Chest CT
Interpretation Guide

Update 2020

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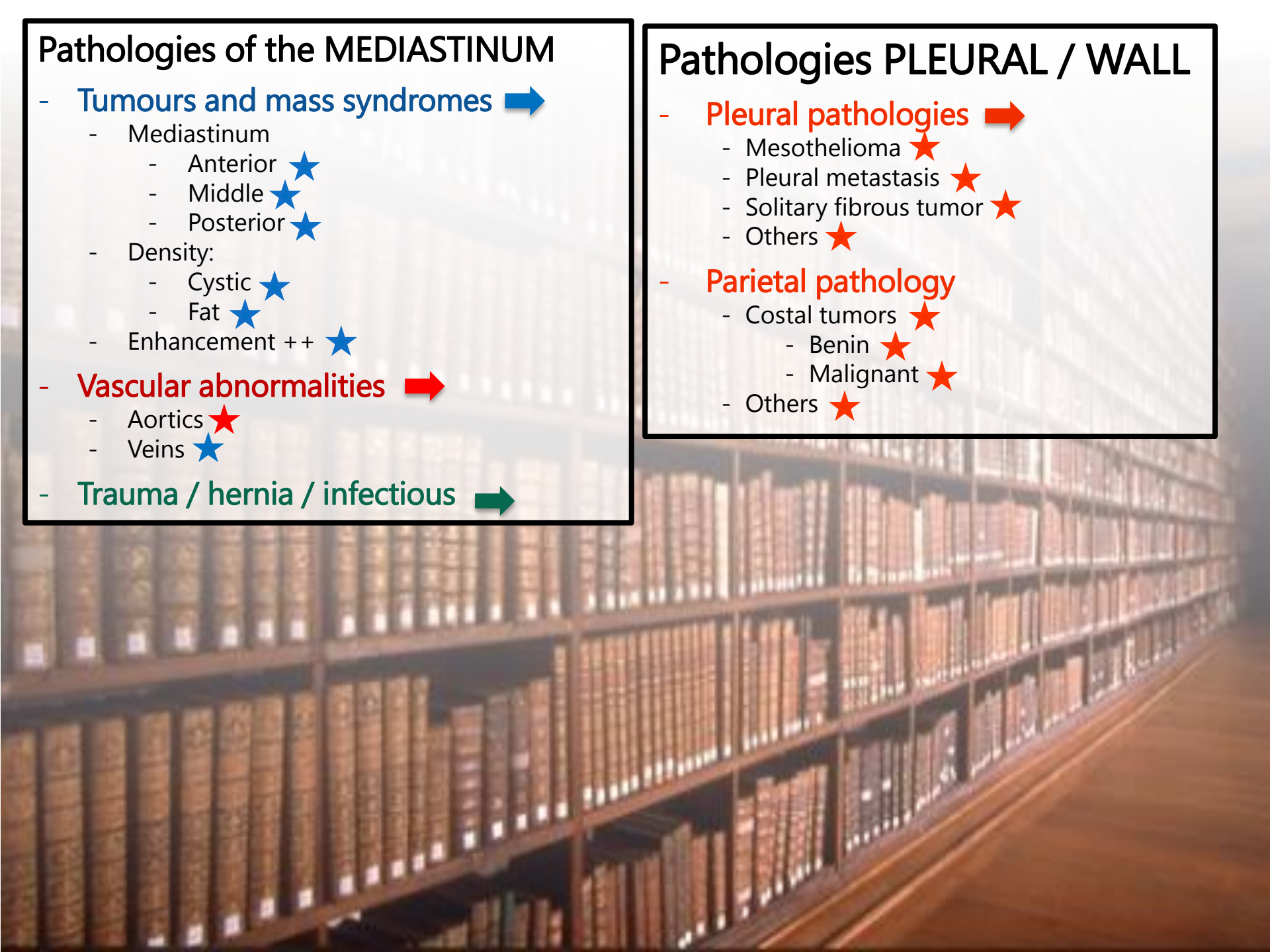
Table of contents

PARENCHYMA pathologies

- **Airways**
  - Tracheal Thickening
  - Other tracheal pathologies
  - Tracheobronchial Tumors
  - Chronic bronchial pathologies
  - Bronchiolitis
- **IP (inerstitial pneumoniae)**
  - **idiopathic IP (IIP)**
    - *Chronic Fibrotic*: **IPF**, **NSIP**
    - *Acute / Subacute*: **COP** , **AIP**
    - *Smoking related*: **DIP, RB ILD**
    - *Rare*: LIP, EPFA
  - **Sarcoidosis**
  - **Connective tissue disease**
  - **Vasculitis**
  - **Hypersensitivity Pneumoniae**
  - **Pneumoconiosis**
  - **Drugs, toxic** **Radic pn**
  - Miscellaneous
    - **Eosinophilic Pn**
    - LAM Hystiocytosis X , rare cysts
    - Erdheim Chester ,Rosai Dorfman , IgG4
    - Amylosis , LP , Alveolar microlithiasis
- **Cardiovascular damage**
  - PO
  - PAH , VOD
  - Pulmonary embolism
- **Infectious diseases**
  - Bacterial , viral , fungal , parasitic
  - Immunocompromised infections
- **Congenital pathologies**
- **Tumor pathologies**
  - Bronchopulmonary cancer
  - Pulmonary Lymphoma
  - Neuroendocrine tumors
  - Sarcomas
  - Others
- **Lung Transplantation / GVH**
  - Complications of lung transplantation
  - Allograft Complication
- **Miscellaneous**
  - Fat embolism
  - Lipid pneumopathy
  - Post op/surgery: Pneumatocele , LM torsion



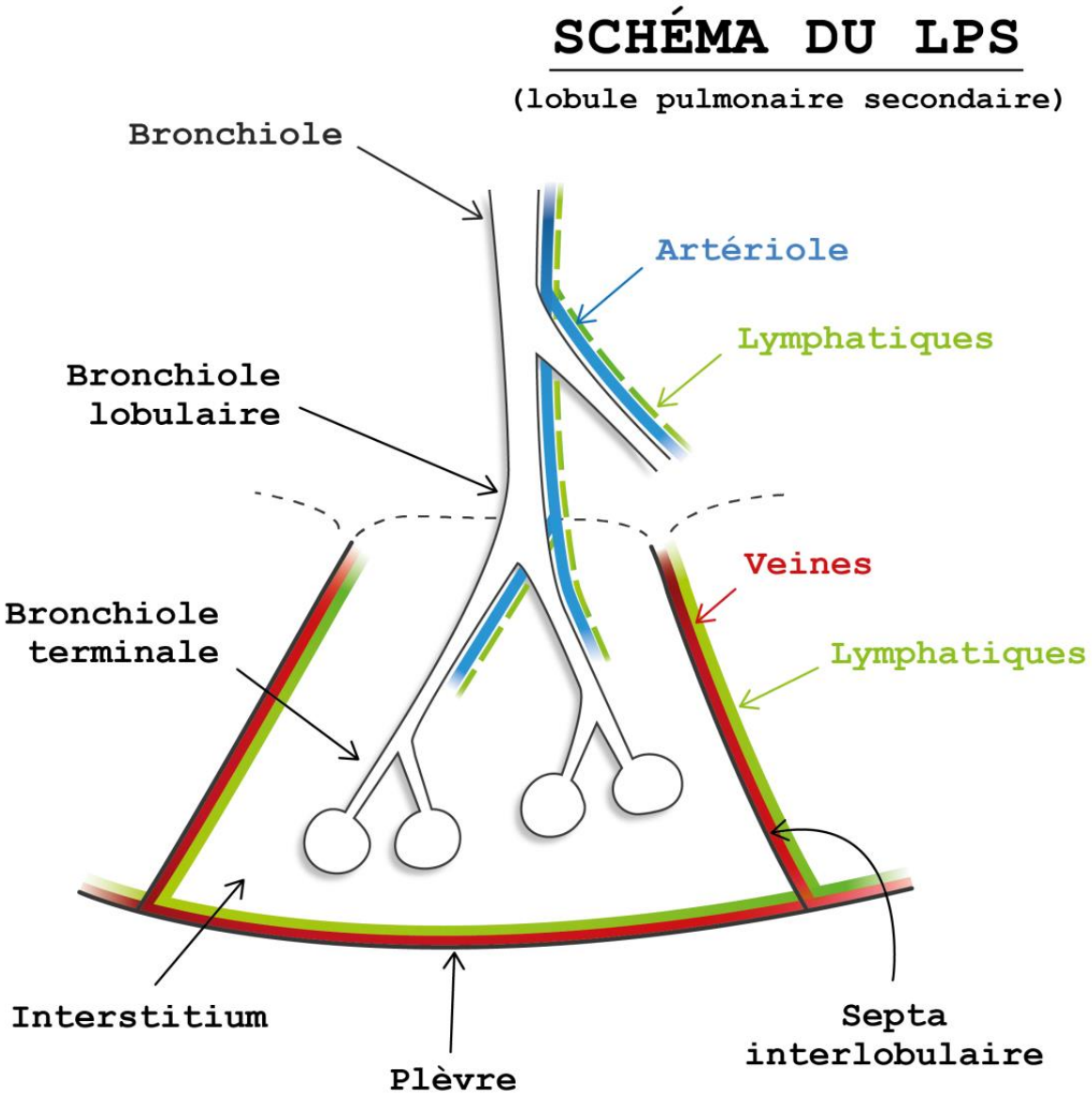
Pathologies of the MEDIASTINUM

- Tumours and mass syndromes
  - Mediastinum
    - Anterior
    - Middle
    - Posterior
  - Density:
    - Cystic
    - Fat
  - Enhancement ++
- Vascular abnormalities
  - Aortics
  - Veins
- Trauma / hernia / infectious

Pathologies PLEURAL / WALL

- Pleural pathologies
  - Mesothelioma
  - Pleural metastasis
  - Solitary fibrous tumor
  - Others
- Parietal pathology
  - Costal tumors
    - Benin
    - Malignant
  - Others

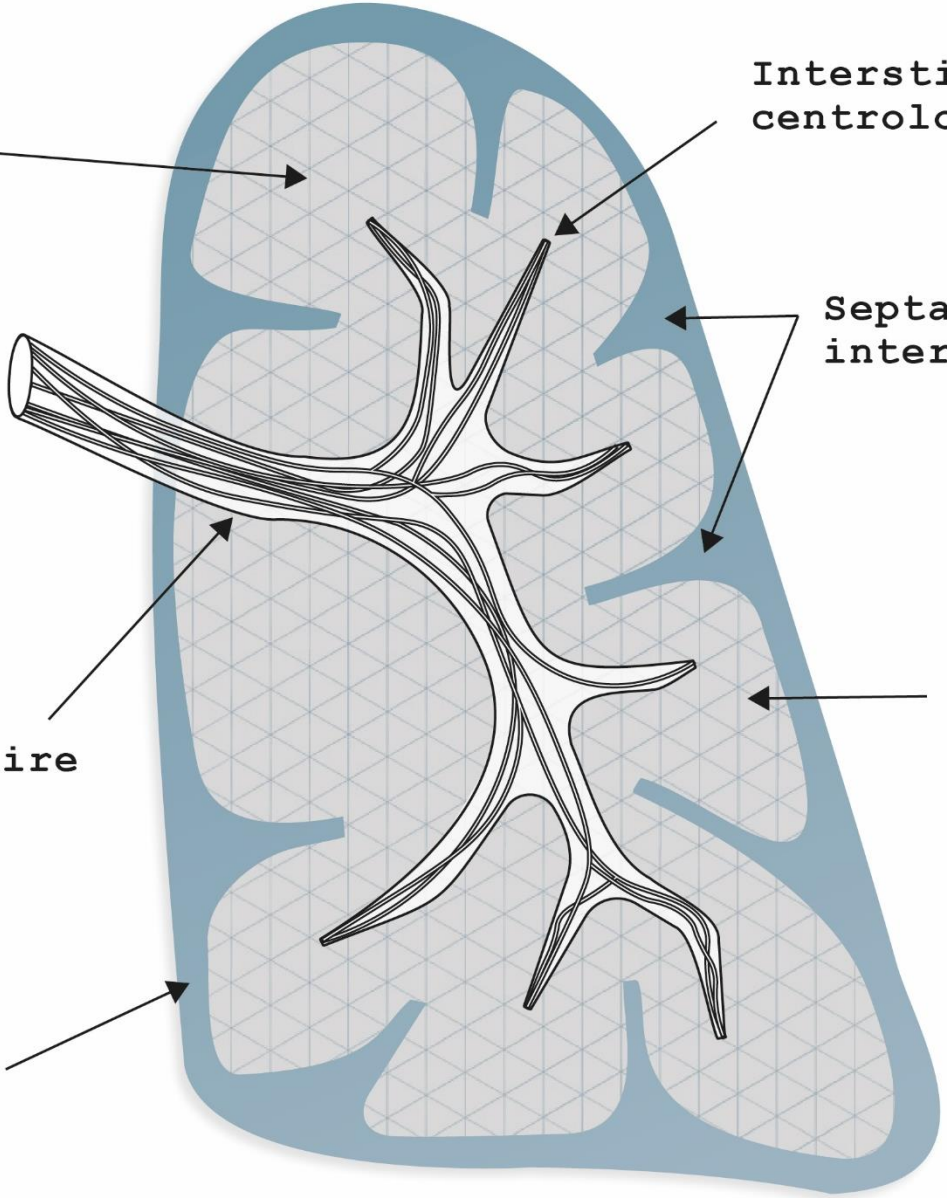
Anatomy



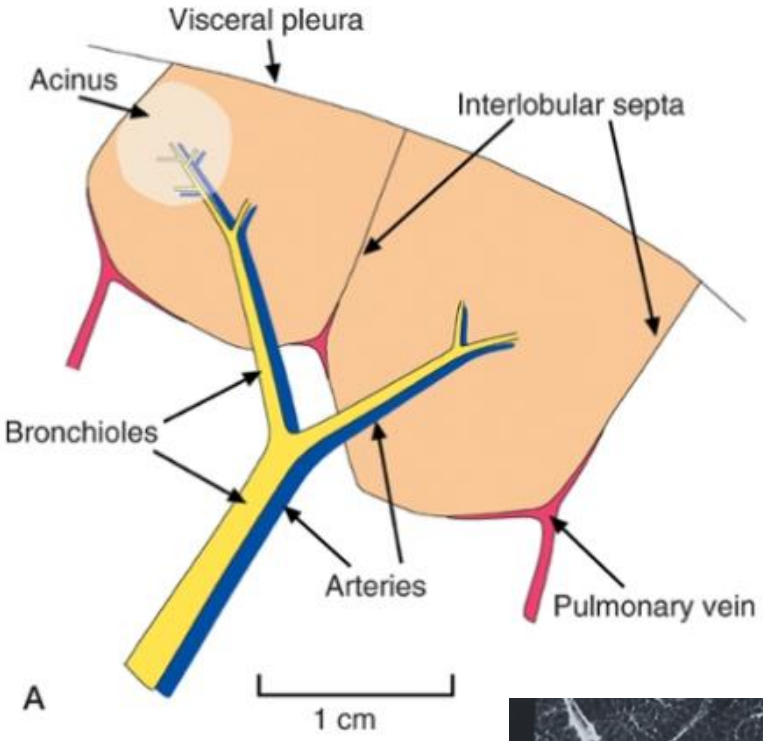
The secondary pulmonary lobule is **the anatomical and functional unit of the lung**

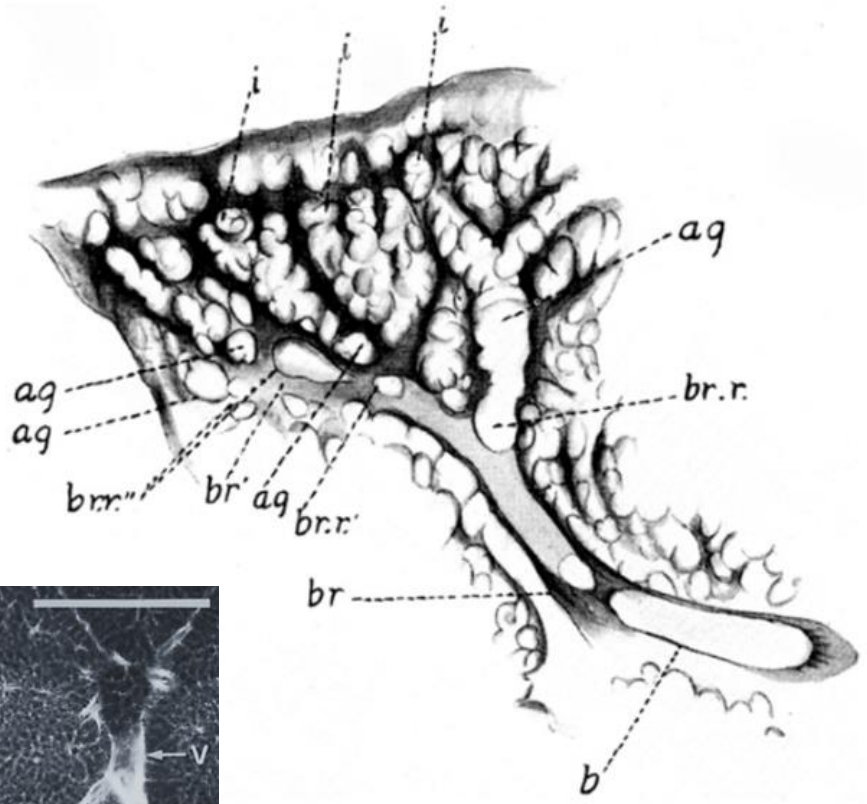
- Polyhedral, **1 to 2.5 cm** diameter
- Contains multiple *acini* (most distal parenchymal structure)
- In the center are **arterioles** and **bronchioles...**
- In the periphery, the **veins** and **lymphatics** drain off.
- The analysis is done by taking into account this anatomy

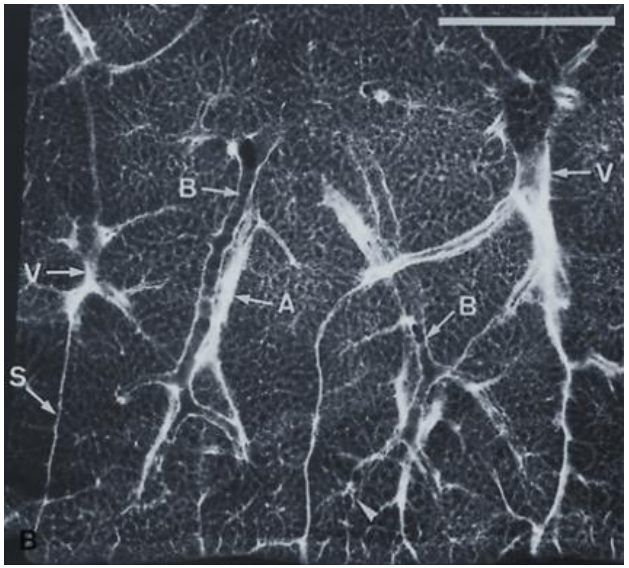
INTERSTITIUM



Webb - High resolution CT of Lung







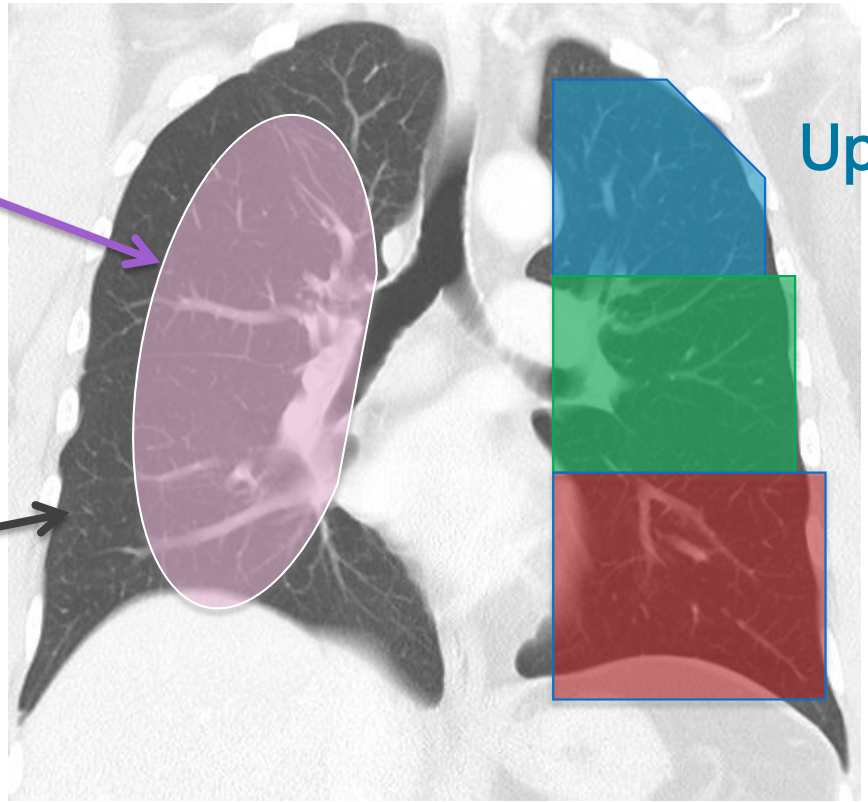
Main syndromes

Several types of opacities

- Non-septal lines
- **Reticular** opacities
  - Inter-lobular
  - Intra-lobular
- **Nodular** opacities
  - **Nodules**
  - **Micronodules**
    - Perilymphatic
    - Ubiquitous
    - Centrolobular
    - Tree in bud
- **Cavities**
- **Consolidation**
- **GGO**
- **Hyperclarity**
  - Cyst
  - Emphysema
- **Revision of pulmonary architecture / fibrosis**

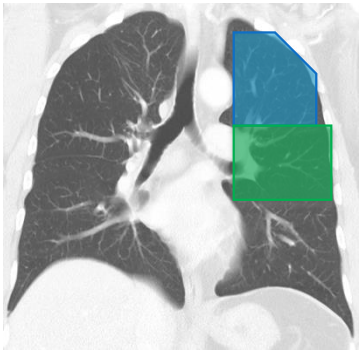
Analyze

- **The main pattern**
- **Associated** signs
- And pinpoint their **topography** in the lung
  - Upper, middle, lower regions
  - Central, peripheral regions



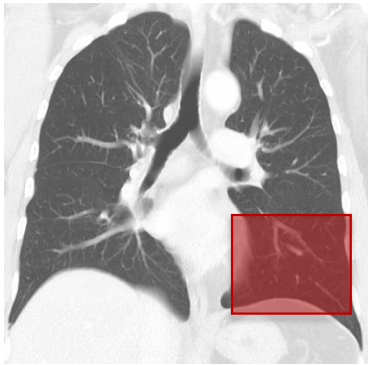
Attention: the next 2 slides give the tendencies of certain pathologies to sit in such and such a region but there are many exceptions to the rule.

Upper/middle regions



- **Sarcoidosis +++** Age: 20-40/ F60, peri-lymphatic micronodules, ggo, +/- fibrosis / fibrotic mass, diffuse lymphadenomegaly
- **Silicosis** Exposure, +/- calcified peri-lymphatic micronodules, +/- fibrotic mass, ganglia with "eggshell" calcifications
- **Chronic eosinophilic pneumopathy (CEP)** 40-50 years, asthma(1/2), multifocal conolidation/ggo, +/- bands, predominantly upper and peripheral
- **Churg and strauss** Asthma, appearance of CEP + centrolobular micronodules + bronchial thickening
- **Smoker's bronchiolitis (RB-ILD)** Tobacco++, upper centrilobular micronodules
- **Acute/subacute hypersensitivity** Middle++ and upper regions, centrilobular micronodules, ggo, lobular trapping
- **Histiocytosis X** tobacco, centrilobular micronodules upper regions
- Pleuroparenchymal fibroelastosis, Ankylosing spondylitis, Erdheim Chester...

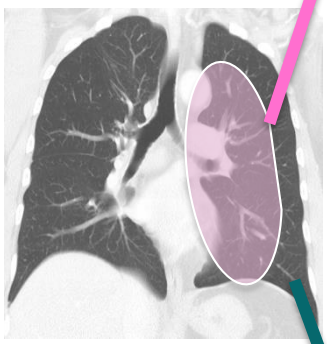
Lower regions



- **Pulmonary Oedema** Regular septal lines + ggo, central regions, slope + effusions + cardiomegaly
- **Lymphangitis carcinomatous** ADK, regular or nodular septal lines, asymmetrical
- **Lymphoma**
- **Lipid pneumopania** Swallowing disorders, consolidation/ ggo/ crazy paving
- **Inhalation pneumonia** Swallowing disorders, consolidation / ggo / Tree in Bud
- Congenital **sequestration**, LLL++, systemic artery
- **Infarction** (PE, sub-pleural triangular), **septic emboli** (toxic/catheter, sepsis, excavated nodules and lower infarction)
- **Organized pneumopathy (OP)** Peripheral, lower, banded, reverse halo sign
- **UIP, IPF, collagen tissue disease, asbestosis** Subpleural **fibrosis,** honeycomb
- **NSIP** Reticular syndrome, frosted glass, traction bronchiectasis, central + peripheral
- **DIP** Tobacco+++, peripheral ggo + micro cysts
- PIL (ggo + cysts), VOD (APH, lower septal lines, normal heart), amyloidosis

Central Regions

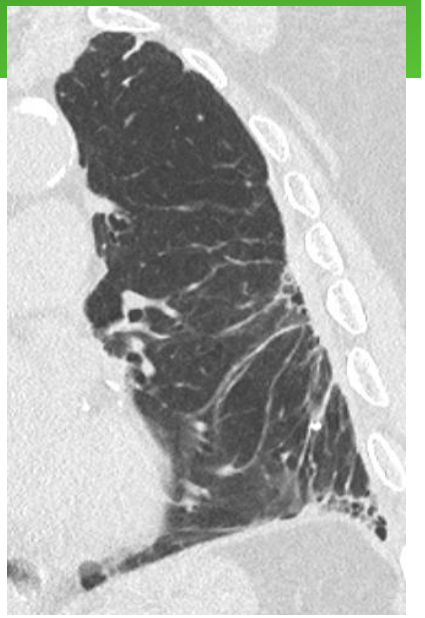
- **Sarcoidosis +++** Age: 20-40/ F60, peri-lymphatic micronodules, ggo, +/- fibrosis / fibrotic mass, diffuse lymphadenomegaly
- **Silicosis** Exposure, +/- calcified peri-lymphatic micronodules, +/- fibrotic mass, ganglia with "eggshell" calcifications
- **PO** Regular septal lines + ggo, central regions, slope + effusions + cardiomegaly
- HIV **pneumocystis**, diffuse ggo, sometimes respect of the areas under pleurals
- **Alveolar hemorrhage**
- **Lymphangitis carcinomatous** ADK, regular or nodular septal lines, asymmetrical
- NSIP Reticular and GGO syndrome, traction bronchiectasis, central + peripheral regions (sometimes sparing band under pleural), sometimes peribronchovascular fibrosis
- Chronic hypersensitivity (chronic HS) Middle++ and upper regions, centrilobular micronodules, ggo, lobular trapping, sometimes peribronchovascular fibrosis



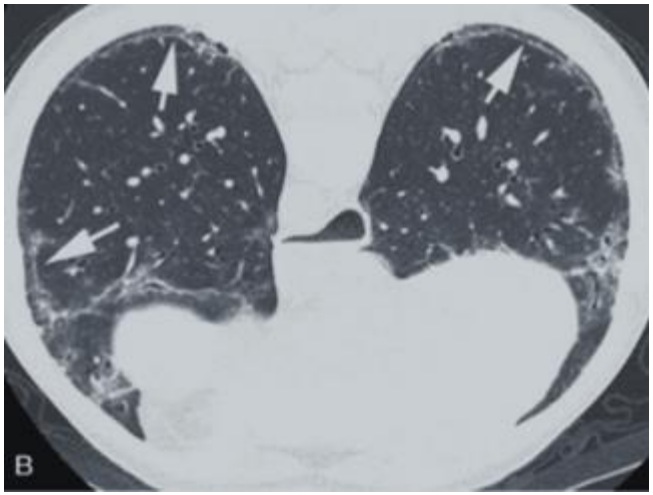
Peripheral regions

- **Chronic eosinophilic pneumopathy (CEP)** 40-50 years, asthma(1/2), multifocal consolidation /GGO +/- bands, predominantly upper and peripheral
- **Churg and strauss** Asthma, appearance of CEP + centrolobular micronodules + bronchial thickening
- **UIP +++, IPF, collagen tissue disease, asbestosis** Subpleural fibrosis, honeycomb +++
- **NSIP ++ (50%)** Reticular syndrome, frosted ggo, traction bronchiectasis, central + peripheral
- **Organized pneumopathy (OP)** Peripheral, lower, banded, reverse halo sign
- **DIP** Tobacco+++, peripheral GGO + micro cysts
- **Infarction** (PE sub-pleural triangular), **septic emboli** (toxic/catheter, sepsis, excavated nodules and lower infarction)
- Pleuro-parenchymal fibroelastosis (apex)

Non-septal lines



- Linear opacity **not repecting the pulmonary architecture** (SPL anatomy)
- **Trans-lobular, trans-pulmonary line**
- Two etiologies
  - **atelectasis**
  - **Fibrosis**



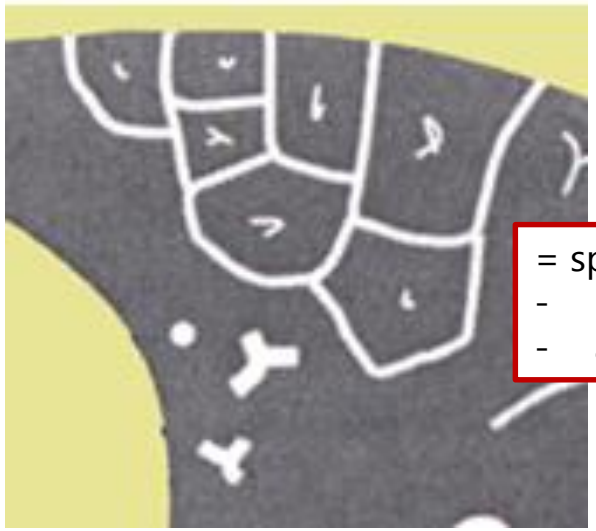
Courtesy Webb - HRCT of The Lung

Particular non-septal line: curvilinear opacity under the pleura

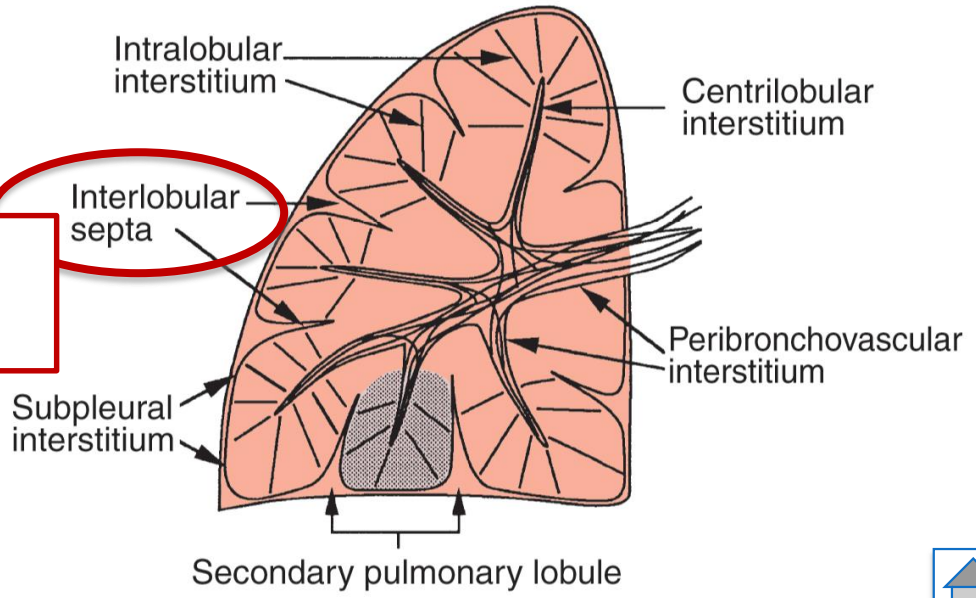
- Definition: **concentric opacity less than 1 cm from the pleural surface.**
- Lg = 2 to 6 cm, thickness < 5 mm
- **Procubitus makes** it possible to differentiate it from gravitational change.
- **Yoshimura** originally described it in **asbestosis** (a mixture of peribronchiolar fibrous lesions and alveolar collapse).
- **No specificity as it has since been observed in other fibroses.**

Inter-lobular septal thickening

Thickening of <u>interlobular septa</u>
= Septal lines
= Septal thickening
→Polygon-shaped linear opacities from 10 to 20 mm
→<u>« Large mesh » cross-links</u>

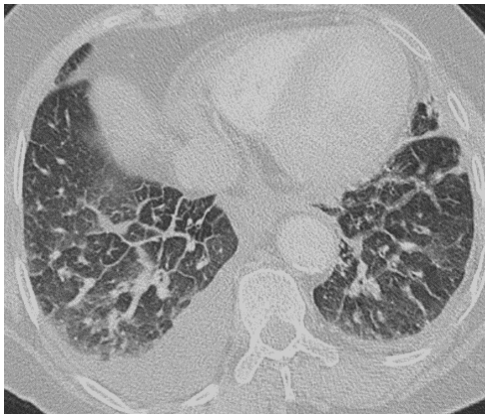


= space occupied by
- **lymphatics**
- and **veins**

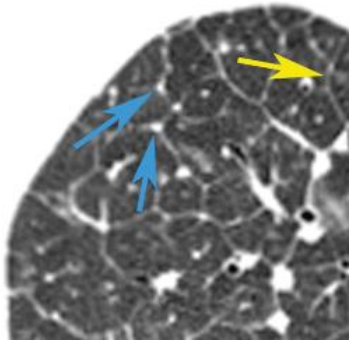


Regular septal thickening

- PO +++ (interstitial edema)
  - By venous/lymphatic stasis, declining zones (gravity)
  - + GGO, peribronchovascular thickening, tortuous veins, cardiomegaly, pleural effusion +/- Diffuse hypodense lymphadenomegaly (engorgement)
- Lymphangitic carcinomatosis
  - Adenocarcinoma
  - + Nodular peribronchovascular thickening +/- ADP +/- pleural carcinosis
- Lymphoma, leukemia
- Atypical pneumonia (viral, mycoplasma)
  - Cough, fever, + ggo (alveolitis) +/- bronchiolitis
- Acute eosinophilic pneumopathy
  - Young patient, fever and acute dyspnea, normal-heart PO scan chart.
- Veno-occlusive disease (VOD)
- Panlobular Emphysema
- Erdheim-Chester
- Lymphangiectasis
- Nieman Pick

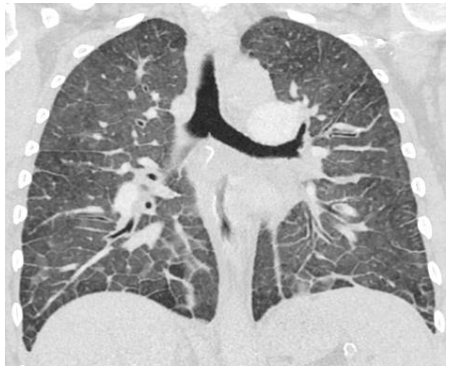


Interstitial PO +++

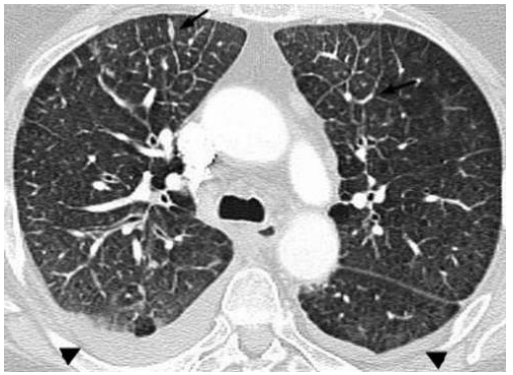


Webb

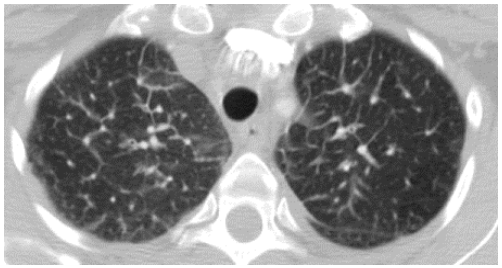
NB: These cross-linkages are best seen at the pulmonary **apexes** because these **interlobular spaces are** better developed in these regions.



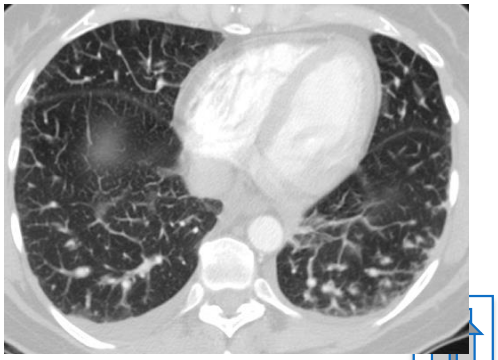
VOD



Secondary Lymphoma
Courtesy S. Hare

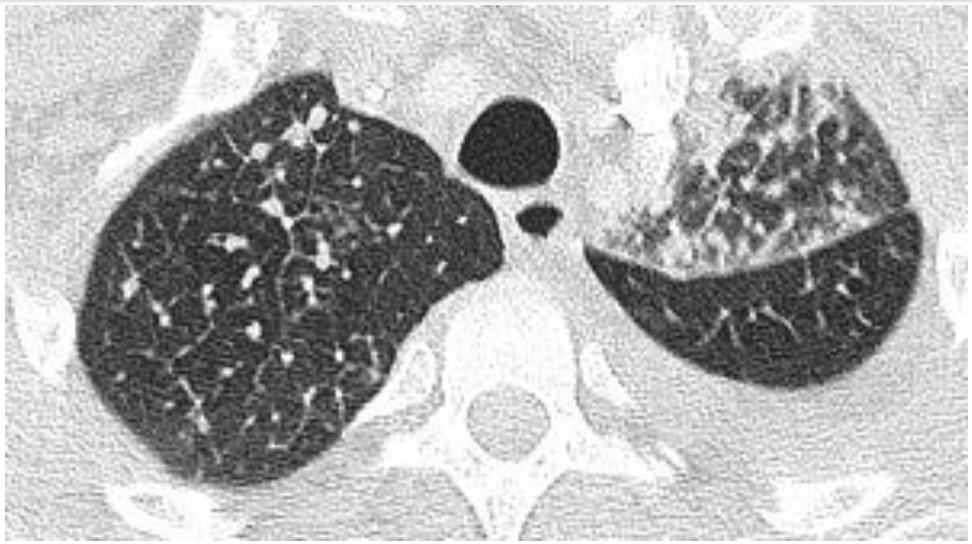


Acute eosinophilic pneumonia

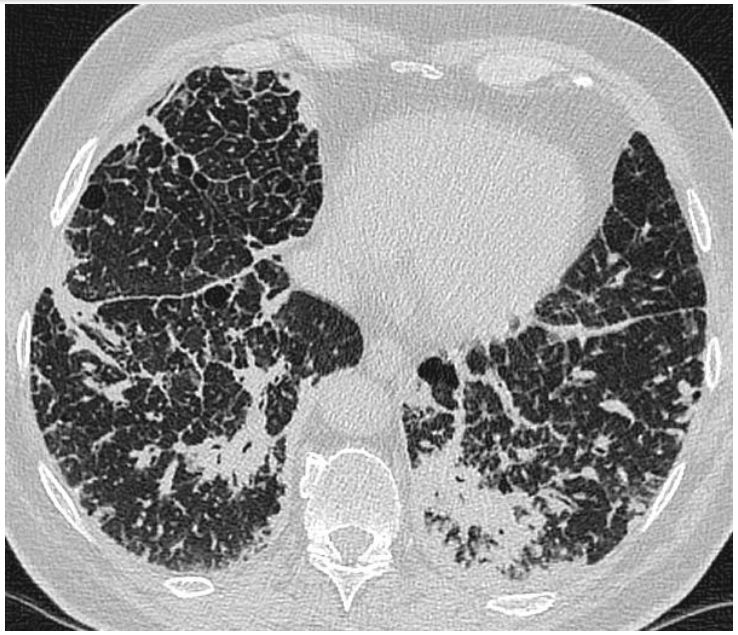


Range of nodular septal thickenings

- Lymphangitic carcinomatosis
  - Adenocarcinoma context
  - + nodular peribronchovascular thickening +/- ADP +/- pleural carcinosis
- Sarcoidosis
  - Young, perilymphatic micronodules, superior predominance + diffuse mediastinal ADP
- Kaposi's Sarcoma
- Lymphoma
- Amylosis (rare)



Lymphangitic carcinomatosis

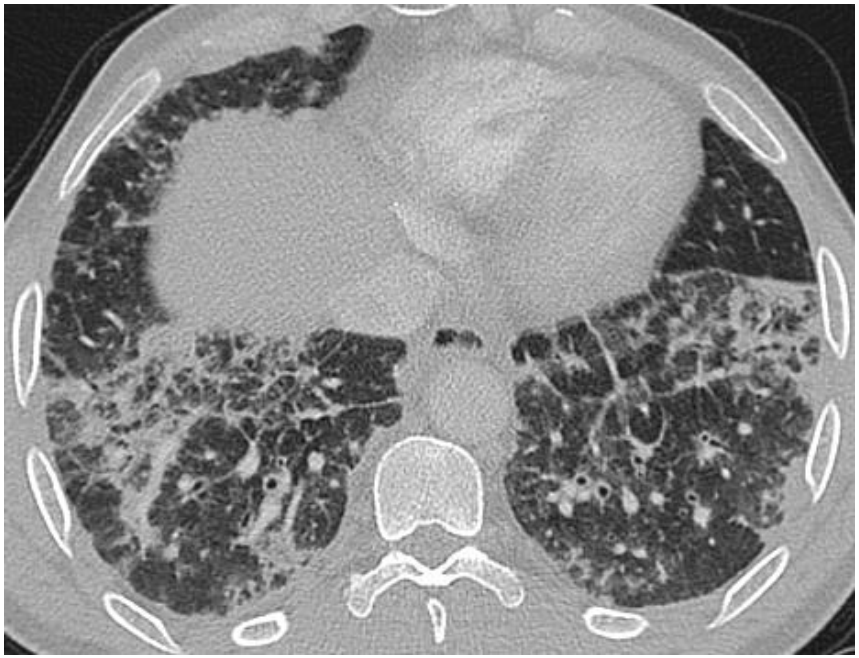


Amylosis

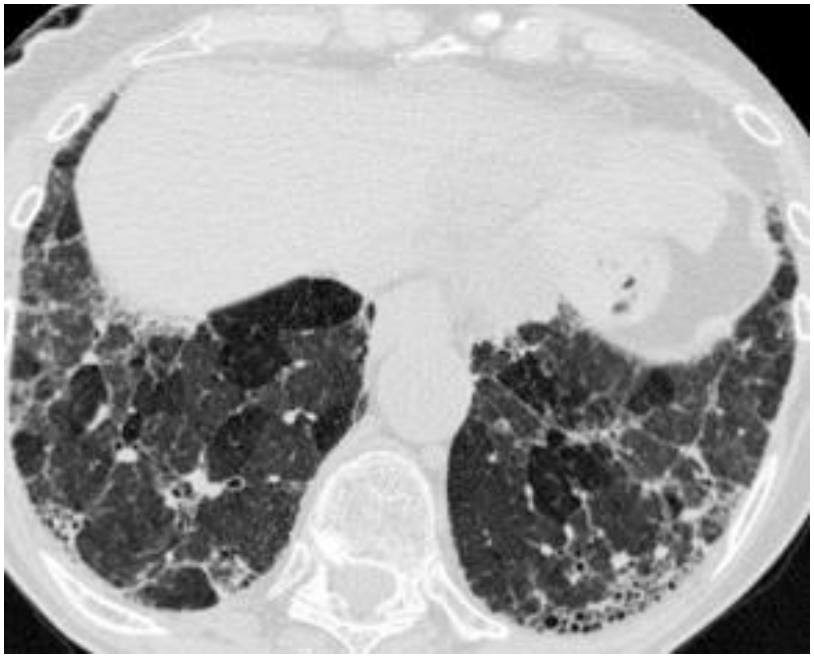
Irregular septal thickenings

- Sarcoidosis with fibrosis
- ILD/Fibrosis (IPF, asbestosis, collagen tissue/vascular disease, chronic HSP)

Stage IV Sarcoidosis

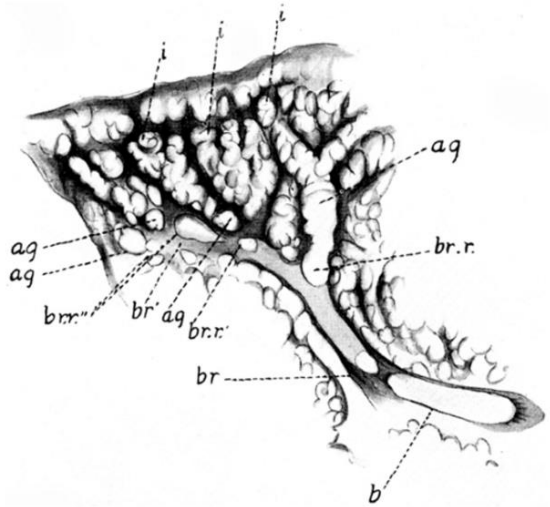


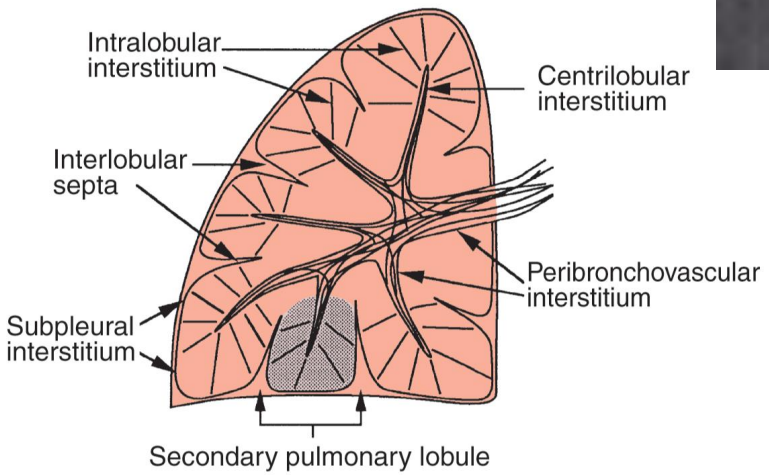
Chronic HSP



Intra-lobular septal thickening

- Small rectilinear or curved intra-lobular opacities forming a **cross-linking with a mesh size of < 10 mm: "small mesh" cross-linkages**
- Histology
  - **Wall alveolitis** (inflammation of the **inter-alveolar septa**)
  - or **luminal** (inflammation of the **wall of the alveoli**)
- Rarely isolated
- Represent a **stage of evolution to honeycomb imaging during fibrotic ILD**. Caution: **fibrosis** can only be confirmed when there are **associated signs of pulmonary architecture revision** (traction bronchiectasis…).





Groung Glass opacities

Definition: Opacity whose density **allows to see the pattern of fissures, bronchi and vessels** and that of any pathological structure.

Translate an **increase in lung parenchyma density**
3 possible mechanisms

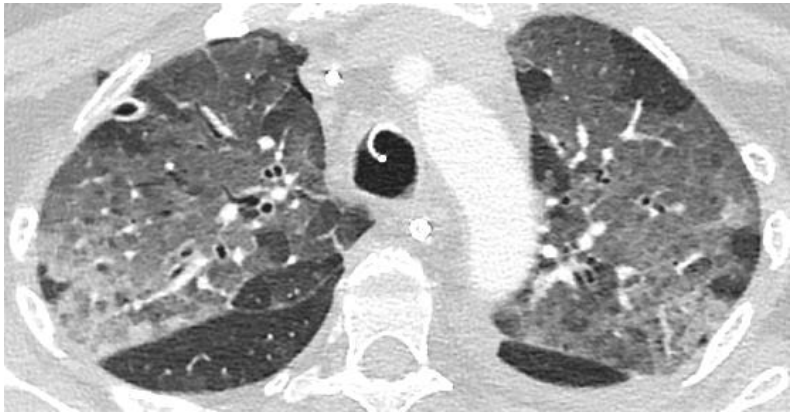
- Partial alveolar filling
- Alveolite: wall or luminal infiltration
- Increased capillary flow : interstitium++

→ lack of specificity because several mechanisms may be at the origin of this phenomenon

Etiologies
More than a hundred possible etiologies!!!

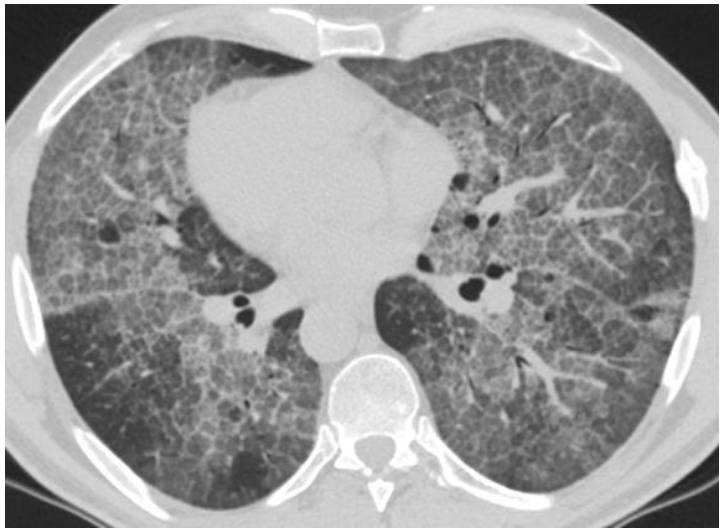
Several pattern

- Centrolobular
- Patchy
- In mosaic
- Crazy paving
- Under pleural
- Diffuse

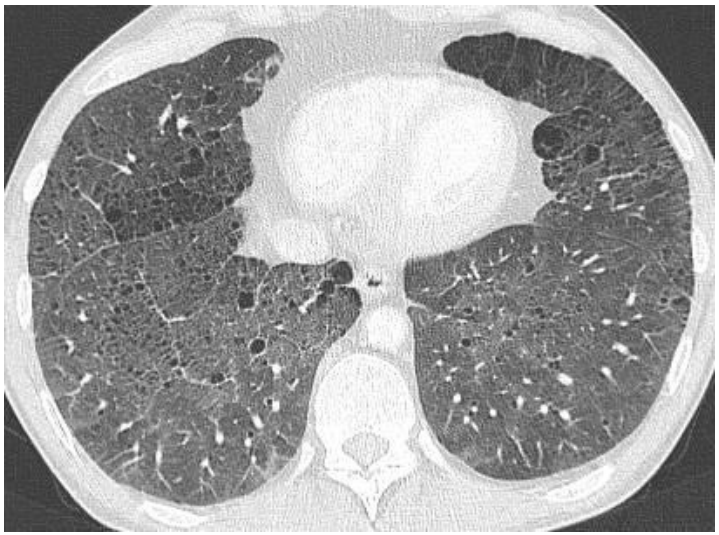


Mosaic

Crazy paving



Diffuse



GGO diagnostic

Location

Diffuse
- PO +++
- Pneumocystis ++
- Drug ++
- Haemorrhages and vasculitis (Churg Strauss, lupus, Good pasture, microangiitis)
- HSP acute/subacute
- ARDS
- Sarcoidosis

Diffused + respect of the regions under pleural
- Pulmonary oedema
- Pneumocystis
- Alveolar hemorrhage
- (LPA)

Periphery
- ILD +++
- Asbestosis
- Drugs

Immunodepression

- Immunosuppressed
  → Opportunistic infections
    - Pneumocystis
    - CMV, HSV, RSV (respiratory syncytial virus)
    - Other viruses
- Aplasia (bone marrow transplant)
  - + Diffuse alveolar damage, alveolar hemorrhage
  - + Drug Toxicity

Temporality

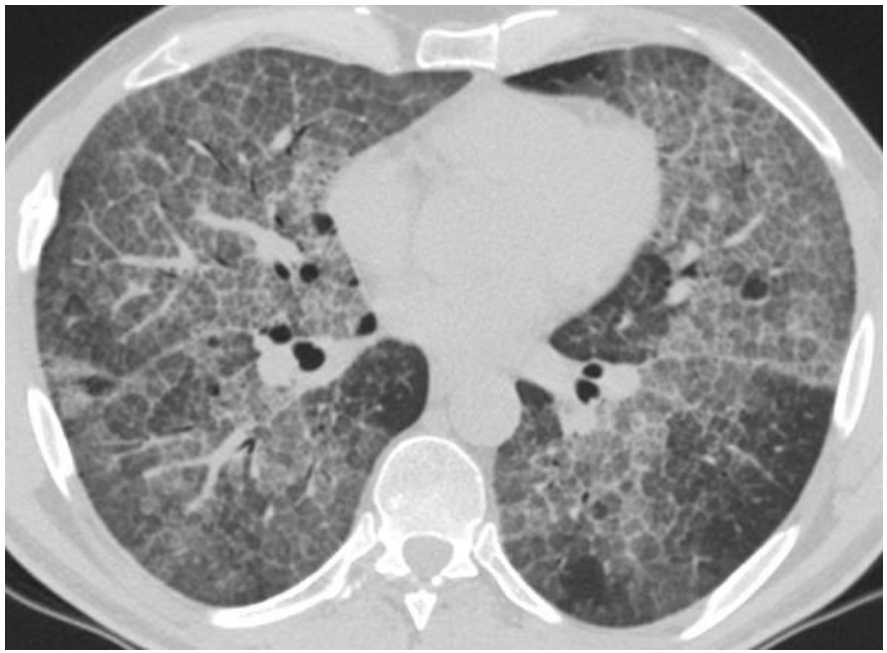
Acute/subacute
- PO
- Pulmonary hemorrhage
- *Mycoplasma pneumoniae*
- Hypersensitivity
- Drugs
- AIP
- Pneumocystis
- Viral (herpes, CMV)
- OP

Progressive dyspnea
- Hypersensitivity Pn
- DIP (desquamative)
- AIP
- NSIP
- RB LTD
- Sarcoidosis
- PO
- Alveolar proteinosis
- adenoK

Crazy paving

Association of

- **GGO**
- Inter-lobular septal thickening
- **Intra-lobular septal thickening**



Etiologies Crazy paving

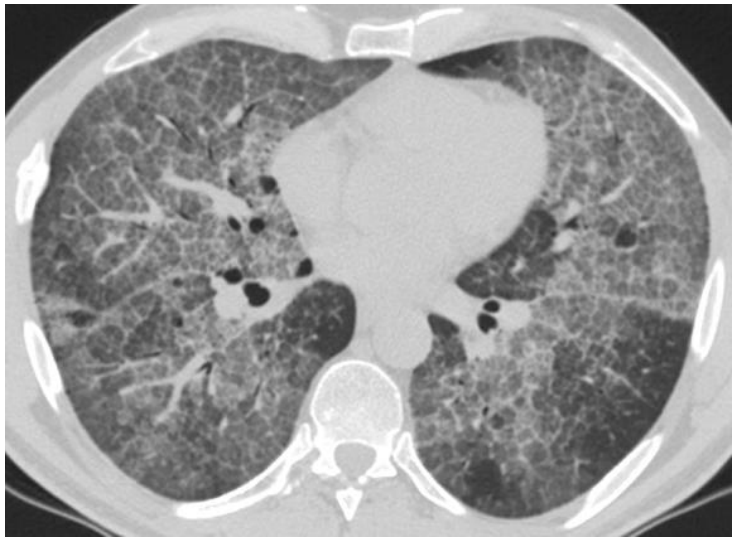
- **Alveolar proteinosis +++** ➡

but also...

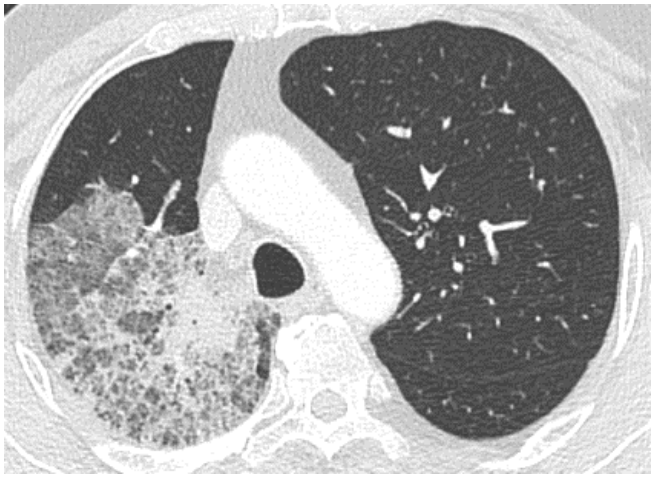
- Pulmnonary oedema ➡
- Infectious pneumonia (viral++) ➡
- Pneumocystis ➡
- Drug induced pneumonia ➡
- Exogenous lipid pneumonia ➡
- Acute eosinophilic pneumonia ➡
- AIP / ARDS ➡
- Lepidic ADK ➡
- Alveolar hemorrhage ➡

Crazy Paving

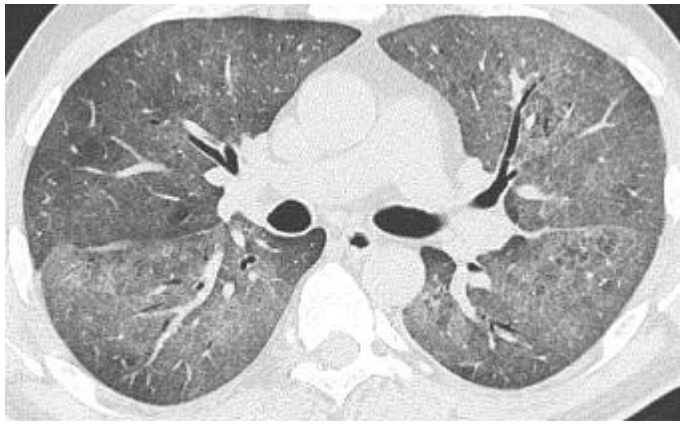
Alveolar proteinosis



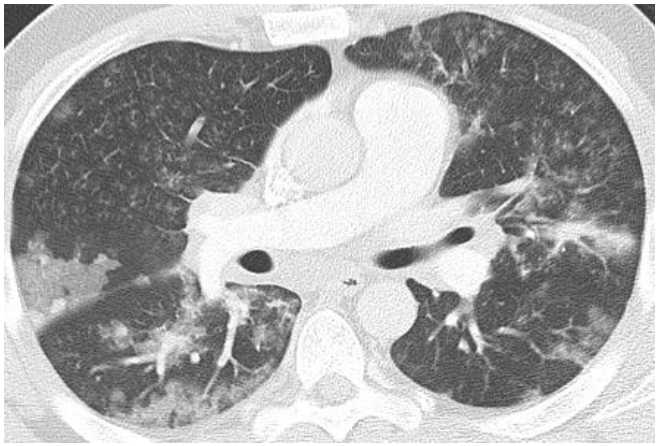
Lepidic adenocarcinoma



Pneumocystis



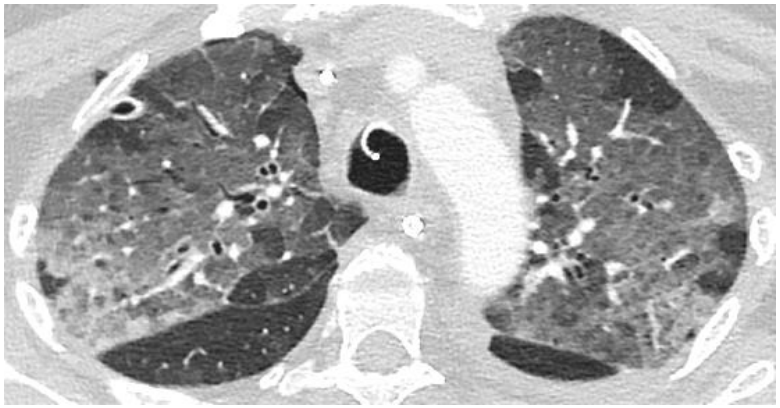
Atypical pneumonia



GGO mosaic

Definition

- Coexistence of
  - **GGO** areas
  - Areas of **normal** or decreased **lung density**
- Distribution **often systematized** lobular, pluri-lobular, sub-segmental
- This aspect is present in several types of damage: alveolitis, bronchiolitis (trapping) or vascular obstruction lesions.

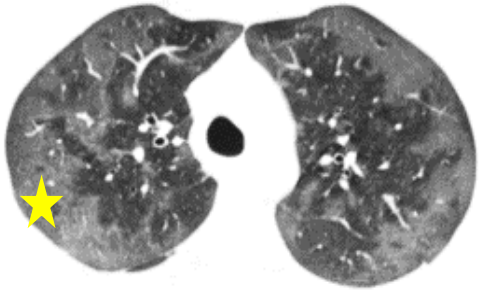
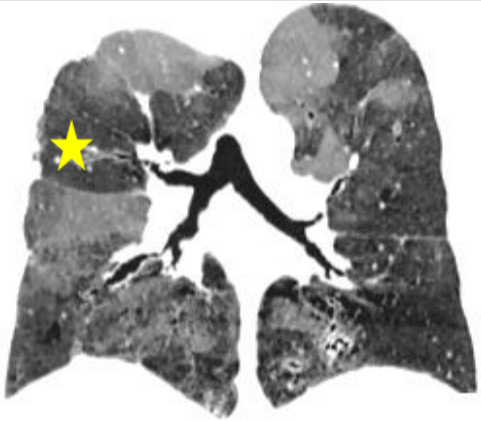
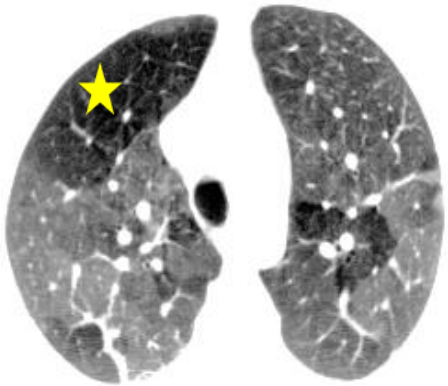


- Alveolitis
  - **Inflammatory** lesions of the alveolar wall
  - Fuzzy contours, not systematized
  - GGO = pathological areas

OR

MOSAIC PERFUSION

- Bronchiolar pathology
  - **Bronchiolar obstruction**
  - Clear areas of **trapping** (where hypoxic reflex vasoconstriction is added) = pathological areas
- Vascular
  - **Pulmonary arterial thrombosis**
  - Blocked arteries
  - Clear **hypoperfused** territories (= pathological)
  - Hyperperfusion in healthy territories (GGO)

	Alveolitis	Bronchiolitis	Vascular
Pathological territories ?	 Pathological territories are those affected by GGO (alveolitis)	 Pathological territories have decreased lung density	
Expiration ?		**Trapping** (When the GGO gradient increases on expiration)	
Vessels?		**Mosaic Perfusion** Caliber Normal or decreased	Caliber Decrease

Head cheese sign

Physiopathology

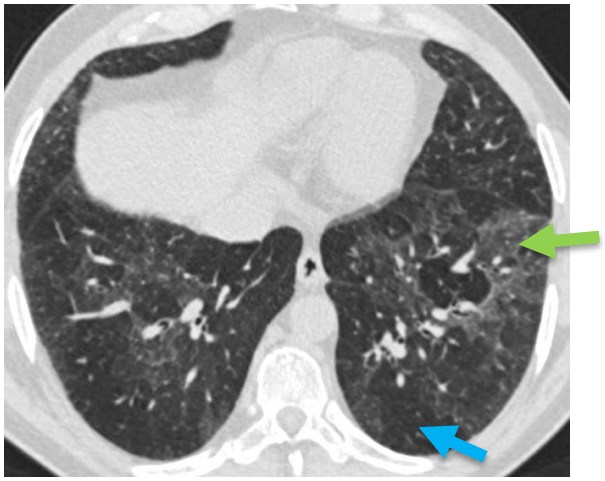
= ALVEOLITIS + BRONCHIOLITIS

- **GGO** mosaic *(alveolitis)*
- **Normal** lung
- **Trapping** involving several lobules *(bronchiolitis)*

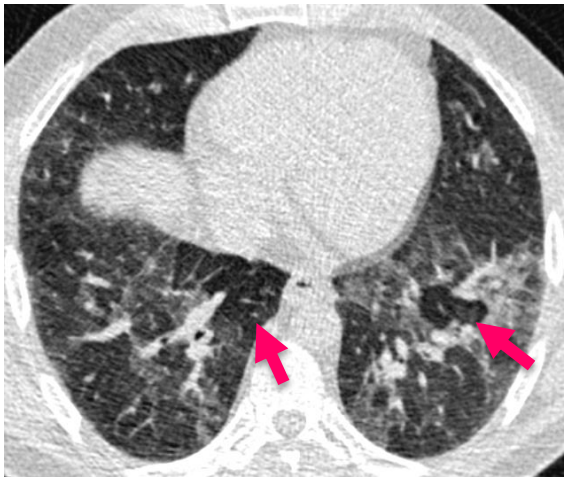
Head cheese sign diagnostic :

- **Hypersensitivity pneumonia+++** ➡
- DIP ➡
- Sarcoidosis ➡
- Atypical pneumonia (viral, mycoplasma…) ➡

In inspiration,
GGO mosaic (alveolitis)
+ Healthy lobules



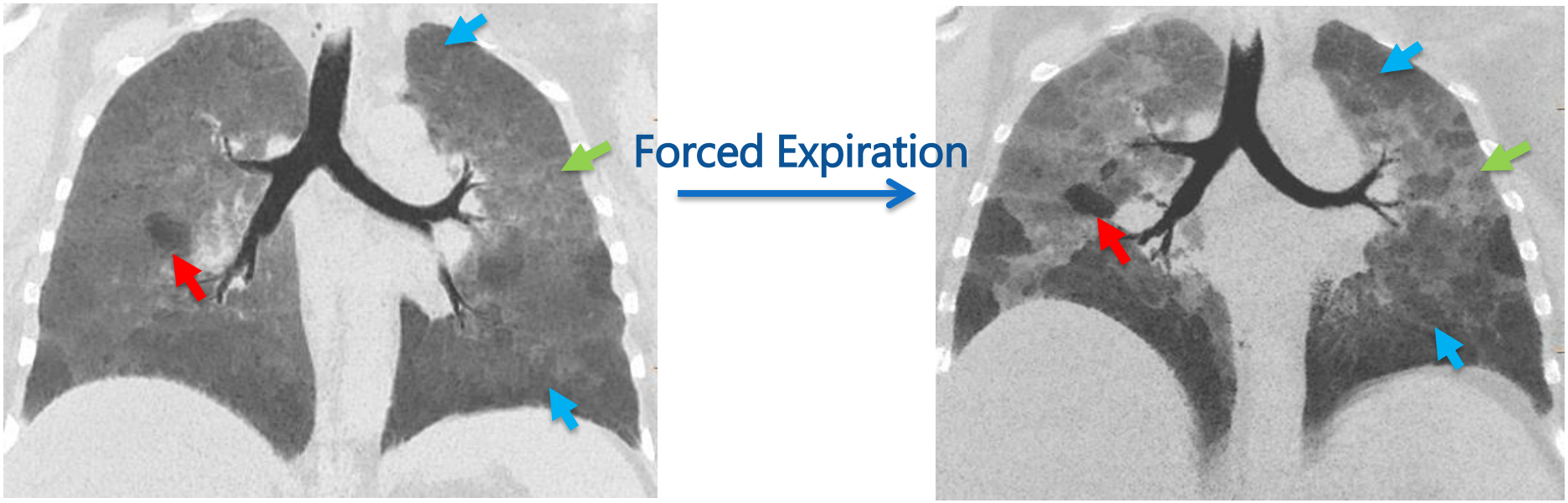
Expiratory
Trapping ++ (lobular)



Head cheese sign
Hypersensitivity pneumonia

In inspiration,
GGO mosaic (alveolitis)
+ Healthy lobules

Expiration
Trapping ++ (lobular)



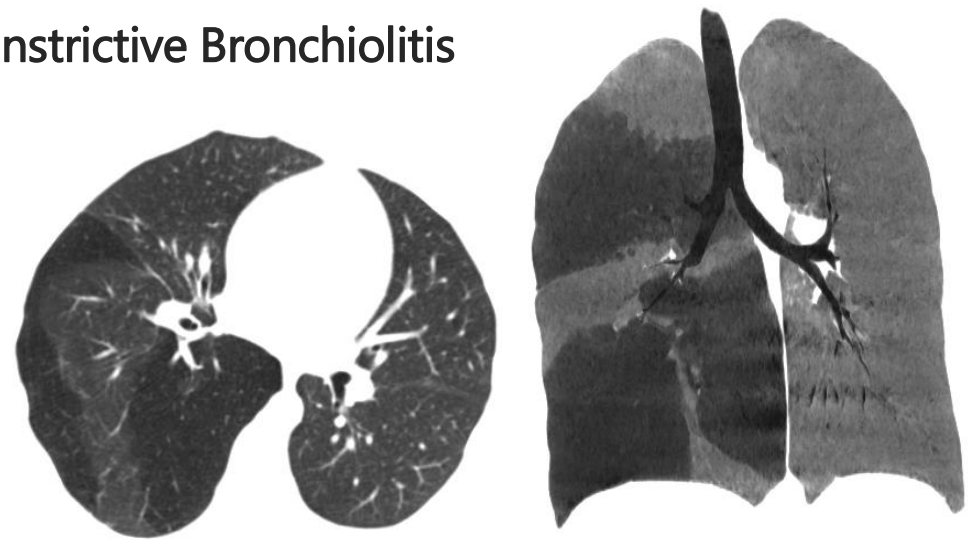
Expiratory trapping

Indirectly explores the **reach of small airways** through the study of **aerial trapping**

- **Chronic pathologies of the airways** (see table etiologies)
- **Mosaic GGO +++** (bronchiolar etiology?)

Use a low-dose protocol for this additional exploration, well enough for "black/white" analysis (0.2mAS/kg).

Constrictive Bronchiolitis



Etiologies affected small airways

- COPD, asthma
- Cystic fibrosis, primary ciliary dyskinesia (PCD)
- Constrictive Bronchiolites
  - Post-infection
    - Adenovirus, RSV, influenza
    - Mycoplasma pneumoniae
    - Mycobacteria
  - Bronchial Aspiration
    - Ammonia, phosgene
  - Collagenoses
    - Rheumatoid arthritis
    - Sjogren's syndrome
  - Transplantation
    - Bone marrow, lung, CP
  - Drugs
    - Penicillamine
  - Others
    - CBID
    - DDB
    - PPA
  - Idiopathic

Consolidation

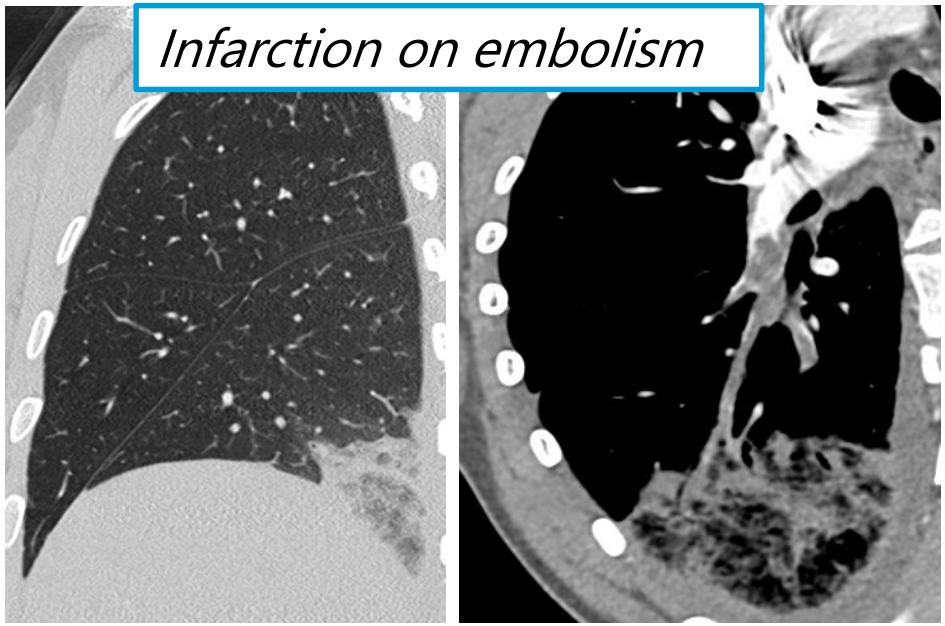
Increased lung density

- Erasing vascular pathways
- Bronchogram
- Absence or low degree of lung collapse (not to be **confused with atelectasis!!!**).

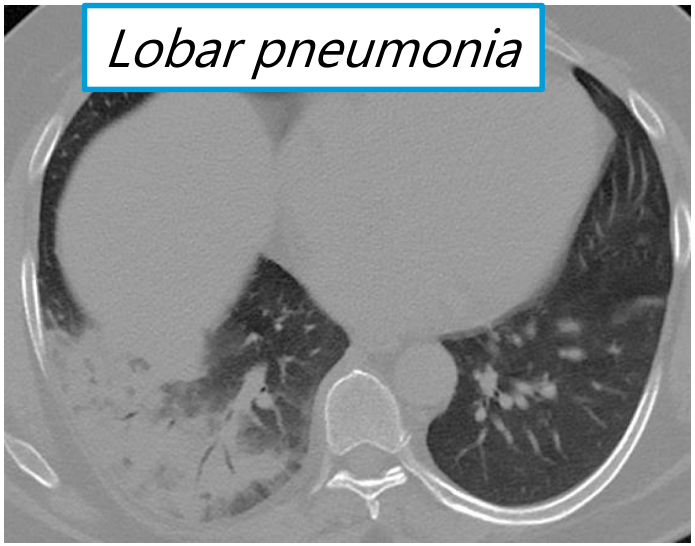
<u>From an etiological point of view</u>
It is essential to distinguish between **acute** and **chronic** consolidation. because the **etiologies** are **different.**

2 examples of acute consolidation

Infarction on embolism



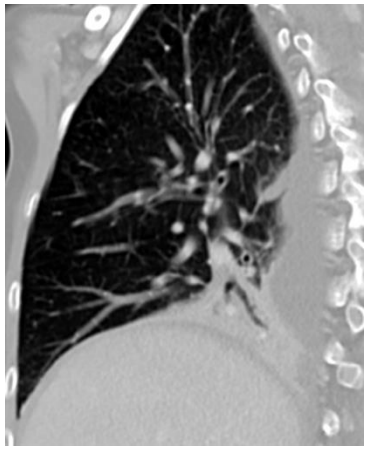
Lobar pneumonia

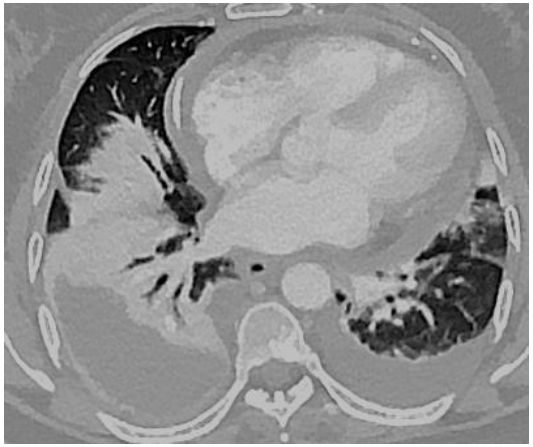


Differentiating consolidation / atelectasis

Atelectasis

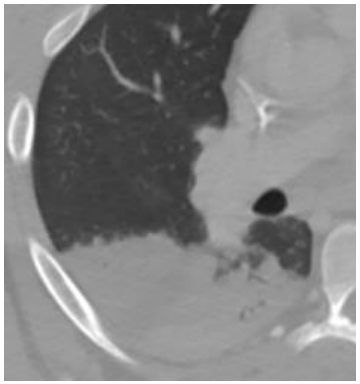
- **Triangular appearance with concave, sharp edges** (use sagittal+++ reconstructions) (consolidation have convex edges, blurred contours with adjacent GGO)
- **Pinching of bronchial structures and vessels**
- **Loss of lobe volume,** fissure attraction
- **Location** (lower lobe++, declive...)/ effusion
- **Contrast pickup +++** if chest IV
- Bronchogram : non-discriminating

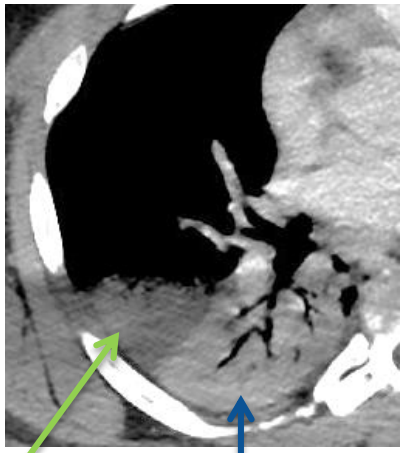




atelectasis

- *Triangular*
- *Concave edges*
- *Loss of volume*
- *Pinching of the bronchi*

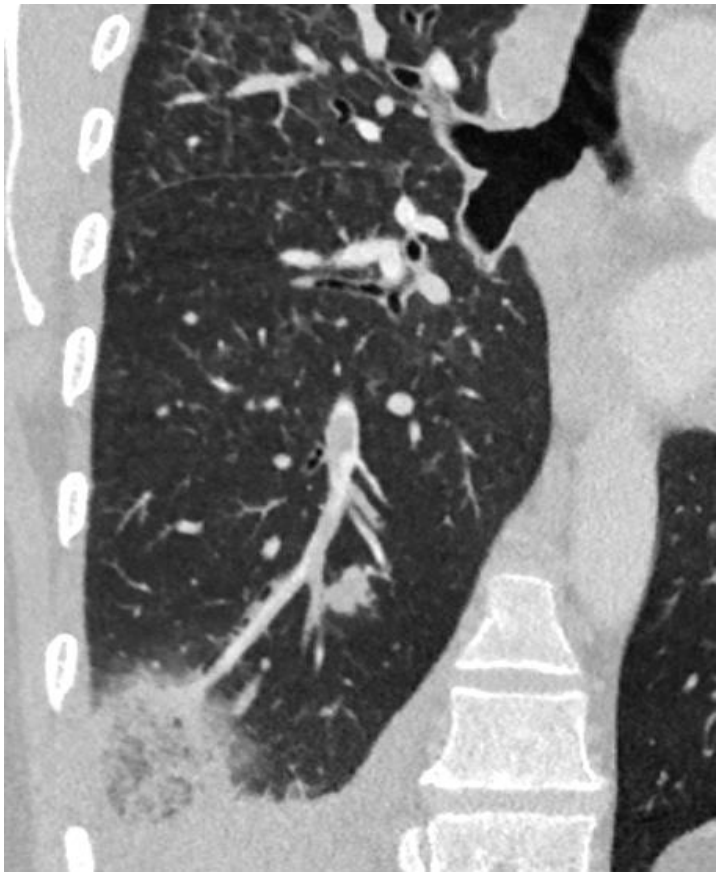




Consolidation
Lack of contrast pickup

Atelectasis
Contrast pickup

Pulmonary infarction



"central lucencies"

- **Peripheral** consolidation
- GGO and **central** intra-lobular reticulation

Reflex!

Peripheral Triangle + **« central lucencies"**

→ Evoke pulmonary infarction → **Angio CT**

Revel MP, Triki R, Chatellier G, Couchon S, Haddad N, Hernigou A,et al. Is It Possible to Recognize Pulmonary Infarction on Multisection CT Images - Radiology 2007

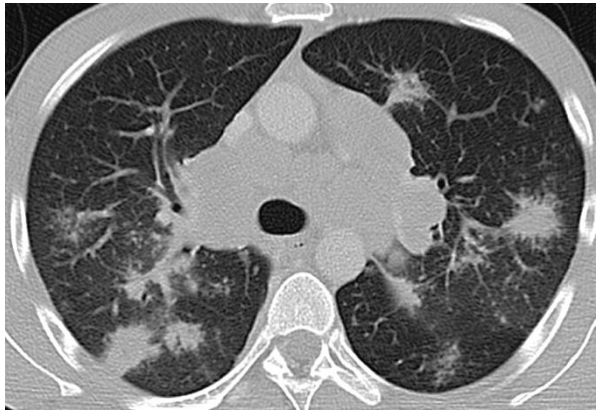
Chronic Consolidation

The 6 most frequent causes of chronic consolidation in the non-immunocompromised patient

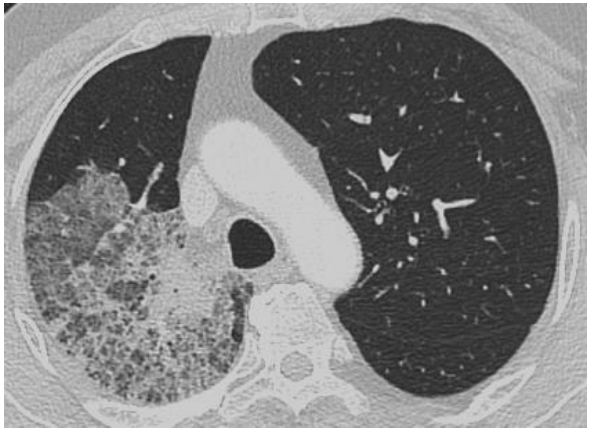
- **Sarcoidosis** ➡
- **ADKL** Lepidic adenocarcinoma ➡
- **Lymphoma** ➡
- **OP** Organizing Pneumonia ➡
- **Connective tissue disease** ➡
- **CEP** Chronic Eosinophilic Lung Disease ➡

Rare

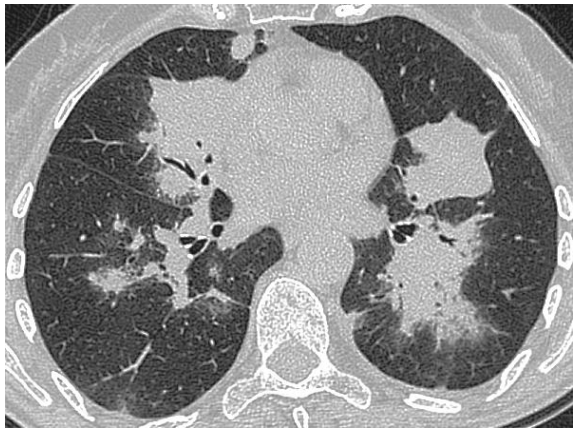
- Exogenous **lipid** pneumopathy ➡
- **Drug related** pneumonia ➡
- **Small** vessel **vasculitis** (Churg Strauss, Wegener) ➡
- **Pneumoconiosis (silicosis...)** ➡
- **Radiation** pneumonia ➡
- **IPF** ➡
- Pulmonary **amyloidosis** ➡
- **Crohn's** disease ➡



Sarcoidosis



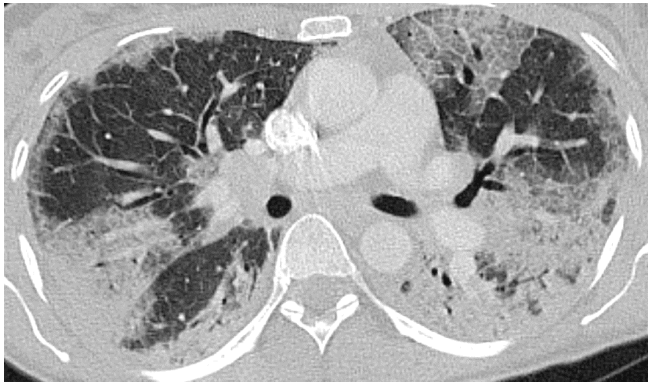
Lepidic adenocarcinoma



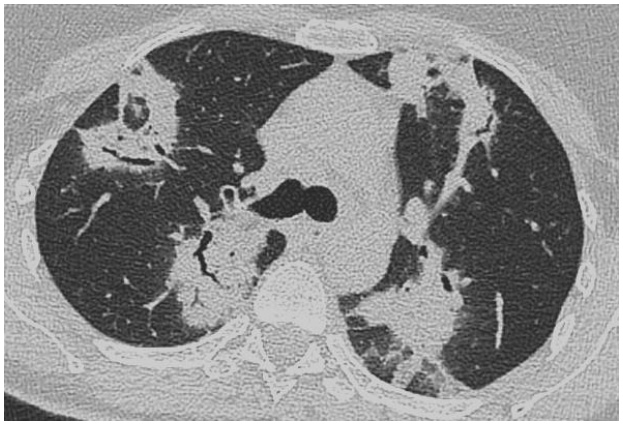
Lymphoma MALT

The 6 most frequent causes of chronic consolidation in the non-immunocompromised patient

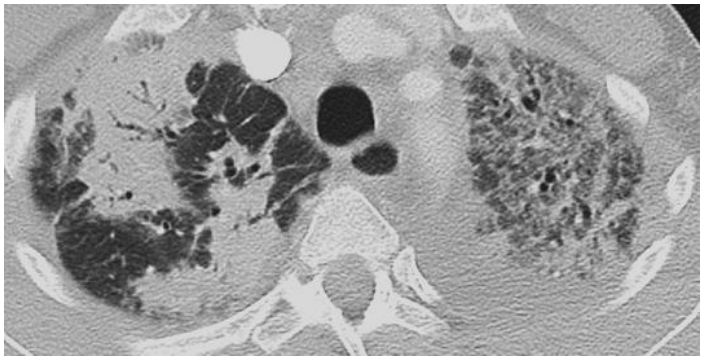
- **Sarcoidosis**
- **Lepidic adenocarcinoma**
- **Lymphoma**
- **OP** Organizing Pneumonia
- **Connective tissue disease**
- **CEP** Chronic Eosinophilic Lung Disease



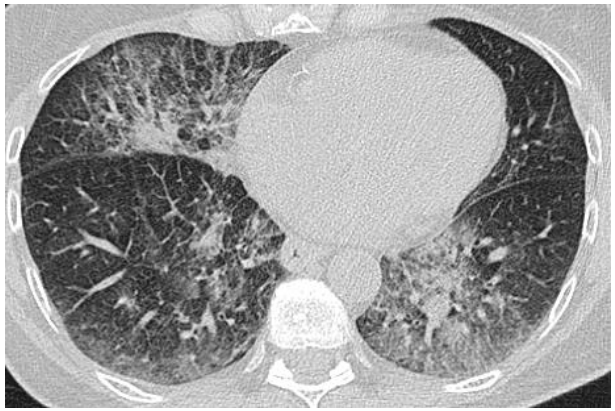
Dermato polymyositis



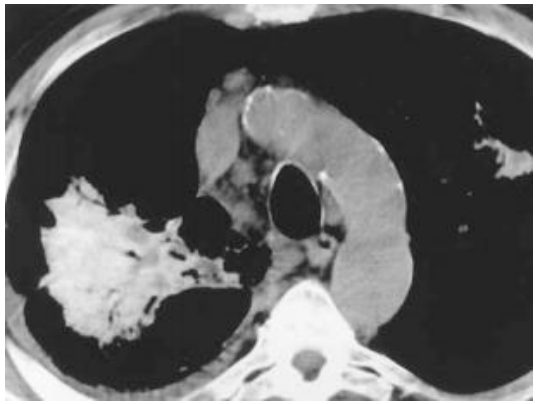
Organizing pneumonia



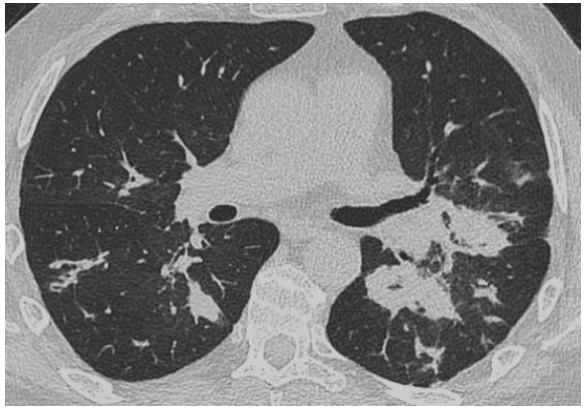
Chronic eosinophilic pneumonia



Lipid pneumonia



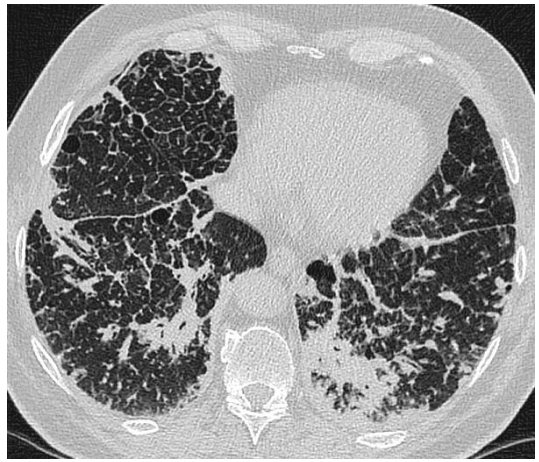
Cordarone Lung



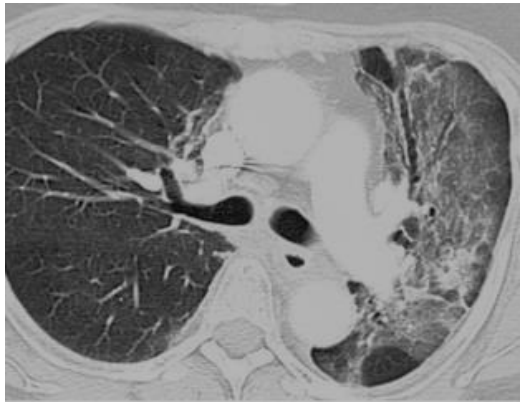
Wegener

Rare

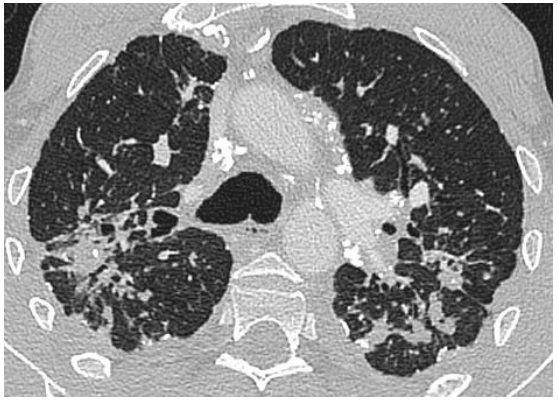
- Exogenous **lipid** pneumonia
- Drug induces pneumonia
- **Small** vessel **vasculitis** (Churg Strauss, Wegener)
- **Pneumoconiosis**
- **Radiation** pneumonia
- **IPF**
- Pulmonary **amyloidosis**
- **Crohn's** disease



Amylose



Radiation pneumonia



Silicosis

Nodule

Definition

Pulmonary infiltration by **round shaped opacities with a diameter of 1 to 30 mm**

- Micronodule < 5 mm
- Nodule > 5 mm
- (Mass > 3 cm)

Single nodule

Malignant tumors

- Bronchopulmonary cancer
- Lung metastasis
- Lymphoma
- Primitive carcinoid tumors

Minor injuries

- Granuloma
- Intrapulmonary lymph nodes
- Hamartochondroma (10%)
- Other causes (10%)

} 80%

Rare lesions

- Tumoral
  - Fibroma
  - Chondroma
  - Leiomyoma
  - Lipoma
- Inflammatory, infectious
  - Focal organized pneumonia
  - Plasmocyte granuloma
  - Winding atelectasis
  - Pneumatocele
- Non-infectious
  - Necrobiotic nodule (PR)
  - Wegener's Granulomatosis
- Vascular
  - Arteriovenous malformation
  - Pulmonary arterial aneurysm
  - Pulmonary varicose veins
  - Pulmonary infarction
  - Hematoma
- Others
  - Bronchocele
  - Mucoid Impaction

Nodule analysis

1) Size

- Less than 5 mm: often benign
- More than 1 cm: often malignant

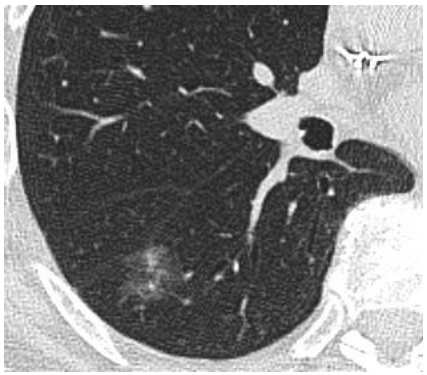
2) Morphology

- Vessel-attached multilobulated form: AVM
- Bilobed glove finger shape: mucoid impaction
- Triangular, polygonal shape: intra-pulmonary lymph node
- Spiculated shape: neoplasia

3) Content

- **Excavation +++: evaluate the wall thickness**
  - < 5 mm: 95% benign
  - 5-15 mm: 73% benign
  - **>15 mm: 84% malignant**
- **Calcification ++:**
  - Diffuse: calcified granuloma
  - Lamellar, concentric: tuberculoma
  - Pop corn: hamartochondroma
  - Off-centre or scattered: neoplasia
- **Fat tissue (-40 to -120 HU)++** Hamartochondroma
- **Contrast enhancement ++** (MRI or CT scan injected)
  - Highly enhanced tumours: sclerosing hemangioma, carcinoid tumour, intrapulmonary solitary fibrous tumour, intrapulmonary Castelman, metastasis and primary neoplasia

4) Density



Mixed nodule

Pre-invasive lesion +++

- GGO = lepidic component
- Solid component = invasive component

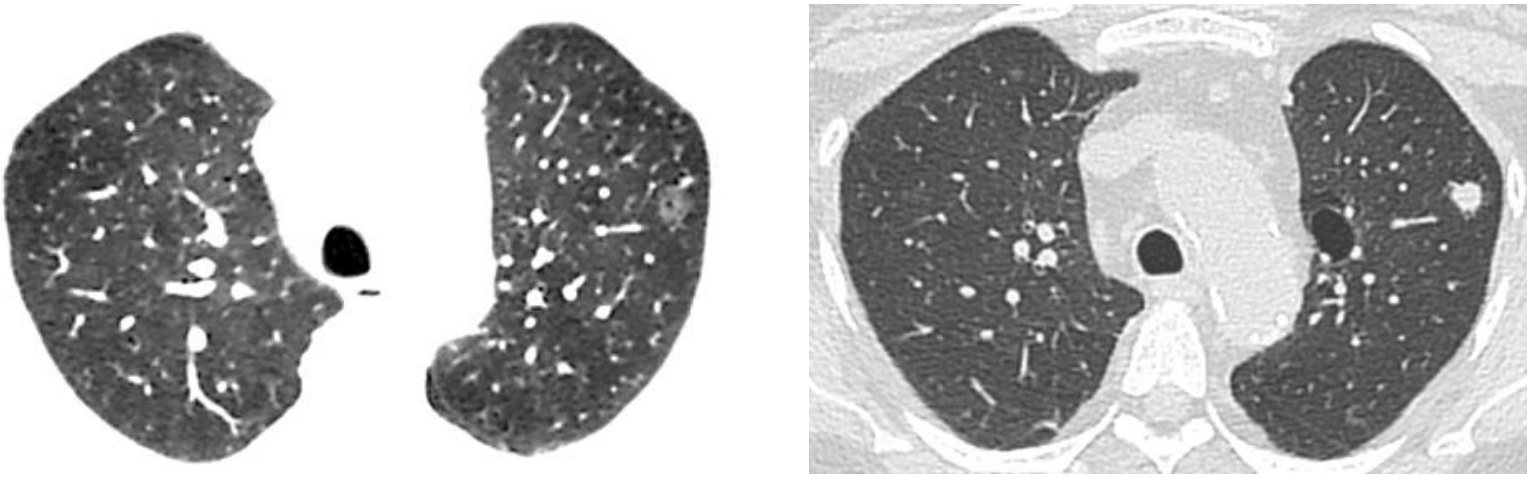
GGO glass nodule

- **Antibiotic test treatment** (to eliminate focal pneumonia)
- Etiologies (table)
- **Very long doubling time** (if neoplastic) monitoring very **spaced in** time
- Pejorative criteria
  - Size increase
  - Appearance of a solid component

Etiologies

- Pre-invasive lesions
  - Atypical adenomatous hyperplasia (AHA)
  - Adenocarcinoma in situ
  - Minimally invasive adenocarcinoma

  Slow evolution, very good prognosis, 5-year survival close to 100%. GGO nodule or partially solid nodule.
- Non-neoplastic
  - **Focal Lung Disease (FLD)**
  - Small area of desquamative (tobacco) lung disease or fibrosis

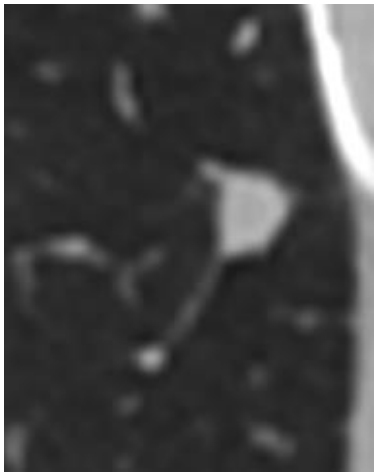


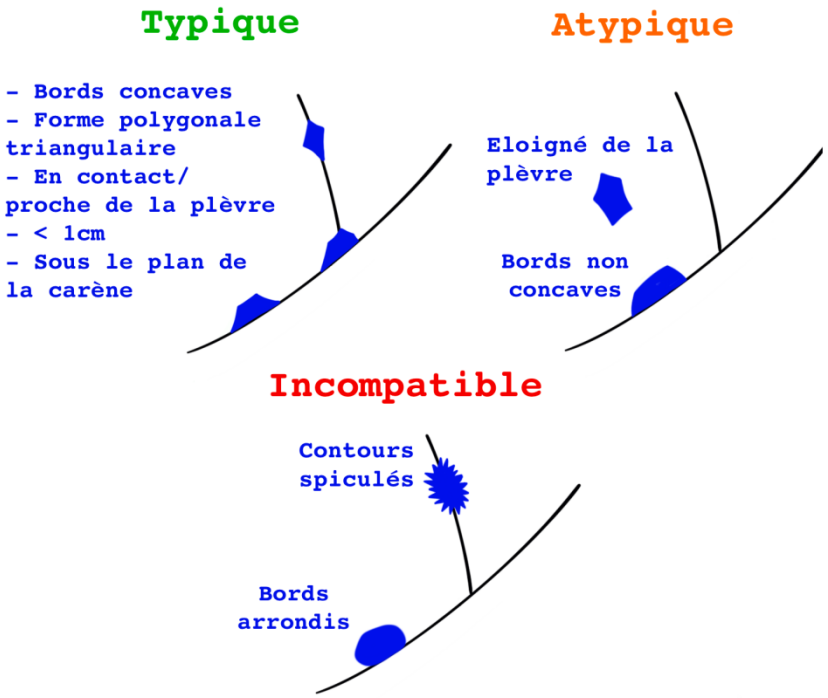
Evolution in adenocarcinoma of a GGO nodule in 2 years

Benign nodules

Intrapulmonary ganglion +++

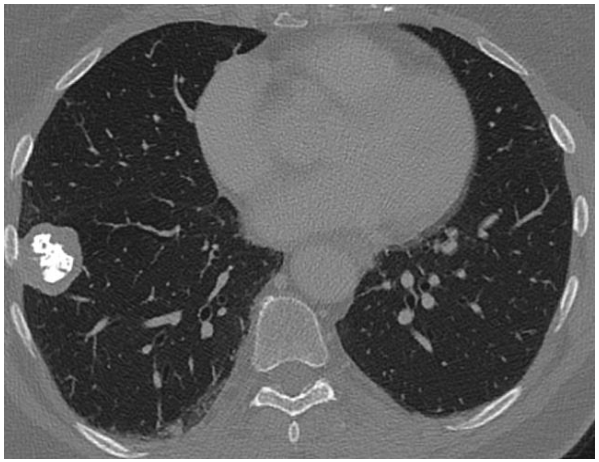
- **Triangular** or **polygonal** nodule
- **Smooth edges**
- Measuring <10mm
- Located **under the carina** (bases)
- **Less than 10mm from a pleural or scissural**

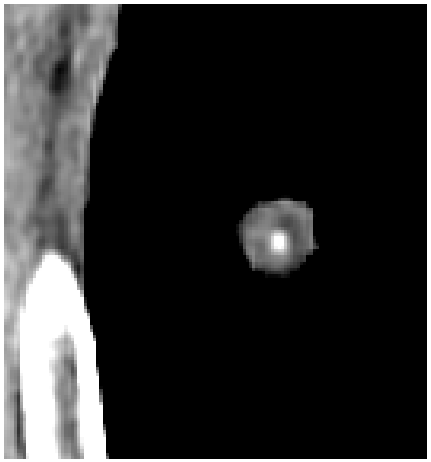


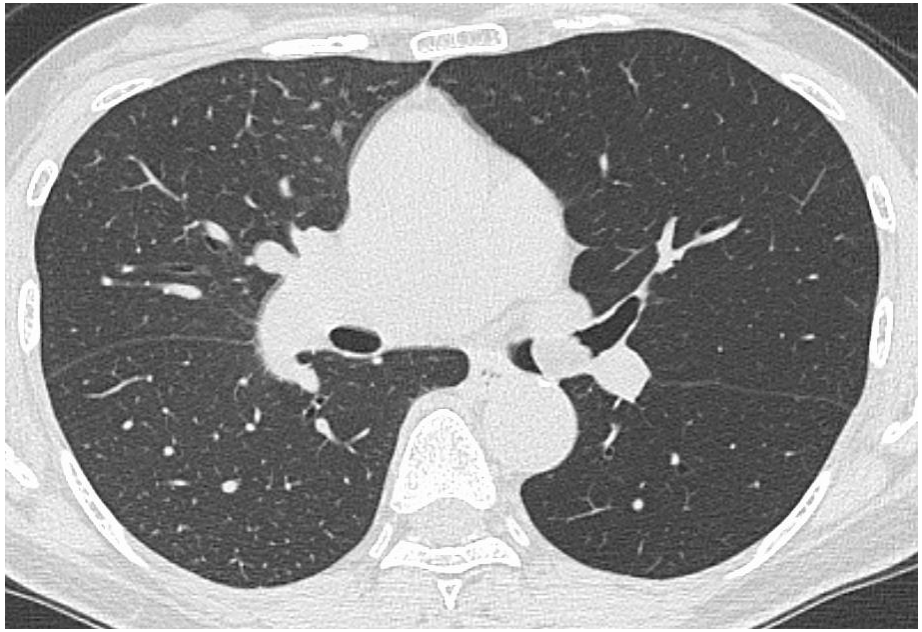


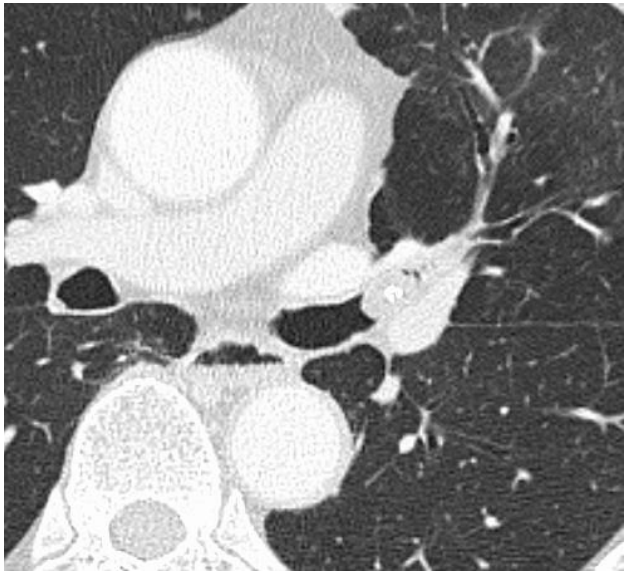
Hamartochondroma +++

- **Most common benign lung tumour**
- **Intra parenchymal, peripheral (90%)**
- **Composition**
  - Cartilage +/- calcifications
  - Bronchial epithelium
  - Fat tissue (-40 to -120 HU)
  - Cystic portions
- **Popcorn calcification (not enough)**
- **Fat ++ (pathognomonic)**



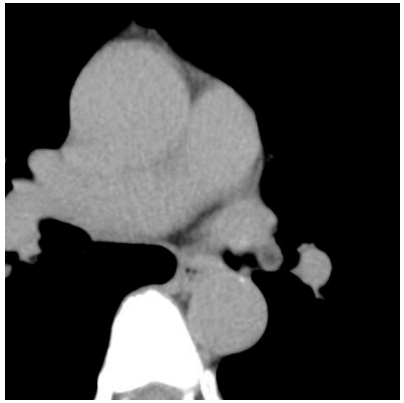


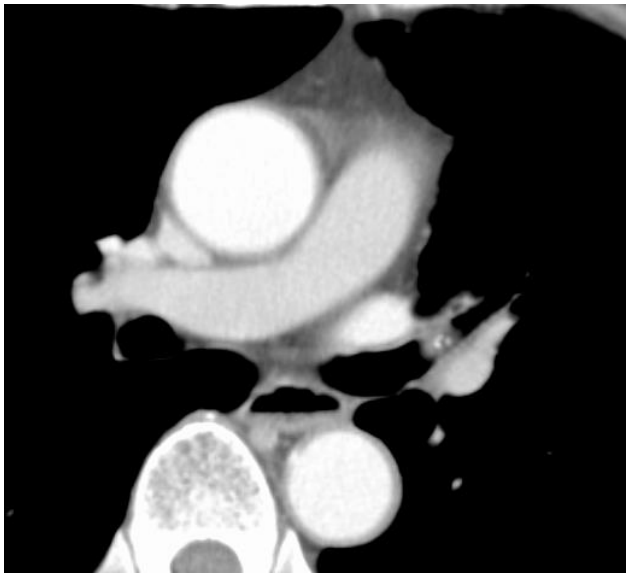


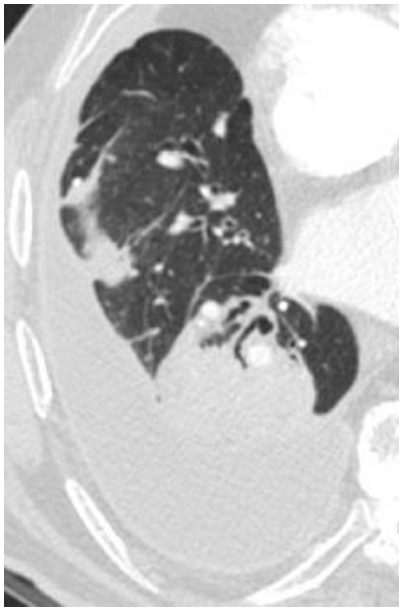


Endobronchial Hamartoma

- Large bronchus
- Tumour well circumscribed
- Light obstruction
- Central fat + fibrous part

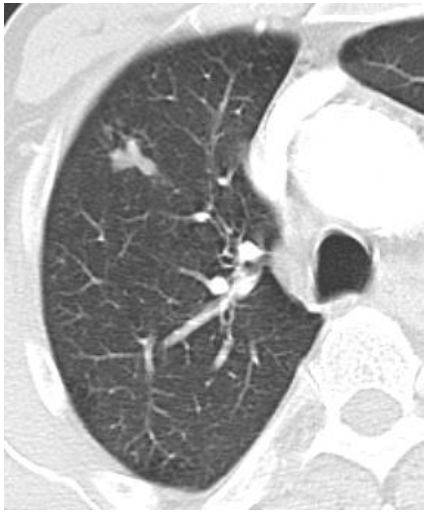


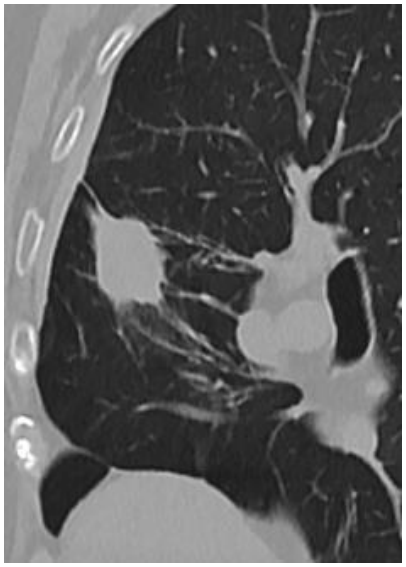


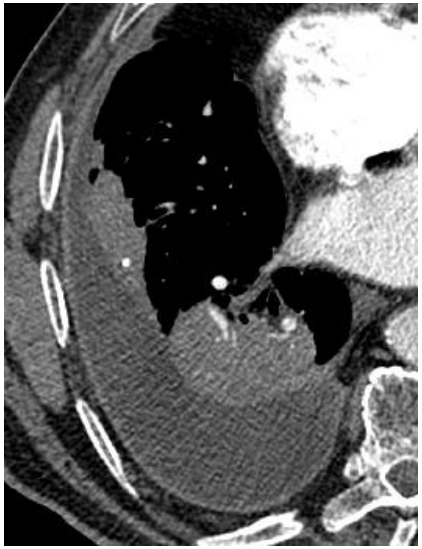


Round atelectasis ++

- **Oval or round atelectasis on pleural pathology** (pleural fibrosis/asbestosis, TB...)
- **Round, oval** shape
- **Thickened pleura**
- Twist of the vessels and bronchial tubes into a **comet tail.**
- **Enhancement** (not discriminating)
  +/- Calcifications, bronchogram







Mucoid Impaction +++

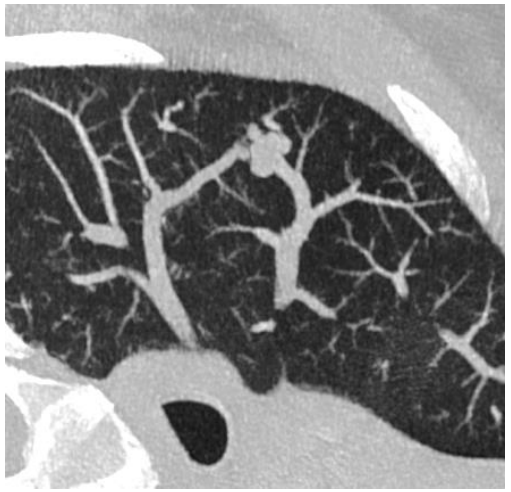
- **Mucus filling of a dilated bronchus**
- V" or "Y" shaped appearance

<u>Variable etiologies</u>

- **Cystic fibrosis**
- **Asthma/ ABPA** (spontaneous hyperdense mucus appearance)
- **Obstructive endobronchial** segmental/sub-segmental **obstructive lesions**
  - Primary / Secondary Carcinoma
  - Carcinoid tumor
  - Congenital bronchial atresia
  - Endobronchial Hamartoma
  - Foreign body/broncholithiasis
  - Endobronchial tuberculosis with bronchial stenosis

Arteriovenous malformation +

- Nodule with **one or more artery(ies) and drainage veins** whose **communication** is objective (PIM)
- Round or oval
- **Lobbed**, well limited
- Multiple (33%), or single (66%)
- Lower lobes (50 to 70%) or 1/3 medium

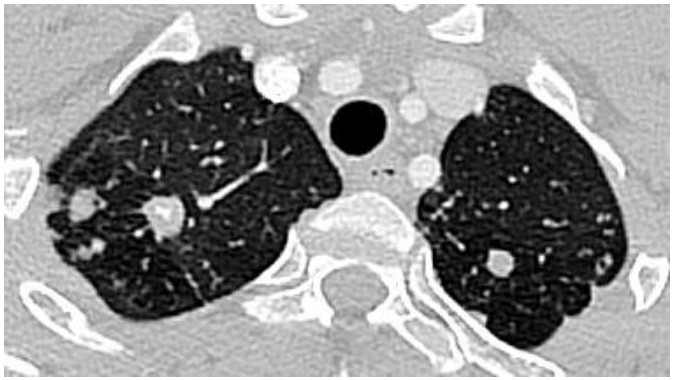


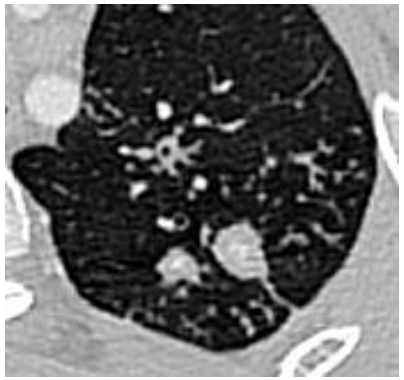
Tuberculoma ++

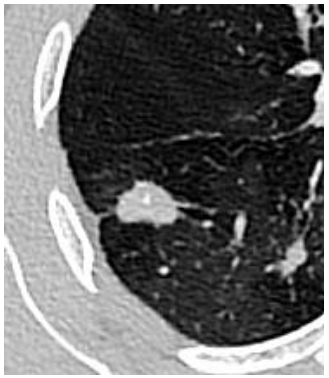
- One of the **most frequent** benign nodules (5 to 24% of nodules resected with sharp borders)
- **Satellite lesions** in 80% of cases
- **Nodular, concentric or diffuse calcification** in 20-30% of the cases.
- Histology: central caseous necrosis, peripheral epithelioid cells, layers of fibrous tissue

Sclerosing hemangioma

- **Rare** benign tumour
- Young or middle-aged woman
- Several histological components: solid, papillary, sclerotic and hemangiomatous.
- Imaging
  - Well limited
  - Juxtapleural
  - **Good ++ enhancement** in MRI or CT, peak at 2 min.
  - Hypo/iso/hyperdense areas



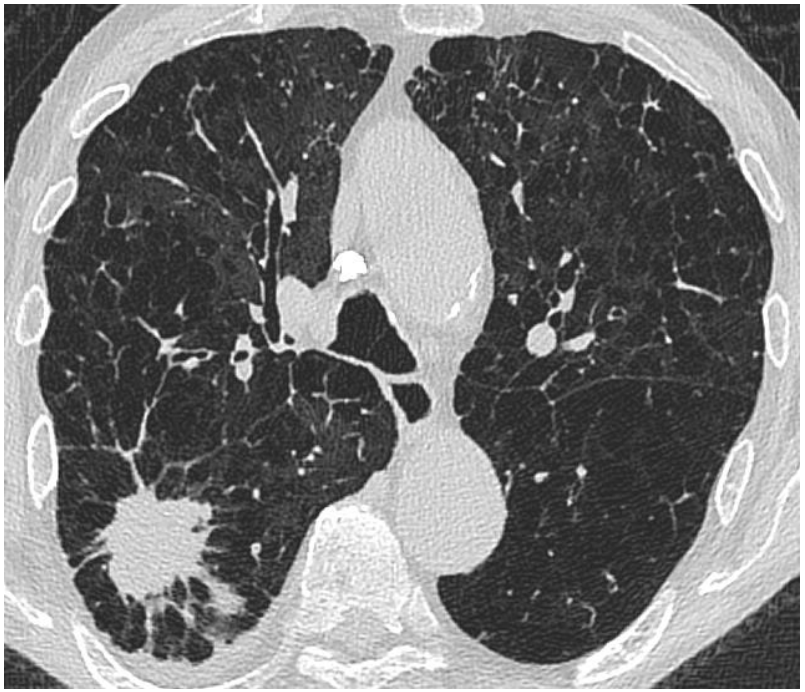




Malignant nodule

Criteria for high suspicion of malignancy

- > 20 mm +++
- Solid / mixed
- Spiculated borders +++
- Excavation
- Eccentric calcifications or scattered clusters
- Evolution +++
- PET scan uptake +++

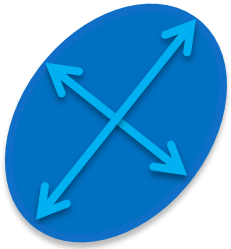


How to think: Nodule

How to measure them?

