Chapter 1

Imaging the chest

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How to read a chest X-ray

Reading a chest X-ray requires a methodical approach that can be applied to all films so that abnormalities are not overlooked. Clinicians and radiologists develop an individual approach, but there are certain core areas that should be looked at on all films. These may be inspected in any order – this is largely down to personal preference. Listed below is the outline of a method which can be applied to read chest X-rays.

Initial quick review of film

To identify any obvious abnormality.

Systematic analysis

Label

Verify the patient's identity. In examination situations look at the name, if present, as this can give a clue to sex and ethnic background.

Projection and patient position

Postero-anterior (PA) is the preferred projection as this does not produce as much radiographic magnification of the heart and mediastinum as an antero-posterior (AP) projection. A PA film is taken with the film cassette in front of the patient and the beam delivered from behind with the patient in an upright position. Portable films and those taken on intensive care are all AP projection. Patient position causes important, although sometimes subtle, variations in appearance. The supine position causes distension of the upper lobe blood vessels, which may be confused with elevated left atrial pressure (see Fig. 1.1).

Films taken in the AP projection are usually labelled as such, but to avoid difficulties when describing films in examinations the use of the term 'frontal projection' is often helpful.

Figure 1.1. AP supine chest X-ray. Note the distended upper lobe vessels.

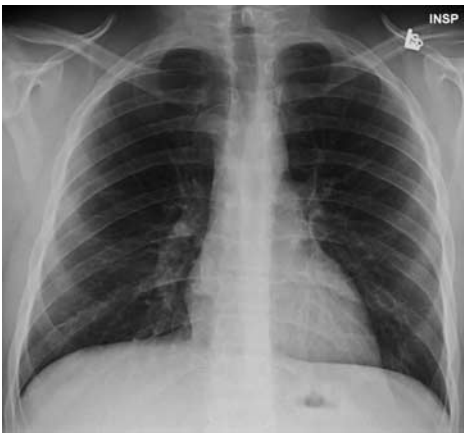

Figure 1.2. PA chest X-ray in inspiration.

Figure 1.3. PA chest X-ray in expiration. The same patient as in Fig. 1.2. Note the crowding of the vascular markings in the lung bases.

A lateral X-ray is used to localize lesions in the AP dimension, locate lesions behind the left side of the heart or in the posterior recesses of the lungs. A left lateral (with the left side of the chest against the film and the beam projected from the right) is the standard projection. The heart is magnified less with a left lateral as it is closer to the film. To visualize lesions in the left hemithorax, obtain a left lateral film and for right-sided lesions a right lateral.

Expiratory films are used to assess air trapping in bronchial obstruction such as a foreign body. A pneumothorax always appears larger on an expiratory film and occasionally a small pneumothorax may only be visible on expiration. Films may be accidentally taken in expiration, resulting in spurious magnifcation of the heart and mediastinum.

Side marker

Dextrocardia is easily missed if the side marker is not identified.

Quality of film

- *Penetration* – the vertebral bodies should just be visible through the cardiac silhouette.
- *Rotation* – the medial aspect of the clavicles should be symmetrically positioned on either side of the spine.
- *Inspiration* – the diaphragm should lie at the level of the sixth or seventh rib anteriorly. A poorly inspired film results in magnification of the mediastinal structures. Crowding of the pulmonary vasculature may mimic lower lobe pathology (see Figs. 1.2 and 1.3).

Large airways, lungs and pleura

The 'lung shadows' are composed of the pulmonary arteries and veins. Apart from the pulmonary vessels, the lungs should appear black because they contain air. Examine the lungs for density variation. Compare the rib interspaces on the right with those on the left. Compare the right side with the left just as you would if auscultating the chest. Look all the way out to the periphery of the lungs. Look at the overall lung vascularity and compare one side

with the other. It is important to look at the main airways – the trachea and the main bronchi. Check the trachea for deviation or narrowing.

Look at the pleural surfaces and the fissures, if visible. Check for masses, calcifications, fluid or pneumothorax.

