PART

1

Basics

INTRODUCTION

X-rays are electromagnetic radiations. X-rays are produced when electron beam strikes anode. X-ray was discovered by Wilhelm Roentgen in 1895.

When X-ray strikes a photosensitive film made up of cellulose acetate, the film gets photosensitized due to presence of radiation sensitive silver halides such as silver bromide or silver chloride. When such a film is developed and fixed chemically, a photography image is obtained.

LABEL

One must look at the label in the corner of the X-ray film for proper identification of the patient. It is embarrassing making the right diagnosis in the wrong patient. Please verify the marker for correct side, usually (L) for the left.

VIEW

The 'view' expresses the direction of flow of the X-rays. In a posteroanterior view, X-rays travel from posterior to anterior side. In anteroposterior view, X-rays travel from anterior to posterior side. It is prime necessity to obtain posteroanterior and lateral views of chest radiograph for all patients who are ambulatory to be transported to the radiology department (Figs 1.1 and 1.2).

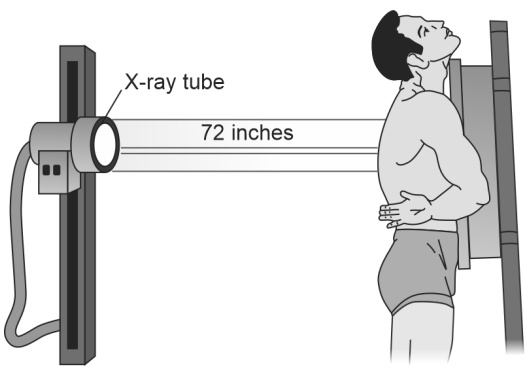

Fig. 1.1: Posteroanterior view

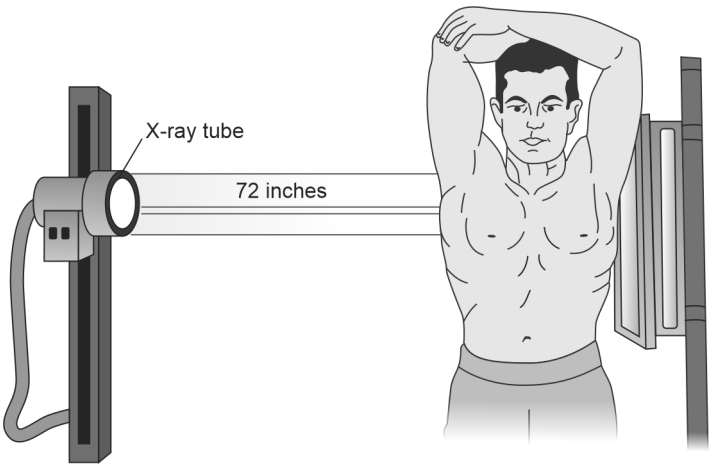

Fig. 1.2: Lateral view

In emergency, obtain an anteroposterior film (portable CXR) in patients who are too ill to be transported. Lateral chest X-ray is taken either the right or left side of the patient against the film.

Frontal views, viz. anteroposterior and posteroanterior views, and lateral views are considered as standard views. Oblique view is obtained occasionally.

DENSITY

Radiolucency or transparency of the film is inversely proportional to the density of the objects. Gas, fat, fluid, bone, and metals are the structural components of X-ray film, and are in order of increasing brightness. Structures, which are easily penetrated, are described as radiolucent, and the structures which are penetrated with difficulty, or not penetrated at all, are described as radiopaque.

QUALITY OF CXR FILM

Criteria for Penetration

In a good quality X-ray, film intervertebral spaces are visible. Outline of vertebral bodies should be demarcated within the cardiac shadow. If the exposure is correct, thoracic spine should be visible through the mediastinum. Overexposure creates a film that is highly black, and may underestimate pneumothorax or bullous changes as in emphysema. If the vessels in the lungs cannot be seen, the film is too black and, therefore, overexposed. If underexposed, the film is too white, making subtle consolidation or effusion difficult to detect. In a nutshell, too dark is overexposed, too white is underexposed.

Criteria for Rotation

Imaginary line (horizontal) passing through the clavicular heads on both sides should be perpendicular to the imaginary line (vertical) passing in the medial plane through vertebral spinous process, in addition there is bilateral symmetry of the clavicle bone, otherwise the patient is probably rotated. Rotated film can make heart appear larger.

The medial ends of the clavicles should be equidistant from the spinous process. If one clavicle is nearer than the other, then the patient is rotated and the lung on that side will appear whiter, while the opposite side will appear somewhat darker due to compensation (Fig. 1.3).

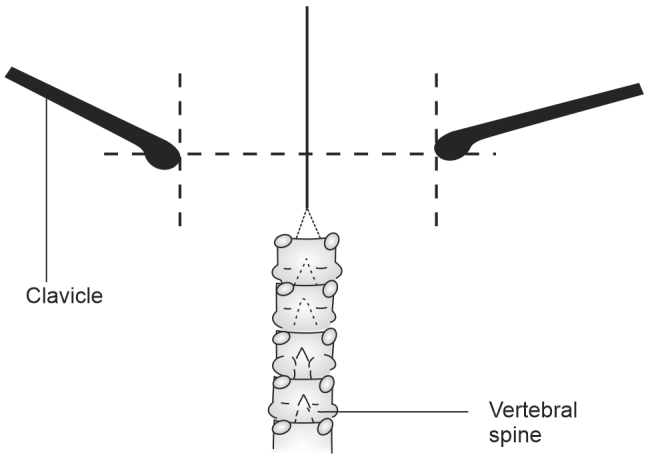

Fig. 1.3: Measurement of rotation

Criteria for Good Inspiratory Effort

In a customary, a CXR is usually taken in a state of end of full and deep inspiratory effort.

Nine posterior ribs visible above the right hemidiaphragm is regarded as a good inspiratory effort. The midportion of the right hemidiaphragm should be below the 9th or 10th rib.

Good inspiratory effort increases anteroposterior diameter of chest. In a PA view, heart lies more close to the X-ray film, which lies against the anterior chest wall. Poor inspiratory effort shows abnormally large cardiac shadow which misleads the interpretation of the X-ray film.

CHEST X-RAY [PA AND AP VIEWS]

Sharpness of the borders of an object relies on closeness of the structures; therefore, it is essential to obtain a CXR with the patient front against the film (PA view) owing to the fact that heart and large vessels lie relatively anterior in the chest.

Anteroposterior view is best suitable for visualizing posterior structures, such as thoracic spine because of the same fact stated above.

Basic rule of radiography is try to get the lesion as close to the film as possible. For this reason, anteriorly located pathology is best seen in PA view and posterior pathology in AP view.

In a posteroanterior view, the maximum transverse diameter of the cardiac shadow should not exceed the half of the maximum transverse diameter of the thorax. This is **cardiothoracic ratio** or **cardiothoracic index** (Fig. 1.4).

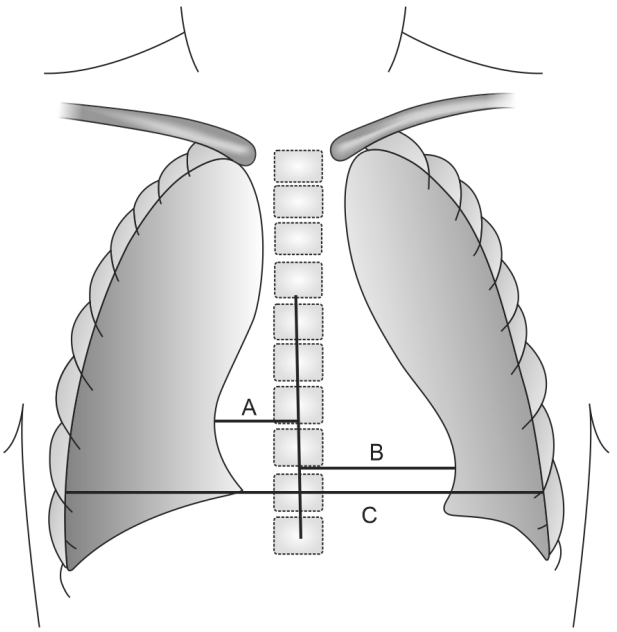

Fig. 1.4: Cardiothoracic index

C = internal diameter of chest at level of right hemidiaphragm (normally undertaken), A = greatest horizontal diameter from midline to right heart border, B = greatest horizontal diameter from midline to left heart border, CT index = (A + B)/C

In an anteroposterior view, X-ray is taken when X-ray film is lying posteriorly against chest wall. In this situation, heart lies relatively posterior to the film in comparison of PA view, giving false impression of large cardiac shadow, with ill-defined borders. Thus comment on size of heart should not be made, if AP view of the chest is being examined.

In addition, **anteroposterior projection** image is of lower quality than **postero-anterior image**. The scapula not retracted laterally and they remain projected over each lung. Increased cardiothoracic ratio is acceptable in this view because of the obvious reasons.

Poor inspiration, obesity, pectus excavatum are some of the few important factors which deceptively increase **cardiothoracic ratio**. All these conditions increase the distance of film in relation to the heart, leading to large image of the heart, which is not true cardiomegaly.

Essentially, comment regarding the cardiac size should not be made in antero-posterior view and bedside X-rays in emergency setting, unless it is chest X-ray posteroanterior view which is ideal to assess cardiothoracic index. All X-rays in the PICU are portable and are AP view.

Demerits of anteroposterior view are—deep inspiration not possible and diaphragm is at highest level; superior mediastinum also widened; lungs are partially expanded and ribs and pulmonary vessels are somewhat crowded; and in addition, cardiac shadow is magnified.