Fleischner 2017 Recommendations

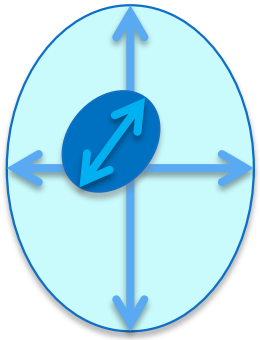
Solid



If < 10 mm: ***average of the 2 axes***
Example: 7 x 9 mm (7 + 9)/2 = 8 mm
If > 10 mm, ***both diameters*** *are mentioned in the report.*

GGO or Mixed

- *GGO size*
  If < 10 mm: ***average of the 2 axes***
  If > 10 mm, ***both diameters*** *are mentioned in the report.*
- *Solid component if > 3 mm, large axis*



- 2D Measurements
- **Axial** cuts
- **Round to the mm**
- Nodules smaller than 3 mm should not be measured (micronodules).
- Taking into account the **oldest imaging**

Single nodule

Fleischner 2017 Recommendations

Low risk

< 6mm.
No monitoring

6-8 mm
CT scan between **6 – 12 months**
Up to **18 - 24 months**

> 8mm
CT scan, PET, biopsy at 3 months

High risk

< 6mm.
Optional 12-month CT scan

6-8 mm
CT scan between **6 - 12 months**
Then at **18 - 24 months**

> 8mm
CT scan, PET, biopsy at 3 months

Multiple nodules

Fleischner 2017 Recommendations

Low risk

< 6mm.	6-8 mm	> 8mm
No monitoring	CT scan between **3 - 6 months** Up to **18 - 24 months**	CT scan at **3 - 6 months** Up to **18 - 24 months**

High risk

< 6mm.	6-8 mm	> 8mm
Optional 12-month CT scan	CT scan between **3 - 6 months** Then at **18 - 24 months**	CT scan at **3 - 6 months** Then at **18 - 24 months**

Nb: apply the recommended follow-up to the most suspect of the CWS.

GGO / mixed nodule

Fleischner 2017 Recommendations

GGO

< 6mm.
No monitoring

≥ 6-8 mm
CT scan between **6 - 12 months**
Then **every 2 years for 5 years** if stable.
Compare to initial CT scan

No follow-up if < 6 mm, but some high-risk patients with nodule < 6 mm may have a CT scan at 2 and 4 years of age.
If growth or appearance of solid portion: consider resection.

Mixed

< 6mm.
Optional 12-month CT scan

≥ 6-8 mm
CT scan between **3 - 6 months**
If unchanged and solid portion < 6 mm,
CT scan **every year / 5 years**
Compare to initial CT scan

A persistent mixed nodule whose **solid portion** is **≥ 6 mm** is considered **very suspect.**

Multiple frosted glass nodules:
- < 6 mm: CT scan at 3 - 6 months to confirm LOC.
If unchanged: CT scan at 2 and 4 years
- ≥ 6 mm: CT scan at 3 - 6 months and then based on the most suspicious LOC.
NB: multiple NPs in frosted glass are most often benign, consider a CT scan at 2 and 4 years if high risk.

PET FDG

Benign/malignant nodule differentiation
(nodule>10mm)
- Sensitivity = 90 %
- Specificity = 83 %

False negatives of malignancy
- **< 8 mm**
- **Carcinoid** tumor
- **Lepidic ADK** (GGO)/low grade adenocarcinoma

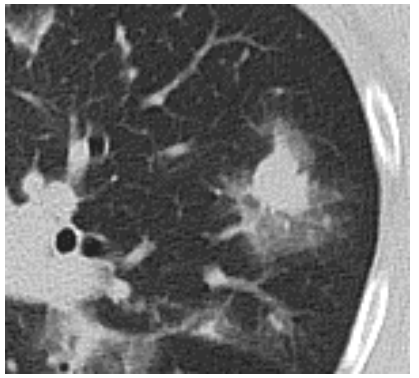
False positives of malignancy
- Tuberculosis, histoplasmosis, cryptococcosis...
- Rheumatoid nodules
- Wegener's Granulomas
- Sarcoidosis
- Lipid pneumonia

Halo sign

Nodule surrounded by a **halo of GGO**

Histology: 3 possible mechanisms in GGO

- Alveolitis
- Alveolar hemorrhage
- Non-specific infiltration

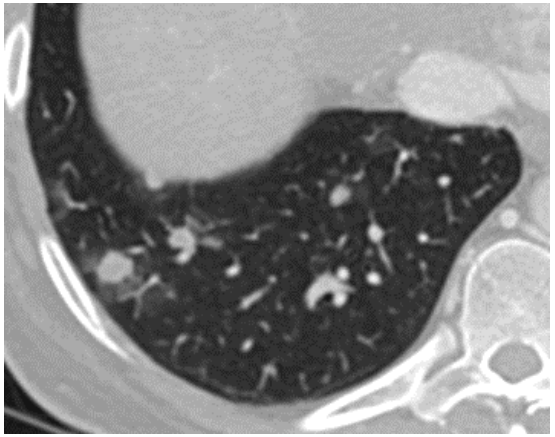


Angio-invasive aspergillosis

Diagnostic halo

- Infectious Diseases
  - **Angio-invasive aspergillosis** ➡
  - Candidosis ➡
  - Viruses: CMV, Herpes ➡
  - Septic Embolism ➡
  - Wegener's Disease (GPA) ➡
- Tumors
  - Haemorrhagic metastasis
  - Kaposi's Sarcoma

Hemorrhagic metastasis of angiosarcoma



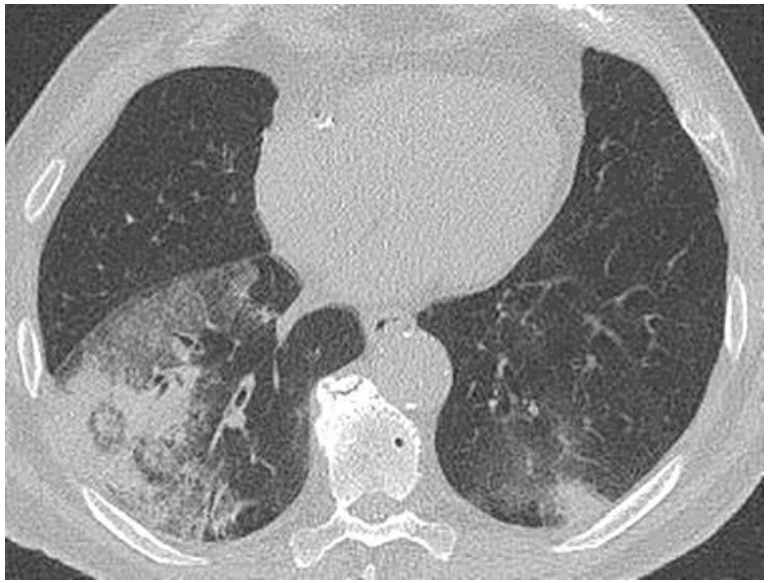
Reverse halo sign

Reverse halo sign = GGO surrounded by a crescent or consolidation ring

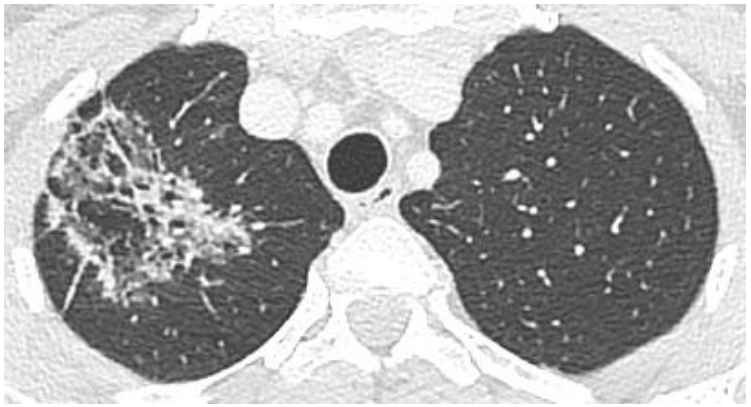
- Atoll sign
- Reverse halo sign

Reverse halo diagnostic :

- **OP** Organizing pneumonia +++ ➡
- **Wegener (GPA)** ➡
- Sarcoidosis
- Invasive aspergillosis
- Pneumocystis
- Tuberculosis
- Lipid pneumonia
- Post RF



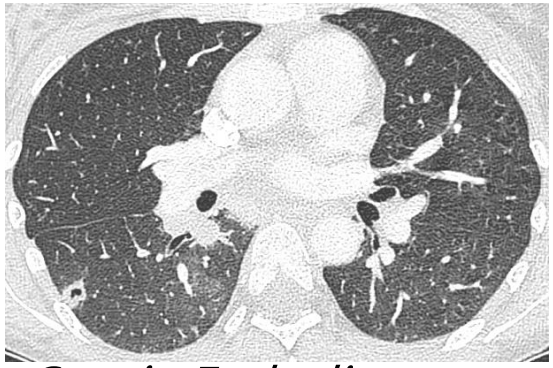
Organizing pneumonia



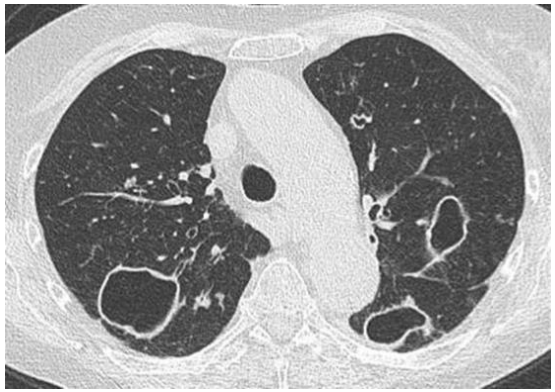
Tuberculosis

Excavated nodules

Histology: **central necrosis++**, ischemic, suppurative or tumourous nec**rosis** or peribronchial cell infiltration with persistent central lumen



Septic Embolism



Wegener's Disease

Diagnostic :

Neoplasia

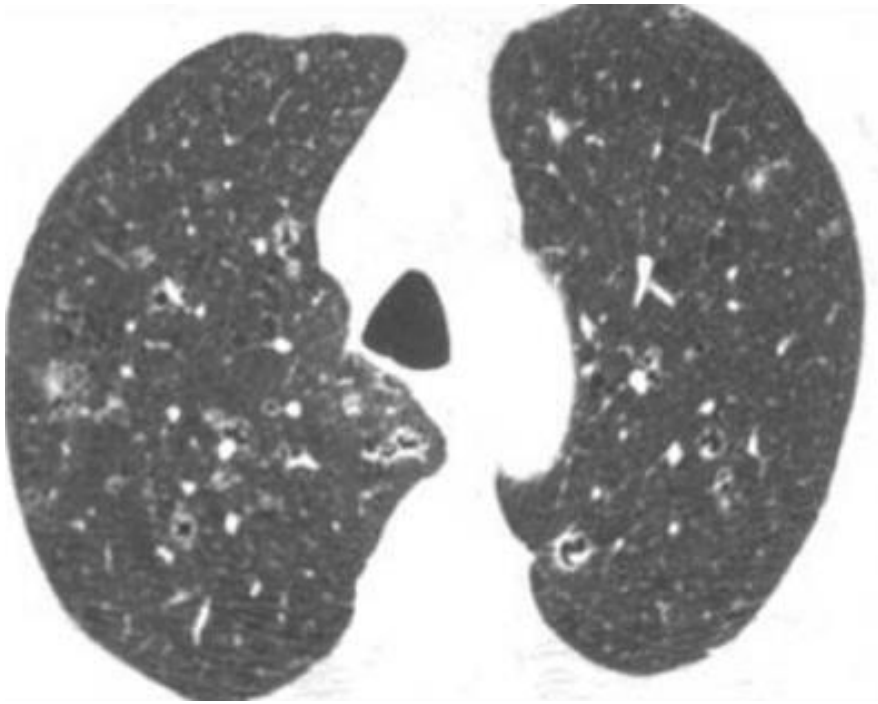
- **Primary bronchopulmonary cancer** ➡
- **Excavated metastasis+++** (squamous cell carcinoma of the cervix or ENT, ADK, sarcoma)
- Tracheobronchial papillomatosis (rare) ➡

Infections

- **Tuberculosis +++** ➡
- **Angio-invasive aspergillosis +++** ➡
- **Suppurative bronchopneumonia/ abscess** ➡
- **Septic embolism+++** ➡
- Rare infections: **nocardiosis**, cryptococcosis, actinomycosis, coccidioidomycosis. ➡

Granulomatosis/Vascularity

- **Wegener (GPA) +++** ➡
- **Nodules** of **aseptic necrobiosis** (**RA**, ulcerative colitis, Crohn's) (perforated nodules) ➡
- **Histiocystis X** (perforated nodules) ➡



Langheransien Histiocytosis

Association

- **Centrolobular irregular nodules**
- **Nodules with holes**
- **Cyst**

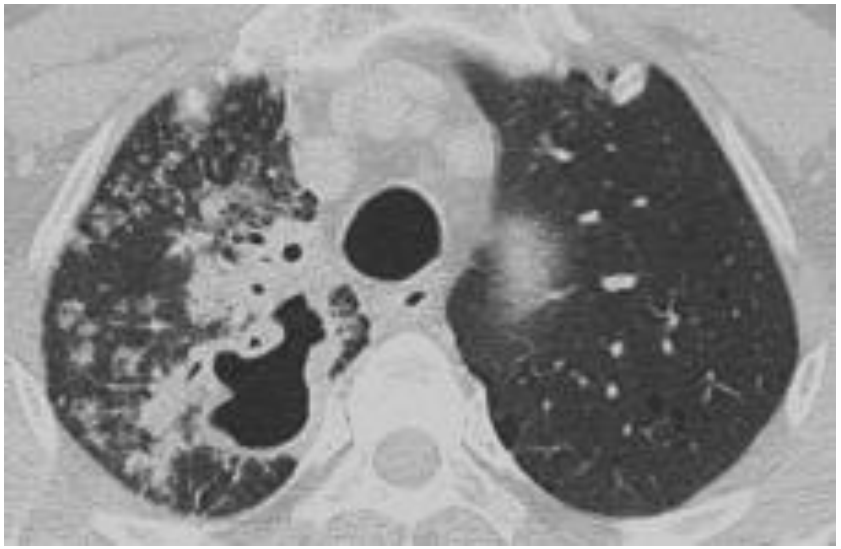
Predominance of **upper regions**

Unique Cavity

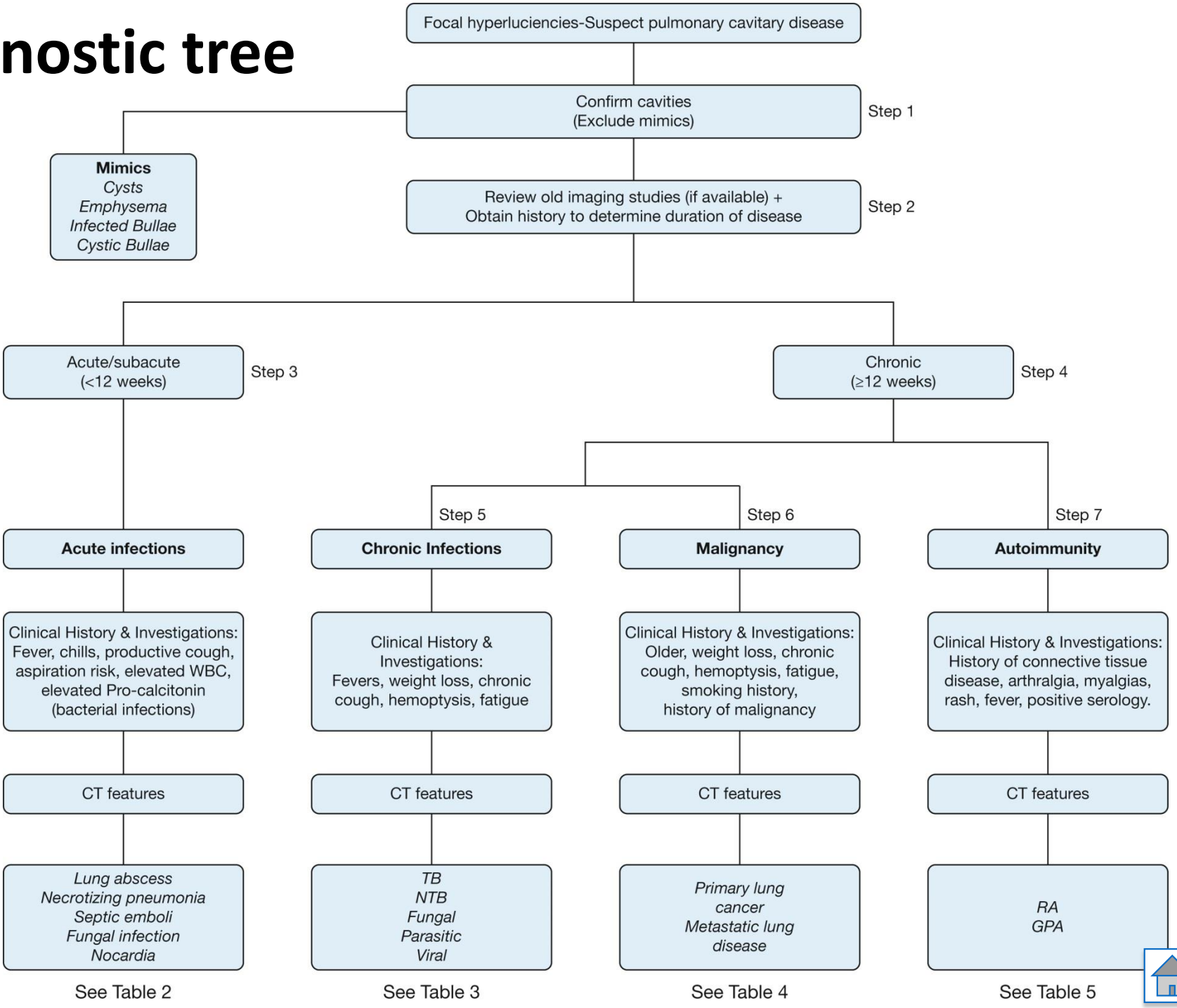
Etiologies single cavity

- **Tuberculosis +++** ➡
- **Bronchopulmonary cancer +++** ➡
- **Abscess ++** ➡
- Metastasis
- Necrosis of a fibrosed mass (silicosis, coal miner's pneumoconiosis) ➡
- Malformations (sequestration, b-cyst, MAK) ➡

Active tubercular cavity
With bronchogenic diffusion
(associated tree in bud)



Diagnostic tree



Multiple Nodules

Tumoral

- **Metastasis**
- **Lymphoma**
- **Lepidic carcinoma**
- Kaposi's Sarcoma
- PTLD
- Benign metastatic leiomyomatosis

Infections

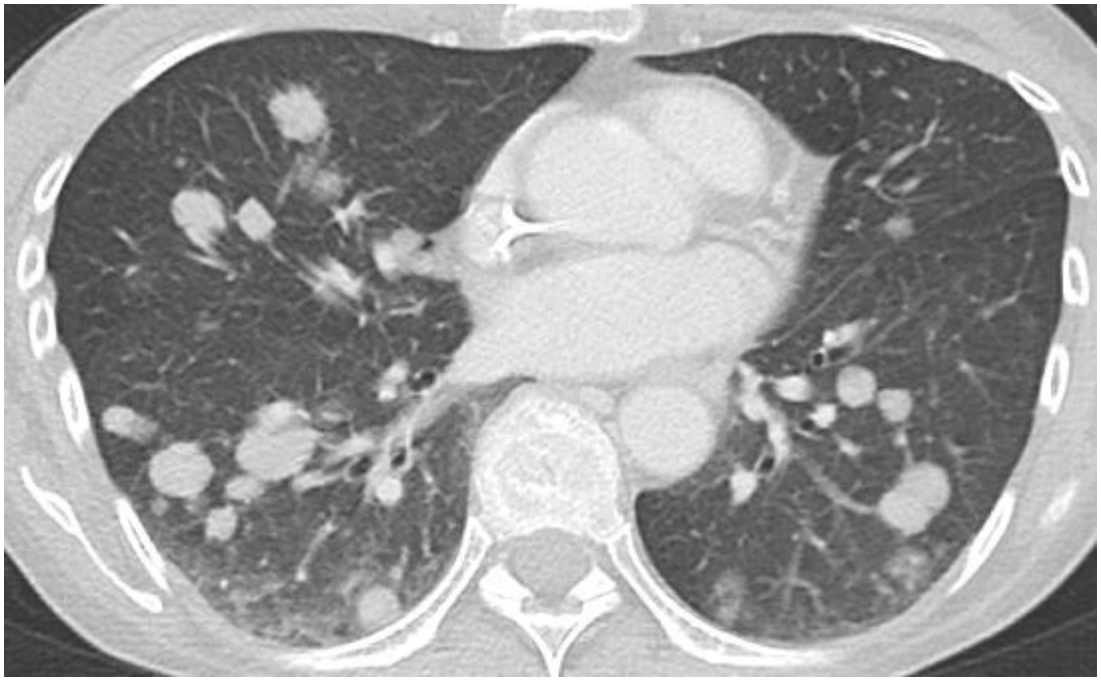
- **Fungal**
  - **Angio-invasive aspergillosis**
  - Histoplasmosis
  - cryptococcosis
- Bacterial
- Nocardiosis
- **Septic Embolism**
- **Viral**: CMV ...
- Mycobacteria

Other

- **Sarcoidosis**
- **Wegener (GPA)**
- Arterio veinous malformation
- Pulmonary infarction
- Amylose
- RL
- Drugs
- Silicosis
- Histiocytosis
- Organizing pneumonia

Rare

- Papillomatosis
- Parasites
  - *Echinococcus*
  - Paragonimiase
  - Cysticercosis
- Lung Chondroma

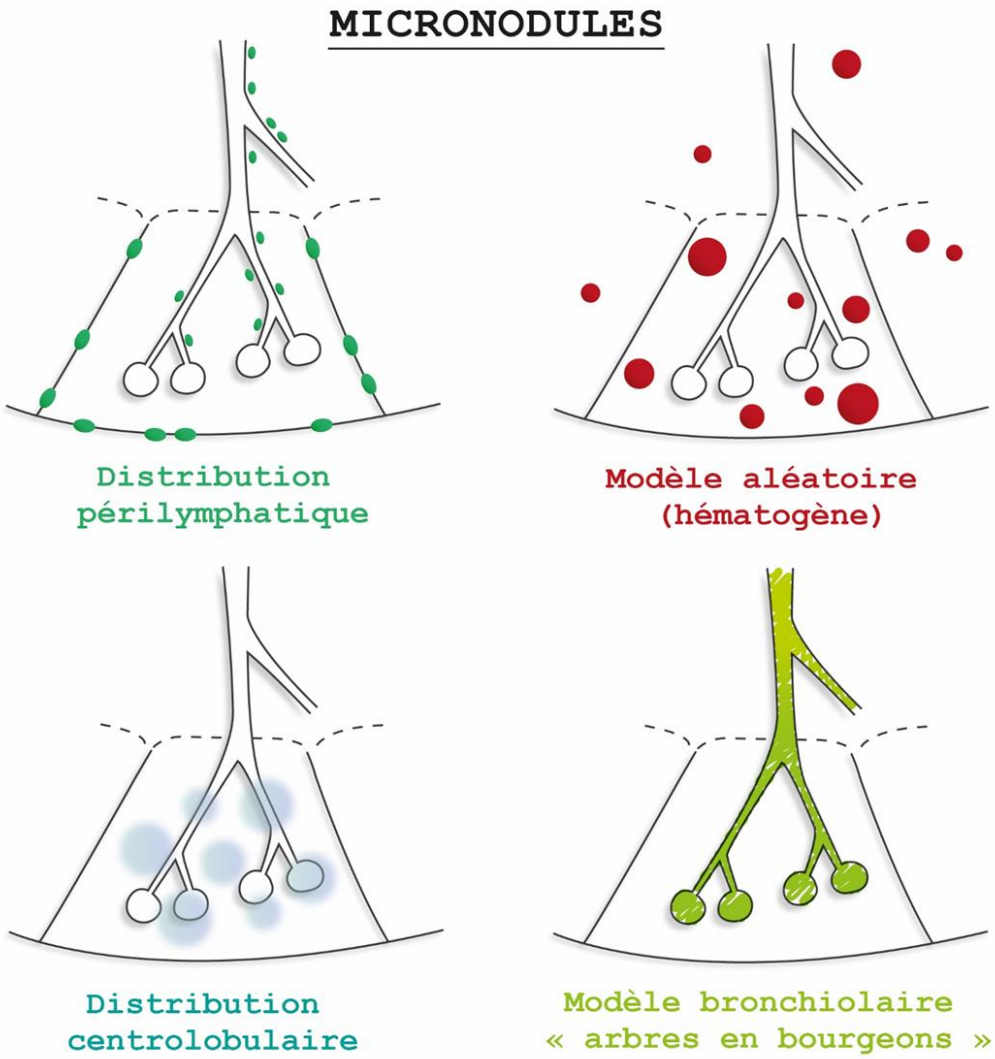


Metastasis of medullary thyroid cancer

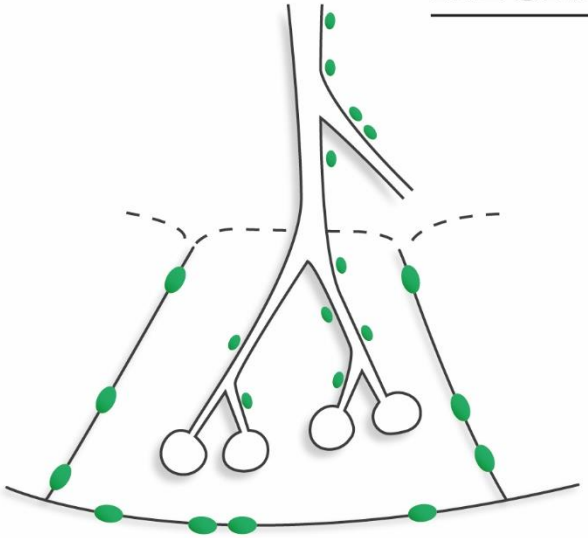
Multiple Micronodules

Analysis of micronodular infiltration :

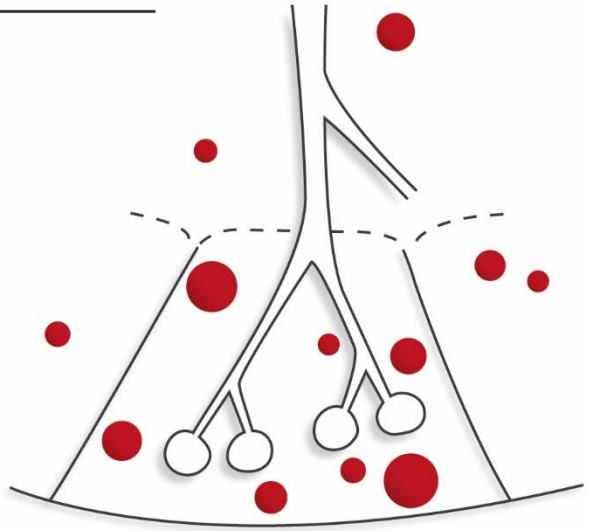
- ✓ **Density** (blurred / dense)
- ✓ **Border** (blurred / sharp)
- ✓ **Distribution** in the lobule



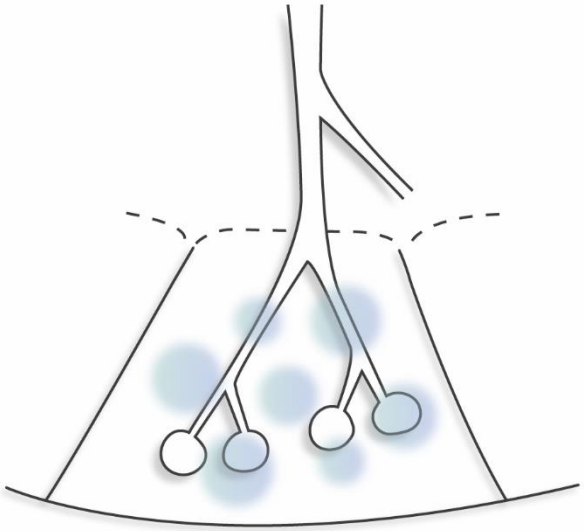
MICRONODULES



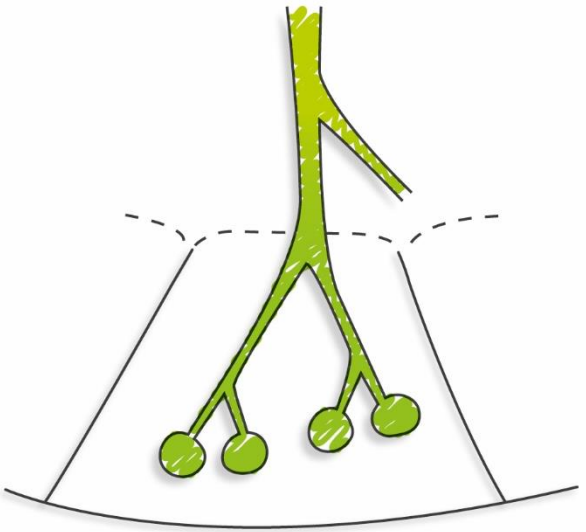
Distribution
périlymphatique



Modèle aléatoire
(hématogène)



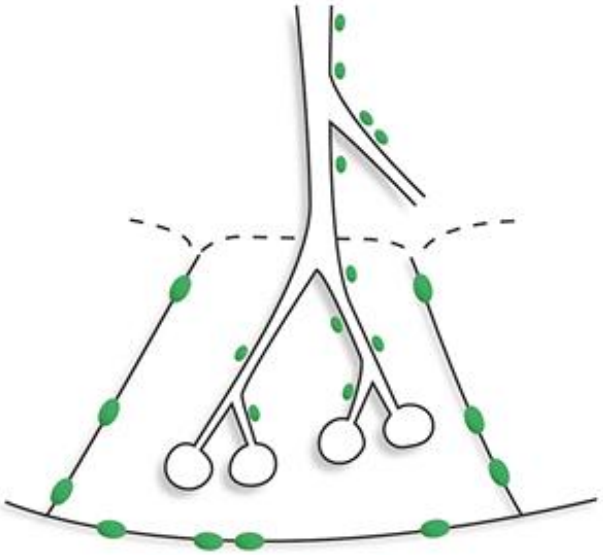
Distribution
centrolobulaire



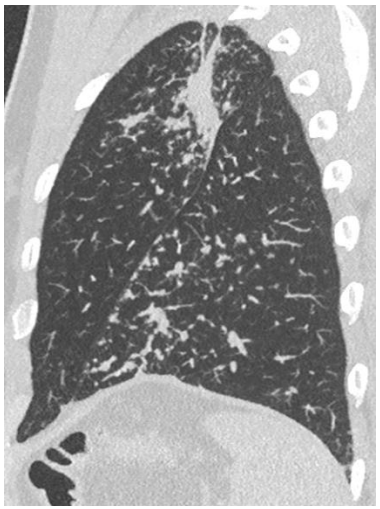
Modèle bronchiolaire
« arbres en bourgeons »

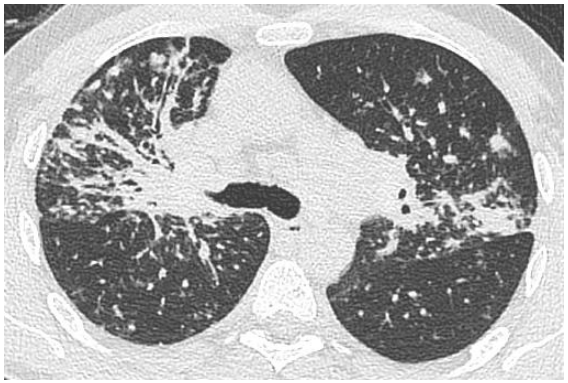
Perilymphatic model

- High density
- Sharp border
- Peri-Lymphatic Distribution
  - Along the **scissure** ("pearl" scissure) and the **pleura**
  - Along the **interlobular septa**
  - Along **vascular and bronchial pathways**
  - At the heart of the lobule: **arteriolo-bronchiolar axes**



Distribution périlymphatique

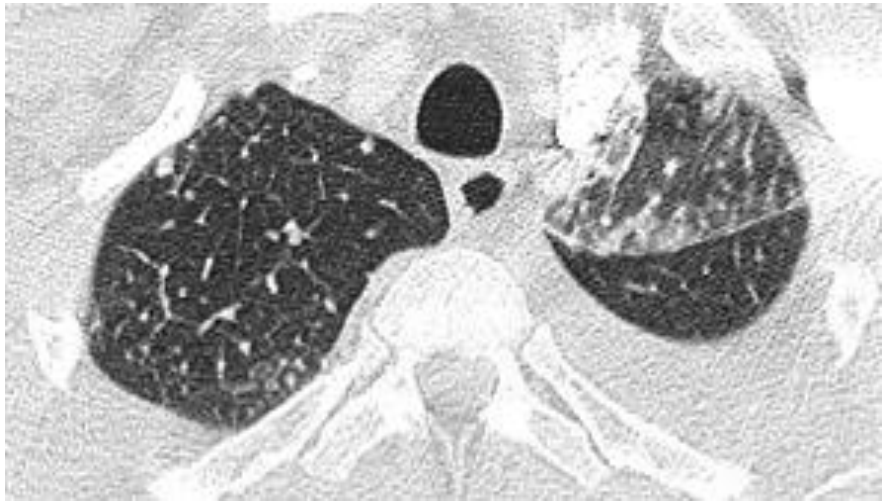


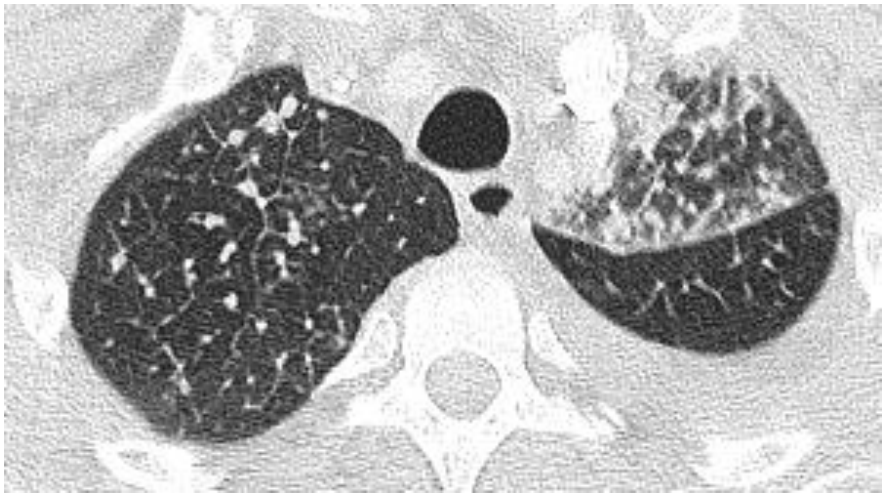


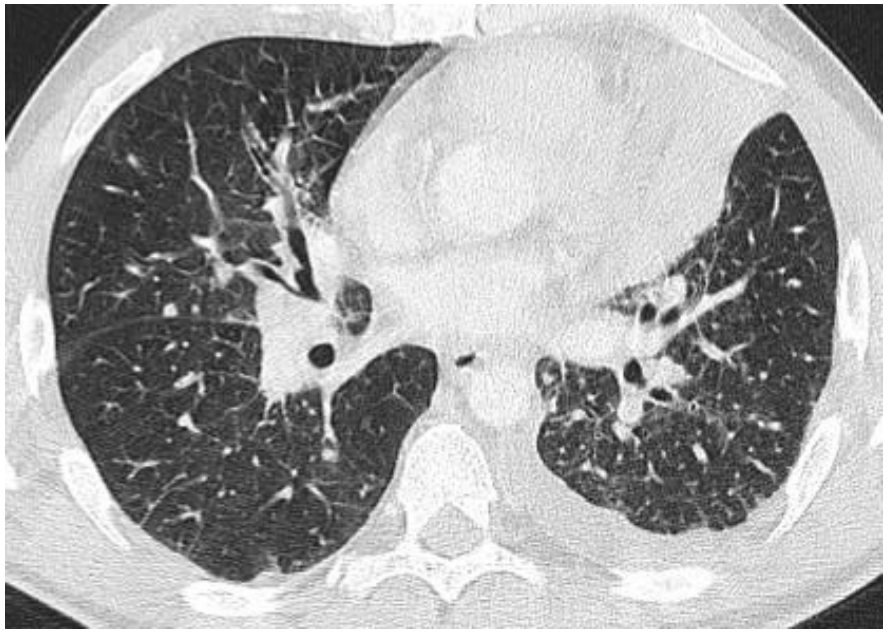
Sarcoidosis

Diagnostic range

- **Sarcoidosis +++** ➡
- **Silicosis** ➡
- Lymphangitic carcinomatosis ➡
- Amylosis ➡



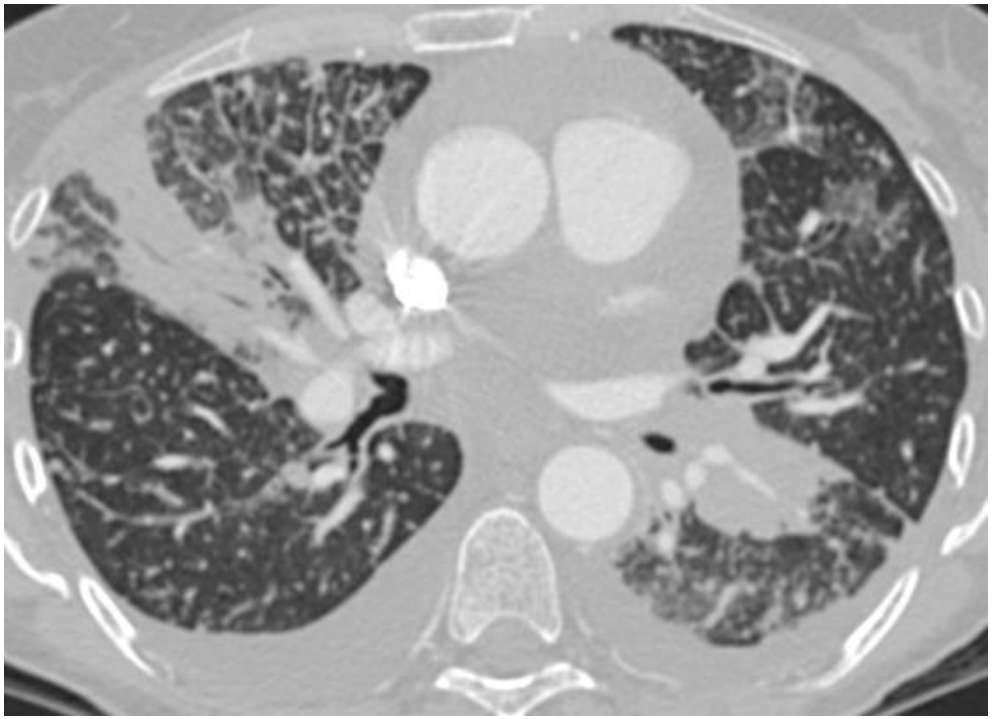


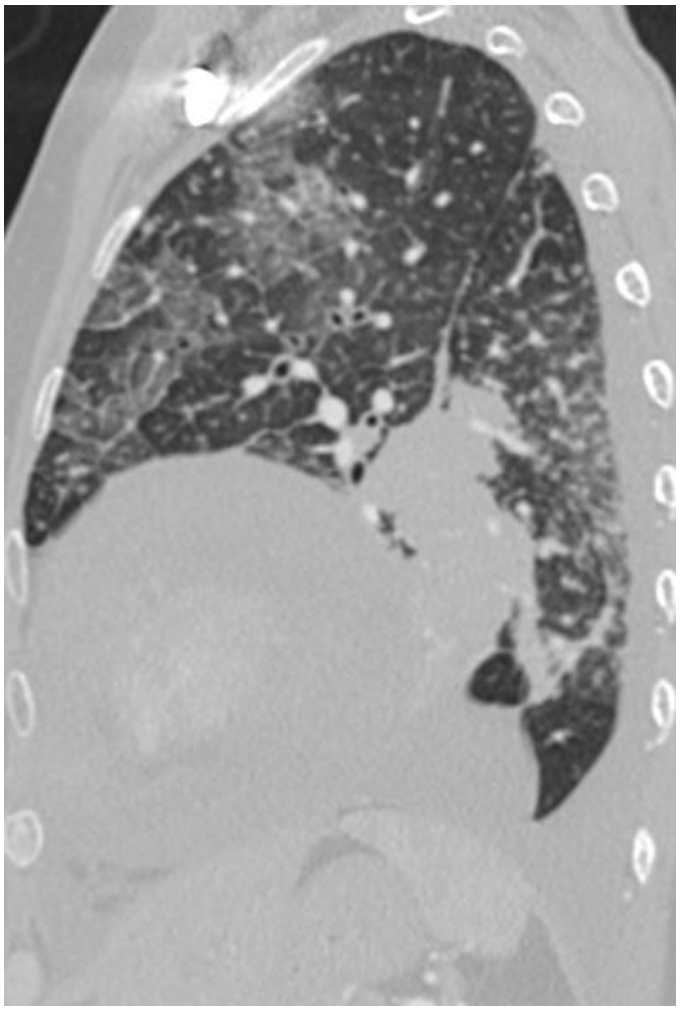


Lymphangitic carcinomatosis

(in the context of **bronchial adenocarcinoma**)

- **Multiple peri-lymphatic micronodules**
- Placed on **thickened interlobular septa**

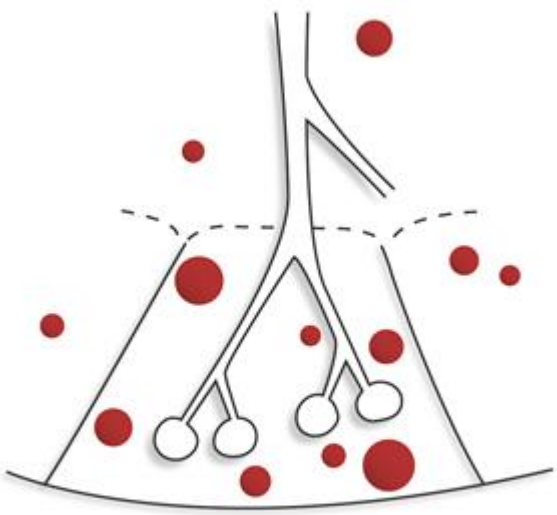


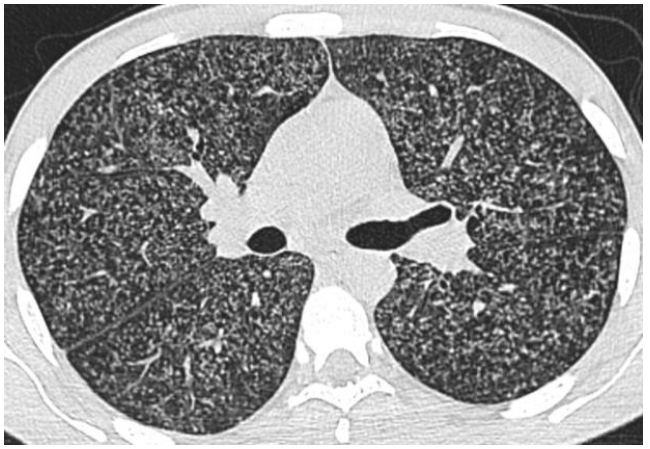


Lymphangitic carcinomatosis

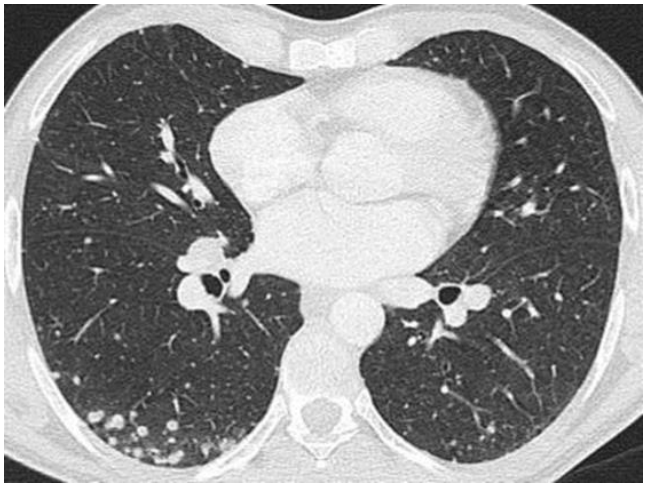
Ubiquitous model

- **Ubiquitous distributed** micronodules
- **Without topographic predominance +++ with** respect to the lobule
- Identical diameter





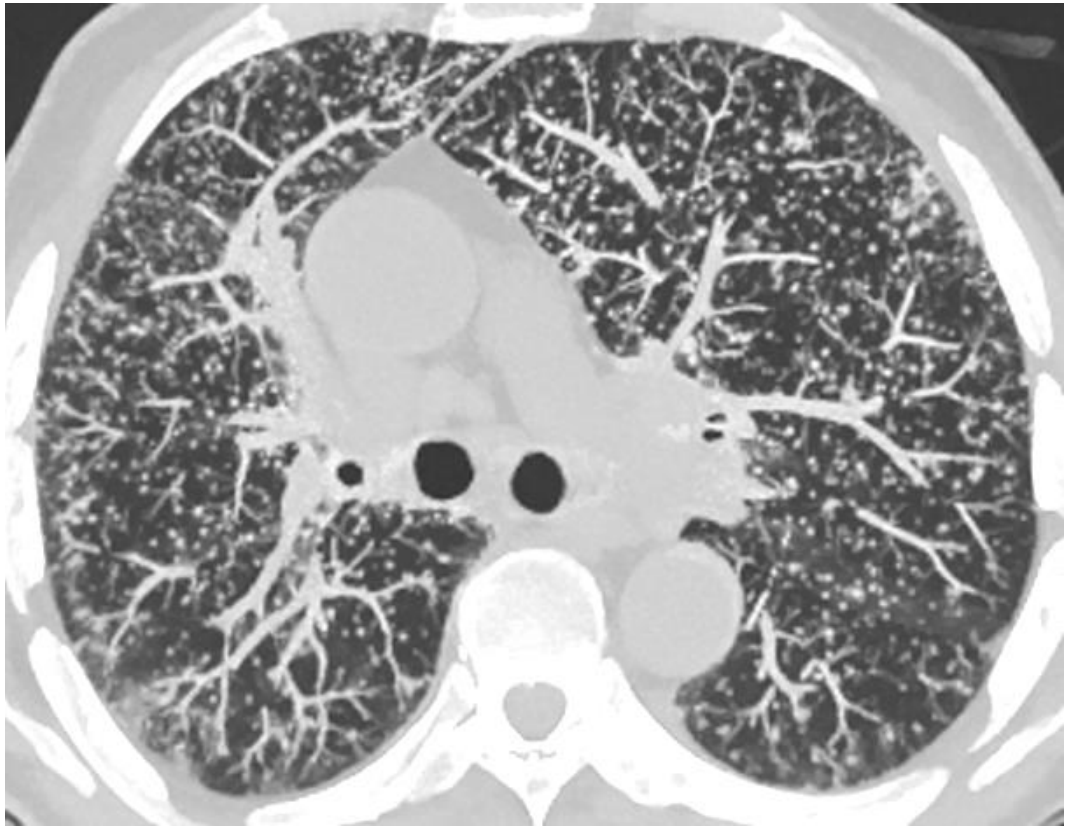
Miliary tuberculosis

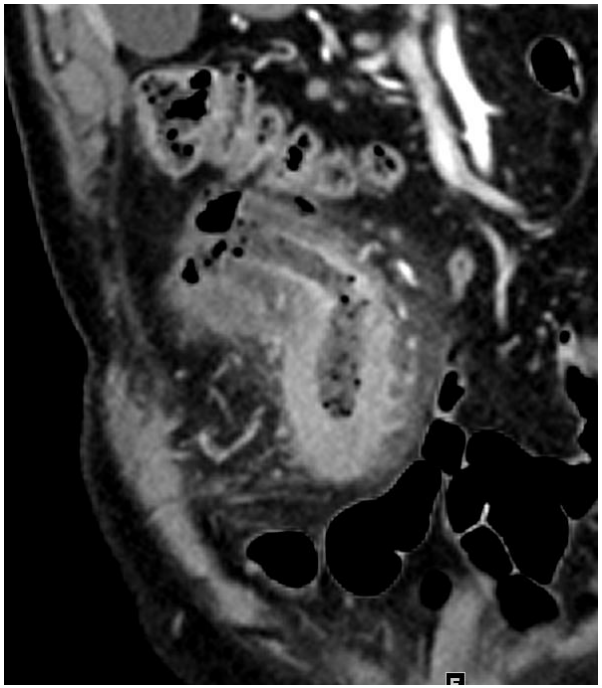


Chickenpox

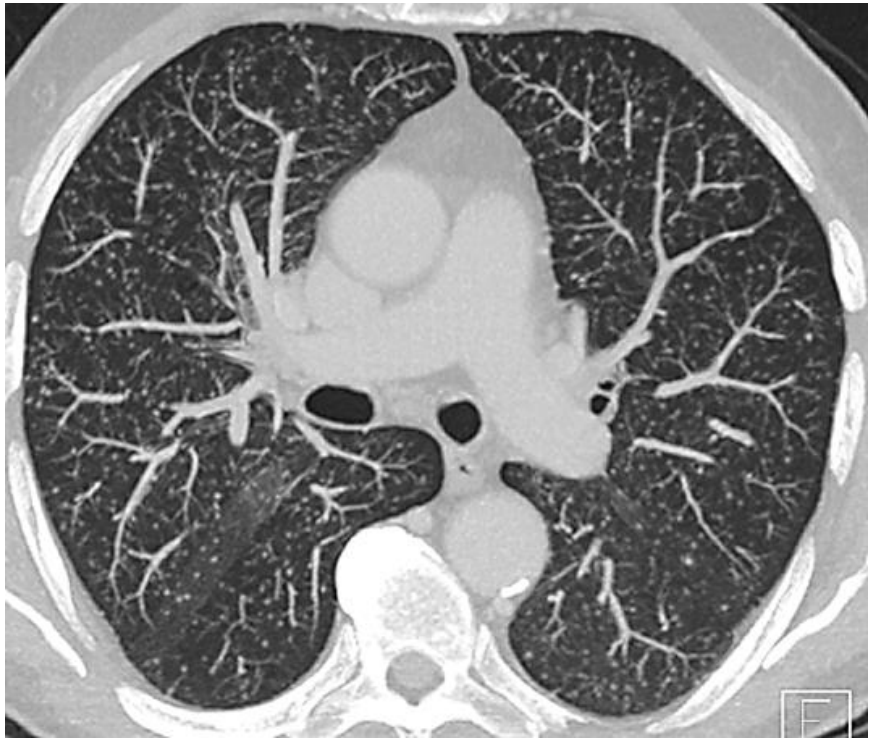
Diagnostic :

- **Tuberculosis miliary** ➡
- **Metastasis**
- If immunocompromised
  - Mycosis (histoplasmosis ➡, blastomycosis, candidosis ➡)
  - Viruses (herpes, CMV, chickenpox) ➡





Miliary tuberculosis
+ Tuberculous Ileitis

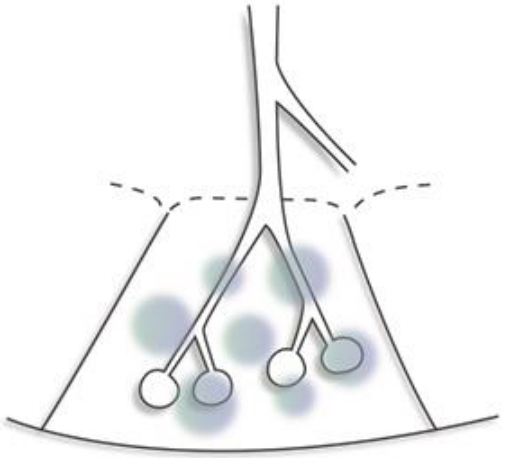


BCGite

- A serious, rare but not exceptional complication of BCG therapy for bladder cancer (non-muscle-invasive tumours).
- Fever after ttt
- Localized (urinary genital tree) or disseminated (pulmonary and hepatic damage)

Centrolobular model

- **Fuzzy density**
- **Ill defined border**
- **At the heart of the lobule,** distance from the pleural surface or septa (respect of the subpleural regions).



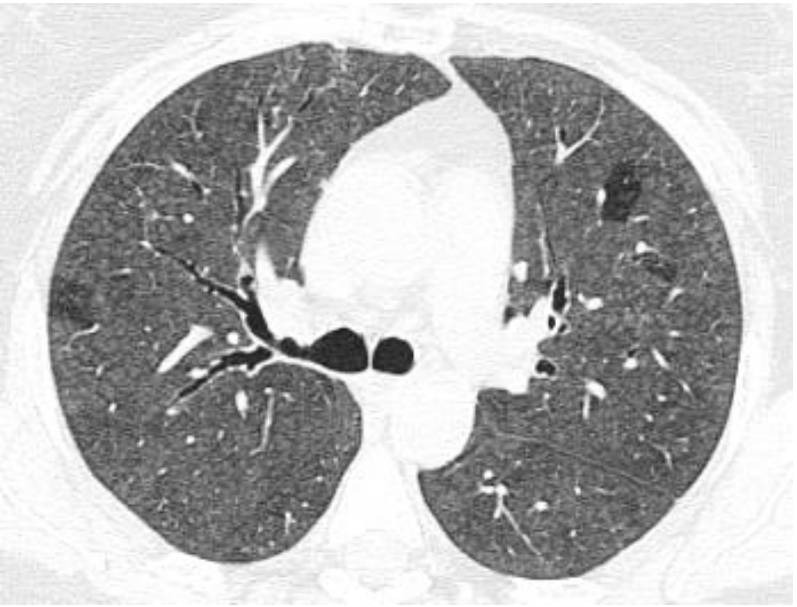
Distribution centrolobulaire

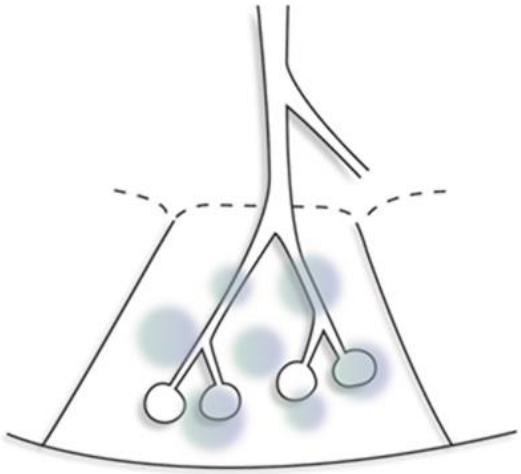
<u>Diffuse</u> and <u>homogeneous</u> distribution

- **Hypersensitivity pneumonia** +++ *(acute, subacute stage)* ➡
- **Vascular disease**
  - **PO** ➡
  - **Alveolar hemorrhage** (Vasculitis, Churg and Strauss, PAM) ➡
  - PHT
- Respiratory bronchiolitis, follicular ➡

<u>Heterogeneous</u> distribution in <u>multifocal</u> ranges

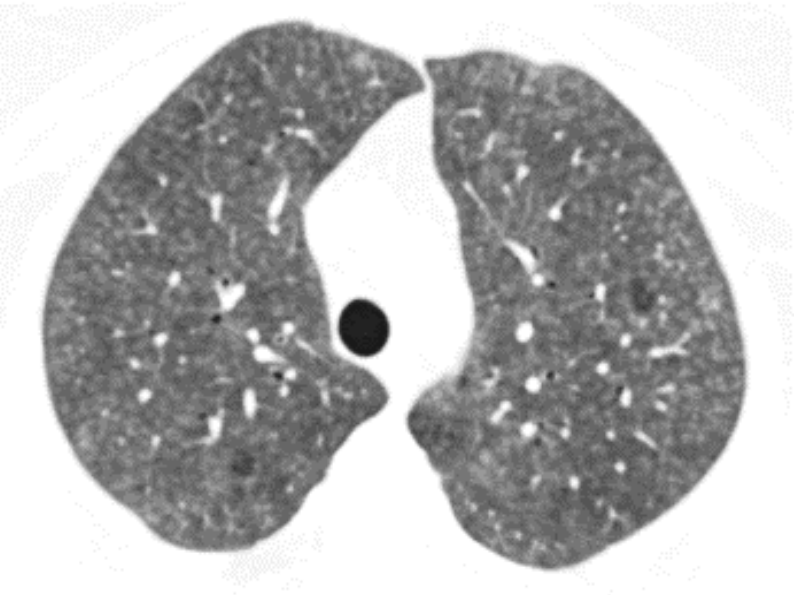
- **Infectious bronchiolitis** ➡
- **Respiratory bronchiolitis** ++ ➡
- Follicular bronchiolitis ➡
- **Early interstitial lung disease**
  - **Histiocytosis X** ++ ➡
  - Sarcoidosis (early) ➡
  - Silicosis - Asbestosis (at the beginning) ➡

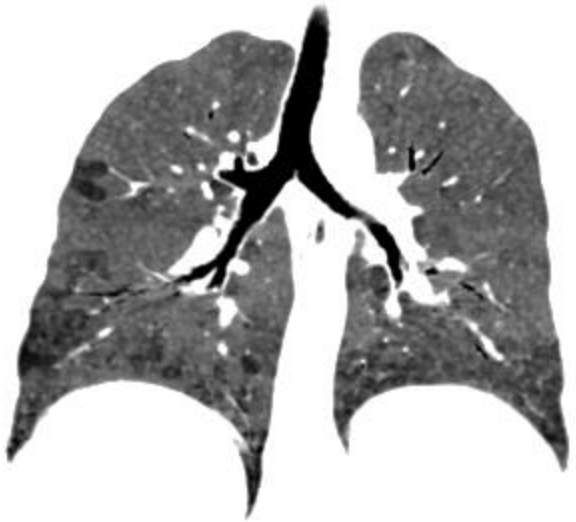




Subacute hypersensitivity pneumonia

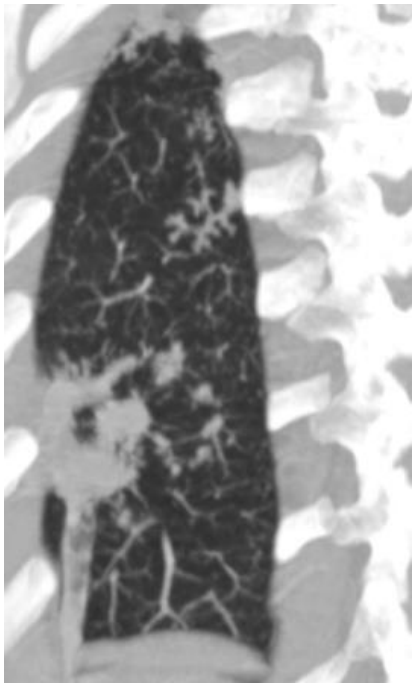
- Central-lobular micronodules
- GGO density
- Ill defined border
- At the heart of the lobule, at a distance from the pleural surface or septa (respect of the subpleural regions).

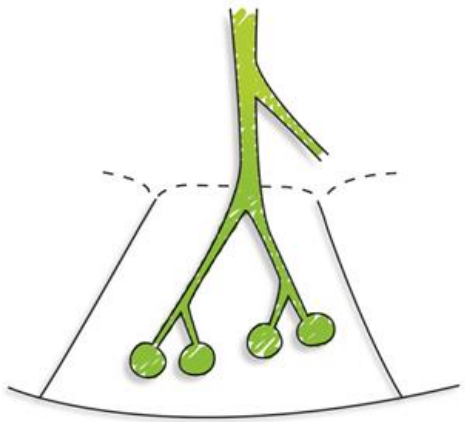




Tree in bud pattern

Appearance of **"plugged-in" micronodules** = **mistletoe ball** appearance
Corresponds to a **bronchiolitis most often infectious.**





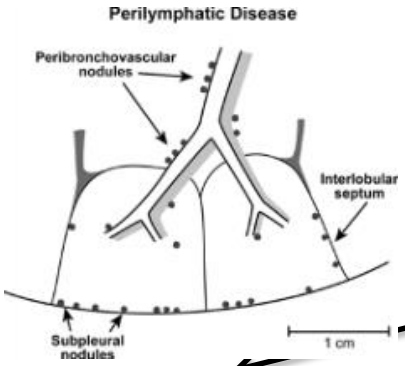
Modèle bronchiolaire
« arbres en bourgeons »

Etiologies Bronchiolitis ++++

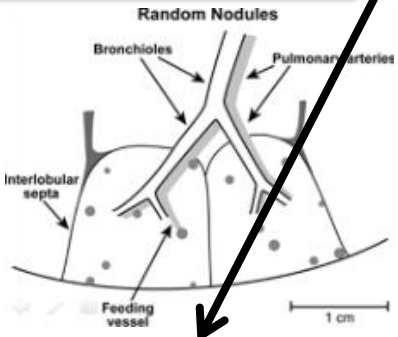
- Infectious +++ ➡
  - Viral, mycoplasma ➡
  - Bacterial ➡ (bronchopneumonia)
  - Tuberculosis ➡ , MA ➡
  - Broncho-invasive aspergillosis ➡
- Bronchiolitis associated with chronic bronchopathies ➡
- Aspiration bronchiolites ➡
- Diffuse panbronchiolite ➡
- Organized pneumonitis ➡

Micronodules under pleural

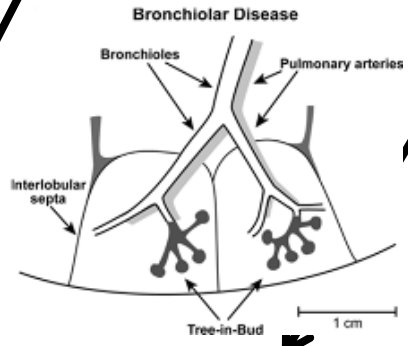
Present



Perilymphatic distribution
- **Sarcoidosis**
- Silicosis
- Lymphangitic carcinomatosis

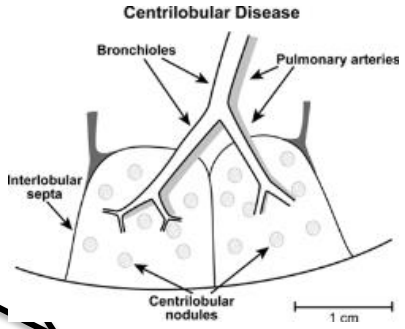


Random distribution
- **Miliary tuberculosis**
- **Metastatic milary**
- Viral infection (herpes, CMV)



Tree in bud
- **Infectious bronchiolitis** (BK, MBA, bact, virus, mycoplasma, aspergillosis)
- Bronchiolitis associated with chronic bronchopathies
- Diffuse panbronchiolite
- Bronchiolite inhalation

Absent



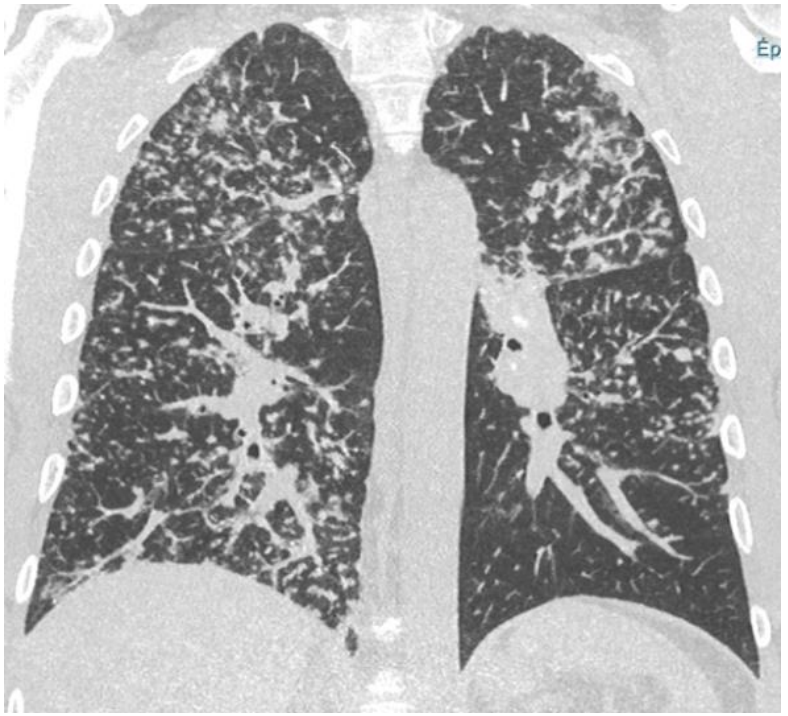
Centrolobular micronodules
- Homogeneous, diffuse distribution
  - **HSP**
  - PO
  - **Alveolar hmrg, vasculitis**
  - **BRPI**
  - Follicular bronchiolitis
- Heterogeneous distribution
  - **Infectious**, inflammatory **bronchiolitis**
  - BRPI
  - Follicular bronchiolitis
  - Sarcoidosis
  - **HX**
  - Silicosis/ asbestosis (top)

FALSE tree in bud

1/ These are **peri-lymphatic micronodules of peri-bronchovascular distribution in the LPS.**
→ **bud mimicking**

Some forms of **sarcoidosis** readily mimic tree in bud by their preferential peribronchovascular distribution up to the centre of the SPL (fairly common diagnostic trap).

	Peri-lymphatic (fake tree in bud)	Tree in bud
Topography	Central Peripherals	Peripheral
Accompanying signs	Septal micronodules, subpleural	Respect of the under pleural area

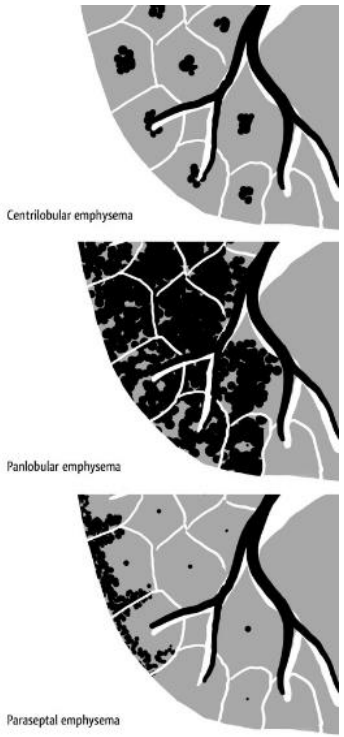


Sarcoidosis

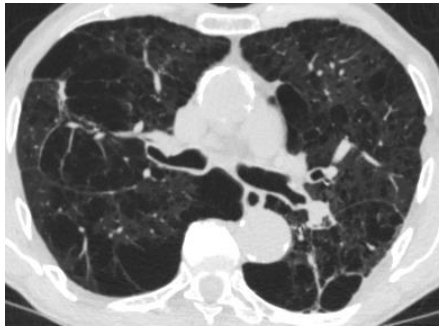
2/ Existence also of **tree in bud vascular in the** context of **tumour emboli** (ADK colon…)

Emphysema

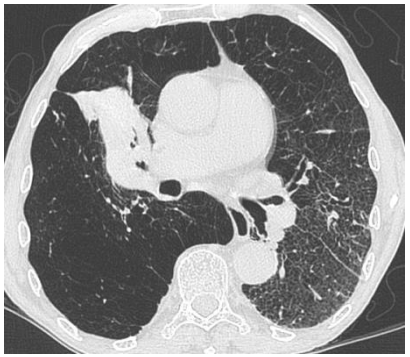
Definition: **destruction of** lung parenchyma.



COPD



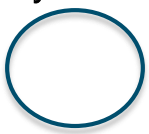
Alpha 1 antitrypsin deficiency



Etiologies

- **Smoking +++**
  - Centrolobular
  - Paraseptal
  - Panlobular (advanced destruction)
- **Alpha 1 antitrypsin deficiency**
  - Pan lobular

Cyst



Emphysema lesion

- No wall
- Centrolobular artery

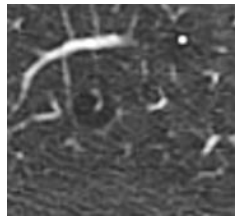
Differential diagnosis

Cyst

- **Thin wall**
  - **But look at the small lesions!!** because around the large emphysema lesions: compression of the pulmonary parenchyma...
- No **central artery**

Honeycomb

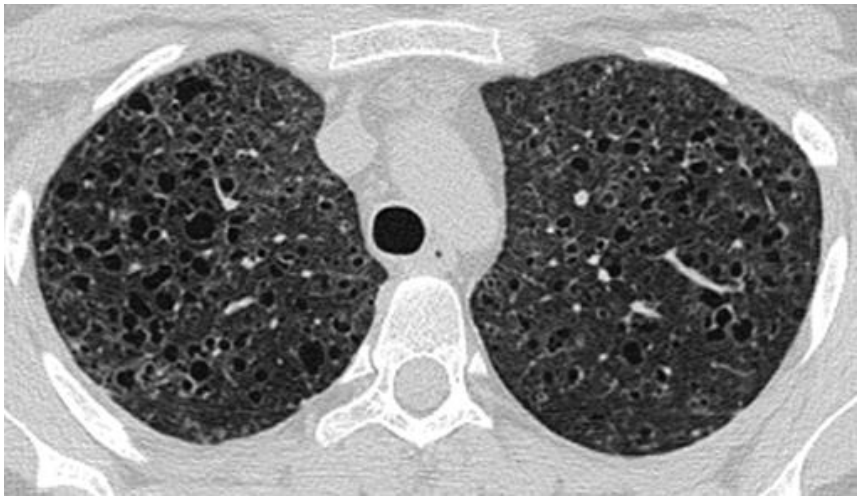
- Differential with honeycom ->**multilayer**
- Differential GGO with emphysema



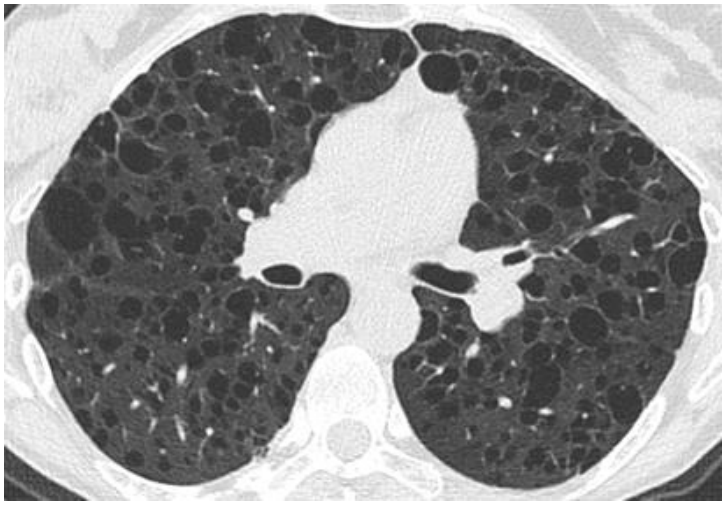
Emphysema

Multi-cystic image

Definition: aerial image circumscribed by a **thin wall**



Histiocytosis X

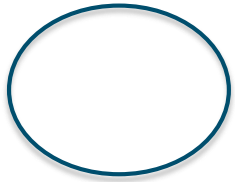


LAM

Differential diagnosis

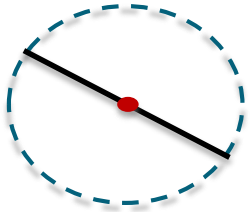
- **Cystic Bronchiectasis**
  - Reformatting, bronchial communication
- **Emphysema**
  - **No wall**
    - **But look at the small lesions!!** because around the large emphysema lesions: compression of the pulmonary parenchyma...
  - Sometimes **central artery** in emphysema lesions.

Cyst



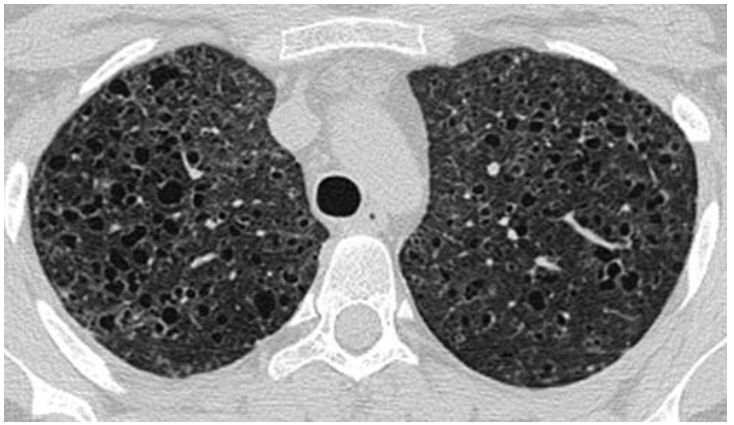
Emphysema lesion

- No wall
- Centrolobular artery

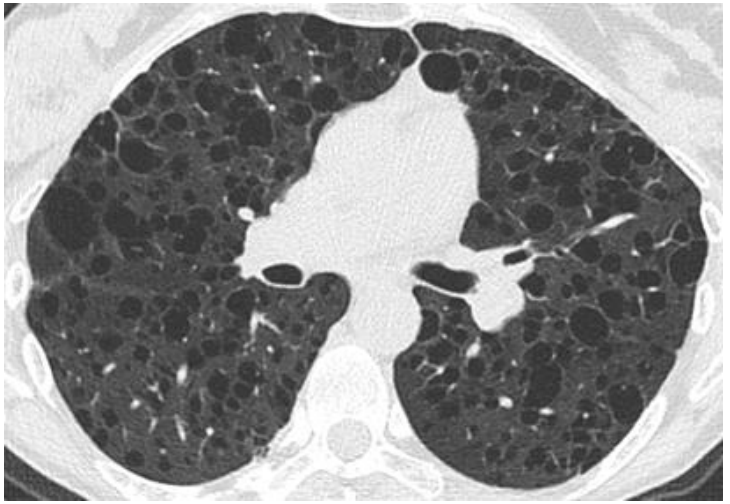


Cyst

- Histiocytosis X +++ ➡
  - Tobacco, centrilobular micronodules, perforated nodules, cysts with irregular contours, predominantly superior
- Pulmonary lymphangio leiomyomatosis ++ ➡
  - Female, regular cysts, diffusely distributed
- Cystic lung metastasis
  - Background (ENT cancer, cervix)
- Interstitial Lymphocyte Lung Disease (ILD) ➡
  - HIV, Sjögren, ggo around cysts, peribronchovascular
- Pneumocystis ➡
  - HIV, acute, ggo+ cysts
- Birt-Hogg-Dubé syndrome ➡
  - Genetics, cysts + kidney + skin tumours
- Desquamative Interstitial Pneumonia (DIP) ➡
  - Smoking+++, GGO under pleural, basal + micro cysts++ in ggo
- Hypersensitivity pneumonia ➡
  - Exposure, fuzzy micronodules, GGO mosaic , trapping, cysts



Histiocytosis X

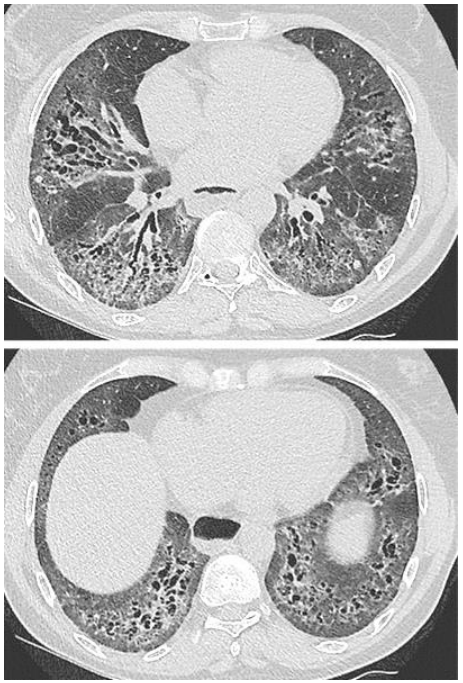


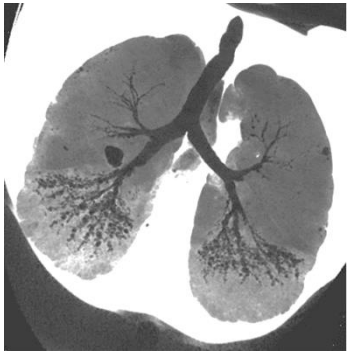
Lymphangioleiomyomatosis

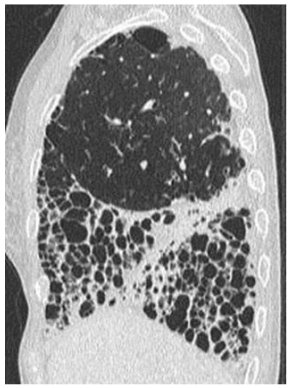
Fibrosis

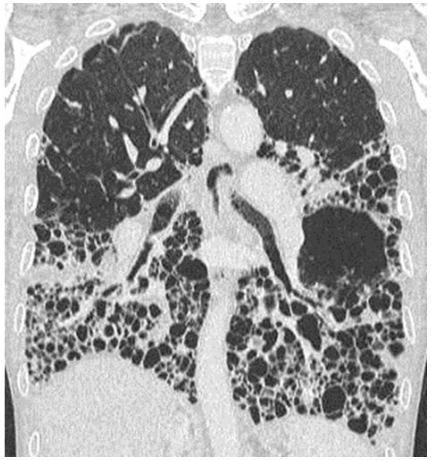
On imaging = ***signs of lung architecture revision***

- **Intralobular septal thickening** and **honeycomb**
- **Thick, irregular and deformed septa**
- **Bronchiectasis and traction bronchiolectasis**
- Thickened, irregular and deformed scissure
- Pinching of bronchovascular pathways
- Irregular consolidation
- Scarring emphysema







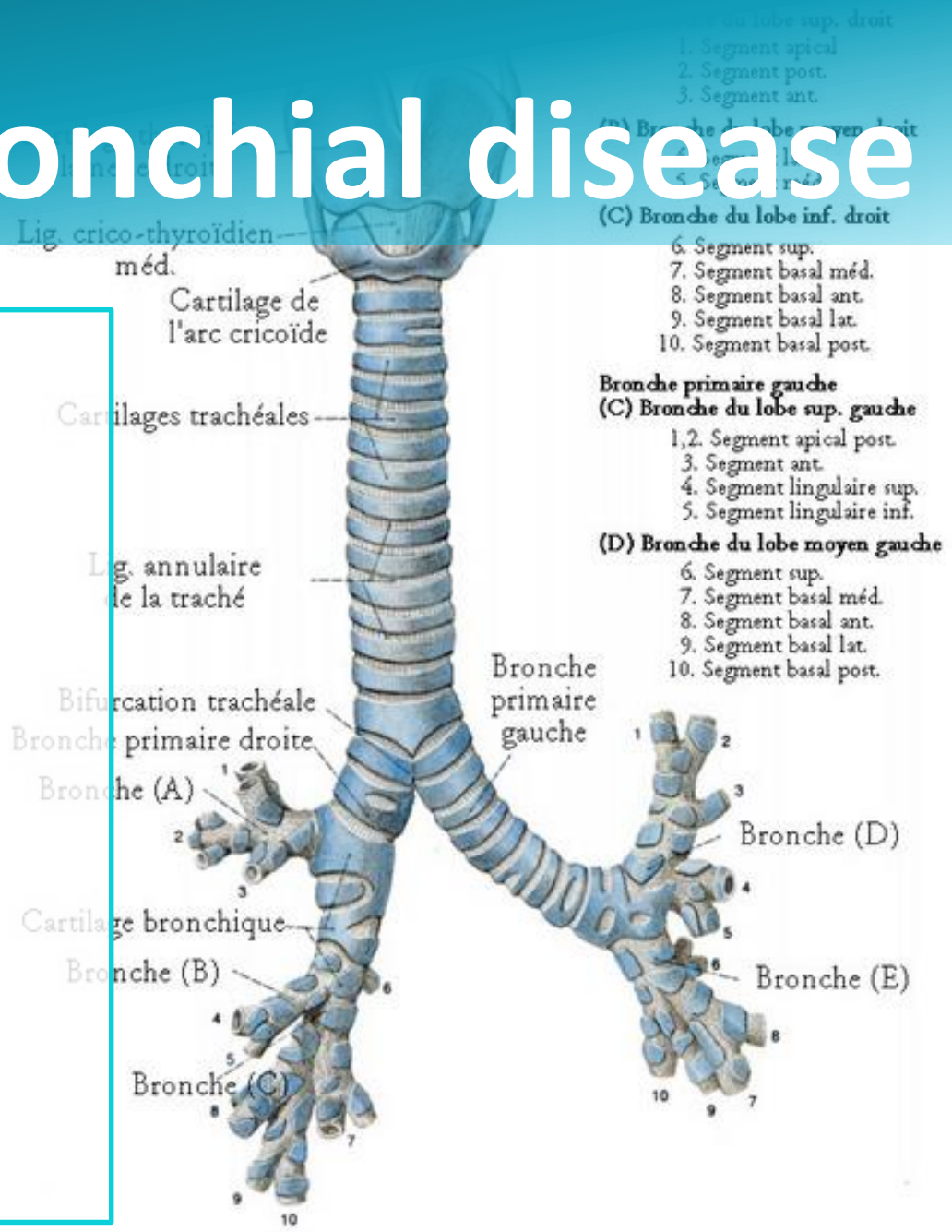


Honeycomb image

- **Juxtaposition of** a **multitude of air spaces of** roughly rounded shape, delimited between them by a **wall with** a thickness exceeding 1 mm
- Predominance in **subpleural areas**
- **Terminal stage of** lung architecture revision
- DD: **lesions of paraseptal emphysema** (which present pseudowalls by compression. In favour of emphysema: topography and a single layer of "cysts" versus several for honeycomb.

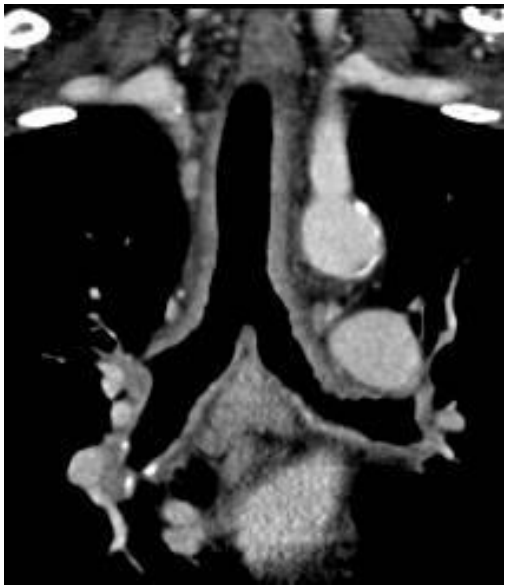
Tracheobronchial disease

- Tracheal thickening ★
  - Relasping polychondritis
  - Amyloidosis
  - Tracheobronchopathia osteochondrodysplasis
- Other tracheal disease ★
  - Mounier Kuhn Disease
  - Tracheobronchomalacia
  - "saber-sheath trachea"
- Tracheobronchial neoplasm ★
  - Tracheobronchial papillomatosis
  - bronchial neoplasm
- Chronic bronchial disease ★
  - Asthma
  - COPD
  - Bronchectasia
  - Broncholithiasis
- Bronchiolitis ★
  - Cellular
  - Constrictive

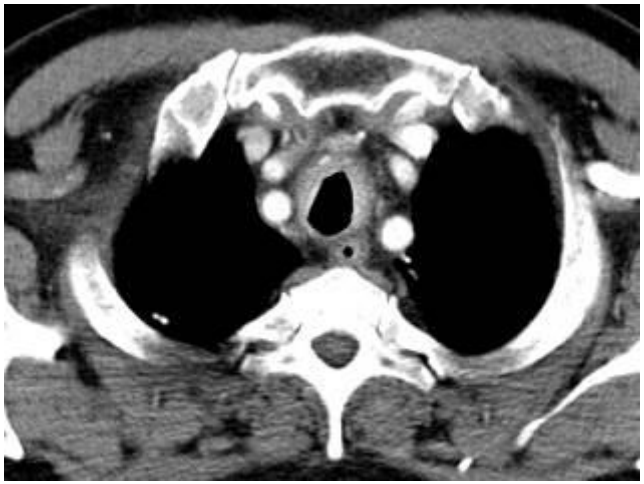


Tracheal thickening

- **Relasping polychondritis**
  - **Rare** (chondral involvement : nose, ears , trachea…)
  - **Thickening, clacification and spontaenous hyperdensity** (+ malacia) sparing the posterior wall **++**
- **Amylosis**
  - **Patchy infiltrative nodular wall thickening with ou without calcification.**
  - Trachea and main bronchi
  - Circumferential involvelement
- **Wegener**
  - **Thickening of tracheal wall/ sus glottic stenosis**, circonférential or asymétric
- Tracheobronchopathia osteochondrodysplasis **Nodular wall thickening +/- calcified . Sparing the posterior wall.**
- Sarcoidosis
- Histoplasmosis
- Tuberculosis
- Rhinoscleroma



Chronic cought , main diagnosis:
- ✓ ***Wegener?***
- ✓ *Amylosis?*
- ✓ *Relaspsing polychondritis?*



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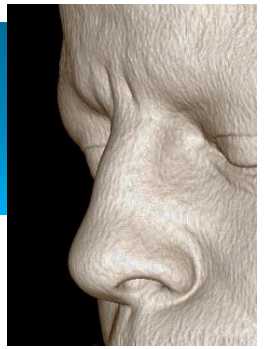
Relapsing polychondritis

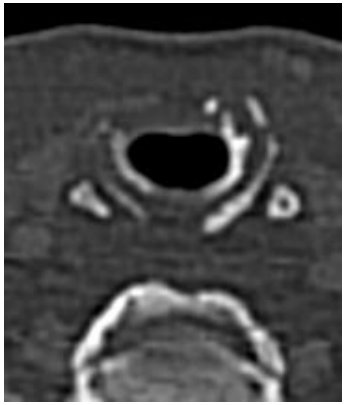
Reccurent chondritis:

- Auto-immune disease
- **Rare**
  - ears (swollen, erythema)
  - Nose
  - Larynx
  - Joint
  - **Tracheo- bronchial wall (50%)**
  - deafness(50%)
  - + uveitis

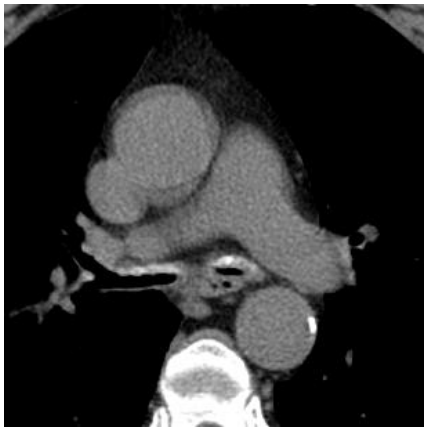
Nose



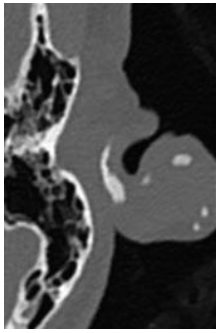
Cricoïde



Trachea



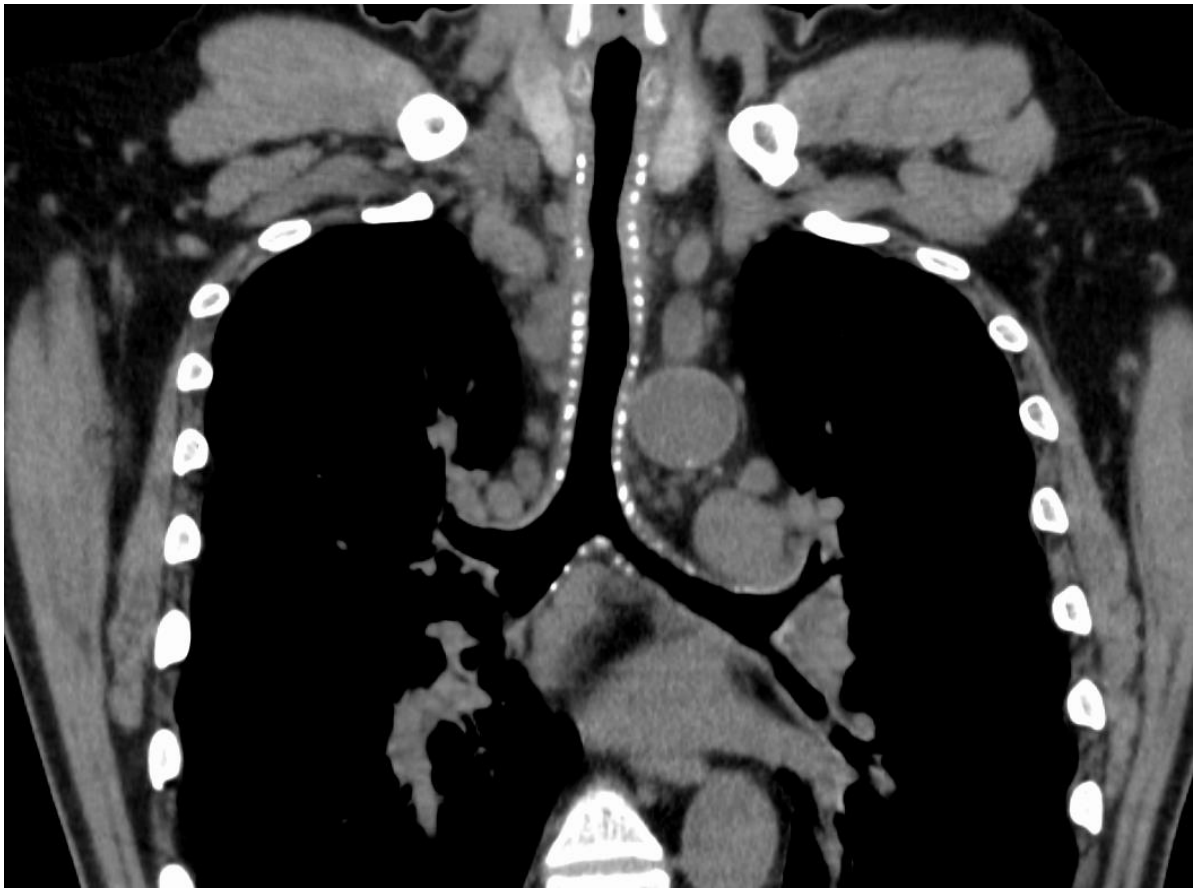
Ear



CT

- **Smooth and regular tracheal wall thickening**
- **Spontaneous hyperdentity**(100%) +/- **calcifications** « dimmed »or «shewed »
- **Sparing posterior wall +++**
- **+/- Stenosis**
- **Trachéobronchomalacia** + **Air trapping** (early sign) (expiratory ++)

Lee KS, Ernst A, Trentham DE et-al. Relapsing polychondritis: prevalence of expiratory CT airway abnormalities. Radiology. 2006
Behar JV, Choi YW, Hartman TA et-al. Relapsing polychondritis affecting the lower respiratory tract. AJR Am J Roentgenol. 2002



Relasping polychondritis

Amylosis

- **Extracellular amyloid deposit**
- Local or systemic
- 2 types: **LC** (Light chain Ig), **AA** (non Ig)
- 2 forms
  - **Primitive Amyloidosis (AL)**
  - **Secondary Amyloidosis**
    - Myeloma, dysglobulinemia**(AL)**
    - Chronic infection(TB), Chronic inflammation(RA), tumot (Hodgkin, neoplasm) **(AA)**

Tracheo-bronchial involvement

Rare

- **Patchy nodular wall thickening**
- **Or diffuse wall thickening**
- +/- stenosis
- +/- calcification
- Trachea/ main bronchi
- **Circonferential**

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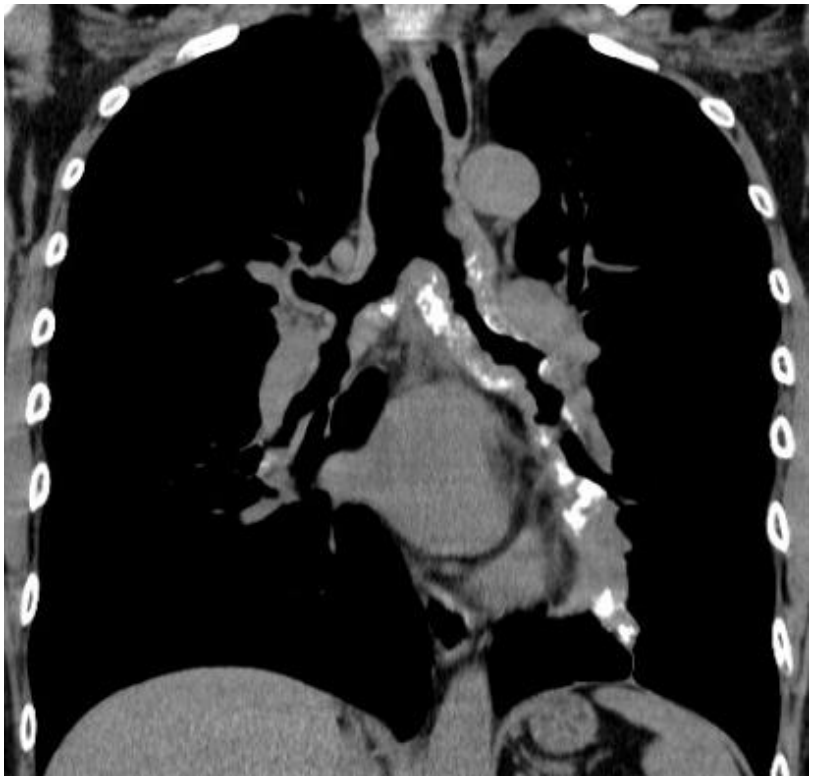
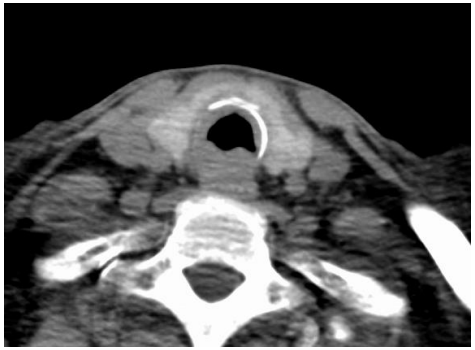
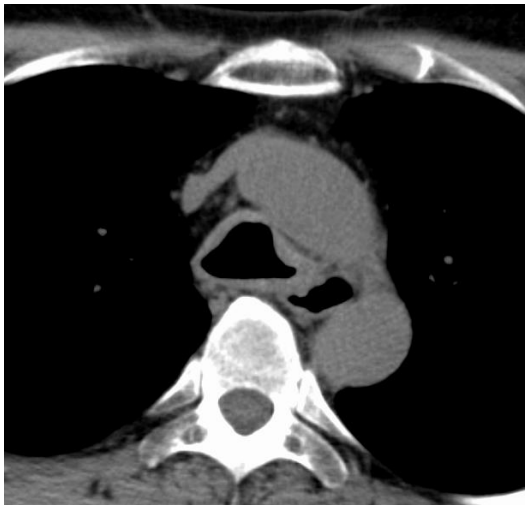
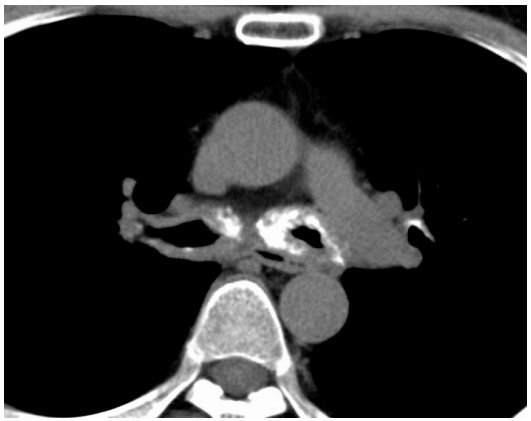
Amyloidosis

- Patchy nodular wall thickening
- Or diffuse wall thickening
- Trachea/ main bronchi
- Circonferential





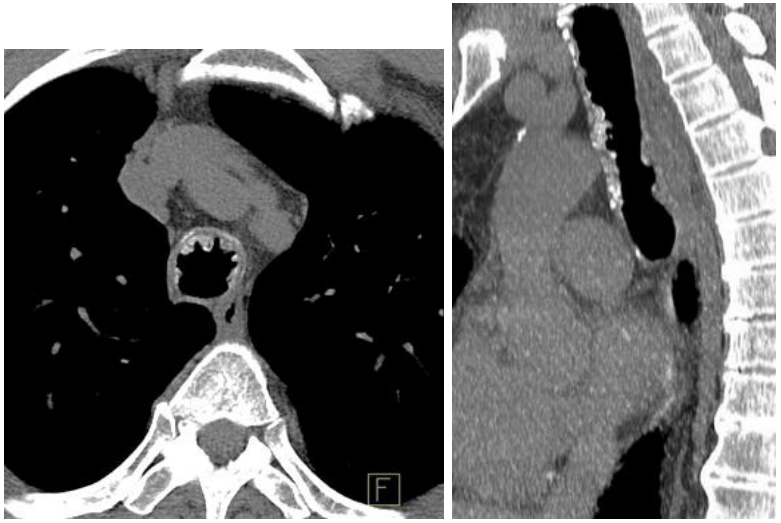




Tracheobronchopathia osteochondrodysplasis

- **Rare**, >50 years old , male>female
- **Irregular thickening and nodularity of tracheal cartilage, sparing the posterior (membranous) tracheal wall in trachea and proximal bronchus**
- Cought, dyspnea , hemoptysis

- ➢ Thickening tracheal wall
- ➢ Irregular calcification
  - +/- lumen protusion
  - +/- obstruction
- ➢ Sparing of the posterior wall



Case courtesy of Dr Bruno Di Muzio, Radiopaedia.org, rID: 21517

Differential diagnosis

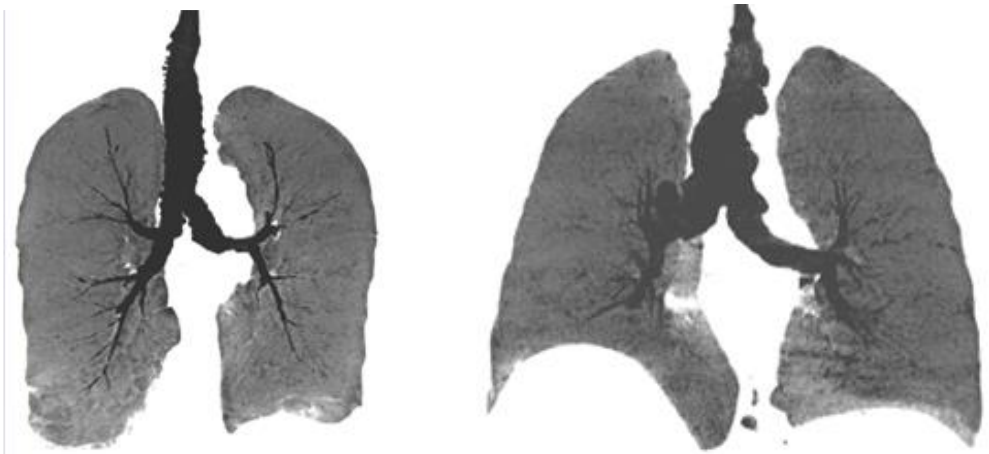
- Amylosis
- Papillomatosis
- Relapsing polychondritis
- Submucosal nodule

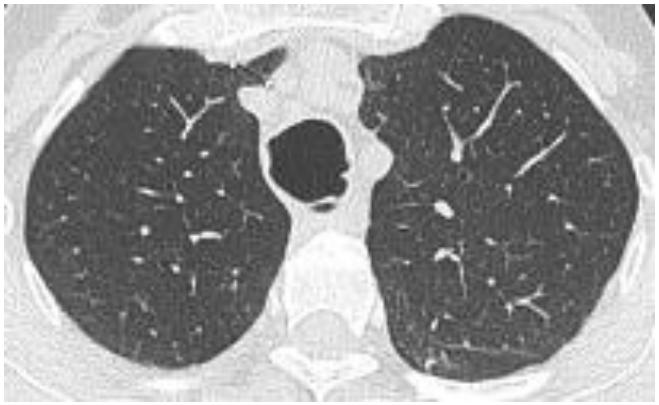
Biblio: Imagerie thoracique de l'adulte 3ème édition – sous la direction de Philippe Grenier

Mounier Kuhn disease

Main bronchi and trachea enlargement

- Associated with tracheal diverticulosis , infection and bronchiectasis
- The underlying abnormality is an absence or marked atrophy of the elastic fibers and smooth muscle within the wall of the trachea and main bronch
- Treatment:
  - **Stop smoking**
  - Physiotherapy
  - Antibiotics for infection





Trachea enlargement during inspiration and collapse during expiration

- **Trachea diameter> 3 cm** (2 cm above the aortic arch)
- RBD > 2,4 cm et LBD > 2,3 cm
- **Sus glottic trachea is normal ++**
- Posteriorly, projecting tracheal diverticula may also be seen.

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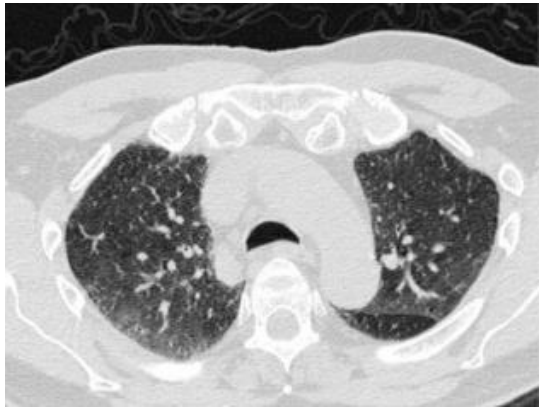
Tracheo-broncho-malacia

Increase in tracheal diameter as well as a tendency to collapse on expiration, by weakness of tracheal cartilaginous ring.

There are numerous causes of tracheomalacia, the commonest of which are :

- Tracheobronchomegaly
- **COPD**
- Inflammatory tracheal disease
- Post-traumatic



Crescent sign radiopedia

Expiration +++

- **↓ trachea lumen/ main bronchi > 50% expiration/ inspiration**
  - → crescent or moon sign
  - → coronal diameter >>sagittal diameter
- COPD → diagnosis criteria :**reduction trachea lumen> 70%**

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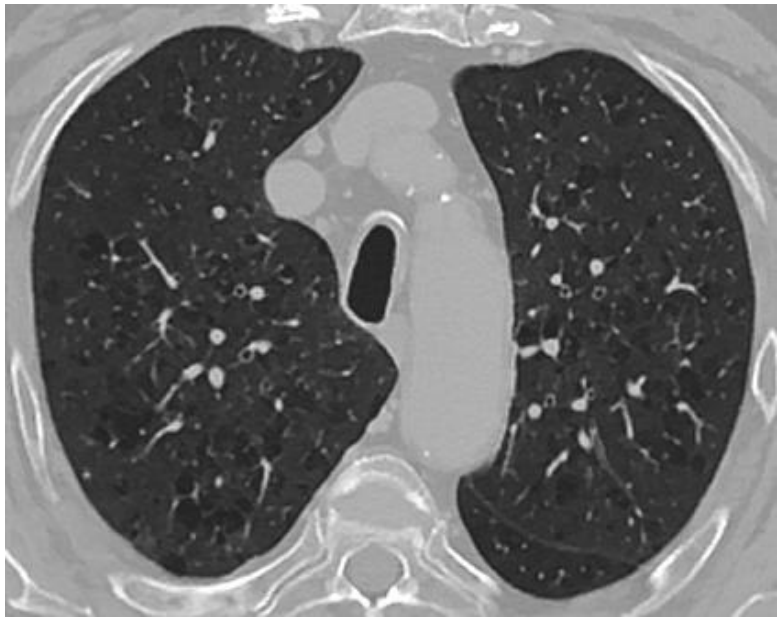
« Saber-sheath trachea"

Diffuse decrease of coronal intrathoracic trachea diameter .

- COPD+++
- Maybe secondary to intrathoracic pressure change.



↓↓ sagittal / coronal ratio is over 2/1 and the extra-thoracic portion of the trachea is not narrowed.

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Tracheal tumors

- Rare
- Asymptomatic for a long time +++
- Dyspnea
  - *Malignant tumor* (90% primary, 10-30% in kids)
    - **Squamous cell carcinoma** and **adenoid cystic carcinoma**(86%)
  - *Benign tumors*
  - **Papilloma and hamartoma.**

Malignant tumors

- Squamous cell carcinoma +++ (50%)
  - Tobacco +/- upper aerodigestive tract (¼ of case), budding, infiltrative or ulcerated, mediastinal invasion? esophagus (+/- esotracheal fistula)? Lymph node ? bronchogenic spread?
- Adenoid cystic carcinoma++ (40%)
  - Potential for recurrence after excision and late metastases, 1/3 medium, rounded, sessile, well limited, invasion of the tracheal wall then mediastinum .

- **Mucoepidermoid tumor :** Endoluminal nodule, 50% <30 years
- **Carcinoid tumor:** Any age, less common than in the lung Intense contrast enhancement
- **Lymphoma (**lymphadenopathy)
- **Sarcomas** (connective tumor simulator)
- **Chondrosarcoma**
- **Secondary tumors,** neighboring tumor extension (thyroid, larynx, bronchial, esophagus)

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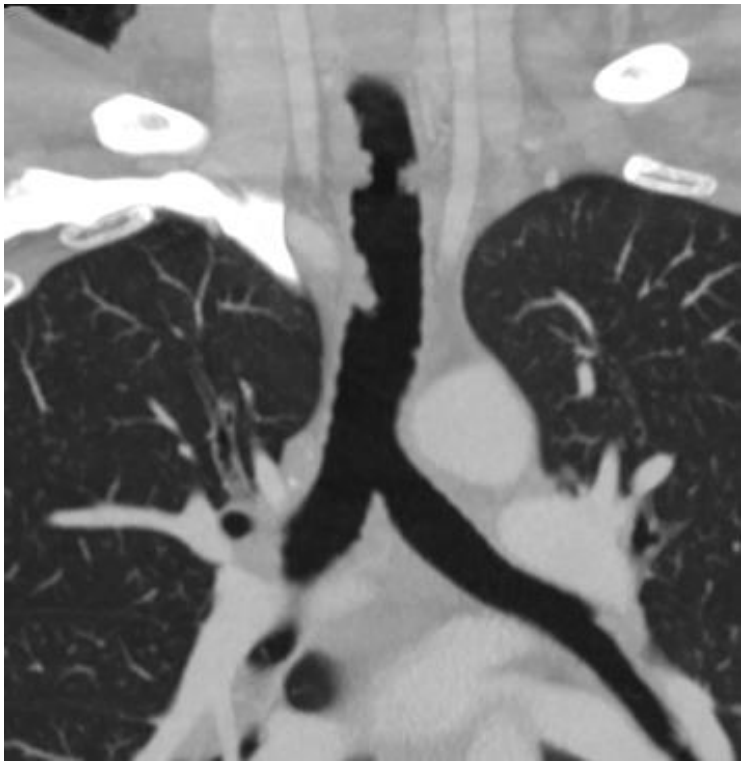
Benign tumors

- **Laryngo-tracheobronchial papillomas / papillomatosis** +++ Multiple papillomas, child / young adult
- **Hamartoma +++**
- **Hemangioma : child ++,** cervical trachea by extension of a laryngeal location, nodular mass +/- phlebitis, +/- hypervascularized
- **Chondroma :** well limited, hard, smooth surface, fixation to the cartilaginous ring, covered with a normal epithelium, mm → 3 cm, calcifications
- **Lipoma**
- **Leiomyoma** In the wall, 1/3 lower trachea, sessile implantation, sometimes in "iceberg«
- **Neuroma** (isolated or NF)



Multiple tracheal papillomas

- **Thyroid tumors**
  - Goiter or malignant tumor of ectopic thyroid tissue: woman, goitrous endemic country, **mass / thyroid connection**
- **Adenomas** (rare)
  - Mucous glands, polypoid masses, clean, smooth contours, in trachea or stem bronchi

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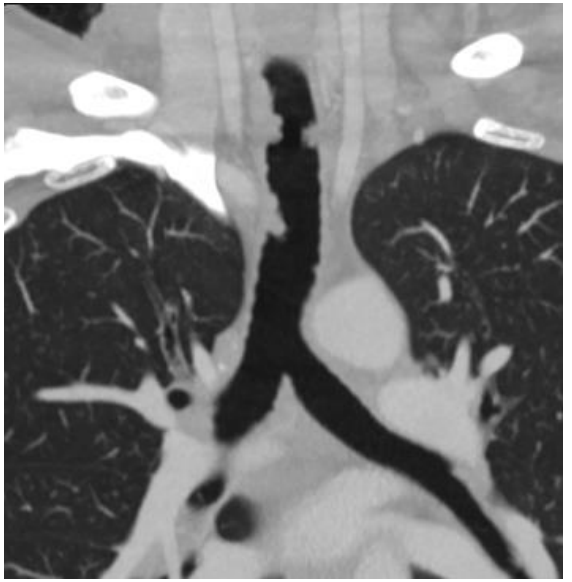
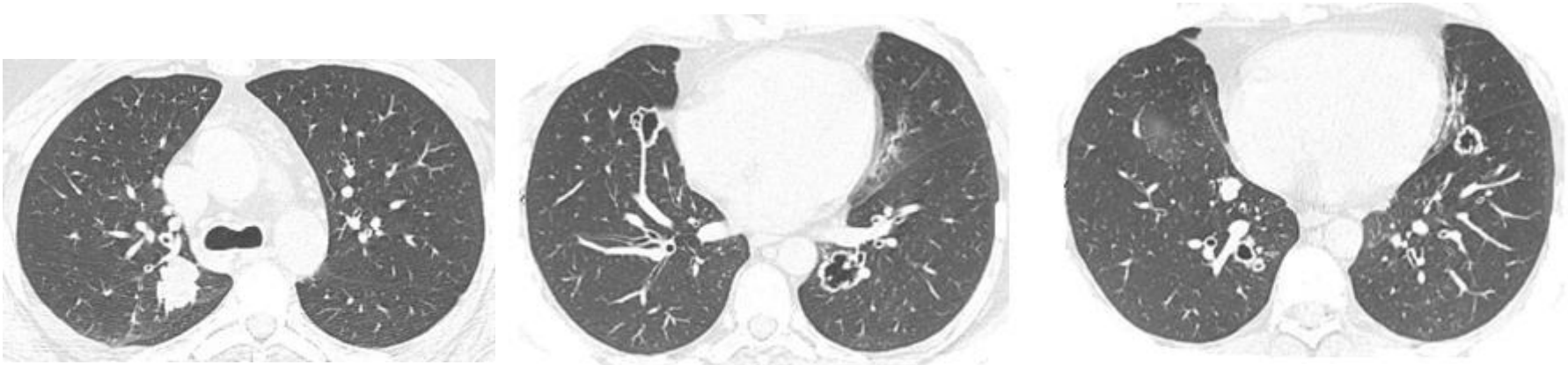
Laryngo-tracheobronchial papillomas / papillomatosis

Rare++, children++, young adult

- **Complication of laryngeal papillomatosis by aerial dissemination** (laryngeal papillomatosis: often acquired at birth by exposure to HPV 6 or 11).
  - 5-10% tracheobronchial
  - <2% lung
  - 10 years after the diagnosis of laryngeal papillomatosis
- Evolution: dyspnea and ↑ risk of squamous cell carcinoma.
- Imaging
- **Tracheo-bronchial nodules**
  - Distal involvement
    - **Monoliform bronchectasis**
    - **Nodules / excavated nodules / thin wall cysts (2-3mm) / Cavities**
    - hydro-aeric level if infection



Multiple tracheal papillomas



Case courtesy of Dr Maxim Stalkov, Radiopaedia.org, rID: 36731

- Ravin CE, Bergin D, Bisset GS et-al. Image interpretation session: 2000. Radiographics. 2000
- *Gruden JF, Webb WR, Sides DM. Adult-onset disseminated tracheobronchial papillomatosis: CT features. J Comput Assist Tomogr 1994; 18:640–642*

Endobronchial tumors

Imaging

- Typically polypoid → "crescent sign"
- Can contain :
  - ✓ Fat → **hamartoma, lipoma**
  - ✓ Calcifications
  - ✓ Necrosis
- Enhancement → **carcinoid ++**
- **Muco epidermoid**
- **Leiomyoma**

Etiologies

- *Malignant*
  - **Non small cell carcinoma (>95%)**
  - Carcinoid
- *Bénignes*
  - **Hamartoma (70%)**

Differencial diagnosis

- Mucus
- Foreign body
- Trachéobronchopathia osteochondrodysplasis
- Broncholithiasis

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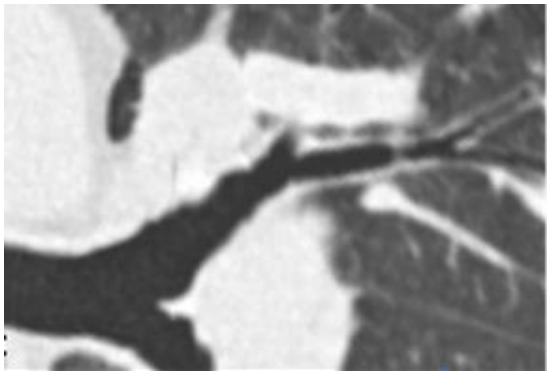
Asthma

Chronic inflammatory airway disease

- **Bronchial hyperreactivity**
- **Reversible obstruction** on expiratory flow rates
- **Bronchial wall reshaping** : Chronic inflammation → neoangiogenesis, sub epithelial fibrosis, hyperplasia of the glands and mucus cells, enlargement of smooth muscle fibers

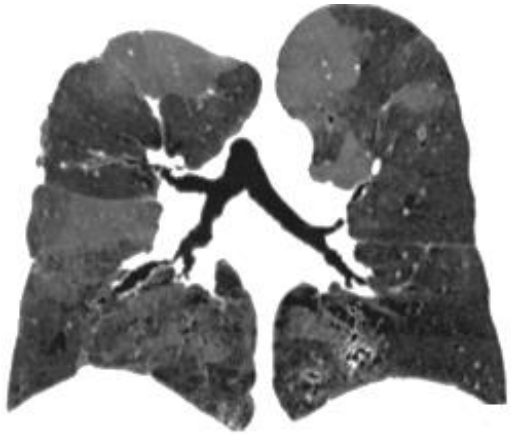


Bronchial wall reshaping:
Bronchial wall thickening

Chest Xray:
In all patients sick enough to be hospitalized, normal ++, DDX

Chest CT: not systematic

- **Bronchial wall thickening =** bronchial remodeling lesion
- **Air trapping** = damage to the small airways
- **Bronchiectasis=** 30%, sub-segmental and distal bronchi



Air trapping

Additional diagnosis

- **Bronchectasis** proximal,segmental, sub-segmental
- **Upper lobes and middle parts**
- Spontaneously hyperdense **mucoid impactions -> suspect ABPA**

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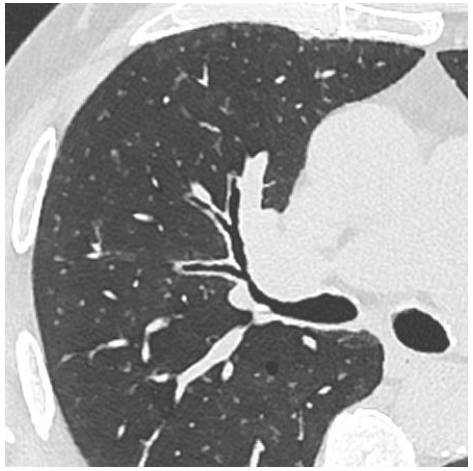
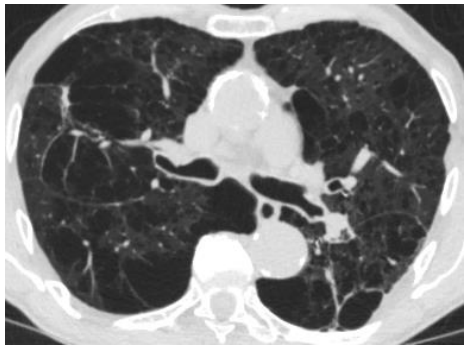
COPD

- Clinic, tobacco and professional exposure.
- **Spirometry : The FEV1:FVC ratio should be <0.70 for all stages**
- stage I: mild, FEV1 > 80% of normal
- stage II: moderate, FEV1 = 50-79% of normal
- stage III: severe, FEV1 = 30-49% of normal
- stage IV: very severe, FEV1 <30% of normal or <50% of normal with presence of chronic respiratory failure present.



