Interpretation of the chest radiograph in the casualty department

Introduction

The chest X-ray (CXR) is the most common radiograph requested in casualty departments. However, all too often relatively junior doctors, who have not been formally trained in interpretation of emergency radiographs, have to make instant decisions that profoundly affect patient management. In the space available here it is not possible to cover the numerous medical and surgical emergencies that may be encountered. This article provides a systematic approach to interpreting the chest film and describes the common emergency conditions requiring CXRs along with radiological signs.

Technical factors

Posteroanterior (PA) film: This CXR is taken in the X-ray department. The X-ray tube is behind the patient and the cassette (or detector) against the anterior chest wall.

Anteroposterior (AP) film: This is taken in the casualty setting when the patient is seriously ill, using a portable X-ray machine with the film cassette placed behind the patient. On an AP film the mediastinum appears falsely widened and there is apparent cardiomegaly, both as a result of the divergent direction of the X-ray beam. The AP film may have to be acquired in the supine position in which case the presence of upper lobe blood diversion is normal and pleural effusions may be missed as fluid tracks up the posterior chest wall.

Lateral chest film: This may be useful to localize abnormalities on the frontal views.

Expiration film: This may be useful to demonstrate a small pneumothorax.

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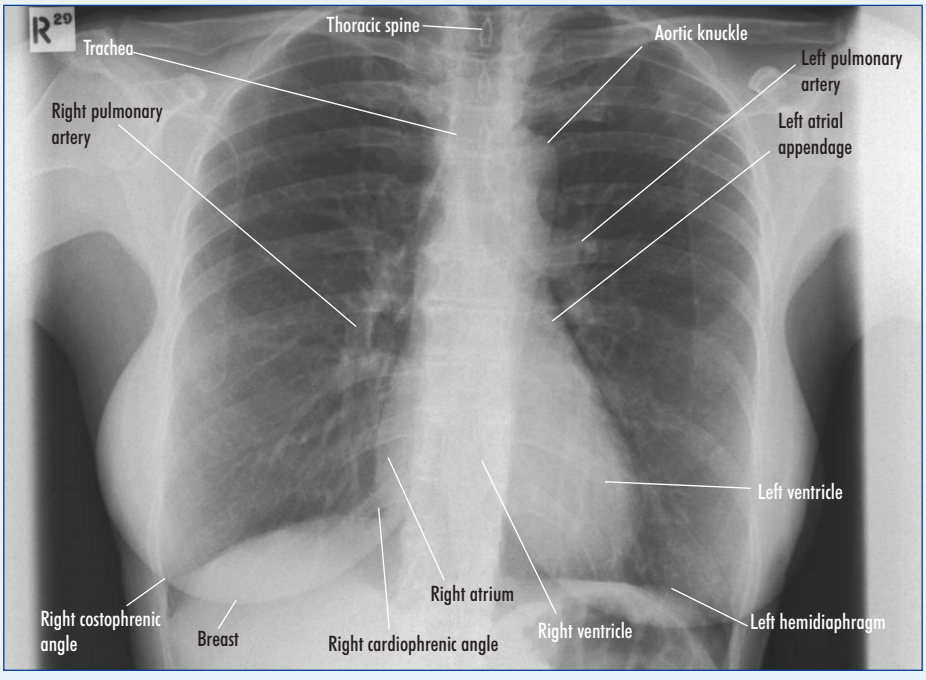


Figure 1. Normal posterioanterior chest radiograph with annotations.

Systematic radiological assessment

The patient's name, date of birth and date on the film should always be checked.

Film quality: The film projection should be checked (i.e. PA, AP, erect, supine). To assess for rotation the medial ends of the clavicles should be equidistant from the spinous processes in a correctly centred film. To assess the degree of inspiration, the right hemidiaphragm should reach the anterior aspect of the sixth rib. A poor inspiration may simulate the appearance of basal collapse and cause spurious cardiomegaly.

Equipment: The position of items such as central lines, endotracheal (ET) tubes and chest drains should be noted. The tip of an ET tube should lie 2 cm above the carina.

Trachea: This should normally be central. It may be deviated away from a superior mediastinal mass, e.g. thyroid goitre, or pulled by any process which causes volume loss, e.g. lung fibrosis.

Mediastinal contour: The entire border of the heart and mediastinum should be clearly visualized. The constituents of the normal mediastinal contour should be recognized and assessed (*Figure 1*).

