Interpreting Chest X-Rays

Stephen Ellis

Radiological imaging is now accessible to a wide range of healthcare workers, many of whom are increasingly taking on extended roles. This book will equip all healthcare professionals, including medical students, chest physicians, radiographers and radiologists, with the techniques and knowledge required to interpret plain chest radiographs.

It is not an exhaustive text, but concentrates on interpretive skills and pattern recognition – these help the reader to understand the pitfalls and spot the clues that will allow them to correctly interpret the chest X-rays they will encounter in their daily practice.

The book features over 300 high quality images, along with a range of case story images designed to enable readers to test and develop their interpretation skills.

Interpreting Chest X-Rays is a handy ready reference that will help you to avoid making errors interpreting CXRs and decide for example:

- if a temporary pacing wire has been inserted correctly
- whether the shadows you can see are real abnormalities
- if all chest tubes and lines are located appropriately in an ITU patient
- what further imaging may assist interpretation of an apparent abnormality
- whether a post-surgical chest is significantly abnormal
- what organism might be causing an infection
- why a patient is short of breath
- whether patient positioning accounts for an abnormal appearance of a CXR
- what impact radiographic technique has had on the appearance of pathology
Interpreting Chest X-Rays
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A silhouette is the outline of an object defined by the shadow it casts. In terms of a CXR, the silhouette sign is based on the same concept except that X-rays, to which soft tissues are translucent rather than opaque, replace light. The formation of a silhouette on a CXR depends on two tissues of sufficiently different density lying against each other in such a way that two adjacent X-rays will pass through one, or the other, but not both tissues. In this way, when the adjacent X-rays reach the film / detector they will generate different shades of grey, which, if sufficiently different will be discernable (see Fig. 4.1). This is the principle that underlies all plain X-rays, but in the chest it is particularly important as aerated lung, which absorbs hardly any X-rays, generates excellent silhouettes (Fig. 4.1). Unfortunately, the contrast resolution of plain radiography is such that silhouettes are only formed by bone, soft tissue, fat and aerated lung. Note that vessels, lymph nodes, muscle, fluid, and connective tissue are all of soft tissue density and are therefore of the same density on plain X-rays (Fig. 4.2).

The loss of the normal silhouettes on a CXR results from an increase in density of the adjacent lower density tissue; on a CXR this is usually aerated lung adjacent to a soft tissue structure, indicating a pathological process. Knowing the anatomy of the silhouettes not only allows the recognition of pathology but also aids localisation of that pathology.

Figure 4.1. Silhouette CXR.
The axial CT image at the level of the aortic arch is projected in perspective over a CXR and the shaded lines match the air—soft tissue interfaces to the silhouettes they form.
Another reason for not seeing an interface between two tissues of sufficiently different density on CXR is because the orientation of the interface is not in line with the incident X-rays (Fig. 4.3).

Perhaps the most important silhouettes on the CXR tend not to be described as such. The density of blood-filled vessels is not great, but is sufficiently different to aerated lung to render all but the very peripheral vessels visible. Indeed, when the bronchi become too small to be seen and the normal lung interstitium is too fine to be seen, the vessels are the only indication of the presence of lung for the majority of the CXR. As a result, it is the appearance of the vessels that gives the most immediate indication of lung pathology.

Figure 4.2. Interfaces.
This is a normal CXR with a few areas highlighted and magnified to demonstrate examples of the various soft tissue interfaces visible on a CXR:

- soft tissue / aerated lung — solid black arrows
- soft tissue / air — solid white arrow (contour of the breast)
- soft tissue / bone — open black arrow
- soft tissue / fat — open white arrow
Figure 4.3. Pleural based lesions on CXR and CT. These are the (a) CXR and (b) CT images of two pleural based lesions. Due to the curvature of the chest wall only the medial margins of the lesions cast a silhouette (arrows); the remainder of the margins are in the wrong orientation to form a silhouette.
4.2 Suggested scheme for CXR viewing

The following scheme suggests a systematic way of viewing a CXR that is not determined by anatomical boundaries. If you develop your own scheme bear in mind the potential pitfalls detailed here.

1. Check the name and date of the film.
2. Is the film the correct way round (side marker)?
3. Is the film PA or AP (assume PA if no alternative indicated on the CXR)?
4. Is the subject erect, semi-erect or supine (AP erect is, in reality, semi-erect)?