Bronchi reshaping



Emphysema

Xray
- Distension
- Arterial defect
- Expiratory trapping

CT
- **Emphysema**
  - Centro-lobular / para-septal
  - Pan-lobular
  - **Bonchial reshaping** (on the entire tracheobronchial tree proximal bronchi → small bronchi)
- Associated sign:
  - Trachéobronchomalacia
  - "saber-sheath trachea"
  - Bronchial diverticulosis
  - Interstitial change

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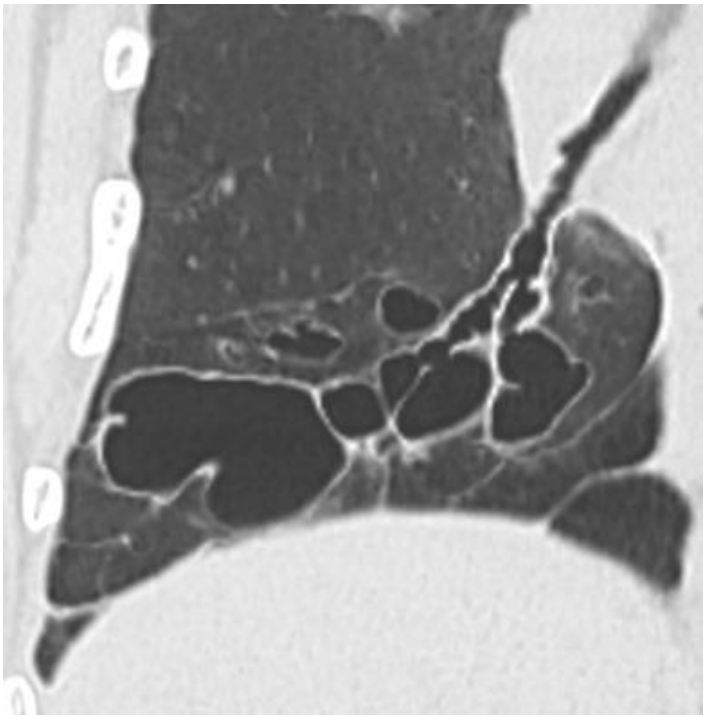
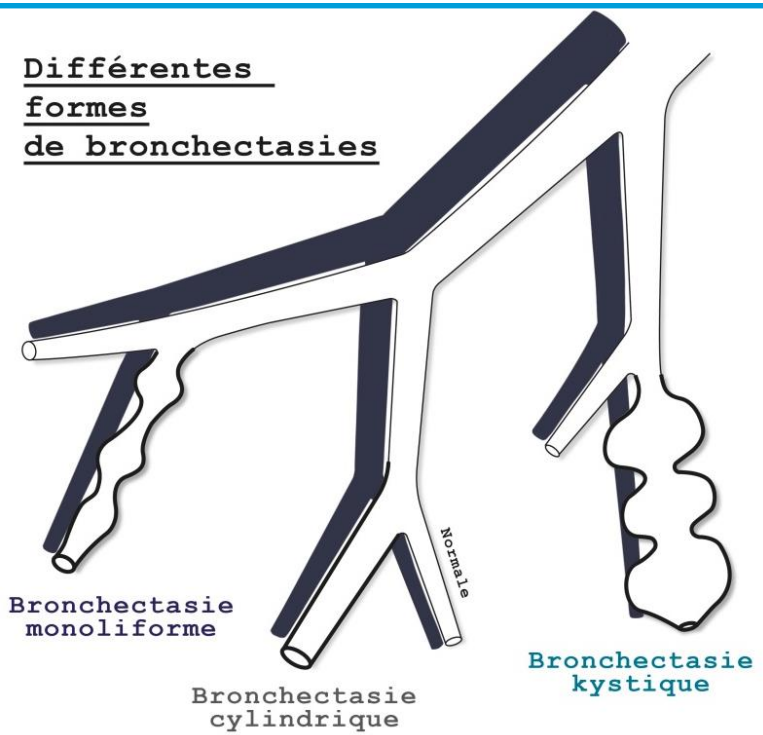
Bronchectasis

Irreversible bronchial dilation associated with inflammation of the bronchial walls

- **Lack of regression in bronchial diameter +++** (from proximal to distal)
- **Visible bronchi at the periphery of the lung**
- **↑ broncho-arterial ratio> 1:** non-specific (elderly, altitude)
- **Acute lung disease can lead to pseudo-bronchiectasis (functional)**
- Associated signs: ventilatory disorders (collapse, atelectasis, constrictive bronchiolitis), bronchopathy / secondary infection, systemic hypervascularization





Bronchiolitis

Cellular bronchiolitis

- **Inflammatory infiltrate** : involve the lumen and the walls of the bronchiole
- **Reversible with possible sequels**
- **Etiologies :**
  - ✓ Infection
  - ✓ Respiratory
  - ✓ Follicular
  - ✓ Aspiration bronchiolitis
  - ✓ Diffuse panbronchiolitis
  - ✓ HSP acute

- **CT Direct signs +++ Centrolobular micronodules , tree in bud+/- Reversible trapping**

Constrictive bronchiolitis

- **Circumferential submucosal fibrosis**
- Resulting in **stenosis** or even obliteration of the bronchiolar lumen and obstruction of air flow .
- **Irreversible**

Etiologies

- **Infection +++:** viral infection during childhood
- Inhalation of toxic fumes
- Connective tissue disease
- Drug toxicity
- Chronic rejection after lung transplant
- Rejection of bone marrow transplant
- Inflammatory diseases of the digestive tract
- Idiopathic

CT

- Indirect sign: **irreversible trapping**

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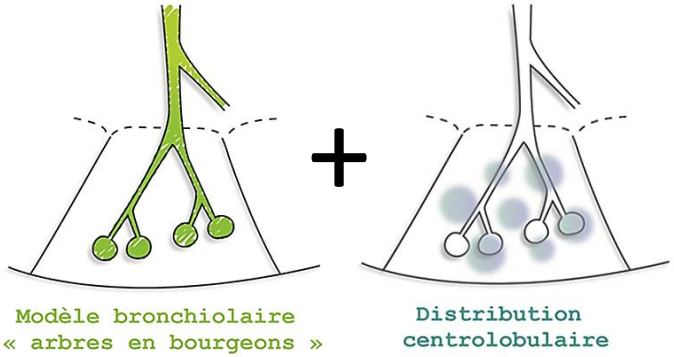
Bronchiolite cellulaire

- **Inflammatory infiltrate** : involve the lumen and the walls of the bronchiole
- **Reversible with possible sequels**

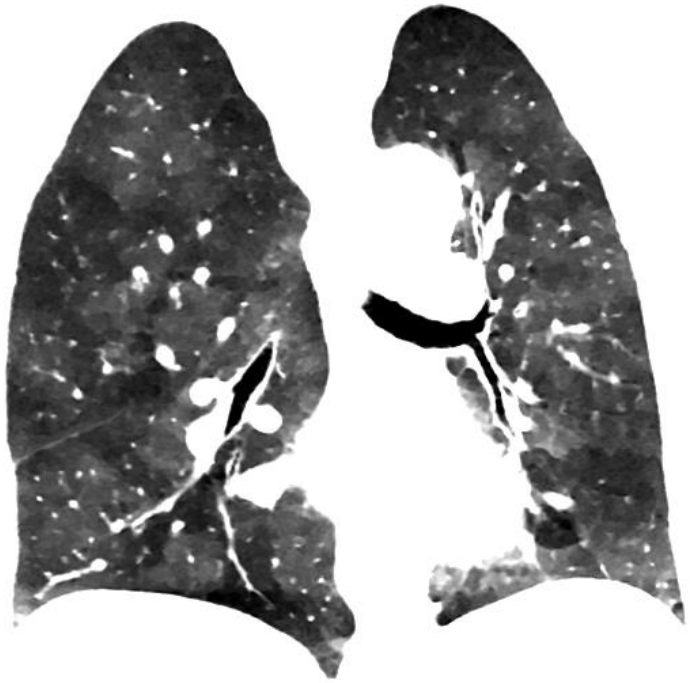
CT
- **Direct signs +++**
- **Centrolobular micronodules, tree in bud**
- **+/- Reversible trapping**

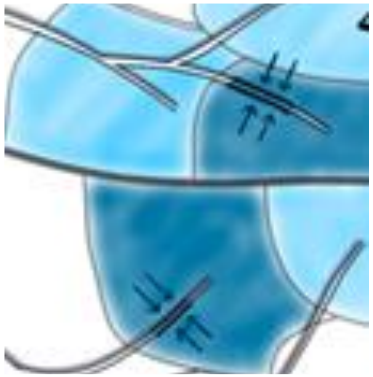


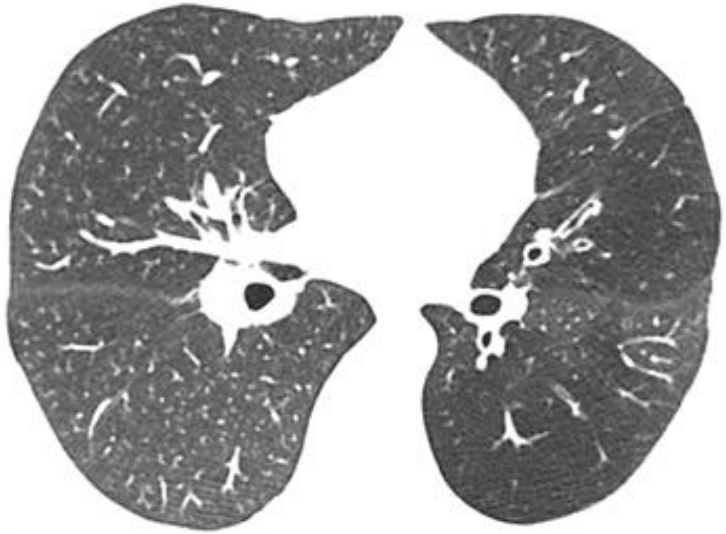
- **Infection**
  - **Tree in bud**
  - **Virus**, **bacteria** (mycoplasma), **BK/MBA**, **aspergillus**; complete regression or bronchiectasis +/- constrictive bronchiolitis
  - Tuberculosis: acinar enlargement (specific if no existing previous bronchiectasis)
- **Respiratory**
  - Tobacco, macrophages, **centrolobular micronodules (CMN) upper.**
- **Follicular**
  - Lymphocytic infiltration → **centrolobular micronodules**, trapping, cylindric **bronchectasis .**
  - **Connective tissue disease (RA, Sjögren) ++**, ID, HS
- **Inhalation bronchiolitis**
  - Repeated inhalations (cognitive impairment / swallowing)
- Diffuse Panbronchiolitis
  - **Asiatic ++, centrolobular micronodules,** tree in bud , bronchiectasis, lower lobe and diffuse.
- HSP acute/ subacute
  - Exposure, ill define micronodules, trapping, mosaic lung.

Contrictive bronchiolitis

Irreversible circumferential fibrosis
Bronchiole stenosis or obliteration, without endoluminal granulation tissue or surrounding parenchymal inflammation







Imaging
- **Air trapping (expiratory)**

→ Mosaic lung
- Reflex vasocontriction
- Bronchectasis

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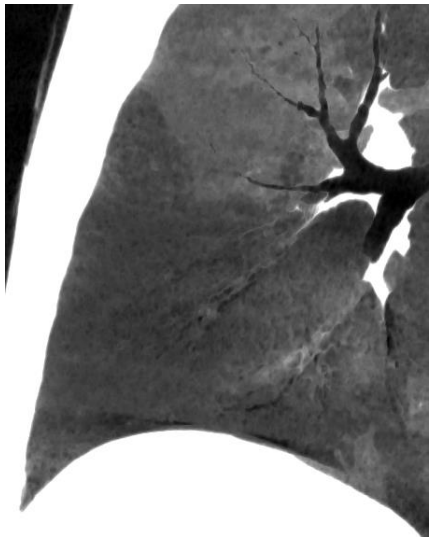

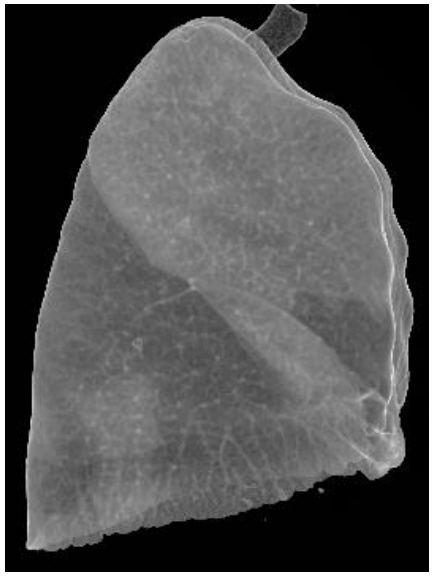

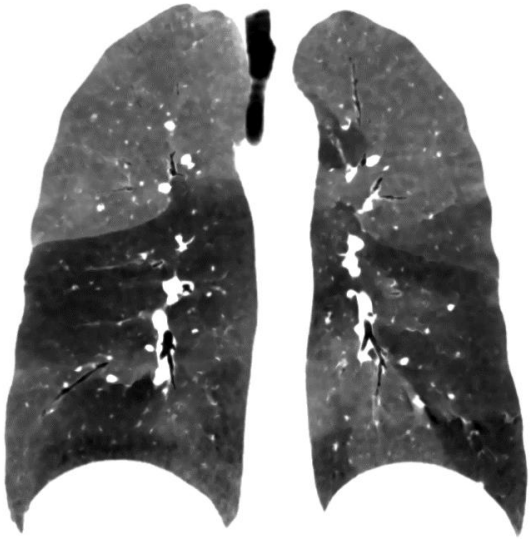

Etiologies

- ✓ **Post-infectious +++**
  - **Viral infection** in childhood (respiratory adenovirus, RSV)
  - Infection occurring in adults or children (mycoplasma, pneumocystosis, influenza)
  - Mycobacteria
- ✓ **Inhalation of toxic fumes**
  - NO^2, SO^2
- ✓ **Connective tissue disease**
  - Rheumatoid arthritis ++
  - Sjögren's syndrom
- ✓ **Drug toxicity**
  - Penicillamine, gold salts…
- ✓ **Transplantation**
  - **Chronic rejection** of **lung transplant**
  - Rejection of **bone marrow transplant**
- ✓ Inflammatory diseases of the digestive tract
- ✓ Idiopathic

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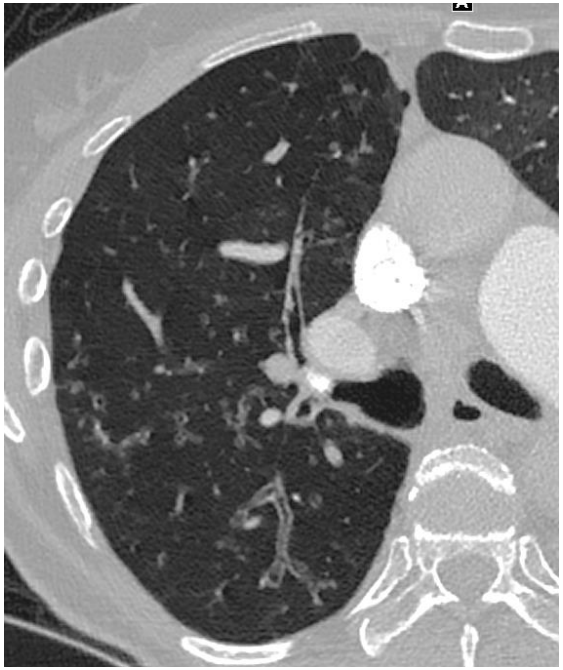
Broncholithiasis

- **Calcium material** in the bronchial lumen, the origin is a partially calcified peribronchial lymph node which has progressively eroded / deformed the wall
- **Rare**

= Lymph node with granulomatosis
- Tuberculosis
- Histoplasmosis
- Sarcoïdosis
- Silicosis



Chest Xray
- Hilar calcified material +/- atelectasis

CT
- ✓ **Peribronchial calcified lymph nodes**
- ✓ **Obstructive complications** (atelectasis, obstructive pulmonary disease, bronchiectasis, expiratory trapping)
- ✓ **Absence of associated tissue mass** .
- ✓ Middle lobe and anterior segment of upper lobes
- ✓ -> Bronchial Fibroscopy

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Tracheobronchial disease :Key point

Spare the posterior membran

- **Relasping polychondritis**
- Trachéobronchopathia osteochondrodysplasis (TPOP)
- Coumadine related chondrocalcinosis

Nodular thickening

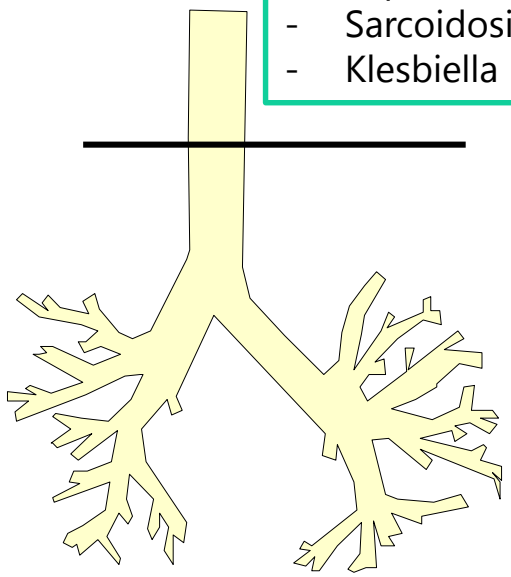
- Infection (TB, klesbiella)
- Papillomatosis
- Wegener
- TPOP
- Amyloidosis

Wall calcified

- Tracheobronchopathia osteochondrodysplasis(TPOP)
- Coumadine related cartilage calcification
- Amyloidosis
- Relpasing polychondritis
- Sarcoidosis
- Fibrosing mediastinitis
- Infection like TB

Sus glottic and upper trachea

- Granulomatosis with polyangitis (**Wegener**)
- Papillomatosis
- Sarcoidosis
- Klesbiella



Diffuse or Lower central airway:

- Amyloidosis
- Relapsing polychondritis
- Idiopathic tracheomalacia
- Asthma / COPD

Distal trachea and main bronchi:

- TPOP

ILD : Interstitial Lung Disease

- ILD : Definition / classification
- Idiopathic ILD
  - *Chronic fibrosing* : IPF ★ , NSIP ★
  - *Acute /subacute* : OP ★ , AIP ★
  - *Tobacco link* : DIP, RB ILD ★
  - *Rarer*: LIP ★ , FEPP ★
  - *Unclassifiable*
- Sarcoïdosis
- Connective tissue disease
- Vasculitis
- HSP
- Pneumoconiosis
- Drugs, toxic
- Post radic
- Miscellaneous
  - Eo LD ★
  - LAM ★ Hystiocytosis X ★ Rare cyst ★
  - Erdheim Chester ★ Rosai Dorfman ★ Ig G4 ★
  - Amylosis ★ LPA ★ Alveolar microlithiasis ★

ILD : Interstitial lung disease

Definition

- **Infiltration of pulmonary interstitium , often fibrosing**
- by cells (inflammatory or neoplastic)
- edema
- or by an extracellular matrix rich in collagen

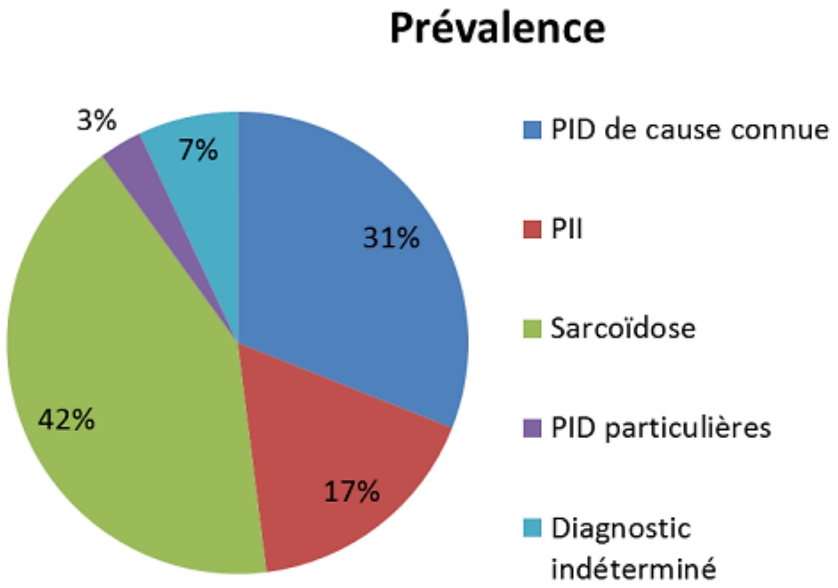
PID timeline:
- **Acute** (PIA): **<3 weeks**
- **Subacute / Chronic** (PCID)**> 3 weeks**

An Official American Thoracic Society/European Respiratory Society Statement: Update of the International Multidisciplinary Classification of the Idiopathic Interstitial Pneumonias, William D. Travis, 2013

- **Idiopathic ILD**
  - Chronic fibrosing
    - **IPF**
    - **NSIP**
  - Acute/ subacute fibrosing
    - **COP**
    - **AIP**
  - Tobacco link
    - **RB-ILD**
    - **DIP**
  - **Unclassable**
  - Rares : LIP, FEPP
- **Granulomatosis: Sarcoïdosis**
- **ILD known cause**
  - Connective tissue disease
  - Vasculitis
  - HSP
  - Pneumoconiosis
  - Drugs, toxic, radic
- **ILD others**
  - LAM, hystiocytosis X
  - Alveolar proteinosis
  - ELD
  - Amylosis

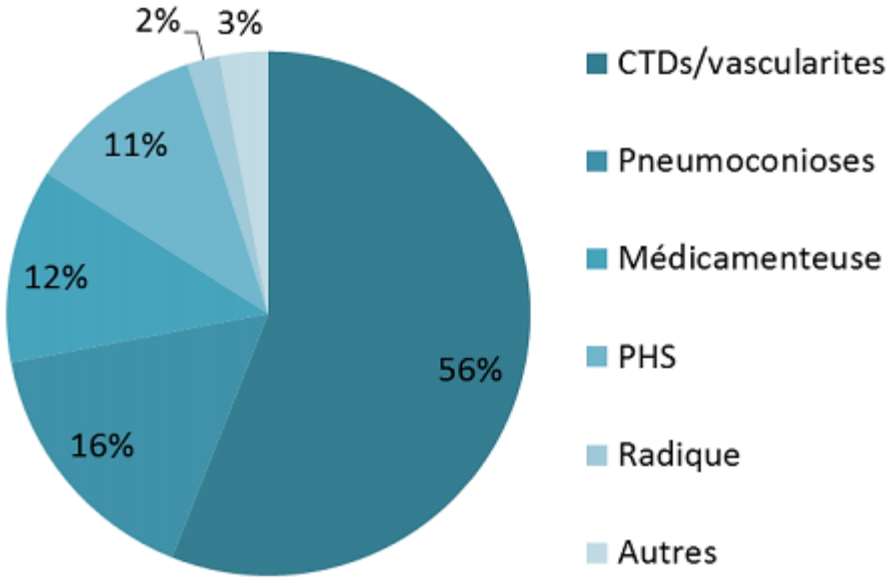
Overall prevalence 97,9/100000

Overall incidence 19,4/100000/an

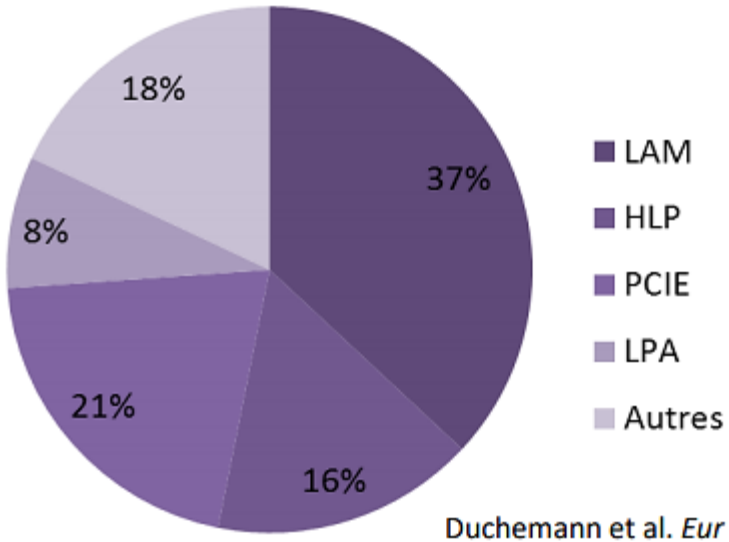


ATS/ERS Am J Respir Crit Care Med 2013

PID de cause connue

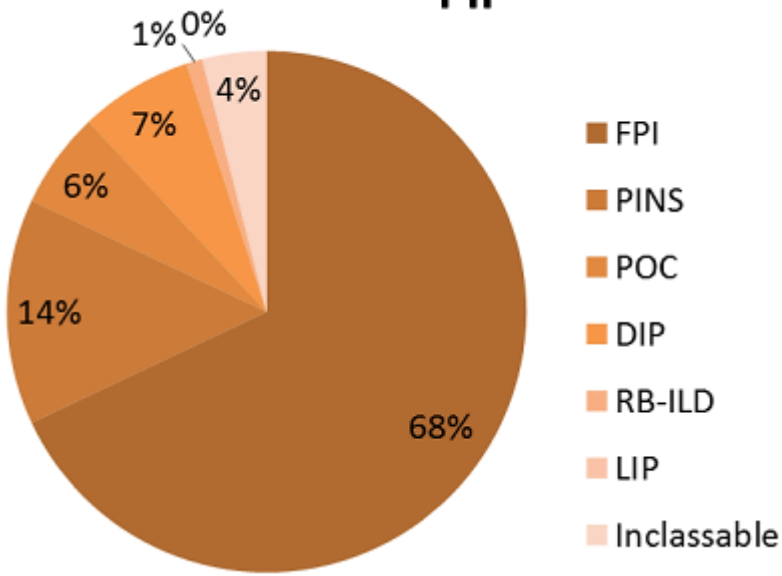


PID particulières



Duchemann et al. *Eur Respir J* 2017

PII



Histopathologic diagnosis	Idiopathic form Clinical diagnosis	Differential diagnosis
UIP Usual interstitial pneumoniae	**IPF** Idiopathic pulmonary fibrosis	Mixed connective tissue disease, asbestosis, CHP
NSIP Non-specific interstitial pneumonia	Idiopathic NSIP	Mixed connective tissue disease, chronic HP, DIP
RB-ILD respiratory bronchiolitis-interstitial lung disease	RB-ILD	Acute HP
DIP Desquamative interstitial pneumonia	DIP	NSIP, Acute HP/ chronic HP
OP organizing pneumonia	COP cryptogenic organizing pneumonia	Mixed connective tissue disease, infection vasculitis, sarcoïdosis, lymphoma, carcinoma, Chronic HP, drugs
LIP Lymphoid interstitial pneumonia	LIP	
DAD Diffuse alveolar damage	AIP acute interstitial pneumonitis	ARDS, infection, PO, hemorrhage

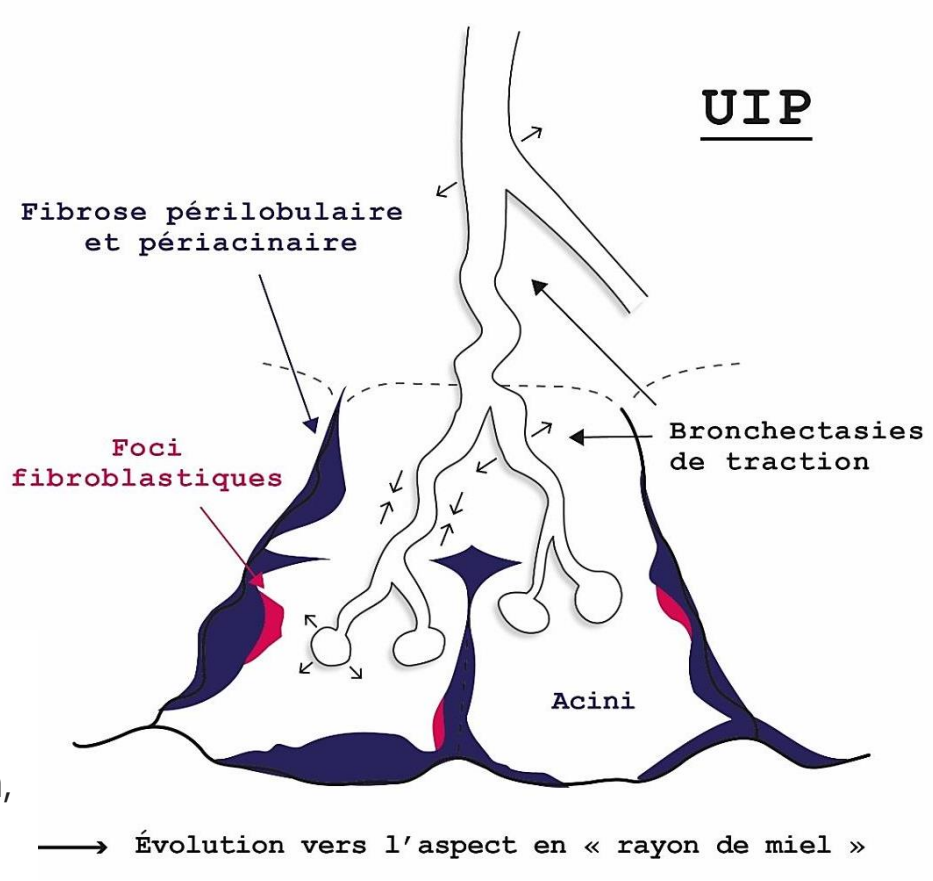
UIP

UIP *usual interstitial pneumoniae*

- ✓ = Anatomo-pathological term
- ✓ Foci of **fibroblasts** and immature connective tissue in the pulmonary interstitium
- ✓ And temporal and spatial **heterogeneity**

It is a pattern !

Histopathological and Imaging aspect and not a pathology. It can be of an **idiopathic nature** (idiopathic pulmonary fibrosis IPF) or **secondary** to a connective tissue disease (example: scleroderma)



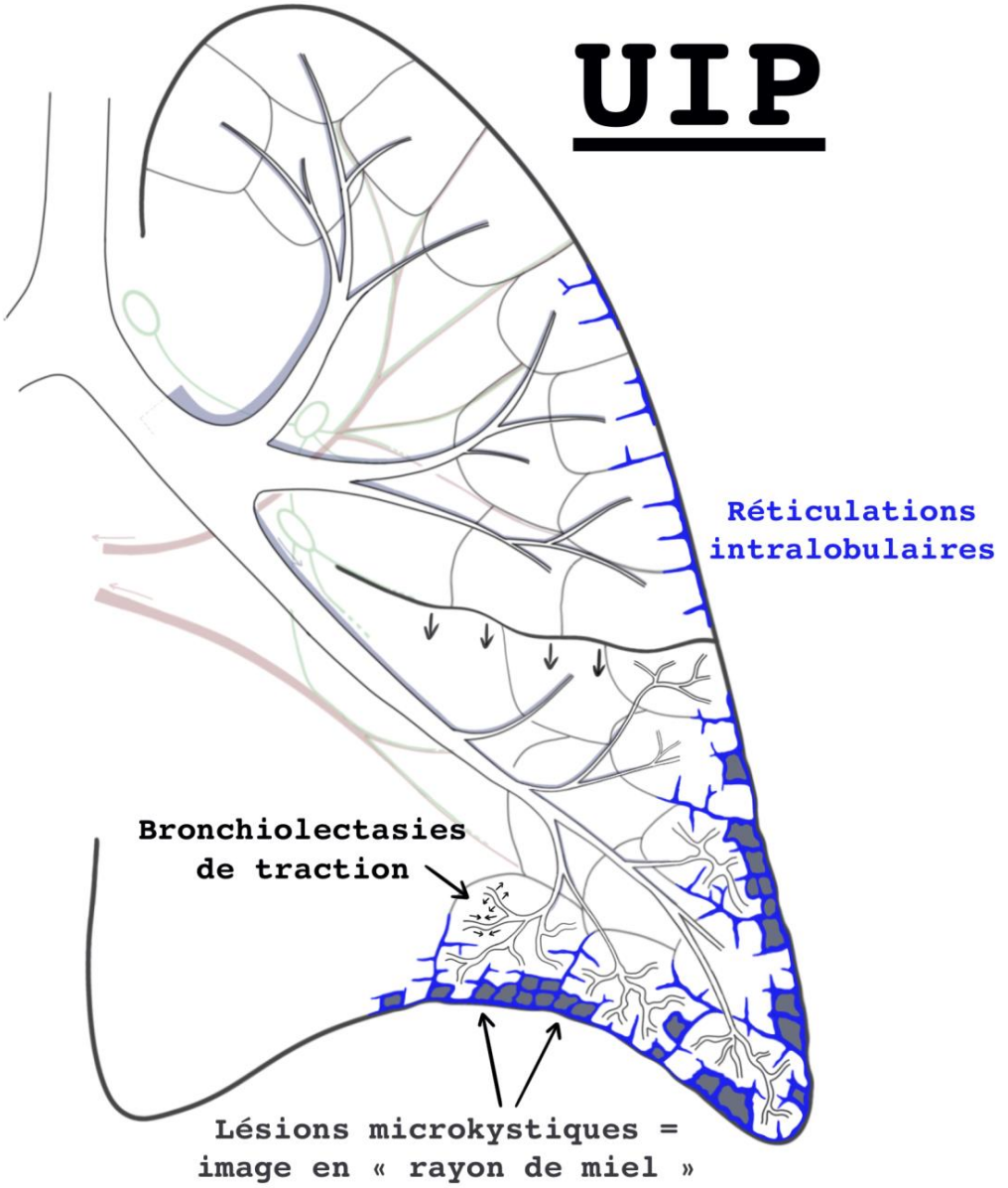
Epidemiology/ pronosis

- 50 years
- Progressive dyspnea and unproductive cough, crackling groans, restrictive syndrome
- Prognosis :
  - Poor response to corticosteroids
  - Poor prognosis (average survival between 2.5 and 3.5 years)

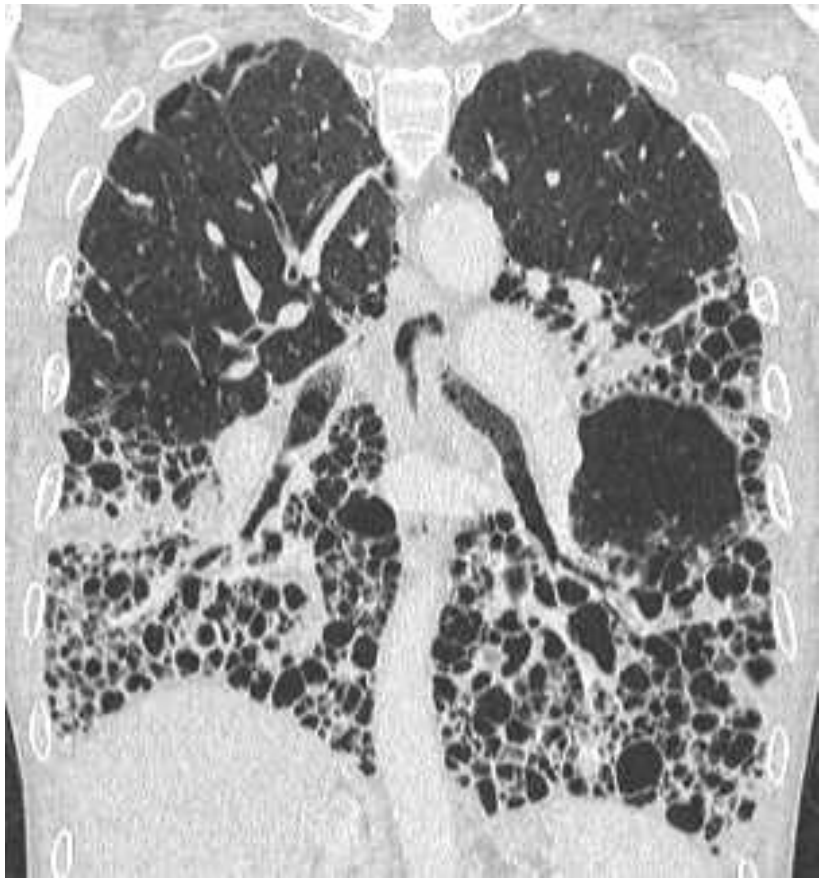
UIP

- Honeycomb +++
- Intra-lobular reticulations
- Traction bronchiectasis
- Location +++
  - Peripheral / subpleural
  - Apico-basal gradient

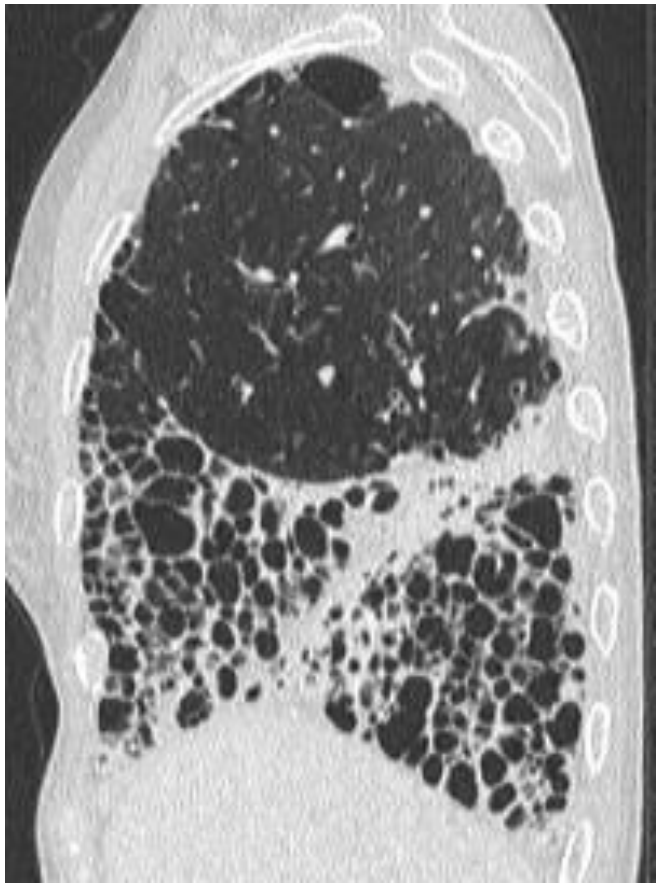
Negative sign: little or **no** Ground glass opacity



Syndrome interstitiel
- des régions sous pleurales et basales
- rayon de miel +/- bronchectasies / bronchiolectasies de traction



Honeycomb



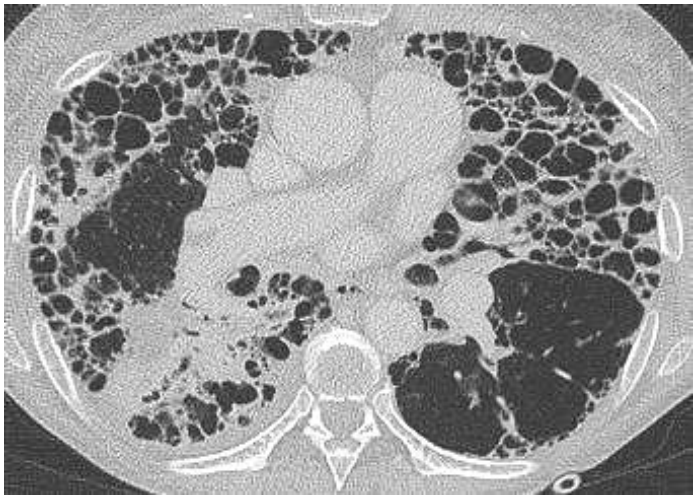
Apico-basal gardient

Subpleural / peripheral

IPF

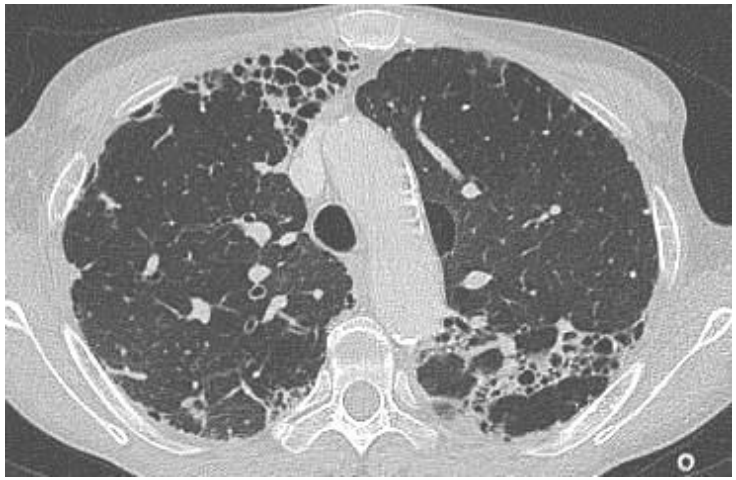
Idiopathic UIP

= IPF (Idiopathic pulmonary fibrosis)



Differential diagnosis (30% UIP)

- Connective tissue disease (RA++)
- Drug induce pneumonia
- Asbestosis
- CHP (chronic hypersensitive pneumonia)



UIP + GGO →

- Disease exacerbation
- APO (acute pulmonary oedema)
- Opportunistic infection
- Drug toxicity

Increased risk of malignancy
Significantly increased risk of lung cancer from fibrosis (x 14 in IPF, peripheral ++)
→ CT: role of screening +++

UIP diagnostic *(ATS /ERS/JRS/ALAT 2018)*

UIP	Probable UIP	Indeterminate for UIP	Alternative diagnosis
Subpleural and basal predominant; distribution is often heterogeneous	Subpleural and basal predominant; distribution is often heterogeneous	Subpleural and basal predominant	Predominant distribution: ◦ Peribronchovascular ◦ Perilymphatic ◦ Upper or mid-lung
Honeycombing with or without peripheral traction bronchiectasis or bronchiolectasis	**Reticular pattern with peripheral traction bronchiectasis or bronchiolectasis** **May have mild GGO**	- Subtle reticulation; may have mild GGO or distortion ("**early UIP pattern**") - CT features and/or distribution of lung fibrosis that do not suggest any specific etiology ("**truly indeterminate for UIP**")	<u>Findings suggestive of another diagnosis, including:</u> CT features: ◦ Cysts ◦ Marked mosaic attenuation ◦ Predominant GGO ◦ Profuse micronodules ◦ Centrilobular nodules ◦ Nodules ◦ Consolidation Other: ◦ Pleural plaques (consider asbestosis) ◦ Dilated esophagus (consider CTD) ◦ Distal clavicular erosions (consider RA) ◦ Extensive lymph node enlargement (consider other etiologies) ◦ Pleural effusions, pleural thickening (consider CTD/drugs)

No need biopsy | Biopsy recommandation

UIP/PIC diagnostic *(ATS /ERS/JRS/ALAT 2018)*

IPF suspected*		Histopathology pattern			
		UIP	Probable UIP	Indeterminate for UIP	Alternative diagnosis
HRCT pattern	UIP	IPF	IPF	IPF	Non-IPF dx
	Probable UIP	IPF	IPF	IPF (Likely)**	Non-IPF dx
	Indeterminate for UIP	IPF	IPF (Likely)**	Indeterminate for IPF***	Non-IPF dx
	Alternative diagnosis	IPF (Likely)** /non-IPF dx	Non-IPF dx	Non-IPF dx	Non-IPF dx

Figure 8. Idiopathic pulmonary fibrosis diagnosis based upon HRCT and biopsy patterns.

*"Clinically suspected of having IPF" = unexplained symptomatic or asymptomatic patterns of bilateral pulmonary fibrosis on a chest radiograph or chest computed tomography, bibasilar inspiratory crackles, and age greater than 60 years. (Middle-aged adults [>40 yr and <60 yr], especially patients with risks for familial pulmonary fibrosis, can rarely present with the otherwise same clinical scenario as the typical patient older than 60 years.)

**IPF is the likely diagnosis when any of the following features are present:

- Moderate-to-severe traction bronchiectasis/bronchiolectasis (defined as mild traction bronchiectasis/bronchiolectasis in four or more lobes including the lingual as a lobe, or moderate to severe traction bronchiectasis in two or more lobes) in a man over age 50 years or in a woman over age 60 years
- Extensive (>30%) reticulation on HRCT and an age >70 years
- Increased neutrophils and/or absence of lymphocytosis in BAL fluid
- Multidisciplinary discussion reaches a confident diagnosis of IPF.

***Indeterminate for IPF

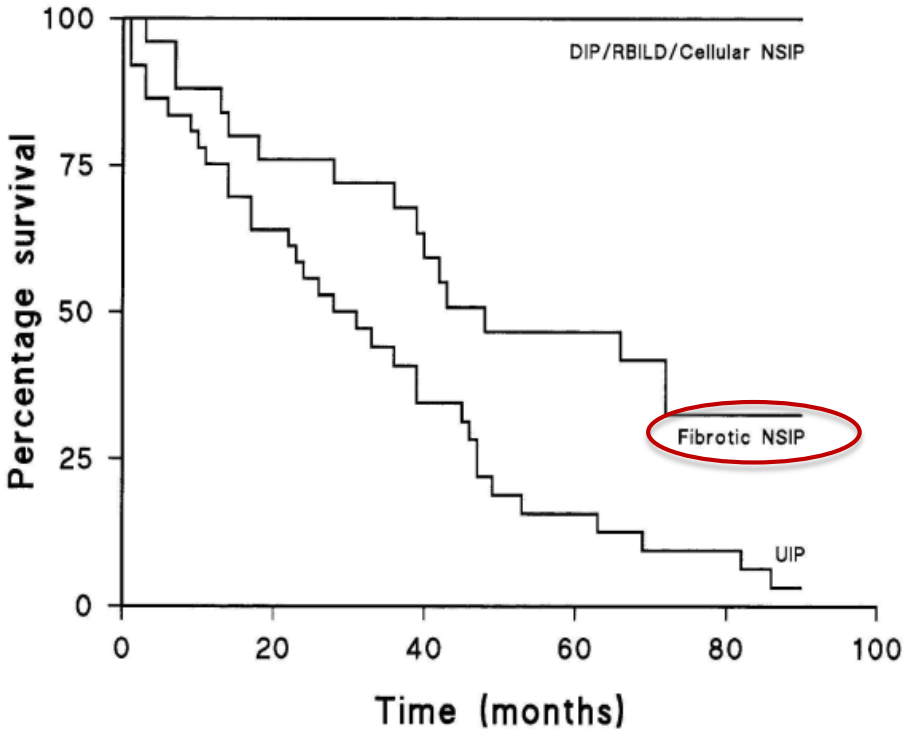
- Without an adequate biopsy is unlikely to be IPF
- With an adequate biopsy may be reclassified to a more specific diagnosis after multidisciplinary discussion and/or additional consultation.

dx = diagnosis; HRCT = high-resolution computed tomography; IPF = idiopathic pulmonary fibrosis; UIP = usual interstitial pneumonia.

NSIP

Histopathology entity

- Homogeneous thickening of the alveolar walls by inflammatory lesions and / or fibrosis
- Spatial and temporal **homogeneity** of lesions

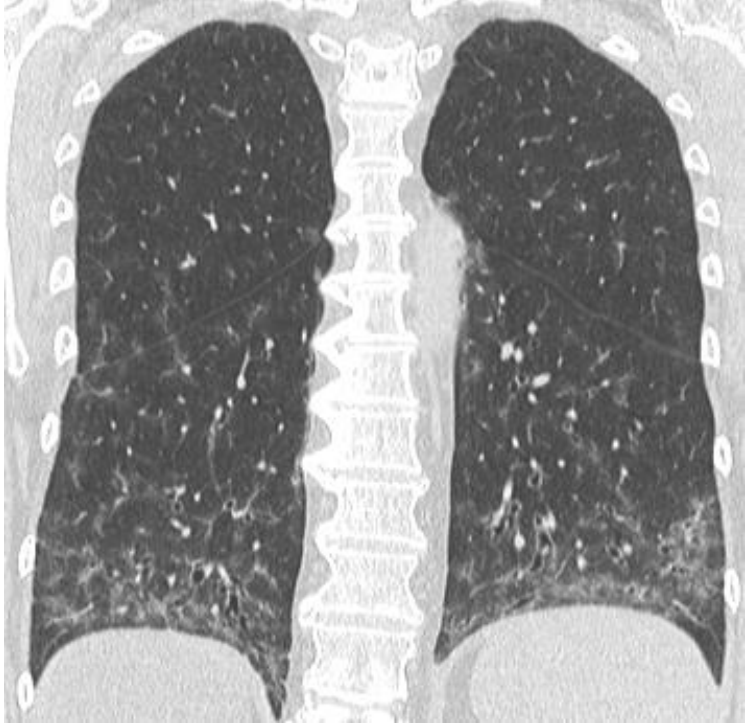


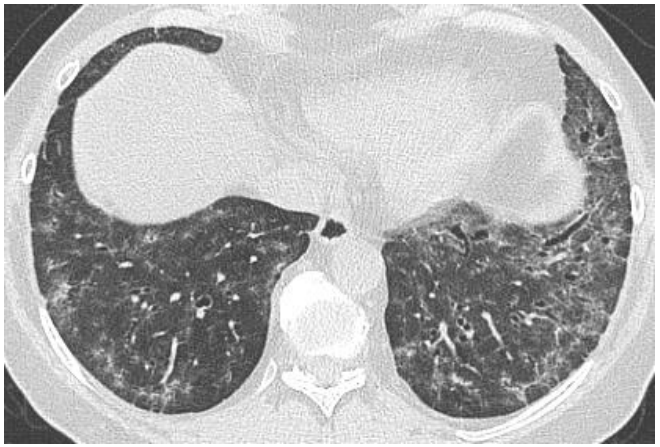
Epidemiology/ prognosis

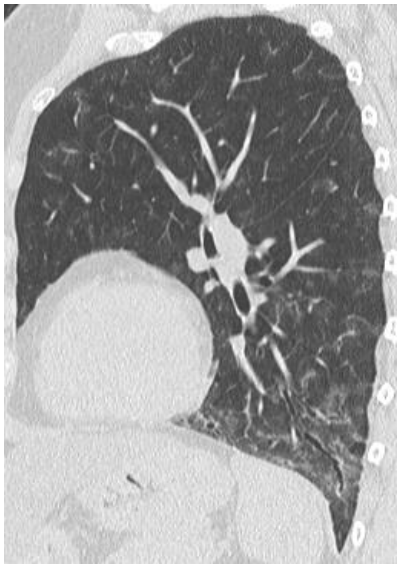
- 40 - 50 years
- Prognosis significantly better than that of the UIP
- NSIP cell / cellular and fibrosis / fibrosing -> prognosis

NSIP

- ✓ **GGO** (100%) **+++**
- ✓ **Intra-lobular reticulations (80%)**
- ✓ **Traction bronchiectasis (80%)**
- ✓ Location
  - ✓ Bilateral +/- symmetrical
  - ✓ **Central + and peripheral ++** with predominantly sub-pleural
  - ✓ **Immediate subpleural sparing**
  - ✓ Apico-basal gradient (50%)
- ✓ **Rare consolidation**



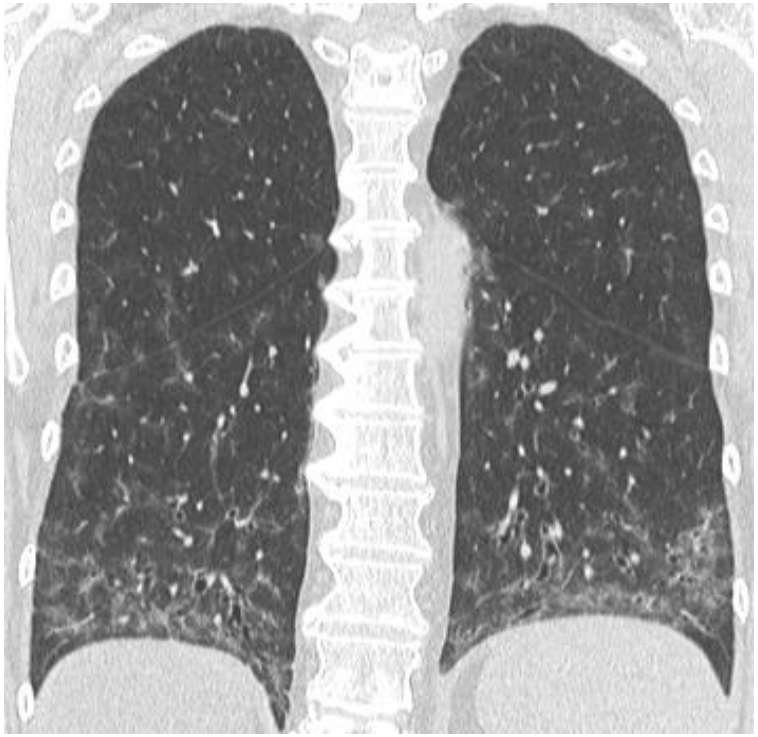


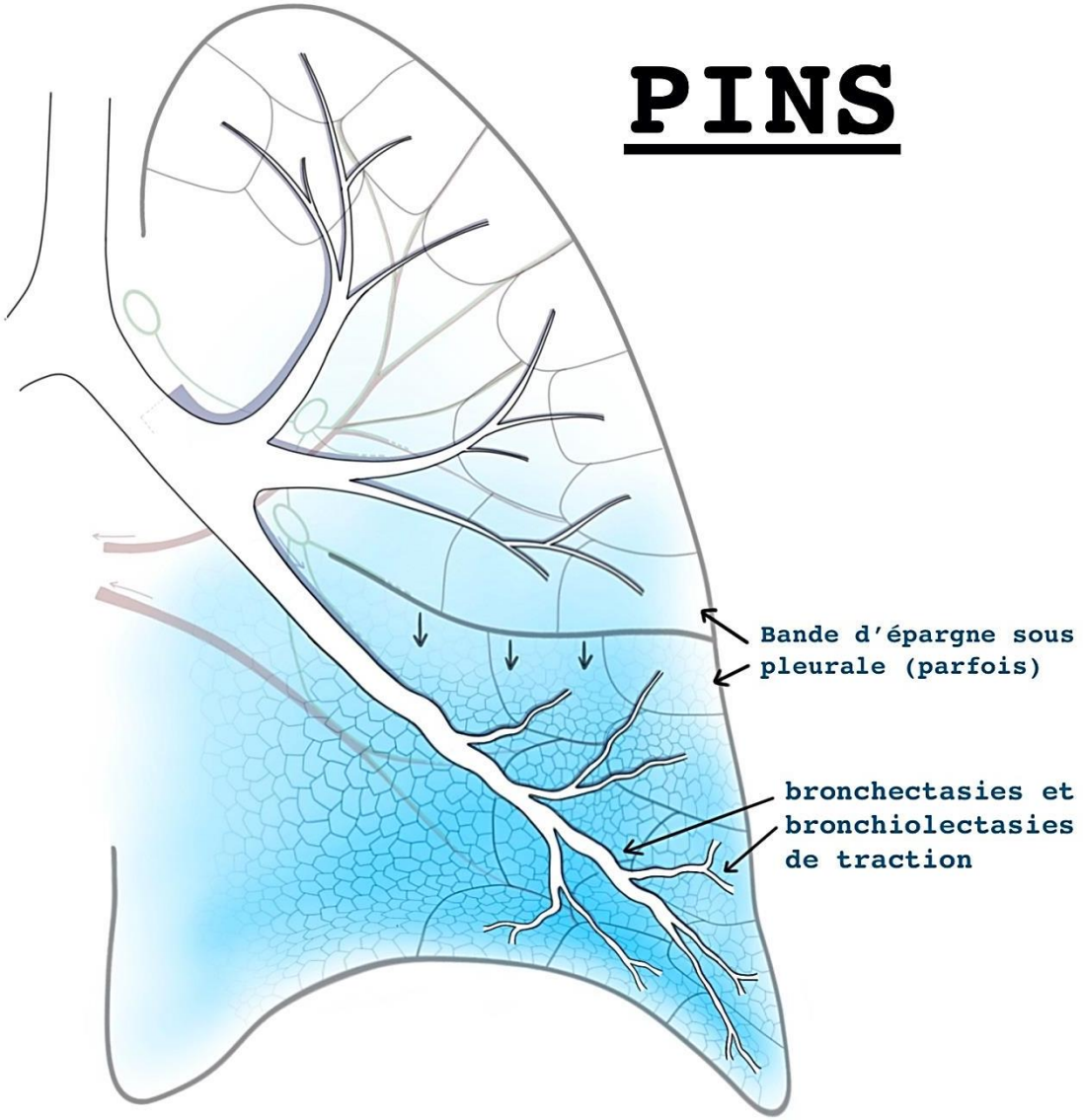


Differential diagnosis

- **Connective tissue disease**
- HP
- Drug induced pneumoniae
- DIP
- UIP
- Sarcoïdosis

PINS

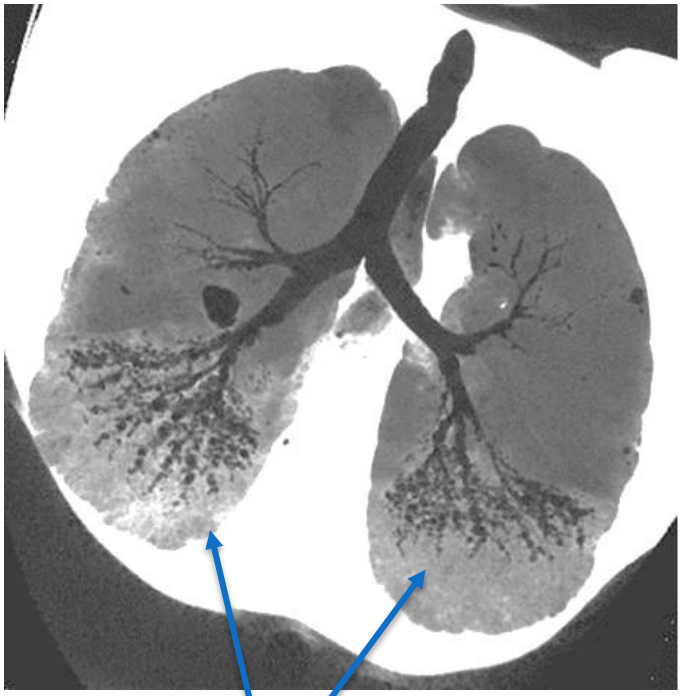


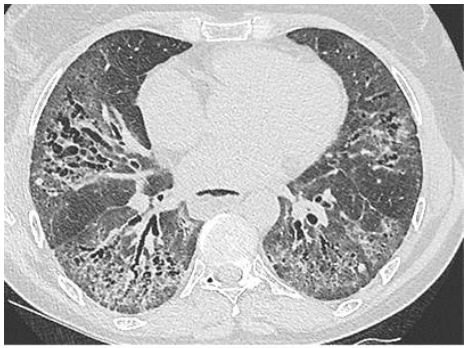


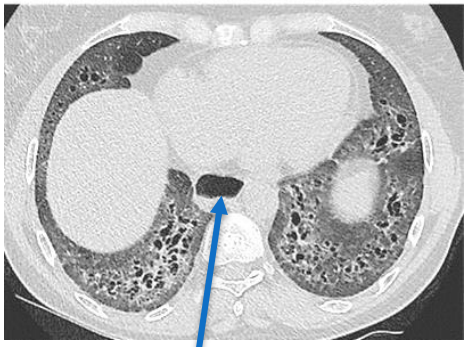
Infiltration diffuse :
- en verre depoli +/- réticulations (crazy paving)
- régions centrales et périphériques
- faible gradient apico basal

Scleroderma with NSIP pattern

TIPS ++
ILD (NSIP++, UIP+)
+ Dilatation of the esophagus
→ Scleroderma

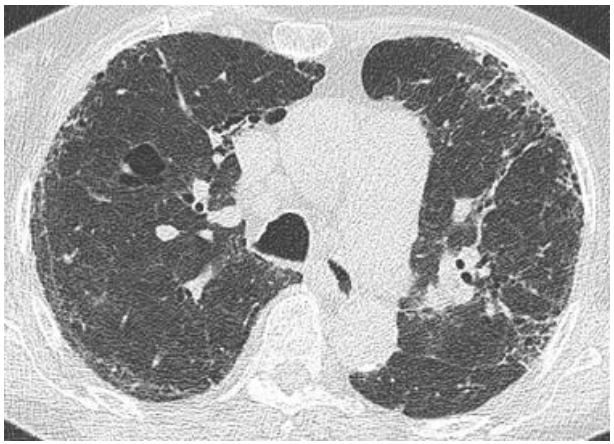


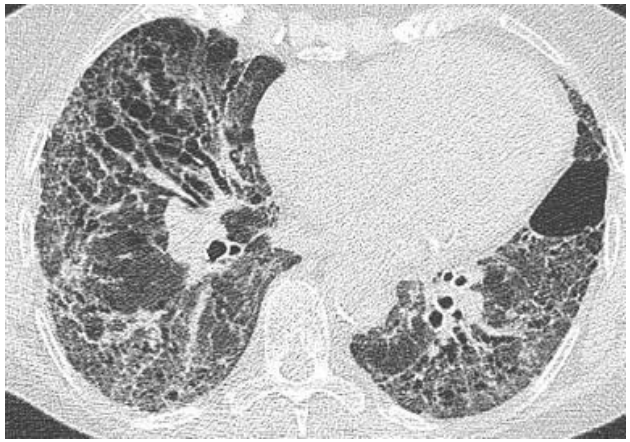


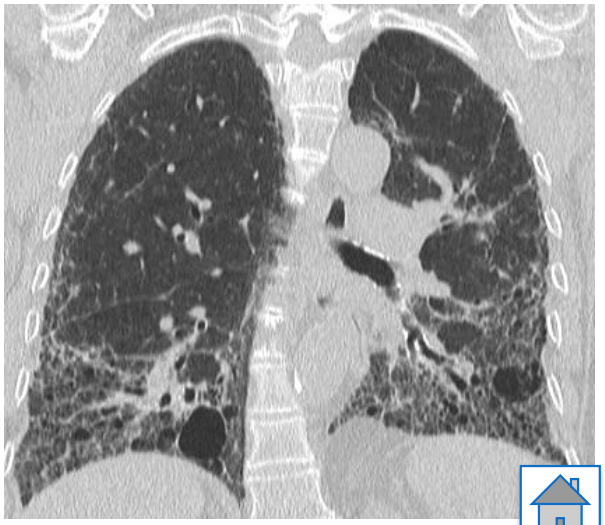


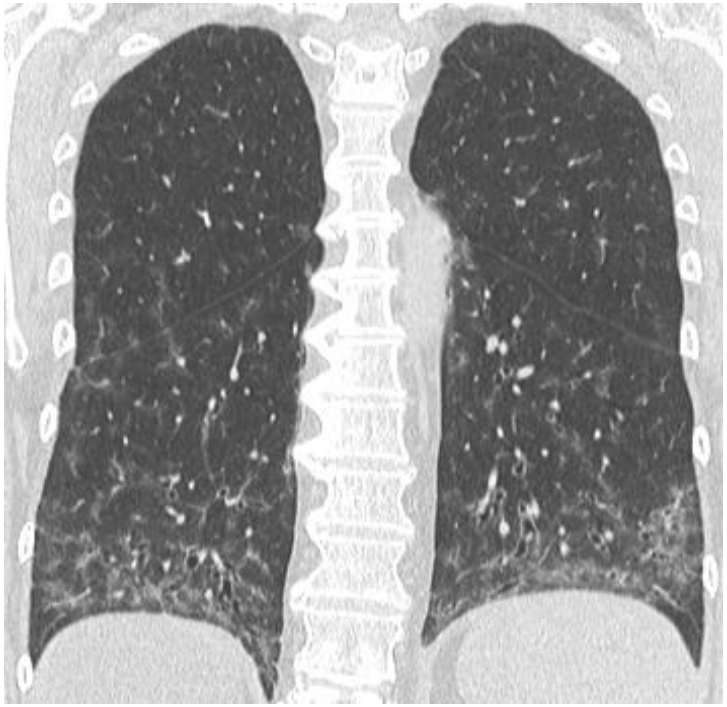
GGO + bronchectasis

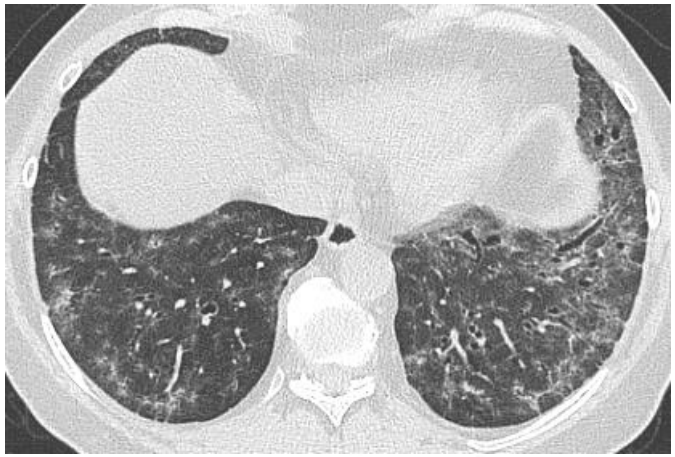
dilatation of the esophagus

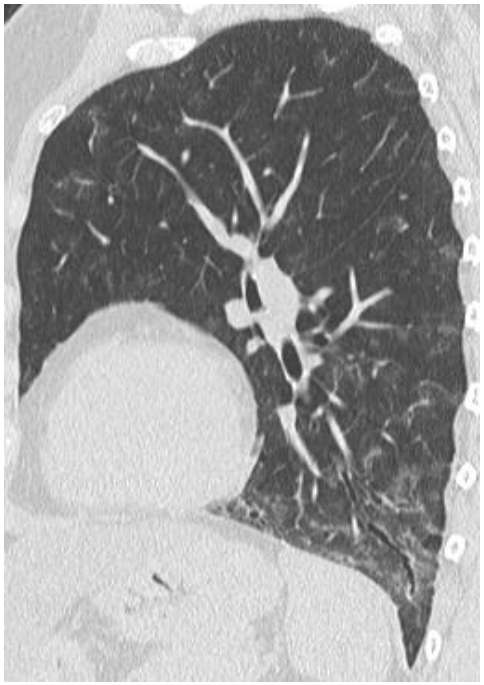


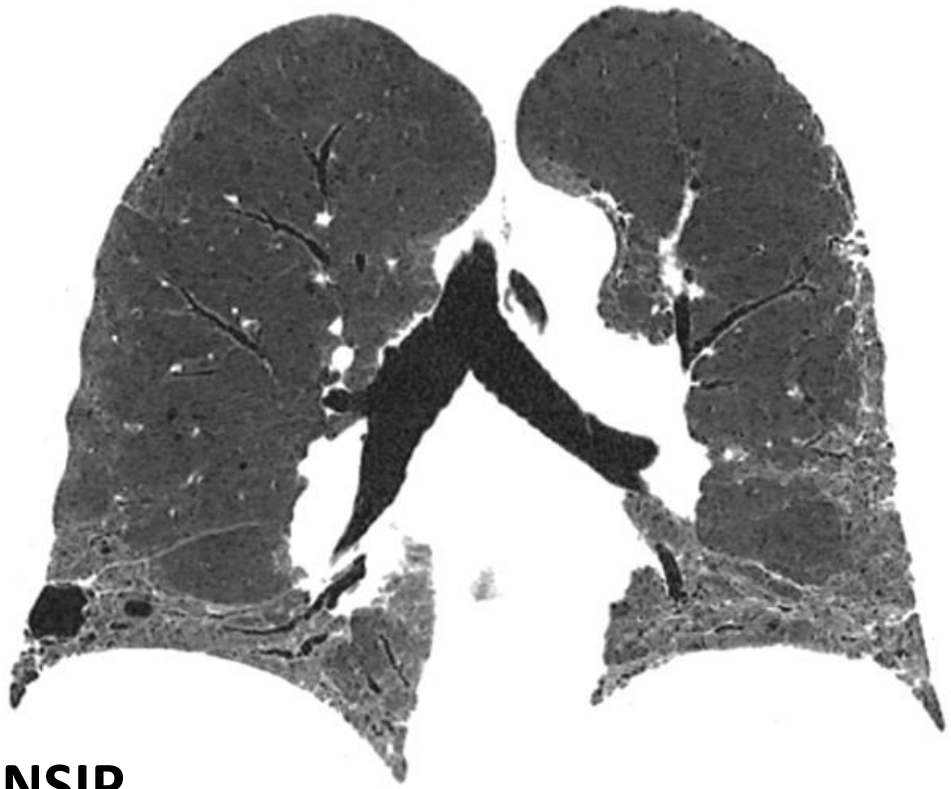












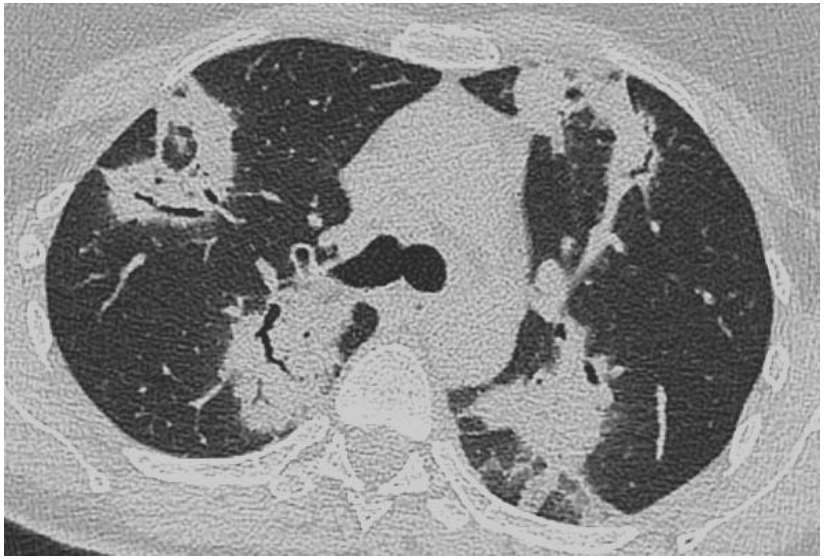
NSIP

Central and peripheral GGO + traction bronchectasis.

OP organizing pneumonia

Definition

- Terminology: BOOP -> OP: organized pneumonia
- Physiopathogy: **Lung tissue repair process**
- **Cryptogenic**
- OP **Secondary**



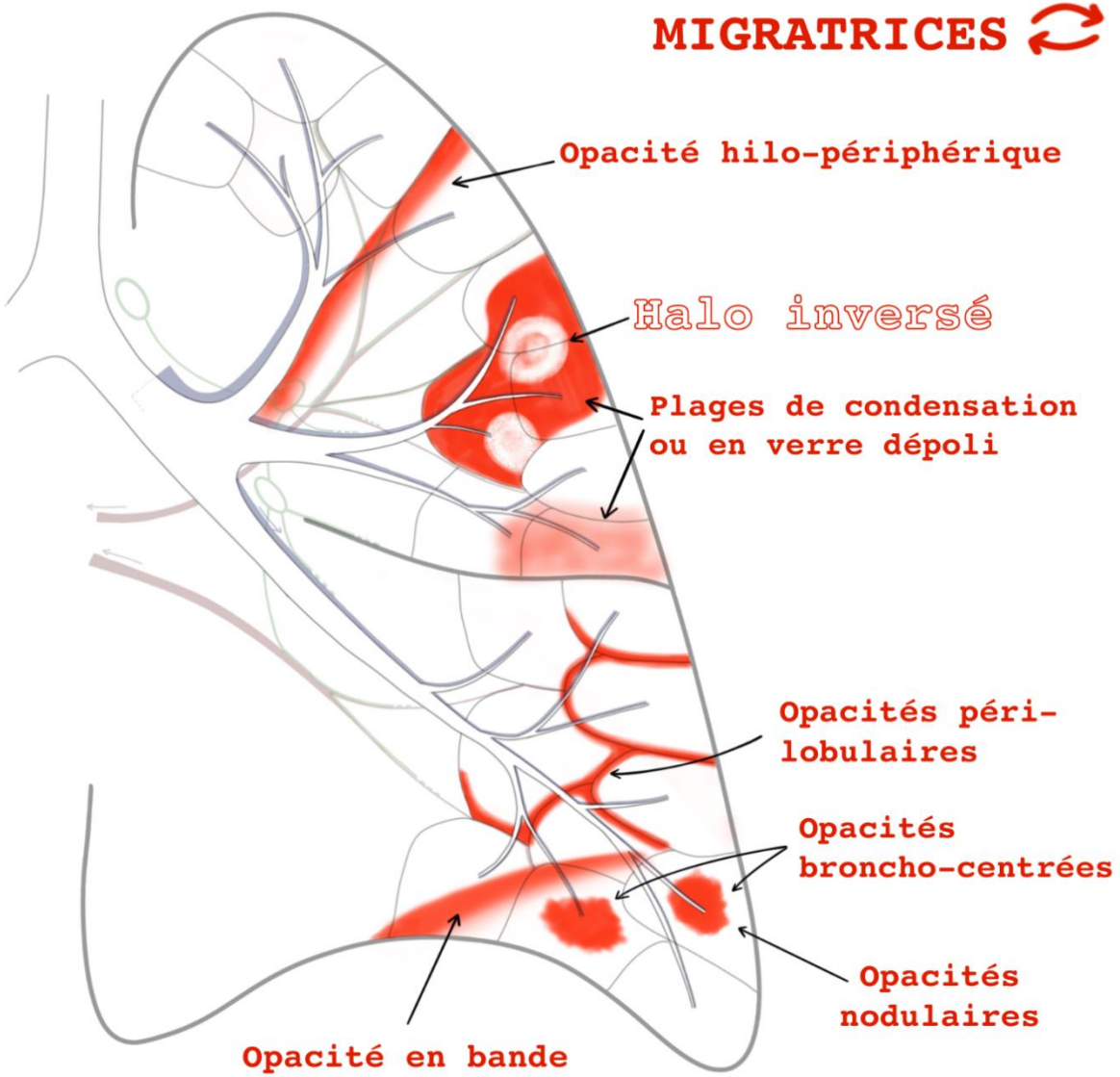
Seconday OP etiology:

- **Pulmonary aggresion:**
  - **Infection**
  - **Drug toxicity** (nitrofurantoin, carbamazepine, amiodarone, interferon)
  - Addiction (**cocaine**)
  - Inhalation of **toxic gas** (hydrogen sulfide, industrial gas)
  - **MCTD** (polymyositis, dermatomyositis)
  - **Organ transplants** (bone marrow)
  - **Radiotherapy** (sometimes away from the irradiation area)
- **Oher pulmonary disease**
  - **Vasculitis** (Wegener)
  - **Tumors** (lymphoma, bronchopulmonary cancer)
  - **Pulmonary infarction**
  - **Hypersensitivity pneumonitis**
  - **Eosinophilic pneumonia**
  - **Diffuse infiltrative pneumonitis** UIP, NSIP, AIP

Pneumopathie organisée; qu'est ce que c'est? Sémiologie conceptuelle et revue iconographique M, Baque-Juston, journal de radiologie 2014

Pneumopathie organisée

Opacités multifocales MIGRATRICES

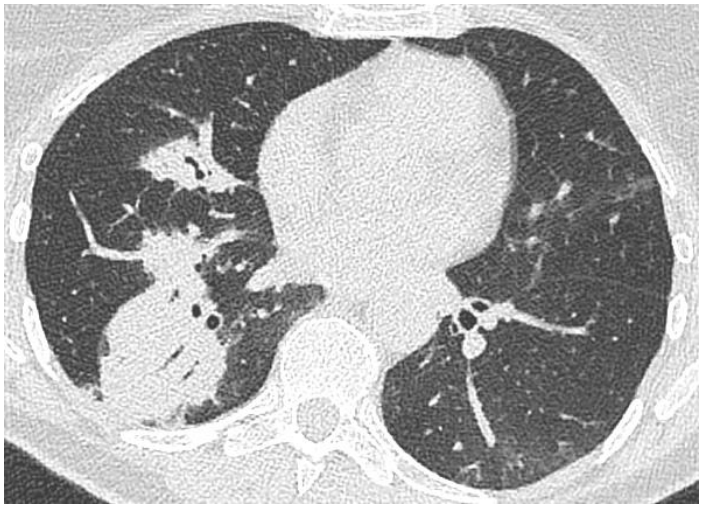


OP organizing pneumonia

1) Migratory multifocal parenchymal consolidation

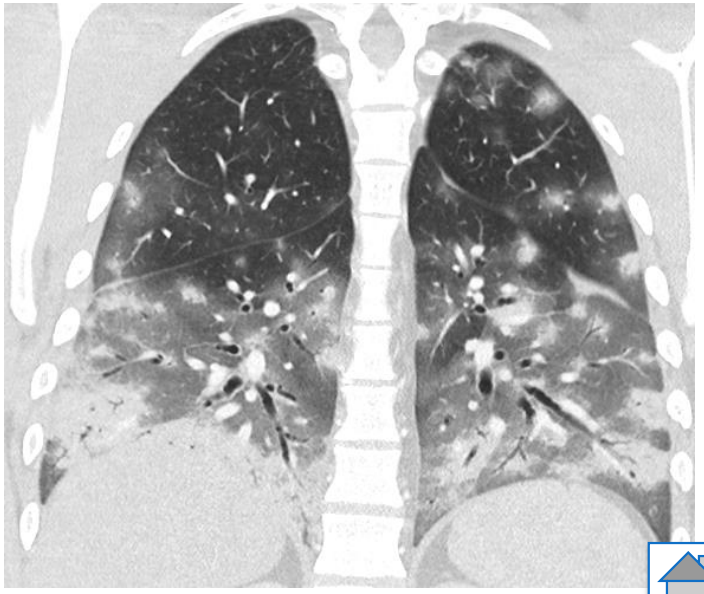
70%

- **subpleural and / or peri-broncho-vascular**
- Lower prevalence (controversial)
- Bilateral and asymmetrical
- +/- GGO glass
- **DDX:** ADK, lymphoma, Eo pn, infectious, Hemorrhage, infarction, sarcoidosis, vasculitis
- **Migrator (30%) +++ DDX: PO , Pn éo C**

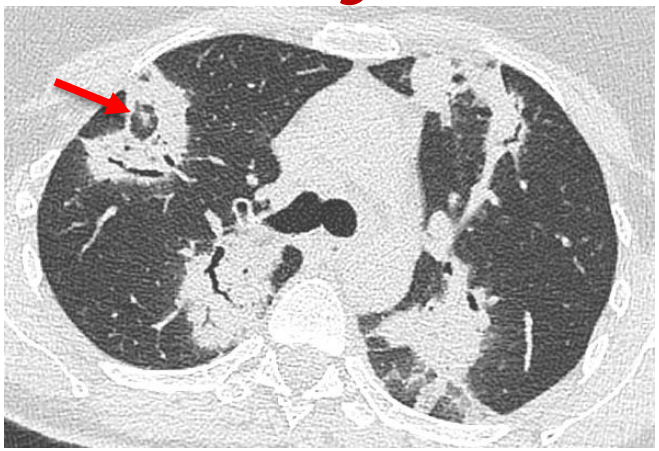


2) Nodules , solitary or multiple mass

- Solid, mixed nodules, rarely in GGO
- centimeter or supra-cm
- Random or peri-broncho-vascular +/- speculated
- frequent fixation with PET scan
- Rare excavation
- Miliary or rare “bud trees”



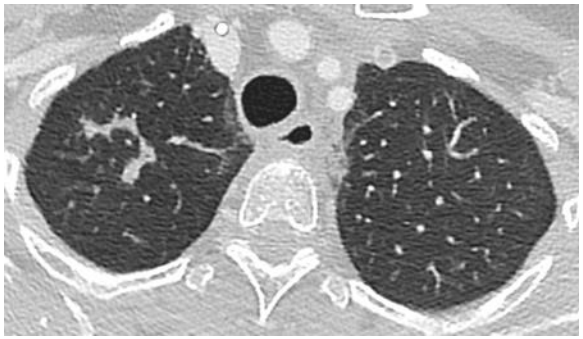
Reverse halo sign +++



3) The reverse halo sign (atoll sign) is considered to be highly specific, although only seen in ~20% of patients with COP:

- GGO surrounded by a crescent or a ring of consolidation

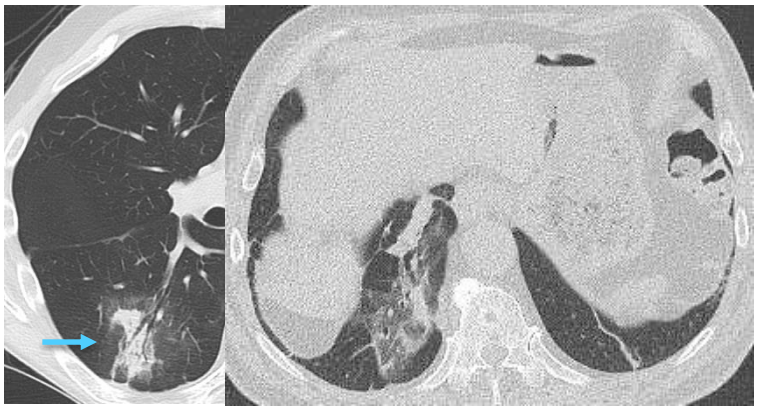
Perilobular consoidation



4) Perilobular pattern with ill-defined linear opacities:

- **Opacities that are thicker than the thickened interlobular septa and have an arcade or polygonal shape.**
- **Thick condensing** strips (> 8mm) Hilo-peripheral, air **bronchogram: very suggestive +++**
- **Under curvilinear pleurals**

Linear opacity

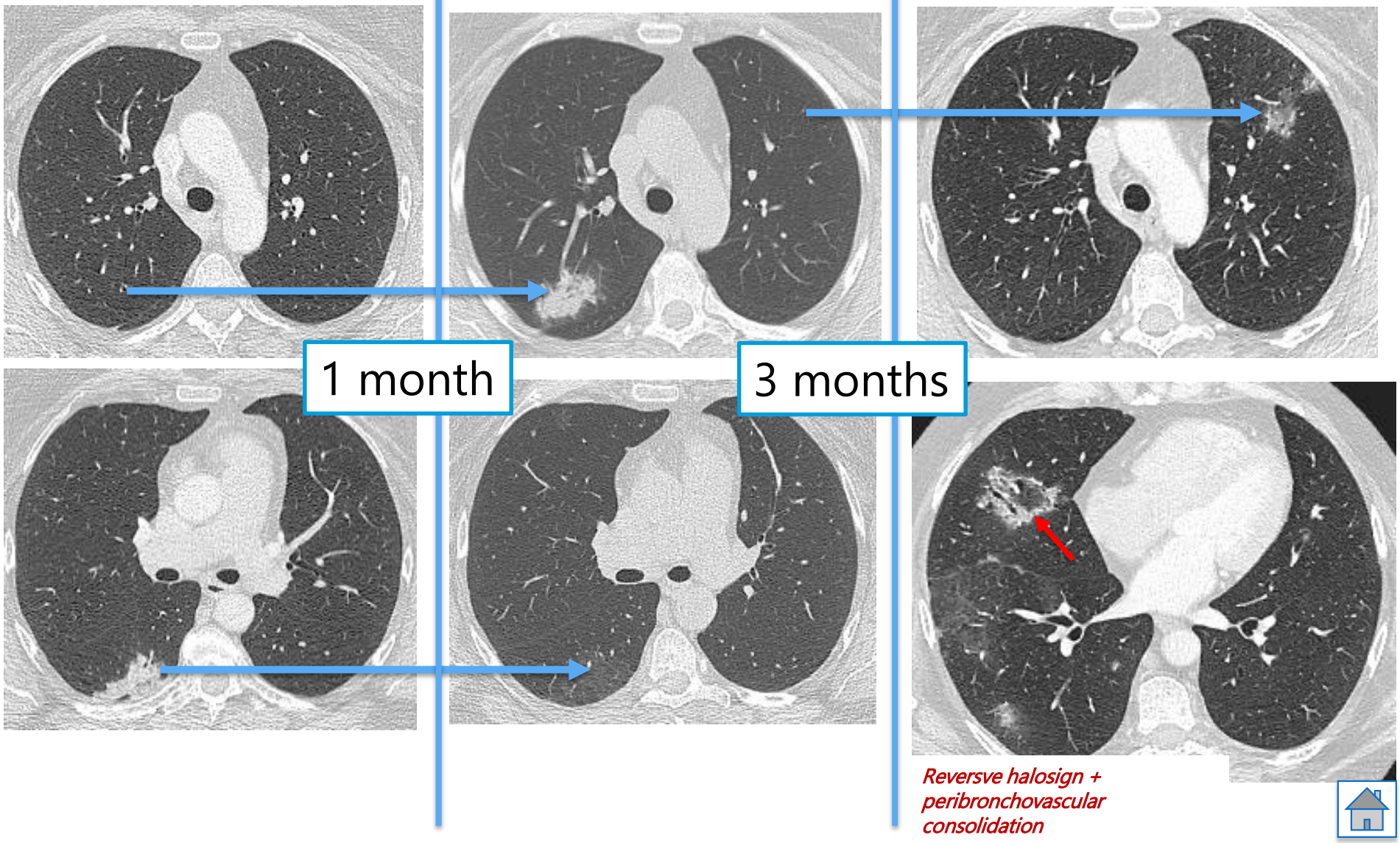


Other signs :

- Crazy paving
- Progressive fibrosis pathology ¼: sub-pleural crosslinks and architectural distortion: same as PINS

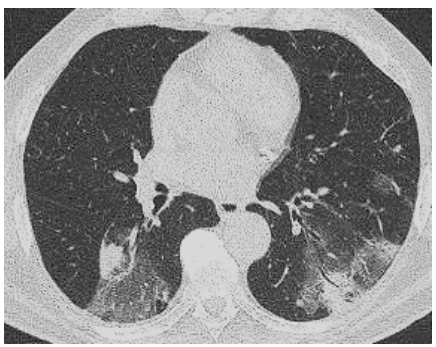
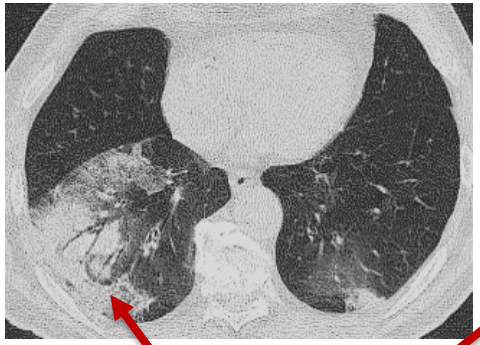
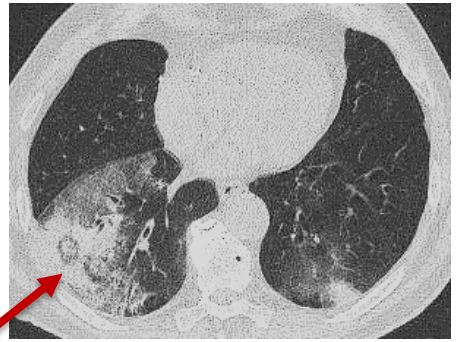
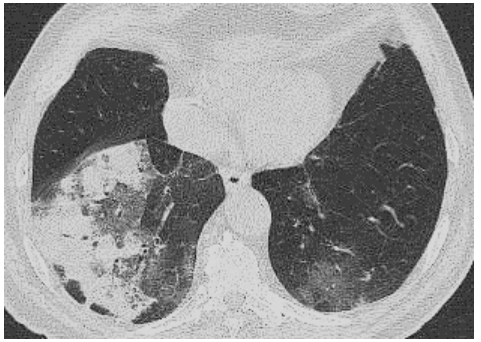
COP

Migratory consolidation

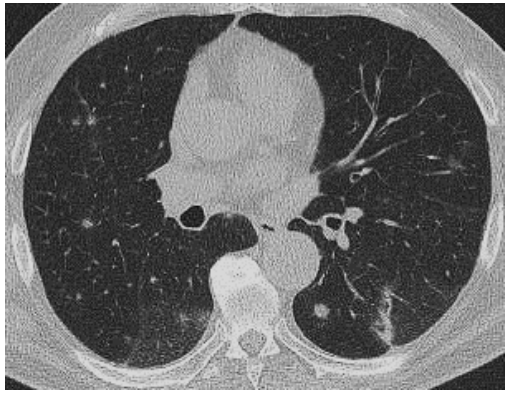


COP

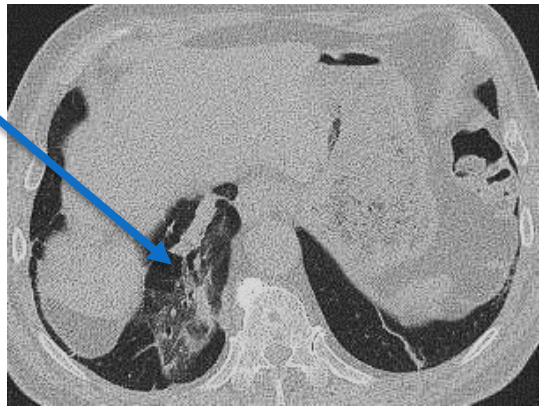
Mai 2011: **subpleural lower lobe consollidation with reverse halo sign**

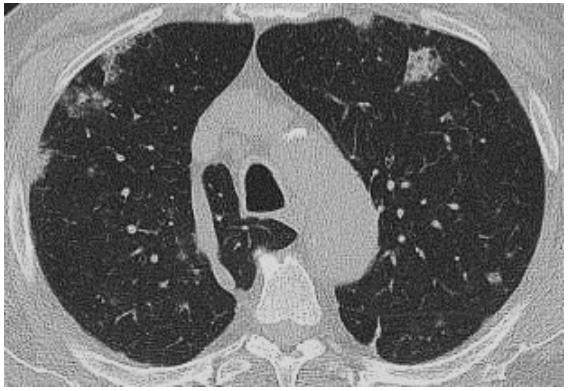
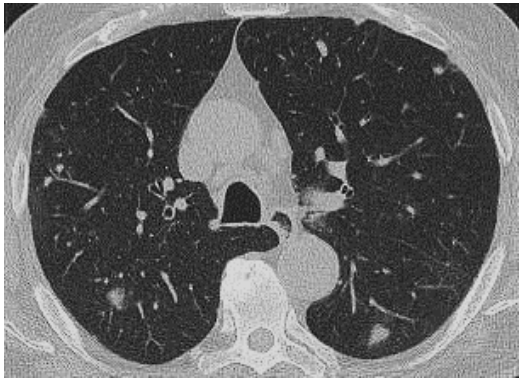
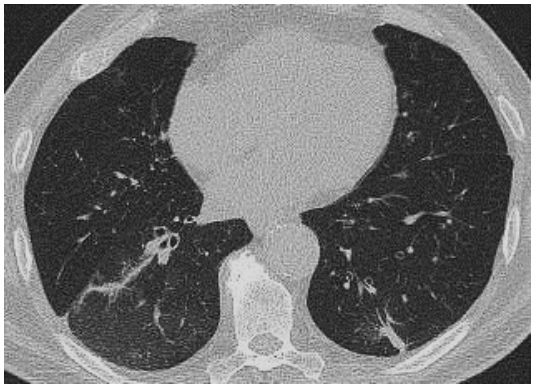
Reverse halo



Subpleural linear opacity

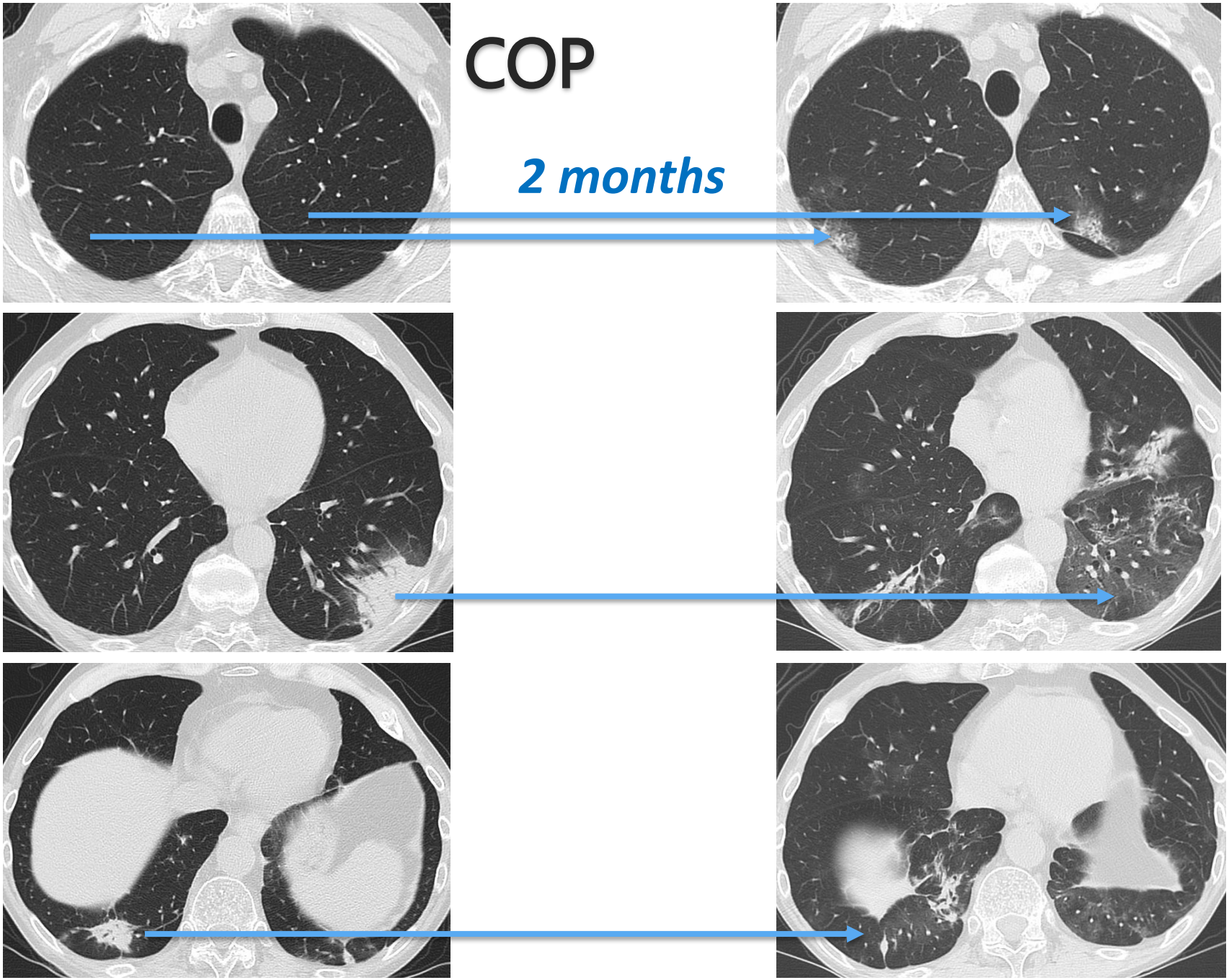


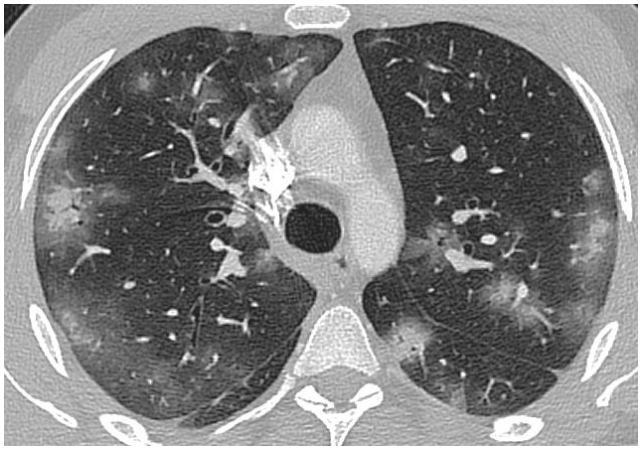
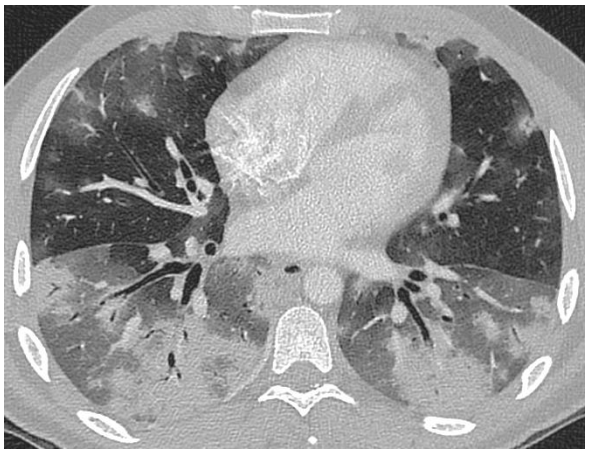
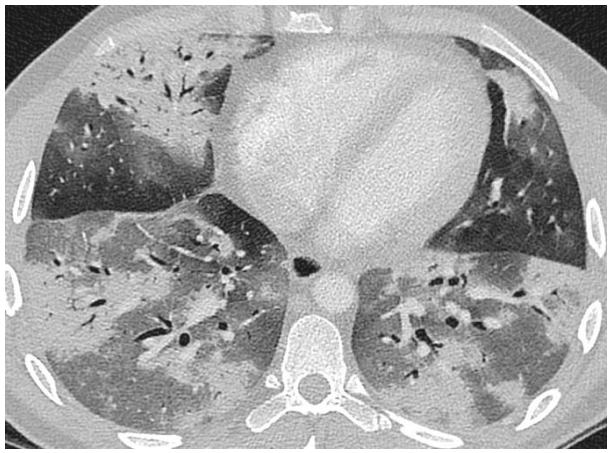
July 2011
- *Migratory*
- *Subpleural linear opacity*

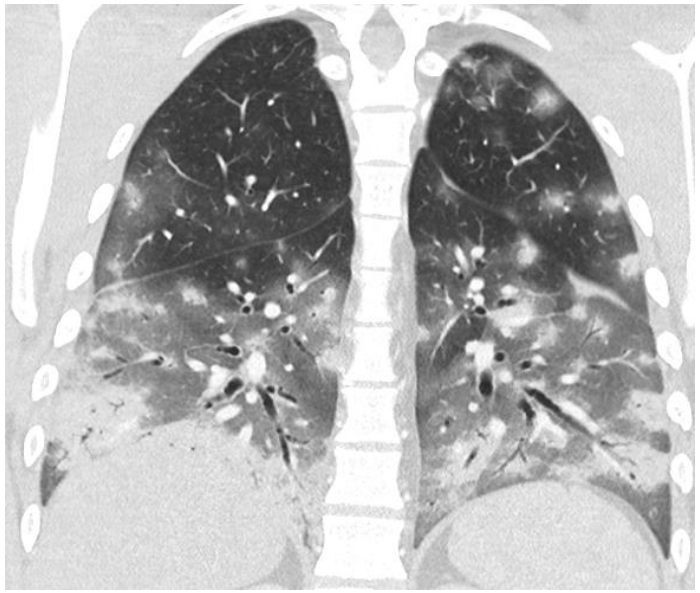
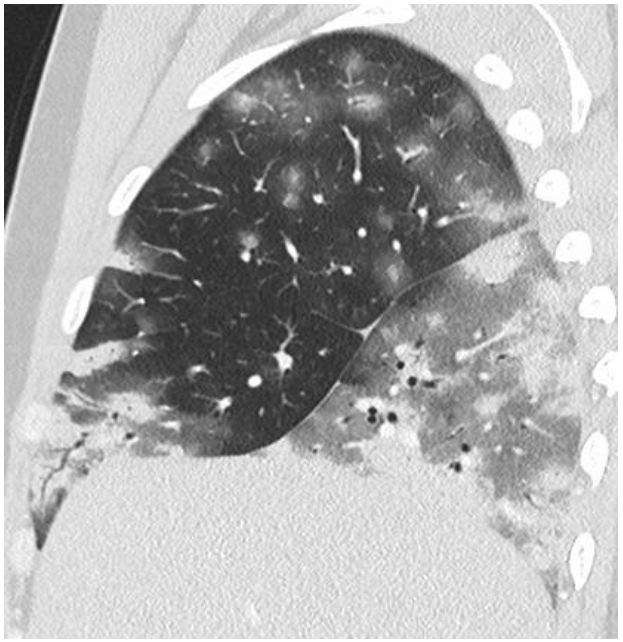
COP

2 months

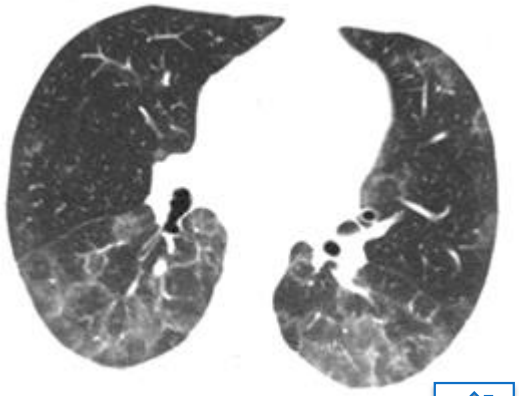


COP Nodular pattern

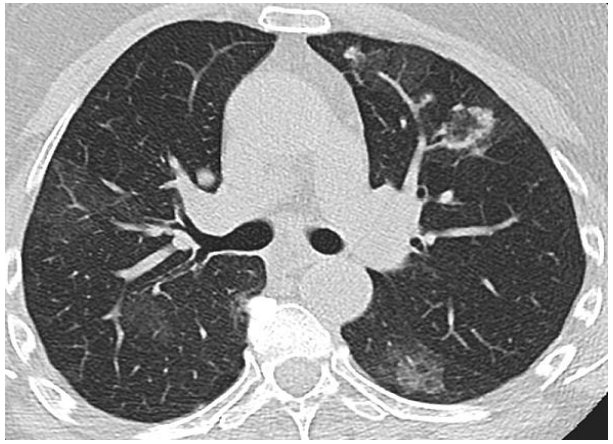



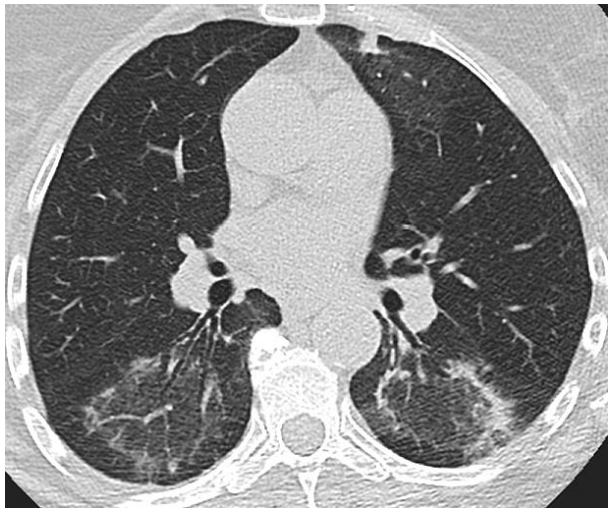
Improvement after steroids



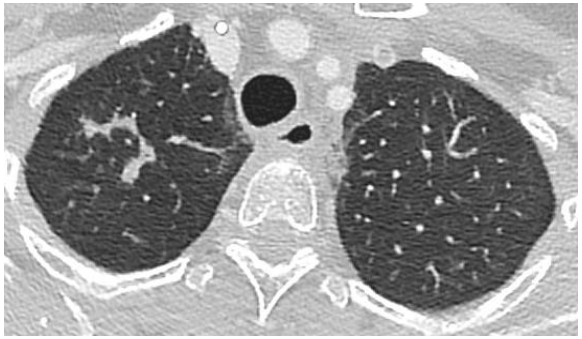
Organised pneumoniae

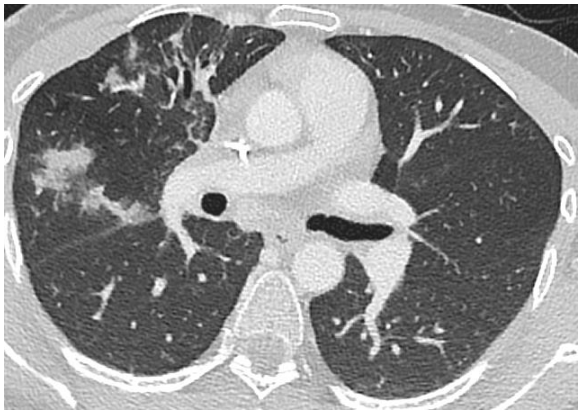
Reverse halo sign

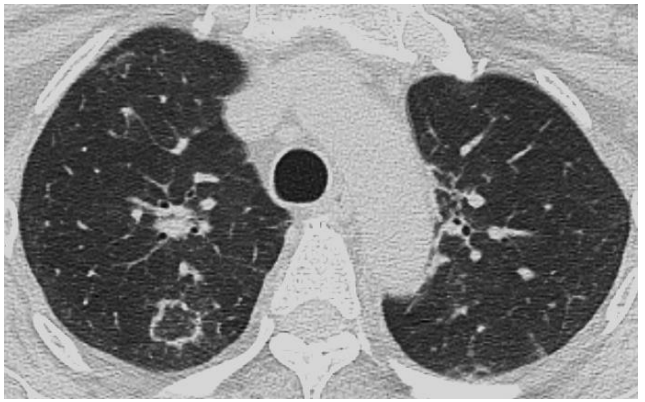


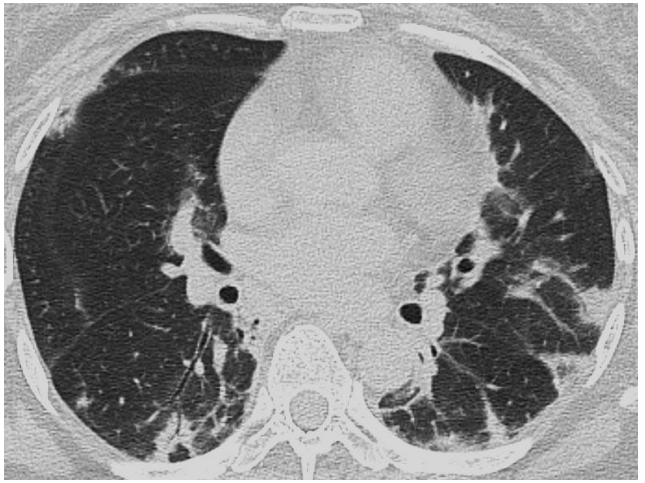


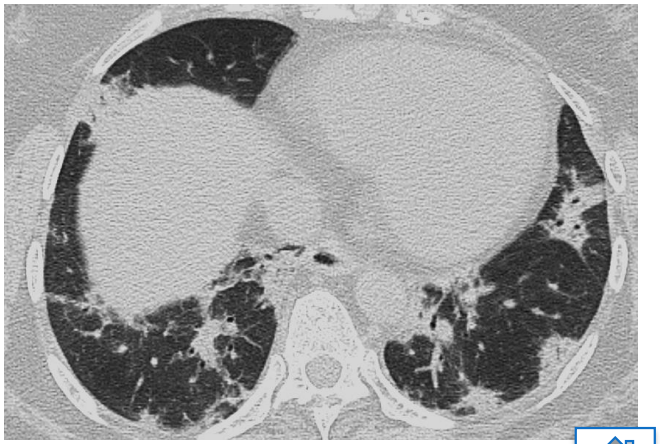
Perilobular location

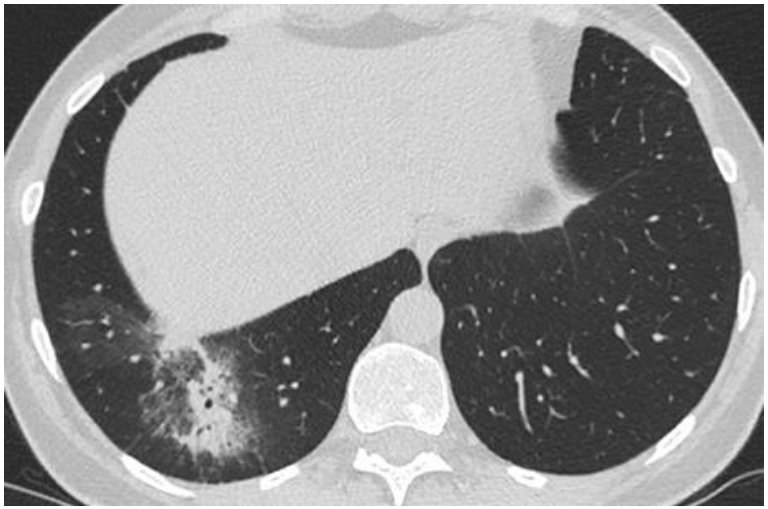
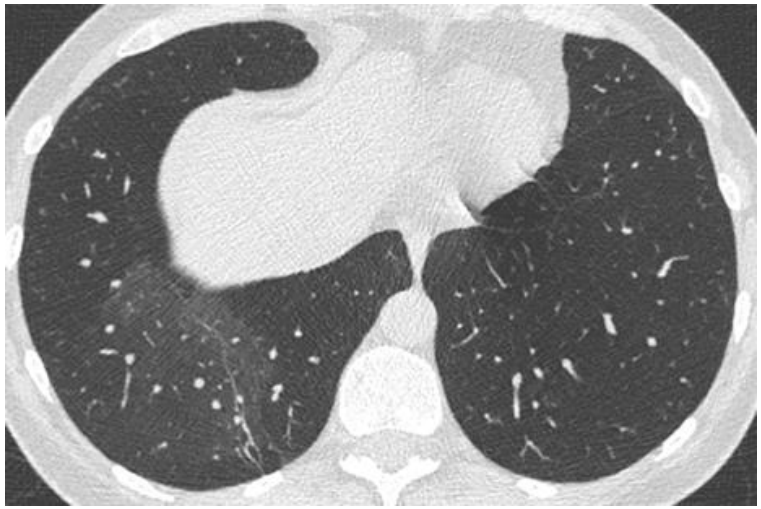




