Abdominal x rays made easy: normal radiographs

Understanding x ray films is something that all clinical students should get to grips with. Starting out as a doctor, you will not need to be an expert but you will need to know the basics. Ian Bickle and Barry Kelly present the first part of a new series on interpreting plain abdominal radiographs.

The abdominal radiograph is one of the most commonly requested images, and all medical students should have a knowledge of common radiological interpretations. This article covers the radiology of normal findings. Subsequent parts of the series will cover abnormal intraluminal gas, abnormal extraluminal gas, calcification, bone and soft tissue abnormalities, and iatrogenic, accidental, and incidental objects.

The standard abdominal radiograph (AXR) taken is a supine projection: x rays are passed from front to back (anteroposterior projection) of a patient lying down on his or her back. In some circumstances an erect AXR is requested: its advantage over a supine film is the visualisation of air-fluid levels. A decubitus film (patient lying on his or her side) is also of use in certain situations.

Although an AXR is a plain radiograph, it has a radiation dose equivalent to 50 posteroanterior chest x rays or six months of standard background radiation.

As with any plain radiograph, only five main densities are seen, four of which are natural: black for gas, white for calcified structures, grey representing a host of soft tissue with a slightly darker grey for fat (as it absorbs slightly fewer x rays). Metallic objects are seen as an intense bright white. The clarity of outlines of structures depends, therefore, on the differences between these densities. On the chest radiograph, this is easily shown by the contrast between lung and ribs—black air against the white calcium containing bones. These differences are much less apparent on the AXR as most structures are of similar density—mainly soft tissue.

Technical features

It is important, as with any image, that the technical details of an AXR are assessed. The date the film was taken and the name, age, and sex of the patient are all worth noting. This ensures you are interpreting the correct film with the correct clinical information and it also may aid your interpretation. You would be a little concerned if you saw what appeared to be a calcified fibroid on an AXR when holding the notes of Mr John Brown.

Next ask what type of AXR is it: supine, erect, or decubitus? Unless specifically labelled the film is taken to be supine.

Intraluminal gas

Begin by looking at the amount and distribution of gas in the bowels (intraluminal gas). There is considerable normal variation in distribution of bowel gas. On the erect or decubitus? Unless specifically labelled the film is taken to be supine. The best way to appreciate normality is to look at as many films as possible, with an awareness of anatomy in mind (fig 1).

Intraluminal gas

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Extraluminal gas

Gas outside the bowel lumen is invariably abnormal. The largest volume of gas you might see is likely to be the right diaphragm: this occurs after a vissus has

Figure 1. Normal film

Figure 2. Rectal gas film

Figure 3. Valvulae conniventes

Figure 5. Faecal matter in the bowel gives a “mot-tled” appearance.
BMJ (intramural gas). Accompanied by gas within the bowel wall such as toxic megacolon, and it may be frequently fatal. It occurs in ischaemic states, portal vein is always pathological and frequently seen as “the absent pedicle.” Beware of gas in the portal vein, as this can look very similar to biliary air. Gas in the right upper quadrant within the biliary tree and the gut.

Soft tissue outlines of the psoas muscles and kidneys are seen. The kidneys are normal in size and shape. There are no apparent bony lesions or abnormal calcification. Incidentally, sterilisation clips can be seen within the pelvis indicating previous gynaecological intervention. Calcium is visible in a variety of structures, both normal and abnormal, and becomes more common with advancing age. However, review the following areas in particular for evidence of calcification: cartilage of ribs, blood vessels (chiefly the aortoiliac and splanchnic arteries), pancreas, kidneys, the right upper abdominal quadrant for gallbladder calculi, and the pelvis, which may contain a variety of calcified structures, most commonly phleboliths. Part 4 of this series is dedicated to calcification on AXR.

Calcification
Calcium is visible in a variety of structures, both normal and abnormal, and becomes more common with advancing age. However, review the following areas in particular for evidence of calcification: cartilage of ribs, blood vessels (chiefly the aortoiliac and splanchnic arteries), pancreas, kidneys, the right upper abdominal quadrant for gallbladder calculi, and the pelvis, which may contain a variety of calcified structures, most commonly phleboliths. Part 4 of this series is dedicated to calcification on AXR.