Heart: The normal cardiothoracic ratio (ratio of transverse cardiac diameter to transverse inner thoracic diameter) is less than 50%. One third of the heart's diameter is positioned to the right and two thirds to the left of the spinous processes.

Hilar regions: These are made up of the pulmonary arteries and veins (predominantly the upper lobe pulmonary vein and the lower lobe pulmonary artery). They have a concave lateral margin. They are of equal density and the right hilum is lower than the left.

Lungs: These should be equal in density. When there is asymmetry, the side of decreased vascularity is usually the abnormal side. Inspect for focal lesions. The right horizontal fissure can be seen on frontal views whereas the oblique fissures are only usually visualized on lateral views.

Diaphragms: On full inspiration the right hemidiaphragm is at the level of the sixth rib anteriorly and up to 3 cm higher than the left hemidiaphragm in 95% of normal subjects. Inspect for free subdiaphragmatic gas resulting from perforation of a viscus (unless there is a known iatrogenic cause, e.g. recent laparotomy or continuous

Table 1. Common errors

Wrong patient or date
Skin lesions, nipples or foreign bodies (buttons) mistaken for intrathoracic lesions
Small apical pneumothoraces missed. Bullae, azygos lobe, skin folds or medial edge of scapula mistaken for pneumothorax
Apparent cardiomegaly as a result of pectus excavatum or scoliosis
Pericardial cyst or fat pad mistaken for tumour
Calcified costal cartilage or healing rib fracture mistaken for pleural or lung lesion
Enlarged pulmonary arteries mistaken for tumour or lymphadenopathy
Mastectomy commonly missed
Costotransverse articulations mistaken for rib fracture
Prominent vessels mistaken for mediastinal mass/nodes

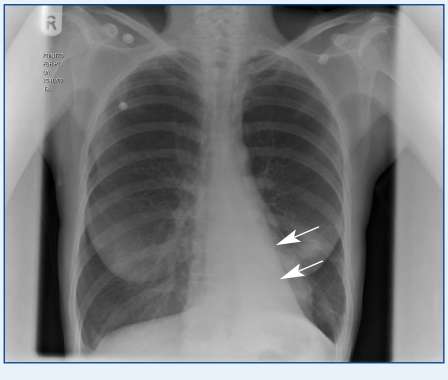
ambulatory peritoneal dialysis). Also look for subphrenic abscesses, calcified liver lesions, gallstones and dilated bowel loops. **Review areas**: Check that both breasts are present, look for lesions behind the heart silhouette and lung apices, or at the hila. Check the bones for focal abnormalities, density and fractures. Check the shoulder joints if they are visible on the CXR. Check the skin for surgical emphysema.

Rigorous radiological assessment may help to avoid common interpretative errors encountered in casualty (*Table 1*).

Common emergencies

The common emergency conditions requiring CXRs can be divided into non-traumatic and traumatic causes.

Figure 2. Left lower lobe collapse (arrows) seen as a wedge-shaped density posterior to the heart shadow. This is loss of the silhouette sign with obscuration of the medial aspect of the left hemidiaphragm. The left hilum is not seen as it has been pulled down with the lobar collapse. Note that the lungs are hyperinflated consistent with chronic obstructive pulmonary disease. The collapse was the result of mucus plugging.



Non-traumatic causes

Chest infections

On a conventional radiograph, four basic densities can be resolved: air, fat, soft tissues and calcification. An example of the value of natural contrast is the loss of silhouette sign. On a normal CXR the heart and mediastinal interface are clearly visualized against the black lungs. However, in cases of adjacent lung collapse or consolidation more X-rays are absorbed by the diseased lung, rendering it more opaque, and of similar X-ray attenuating density to the adjacent mediastinum, resulting in loss of the contour of adjacent structures (loss of the silhouette sign).

An example of loss of the silhouette sign occurs in left lower lobe collapse: the medial aspect of the left hemidiaphragm and the lateral border of the lower descending thoracic aorta is lost because these structures now lie adjacent to the collapsed left lower lobe which is denser than the alveolar air which would be present in the normal left lower lobe (*Figure 2*).

