

30 Ans SPIF

Les Grandes Avancées en Pneumologie

L'Imagerie Thoracique
au service du Pneumologue:
hier, aujourd'hui et demain?

Philippe Grenier

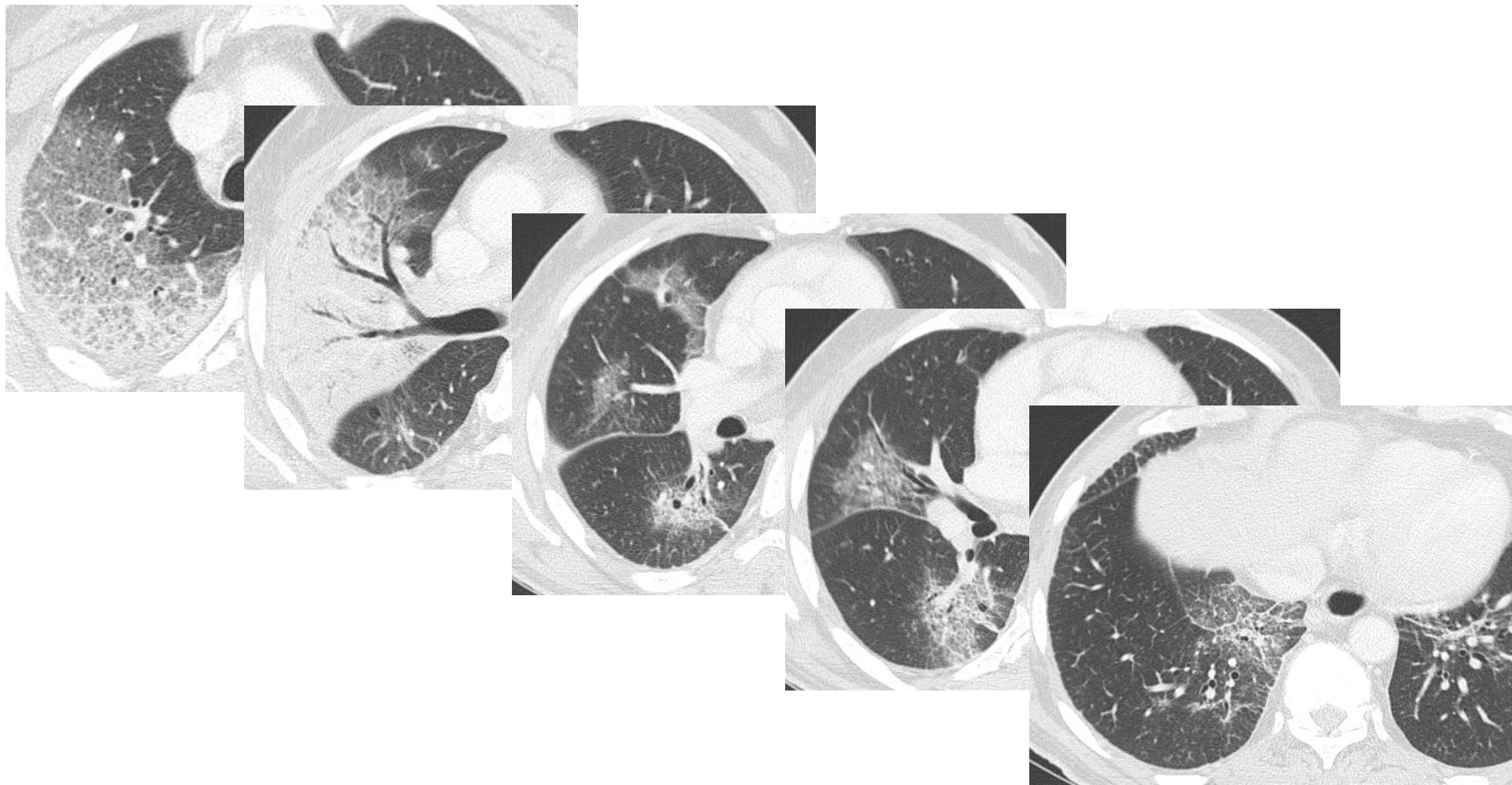
La Tomodensitométrie en Coupes Fines (Haute Résolution)

Coupes de 1,5 mm d'épaisseur avec un intervalle de 10 mm
Filtre de reconstruction favorisant la résolution spatiale



Nakata. Radiology; 1985;157: 181
Zerhouni. J Thorac Imaging;1985;1:54
Naidich. J Thorac Imaging;1985;1:39
Mayo. Radiology;1987;163:507
Murata. Invest Radiol;1988;23:170

La Tomodensitométrie en Coupes Fines (Haute Résolution)



Mayo. Radiology; 1987; 163: 507

La Tomodensitométrie en Haute Résolution du Thorax pour le Diagnostic des DDB et des PID



Grenier. Radiology;1986;161:95-99

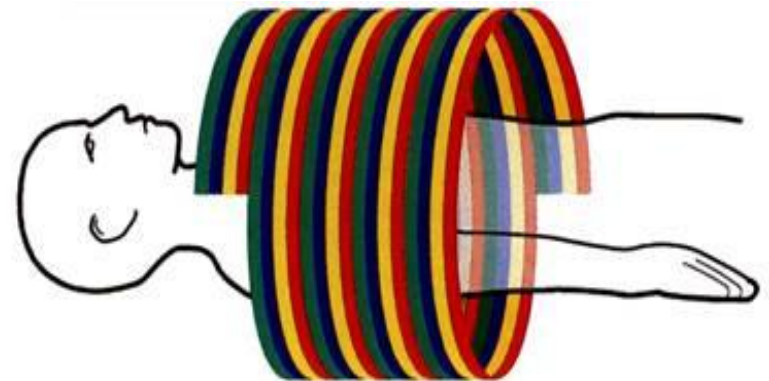
Grenier. Radiology; 1991;179:123

Grenier. Radiology; 1994;191:383

La Tomodensitométrie Spiralee (Hélicoidale)

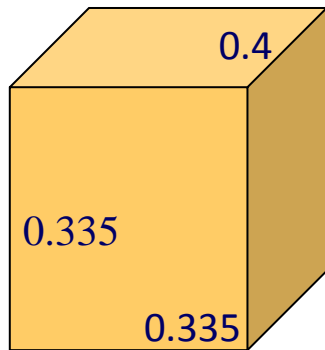


TDM Multidétecteur



La TDM Volumique en Haute Résolution

0.625 mm detector size
Axial thickness 0.8 mm
Reconst. increment 0.6 mm
High frequency algorithm
768² matrix
325 FOV

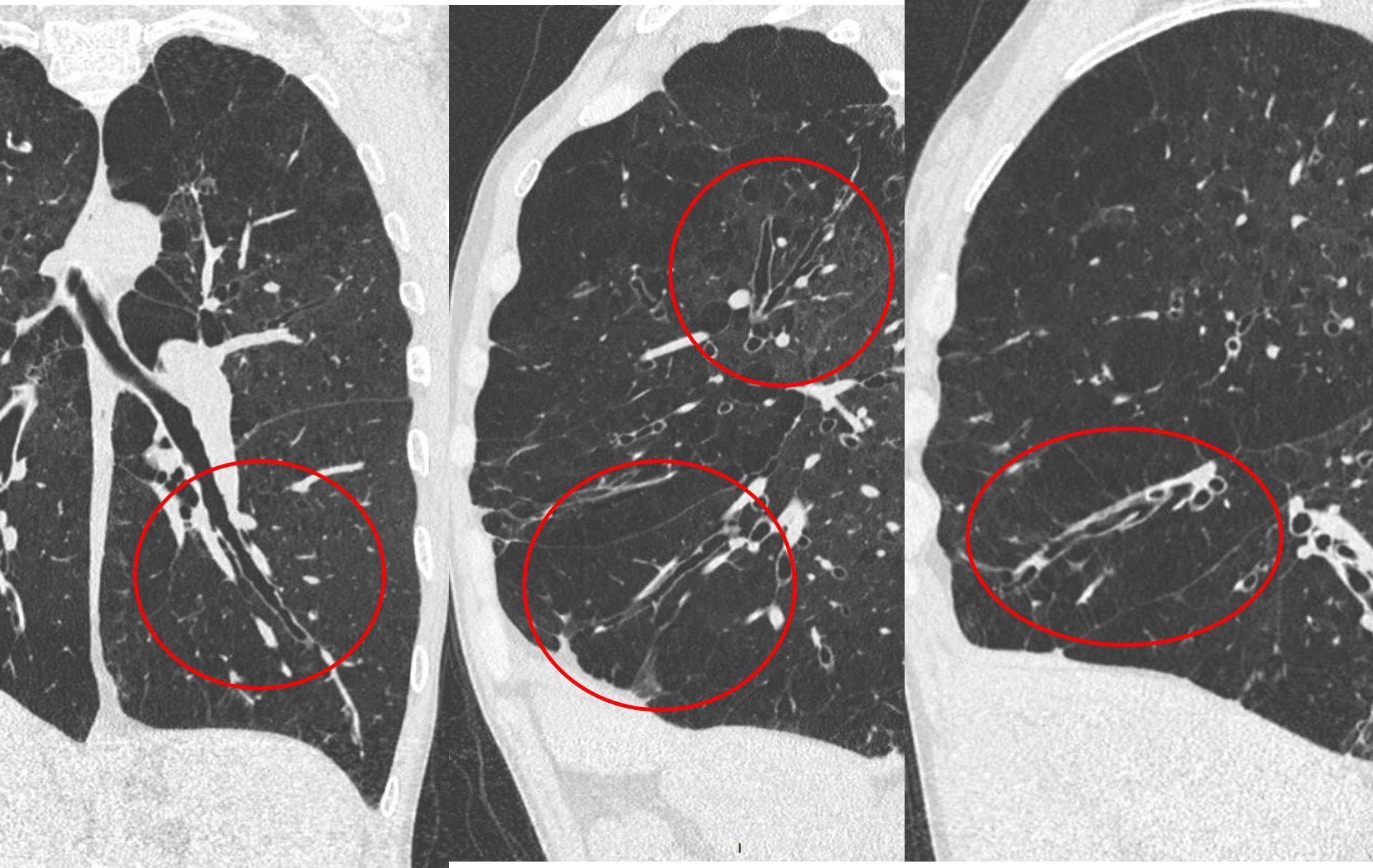


120 Kv
80-160 mAs



DLP: 326 mGy.cm

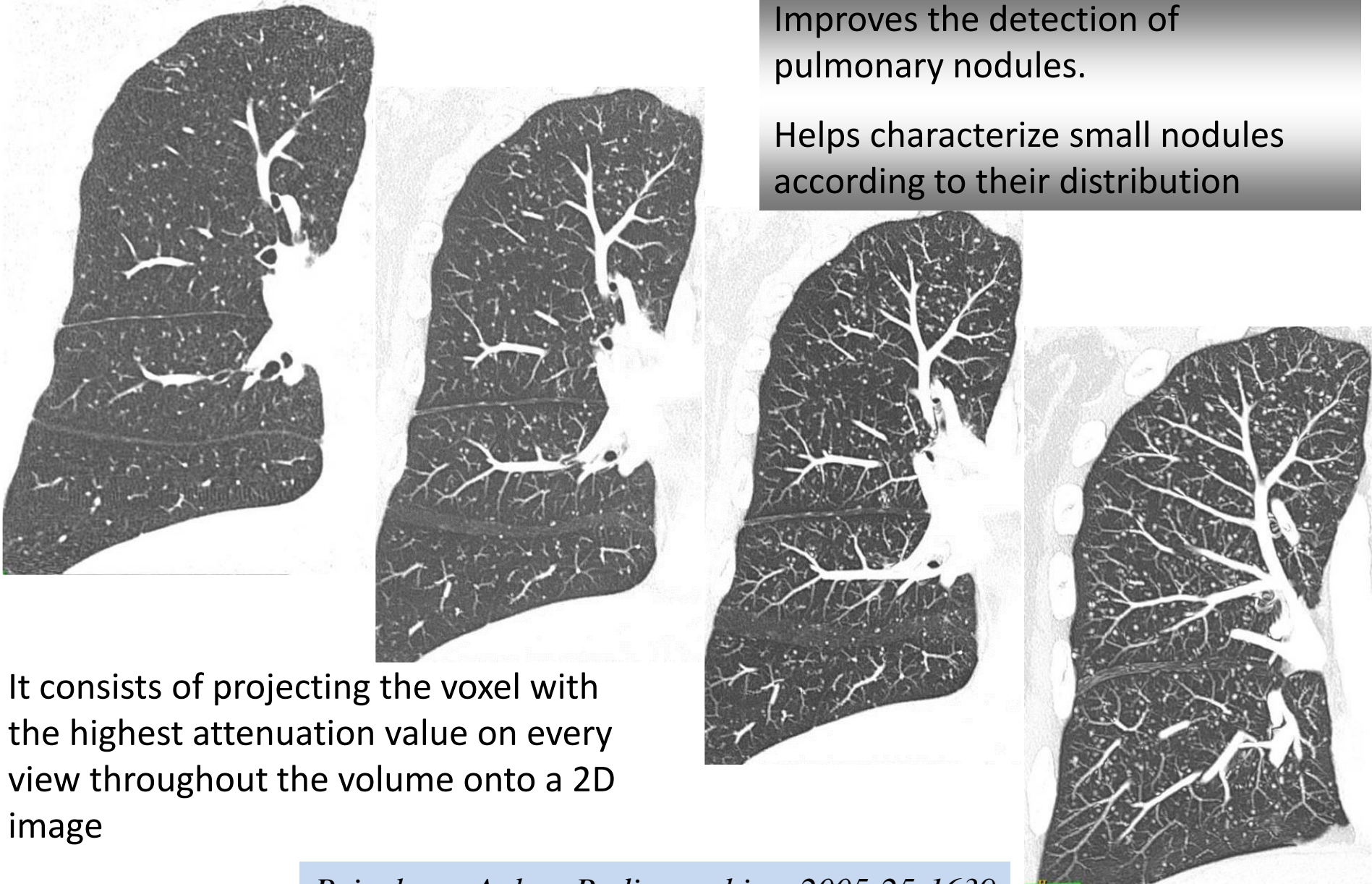
CT Assessment of Longitudinal Shape of Airway Lumen



Maximum Intensity Projection (MIP)

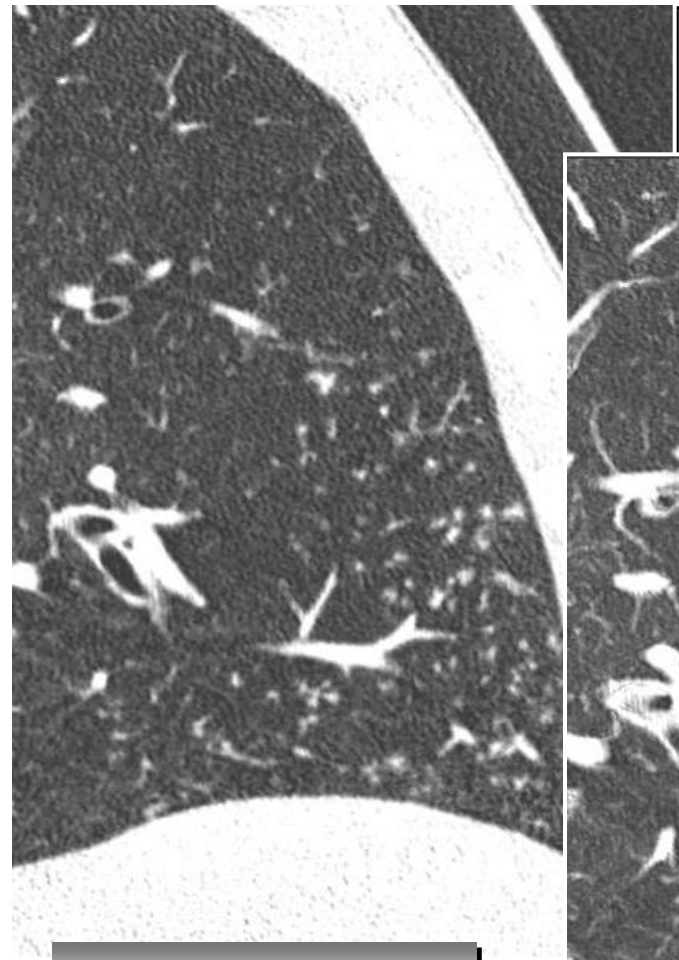
Improves the detection of pulmonary nodules.

Helps characterize small nodules according to their distribution

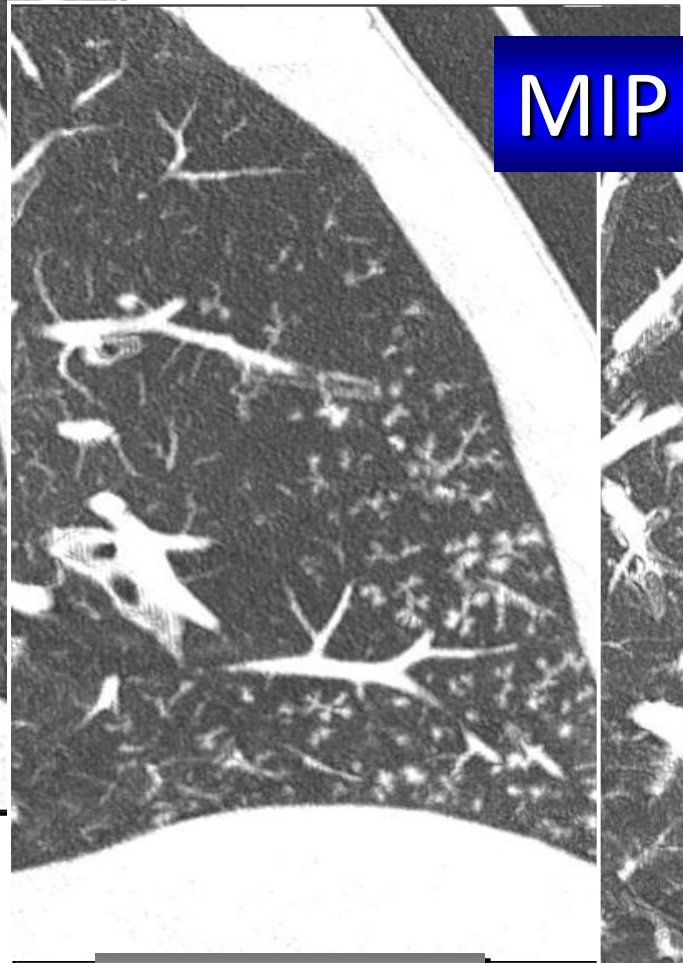


It consists of projecting the voxel with the highest attenuation value on every view throughout the volume onto a 2D image

Tree in bud pattern



0.8-mm thick



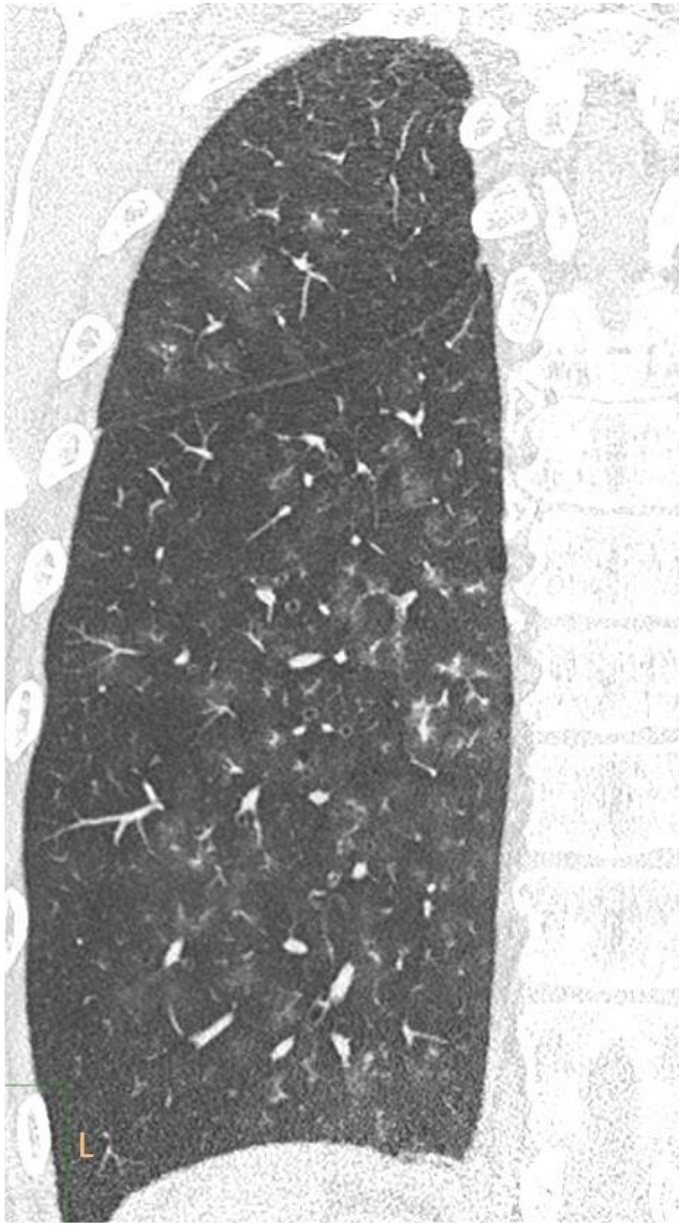
3-mm thick



7-mm thick

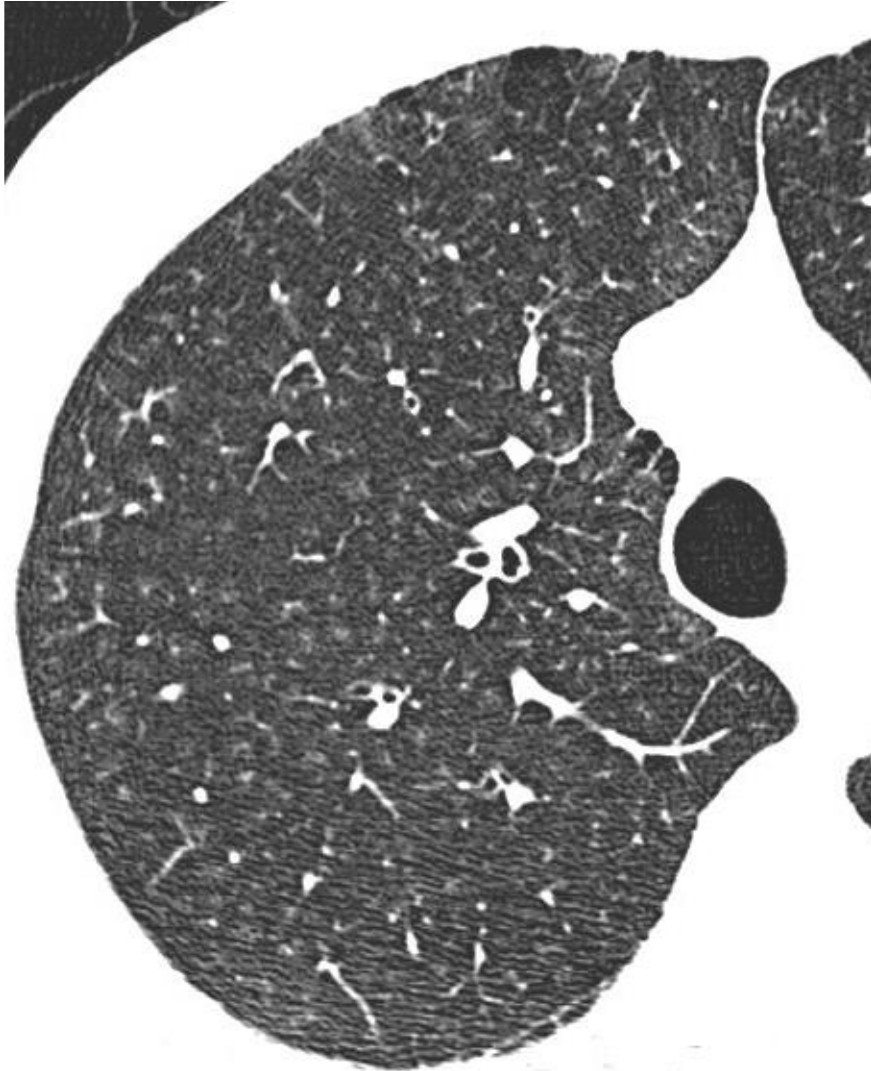
Tree in bud pattern

MIP

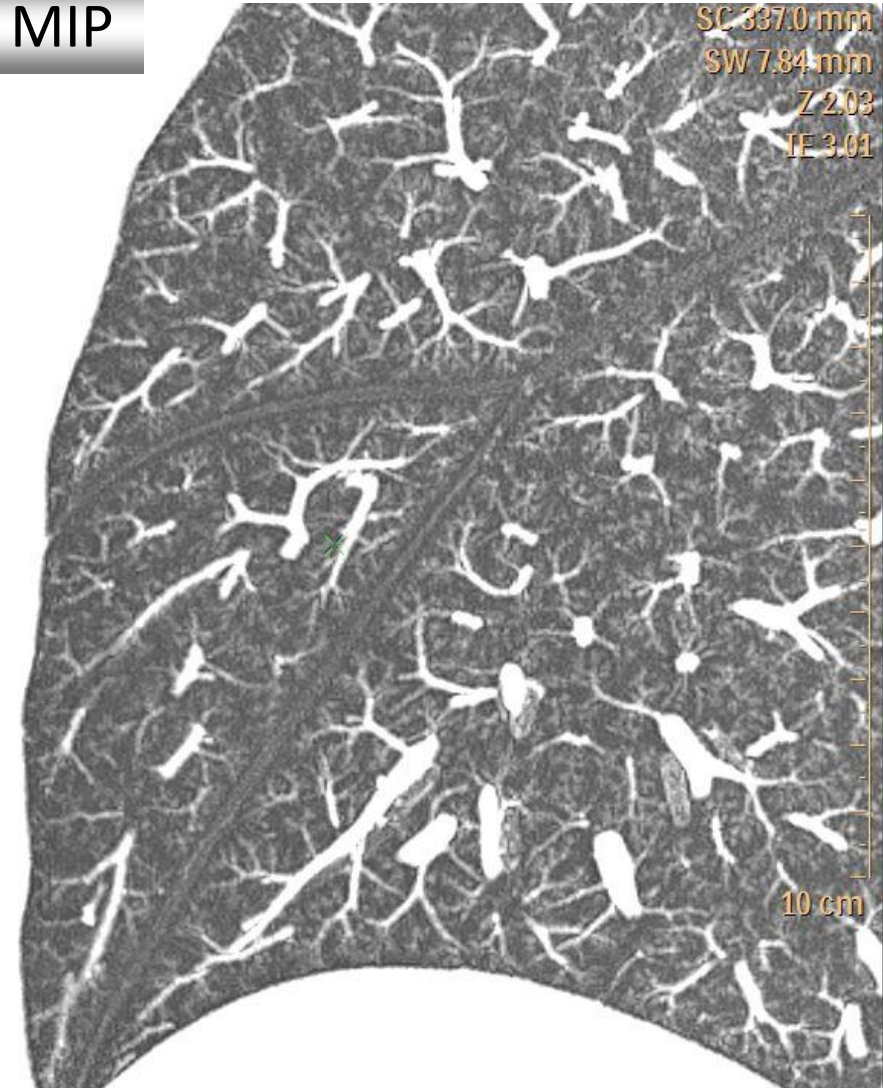


Respiratory Bronchiolitis

Smoking-related inflammation of the respiratory bronchioles



MIP



Minimum Intensity Projection (minIP)