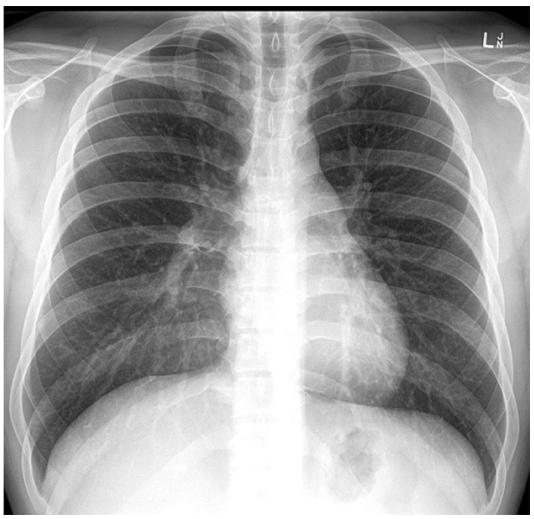

Fig. 1.5: Normal chest X-ray

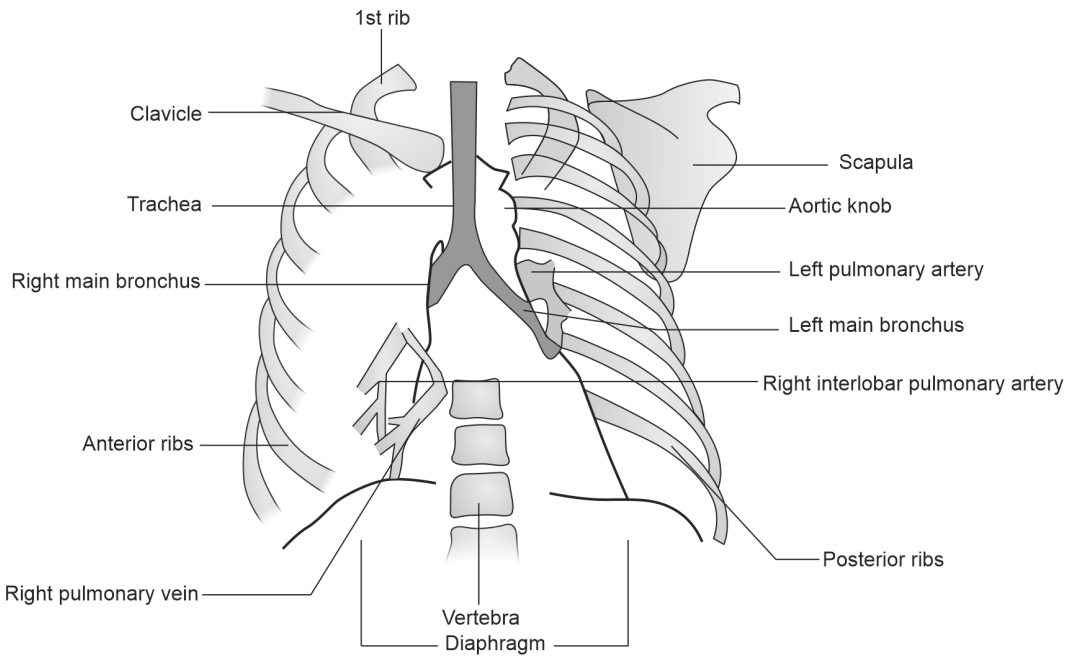

Fig. 1.6: Normal chest X-ray (diagrammatic)

Frontal view chest X-ray has specific positioning of each and every structure, use the knowledge of anatomy to make out the shape, size, position and symmetry of the chest (Figs 1.5 and 1.6).

- **First rib:** Behind the clavicle.
- **Clavicle:** Equidistantly and symmetrically placed on imaginary line passing through the spine process. Articulate with manubrium on either side. Absent in cleidocranial dystosis.

- **Trachea:** Midline translucent structure.
- **Vertebra:** Seen through cardiac shadow.
- **Anterior and posterior ribs:** Identified by the direction of curve they assume.
- **Pulmonary veins:** Normal vascularity of the lung. Do not interpret them as pathology in the lung. Upper lobe veins lie lateral to the arteries and lower lobe veins lie medial to the arteries.
- **Pulmonary arteries:** Left and right pulmonary arteries are seen. Upon reaching the hilum of right lung, the right main pulmonary artery is divided into two branches: Truncus anterior which supplies right upper lobe and right descending interlobar pulmonary artery which supplies middle and lower lobes of the lung.

  Abnormally dilated right descending interlobar pulmonary artery (Fig. 1.6) is called as Pella's sign. Abnormal dilatation and abrupt change in caliber of right descending interlobar pulmonary artery is known as Chang's sign. Prominent right main pulmonary artery is called Fleischer's sign. All these signs may be seen in the pulmonary embolism. These signs have a relatively high specificity but low sensitivity for pulmonary embolism.

  Diameter of the descending right interlobar pulmonary artery >1 6 mm is the objective sign of identifying pulmonary plethora in a chest X-ray (Fig. 1.6).
- **Scapula:** Identify all three angles. Glenoid cavity is present at lateral angle, seen additively with the head of humerus.
- **Aortic knob:** Aorta passes left side and becomes descending aorta.

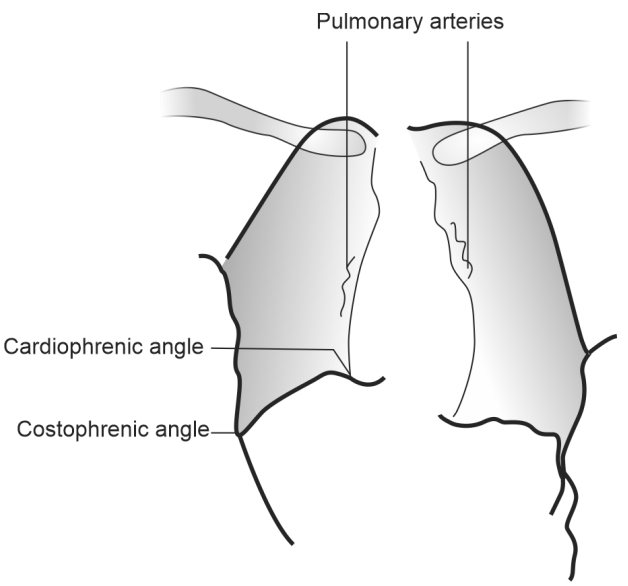

Fig. 1.7: Pulmonary artery, costophrenic angle and cardiophrenic angle

Note: Figure 1.7 shows left hilum higher than the right as left pulmonary artery passes above the bronchus and right passes anterior to its bronchus. Note the laterally placed costophrenic angles on either side, and cardiophrenic angle between the heart and the diaphragm. The branches of the pulmonary artery fan out through the lung from hilum. Keep in mind hilum is predominantly made up of pulmonary artery.

CLAVICLE

Examine basically to assess symmetry. Artificial asymmetry induces artificial scoliosis. Scoliosis is misalignment of spine when looking at an individual face-to-face (vis-à-vis) in frontal view. Fractures are common in medial one-third where it is curved the most, so the weakest.

ANTERIOR AND POSTERIOR RIBS

Posterior ends of the ribs cast dense shadow and run downward and laterally, the anterior ends run downward and medially (Fig. 1.6). Counting of the ribs is done with their anterior faint ends. Identify the first rib articulation anteriorly in the manubrium (Fig. 1.6) and following this rib backward to the spine, than start counting the posterior ribs. The method to count anterior rib is to locate the posterior attachment of the first rib with first thoracic vertebra and trace each rib as far as the anterior faint end, not visible on X-rays because made up of costal cartilage. On PA view, the horizontal ribs are posterior, and anterior ribs are angled downward (Fig. 1.6).

Clinical Pearl

- The ribs become horizontal in the medical conditions such as COPD due to hyperinflation of the chest.
- Rib fracture is the break in the continuity of a rib with or without overlap. Fractures most commonly occur at the lateral aspect of the rib where it is curved the most, therefore, the weakest. Oblique films aid in seeing the axillary margins of the rib which are overlapped on routine X-rays. Rib fracture is associated with pneumothorax in most of the occasions.
- Lung diseases which may likely to present with rib destruction are bronchogenic carcinoma, i.e. pancoast tumor, actinomycosis, blastomycosis and multiple myeloma.

SCAPULA

Identify borders, angles and processes. The medial border overlaps the chest wall. Glenoid cavity articulates with the head of humerus, seen additively.

TRACHEA

Translucent shadow in front of **the cervicothoracic spine** (Fig. 1.6). It is invariably in the midline. It is inverted Y shape. Deviation indicates mediastinal shift.

Trachea divides at the level of the lower border of the 4th thoracic vertebra into two principal bronchi. The right principal bronchus is shorter (1 inch), wider and more in line with trachea than the left. The inhaled particles, therefore, tend to pass more frequently to the right lung, with result that lung abscess is more common on right side than the left, so are the foreign bodies. The left principal bronchus is longer (2 inches), narrower and more oblique.

Carinal angle is the angle between right and left mainstem bronchus at the bifurcation of the trachea (Fig. 1.6). Widening or distortion of the carina is a serious sign because

it indicates carcinoma and lymph node enlargement near the region where the trachea divides. Left mainstem bronchus rests on the left atrium. Left atrial hypertrophy or enlargement causes splaying of the normal carinal angle to over 90 .

At age less than 4 years, it is about 50–50 chance to go foreign body into the right or left main bronchus. At the age 4 or above, most of the foreign bodies go into the right bronchus because it develops into a straight shot (less of an angle).

When the visceral and parietal pleura of the right upper lobe come in contact with the right lateral border of trachea and the intervening mediastinal fat, air within the right lung and trachea outlines these entities to form the right paratracheal stripe (Fig. 1.29). This **right paratracheal space or stripe** is generally 2–3 mm wide. If the space is >5 mm, it is reliable evidence of disease. Paratracheal lymphadenopathy, thyroid and parathyroid neoplasms, tracheal carcinoma, pleural diseases, such as effusion or thickening are among the most common causes for widening of the right paratracheal stripe.

I have discovered a large number of tumor cases by using this simple method alone in majority of suspected cases. However, definite diagnosis requires pathologic assessment and confirmation.

MEDIASTINAL SPACE

Mediastinal space contains viscera including heart, larger vessels, wind pipe, food pipe, etc. excluding right and left lungs and their double-layered surrounding pleura.

Look for the widening due to variety of causes.

- Mass lesion (e.g. tumor, lymph nodes)
- Inflammation (e.g. granulomatous inflammation, mediastinitis)
- Trauma and dissection (e.g. hematoma, aneurysm of major mediastinal vessel).

Remember always, mediastinum surely widened or magnified in AP view and even more so in portable supine film, making interpretation of mediastinal widening difficult.

