Hypersensitivity Pneumonitis and Mosaic Attenuation

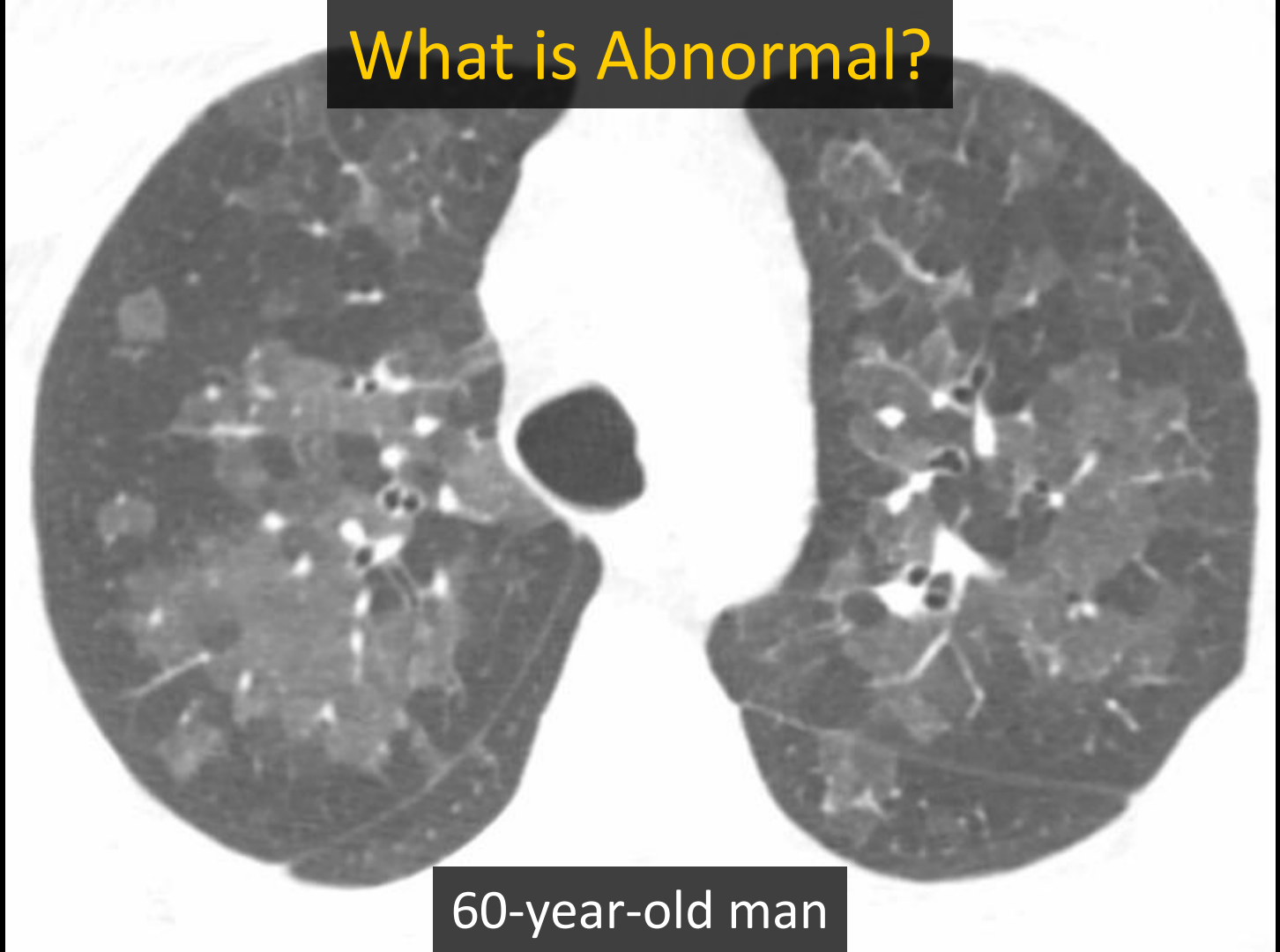
We Have No Relevant Disclosures

Mosaic Attenuation

- Patchwork of regions of differing attenuation that may represent:
  (a) patchy interstitial disease
  (b) obliterative small airways disease
  (c) occlusive vascular disease

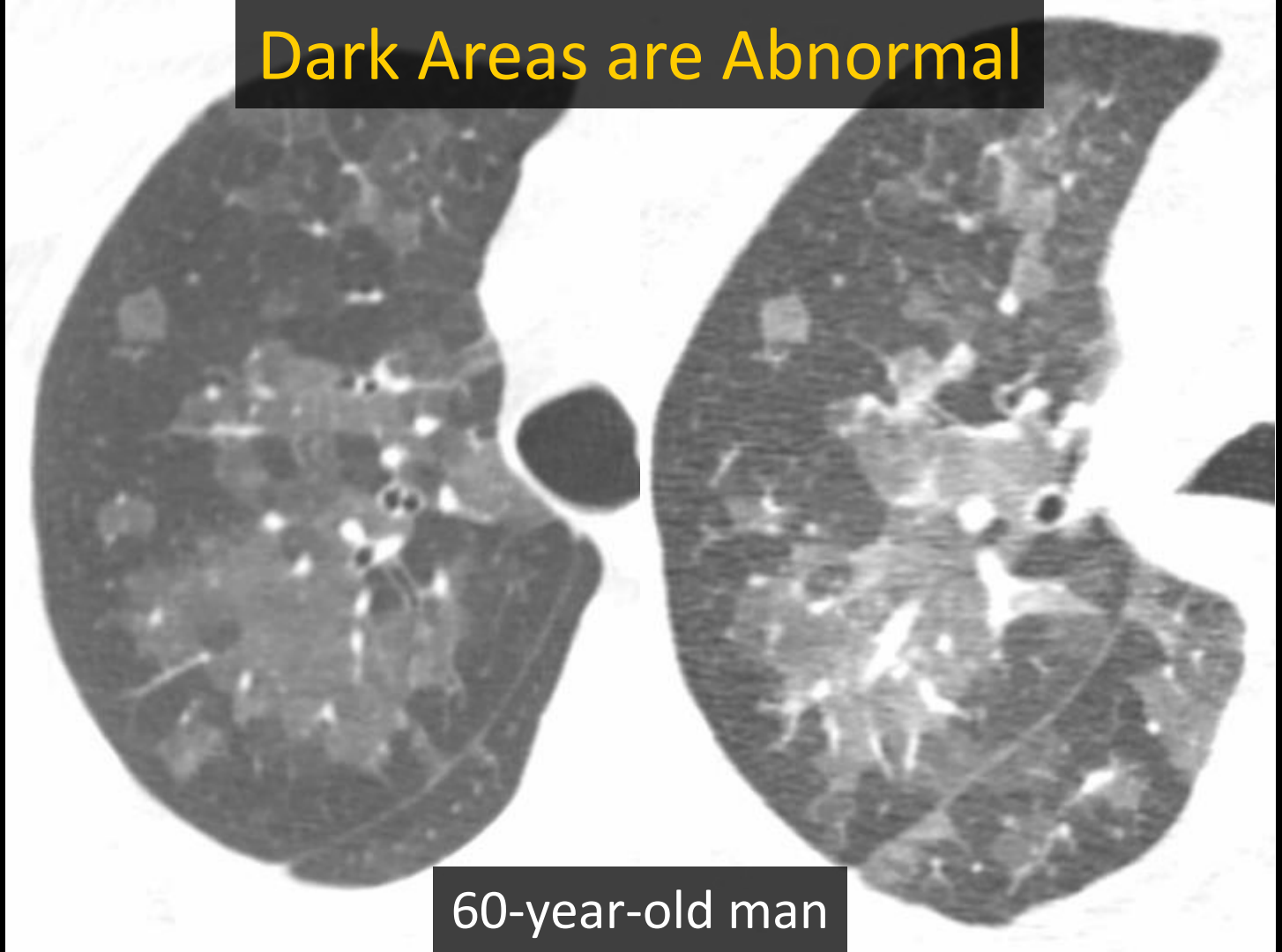
Fleischner Society glossary of terms

What is Abnormal?