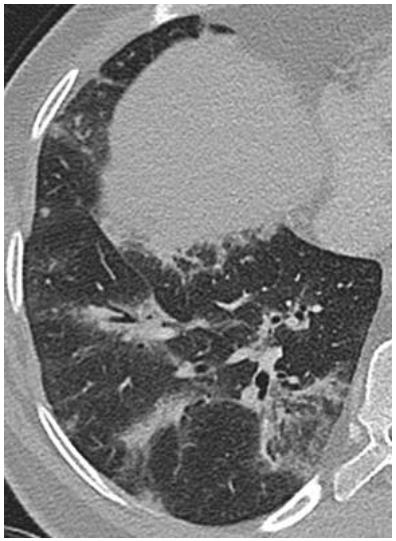
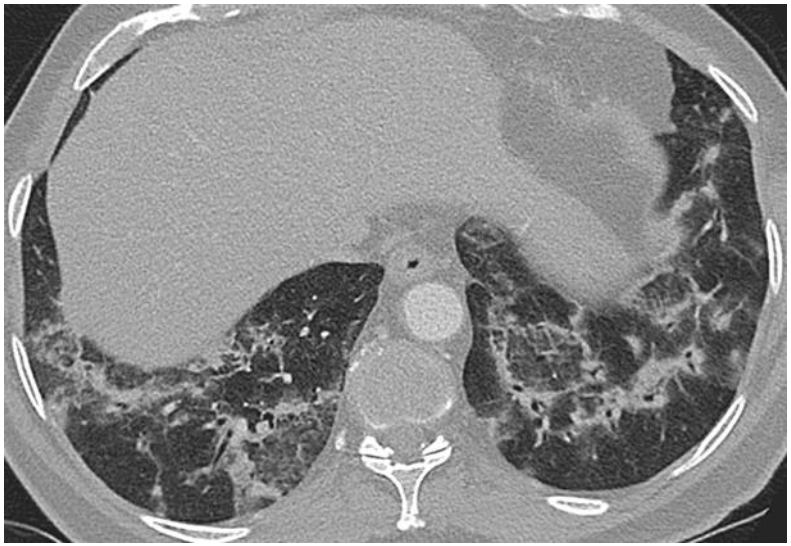
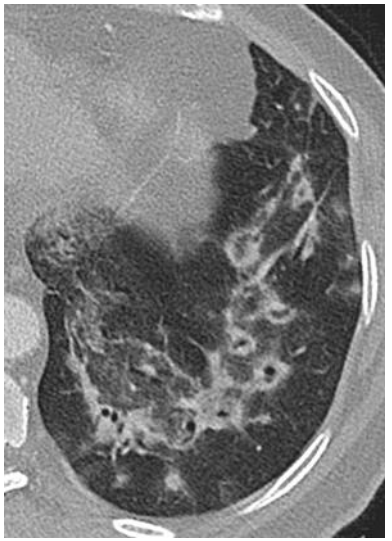






OP reverse halo sign regression after steroids

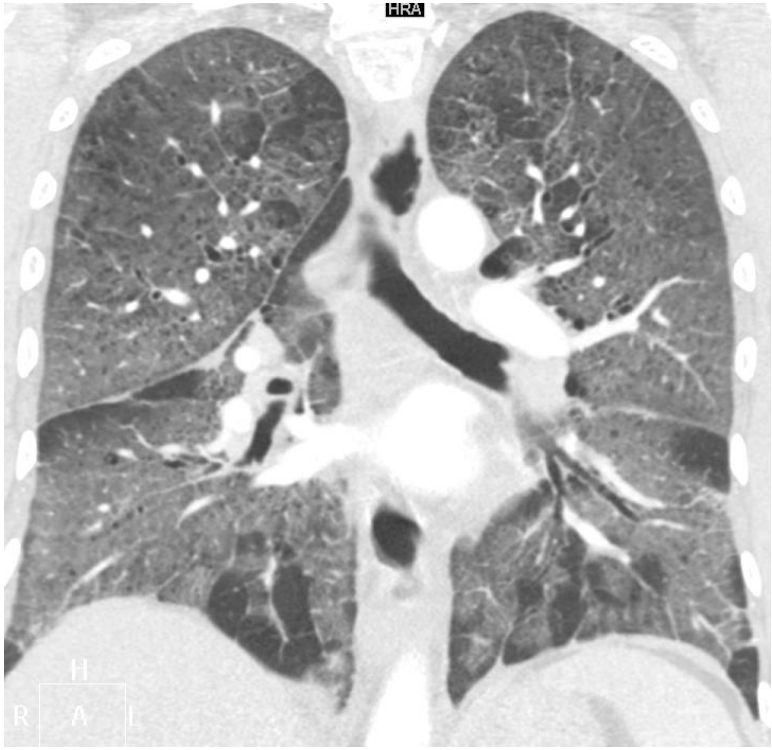




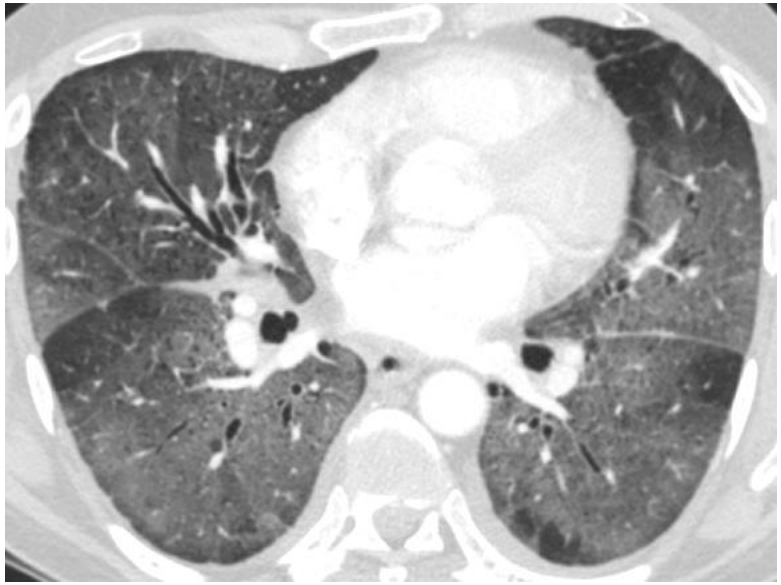
OP : perilobular consolidation +++ biopsy proof

AIP Acute interstitial pneumonia

= Diffuse alveolar damage (DAD)

- Acute, fulminant presentation
- Unknown etiology: "Idiopathic ARDS"
- Often in patients without any medical history
- Poor prognosis





Imaging

- **GGO opacities,** bilateral and symmetrical, geographic or diffuse
- **Consolidation**

Tobacco link disease

- COPD
- Neoplasia
- Atherosclerosis

- PID due to tobacco
  - Chronic
    - **RB-ILD ++** (interstitial involvement in the form of centrolobular micronodules of the upper region)
    - **DIP** (continuum with RB-ILD, basal and subpleural GGO)
    - **Histiocytosis X** (pathology closely related to tobacco, irregular cystic lesions, upper region)
  - Acute
    - **Eosinophilic pneumonia** (recently started tobacco)
- Fibrosis
  - **IPF ++**
  - **NSIP**
  - **AEF** (cystic lesions with thick walls of the bases)
  - **Emphysema-fibrosis syndrom** (emphysema of the apex and basal fibrosis)
- Asymptomatic anomalies
  - **RB** (like RB ILD but asymptomatic)
  - **ILA** (interstitial lung abnormalities, asymptomatic interstitial discovery abnormalities)

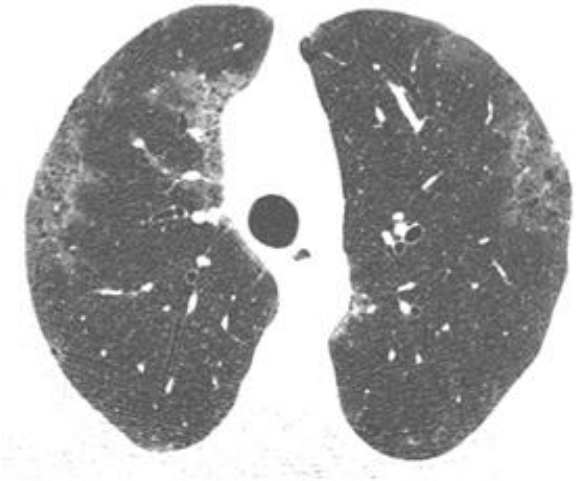
RB et RB-ILD

- Smoker
- RB = Respiratory bronchiolitis
  - It is asymptomatic bronchiolar and peribronchiolar inflammation
  - Histo pathology: **macrophagic infiltration**
  - CT: **Centronobular fuzzy micronodules**

- RB ILD
  - ✓ **Same as RB but symptomatic**

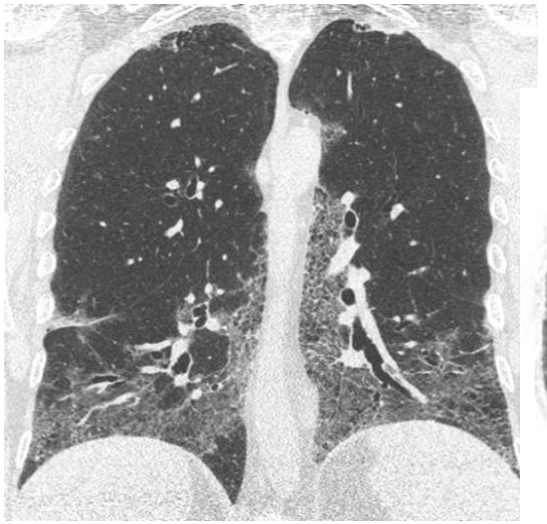
DIP desquamative interstitial pneumonia

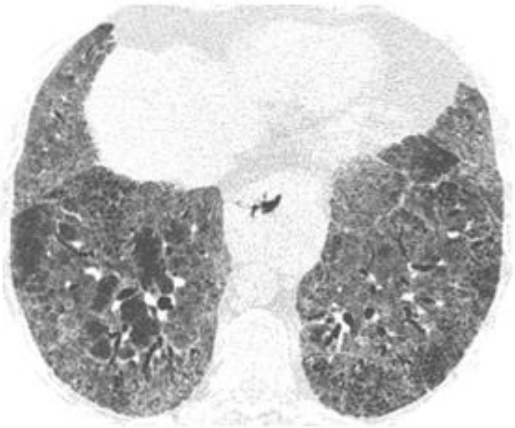
- **Rare**
- **Active smoking +++**, 40-50 years, predominantly male
- Histology: alveolar septa thickening + **macrophagic intra-alveolar infiltration**
- Clinic: dry cough, progressive dyspnea, digital hippocratism
- Treatment: **smoking cessation** and **corticosteroids**



Spectrum of tobacco-related lung diseases
- Respiratory bronchiolitis (**RB**)
- RB + interstitial lung disease (**RB-ILD**)
- Desquamative pneumonitis (**DIP**)

CT
- **Diffuse GGO**
  - Peripheral / subpleural (60%)
  - Lower region
  - Basal bilateral in 70%
- **Microcyst in GGO area**
- +/- intralobular reticulation
- +/- traction bronchiectasis
- +/- honeycomb

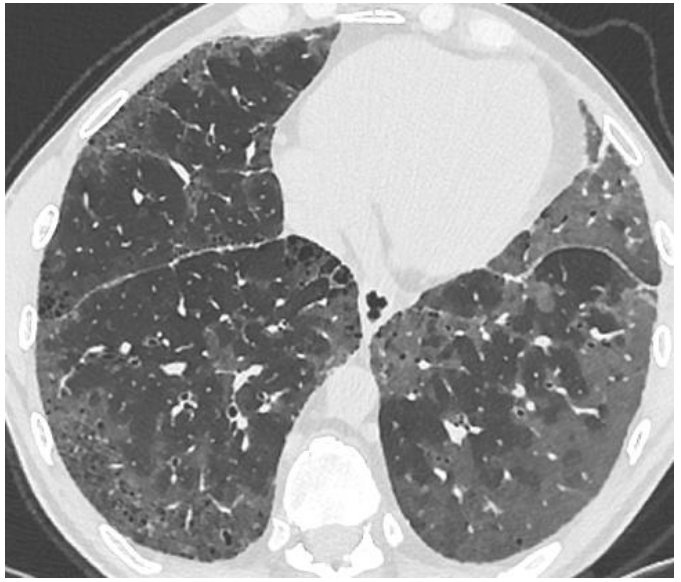


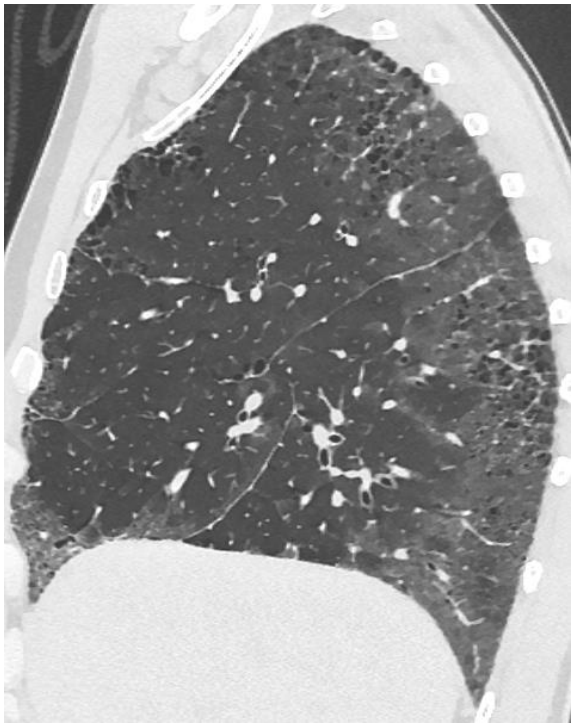


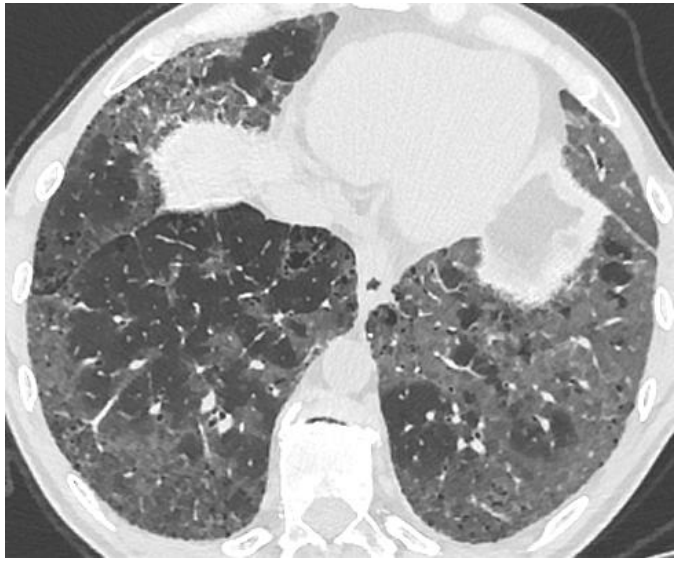
Biblio: Desquamative interstitial pneumonia: thin-section CT findings in 22 patients. Hartman TE, Primack SL, Swenwen SJ, et al. Radiology 1993

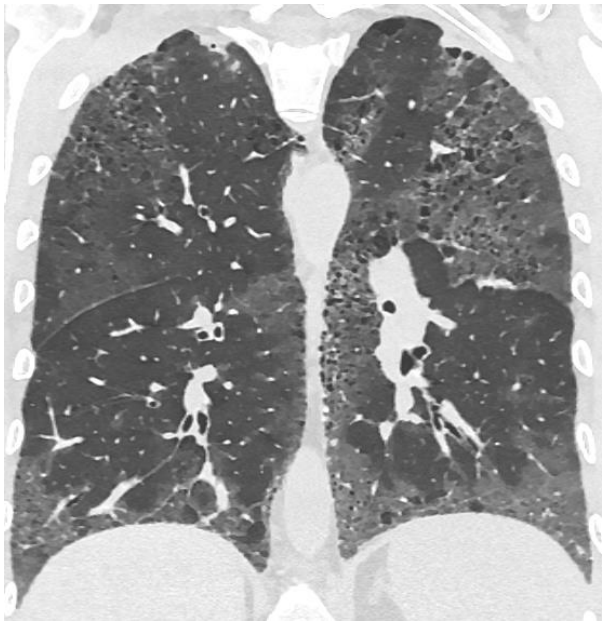
DIP

- GGO
- Location: lower lobe and peripheral
- Small cyst in the same area









AEF Airspace enlargement with fibrosis

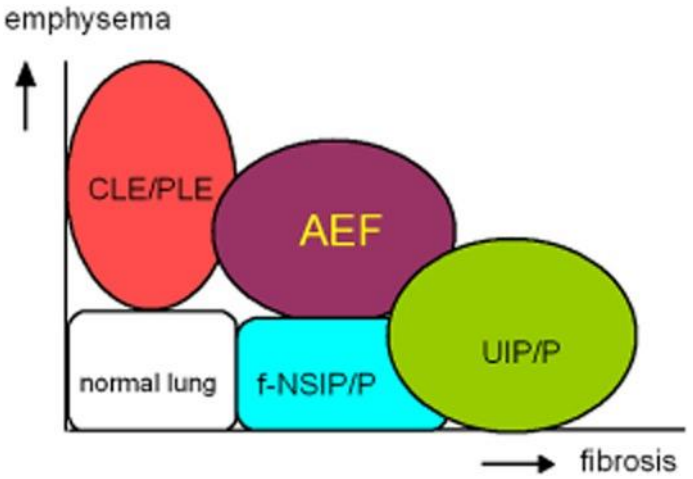
- In 2008 Kawabata et al. describe an entity called "airspace enlargement with fibrosis" (AEF) which can be included in the **spectrum of tobacco-related pathologies**

- These lesions are **bronchiolo-centered** and are characterized by **interstitial fibrosis**, readily hyalinized, **without fibroblastic foci**, with **more fibrosis than in the emphysema lesion** (intermediate lesion between emphysema and fibrosis)

- The histological characteristics differ from the other fibroses described in smoking (UIP, PINS, centrolobular emphysema, etc.)

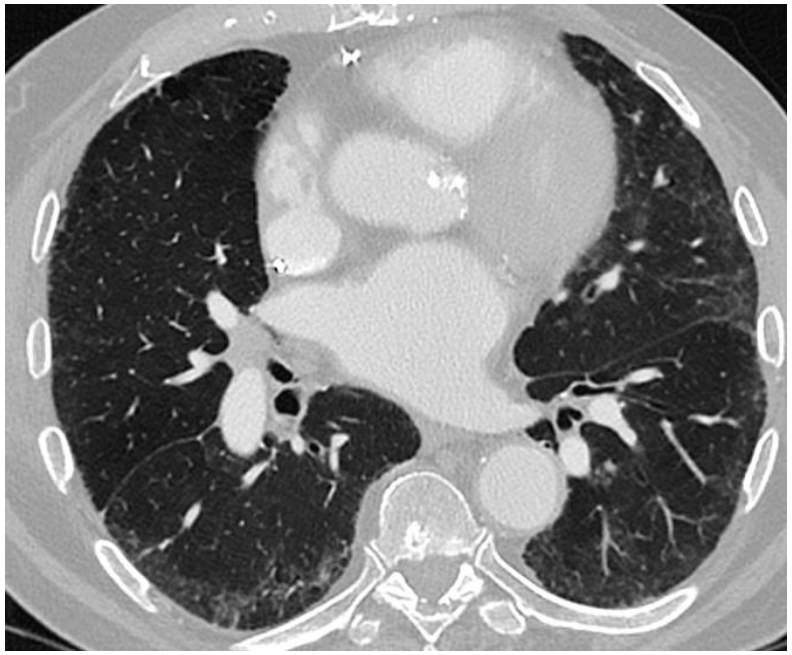
- In imaging, they appear as **large, thick-walled cystic lesions located in the lower regions.**

- In patients with AEF lesions, there are few reports of exacerbations and a **favorable prognosis.**



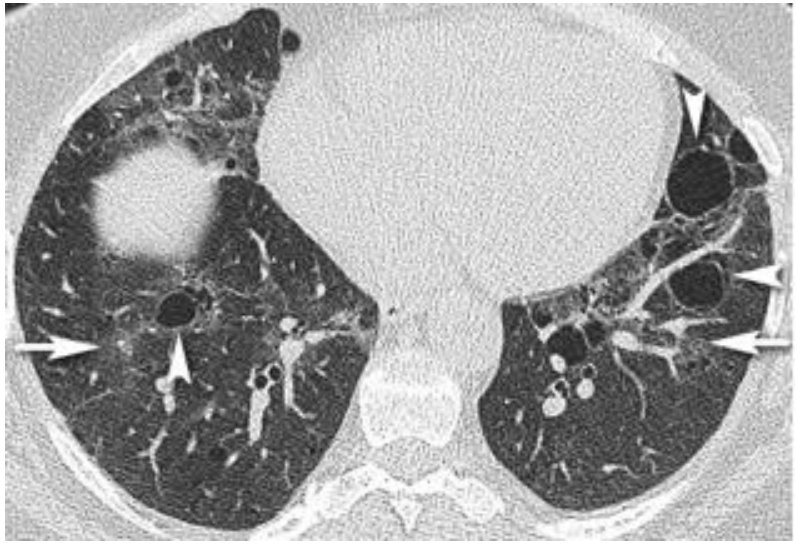
ILA Intersitial lung abnormalities

- **Interstitial opacities of chance discovery +++**
- **7 to 9% in smokers, 2 to 7% in non-smokers**
- **GGO, reticulations**
- Traction bronchiolectasis, honeycomb
- **Sub pleural, posterior inferior regions**
- **Stable in 60% of cases, progression in 20 to 40% of cases**
- **Interrogate the patient** (treatment? System disease? ...) to eliminate interstitial pathologies of drug origin, autoimmune ...



LIP Lymphocytic interstitial pneumonitis

- **Rare**
- **Histology:** Diffuse interstitial lymphocytic infiltration
- polyclonal lymphocytic proliferation
- Often associated with **Sjögren's syndrome AIDS Castelman disease, CBP, hepatitis and autoimmune thyroiditis**



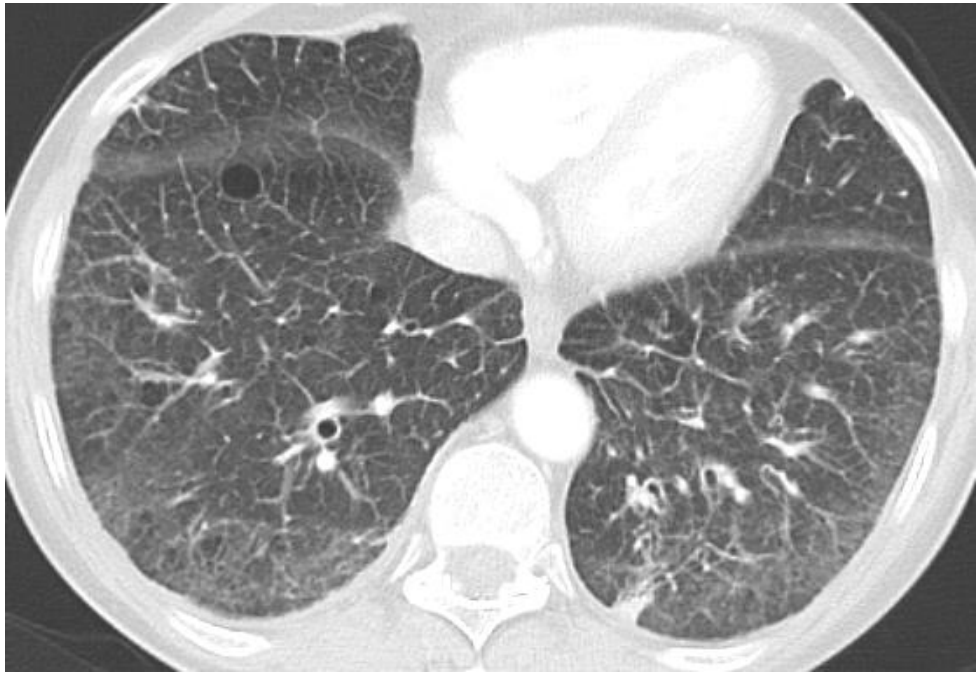
CT

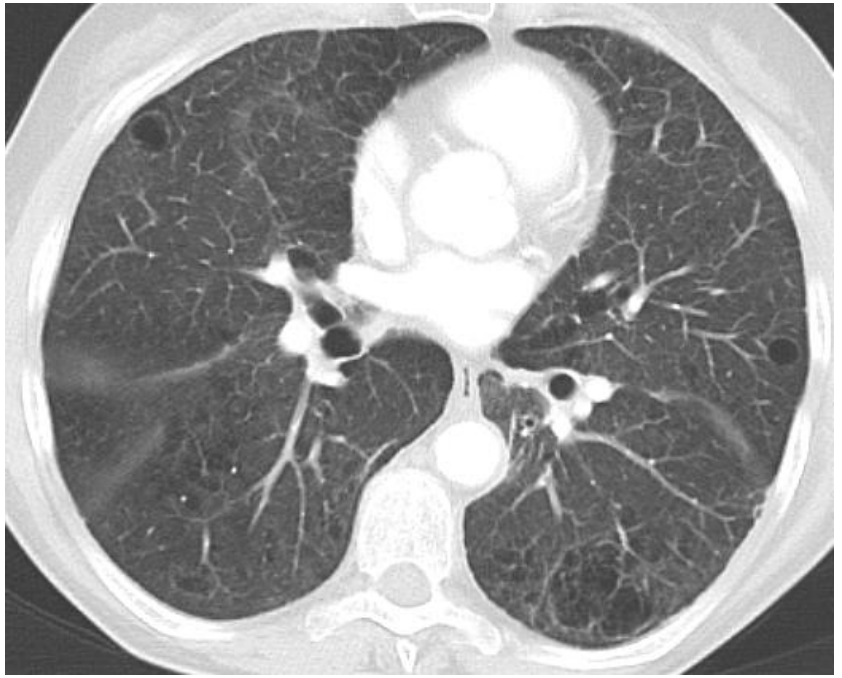
- **GGO** 100%
- **Round peri-vascular cysts> 50%**

+/- peri-bronchovascular thickening
+/- septal lines
+/- fuzzy or peri-lymphatic micronodules

LIP + Sjogren

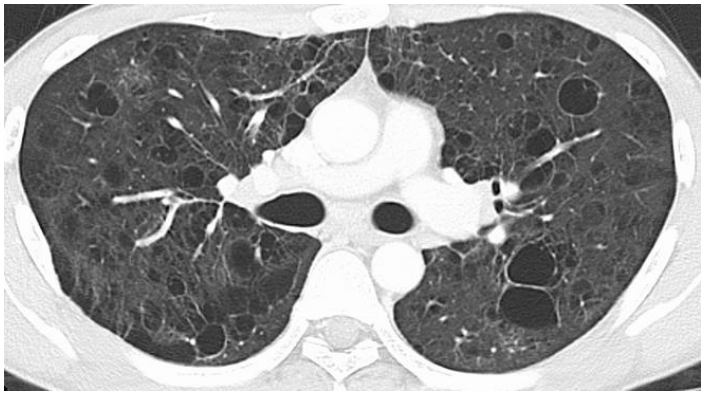
Courtesy Kokosi MA Respirology 2015

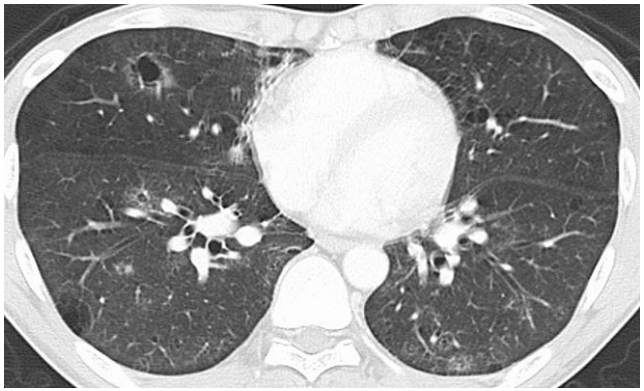


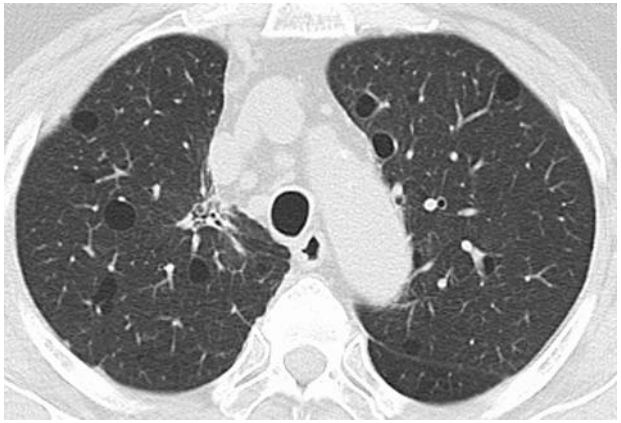


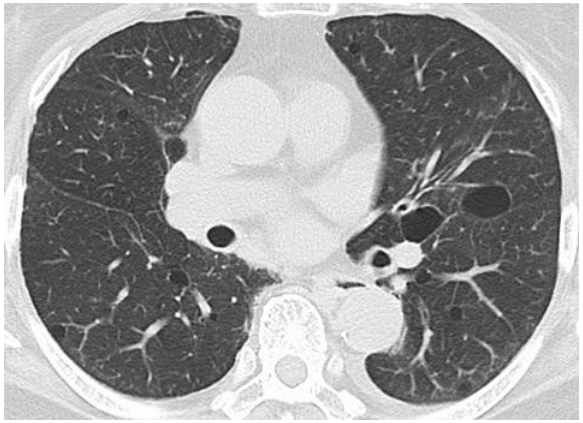
LIP / Sjögren

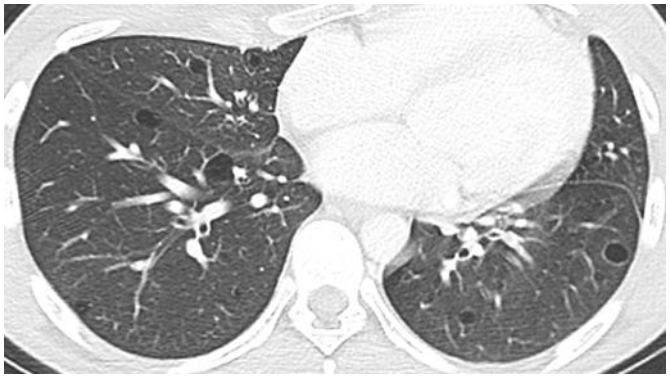
- GGO
- Cyst

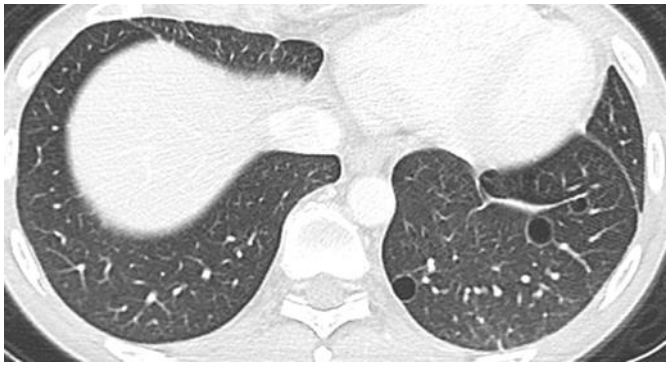






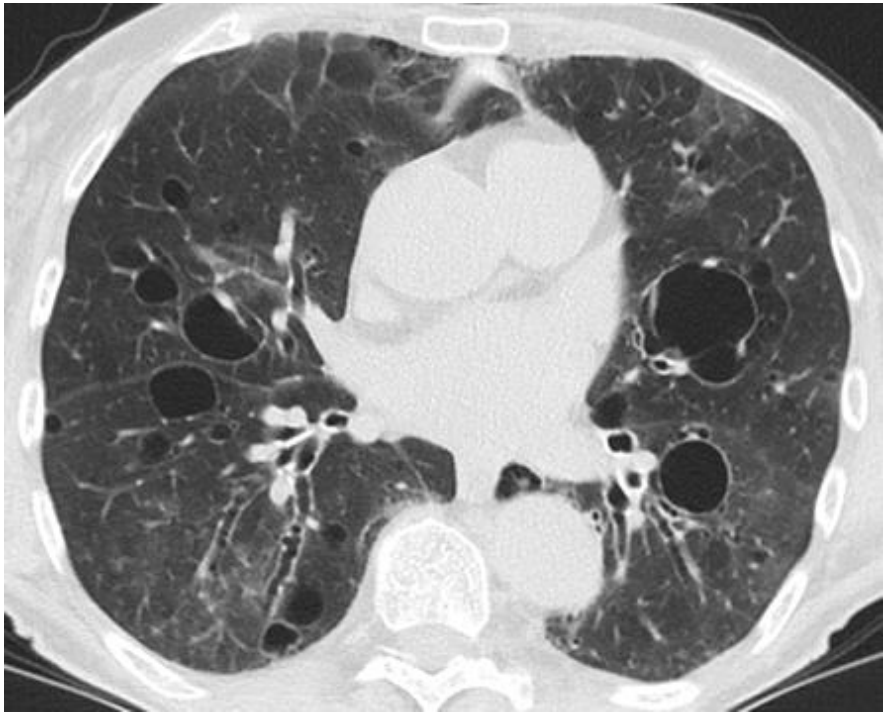


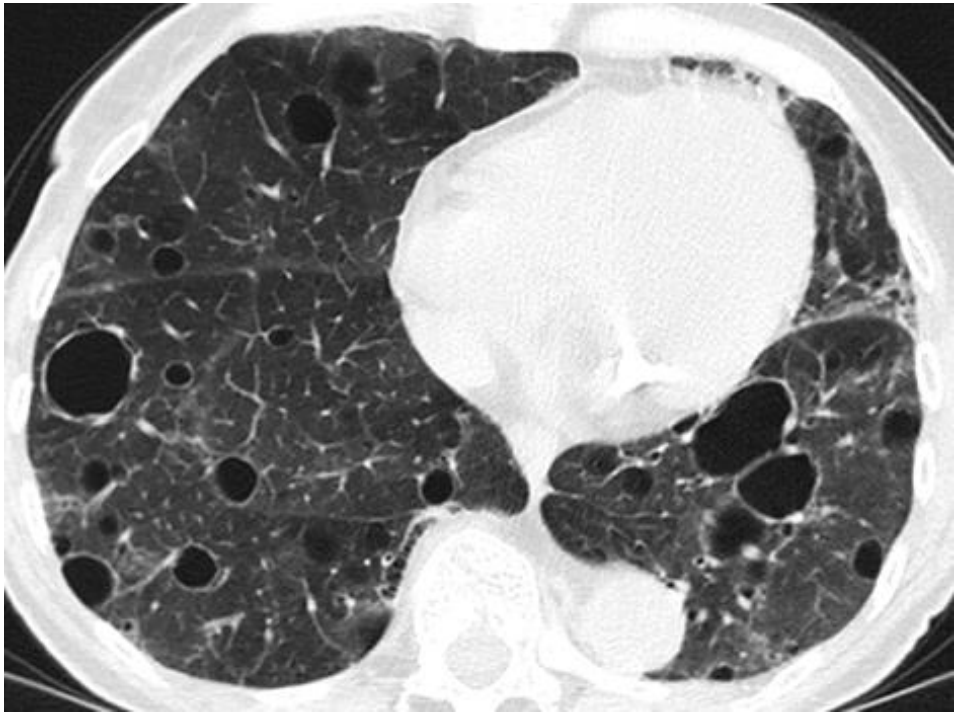




3 examples of LIP

LED + LIP + Sjogren



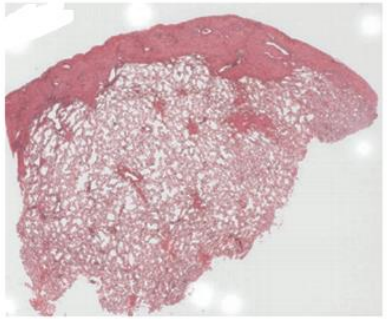


LIP + Sjogren

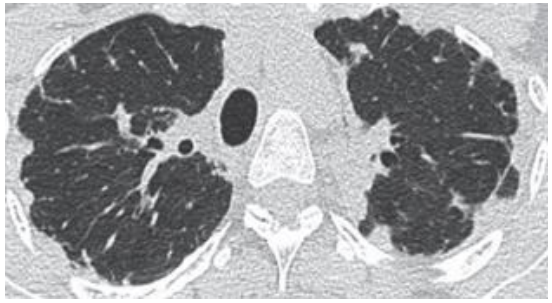
PPFE Pleuroparenchymal fibroelastosis

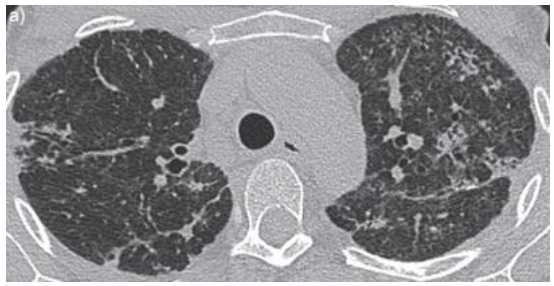
Histology: visceral pleura fibrosis and underlying parenchyma with elastic fibers highlighted on hematoxylin and eosin (HE) staining

- Recently described
- Very rare
- Benign 5th decade (3rd ->6th decade)
- Etiologies
  - Idiopathic (50%)
  - Post-transplant (50%)



Courtesy Taryn et al
European respiratory journal





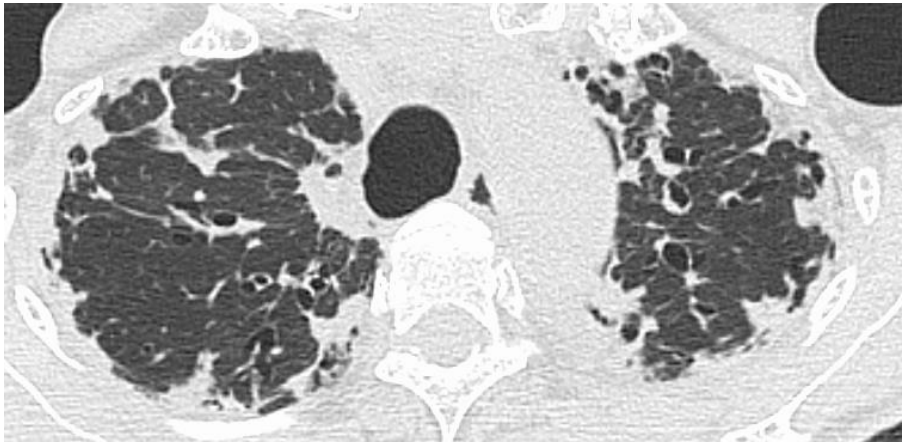
CT

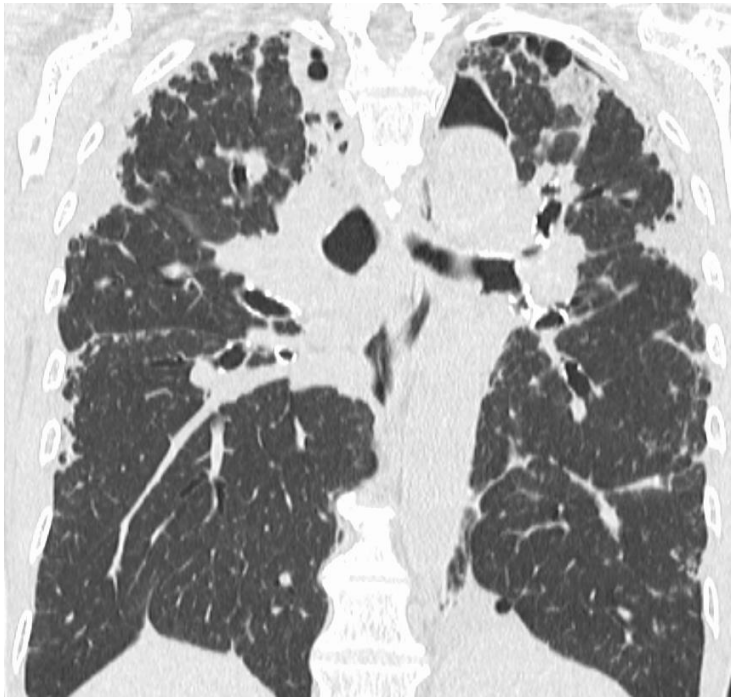
- **Apical cap +++**
- **Pleural thickening** (visceral pleura fibrosis)
- **Sub-pleural pulmonary fibrosis** with **thickening of the interlobular septa** and **traction bronchiectasis**

Differencial diagnosis

- **Sarcoidosis fibrosis stage**
- Chronic hypersensitivity pneumonitis
- Connectivity
- Asbestosis
- Radiation pneumonia
- Toxic pneumonia
- Spondylarthopahty

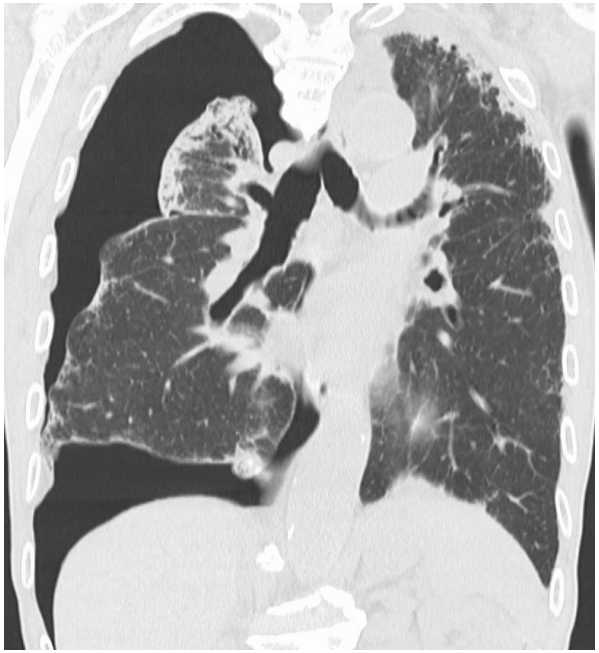
Pleuroparenchymal fibroelastosis: a spectrum of histopathological and imaging phenotypes
Taryn L. Reddy - European Respiratory journal 2012





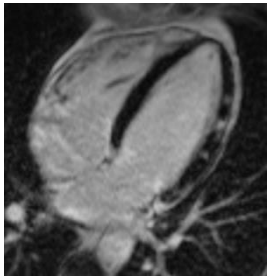
PPFE

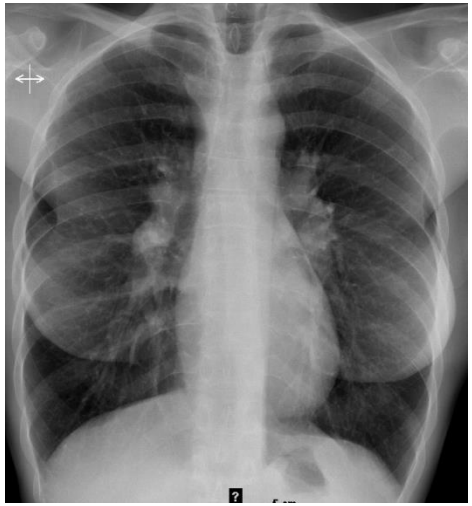
- Opacities of the apical caps with type of pleural pulmonary fibrosis (thickening of the septa and bronchiectasis)
- Risk of pneumothorax ++ (note the loss of volume of the upper lobe



Sarcoïdosis

- Histopathology: Granulomatosis of unknown etiology, the basic lesion of which is **gigantocellular epithelioid granuloma without caseous necrosis**
- 2 peaks: **20 to 40 years old** and **> 60 years old** (women)
- Extra-thoracic manifestations (50% of cases)
  - **Eyes** (uveitis)
  - **CNS**
  - **Cardio (life-threatening !)**
  - **Skin** (knotty erythema)
  - **Articulations**
  - **Bone**…
- Paraclinical:
  - Tuberculin anergy
  - ACE elevation
  - **Epithelioid granulomas without caseous necrosis** (transbronchial biopsy),
  - CD8 lymphocyte alveolitis at LBA





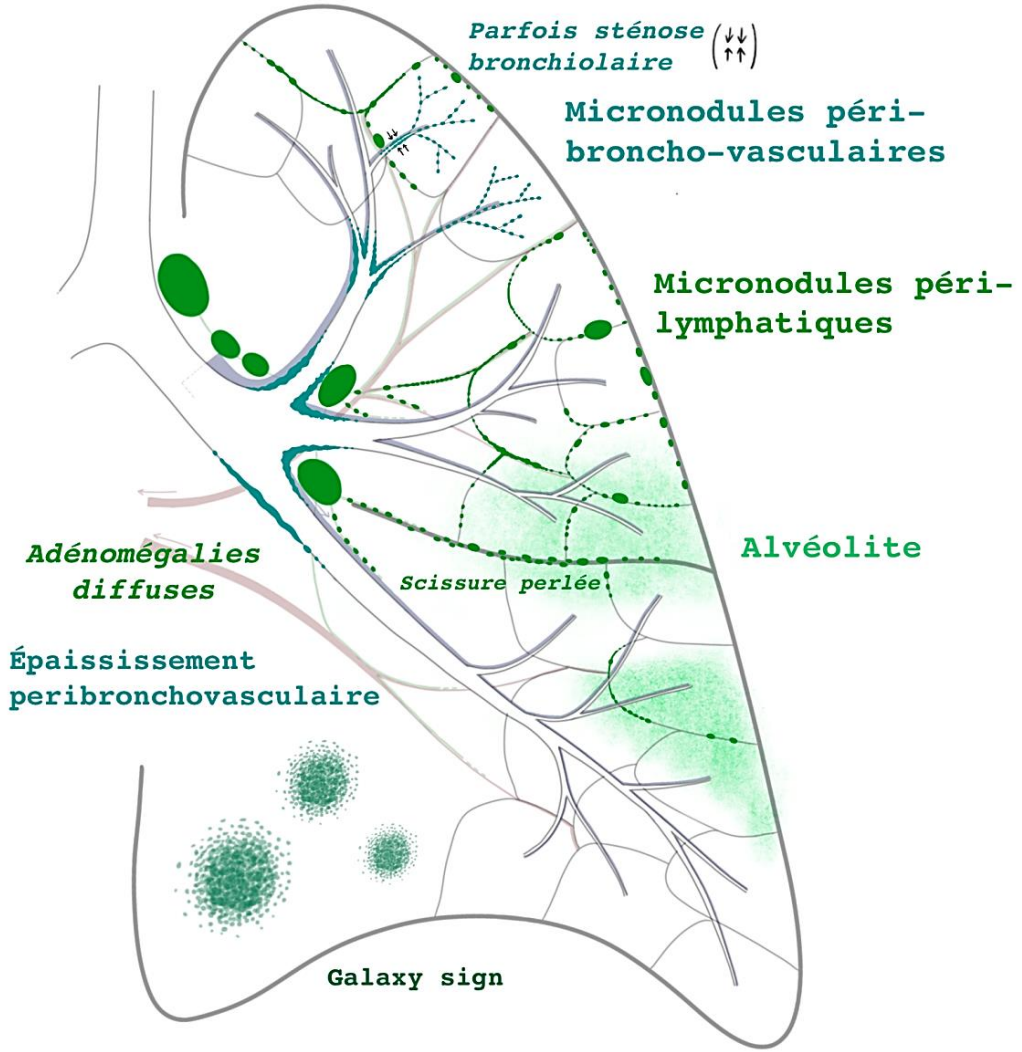
Stage 1

Xray :

- **Stage 1**: Non-compressive bilateral mediastino-hilar lymphadenopathy
- **Stage 2:** Lymphadenopathy + interstitial involvement
- **Stage 3**: Interstitial involvement alone
- **Stage 4:** Fibrosis

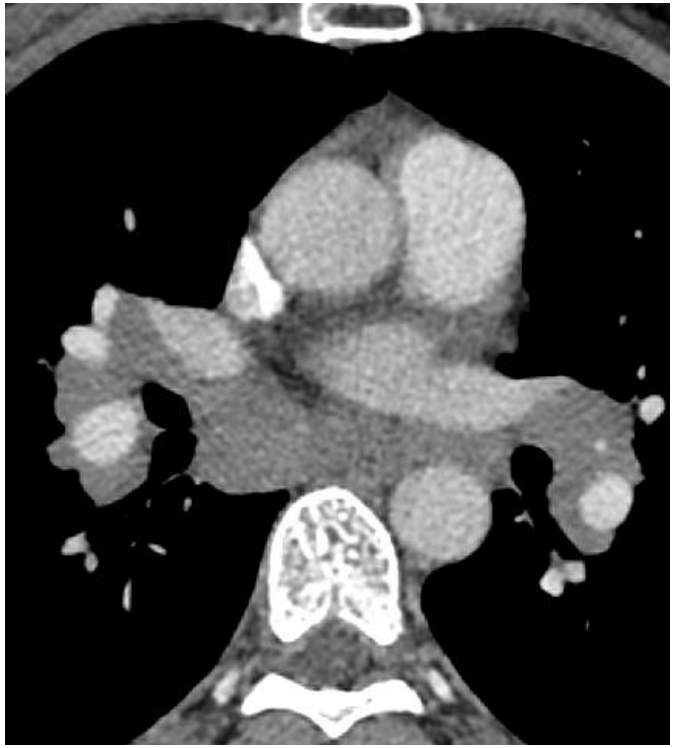
SARCOÏDOSE

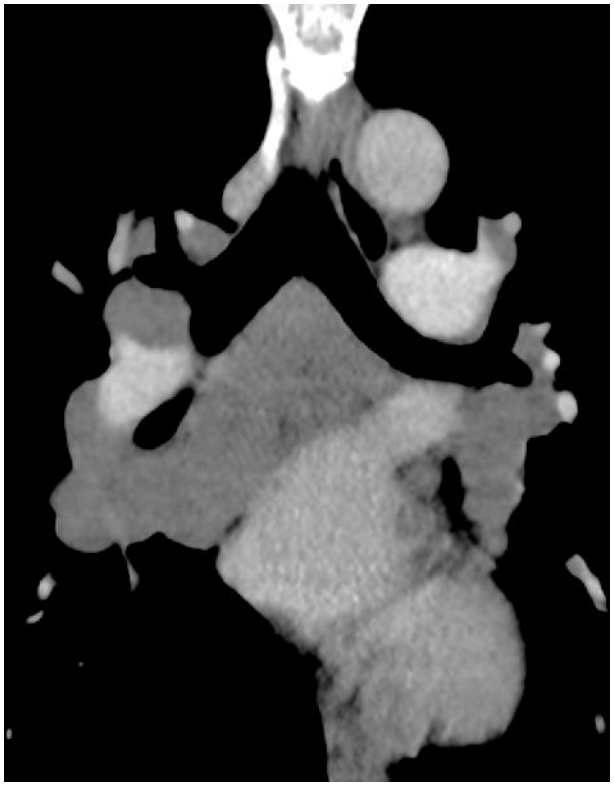
Granulomatose de topographie péri-lymphatique et prédominance supérieure



Mediastinum

- Hilar and mediastinal lymphadenopathy
- Non-compressive
- Symmetrical
- ± calcificied (punctuated, in popcorn, diffuse)

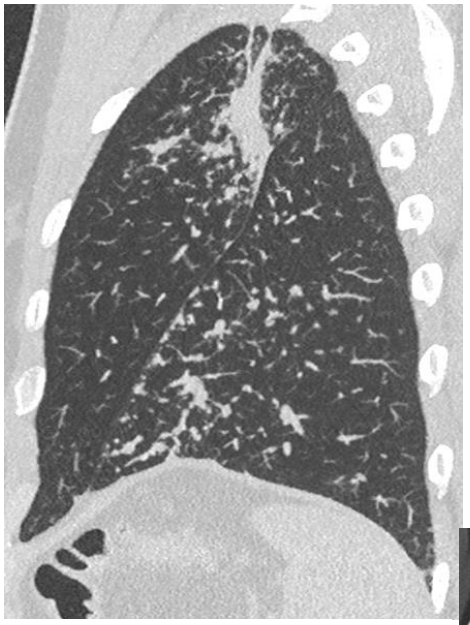


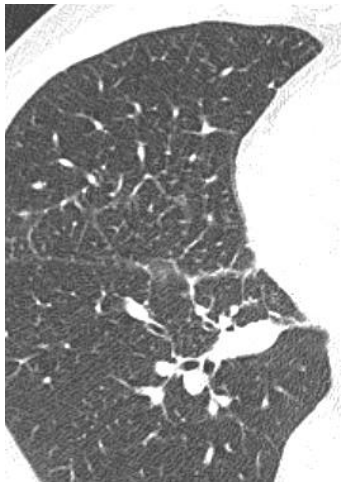


Parenchyma

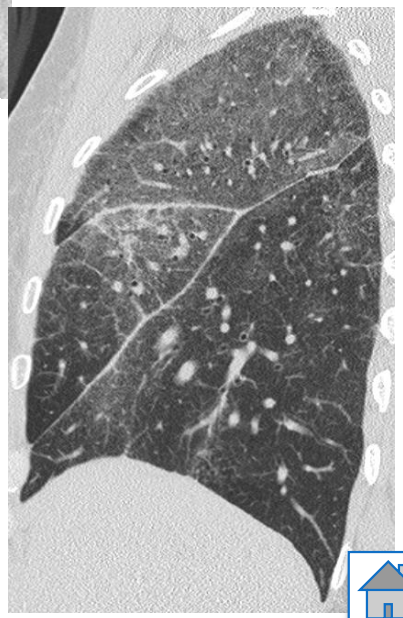
- Peri-lymphatic micronodules (27%): **upper regions** +++, often extending in line **from the hilum to the periphery**
- Nodules (often irregular borders)
- Nodular / regular / irregular septal lines
- Peri-broncho-vascular thickening (12%)
- GGO (11%): most often associated with nodules and septal lines

Septal thickening



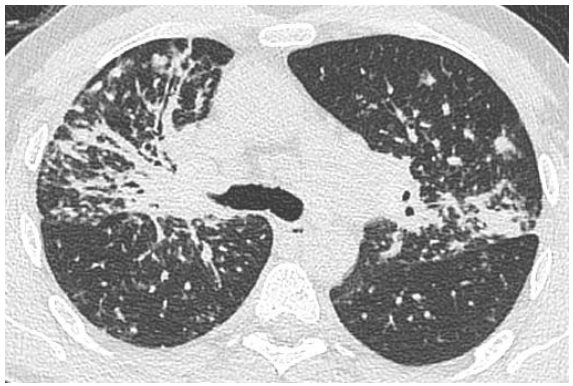


Peri-lymphatic micronodules



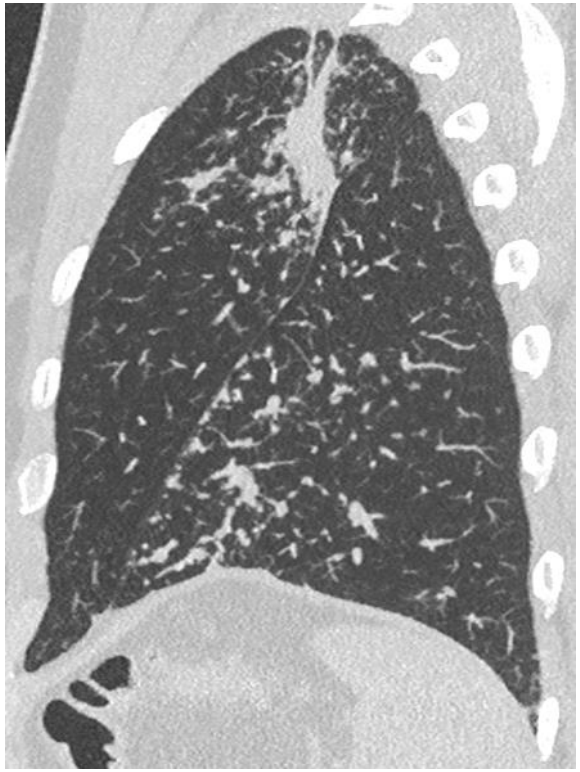
GGO

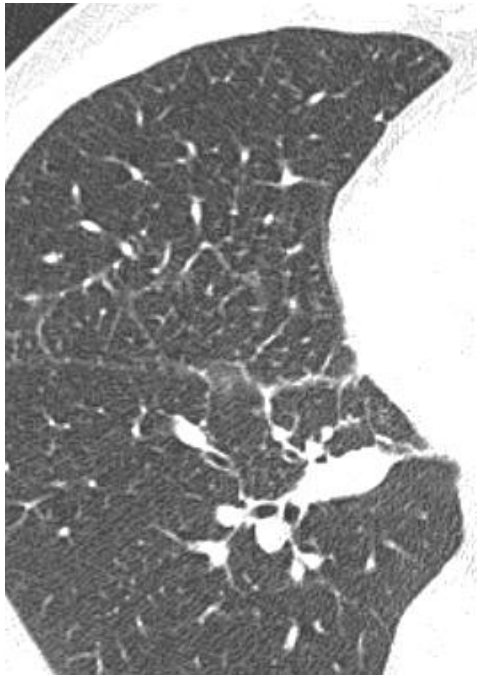
Septal thickening

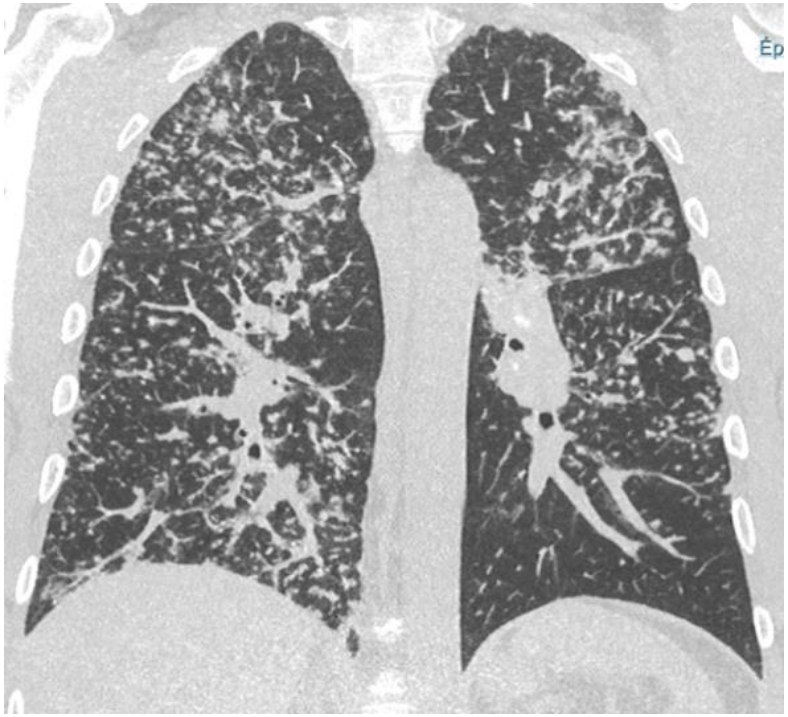


Nodule

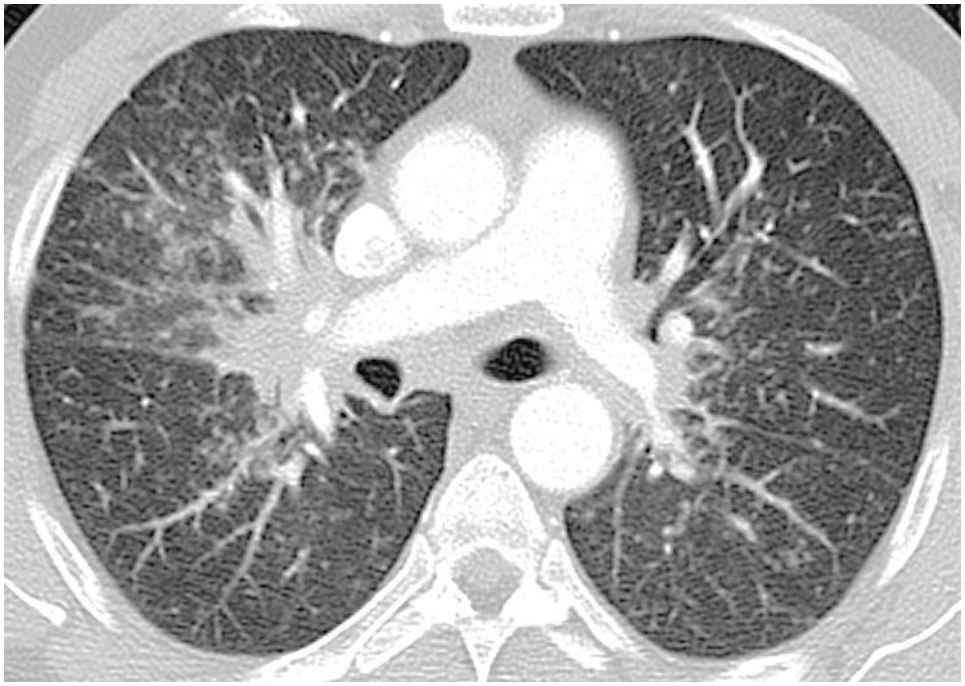
PBVT





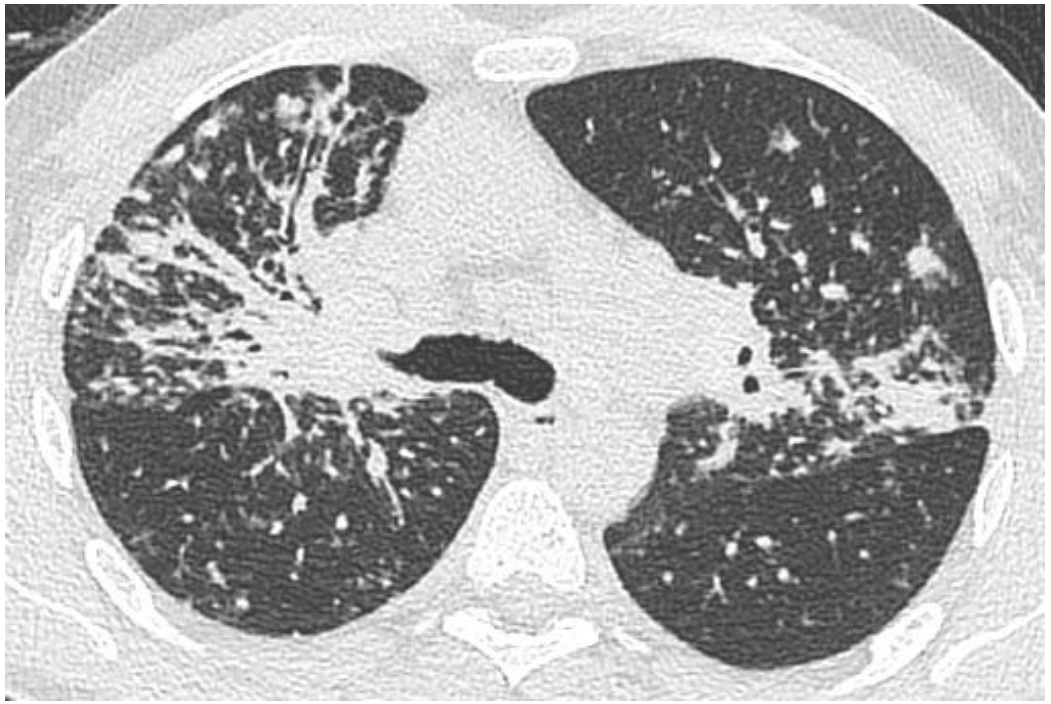


Beaded along the fissures



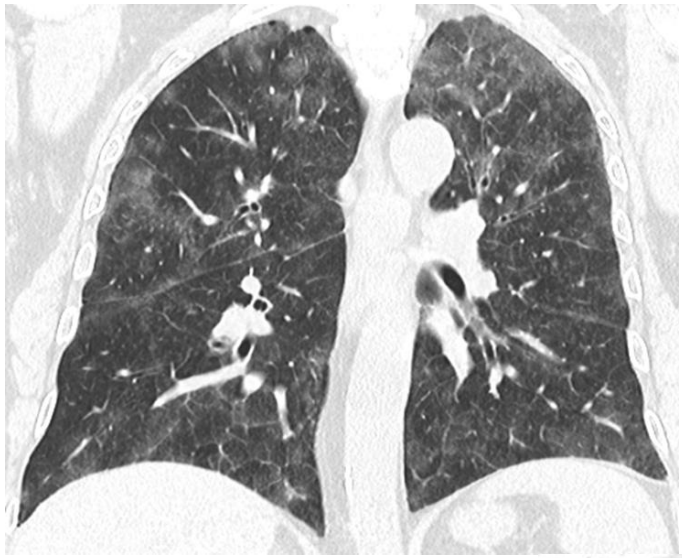
Sarcoidosis

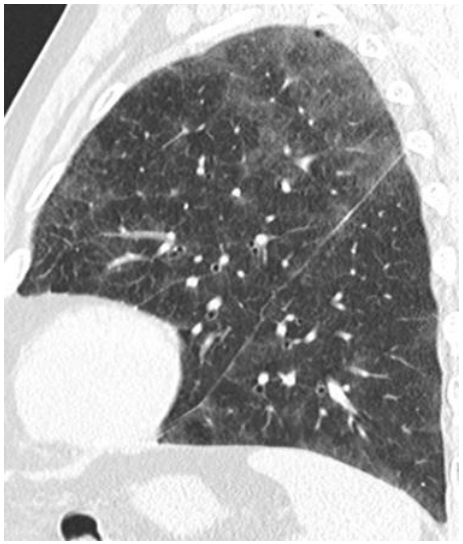
- Perilymphatic irregular nodular thickening in an upper/mid lung distribution
- **Peribronchovascular thickening+++**

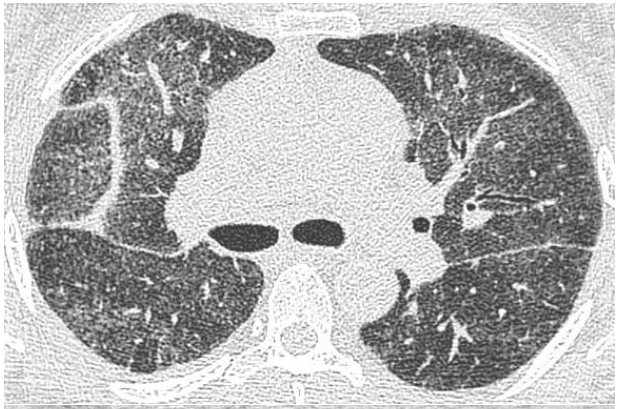


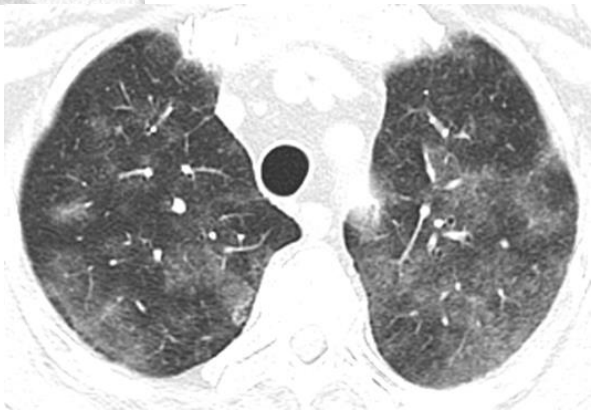
Sarcoidosis

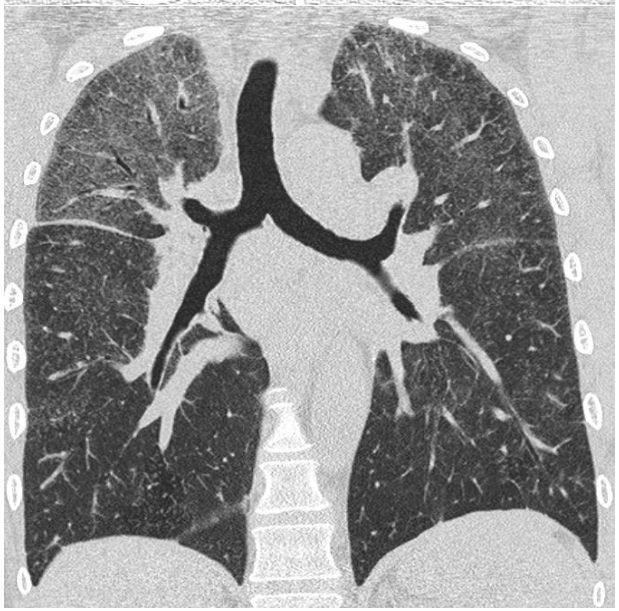
- GGO + Beaded along the fissures

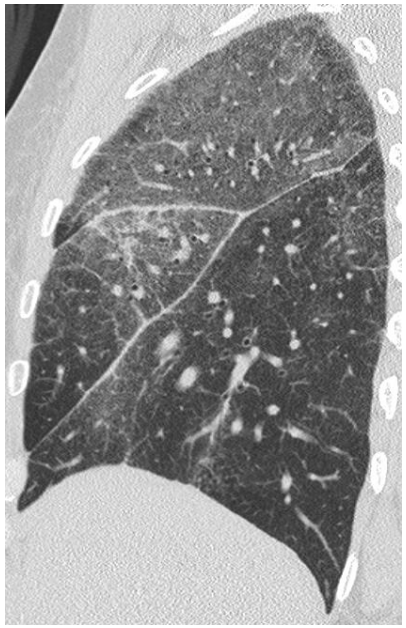


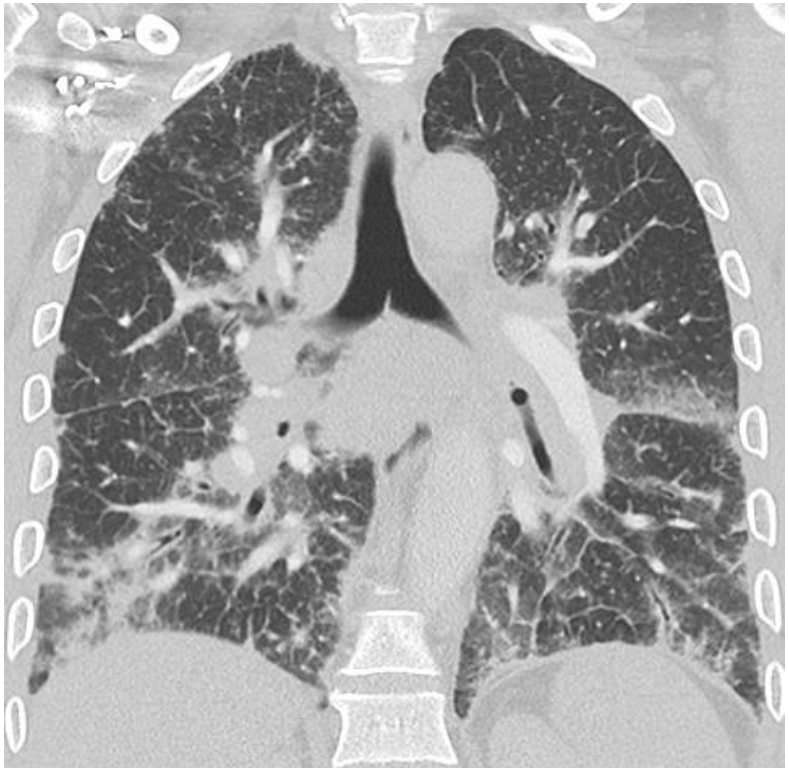


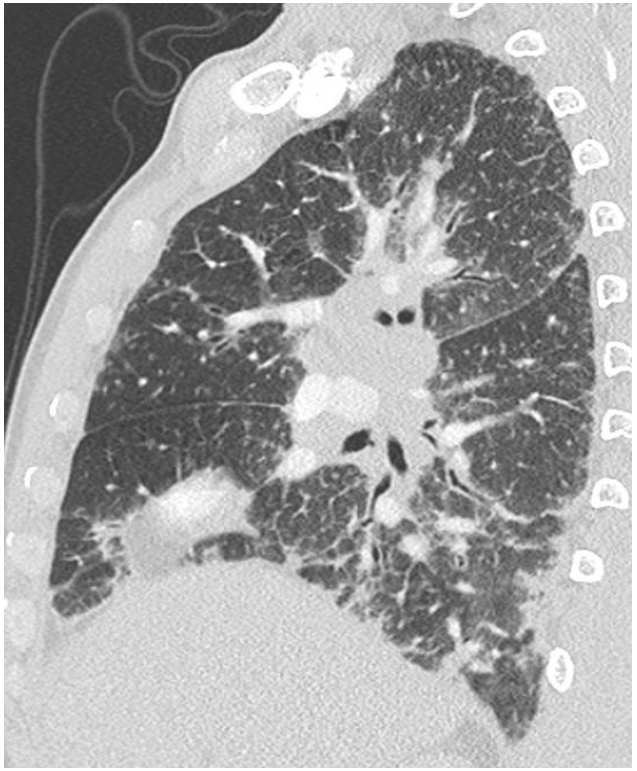


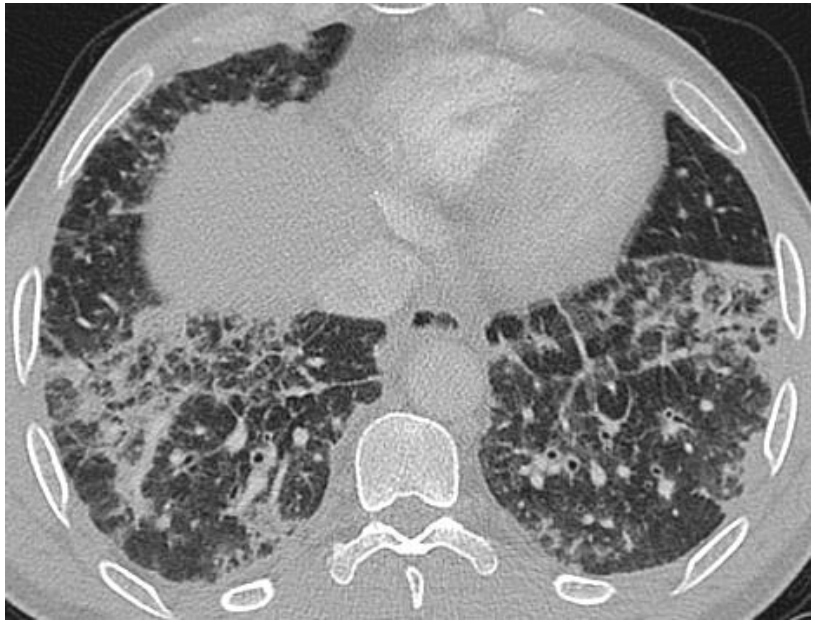






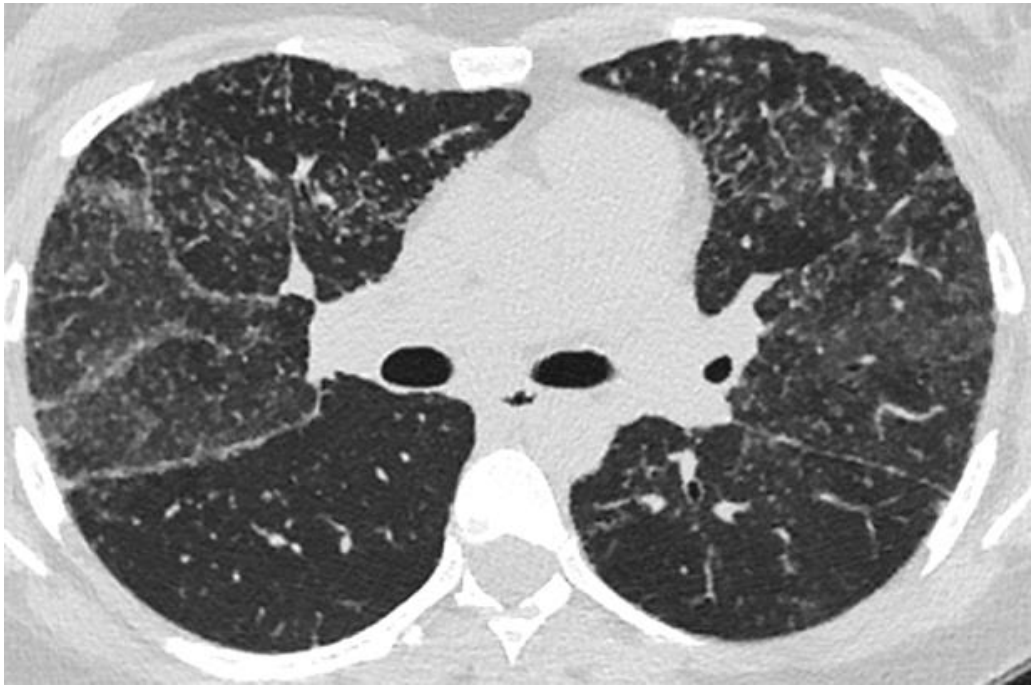




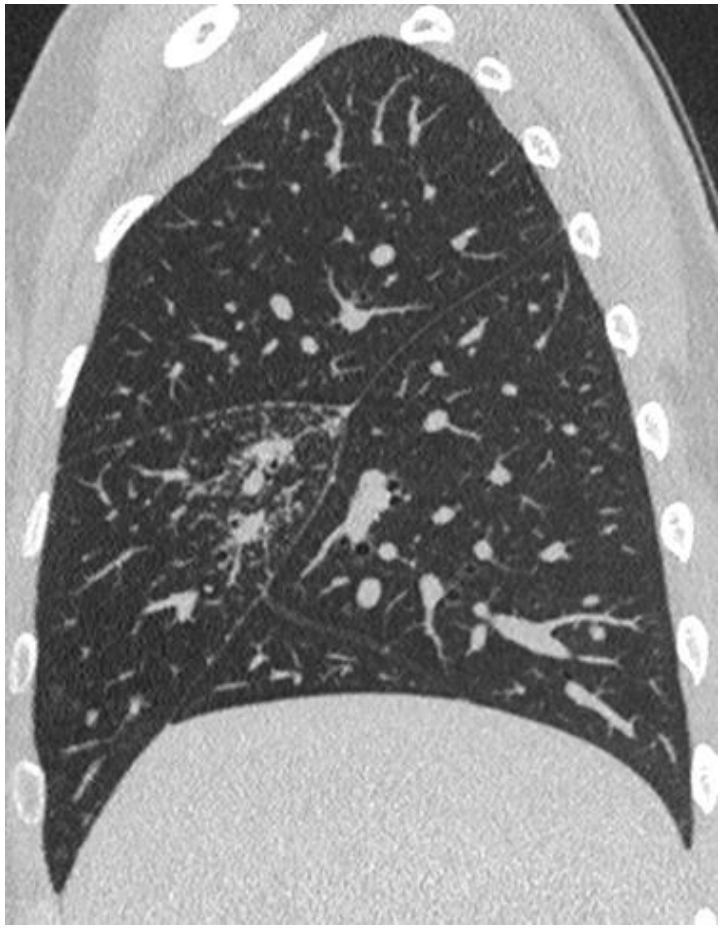


Sarcoidosis

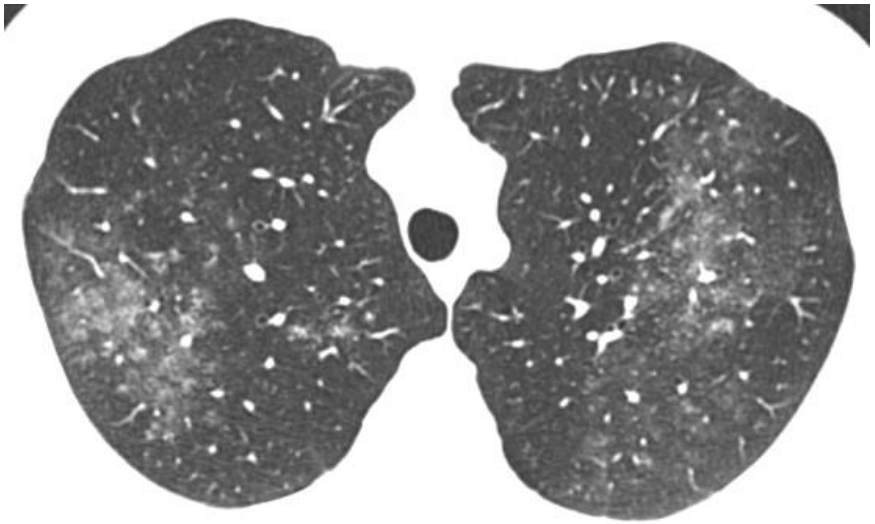
- Septal thickening
- Peri-broncho-vascular thickening

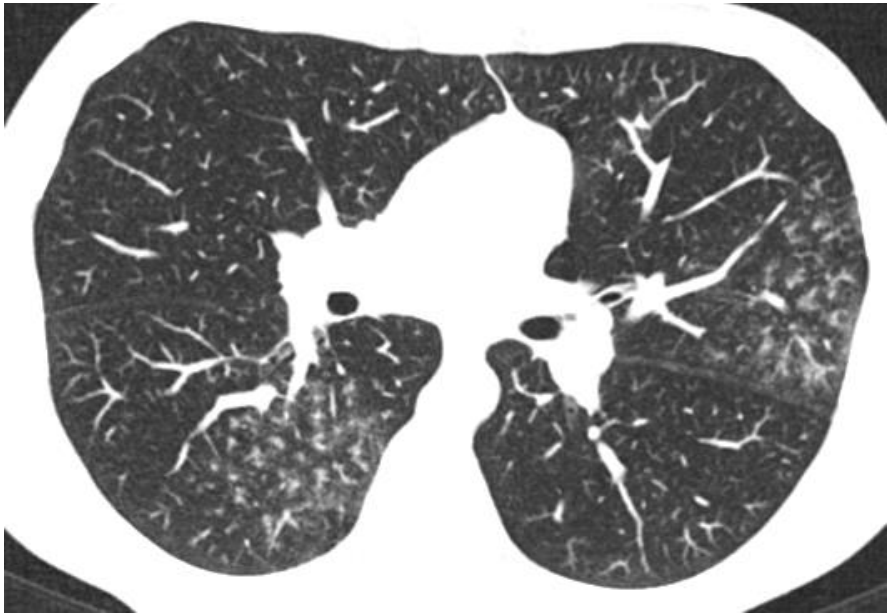


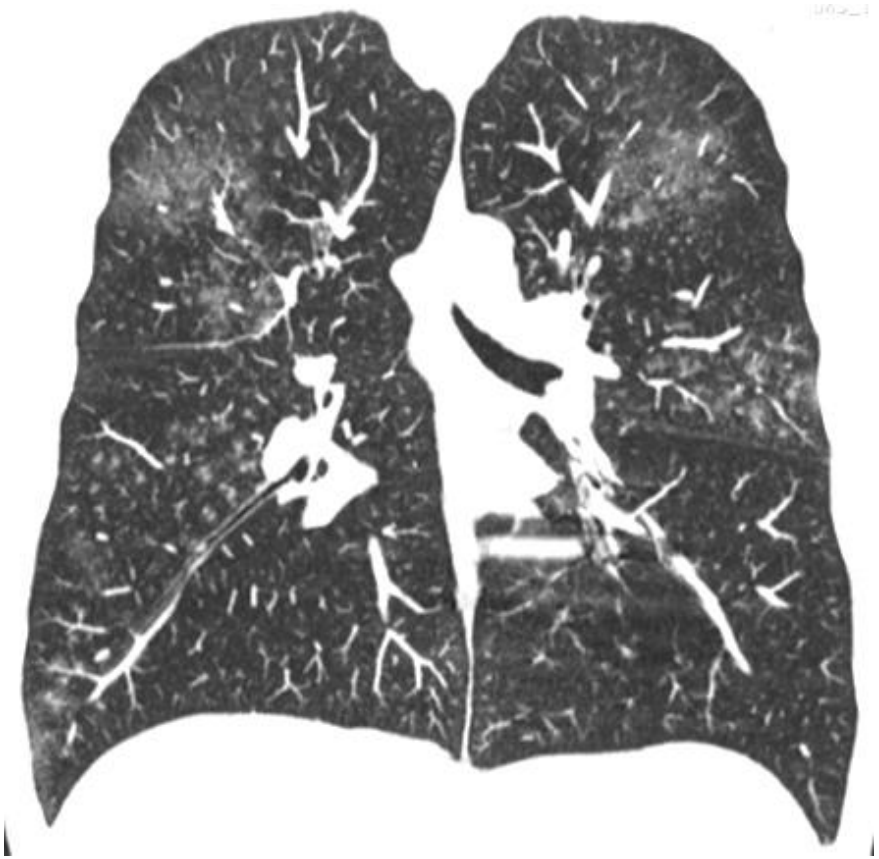
Multitude of perilymphatic topography micronodules



Beaded along the fissures



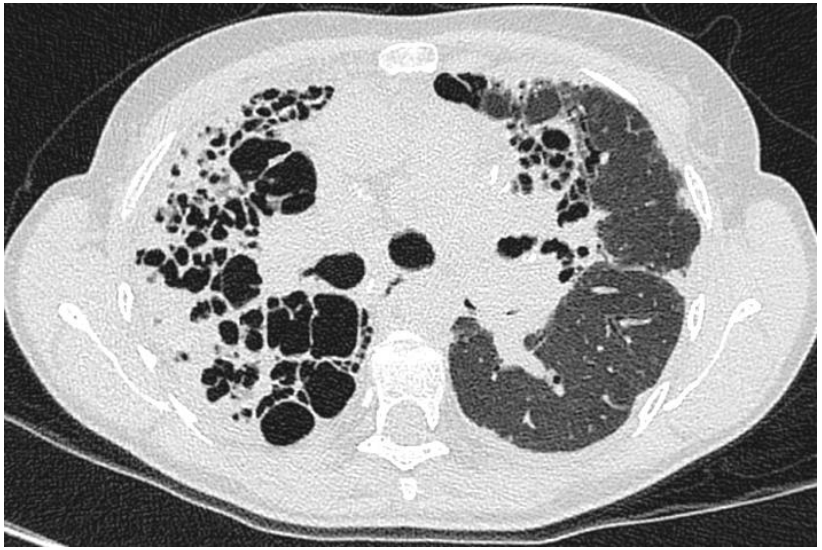




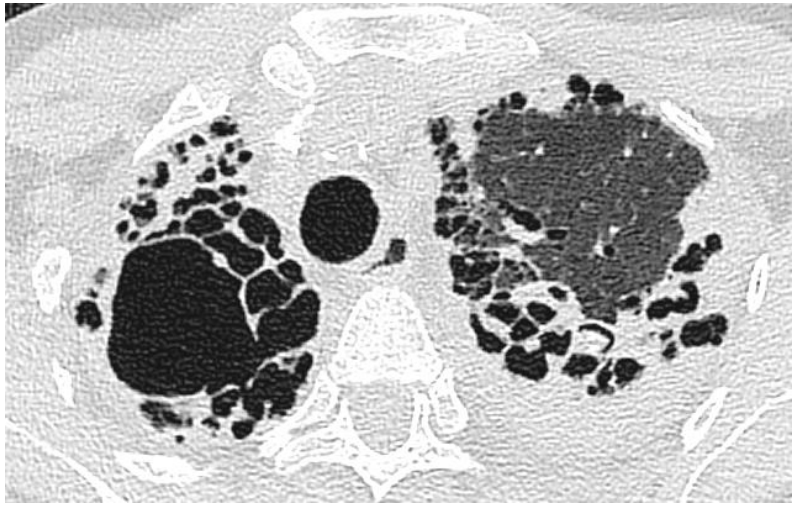
Sarcoidosis

- **GGO**
- and **centrolobular micronodules** of the upper regions
- and **pseudo "tree in bud"** of medium regions

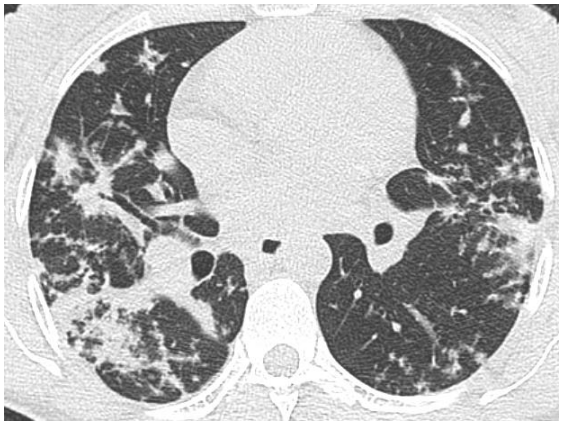
Fibrosis

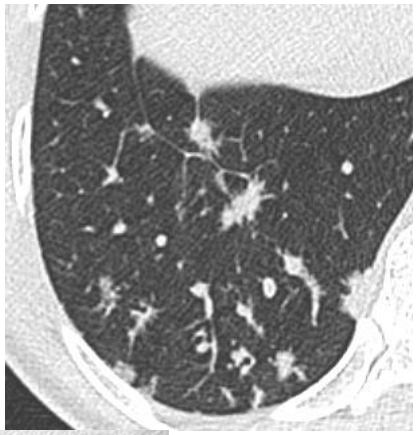


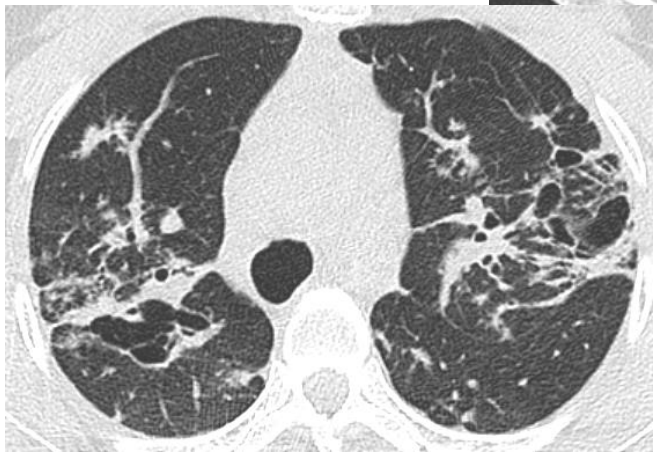
- **Fibrosis (9%)** : peri-bronchovascular / proximal
- **Fibrosis masses : s**uperior predominance and peribronchovascular, can be excavated (aspergilloma)



Sarcoidosis stage IV





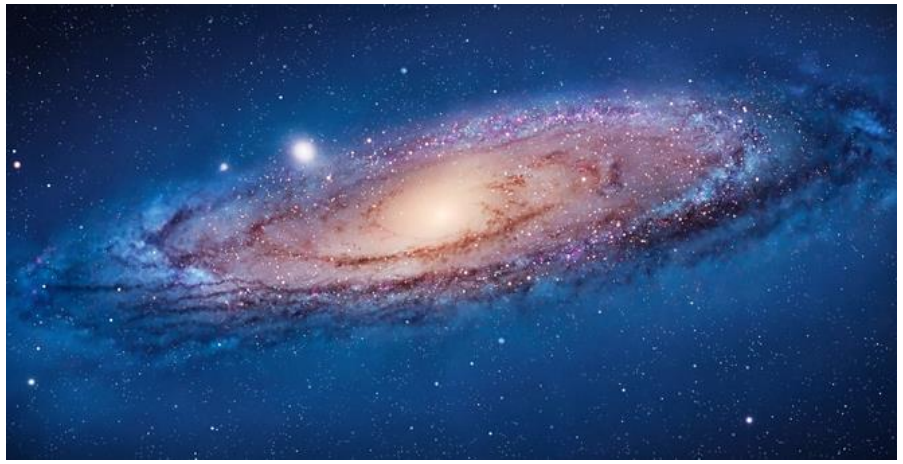


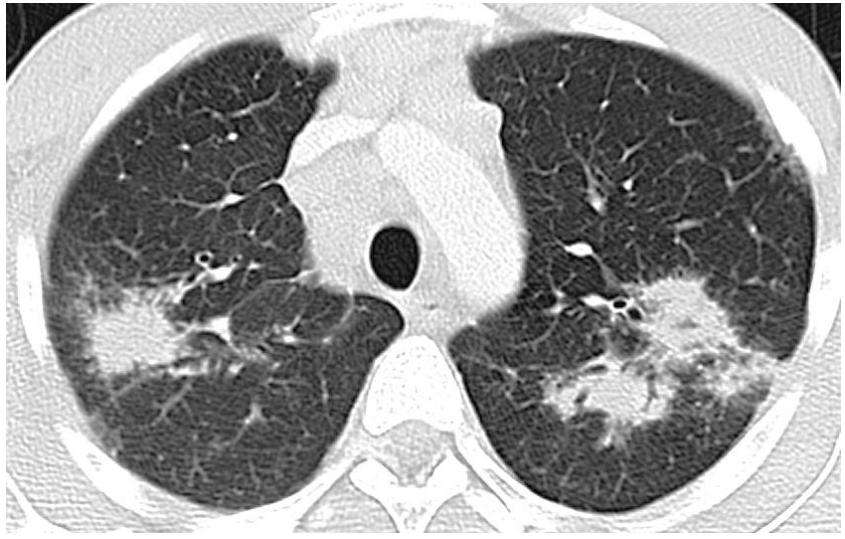
Pleural involvement

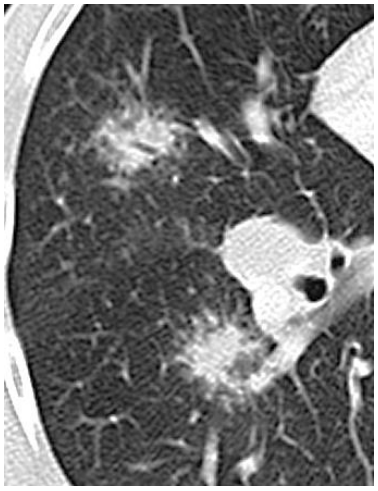
- Pleural thickening
- Effusions

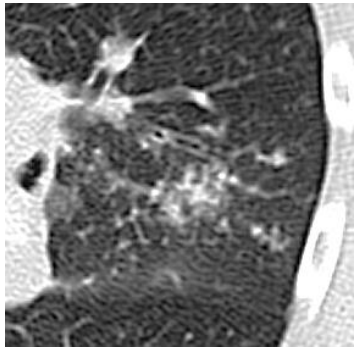
Galaxy sign

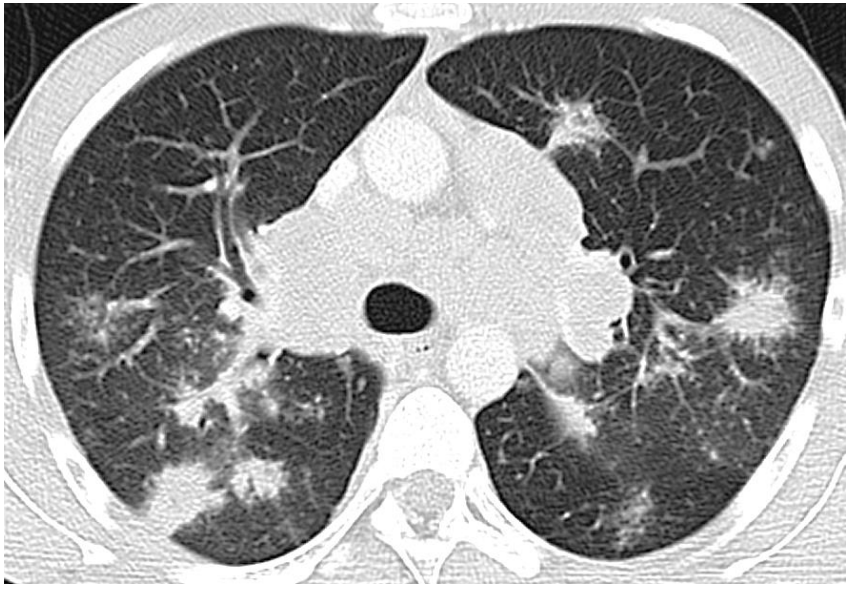
= cluster of confluent micronodules

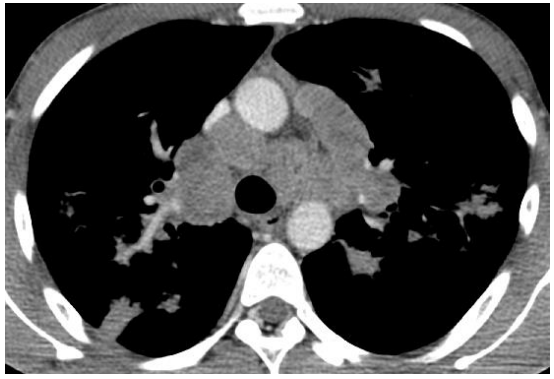


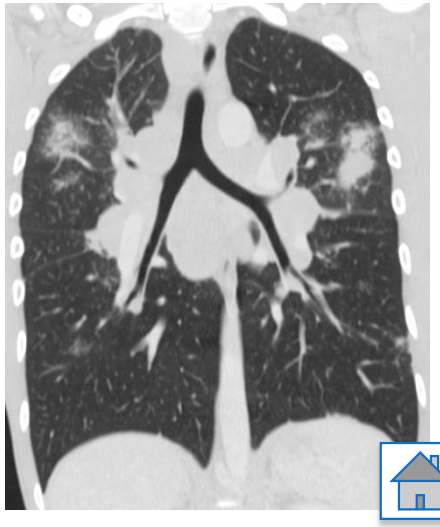






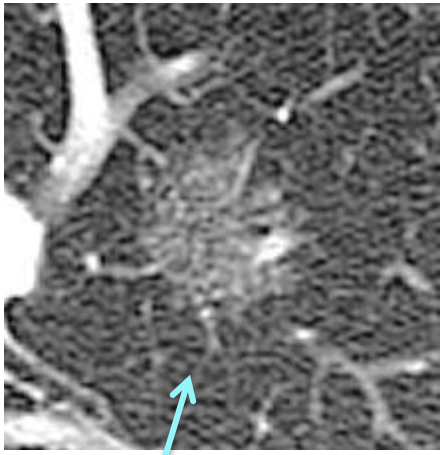




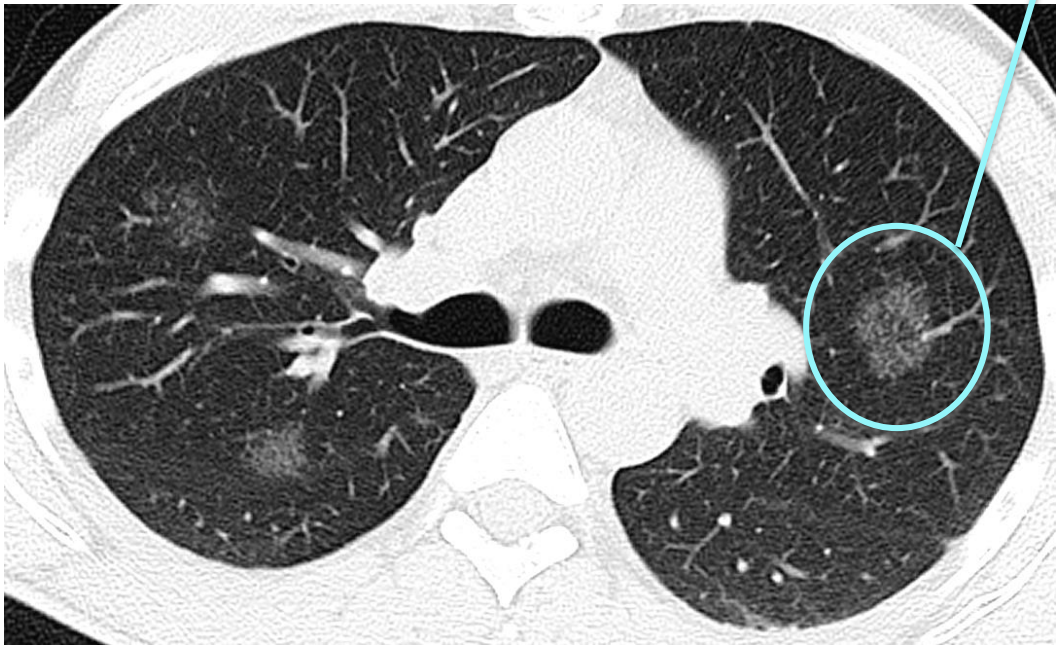


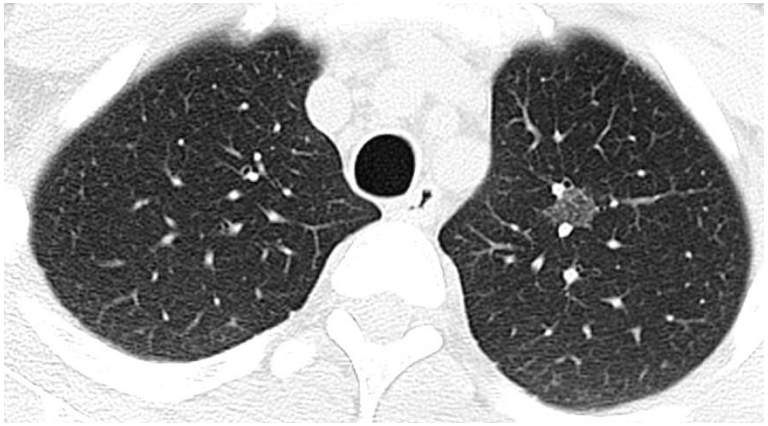
28-year-old patient with hearing loss with vertigo
And uveitis
Chest involvement with
« Galaxy sign »

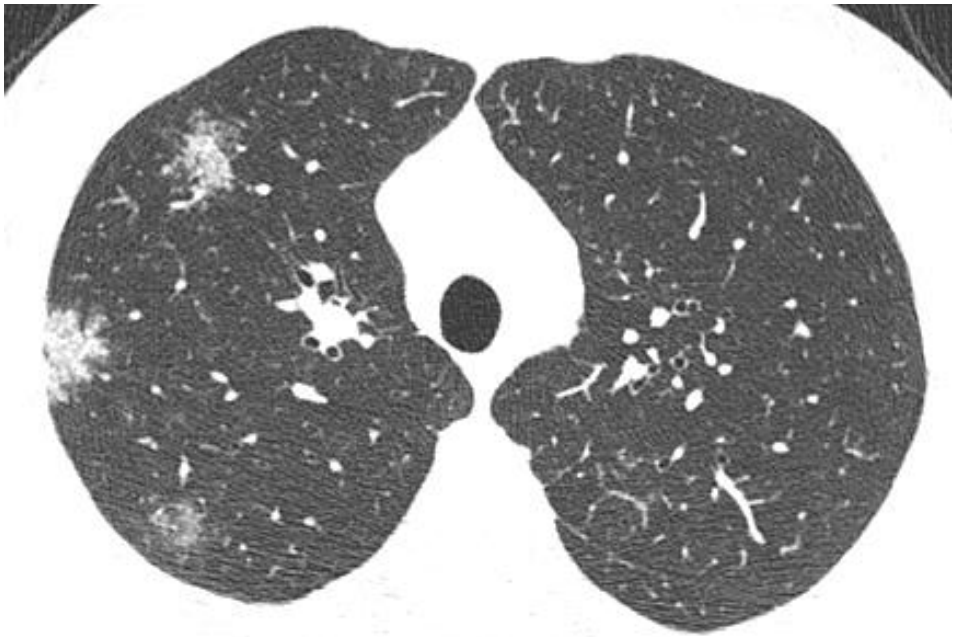
→ **Sarcoidosis**

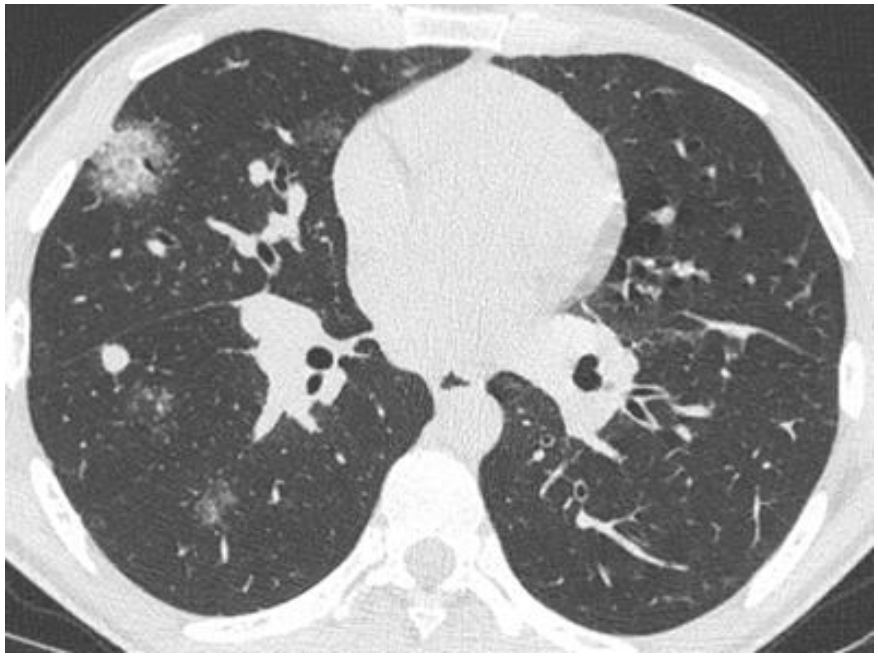


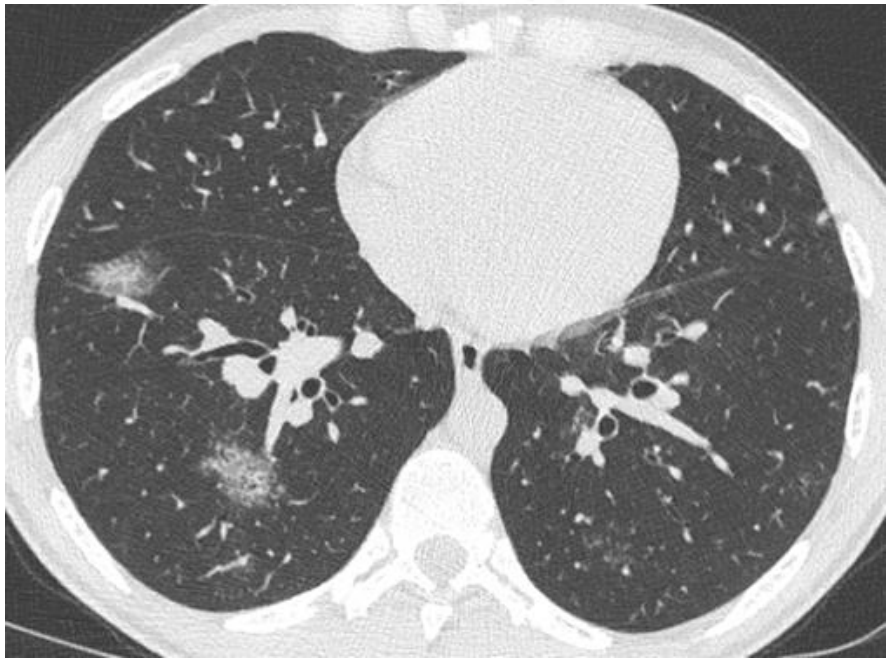
By zooming in, we visualize a multitude of dense micronodules, with sharp edges, grouped in clusters



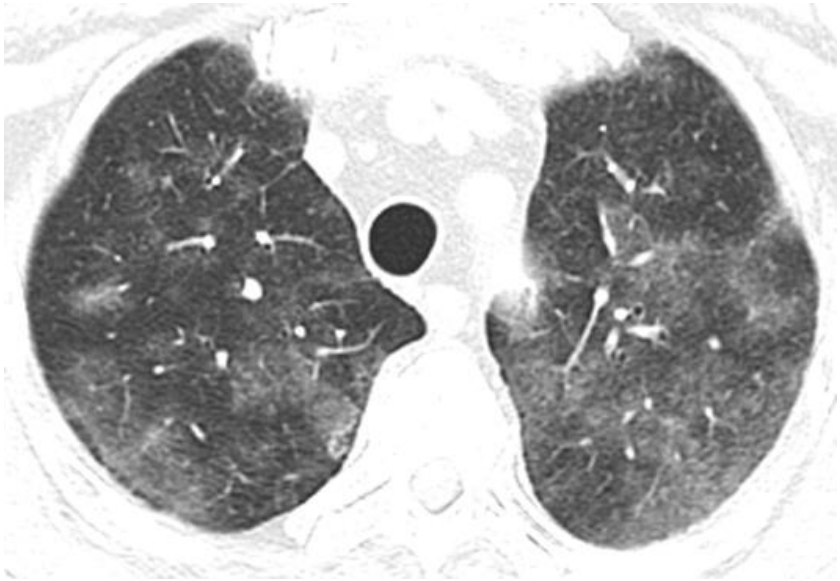


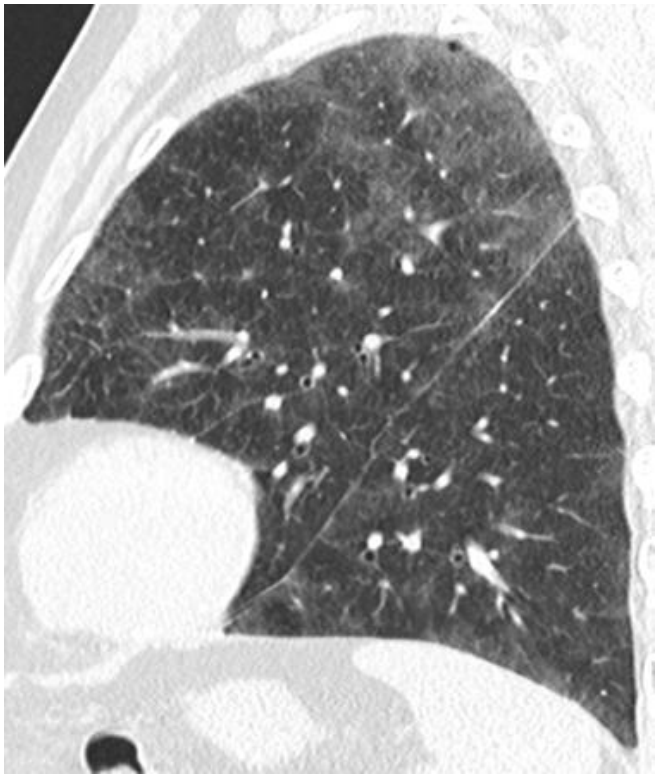


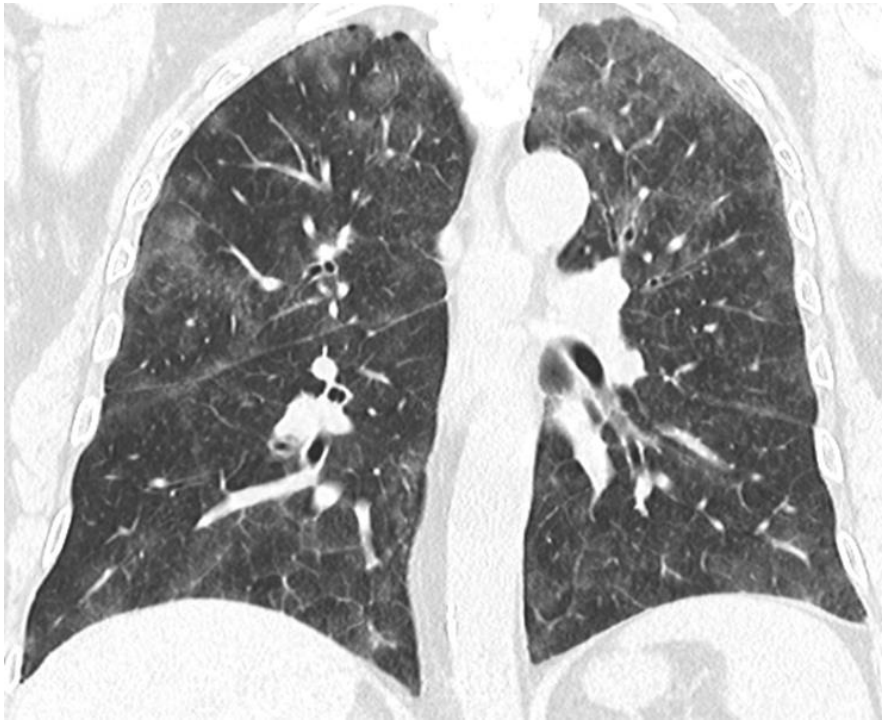




« Galaxy sign »
Sarcoidosis







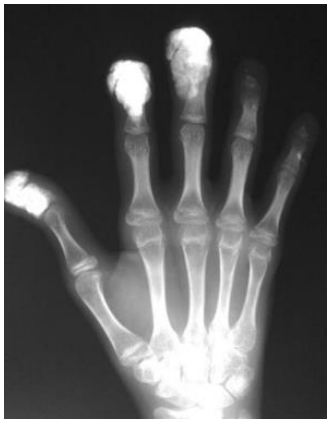
Sarcoidosis

- Predominant GGO
- Slight septal thickening
- Beaded fissure

Connective tissue disease and Lung

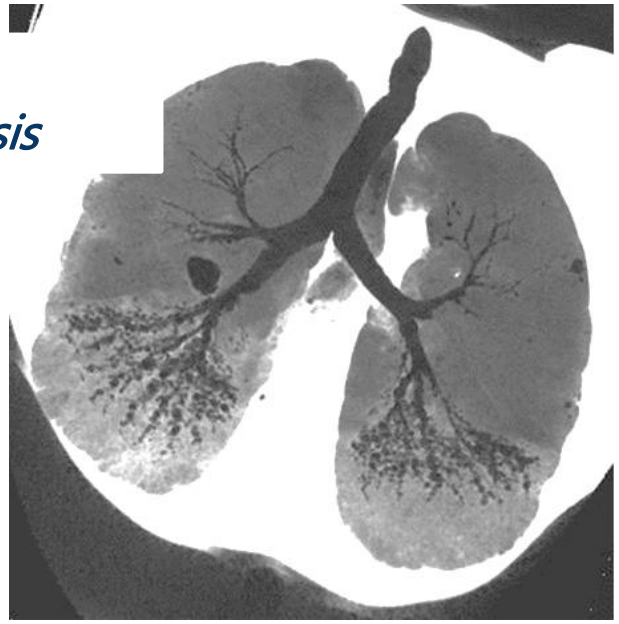
	SLE	Rhumatoid arthritis	Systemic sleroderma	Polymyositis Dermato-poly-myositis	Sjögren	Mixed connective tissue disease
UIP	+	++	++	++	+	++
NSIP	+	+	++++	++++	+	+++
AIP	++	+	+	+		
OP	+		+	++	+	
LIP					+++	+
Alveolar hemorrhage	+++					
Respiratory tracks		++			++	