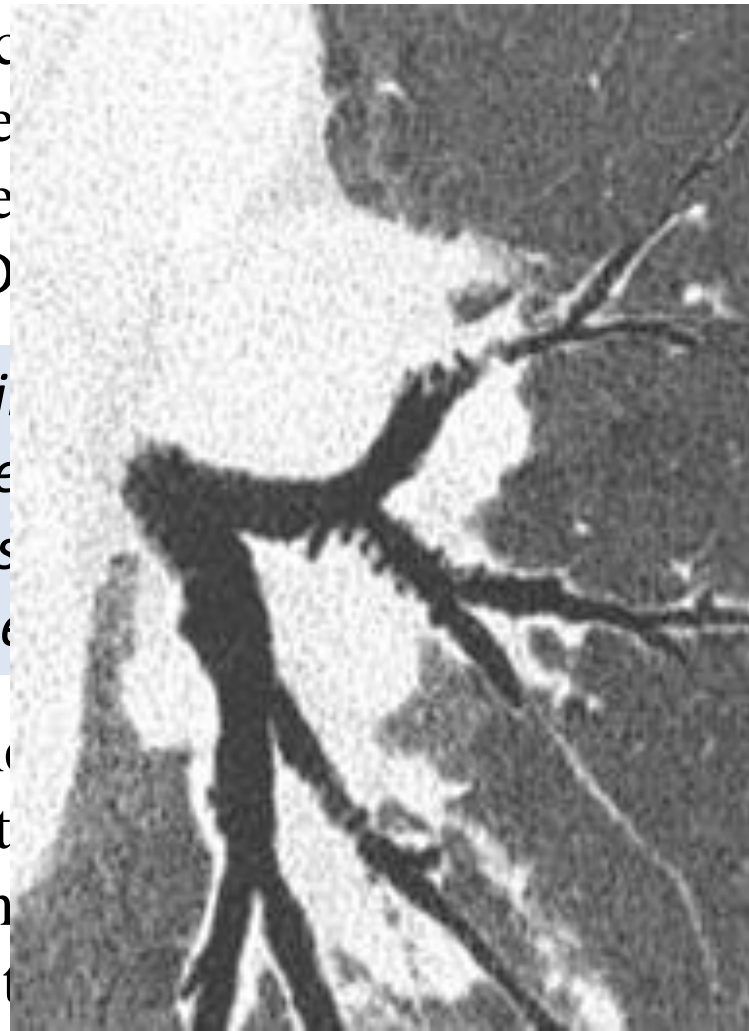


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Minimum Intensity Projection (minIP)

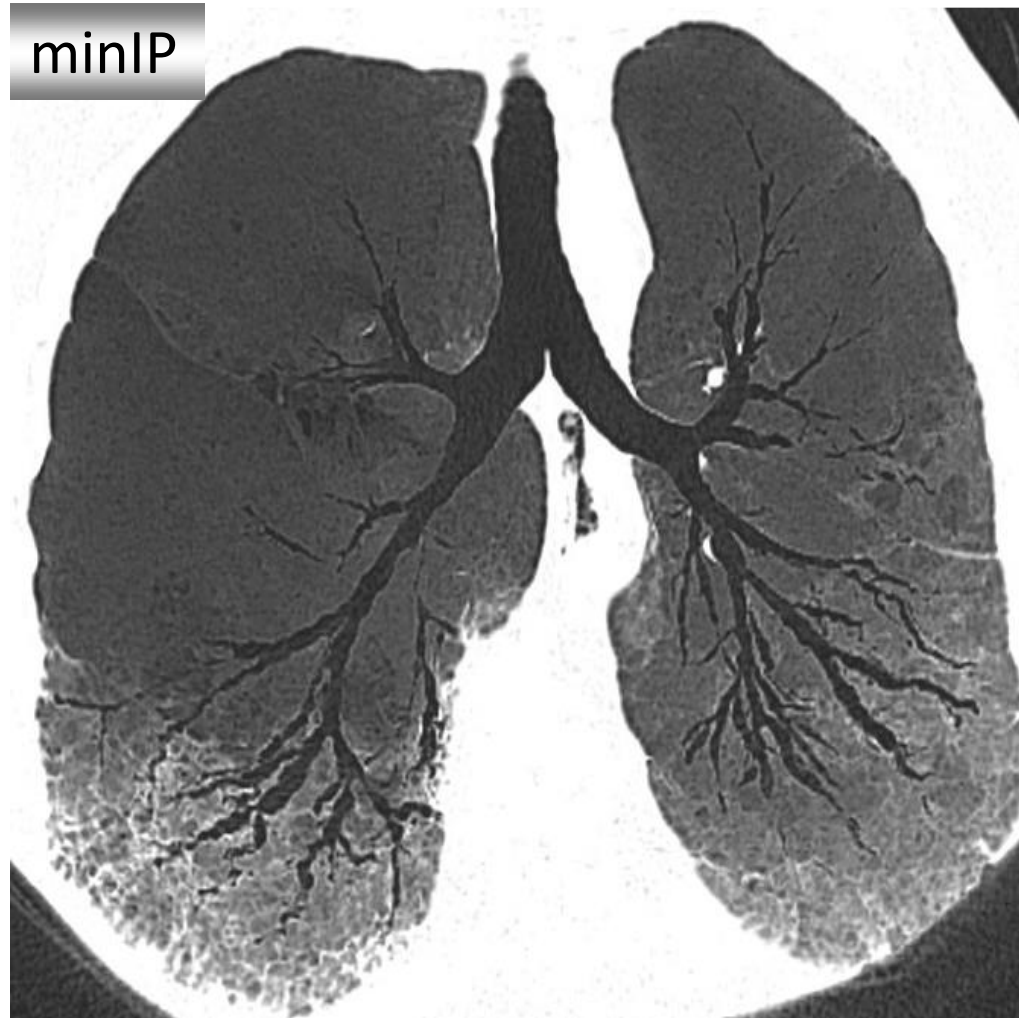
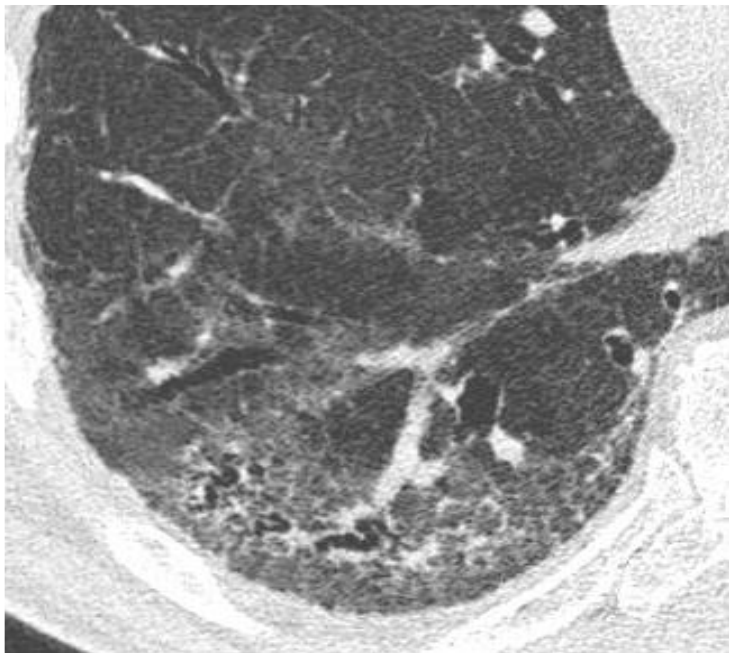
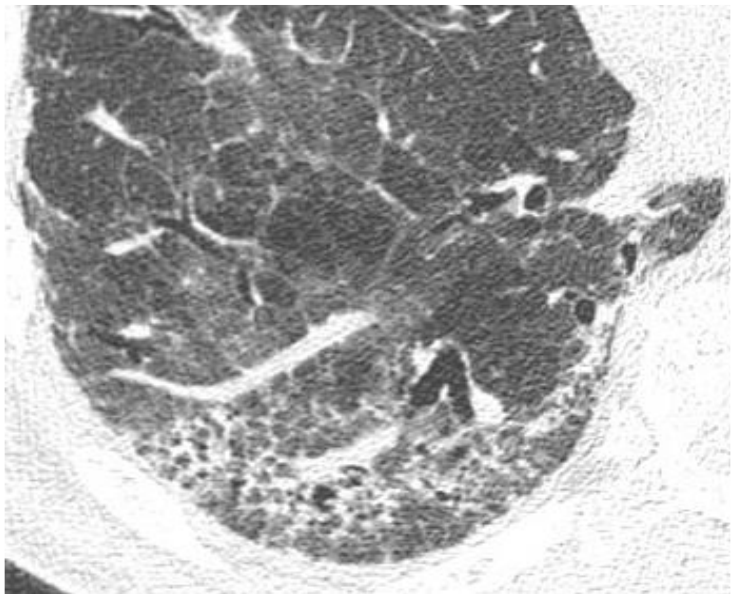
Distal traction bronchiectasis
and bronchiolectasis

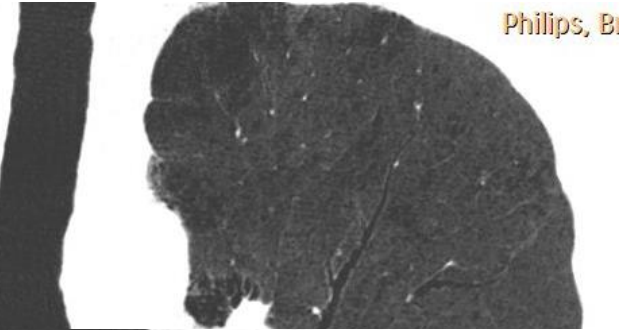
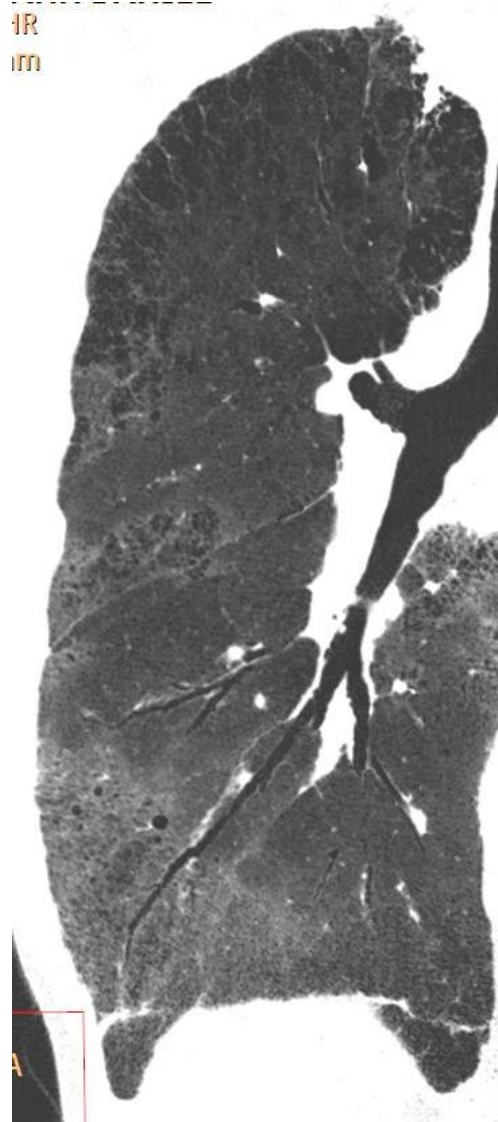
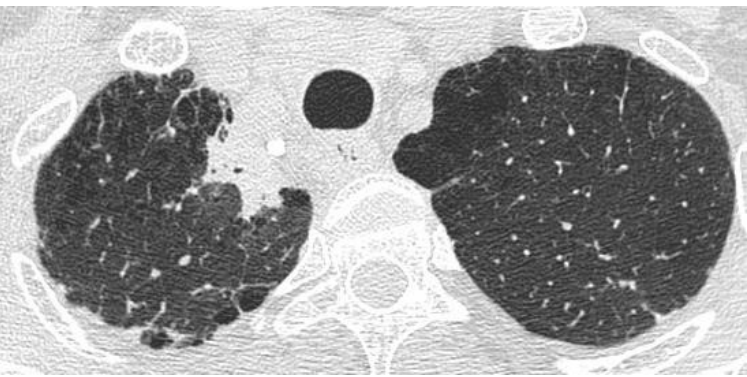


Peribronchovascular fibrosis (sarcoidosis)

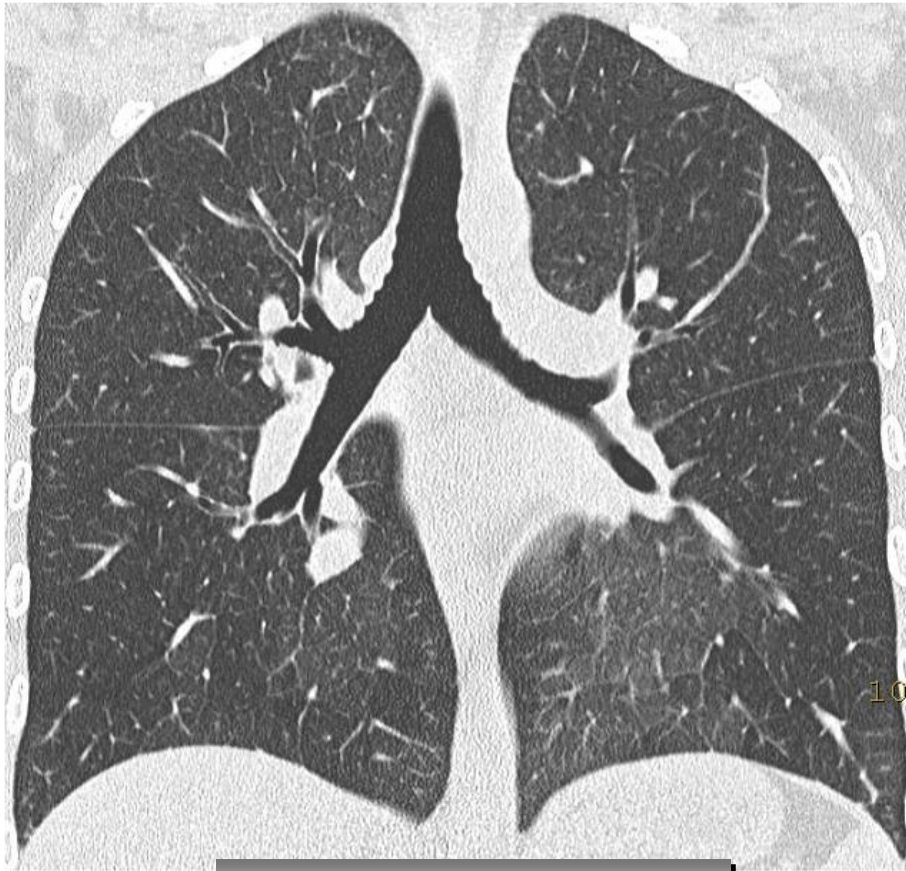
Oblique mIP-multiplanar VR image (30-mm-thick slab)

minIP

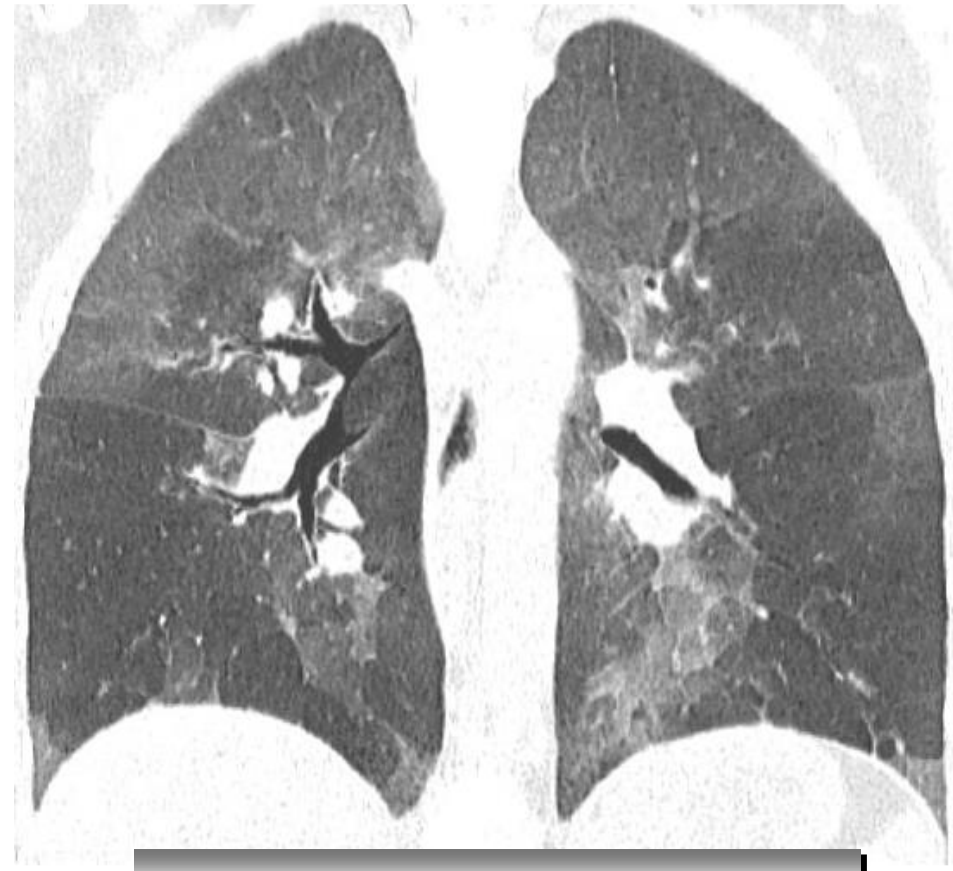




Decreased lung attenuation and air trapping



Mosaic perfusion



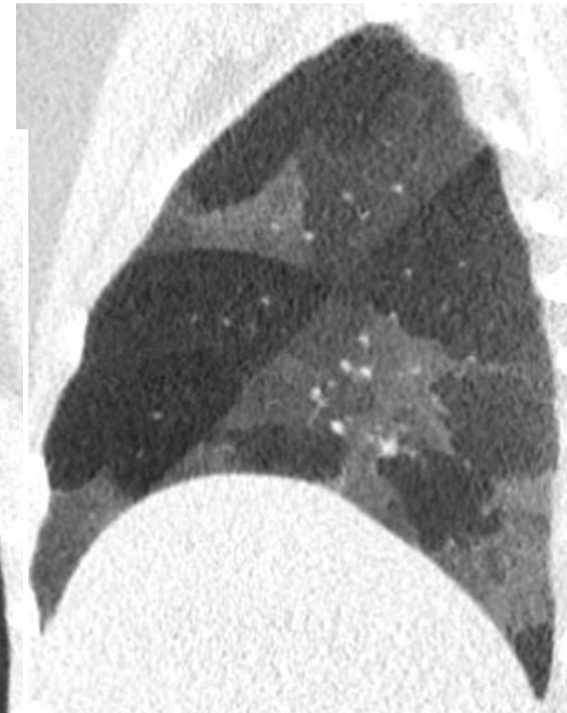
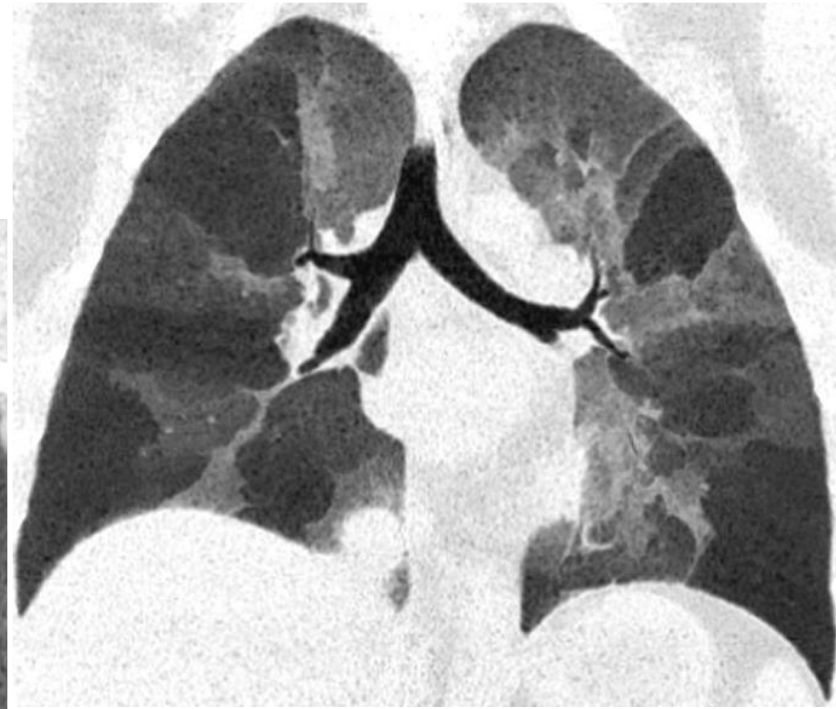
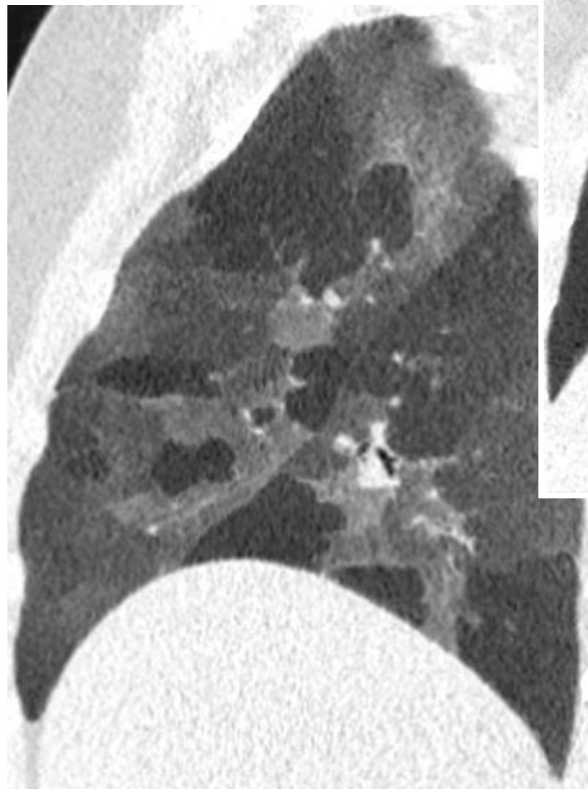
Exp. Air Trapping minIP

- The most common causes:
 - Obliterative bronchiolitis
 - Asthma
 - Hypersensitivity P.

