Paediatric Chest Imaging

Adj Associate Professor Dr Marielle V. Fortier
Senior Consultant, Department of Diagnostic & Interventional Imaging
KK Women's & Children's Hospital, Singapore

Indications for Advanced Imaging

Lung parenchymal assessment
Cardiovascular assessment
Bronchopulmonary Foregut Malformation
Mediastinal masses
Pleural fluid/thickening/nodules
Ribs and chest wall

CT Protocol for Paediatric Thorax

PATIENT PREPARATION	
Non contrast scan:	no preparation needed
With IV Contrast:	3-4 hrs of fasting prior to the scan
Require sedation:	Minimal to moderate sedation -3 hours from last meal
Require deep sedation/GA:	2 hours for clear non-carbonated liquids; 4 hours for breast milk 6 hours for milk, solids and citrus juices
IV cannula	A minimum of 22G cannula or a 24 G Nexiva is needed

PATIENT POSITION	**SCAN PLAN**
• Feet in • Supine • Arms up • Scanogram : Vertical	• Start: Apices of lungs • End: Lung bases • Scan plane: Straight gantry

CT Protocol for Pediatric Thorax

IV CONTRAST:
Usually no IV contrast needed if assessing lung parenchyma or looking for pneumothorax

Contrast	Parameters
Contrast Type	Non-ionic contrast
Contrast Volume	1.5-2 ml per Kg of body weight for child (70-80% dilution of contrast can be done for infants-small children)
Saline Flush	N/A
Injection Rate	0.5-2.0 ml/sec for child
Comments	Scan delay 25-30 sec

Role of Ultrasound in assessing pleural fluid

Identification of parapneumonic pleural collections

-The most straightforward and most frequent use of US is to confirm the presence of a pleural fluid collection when this is suspected on clinical and radiological grounds.

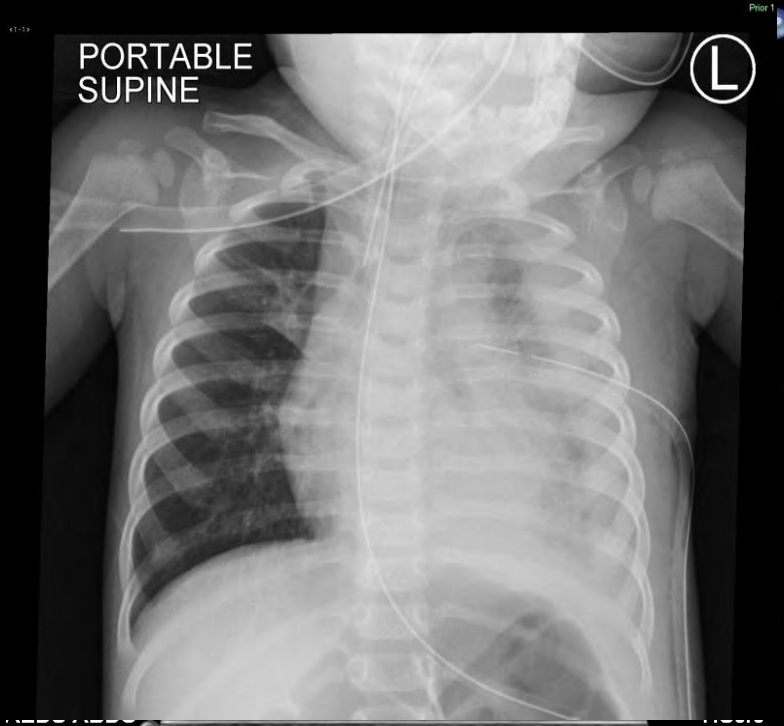
-U/S is able to detect even very small effusions and is readily capable of distinguishing between pleural fluid and underlying lung consolidation.

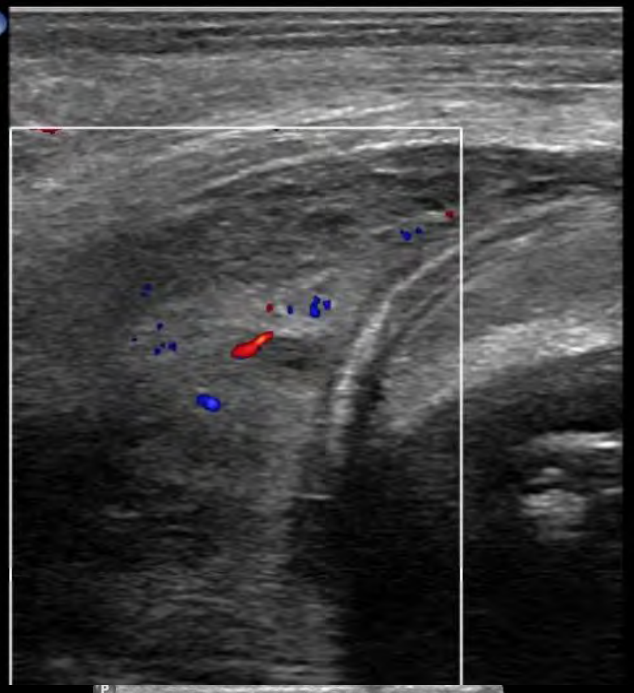
- <u>Identifying those pleural collections that require drainage</u>

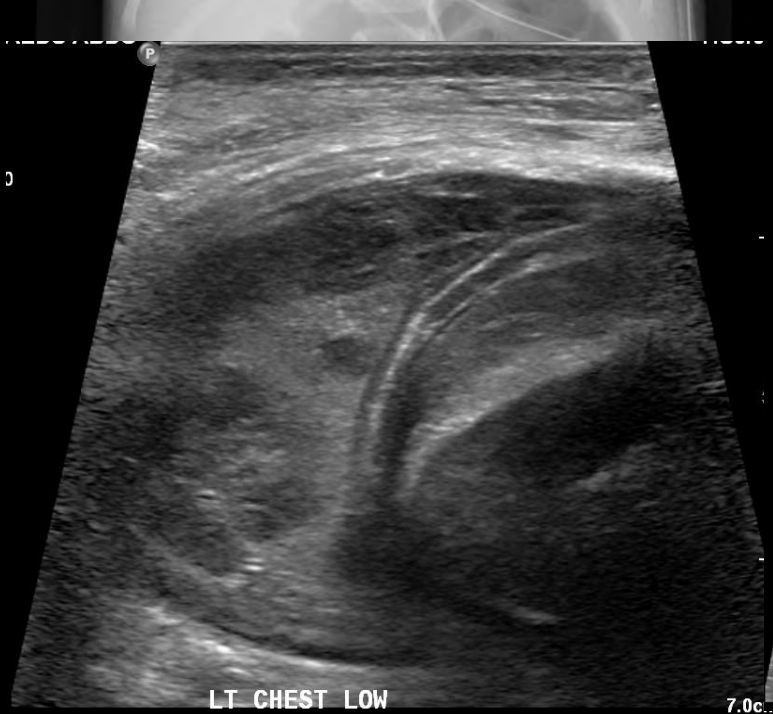
- "Does this collection need draining?".
- This decision may be based on two features

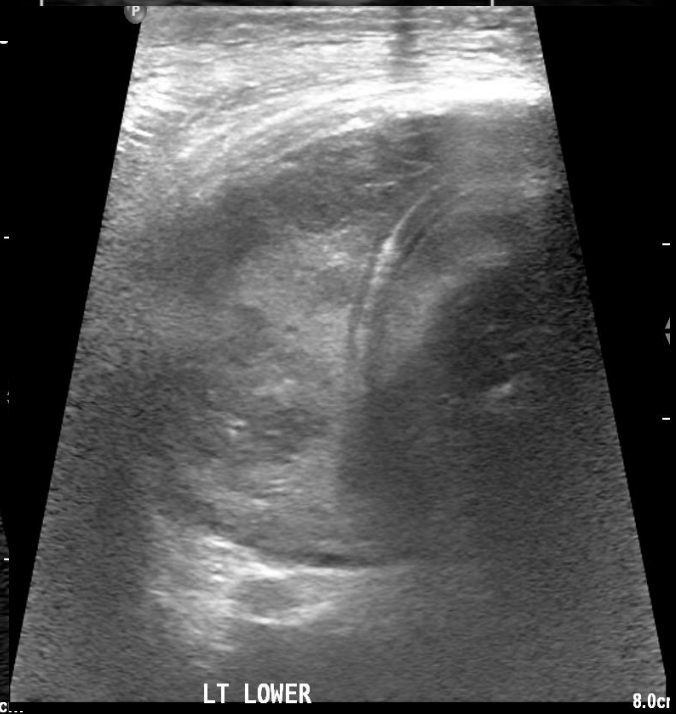
  -the size and the nature of an effusion.
- US is of some use in distinguishing between transudates and exudates

- BTS guidelines advise drainage of effusions that are enlarging or compromising respiratory fx: imaging features do not constitute an absolute indication for drainage


PORTABLE
SUPINE
L




LT CHEST LOW


LT LOWER

CT features

- Pleural enhancement and thickening - more readily appreciated in the parietal than the visceral pleura
- Thickening and increased density of the extrapleural subcostal fat
- Increased density of extrathoracic fat
- Loculation may be inferred in the presence of a lenticular/internally convex pleural collection

CT may not document pleural septations or fibrin stranding as the strands/ septations are too thin.

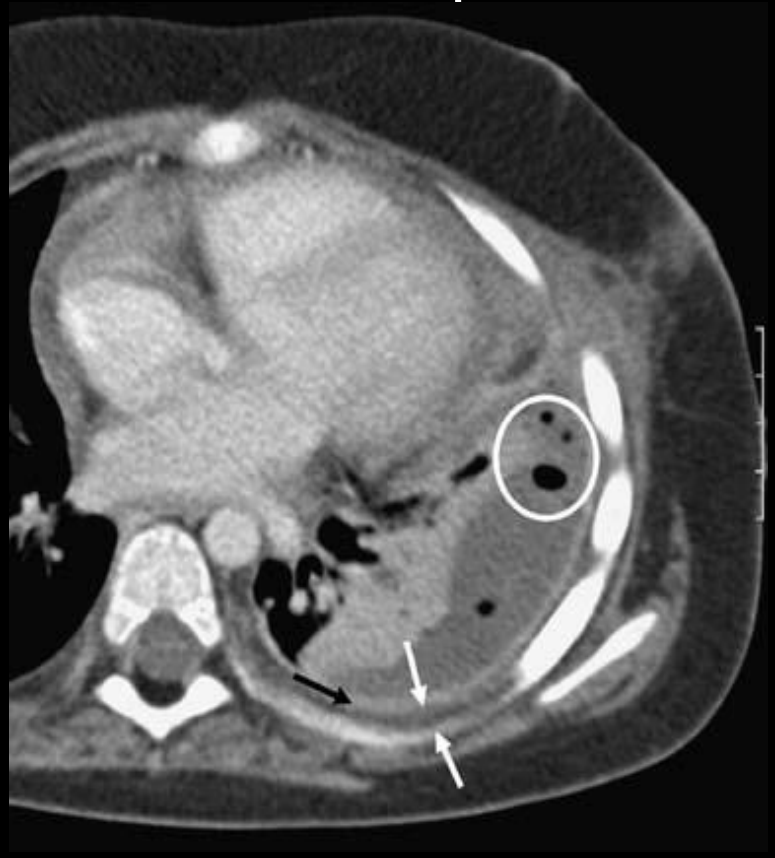


Fig. 7 CT features of complicated PPE. Contrast-enhanced axial CT image of the thorax in a child following failed drainage of a left-sided empyema. There is thickening and enhancement of the parietal pleura (black arrow), thickening and increased density of the subcostal fat (white arrows), and an internally convex pleural fluid collection containing bubbles of gas, indicating the presence of septations (circled)

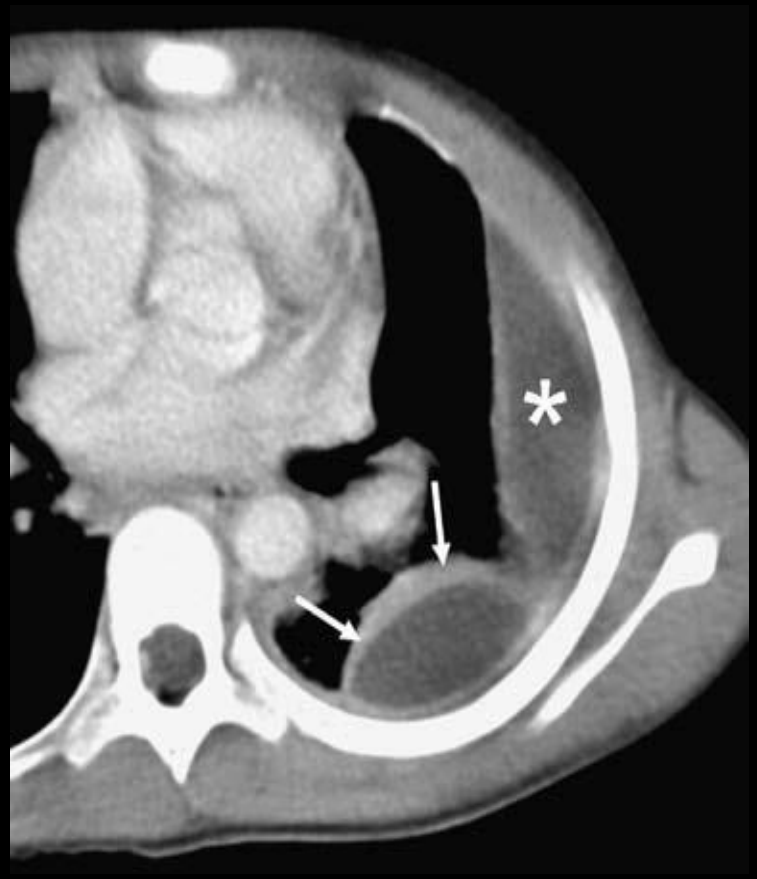
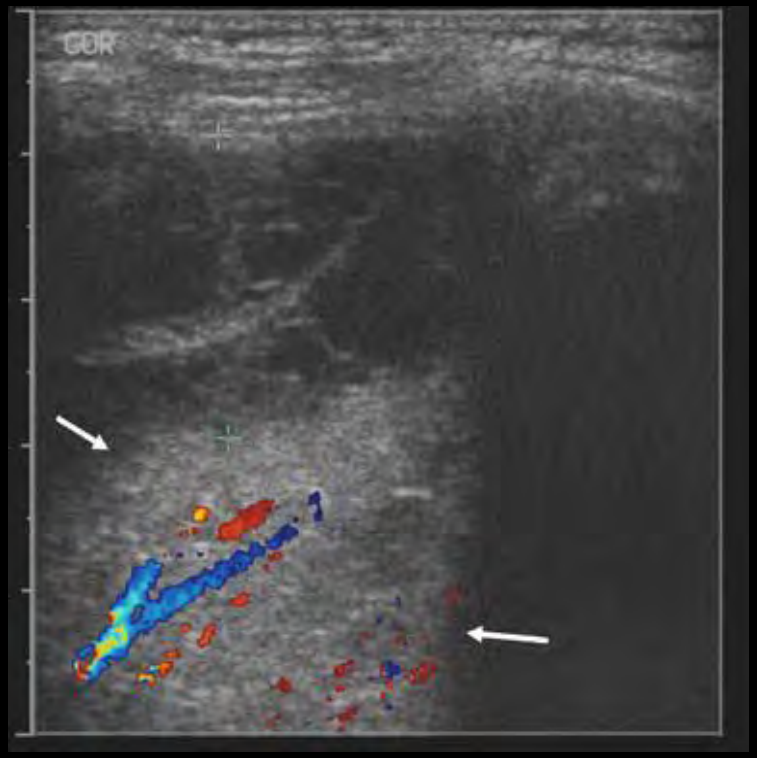
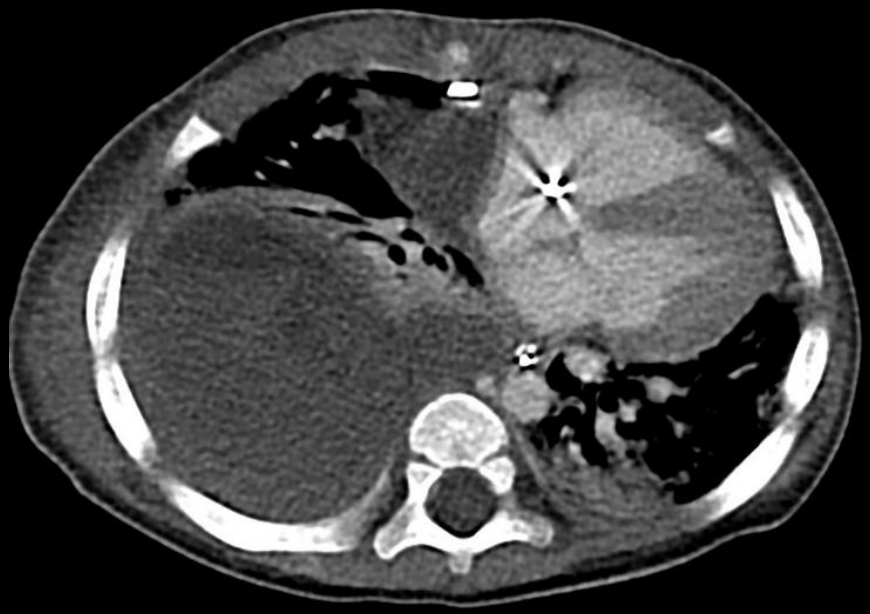


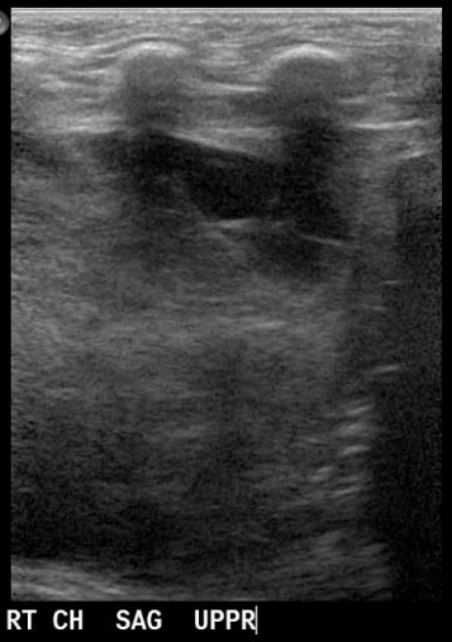
Fig. 8 Loculation on CT. Contrast-enhanced axial CT image of the thorax in a child with a left PPE prior to surgical drainage. There is an internally convex pleural fluid collection in the posterior paravertebral recess (arrows), with a second adjacent locule (asterisk), connected by a bridge of thickened pleura

A highly organized empyema may be solid appearing and difficult to distinguish from the underlying lung on grey-scale imaging.

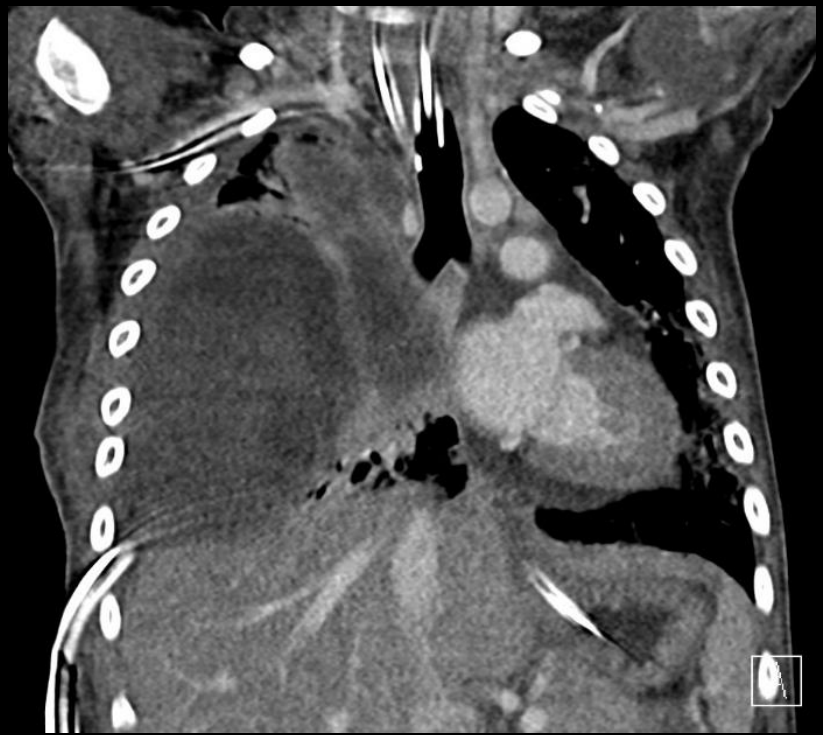
Colour Doppler is useful as the pleural collection will be avascular, clearly visible separately from the highly vascular consolidated lung .

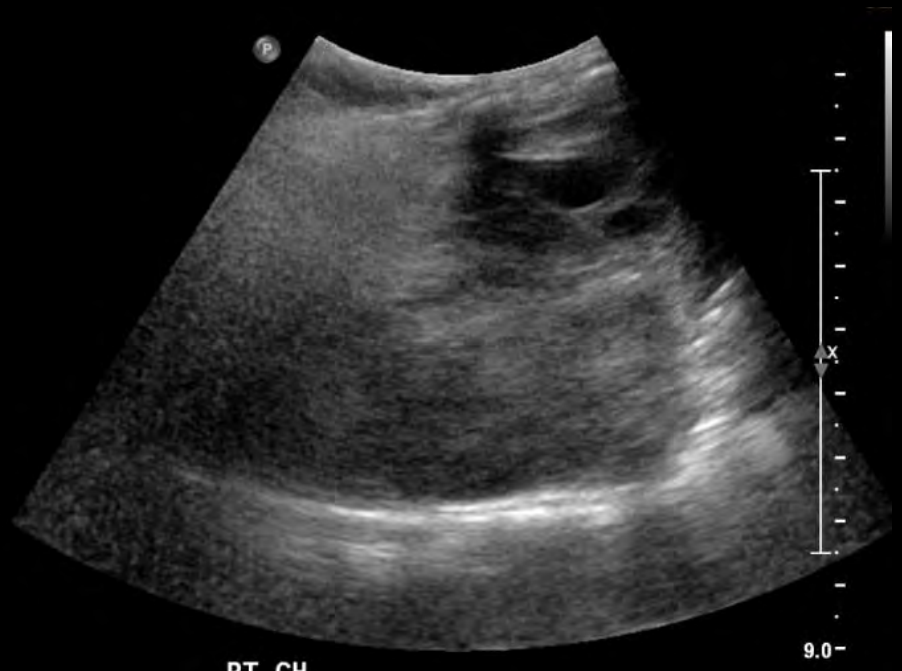


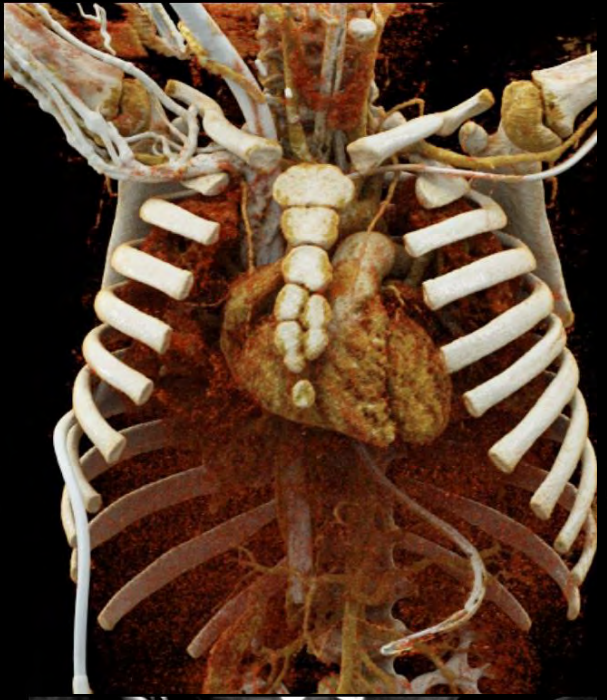




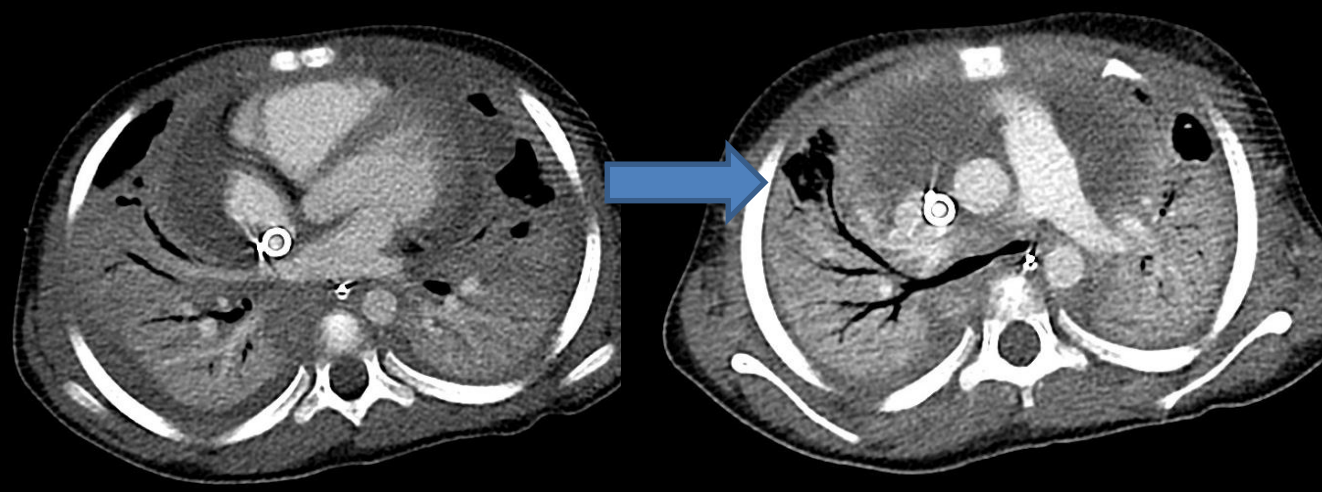
Haemothorax

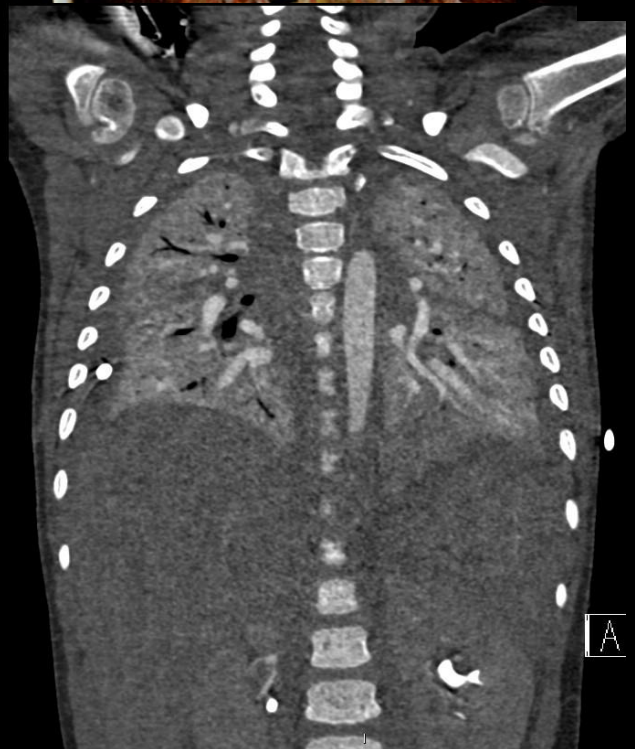


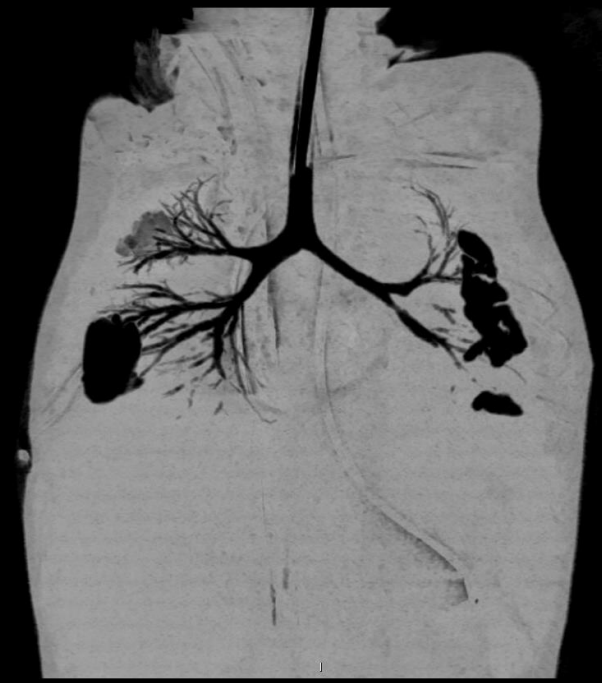




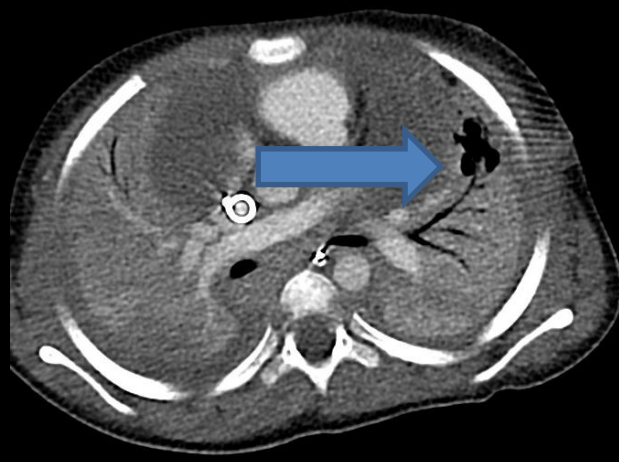
Child with necrotizing pneumonia on ECMO