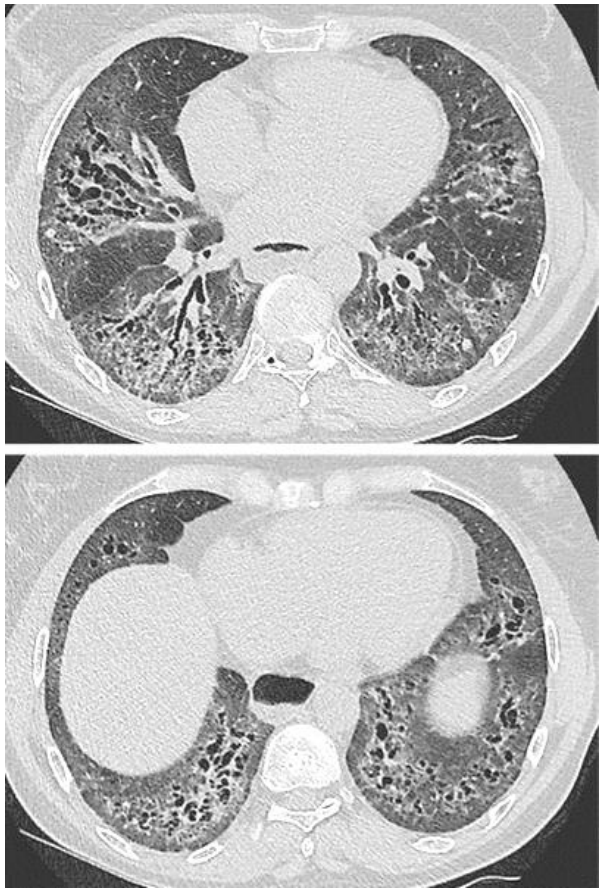
Kim E. A. Radiographics 2002



Case courtesy of Dr Wael Nemattalla, Radiopaedia.org, rID: 7409

GGO
Bronchectasis





Esophagus enlargement

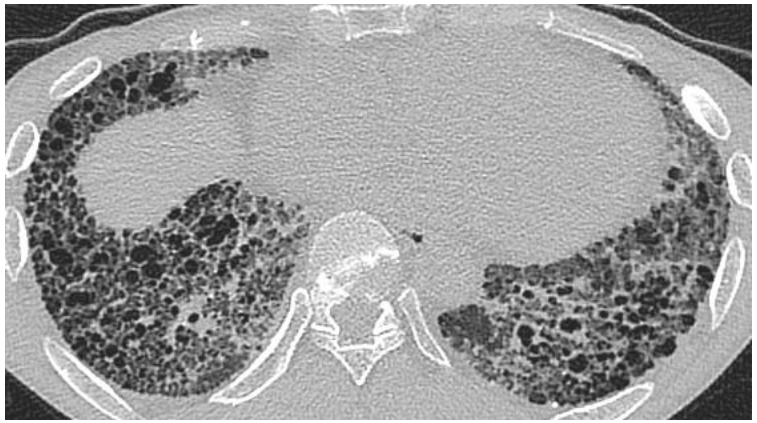
Scleroderma

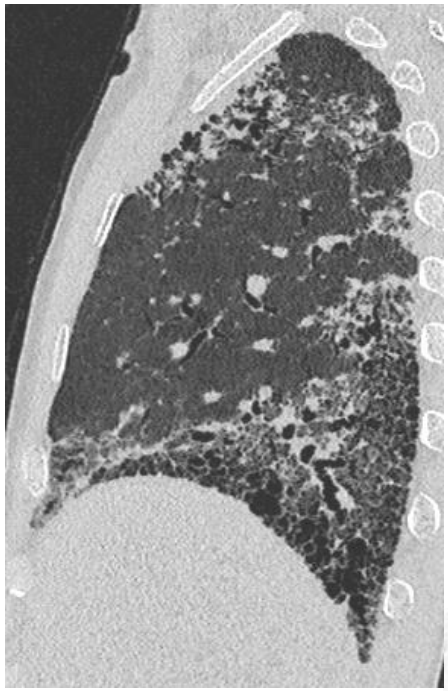
Multi-system autoimmune connectivitis

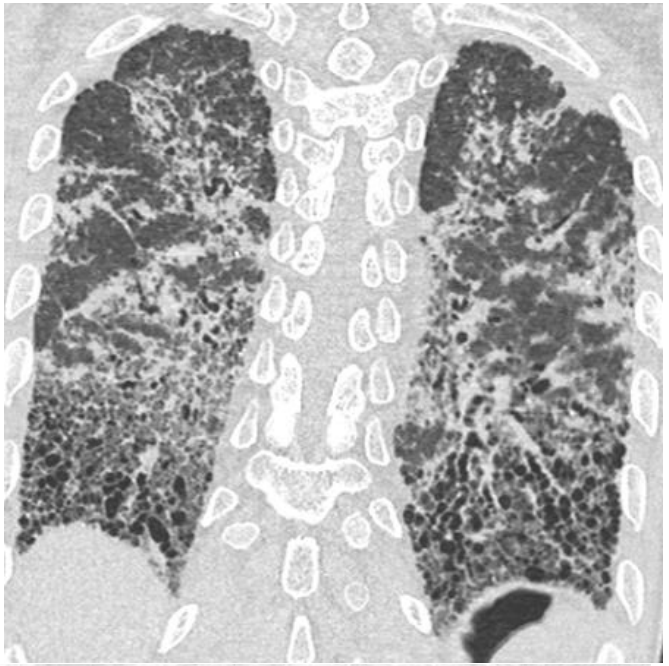
- 30-50 years, F> M 3: 1 (reproductive period ++)
- **Biology:** FR, Anti-nuclear Ab, Anti SCL-70 Ab (30-70%), Anti-centromere Ab (20-40%)
- **Musculoskeletal involvement:** hand ++ Acro-osteolysis Subcutaneous and para-articular calcifications
- **Gastrointestinal involvement**: esophagus +++ (80%) 2/3 lower dilation + hypomobility ->Inhalation pneumonia
- **Pulmonary involvement** NSIP +++ or UIP +
- **PAH** secondary to scleroderma (vascular involvement)

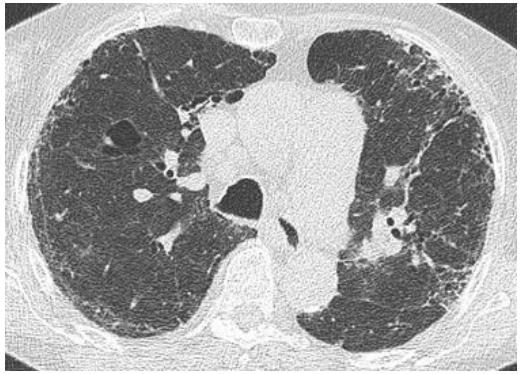
ILD (NSIP++, UIP)
+ **esophagus enlargement**
→ Scleroderma

Desai SR et al. CT features of lung disease in patients with systemic sclerosis: comparison with idiopathic pulmonary fibrosis and nonspecific interstitial pneumonia. Radiology. 2004

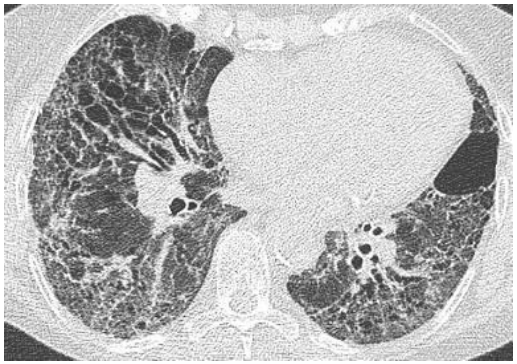


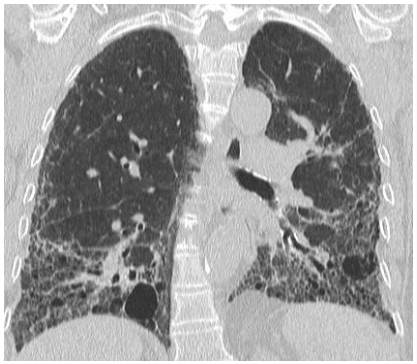


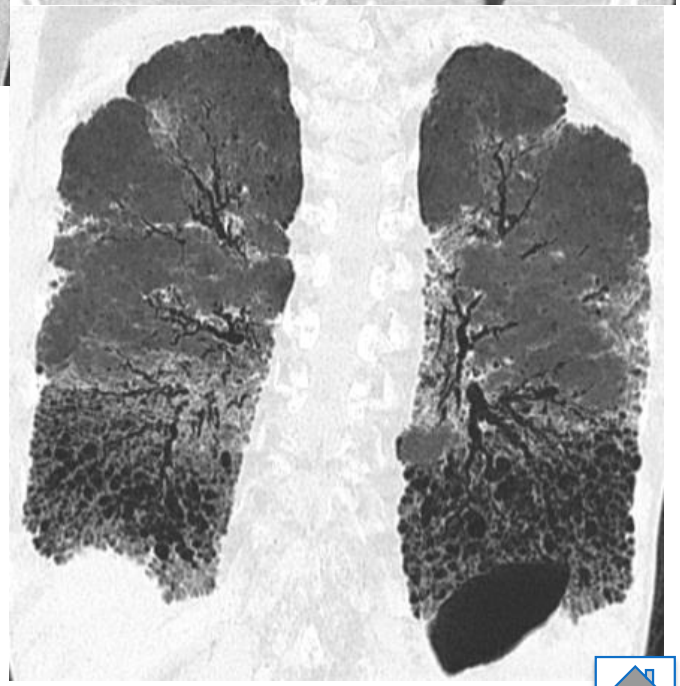


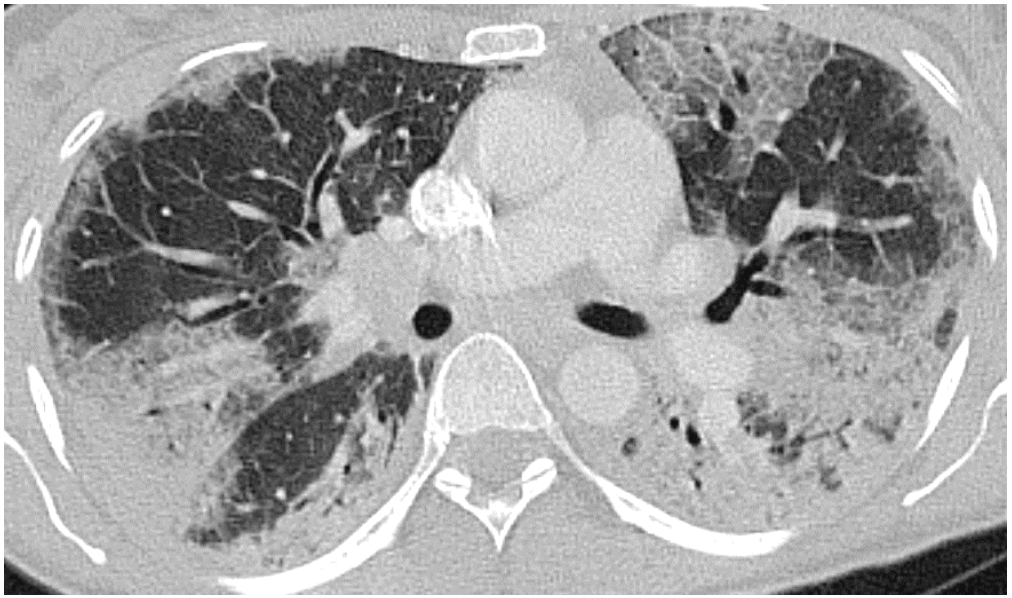


Scleroderma
NSIP



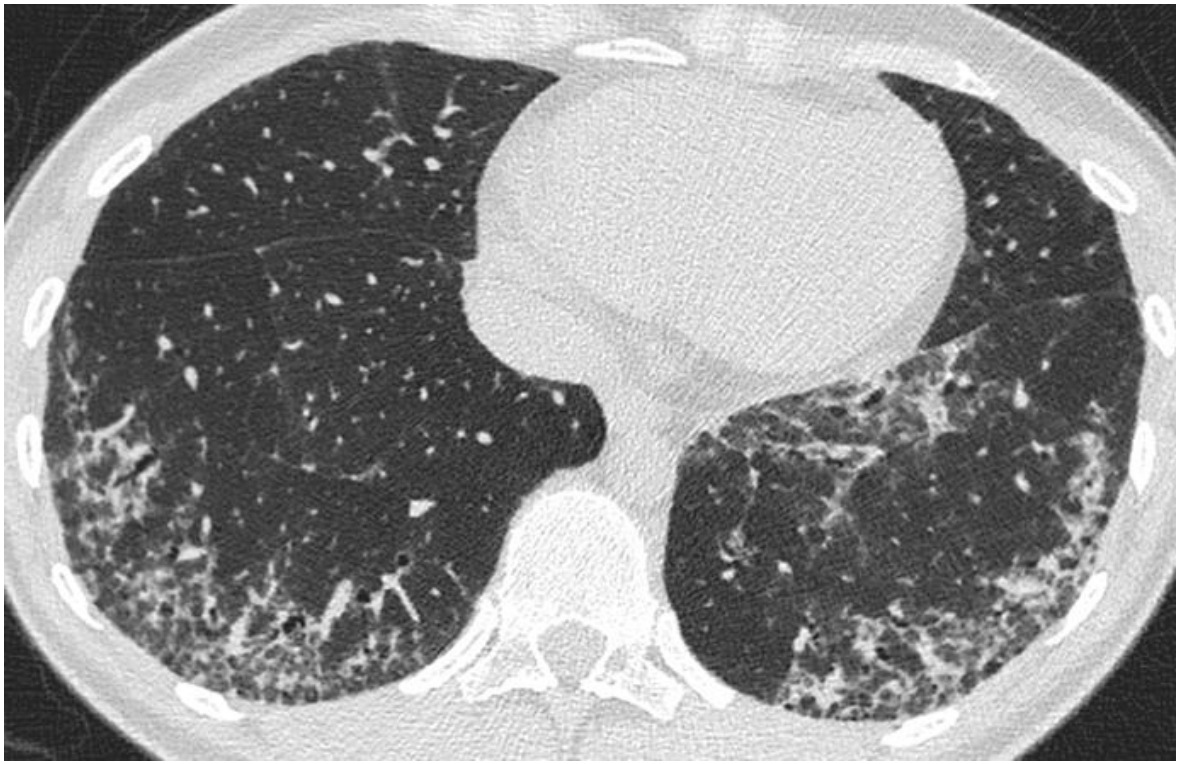






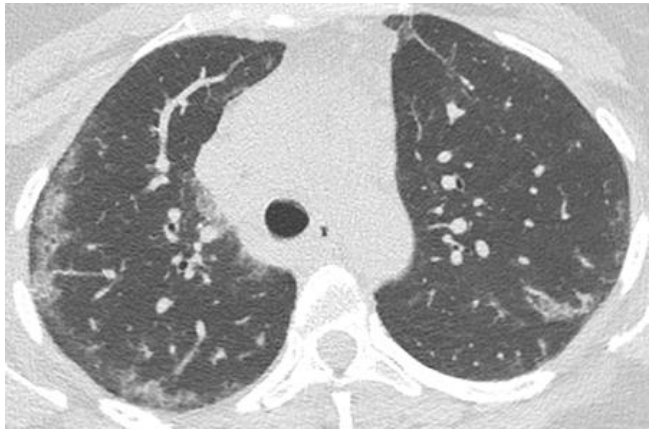
Dermato-polymyositis

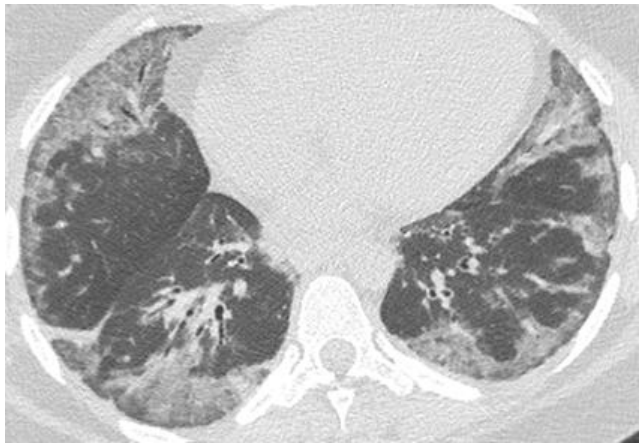
- Autoimmune myositis
- Adult around the age of 50
- Biology: Increase CPK and specific anti-RNA and anti-Mi2 antibodies
- **Imagery:**
- Myositis (edematous lesions + fatty infiltration + atrophy), posterior compartment thigh or diffuse
- Dystrophic calcifications: calcinosis, acro-osteolysis
- **NSIP**-type lung damage

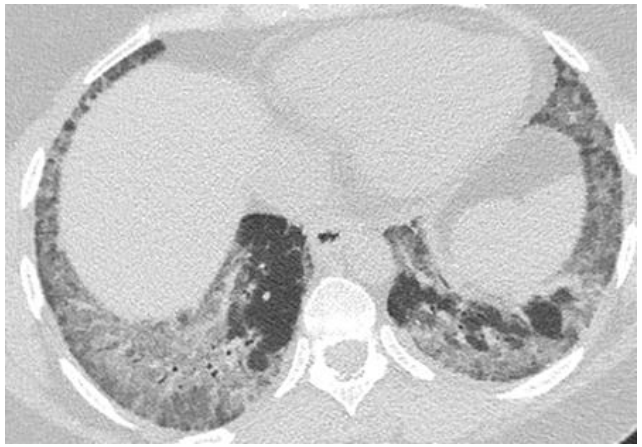


Sharp syndrom

- = cross of 2 connective tissue disease
- Pattern **NSIP**

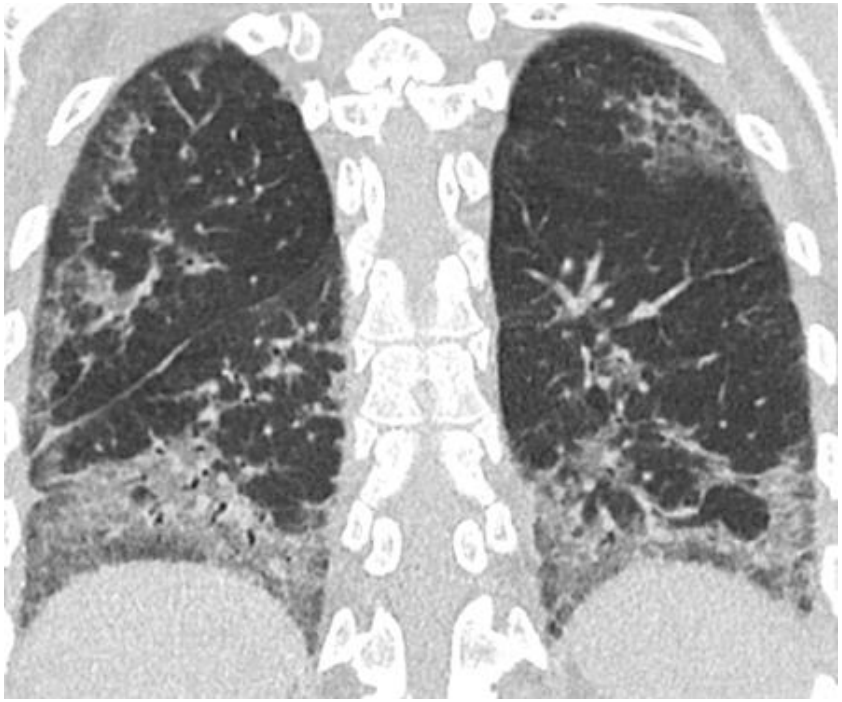




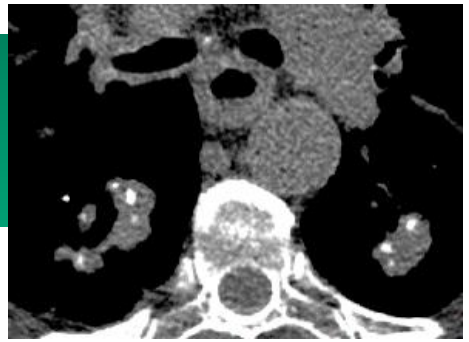


Antisynthetase syndrome

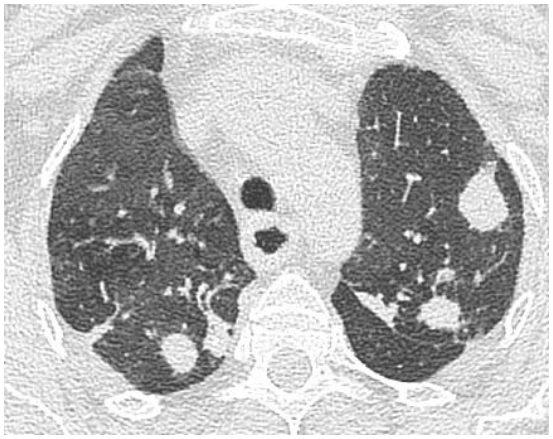
- **Rare disease**, affecting more women than men (sex ratio W / M: 3: 2), without predominance of age.
- Association:
  - skin manifestations such as **"mechanic hands"**
  - **inflammatory myopathy**
  - **Raynaud's syndrome**
  - **RA**
  - **pulmonary involvement: NSIP pattern +++**, OP ++ or mixed COP + NSIP
- Biologically, presence of **anti-nuclear auto antibodies called anti-synthetases**
- Complication: pulmonary arterial hypertension.

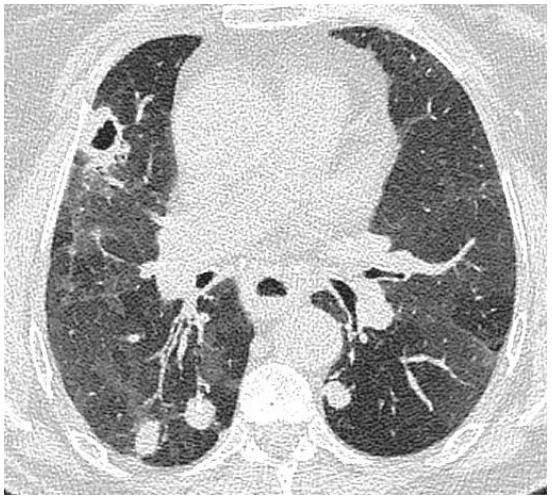


Rhumatoid arthritis



- Bilateral and symmetrical arthritis
- Pleuro-pulmonary manifestations during evolution





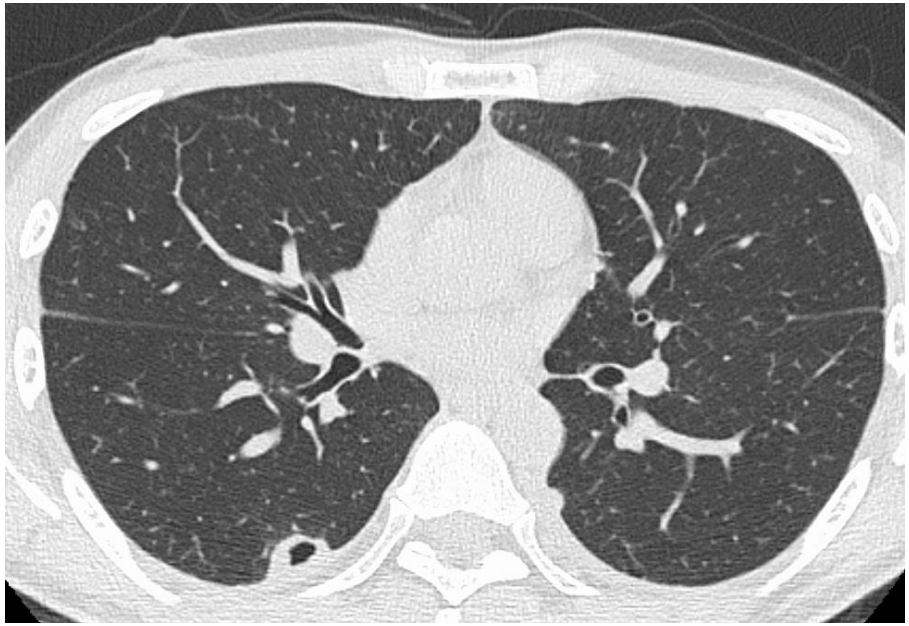
- Pleural involvement +++
  - **Pleural thickening** ++, effusions
- Rheumatoid nodules (aseptic necrobiosis nodules)
  - Prevalence histo series 32%, CT 49%
  - **Nodules or masses**, rounded, well limited, 0.5 - 7 cm, single / **multiple** ++, upper and middle territories, peripherals
  - **Excavation ++** (50%)
  - **Same appearance as neoplastic nodules**
  - Stable or ↓ spontaneously
- ILD
  - **UIP** (honeycomb) or **NSIP**
  - Biapical fibro-cavitary lesions (idem Ankylosing spondylitis)
- Airway damage ++
  - Bronchiectasis
  - **Constrictive bronchiolitis**
  - **Follicular bronchitis / bronchiolitis**
  - Thickening of the bronchial wall, « tree in bud »

Aseptic necrobiosis nodules
- PR
- Crohn

Tanaka N, Kim JS, Newell JD et-al. Rheumatoid arthritis-related lung diseases: CT findings. Radiology. 2004

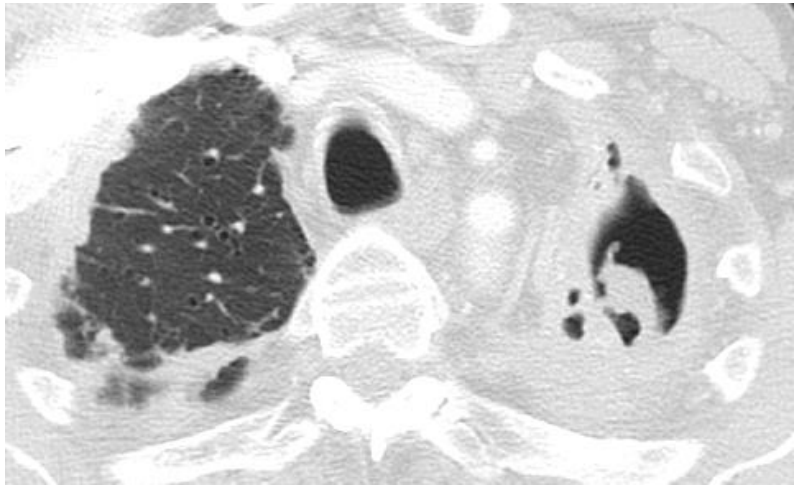
Caplan-Colinet syndrom
RA + sillicosis

Aseptic necrobiosis nodules in RA



Ankylosing spondylitis

- Pulmonary involvement is rare and always preceded by involvement of the axial skeleton
- Frequently causes restrictive ankylosis syndrome



AS+ aspergilloma

Imaging

- **Mosaic lung with air trapping**
- Thickening of the bronchial walls
- **Thickening of the apical cap and / or apical reticulo-nodular opacities**
- Parenchymatous bands
- Later Retractile and mutilating fibrosis with banded opacities and **cystic cavities** which can be complicated by aspergilloma
- In the most severe forms the retraction of the upper lobes leads to an ascent of the hilum with traction bronchiectasis .

Vasculitis and lung

Primitive vasculitis

1) Small caliber vessels
- Wegener's granulomatosis (GPA)
- Churg and Strauss Syndrome
- Microscopic polyangiitis (MPA)

2) Medium caliber vessels
- Knotty peri-arteritis
- Kawasaki disease

3)Large vessels
- Takayasu primary aortitis
- Behcet's disease
- Horton giant cell arteritis

Diagnostic guidelines

- Nodules
- Condensations
- Cavitations
  → GPA (ex Wegener)

- Thrombosis
- Pulmonary artery aneurysm
  → Behçet /Takayasu

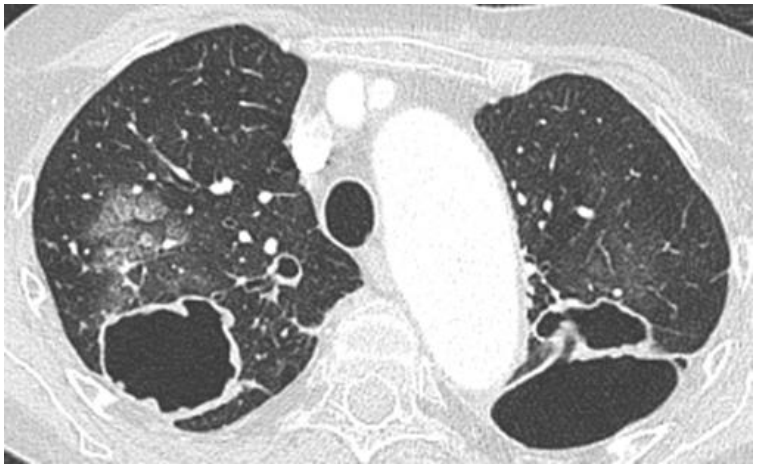
- Peribronchovascluar thickening
- Diffuse GGO
- Crazy paving
  → EGPA (ex Churg)

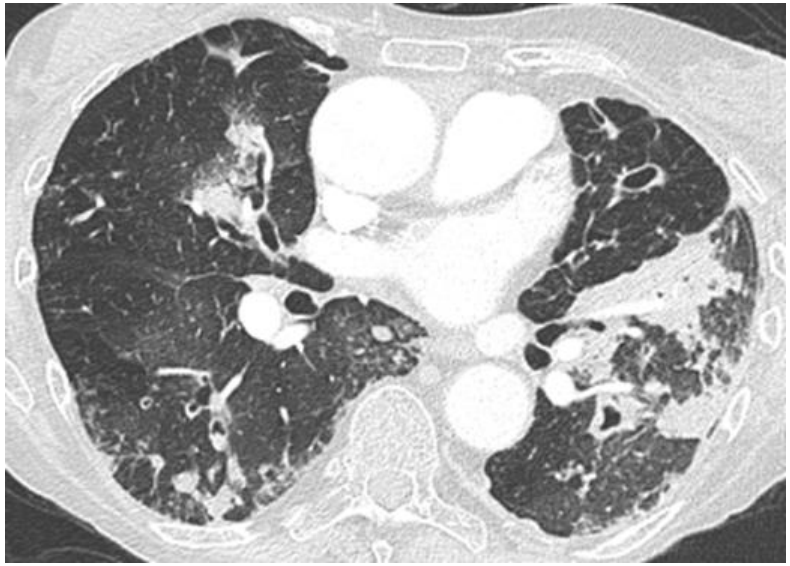
Intra-avleolar hemorrhage
→ MPA
→ GPA
→ Goodpasture
→ SLE

Wegener disease (GPA)

Granulomatosis with polyangiitis (GPA) (new name)
Necrotizing granulomatous vasculitis of small and medium caliber vessels

- Necrosis and hemorrhage
- Multisystem disease Lungs (90%)
- Tracheobronchial Kidneys, ORL
- Age of onset ≈ 40 years old
- Biology: inflammatory syndrome, ANCA



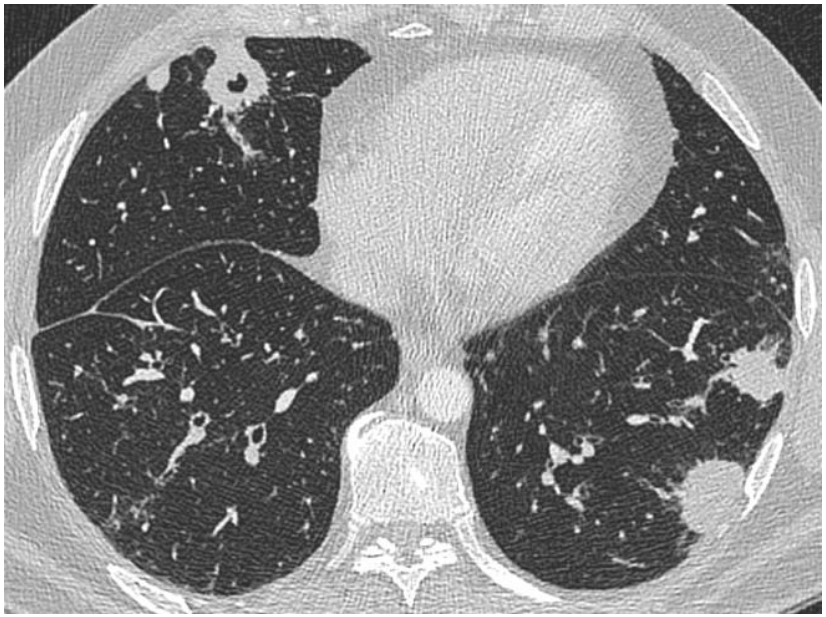


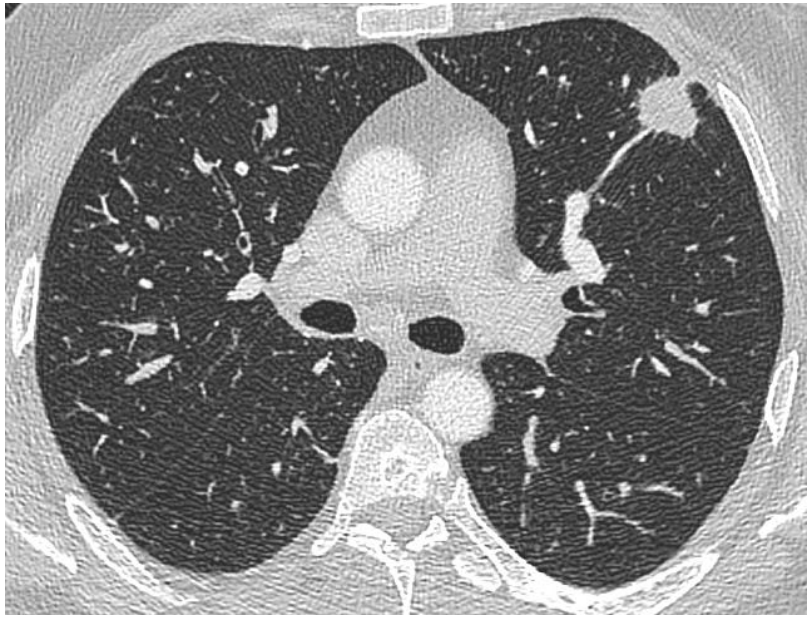
Imaging

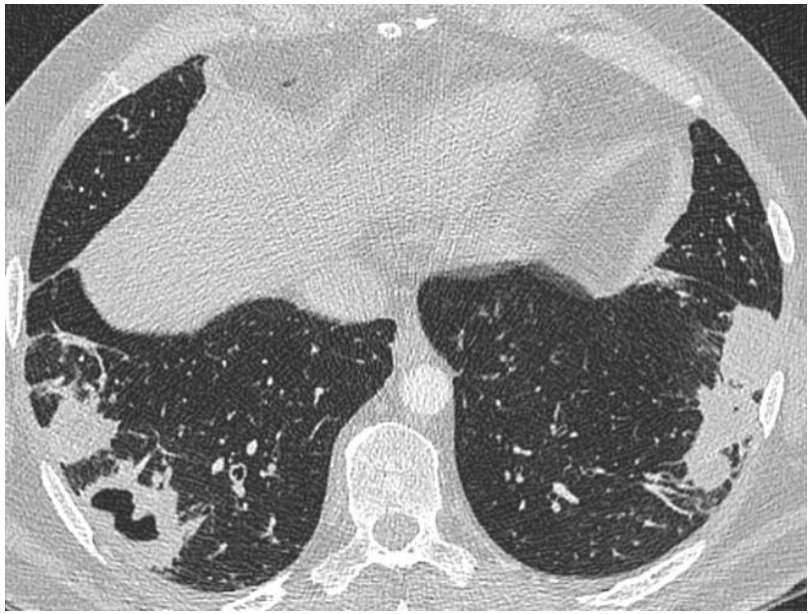
- **Nodules and masses (1-4 cm) +++**
  - **Excavation**
  - +/- **GGO halo** (perinodular hemorrhage)
- **Condensation / focal or diffuse GGO** (alveolar hemorrhage)
- **Triangular sub pleural condensation** (infarction)
- **Circumferential subglottic tracheal thickening** / tracheal proximal portion, smooth and regular stenosis

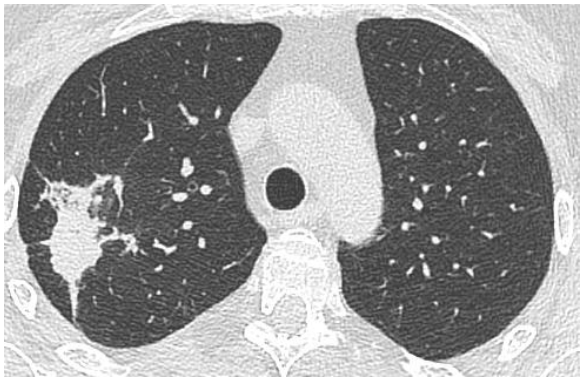
Wegener

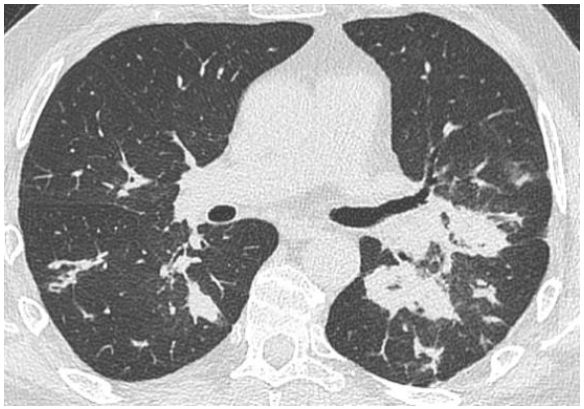
Multiple mass syndromes +/- excavated

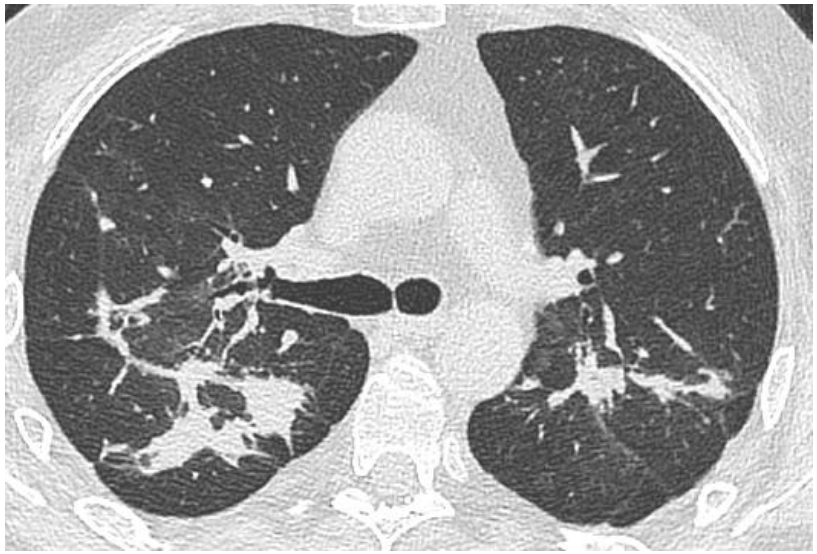








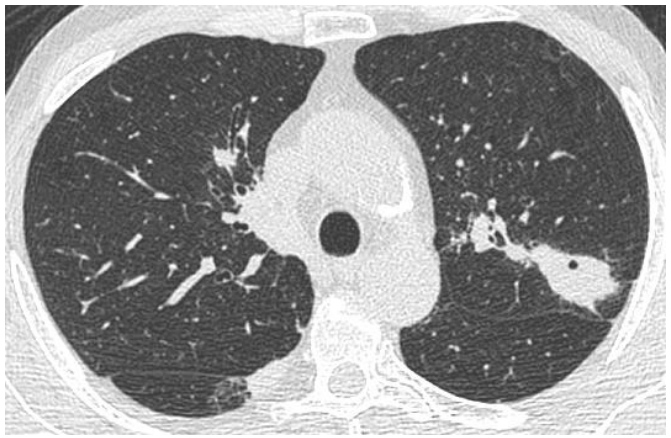


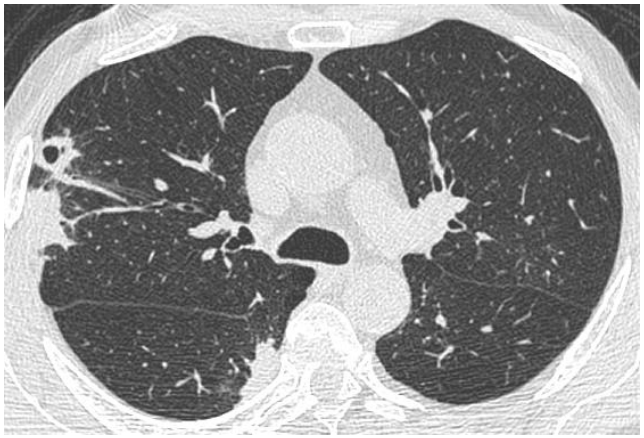


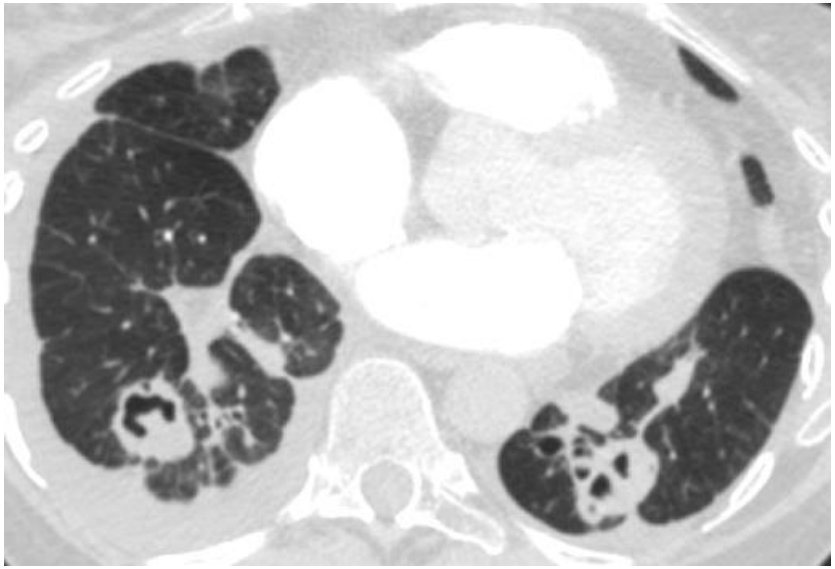
Retractile mass without excavation

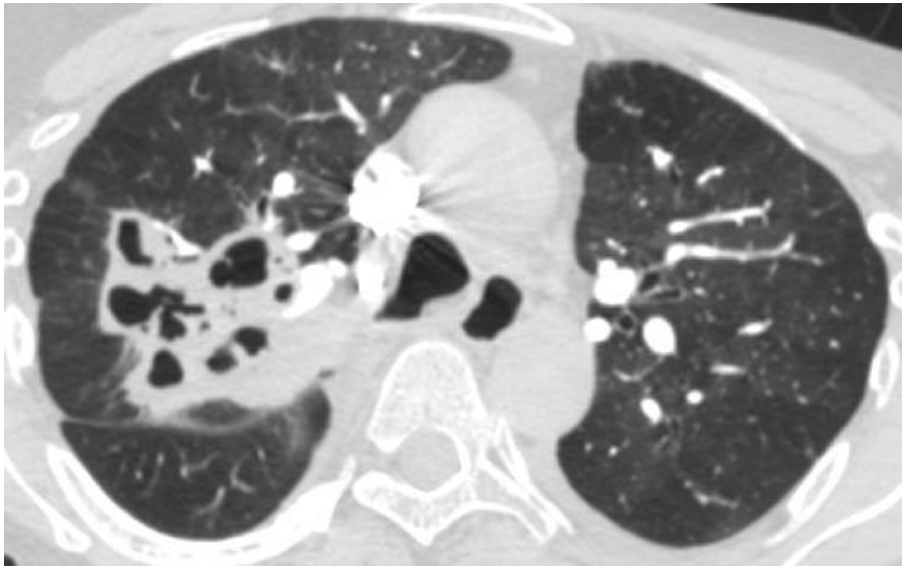
Wegener disease

Multiple mass ,excavated

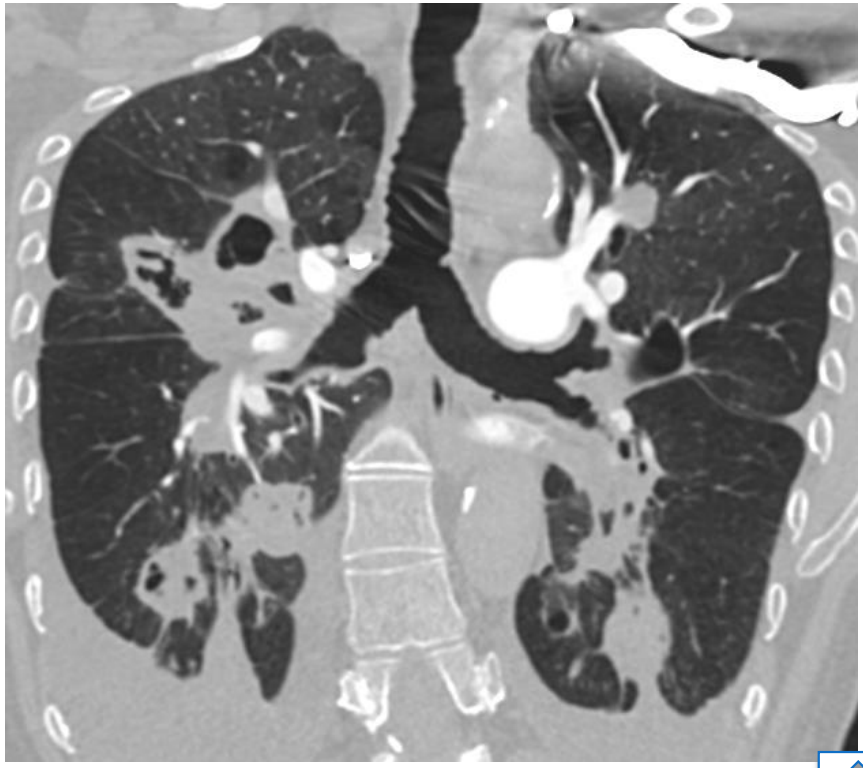


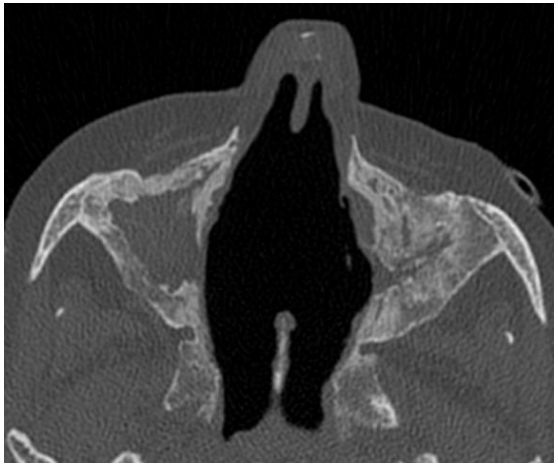






Multiple mass , excavated





Wegener disease

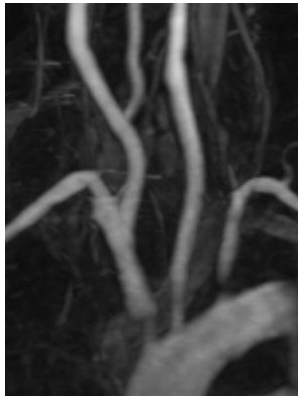
ORL

- Necrosis of the nasal septum, cones, etc.
- Pansinusitis with major thickening of the sinus bone walls

Takayasu

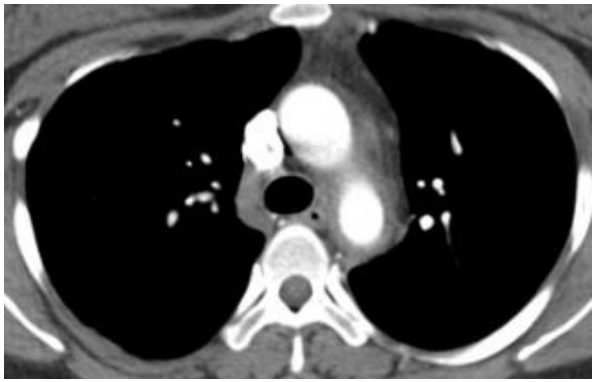
Granulomatous vasculitis of large vessels Disease of "women without pulse" (9F / 1H), beginning: 15-30 years .

- 2 phases
  - **Early or active** = **reversible inflammatory lesions** of the vascular wall
  - **Late** = **irreversible scar fibrous lesions**
- Treatment: corticosteroids, immunosuppressants, surgery, angioplasty



Aortic arch syndrome

Case courtesy of Dr Roberto Schubert, Radiopaedia.org, rID: 14316



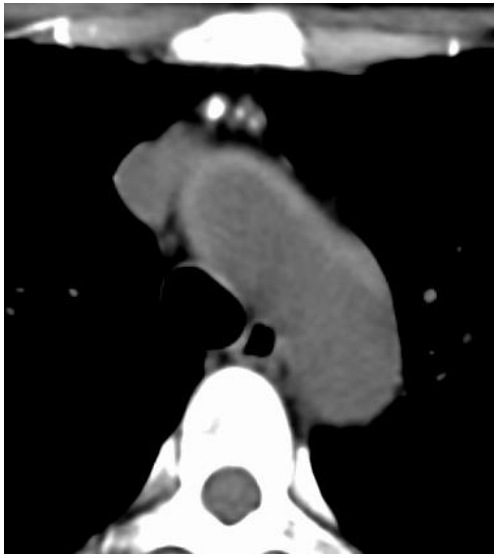
Case courtesy of Dr Varun Babu, Radiopaedia.org, rID: 45951

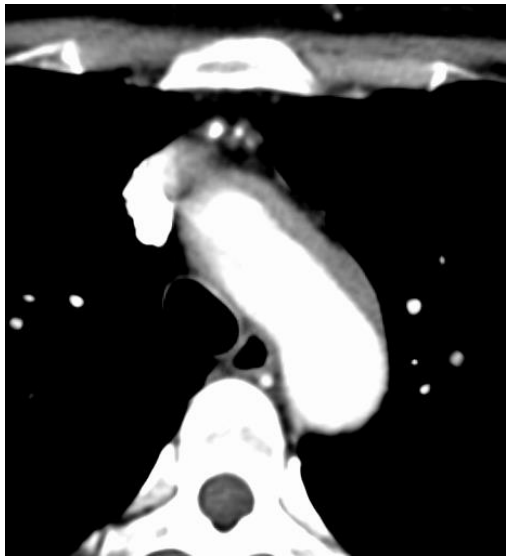
US / CT / MRI

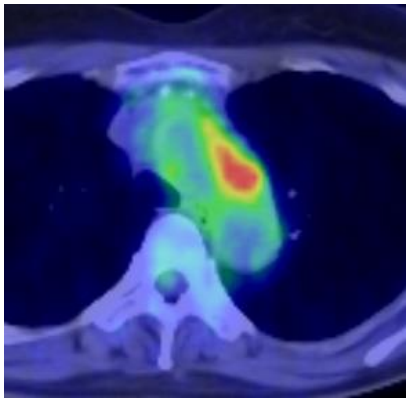
- Active phase
  - **Vascular wall thickening**: ASD, thoracic aorta, abdominal aorta
  - **Aorta wall tickening** from 3 to 7mm
  - **Wall enhancement**
- Late phase = complications
  - **Stenosis** 68%, occlusions
  - **Ectasias** 12%, aneurysms 4%
  - **Coronaries : ostial and non-ostial stenosis**, aneurysms

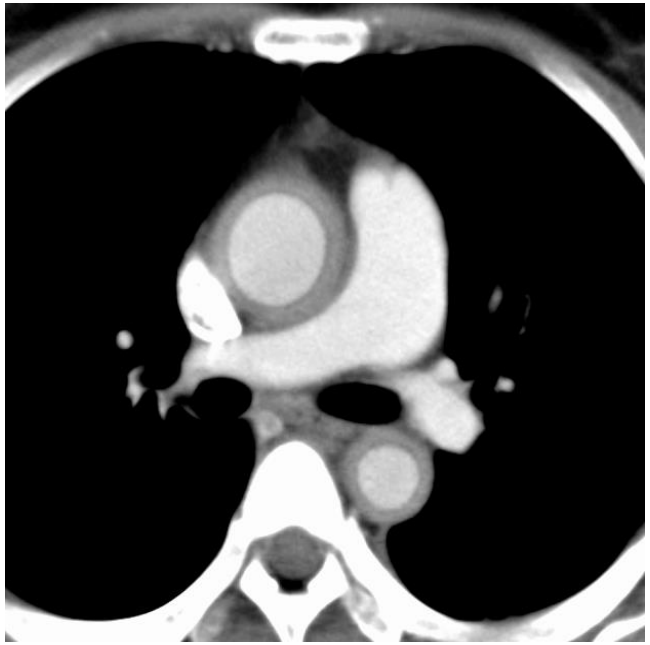
Gotway MB, Araoz PA, Macedo TA et-al. Imaging findings in Takayasu's arteritis. AJR Am J Roentgenol. 2005

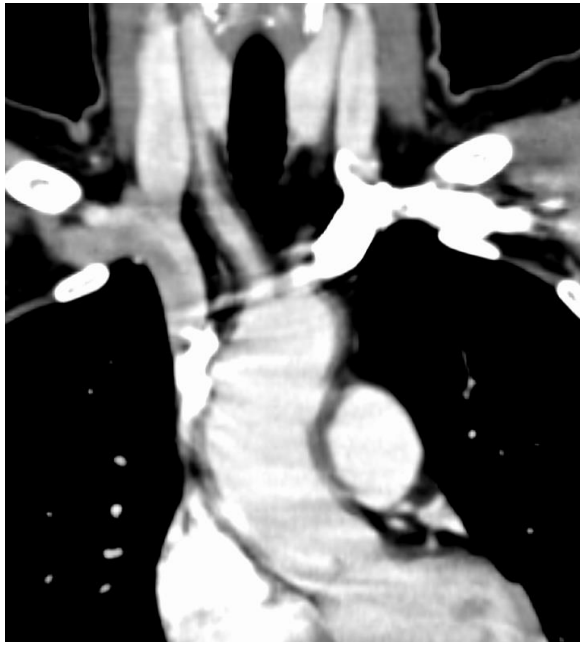
Takayasu



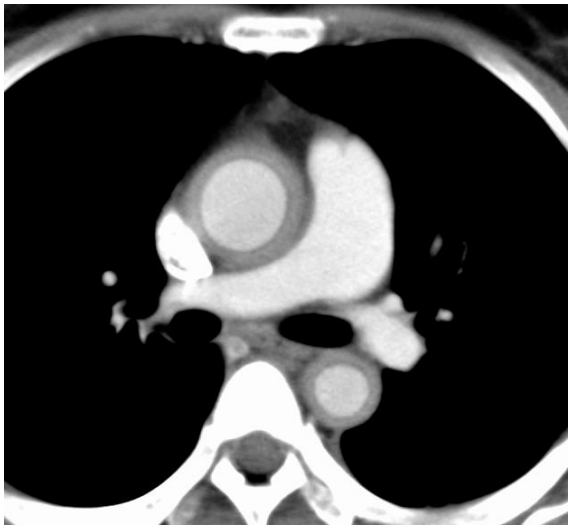


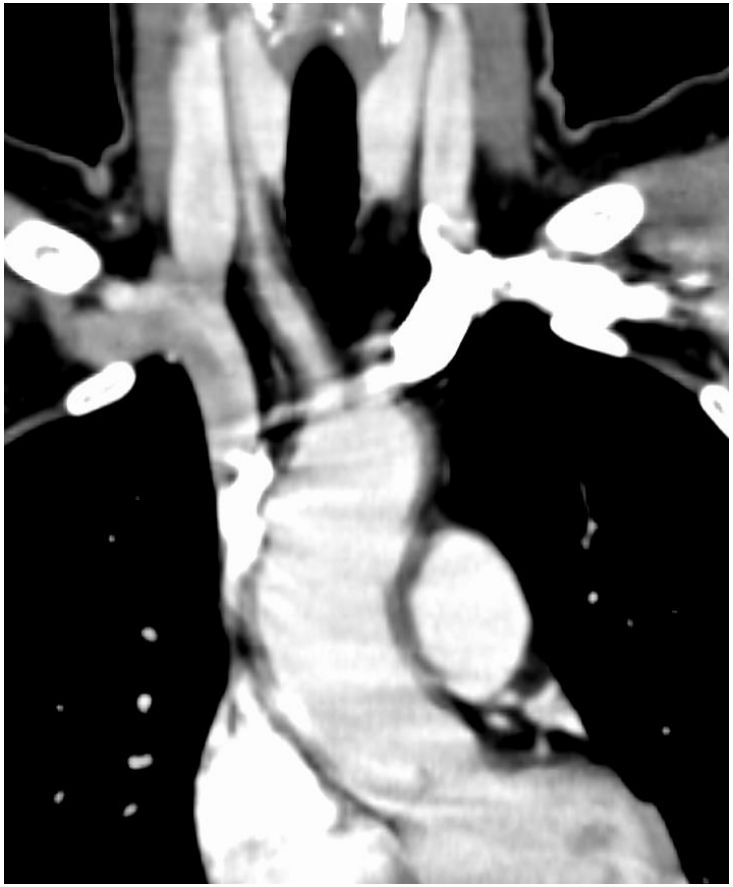






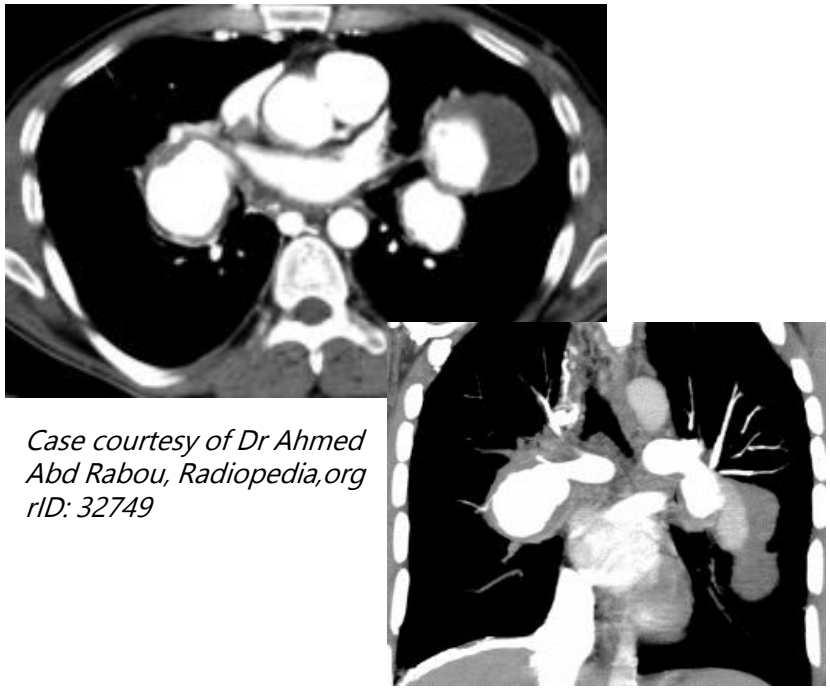
Takayasu





Behçet

- **Necrotizing lymphocytic vasculitis** of vessels of any size (artery, vein, capillaries): destruction of the media -> aneurysms and thromboses
  - **Skin and mucosal involvement** (most common): **oral and genital ulcers**
  - **Uveitis**
  - **Thoracic (10%):** chest pain, dyspnea, hemoptysis
- Autoimmune systemic disease by lymphocyte activation via the stress protein HSP evolving by flares
- **Young man from the Mediterranean basin**
- Treatment: corticosteroids / IS (inconstant efficacy), endovascular treatment of aneurysms



Case courtesy of Dr Ahmed Abd Rabou, Radiopedia,org rID: 32749

Imaging

- **Aneurysms and stenoses of the pulmonary arteries and their branches** □ Vital risk from bronchovascular fistula and cataclysmic hemoptysis
- **Alveolar hemorrhage:** localized or diffuse alveolar opacities
- **Pulmonary infarction**: triangular subpleural condensations.
- **Venous thrombosis** (VCS / VCI)
- **Perfusion disorders: mosaic lung**

Hiller N, Lieberman S, Chajek-Shaul T et-al. Thoracic manifestations of Behçet disease at CT. Radiographics. 2004

Churg and Strauss (EGPA)

EGPA = Eosinophilic Granulomatosis with Polyangeitis =
necrotizing vasculitis and granulomatous extravascular inflammation

- Clinical, histological and radiological **similarities with chronic eosinophilic pneumonitis** but associated vasculitis lesions
- Rare, middle-aged adult, predominantly male
- Biology Inflammatory **syndrome Hyper-eosinophilia +++** (blood and LBA)

Multisystem involvement

- **Late onset asthma> 20 years**
- **Chronic sinusitis**
- Asthenia, prolonged fever
- **Neuritis** lower extremities, cardiac involvement, skin involvement

Classically evolution in 3 phases

✓ **Prodromal phase**:
  - Asthma and rhinitis appearing around the thirties on an allergic ground
  - **Asthma is an absolute criterion** (sensitivity = 100%)

✓ **Hypereosinophilic phase**
  - Pulmonary ++
  - Intestinal

✓ **Vasculitic phase** Pulmonary infiltrates Multineuritis Pleurisy, myocarditis Digestive, skin, kidney damage

Biblio: Jeong, Yeon Joo, et al. "Eosinophilic Lung Diseases: A Clinical, Radiologic, and Pathologic Overview - Radiographics 2007

Imaging

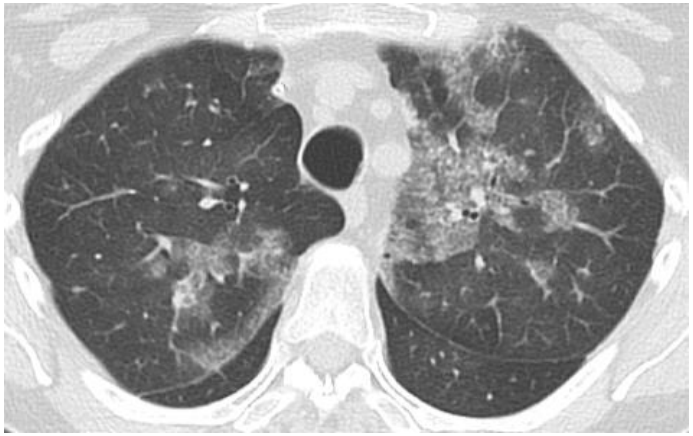
- **GGO/ consolidation areas**
- In scattered areas
- **Peripheral and superior predominance**
- ***(Looks like PCE but more polymorphic :)***
- **Central lobular micronodules** (12%) Nodules (12%)
- **Bronchial wall thickening** +/- septal thickening: interstitial edema secondary to cardiac involvement

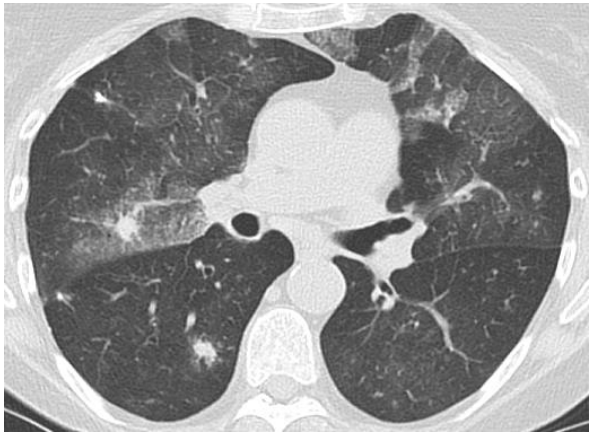
ACR (4 des 6 critères)

- Asthma
- Blood hyper-eosinophilia> 10%
- Multineuritis or poly-neuropathy
- Pulmonary infiltrate
- Sinusitis
- Extravascular eosinophilia

- **GGO ranges / consolidation**
- in an **asthmatic patient**
- With **hypereosinophilia**

Think of Churg and Strauss

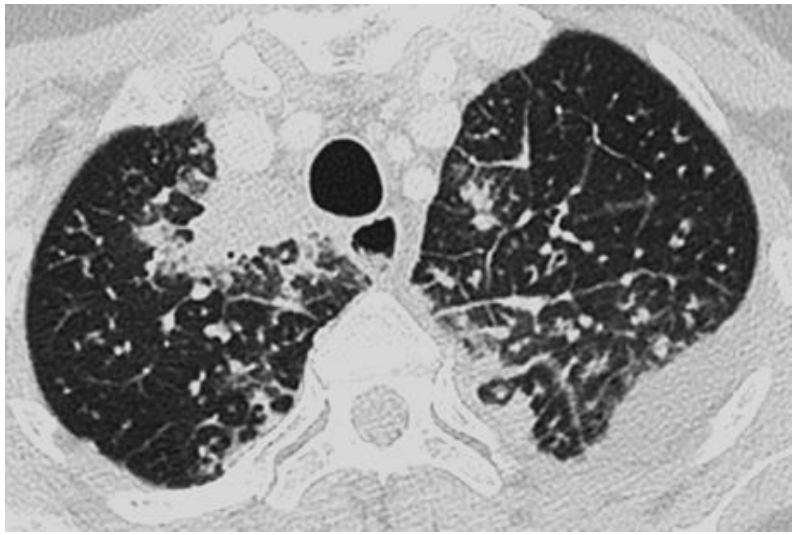


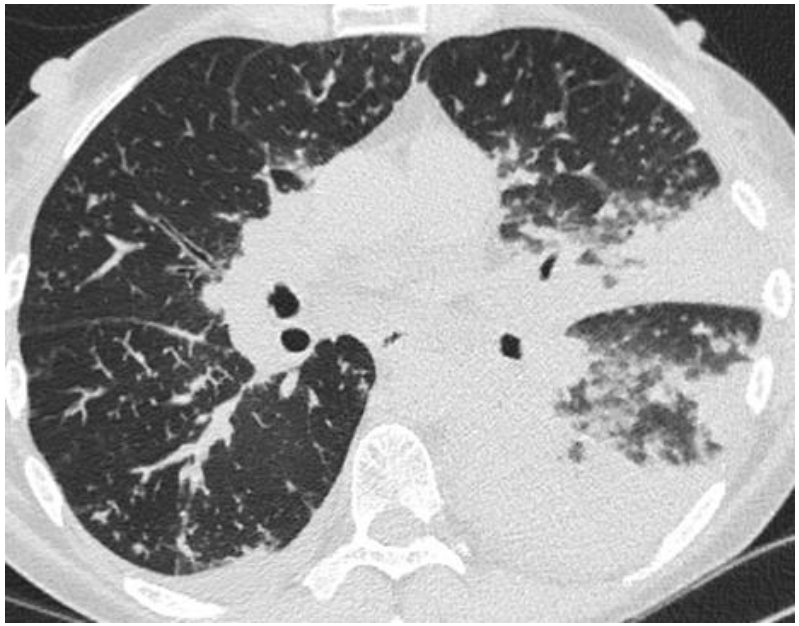


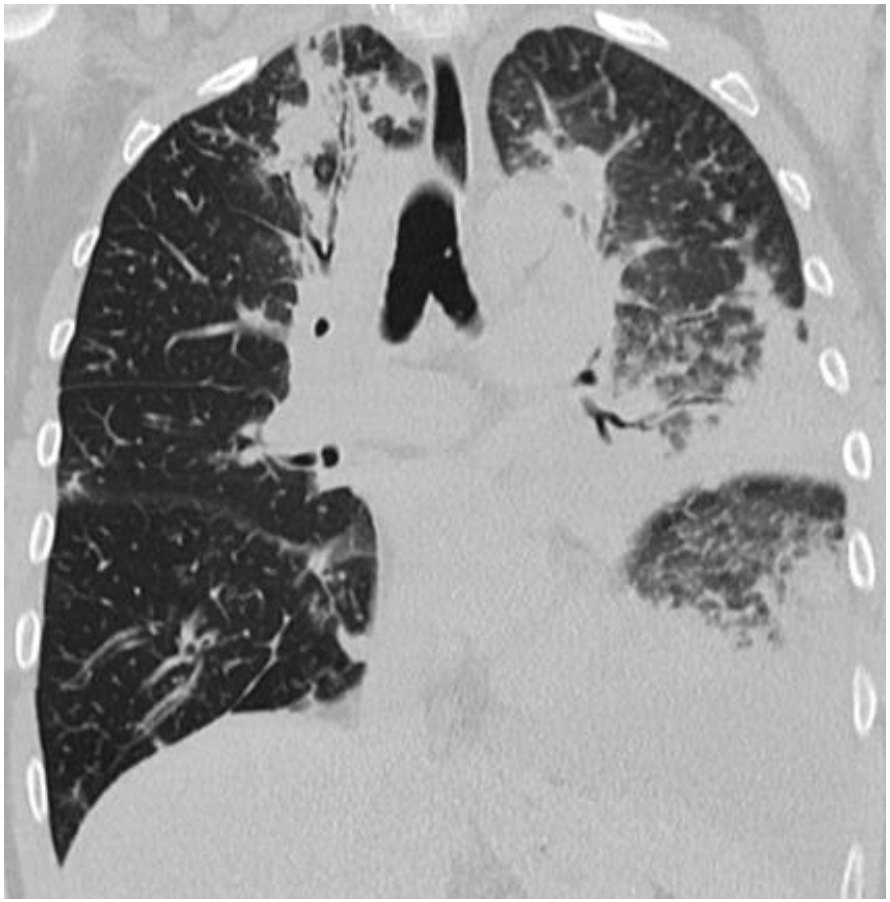
DDX

Other pulmonary diseases associated with hyper-eosinophilia:

- Löffler
- ABPA
- PCE
- but no extrathoracic signs in these diseases





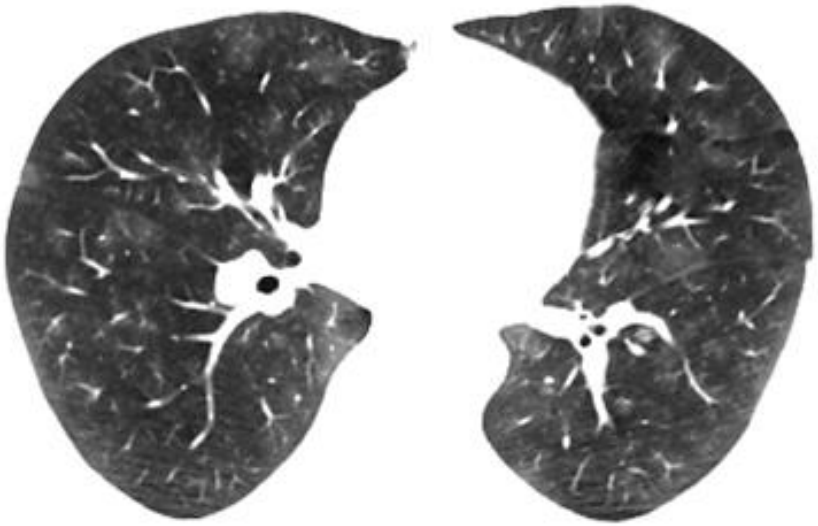


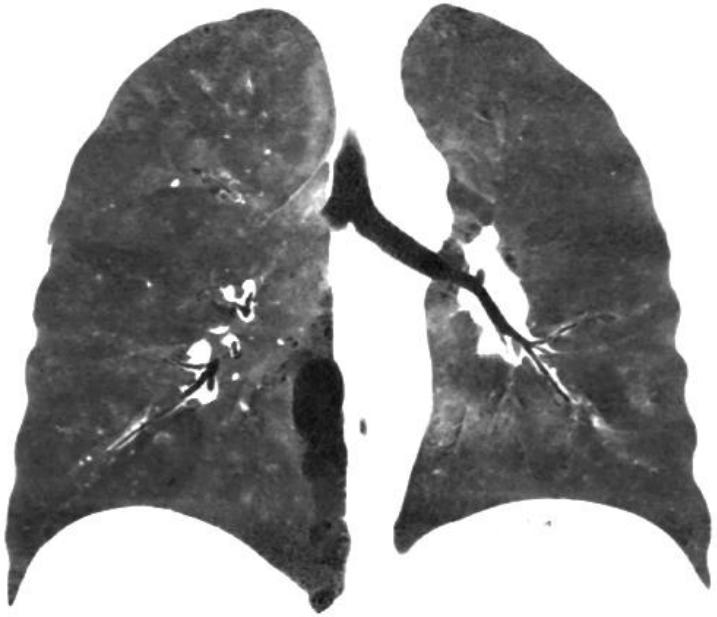
EGPA (ex Churg and Strauss)

- Asthma
- Hyper eosinophilia
- Bilateral consolidation
- bronchiolar involvement
- In addition, sinus involvement and multiple mononeuropathy

Microscopic polyangiitis

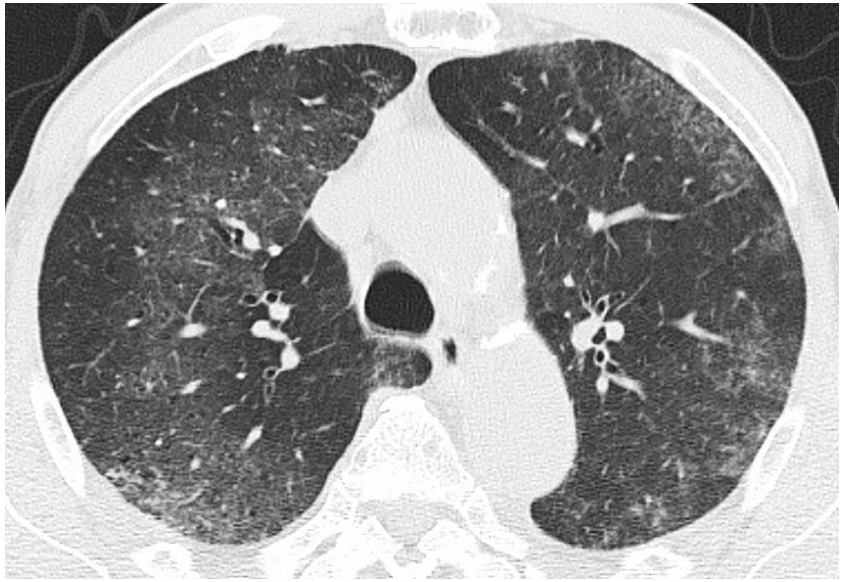
- **Non-glomerulomatous necrotizing vasculitis**
- Inflammation of arterioles, venules and capillaries
- Main cause of **pneumo-renal syndrome** (alveolar hemorrhage + glomerulonephritis)
  - Frequent and severe kidney damage (90%)
  - Pulmonary involvement (15 to 30% of patient
- Male ++, start at 50
- **pANCA anti MPO**

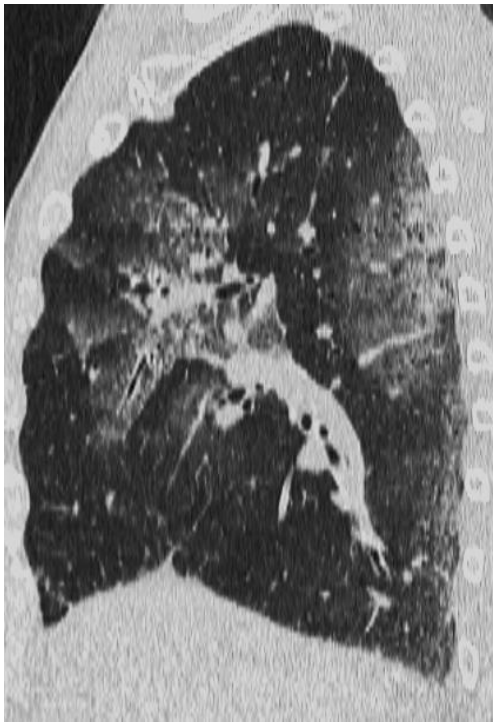




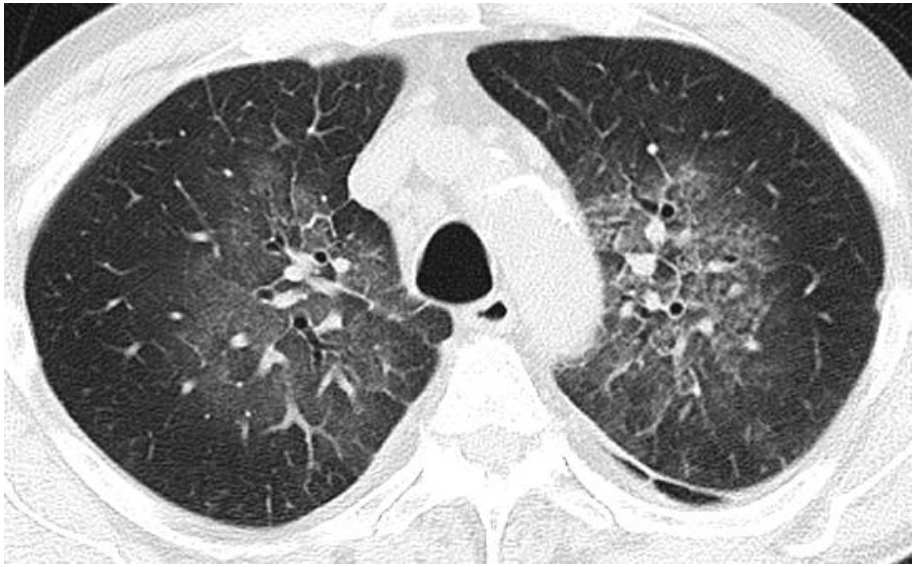
Imaging

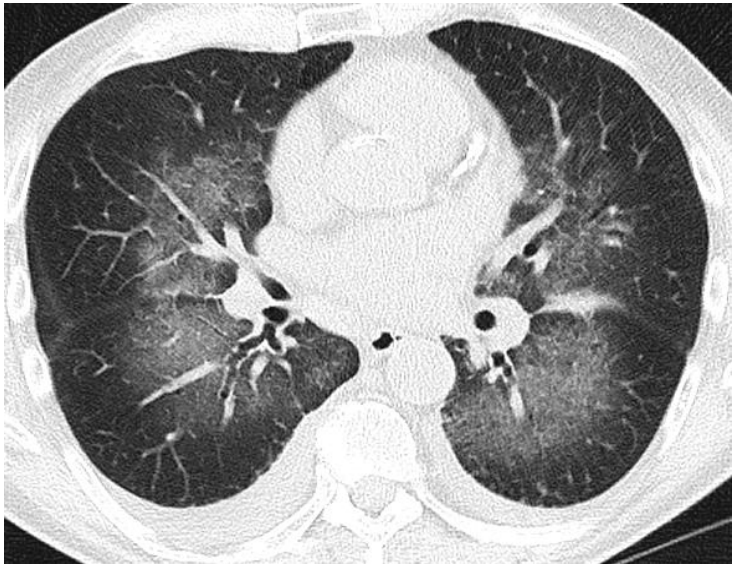
- **GGO and centrolobular micronodules** (reflecting intra-alveolar hemorrhage)
- Pleural effusion in 15% of cases
- Pulmonary edema in about 5% of cases





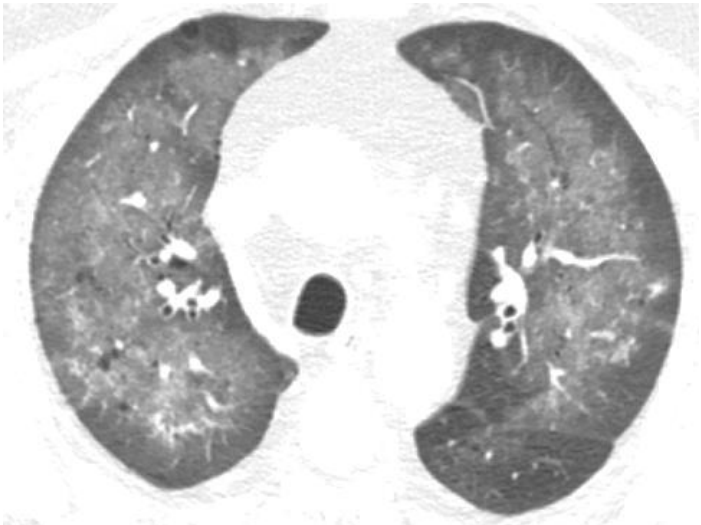
MPA

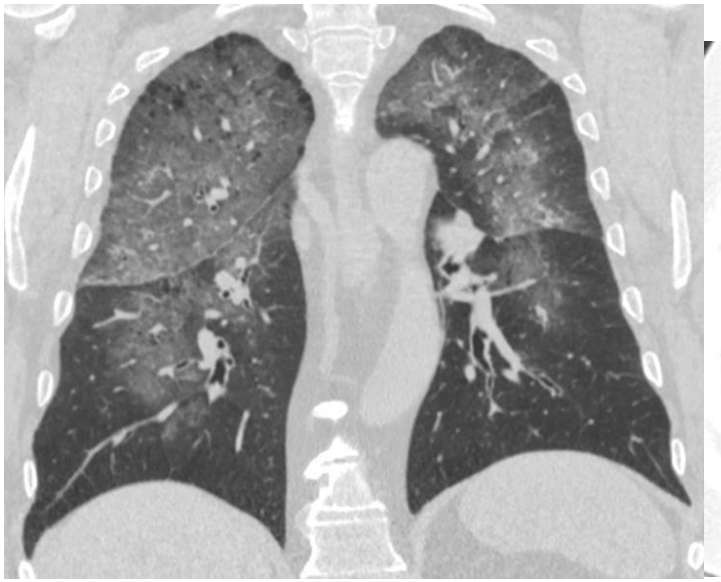


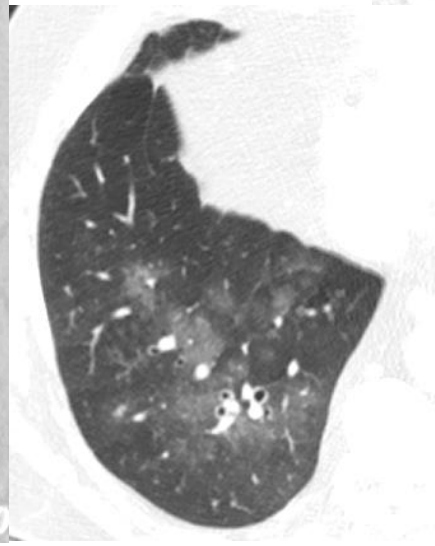


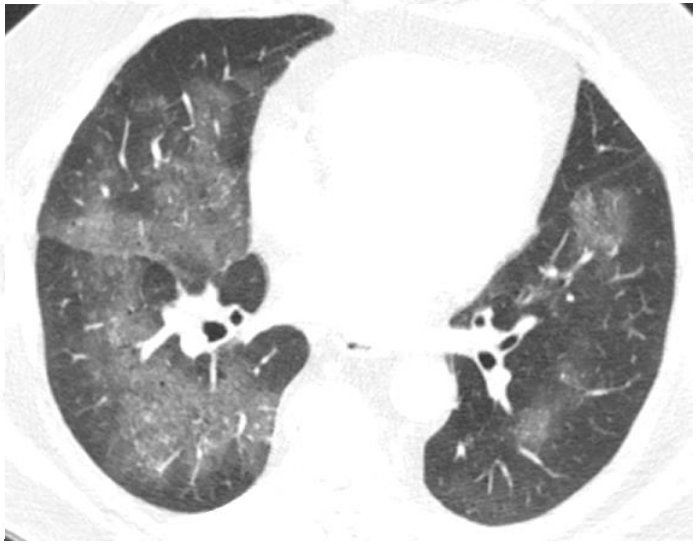
Cryoglobulinaemic vasculitis

- **Vasculitis of small and medium vessels**
- Cryoglobulins: Ig which precipitate, several types I, II, III
- Associations with several pathologies: hepatitis C, autoimmune hepatitis, leukemia, myeloma, mycoplasma, PR, lupus, Sjögren
- CT: **GGO** (alveolar hemorrhage)









G Kirkpatrick - Pulmonary hemorrhage in cryoglobulinemia – Can Resp J 2015

Goodpasture syndrom

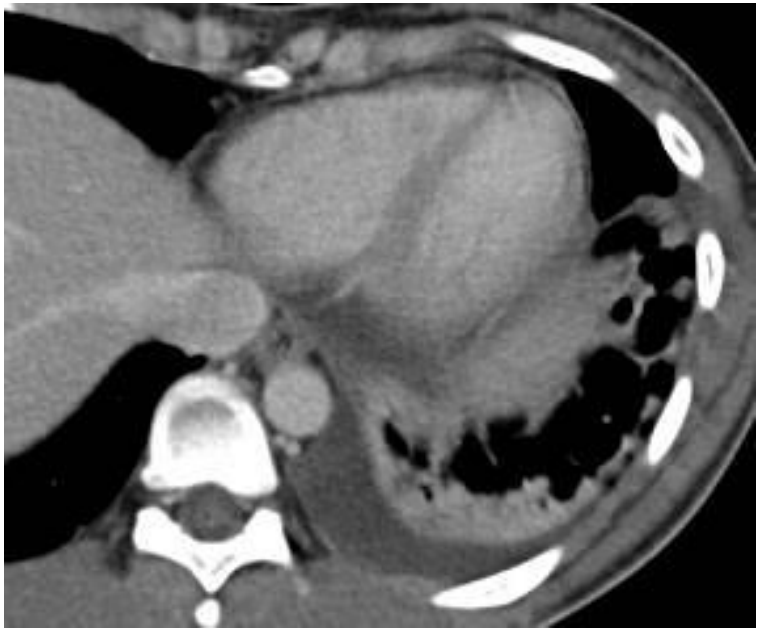
- **Reno-pulmonary syndrome with anti-GBM Ab (basement membrane)**
- Rare (0.5 / 1,000,000), young adult, predominantly male
- Clinical:
  - Diffuse alveolar hemorrhage, hemoptysis, respiratory failure, iron deficiency, anemia
  - Glomerulonephritis, ARI and CRI
- Treatment: Corticosteroids and immunosuppressants

Imaging finding

- **Acute: alveolar hemorrhage**
  - GGO and multiple bilateral condensations
  - **perihilar** and **lower** topography
- **Evolution** towards an interstitial disease
  - Reticulo-nodular opacities
  - Septal thickening
  - Fibrosis .

SLE Systemic Lupus Erythematosus

- Pleuritis ++
- pericarditis
- Pulmonary hypertension
- Lupus pneumonia (DAD,…)
- PID
- Alveolar hemorrhage
- Diaphragmatic dysfunction
- .....



Pleuropulmonary manifestations of systemic lupus Erythematosus - Michael P Kean -Thorax 2000

Hypersensitivity pneumonitis

HP Hypersensitivity pneumonitis

- = **EAA** Extrinsic allergic alveolitis
- **Inflammation secondary to inhalation of an allergen**
- **Organic** or **inorganic** particles: microbes, animal or plant proteins, chemical compounds, **> 200** antigens
- Farmer's lung, bird breeder, ...

Examples of Hypersensitivity Pneumonitis

Disease	Antigen Source	Putative Antigen
Bird fancier's disease	Various birds	Protein in avian feces, feathers
Cheese worker's lung	Moldy cheese	*Penicillium* species
Coffee worker's lung	Coffee bean	Unknown
Farmer's lung	Moldy hay	Thermophilic actinomycetes
Furrier's lung	Animal fur	Protein in animal fur
Hot tub lung	Warm water	*Mycobacterium avium* complex
Humidifier lung	Warm water	Thermophilic actinomycetes
Japanese summer disease	Moldy houses	Various fungi
Machine worker's lung	Metal-cutting fluid	*Mycobacterium* species, Gram-negative bacilli
Malt worker's lung	Moldy malt	*Aspergillus* species
Mushroom worker's lung	Mushrooms	Mushroom spores, various other fungi
Peat moss worker's lung	Moldy peat moss	Various fungi
Sauna bather's lung	Sauna water	Various fungi
Sequoiosis	Moldy redwood dust	Various fungi
Suberosis	Cork	*Aspergillus* species, cork dust

Histopathology

= **Chronic** bronchial **inflammation** and peribronchial tissue

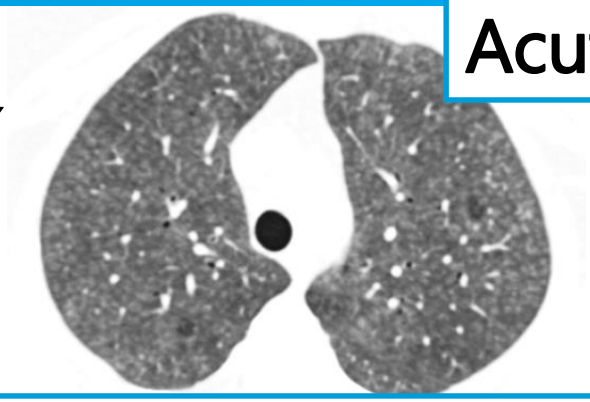
- Cellular Bronchiolitis
- Chronic interstitial inflammatory infiltration
- Poorly limited granulomas
- Alveolar/interstitial giant cells

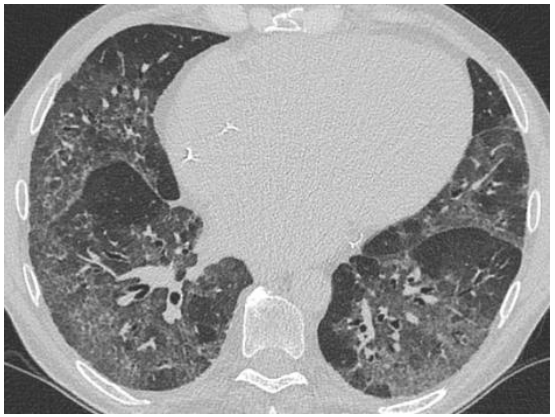
Biblio: Hypersensitivity pneumonitis: a historical, clinical, and radiological review
Jan V, Hirschmann, Radiographics 2009

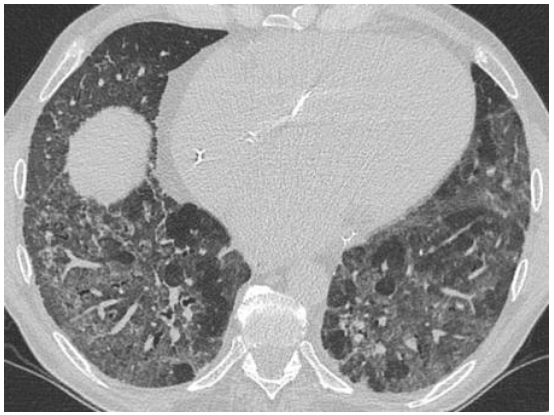
Hypersensitivity pneumonitis

Acute/sub-acute form

Typical appearance
*Numerous **centrolobular fuzzy micronodules with upper** predominance .*



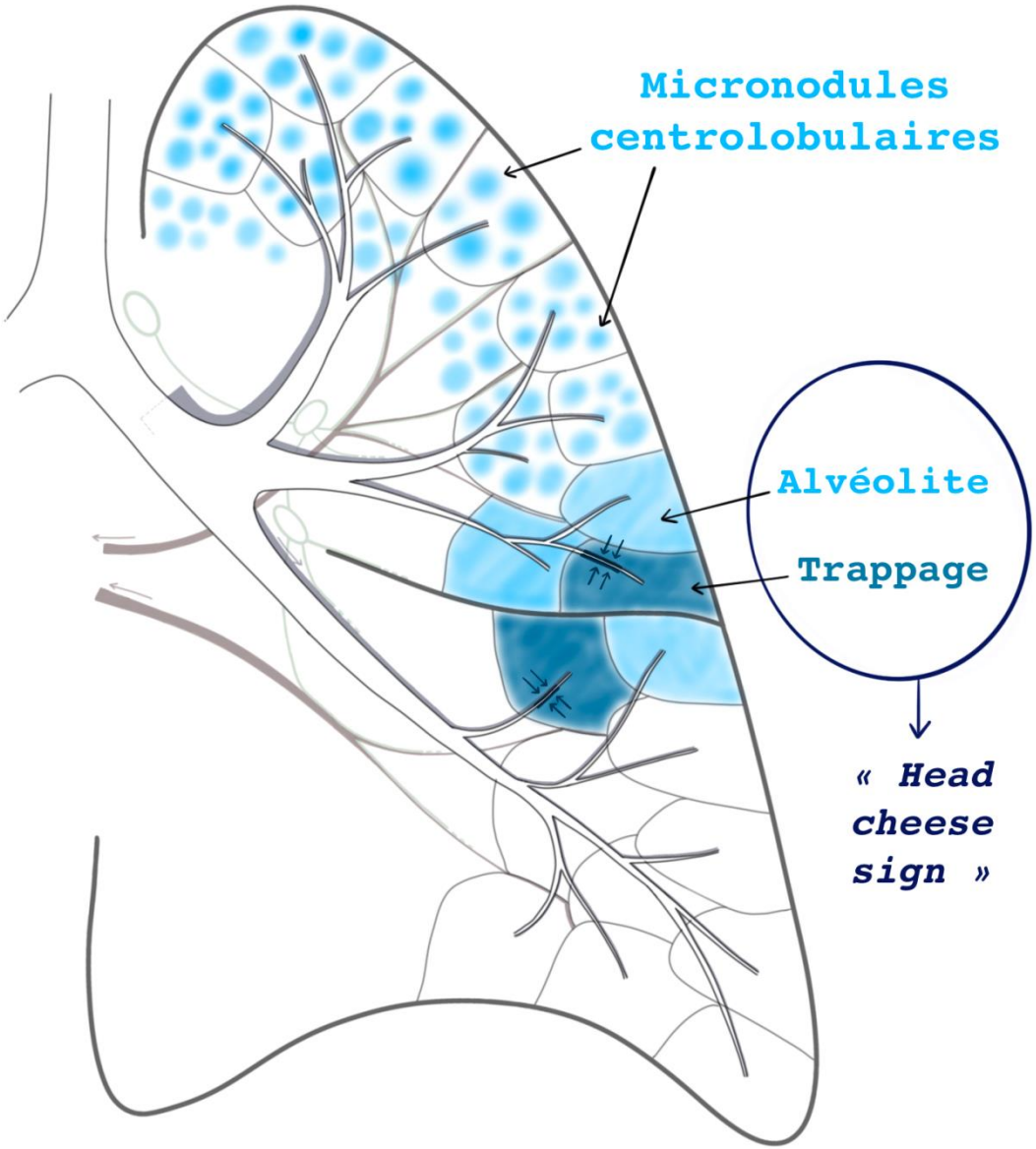


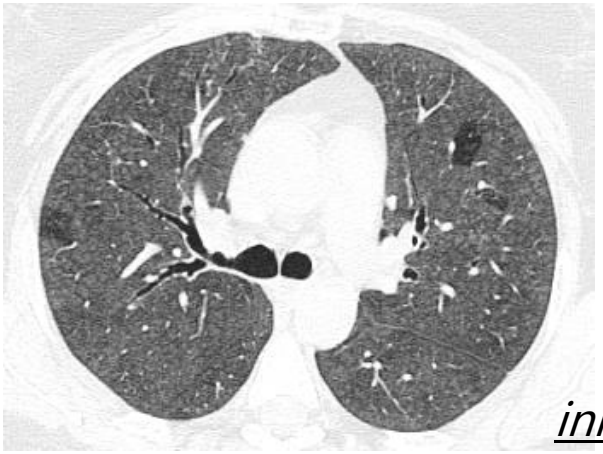


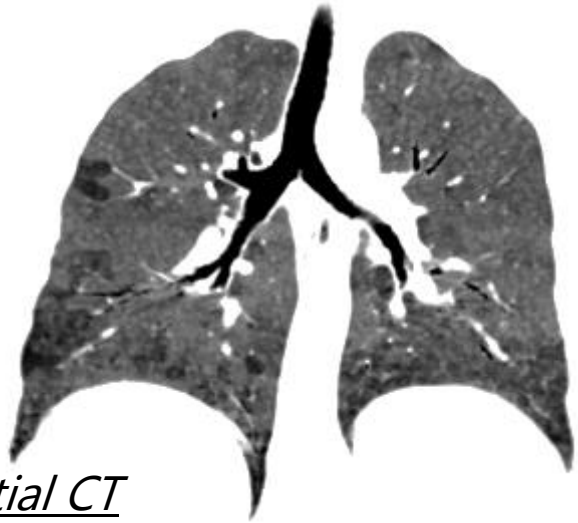
- Clinic: **4-12 hrs after exposure,** fever, myalgia, headache, dyspnea
- Imaging
  - **Centrolobular ill defined nodules ++**
  - **GGO**
    - **Diffuse** bilateral and symmetrical or patchy **middle** and lower lung regions
  - **Hypodense lobule** (trapping due to bronchiolar obstruction) **+/- cysts**
  - Combination GGO patchy (alveolitis) + normal lung + trapping (bronchiolitis) **"head cheese sign".**
- BAL: white blood cells ++ with lymphocytes ++, CD8 ++.
- DD: smoker's bronchiolitis, NSIP, DIP, infantile bronchiolitis, acute Pn eo, viral infection, pneumocystis.

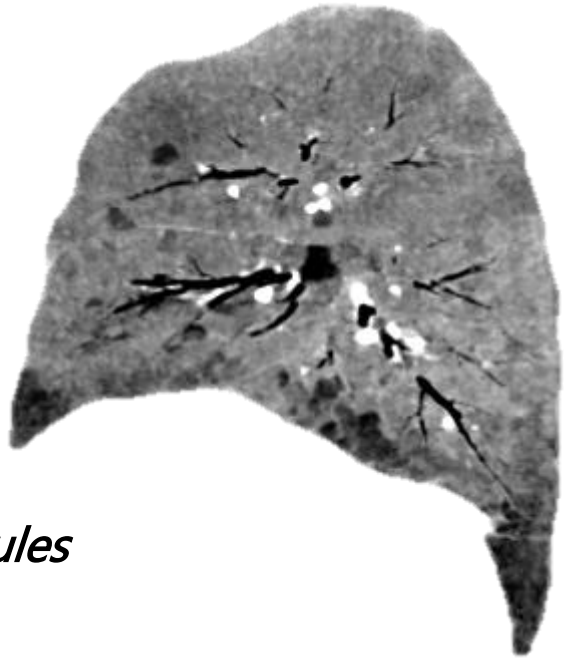
Biblio: Hypersensitivity pneumonitis: a historical, clinical, and radiological review - Jan V, Hirschmann, Radiographics 2009

Pneumopathie d'hypersensibilité



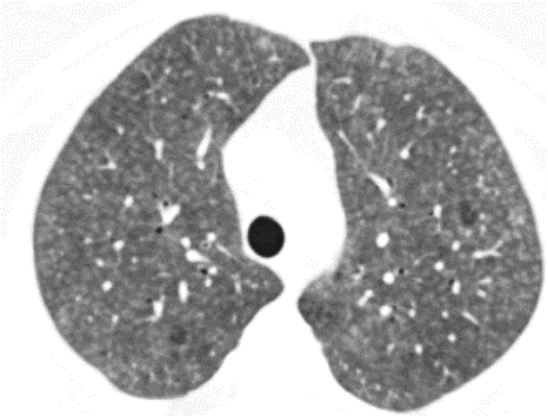


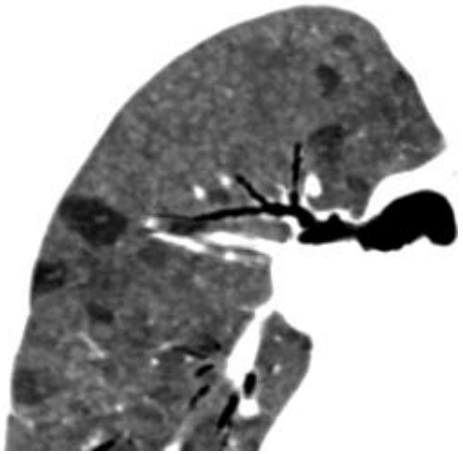




initial CT

- ***Diffuse ill defined micronodules***
- ***Hypodense lobules***



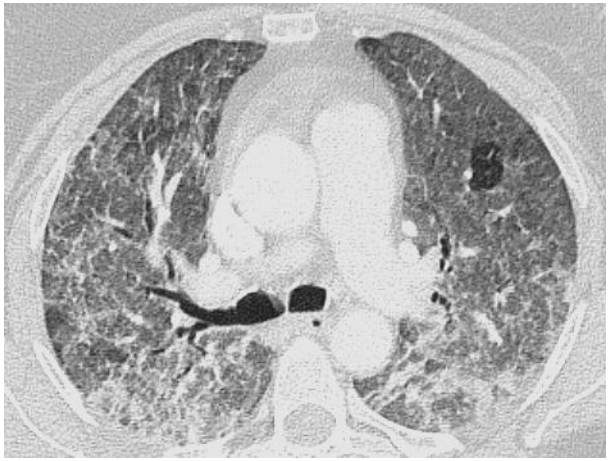


58-year-old patient, who "shelters" pigeons on her balcony, with non-febrile dyspnea.

*= **Hypersensitivity pneumonitis***

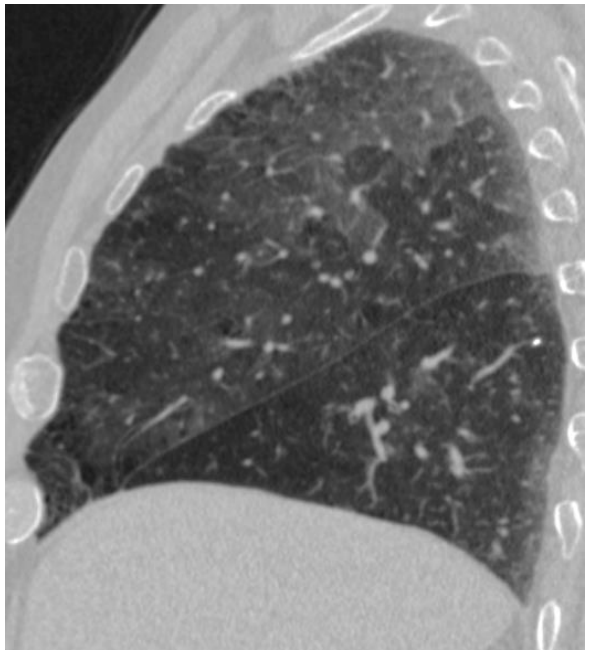
CT scan 2 weeks later (intensive care)

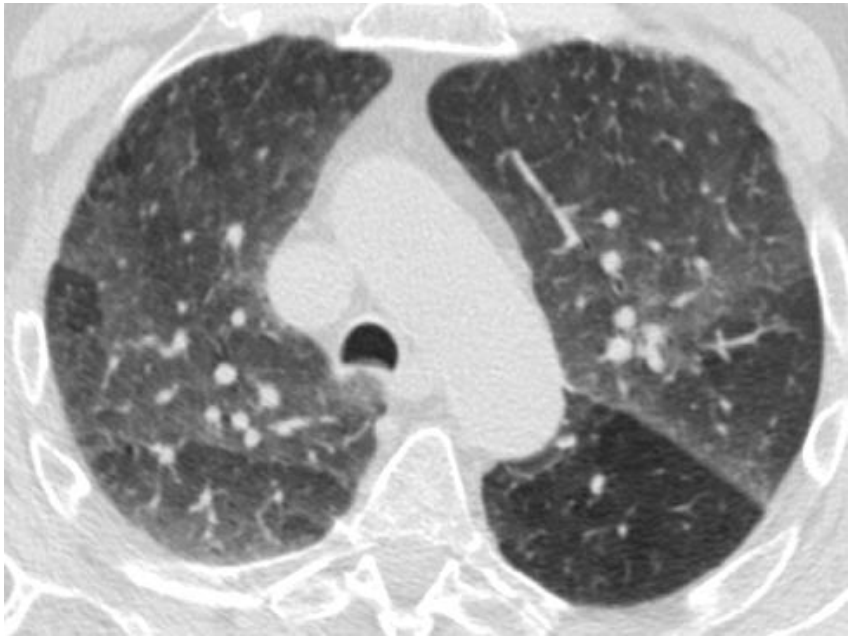
- ***Diffused ggo***
- ***Intralobular reticular syndrome (crazy paving)***
- ***Hypodense lobules***

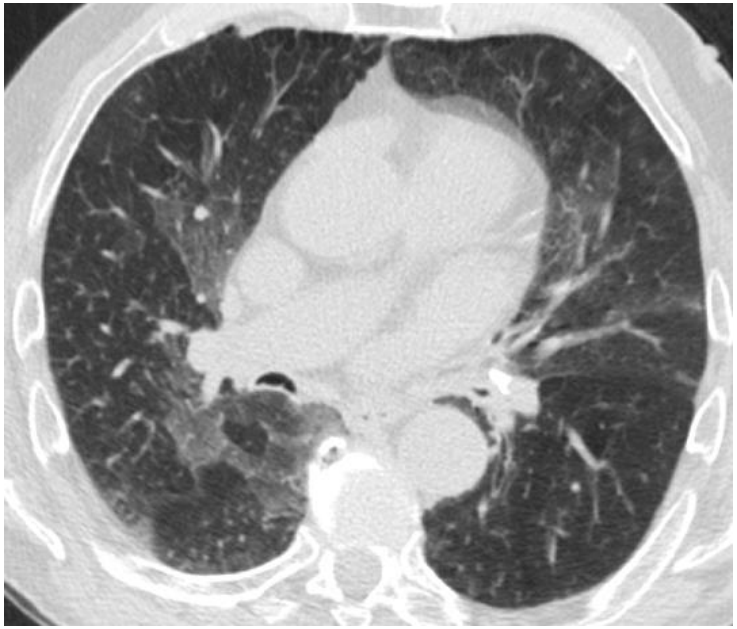


Hypersensitivity pneumonitis

Farmer's lung in an 81-year-old man

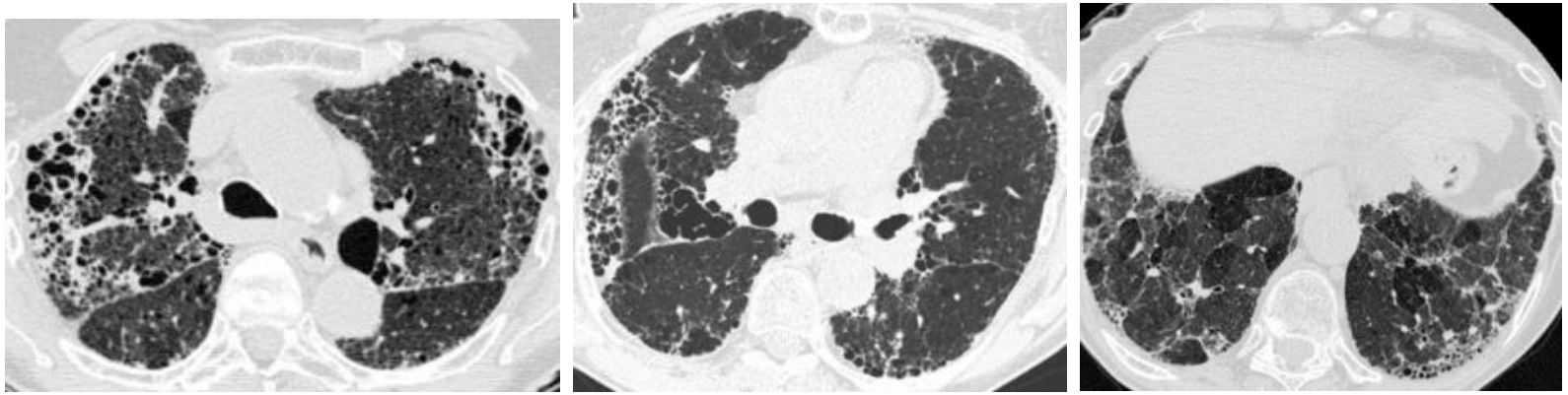






Hypersensitivity pneumonitis

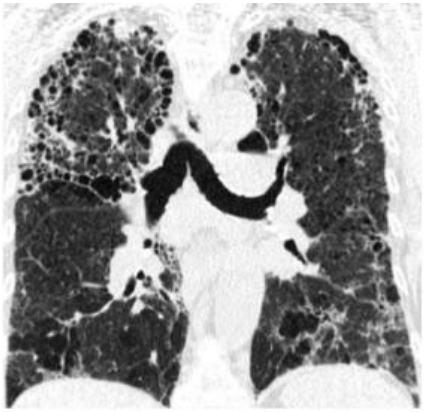
Chronic form with fibrosis



Anarchic fibrosis ++ without any particular distribution

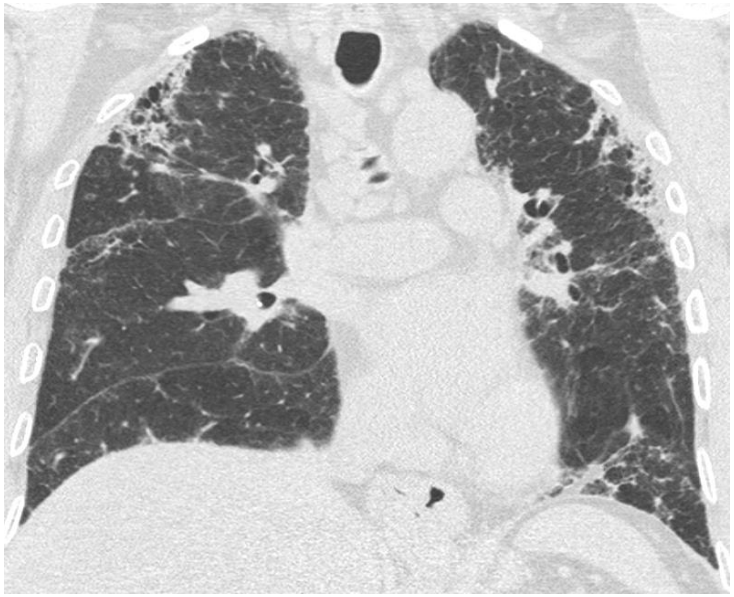
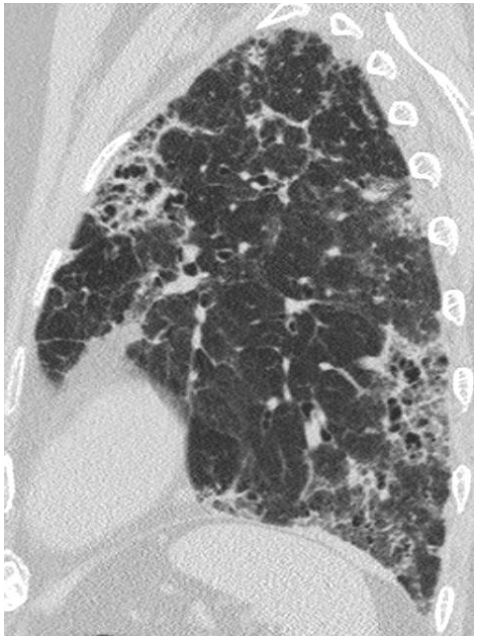
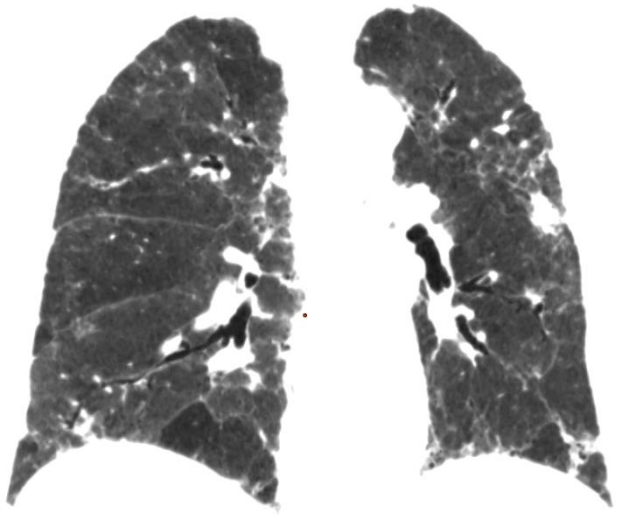
- **Intra-lobular reticulation**
- **Bronchiectasis / Traction bronchiolectasis**
- +/- Honeycomb
- **Middle regions of** the lung, **relative respect for extreme bases and apex**

- +/- **Centrolobular ggo**(active inflammation)
- +/- **Lobular trapping**
- DD
  - NSIP, IPF
  - PHS-like: ggo, trapping, no basal predominance

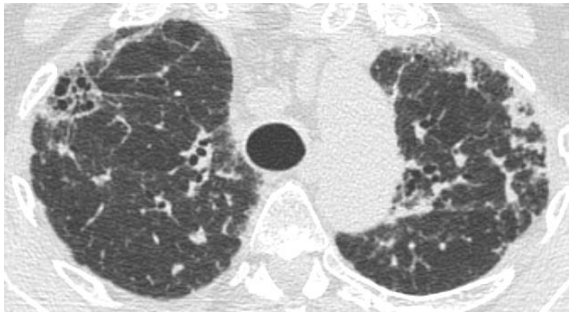
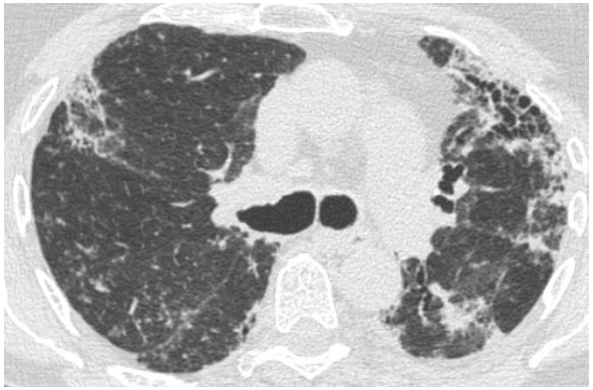
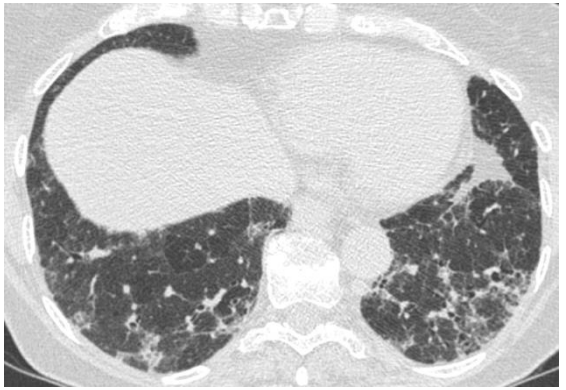


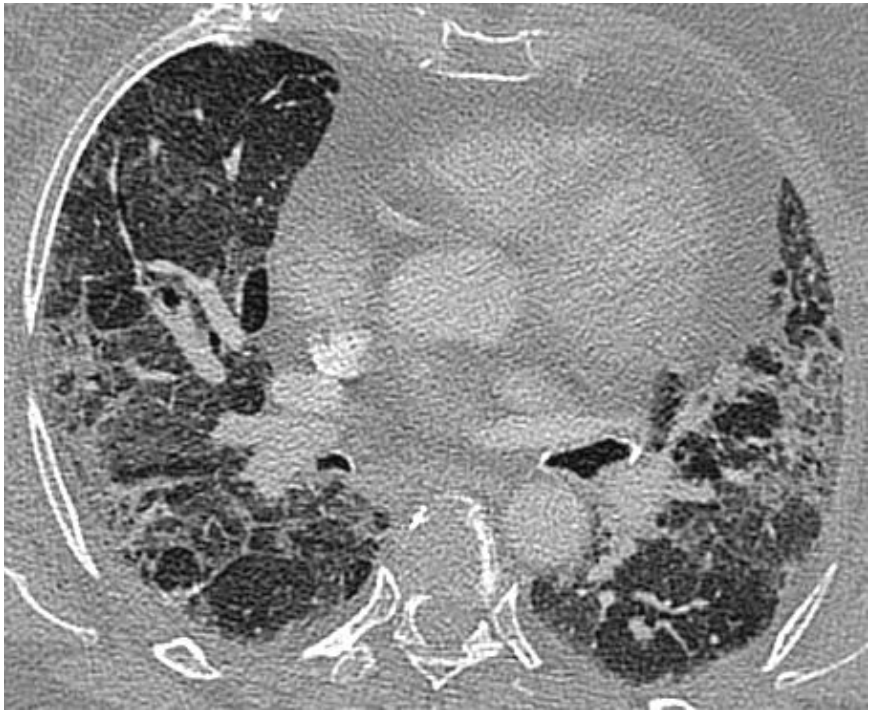
chronic PHS
Jan V. Hirschmann
Radiographics 2009

Biblio: Hypersensitivity pneumonitis: a historical, clinical, and radiological review - Jan V, Hirschmann, Radiographics 2009

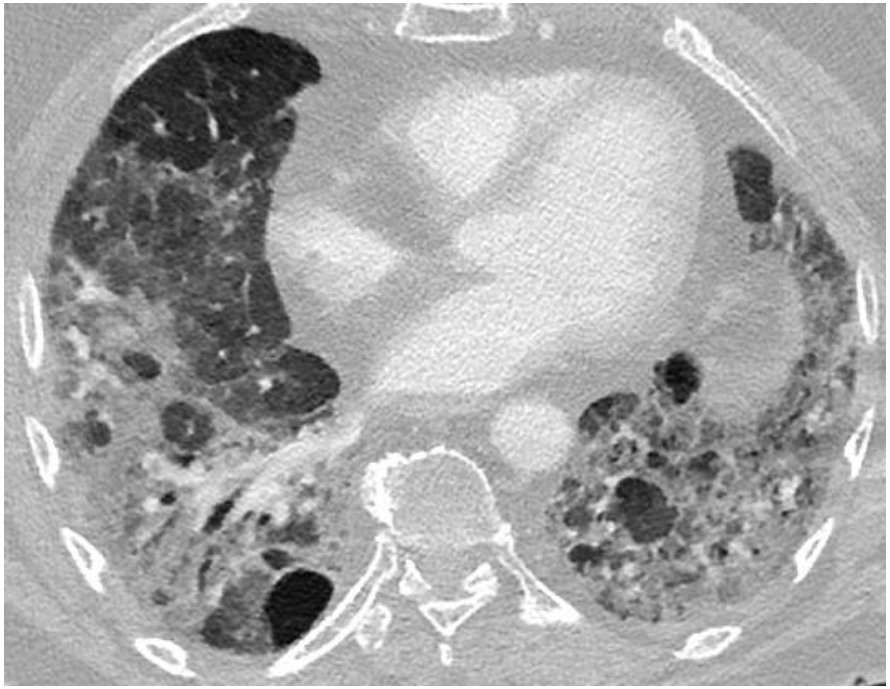




Chronic HP
Anarchic fibrosis



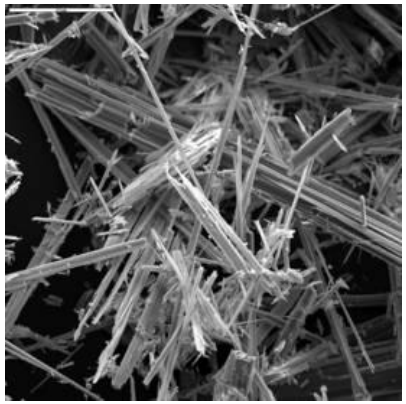
HP chronic



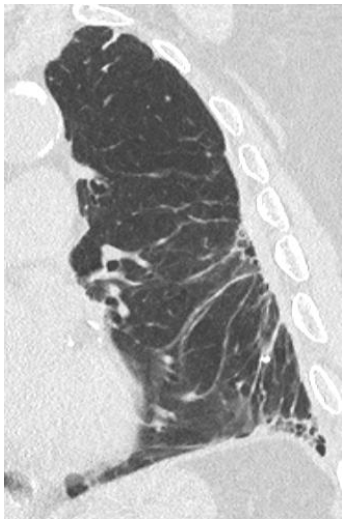
Asbestosis-related diseases

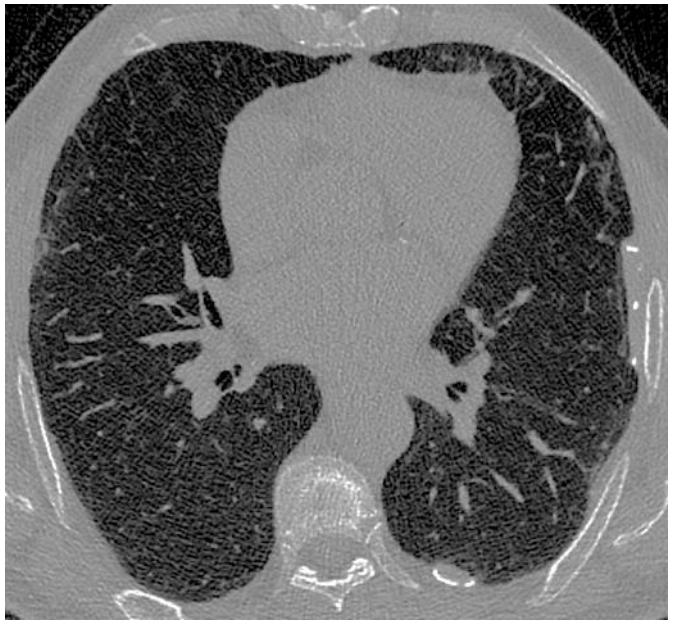
Pneumoconiosis due to prolonged inhalation of asbestos fibres

- Asbestos fibre: lg 100µm, Ø3µm bronchioles, alveoli fibrosis
- Anapath: asbestos **bodies**, asbestos fibres, fibrosis.



