RAD 420

Introduction to Interpretation of Chest Radiograph – Normal Radiological Anatomy

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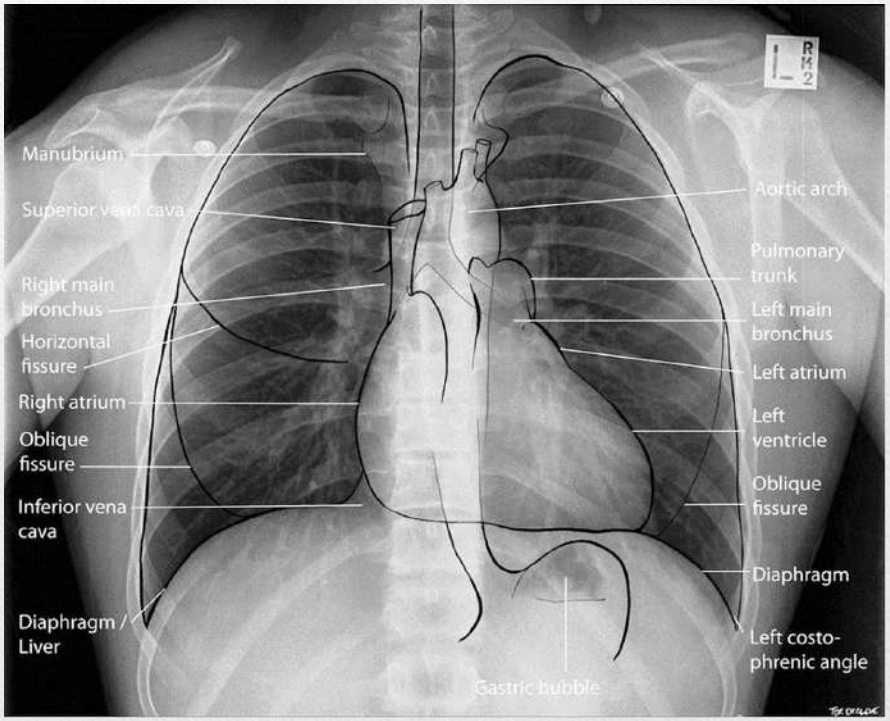
Introduction: The respiratory system and mediastinum

- The routine chest radiographs to examine the respiratory system and mediastinum comprise a posteroanterior (PA) and a lateral view.
- Ideally, both should be exposed on full inspiration with the patient in the upright position.
- Films taken on expiration are difficult to interpret because in expiration the lung bases appear hazy and the heart shadow increases in size.
- Even though chest films are the commonest x-ray examinations performed they are also one of the most difficult plain films to interpret.

The Normal Radiological Anatomy of the Chest

- The chest radiograph is an image of the anatomy of the thorax. Diseases produce additional features or alter the anatomy in ways which are characteristic of the disease process involved.
- An ideal PA radiograph of the chest is the one shown in figure 1. The radiograph has been annotated to make understanding of the radiological anatomy which follows thereafter easy.

Figure 1: An ideal chest radiograph exposed in PA position



The lungs

- The lung fields are divided for descriptive purposes into three zones:
  - the upper zone, above the anterior part of the second rib;
  - the lower zone, below the upper part of the fourth anterior rib; and
  - the middle zone lying in between the upper and lower zones.
- The lungs are the main translucent areas in chest radiograph. Within them are seen some structures which are relatively less well penetrated by the x-ray beam. These are the hilar pulmonary artery branches, pulmonary veins and the septae. The bronchi because they contain air are not normally visible.

The hilar shadows

- These are largely due to the pulmonary arteries and their main branches, and also the upper lobe pulmonary veins.
- Normal lymph nodes are too small to contribute significantly to these shadows.
- They are normally V-shaped lying on its sides, that is “>”. The upper limb of the V-shaped shadow is formed by the upper lobe veins reaching the left atrium while the lower limb represents the branch of the pulmonary artery to the lower lobe.
- The midpoint of the right hilum lies at the level of the sixth rib in the axillary line (that is the horizontal fissure).
- The left hilum lies about 1-2 cm higher than the right. This is because the right pulmonary artery lies below the right main bronchus while the left pulmonary artery lies above the left main bronchus as illustrated in figure 2.

Figure 2: *A posteroanterior chest x-ray illustrating the relative positions of the lung hila*

Trachea

- **Trachea**: It appears as a vertical translucent band centrally situated in the neck at the level of the thoracic inlet and slightly deviating to the right in its lower third.
- The walls of the trachea are usually not visible on radiographs.

