Different tissues in our body absorb X-rays at different extents:

Air fat soft tissue bone metal

Least opaque	to	most opaque
Most lucent	to	least lucent
Black	to	white

Relative Densities

The images seen on a chest radiograph result from the differences in densities of the materials in the body.

The hierarchy of relative densities from **least dense** (dark on the radiograph) to **most dense** (light on the radiograph) include:

- Gas (air in the lungs)
- Fat (fat layer in soft tissue)
- Water (same density as heart and blood vessels)
- Bone (the most dense of the tissues)
- Metal (foreign bodies)

Four major view of chest radiograph

Postero-anterior (PA)

Antero-posterior (AP)

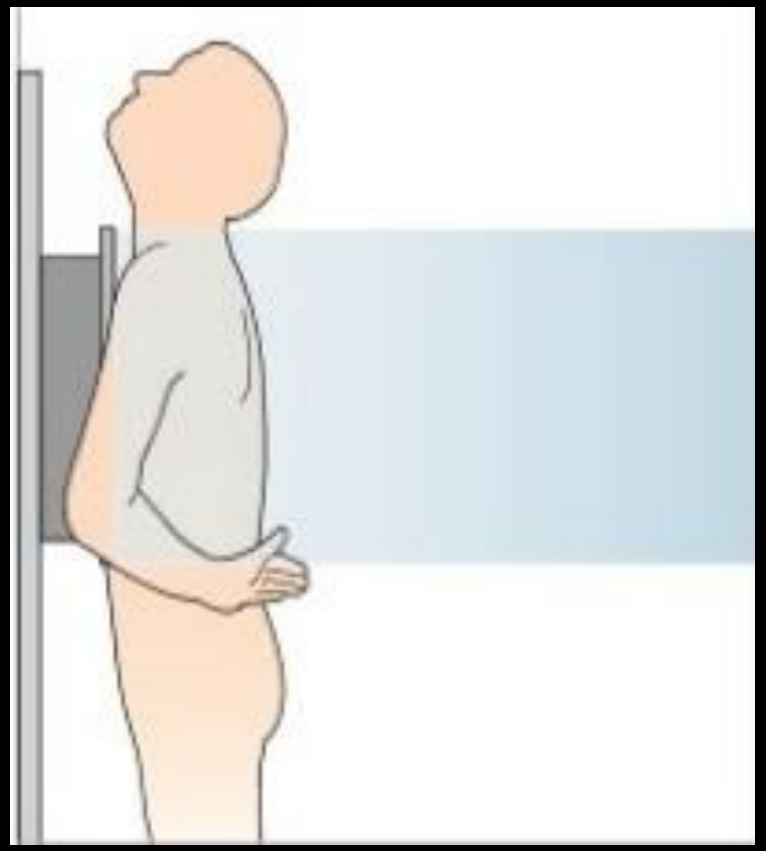
Lateral view

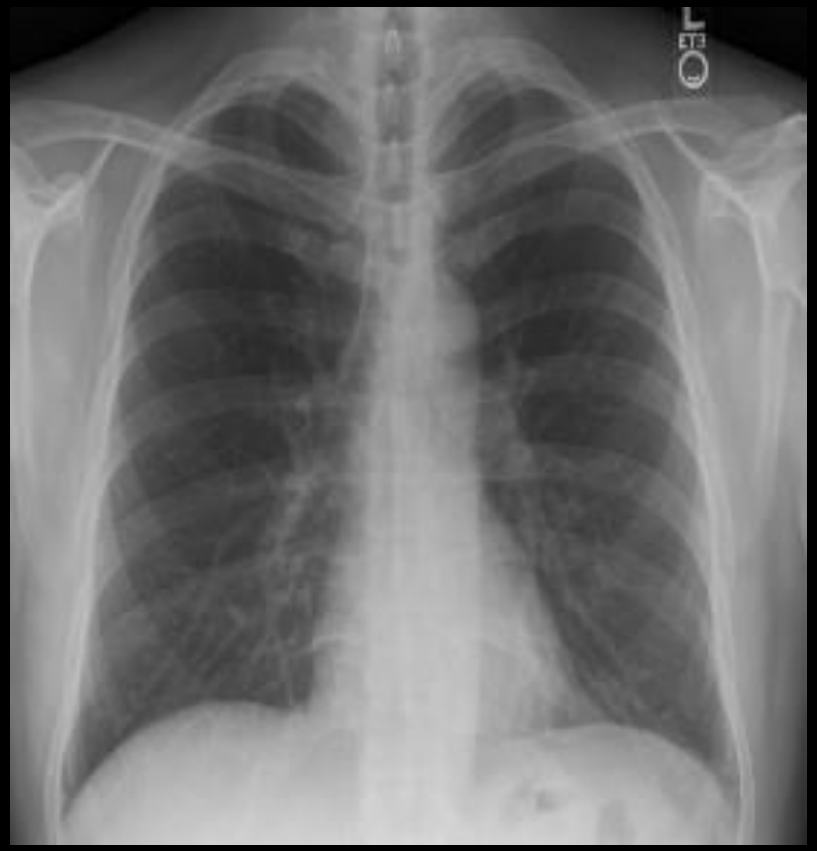
Other- Apical lordotic view

Postero-anterior position (PA View)

- The standard position for obtaining a routine chest radiograph.
- Patient stands upright with anterior wall of the chest placed against the film
- The shoulders are rotated forward enough to touch the film, ensuring that the scapulae does not obscure a portion of the lung fields.
- Usually taken with the patient in full inspiration.
- The PA film is viewed as the patient is standing in front of you.
- Patient and X-Ray tube distance is 6 ft (180 cm).

PA View

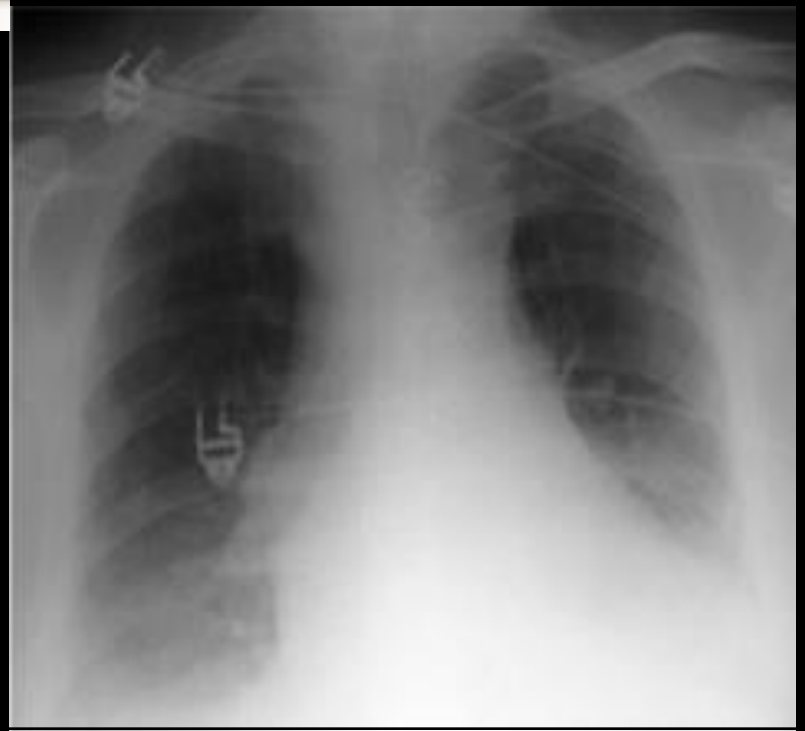




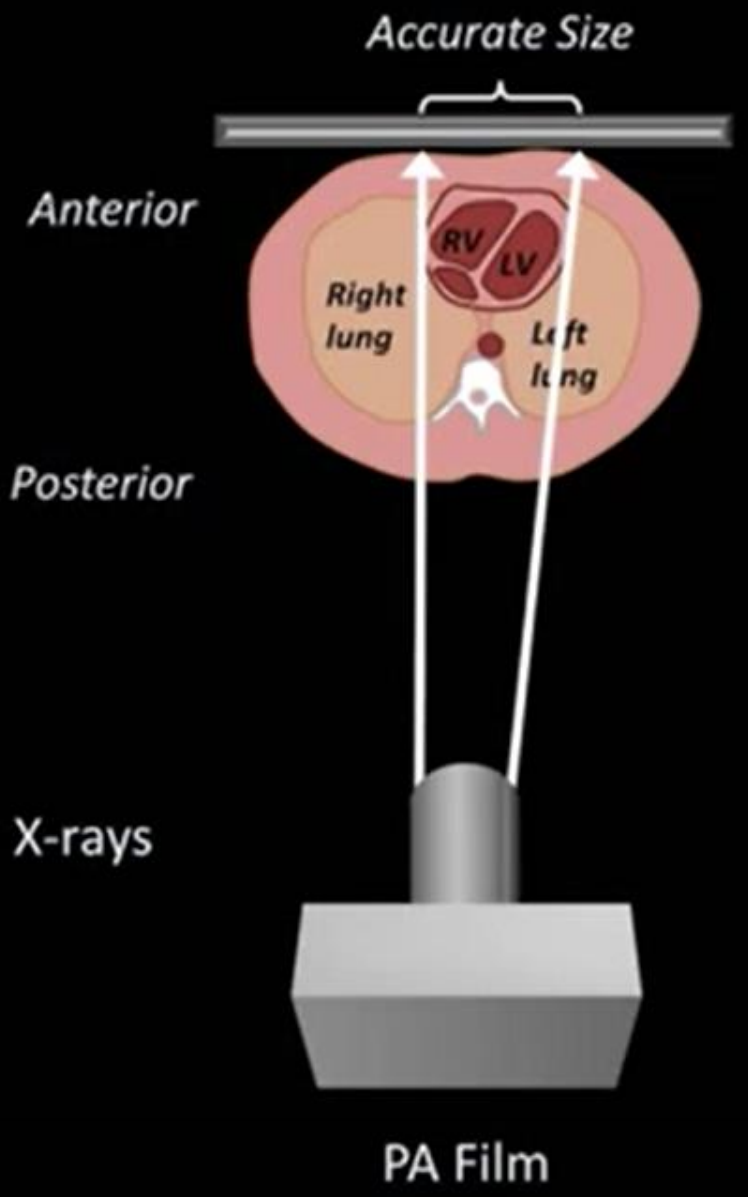
Antero-posterior (AP View)

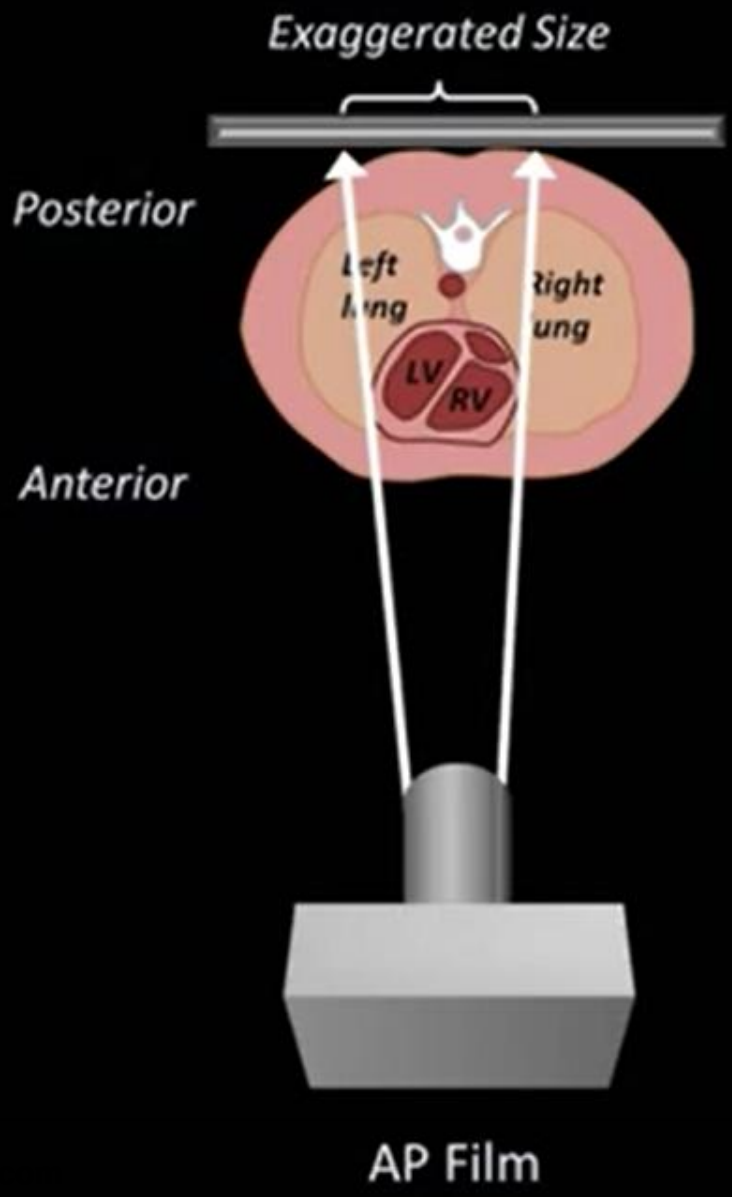
- Used when patient is debilitated, immobilized or unable to cooperate with the PA procedure.
- Film is placed behind the patient’s back with the patient in a supine position.
- Heart is at greater distance from the film hence appear more magnified than in the PA.
- The scapulae are visible because they are not rotated out of the view as they are in a PA.

AP View



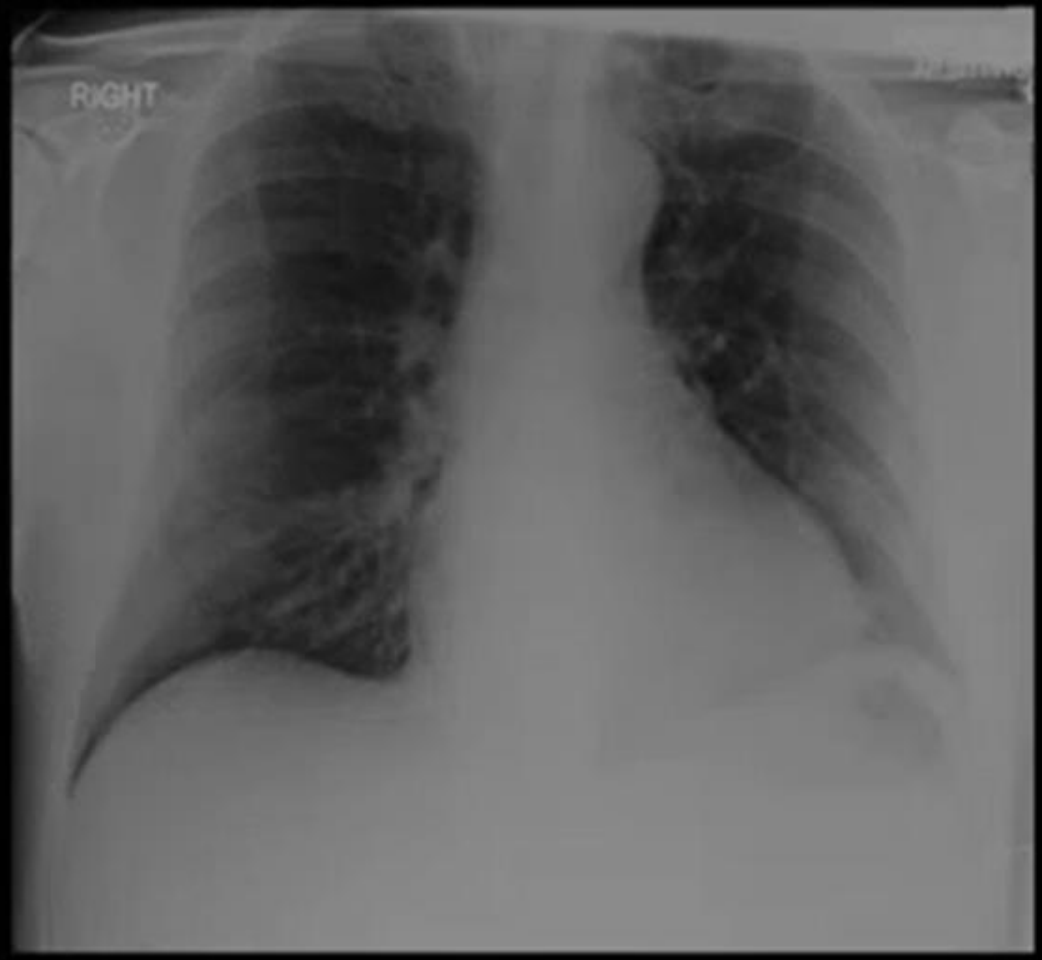
PA vs. AP Films





PA vs. AP Films

PA Film



AP Film

Same Patient

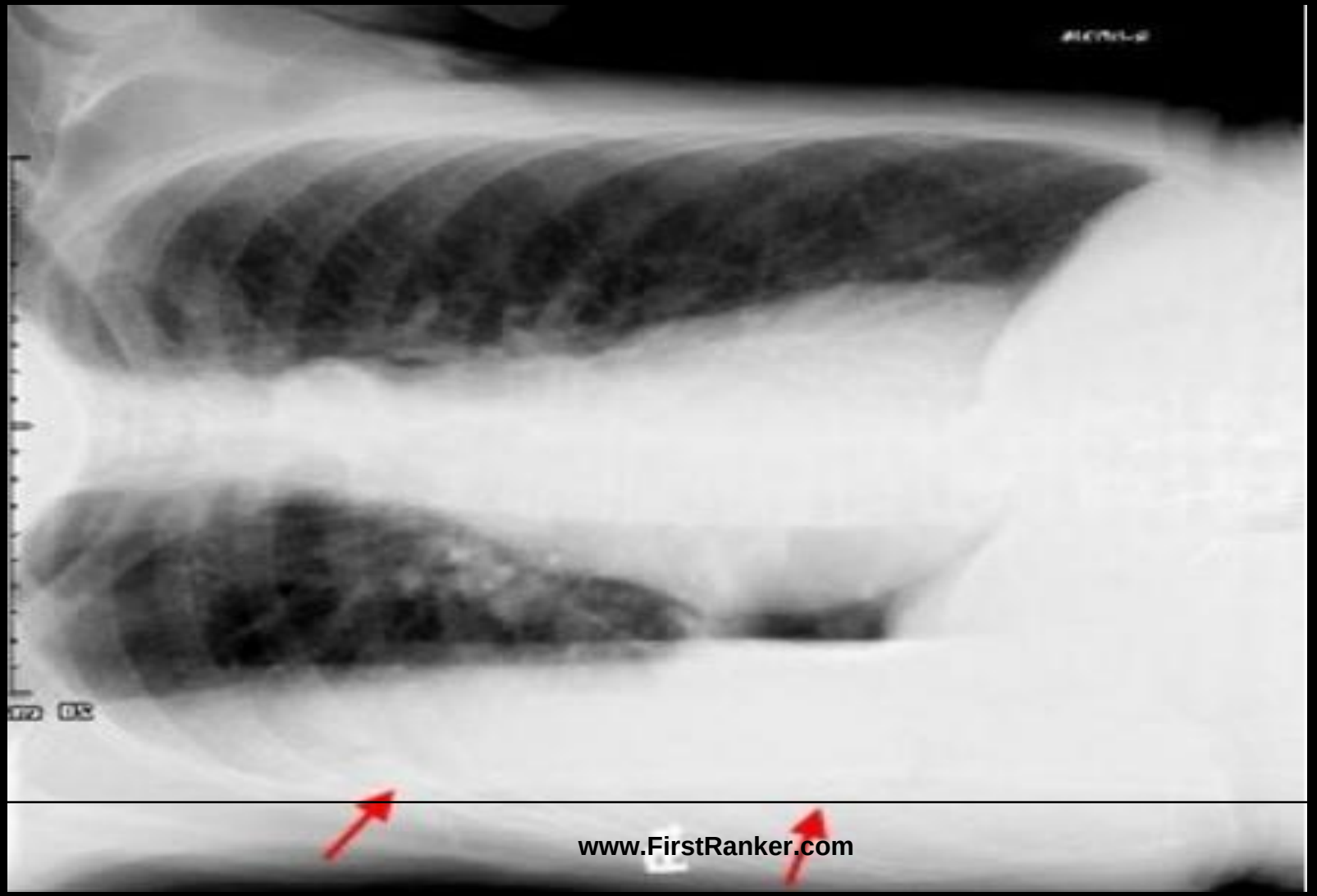
Lateral view

- Patient stands upright with the left/right side of the chest against the film and arm raised over the head.
- Allow the viewer to see behind the heart and diaphragmatic dome.
- Typically used in conjunction with PA view of the same side of chest to help determine the three dimensional position of organs or abnormal densities.

Lateral View

Lateral decubitus

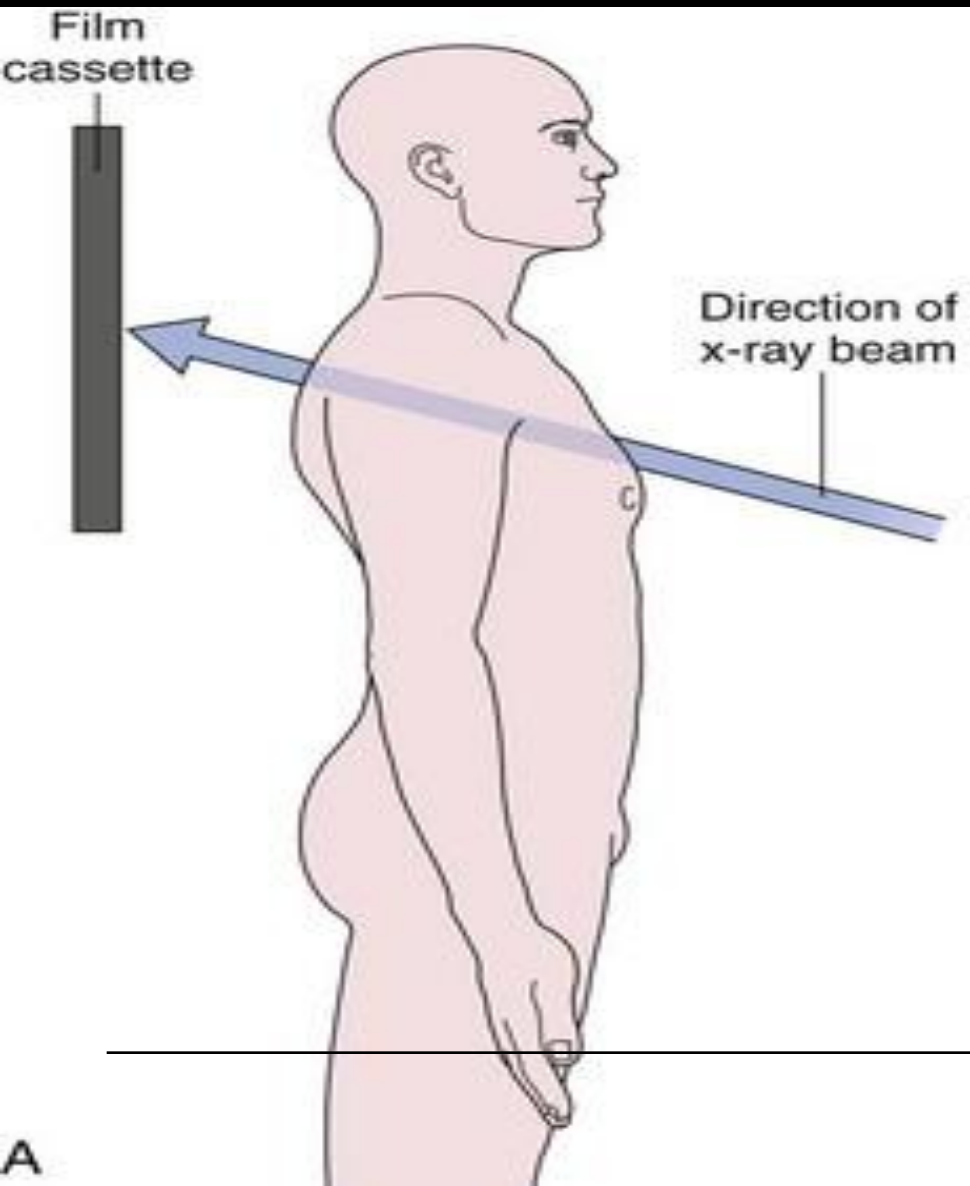
- The patient lies on either left or right side than in the standing position as with the regular lateral radiograph.
- Often used to differentiate between loculated and non loculated pleural effusion, since the non loculated effusion will collect in the dependent position

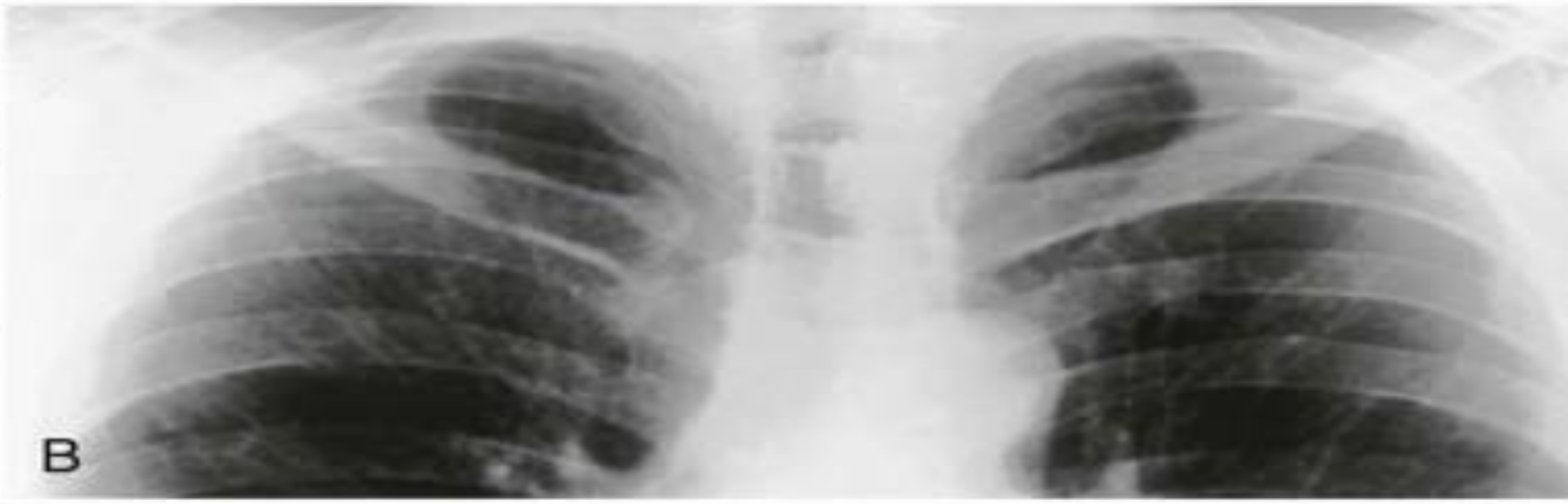


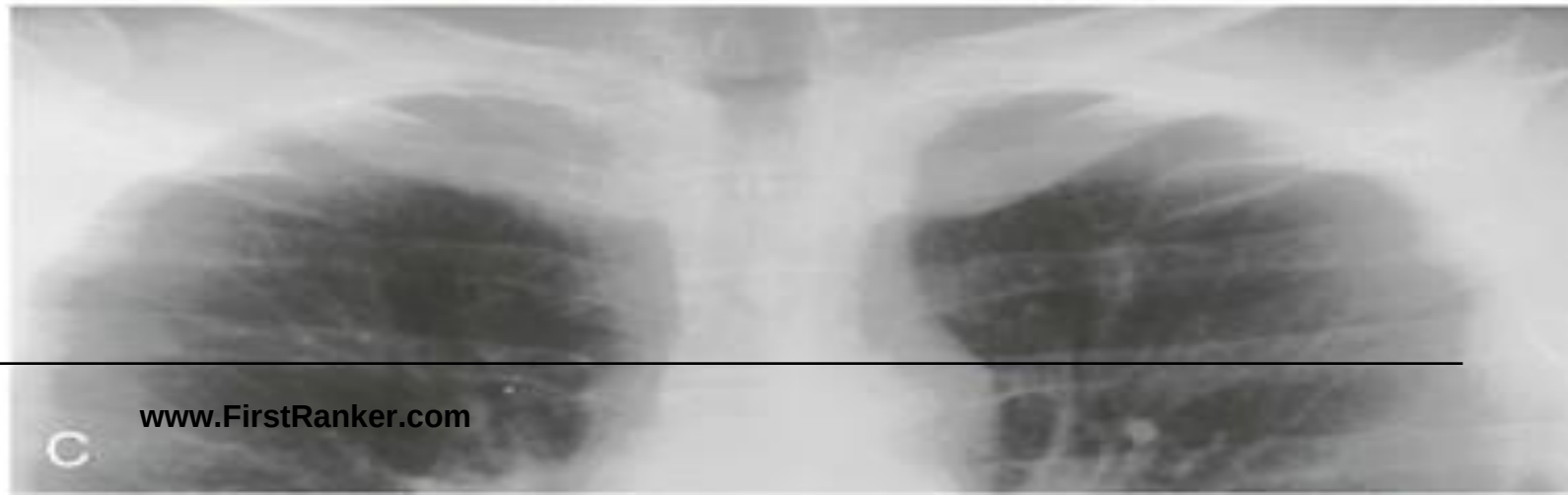
Apical Lordotic View

- Used to observe pathology of apex that not clearly visible in PA view.
- In this view X-Ray beam is angled towards the head.

