HRCT in ILD

Recognizing Key Diagnostic Patterns

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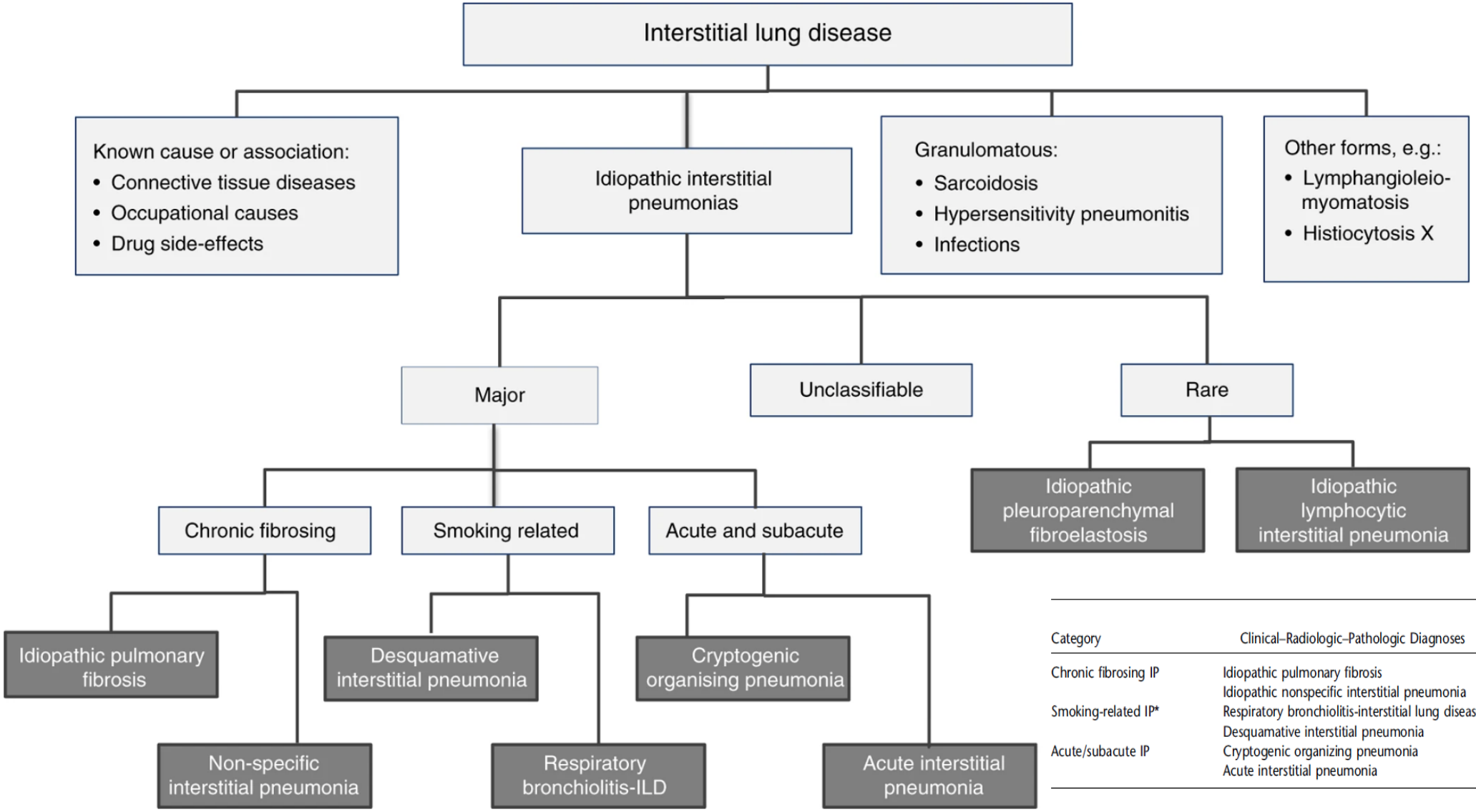
차례

- ILD Classification & ILA
- CT Signs of Fibrosis
- HRCT UIP Pattern (2018 & 2022 ATS/ERS/JRS/ALAT Guidelines)
- Other ILD CT Pattern (alternative diagnosis)

차례

- **ILD Classification & ILA**
- CT Signs of Fibrosis
- HRCT UIP Pattern (2018 & 2022 ATS/ERS/JRS/ALAT Guidelines)
- Other ILD CT Pattern (alternative diagnosis)

2013 ATS/ERS classification of idiopathic interstitial pneumonias



Category	Clinical–Radiologic–Pathologic Diagnoses	Associated Radiologic and/or Pathologic–Morphologic Patterns
Chronic fibrosing IP	Idiopathic pulmonary fibrosis	Usual interstitial pneumonia
	Idiopathic nonspecific interstitial pneumonia	Nonspecific interstitial pneumonia
Smoking-related IP*	Respiratory bronchiolitis-interstitial lung disease	Respiratory bronchiolitis
	Desquamative interstitial pneumonia	Desquamative interstitial pneumonia
Acute/subacute IP	Cryptogenic organizing pneumonia	Organizing pneumonia
	Acute interstitial pneumonia	Diffuse alveolar damage

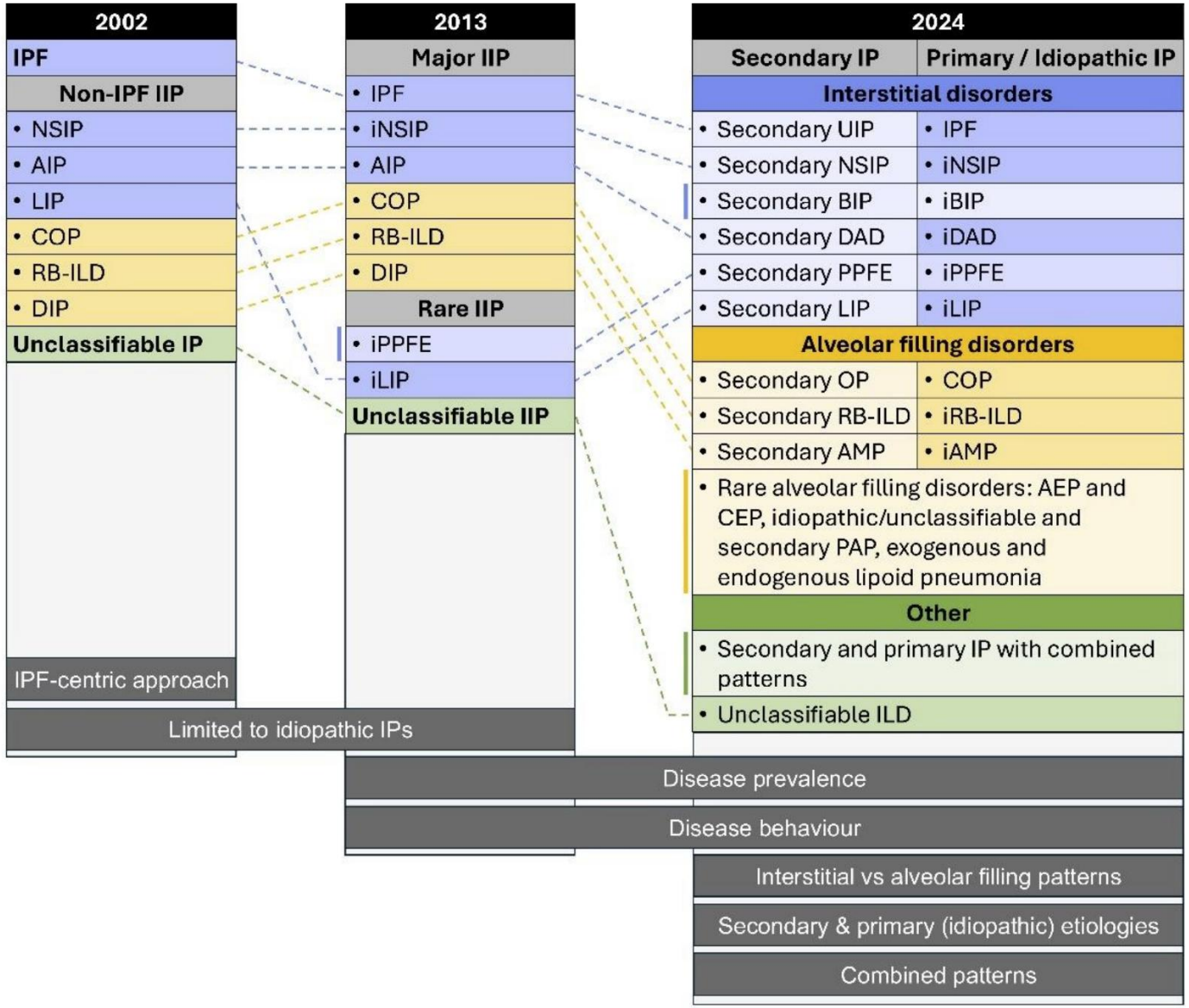
Travis WD et al. AJRCCM 2013; Zibrak JD et al. NPJ Prim Care Respir Med 2014

2024 ERS/ATS Multidisciplinary Classification of interstitial pneumonias

	Morphologic patterns by Pathology and Imaging	Major clinical-radiologic-pathologic diagnoses	
		Secondary	Primary / Idiopathic
Interstitial patterns	Usual interstitial pneumonia (UIP)	**Secondary UIP** (*e.g.*, CTD, HP, medications)	**Idiopathic pulmonary fibrosis** (Idiopathic UIP)
	Nonspecific interstitial pneumonia (NSIP)	**Secondary NSIP** (*e.g.*, CTD >>> HP, medications)	**Idiopathic NSIP**
	Bronchiolocentric interstitial pneumonia (BIP)*	**Secondary BIP** (*e.g.*, HP >>> CTD, aspiration, inhalational exposures, medications)	**Idiopathic BIP** *(provisional diagnosis*)*
	Diffuse alveolar damage (DAD)	**Secondary DAD** (multiple causes)	**Idiopathic DAD** (acute interstitial pneumonia)
	Pleuroparenchymal fibroelastosis (PPFE)	**Secondary PPFE** (*e.g.*, IPF, CTD, HP, medications, radiation, transplant [restrictive allograft syndrome, pulmonary infection [post-tuberculosis], occupational)	**Idiopathic PPFE**
	Lymphoid interstitial pneumonia (LIP)	**Secondary LIP** (*e.g.*, CTD, immune deficiency)	**Idiopathic LIP**
Alveolar filling patterns	Organising pneumonia (OP)	**Secondary OP** (*e.g.*, CTD, post-infectious, medications, aspiration)	**Cryptogenic OP** (Idiopathic OP)
	Respiratory bronchiolitis-ILD (RB-ILD)	**Secondary RB-ILD** (*e.g.*, smoking >>> CTD, medications, aspiration, hereditary)	**Idiopathic RB-ILD**
	Alveolar macrophage pneumonia† (AMP)	**Secondary AMP** (*e.g.*, smoking >>> CTD, medications, aspiration, hereditary	**Idiopathic AMP**
	Rare alveolar filling disorders	*e.g.*, **Acute and chronic eosinophilic pneumonia**, **pulmonary alveolar proteinosis, lipoid pneumonia** (See **Supplemental Table 1**)	
Other	Combined pattern	**Multiple combinations** (*e.g.*, NSIP + OP, UIP + PPFE)	
	Unclassifiable pattern	**Unclassifiable ILD** (multiple undefined patterns)	

Ryerson CJ et al. ERJ 2025

2024 ERS/ATS Multidisciplinary Classification of interstitial pneumonias



Ryerson CJ et al. ERJ 2025

Interstitial lung abnormality

Chest CT showing bilateral and nondependent ground-glass opacities, reticular abnormalities, lung distortion, traction bronchiectasis, and/or honeycombing involving ⩾5% of a lung zone*

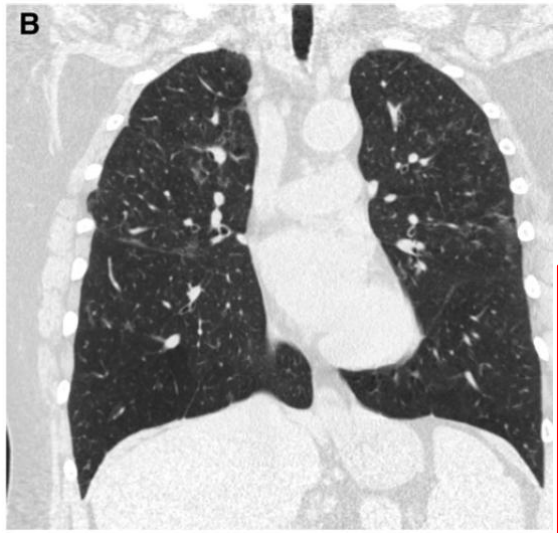
Definition of interstitial lung disease for those with ILAs

In a person with CT features of ILAs, at least one of the following criteria must be present to define ILD*

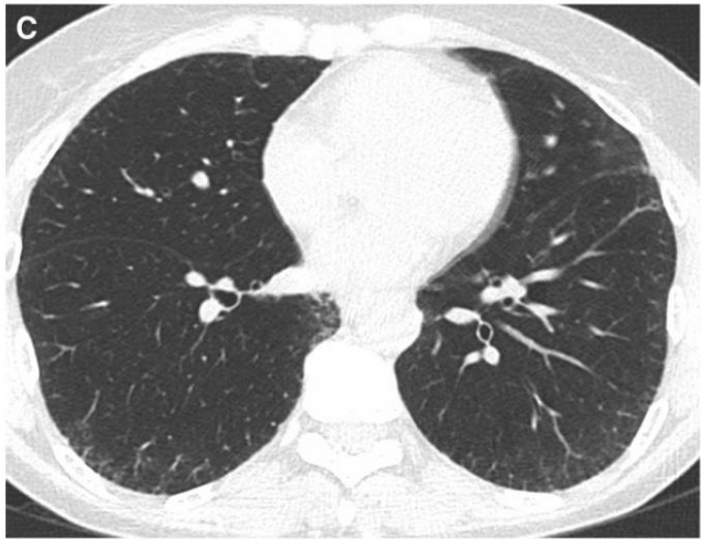
- Symptoms: Any amount of dyspnea and/or cough that a clinician attributes to ILD
- Physiology (any of)
  - Any abnormality in FVC, TLC, or D_{LCO} that a clinician attributes to ILD (defined as a value or *z*-score below the lower limit of normal)
  - Satisfies physiologic criteria for progressive pulmonary fibrosis that a clinician attributes to ILD (9)
- Imaging (any of the following on chest CT)
  - Fibrotic abnormalities (honeycombing and/or reticulation with traction bronchiectasis) involving ⩾5% of total lung volume by visual estimate
  - Progressive fibrotic abnormality on serial chest CT
  - Presence of a major fibrotic ILD pattern on chest CT (i.e., UIP/probable UIP, fibrotic HP, or fibrotic NSIP)
- Pathology: Presence of a major fibrotic ILD pattern (i.e., UIP/probable UIP, fibrotic HP, or fibrotic NSIP)