Fissures

- The lungs are anatomically divided into lobes which are separated by tissues formed by the reflections of visceral pleura.
- The right lung is divided into three lobes which are referred to as upper, middle and lower lobes. The left lung is divided into two lobes namely; upper and lower lobes. The left lung has an equivalent of the right middle lobe in the lingula which is a part of the left upper lobe.
- The normal interlober fissures vary considerably in depth, but the lobes are never completely separated to the lung root.

Fissures

- The horizontal fissure on the right separates the upper and middle lobes and is seen as a fine line running horizontal or slightly downwards from the hilum to end anywhere between the mid-portion of the third and sixth ribs.
- The horizontal fissure is only seen in about 65-80% of subjects. In rare instances, there may be an azygous lobe and an associated fissure; and also an inferior accessory fissure in the basal portion of the right lung.

Diaphragm

- **Diaphragm**: The hemi diaphragms appear as convex bands lying at the level of the anterior end of fifth rib on the right and sixth rib on the left in full inspiration.
- The right hemi diaphragm is usually higher them its left counterpart by between 1-3 cm but in 10% of the cases the right and left hemi diaphragms may lie at the same level.
- On very rare occasion the left hemi diaphragm may be higher than its right counterpart.

Diaphragm

- Occasionally, a hemi diaphragm may appear to be high due to a diaphragmatic hump. This is a congenital elevation of the anteromedial segment of the diaphragm.
- The diaphragm forms the costophrenic angles with the lateral chest walls and cardiophrenic angles with the heart.
- The acuity of costophrenic angles is an important consideration in diagnosing pleural effusion. The costophrenic angles should not be missed in any chest radiograph.

The thoracic cage and overlying soft tissues

- The thoracic cage consists of the ribs, sternum and the lateral chest walls.
- At least 6-7 anterior ribs should be visible on a normal and appropriately taken PA chest radiograph.
- Companion shadows are water density reflections of the skin over the clavicles. The skin reflections lie directly in the longitudinal axis of the x-ray beam.
- They are almost always visible over both clavicles and may also occur below the first and second ribs.

The thoracic cage and overlying soft tissues

- The overlying soft tissues visible are breast shadows, nipples and anterior skin fold associated with the pectoralis major muscle.
- The nipples are seen as rounded opacities between 5 mm and 10 mm in diameter with varying position. The variation in positions is a direct result of turgidity of the mammary tissues.
- The very turgid breast tissues are firm while the non-turgid tissues cause the breasts to become pendulous with attendant instability in nipple position.

The intrapulmonary vessels

- The intrapulmonary arteries are seen passing out into the lungs from the main pulmonary arteries.
- They are well seen in the medial portion of the right lung base. They become smaller as they pass towards the periphery of the lung.
- They are normally smaller in the upper zones than in the lower in radiographs done in erect position as shown in figures 1 and 2.

The intrapulmonary vessels

- The segmental pulmonary arteries have the same arrangement as the bronchi.
- The segmental pulmonary veins do not lie with the arteries or bronchi, but at the periphery of the lung segments. They form two main pulmonary veins on each side which empty into the left atrium.
- The veins are slightly larger than the arteries; those from the upper zones being smaller than those from the lower zones.

The mediastinum

- This is one continuous space between the sternum at the front, the spine and ribs at the back and the lungs on the two sides.
- The mediastinum is divided into superior and inferior compartments.
- The superior mediastinum lies above the imaginary line joining the manubrosternal joint (sternal angle) and the upper border of the fifth thoracic (T5) (dorsal D5) vertebral body.
- The inferior mediastinum lies below the sternal angle and is divided into anterior mediastinum which is anterior to the heart; middle mediastinum which includes the heart and the great vessels; and posterior mediastinum which is behind the heart.

The mediastinum

- In the centre of the chest overlying the spine is the heart.
- The heart is a dome-shaped structure in the midline with a maximum transverse diameter of 15.5 cm or less.
- Approximately, two third to three quarter of the cardiac mass lie to the left of midline. The heart and the great vessels form most of the mediastinal borders. The right mediastinal border is formed superiorly by the superior vena cava (SVC).
- With increasing age and tortousity of vessels the innominate artery often comes to form this border.