Begin in the top left-hand corner of the film (patient’s right shoulder) and then use the following systematic scanning approach:

A. Scan from left to right and back again (Fig. 4.4).
B. Scan from top left to bottom left (Fig. 4.5).
C. Move to under the right diaphragm and scan up to the right apex (Fig. 4.6).
D. From the right apex scan down the right mediastinal contour (Fig. 4.7).
E. Scan up the centre of the film (Fig. 4.8).
F. Scan down the left mediastinal contour (Fig. 4.9).
G. Move to under the left hemi-diaphragm (the gastric fundus and the spleen reside here) and scan up to the left apex (Fig. 4.10).
H. Move to the left shoulder and scan down the left periphery of the chest (Fig. 4.11).
I. Finally compare the lung parenchyma left to right in the upper, mid and lower zones (Fig. 4.12).

This scheme is easy to follow and encourages interpretation of the CXR unhindered by the bias created by a snapshot impression.

Figure 4.4. Scan from left to right and back again. Check the soft tissues and bones of the shoulder girdle (clavicles, scapulae) and neck; are there any bony lesions (fractures, deposits, cervical ribs, joint abnormalities, etc.) or soft tissue masses? Is the trachea normal (position, calibre)? Compare the apices of the lung; are they the same density? Return to the top left-hand corner repeating the above observations.
4.2 SUGGESTED SCHEME FOR CXR VIEWING

Figure 4.5. Scan from top left to bottom left.
Check the soft tissues of the chest wall, the lateral aspect of the ribs, the peripheral lung, pleura and costophrenic angle.

Figure 4.6. Move to under the right diaphragm and scan up to the right apex.
Check behind the diaphragm as there is enough space here to ‘hide’ a 7–8 cm tumour. Observe the parenchyma of the right lung: are the vessels visible and of normal calibre? If the vessels are obscured that suggests abnormal opacity in the adjacent lung.
Figure 4.7. From the right apex scan down the right mediastinal contour.
The right paratracheal stripe should be visible. Is the mediastinal contour visible? Check the position of the hilar point: this should be at the level of the lateral extent of the right 6th rib. End at the right cardiophrenic angle, which is where the inferior vena cava lies.

Figure 4.8. Scan up the centre of the film.
Note the structures that should be visible behind the heart, particularly the spine, paraspinal region and azygo-oesophageal line (often overlooked). Is the mediastinum central, the carina normal, and the trachea normal in position and calibre?
4.2 SUGGESTED SCHEME FOR CXR VIEWING

Figure 4.9. Scan down the left mediastinal contour.
Check the aortic knuckle, aorto-pulmonary window, the left hilar point (1–1.5 cm higher than the right hilar point), and the left contour of the heart (pulmonary outflow tract, left atrial appendage and left ventricle). End at the left cardiophrenic angle.

Figure 4.10. Move to under the left hemidiaphragm, and scan up to the left apex.
Scan up the film looking at the lung parenchyma ending in the left apex. Under the diaphragm are the gastric fundus and the spleen.
Figure 4.11. Scan from the left shoulder, scan down the left periphery of the chest. Concentrate on the peripheral lung, ribs and soft tissues of the chest wall.

Figure 4.12. Compare the lung parenchyma left to right in the upper, mid and lower zones.

Comparison of the two lung fields can be performed by switching your gaze from one to the other rapidly, but this relies on immediate visual memory and is susceptible to the errors outlined in the section on the eye–brain apparatus (see Section 3.7). By developing a technique whereby you centre your gaze on the mediastinum, but concentrate your perception on both lungs simultaneously, you are utilizing the area of your retina surrounding the fovea; this area contains the greatest density of rods designed to detect contrast differences which are ideal for this type of comparison. Colour perception is irrelevant when viewing a plain film.
4.3 Review areas

In the ‘busy’ or obscured areas of the CXR an abnormality can easily be missed; these areas warrant a second look and are termed review areas (see Fig. 4.13). In the following section the various review areas are highlighted and the typical abnormalities and structures potentially hidden in these areas are demonstrated.

4.3.1 The apices

The apices of the lung are obscured by overlying first rib and clavicle causing an increase in the density of the area at the expense of clarity in the low density aerated lung. In addition, at the extreme apex it is not unusual to have a ‘cap’ of pleural thickening that is of no clinical significance.