Whenever there is blunt trauma to the chest as in **'motor vehicle accidents'**, the mediastinal widening occurs, in that case blood collects near the aortic arch, so aortic knuckle gets blurred. Mediastinal pleura attempt to contain the hematoma. The hematoma pushes the trachea to the right and the left mainstem bronchus downwards.

RIGHT AND LEFT LUNGS

The lung shadows are translucent due to the contained air. The lung markings are produced by the pulmonary vessels, including lymphatics; these are less marked in the periphery, so peripheral part of lung is more translucent.

The lung shadows are arbitrarily divided into the following four fields for recording the lesions: (a) Apical area—above the clavicles, (b) upper zone, (c) middle zone, and (d) lower zone. The lines of division used are clavicles and horizontal lines through the anterior ends of second and fourth ribs; or more simply, the lung fields are divided imaginary into thirds (superior 1/3rd, middle 1/3rd and lower 1/3rd of the lung fields) with two imaginary horizontal lines. Compare both lung fields simultaneously.

General search pattern includes observation of mediastinum first for size and shape, then lungs, then chest wall, and in the end diaphragm and upper abdomen. In this X-ray observation general search pattern, we proceed from center to the periphery of the chest, lower part of the X-ray which has diaphragm and upper part of abdomen is examined in last.

In lung fields, search for the infiltrates, increased interstitial markings, masses, absence of normal margins, air bronchograms and increased vascularity.

Regarding anatomy, each lung has (1) an apex at the upper end, (2) a base resting on the diaphragm, (3) three borders—anterior, posterior and inferior, and (4) two surfaces—costal and medial. The medial surface is subdivided into vertebral and mediastinal parts. Vertebral part is related to the vertebral bodies, and intervertebral disks.

Right lung is divided into three lobes (superior, middle and inferior) by two fissures—oblique and horizontal. Left lung is divided into two lobes (upper, lower) by only oblique fissure (Fig. 1.8).

Oblique fissure cuts into the whole thickness of the lung except at the hilum. It passes obliquely downwards and forwards (Fig. 1.9), crossing the posterior border about 2½ inches below the apex and inferior border about 2 inches from the median plane. Due to the oblique plane of the fissure, the lower lobe is more posterior and the upper (and middle) lobe is more anterior. In the right lung, the horizontal fissure cuts from the anterior border into the oblique fissure and separates a wedge-shaped middle lobe from the upper lobe (Fig. 1.9). It runs horizontally at the level of the 4th costal cartilage and meets the oblique fissure on the midaxillary line. The tongue-shaped projection of the left lung below the cardiac notch is called lingula and represents the middle lobe morphologically (Fig. 1.8).

In posteroanterior view and anteroposterior view, only horizontal fissure can be seen in X-ray, it is because the X-rays passes parallel through the fissure, oblique fissure not seen because of its course which follow a downward and forward course anteriorly; however, in lateral view, both fissures can be seen owing to the fact now X-rays pass through the fissures all along its whole dimension.

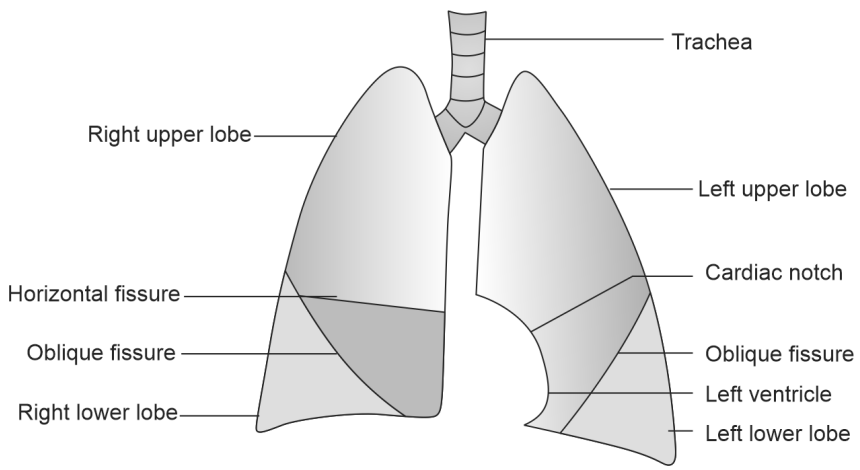

Fig. 1.8: Frontal lung anatomy

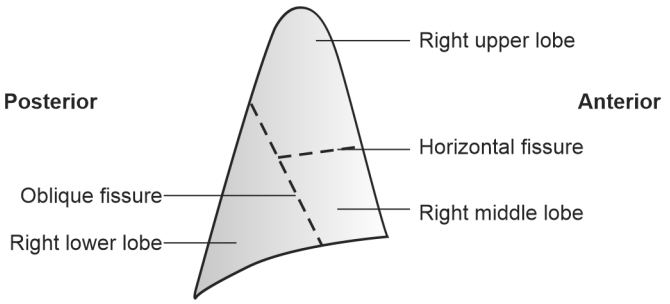

Fig. 1.9: Lateral right lung anatomy

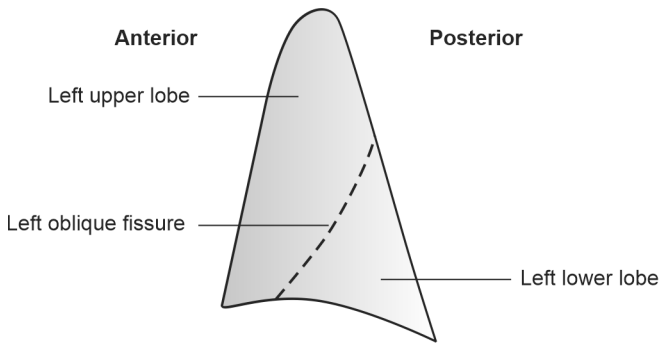

Fig. 1.10: Lateral left lung anatomy

Note: Understand the orientation of lung lobes. In right lung, upper and middle lobes are anterior in relation to lower lobe. In left lung, upper lobe is anterior and lower lobe is posteriorly located (Figs 1.9 and 1.10).

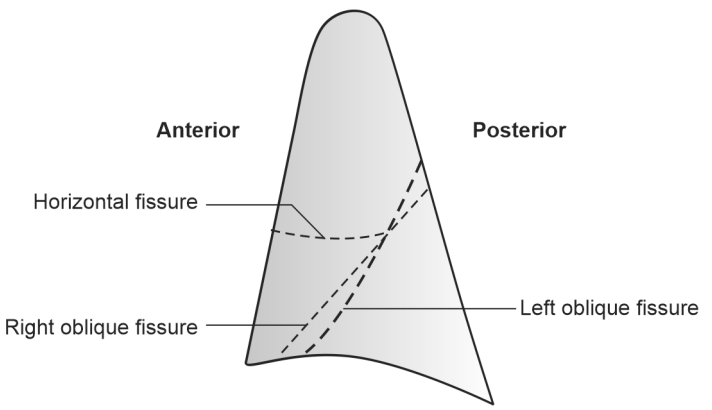

Fig. 1.11: Left lateral CXR with fissures

Note: Left lateral chest radiograph (Fig. 1.11) shows both the superimposed oblique fissures of the right and left lungs and horizontal fissure of the right lung. It can be seen only on the lateral projection.

COSTOPHRENIC ANGLE

The angle between the ribs and the diaphragm at the bottom of the lungs (Fig. 1.7). Normally clear, translucent and acute but obliterated in the pleural effusion. An abnormally sharp and deep costophrenic angle in AP supine view in suspected ipsilateral pneumothorax is called deep sulcus sign.

CARDIOPHRENIC ANGLE

The angle between the corresponding diaphragm domes and the lower right and left heart border (Fig. 1.7). Cardiophrenic angle becomes acute in pericardial effusion.

Gas shadow beneath both the diaphragm signifies air in the peritoneal cavity due to perforation of GIT or artificial pneumoperitoneum created during abdominal surgery. Even minute amount of gas under diaphragm is highly suspicious of gastrointestinal perforation. This is medical emergency.

Chilaiditi's syndrome is rare disorder in which intestine lies between liver and diaphragm simulating gas under diaphragm, which is investigated and identified by barium studies and other procedures.

Gas shadow lonely below the right hemidiaphragm indicates a subdiaphragmatic abscess.

Masses in cardiophrenic angle are pericardial cyst, diaphragmatic hernia, pericardial cyst, etc.

MEDIASTINAL SHADOW

Look for size and shape. Silhouette margins should be sharp. Mediastinum connects with each lung through bridge-like structure called roots of the lungs (hila).

Right border (from above downwards): (a) Right brachiocephalic vein, which is seen rarely, (b) superior vena cava, (c) right atrium and (d) inferior vena cava (sometimes seen) (Fig. 1.12).

Left border (from above downwards): (a) Right subclavian, (b) aortic knuckle, (c) pulmonary trunk and left pulmonary artery, (d) auricle of the left atrium, and (e) left ventricle (Fig. 1.12).

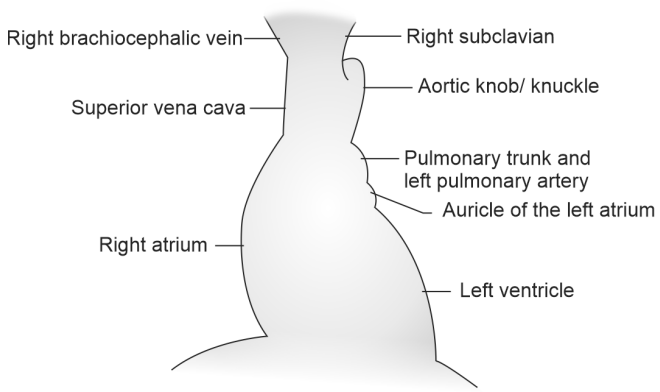

Fig. 1.12: Bumps of the cardiac shadow

Trachea, aortic knob, and right atrium are three best landmarks utilized in the normal, well-positioned and exposed CXR that yield the most information about **mediastinal shift**.

Clinical Pearl

The angular area between aortic knob or knuckle and pulmonary trunk is termed as **aortopulmonary window** (Fig. 1.12). It is lost in aortic aneurysm, nodes enlargement and dilated/aneurysm of pulmonary artery.