Soft tissues and bone
A review of the soft tissues entails evaluating the outlines of the major abdominal organs. Observing these structures is made easier by the “fatty” rim (peritoneal fat lines) surrounding them. In fact, the loss of these fat planes may indicate an ongoing pathological process, such as peritonitis. Look at the size and position of the liver and spleen. Look at the position and size of the kidneys, lateral to the midline in the region of the T12-L2 vertebrae (a useful way of identifying vertebrae: the lowest one to give off a rib is T12 and serves as a reference point). The renal outline is usually three to three and a half vertebral bodies in length. Also, look for the clear outline of the psoas muscle shadow(s). Finally, try to identify the outline of the bladder, seen more clearly if full, within the pelvis.

Places to look for abnormal extraluminal gas
- Under the diaphragm
- In the biliary system
- Within the bowel wall

Key to densities in AXRs
- Black—gas
- White—calcified structures
- Grey—soft tissues
- Darker grey—fat
- Intense white—metallic objects

Artefacts
You should be able to identify “man made” structures correctly. These may be iatrogenic (put there by health professionals), accidental (put there by the patient or other), or projectional (lying in front of or behind the abdomen but spuriously projected within it on the AXR). Examples of iatrogenic structures would be surgical clips, an interuterine contraceptive device, renal or biliary stent, an endoluminal aortic stent, or inferior vena cava filter. Accidental findings include bullets or a per rectum object. Projectional findings include pyjama buttons, coins in pockets, or body piercings (see part 6 of the series).

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Next month: Abnormal intraluminal gas

Review points
- Technical specifics of the radiograph
- Amount and distribution of gas
- Extraluminal gas
- Calcification
- Soft tissue outlines and bony structures
- Iatrogenic, accidental, and incidental objects
On an abdominal radiograph, as with all plain film images, four densities can be seen—white, grey, slightly darker grey, and black—representing bone, soft tissue, fat, and air. Metallic objects are seen as intense bright white. The abdominal radiograph is a representation of the abdominal viscera and bowel: the presence of gas in most instances is normal. Several medical and surgical conditions, however, are recognisable by an abnormal amount, distribution, or location of air on the radiograph. Abnormal gas can be (a) intraluminal, in the stomach, duodenum, and intestine, or (b) extraluminal—that is, elsewhere.

**Large bowel obstruction and paralytic ileus**
Most intraluminal gas is in the large intestine, which has the greatest luminal diameter of the intestinal tract. A diameter of more than 5 cm suggests a large bowel obstruction and would be considered abnormal (except in the caecum). As the intestine is a long tube, any obstruction, either from within or by external compression, prevents the passage of faecal material and gas. Consequently, both will build up proximal to the obstruction, causing dilation.

Unless the ileocaecal valve is incompetent this gas-faecal material mix will be contained entirely within the large bowel. With time, the passage of a motion will empty any faecal material and gas distal to the blockage. This gives the appearance of a “cut off” point on the radiograph (fig 1). This is an important sign to appreciate, as it is indicative of a mechanical large bowel obstruction.

The large bowel can also dilate with paralytic ileus. In this condition, the bowel is adynamic (not undergoing normal peristalsis). This allows gas—which everyone swallows normally—to accumulate in the bowel, but importantly this air is contained within both the small and large bowel loops. The number of small bowel loops gives an indication of the level at which the obstruction within the small bowel has occurred: the higher the obstruction, the fewer the number of loops seen. Unlike large bowel obstruction (table), no gas should be seen within the large bowel (fig 2).

**Small bowel obstruction**
In small bowel obstruction, dilated small bowel loops are seen centrally on the radiograph. The valvulae conniventes should be visible across the whole width of this dilated bowel. The dilated bowel diameter is greater than 3 cm but usually less than 5 cm. There are likely to be several dilated bowel loops. The number of small bowel loops gives an indication of the level at which the obstruction within the small bowel has occurred: the higher the obstruction, the fewer the number of loops seen. Unlike large bowel obstruction (table), no gas should be seen within the large bowel (fig 3).

So far we have considered supine abdominal radiographs. An erect film may show further evidence of small bowel obstruction: fluid levels, indicating an air-fluid interface. An erect film tends to show multiple small bowel gas fluid levels, a “stepladder” appearance (fig 4).