The best way to approach the apices is by comparing the density of the two sides; if there is a difference in opacity, can this be explained by the overlying ribs?

If a parenchymal abnormality is suspected, in the first instance a lordotic view should be performed whereby the angle of the incident X-rays is altered; for a PA film the X-rays are angled downwards and for an AP film upwards (see Figs 4.14 and 4.15).
The magnified area on this PA film (a) raises the possibility of a cavitating lesion in the right apex (open black arrow). The index of suspicion is low as there are numerous overlapping structures in this region so CT scanning would seem to be overzealous. On the lordotic view (b) the relevant area of lung is confirmed as clear.
4.3 REVIEW AREAS

4.3.2 The thoracic inlet

The only structure readily seen at the thoracic inlet is the trachea as it contains air; the oesophagus may be visualized, but air found that high up in the oesophagus would normally only be a transient finding. Most of the vessels in the superior mediastinum are not readily seen, because the interfaces between them and the aerated lung in the apices are at the wrong orientation to be seen on a frontal CXR (Fig. 4.16); the SVC in particular, and sometimes the left subclavian artery, are only discernable below the sternal notch (Fig. 4.17).

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Figure 4.15. (a) Standard PA film and (b) lordotic view.
The initial PA CXR (a) demonstrates subtle differences between the two apices; the open white arrow in the magnified region highlights a possible lung parenchymal lesion. A subsequent lordotic view (b) projects the first rib and clavicle cranially leaving the lesion readily identifiable.
Figure 4.16. Thoracic inlet.
This is a normal CXR with the thoracic inlet magnified. Note that the left subclavian artery may form a silhouette (open white arrow), but the other superior mediastinal contours, particularly above the sternal notch, are at the wrong orientation to form a silhouette on a frontal chest radiograph (white arrows).

Figure 4.17. Arch vessels.
Limited view of the upper mediastinum with a projection of part of an axial CT scan at that level. The shading identifies the interfaces between aerated lung and the SVC (white arrow) and left subclavian artery (open white arrow); the margins of the trachea are also shaded.
The trachea may be narrowed due to intrinsic disease or external compression, or deviated due to an external mass (most commonly a goitre; Figs 4.18 and 4.19). Note that only the coronal diameter is appreciated on a frontal CXR and that a significant compression in the sagittal plane, as may be caused by a retrosternal goitre, can only be seen on a lateral view of the thoracic inlet. Care should be taken not to confuse the false cords as pathological tracheal stenosis; false cords represent a normal narrowing of the trachea just inferior to the larynx that is often visible during the valsalva manoeuvre, encouraged by the command ‘breathe in and hold your breath’ (see Fig. 4.20).

Figure 4.18. Goitre.
Frontal CXR of an adult female with a goitre. Note the deviation of the trachea (open black arrow) and the lateral margin of the enlarged thyroid causing a silhouette with adjacent aerated lung (open white arrow).
Figure 4.19. Large goitre.
Frontal CXR of an adult with a very large goitre, the lateral margins of which are seen (white arrows). This goitre encases the trachea and therefore causes narrowing (black arrow) rather than deviation.

Figure 4.20. False cords.
This is an AP portable CXR. Note the narrowing of the trachea in the magnified area (open white arrow); this is the false cords and should not be confused with pathology.
4.3.3 Overlying the scapulae

Ideally the scapulae should be projected off the chest but this is often not the case. As a result, the upper lateral regions of the lung on a CXR are of increased density due to superimposed scapulae. As you become familiar with viewing CXRs you will expect some increased opacity in this region and therefore a subtle real abnormality such as a soft tissue nodule unrelated to the scapulae can easily be overlooked (Fig. 4.21).

4.3.4 Costophrenic angles

The costophrenic angle should be ‘sharp’, i.e. the diaphragm should form an acute angle with the chest wall. ‘Blunting’ of the costophrenic angle indicates that there is soft tissue or fluid where the lowest limits of the lung should be; this is usually due to pleural fluid or thickening (Fig. 4.22). Caution should be taken when the lungs are of large volume causing flattening of the hemi-diaphragms; in such cases blunting of the costophrenic angles may be due to the diaphragmatic slips becoming visible, because the normally quite deep lateral pleural recess is exposed by over-expanded lung (Fig. 4.23).

