CHAPTER 3

How to read a CXR

- Air absorbs no X-rays and the lung contains mainly air. A deflated adult lung is about the size of a fist.
- Beyond the proximal airways the only structures visible in a normal lung on a CXR are the vessels due to the contrast between blood and air filled lungs; the lung interstitium and the walls of the bronchioles are too fine to be seen.
- Interpretation of the CXR depends to a great extent on determining how the visualization of the vessels has been altered.
- If the vessels are obscured the cause is opacification of the adjacent lung.
- If the vessels are of reduced calibre there is a reduction in blood flow.
- If the vessels are of increased calibre, an increase in blood flow or perhaps pressure may be the reason.
- The absence of vessels in aerated lung suggests lung destruction (e.g. emphysema).
- Spread out normal calibre vessels suggest overexpansion of the lung (e.g. accommodating collapse of another lobe).

The silhouette sign

- When there are tissues of different density next to each other there is a sudden change in the amount of X-rays passing through the body, this results in a sudden change in the density on the resulting X-ray film. In this way a silhouette of the more dense structure is created.

Figure 3.1
The simulated shadow cast by a 3D CT reconstruction of the mediastinum demonstrates the principal behind the silhouette of the mediastinal contours.
The bars depict the intensity of X-rays in relation to the edge of the descending aorta (image on left) and the left heart border (image on right). Note the resulting lines on the CXRs and the fact that these lines are visible overlying the other opacities (left upper lobe collapse—left image, left lower lobe abscess—right image).

- The presence of the silhouette enables the margins of a structure to be seen but, more importantly, the loss of a silhouette that should be visible indicates that the lower density tissue now has a higher density.

- In the lungs, the term silhouette sign refers to interfaces (boundaries) between soft tissue structures and aerated lung. When a silhouette is lost it means that either the lung in that region is no longer aerated, (e.g. consolidation/collapse) or that it has been replaced by different tissues such as a tumour.

- The position of the abnormality causing the loss of the silhouette can be localized if the origin of the silhouette is known, e.g. the aerated right middle lobe creates the silhouette of the right heart border and the lingual that on the left.

**Suggested scheme for reading a frontal CXR**

- Everyone should develop a scheme for reading the CXR. As there are many overlapping structures, many possible pathologies and significant blind spots, a thorough strategy is essential and with practice can be performed surprisingly quickly.

- We outline one strategy and explain the reasoning behind it. It highlights the areas of the CXR that require particular scrutiny and those that are often overlooked.

- As soon as a CXR is viewed a snapshot decision as to whether the film is normal or abnormal is made. If an abnormality is missed during this snapshot, it has in all likelihood been seen but incorrectly interpreted. All of this has happened in a few seconds and is not under conscious control.
• The eye is readily deceived and a CXR should be approached with as few preconceptions as possible.

• Even if a snapshot impression identifies an abnormality, other abnormalities may have been missed and the interpretation of a CXR should still be approached systematically.

• The following scheme covers the film but is not dependent on anatomical boundaries. You may develop your own scheme, but bear in mind the potential pitfalls detailed here.

• Check the name and date of the film.

• Check the film the correct way round (side marker).

• Is the film PA or AP (see earlier).

• Is the subject, erect, semi-erect or supine.

Begin in the top left hand corner of the film (patients right shoulder).

A. Scan from left to right

![Figure 3.3](image)

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), soft tissue masses and is the trachea normal (position, calibre)? Compare the apices of the lung. Are they of the same density?

B. Return to the top left hand corner repeating the above observations.

![Figure 3.4](image)
C. Scan from top left to bottom left

![Figure 3.5](image)

*Figure 3.5*
Check the soft tissues of the chest wall, the lateral aspect of the ribs, the peripheral lung, pleura and costophrenic angle.

D. Move to the mid right diaphragm and scan up to the right apex

![Figure 3.6](image)

*Figure 3.6*
Check behind the diaphragm, 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 this suggests abnormal opacity in the adjacent lung.

E. From the right apex scan down the right mediastinal contour

![Figure 3.7](image)

*Figure 3.7*
The right paratracheal stripe should be visible. Is the mediastinal contour visible? Check the position of the hilar point, which should be at the level of the lateral extent of the right 6th rib. End at the right cardiophrenic angle, the inferior vena cava lies here.
E. Scan up the centre of the film

Figure 3.8
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, the trachea normal in position and calibre?

G. Scan down the left mediastinal contour

Figure 3.9
The aortic knuckle, aorto-pulmonary window, the left hilar point (slightly 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.

