

# The Tracheobronchial Tree

David L. Smith, MD

Professor of Radiology

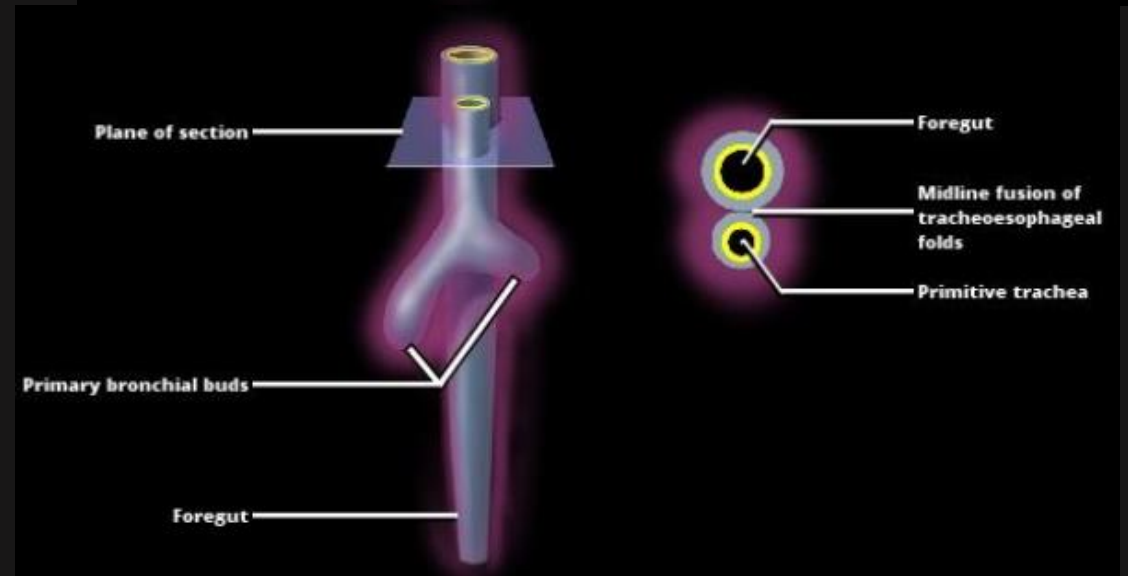
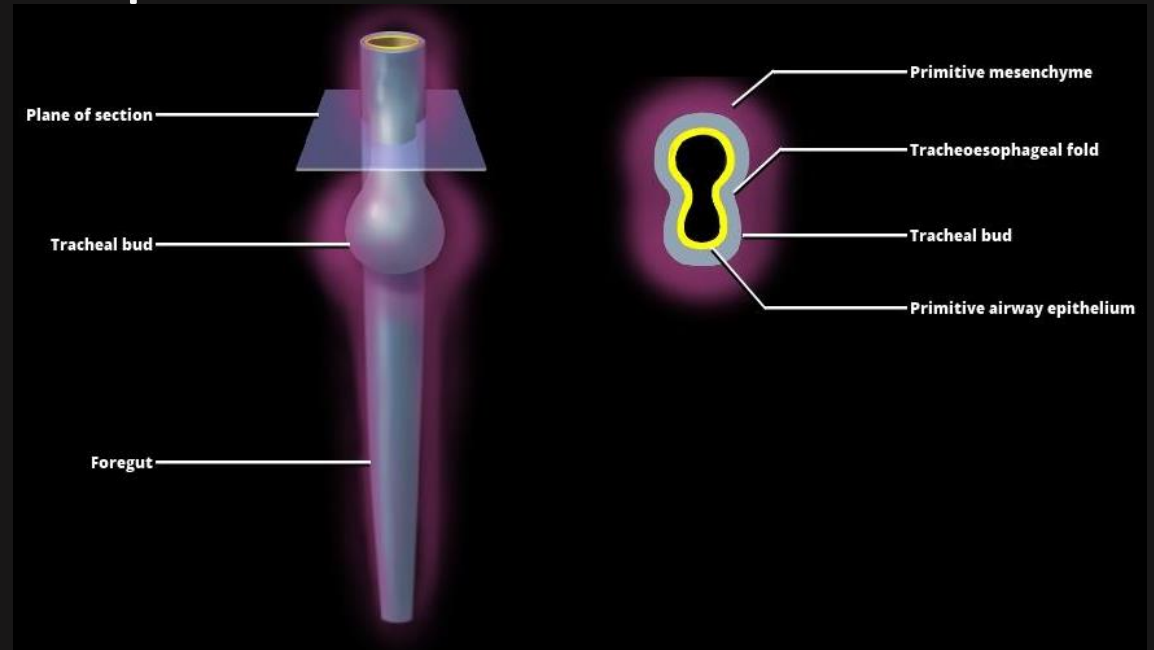
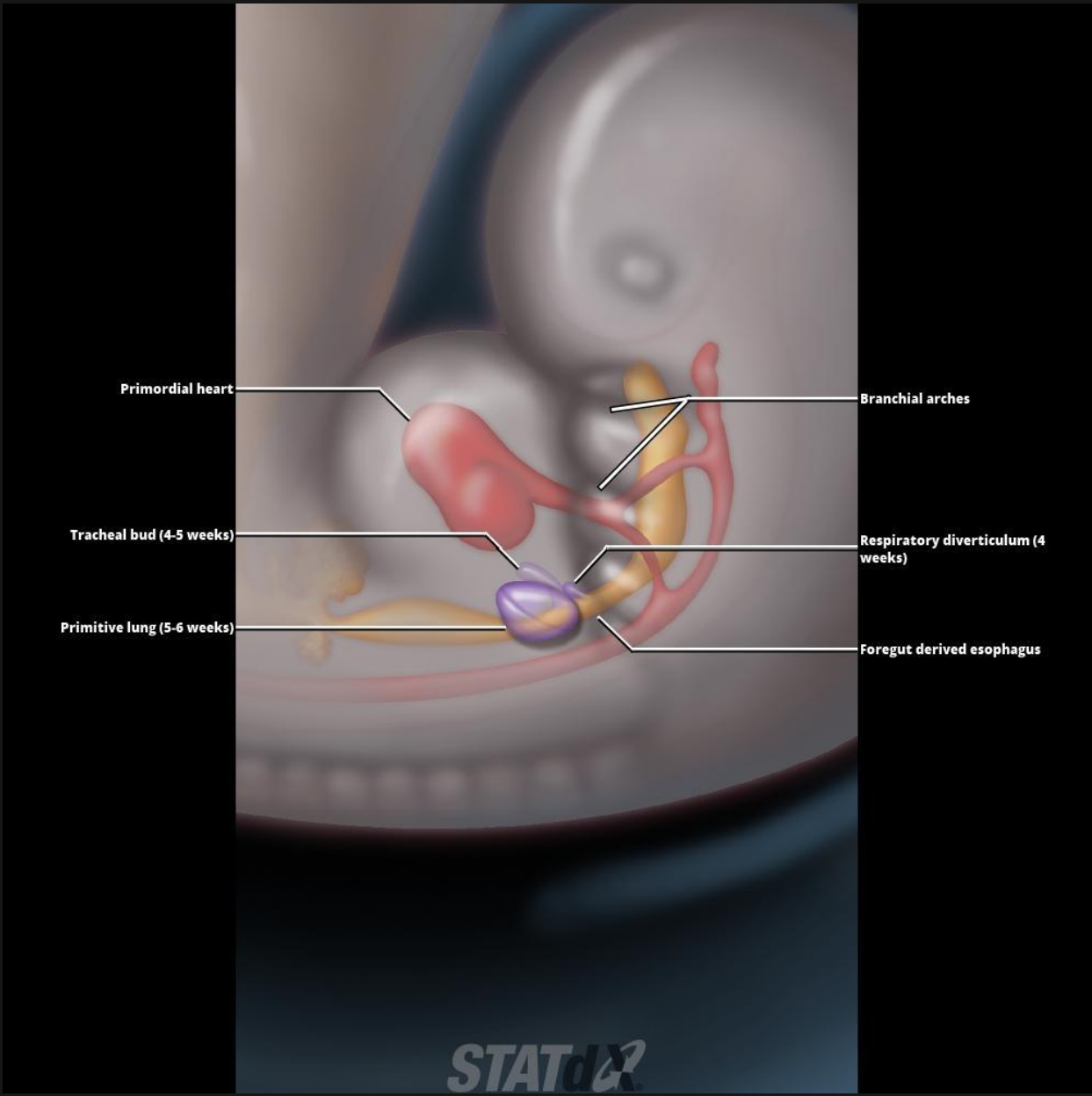
Professor of Medicine

Professor of Cell Biology & Anatomy

# Tracheobronchial Tree

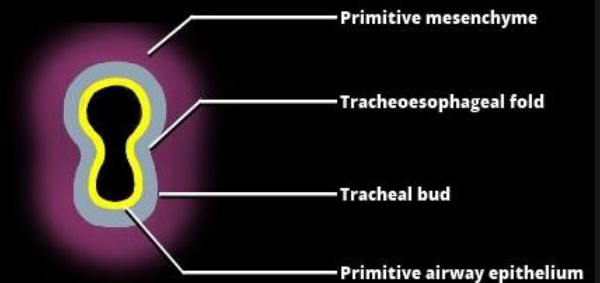
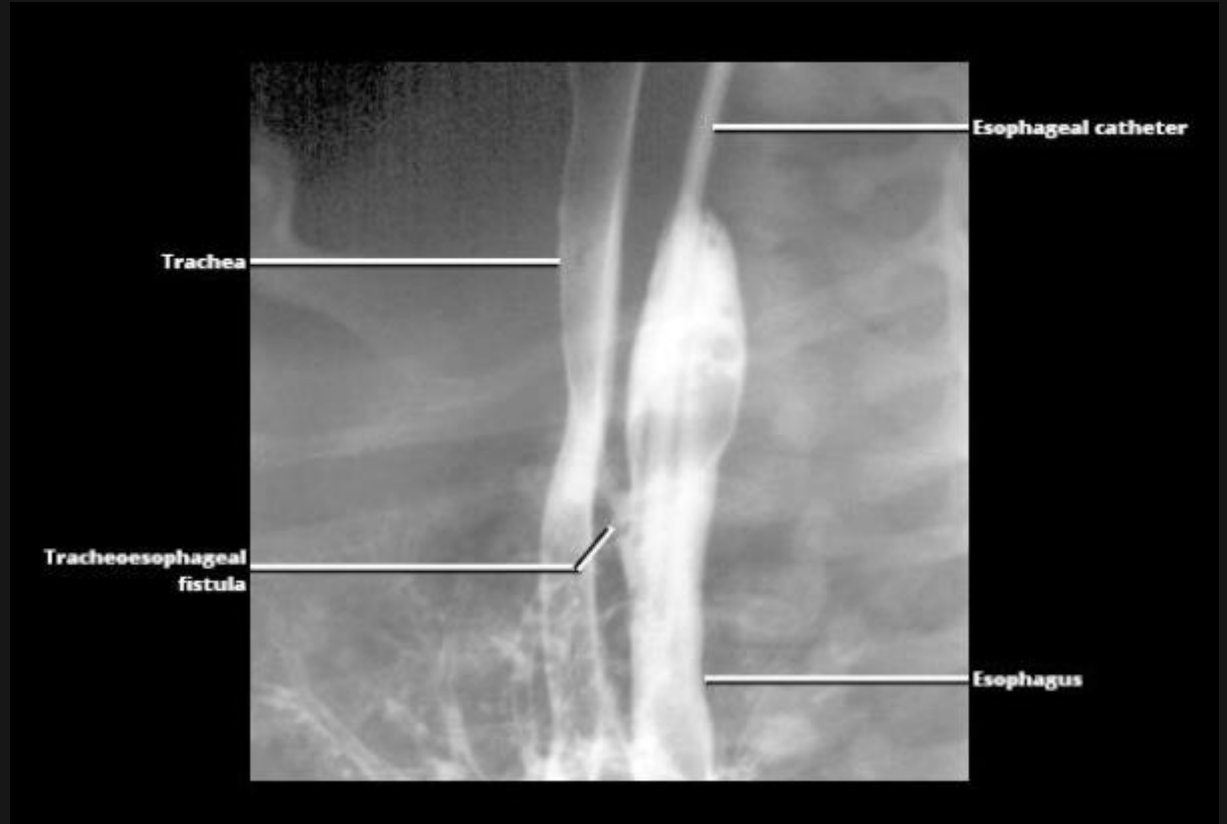
- Development
- Congenital/developmental disease
- Variants
- Benign neoplasms
- Malignant neoplasms
- Wall thickening
- Bronchiectasis
- Narrowing