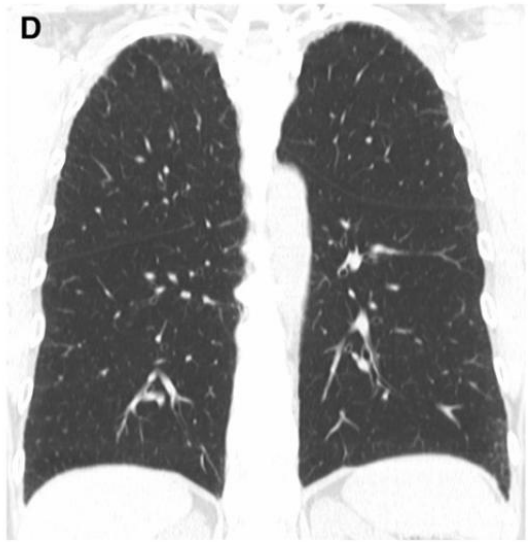
Podolanczuk AJ et al AJRCCM 2025

Interstitial lung abnormality

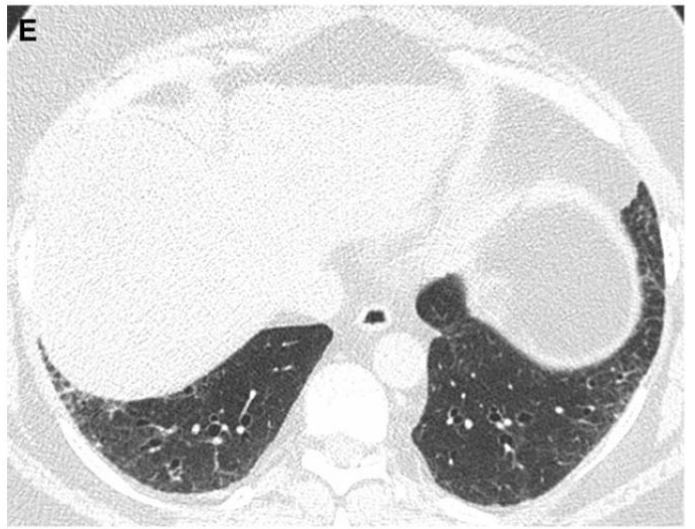


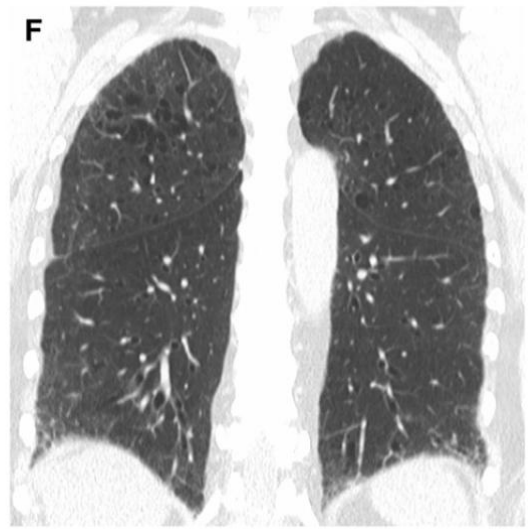
Nonsubpleural ILA





Subpleural nonfibrotic ILA





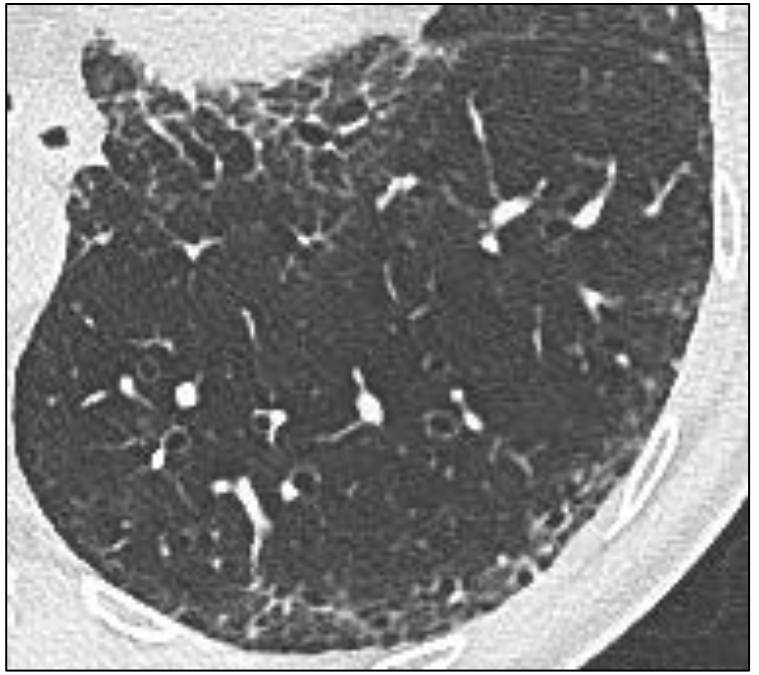
Subpleural fibrotic ILA

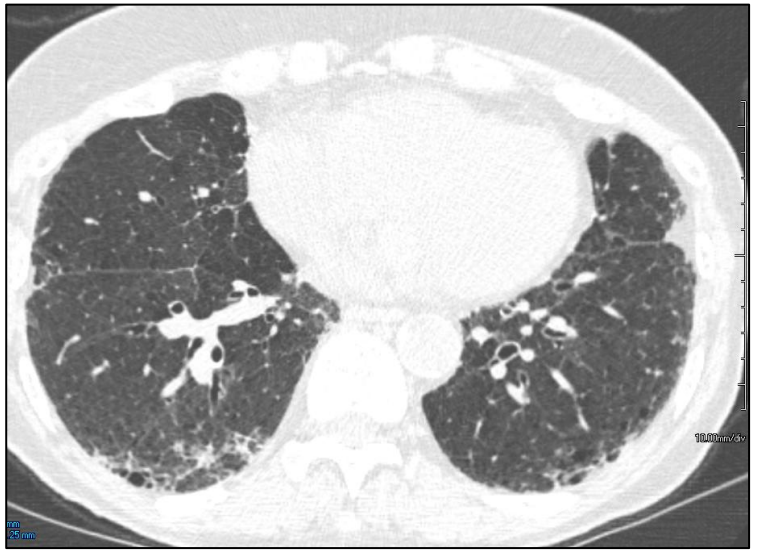
Podolanczuk AJ et al AJRCCM 2025

차례

CT signs of fibrosis

- Reticular opacity
- Traction bronchiectasis
- Honeycombing cyst
- Volume decrease & lung distorsion
- Three density sign
- Non-emphysematous cysts



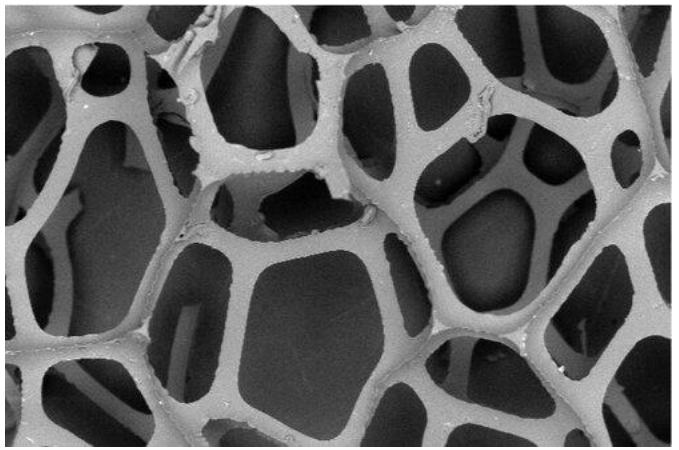


Travis WD et al. AJRCCM 2013

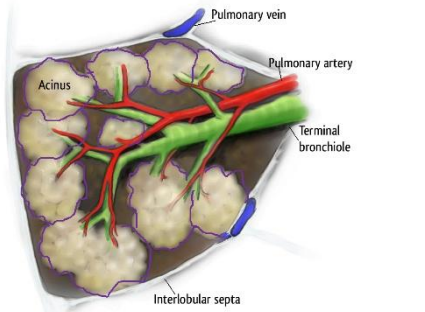
Reticular opacity

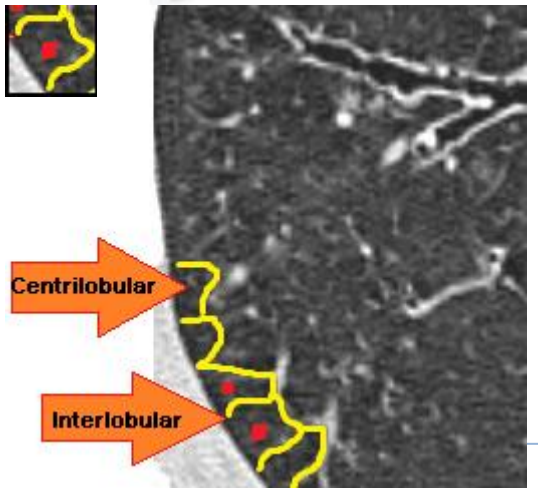
reticulation

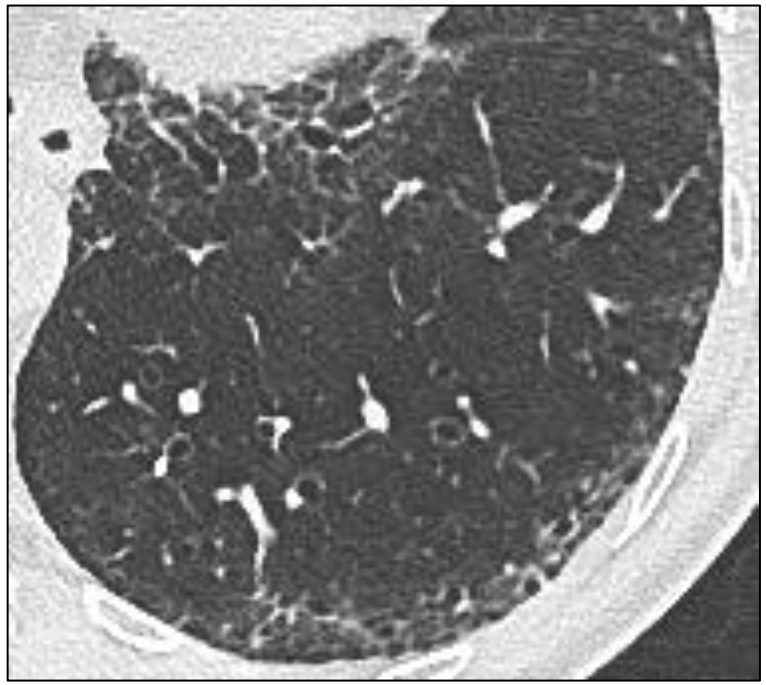
1. 명사 그물코, 망상 조직, 그물 세공(network)
2. 명사 사진 그물 모양의 주름 ((감광 유제(乳劑)에 생기는))
3. 명사 수도관 망



- Innumerable small linear opacities resembling net
  - Used in chest radiographs & chest CT
  - **Fibrosis**: interlobular septal thickening or cyst walls of honeycombing cysts





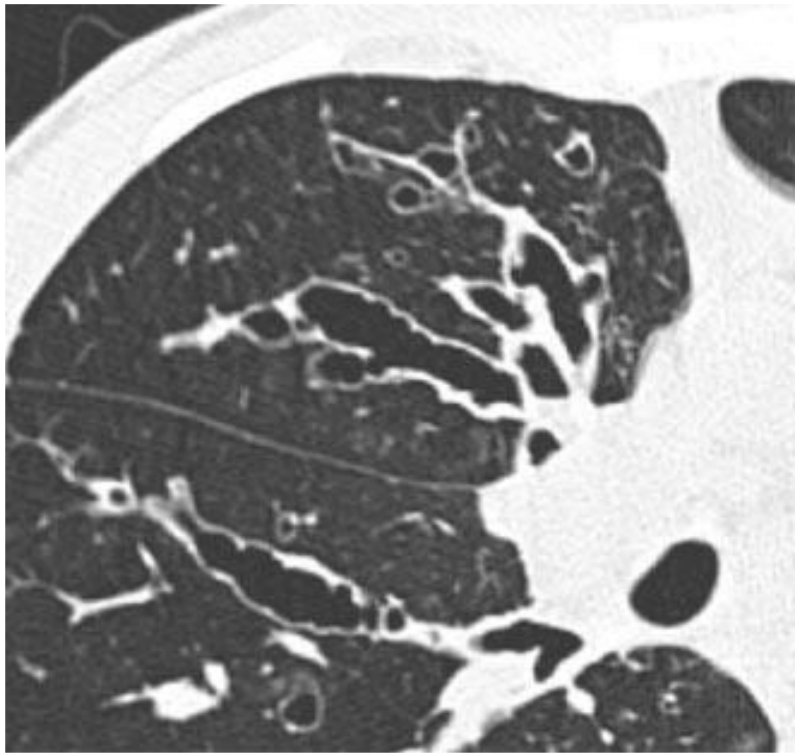


Hansell DM, et al. Radiology 2008

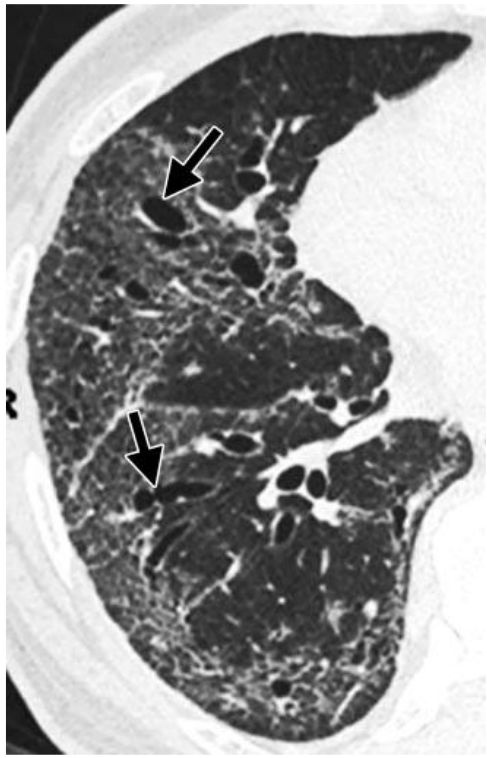
Traction bronchiectasis

Hansell DM, et al. Radiology 2008

- Irregular bronchial dilatation caused by **surrounding retractile pulmonary fibrosis**
- **Traction bronchiectasis ~ Honeycombing cyst: continuum (?)**



Bronchiectasis

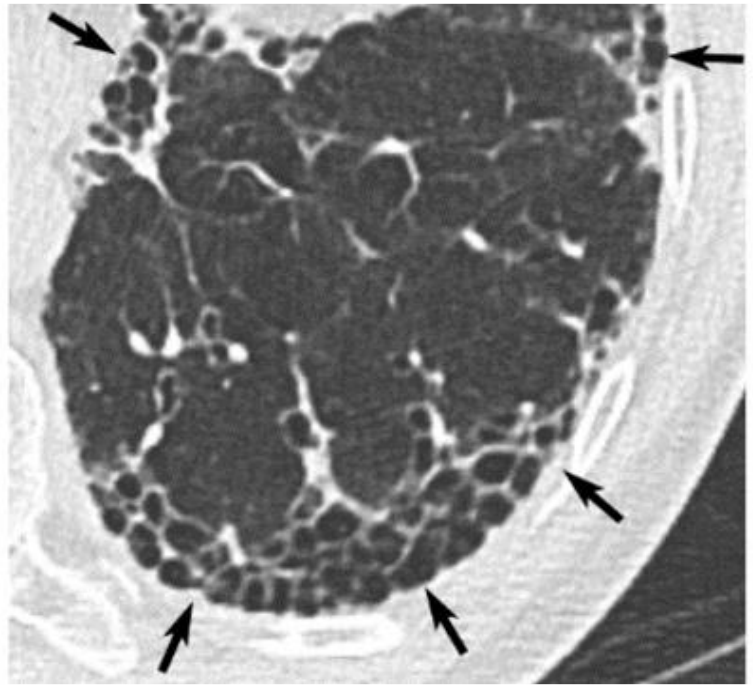


Traction bronchiectasis

Honeycombing cyst

Hansell DM, et al. Radiology 2008
Travis WD et al. AJRCCM 2013

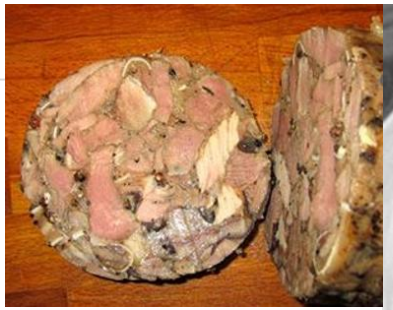
- **Pathology**
  - Destroyed fibrotic lung tissue containing numerous cystic airspaces with thick fibrous walls
- **CT**
  - Clustered cystic air spaces, typically 3-10 mm up to 2.5 cm
  - Usually subpleural, characterized by well-defined and shared walls
  - Important criterion in the diagnosis of UIP
  - Increase in size and number during disease progression
  - A single layer can be honeycombing cyst

