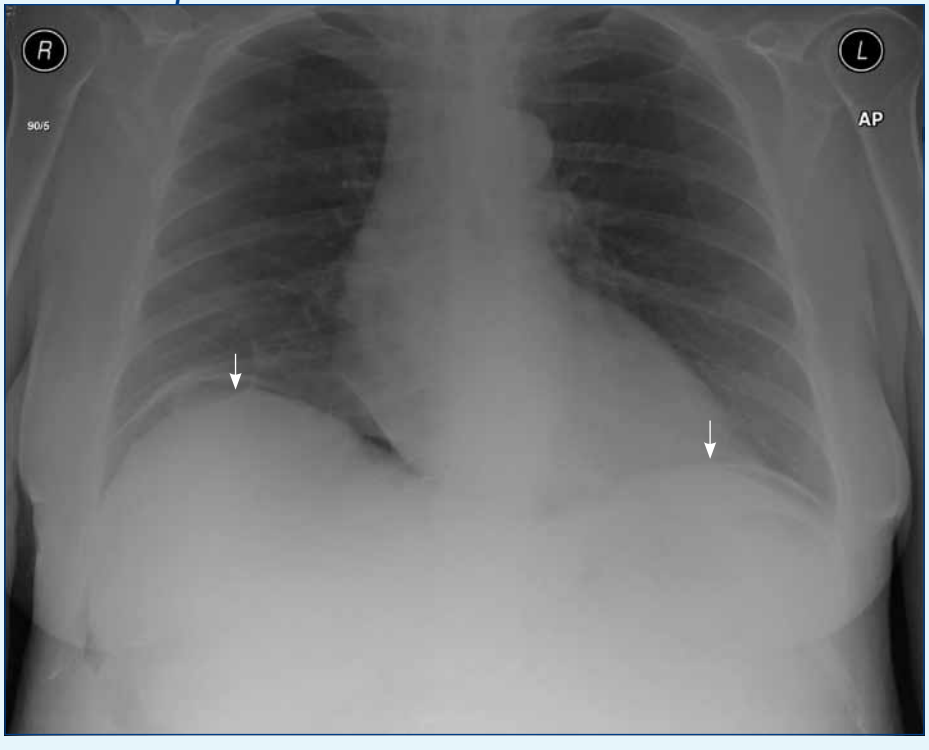
The main indications for imaging in acute abdominal pain are suspected perforation, obstruction or renal colic. In these clinical situations the initial radiological investigation is usually plain films. In some centres unenhanced computed tomography of the kidneys, ureter and bladder is often the first-line investigation for renal colic.

Assessing gas

Free intraperitoneal gas (suspected perforation)

In the investigation of bowel perforation a well-penetrated erect chest radiograph is the most useful investigation to assess for free intraperitoneal gas below the diaphragm (*Figure 2*). If the patient is

Figure 2. Erect chest radiograph demonstrating free intraperitoneal gas below the diaphragm (arrows) indicative of bowel perforation.



unable to sit up, a left lateral decubitus radiograph using a horizontal beam can be useful and can demonstrate as little as 1.0 ml of free gas.

On an anteroposterior abdominal radiograph there are a number of classical radiological signs that are subtle but can often be seen if looked for such as Rigler's sign (*Figure 3*) and the 'football' sign. Rigler's sign is seen when gas is on both sides of the bowel wall, i.e. luminal and extraluminal. The football sign occurs when a patient is lying supine and free intraperitoneal gas lies in the upper most part of the abdominal cavity resulting in a spherical lucency that resembles a football. Rarely free gas is seen to outline both sides of the falciform ligament.

Pitfalls

The absence of free gas does not exclude perforation, for example in sealed perforation of the duodenum or bowel. Computed tomography is more sensitive in detecting small locules of free gas in these instances.

Bowel gas pattern (suspected obstruction)

A supine anteroposterior abdominal radiograph is used to determine the presence of small or large bowel obstruction and in some cases it is possible to identify the cause of the obstruction on the plain film.

Figure 3. Abdominal radiograph demonstrating Rigler's sign that is characteristic of bowel perforation. Arrow demonstrates bowel wall that is easily identified because of gas on both sides of the bowel.

However, almost all patients will end up with an intravenous contrast-enhanced computed tomography scan of the abdomen to identify the cause of the obstruction and to help plan appropriate patient management.