Bilateral bronchopleural fistulae

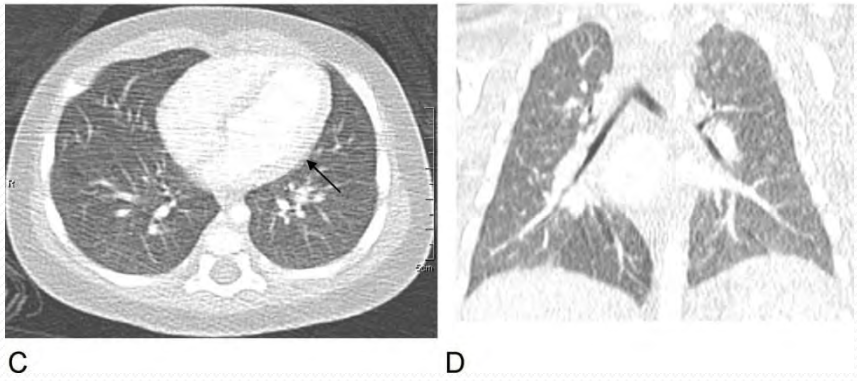


Indications for CT Chest Lungs and Airway

- Pneumonia & Empyema
- Bronchiectasis
- Interstitial Lung Disease

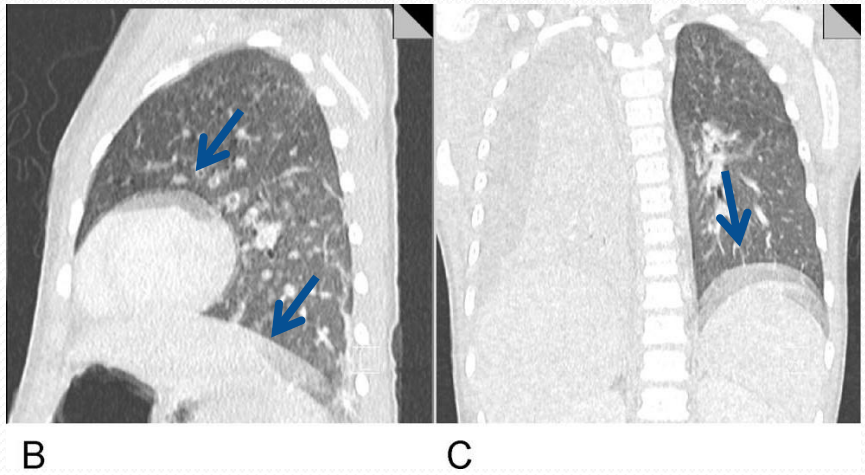
- Check radiographs and prior CTs
- Low dose technique
- Concentrates on pulmonary parenchyma
- ? Does not evaluate large airways or mediastinum
- ??Does not help if conventional CT is normal

Different types of CT scanners



C D

- Dual Source CT
- Acquistion time < 1 sec
- 4 mo
- No sedation
- No breathing artefacts

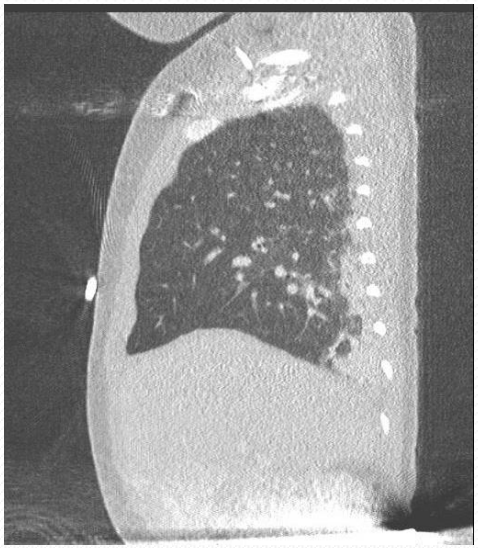


B C

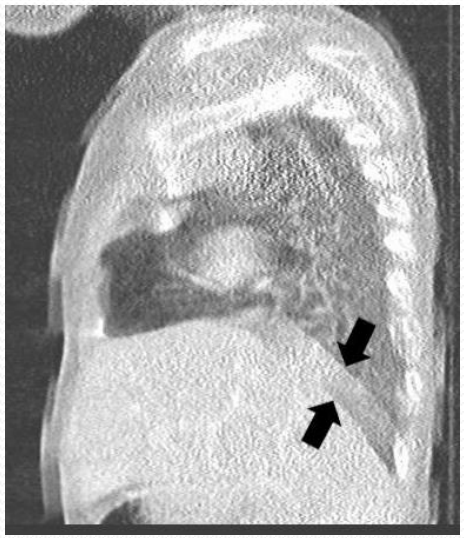
- Single Source CT
- Acquistion time > 2 sec
- 2 yo
- sedation
- breathing artefacts

High-Pitch Spiral Computed Tomography Effect on Image Quality and Radiation Dose in Pediatric Chest Computed Tomography. Lell et all. 2011

No longer any need for breath-holding



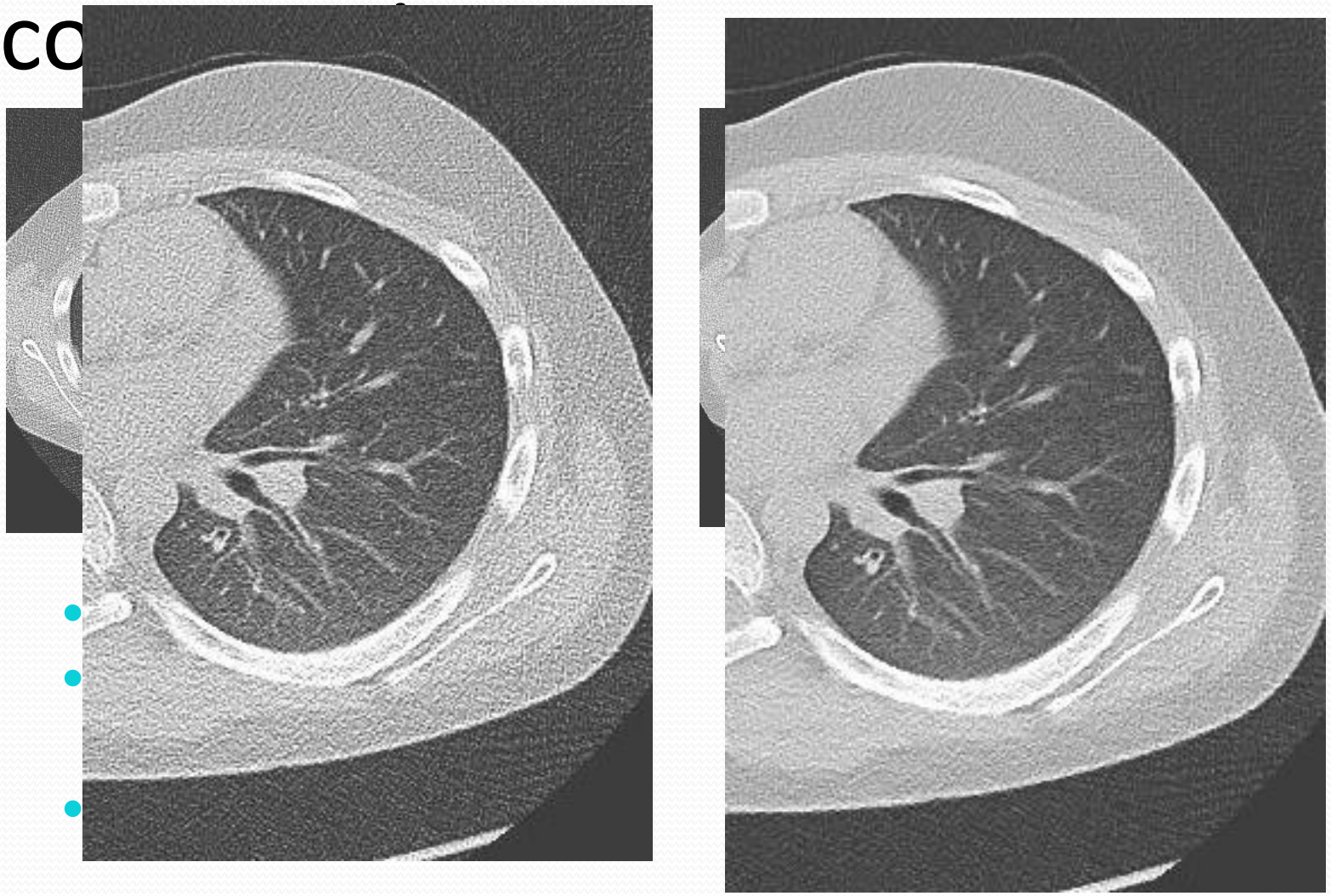
- Dual Source CT
- 2 mo
- Free Breathing
- No breathing artefacts



- Single Source CT
- 3 mo
- Free Breathing
- Breathing artefacts

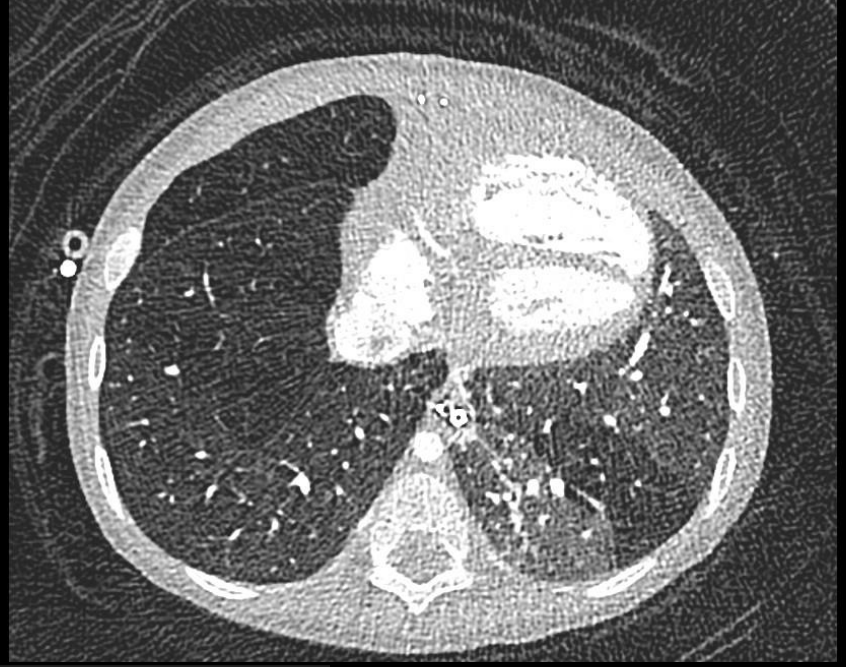
Free-breathing High-Pitch 80 kVp Dual-Source Computed Tomography of the Pediatric Chest: Image quality, Presence of Motion Artifacts and Radiation Dose. Bodelle et al. 2017

CT Chest: effect of Iterative reco

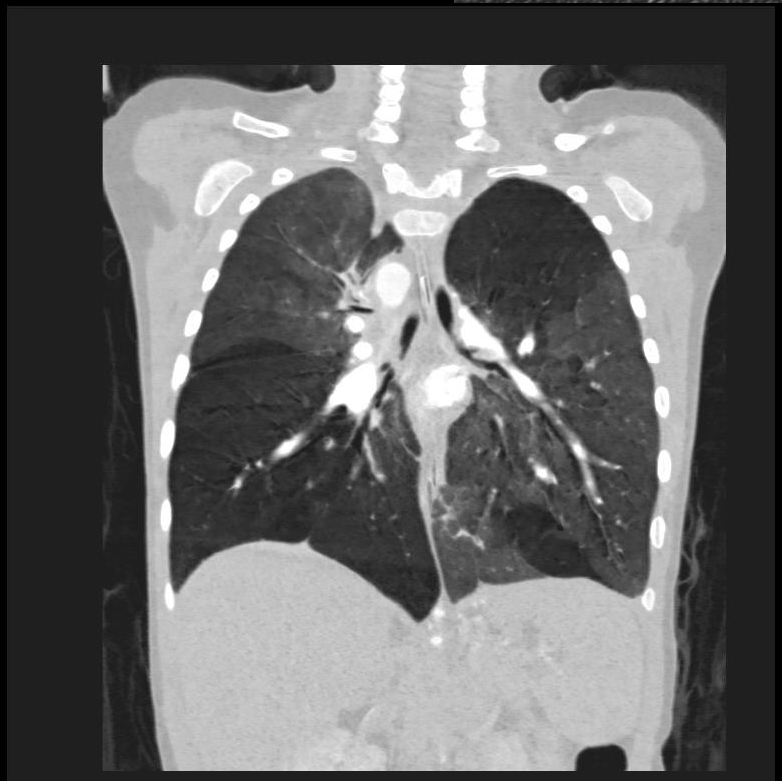


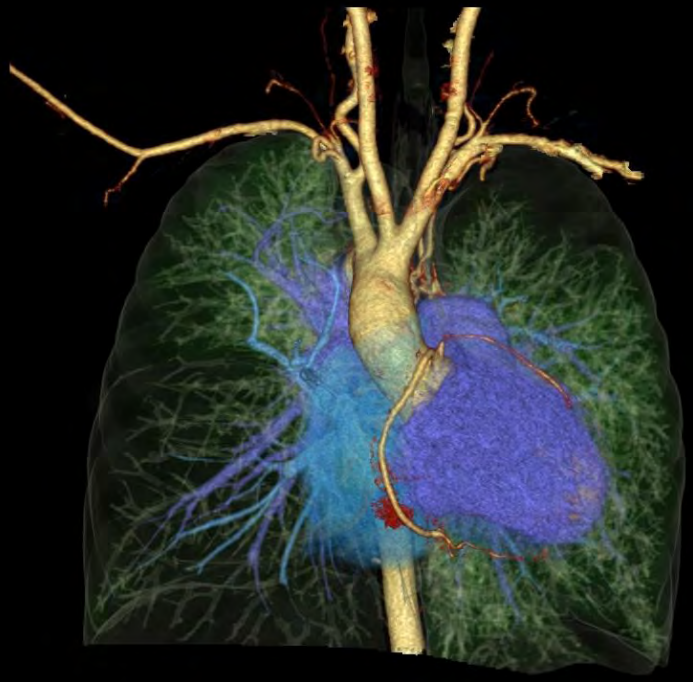
Single-energy pediatric chest computed tomography with spectral filtration at 100 kVp: effects on radiation parameters and image quality. Bodelle et al. 2017 Pediatr.Rad

1 year old TOF with absent pulmonary valve and bronchial stenosis/compression



70 kV
0.3 sec acquisition time
80% contrast
2.5 ml/sec
10 and 14 second delay





When to Perform CT for ILD

Patient is symptomatic but CXR is normal
To confirm an interstitial pattern seen on CXR
To determine the severity of disease
To look for bronchiectasis
To look for predisposing factors
To identify the main abnormality and refine differential diagnosis
To look for sequelae of infection
To determine best site for biopsy.

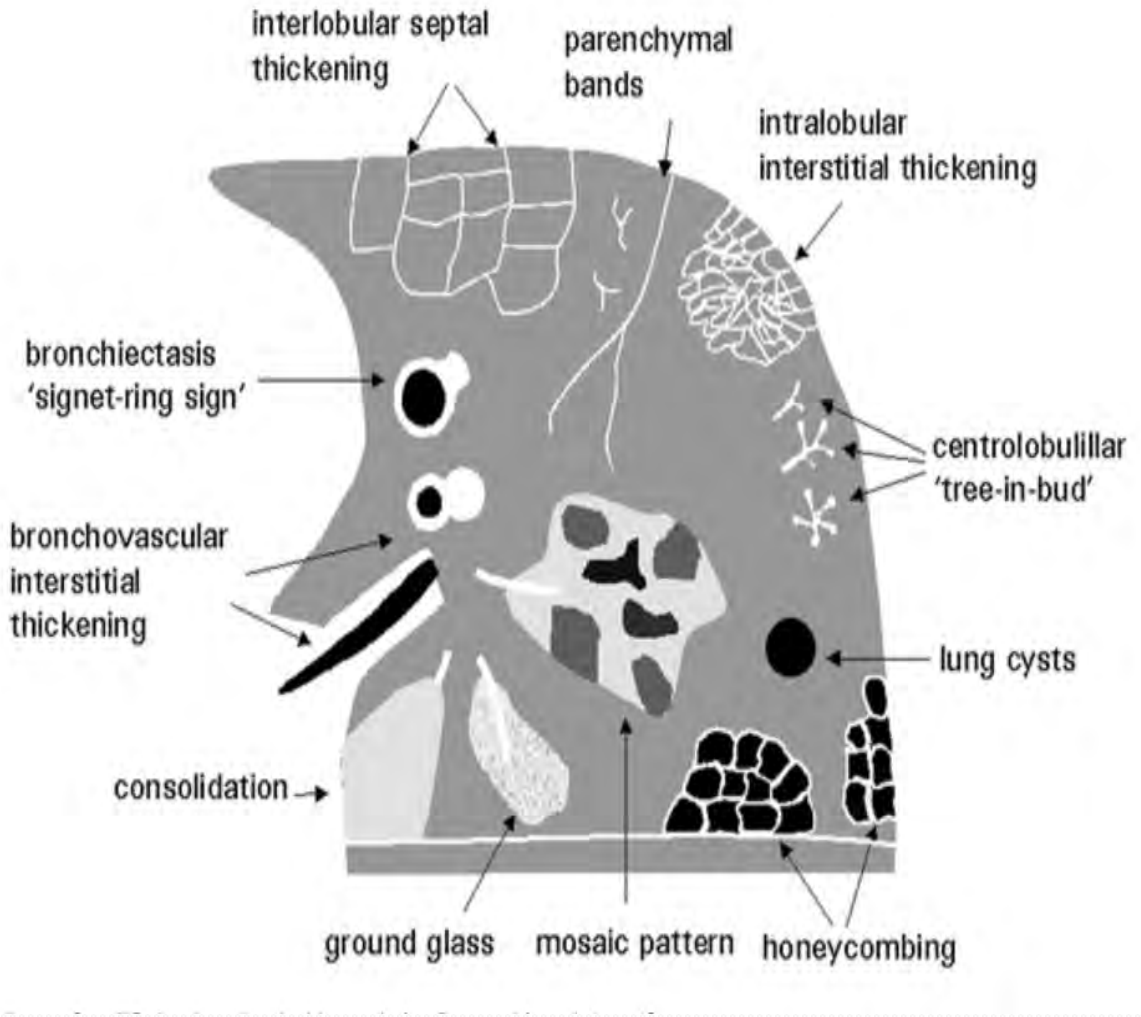
Approach to CT interpretation

- Look for :

a) Airway Disease: bronchiectasis, bronchial wall thickening and air trapping.

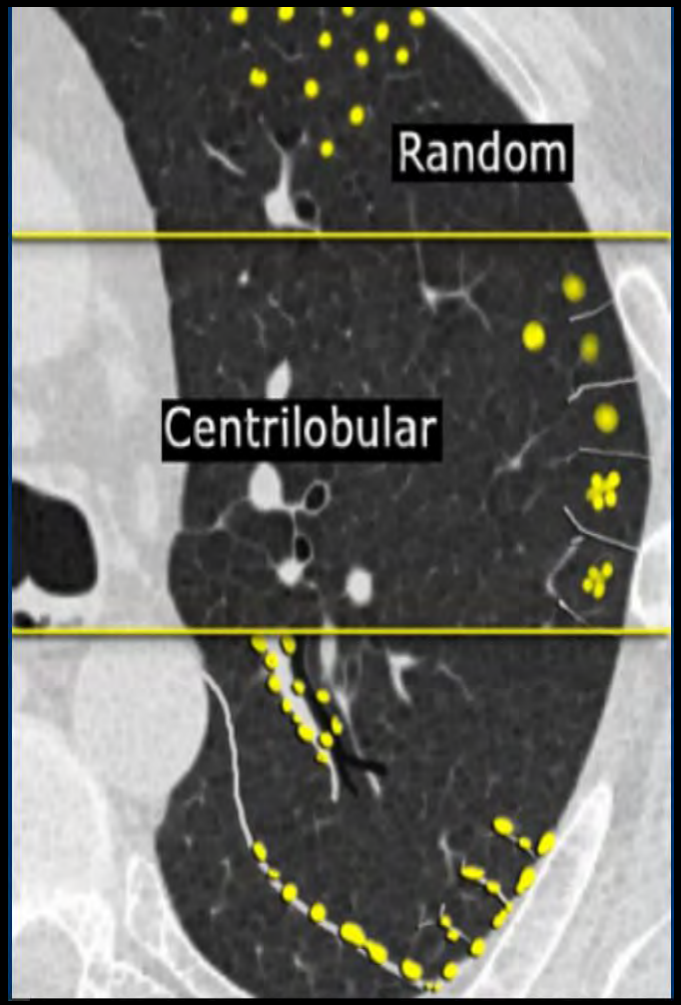
b) Airspace / Alveolar Disease : nodules, ground glass, mosaic pattern and consolidation.

c) Interstitial Disease: nodules, ground glass, mosaic pattern, septal thickening, parenchymal bands, air-filled cysts, honeycombing, and architectural distortion.



https://radiologykey.com/ct-of-the-lung-in-children-technique-indications-anatomy-and-features-of-lung-disease/

Centrilobular distribution
In certain diseases, nodules are limited to the centrilobular region.
Centrilobular nodules spare the pleural surfaces.
The most peripheral nodules are centered 5-10mm from fissures or the pleural surface.

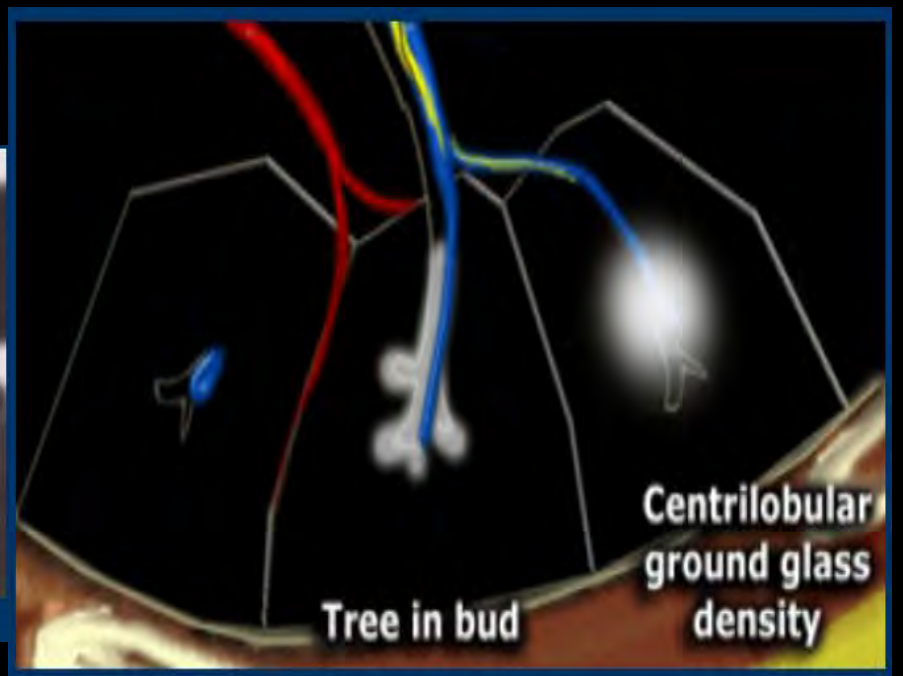


Random distribution
Nodules are randomly distributed relative to structures of the lung and secondary lobule.
Nodules can usually be seen to involve the pleural surfaces and fissures, but lack the subpleural predominance often seen in patients with a perilymphatic distribution.