Apical Lordotic View





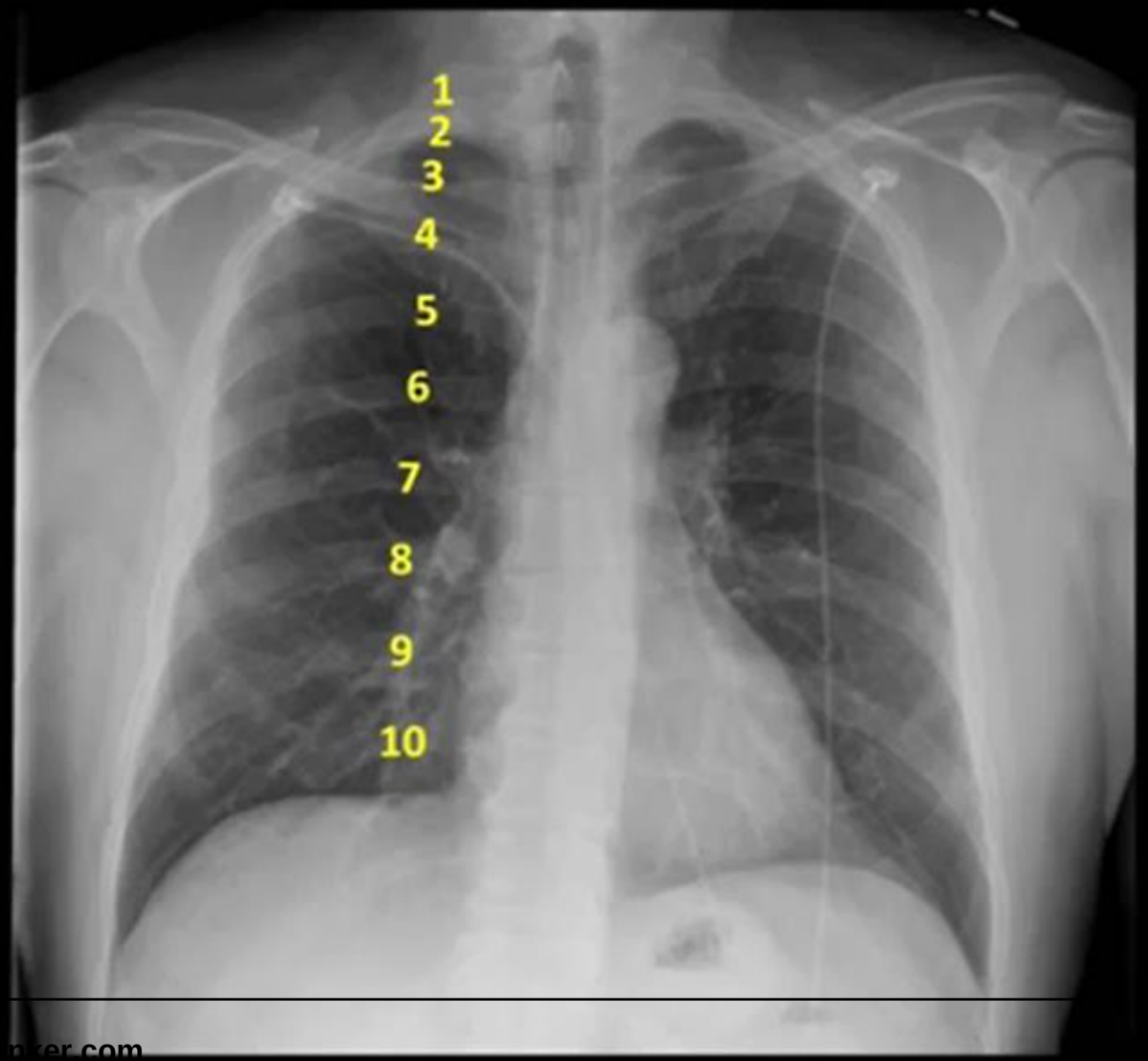


- Three Main Factors Determine the Technical Quality of the Radiograph
  - **Inspiration**
  - **Penetration**
  - **Rotation**

Assessment of Adequate Inspiration

In a patient with normal lung volumes, on a chest X-ray taken during full inspiration:

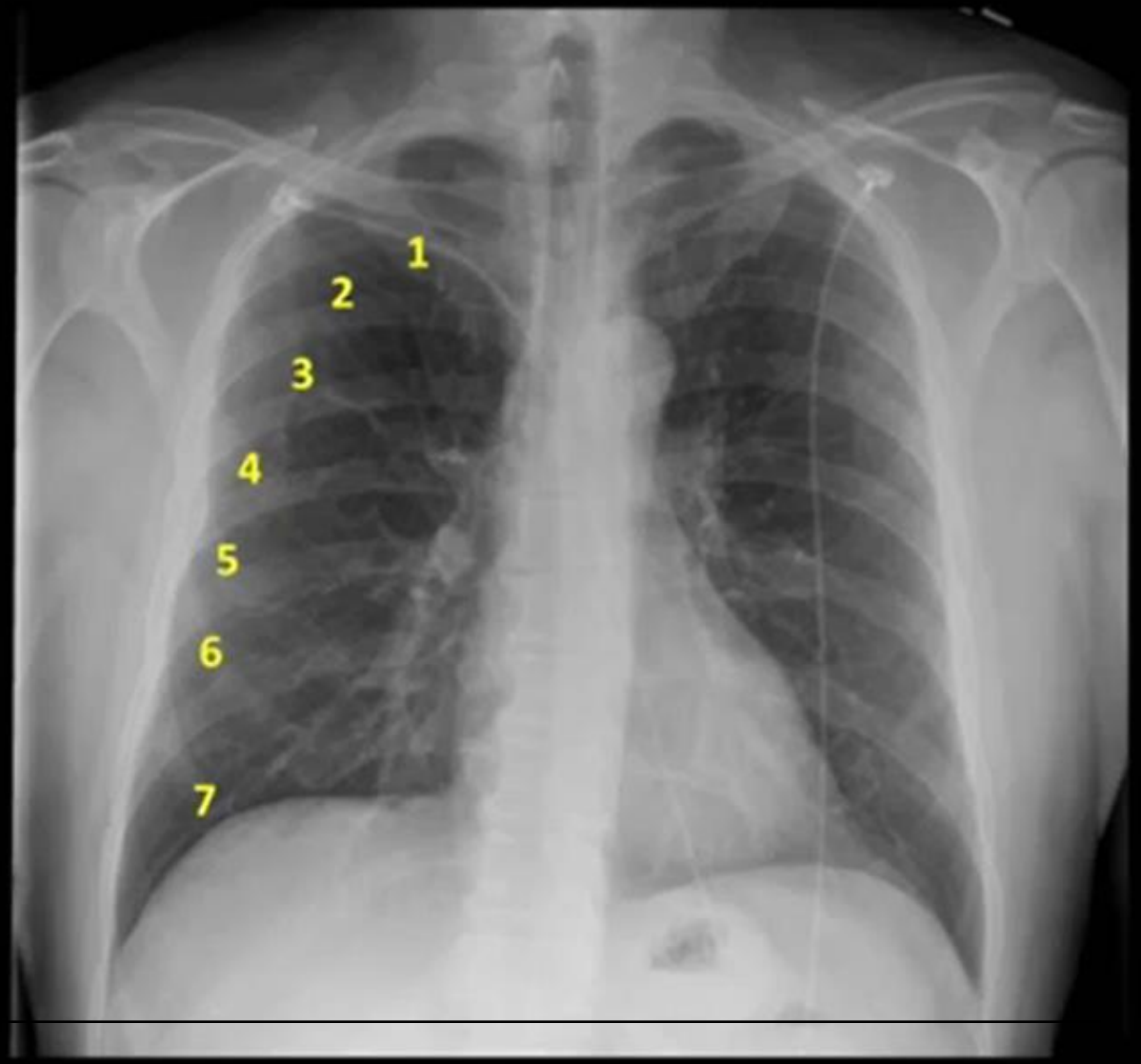
- 9-10 posterior ribs should be visible



Assessment of Adequate Inspiration

In a patient with normal lung volumes, on a chest X-ray taken during full inspiration:

- 9-10 posterior ribs should be visible
- 6-7 anterior ribs should be visible, with the 7th rib "piercing" the diaphragm



Penetration

On a **properly exposed** chest radiograph:

- The lower thoracic vertebrae should be visible through the heart
- The bronchovascular structures behind the heart (trachea, aortic arch, pulmonary arteries, etc.) should be seen

1----Underexposure

In an **underexposed** chest radiograph,

* The cardiac shadow is→ **opaque**,

* With little or no visibility of the **thoracic vertebrae.**

* The **lungs** may appear much **denser and whiter,** much as they might appear as with infiltrates present.

2-----Overexposure

With greater exposure of the chest radiograph, the

*__Heart__ becomes __more radiolucent__ and

*__Lungs__ become proportionately __darker.__

In an overexposed chest radiograph, the air-filled lung periphery becomes __extremely radiolucent__, and often gives the appearance of lacking lung tissue, as would be seen in a condition such as __emphysema.__

Assessing Exposure/Penetration

Good quality film

Too bright

(Underexposed)

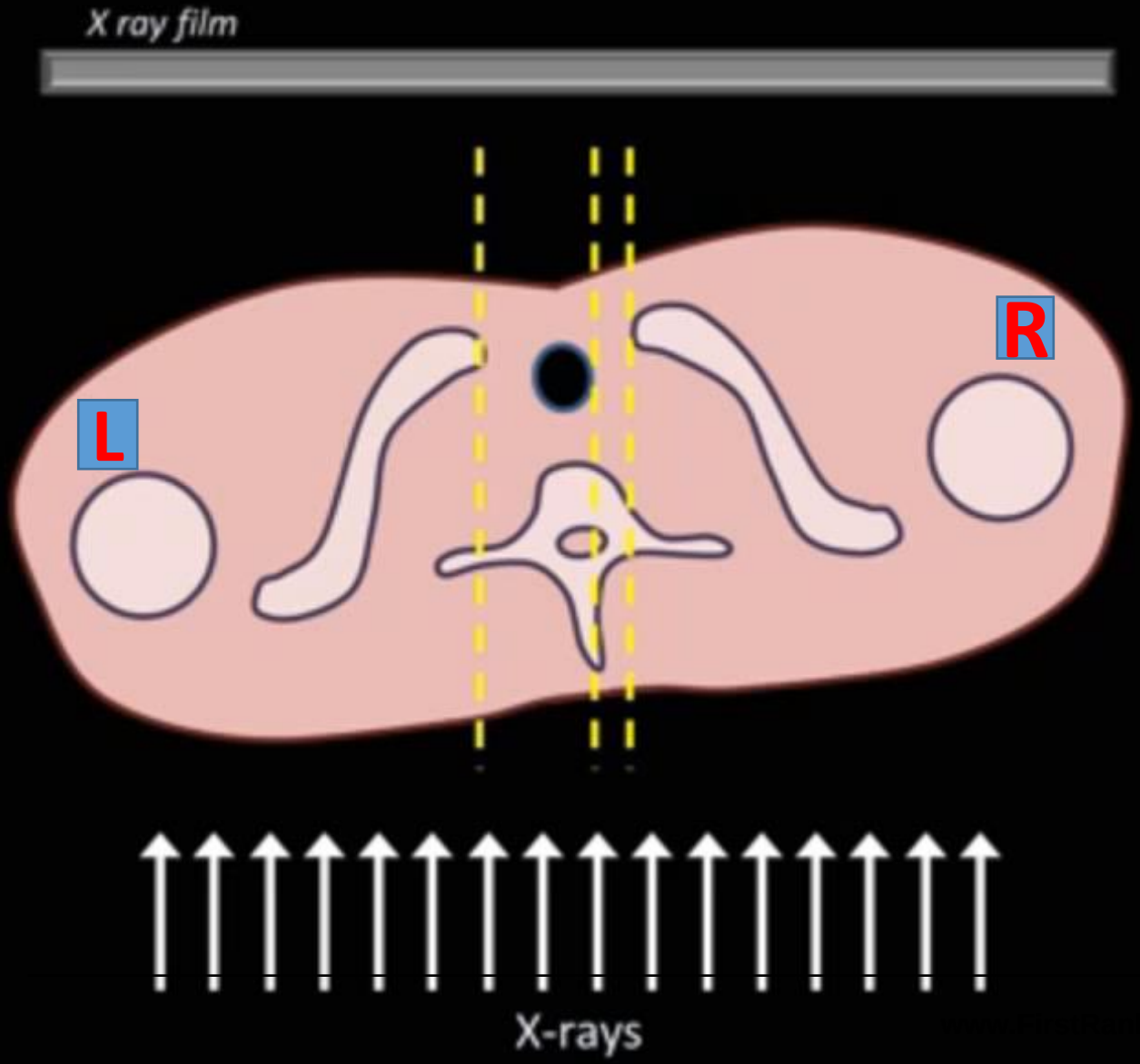
Too much contrast

(Overexposed)

Rotation

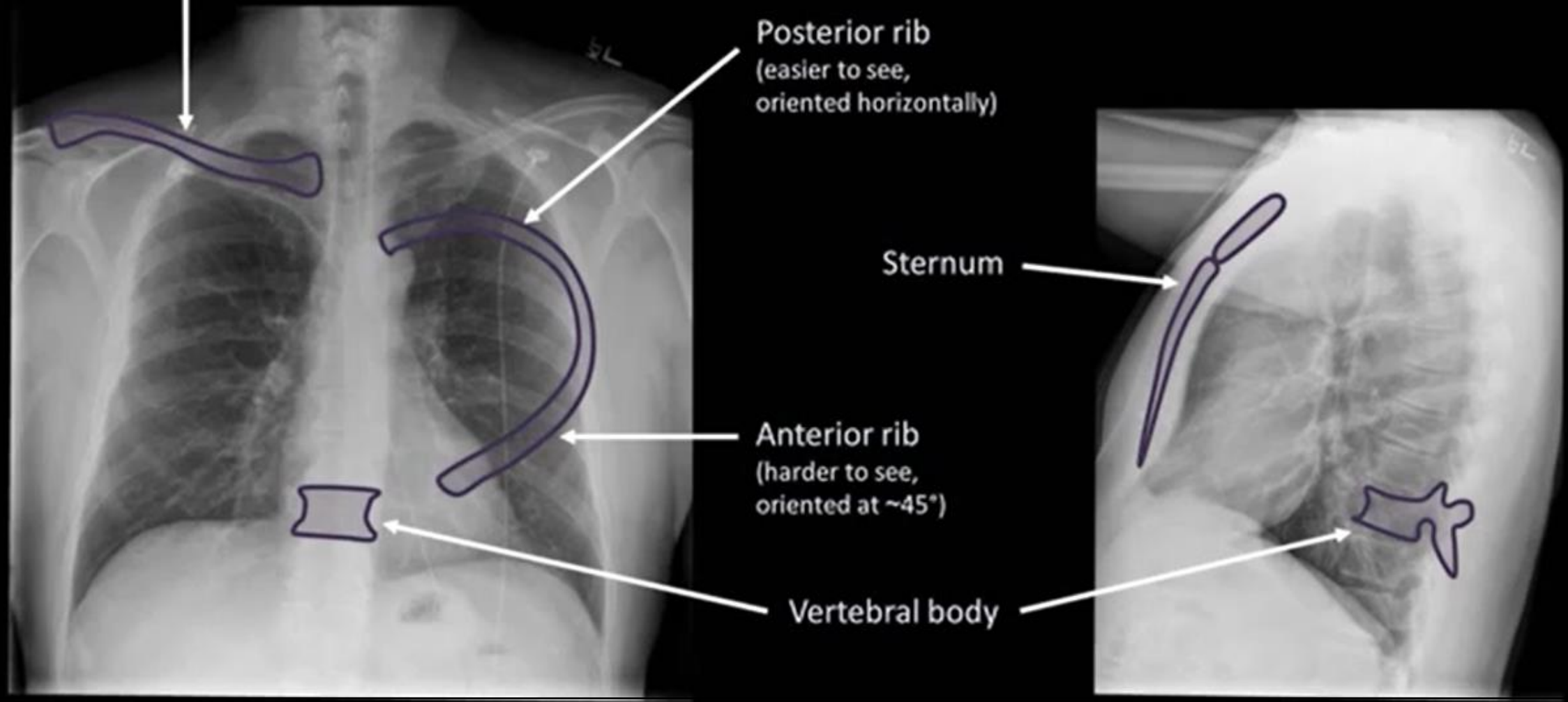
Patient rotation can be assessed by observing the clavicular heads and determining whether they are equal distance from the spinous processes of the thoracic vertebral bodies.

Relationship Between Clavicle and Vertebral Spinous Processes

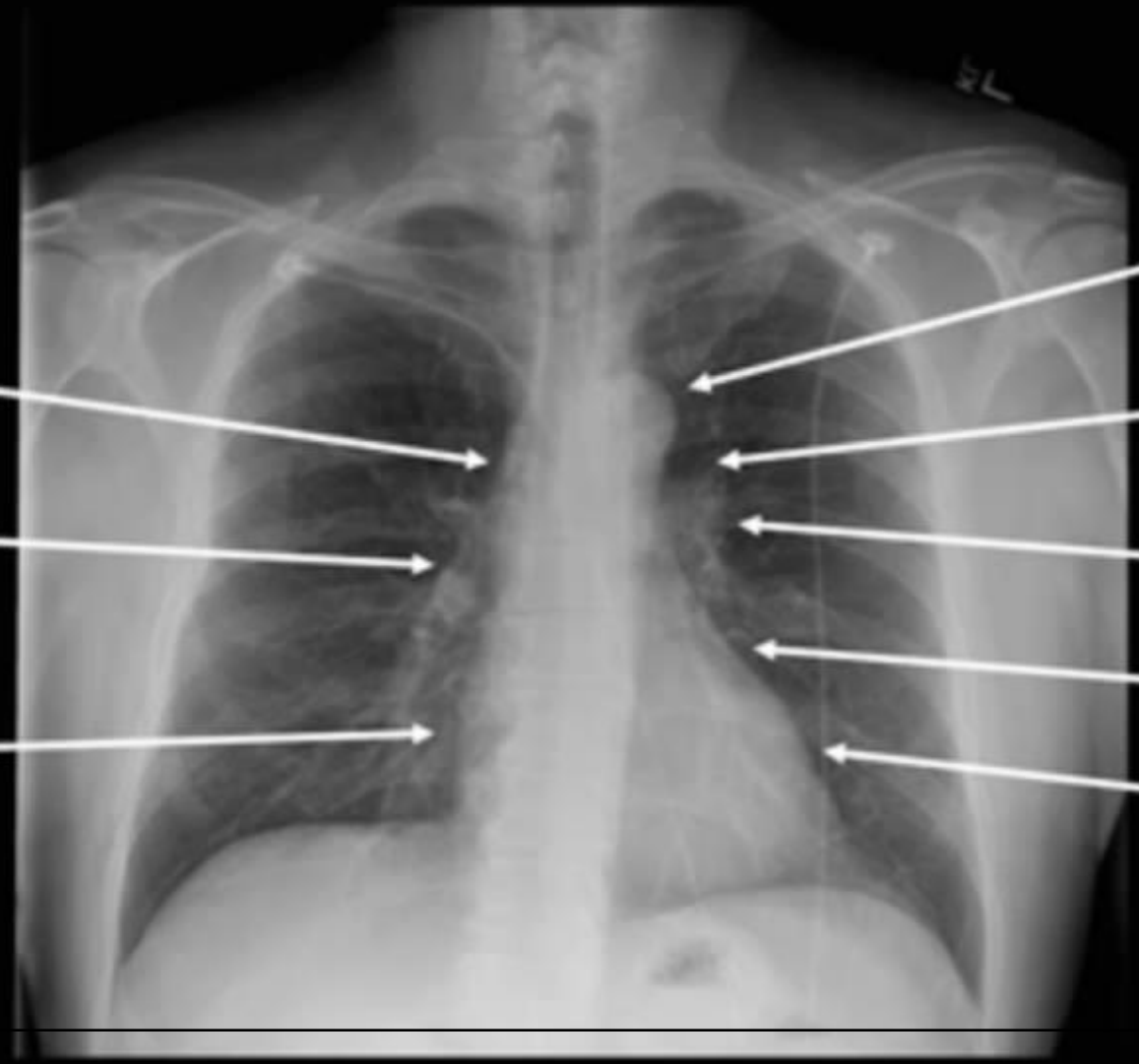


The spinous processes will be closer to the clavicle on the side that is rotated forward.