# Normal Development



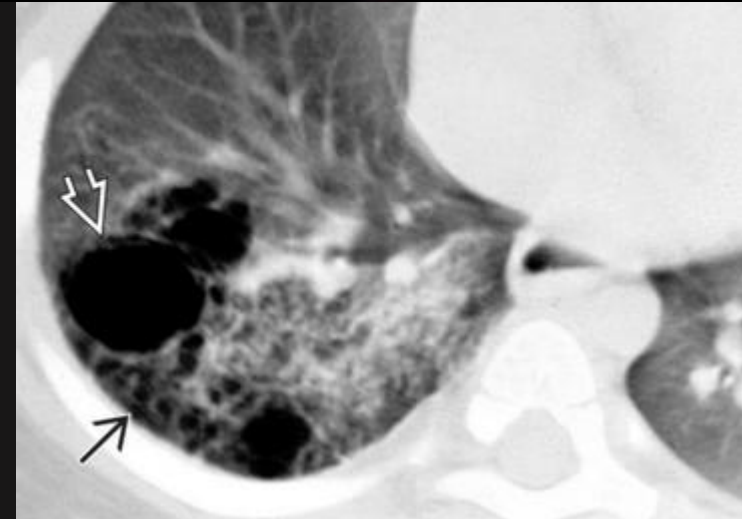
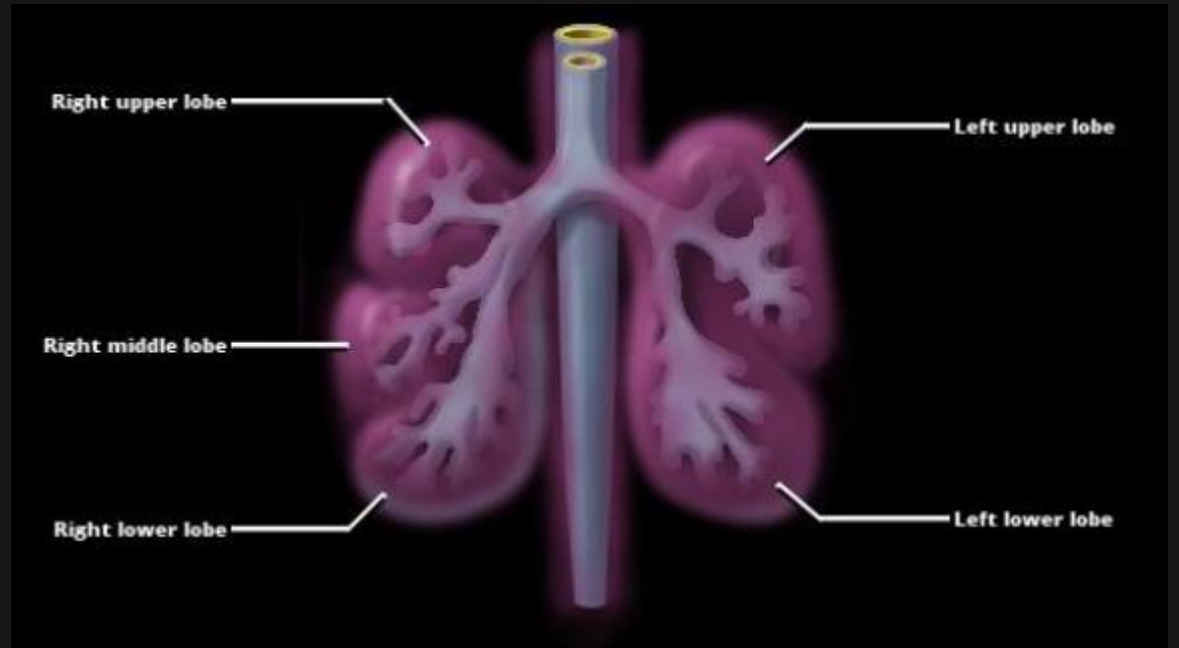
# Congenital/Developmental Pathologies

- Tracheo-esophageal fistula
- Congenital Pulmonary Airway Malformation (CPAM)
- Foregut duplication cyst
- Bronchial atresia
- Congenital lobar emphysema
- Sequestration



# Congenital/Developmental Pathologies

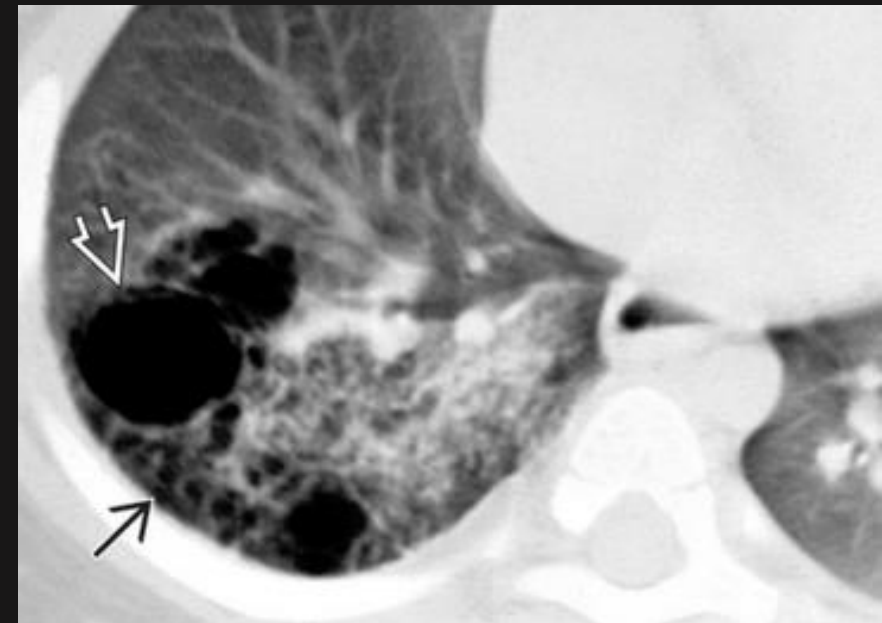
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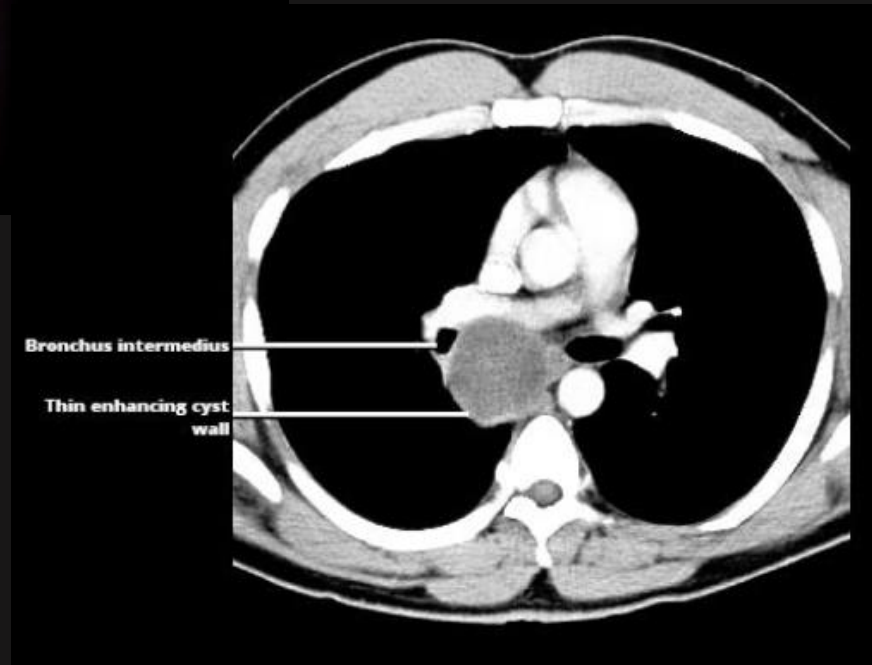
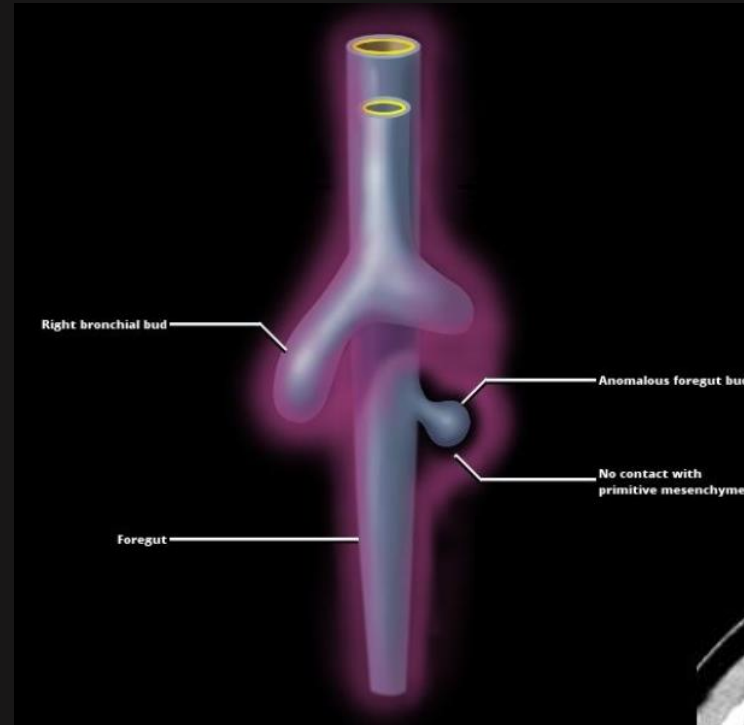
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- Type 1--bronchial and bronchiolar origin
  - Most common type; **60-70%** of all cases
  - Bronchial- and bronchiolar-like structures lined by ciliated pseudostratified columnar epithelium
- Type 2--bronchiolar origin
  - **15-20%** of all cases; associated anomalies; may occur within extralobar sequestration
  - Back-to-back dilated bronchiole-like structures lined by cuboidal to low columnar epithelium



