

肺實質化病變 (Consolidation) 與 肺塌陷 (Atelectasis)

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誌謝

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- 姜佑承 醫師
- 黃立果 醫師
- 台灣胸腔暨重症醫學會 影像課程教學資料

Outline

- Consolidation
- Atelectasis

Definitions

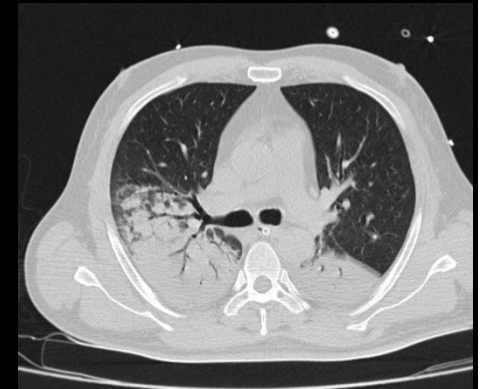
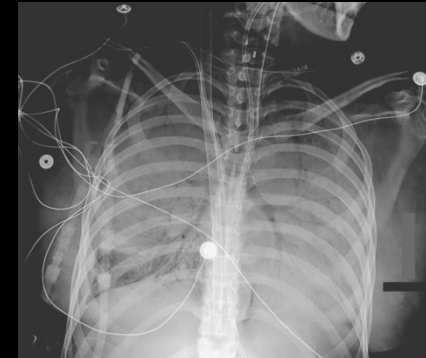
- Consolidation – **Replacement** of gas within the airspaces by fluid, pus, protein, cells, other
- Atelectasis – **Diminished** gas within the lung associated with **reduced** lung volume
- Both cause increased opacity of lung

Causes of Consolidation

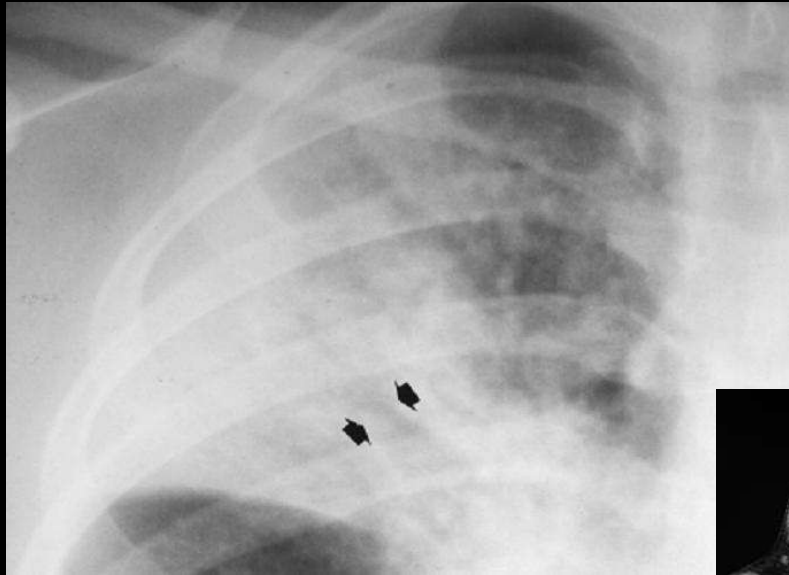
- Fluid(水): pulmonary edema, ARDS, drowning
- Blood(血): pulmonary hemorrhage
- Pus(膿): pneumonia
- Cells: alveolar cell carcinoma, lymphoma
- Protein: alveolar proteinosis
- Fat: lipoid pneumonia

Imaging Features of Air Space Consolidation

- Air Bronchogram
 - Air in alveoli is replaced
 - But bronchus leading into airway is not obstructed
- If present – Must be Intrapulmonary lesion (wont be pleural or mediastinal)
- If absent – Does not rule out consolidation

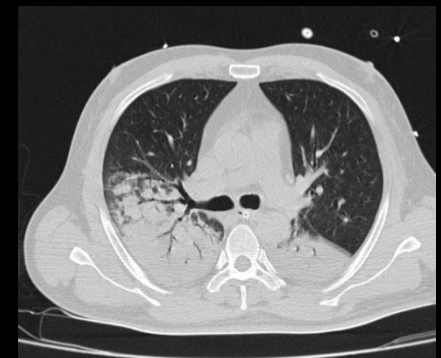
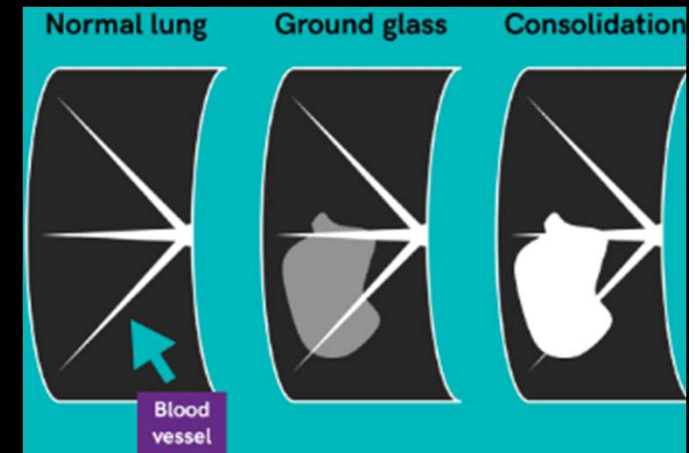


Air Bronchogram



Imaging Features of Air Space Consolidation

- Lung attenuation increased so that bronchial walls and blood vessels are obscured (on non contrast CT), leading to homogenous opacity
 - Vs ground glass opacity (bronchial wall, vessels visible)



Imaging Features of Air Space Consolidation

- Silhouette Sign
 - Present if consolidation extends to diaphragm, mediastinum, hilum, edge of lung
 - Can be used to identify which lobe consolidation is affecting

How do we approach Consolidation

- Goal is identify a diagnosis
 - Associated Findings
 - Distribution / Pattern
 - Clinical history
 - Chronicity

Distribution / Pattern

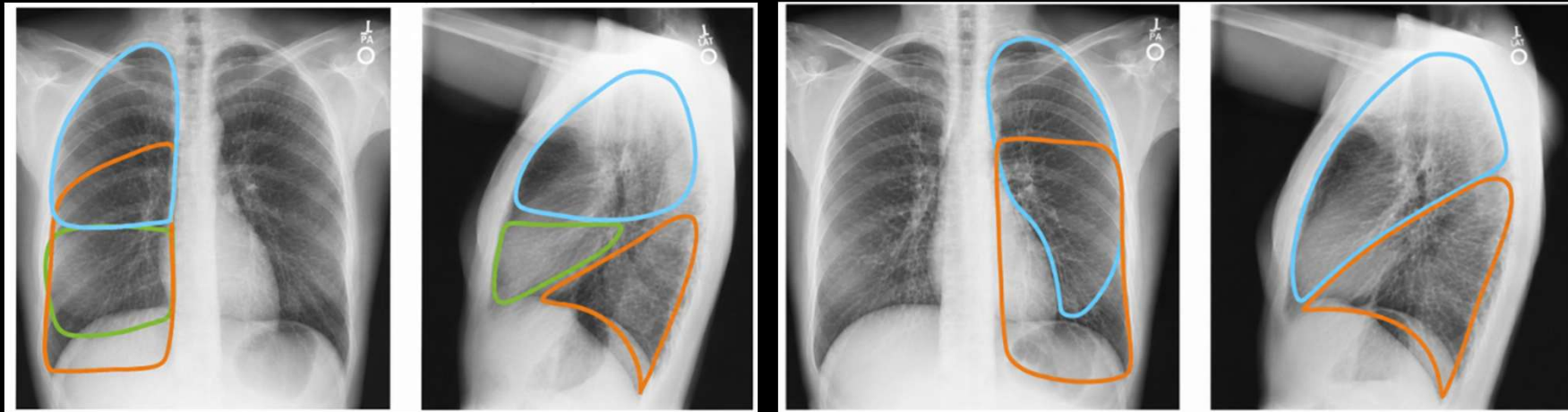
Timing

Lobar	Diffuse	Multi-focal
Lobar pneumonia - Streptococ pneum. - Klebsiella - TB - viral - fungal - Aspiration Neoplasm - Lungca with obstructive pneumonia - BAC - Lymphoma Hemorrhage - Contusion - Infarction Others - Organizing pneumonia - Eosinophilic pneum - Sarcoidosis - Sequestration - Mitral regurgitation with RUL edema	Edema - Heart failure - Volume overload - ARDS - Low albumin - Renal failure - Transfusion reaction Bronchopneumonia - Staph Aureus - Gram negative - PCP - Viral - fungal Neoplasm - BAC - Lymphoma Hemorrhage - SLE - Henoch-Schönlein - Wegener - Goodpasture Others - Organizing pneumonia - Eosinophilic pneum - Hypersensitivity pneum - Alveolar proteinosis	Bronchopneumonia - Staph Aureus - Legionella - Gram negative - Streptococcus pneum - Klebsiella - Pseudomonas - Anaerobe - PCP - TB - Aspiration Vascular - Septic emboli - Wegener's Neoplasm - BAC - Lymphoma - Metastases Others - Organizing pneumonia - Eosinophilic pneum - Lipoid pneumonia

Acute Consolidation	Chronic Consolidation
Pulmonary edema Pneumonia Aspiration Hemorrhage / Contusion Infarction	Neoplasm • post-obstruction • Bronch-alveolar ca • Lymphoma Sarcoidosis Organizing Pneumonia Eosinophilic pneumonia Alveolar proteinosis

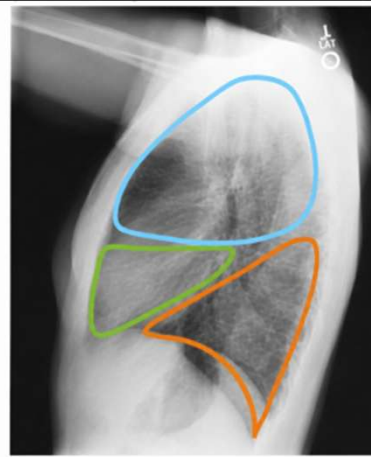
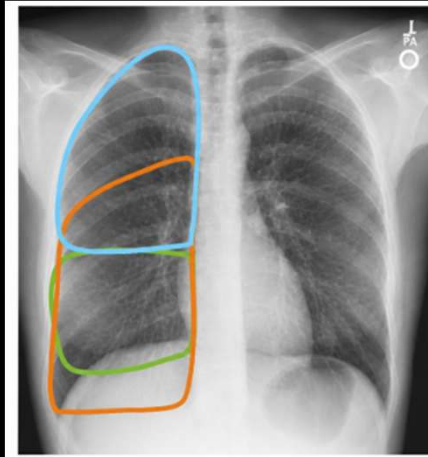
<https://radiologyassistant.nl/chest/chest-x-ray/lung-disease>

Lobar Distributions of Consolidation



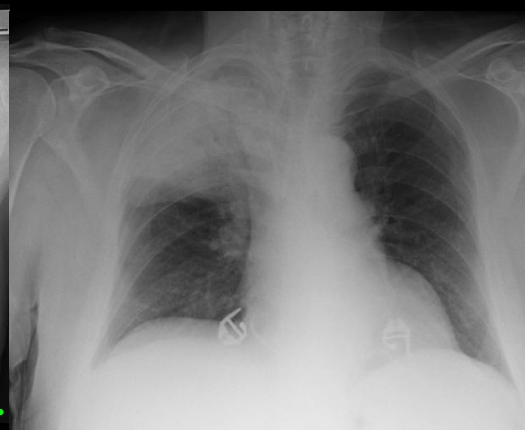
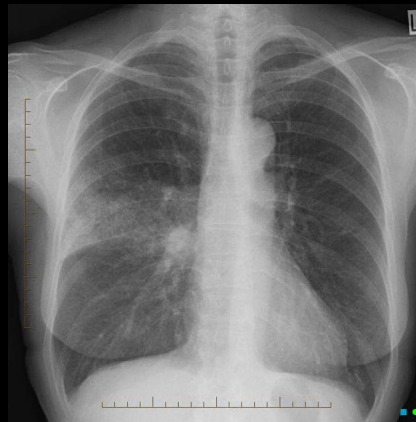
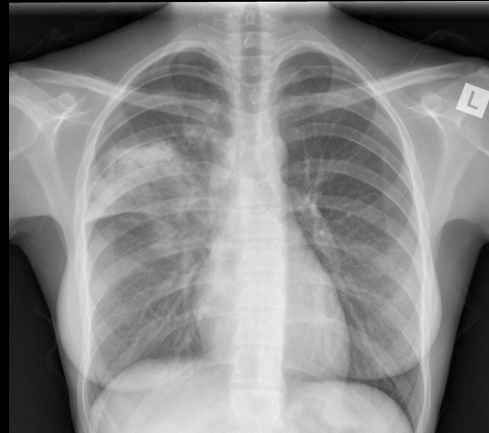
<https://www.netterimages.com/imaging-of-the-lungs-pa-and-lateral-chest-x-rays-of-the-lungs-lobes-of-lung-labeled-77461.html>
<https://radiopaedia.org/articles/consolidation>

Right Upper Lobe



Right Upper Lobe Consolidation

- Horizontal Fissure Visible
- Right diaphragm border clear
- Right heart border clear
- May silhouette with right hilum





Right Middle Lobe

Often fainter than upper or lower consolidation due to smaller volume

Consider lateral view

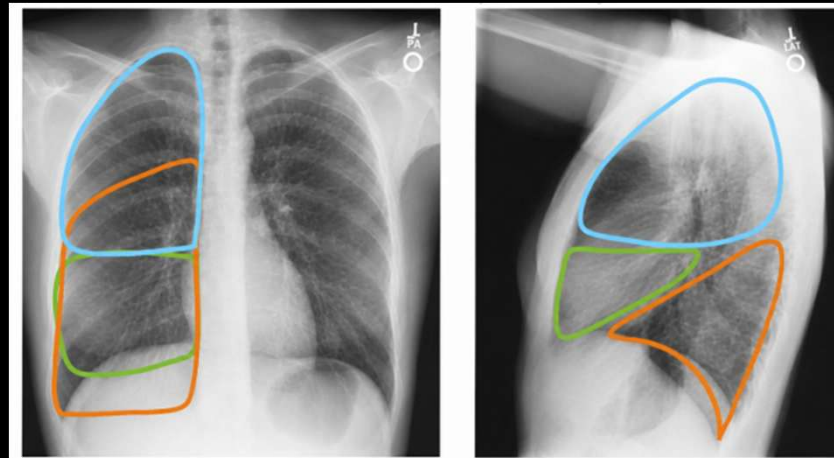
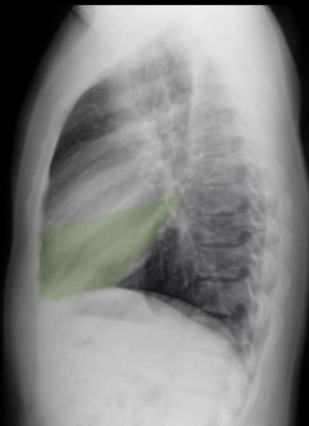
Vs right lower lung

Silhouette right heart border

Usually clear diaphragm border

Vs right upper lung

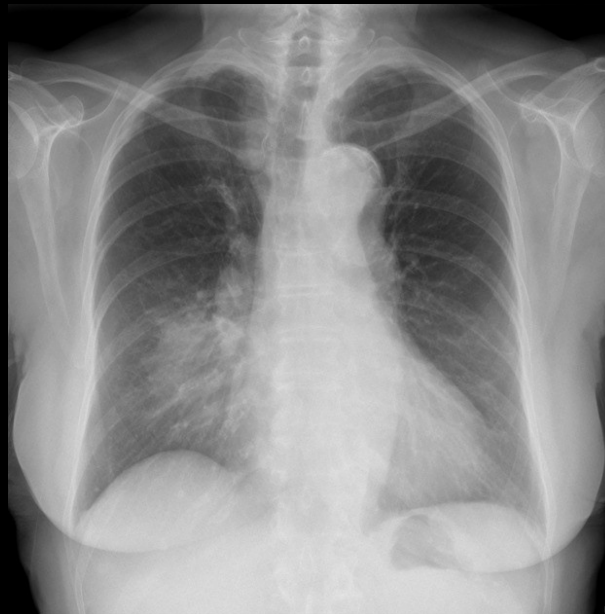
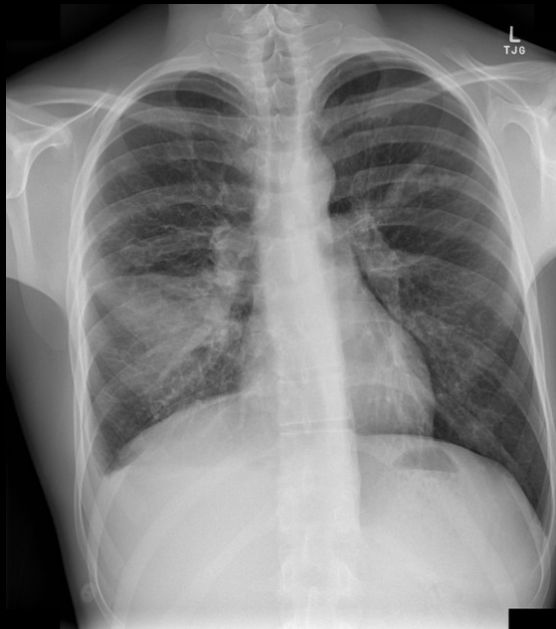
clear right superior mediastinum



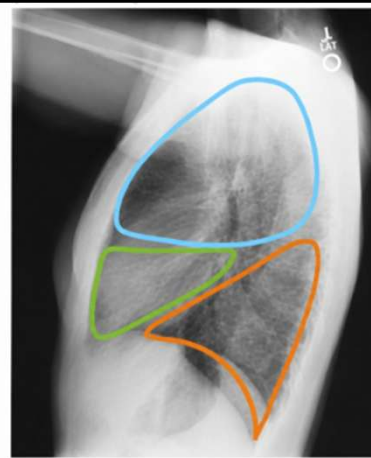
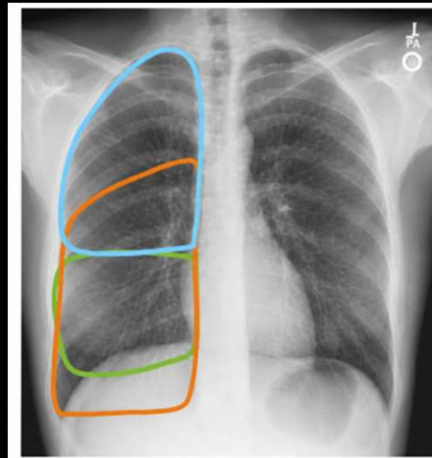
Right Middle Lobe Consolidation



Right Middle Lobe Consolidation



• Right Lower Lobe



Silhouettes right diaphragm

Visible horizontal fissure

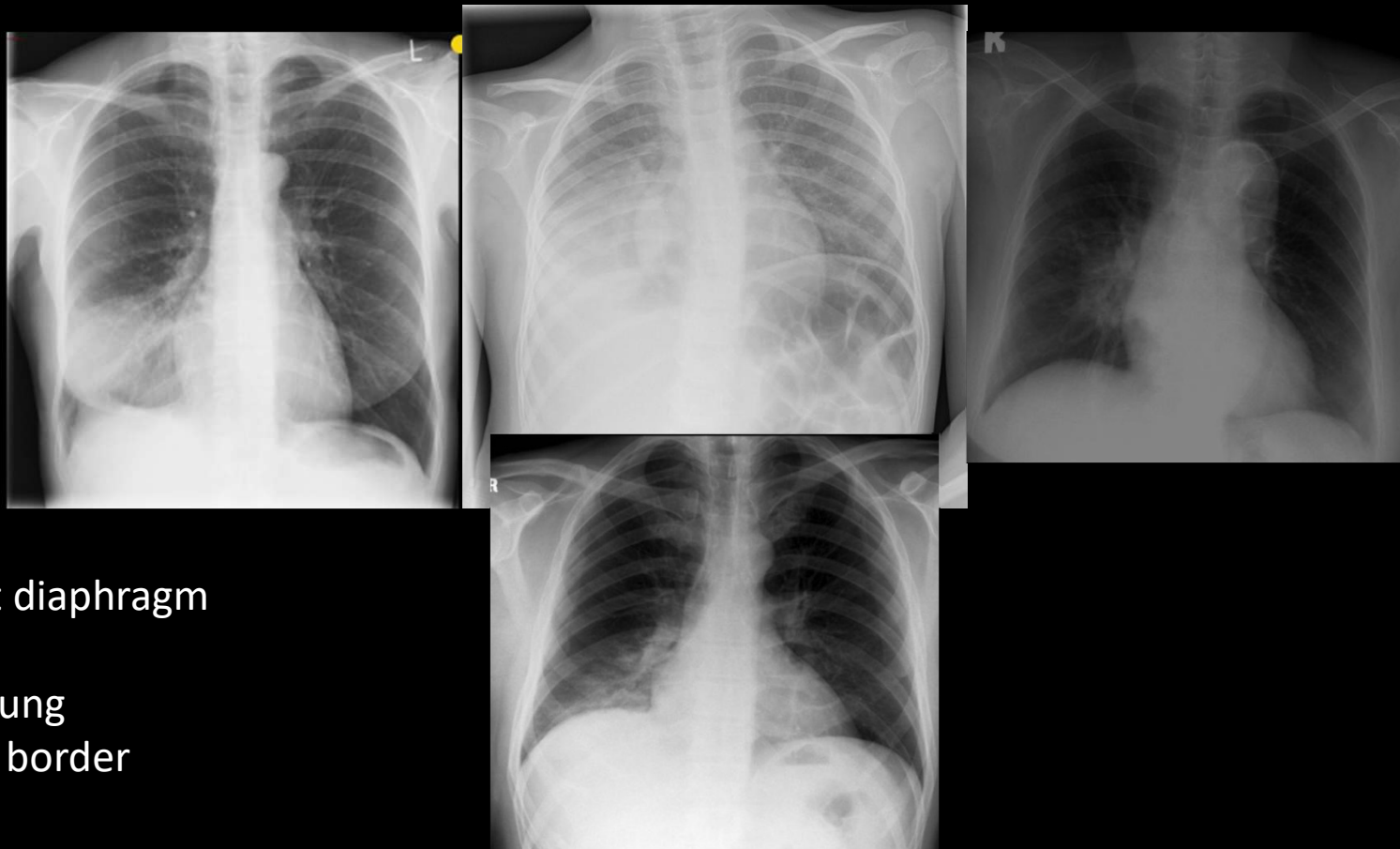
Vs right middle lung

Clear heart border

Vs right upper lung

clear right superior
mediastinum

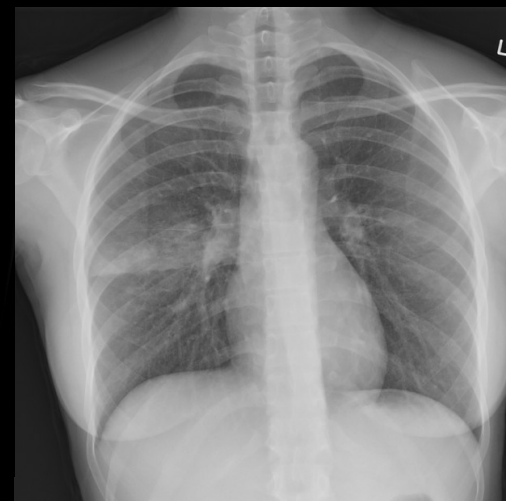
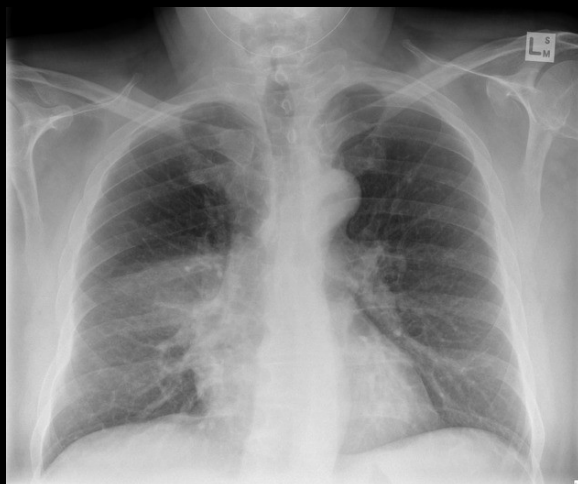
Right lower Lobe Consolidation