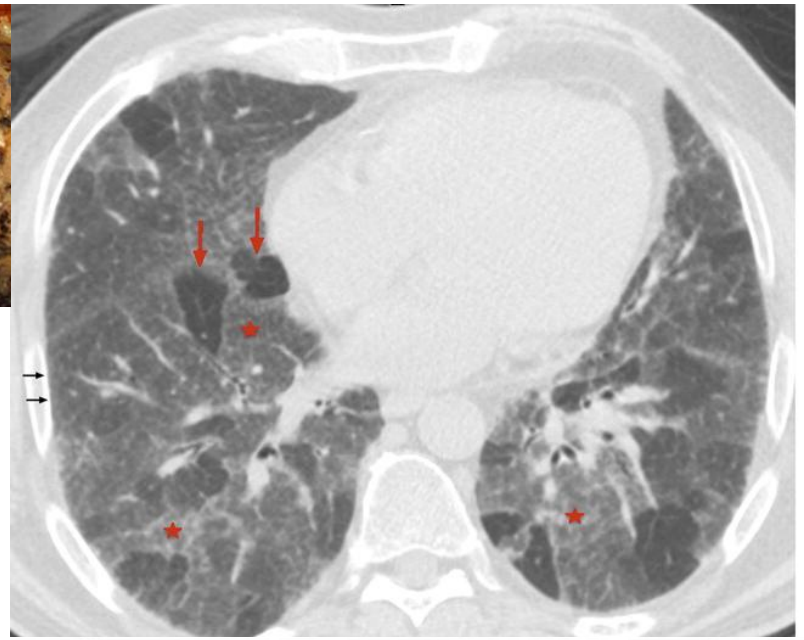


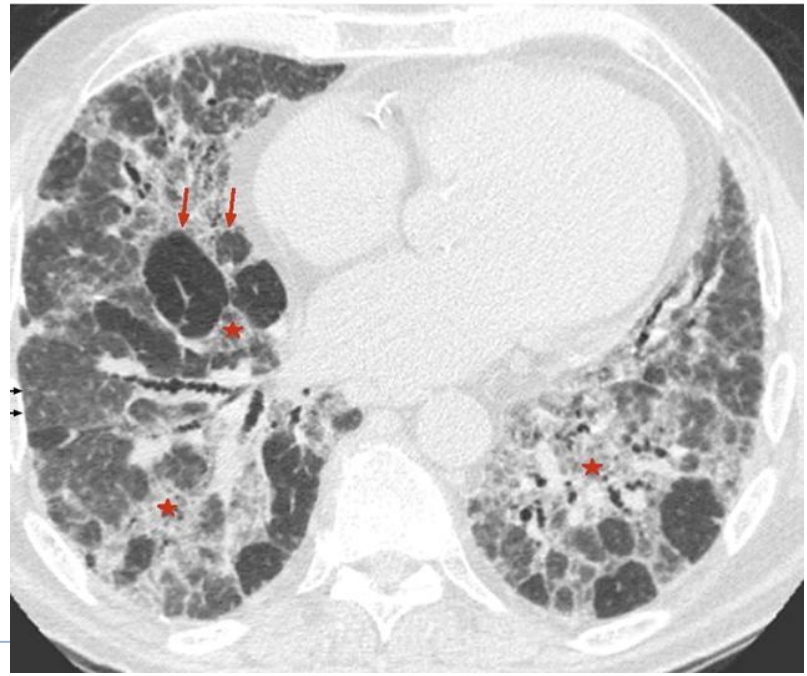
Galvin JR, et al. Radiology 2010

Three-density pattern

- **Combination of three attenuation**
  - **Normal appearing lung**
  - **High attenuation (GGO)**
  - **Hypoattenuating area (air-trapping & associated decreased vascularity)**
- Sharply demarcated from each other
- Headcheese sign
- **Highly specific for fibrotic HP**



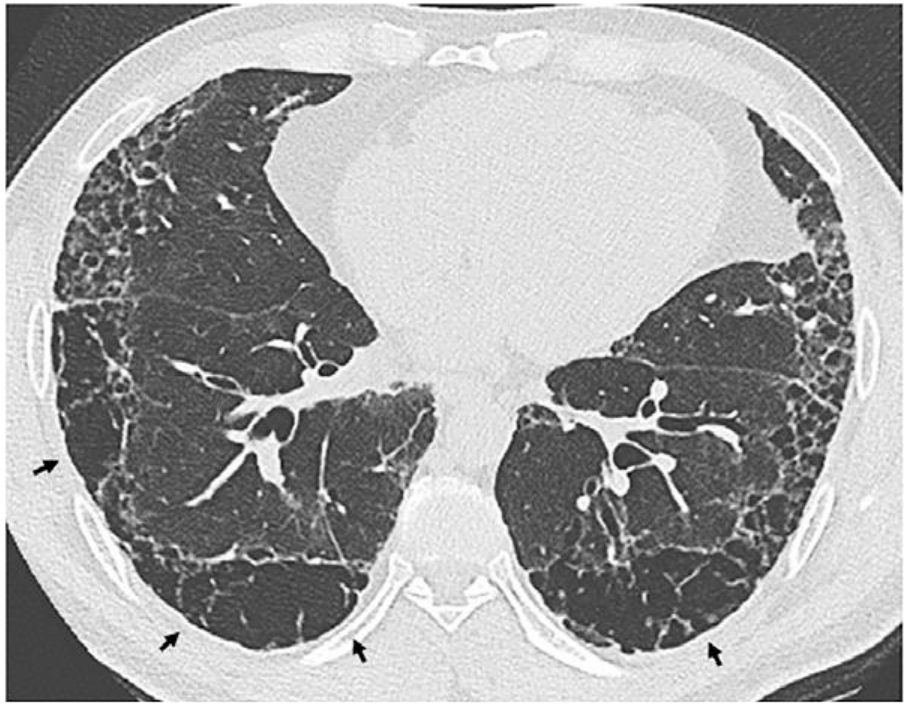




Raghu et al., AJRCCM 2020

Non-emphysematous cysts

- Non-emphysematous cysts
  - SRIF (smoking related interstitial fibrosis)
  - Airspace enlargement with fibrosis
  - RB-ILD with fibrosis
  - Respiratory bronchiolitis with fibrosis

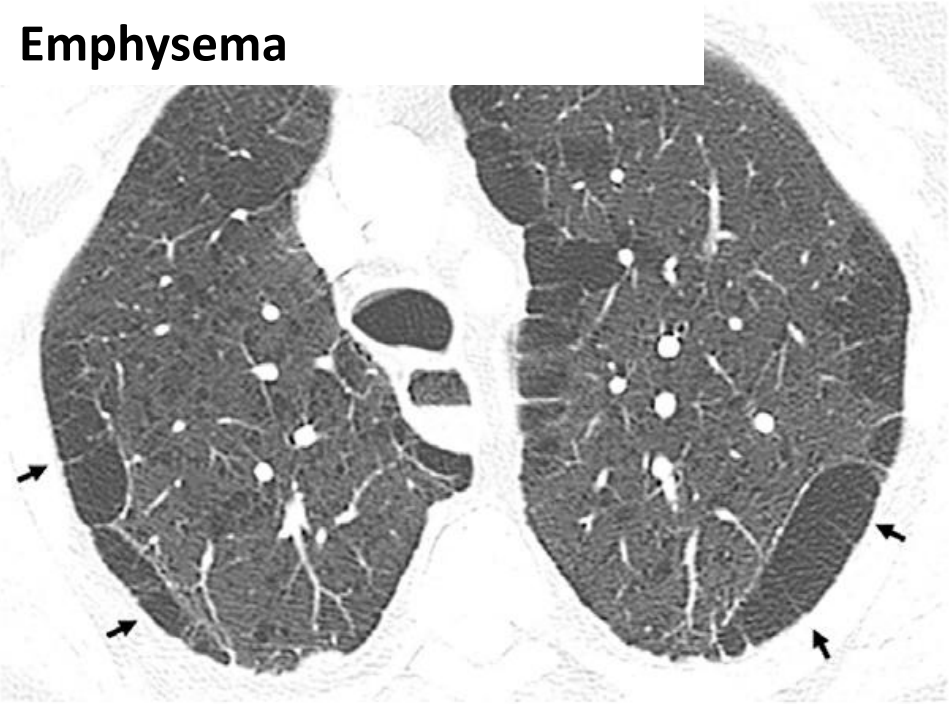


- Pathology: fibrotic alveolar septal thickening with hyalinized collagen bundles and hyperplastic smooth muscle
- **CT: Cysts with irregular, well-defined (=1mm) walls; juxtapleural sparing (upper lateral and lower dorsal)**

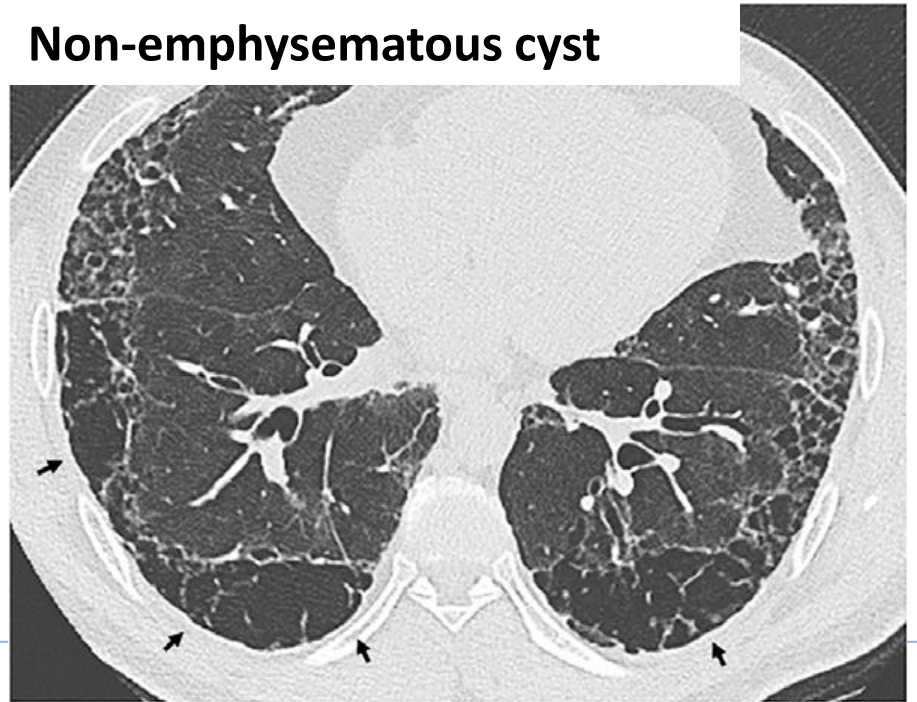
Non-emphysematous cysts

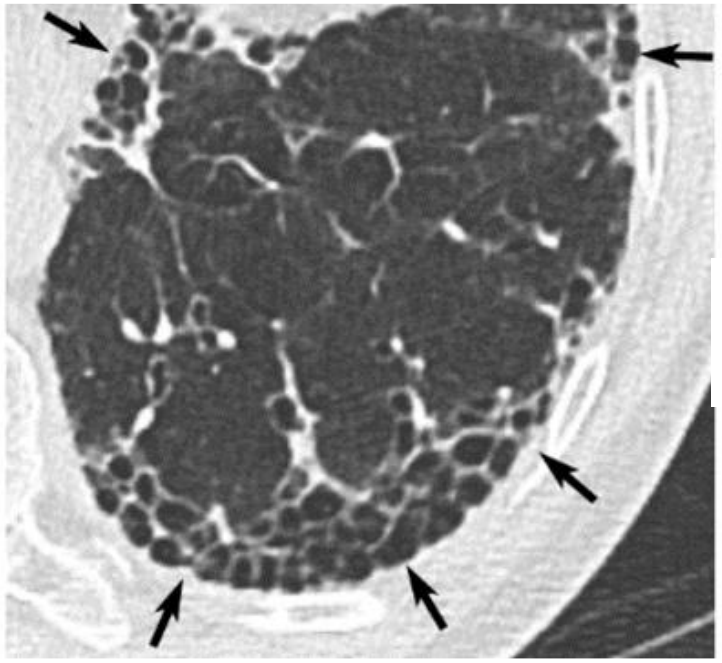
- DDx from emphysema: thin or indiscernible wall; absence of GGO, reticular opacity
- DDx from honeycombing: thick wall, uniform cyst; subpleural predominance, no interrupted septa