The mediastinum

- Below the SVC the lower one third of the right mediastinal border is formed by the right atrium and occasionally by a small portion of inferior vena cava (IVC) inferiority.
- The left mediastinal border is formed superiorly by the aortic knuckle (aortic arch) and below this by the pulmonary artery and left atrial appendage.
- Approximately, the lower half of the mediastinum is formed by the left ventricle.

Criteria for ideal PA chest radiograph

- The radiograph must be taken with the patient in deep inspiration. To meet this criterion about 9-10 posterior rib segments must be seen or the fifth anterior rib segment must bisect the dome of the diaphragm.
- The costopheric and cardiophrenic angles must be seen on the radiograph.
- Both lung apices must be seen on the radiograph.
- The scapula should not obscure any part of the lung field. The scapula overlying any part of the lung field is indicative of poor positioning.

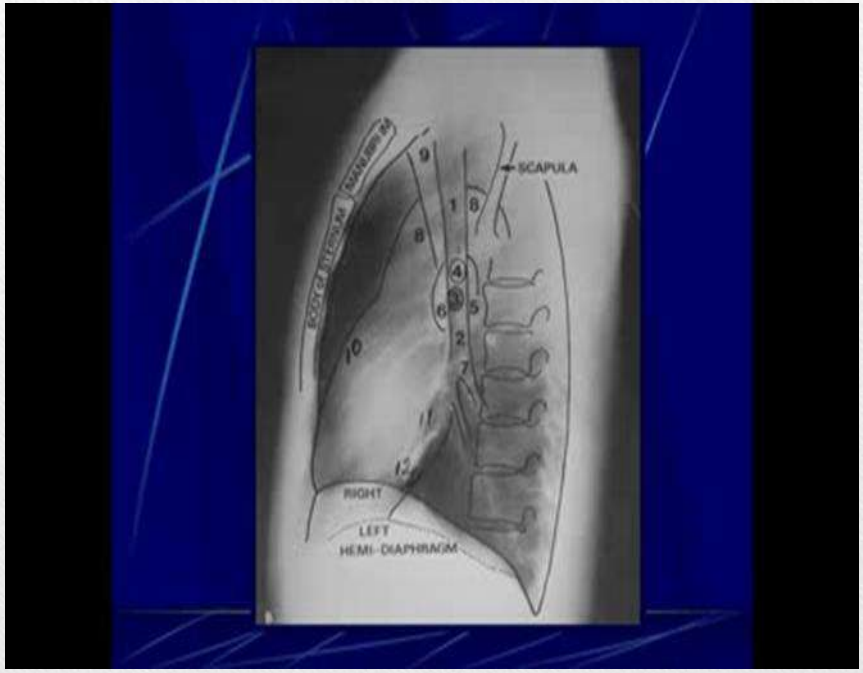
Criteria for ideal PA chest radiograph

- The sternoclavicular joints must be equidistant from the midline. Unequal sternoclavicular joint spaces indicate rotation. If the patient's thorax is rotated and is not parallel with film the distances between the medial ends of the clavicles and the spinous processes of the vertebral bodies will not be equal. The side of the chest rotated away from the film is the one in which this joint space is larger. The lung field on that side will also appear more lucent.
- Some cervical vertebrae should be seen; at least 4-6 lower cervical vertebrae should be visible on the radiograph.
- The trachea should be clearly delineated.
- The spine behind the heart shadow should be seen but the disc spaces should not be delineated. Delineation of the disc spaces is an indication for over- penetration. Over-penetration of chest radiographs can cause missed lesions because the lesions will be "burnt-off".
- The cardiac outline should be seen on the radiograph.

Lateral Radiograph

- A lateral radiograph, which is shown in figure 3 may give additional information and normally the one obtained is the left.
- However, if a pathological process is known to be present the lateral view which brings it closest to the radiographic film should be the one obtained.
- A lateral radiograph is particularly important in confirming the position of an abnormality and identifying lesions in the mediastinum.

Figure 3: *An ideal chest radiograph exposed with the patient in lateral position*



Lateral Radiograph

- The oblique and horizontal fissures may be seen in the lateral view.
- The horizontal fissure is seen running anteriorly from the hilum towards the sternum. It is normally convex upwards.
- The oblique fissures usually have their upper extent at the level of fifth thoracic (T5) vertebral body or disc space; the right being lower than the left. They lie parallel with the sixth rib and reach the diaphragm several centimeters behind the anterior costopheric angle.
- The left oblique fissure is usually more vertical than the right.