Anatomy - Bones



Anatomy – Cardiac Silhouette and Mediastinum



Aortic arch

Ascending aorta

Aortopulmonary window

Right pulmonary artery

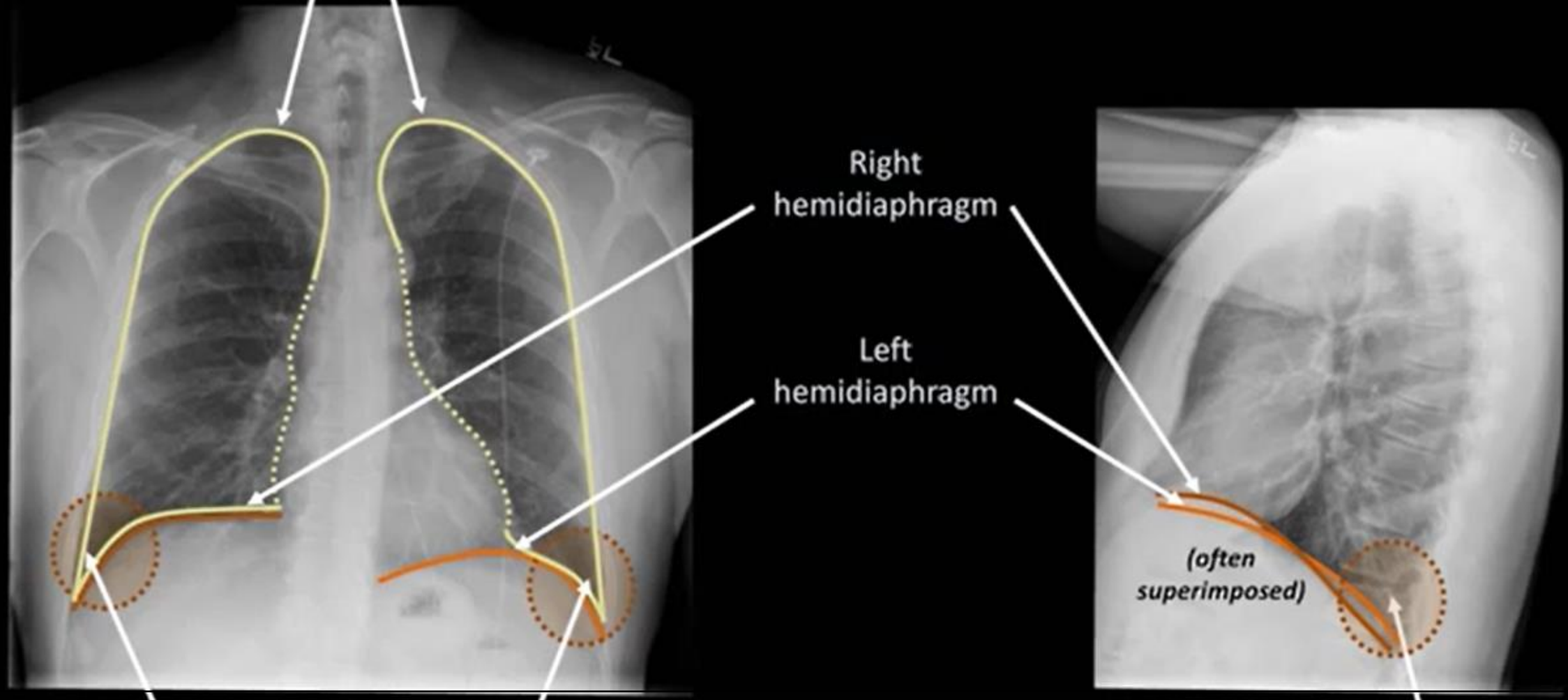
Left pulmonary artery

Left atrium

Right atrium

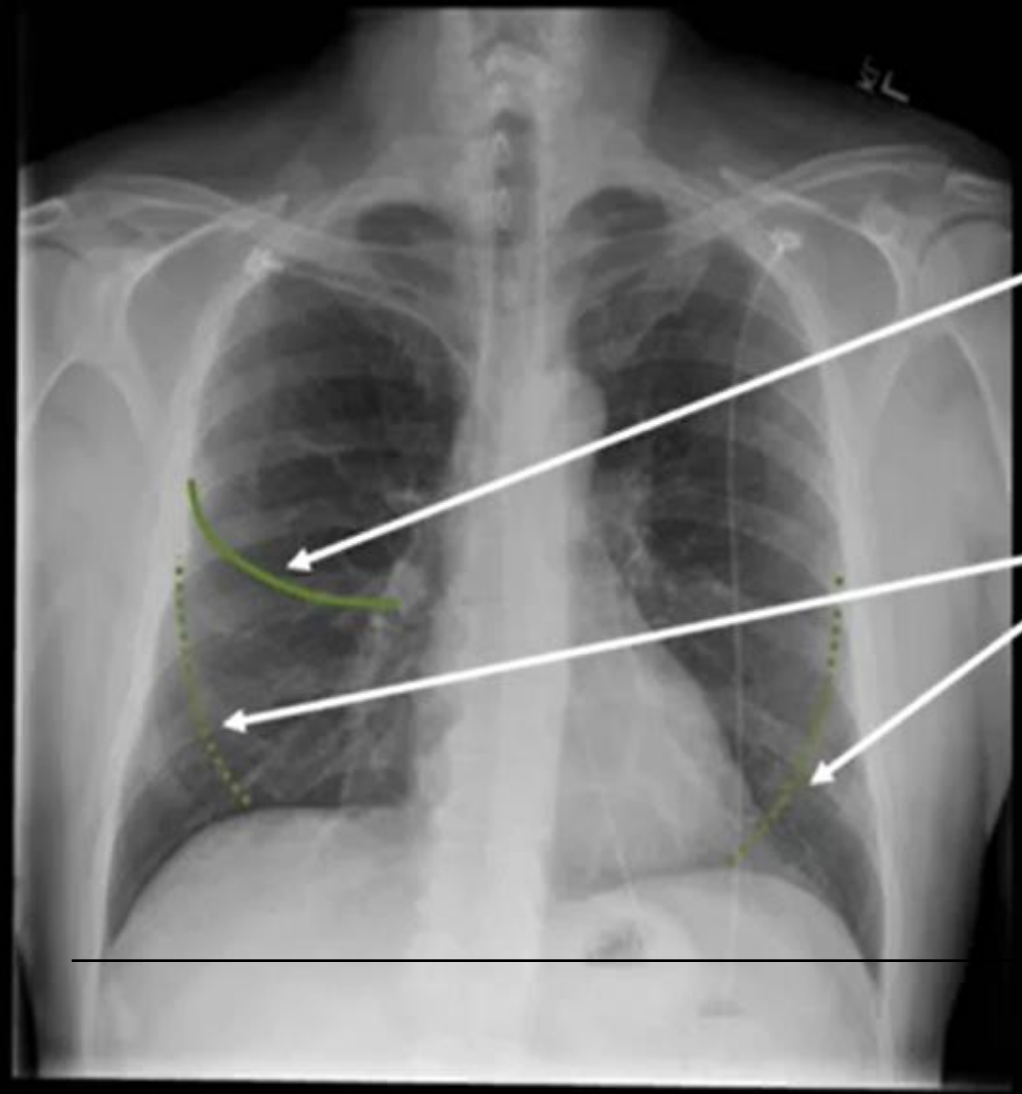
Left ventricle

Anatomy – Diaphragm and Pleura



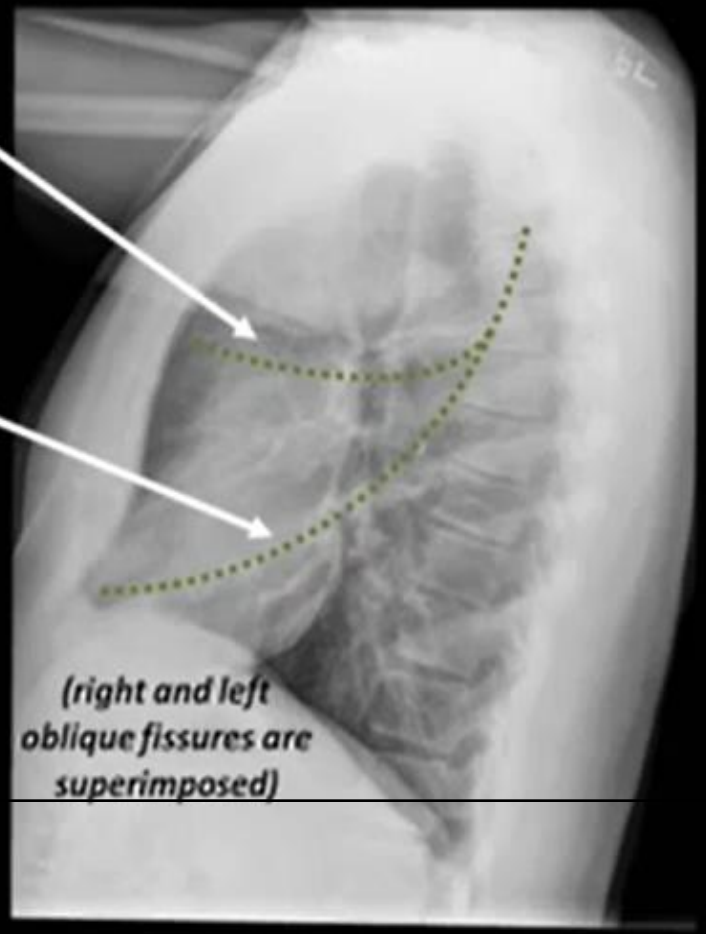
Anatomy – Lungs

Fissures



Horizontal fissure

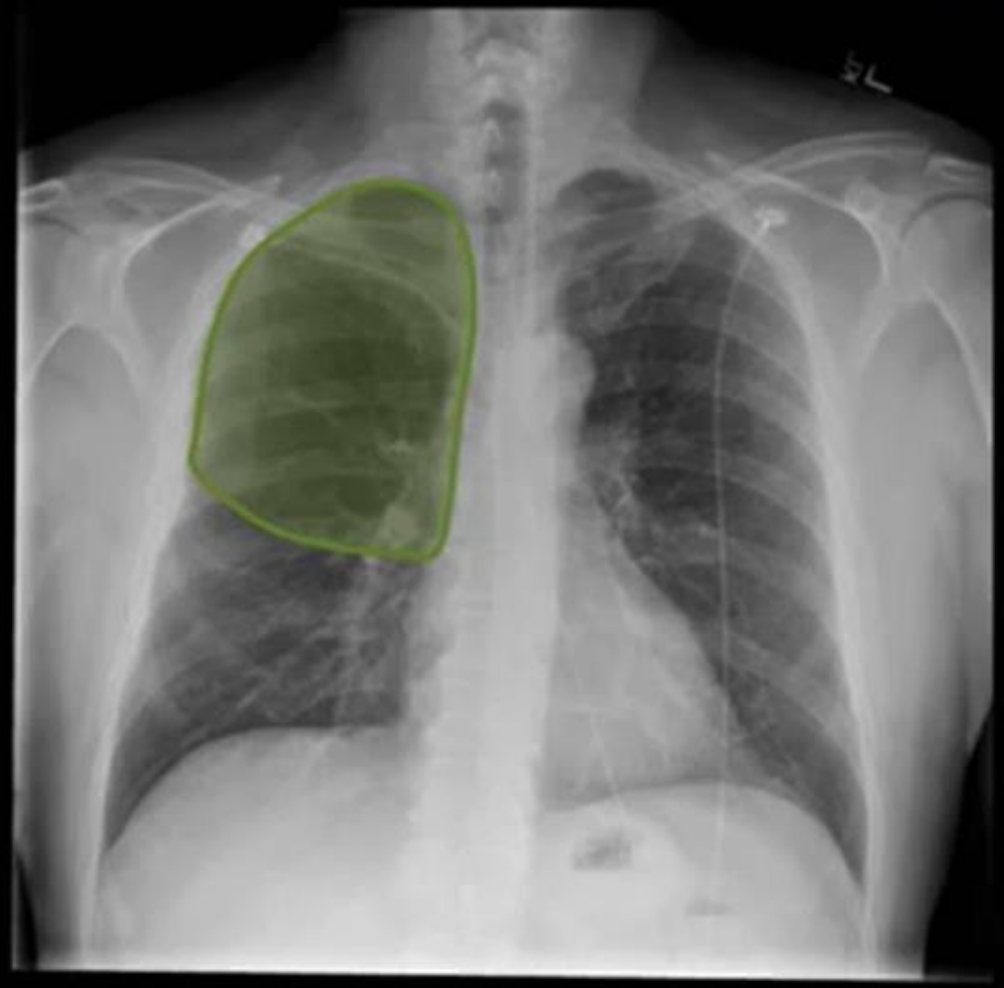
Oblique fissures



(right and left oblique fissures are superimposed)

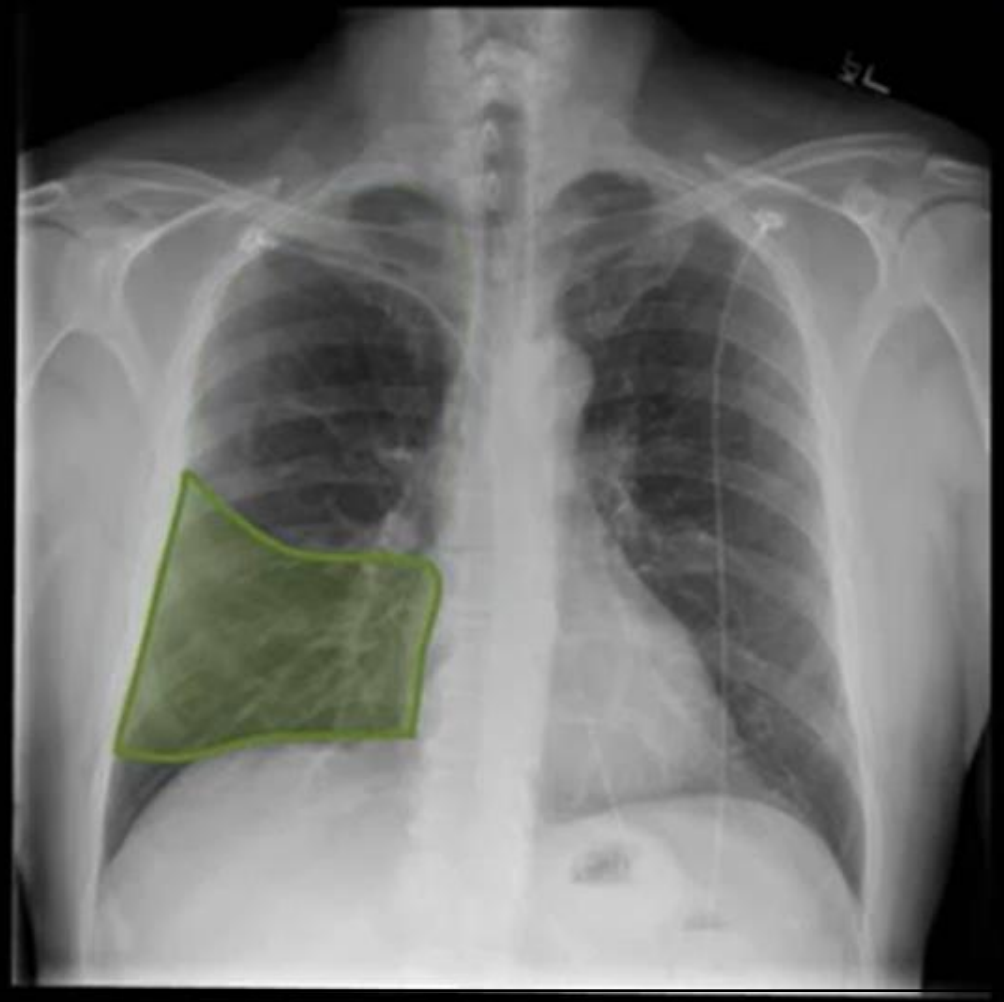
Anatomy – Lungs

Right Upper Lobe



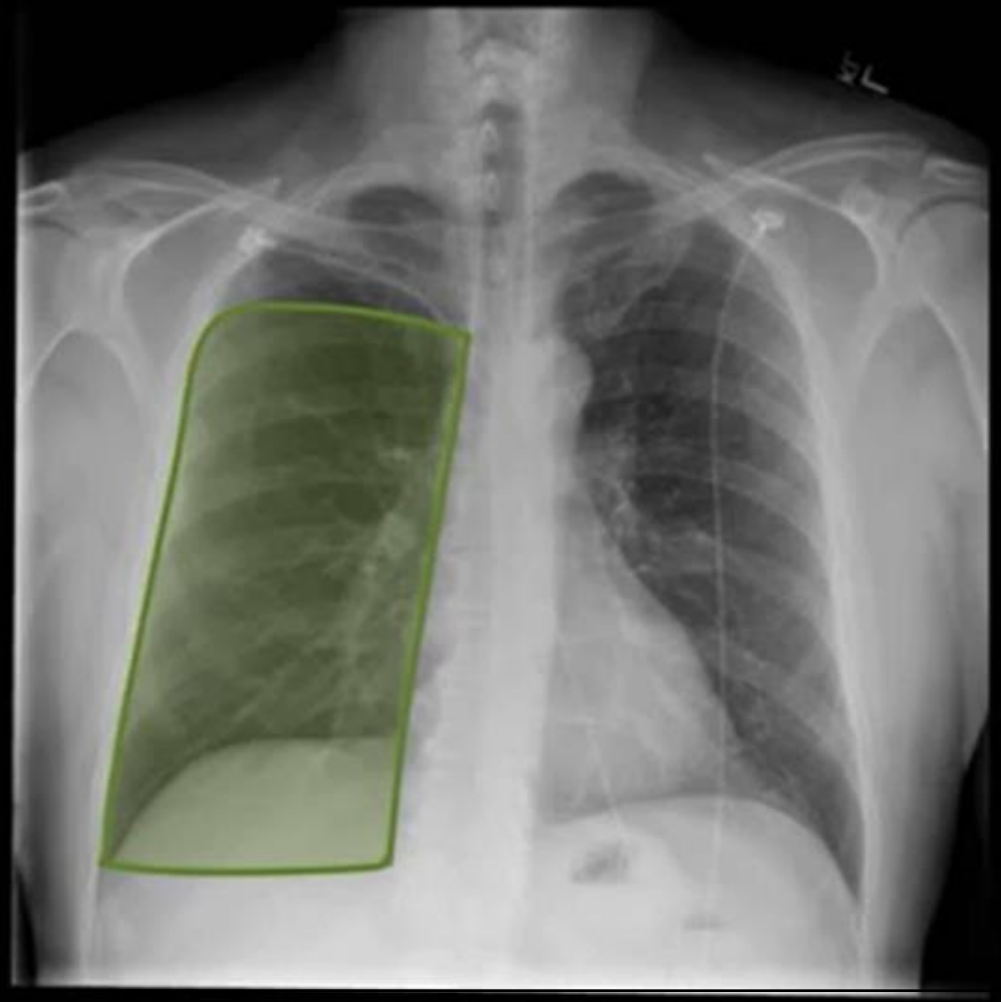
Anatomy – Lungs

Right Middle Lobe



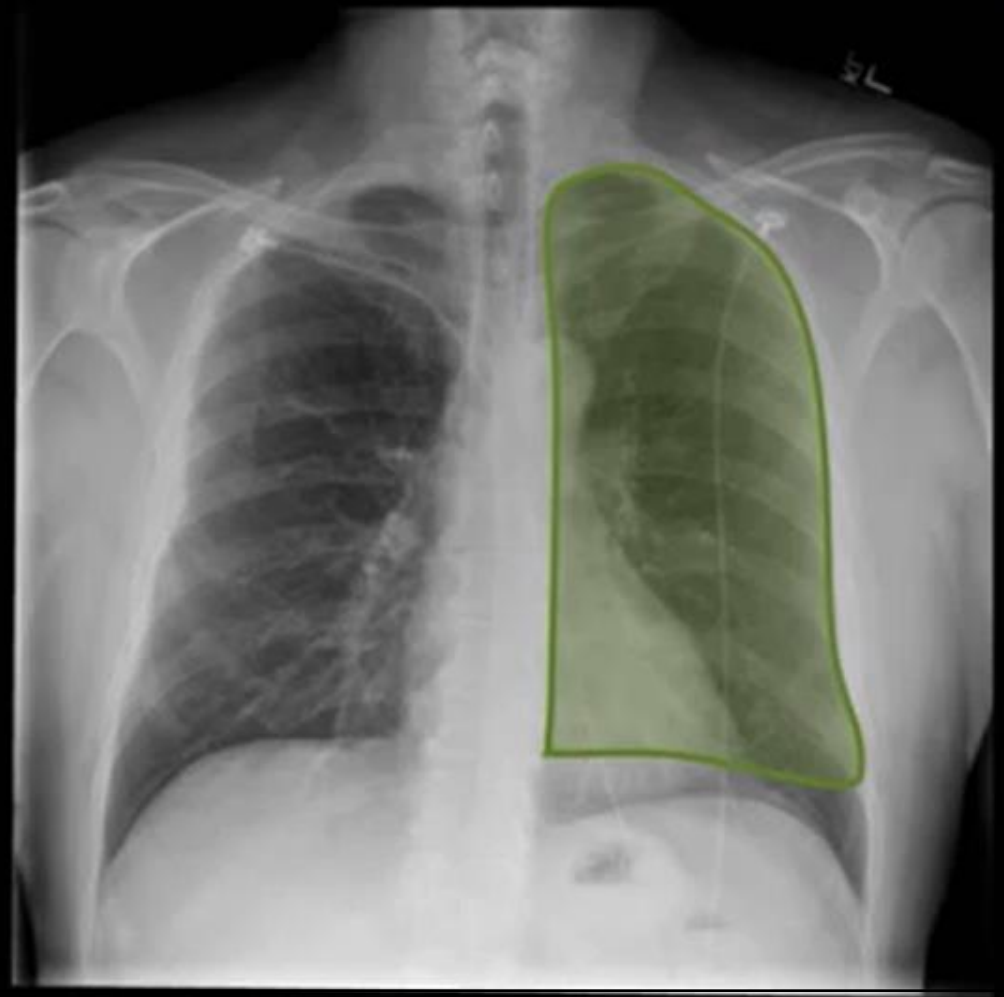
Anatomy – Lungs

Right Lower Lobe



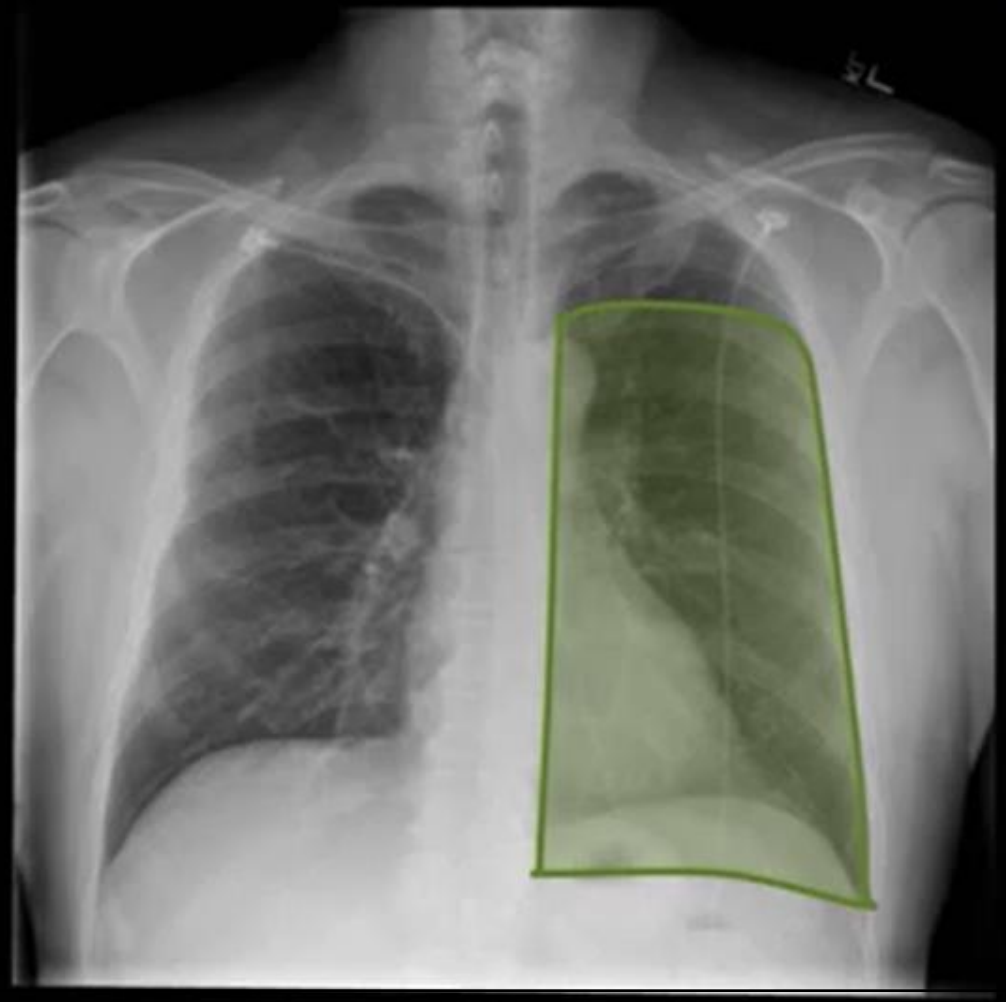
Anatomy – Lungs

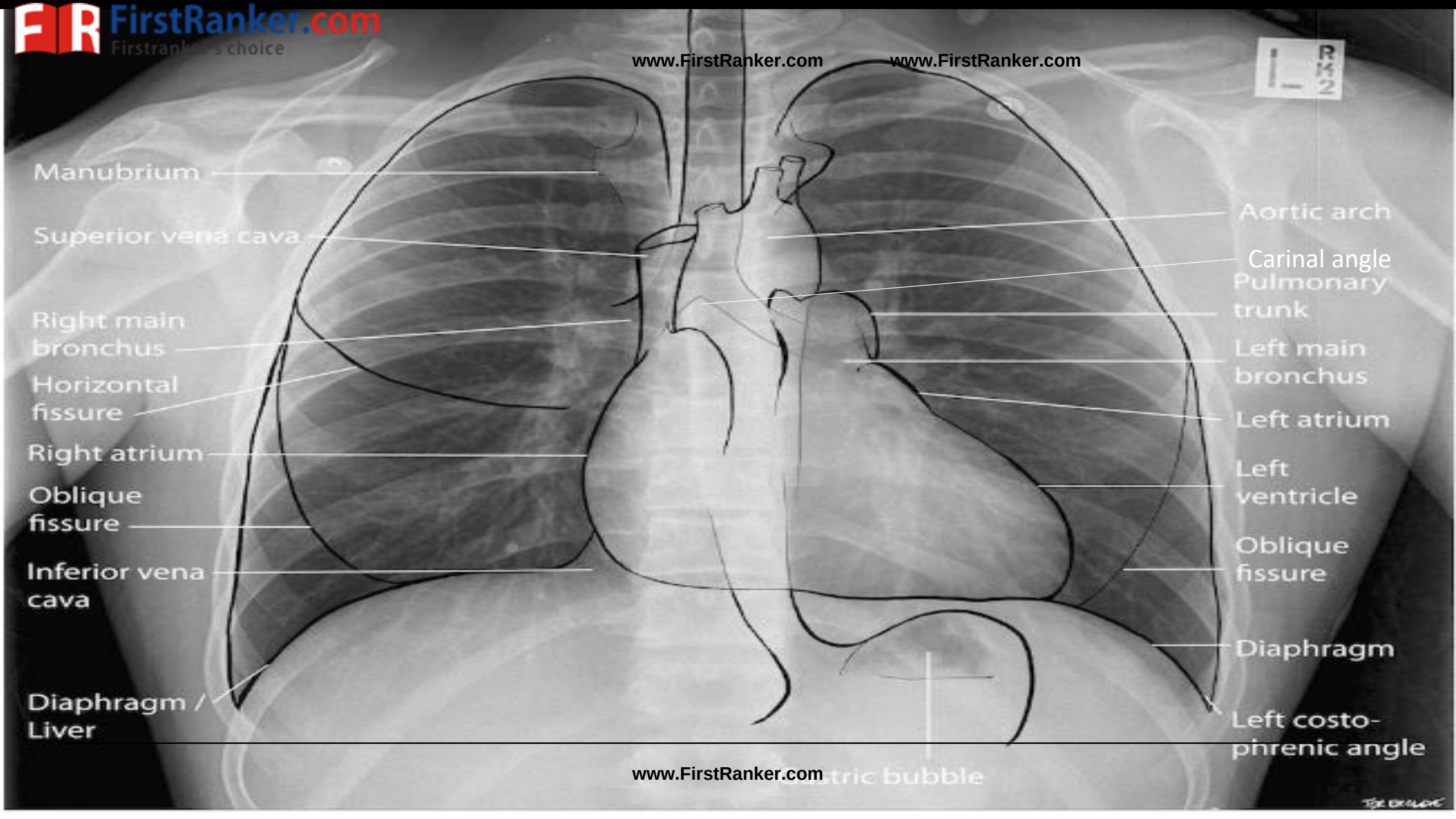
Left Upper Lobe



Anatomy – Lungs

Left Lower Lobe





The ABCDEF System

(Assess the technical quality)

