High Resolution Chest CT (HRCT): Protocol, Indications, and Pathologies

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What is HRCT

- ACR defines HRCT as "…the use of thin section CT images (0.625 mm - 2 mm slice thickness) often with a high-spatial-frequency reconstruction algorithm…"
- Requesting physicians sometimes don't understand the definition of HRCT and may order it improperly
- HRCT does not have to, but also often includes expiratory and prone imaging

Benefits of HRCT

- Gold standard for evaluation of lung parenchyma and airways
- HRCT can distinguish between the causes of the mosaic attenuation pattern
- HRCT allows for dynamic evaluation of the airways
- HRCT findings in interstitial lung disease may have survival implications

HRCT Protocol

- 1) Standard 2.5 mm chest without contrast at full inspiration
  - 1.25 mm images will also be reconstructed using bone algorithm and both sets of images will be sent to PACS
- 2) Supine expiratory images performed at 1.25 mm with 20 mm gaps, using bone algorithm
- 3) Prone inspiratory images performed at 1.25 mm with 20 mm gaps, using bone algorithm

HRCT Protocol

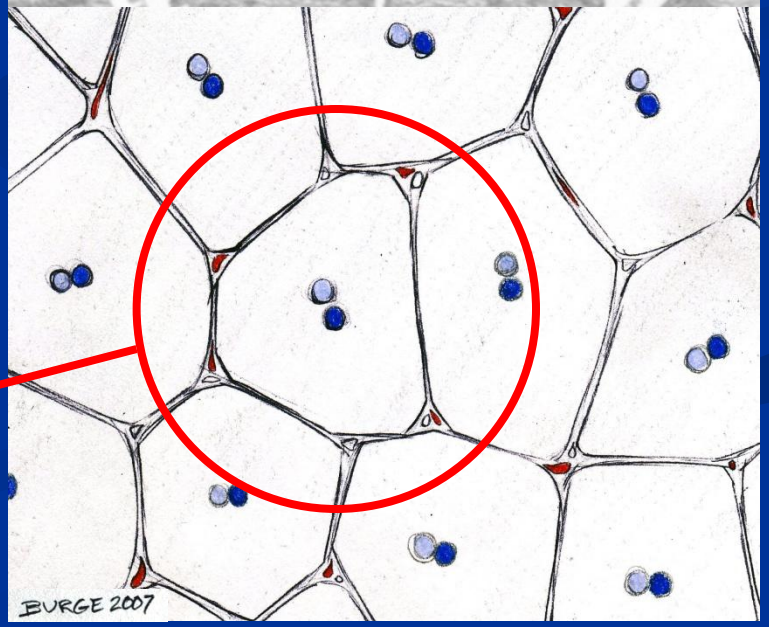
- Thin section inspiratory
  - Fine detail of lung parenchyma and airways
  - Volumetric images can be constructed
- Thin section expiratory
  - Mosaic attenuation pattern
  - Tracheobronchomalacia
- Thin section prone
  - Atelectasis vs. interstitial lung disease

HRCT indications

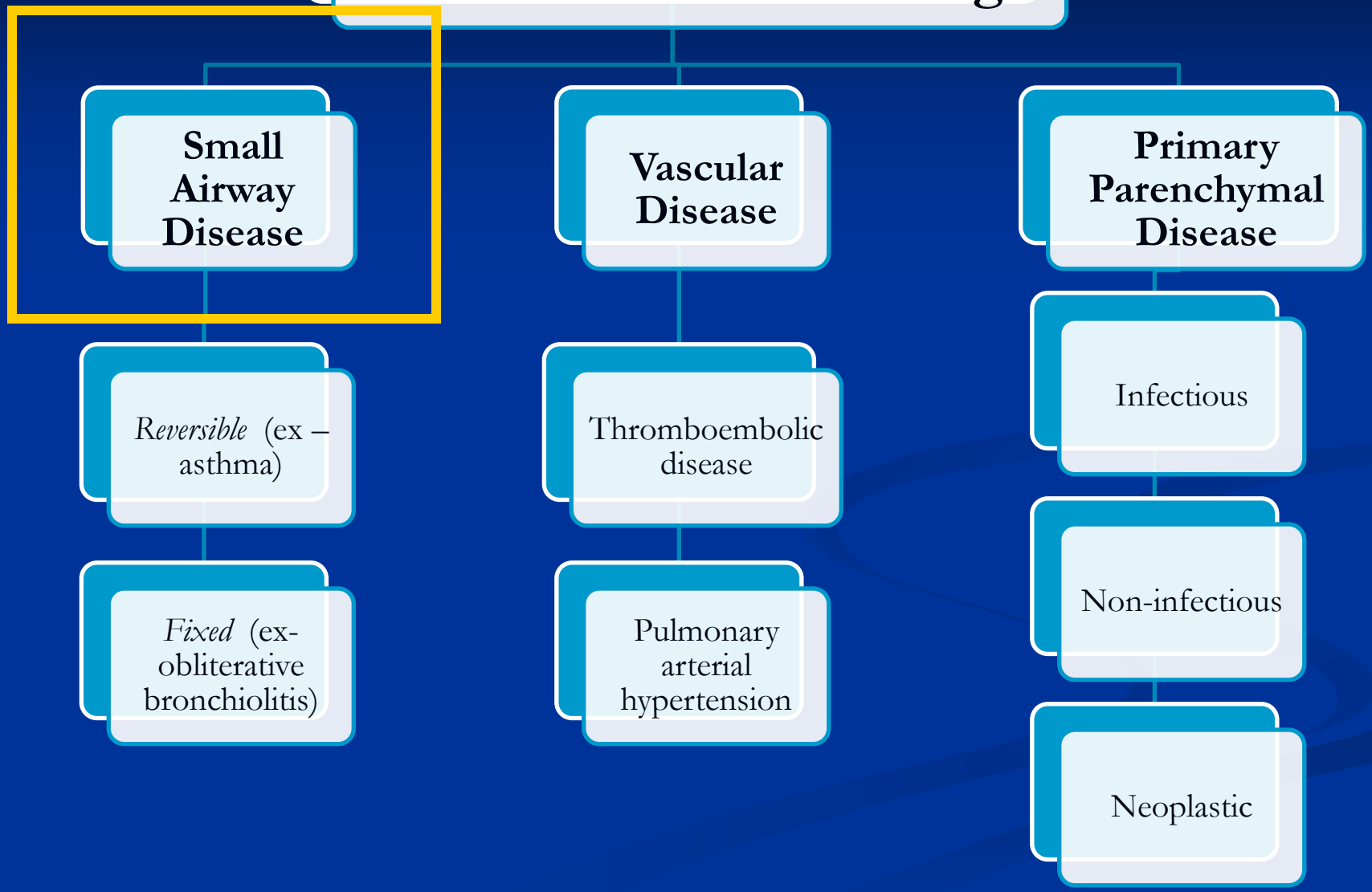
- Indications
  - Small airways vs. small vessel disease (mosaic attenuation pattern)
  - Large airways
    - Tracheobronchomalacia
    - Bronchiectasis
  - Restrictive lung diseases
    - Idiopathic interstitial pneumonias
    - Secondary diffuse lung disease

"Mosaic Attenuation"

- Variable areas of lung attenuation in lobular or multi-lobular distribution
- Mosaic pattern of fairly well defined areas of low and high attenuation lung is a result of disease demarcated by ***Secondary Pulmonary Lobule***