Silhouettes right diaphragm

Vs right middle lung
Clear heart border

Right lower Lobe Consolidation



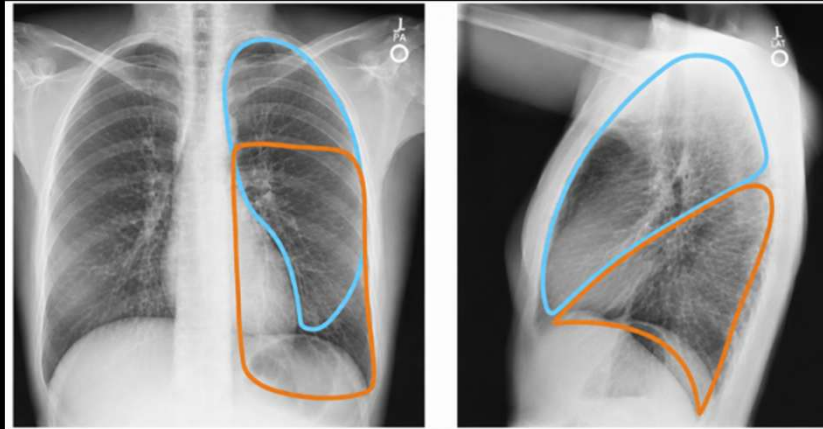
Superior Segment RLL
Vs right upper lung
clear right superior
mediastinum

Right lower Lobe Consolidation

Look behind
diaphragm



Left Upper Lobe



Silhouettes

- Superior mediastinum
- Heart border
- Left hilum

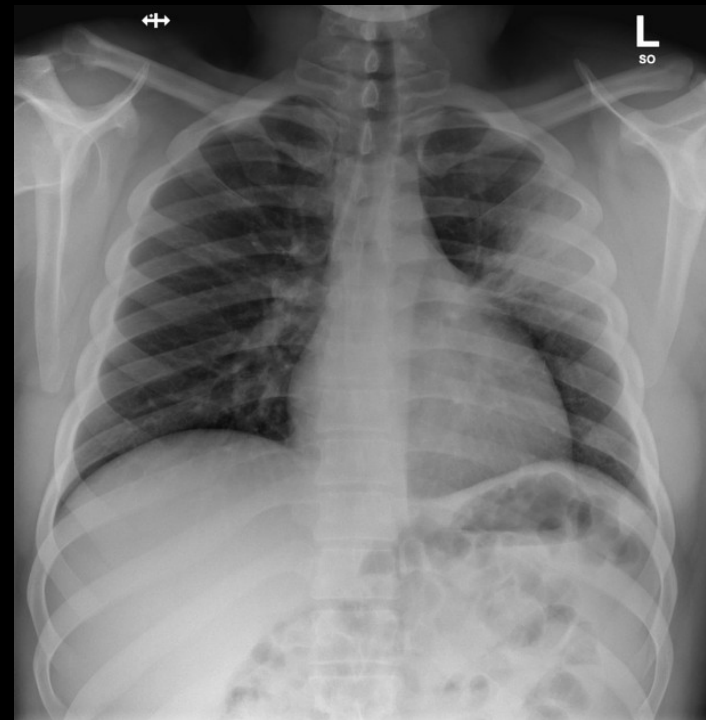
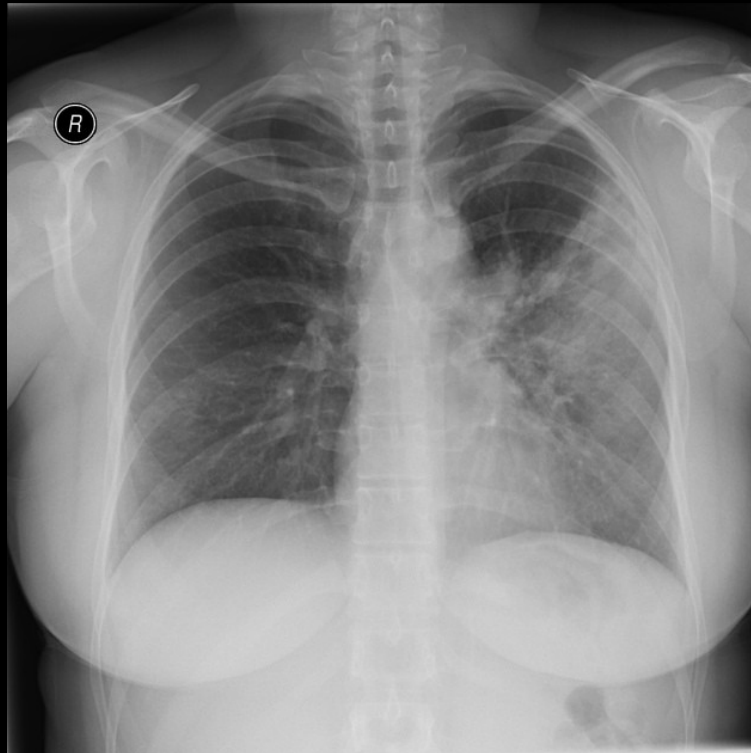
Clear

- Diaphragm
- Descending aorta

Left Upper Lobe Consolidation



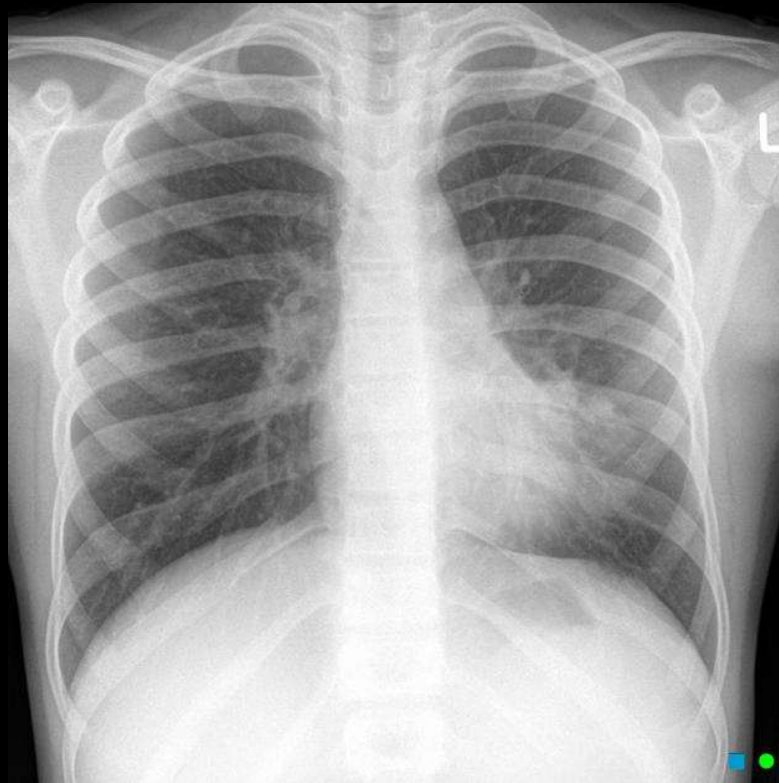
Left Upper Lobe Consolidation



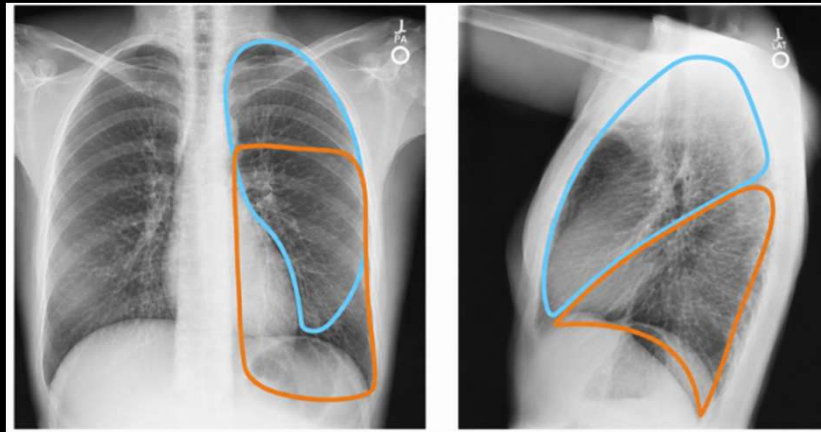
Left Upper Lobe Consolidation

Lingula

Vs left lower
Silhouettes heart
border



Left Lower Lobe



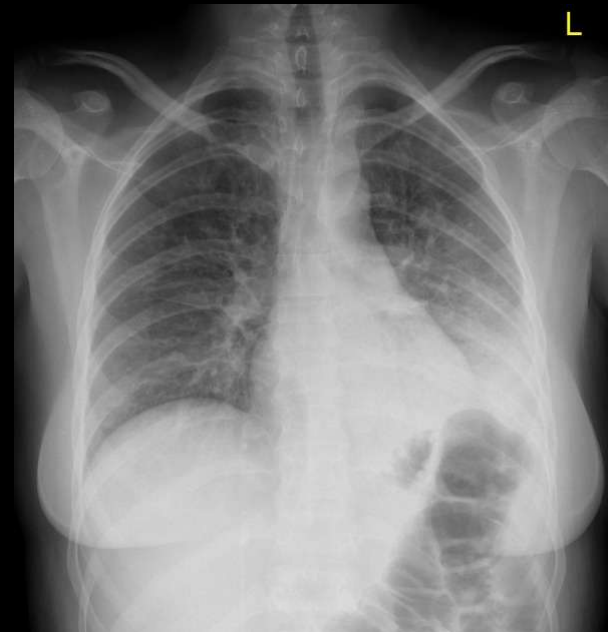
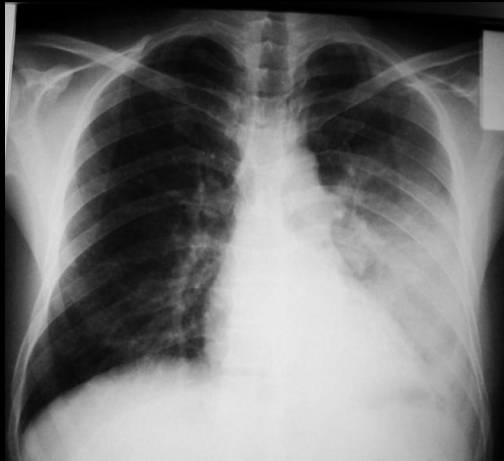
Silhouettes

- Diaphragm
- Hilum
- Descending Aorta

Clear

- Heart border
- Superior mediastinum

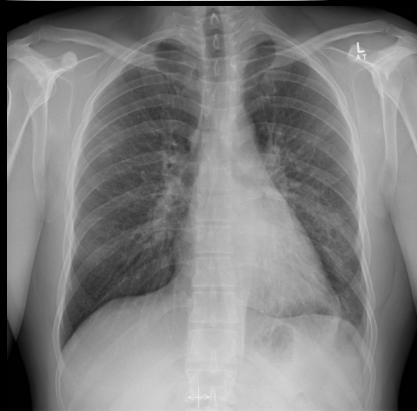
Left lower Lobe Consolidation



Silhouettes
Diaphragm
Clear heart border

Left lower Lobe Consolidation

Care with
Retrocardiac Lesions



Distribution / Pattern

Timing

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<https://radiologyassistant.nl/chest/chest-x-ray/lung-disease>

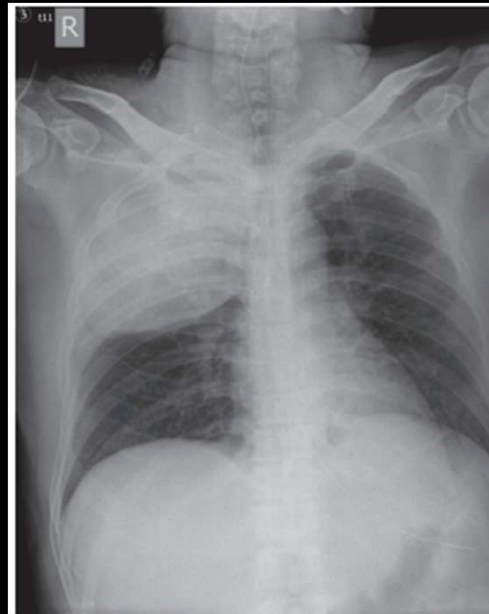
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Lobar/
Acute

Klebsiella Pneumonia

Volume increase
Bulging Fissure
sign



https://www.tscdm.org.tw/od/Magazine/Folder/a03_1/N201812520552_08-1611-%AF%CE%BA%FB%C2@-49-51.pdf

Lobar/
Chronic

Pulmonary Tuberculosis

**Slight volume
reduction**

Cavitation

Reticulonodular
Opacities

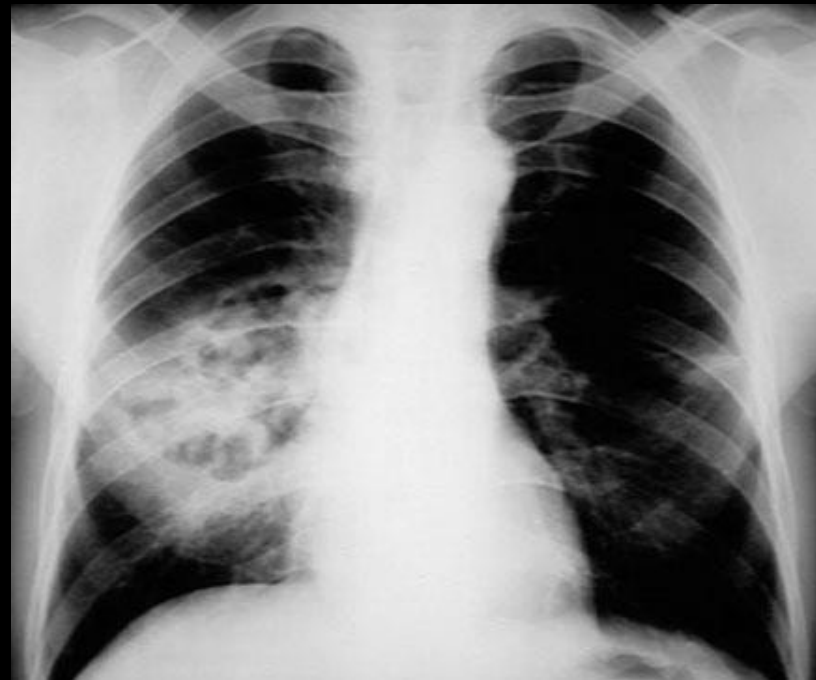


Focal /
Acute

Necrotizing Pneumonia

Consolidation with
cavity formation

Spectrum with lung
abscess (usually less
consolidation)



Lobar/
Acute

Pulmonary Infarction



Lobar/
Acute

Acute Mitral Regurgitation

May cause
unilateral / focal
pulmonary
edema due to
direction of
regurgitation jet

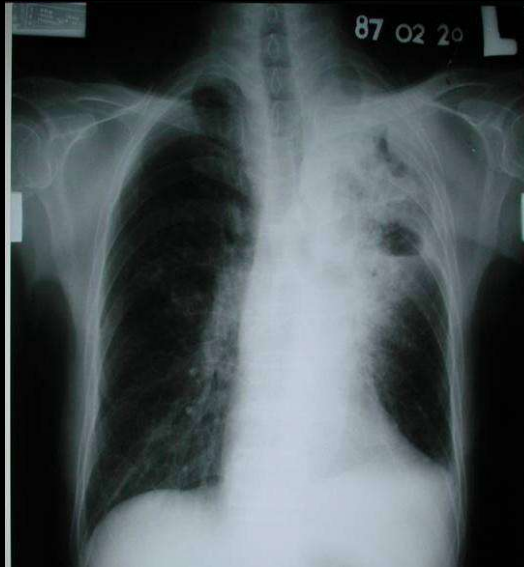


After diuretics

Lobar /
Chronic

Lung Cancer with Obstructive Pneumonitis

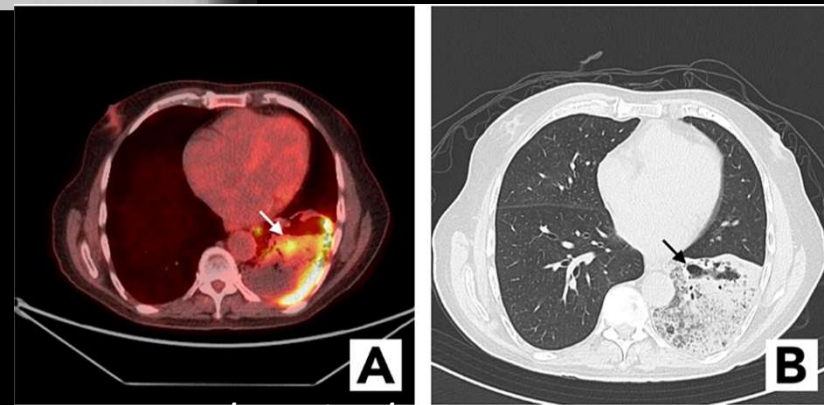
- No air bronchogram
- May form abscess / cavities with air fluid levels
- Usually has volume reduction



Lobar / Chronic

Pulmonary Mucinous Adenocarcinoma

- Lung cancer that looks like pneumonia due to mucin production
- No typical signs of infection
- Nonresponsive to antibiotics

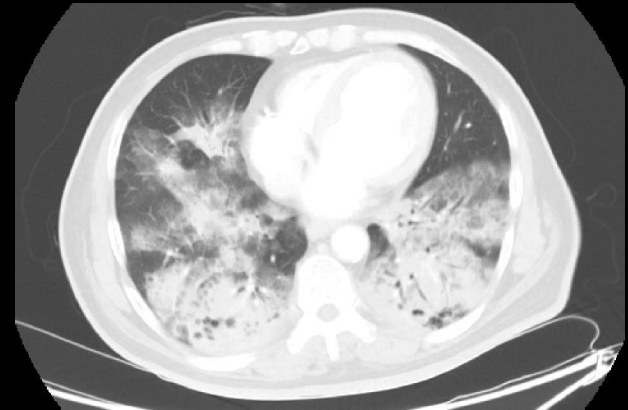


<https://www.cureus.com/articles/143835-mucinous-adenocarcinoma-of-the-lung-a-great-mimicker-of-pneumonia#!/>

Lobar /
Chronic

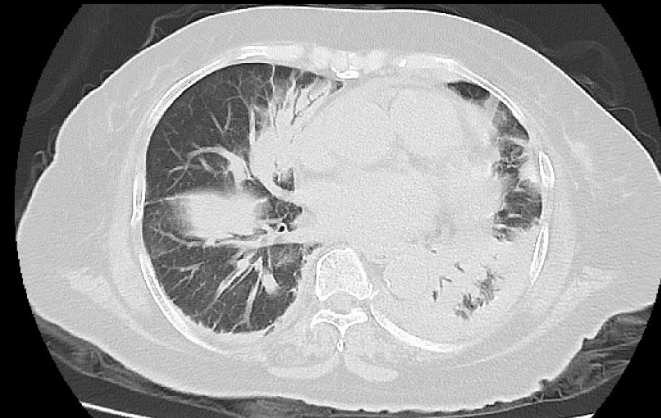
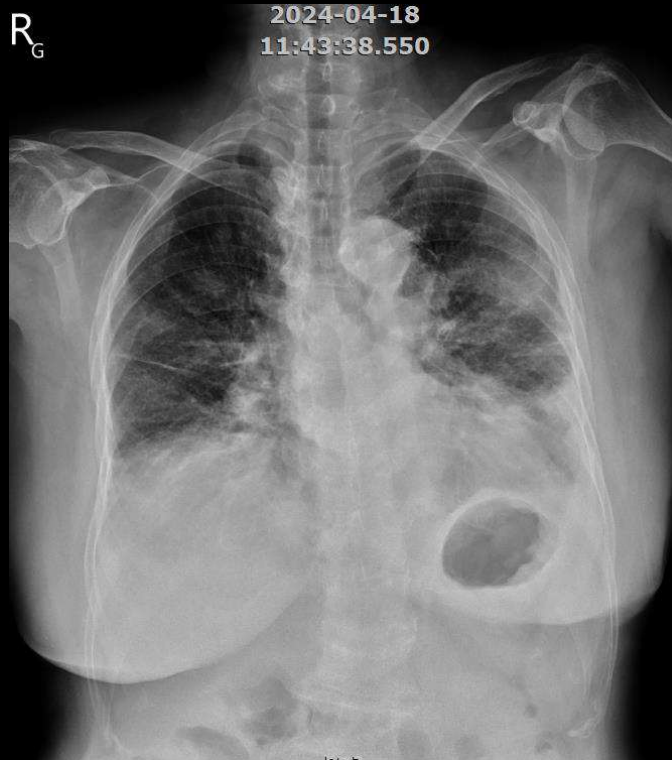
Pulmonary Mucinous Adenocarcinoma

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Chronic

Pulmonary Lymphoma



Diffuse /
Acute

Hemorrhage

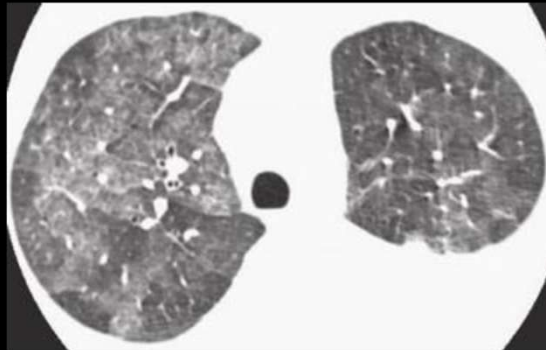
- Patchy-Widespread consolidation
- Associated with hemoptysis, Anemia
- Causes
 - Vasculitis (SLE, Granulomatosis with Polyangitis)
 - Goodpasture Syndrome
 - Idiopathic Pulmonary Hemisiderosis
 - Thrombocytopenia
 - Leukemia

Diffuse /
Acute

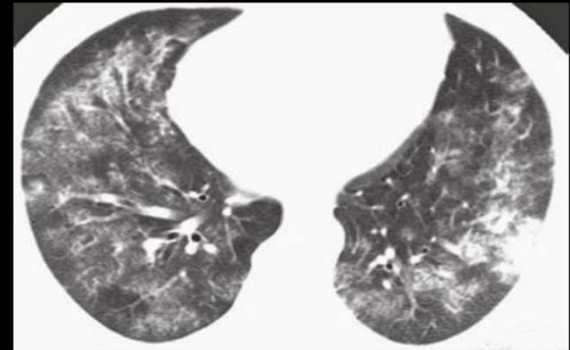
Hemorrhage



Leukoclastic
Vasculitis



GGO, pulmonary hemorrhage
(Leukemia & thrombocytopenia)



