Current CT imaging in obstructive lung disease

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COPD

Chronic airflow limitation

Parenchymal destruction

Emphysema

Small airway disease

Obstructive bronchiolitis

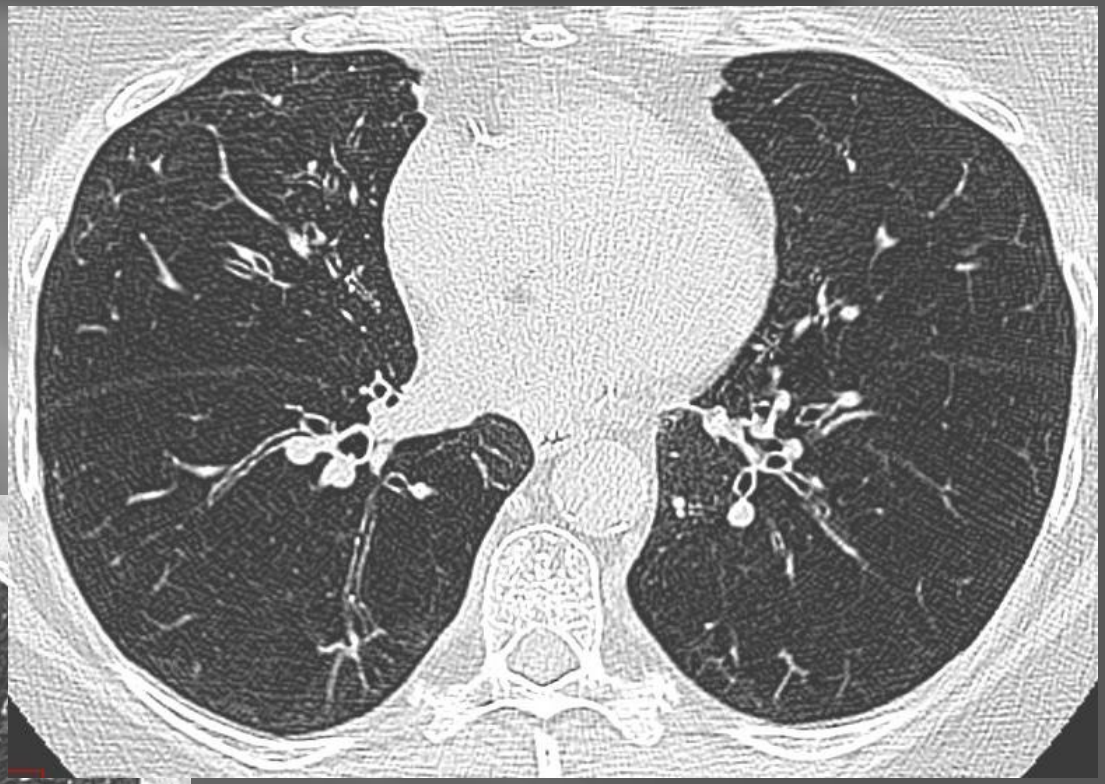
Variable relative contribution

Having the ability to phenotype patients may affect clinical management

Stewart et al. Curr Opin Pulm Med 2013 Mar; 19(2):109
Mets et al. Eur Radiol (2012) 22:120

MORPHOLOGICAL ASPECTS

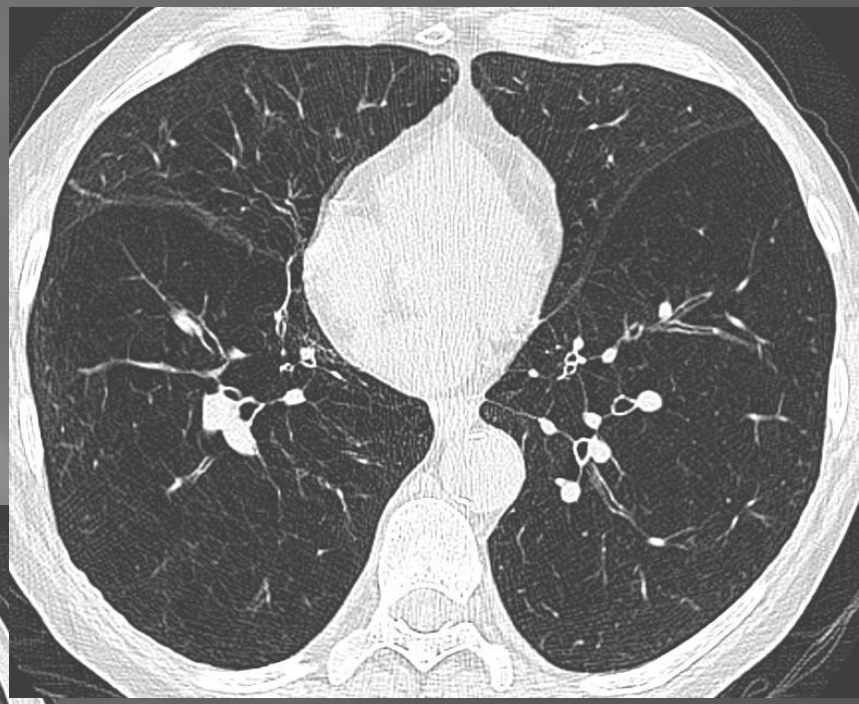
Emphysema Phenotype

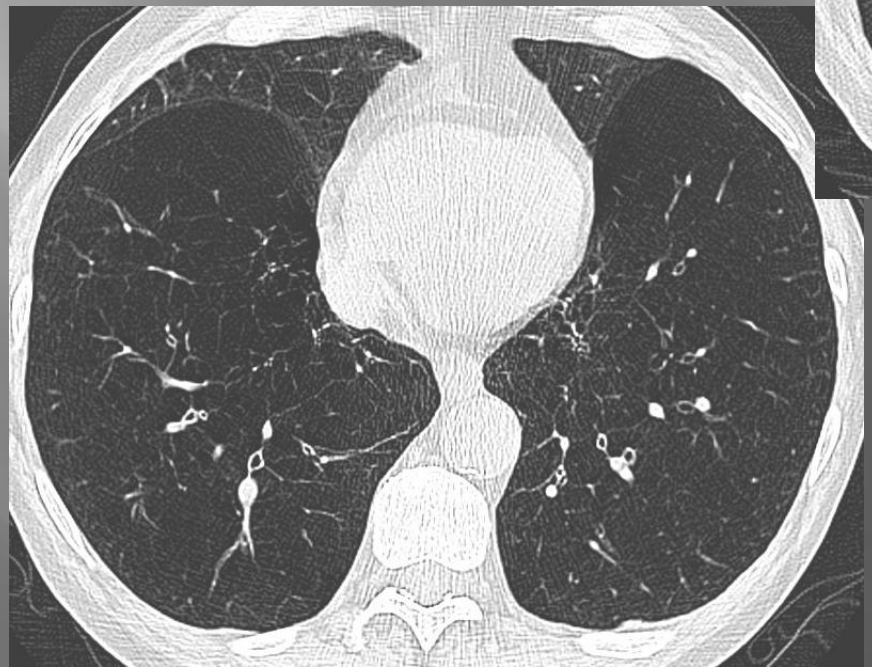


Airway Disease Phenotype

May be related to differences in physiopathoogy and genomic profile

Mixed pattern





Emphysema Phenotypes at CT

Morphologic Types

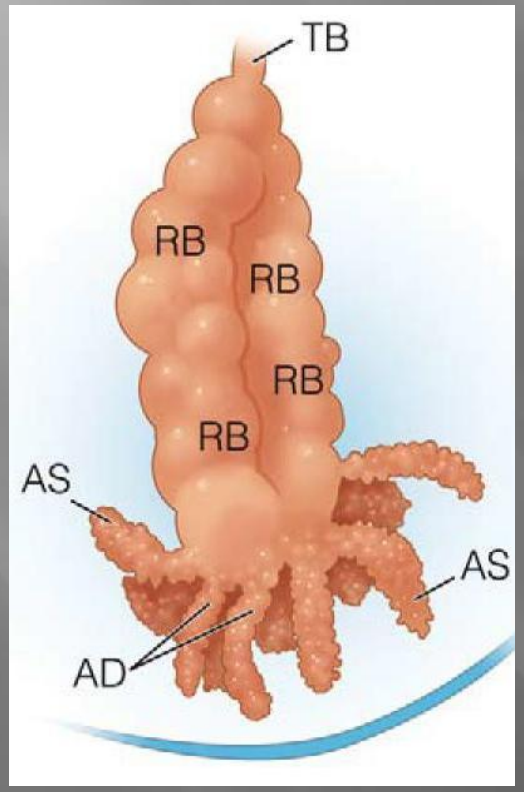
Ability to distinguish between various subtypes

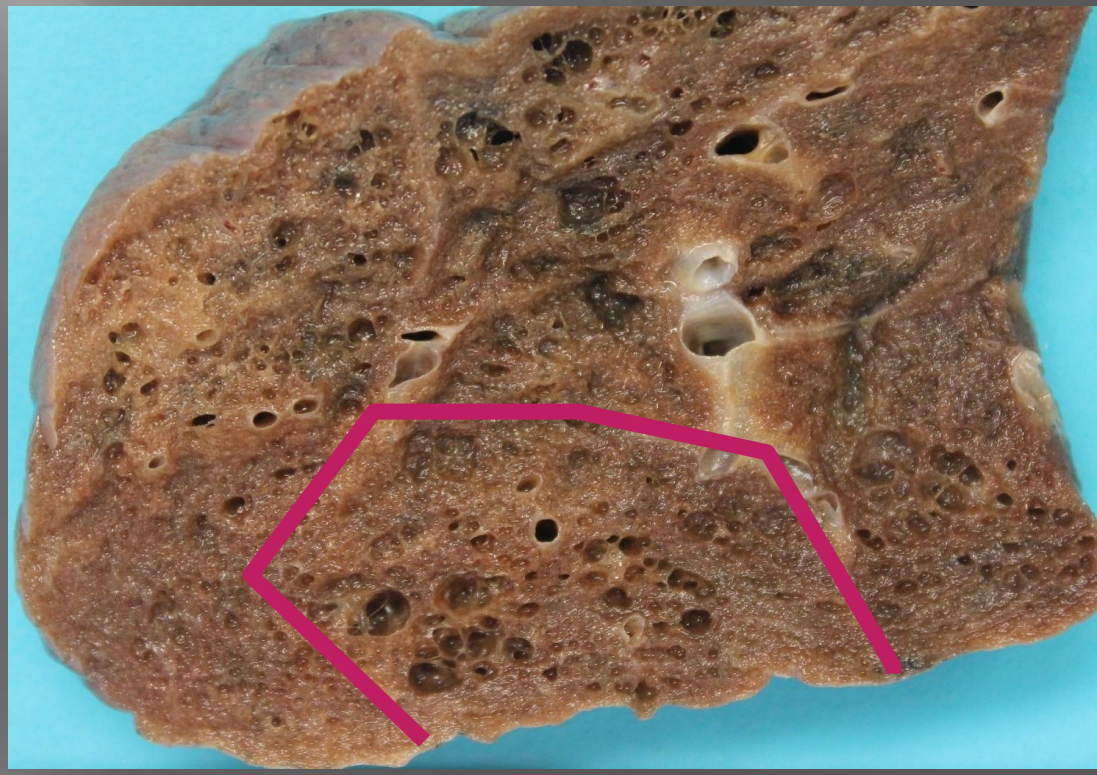
Centro-lobular emphysema
Paraseptal emphysema
Panlobular emphysema
Bullous emphysema

Centro-lobular emphysema

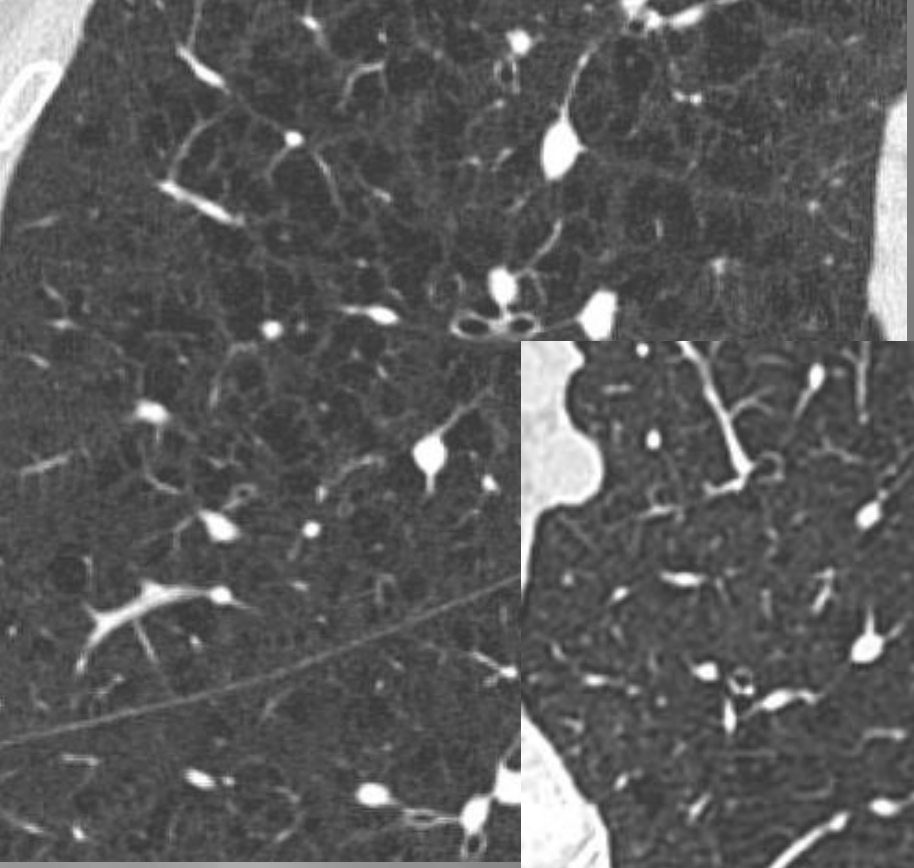
Most common type of emphysema
Begins near the center of the secondary pulmonary lobule
Relative sparing of the periphery of the pulmonary lobule

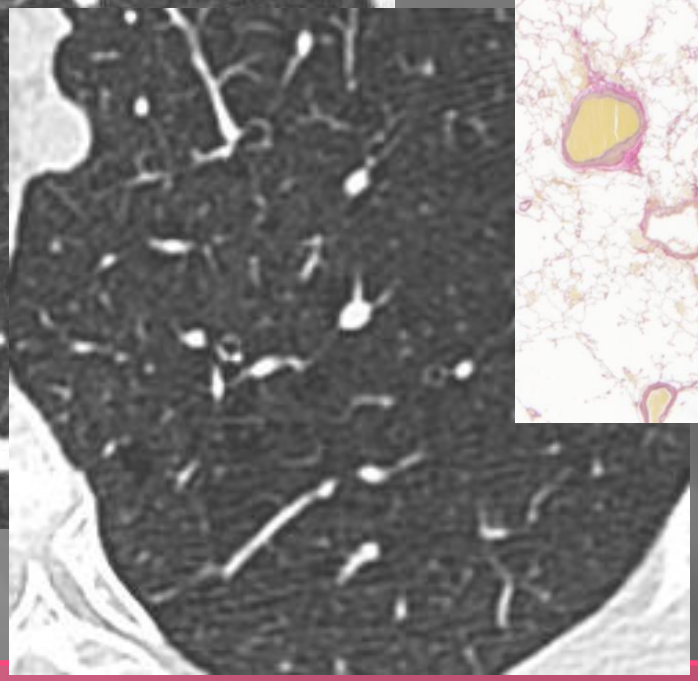
Respiratory bronchioles primarily affected

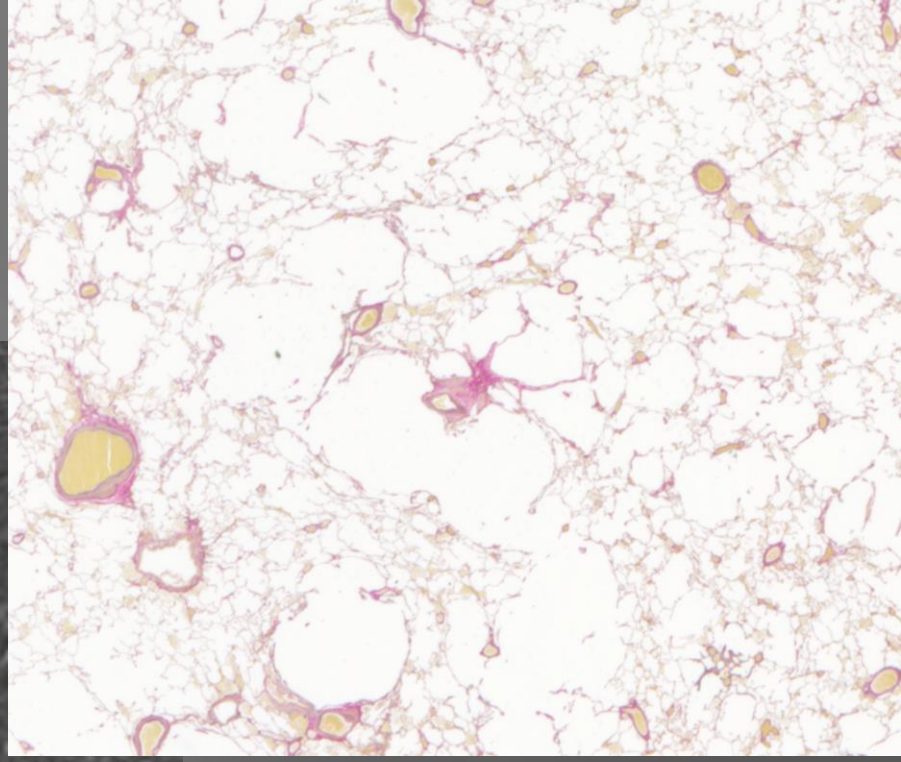




Pipavath et al. J Thorac Imaging 1009; 24, 171







- Small and well-marginated round lucencies
- No visible wall
- Central dot ⟺ centrilobular core and artery