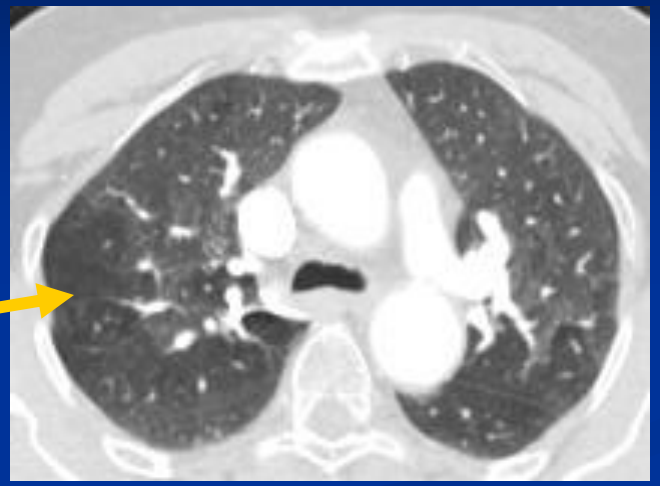


Causes of Mosaic Attenuation in the Lung



Small Airway Disease

- **AIR TRAPPING**
- Abnormal Lung:
  - Lower in attenuation.
- Cause:
  - Air trapping and decreased blood flow, (combination of hypoxic vasoconstriction and mechanical pressure on vessels from air trapping).



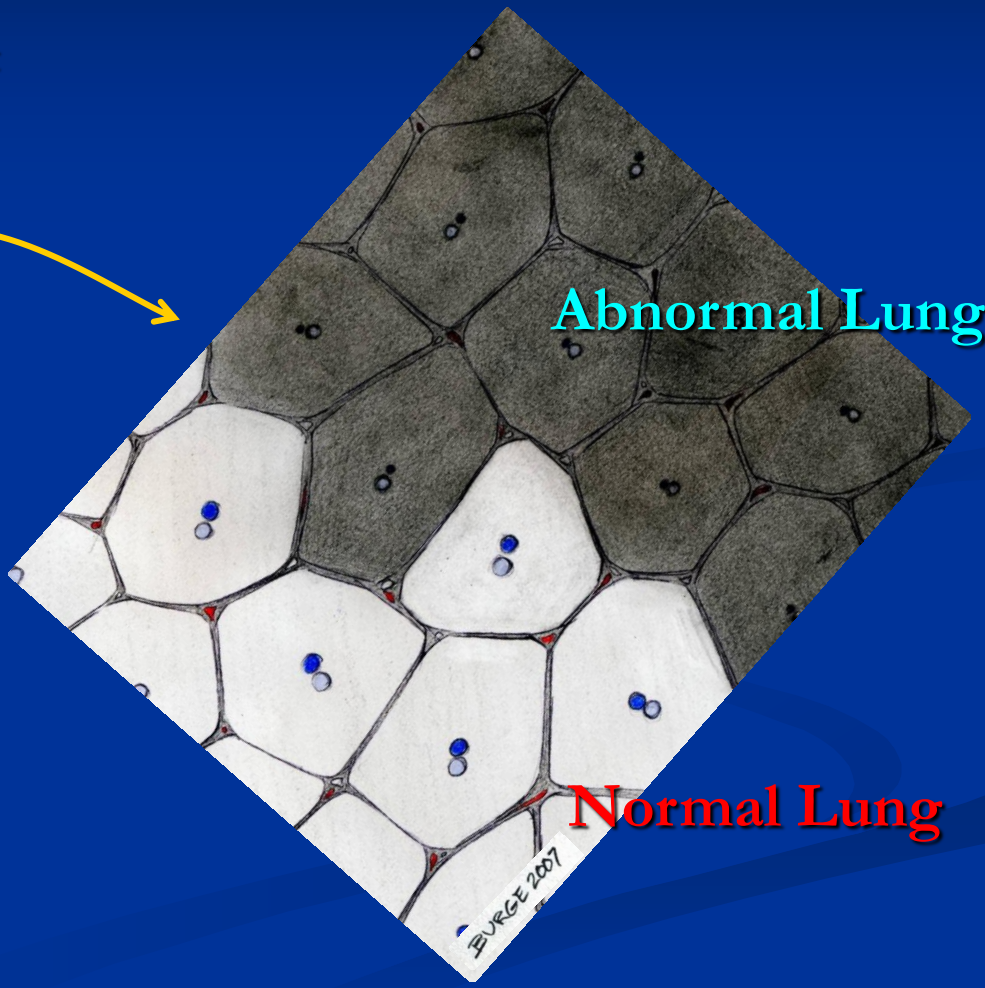
- When process at lobular or multi-lobular level, mosaic pattern of attenuation results.

Small Airway Disease

- Differential Diagnosis:
  - Reversible
    - Asthma
  - Fixed
    - Bronchiolitis Obliterans (including bronchiectasis associated small airway disease)
      - Example: Swyer-James Syndrome
    - Cystic Fibrosis
    - Allergic Bronchopulmonary Aspergillosis

Small Airway Disease – *CT Findings*

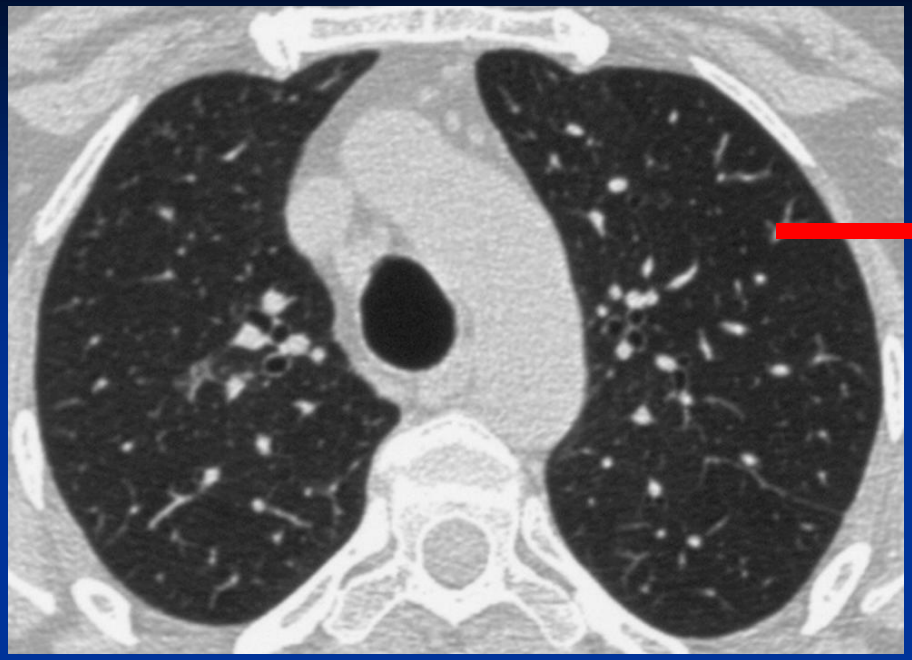
Expiratory CT scan shows alternating patchy areas of low and high attenuation consistent with air trapping in an individual with Bronchiolitis Obliterans



Small Airway Disease – *CT Findings*

- *Expiratory CT*:
  - Lower attenuation regions of lung:
    - remain lucent
    - show no or minimal change in volume due to air trapping
  - May be necessary for detection of air trapping.
  - Can be used to accentuate attenuation difference.