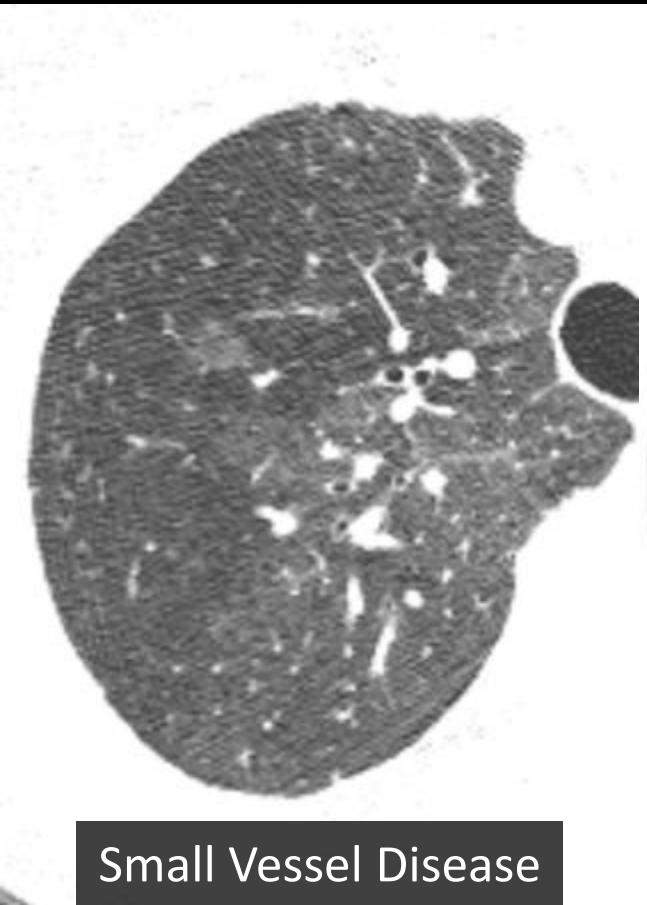
60-year-old man

Dark Areas are Abnormal

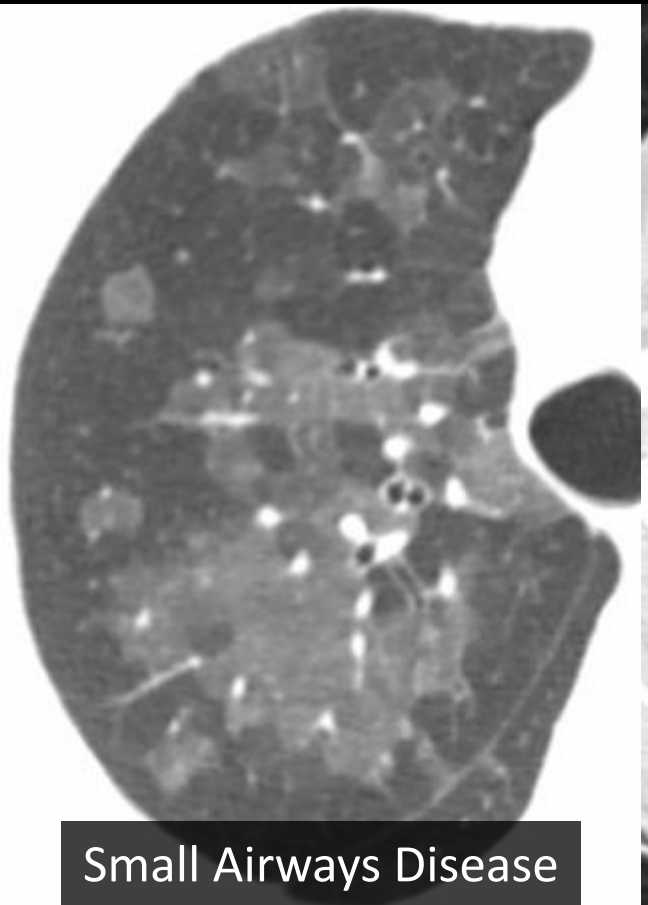


60-year-old man

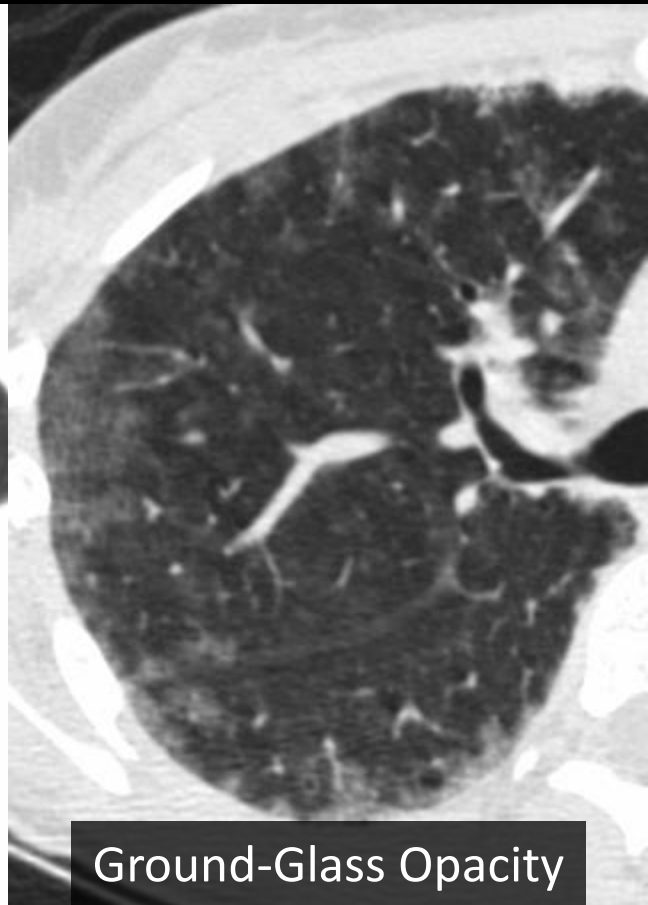
Mosaic Attenuation



Small Vessel Disease



Small Airways Disease



Ground-Glass Opacity

Mosaic Attenuation

(all inclusive term)