It is helpful to divide the lungs into zones when describing abnormalities. The upper zone extends from the apex to the inferior border of the second rib anteriorly, the mid zone from the inferior border of the second rib to the inferior border of the fourth rib anteriorly, and the lower zone from the fourth anterior rib to the diaphragm.

Heart and mediastinum

Examine the cardiac outline identifying all the heart borders and the outline of the great vessels (see Figs. 1.4 and 1.5). Check that there are not any abnormal densities projected through the cardiac silhouette. Look at the aortic and pulmonary artery outlines. The heart and mediastinal outline are made up of a series of 'bumps' (see Fig. 1.6). On the right side,

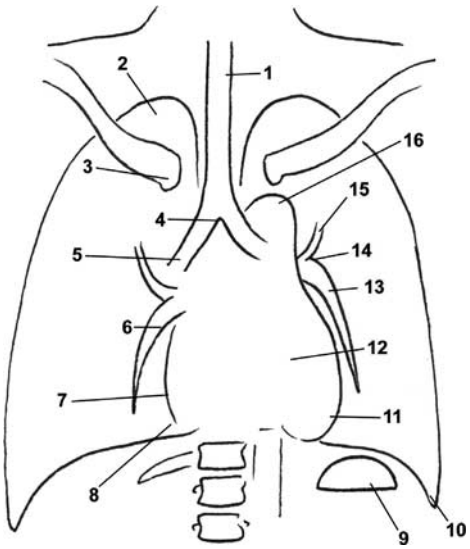

Figure 1.4. Diagram of normal frontal chest X-ray: 1. trachea, 2. right lung apex, 3. clavicle, 4. carina, 5. right main bronchus, 6. right lower lobe pulmonary artery, 7. right atrium, 8. right cardiophrenic angle, 9. gastric air bubble, 10. costophrenic angle, 11. left ventricle, 12. descending thoracic aorta, 13. left lower lobe pulmonary artery, 14. left hilum, 15. left upper lobe pulmonary vein, 16. aortic arch.

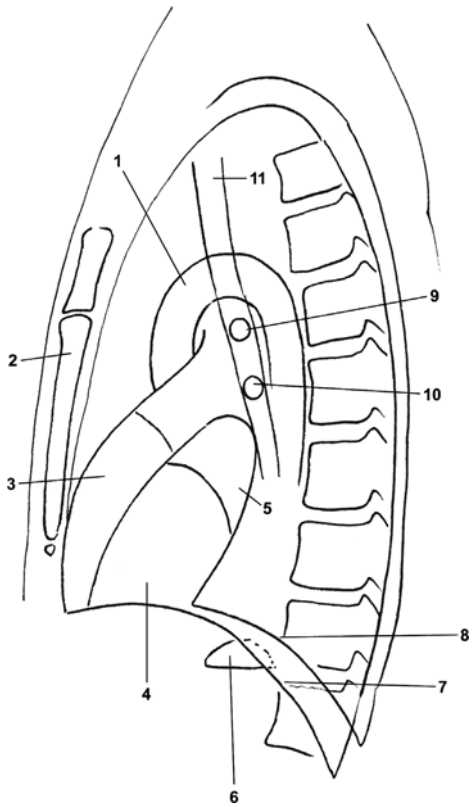

Figure 1.5. Diagram of normal lateral chest X-ray: 1. ascending thoracic aorta, 2. sternum, 3. right ventricle, 4. left ventricle, 5. left atrium, 6. gastric air bubble, 7. right hemidiaphragm, 8. left hemidiaphragm, 9. right upper lobe bronchus, 10. left upper lobe bronchus, 11. trachea.

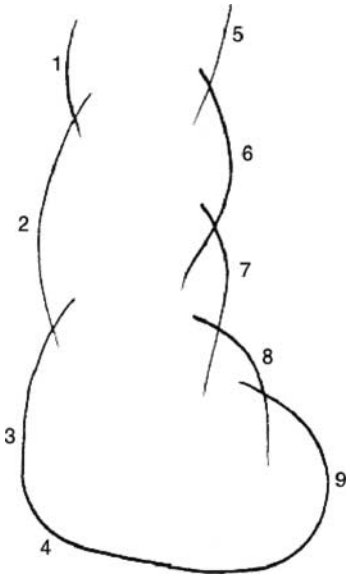

Figure 1.6. The 'bumps' which make up the cardiac silhouette: 1. right brachiocephalic vein, 2. ascending aorta and superimposed SVC, 3. right atrium, 4. inferior vena cava, 5. left brachiocephalic vessels, 6. aortic arch, 7. pulmonary trunk, 8. left atrial appendage, 9. left ventricle.

