Cardiac disease on chest X-ray: a pictorial review

Introduction

The chest radiograph is the most commonly performed radiological examination in hospitals. Almost all patients admitted to the medical or surgical words will have at least one chest X-ray during their hospital stay.

Chest X-rays are frequently performed as an emergency examination, and the interpretation of this very complicated picture falls within the duty of junior doctors. In many situations, a correct diagnosis can be made on the basis of subtle radiological signs, which may significantly influence the immediate treatment and management of seriously ill patients. Therefore, knowledge of these subtle signs should be part of any medical training curriculum.

Technical quality of the chest X-ray

There are several technical factors which need to be considered to avoid a misinterpretation of the chest radiograph: projection, the patient's position and rotation, penetration of the X-rays and the degree of inspiration. All these factors can significantly influence the appearance of the heart, mediastinum and lung fields.

The projection of the radiograph (anteroposterior or postero-anterior) and the patient's position (elevated or supine) should always be clearly marked on the X-ray to alert clinicians to significant limitations of the test and possible false positive or negative findings.

Figure 1 shows a significant difference in the size and shape of the heart and mediastinum in the same patient on chest X-rays taken in different projections.

Inadequate depth of inspiration can cause an elevation of the diaphragm, haziness of lung bases, crowding of vascular markings and increase of heart size, which can closely mimic the radiographic features of congestive heart failure or bilateral basal pneumonia (*Figure 2*).

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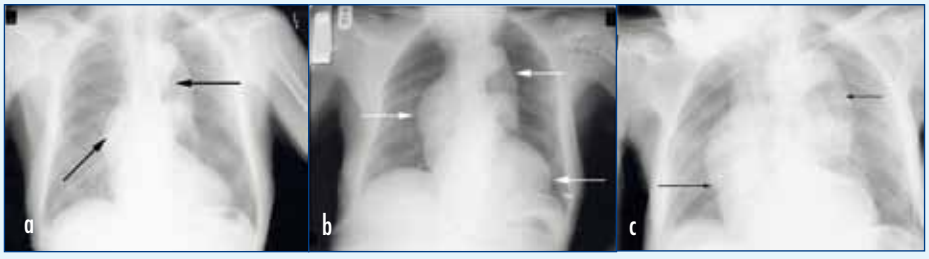


Figure 1. Postero-anterior, anteroposterior and supine chest X-ray of the same patient showing the positional effect on the appearance of the mediastinal structures. a. The postero-anterior projection demonstrates a normal size heart and slight widening of the mediastinum as a result of unfolding aorta. b. The anteroposterior projection shows an increase in size of the heart and the width of the mediastinum. c. Anteroposterior supine film demonstrates severe widening of the mediastinum, simulating soft tissue mass.

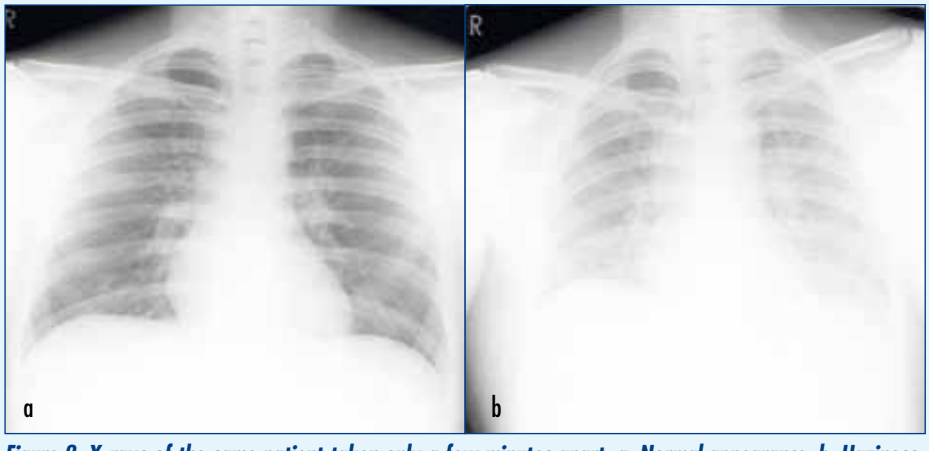


Figure 2. X-rays of the same patient taken only a few minutes apart. a. Normal appearance. b. Haziness of lung fields in the lower zones bilaterally, indistinguishable left hemidiaphragm and prominence of hilar vasculature. Changes are secondary to poor inspiration.