HILAR SHADOW

It is medial one-third of the lung field. It is composed of pulmonary artery, its main branches, adjacent airways and pulmonary veins making root of the lungs, the structures entering or coming out of the lungs. Lower lobe veins do not take part in formation of **radiological hilum**. **Increase in size or density signifies enlargement of the bronchopulmonary lymph nodes**.

The hila also become prominent in conditions of hyperdynamic pulmonary circulation (pulmonary plethora) as seen in congenital heart diseases like **atrial septal defect**. In addition, eggshell calcification (Fig. 1.13) in hilar lymph nodes is pathognomonic for **silicosis** and **sarcoidosis**.

Hilum overlay sign: If the pulmonary artery seen clearly through a lesion, the lesion is either in front of or behind the hilum (i.e. not a hilar mass).

Fig. 1.13: Eggshell calcification

THE DIAPHRAGM (PA VIEW)

Examine the shape and level of the two domes of the diaphragm. Normally, right dome is higher than the left due to position of liver. Left dome of the diaphragm is lower than the right because heart pushes the left dome down. If the left hemidiaphragm is higher than the right or the right is higher than the left by more than 3 cm, one of the many causes of diaphragmatic elevation should be considered.

Below the left dome, there is **gas shadow bubble** in the fundus of the stomach. Situation of the gastric bubble may aid in the diagnosis of the correct side of the chest X-ray film. Gastric bubble may be absent, if there is large abdominal mass, splenomegaly or a full stomach. In cases of **hiatal hernia**, it may be seen inside thoracic cavity.

If dome of the either side of the diaphragm is obscured, suspect pathology in the adjacent lower lobe. Majority of the portion of the lung actually rests on the diaphragm, consequently an abscess from the liver may extend through the diaphragm and causes right middle lobe pneumonia.

The height of the diaphragm in the thorax is variable according to the position of the body and tone of the abdominal muscles. It is highest on lying supine, higher on standing, and lowest on sitting down.

Abnormally unilateral high held diaphragm is seen in diaphragm paralysis, subdiaphragmatic abscess and atelectasis.

The most common pathology for unilateral phrenic nerve paralysis is malignancy in the mediastinum.

Clinical Pearl

In female, the breast shadow cast a fat density impression overlying lower part of chest bilaterally. Nipple shadows are nodular opacities that are consistent in shape which is oval or round, size about 5–15 mm in diameter and located between the 9th and 10th rib posteriorly or the 5th and 6th rib anteriorly. It is always made clear that these opacities are not due to pulmonary lesions such as solitary pulmonary nodule or pleural or chest wall lesions.

CHEST X-RAY [LATERAL VIEW]

Obtain as a complement to posteroanterior X-ray film to localize lung lesions, which are obscured behind the heart or the diaphragm. It is taken as right or left side of the patient against the film.

The right pulmonary artery is the bright, white opacity anterior to the airway in the centre of the lungs on the lateral view (Fig. 1.14). Its shape is usually ovoid, size of a thumb print, the left pulmonary artery is usually less opaque and more translucent as it emerges from the mediastinum just above the left main bronchus. Its posterior margin curves downward with the same shape as the arch of aorta, which is located anatomically just above it. Thus the anterior margin of the left pulmonary artery is in opposition with left bronchus (Fig. 1.15).

Fig. 1.14: Lateral view

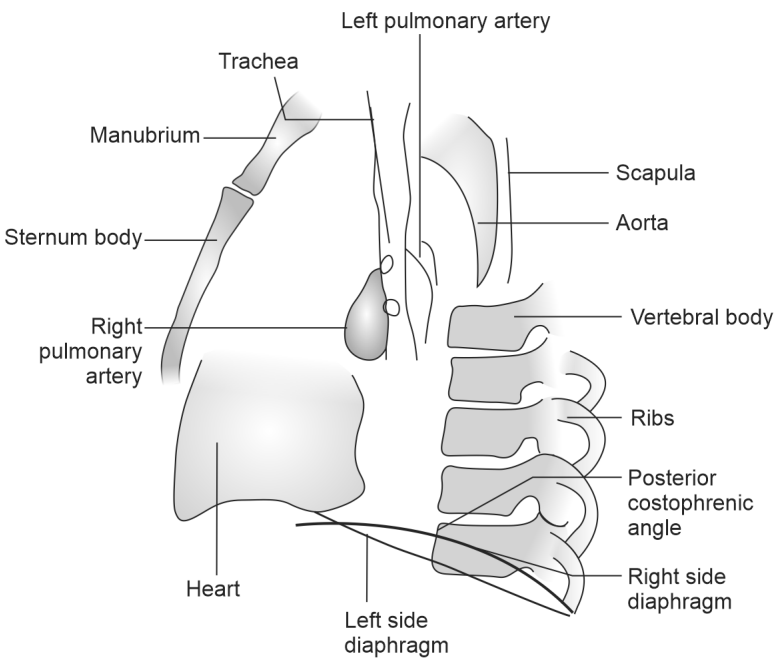

Fig. 1.15: Lateral view (diagrammatic)

Normal lateral chest X-ray shows increased translucency of the spine as we descend cranially to caudally because of the abundant soft tissue is present at the level of the shoulder spine than at the diaphragm level. This is ''spine sign''. Causes of failure to

darken gradually above the diaphragm are pleural thickening, lower lobe collapse, mediastinal mass, etc.

Heart sits anteriorly in the diaphragm. The portion of the anterior border of the heart is formed by the right ventricular wall, posterosuperior border formed by the left atrial wall, posteroinferior border formed by left ventricle (Fig. 1.16). Look for the hypertrophy and other pathology associated with these chambers. Anterior border of the heart usually touches the lower one third of the sternum.

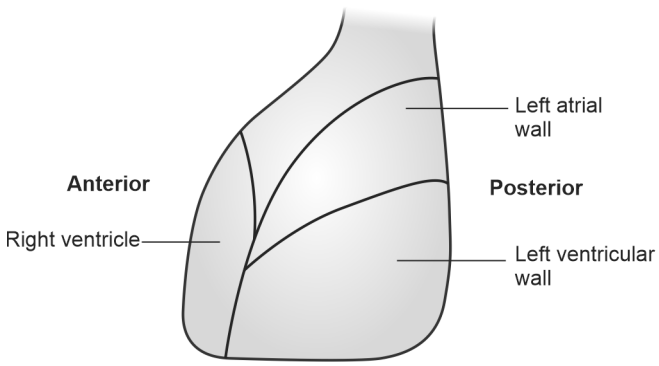

Fig. 1.16: Left lateral view of the heart

RETROSTERNAL AND RETROCARDIAC SPACE

These are the areas of **increased translucency** corresponding to the site where both the lungs meet. Loss of translucency indicates pathology.

Retrosternal space is the space between sternum and ventral cardiac surface (Fig. 1.15). It is not more than 3 cm at its maximum measurement point. Retrosternal space gets filled in right ventricular hypertrophy so now it touches the lower half of the sternum. An increased retrosternal airspace is a reliable sign of pulmonary emphysema, while obliteration indicates anterior mediastinal mass, e.g. lymphoma.

Carefully observe for proper penetration and inspiration by observing that the spine appears to be darken as you go caudally. This is due to more air in the lower lobes. Vertebral bodies gradually show more radiolucency or transparency (black) as we descend caudally. Loss of radiolucency signifies posterior basal segment lower lobe pathology in lung (Fig. 1.20). Rarefaction of the vertebral bodies is seen in the osteoporosis (Fig. 1.15).

PULMONARY ARTERY

The right pulmonary artery seen 'head on', looks like a white thumb print and should be no larger than thumb – enlarged or engorged size may be seen in pulmonary hypertension (Fig. 1.15).

The measurement of pulmonary artery size is suggested for diagnosing pulmonary hypertension on chest X-ray, albeit echocardiography would be more accurate method. Right descending interlobar pulmonary artery size (caliber/diameter) more than 16 mm

in PA view and left descending pulmonary artery size of more than 18 mm in lateral view are considered suggestive of pulmonary hypertension (Fig. 1.15).

POSTERIOR COSTOPHRENIC ANGLE

Posterior costophrenic angle is the **deepest** costophrenic angle, seen in the lateral view of the chest X-ray where the deep and posterior portion of the diaphragm meets the vertebral column and posterior wall of chest cavity (Fig. 1.15). Since it is the deepest, minor amount of pleural effusion can be detected over here. Therefore, it is better to locate effusion more precisely with lateral view than frontal views (PA/AP).

MEDIASTINAL MASSES

Mass lesions are called when they are more than 3 cm in size but nodular opacities are less than 3 cm in CXR for any pathological lesion (Fig. 1.17).

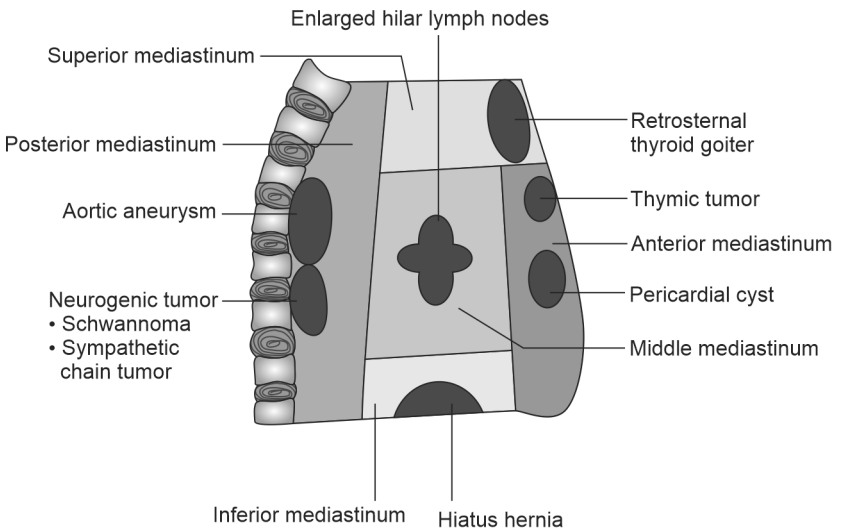

Fig. 1.17: Mass lesions in mediastinum

Most common causes according to location:

- Anterior mediastinum: Thyroid, teratogenic tumors, lymphoma, thymoma
- Middle mediastinum: Lung cancer, lymphoma, aneurysms, cysts
- Posterior mediasinum: Neurogenic tumors, esophageal masses, enteric cysts, aneurysms.

