

肺實質化病變與肺塌陷

2026/8/1 11:10~12:00

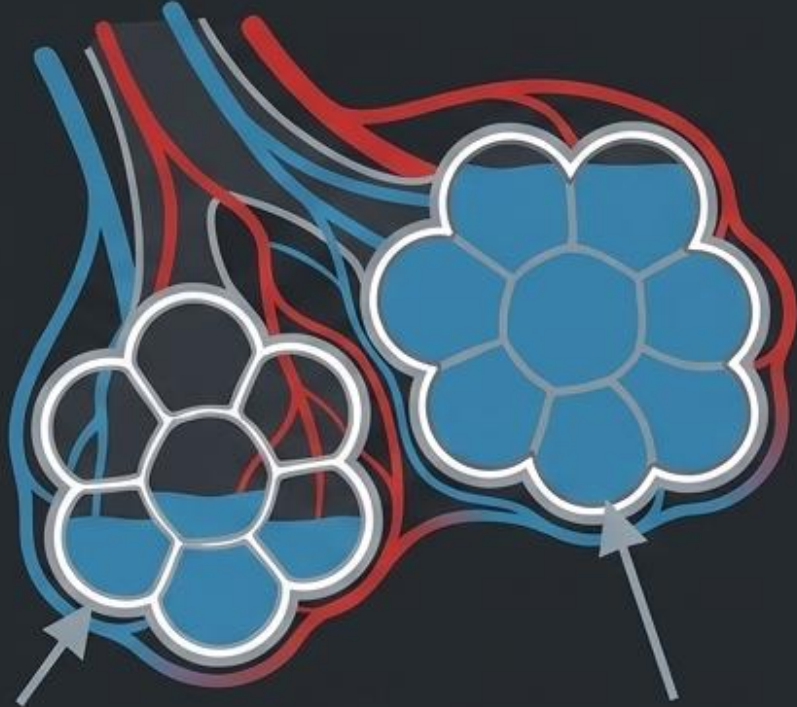
屏東榮民總醫院 胸腔內科 洪緯欣醫師

Air space consolidation

Consolidation: The Architecture Remains

Consolidation occurs when alveolar air is replaced by fluid or solid material. Crucially, the underlying lung architecture and total lung volume are preserved.

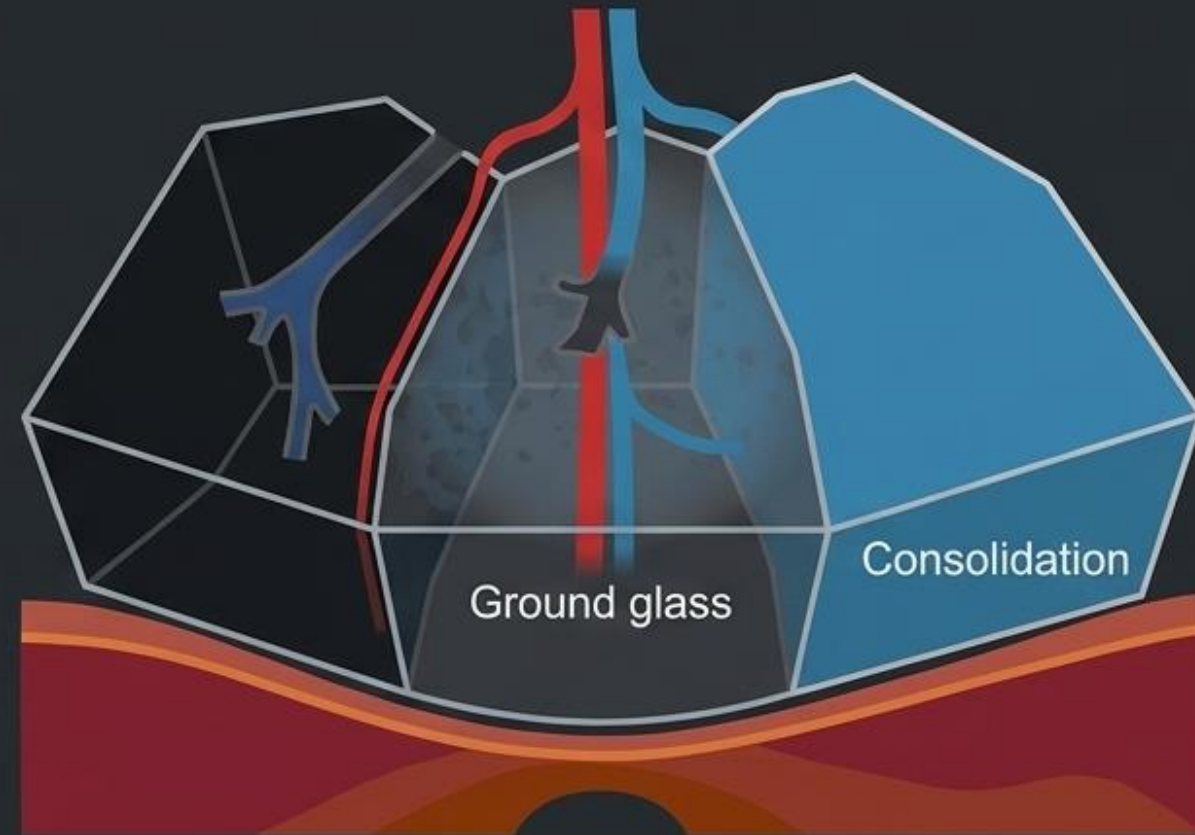
Micro View



Ground-glass opacity:
Partial filling, preserved
vascular markings

Consolidation:
Complete filling, obscured
vascular markings

Macro View



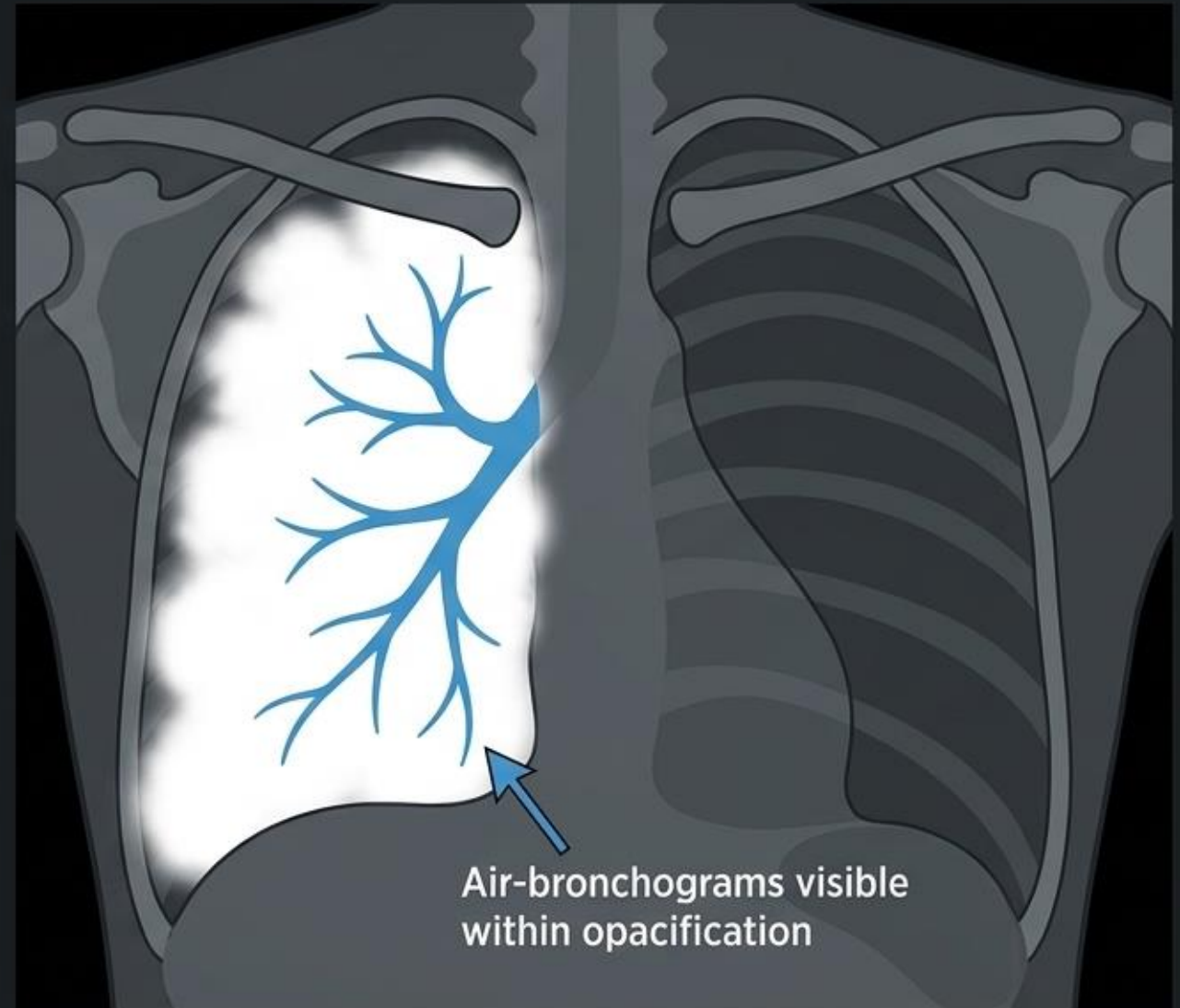
Classification of Alveolar Contents

Opacification is simply air replacement. Diagnosis depends on identifying which of these four materials has flooded the airspaces.

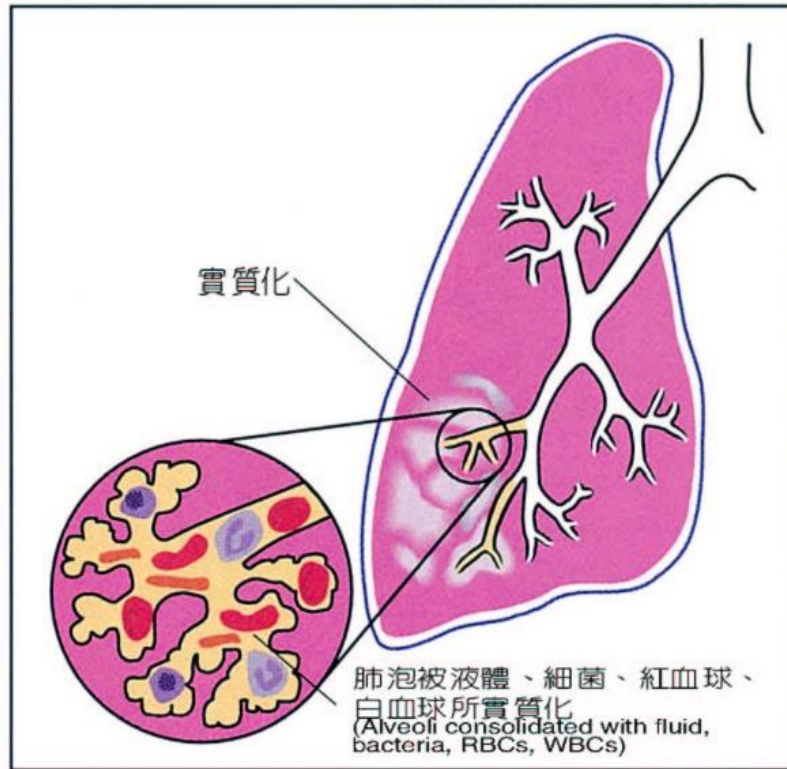
Water (Transudate)	Pus (Exudate)	Blood (Hemorrhage)	Cells (Proliferation)
			
Cardiogenic pulmonary edema ARDS Hypoalbuminemia	Bacterial pneumonia Viral pneumonia Aspiration	Pulmonary trauma Goodpasture syndrome SLE	Bronchoalveolar carcinoma Lymphoma Organizing pneumonia

Radiographic Hallmarks of Consolidation

- **Ill-defined opacities:** Fluffy, cloud-like borders blending into normal lung tissue.
- **Preserved Volume:** No shift in surrounding anatomy.
- **The Air-Bronchogram:** The definitive sign of alveolar filling with patent airways.



肺實質化病變



大葉性肺炎 (Lobar Pneumonia)

狀況：肺臟實質組織受到感染，使得肺泡水腫及滲透性增加，故紅血球、白血球由血液滲透到肺泡。肺泡逐漸被這些細菌、壞死的細胞碎片、分泌物及血球細胞所充滿（實質化）。上述物質取代了肺泡中的氣體，因而造成呼吸膜的表面積減少，而導致缺氧。

視診：呼吸速率增加；受影響側有保護性動作，且胸廓運動性遲緩；孩童可見胸骨凹陷、鼻翼煽動。

觸診：受影響側的胸廓擴張減少。若支氣管通暢觸覺震顫強度會增加；若支氣管阻塞則觸覺震顫強度減少或消失。

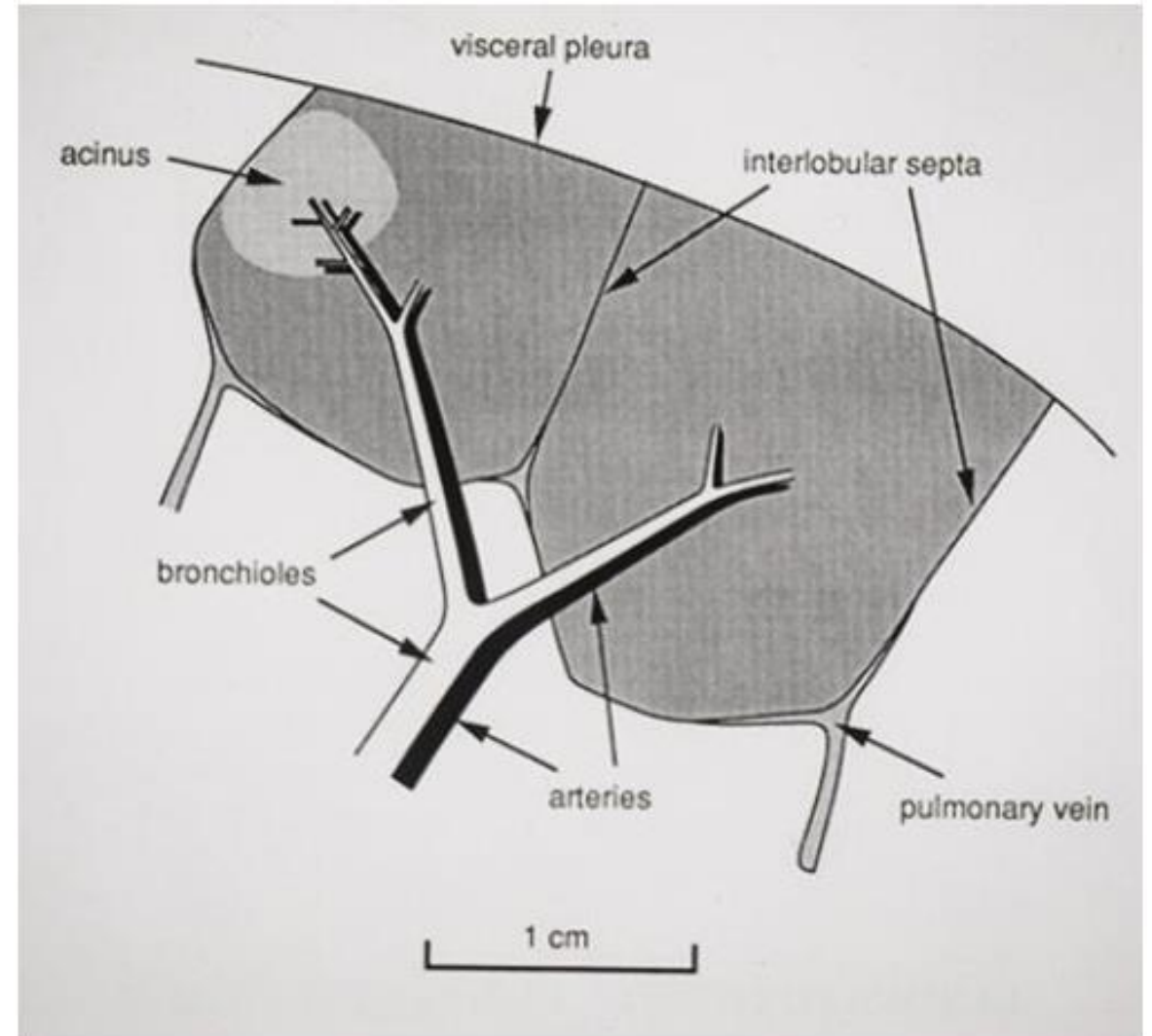
叩診：在大葉性肺炎區域為濁音出現。

聽診：若支氣管通暢則呼吸音大聲，如同聲音直接來自喉部。傳導性語音檢查很明顯地增加，可能有支氣管語響、羊語音及耳語胸語響。孩童在肺炎早期，呼吸音可能會降低。

額外異常呼吸音：細到中等程度的爆裂音。

Alveolar vs. Interstitial pattern

- **Alveolar Lung Disease**
 - Filling of the airspaces
- **Interstitial Lung Disease**
 - Attenuation of the interstitium



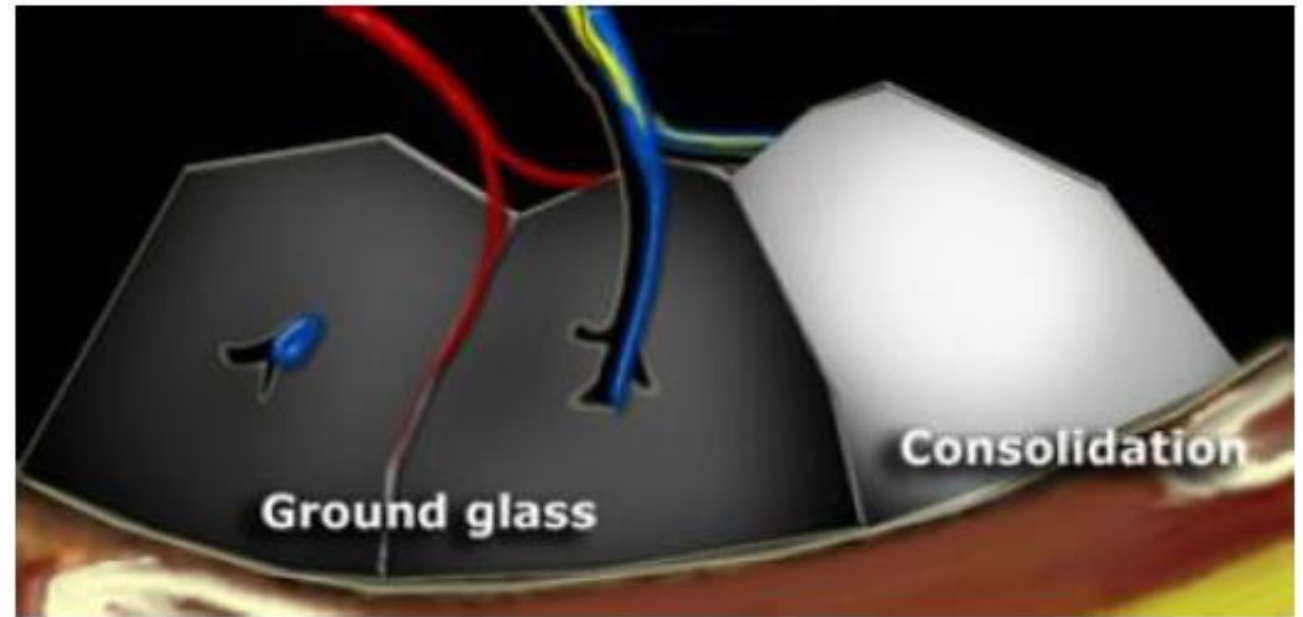
Ground-glass opacity vs. Consolidation

- **Ground glass opacity**

- Partial filling 肺泡部分充填，部分肺泡尚有空氣
- 特色：preserved broncho-vascular markings

- **Consolidation**

- Complete filling 肺泡完全充填
- 特色：obscured bronchial-vascular markings



Alveolar disease的典型徵象

Airspace opacification

- 肺泡被液體、膿、血液、蛋白質或細胞填滿，導致局部密度增加; 遮蔽血管紋
- X光上呈現模糊且無明顯邊界的陰影 (ill-defined opacities)

Air-bronchogram and CT angio-gram

- 肺泡充滿液體但支氣管仍充滿空氣，在X光上看到氣管樹在陰影中清晰可辨
- CT肺泡充滿液體但支氣管及血管仍可見

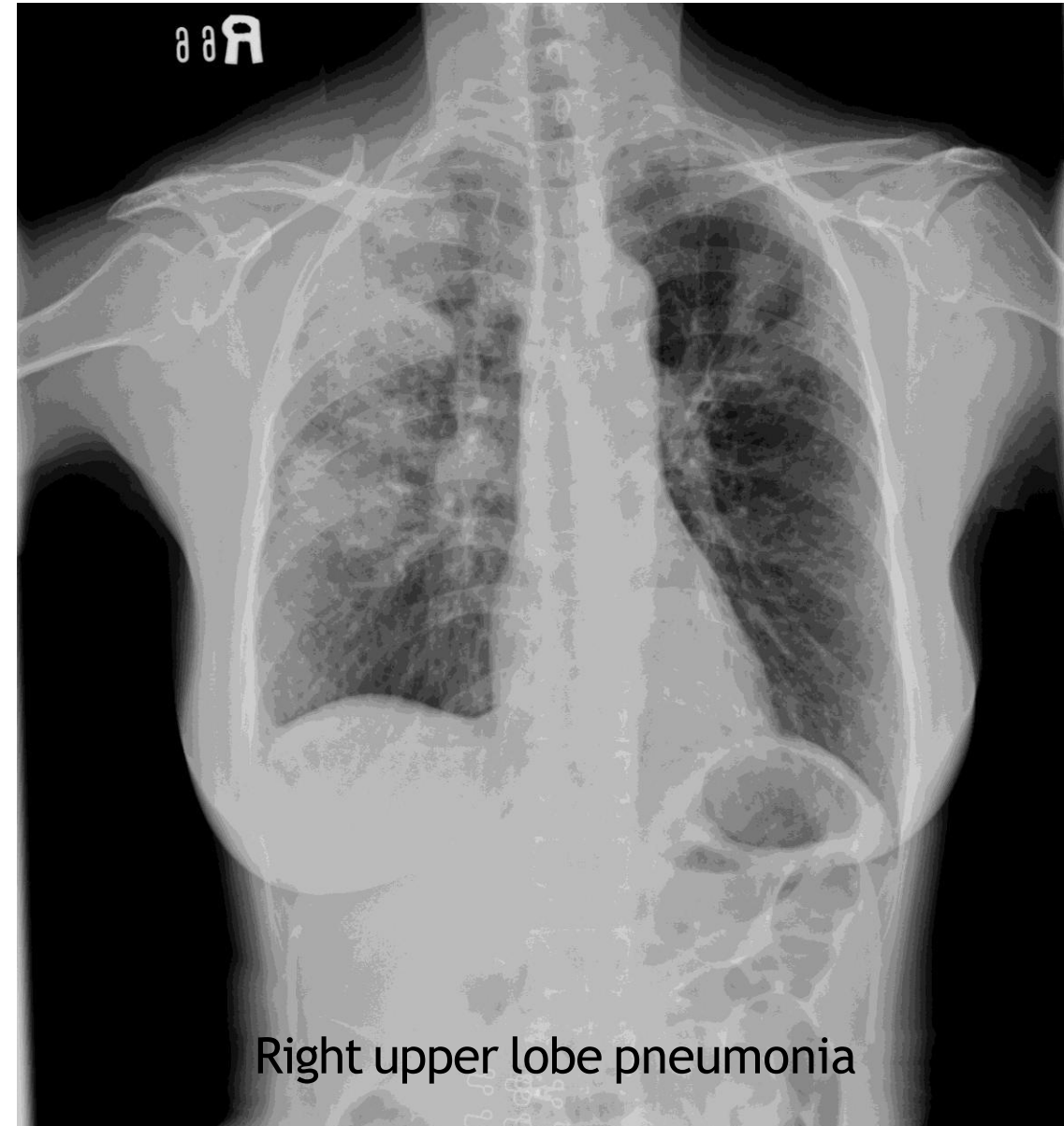
Coalescence of opacities: 個別小病灶融合成大片實變

Rapid change: 常在幾天內快速進展或改善，反映「急性且可逆」的特性

Lobar or segmental distribution: 肺泡疾病常呈現特定解剖區域的分布

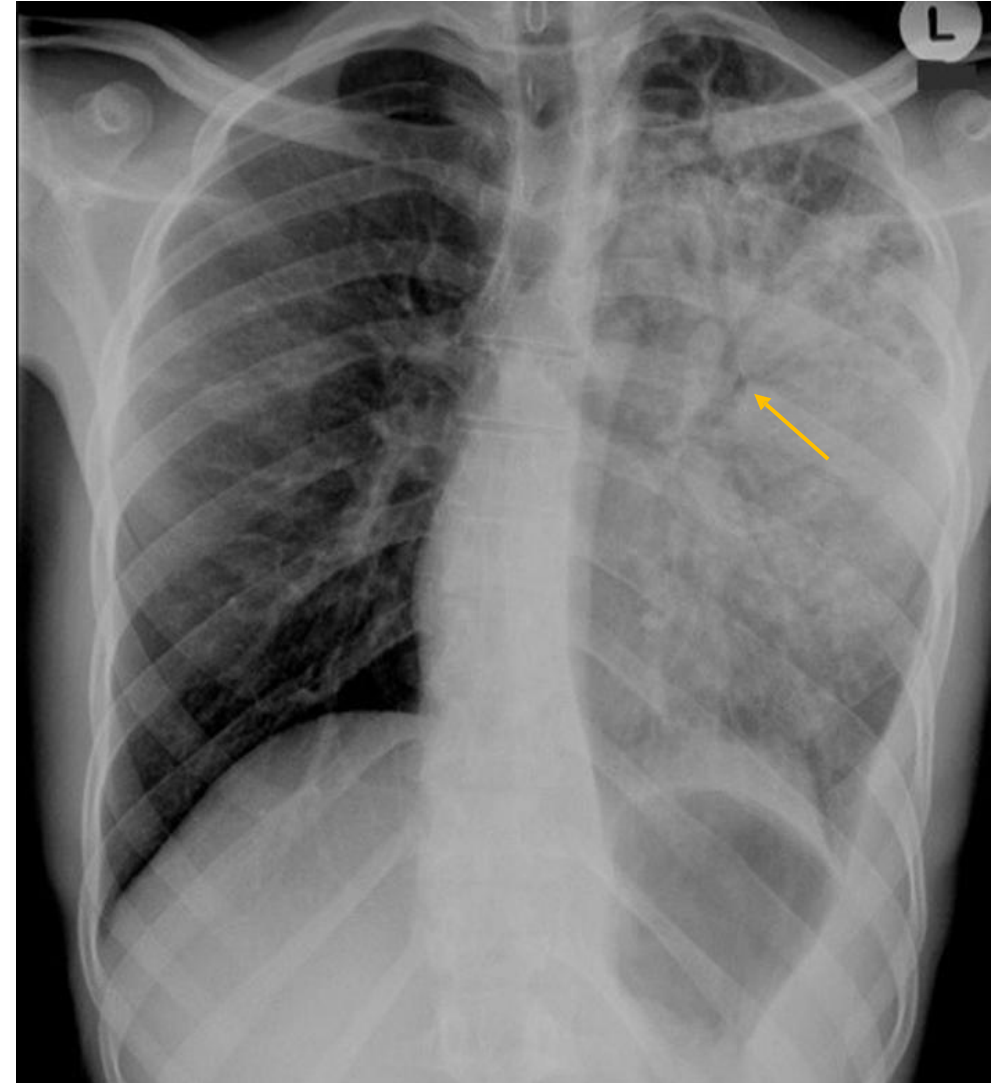
Airspace opacification

- X光上呈現模糊且無明顯邊界的陰影 (ill-defined opacities)

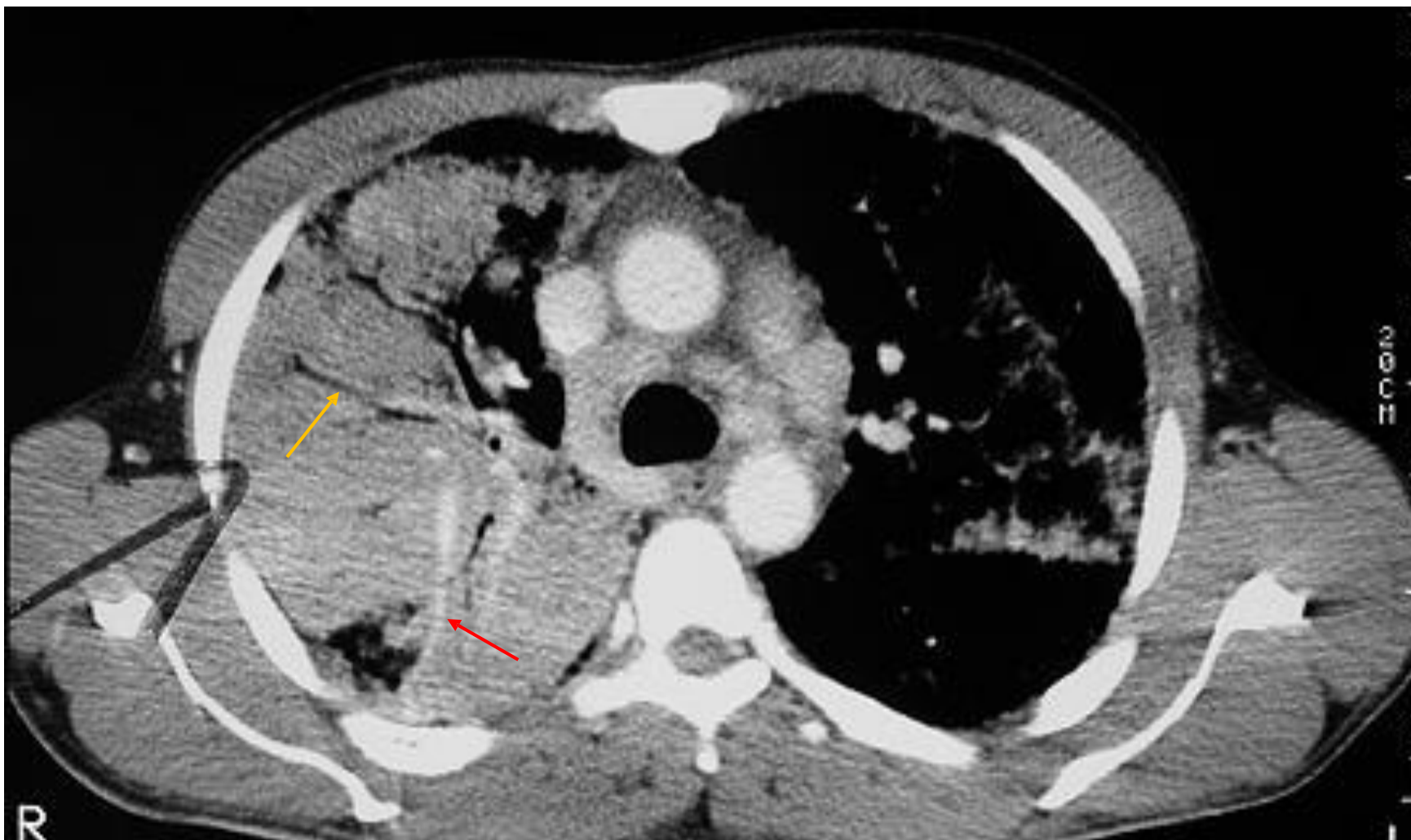


Air-bronchogram

- 肺泡充滿液體但支氣管仍充滿空氣
- 出現air-bronchogram 代表
intrapulmonary lesion
 - Exclude pleural or mediastinal lesion
 - Exclude solid or cystic tumor

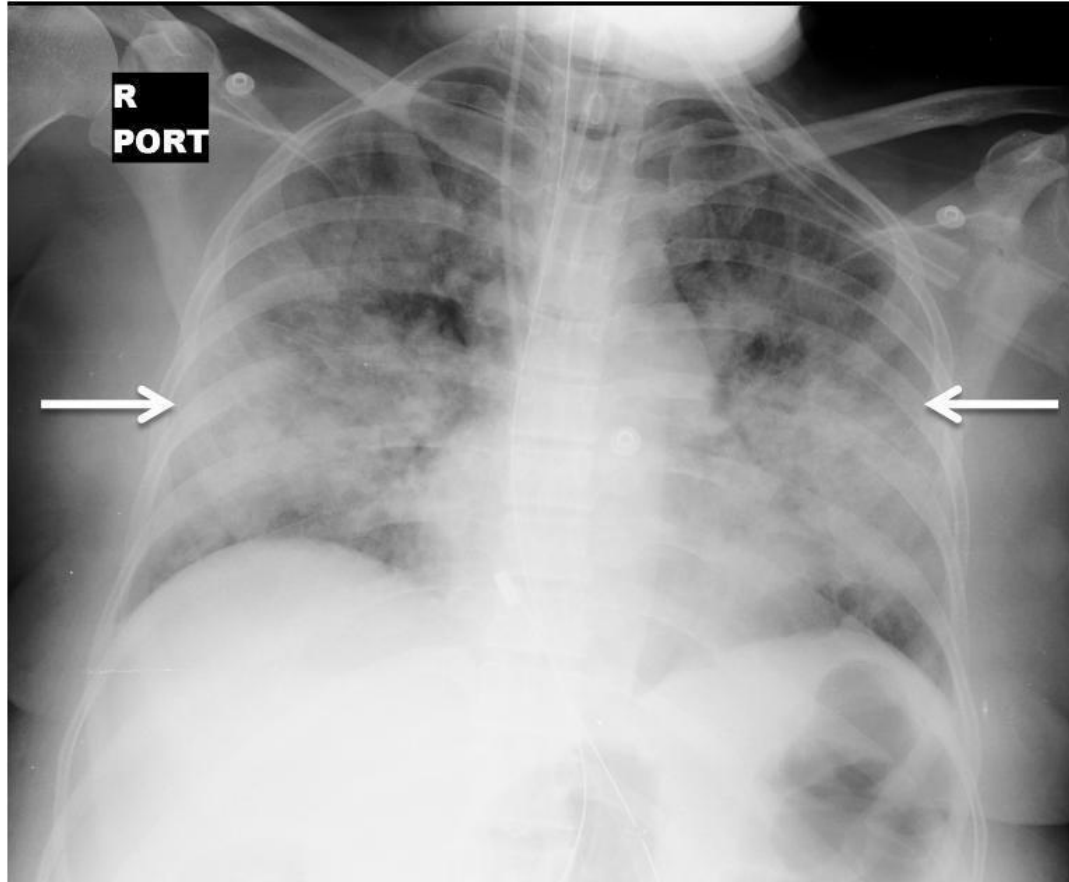


CT air-bronchogram and CT angiogram



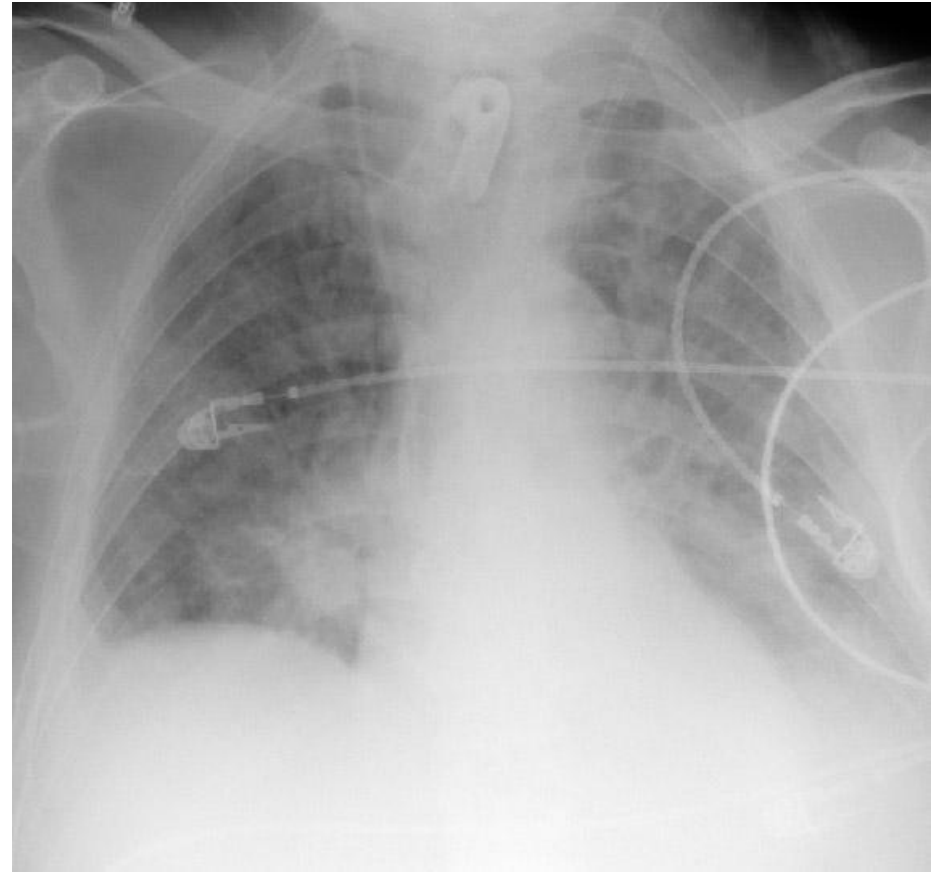
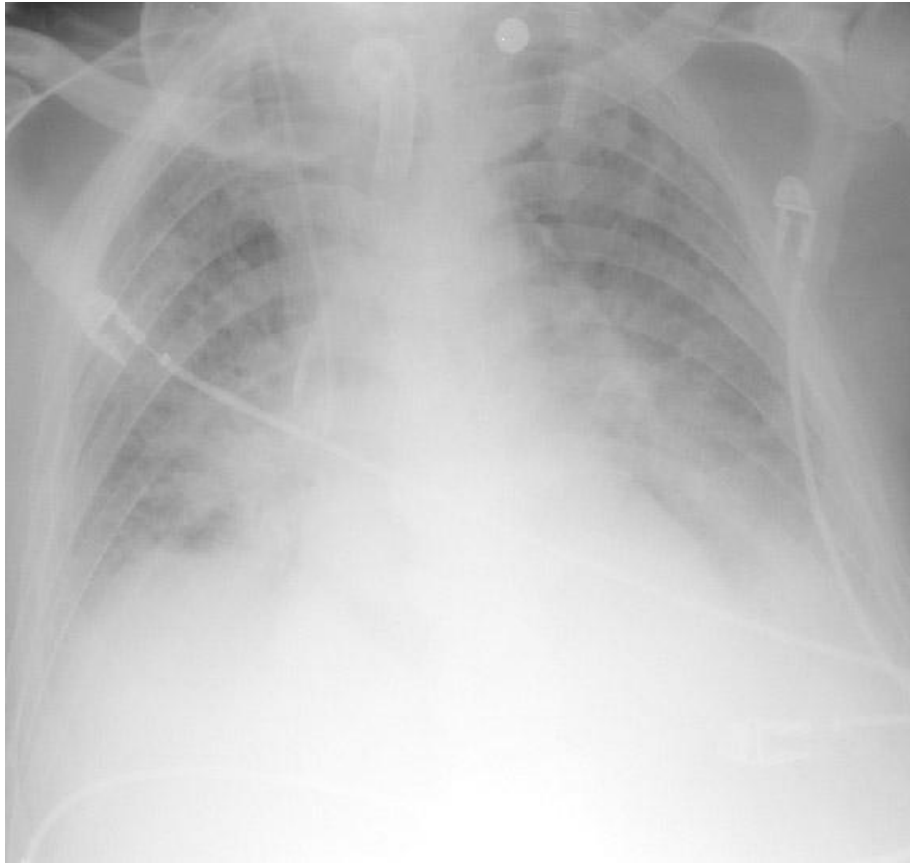
Coalescence of opacities