**Volvulus**
A volvulus is the twisting of bowel about its mesentery, causing intestinal obstruction. The two most common sites are the sigmoid and the caecum. With a sigmoid volvulus, an extremely dilated loop of sigmoid bowel forms two large compartments which look like a coffee bean (hence the name of the sign). This single loop usually fills most of the lower abdominal radiograph. On erect abdominal radiographs a fluid level may be noted.

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**Comparison of large and small bowel obstruction features**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Small bowel</th>
<th>Large bowel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowel diameter (cm)</td>
<td>&gt;5</td>
<td>&gt;3 and ≤5</td>
</tr>
<tr>
<td>Position of loops</td>
<td>Central</td>
<td>Peripheral</td>
</tr>
<tr>
<td>Number of loops</td>
<td>Many</td>
<td>Few</td>
</tr>
<tr>
<td>Fluid levels (on erect film)</td>
<td>Many, short</td>
<td>Few, long</td>
</tr>
<tr>
<td>Bowel markings</td>
<td>Valvulae (all the way across)</td>
<td>Haustra (partially across)</td>
</tr>
<tr>
<td>Large bowel gas</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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**Fig 1. Large bowel obstruction**

**Fig 2. Paralytic ileus**

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Got a blockage in your learning? Let Ian Bickle and Barry Kelly help by explaining bowel obstruction and other causes of abnormal intestinal gas, in the second part of our series on abdominal radiographs.
In caecal volvulus, the caecum is displaced to the upper left abdominal quadrant from its normal location (the right lower quadrant). This leaves the area empty so the term “empty caecum” is used. The volvulus usually consists of a single loop, again showing a fluid level on an erect radiograph. Distal to the volvulus the large bowel is empty.

**Toxic megacolon, acute pancreatitis, duodenal obstruction, and meteorism**

Toxic megacolon, seen in inflammatory bowel disease (especially ulcerative colitis), has an associated risk of bowel perforation. It is seen as grossly dilated large bowel, typically the transverse colon, with “thumb printing” evident (fig 5).

In acute pancreatitis a small sentinel loop (a collection of intraluminal gas) of bowel may be seen: the inflamed pancreas paralysing the adjacent bowel, making it adynamic. Duodenal obstruction, congenital or acquired, gives the appearance of two gas bubbles, one in the duodenum and the normal gastric air bubble; this is termed the “double bubble” sign.

Meteorism (excessive swallowed air) is particularly common in crying children and hyperventilating adults. Although there are prominent bowel loops, there is no cut off point: the bowel has been likened to crazy paving (fig 6).

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Next month: Abnormal extraluminal gas

This month, in the third part of our series on abdominal radiographs, Ian Bickle and Barry Kelly look at identifying abnormal extraluminal gas on plain abdominal films.

Extraluminal gas is gas outside the sealed gastrointestinal tract.

**Pneumoperitoneum**
A most important and potentially devastating finding is that of free intraperitoneal gas, which is known as pneumoperitoneum. Emergency surgical intervention is likely to be necessary, as pneumoperitoneum usually indicates a perforated viscus. The supplementary plain radiograph should be an erect chest radiograph that visualises gas collecting beneath the diaphragm. Depending on the volume of gas in the peritoneum, it may be apparent under one or both hemidiaphragms. As you may recall from the first part of the series (normal radiographs) a gastric air (“gas”) bubble is usually seen in the left hypochondrium on the erect film. This can make distinguishing free air on this side problematic. For this reason, identification of free gas on the right side is more straightforward. The air is trapped between the underside of the diaphragm and the upper surface of the liver (fig 1). A small volume of gas has a crescentic appearance.

Should a supine abdominal radiograph be the only film available—if, for example, the patient is too ill to undergo an erect chest radiograph—there are radiological conditions causing extraluminal air
- Perforated abdominal viscus
- Abscesses (subphrenic and other)
- Biliary fistula
- Cholangitis
- Pneumatosis coli
- Necrotising enterocolitis
- Portal pyaemia

Fig 1. Gross pneumoperitoneum with free air under both hemidiaphragms. In addition there is a large dark egg shape projected through the heart. This is a large, fixed, hiatus hernia—an incidental finding, but one which shows an abnormal air collection.