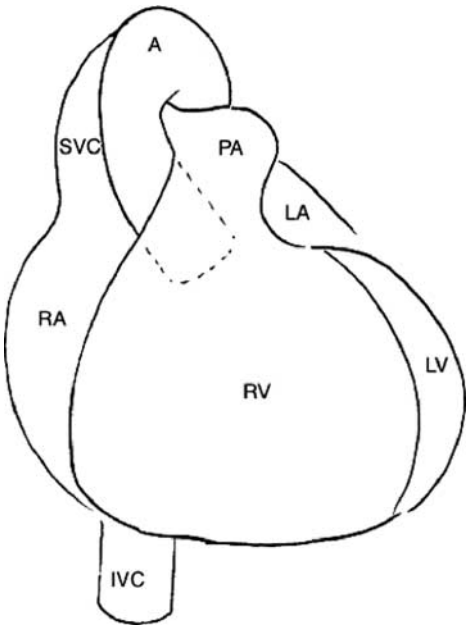

Figure 1.7. Cardiac chambers and great vessels: LA, left atrial appendage; RA, right atrium; LV, left ventricle; RV, right ventricle; IVC, inferior vena cava; SVC, superior vena cava; PA, pulmonary artery; A, ascending aorta.

there are right brachiocephalic vessels, the ascending aorta and superior vena cava, the right atrium and the inferior vena cava. On the left side, there are four 'moguls' in addition to the left brachiocephalic vessels: these are the aortic arch, the pulmonary trunk, the left atrial appendage and the left ventricle. The size and shape of each of these structures need to be looked at for signs of enlargement or reduction in size. The right heart border is created by the right atrium alone (the right ventricle is an anterior structure, therefore does not contribute to any heart borders on a PA film) – this is a question examiners love to ask (see Fig. 1.7).

Heart size can be estimated using the cardiothoracic ratio. The cardiac measurement is taken as the greatest transverse heart diameter and is compared to the greatest internal width of the thorax. A ratio of greater than 0.5 is often used in clinical practice to indicate cardiomegaly on a PA film (0.6 on an AP film).

Look at the position of the hila and their density – compare the left with the right side. Tumours and enlarged lymph nodes can occur here making the hila appear bulky. On a frontal X-ray, increased hilar density may be the only sign of a mass lying in front of, or behind the hilum.

Diaphragm

Check the shape, position and clarity/sharpness of both hemidiaphragms. Both costophrenic angles should be clear and sharp. The cardiophrenic angles should be fairly clear – cardiophrenic fat pads can cause added density. The right hemidiaphragm is usually slightly higher than the left – up to 1.5 cm. On the lateral film, the right hemidiaphragm is seen in its entirety

but the anterior aspect of the left hemidiaphragm merges with the heart, so is not seen (see Fig. 1.14).

Bones

This is an area which is frequently overlooked.

- *Ribs*: The ribs are a common site for fracture or metastatic deposits, but the remainder of the skeleton must also be carefully examined. Identify the first rib and carefully trace its contour from the spine to its junction with the manubrium. Each rib must be carefully and individually traced in this manner, initially for one hemithorax and then the contralateral side. A useful trick is to rotate the image on its side; rib fractures may then appear more obvious.
- *Thoracic spine*: Look at the thoracic spine alignment – is it straight or is there a scoliosis? Take particular care to exclude pathology from the thoracic spine in trauma patients when even moderate malalignment can be overlooked when projected through the heart or mediastinal shadows.
- *Clavicles, scapulae and humeri*: Fractures and dislocation of the humerus are often obvious when looked for. Look for fractures, metastatic deposits, abnormal calcifications or evidence of arthritis around the shoulders.