Perilymphatic distribution
Nodules are seen in relation to pleural surfaces, interlobular septa and the peribronchovascular interstitium.
Nodules are almost always visible in a subpleural location, particularly in relation to the fissures.

Tree- in bud

Typical Tree-in-bud appearance in a patient with active TB.



A special type of nodule is the centrilobular opacity (CLO). These are about 5 mm in size and are seen within the secondary lobule as nodules, branching 'Y' structures or 'trees in bud' (Fig. 2b). They represent material within the central bronchiole of the secondary lobule

Tree in bud

Infection *Tuberculosis*
MAC (mycobacterium avium)
bacterial, fungal

Airway disease (i.e. cystic fibrosis or bronchiectasis)
ABPA (Allergic bronchopulmonary aspergilosis (rare)

Bronchiectasis

- Can either be a diagnosis or a feature of another disease.
- It indicates irreversible dilation of a bronchus
- The signature feature is the ‘signet ring sign’
- This represents a thick walled bronchus, which is larger than the adjacent pulmonary artery.
- Other indicators

-non-tapering of a bronchus

-bronchial wall thickening - visualisation of a bronchus within 1 cm of the periphery (including the fissures).

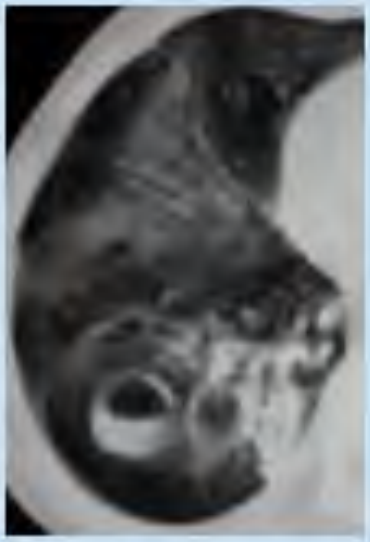


Fig. 12a. Bronchiectasis.

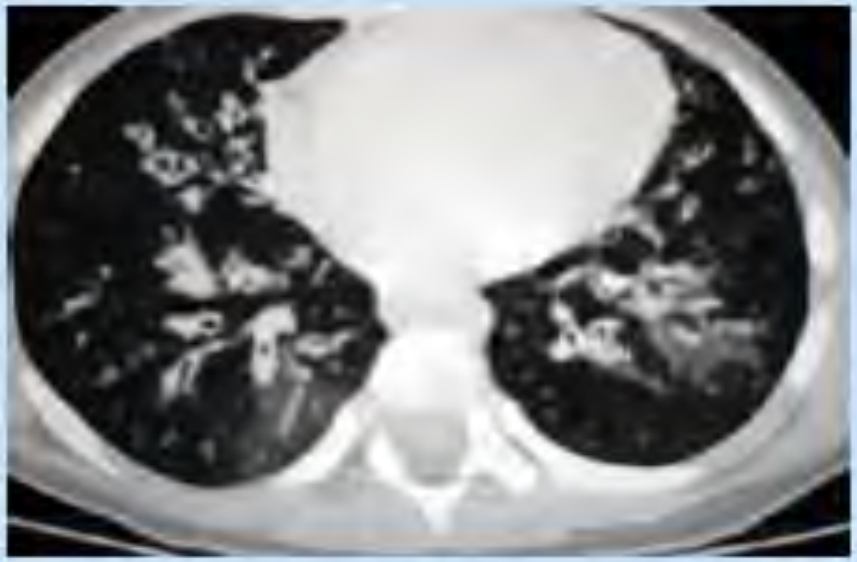
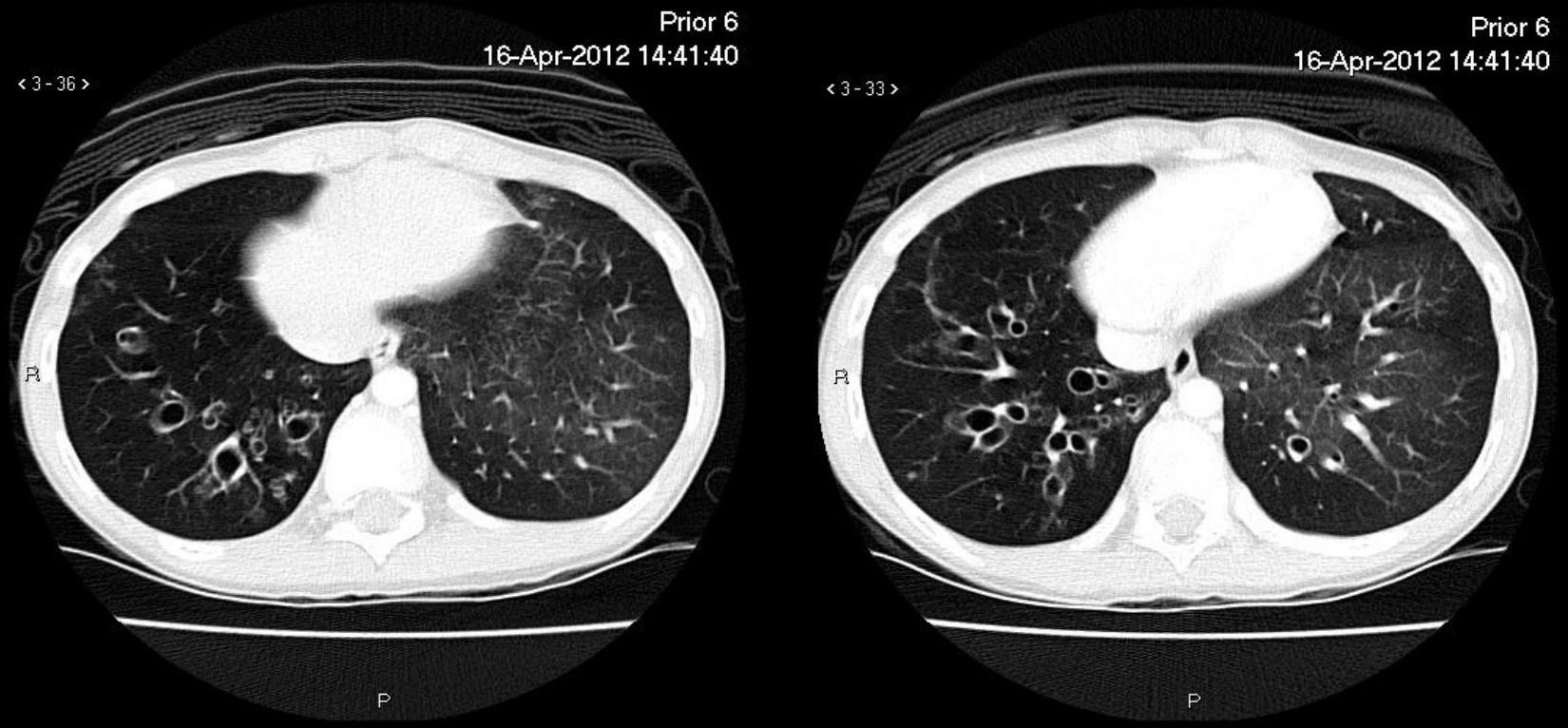


Fig. 12b. Bronchial wall thickening and ‘signet ring sign’.

Radiol med (2016) 121:352–361



- Associated with bronchiectasis are
  - atelectasis, mosaic pattern and CLOs.
- Air fluid levels may also be present within dilated bronchi.
- The causes of bronchiectasis are many but are most commonly associated with previous, current or recurrent infection, cystic fibrosis and aspiration.

Langerhans Cell Histiocytosis

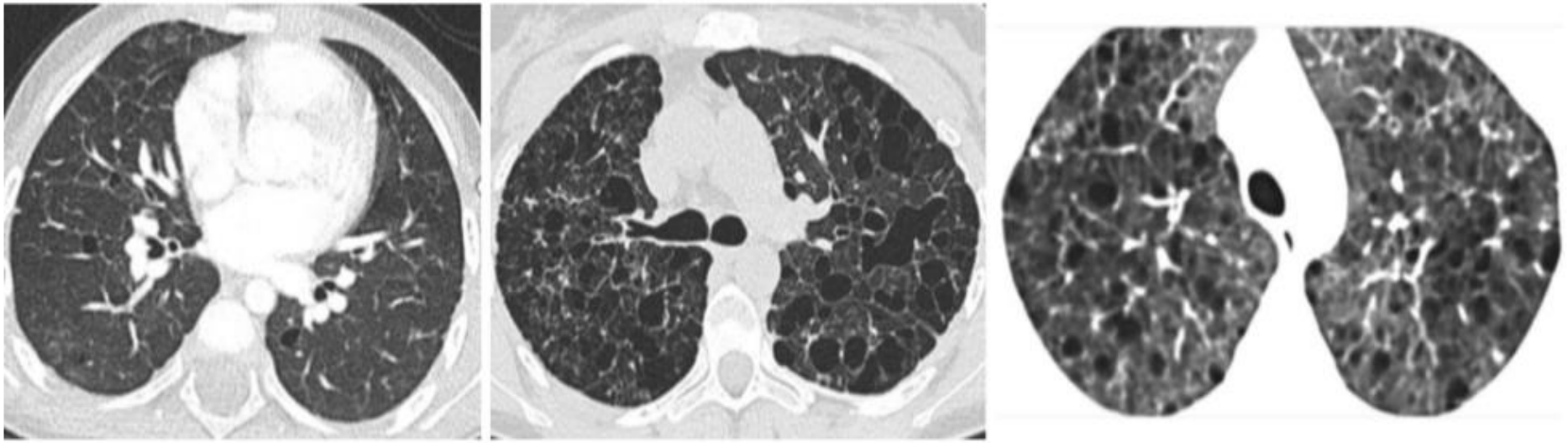


Fig. 6 Three patients with differing degrees of pulmonary involvement in pulmonary Langerhan's cell histiocytosis. CT demonstrates multiple thin walled irregular cystic air spaces

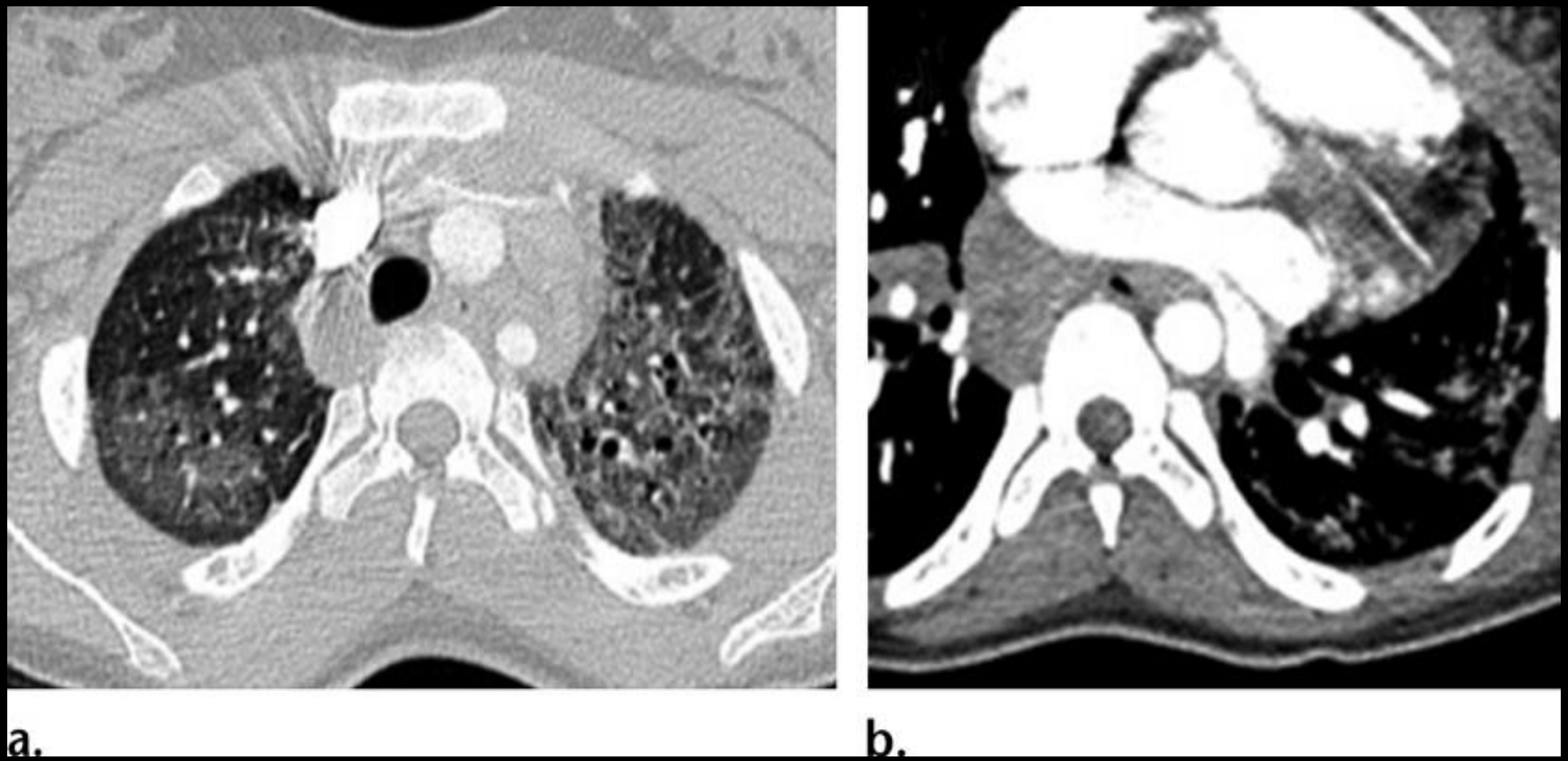
Radiol med (2016) 121:352–361

- Sarcoidosis

  -2 distinct types in childhood

  - majority 13-15 yrs of age with a multi-system disease

  -Lymphadenopathy and Lung disease



Semple et al RadioGraphics 2017; 37:1679–1703

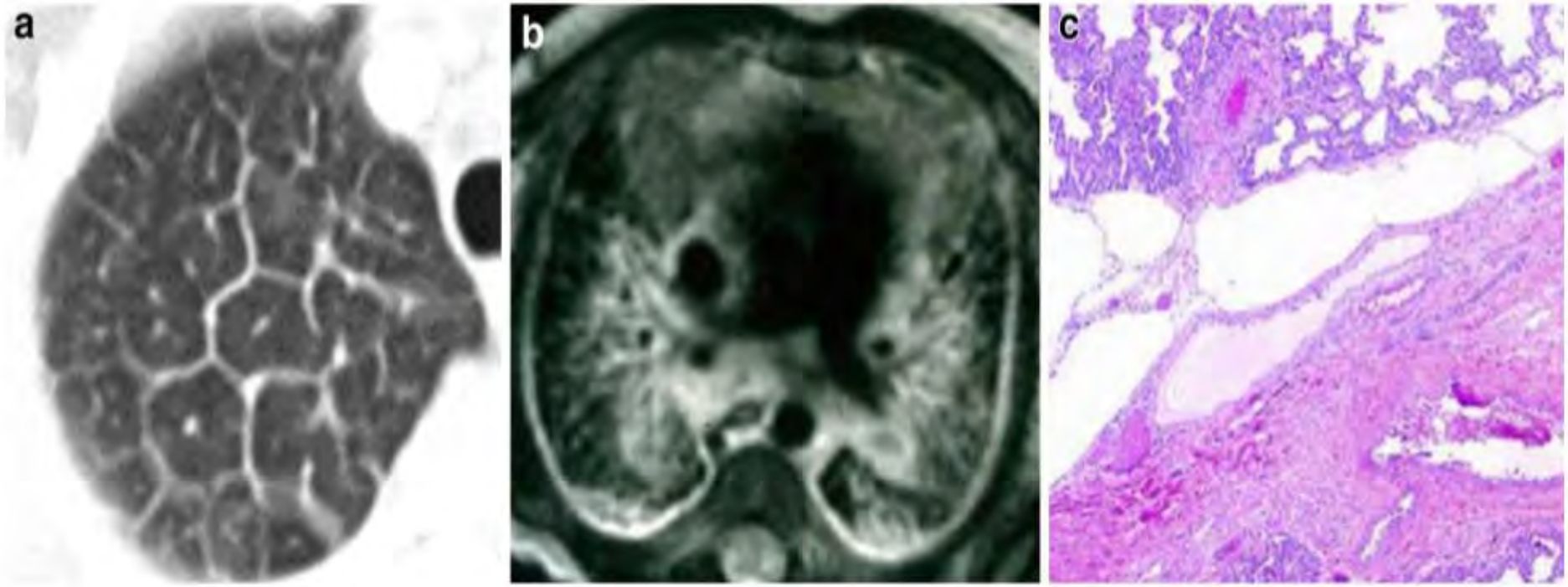
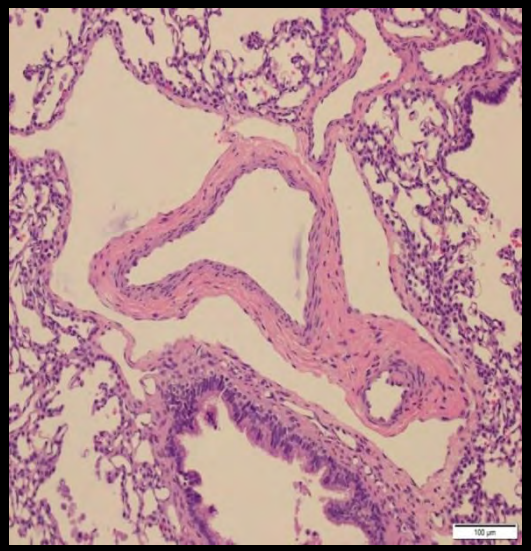
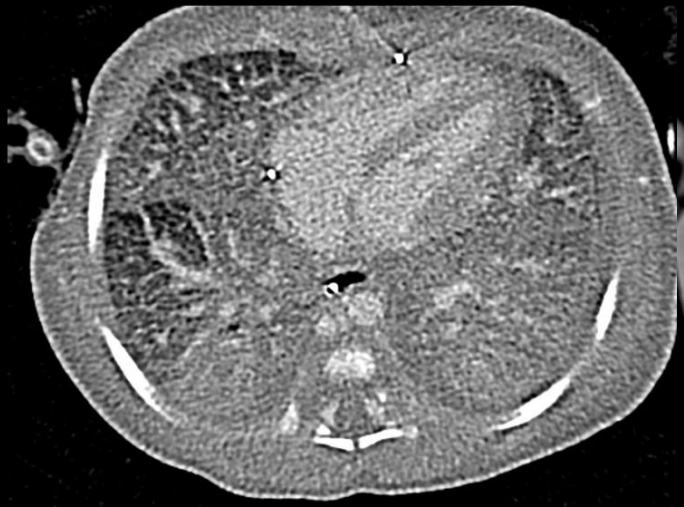
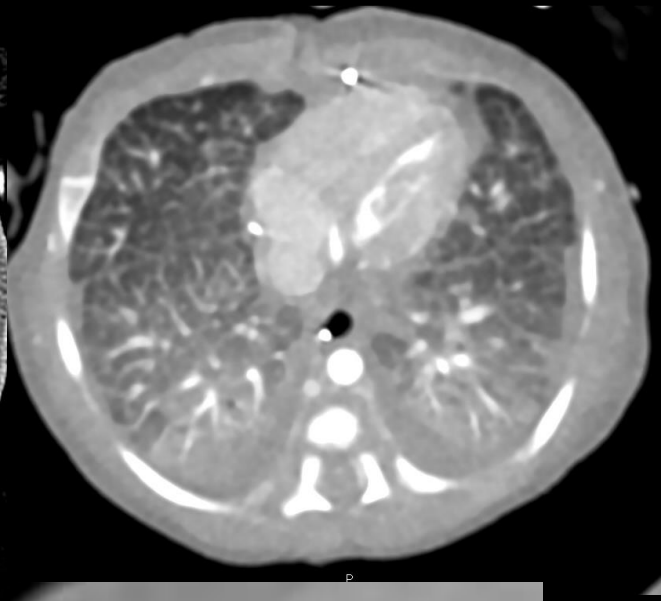


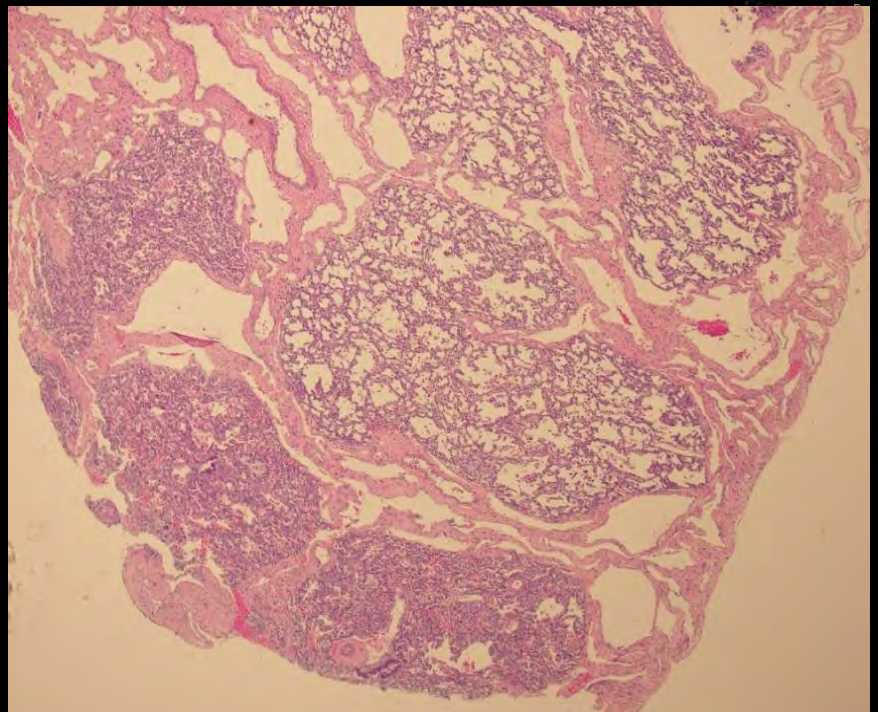
Fig. 4 Pulmonary lymphangiectasia. CT demonstrates smooth interlobular septal *thickening* (a). b An MRI demonstrating bilateral pleural effusions and high T2 signal within the mediastinal fat. The histology demonstrates a dilated 'ectatic' lymphatic channel (c)

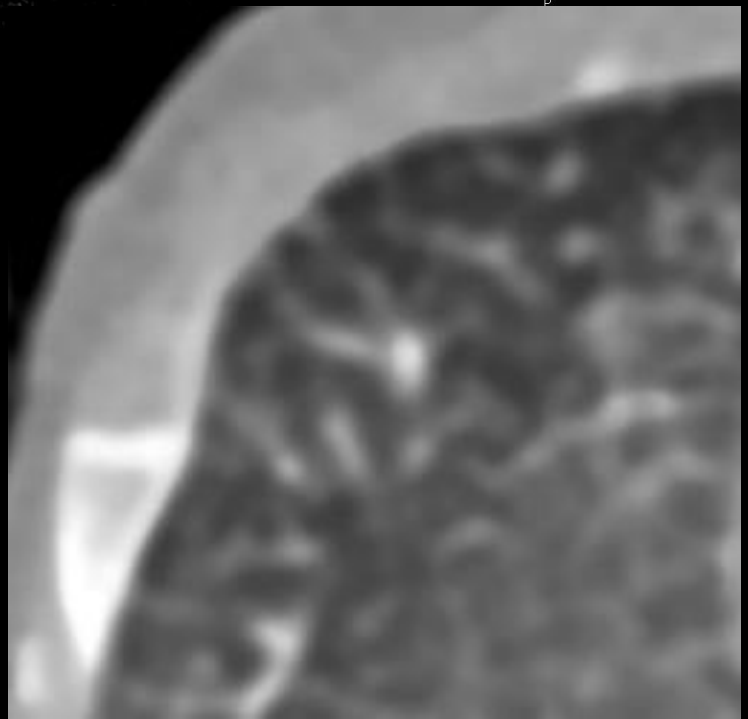
Pulmonary lymphangiectasia in setting of TAPVR











Bronchopulmonary Foregut Malformation

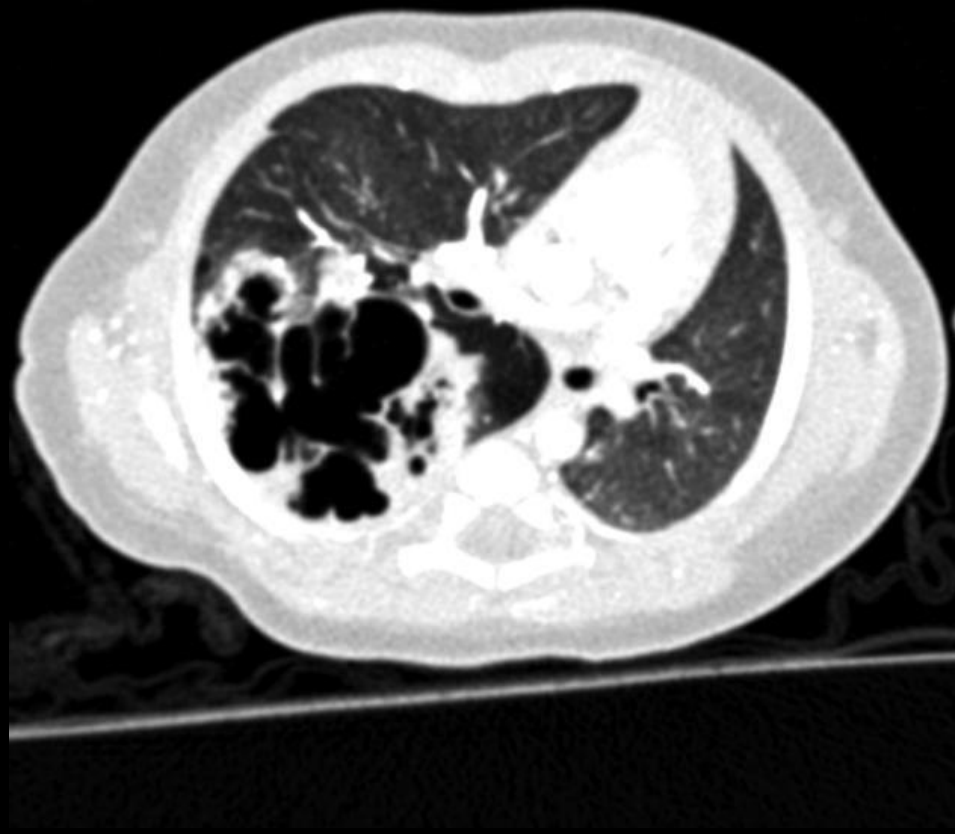
- -Congenital Pulmonary Airway Malformation
- -Pulmonary Sequestration
- -Hybrid “Lesion”
- -Foregut Duplication cysts:
- Bronchogenic
- Neurenteric
- Enteric

CPAM

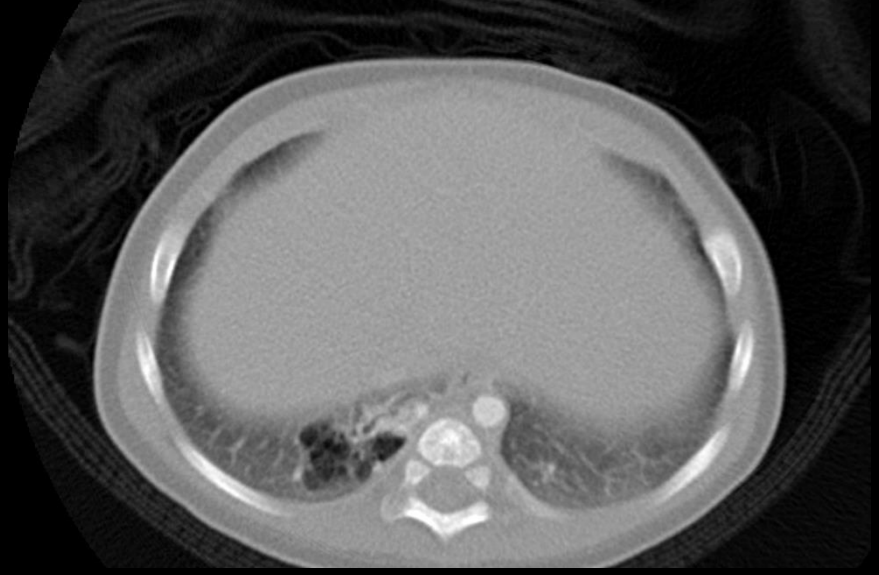
- Co**ngenital pulmonary airway malformation (CPAM)** is a multicystic mass of segmental lung tissue with abnormal bronchial proliferation .
- Until recently were described as a **congenital cystic adenomatoid malformation (CCAM)**.
- They account for ~25% of congenital lung lesions.