Fig 2. A subtle pneumoperitoneum

Fig 3. Falciform ligament (left) and Rigler’s sign (right) dark triangles outlined by the bowel wall serosa.
signs that help identify free gas on the radiograph. The falciform ligament sign is seen when free air outlines the falciform ligament, identified as a thin straight line starting in the right upper quadrant, where it originates, and ending near the umbilicus, where it terminates (fig 2). In Rigler’s sign, gas can be seen on both sides of the bowel wall (fig 3). This makes the serosal surface of the bowel easily visible.

**Chilaiditi’s syndrome**

Chilaiditi’s syndrome is an important normal variant on the erect chest radiograph, which must be distinguished from pathological free gas under the diaphragm. In this phenomenon, gas is seen between the hemidiaphragm and the liver or spleen (fig 4). On close and careful observation this should be identified as gas filled large bowel, most likely transverse colon (apparent, as haustra are seen within the gas filled structure). This gas is still contained in the bowel loop.

**Subphrenic abscess**

This is a localised collection of free gas and fluid, which usually forms under the right hemidiaphragm, above the solid liver. This gas collection usually occurs above the 11th rib (fig 5).

**Biliary gas**

On the plain abdominal x ray film, gas is not normally identified in the biliary system, either intra- or extrahepatic. There are, however, situations when gas might be seen as branching “tree-like” streaks of black projected in the liver shadow. After endoscopic retrograde cholangiopancreatography with sphincterotomy, gas may travel from the duodenum into the biliary tree as the sphincter of Oddi in the second part of the duodenum is incompetent. Similarly, after a gallstone has been passed, the sphincter may become dilated. Biliary fistulas are less common but may develop with a gallstone ileus. Fistulation between the gallbladder and adjacent bowel allows a route for gas into the biliary system. The final aetiology is cholangitis. If the biliary ducts are infected with gas forming organisms, gas will be produced, and contained, in the ducts, effectively creating a negative contrast to the surrounding soft tissue of the liver.

**Miscellaneous causes**

The final causes of extraluminal gas are conditions where gas has escaped from the lumen of the gastrointestinal tract but remains within the bowel wall; this is known as intramural gas. This gas may migrate to the portal vein and is effectively an “ante mortem” sign, except in the case of neonatal necrotising enterocolitis.

Necrotising enterocolitis is a condition seen in premature babies when gas “leaks” into the bowel wall.

In bowel wall infarction, abscesses may form, which produce gas contained in the bowel wall.

Pneumatosis coli, a condition where blebs of gas form on the bowel wall, is of obscure aetiology and makes the bowel wall look like “bubble wrap.” These blebs may rupture to produce a pneumoperitoneum.

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Next month: Calcification
Abdominal x rays made easy: calcification

Ian Bickle and Barry Kelly return after a month off with the fourth part in their series on reading plain abdominal x ray films

As outlined earlier in the series a small number of densities may be seen on plain radiographs. The most radio-opaque (brightest) of any natural substance is calcium, which appears white. The reason calcium shows the greatest radio-opacity is that it “obstructs” x rays more than any other natural substance. Consequently, fewer of those x rays reach the x ray plate, and the film appears white.

Iatrogenic or artefactual metallic objects appear even brighter white (this will be discussed in the final part of this series). The vast majority of calcium is contained in the bones—a normal, expected location (bony abnormalities will be covered in the next part of this series).

The incidence of physiological calcification of normal anatomical structures increases with age and reflects that calcium is deposited over time.

Calcium can be seen in normal and abnormal structures. Abnormal calcification in some cases merely indicates underlying pathology whereas in others the calcification is the pathology.

**Box 1: Normal structures that calcify**
- Costal cartilage
- Mesenteric lymph nodes
- Pelvic vein clots (phlebolith)
- Prostate gland

**Calcification of normal structures (box 1)**
Evaluation of the abdominal radiograph might start at the top, working down the film. The film should include the lower anterior ribs. As you will recall, towards the midline anteriorly, a rib changes from bone to cartilage and is termed costal cartilage. The cartilage of ribs one to seven articulates with the sternum whereas ribs eight to 10 indirectly connect to the sternum by three costal cartilages, each of which is connected to the one immediately adjacent to it (ribs 11 and 12 are floating). This cartilage can calcify, which is termed costocalcinosis. Although appearing strikingly abnormal, it is harmless and usually age related (fig 1).