Crow's feet

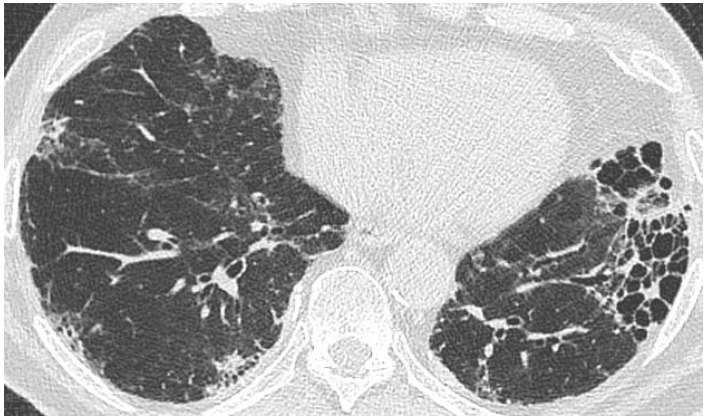
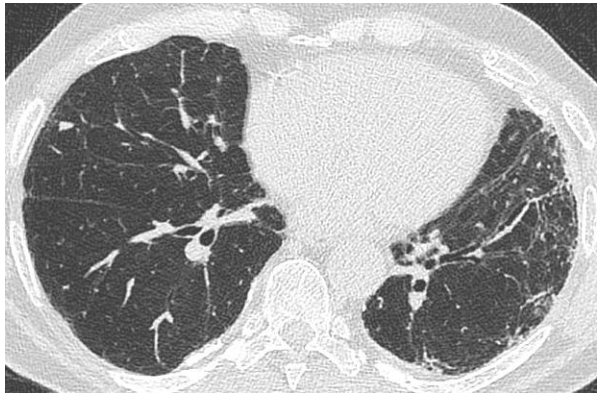
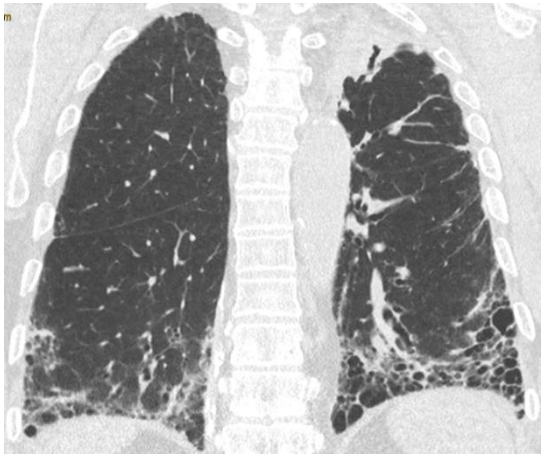
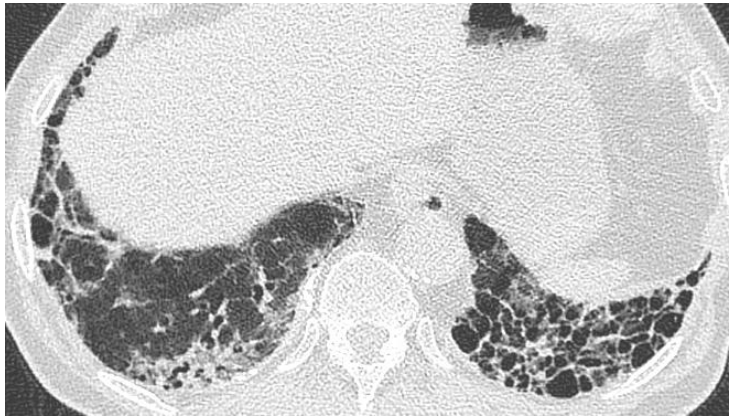




1) Pleural abnormalities - (does not fit the definition of asbestosis!!!!)

- **Pleural plaque +++**: parietal leaflet, sign asbestos **exposure,** > 20 years old, raised **+/-** calcified, bilateral asymmetrical
- **Pleural effusion**: 1st sign of pleural involvement, within 10 years, hemorrhagic exudate
- **Visceral pleural fibrosis**: less specific, thickening and fibrosis of the visceral pleura / fusion with parietal pleura

- *Computed tomographic atlas of benign asbestos pathologies - C Beigelman-Aubry, Journal of Radiology 2007*
- *Asbestos: When the Dust Settles—An Imaging Review of Asbestos-related Disease - Huw D. Roach, Radiographics 2002*

2) Parenchymal abnormalities

Consequences of pleural abnormalities

- "Crow's foot"
- Round atelectasis

Asbestosis ++++

- Subpleural, basal regions
- Centrolobular micronodules :"dot sign" *(*early)
- Intra-lobular reticulation
- GGO
- Curvilinear subpleural line (Yoshimura)
- Traction bronchiectasia, honeycomb

- *Computed tomographic atlas of benign asbestos pathologies - C Beigelman-Aubry, Journal of Radiology 2007*
- *Asbestos: When the Dust Settles—An Imaging Review of Asbestos-related Disease - Huw D. Roach, Radiographics 2002*

CT protocol

- Spontaneous contrast, forced inspiration !! **To think of a propeller in procubitus if declining anomalies !!!**
- PDL must be located at 200 mGy.cm

!! Search well

- Bronchopulmonary cancers
- Mesothelioma

CT report

3 types of answers in the conclusion

- ❑ Absence of asbestosis
- ❑ Undetermined interstitial findings
  - Postero-basal abnormalities but no procubitus
  - Isolated interstitial images
    - Non-postero-basal images
    - Cross-linkages / ggo / lines under pleurals
    - unilateral
    - or bilateral on a level/3 (hull / VPI / CdS)
    - or scattered
- ❑ Probable asbestosis
  - Several levels, bilateral
  - Only one level but thickness>1cm
  - Honeycomb

Silicosis

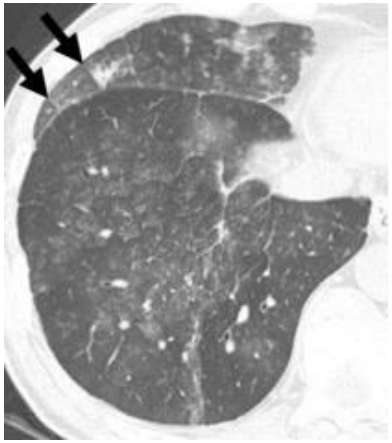
Inhalation of mineral dust (quartz)

- Acute silico-proteinosis (rare)
- **Single** silicosis: micronodules after 10 years of exposure
- **Complex** silicosis

Acute silico-proteinosis

(rare, severe++, 6 months to 3 years after exposure)

- **Centrolobular nodules**
- **GGO**
- **Consolidation , crazy paving**

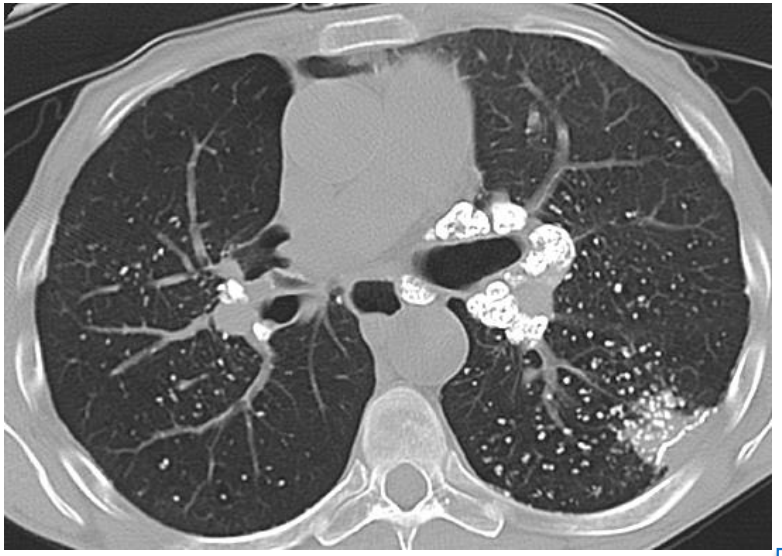


Silicoproteinosis acute *(courtesy Chong Radiographics)*

Simple silicosis +++

- **Peri-lymphatic micronodules** (+/- calcified)
  - **Subpleural** (pseudo-plaque forming clusters under pleural) and **peribronchials**
  - **Upper** predominance (inhalation pathology): **dorsal segment upper lobes +++**
  - Pleural thickening
- Symmetrical mediastinal and hilar **adenomegaly**, eggshell calcifications (very suggestive)

Simple silicosis



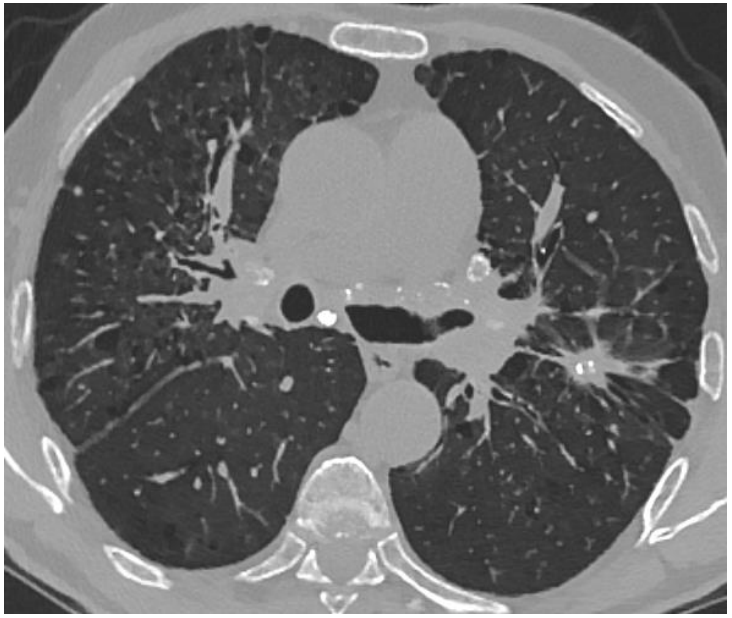
Chong S, Lee KS, Chung MJ et-al. Pneumoconiosis: comparison of imaging and pathologic findings. Radiographics. 2006

Complex silicosis

- **Aggregation of nodules in a larger mass > 1 cm**
- Evolution from single silicosis

CT SCAN

- **Peri lymphatic Micronodules + lymph nodes**
- **Progressive massive fibrosis**
  = Mass Syndrome > 1cm
  - Associated with peripheral micronodules
  - **Bilateral**
  - **Upper lobes** (posterior and apical segment of the lower lobes, right ++)
  - If >4 cm: hypodense patches corresponding to **central necrosis** excavation
  - Periphery hiles
  - PET: can be very positive (inflammatory activity)
  - **If evolution: suspect tuberculosis or carcinoma**



The differential diagnosis with neoplasia is difficult:

- **Evolution ++**
- PET : non discriminative
- **MRI** ++ because **neoplasia: hyperT2** while fibrosis : hypoT2 / muscle

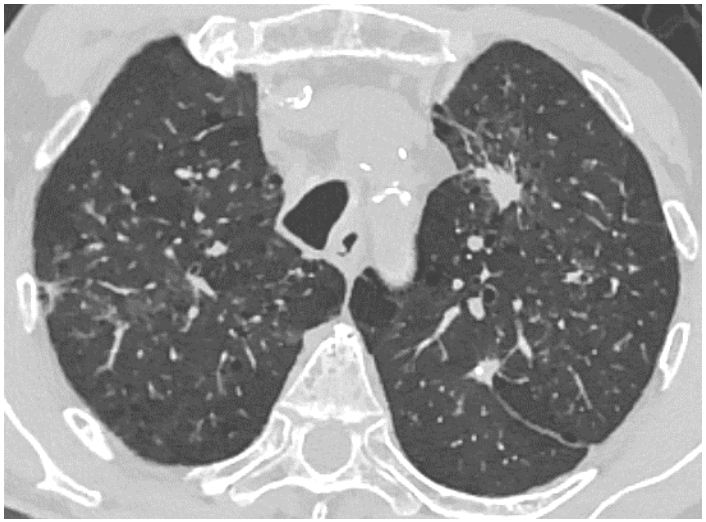
Matsumoto S. Diagnosis of lung cancer in a patient with pneumoconiosis and progressive massive fibrosis using MRI. Eur Radiol 1998

DD silicosis

- **Sarcoidosis ++**
- **Other pneumoconiosis**
  - Anthracose (silica-free coal): similar appearance
  - Berryliosis

Associations

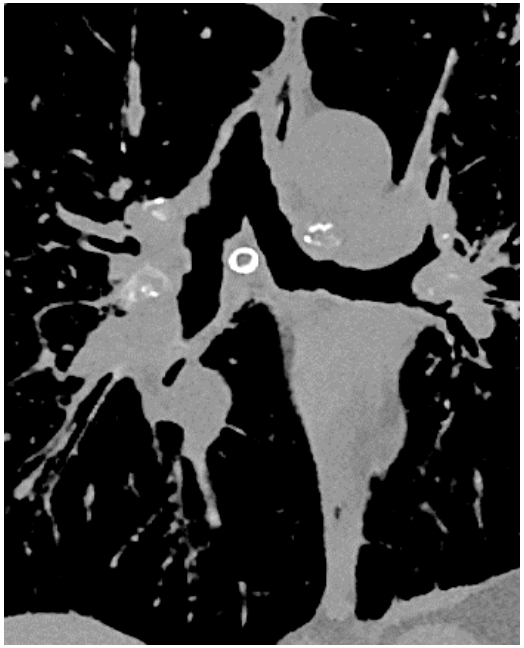
- **Caplan Syndrome:** RA+ pneumoconiosis
- **Erasmus Syndrome:** pneumoconiosis+ scleroderma
- Silico-tuberculosis

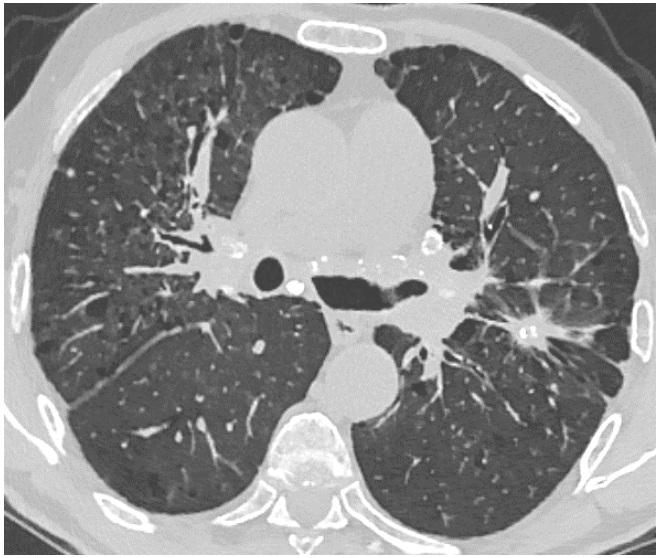


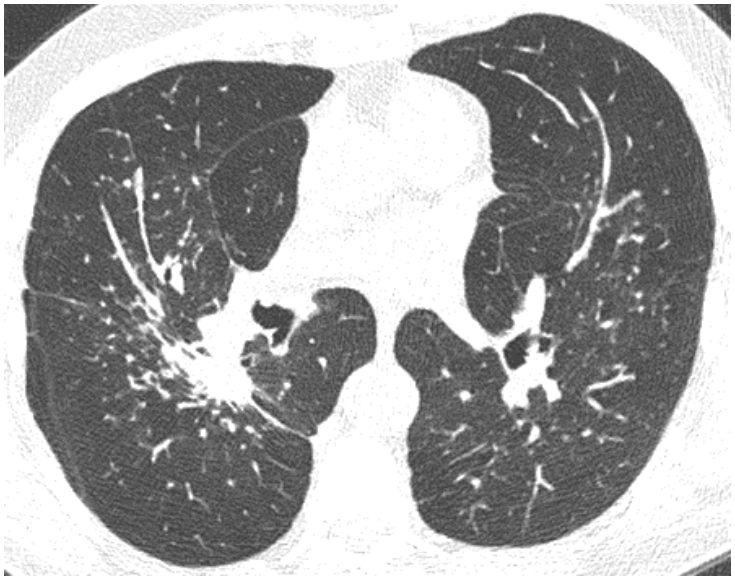
Complex silicosis

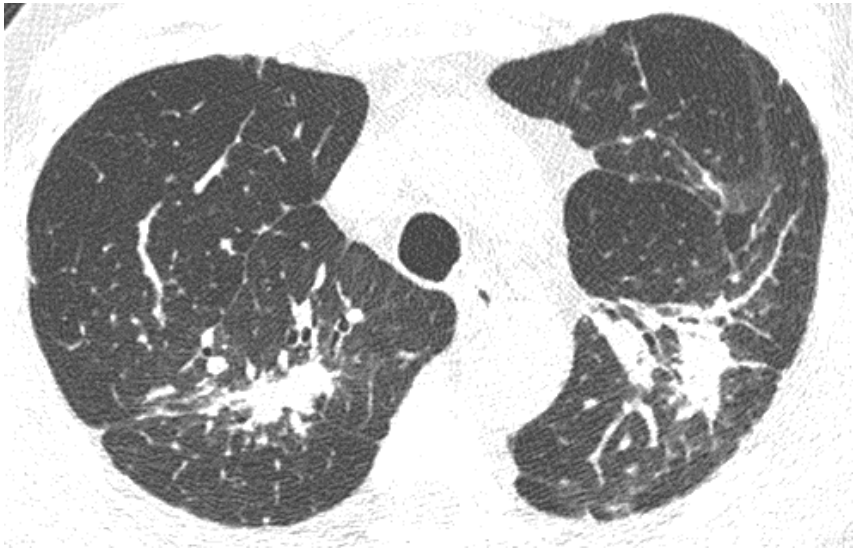
Calcified nodes

+ **Perihilar and upper fibrotic pseudomass**



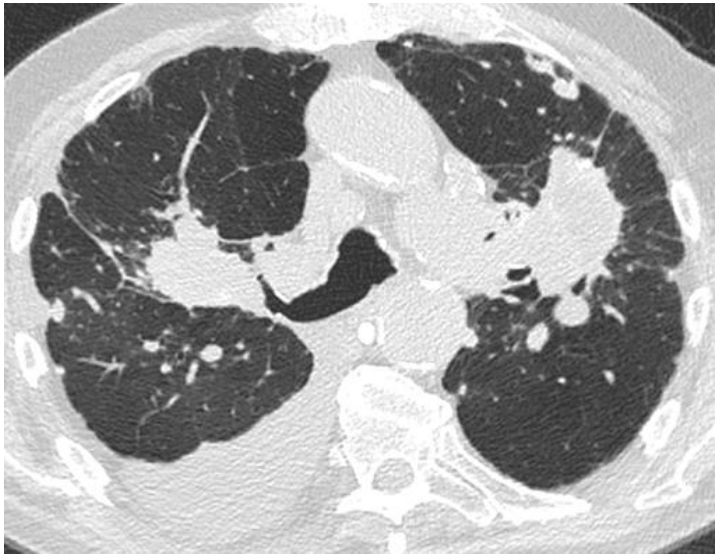


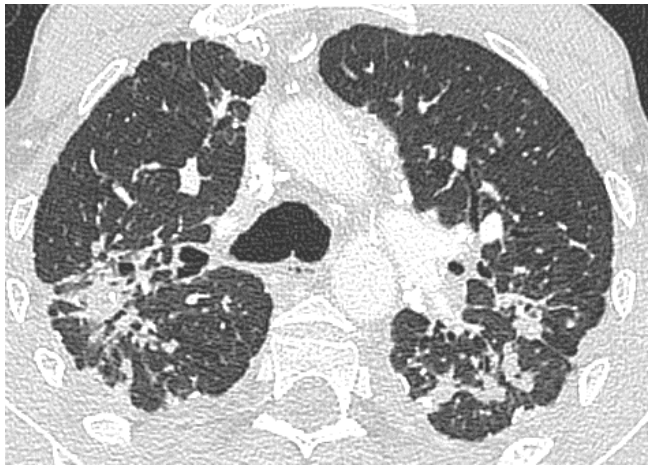


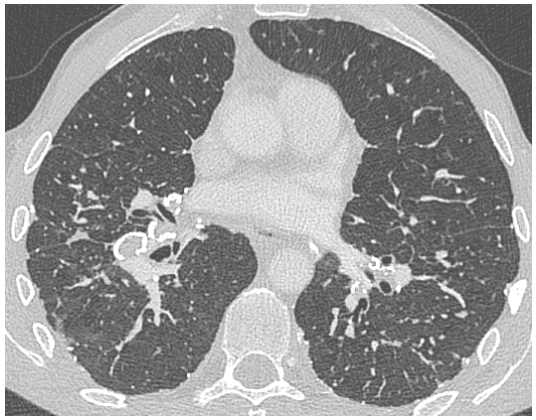


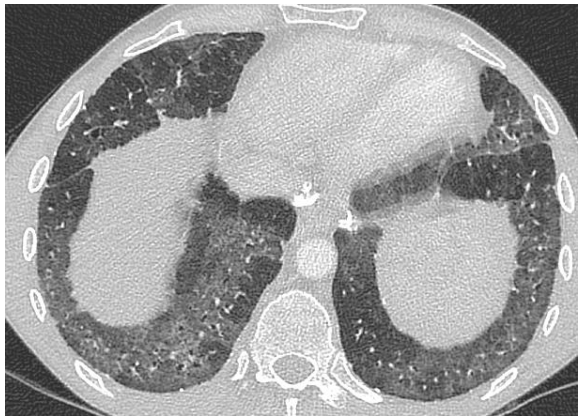
Two cases of complex silicosis

- Pseudo mass of the upper and para hilar regions
- Architectural distortion
- Peri-Lymphatic micronodules

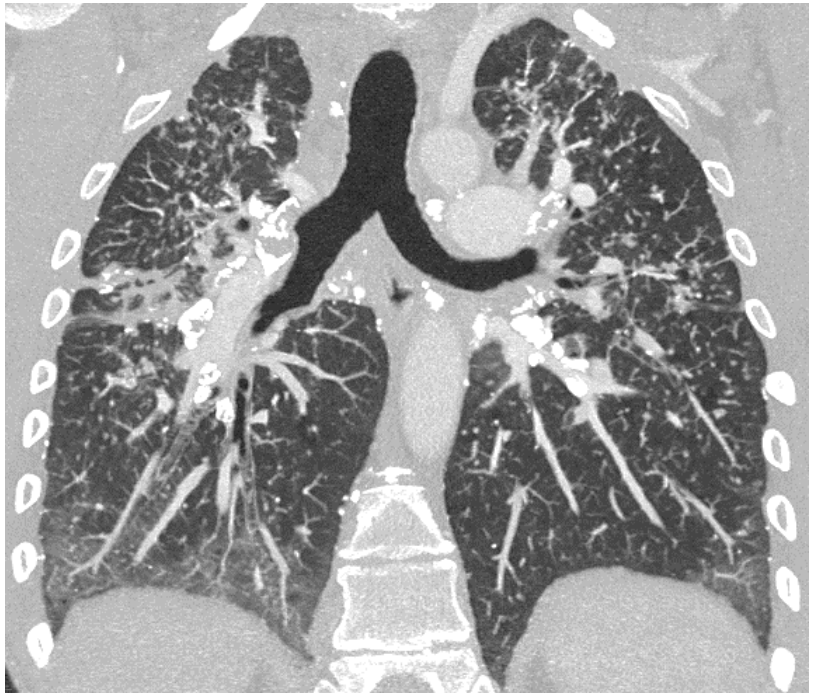




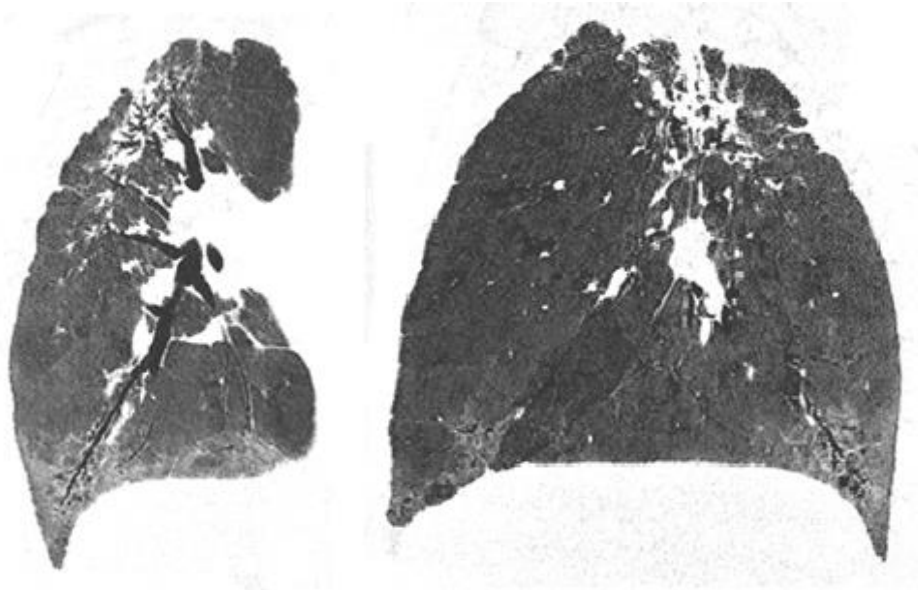




Erasmus Syndrome



- **Silicosis:** calcified +/- **perihilar** and bi-apical **fibrotic mass** +/- calcified lymph nodes
- **Scleroderma: interstitial** base **syndrome** with fibrosis.



Other pneumoconiosis

- Anthracosis
  - Coal (coal worker)
  - Silicose-like imaging
- Berylliosis
  - Ceramics, aerospace
  - Granulomes
  - Imaging similar to sarcoidosis
- Heavy Metals
  - Cobalt++, tungsten, titanium, tantalum
  - Interstitial syndrome (GGO, cross-linking, +/- honeycomb)
  - DDX: UIP, NSIP
- Talcosis
  - Inhaled: centrolobular and subpleural µnodules, pseudomass (hyperdense foci).
- Siderosis
  - Iron oxide dust, soldering arc
  - Ill defined centrolobular micronodules +/- VD

Dénomination	*Fibrogène* non = 0 oui = +	*Contaminant*	*Professions exposées*
Silicose	+	Poussière renfermant de la silice libre	Forage, extraction du minerai ou de roches Broyage de roches Forage de tunnels Manutention de produits et poudres contenant de la silice Fabrication porcelaine, céramique Fonderie, polissage, décapage Polissage au jet de sable
Asbestose	+	Amiante (silicate complexe) Variétés communes : chrysotile, amosite, trémolite, crocidolite	Très nombreuses, mais à des degrés divers surtout : Extraction du minerai (+) Transformation textile du minerai (+) Calorifugeage, isolation Garnitures et joints (freins) Application au pistolet (+) Fabrication carton et papier d'amiante
Béryllose	+	Béryllium (silicate double d'aluminium et de glucinium)	Extraction du minerai Fabrication d'alliages pour industrie aéronautique de précision Fabrication tubes fluorescents et rayons X Industrie atomique Verrerie d'art
Fibrose à « poussières mixtes »	+ + + + + + + + +	Quartz Talc Mica (composés de silicates d'aluminium) Smyridose : émeri et corindon (oxydes d'aluminium impurs) Bauxite (alumine ou oxyde d'aluminium) Schistes Sidérosilicose due aux poussières d'oxyde de fer et de silice Spath-fluor (fluorine) Tungstène	Fonderie, sablage, minage dans les industries de fer et acier Mines d'hématite, nettoyage et écaillage de chaudières Soudure à l'arc, découpage au chalumeau dans les fonderies Extraction dans les mines, industries du caoutchouc, de céramique, produits de beauté, papiers Papeterie, isolants électriques Polisseurs de métaux qui utilisent le papier d'émeri et ceux qui le fabriquent Fondeurs de corindon Mineurs de bauxite Manufacture d'abrasifs Ardoisiers Fonderies, meuleurs de fer Mineurs de fer du Bassin lorrain Employés à l'extraction de ce minerai Industries aéronautique, automobile, instruments divers de haute résistance
Anthracose (pure)	0	Poussière de charbon	
Argyro-sidérose	0	Poussière d'argent et de fer	Mineurs, polisseurs
Barytose	0 + si association de silice	Dérivés du sulfate de baryum	Céramique, verrerie d'optique, pyrotechnie, laques, peintures, insecticides, usages en laboratoire, glaçage du papier, industrie du savon, linoléum, caoutchouc
Sidérose	0 + si association de silice	Poussières et fumées d'oxyde de fer	Mines de fer, soudure à l'arc en air confiné
Stannose	0	Oxyde d'étain	Raffinage du minerai, préparation de l'oxyde d'étain, céramique

Chong S, Lee KS, Chung MJ et-al. Pneumoconiosis: comparison of imaging and pathologic findings. Radiographics. 2006

Pulmonary Drugs Toxicity

- **Frequent** and **under-diagnosed**
- **Cytotoxic+++** (cyclophosphamide, busulfan ++) and **non-cytotoxic** drugs (amiodarone→ NSIP, hyperdense opacities (+dense liver/rate)
- > 100 drugs
- **Pneumotox ++** website

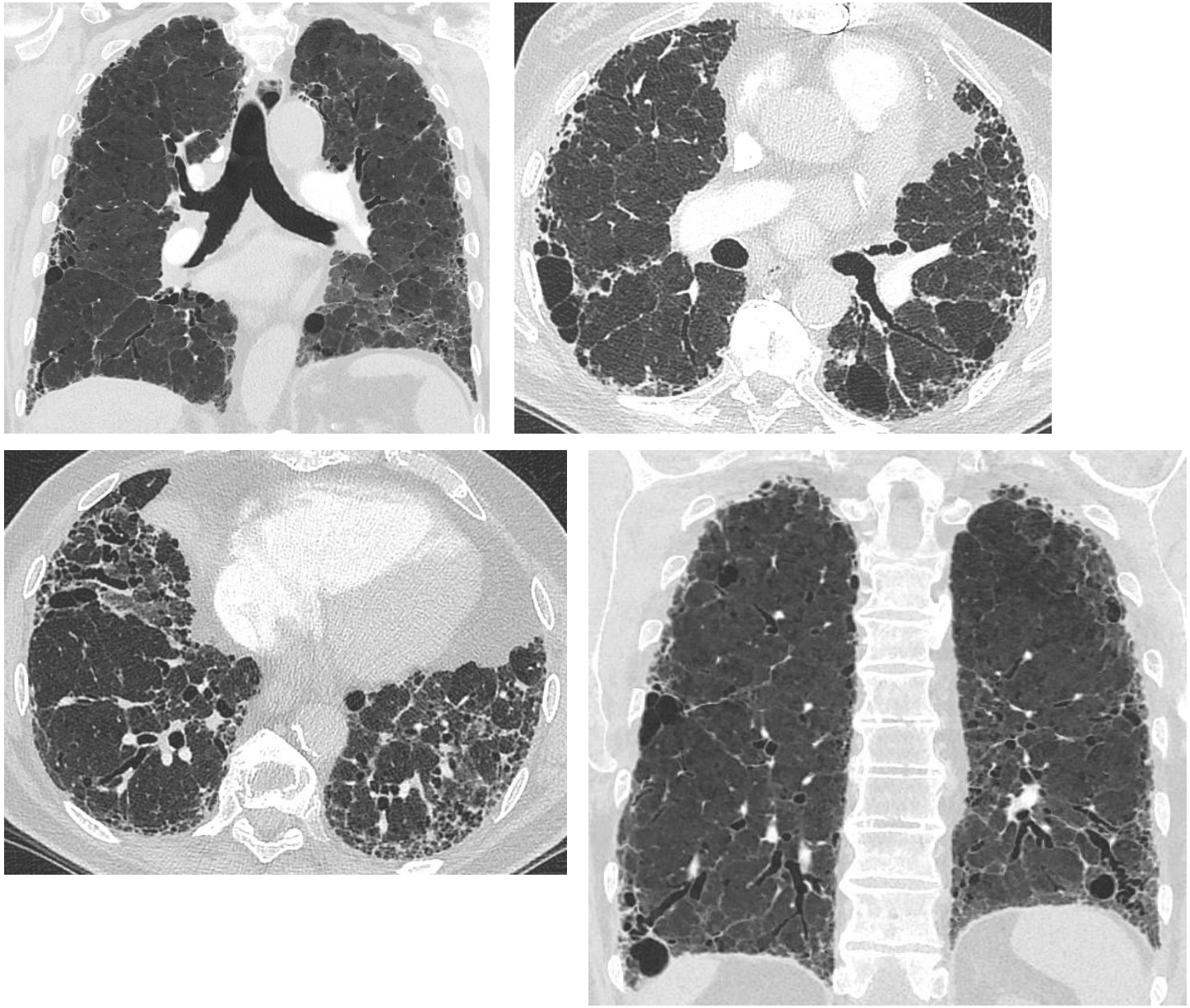
Variable histopathological manifestations

- DAD +++ Exudative phase (1st week) then proliferative, fibrosis appears within a week
- NSIP
- OP
- Eosinophilic pneumonia
- Obliterative Bronchiolitis
- Pulmonary hemorrhage, edema, hypertension
- Veno-occlusive disease

Principal Histopathologic Manifestations of Pulmonary Drug Toxicity

Mechanism of Injury	Drugs
DAD	Bleomycin, busulfan, carmustine, cyclophosphamide, mitomycin, melphalan, gold salts
NSIP	Amiodarone, methotrexate, carmustine, chlorambucil
BOOP	Bleomycin, gold salts, methotrexate, amiodarone, nitrofurantoin, penicillamine, sulfasalazine, cyclophosphamide
Eosinophilic pneumonia	Penicillamine, sulfasalazine, nitrofurantoin, nonsteroidal anti-inflammatory drugs, para-aminosalicylic acid
Pulmonary hemorrhage	Anticoagulants, amphotericin B, cytarabine (ara-C), penicillamine, cyclophosphamide

Pulmonary Drug Toxicity: Radiologic and Pathologic Manifestations
Santiago E. Rossi, Radiographics 2000



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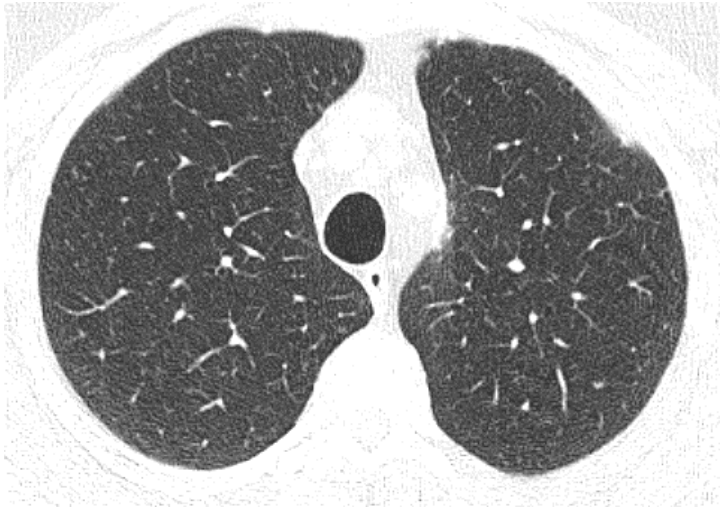
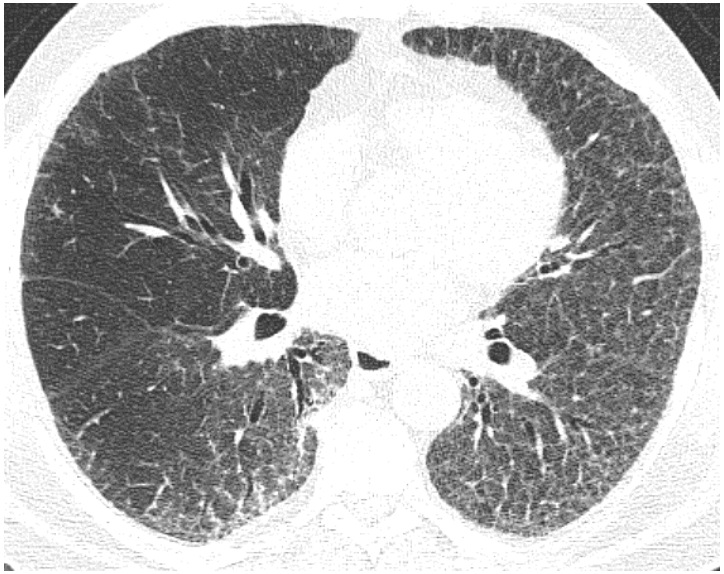
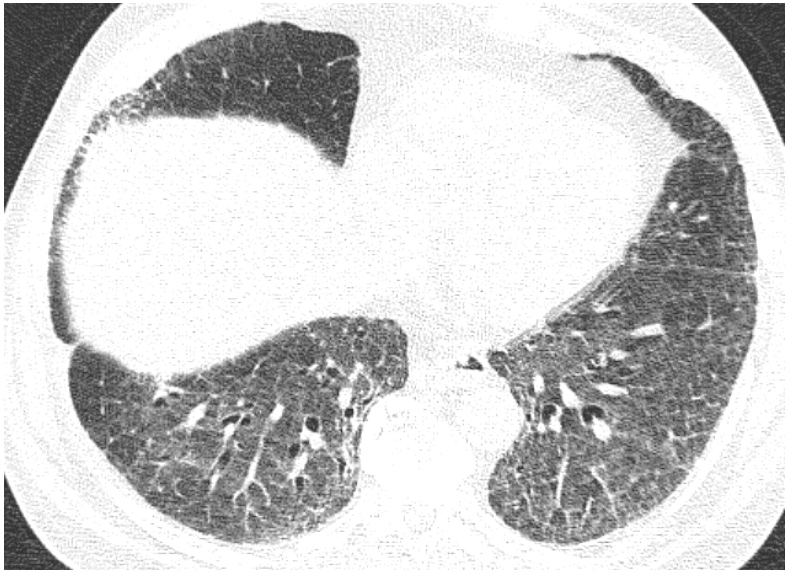
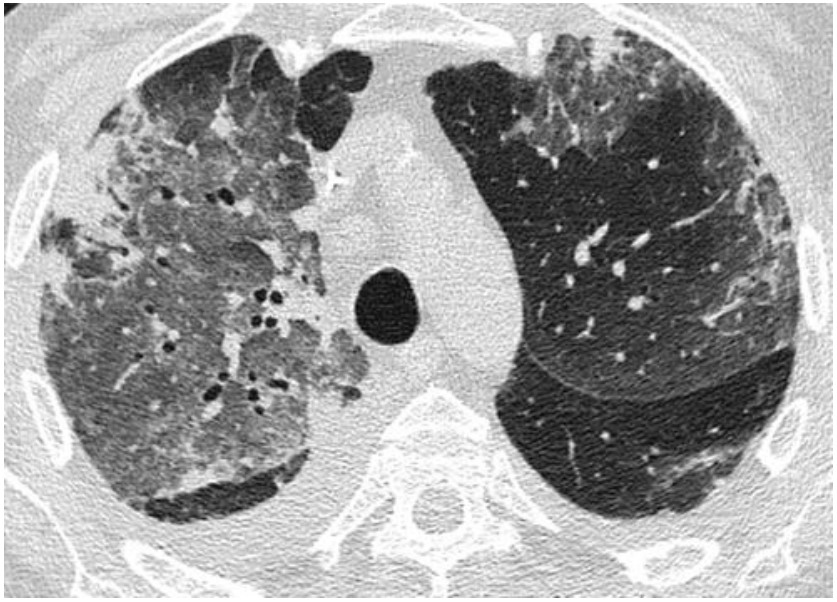
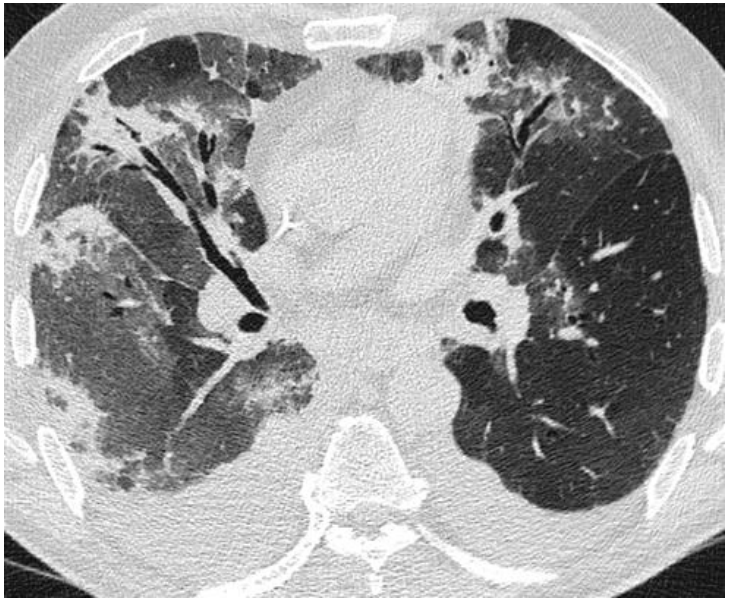


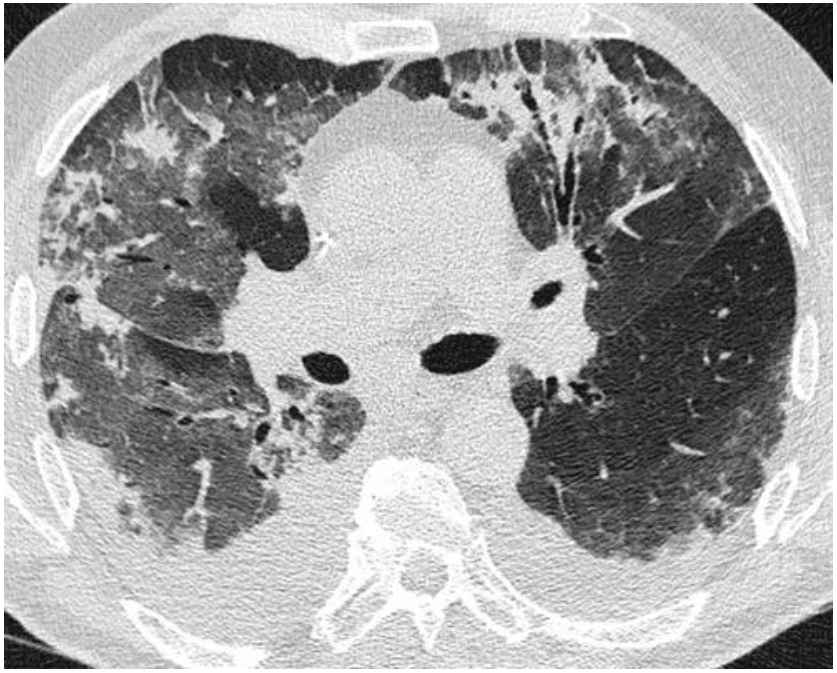
Drug induced pneumonia
NSIP type









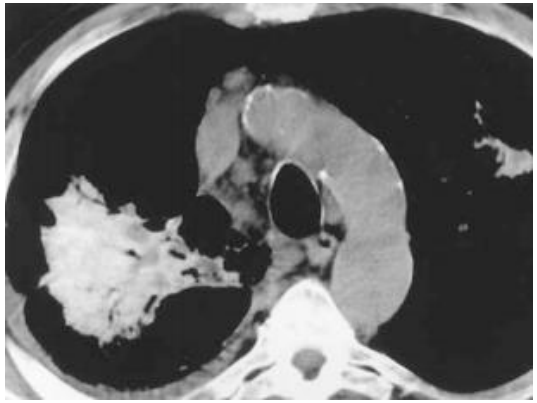


Toxic eosinophilic pneumonia link to intake of Daptomycin

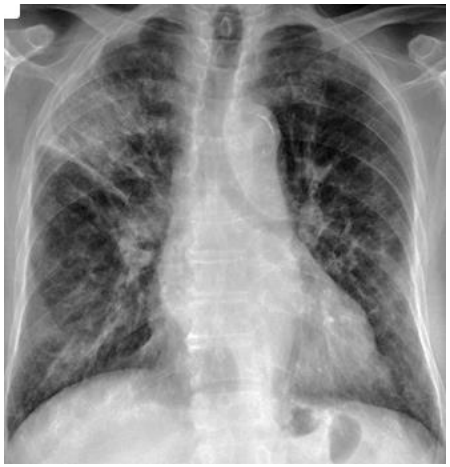
- Acute dyspnea and hypereosinophilia at D5 of treatment
- Bilateral multifocal opacities and bilateral effusions, traction bronchiectasis begin in anterior regions

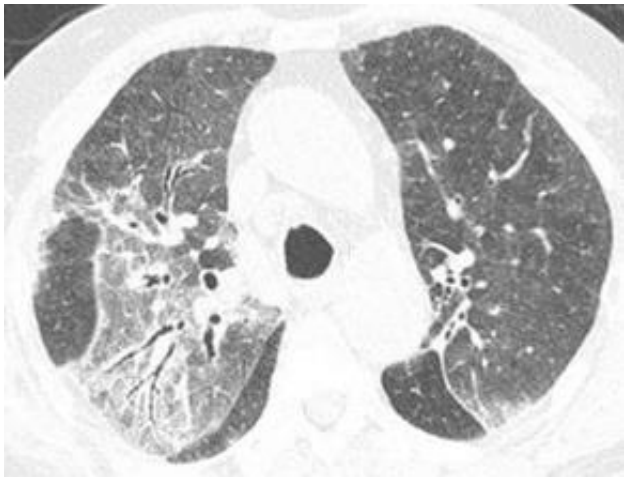
Amiodarone Lung

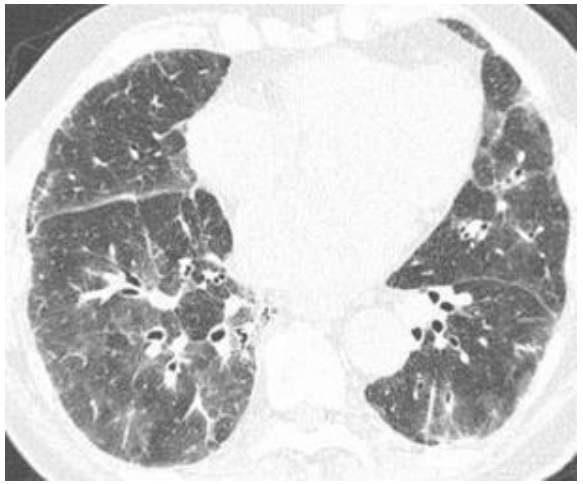
- treatment > 2 months, >60 years, dose >400mg...
- Prevalence: 1.4-18%.
- Imaging
  - Lung
    - **ILD : NSIP++**
    - **Consolidation often hyperdense** (due to iodine)
  - Hyperdensity **liver** (80%) + **heart** (20%)



Courtesy Santiago E. Rossi Radiographics

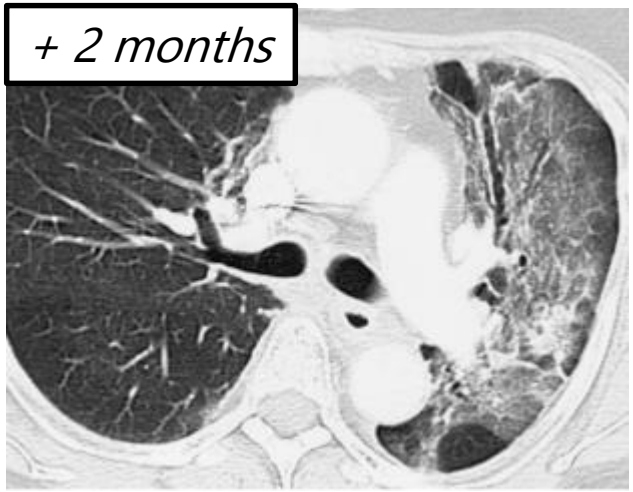






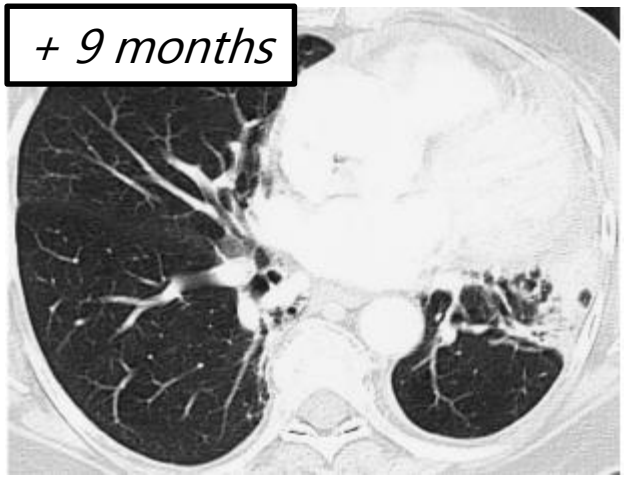
Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 6539

Radiation induced lung disease



Imaging

- **GGO** (minimal shape) / **lung consolidation**
- **Well-defined** or curvilinear **limits**, not **anatomical** but **radiation field**
- **OP** : especially in breast cancer under radiotherapy



Courtesy Choi et al -Radiographics

Rule of 4

- 4 weeks to deliver 40 Gy (dose>40Gy)
- **4 weeks** after the end of SR: **early attainment**
- **4 months** later: **peak of radiation pneumopathy.**
- **12 months** (4x3): consolidation decrease , scars ++
- After 12 to 18 months, change in appearance → recurrence, infection. PET useful for detecting recurrence

Effects of Radiation Therapy on the Lung: Radiologic Appearances and Differential Diagnosis
Yo Won Choi et al - Radiographics 2004

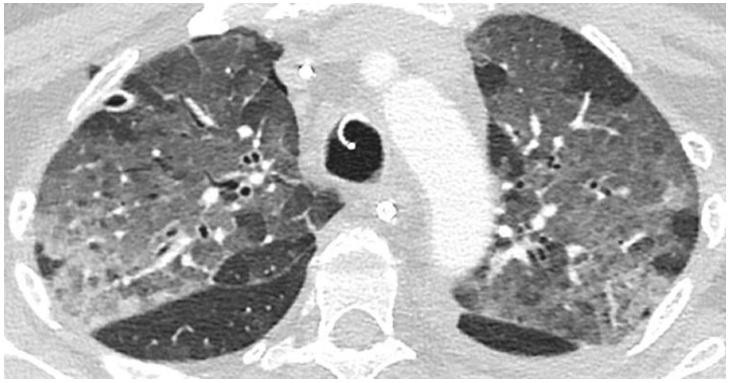
ARDS

- = **Lesional Pulmonary Oedema Secondary** to a condition
  - **Lung**
  - or **extra-pulmonary**
- **AIP** = idiopathic form of ARDS
- Histology: **Epithelial** and **endothelial** lesions

Diagnostic Criteria
- Pa02/FiO2 < 200
- Bilateral lung opacities
- No cardiac failure

Lung etiologies
- Fat embolism
- Drowning
- Viral pneumonia
- Oxygen toxicity
- Inhalation tobacco
- CIVD
- Gastric fluid aspiration
- Contusion

Extra-pulmonary etiologies
- Pancreatitis
- Burns
- Trauma
- Sepsis
- Hypovolemic shock
- Brain damage
- Transfusion reaction
- Cardiopulmonary bypass



Zompatori M, Ciccarese F, Fasano L. Overview of current lung imaging in acute respiratory distress syndrome. Eur Respir Rev. 2014

ARDS Imaging

1) Acute phase: 1st week

Bilateral diffuse opacities
with **antero-posterior gradient+++**

- **Consolidation of** the **declive regions** (atelectasis) of the lung with **GGO on the** surface
- Normal lung in non-declivable areas
- **More peripheral distribution/** PAO
- **Pleural effusion** (50%)

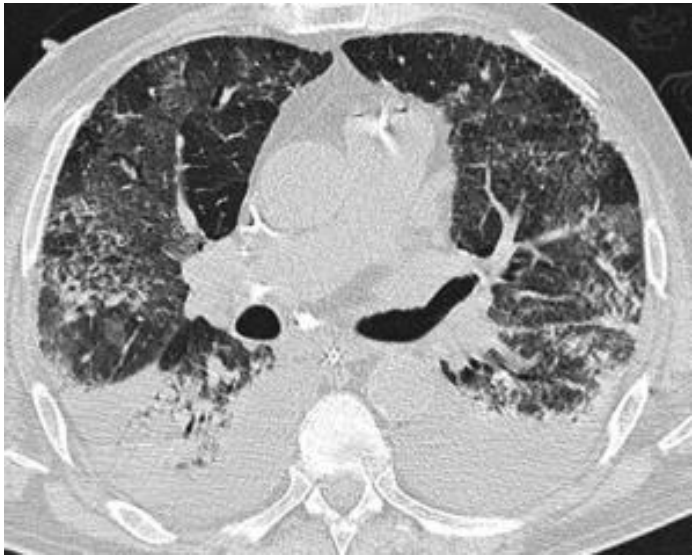
2) Intermediate or proliferative phase: 2nd week

- Occurrence of **reticular opacities**
- **Traction bronchiectasias** (sometimes reversible)

2) Late stage (fibrosis)

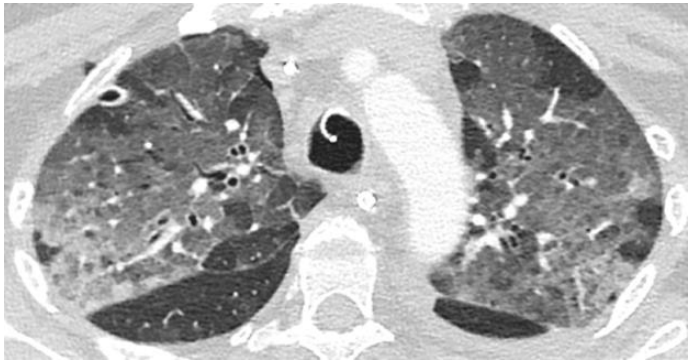
- **Normal** or **abnormal** (> 70% of patients keep abnormalities at 6 months)
- GGO, **reticulation**
- **Cysts** (hyper-insufflation?)
- **Traction bronchiectasia** ++
- **Anterior ++** (hyper-insufflation lesions?) or diffuse ++ (rarely posterior) **regions**

ARDS of **extra-pulmonary** origin
- Symmetry, slope



Courtesy Sarah Sheard - Respiratory Care

ARDS of **pulmonary** origin:
- Asymmetry, less sloping



Zompatori M, Ciccarese F, Fasano L. Overview of current lung imaging in acute respiratory distress syndrome. Eur Respir Rev. 2014

ARDS differential diagnosis

- **PAO**
  - Difficult to distinguish, but <u>some signs point to PAO:</u>
    - Cardiomegaly
    - Central distribution (butterfly wings) +++
    - Increased septal+++ and peri-bronchial thickening
    - Spreads ++
- **AEP** Acute eosinophilic pneumopathy
- **Diffuse alveolar hemorrhage** (anemia, hemoptysis)
- **Pneumopathy** (no gravitoid dependence)

Zompatori M, Ciccarese F, Fasano L. Overview of current lung imaging in acute respiratory distress syndrome. Eur Respir Rev. 2014

Eosinophilic lung

Definition: a group of conditions characterised by **pulmonary infiltrates,** associated with **hypereosinophilia in the blood or alveoli.**

Primitive

- **Acute eosinophilic pneumonia**
- **Chronic eosinophilic pneumonia**
- **Churg and Strauss**
- Chronic idiopathic hypereosinophilic syndrome

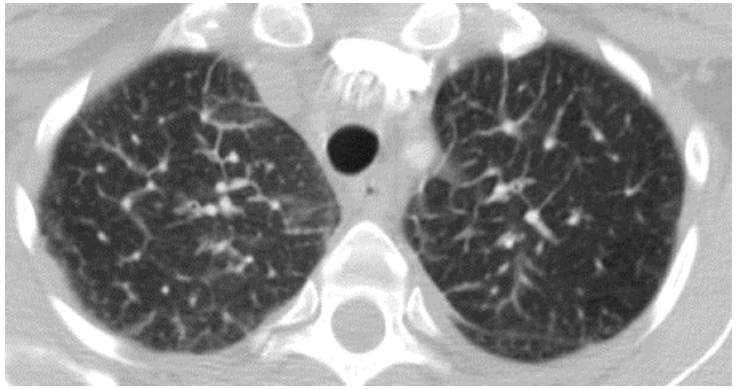
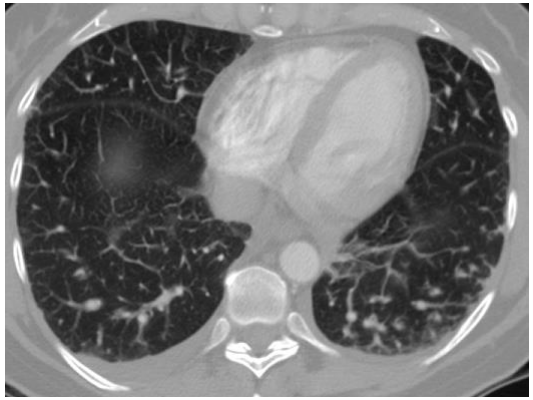
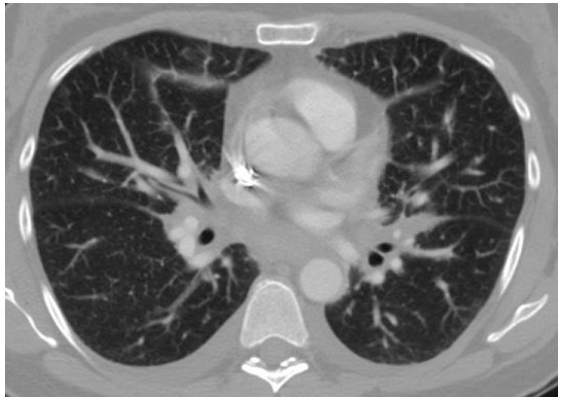
Secondary

- **Parasites**
- **ABPA**
- **Medicinal / Toxic**
- Bronchocentric Granulomatosis

Biblio: Jeong, Yeon Joo, et al. "Eosinophilic Lung Diseases: A Clinical, Radiologic, and Pathologic Overview - Radiographics 2007

Acute eosinophilic pneumonia

Acute febrile idiopathic pathology with dyspnea due to pulmonary eosinophilia

CT: Looks like a PAO +++

- **GGO +++** (100%)
- **Consolidation**
- **Regular septal thickening +++** (90%)
- Centrolobular **nodules**
- Random distribution, diffuse
- **Pleural effusion** (bilateral, possible)
- Absence of cardiomegaly

AEP to discuss whether

- **Normal heart** PAO
- **Young adult** without cardiac deficiency
- Even in the absence of plasma hypereosinophilia (initial phase)

Differential diagnosis

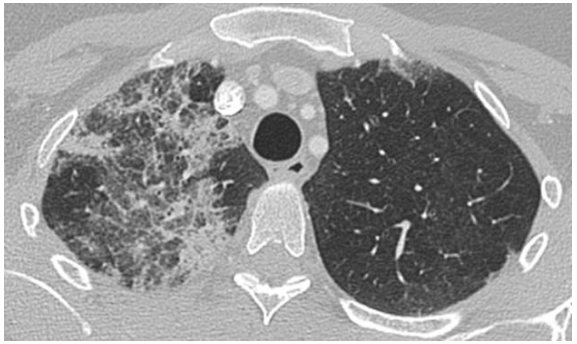
- **PAO**
- AIP/ARDS
- Eosinophilic lung (toxic, parasites, Churg & Strauss, chronic hypereosinophilic syndrome)

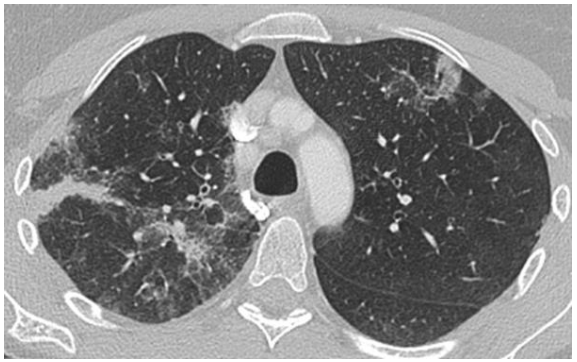
Diagnostic Criteria

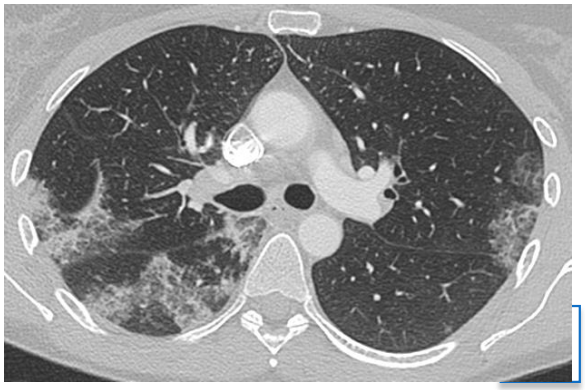
- **Acute febrile** illness < **1 month**
- **Hypoxemia**
- Diffuse **GGO**, reticulations, **consolidation , eosinophils** in the **BAL** > 25%.
- Staining for negative fungal and parasitic infections
- **Response to corticosteroids**, **no recurrence** after discontinuation

Chronic eosinophilic pneumonia

- Most frequent form of hypereosinophilic pneumonia in metropolitan France
- Coexistence of **asthma** (50%) (and/or atopy) sometimes several years earlier
- Peak frequency: **40 to 50 years**, predominantly **female** (2/1)

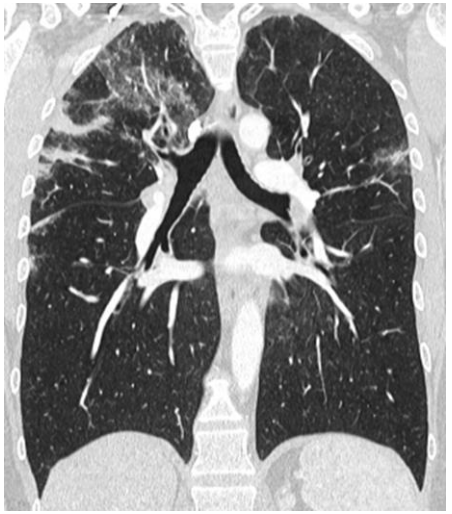




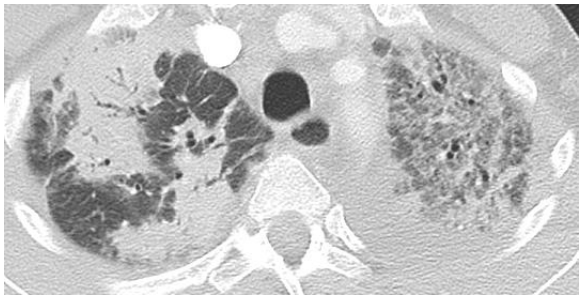


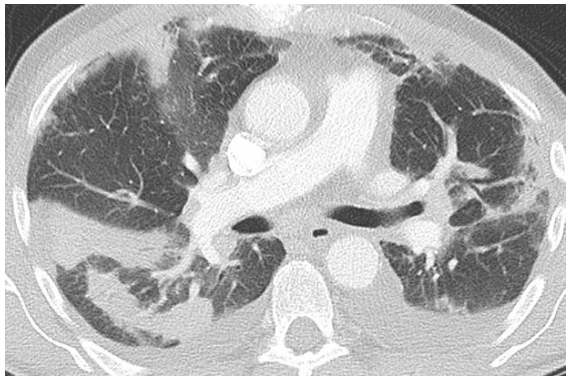
Imaging

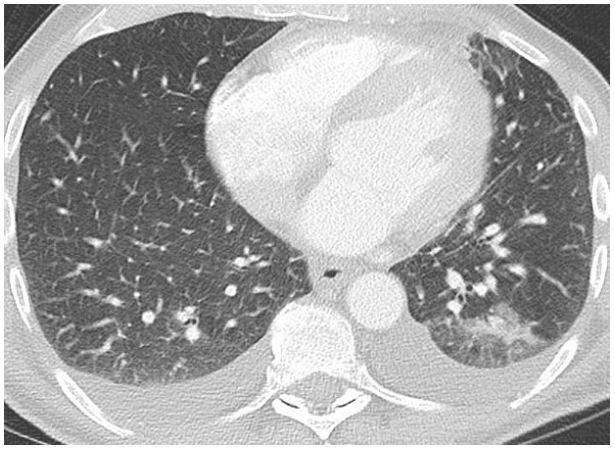
- **Alveolar consolidation** (100%)
- **GGO** (88%)
- **Peripheral** distribution (85%)
  → Distribution in **« reverse butterfly wings"**
- **Upper regions** predominance (40%)
- Absence of pulmonary fibrosis
- Fixed Condensations
- + alveolar nodules, strip opacities

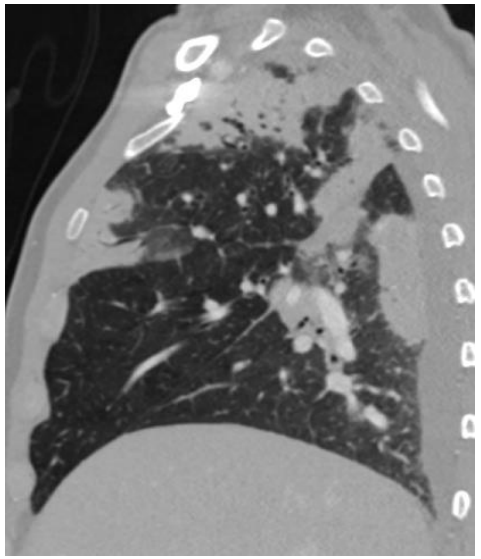


Chronic eosinophilic pneumonia

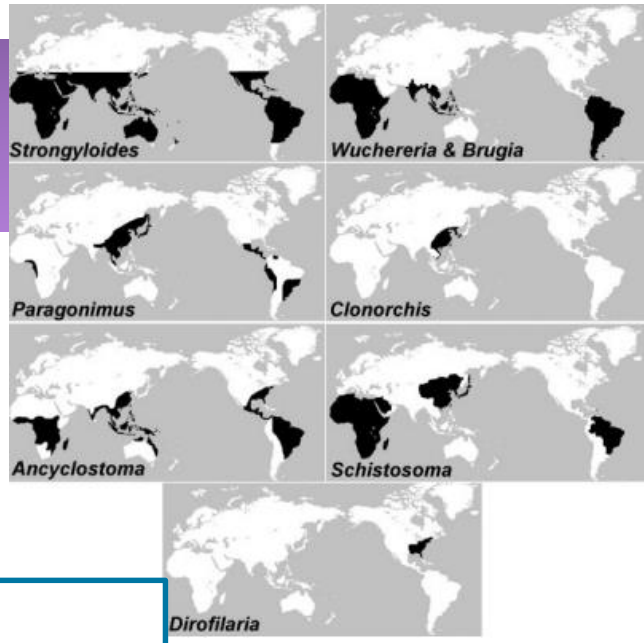








Parasities Cause



Courtesy Yeong Joo Jeong
Radiographics

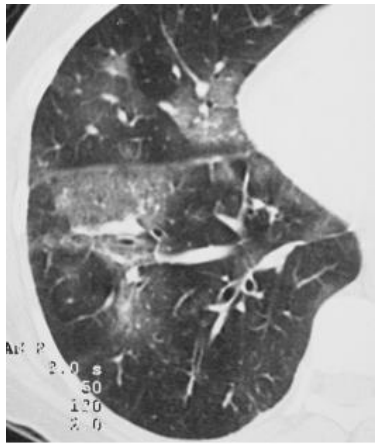
Physiopathology

2 mechanisms to eosinophilic infiltration in parasites infections

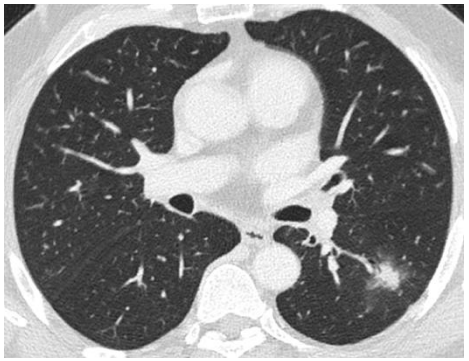
- **Direct invasion** (ascaris, *schistosoma,* filariasis, paragonimiasis...)
- **Allergic reaction** (*entomoeba histolytica*, toxocarose, *clonorchis sinensis*)

Imaging

- Loeffler's syndrome
  - **Ascaris++, anguillulose:** refers to an acute benign eosinophilic pneumonia of **unknown cause**. In some patients a **parasitic cause, a drug** cause, an ABPA is found.
  - **Peripheral eosinophilia**
  - Absent or slight symptoms: cough, fever, dyspnea.
  - One or more **consolidation** ranges with blurred contours or **GGO** or **nodule with ggo halo**
    - **Transitional** and/or **migratory**
  - Spontaneous resolution of opacities (1 month)
- Specific lesions for each parasite



Ascariasis
Courtesy Martnez S
Radiographics



Anguillulose

Idiopathic hypereosinophilic syndrom

- Very rare, middle age, predominantly female
- **Major and prolonged peripheral hypereosinophilia** (>6 months)
- Negative etiologic balance
- Presentation
  - General non-specific signs: AEG, febricule
  - **Visceral damage** secondary **to** eosinophilic infiltration: **cardiovascular (severe)++**, **neurological (severe)**, **pulmonary** ...

Imaging

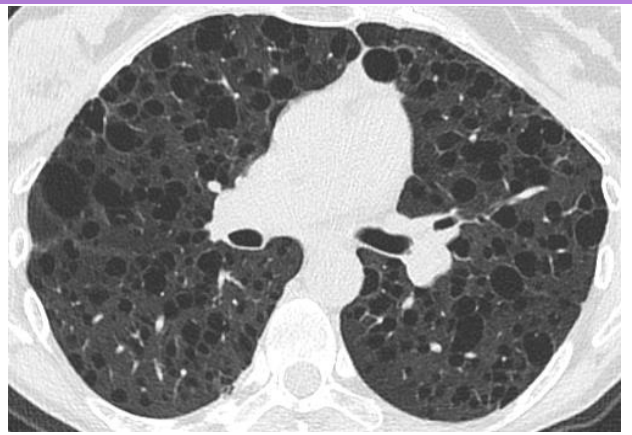
- Pulmonary damage in **40-50% of cases** (often OAP secondary to cardiac damage)
- Histology: major eosinophilic infiltration, architectural destruction, necrotic areas
- **Non-specific** radiological signs
- **Consolidation**
- **GGO** focal or diffused
- **Nodules +/- halo**
- Septal thickening in case of cardiac damage

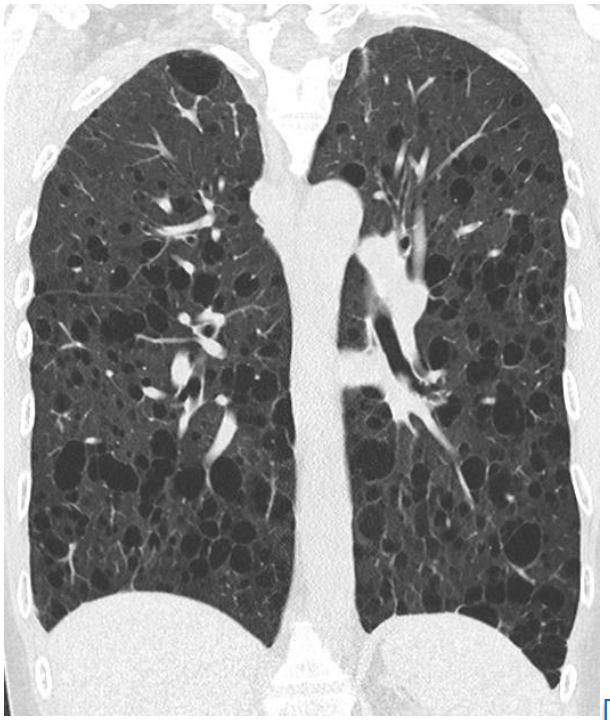
Lymphangio-leiomyomatosis (LAM)

- Rare, **woman of childbearing age**
- **Smooth muscle cell proliferation**
  - In the pulmonary interstitium
  - And along the retroperitoneal and thoracic lymphatic vessels
- Can be integrated with **tuberous sclerosis** (1% of cases)

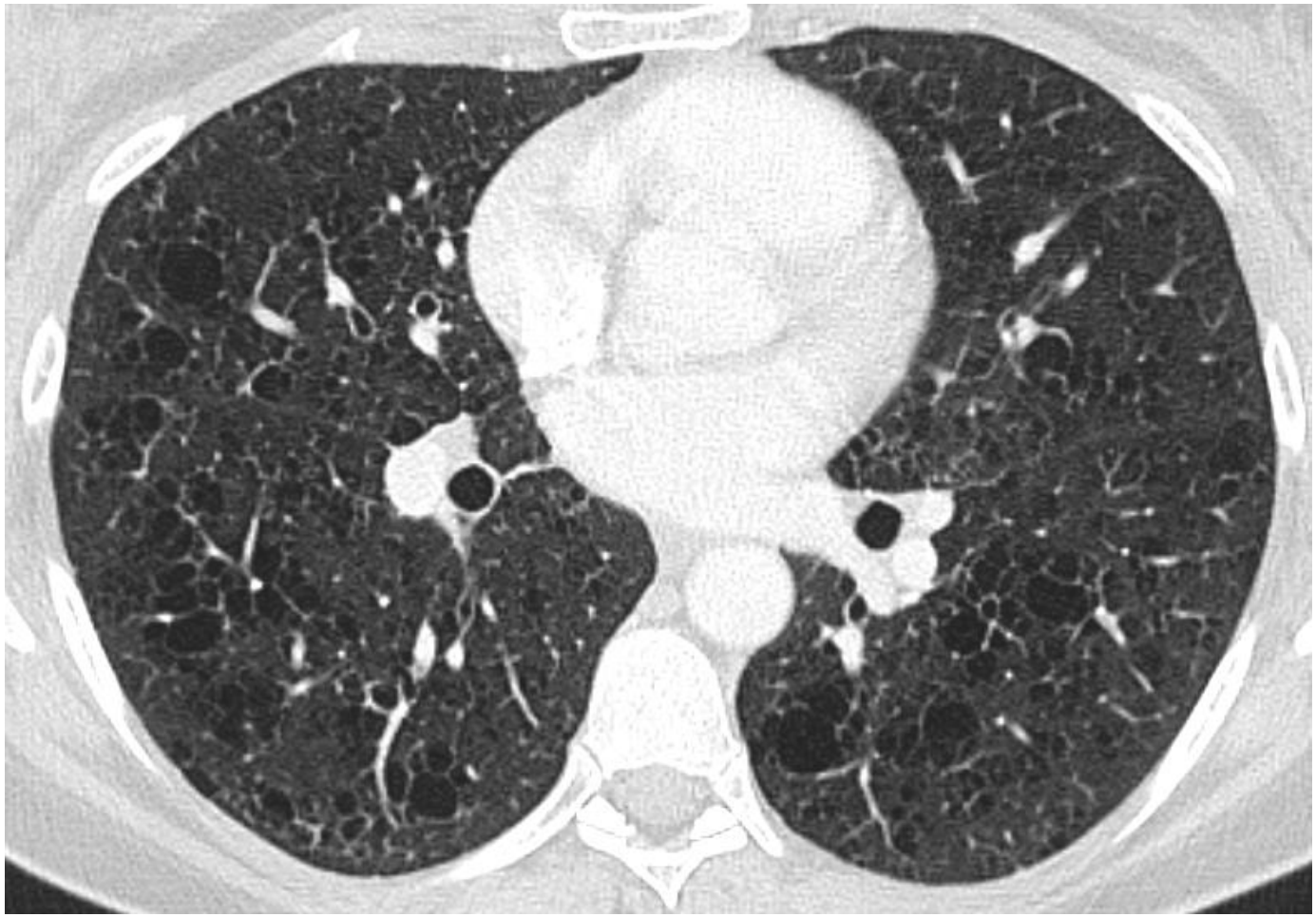
CT SCAN

- Lung: **cysts of diffuse distribution**, variable size 2-5mm to 10mm (depending on evolution time), otherwise normal lung
- Pleura: **chylothorax,** pneumothorax
- Extra-pulmonary impairment (76%):
  - Retroperitoneal lymphangioleiomyomas + lymphadenopathy
  - **Renal angiomyolipomas**





Biblio: Case 116: Lymphangioleiomyomatosis - Anil K. Attili and Ella A. Kazerooni - Radiology 2007



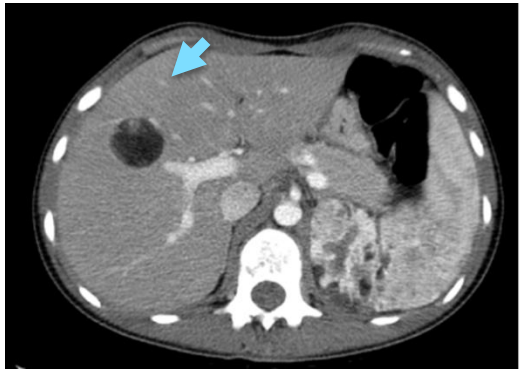
Lymphangio-leiomyomatosis (LAM)

Tuberous sclerosis

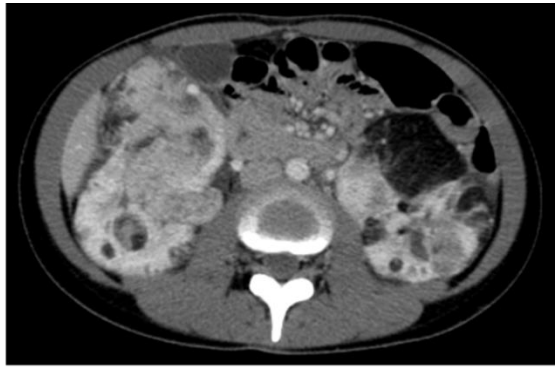
- Autosomal dominant hereditary with variable penetrance and phenotypic expression. Phacomatosis.
- 50-70% spontaneous mutations
- 1/6000 to 10 000 births

<u>Ubiquitous hamartomatous locations</u>

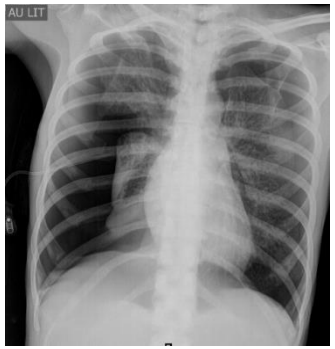
- **Brain** (mental retardation, epilepsy)
  - **Subependymal nodules**
  - **Cortical Hamartoma (tubers)**
  - Giant cell astrocytoma
- Eyepiece
- Cutaneous
- kidney
  - **kidney angiomyolipomas**
- **Lung**
  - **LAM (1%)**
  - More rarely, Multifocal micronodular pneumocyte hyperplasia(**MMPH**): ill defined micronodules, bilateral, 1-10mm.
- Hepatic
  - Hamartoma or adenoma
- Cardiac
  - Rhabdomyoma
- MSK
  - Osteopoecilia



Hepatic Hamartoma

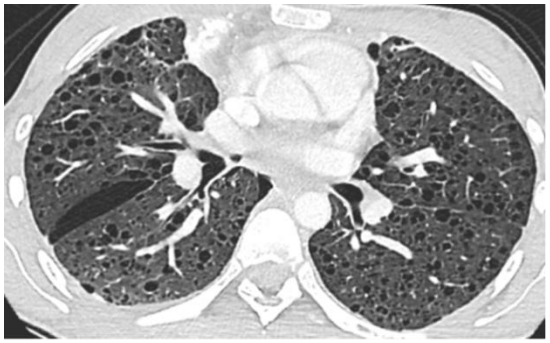


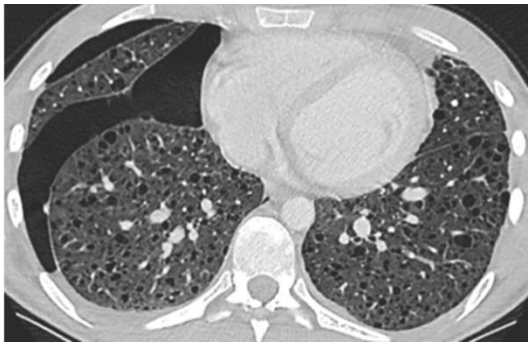
Renal angiomyolipomas

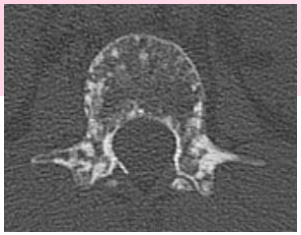


LAM/ Bourneville disease

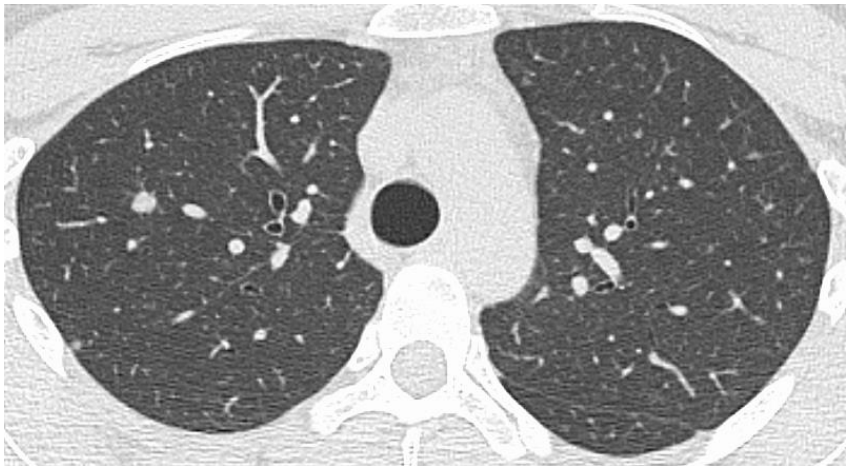
Lymphangioleiomyomatosis (cysts with regular, diffusely distributed contours) complicated by bilateral pneumothorax

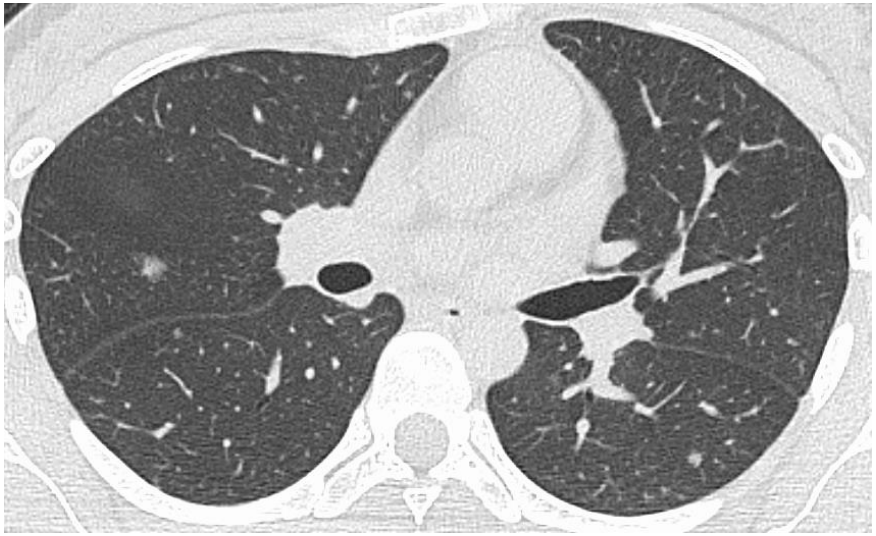






Multifocal micronodular pneumocyte hyperplasia(**MMPH**)



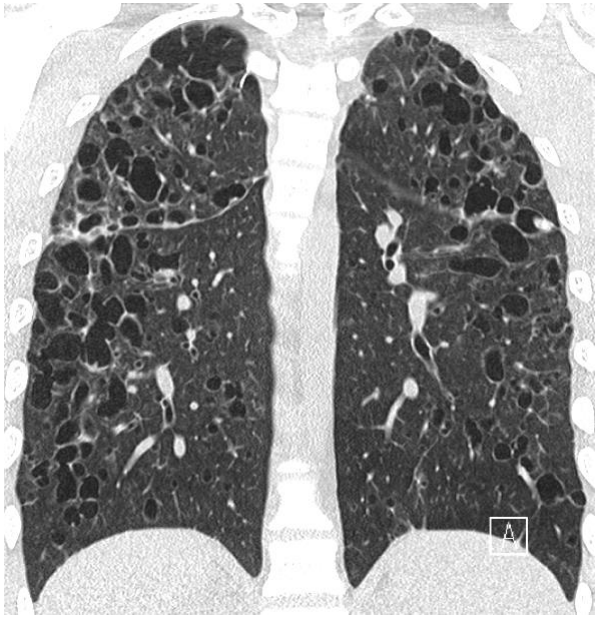


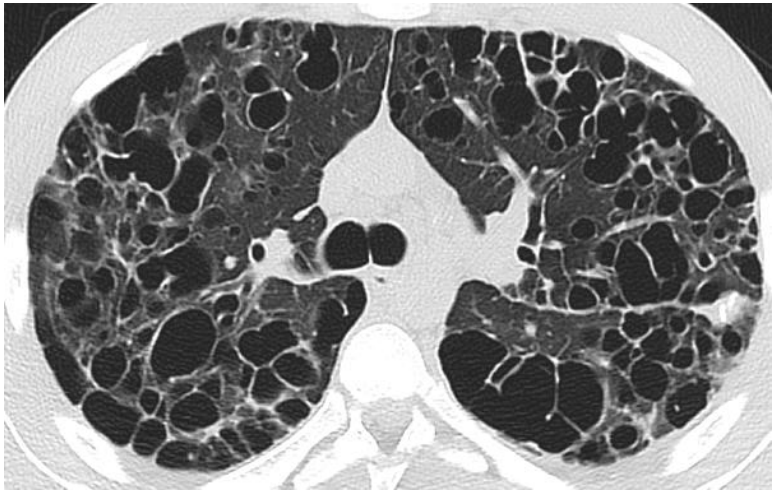
Langerhans cell histiocytosis

- Rare, almost exclusively in **smokers** (consistent with antigenic exposure hypothesis)
- Diagnosis often confirmed by **biopsy**
- Treatment: stop **smoking +++**
- Variable evolution: 1/2 stable, 1/4 regression, 1/4 progression

Imaging (the semiology differs according to the evolutionary stage)

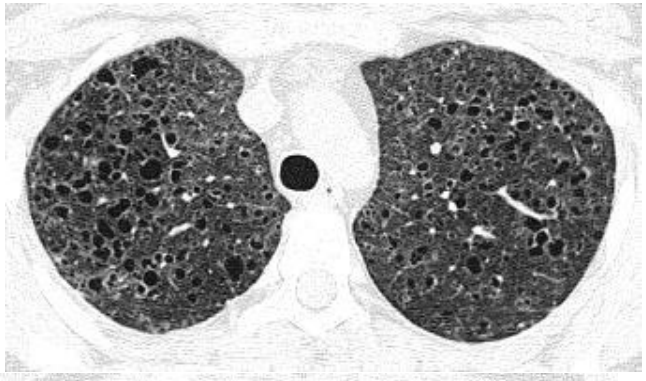
- **Diffuse centrolobular ill defined micronodules** (early stage)
- **Excavated** ("holed") **nodules** and/or thin or thick-walled **cysts** with **irregular margins+++**
- Evolution to "lacey" lung appearance.
- **Middle and upper regions** with **respect to costo-diaphragmatic +++**
- DD: in contrast to lymphangiomyomatosis, cysts of varying size, sometimes confluent, lose their rounded contours.
- pneumothorax

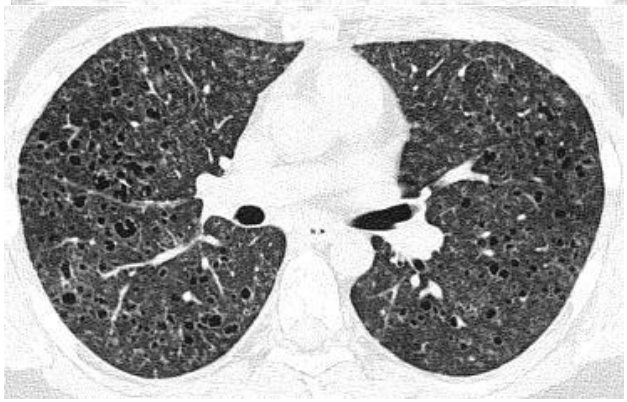




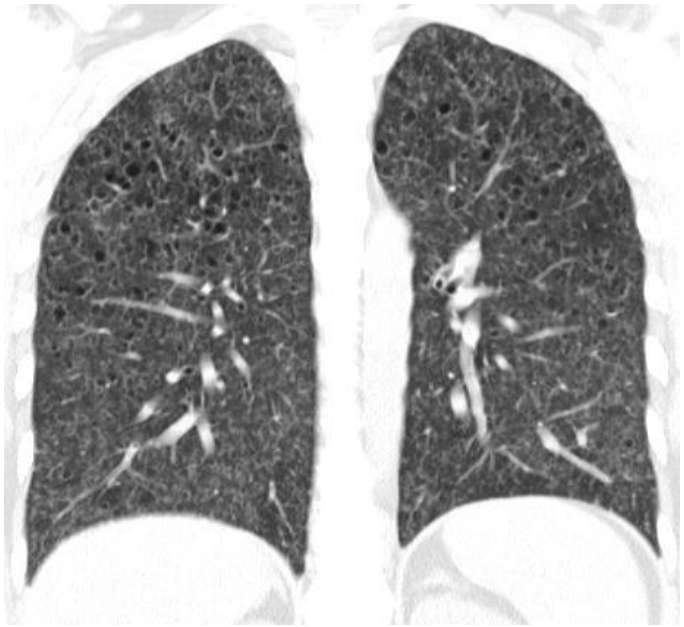
Leatherwood D. et al. Radiographics. 2007;27:265-8 Pulmonary Langerhans Cell Histiocytosis.

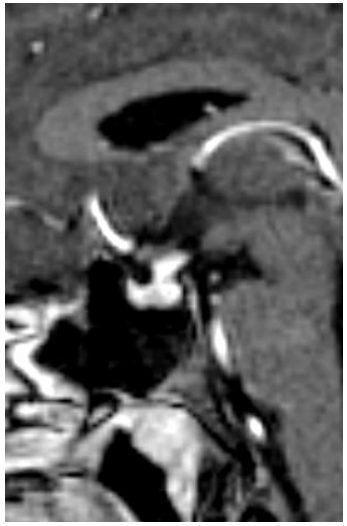
cyst





Centrolobular micronodules





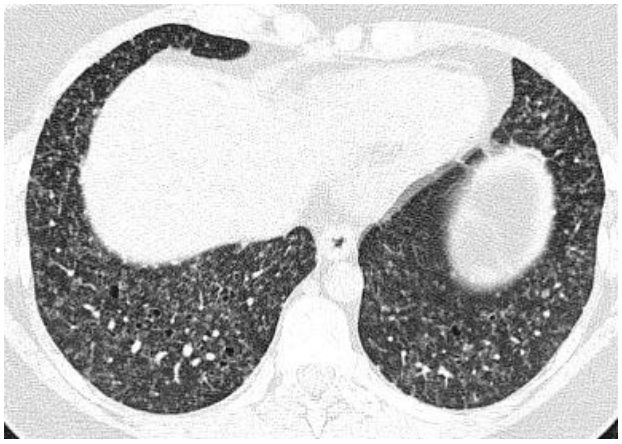
Pituitary infundibulum thickening

Langerhans cell histiocytosis

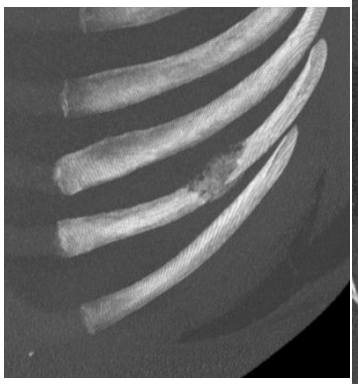
- Lung damage (**centrilobular micronodules + cysts**)

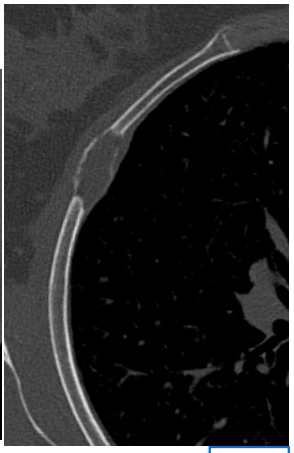
  Costal eosinophilic granuloma

  Pituitary infundibulum thickening

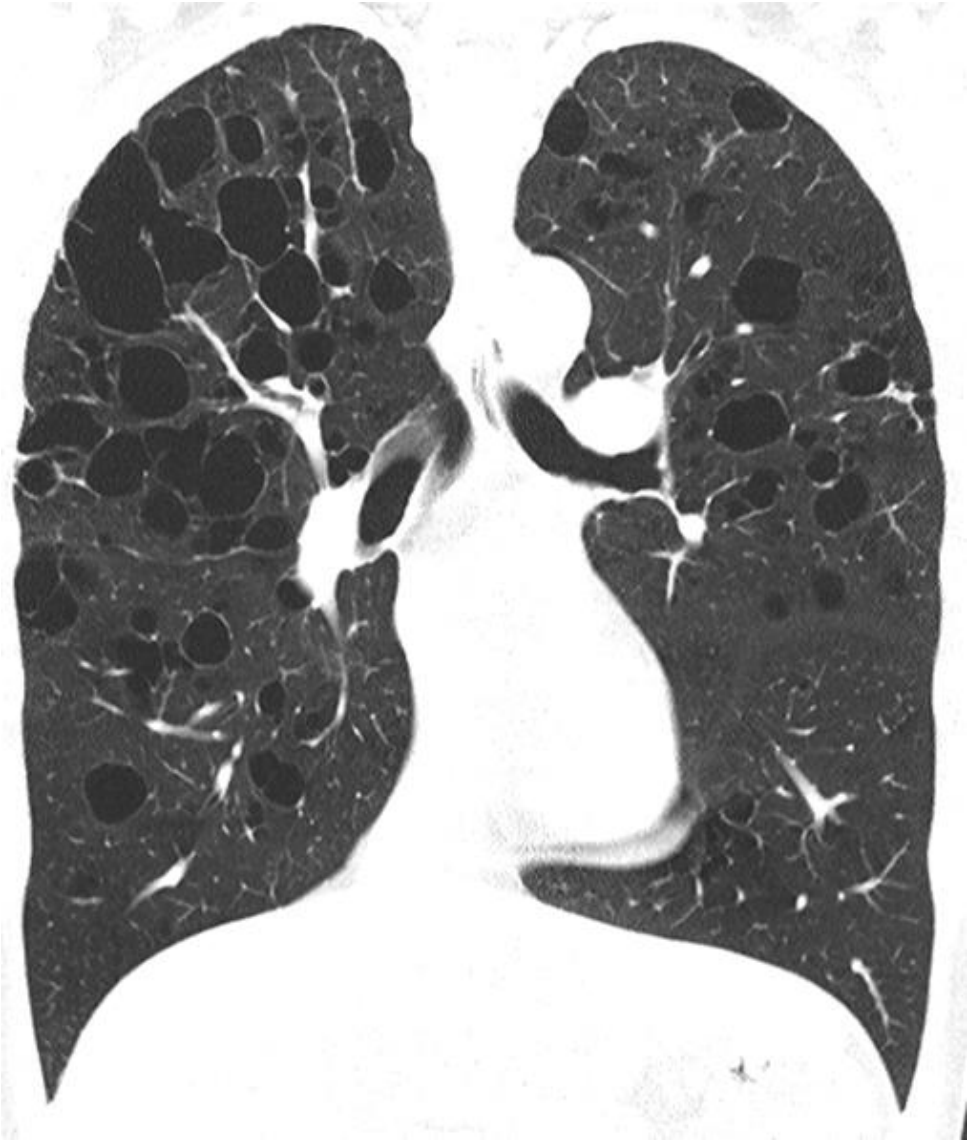


Micronodule
→ Nodule with hole
→ Thick-walled cyst
→ Thin-walled cyst
→ Confluent cyst





Costal eosinophilic granuloma



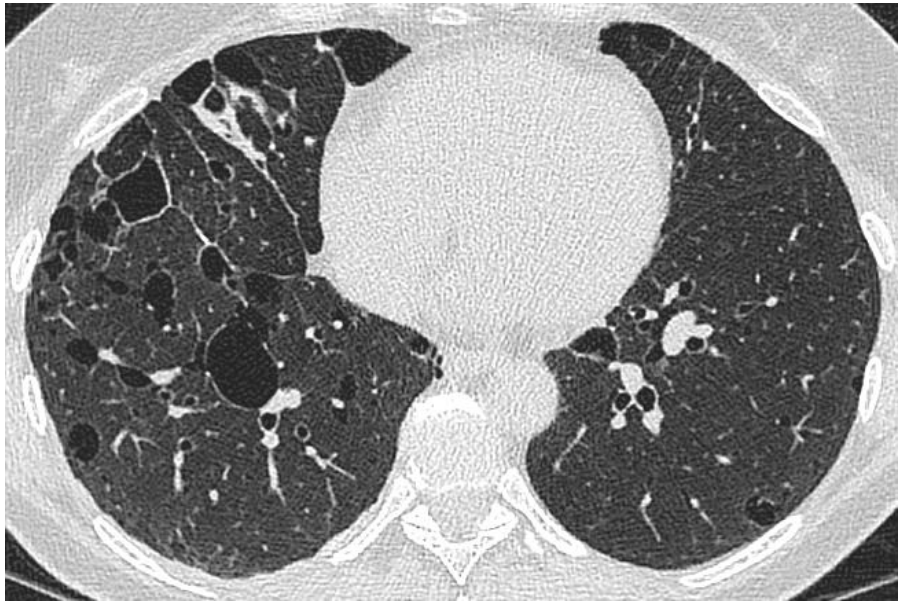
Langerhans cell histiocytosis

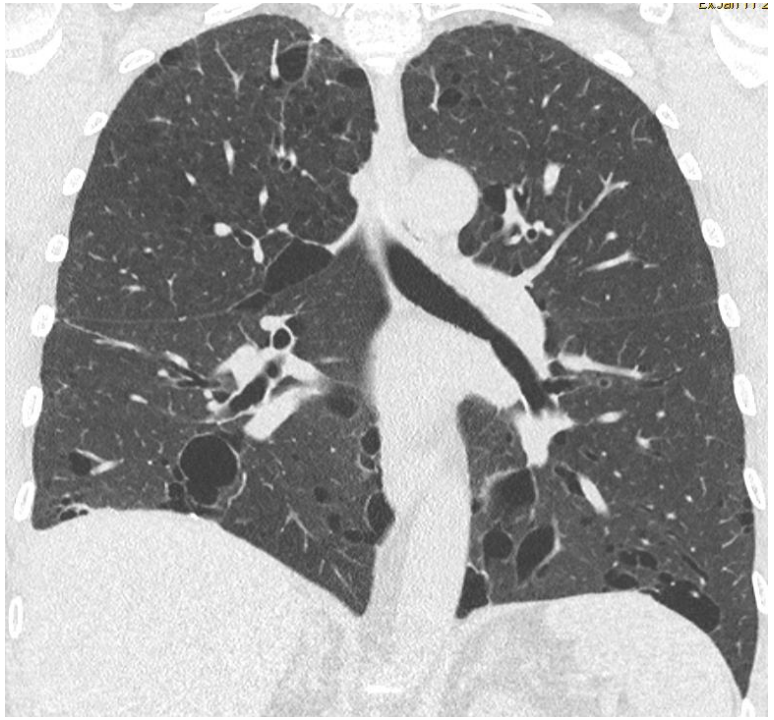
: irregular shaped cysts

Rare cystic diseases

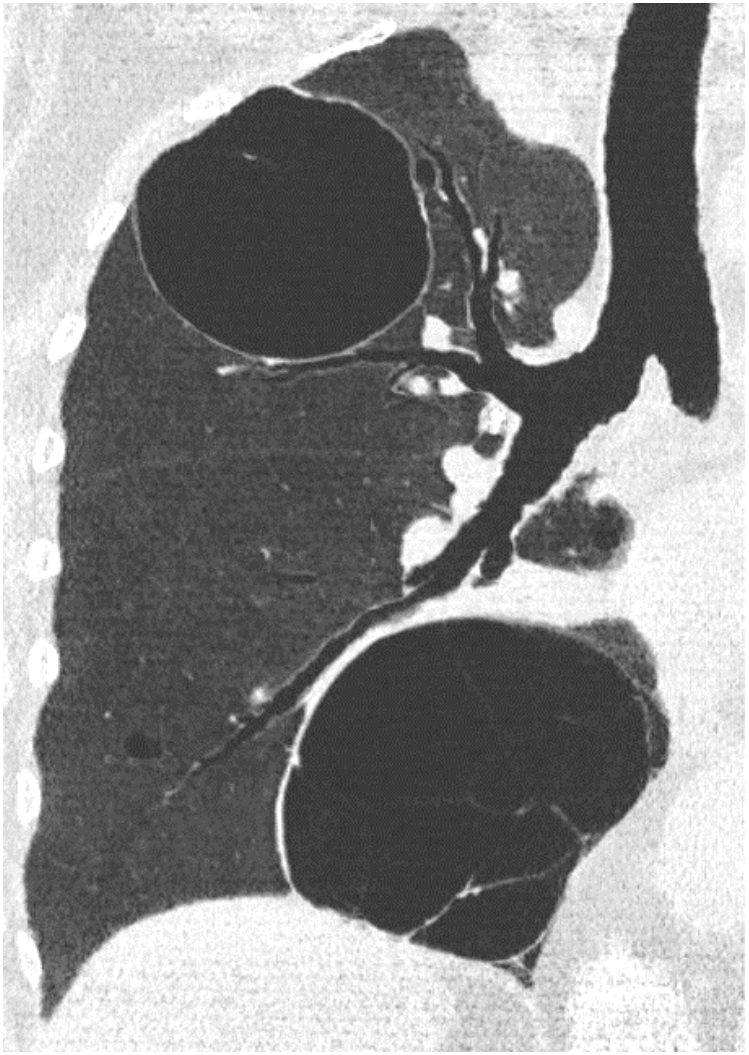
Birt Hogg Dubé Disease

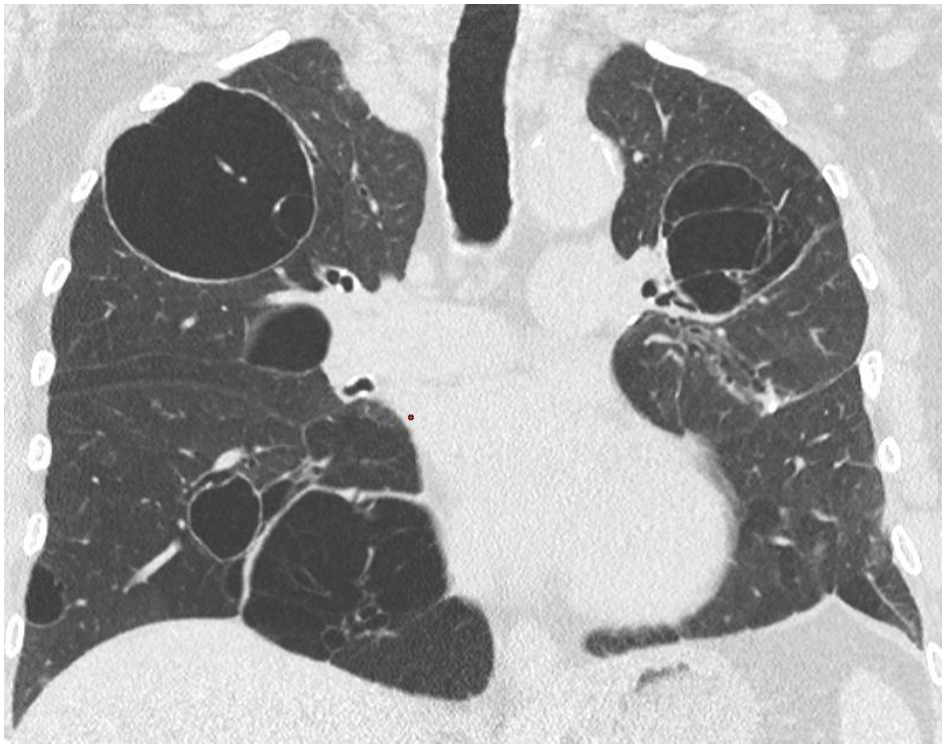
- **Pulmonary cysts** (spontaneous pneumothorax)
- **Kidney tumours** (chromophobic cell cancer, oncocytomas)
- **Cutaneous manifestations** (angiofibromas, perifollicular fibroids…)





Birt Hogg Dubé disease in a 48-year-old patient

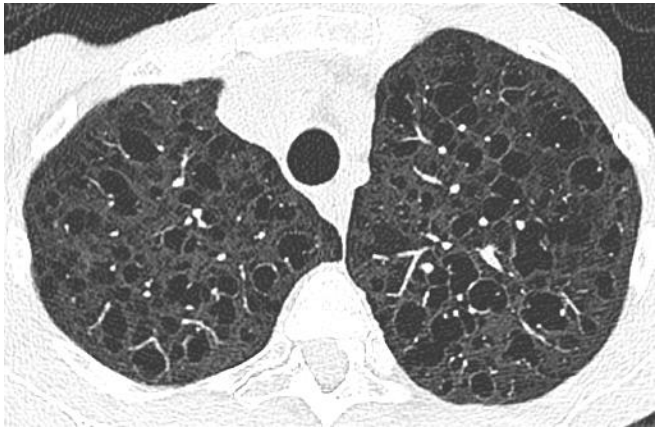


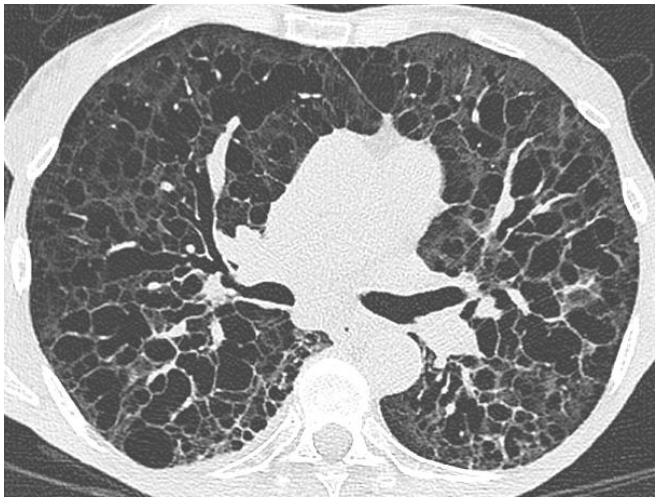


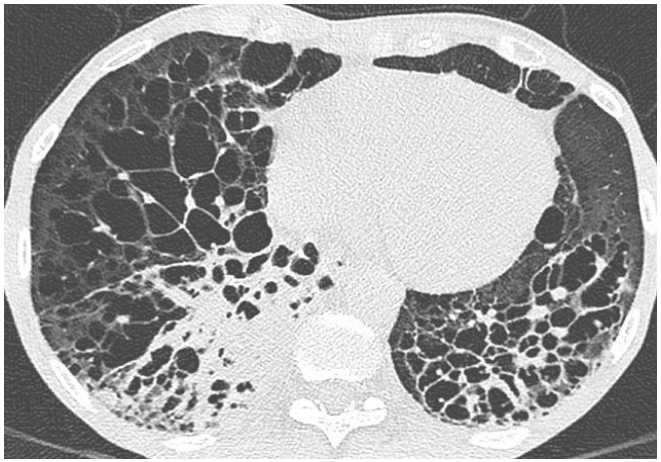
Light chain deposition disease
in a 72-year-old patient

Light chain deposition disease

- Multiple **cysts**
- **Monoliform bronchiectasias**



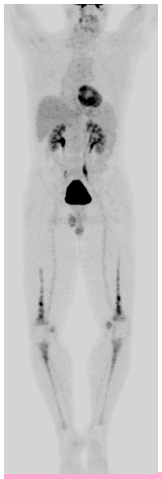


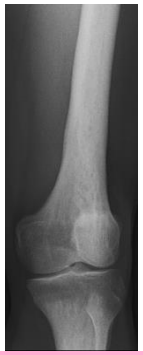


Non-amyloid light chain deposit disease

Diffuse significant cystic impairment associated with monoliform and cylindrical bronchiectasias

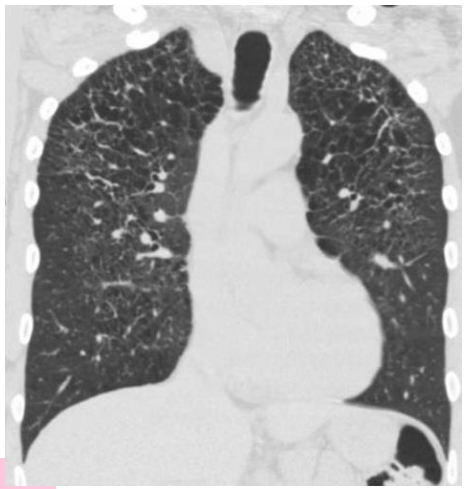
Erdheim Chester disease

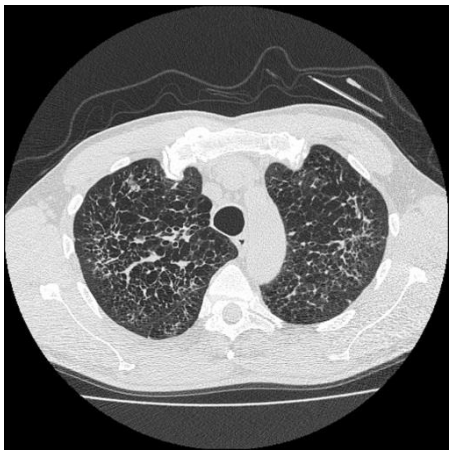




Non-Langherhansian histiocytosis

- Etiology unknown (rare)
- infiltration by lipid-laden histiocytes (foamy macrophages.