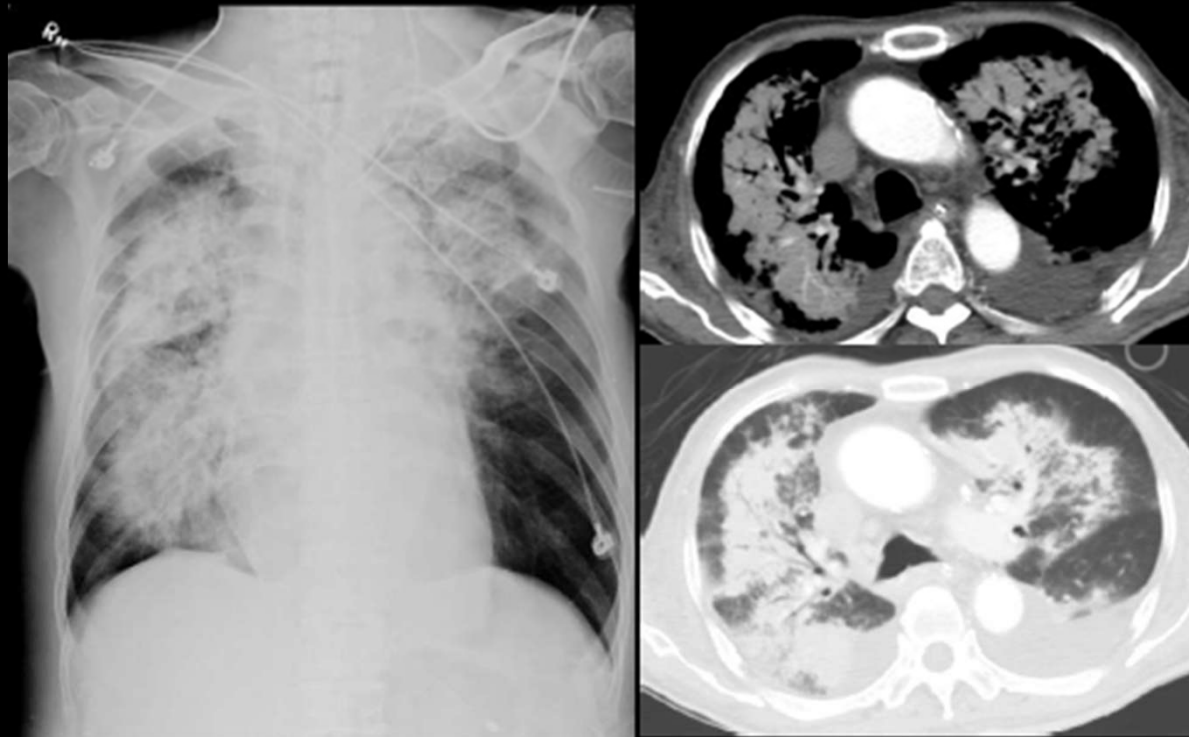
Patchy GGO and consolidation, perihilar
(SLE with pulmonary hemorrhage)



Goodpasture's syndrome

Diffuse /
Acute

Microscopic Polyangitis

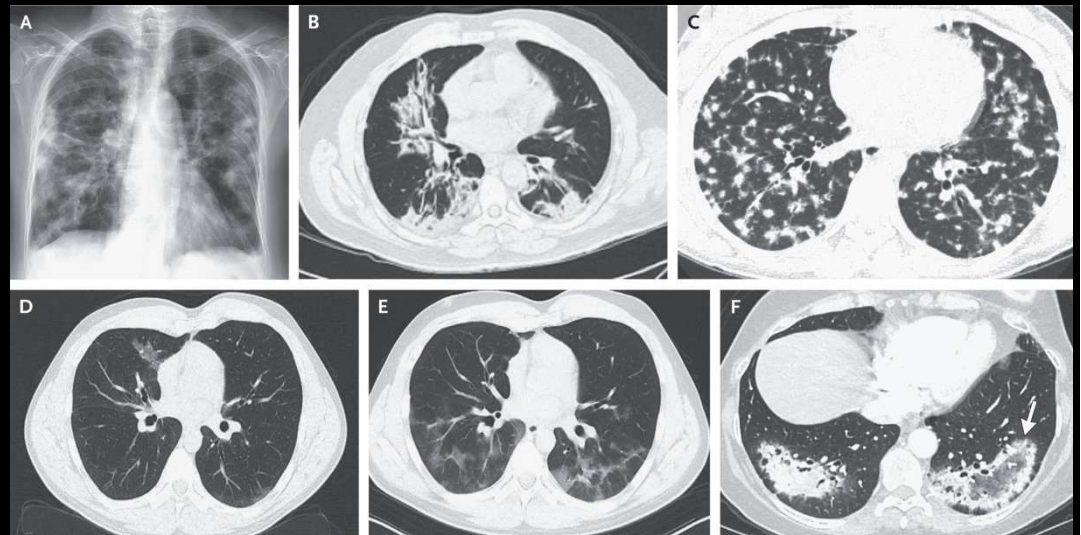
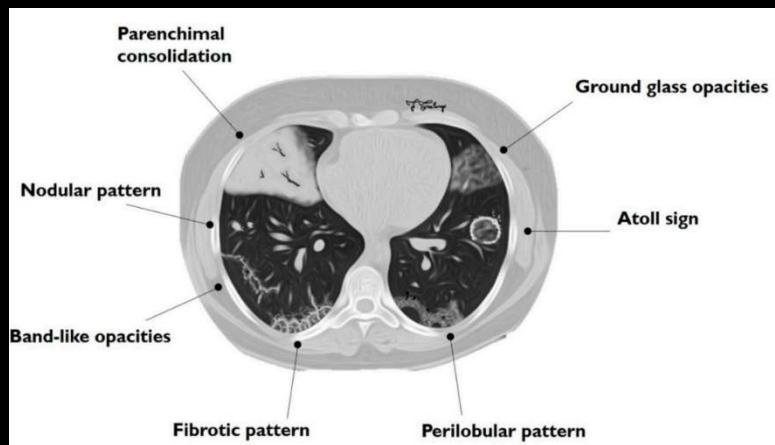


Hemoptysis, hematuria, renal failure, p-ANCA(+)

Diffuse/
Subacute

Organizing Pneumonia

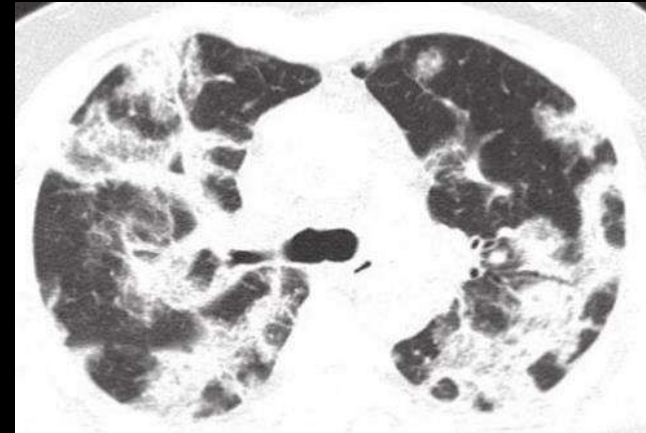
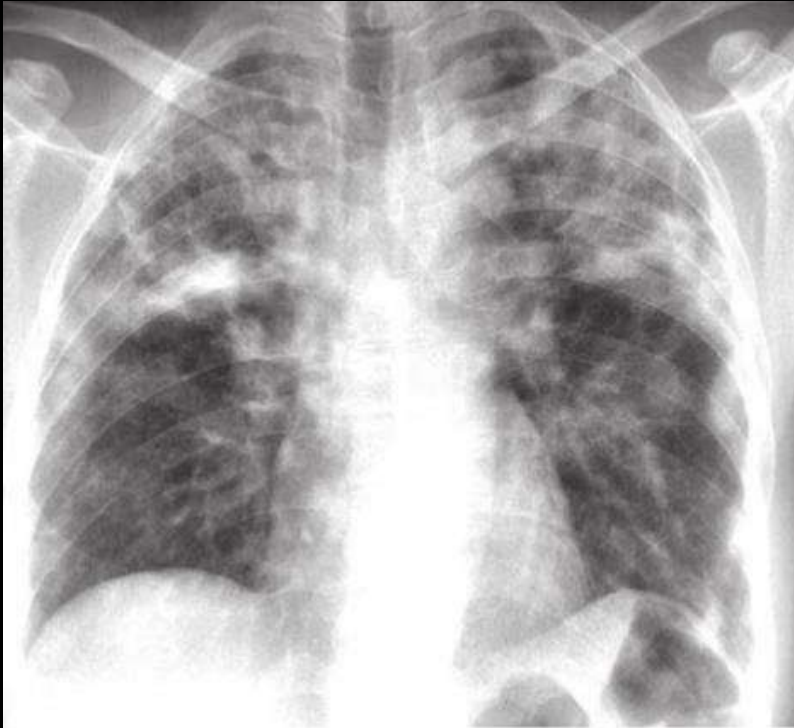
- Inflammatory Response to lung injury
- Confirmed via biopsy



<https://www.nejm.org/doi/full/10.1056/NEJMra2116777>

Chronic /
Diffuse

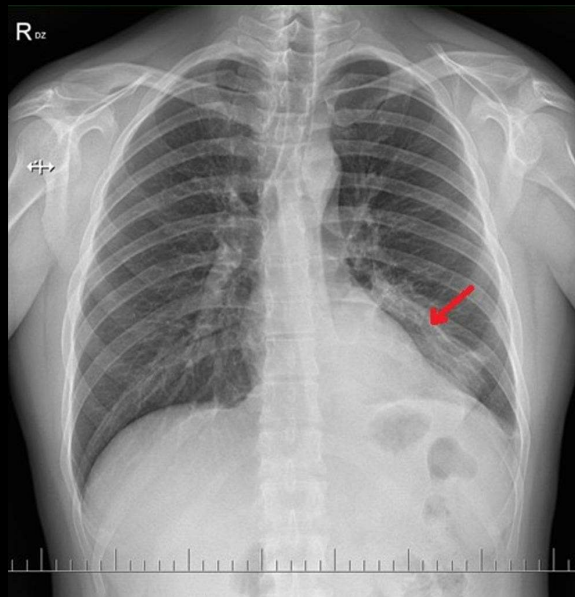
Chronic Eosinophilic Pneumonia



Chronic/
Focal

Pulmonary Sequestration

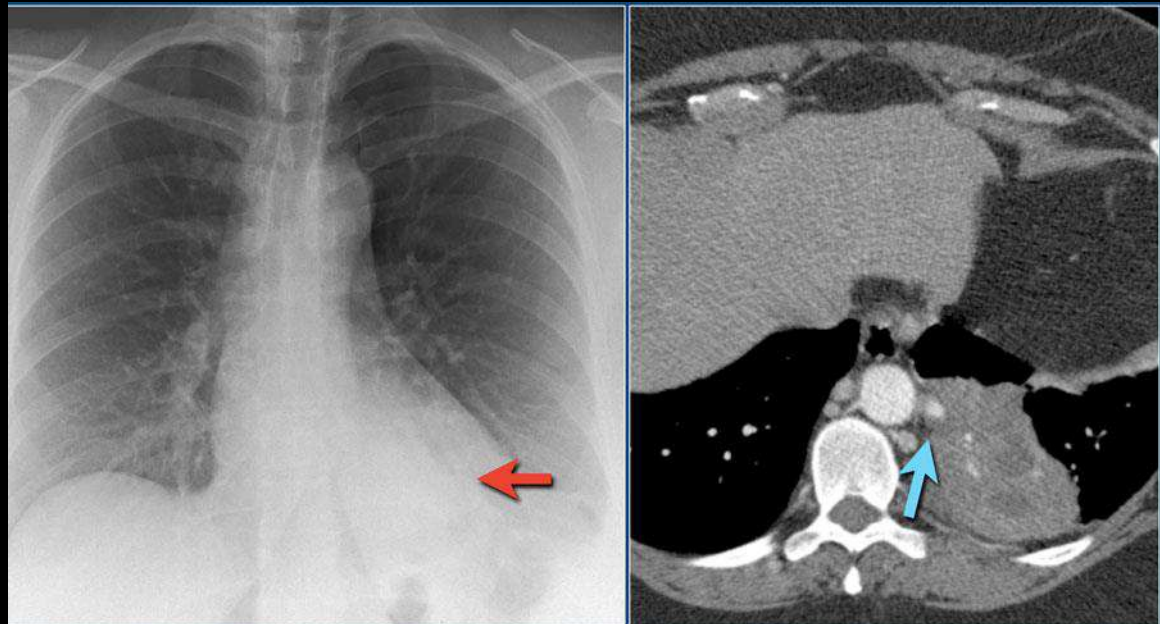
- Aberrant congenital formation of lung tissue that has no connection with the bronchial tree or pulmonary arteries
- Usually Basal lung fields
- Asymptomatic or may become infected



Chronic/
Focal

Pulmonary Sequestration

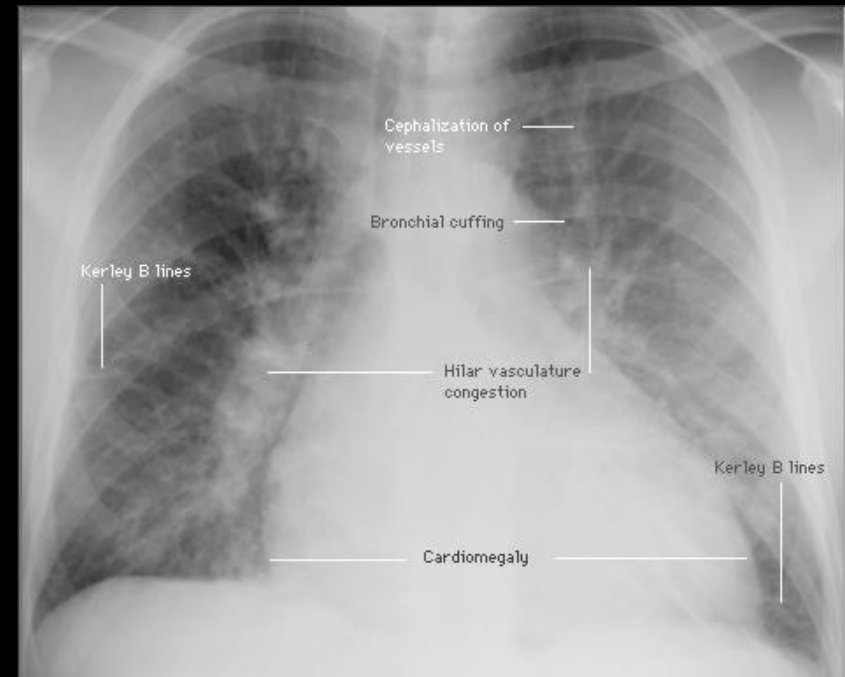
- Aberrant congenital formation of lung tissue that has no connection with the bronchial tree or pulmonary arteries
- Usually Basal lung fields
- Asymptomatic or may become infected



Diffuse /
Acute

Cardiogenic Pulmonary Edema

- Associated with cardiomegaly (may not be present in AMI, acute arrhythmia)
- May be associated with pleural effusion
- Distribution may be atypical if patient bedridden, or associated emphysema, bullae, pneumonia

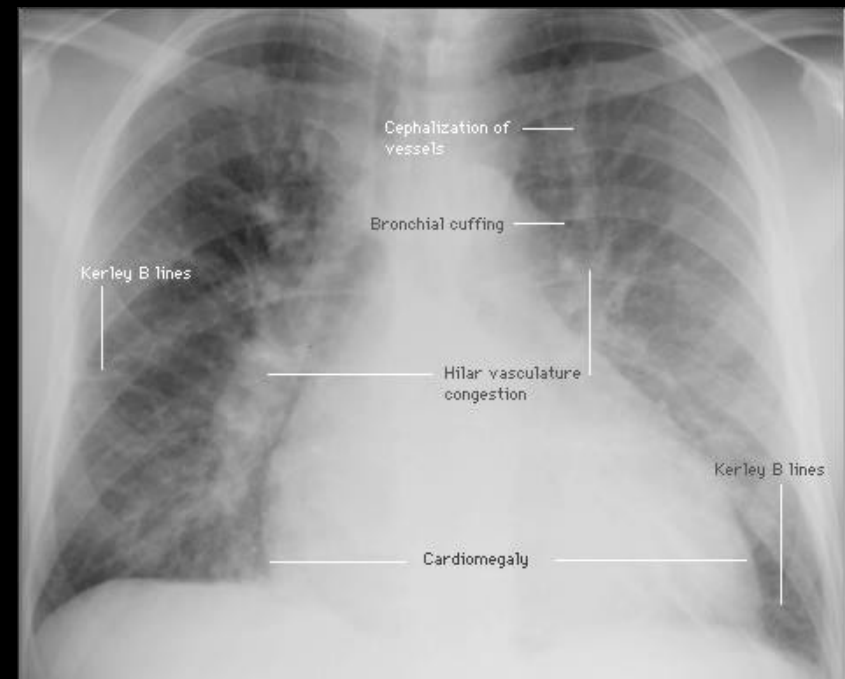


Diffuse /
Acute

Cardiogenic Pulmonary Edema

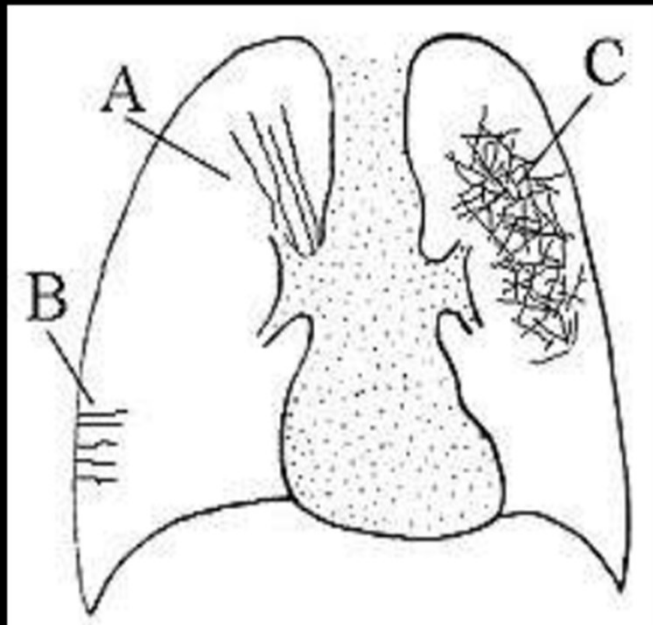
Disease course progression (Associated with wedge pressure)

- **Redistribution (PCWP = 12–18 mmHg)** Cephalization:
Upper lobe vessels diameter $\geq$ lower lobe
 - Increased bronchial artery/bronchus ratio in upper lobes
 - Blurring of lower lung vessels: loss of normal shape margin
- **Interstitial edema (PCWP = 18–25 mmHg)**
 - Thickening of interlobular septum: Kerley's A, B, C lines
 - Peri-bronchial cuffing
 - Perihilar and lower zone haziness
- **Alveolar edema (PCWP > 25 mmHg)** Confluent, irregular and poorly defined patchy opacities
 - Batwing (or butterfly) appearance
 - Rapid appearance and disappearance: diuretics trial

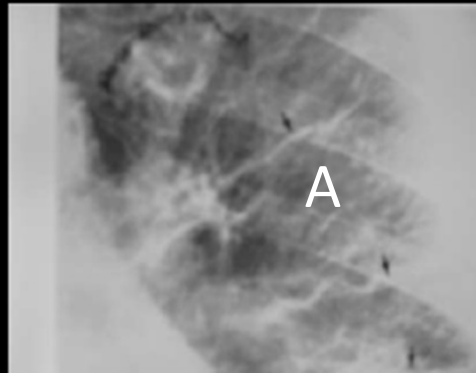


Diffuse /
Acute

Kerley's Lines



A



C

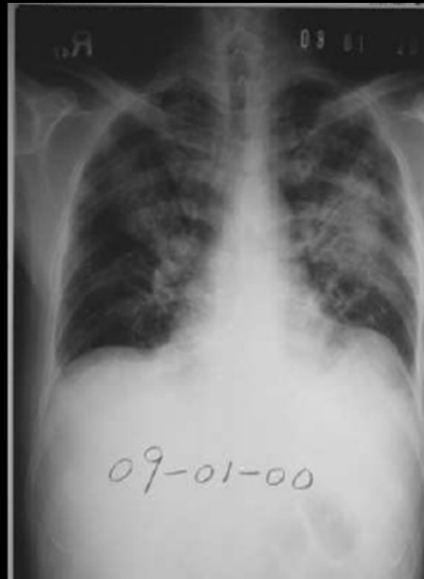


B



Diffuse /
Acute

Batwing Pulmonary Edema



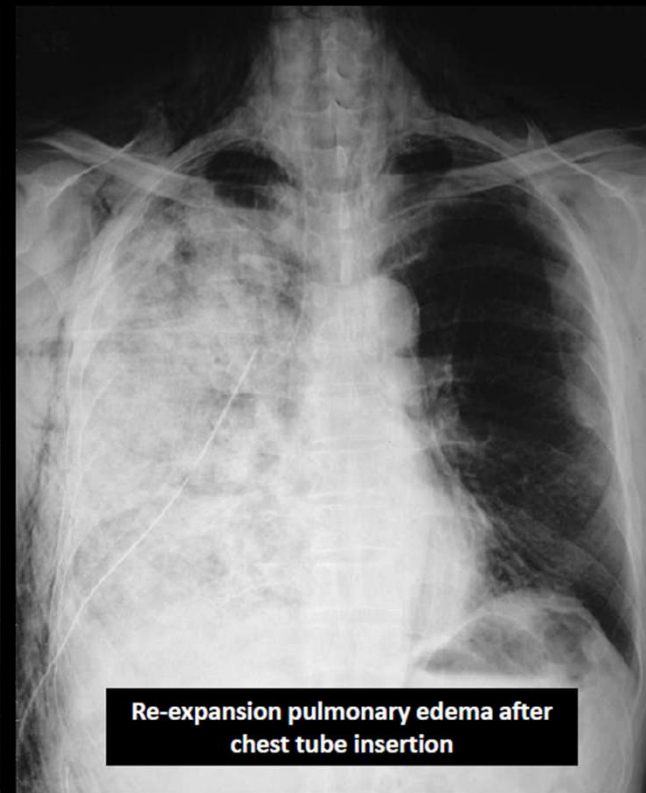
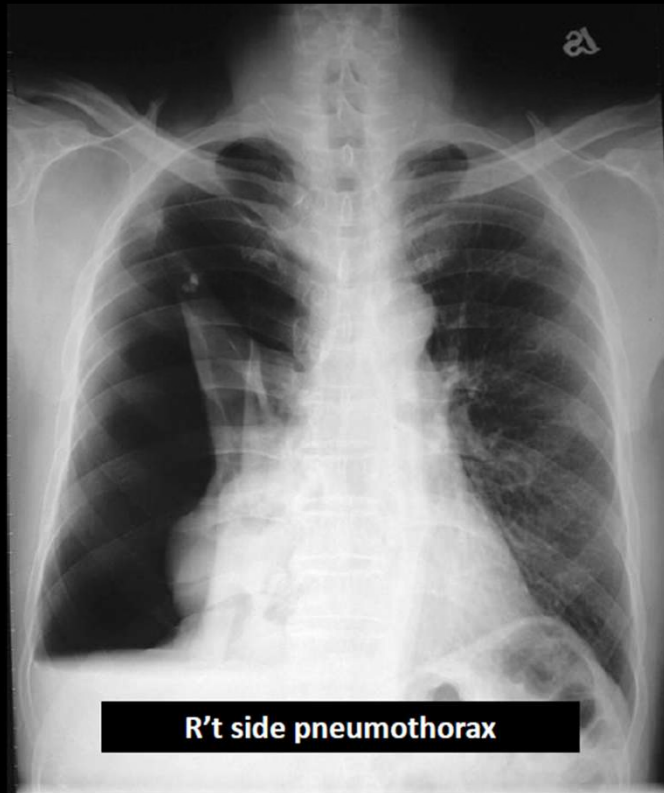
Diffuse /
Acute

Non- Cardiogenic Pulmonary Edema

- Non increased capillary wedge pressure
- Normal heart size
- Near drowning
- Oxygen therapy
- Trauma or TRALI
- CNS (neurogenic pulmonary edema)
- Allergic alveolitis or aspiration
- Re-expansion pulmonary edema
- Drugs (heroin or methadone)
- Inhaled toxins
- Altitude (high altitude pulmonary edema)
- ARDS
- Contusion

Diffuse /
Acute

Re-expansion



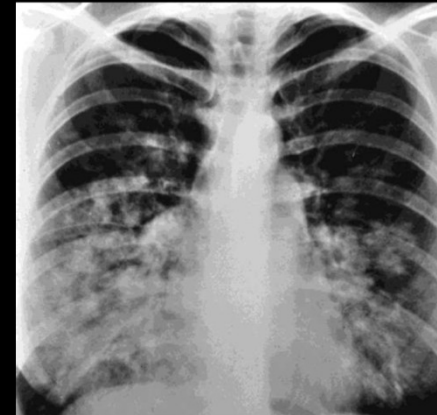
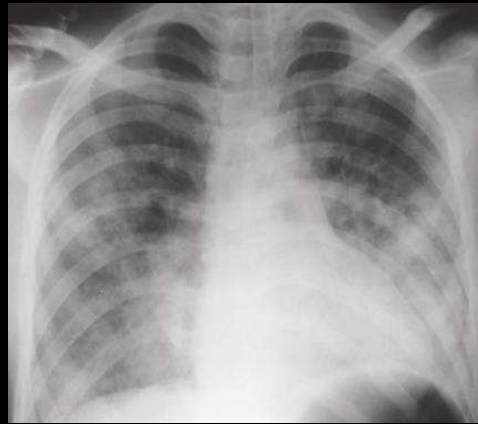
Diffuse /
Acute