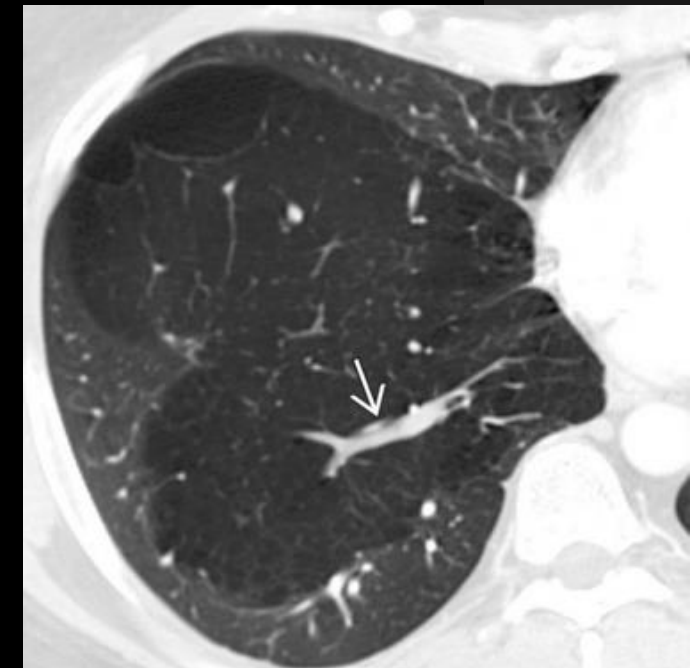
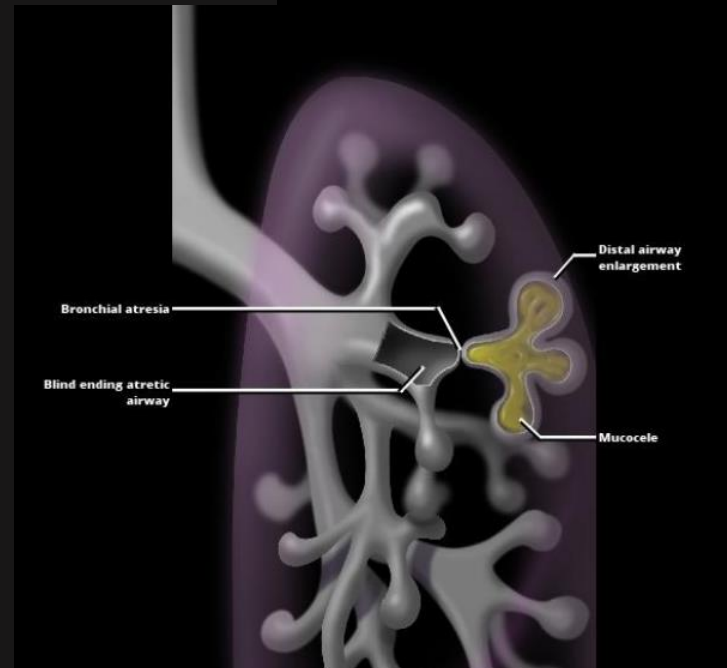
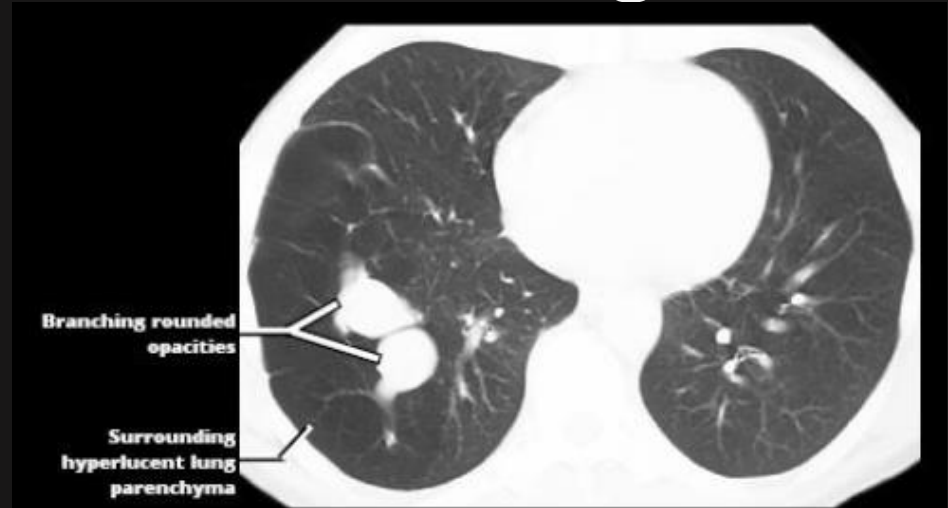
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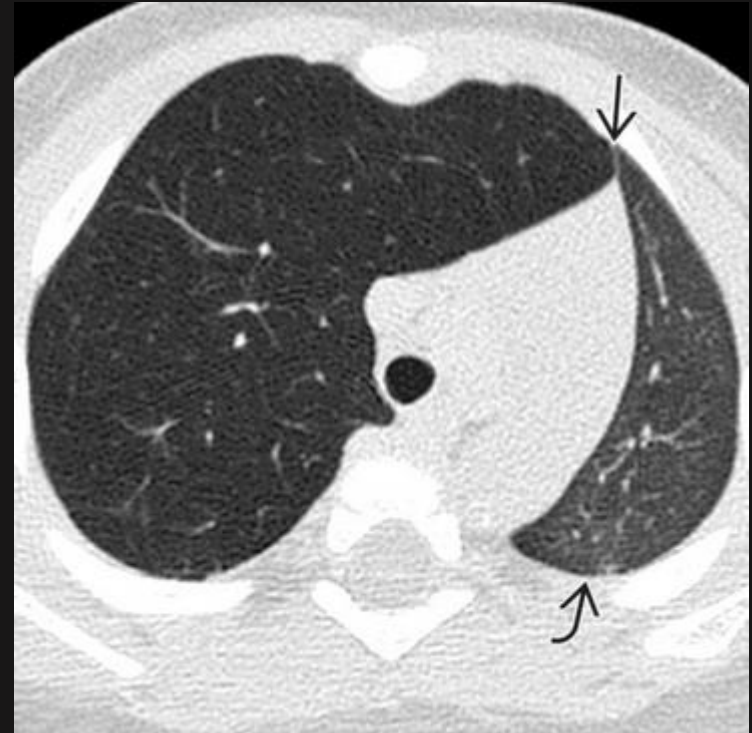
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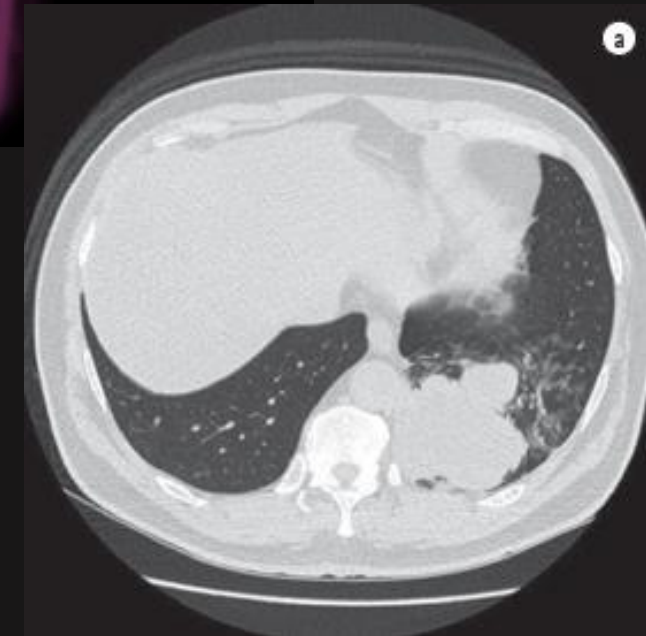
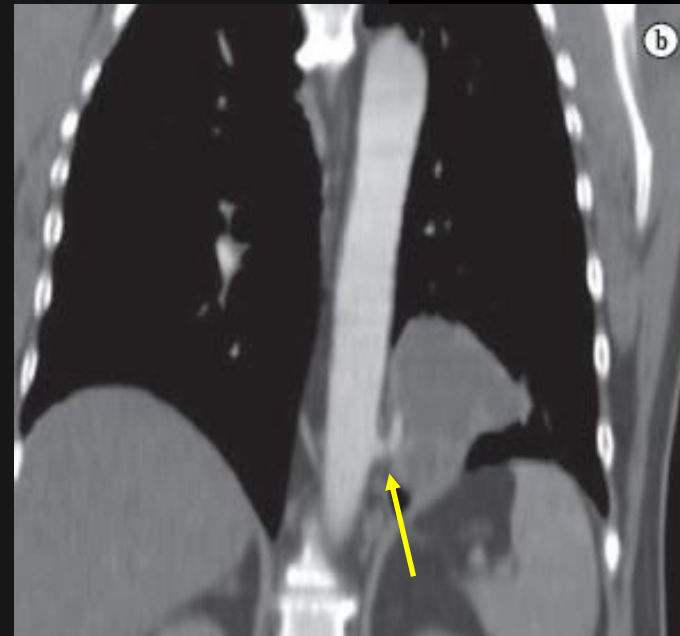
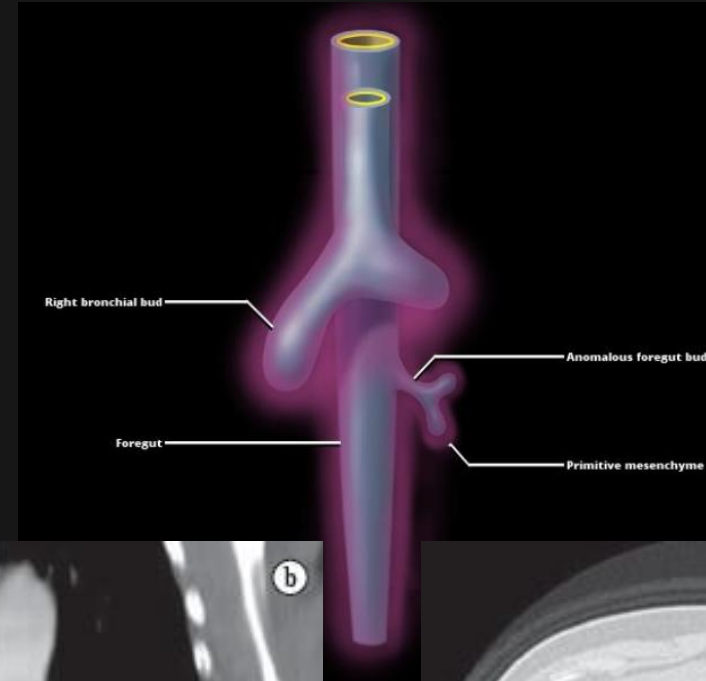


One-way valve bronchial obstruction: Air enters distal airways but does not exit → progressive lobar expansion

- Abnormal bronchial cartilage
- Abnormal mucosal folds
- Mucoid impaction
- Extrinsic compression: Congenital cyst, anomalous vasculature

# Congenital/Developmental Pathologies

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# Anatomic Variants

Anomalies arising from sites typically lacking branches

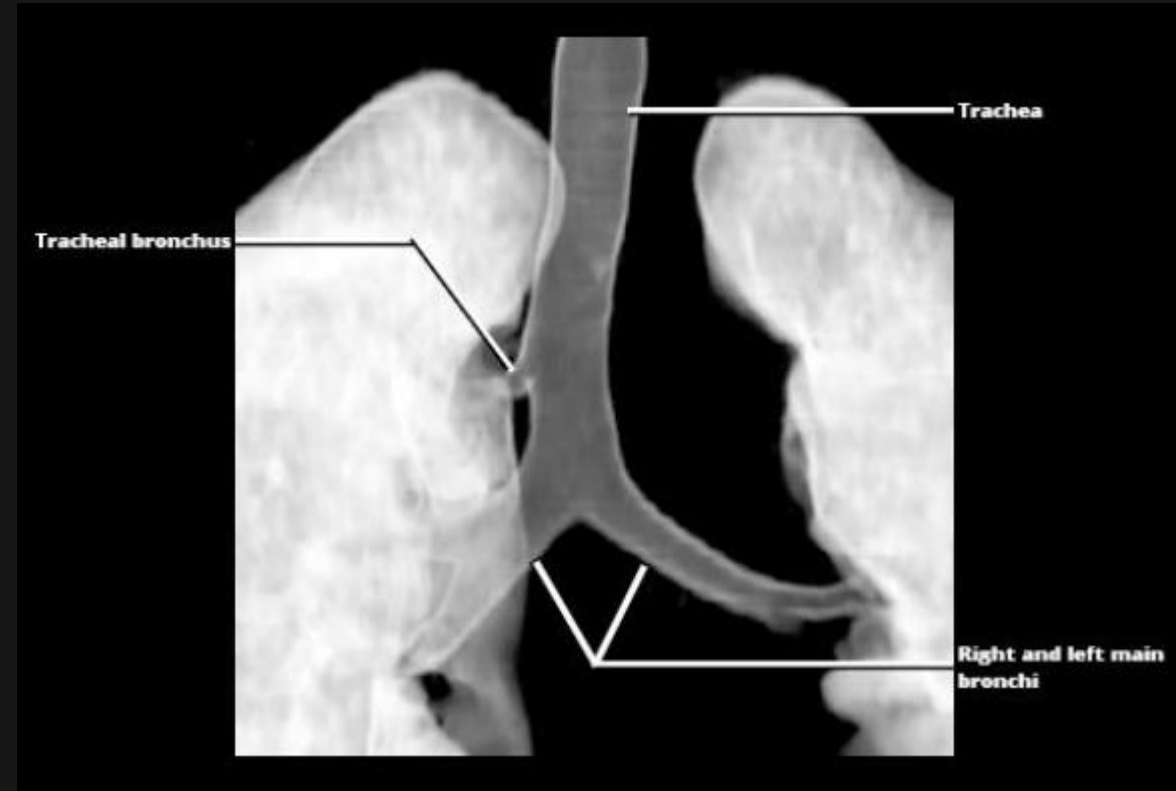
- Spectrum of "tracheal bronchus"
- Accessory cardiac bronchus
- Bridging bronchus

Anomalies arising from normal higher order bronchial divisions

- Accessory superior segmental bronchi
- Axillary bronchi

Anomalies associated with abnormalities of situs/heterotaxy (Bronchial isomerism)

- Bilateral left-sided (Eparterial): Polysplenia
- Bilateral right-sided (Hyparterial): Asplenia