- *Ancillary Findings*:
  - Bronchiectasis, mucoid impaction, tree-in-bud opacities

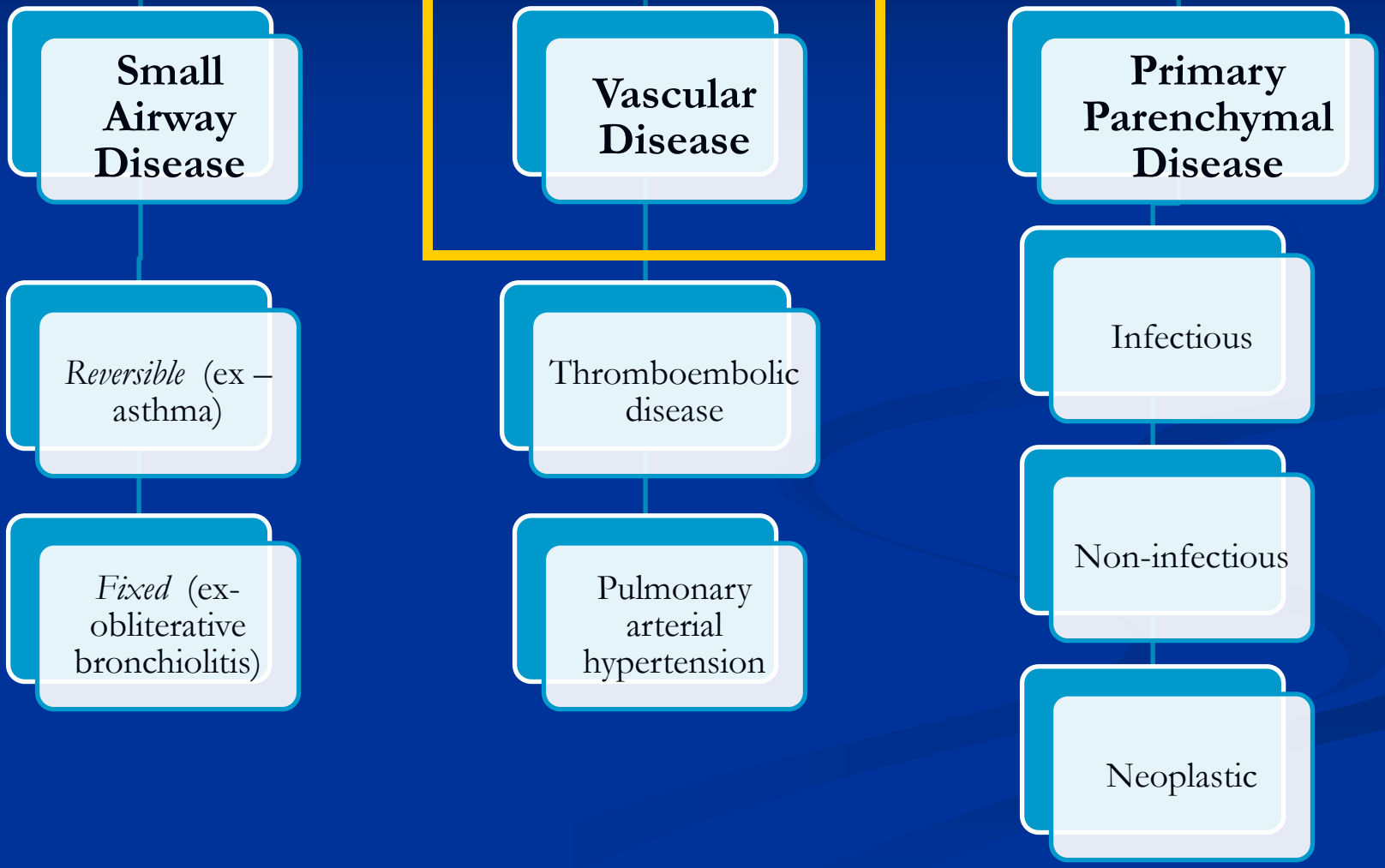


Inspiratory **Expiratory**

Patient with Bronchiolitis Obliterans

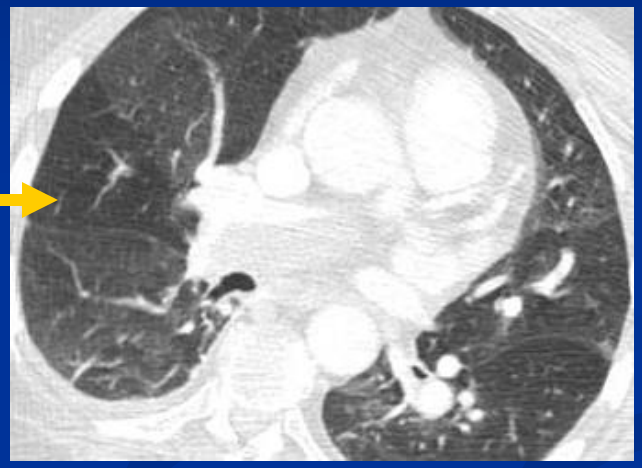
- Mosaic attenuation and air trapping only seen on expiratory views.

Causes of Mosaic Attenuation in the Lung



Vascular Lung Disease

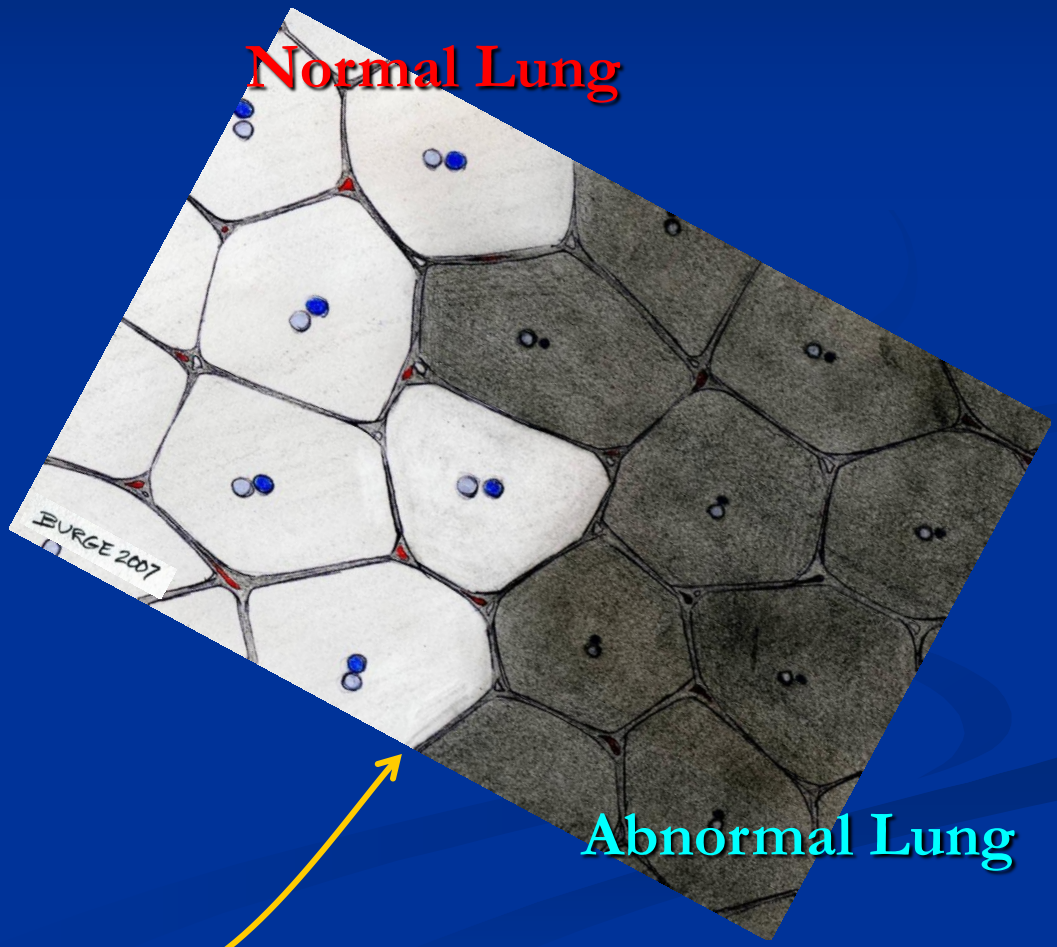
- DIFFERENTIAL PERFUSION
- Abnormal Lung:
  - Lower in attenuation.
- Cause:
  - Decreased perfusion.