A – Airways

B – Bones (and soft tissue)

C – Cardiac silhouette (and mediastinum)

D – Diaphragm (and gastric bubble)

E – Effusions (i.e. Pleura)

F – “Fields” (i.e. Lung Fields)

(Lines, Tubes, Devices, Surgeries)

Airway Deviation

Abnormalities deviating trachea away from affected side	Abnormalities deviating trachea towards the affected side
Pneumothorax	Marked atelectasis / collapsed lung
Pleural effusion	Lobectomy / Pneumonectomy
Large mass	Pleural fibrosis
	Pulmonary fibrosis (rarely unilateral)

Airway Deviation

High pressure in left hemithorax

↓

Massive left pleural effusion

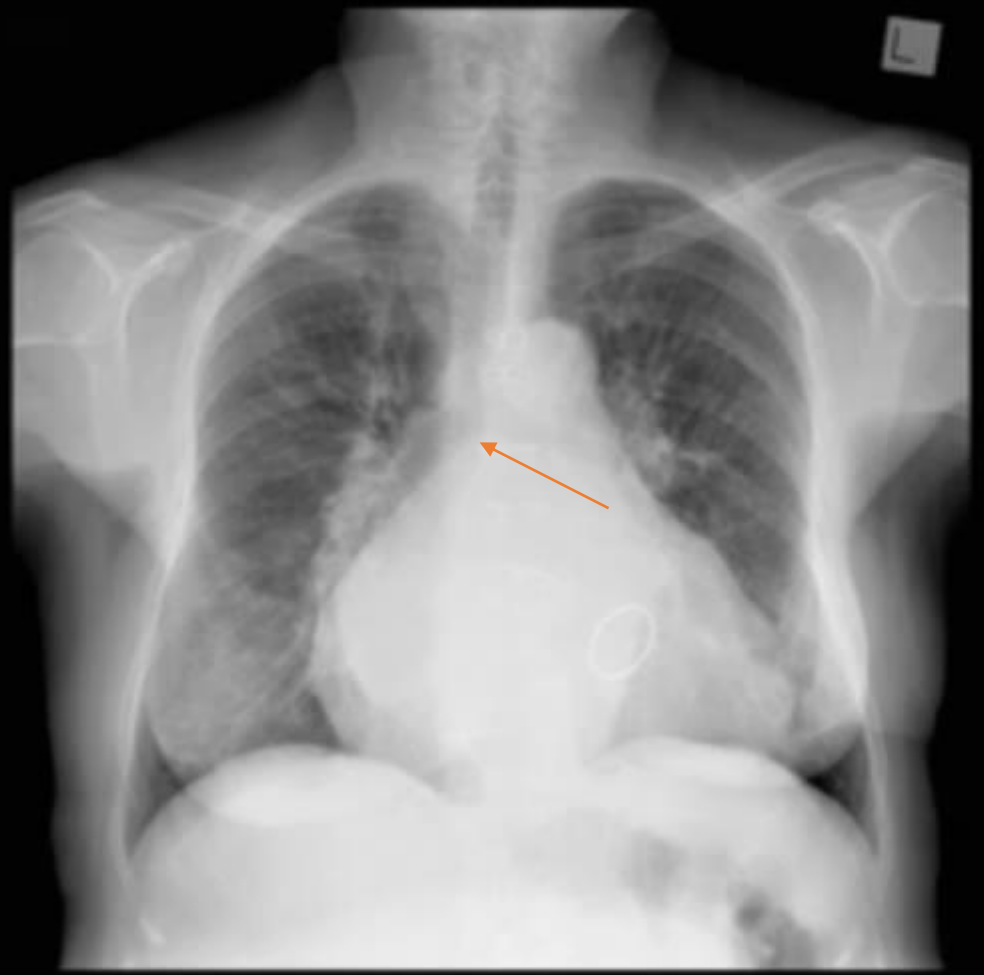
Low pressure in left hemithorax

↓

Total collapse of left lung (no pneumothorax)

Airway Deviation

Rightward deviation of trachea
due to mediastinal mass



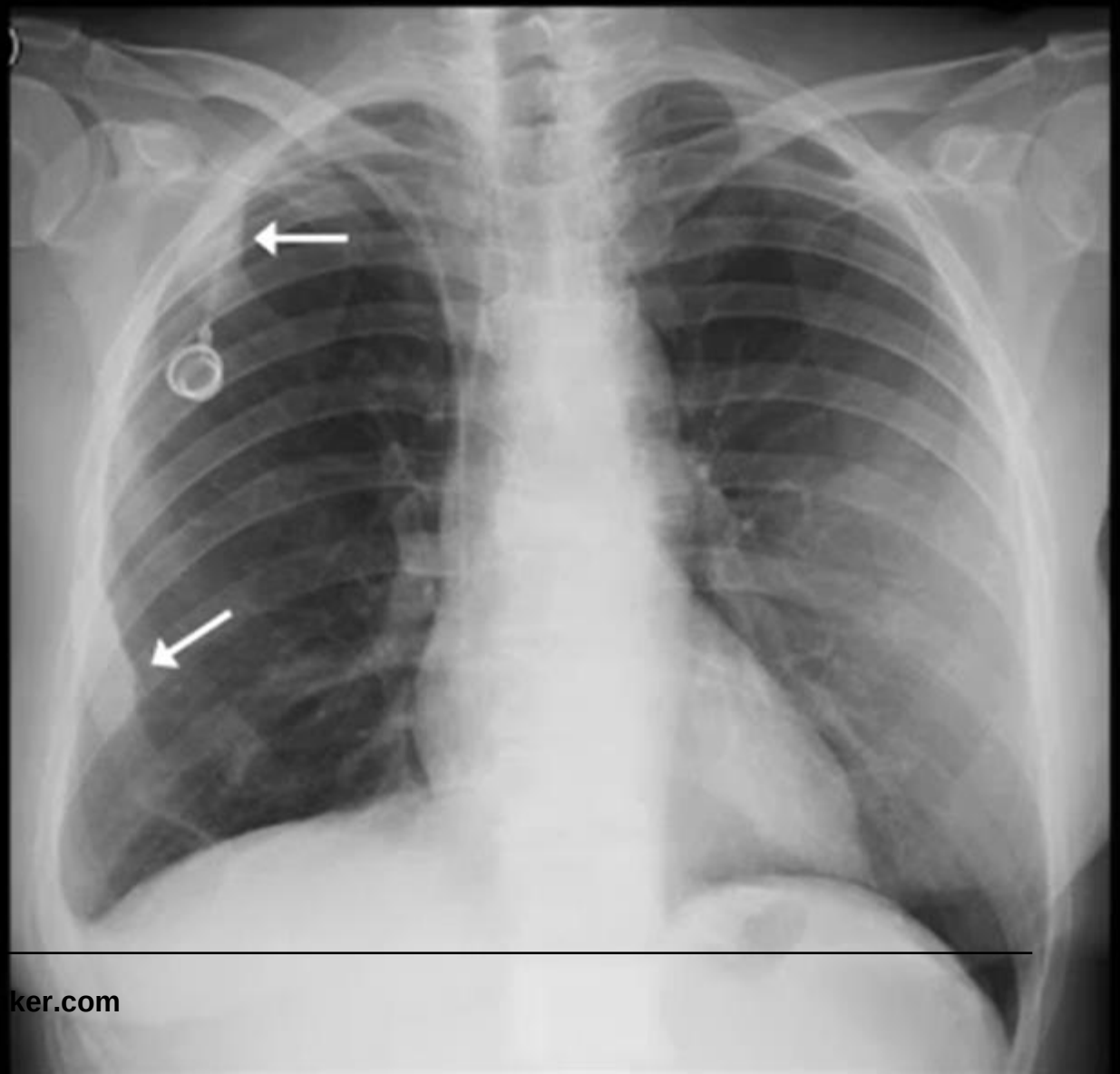
Splaying of the right and left
main bronchi (carinal angle > 90°)

B- Bone and soft tissues

- Look at each rib in turn
- Clavicles
- Scapula and humerus if visible
- Lower cervical and thoracic spine

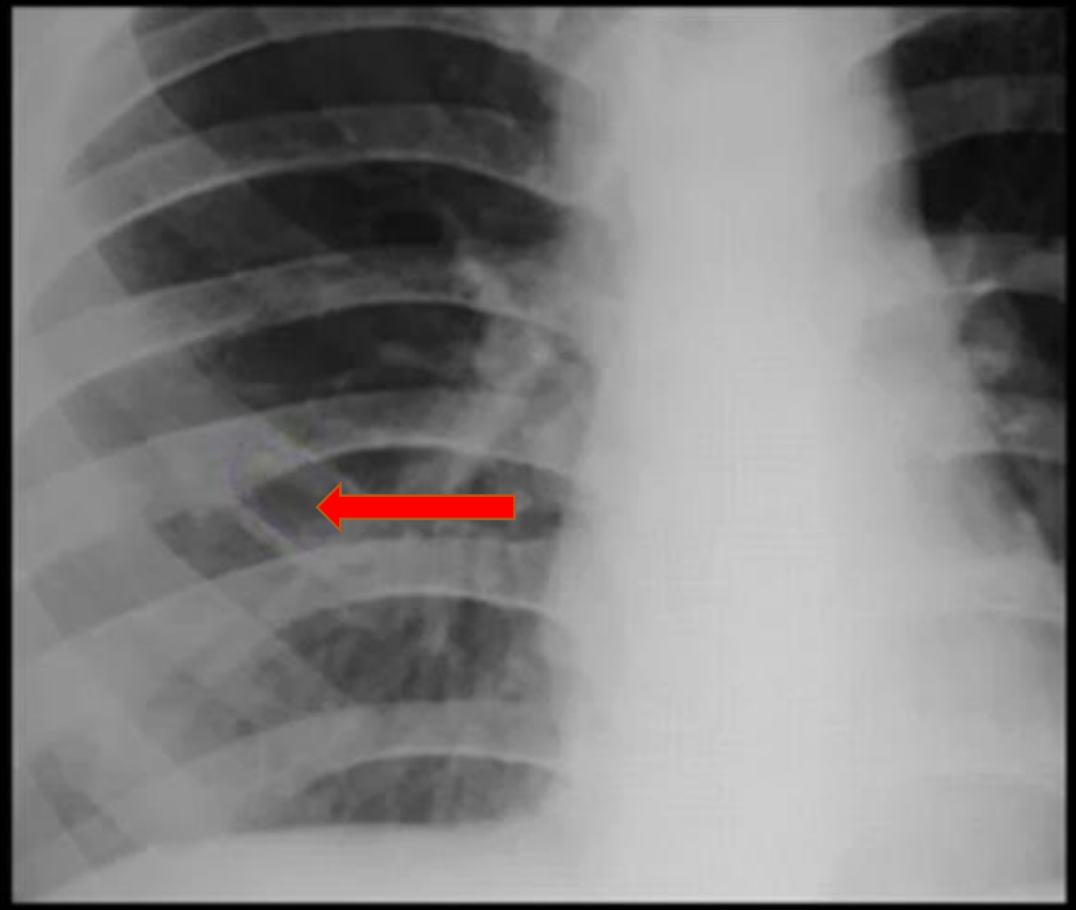
Sclerosis

- Sclerosis – ↑ Density of bone.
- Can be focal or diffuse
- Etiologies include:
  - Osteoblastic metastasis
  - Primary bone tumor
  - Various benign tumor-like bone lesions
  - Paget's disease
  - Chronic osteomyelitis



Lytic Lesions

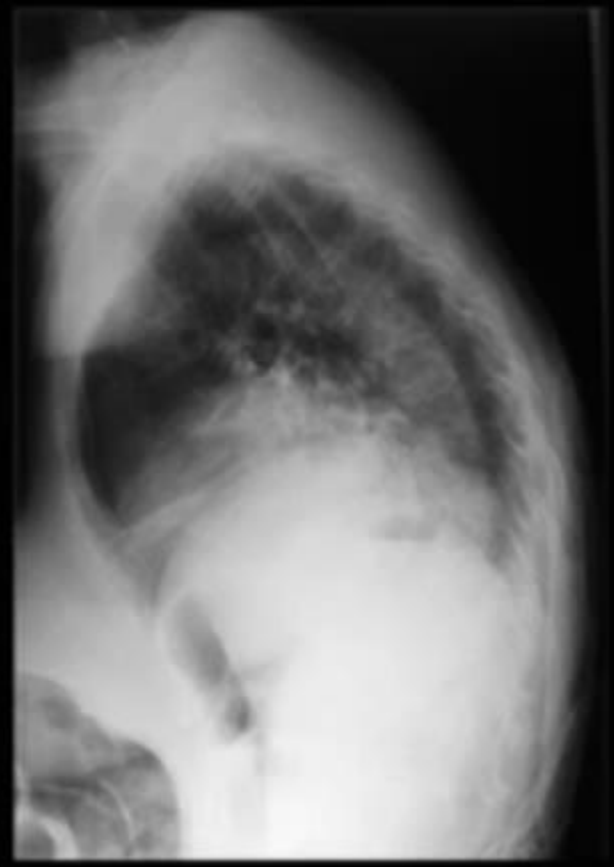
- Lytic lesions – ↓ Density of bone.
- Can be solitary or multiple
- Etiologies include:
  - Osteolytic metastasis
  - Multiple myeloma
  - Various benign cyst-like bone lesions
  - Paget's disease
  - Acute osteomyelitis



Scoliosis vs. Kyphosis

Scoliosis

Spine curves from side to side.
Seen on PA/AP views.



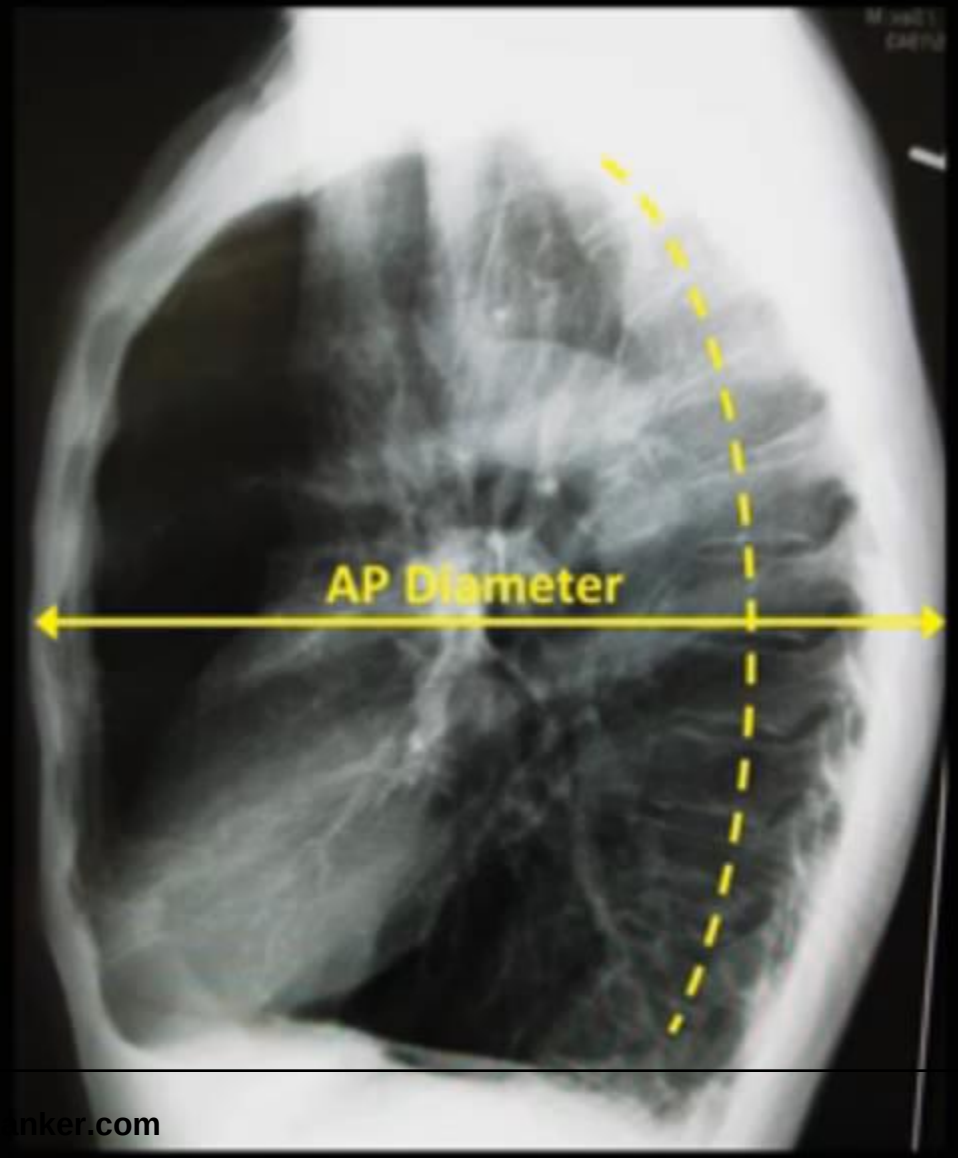
Kyphosis

Exaggerated front to back curvature of upper spine. Seen on lateral views.

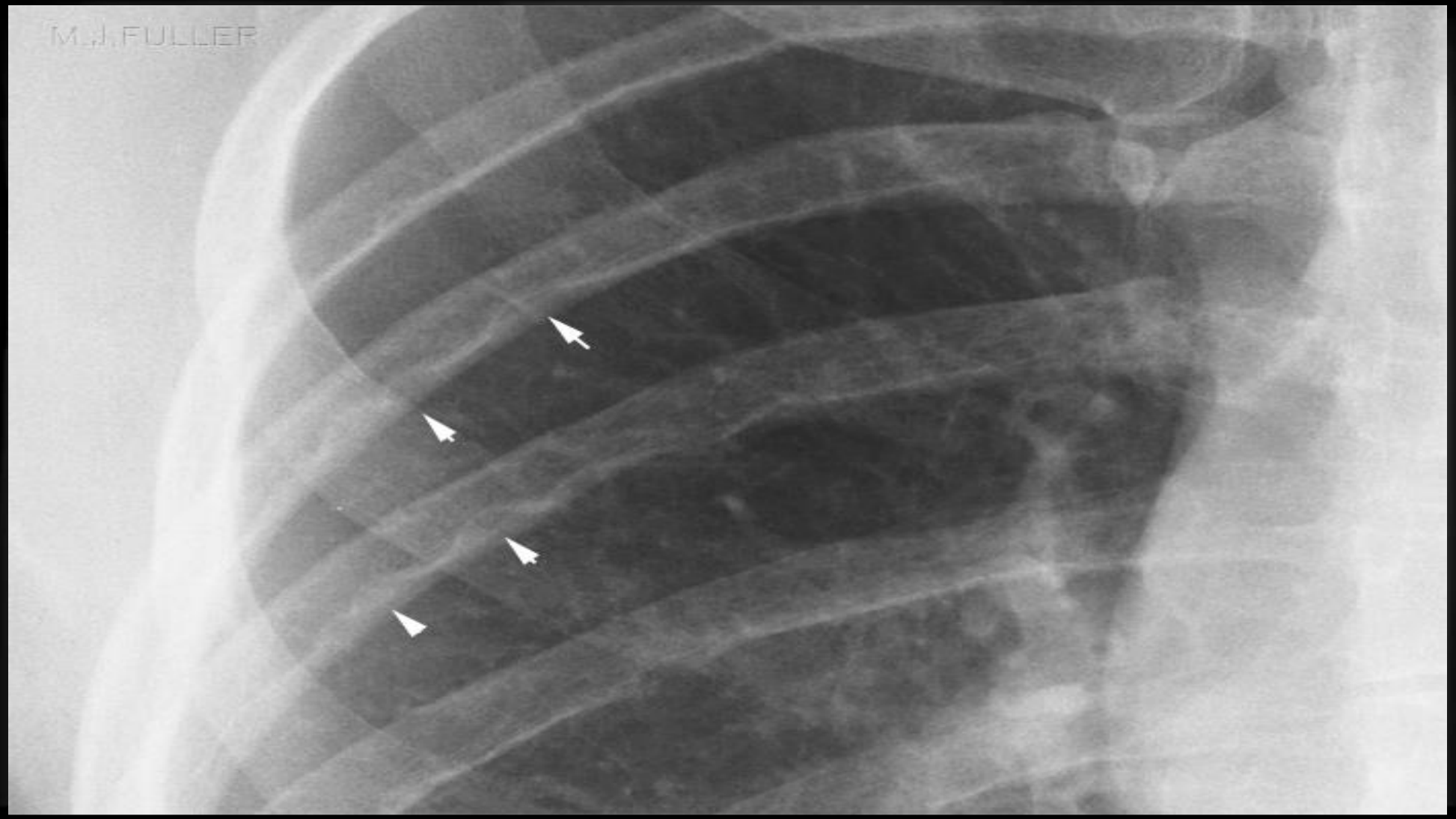
"Barrel Chest"

Refers to specific thoracic deformity that occurs in advanced COPD:

- Kyphosis
- Increased AP diameter



Rib Notching



Rib Notching

- Rib notching is focal deformation of one or more ribs.

- Etiologies depend upon whether the superior or inferior surface is affected:

Superior Surface	Inferior Surface
Osteogenesis imperfecta	Coarctation of the aorta
Connective tissue diseases	Subclavian or SVC obstruction
Local pressure	s/p Blalock Taussig shunt (only 2 upper ribs)
Hyperparathyroidism	

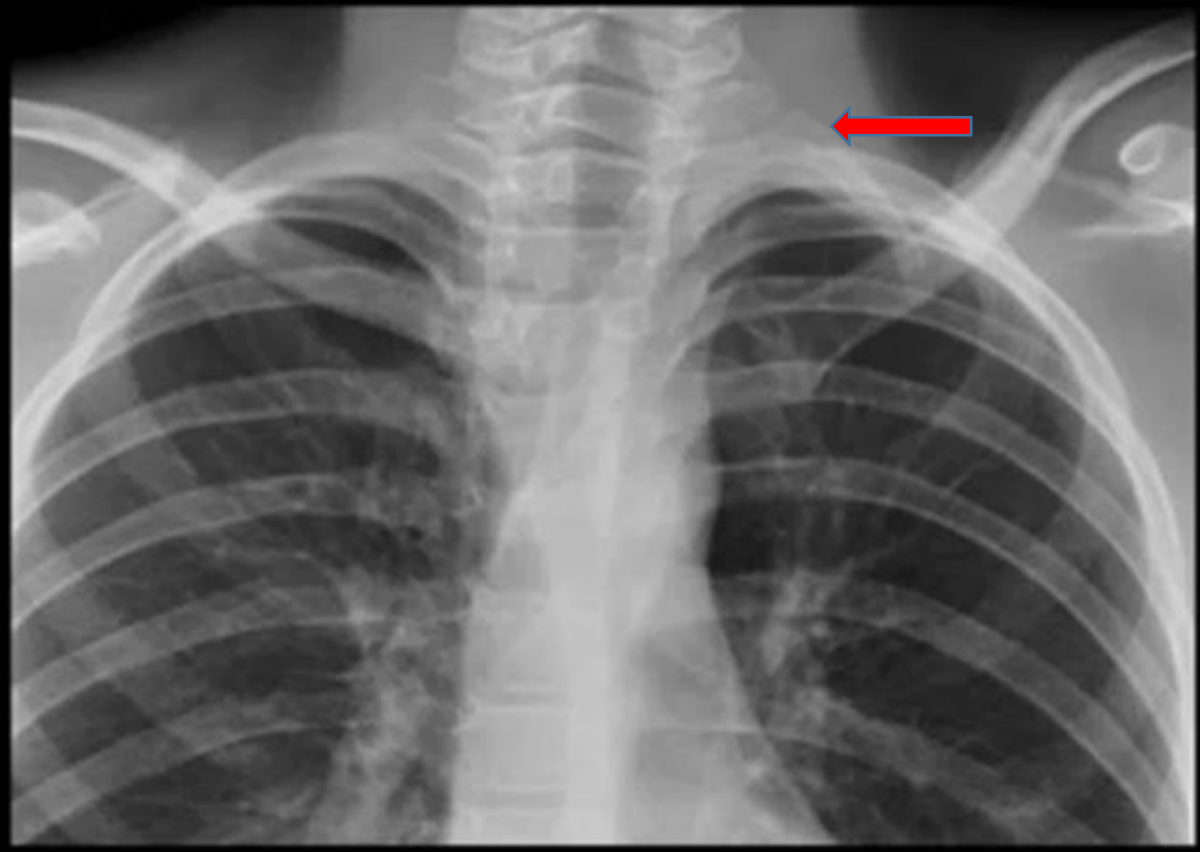
Subcutaneous Emphysema

Air within the subcutaneous tissues can occur due to:

- Air introduced internally
  - Pneumothorax
  - Pneumomediastinum
  - Pulmonary interstitial emphysema
- Air introduced externally
  - Penetrating chest wall trauma
  - Post-surgical
  - Complications from chest tube
- Air produced locally
  - Necrotizing infection with gas producing organisms (“gas gangrene”)

Cervical Ribs

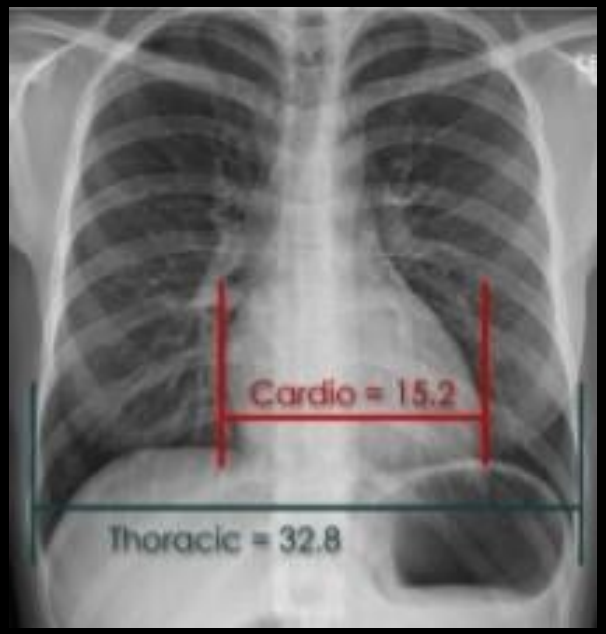
- Anatomic variant
- Prevalence ~ 0.5 – 1%
- Can by unilateral or bilateral
- Usually an incidental finding
- Can cause thoracic outlet syndrome

