Pediatric High-Resolution Chest CT

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Pediatric High-Resolution CT

- Short review of CT scanning
- What is a high-resolution CT?
- How can we get the best images?
- What can we learn from the images?


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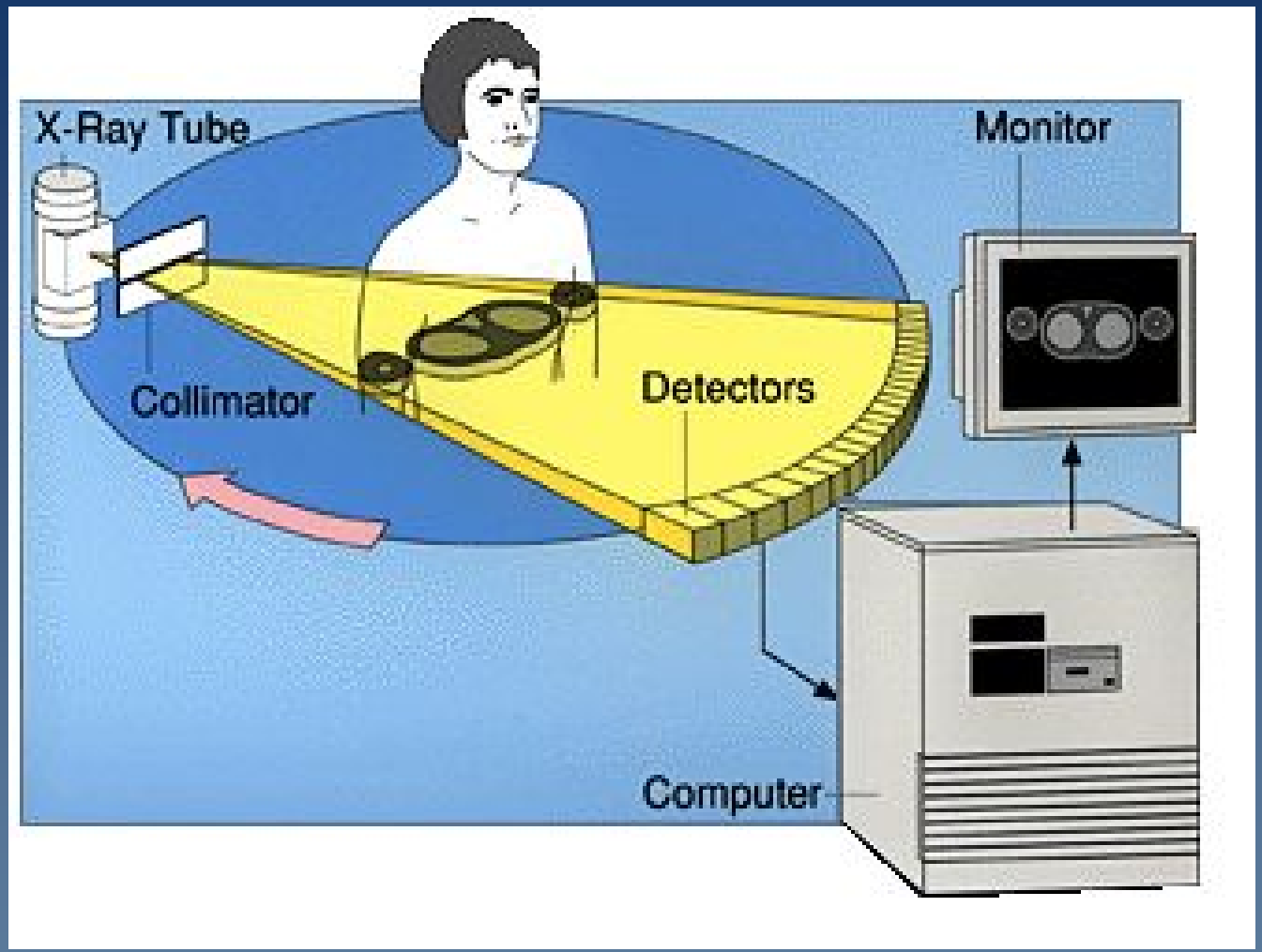

X-Ray Tube
Monitor
Collimator
Detectors
Computer

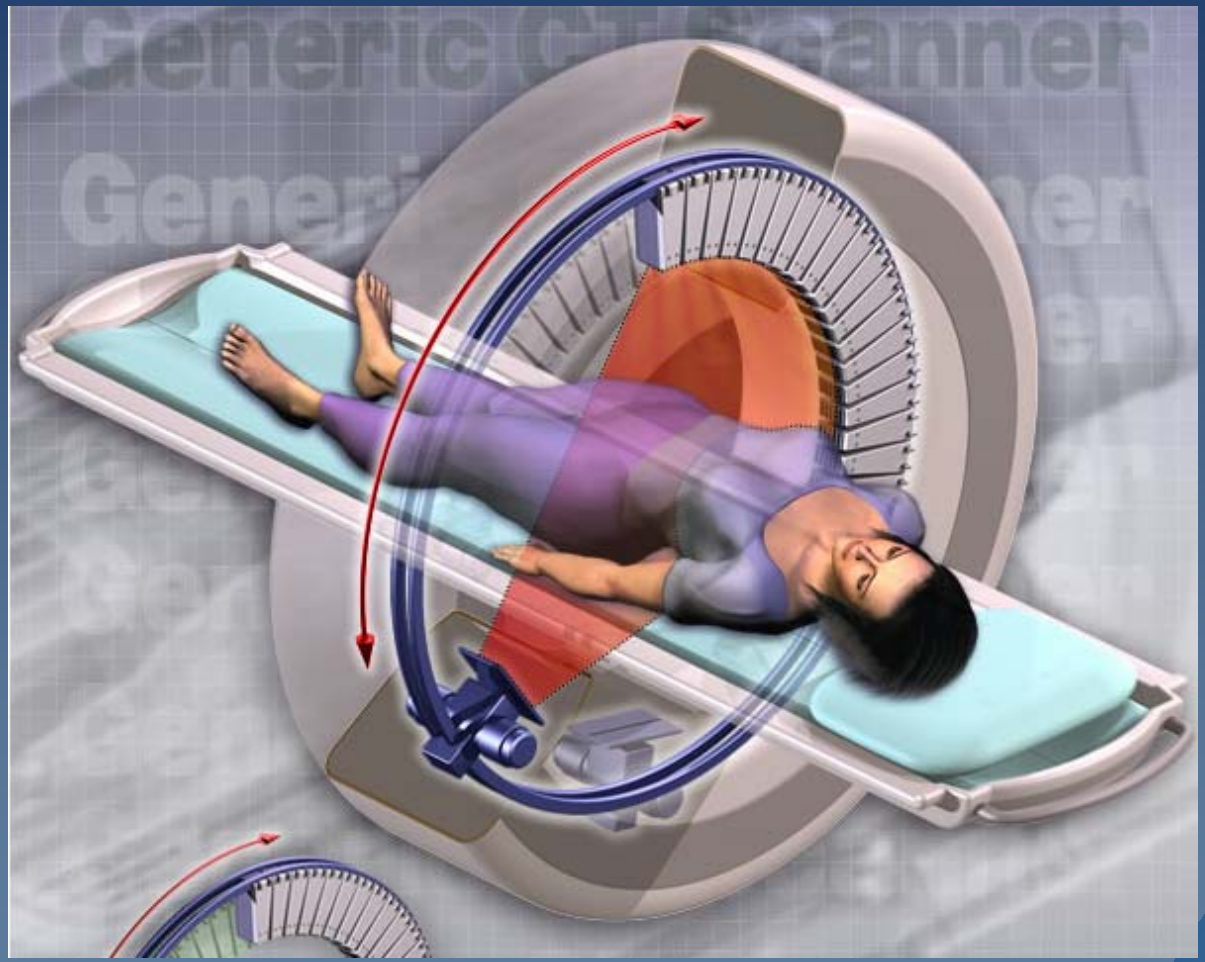
CT Scanning

- CT uses the same X-rays as a chest X-ray, but it uses many times more
  - 1 CT scan may have the same dose as 100 chest X-rays
- CT images all tissues in the body, from lung to bone

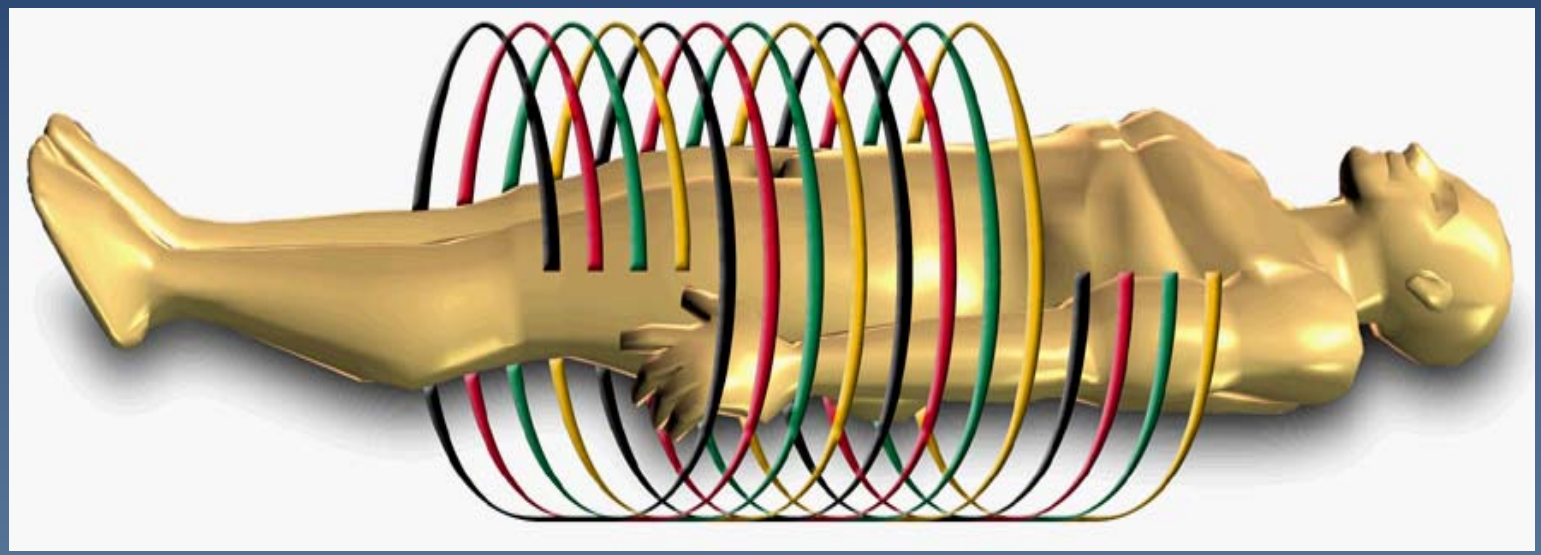
CT Scanning

- Most conventional CT scanning now uses helical or spiral technique
  - The patient moves through the scanner continuously as images are acquired
- High-resolution CT scanning uses axial technique
  - The CT scanner moves to position, one slice is acquired, and the CT scanner moves to the next position

Axial CT



Conventional CT
(also called helical or spiral CT)



Conventional and High-Resolution CT Scanning

- The newest CT scanners can reconstruct conventional images to produce images nearly as good as high-resolution CT
- With all other CT scanners we must choose between conventional and high-resolution CT, or scan the patient twice to get both

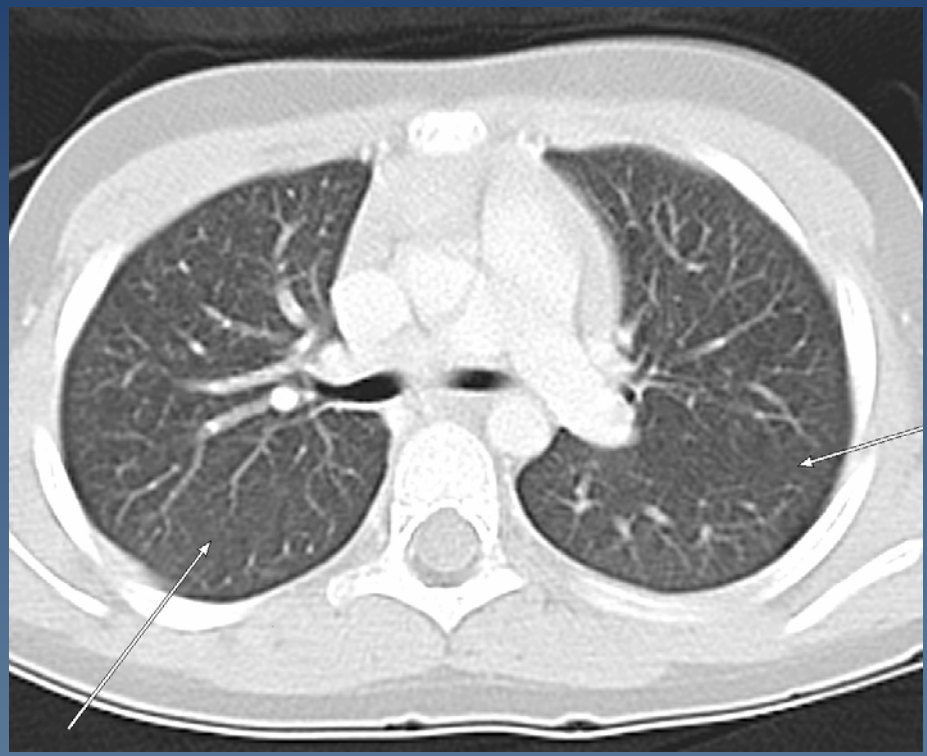
What is a High-Resolution CT?