# Anatomic Variants

Anomalies arise from sites typically of bronchial branches

- Subcarinal bronchial branches
- Subsegmental bronchi
- Bronchovascular bundles

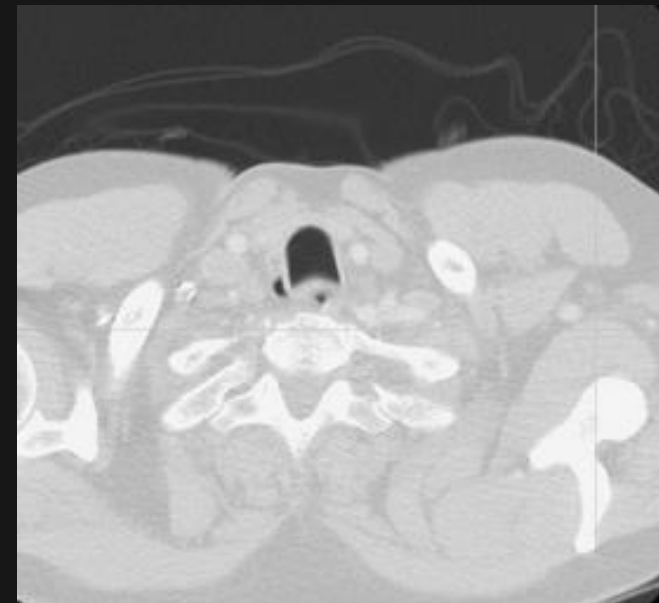
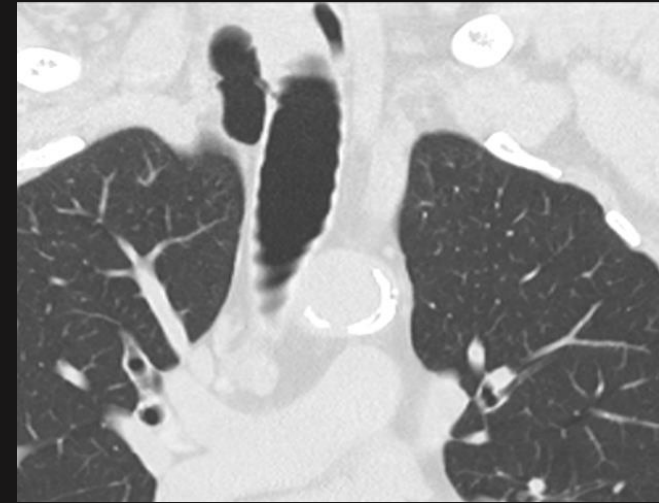
Anomalies arise from sites under bronchial divisions

- Accessory bronchi
- Axillary bronchi

Anomalies arise from sites of the spleen

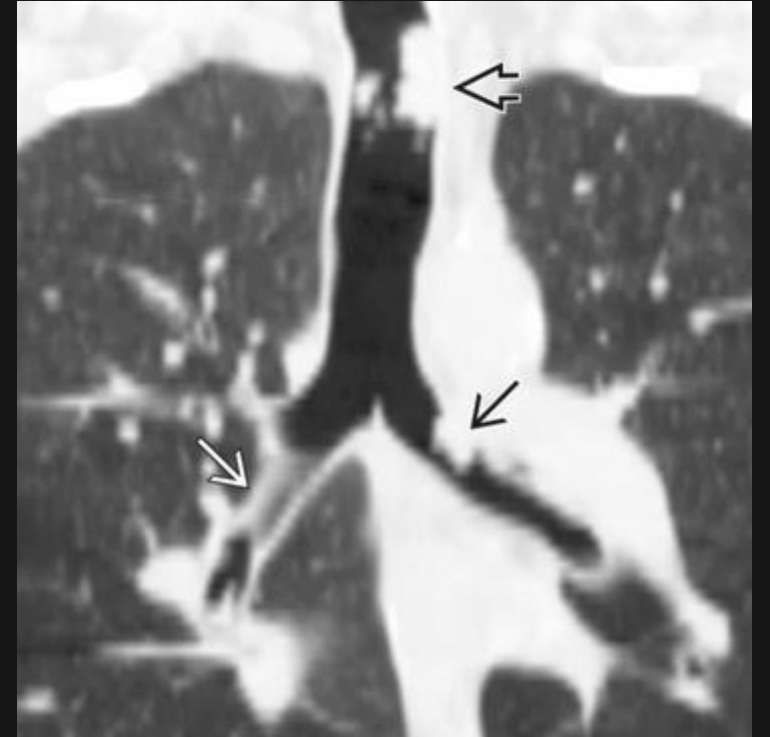
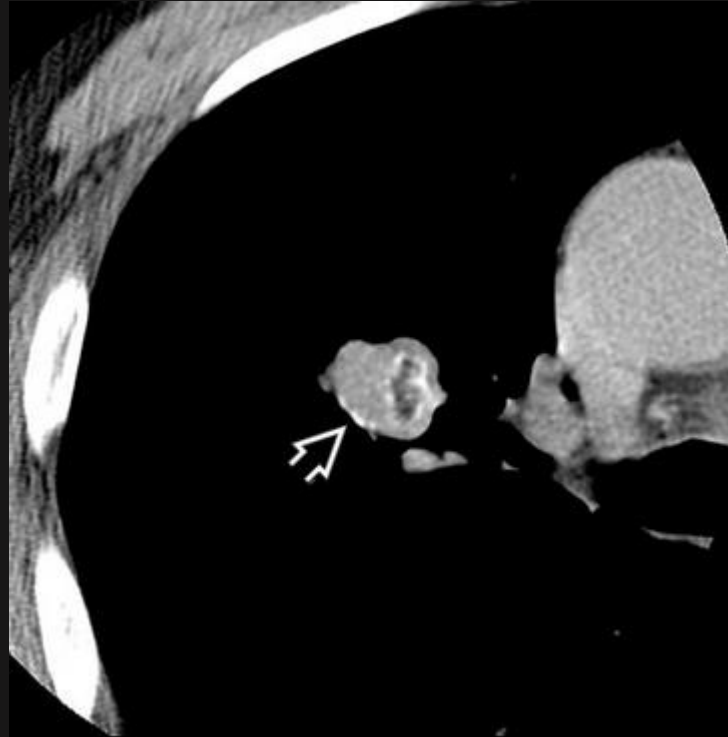
(Bronchovascular bundles)

- Bilateral right-sided (Eparterial) asplenia
- Bilateral left-sided (Hyparterial) asplenia



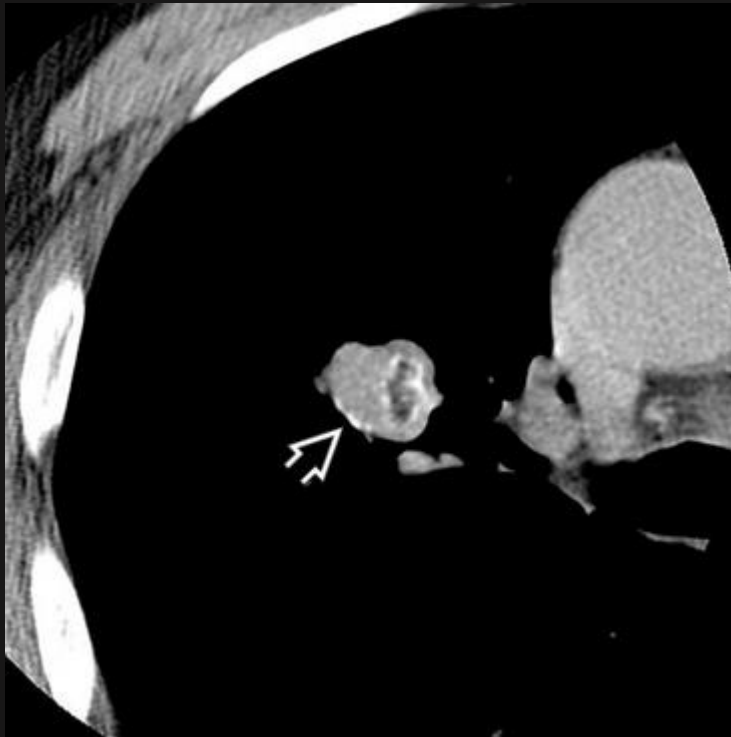
# Benign Neoplasms

- Hamartoma
- Papillomatosis



# Benign Neoplasms

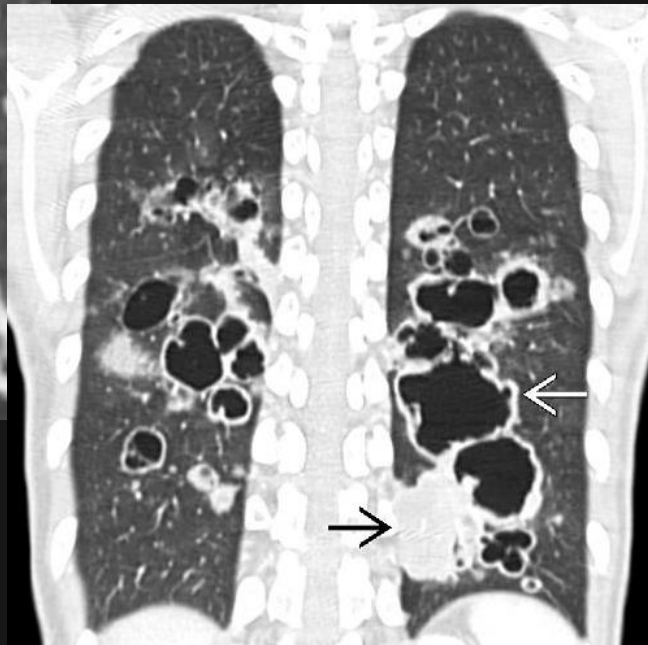
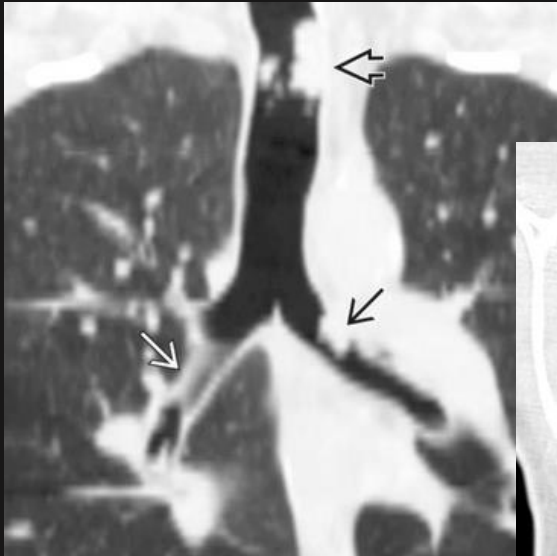
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- Focal endoluminal lesion in central airway
- **Internal fat and/or calcification** suggest diagnosis
- Postobstructive findings: atelectasis, consolidation, bronchiectasis

# Benign Neoplasms

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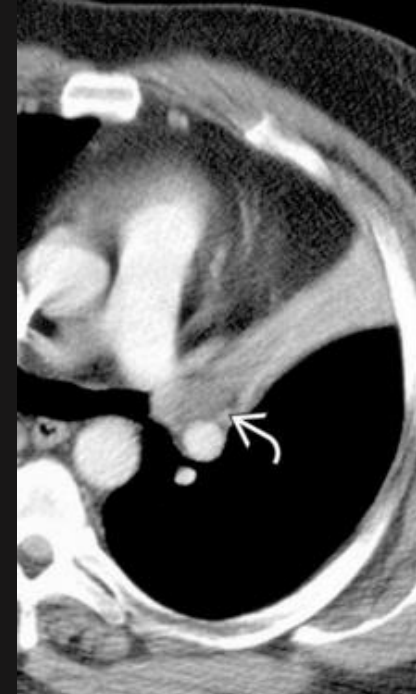
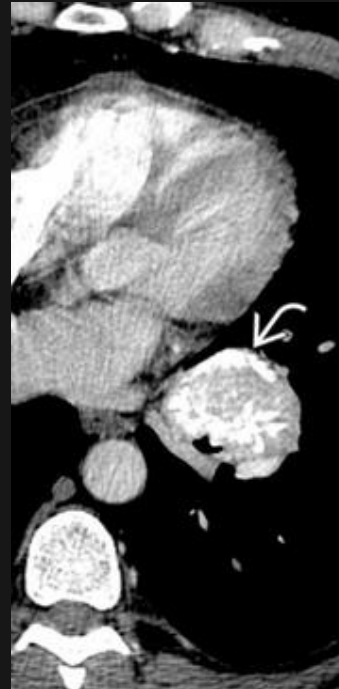
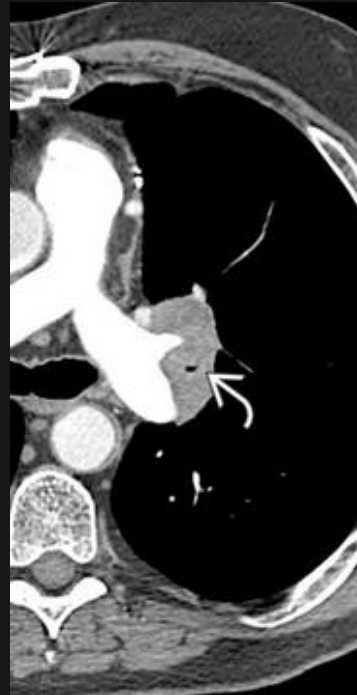