Small Vessel Disease

Small Airways Disease

Groundglass Opacity

Kligerman *Radiographics* 2015

Small Airways Disease

Bronchiolar obstruction

↓

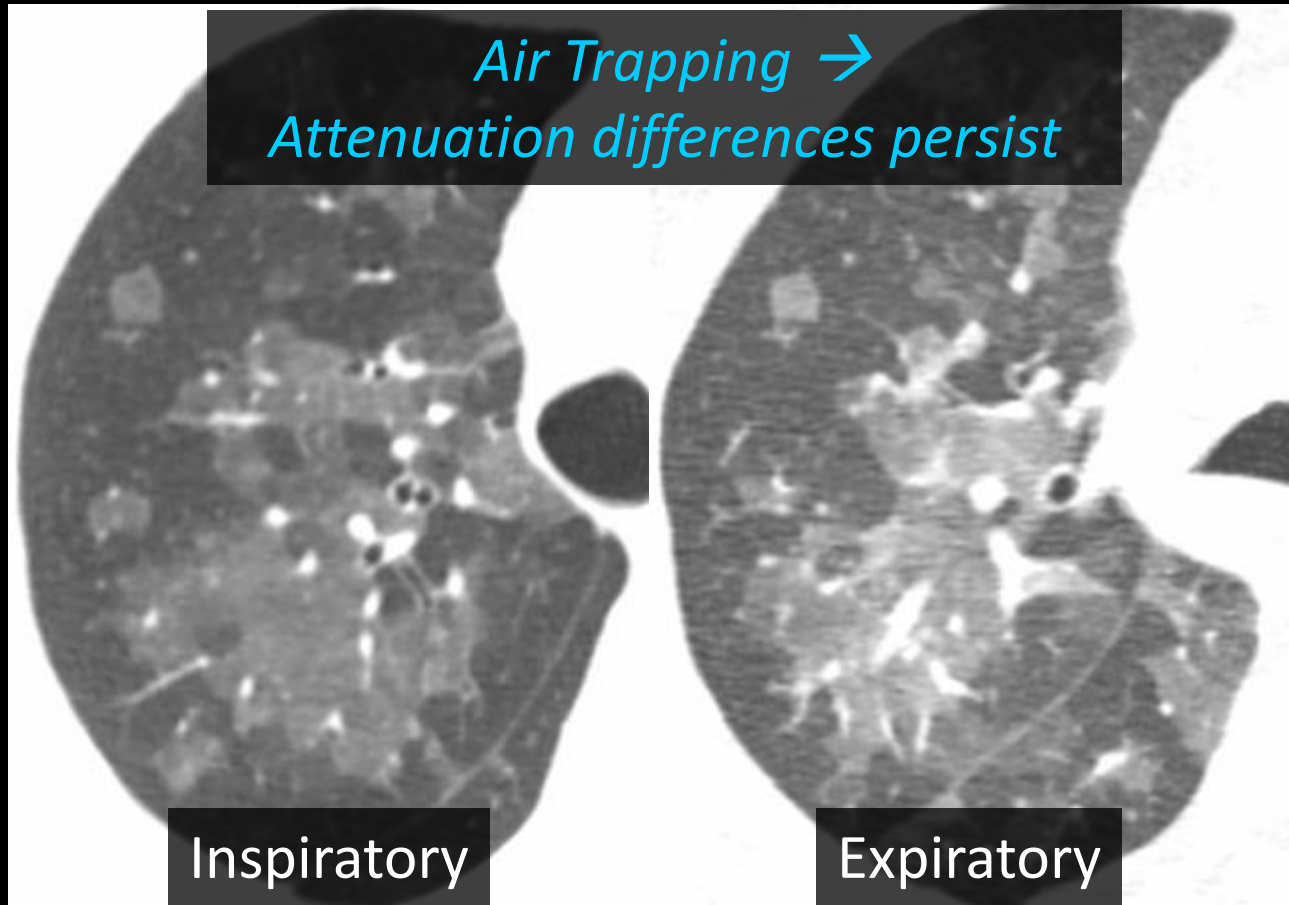
Reduced ventilation

↓

Hypoxic vasoconstriction

↓

Lucent lung



Small Vessel Disease

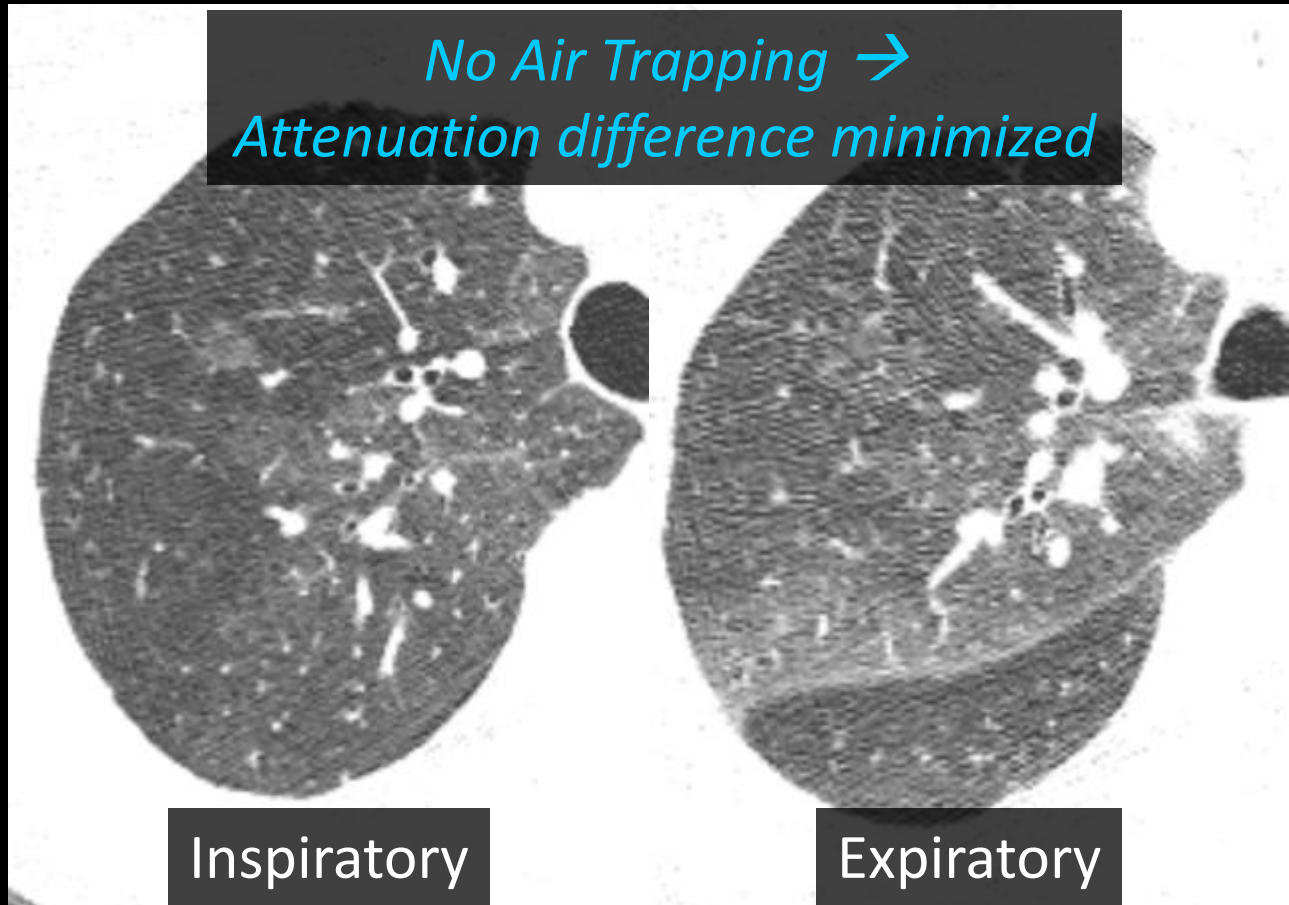
Vessel obstruction

↓

Decreased blood flow

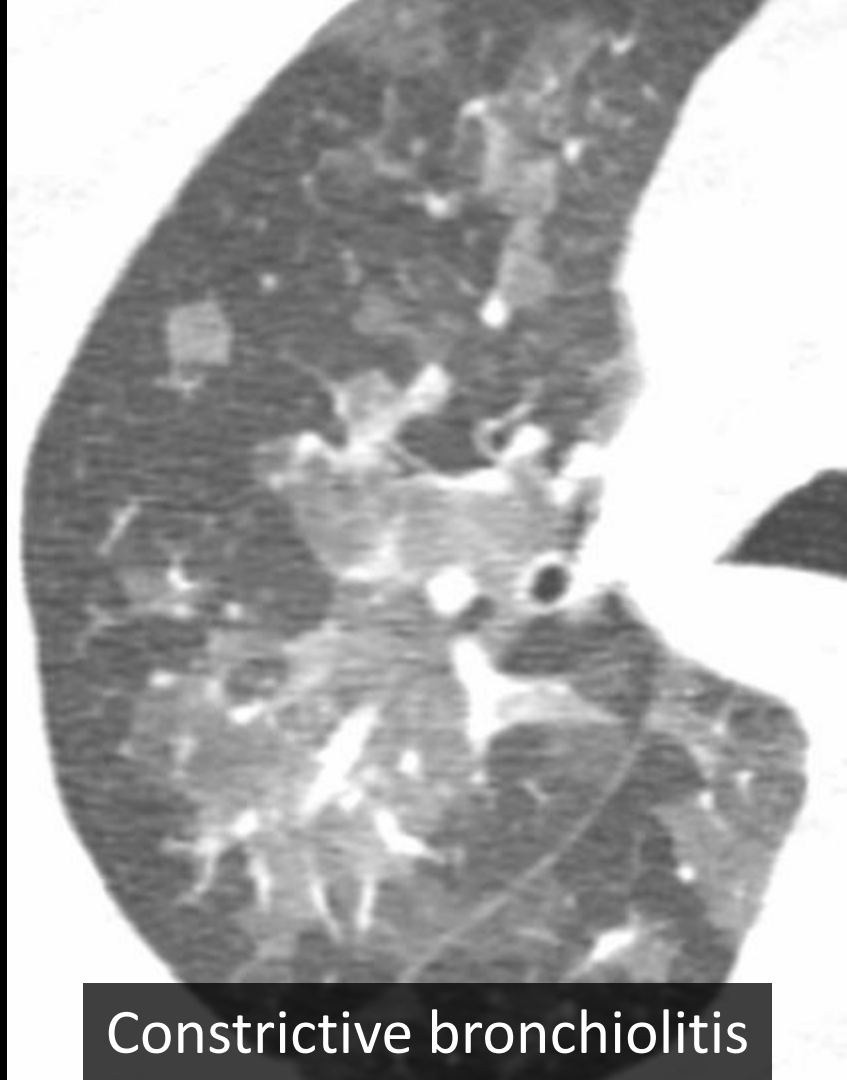
↓

Lucent Lung



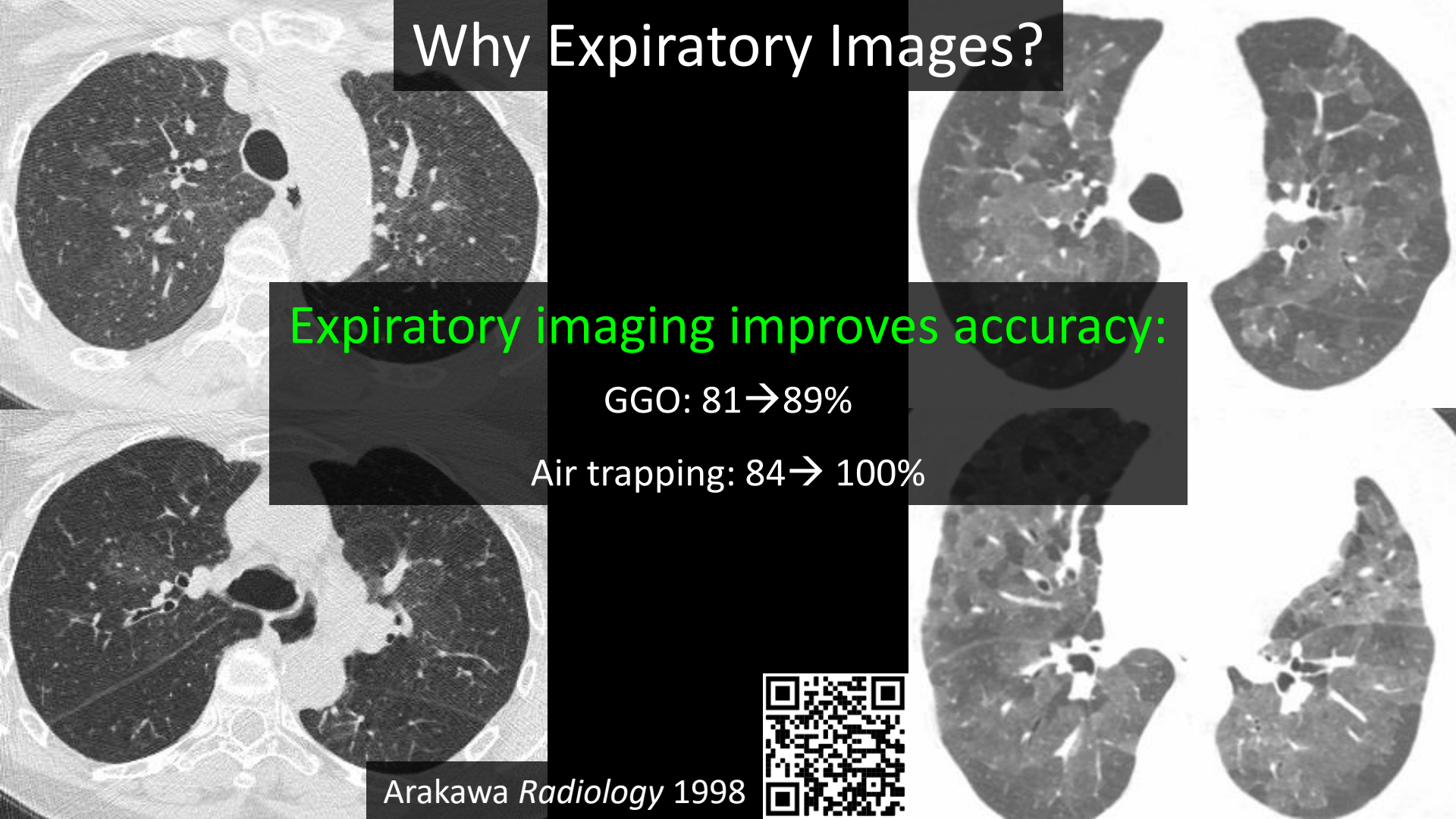
Air Trapping

- Constrictive (obliterative) bronchiolitis
- Bronchiolar obstruction



Constrictive bronchiolitis

Why Expiratory Images?



Expiratory imaging improves accuracy:

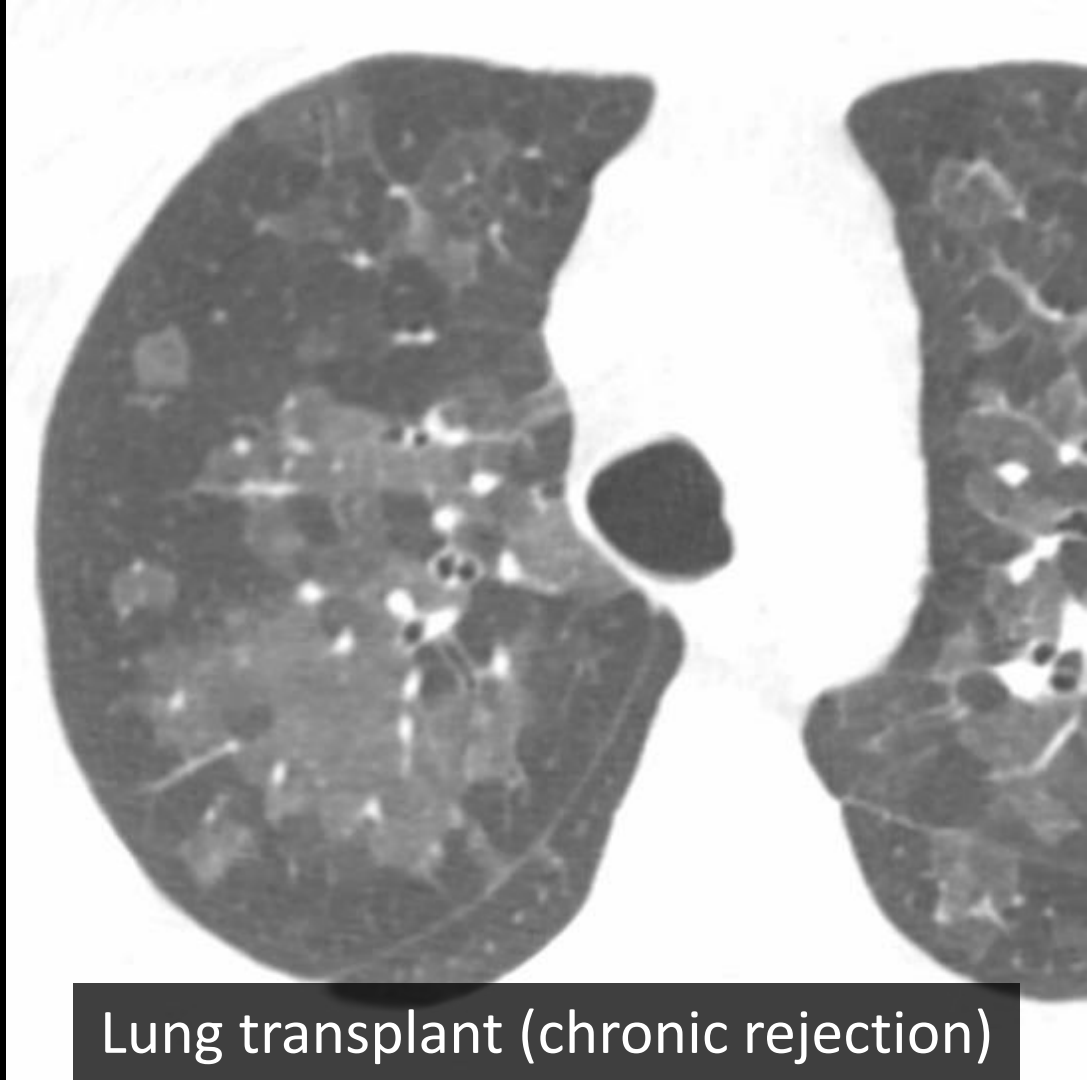
GGO: 81→89%

Air trapping: 84→ 100%

Arakawa *Radiology* 1998

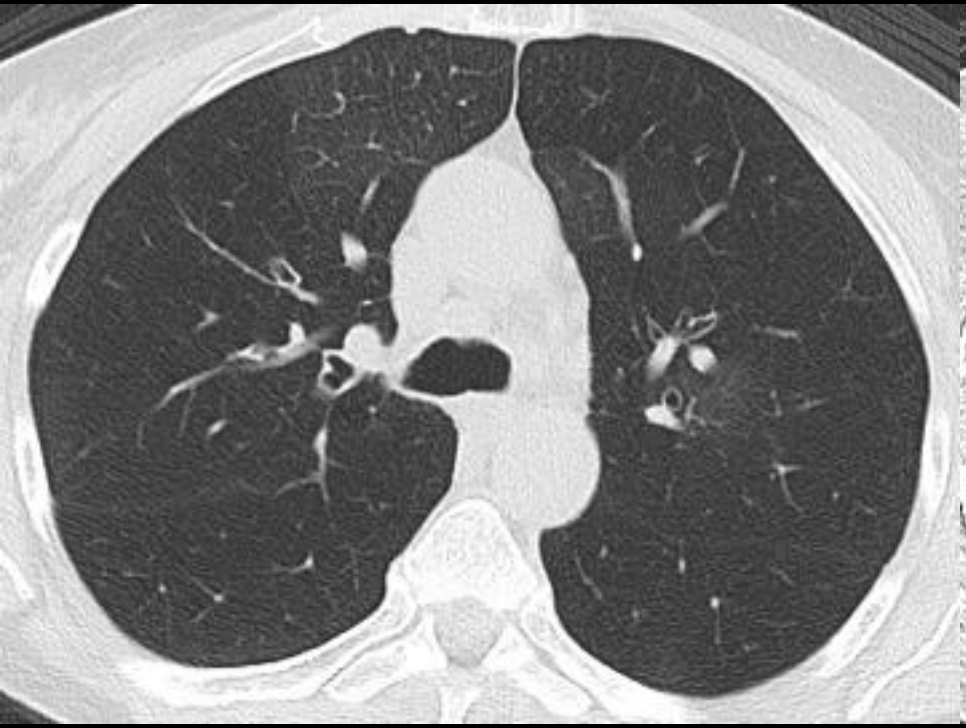
Constrictive bronchiolitis

- Lung transplant
- Bone marrow transplant
- Autoimmune
- Exposure
- Infection
- DIPNECH



Lung transplant (chronic rejection)