- High-resolution CT describes a different way to do a CT scan NOT a better way
- High-resolution CT does not replace conventional CT scanning
- High-resolution CT should only be used in certain cases

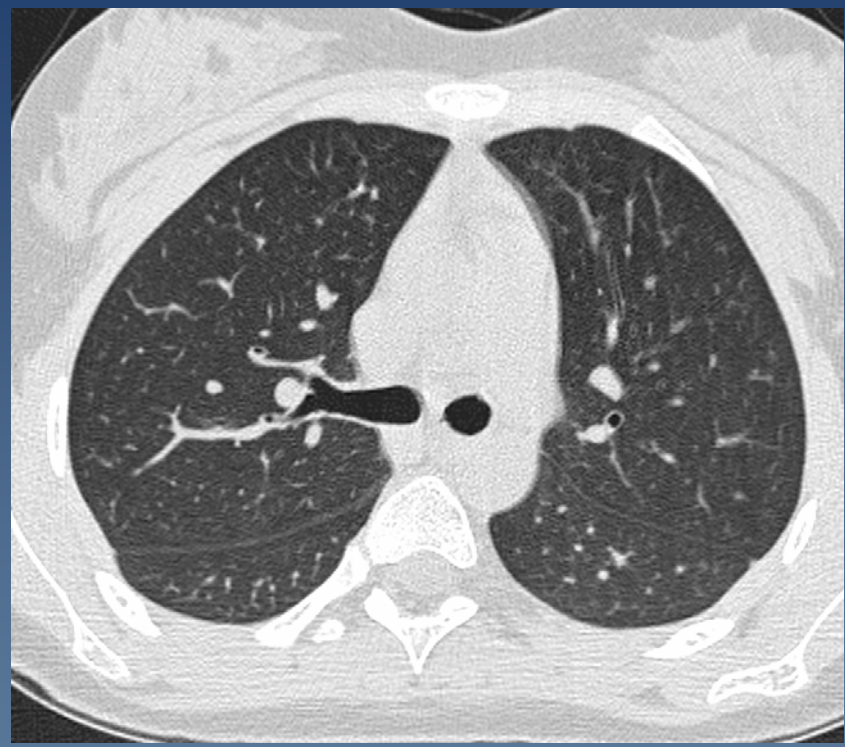
What Makes High-Resolution CT Different?

- Very thin slices are used, usually 1mm thick
- The entire lung is not imaged; usually a 1mm slice is obtained every 10mm
- No intravenous contrast is used
- Images are computer processed to show the lung better than the soft tissues

Effect of Slice Thickness



5mm thick

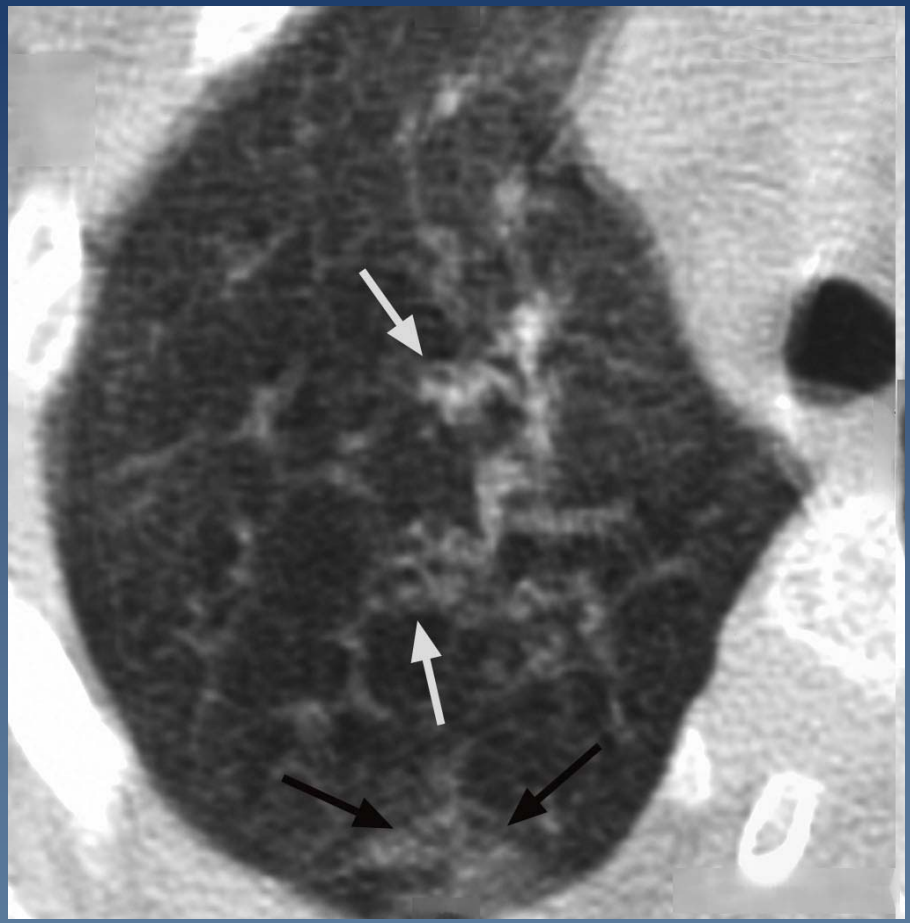


1.25mm thick

High-Resolution CT

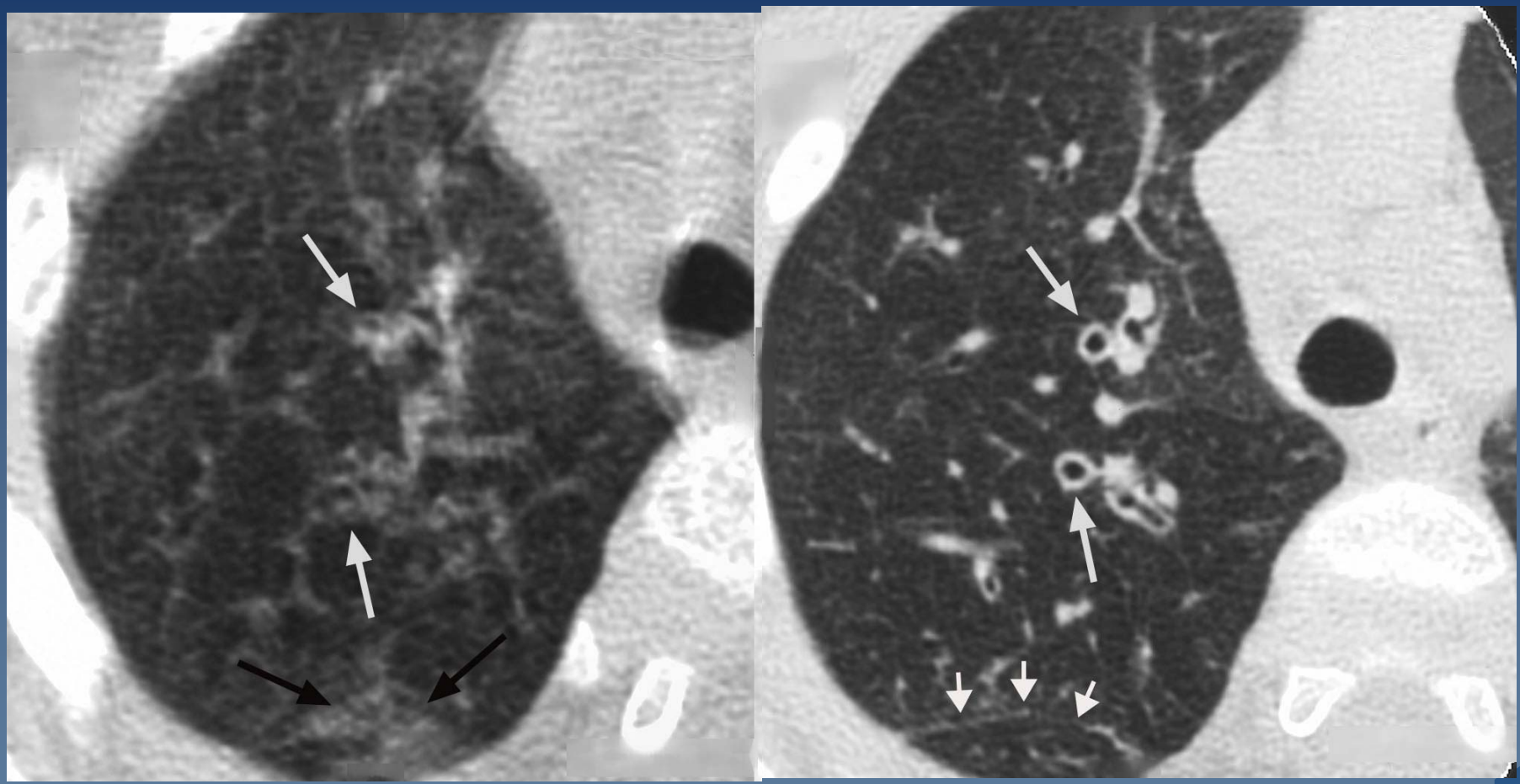
- HRCT is more technically demanding than conventional CT
- HRCT is only useful if high quality images are obtained

Bronchial wall thickening?



Quiet breathing

Bronchial wall thickening?

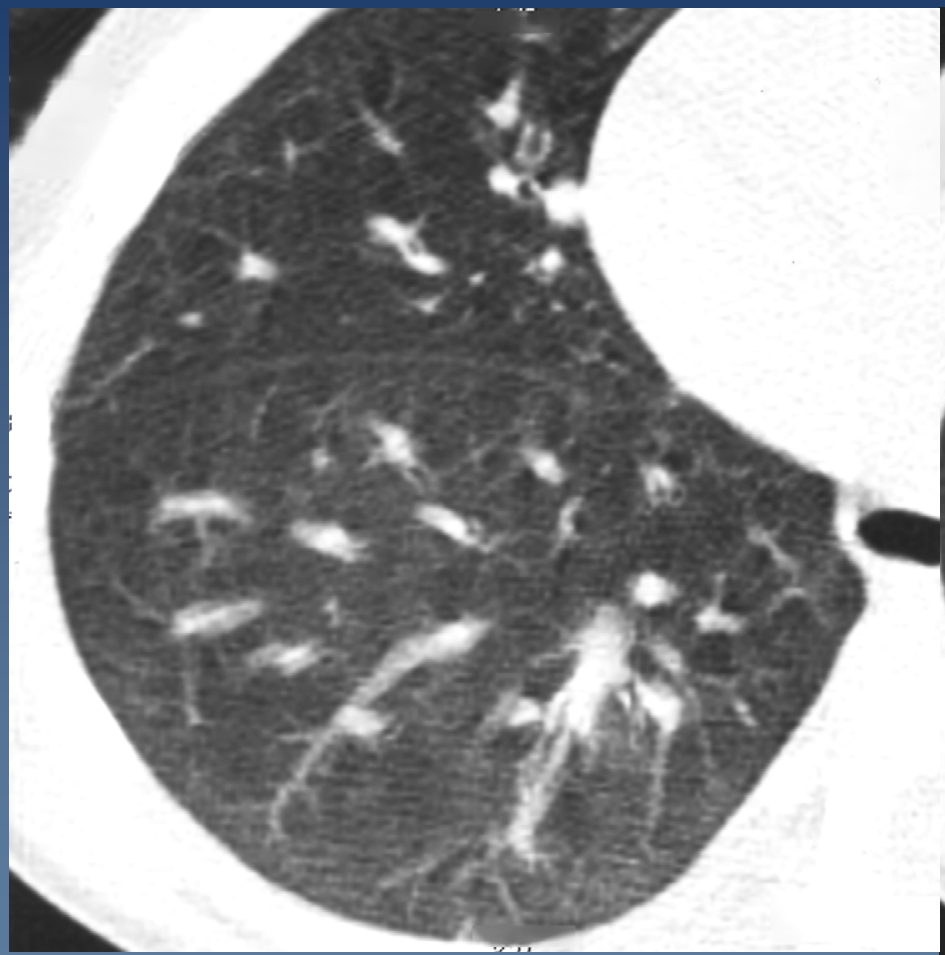


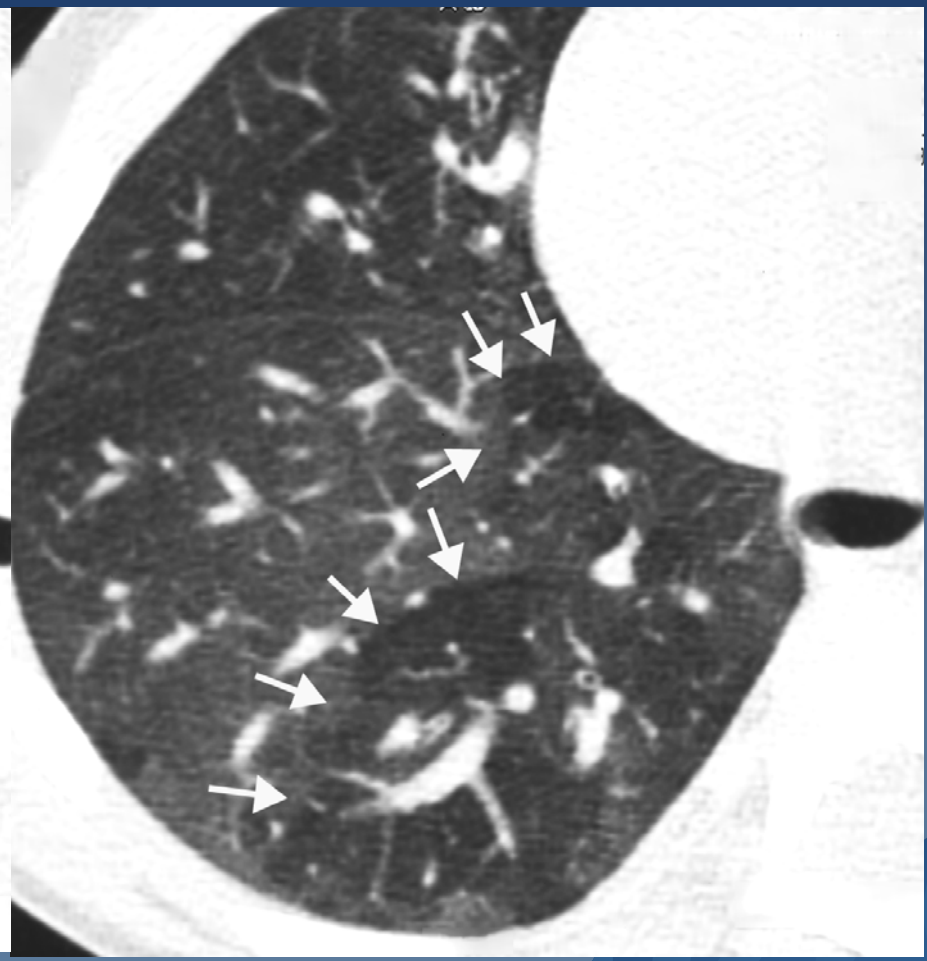
Quiet breathing **Controlled Breath Hold**

Air trapping?

Quiet breathing

Air trapping?