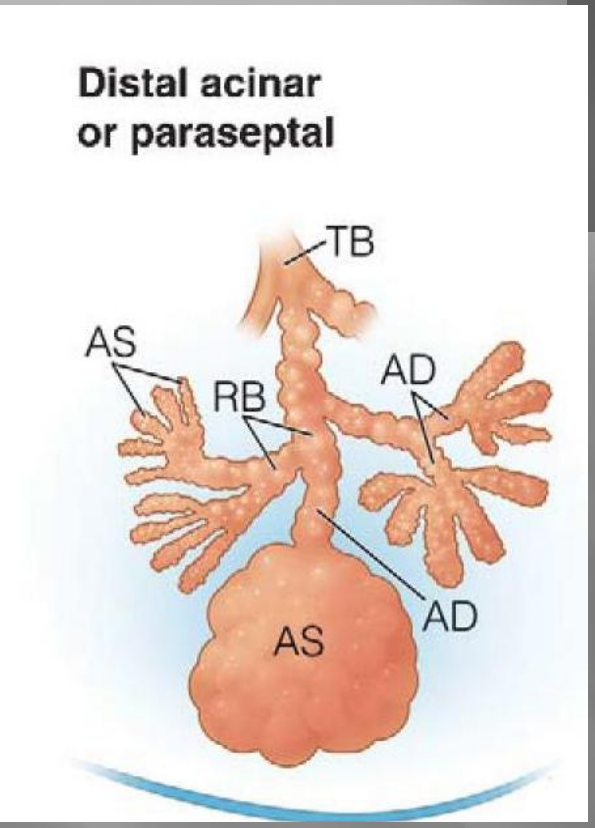
Definite recognition

Severe centrilobular emphysema

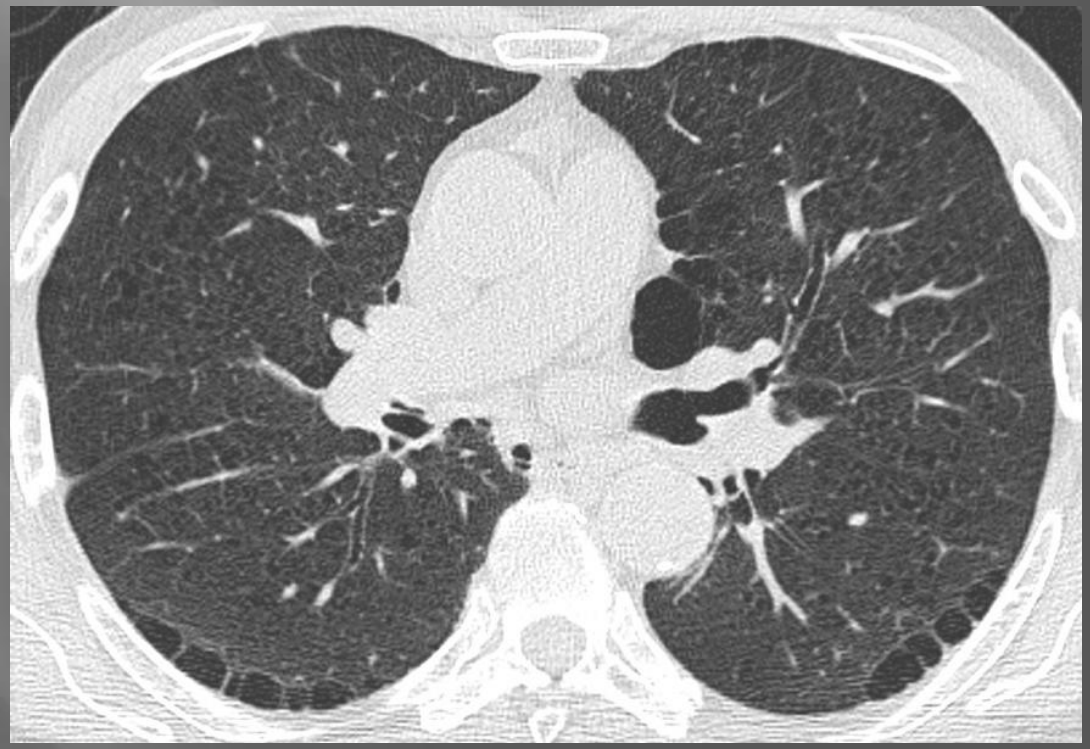
Confluent
Loose their round shape

Some hypoattenuated areas seem marginated by a « wall » corresponding to compresssed lung tissue and perilobular vessels

Paraseptal emphysema

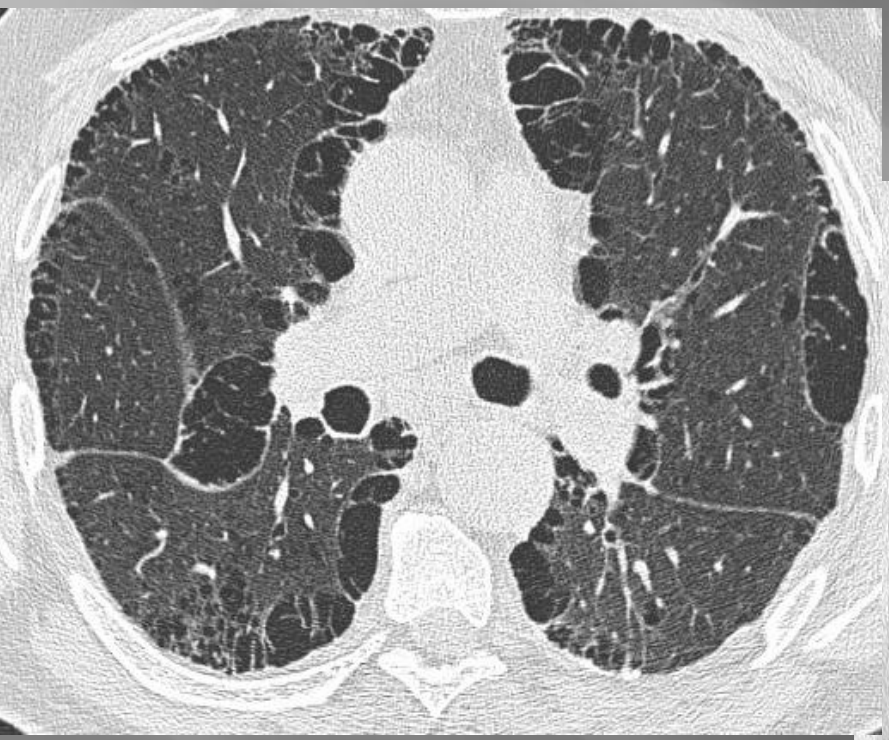


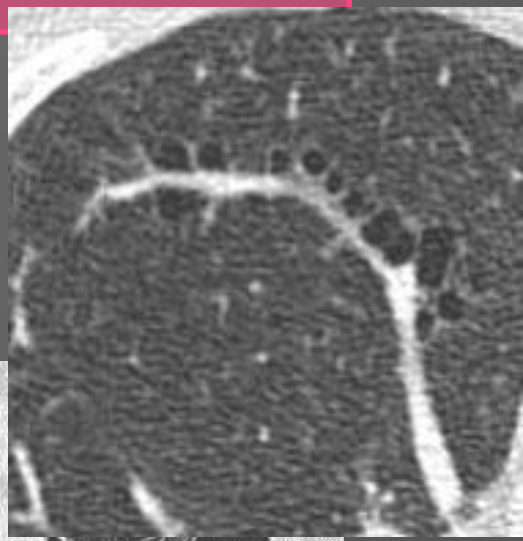
Predominant involvement of the distal alveoli and their ducts and sacs
Sparing of the respiratory bronchioles

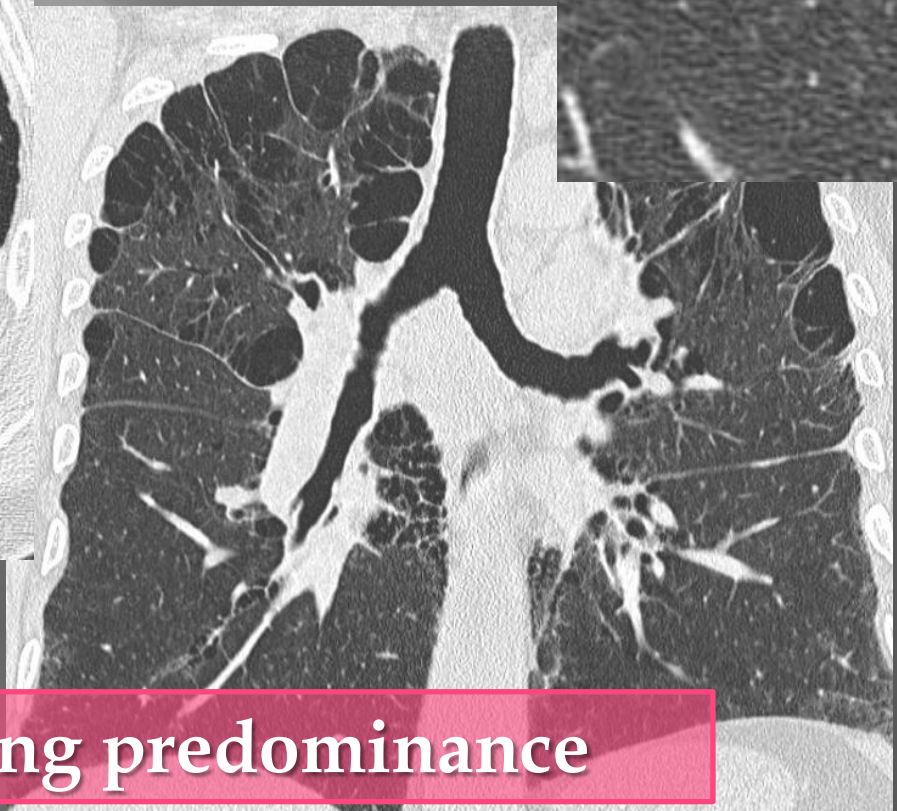


Pipavath et al. J Thorac Imaging 1009; 24, 171

Well-marginated hypodensities
Distinct hairline walls corresponding to septa
Subpleural, along fissures and bronchovascular bundles







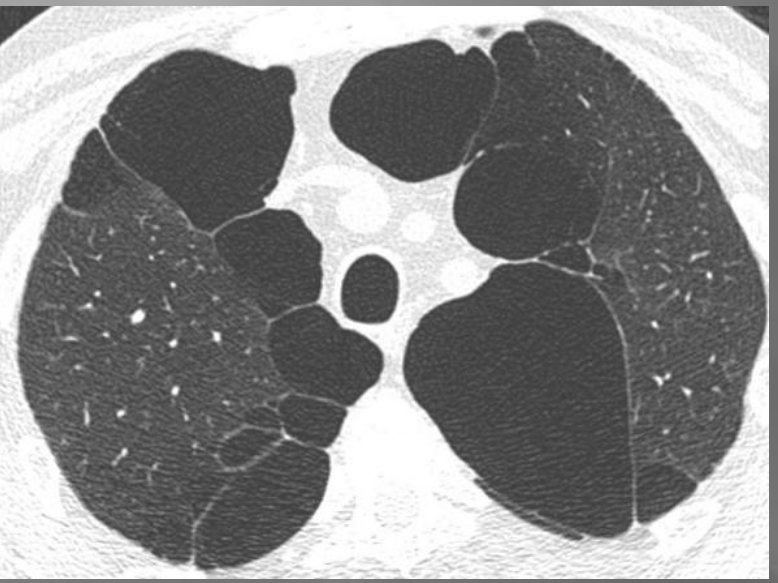
Upper lung predominance

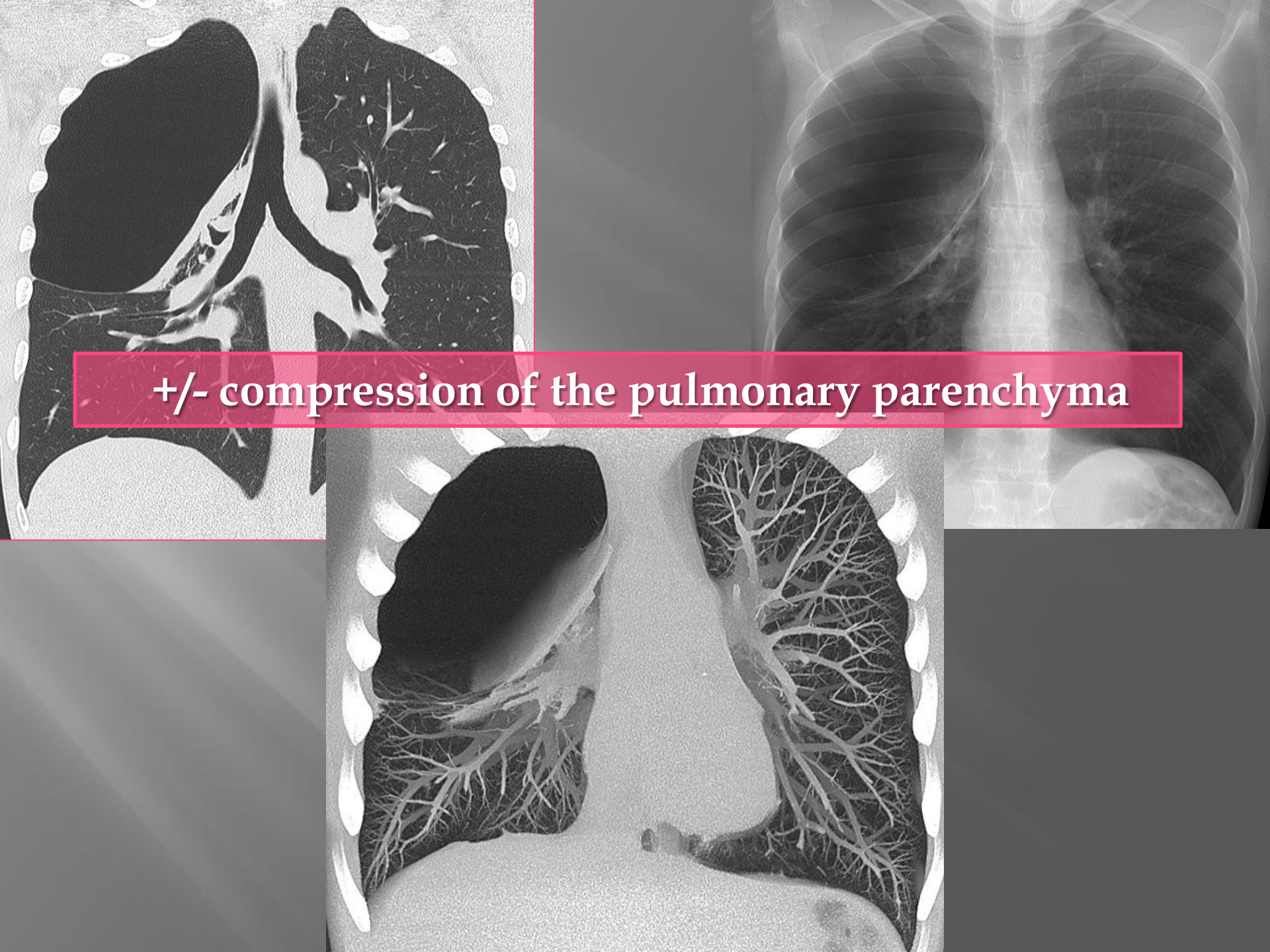
Bullous emphysema

Centrilobular or paraseptal emphysema may develop into bullae

> 1 cm diameter

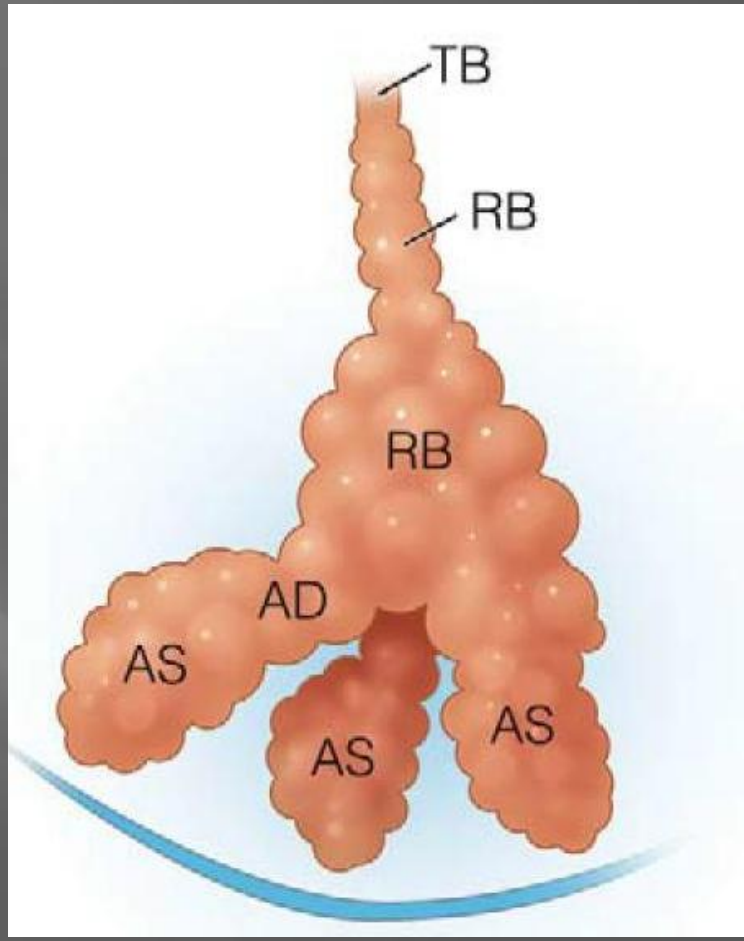
< 1 mm wall thickness




+/- compression of the pulmonary parenchyma

Panlobular emphysema

Uniform loss of alveolar septa throughout the primary and secondary lobules, including
- **respiratory bronchioles**
- **alveolar ducts**
- **alveolar sacs**

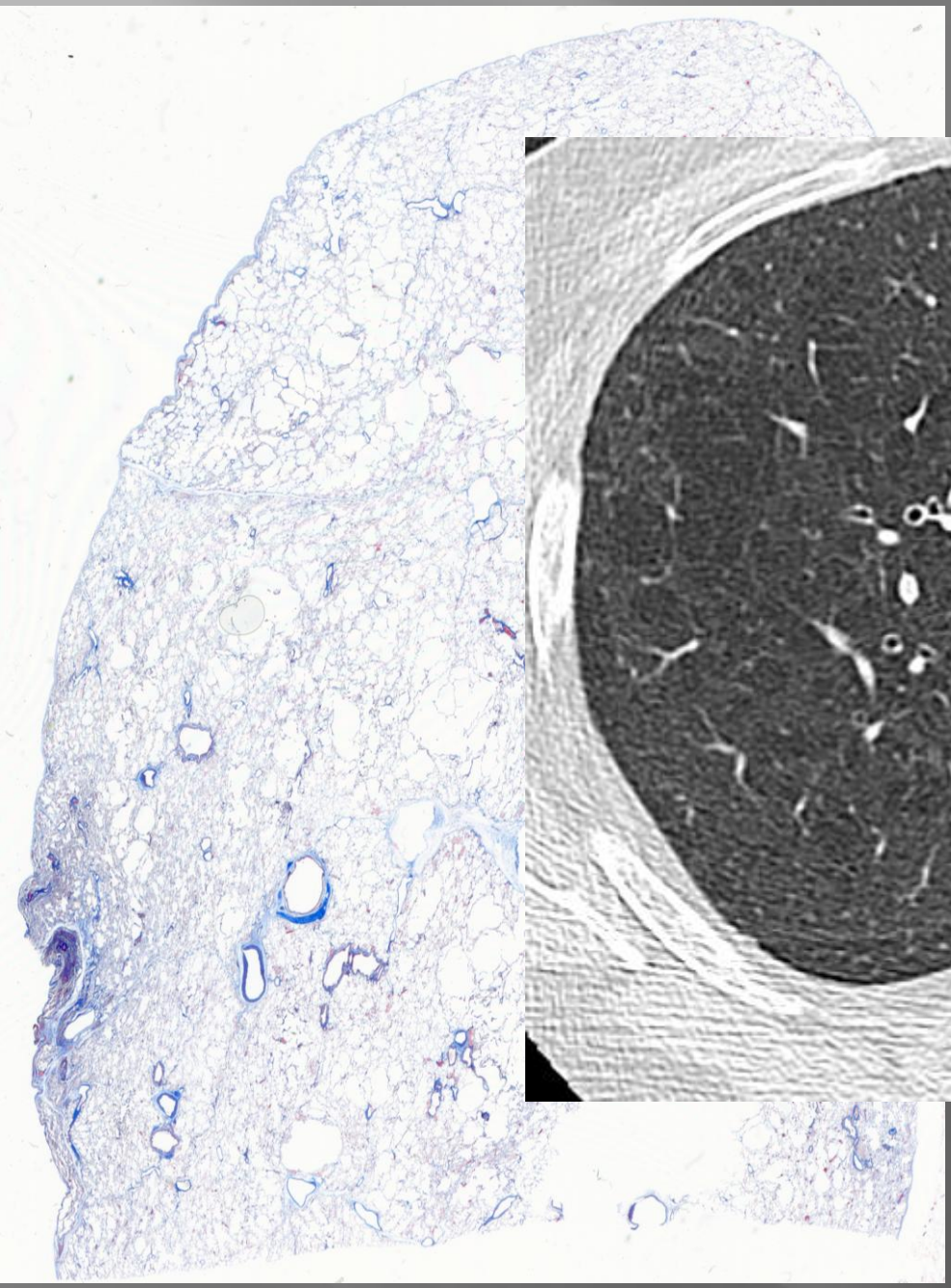


PLE may coexist with other forms of emphysematous lesions in polymorphous emphysema