ESOPHAGUS

The posterior wall of trachea and the anterior wall of esophagus are in close opposition and form the **tracheoesophageal strip** in the lateral view (Fig. 1.15). When it becomes wider, it is abnormal. Common causes of widening of tracheoesophageal strip (in lateral view) are esophageal diseases such as neoplasia and lymph node enlargement.

Barium swallow right lateral projection of the esophagus is shown below to identify the indentations caused by the different structures resting on it (Fig. 1.18). The lowermost shallow indentation is more compressed and constricted in the left atrial hypertrophy, commonly seen in barium swallow lateral projection of the chest.

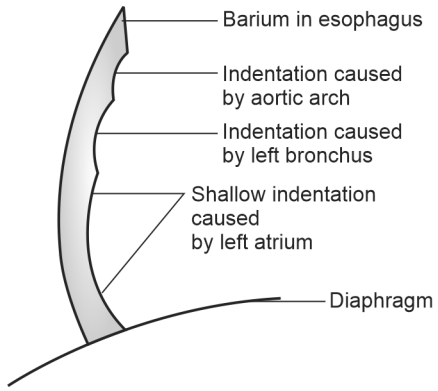

Fig. 1.18: Right lateral view esophagus barium swallow

THE DIAPHRAGM (LATERAL VIEW)

Anterior portion of left hemidiaphragm is not visible because of cardiac silhouette. Entire right hemidiaphragm can be seen, however (Fig. 1.15).

The hemidiaphragm, which passes through the cardiac shadow to the anterior chest wall is the right hemidiaphragm. It is higher in position, while the left can only be traced till the posterior cardiac border (Fig. 1.15).

BRONCHOPULMONARY SEGMENTS

A bronchopulmonary segment is a portion of lung supplied by a specific segmental bronchus and arteries (Fig. 1.19). They are the anatomic, functional and surgical units of lung.

Each lobar (secondary) bronchus gives off segmental (tertiary) bronchi. Each segmental bronchus passes to a structurally and functionally independent unit of a lung lobe called a bronchopulmonary segment (Fig. 1.20).

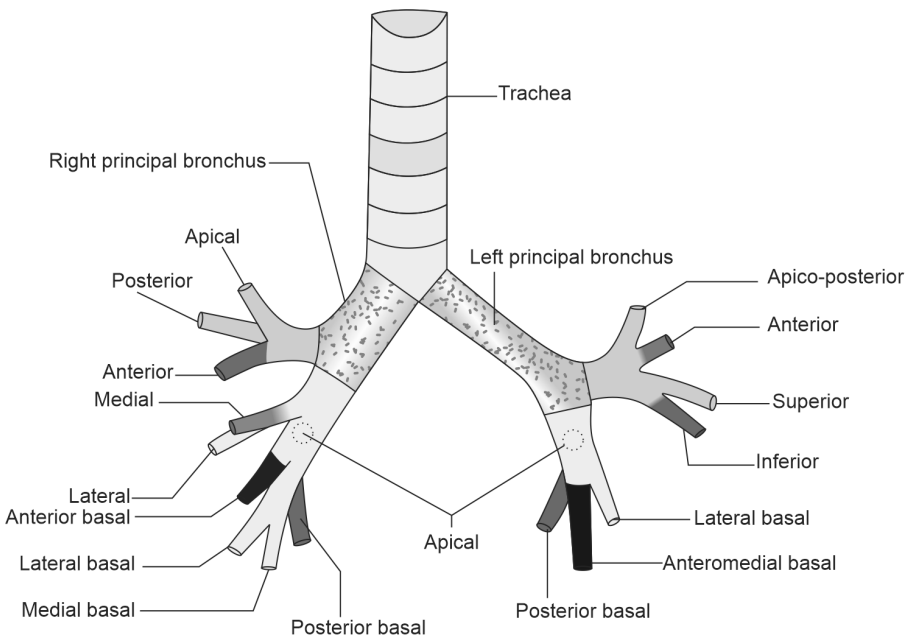

Fig. 1.19: The bronchial tree

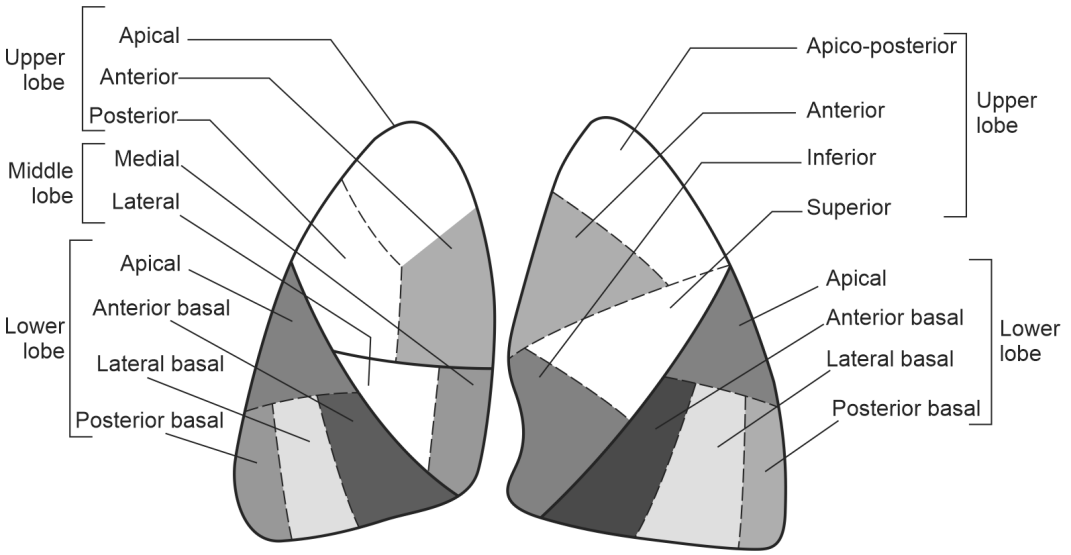

Fig. 1.20: The bronchopulmonary segments (lateral view)

HYPERTROPHY SIGNS

Left Ventricle Hypertrophy

Cardiac apex advances downward and left. Left heart border progresses toward left. *See* Fig. 1.21A below and identify the axis of left ventricle hypertrophy.

Clinical Pearl

Left ventricular hypertrophy is more readily suspected from changes in QRS voltage on the ECG and can be accurately determined from measuring wall thickness on echocardiography.

Left Atrium Hypertrophy

Left auricle becomes prominent. Elevated left main bronchus, because it rests on the left atrium. Straightening of the left heart border (may be a normal finding in some subject). Left atrial enlargement ensues in chronic mitral regurgitation, rheumatic mitral stenosis, and as a consequence of left ventricular failure, etc. A "double density" within the cardiac shadow is present because of the fact that left atrium is posterior to cardiac chamber representing enlargement of the left atrium to the right side. The compressed esophagus is seen in left lateral projection in barium swallow. Some time oblique view is also necessary. **Left atrial position is shown in Fig. 1.21B and C for the purpose of simplification by removing the other chambers of the heart**.

Right Ventricle Hypertrophy

Cardiac enlargement and elevated rounded apex towards left. Right ventricular enlargement is present in left ventricular failure, rheumatic mitral stenosis, pulmonary

hypertension, etc. Right ventricular enlargement is best visualized in the lateral projection, as it forms anterior border of the heart right behind the sternum with a definite retrosternal space distance. Retrosternal space is lost in the right ventricular hypertrophy (Fig. 1.22).

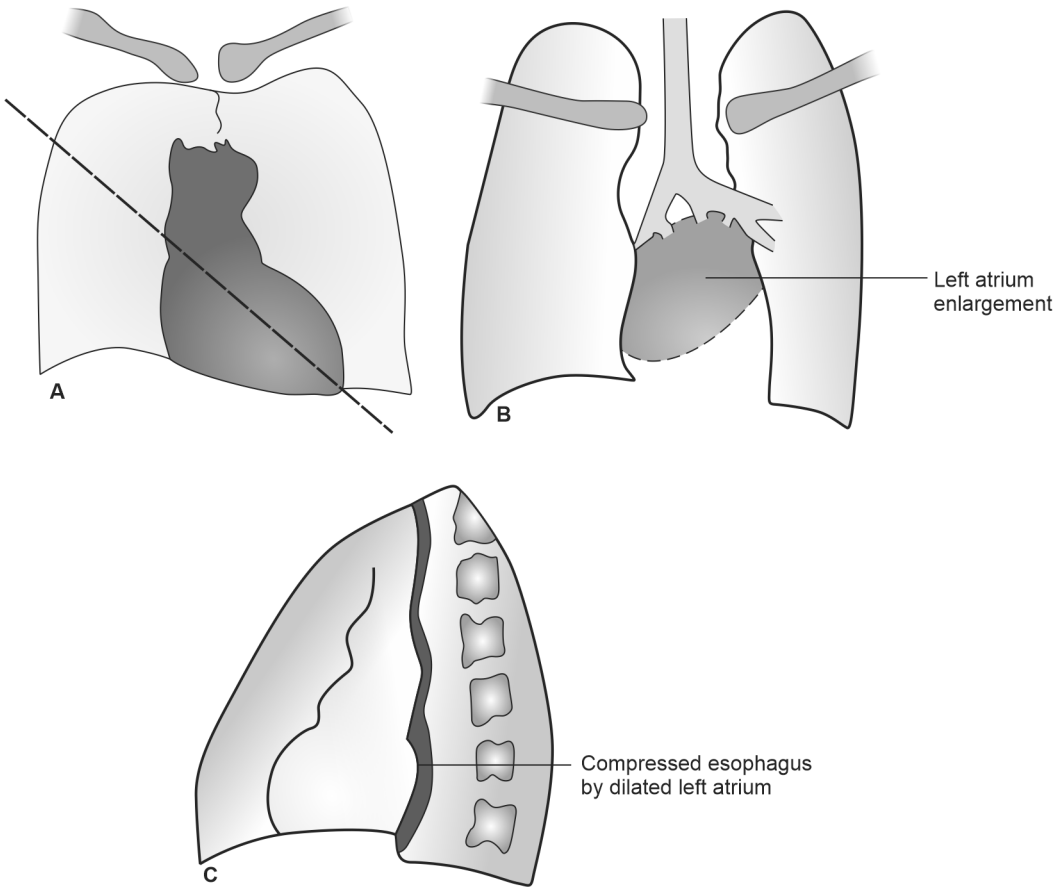

Fig. 1.21A to C: (A) Left ventricular hypertrophy; (B) Left atrial hypertrophy (frontal view); (C) Left atrial hypertrophy (left lateral view)

Right Atrial Hypertrophy

Right border of the cardiac shadow shifts towards right. Cardiac shadow measuring more than 5.5 cm to the right signifies right atrial enlargement. Right atrial hypertrophy seen in tricuspid valve diseases, right atrial tumor, pulmonary hypertension, cardiomyopathy, etc. (Fig. 1.21).