Emphysema



Non-emphysematous cyst

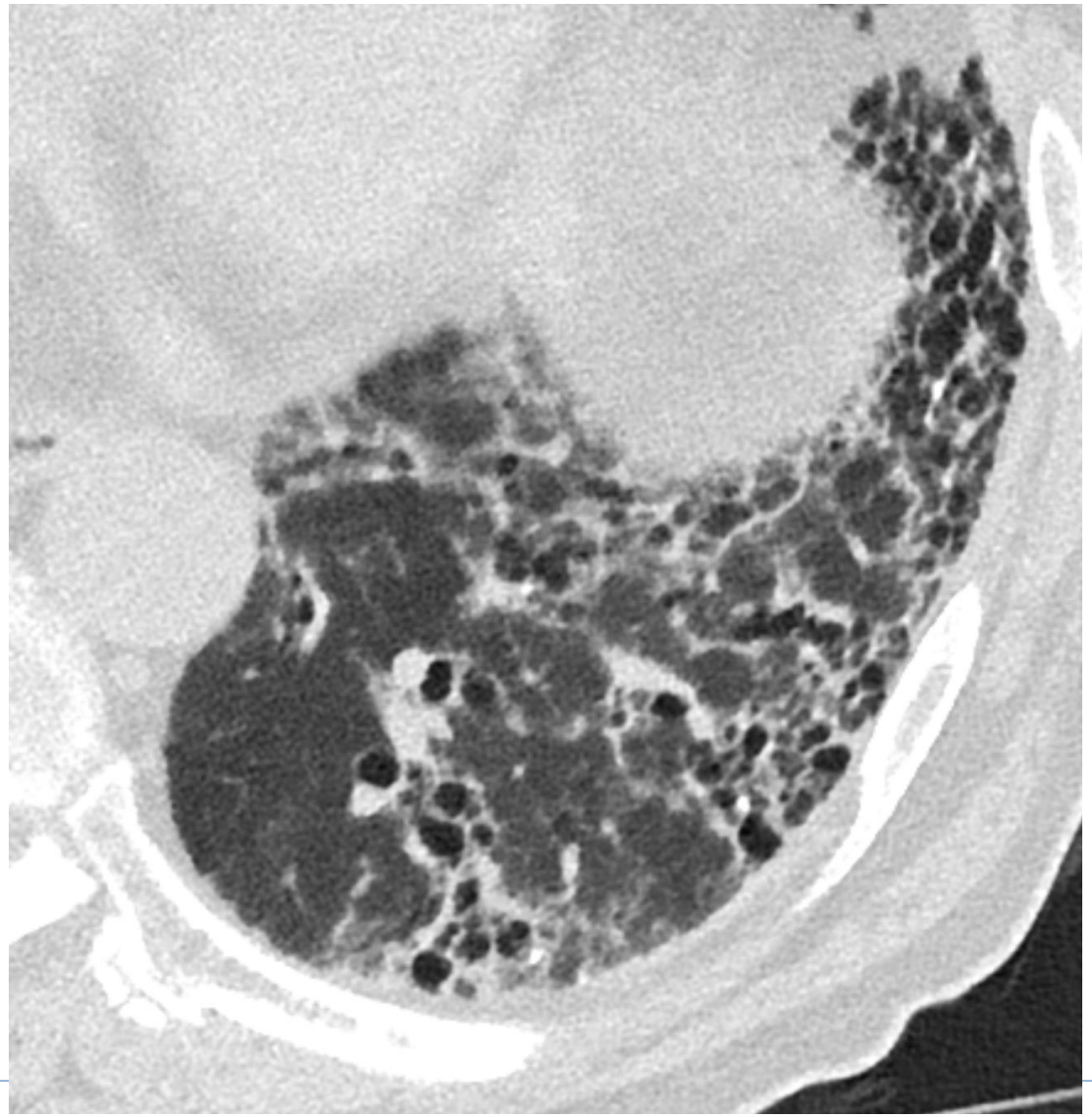




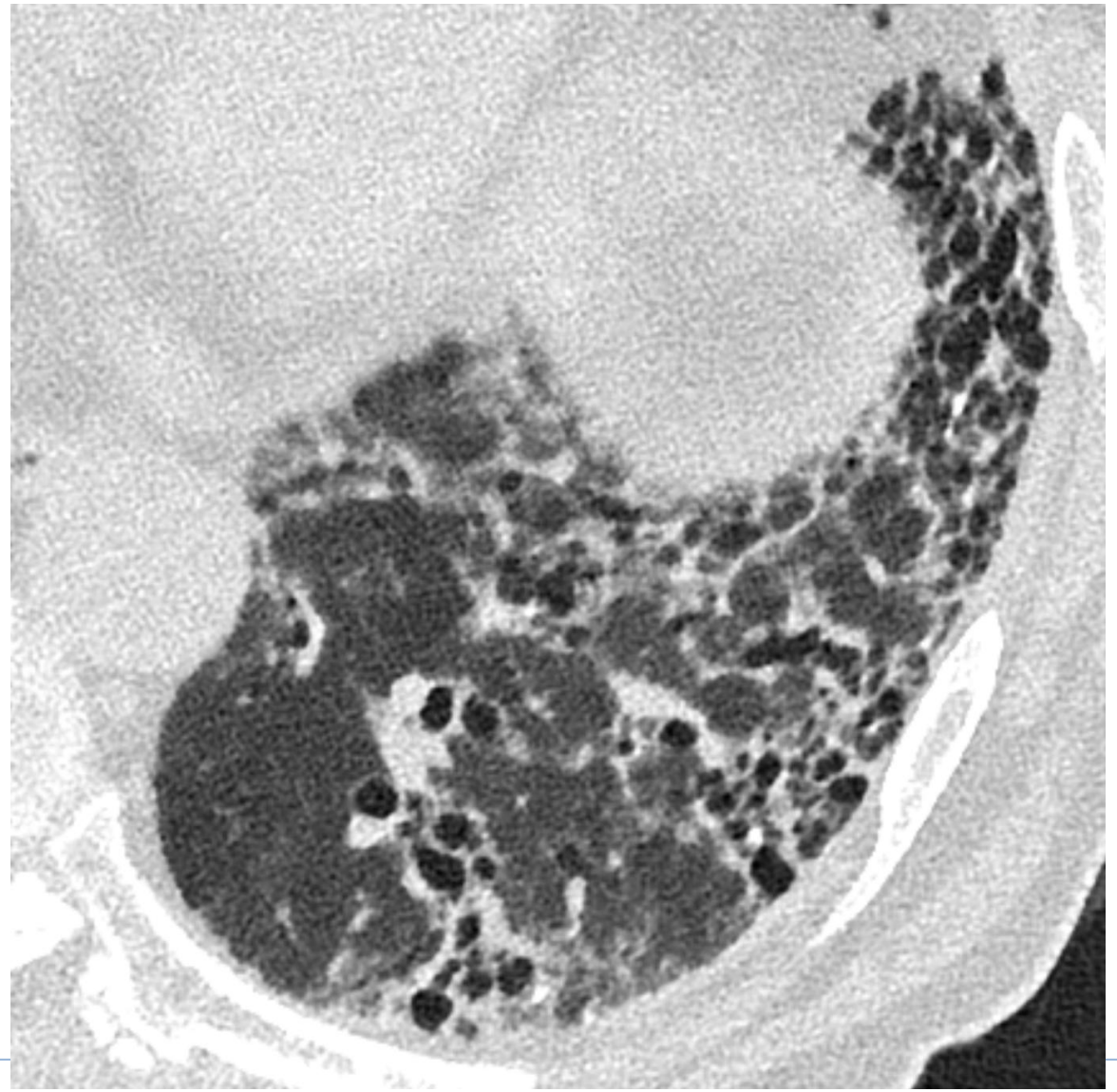
Honeycombing cyst

Photon-counting CT for ILD

70keV, Br64, QIR 3, 1mm, 1024x



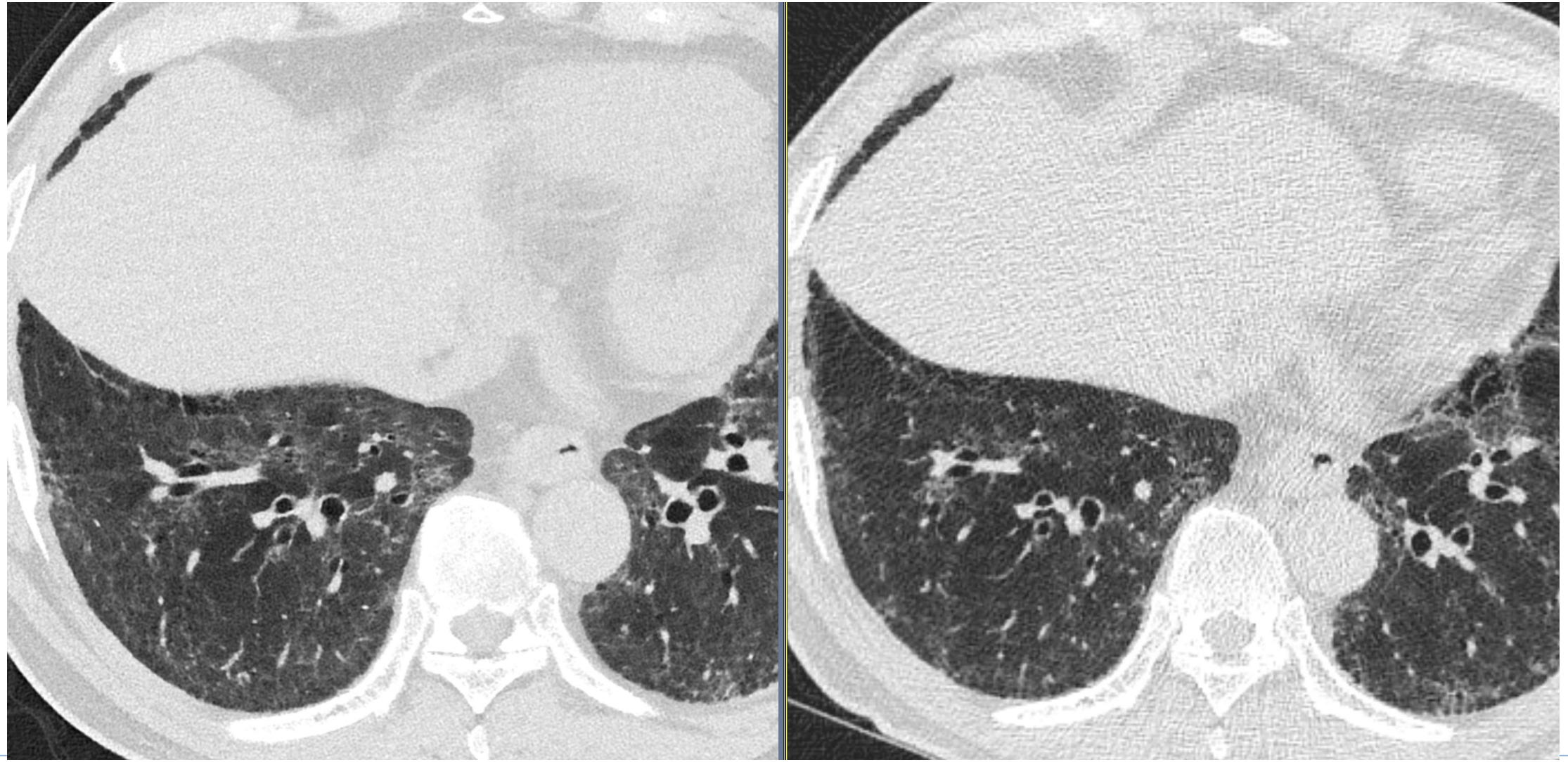
70keV, Br64, QIR 3, 0.4mm, 1024x



Photon-counting CT for ILD

70keV, Br64, QIR 3, 1mm, 1024x

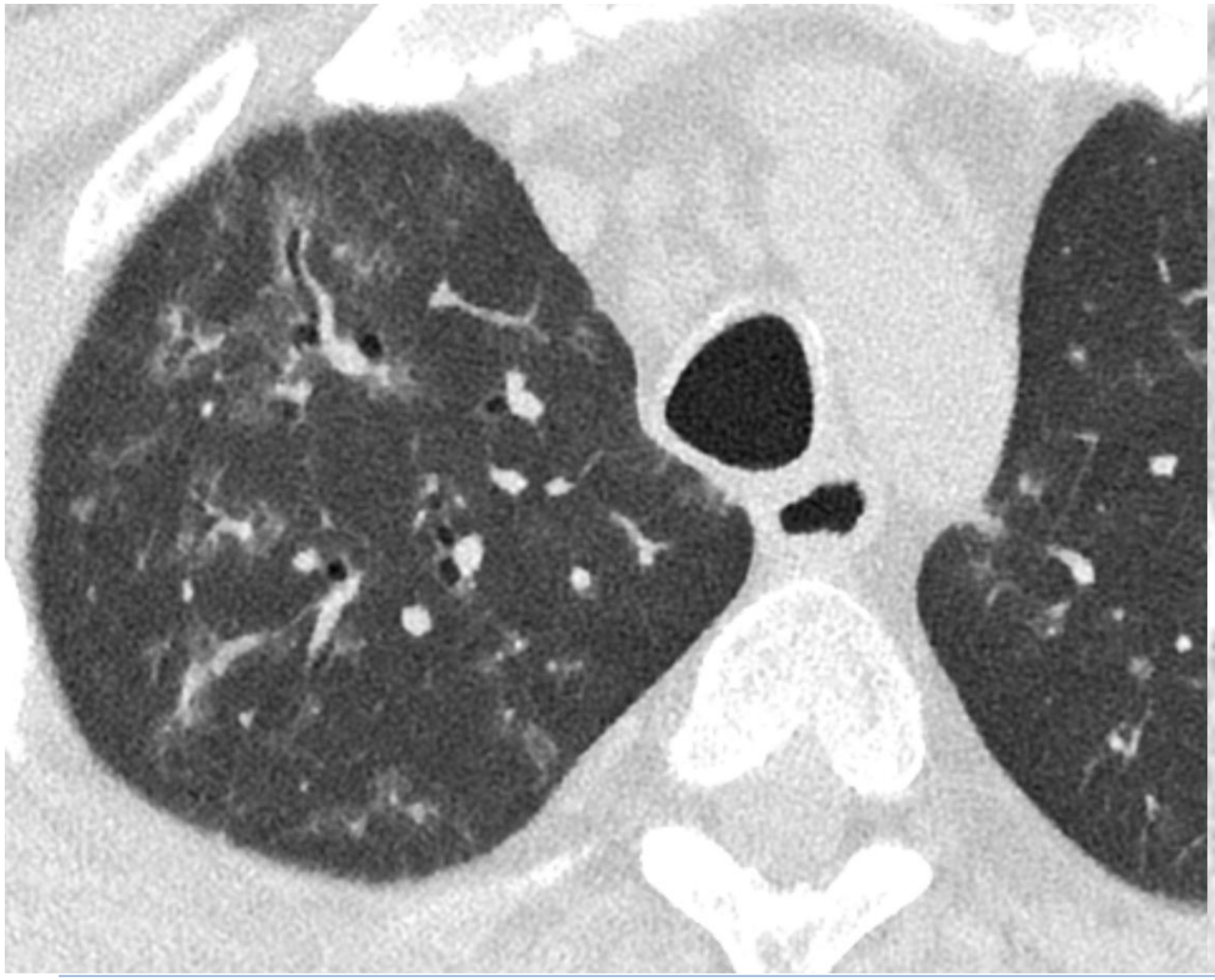
120kV, YC, iDose(4), 1mm, 512x

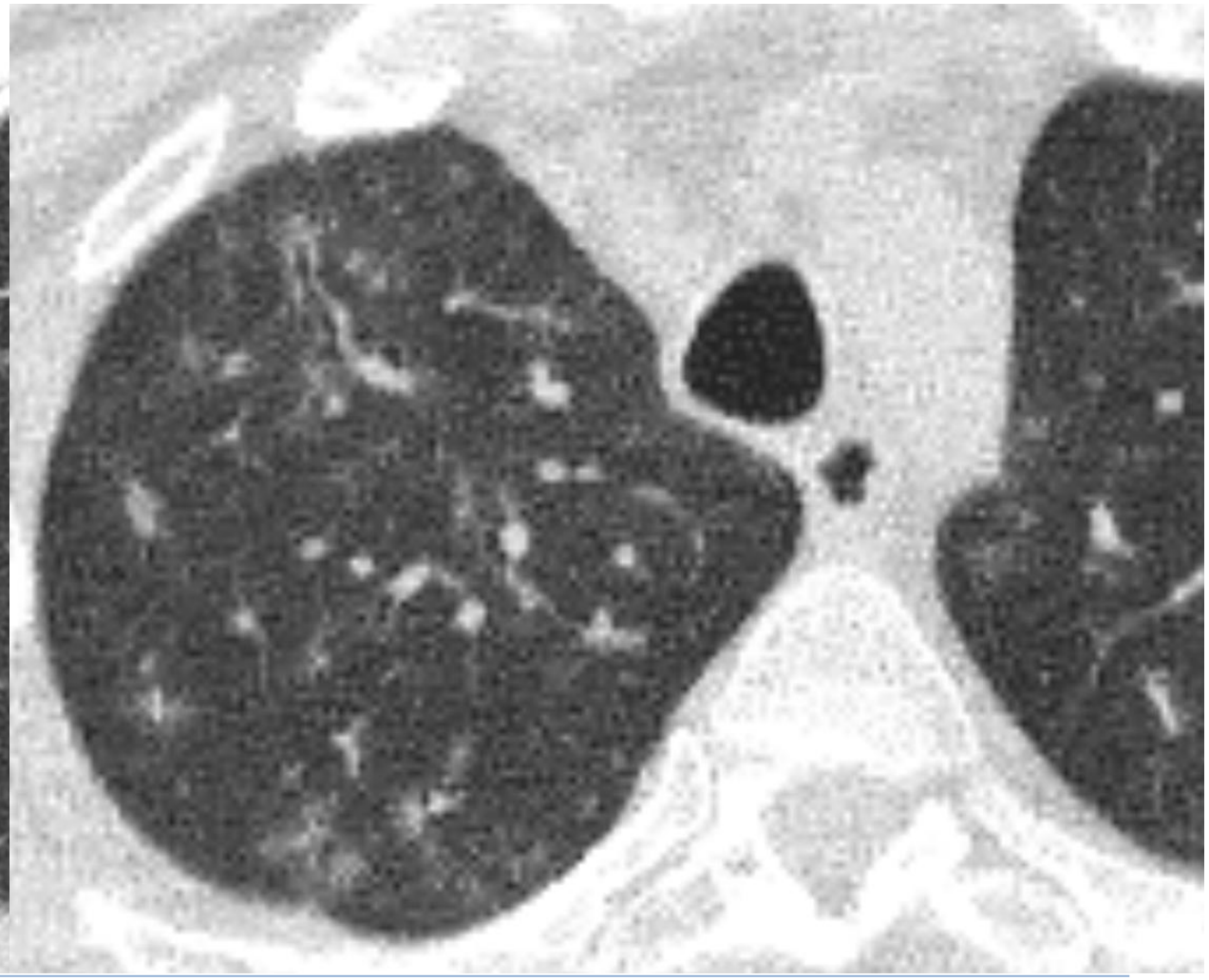


Photon-counting CT for ILD

70keV, Br64, QIR 3, 1mm, 1024x

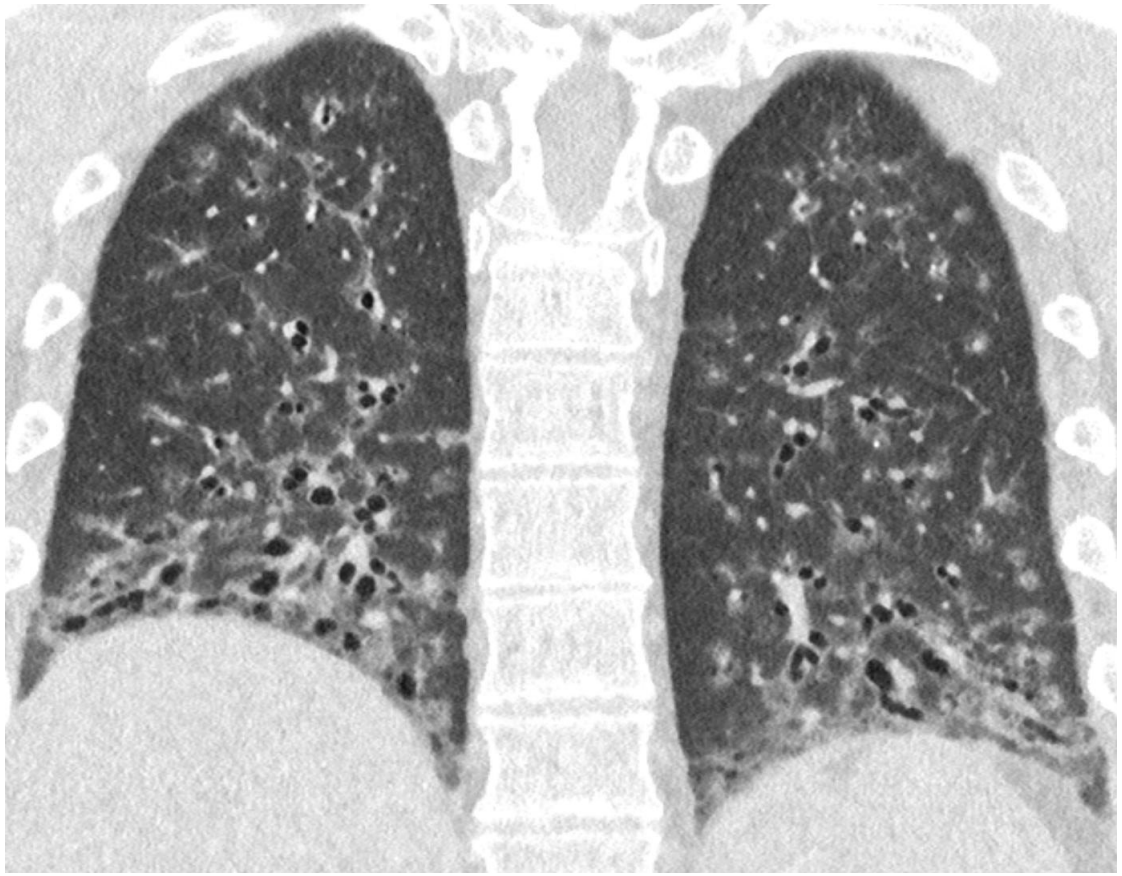
120kV, Bone, AR50%, 1.25mm, 512x



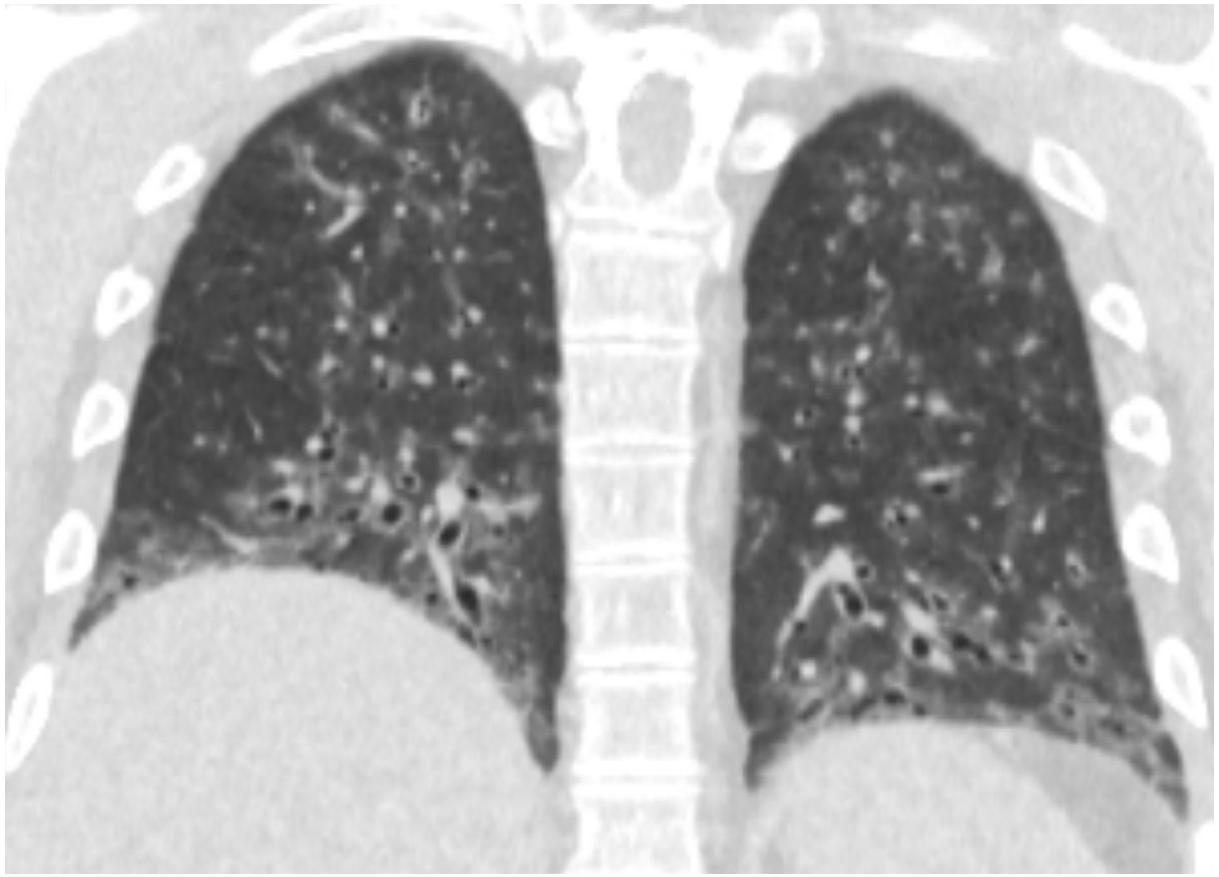


Photon-counting CT for ILD

70keV, Br64, QIR 3, 1mm, 1024x



120kV, Bone, AR50%, 1.25mm, 512x



차례

- ILD Classification & ILA
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- **HRCT UIP Pattern (2018 & 2022 ATS/ERS/JRS/ALAT Guidelines)**
- Other ILD CT Pattern (alternative diagnosis)

Usual interstitial pneumonia (UIP) pattern on CT

Ragu G, et al. AJRCCM 2018 and 2022

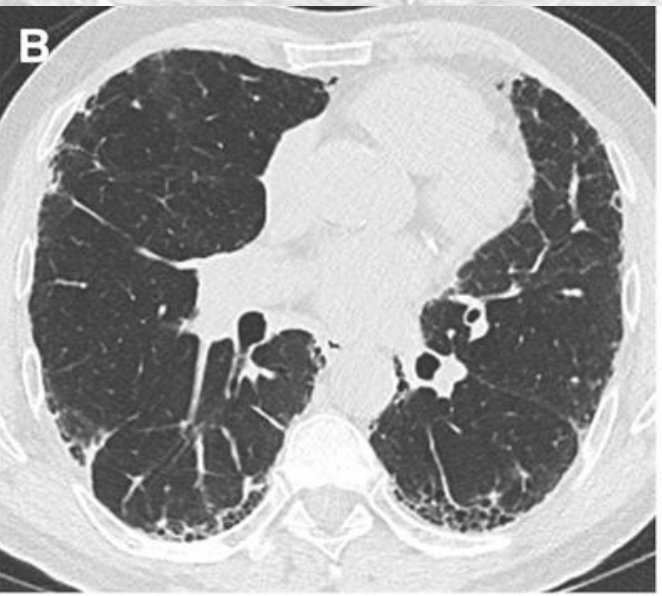
	HRCT Pattern			
	UIP Pattern	**Probable UIP Pattern**	**Indeterminate for UIP**	**CT Findings Suggestive of an Alternative Diagnosis**
Level of confidence for UIP histology	Confident (>90%)	Provisional high confidence (70–89%)	Provisional low confidence (51–69%)	Low to very low confidence (⩽50%)