- Infection with **HPV**; types 6 & 11 most common
- Larynx most commonly affected
- Diagnosis made by laryngoscopy and biopsy
- Laryngeal and pulmonary lesions composed of **squamous cells**



# Malignancies

- Squamous cell carcinoma
- Carcinoid
- Mucoepidermoid
- Adenoid cystic carcinoma
- Metastasis

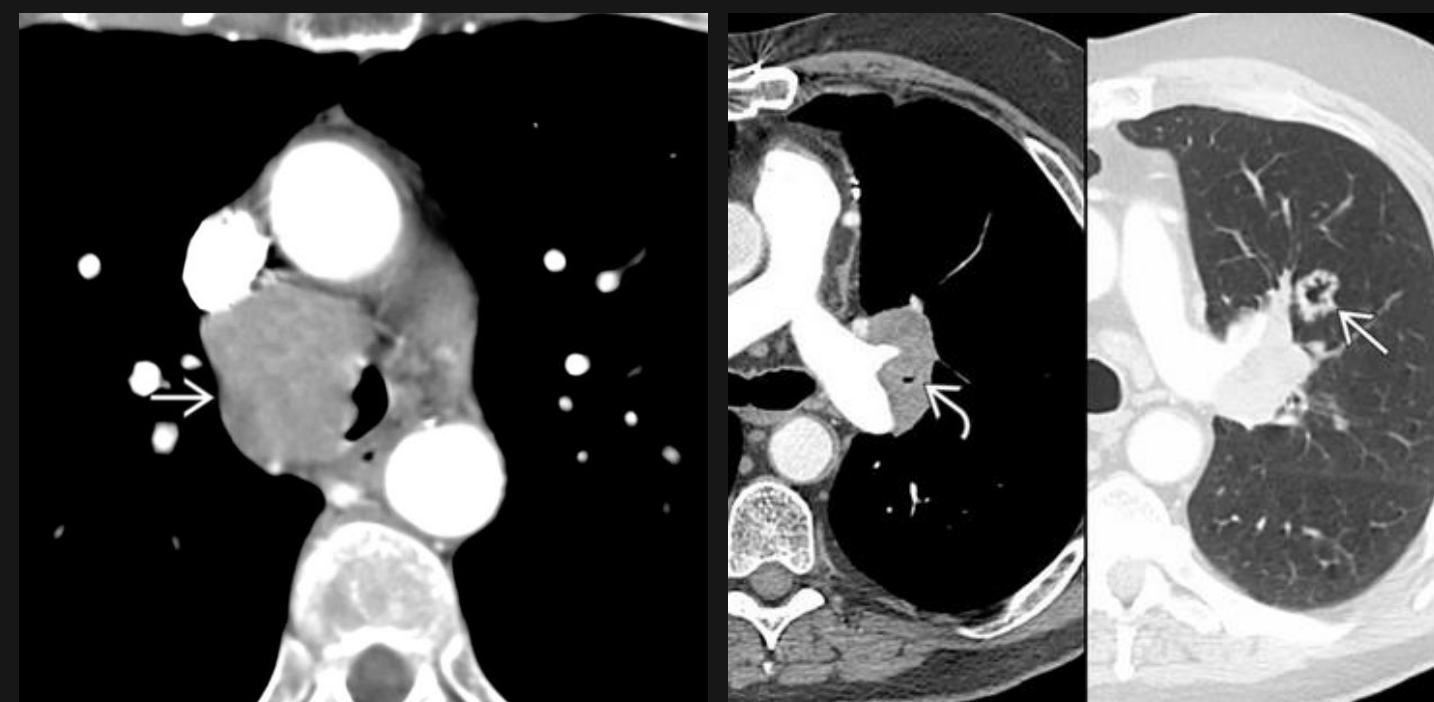




# Malignancies

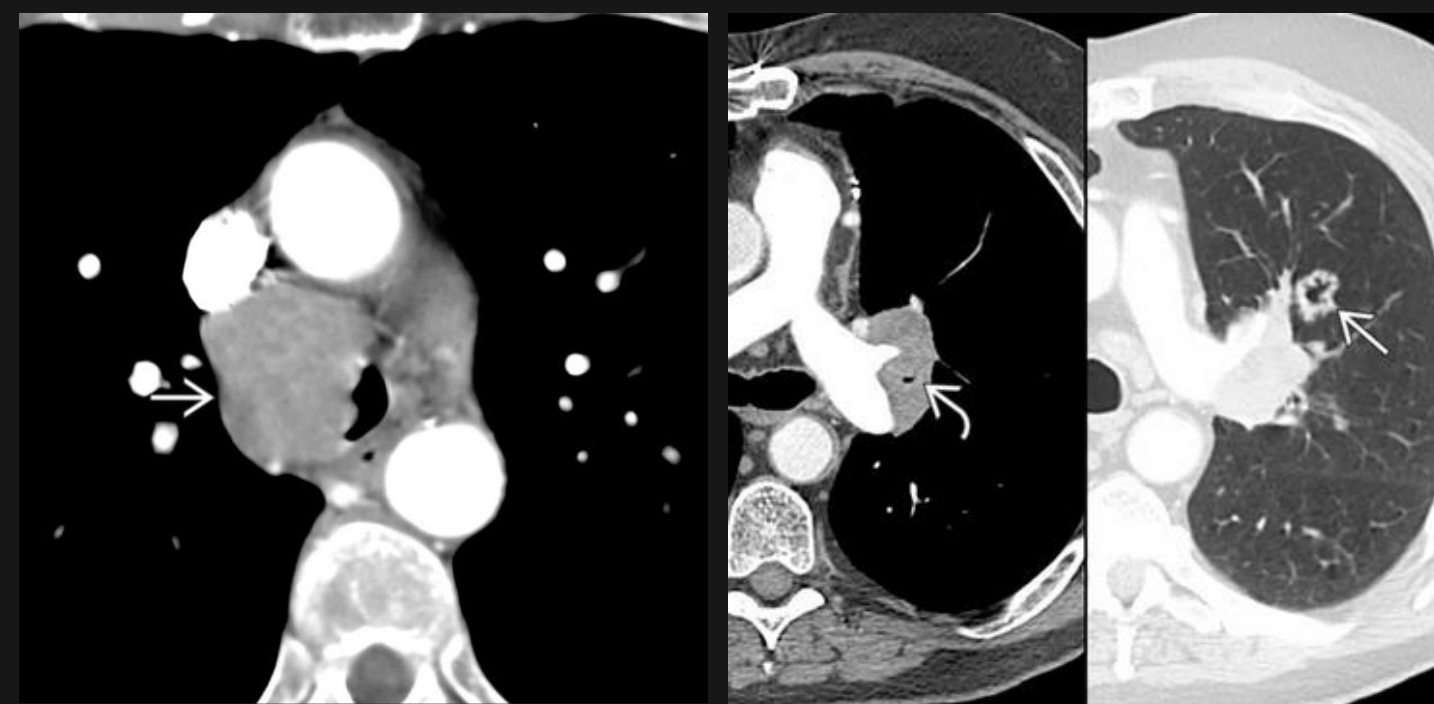
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- Postulated progression: **Squamous metaplasia** → **dysplasia** → **carcinoma in situ** → **invasive carcinoma**
- Strong association with **cigarette smoking**
  - 50% of lung cancers develop in smokers or former smokers
  - Lung cancer risk directly related to number of cigarettes smoked, length of smoking history, & tar/nicotine content
  - Cessation of smoking reduces lung cancer risk



# Malignancies

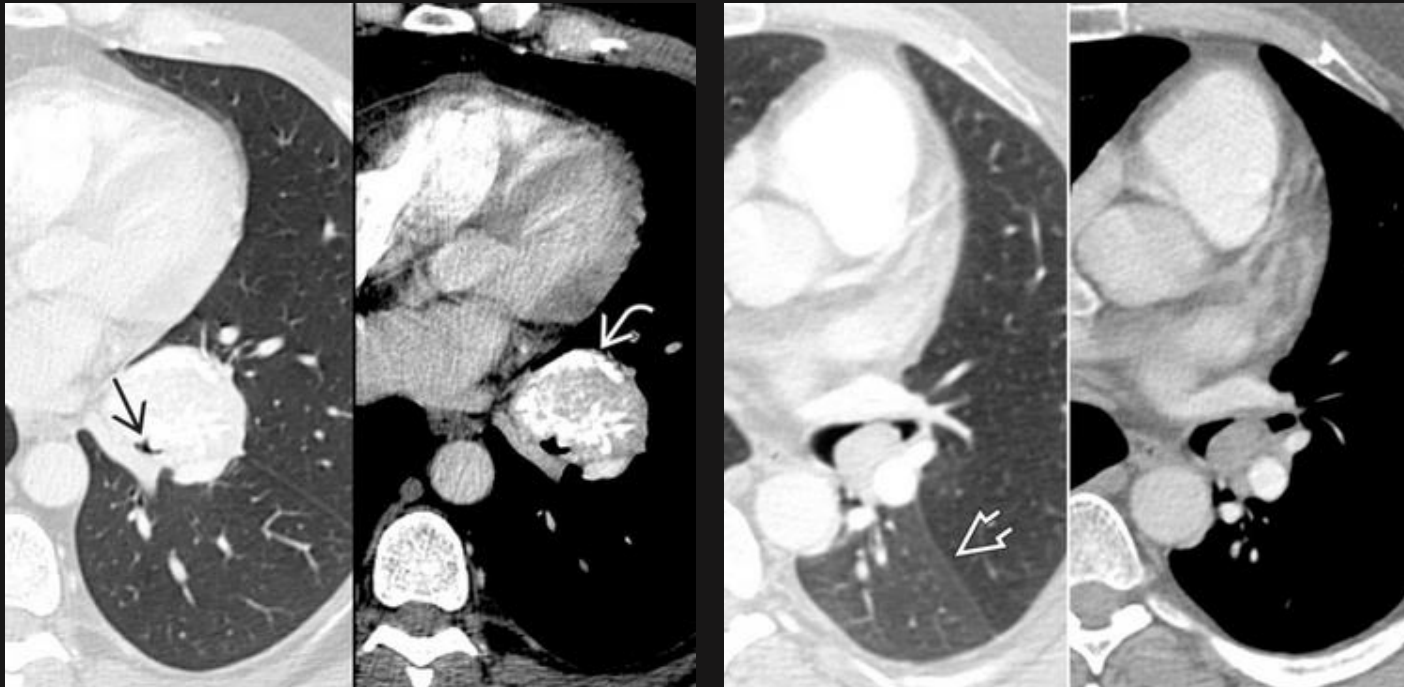
- Squamous cell carcinoma
  - Carcinoid
  - Mucoepidermoid
  - Adenoid cystic carcinoma
  - Metastasis
- Endoluminal **obstructing lesion with postobstructive consolidation**
  - Typically central
    - 2/3 in mainstem, lobar, or segmental bronchi



# Malignancies

- Squamous cell carcinoma
- Carcinoid
- Mucoepidermoid
- Adenoid cystic carcinoma
- Metastasis

- Low-grade malignant neoplasm arising from neuroendocrine cells normally scattered throughout tracheobronchial epithelium
- **Avidly enhancing** central nodule or mass
- **Calcification/ossification** in 30%
- Endobronchial, **partially endobronchial**, abutting bronchus, peripheral
- Postobstructive effects: Atelectasis, consolidation bronchiectasis
- Classically **hypometabolic** (PET negative)