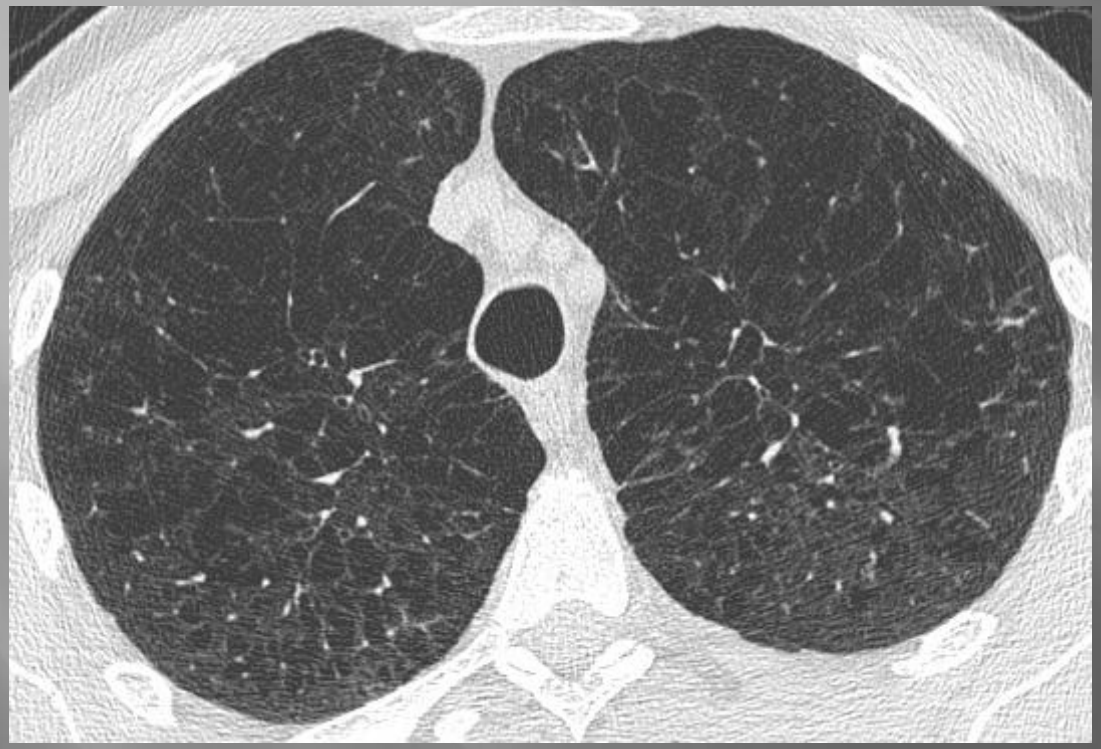
Pipavath et al. J Thorac Imaging 1009; 24, 171

Poumon normal

Emphysème pan acinaire



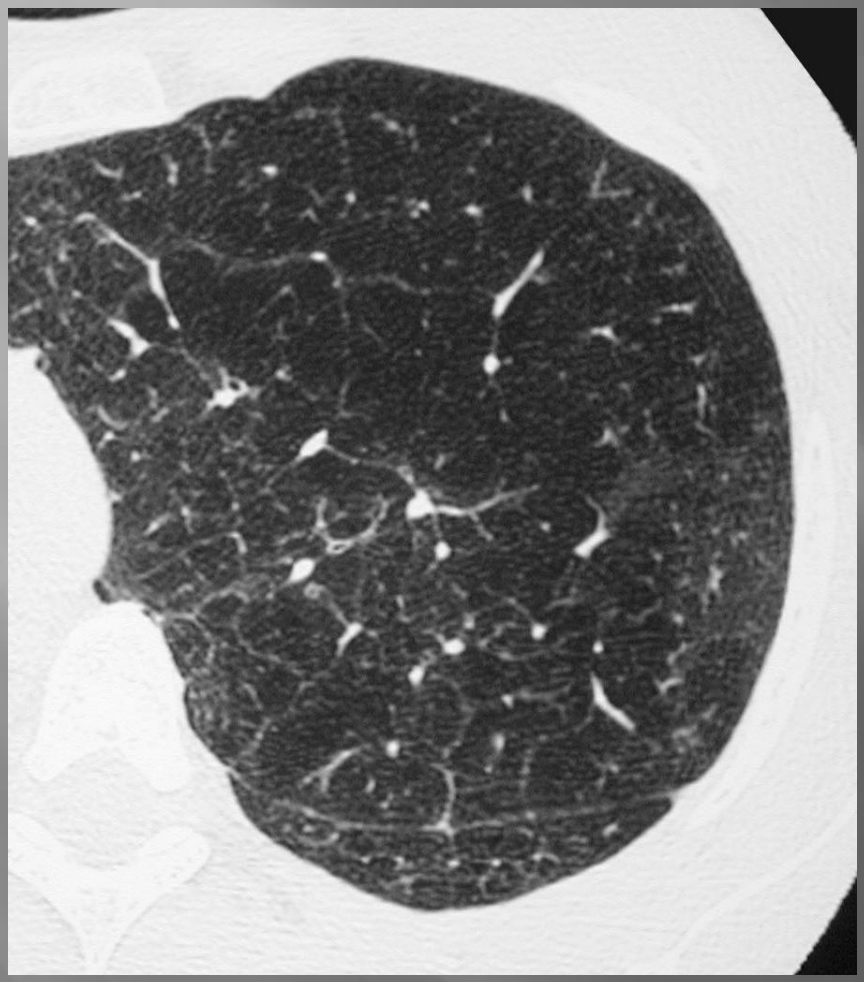
Differential diagnosis and pitfalls



Polymorphous emphysema in a heavy smoker
Various types difficult to individualize

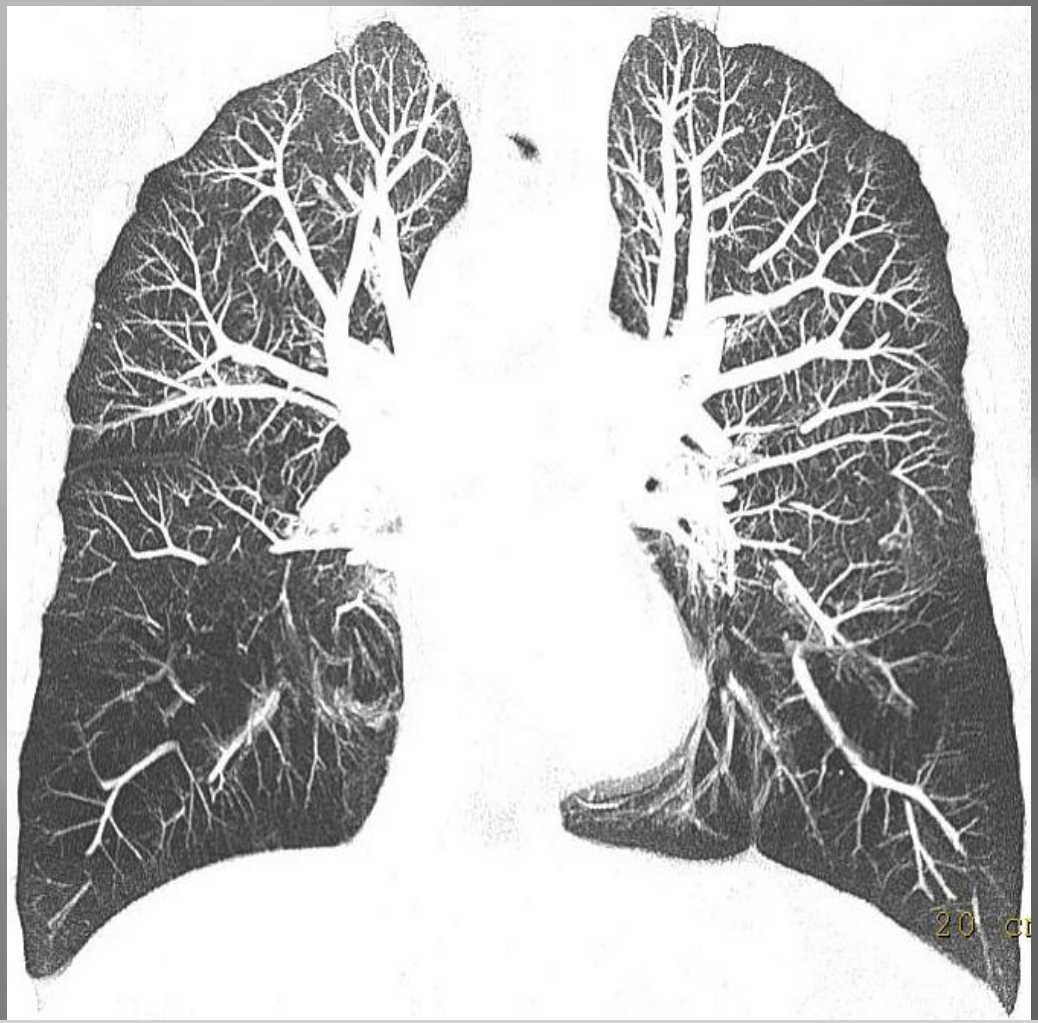
Associated Langerhans cell granulomatosis

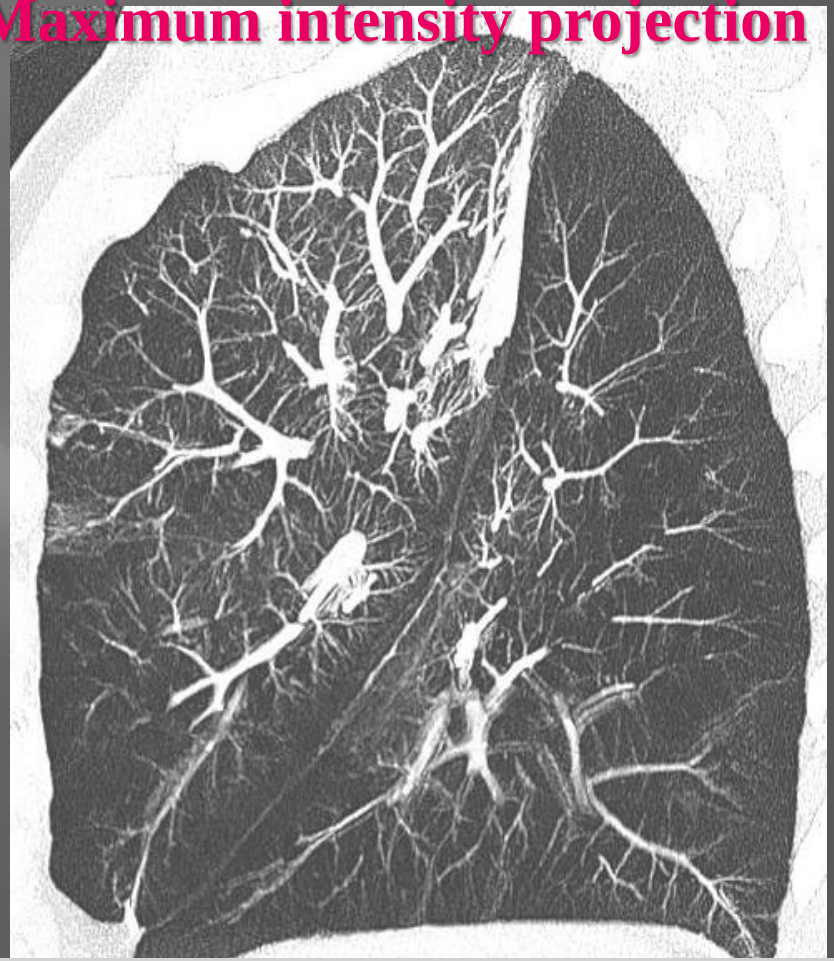
Alpha 1-antitrypsin deficiency



Heterogenous without lower lobe predominance

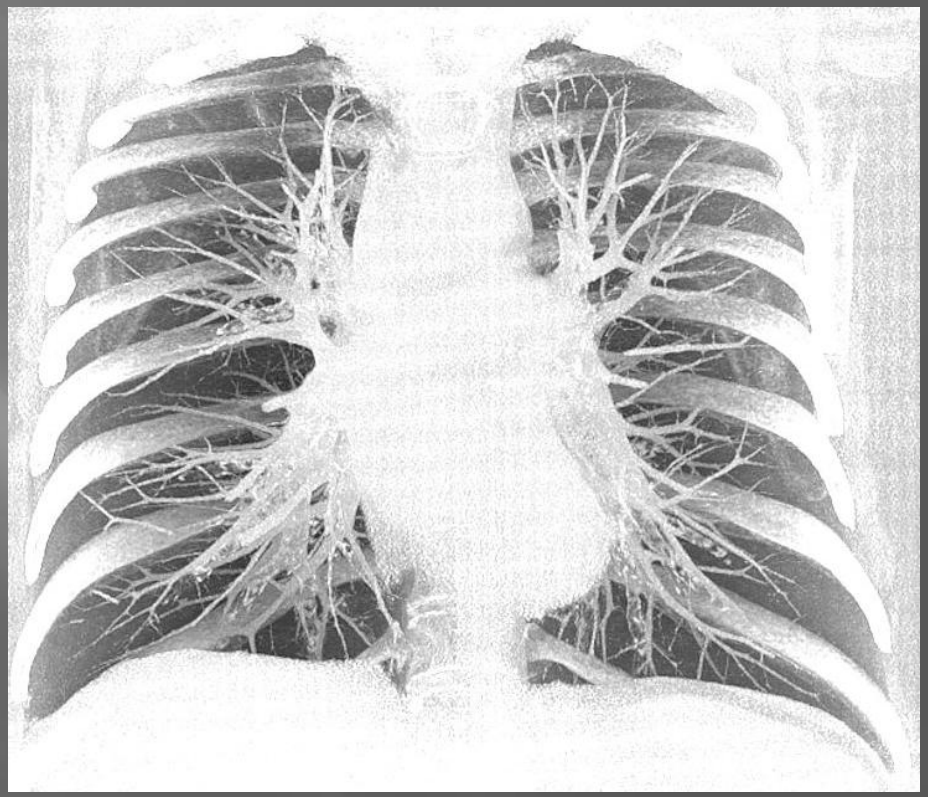
Fairly uniform and diffuse decrease in attenuation
Loss of vessel caliber predominating in lower lobes