Neurogenic

High Altitude

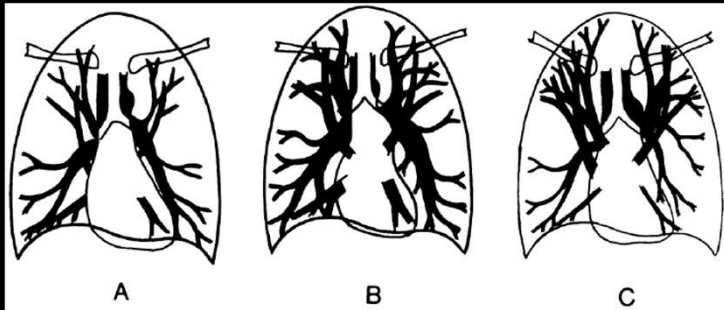
Near Drowning

ARDs



Approaching Pulmonary Edema

Distribution of Pulmonary Blood Flow

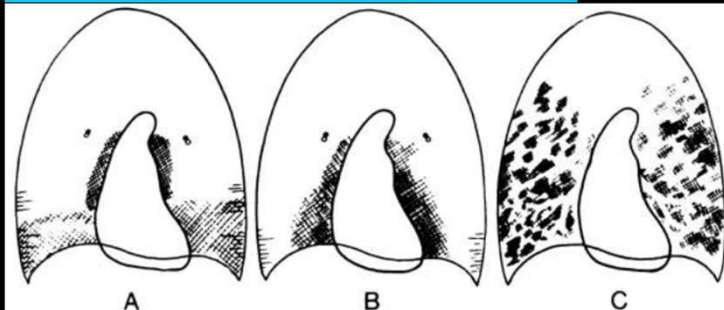


A: normal, in permeability edema

B: balanced, in overhydration and renal failure

C: inverted, in heart failure

Distribution of Pulmonary Edema



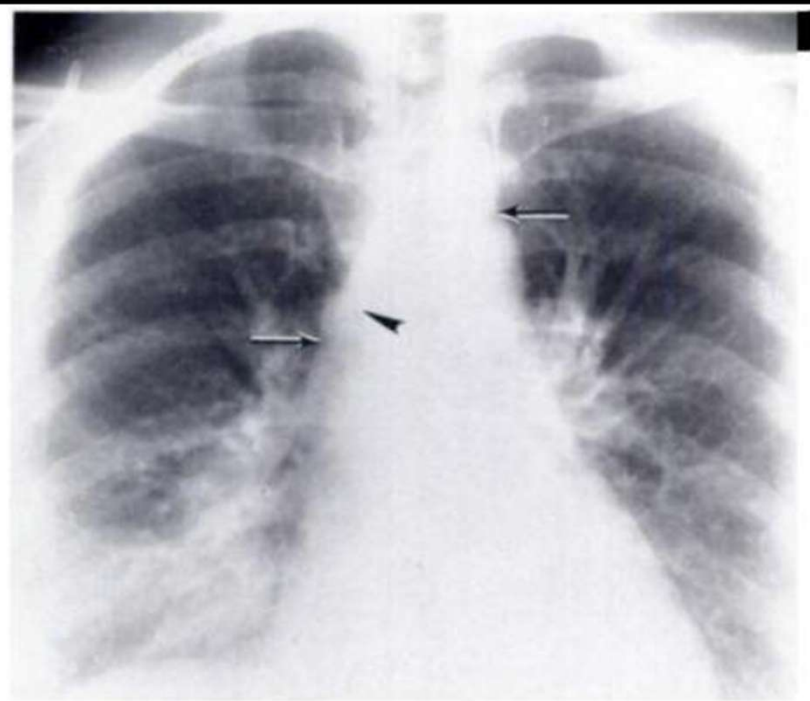
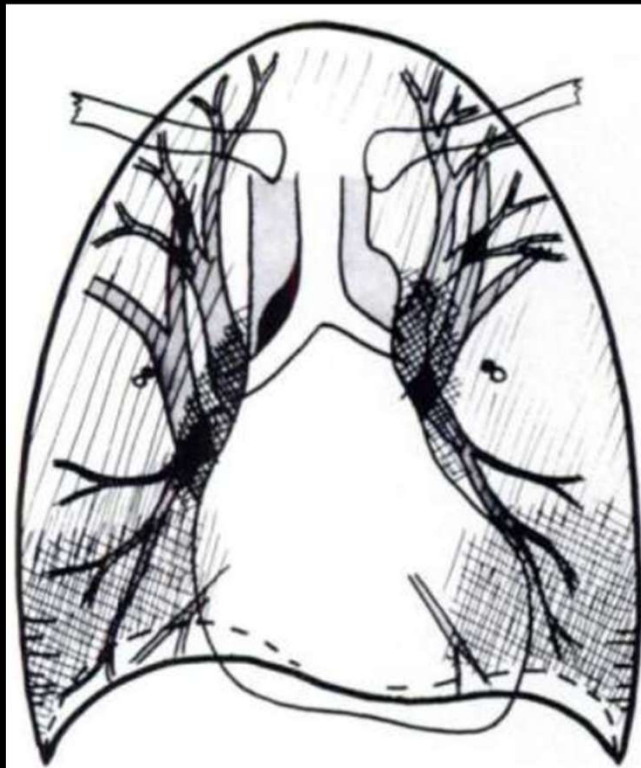
A: Even; principally basal (gravitational) and homogeneous from chest wall to heart but with perihilar component also. In heart failure mainly.

B: Central; occurs principally in overhydration or renal failure.

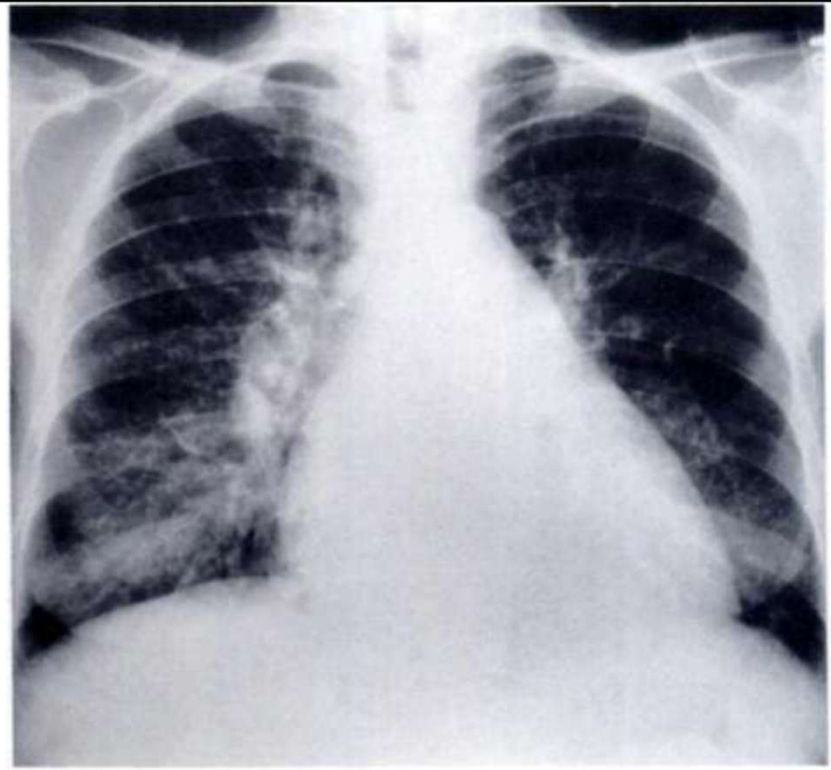
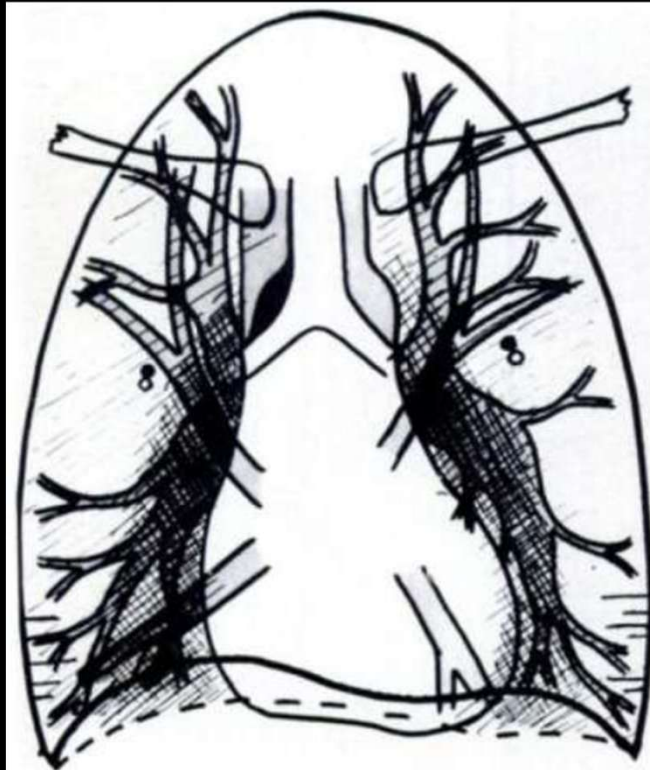
C: Peripheral; markedly patchy, often spares CP angles. Air bronchograms(+). Almost in capillary permeability edema.

AJR 144:879-894, May 1985

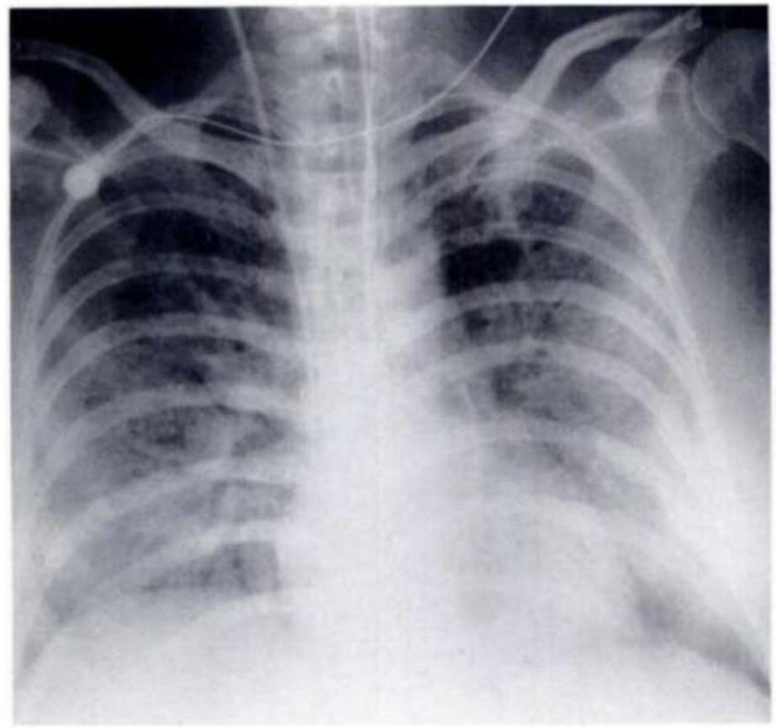
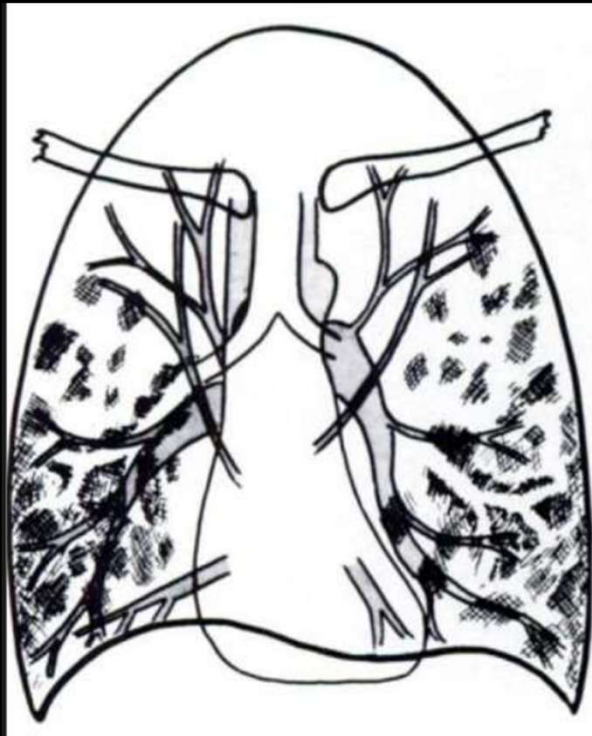
Chronic Heart Failure



Renal Failure with Fluid Overload



Non-cardiogenic Pulmonary Edema



Consolidation + Cavitation

- **Infection**
 - **Bacterial:** *S. aureus*, GNB, *Nocardia*
 - **Mycobacterial:** TB, NTM
 - **Fungal:** *Aspergillus*, mucormycosis, *Cryptococcus*
- **Vascular**
 - Pulmonary infarct
 - Wegeners Granulomatosis (Granulomatosis with Polyangiitis)

Mimickers Of Consolidation

Extrapulmonary

Soft Tissue

Foreign Body

Pleural effusion

Pericardial Fat

Intrapulmonary

Poor Inspiration

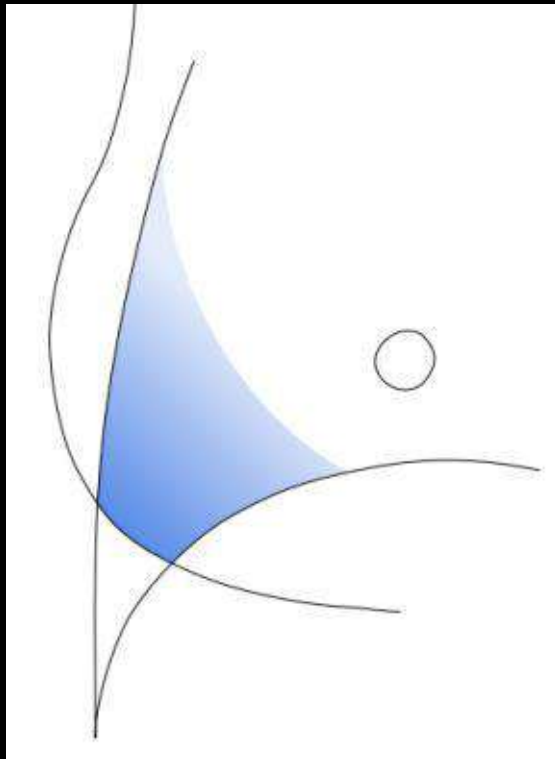
Mass

Atelectasis

GGO

Mimickers Of
Consolidation

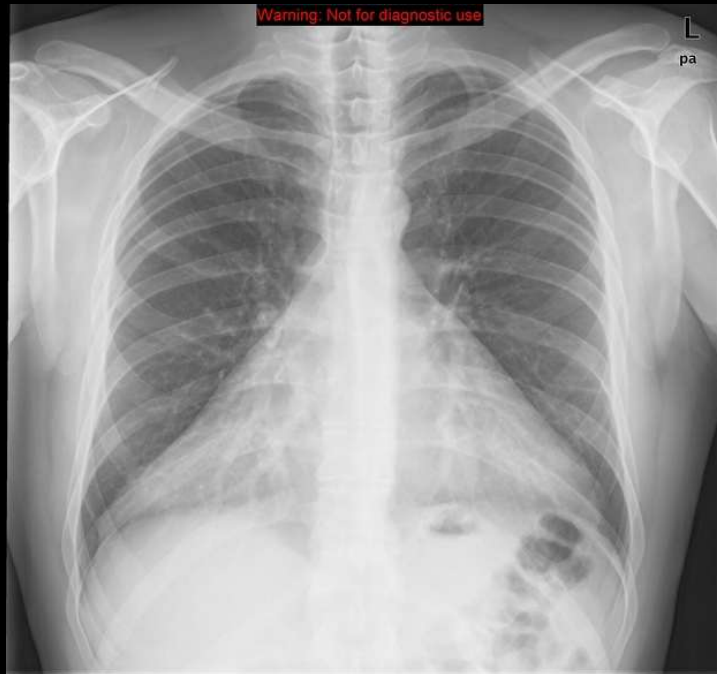
Bilateral Mammoplasty



Mimickers Of Consolidation

Pericardial Fat

Diaphragm
silhouette
Visible



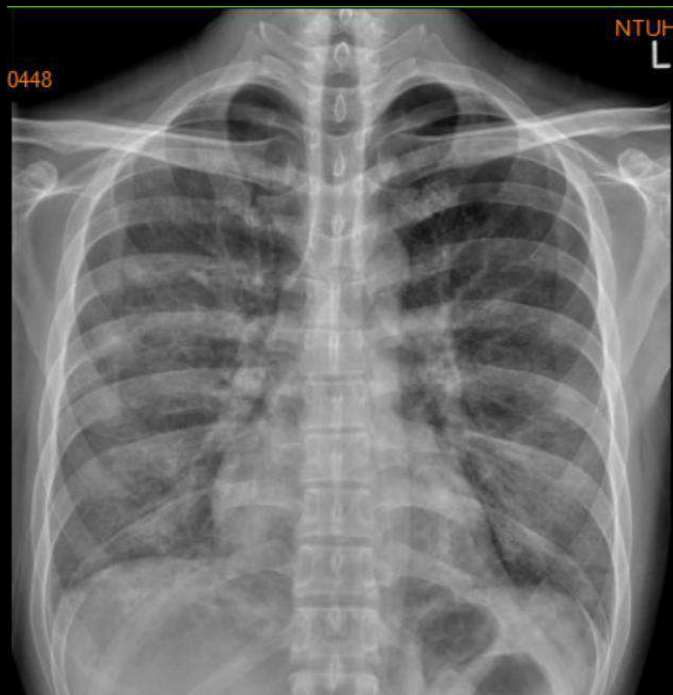
Mimickers Of
Consolidation

Inadequate Inspiration



Mimickers Of Consolidation

GGO - PJP



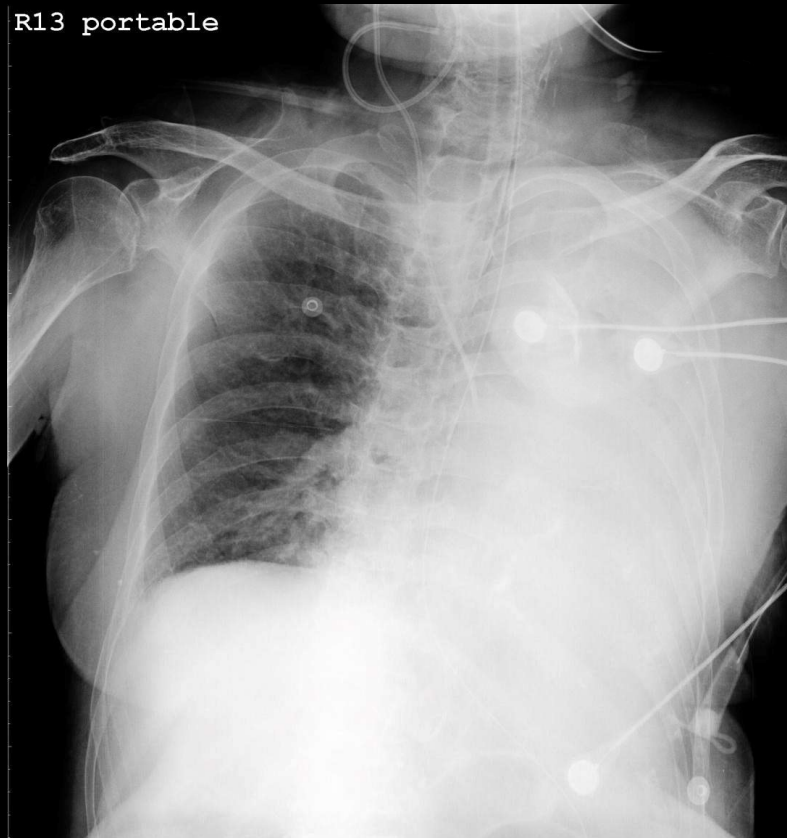
Mimickers Of
Consolidation

Lung Tumors

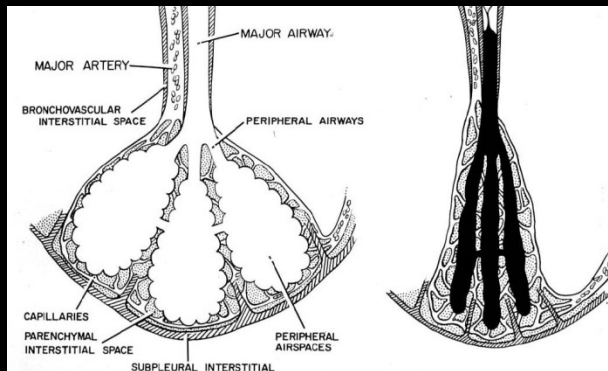


Mimickers Of Consolidation

Atelectasis



Atelectasis

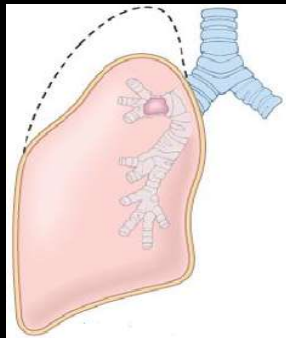


- Atelectasis – **Diminished gas within the lung** associated with reduced lung volume



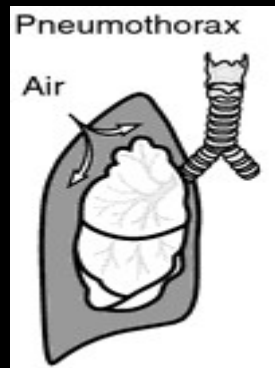
Causes of Atelectasis

Resorption Obstruction



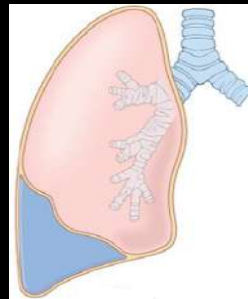
Airway obstruction, may result from a foreign body, aspiration, endobronchial tumor, or inflammatory reactions

Passive



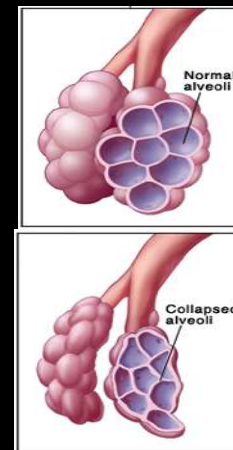
Changes in intrapleural pressure (e.g., pneumothorax)

Compressive



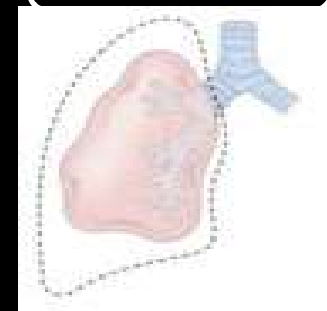
Intrapulmonary abnormalities (e.g., a large lung mass or large bulla) that **compress** the **surrounding** lung

Adhesive



Surfactant deficiency; the luminal surfaces of the alveolar walls stick together.