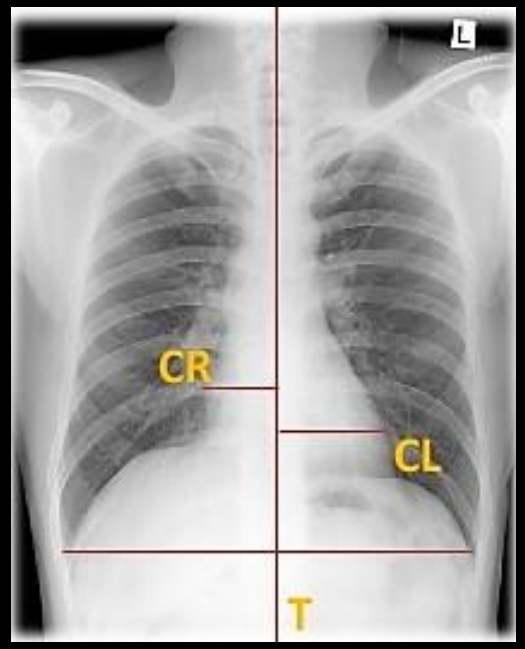


C-Cardia

- Two third of the heart lie on the left with one third on the right.
- The heart should take less than half of the thoracic cavity.
- Left atrium, left ventricle create left heart border.
- Right heart border is entirely created by right atrium

Cardiothoracic ratio





CT ratio= CR+CL/T

CR+CL= Transverse Cardiac Diameter

T= Transverse Thoracic Diameter

CTR is more than 50% but heart is normal

Spurious causes of cardiac enlargement

- Portable AP films
- Obesity
- Pregnant
- Ascites
- Straight back syndrome
- Pectus excavatum

RVH v/s LVH

RV Hypertrophy

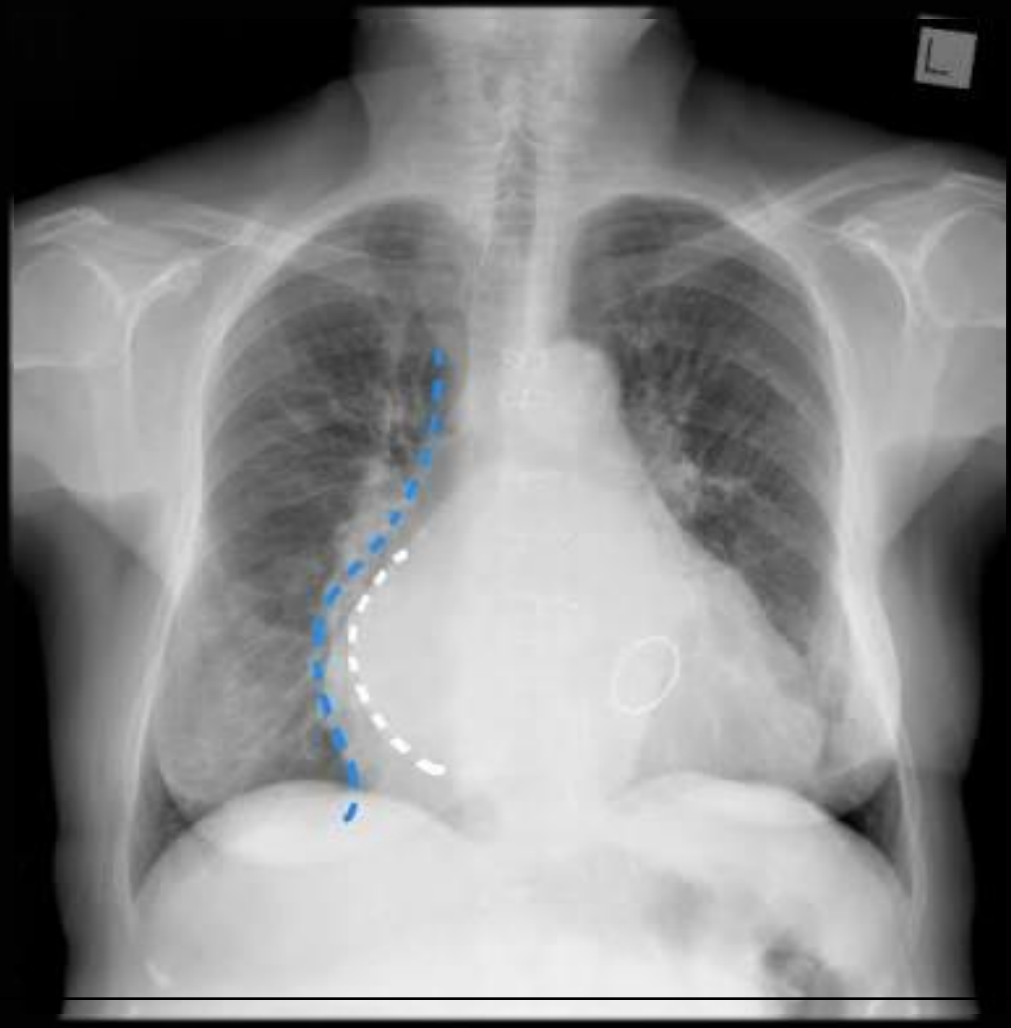
LV Hypertrophy

Left Atrial Enlargement

Findings include:

- Splaying of the carinal angle > 90°
- Double density sign

Left Atrial Enlargement
Left sided heart failure (any cause)
Mitral valve disease (e.g. mitral stenosis, mitral regurgitation, mitral valve prolapse)



Right Ventricular Enlargement

Findings include:

- Filling of retrosternal space (on lateral view)

Right Ventricular Enlargement
Pulmonary hypertension (any cause)
Pulmonary valve disease (e.g. pulmonic stenosis, pulmonic regurgitation)

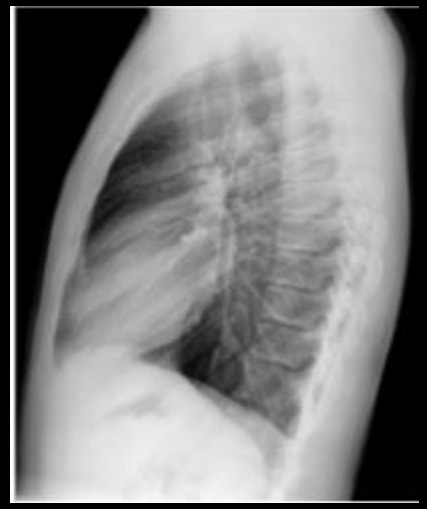
Normal

Right Ventricular Enlargement

Pericardial Effusion

Classic water bottle shape of a large effusion

D-Diaphragm

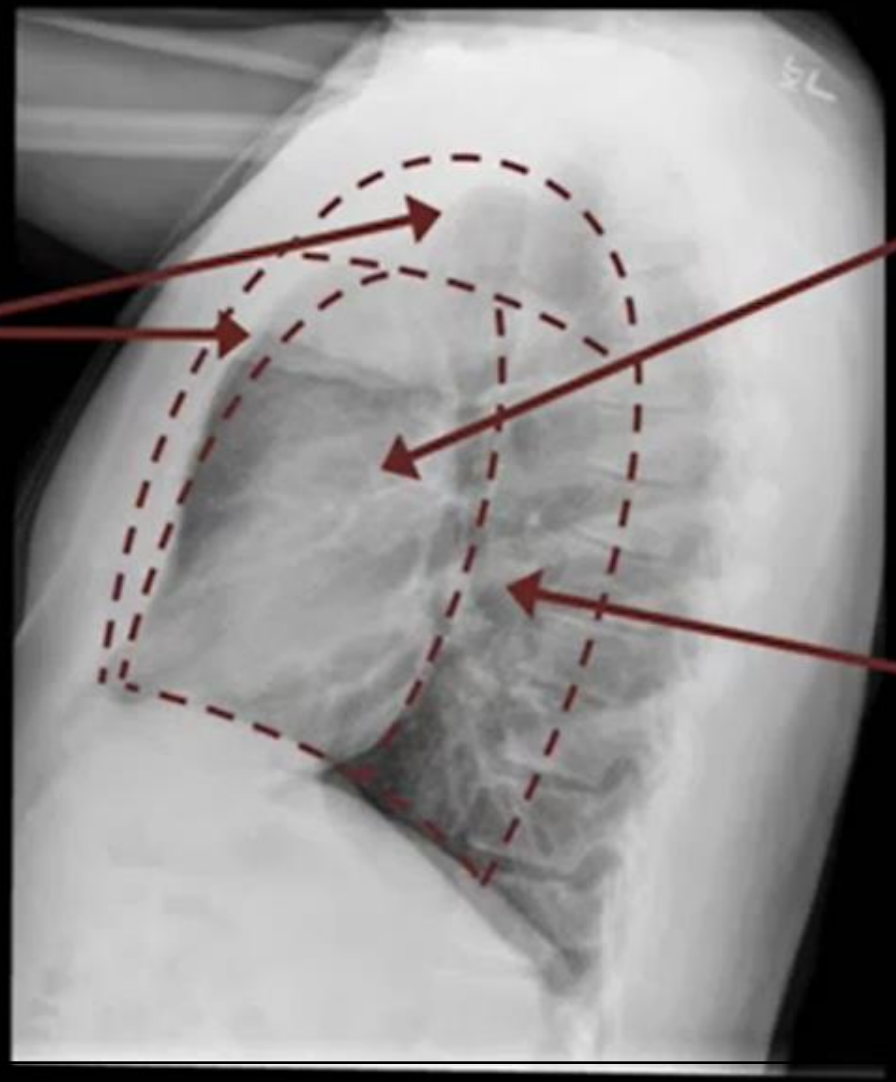


Both diaphragm should form sharp margin with lateral chest wall
Both diaphragm contour should be clearly visible medially to the spine

Mediastinal Masses

Anterior / Superior

- Lymphoma
- Thyroid
- Thymus
- Teratoma
- Aortic aneurysm (superior only)



Middle

- Lymphadenopathy
- Aortic aneurysm
- Pericardial cysts
- Dilated esophagus
- Hiatal hernia

Posterior

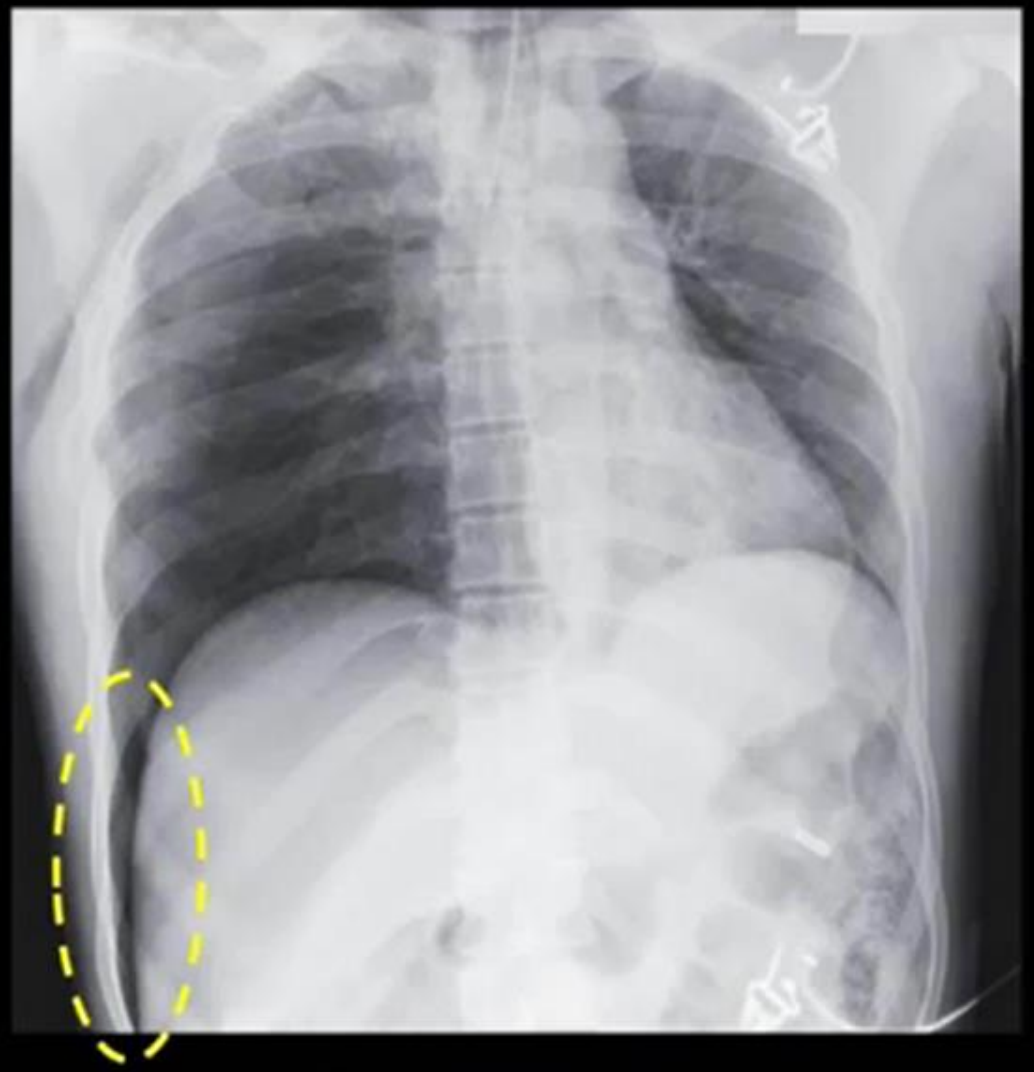
- Neurogenic tumors
- Extension of spinal masses (e.g. tumors, infection)

Mediastinal Masses

Aortic Aneurysms

Hilar Enlargement

Pneumothorax



Deep Sulcus Sign

Pneumothorax

Primary pneumothorax
(a.k.a. "spontaneous pnuemothorax)

Secondary pneumothorax

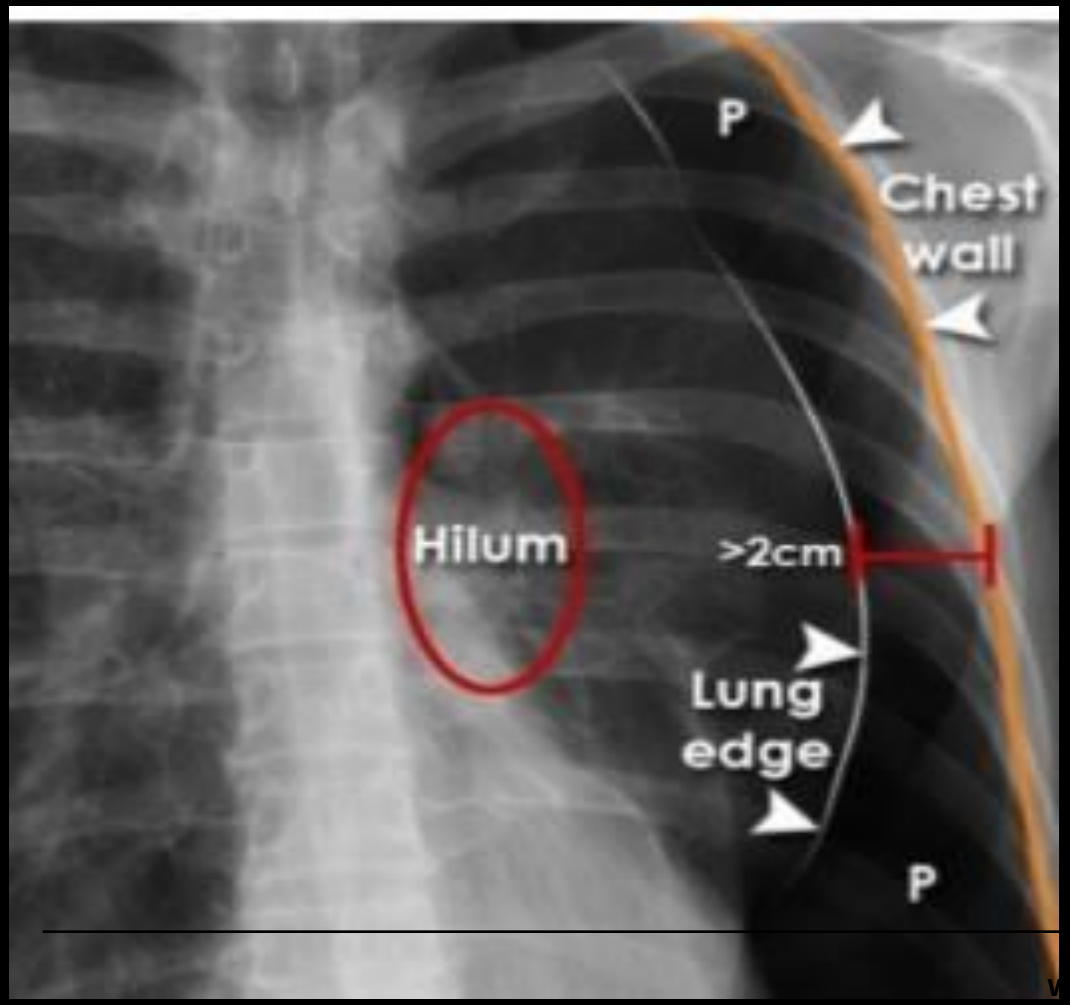
Iatrogenic
(e.g. thoracentesis, lung biopsy, central line placement)