Anatomy

The heart lies in the anterior mediastinum, immediately posterior to the sternum. The position of the heart is very variable; on average one third lies to the right of the midline, but anything from one half to one fifth of the heart lying on the right side is within the normal range.

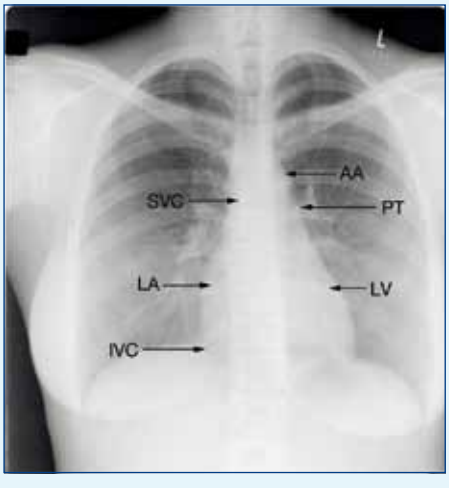
The right heart border comprises the superior vena cava, right atrium and sometimes a short segment of inferior vena cava. The right ventricle does not contribute to the right heart border.

The left border of the cardiac silhouette is formed by the aortic arch, pulmonary trunk, left atrial appendage and left ventricle (*Figure 3*).

Figure 3. Normal chest radiograph. The right heart border (comprising the IVC = inferior vena cava; RA = right atrium; SVC = superior vena cava) and the left heart border (comprising the AA = aortic arch; LA = left atrium; LV = left ventricle; PT = pulmonary trunk) can be seen.

Cardiac enlargement

A commonly used measurement of the heart size, the cardiothoracic ratio, expresses the proportion of the heart size to inter-



nal thoracic diameter and should normally be below 50%. It is often increased in neonates and elderly patients. Although a good initial indicator of the heart size, it is not very accurate, and comparison with previous chest radiographs is more useful than the cardiothoracic ratio in isolation.

Enlargement of the heart can be generalized, commonly described as global cardiomegaly, or selective where one or two chambers predominate. Causes of generalized cardiomegaly include congenital heart disease, valvular disease, cardiomyopathy, coronary disease, pericardial effusion, masses and tumours (*Figure 4*).

Multi-chamber enlargement is more commonly seen in everyday practice, as it very often represents a sequence of dynamic changes and subsequent compensatory mechanisms in impaired cardiovascular circulation. For example, failure of the left ventricle would cause an enlargement of the left atrium, which would further cause an increase in pulmonary pressure and enlargement of the right side chambers.

Therefore, radiological features associated with specific chamber abnormality and its careful assessment can guide diagnosis of initial pathology and understanding of dynamic changes in complicated cardiac function (*Figure 5*).

Figure 4. Generalized cardiomegaly in a child with dilated cardiomyopathy.

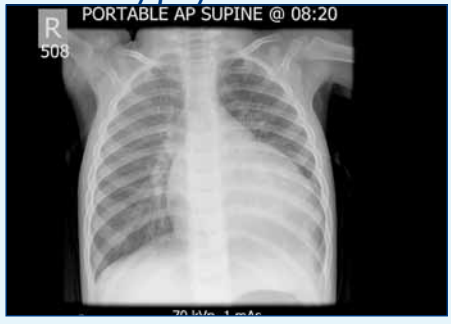


Table 1 shows characteristic features of specific atrial and ventricular abnormality.

Abnormal size and shape of the heart can be also caused by focal abnormalities not related to chamber enlargement. These include pericardial cyst, ventricular aneurysm, myocardial mass, coronary artery aneurysm or pericardial sac defect (*Figure 6*).

Pulmonary vascularity

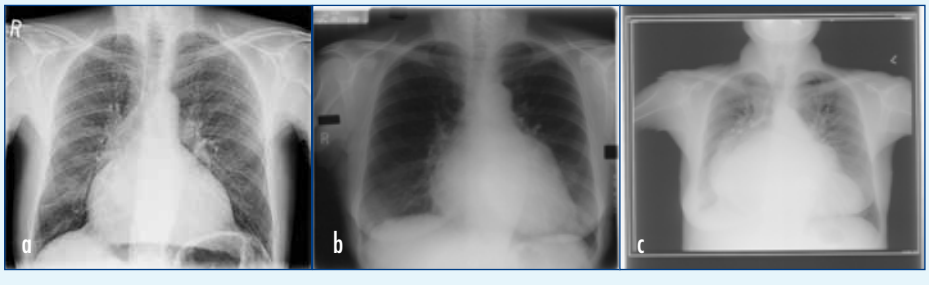
Cardiac diseases not only affect the size and shape of the heart, but most of them cause significant changes in the pulmonary vasculature.