- Regions of oligemia adjacent to normal/hyperemic lung creates mosaic pattern.
- "Mosaic perfusion" or "Mosaic oligemia" are terms also used referring to this particular etiology.

Vascular Lung Disease – *CT Findings*

Patchy areas of high and low attenuation in a patient with Chronic Thromboembolic Disease



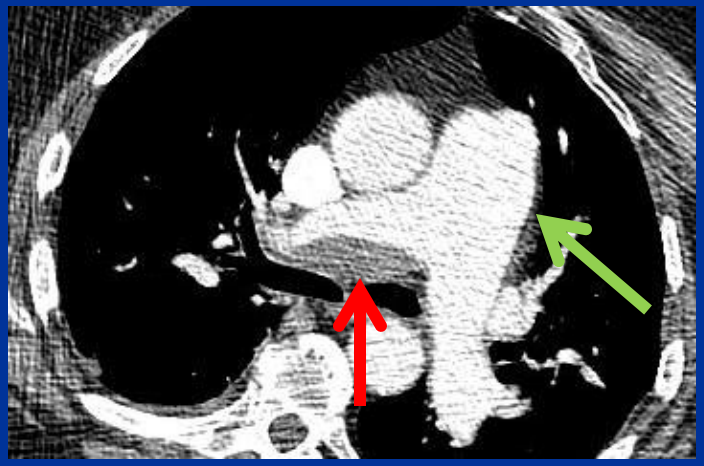
Vascular Lung Disease – *CT Findings*

- *Expiratory CT*:
  - Attenuation of both low and high attenuation lung increases in similar fashion.
  - Volume of normal/abnormal lung decreases similarly.

- *Ancillary Findings:*
  - Eccentric filling defects in pulmonary artery and its branches
  - Arterial webs
  - Pruning and/or stenoses
  - Enlargement of main pulmonary artery

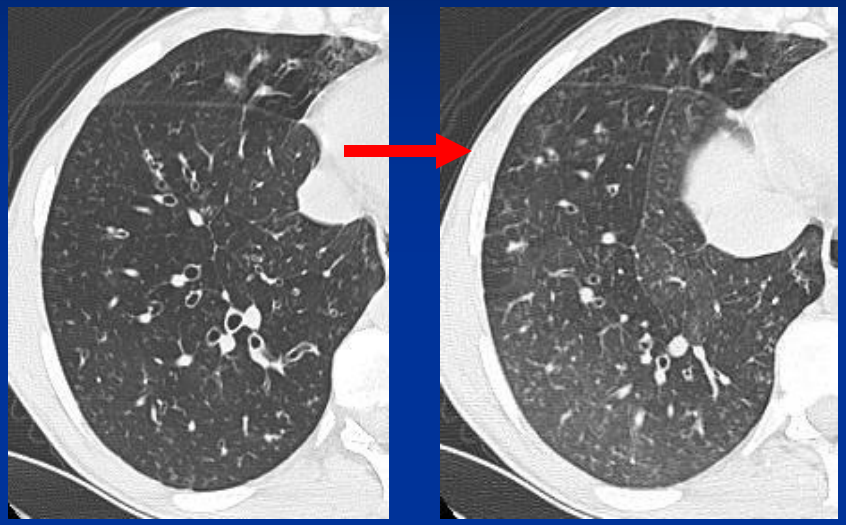
Elderly female with pulmonary artery hypertension secondary to chronic thromboembolic disease

- Vessel number and caliber decreased in lower attenuation (oligemic) lung.

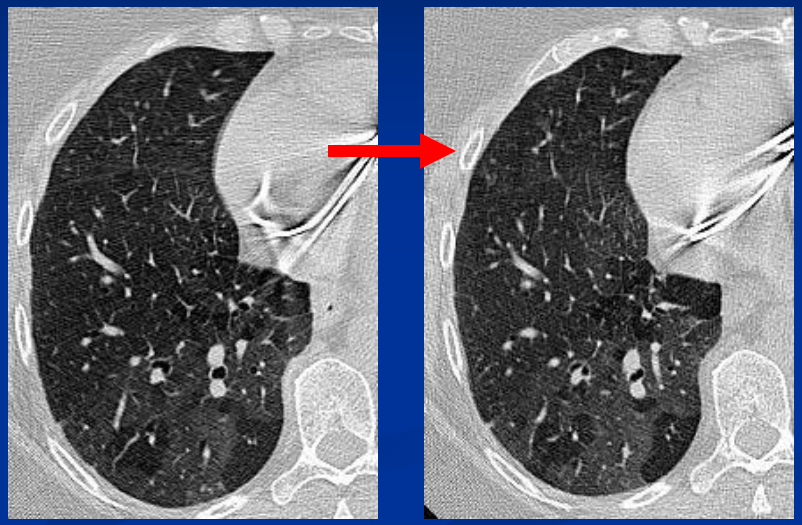


- Mediastinal windows demonstrate eccentric filling defect consistent with chronic embolus and enlargement of main pulmonary artery.

Small Airways Disease vs. Vascular Disease – *Expiratory CT*



Inspiratory Expiratory



Inspiratory Expiratory

Cystic Fibrosis

Expiratory Image:

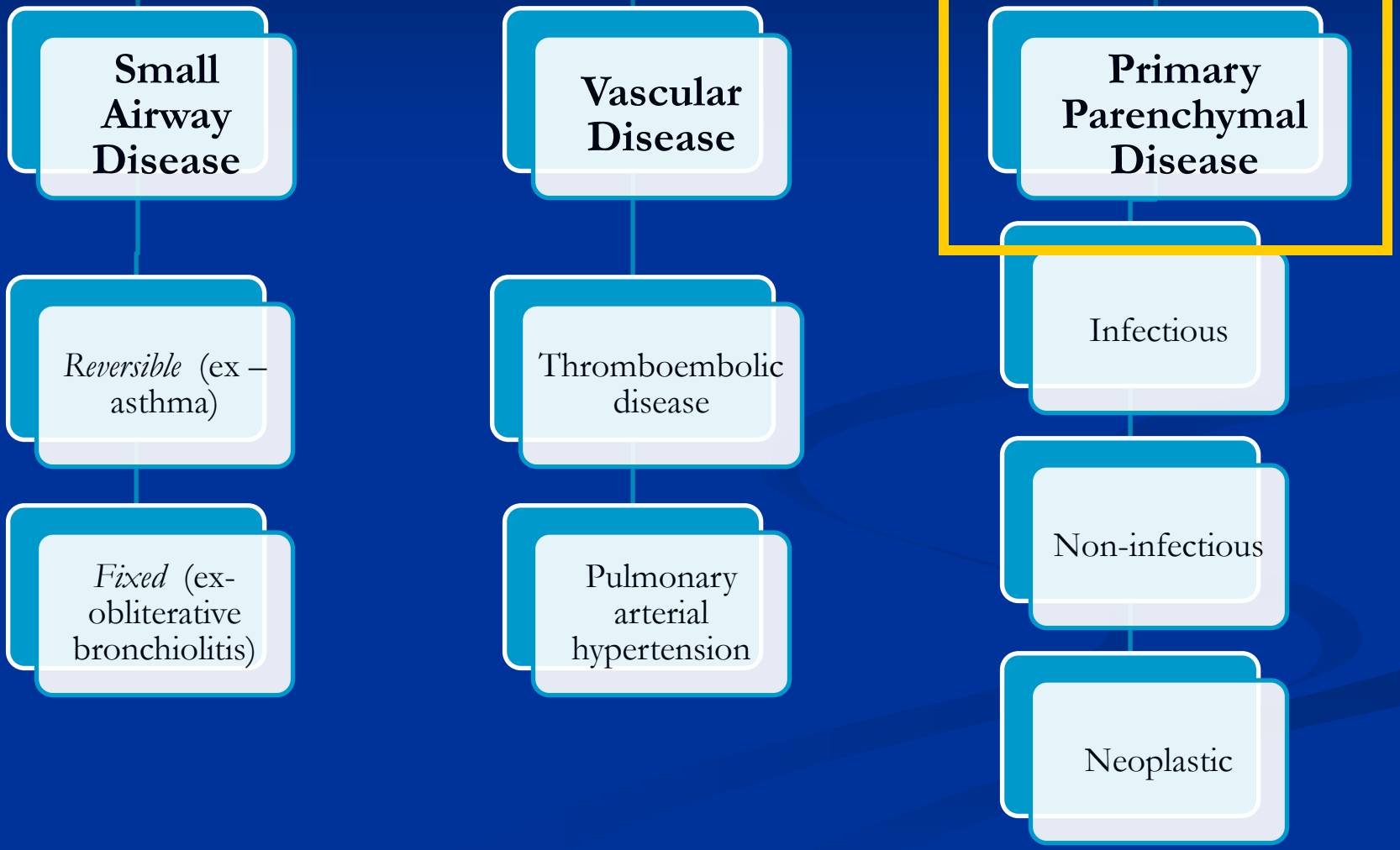
- Lucent areas more pronounced suggesting air trapping.

Chronic Thromboembolic Disease

Expiratory Image:

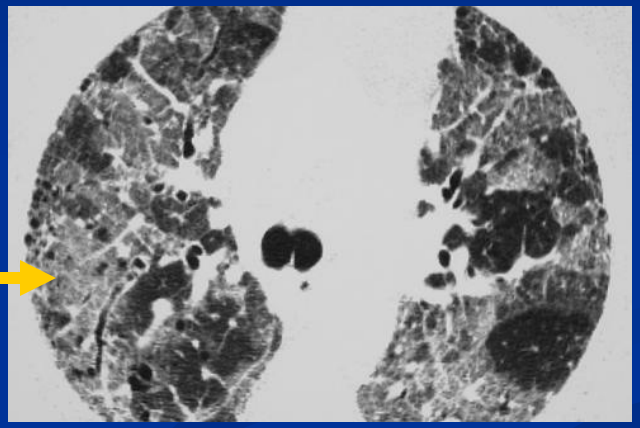
- Opaque areas remain white while lucent areas remain dark.
- Opaque and lucent areas of lungs decrease in size uniformly.

Causes of Mosaic Attenuation in the Lung



Primary Parenchymal Lung Disease

- PATCHY RETICULAR /AIRSPACE DISEASE

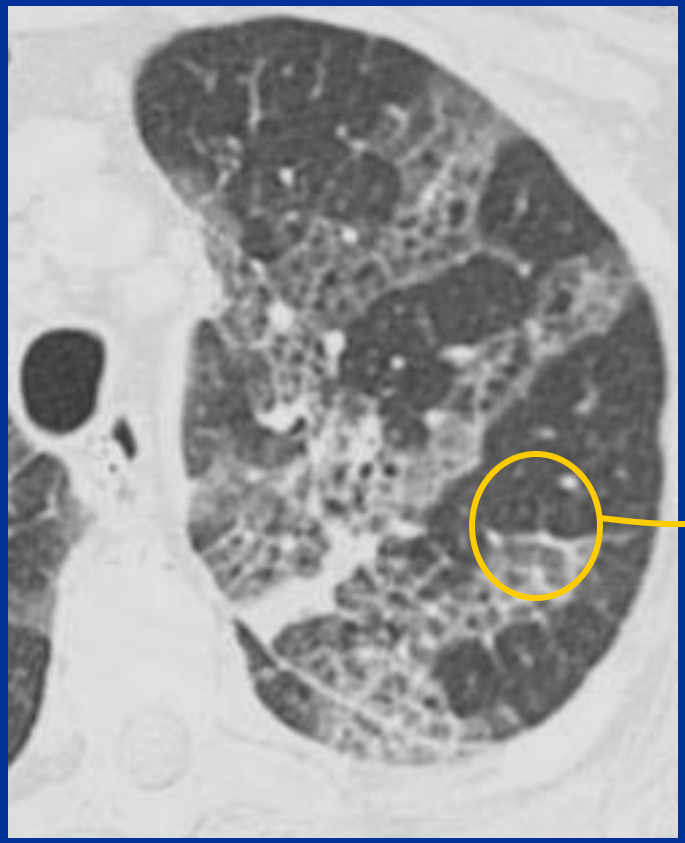


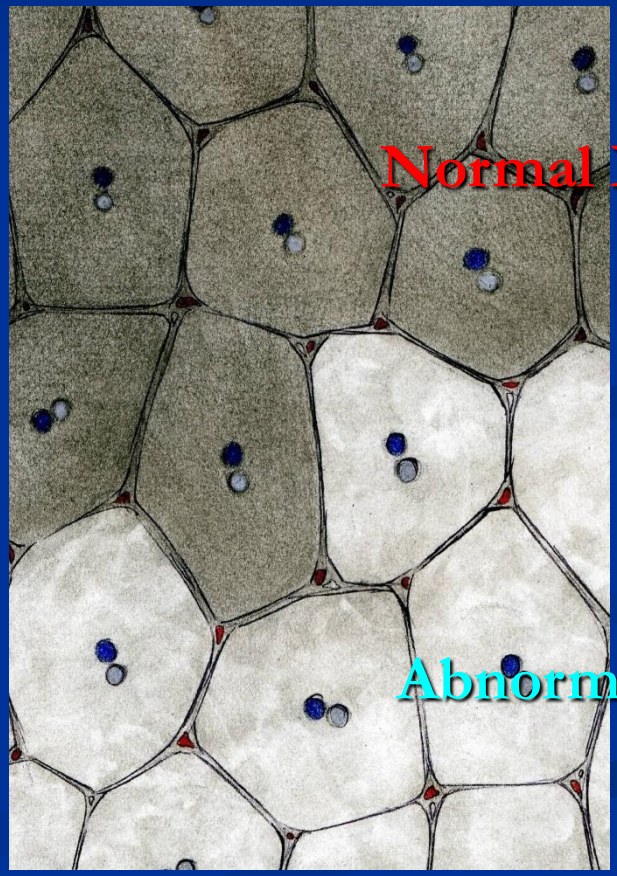
- Abnormal lung:
  - Higher in attenuation.
- Cause:
  - Partial filling of airspaces/interstitium with fluid, cells, fibrosis.

- Normal lung adjacent to diseased lung creates mosaic appearance.