COPD

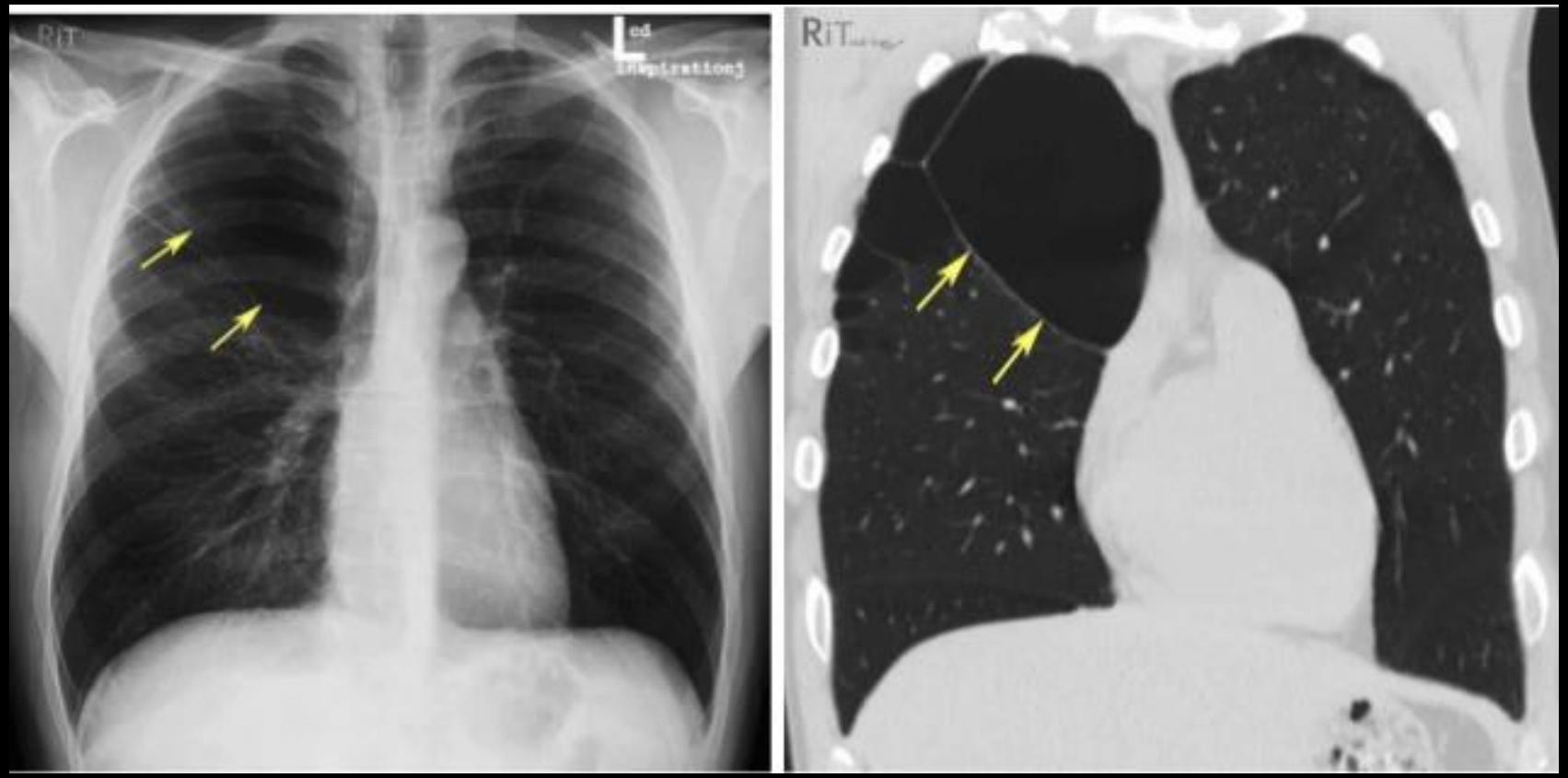
Cystic fibrosis

Pneumonia

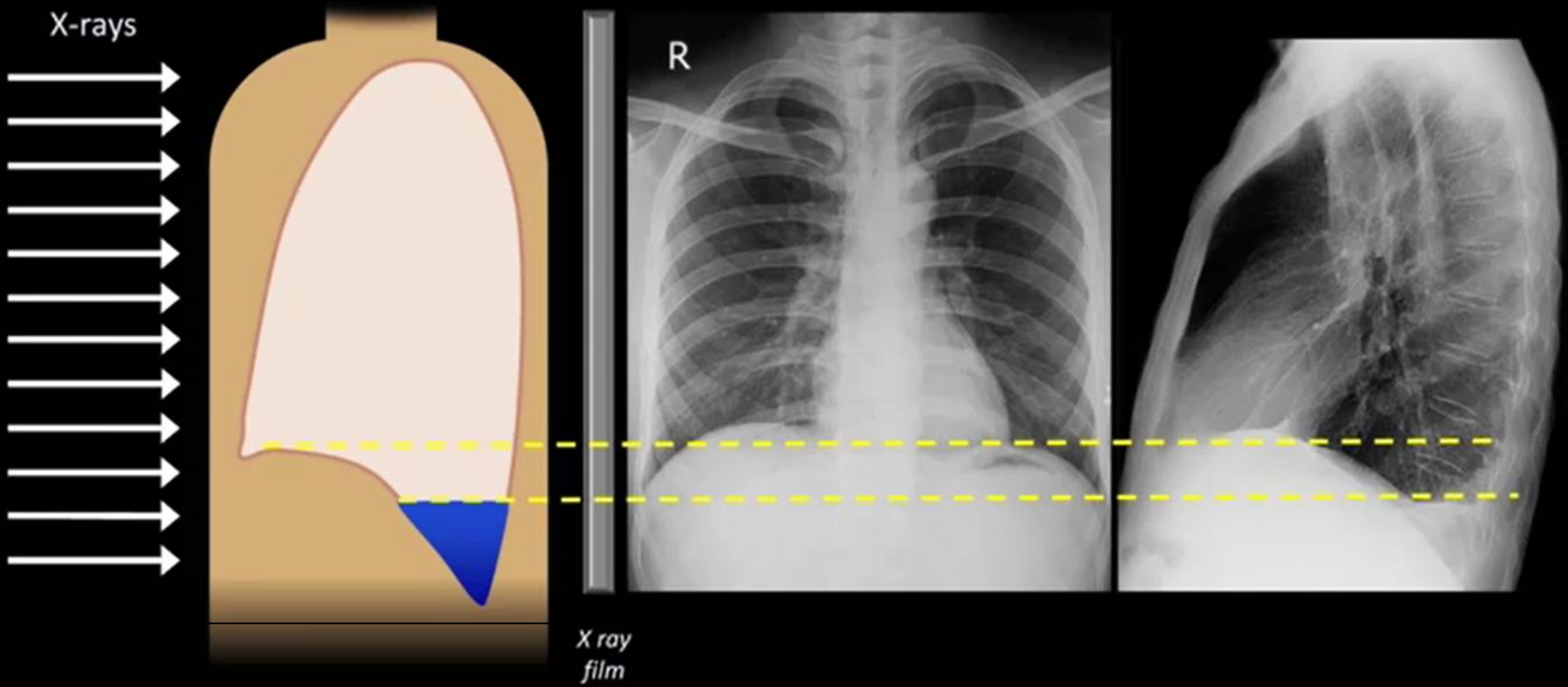
Pneumothorax



Giant Emphysematous bulla



Minimal Pleural Effusion



Pleural Effusions

Free Flowing vs. Loculated

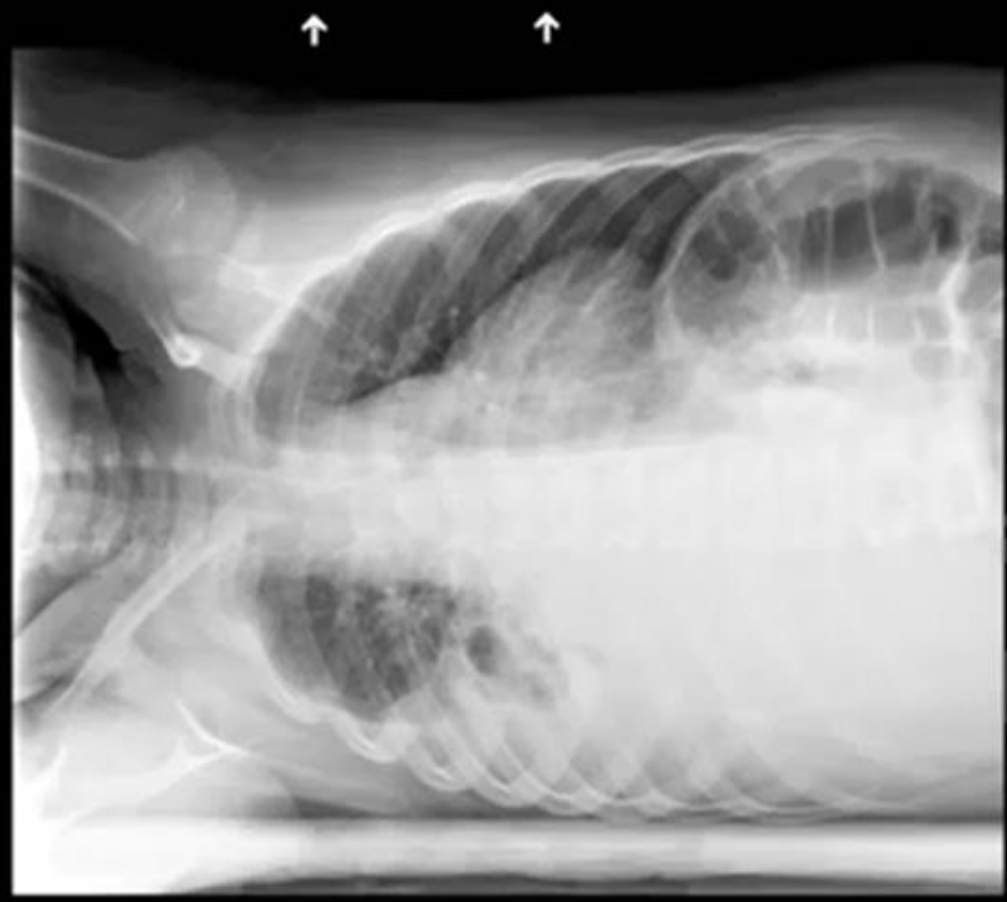
Free flowing effusion

Loculated effusion

Free Flowing vs. Loculated

Lateral Decubitus View

Free flowing effusion



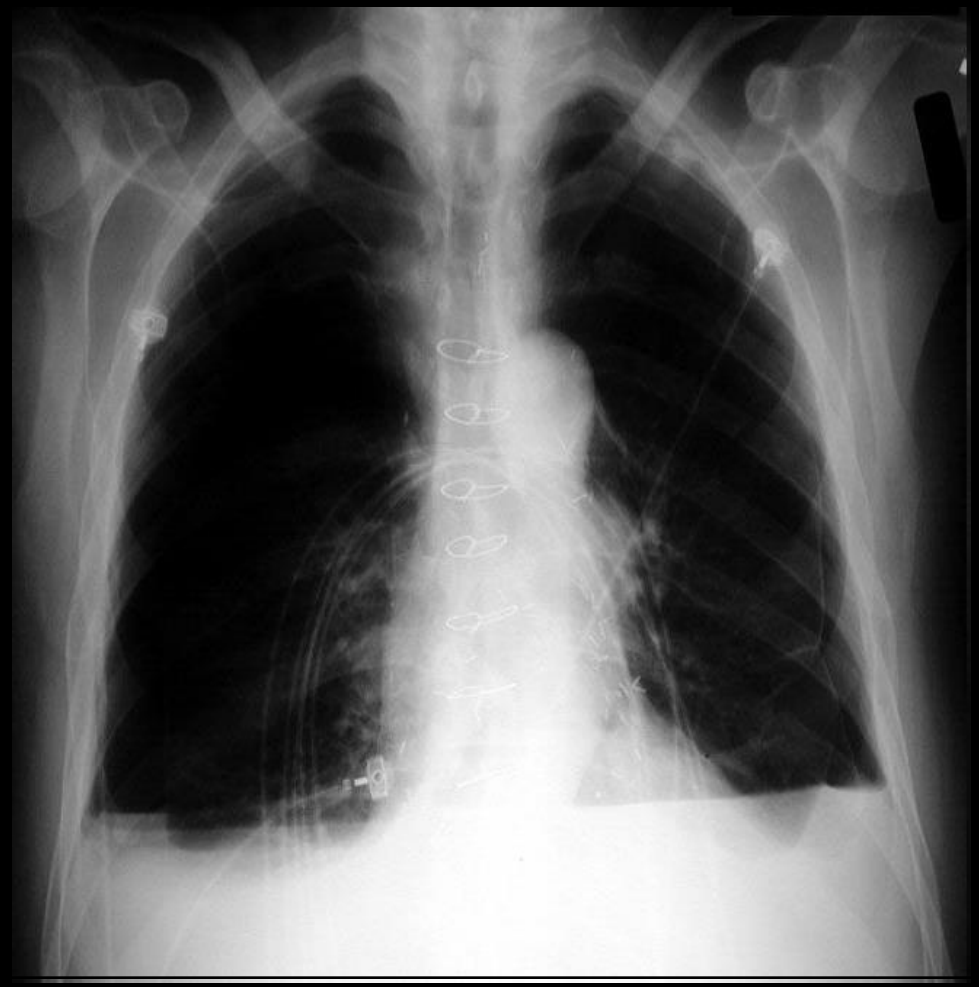
Loculated effusion

"Pseudotumor"

- Term most commonly used to refer to a fluid collection trapped within a fissure, which can give the appearance of a lung mass.

- Suspicion for trapped fluid is based on:
  - Location at a fissure (most occur in the horizontal fissure)
  - Smooth lenticular contour

Hydropneumothorax



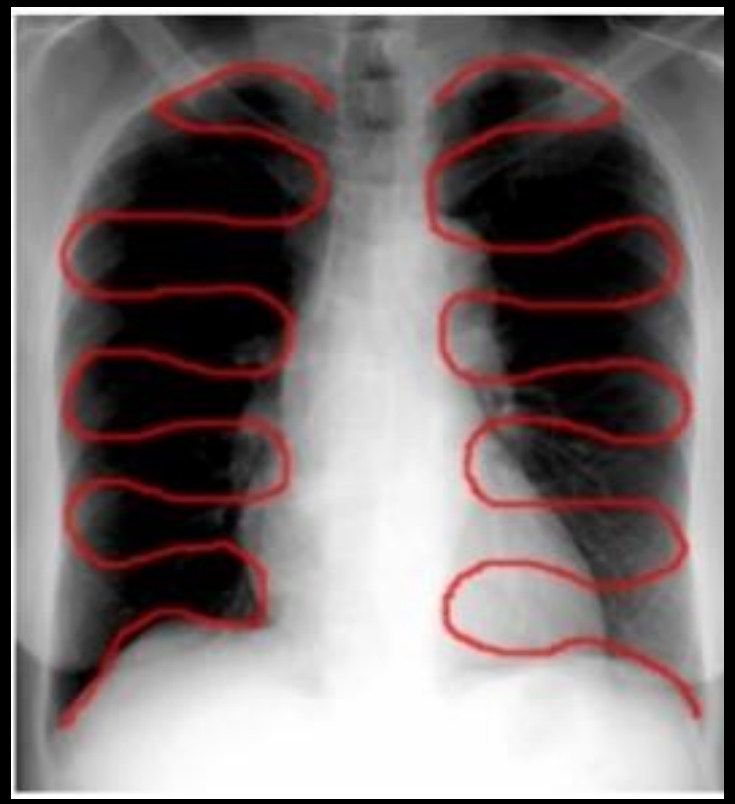
- Air in pleural cavity
- Lung margin visible
- Bilateral fluid level: Any time you see a horizontal fluid level, it means that there is air and fluid in the pleural space

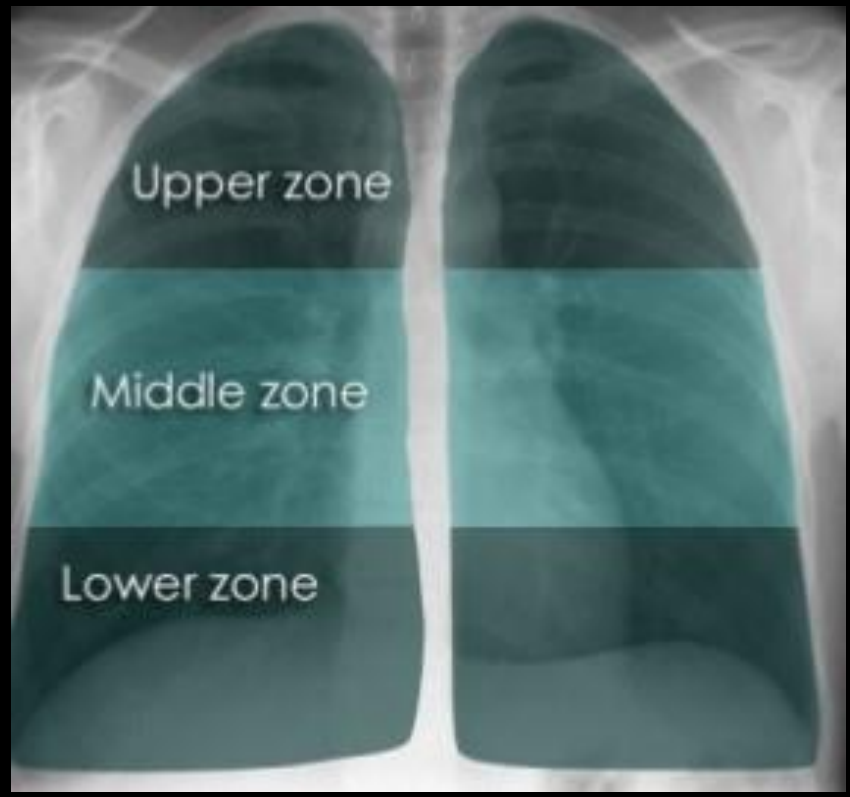
F- Lung fields

- Normally there is a visible markings throughout the lungs due to the pulmonary artery and veins, continuing all the way to the chest wall.

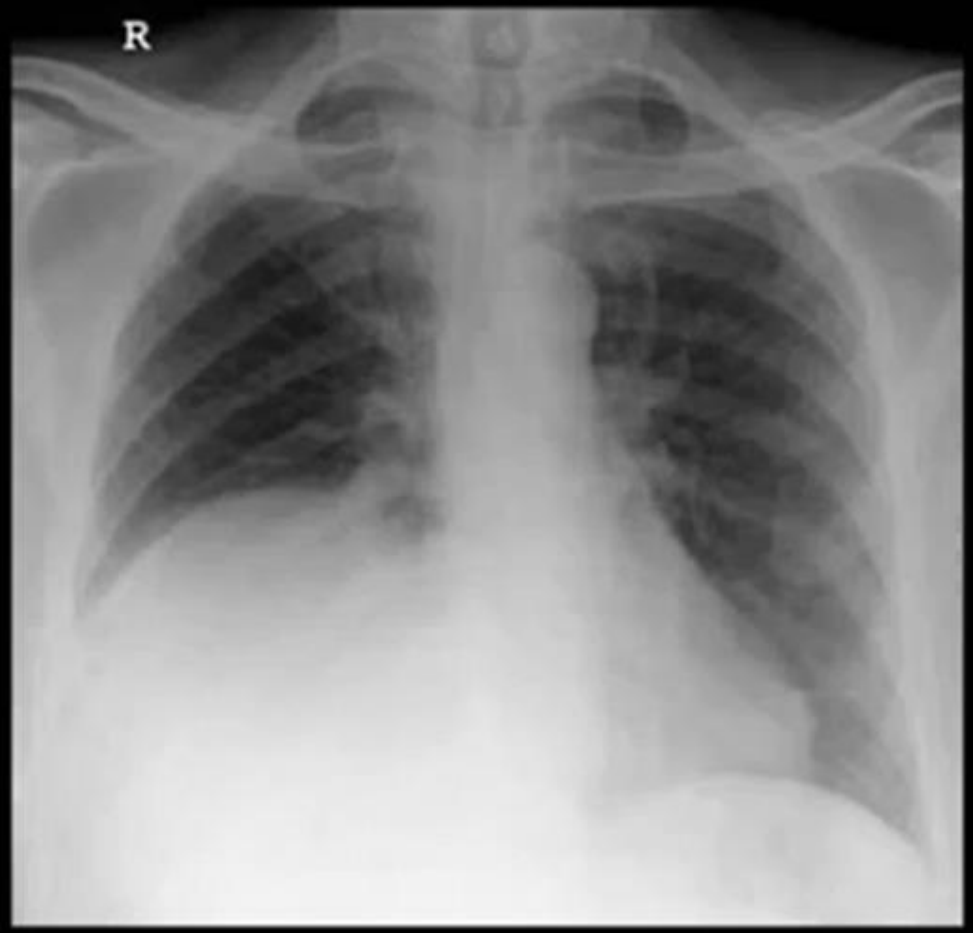
- Both lungs should be scanned, starting at the apices and working downwards, comparing the left and right lung fields at the same level.

Lung fields





Elevated Hemidiaphragm



Elevated Hemidiaphragm

Diminished lung volume
(e.g. atelectasis)

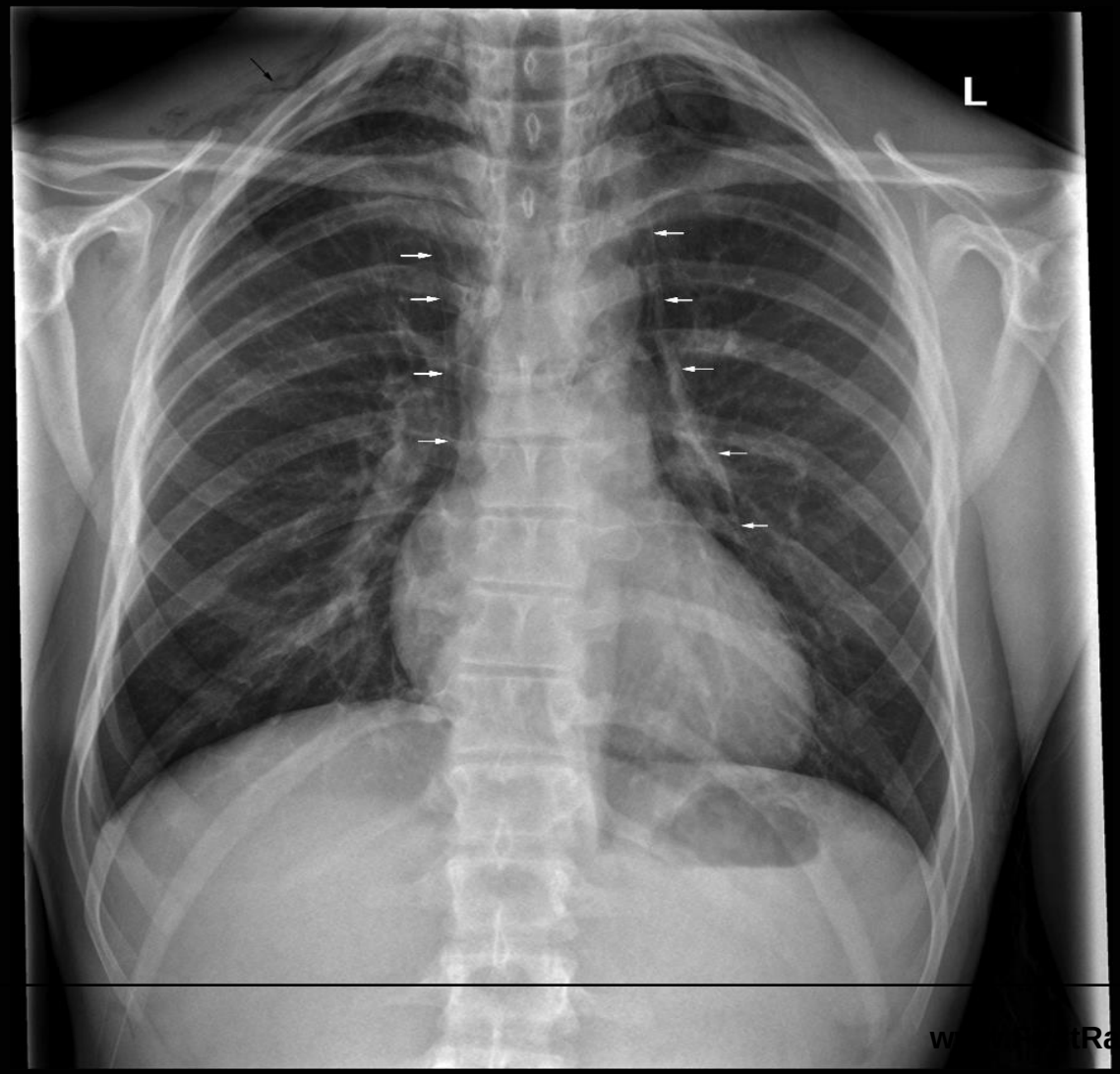
Phrenic nerve paralysis

Eventration of the diaphragm

Subphrenic abscess

Hepatomegaly or splenomegaly

Pneumomediastinum



Pneumomediastinum
Trauma
Esophageal rupture
Vomiting
Asthma
Post-neck or chest surgery
Barotrauma (e.g. diving, positive pressure ventilation)

Pneumopericardium

Pneumopericardium

Trauma

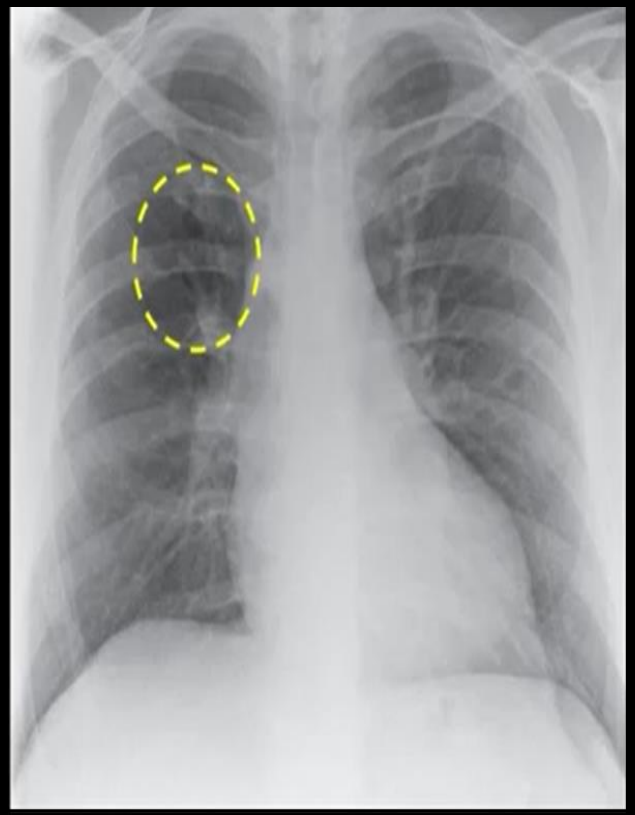
Bacterial pericarditis secondary to gas-producing organism

Post-cardiac surgery or pericardial drain

Fistula between pericardium and either lung, stomach, or esophagus.

Pulmonary Embolism

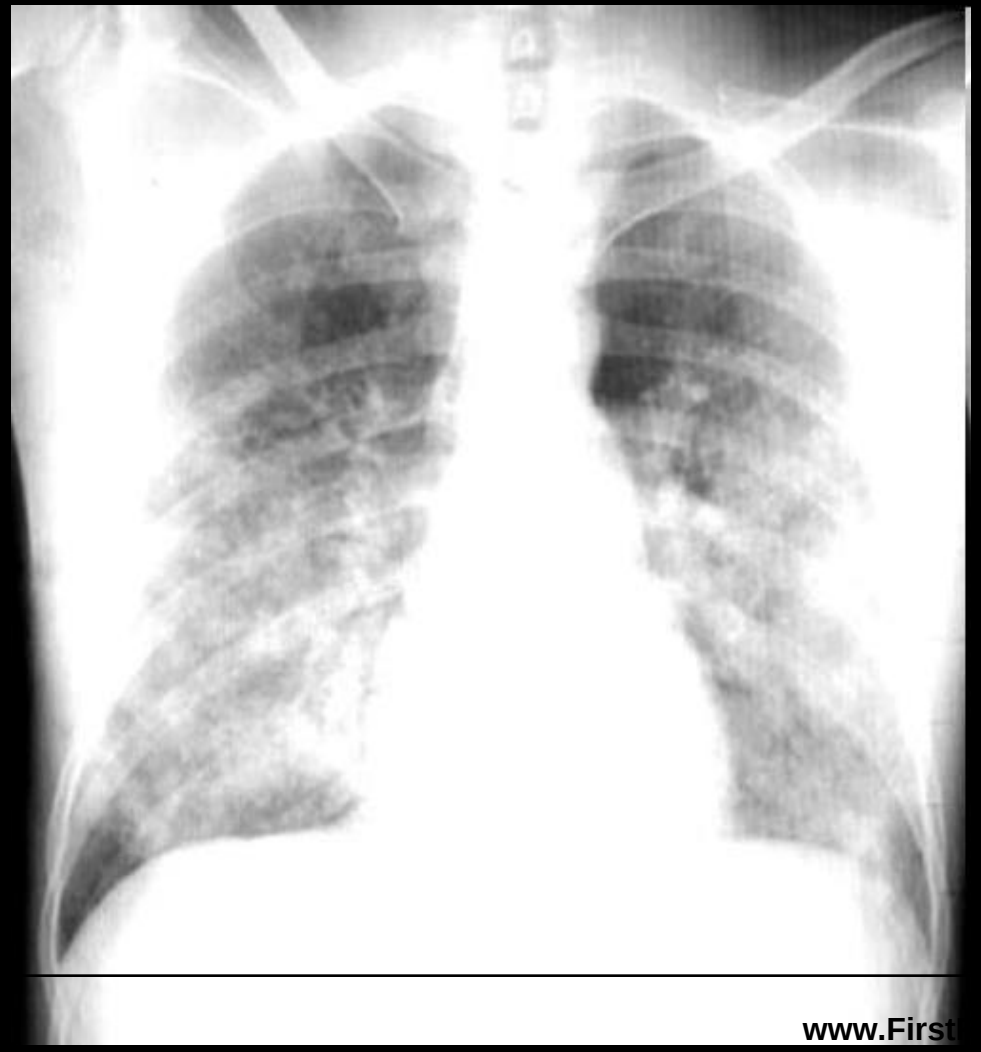
Hampton's sign



Westermark sign

Fleischner sign

Pulmonary Edema



Pulmonary Edema
Acute Diffuse Alveolar

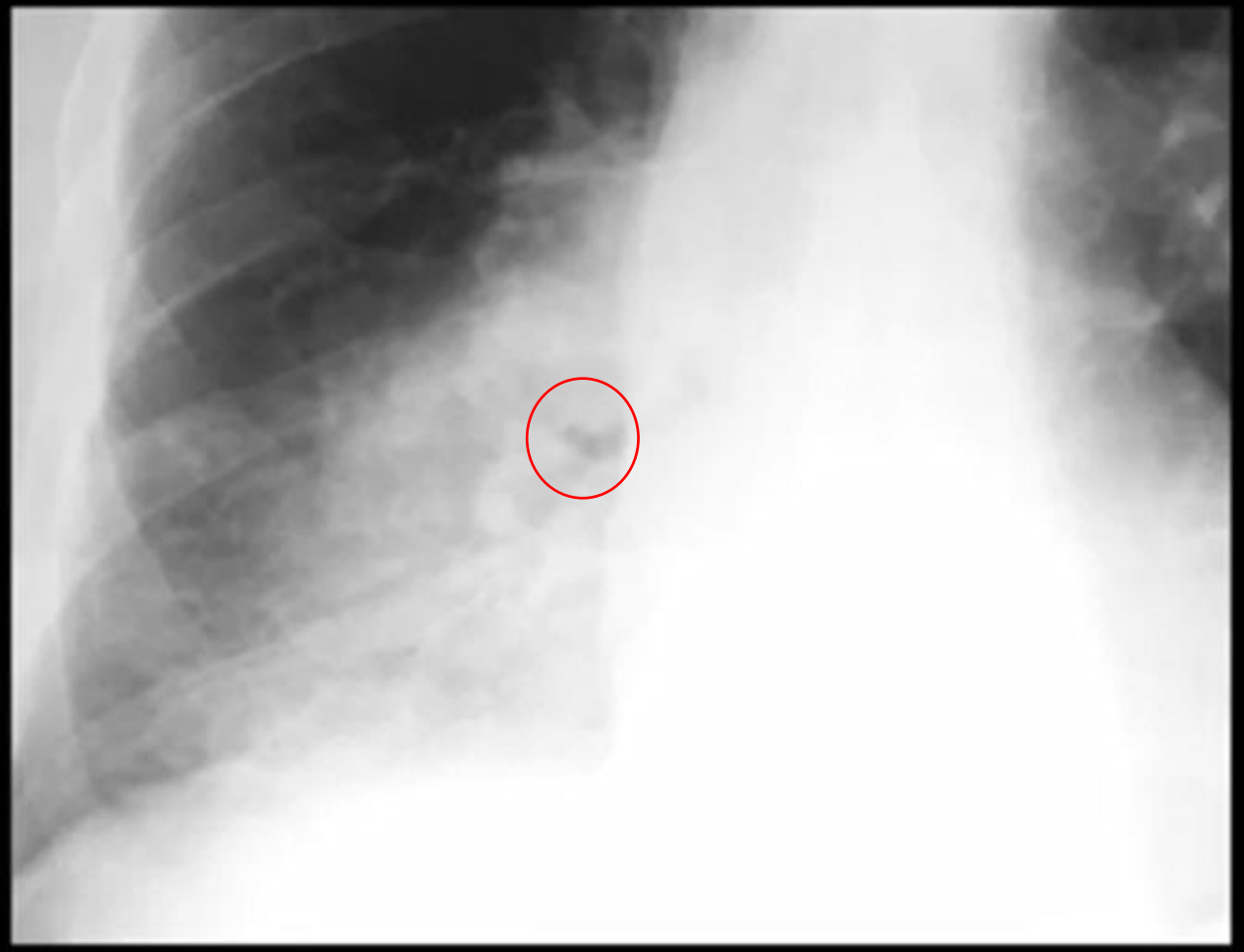
- Bilateral
- Diffuse
- Butterfly pattern
- Soft fluffy lesions
- Coalescing
- Air bronchogram

Differentiating Cardiogenic From Non-Cardiogenic Edema

- Air Bronchograms
- Peribronchial Cuffing
- Kerley Lines
- Cephalization
- Bat's Wing Pattern

Air Bronchograms

- Bronchi are usually not visible on X-ray.
- Opacification of alveoli adjacent to bronchi results in the dark, air-filled bronchi becoming identifiable.