Further down, mesenteric lymph nodes may calcify and appear as oval, smooth, outlined structures (fig 2). These can be confused with small kidney stones, especially in a patient without previous films who presents with abdominal pain. Are such incidental harmless calcified nodes responsible for the pain or are renal calculi? This diagnostic dilemma may be solved by the exact location. If due calcification is identified along the urinary pathway (typically along the line of the transverse processes of the vertebral bodies) an intravenous urogram to compare against a plain control film may be necessary for a decisive diagnosis. Alternatively, unenhanced computed tomography can be used. Also contained in the pelvis is the pelvic phlebolith, seen as a small, smooth, round, white opacity. Phleboliths are small areas of calcification in a vein. They may be difficult to differentiate from small kidney stones.

The final calcification in this section is found only in men. This is calcium that collects in the ageing prostate gland and is therefore observed low down in the pelvic brim. Prostate calcification may also occur in cancerous tissue.

**Calcification indicating pathology (box 2)**

**Pancreas**
The pancreas lies at the level of T9-T12 vertebrae. Calcification of the pancreas is usually found in chronic pancreatitis, although there are some rarer causes. If calcification is extensive, the full outline of the pancreas may be observed, mostly on the left side, but may cross over the midline. This “speckled” calcification occurs on the network of ducts within the pancreatic tissue where most of the calcium is deposited (fig 3).

**Renal calcification**
Between the T12-L2 vertebral region, nephrocalcinosis may be identified. This is calcification of the renal parenchymal tissue (fig 4). This is indicative of renal pathology, which includes hyperparathyroidism, renal tubular acidosis, and medullary sponge kidney.

**Vascular calcification**
Perhaps the most striking calcification is in the blood vessels, most notably the arteries. The whole vessel(s) may be exquisitely
outlined by calcium (fig 5). A great deal of calcification may be indicative of a widespread atheromatous process within the arteries, especially in diabetes.

In the infrarenal arterial region, below the second lumbar vertebrae, abdominal aortic aneurysms are typically located. Over time, as the atheromatous material is laid down in the lumen, calcium may be deposited. This may appear on an abdominal radiograph, and can be identified, often incidentally, by giving a rough indication of the internal diameter. An abdominal ultrasound scan should immediately follow for accurate assessment, and to determine the timing of surgery or observational follow up.

**Gynaecological calcification**

The final structure in this section is found only in women—fibroids. These can become calcified and appear as rounded structures of varying size and location in the pelvis (fig 6).

**Pathological calcification**

The final section on calcification on abdominal x-ray film refers to pathological calcification. This almost exclusively manifests as calculi in various locations. Calculi may be asymptomatic.

**Biliary calculi**

Biliary calculi are commonly referred to as gallstones. Plain abdominal x-ray film in itself is poor at identifying these calculi and detects only 10-20%. Ultrasound is the gold standard for first line imaging. A plain abdominal radiograph is often the initial investigation in patients with abdominal pain and may identify these laminated, faceted, often multiple, radiopaque structures in the right upper quadrant of the radiograph (fig 7). Very rarely a large calculus may erode into the gallbladder wall, creating a fistula to the adjacent small bowel. This calculus may then pass along the intestinal tract until it cannot travel any further, usually in the distal ileum a little proximal to the ileocaecal valve, and cause an obstruction of the small bowel (see part 2 of this series). Gas may also be seen in the biliary tree on the abdominal radiograph (see part 3 of this series). This phenomenon is termed a gallstone ileus. In the right upper quadrant the wall of the gallbladder itself may
become calcified after repeat incidences of cholecystitis—this is termed a porcelain gallbladder (fig 8). A significant relation (20%) exists between this and the development of gallbladder malignancy.

Renal calculi
These are much more commonly identified on the abdominal radiograph; up to 80% are visible. The variable detection is a result of the different degree of radio-opacity, which, in turn, is dependent on the composition of the calculus. Renal calculi may also vary greatly in size, the largest being a “staghorn” calculus. They are, however, usually smaller but found on the well defined pathway of the urinary tract and seen by looking down the transverse processes of the vertebrae, across the sacroiliac joint to the level of the ischial spine. It is also worth noting that calculi tend to obstruct at some favoured locations, which include the pelviureteric, brim of the pelvis, and vesicoureteric junctions.