Cicatrization



The result of **scarring by fibrosis** (e.g., TB, IPF)

Patterns of Atelectasis

- **Entire lung collapse**
- **Lobar collapse**
- **Segmental collapse**
- **Linear Atelectasis**
- **Round atelectasis**

Signs of Collapse

Direct sign

- Displacement of interlobar fissures
- Increased radiopacity (loss of aeration)
- Vascular and bronchial crowding

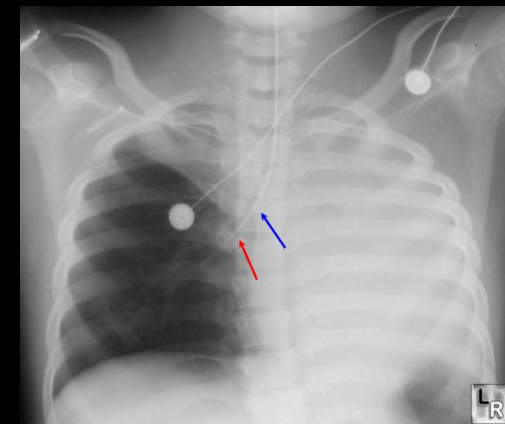
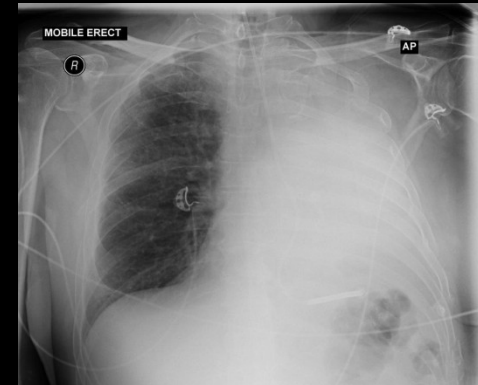
Indirect sign

- Displacement of hilum
- Elevation of diaphragm
- Shift of mediastinum, heart and trachea
- Compensatory hyperinflation
- Narrowing of intercostal space
- Herniation of contralateral lung
- Absence of air bronchogram

Total Lung Collapse

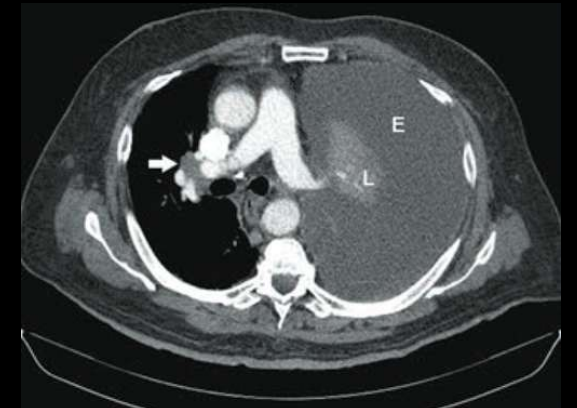
Main Bronchus Obstruction

- No air bronchogram
- Mediastinal shift
- Narrowing intercostal Space
- **Bronchial cutoff sign**

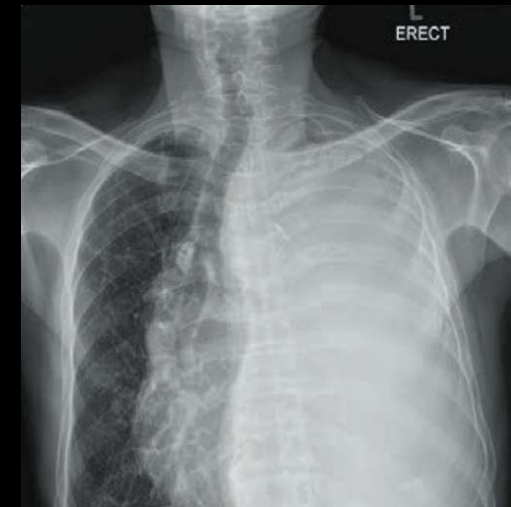
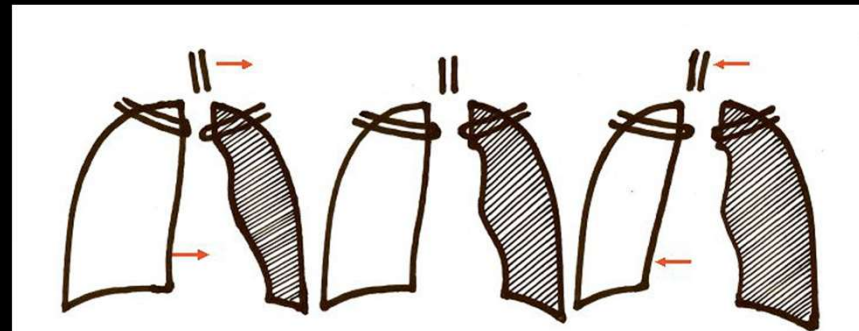
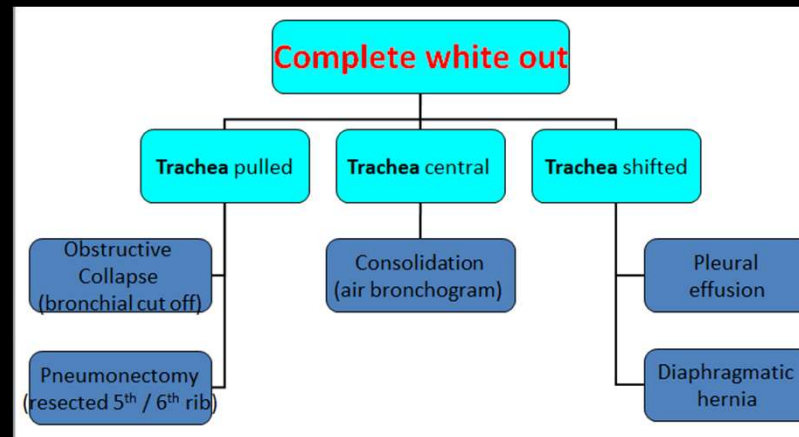


Massive Pleural Effusion

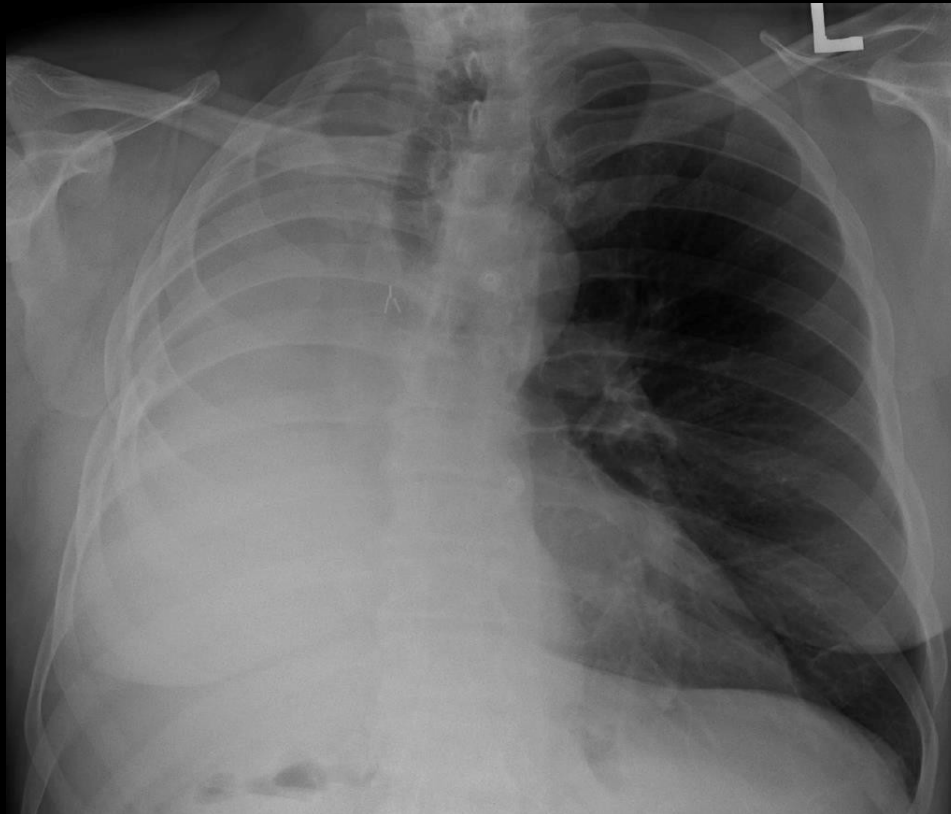
Mediastinal
Shift to
opposite side



Total Lung Whiteout



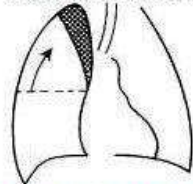
Pneumonectomy



Lobar Atelectasis

Right upper lobe collapse

Trachea deviated to R

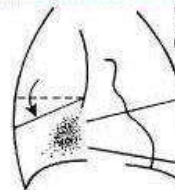


Horizontal fissure and R hilum displaced upwards

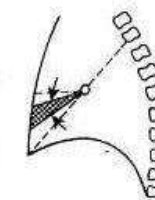


Triangular opacity with well-defined margins

Right middle lobe collapse

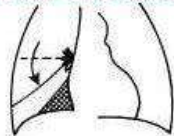


Horizontal fissure displaced down
Ill-defined opacity adjacent to R heart border
Loss of R heart border



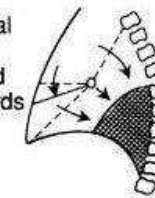
Well-defined triangular opacity running from hilum

Right lower-lobe collapse



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

Horizontal fissure displaced downwards



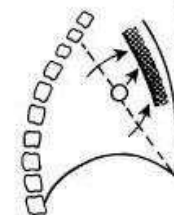
Oblique fissure and hilum displace posteriorly
Well-defined posterior opacity

Left upper-lobe collapse

Trachea deviated to L

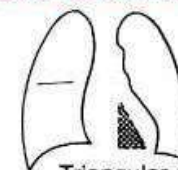


Ill-defined opacity
Indistinct elevated L hilum

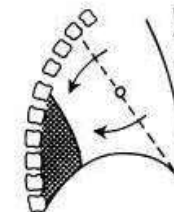


Sharply-defined posterior border due to anterior displacement of oblique fissure

Left lower-lobe collapse

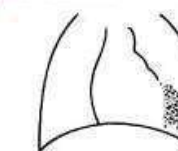


Triangular opacity visible through the heart with loss of medial end of diaphragm



Oblique fissure displaced posteriorly

Lingular consolidation

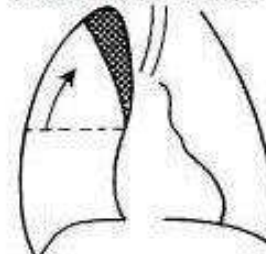


Indistinct L heart border

Right Upper Lobe Atelectasis

Right upper lobe collapse

Trachea deviated to R

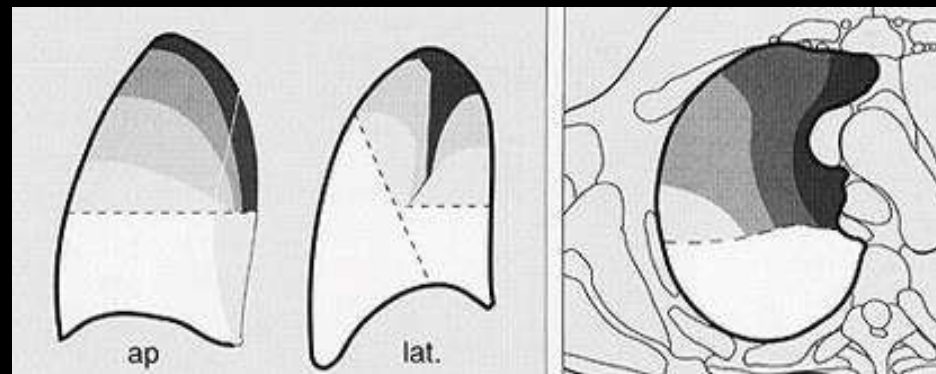
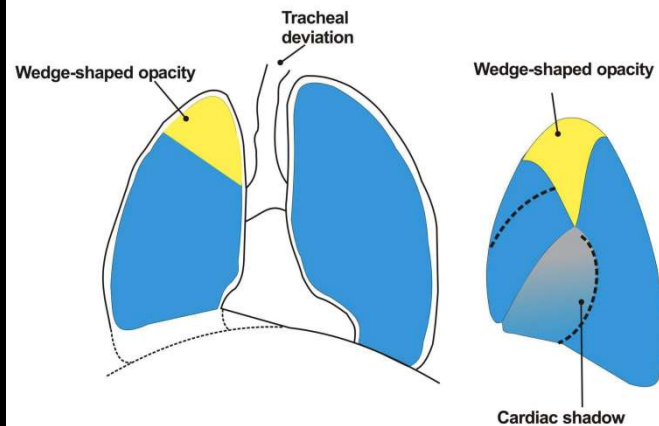


Horizontal fissure and R hilum displaced upwards



Triangular opacity with well-defined margins

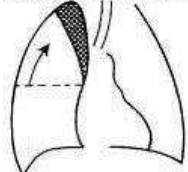
Right upper lobe collapse



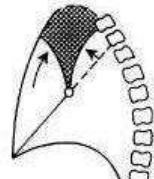
Right Upper Lobe Atelectasis

Right upper lobe collapse

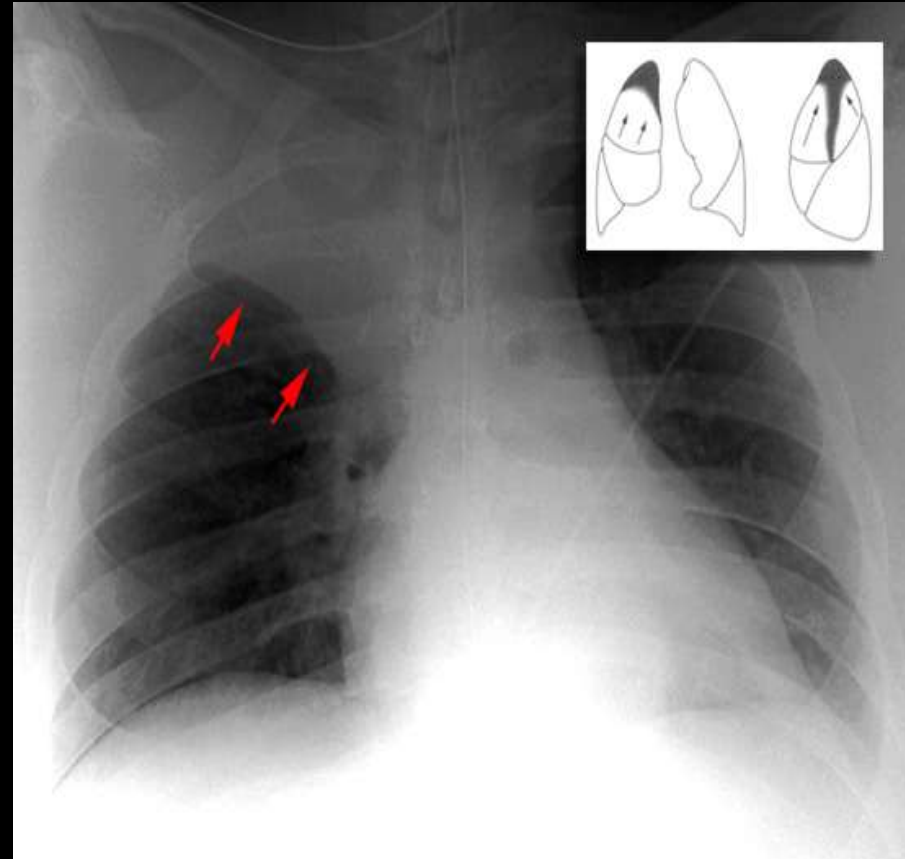
Trachea deviated to R



Horizontal fissure and R hilum displaced upwards



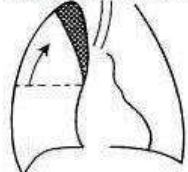
Triangular opacity with well-defined margins



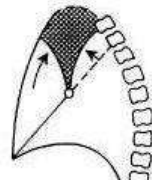
Right Upper Lobe Atelectasis

Right upper lobe collapse

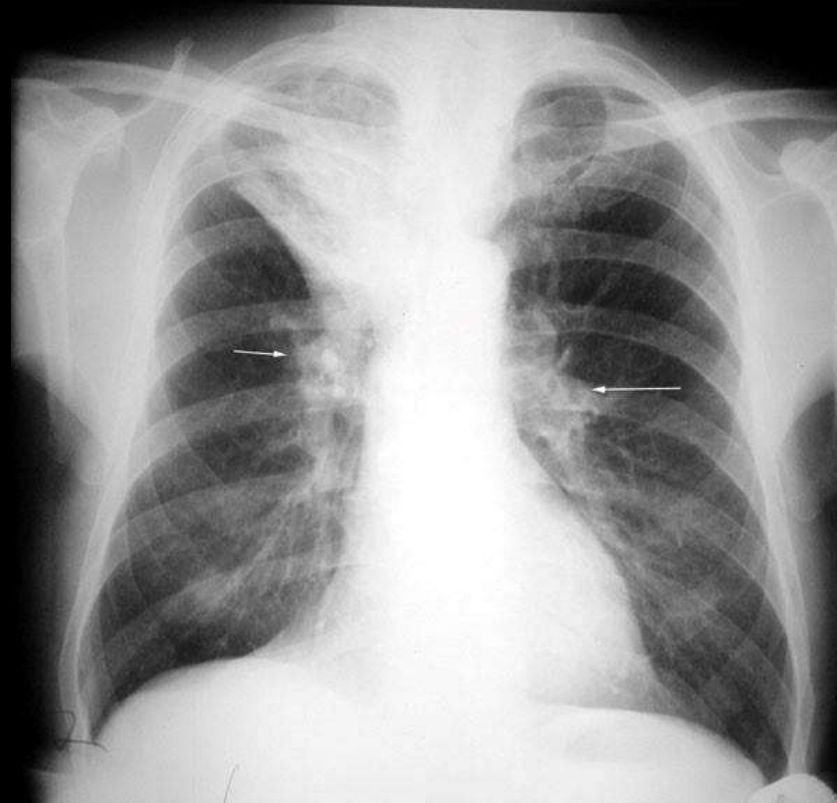
Trachea deviated to R



Horizontal fissure and R hilum displaced upwards

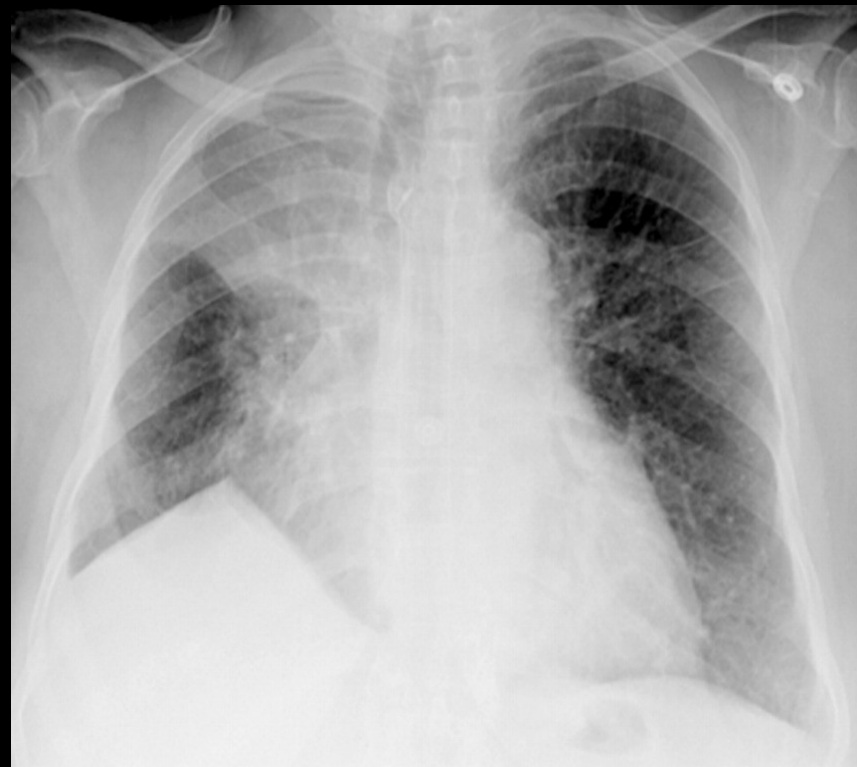
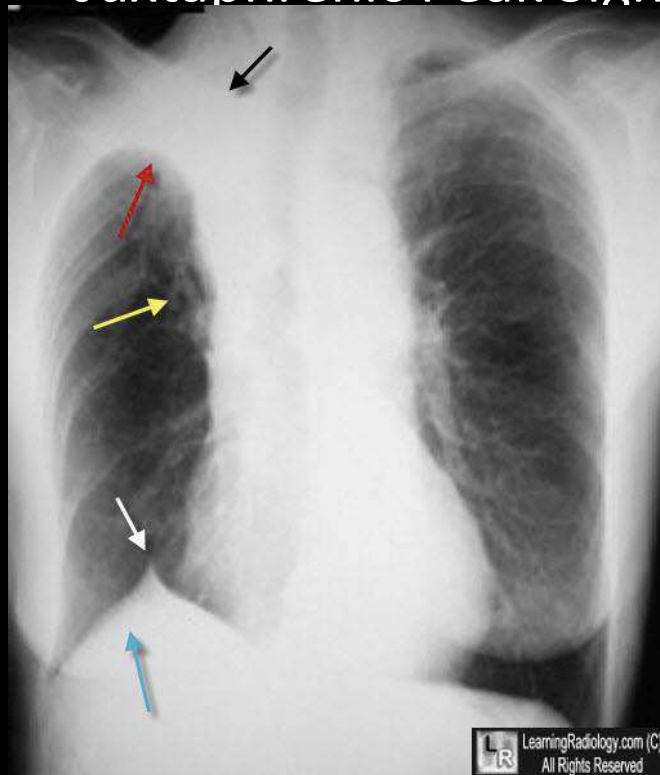


Triangular opacity with well-defined margins



Right Upper Lobe Atelectasis

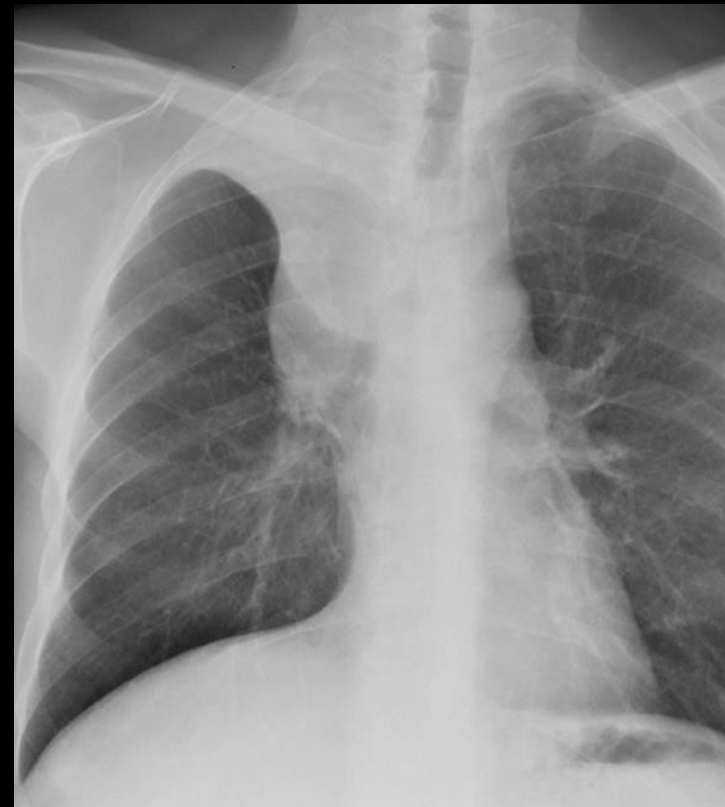
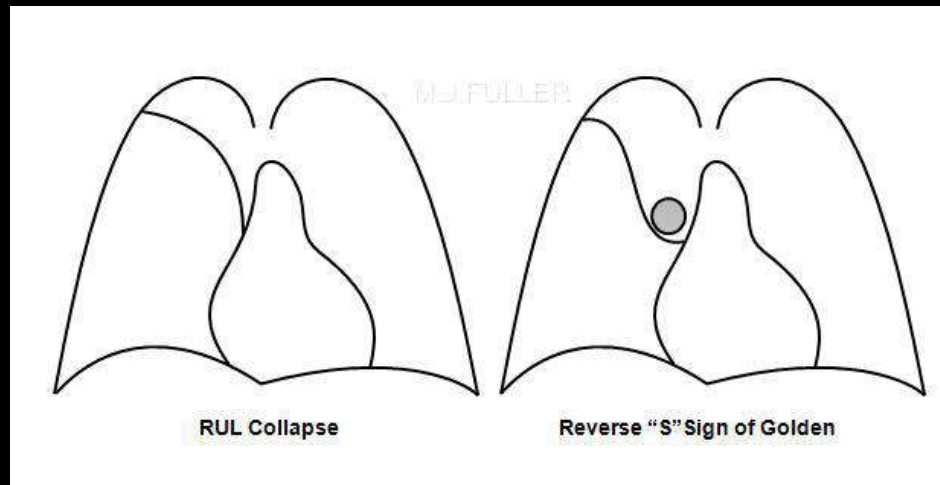
Juxtaphrenic Peak Sign