Low dose expiratory MDCT

20 mAs

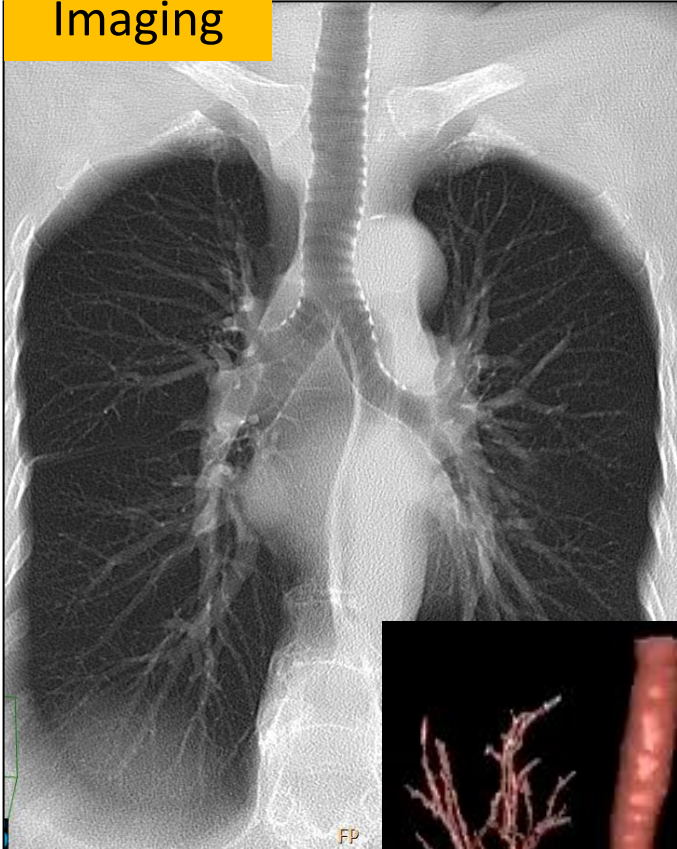
minIP



Expiratory air trapping in asthma

Volumetric MDCT Imaging of the Trachea

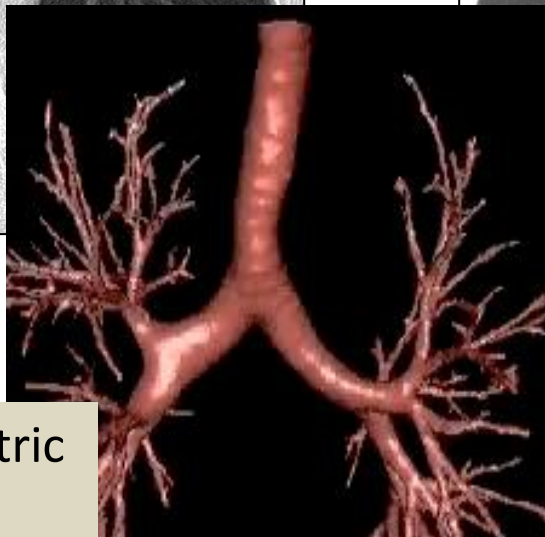
Averaging
Imaging



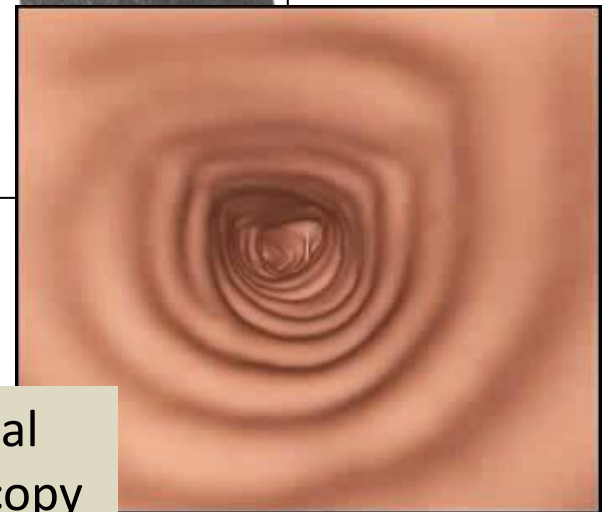
Minimum Intensity
Projection



External Volumetric
Rendering



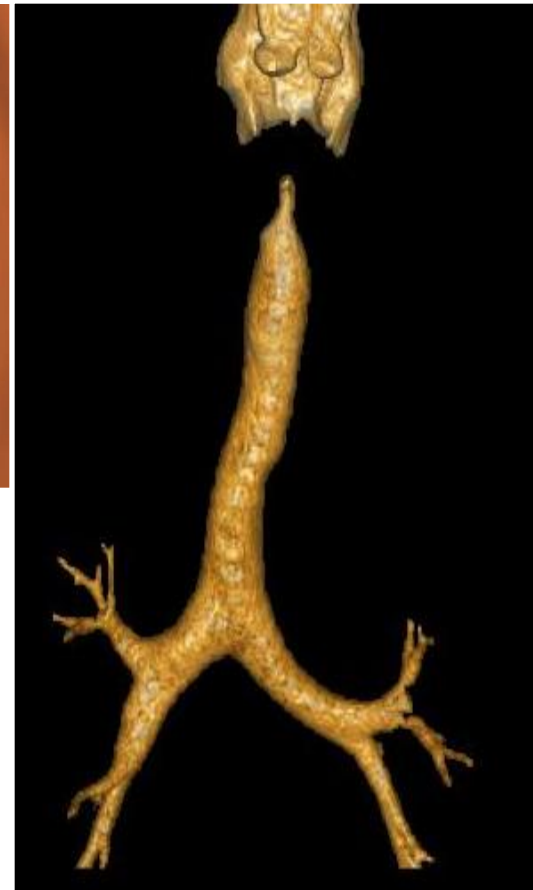
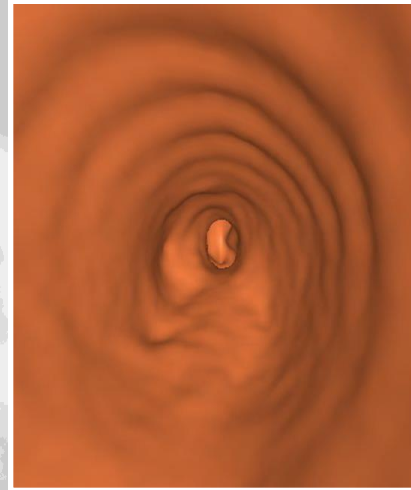
Virtual
Endoscopy



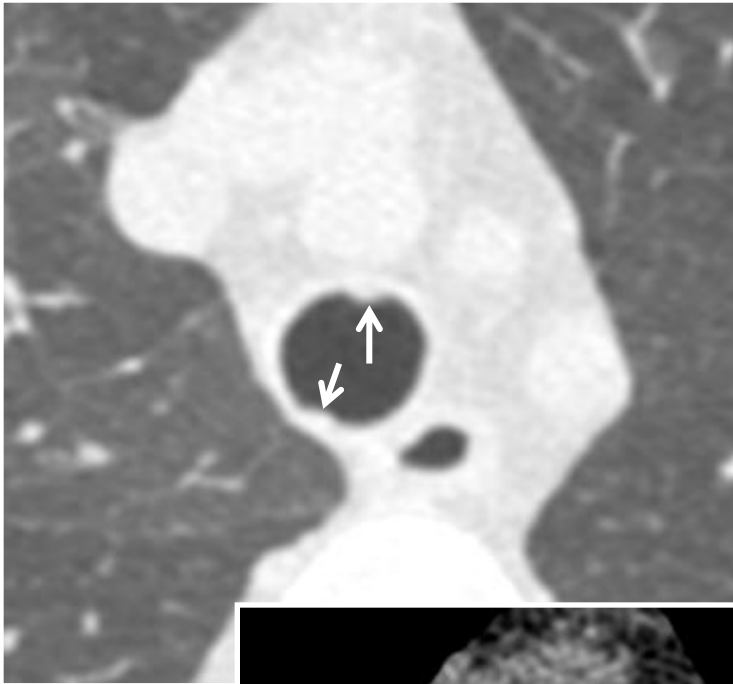
Tracheal Disease

Ulcerating tracheobronchitis and fibrosis causing erosion of cartilage, fistulas, and tracheobronchial stenosis

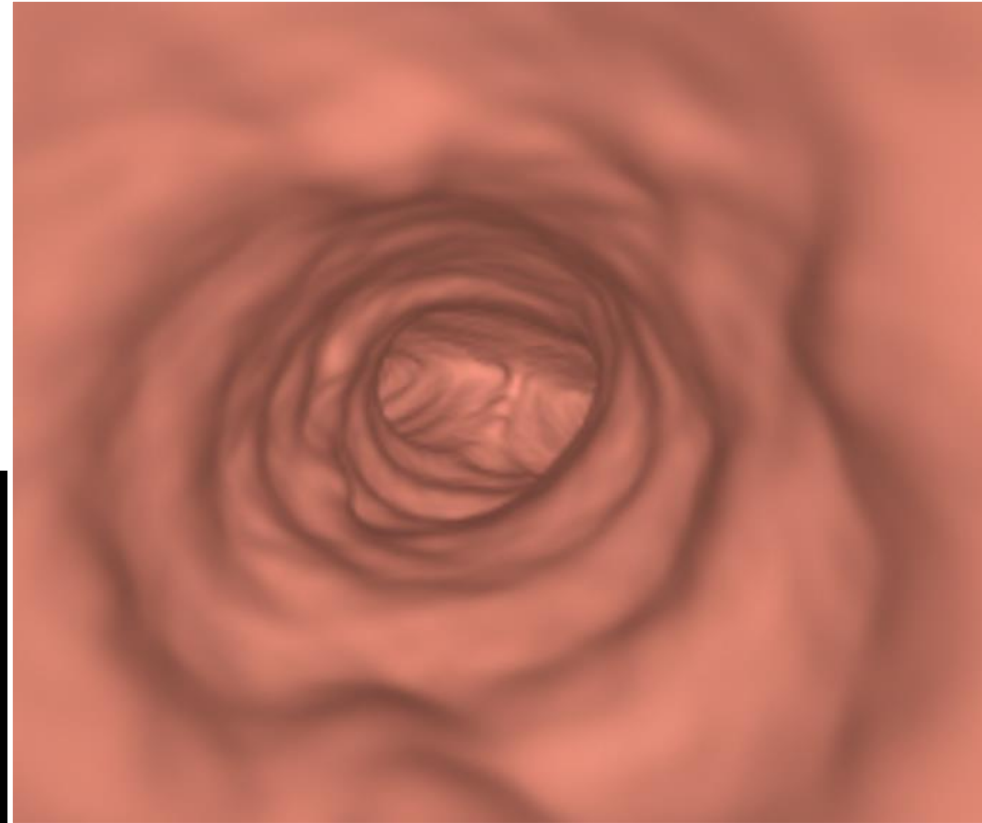
Granulomatosis with polyangiitis



Multinodular Appearance of Airway Inner Surface

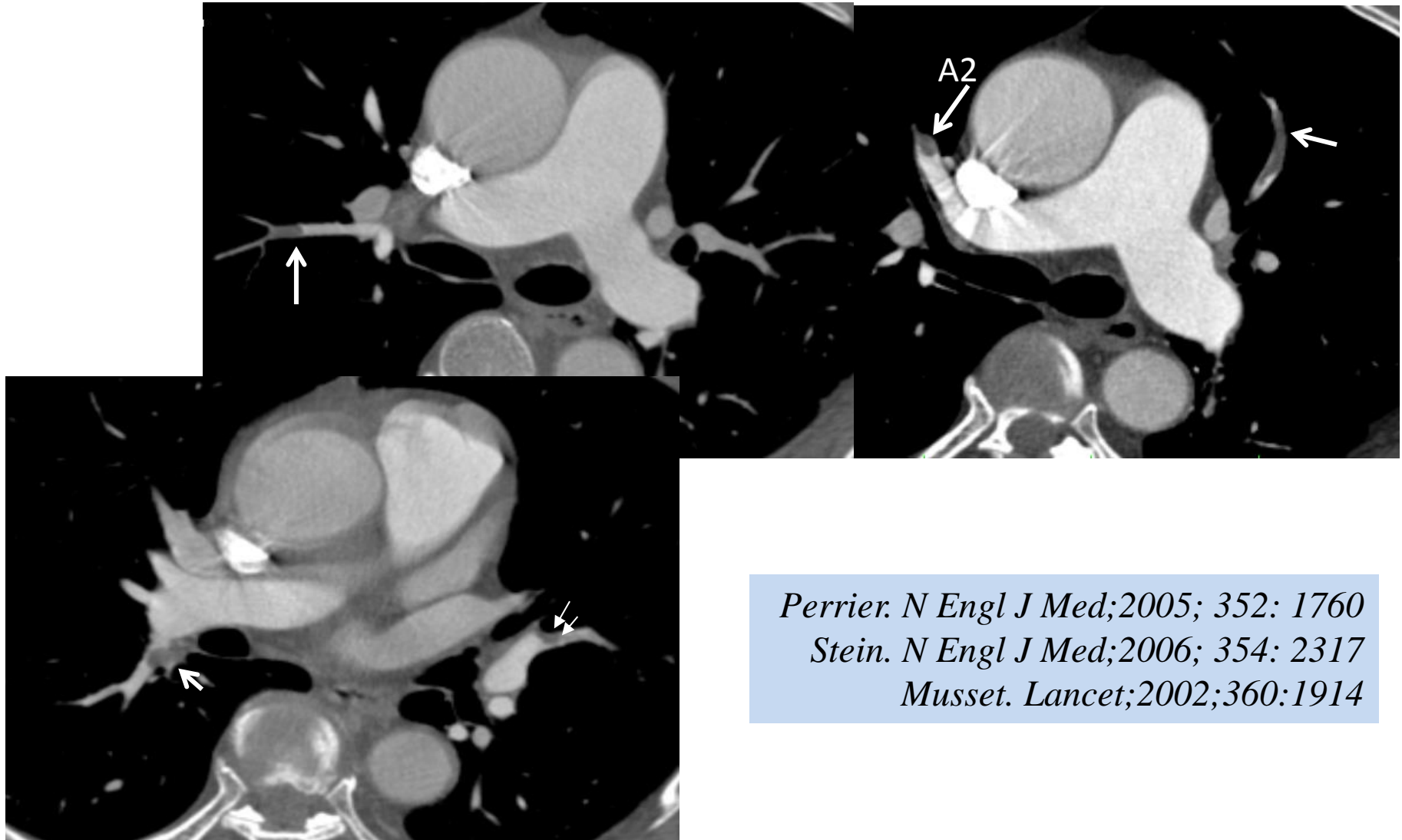


Granulomatosis with Polyangiitis



Granulomatous inflammation and vasculitis in the mucosa and the submucosa of the airways

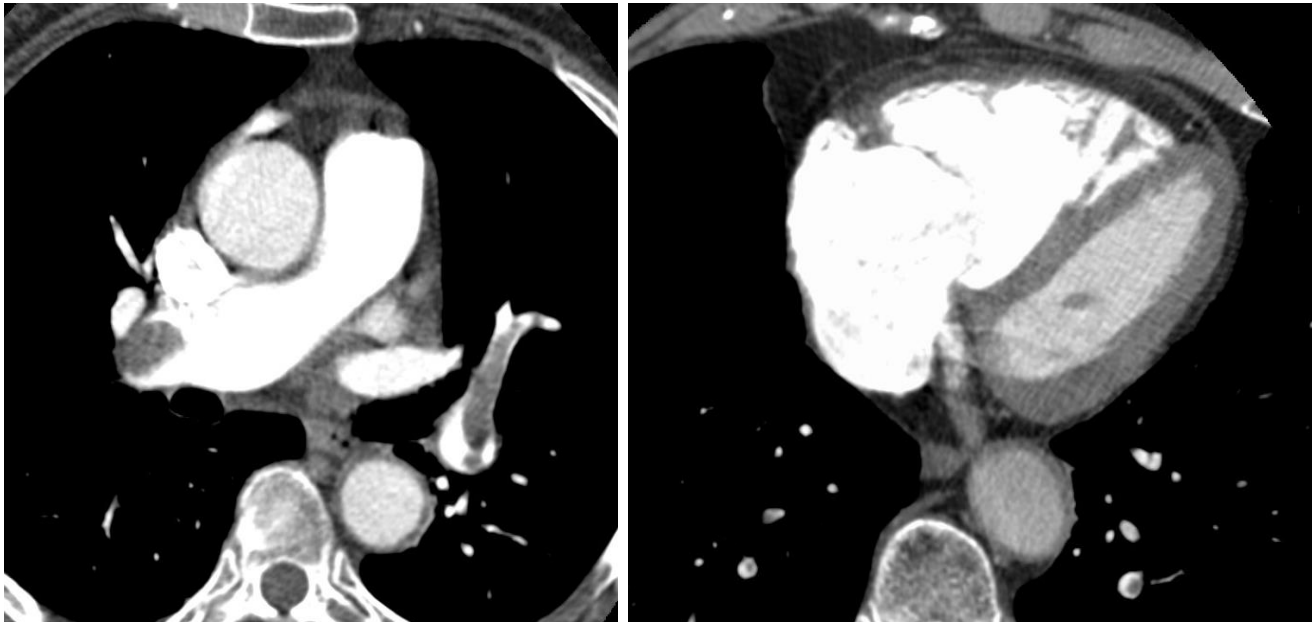
Angioscannographie dans le Diagnostic d'Embolie Pulmonaire



Perrier. N Engl J Med;2005; 352: 1760
Stein. N Engl J Med;2006; 354: 2317
Musset. Lancet;2002;360:1914

Angioscannographie dans le Diagnostic d'Embolie Pulmonaire

Signes Scannographiques de Gravité



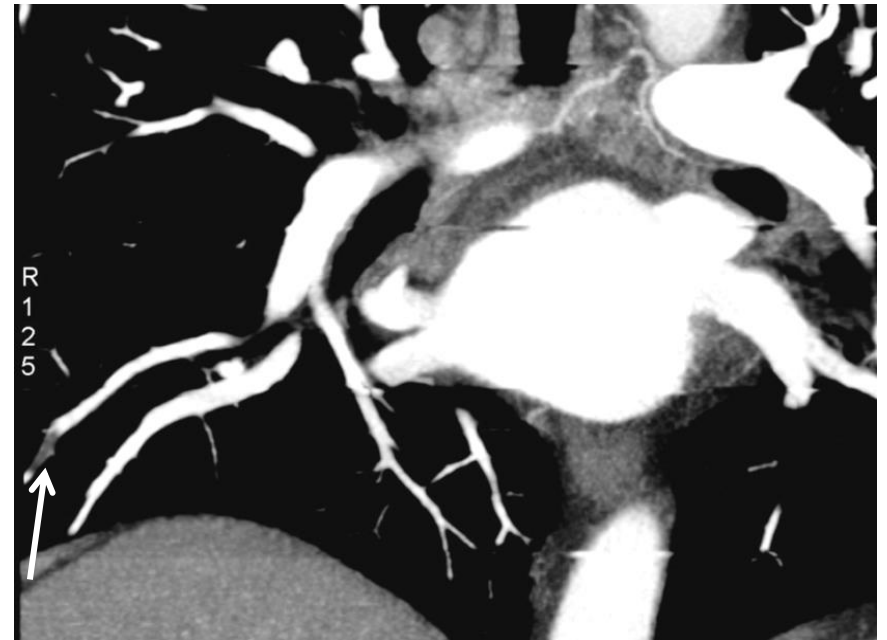
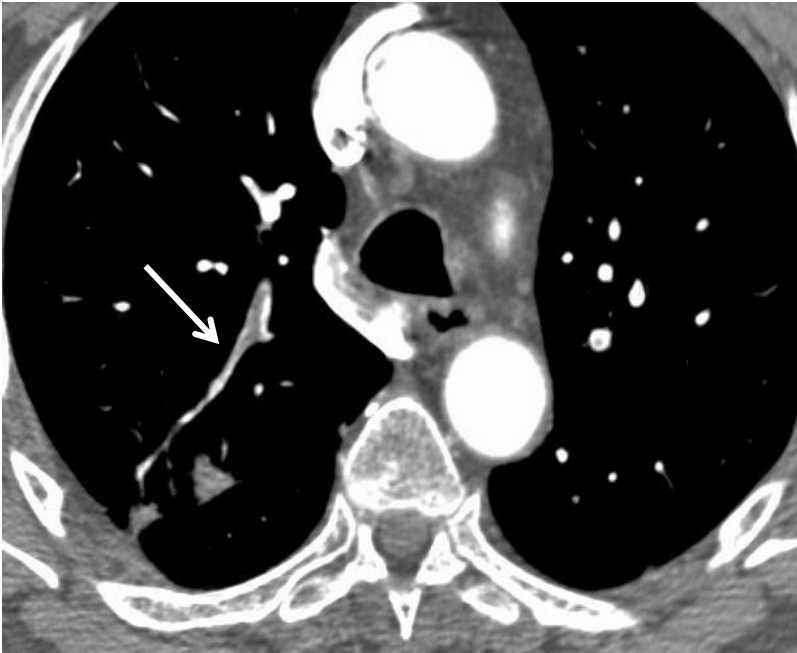
VD/VG > 0.9: facteur de gravité avec mortalité élevée

Absence d'élargissement ventriculaire droit a une valeur prédictive négative de 99% concernant la mortalité à 30 jours

*Schoeft. Circulation. 2004;110:3276
Becattini. Eur Respir J; 2014;43: 1678*

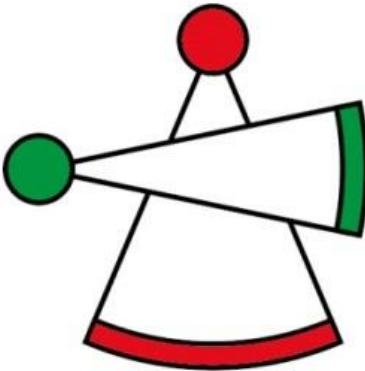
Angioscannographie dans le Diagnostic d'Embolie Pulmonaire