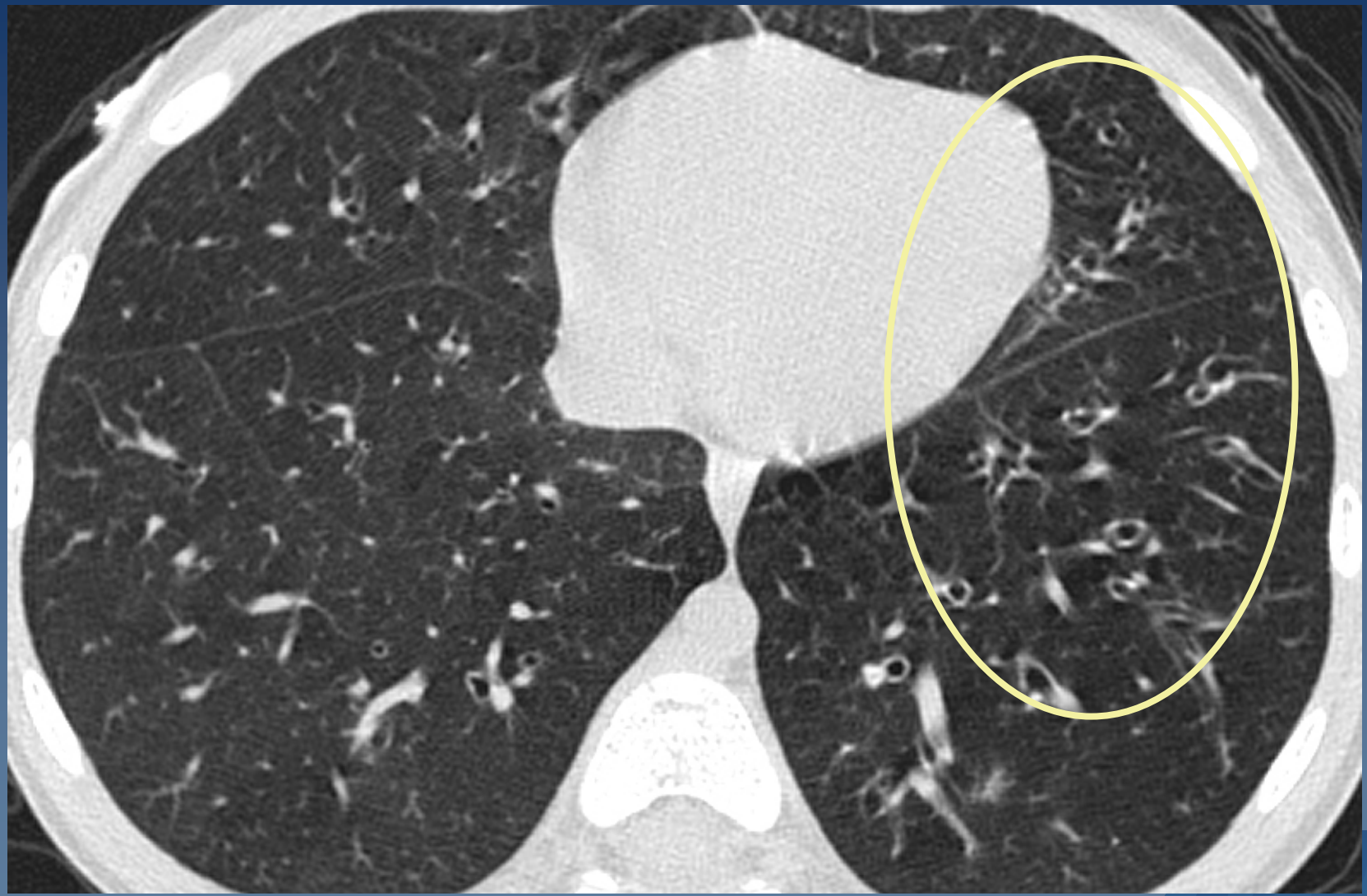
Quiet breathing

Controlled Breath Hold

Bronchiectasis?

Quietly breathing

Bronchiectasis



Full inflation and no motion

When to do an HRCT

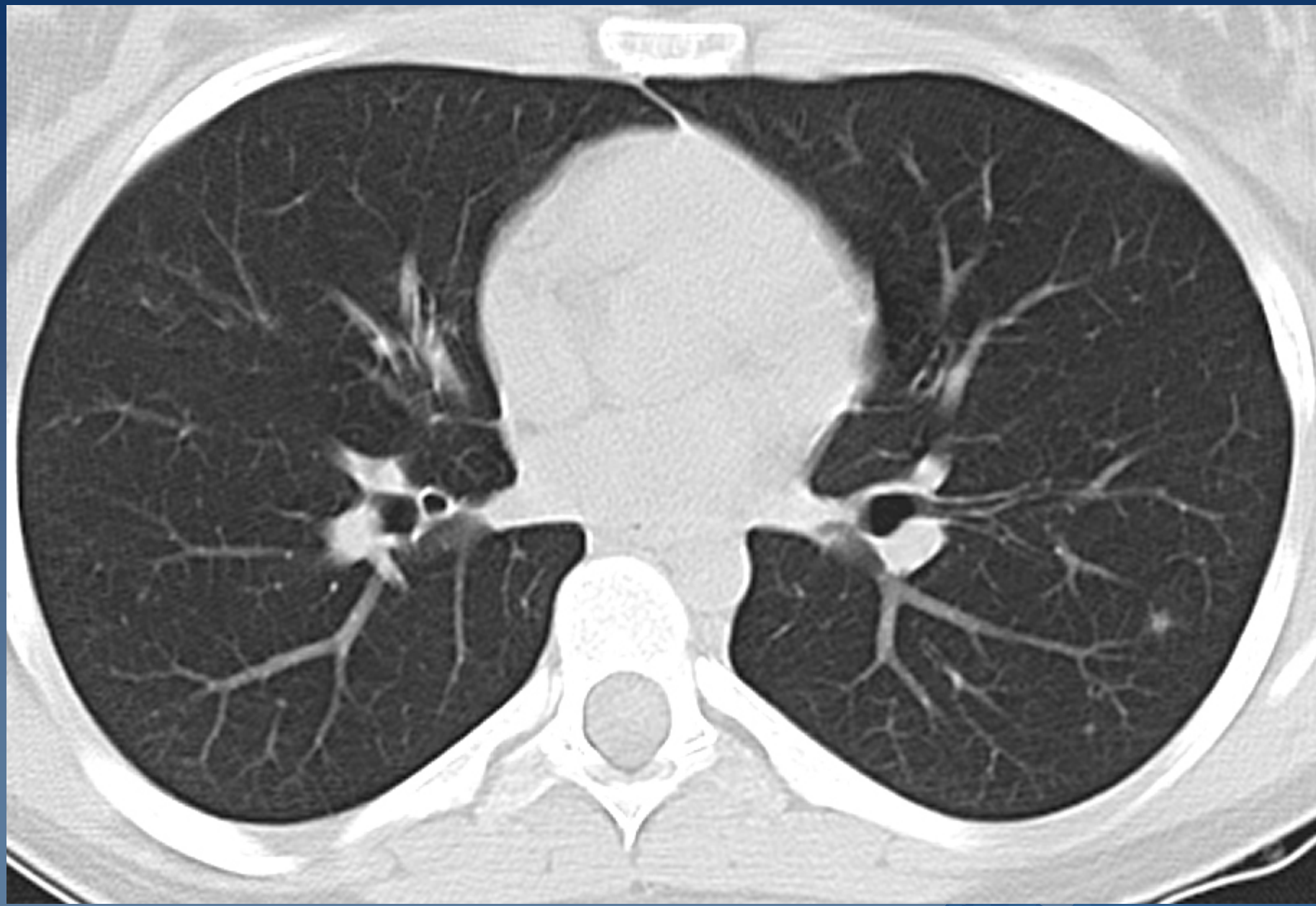
- HRCT provides a low dose way to look at widespread abnormalities
- HRCT does not evaluate the mediastinum or central airways
- HRCT is very unlikely to be useful if conventional CT is normal

Use High-Resolution CT

- For diseases that affect large areas of the lung
  - Interstitial lung disease
  - Emphysema
- When an abnormality is expected to occur at many locations in the lung
  - Bronchiectasis
  - Cystic lung disease

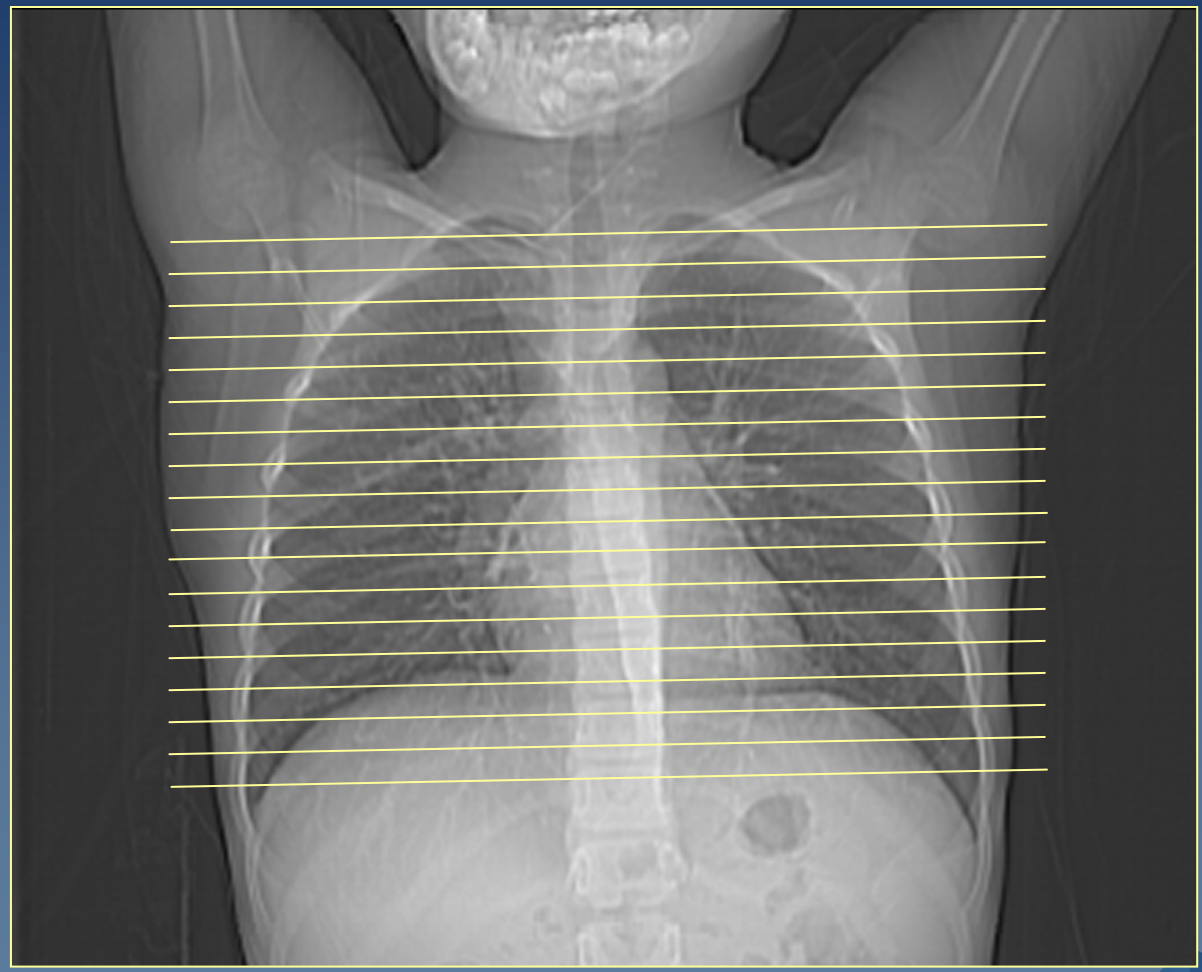
Do Not Use High-Resolution CT

- To evaluate the central airways, the mediastinum, or great vessels
- Any time a small abnormality would change the diagnosis



Conventional CT

High-Resolution CT



Technique

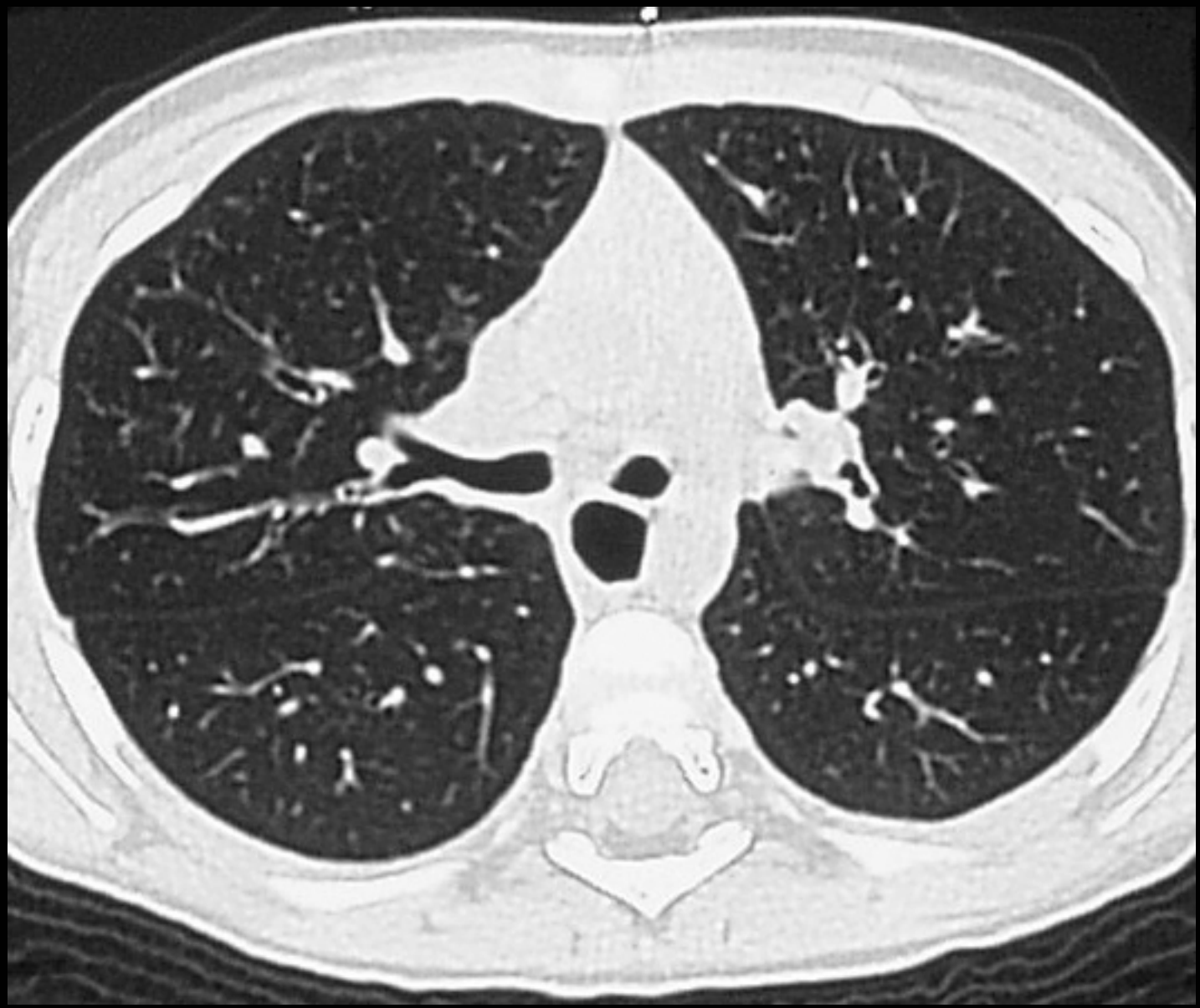
Technique

- The CT scanner should be adjusted to keep the radiation dose as low as possible
  - Smaller patients require less radiation
  - The chest requires less radiation than the abdomen
- 1 slice every 10mm for most patients
- Expiratory images are very helpful, but you should obtain fewer