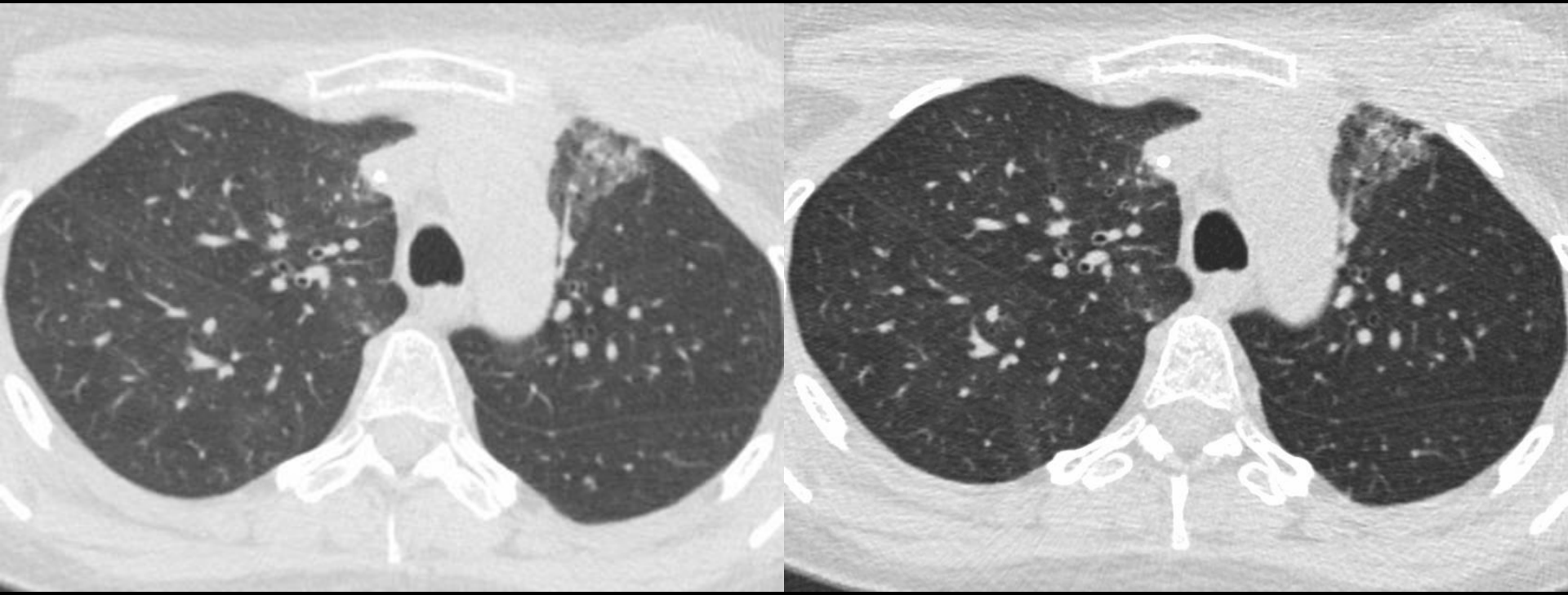
60-year-old female with SSc



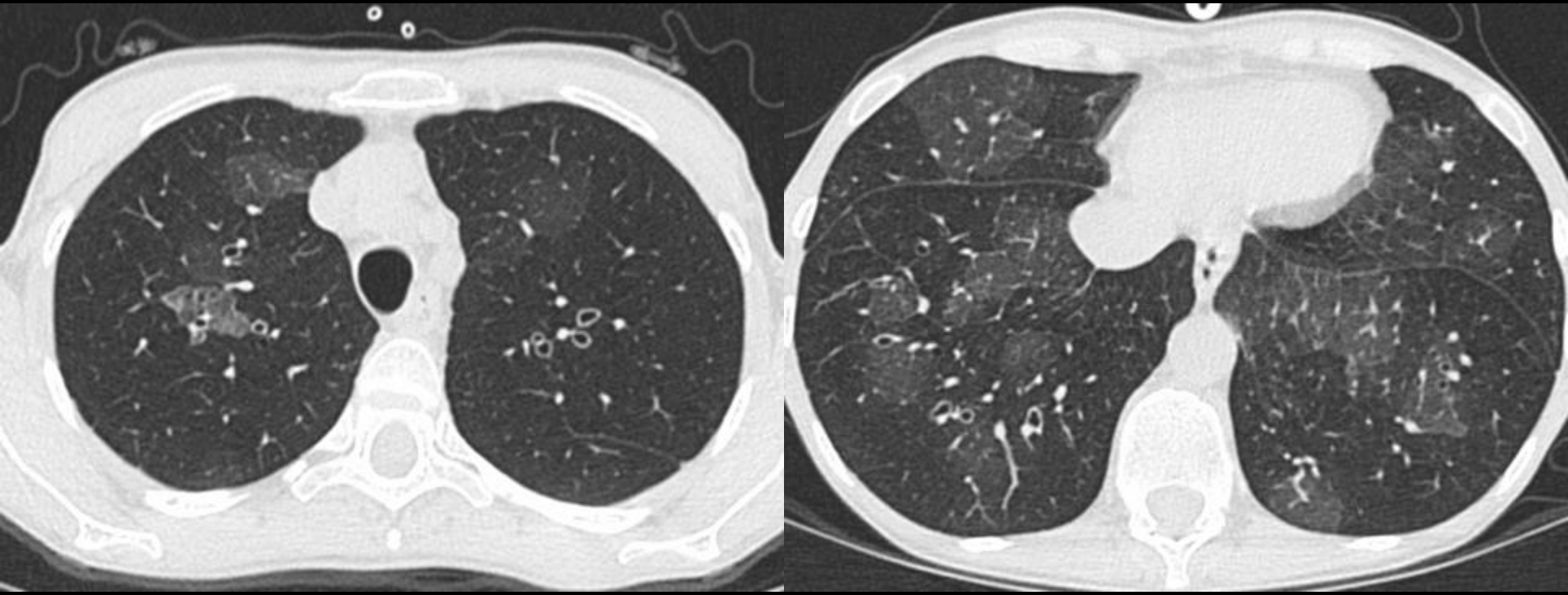
Inspiratory

Expiratory

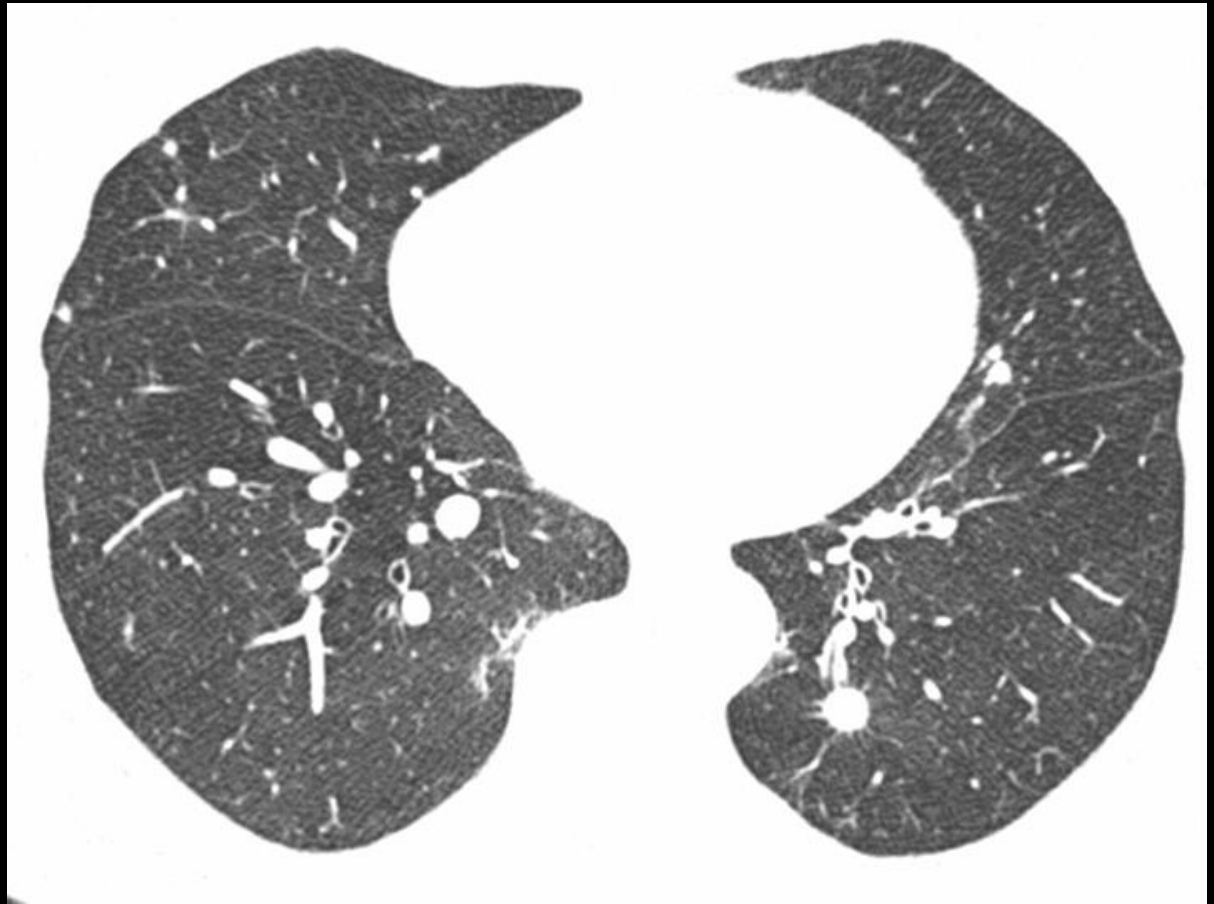
Graft-Versus-Host Disease



Crohn Disease



DIPNECH



Hypersensitivity Pneumonitis

- Immune-mediated disease producing ILD in susceptible patients after exposure (either known or unknown)
- Antigen never identified in up to 60% of patients
- TWO types as of 2020 ATS guidelines

ATS 2020 Guidelines

- Two types of HP:
  - Nonfibrotic HP – purely inflammation
  - Fibrotic HP – fibrosis +/- inflammation

Revisiting Terminology

- Mosaic Attenuation
- Air Trapping
- Mosaic Perfusion
- Three Density Pattern

Mosaic Attenuation

- Descriptor for inspiratory images only
- Combination of areas of low and high attenuation that can correspond to two main situations:
  - Areas of GGO (“high”) and normal lung (“low”)or
  - Areas of normal lung (“high”) and areas of decreased attenuation (“low”)

Air Trapping

- Term exclusively used for description of expiratory CT images
- Focal zones of hypoattenuation in the background of hyperattenuating normal lung on expiratory CT images
- Affected lobules often expanded

Mosaic Perfusion

- Term used for description of inspiratory CT images
- Presence of decreased vascular sections within areas of low attenuation in comparison with areas of normal lung

Three Density Pattern

- Combination of three attenuations on inspiratory CT images:
  - Normal-appearing lung
  - High attenuation (GGO)
  - Lucent lung (regions of decreased attenuation and decreased vessel caliber)
- Sharply demarcated from each other

Nonfibrotic HP

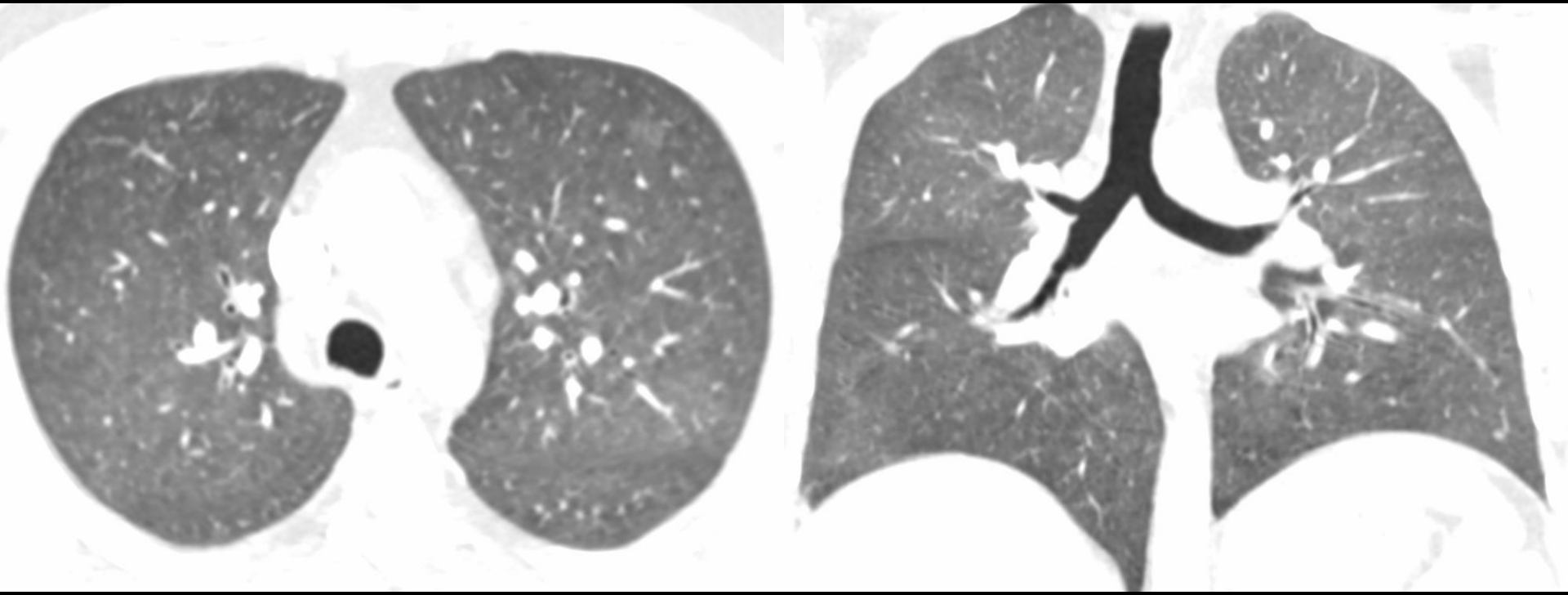
Table 5. Chest HRCT Scan Features of the Nonfibrotic HP Pattern

HRCT Pattern	Typical HP	Compatible with HP	Indeterminate for HP
Description	The "typical HP" pattern is suggestive of a diagnosis of HP. It requires *a*) at least one HRCT abnormality indicative of parenchymal infiltration and *b*) at least one HRCT abnormality indicative of small airway disease, both in a diffuse distribution	"Compatible-with-HP" patterns are nonspecific patterns that have been described in HP	N/A
Relevant radiological findings	HRCT abnormalities indicative of parenchymal infiltration: • GGOs • Mosaic attenuation* HRCT abnormalities indicative of small airway disease: • Ill-defined, centrilobular nodules • Air trapping Distribution of parenchymal abnormalities: • Craniocaudal: diffuse (with or without some basal sparing) • Axial: diffuse	Parenchymal abnormalities: • Uniform and subtle GGOs • Airspace consolidation • Lung cysts Distribution of parenchymal abnormalities: • Craniocaudal: diffuse (variant: lower lobe predominance) • Axial: diffuse (variant: peribronchovascular)	N/A

Definition of abbreviations: GGO = ground-glass opacity; HP = hypersensitivity pneumonitis; HRCT = high-resolution computed tomography; N/A = not applicable.

*Mosaic attenuation corresponding to parenchymal infiltration is created by GGOs adjacent to normal-appearing lung.