Case courtesy of Dr Andrew Dixon, Radiopaedia.org, rID: 9351

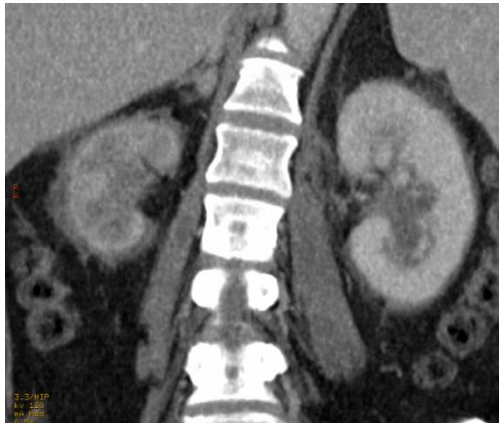
Multi-systemic impairment

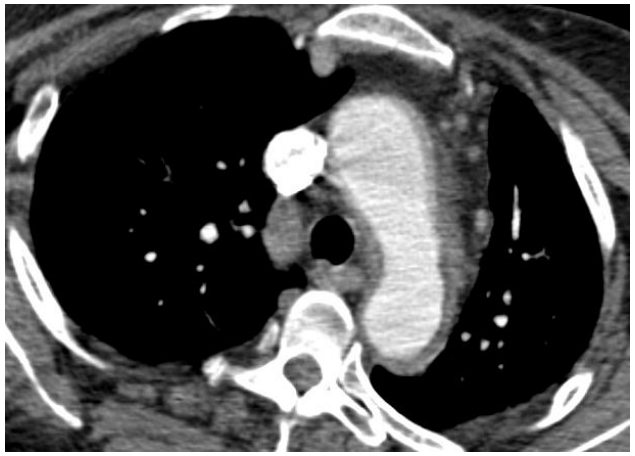
- Bone: bone pain, **bilateral and symmetrical osteosclerosis of the long bones,** diaphyseal, metaphysis +/- epiphysis of the lower limbs, periosteitis (2/3), scintigraphic fixation.
- Lung: **interstitial syndrome**
- Vascular
  - Thoracic **peri-aortic (aortic) infiltration** + coronary + OSAD + abdo/iliac
  - **Retroperitoneal fibrosis**
- Peri-renal infiltration +++ (**"hairy" kidneys**)
- CNS: pituitary infundibulum /posthypophysis (diabetes insipidus), exophthalmos, xanthelasma
- Bilateral adrenal hypertrophy

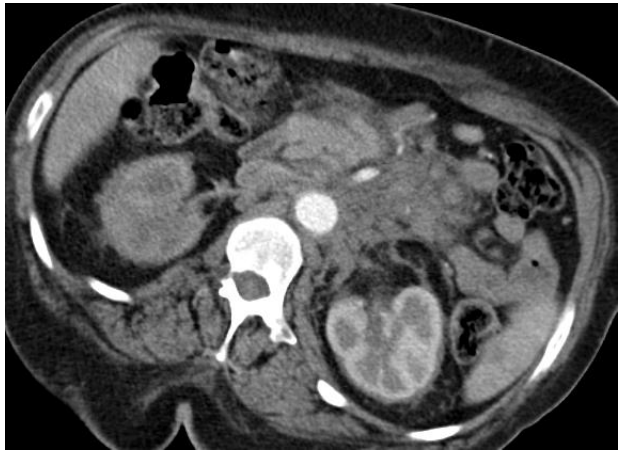
Lung: Interstitial syndrome

- Predominant **septal lines** in **the anterior and superior regions with symmetrical** reticulations
- **Centro-lobular micronodules**
- **Multifocal GGO areas, diffused**
- **Pleural effusion /** associated **pleural thickening in** about 50% of cases
- Rarer cysts (borderline with histocytosis X)
- Frequent periaortic infiltrate
- +/- pericardial infiltrate, posterior infra mediastinal

Pleuro-pulmonary impairment in Erdheim-Chester disease. A.L. Brun , D. Touitou, J. Haroche, Y. Badachi, P. Grenier, C. Beigelman-Aubry, Journal of Radiology. Vol 89 - N°10, Oct 2008, p1455

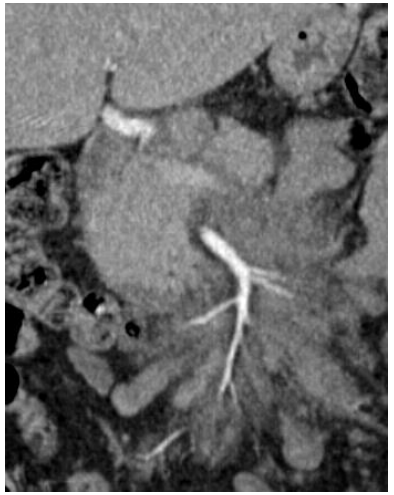


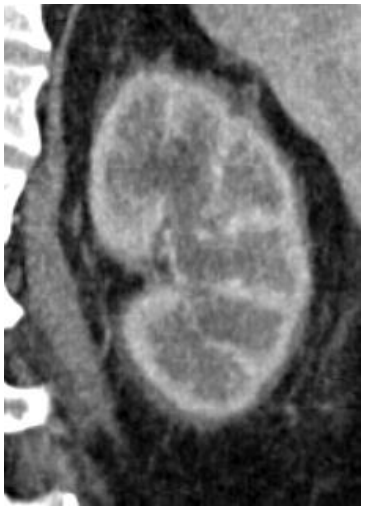




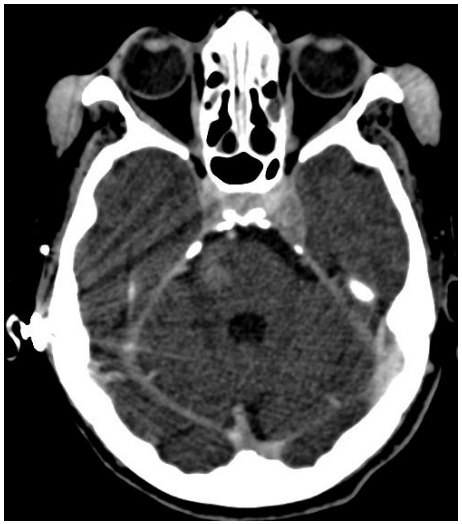
« Hairy » kidneys

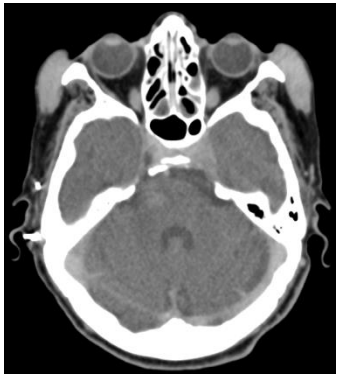
Thoracic aorta/ abdominal aorta/ AMS





Erdheim Chester





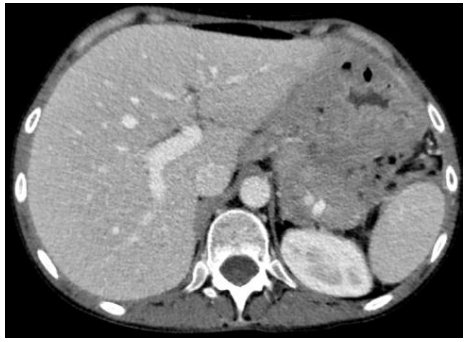
Neuro/ORL impairment

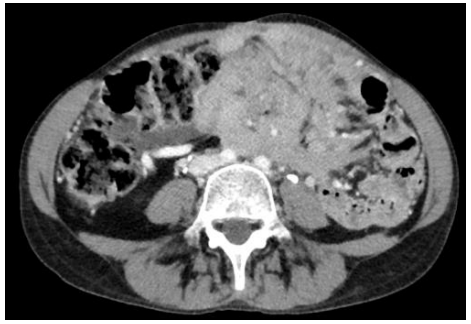
- ***Xanthelasma***
- ***Brain infundibulum enhancement***
- *Thickening meckel cavum*

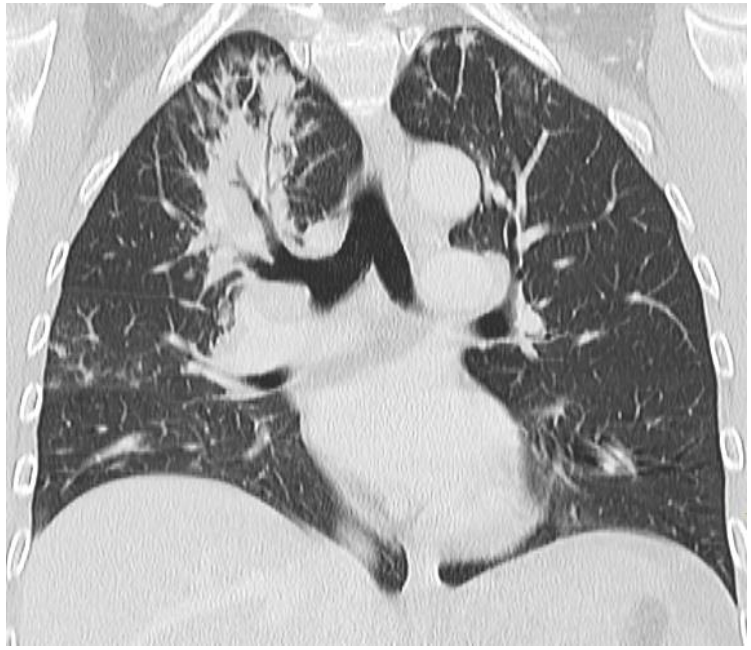
Rosai Dorfman disease

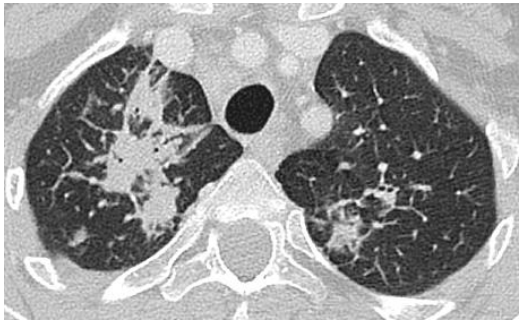
Non-Langerhansian histiocytosis, inflammatory

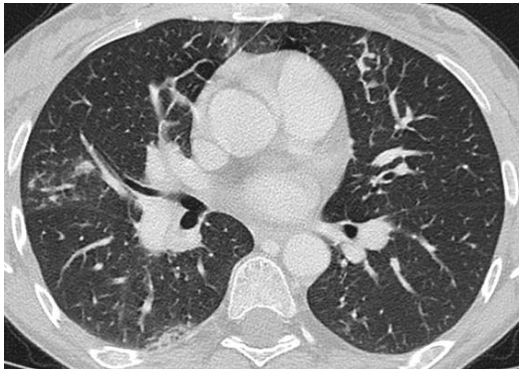
- Rare
- CD68 positive, CD1a negative histiocyte infiltration of the sinus ganglia
- **Massive lymphadenopathy** beginning in childhood or young adulthood (mean age 21)
  - **Cervical lymphadenopathy ++**
  - Inguinal, axillary, mediastinal, para aortic lymph nodes
- Extranodal damage (30%)
  - **Lung (2.5%): nodules and perilymphatic interstitial infiltration**
  - Skin, nasal cavity, orbit(7%), bone, intracranial and spinal disease: rare (rare)





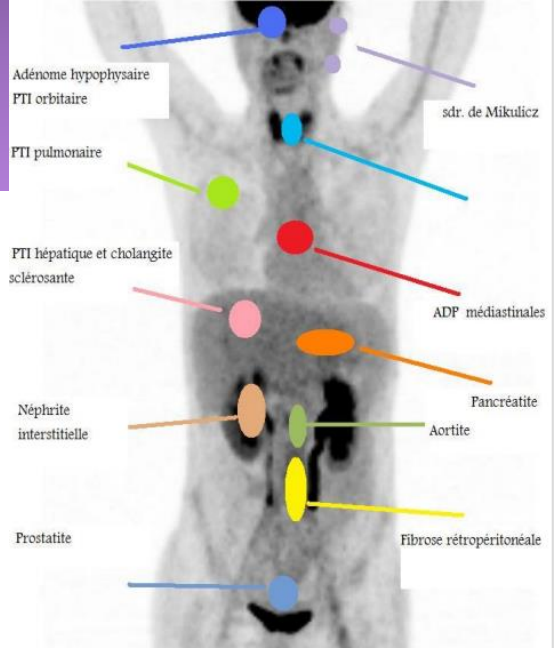






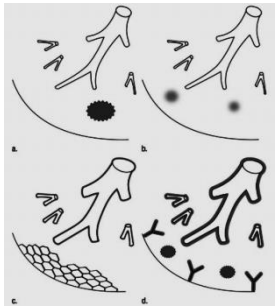
IgG4 disease

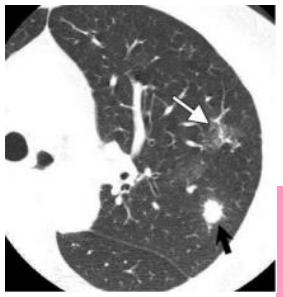
- **Extensive IgG4-positive plasma cells and T-lymphocyte infiltration of various organs**
- Keys to diagnosis
  - Determination IgG type (IgG4>1.35g/L)
  - **Immunostaining the biopsy** with Ab anti-IgG4
  - Sensitivity to corticosteroids



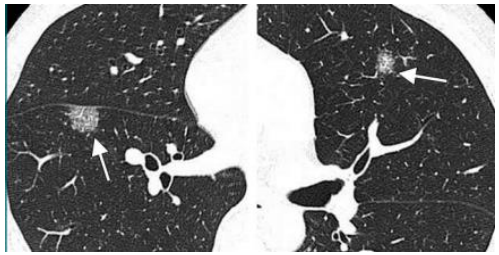
Courtesy Uncle Paul

a) **Solid nodule**
b) **Round-shaped ground-glass opacities**
c) **Interstitial: septal thickening** +/- peribronchial/pleural consolidation
d) **Broncho-vascular inflammation**



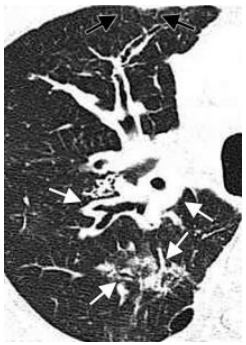


Solid nodule

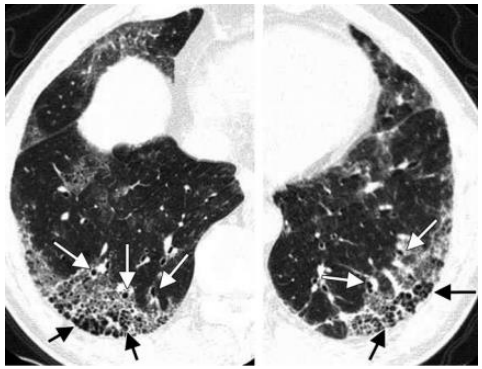


Round GGO

Courtesy Inoue and al- Radiographics



BV thickening



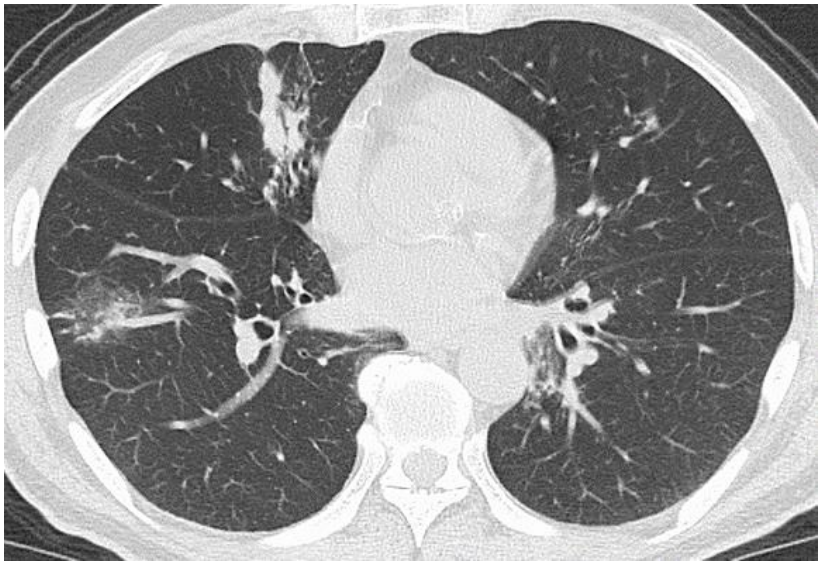
Interstitial

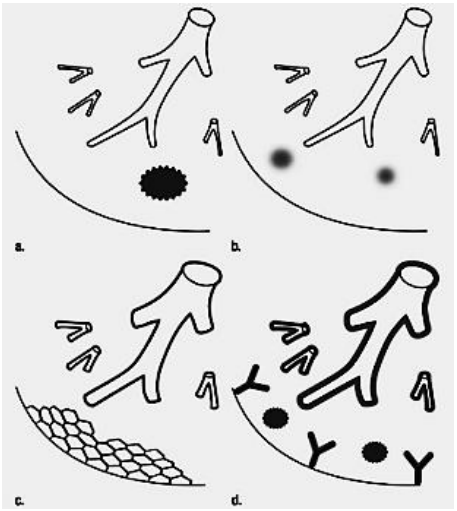
Multisystemic disease

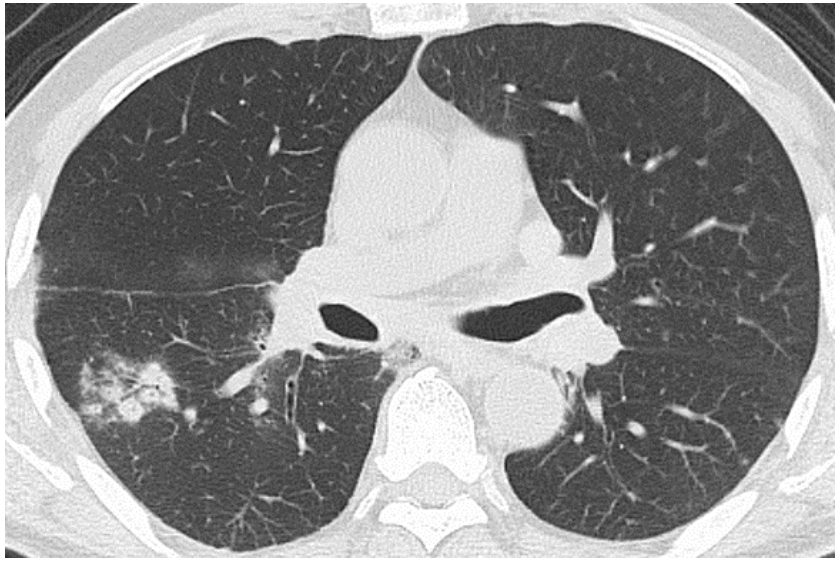
- **Retroperitoneal fibrosis**
- **Kidney** damage: tubulo-interstitial nephropathy or pseudotumoral damage.
- **Autoimmune pancreatitis**
- **Sclerosing Cholangitis**
- **Lymphadenopathy**
- Riedel's thyroiditis
- Mikulicz's disease
- Inflammatory pseudotumors
- Lung

D. Inoue, Y. Zen, H. Abo,T. Gabata, H. Demachi, T. Kobayashi, et al. Immunoglobulin G4 related lung disease: CT findings with pathologic correlations. Radiology 2009

IgG4 Disease

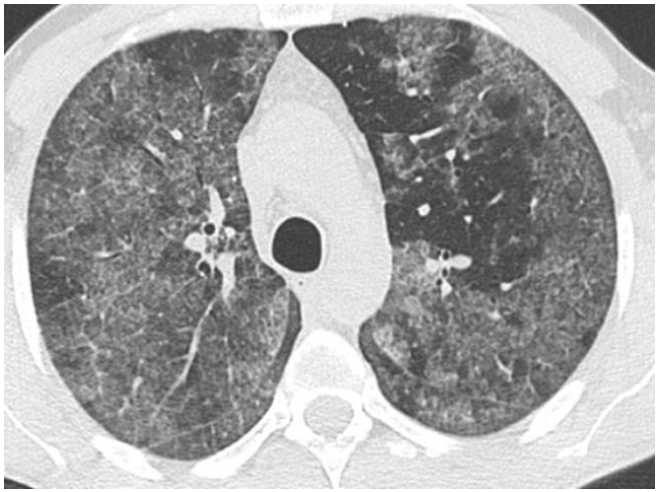


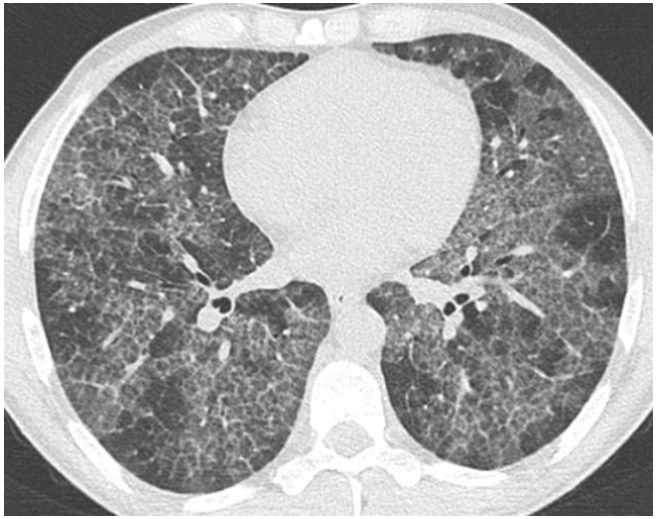




Pulmonary Alveolar proteinosis

- **Dysfunction of pulmonary surfactant properties and immune function**
  - **Idiopathic** (90%): middle-aged patient
  - **Secondary** (5-10%): inhalation/occupational exposure (silica, cement, aluminium, titanium, NO2...), hematological disease, immunodeficiency.
  - **Congenital** (2%)
- Rare, strong association with **smoking**
- Clinical (variable): moderate dyspnea progressive respiratory distress

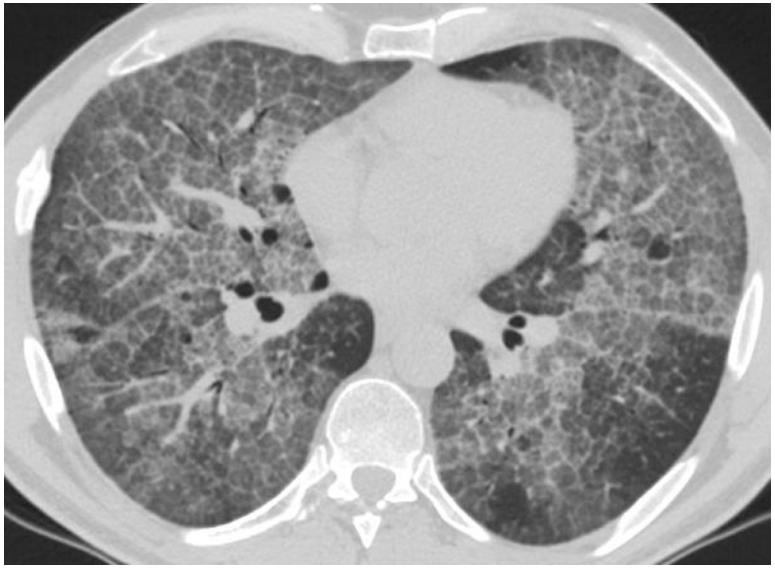




Diagnosis: lung biopsy or **BAL** (intra alveolar deposition of **protein material**, dissolved cholesterol and eosinophils)

Treatment
- Idiopathic **whole-lung bronchoalveolar lavage**
- Secondary shutdown of the trigger factor
- Congenital: transplantation

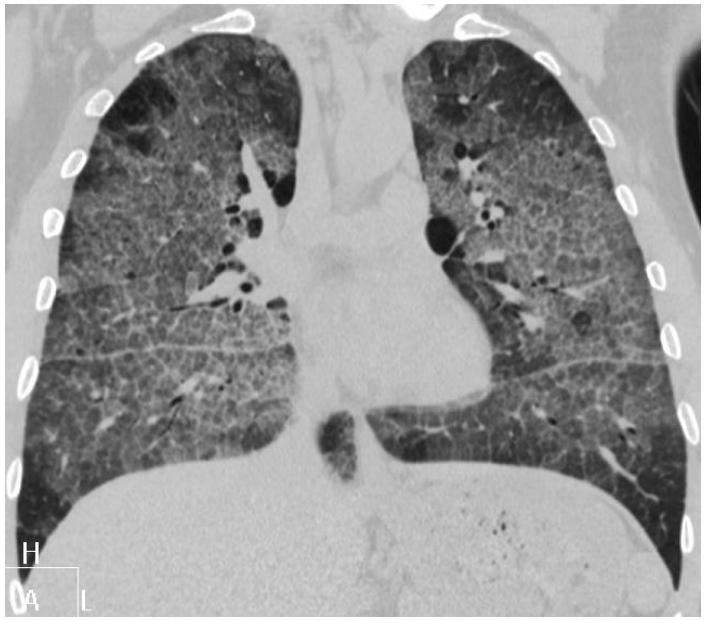
Biblio: Pulmonary alveolar proteinosis - Aletta Ann Frazier, Radiographics 2008

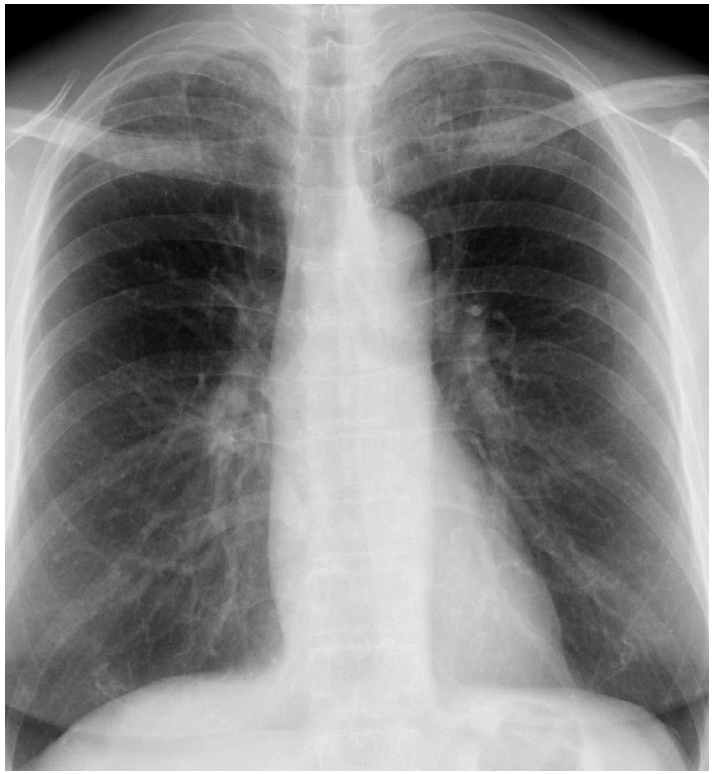


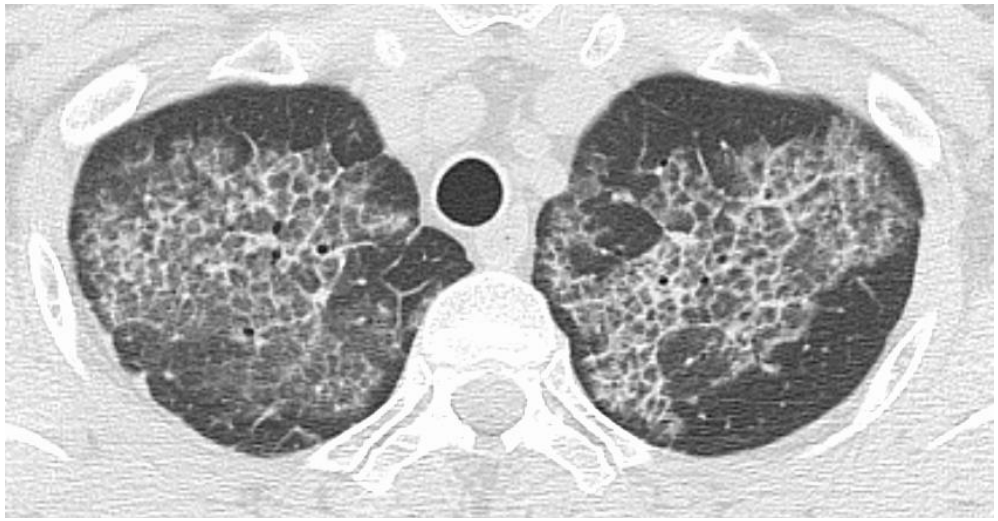
Imaging

- **Crazy paving +++**
  - **Diffuse**, **bilateral**, **geographical** with clear limits, **savings of healthy lobules**
- Often respect of costo-phrenic angles, apex, sub-pleural regions, etc.
- Fibrosis (<5%, late)

Multiple differential diagnosis (see diagnostic range semiology)

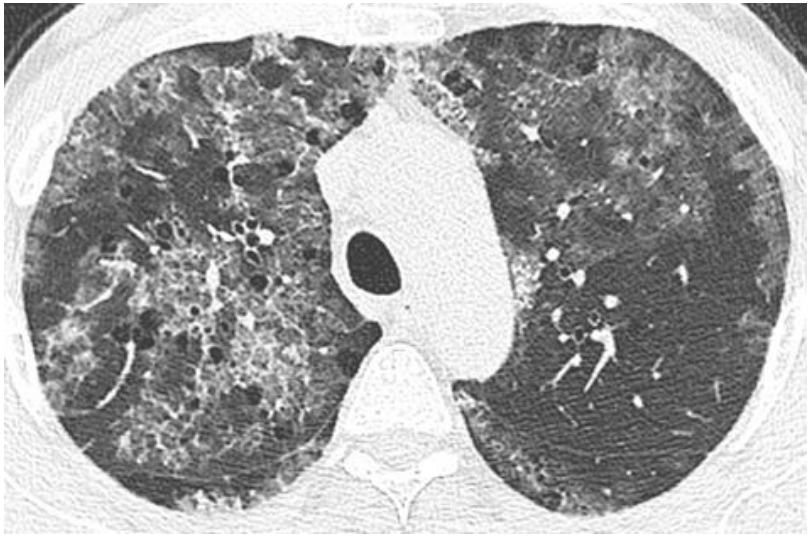


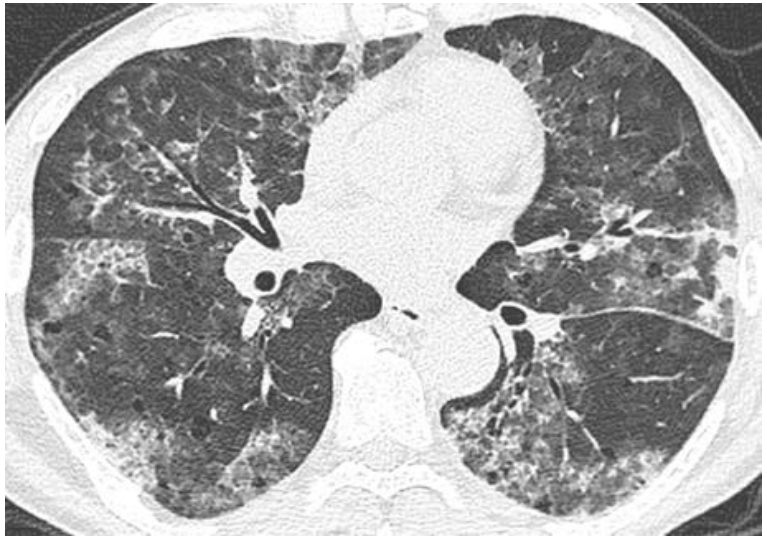


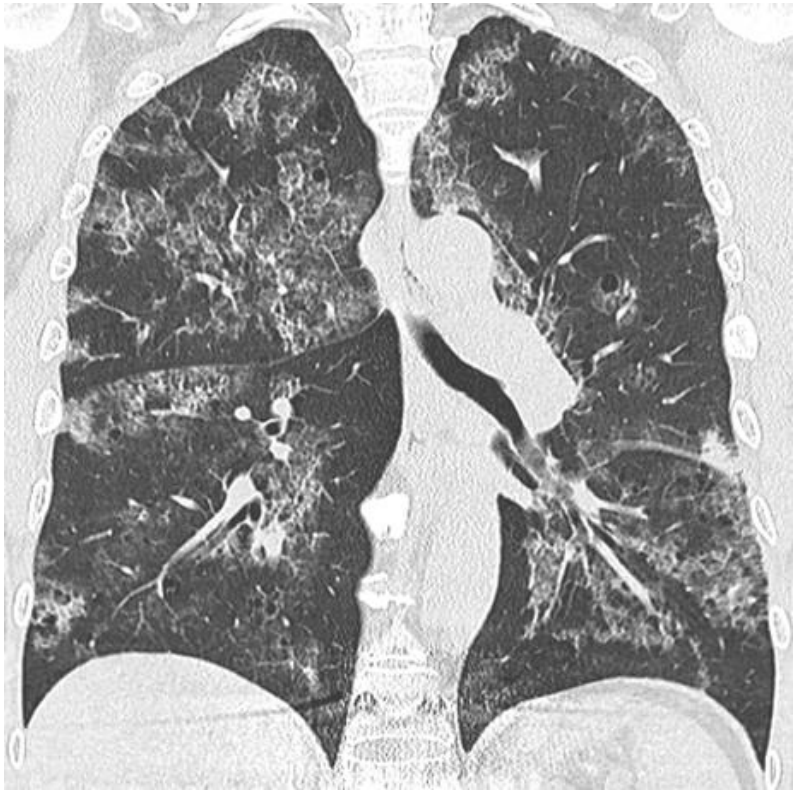


Alveolar lipoproteinosis

Crazy paving with here a superior predominance of opacities and a respect of the under pleural regions.







Autoimmune alveolar proteinosis

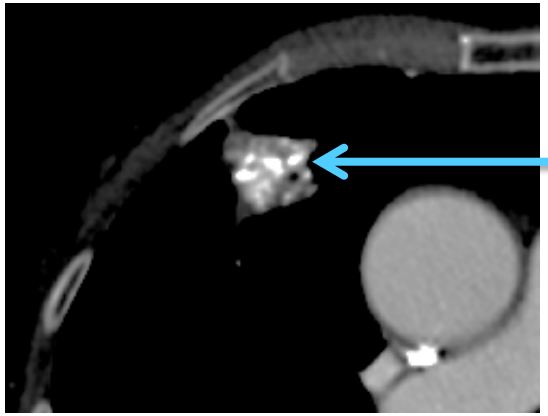
Amylosis

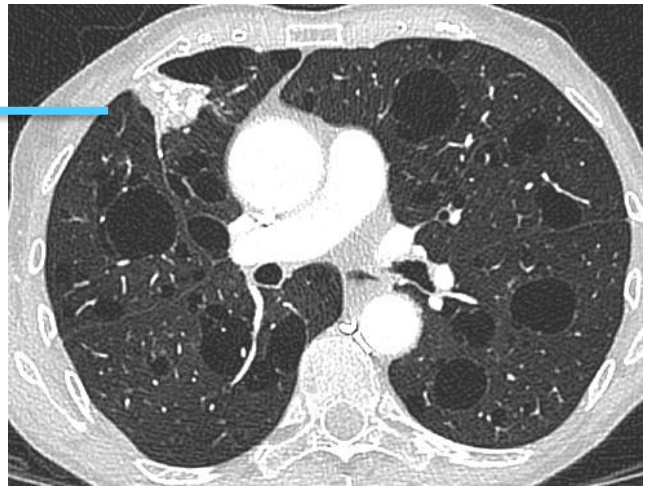
- **Extracellular tissue deposit : amyloid substance (fibrillar proteins)**
- Localized to a specific organ or systemic
- Biochemistry: 2 types: **AL (**Ig light chains) or **AA** (non-Ig protein)
- 2 forms
  - **Primitive amyloidosis (AL)**
  - **Secondary amylose**
    - Dysglobulinemia / myeloma **(AL)**
    - Chronic infection (tuberculosis), chronic inflammation (RA), tumour (Hodgkin's, deep cancer) **(AA)**

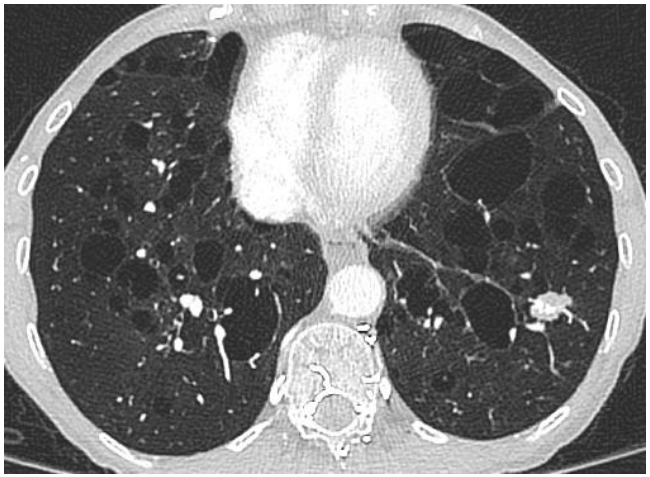
Tracheobronchial shape

Rare

- **Multiple small dispersed or confluent plaques**
- **Or diffuse damage**
- +/- stenosis
- +/- calcifications
- Trachea/ large bronchus
- **Circumferential ++**







Nodular amylosis

Elderly patients. Often isolated, often asymptomatic, good prognosis.

- **Solitary or multiple ++ nodule** size, shape, variable number (0.5 to 5 cm), peripherals, well defined contours, round/ oval/ lobulated
- **+/- Cysts**
- **+/- Calcifications** (central or irregular or cloudy) or ossifications
- Slow increase in nodule volume, no regression

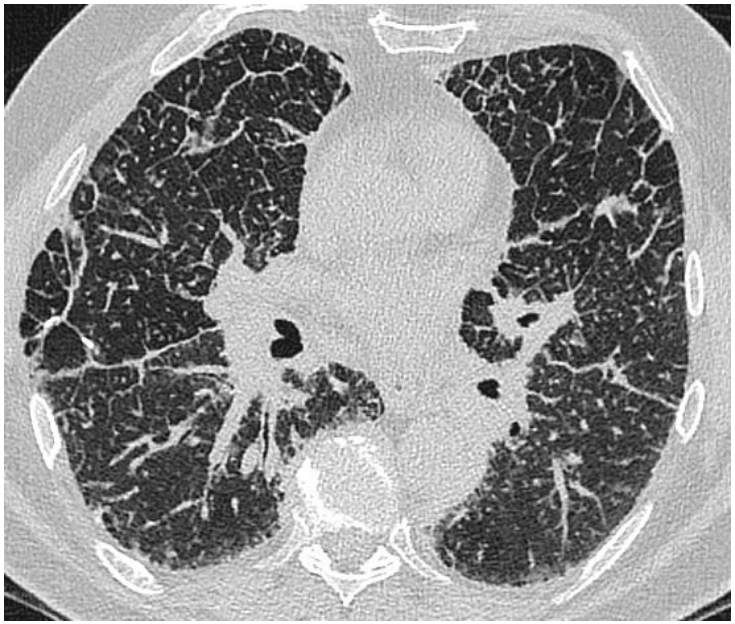
Biblio: Chest Imaging of Adults 3rd edition - edited by Philippe Grenier

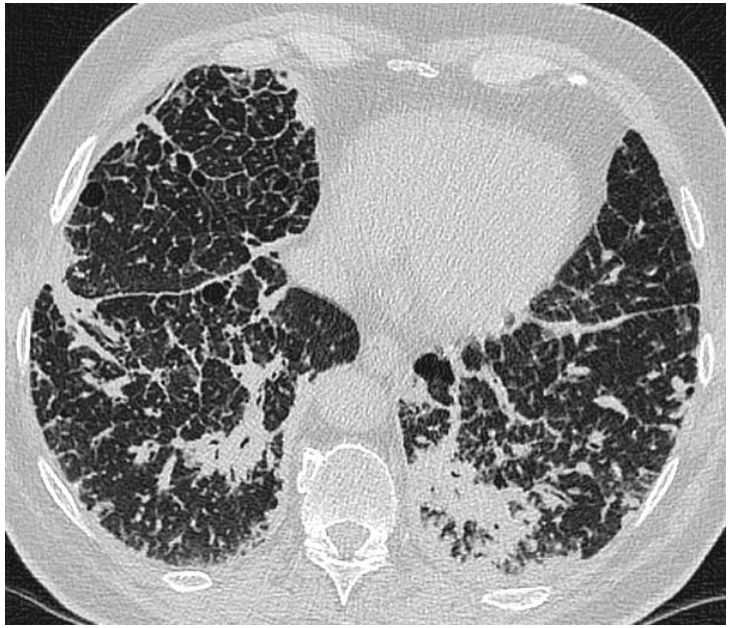
Diffuse pulmonary amylosis

Rare form

Latent, progressive dyspnea

- **Irregular thickening of interlobular septa**
- Intralobular reticulation
- Micronodules
- Consolidation
- Lower and sub-pleural regions of the lung
- +/- small foci of calcifications





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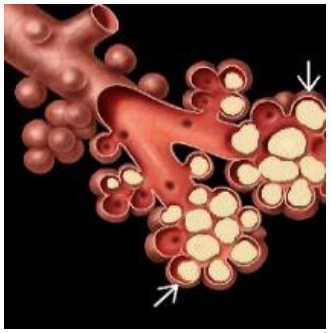
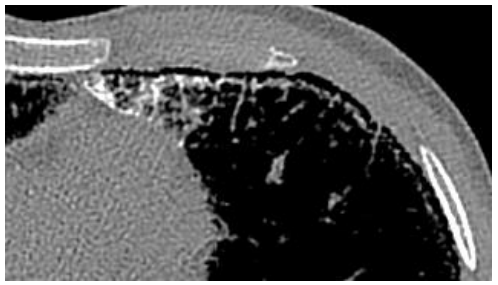
Alveolar microlithiasis

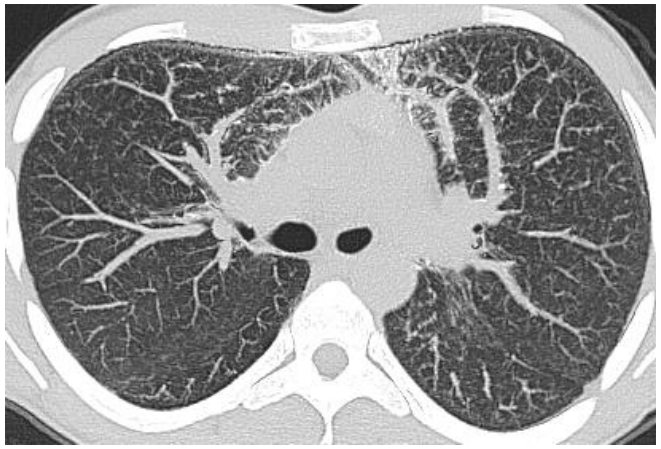
- **Alveolar calcospherite deposits**
- **Rare**, etiology unknown

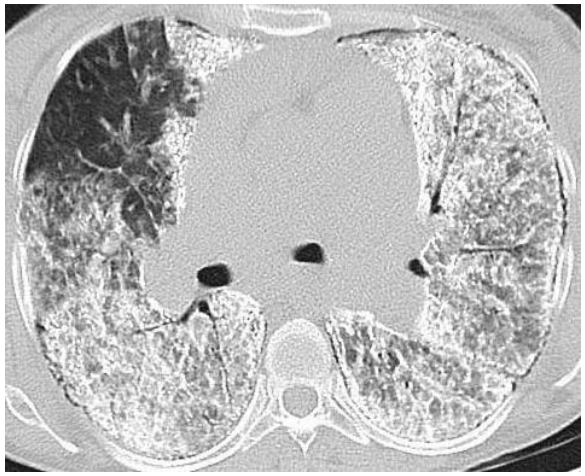


CT SCAN

- **GGO**
- **Micronodular calcifications +++**
  - Slight on ggo area
  - On the periphery of theSPL
  - **Subpleural cysts (black band)** (risk of pneumothorax)
- Distribution: 2 patterns
  - Peripheral and basal
  - Previous Regions







Case courtesy of Dr Dalia Ibrahim, Radiopaedia.org, rID: 47106

Differential diagnosis

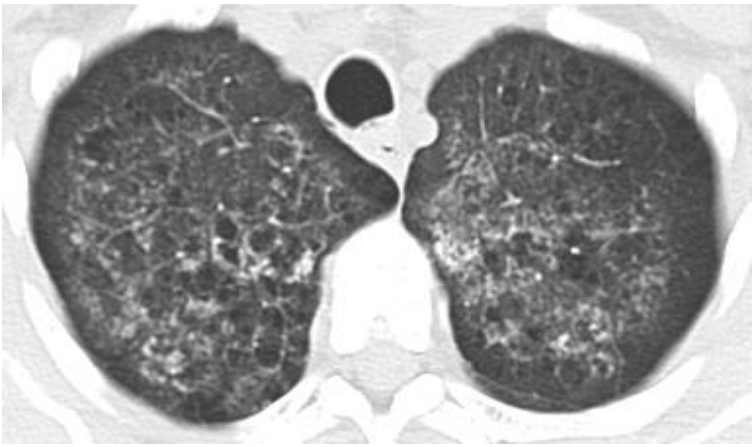
- **Metastatic pulmonary calcification** see next slide, larger calcifications, within GGO centrolobular, less well limited, upper areas
- **Idiopathic ossification:** elderly patients, dendritic ("coral") calcifications of the lower regions
- Talcosis, silicosis, sarcoidosis, amyloidosis, tuberculosis, mitral stenosis

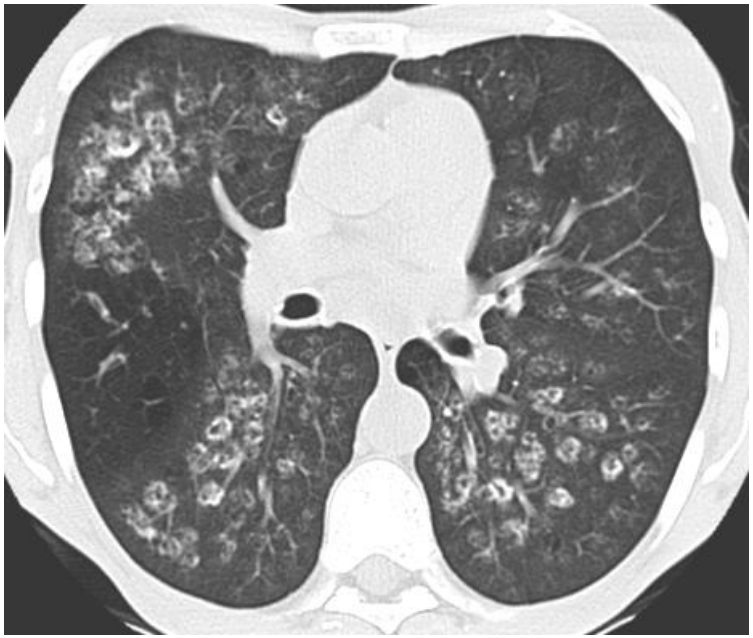
Metastatic pulmonary calcification

- ***Misleading term for*** *metastatic: these are not metastases but an accumulation of excess calcium in the lung.*

- **Secondary to a calcium homeostasis disorder**
  - Primary or secondary **hyperparathyroidism**
  - **Chronic Kidney Failure**
  - Calcitherapy
  - Myeloma
  - Multiple bone metastases

- CT SCAN:
  - **Calcifications** with densities greater than 100 HU in **GGO centrolobular glass hearths**
  - **Medium and apical** predominance

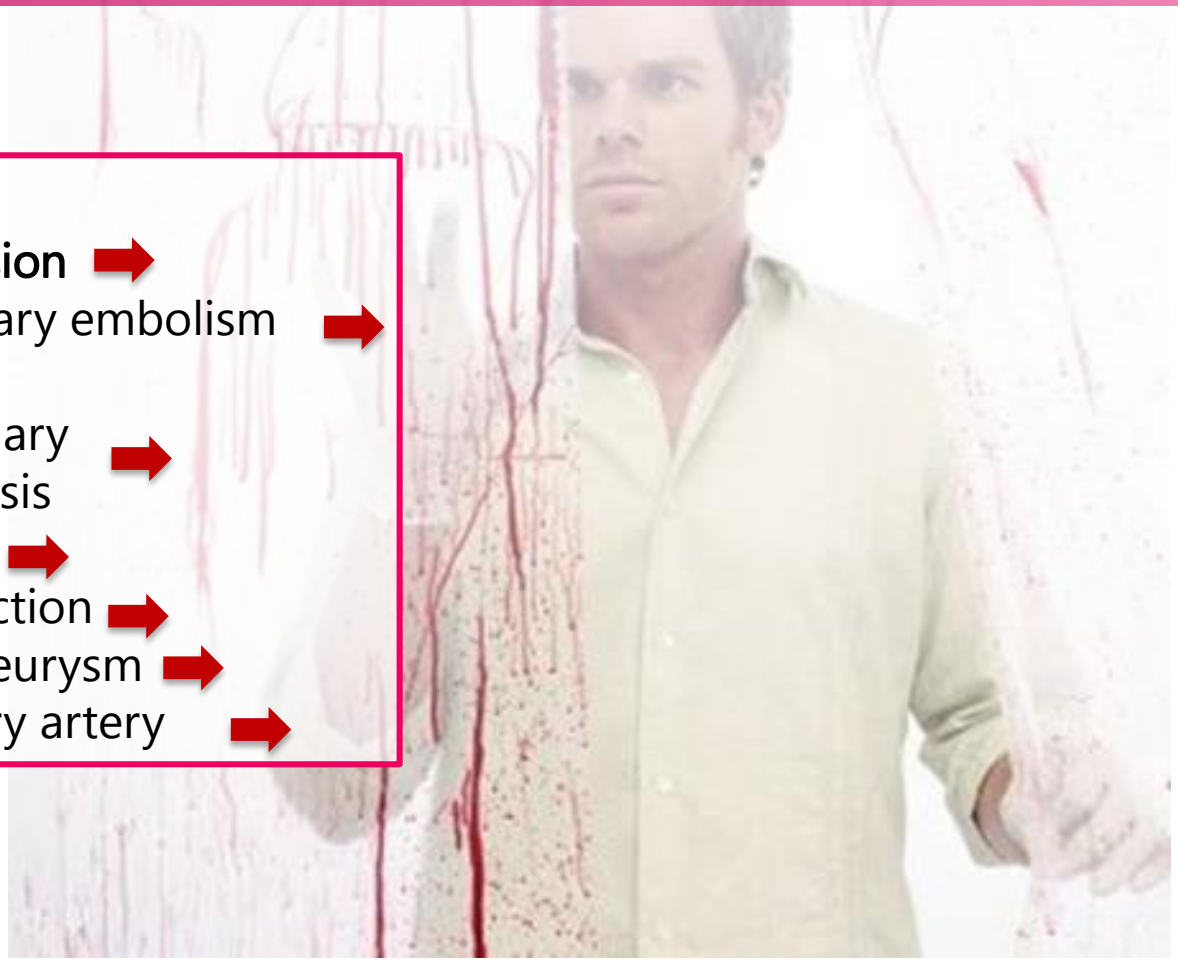




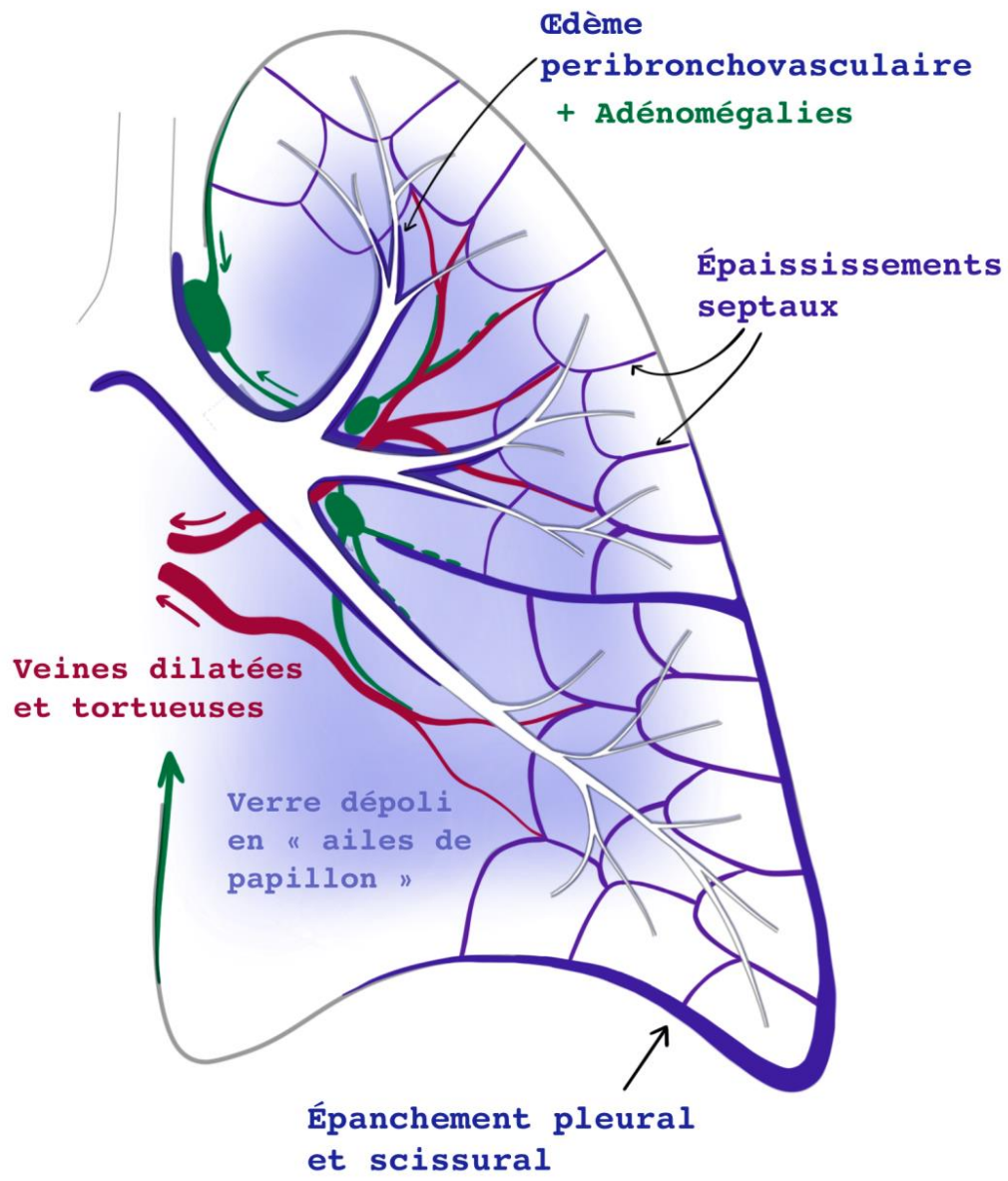
Case courtesy of Dr Alexandra Stanislavsky, Radiopaedia.org, rID: 10887

Cardio-vascular disease

- PO
- Pulmonary hypertension
  - Chronic pulmonary embolism
  - PVOD
  - Pulmonary capillary haemangiomatosis
- Pulmonary embolism
  - Pulmonary infarction
- Pulmonary artery aneurysm
- Stenosis of pulmonary artery

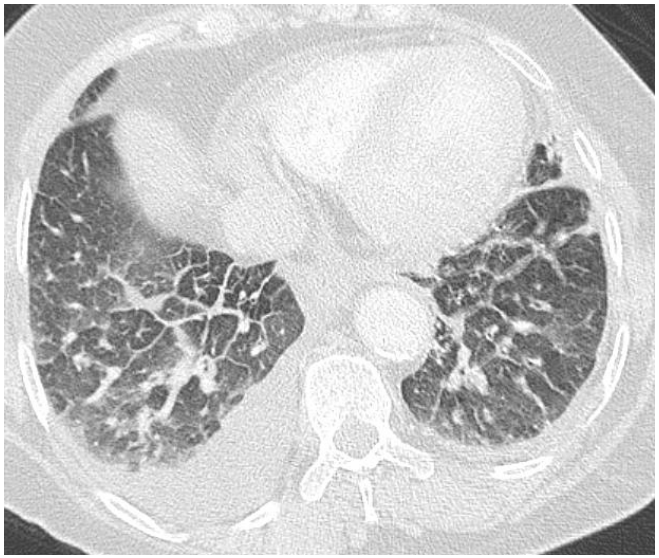


Œdème aigu du poumon

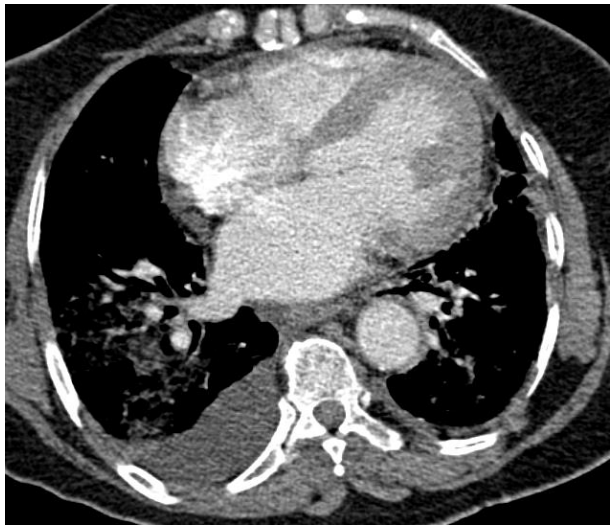


Imaging

- Alveolo-interstitial syndrom
  - **Interstitial syndrom: regular septal lines** (interstitial + chronic component)
  - **+/- Alveolar syndrom: GGO** (alveolar component visible in acute installation pulmonary oedema)
  - **Bilateral, symmetrical**, **peri-hilar "butterfly wing"** (sparing subpleura space because of resorption of the interstitial liquid by the pleura, absent in the acute stage before resorption).
  - **Posterior Slope Gradient**
- Associated signs
  - **Dilated tortuous veins**
  - **Pleural effusions**
  - Frequent hypodense **centimetric lymph node swollen** regressing after treatment
  - **Cardiomegaly** / left atrium dilatation / signs of heart disease

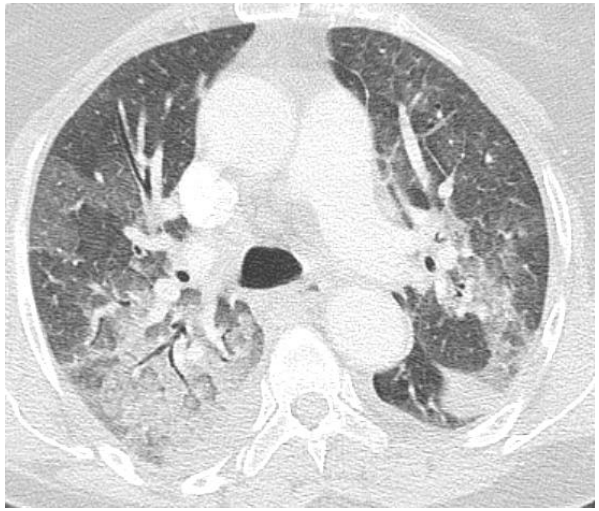


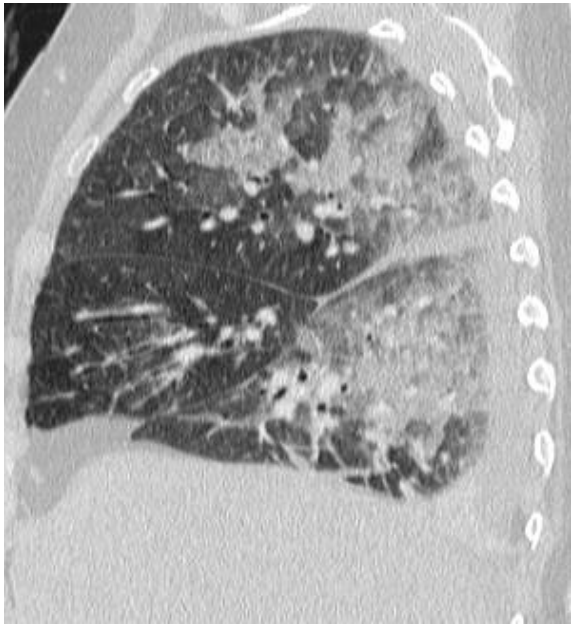
Interlobular septal thickening +++
(interstitial component)



Pleural effusion

Pulmonary Oedema
Alveolo-interstitial

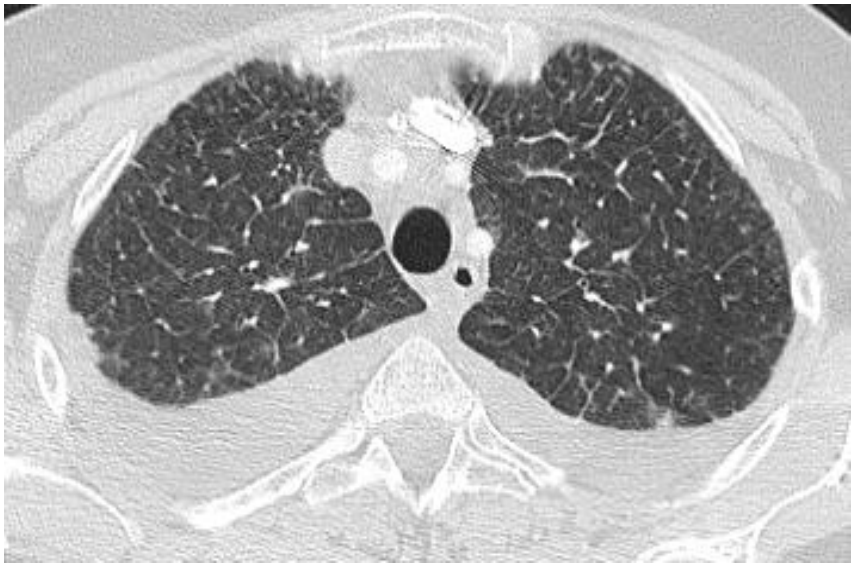


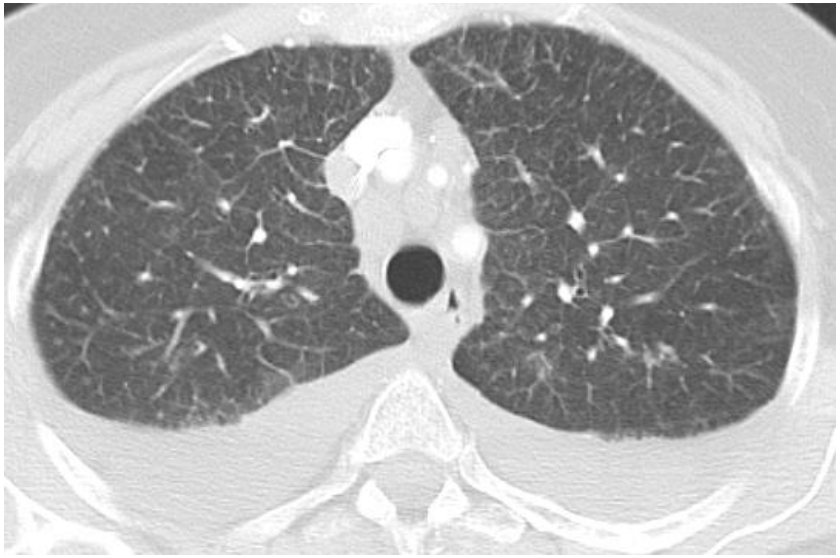


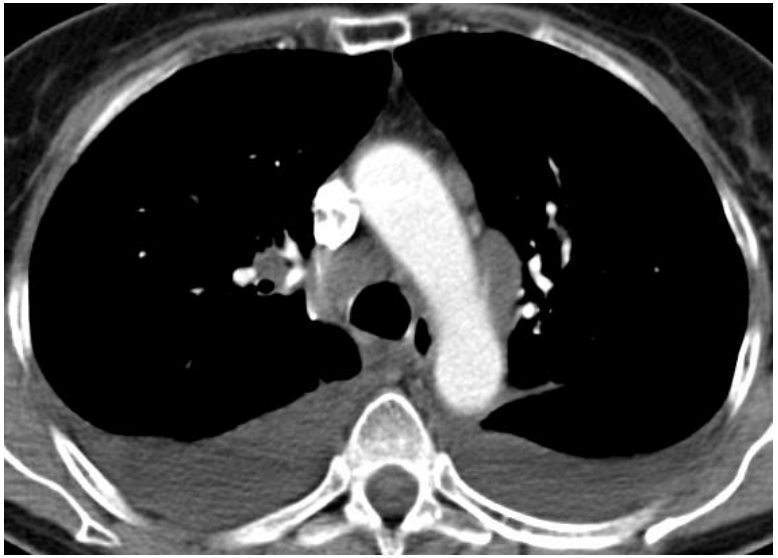
GGO +++
(Alveolar component)

PO

- **Thickening of septal lines**
- Diffuse **hypodense lymphadenopathy** related to heart failure







Other types of POs

High altitude mixed edema

- **Alteration of alveolar-capillary permeability** by **hypoxic vasoconstriction** and increase in capillary pressure
- 2-5 d, 4000 m, individual susceptibility
- Rapid improvement (downhill/O2)

Neurogenic mixed edema

- **Severe head trauma**
- Mechanism: **hydrostatic pressure increase++** and vasoconstriction PA + endothelial lesions
- Exclusion of other causes: cardiac infarction, inhalation, overload
- Imaging: Bilateral PO upper lobe.

Lesional edema without DAD

- Etiologies
  - Transfusions, drugs
  - Causes of ARDS: gas embolism, toxic shock.
  - Immunotherapy IL2
  - Infectious (hantavirus)
- **Hydrostatic edema** > ARDS

Focal pulmonary edema

- **Trap** (differential diagnosis with pneumopathy, infarction, inhalation)
- Observed in **RSL**
- In patients with **mitral insufficiency**
- (Flow directed to the right upper pulmonary vein)

Mixed edema by re-expansion *"a vacuo"*

- **Rare complication of re-expansion of the lung parenchyma after collapse** (fluid or gas effusion).
- Uncertain pathophysiology (mechanical factors, pro-inflammatory cytokines, altered capillary permeability)
- Risk factor
  - **Duration and extent of collapse**
  - **Rapid re-expansion of the lung**

Post-obstructive mixed edema

- Secondary to **upper airway obstruction**
- Misunderstood mechanism: ↓+++ P inspiratory (↑gradient transcapillary) + ↑ permeability
- **Laryngospasm ++** (during intubation or post-operatively after anesthesia), foreign body, strangulation

ARDS ➡

- **Increased capillary permeability** by **endothelial damage** associated with major lesions of the alveolar **epithelium**
- Imaging: see chapter ARDS

Pulmonary hypertension

- PH = **Average Pap > 25 mmHg at rest**
- Hemodynamic classification
  - *Hyperkinetics* (increased flow)
  - *Post-capillary* Pulmonary Arterial Hypertension (Papo augmentation): cardiac origin and pulmonary veins
  - *Post-capillary PH* (increased Rvp): respiratory system, pulmonary arteries
- Venice Classification 2003

Venice Classification

1/ PH-P ("proliferating")

- **Primitive**: sporadic or familial
- **Associated** (no pulmonary parenchyma involvement): anorexigenics, HIV, connective tissue diseases, portal hypertension, drugs...
- **Venous** (MVOP) or **capillary** (pulmonary capillary hemangiomatiosis) **abnormalities**
- Persistent hypertension of the newborn, congenital heart disease

2/ PH-VD

Left heart disease and valvulopathy

3/ PAH-pathology and/or hypoxemia

COPD, ILD, OSA, altitude, fibrosis, alveolar-capillary dysplasia

4/ HTAP-TED

Proximal or distal thromboembolic disease

5/ Miscellaneous PAHs (rare)

Sarcoidosis, histiocytosis X, pulmonary vessel compression (adenopathy, mediastinal fibrosis, tumour)

Poster "Pulmonary Arterial Hypertension: What role for the radiologist?
Lombard V, CHU Nancy-brabois, JFR 2010

Pulmonary hypertension

Positive diagnosis in CT scan

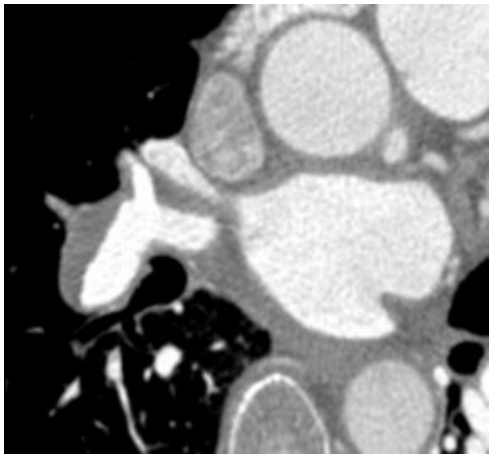
- PA diameter > 29 mm or > aortic diameter
- **Segmental branches > 1.1 x bronchial size** (3/4 lobes)
- Rapid reduction in arterial size
- Dilatation and hypertrophy RV
- Mosaic Perfusion
- Dilatation of bronchial arteries

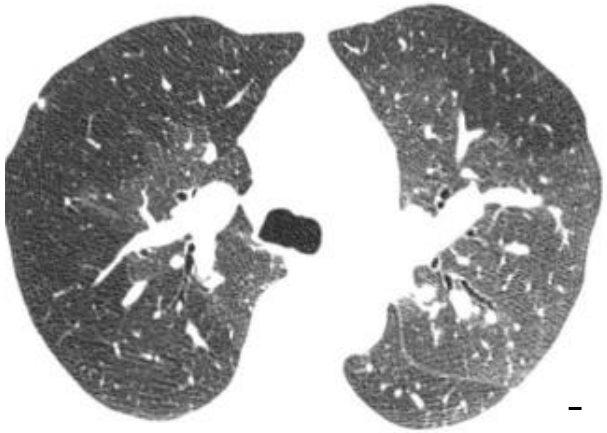
Confirmation by catheterization of the right cavities and evaluation of its pre- or post-capillary character.

Poster "Pulmonary Arterial Hypertension: What role for the radiologist?
Lombard V, CHU Nancy-brabois, JFR 2010

Chronic pulmonary embolism

Off-centre « marginated" thrombus





Pulmonary angio CT +++

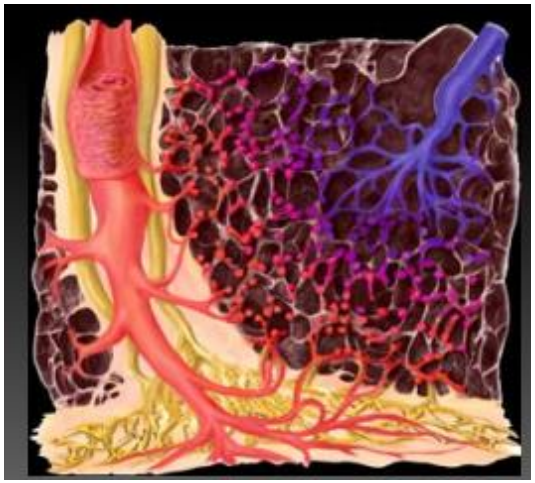
- HP
- Off-centre "parietalized" thrombus / eccentric thrombus+++
- pulmonary arterial bands/pulmonary arterial webs
- « Dead tree » appearance of the pulmonary arteries
  - By reduction of irregular caliber of occluded arteries
- +:- Calcifications
- Mosaic perfusion aspect +++
  - Alternating clear hypoperfused areas
  - And healthy hyperdense areas with large vessels++
  - No change in the expiration gradient

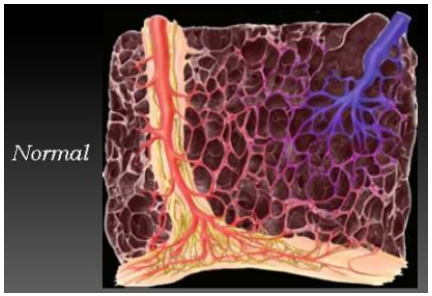
- Mosaic Perfusion
- « Dead tree » aspect

Poster "Pulmonary Arterial Hypertension: What role for the radiologist?
Lombard V, CHU Nancy-brabois, JFR 2010

PVOD : pulmonary Veno-Occlusive Disease

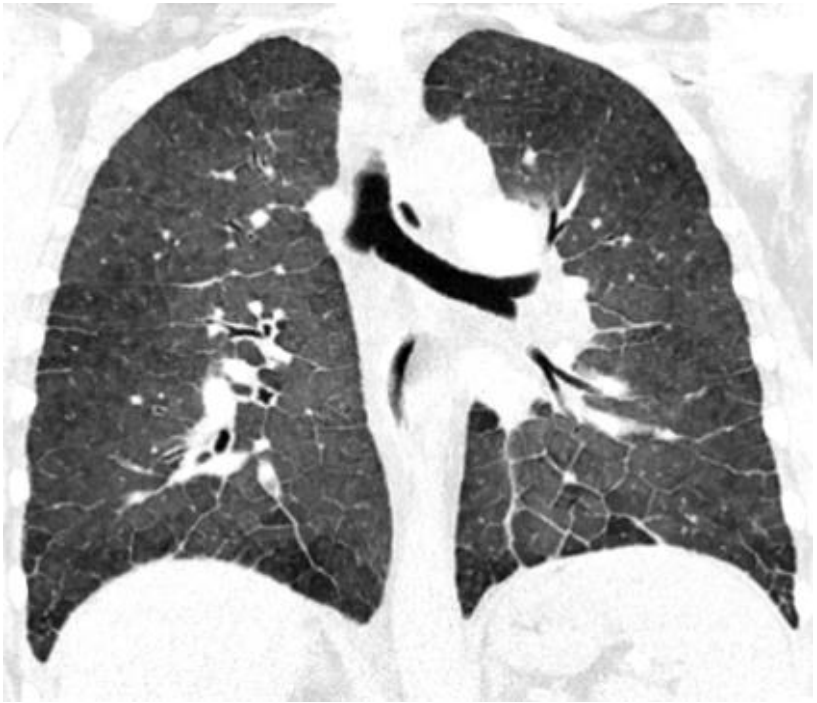
- **Child or young subject, rare**
- **Repeated thrombosis and fibrosis of pulmonary veins and venules, capillary proliferation**
- Sometimes combined with contraception, chemotherapy, BM transplant, autoimmune disease
- Clinic: Progressive dyspnea, PO





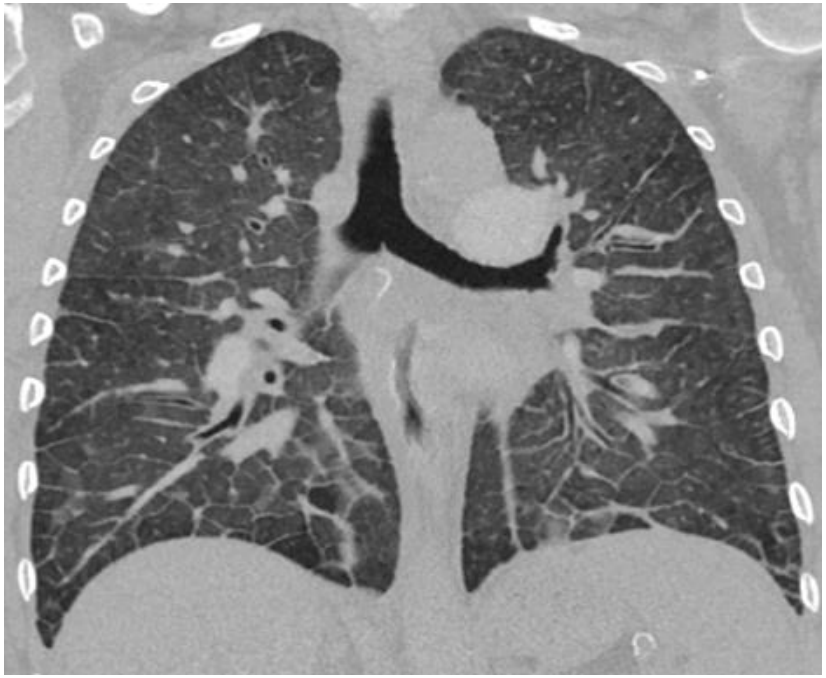
PVOD

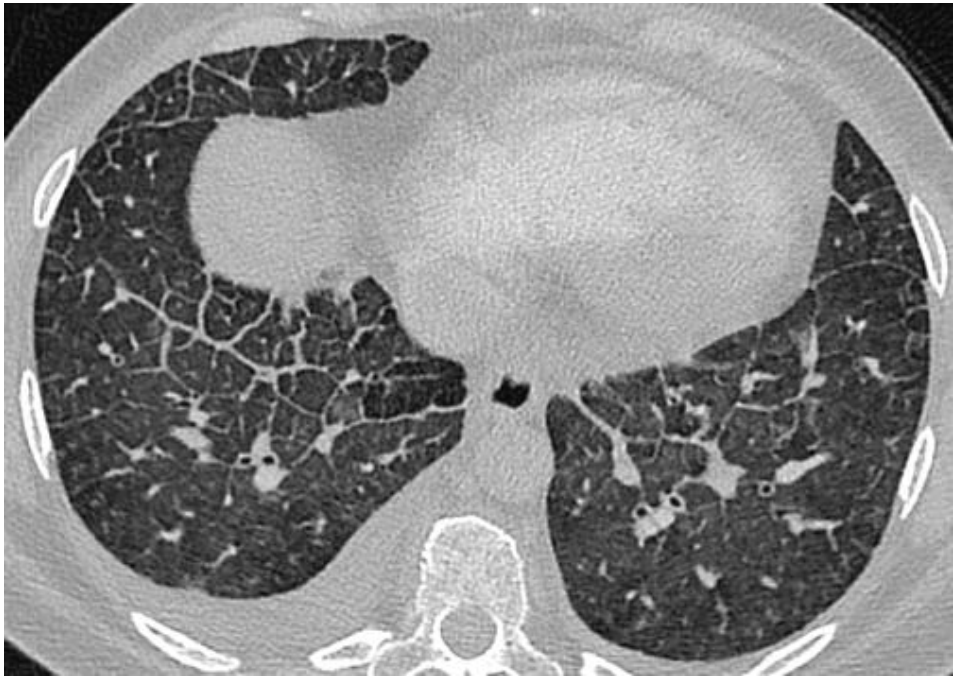
Imaging
- **Septal thickening +++**
- **GGO** (decompensation, advanced stage)
- **Lower and declining** regions
- Absence of left cardiac hypertrophy +++



PVOD and scleroderma

PVOD

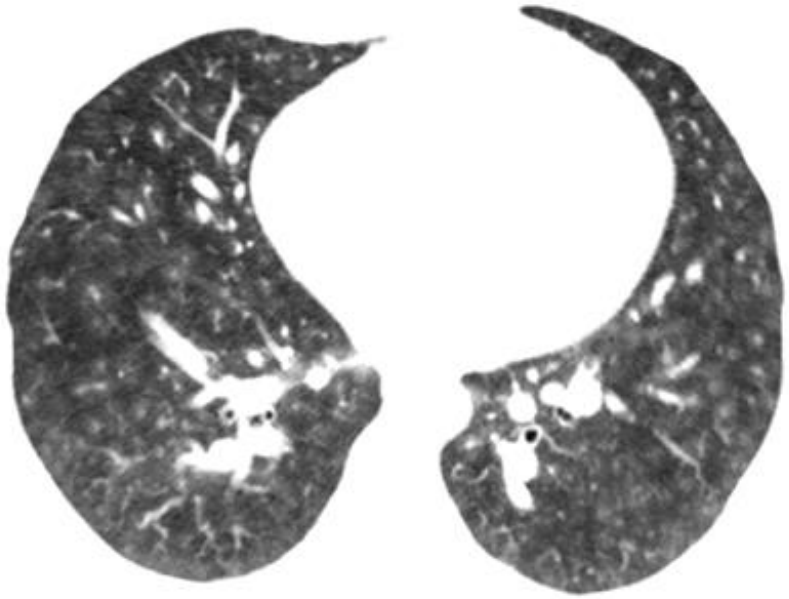


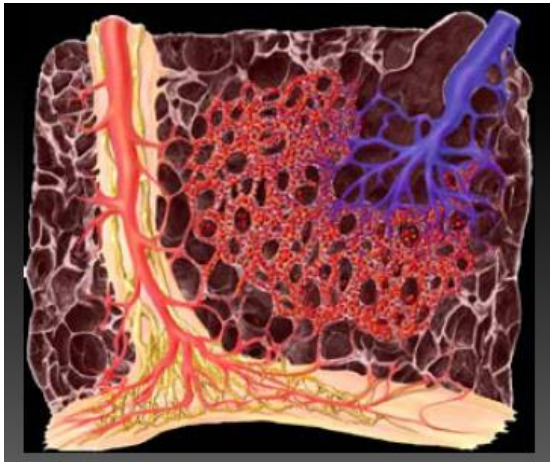


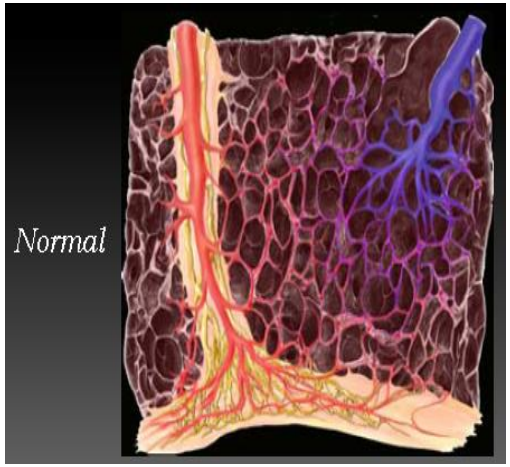
Septal thickening and **GGO of** post-capillary origin
+ no cardiomegaly
= PVOD

Pulmonary capillary hemangiomatosis

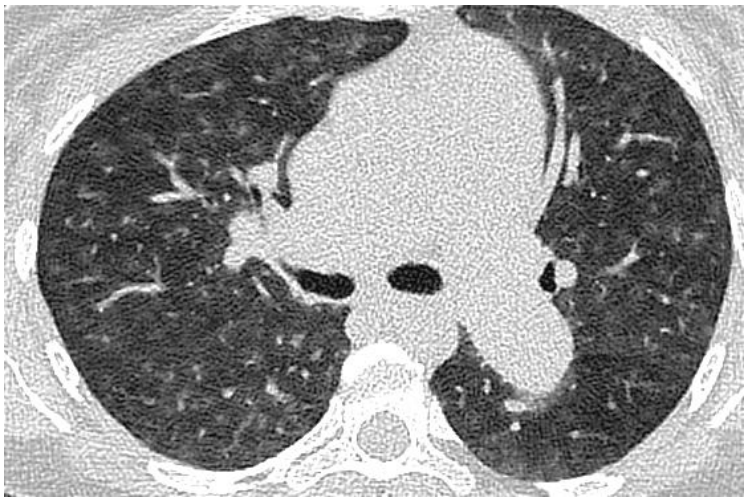
- Very rare
- physiopathology: **intralobular capillary proliferation in the foreground**



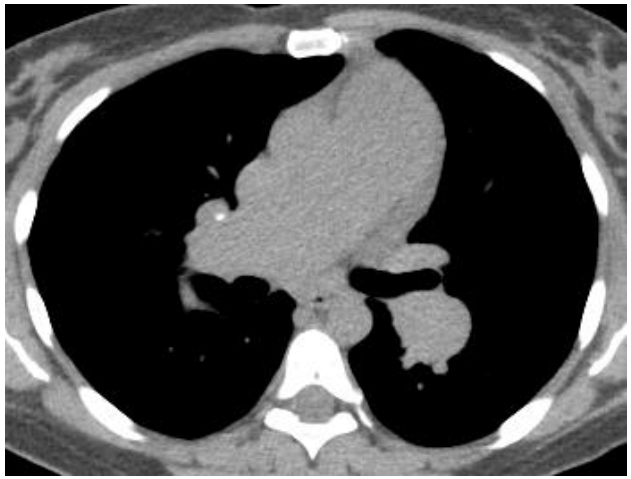


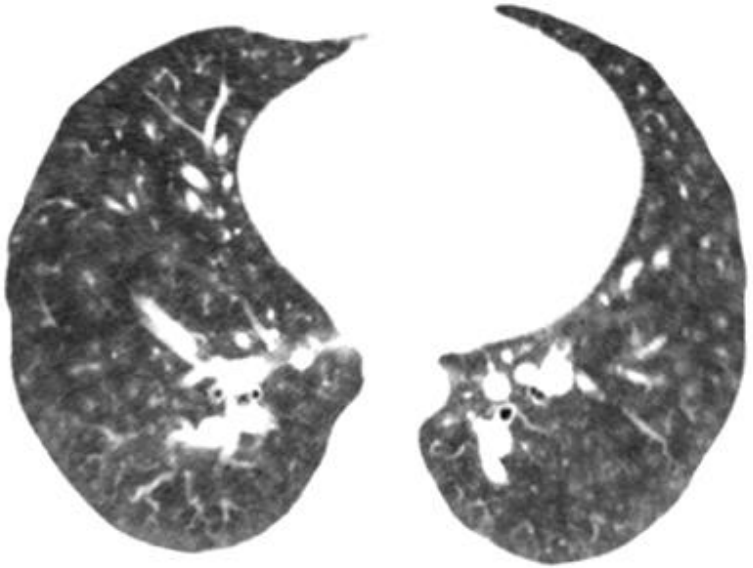


CT : ill defined **micronodules related** to capillary proliferation



Pulmonary capillar, hemangiomatosis *Centrolobular micronodules*



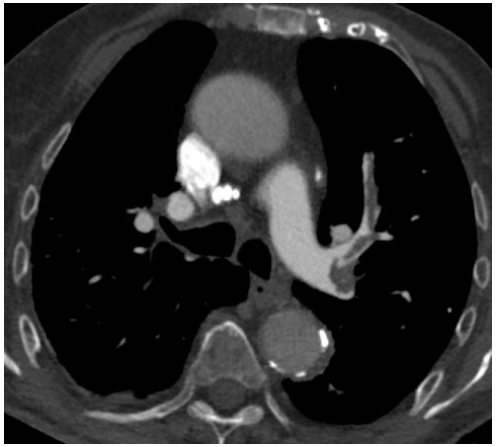


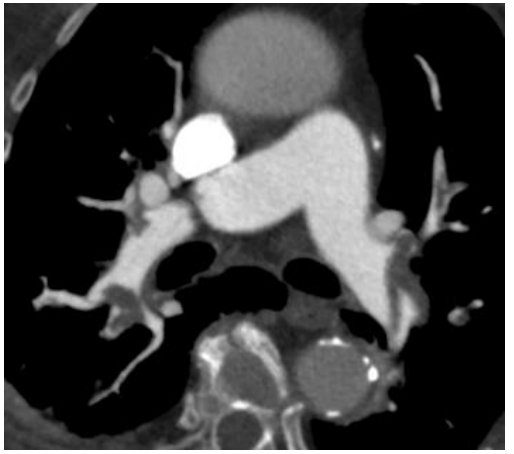
Pulmonary embolism

- **Occlusion of one or more pulmonary artery(ies) by fibrinocruoric thrombus**
- **3rd cause of acute mortality**
- Mortality: past medical history + right ventricular failure
- Morbidity: persistent right heart failure

Pulmonary angioscanner +++

- Direct signs
  - **Endoluminal defect of** the lobar arteries, segmental, sub-segmental...
- Indirect signs
  - **Pulmonary infarction**
  - Pleural effusion
  - atelectasis





Technique

- **Rapid injection** (> 4 cc/sec)
- and ROI of detection in the pulmonary artery or straight cavities (alternative: bolus test)

Interpretable if

Pulmonary artery trunk density **> 200 HUs**

Interpretable **sub-segmental arteries**

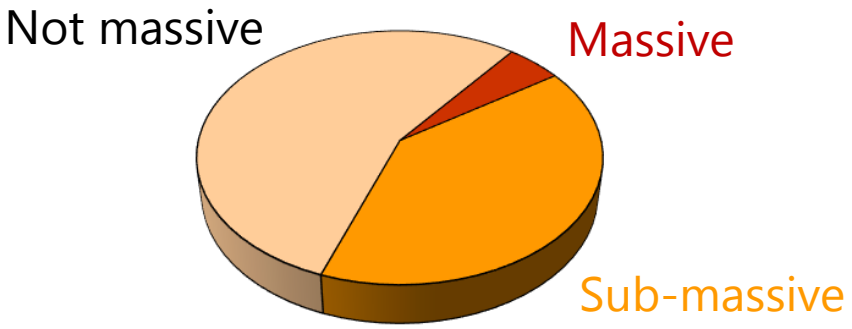
- *Stein PD, Woodard PK, Weg JG et-al. Diagnostic pathways in acute pulmonary embolism: recommendations of the PIOPED II Investigators. Radiology. 2007*
- *Wittram C, Maher MM, Yoo AJ et-al. CT angiography of pulmonary embolism: diagnostic criteria and causes of misdiagnosis. Radiographics. 2004*

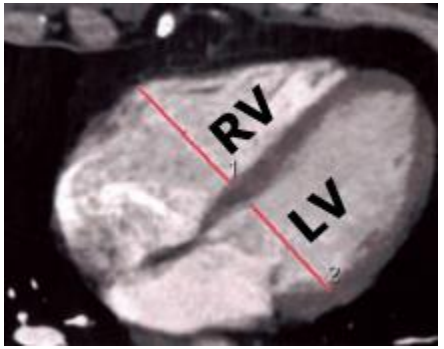
Risk stratification

- Non-massive EP
- **sub-massive EP**
  - RV Dysfunction
- **massive EP**
  - RV Dysfunction
  - Hemodynamic failure
  - **Intravenous thrombolysis**

RV Dysfunction
- **RV/LV ratio > 1**
- Biological criteria (BNP, pro BNP)
- and ECG

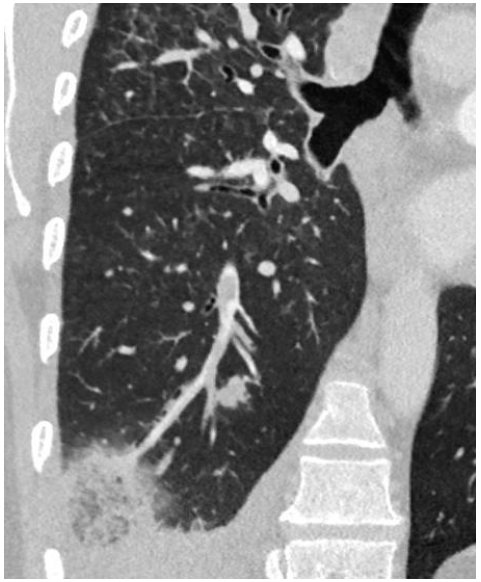
Always state the **RV/LV ratio** (calculated on a **strict axial section** and **endocardium to endocardium**) in the **report.**





Pulmonary infarction

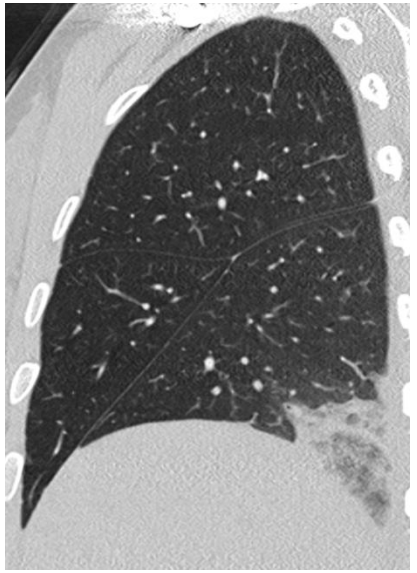
Heart attack:
<15% of embolisms

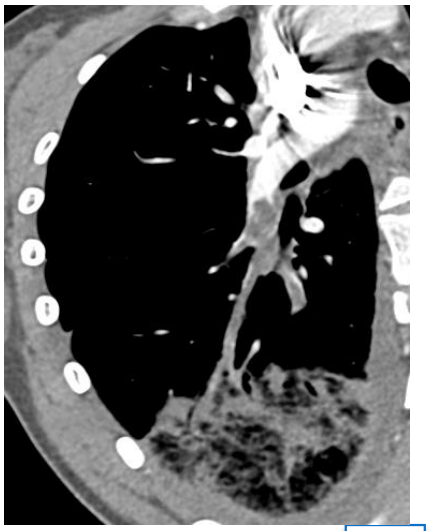


Imaging

- **Juxtapleural consolidation** without bronchogram
- **Triangular**
- **Central lucencies** : very specific for heart attack (Se:46%, Sp:98%)
- **Embolism** in the same territory, **feeding vessel**
- **Lower lobes** (more vascularized territories)
- **Multiple** ++
- +/- hypodensity and peripheral enhancement
- +/- convex edges with halo (alveolar hemorrhage)
- +/- excavation
- +/- minimal pleural effusion

Spontaneous resolution in 3 months (like a "melting ice cube")





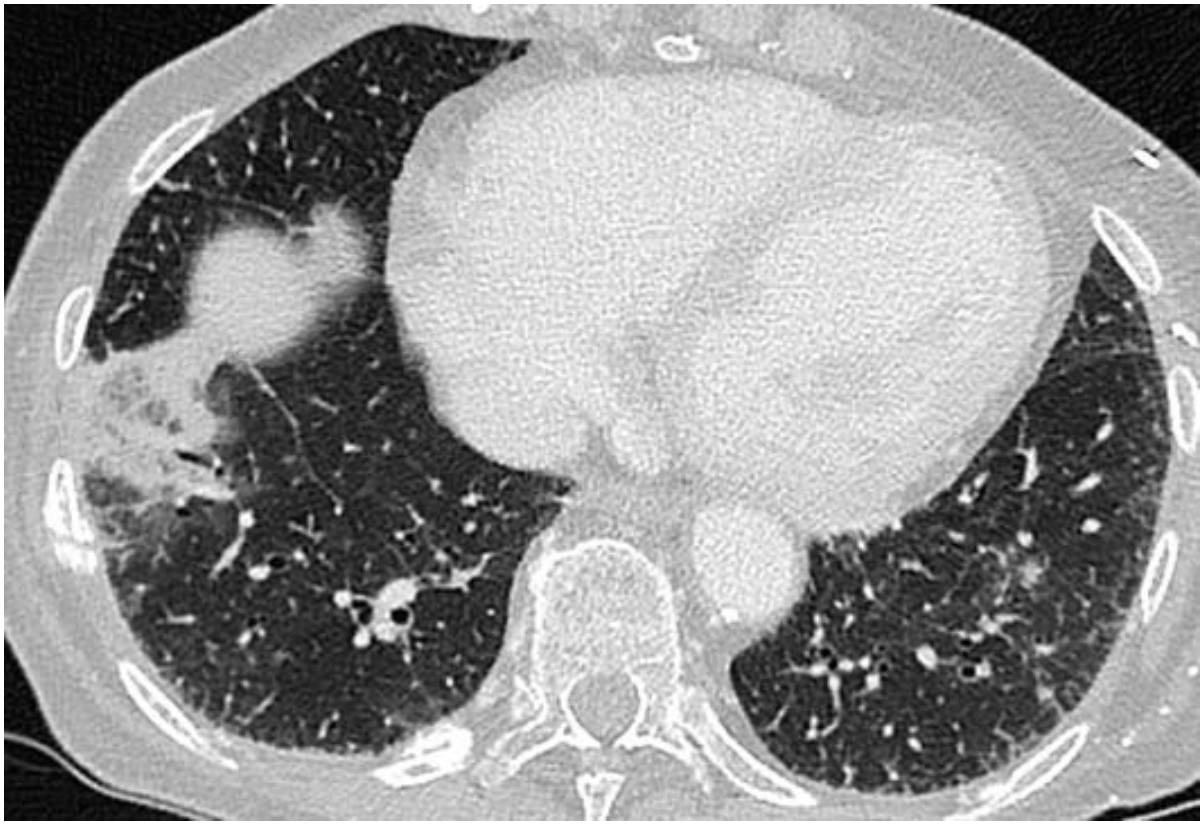
Pattern « central lucencies »

or "bubbly consolidation" in Anglo-Saxon)

- **Peripheral consolidation**
- **GGO and central intra-lobular thickening**

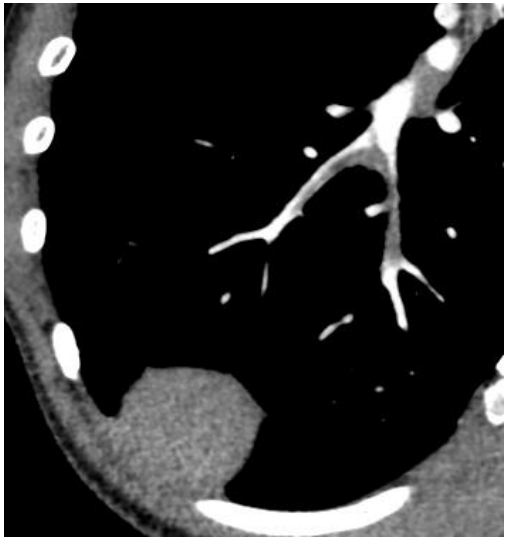
Reflex!
Triangle under pleural
+ **central lucencies**
→ Think of **pulmonary infarction**
→ Pulmonary angio CT

Revel MP, Triki R, Chatellier G, Couchon S, Haddad N, Hernigou A,et al. Is It Possible to Recognize Pulmonary Infarction on Multisection CT Images? Radiology 2007

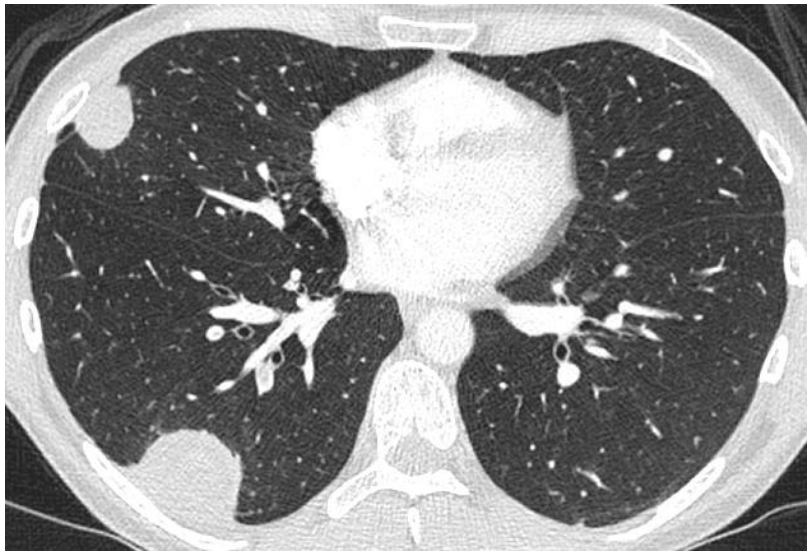


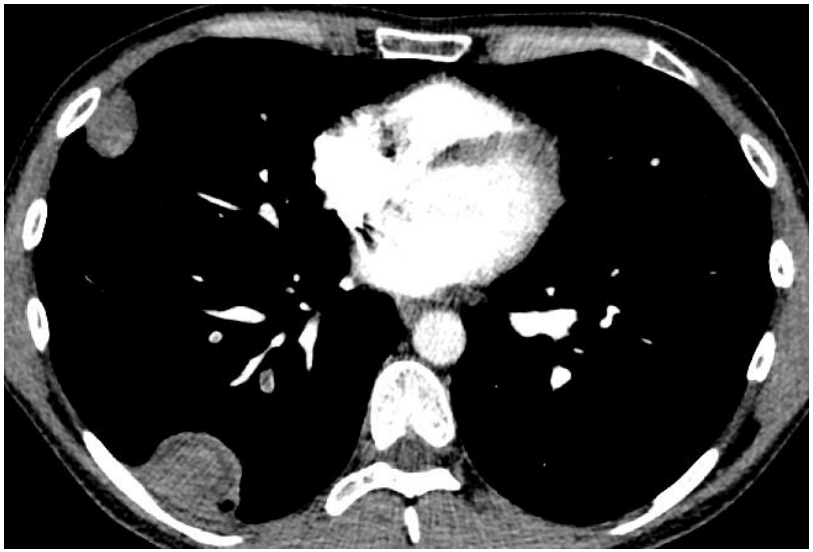
Pulmonary infarction with
« central lucencies » sign

Segmental embols



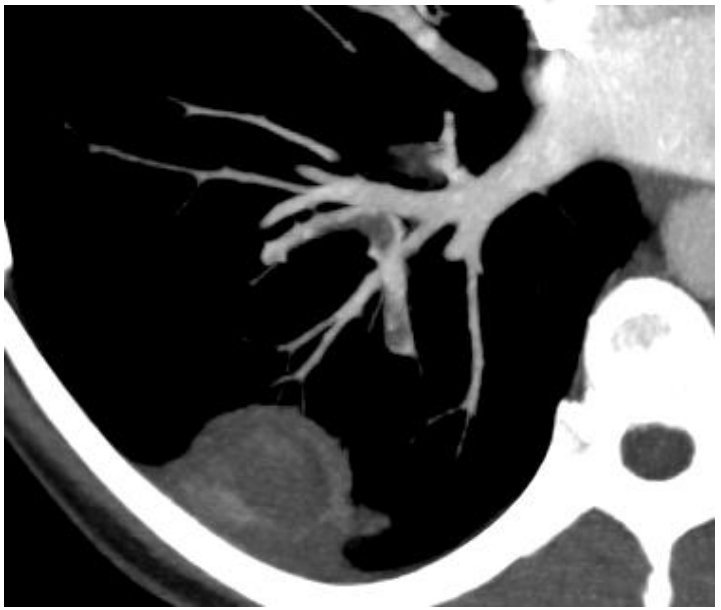
Atypical pulmonary infarction with convex edges ++





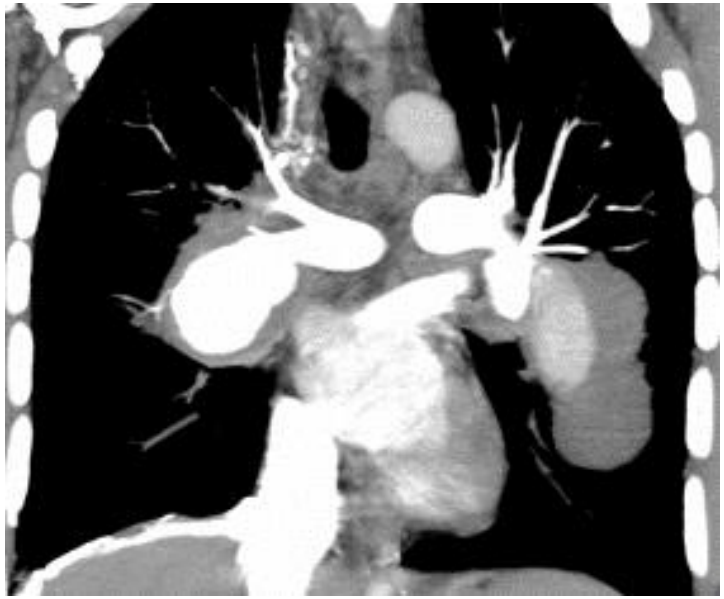
Feeding vessel sign

- A central vein ⇨
- the arteries bypass ⇨



Pulmonary artery aneurysm

- Normal diameter of the PA = 29mm
- **Aneurysm if diameter increases by more than 50%.**



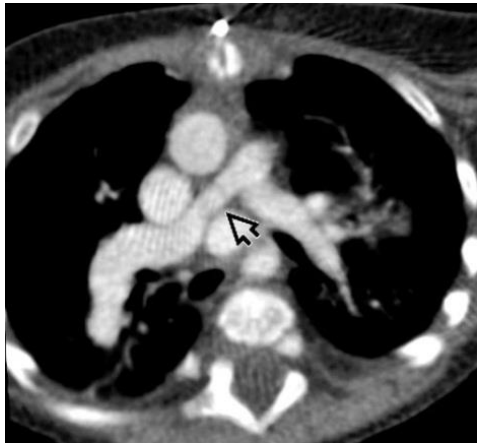
Case courtesy of Dr Ahmed Abd Rabou, Radiopaedia.org, rID: 32749

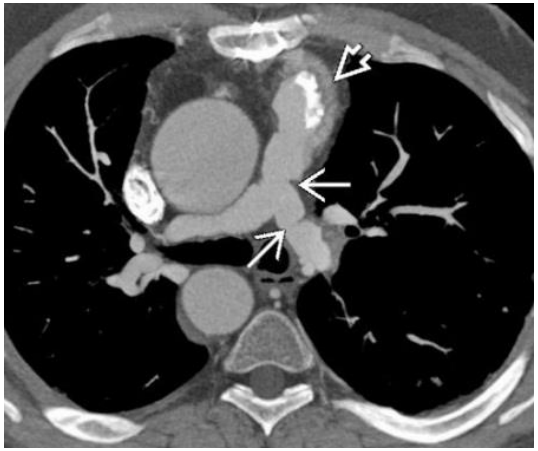
Etiologies

- **Post Pulmonary Hypertension++**
- Primitives
  - **Elastic Tissue Disease**: Marfan, Ehlers Danlos, Williams-Beuren Syndrome
  - **Infectious disease**: Infectious endocarditis, mycotic aneurysm, syphilis, necrotizing pneumonia
- Secondary
  - Venous thrombo embolic disease
  - Shunt left / right

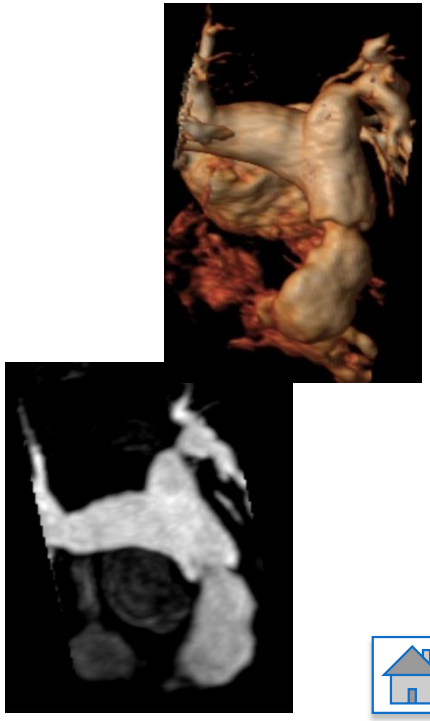
Stenosis of a pulmonary artery

- Congenital pathology
- Often associated with congenital heart disease
- Differential diagnosis: **acquired stenoses**
  - chronic PE
  - Vasculitis (Takayasu, Connectivitis, Behcet's, Wegener's, allergic vasculitis)
- Treatment: surgical revascularization or angioplasty/stenting





Imaging
- **Stenosis**
  - ***Focal***
  - ***Long***
- **Post-stenotic dilation**
- **Aorto-pulmonary circulation**
- Normal size heart



Congenital interruption of a pulmonary artery

- **Left ++**
- X-ray: **small hemithorax** with **small hilum** and contralateral aortic arch.
- Scanner
  - **Absence of pulmonary artery**
  - Normal Bronches
  - **Hemithorax volume reduction**
  - **Collateral circulation**
  - Extrapleural fat hypertrophy
  - Pleural thickening
  - Peripheral interstitial syndrome, subpleural parenchymal bands, mosaic
  - Bronchiectasis (complication of infection)

Infectious diseases

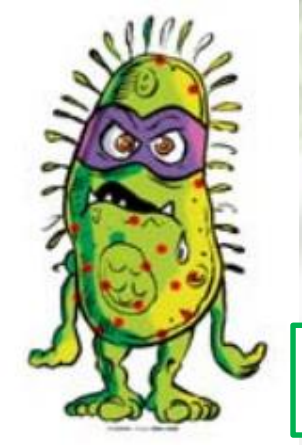
Main syndrom
- Lobar pneumonia
- Bronchopneumonia
- Interstitial lung disease
- Pulmonary abscess
- Septic embolism

Viral infections
- Influenza
- Measles
- CMV
- VZV
- COVID 19

Fungal infections
- Aspergillosis
  - Aspergilloma
  - ABPA
  - Chronic Necrotizing Asp.
  - Invasive aspergillosis
    - Broncho-invasive
    - Angio-invasive
- Candidiasis
- Cryptococcosis
- Histoplasmosis

Parasites
- Hydatid cyst
- Paragonimiase
- Other parasitic diseases

Bacterial damage
- Tuberculosis
  - Primary
  - Post-primary
- Atypical Mycobacteria
- Pneumocystis
- Legionella
- Nocardiosis
- Actinomycosis
- Leptospirosis



Immunocompromised infections
- Lung infections **HIV**

Lobar pneumonia

Histology

Alveolar filling (inflammatory exudate)

Germs

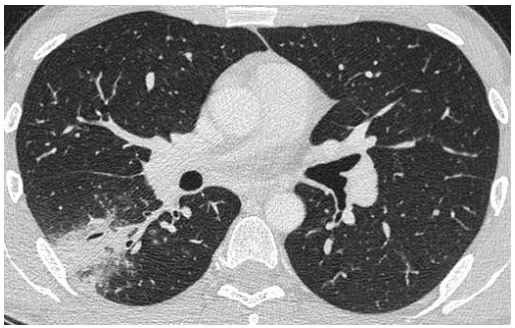
- <u>Acute community lung disease</u>
  - **Pneumococcus** (++++, extreme ages, post-influenza, HIV, chronic alcoholics, asplenia)
  - ***Klebsiella*** *(diabetics, alcoholics, aspiration, edema, excavation)*
  - ***Legionella*** *(2-15% CAP, mortality 10%, male, > 60 years, chronic lung disease, immunodepression, inhalation aerosols)*
- <u>Similar aspects</u>
  - Atypical germs (*mycoplasma*, *chlamydia*)
  - BGN: *pseudomonas*, *enterobacter*, *E.Coli* (nosocomial++)
  - G+: Community *Staphylococcus aureus*
- <u>Immunosuppressed</u>
  - Pneumocystis, fungal, mycobacterium