Embolies distales de découverte fortuite

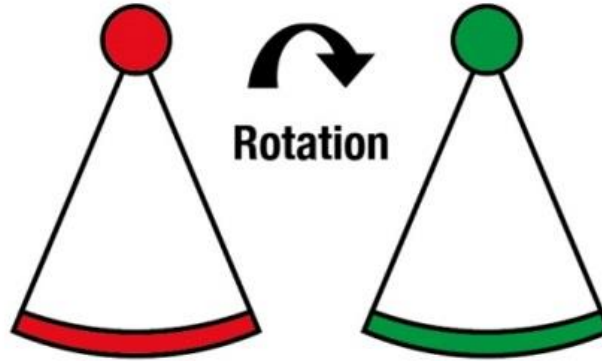


Dans une série de 2216 angioscanners, la prévalence des EP sous segmentaires étaient de 3,9%, soit 15% des EP détectées. Seulement 50% de ces embolies ont été traitées, et aucune n'a récidivé, qu'il y ait ou non anticoagulation

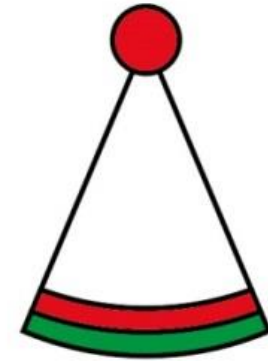
Modes d'acquisition spectrale



Double source



**Oscillation des kV
en cours de rotation**

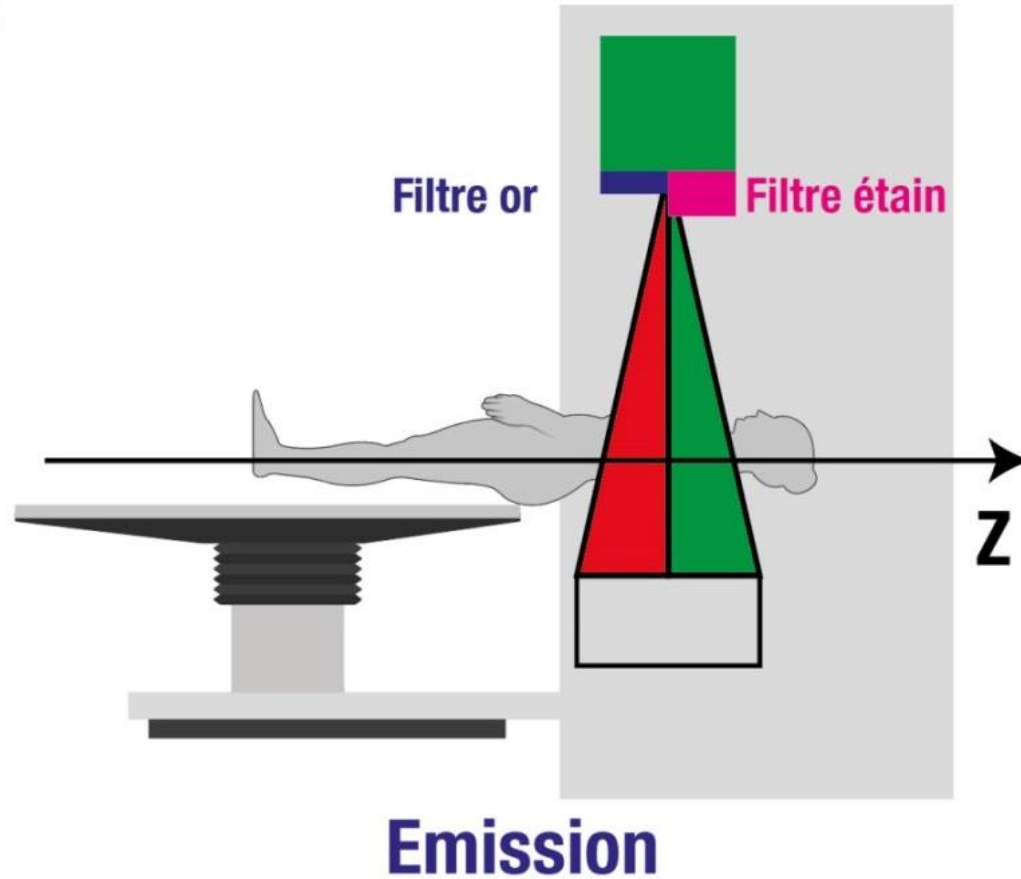


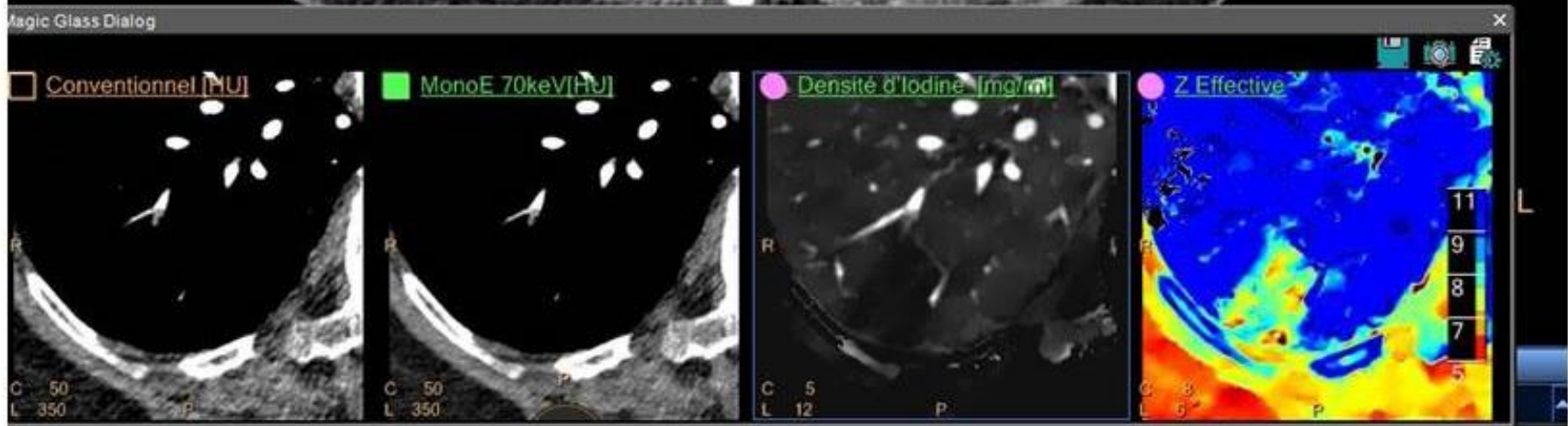
Détecteur double couche

CT spectral avec pré-filtration des rayons X



TwinBeam





Courtoisie E. Coche



National Lung
Screening Trial

National Cancer Institute

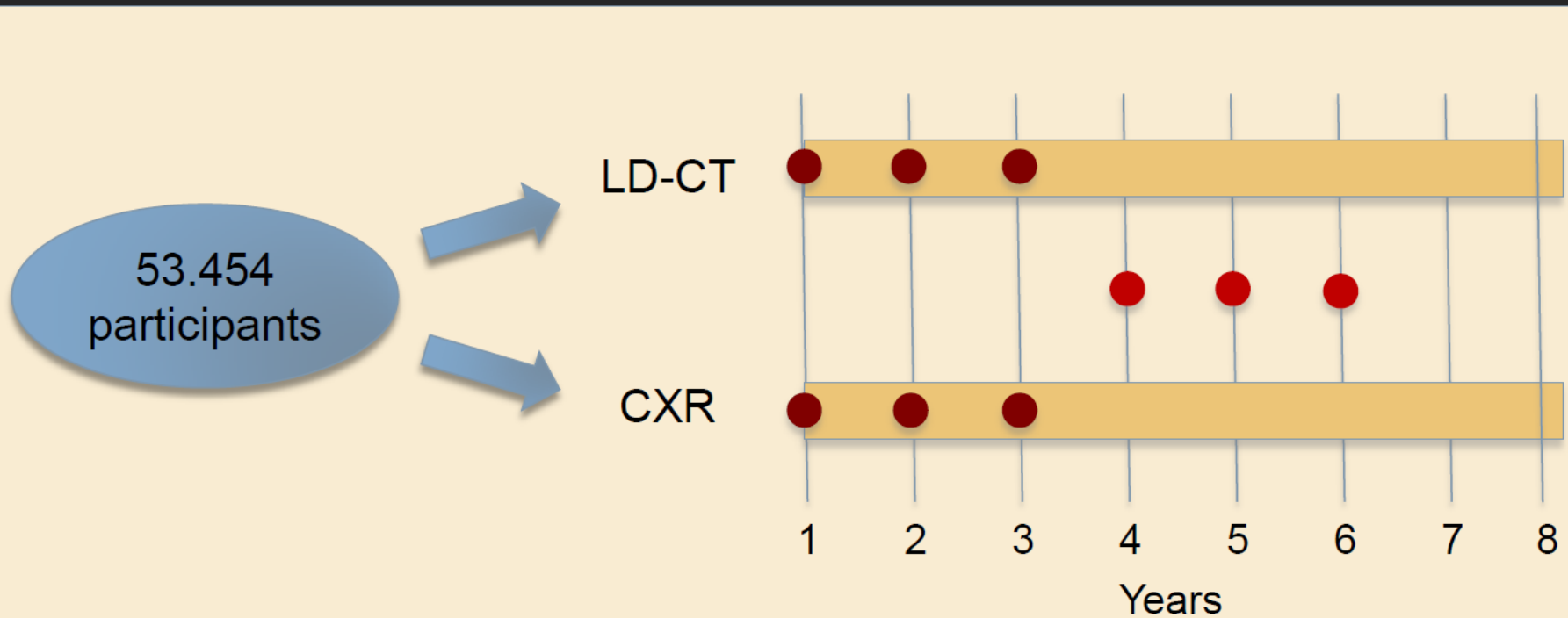
National Lung Screening Trial (NLST)

Etude Prospective Randomisée comparant le dépistage par scanner faible dose à un celui par radiographie thoracique avec comme critère principal de jugement la mortalité par cancer pulmonaire dans une population à haut risque de cancer du poumon

53 454 sujets

- Age 55-74 ans
- Asymptomatiques, fumeurs ou anciens fumeurs (30 PA)
- Anciens fumeurs: arrêt au cours des 15 années précédentes
- Absence d'antécédent de cancer du poumon
- Absence de scanner thoracique au cours des derniers 18 mois
- Absence d'hémoptysie
- Absence de perte de poids > 15 livres au cours de l'année N-1

National Lung Screening Trial – Study Design



Résultats du NLST

Réduction de 20% de la mortalité par cancer du poumon dans le groupe ayant eu le dépistage par scanner

Le risque absolu de décès par cancer du poumon diminue de 1,66% à 1,33% dans le bras dépisté par scanner

Réduction de 6,7% du taux de décès, toutes causes confondues parmi les sujets du bras scanner comparé à ceux ayant eu un dépistage par radiographie thoracique

Aberle. N Engl J Med 2011; 365: 395

NLST: Complications

Taux de complications

Scanner Faible dose: 1,4%

Radiographie thoracique 1,6%

Complication majeure après une procédure invasive

0.06% (Scanner) et 0.02% (Radio) des résultats du test positif ne conduisant pas à un diagnostic de cancer du poumon

11.2% (Scanner) et 8.2% (Radio) résultats du test positif conduisant à un diagnostic de cancer du poumon

Décès du patient dans les 60 jours suivant une procédure diagnostique invasive

Scanner: 16 (10 ayant un cancer)

Radio: 10 (10 ayant un cancer)

Essais Européens Randomisés (N=7)

NELSON Trial (Pays-Bas et Belgique) <i>Van Iersel. Int J Cancer 2007; 120:868</i>	15822	3 ans
DLCST (Danemark) <i>Pedersen. J Thorac Oncol; 2009; 4: 608</i>	4104	5 ans
MILD (Italie) <i>Pastorino. Respiration; 2006; 73: 5</i>	4471	10 ans
ITALUNG (Italie) <i>Lopes Pegna. Lung Cancer; 2009; 64: 34</i>	3206	5 ans
DANTE (Italie) <i>Infante. Am J Respir Crit Care Med; 2009; 180: 445</i>	2472	4 ans
LUSI (Allemagne) <i>Becker. J Cancer Res Clin Oncol; 2012; 138: 1475</i>	6356	3ans
UKLS (Grand Bretagne) <i>Field. Thorax; 2016; 71: 161</i>	4055	1 an

Qu'en est-il en France?

Depiscan

Etude de faisabilité sur 1000 sujets fumeurs d'un essai randomisé (scanner thoracique faible dose vs radiographie du thorax / PHRC-Inserm)

Relative échec d'inclusion et forte contamination

Blanchon. Lung Cancer; 2007; 58: 50

La HAS

En janvier 2016 la HAS ne recommande pas le dépistage du cancer pulmonaire faute d'évaluation suffisante

Attente des résultats des essais européens

Un dépistage par scanner thoracique faible dose peut-il entraîner une réduction significative de la mortalité par cancer du poumon?

Contributions des Essais Randomisés Européens

Pooler les résultats des Essais Randomisés

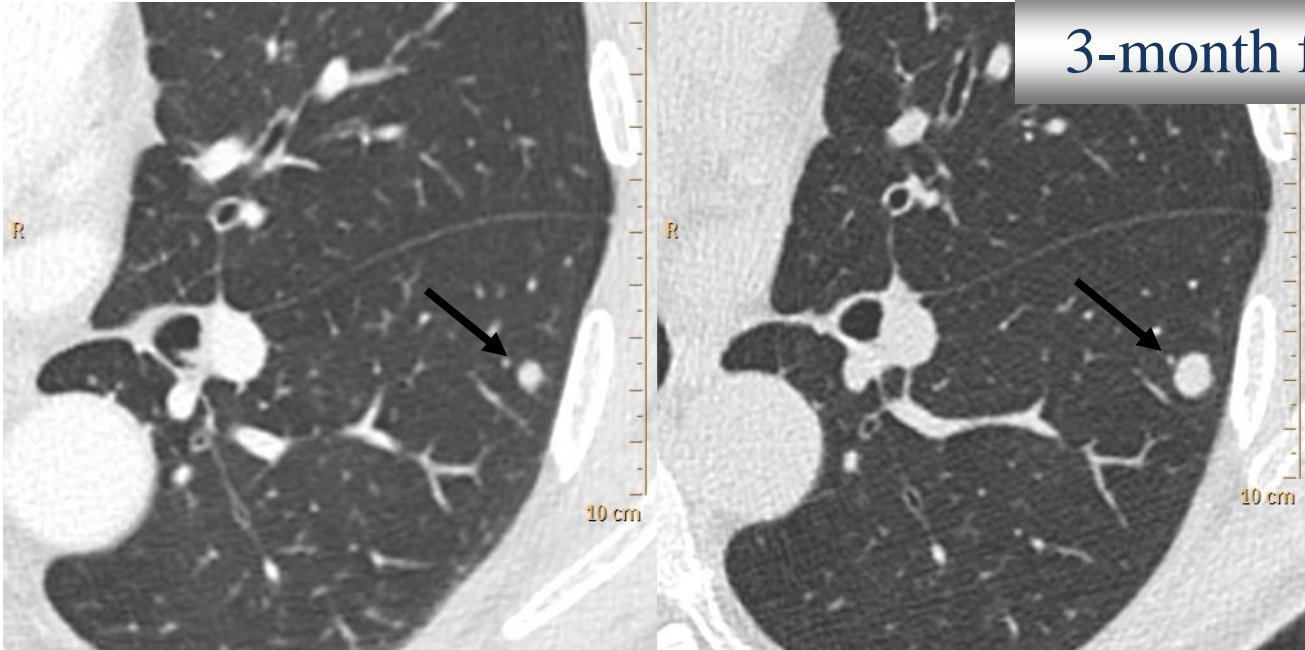
Sélectionner des populations à plus haut risque de cancer du poumon afin d'améliorer sensibilité, spécificité, et cout-efficacité

Déterminer l'intervalle optimal entre deux scanners de dépistage

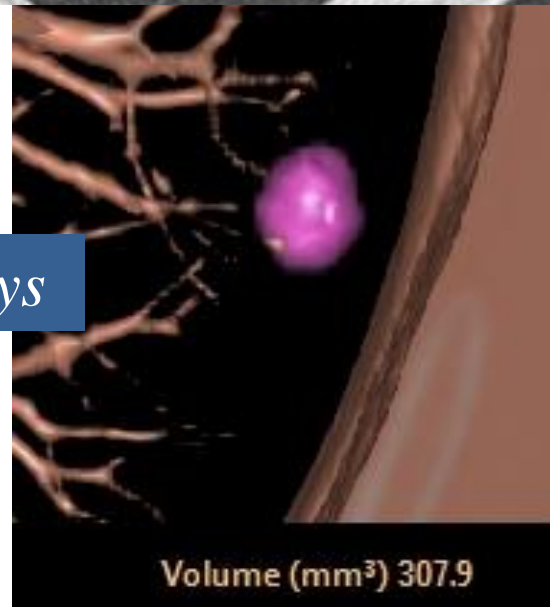
Comparer les mesures volumiques aux mesures de diamètre des nodules

Heuvelmans. J Thorac Imaging; 2015; 30: 101

3-month follow_up



DVT: 30 days



Comparaison des Mesures de Volume et de Diamètre des Nodules Pulmonaires

Le pourcentage des tests positifs des 2 premiers scanners

NELSON: 2,6% et 1,8%

NLST: 27,3% et 27,9%

Valeur prédictive négative comparable (99,7% - 99,9% vs 99,9%)

Le protocole de l'étude NELSON basée sur la mesure de volume du nodule et l'usage du temps de doublement volumique pour le management des nodules est plus efficient avec moins de co-morbidité et des coûts inférieurs

Heuvelmans. J Thorac Imaging; 2015; 30: 101

Même protocole dans LUSI, UKLS et DLCST

Solid Nodule

Benignancy Criteria

STOP

High Suspicion of Malignancy

MDT meeting

Indeterminate

Absence of cancer risk factor*

Presence of cancer risk factor*

< 6 mm

6-10 mm

3-6 mm

< 3 mm

STOP

3-month follow-up CT: *DVT*
2D measurement as an alternative

CT at 1-year

STOP

DVT \geq 400 days or
 \uparrow diameter < 25% or < 2 mm

DVT < 400 days or
 \uparrow diameter > 25% or \geq 2 mm

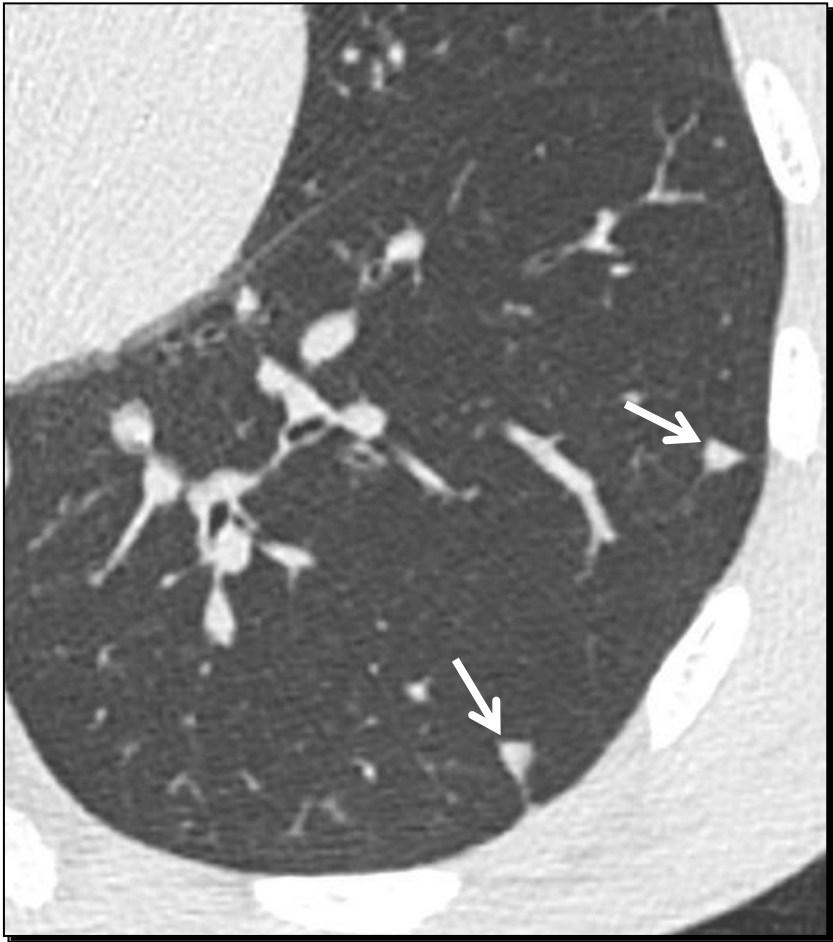
CT at 1-year

MDT meeting

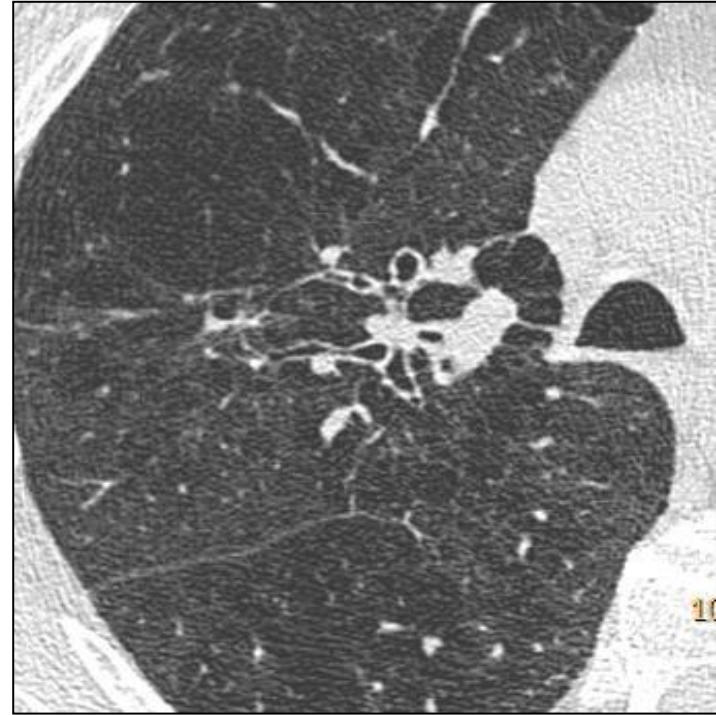
* Cancer risk factors:

> 40 yo. Smoking > 30 PY. Asbestos exposure. Oncologic patient.