Peribronchial Cuffing

- Bronchi are usually not visible on X-ray.
- Interstitial edema can accumulate around bronchi, making the bronchial walls thick.
- Appears like a ring when seen in cross section, and like tram tracks when seen longitudinally.

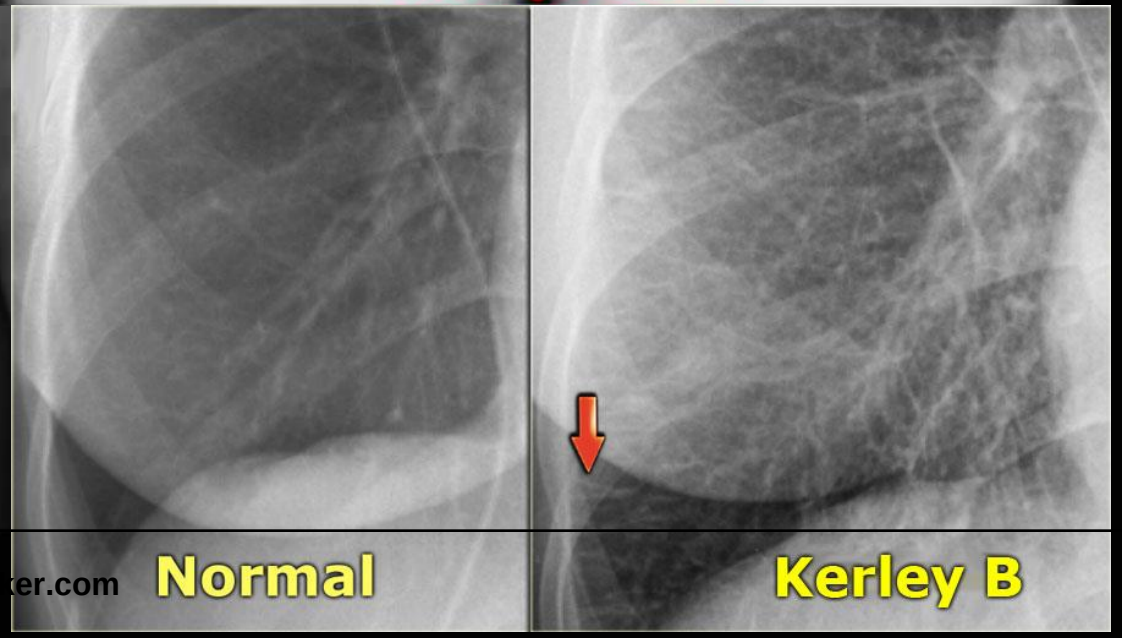
Kerley A and B Lines

- Kerley A Lines

  Diagonal, unbranching lines, 2-6cm long, extending from the hilum. Represent channels between peripheral and central lymphatics.

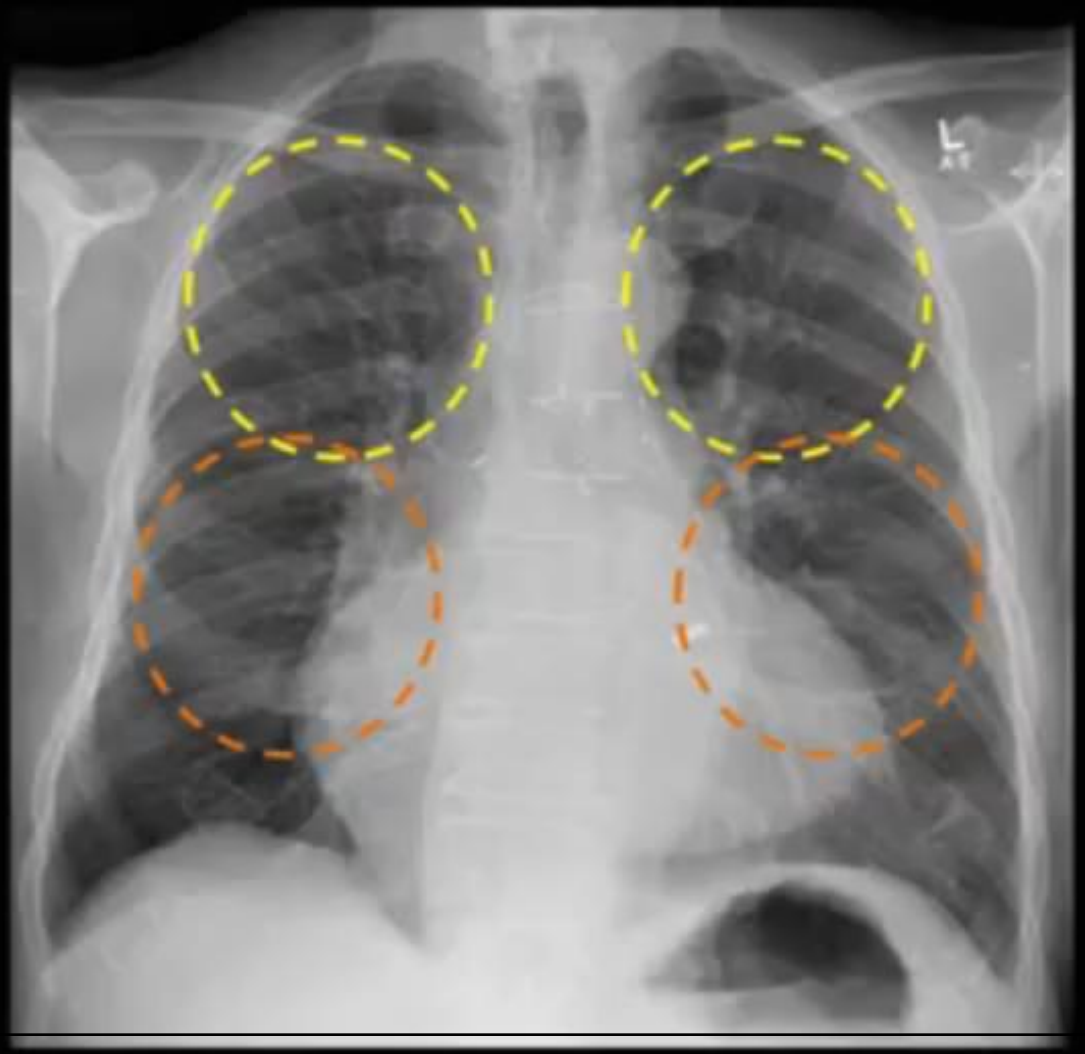
- Kerley B lines

  Faint, thin horizontal lines, 1-2cm long, at the lung periphery, usually at the bases. Represent interlobular septa.



Cephalization

- Increased visibility of pulmonary vessels at the lung apices as compared to the bases.
- Suggestive of increased left atrial pressure.
- Highly subjective with relatively poor interobserver agreement.



"Bat's Wing" Pattern

- Bilateral, perihilar concentration of opacification.

"Bat's Wing" Pattern
Cardiogenic Pulmonary Edema
Pneumonia: Viral, PCP, Aspiration
Inhalational Injury
Pulmonary Alveolar Proteinosis
Pulmonary Hemorrhage

Cardiogenic vs. Non-Cardiogenic Pulmonary Edema

Cardiogenic	Non-Cardiogenic (e.g. ARDS)
Cardiac size typically enlarged	Cardiac size typically normal
Regional distribution of opacities relatively homogeneous	Regional distribution of opacities relatively patchy
Air bronchograms uncommon	Air bronchograms common
Peribronchial cuffing common	Peribronchial cuffing uncommon
Concurrent pleural effusion(s) and Kerley B lines more common	Concurrent pleural effusion(s) and Kerley B lines less common

Radiographic Patterns of Pneumonia

Subtype of Pneumonia	Radiographic Features	Classic Causative Organisms
Lobar Pneumonia	Homogenous consolidation Air bronchograms common Sharp borders corresponding to fissures	*Streptococcus pneumoniae* *Klebsiella pneumoniae*
Segmental Pneumonia (a.k.a. Bronchopneumonia)	Patchy opacification Air bronchograms uncommon Vague borders Frequently bilateral	*Staphylococcus aureus* *Pseudomonas aeruginosa* *Haemophilus influenzae*
Interstitial Pneumonia	Reticular pattern No air bronchograms Often develops into airspace disease	*Mycoplasma pneumoniae* Viral pneumonia *Pneumocystis pneumonia*
Round Pneumonia	Spherical opacification Easily mistaken for tumor or other lung mass Much more common in children than adults	*Haemophilus influenzae* *Steptococcus pneumoniae*
Cavitary Pneumonia	Distinguished by cavities May or may not have air fluid level	Tuberculosis *Staphylococcus aureus*

RML Lobar Pneumonia

LLL Lobar Pneumonia

Bronchopneumonia

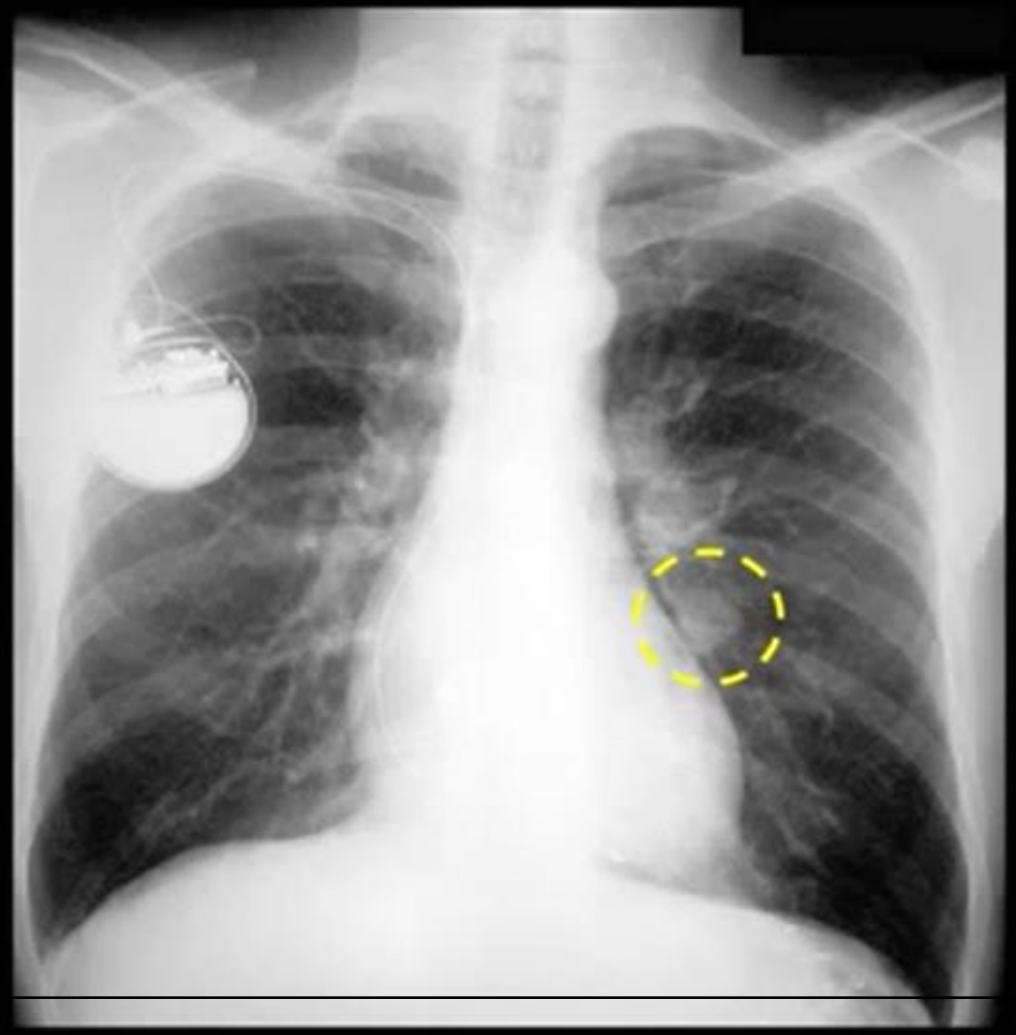
Round Pneumonia

Solitary Pulmonary Nodule

- Defined as a well circumscribed, generally round density, smaller than 3cm in diameter.
- Although nodules are one of the most important findings which radiologists look for when evaluating a chest X-ray, the majority of nodules may be missed on initial review.
- Comparison to prior chest X-ray is critical when evaluating for nodules.

Solitary Pulmonary Nodule
Cancer
Primary Lung Cancer
Solitary Pulmonary Metastasis
Lymphoma
Carcinoid
Infectious/Inflammatory
Granuloma
Pneumonia
Congenital
Arteriovenous Malformation

Solitary Pulmonary Nodule



Multiple Pulmonary Nodules

Multiple Pulmonary Nodules

Cancer

Pulmonary Metastasis

Lymphoma

Miscellaneous

Amyloidosis

Infectious/Inflammatory

Fungal Pneumonia
(e.g. Histoplasmosis, Coccidioidomycosis, Cryptococcus, invasive Aspergillus)

Mycobacteria

Nocardia

Septic Emboli

Parasites
(e.g. Echinococcus, Paragonimiasis, Schistosomiasis)

Rheumatoid arthritis

Vasculitits

Multiple Pulmonary Nodules

Metastatic Disease

Invasive Aspergillus

Multiple Pulmonary Nodules

Amyloidosis

Echinococcus

Silhouette Sign

- Loss of the normally visible border of an intrathoracic structure caused by an adjacent pulmonary density.

Lobe	Adjacent Structure
RUL	Ascending Aorta
RML	Right heart border
RLL	Right diaphragm
LUL	Aortic knob Left heart border (bordered by lingula)
LLL	Left diaphragm Descending aorta

Cavitation

Cavitating Lung Lesion

Pneumonia
(Most common: Staph, Pseudomonas, Klebsiella)

Lung Abscess

Tuberculosis

Pulmonary Metastases
(Most common: SCC)

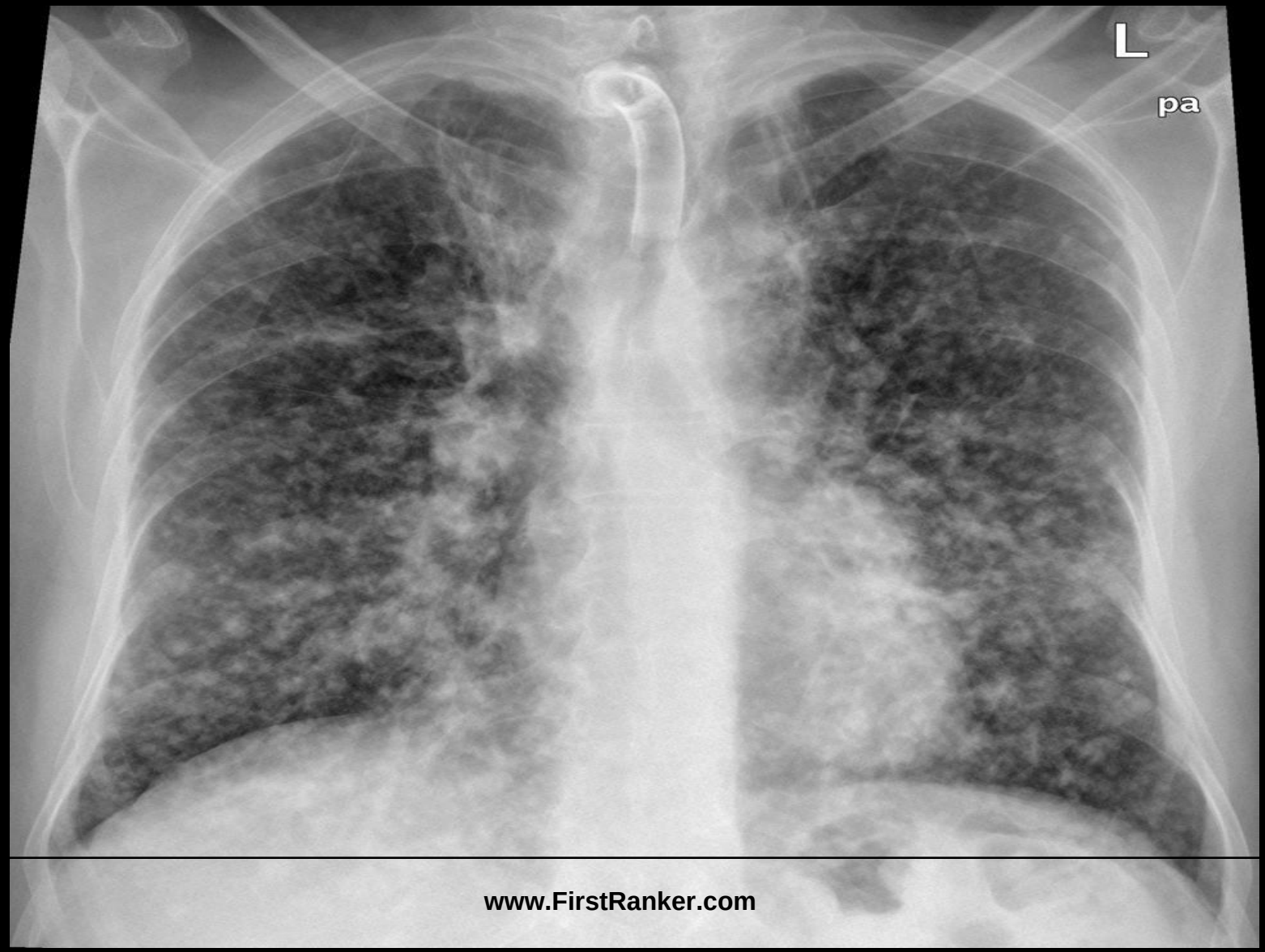
Septic Pulmonary Emboli

Pulmonary Infarct

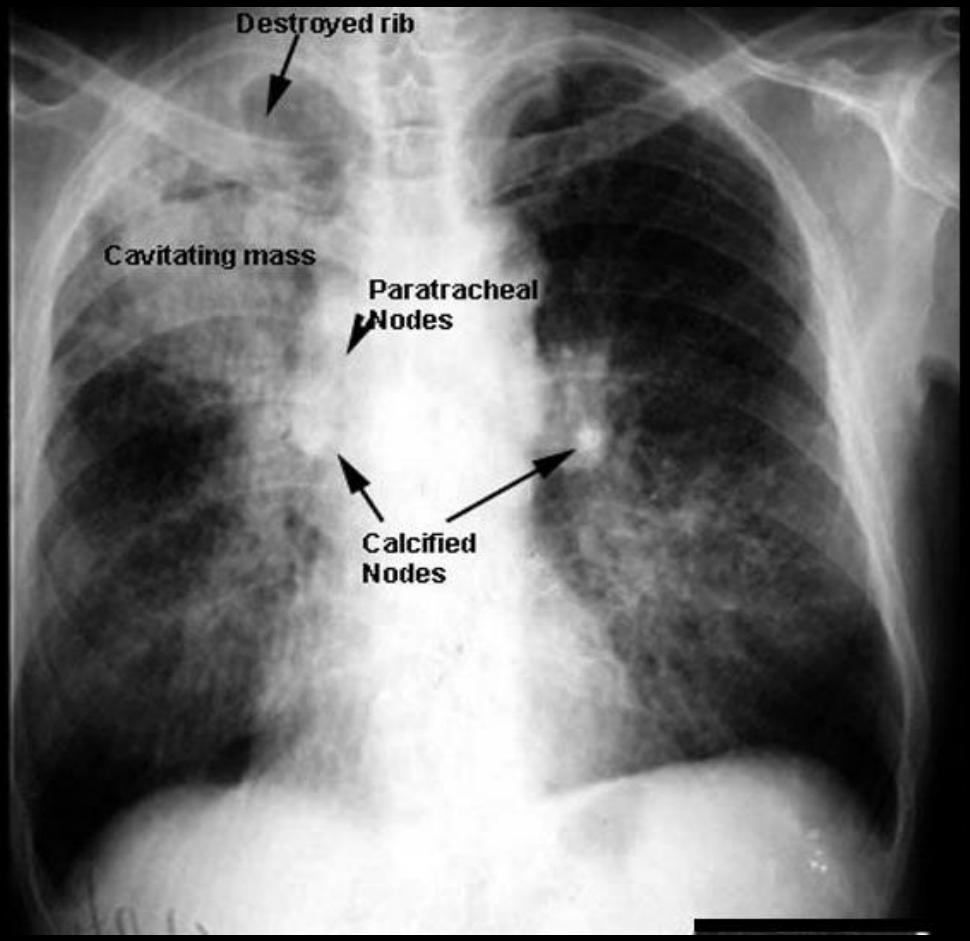
Aspergilloma

- Aspergillomas typically arise within preexisting lung cavities that become colonized with aspergillus.
- Typically asymptomatic, but may be associated with chronic cough.
- Also known as a “fungus ball”.

Miliary tuberculosis

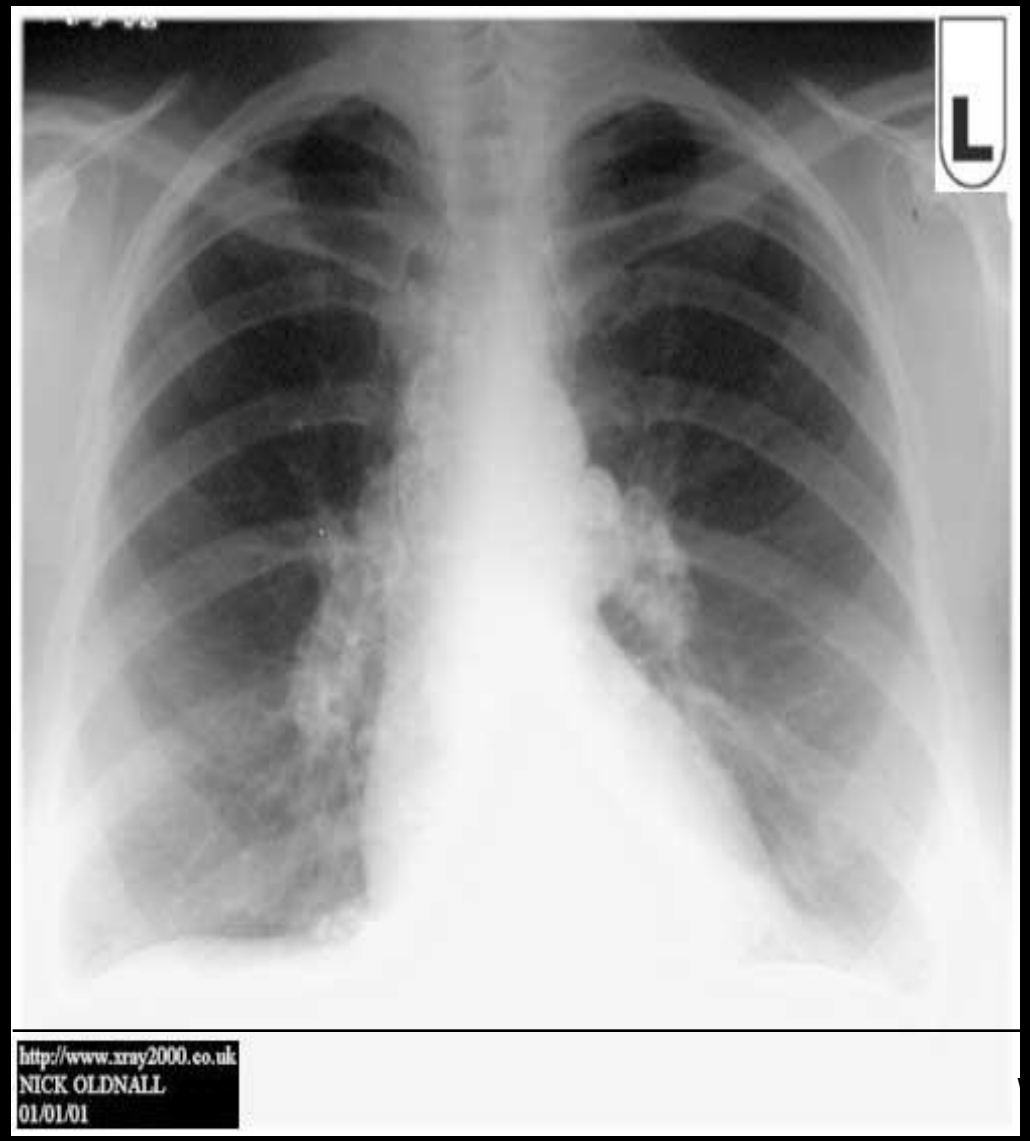


Pancoast Tumour



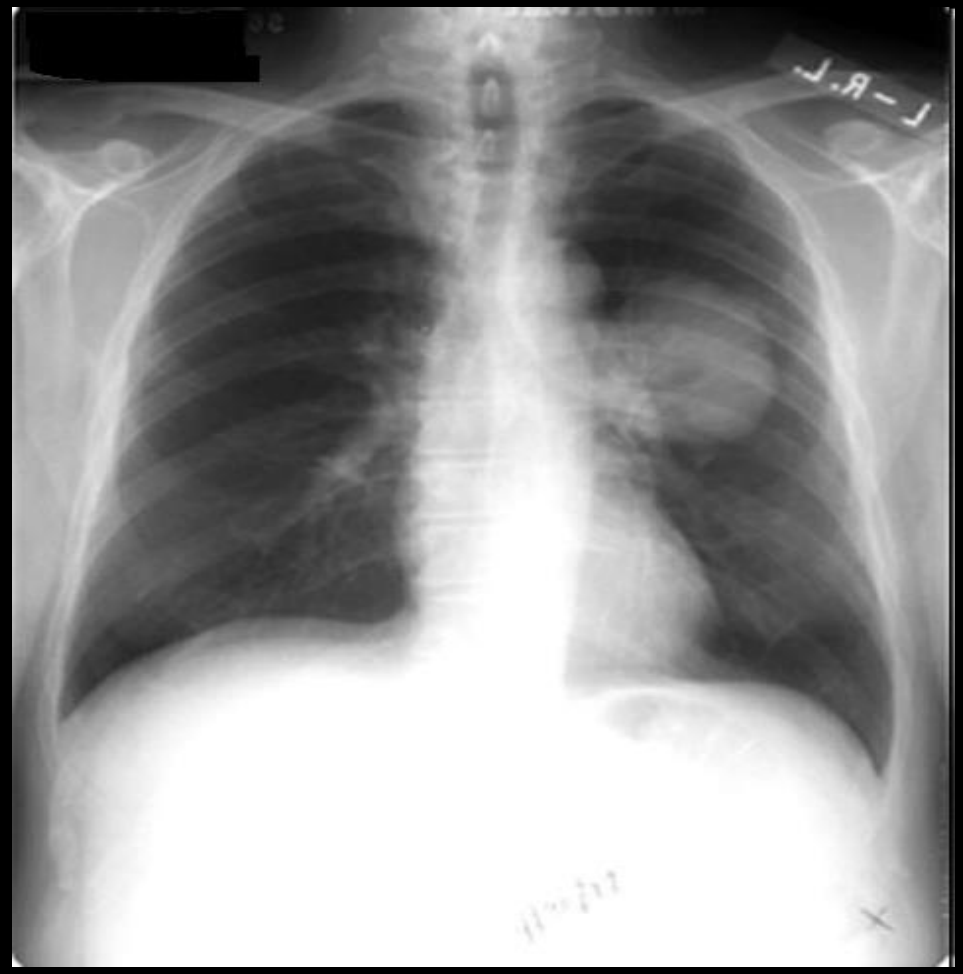
- Right apical mass
- Cavitating mass
- Para tracheal nodes
- 2nd rib destruction
- Calcified nodes