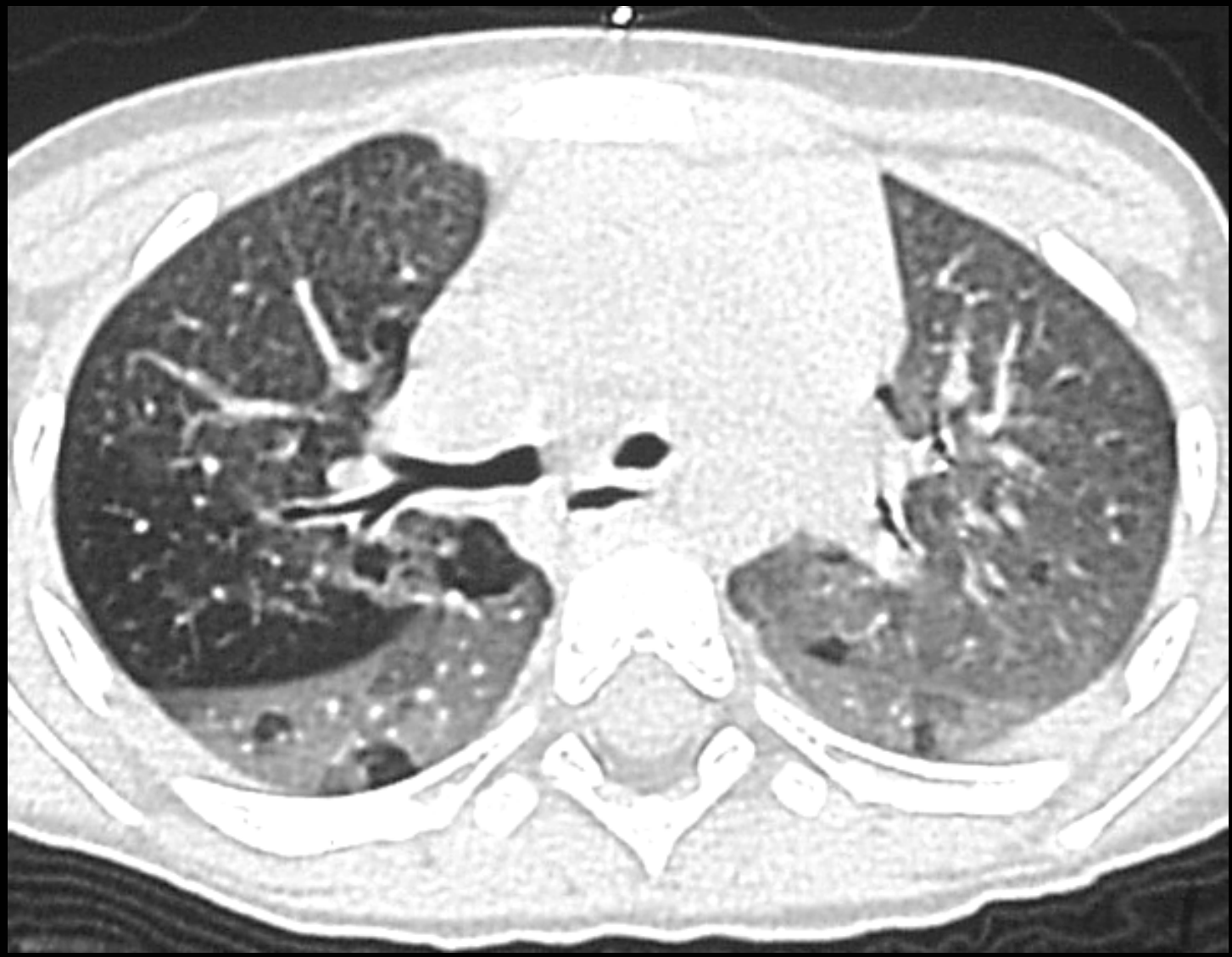
Pediatric CT Technique

	Single Detector		Multi Detector	
Weight (lbs)	Chest mAs	Abdomen/Pelvis mAs	Chest mAs	Abdomen/Pelvis mAs
10-19	40	60	32	48
20-39	50	70	40	56
40-59	60	80	48	64
60-79	70	100	56	80
80-99	80	120	64	96
100-150	100-120	140-150	80-96	112-120
150 +	≥140	≥170	≥110	≥135

4 Year Old with Cystic Fibrosis



Focal Air Trapping



Cooperation for HRCT

- HRCT requires cooperation or control
- Inspiratory images 4 to 6 years old
- Expiratory images 6 to 8 years old
- Coach in room helpful until 10-12 years old

Patient Preparation

- Explain and practice the procedure before entering the scan room
- Practice again on the scanner table
- Talk your patient through the entire procedure

Patients Who Can't Cooperate

- Imaging young children during quiet breathing markedly limits HRCT
  - Motion degrades images
  - Lung volumes are variable, and level of inspiration is unknown
  - Inspiratory/expiratory images cannot be obtained

Controlling Lung Volume

- Decubitus imaging
- Controlled ventilation CT
- General anesthesia

Decubitus Imaging

Decubitus Imaging

- Perform initial high-resolution CT
- Place child in lateral decubitus position
- Down side is expiratory, up side is well inflated

Lucaya, et al. AJR 2000 174:235-41

2 Year Old

Normal appearance

Courtesy Javier Lucaya, MD

Multiple Bronchial Atresias

Courtesy Javier Lucaya, MD

5 Year Old ? Bronchiectasis

Courtesy Javier Lucaya, MD

5 year old

Bronchi abut the mediastinal pleura indicating bronchiectasis

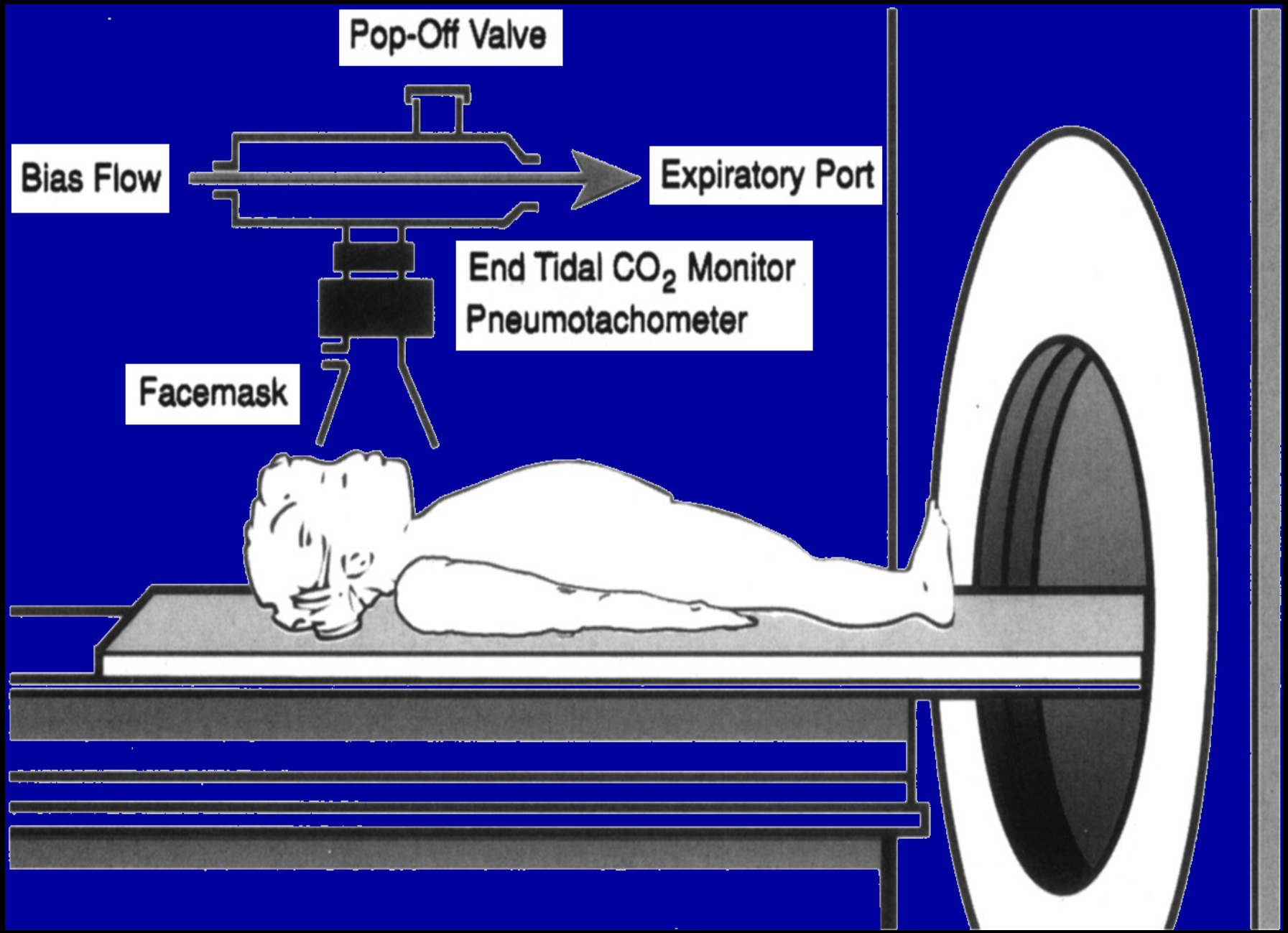
Courtesy Javier Lucaya, MD

Controlled Ventilation CT

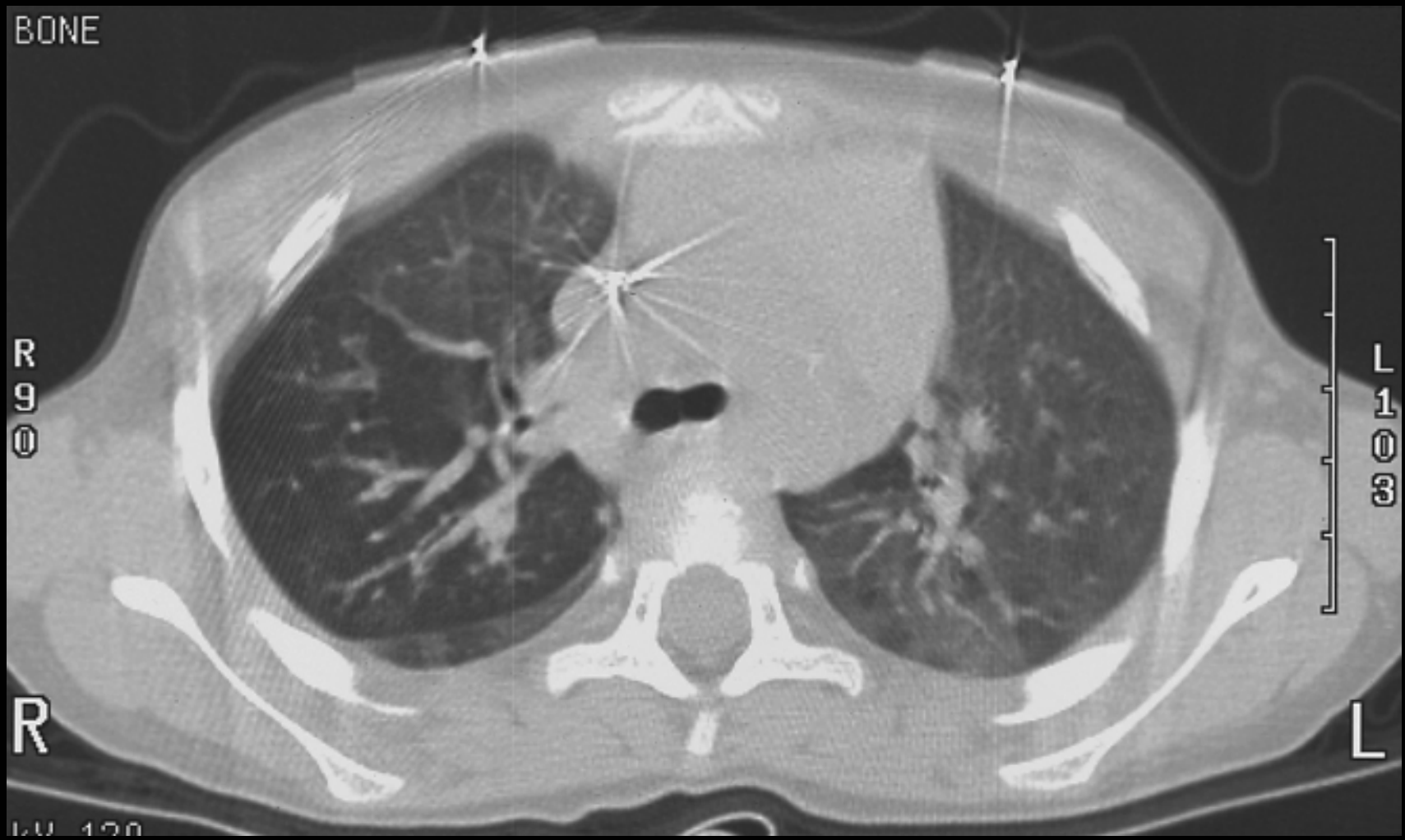
Controlled Ventilation CT (CVCT)

- Mask ventilate sedated child
- CO_2 and chest stretch receptors produce 10-15 seconds of apnea
- Obtain inspiratory and expiratory images during apneic period