The area of lung seen at the costophrenic angle is the most peripheral gravity-dependent region. In circumstances where excess fluid is accumulating in the lung it tends to accumulate between the secondary pulmonary lobules. The secondary pulmonary lobule is a defined unit of lung that is polygonal in shape and each is supplied by its own respiratory bronchiole. The lung consists of many such lobules of varying size fitted together like a 3-D jigsaw. Where these lobules contact each other is termed the interlobular septum. These septa are not usually visible on a CXR, but if they become thickened due to accumulation of fluid (e.g. in left heart failure, or lymphangitis carcinomatosa) they may be seen, but only when in the correct orientation to the incident X-ray (Fig. 4.24). These thickened septal lines are best appreciated at the costophrenic angles where there are numerous septa in line with the X-ray beam but no normal vascular structures visible to obscure them.
Figure 4.22. Subtle pneumothorax.
This is the frontal CXR of a young man with a spontaneous pneumothorax. Note the blunting of the left costophrenic angle (black arrow) due to the accumulation of the pleural fluid at the base rather than being normally distributed over the surface of the lung. The lung edge can be discerned by careful scrutiny (white arrows). In the context of sudden onset chest pain, with a unilateral blunting of the costophrenic angle, a spontaneous pneumothorax should be excluded.

Figure 4.23. COPD.
This is the frontal CXR of a patient with chronic airway disease. Due to the over-expansion of the lungs, the diaphragms are flattened and the diaphragmatic slips give the appearance of small bilateral effusions. There are also bilateral calcified plaques in this patient indicating a previous exposure to asbestos.
4.3.5 Under the hemi-diaphragms

A large amount of aerated lung is projected behind the hemi-diaphragms which tend to peak anteriorly; note the margin of the hemi-diaphragm giving rise to the diaphragmatic silhouette also lies anterior to the midline (see Fig. 2.2). High kV and, in particular, digital CXRs display a significant amount of this ‘hidden’ lung tissue and these areas are worth a second look as review areas.

Lucency beneath the hemi-diaphragms indicates gas, either free or in the bowel. Gas in the bowel outlines the inner wall of the intestines and usually has curved margins in keeping with the internal contour of tubular structures. On the left the fundus of the stomach and sometimes the splenic flexure of the colon lie beneath the hemi-diaphragm. On the right the liver usually occupies the sub-diaphragmatic space, but in some individuals there is interposition of the hepatic flexure of the colon so that gas under the right hemi-diaphragm may still be a normal finding. Free gas lies between the normal abdominal viscera of the abdomen and tends to form sharp margins (Figs 4.25 and 4.26).

If the CXR findings are uncertain, then a lateral decubitus AXR view should resolve the issue; the free gas will travel to the least dependent area, i.e. the upper most lateral margin of the abdomen, and it is readily appreciated there. Similarly, a supine CXR will fail to identify free sub-diaphragmatic gas because the free gas will accumulate under the anterior abdominal wall.
4.3.6 Behind the heart

Thoracic spine
On a well taken CXR the thoracic spine should be visible, superimposed on the mediastinal shadow. On a CXR where the spine is not visible the exposure is insufficient and the CXR should be viewed with caution because a significant portion of the thorax has not been adequately visualized.

Vertebral height and alignment of the thoracic spine may be appreciated on a CXR, particularly end plate changes (Fig. 4.27), scoliosis (see Fig. 6.2), even ankylosis (Fig. 4.28). Loss of vertebral height in the mid...
and upper thoracic spine may be difficult to detect as the thoracic spine is kyphotic and therefore most of the vertebral bodies in this part of the thoracic spine are not in line with the X-rays. Nevertheless, vertebral height in the lower thoracic spine, behind the heart, may be determined and should not be ignored.

A clue to spinal pathology may be the presence of extra paraspinal soft tissue, either haematoma secondary to trauma, or as a result of an infectious or neoplastic process (Fig. 4.29).
Figure 4.29. Spinal metastases.
Frontal CXR on a patient with metastatic cancer. There are metastases in the upper thoracic spine best seen on the MRI insert (white arrow) causing paraspinal soft tissue density on the CXR (open white arrow) Note the preservation of the right para-tracheal stripe indicating that the abnormality lies posteriorly.