Appearance of featureless decreased attenuation

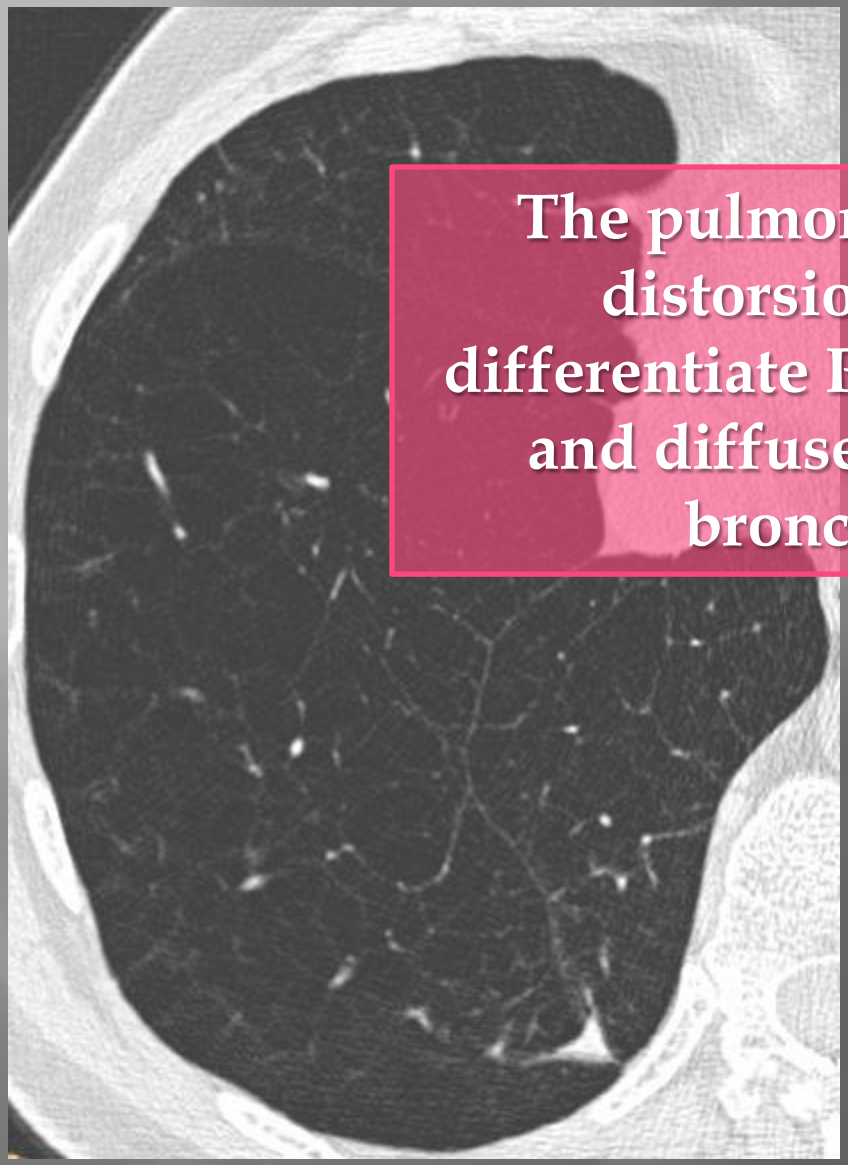
Panlobular emphysema

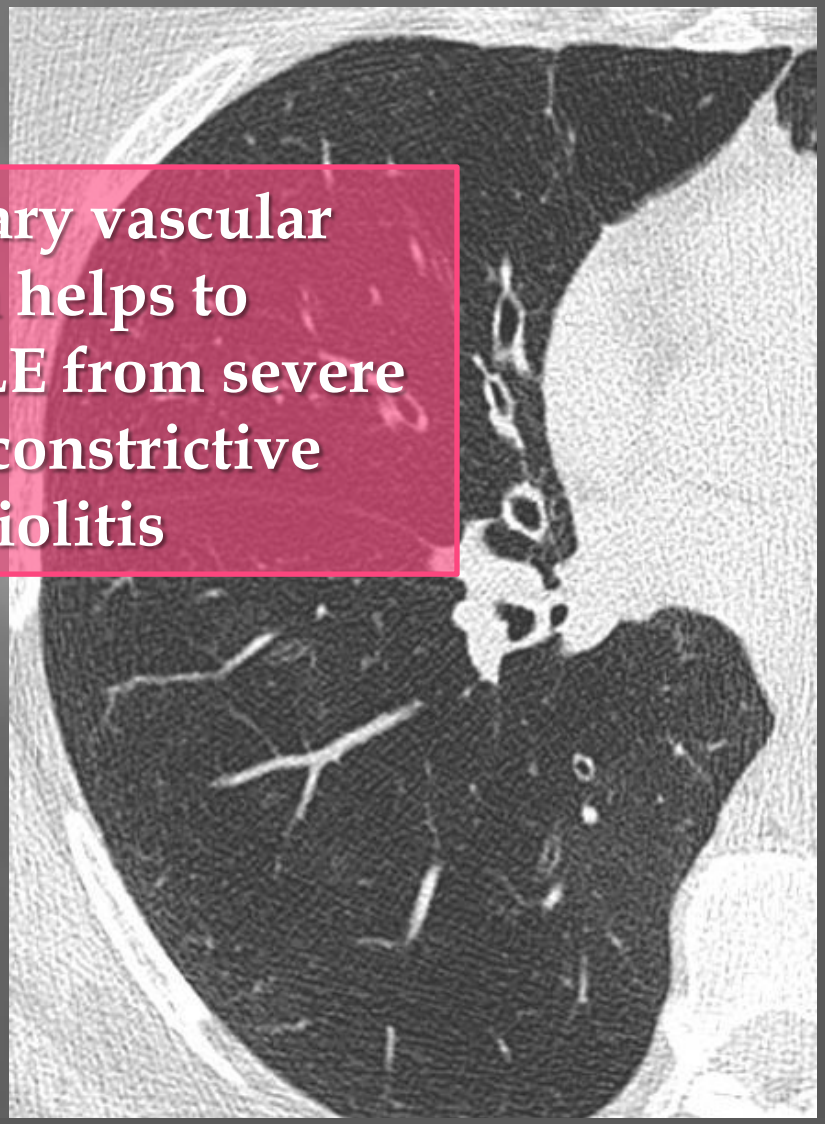


Constrictive bronchiolitis

Panlobular emphysema

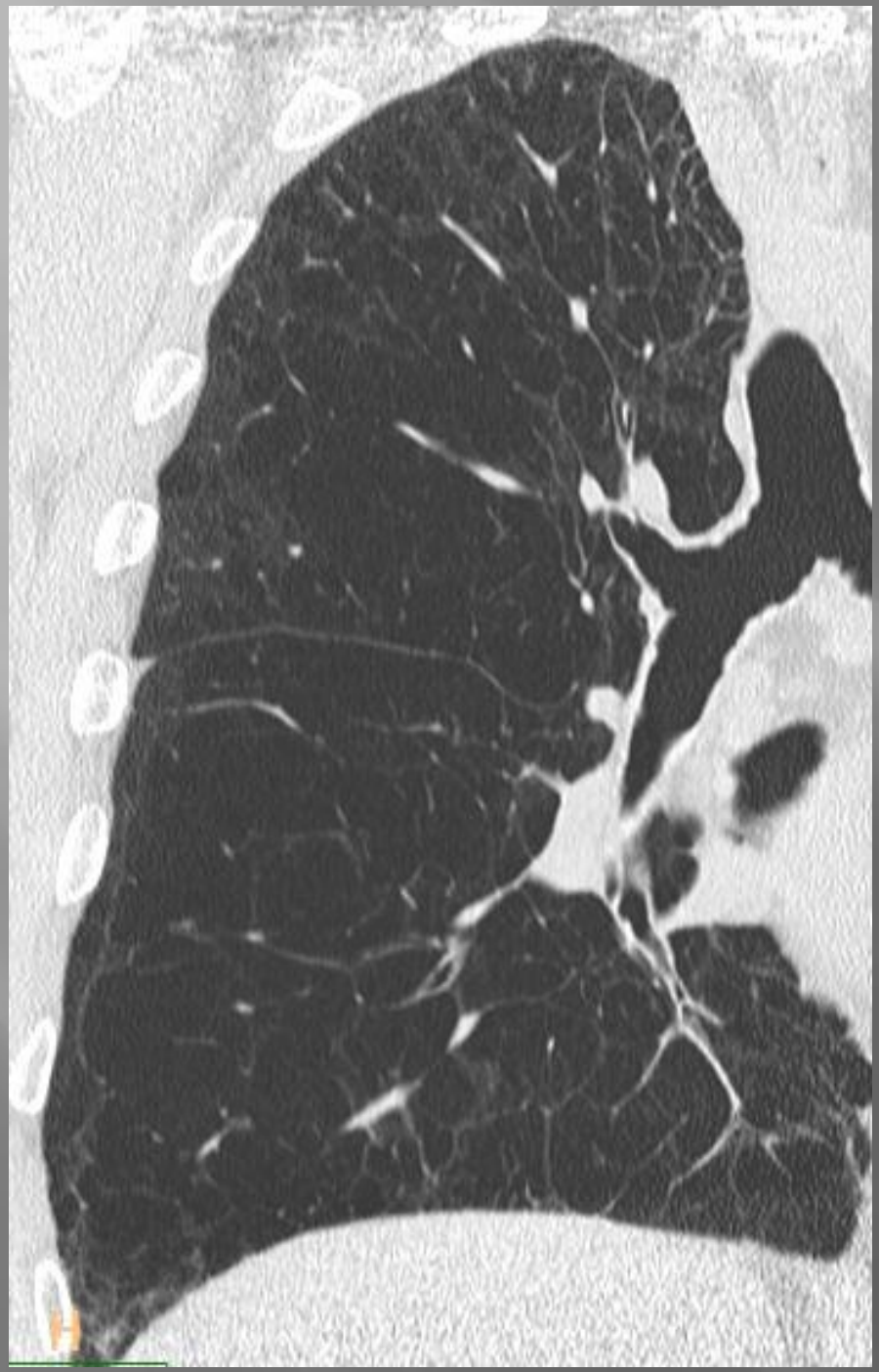
Constrictive bronchiolitis





The pulmonary vascular distorsion helps to differentiate PLE from severe and diffuse constrictive bronchiolitis

Sjögren syndrom and relapsing polychondritis



Angioarchitecture

Volume intensity projection

Airway Disease Phenotypes at CT

Small airway disease

Progression of COPD from GOLD stages 0 to 4

Strongly associated with small airway wall thickening

Result of lung repair or remodeling

Mosaic perfusion and air trapping

Indirect findings

Large Airway Disease in COPD

Inflammation and remodeling

Bronchial Wall Thickening

Diameter ratio of
inner and outer lumen < 0.8

Bronchiectasis

Elevated prevalence in patients with moderate to severe COPD

Moderate cylindrical bronchiectasis (29-58%)

Lower lobes

Associated with

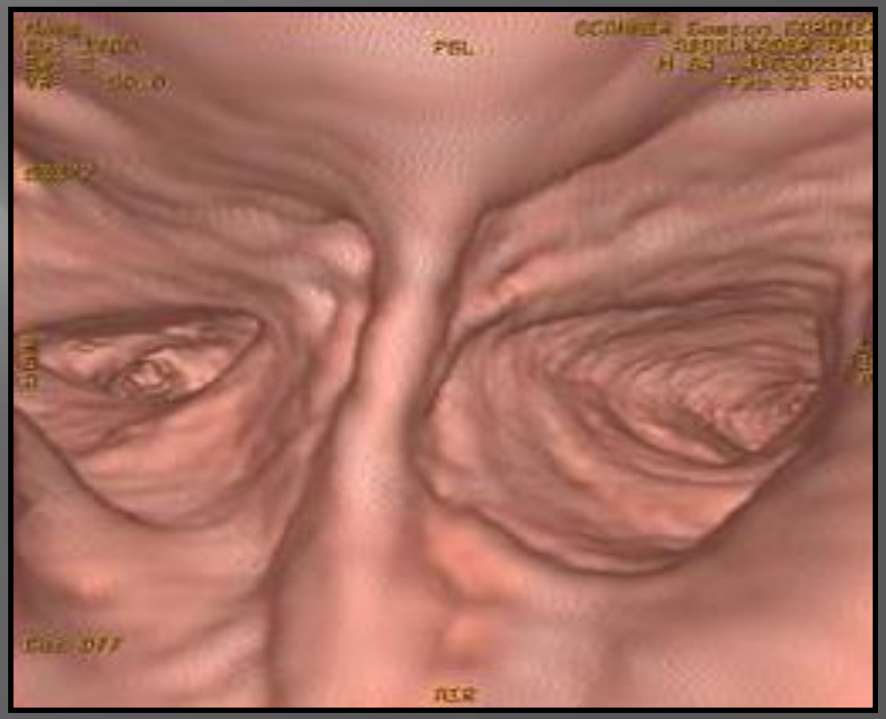
- Severe airflow obstruction
- Isolation of PPM from sputum
- At least one hospital admission for exacerbations in the previous year

O'Brien. Thorax; 2000; 55: 635

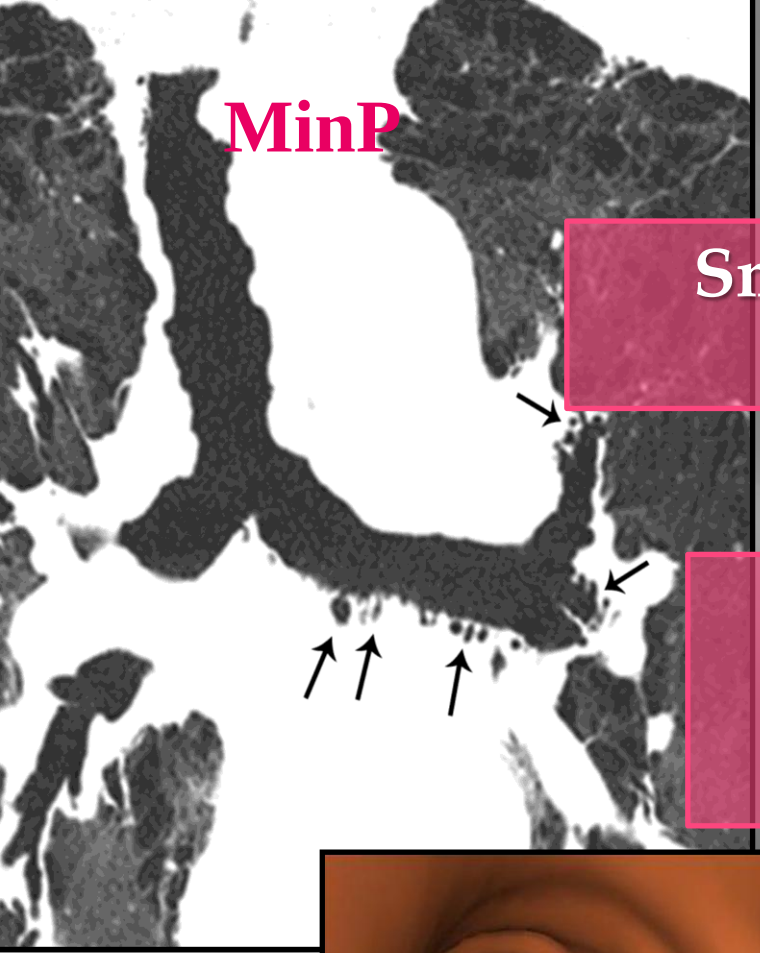
Irem. AJRCCM ; 2004; 170: 400

Martinez-Garcia. Chest; 2011; 140: 1130

Bronchial Wall and Lumen Irregularities

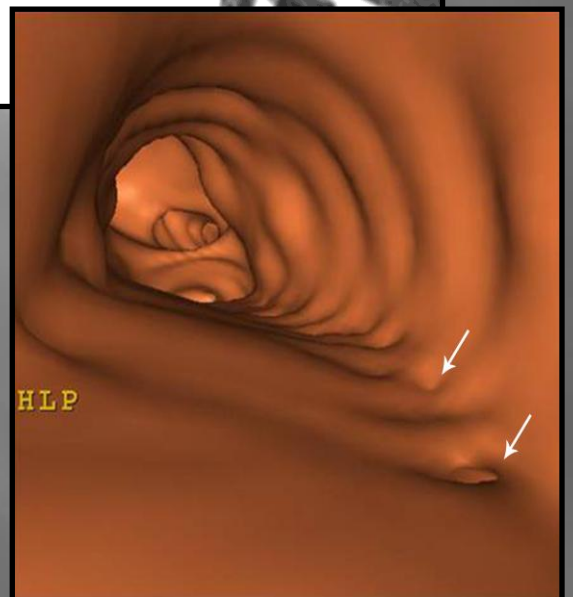


Bronchial Diverticulas



Small air collections in the wall of the main and lobar bronchi

Fusion of multiple depressions and dilatations of bronchial gland ducts



Sverzellati. Eur Radiol. 2010; 20: 88

Bronchial Diverticulas

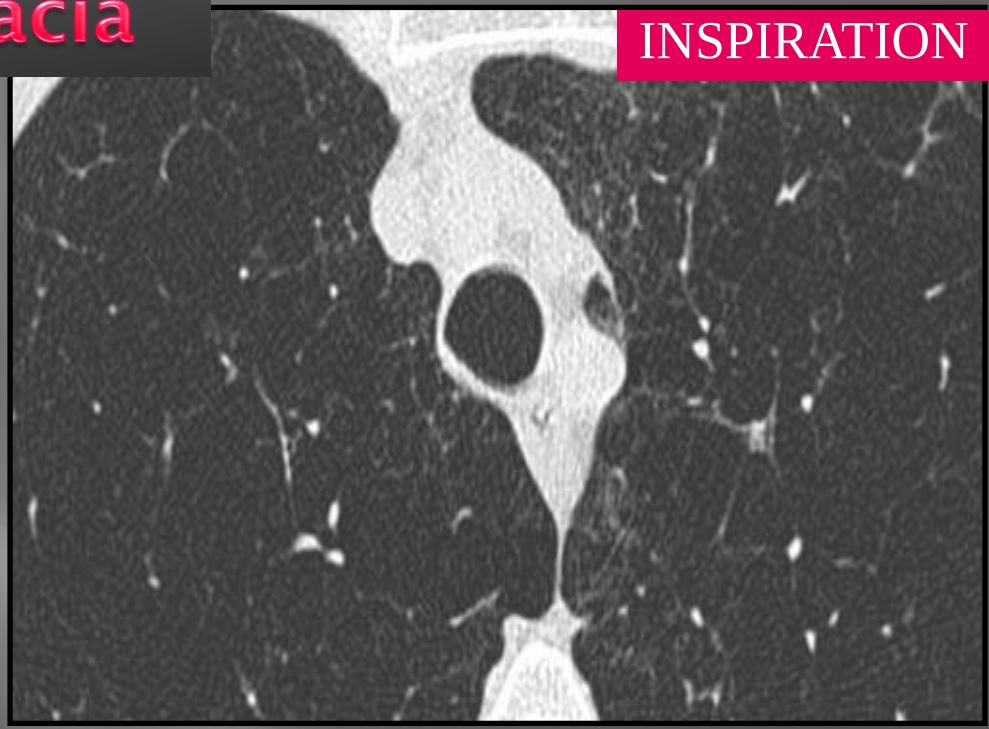
Air-filled outpouchings
Accordion-like or comb-wide teeth appearance

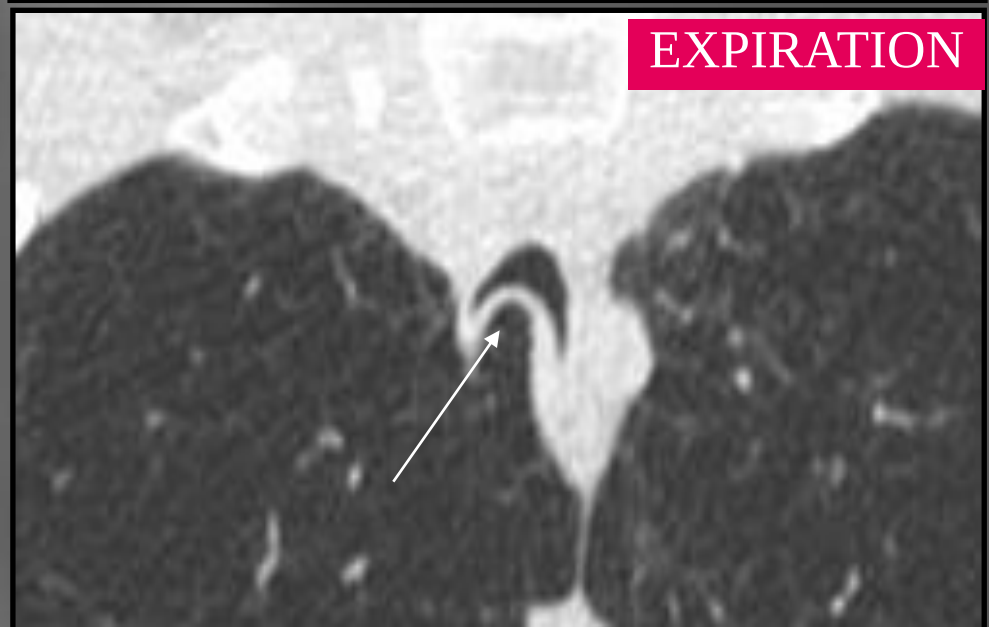
Tracheobronchomalacia

Frequent cartilage deficiency in COPD patients
Prominent collapse of airway lumen occuring at forced expiratory maneuver

Decrease of the axial tracheal lumen area > 70% on dynamic expiratory CT

Frown Sign





Dynamic Expiratory Tracheal Collapse in COPD

- Risk factor
- Observed in 20/100 patients
- Magnitude of collapse independent of disease severity
- No correlation with physiologic parameters
  - PFTs
  - 6-min walk test
  - St. George's Respiratory Questionnaire