Appendix and bladder
In the region of the right iliac fossa, a small calcified, round radio-opacity may well be an appendicolith. These are seen in 15% of appendicitis. In the pelvic region of the abdominal x ray film bladder calculi may be seen, but less commonly than biliary or renal calculi. Bladder stones are usually quite large and often multiple. Calcification of a bladder tumour may also occur.

A final mention goes to the teratoma, a type of tumour derived from the primitive germ cell lines, which occurs in the ovaries and testes. In some instances teeth may develop from the ectoderm layer; as they are highly calcified they will appear on the radiograph and are easily identified as they look tooth shaped (fig 9).

The next part of this series looks at bones and soft tissue findings on abdominal x ray films.

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Neurodegenerative terms

β-Amyloid: β-Amyloid protein causes problems only when it is converted from its normal soluble form to insoluble β-pleated sheets, which accumulate into neurotoxic amyloid plaques. In its healthy role it is probably involved in stabilising cell walls.

Prions: These are proteins produced by the prion gene and probably have a role in maintaining the electrical activity of cells. In Creutzfeldt-Jakob disease, the normal soluble form changes its configuration by folding up differently, allowing it to form insoluble β-pleated sheet structures. The protein forms prion plaques that are neurotoxic. The pathological changes are transmissible.

α-Synuclein: This protein is found in Parkinson’s disease and dementia with Lewy bodies. Its role in the normal state is unclear. In pathological states this protein forms intraneuronal inclusions (Lewy bodies).

Tau: This protein is found in the microtubules of nerve cells, and its role is to help stabilise them. The role of microtubules is to transport cellular components. In Alzheimer’s disease, tau protein becomes hyperphosphorylated and then accumulates into neurofibrillary tangles that disrupt the microtubules. In frontal lobe dementias the balance of different forms of tau protein change, interfering with transportation in the cells.

Parkin: A second protein found in Lewy bodies and implicated in Parkinson’s disease.

Ubiquitin: Ubiquitin is associated with proteins that are about to break down. Their usual function is probably to protect proteins. In many dementias an accumulation of ubiquitinated proteins is found—for example, in Lewy bodies.

Glutamine repeats: These are additional repeats of the amino acid glutamine, which when joined to proteins, increase the risk of soluble proteins folding into insoluble β-pleated sheets. They are commonly found on huntingtin, the abnormal protein found in Huntington’s disease.

Neuroserpinopathies: Neuroserpin is a protein that is precipitated out to form insoluble inclusions in nerve cells, eventually causing cell death. Familial encephalopathies with neuroserpin inclusion bodies are rare but have been identified in a small number of families.

Superoxide dismutase 1: This is a natural human antioxidant enzyme that clears free radicals from the brain, maintaining the health of cell membranes.

Abi Berger BMJ
Abdominal x rays made easy: bones and soft tissues

In the fifth article in their series on how to read plain abdominal x ray films, Ian Bickle and Barry Kelly discuss inspecting bones and soft tissues and interpreting the findings.

Often, little attention is paid to bones and soft tissues when reviewing an abdominal x ray film. However, careful inspection may find new, associated, or longstanding concomitant pathology. With concomitant pathology two abnormalities are identified but have no direct association—for example, an abdominal aortic aneurysm and a fracture of the femoral neck. So including bone and soft tissues as part of a systematic review ensures that no significant findings are overlooked (box 1).

Box 1: Interpreting an abdominal x ray film (a reminder)

- Technical specifics
- Amount and distribution of intraluminal gas
- Extraluminal gas
- Calcification
- Bone and soft tissues
- Iatrogenic, accidental, and incidental objects

Let’s begin by reminding ourselves of the bones and soft tissues shown on an abdominal x ray film.

Anatomy

Bones include the lower ribs and their articulations, the lower thoracic and the lumbar spine, the bony pelvis, and the proximal femora. Soft tissues include the abdominal viscera and the surrounding muscle and soft tissues that envelop the lower trunk.

Pathology of the bone and soft tissues can be identified on abdominal x ray film for three main reasons: it may be new pathology, causing the symptoms that precipitated the abdominal x ray film, associated pathology, or concomitant pathology.