H. Now move to the mid left hemidiaphragm. The gastric fundus and the spleen are under the diaphragm.

Figure 3.10
Scan up the film looking at the lung parenchyma ending in the left apex.
I. Move to the left shoulder and scan down the left periphery of the chest

![Figure 3.11](image1)

Concentrate on the peripheral lung, ribs and soft tissues of the chest wall.

J. Finally, compare the lung parenchyma left to right in the upper, mid and lower zones

![Figure 3.12](image2)

This scheme is easy to follow and includes the main areas in which abnormalities are missed.

**Review areas**

The review areas are those parts of the CXR in which an abnormality can easily be overlooked and therefore require particular attention (Fig 3.13).

![Figure 3.13](image3)

The review areas.
The apices

- At the apices of the lung there is little lung parenchyma compared to the amount of overlying soft tissue and bone.

- The anterior part of the first rib overlies the posterior parts of the first 3 to 4 ribs and all these relatively dense structures contribute to an overall increased opacity in the apex at the expense of definition of the lung parenchyma.

- 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 two sides. Is there a difference in opacity and if so, can this be explained by the overlying ribs?

- If not, then some parenchymal abnormality should be suspected and in the first instance, a lortodotic view should be performed (Fig 3.14).

![Figure 3.14](image)

On the left image there is increased density in the right apex (white arrow) but this may be due to overlap of anterior 1st rib, clavicle and posterior 4th rib. The lortodotic view (right image) projects the 1st rib and clavicle off the chest revealing the underlying nodule (white arrow), a carcinoma that was subsequently resected.

The thoracic inlet

- This is a review area because it is easily overlooked.

- The trachea dominates the thoracic inlet; the other structures in this area are the vessels arising from the aortic arch and the veins feeding into the superior vena cava.

- Abnormalities in the thoracic inlet are usually due to extra soft tissue such as lymphadenopathy or thyroid enlargement or intrinsic abnormality (narrowing or dilatation) of the trachea (Figs 3.15, 3.16).
Overlying the scapulae

- The region of lung overlying the scapula appears to be of slightly increased density, therefore subtle density changes such as soft tissue nodules unrelated to the scapulae could be overlooked (Fig 3.17).
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. Usually this is due to pleural fluid or thickening (3.18).

Figure 3.18
Blunting of the left costophrenic angle in a young man with a "long" chest indicates the possibility of a spontaneous pneumothorax. The subtle lung edge (white arrows) is marked on the magnified image.

- Septal lines ("Kerly B lines") are best seen at the costophrenic angles and are easily overlooked; they indicate interstitial lung infiltrates, usually due to heart failure, but also consider lymphangitis carcinomatosa (see pattern recognition>lines).

Under the hemidiaphragms

- Lung lesions lying posteriorly in the lung bases are projected beneath the hemidiaphragms and may prove very difficult to see (Fig 3.19).
• The liver lies under the right hemidiaphragm. Therefore lucency beneath this hemidiaphragm suggests the presence of free gas within the abdomen.

• The colon may interpose between the liver and the diaphragm mimicking free gas, but sharp medial and lateral extremities to the gas shadow would favour free gas, as that found within a tubular structure such as the colon, will not form these sharp margins (Fig 3.20).

Figure 3.19
A large (7 cm) mass is sited posteriorly in the right lower lobe projected behind the right hemidiaphragm (margins marked by arrows).

Figure 3.20
Frontal CXR of a post-operative patient. Note the visibility of both sides of the right hemidiaphragm (white arrows) due to free gas in the abdomen. As a result, the superior surface of the liver is visible (black arrow).
- On the left, the normally air filled gastric fundus lies beneath the diaphragm.
- If there is free gas on the left, only the diaphragm, about 3–4 mm thick, separates the free gas from the lung. Air in the gastric fundus is separated from the lung by the diaphragm and the gastric wall.
- Again, sharp margins to the gas shadow increase the likelihood of free gas.
- If uncertainty remains, a lateral decubitus AXR view should resolve the issue, as the free gas will travel to the least dependent area, i.e. the upper most lateral margin of the abdomen.

**Behind the heart**
- A well taken CXR will demonstrate the thoracic spine projected through the cardiac shadow. A "soft" or underexposed film where the spine is not visible should be read with caution as a significant portion of the thorax has not been adequately visualized.
- Abnormalities of the thoracic spine may be apparent, there may be masses or swelling related to the paraspinal lines (see anatomy).
- The descending aorta is projected behind the heart and the left edge of this should be visible.
- A hiatus hernia or oesophageal dilatation will be projected behind the heart and often contains gas (Fig 3.21).