Lateral Radiograph

- The heart is seen as an elliptical structure in the anterior half of the chest stretching from the anterior costophrenic angle to the tracheal bifurcation.
- The aortic arch is seen passing upwards and then inferiorly behind the heart.
- Behind the manubrium sternum and in front and above the heart is a transradiant area called ***retrosternal transradiancy*** or ***retrosternal space***.
- In this region the two lungs are nearly in apposition and because of this high aeration the space is the darkest on lateral radiograph of the chest.
- There is also a dark patch behind the heart known as ***retrocardiac transradiancy*** or ***retrocardiac space***.

Anteroposterior (AP) Radiograph

- An anteroposterior (AP) film may at times be obtained from a very ill patient with the patient lying on the film or sitting with his back to it.
- This film will demonstrate the lung fields clearly but is not appropriate for heart or mediastinal size evaluation because of geometric distortion.
- It should be noted that whenever possible AP projection should be avoided.

Projection

- Is the film a PA or AP view?
- This is especially important for radiographs meant for cardiac size assessment.

Patient's Data

- Details regarding the patient such as name, age, sex, date of examination and clinical history should be retrieved and documented in the radiological report.
- Apart from assisting in patient identification, parameters such as sex can influence the appearances seen in a chest radiograph. For instance, an adult female patient is expected to have breast shadows and men tend to have broader chest than women.

Symmetry of Chest Wall

- Any slight rotation produces unequal transradiancy of the lungs and undue prominence of one hilum which can be mistaken for a lung disease. Rotation is assessed by looking at the space between the medial ends of the clavicles and the lateral margins of the dorsal vertebrae.

Adequacy of Penetration

- This is assessed by the visibility of disc spaces between the dorsal vertebral bodies behind the heart. They should just be barely visible. Subtle lesions behind the hilar and heart shadows may be missed in an underpenetrated film. On the other hand pulmonary lesions could be burnt off in over penetrated chest radiographs.

Diaphragm

- Trace the diaphragmatic contour and assess the level of the hemi diaphragm on both sides. Evidence of depression or elevation of one or both hemi diaphragms should be documented and evaluated to determine the clinical cause of such appearance. The diaphragm can be elevated in segmental collapse of the lung, hepatomegaly, subphrenic abscess, and phrenic nerve palsy. It can become flattened in chronic obstructive airway disease (COAD) such as chronic bronchitis and emphysema, massive pleural effusion, tension pneumothorax and even in excessive inspiration effort in normal subjects. Assess the costophrenic angles which should be acute if normal. In erect position, costophrenic angles represent the lowest dependent areas and early pleural effusion is seen as blunting of these recesses where the fluid collects.

Heart

- The size of the cardiac silhouette should be assessed for size and contour. The maximum transverse cardiac diameter should be 15.5 cm or less in normal subjects. Cardiac size and contour assessments are important for diagnosis of cardiomegally. It is also important to check for abnormal displacement of cardiac silhouette to the right or left of midline.

Mediastinal Shift

- Evidence of mediastinal shift should be checked using the positions of the trachea and heart. Mediastinal shift can occur in chronic pulmonary tuberculosis (PTB), lobar collapse of the lungs, mediastinal mass, and pneumothorax.

Hilar Shadow

- Both shadows should be assessed for prominence or otherwise. Hyperaemia of hilar vessels may occur in disorders such as pneumonia, sickle cell disease (SCD) and hypertension. Enlarged hilar lymphnodes can be seen in situations of inflammatory response such as pneumonia and PTB. Displacement of hilar shadows occurs is usually a feature seen in atelectasis.

Fissures

- Examine the fissures very well to find out any changes in the position. Displacement of lung fissures from their normal positions is also indicative of atelectasis.

Lung Fields

- The following inspections should be carried for lung fields:
- Look for evidence of homogenous opacity such as in pleural effusion.
- Look for evidence of segmental or lobar consolidation such as in lobar pneumonia.
- Look for evidence unequal transradiancy such as in atelectasis. Note that rotation of the chest or x-ray tube in relation to the chest (technical factor) can lead to unequal transradiancy of both lungs. Always be sure that unequal transradiancy of both lung fields when seen is not due to technical factors.
- Look for evidence of mottled appearances or opacities that may indicate miliary PTB, metastases from a distant primary malignancy, and pneumoconiosis.