Distribution	• Subpleural and basal predominant • Often heterogeneous (areas of normal lung interspersed with fibrosis) • Occasionally diffuse • May be asymmetric	• Subpleural and basal predominant • Often heterogeneous (areas of normal lung interspersed with reticulation and traction bronchiectasis/ bronchiolectasis)	• Diffuse distribution without subpleural predominance	• Peribronchovascular predominant with subpleural sparing (consider NSIP) • Perilymphatic distribution (consider sarcoidosis) • Upper or mid lung (consider fibrotic HP, CTD-ILD, and sarcoidosis) • Subpleural sparing (consider NSIP or smoking-related IP)
CT features	• Honeycombing with or without traction bronchiectasis/ bronchiolectasis • Presence of irregular thickening of interlobular septa • Usually superimposed with a reticular pattern, mild GGO • May have pulmonary ossification	• Reticular pattern with traction bronchiectasis/ bronchiolectasis • May have mild GGO • Absence of subpleural sparing	• CT features of lung fibrosis that do not suggest any specific etiology	• Lung findings ◦ Cysts (consider LAM, PLCH, LIP, and DIP) ◦ Mosaic attenuation or three-density sign (consider HP) ◦ Predominant GGO (consider HP, smoking-related disease, drug toxicity, and acute exacerbation of fibrosis) ◦ Profuse centrilobular micronodules (consider HP or smoking-related disease) ◦ Nodules (consider sarcoidosis) ◦ Consolidation (consider organizing pneumonia, etc.) • Mediastinal findings ◦ Pleural plaques (consider asbestosis) ◦ Dilated esophagus (consider CTD)

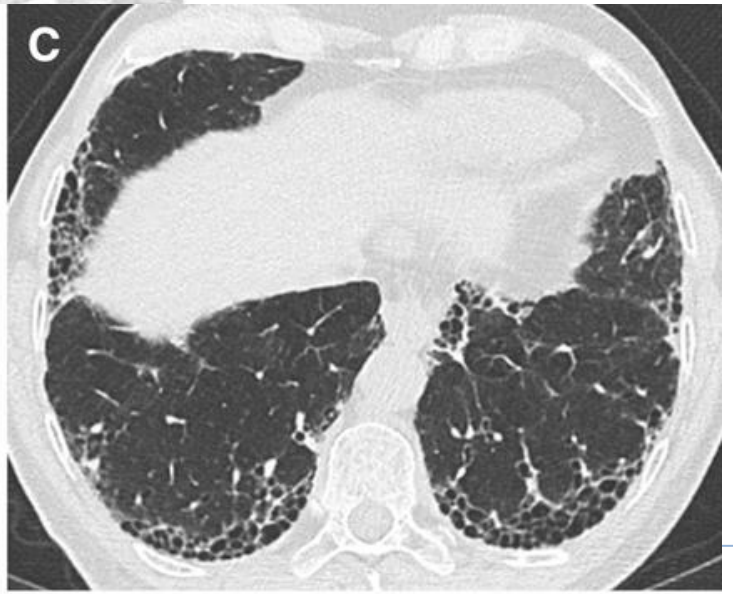
Usual interstitial pneumonia (UIP) pattern CT