Right Upper Lobe Atelectasis

Golden S Sign

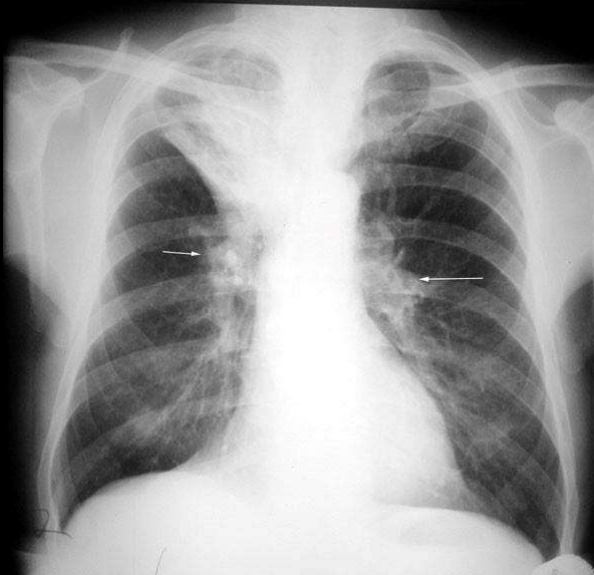
Due to right hilar mass collapsing
RUL bronchus



Right Upper Lobe Atelectasis

Atelectasis

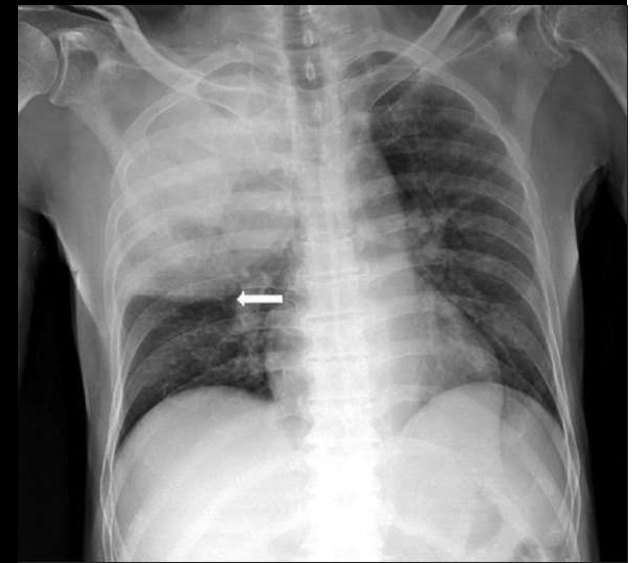
Height of Hilum
Fissure Displacement



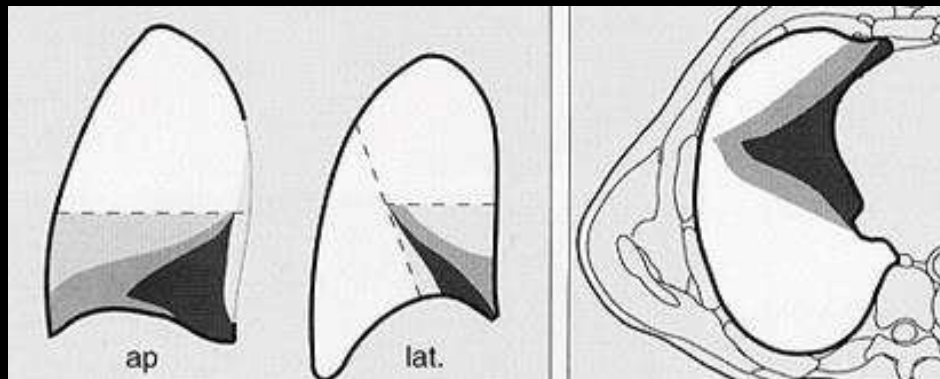
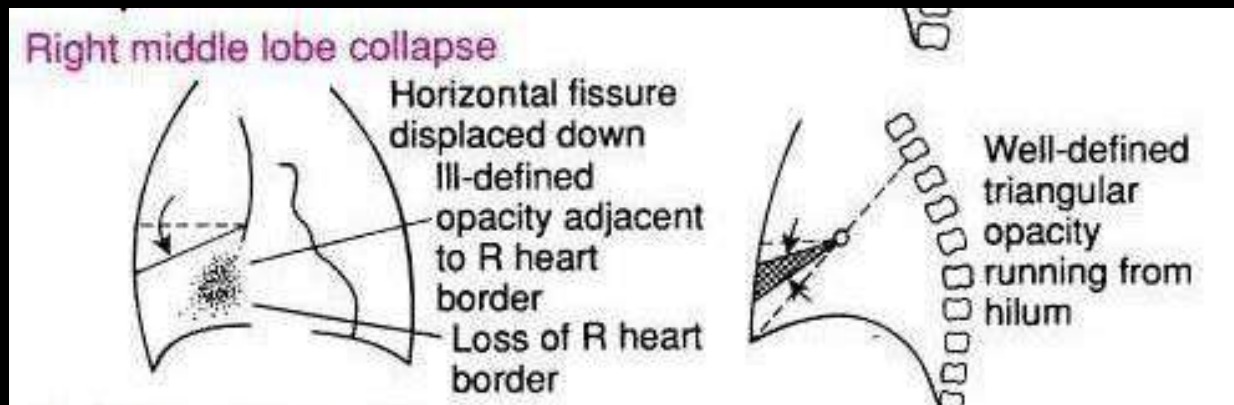
Tumor



Consolidation

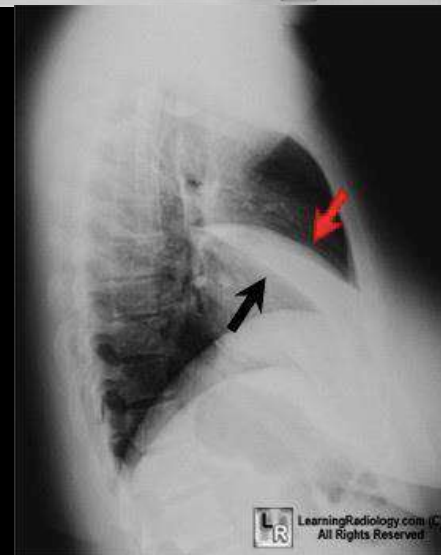
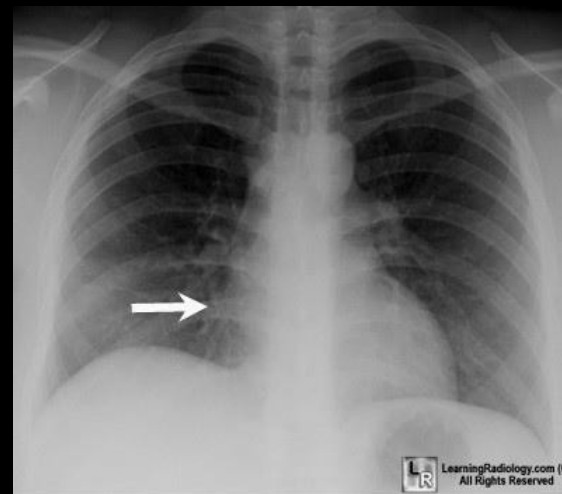


Right Middle Lobe Atelectasis

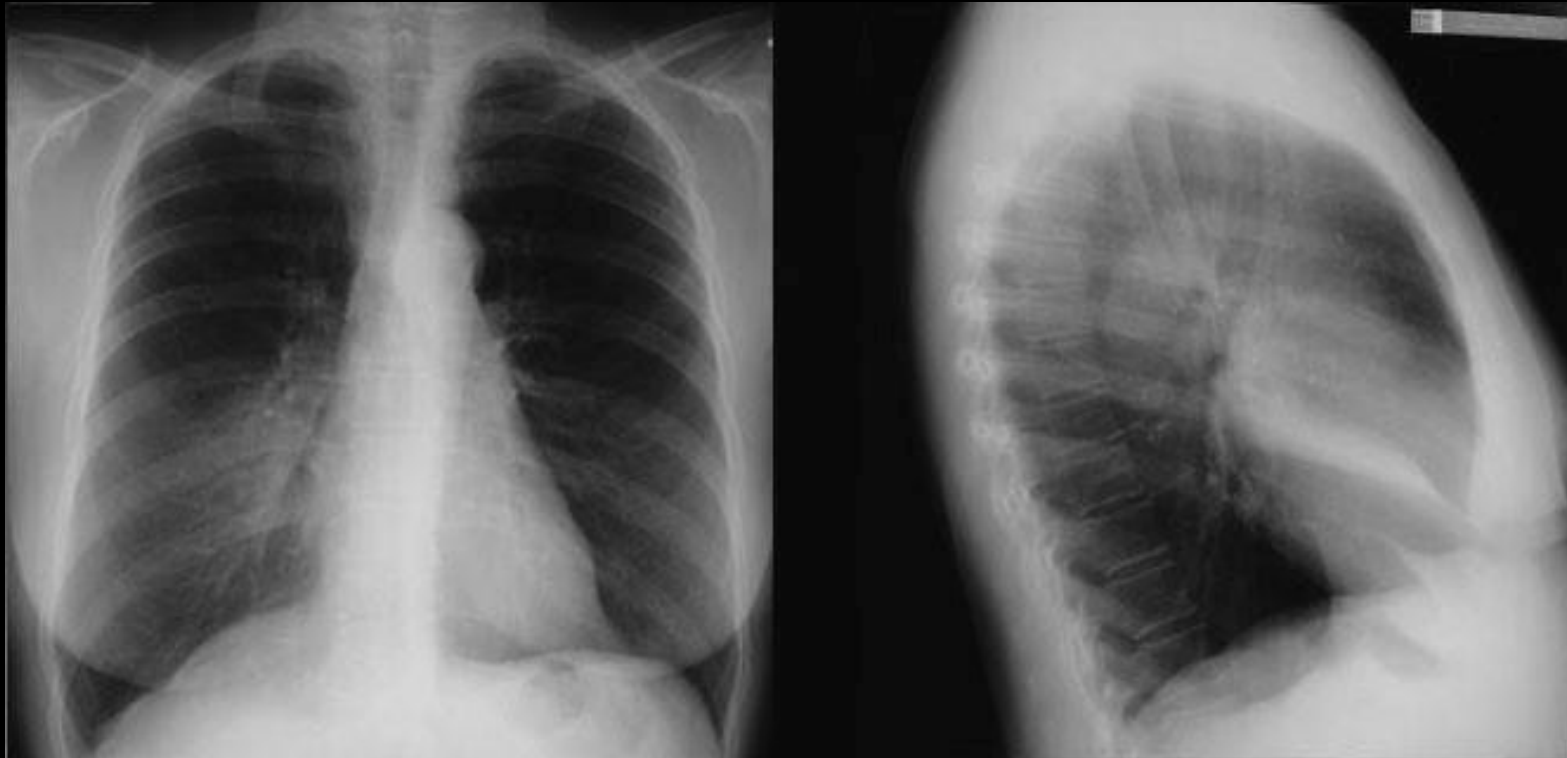


Volume of this lobe is small, so indirect signs occasionally present only

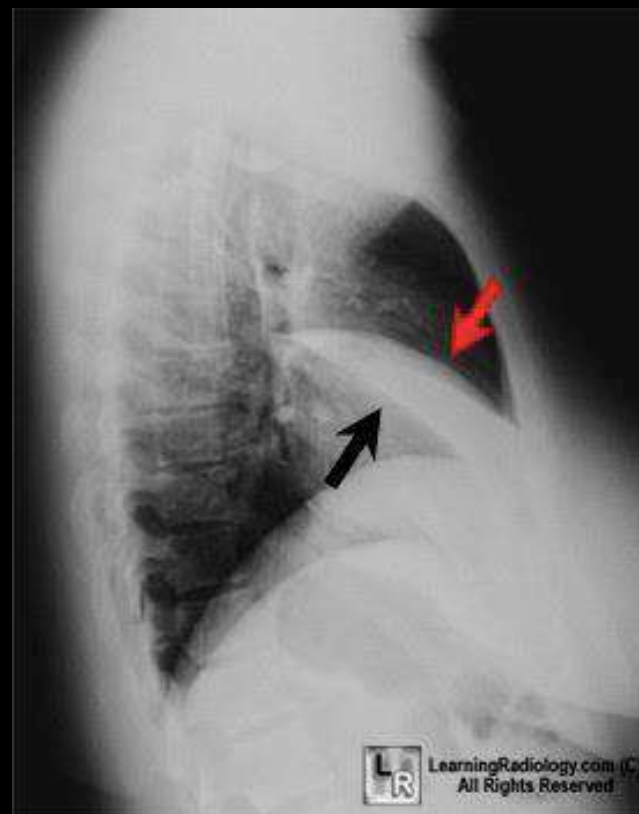
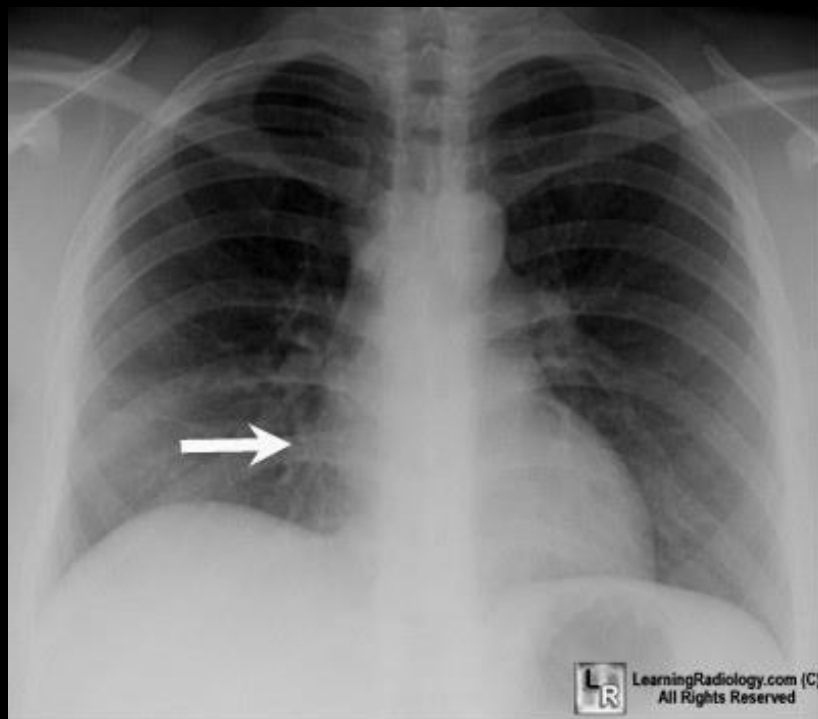
Right Middle Lobe Atelectasis



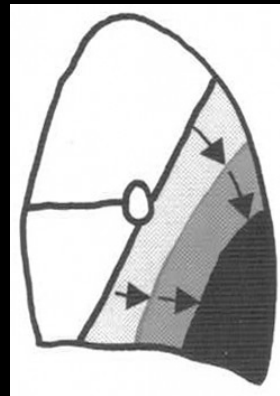
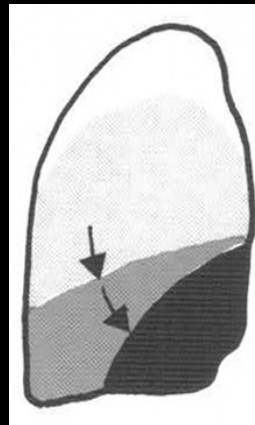
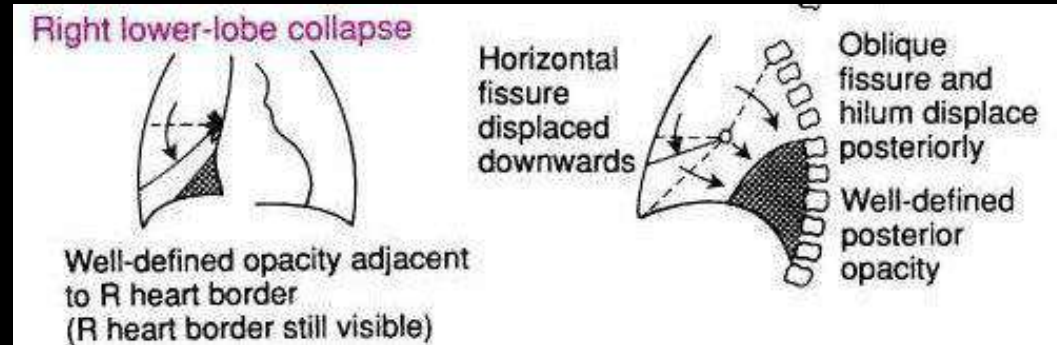
Right Middle Lobe Atelectasis



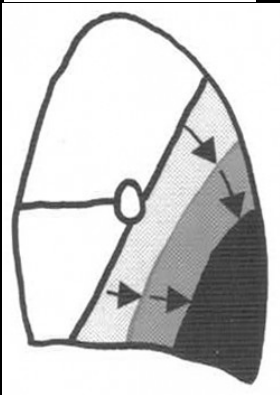
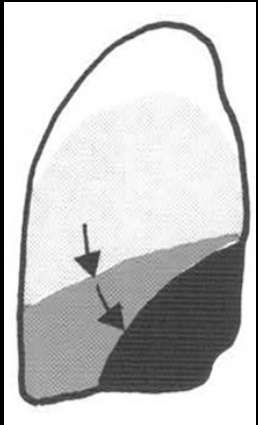
Right Middle Lobe Atelectasis



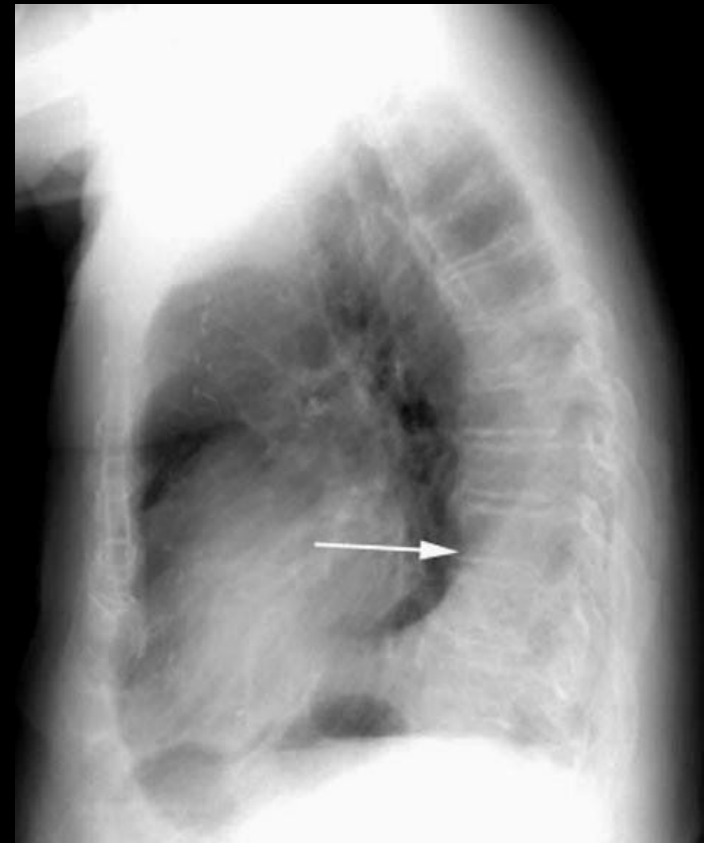
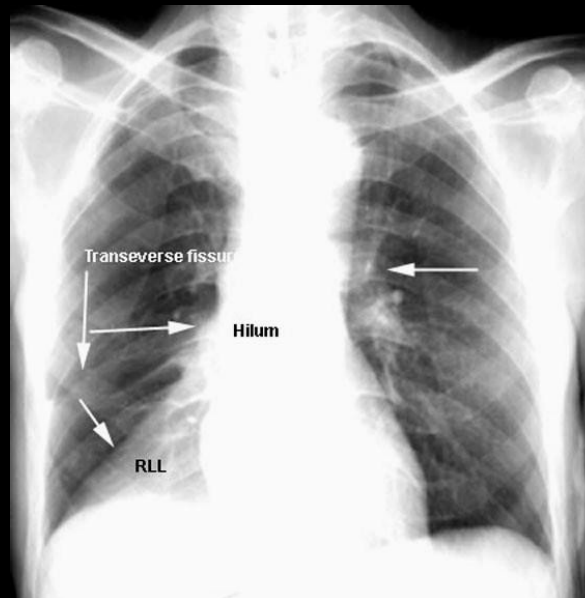
Right Lower Lobe Atelectasis



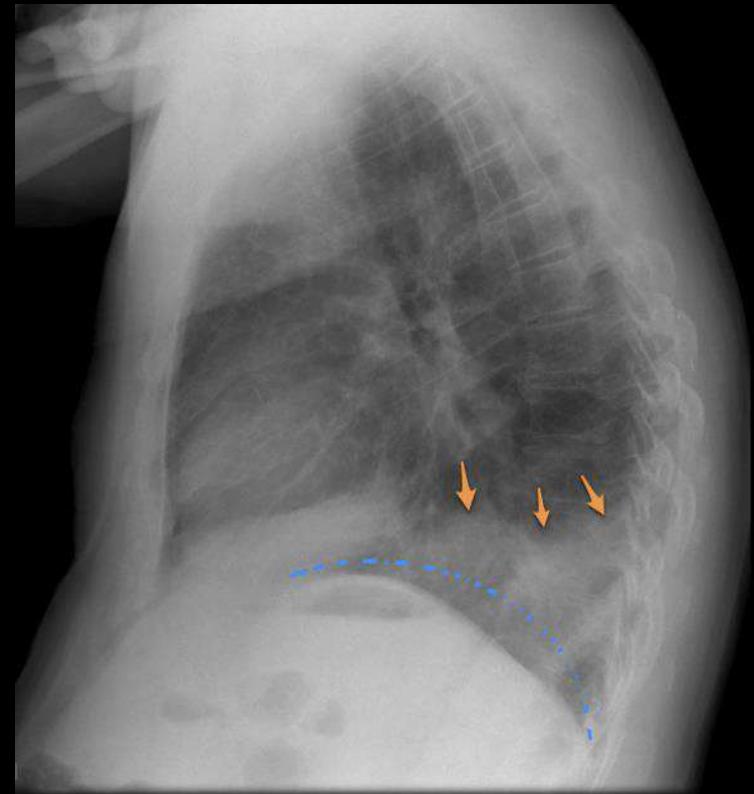
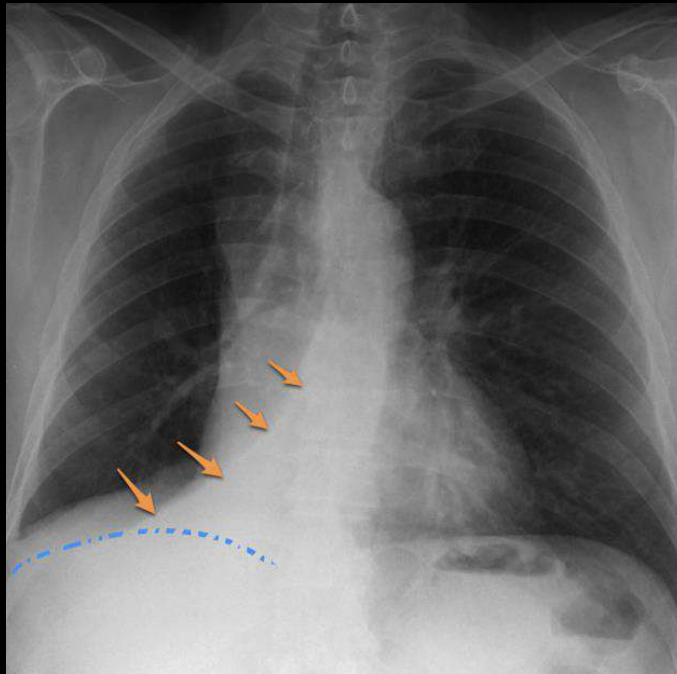
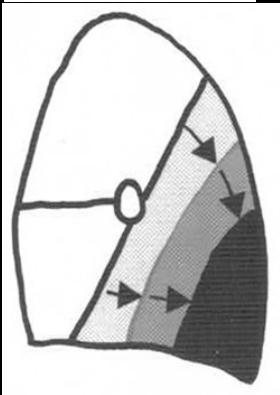
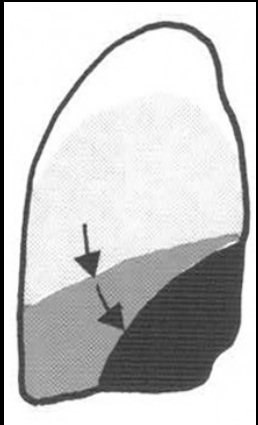
Right Lower Lobe Atelectasis