Ganglions Lymphatiques Intrapulmonaires



Spontaneous Resolution of Solid Nodules



Approximately 10% (97/964) of solid nodules of intraparenchymal location and of intermediate (5-12 mm /50-500 mm³) size disappear on follow-up CT scans

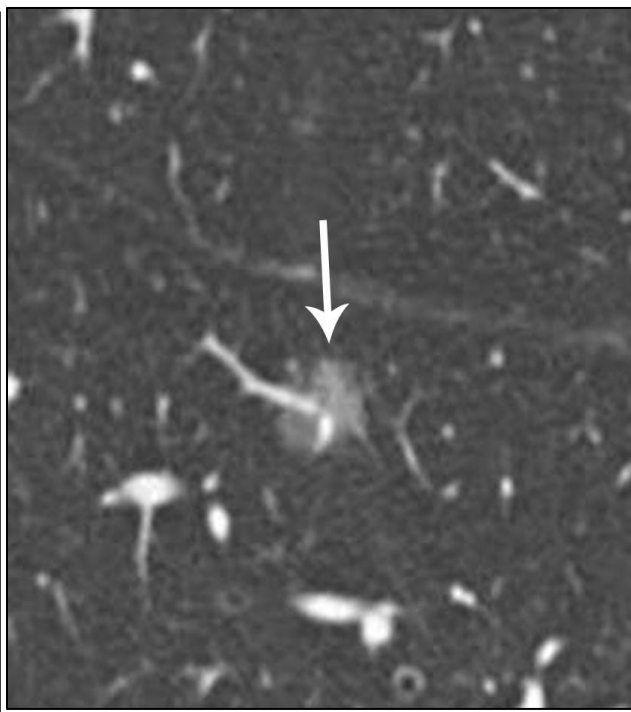
The spontaneously resolvable nodules have the same morphologic characteristics than malignant nodules

Typologie des Nodules Pulmonaires Détectés en TDM

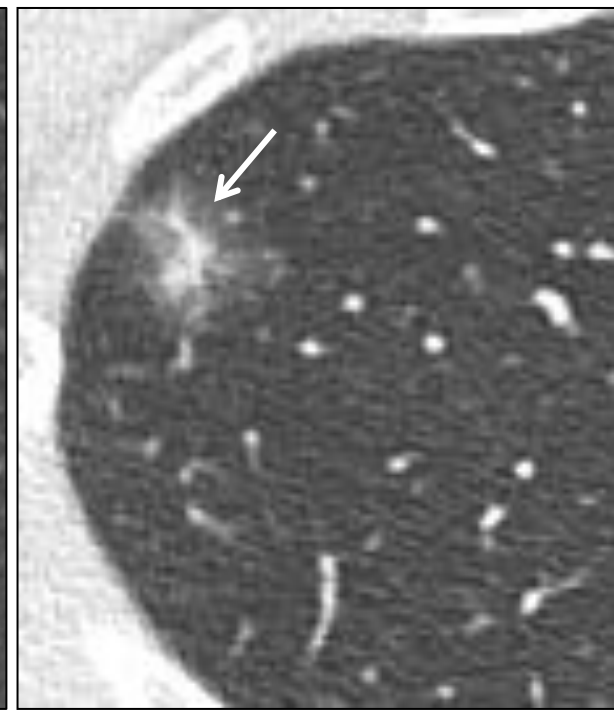
Solide



Non Solide (NS)



Mixte (PS)



New Histological Classification of Lung Adenocarcinomas (IASLC/ATS/ERS)

Pre-invasive lesions

Atypical adenomatous hyperplasia (AAH)

Adenocarcinoma in-situ

Minimally invasive adenocarcinoma

Non Solid

Invasive Adenocarcinomas

Lepidic predominant adenocarcinoma

Acinar predominant adenocarcinoma

Papillary predominant adenocarcinoma

Micropapillary predominant adenocarcinoma

Solid predominant adenocarcinoma

Part Solid

Invasive Variants

Invasive mucinous A. / Colloid A.

Well-differentiate fetal A. / Enteric A.

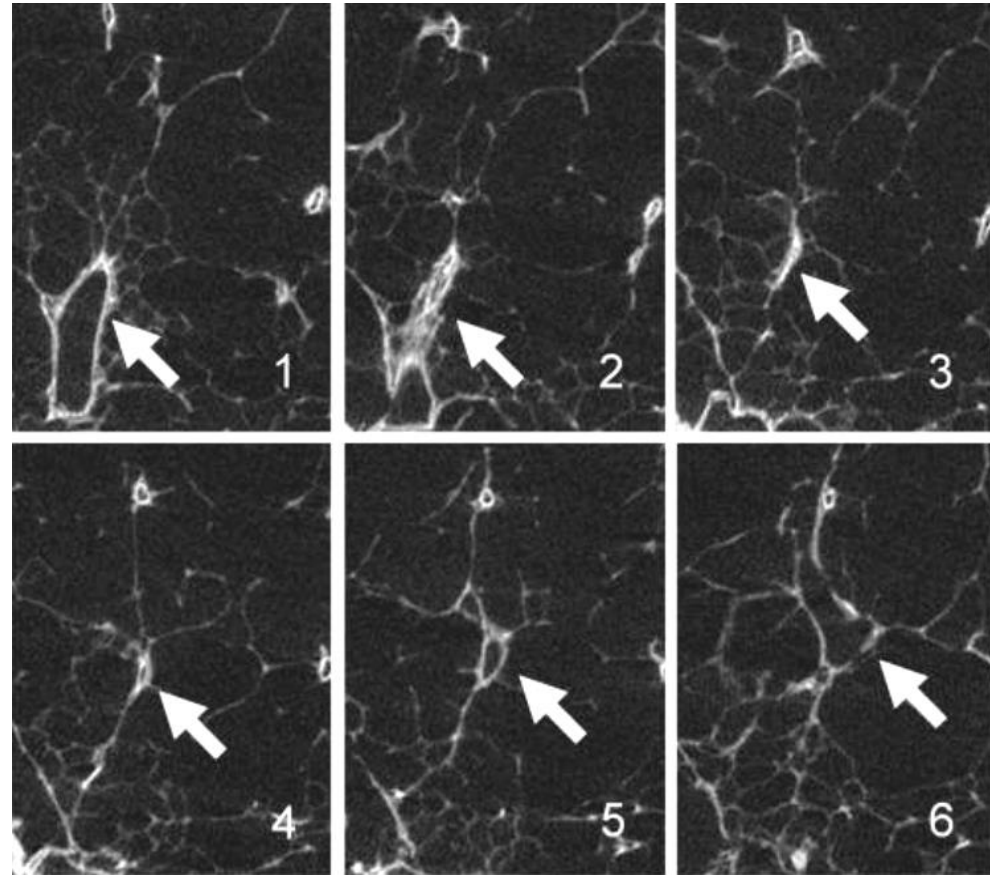
Table 1: Fleischner Society 2017 Guidelines for Management of Incidentally Detected Pulmonary Nodules in Adults

Solid Nodules ²		<6mm (<100mm ³)	6 to 8mm (100mm ³ - 250mm ³)	>8mm (>250mm ³)	Comments
Single	Low risk ³	No routine follow-up	6 to 12 months CT, then consider 18 to 24 months CT	Consider 3 months CT, PET-CT, or tissue sampling	Nodules <6mm do not require routine follow-up, but certain high risk patients with suspicious nodule morphology and/or upper lobe location may warrant 12 month follow up. (Recommendation 1A)
	High risk ³	Optional 12 months CT	6 to 12 months CT then 18 to 24 months CT		
Multiple	Low risk ³	No routine follow-up	3 to 6 months CT, then consider 18 to 24 months CT		Use most suspicious nodule as guide to management. Follow-up intervals may vary according to size and risk (Recommendation 2A).
	High risk ³	Optional 12 months CT	3 to 6 months CT, then 18 to 24 months CT		
Subsolid Nodules ²		<6mm (<100mm ³)	≥6mm (>100mm ³)		
Single	Ground glass	No routine follow-up	6 to 12 months CT to confirm persistence, then CT every 2 years until 5 years		In certain suspicious nodules <6mm, consider follow-up in 2 and 4 years. If solid component(s) or growth develops, consider resection. (Recommendations 3A and 4A).
	Part-Solid	No routine follow-up	3 to 6 month CT to confirm persistence. If unchanged and solid component remains <6mm: annual CT for 5 years		In practice, part-solid nodules cannot be defined as such until ≥6mm, and nodules <6mm do not usually require follow-up. Persistent part solid nodules with solid components ≥ 6mm should be considered highly suspicious. (Recommendations 4A - 4C)
Multiple	3 to 6 months CT If stable consider 2 and 4 year CT		3 to 6 months CT Subsequent management based on the most suspicious nodule(s)		Multiple <6mm pure ground glass nodules are usually benign, but consider follow-up in selected high-risk patients at 2 and 4 years (Recommendation 5A).

1. Recommendations do not apply to lung cancer screening, immunosuppressed patients, or patients with known primary cancer.
2. Dimensions are average of long and short axes, rounded to nearest millimeter.
3. Consider all relevant risk factors (See Risk Factors).

BPCO: Bronchiolite Obstructive et Emphysème

Analyse en microscanner de poumons prélevés sur des patients BPCO traités par transplantation pulmonaire (n=12) et de poumons (contrôles) de donneurs (n=4)

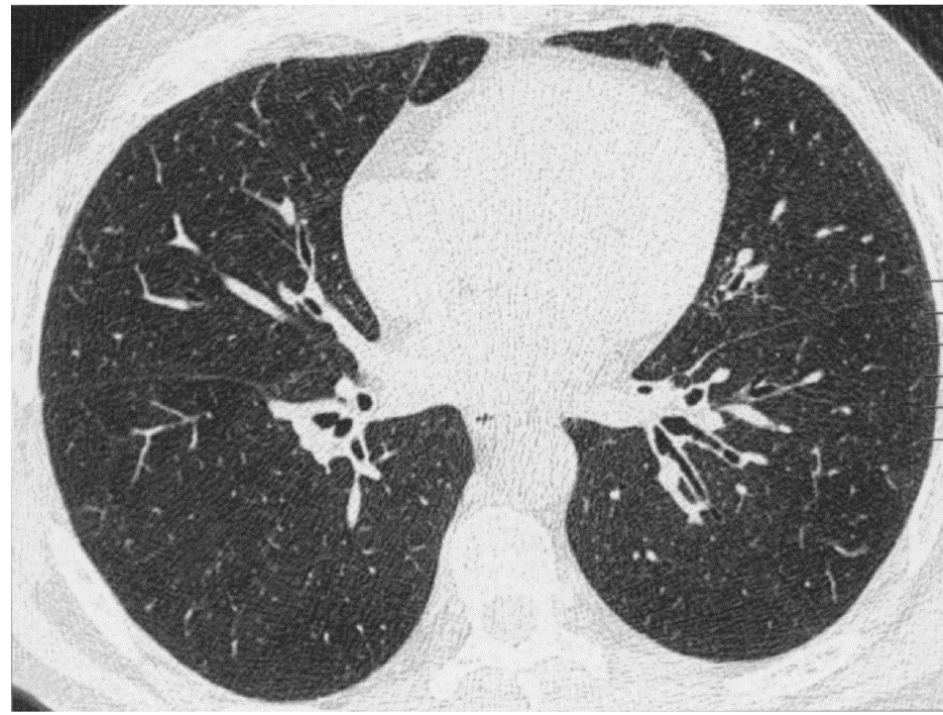


Les sténoses et la destruction des bronchioles terminales précèdent clairement l'apparition de la destruction microscopique emphysémateuse

Evaluation des Patients BPCO: Différentes Apparences Morphologiques



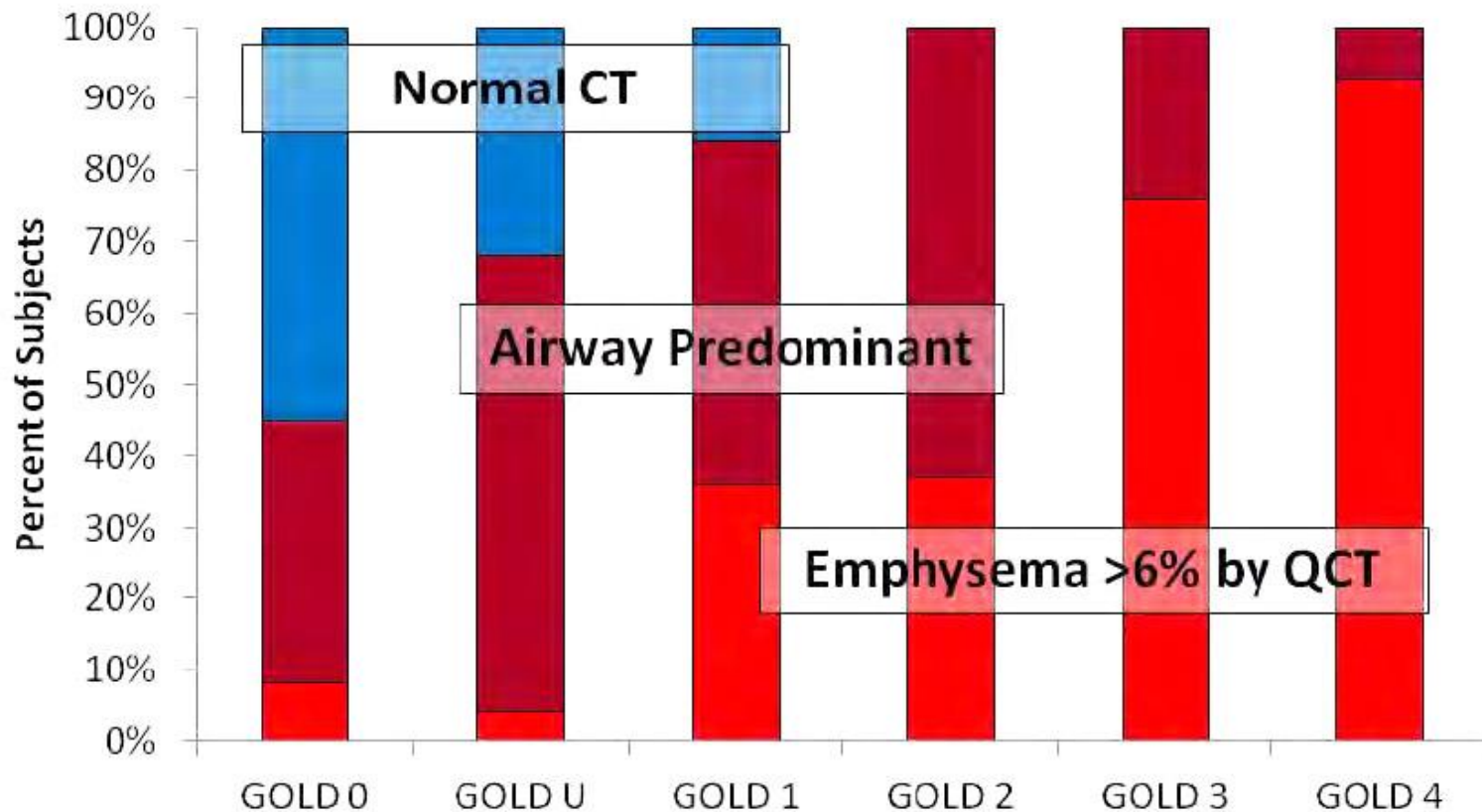
VEMS: 25%



VEMS: 28%

QCT of Emphysema Extent and Gas Trapping in 700 CT Scans from the COPDGene Cohort

Frequency of occurrence of emphysema and airway predominant disease as a function of GOLD grade



CT-Definable Subtypes of Chronic Obstructive Pulmonary Disease: A Statement of the Fleischner Society¹

David A. Lynch, MB
John H. M. Austin, MD
James C. Hogg, MD, PhD
Philippe A. Grenier, MD
Hans-Ulrich Kauczor, MD
Alexander A. Bankier, MD
R. Graham Barr, MD
Thomas V. Colby, MD
Jeffrey R. Galvin, MD
Pierre Alain Gevenois, MD, PhD
Harvey O. Coxson, PhD
Eric A. Hoffman, PhD
John D. Newell, Jr, MD
Massimo Pistolesi, MD
Edwin K. Silverman, MD, PhD
James D. Crapo, MD

The purpose of this statement is to describe and define the phenotypic abnormalities that can be identified on visual and quantitative evaluation of computed tomographic (CT) images in subjects with chronic obstructive pulmonary disease (COPD), with the goal of contributing to a personalized approach to the treatment of patients with COPD. Quantitative CT is useful for identifying and sequentially evaluating the extent of emphysematous lung destruction, changes in airway walls, and expiratory air trapping. However, visual assessment of CT scans remains important to describe patterns of altered lung structure in COPD. The classification system proposed and illustrated in this article provides a structured approach to visual and quantitative assessment of COPD. Emphysema is classified as centrilobular (subclassified as trace, mild, moderate, confluent, and advanced destructive emphysema), panlobular, and paraseptal (subclassified as mild

Visually Defined Patterns of COPD at CT

Emphysema

Centrilobular Emphysema

Panlobular Emphysema

Paraseptal Emphysema

Airway Disease

Bronchial Disease

Small Airway Disease (SAD)

Associated Features

Bronchiectasis

Large Airway Disease

Interstitial Lung Abnormality

Pulmonary Arterial Enlargement

Visually Defined Patterns of Emphysema at CT

1- Centrilobular Emphysema

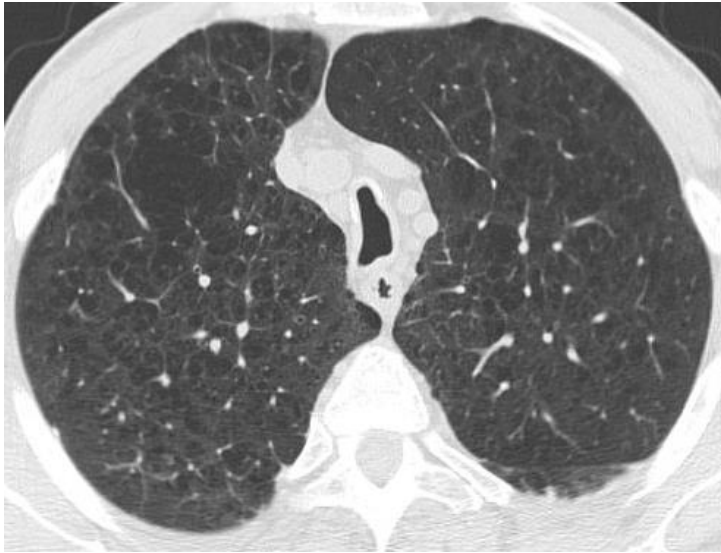
- a. Trace Centrilobular Emphysema (CLE)
- b. Mild CLE
- c. Moderate CLE
- d. Confluent CLE
- e. Advanced Destructive Emphysema (ADE)

2- Panlobular Emphysema

3- Paraseptal Emphysema

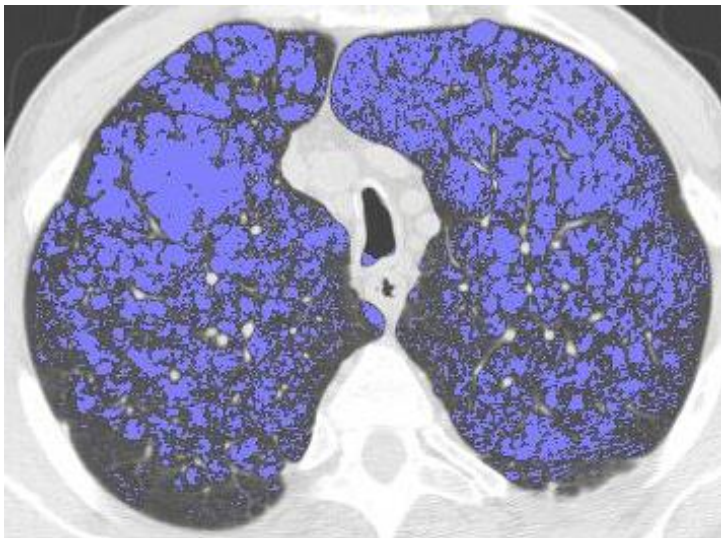
- a. Mild Paraseptal Emphysema (PSE)
- b. Substantial Paraseptal Emphysema

Densitométrie Pulmonaire en TDM



Masque de Densité
(Pourcentage d'Emphysème)

-950 UH

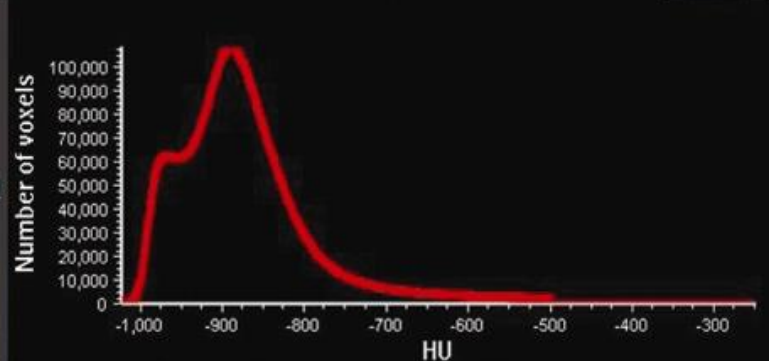
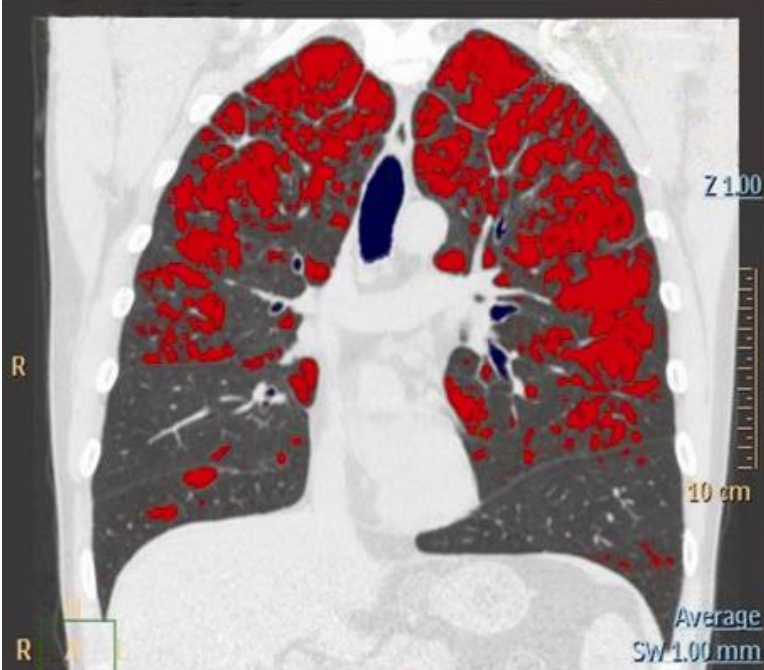
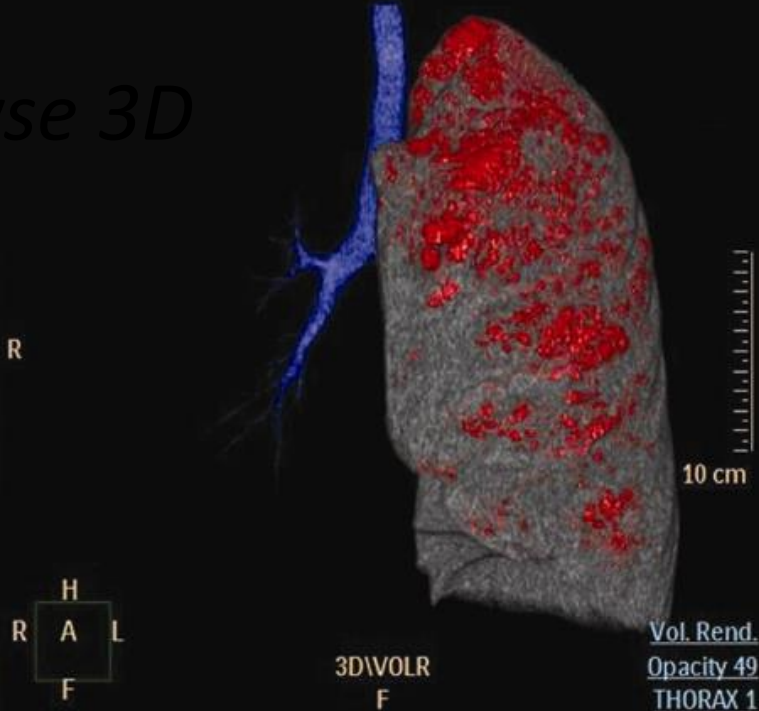
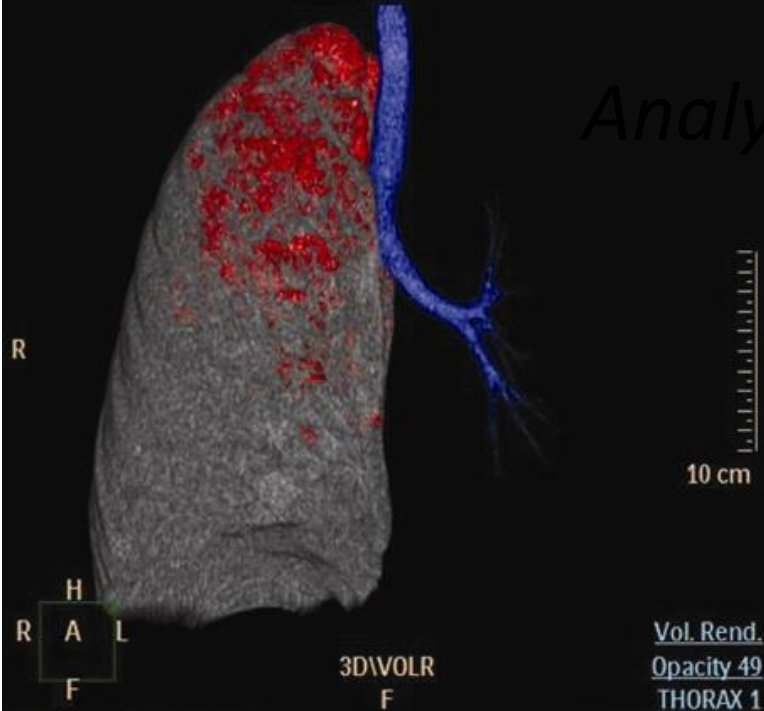