Table 2 lists radiological signs which may be present in collapse. Pure consolidation is denoted by the presence of opacification containing air bronchograms, no volume loss and obscuration of the normally visualized pulmonary vessels (normally their soft tissue density contrasts against the air-filled lung). Air bronchograms are caused by the presence of air-filled bronchi surrounded by pus-filled alveolar spaces. Collapse and consolidation frequently coexist. The most common causes of collapse are pneumonia, mucous plugging (asthma), bronchial neoplasm and inhaled foreign body (*Figures 3* and *4*). The site of the consolidation or collapse can be deduced by analysis of the film. If there is loss of clarity of a heart border or hemidiaphragm then collapse or consolidation in the adjacent lung is likely (*Table 3*).

Figure 3. Right middle lobe collapse seen (a) on the frontal view as an opacity associated with loss of the right heart border (loss of the silhouette sign) and (b) on the lateral view as a wedge-shaped opacity (arrows).

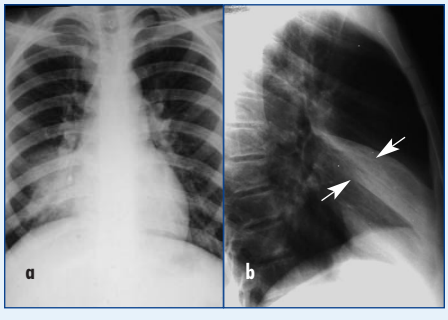


Table 2. Radiological features of collapse

On a chest X-ray the basic features of lobar collapse are opacity and loss of volume. The resulting signs are:
■ Increased density of pulmonary tissue
■ Completely obscured pulmonary vessels
■ Effacement of normally identified interfaces between air within the lung and surrounding soft tissues (silhouette sign)
■ Displacement of fissures
■ Displacement of the hilum towards the collapse
■ Movement of bronchi and blood vessels (crowding in the affected lobe and splaying in the normal lobes on the same side)
■ Elevation of the hemidiaphragm
■ Shift of the mediastinum (heart and/or trachea) towards the side of collapse
■ Compensatory hyperinflation of normal lung

Pulmonary embolism

The CXR is usually the first line of radiological investigation. There are many signs including subsegmental atelectasis (small volumes of collapse seen as linear densities), consolidation, infarction (classically wedge-shaped) and pleural effusion. These signs are non-specific. There are also some well-recognized signs including the Westermark sign (focal reduction in blood flow distal to an embolus resulting in increased translucency) and the Fleischner sign (dilatation of the pulmonary artery proximal to an embolus). However, in pulmonary embolism without infarction the CXR is normal in more than a third of cases.

Figure 4. Complete collapse of the left lung and right upper lobe collapse (arrow) as a result of erroneous position of an endotracheal tube in the bronchus intermedius.

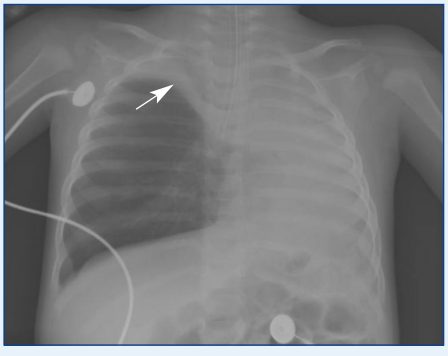


Figure 5. Acute left ventricular failure. There is bilateral perihilar airspace shadowing with bronchograms (arrow). Note the normal heart size in this case of pulmonary oedema associated with acute myocardial infarction.

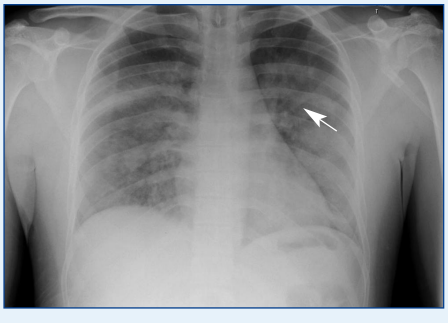


Table 3. Radiological signs indicating the site of consolidation/collapse

Ill defined	Site of consolidation
Left heart border and aortic knuckle	Left upper lobe
Left hemidiaphragm and descending aorta	Left lower lobe
Right heart border	Right middle lobe
Right hemidiaphragm	Right lower lobe
Right superior mediastinum	Right upper lobe

Pulmonary oedema

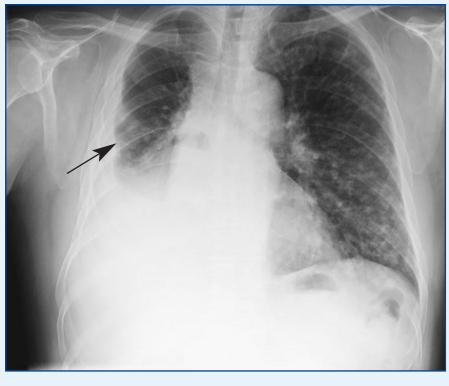
Radiological signs (*Table 4, Figure 5*) usually precede clinical signs of cardiac failure. Cardiomegaly and pleural effusions may be present as part of cardiac failure.