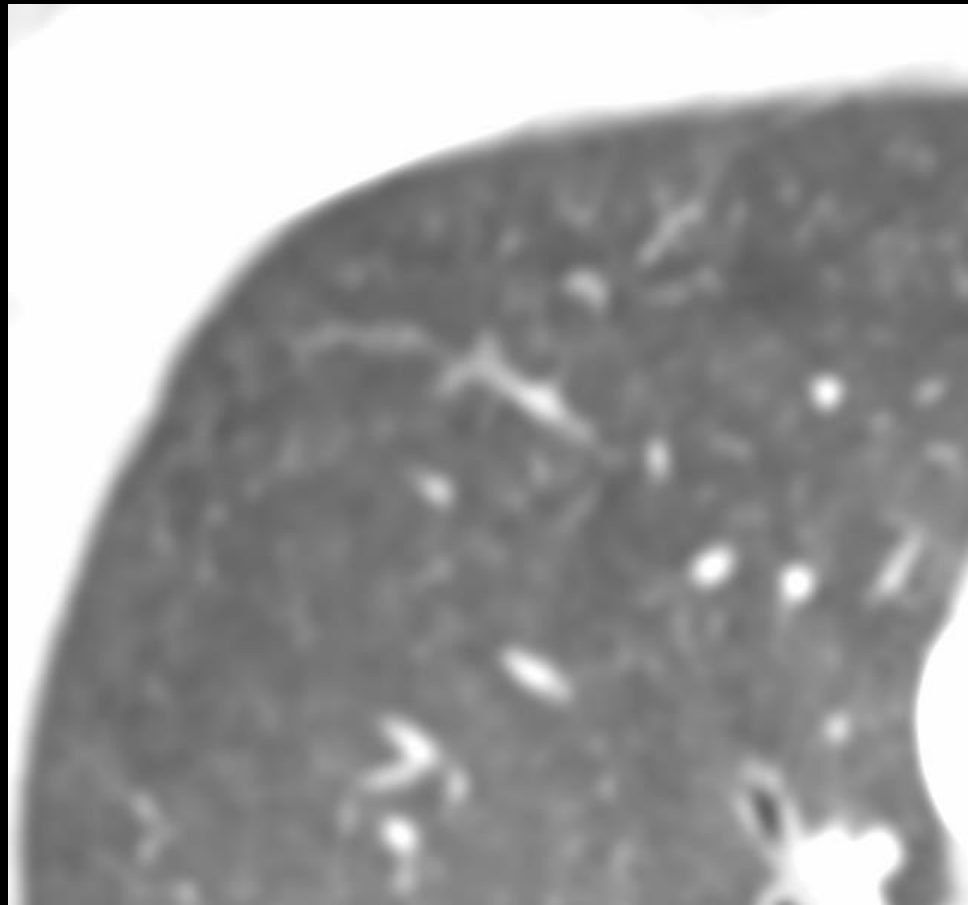
Nonfibrotic HP



32-yo with dyspnea after new job as spray painter

Nonfibrotic HP

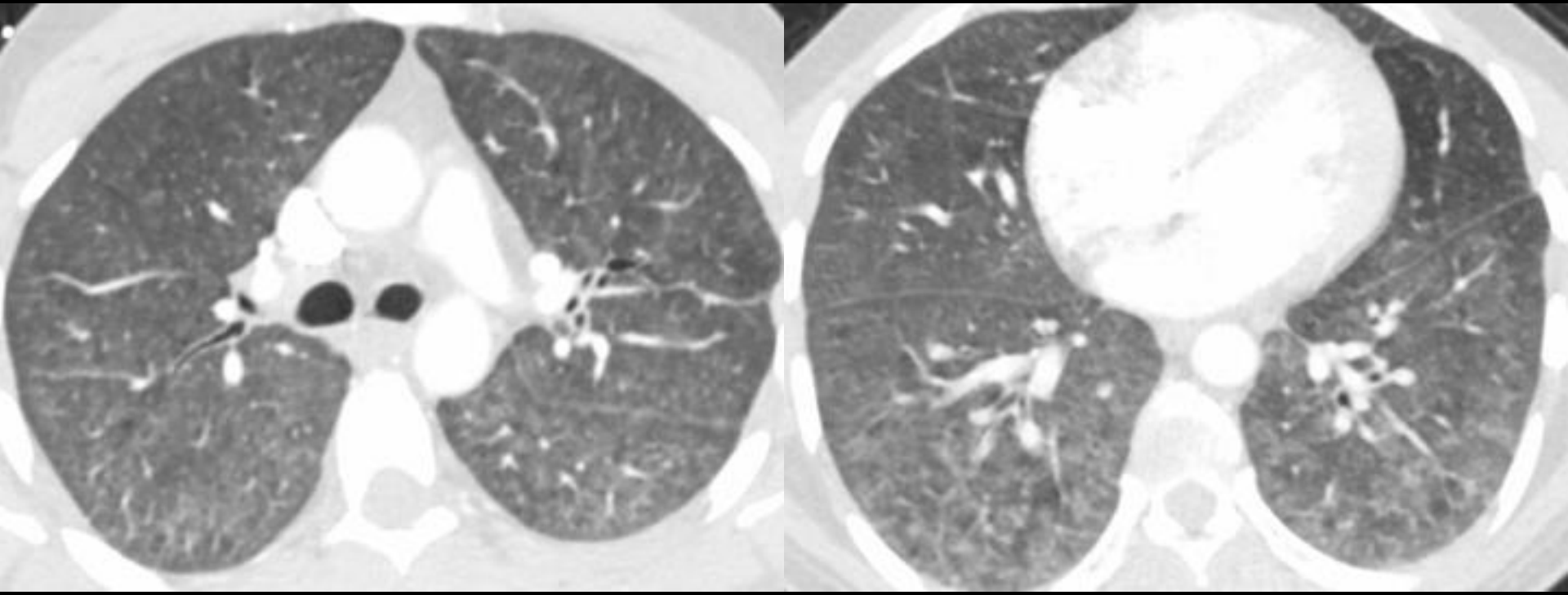
- Parenchymal infiltration + small airways disease:
  - Diffuse GGO
  - Centrilobular ground-glass attenuation nodules