Primary Parenchymal Lung Disease – *CT Findings*

Filling of airspaces with fluid in patient with Pulmonary Edema creates mosaic appearance

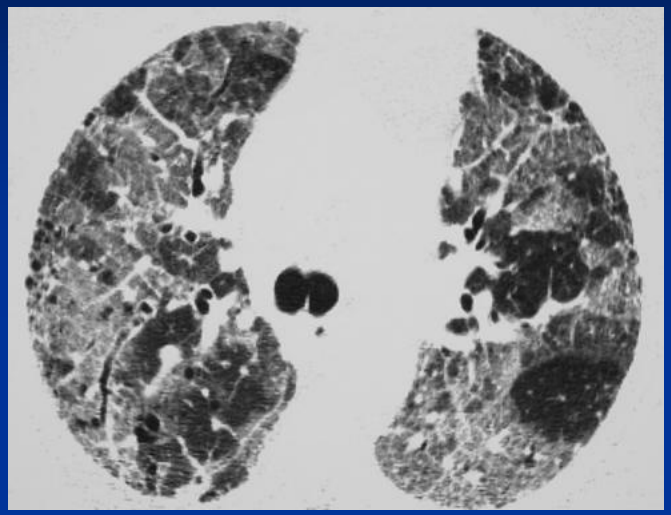




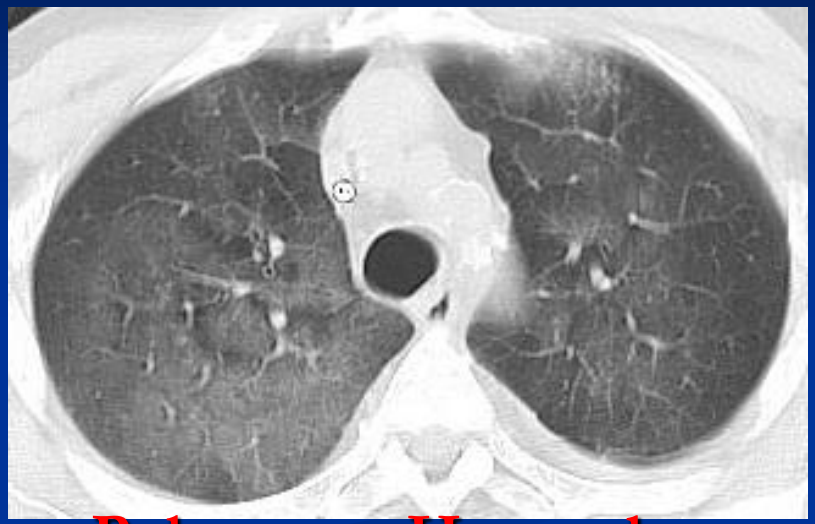
Primary Parenchymal Lung Disease

- Differential Diagnosis:
  - Infectious:
    - Pneumocystis carinii pneumonia, pyogenic pneumonia
  - Noninfectious:
    - Chronic eosinophilic pneumonia, hypersensitivity pneumonitis, cryptogenic organizing pneumonia, sarcoidosis, alveolar proteinosis, pulmonary edema
  - Neoplastic:
    - Bronchioloalveolar carcinoma, lymphoma

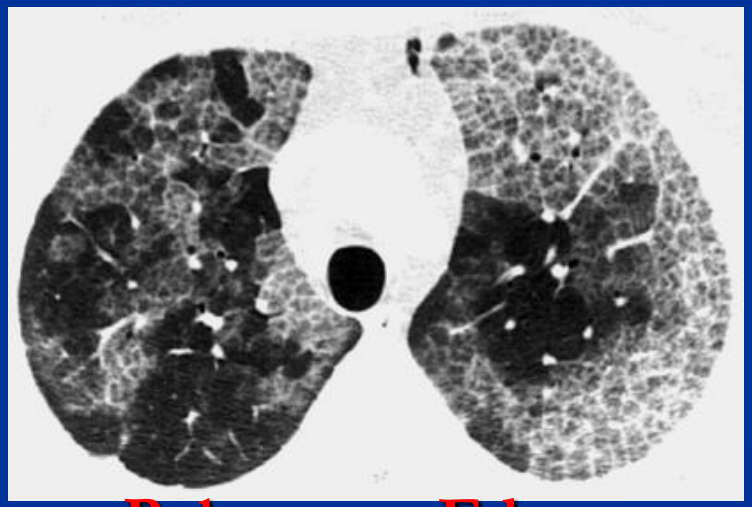
Primary Parenchymal Lung Disease



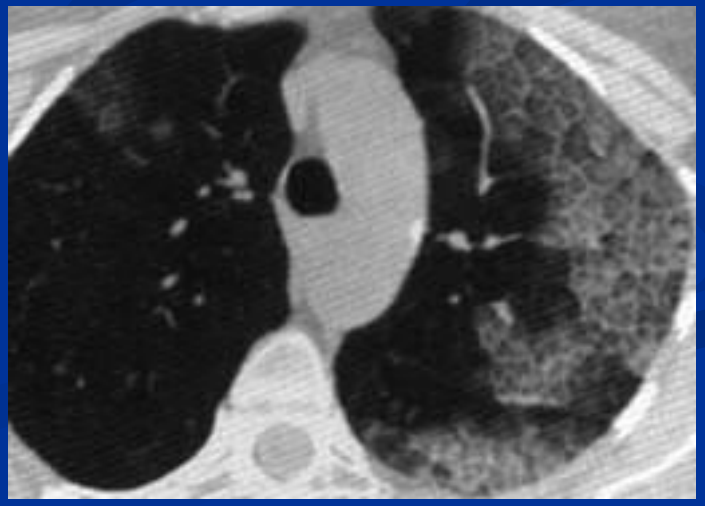
Hypersensitivity Pneumonitis



Pulmonary Hemorrhage



Pulmonary Edema



Bronchioloalveolar carcioma

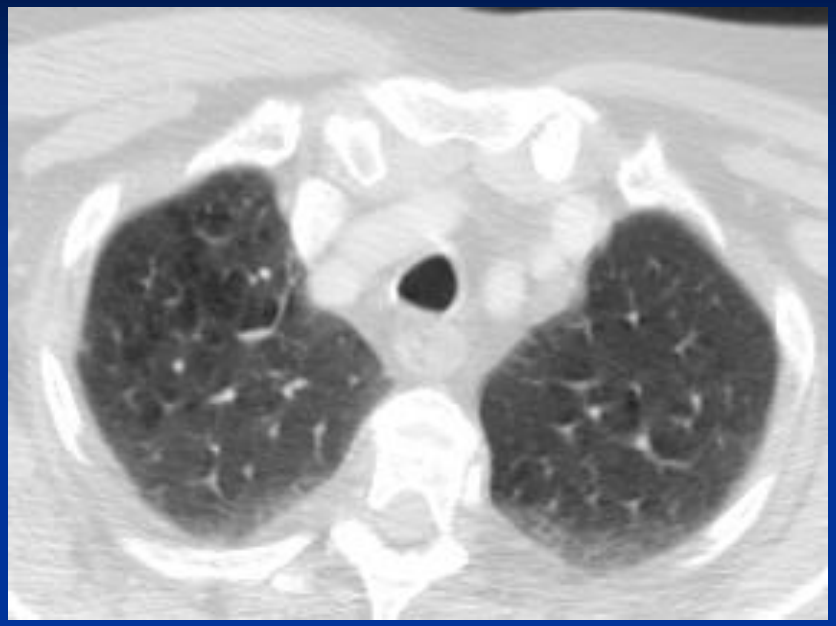
Mosaic Attenuation – Prominent CT Findings