In acquired heart disease, a dominant pathology presents as pulmonary venous hypertension, which may progress to pulmonary arterial hypertension. Congenital heart disease usually involves different types of arteriovenous shunts and therefore presents as a plethora or oligaemia.

Table 1. Characteristic features of cardiac chambers enlargement

Left atrium	Prominent left atrial appendage
	Double right heart border or double shadow seen through the heart
	Increased density over the heart
	Elevation of left main bronchus and splaying of the carina
Left ventricle	Displacement of apex inferiorly
	Elongation of long axis of left ventricle
	Prominent left heart border
	Rounding of left heart border
Right atrium	Prominent right heart border
Right ventricle	Elevation of the apex
	Prominent left heart border

Figure 5. Chest X-rays showing different stages of cardiomegaly secondary to left atrial enlargement. a. Enlargement of left atrium with a elevation of the left main bronchus and double right heart border. b. Enlargement of left atrium with bulging of left heart border, sternotomy sutures. c. Gross heart enlargement, changes in pulmonary vasculature and mitral valve replacement.



Pulmonary venous hypertension is typically divided into three grades of severity:

1. Reversal of the normal gradient of pulmonary flow
2. Interstitial pulmonary oedema with pleural effusion
3. Alveolar pulmonary oedema.

Early stages of pulmonary hypertension are usually very subtle on the chest X-ray, therefore special attention needs to be paid to evaluation of the pulmonary vessels in the upper lobes on every X-ray. Under normal conditions, most of the blood passes through vessels in the lower lobes, which appear significantly bigger. With increased pulmonary pressure, blood is being diverted to vessels located more superiorly, which become either equivalent to or wider in diameter than lower zone vessels. The normal concave shape of the hila has been changed and blood vessels become less distinct peripherally (*Figure 7*).

These signs should always be evaluated on the standard chest X-ray, taken in the elevated position, as prominence of the upper lobes vessels is a well-described phenomenon on the supine projection and should not be mistaken for early cardiac impairment (*Figure 8*).

Figure 6. Right pericardial cyst.

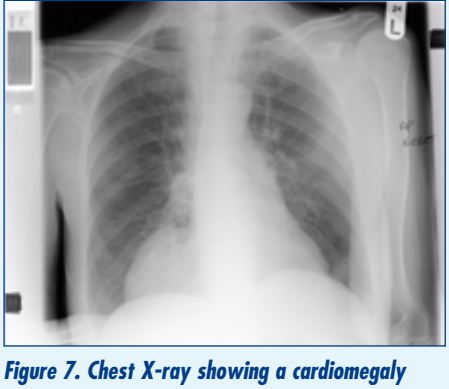


Figure 7. Chest X-ray showing a cardiomegaly with a prominence of upper lobe vessels.

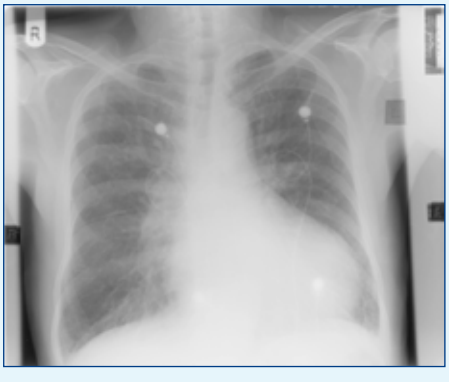


Figure 8. The anteroposterior supine chest X-ray shows increased prominence in the hilar vasculature and the dilatation of the vessels in the upper lobes. These changes are caused by the supine position of the patient, not cardiac failure.

The most common and clear sign of interstitial pulmonary oedema is Kerley B lines; short horizontal lines in the periphery of the lungs, perpendicular to the pleural surface, and often visible at the costophrenic angles, which are caused by accumulation of fluid in the interlobular septa and lymphatics. Accumulation of fluid in the interstitial space also causes an indistinctiveness of the vessel margin, perihilar clouding, peribronchial thickening, a reticular parenchymal pattern in lower zones and subpleural oedema (*Figure 9*).