Pleural effusion

On an erect CXR an effusion is seen as blunting of the costophrenic angle with basal opacification. The upper margin of this is concave to the lung and higher laterally (*Figure 6*). In contrast the presence of a hydropneumothorax is denoted by a straight horizontal superior border of an effusion (*Figure 7*). There may be 200–500 ml present before this sign develops as fluid initially collects in the posterior costophrenic recess.

On the supine CXR there is reduced transradiancy as a result of dorsal pooling, with preserved lung vascular markings.

Figure 6. Right pleural effusion (arrow) with multiple pulmonary metastases seen in the left lung.



Abdominal pain

The erect CXR is very sensitive for the detection of pneumoperitoneum (*Figure 8*). Certain conditions may mimic pneumoperitoneum, including Chilaiditi's syndrome (colon interposed between liver and diaphragm), subdiaphragmatic fat, subphrenic abscess, uneven diaphragm, pneumatosis coli and curvilinear basal collapse.

Inhaled foreign body

The foreign body may be seen if it is radiopaque. A lateral view may help to localize the lesion in the trachea or oesoph-

Figure 7. Left hydropneumothorax with a straight superior margin of the effusion. Note the basal pneumothorax (arrow).

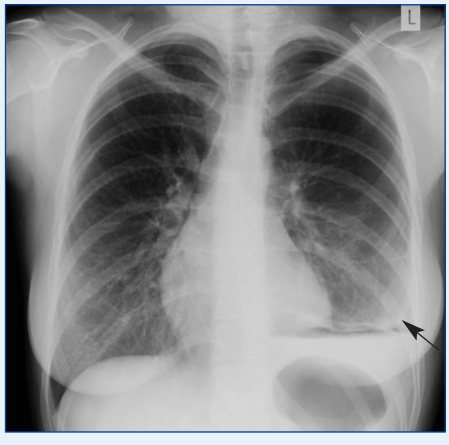


Figure 8. Pneumoperitoneum with free subdiaphragmatic gas bilaterally.

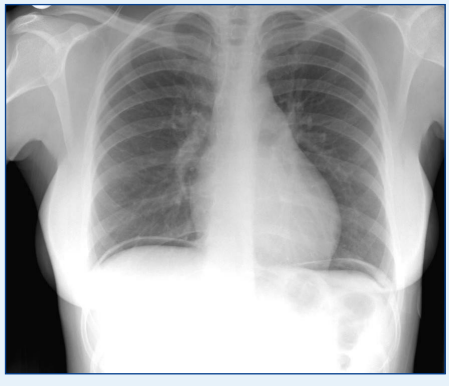


Table 4. Radiological signs of pulmonary oedema

Upper lobe blood diversion
Increased density over the lower zones of the lungs
Peribronchial cuffing
Perihilar airspace shadowing (bronchograms as a result of fluid in the alveolar spaces)
Kerley's A and B lines (owing to fluid in the interstitium causing thickening of the interlobular septa)

agus. Typically segmental or lobar collapse is seen. Acutely air trapping may occur with hyperinflation and contralateral mediastinal shift because of a ball-valve effect.

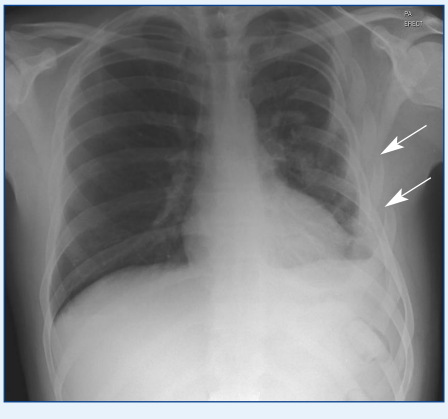
Aortic aneurysm

Radiological signs include mediastinal widening >8 cm with an abnormal aortic contour (*Figure 9*). In aortic dissection other radiological features that may be present are tracheal or oesophageal displacement with calcification in the aortic knuckle which is separated from the outer margin by more than 1 cm. There may be cardiomegaly as a result of haemopericardium or aortic regurgitation. There may also be a pleural effusion or pleural apical cap.