Soft tissues

A visual examination should be routinely performed on the chest wall, the neck and both the breast shadows. Look for surgical emphysema and abnormal calcification. With reference to the breast shadows, be sure to check whether there are two breast shadows and whether there is symmetry of size, shape and position. The lung field missing a breast will appear a little darker than the other side.

Review areas

These review areas are sites where pathology is commonly missed and warrant a second look before any chest X-ray is reported as normal:

- Breasts (symmetry/mastectomy).
- Below the diaphragm (do not forget that the lungs extend below the diaphragm, also look at the upper abdomen for surgical clips/calcification/pneumoperitoneum).
- Behind the heart (hiatus hernia/lung nodules/left lower lobe collapse).
- Thoracic spine and paraspinal lines (trauma).
- Clavicle (nodule behind medial end and eroded lateral end).
- Shoulder (dislocation).
- Apices (pancoast tumour).
- Hila (assess position, size and density).
- Lung parenchyma.
- Bones, especially ribs (look for metastases or fractures).

Principles of chest X-ray interpretation

Having looked at the chest X-ray, it remains to classify the signs into a radiographic pattern. Particular radiographic patterns have a list of diagnostic possibilities. At its simplest, a chest X-ray abnormality can be classified into increased or decreased density. Patterns

Figure 1.8. Air space opacification/consolidation. Note the 'fluffy' or 'cotton wool-like' appearance. Air bronchograms are a sign of consolidation but are often not visible on chest X-ray.

Figure 1.9. Interstitial opacification. Note the 'mesh-like', reticular pattern. Small nodules and Kerley B lines may also be seen in interstitial disease.

Figure 1.10. Pleural effusion. Note the meniscus-like arc at the interface between the fluid and the chest wall.

of increased density include nodules and masses, air space opacification or consolidation (see Fig. 1.8),[1] interstitial opacification (see Fig. 1.9) and pleural disease such as pleural effusion (see Fig. 1.10).

An important radiological sign that can help to detect and localize pulmonary abnormalities is the 'silhouette sign'.[1, 2] The mediastinal silhouette is visible on a chest X-ray because it is bordered by aerated lung. When consolidation (which is soft tissue density) abuts a mediastinal border, that border becomes obscured. For example, the right middle lobe is an anterior structure and lies adjacent to the right atrium. The only clue to pathology causing increased density in the right middle lobe (such as collapse or consolidation) may be obscuration of

Figure 1.11. Right middle lobe consolidation. Note the silhouette sign with loss of clarity of the right heart border.

Figure 1.12. Lateral chest X-ray showing right middle lobe consolidation. Note the consolidation is bordered by the horizontal fissure superiorly and oblique fissure posteriorly.

the right heart border (see Figs. 1.11 and 1.12). The right middle lobe has little contact with the diaphragm, so right middle lobe opacification does not result in obscuration of the right hemidiaphragm. Similarly, obscuration of the left heart border usually indicates pathology in the lingular segment of the left upper lobe, which lies adjacent to the left ventricle. By contrast, pathologies causing increased density in a lower lobe result in loss of clarity of part or all of the relevant hemidiaphragm.

Case histories

Question 1

- Name the normal structures on these chest X-rays (Figs. 1.13 and 1.14).