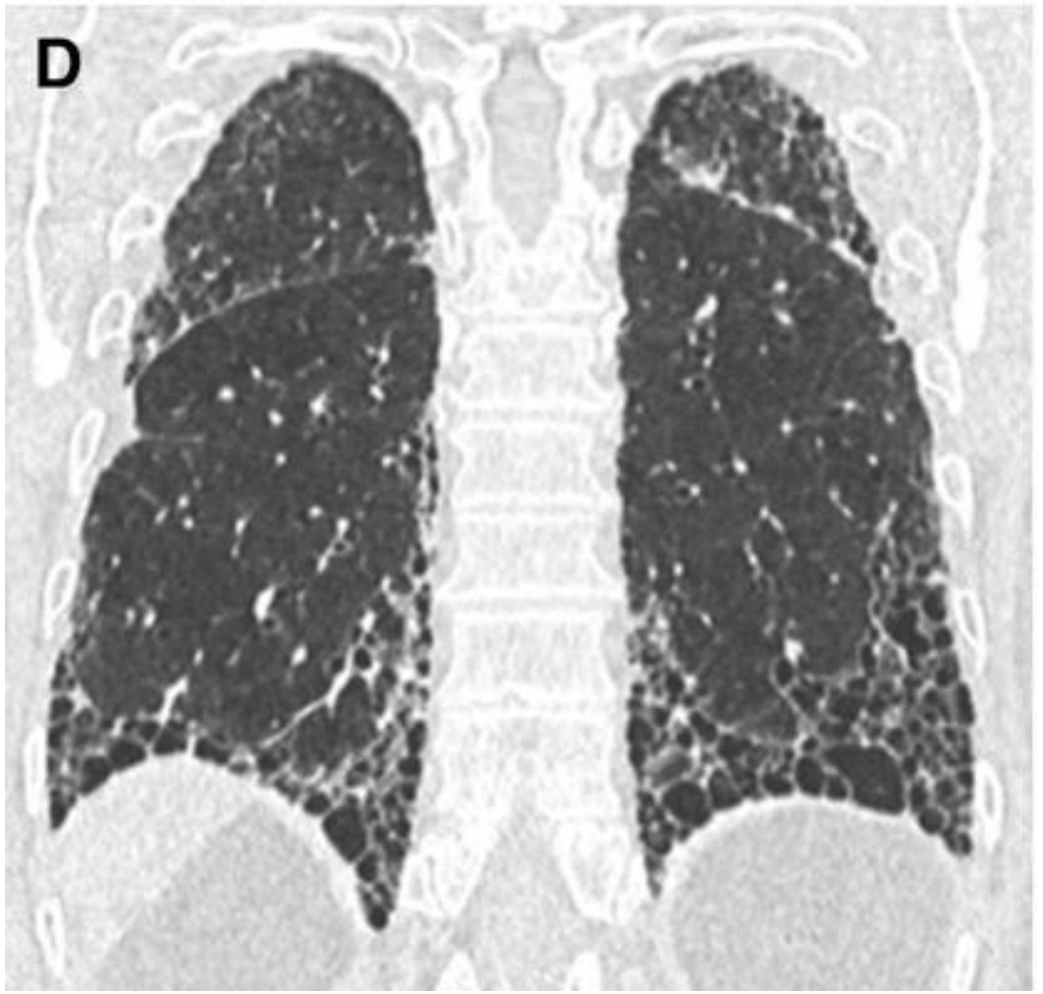
Raghu G, et al. AJRCCM 2018 and 2022

Reticular opacity

Traction bronchiectasis + Honeycombing



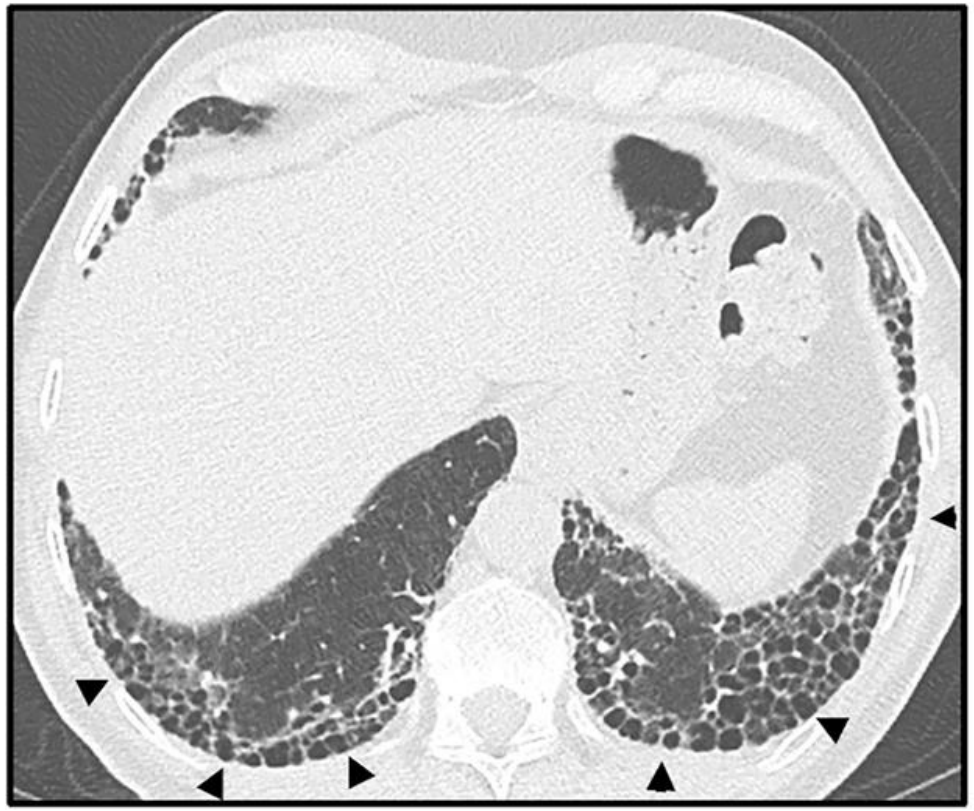


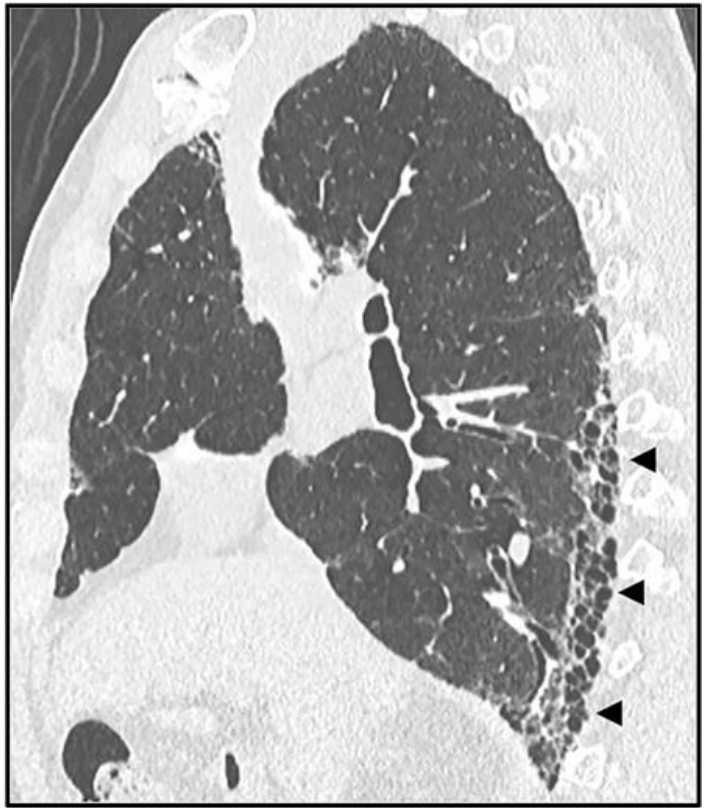


Subpleural and basal predominance

Usual interstitial pneumonia (UIP) pattern CT

Raghu G, et al. AJRCCM 2018 and 2022



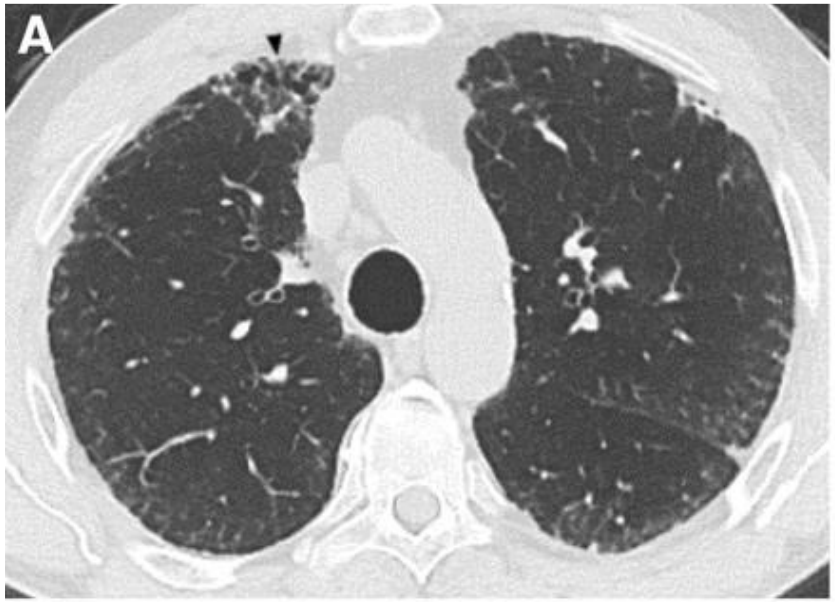


Traction bronchiectasis + Honeycombing

Subpleural and basal predominance

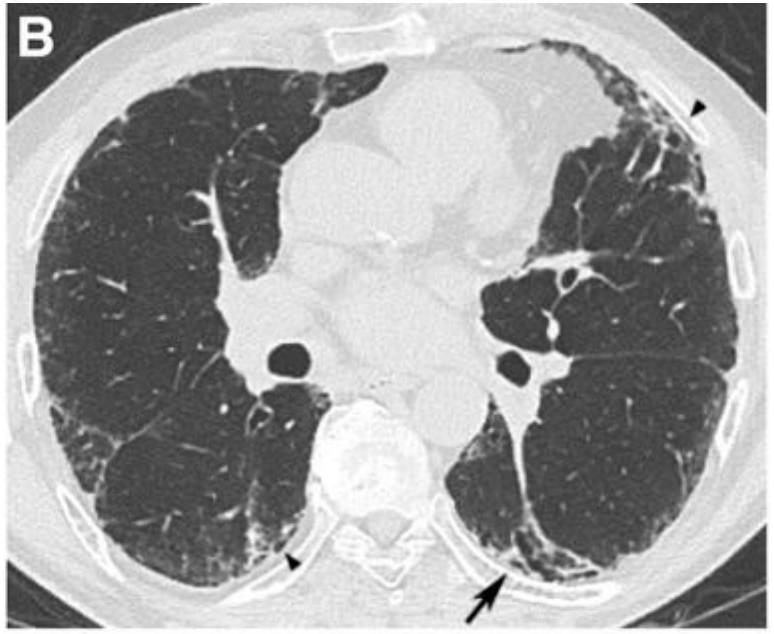
Probable usual interstitial pneumonia (UIP) pattern CT

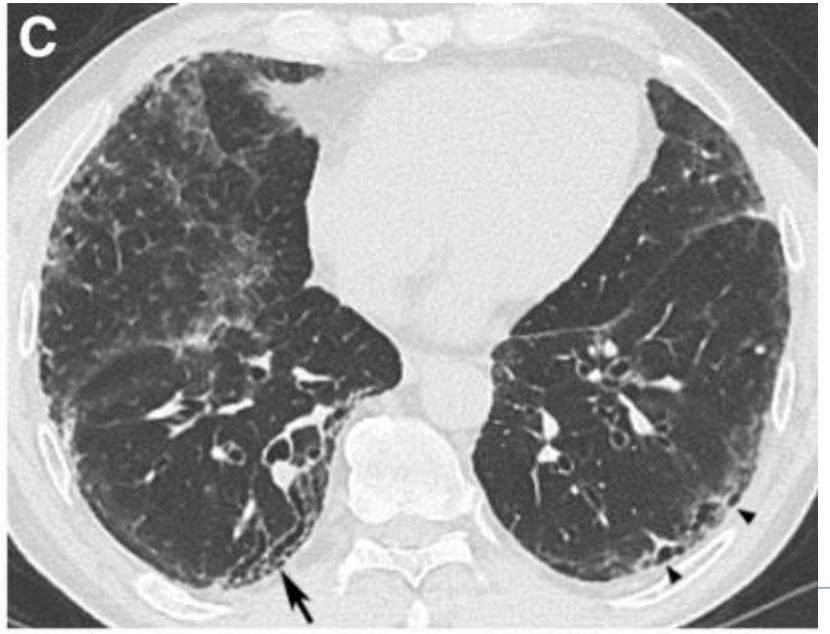
Raghu G, et al. AJRCCM 2018 and 2022

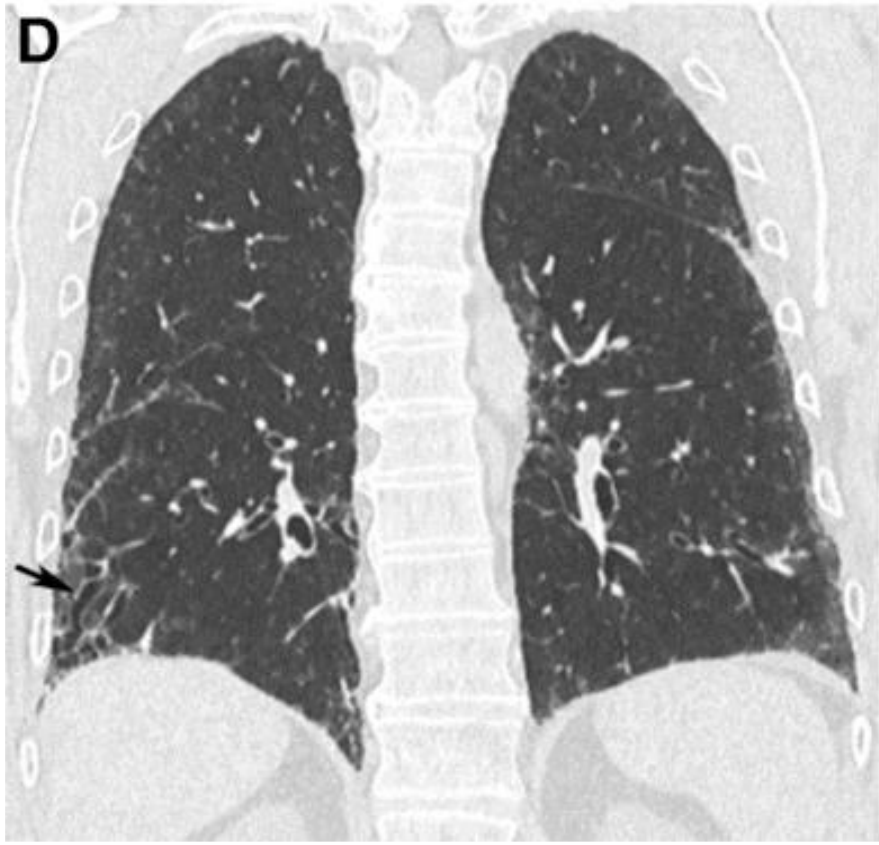


Reticular opacity

Traction bronchiectasis + mild GGO





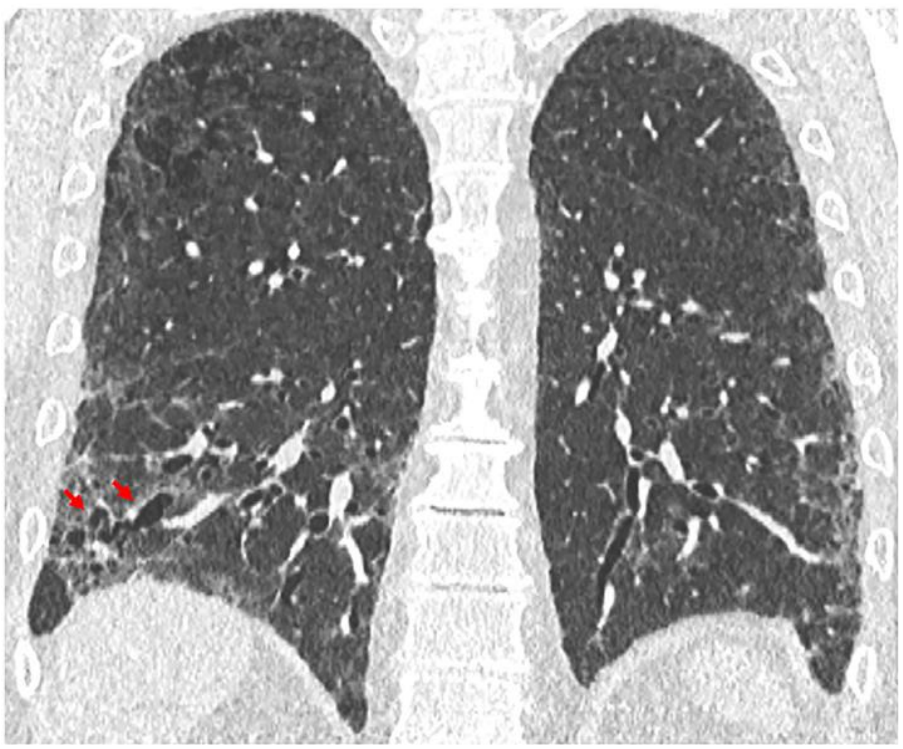


Subpleural and basal predominance

Probable usual interstitial pneumonia (UIP) pattern CT

Raghu G, et al. AJRCCM 2018 and 2022

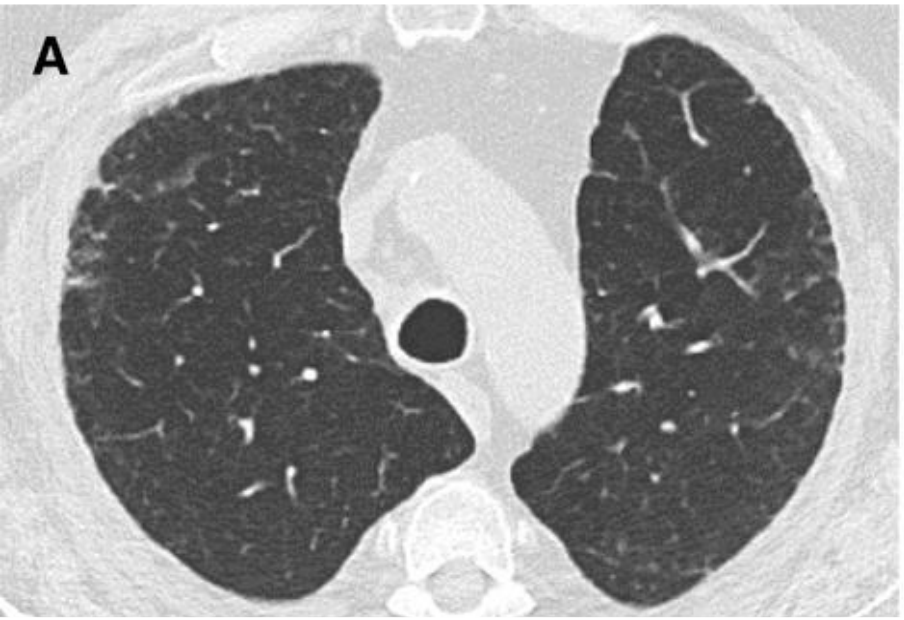
Reticular opacity + traction bronchiectasis + mild GGO