Densité du Percentile

(Valeur de Densité au dessous de laquelle un pourcentage de voxels prédéfini se trouve)

15ième Percentile

Analyse 3D

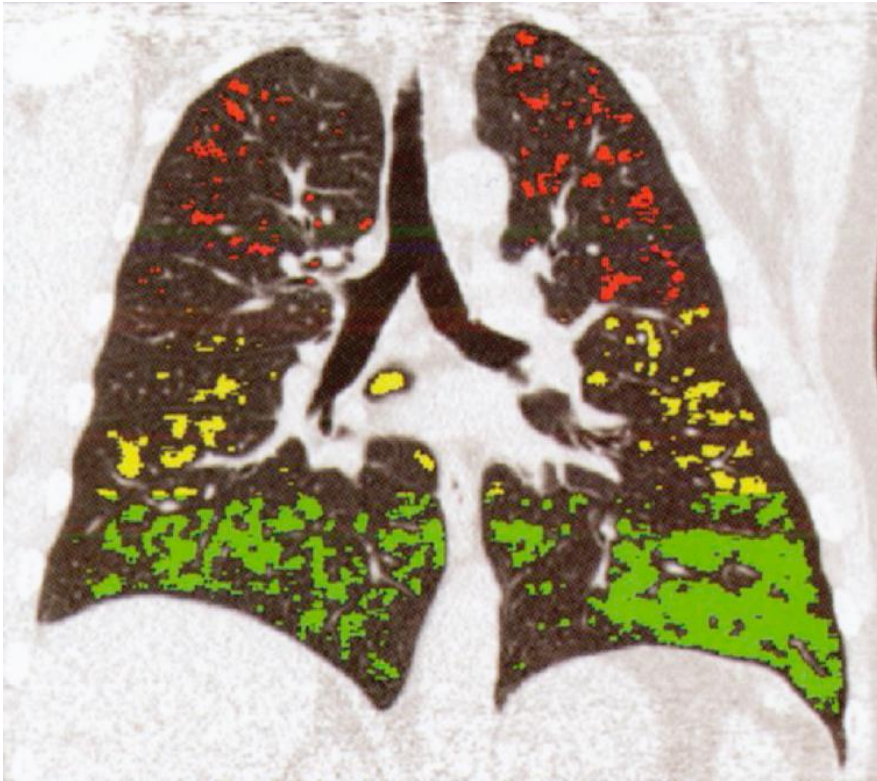


	Lung (cm ³)	Emphysema (c...)	Ratio (%)
Total Lung	8407.62	1352.90	16
Right Lung	4197.97	521.63	12
Left Lung	4209.65	831.27	20
Trachea	85.57		

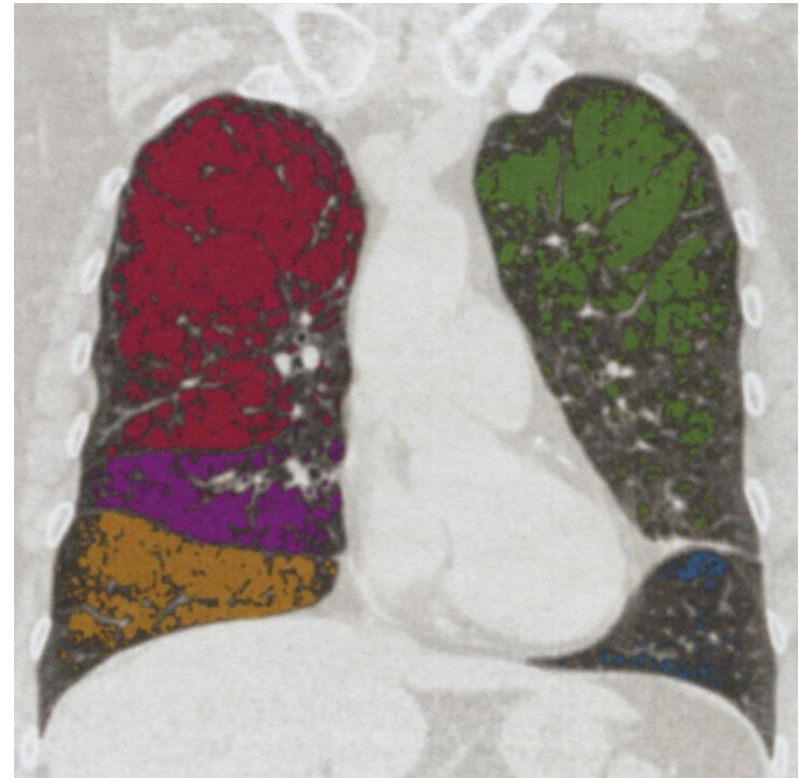
QCT Analysis of Emphysema Extent

Regional and lobar distribution

Upper, mid, lower



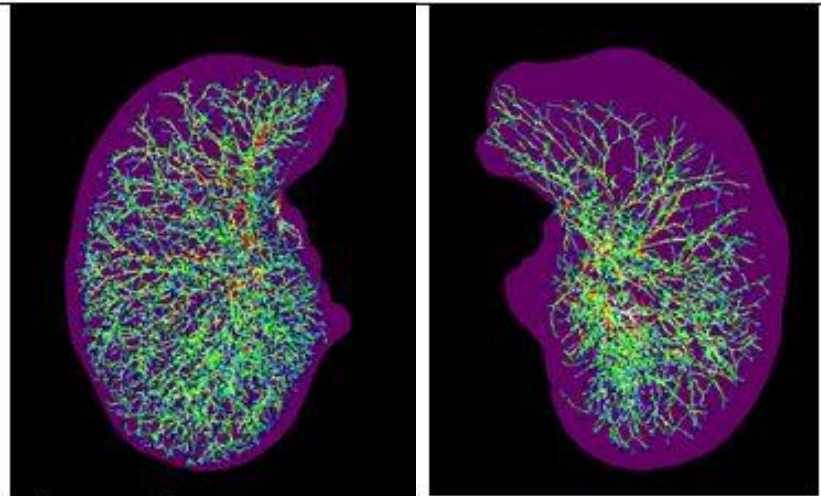
Lobar segmentation



Gietama. Radiology; 2007; 244: 890

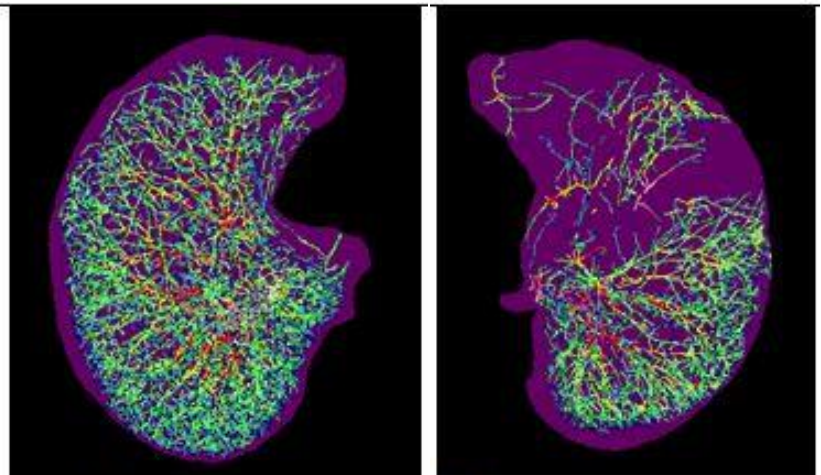
Lynch. J Thorac Imaging; 2013; 28: 284

Quantitative Analysis of Pulmonary Vessels at CT in COPD Patients



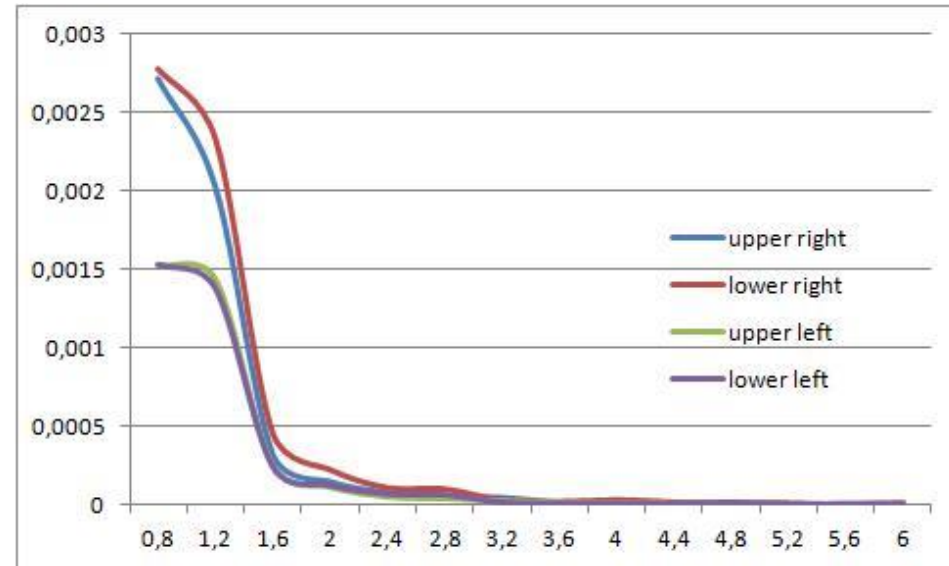
Right upper lung

Left upper lung



Right lower lung

Left lower lung



Visually Defined Patterns of Airway Disease at CT

Airway disease is commonly found with all forms of emphysema, but also commonly occurs in the absence of emphysema as a predominant expression of COPD

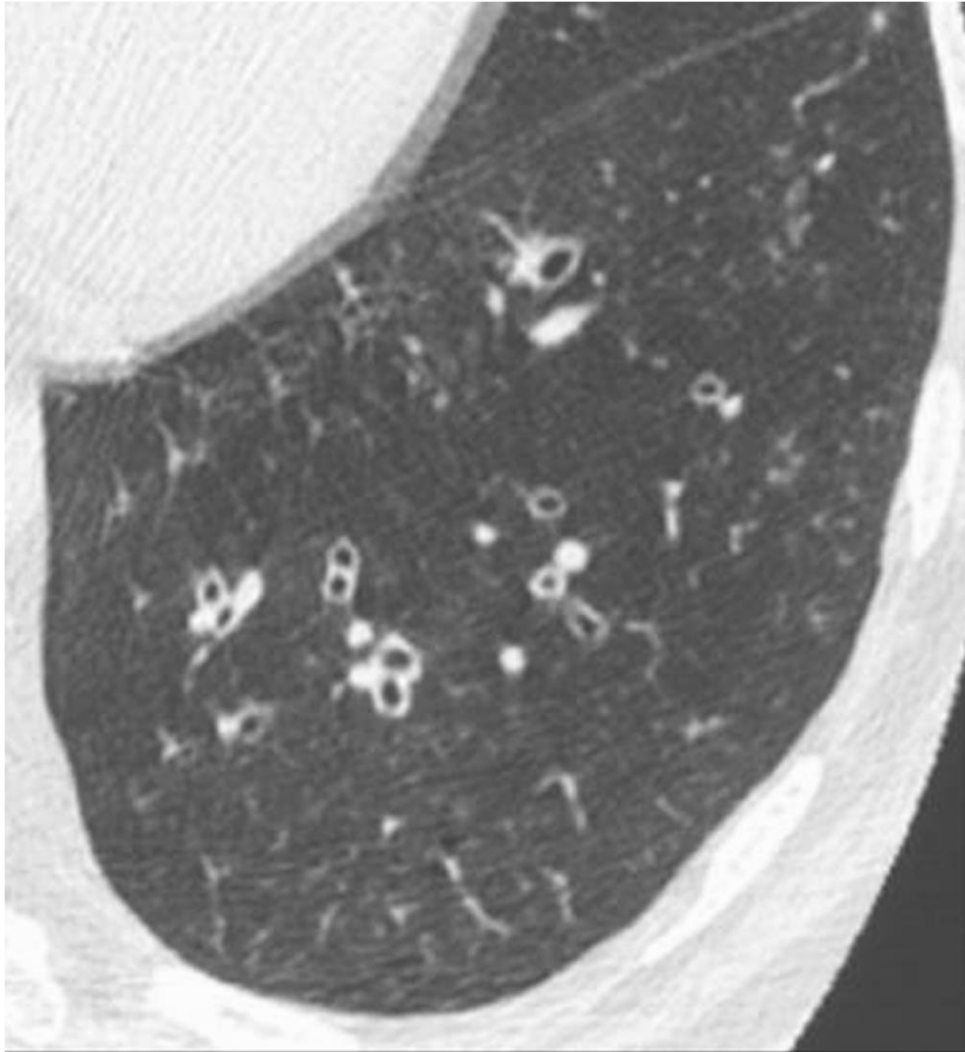
1- Bronchial Disease: thickening of walls of segmental and subsegmental airways

2- Small Airway Disease (SAD):

a. *Inflammatory SAD* can be directly identified on CT scan by the presence of centrilobular micronodular opacities

b. *Obstructive SAD* is identified by gas trapping on expiratory CT, or FEV1/FVC ratio < 0.7 , in the absence of significant emphysema

Epaississement Pariétal Bronchique en TDM chez des patients BPCO



Signe subjectif avec importante variation interobservateur

Grenier. Eur Radiol; 1996; 6: 199
Barr. COPD; 2012; 9: 151

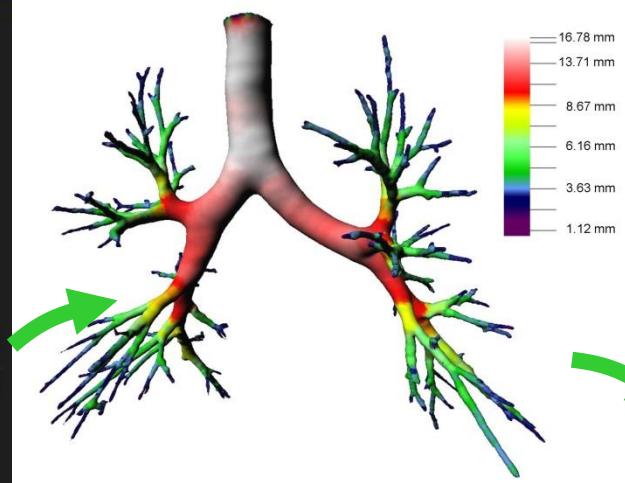
Mieux apprécié par comparaison avec des standards visuels de sujets normaux et de patients BPCO

Lynch. Radiology; 2015; 277: 192

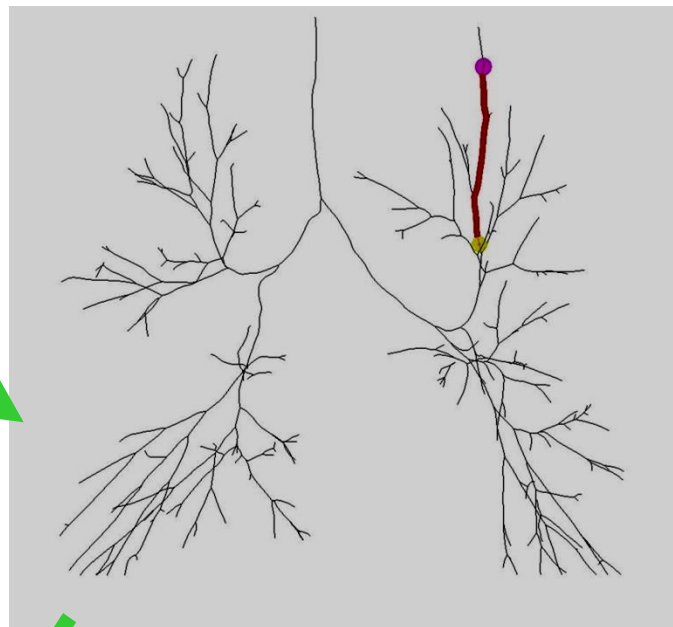
Morphometric Analysis of Airways in Multislice CT



3D airway lumen segmentation

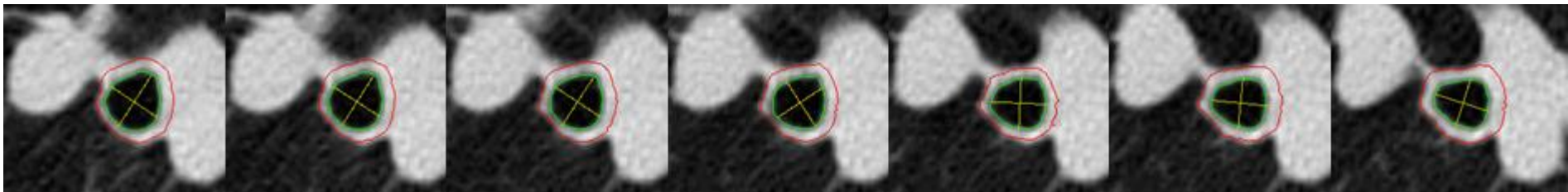


lumen caliber analysis



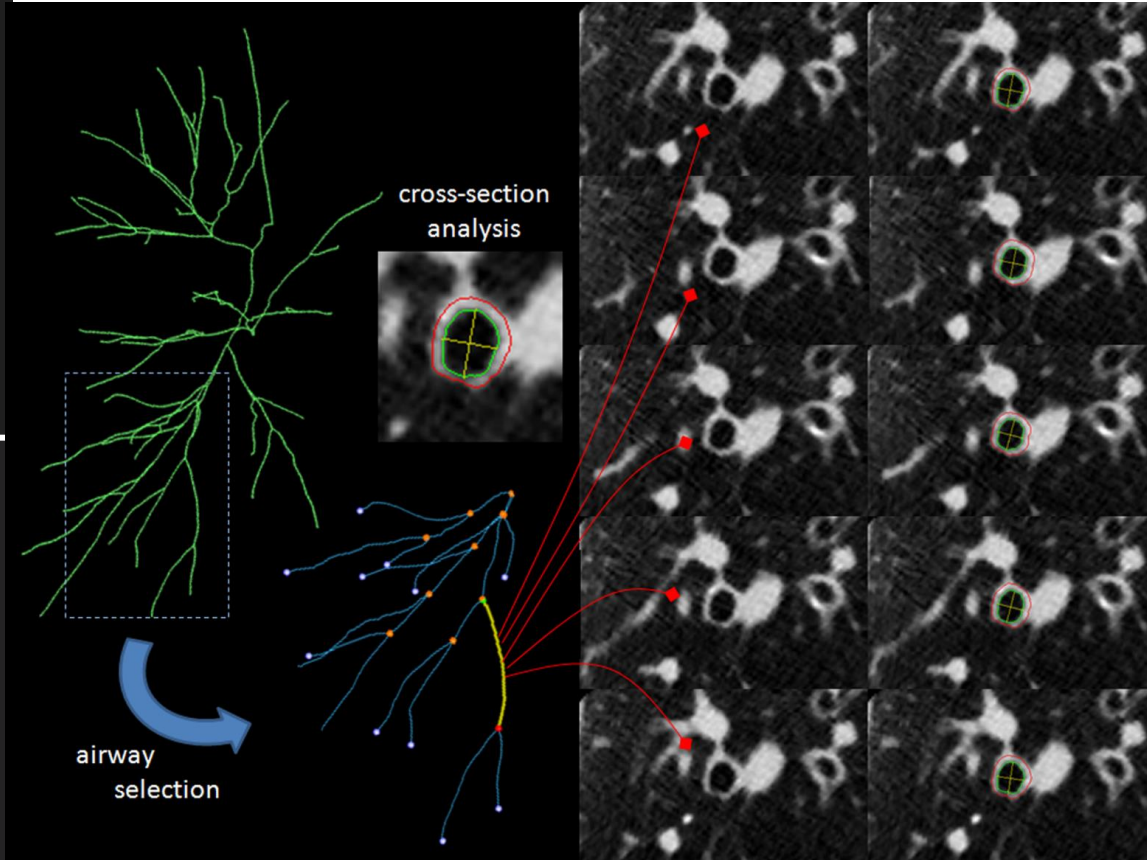
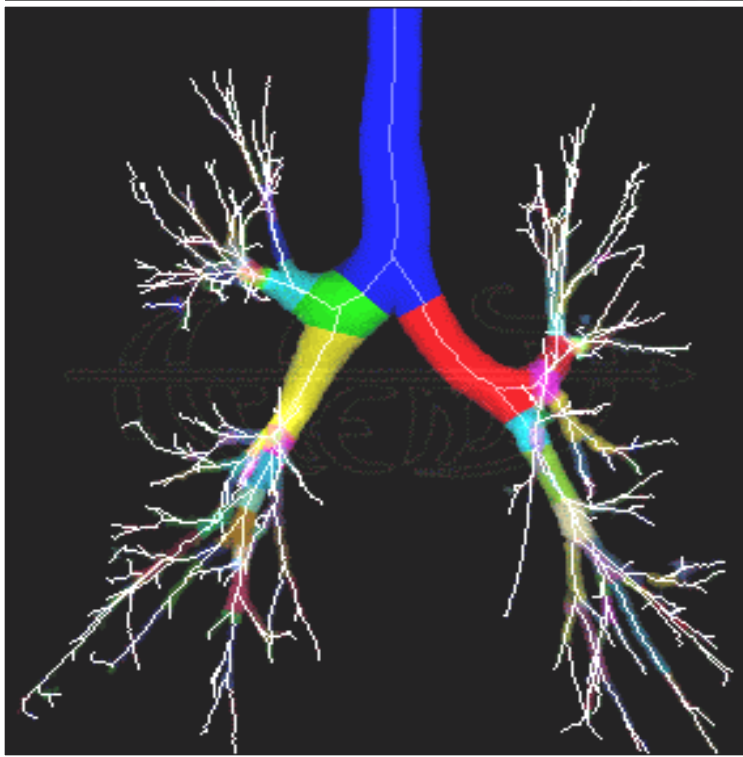
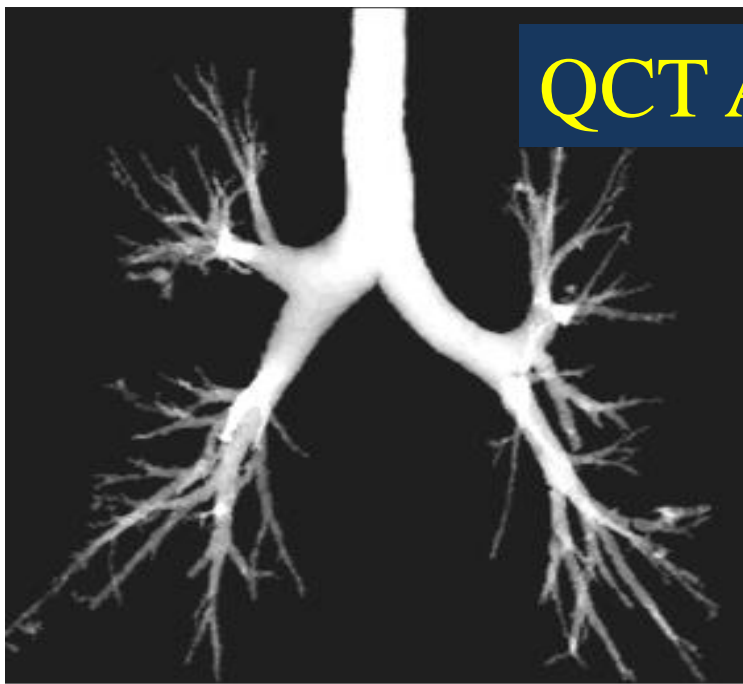
central axis interaction

cross-section morphometric analysis



QCT Analysis of Airways Dimensions

WA / LA / WA%



Fetita. IEEE Trans Med Imaging; 2004; 23: 1353

Brillet. Eur Radiol; 2007; 17: 1483

QCT Analysis of Airways: *Metrics*

LA: luminal area

WA: wall area

WT: wall thickness

WA%: wall area percentage: $WA / (LA+WA)$

LV%: luminal volume percentage

Peak WAV: peak wall attenuation value

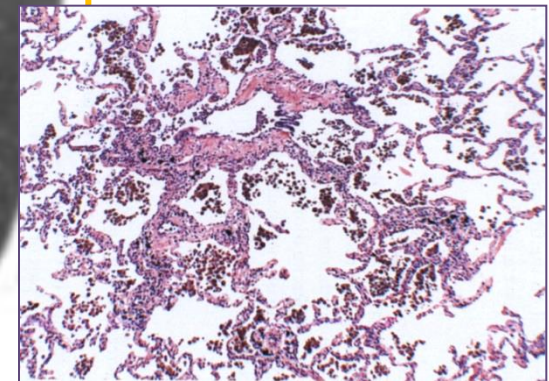
Mean WAV: mean wall attenuation value

WA-Pi10mm / WT-Pi10mm

SR WA-Pi10mm: square root of wall area of a hypothetical bronchus with a 10 mm luminal perimeter, calculated from linear regression of all measured bronchi