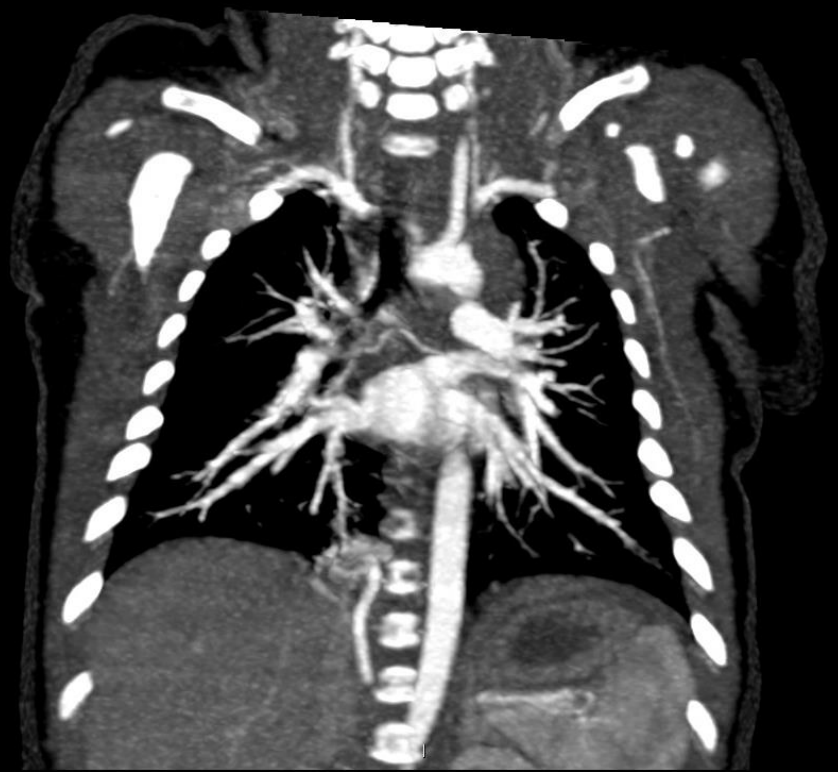
CPAM

- **Type I**
  - most common: 70%
  - large cysts
  - one or more dominant cysts: 2-10 cm in size
  - may be surrounded by smaller cysts

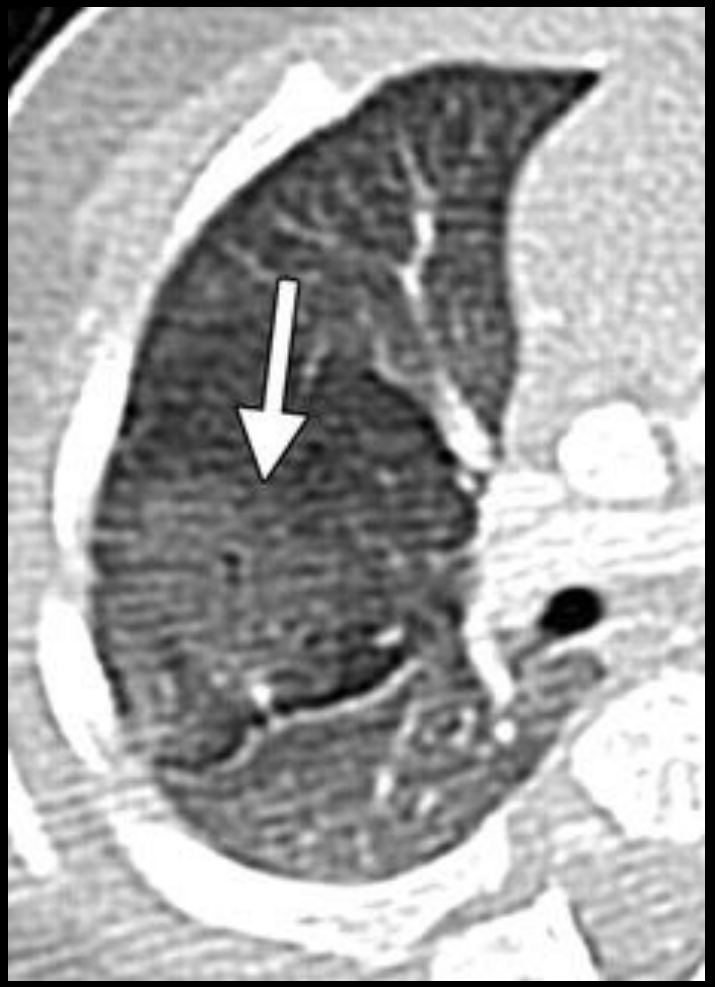


- **Type II**
  - 15-20% of cases
  - cysts are <2 cm in diameter
  - associated with other abnormalities
    - renal agenesis or dysgenesis
    - pulmonary sequestration
    - congenital cardiac anomalies





- **Type III**
  - ~10% of cases
  - microcysts: <5 mm in diameter
  - typically involves an entire lobe
  - has a poorer prognosis



- Type IV
- “Large” thin-walled cysts are present at the periphery of the lobe and appear to be lined by a smooth membrane.
- Microscopically, the cysts are lined by flattened epithelial cells (type I and II alveolar lining cells) over most of wall.
- The wall of the cyst is composed of loose mesenchymal tissue with prominent arteries and arterioles.
- NB-Loose mesenchyme must not be confused with similar features seen in the cystic type of PPB.

CPAM

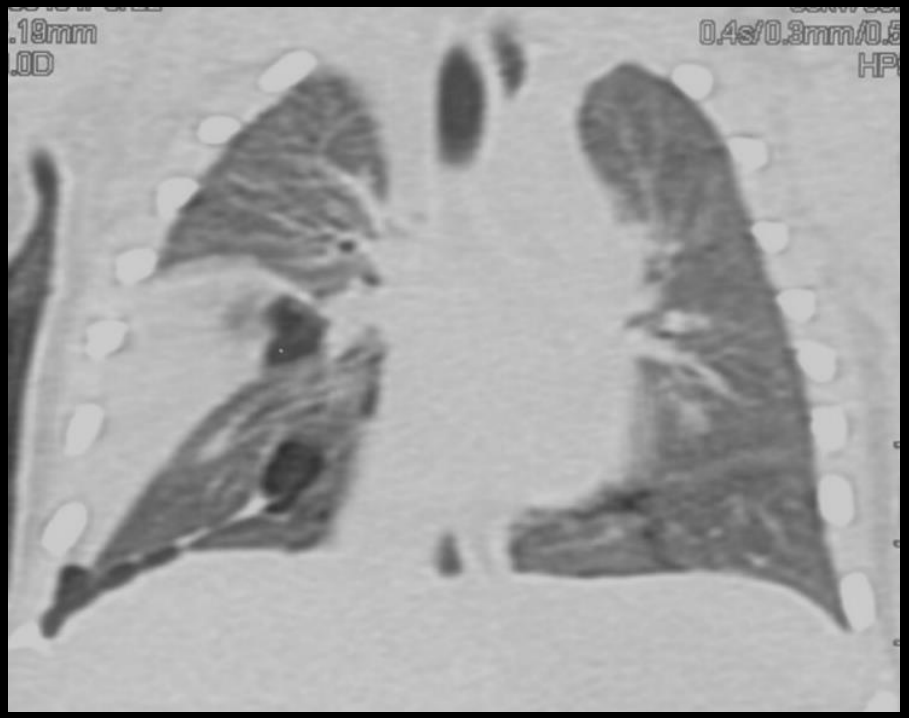
Potential postnatal complications include:

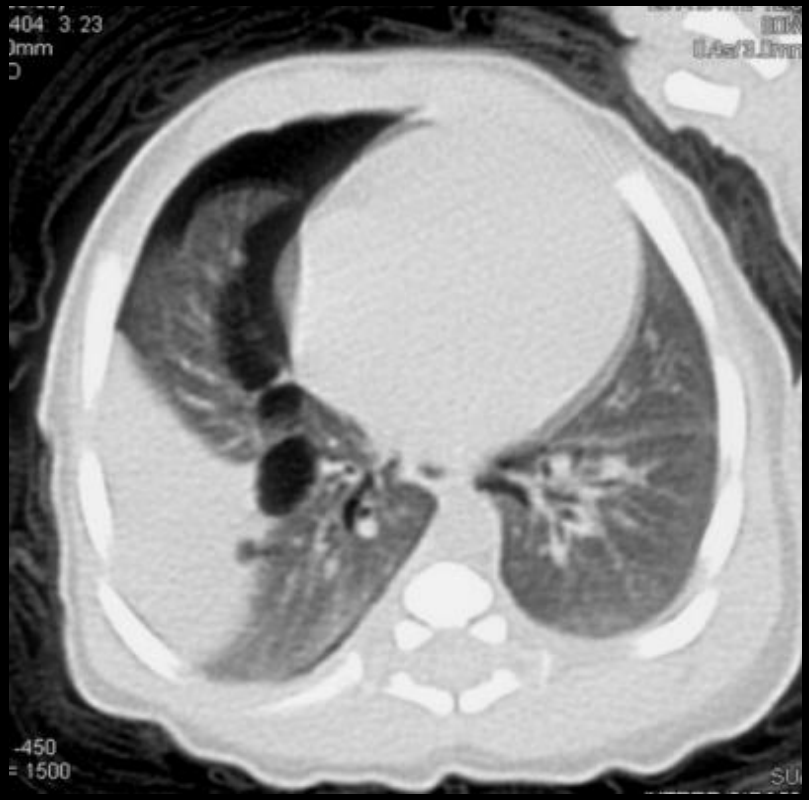
- recurrent pneumothorax
- haemopneumothorax
- pyopneumothorax

Possible incidence of certain malignancies:

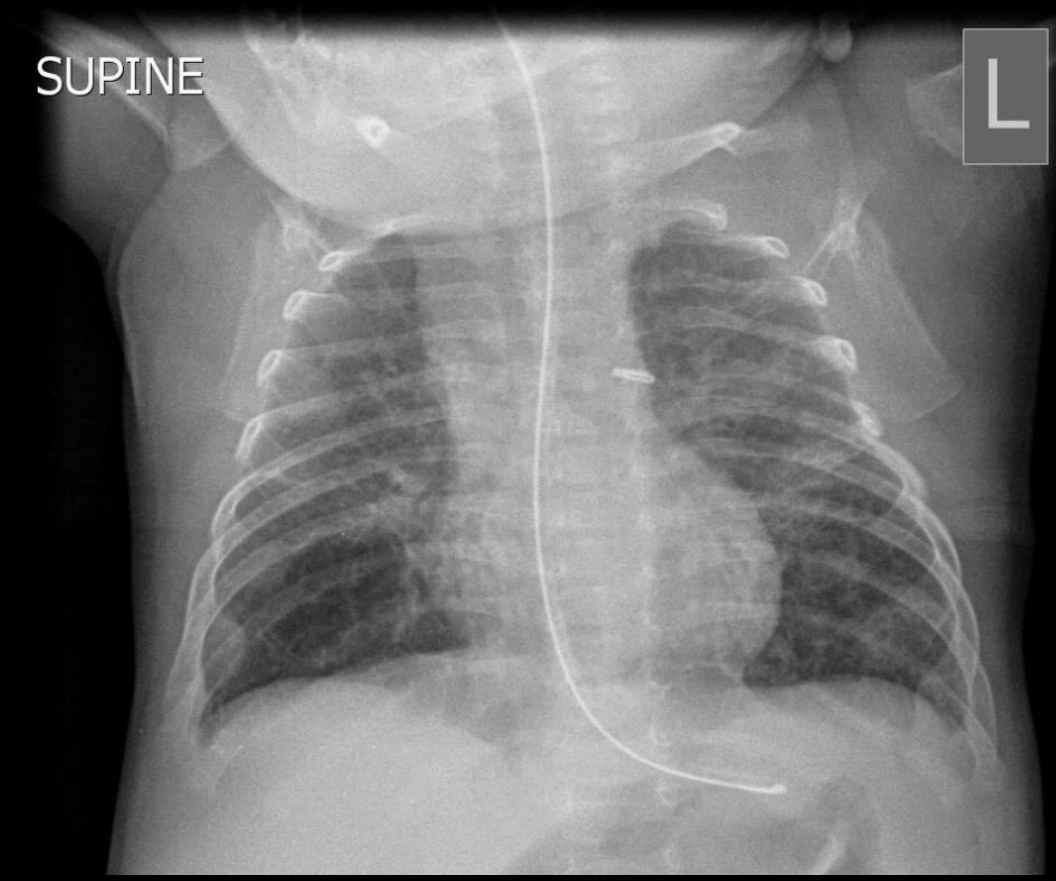
- bronchoalveolar carcinoma
- bronchogenic carcinoma
- pleuropulmonary blastoma
- rhabdomyosarcoma

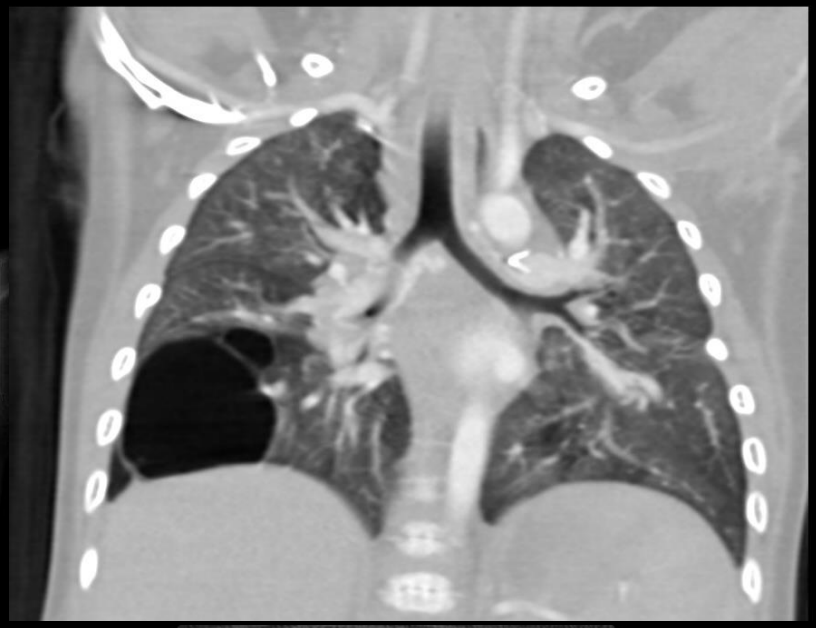
CPAM presenting with spontaneous pneumothorax

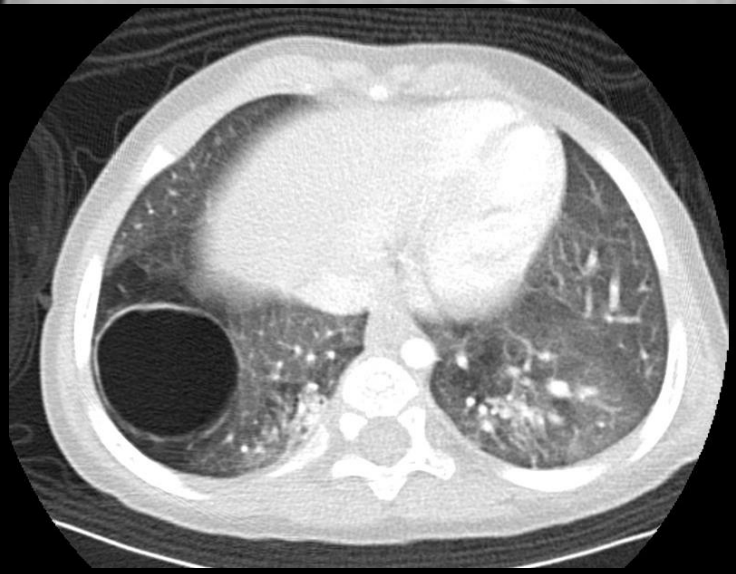




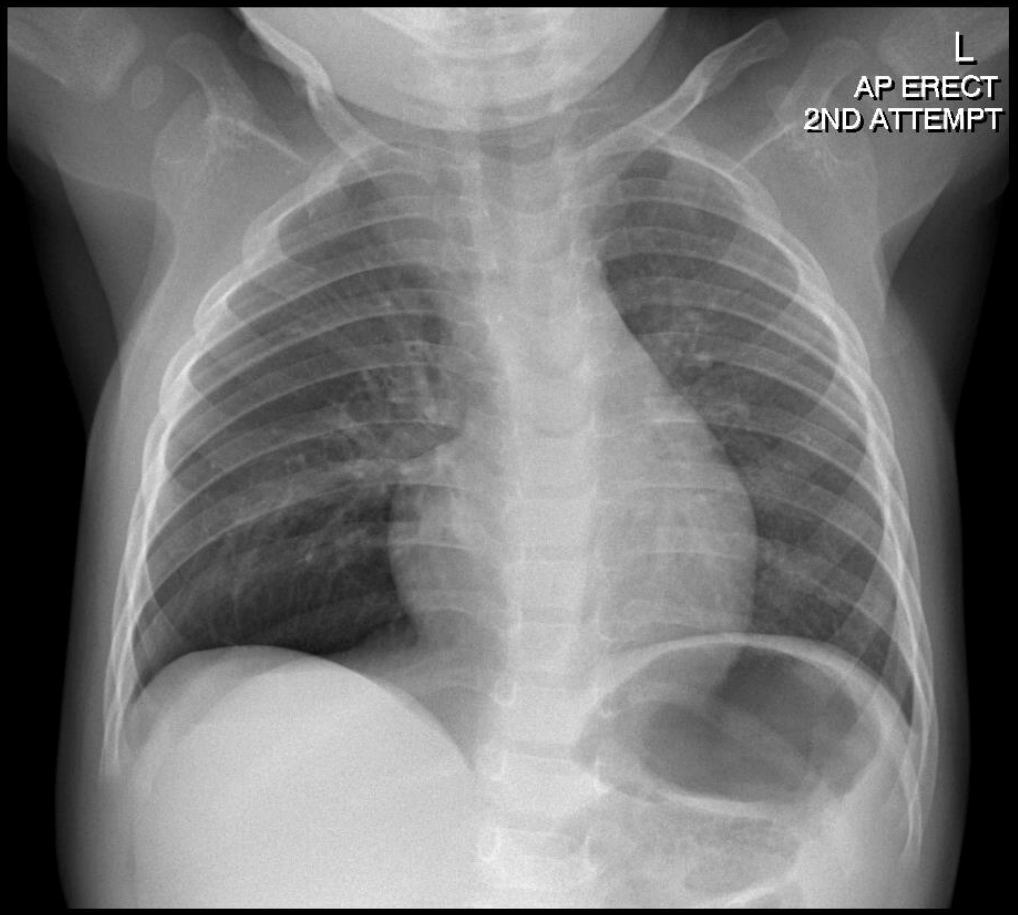
Ex prem 24 weeks with CLD and PDA ligation.
Had persistent lucency in right lower lung



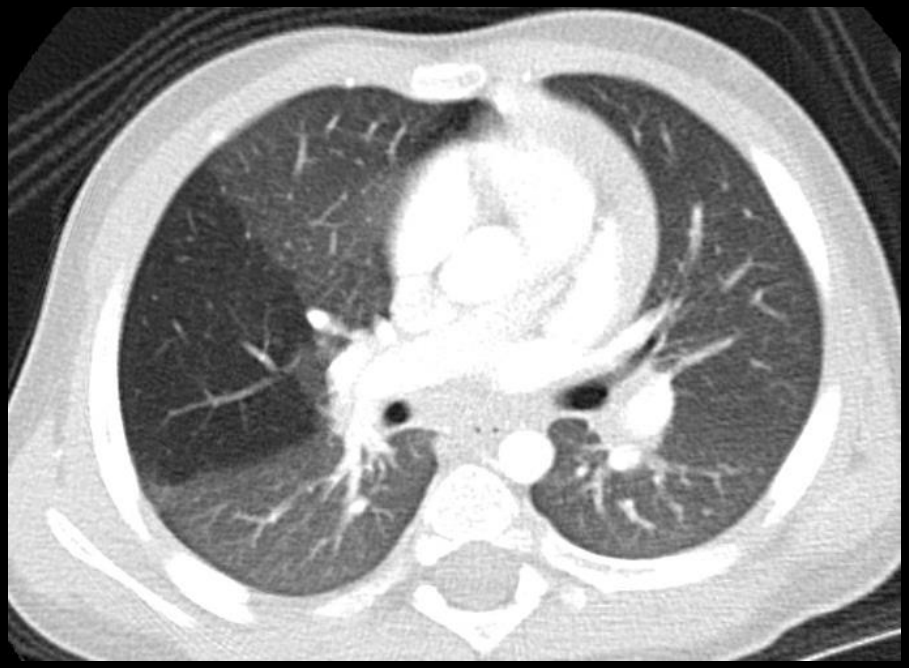


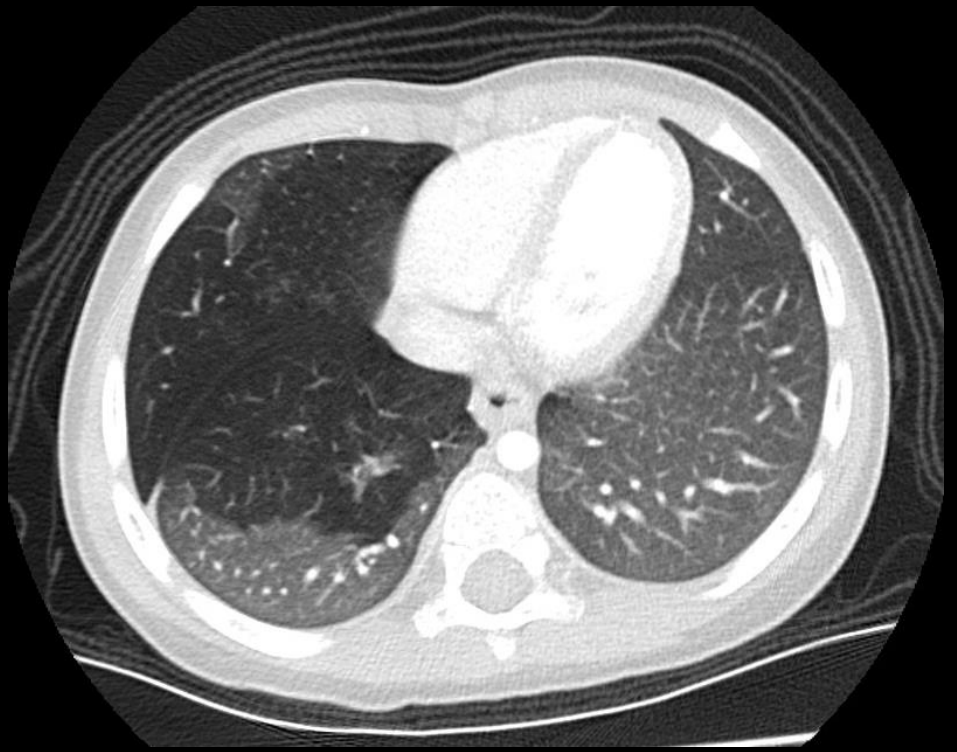


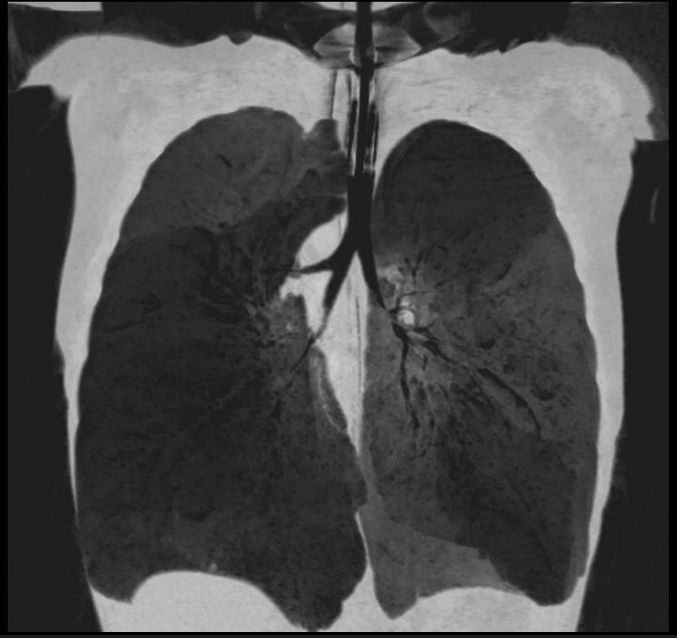
Term infant with prenatal diagnosis of CPAM - Mimic