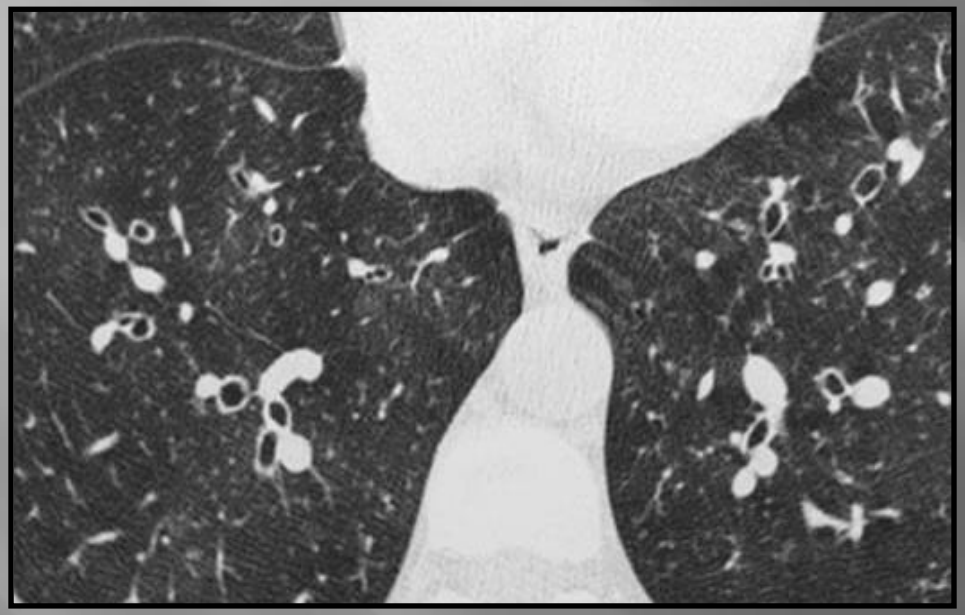
Incidental identification of excessive expiratory tracheal collapse in a general COPD population not necessarily clinically significant

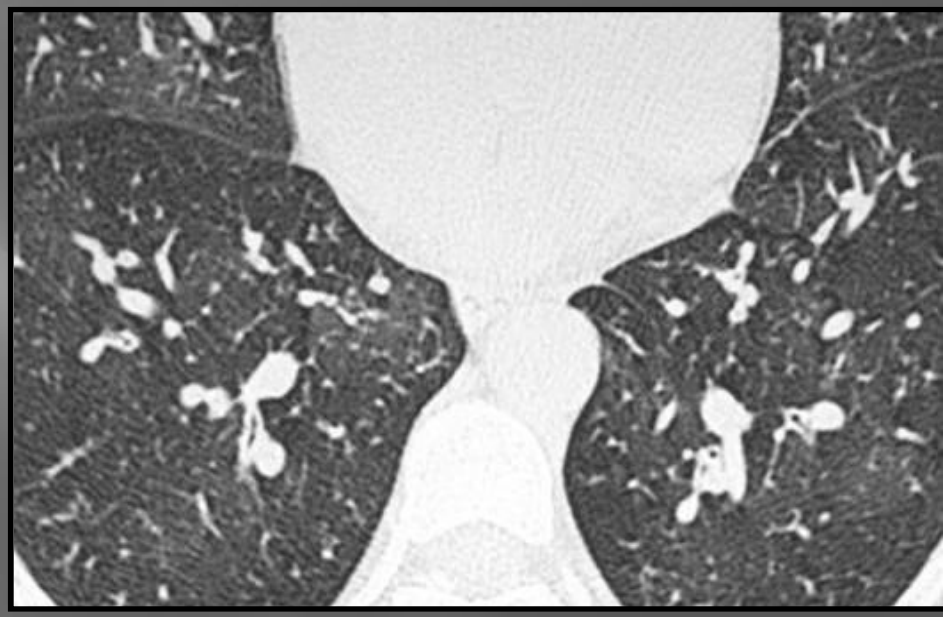
Boisselle et al. Chest 2012; 142(6):1539

Bronchomalacia

INSPIRATION

EXPIRATION





Changes in bronchial section areas between inspiration and expiration strongly correlated with FEV1

Matsuoka. Radiology. 2008; 248: 1042

Saber Sheath Trachea

Acquired deformity related to the abnormal pattern and magnitude of intrathoracic pressure changes in COPD

CT QUANTITATIVE ANALYSIS FOR PHENOTYPING COPD

Quantitative analysis of
Emphysema
Lung Densitometry

Quantitative analysis of
Small Airway
Obstruction
Expiratory Air Trapping

Quantitative Analysis of
Airway Wall Remodeling
Bronchial Wall Thickness

Quantitative CT assessment of emphysema

Visual subjective grading

Has yielded good correlation between CT and pathological measures of extent of emphysema

Objective CT densitometric analysis

More accurate and suitable for follow-up

Burgel et al. Eur Respir Rev 2011; 20: 119, 7

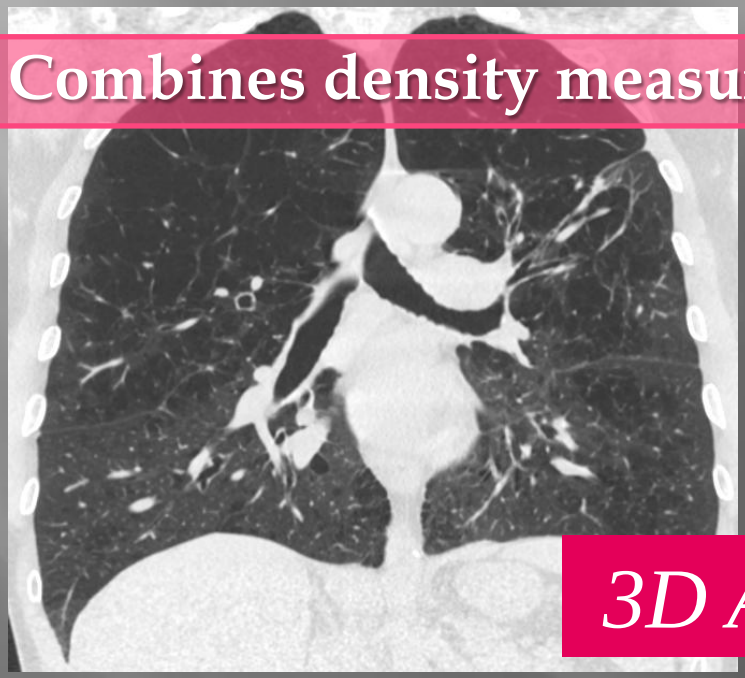
Quantitative CT assessment of emphysema

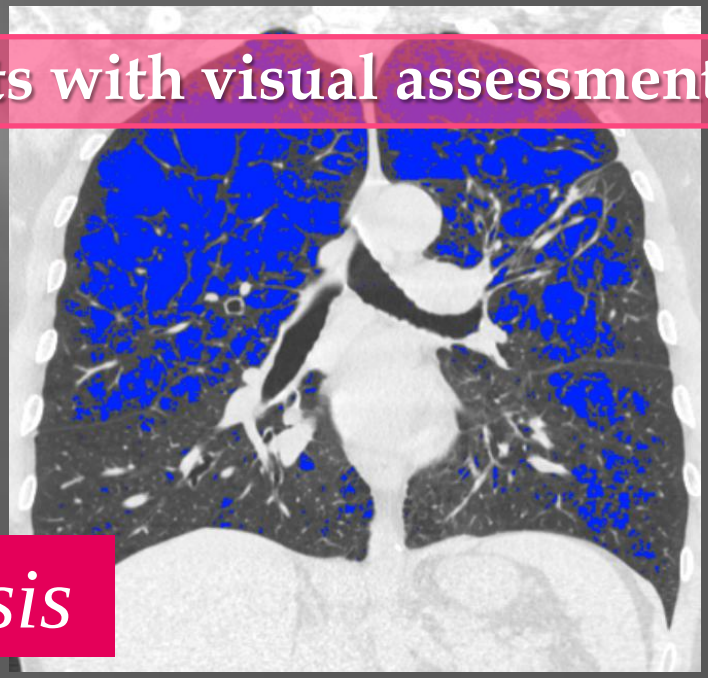
Validated by CT - pathological correlations

Density mask technique

Percentage of the total lung volume that contains voxels with attenuation values below a predefined threshold