Clinical Pearl

Right atrial enlargement produces a peaked P wave (P pulmonale) with amplitude:
- More than 2.5 mm in the inferior leads (II, III and AVF)
- More than 1.5 mm in V1 and V2.

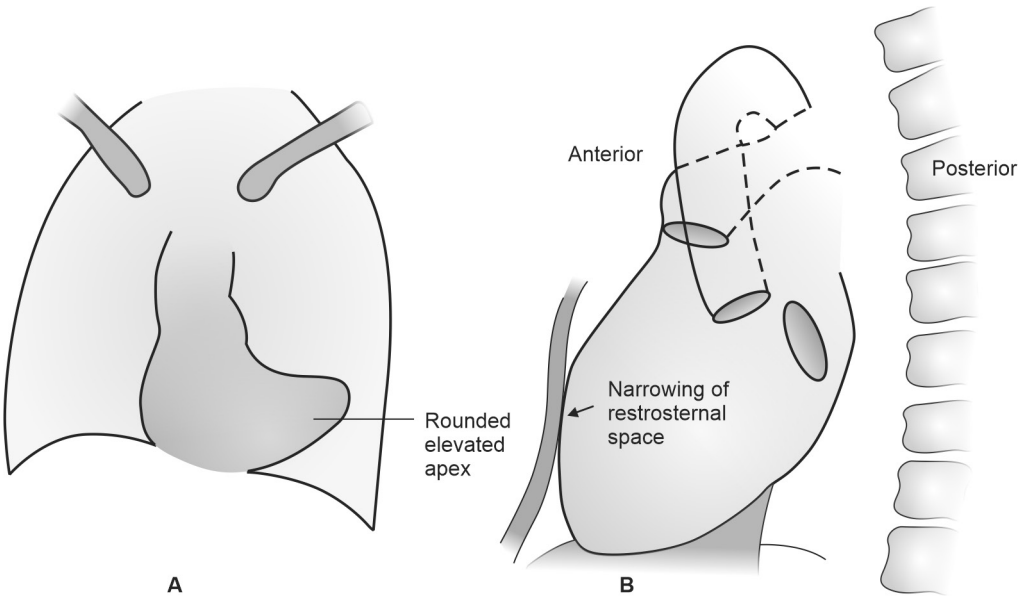

Fig. 1.22: Right ventricular hypertrophy: (A) Frontal view; (B) Lateral view

LUNG DISEASE PATTERN

Interstitial Disease Pattern

Thin white lines haphazardly distributed throughout the lung fields. This pattern arises due to collection of fluid density material in the interstitium (Fig. 1.23A).

The interstitium is the scaffolding of the lung. It includes the interlobular septa with containing vascular structures and lymphatics, the bronchi, pulmonary arterioles and alveolar walls. Viruses or Mycoplasma infection usually produces this pattern. Interstitial pattern is sometimes referred as reticular (net-like) and/or reticulonodular pattern.

Air Space Disease Pattern

Areas of white opacity due to edema and exudates in the acini and alveoli. Air bronchogram sign often seen resulting from fluid density material in the alveoli. **Air bronchogram sign** signifies that the airways are patent proximal to the acini and alveoli. Thus the air stands out as dark branching pattern. Conditions which cause alveolar filling are pneumonic consolidation and pulmonary edema.

The bronchus is usually air filled. It becomes visible when air is lost from the surrounding alveolar parenchyma and filled with exudative or transudative fluid. Lung appears abnormally white.

Bacterial infection usually causes this pattern. This pattern also referred as **consolidation** (Fig. 1.23B).

Honeycombing

Lung parenchyma shows honeycombing due to irregular, irreversible, widespread scarring or fibrosis. Small cystic spaces with irregularly thickened walls. Honeycombing is a feature of asbestosis, fibrosing alveolitis, etc.

Honeycomb lung refers to a scarred shrunken lung and is an end stage finding with poor prognosis. Air spaces are dilated, and there are fibrous scars in the interstitium (Fig. 1.23C).

Miliary

Tiny white dots or miliary mottling diffusely present over the lung field. It is called miliary because lesion resembles appearance of millet seeds (Fig. 1.23D). Miliary shadowing is common in:

- Tuberculosis
- Sarcoidosis
- Pneumoconiosis
- Histoplasmosis
- Chickenpox

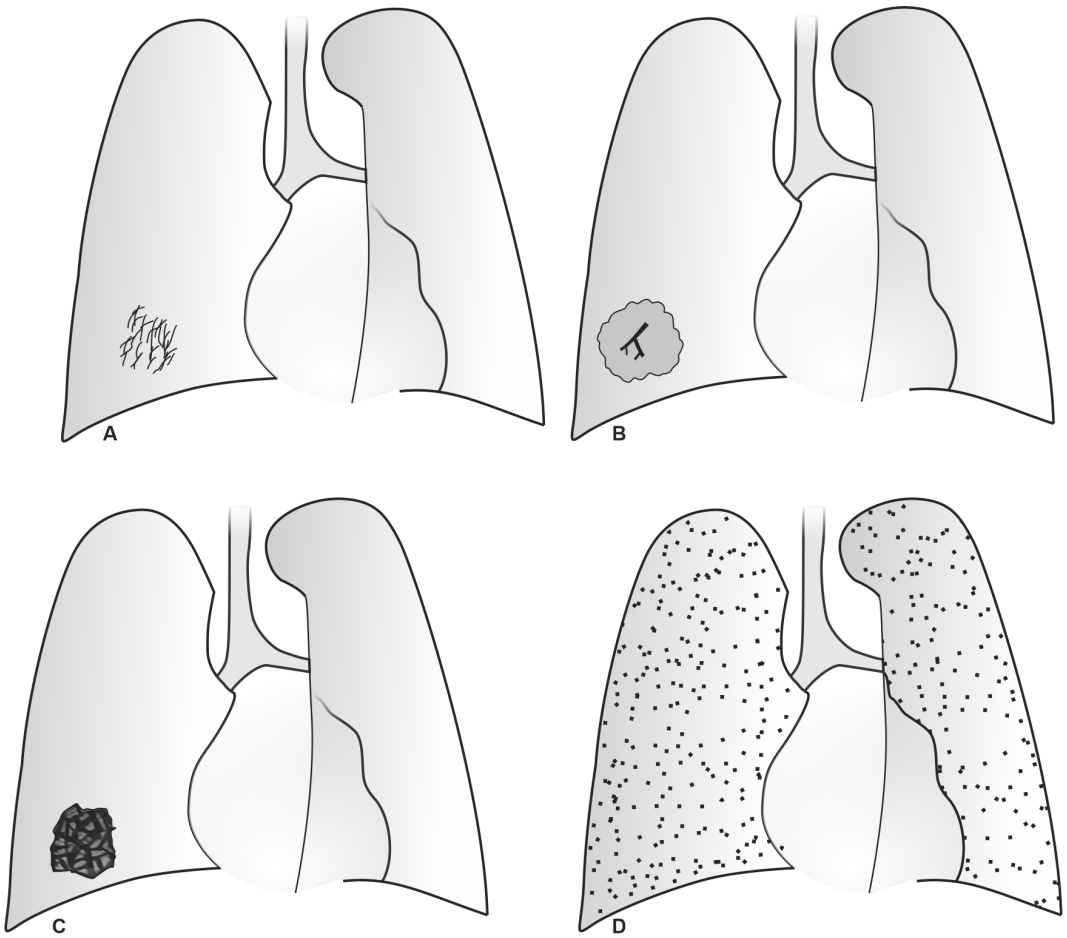

Fig. 1.23A to D: (A) Interstitial diseases pattern; (B) Air space disease pattern; (C) Honeycombing; (D) Miliary pattern

OPACITY

Opacity is decreased radiolucency. Increased opacity arises either due to pulmonary infiltration in inflammatory processes or neoplasia.

More important concept is, these opacities are detectable more easily in the peripheral part of the lung field, which is inherently more radiolucent. Lateral one-third is more translucent because area has less prominent bronchovascular structures/markings (Fig. 1.24).

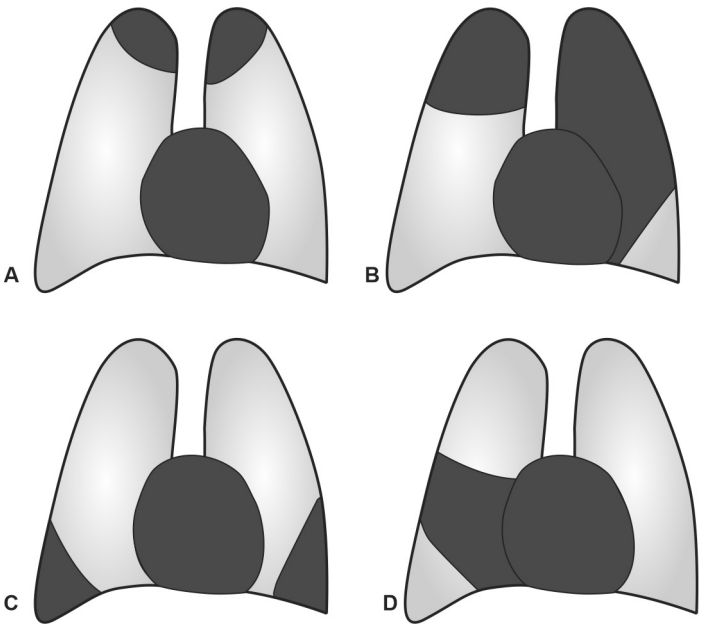

Fig. 1.24A to D: Opacity in lung lobes: (A) Apical lobe opacity; (B) Upper lobe opacity; (C) Lower lobe opacity; (D) Middle lobe opacity

LUNG COLLAPSE

Atelectasis is volume loss due to alveolar collapse or failure to expand causing increased opacification or decreased transparency of CXR.