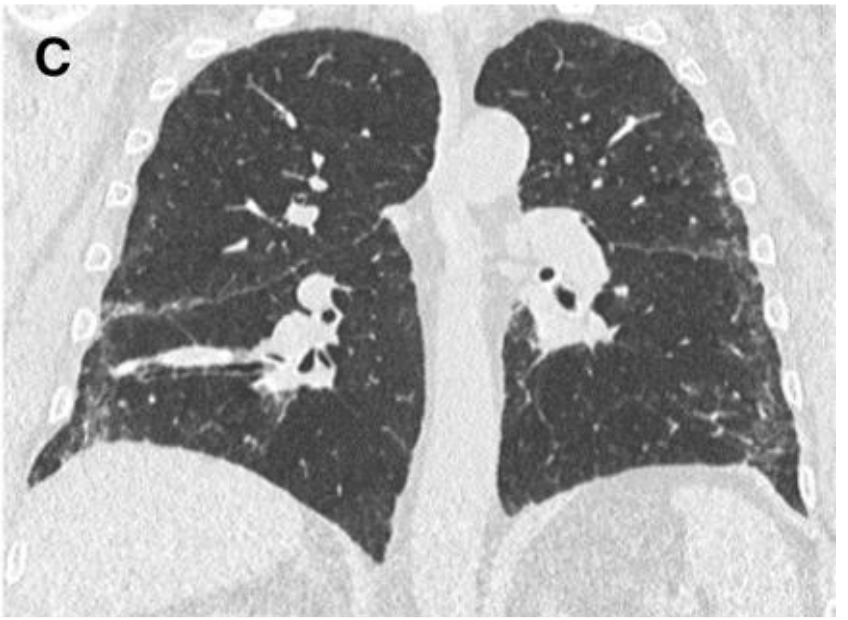


Subpleural and basal predominance

Indeterminate usual interstitial pneumonia (UIP) pattern CT

Raghu G, et al. AJRCCM 2018 and 2022





Reticular opacity + mild GGO

Subpleural and basal predominance

Indeterminate usual interstitial pneumonia (UIP) pattern CT

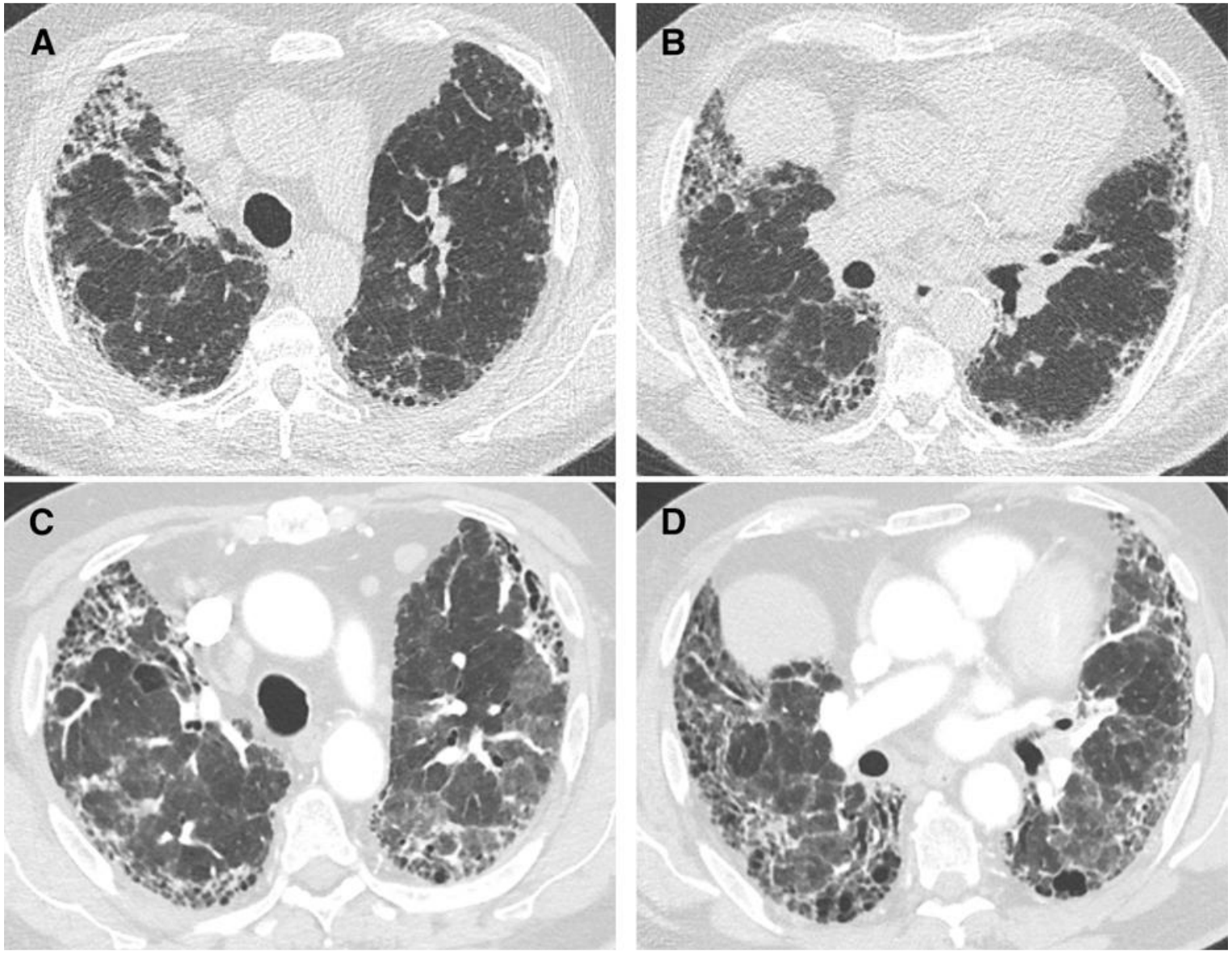
Raghu G, et al. AJRCCM 2018 and 2022

Marked GGO + reticular opacity + traction bronchiectasis

Subpleural and basal predominance

Acute exacerbation of IPF

Raghu G, et al. AJRCCM 2018 and 2022



Reticular opacity
Traction bronchiectasis
Honeycombing cyst
Subpleural and basal predominance

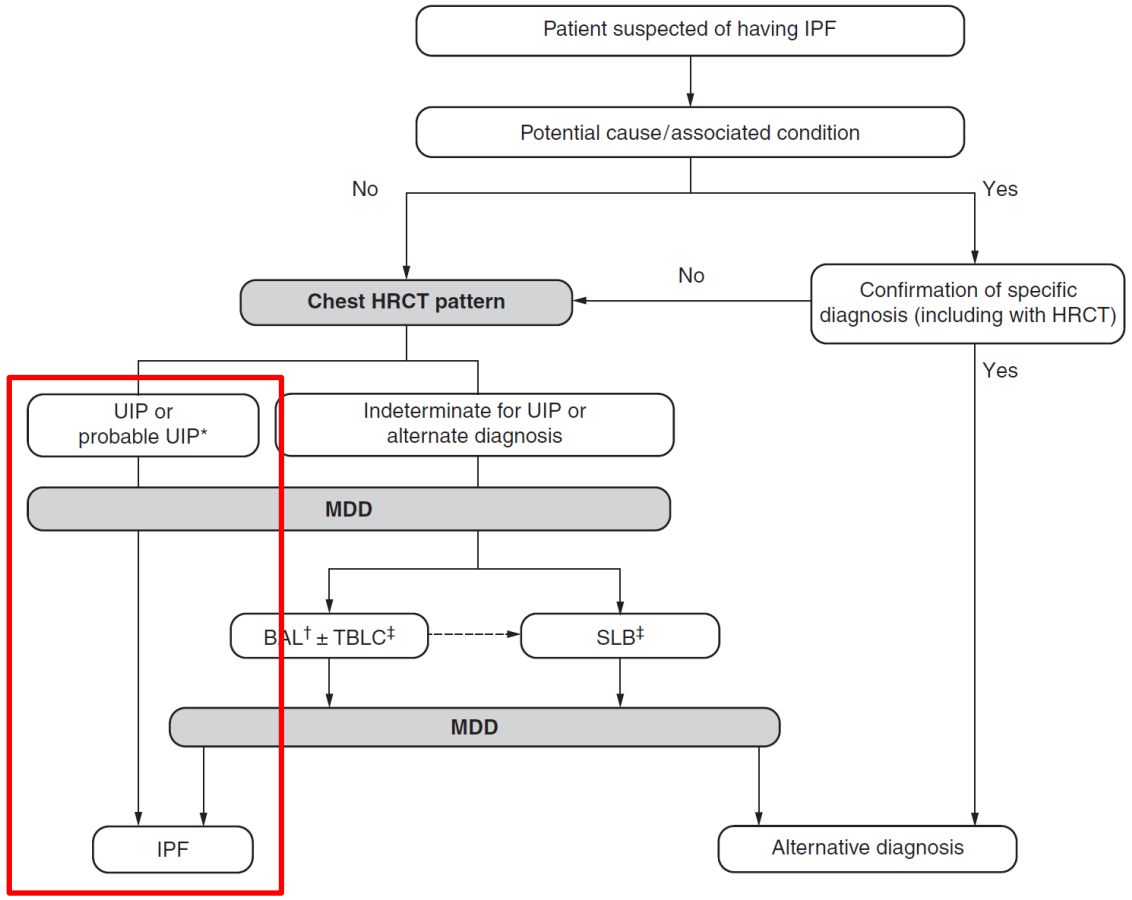
= UIP pattern

New GGO in bilateral lung
= AE-IPF

Versus fibrotic NSIP?

IPF diagnosis

Raghu G, et al. AJRCCM 2018 and 2022



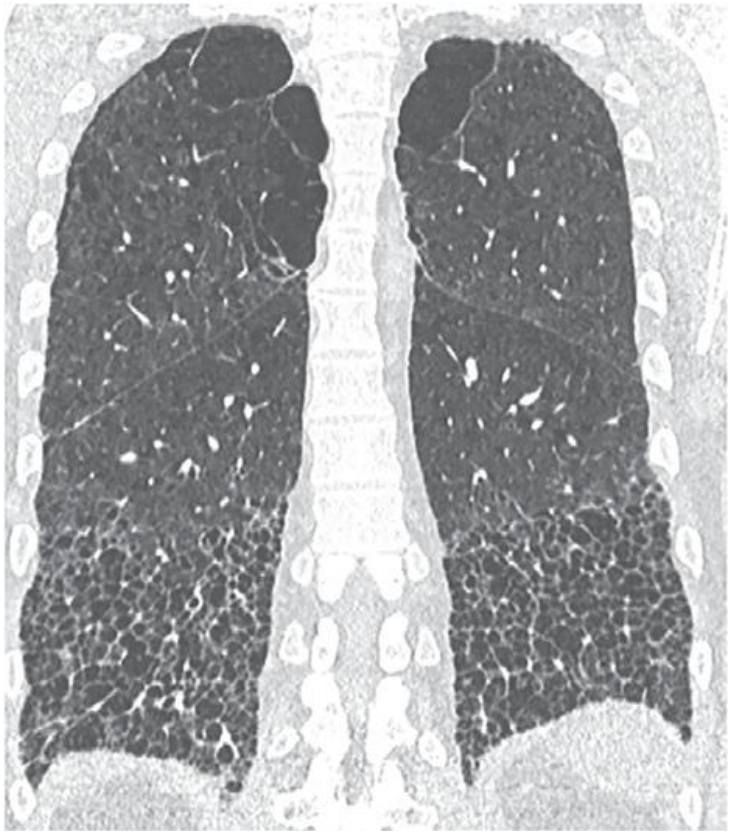
*Appropriate setting: old age, male, smoker

IPF suspected*		Histopathology pattern†			
		UIP	Probable UIP	Indeterminate for UIP or biopsy not performed	Alternative diagnosis
HRCT pattern	UIP	IPF	IPF	IPF	Non-IPF dx
	Probable UIP	IPF	IPF	IPF (Likely)‡	Non-IPF dx
	Indeterminate	IPF	IPF (Likely)‡	Indeterminate§	Non-IPF dx
	Alternative diagnosis	IPF (Likely)‡	Indeterminate§	Non-IPF dx	Non-IPF dx

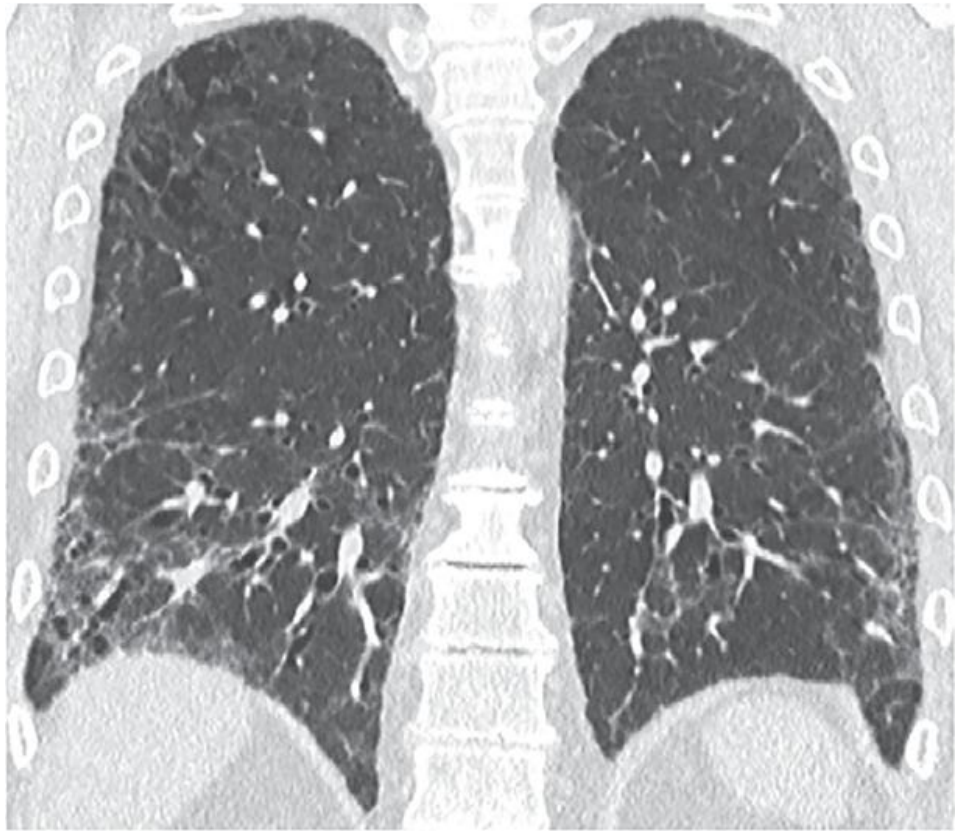
*IPF (likely)

- **Moderate to severe traction bronchiectasis in a man>50Y or in a woman>60Y old**
- **Extensive (>30%) reticulation on HRCT and age>70Y**
- **Increased neutrophils and/or absence of lymphocytosis in BAL**
- **Multidisciplinary discussion: confident diagnosis of IPF**

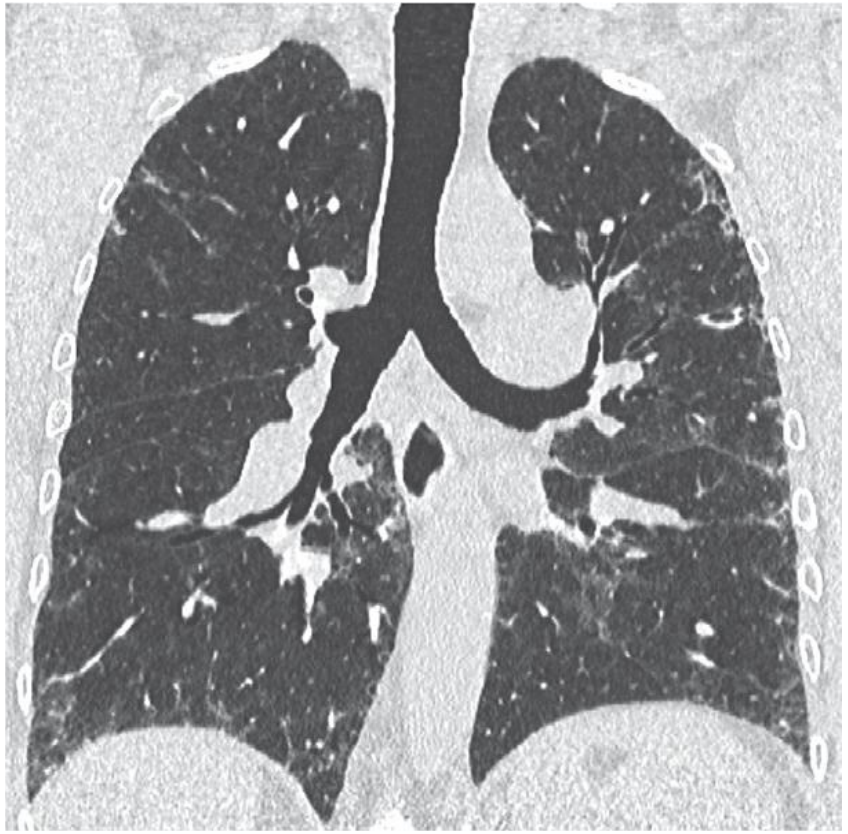
UIP pattern spectrum



UIP pattern



Probable UIP pattern



Indeterminate UIP pattern

차례

- ILD Classification & ILA
- CT Signs of Fibrosis
- HRCT UIP Pattern (2018 & 2022 ATS/ERS/JRS/ALAT Guidelines)
- **Other ILD CT Pattern (alternative diagnosis)**