Bones

Bony pathology may be divided into local and generalised disease (box 2).

Box 2: Bony pathology

Generalised osteoporosis (seen as osteopenia)
Paget’s disease
Metastatic deposits (sclerotic and lytic)
Osteoarthritis
Fractures
Ankylosing spondylitis
Generalised bone pathology

Osteoporosis can be identified as osteopenia when at least 15% of bone mass has been lost. It is commonly seen in the vertebral bodies, often coincidentally, in otherwise symptomless, postmenopausal women who are being investigated for other reasons. Its manifestation may also be as a vertebral wedge ("crush") fracture, leading to scoliosis and kyphosis see fig 1 (also see this month's Minerva picture, p 352).

Similarly, Paget's disease affects almost exclusively elderly people. In the spine, there is usually involvement of the vertebral body with coarsening and thickening of the trabeculae, bony enlargement, and sometimes an "ivory vertebra" (uniformly white, without contours). Another common site is the iliopectineal line of the pelvis (fig 1).

Localised bone pathology

Localised Paget's disease may be difficult to distinguish from sclerotic metastases. A useful clue is that Paget's disease typically extends to the end of the bone whereas metastases are more randomly distributed. Sclerotic metastases are typical of prostatic carcinoma or lymphoma. Metastases are, however, more commonly lytic. These are destructive lesions; seen as areas of bony radiolucency, which appear as "dark" areas within a bone.

The term "lucent" or "lucency" is used to describe a focal area of bony osteopenia—for example, a bone cyst. The term "lytic" however implies a lucent lesion that appears infiltrative—for example, metastases or osteomyelitis. A lytic bony metastasis classically presents as an absent pedicle on the anterior view, the metastasis having destroyed the pedicle.

Metastases are one of the causes of fractures seen on abdominal x ray film. Fractures may be recent (and may be the immediate cause for the assessment) or old. Vertebral, femoral neck, rib, and pelvic fractures feature on the abdominal x ray film and may have relevance to other features on the film.

Primary bone disease seen on abdominal x ray film is usually a coincidental finding, often already recognised and cared for by other hospital specialists. In elderly people, osteoarthritis of both the spine and the femoral head are found often. Osteoarthritis of the femoral head has several well recognised radiographic features (box 3).

Box 3: Radiographic features of osteoarthritis of the hip

- Loss of joint space
- Osteophyte formation
- Subchondral sclerosis
- Bone cysts

In younger patients, ankylosing spondylitis may affect the spine and the pelvis. Fusion of the sacroiliac joints precedes spinal involvement. This latter feature is described classically on radiographs as a bamboo spine, with evidence of syndesmophyte formation and calcification of the longitudinal spine ligaments (see Figs 2 and 3).
Soft tissues

The yield of positive radiographic findings involving the soft tissues is less than for bone. Calcification involving soft tissue structures was discussed in an earlier part of this series. Alteration in size and shape of solid organs, such as the kidneys (box 4), liver, and spleen can be observed, as may the loss of their properitoneal fat lines. Furthermore, the loss of the psoas muscle shadows may indicate intraperitoneal disease (see Fig 4).

Box 4: An illustrated case

Renal carcinoma with bony metastases

A school caretaker aged 58 years presented complaining of a three week history of blood in his urine and loin pain. He also admitted to noting a drop in his weight in the region of 5 kg over the past three months. He had experienced no recent trauma or previous medical history of note.

On examination, a mass was palpable in the right loin with an area of overlying tenderness. A 2 cm hepatic margin was also noted. The rest of the examination did not show any abnormal findings. The casualty officer had ordered a supine abdominal X-ray film.

During a quiet moment you inspect the radiograph and note the presence of an irregular tissue mass measuring 13 X 10 cm on the right side, lateral to the vertebral column. Some adjacent displacement of bowel is visible. Continuing to inspect the film fully you notice a lytic lesion in the region of the T12 vertebra that seems to have destroyed the pedicle.