- 個別小病灶融合成大片實變



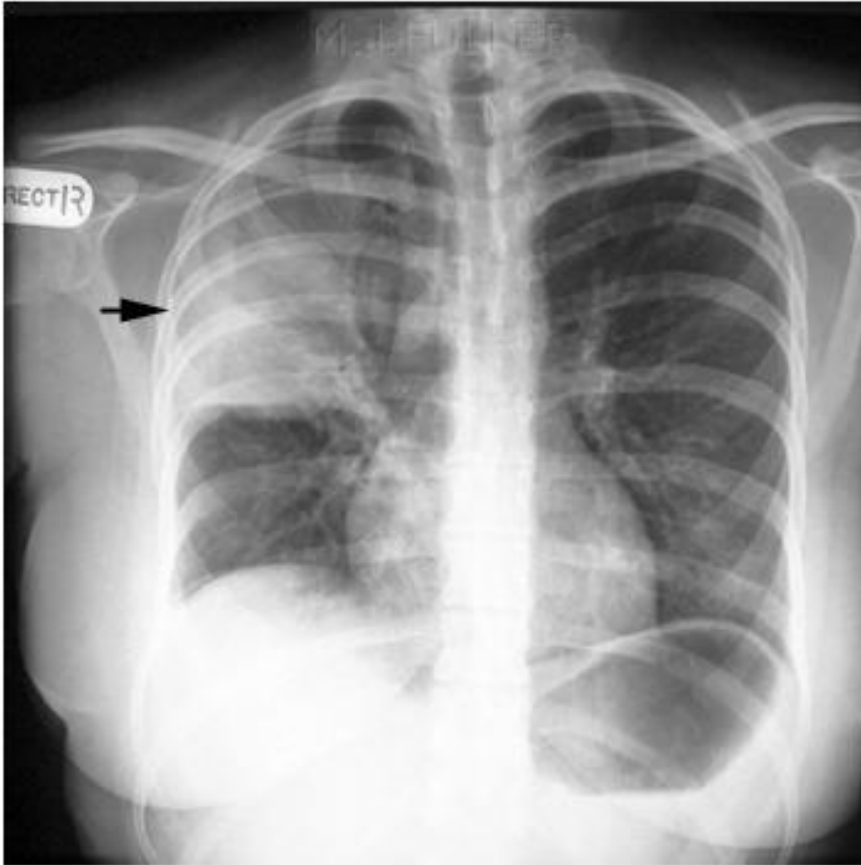
Rapid change

- 幾天內快速進展或改善，反映其「急性且可逆」的特性



Pulmonary edema and interlobar effusion after diuresis

Lobar or segmental distribution



- 呈現lobar distribution (Dense opacity seen above the horizontal fissure)
- Air-bronchogram
- Preserved lung volume

Differential diagnosis of alveolar lung disease

- Alveolar contents
- Course of consolidation
 - Acute -- 水、血、膿
 - Subacute/chronic
- Radiographic distribution
 - Focal
 - Multi-focal
 - Diffuse
- Associated radiographic findings
 - Batwing
 - Reverse batwing

		Water	Pus	Blood	Cells
		Heart failure ARDS low albumin volume overload renal failure	Pneumonia	Trauma Goodpasture Henoch Schönlein SLE	BAC Organizing pneum. Chron eosinophilic Sarcoid
1. Consolidation		Content of the alveoli	Pattern		
Acute	Chronic		Diffuse	Lobar	Multiple ill-defined
			Edema • Heart failure • volume overload • low albumin • renal failure • ARDS • Transfusion reaction Bronchopneumonia • Staph Aureus • Gram-negative • PCP • viral - fungal Hemorrhage • SLE • Henoch-Schönlein • Wegener • Goodpasture BAC Lymphoma Organizing pneum. Eosinophilic pneum. Hypersensitivity pneum	Lobar pneumonia • Streptococ. Pneum. • Klebsiella • Aspiration Hemorrhage • Contusion • Infarction Others • BAC • Lymphoma • Organizing Pneum. • Eosinophilic pneum. • Sarcoidosis	Bronchopneumonia • Staphylococcus • Legionella • Gram negative • Streptoc. Pneum. • Klebsiella • Pseudomonas • Anaerobe • PCP • TB Vascular • Septic emboli • Wegener's Neoplasm • BAC • Lymphoma • Metastases
Acute	Chronic			Batwing	Reversed Batwing
				Edema Bact pneumonia PCP viral pneumonia	Broncho-alv. carcinoma Organizing Pneum (BOOP) Eosinophilic pneumonia Sarcoidosis Radiation
Pneumonia Aspiration Infarction Edema	BAC Lymphoma Organizing pneum. Eosinoph. pneumonia Alveolar proteinosis Sarcoidosis				

Alveolar contents

- Replacement of air in one or more acini by fluid or solid material
- Presentation with or without atelectasis

Alveolar contents	Examples
Fluid	Pulmonary edema ARDS Hypoalbuminemia
Pus	Pneumonia
Blood	Alveolar hemorrhage Trauma
Cells	Bronchoalveolar carcinoma Lymphoma
Others	Alveolar proteinosis (protein) Alveolar microlithiasis (stone) Lipoid pneumonia

Course of consolidation- Acute

- Pulmonary edema (水)
 - Cardiogenic
 - Non-cardiogenic
- Pneumonia (膿)
 - Infectious: bacterial, atypical
 - Noninfectious: ARDS, aspiration, AEP (acute eosinophilic pneumonia)
- Pulmonary hemorrhage (血)
 - Trauma
 - Diffuse alveolar hemorrhage(DAH)

Course of consolidation- Chronic

- Inflammation:
 - Infectious:
TB, NTM, fungus, nocardia, actinomycosis
 - Non-infectious:
HP, BOOP, DIP, CEP, radiation pneumonitis, lipoid pneumonia, sarcoidosis
- Neoplasm
 - Bronchoalveolar carcinoma
 - Lymphoma
- Pulmonary alveolar proteinosis (PAP)
- Alveolar microlithiasis

Radiographic distribution - Focal consolidation

- Pneumonia
- Neoplasm
- Hemorrhage
- Others:
 - Organizing pneumonia
 - Sequestration

Pneumonia

- Lobar pneumonia : 始於週邊肺組織，經肺泡間孔道(ex: pores of Kohn)向四週擴散，終止於肺裂
 - Rapid evolution and confluent
 - Pleural effusion/empyema
 - Common pathogens: Streptococcus pneumoniae, Klebsiella pneumoniae

Volume Increase:

- Streptococcus pneumoniae
- Klebsiella pneumoniae
- Pseudomonas
- Staphylococcus
- Tuberculosis
- Carcinoma with chronic obstructive pneumonia

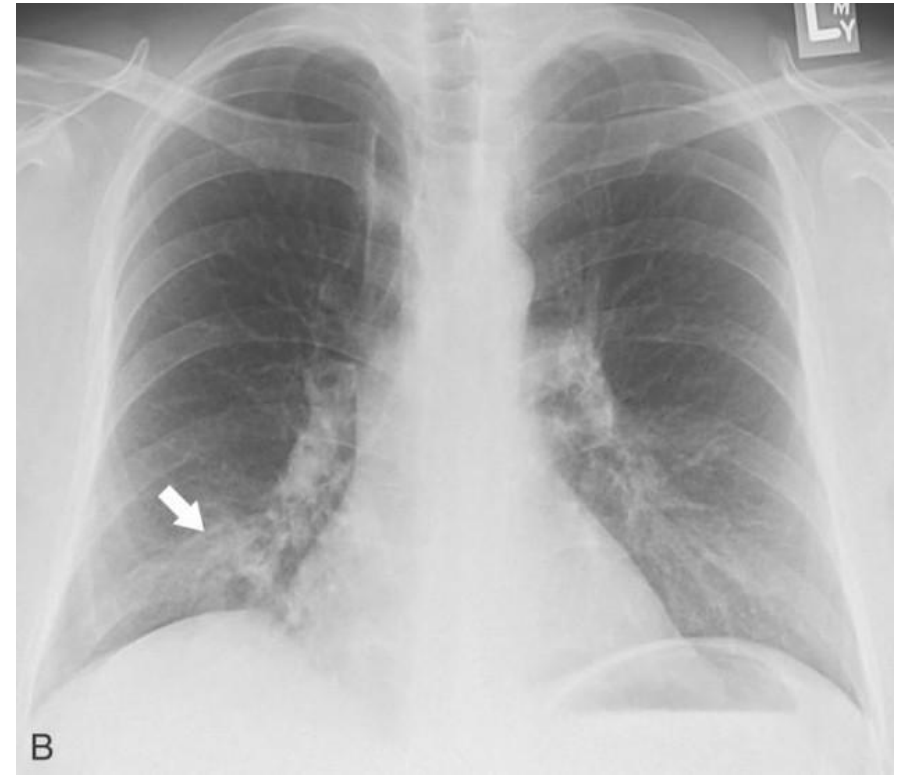
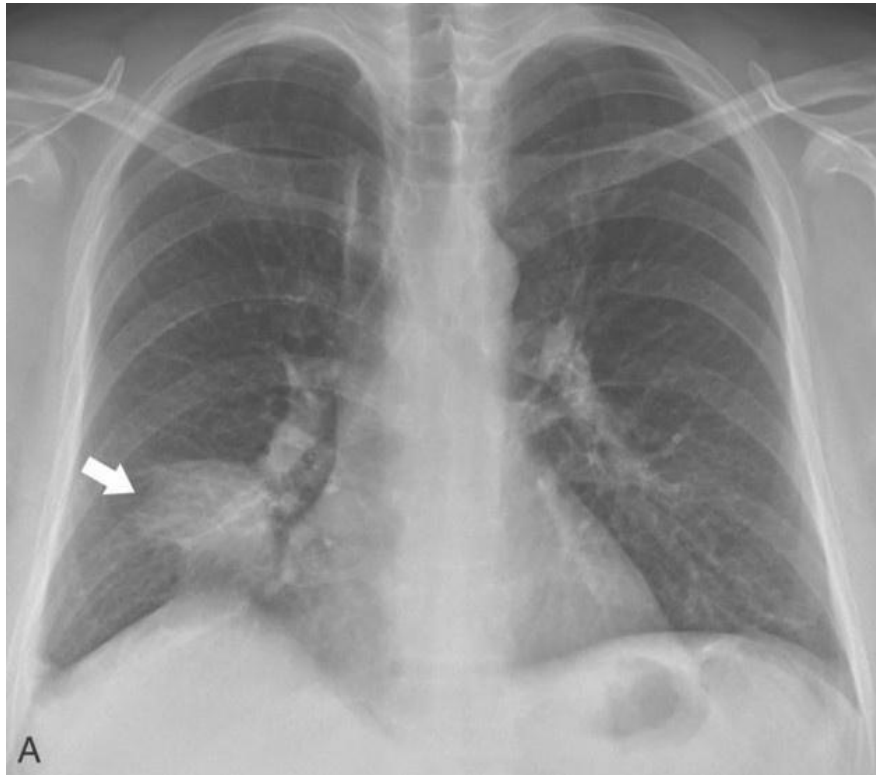
Volume Decrease:

- During resolution
- Central obstruction

RUL s RML lobar pneumonia



Round pneumonia

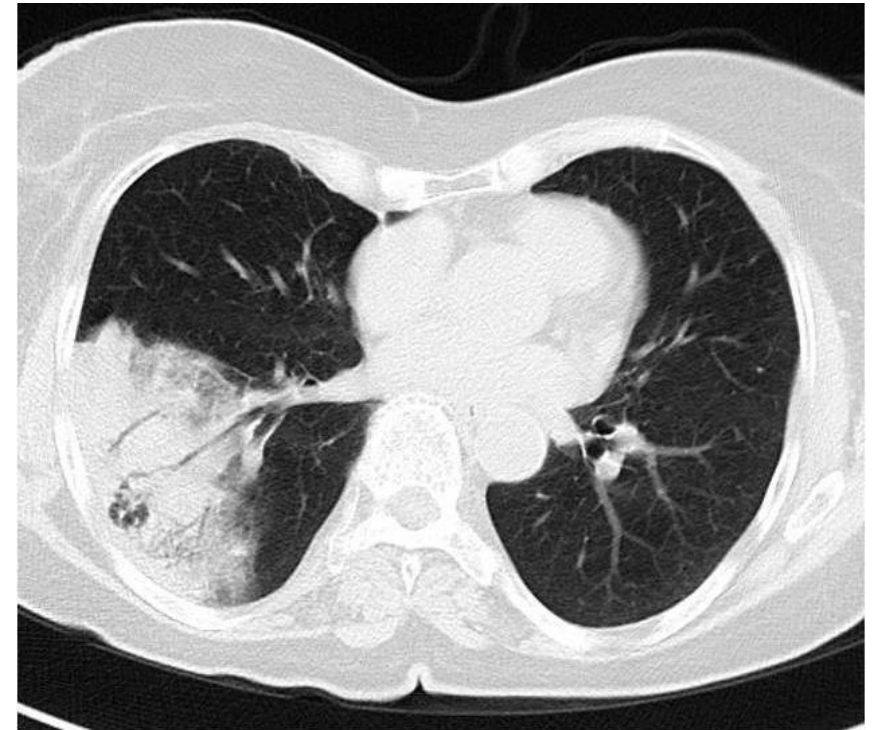


Children more common

- Underdeveloped pores of Kohn and Lambert's channels that may cause the centrifugal spread of fluid or bacteria

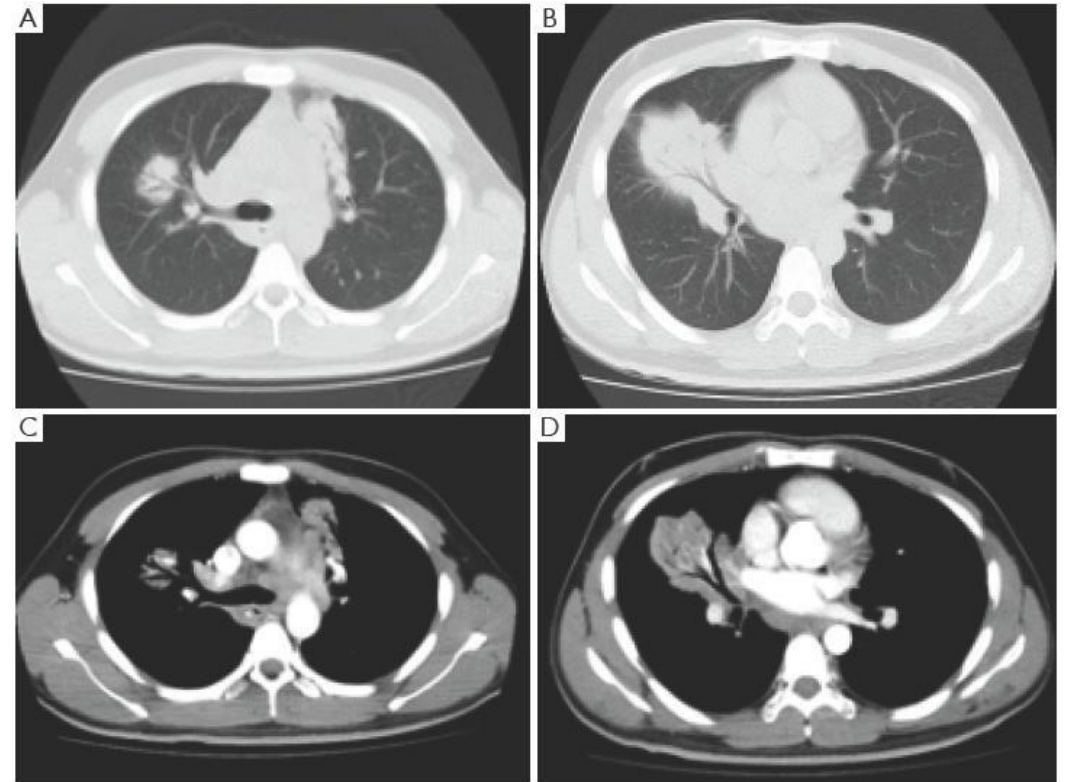
S/P ABx

Bronchoalveolar carcinoma



watery sputum (+)

Lymphoma



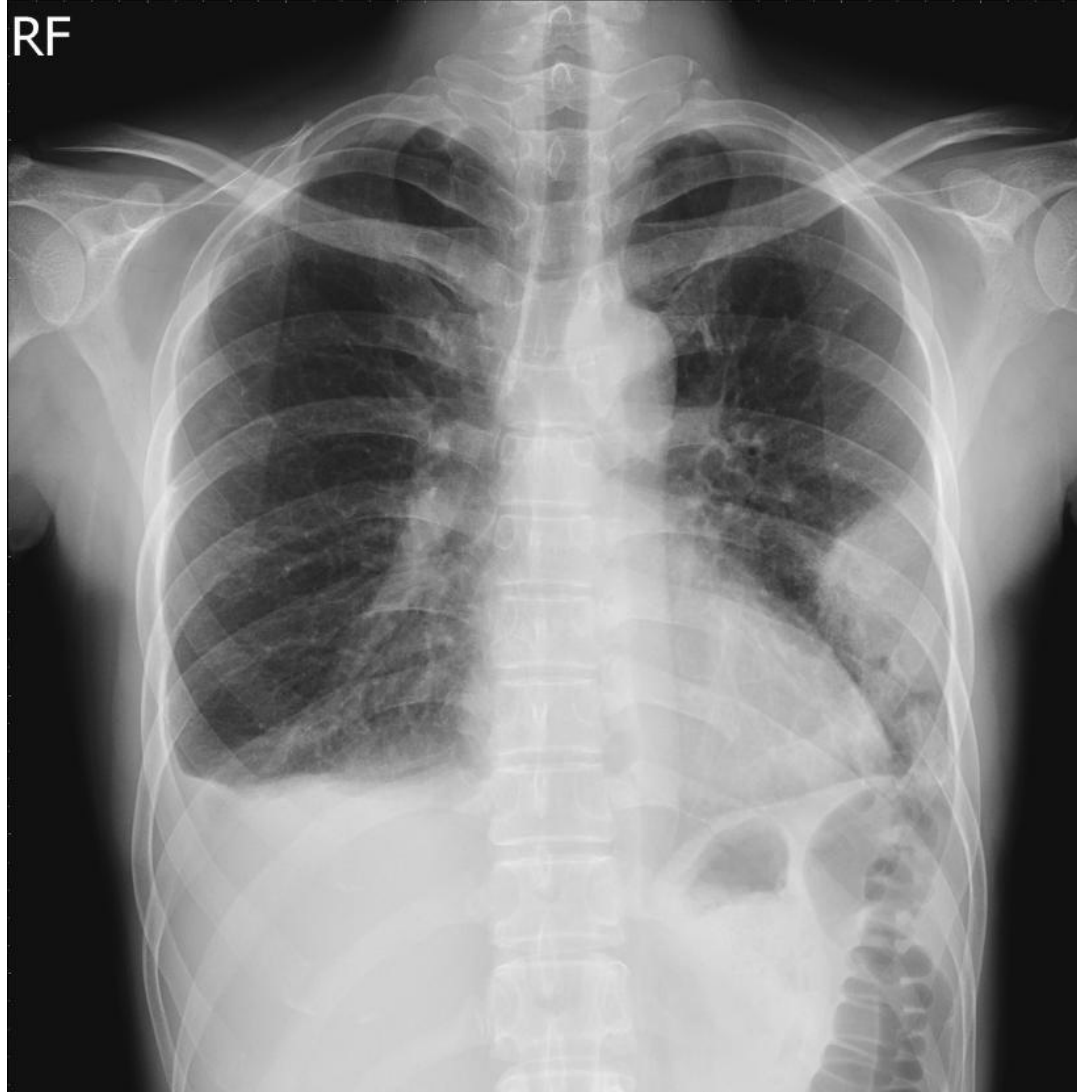
sweating, weight loss

Lymphoma



s/p biopsy

Right segmental and left lobar pulmonary embolism with pulmonary infarction



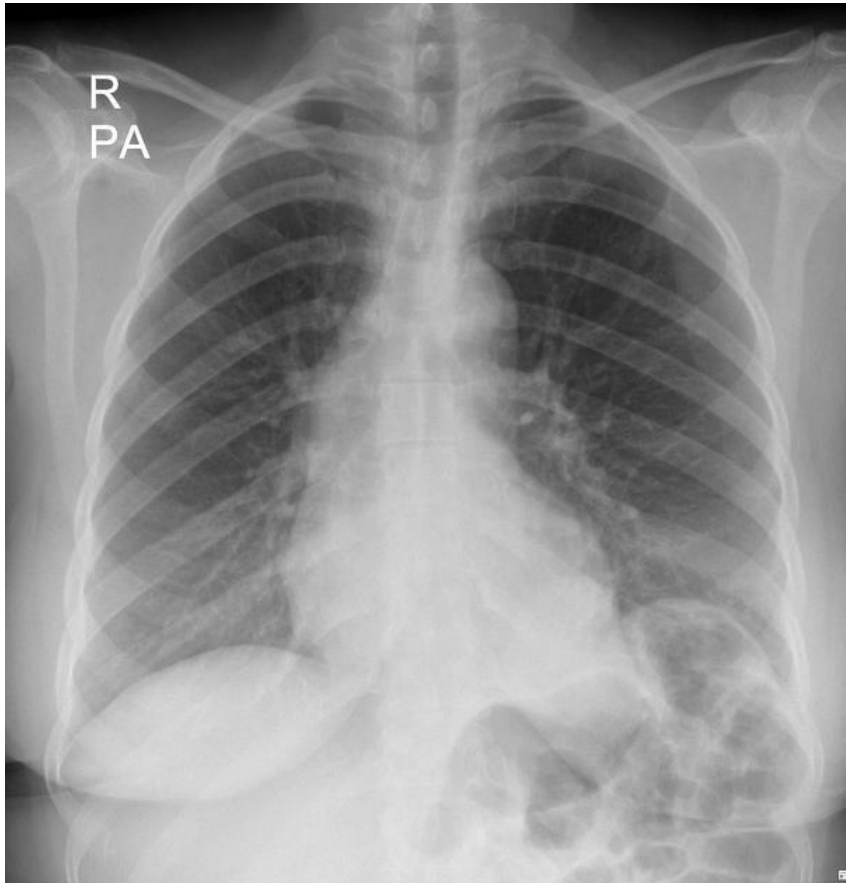


Hampton hump

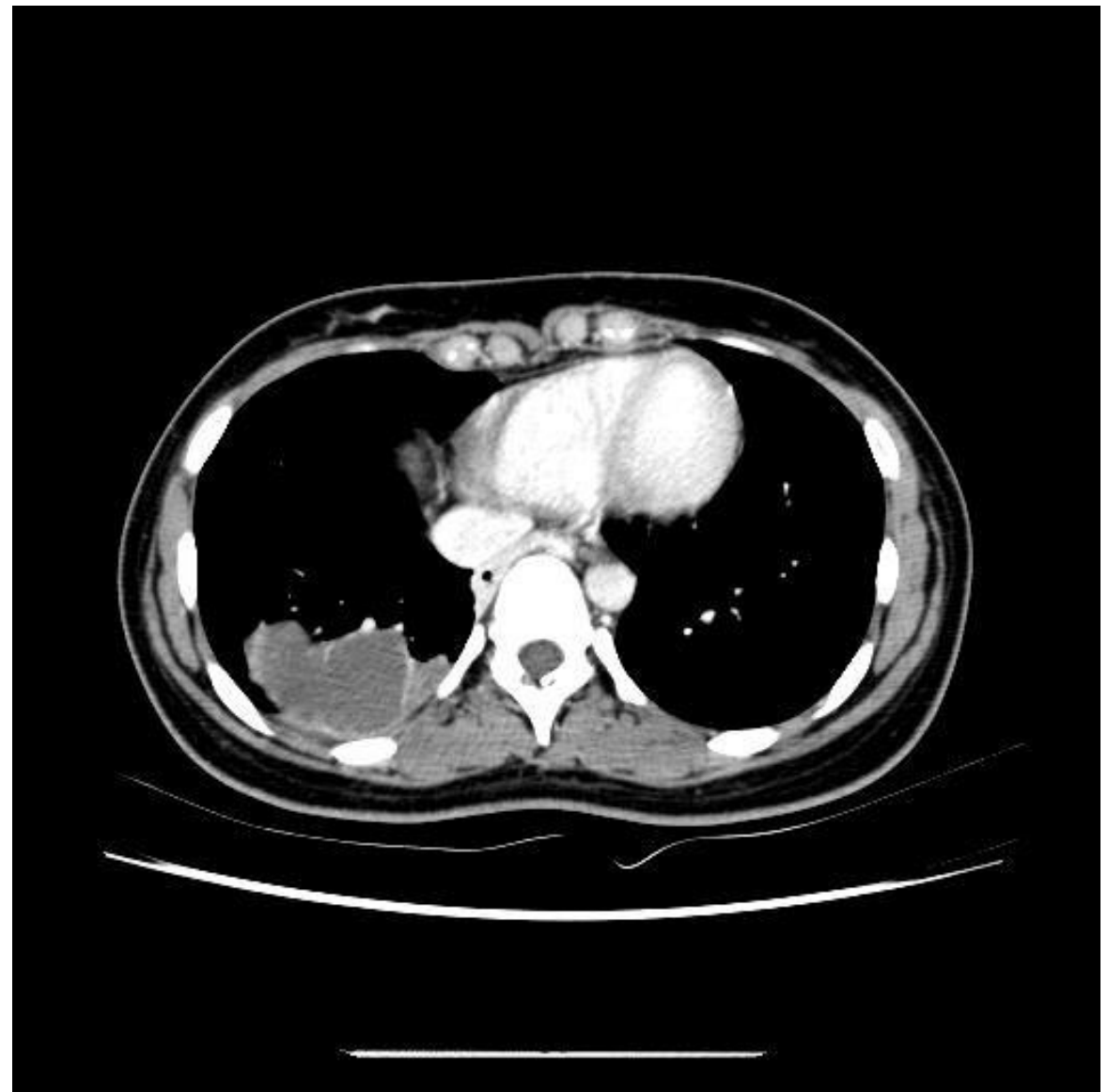
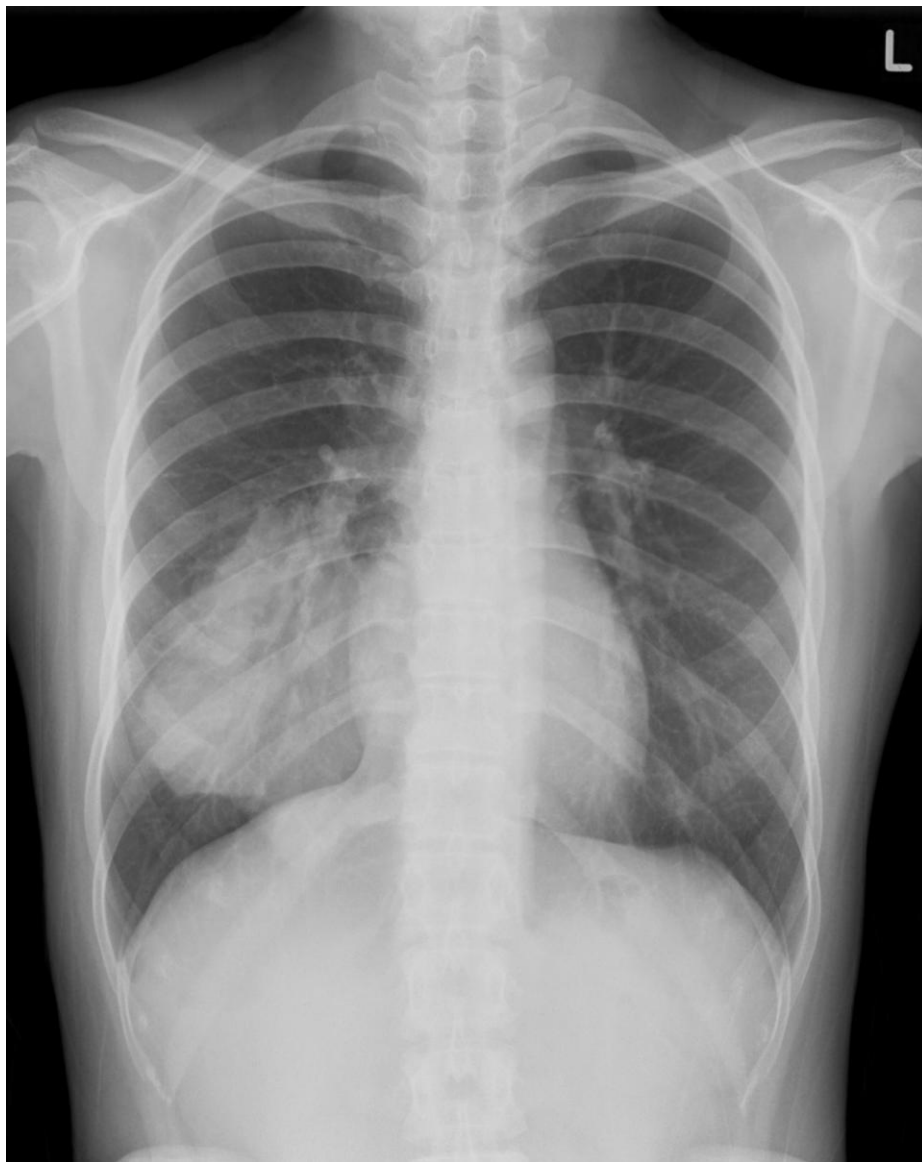


Melting sign

Right segmental and left lobar pulmonary embolism with pulmonary infarction



frequent pneumonia



RLL sequestration

Radiographic distribution - Multifocal consolidation

- Bronchopneumonia
- Vascular
 - Septic emboli
 - Wegener's granulomatosis (granulomatosis with polyangiitis)
- Neoplasm
- Others

Bronchopneumonia

- 病灶始於小支氣管，引起急性支氣管炎，嚴重時導致支氣管壁潰瘍，若致病菌為毒性較強者，如*S. aureus*或*Pseudomonas*等，常引起肺組織壞死，產生膿瘍及血管栓塞
- CXR pattern: depend on host/pathogen interaction
 - Multi-focal/ non-lobar distribution
 - Peribronchial infiltration – increased lung marking
 - Small, ill-defined nodules – acinar consolidation
 - Coalescence – localized or diffuse ill-defined densities