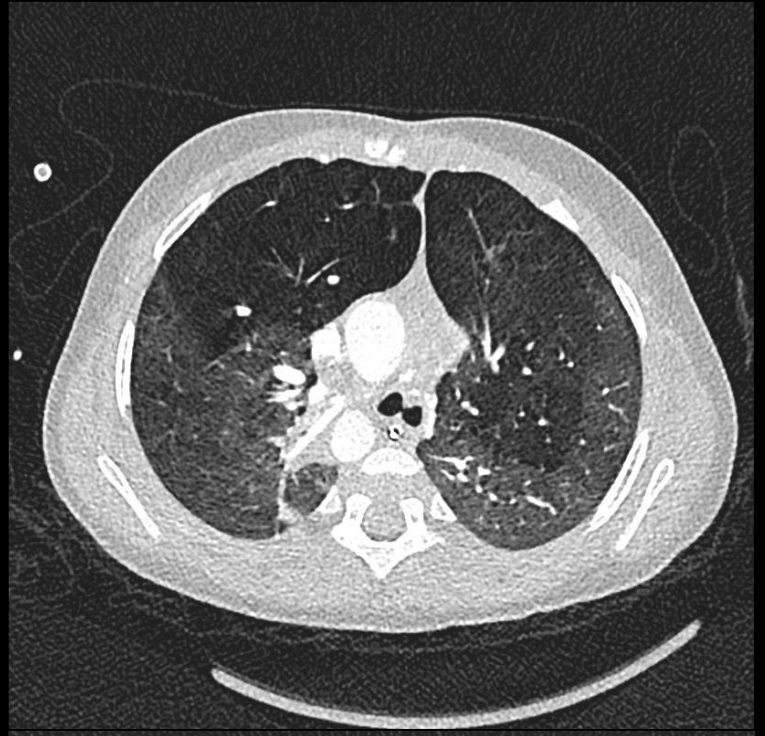


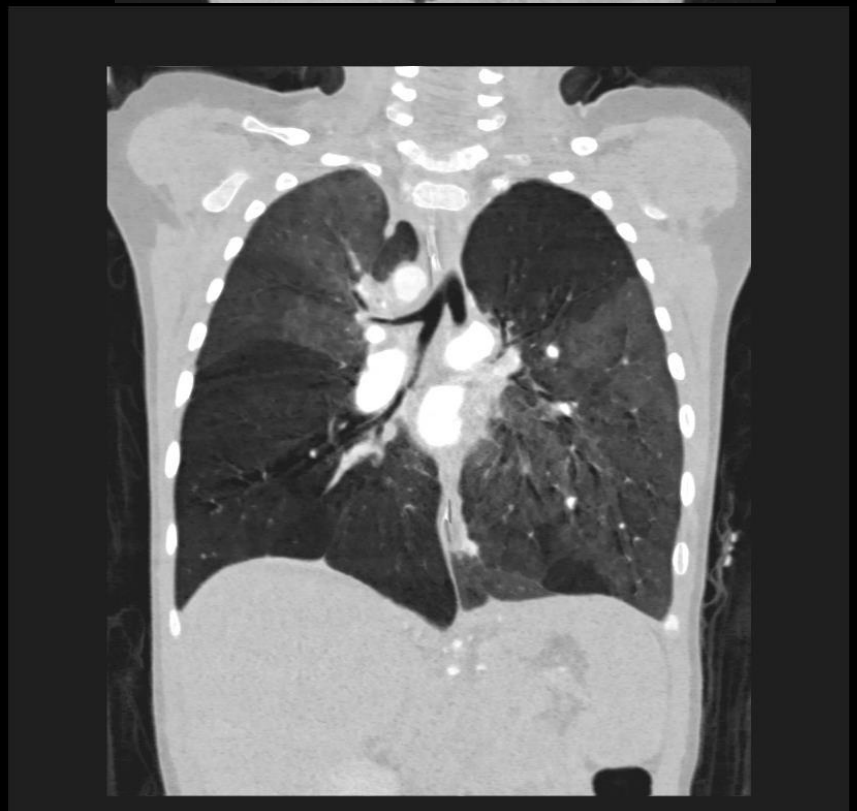
Congenital Lobar Overexpansion/Emphysema

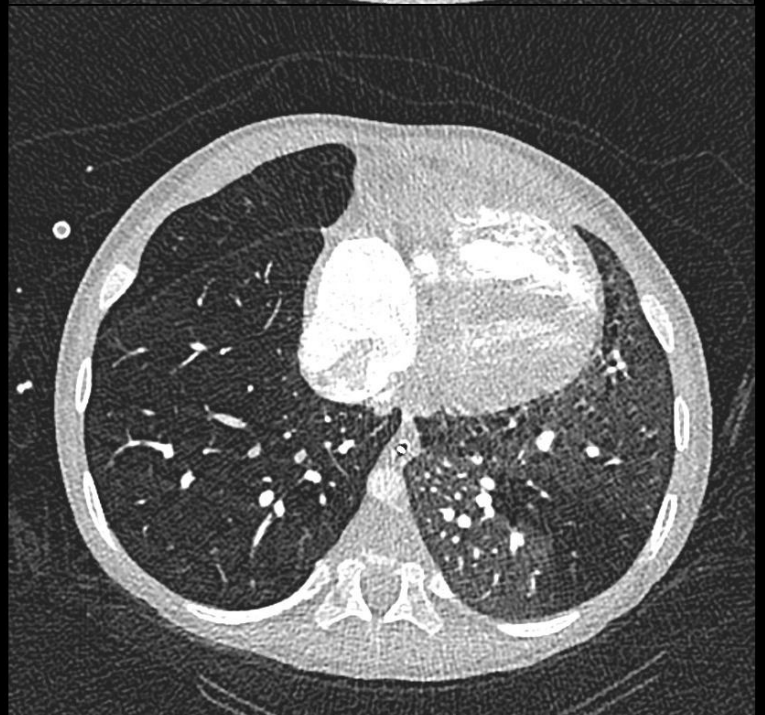












Congenital lobar overexpansion – aka congenital lobar emphysema

- Characterized by progressive lobar overexpansion, usually with compression of the remaining (ipsilateral) lung. The underlying cause can be secondary to an intrinsic cartilaginous abnormality with resultant weak or absent bronchial cartilage or extrinsic compression of an airway.
- In either case, the collapsed airway can act as a one-way valve, resulting in air trapping.
- The left upper lobe is involved in 42% of cases, the right middle lobe in 35%, the right upper lobe in 21%, and either lower lobe in less than 1% .
- CLO may be associated with cardiovascular anomalies in 12%–14% of cases. Males are more frequently affected than females

Pulmonary sequestration

- **Pulmonary sequestration** (also called **accessory lung**) refers to aberrant formation of segmental lung tissue that has no connection with the bronchial tree or pulmonary arteries
- Overall, sequestration preferentially affects the lower lobes. 60% of intralobar sequestrations affect the left lower lobe and 40% the right lower lobe. Extralobar sequestrations almost always affect the left lower lobe, and approximately 10% of extralobar sequestrations can be sub-diaphragmatic .

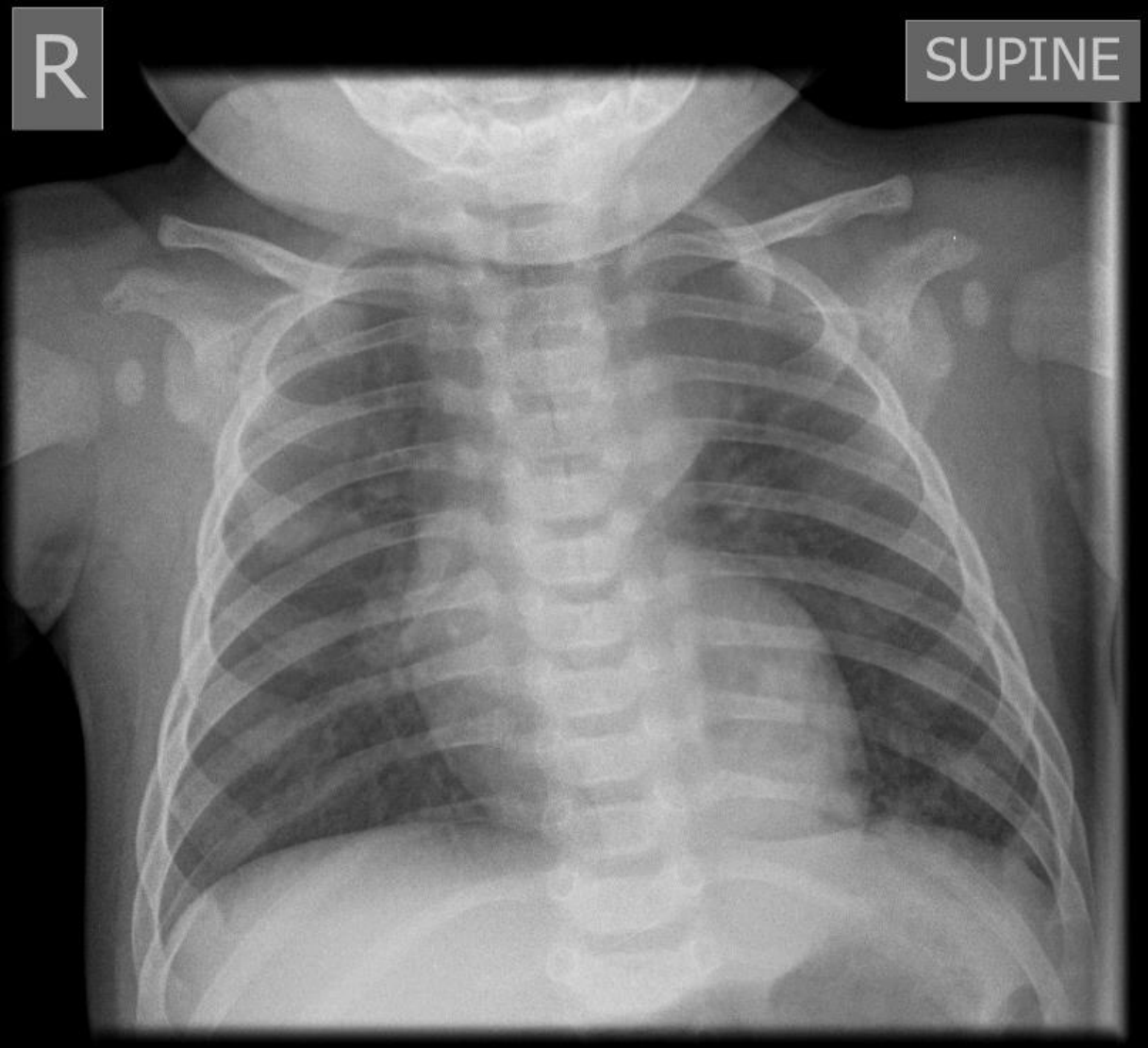
Pulmonary sequestration can be divided into two distinct groups based on the relationship of the aberrant segmental lung tissue to the pleura:

- intralobar sequestration (ILS)
  - accounts for the majority (75-85% of all sequestrations)
  - present later in childhood with recurrent infections
- extralobar sequestration (ELS)
  - less common (15-25% of all sequestrations)
  - usually present in the neonatal period with respiratory distress, cyanosis and/or infection
  - recognized male predilection M:F ratio ~4:1
  - can be subdiaphragmatic in ~10% of cases

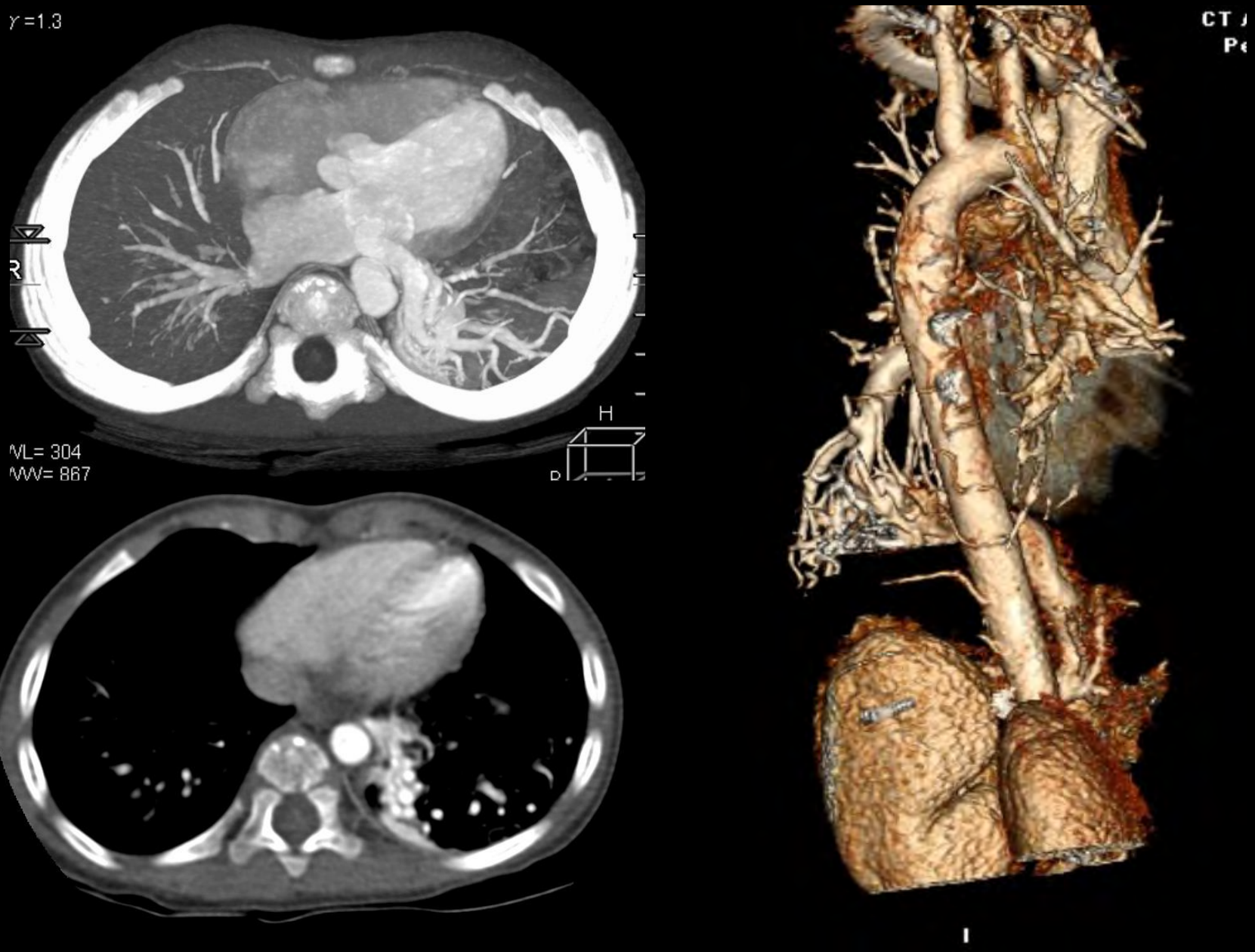
In the vast majority of cases, the anomalous lung tissue has a systemic arterial supply which usually arises from aorta. Venous supply is variable and dependant on the type of sequestration:

- intralobar sequestrations
  - venous drainage commonly occurs via the pulmonary veins but can occur through the azygous/hemi-azygous system, portal vein, right atrium or the IVC
- extralobar sequestrations
  - venous drainage most commonly through the systemic veins into the right atrium
  - separate from any surrounding lung with its own pleura