![Image](image.png)

**Figure 3.21**
Hiatus hernia. Note on the magnified image the lateral margins of the hernia (white arrows) and the air fluid level (black arrow).

- The azygo-oesophageal line should be identified. An abnormal contour suggests a mediastinal mass, usually lymphadenopathy but also consider oesophageal pathology (Fig 3.22).
Figure 3.22
Frontal CXR of an adult female with lymphoma. Note the soft tissue mass in the aorto-pulmonary window (white arrow) also seen on the CT image (inset) and the bulging of the azygo-oesophageal line (black arrows) due to sub carinal lymphadenopathy.

- Left lower lobe collapse partially hidden behind the heart is often overlooked (Fig 3.23).

Figure 3.23
CXR of an infant demonstrates left lower lobe collapse. The lateral margin of the lobe is marked (arrows). Note the increased density behind the heart and the loss of the medial portion of the left hemidiaphragmatic silhouette.

The cardiophrenic angles

- A poorly defined opacity is often seen at the cardiophrenic angles due to pericardial fat pads.
- Abnormal soft tissue in the region is readily overlooked.
- A pericardial fat pad will not be separable from the cardiac outline, and being composed of fat, it should be of low density.
- The margins of the pericardial fat pad are usually indistinct, if at all discernable, such that opacity in the cardiophrenic angle with defined margins is unlikely to represent pericardial fat (Fig 3.24).
Figure 3.24
A 2 cm carcinoma projected over the left cardiophrenic angle. The margins of the nodule are marked by arrows in the magnified view.

Pitfalls

**Pseudo-pneumothorax**

- Folds in the skin can trap air creating a soft tissue/air interface and thus a line on the CXR which can mimic the lung edge of a pneumothorax.

- This is usually seen on AP films taken with the patient lying against the X-ray cassette.

- The key points are that there will be lung markings beyond the assumed lung edge and the line will cease more abruptly than a lung edge would (Fig 3.25).

Figure 3.25
CXR taken in intensive care unit. Note endotracheal tube, internal jugular line, Swann Gantz catheter and a balloon pump in the aorta. An apparent lung edge is marked (black arrows) but careful scrutiny reveals lung markings beyond this edge (white arrow). The edge is 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.
**Patient rotation**

- A correctly centred CXR will project the spinous processes of the thoracic spine mid way between the medial ends of the clavicles.

- As the clavicles are anterior structures and the spinous processes are posterior structures, any rotation of the patient, i.e. to the left or right, will result in the movement of the clavicles in relation to the spinous processes.

- As a result the projected distances between the medial ends of the clavicle and the spinous process will increase on the side to which the patient is rotated (Fig. 3.26).

![Figure 3.26](image)

**Figure 3.26**
Frontal CXR with subject rotated to the left. Note an enlarged heart and small left pleural effusion. The left hemithorax is darker than the right due to the rotation. Note the distance between the medial end of the right clavicle and the spinous process of T2 (distance a) is less than the distance between the spinous process and the medial end of the left clavicle (distance b) indicating rotation to the left as demonstrated in the 3D reconstruction.

- Rotation may cause an increase in the transradiancy (blackness) of the lung on the side to which the patient is rotated, which should be taken into account when reading the film.

- Rotation will also alter the relative appearance on the hila and can mimic hilar asymmetry and the projection of the sternum over the hilum may be evident (Fig. 3.27).

![Figure 3.27](image)

**Figure 3.27**
The subject is rotated to the left and as a result the sternum is projected over the left mediastinal contour (white arrow). The sternum is outlined on the magnified view.
Poor inspiration

- If there are less than 6 anterior ribs projected above the hemidiaphragms then the film has been taken with a poor inspiratory effort.
- The lower zone vessels become crowded and there is an overall increase in lower zone opacity.
- The hila are compressed and appear more bulky (Fig 3.28).

![Figure 3.28](image)

Two frontal CXRs of the same patient taken on the same day. For the CXR on the left the patient has made a poor inspiratory effort. Note the apparent bulkiness of the hila, increased density in the lower zones and the enlarged cardiac silhouette. The CXR on the right taken in full inspiration demonstrates that the patient's CXR is normal and previous apparent abnormalities were due to poor inspiratory effort (images courtesy of D M Hensell).

Nipple shadows

- When seen as symmetrical, nipple shadows rarely cause diagnostic difficulties.
- It is not uncommon that only one nipple is evident on a CXR.
- Features that suggest a shadow is due to a nipple are a position appropriate to the breast shadow and well-defined margins on only two sides usually inferior and lateral (Fig 3.29).