Bronchopneumonia

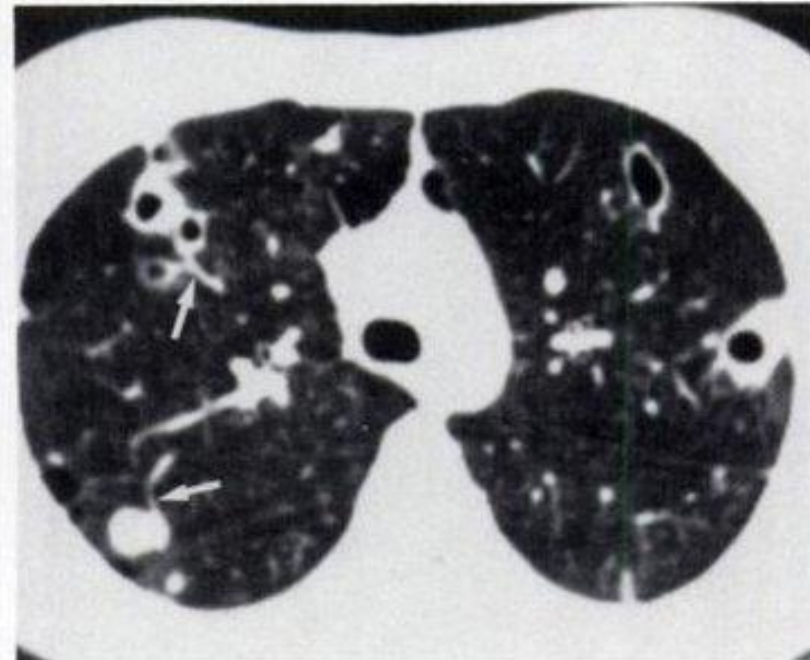
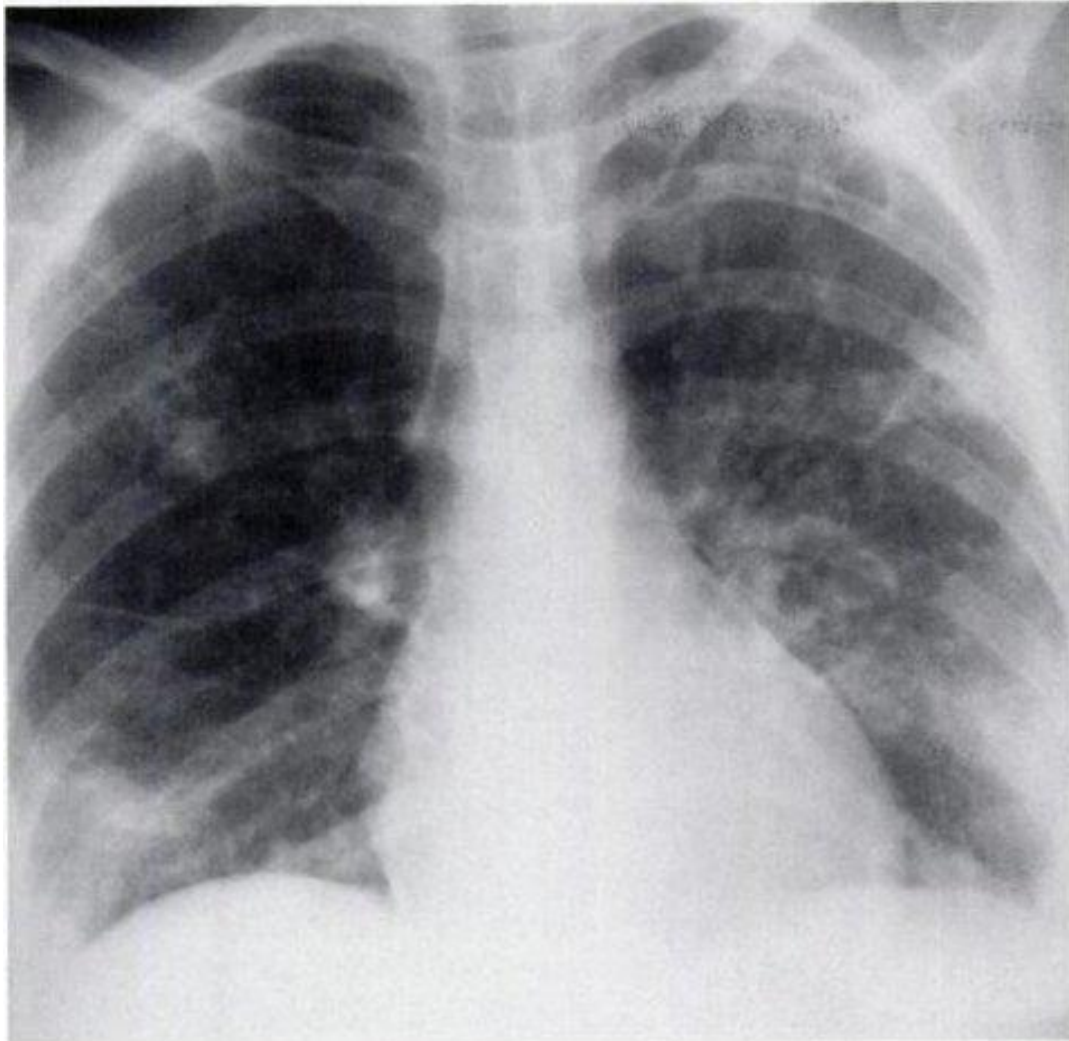


fever, cough

Bronchopneumonia due to *Haemophilus influenzae*

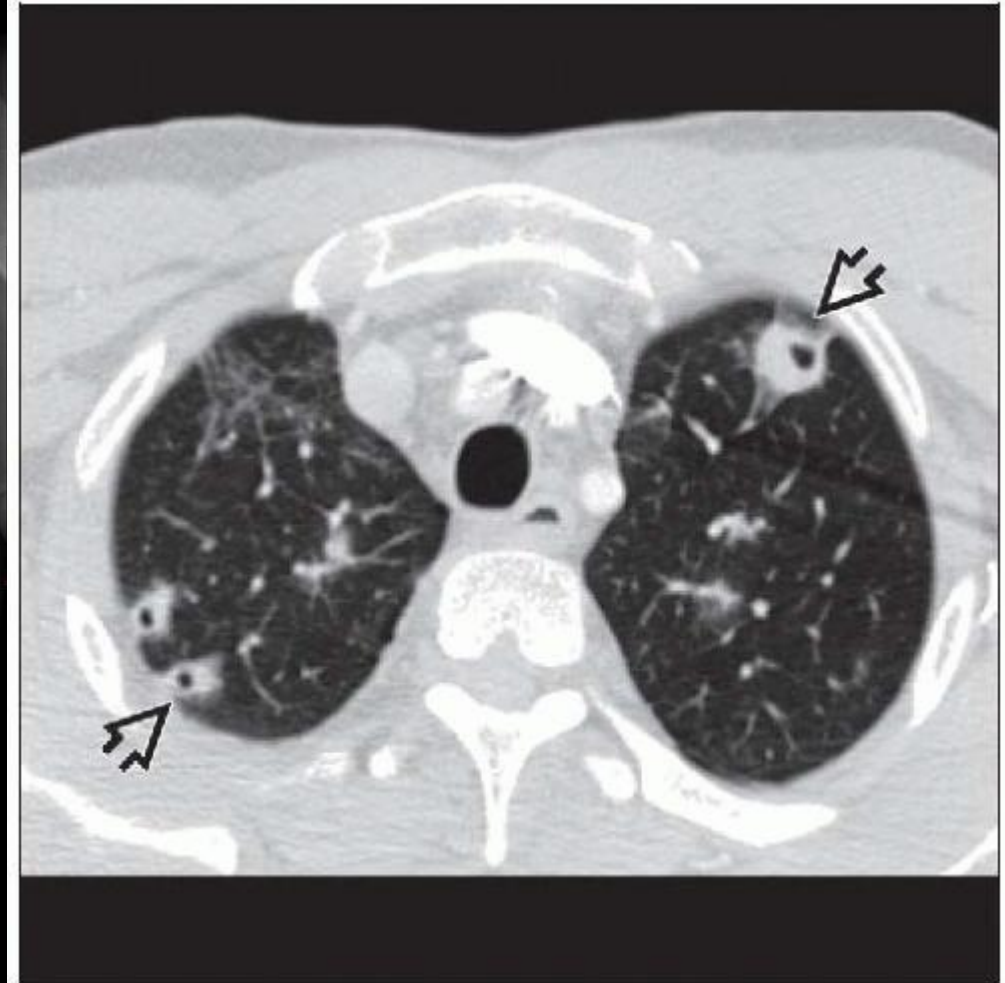
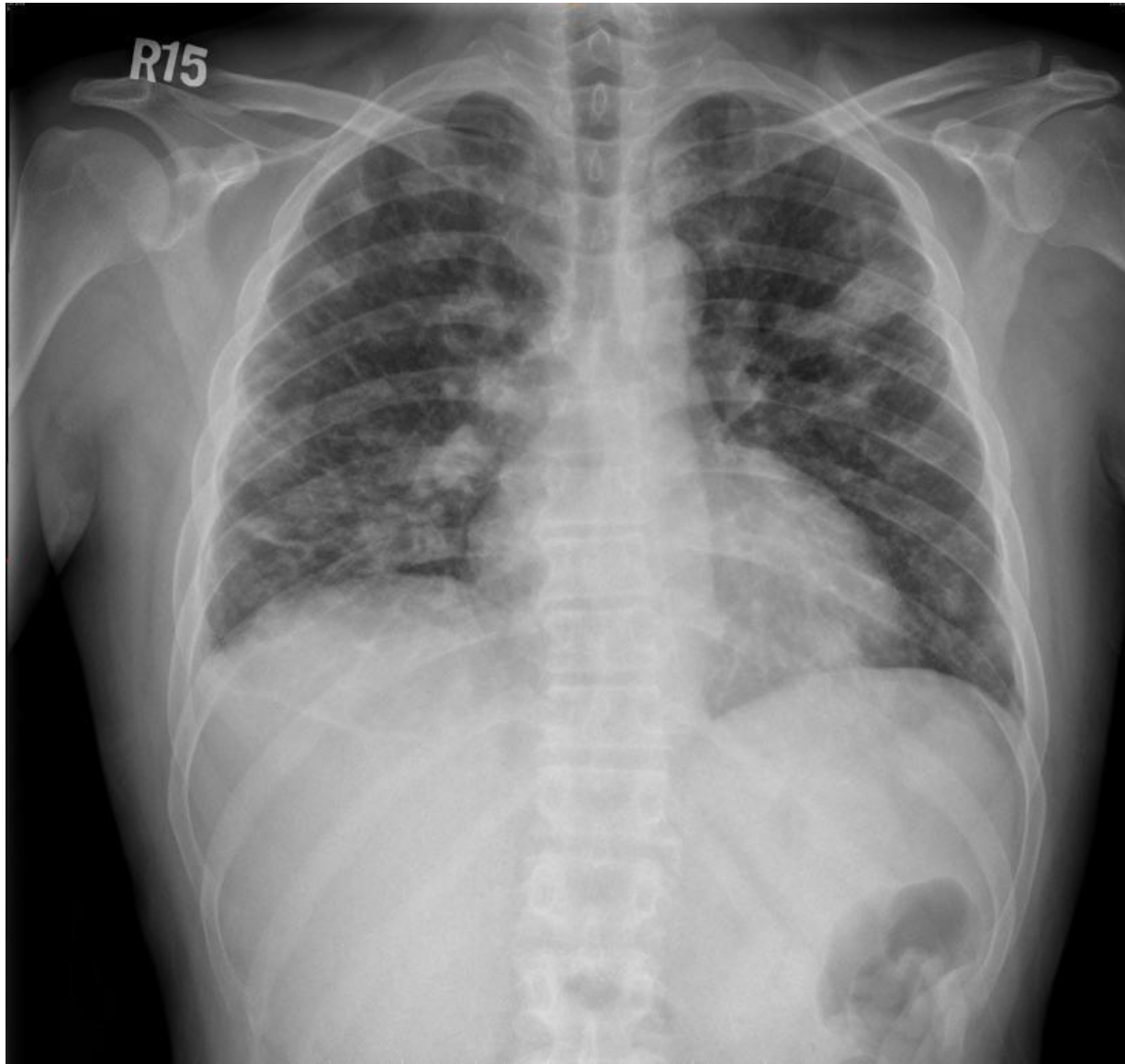


Septic emboli

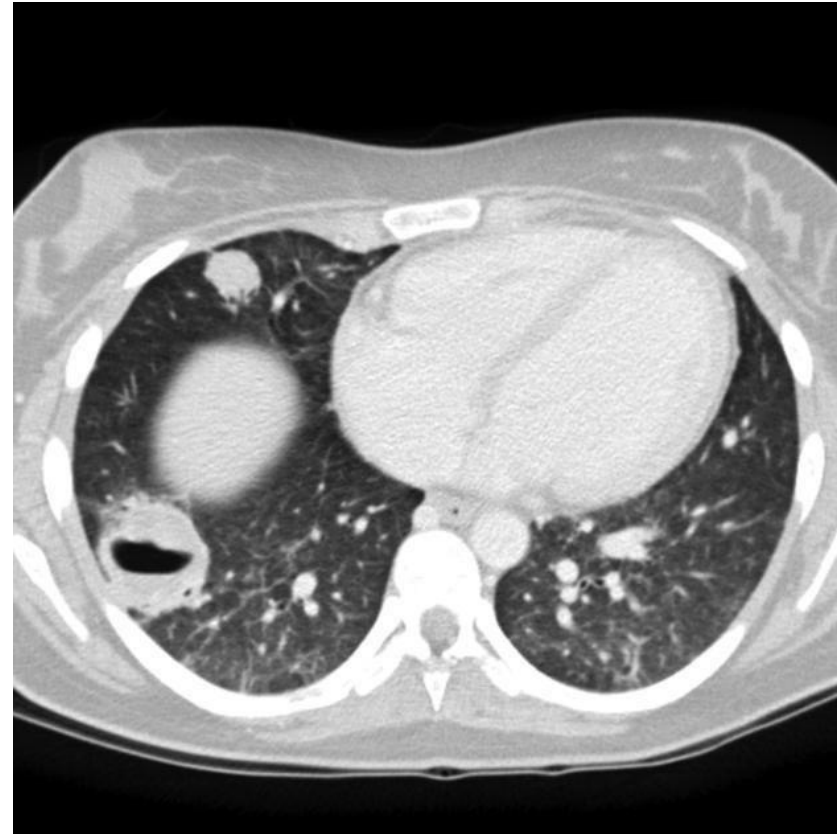
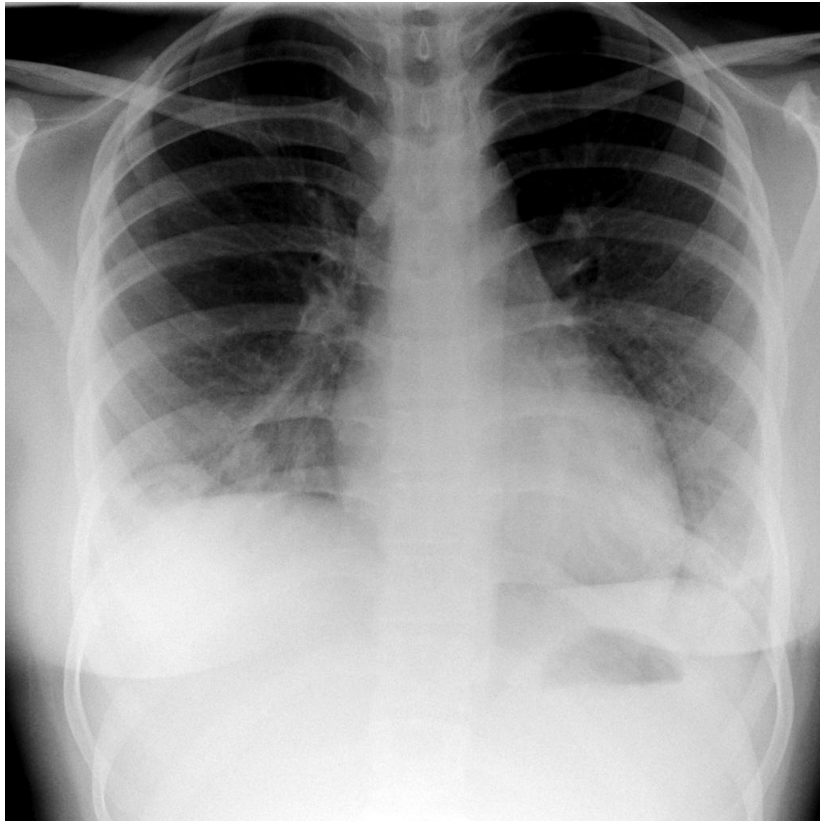


fever, cough

Septic emboli

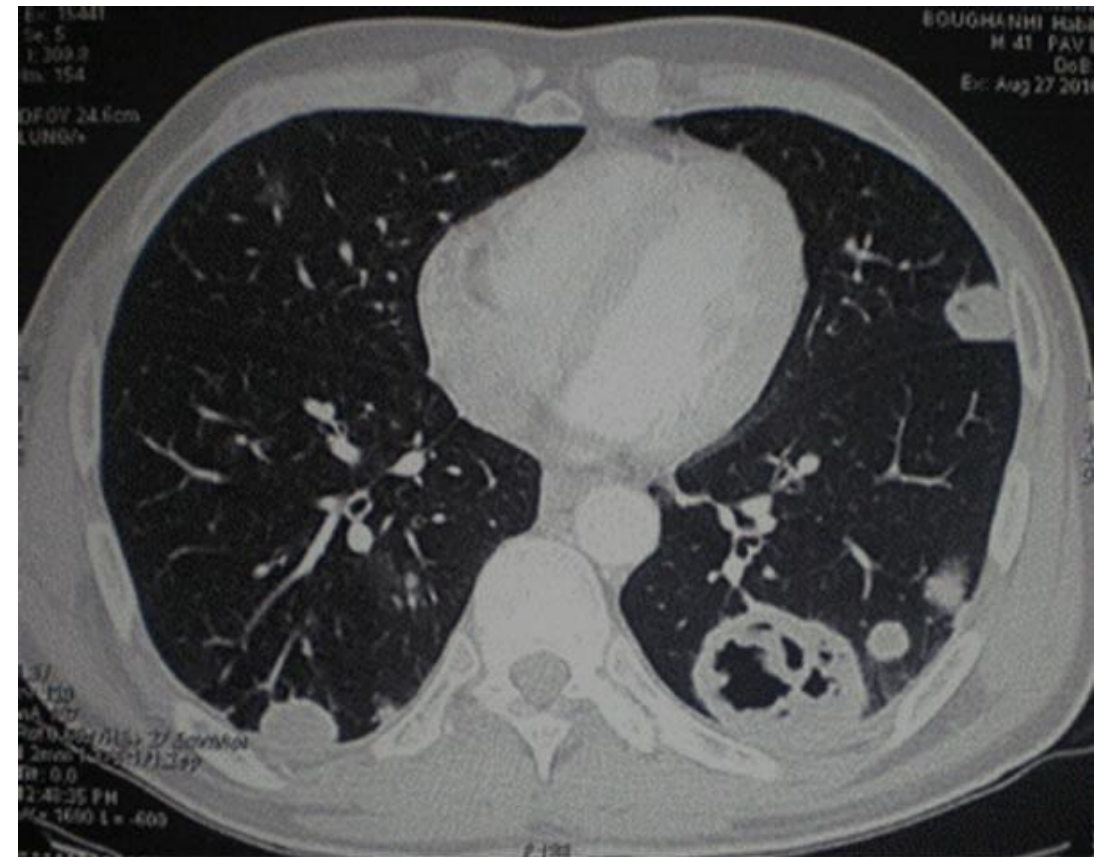
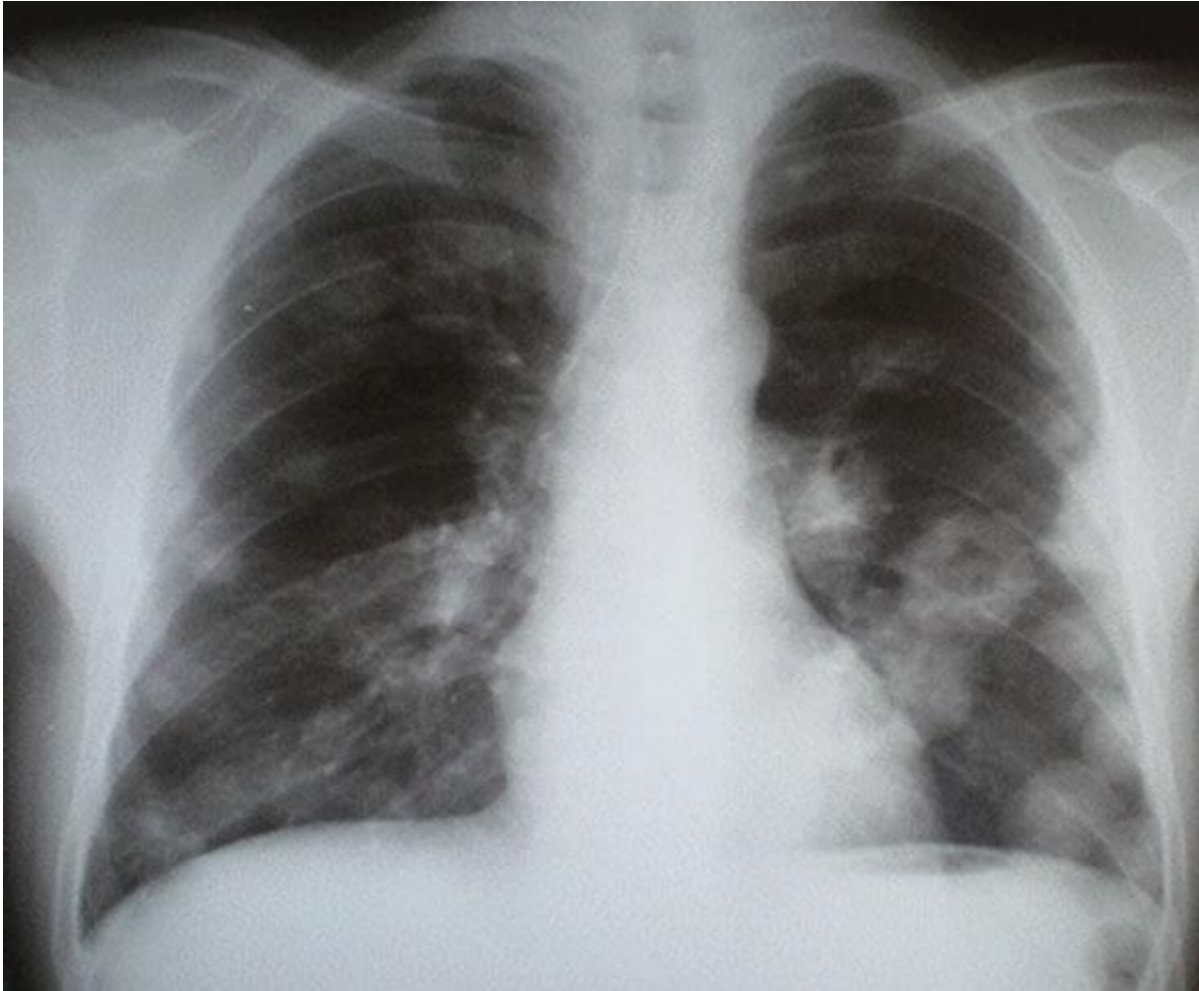


Wegener's granulomatosis



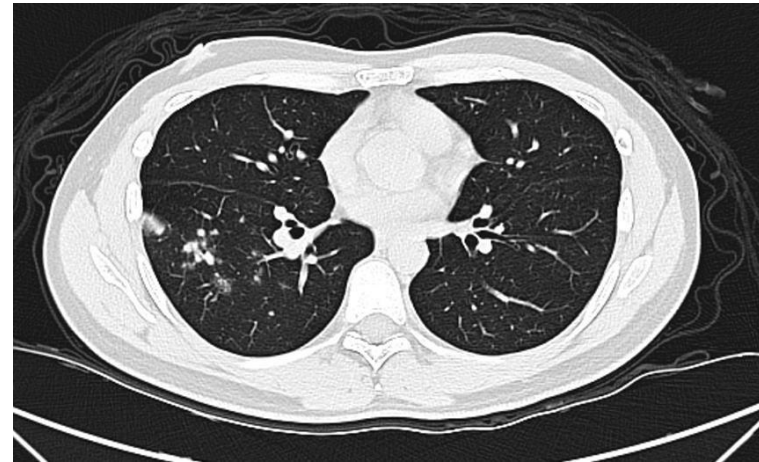
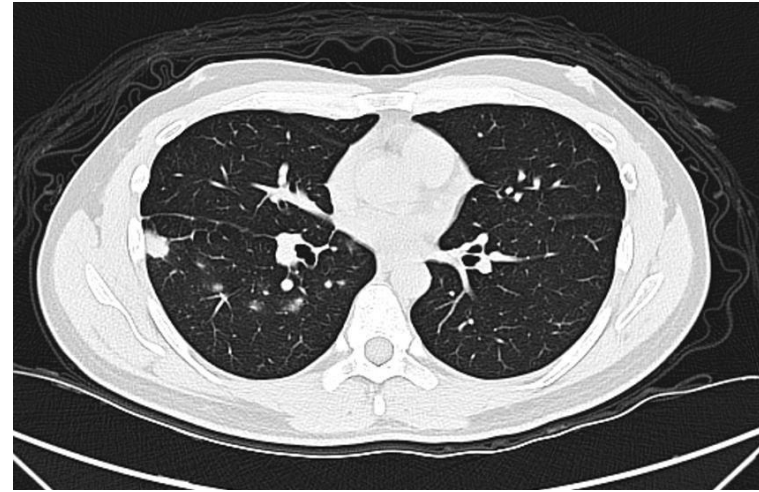
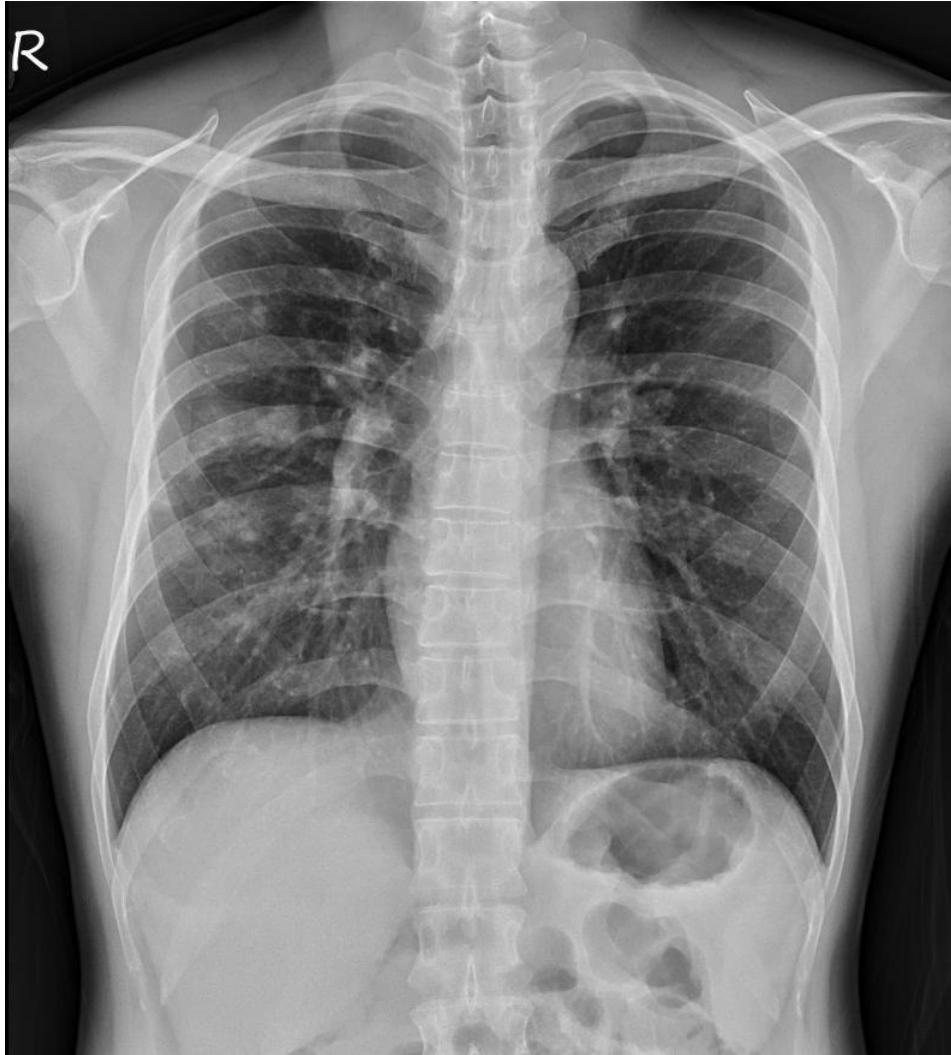
s/sx(-)

Wegener's granulomatosis

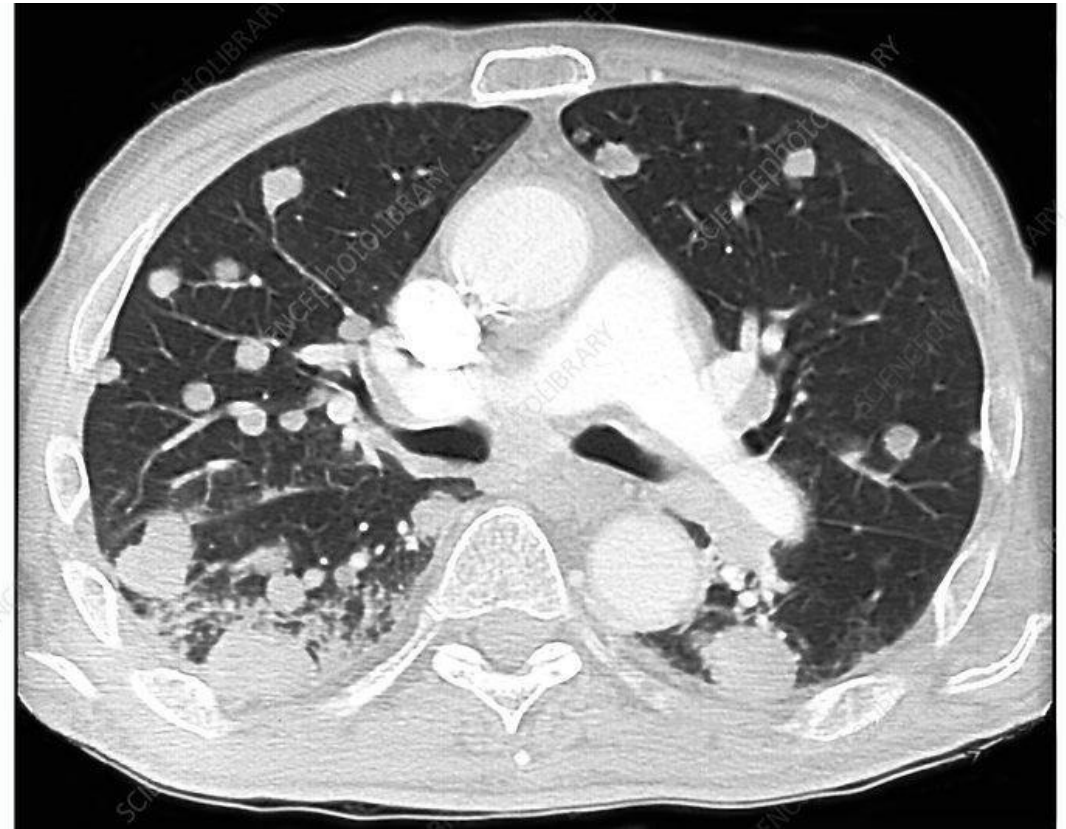
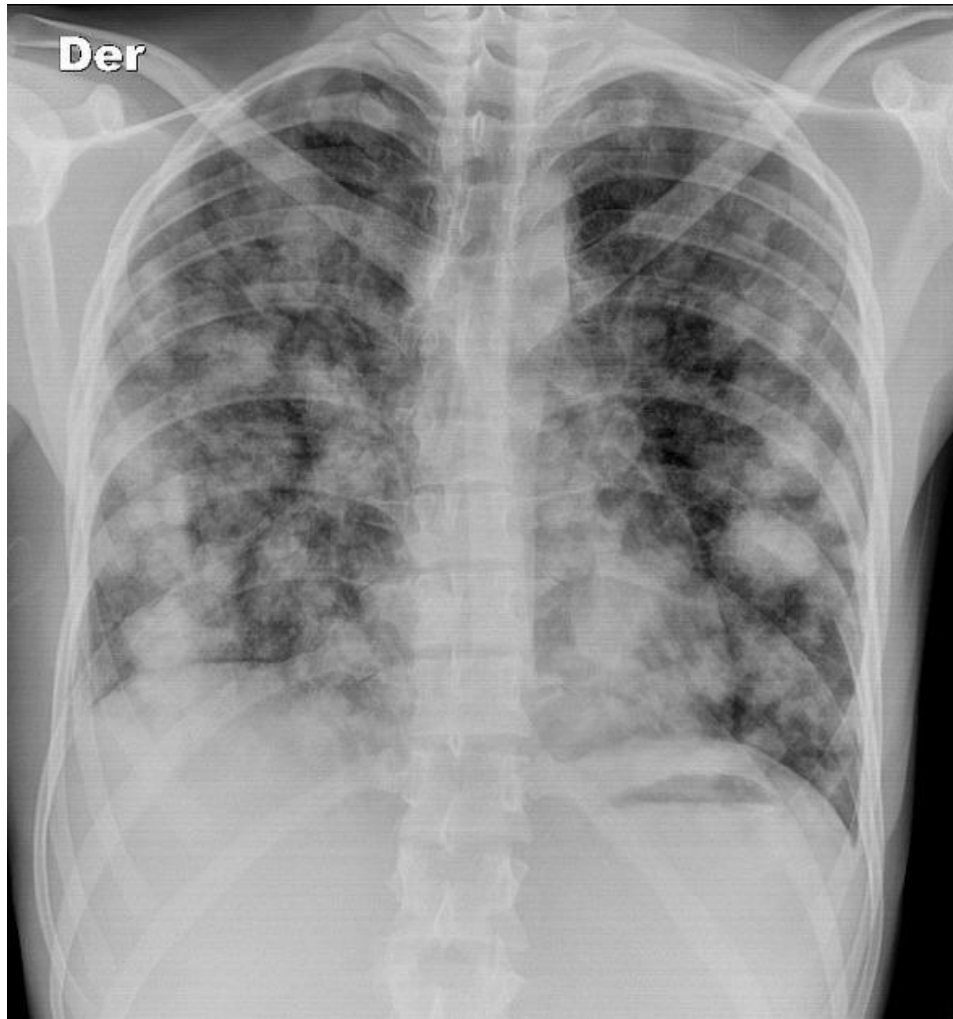


blood-tinged sputum

Pulmonary cryptococcosis



Pulmonary metastases



Multifocal consolidation with cavitation

- Infection
 - Bacteria: S.aureus, GNB, norcardia
 - Mycobacterium: TB, NTM
 - Fungus: aspergillus, mucromycosis, cryptococcus
- Vascular
 - Pulmonary infarction
 - Wegener's granulomatosis (granulomatosis with polyangiitis)
- Pulmonary metastases

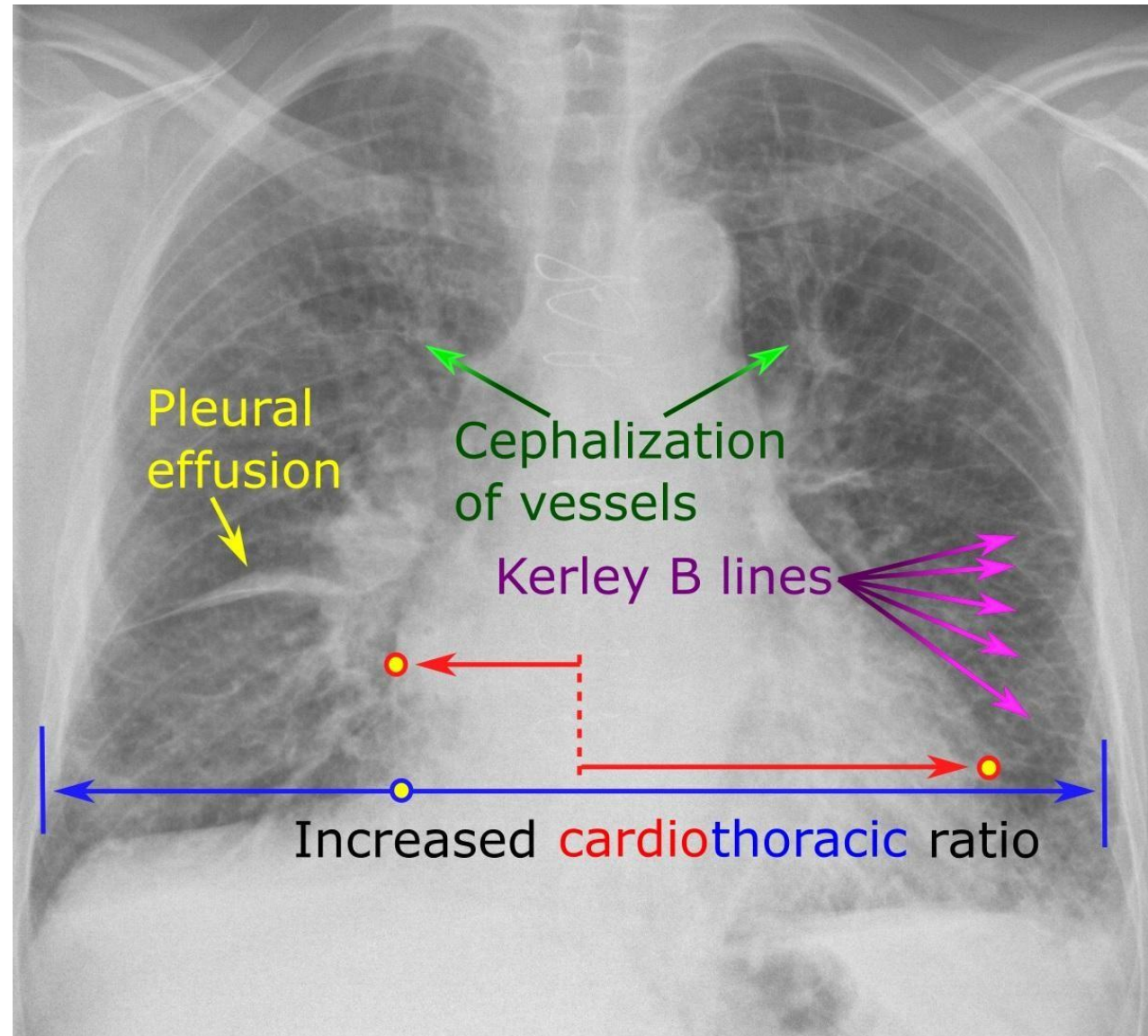
Radiographic distribution - Diffuse consolidation