Combines density measurements with visual assessment

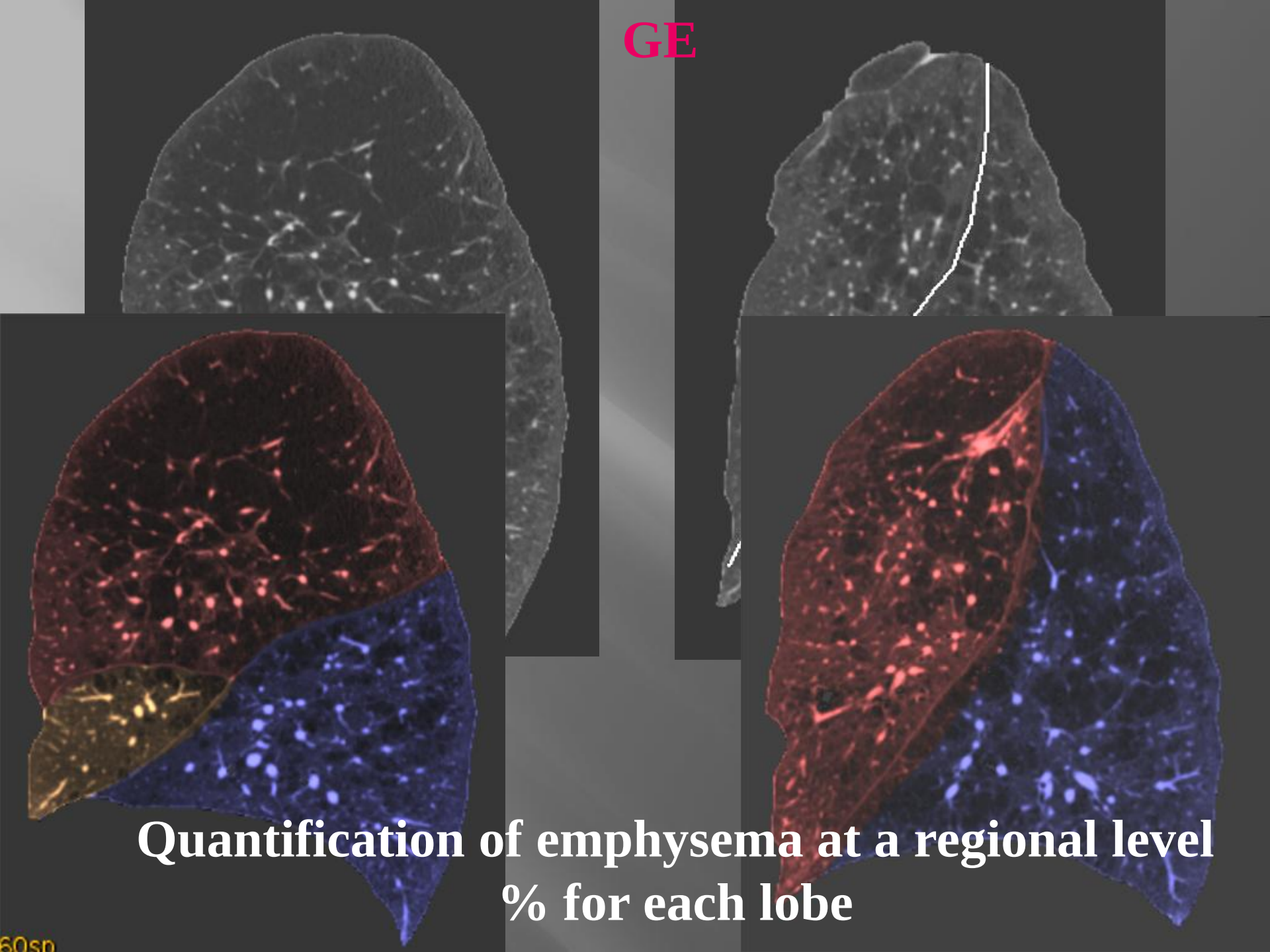


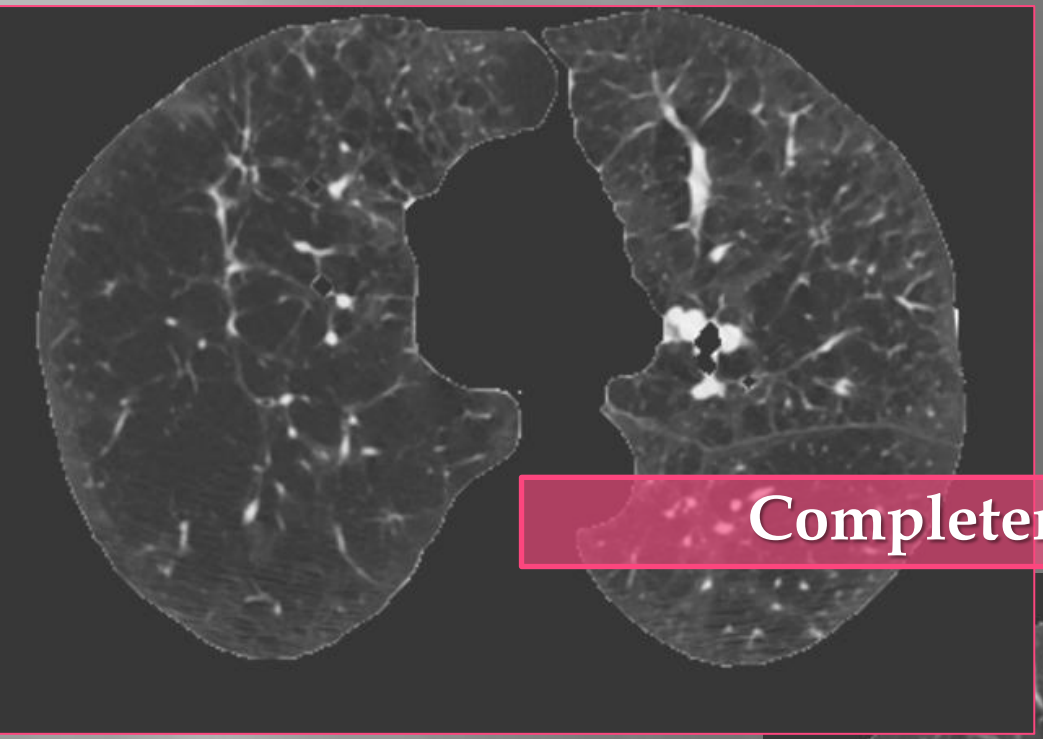


3D Analysis

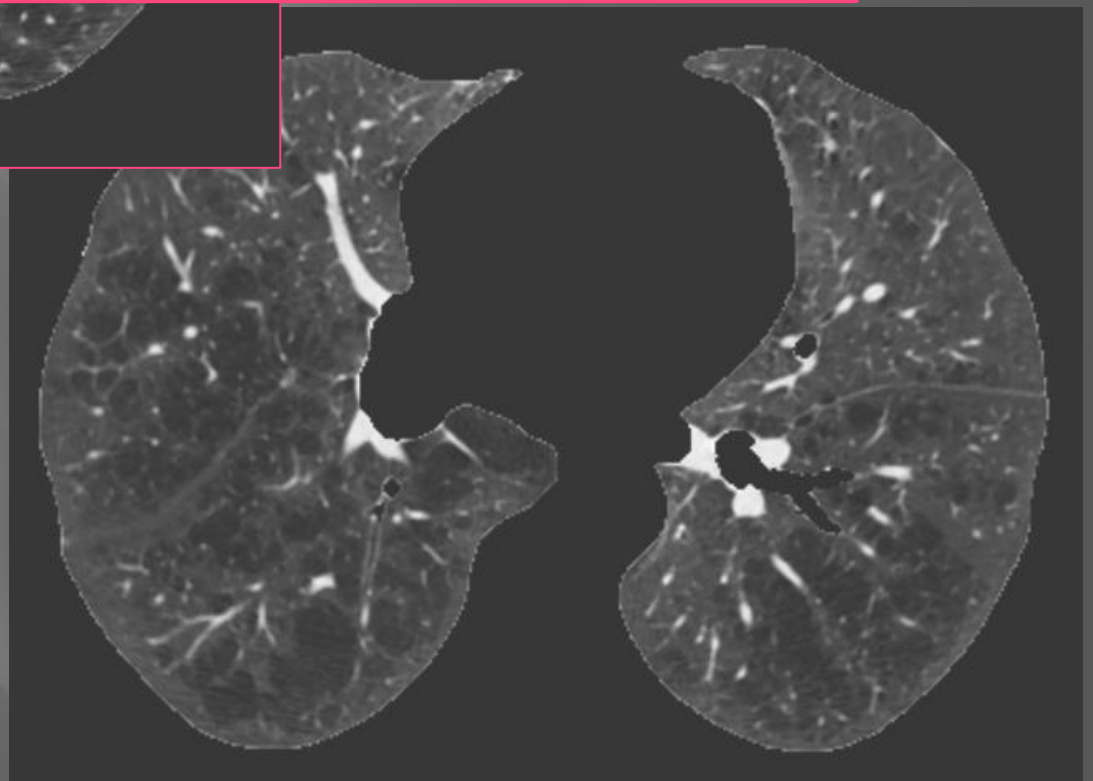
Percentile method

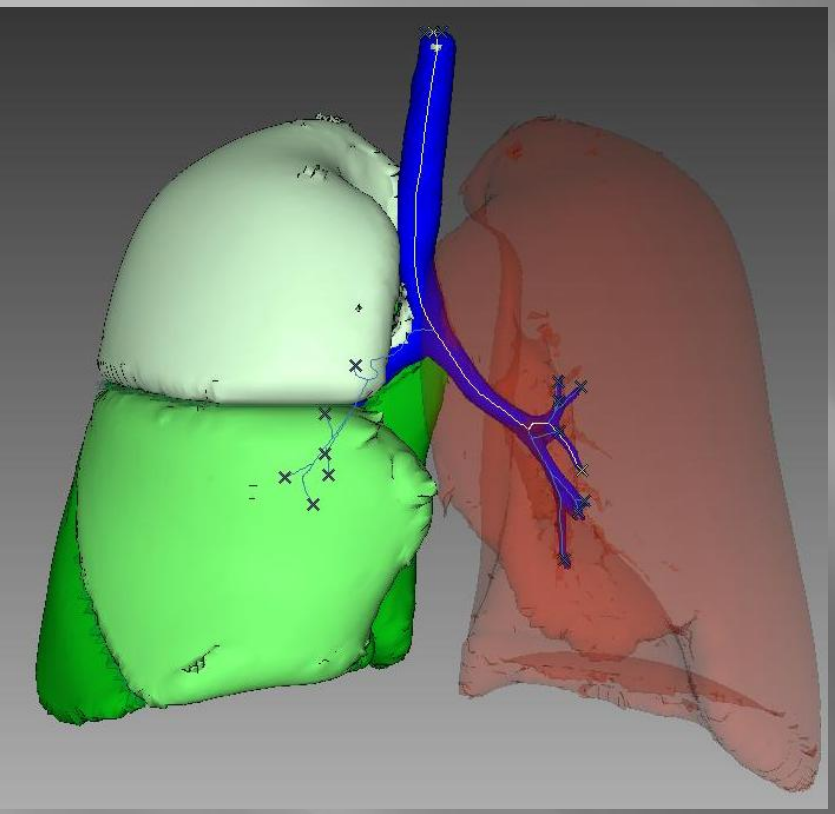
Madani et al. Radiology 2006;238:1036

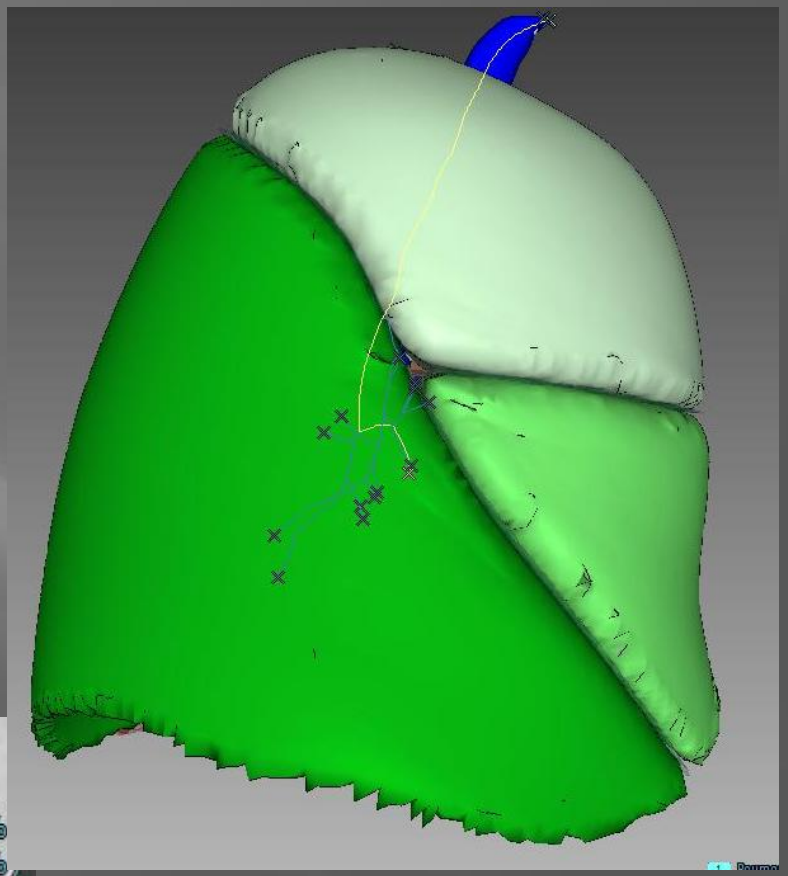

GE
Quantification of emphysema at a regional level
% for each lobe

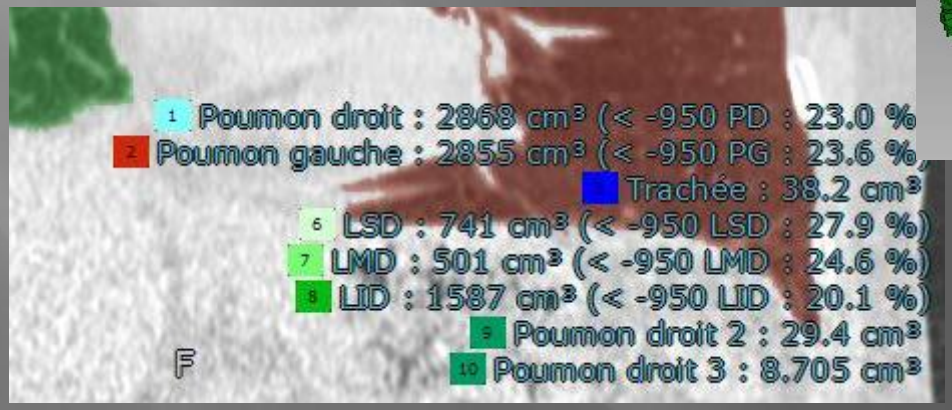


Completeness of fissures







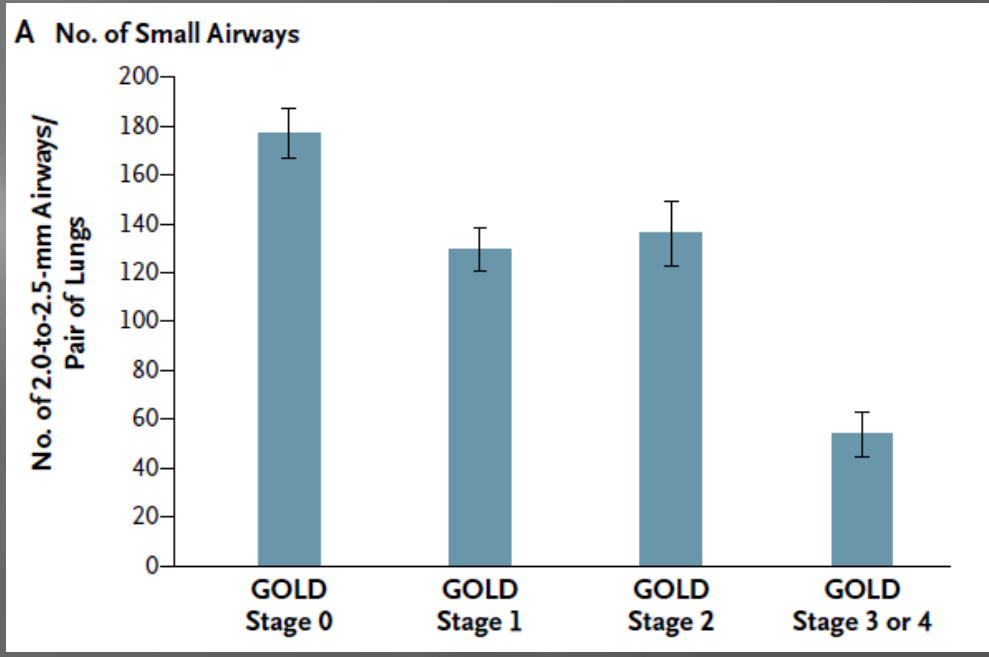

1 Poumon droit : 2868 cm³ (< -950 PD : 23.0 %
2 Poumon gauche : 2855 cm³ (< -950 PG : 23.6 %
Trachée : 38.2 cm³
6 LSD : 741 cm³ (< -950 LSD : 27.9 %)
7 LMD : 501 cm³ (< -950 LMD : 24.6 %)
8 LID : 1587 cm³ (< -950 LID : 20.1 %)
9 Poumon droit 2 : 29.4 cm³
10 Poumon droit 3 : 8.705 cm³
F

Myrian

Quantification of Small-Airway Obstruction

Use of CT exam to quantify the reduction in the number of airways < 2.0-2.5 mm in luminal diameter measured by the Disector counting method

Reduction in the number of the terminal bronchioles in lungs with CLE and PLE emphysema



Narrowing and loss of small airways occurs prior to emphysematous destruction

McDonough. NEJM; 2011; 365: 1567

Extent of Air Trapping

- Several techniques: parametric response map….
- Change in relative lung volume with attenuation values from -850 HU to -950 HU between paired inspiratory and expiratory examinations
- Close correlation with results of PFTs
- Reflect the severity of airway dysfunction whatever the severity of emphysema

Mets. Eur Radiol; 2012; 22: 120
Matsuoka. J Comput Assist Tomogr; 2007; 31: 384
Matsuoka. AJR; 2008; 190: 762

Bronchial Wall Thickening at CT in COPD

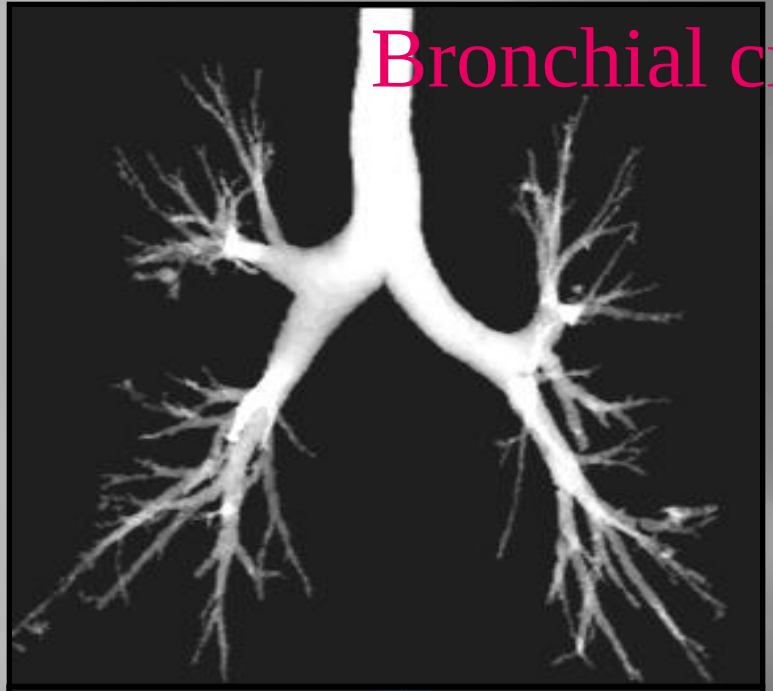
BWT related to FEV1 in cigarette smokers

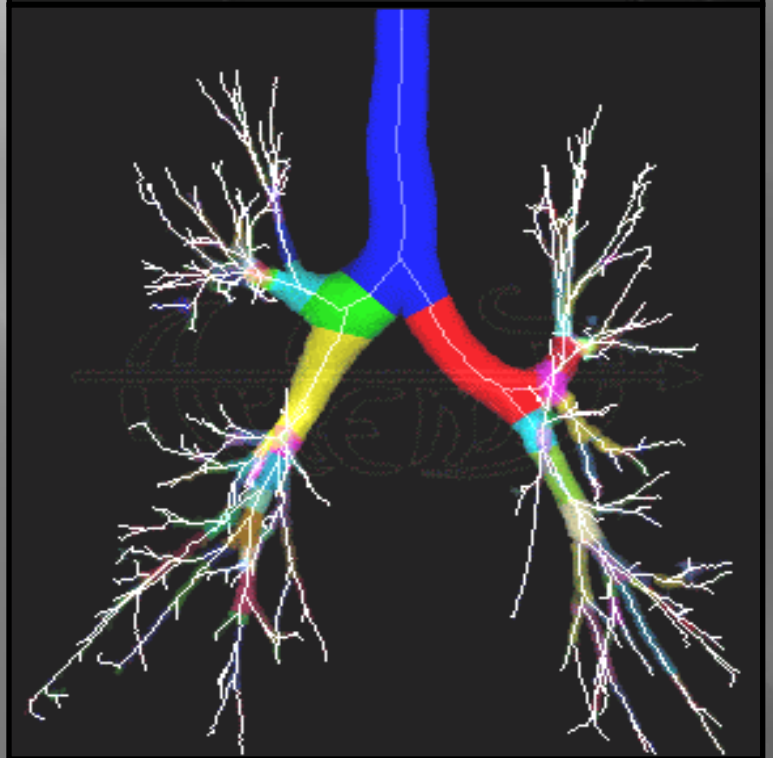
BWT is a strongest determinant of FEV1 in COPD as is extent of emphysema

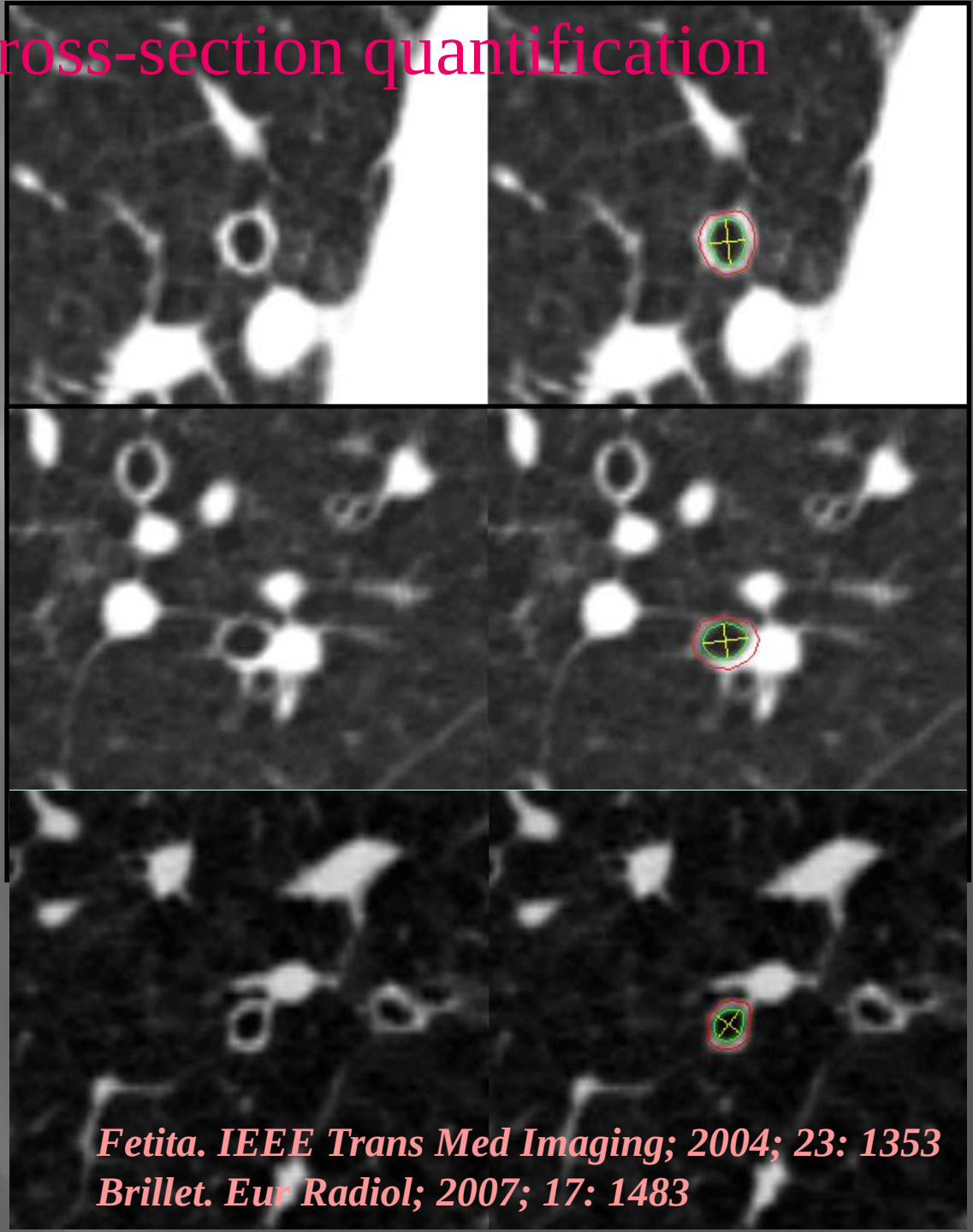
BWT and total lung emphysema percentage associated with COPD exacerbation frequency

Berger. Radiology; 2005; 235: 1055
Aziz. AJR 2005; 185:1509
Nakano. AJRCCM; 2000;162:1108
Han. Radiology; 2011; 261: 274

Bronchial cross-section quantification







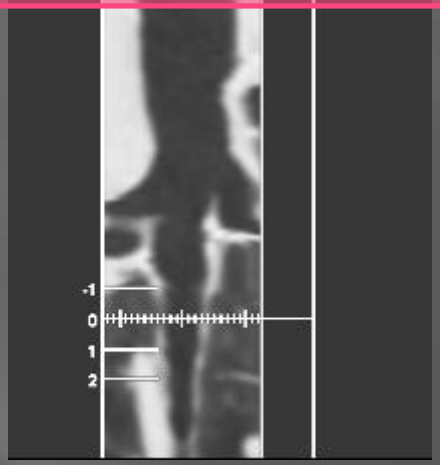
Fetita. IEEE Trans Med Imaging; 2004; 23: 1353
Brillet. Eur Radiol; 2007; 17: 1483

Bronchial cross-section quantification

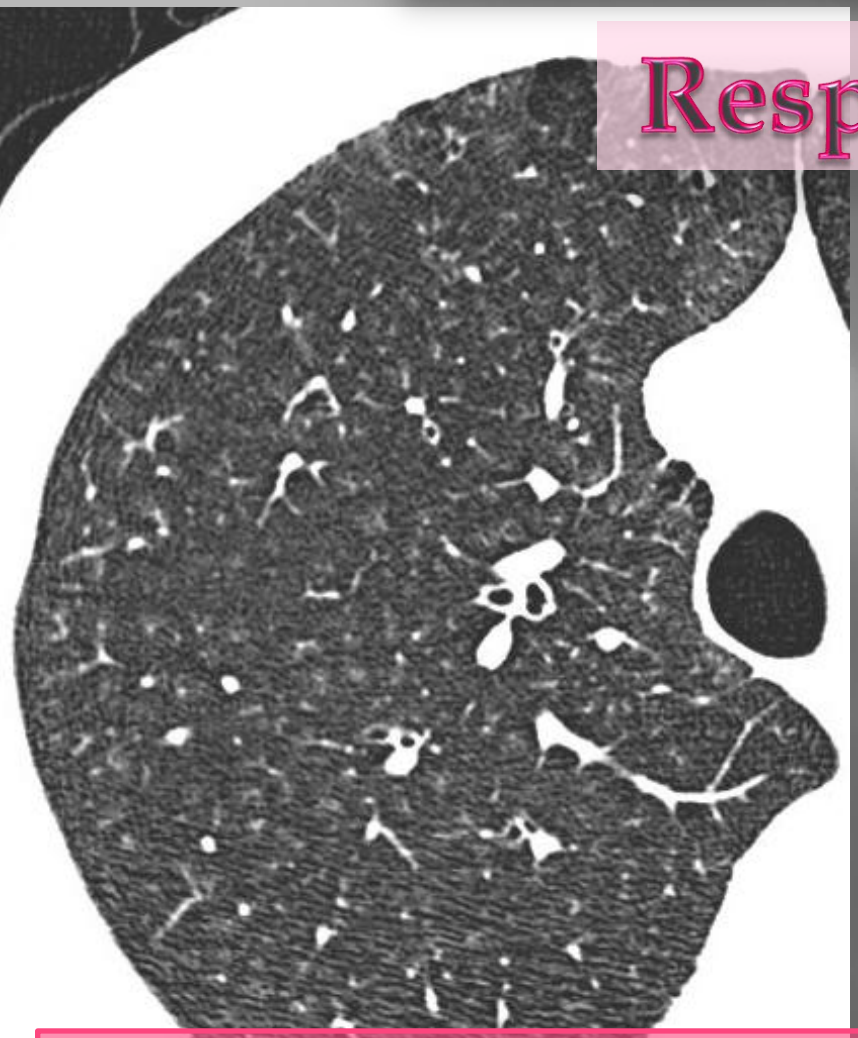
In order to assess the heterogeneity of the disease, several airway segments can be selected for analysis

Cross-section MPR images are generated on each selected airway at desired sampling interval along the central axis