Alternative diagnosis

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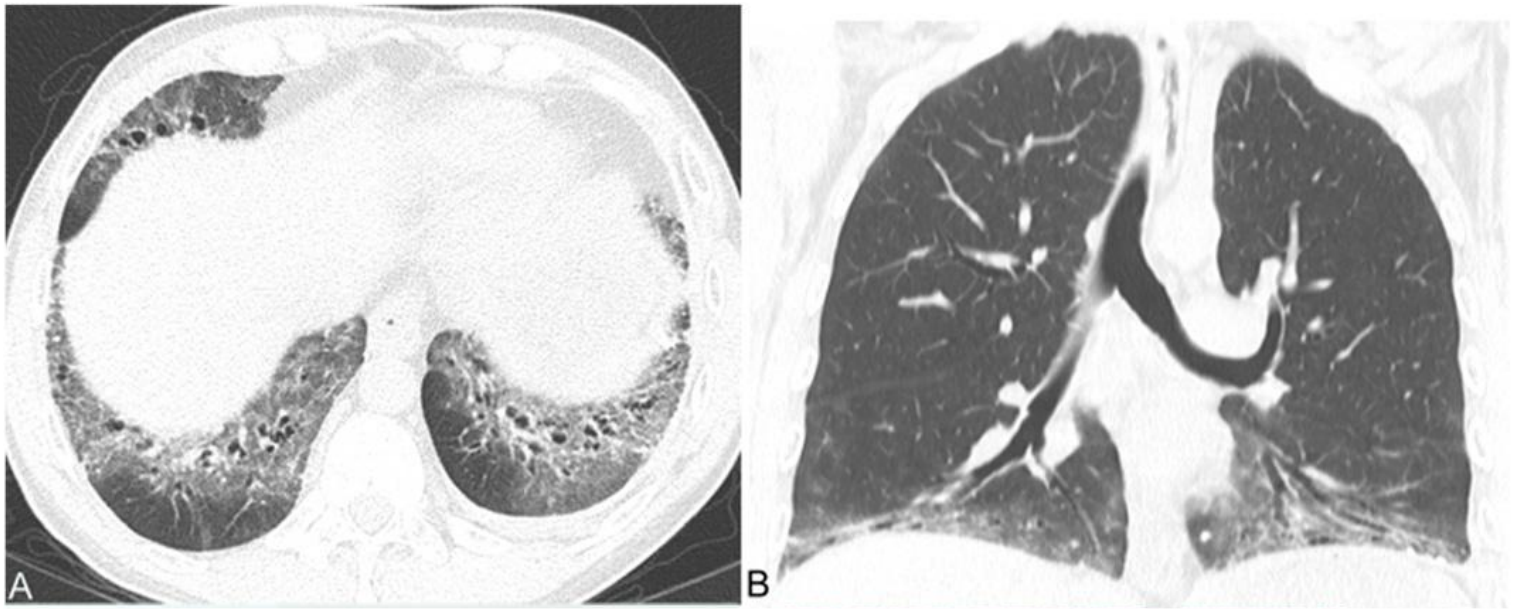
	HRCT Pattern			
	UIP Pattern	**Probable UIP Pattern**	**Indeterminate for UIP**	**CT Findings Suggestive of an Alternative Diagnosis**
Level of confidence for UIP histology	Confident (>90%)	Provisional high confidence (70–89%)	Provisional low confidence (51–69%)	Low to very low confidence (⩽50%)
Distribution	• Subpleural and basal predominant • Often heterogeneous (areas of normal lung interspersed with fibrosis) • Occasionally diffuse • May be asymmetric	• Subpleural and basal predominant • Often heterogeneous (areas of normal lung interspersed with reticulation and traction bronchiectasis/ bronchiolectasis)	• Diffuse distribution without subpleural predominance	• Peribronchovascular predominant with subpleural sparing (consider NSIP) • Perilymphatic distribution (consider sarcoidosis) • Upper or mid lung (consider fibrotic HP, CTD-ILD, and sarcoidosis) • Subpleural sparing (consider NSIP or smoking-related IP)
CT features	• Honeycombing with or without traction bronchiectasis/ bronchiolectasis • Presence of irregular thickening of interlobular septa • Usually superimposed with a reticular pattern, mild GGO • May have pulmonary ossification	• Reticular pattern with traction bronchiectasis/ bronchiolectasis • May have mild GGO • Absence of subpleural sparing	• CT features of lung fibrosis that do not suggest any specific etiology	• Lung findings ◦ Cysts (consider LAM, PLCH, LIP, and DIP) ◦ Mosaic attenuation or three-density sign (consider HP) ◦ Predominant GGO (consider HP, smoking-related disease, drug toxicity, and acute exacerbation of fibrosis) ◦ Profuse centrilobular micronodules (consider HP or smoking-related disease) ◦ Nodules (consider sarcoidosis) ◦ Consolidation (consider organizing pneumonia, etc.) • Mediastinal findings ◦ Pleural plaques (consider asbestosis) ◦ Dilated esophagus (consider CTD)

Nonspecific interstitial pneumonia (NSIP)

- Bilateral, symmetric, predominantly lower lung, **bronchovascular bundle distribution**
- **GGO, reticular opacity with traction bronchiectasis, volume decrease**
- **Subpleural sparing**
- Commonly associated diseases in NSIP: connective tissue disease, drug toxicity, etc.
- With consolidation: OP pattern, suggesting connective tissue disorder



Travis WD et al. AJRCCM 2008, AJRCCM 2013

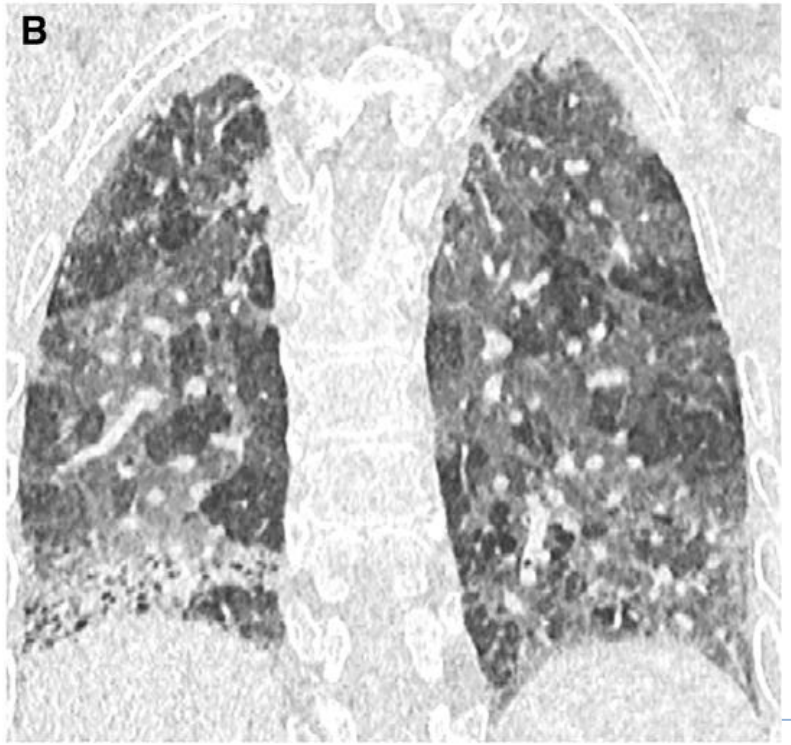
UIP VS. NSIP

	UIP	NSIP
Median age, Sex	50-70, men	40-50, women
Subpleural sparing	-	+
Reticulation	Most prominent feature (subpleural)	Variable: absent to extensive (subpleural sparing)
GGO	Mild	Most prominent feature
Traction bronchiectasis	Common (subpleural)	Common (bronchovascular bundle)
Honeycombing	Common; subpleural and basal	Uncommon at presentation

Travis WD et al. AJRCCM 2013 & Sverzellati N,et al. Radiographics 2013

Fibrotic hypersensitivity pneumonitis

- **Bronchiolocentric interstitial pneumonia**
- **Air-trapping or Three-density sign, Diffuse or mid-to-upper lung predominancy**
- Centrilobular nodules, central peribronchovascular reticulation and distortion
- Traction bronchiectasis & Honeycombing: may be present but do not predominate

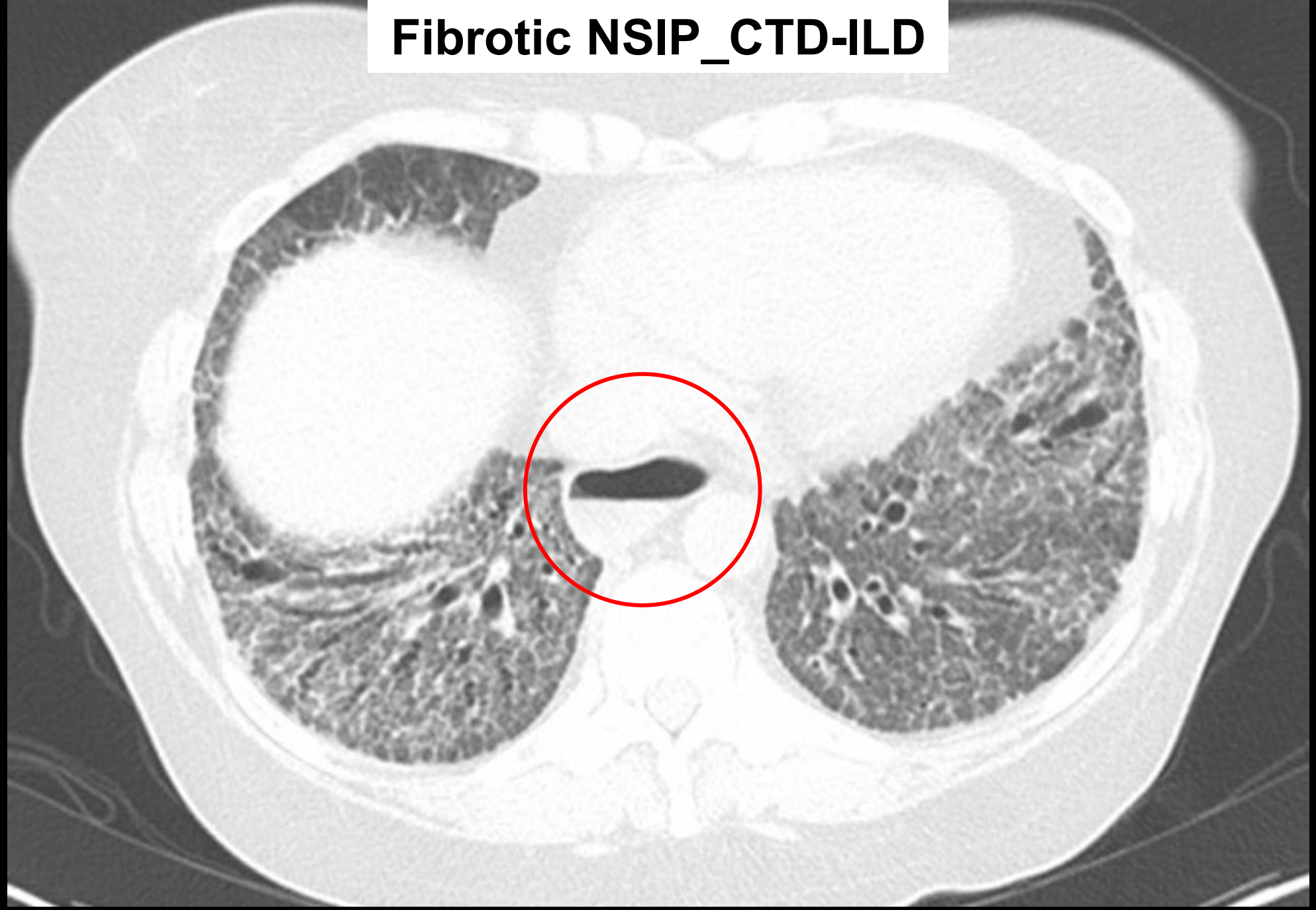


Raghu et al., AJRCCM 2020

Connective tissue disease-ILD

- **Basically, indistinguishable from idiopathic interstitial pneumonia**
- **Tend to cause other thoracic manifestations**
  - Pleural/pericardial effusion or thickening (e.g., SLE)
  - Esophageal dilatation (e.g., scleroderma)
  - Airway involvement: Bronchiectasis, constrictive bronchiolitis
  - Pulmonary artery dilatation
  - Myocarditis
  - Musculoskeletal: soft tissue calcification, joint abnormalities

Fibrotic NSIP_CTD-ILD



Fischer A, et al. Eur Respir J 2015

Connective tissue disease-ILD

Anterior upper lobe sign

Concentrated fibrosis in the anterior of aspect of the upper lobes while sparing the other aspect of the upper lobes

Chung JH, et al. AJR 2018

Connective tissue disease-ILD

Exuberant honeycomb sign

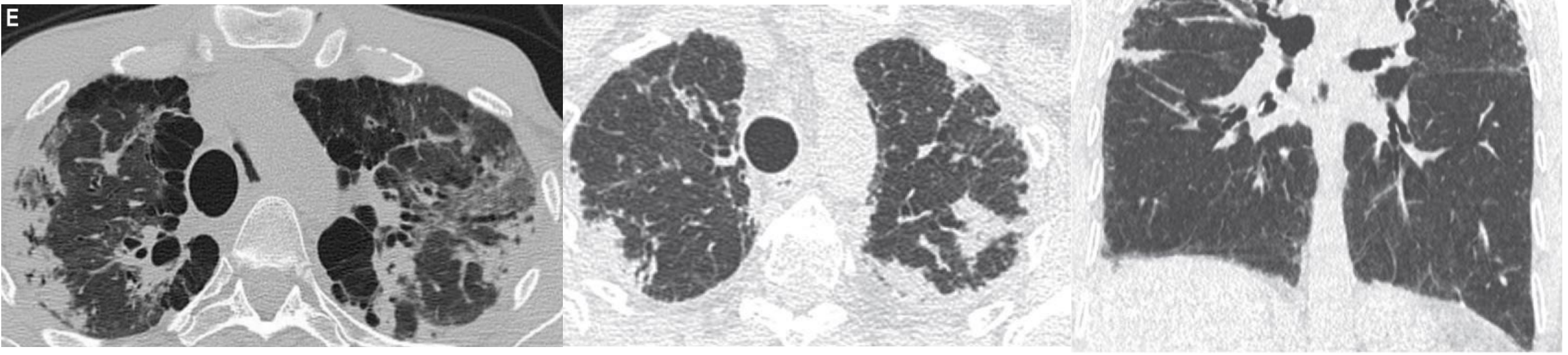
: >70% of fibrotic portion of lung

Straight-edge sign

Chung JH, et al. AJR 2018

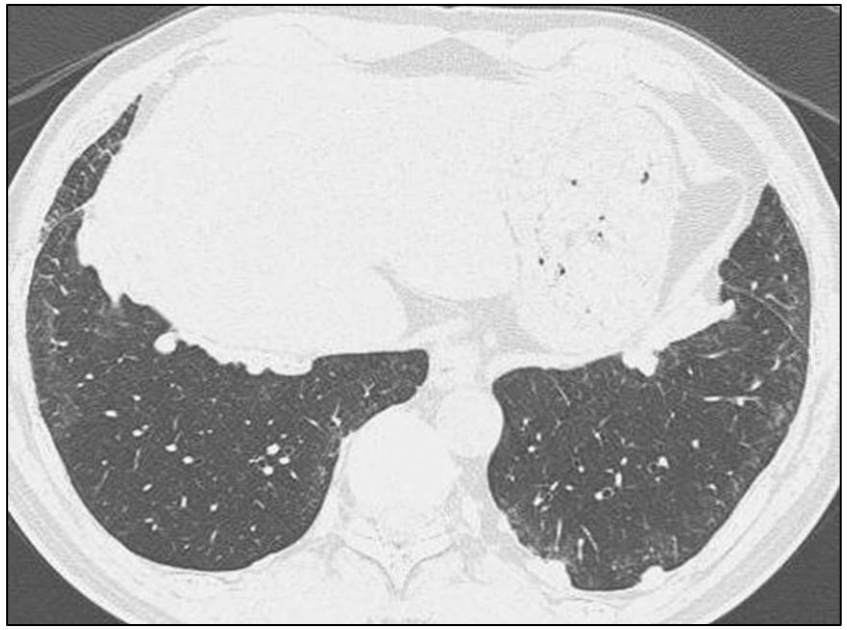
Pleuroparenchymal fibroelastosis (PPFE)

- Irregular visceral pleural thickening and merge with fibrotic changes in the subjacent lung
- “Tags” in the upper lungs (triangle)
- Substantial upper lobes volume loss, architectural distorsion
- Pneumothorax, pneumomediastinum



Travis WD, et al. AJRCCM 2013; Sverzellati N,et al. Radiographics 2013

Asbestosis & End-stage sarcoidosis



- Exposure history
- Pleural plaques or diffuse pleural thickening
- Lower lung: subpleural dotlike or branching opacities, less coarse reticular shadow

- Middle to upper lungs
- Fibrotic distortion with peribronchovascular distribution & perilymphatic nodules
- Large cyst, honeycomb-like cysts

Criado E, et al. Radiographics 2010

Take-home message

- **ILD classification & ILA**
- **Lung fibrosis CT findings**
  - Reticular opacity, traction bronchiectasis, honeycombing cyst, three density sign, non-emphysematous cysts
- **UIP pattern spectrum**
  - UIP, probable UIP, indeterminate UIP pattern definition
- **Alternative diagnosis**
  - NSIP, fibrotic HP, CTD-ILD, PPFE, asbestosis...

Criado E, et al. Radiographics 2010

Thank you for your attentions