	Normal Lung	Abnormal Lung	Vessel Number and Caliber in Low Attenuation Lung	Air trapping on expiratory CT?
Small Airways Disease	Higher attenuation	Lower attenuation	decreased	yes
Vascular Disease	Higher attenuation	Lower attenuation	decreased	no
Primary Parenchymal Disease	Lower attenuation	Higher attenuation	No difference	no

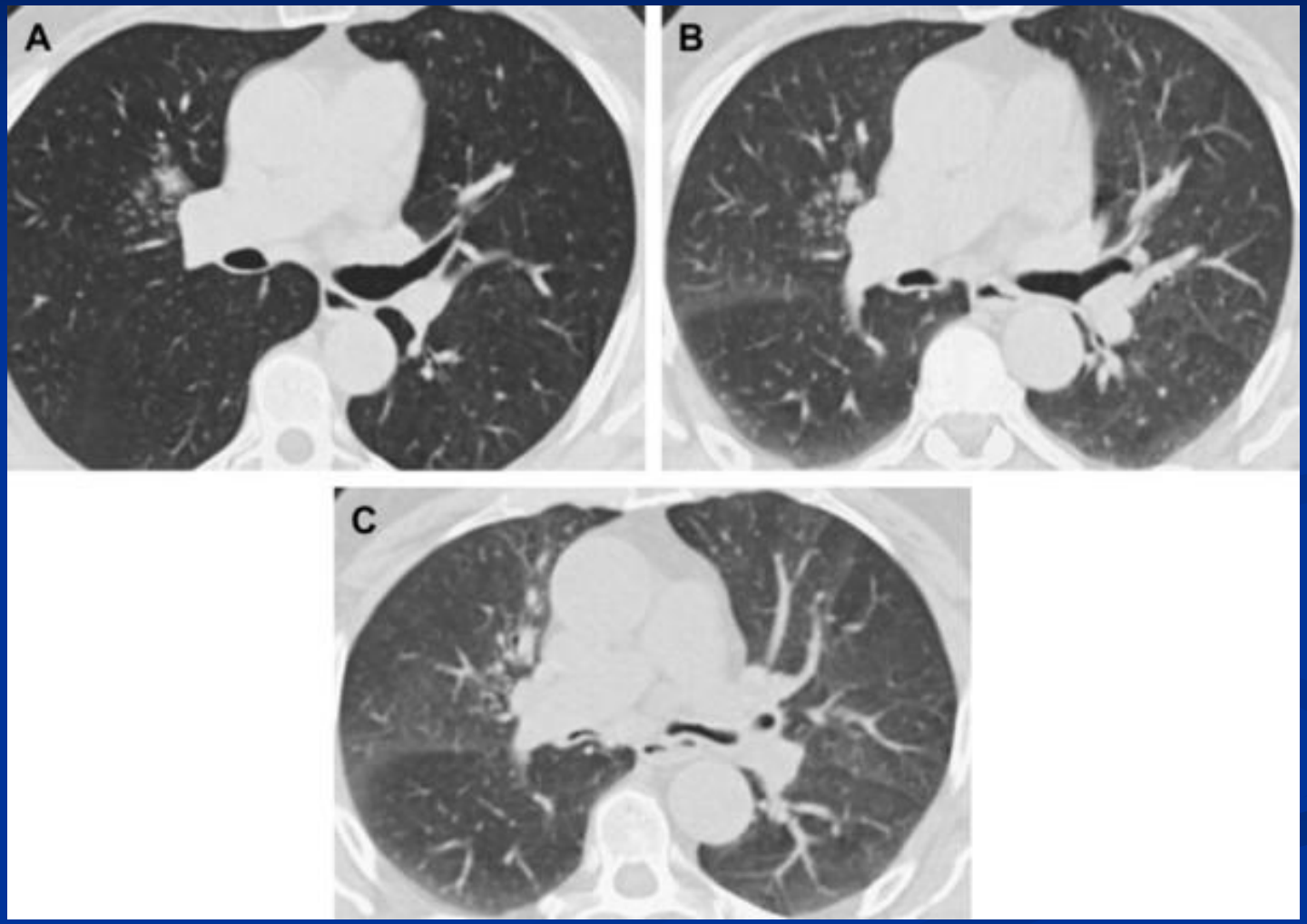
Large airways

- Tracheobronchomalacia is a condition caused by excessive collapsibility of the trachea/bronchi due to weakness of the airway walls or supporting cartilage
- Patients get chronic inflammation of their downstream small airways due to inability to clear secretions and improper coughing mechanism
- End-expiratory HRCT can evaluate for tracheobronchomalacia, although dynamic forced expiratory HRCT is the imaging gold standard

Tracheomalacia



Bronchomalacia



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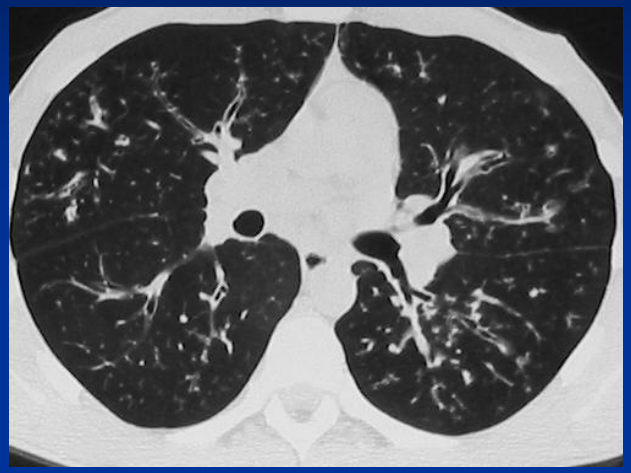
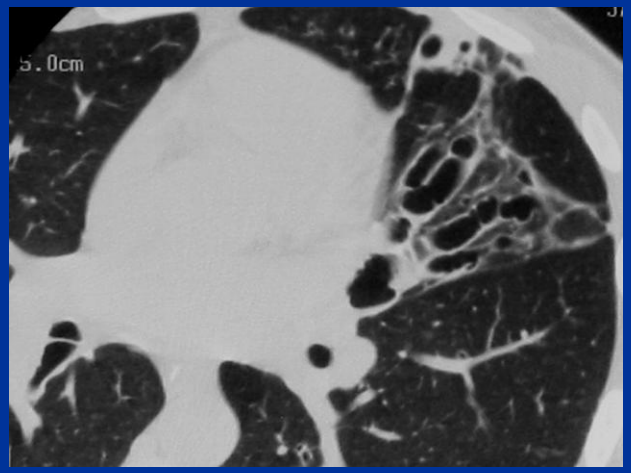
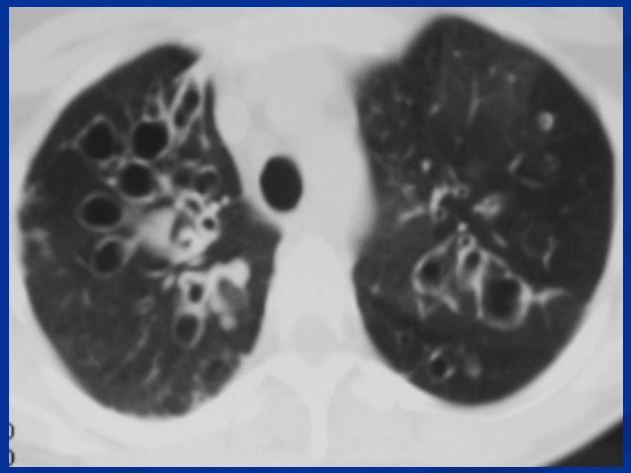
Bronchiectasis