Long et al. Radiology, Aug 1999; 588-93

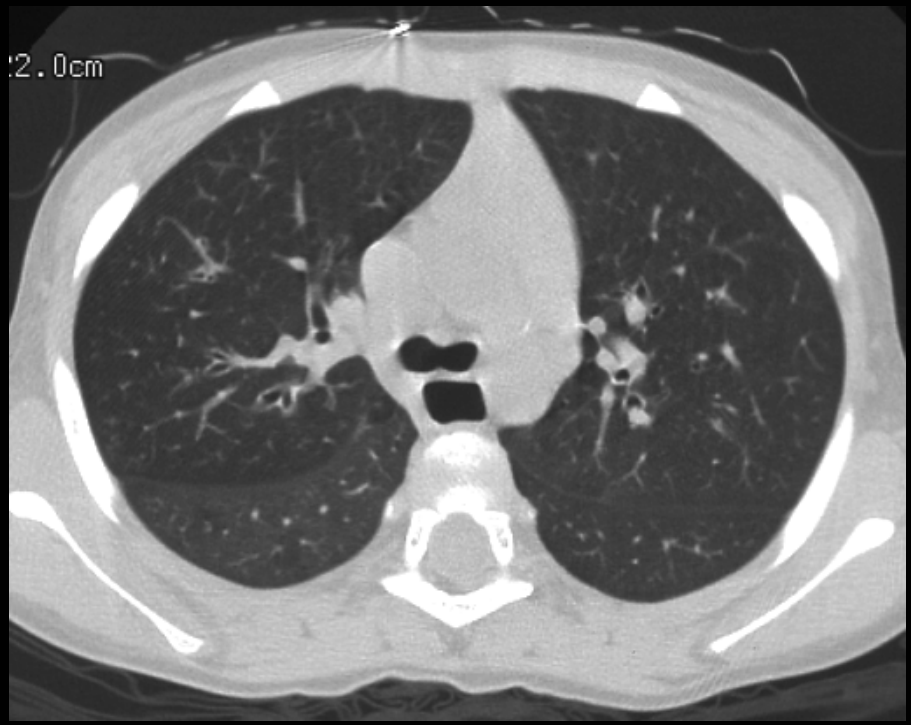

Pop-Off Valve
Bias Flow
Expiratory Port
End Tidal CO_2 Monitor
Pneumotachometer
Facemask

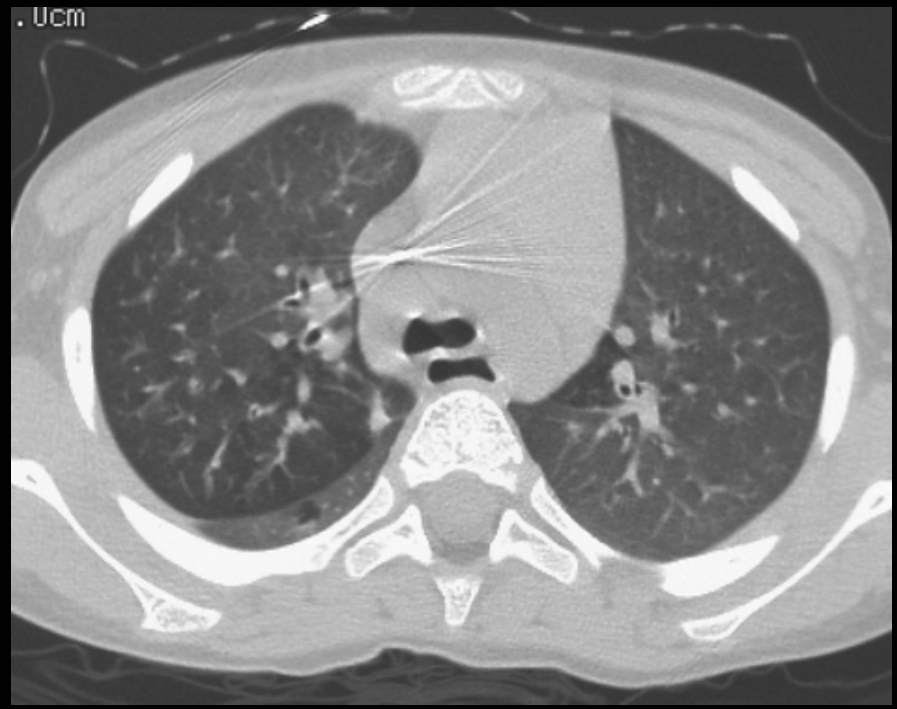
2 Year Old with CF



Courtesy Frederick R. Long, MD

2 yo with CF Controlled Ventilation



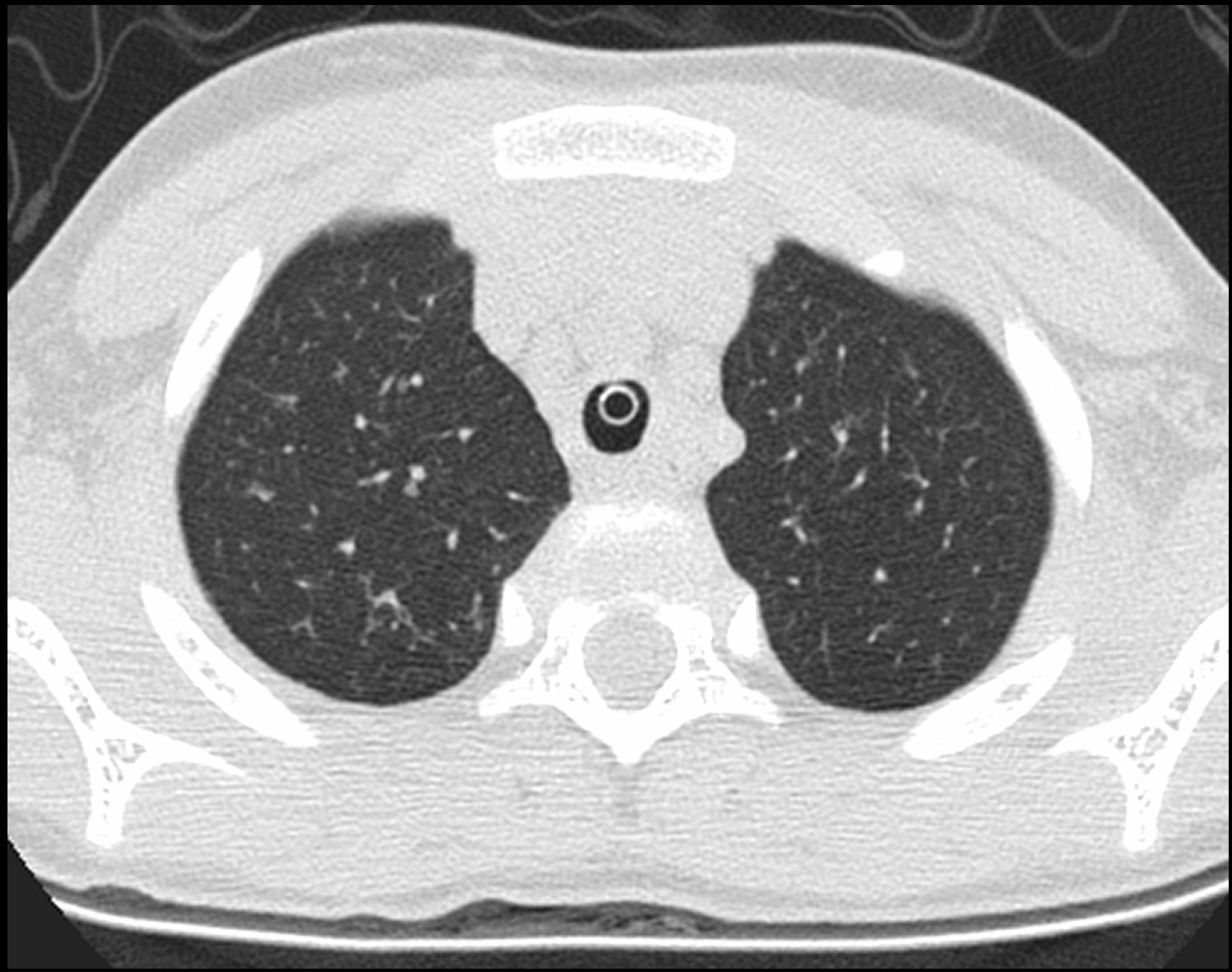


Courtesy Frederick R. Long, MD

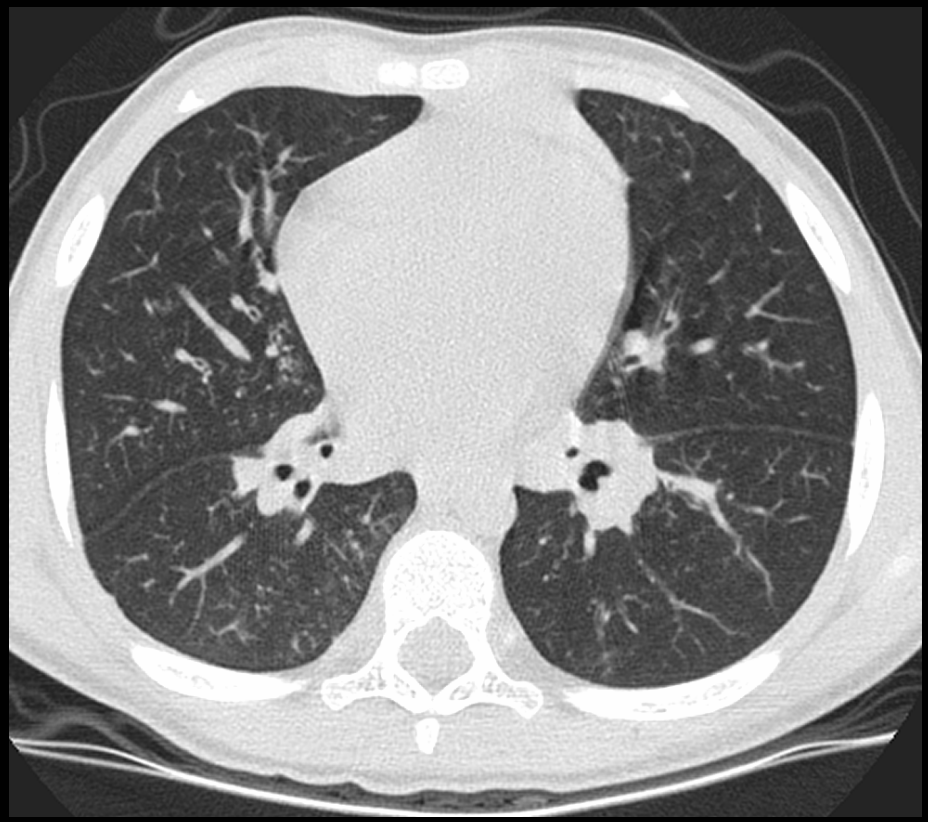
Controlled-Ventilation CT

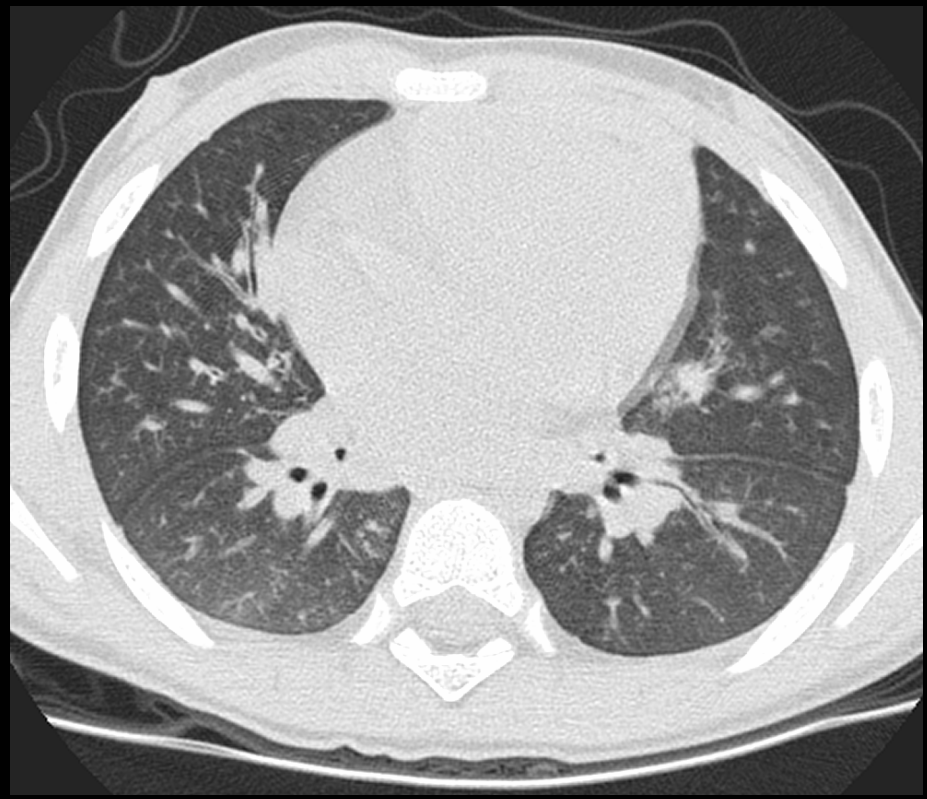
- Safe technique
  - used for infant PFTs on thousands of children
- Effective
  - success rate > 90%
- Requires training
  - Respiratory Therapist or other health care provider
  - Coordination with CT technologist
- Must have a well-established sedation program in place

General Anesthesia



General Anesthesia
Inspiratory and Expiratory Images





General Anesthesia

- Atelectasis is a frequent problem
- Maintain 30 cm water inspiratory pressure with frequent sighs
- Begin scanning as soon as possible

Interpreting Pediatric HRCT

Interpreting Pediatric HRCT

- “Evaluation of the lung parenchyma is not straightforward in neonates and infants”