**Descending aorta**
The lateral contour of the descending aorta is adjacent to aerated lung and therefore can be seen projected behind the heart, but the medial border is not appreciated on CXR (Fig. 4.30), and therefore the calibre of the descending aorta is not readily appreciated unless markedly abnormal (Fig. 4.31). A tortuous descending aorta is a far more common cause of a deviated lateral margin of the descending aorta than an aneurysm (Fig. 4.32).
### Figure 4.31. Descending aortic aneurysm.
Frontal CXR demonstrating a large descending aortic aneurysm; note that the preservation of the left heart border and hilar point localize this soft tissue to the posterior chest. The contour of the descending aorta is markedly displaced (white arrows); a clue to this being aneurysmal rather than unfolding is the increase in diameter of the arch.

![Descending aortic aneurysm](image1)

### Figure 4.32. Unfolded aorta.
Frontal CXR demonstrating an unfolded aorta. Some of the margins of this are marked (open black arrows). Note that, unlike the aneurysm in Fig. 4.31, the left contour of the descending aorta remains close enough to the likely position of the right margin of the aorta to retain a more normal calibre. Also, the lateral contour of the aorta does not extend upwards from the arch as it did with the aneurysm in Fig. 4.31.

![Unfolded aorta](image2)
Oesophagus
The oesophagus is not normally seen on a CXR but may become visible if it contains air (Fig. 4.33) or is abnormally dilated as in achalasia (Fig. 4.34). When the stomach protrudes into the mediastinum, a hiatus hernia, it occupies a region of the mediastinum usually occupied only by the oesophagus and therefore, even when small, it is likely to abut adjacent aerated lung, forming a line that is visible on a CXR. In addition, there is often air and fluid in the stomach and an air–fluid level may be seen: a horizontal line separating an area of low density above (air) from an area of high density below (fluid), provided the CXR is taken with the patient erect (Fig. 4.35). Note that the air–fluid level will only be apparent when the air–fluid interface is in line with the X-ray beam, hence the necessity for the CXR to be erect so that the incident X-rays are horizontal in orientation (see later). Furthermore, if there is solid material in the hiatus hernia there may be no air–fluid level to see (Fig. 4.36).

Figure 4.33. Free gas in oesophagus from a burp.
Frontal CXR on a patient that has had mitral (small black arrow), tricuspid (large black arrow) and aortic valve (open black arrow) replacements. The oesophagus is readily identified filled with air (white arrow) but the appearance did not persist as would be expected if the cause was oesophageal dilatation and the patient has probably just burped as the CXR was taken. In addition there is free sub-diaphragmatic gas (open white arrow).
Figure 4.34. Achalasia.
Frontal CXR with a barium swallow insert. Note, in the upper magnified area, the wall of the oesophagus (white arrow) is seen separate to the right tracheal wall (open black arrow). In the lower magnified area the dilated oesophagus is again noted, and the lateral wall is marked by the black arrow. The barium swallow confirms the markedly dilated oesophagus in this case due to achalasia.

Figure 4.35. Hiatus hernia with air–fluid level shown.
Frontal CXR showing a hiatus hernia. Note the lateral margins of the hernia (white arrows) and the air–fluid level (black arrow).
**Azygo-oesophageal line**

The azygo-oesophageal line is formed by the interface between the azygos and/or the right side of the oesophagus and adjacent aerated lung (Fig. 4.37); it ascends vertically, overlying the vertebral bodies (the spinous processes can cause confusion), and then arches to the patient’s right as the azygos vein passes over the right main bronchus to drain into the superior vena cava. The line does not extend above the carina. If the azygo-oesophageal line is seen, and this is not always the case, then bulging or loss of the line indicates sub-carinal pathology, usually lymphadenopathy (Figs 4.38 and 4.39).
4.3 REVIEW AREAS

Figure 4.37. Azygo-oesophageal line.
Frontal CXR demonstrating the azygo-oesophageal line (black arrows). The soft tissue / aerated lung interface giving rise to the line is marked on the CT image in Fig. 4.30.