In traumatic aortic transection the CXR findings are indicators of the associated mediastinal haematoma. They include mediastinal widening, tracheal shift to the right, inferior displacement of the left main bronchus and widening of the paraspinal line without spinal fracture.

Figure 9. Large thoracic aortic aneurysm with gross mediastinal widening and abnormal aortic contour. The cardiomegaly was the result of aortic regurgitation.

Figure 10. Flail segment of the left chest wall with multiple ribs fractured in two or more sites (arrows) following a road traffic accident.



Trauma

Rib fractures

The role of the CXR in this situation is to exclude associated complications such as pneumothorax and lung contusion. Oblique views of the ribs are unnecessary because management is seldom altered by demonstration of the fracture. In a flail segment (*Figure 10*) two or more ribs are fractured in two or more places. It is associated with major intrathoracic injury and may progress to respiratory failure.

Pneumothorax

This is best looked for on an erect expiratory film. The radiological signs are the presence of a lung edge and lack of lung markings peripheral to this edge. It is important not to confuse skin folds and bullae with pneumothoraces. The presence of contralateral mediastinal shift and ipsilateral diaphragmatic flattening or inversion is indicative of a tension pneumothorax which is a medical emergency (*Figure 11*). Surgical emphysema (*Figure 12*) and pneumomediastinum may be associated with pneumothoraces.

Figure 11. Tension pneumothorax with mediastinal shift to the left.

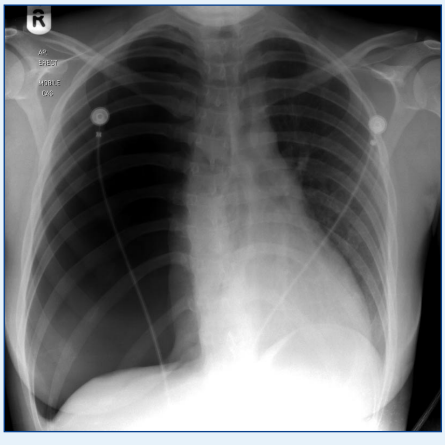
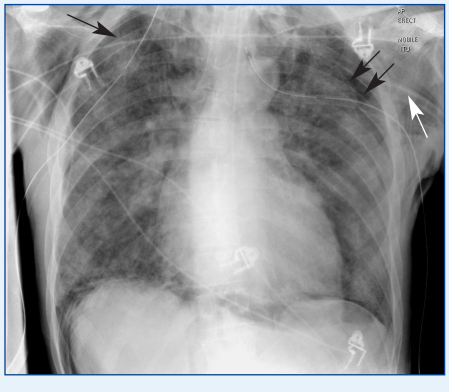


Figure 12. Adult respiratory distress syndrome with bilateral airspace shadowing consistent with pulmonary oedema, bilateral pneumothoraces (black arrows) and surgical emphysema (white arrow).



Diaphragmatic rupture

This may be caused by penetrating trauma or crush injury. It is more common on the left. Radiological signs include an ill-defined hemidiaphragmatic contour with herniation of bowel and organs into the thoracic cavity.

Pulmonary contusion

Radiologically this is seen as patchy airspace shadowing caused by the presence of blood in the alveolar spaces. Associated injuries such as pneumothorax, cardiac contusion and fractures should be sought.

Penetrating chest trauma

Check for pneumothorax, pneumoperitoneum, cardiac tamponade (globular cardiomegaly), transected aorta, ruptured diaphragm and major airway injury. BJHM

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Conflict of interest: none.

Further reading

Engeler CE (2001) Interpreting the chest radiograph. In: Grainger RG, Allison DJ, Adam A, Dixon AK, eds. *Diagnostic Radiology: A Textbook of Medical Imaging*. 4th edn. Churchill-Livingstone, Edinburgh: Vol 1, 303–14

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KEY POINTS

- Always check the name, age and date.
- Assess film quality.
- Check the mediastinal contour and hilar regions.
- Check the diaphragms and subdiaphragmatic areas.
- Inspect the lungs paying particular attention to the apices and behind the heart.
- Note the presence of medical equipment.
- Check the bones and extrathoracic soft tissues.