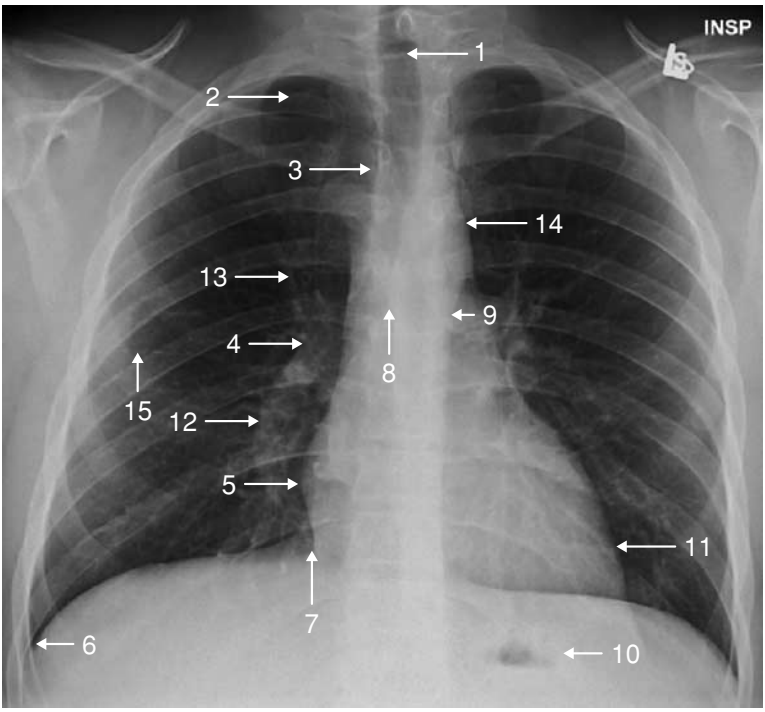

Figure 1.13. Quiz case.

Answer (Fig. 1.13)

1. Trachea
2. Lung apex
3. Right para-tracheal stripe
4. Right hilum
5. Right atrium (not ventricle!)
6. Right costophrenic angle
7. Right cardiophrenic angle
8. Carina
9. Descending thoracic aorta
10. Gastric air bubble
11. Left ventricle
12. Right lower lobe pulmonary artery
13. Right upper lobe pulmonary vein
14. Aortic arch
15. Horizontal fissure

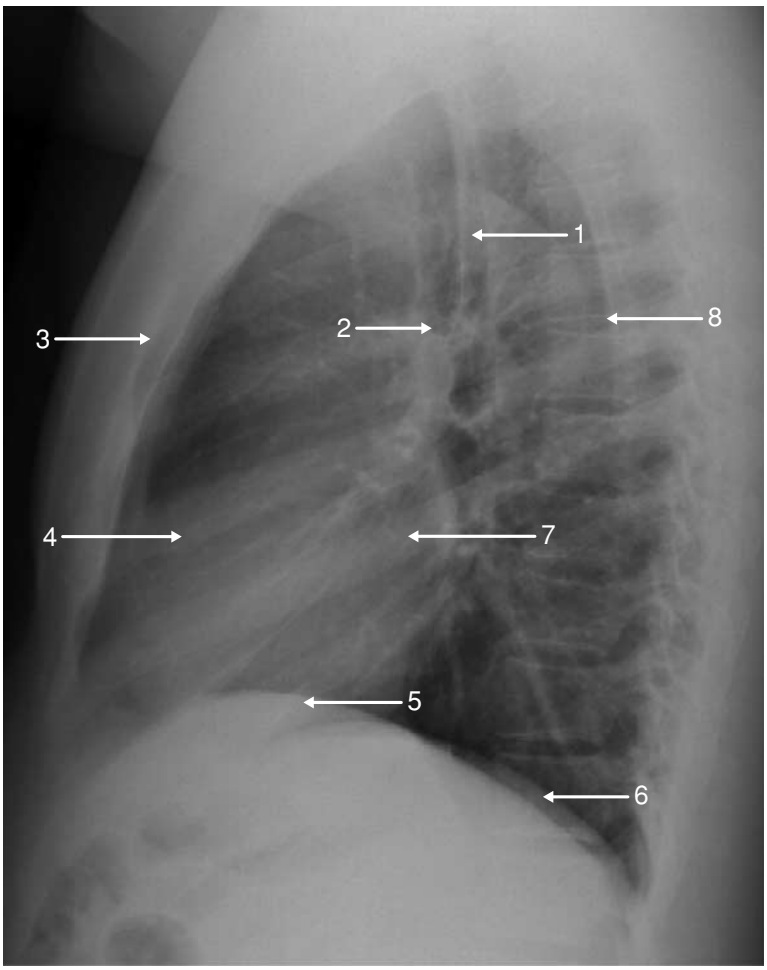

Figure 1.14. Quiz case.

Answer (Fig. 1.14)

1. Trachea
2. Aortopulmonary window
3. Sternum
4. Right ventricle
5. Right hemidiaphragm
6. Left hemidiaphragm
7. Left atrium
8. Scapula