Figure 4.38. Sub-carinal adenopathy.
Frontal CXR showing sub-carinal adenopathy causing bulging of the azygo-oesophageal line (open black arrow).
4.3.7 Hidden lung

Approximately 30% of the left lower lobe (LLL) is projected behind the heart; a lesser proportion of the right lower lobe (RLL) is obscured by the heart, but still sufficient to ‘hide’ sizeable abnormalities (Fig. 4.40). In addition there is a significant amount of lung hidden behind the hemi-diaphragms (Fig. 4.41). As elsewhere in the chest, the parenchymal vessels are visible, but care must be taken not to overlook any abnormality in this part of the lung; the general increase in density due to the heart reduces the observer’s sensitivity for detecting abnormal densities (Fig. 4.42). Particular mention must be made of LLL collapse, which is dealt with in detail in Section 5.1.5.
Figure 4.40. Carcinoid behind heart CXR.
Frontal (a) and lateral (b) CXRs demonstrating a subtle mass behind the heart. The lateral margin is marked with a black arrow, and the white arrow marks the right heart border. Note the difference in density between the right heart and left heart. On the lateral view (b) and the CT inset, the posterior margin of the carcinoid is marked (white arrow). Note the calcification (open black arrow) often found in carcinoid tumours.
Figure 4.41. Deposit behind diaphragm.
There is a 2.5 cm metastatic deposit behind the right hemi-diaphragm (open black arrow).

Figure 4.42. Unmarked hidden mass.
Take a look at this CXR. Now you have been sensitized to detecting masses in the hidden areas of the lung, can you identify the 4–5 cm mass on this CXR? The answer is in Fig. 4.43.
4.3 REVIEW AREAS

Figure 4.43. (a) Marked hidden mass and (b) same mass shown on a CT with coronal overlay.

This is a tricky one with the heart and left hemi-diaphragm obscuring what is actually a large mass (black arrows). (b) has an inset demonstrating the mass on an axial CT image and there is a coronal overlay to localize the mass on the CXR.
4.3.8 The cardiophrenic angles

The cardiophrenic angles form at the point where the heart shadow meets the diaphragms. The angle made by the heart and diaphragms at the cardiophrenic angles is acute in nature but blunted by the cardiac fat pads. As a result, the density in this region is in between aerated lung and soft tissue and can confuse the eye. It gives the impression of an abnormality that doesn’t exist by ‘blurring’ the silhouette of the heart (Fig. 4.44), or obscuring a real abnormality as, with experience, the viewer will come to accept a slightly abnormal appearance in this region (Fig. 4.45).

When prominent, a fat pad can be difficult to discard unless previous imaging confirms that it is a consistent feature.

Figure 4.44. Fat pad.
Frontal CXR of an adult. At first glance the left heart border, although well defined at the left atrial appendage (open black arrow), becomes indistinct suggesting adjacent lingula pathology. In the absence of previous imaging, a limited CT was performed (inset image) which confirms the appearance is due to a prominent fat pad (open white arrow).

Figure 4.45. Cardiophrenic angle.
There is a 3 cm lesion in the region of the left cardiophrenic angle (open black arrow). Note the increased density has defined margins superiorly and medially that would not occur if due to a fat pad.
4.4 Pitfalls

4.4.1 Pseudo-pneumothorax

Any line that follows the contour of the chest wall may give the impression of a lung edge, implying the presence of a pneumothorax. Two instances to be aware of are the linear pleural thickening resulting from a previous chest drain (see Fig. 4.46), and AP mobile CXRs (see Fig. 4.47) which are taken with the patient lying against the X-ray plate to hold it in position. In the case of the AP film, the skin of the back may fold generating an air / soft tissue interface that subsequently appears on the CXR and mimics the lung edge seen in a pneumothorax (Fig. 4.46). Unlike a true pneumothorax, there will be lung markings visible beyond the apparent lung edge of a pseudo-pneumothorax.

Figure 4.46. Pseudo-pneumothorax from chest drain.
Images from two CXRs combined. The right-hand image demonstrates a curvilinear line mimicking a lung edge (open white arrow). The cause is evident from the position of the in situ chest drain (white arrow) in the left-hand image. Note that there was a pneumothorax originally and the surgical emphysema can be seen on the left-hand image (black arrow).