David Hansell, HRCT of Diffuse Lung Disease, Radiol Clin North Am, Nov 2001

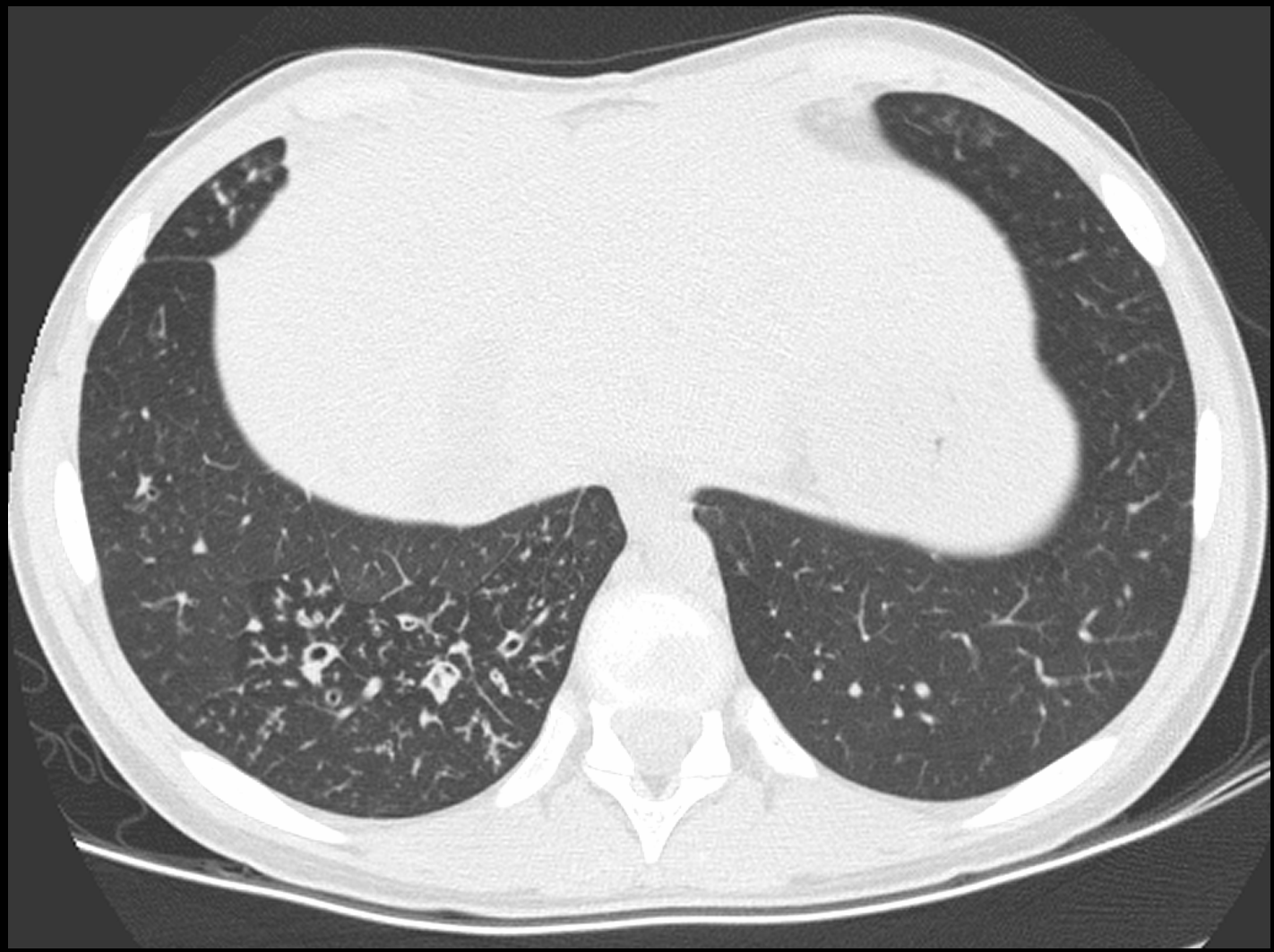
Interpreting Pediatric HRCT

- Evaluate the large and small airways
- Identify parenchymal abnormalities
  - ground glass, nodules, cysts, emphysema, linear/reticular densities
- Adult terms work well for description
- Diagnostic possibilities are often very different

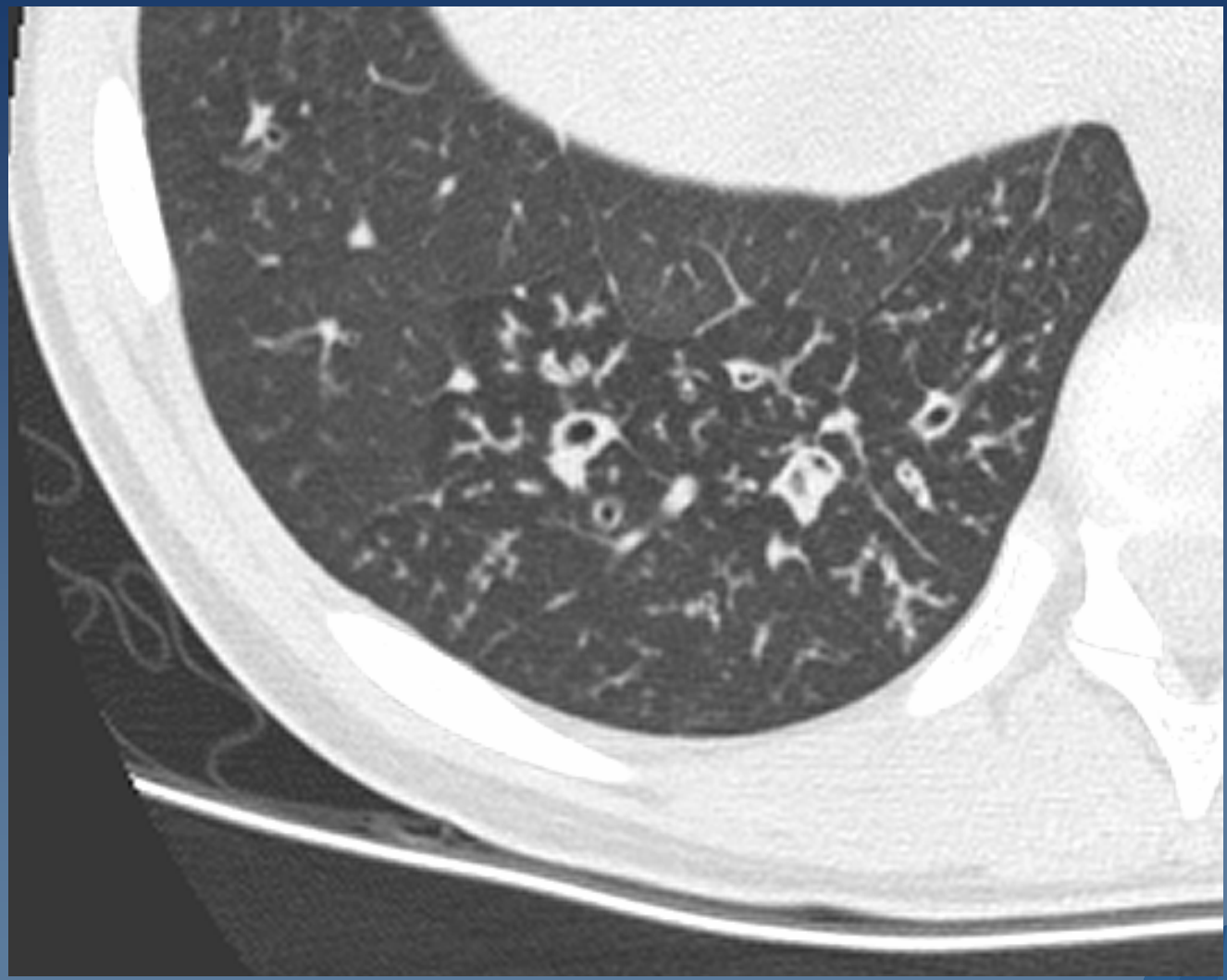
Illustrative Cases

- Children are not little adults
- Make friends with your pathologist
- Pulmonologists and radiologists must work together
- Take advantage of new information

11 yo with Frequent Infections



Tree-In-Bud Opacities



Tree-In-Bud

- Material filling distal bronchioles
- Frequently thought to mean infection, especially non-tuberculous mycobaterium
- In children without an underlying condition probably most often seen with chronic aspiration

15 Year Old Shortness of Breath

?? Idiopathic Pulmonary Fibrosis ??

- Appearance in children often associated with autoimmune/ connective tissue disorders
- Little fibrosis on biopsy
- May respond to steroids or hydroxychloroquine
- Often stable for long periods of time

Idiopathic pulmonary fibrosis in infants: good prognosis with conservative management. Hacking, et al. Arch Dis Child 2000;83:152-157

?? Idiopathic Pulmonary Fibrosis ??

- "… despite more than 100 reported cases of IPF in children (including two reported by LLF), the diagnostic fibroblastic foci were not reported in any"

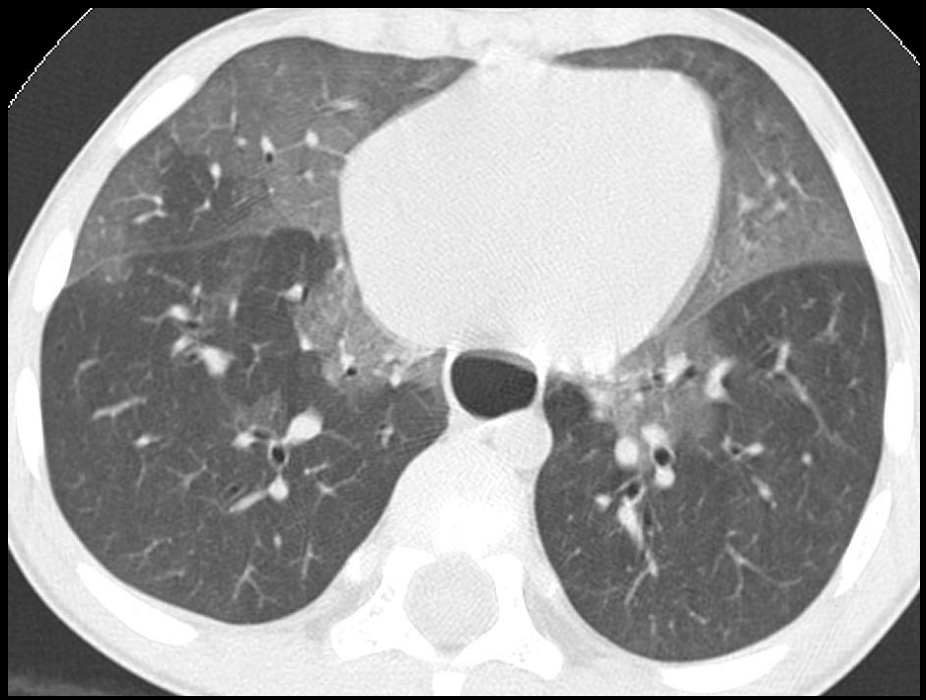
Fan LL, Deterding RR, Langston C. Pediatric Interstitial Lung Disease Revisited. Ped Pulmonol 2004 38:369-378

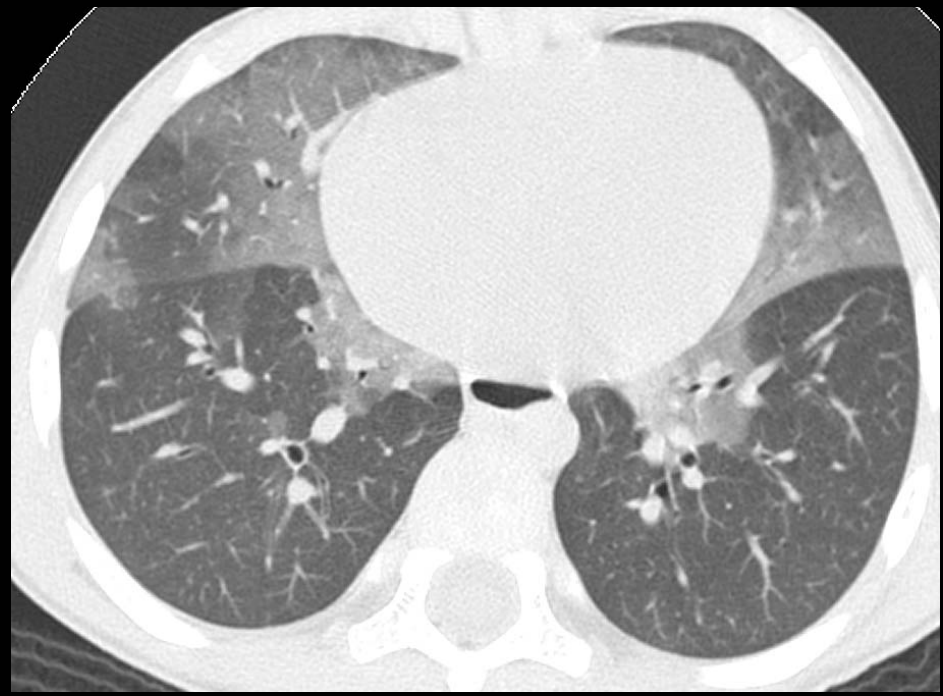
?? Idiopathic Pulmonary Fibrosis ??