# Malignancies

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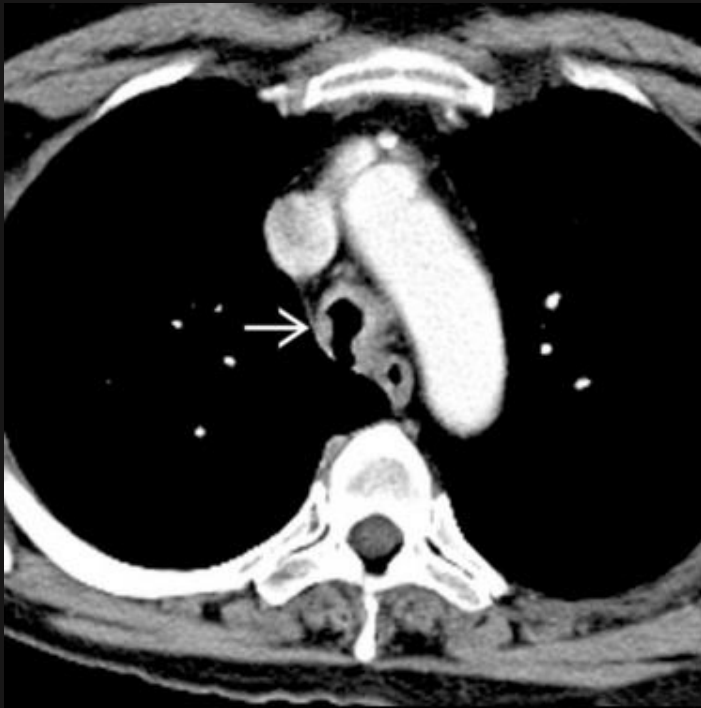


- Well-circumscribed endobronchial lesion
  - **Central airway: ~ 45%** (main bronchus > trachea)
  - Distal obstructive pneumonia or atelectasis
  - **Punctate calcification: ~ 50%**
- Cough, hemoptysis, wheeze, stridor, pneumonia
- **50% of patients younger than 30 years**
- Surgical resection; prognosis usually good

# Malignancies

- Squamous cell carcinoma
- Carcinoid
- Mucoepidermoid
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- Rare primary malignant neoplasm arising from tracheobronchial glands
- **Polypoid or circumferential tracheal nodule** or mass; may also involve central bronchi
  - Often affects long segments of trachea



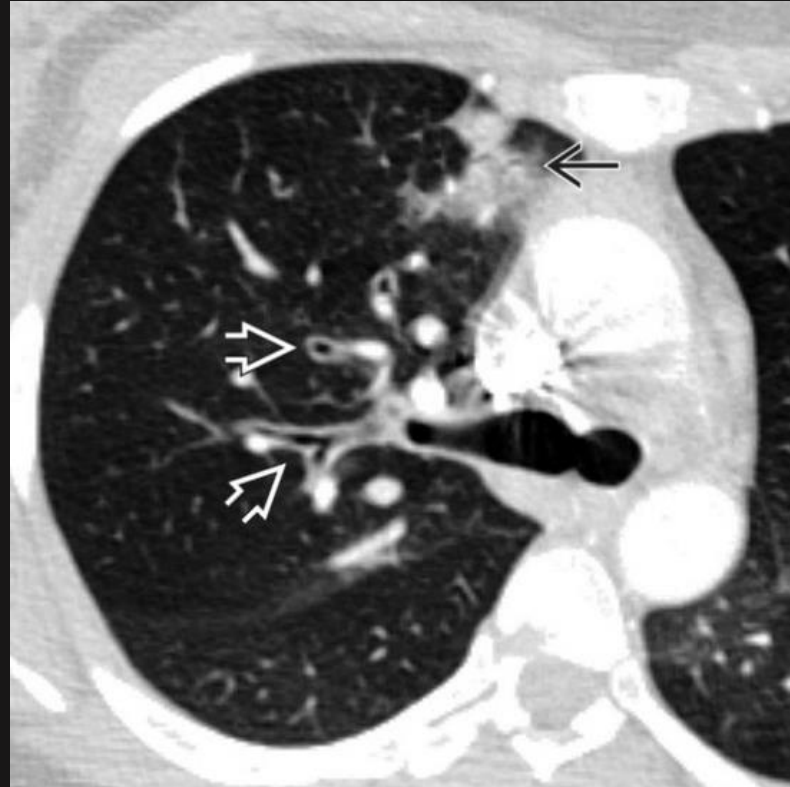
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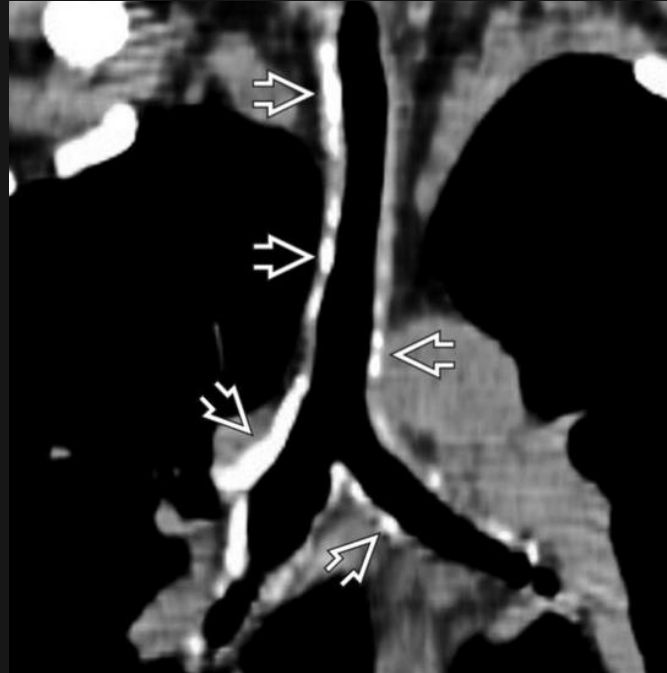
# Wall Thickening

- Bronchitis
- Relapsing polychondritis
- Amyloidosis
- Sarcoidosis
- Rhinoscleroma
- Granulomatosis with polyangitis
- Tracheobronchopathia osteochondroplastica



# Wall Thickening

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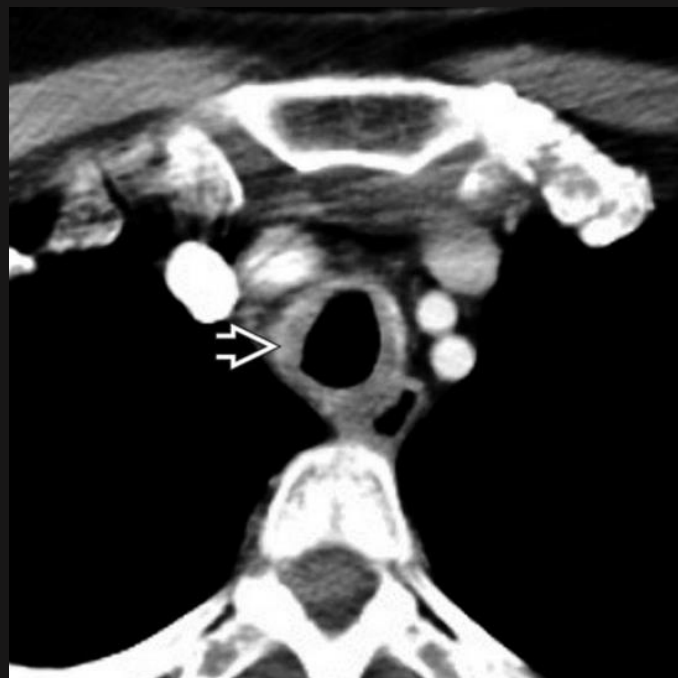


- Rare autoimmune disorder resulting in **cartilage inflammation & destruction**
- Focal or diffuse involvement airway wall thickening **posterior tracheobronchial membrane spared**



# Wall Thickening

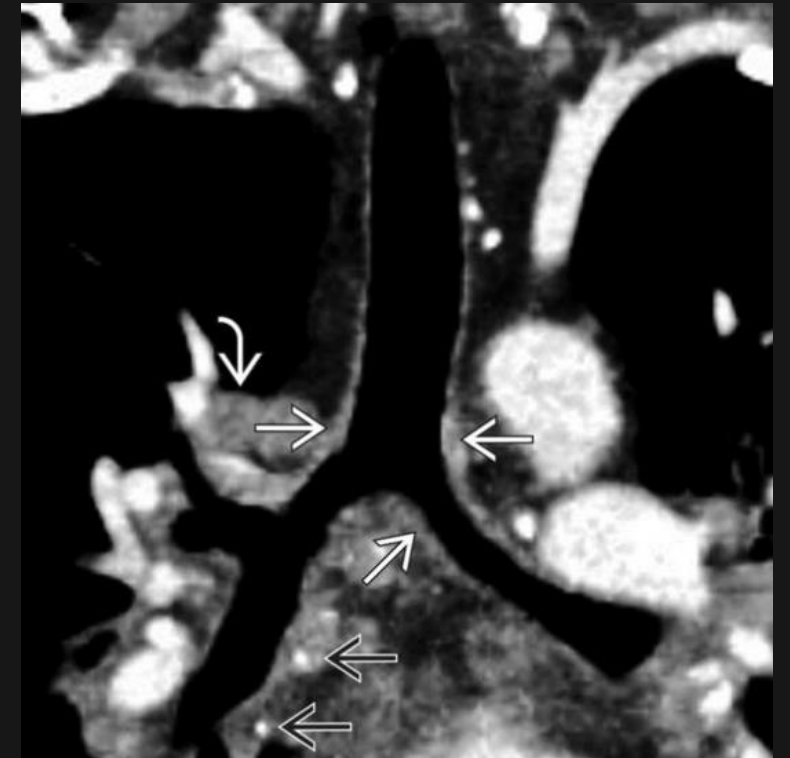
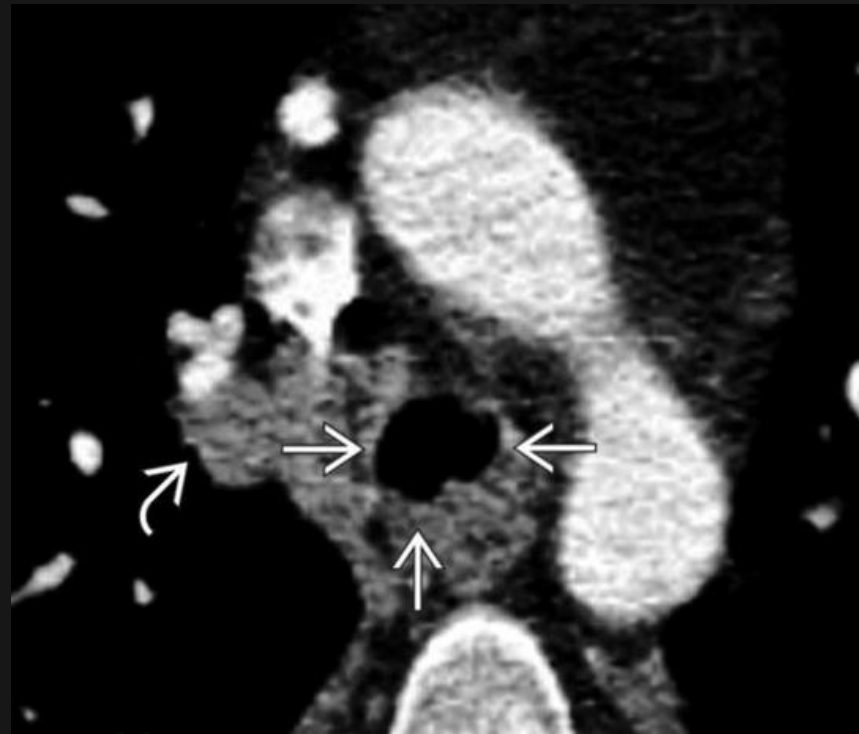
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- **Focal or diffuse** submucosal deposition of amyloid light chain (AL) protein in tracheobronchial
- Nodular soft tissue thickening of airway wall
  - Multifocal submucosal plaques (most common)
  - May involve posterior tracheal wall
  - May exhibit foci of calcification