Obstructed bowel becomes dilated as bowel contents are unable to pass the cause of the obstruction. The small bowel is dilated when it measures >3 cm in diameter and is often seen dilated >5 cm. The large bowel is dilated when it measures >5 cm in diameter (*Figures 4, 5* and *6*).

Interpretation of bowel gas patterns in bowel obstruction

If the small bowel is dilated and there is no colonic gas, there is likely to be a complete mechanical small bowel obstruction (*Figure 4*). In patients who have had previous surgery the most likely cause is adhesions. In adult patients who have not had previous surgery tumour is a common cause.

If the small bowel is dilated and there is gas in an undistended colon there is likely to be an incomplete mechanical obstruction or a localized paralytic ileus.

If the small bowel and colon are both dilated there is likely to be a large bowel obstruction with an incompetent ileocaecal valve (*Figure 5*), allowing backflow of bowel contents into the small bowel, or there is a generalized ileus.

Figure 4. Abdominal radiograph showing dilated bowel in the centre of the abdomen with visible valvulae conniventes (arrow) that is characteristic of small bowel obstruction.

If the large bowel is dilated but the small bowel is not this implies mechanical large bowel obstruction with a competent ileocaecal valve (*Figure 6*).

Other specific causes of obstruction

Volvulus of the bowel is a specific cause of large bowel obstruction and is the result of the sigmoid colon or caecum twisting on its mesentery causing obstruction of the lumen. In sigmoid volvulus (*Figure 7*) the bowel gas pattern looks like a coffee bean or inverted 'U' shape as the axis extends

Figure 5. Abdominal radiograph showing dilated small (large arrowhead) and large bowel (small arrow) caused by a splenic flexure bowel tumour. Small bowel dilation is present because of an incompetent ileo-caecal valve.

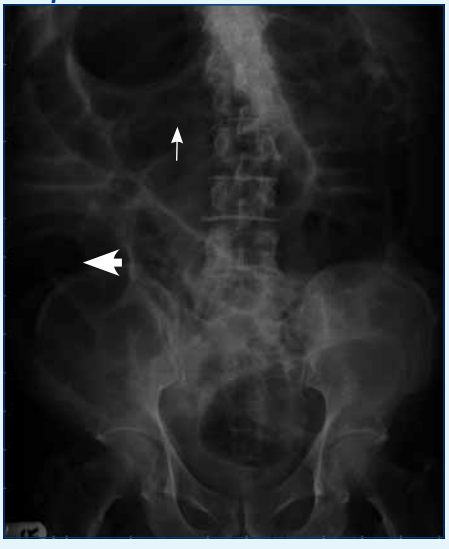


Figure 6. Abdominal radiographs showing dilated bowel in the periphery of the abdomen with teniae coli characteristic of large bowel obstruction.

from the left iliac fossa superiorly and to the right. The caecal volvulus (*Figure 8*) axis classically extends from the right iliac fossa superiorly and to the left but the appearance of the caecal volvulus can be variable. Sigmoid volvulus can often be decompressed by passing a flatus tube per rectum. Caecal volvulus often requires surgical decompression.

Intussusception (*Figure 9*) of the bowel is another cause of small bowel obstruction that can sometimes be seen on a plain abdominal radiograph and is the result of the proximal bowel (intussusceptum) 'telescoping' into the distal bowel (intussuscipiens). Intussusception is commoner in children but in adults the lead point of the intussusception is often the site of pathology such as a tumour.

Gas can also be seen in unusual locations such as the abdominal organs, for example the gall bladder in emphysematous cholecystitis (*Figure 10*) or in the bowel wall in necrotizing enterocolitis which is commonly seen in neonates.

Figure 7. Abdominal radiograph showing the twisted and dilated sigmoid colon which has the inverted 'U' or 'coffee bean' appearance (arrow) that is characteristic of sigmoid volvulus.

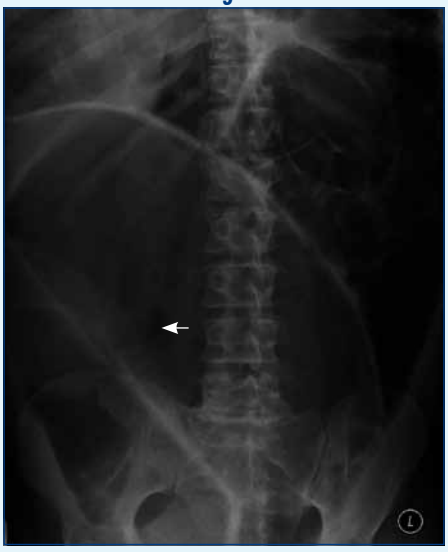


Figure 8. Abdominal radiograph demonstrating caecal volvulus that required surgical decompression. The dilated large bowel is the caecum (arrows). Although it is not in the classical position in the right iliac fossa it does extend up to the left hypochondrium characteristic of caecal volvulus.