26-yo Female - nfHP

26-yo Female - nfHP

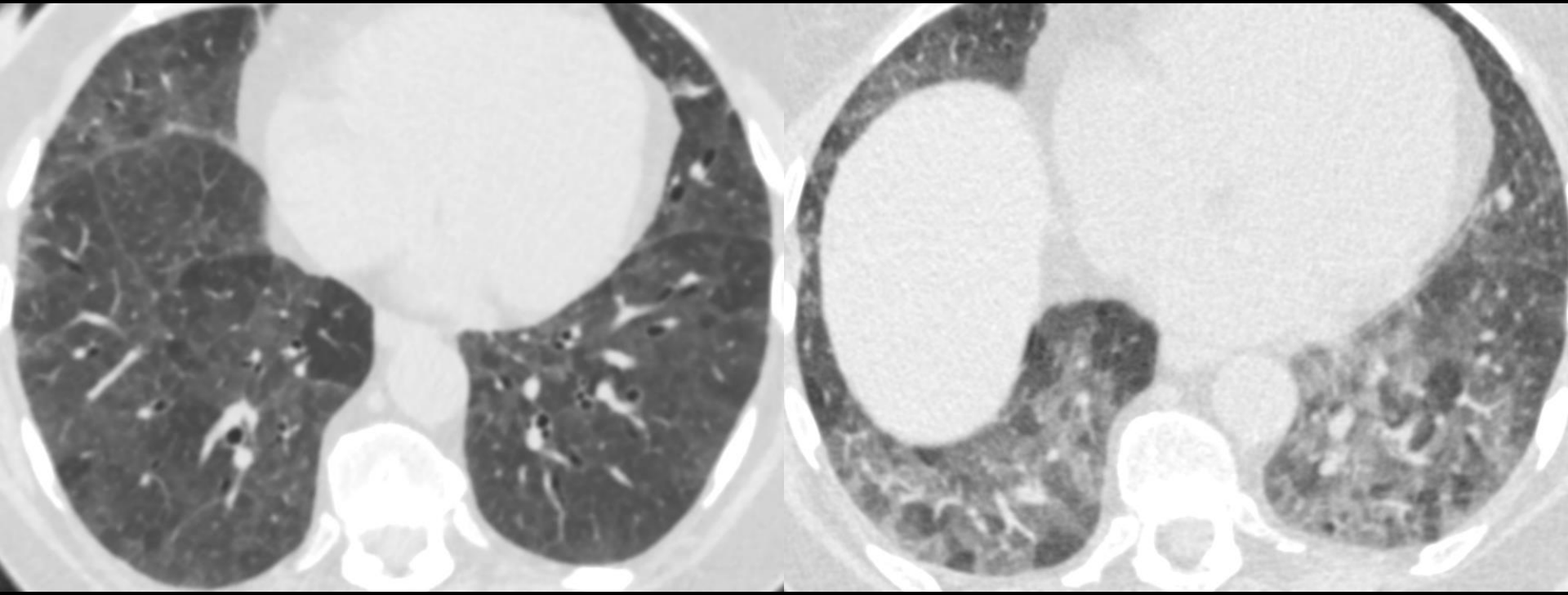
Poultry Worker



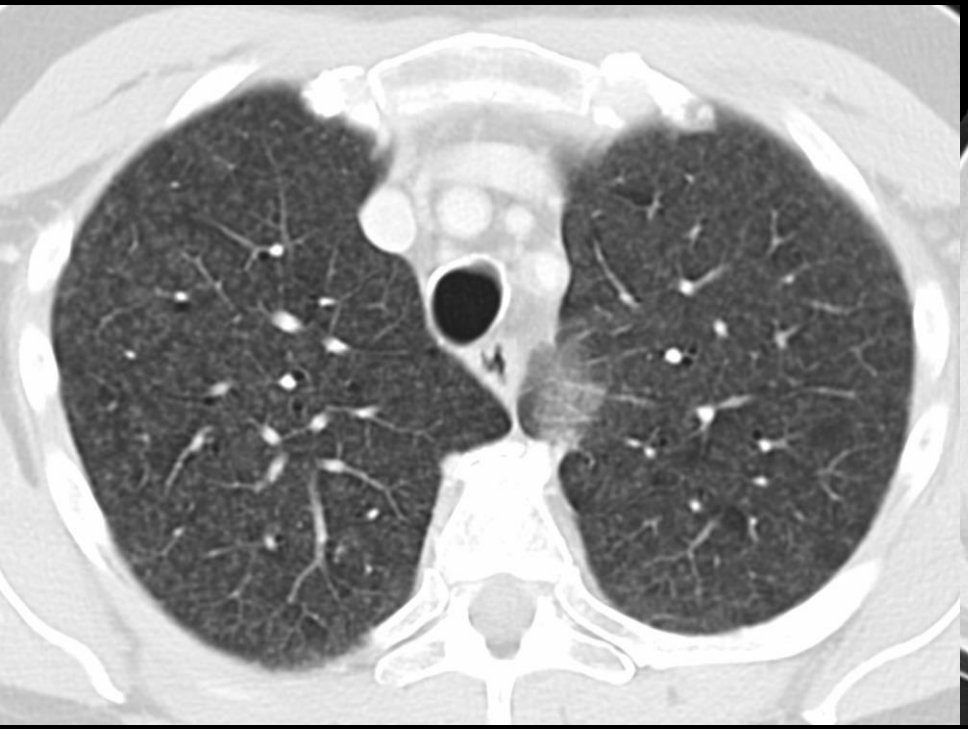
Bird Owner

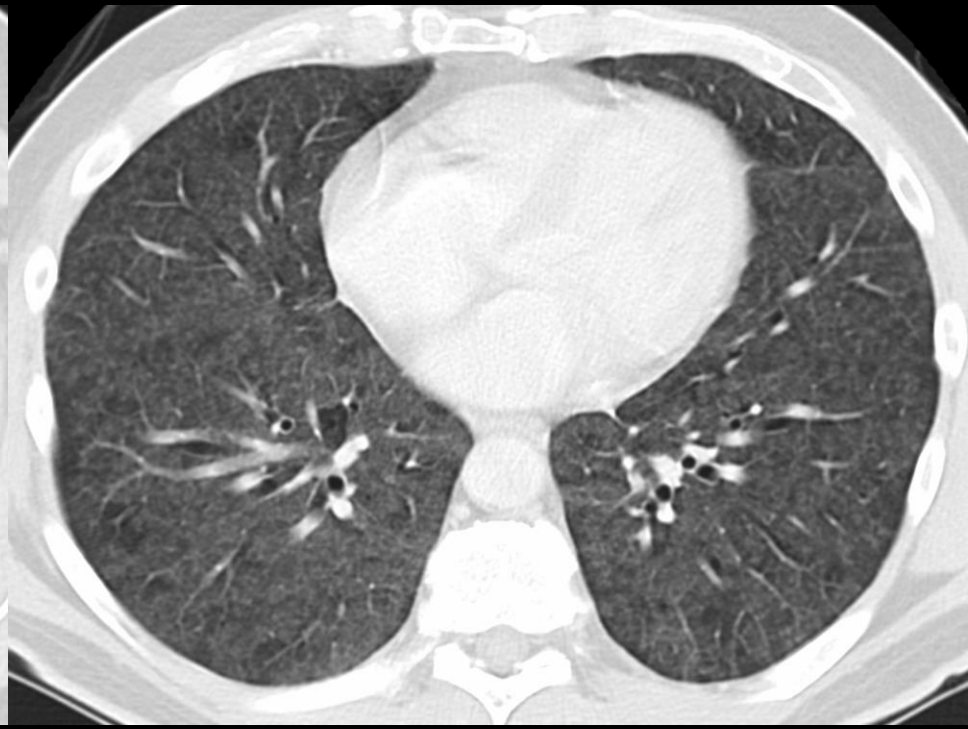
Smoker with cough → RB

Compatible With nfHP



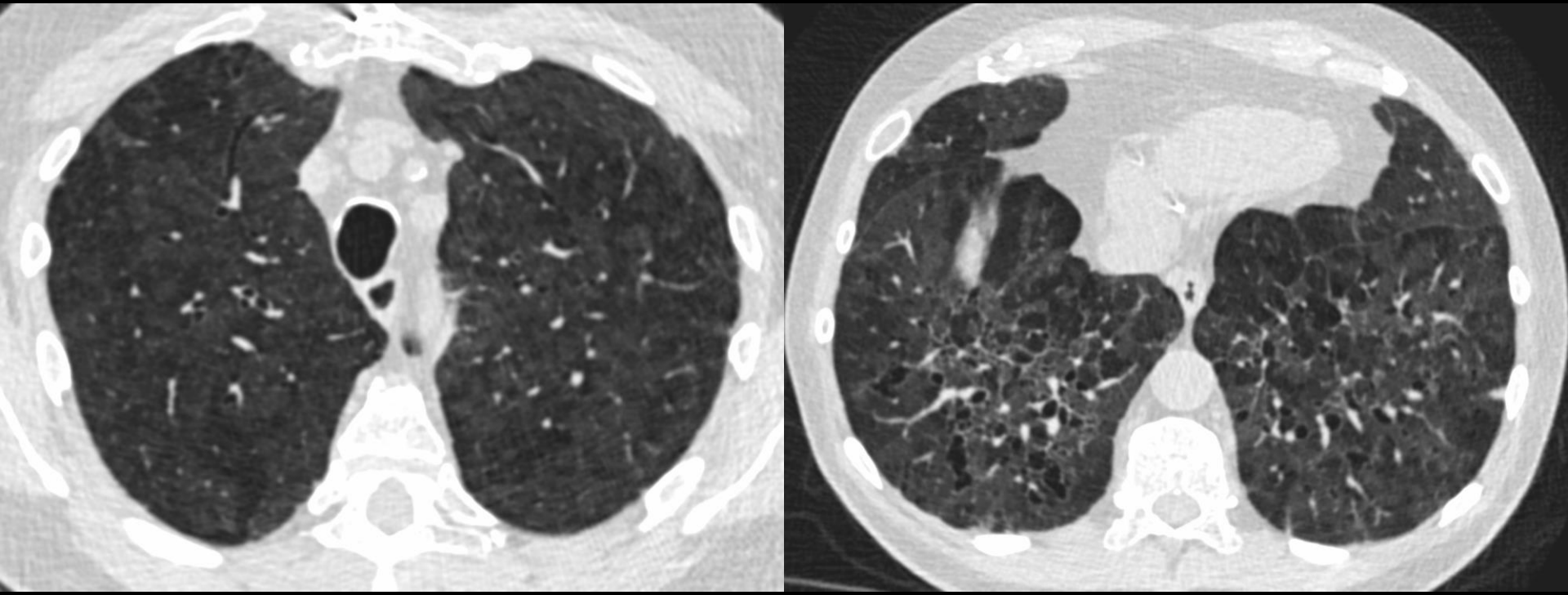
nfHP progressing to fHP





64-year-old male, intermittently responds to steroids

nfHP progressing to fHP



11 years after baseline

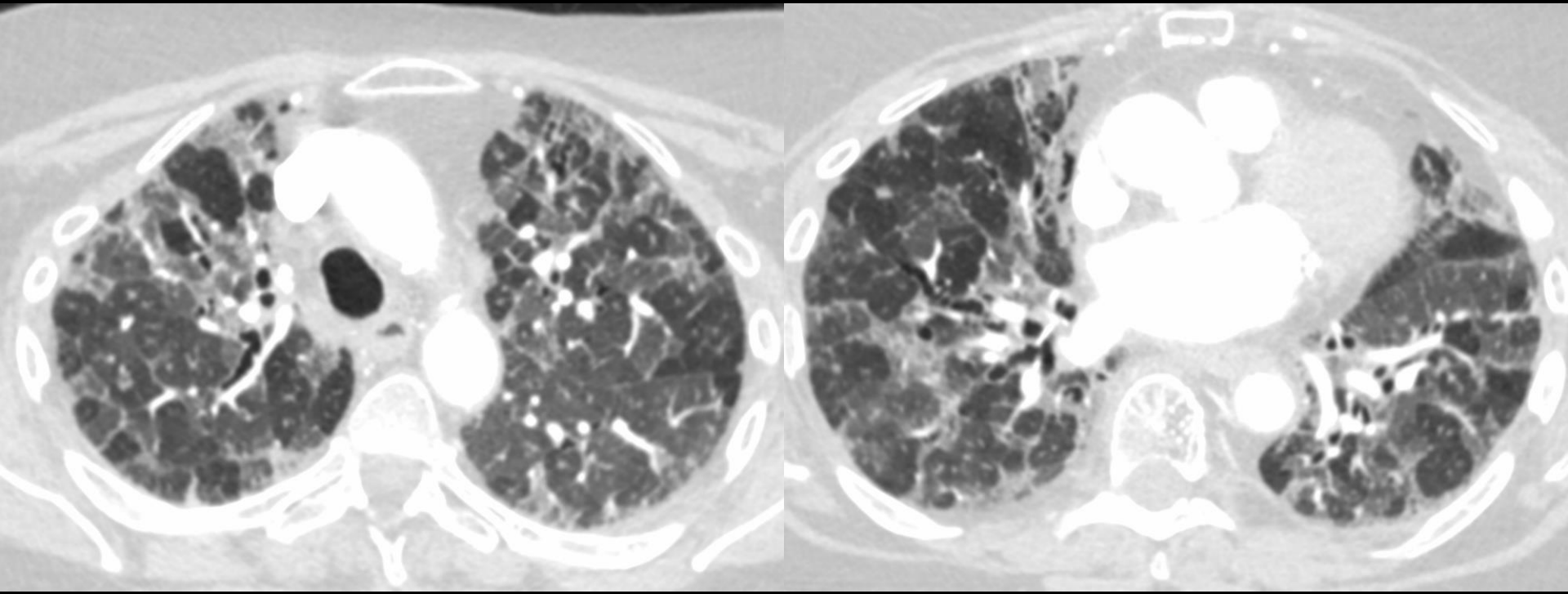
Fibrotic HP

Table 6. Chest HRCT Scan Features of the Fibrotic HP Pattern

HRCT Pattern	Typical HP	Compatible with HP	Indeterminate for HP
Description	The "typical HP" pattern is suggestive of a diagnosis of HP. It requires *a*) an HRCT pattern of lung fibrosis (as listed below) in one of the distributions and *b*) at least one abnormality that is indicative of small airway disease	"Compatible-with-HP" patterns exist when the HRCT pattern and/or distribution of lung fibrosis varies from that of the typical HP pattern; the variant fibrosis should be accompanied by signs of small airway disease	The "indeterminate-for-HP" pattern exists when the HRCT is neither suggestive nor compatible with a typical and probable HP pattern
Relevant radiological findings	HRCT abnormalities indicative of lung fibrosis are most commonly composed of irregular linear opacities/ coarse reticulation with lung distortion; traction bronchiectasis and honeycombing may be present but do not predominate The distribution of fibrosis may be: • Random both axially and craniocaudally or • Mid lung zone–predominant or • Relatively spared in the lower lung zones HRCT abnormalities indicative of small airway disease: • Ill-defined, centrilobular nodules and/or GGOs • Mosaic attenuation, three-density pattern,* and/or air trapping (*often in a lobular distribution*)	Variant patterns of lung fibrosis: • UIP pattern: basal and subpleural distribution of honeycombing with/without traction bronchiectasis (*per 2018 diagnosis of IPF guidelines* [20]) • Extensive GGOs with superimposed subtle features of lung fibrosis Variant (predominant) distributions of lung fibrosis: • Axial: peribronchovascular, subpleural areas • Craniocaudal: upper lung zones HRCT abnormalities indicative of small airway disease: • Ill-defined centrilobular nodules, or • Three-density pattern* and/ or air trapping	Lone patterns (i.e., not accompanied by other findings suggestive of HP) of: • UIP pattern (*as per 2018 IPF diagnosis guidelines* [20]) • Probable UIP pattern (*as per 2018 IPF diagnosis guidelines* [20]) • Indeterminate pattern for UIP (*as per 2018 IPF diagnosis guidelines* [20]) • Fibrotic NSIP pattern • Organizing pneumonia–like pattern • Truly indeterminate HRCT pattern

Definition of abbreviations: GGO = ground-glass opacity; HP = hypersensitivity pneumonitis; HRCT = high-resolution computed tomography; IPF = idiopathic pulmonary fibrosis; NSIP = nonspecific interstitial pneumonia; UIP = usual interstitial pneumonia.
Rarely, fibrotic HP may be seen *1*) as a component of combined pulmonary fibrosis and emphysema or pleuroparenchymal fibroelastosis with emphysema, *2*) as a pure emphysematous form of HP, or *3*) in acute exacerbation.
*The three-density pattern was formerly called the "headcheese sign." It is described in detail in Table 4.