- Edema
- Bronchopneumonia/PJP pneumonia/CMV pneumonia
- Diffuse hemorrhage
- Others

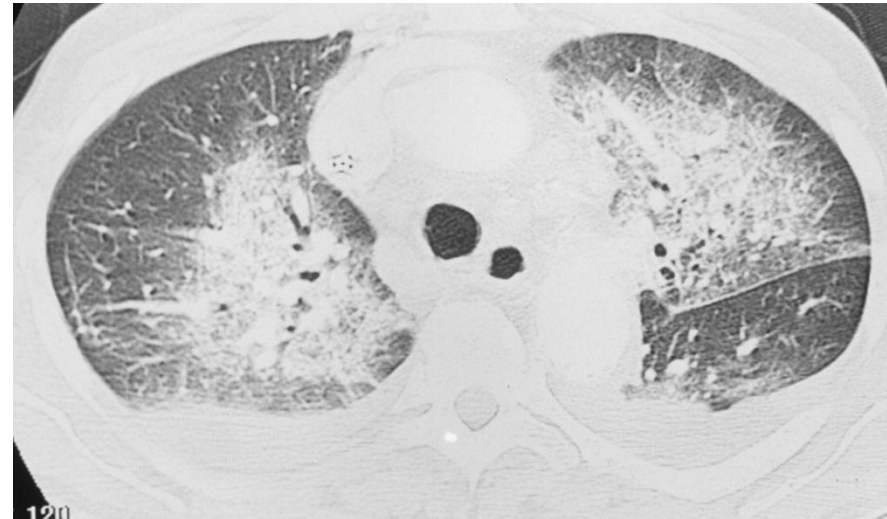
Edema

- Cardiogenic
- Non-cardiogenic
 - High-altitude pulmonary edema
 - Hypoproteinemia
 - Near-drowning
 - Neurogenic edema
 - ARDS
 - Anaphylaxis
 - Uremic lung
 - Re-expansion pulmonary edema
 - Drug/toxin inhalation

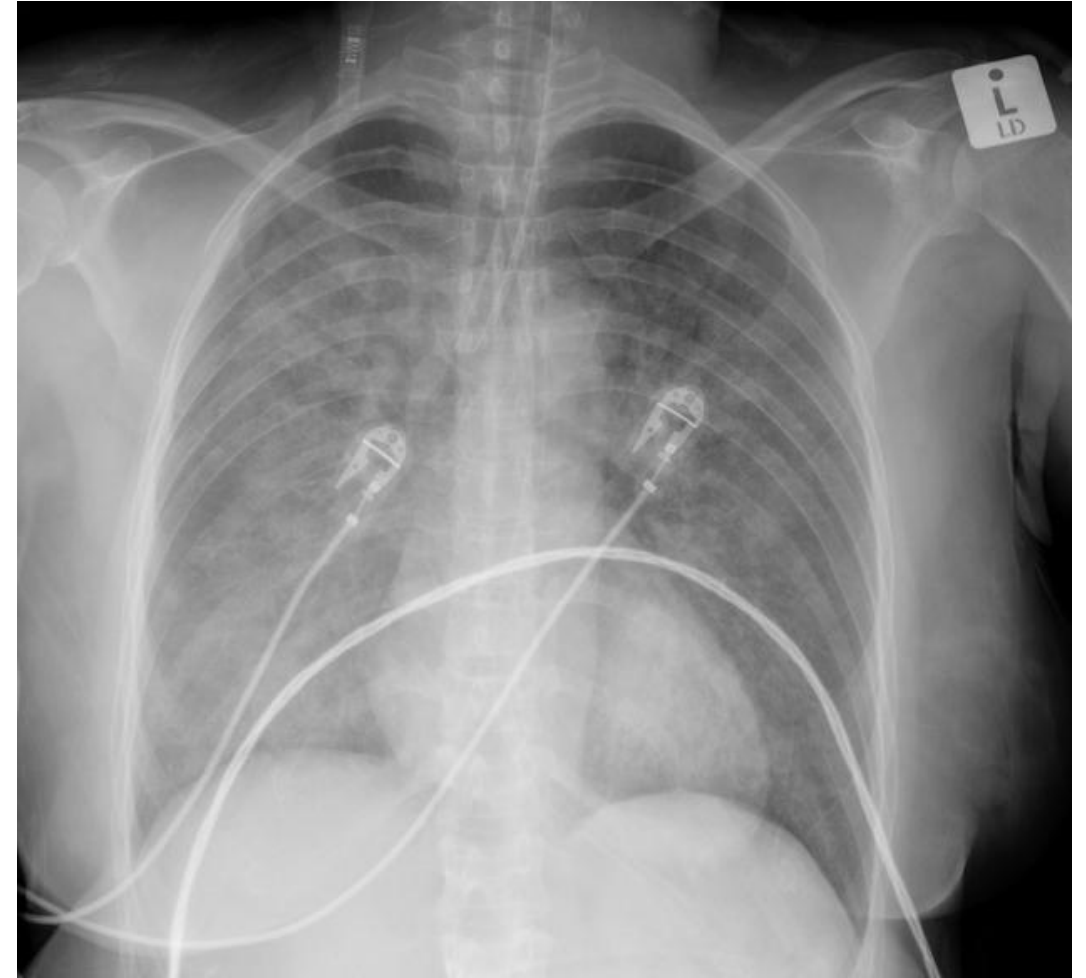
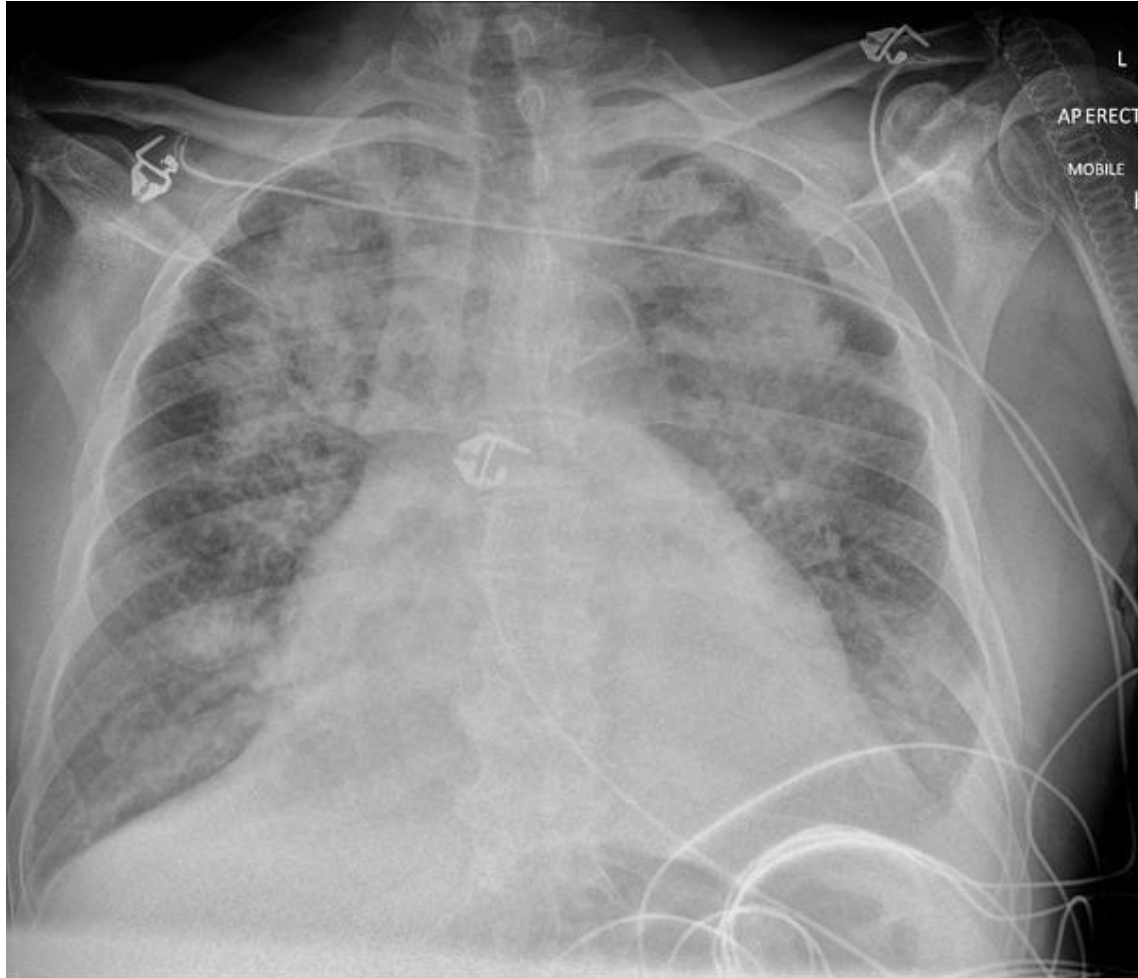
Cardiogenic edema



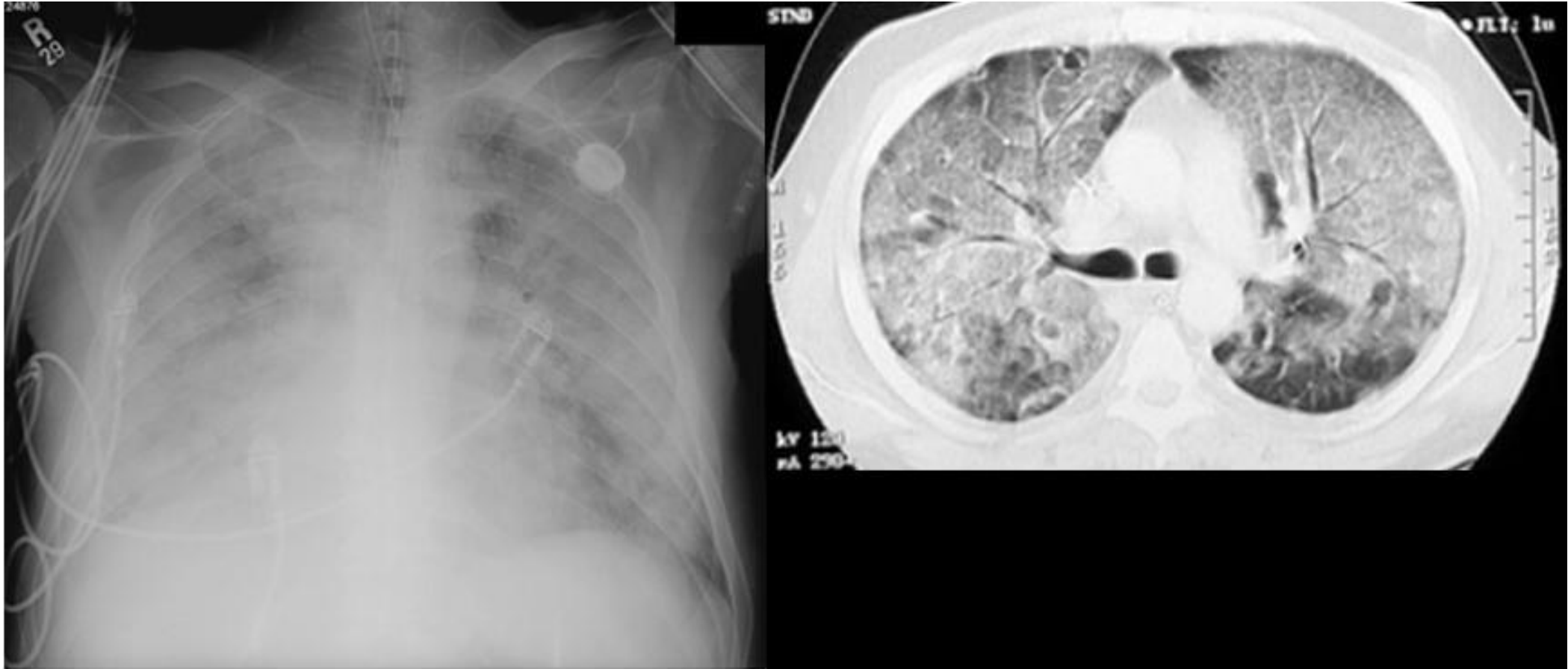
Cardiogenic pulmonary edema (Batwing)



Rapid resolution of cardiogenic pulmonary edema



ARDS



Severe hypoxemia

Bronchopneumonia due to *Mycoplasma pneumoniae*

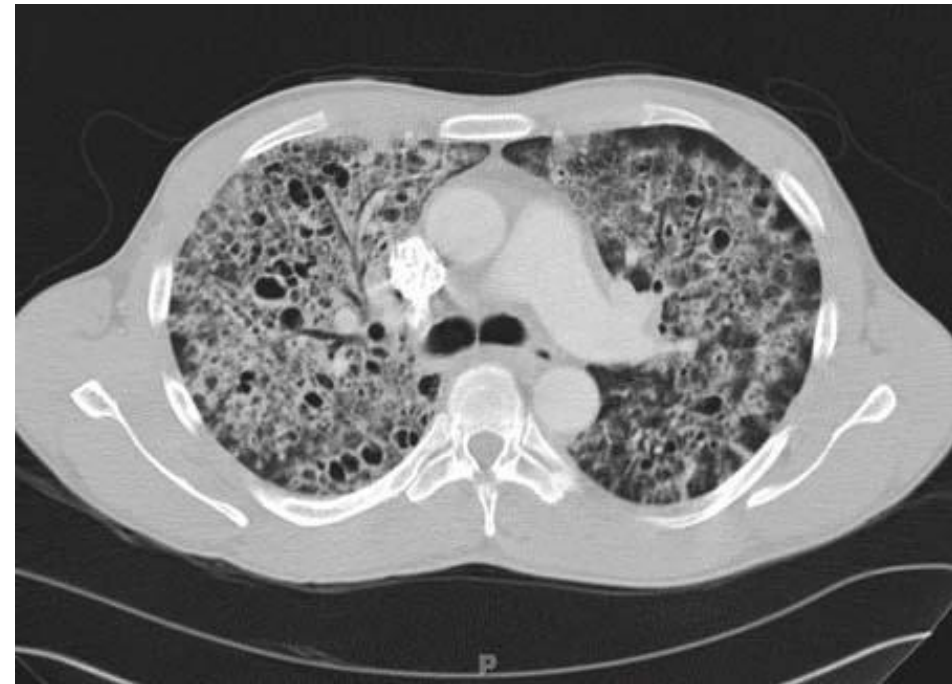


PJP pneumonia



SOB

PJP pneumonia



fever, SOB

CMV pneumonia



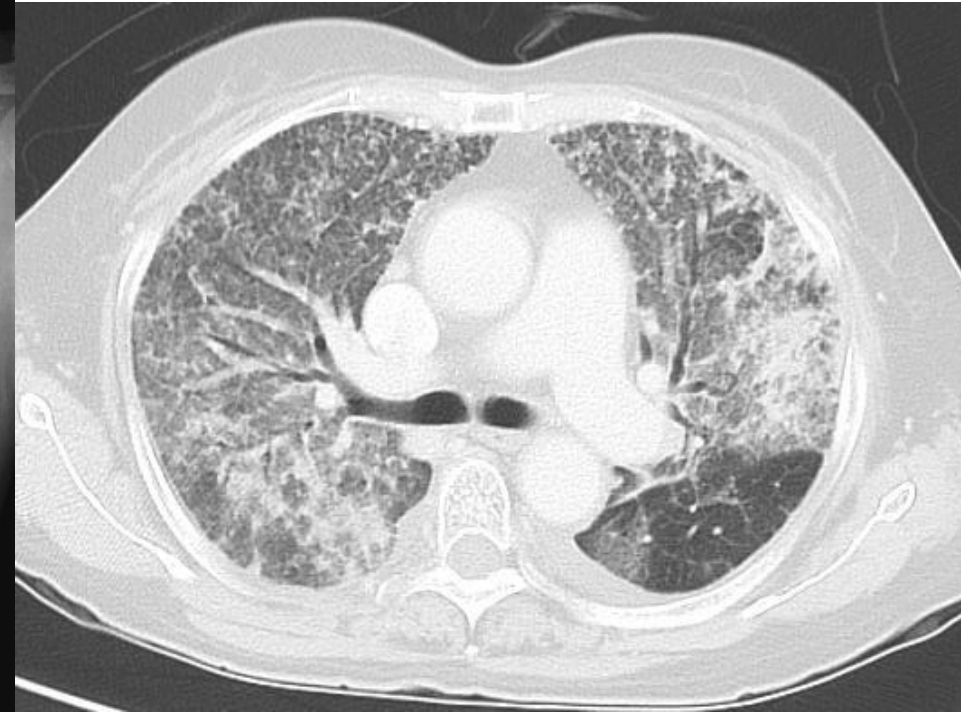
Bilateral reticular, GGO, consolidations

Goodpasture syndrome with pulmonary hemorrhage

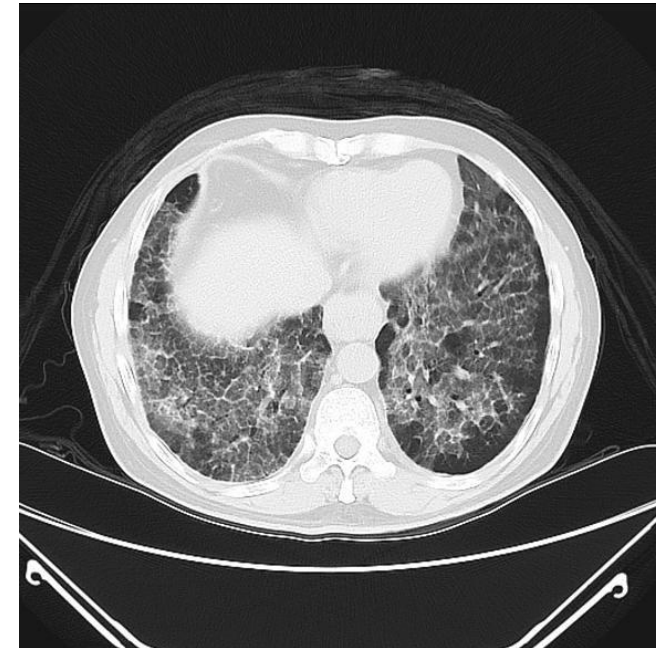
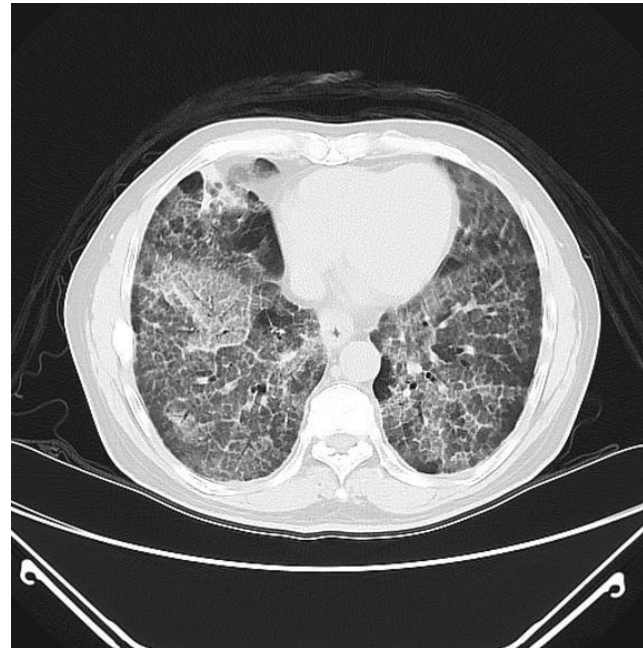
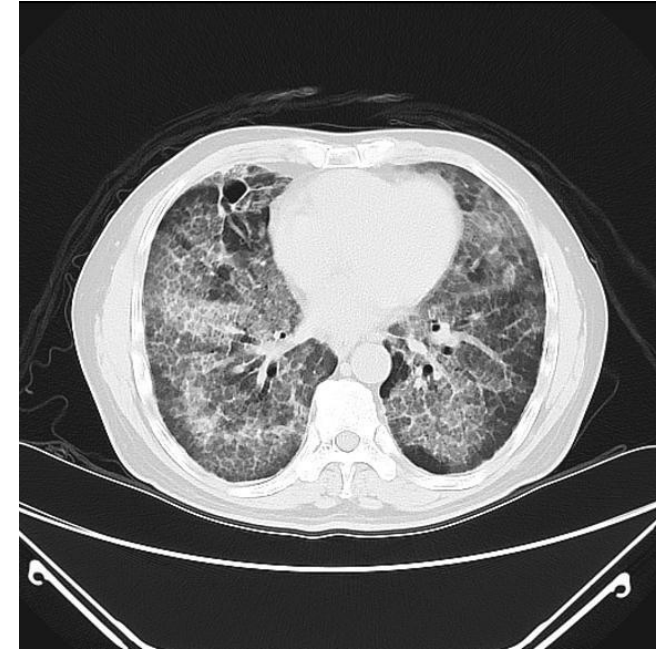
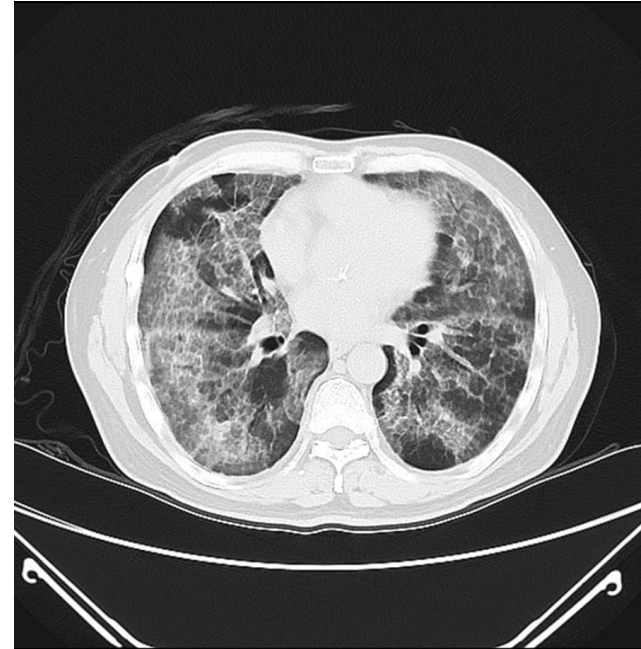


Massive hemoptysis(+)

Pulmonary hemorrhage (Idiopathic thrombocytopenia)

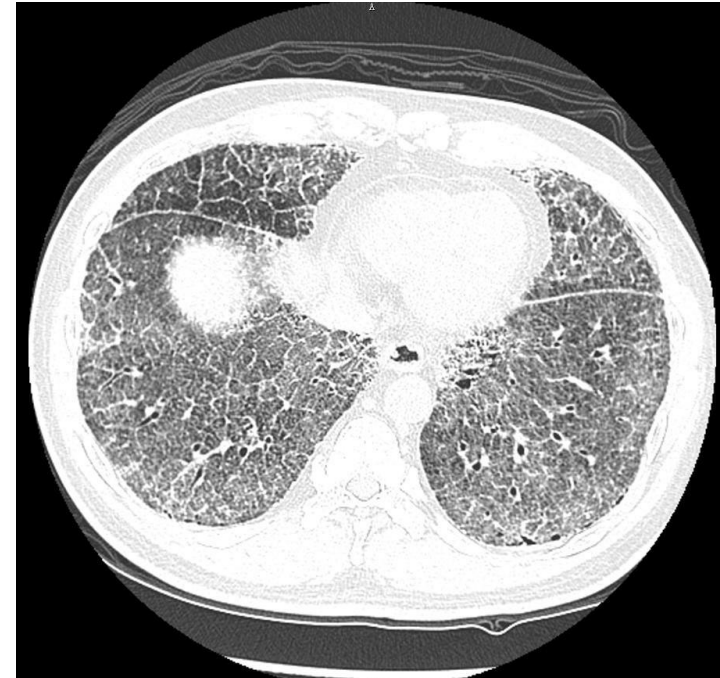
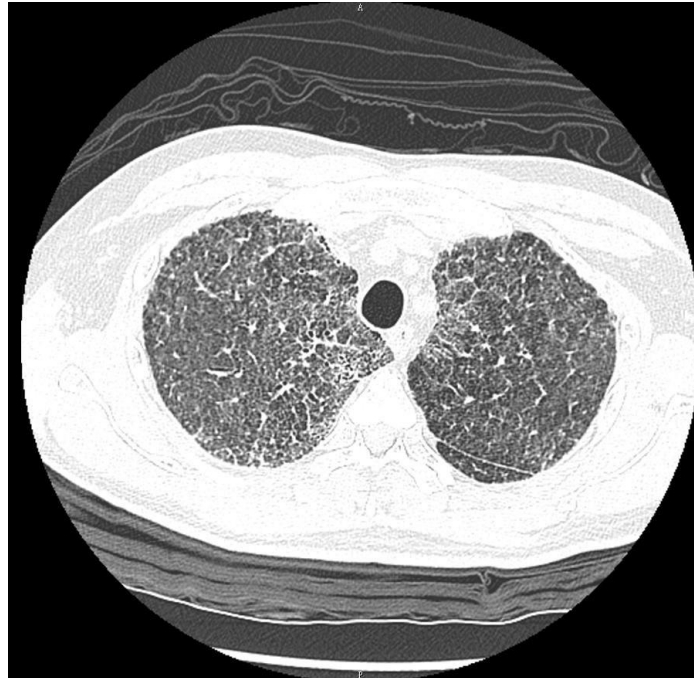


Pulmonary alveolar proteinosis (crazy paving)



Alveolar microlithiasis

- Tiny fragments (microliths) of calcium phosphate gradually accumulate in the alveoli
- Impaired activity of the SLC34A2 gene -- phosphate transport
- CXR: bilateral **diffuse micronodular calcifications (sandstorm)**; first involves the lower and then the middle and upper lungs
- HRCT: diffuse hyperdense ground-glass attenuation and subpleural linear calcifications; **predominant in the inferior and posterior portions and medial aspects**



Alveolar microlithiasis

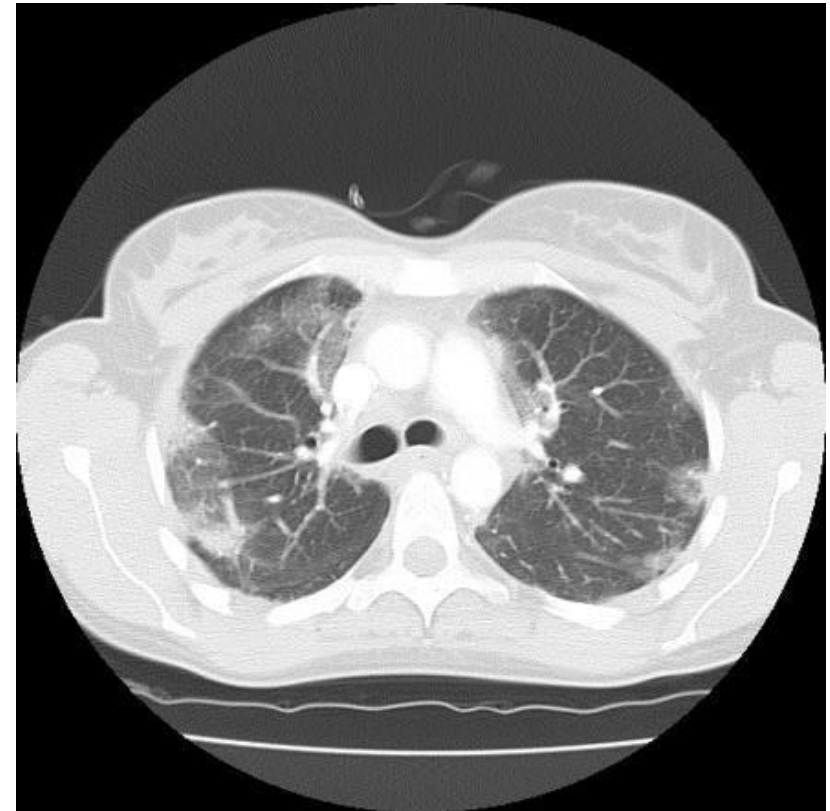


Differential diagnosis of batwing pulmonary opacities

- Pulmonary edema (cardiogenic)
- Overhydration /uremic lung
- Pneumonia
 - Aspiration pneumonia
 - Pneumocystis pneumonia (PCP)
 - Viral pneumonia
 - Lipoid pneumonia
- Inhalation injury
- Pulmonary hemorrhage (e.g. Goodpasture syndrome)
- Lymphoma/leukemia
- Adenocarcinoma
- Pulmonary alveolar proteinosis
- Microlithiasis

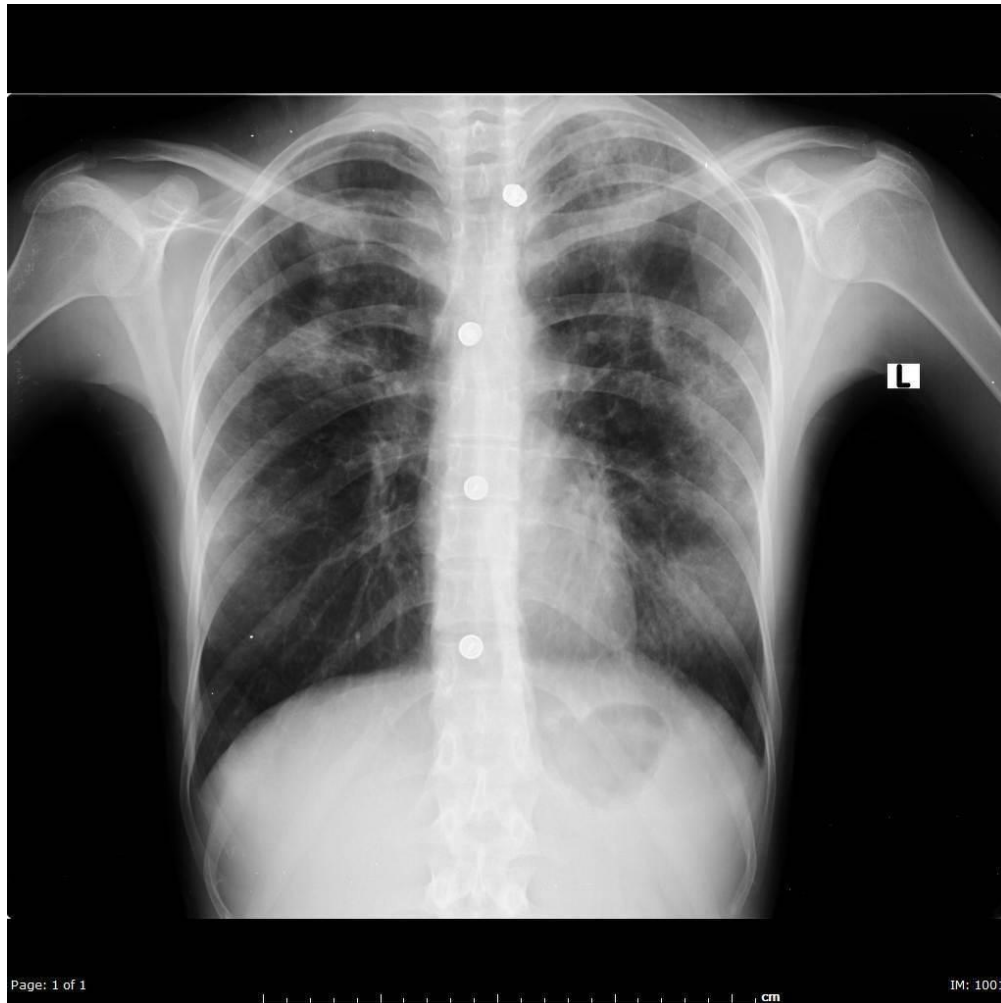
Reverse batwing pulmonary opacities

- Peripheral opacities of the lungs, sparing the perihilar region
- Common
 - **Chronic eosinophilic pneumonia (upper lung)**
 - **Organizing pneumonia**
- Rare
 - Pulmonary contusion
 - Pulmonary hemorrhage +/- infarction (pulmonary embolism)
 - Pulmonary vasculitis
 - Pneumonitis (radiation)
 - Sarcoidosis
 - Pulmonary adenocarcinoma

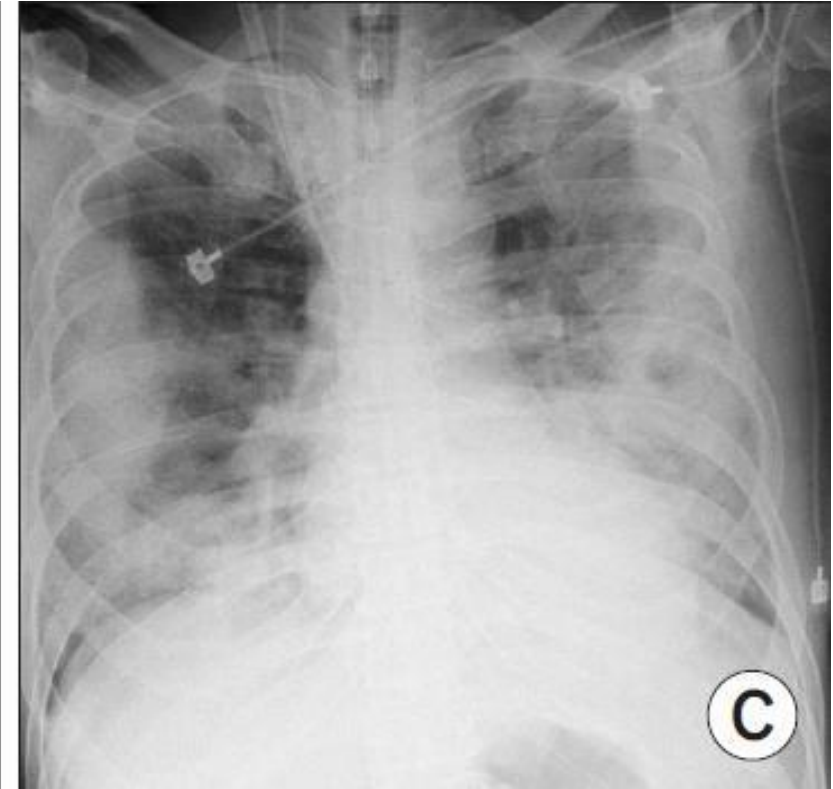
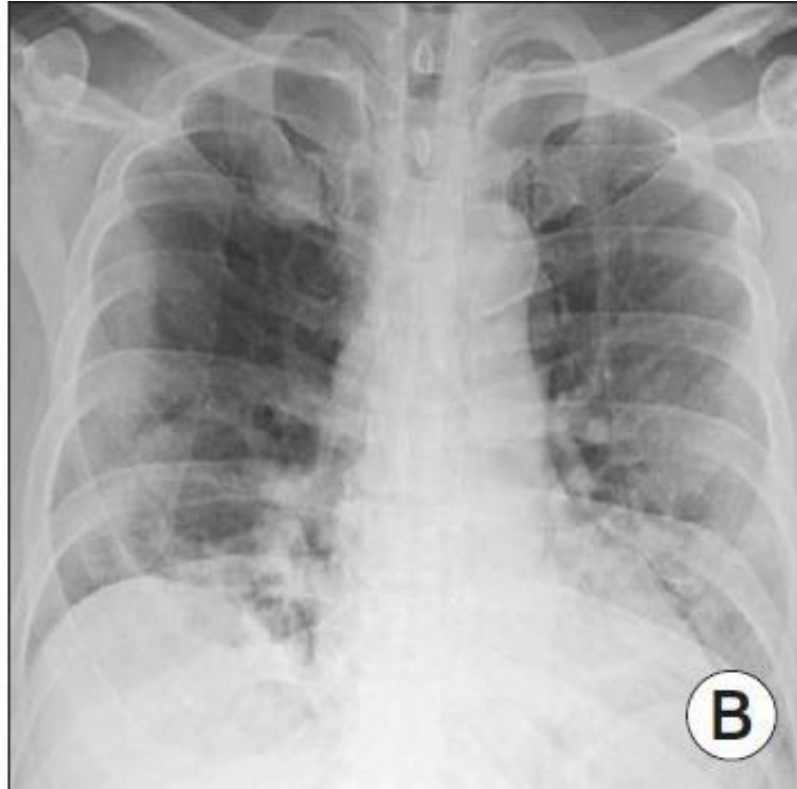


Organizing pneumonia

Chronic eosinophilic pneumonia



Organizing pneumonia



Reverse Batwing sign in COVID-19 pneumonia

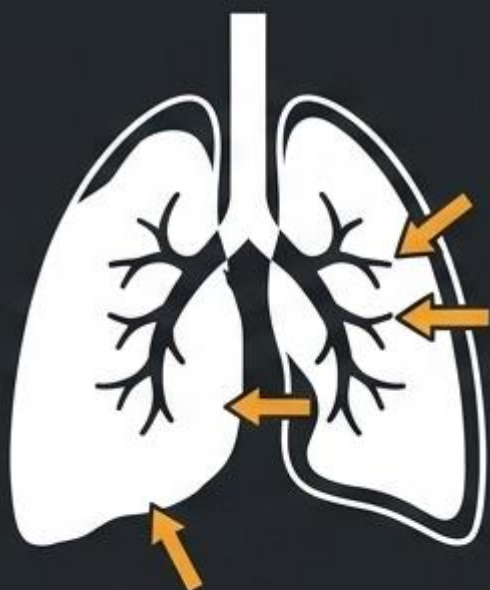
Lung atelectasis

The 5 Mechanisms of Volume Loss

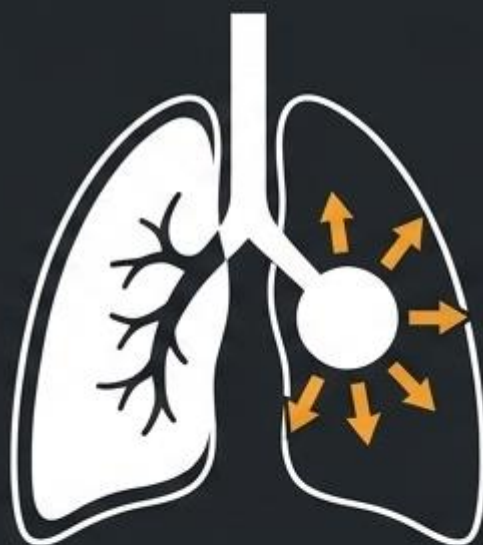
Collapse is always driven by specific physical forces.