Right Heart Border Still
Visible

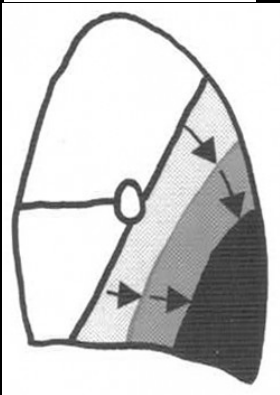
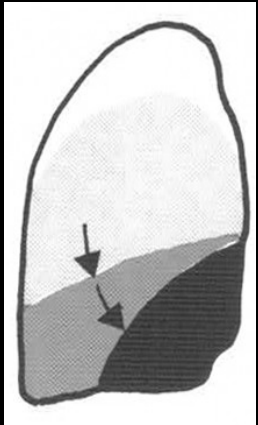


Right Lower Lobe Atelectasis

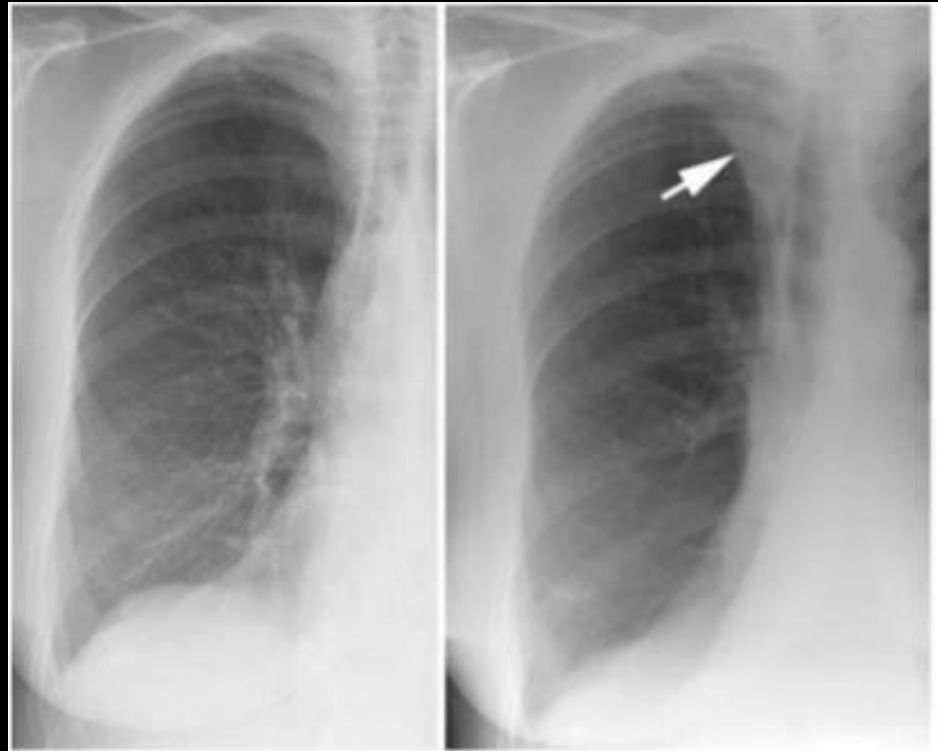


Right Lower Lobe Atelectasis

Superior Triangle Sign

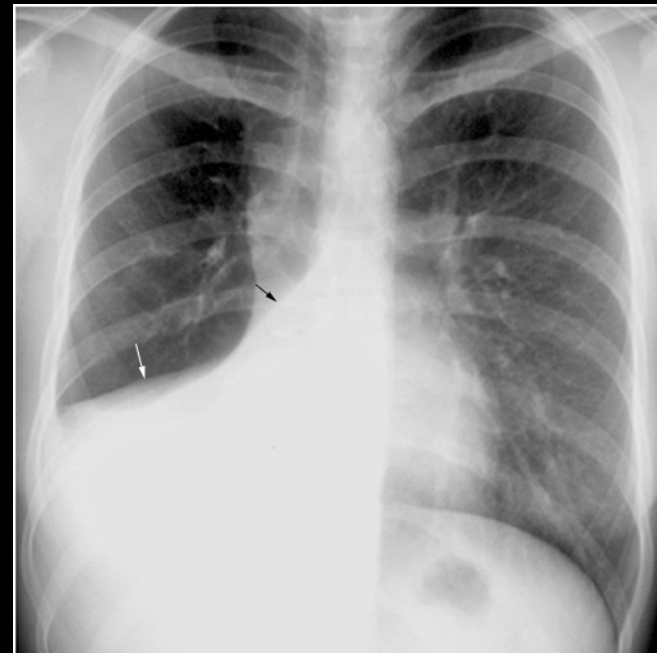
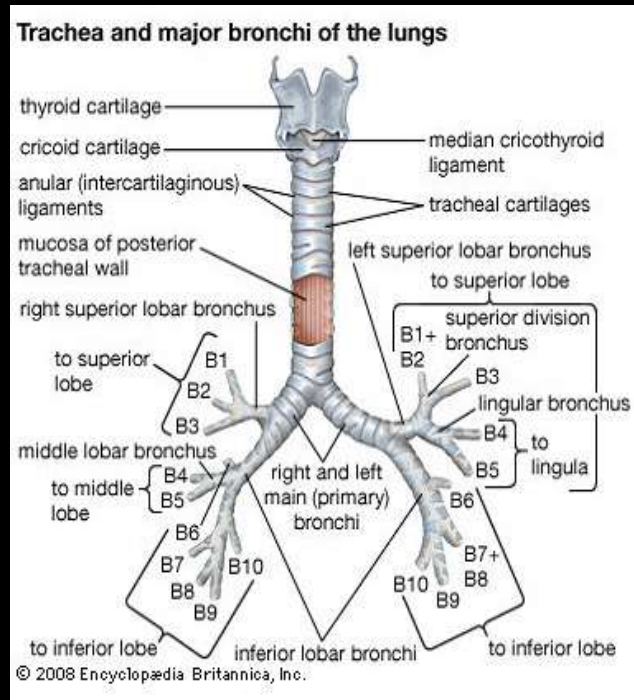


Widening of the superior mediastinum, usually on the right, associated with collapse of the lower lobe producing traction on the mediastinal pleura



Combined RLL and RML

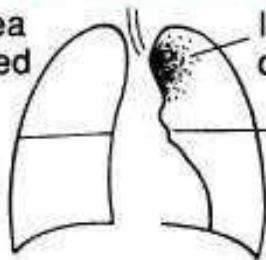
Right Heart Border AND Diaphragm no longer visible



Left Upper Lobe Atelectasis

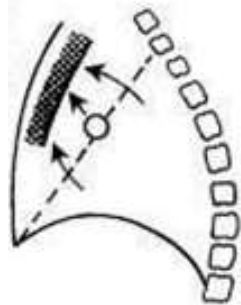
Left upper-lobe collapse

Trachea deviated to L

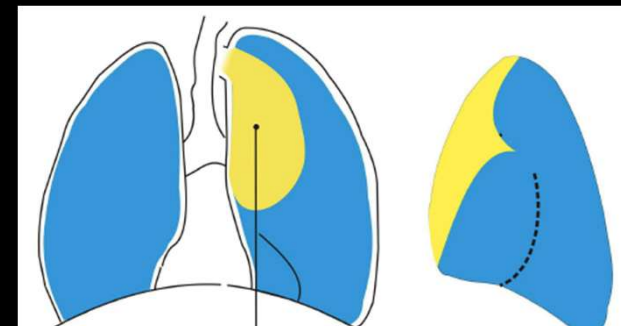
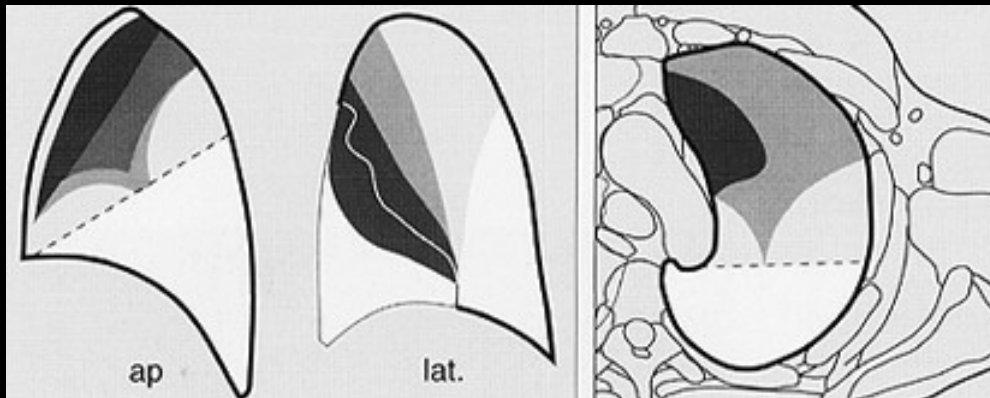


Ill-defined opacity

Indistinct elevated L hilum



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

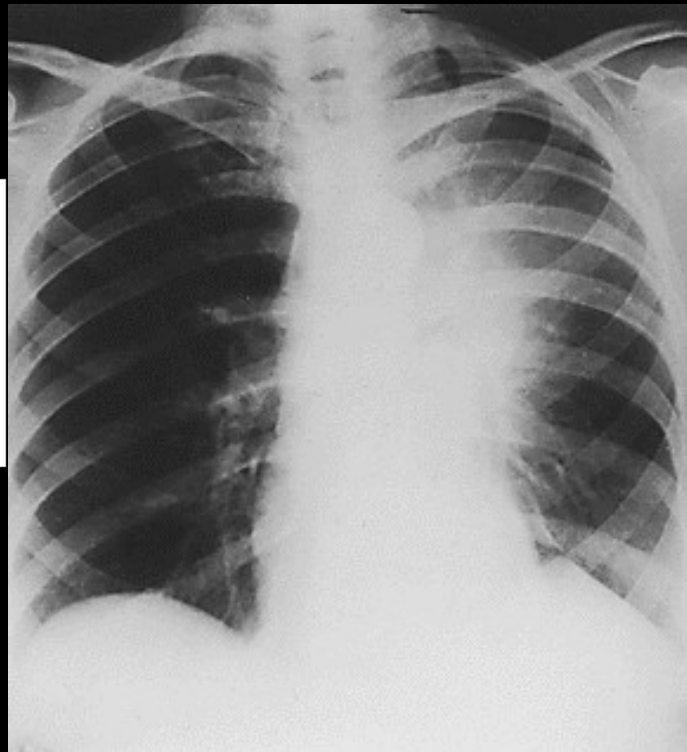
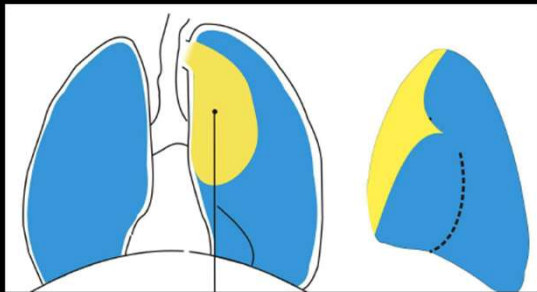


No Minor Fissure on left

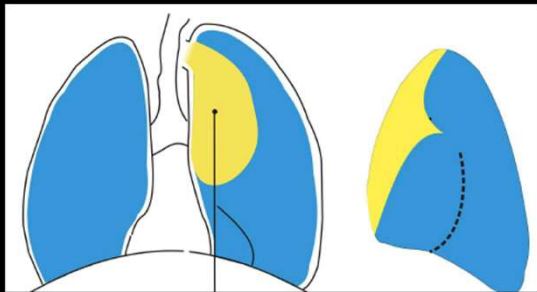
Hazy, Ill Defined opacity

Elevated hilum, diaphragm

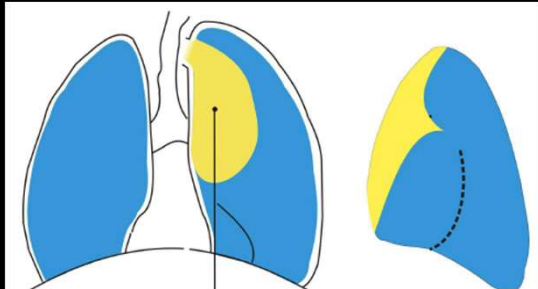
Left Upper Lobe Atelectasis



Left Upper Lobe Atelectasis



Left Upper Lobe Atelectasis



Right Heart Border Still
Visible

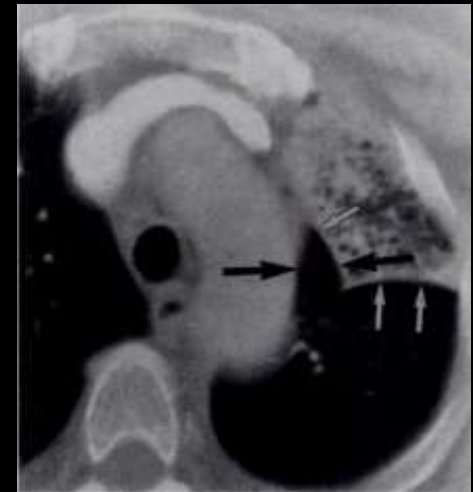
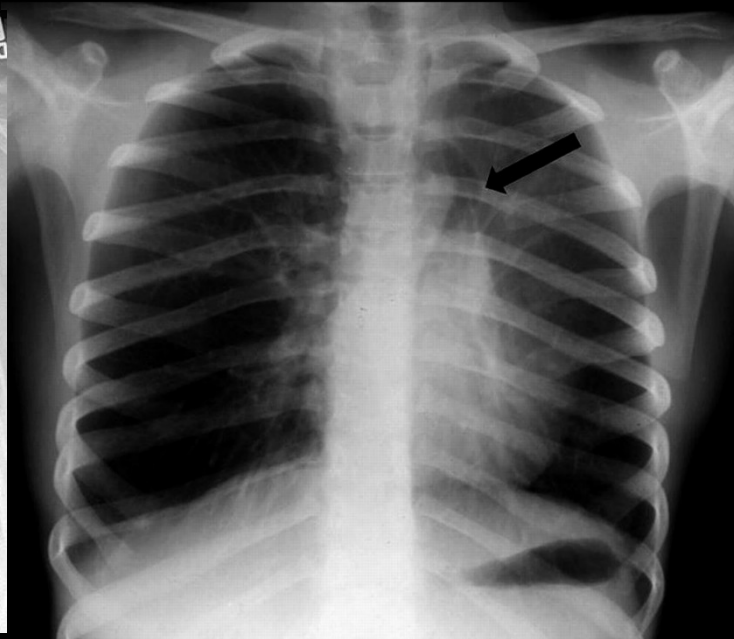
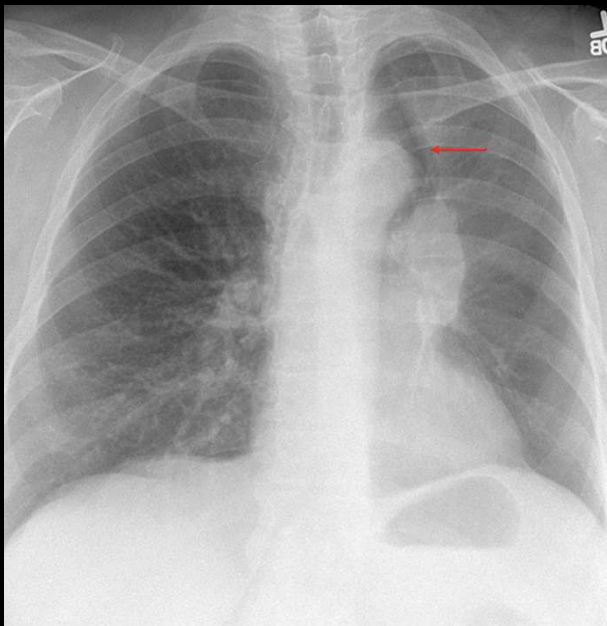
Left diaphragm Elevation



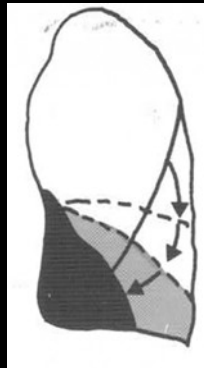
Left Upper Lobe Atelectasis

Luftsichel Sign

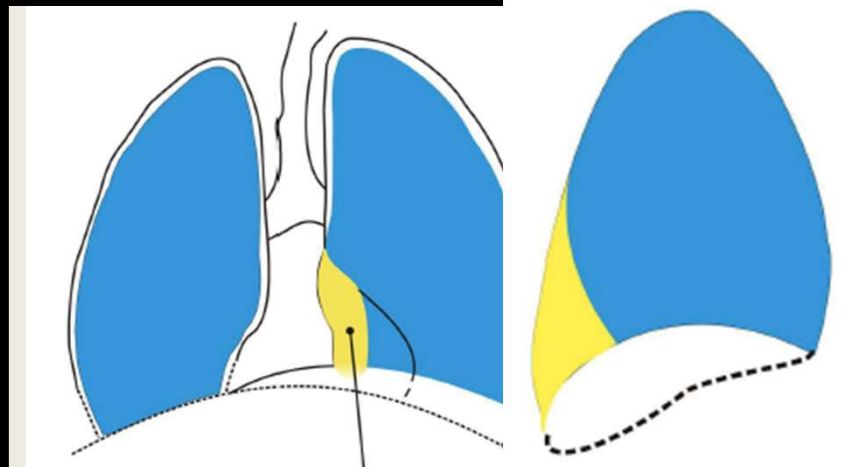
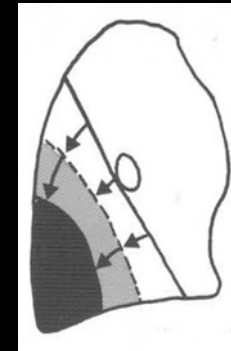
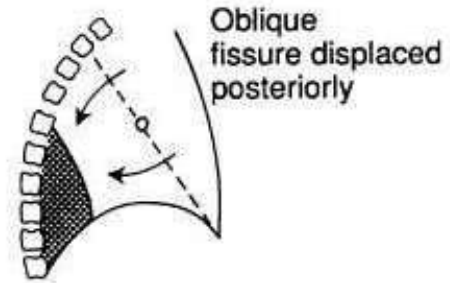
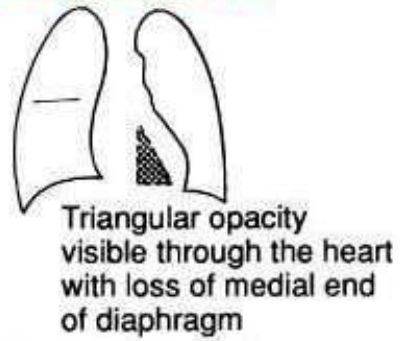
Due to herniation of hyperinflated superior left lower lobe



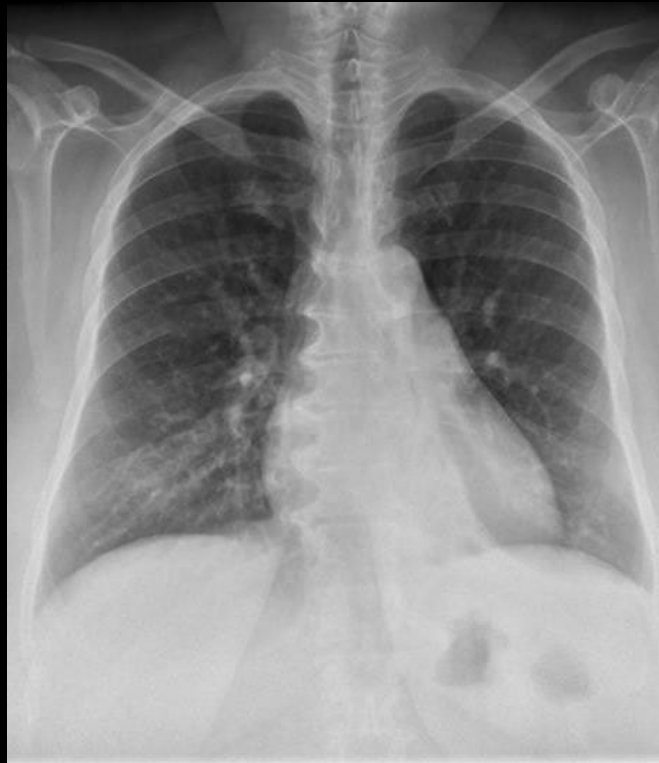
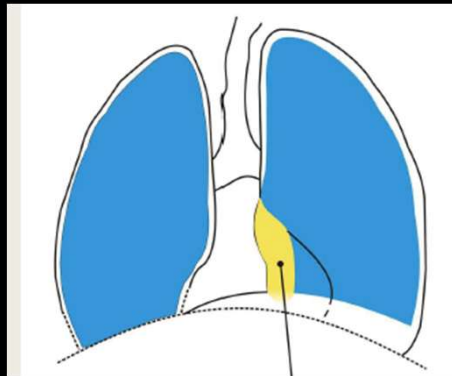
Left Lower Lobe Atelectasis



Left lower-lobe collapse

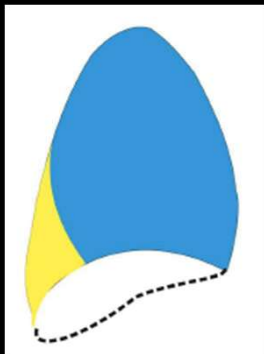
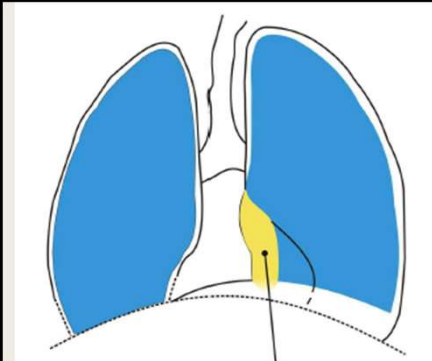


Left Lower Lobe Atelectasis

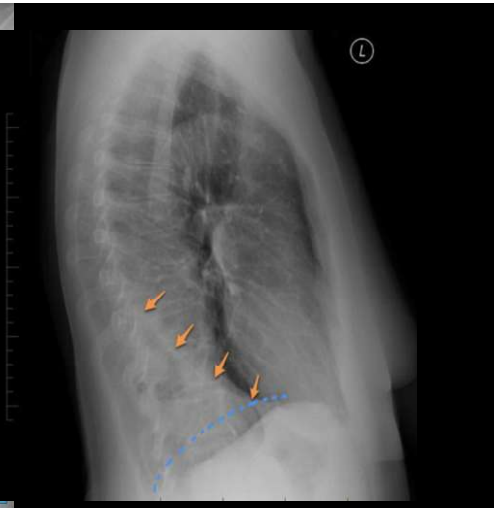
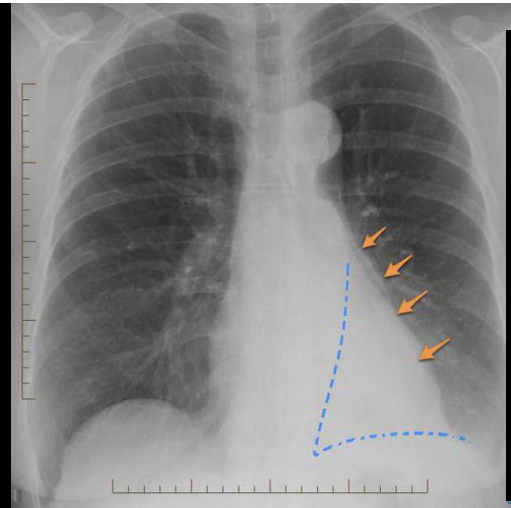