Segmentation of the airway lumen and wall performed on each refrmat image



ASSOCIATED FINDINGS



Respiratory Bronchiolitis

Small centrilobular nodules without tree in bud appearance

Poorly defined
3-5 mm of diameter
> 3 mm of the pleura

Ground glass attenuation

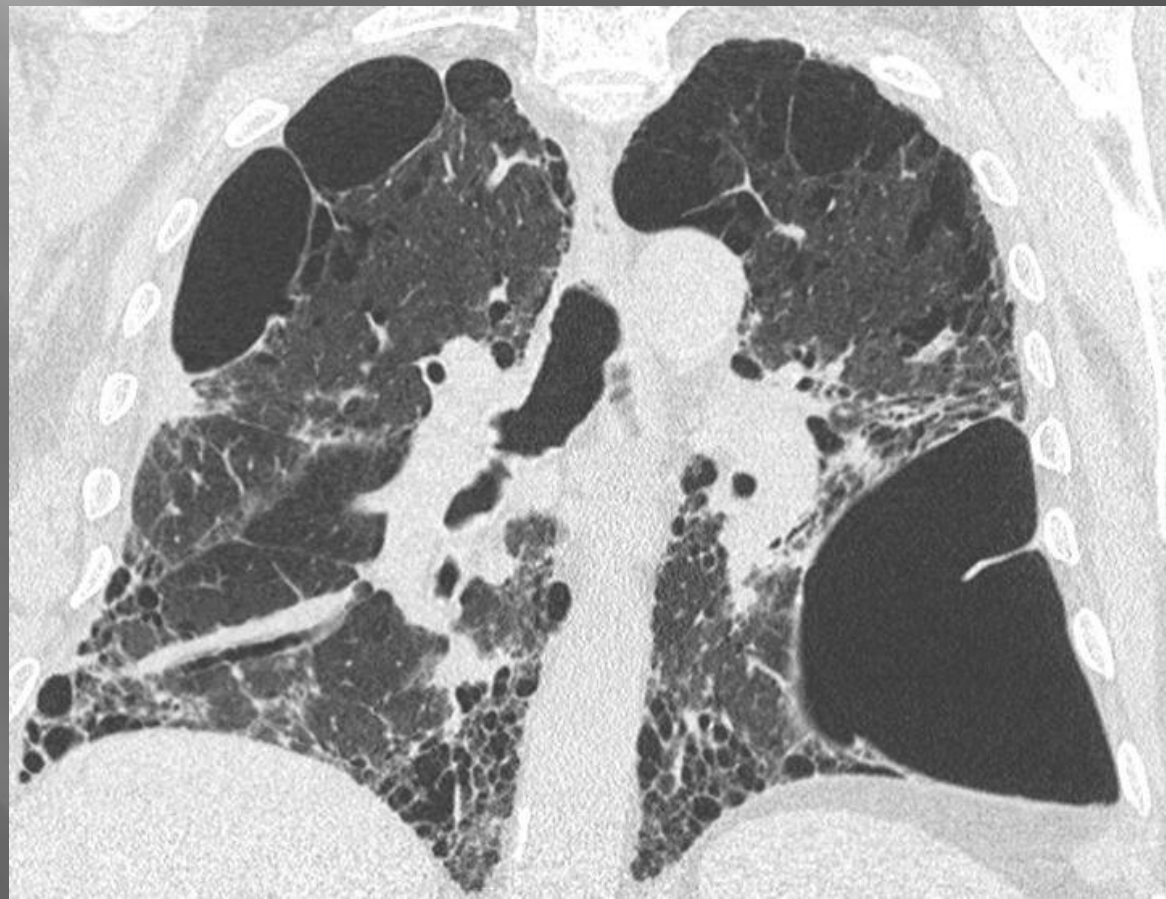
Homogeneous distribution

Exclusive or predominant upper lobe location

Associated centrilobular emphysema

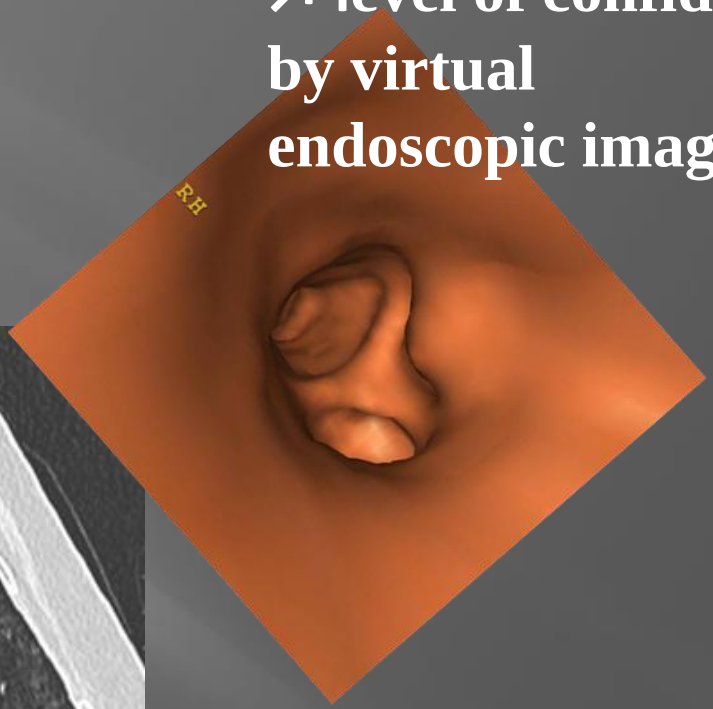
Syndrome of combined pulmonary fibrosis and emphysema

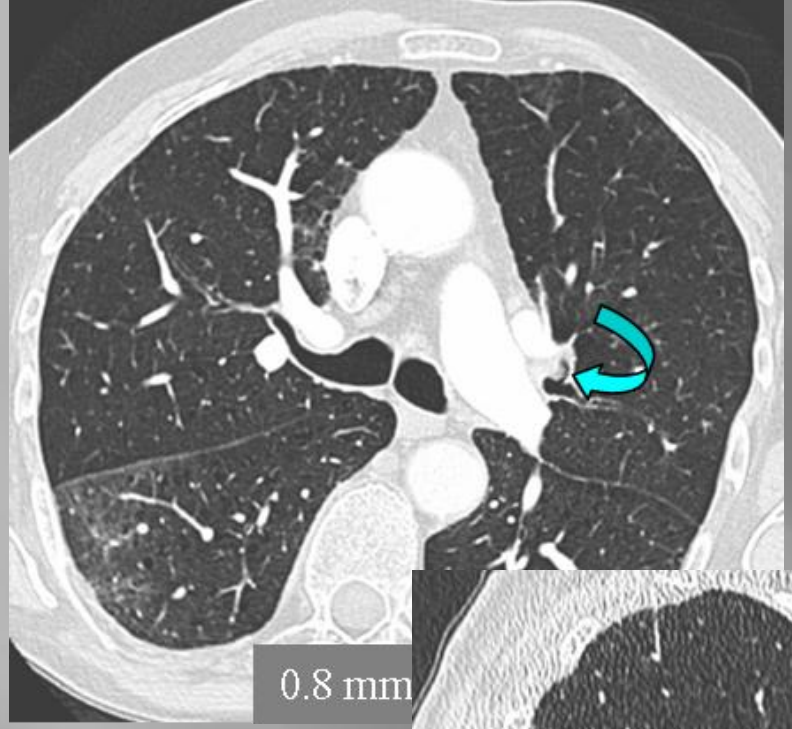
Heavy smokers
Severe dyspnea
TLCO low
Preserved pulmonary volumes



Focal abnormalities

↗ level of confidence by virtual endoscopic imaging





Leads to proceed a fiberoptic bronchoscopy and a guided biopsy

Detection of small primary tumours

OTHER CAUSES

Constrictive bronchiolitis

Clinical and imaging findings may be similar regardless of the cause

Infection sequelae

Adenovirus, respiratory syncitial virus, Mycoplasma pneumoniae, measles, whooping cough

Lung, heart-lung, and bone marrow transplantation sequelae

Chronic rejection or graft versus host disease

Rheumatoid arthritis

Drug toxicity (penicillamine)

Exposure to toxic fumes

Neuroendocrine cell hyperplasia

Irreversible circumferential submucosal fibrosis

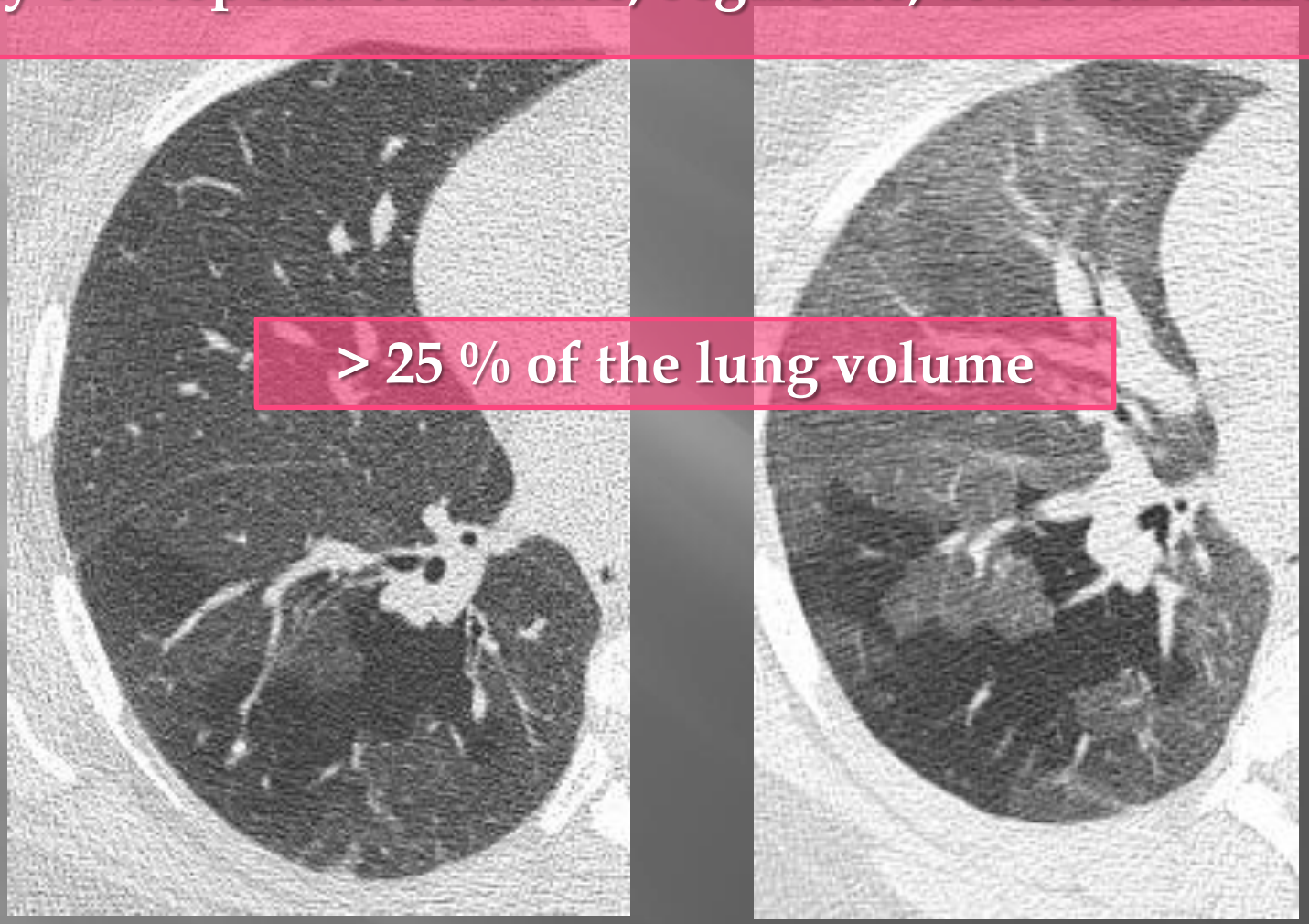
Mosaic perfusion pattern

Inhomogeneous lung attenuation resulting from regional differences in lung perfusion

Airways disease

Pulmonary vascular disease

Areas of decreased lung opacity of varying sizes
May correspond to lobules, segments, lobes or entire lung



> 25 % of the lung volume

On expiration, the contrast in attenuation between normal and abnormal areas increases

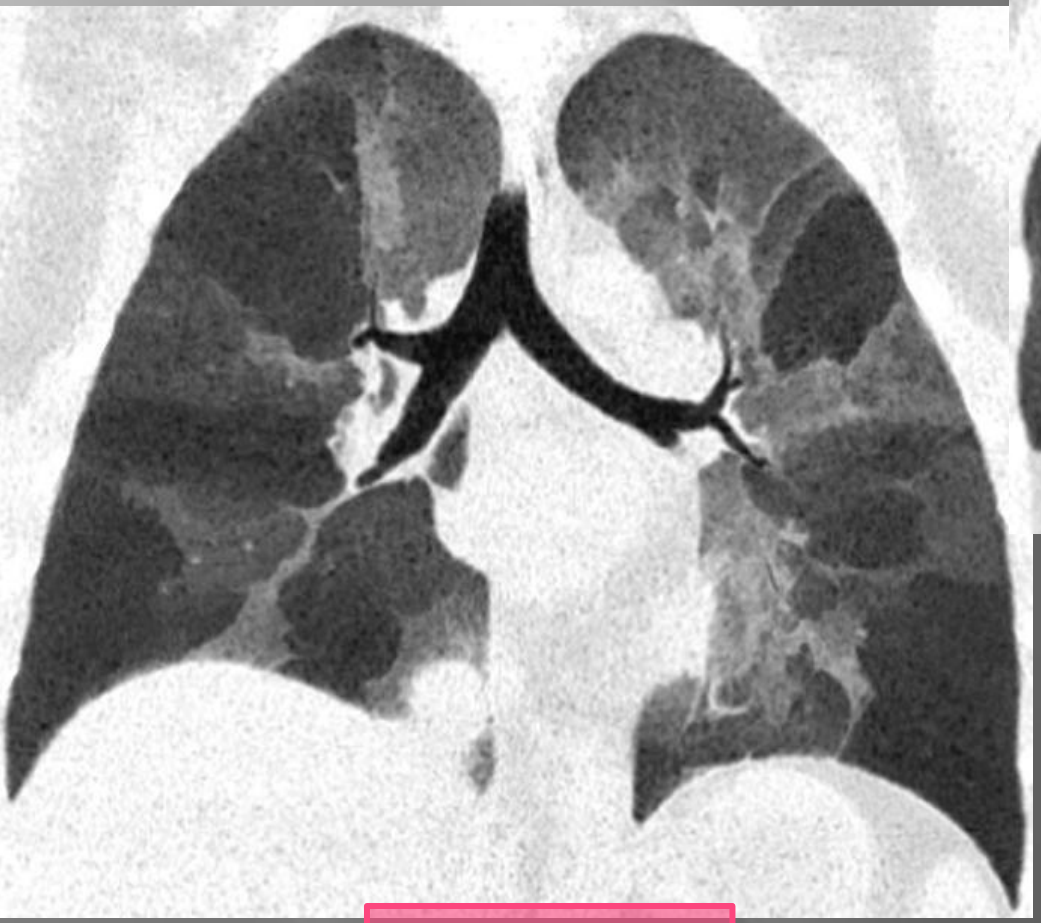
Expiration ?

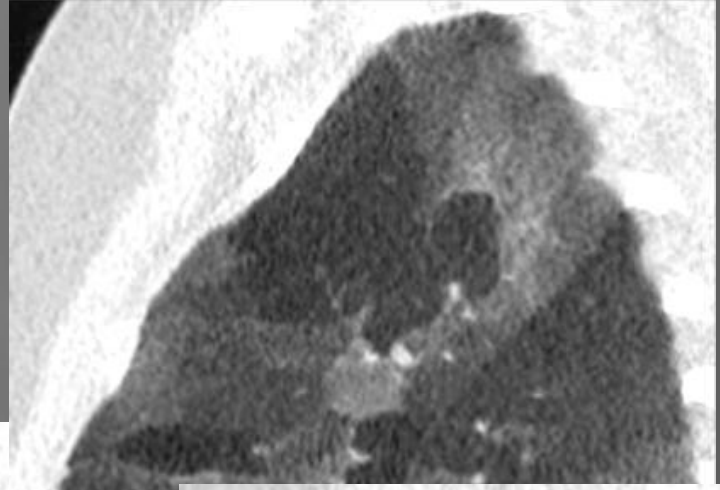
Homogenous decreased lung attenuation and perfusion

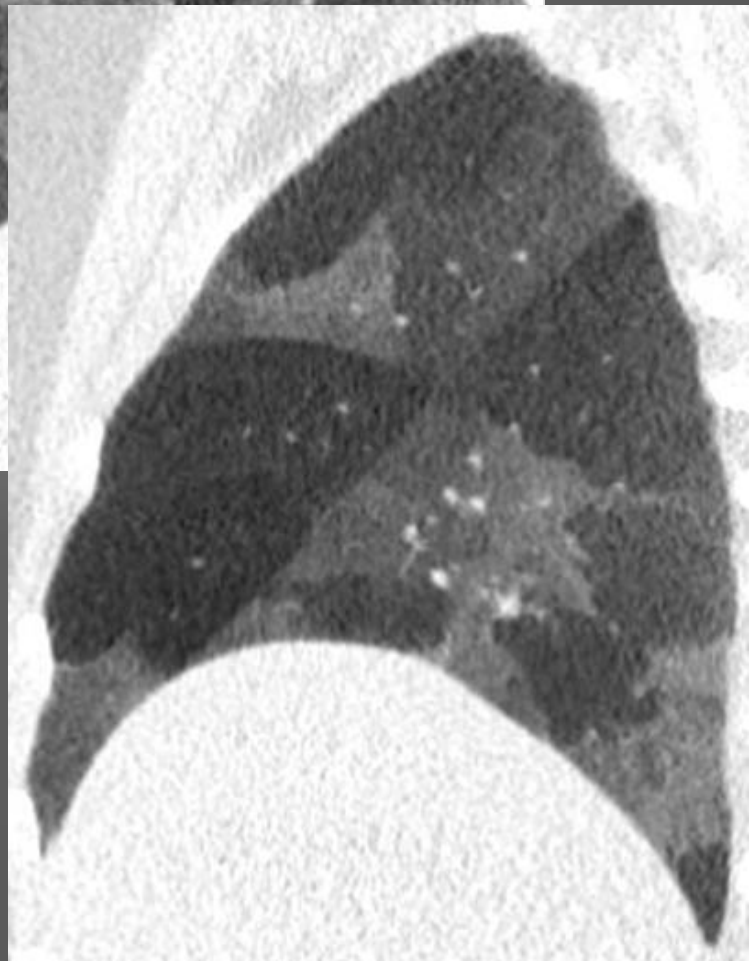
No increase in lung attenuation nor significant change in lung volume
Good quality of expiratory maneuver according to collapse of airrway lumen