Hackx. Radiology. 2012; 265: 34
Hackx. Radiology; 2015; 277: 853

Inflammatory Small Airway Disease

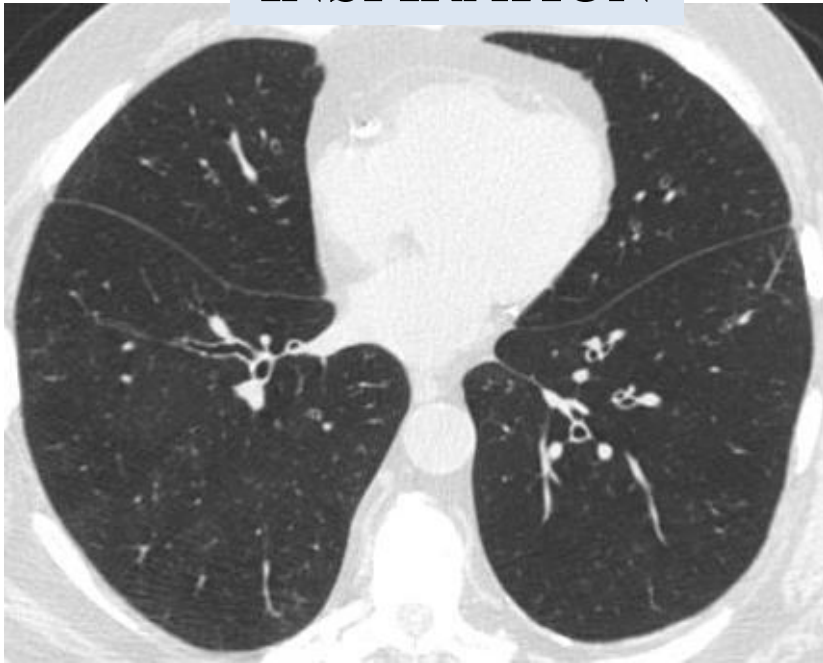


Small Centrilobular Nodules of Ground Glass Attenuation

Obstructive Small Airway Disease in COPD

Expiratory CT, performed at functional residual capacity or at residual volume is a power tool for determining the severity of airway obstruction and to quantify gas trapping

INSPIRATION



EXPIRATION



Expiratory CT may be performed at a lower CT radiation dose (50 mAs or less)

QCT Analysis of Gas Trapping in COPD

% low attenuation area at -856 HU or -850 HU at end-expiration CT (Exp₋₈₅₆ Exp₋₈₅₀)

In a study on 4062 COPDGene subjects with or without COPD, LAA_{exp-856} provided remarkably high correlations with predicted FEV₁% and FEV₁/FVC ratio

Schroeder. AJR; 2013; 201:460

The expiration to inspiration ratio of mean lung density (E/I-ratio_{MLD})

(E/I-ratio_{MLD}) is most suitable for detecting air trapping in smokers and performs significantly better than other suggested quantitative measures

Mets. Eur Radiol; 2012; 22:120

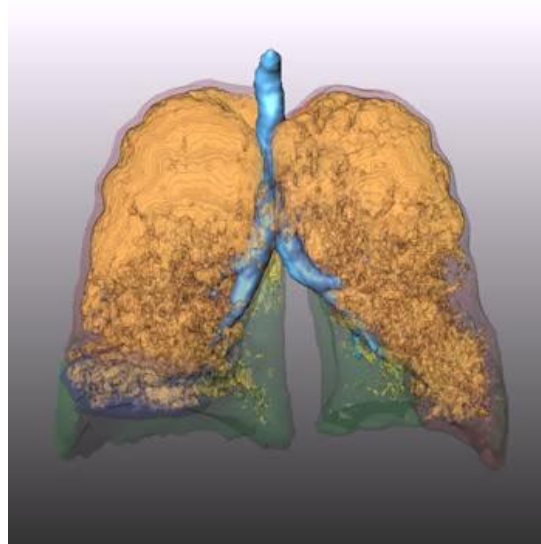
QCT Analysis of Gas Trapping in COPD

Change in relative lung volume with attenuation values from -860 HU to -950 HU ($RVC_{-860-950}$) between paired inspiratory and expiratory scans

Matsuoka. AJR; 2008; 190: 762

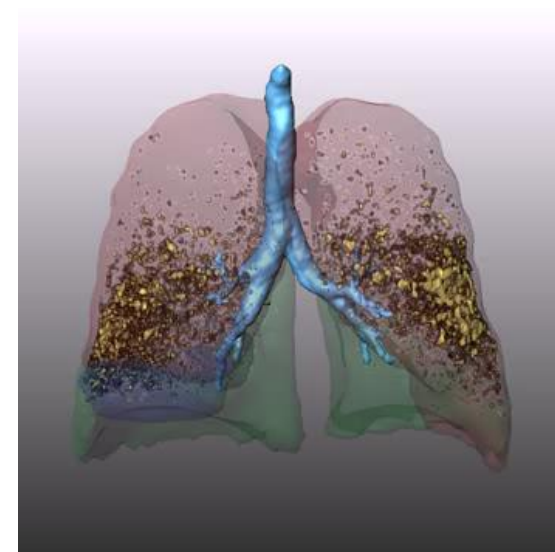


Emphysema extent



-950 HU_{insp}: 45.6%

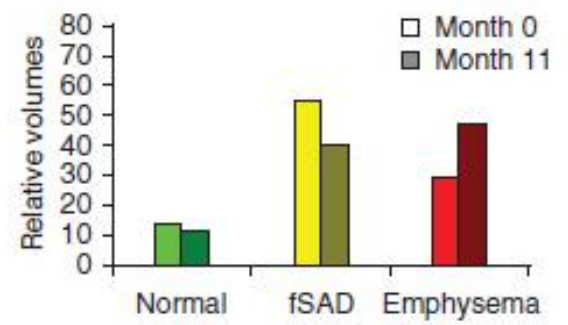
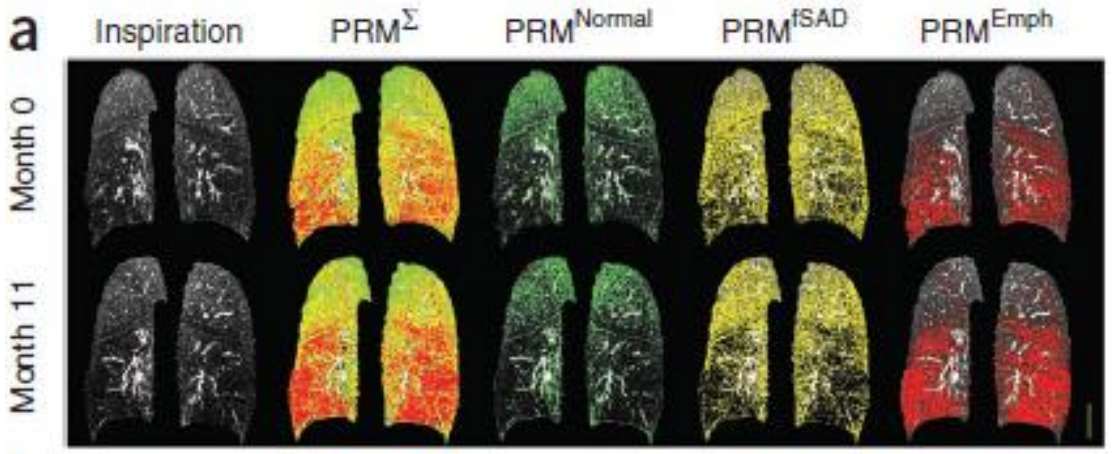
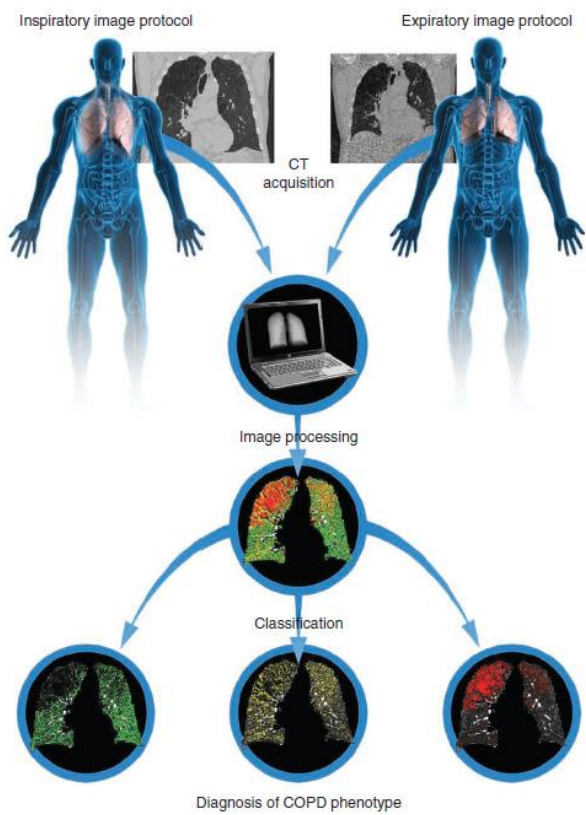
Gas trapping extent



-860 // -950 HU: 10.3%

Courtesy to N. Sverzelatti

Parametric Response Map (PRM): a Voxel-wise Image Analysis Technique



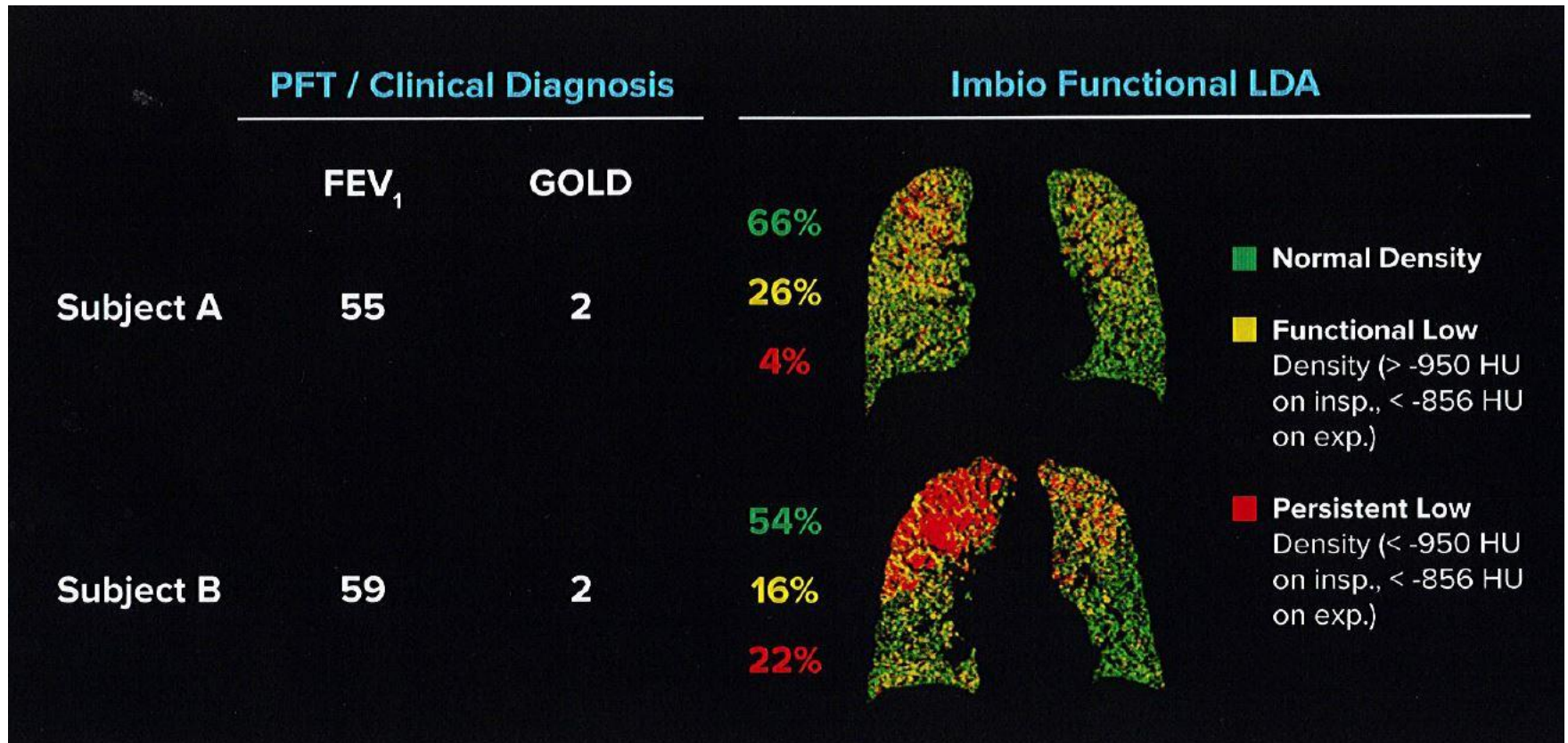
PRM^{fSAD} %voxels $\geq -950HU_{insp}$ and $< -856_{exp}$

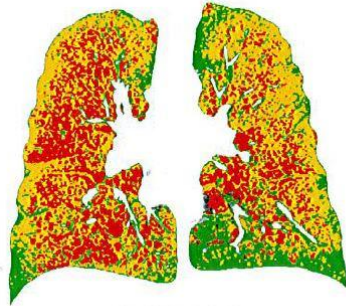
PRM^{Emph} %voxels $< -950HU_{insp}$ and $< -856_{exp}$

PRM^{Normal} %voxels $\geq -950HU_{insp}$ and $> -856_{exp}$

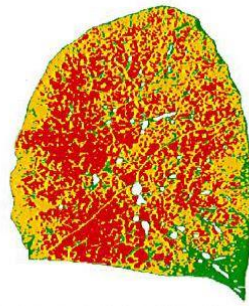
Galban. Nat Med; 2012; 18:1711

Parametric Response Map (PRM): a Voxel-wise Image Analysis Technique

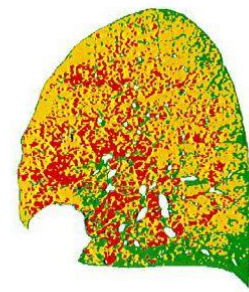




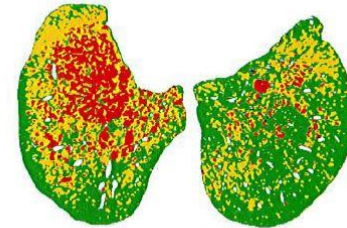
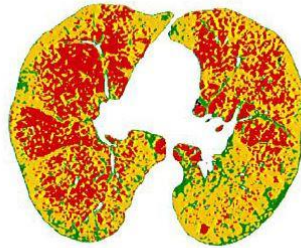
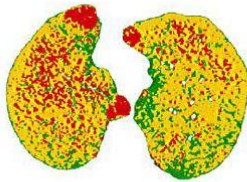
CORONAL SLICE



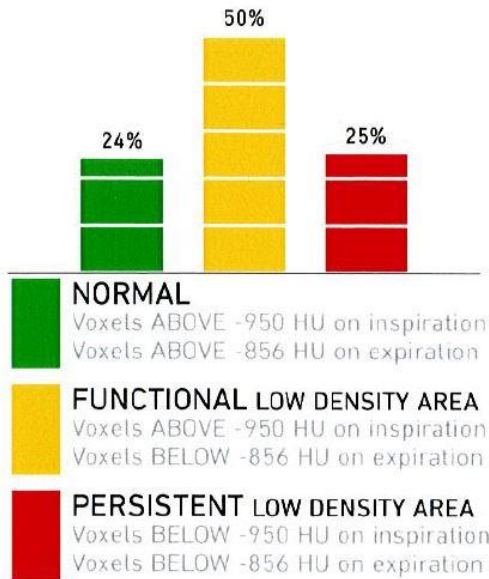
SAGITTAL SLICE - RIGHT MIDLINE



SAGITTAL SLICE - LEFT MIDLINE



SUMMARY



%	TOTAL LUNG	LEFT LUNG				RIGHT LUNG			
		Total	Upper	Middle	Lower	Total	Upper	Middle	Lower
Normal	24 ± 1*	27 ± 1	23 ± 1	16 ± 1	48 ± 2	21 ± 1	15 ± 2	12 ± 1	34 ± 2
Functional	50 ± 1	51 ± 1	61 ± 2	56 ± 1	37 ± 2	49 ± 1	57 ± 2	51 ± 1	41 ± 2
Persistent	25 ± 1	20 ± 1	15 ± 1	27 ± 1	14 ± 1	30 ± 1	27 ± 1	36 ± 1	24 ± 1

Data was run with FILTERING ON

Vol (L)	TOTAL LUNG	LEFT LUNG	RIGHT LUNG
Inspiration	9.4	4.5	4.9
Expiration	7.2	3.5	3.8

*THE RANGES PROVIDED WITH THE LDA RESULTS ARE AN INDICATION OF THE ACCURACY OF REGISTRATION (SEE USER MANUAL FOR MORE INFORMATION). THIS DOES NOT ACCOUNT FOR ADDITIONAL SOURCES OF VARIATION SUCH AS SLICE THICKNESS, IMAGE NOISE, SCANNER CALIBRATION OR RESPIRATORY PHASE.

VALUES ON FUNCTIONAL ASSESSMENT REPORT ARE CALCULATED BASED ON THE EXPIRATORY IMAGE. VALUES MAY DIFFER FROM INSPIRATION ASSESSMENT REPORT AS THE PERSISTENT LOW DENSITY AREA REPRESENTS VOXELS WHICH ARE LOW ON BOTH INSPIRATION AND EXPIRATION AND THE PERCENTAGES ARE CALCULATED BASED ON THE EXPIRATORY IMAGES.

Quantitative CT for Phenotyping Patients with COPD

427 male smokers (187 without COPD and 240 with COPD)

Measurement of %LAA₋₉₅₀ and SR-WAPi10mm

CT-normal Phenotype (*N=52*)

Airway-dominant Phenotype (*N=39*)

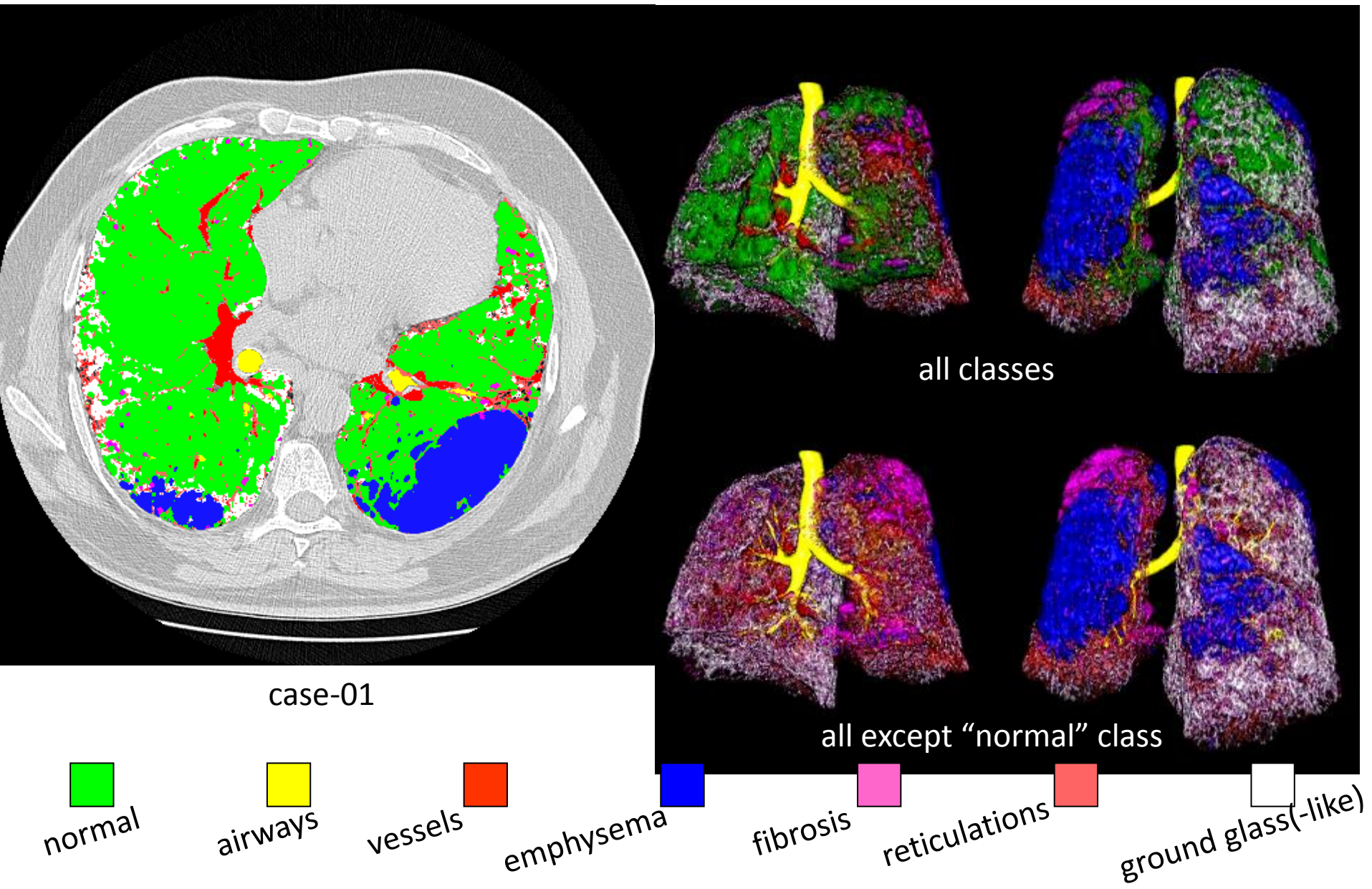
Emphysema-dominant Phenotype (*103*)

Mixed Phenotype (*N=46*)

COPD patients with the mixed phenotype are associated with more severe dyspnea and more frequent hospitalisations (2.0 to 3.6 times) than those with each of the remaining CT-phenotypes ($P < 0.05$)