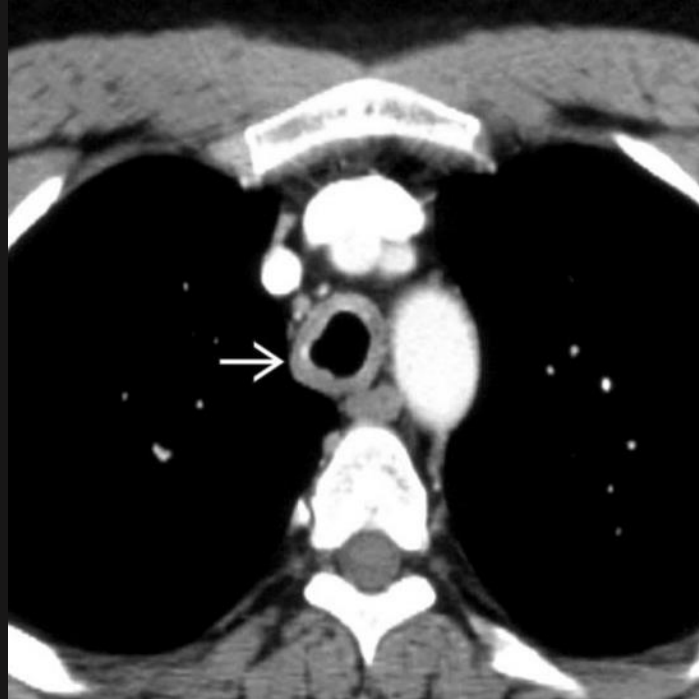
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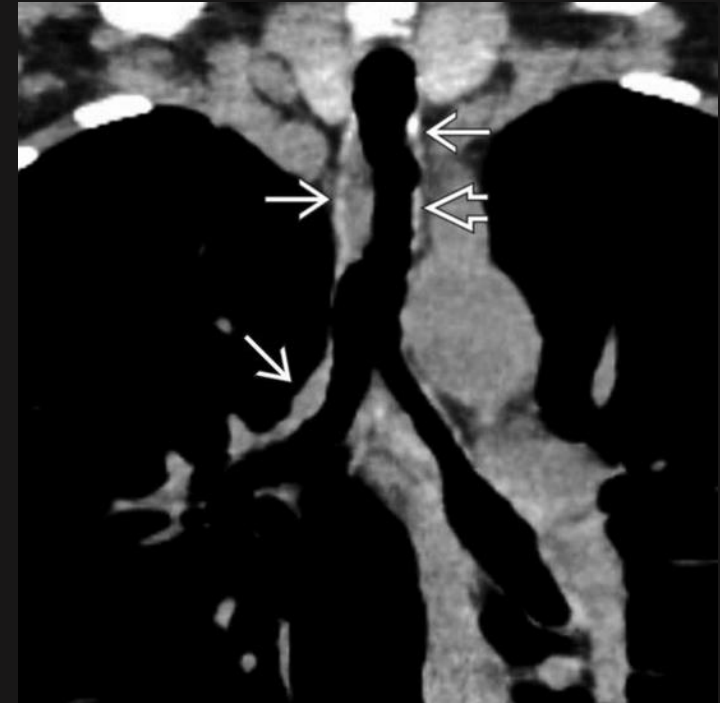
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- Progressive upper respiratory tract granulomatous infection by *Klebsiella rhinoscleromatis*
- **Crypt-like spaces** nearly diagnostic
- Nodularity of tracheal mucosa
- Concentric tracheobronchial narrowing
- Calcification not common

# Wall Thickening

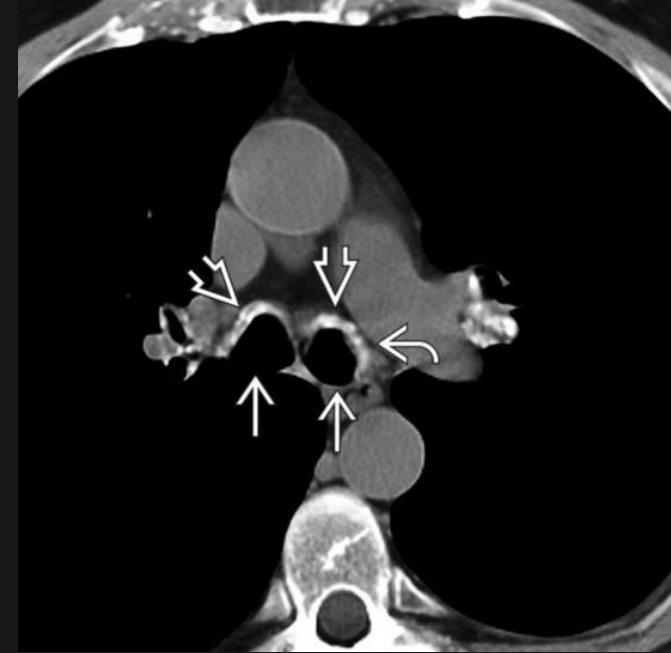
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- Trachea & bronchi concentrically thickened
- Smooth or irregular wall thickening, may be circumferential
- Focal or long segment stenosis
- Focal involvement common in subglottic area

# Wall Thickening

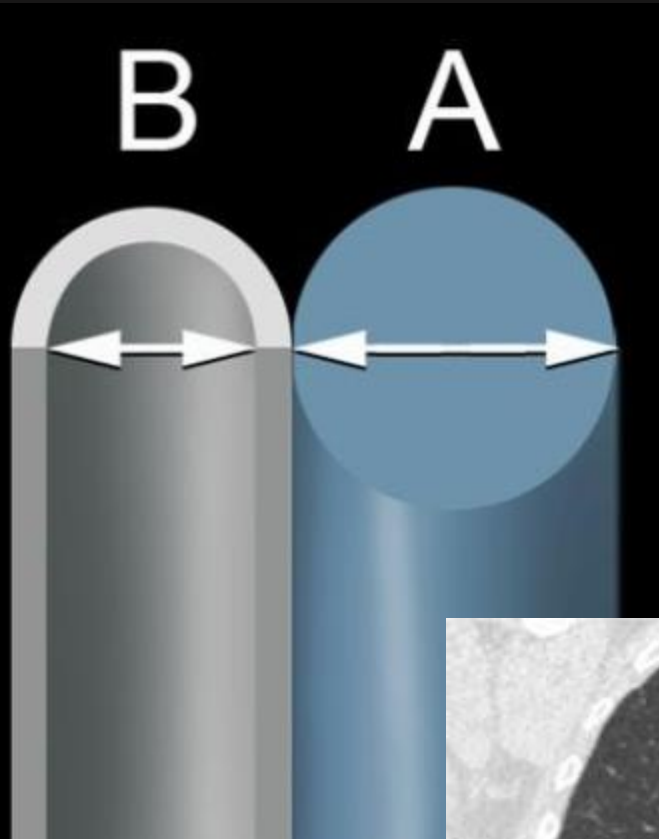
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- Rare idiopathic benign condition characterized by multiple **submucosal osteocartilaginous nodules** in central airway walls
- Hyalinized fibrocollagenous tissue with fibrosis, calcification, necrosis



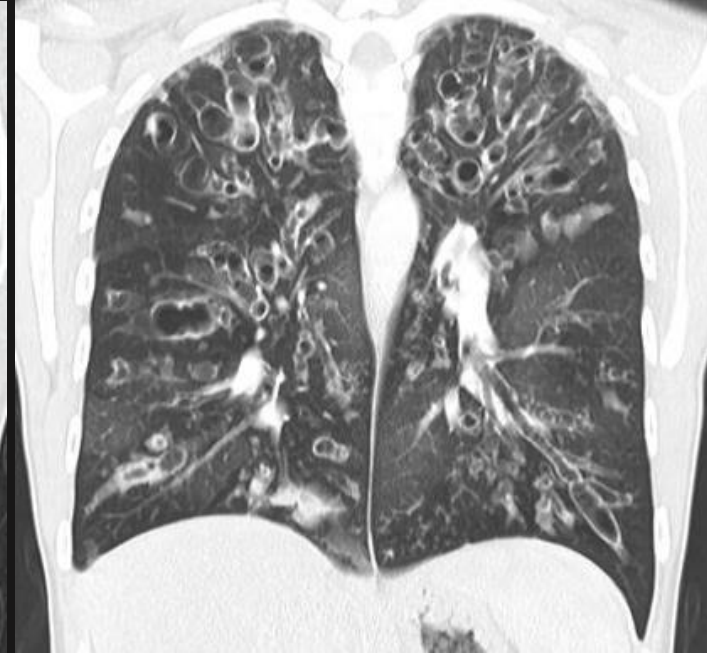
# Bronchiectasis



Cylindrical

Cystic

Varicoid



# Bronchiectasis

Lack of structural elements



- Congenital (WC & MK)
- Post inflammatory
  - Congenital/Genetic abnormality
    - PCD, CF, immunodeficiency, etc.
  - Recurrent or severe infection
    - ABPA, TB, NTB, etc.
  - Recurrent or severe inflammation
    - Sarcoid, aspiration, rejection, inhalation, etc.

Traction



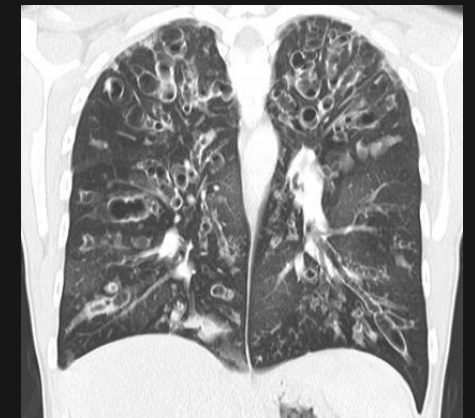
- Fibrosis



Cylindrical



Cystic



Varicoid

# Bronchiectasis

- **Congenital**

- Cystic fibrosis
- Primary ciliary dyskinesia
- Mounier-Kuhn syndrome
- Williams-Campbell syndrome
- Immunodeficiency (e.g., HIV)
- Bronchial atresia

- **Infectious**

- Allergic bronchopulmonary aspergillosis
- Chronic mycobacterial infection
- Post-infectious from fungal, bacterial, or viral pathogens

- **Inflammatory**

- Rheumatoid arthritis
- Sarcoidosis
- Post-transplant chronic rejection
- Pulmonary fibrosis

- **Acquired**

- Chronic aspiration
- Toxic inhalation
- Obstruction
  - Tumor, foreign body, lymphadenopathy



# Bronchiectasis

## Examples...

- Mounier Kuhn
- Williams-Campbell
- Cystic fibrosis
- Allergic bronchopulmonary aspergillosis
- Primary ciliary dyskinesia



- Atrophy or **absence of elastic fibers** and thinning of smooth muscle layer in trachea and main bronchi
- **Large tracheal/bronchial diameters on inspiration**
- **Corrugated effect** due to redundant mucosa prolapsing between tracheal rings
- Central bronchiectasis, **1st to 4th order bronchi**
- Tracheobronchial diverticula
- Tracheobronchial **collapse with expiration**

# Bronchiectasis

## Examples...

- Mounier Kuhn
- Williams-Campbell
- Cystic fibrosis
- Allergic bronchopulmonary aspergillosis
- Primary ciliary dyskinesia



- Congenital form of bronchiectasis related to **cartilage deficiency** in subsegmental bronchi
- **Varicoid and cystic** bronchiectasis
- **4th to 6th order bronchi** involved
- Other **central airways normal**
- Bronchial wall thickening, mucus plugs, fluid

# Bronchiectasis

## Examples...

- Mounier Kuhn
- Williams-Campbell
- **Cystic fibrosis**
- Allergic bronchopulmonary aspergillosis
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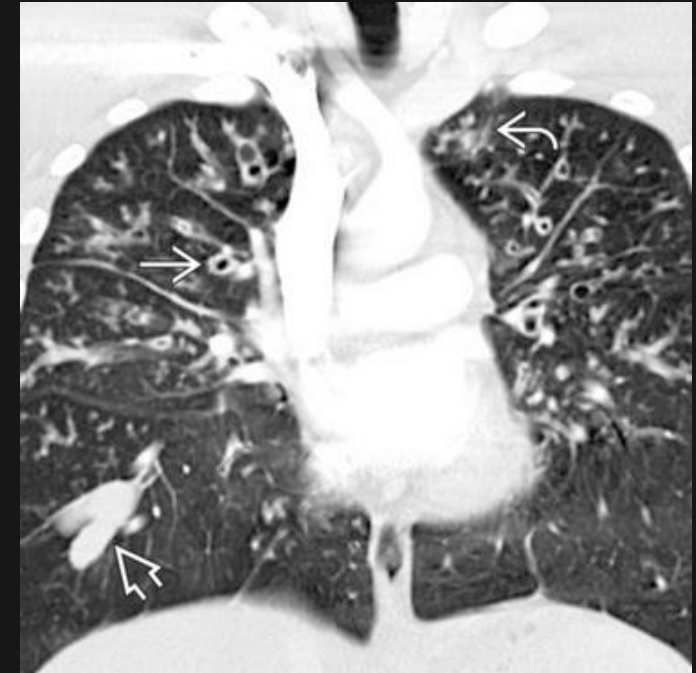