Figure 4.47. Pseudo-pneumothorax on a mobile AP film.
A mobile AP film demonstrating an apparent lung edge (open black arrow), but note that there are vessels beyond it. The edge is actually formed by a fold of skin on the patient’s back as the patient is sitting semi-erect and the film cassette is against his back.
4.4.2 Patient rotation

The presence or absence of rotation is determined by comparing the projection of the spinous processes between the anterior ends of the clavicles. Rotation occurs around a central axis to which the clavicles are anterior and the spinous processes are posterior. Therefore, if the patient is rotated to the right the clavicle heads move to the right and the spinous processes to the left. On a properly centred CXR the spinous process will be projected equidistant between the anterior ends of the clavicles; rotation will result in the distance between the spinous process and the anterior ends of the clavicle being unequal, with the greater distance on the side to which the patient is rotated (Fig. 4.48).

The main reason for detecting rotation on a CXR is to explain apparent abnormalities that might otherwise be attributed to pathology. The transradiancy of the hemithorax to which the patient is rotated may be greater (i.e. the hemithorax appears darker) mimicking, for example, asymmetry in chest wall soft tissues, reduced vascularity, or increased density in the other hemithorax. The relative size and density of the hila may alter due to their different orientation, and apparent mediastinal shift toward the side to which the patient is rotated (the heart is an anterior structure in the chest) may mimic volume loss. Difference in rotation should always be considered when comparing two CXRs on the same patient (Fig. 4.49).
4.4 PITFALLS

4.4.3 Poor inspiration

There should be at least six anterior ribs visible superior to the hemidiaphragms. More than six ribs may just indicate a good inspiratory effort rather than obstructive airways disease, which is better assessed.
in terms of flattening of the hemi-diaphragms (see later). If a poor inspiratory effort is made, the lower zones are most affected with crowding of the vessels causing increased density, physiological atelectasis, widening of the cardiac silhouette, and increase in apparent size and density of the hila. A poor inspiratory film should be interpreted with great caution (Fig. 4.50).

Figure 4.50. Effect of inspiratory effort.
Two normal frontal CXRs from the same patient; the numbers indicate the number of the lower-most anterior rib projected above the hemi-diaphragm. In image (a) there has been a sub-optimal inspiratory effort. As a result, the lungs appear more ‘congested’ and the hila more bulky when compared to image (b) where a good inspiratory effort has been made.
4.4.4 Mimics of nodules

Just as the silhouettes of the CXR are formed by aerated lung adjacent to soft tissue, any instance where soft tissue on the skin surface forms an interface with air, in line with the incident X-rays, will also form a silhouette. A dramatic example of this effect is the observation of multiple lesions on the skin of a patient with neurofibromatosis (Fig. 4.51).

![Image of neurofibromatosis](image)

Figure 4.51. Neurofibromatosis.
AP CXR of a patient with neurofibromatosis; inset is an HRCT image. The lesions marked with black arrows are neurofibromas on the skin; where these overlay the lungs they mimic nodules in the lung (open white arrow). Note also the ‘holes’ in the lung on the CT image characteristic of neurofibromatosis involvement of the lung.

Similar in appearance, but far more common, are the apparent nodules simulated by the silhouette of the nipples. These can usually be identified by their position in relation to the breast contours, their symmetrical appearance, and a characteristic lack of definition to the supero-medial margin (Fig. 4.52).

If doubt remains, particularly if the appearances are asymmetrical, then a repeat film should be performed with the nipples marked by something radio-opaque. Similarly the use of nipple markers may confirm the appearances are not due to a nipple (see Fig. 4.53).
Figure 4.52. Nipple shadows.
Frontal CXR of an adult female. Both nipples are identifiable (open white arrow). Note the upper medial margin of the right nipple is not well defined.
Figure 4.53. Nipple marking.
Frontal CXRs of an adult male. On the initial CXR (a) there is a possible soft tissue nodule felt most likely to represent a nipple shadow (white arrow) but a follow-up CXR with nipple markers (b) confirms that it is not a nipple. The degree of movement of the ‘nodule’ between the two CXRs despite only a minor amount of rotation indicates it is a surface abnormality and actually corresponded to a skin tag.
4.4.5 Pulmonary venous confluence

A minor anatomical variant of the draining of the pulmonary veins into the left atrium results in the joining of the superior and inferior pulmonary veins prior to entering the atrium. This pulmonary venous confluence (Fig. 4.54) can mimic a mass behind the right heart and may require further investigation; a limited CT scan usually resolves the issue.