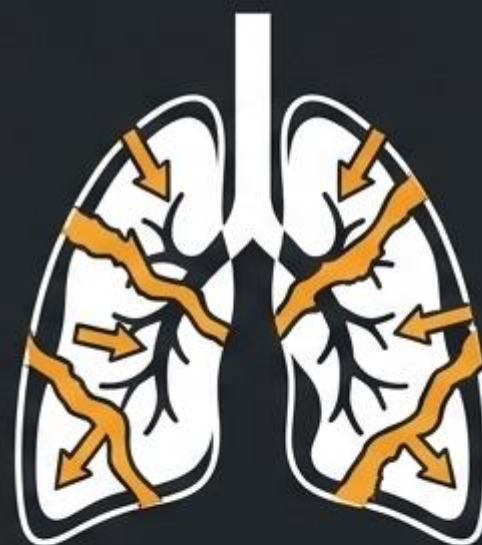
Obstructive
(Resorptive)



Passive
(Extrapulmonary)



Compressive
(Intrapulmonary)



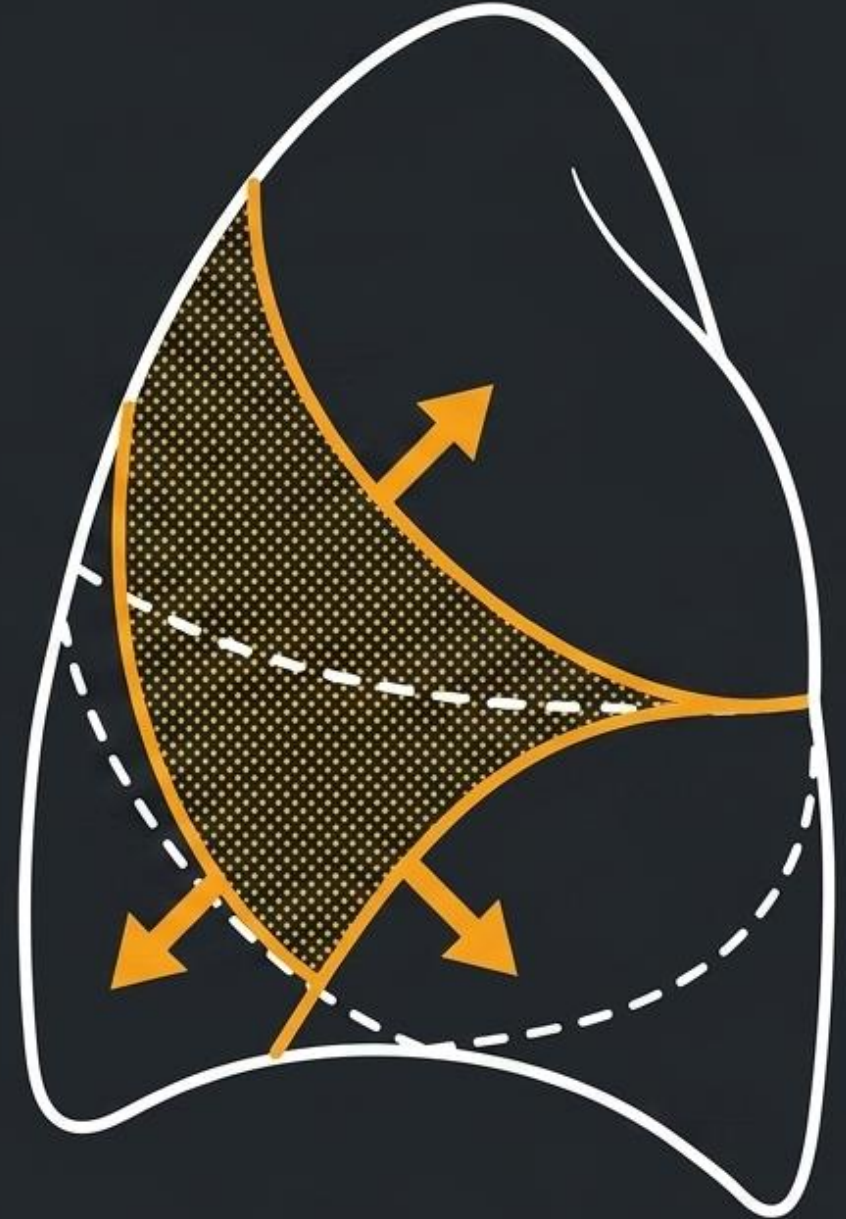
Cicatricial



Adhesive

Radiographic Hallmarks: Direct Signs

- **Increased Opacity:** Deflated tissue becomes dense.
- **Fissure Displacement:** The most reliable direct sign of lobar collapse.
- **Vascular Crowding:** Broncho-vascular markings bunch together as volume decreases.



Signs of lung collapse

Direct

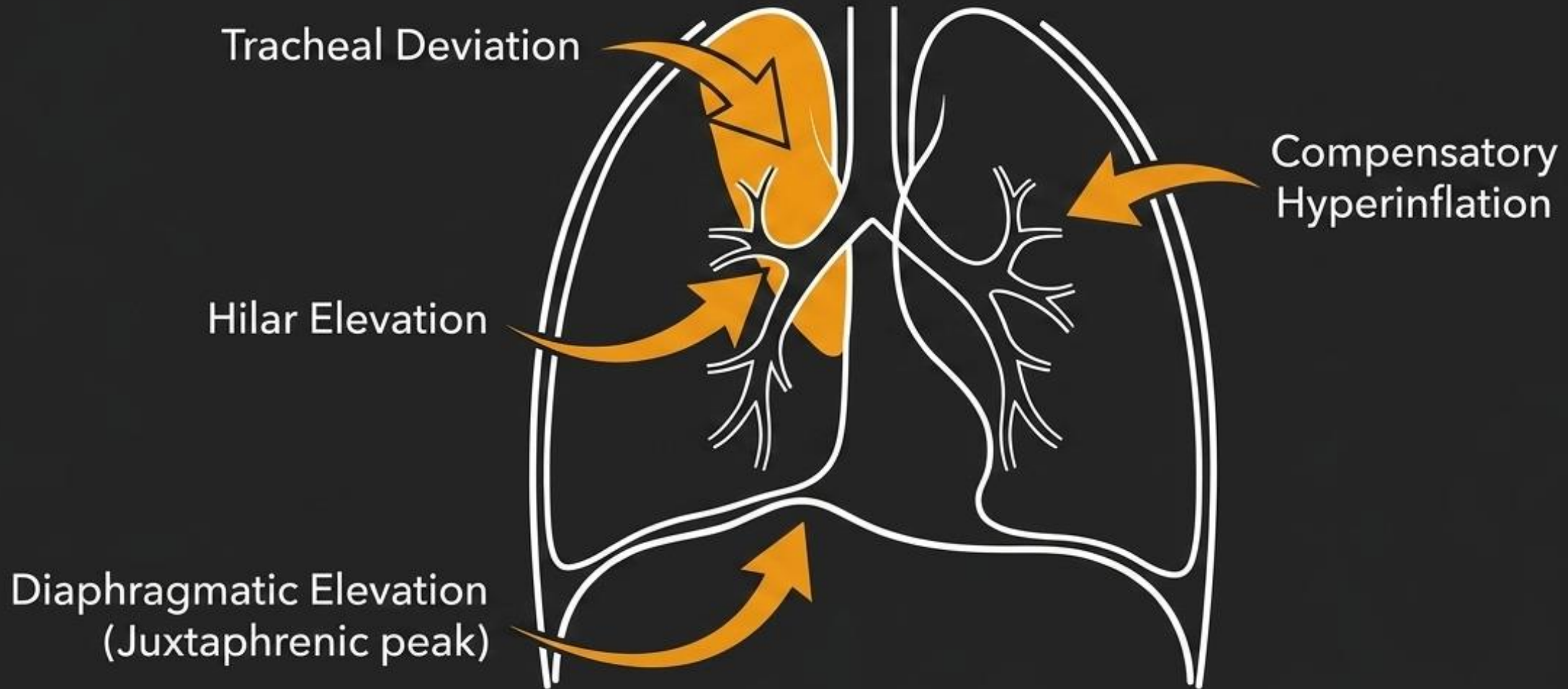
- Displacement of interlobar fissure
- Crowding of the broncho-vascular markings
- Increased lung opacity
- Luftsichel sign

Indirect

- Hilar displacement
- Mediastinal shift
- Diaphragmatic elevation
- Rib approximation
- Compensatory hyperinflation
- Juxtaphrenic peak
- Superior triangle sign

Radiographic Hallmarks: The Vacuum Effect

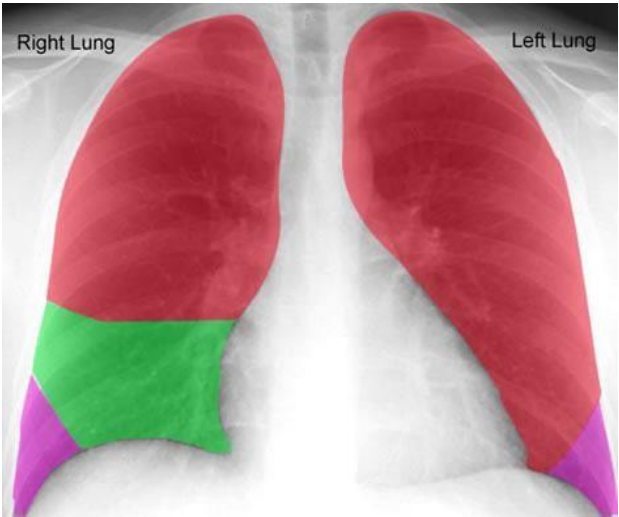
The thorax is a closed system. When a lobe loses volume, surrounding structures are forcefully dragged into the void to compensate.



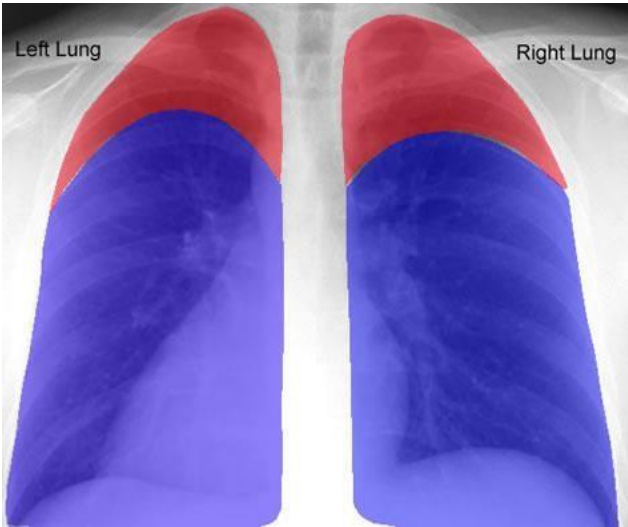
CXR anatomy

Lobes

A

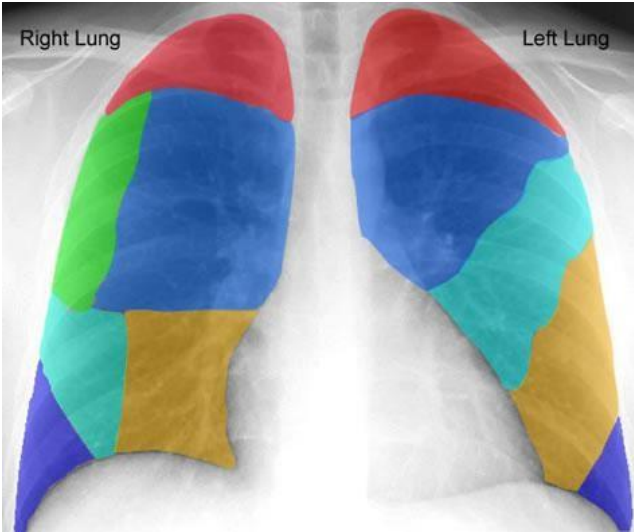


P

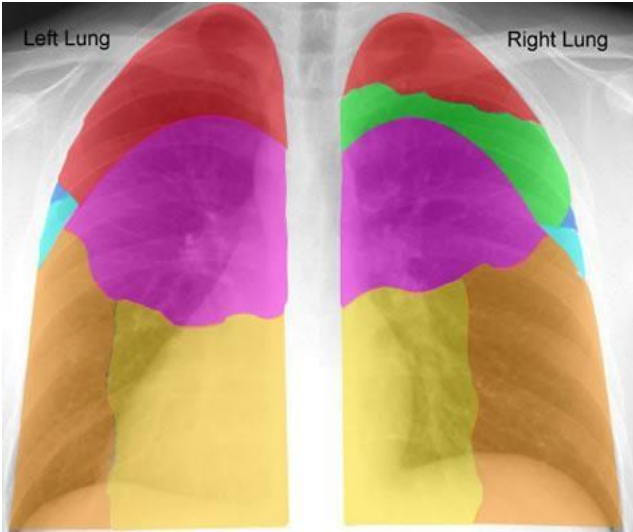


Segments

A



P



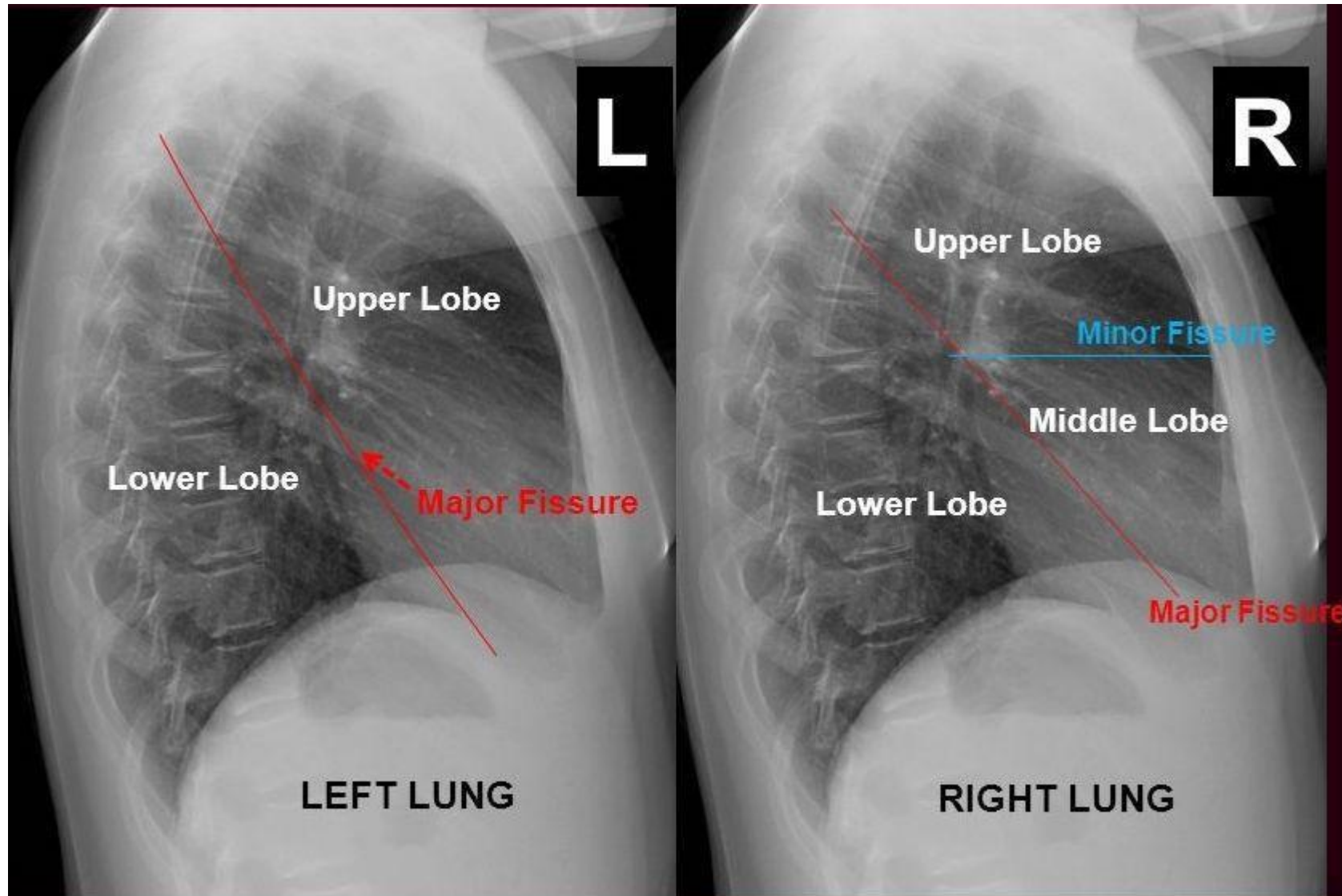
• **Right Lung containing:**

- Upper Lobe: Apical Segment
- Upper Lobe: Posterior Segment
- Upper Lobe: Anterior Segment
- Middle Lobe: Lateral Segment
- Middle Lobe: Medial Segment
- Lower Lobe: Anterior Basal Segment

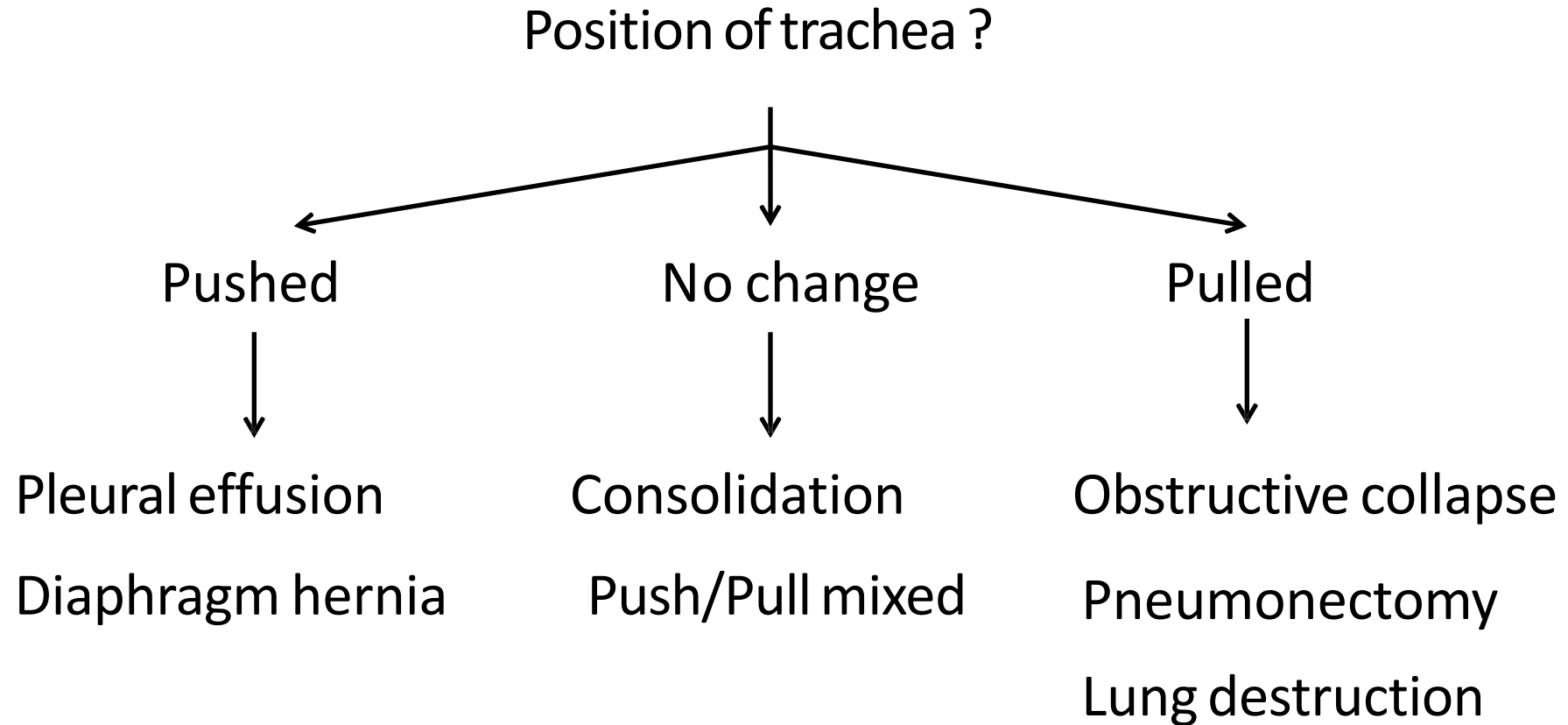
• **Left Lung containing:**

- Upper Lobe: Apical Posterior Segment
- Upper Lobe: Anterior Segment
- Upper Lobe: Lingula Superior Segment
- Upper Lobe: Lingula Inferior Segment
- Lower Lobe: Anteromedial Segment

CXR anatomy



DDx of complete opacification

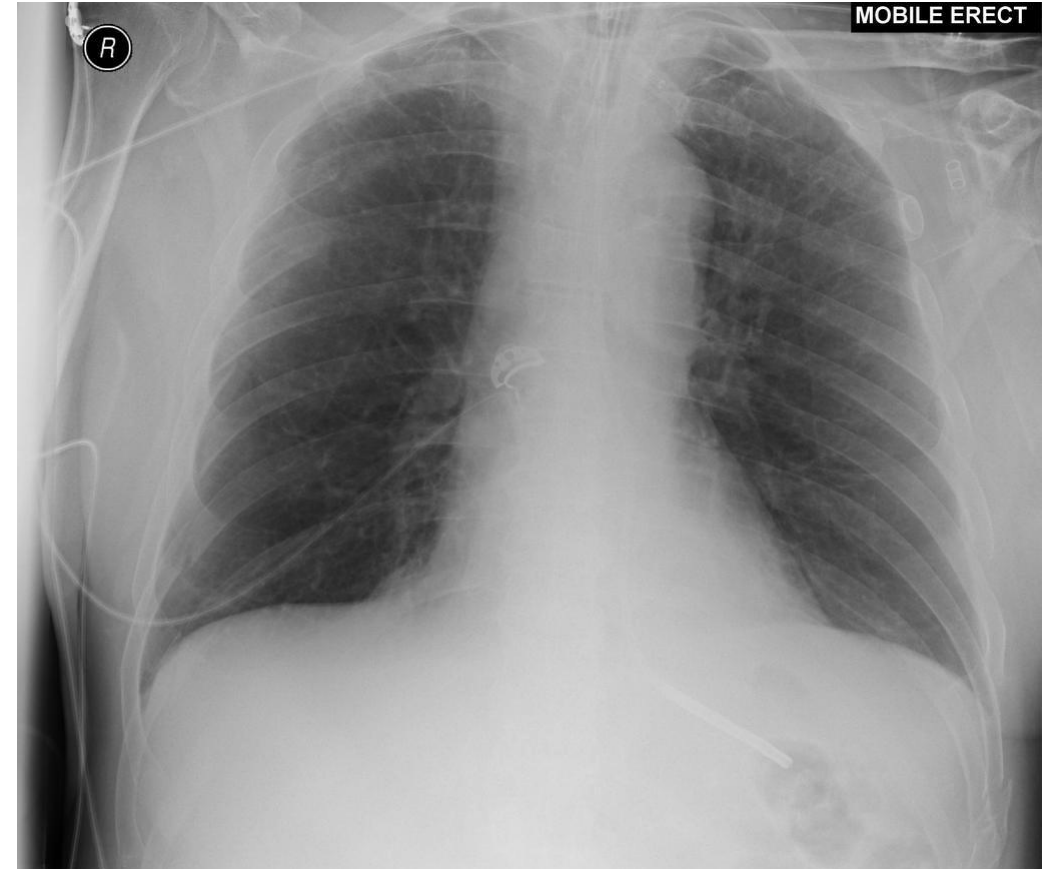
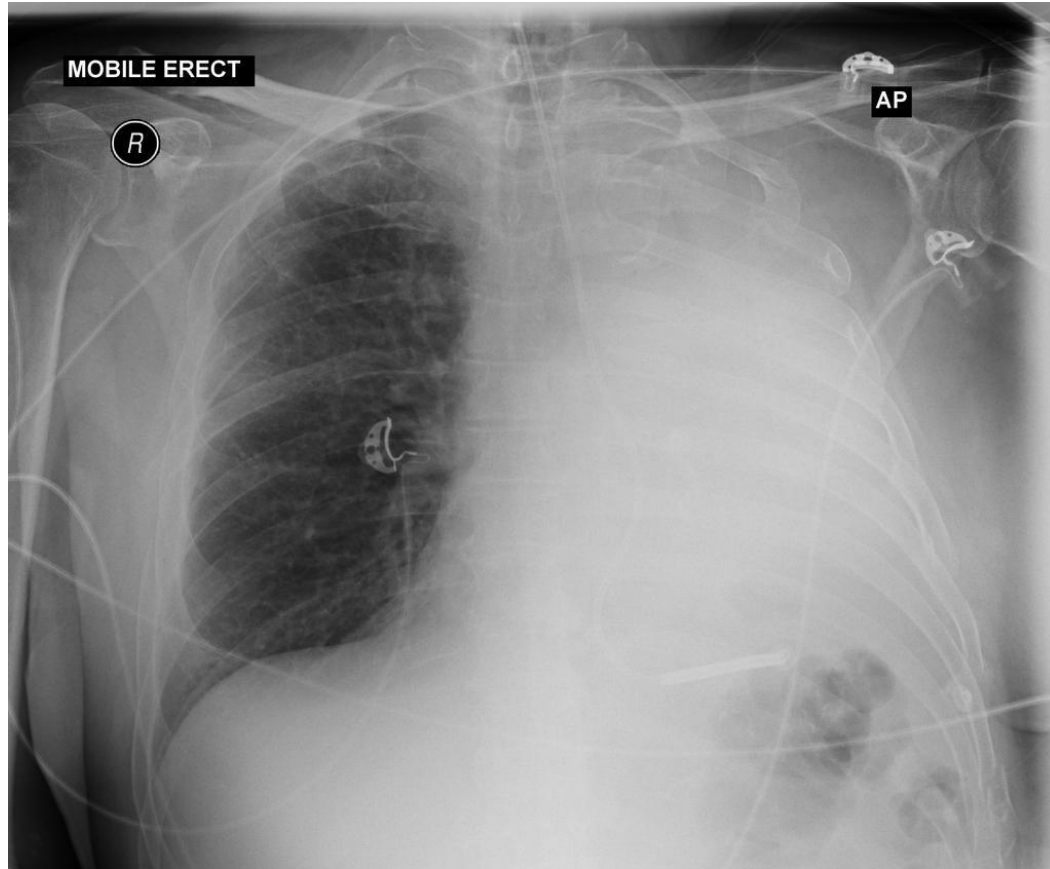


Main bronchus obstruction

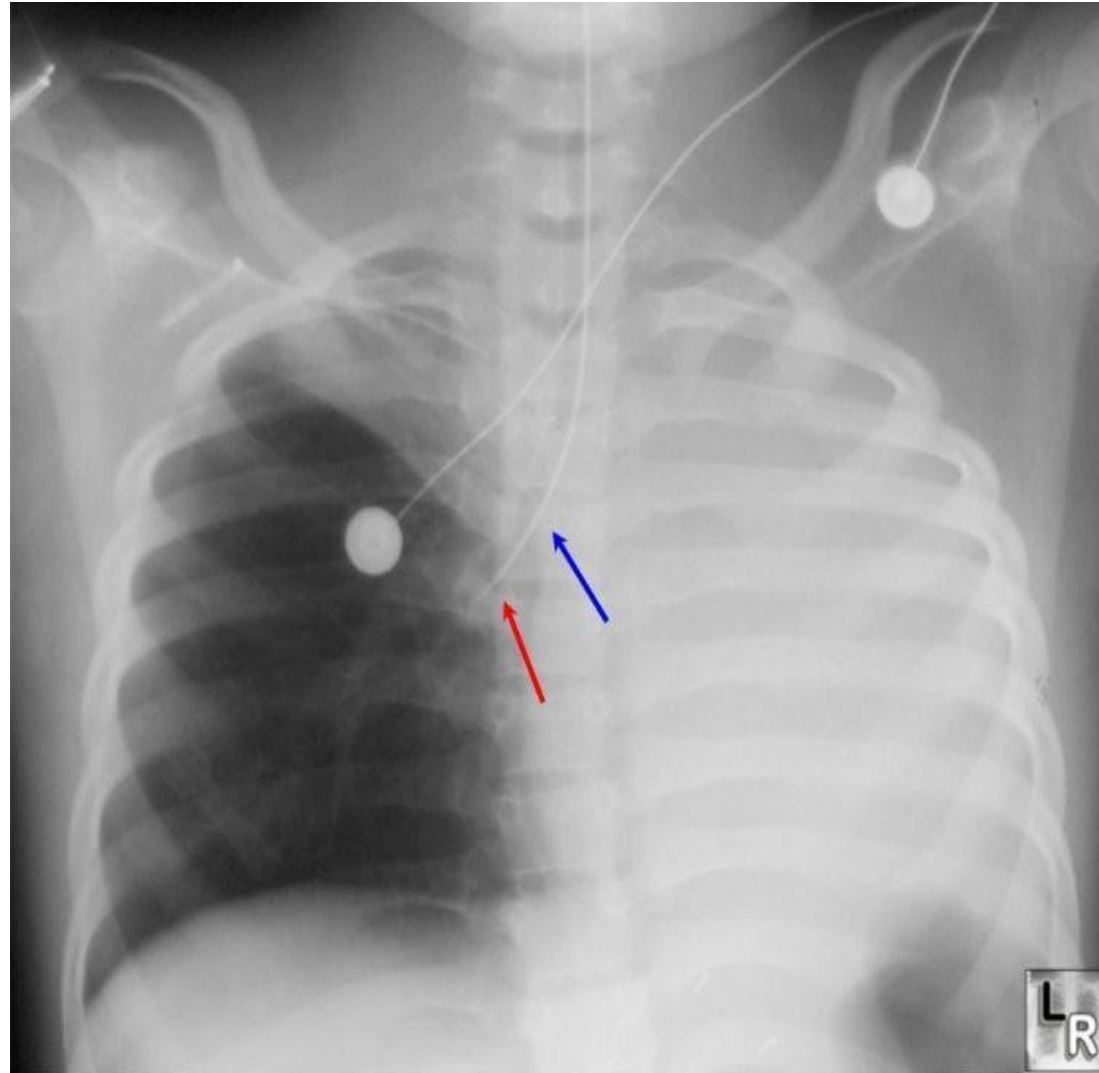


- Absence of air-bronchogram
- Mediastinal shift
- Rib approximation
- Compensatory hyperinflation
- Bronchial cutoff

Sputum impaction



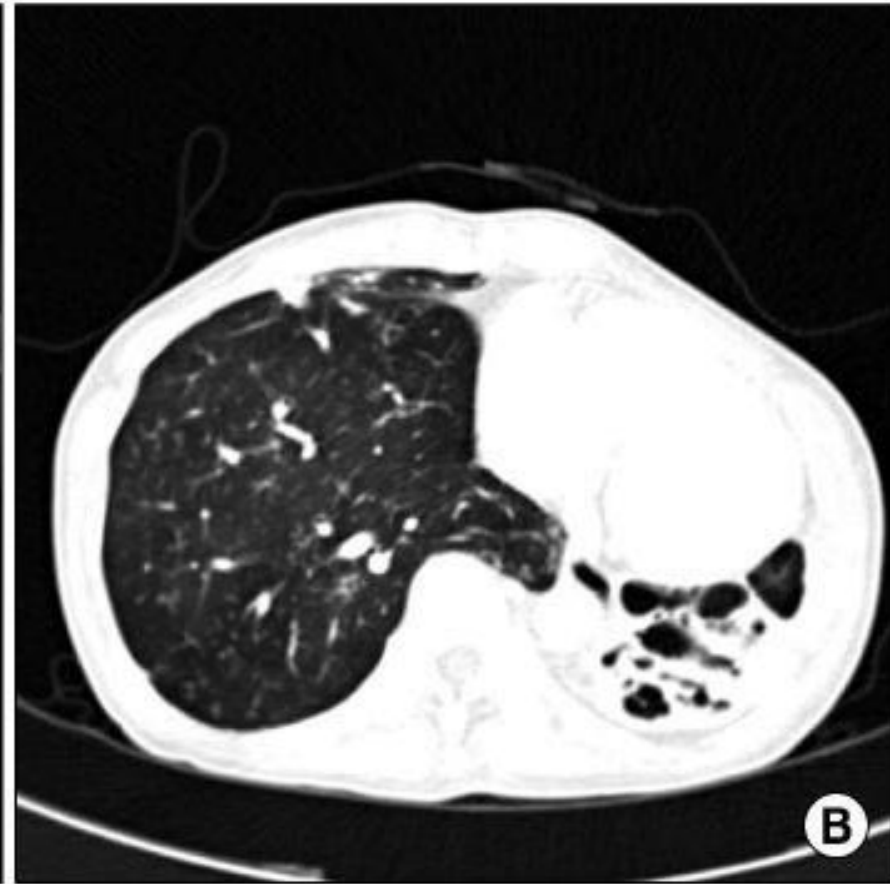
One lung intubation



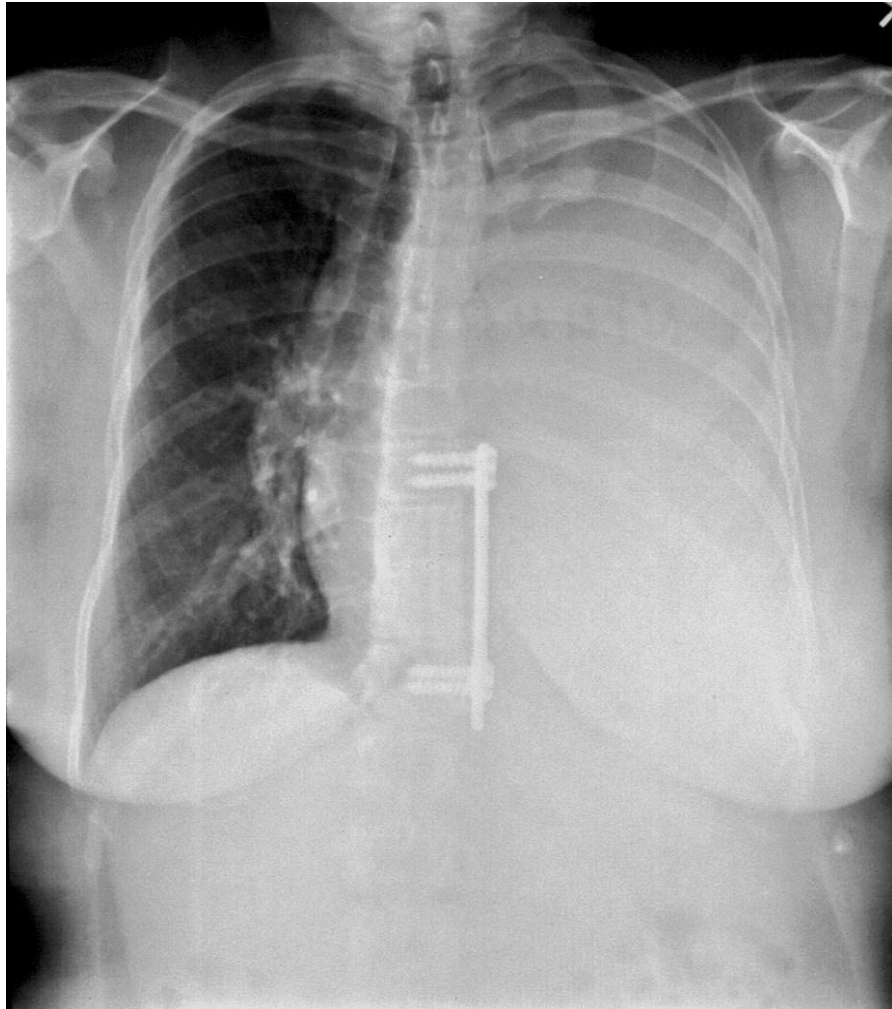
s/p pneumonectomy



Old TB with lung destruction



Massive pleural effusion

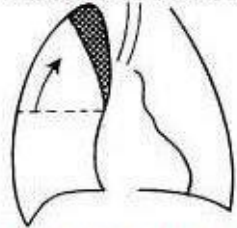


- Complete opacification of the ipsilateral hemithorax
- Absence of air-bronchogram
- Mediastinal shift to the opposite side