Figure 9. Abdominal radiograph showing a 'target sign' or 'coiled spring' type appearance in the left flank (white arrow) with proximal small bowel dilation (black arrow) characteristic of intussusception.

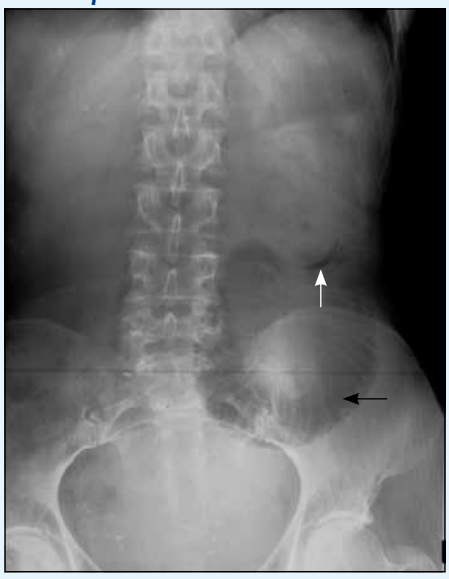


Figure 10. The gall bladder is filled with gas (arrow) in emphysematous cholecystitis.

Assessing the soft tissues and calcifications

Ruptured abdominal aortic aneurysm

This may be picked up on an abdominal radiograph when the rupture is retroperitoneal as there is loss of one of or both of the psoas shadows and calcification of the aneurysm wall may also be noted (*Figure 11*).

Gallstones

While a plain abdominal radiograph is not indicated for the investigation of gallstones they may be seen incidentally (*Figure 12*).

Figure 11. Loss of the right psoas shadow and displacement of wall calcification (arrow) in a ruptured abdominal aortic aneurysm.

Figure 12. Abdominal radiograph demonstrating incidental radio-opaque gallstone (black arrow) and bladder calculus (white arrow).

Suspected renal colic

A kidneys, ureter and bladder abdominal radiograph is diagnostic when there is a radio-opaque calculus within the renal tracts (*Figure 13*), but only approximately 50% of renal calculi are radio-opaque. Non-contrast computed tomography of the kidneys, ureter and bladder is now the first-line investigation for suspected renal colic in many centres.

Figure 13. Kidney ureter bladder radiograph showing right ureteric calculus (arrow) at the level of L4 vertebra and several small calculi within the left kidney.

Assessing the visible bones

The visible bones on the abdominal X-ray need close scrutiny. Fracture of the lower ribs, which lie close to the spleen on the left side and the liver on the right side, may suggest injury to these viscera. Similarly, pelvic fractures are associated with injury to adjoining soft tissues such as bladder. The presence of these bony injuries should instigate further assessment with computed tomography to search for soft tissue injuries, which may be life threatening.

Trauma: penetrating or blunt injury

Plain abdominal radiography is not indicated unless a retained foreign body is suspected as rapid assessment of the injury is critical and a delay increases morbidity and mortality. Ultrasound or computed tomography are useful in haemodynamically stable patients to assess the degree of injuries. In an unstable patient urgent surgery is required.

Conclusions

Plain radiograph is still the first line of investigation in the vast majority of patients presenting with acute abdomen. Systematic assessment of the abdominal X-ray will help detect the underlying source of the acute abdomen in many cases before proceeding with cross-sectional imaging such as computed tomography. BJHM

Conflict of interest: none.

Further reading

Raby N, Berman L, Lacey G (2005) *Accident & Emergency Radiology. The survival Guide.* 2nd edn. Elsevier Saunders, Philadelphia

Squire LF, Novelline RA (1988) *Fundamentals of Radiology.* 4th edn. Harvard University Press, Massachusetts

KEY POINTS

- Assess whether there is free intra-peritoneal gas which indicates bowel perforation.
- Assess the bowel gas pattern as this can indicate whether the cause is a mechanical obstruction or ileus.
- Assess soft tissues and calcifications.
- Plain abdominal radiographs are not indicated in abdominal trauma and delay treatment.