Combined Sjögren's disease and relapsing polychondritis

Normal inspiration

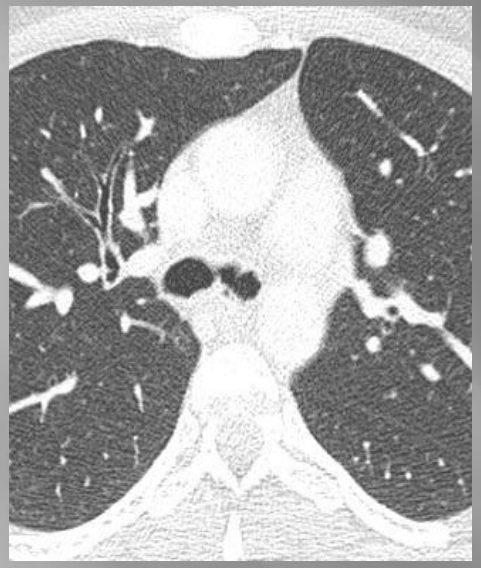




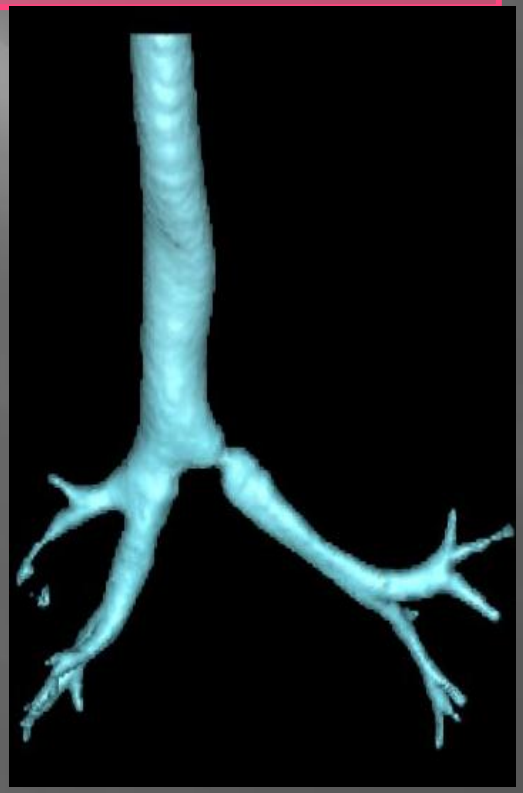


15 mAs

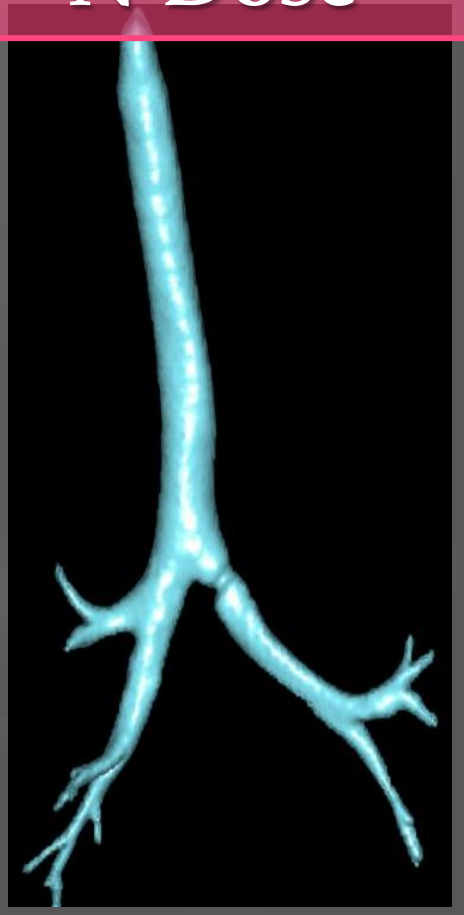
Infection sequelae



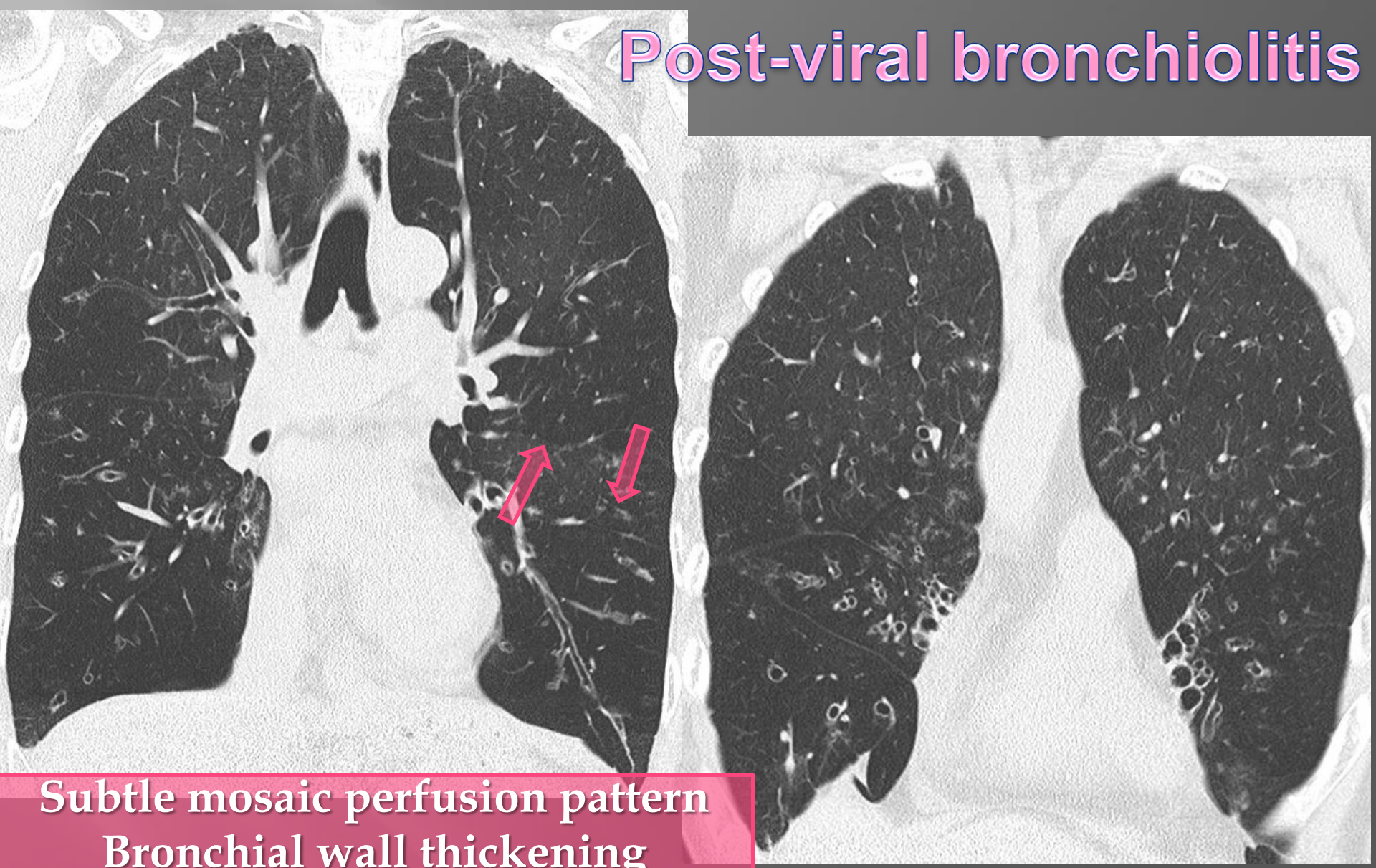
Expiration
Low dose



Inspiration
N Dose



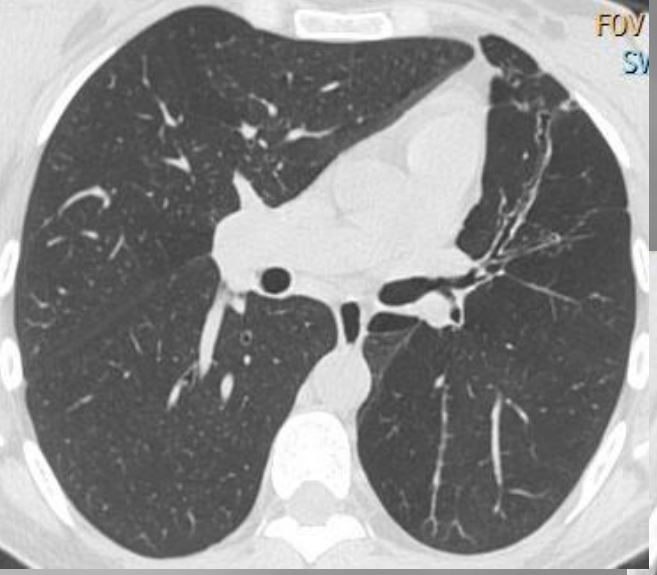
Post-viral bronchiolitis

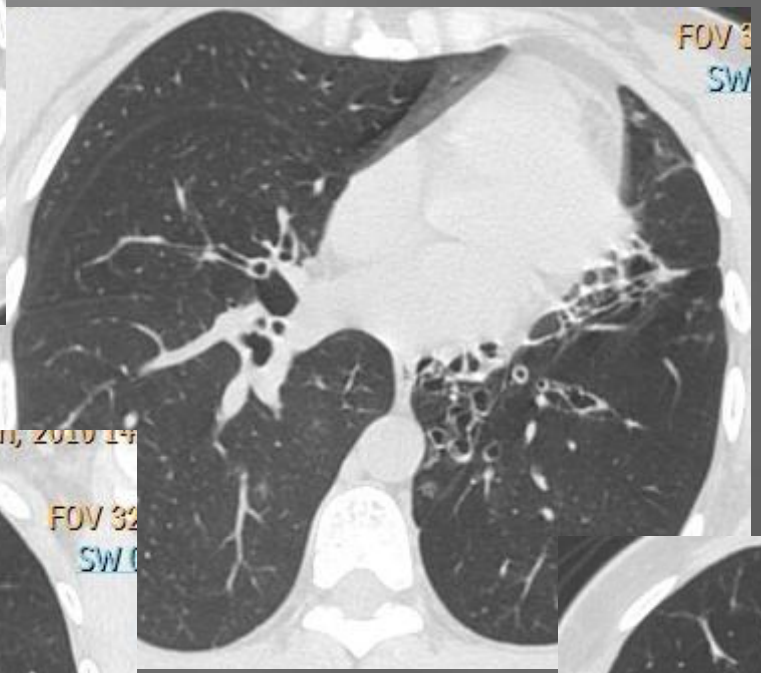


Subtle mosaic perfusion pattern
Bronchial wall thickening
Tubular dilatation > 90 %

Frequently asymptomatic despite the severity of the lesions

Swyer James syndrome





Bone marrow transplantation

Pre transplant

Post transplant

Diffuse idiopathic pulmonary neuroendocrine cell hyperplasia: an under-recognised spectrum of disease

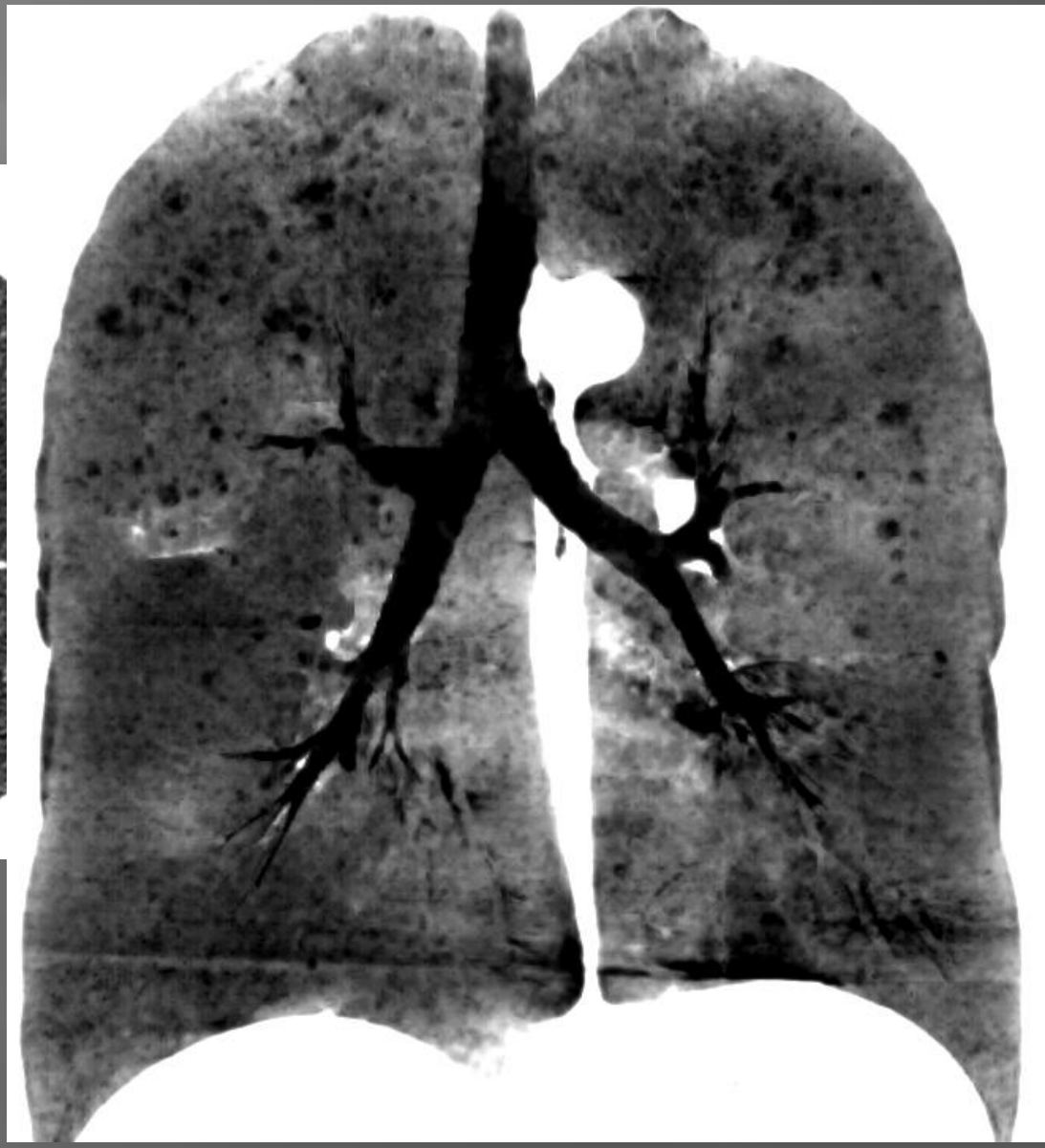
Susan J Davies, John R Gosney, David M Hansell, Athol U Wells, Roland M du Bois, Margaret M Burke, Mary N Sheppard, Andrew G Nicholson

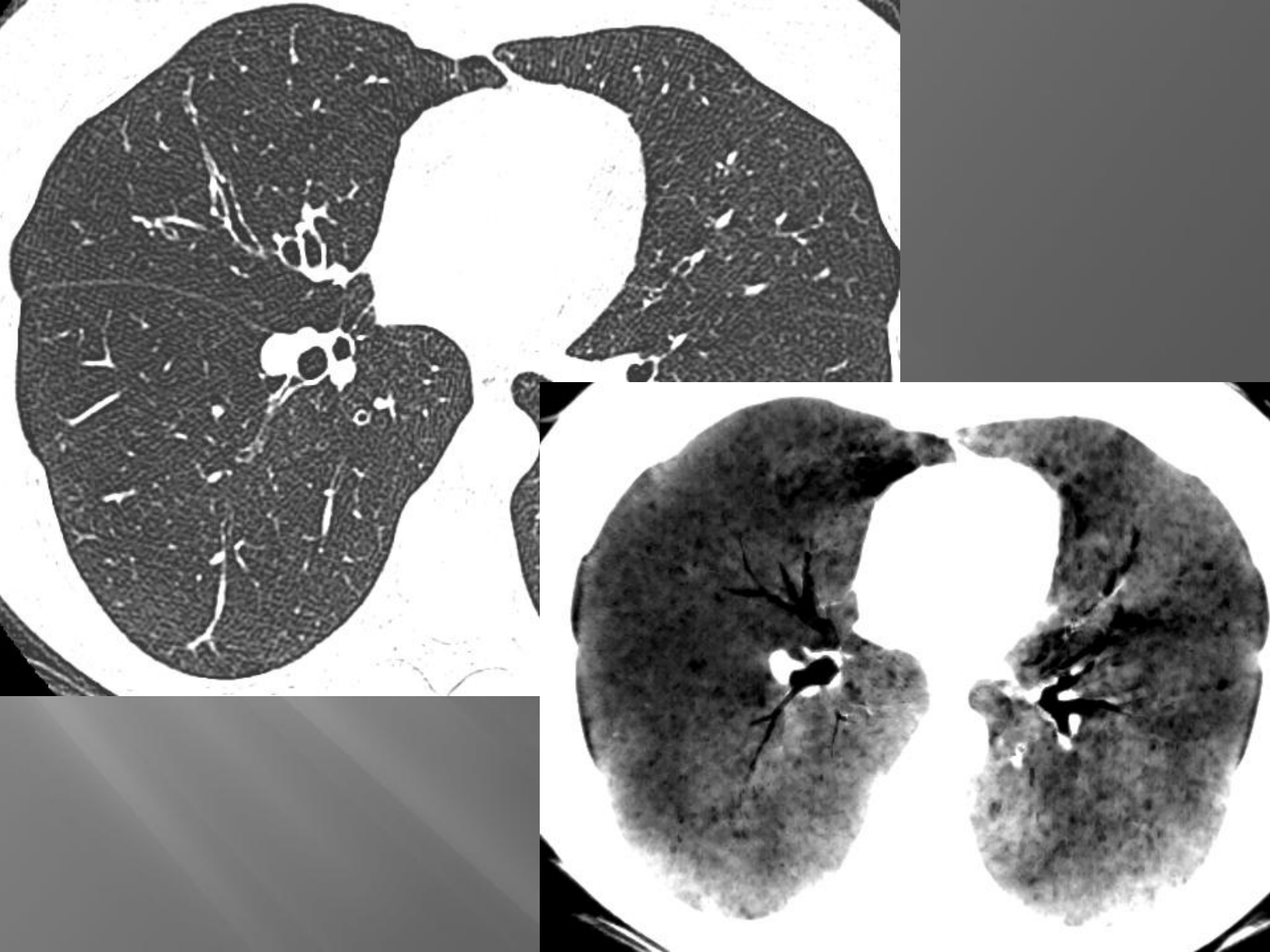
20 PA
Obstructive Sd

Precursor lesion of pulmonary carcinoid tumors

Collections of scattered single cells, small nodules or linear proliferations of neuroendocrine cells confined to the airway mucosa

Davis SJ. Thorax 2007; 62-248
Falkenstren-Ge J Cancer Res Clin Oncol 2011; 137; 1495





Summary

MDCT provides additional data to that derived from traditional measures of lung function in COPD patients

Phenotypic abnormalities may be recognized on visual and quantitative evaluation of CT images in patients with COPD

Better stratification of patients with COPD in clinical trials, and for a given patient this may help optimize treatment

Other causes of obstructive lung disease