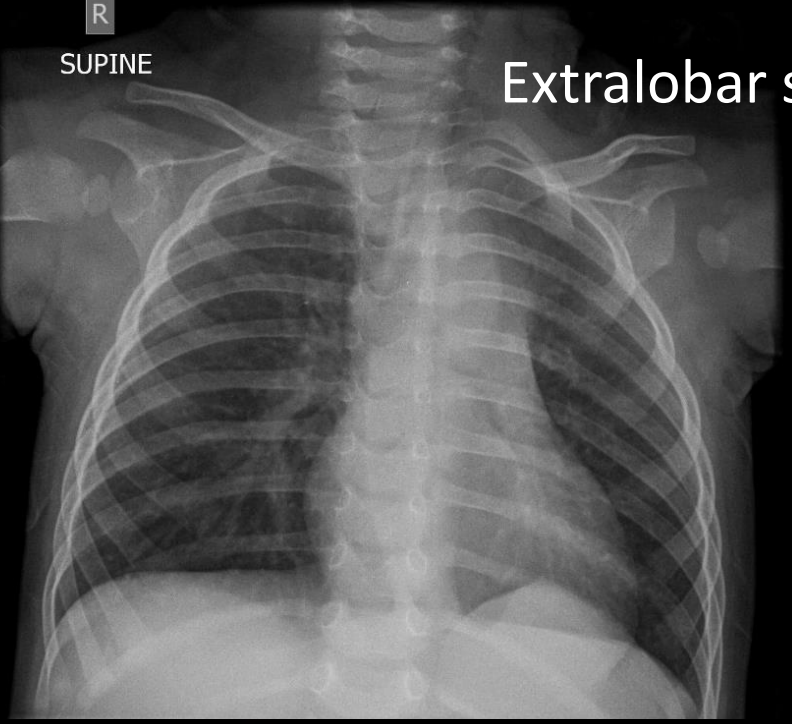
1 yr old with recurrent pneumonia

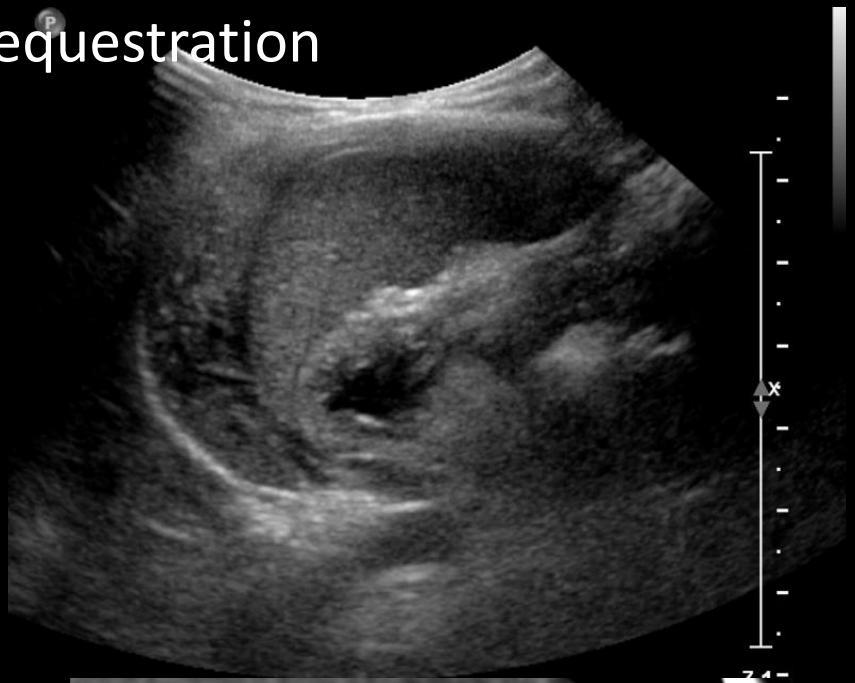


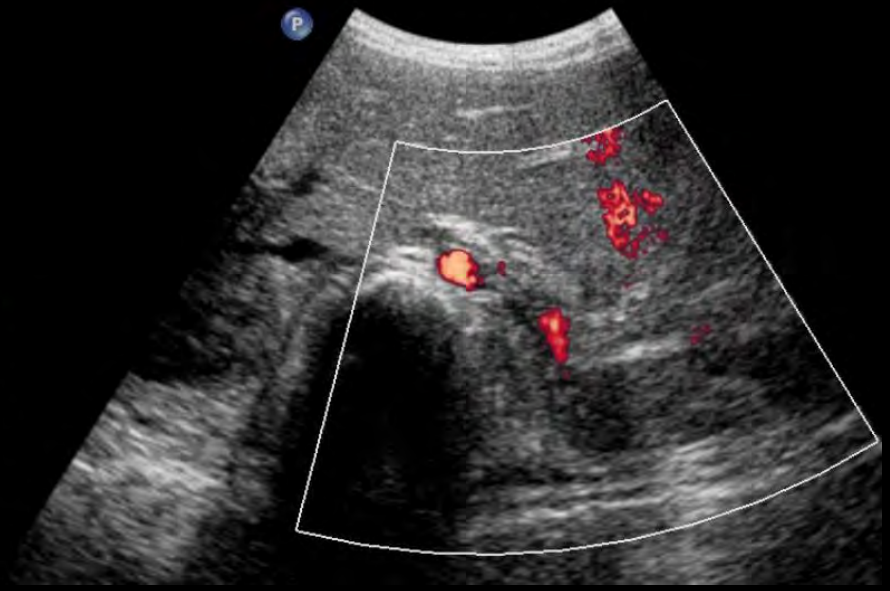
LLL Intralobar sequestration

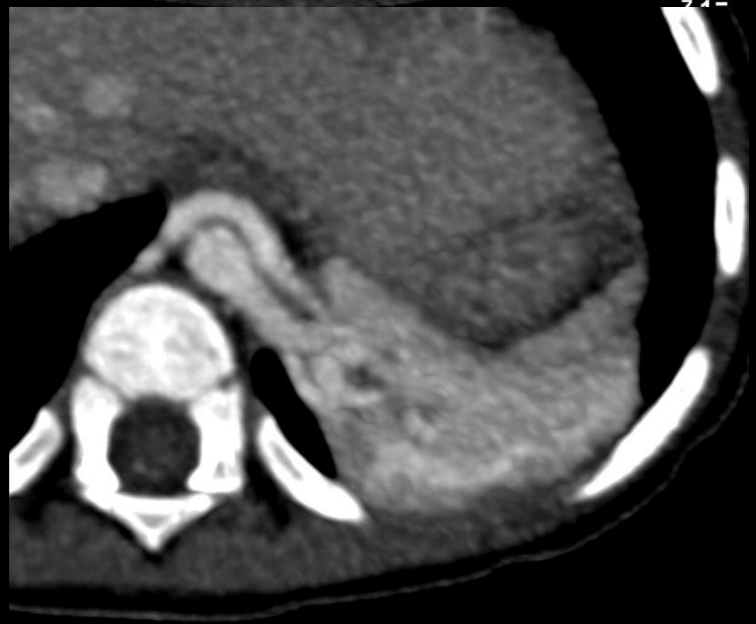


Extralobar sequestration

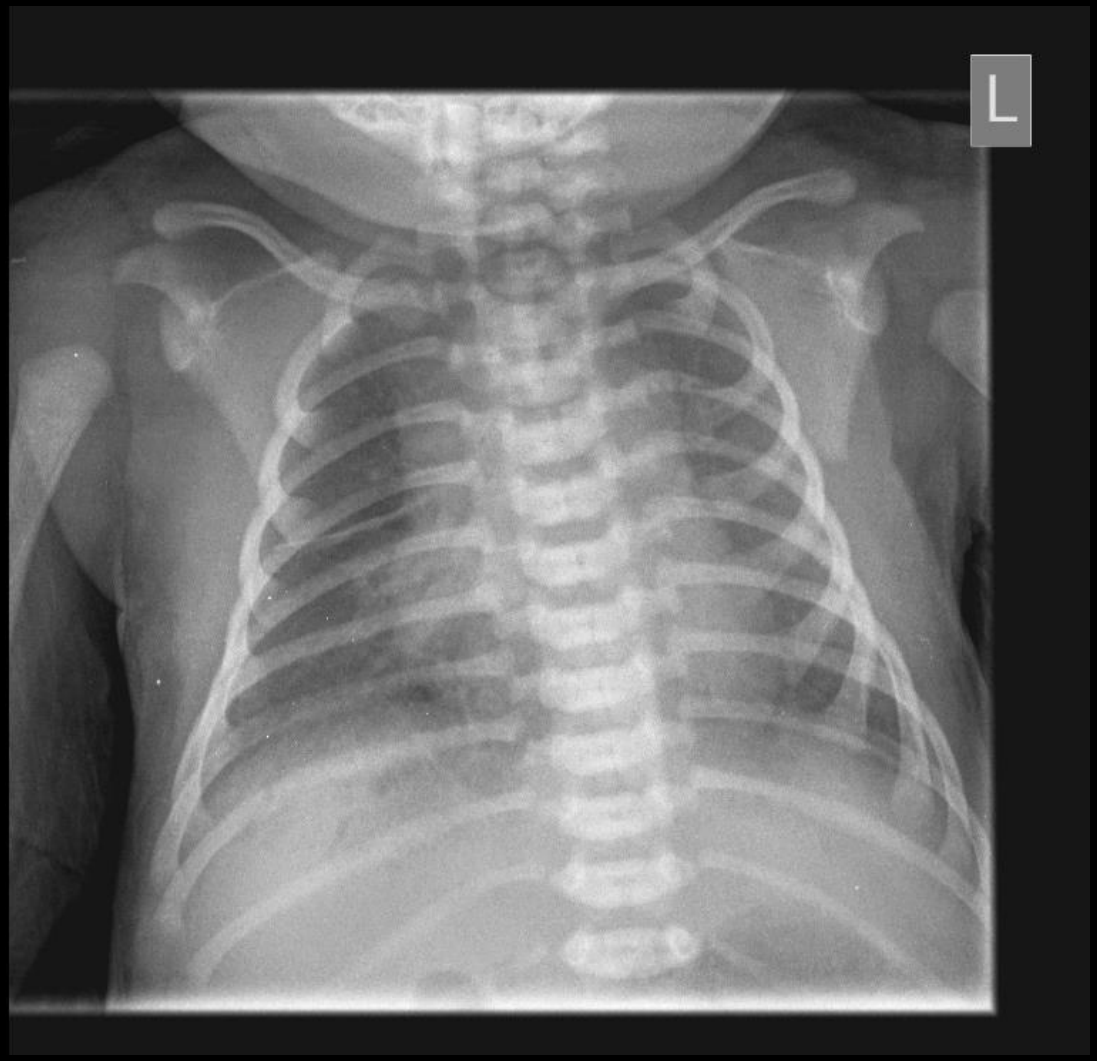


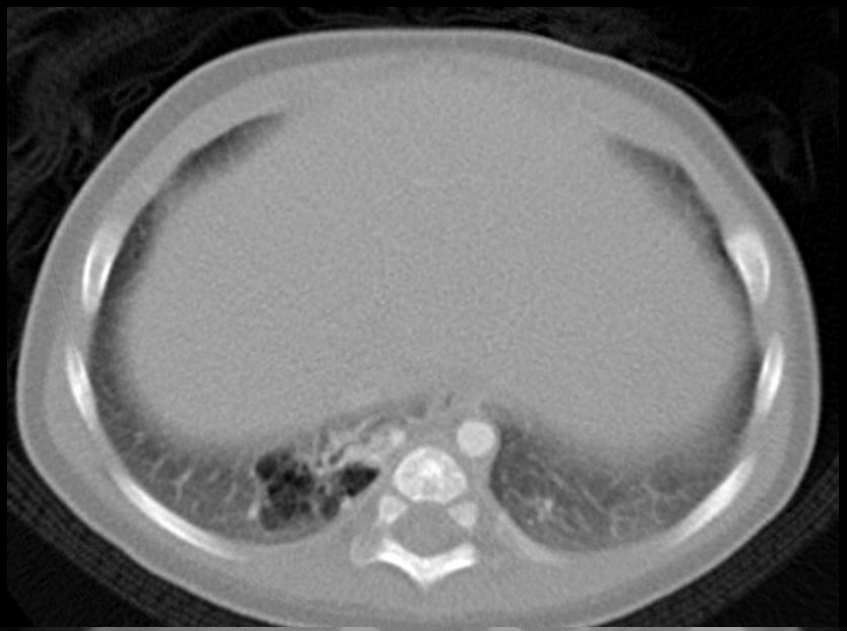


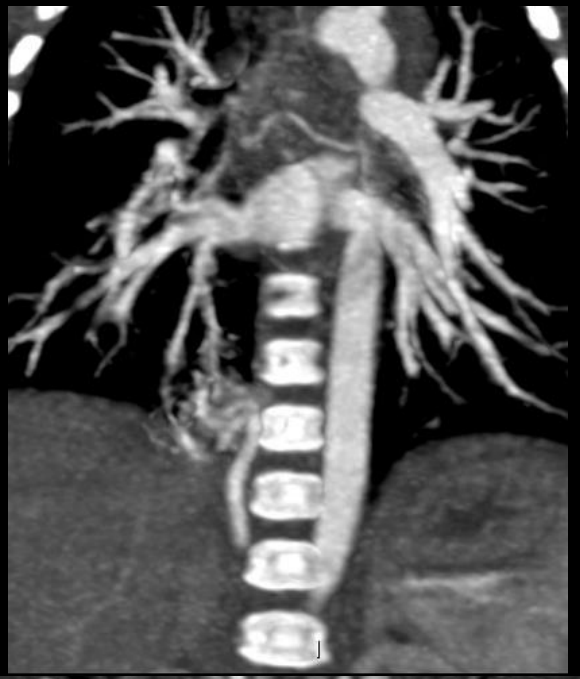


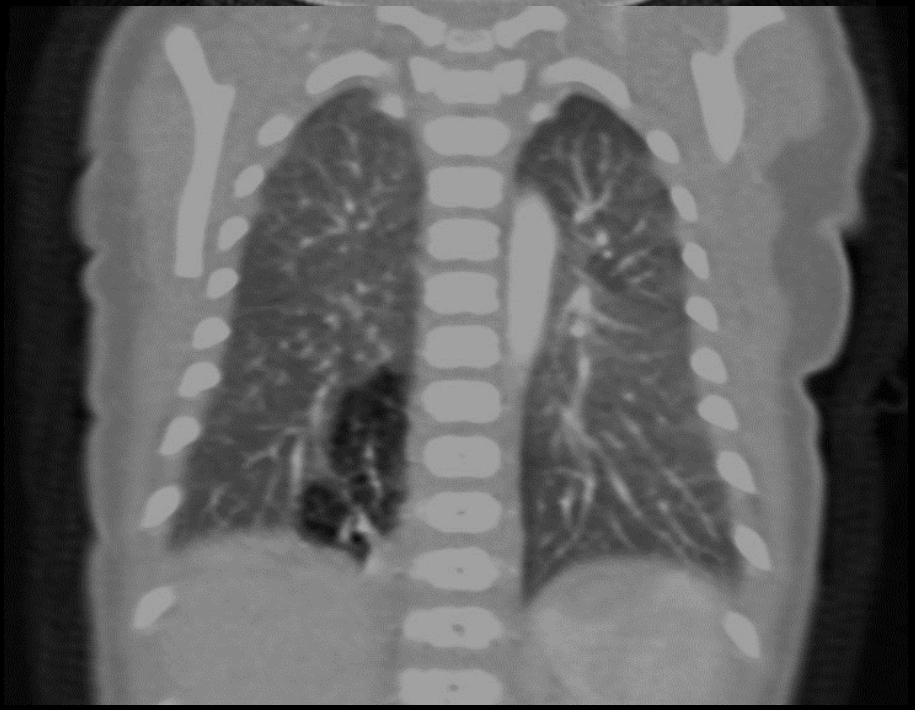


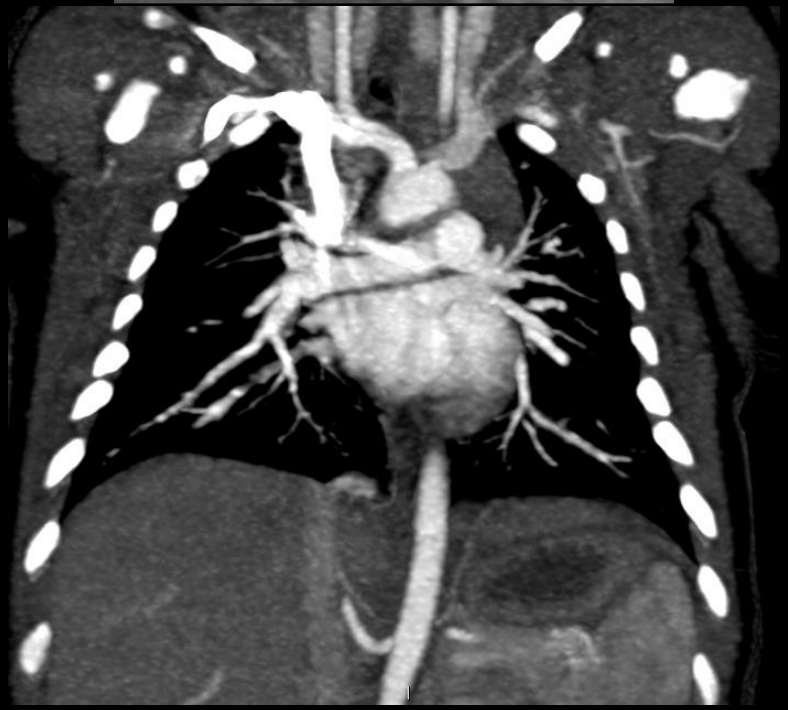
Faint lucencies in RLL



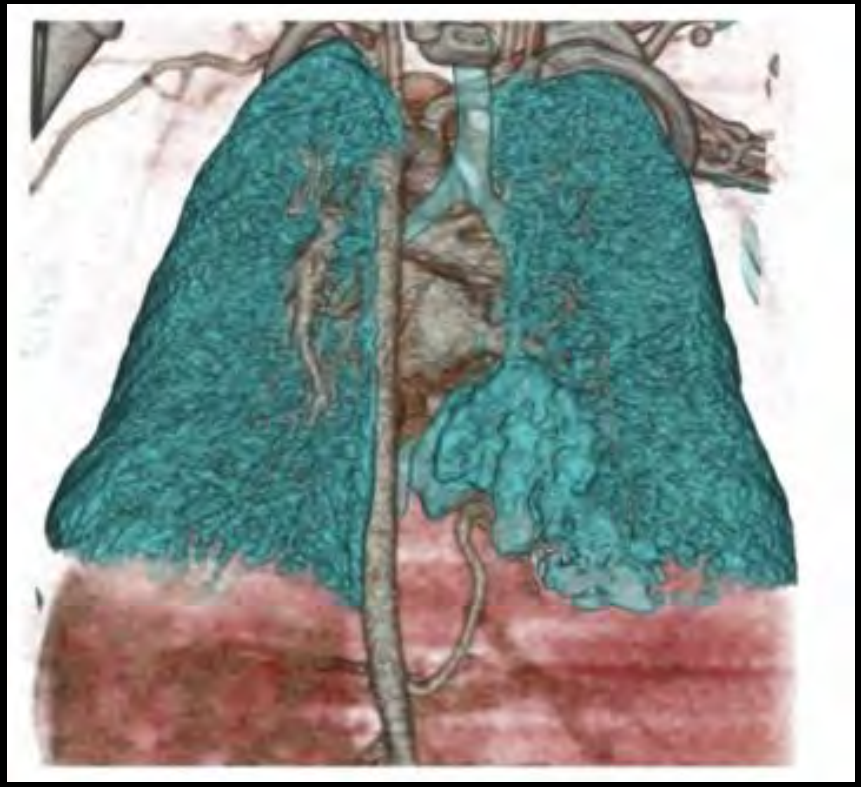


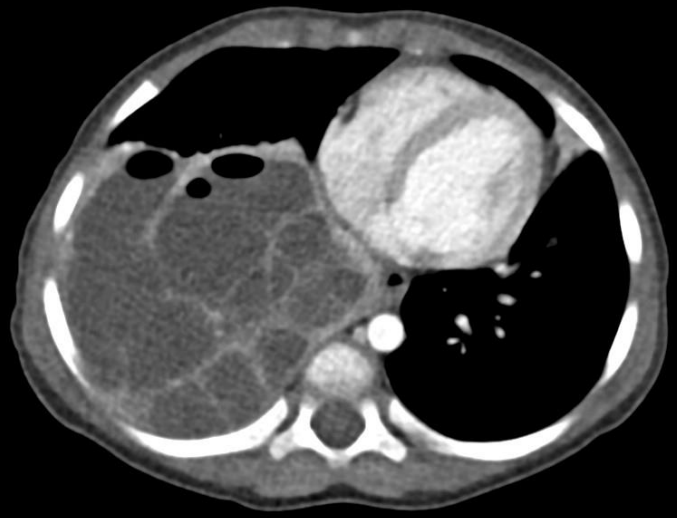


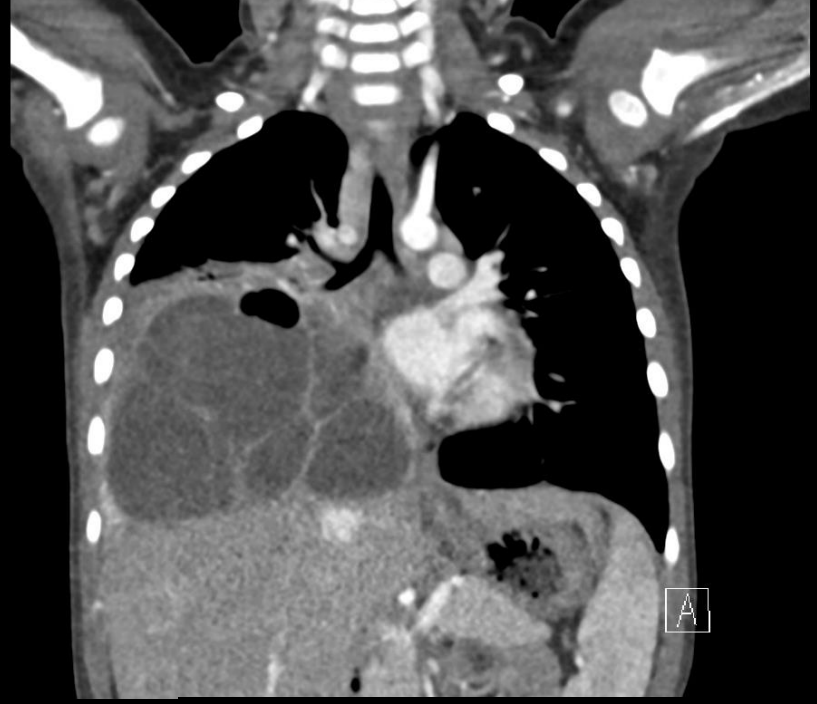




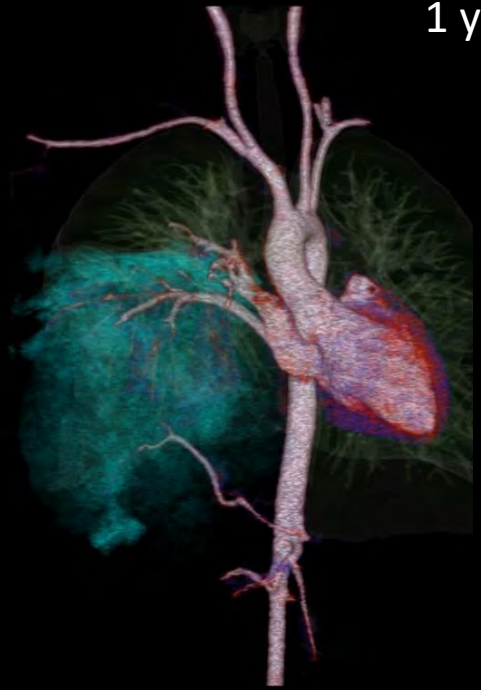
Hybrid lesion has elements of CPAM and sequestration

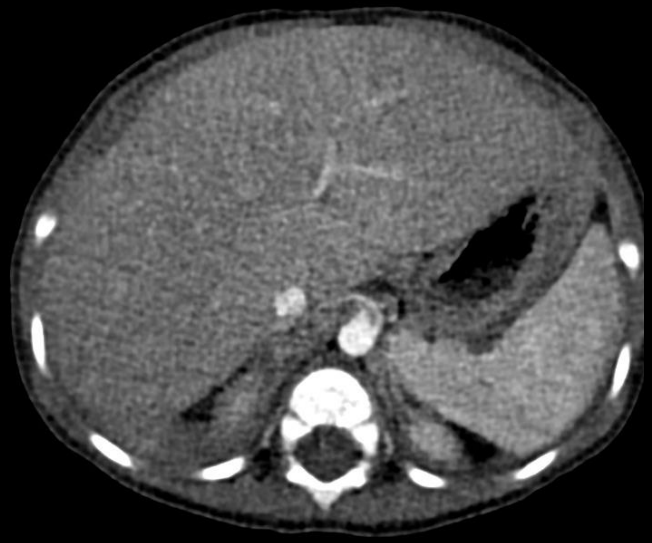


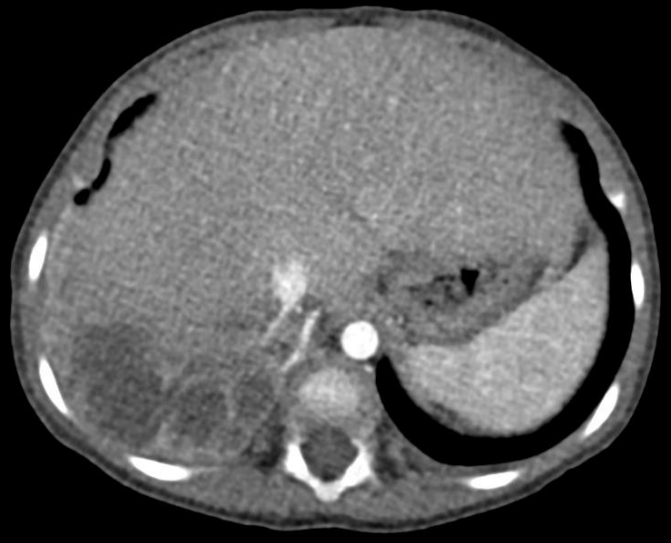


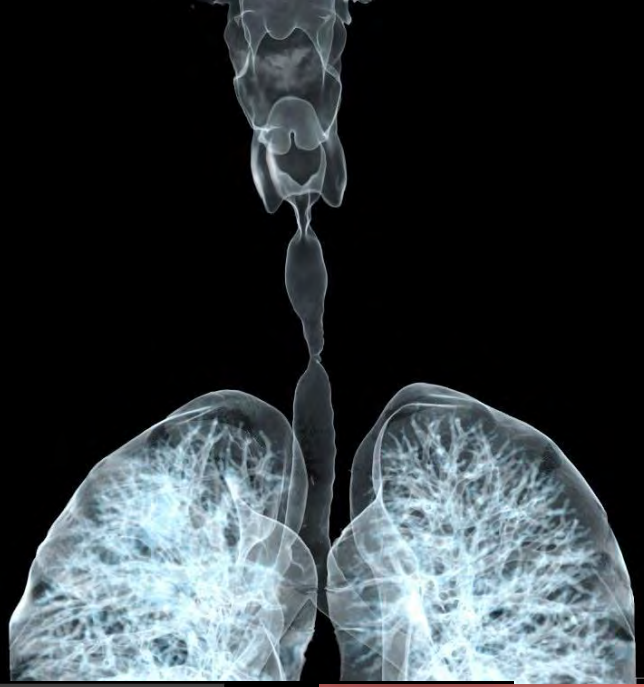


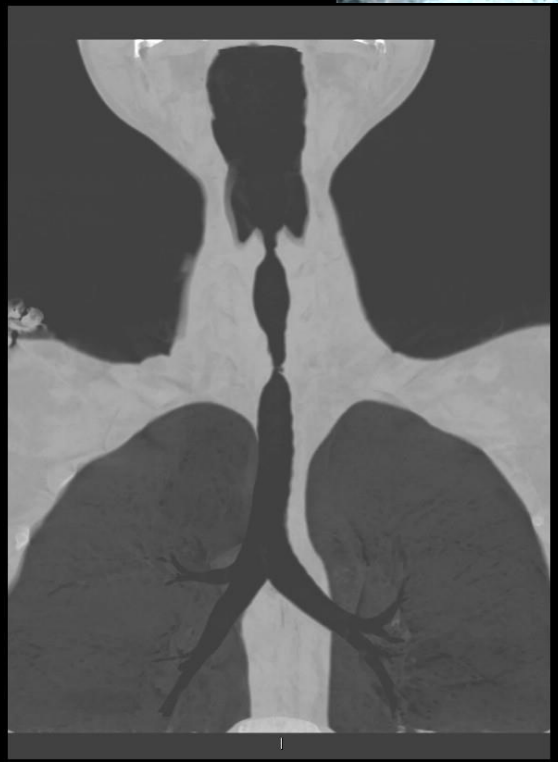
1 yr 3 mo with infected CPAM and sequestration