You are suspicious of a sinister renal mass so request an urgent ultrasound scan of the abdomen. The radiologist subsequently phones the ward and reports the presence of a solid, irregular mass in the right kidney, which extends to the right renal vein, reducing its patency. A radiologically guided biopsy confirmed your suspicions, diagnosing a renal cell carcinoma.
Abdominal x rays made easy: iatrogenic, accidental, and incidental objects

In the final part of this series, Ian Bickle and Barry Kelly look at some of the more unusual findings on an abdominal x ray film.

In the final part of our series we will focus on iatrogenic, accidental, and incidental objects seen on abdominal x ray films. These artefacts may be placed inside the body (internal) or be about the person (external). Internal objects may have been placed with intention by a health professional or temporarily by the individual concerned. Intentionally placed internal objects may have required surgery or been inserted through one of the body's natural orifices (mouth, vagina, anus). Incidental objects are those that become projected on to the radiograph.

**Iatrogenic objects**
These are placed intentionally by a health professional.

A wide range of medical devices appear on the abdominal x ray film, and many have been placed by radiologists themselves. On some occasions a radiograph's sole purpose is to confirm the position of an object, such as a tube device, most commonly the nasogastric tube (figure 1). These are the most commonly found iatrogenic objects, and their position is sometimes confirmed by a chest x ray film.

Other devices may be in the vascular, hepatopancreatobiliary, gastrointestinal, and

### Internal objects
- Iatrogenic
- Biliary or vascular stent
- Intrauterine coil devices
- Sterilisation clips
- Surgical clips
- Greenfield filter (inside inferior vena cava)
- Percutaneous endoscopic gastrostomy tube
- Nasogastric tube
- Accidental
- Swallowed objects: razor blades, batteries, paper clips
- Objects placed inside rectum or vagina: caps, bottles, vibrator

### External objects
- Incidental
- Stoma ring
- Objects in clothing: coins, keys, comb
- Objects on clothing: buttons, clips, zips
Evidence of vascular intervention may be seen in the form of arterial stents and the placement of filters in the venous system—for example, the Greenfield filter placed in the inferior vena cava, which is used to prevent recurrent pulmonary emboli.

The hepatopancreatobiliary system is also routinely stented, often for palliative relief of obstructive jaundice secondary to neoplasm. The stenting is performed either by radiological percutaneous transhepatic cholangiography (PTC) or by endoscopic retrograde cholangiopancreatography (ERCP).

A percutaneous endoscopic gastrostomy (PEG) tube may also be seen on an abdominal x-ray film.

In women, intrauterine coil devices and sterilisation clips are readily seen in the lower half of the abdominal x-ray film within the pelvis (figure 2). Tampons may also appear as tubular gaseous densities within the pelvis and should not be confused with anything more sinister.

**Incidental objects**

These objects seen on an abdominal x-ray films usually do not affect the wellbeing of the patient. These objects are external; they are either attached to the patient’s body or contained on or inside the patient’s clothes. Attached objects may indicate medical conditions, such as a stoma ring (figure 3) or represent body art, such as a navel ring (figure 4). Other incidental objects can be part of people’s clothing, such as buttons, zips, clips, or brooches.

Alternatively, the projected objects are inside a patient’s clothing—in the case of the abdominal x-ray film, usually a trouser pocket that has not be emptied before a film is taken. These can be metallic objects such as coins, paper clips, and keys, or other dense objects such as a comb.

**Accidental objects**

These are objects that have been placed in the body by the individual concerned. The object then either remains in place and becomes immovable or progresses further through the gastrointestinal tract and becomes lodged. Distinction can be made between objects swallowed or objects placed in the rectal or vaginal orifices. On occasion these objects may be retained foreign bodies, such as a knife after a stabbing (figure 5).

Swallowed objects may be ingested intentionally or by misfortune. They usually travel through the gastrointestinal tract, but on occasion they become lodged. Razor blades, batteries, coins, paper clips, and small toys are just a few of the potential objects (figure 6). Three chief groups of patients fall into this category—patients with psychiatric illness, children, and drug smugglers.

Per rectum (PR) objects, such as bottles, vibrators, and light bulbs, are almost always placed inside the rectum for sexual purposes, only to become retained, requiring medical attention for extraction (figure 7).

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*Figure 3 (top): stoma ring, figure 4 (above): navel ring, and figure 5 (below): a knife in the abdomen*

*Figure 6: swallowed objects (3 cigarette lighters)*

*Figure 7: a bottle per rectum*