Lobar collapse

Right upper lobe collapse

Trachea deviated to R

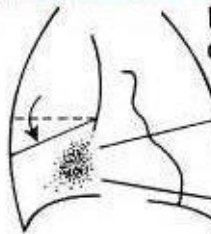


Horizontal fissure and R hilum displaced upwards

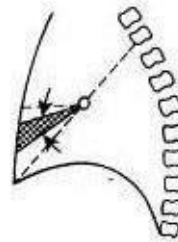


Triangular opacity with well-defined margins

Right middle lobe collapse

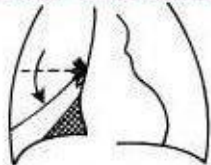


Horizontal fissure displaced down
Ill-defined opacity adjacent to R heart border
Loss of R heart border



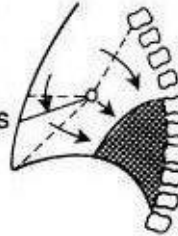
Well-defined triangular opacity running from hilum

Right lower-lobe collapse



Well-defined opacity adjacent to R heart border
(R heart border still visible)

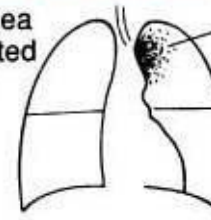
Horizontal fissure displaced downwards



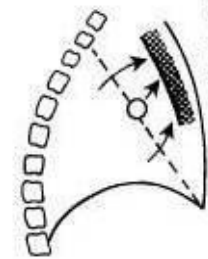
Oblique fissure and hilum displace posteriorly
Well-defined posterior opacity

Left upper-lobe collapse

Trachea deviated to L



Ill-defined opacity
Indistinct elevated L hilum

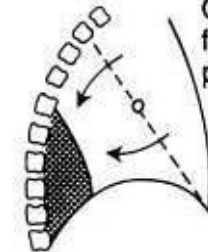


Sharply-defined posterior border due to anterior displacement of oblique fissure

Left lower-lobe collapse

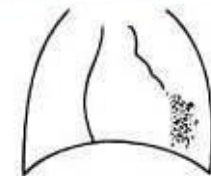


Triangular opacity visible through the heart with loss of medial end of diaphragm



Oblique fissure displaced posteriorly

Lingular consolidation

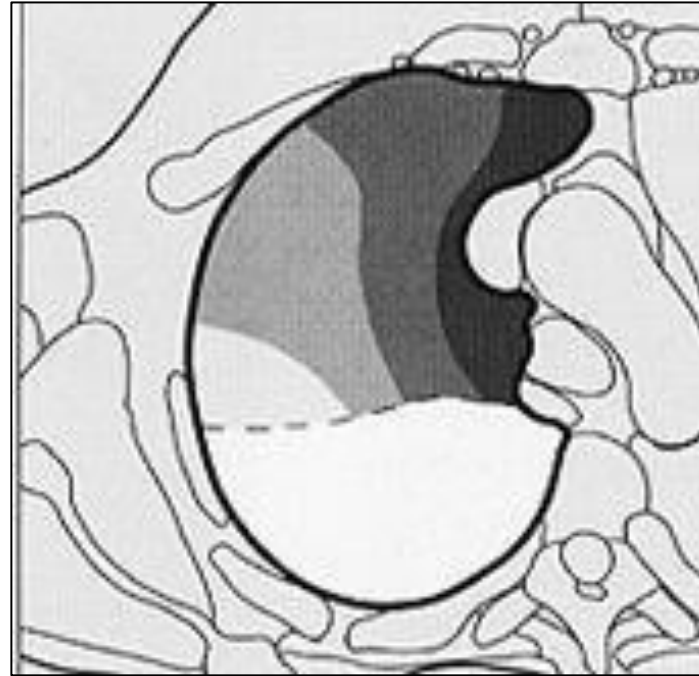
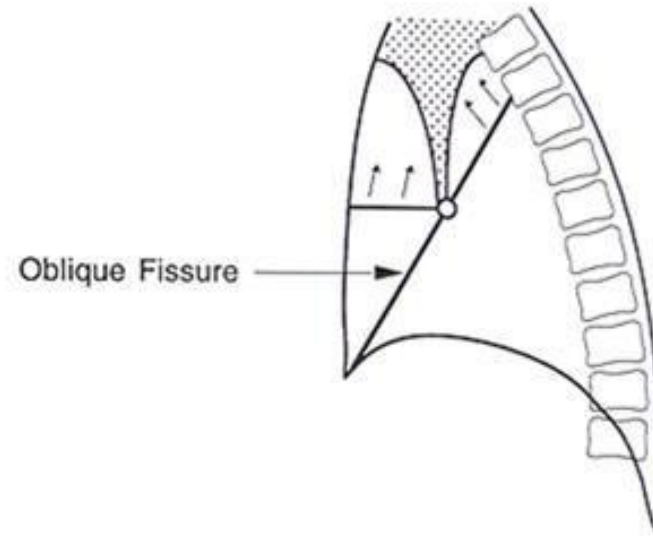
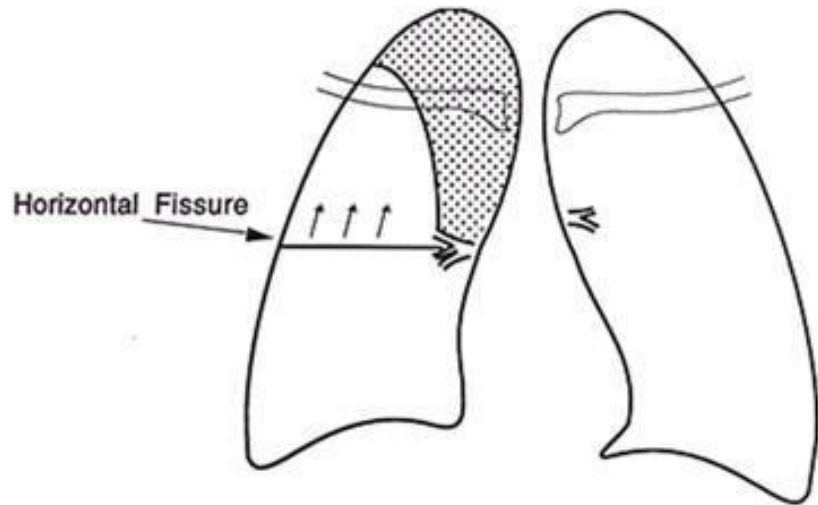


Indistinct L heart border

Silhouette sign and corresponding lung lobe involvement

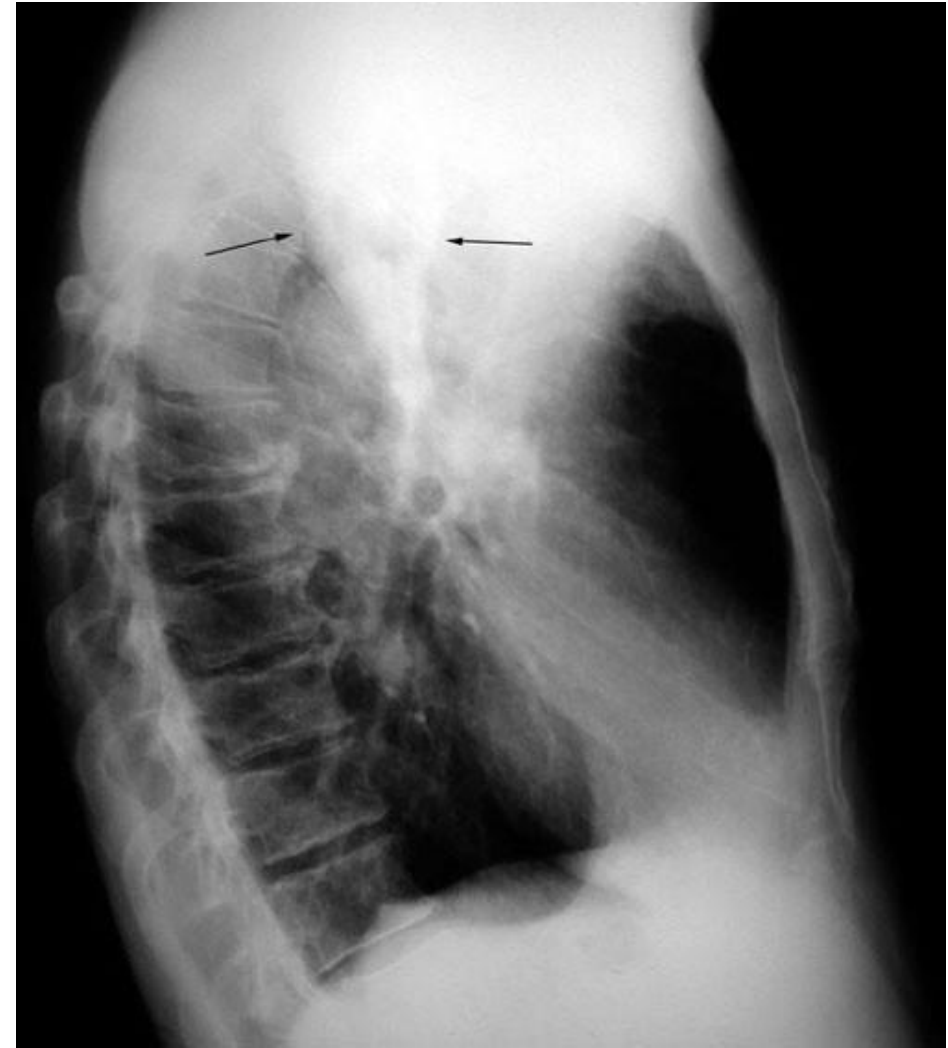
Obliterated Silhouette	Corresponding Lung Lobe
Right heart border	Right middle lobe
Left heart border	Lingula of the left upper lobe
Right hemidiaphragm	Right lower lobe
Left hemidiaphragm	Left lower lobe
Aortic arch	Left upper lobe (apicoposterior segment)
Ascending aorta, SVC	Right upper lobe (anterior segment)
Descending aorta (on lateral view)	Left lower lobe (posterior segment)

RUL collapse

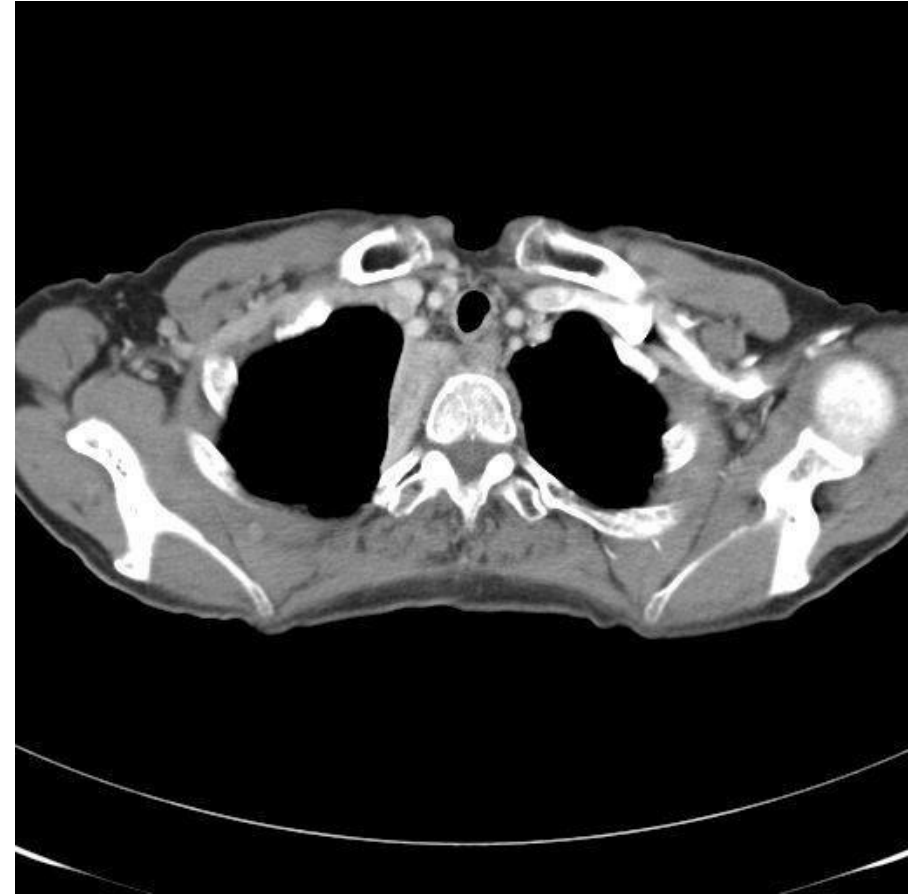


Features of RUL collapse

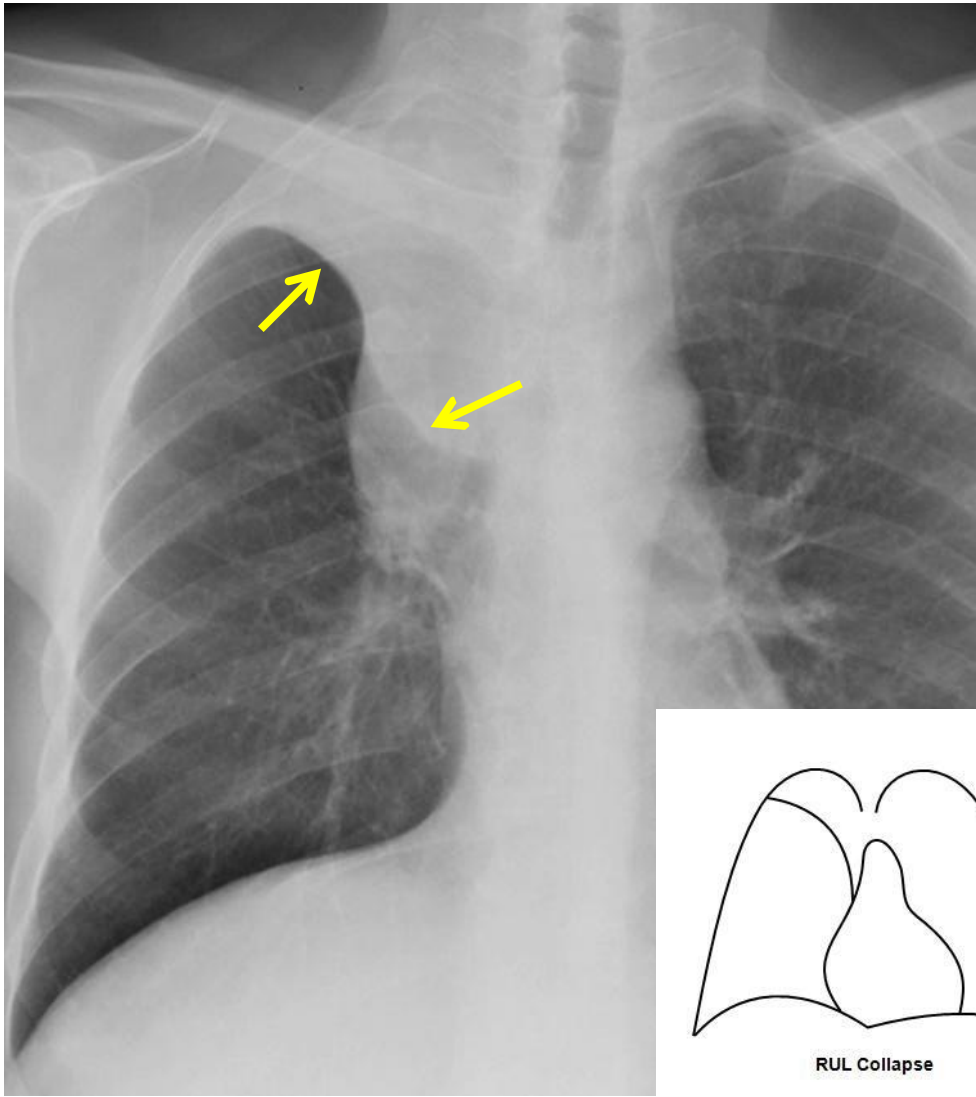
- Major and minor fissures move upward
- Minor fissure shows concave figure
- RUL packs against the mediastinum and lung apex
- Causes silhouette sign with SVC shadow
- Juxtaphrenic peak



Elevated hilum



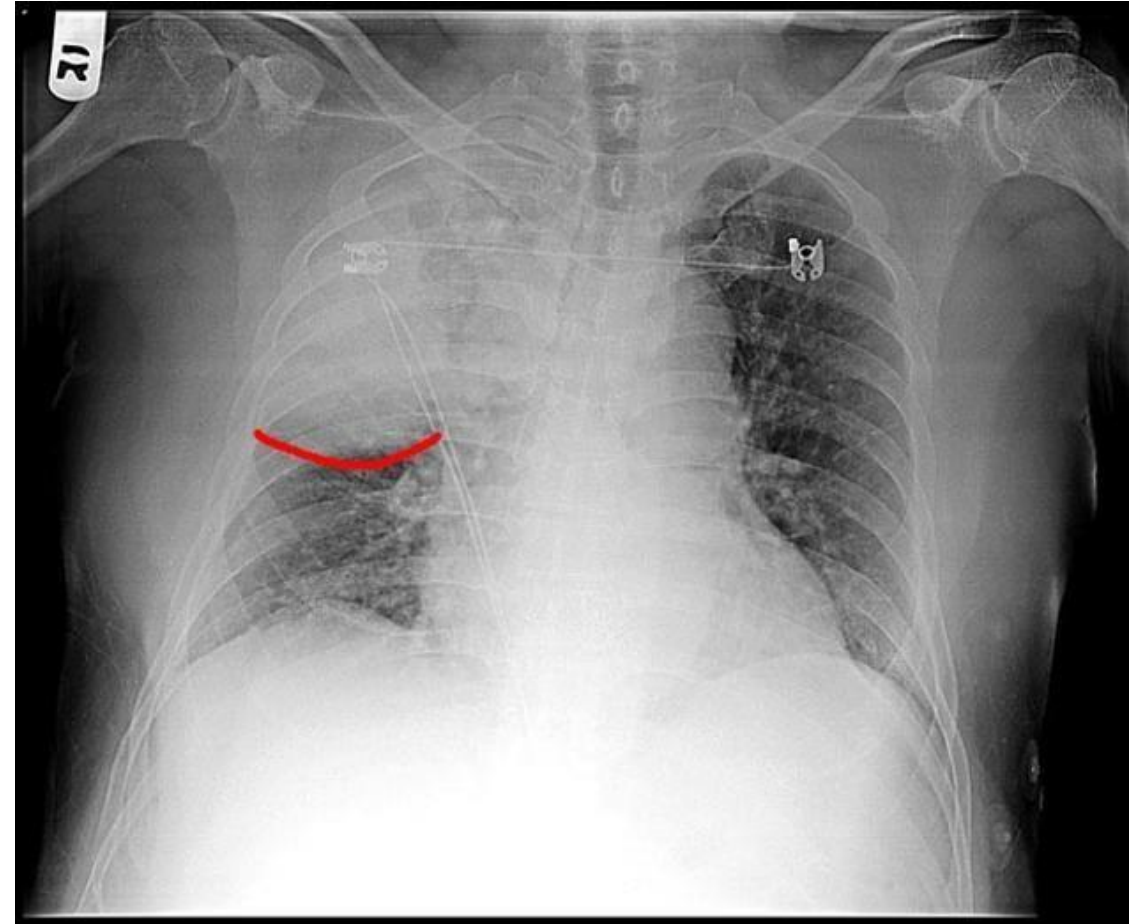
Golden S sign- RUL collapse



DDx -- RUL mass

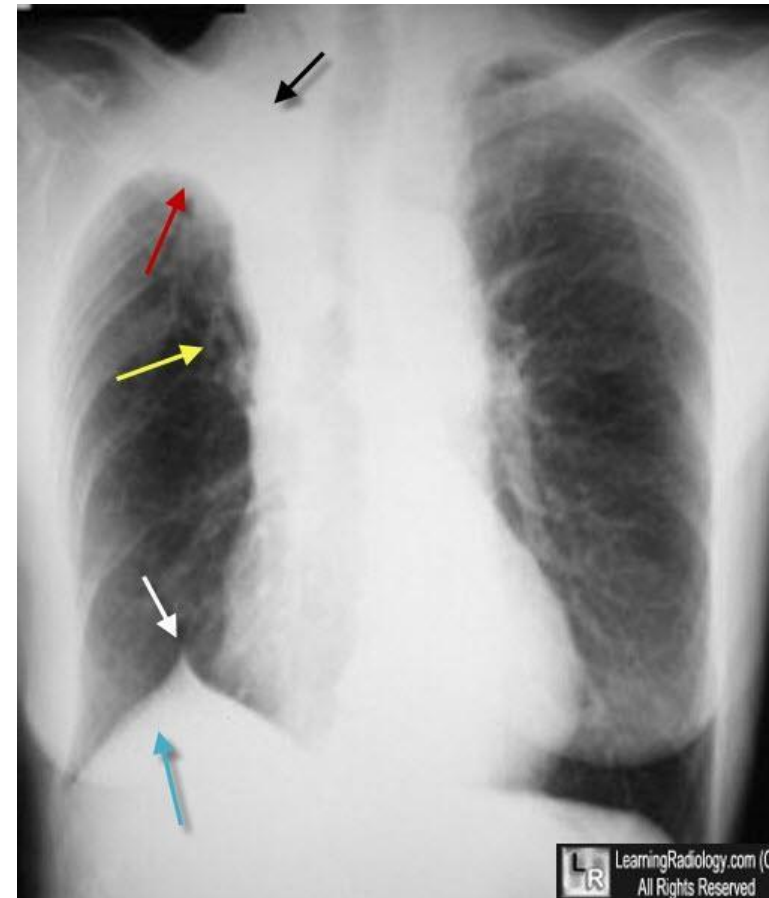
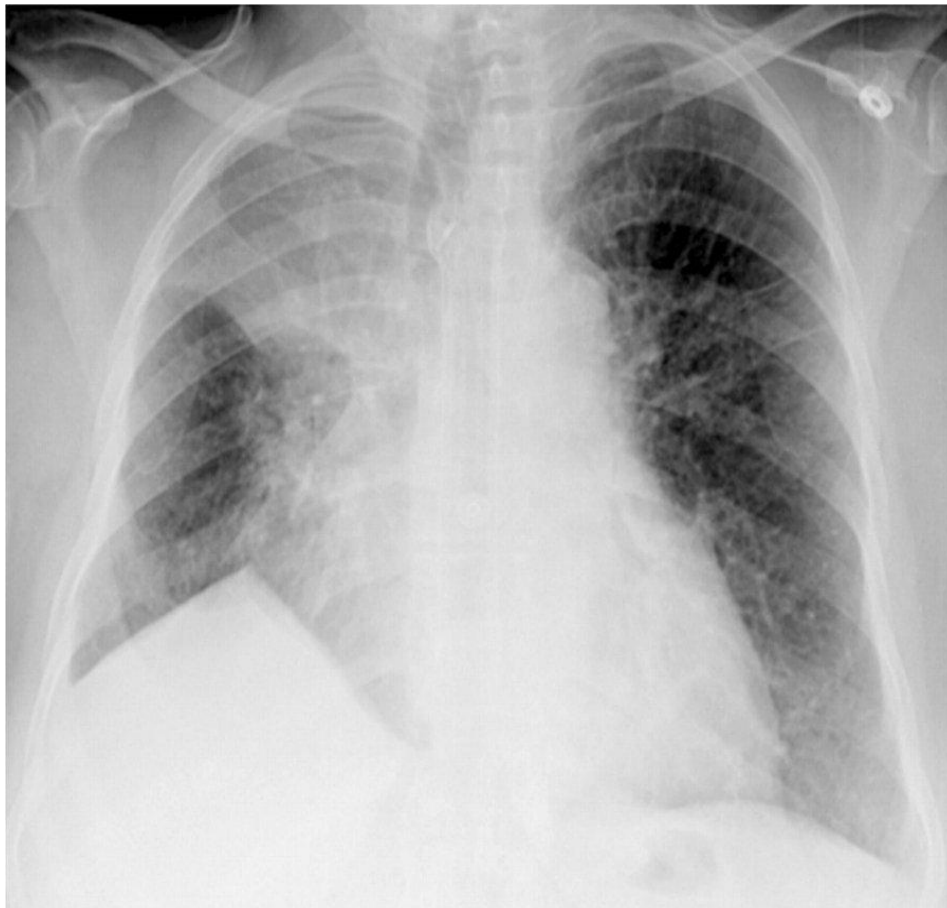


DDx -- RUL consolidation

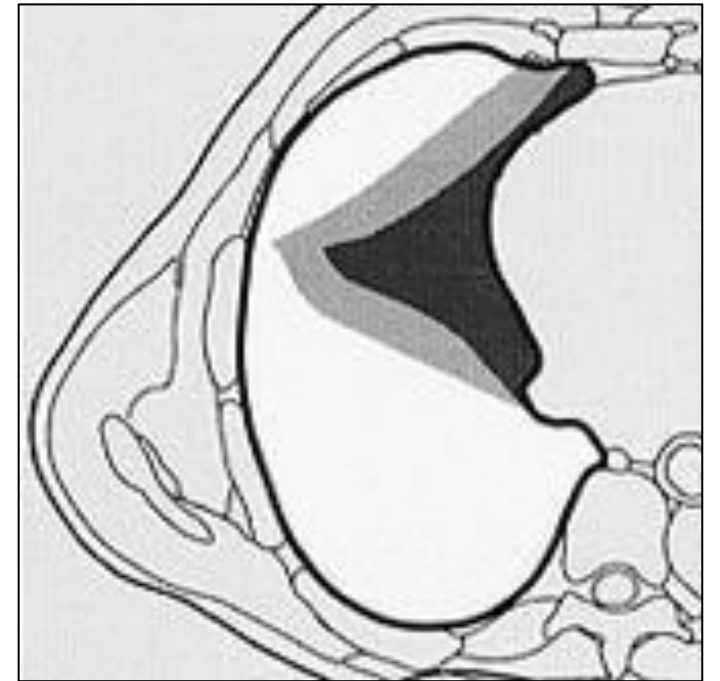
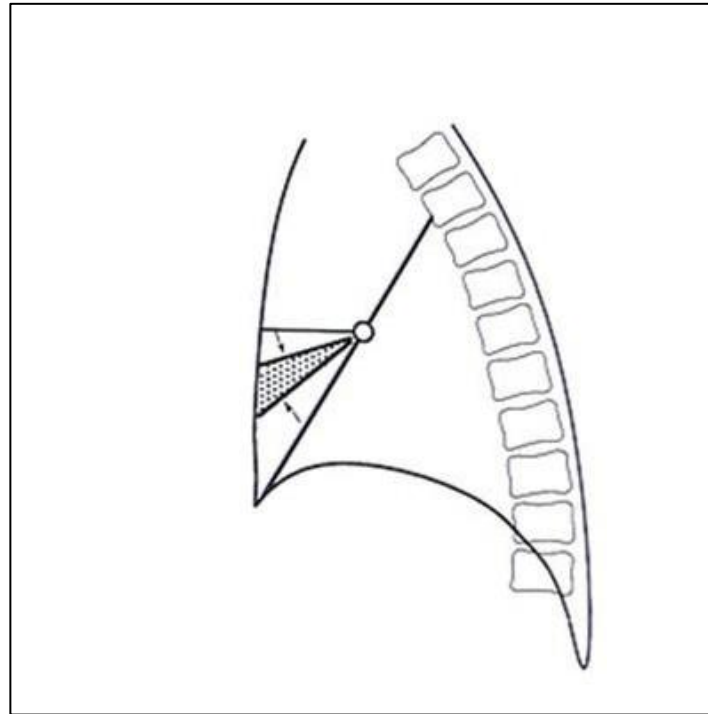
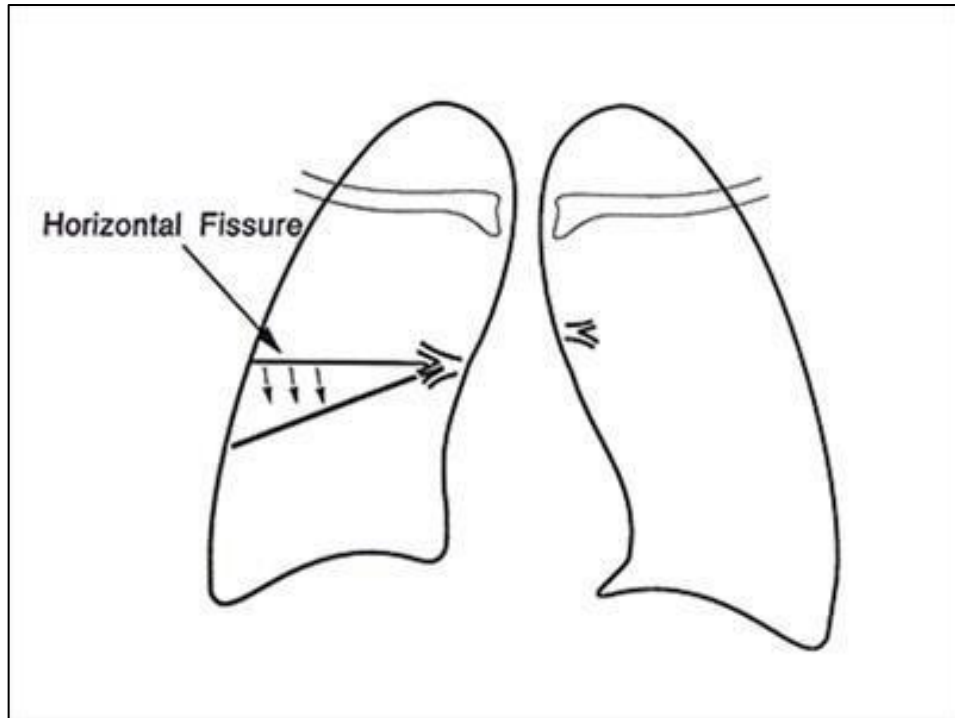


Juxtaphrenic peak

- Retraction of the diaphragm at an inferior accessory fissure (most common), major fissure, or inferior pulmonary ligament



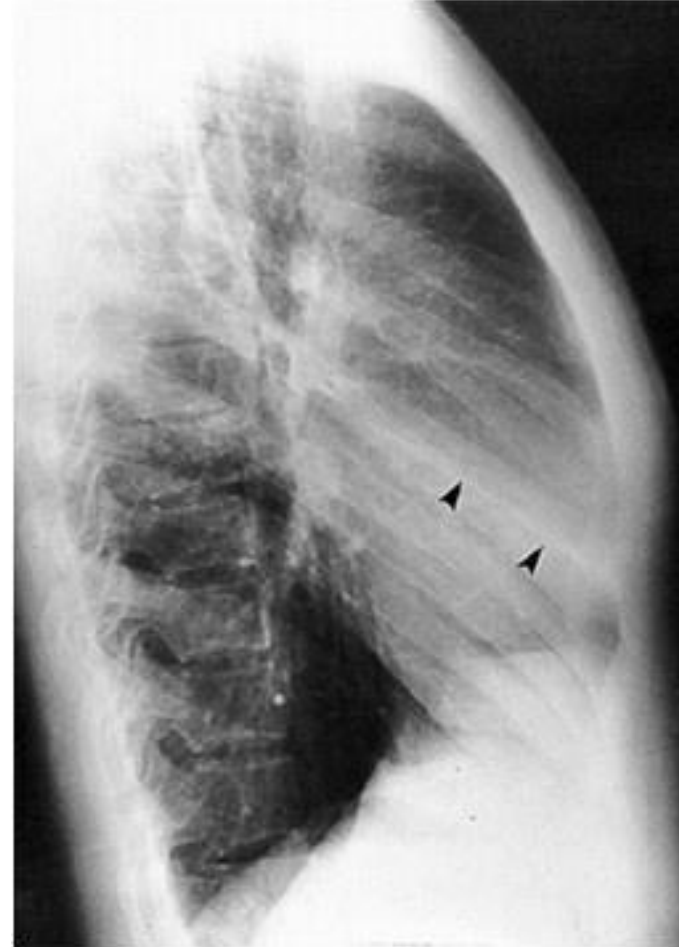
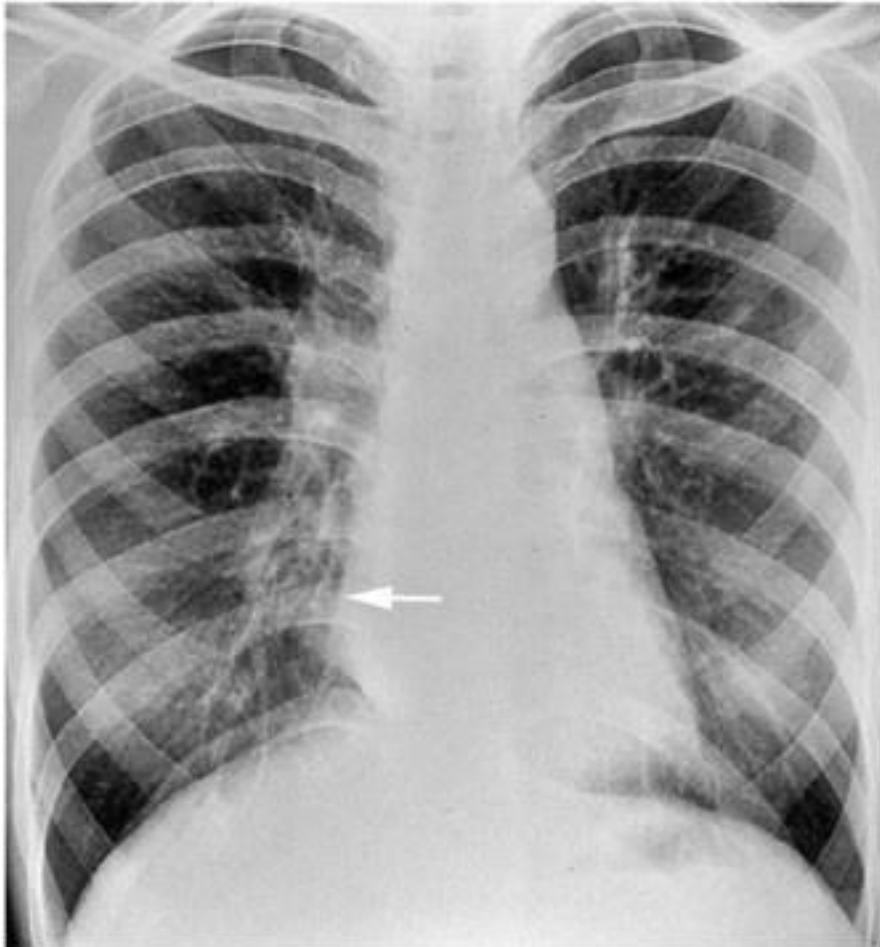
RML collapse



Features of RML collapse

- Minor fissure is no longer visible
- Obscuration of right heart border
- Increased opacity adjacent to the right heart border