Collapse may affect a whole lung, lobe of lung or a division. There are essentially three main reasons of atelectasis among them first one is the mass lesion, viz. tumor or foreign body impingement producing obstruction of the supplying bronchus leading to collapse of the alveoli aerated by them.

Second reason is the compression forces that push against the alveoli and drive out the air. This is caused by pneumothorax and pleural effusion in most of the clinical settings.

Lastly, traction atelectasis is due to scarring, which distorts the alveoli and contracts the lung. This pattern collapse is seen most commonly associated with severe infection, such as tuberculosis or chronic lung fibrosis due to variety of insults.

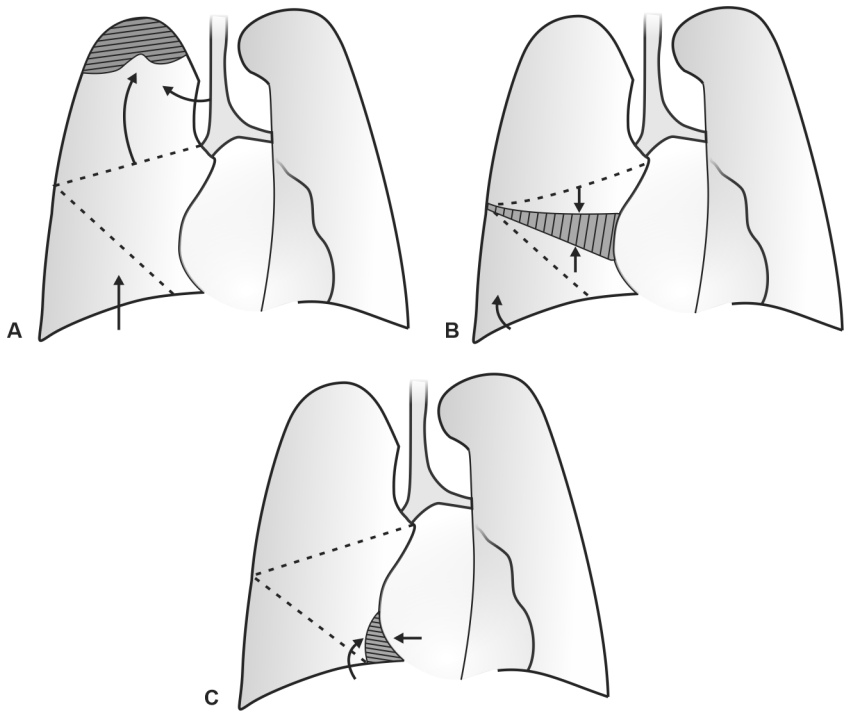

Fig. 1.25: Frontal view of typical lobar collapse patterns: (A) Right upper lobe collapse; (B) Right middle lobe collapse; (C) Right lower lobe collapse

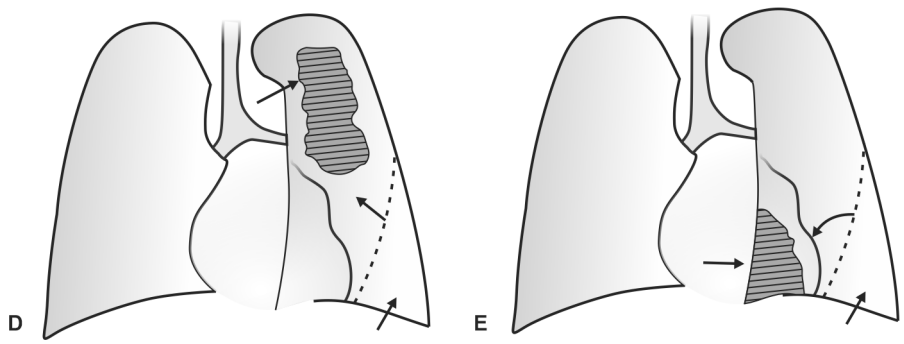

Fig. 1.26: Frontal view of typical lobar collapse patterns: (D) Left upper lobe collapse; (E) Left lower lobe collapse

Right and left lateral projections are also compared simultaneously. Identify anterior and posterior relations and typical locations of transverse and horizontal fissures (Figs 1.25 and 1.26).

Corresponding arrows (Fig. 1.27) indicate shifting of fissure, displacement of mediastinum and displacement of diaphragm. Shifting of fissure is most reliable sign of collapse.

General Features of Collapse

- Shifting of fissures
- Homogeneous opacity

- Crowding of vessels
- Tracheal deviation
- Shift towards the side of the collapse
- Elevation of the hemidiaphragm
- Hilar displacement

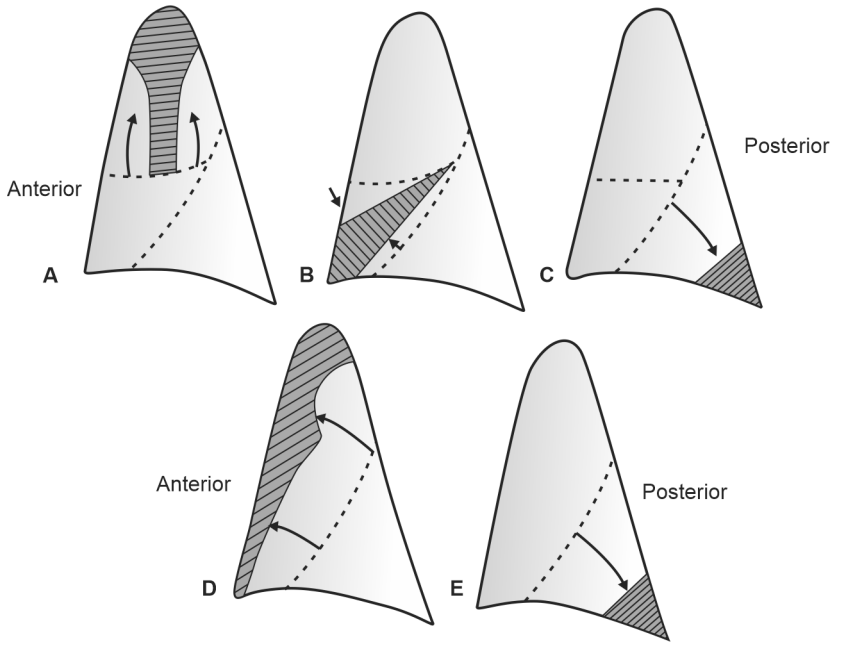

Fig. 1.27A to E: Lateral view—typical lobar collapse patterns: (A) Right upper lobe collapse; (B) Right middle lobe collapse; (C) Right lower lobe collapse; (D) Left upper lobe collapse; (E) Left lower lobe collapse

Clinical Pearl

Lobar collapse in acute setting is often due to mucus plugging. You get the normal chest X-ray one day and abnormal collapsed lung on the next day, most commonly due to mucus plugging in inpatients. If u have lobar collapse in older patients, unexplained and not acute, need to consider cancer until proven otherwise.

RADIOLOGICAL SIGNS

Silhouette Sign

If radiological density of structures in anatomical contact is same, then the border between these structures cannot be identified. Lung is air density structure and heart is water density structure; inflammatory processes in the lungs render them to lose the border with the heart. This is called **silhouette sign**.

If the border between the lung and an anterior structure such as the heart is lost, then suspect pathology lies anteriorly in the chest. In other situation when the border between the lung and a posterior structure is obliterated, the pathology is located posteriorly in the chest.

Right heart border obliterated in right middle lobe pneumonia, left heart border obliterated in left upper lobe, right hemidiaphragm in right lower lobe, left hemidiaphragm in left lower lobe, and descending aorta in left lower lobe. Descending aorta is posterior structure and considering the anatomy of the lungs, lower lobe is predominantly posterior in relation to other lobes of the lungs (Figs 1.28 and 1.29).