Three Density Sign



Finding on INSPIRATORY IMAGES ONLY

Three Density Sign

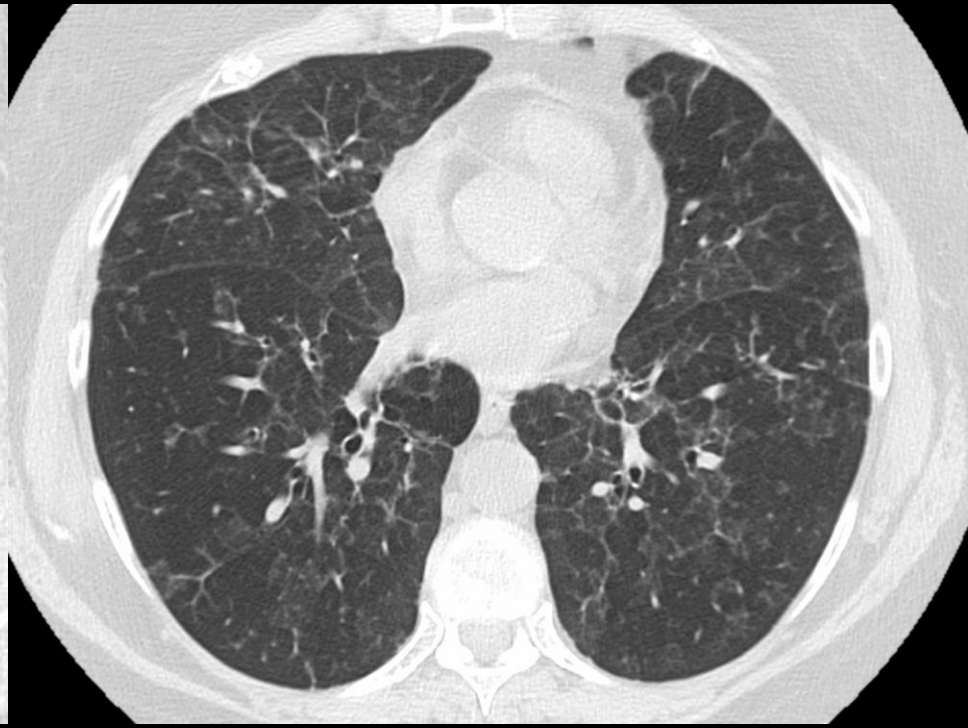
Finding on INSPIRATORY IMAGES ONLY

Fibrotic HP – 73-yo Female

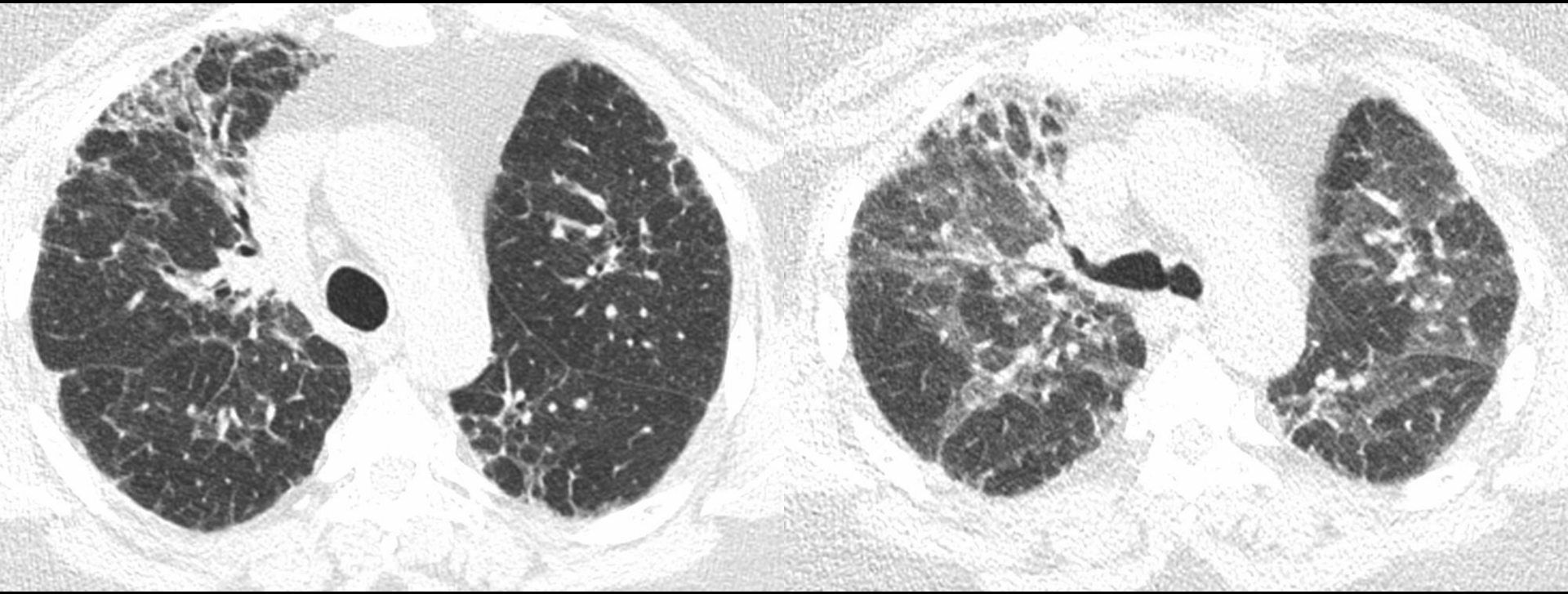
Fibrotic HP – 73-yo Female

Expiratory – air trapping but not three density sign

Fibrotic HP – Bird Owner



Fibrotic HP – Air Trapping



Fibrotic HP – Air Trapping

Normal “Air Trapping”

Radiology

Thoracic Imaging

Nobuyuki Tanaka, MD
Tsuneo Matsumoto, MD
Gouji Miura, MD
Takuya Emoto, MD
Naofumi Matsunaga, MD
Katsuhiko Ueda, RT
David A. Lynch, MB

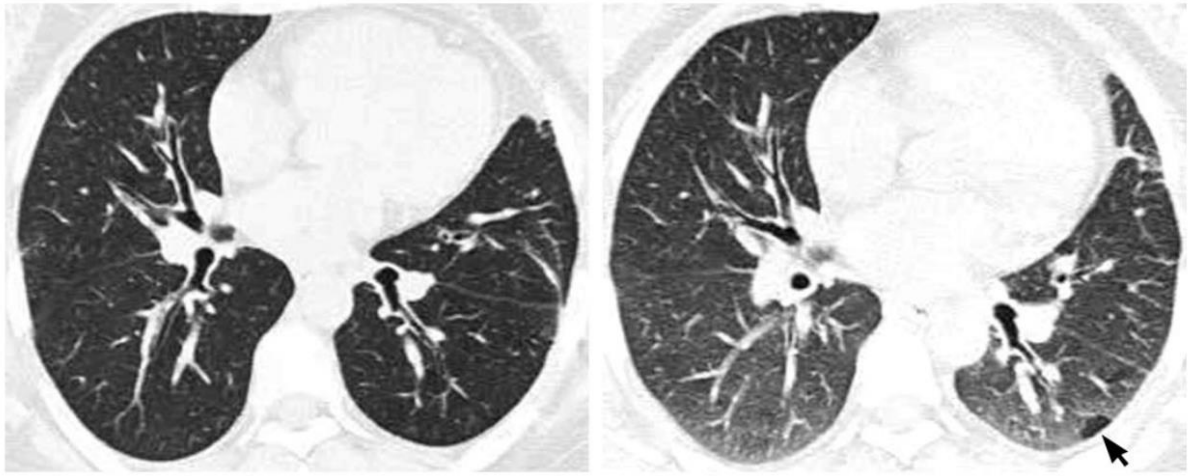
Index terms:
Emphysema, pulmonary, 60.751
Lung, air trapping, 60.751
Lung, CT, 60.12118
Lung, function

Published online before print
10.1148/radiol.2273020352
Radiology 2003; 227:776–785

Air Trapping at CT: High Prevalence in Asymptomatic Subjects with Normal Pulmonary Function[1]

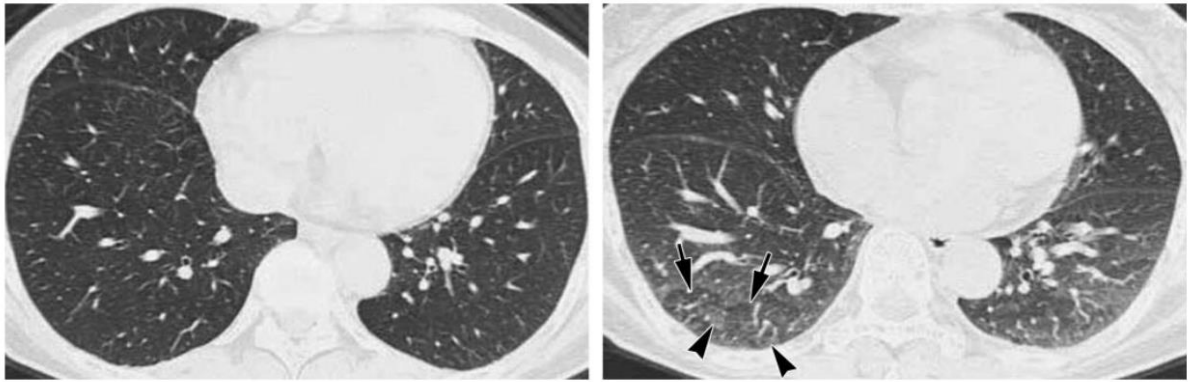
PURPOSE: To determine the degree and extent of air trapping at tomography (CT) in subjects with normal pulmonary function test resu

MATERIALS AND METHODS: The study group consisted of 50 su normal pulmonary function, including 26 nonsmokers and 24 smokers and 10 ex-smokers; 11 mild and 13 heavy smokers). All 50 subjects thin-section CT at which images were obtained during deep inspiratio ration at three lung levels. The mean expiratory increase in lung atten

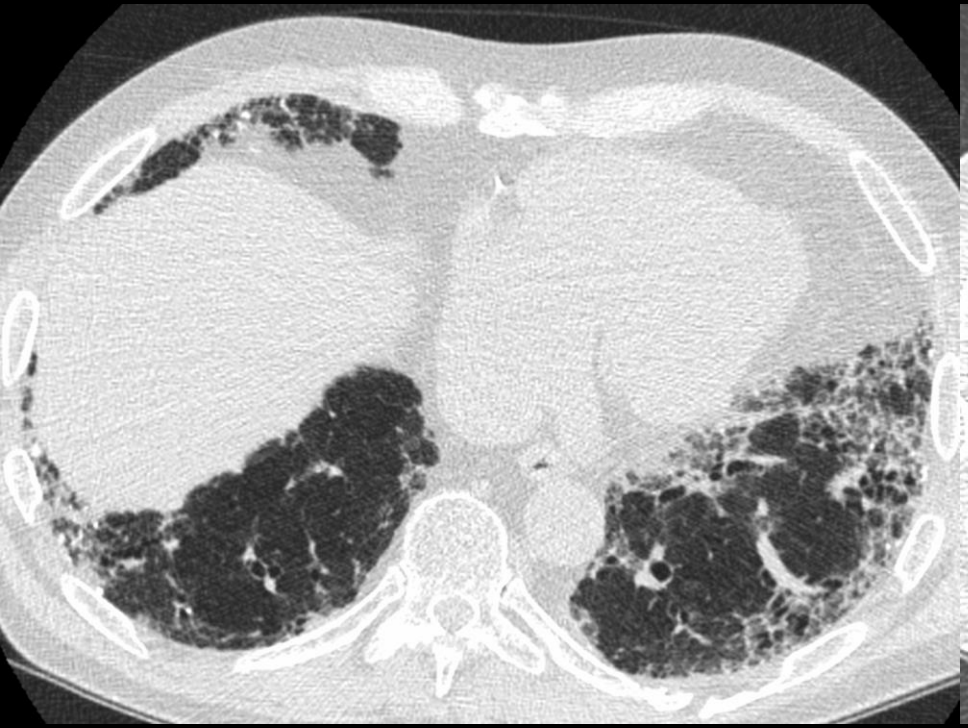


a. b.

Figure 2. Lobular air trapping. **(a)** Inspiratory and **(b)** expiratory transverse thin-section CT images at the middle level of the lung in a 44-year-old nonsmoking woman who had an FEV_1/FVC value of 89.5% and a percent predicted $MEF_{50\%}$ value of 132.5%. Normal lung tissue increases in attenuation during expiration, especially in the dependent lung area. A small area of hypoattenuation (arrow), corresponding to a single secondary pulmonary lobule, is seen in the subpleural zone of the left lower lobe. The overall ratio of air trapping was 2.7% in this case.



Normal Expiratory



Air trapping seen in ~50% of UIP cases

Questions?