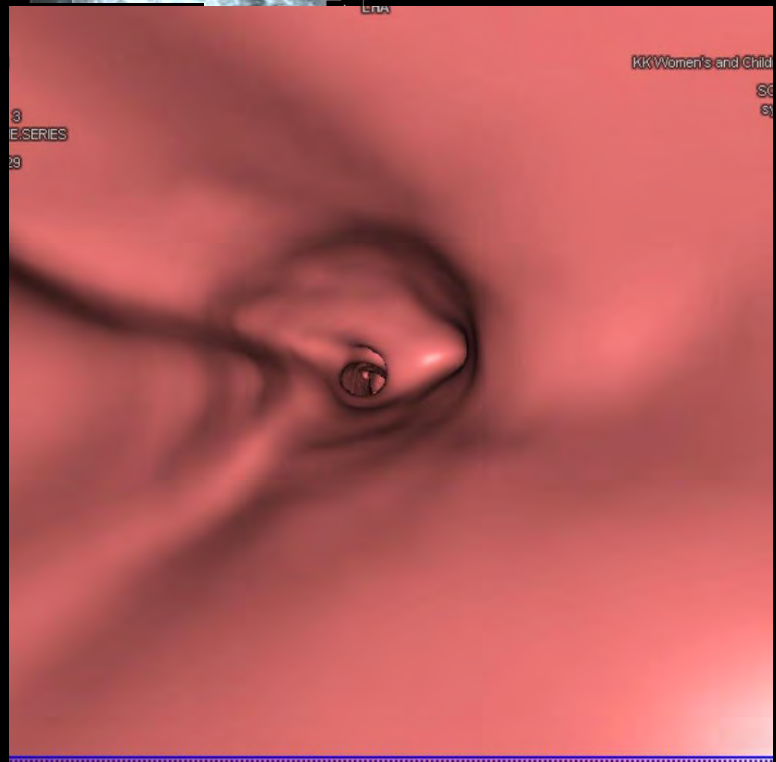


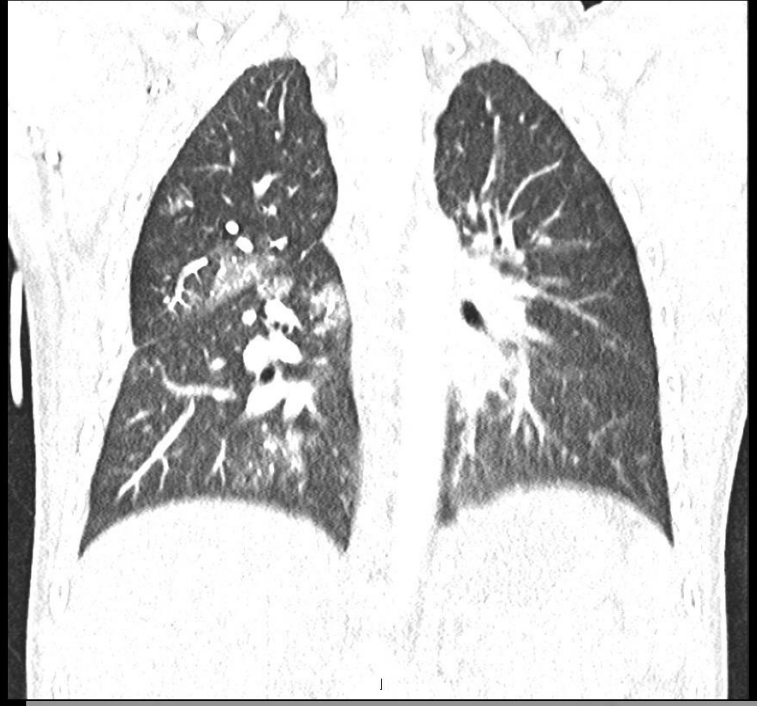


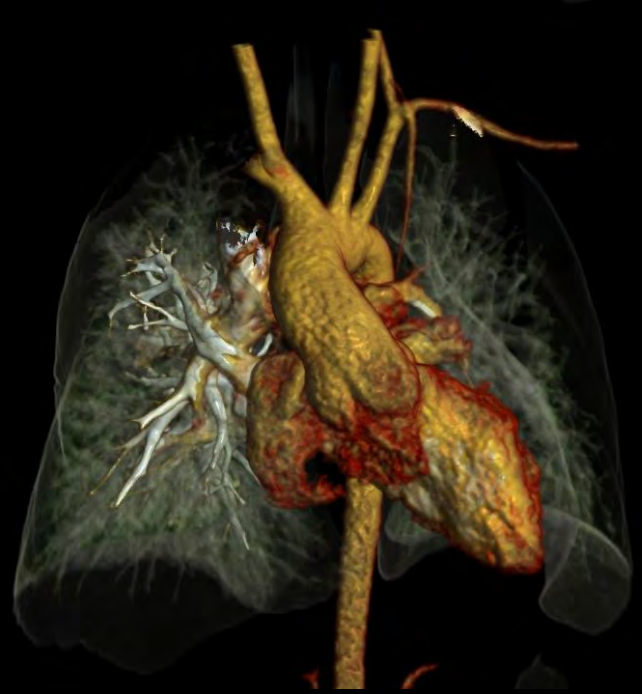


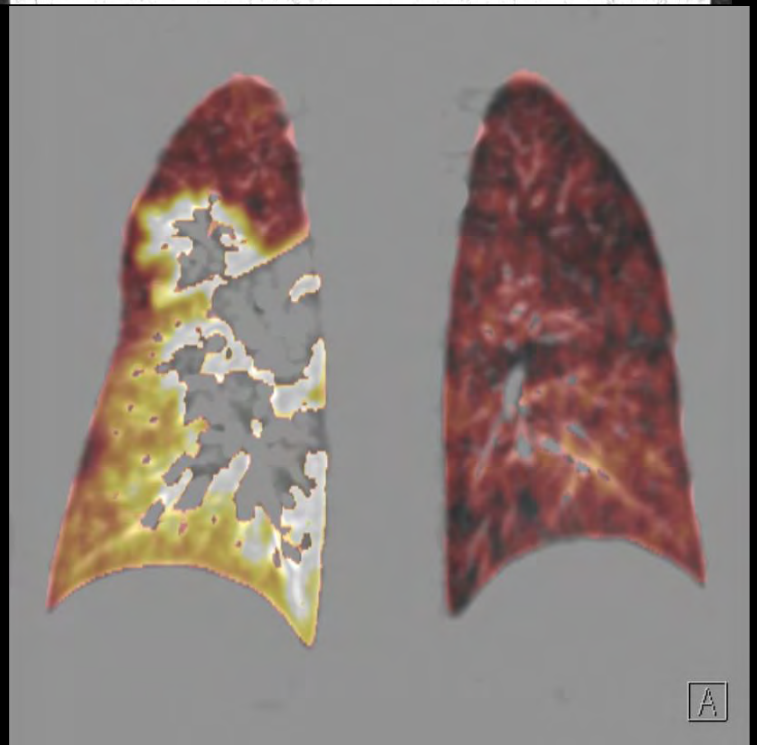


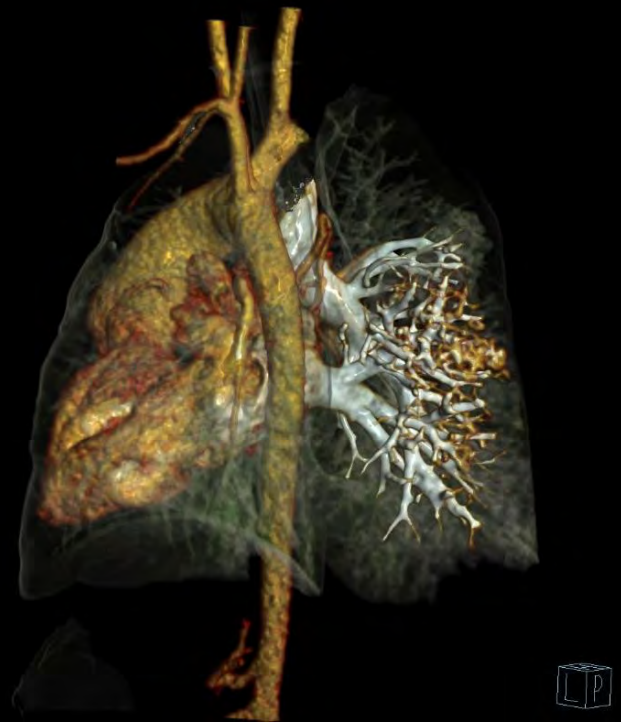



KK Women's and Child
E SERIES

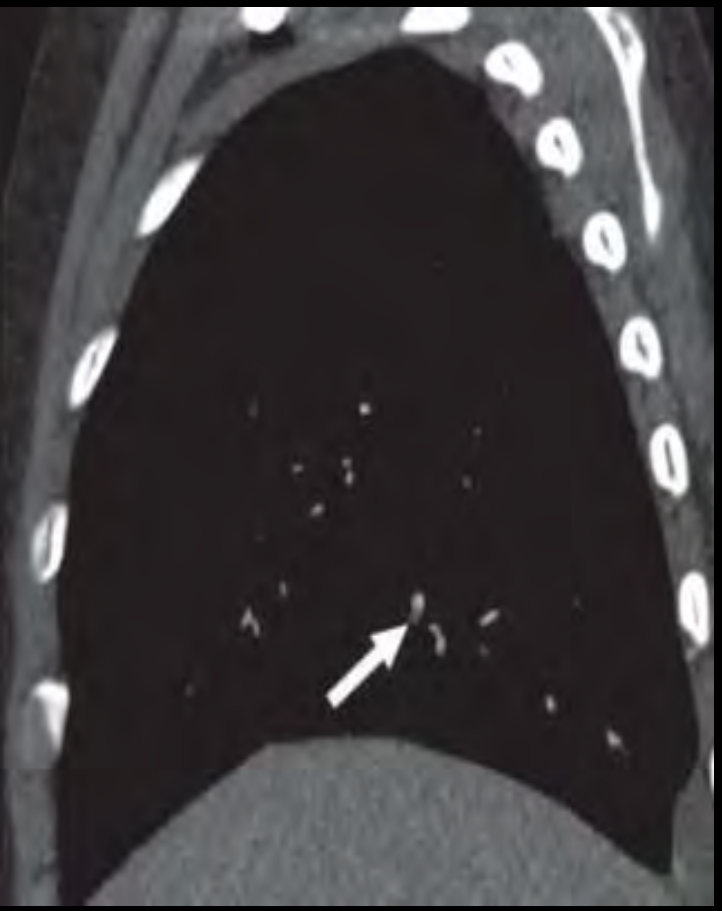


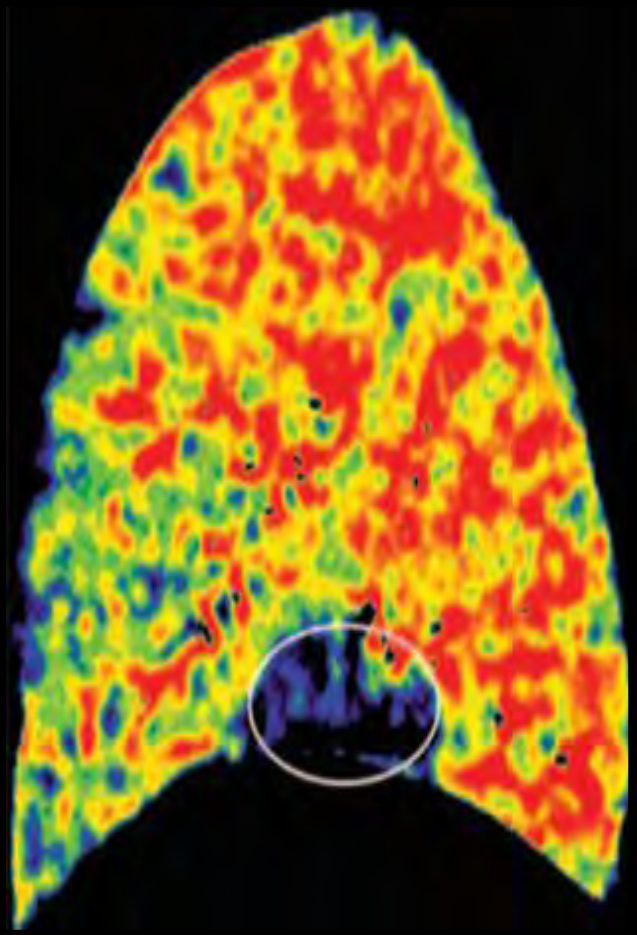


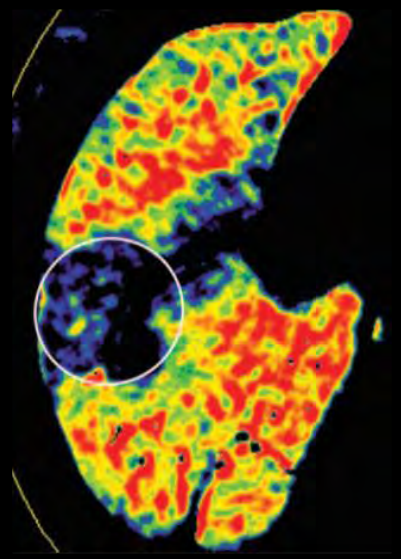

A

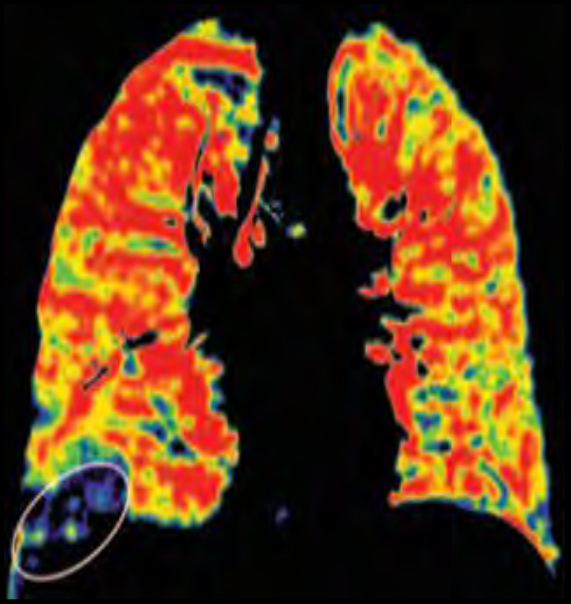


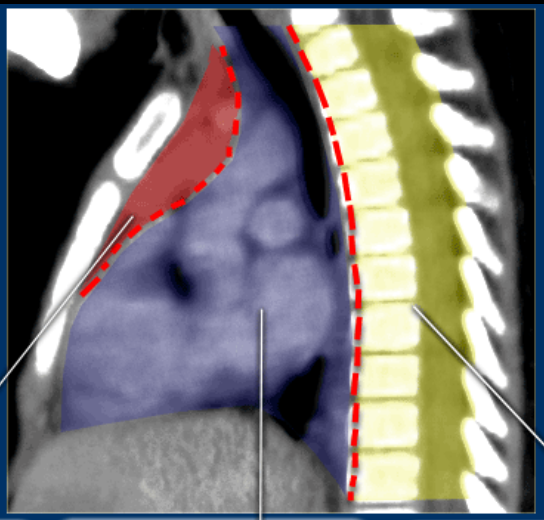
9 yr old with pulmonary embolism in RLL











Anterior

Soft tissue
Lymphoma
Hyperplasia

Fat
Germ Cell Tumor
Thymolipoma

Water
Lymphangioma

Middle

Foregut duplication cysts

Lymph nodes
Granulomatous
Metastatic
Lymphoma/Leukemia

Low Attenuation
TB
Fungal

Calcified
TB
Fungal
Osteosarcoma

Posterior

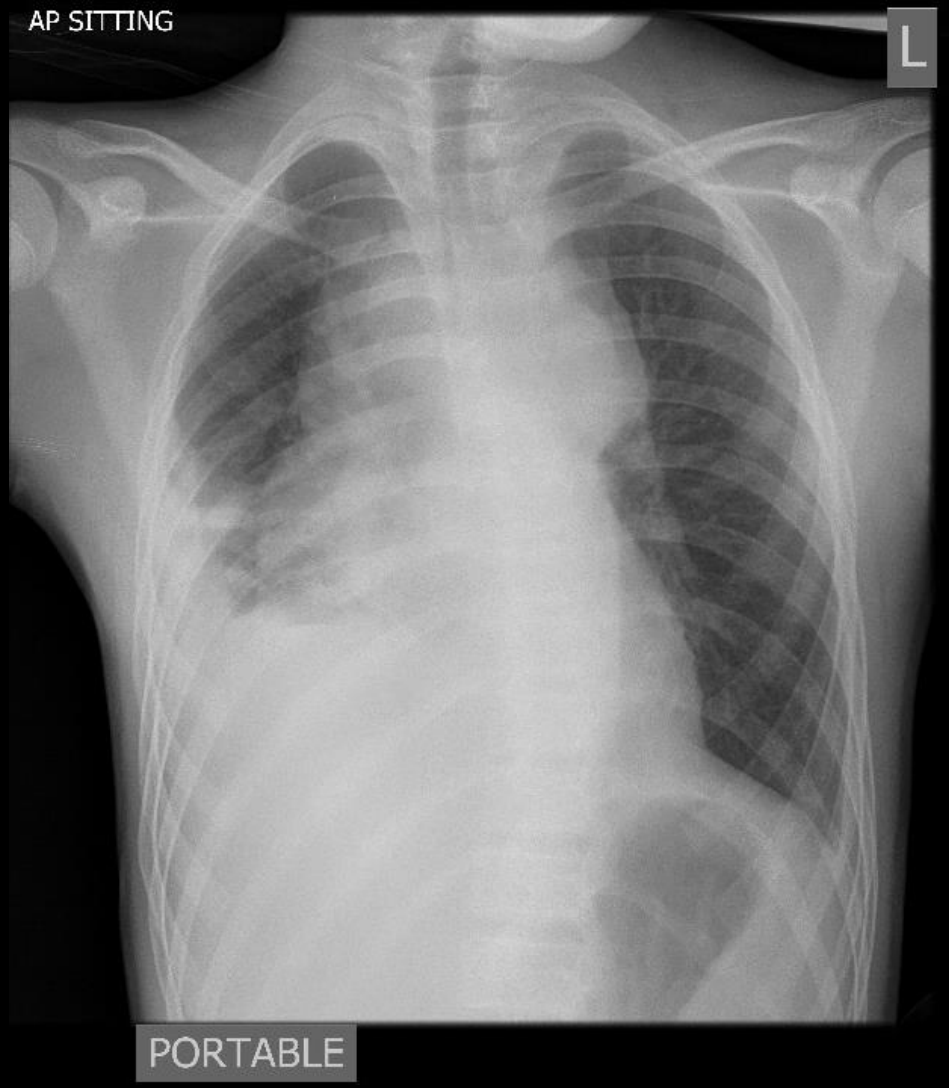
Virtually always neurogenic origin

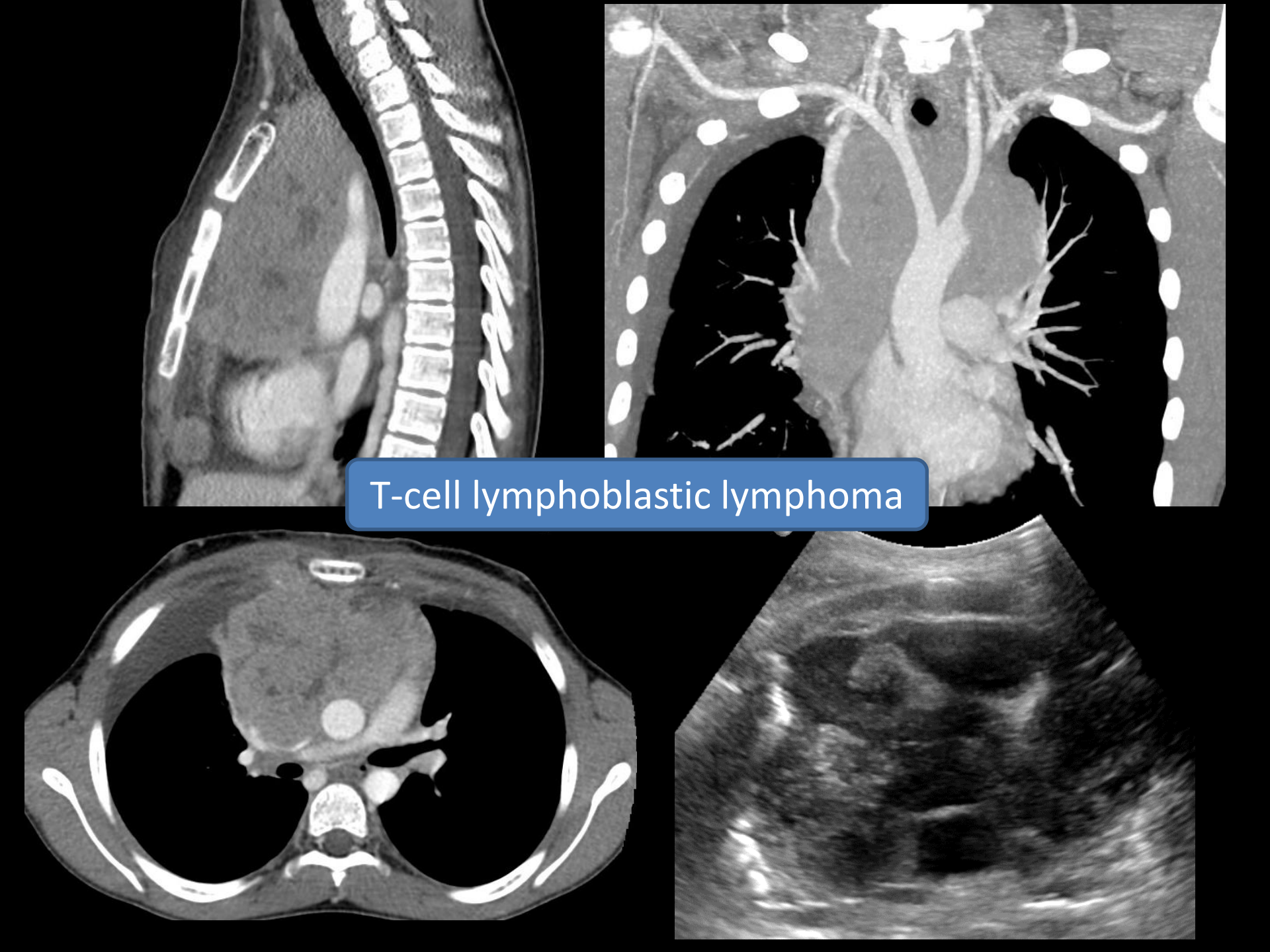
1st decade
usually malignant
Most commonly neuroblastoma

2nd decade
usually benign
Ganglioneuroma
Neurofibroma
Rarely schwanoma
Extramedullary hematopoiesis

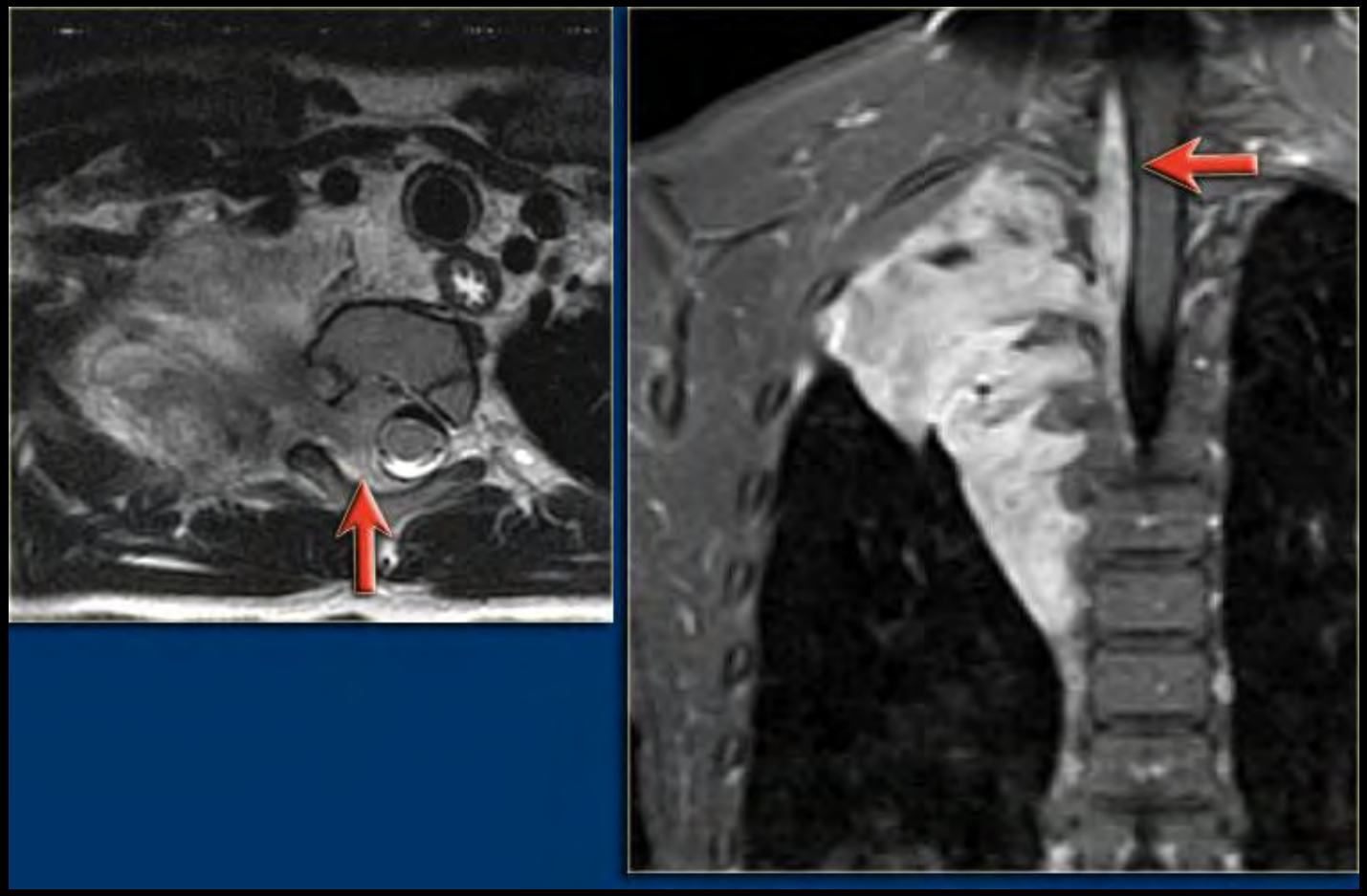
Courtesy of Dr Marilyn Siegel

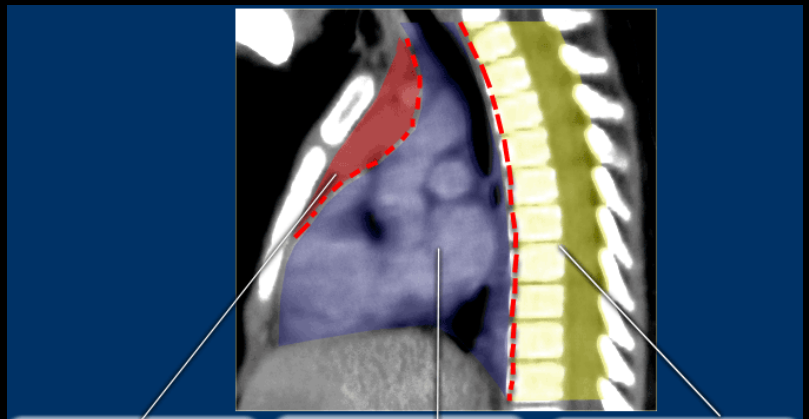
Dyspnea and weight loss




T-cell lymphoblastic lymphoma

Post mediastinum- Thoracic NB





Anterior	Middle	Posterior
Soft tissue Lymphoma Hyperplasia	**Foregut duplication cysts**	Virtually always neurogenic origin
Fat Germ Cell Tumor Thymolipoma	**Lymph nodes** Granulomatous Metastatic Lymphoma/Leukemia	**1st decade** usually malignant Most commonly neuroblastoma
Water Lymphangioma	**Low Attenuation** TB Fungal	**2nd decade** usually benign Ganglioneuroma Neurofibroma Rarely schwanoma Extramedullary hematopoiesis
	Calcified TB Fungal Osteosarcoma	

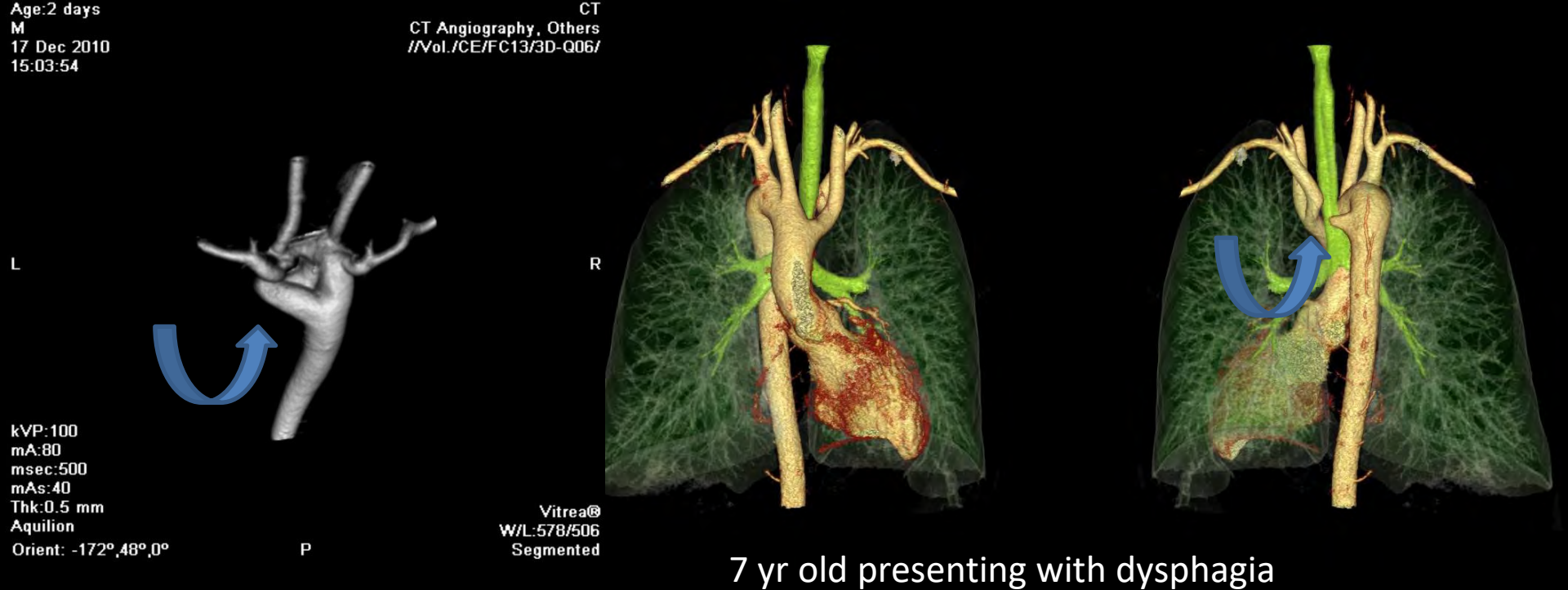
Common Anterior Mediastinal Masses:

SOFT TISSUE : Lymphoma - Hyperplasia

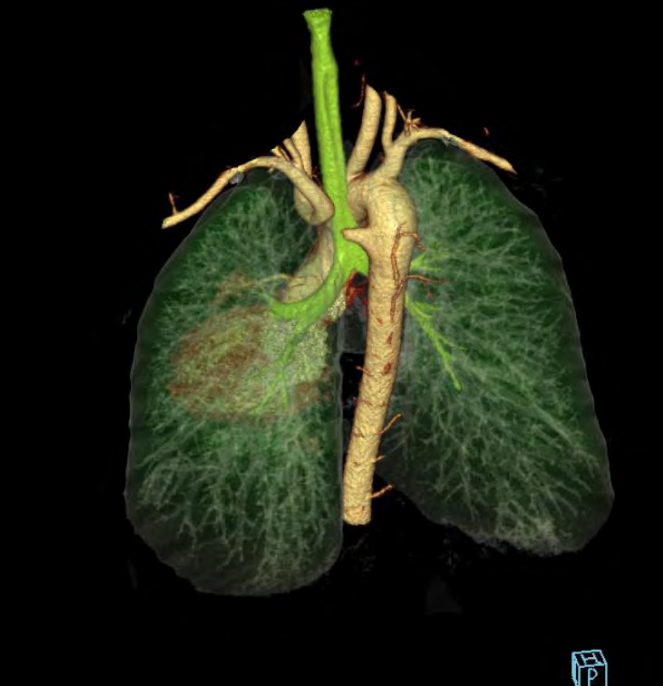
FAT : Germ cell tumor

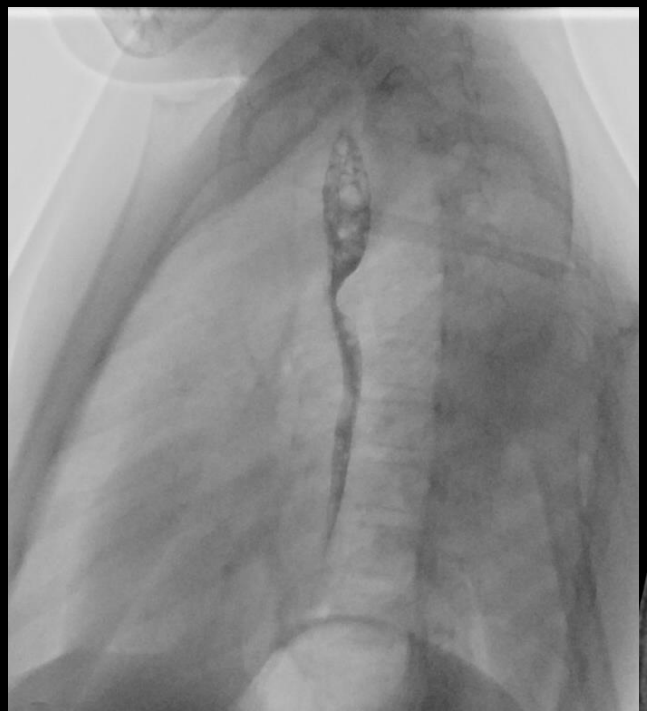
WATER : Lymphangioma

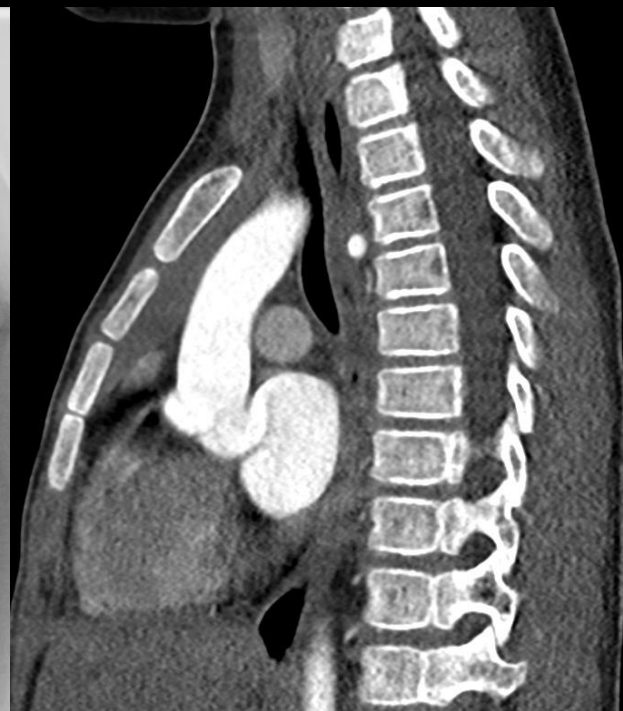
Forget thymoma, thymic carcinoma, goiter!!!