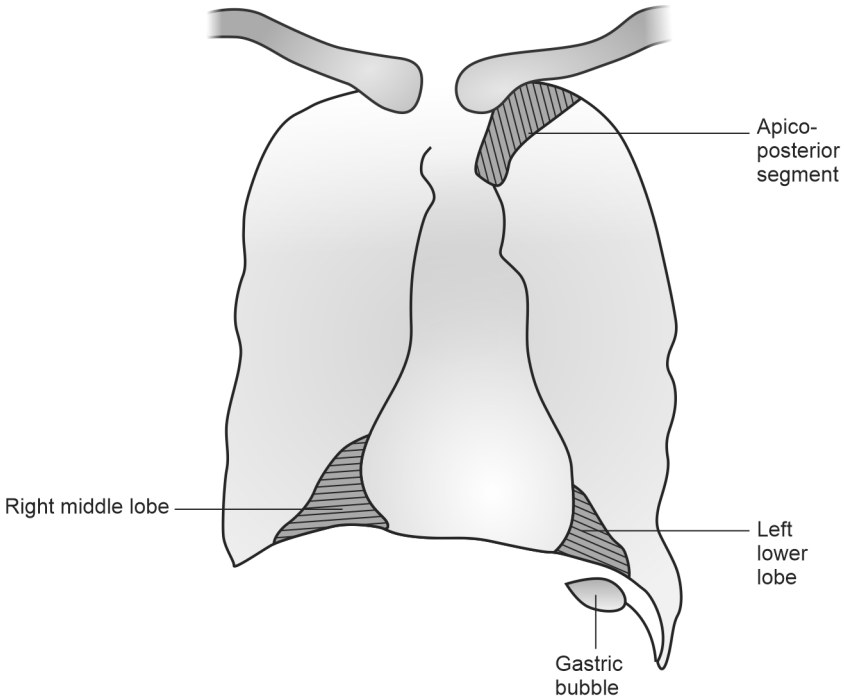

Fig. 1.28: Silhouette sign

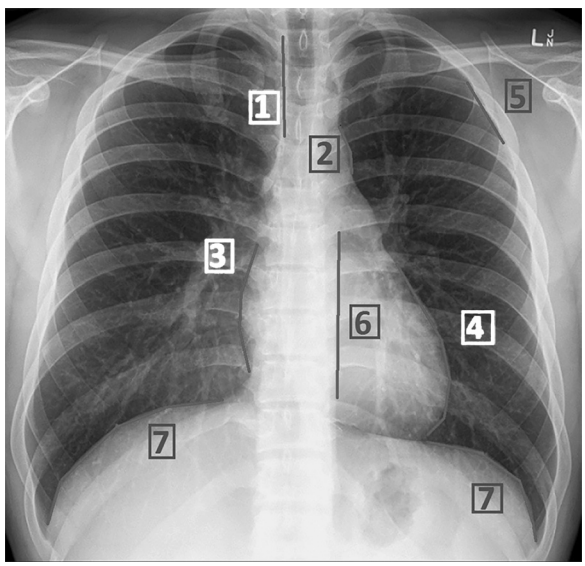

Fig. 1.29: Silhouette sign
1. Right paratracheal stripe: Nodal disease
2. Aortic knuckle: Anterior mediastinum or left upper lobe
3. Right heart border: Right middle lobe disease
4. Left heart border: Lingular disease
5. Chest wall: Lung/pleura/rib pathology
6. Para-aortic line: Para-aortic lymphadenopathy, aortic aneurysm
7. Diaphragm: Lower lobe pathology

Fig. 1.30: Lower lobe pneumonia

Note: Chest X-ray (Fig. 1.30) showing lower lobe pneumonia with silhouette sign, i.e. obliteration of right dome of diaphragm.

Air Bronchogram Sign

Bronchi are filled with air and surrounded by air, not visible usually on X-ray due to thin wall. In an event, when surrounding alveoli filled with a fluid density material owing to any pathological process the air in the bronchi becomes prominent and seen as dark branching pattern in the abnormal white lung. It is diagnostic of **consolidation**. Trachea is best example of an air bronchogram pattern in a normal chest X-ray, however, not due to surrounding inflammation or infection (Figs 1.31 and 1.32). Some of the common causes are:

- Pulmonary edema
- Pneumonic consolidation
- Hyaline membrane disease.

Clinical Pearl

An air bronchogram is not seen within pleural fluid, that means if air bronchogram is present, the lesion must be there in the lung.

Kerley A, B, C Lines

Kerley A lines (Fig. 1.33) seen as arcuate lines radiating out from the hilum due to **involvement of central interlobular septa in severe cardiac failure**. Most conspicuous in the upper and mid portion of the lungs. These are approximately 4 cm in length. They do not reach up to the pleura.

Kerley C lines (Fig. 1.33) seen as cobweb mesh of linear opacities in the middle portion of the lung (**spider web appearance)**.

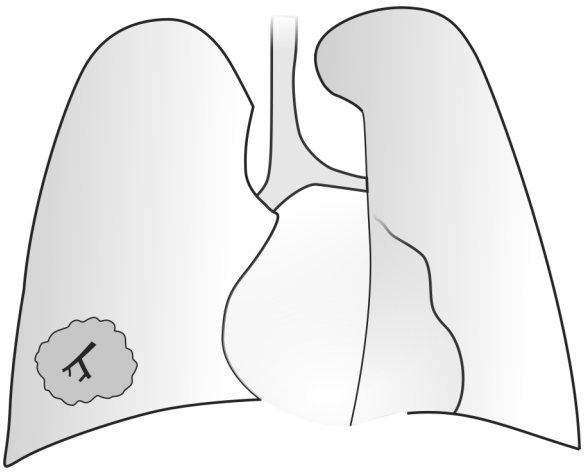

Fig. 1.31: Air bronchogram sign

Fig. 1.32: Air bronchogram

Kerley B lines (Figs 1.33 and 1.34) are fluid density nonbranching horizontal perpendicular lines (to pleural surface) seen in the periphery of the lung extending to the pleura. These are horizontal lines present at lung bases in the lower zones peripherally, and parallel to each other but at right angles to the pleural surface. These arise due to increased fluid density material in the peripheral interlobular septa.

Congestive cardiac failure is the **most common** offending event which produces this, however, in some instances, lymphatic spread of tumor through the interlobular fissure may be present **(lymphangitis carcinomatosis)**. Distinction is essential between those arising from increased hydrostatic pressure and those septal Kerley B lines arising due to tumor spread for therapeutic purpose, as treatments for both are **entirely different**.

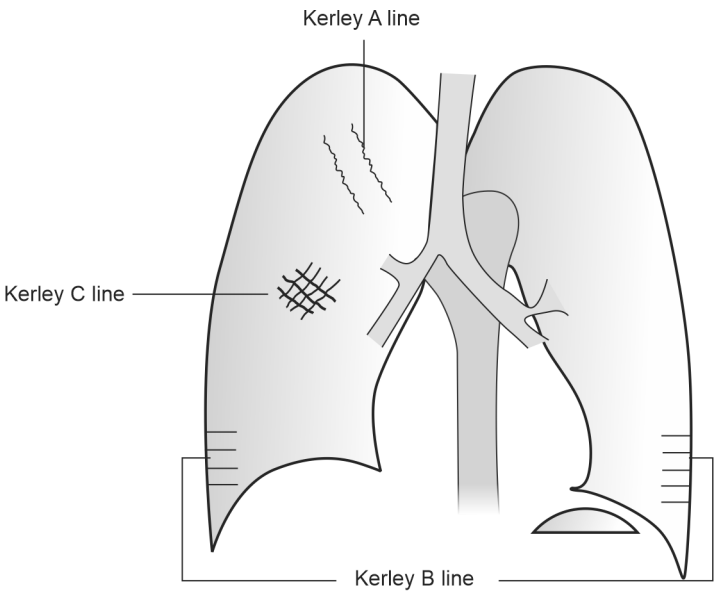

Fig. 1.33: Kerley A, B, C lines

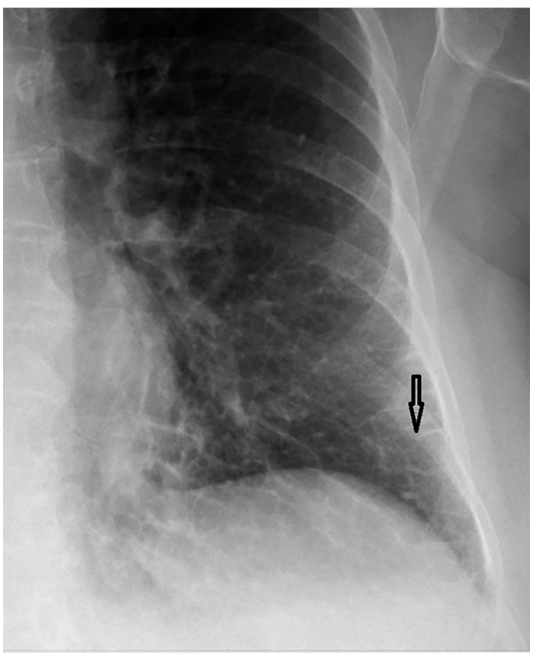

Fig. 1.34: Kerley B lines

Extrapleural Sign

Snowball sign used to differentiate whether peripheral nodule/mass arising from the lung or the surrounding structure. If looks like intact snowball suspect pathology in

lung parenchyma, if appears flattened suspect pathology in the surrounding structures, e.g. from pleura, chest wall, etc.

Pleural lesion forms an obtuse angle with the chest wall while parenchymal lesions form an acute angle (Figs 1.35 and 1.36).

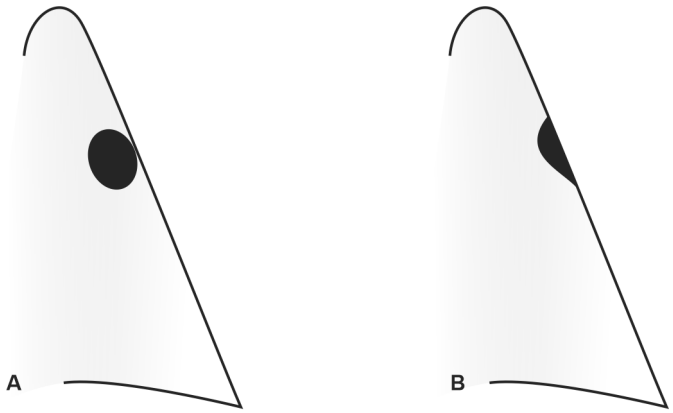

Fig. 1.35: Extrapleural sign

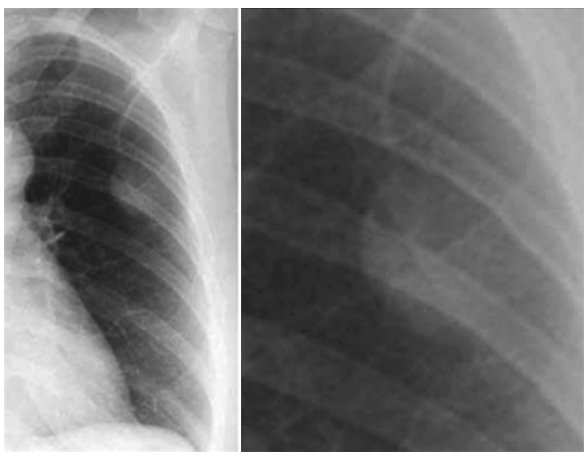

Fig. 1.36: Extrapleural sign

Canon Ball Metastases

Cannon ball metastases/secondaries refer to multiple, large, well-circumscribed, round/ball shape, pulmonary metastases. It is classical presentation of hematogenous dissemination of a malignant tumor to the lung (Fig. 1.37). The primary tumors for these lesions can be remembered with the help of this mnemonic:

CRESP

C: Choriocarcinoma
R: Renal cell carcinoma

Fig. 1.37: Cannon ball metastases

E: Endometrial carcinoma
S: Synovial sarcoma
P: Prostate carcinoma.