Lung Fields

- Look for evidence of nodular masses which may be indicative of cancer of the bronchus and bronchial adenoma.
- Look for evidence of changes in pulmonary vasculature. Loss of pulmonary vascular markings may be due to emphysema while undue prominence of vascular markings may be as a result of hyperaemia. Reversal of the normal pattern of pulmonary vasculature is usually linked to cardiac disease.
- Look for evidence of hyperinflation such as loss of pulmonary vascular markings, flattened hemi diaphragms, and over-expansions of the lungs. All these appearances are indicative of COAD.

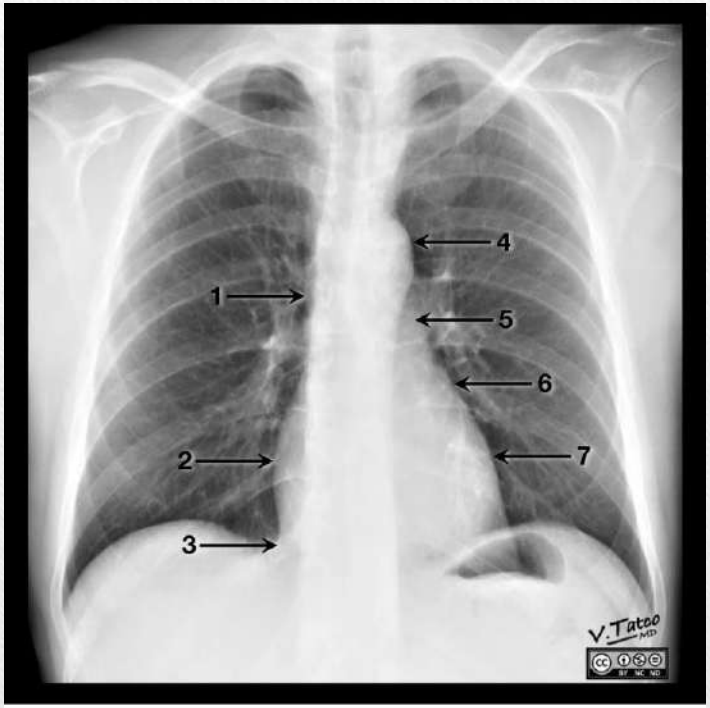
Bony Thorax

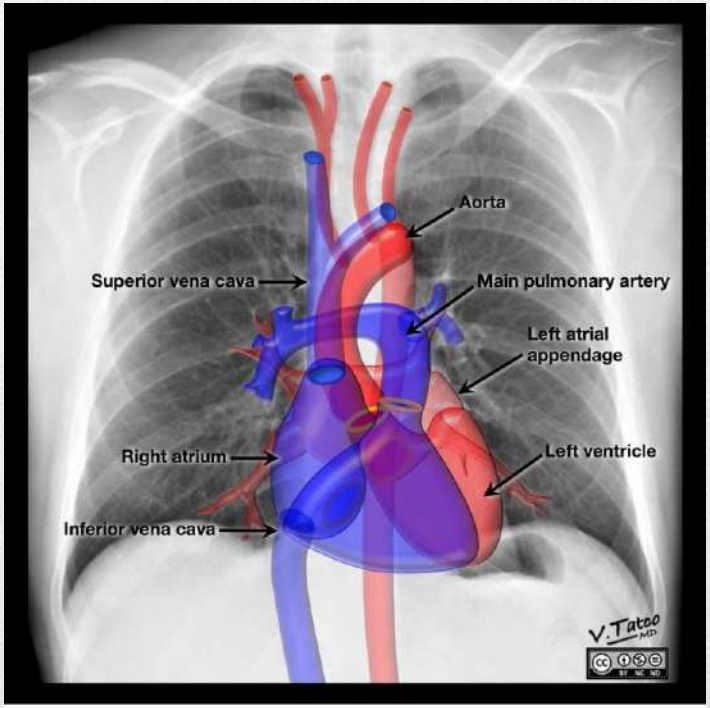
- The thoracic cage should be assessed to rule out fractures in cases trauma. Arthropathies of the shoulder joint such as rheumautoid arthritis should be ruled out. Bony outline should be evaluated to discover areas of bone destructive lesions such as metastases from a distant malignant tumor.

Soft Tissue Shadows

- Breast shadows may be absent in post mastectomy women.
- Axillary soft tissue fullness can give indication of the nutritional status of a patient. In emaciated patient thickness of the axillary line is usually decreased.

The Heart and Great Vessels





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Thank you for listening