![Figure 4.54. Pulmonary venous confluence.](image)

Frontal CXR of an adult. Note the increased density behind the right heart in the magnified area (open black arrow). This corresponds to the pulmonary venous confluence where the pulmonary veins form a pseudo-chamber that then empties into the left atrium.

4.4.6 The manubrium sterna

The sternum overlies the mediastinum and has insufficient definition on a CXR to be discerned over the mediastinal density. However, the widest part of the sternum, the manubrium, corresponds to the narrowest, least dense part of the mediastinal silhouette and may therefore be seen overlying the trachea and adjacent structures. The lateral margins of the manubrium, when visible, may mimic para-tracheal lymphadenopathy, but careful scrutiny will reveal the characteristic shape of the manubrium.

The appearances when carefully observed will reflect a well-defined angular edge of appropriate shape (Fig. 4.55).
4.4.7 Artefacts

Most surface artefacts can be identified for what they are without the need for further imaging. However, if doubt remains a repeat film with all possible artefactual objects removed should resolve the issue.

Clothing
A button or other potentially radio-opaque items on clothing can readily mimic soft tissue nodules. When solitary and overlying the lung the only indication that the appearances are artefactual may be the observation of regularly spaced holes for stitching the button into place (Fig. 4.56). When multiple, the artefactual nature is more readily appreciated with apparent nodules appearing in a line or even outside the confines of the lung (Fig. 4.57).
**Figure 4.56.** Button artefact.
The apparent nodule in the magnified area (white arrow) is a button. Careful scrutiny reveals the four stitching holes, but a follow up CXR (right image) was performed as a precaution and confirms the appearance was artefactual.

**Figure 4.57.** Clothing artefact.
Frontal CXR of an adult. There are multiple apparent nodules (open white arrow) but also multiple similar opacities (open black arrow) outside the chest. The abnormalities could potentially be skin-based, but in this case were due to sequins on a scarf.
**ECG tabs**

It is not unusual for ECG tabs to be left on patients when they are having a CXR (Fig. 4.58), and these artefacts can appear to be consistent over a series of films if they are left on the patient for any length of time. The CXR appearance is that of soft tissue density; the clue to their true nature is from the well-defined margins with rounded corners and their position with respect to the heart, especially if projected outside the chest. Again, repeat film with tabs removed should resolve the issue (see Fig. 4.59).

*Figure 4.58. ECG tabs.*

AP CXR of an adult. Note the numerous ECG tabs (open black arrows) and, in the magnified area, a further ECG tab that could easily be confused for a mass (open white arrow).
Figure 4.59. Opacity due to ECG tabs or cancer?

(a) Frontal CXR of an adult from cardiac pre-admission clinic. ECG leads are evident and it is not unreasonable to assign the opacity in the magnified area as being due to an ECG tab with what appear to be well defined, straight borders (open white arrows). The position of this supposed ECG tab was deemed to be a little high so a precautionary follow-up film with no surface artefacts was performed (b) and a primary lung cancer revealed.
Hair braids
Hair braids can cause disconcerting densities overlying the chest, particularly the apices (Fig. 4.60). As the braid originates from the head there will be no upper margin with the opacification extending above the chest; the stranding of the hair may trap air that is discernable on CXR. Repeating the CXR with the hair held out of the way will resolve the issue.

Figure 4.60. Hair braid on CXR.
The opacity projected over the left hemithorax is a hair braid (open white arrow). Note the hair band (open black arrow).

Film / screen and CR plate artefacts
Film screen (i.e. non-digital) systems use a material that fluoresces in response to incident X-rays and it is the resulting light that exposes the film. Foreign bodies such as dirt, dust and strands of hair, that are effectively transparent to X-rays when found on the fluorescing screen, will cast sharp shadows on the X-ray film as they are adjacent to the film being exposed by light, to which they are opaque (Fig. 4.61).
CR film is only exposed to laser light after exposure to X-rays and removal from the cassette and is therefore less susceptible to artefacts due to foreign bodies on the film, but is susceptible to discrepancies due to film handling within the laser reader (Fig. 4.62). DR plates do not have a separate reading / digitising process and are therefore not susceptible to such artefacts.
Figure 4.62. Roller artefact.
Frontal CXR of an adult taken using a CR digital system. Note the vertical linear artefact in the magnified area due to the handling of the digital plate in the reader.