7 yr old presenting with dysphagia

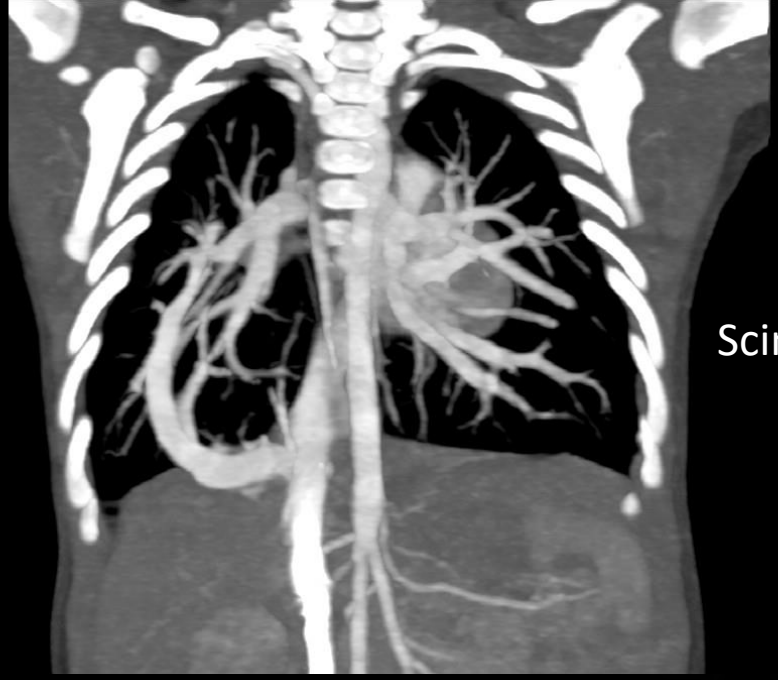






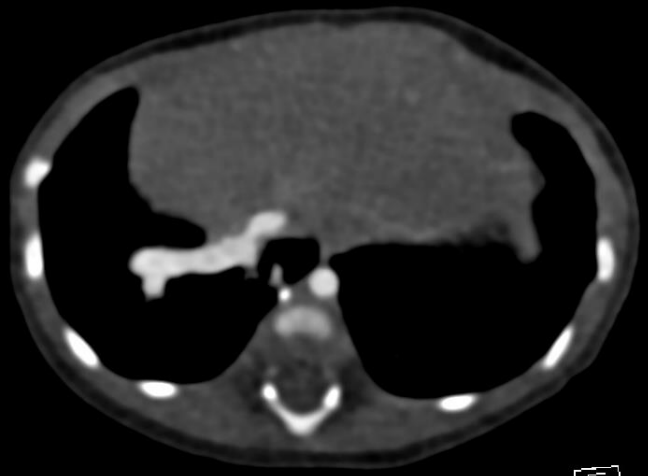
<1016-0>

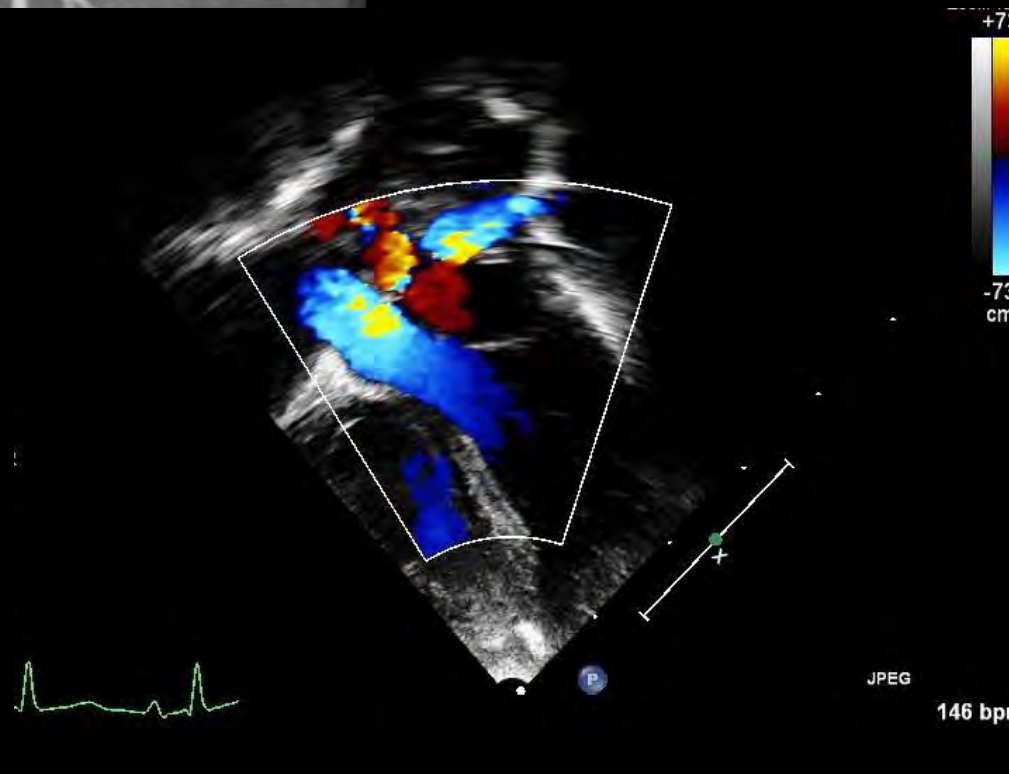
5 month old with turbulent flow in left lower pulmonary vein and pulmonary hypertension on echo



Scimitar Syndrome - PAPVR

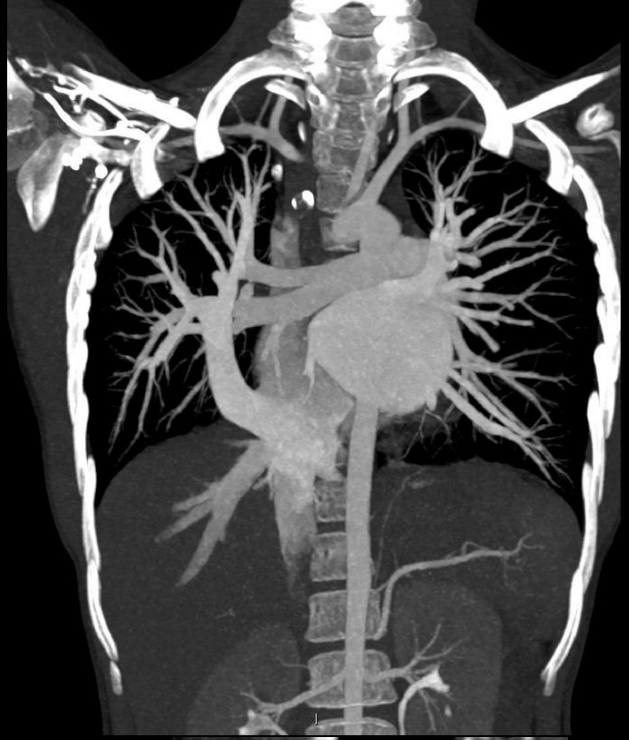
R

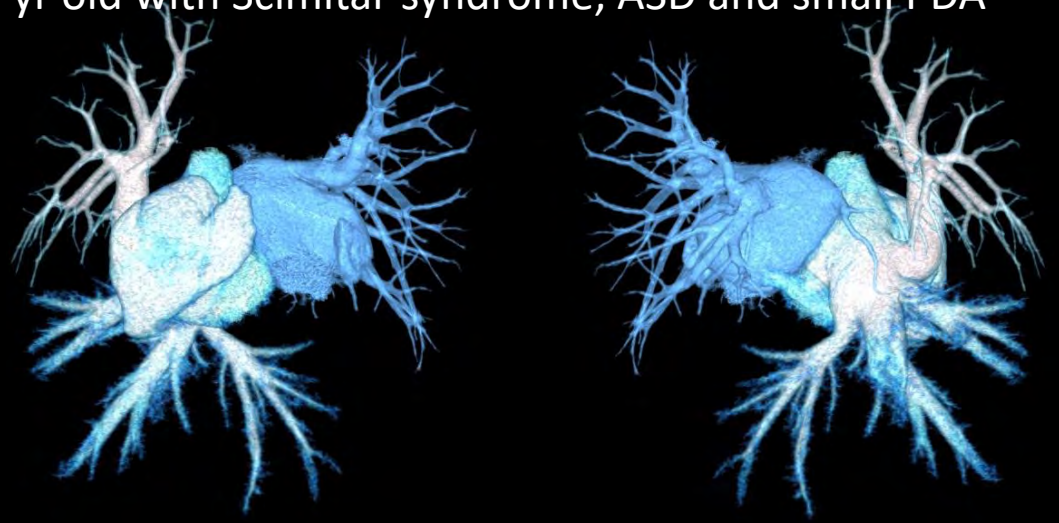




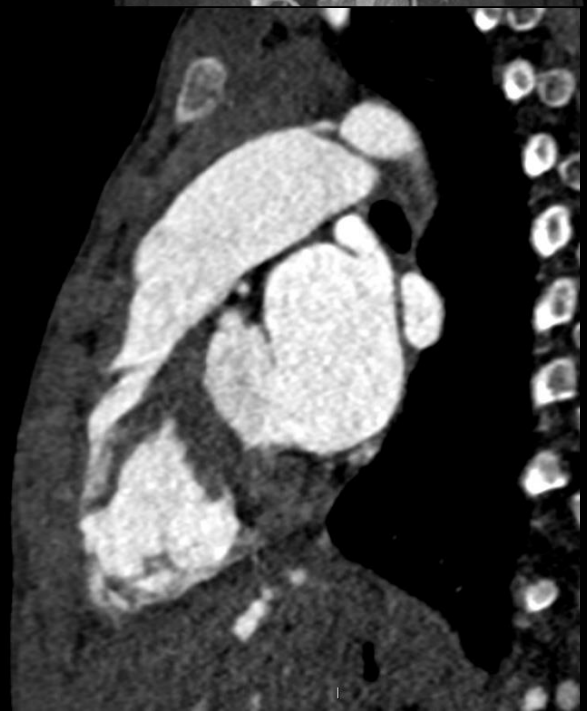
P

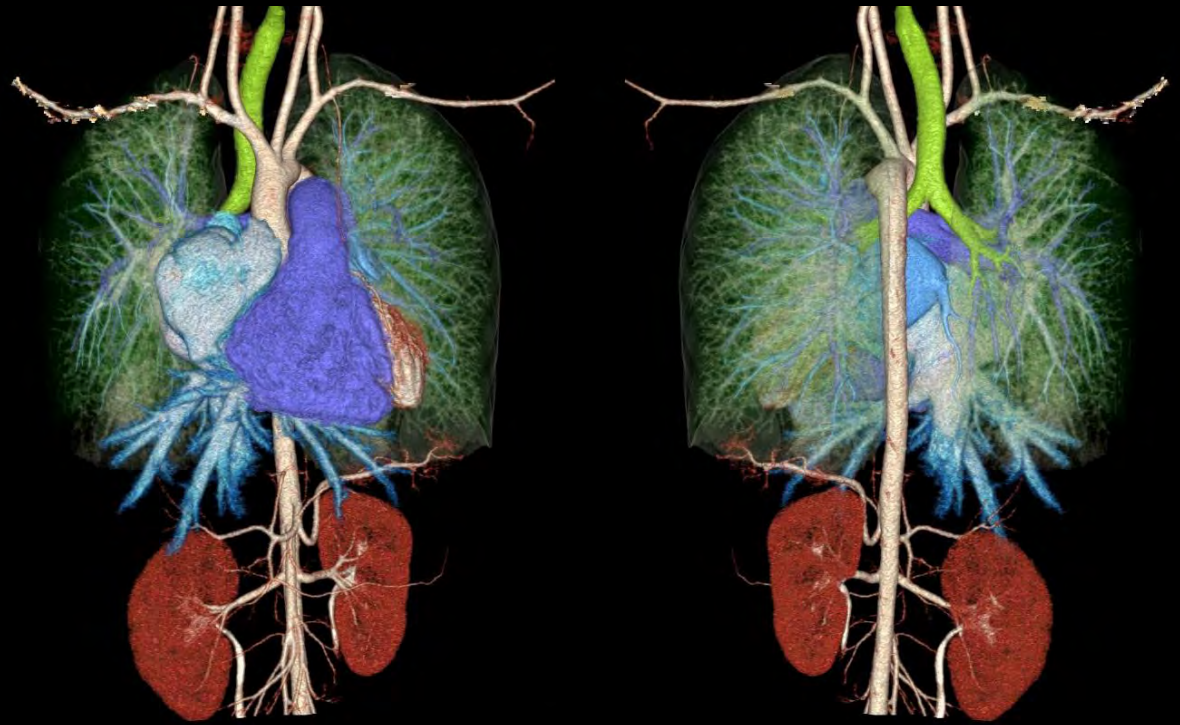
8 yr old with Scimitar syndrome, ASD and small PDA

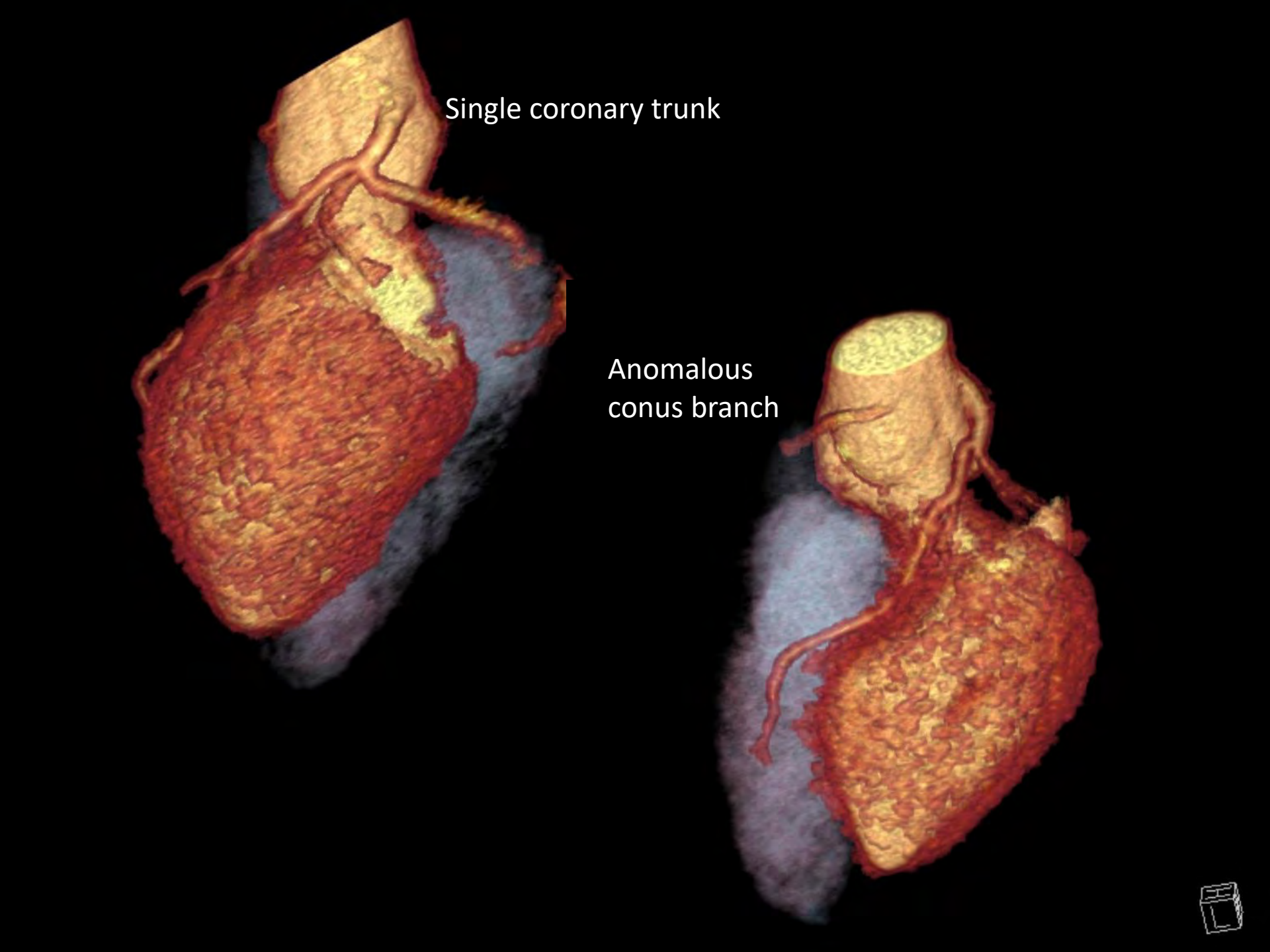


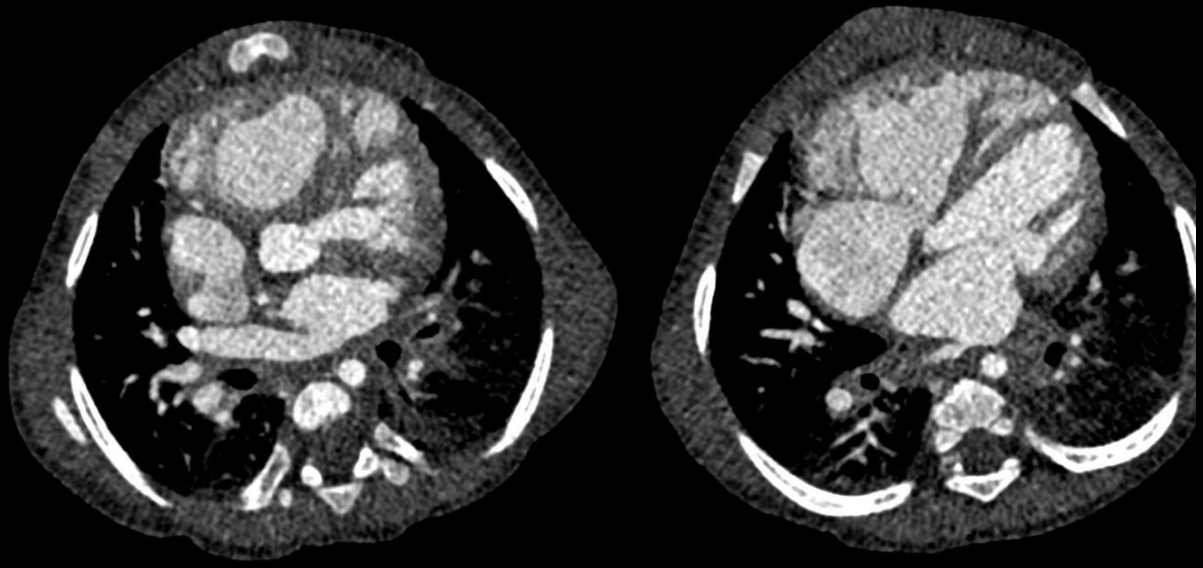


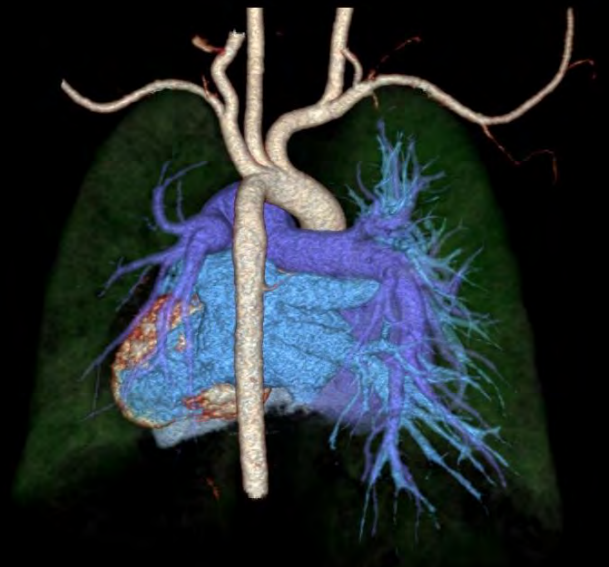
25cc contrast 80%, 2.5 ml/sec
70 kv, 14 and 24 second delay



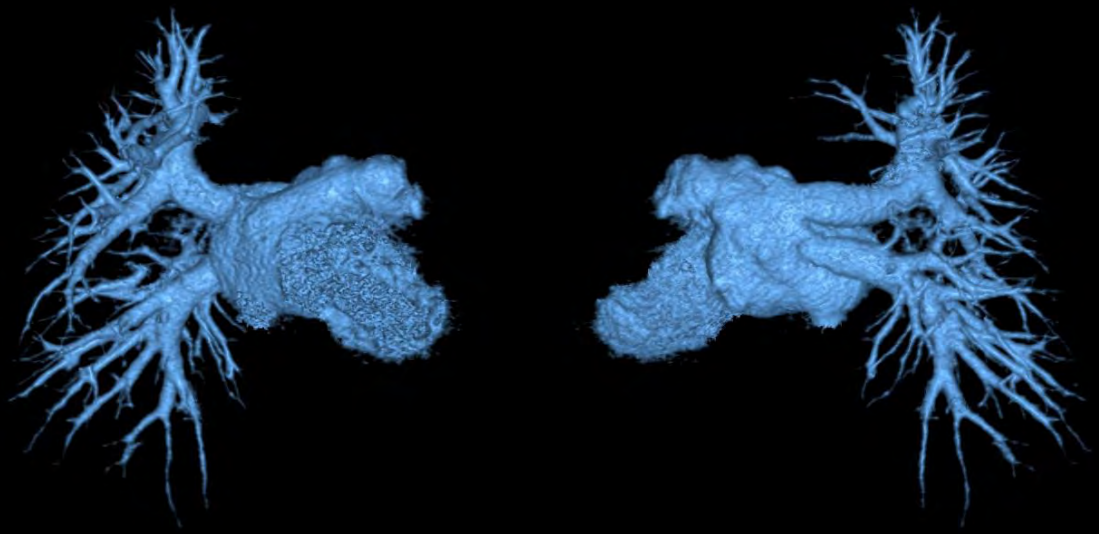


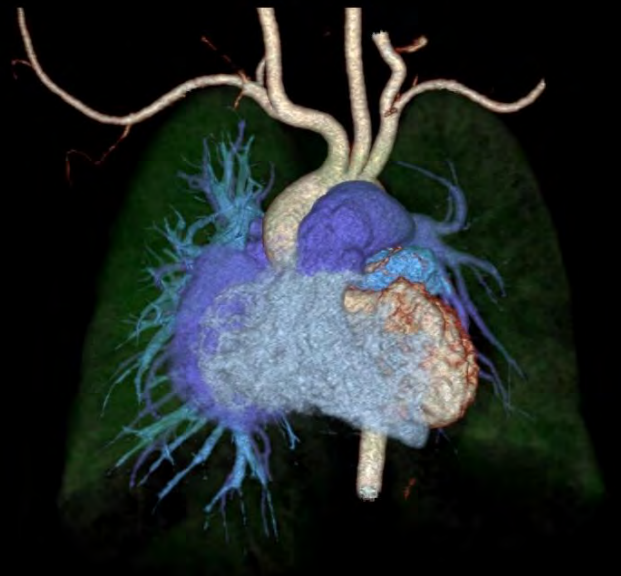

Single coronary trunk
Anomalous
conus branch





1 yr old with TAPVR repair presenting with obstructed left PVs
70 kV 5ml /15 ml Contrast diluted 70%, 1.5 ml/ sec, 12 & 14 sec delay





Indications for Advanced Imaging

Pleural fluid – Ultrasound is valuable

Lung parenchymal assessment - CT

Bronchopulmonary Foregut Malformation

Mediastinal masses

Cardiovascular assessment

Effective Radiation
Dose = 0.68 mSv