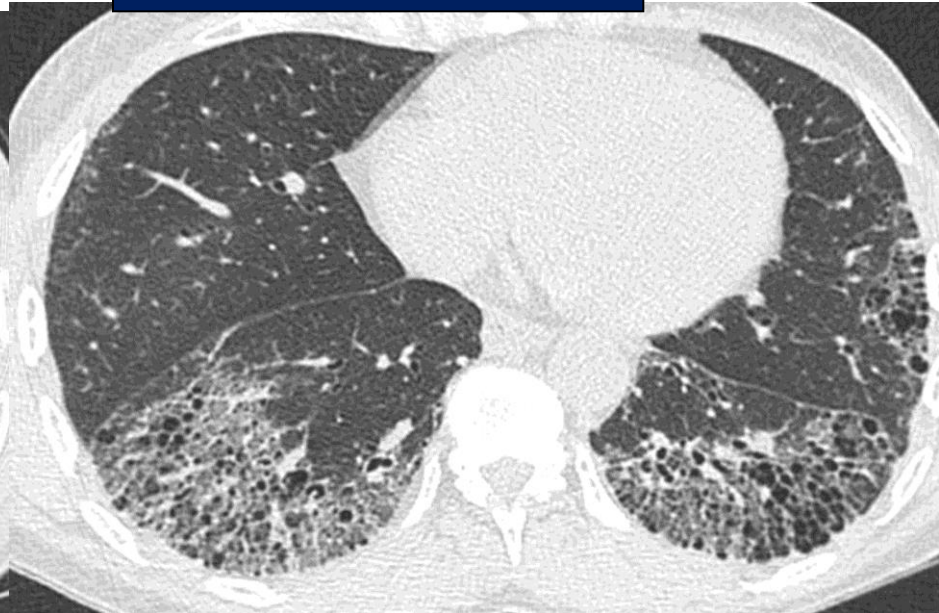
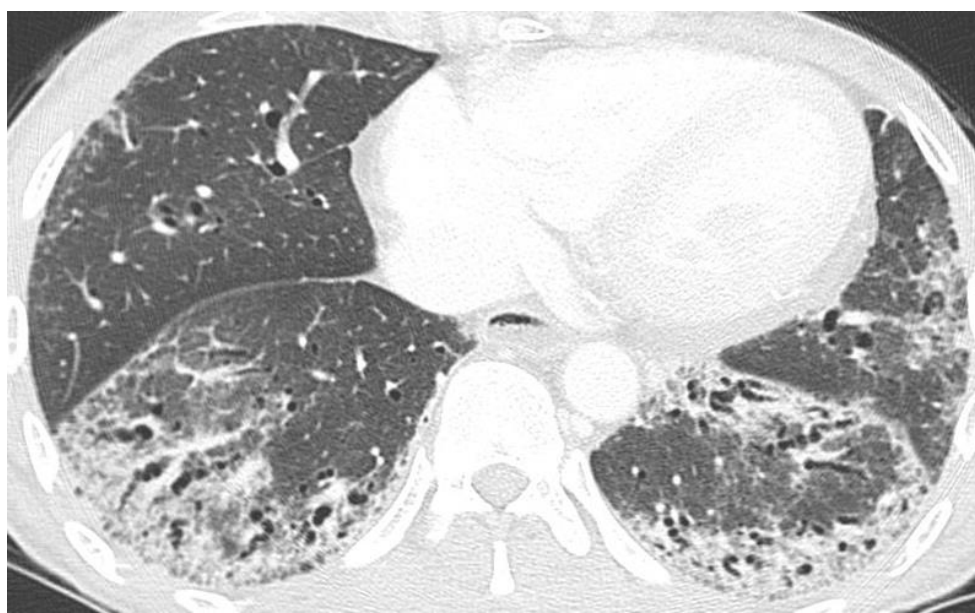
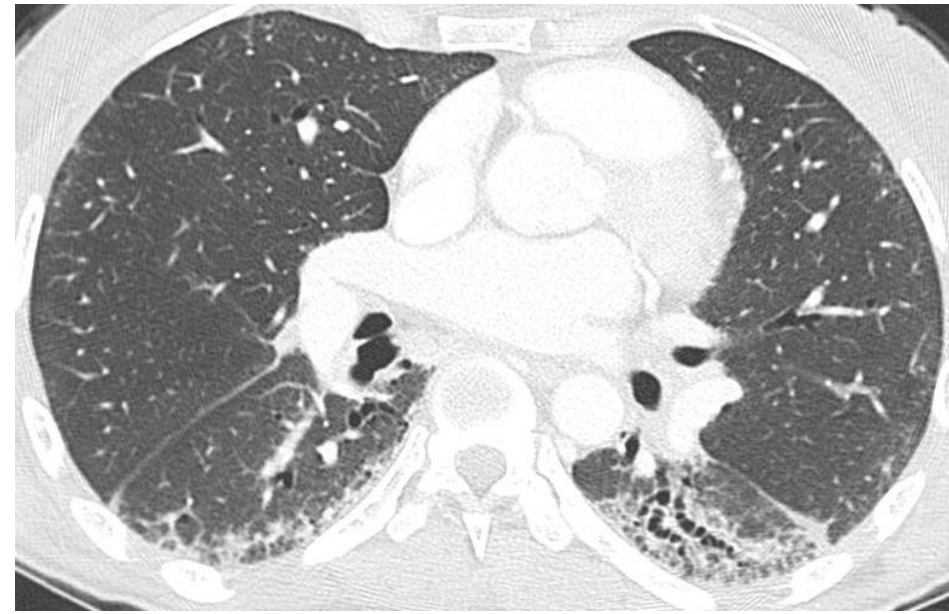
Tho. Ann Am Thorac Soc; 2015; 12: 988

Lung Texture Analysis for Quantitative CT Imaging



Association PO/PINS chez une femme âgée de 53 ans souffrant d'un syndrome des anti-synthétases (Anti-JO1)

Contrôle à 3 ans



ORIGINAL CT SCAN



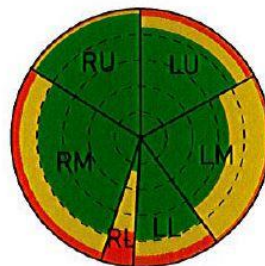
CT SCAN ANALYSIS



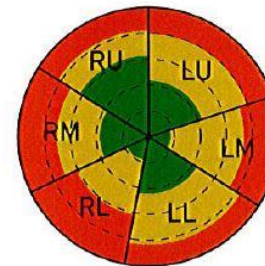
TEXTURE KEY



LUNG TOTAL
2.7 L



LUNG CORE



LUNG RIND

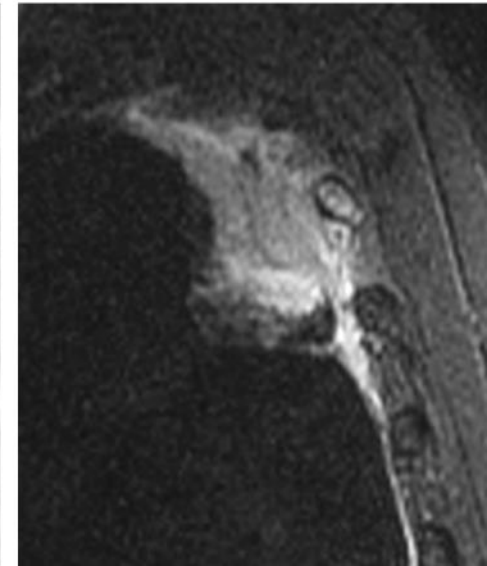
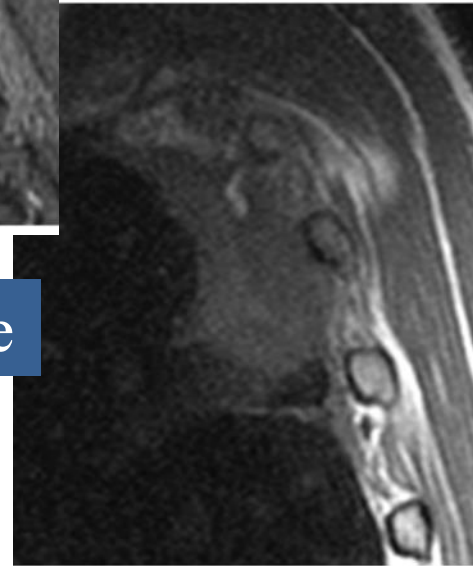
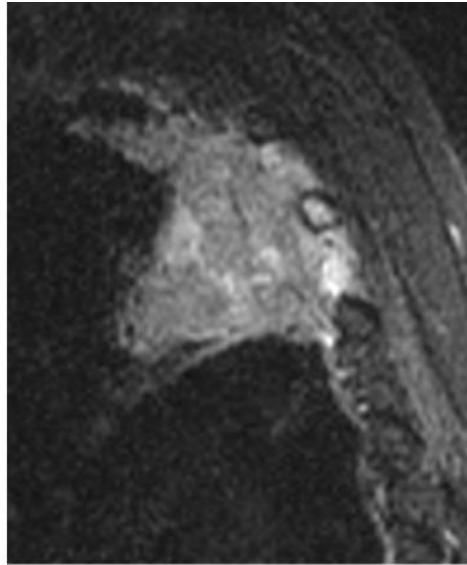
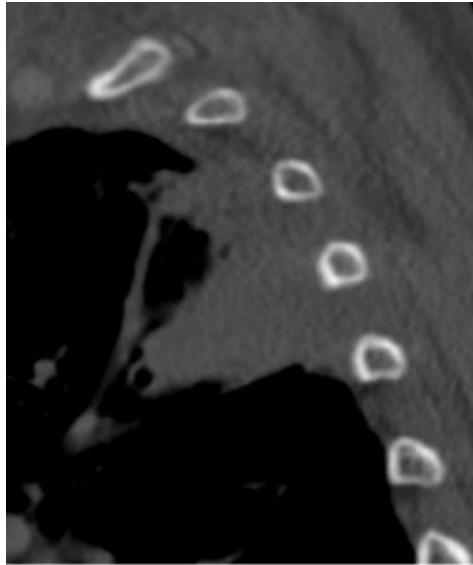
SUMMARY

	NORMAL	HYPERLUCENT	GROUNDGLASS	RETICULAR	HONEYCOMB
TOTAL LUNG	58 %	0 %	27 %	15 %	0 %
Left Lung (1.4 L)	56 %	0 %	31 %	13 %	0 %
Left Upper (T/C/R)	63 % / 85 % / 43 %	0 % / 0 % / 0 %	23 % / 9 % / 36 %	14 % / 6 % / 21 %	0 % / 0 % / 0 %
Left Middle (T/C/R)	49 % / 68 % / 17 %	0 % / 0 % / 0 %	39 % / 29 % / 56 %	12 % / 3 % / 27 %	0 % / 0 % / 0 %
Left Lower (T/C/R)	57 % / 80 % / 44 %	0 % / 0 % / 0 %	29 % / 12 % / 39 %	13 % / 7 % / 17 %	1 % / 1 % / 0 %
Right Lung (1.3 L)	60 %	0 %	22 %	18 %	0 %
Right Upper (T/C/R)	79 % / 96 % / 62 %	0 % / 0 % / 0 %	11 % / 2 % / 20 %	10 % / 2 % / 18 %	0 % / 0 % / 0 %
Right Middle (T/C/R)	63 % / 79 % / 37 %	0 % / 0 % / 0 %	21 % / 14 % / 33 %	16 % / 7 % / 30 %	0 % / 0 % / 0 %
Right Lower (T/C/R)	20 % / 26 % / 18 %	0 % / 0 % / 0 %	44 % / 47 % / 43 %	36 % / 27 % / 39 %	0 % / 0 % / 0 %

T = total, C = core, R = rind, T = C + R

*Total lung capacity predicted using Crapo's method as noted in Crapo RO, Morris AH, Clayton PD, and Nixon CR. Lung Volumes in Healthy Nonsmoking Adults. Bull. Europ. Physiopathol. Respir. 1982; 18:419-425.

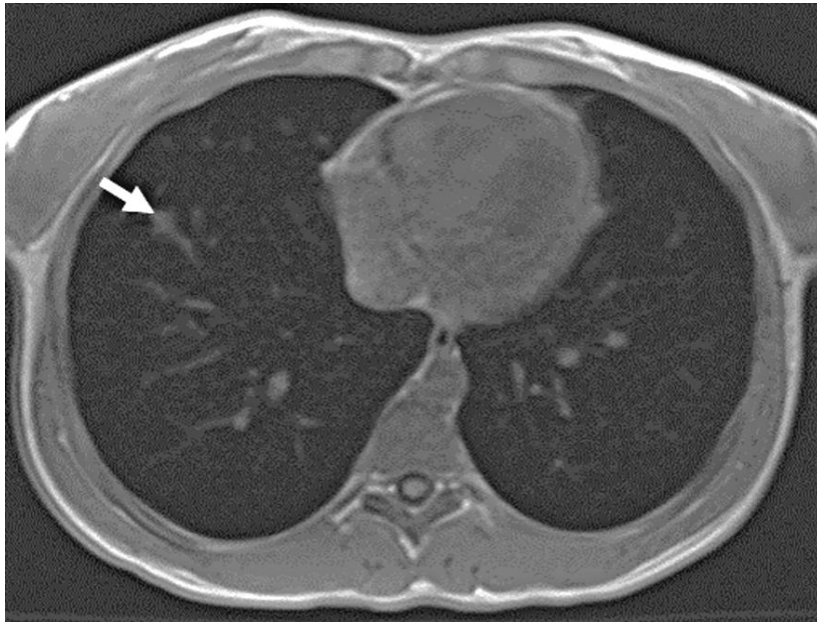
Imagerie par Résonance Magnétique du Thorax



Cancer de l'apex pulmonaire

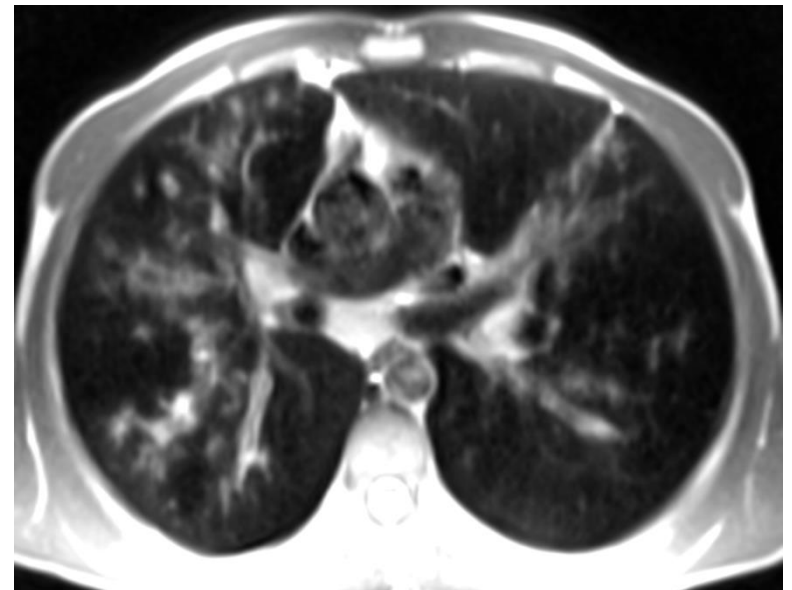
Imagerie par Résonance Magnétique du Poumon

Séquence de contraste (T1 et T2)



Nodule pulmonaire

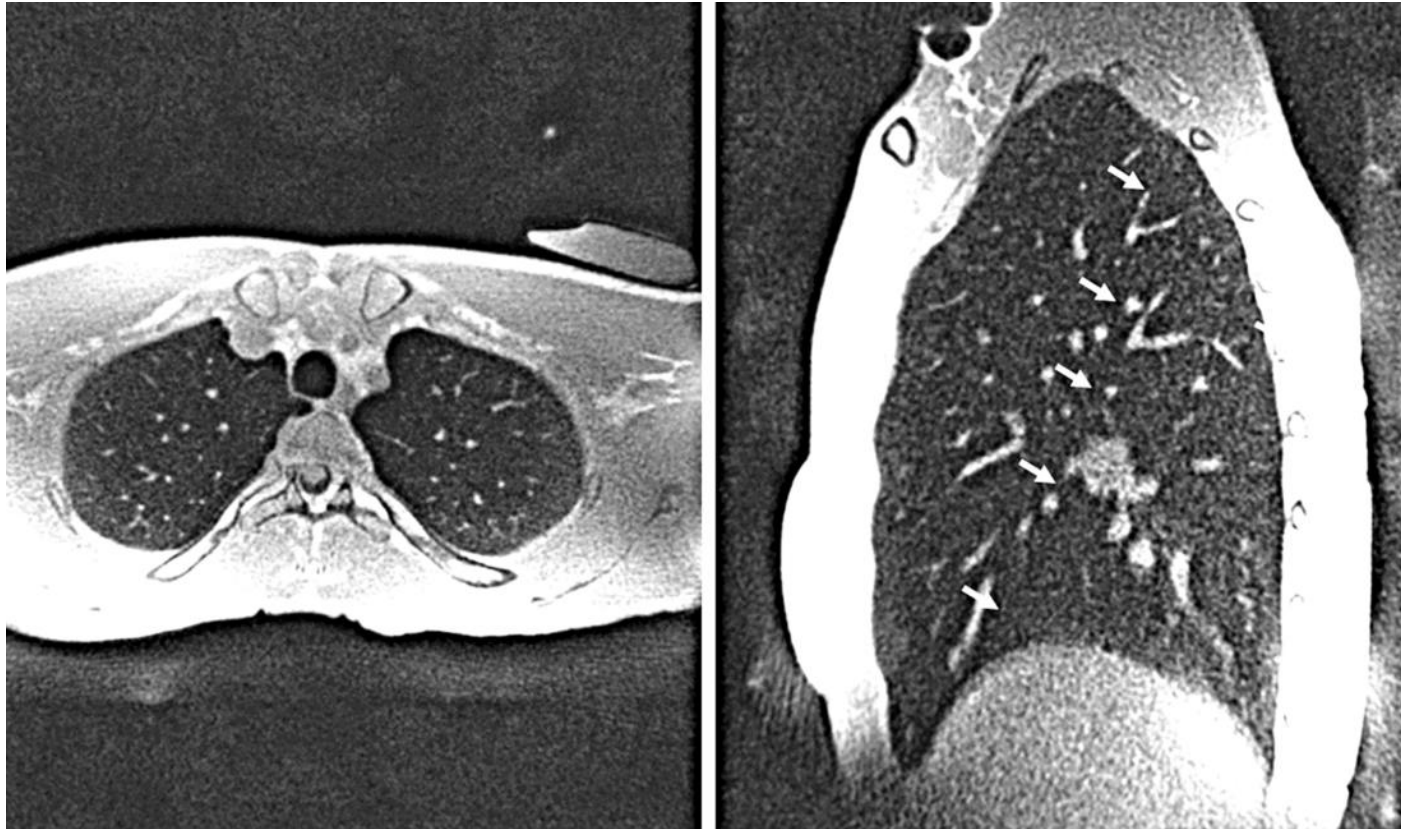
Mucoviscidose



Courtoisie François Laurent

Imagerie par Résonance Magnétique du Poumon

Séquence à temps d'écho ultracourt (UTE)
Séquence PETRA (acquisition 3D avec synchronisation
respiratoire)



Courtoisie François Laurent

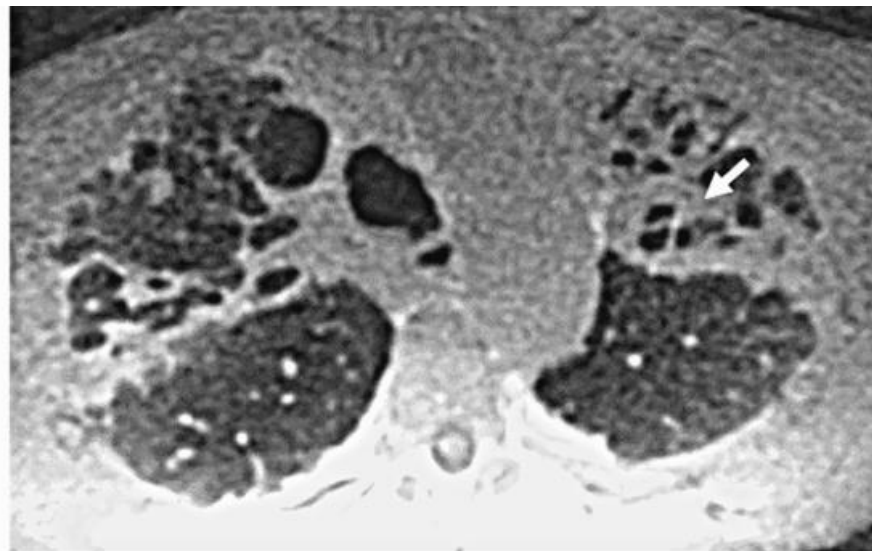
Imagerie par Résonance Magnétique du Poumon

Séquence PETRA (acquisition 3D avec synchronisation respiratoire)

Mucoviscidose



Imagerie par Résonance Magnétique du Poumon



Courtoisie François Laurent

Imagerie par Résonance Magnétique du Poumon

- Séquences morphologiques (séquences à temps d'écho ultracourt)
- Séquences de contraste (T1 et T2)
- Séquences fonctionnelles

Angiographie et perfusion

Ventilation (Helium et Xénon hyperpolarisés)

Diffusion

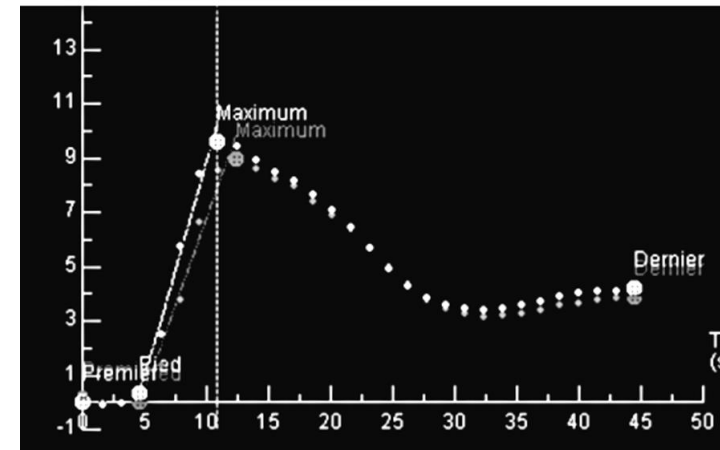
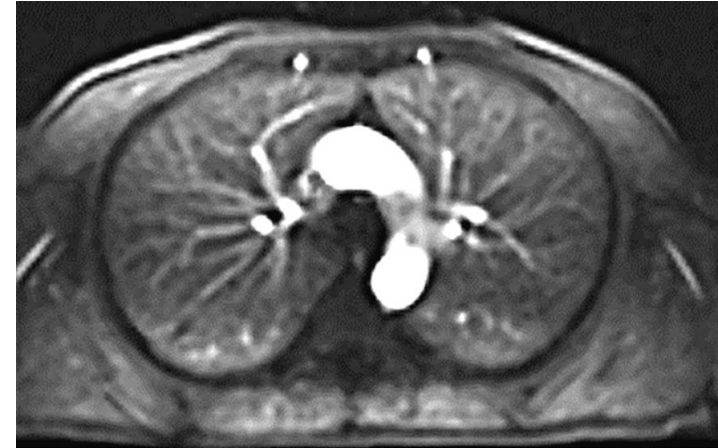
O₂ (Ventilation et diffusion)

Indications

Pédiatriques cardiovasculaires
Mucoviscidose
Cancer de l'apex
HTAP post-emboliques
Embolie pulmonaire au cours de la grossesse
Seconde intention en oncologie

Perspectives

BPCO / Asthme / PID / Réponse tumorale



Courtoisie François Laurent

Futurs Développements en Imagerie Thoracique

Progrès Technologiques en TDM

- Diminution de la taille des détecteurs (0,25 mm)
- Augmentation de la matrice (2048)
- Imagerie Spectrale
- TDM à Comptage Photonique

Progrès en Analyse d'Image

- CAD
- Analyse de Texture
- Intelligence Artificielle (Machine Learning)

Progrès de L'IRM

- Imagerie morphofonctionnelle
- Application de la TEP-IRM en oncologie