Sarcoidosis



- Granulomatous Inflammation
- Bilateral & symmetrical hilar & mediastinal enlargemet
- Generalized fibrosis

Lung Mass



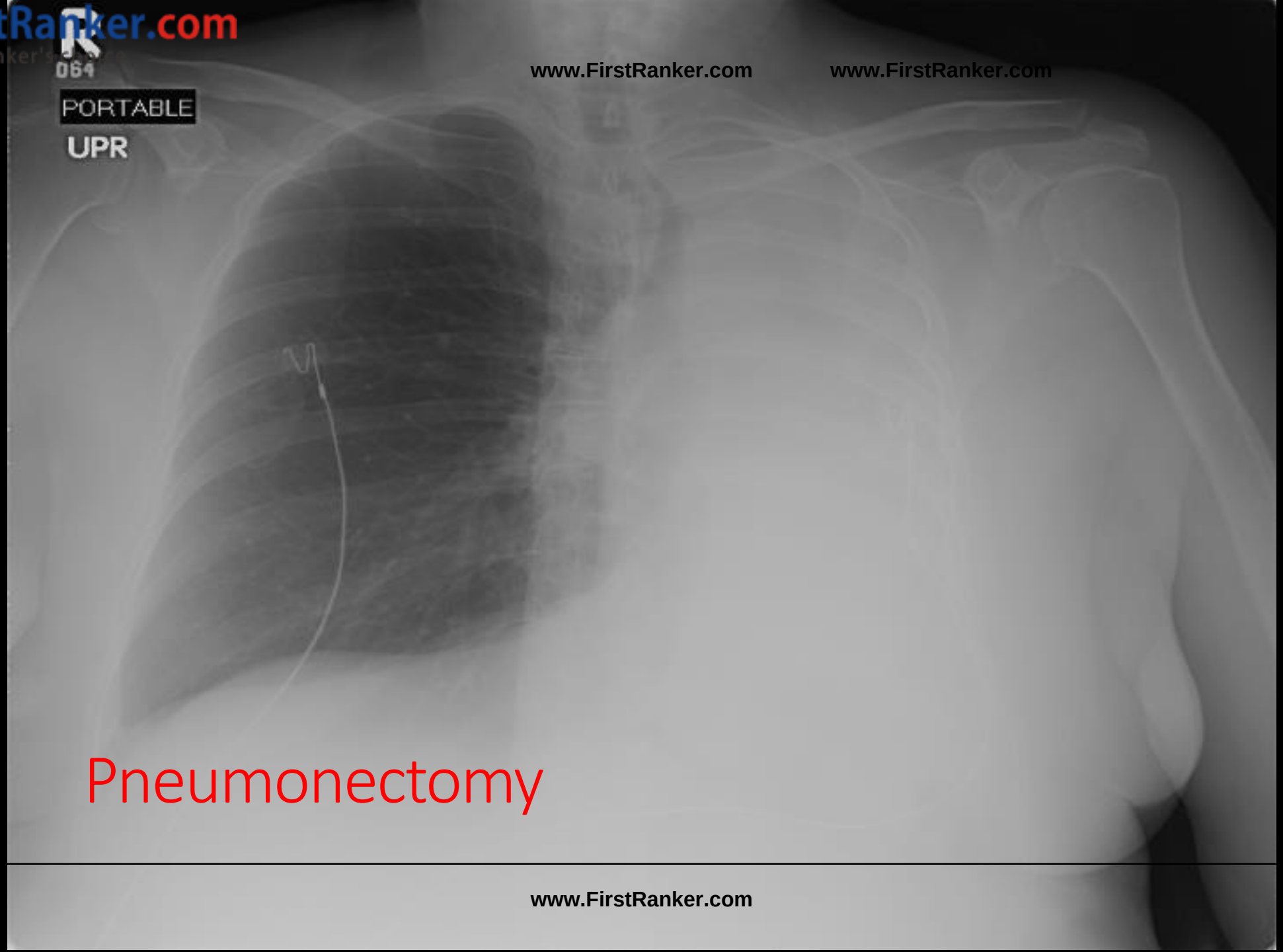
- Round or oval
- Sharp margin
- Homogenous

Lung Abscess

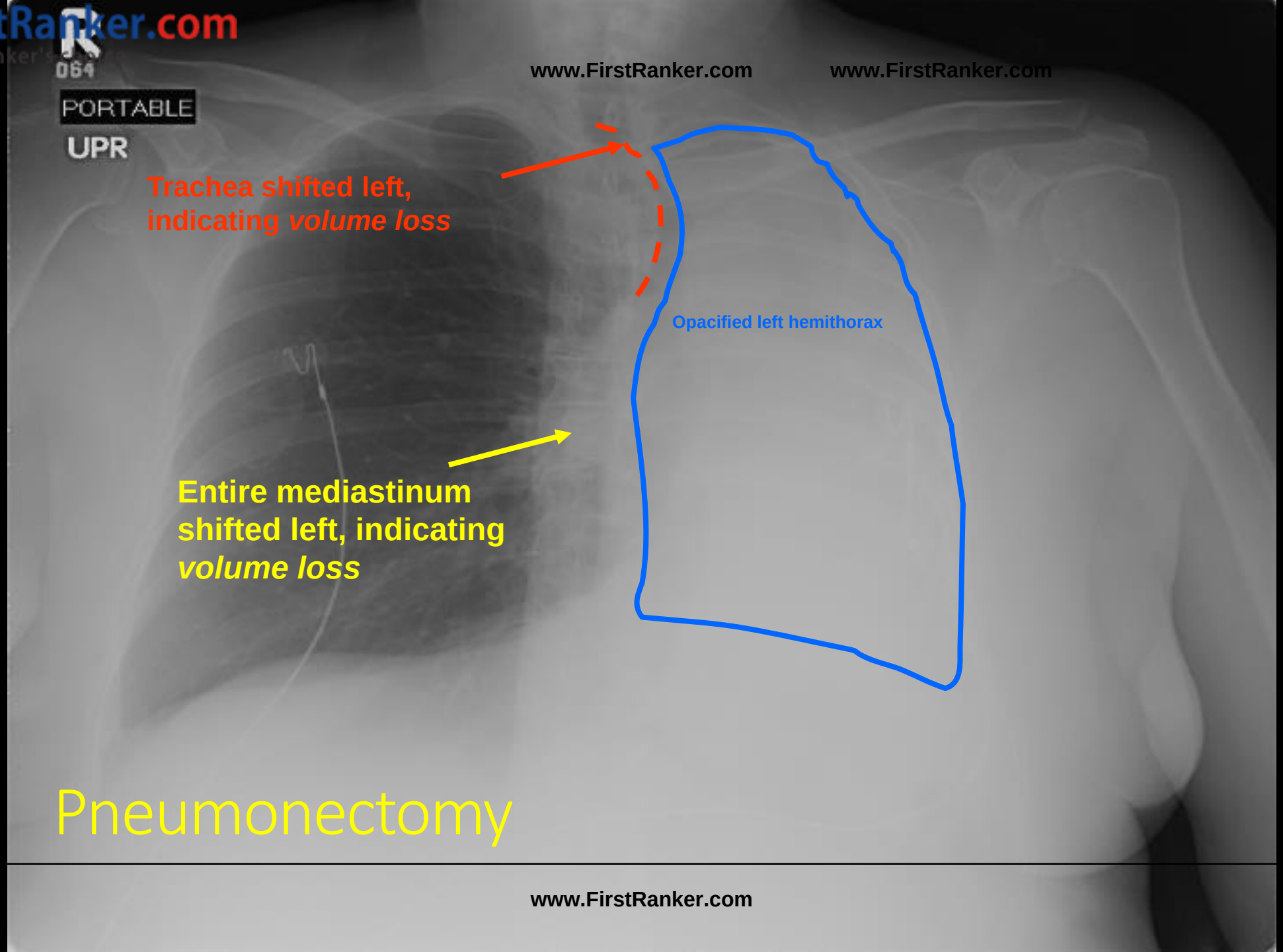
- Bilateral
- Multiple
- Fluid level

Emphysema

- Hyperinflation
- Hyperlucency
- Low set flat diaphragm
- Vertical heart
- Pre and infra cardiac lungs
- Barrel shape



Pneumonectomy

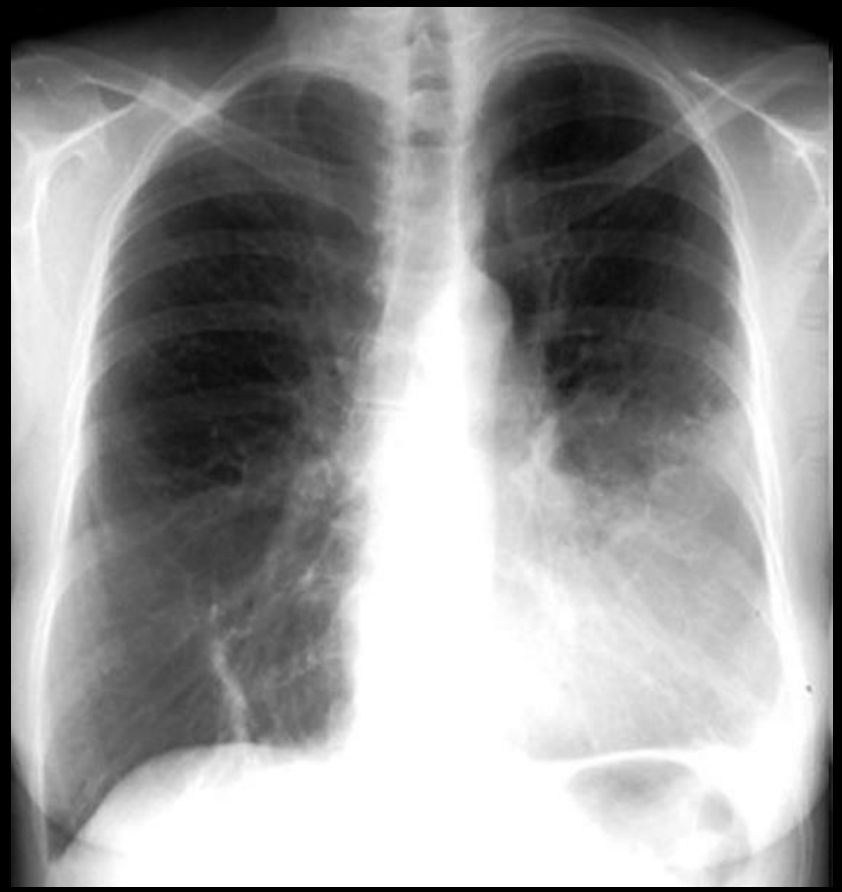


Pneumonectomy

Consolidation

- Lobar or Segmental Density
- Air Bronchogram
- No Loss of Lung Volume

Consolidation



- Density in left lower lung field
- Loss of left heart silhouette
- Diaphragmatic silhouette intact
- No shift of mediastinum
- Blunting of costophrenic angle

Consolidation

- Density in right upper lung field
- Lobar density
- Loss of ascending aorta silhouette
- No shift of mediastinum
- Transverse fissure not significantly shifted
- Air bronchogram

Atelectesis

- loss of air in the alveoli; alveoli devoid of air

- Increased density, Signs indicating loss of lung volume
- **Types of Atelectesis:**
  - Resorptive Atelectasis
  - Relaxation Atelectesis
  - Adhesive Atelectesis
  - Cicatricial Atelectesis
  - Round Atelectesis

Signs of Atelectesis

Generalized

- Shift of mediastinum
- Elevation of diaphragm
- Drooping of shoulder.
- Crowding of ribs
- Movement of Fissures
  - movement of oblique fissures.
  - Forward movement - LUL atelectasis.
  - Backward movement - lower lobe atelectasis.
  - Movement of transverse fissure on PA film.
- Movement of Hilum

Cont…

Compensatory Hyperinflation

Alterations in Proportion of Left and Right Lung

Hemithorax Asymmetry

Atelectesis Right Lung

- Homogenous density right hemithorax
- Mediastinal shift to right
- Right hemithorax smaller
- Right heart and diaphragmatic silhouette are not identifiable

Left Lower Lobe Atelectesis

- Inhomogeneous cardiac density
- Left hilum pulled down
- Non-visualization of left diaphragm
- Triangular retrocardiac atelectatic LLL

Fibrosis

- Diffuse haziness
- Apical cap thickening
- Blunting of costophrenic angle
- No shift of fluid in lateral decubitus
- Loss of lung volume
- Lines not corresponding to fissures

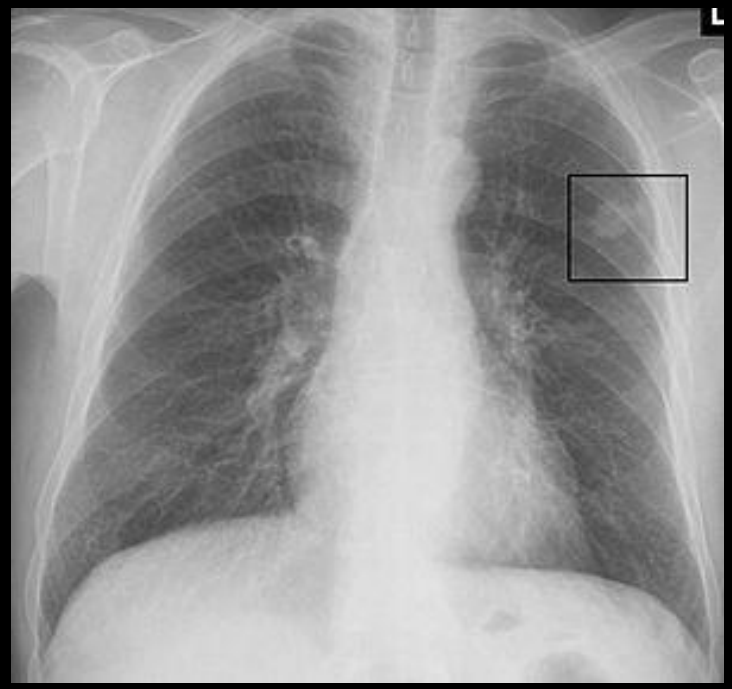
Pleural Fibrosis

- Small right hemithorax
- Diffuse haziness
- Tracheal shift to right
- Blunted costophrenic angle
- Lines not corresponding to fissures

Application of knowledge

Coin lesion <3 cm

- Carcinoma/Congenital
- Hamartoma/Hematoma
- AVM/Abscess
- Neoplasm–metastasis
- Granuoma
- TB pneumonia



Multiple Nodules or Mass >3 cm

- Metastasis/Carcinoma/Lymphoma
- TB/granuloma
- Wegener's granulomatosis
- Rheumatoid nodules/Round pneumonia
- Fungal
- Sarcoid
- Septic pulmonary emboli

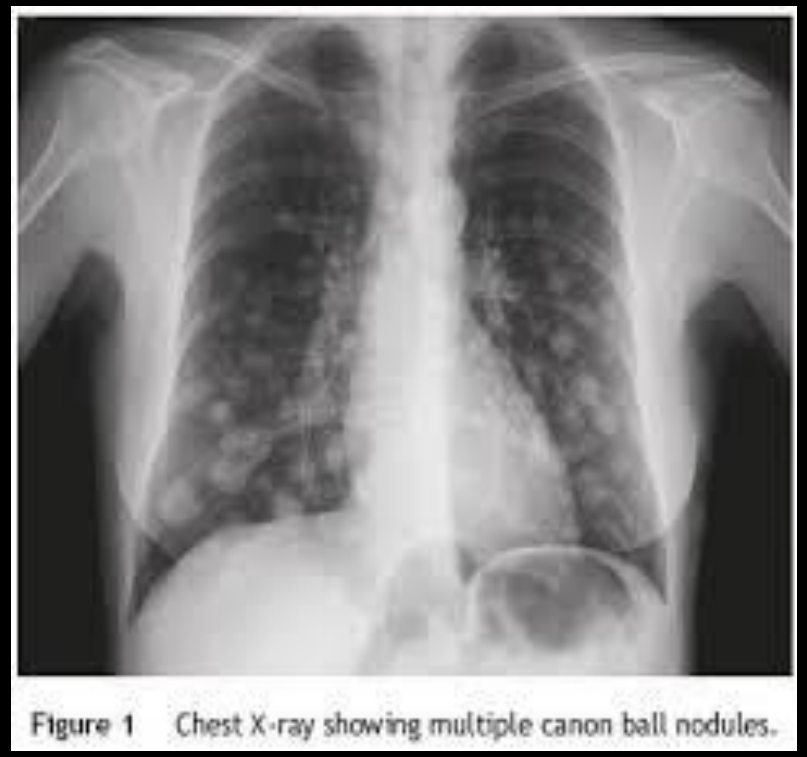


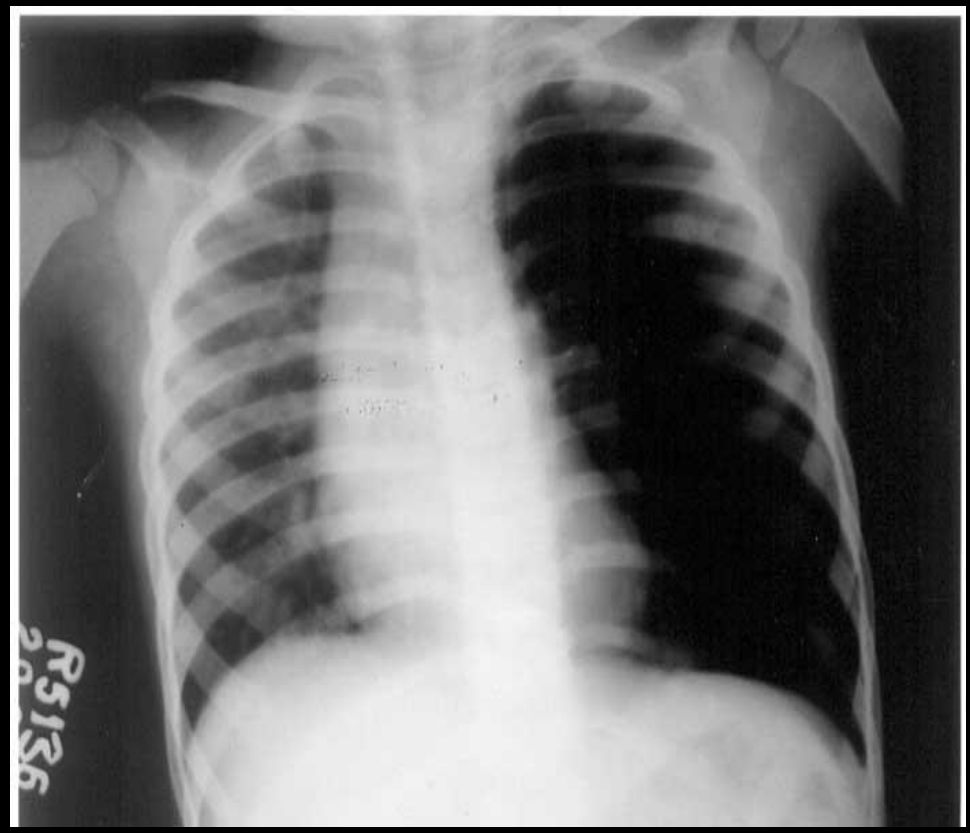
Figure 1 Chest X-ray showing multiple canon ball nodules.

Cavity

- Carcinoma-SCC
- Abscess-fungal/bacterial/TB
- Vascular-septic emboli
- Inflammatory-rheumatoid nodule
- Trauma-resolving contusion
- Young-bronchogenic cyst

Unilateral Hyperlucent Lung

- Poland syndrome/Pneumothorax
- Oligemia/Obstruction (PE)
- Emphysema
- Mastectomy
- Swyer James syndrome



Opacified Hemithorax

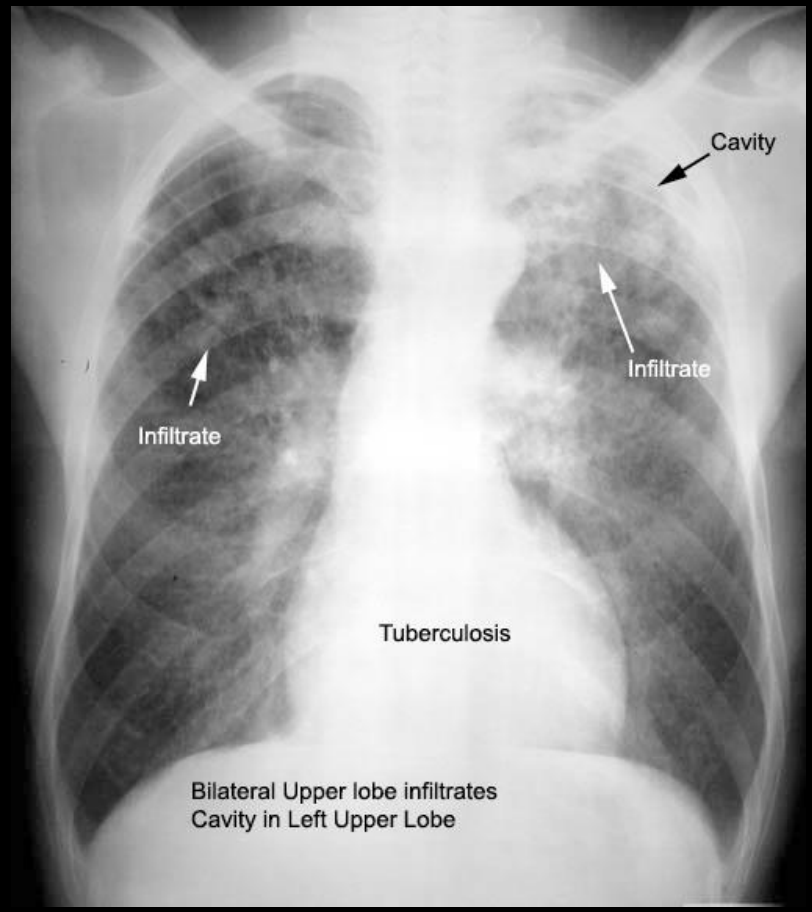
- Atelectasis
- Pleural effusion
- Pneumonia
- Post-pneumonectomy/ agenesis

Large Cavitary Lung Lesions

- Abscess
- Carcinoma
- TB

Upper Lobe Disease

- Secondary tuberculosis
- Silicosis
- Eosinophilic granuloma



Cavitatory Pneumonia

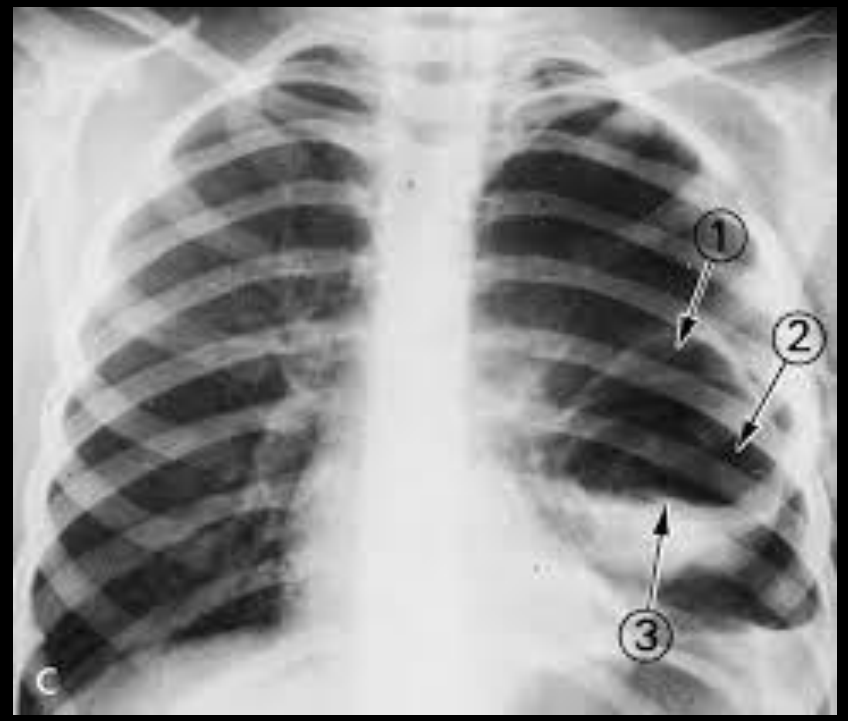
- Staph
- Strep
- TB
- Gram negative (Klebsiella)

Hilar Adenopathy

- Sarcoidosis
- TB
- Lymphoma
- Bronchogenic ca
- Metastasis

Cavities Containing Masses

- Aspergillosis
- Cavitating bronchogenic carcinoma
- Tuberculosis
- Hydatid cyst



Take home message

- Look carefully for patient identification details and technical issues.
- Be systematic in approach.
- Compare with old films and lateral films.
- It’s a chest x-ray, not a lung x-ray.

Thank You