- Idiopathic pulmonary fibrosis is not seen in children
- Pulmonary fibrosis does occur; when suspected biopsy is required

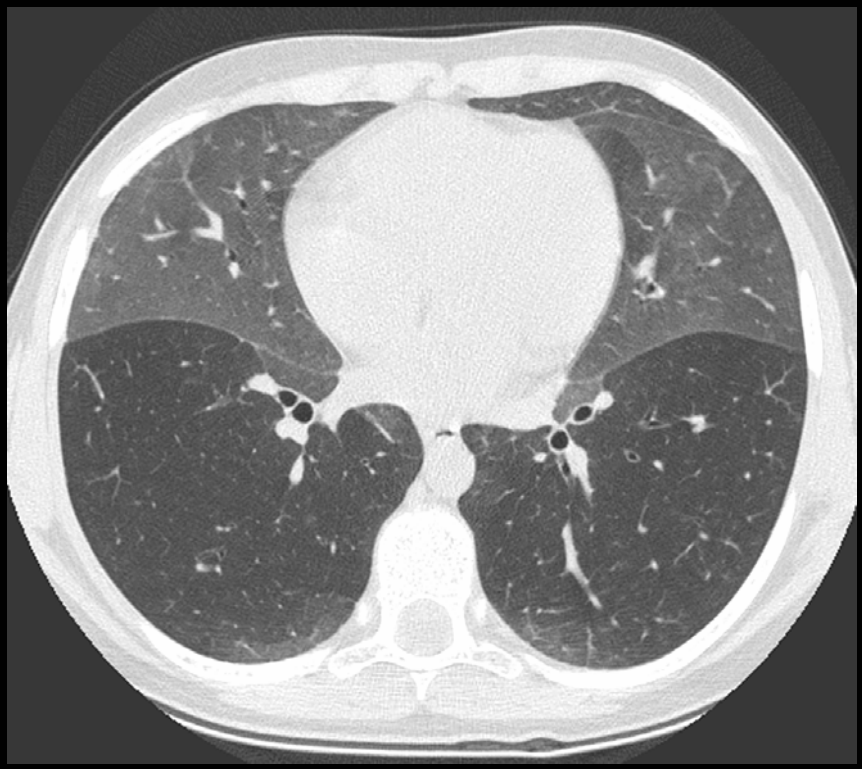
Two Children with Tachypnea

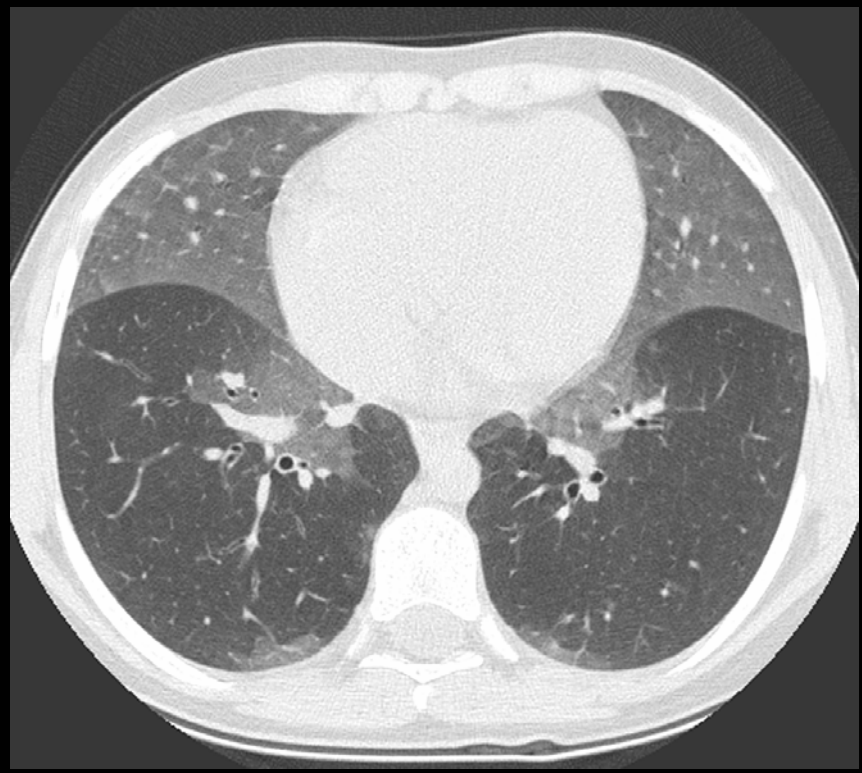
2 year old
Follicular Bronchiolitis



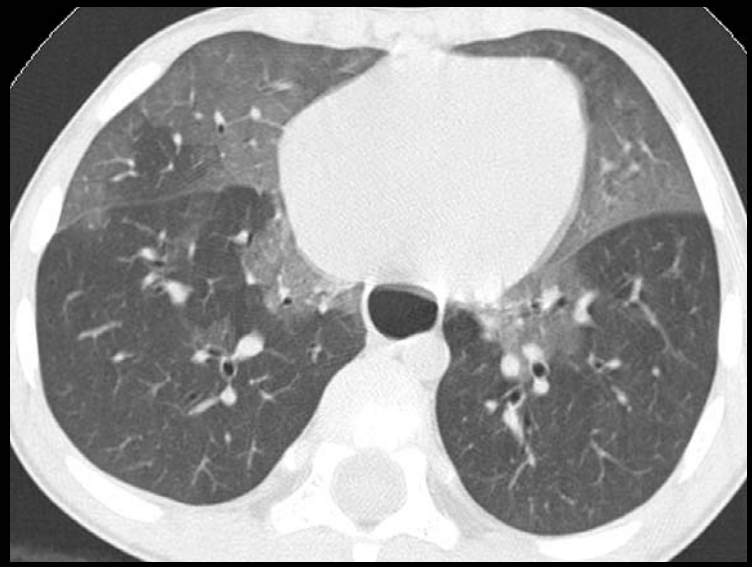


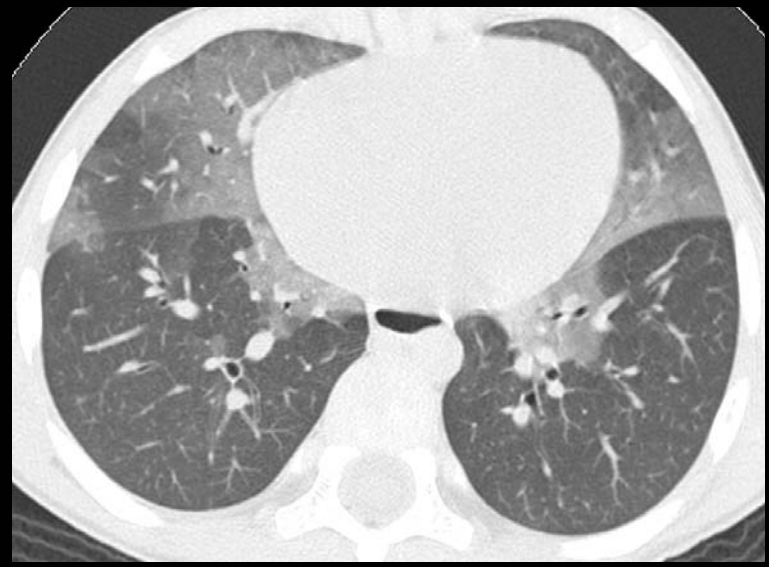
4 Year Old
Nonspecific Lymphoid Infiltrate



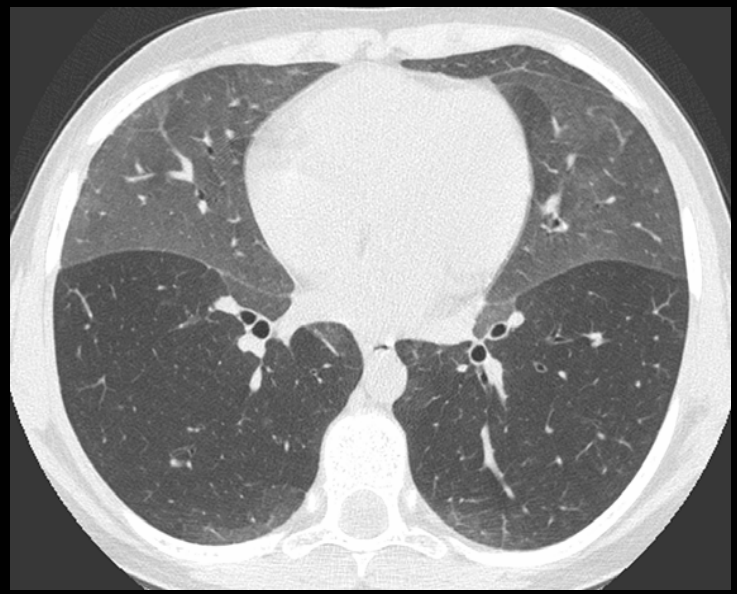


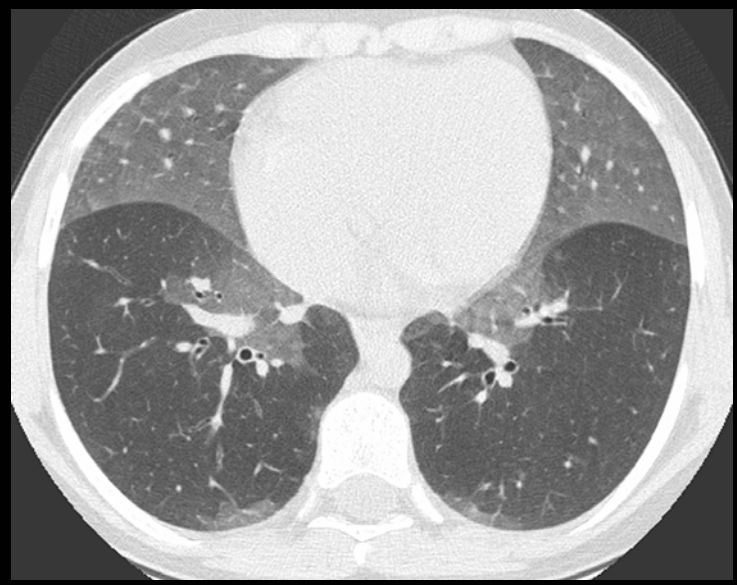
Follicular Bronchiolitis



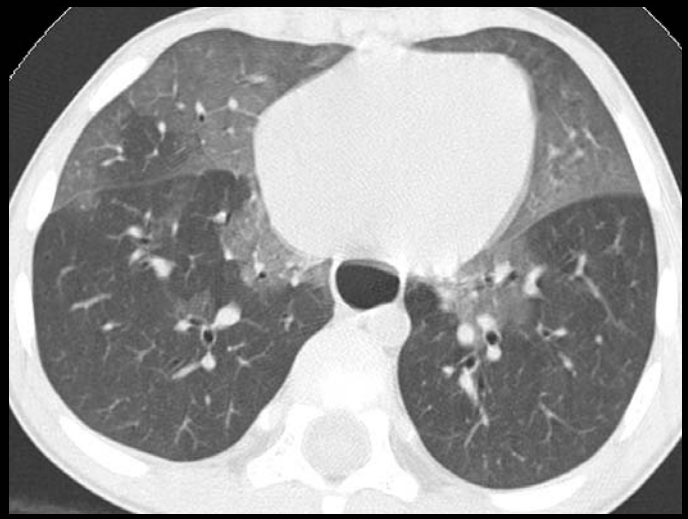


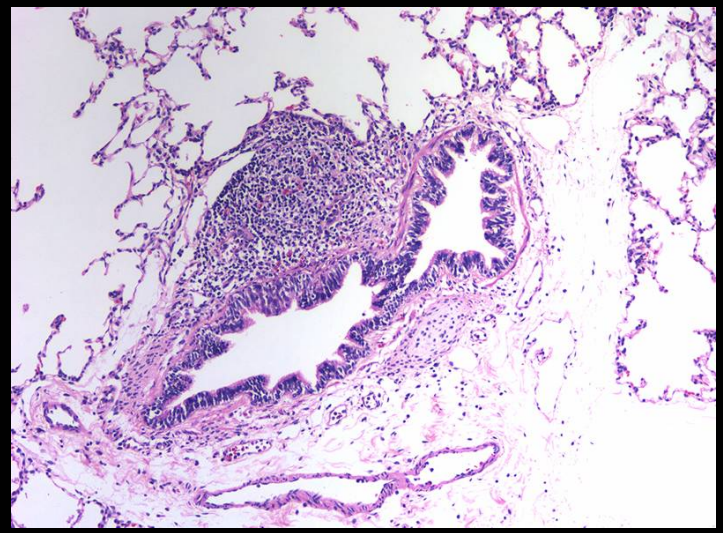
Nonspecific Lymphoid Infiltrate



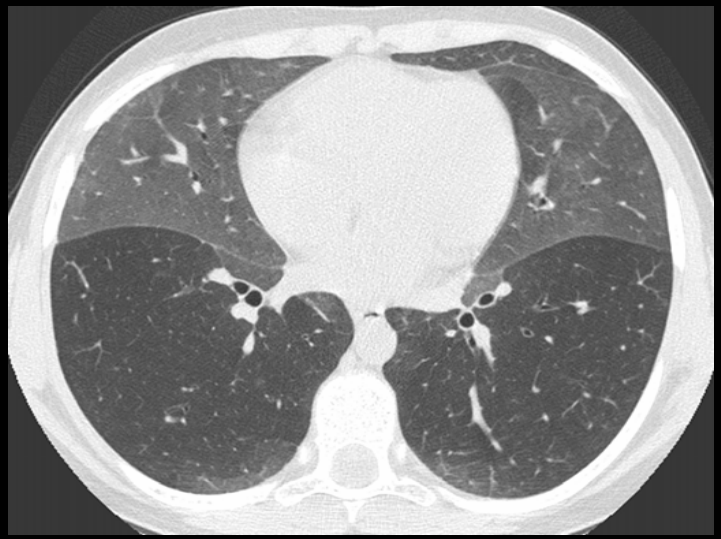


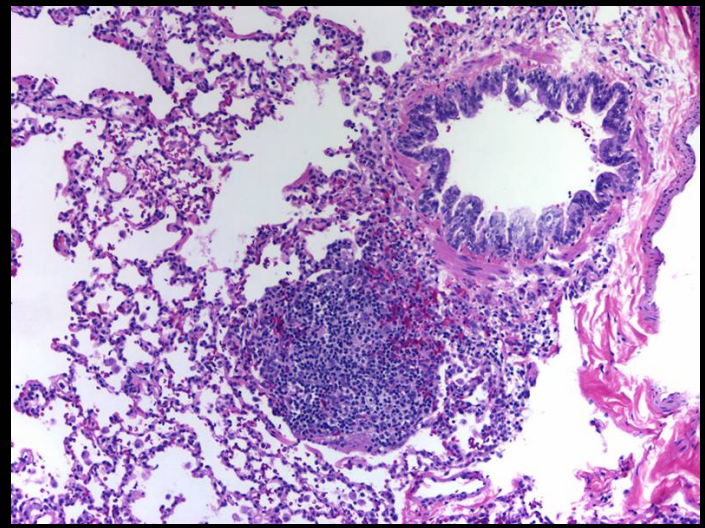
“Follicular Bronchiolitis”





Nonspecific Lymphoid Infiltrate





Neuroendocrine Cell Hyperplasia of Infancy (NEHI)