![Figure 3.29](image)

Left image-right nipple shadow marked (black arrow). Note relative position to right breast margin (white arrows). Right image is a magnified view of the left nipple shadow (white arrows). Note the indistinct superior medial margin (black arrow).
• If uncertainty remains, a repeat film with the nipples marked by something radio-opaque will resolve the issue (Fig 3.30).

![Figure 3.30](image)

Top left image is a frontal chest radiograph, 2 areas magnified demonstrate possible nodules, the asymmetry on this image raises the possibility that at least one of the shadows represents a nodule. A repeat film bottom right with nipple markers resolves the issue demonstrating that both are nipples.

**Pulmonary venous confluence**

• Sometimes the pulmonary veins draining the right lung combine prior to entering the left atrium.

• The result is opacity visible behind the right side of the heart mimicking a mass (Fig 3.31).
Figure 3.31
Frontal and lateral CXR of an adult male. The pulmonary venous confluence mimics a mass behind the right heart (white and black arrows).

- The clues to its identity are the absence of a medial margin, confluence with the left atrium and the draining pulmonary veins.
- Nevertheless the appearance can be quite compelling and a lateral CXR should help resolve the issue.

The azygos lobe

- During embryological development, the azygos vein may course through the upper developing lung on its way to taking its position, arching over the right main bronchus into the superior vena cava.
- A fold of pleura, azygos fissure, accompanies the vein and creates the azygos lobe as part of the upper lobe, which may have its own bronchus.
- The azygos fissure runs a curved course from the azygos nob to the apex and should not be confused with pathology.
- Pathology may be confined to the azygos lobe causing opacity with a very well defined lateral margin, which could easily be confused with right upper lobe collapse (Fig 3.32).
**The manubrium sterni**

- If the patient is slightly rotated, particularly to the right, the lateral margin of the manubrium becomes visible and may appear to represent para-tracheal lymphadenopathy.

- The appearances when carefully observed will reflect a well defined angular edge of appropriate shape (Fig 3.33).

**Artifacts**

In general surface artefacts can be identified for what they are by careful scrutiny. However, if doubt remains a repeat film with all possible artefactual objects removed should resolve the issue.

**Buttons**

- When solitary, buttons can look convincingly like nodules particularly due to the soft tissue density they mimic.

- The presence of other nodules elsewhere of exactly the same size or outside the lung parenchyma are useful clues and most buttons will have discernable holes in a regular pattern (Fig 3.34).
Figure 3.34
Frontal CXR of an adult male with an apparent nodule in the left upper/mid zone (horizontal black arrows). On closer inspection, the regular shape of this "nodule" and the presence of four equally spaced holes (diagonal black arrows) confirms that this is a button.

ECG tabs

- Commonly left on the patient's chest for days on end, these artefacts can appear to be consistent over a series of films and have a disconcerting soft tissue density appearance.

- As for buttons the appearance of these outside the lung is a useful clue and the well-defined curved corners are characteristic.

- Again, repeat film with tabs removed would resolve the issue (Fig 3.35).

Figure 3.35
Left image suggests 2 large soft tissue masses, the magnified image on the right shows these to be ECG tabs.
Hair braids

- When multiple, hair braids do not pose a diagnostic problem but single braids that are short or folded can overlay the apices giving the appearance of parenchymal opacity.
- The clue is in the extension of this opacity beyond the apex to overlay the neck where, unlike a true soft tissue mass, its margins will still be definable.
- In addition, the air trapped in a braid may be seen as radiolucent lines (Fig 3.36).

Figure 3.36
Left image shows increased opacity in the right apex (white arrow) in a subject being screened for TB. Right magnified image highlights the thin lucent lines within the hair braid (small black arrow) and the hair band (large black arrow).

Film/screen artefacts

- Foreign bodies such as dirt, dust and hair on the fluorescent screen will cast sharp shadows on the X-ray film as they are adjacent to the film compared to the structures in the lung that are further from the film and therefore have less sharp margins (Fig 3.37).
Figure 3.37
A magnified portion of a frontal CXR demonstrates the curvilinear opacity (black arrows) that appears far too sharply defined to represent an abnormality in the chest. Note the difference in sharpness between the artefact and the ribs. The artefact has been caused by a hair trapped between the film and the screen. Note also reticulation and septal lines (white arrows) due to lymphangitis carcinomatosis.
Film kinking during processing

- At the point at which a film is being gripped, particularly using the thumb and one finger, the film may become kinked. If this occurs prior to developing an artefact is created (Fig 3.38).

Figure 3.38
Frontal CXR of an adult male. The curved marks appearing on the film in two places (black arrows) are due to the film kinking when gripped between the thumb and fingers.