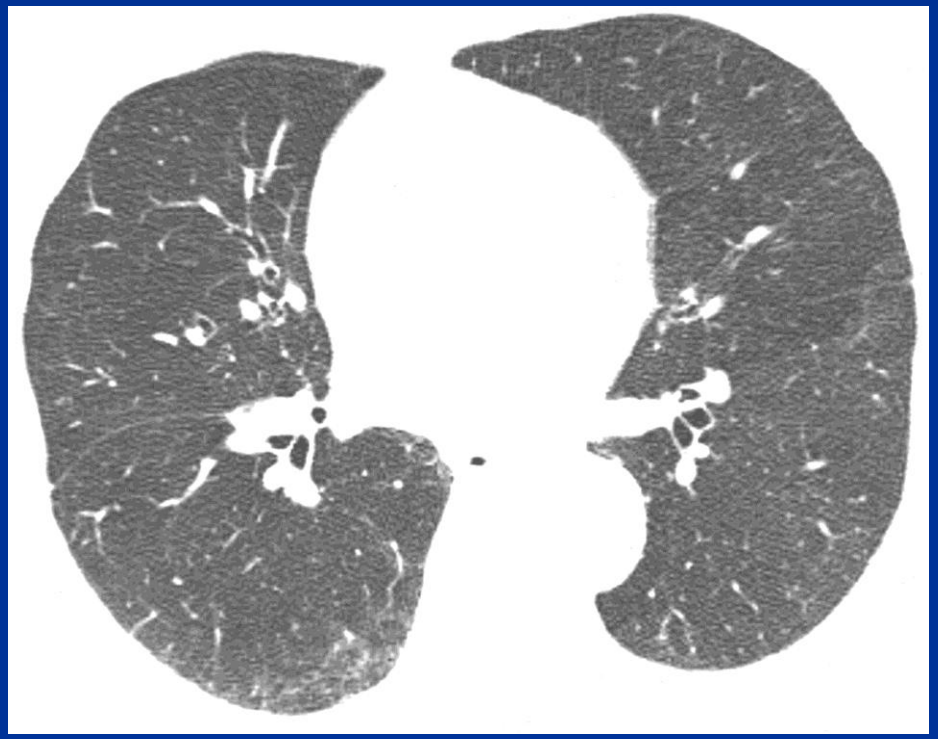


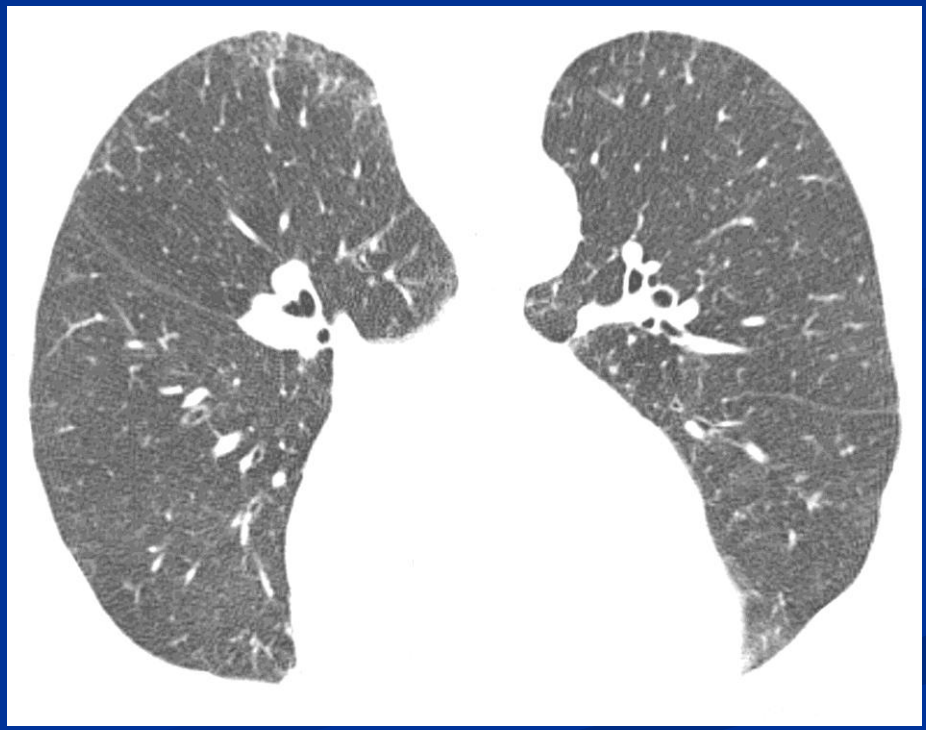


Diffuse lung disease (DLD)

- Idiopathic interstitial pneumonia
  - UIP
  - NSIP
- Secondary DLD
  - Scleroderma
  - Asbestosis
- Prone HRCT series helps for evaluation of basilar DLD

Prone Imaging





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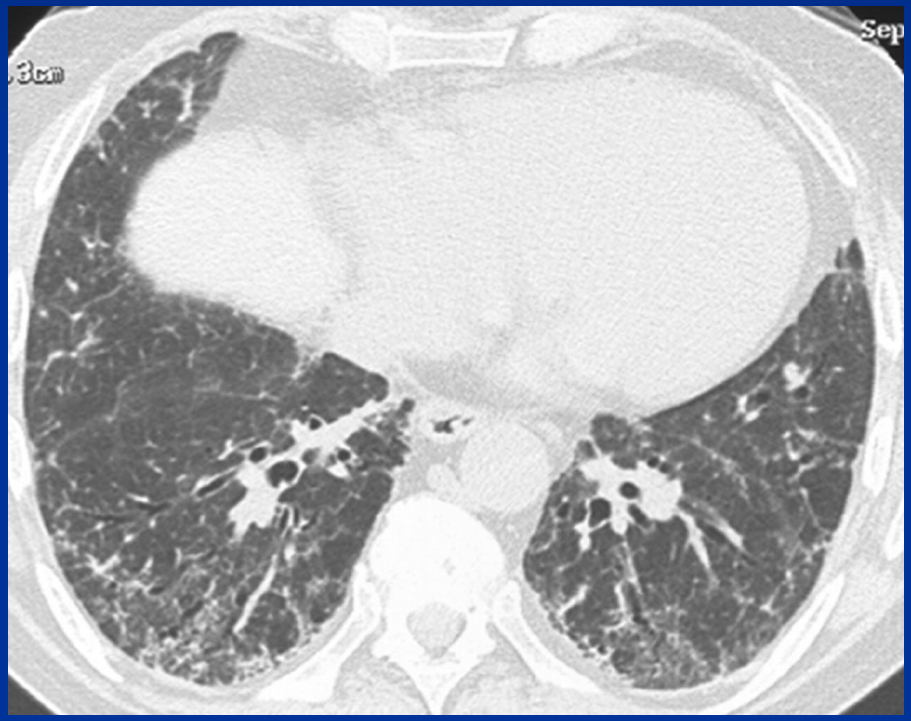
UIP

NSIP



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Conclusion

- At AMI, indications for HRCT include:
  - Evaluation for small airway/small vessel disease (mosaic attenuation)
  - Evaluation for large airway disease (tracheobronchomalacia, bronchiectasis)
  - Evaluation for interstitial lung disease, especially those with a basilar predominance
  - Any reasonable request from an ordering physician

Conclusion

- Mosaic attenuation pattern: air trapping vs. no air-trapping, with additional ancillary findings
- Tracheobronchomalacia
  - < 50% AP change is normal
  - 50-75% is a grey area
  - > 75% is definitely abnormal
- Interstitial lung disease
  - Reticulation at the base which resolves on prone imaging = atelectasis

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