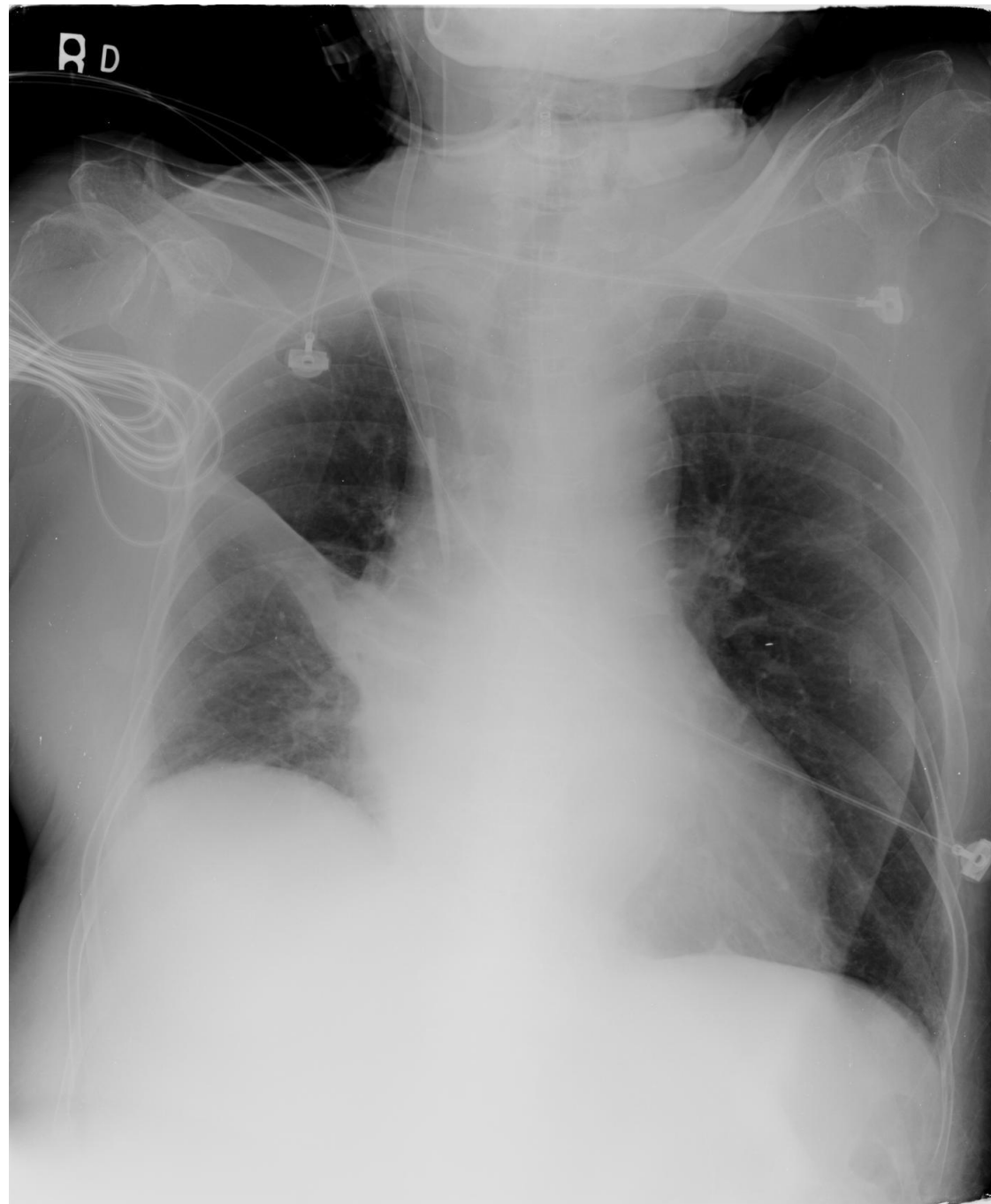
RML collapse



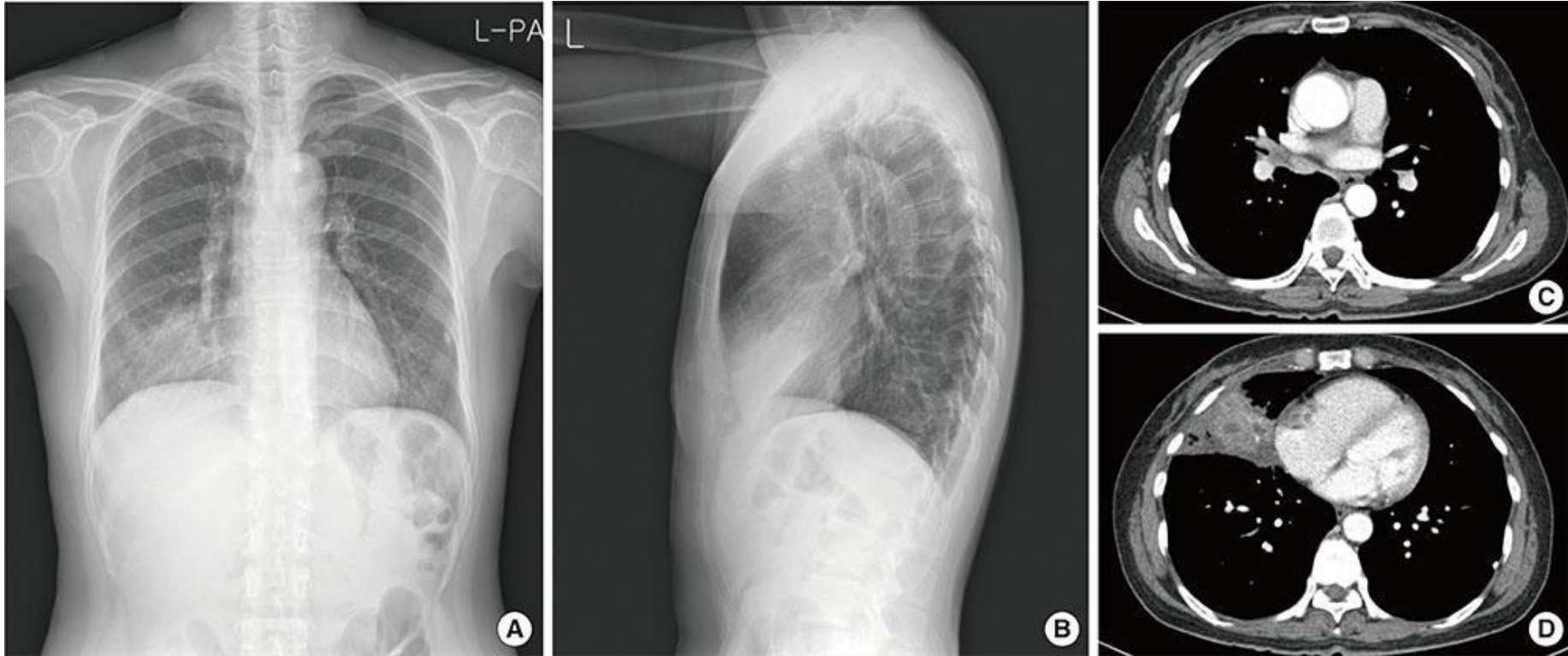
RML collapse



RML collapse

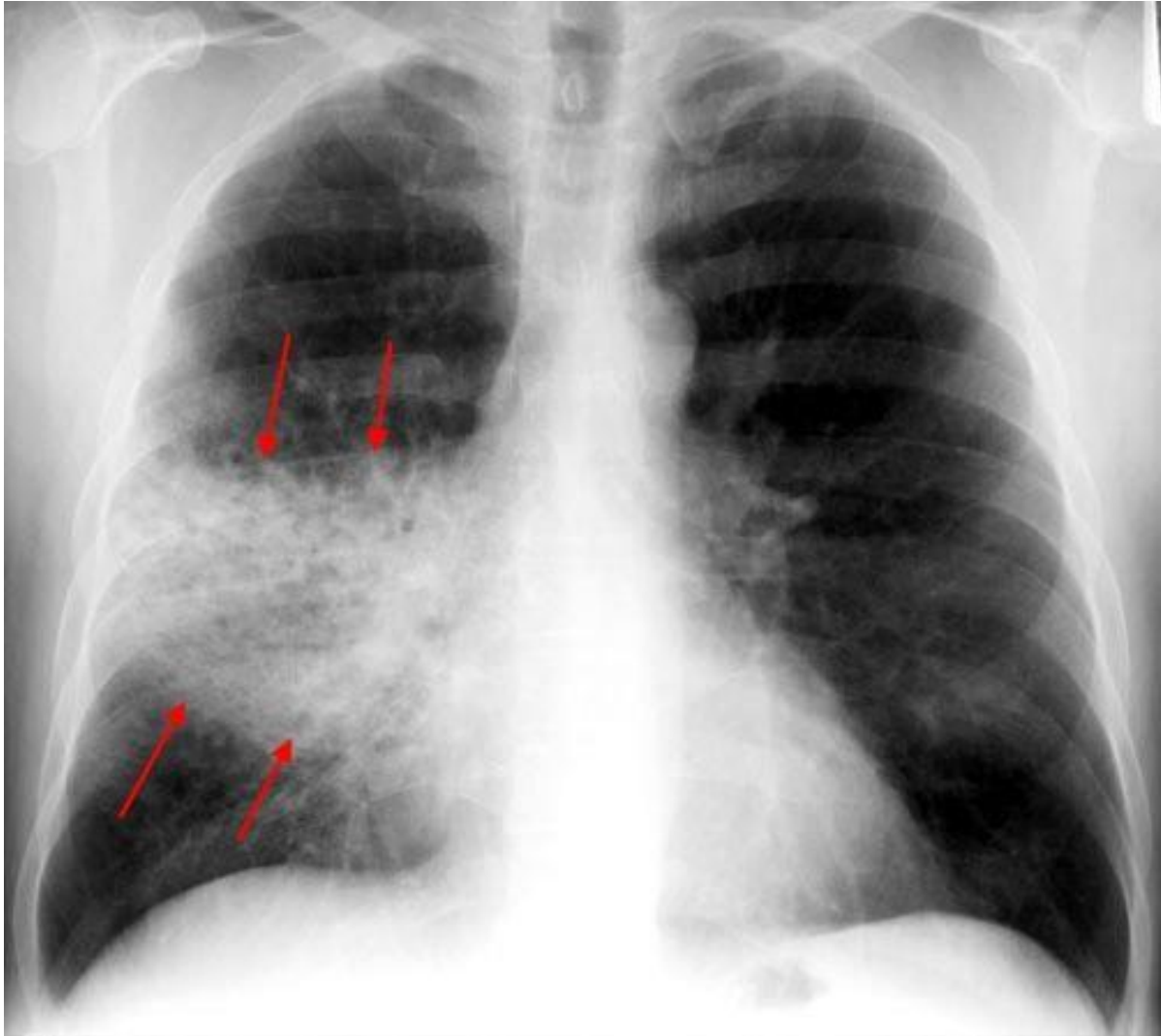


RML syndrome

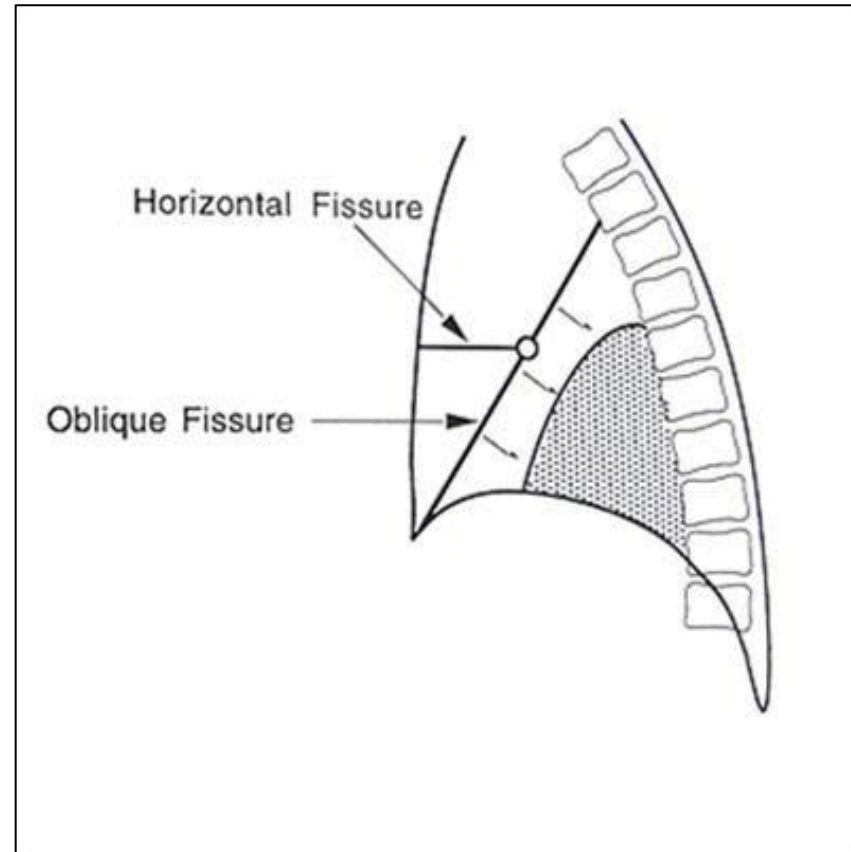
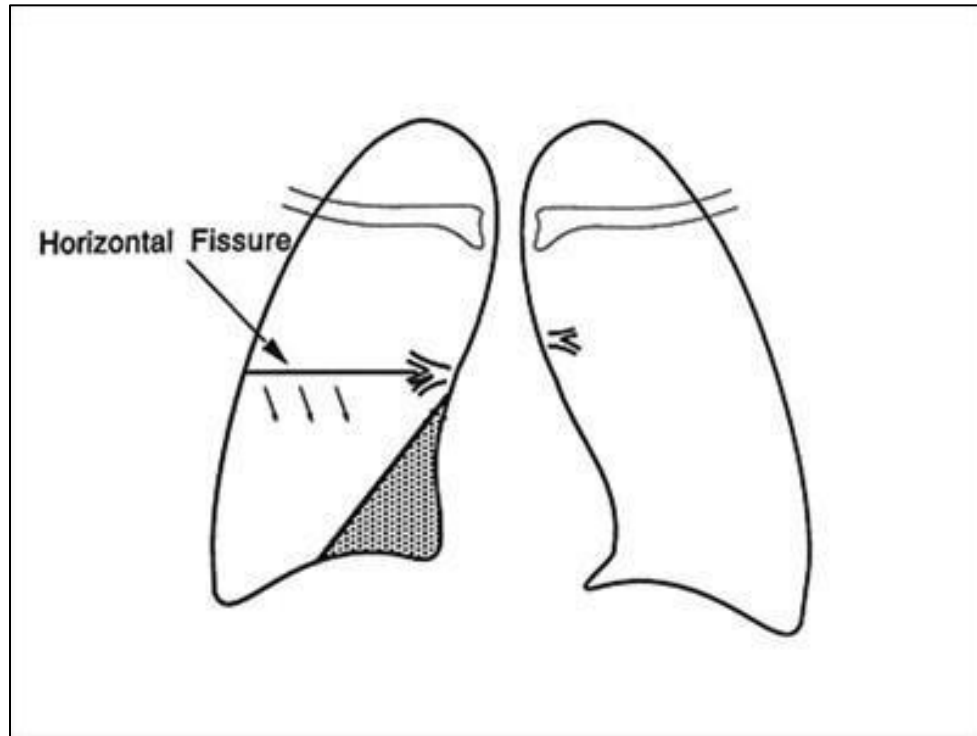


Chronic non-obstructive collapse of right middle lung lobe; usually associated with bronchiectasis

DDx -- RML pneumonia



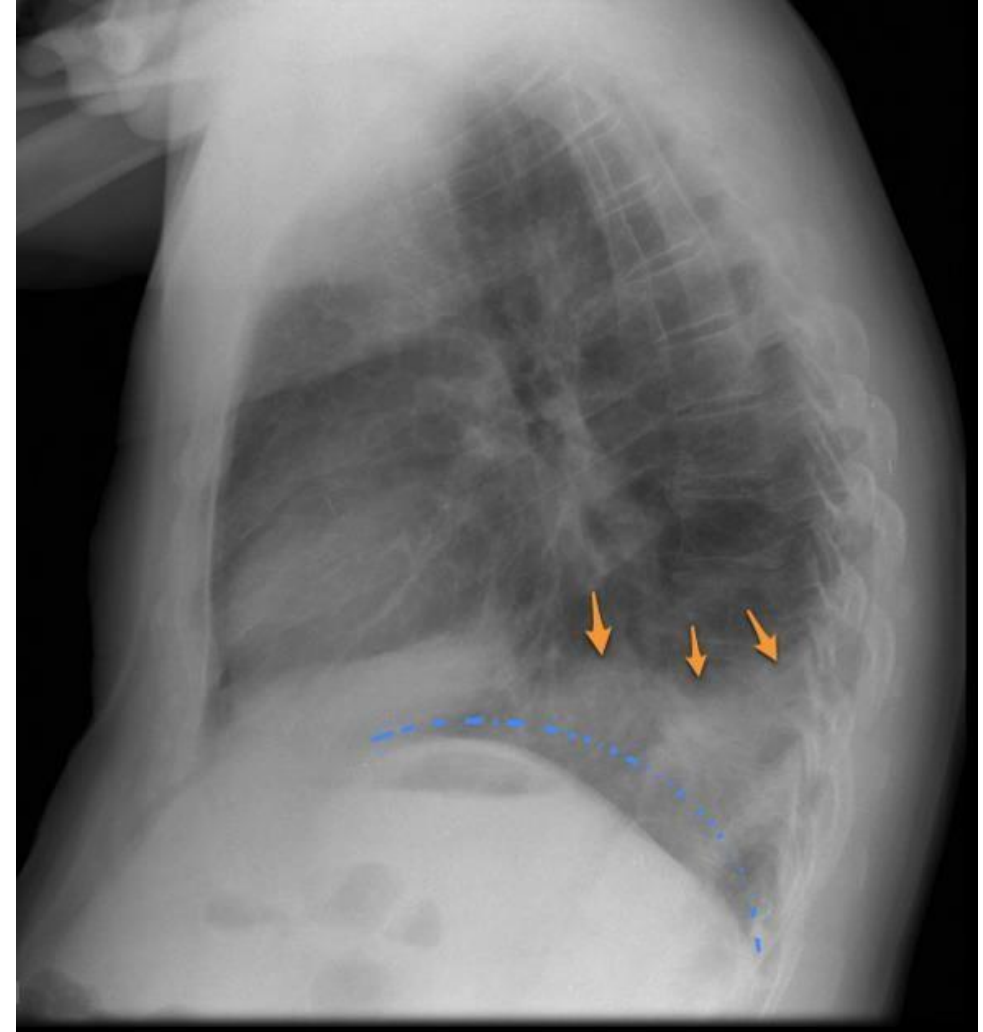
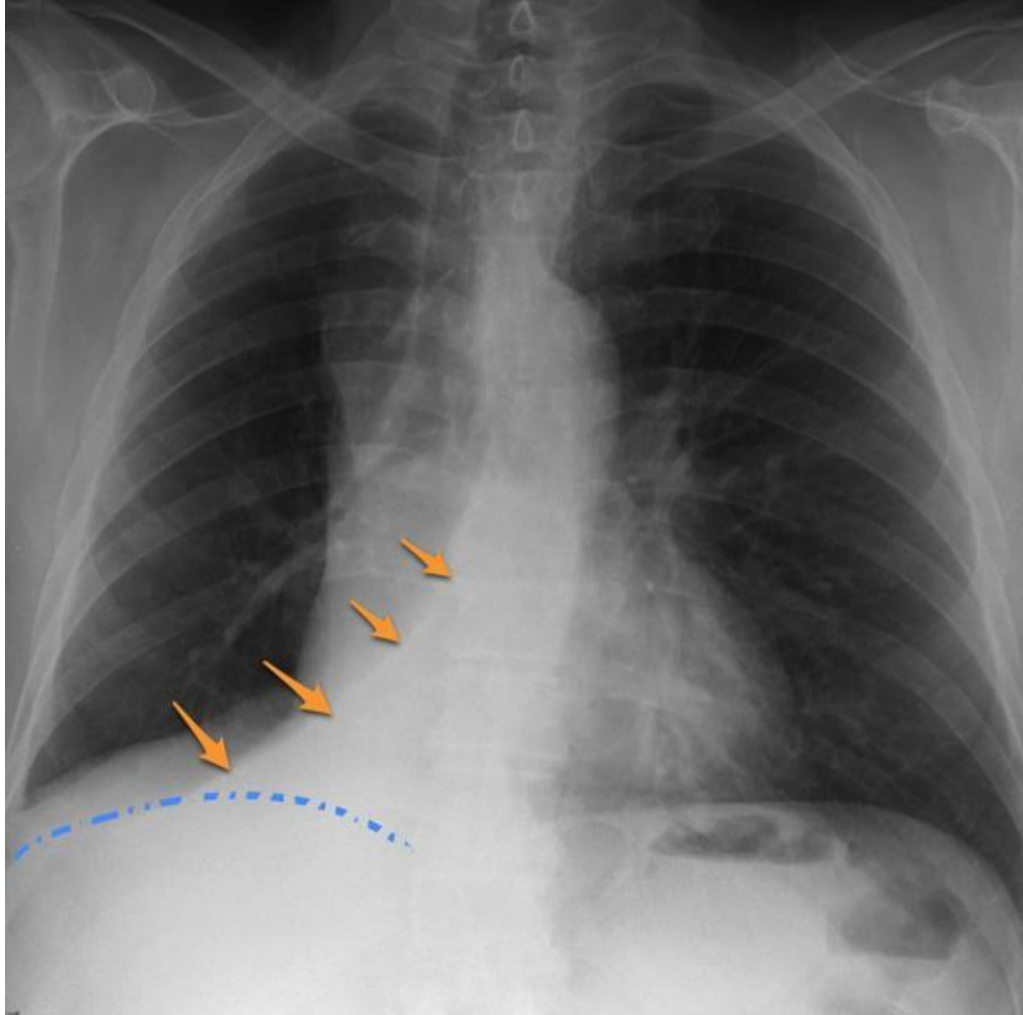
RLL collapse



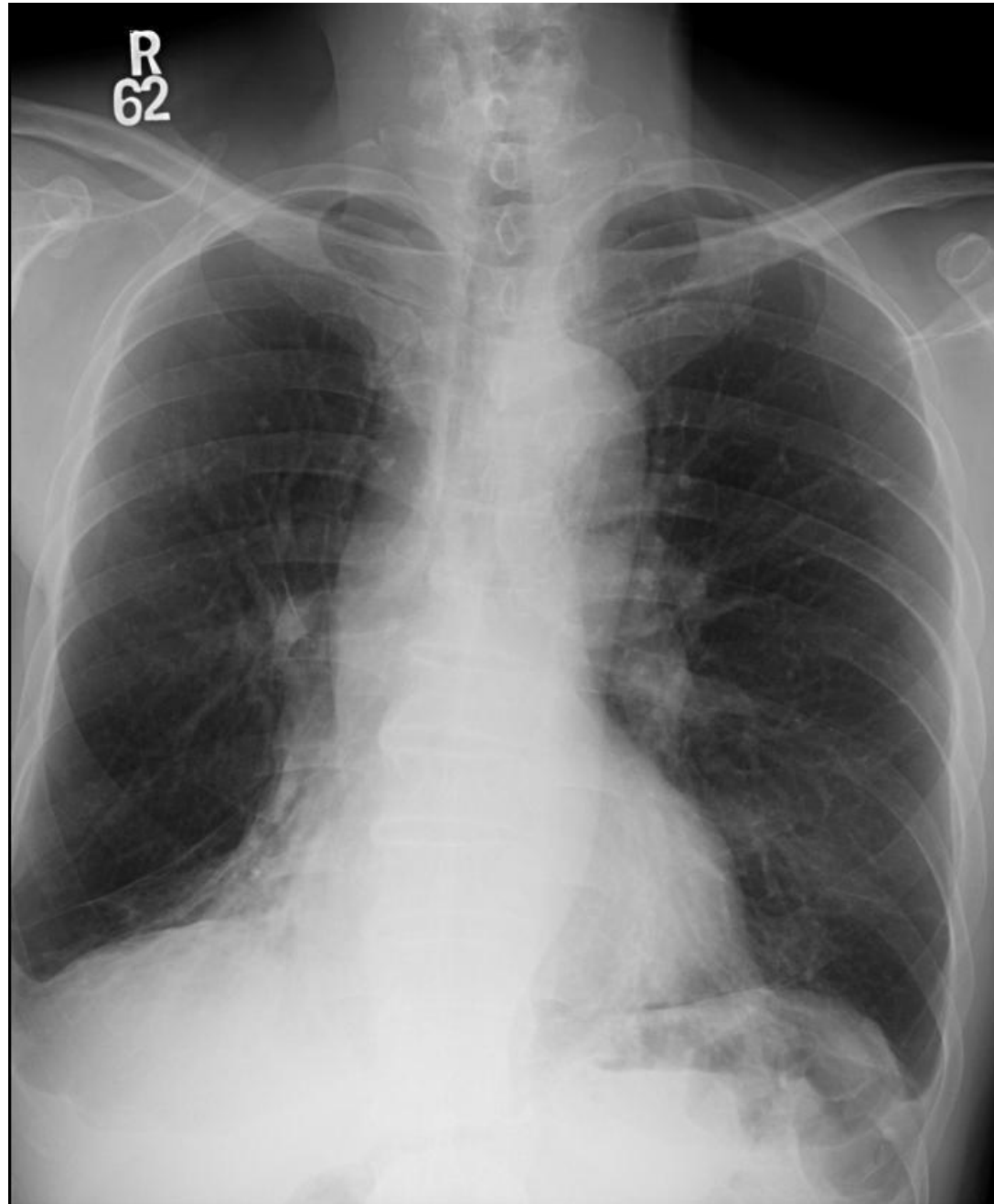
Features of RLL collapse

- Major fissure rotates backward and medially
- Triangular opacity lies on the right posterior medial mediastinum
- Loss of the diaphragmatic border
- Diaphragm is elevated
- Downward displacement of the right hilum
- Superior triangle sign
- No loss of the right cardiac border

RLL collapse



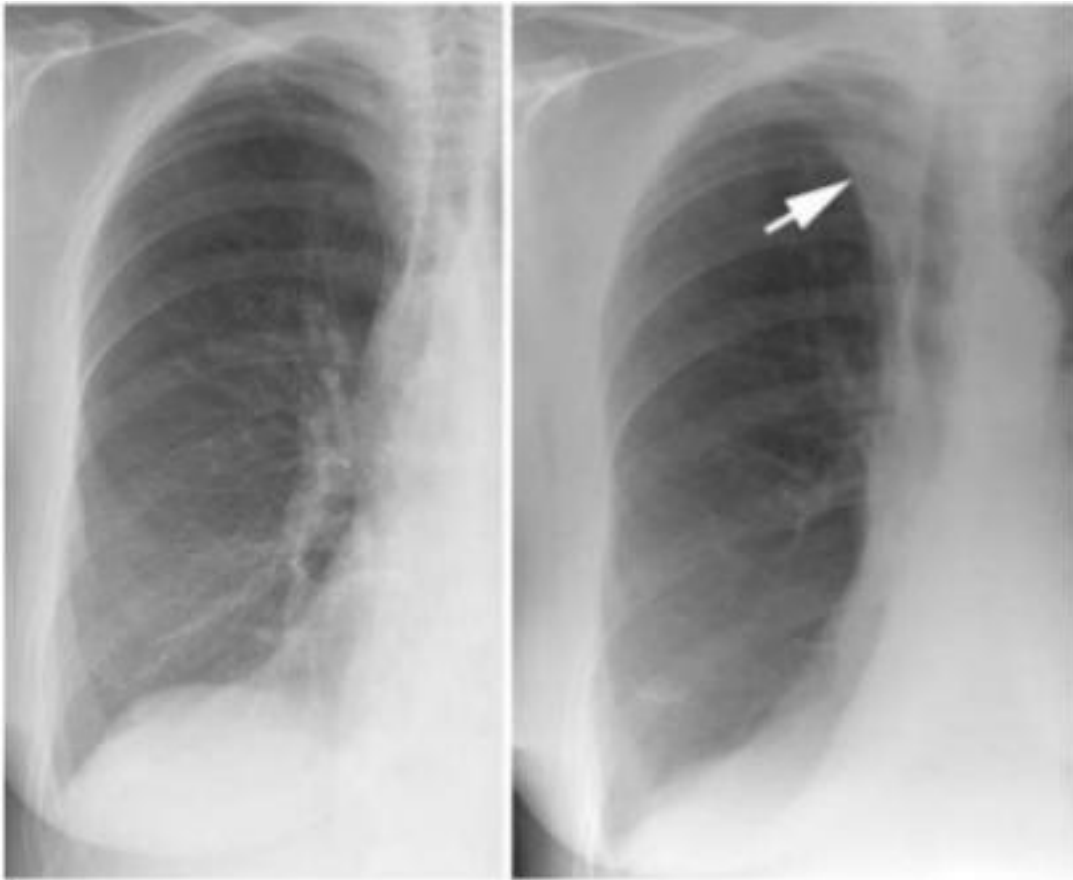
Bronchiectasis with RLL collapse



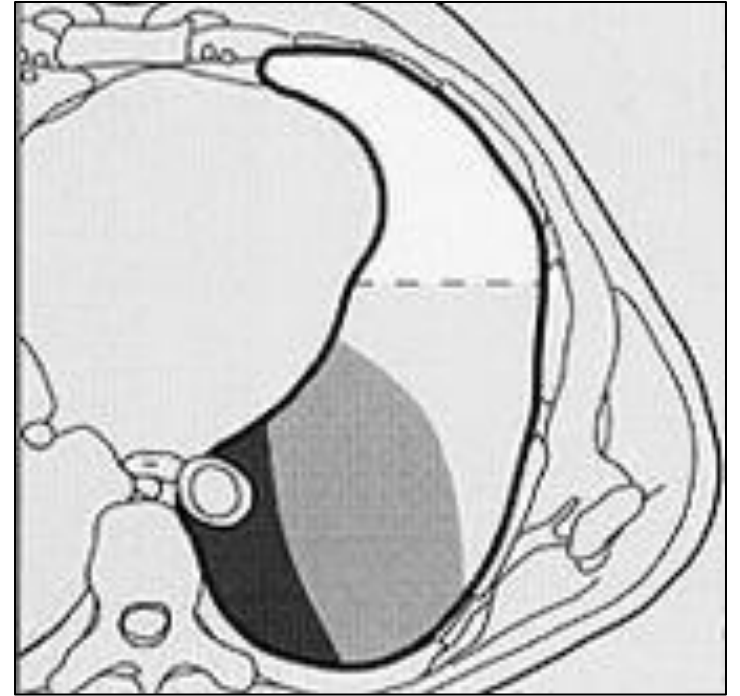
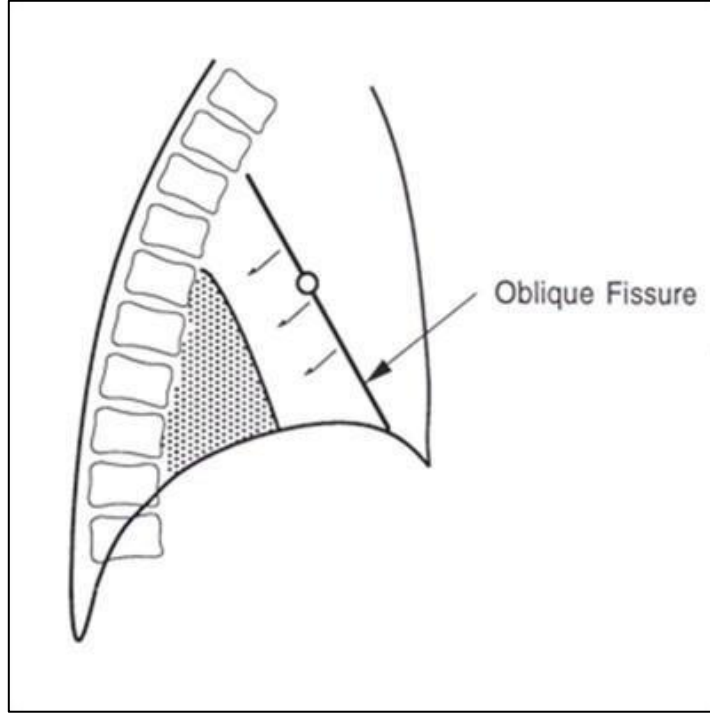
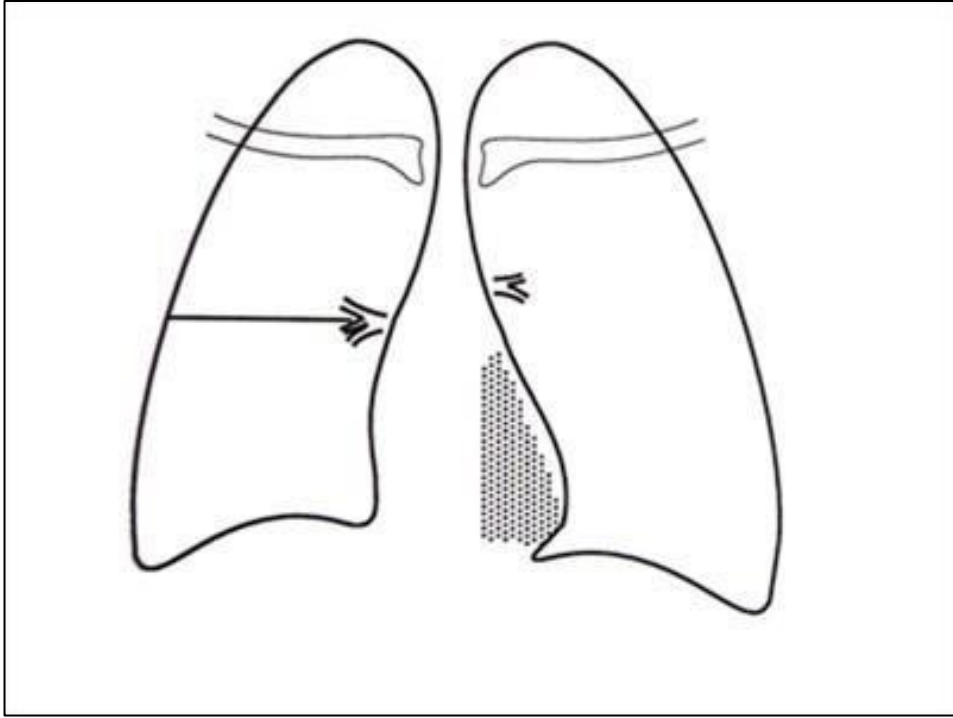
Superior triangle sign