- Autosomal recessive hereditary disorder; abnormality in gene regulating chloride transport → thick viscous secretions affecting primarily lung & pancreas
- Thick mucus → reduced mucociliary clearance → airway obstruction → **recurrent infections** → **airway destruction**
- **Upper lobe predominant** bronchiectasis

# Bronchiectasis

## Examples...

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- Williams-Campbell
- Cystic fibrosis
- **Allergic bronchopulmonary aspergillosis**
- Primary ciliary dyskinesia

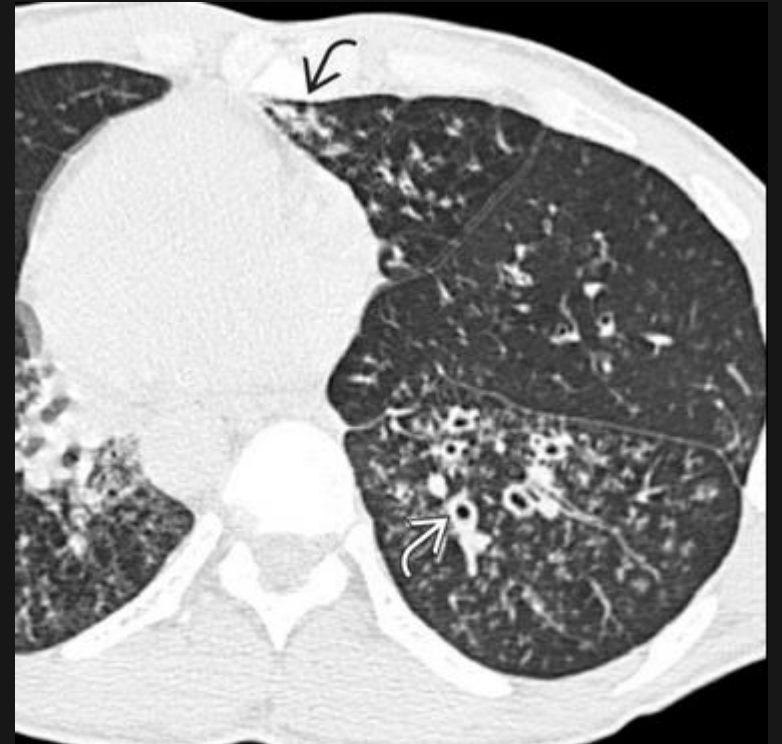


- Central multifocal bronchiectasis with mucoid impactions
- Atelectasis related to bronchial obstruction
- Centrilobular nodules that may be branching
- Areas of consolidation & ground-glass opacities
- Mosaic perfusion or air-trapping

# Bronchiectasis

## Examples...

- Mounier Kuhn
- Williams-Campbell
- Cystic fibrosis
- Allergic bronchopulmonary aspergillosis
- Primary ciliary dyskinesia



- **Abnormal ciliary ultrastructure** with resultant mucociliary dysfunction & sinopulmonary disease
- Bronchial wall thickening and bronchiectasis with predilection for **lingula, middle & lower lobes**
- **Kartagener syndrome: 50%** of PCD
  - Triad of situs inversus, sinusitis or nasal polyposis, & bronchiectasis

# Bronchiectasis

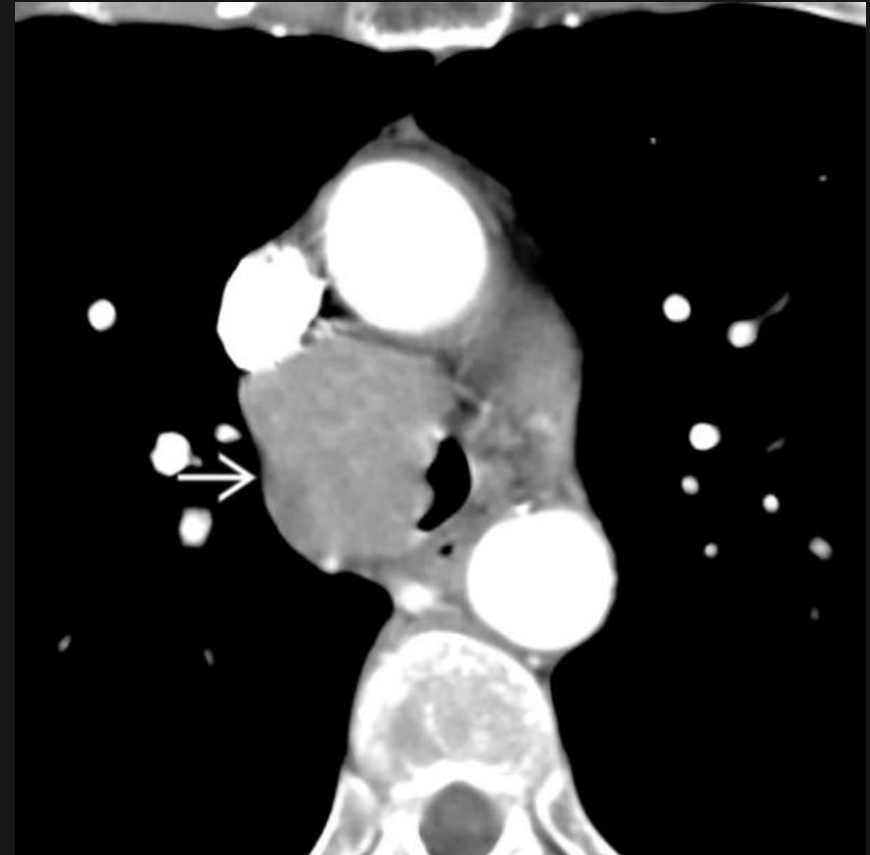
**Focal** bronchiectasis often post-infectious or from airway obstruction

When diffuse...

- **Upper lobe predominance**
  - Cystic fibrosis: Central & peripheral
  - Allergic bronchopulmonary aspergillosis (ABPA): Often bilateral, asymmetric, central
  - Tuberculosis: Often unilateral or asymmetric
- **Middle lobe & lingular predominance**
  - Nontuberculous mycobacterial infection
- **Lower lobe predominance**
  - Chronic aspiration
  - Viral infection
  - Primary ciliary dyskinesia
  - Immunodeficiency

# Narrowing

- Extrinsic/intrinsic mass
- Tracheo(broncho)malacia
- Post-intubation stenosis

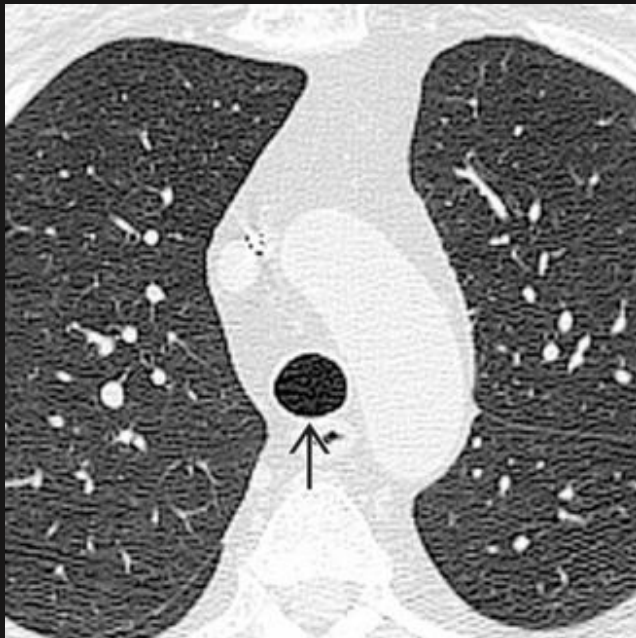




# Narrowing

- Internal/external mass
- Tracheo(broncho)malacia
- Post-intubation stenosis

- Increased compliance & excessive collapsibility of trachea or bronchi
- Weakening of cartilage and/or hypotonia of posterior membranous trachea with degeneration & atrophy of longitudinal elastic fibers
- Paired inspiratory-expiratory CT
- Malacia defined as **> 70% decrease in cross-sectional area** with expiration
- Most common finding during dynamic expiration: Tracheal collapse with crescentic bowing of posterior membranous trachea ("**frown**" sign)
- Coughing is most sensitive method for eliciting tracheal collapse

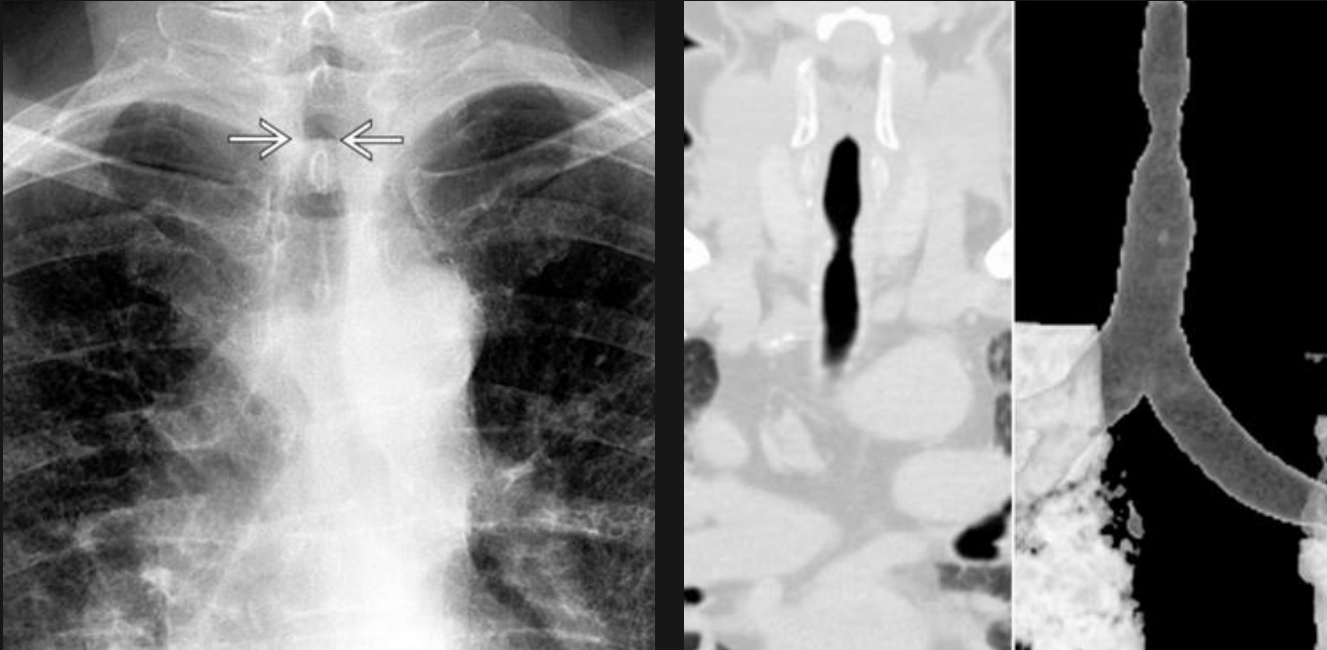




# Narrowing

- Internal/external mass
- Tracheo(broncho)malacia
- **Post-intubation stenosis**

- Post-intubation or tracheostomy
- Typically short segment, proximal, concentric
- Edema & granulation tissue cause acute stenosis
- Fibrosis & tracheal deformity in chronic stenosis



# Tracheobronchial Tree

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- Variants
- Benign neoplasms
- Malignant neoplasms
- Wall thickening
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- Narrowing

# Resources

- StatDx articles on the above topics
- Philips Intellispace Portal thin client software