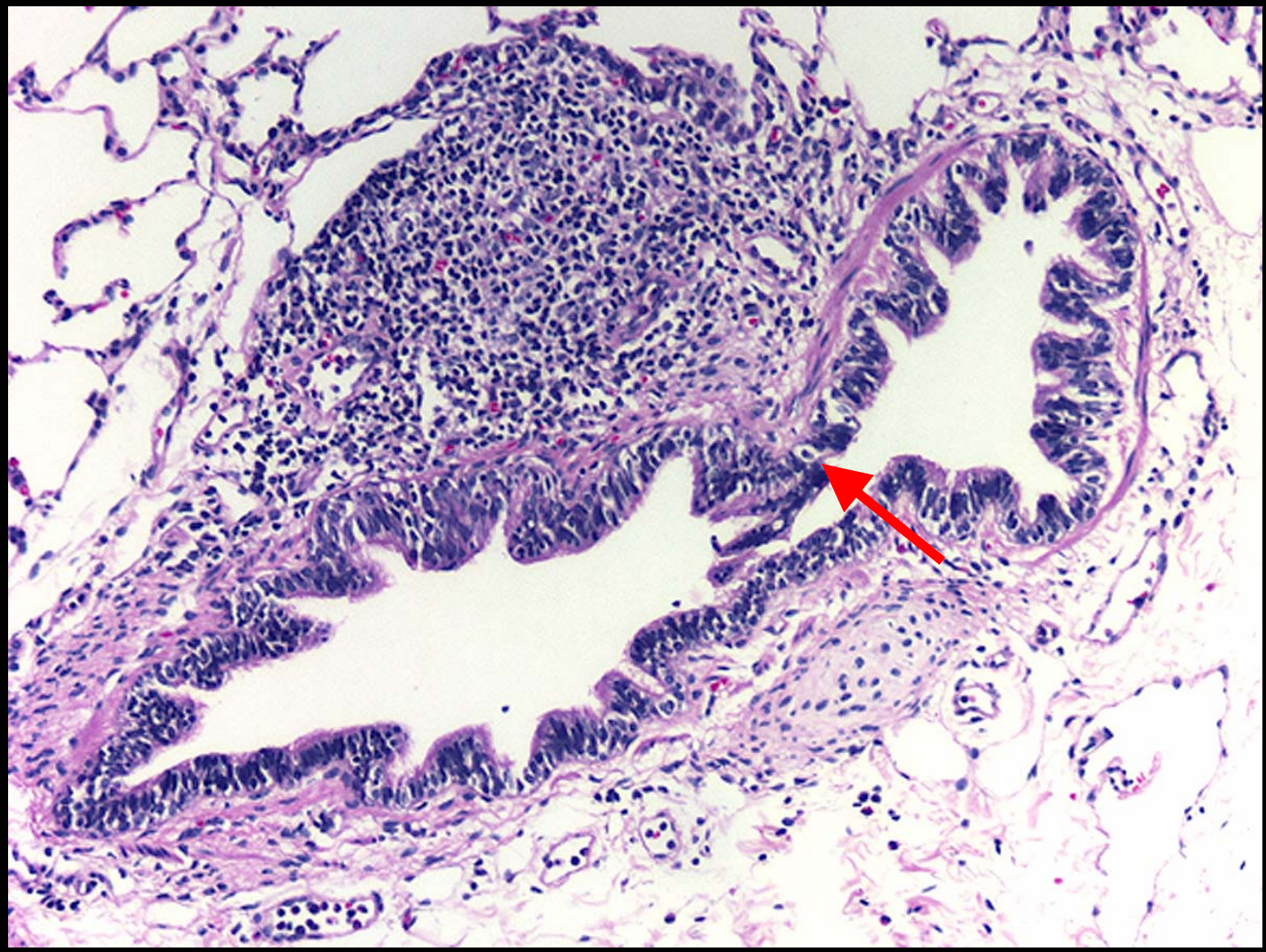
Neuroendocrine Cell Hyperplasia of Infancy (NEHI)

- Originally called Persistent Tachypnea of Infancy (PTI)
- New entity with specific clinical and pathologic findings
- Begins in first year with tachypnea, hypoxia, and minimal abnormalities on CXR and auscultation

Neuroendocrine Cell Hyperplasia of Infancy (NEHI)

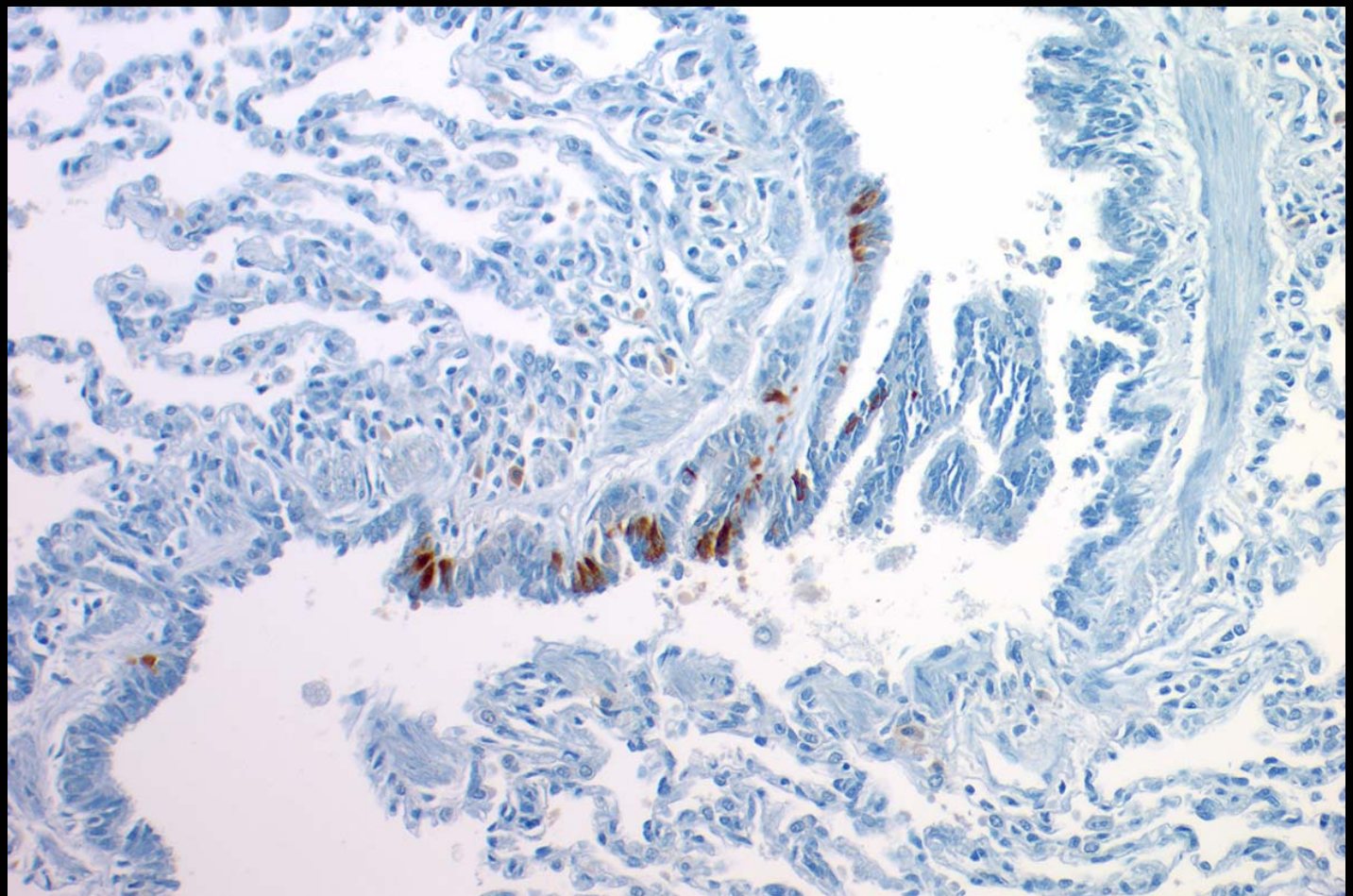
- Pathology characterized by mild inflammatory and lympocytic infiltration on biopsy
- Increased clear cells in distal airways
- Clear cells stain with bombesin, a neuroendocrine cell marker

Neuroendocrine Cell Hyperplasia of Infancy (NEHI)



Neuroendocrine Cell Hyperplasia of Infancy

Bombesin Immunostaining



Neuroendocrine Cell Hyperplasia of Infancy

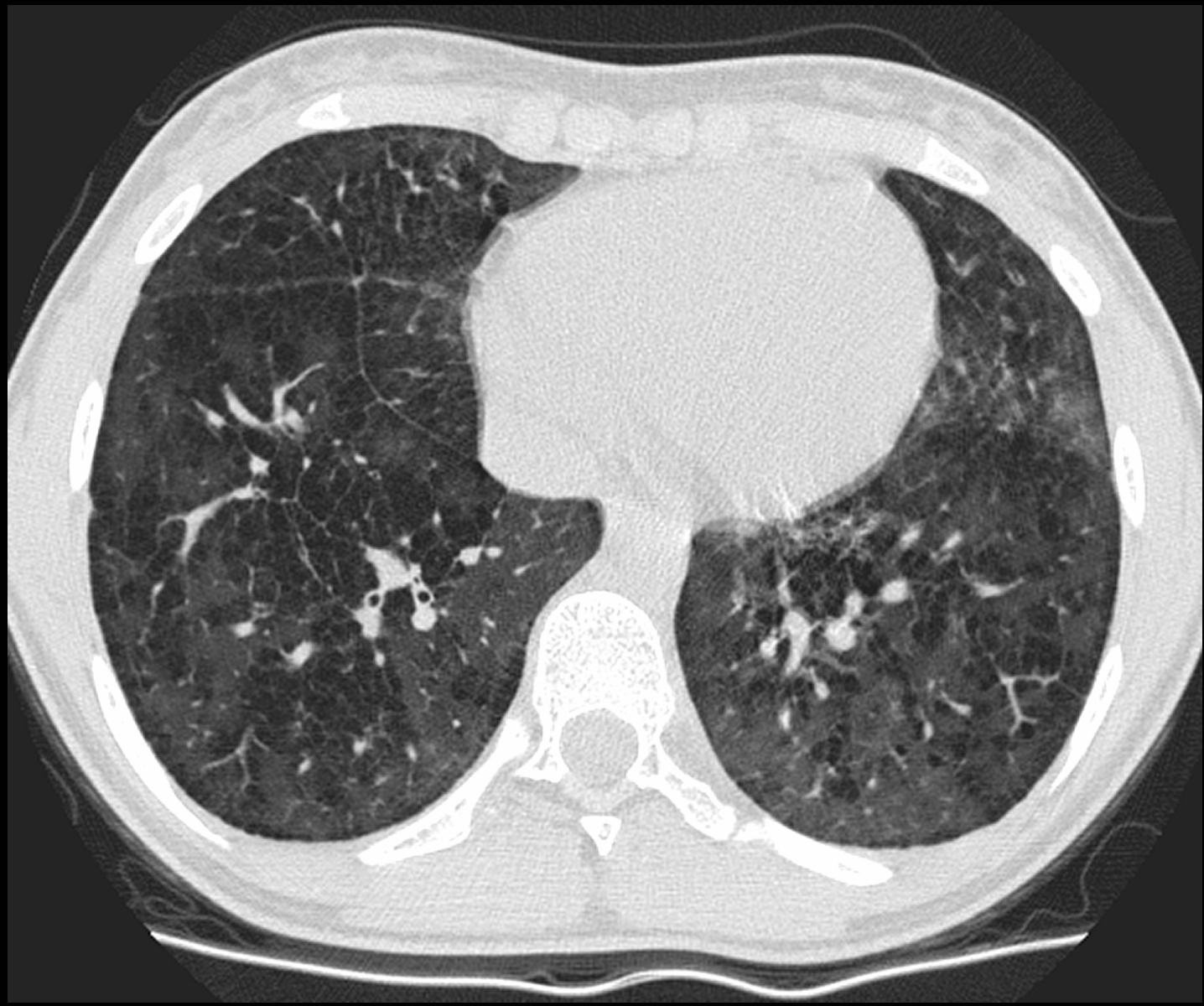
- Prolonged course (years), but eventual improvement
- Steroids are often ineffective

- Bombesin immunostaining must be performed to make the diagnosis

Two Children with Chronic Lung Disease

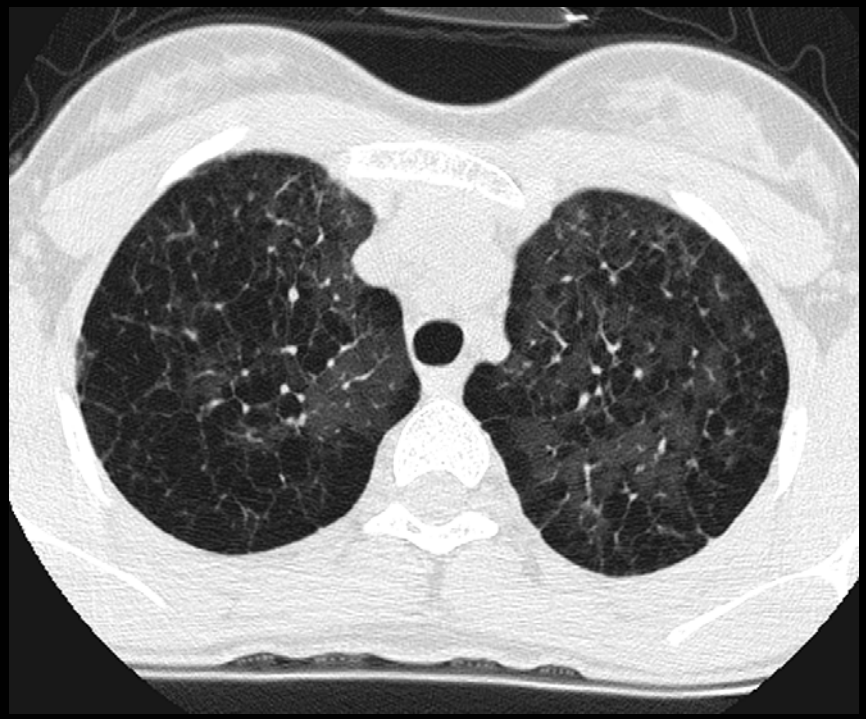
5 Year Old, Chronic Lung Disease

13 Year Old, Chronic Lung Disease



Sisters with Surfactant Protein C Deficiency

5 year old



13 year old

Surfactant Protein Mutations

- Surfactant protein is composed of 4 parts A to D
- Surfactant protein B mutation
  - autosomal recessive
  - lethal in the newborn period
- Surfactant protein C mutation and ATP binding cassette A3 mutation (ABCA3)
  - probably dominant
  - variable course

Surfactant Protein Mutations

- Can cause interstitial lung disease from infancy through adulthood
- Many cases of nonspecific interstitial pneumonia (NSIP) in children are probably due to surfactant mutations

Summary

When Should I Request an HRCT?

- When a diffuse process is suspected
- When I need the best possible evaluation of the lung parenchyma
- When I am not looking at small lesions, the mediastinum, or the vascular structures

How Do I Get Better Images?

- Train cooperative children
- Control ventilation when needed
- Be sure that the radiation dose is low and the quality is high

How Can I Learn More from the Images?

- Form a team
  - Radiologist
  - Pulmonologist
  - Pathologist
- Seek out new information
  - Idiopathic pulmonary fibrosis does not occur in children
  - Neuroendocrine cell hyperplasia of infancy
  - Surfactant protein abnormalities

Contributors

- Robin Deterding
- Gail Deutsch
- Eric Crotty
- Eric Effmann
- Leland Fan
- Claire Langston
- Fred Long
- Javier Lucaya
- Robert Wood

Thank You for Your Attention

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