Widening of the superior mediastinum

-- Collapse of the lower lobe producing traction on the mediastinal pleura



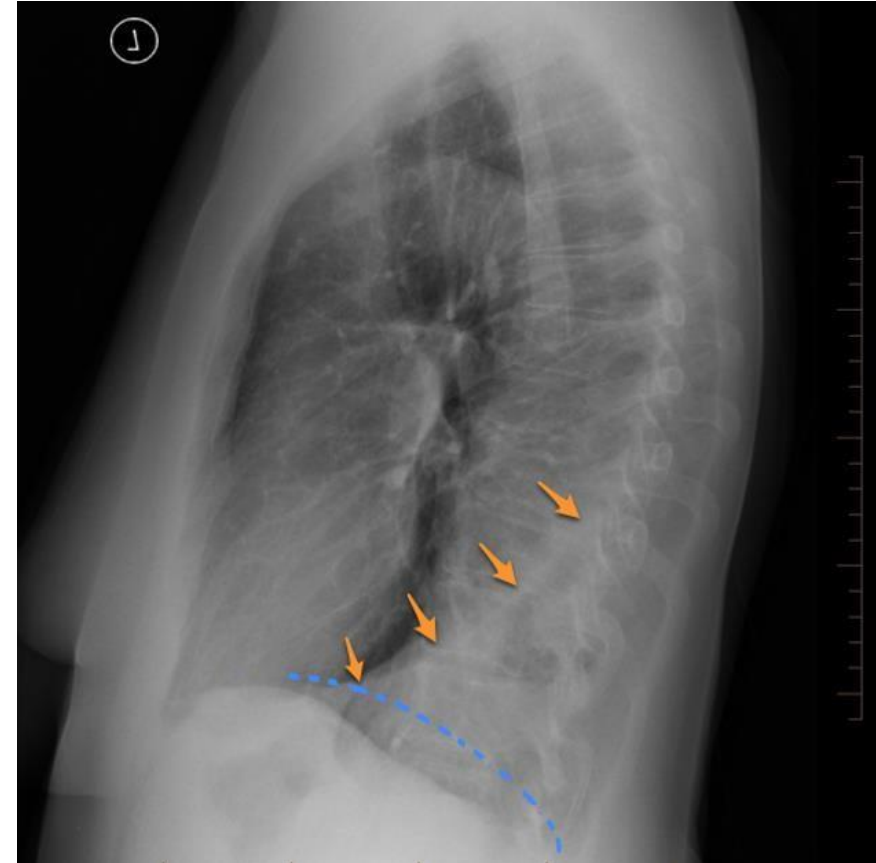
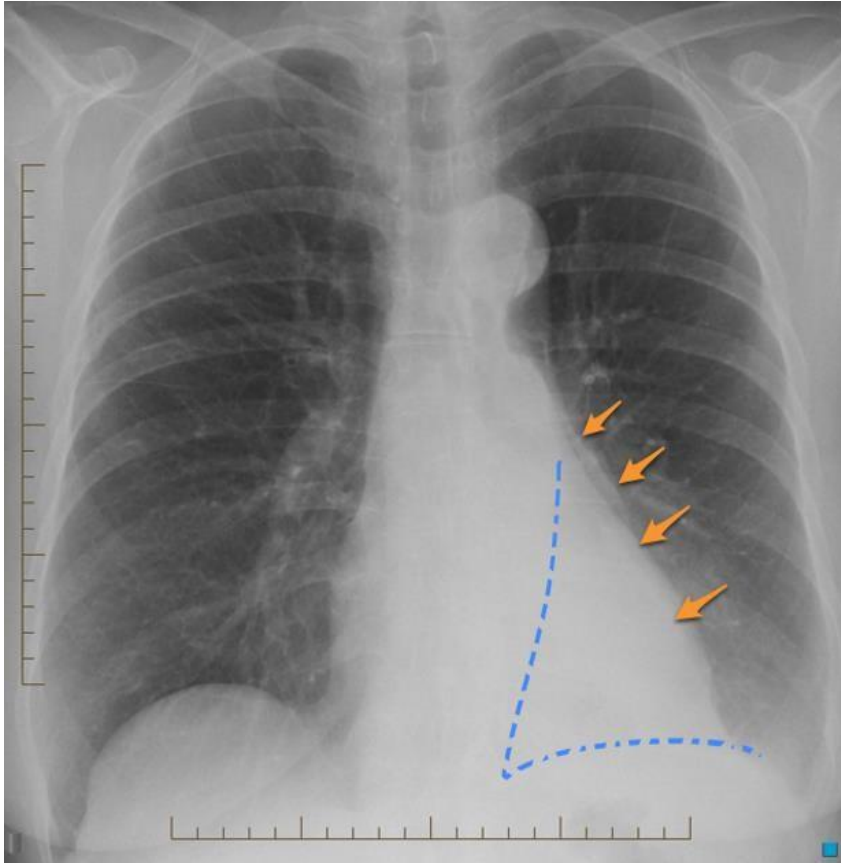
LLL collapse



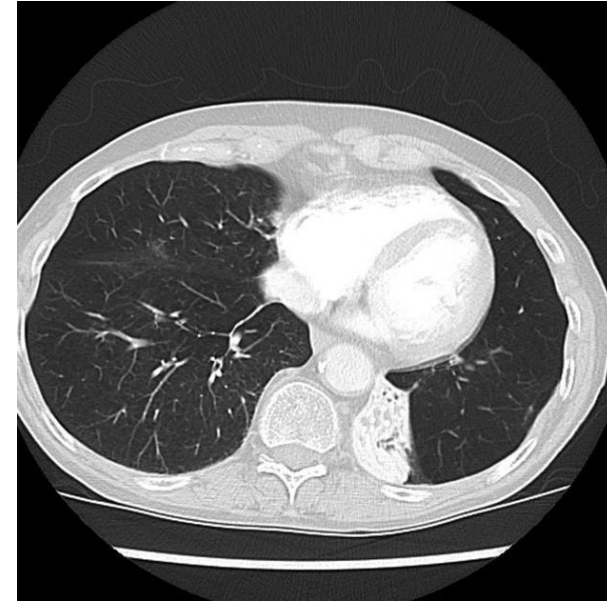
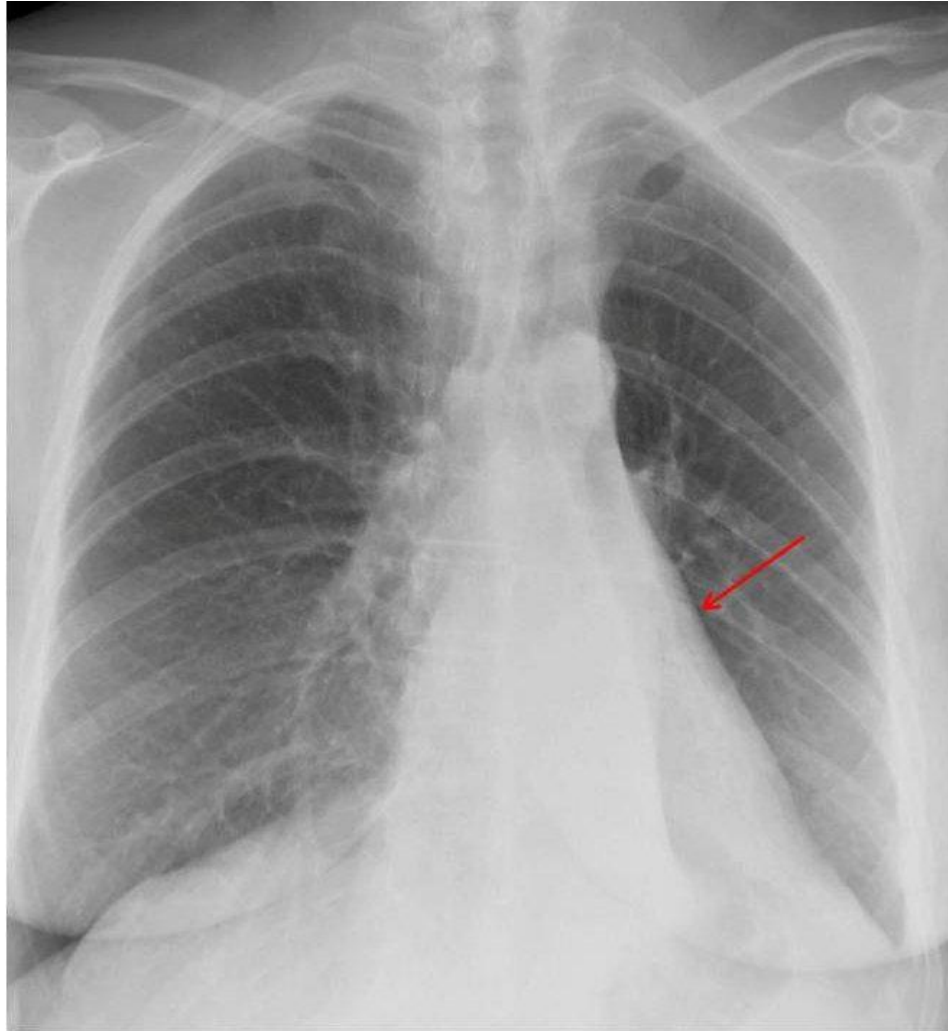
Features of LLL collapse

- Equivalent to the RLL collapse
 - Triangular opacity lies on the left posterior medial mediastinum
 - Loss of the diaphragmatic border
 - Diaphragm is elevated
 - Downward displacement of the left hilum
 - No loss of the left cardiac border
- Edge of collapsed lung may create a "double cardiac contour"
- Flat waist sign
- Loss of the outline of the descending aorta

LLL collapse (Double cardiac contour)



Flat waist sign



Flattening of the left cardiac border in left lower lobe collapse due to leftward displacement and rotation of the heart

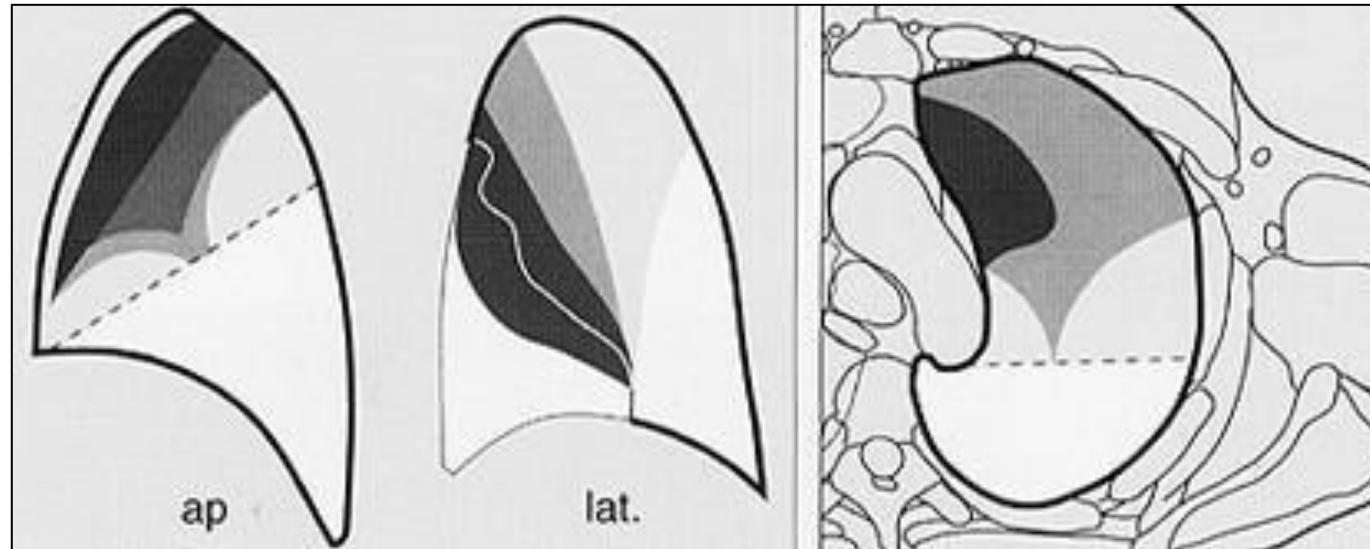
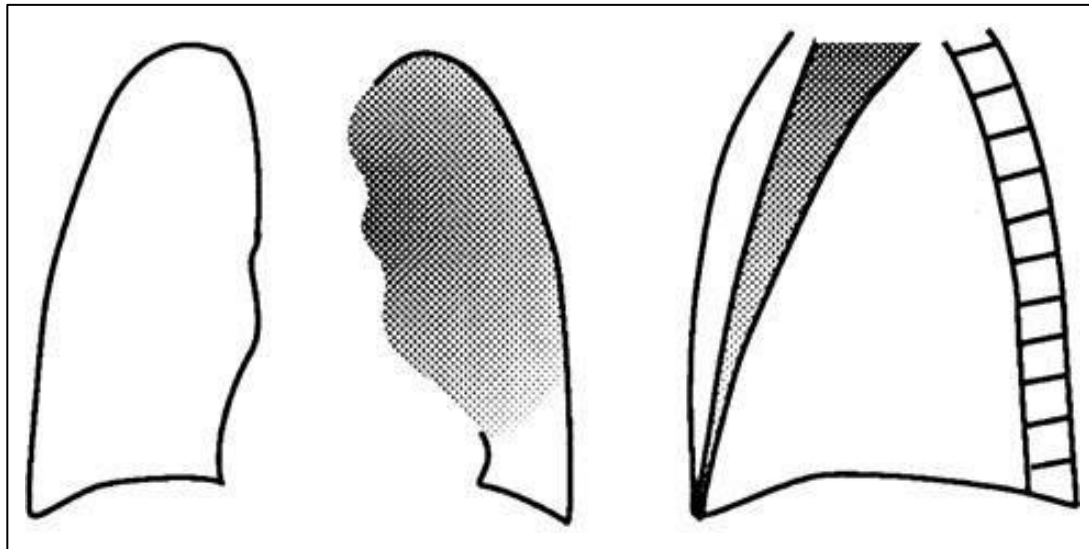
Bilateral bronchiectasis with LLL collapse



BLL collapse



LUL collapse



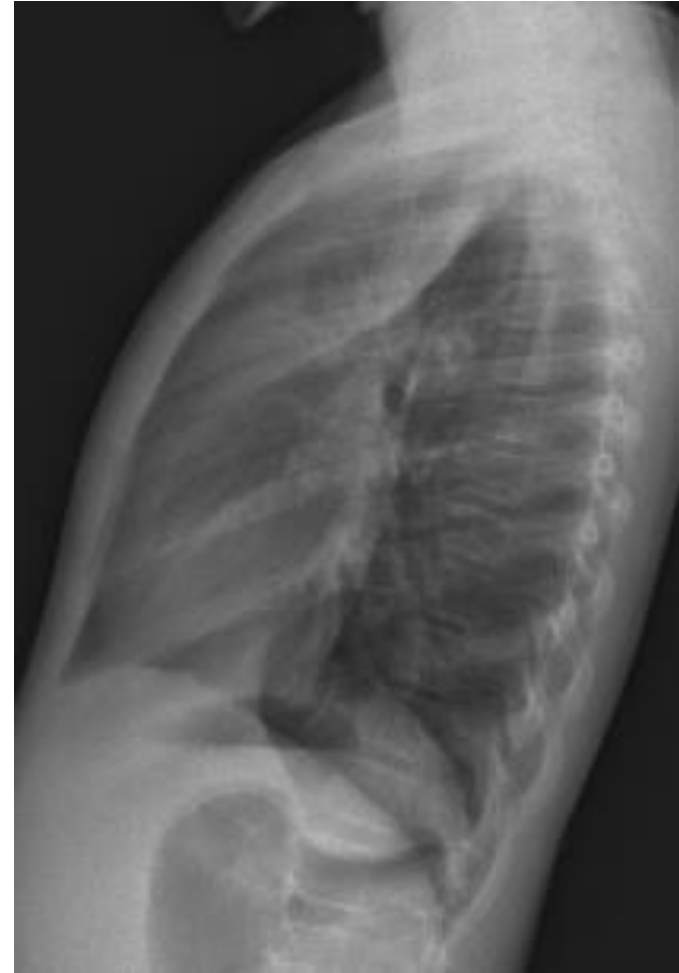
Features of LUL collapse

- Different from RUL atelectasis -- no minor fissure on the left
- Hazy density extending from the left hilum
- Elevation of the left hilum and diaphragm
- Outward angulation of the LLL artery and left main bronchus
- On lateral film, an elongated opacity extending from apex and almost reaching diaphragm

LUL collapse



- Ill defined haziness at the left upper and middle lung
- Elevation of the left hilum and diaphragm

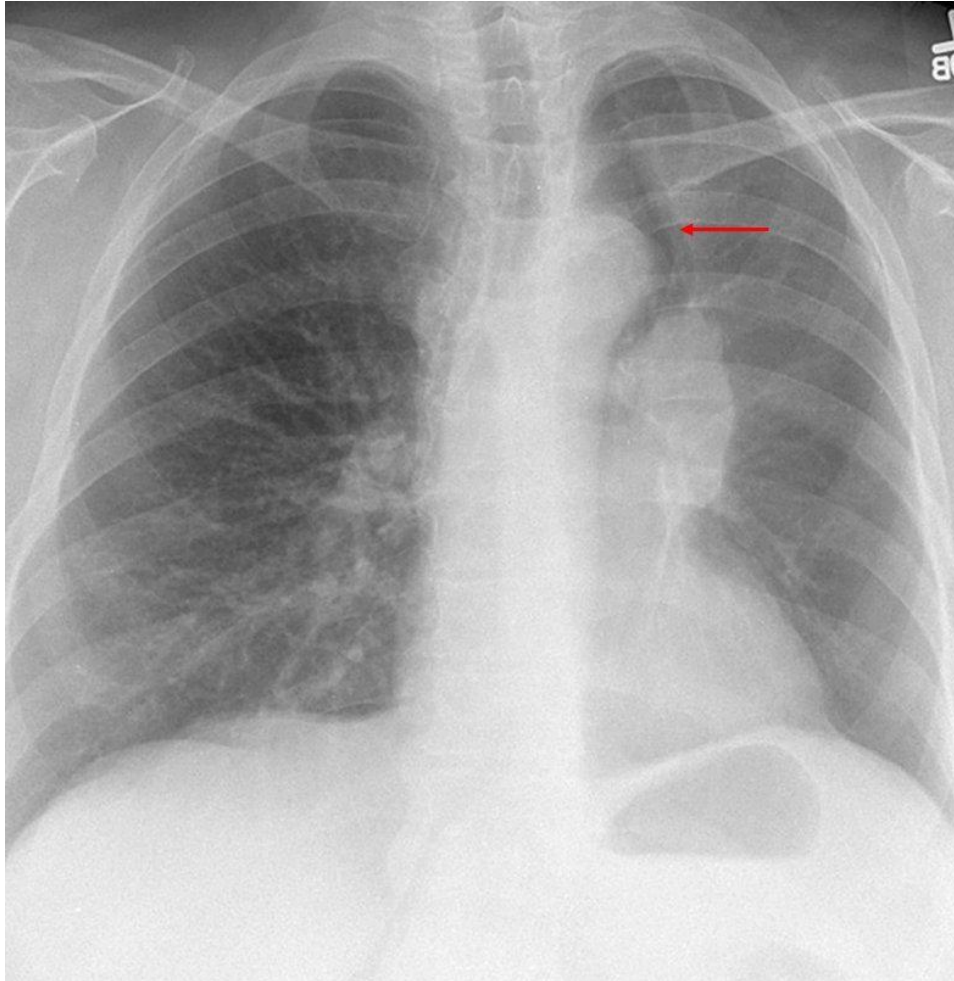


- Anterior displacement of major fissure
- Opacity at the retrosternal space parallel the anterior chest wall

LUL collapse



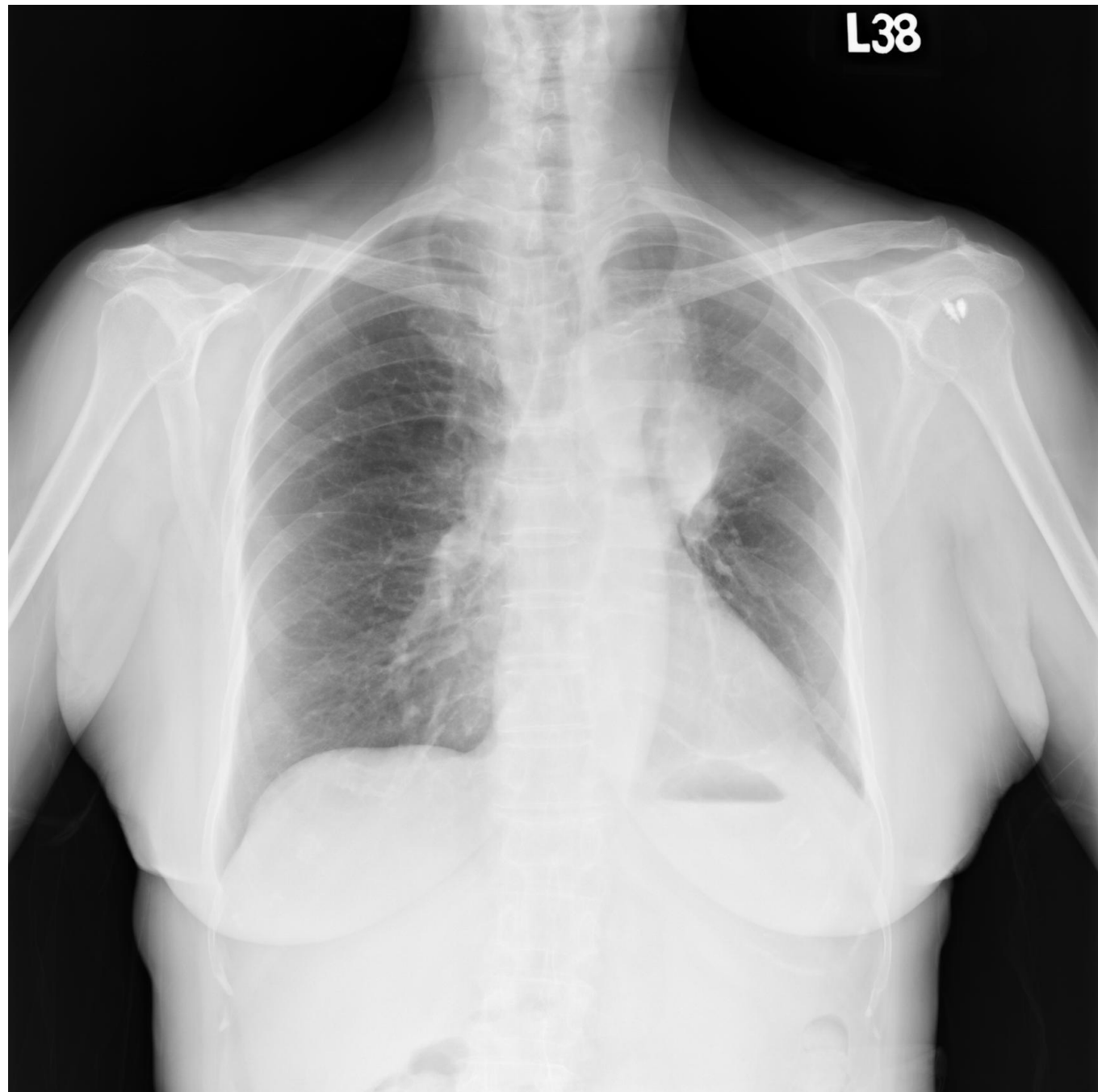
Luftsichel sign



Herniation of the superior segment of left lower lobe between the mediastinum and the collapsed left upper lobe



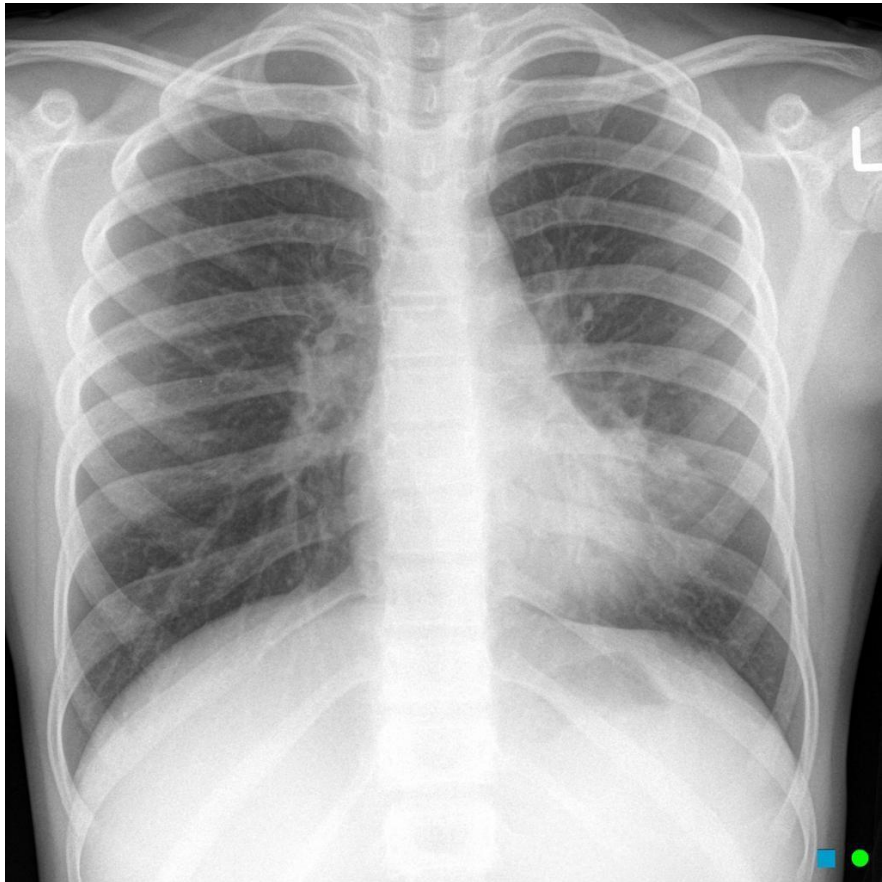
LUL collapse



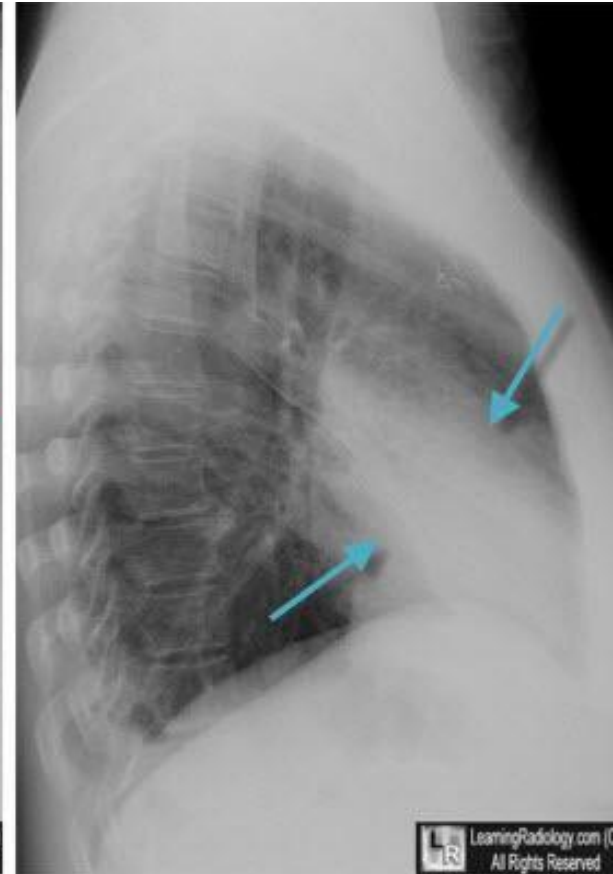
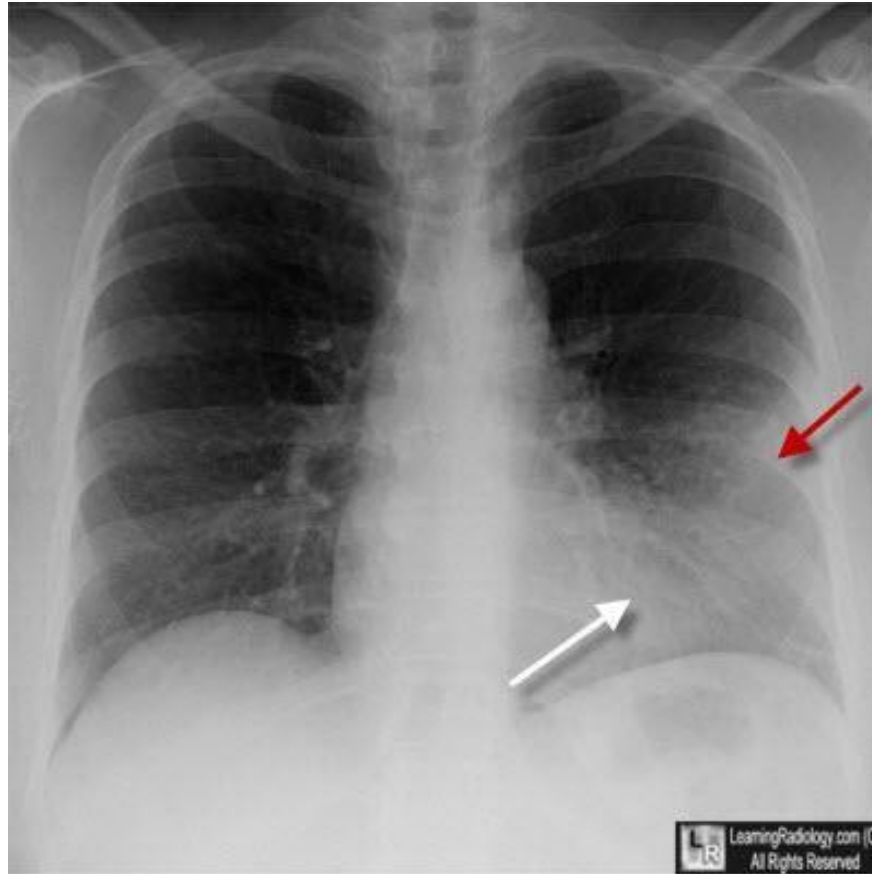
Features of lingula collapse

- Often involved with LUL collapse, but may collapse alone
- Increase opacity and obscuration of left heart border

Lingula collapse



DDx -- lingular pneumonia



Segmental atelectasis

- Direct signs
 - Wedge shaped opacity with its apex at the hilum and its base in contact with the pleura
 - Fissure displacement
 - Silhouette sign
- Indirect signs: usually absent

Segmental atelectasis (Ant. seg. of RUL)

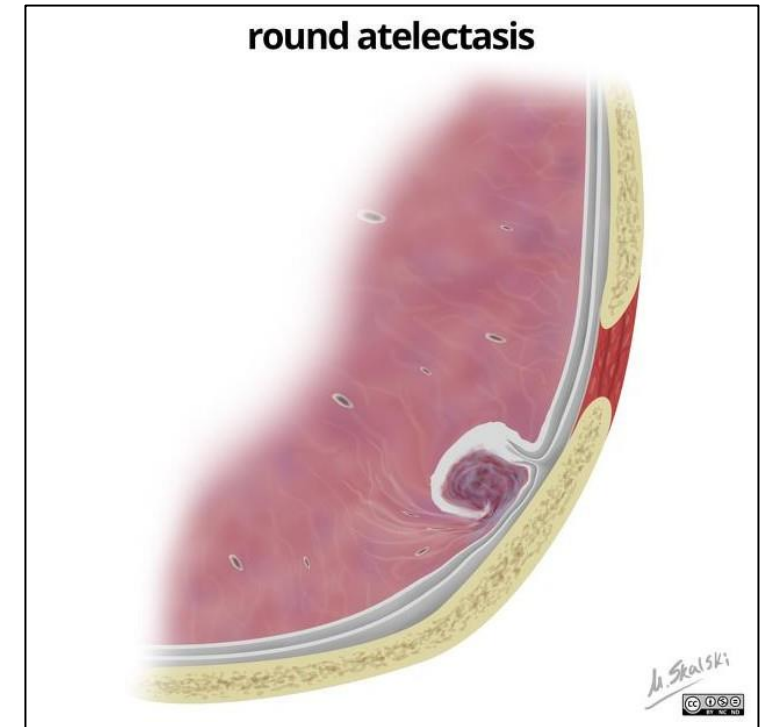


Segmental atelectasis (Ant. seg. of LUL)

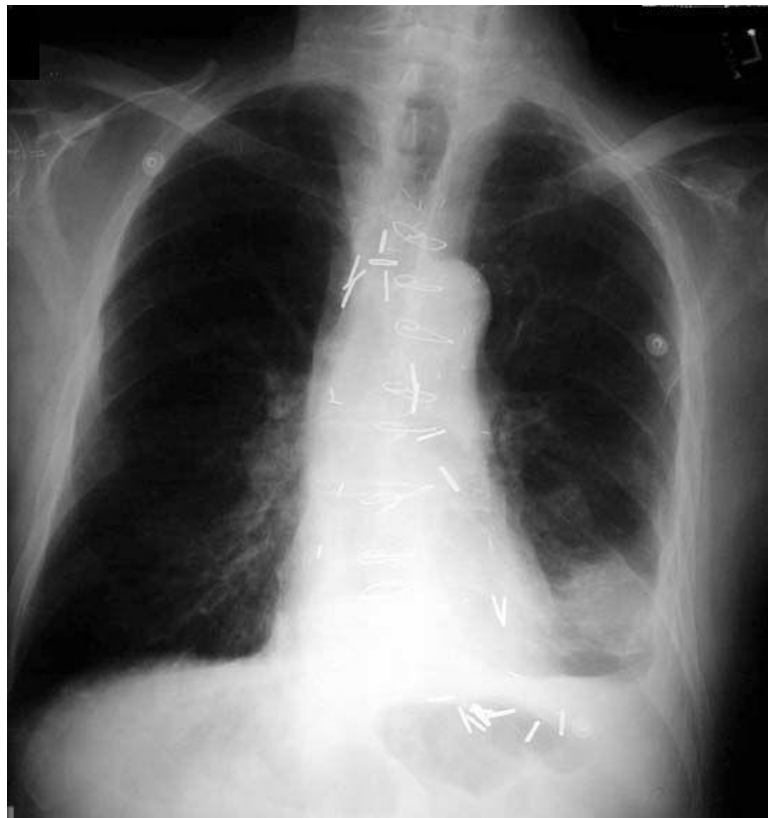


Round atelectasis

- Folded lung
 - Unusual type of lung atelectasis
 - Infolding of a redundant pleura
- Etiology
 - Exposure to mineral dust
 - Exudative pleuritis
- Location:
 - Posterior basal segment of the lower lobe (for mechanical reasons)



Round atelectasis



Comet-tail sign

- Pulling of bronchovascular bundles



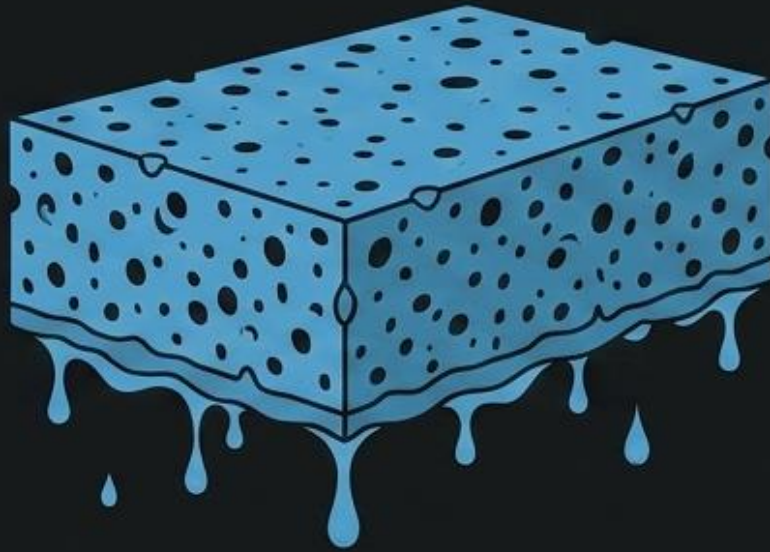
The Diagnostic Matrix

When faced with a fully opaque hemithorax, evaluate these three mechanical dimensions.

	Consolidation	Atelectasis
Lung Volume	Preserved / Normal	Decreased / Lost
Mediastinum & Trachea	Central (No shift)	Shifted towards the opacification
Air-Bronchograms	Present & Common (airways patent)	Usually Absent (unless non-obstructive)

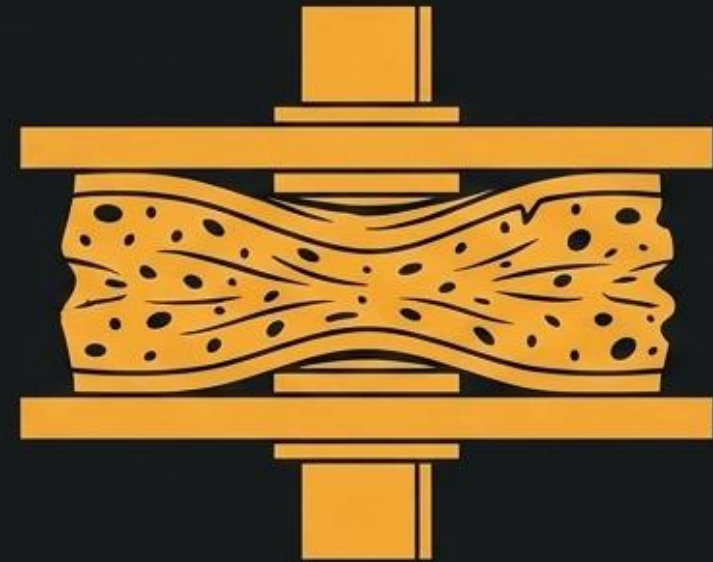
The Physical Intuition

Radiographic shadows are merely reflections of physical mechanics.
Does the lung fill, or does it fold?



The Filled Sponge.

- Volume preserved.
- Heavy.
- Replaced air.



The Crushed Sponge.

- Volume lost.
- Shrunk.
- Vacuum effect.

Thank you

洪緯欣

evelny1985@gmail.com