Alveolar pulmonary oedema is characterized by a confluent air space pattern, which can be generalized but more frequently has a perihilar or lower zones distribution (*Figure 10*).

Bone structures

Detailed assessment of bony structures is also very important. Some skeletal abnormality such as a lytic lesion or a missing rib may be explained by a previous surgical procedure. The presence of bilateral rib notching should immediately raise the suspicion of coarctation of the thoracic aorta, whereas the rare finding of unilateral rib notching on the left side will represent an anomalous right subclavian artery. A shape abnormality such as a pectus excavatum should also be clearly identified for its association with Marfan's disease and a prolapse of the mitral valve.

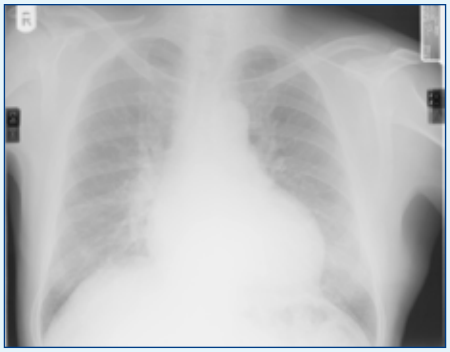


Figure 9. Chest X-ray shows cardiomegaly, prominence of upper lobe vessels, perihilar haziness and Kerley B lines in the right lower zone.

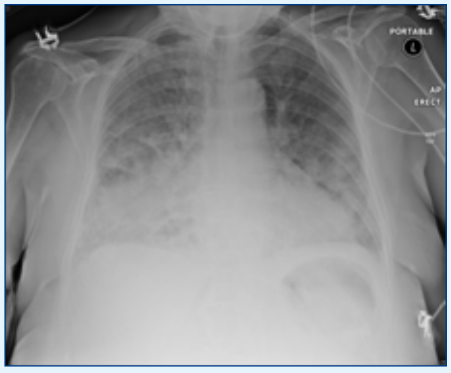


Figure 10. Cardiomegaly and alveolar pulmonary oedema.

Previous surgery

Paying special attention to foreign bodies and surgical devices visible on the chest X-ray may give further information about a patient's condition and previous surgical treatment. While a pacemaker or cardiac stimulator is visually obvious on the X-ray, surgical clips after bypass surgery or small closing devices for congenital defects, as ventricular septal defect or atrial septal defect may be difficult to notice without knowing that they may be present (*Figure 10*). After open bypass surgery patients very often present with focal pleural thickening and persistent pleural effusion, mainly on the left side. In many patients this is a longstanding feature, which has been well described in large groups of patients (*Figure 11*).

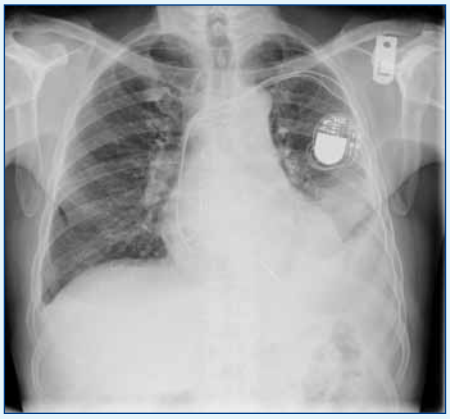


Figure 11. Chest X-ray showing a marked cardiomegaly with enlarged left atrium and left sided pleural effusion. Sternotomy sutures, double-lead pacemaker and surgical clips over the left heart border are also present.

Conclusions

The chest X-ray is an extremely valuable test in the assessment of cardiac disease. It demonstrates not only size and shape of the heart, but also characteristic features of specific chamber enlargement. Changes in the pulmonary vasculature, appearance of the lung fields and pleura will provide further information of cardiovascular function. Additional features, such as metallic implants, calcifications or bony abnormalities, may also be related to underlying heart abnormality. BJHM

Conflict of interest: none.

KEY POINTS

- Chest X-ray provides a good initial assessment of patients with cardiac disease.
- Patient position and technical quality of the X-ray can significantly affect the appearance of chest structures.
- Radiographic features of cardiac disease involve not only the size and shape of the heart, but also changes in pulmonary fields, soft tissue and bony structures.

Further reading

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