- Double Cardiac Contour
- Loss of descending Aorta
- Lower Left hilum

Left Lower Lobe Atelectasis



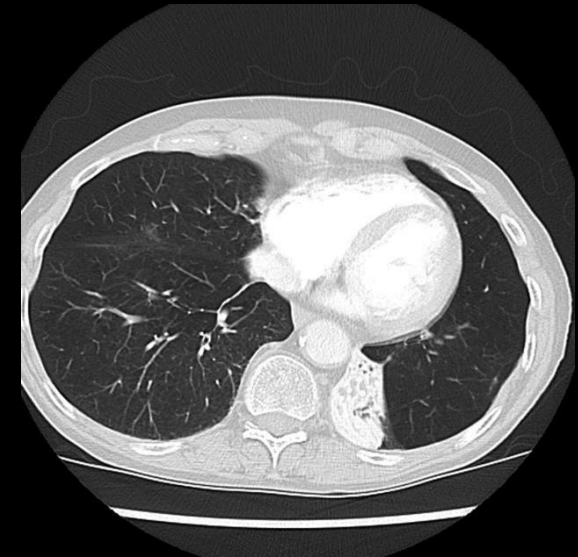
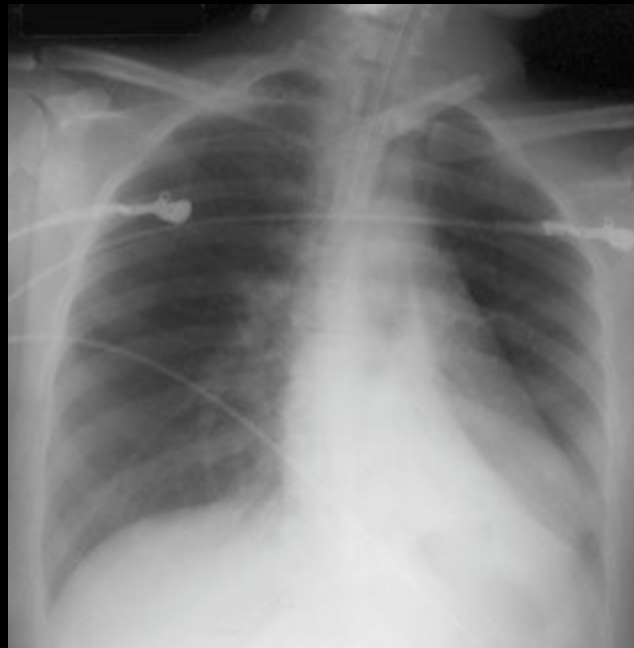
- Double Cardiac Contour
- Loss of descending Aorta
- Lower Left hilum



Left Lower Lobe Atelectasis

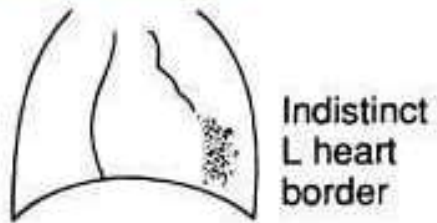
Flat Waist Sign

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

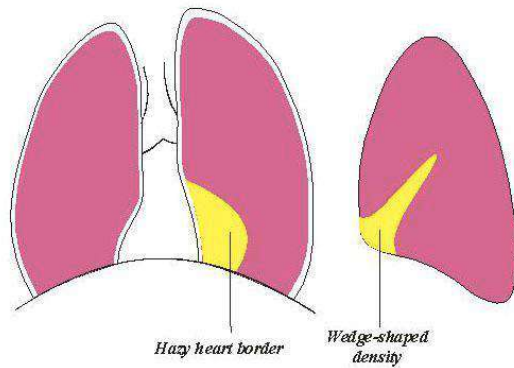


Left Lower Lobe Atelectasis

Lingular consolidation

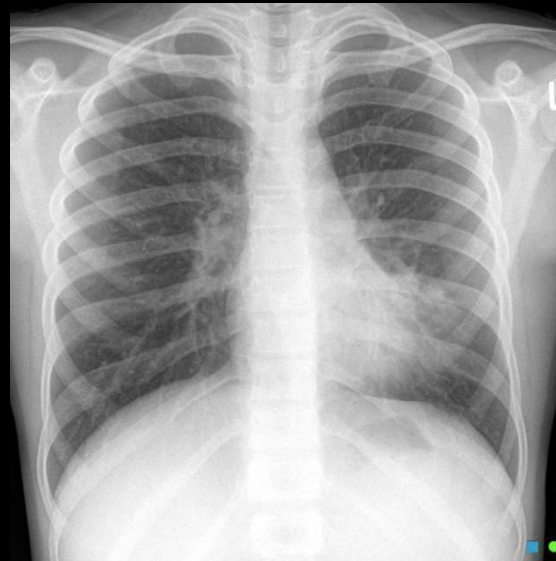


Lingular collapse



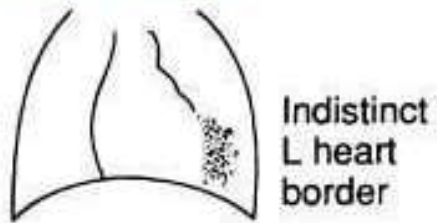
Lingular Collapse

Left Heart Border is Obscured

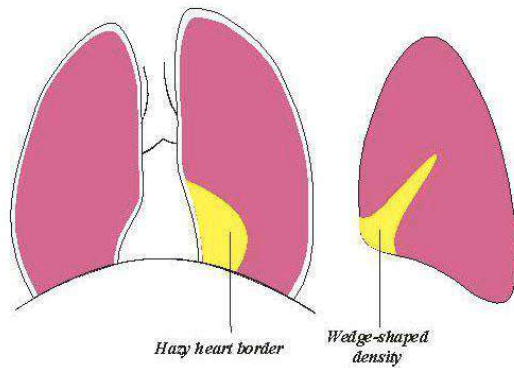


Left Lower Lobe Atelectasis

Lingular consolidation

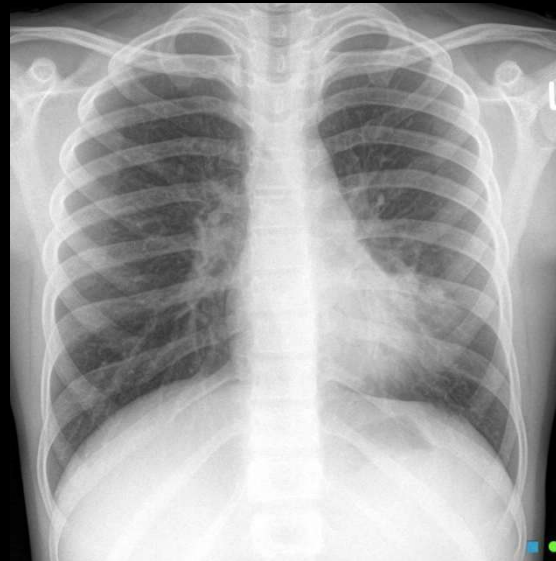


Lingular collapse



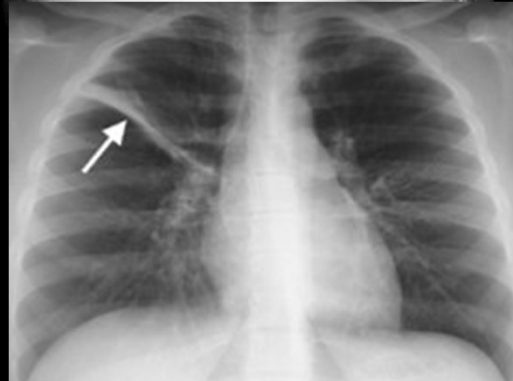
Lingular Collapse

Left Heart Border is Obscured



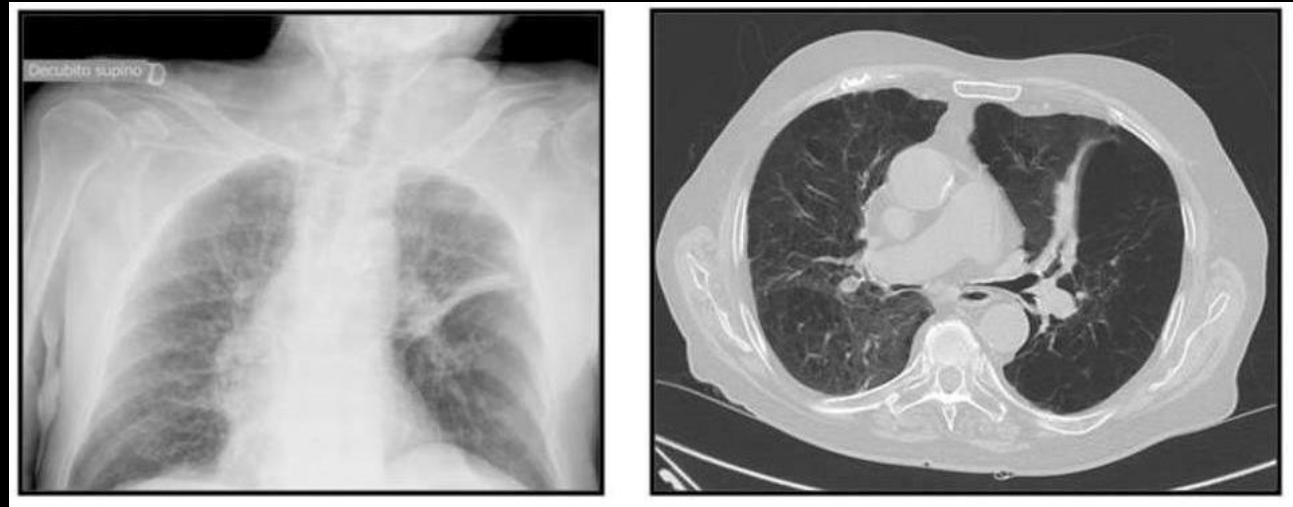
Segmental Atelectasis

- Wedge Shaped opacity
- Fissure Displacement
- Segmental
- Subsegmental
- Linear (discoid, plate, band)

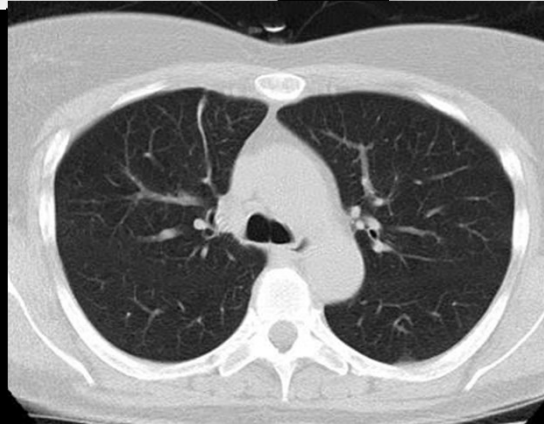
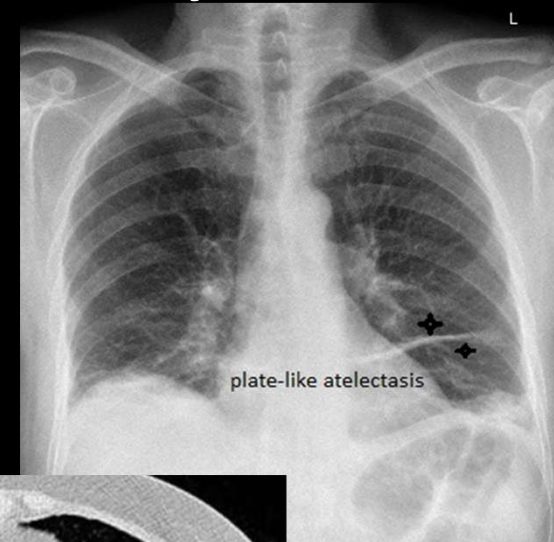
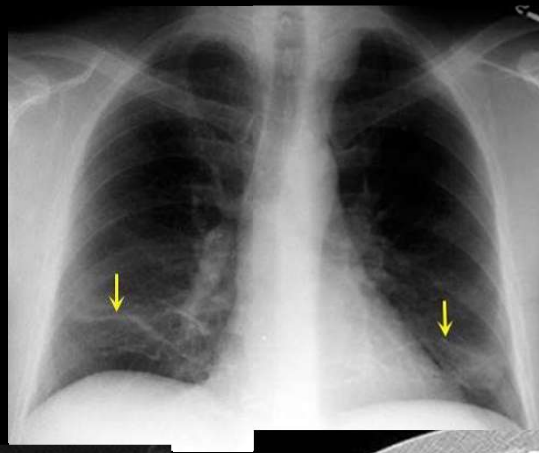
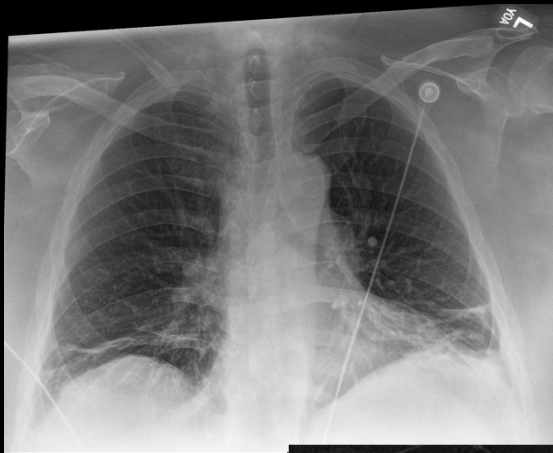


Segmental Atelectasis

- Wedge Shaped opacity
- Fissure Displacement

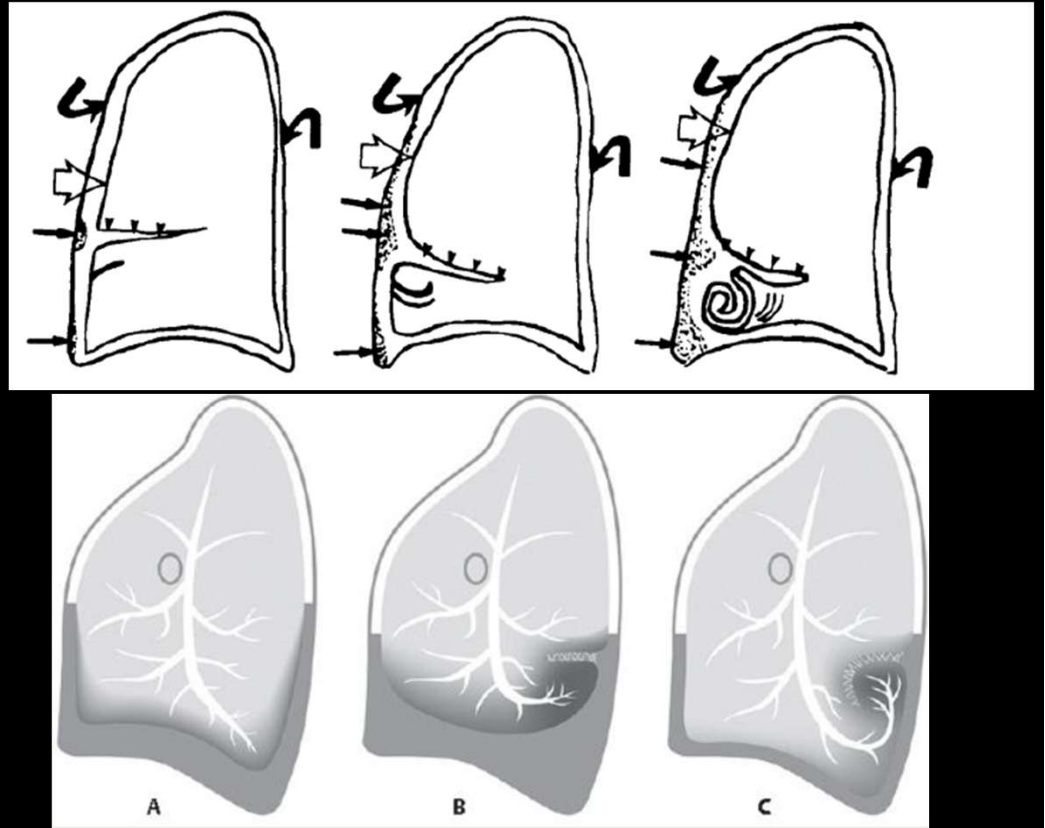


Linear (discoid, plate, band)



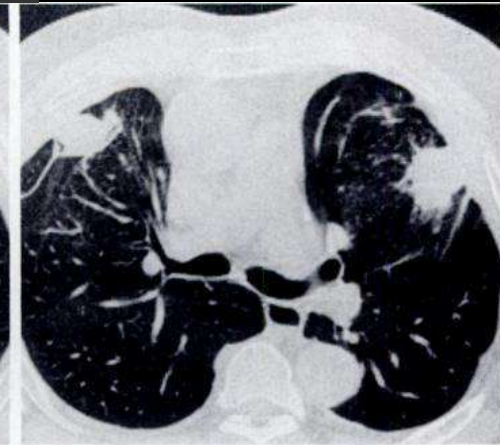
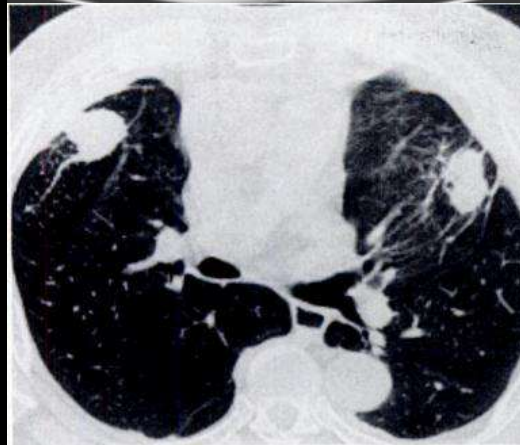
Round Atelectasis

- Parietal pleural folds in on itself
- Usually due to prior pleural inflammation



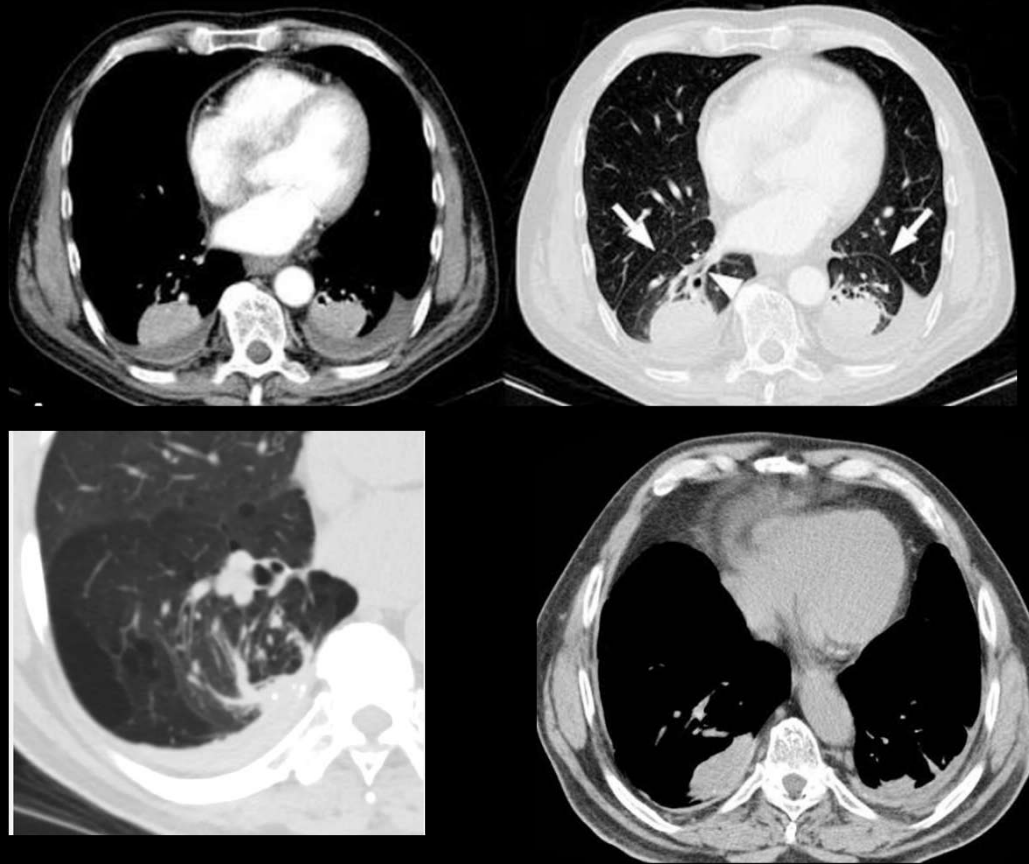
Round Atelectasis

May mimic
tumor
Comet Tails
from traction



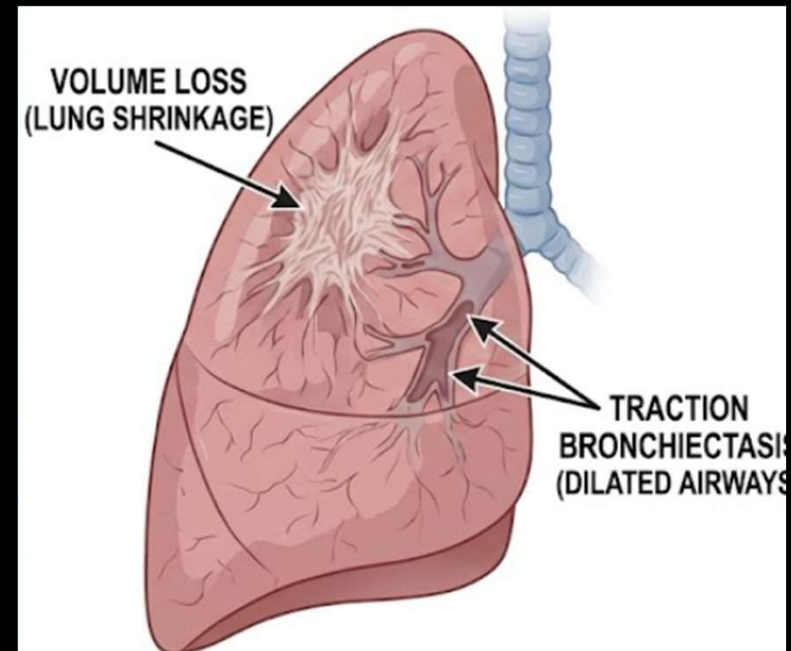
Round Atelectasis

May
associated
with chronic
pleural
effusion

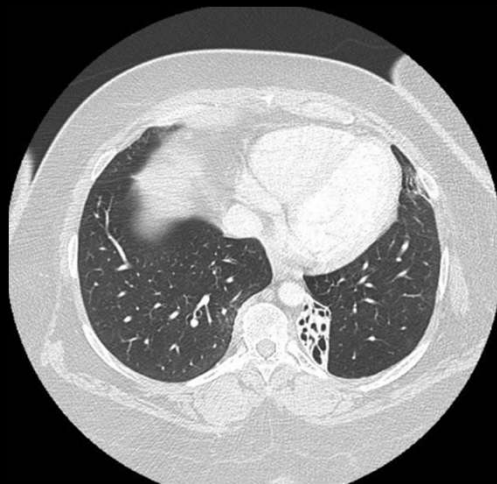
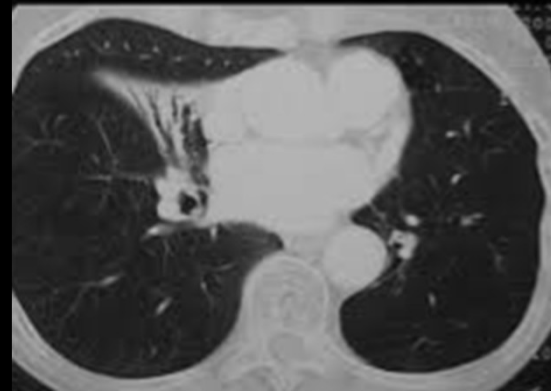


Cicatricial Atelectasis

- Lung parenchymal scarring limits expansion
- Lung collapses
- Traction bronchiectasis of affected bronchi
- Classic post pulmonary TB



Cicatricial Atelectasis



Thank you

- Questions?