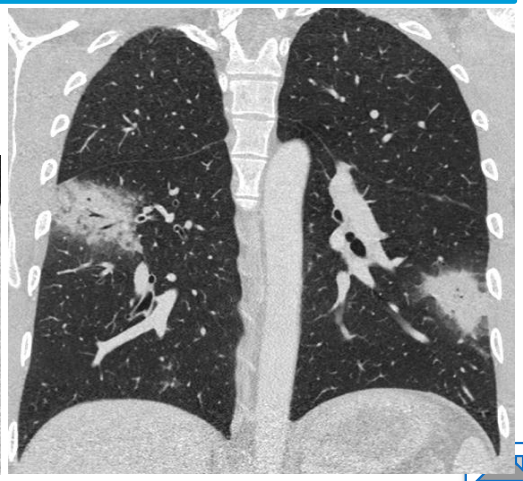
Imaging

Lobar consolidation syndrom

- Peripheral start, rapid extension

- <u>Round Pneumonia</u>
  - May look like a nodule/mass
  - **Child +++** but also in **young adults**
  - Pneumococcus ++
  - If signs of infection -> control after treatment TBA ->stable: biospy
- <u>Interest of imaging</u>
  - Positive diagnosis, prognosis (unilateral vs. bilateral), post-treatment follow-up +++
  - Low for etiological diagnosis





Broncho-pneumonia

Histology

- **Airway-centric lesions**
- **Plurifocal ++**
- **Alveolar damage ++**, more virulent organisms (lung destruction ++)
- Nosocomial > CAP
- Slower expansion

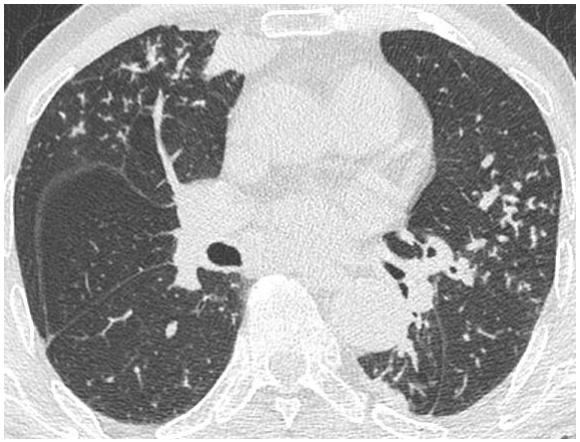
Germs

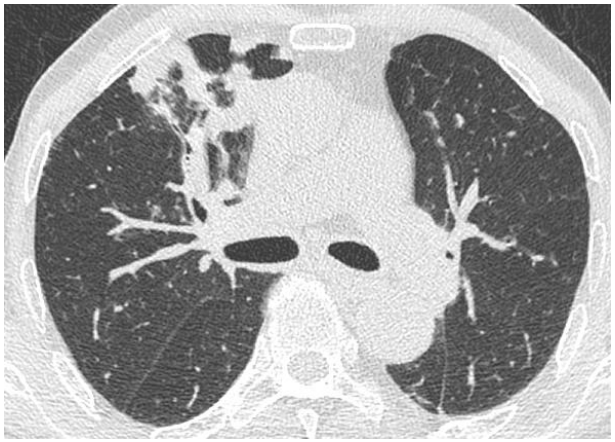
- *Staphylococcus aureus*
- *Haemophilus*
- *BGN (pseudomonas aeruginosa, Escherichia coli)*
- *Anaerobes*
- *Invasive aspergillosis*

If hospital-acquired infection
BGN: *Pseudomonas aeruginosa, E Coli*

Imaging

- Bilateral multifocal alveolar consolidation
- Bronchitis / Bronchiolitis
  - Bronchial parietal thickening
  - Centrolobular nodules
  - Tree in bud





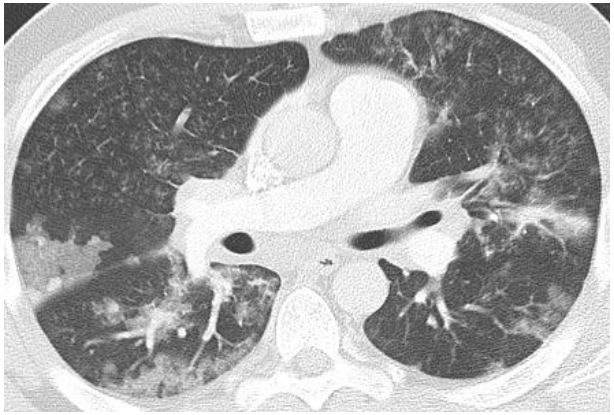
Interstitial lung diseases

Histology

- Inflammation by mononuclear cells
  - **alveolar *septa*: alveolitis**
  - And **distal peribronchovascular interstitial tissue**
- Minimal alveolar damage
- **Bronchiolitis often associated** (mycoplasma, virus)

Interstitial syndrom +++

- **GGO**
- **Reticulations**
- +/- tree in bud
- +/- consolidation



Differential diagnosis

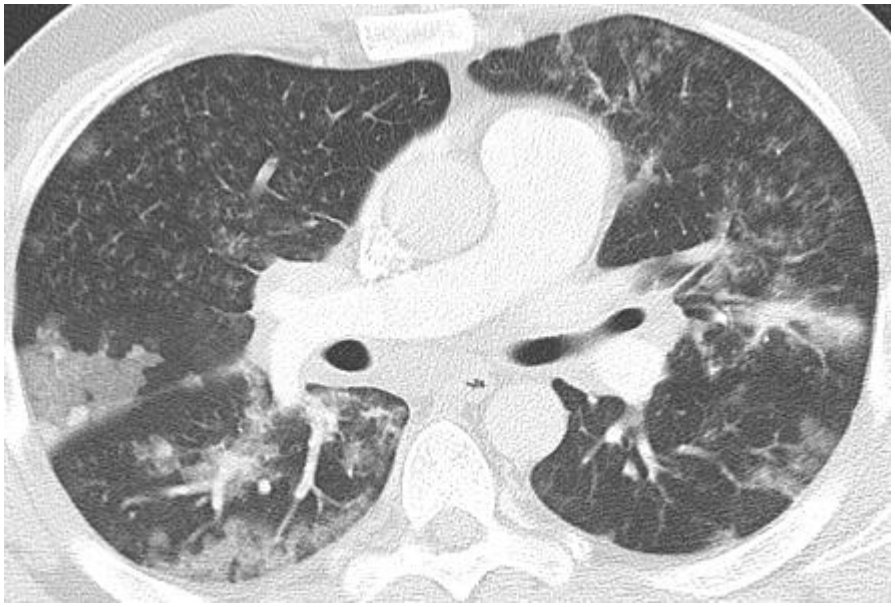
- Pn. Med
- PO
- Pulm Hg
- OP
- HP

Germs

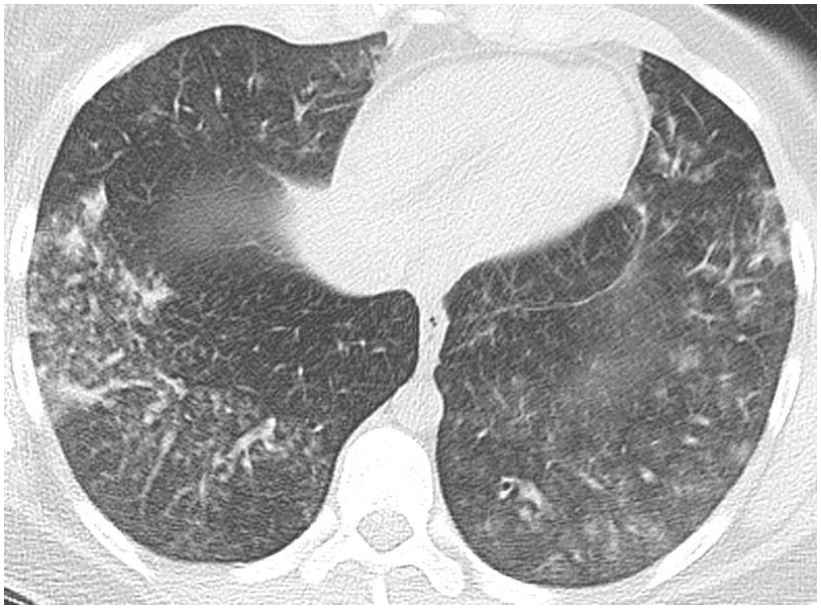
- **Virus +++**
- ***Mycoplasma***
- ID pneumocystis, CMV, mycoplasma

Cause of Pneumonia	Centrilobular Nodules	Attenuation with Lobular Distribution	Segmental Consolidation	Thickened Interlobular Septa	Diffuse Ground-Glass Attenuation
Influenza virus	+++	+++	+	. . .	+
Measles virus	++	+	+	. . .	+
Hantavirus	. . .	. . .	++	+	+++
Adenovirus	++	+	+++	. . .	. . .
Herpes simplex virus	+	+++	+++	. . .	+
Varicella-zoster virus	+++	+	. . .	. . .	. . .
Cytomegalovirus	++	++	+	+	++
Epstein-Barr virus	+	+	+	. . .	+

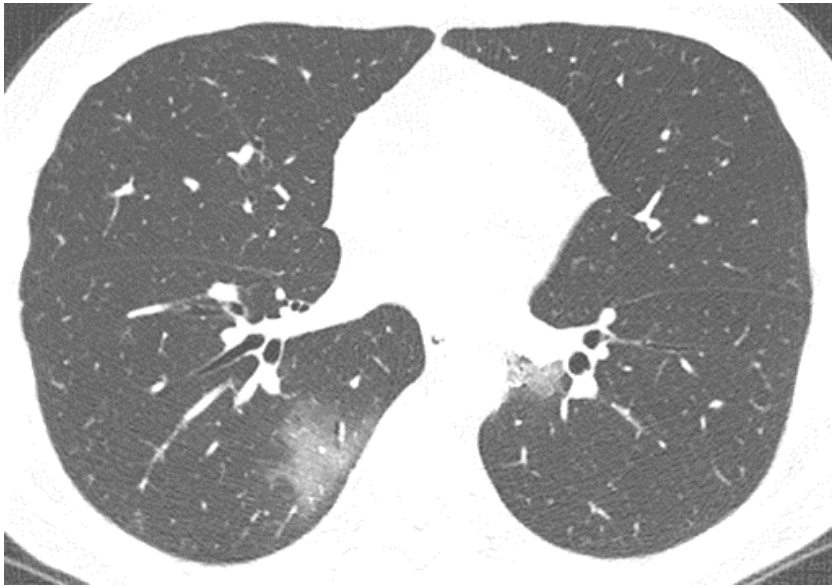
Interstitial / atypical pneumonia

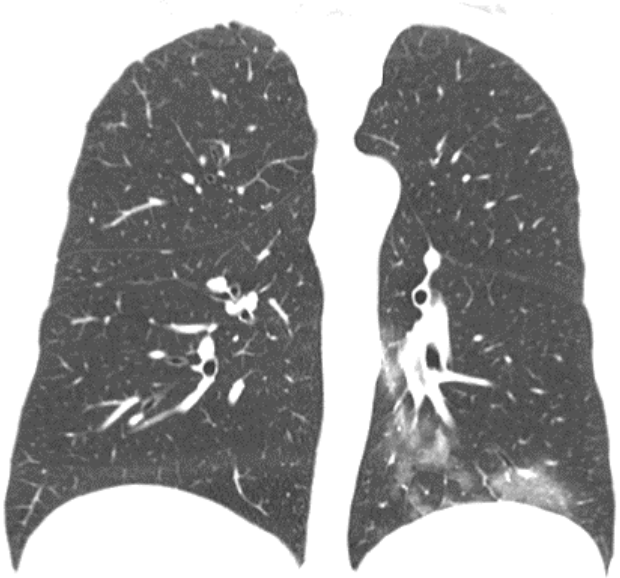


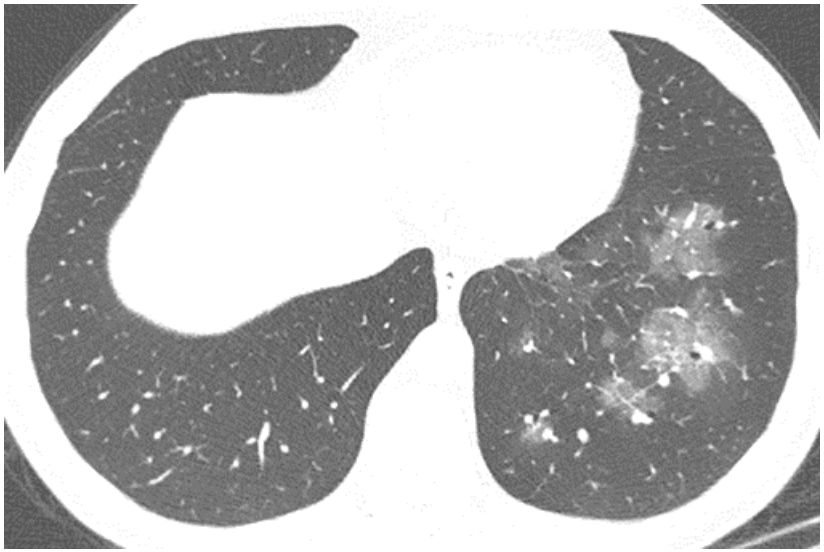
TBA-resistant atypical pneumonia
No germ found

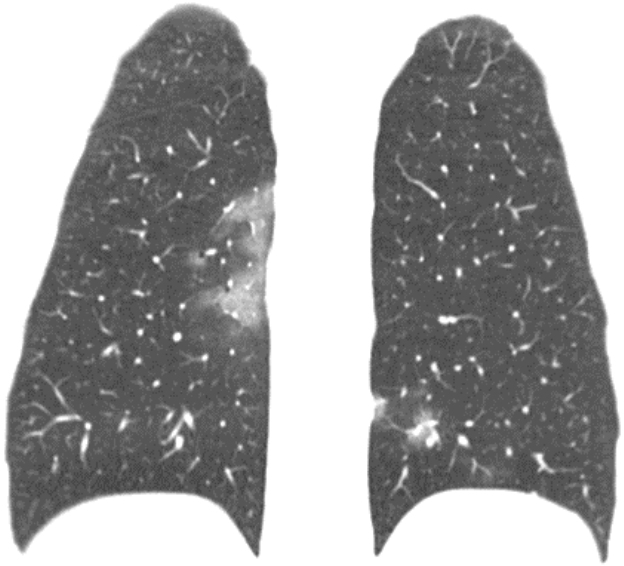


Mycoplasma

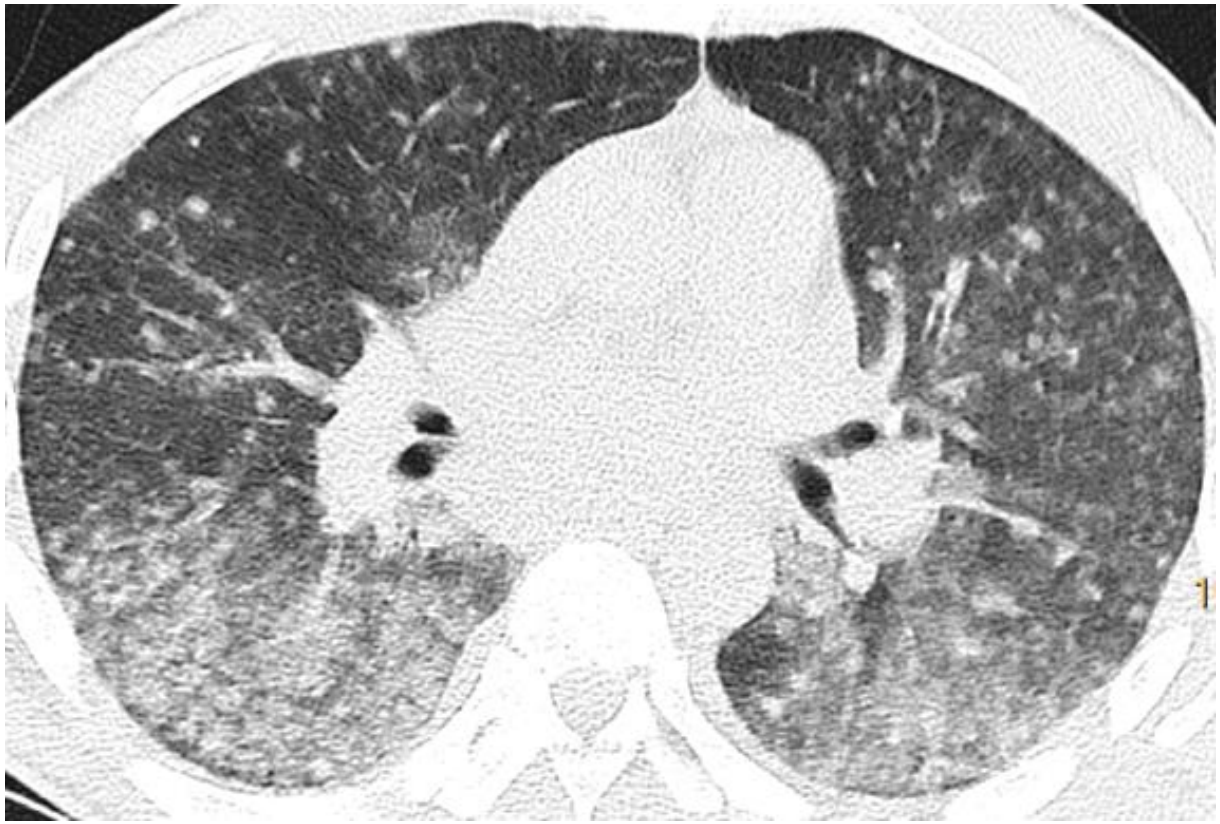








Coronarovirus infection (Covid 19): GGO areas of lower distribution



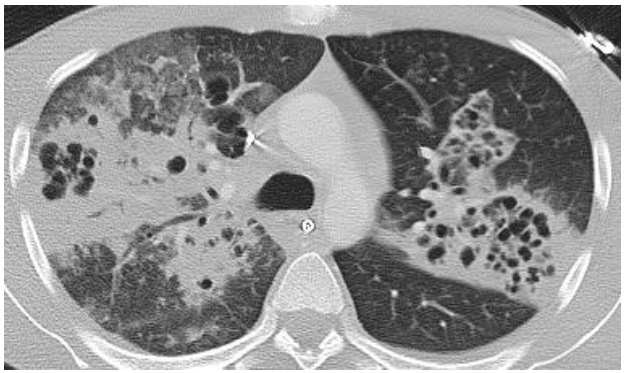
Varicella pneumonia

Multitude of ill defined, randomly distributed micronodules, confluent in the declining regions

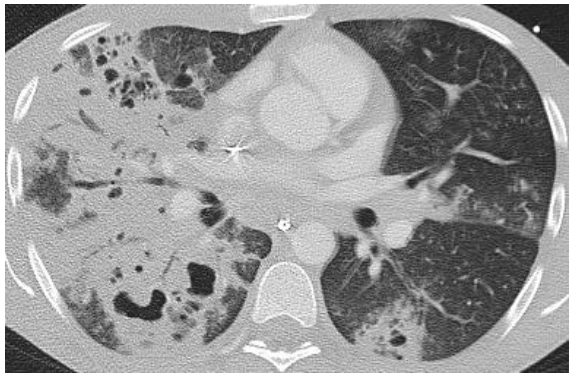
Suppurative pneumonia

Several pattern

- **Excavated lung disease**
  Excavated consolidation ranges
- **Pulmonary abscess**
  Unique, air-generated, sloping, posterior
- **Lung Gangrene**
  Ischemic necrosis of a territory
- **Septic emboli**
  Multiple, disseminated, hematogenous
- Complications
  - **Broncho-pleural fistulas**
    Ruptured necrotic lesion in the pleura
  - **Empyèmes**
    By Pleural Suppuration



Pulmonary Staphylococcal Disease



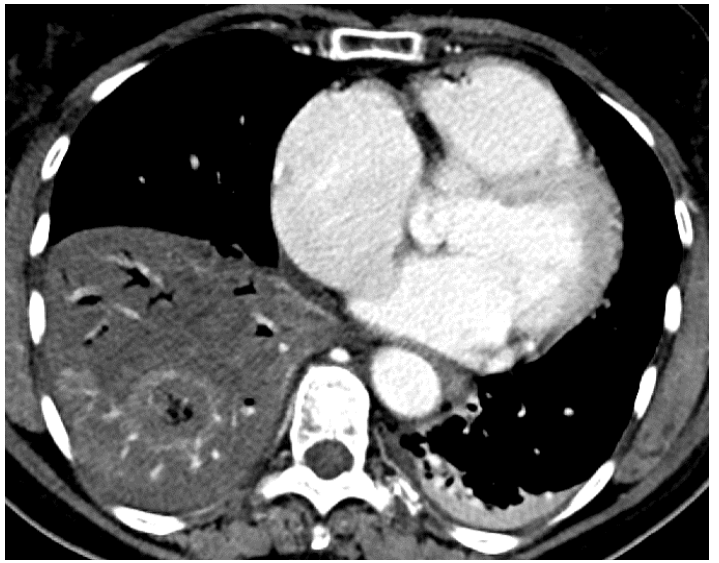
Frequent germs

- Staphylococcus aureus
- Streptococcus
- Pseudomonas aeruginosa
- Klebsiella pneumoniae
- Anaerobes

Pulmonary abscess

Imaging

- **Spherical mass** (2 to 6 cm in diameter)
  - **Necrotic content**
    Cavitation (if bronchial communication)
  - **Contrast** (granulation tissue vascularized by hypertrophied bronchial arteries)
  - **Irregular wall thickness**
  - **Single** or **multiple**
- **Adjacent parenchymal consolidation** (50%)
- Location: RUL posterior segment, IL apical, LIL posterior segment.
- Complication:
  - **Broncho pleural fistula**



Pulmonary abscess in a 78-year-old patient with bone marrow aplasia

Frequent germs

- Staphylococcus aureus
- Streptococcus
- Pseudomonas aeruginosa
- Klebsiella pneumoniae
- Anaerobes

Lung Gangrene

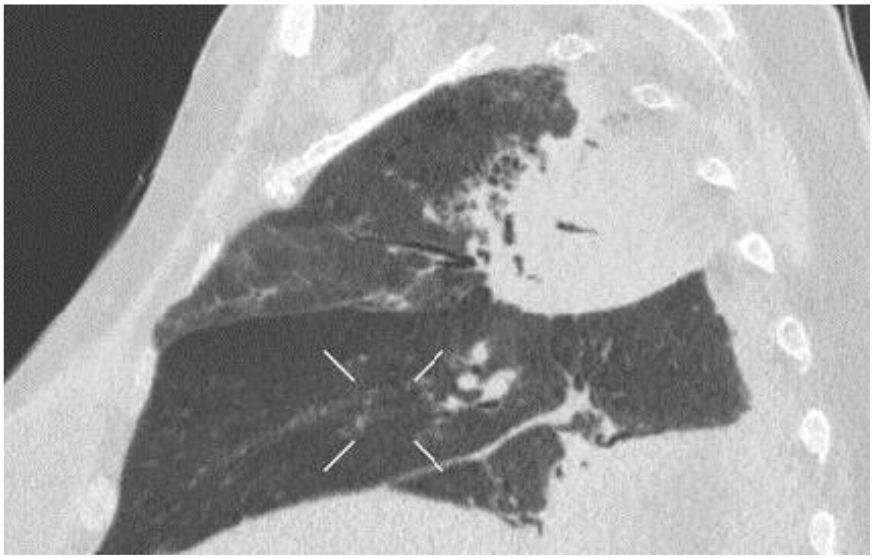
Physiopathology

- Bronchogenic or hematogenic
- A single lesion
- **Thrombosis of the feeder artery of the affected area**

Klebsiella +++
Staphylococcus

Imaging

- **Alveolar opacity**
  - Clarity **"in meniscus" in the** periphery
  - **Liquefaction**
  - Sequestrum
- **Hydro-aerodynamic content**
- **More or less extensive**



! If hemoptysis Think about looking for a **pseudoaneurysm...**

Septic embolism

Origin

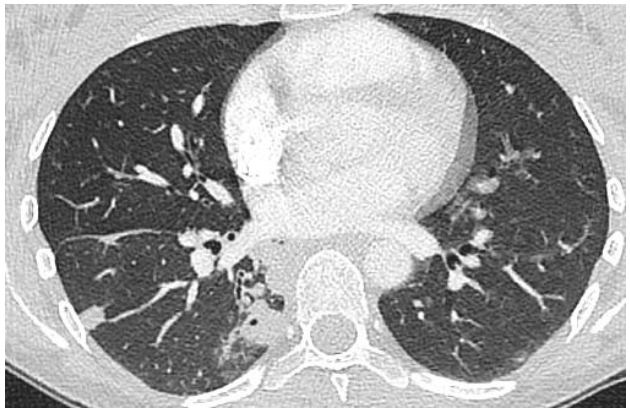
- Heart valves: **endocarditis tricuspid valve +++**, IV drug addiction
- Thrombophlebitis
- Venous catheters / pacemaker
- **Staphylococcus +++**, *pseudomonas aeruginosa*

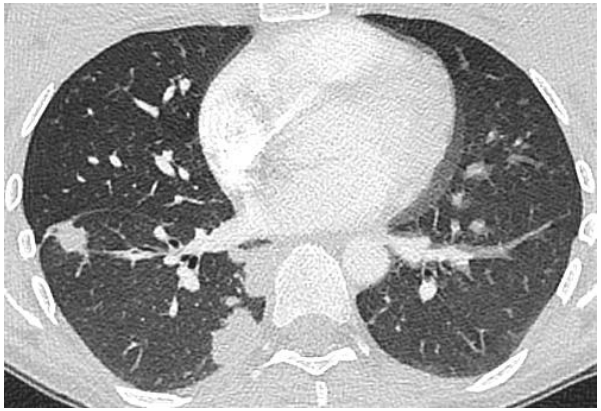
Pathology

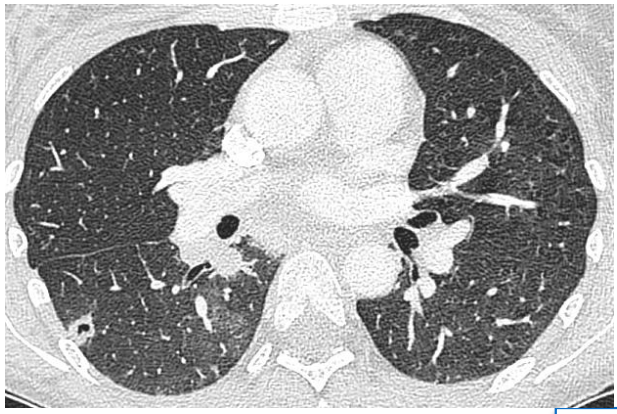
- Endothelial damage, brittle thrombus containing bacteria/fungi
- **Ischemic infarction, hemorrhage...**
- Toxins

Imaging

- ✓ **Lung nodules** 0.5 to 3 cm in size
  - Ill-defined
  - **Excavated** ++
- ✓ **Infarction**
  - **Peripheral triangular shaped** consolidation(under pleura)
- ✓ **Lower ++ regions** (most vascularized)
- ✓ **Nourishing" vessel ++** (arteries bypass, **veins center the embolus**)

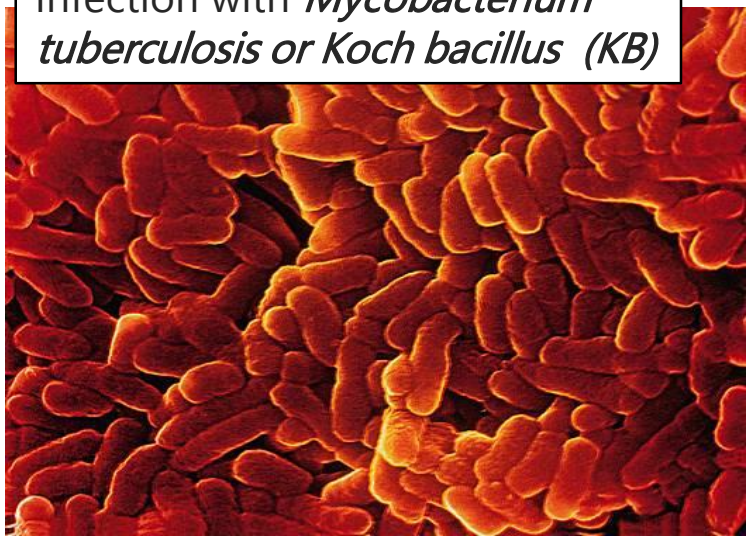


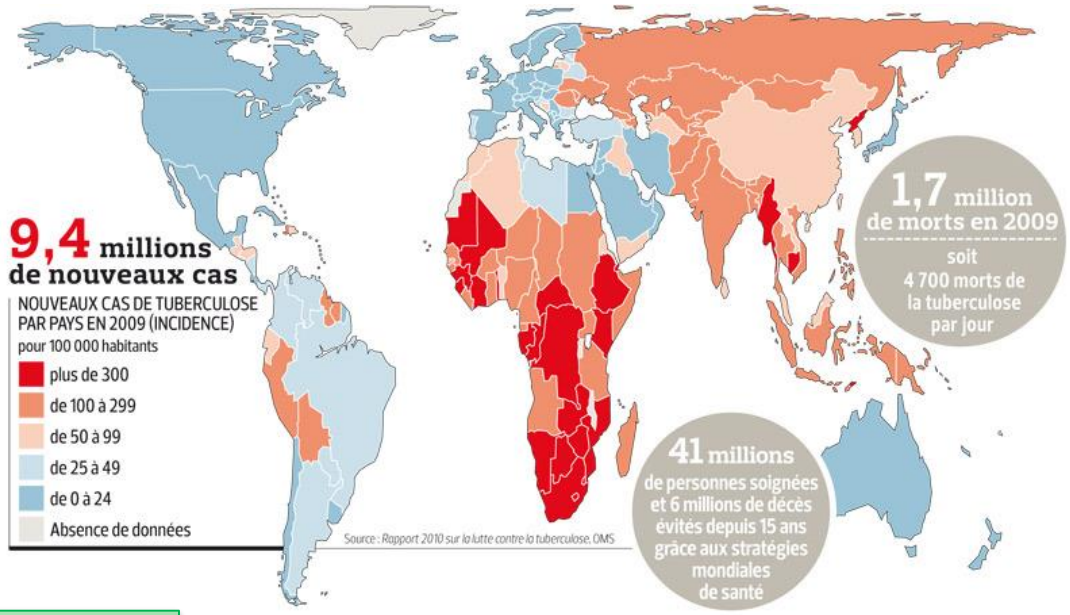




Pulmonary tuberculosis

Infection with *Mycobacterium tuberculosis or Koch bacillus (KB)*





Several stages

1) Primo-infection and **primary infection**
2) **Latent** tuberculosis infection
3) **Post-primary** (or **secondary**) infection

Treatment (tuberculosis adult disease)

- **6 months,** 2 phases: 2 months isoniazid, rifampicin, pyrazinamide and ethambutol followed by 4 months isoniazid and rifampicin.
- Radiological follow-up: 2 months of treatment, end of treatment, 18 months

Primary tuberculosis

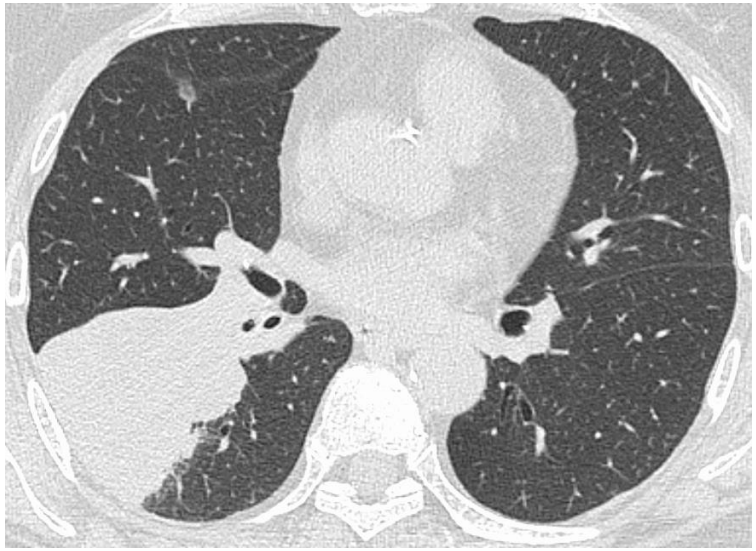
Physiopathology

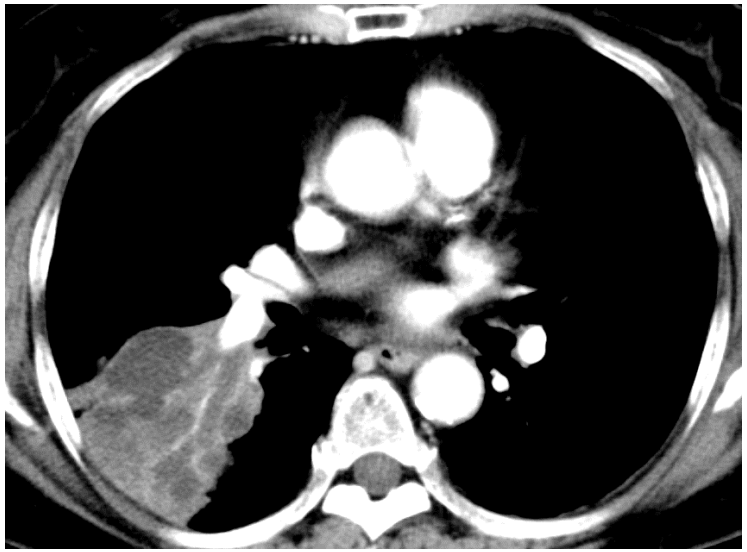
- Time-limited, child++, droplets inhalation (BK)
- One or more primary site(s): **granuloma** healing (calcium nodules) or excavation or dissemination of blood.
- Hilar or mediastinal lymph nodes healing

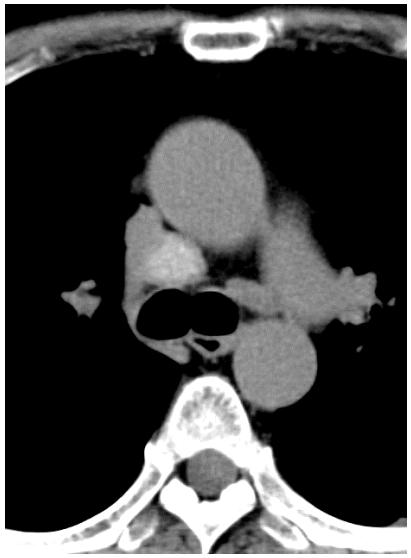
- **Lobar consolidation**
  - **Lower lobe / medium lobe ++**
  - *Not distinguishable from a bacterial pneumopathy*
  - 2/3 cases: resolution without sequelae
  - Sometimes calcification (Ghon's focus), tuberculoma (9%)
- **Lymphadenopathy**
  - 96% child, 43% adult
  - **Homolateral hilum, right paratracheal+**, >2cm: necrosis, hypodense ganglion
  - Ranke complex: calcified ganglion + calcified nodule
- **Miliary** (1 to 7%)
  - Micronodules 2-3mm hematogenous resolution
- **Pleural effusion** (1/4 of the cases)

Primary tuberculosis

- Looks like bacterial pneumopathy
- Necrotic evolution under antibiotic treatment







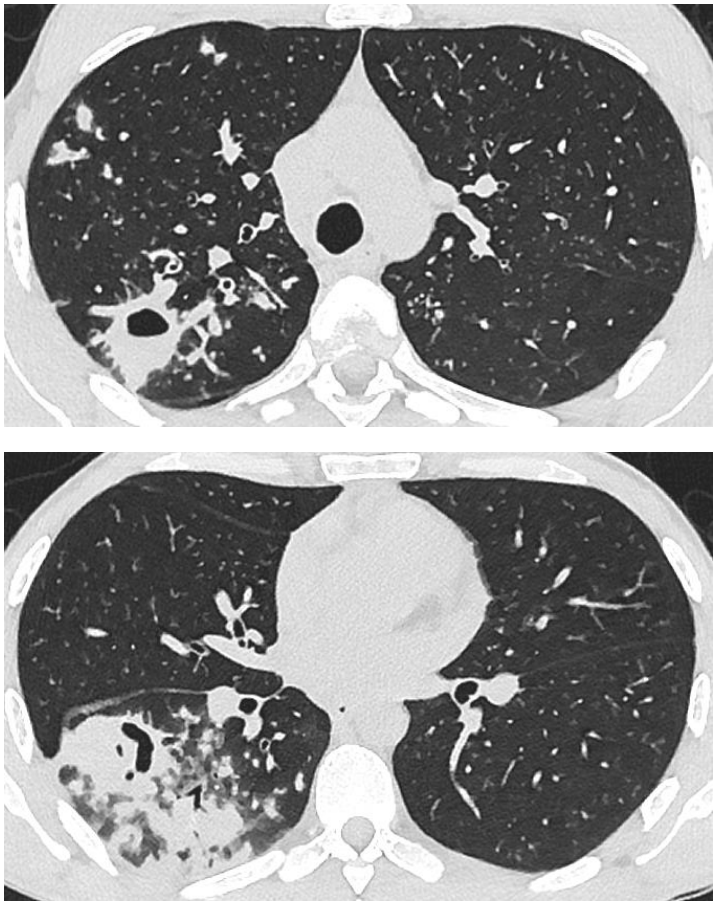
Associated calcified adenopathy

Post-primary tuberculosis

Physiopathology
- **BK reinfection/reactivation**, **cavitation +++**
- **Bronchogenic** and **hematogenic** dissemination
- Healing with fibrosis and calcifications

Parenchyma +++
- ✓ **Consolidation**
  - **Apical and posterior segment of LS**, patchy, blurred edges, earliest sign, often bilateral
- ✓ **Cavitation (1/2)**
  - **Thick wall**, irregular, multiple, in thin-walled condensations with ttt
  - Look for **Rasmussen ++ aneurysm** (aneurysm of the adjacent pulmonary artery or in a cavity)
- ✓ **Tree in bud +++** (active tuberculosis)
- ✓ Bronchial stenosis (10 to 40% active tuberculosis)

Lymphadenopathy (5%)
Pleura (18%): effusion (partitions++), thickening, empyema, risk of bronchopleural fistula. Pleural thickening and calcifications may persist
Wall: direct extension, bone/cartilage destruction, skin fistula

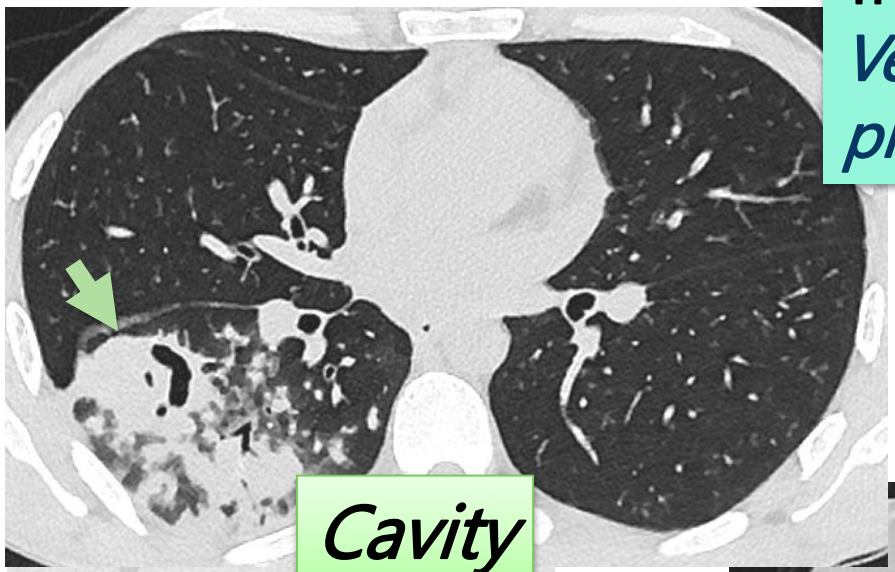


- **Cavity** (apical++)
- **Tree in bud**
  --> **Tuberculosis**

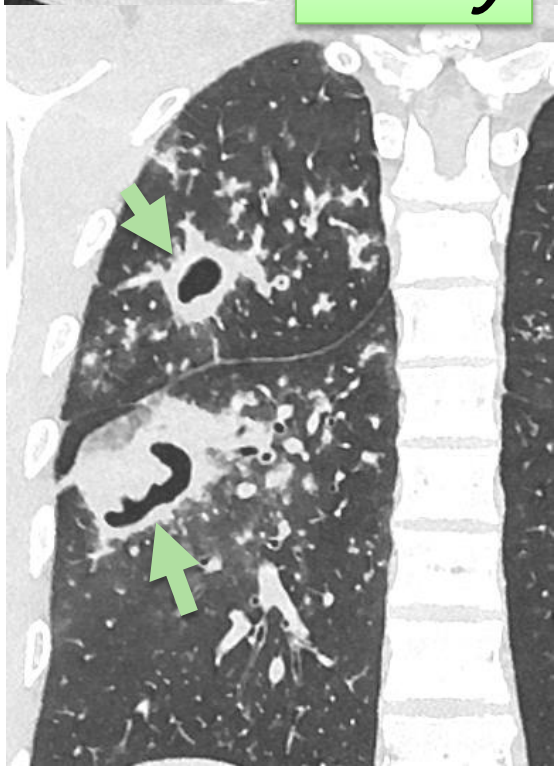
Tuberculosis: A Radiologic Review -Joshua Burill – Radiographics 2007

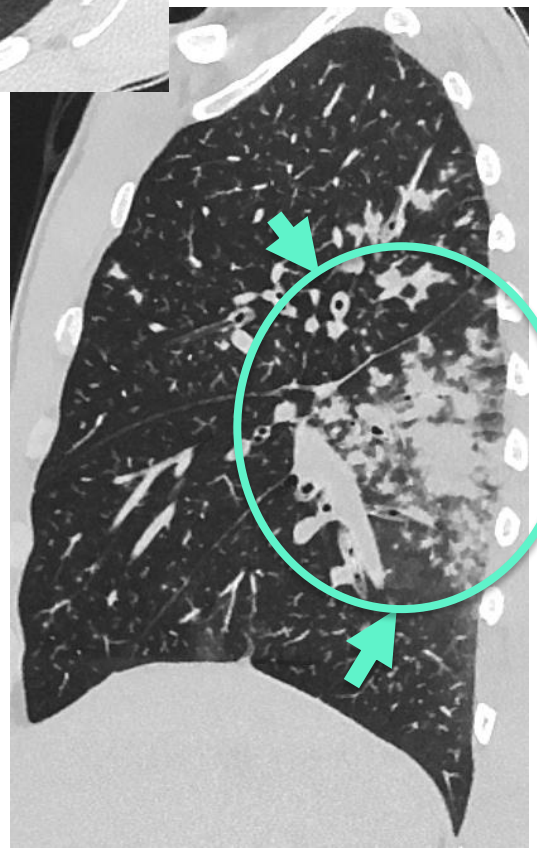
Tree in bud , with **acinar dilations**

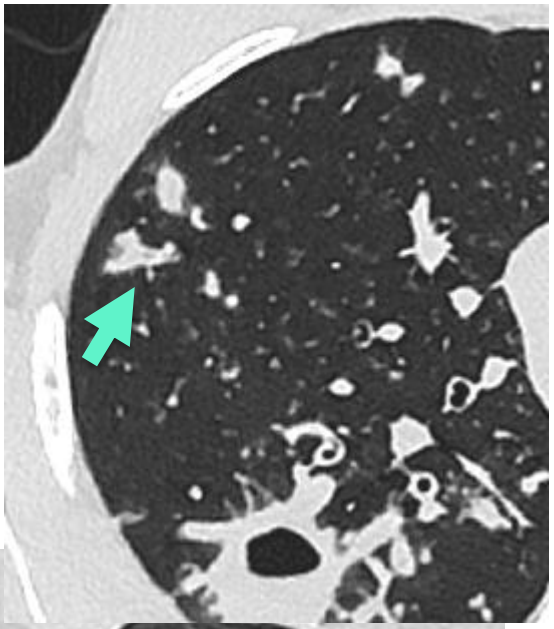
Very specific for tuberculosis if no preexistent bronchial dilatations!!!!

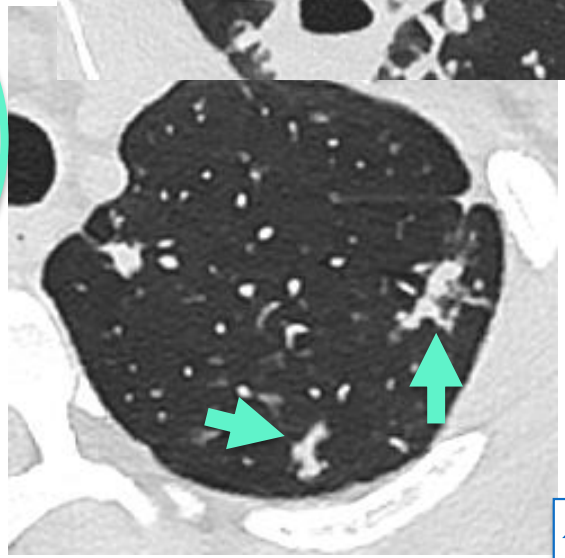


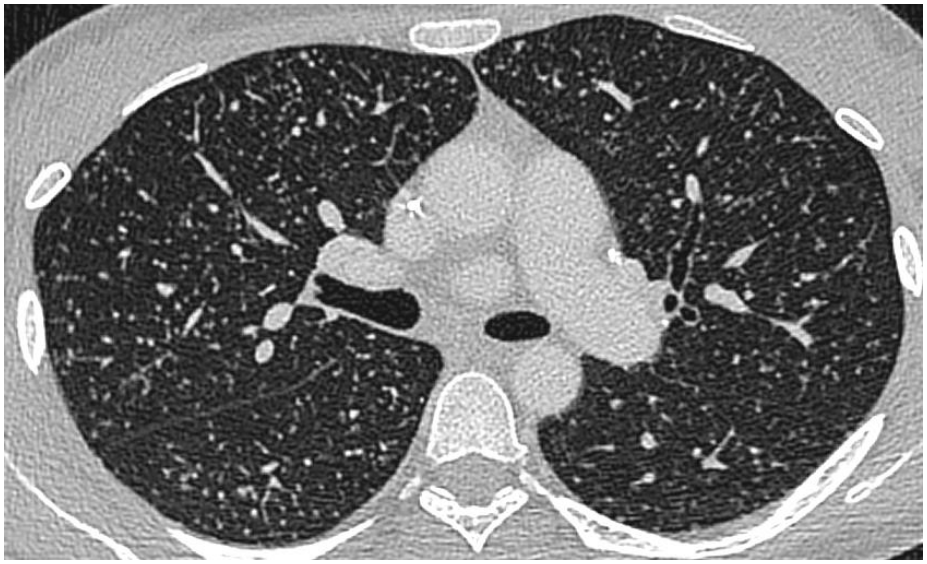
Cavity

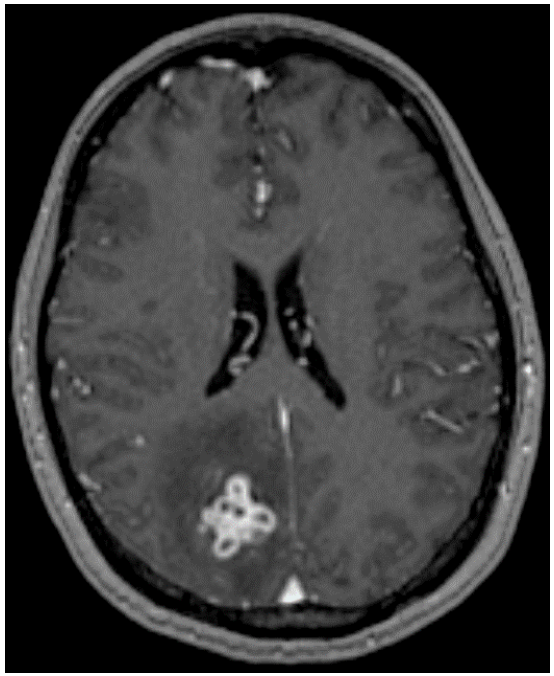


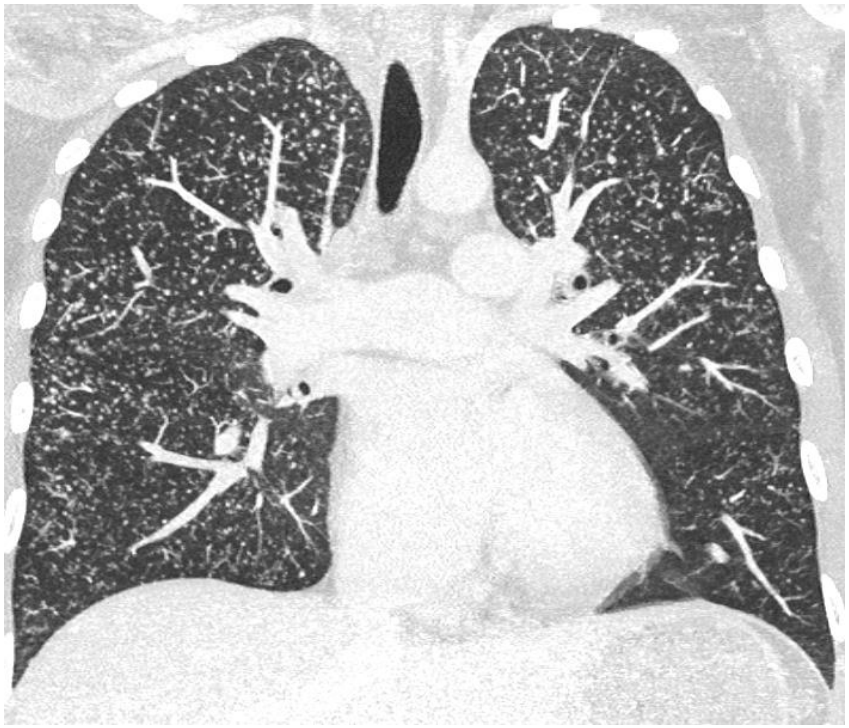








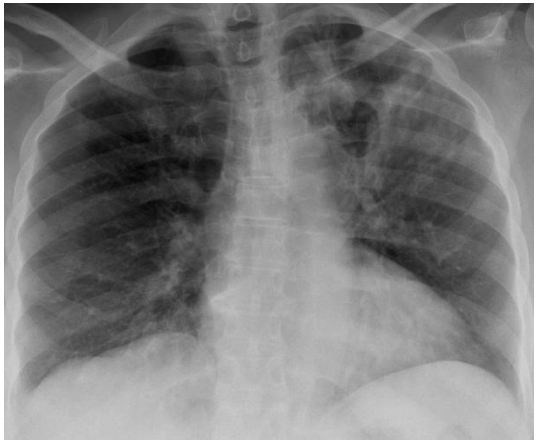


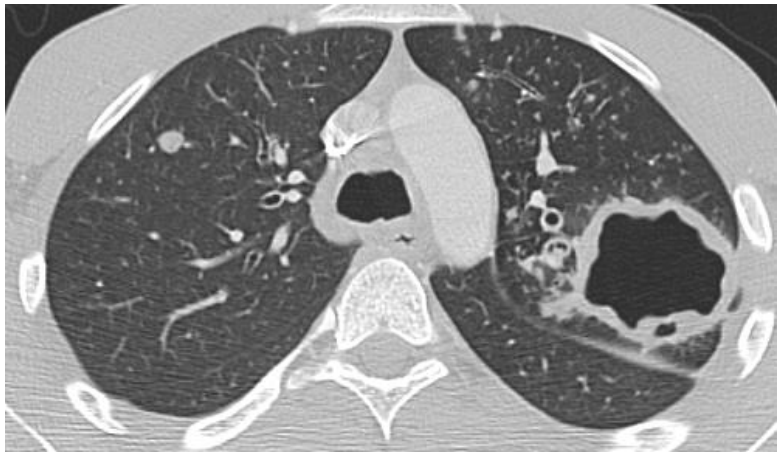


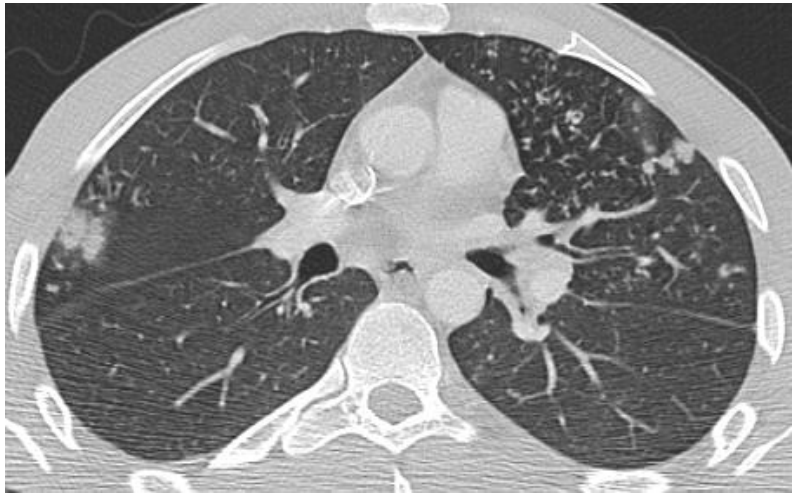
Pulmonary **miliary tuberculosis** associated with a **cerebral tuberculous abscess** ("bunch of grapes" sign)
= Blood diffusion

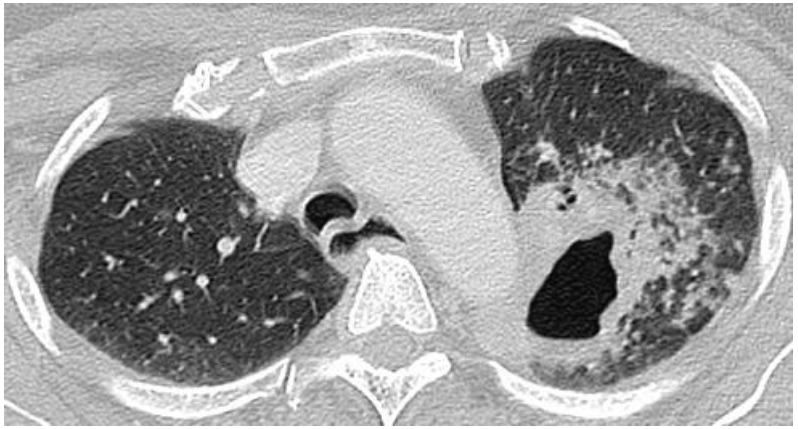
Active bronchogenic tuberculosis

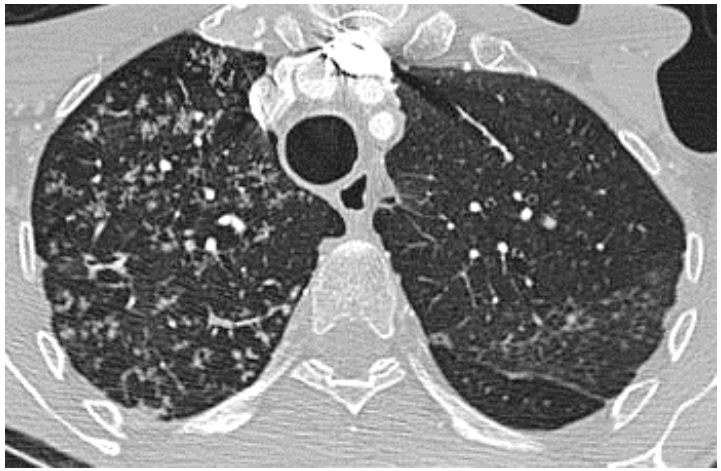
- Left apical cavity
- Multiple micronodules in « tree in bud"





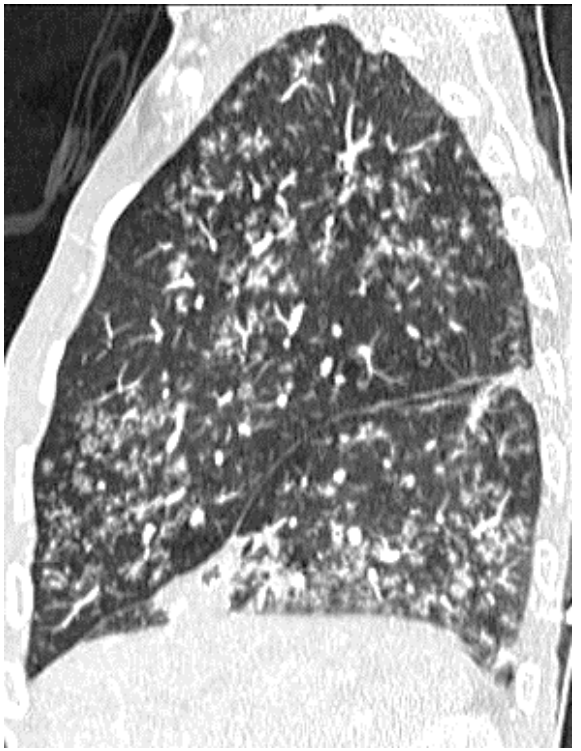


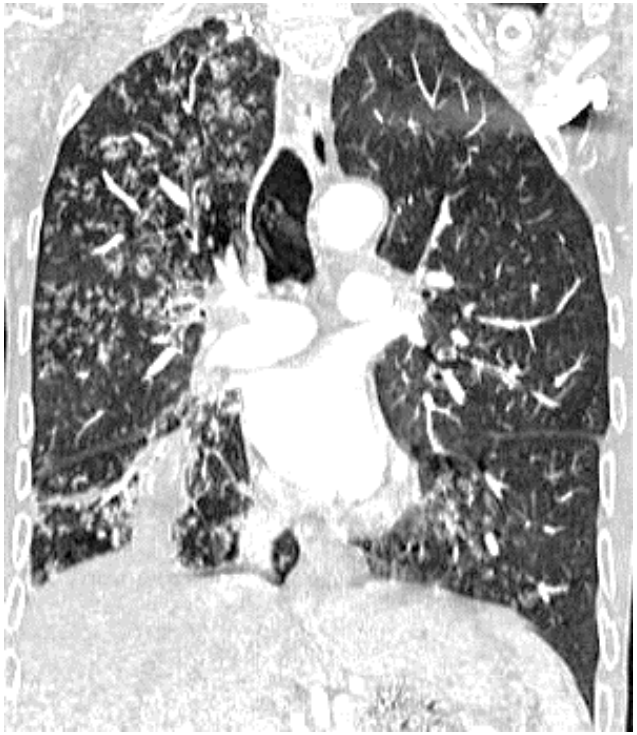


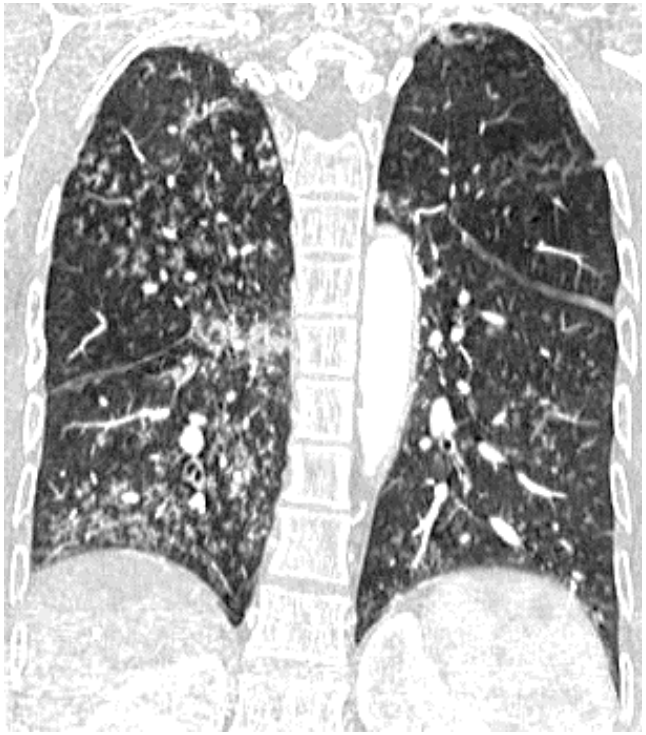


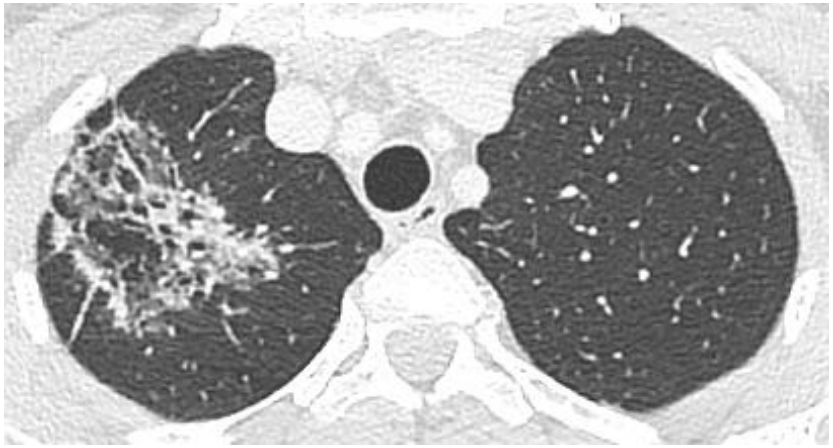
Tuberculosis

Many **"tree in bud"**







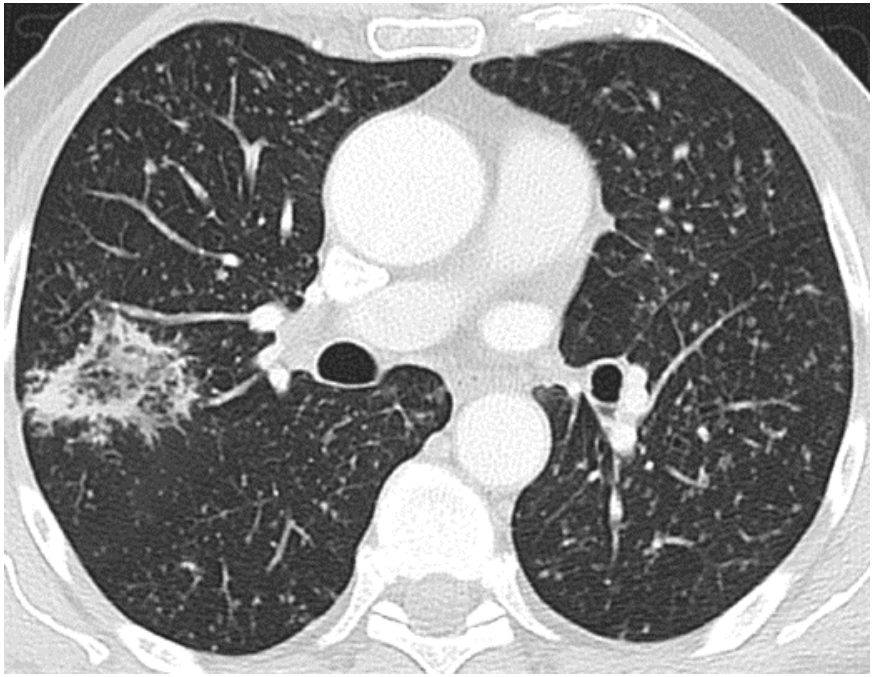


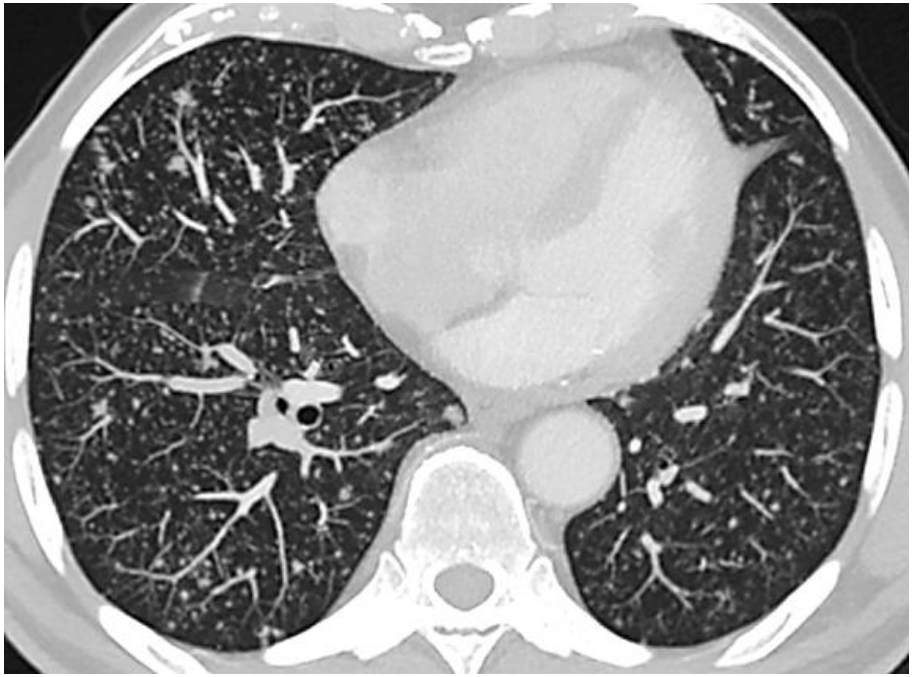
Chronic active tuberculosis

Cluster of micronodules with a perilymphatic distribution with **reverse halo sign**

Tuberculosis: galaxy sign (and reverse halo)

+ Profusion of random micronodules and a few « tree in bud"





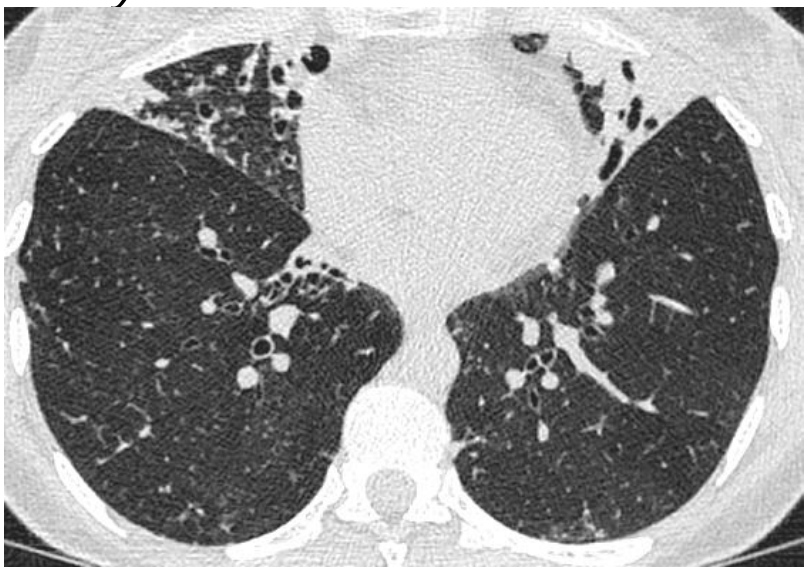
Non tuberculosis Mycobacterial infection

- 15 pathological species including M. avium, M. intracellulare, M. kansasii, M. xenopi ...
- 2 positive BAL cultures for diagnosis

Differences from tuberculosis

- **Non-human-to-human transmission**
- **Transmission through water**
- **No primary / secondary evolution**
- **Less sensitivity to anti-tuberculosis drugs**
- Place of surgery

Lady Windermere's Disease



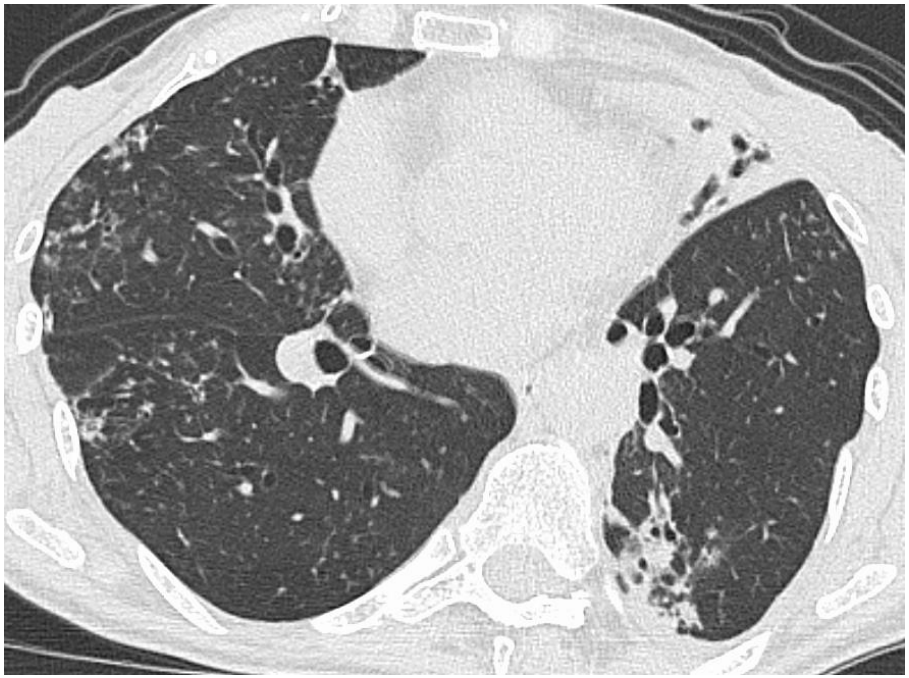
Imaging: different pattern possible

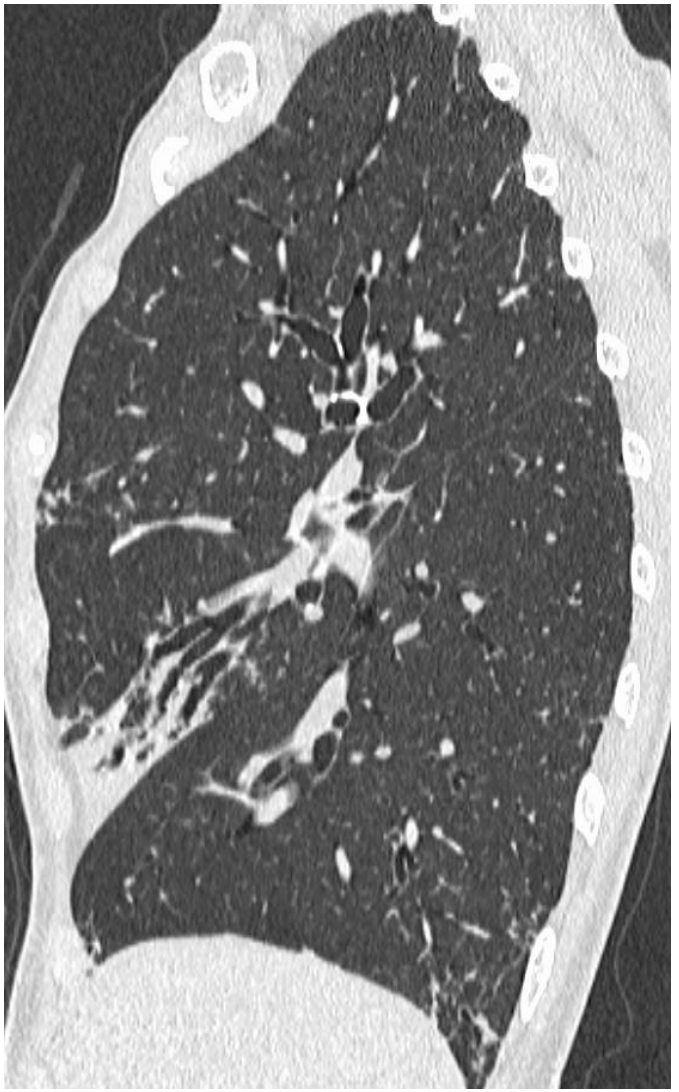
- **Bubble superinfection**: +/- pathogenic
- **Pseudo tuberculosis**: idem post-primary tuberculosis
- **Lady Windermere Disease**
  - Mycobacterium avium complex infection (MAC infection)
  - Female, 60 years old, non-immunocompromised
  - **ML Bronchiectasias with atrophy**
  - Micronodules « tree in bud », apex respect
- Superinfection of lipid pneumoniae

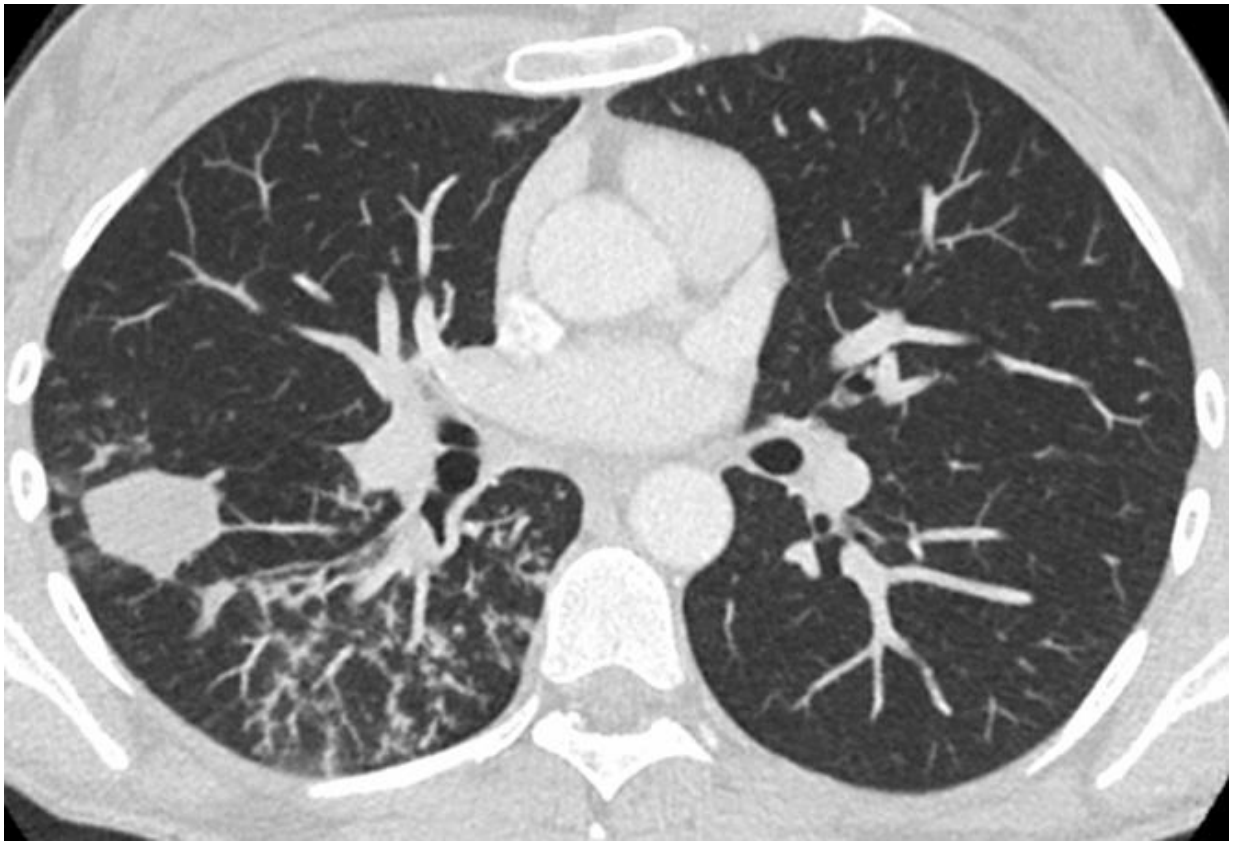
Immunocompromised patient CD4<50:

- MAC infection, M.kansasii
- Disseminated infection. Highly variable presentation
- Hilar or mediastinal adenopathies ++, Nodules ++

Non tuberculosis Mycobacterial infection

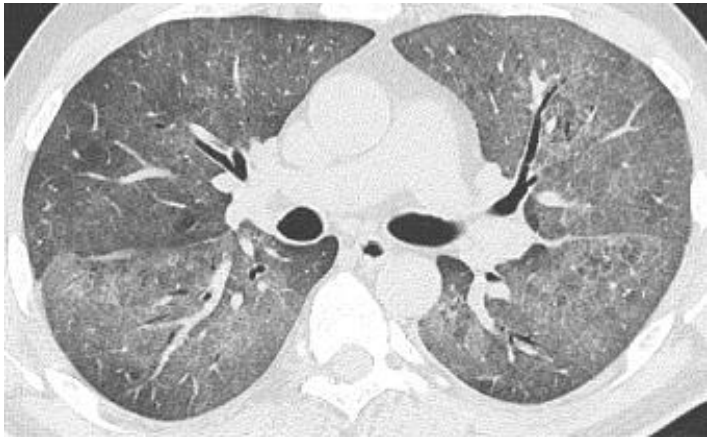


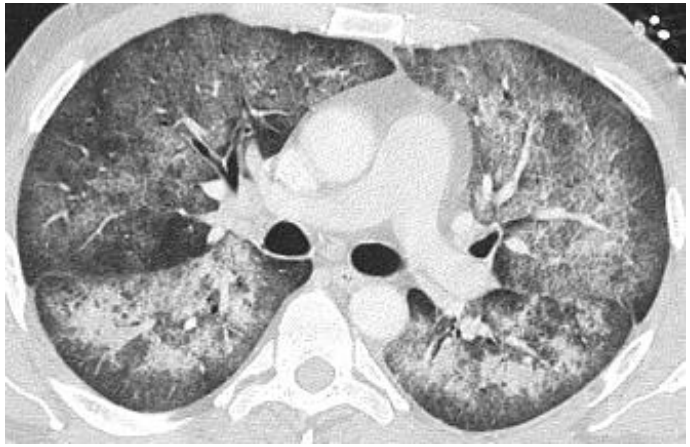




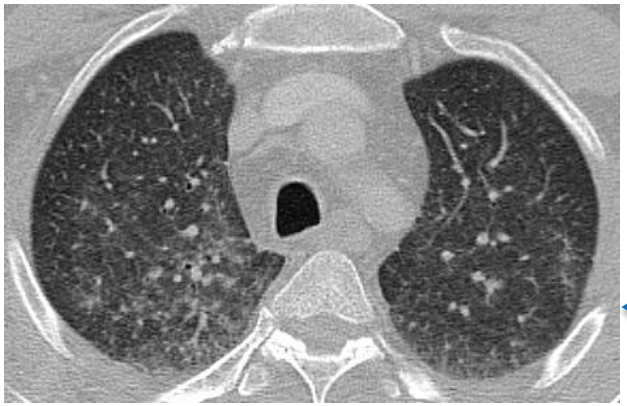
Non tuberculosis Mycobacterial infection

Pneumocystis jiroveci



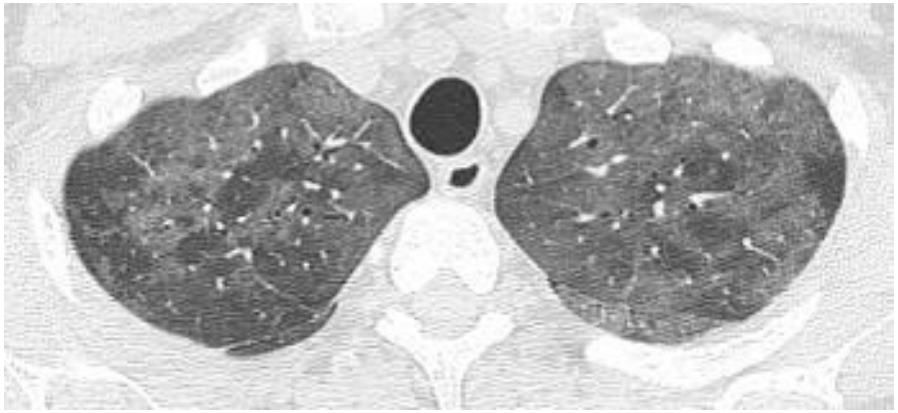


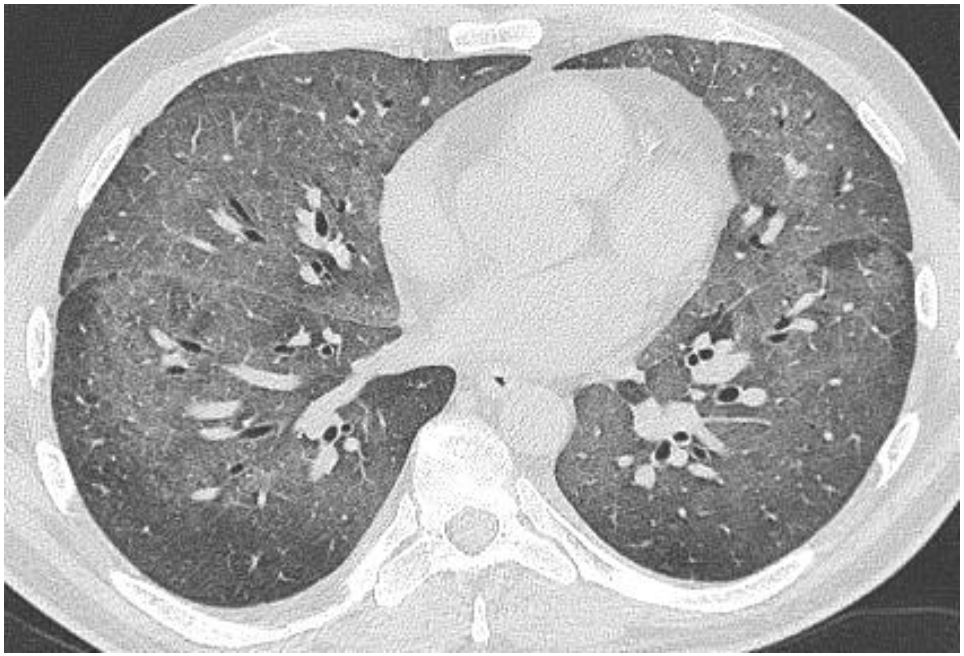
- HIV, CD4 < 200/mm3
- **1st** mycosis in the AIDS patient
- Main differential diagnosis = **CMV**



- **GGO**(100%)
  - Symmetrical, **diffuse** / mosaic / **crazy paving**
  - **Subpleural sparing**(40%)
  - Bronchiectasis within ggo
- **Cysts** (30%)
  - Atypical forms, patient HIV++.
  - Multiples, upper regions, diminish or disappear
  - Risk of **pneumothorax+++**
- **Diffuse Consolidation** in Severe Forms
- *"Miliary pattern*: centrolobular micronodules, rarer (5%), moderate immunosuppression, granulomatous inflammation.

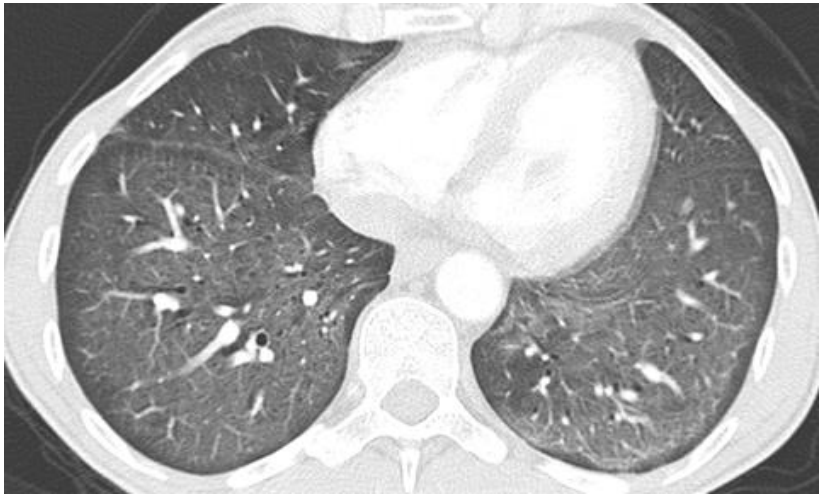
Kanne JP, Yandow DR, Meyer CA. Pneumocystis jiroveci Pneumonia: High-Resolution CT Findings in Patients With and Without HIV Infection. AJR 2012

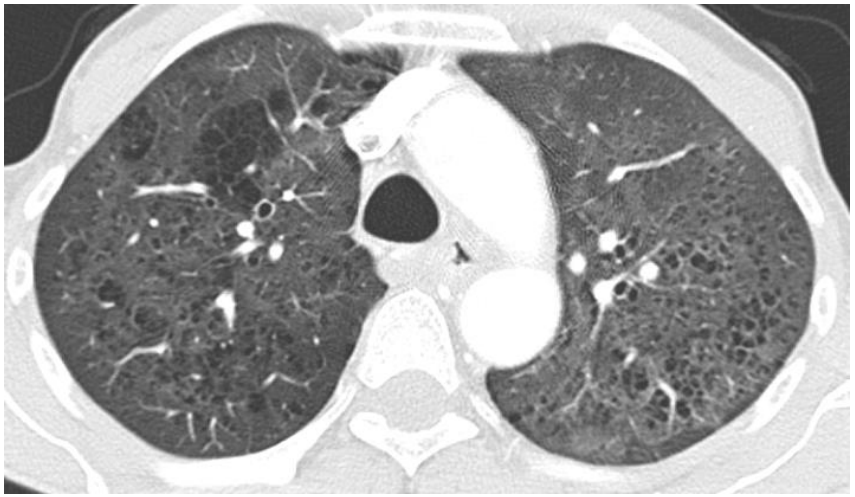




Pneumocystis

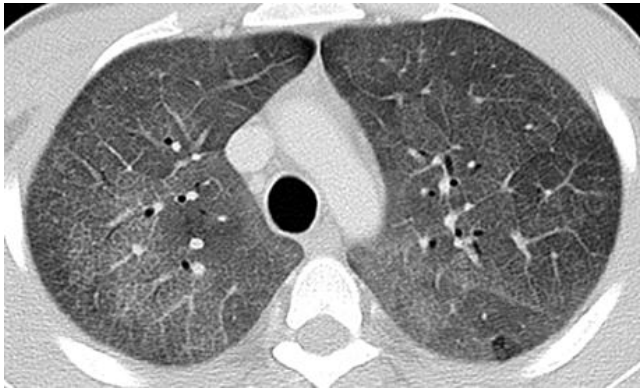
49-year-old patient, HIV, CD4 = 8/mm3,
dyspnea, diffuse GGO+ cysts

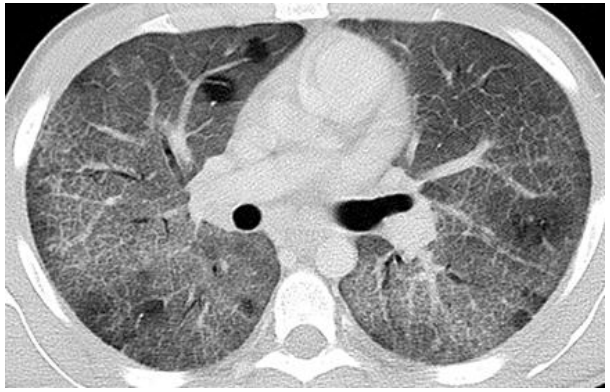


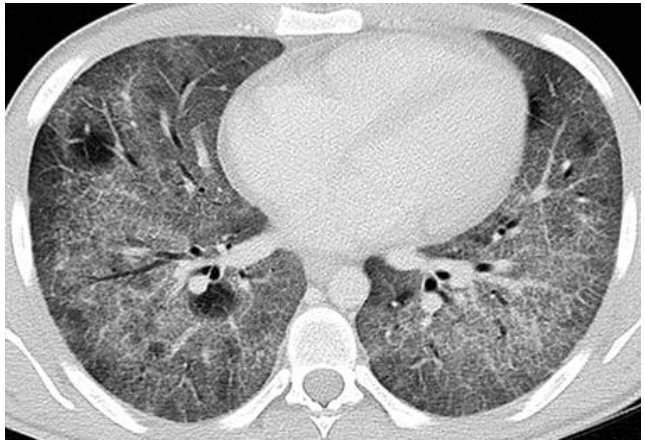


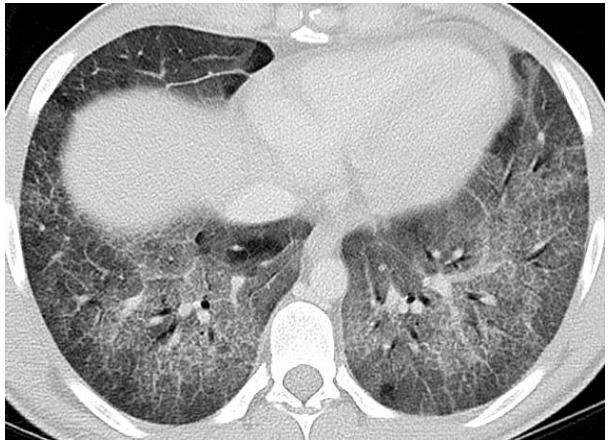
Pneumocystis

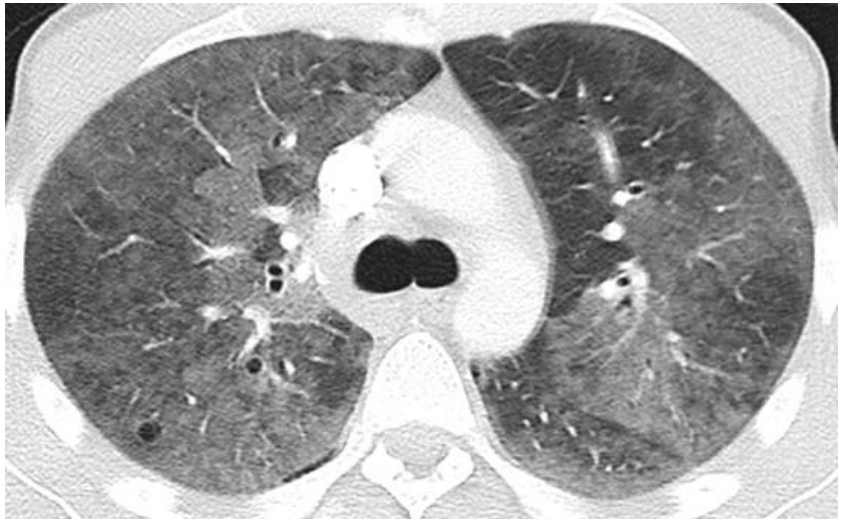
- Diffuse **crazy paving**
- **Cysts ++**
- Relative **sparing of subpleural area**











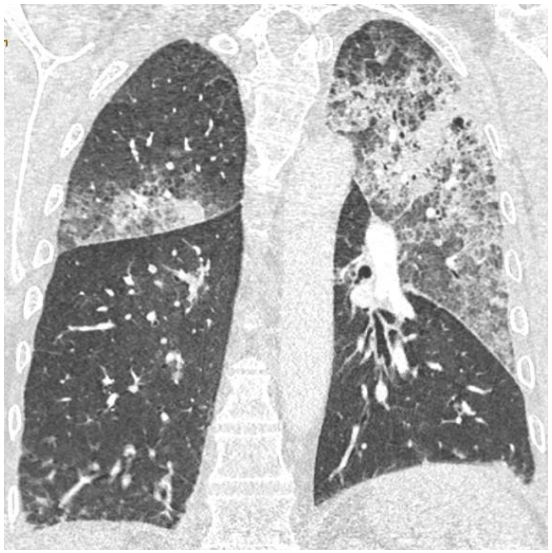
Pneumocystis (HIV discovery)

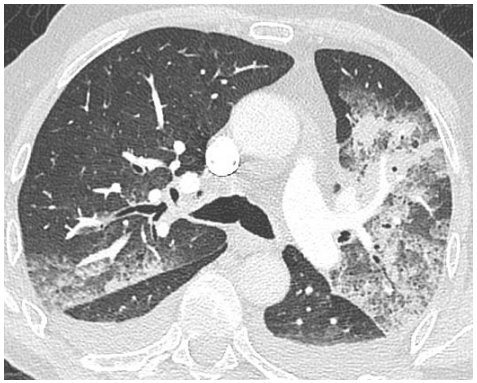
Legionella pneumonia

- *Legionella pneumophila*, BG negative, aquatic environment
- **Immunosuppressed** (kidney transplant, corticosteroid therapy)
- Clinical: rapid onset, hyperthermia, focal symptomatology, **extra-pulmonary signs** (digestive disorders, neurological disorders)
- Diagnosis: Legionella serology and antigen

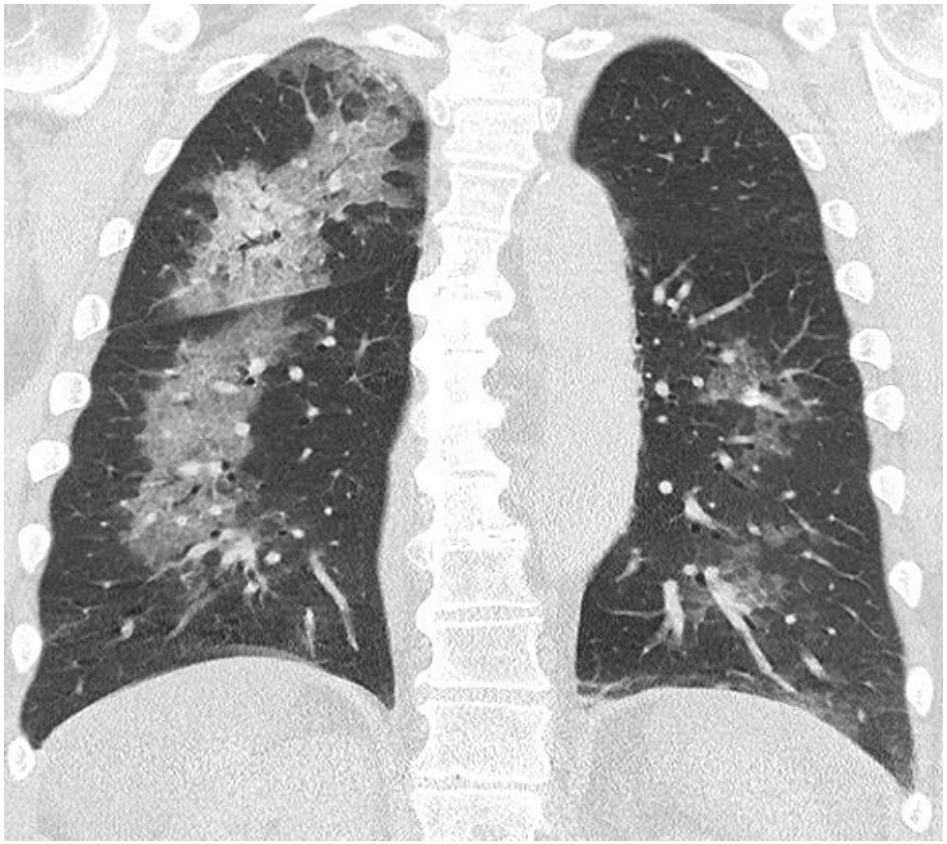
Imaging

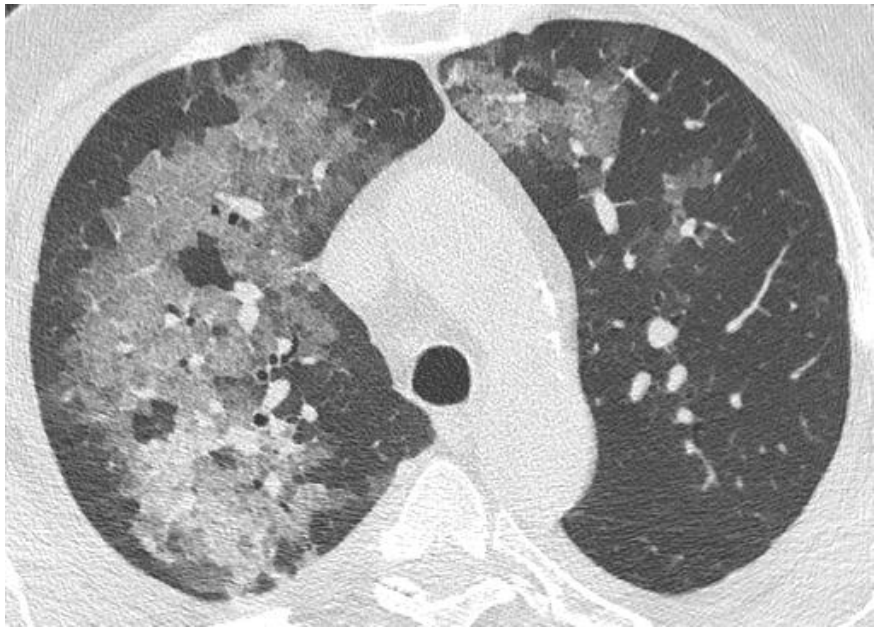
- **Systematic or non-systematic alveolar consolidation**
  → multiple
- **Diffuse opacities** (delayed shock oedema)
- Minimal pleural effusion (30%)
- Strip atelectasis
- Excavation in the immunocompromised

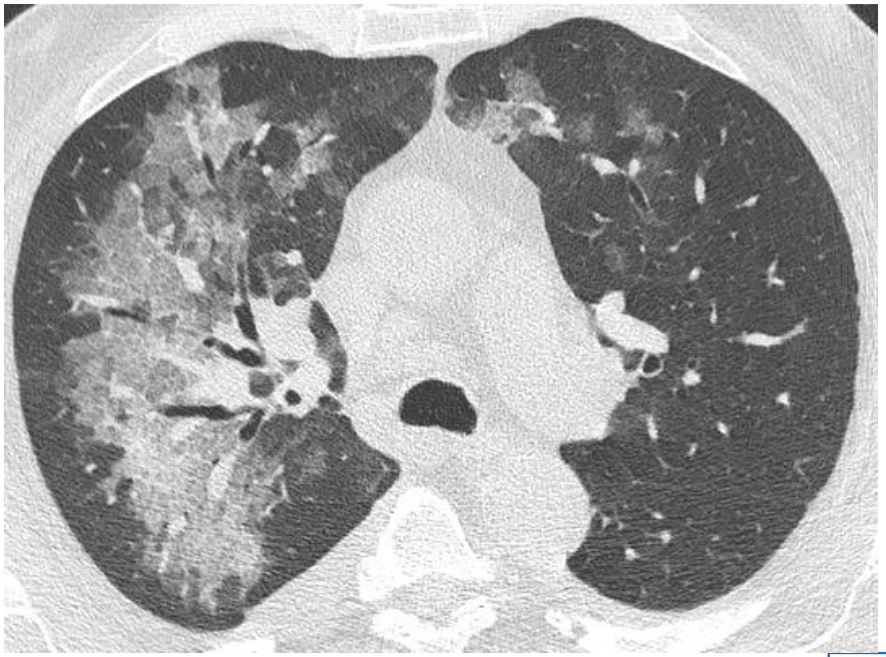




Legionella pneumonia

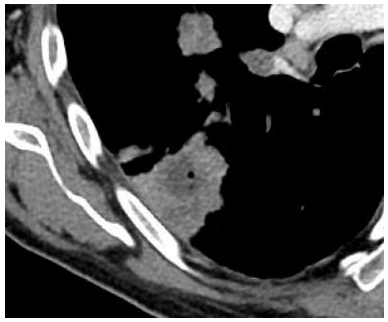


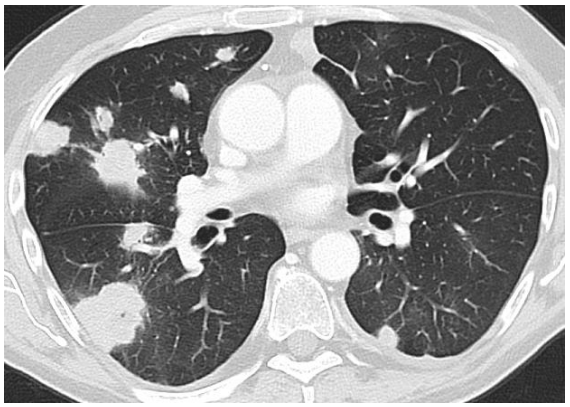




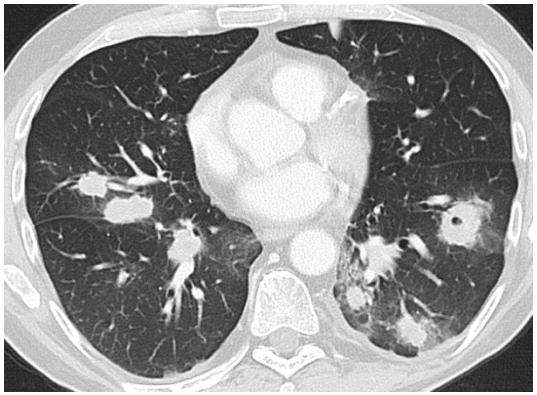
Pulmonary Nocardiosis

- BG (+), **severe immunocompromised**, **cellular immunity deficiency** (AIDS, transplantation, corticosteroid therapy)
- Clinic idem KB
- Extension to **brain (abscess)**, skin, bones/joints





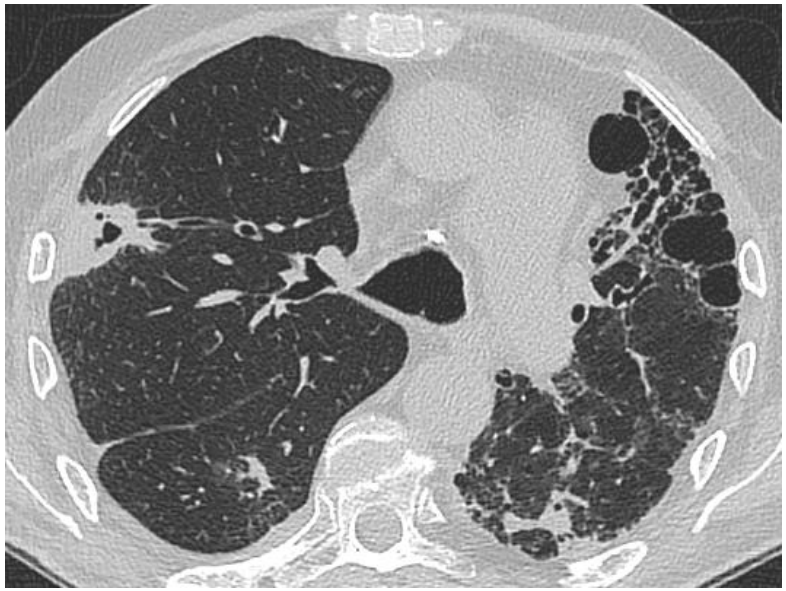
Nocardiosis in an allograft context

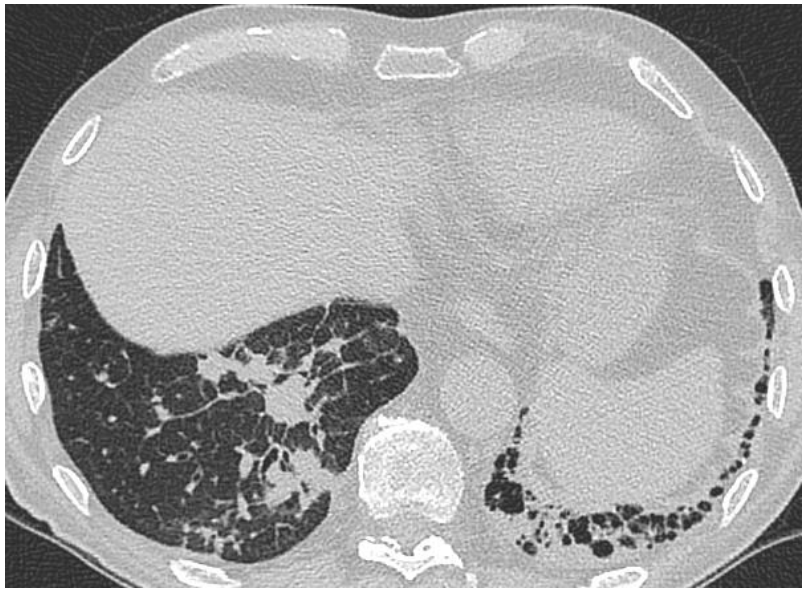


Imaging
- **Consolidation(s)** uni- or multifocal, patchy, segmental, lobular
- **Nodule(s) or mass(es)** with irregular edges
- **Hypodensity / Excavation +++**
- +/- Pleural effusion
- Sometimes **pleural** (empyema) or **parietal** involvement
- Sometimes endo-bronchial tumor

Differential diagnosis
(consolidation/cavitation/nodules)
- **Septic embolism**
- **Cancers, metastasis**
- Vasculitis (**Wegener's**)
- Other infections, in particular **actinomycosis** (but not blood-born), cryptococcosis, etc.

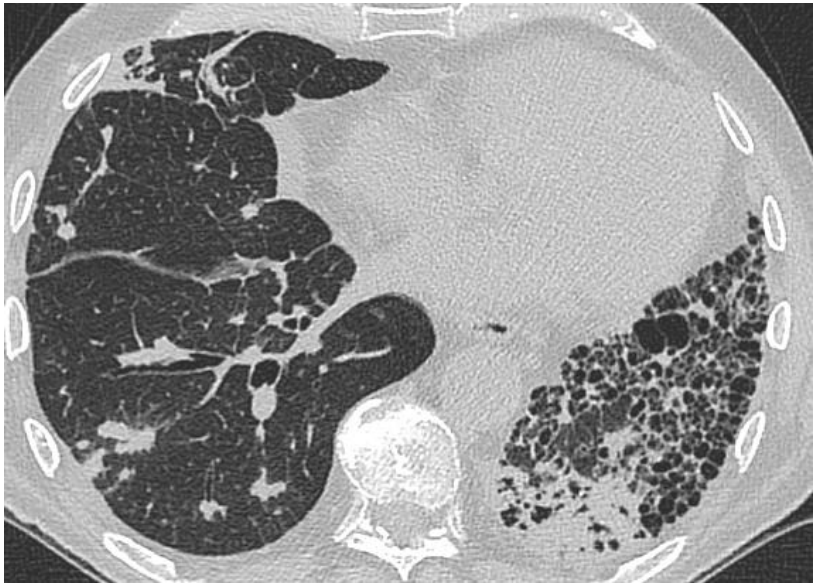
Kanne JP, Yandow DR, Mohammed TL et al. CT findings of pulmonary nocardiosis. AJR Am J Roentgenol. 2011

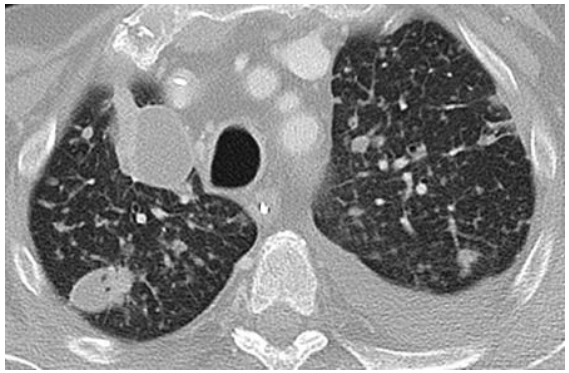
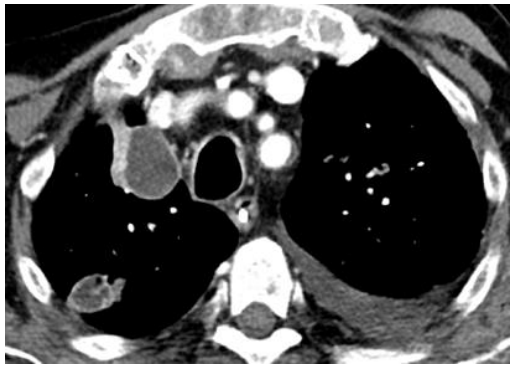
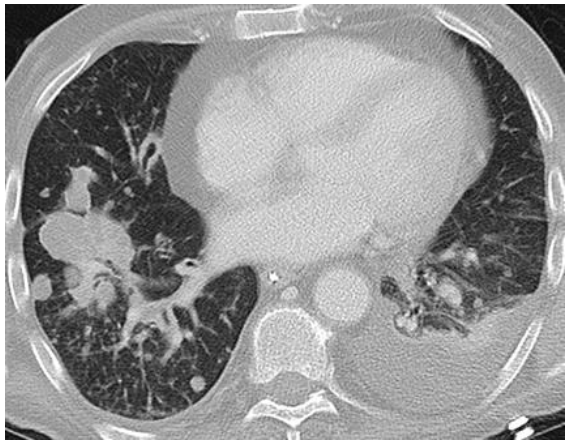
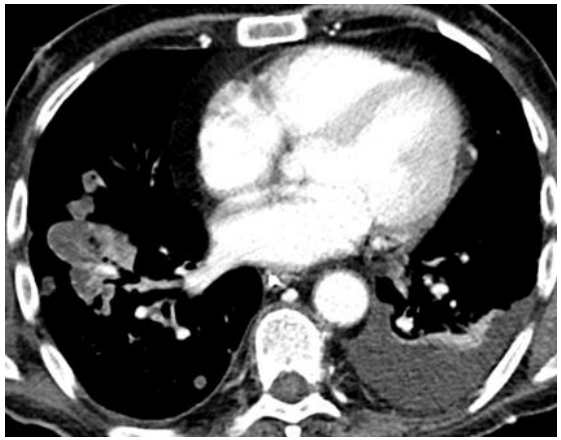
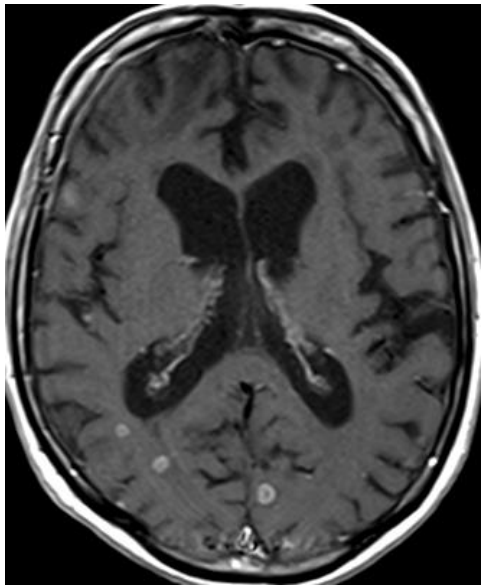
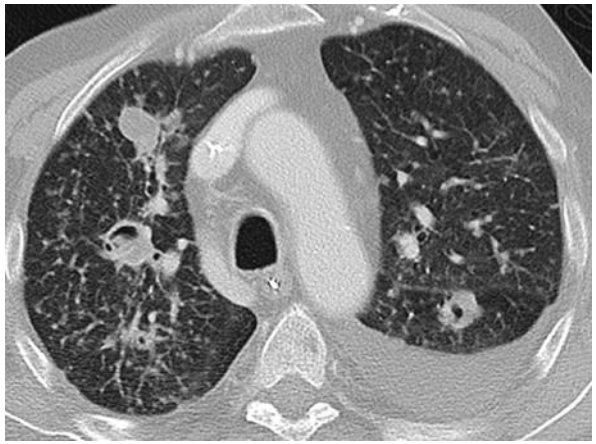




Nocardiosis

Nodules and pseudomasses with irregular edge +/- excavated



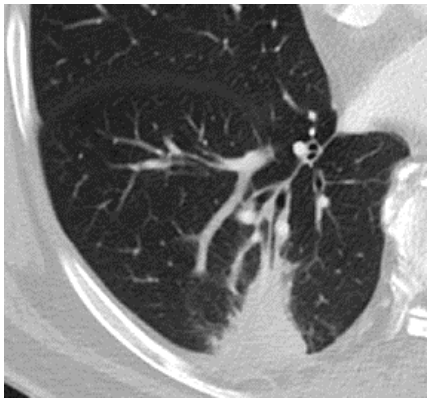







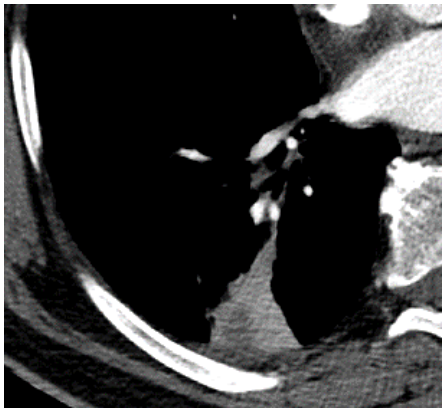
Disseminated nocardiosis

- in a patient receiving long-term corticosteroid therapy
- **bilateral excavated or hypodense nodules**
- and **multiple brain abscesses**

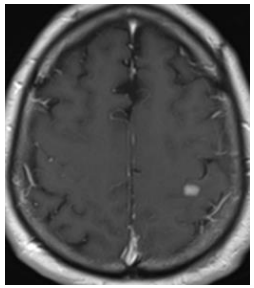
Actinomycosis

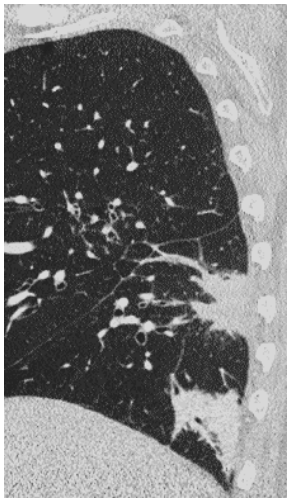
- **Immunocompetent**
- **Oropharynx (poor dental hygiene)** → lung
- Interconnected multiple abscesses + fibrous tissue at the periphery





Pulmonary and cerebral actinomycosis
74-year-old diabetic patient Improvement in lesions after antibiotic therapy





Imaging: *several pattern*

Pulmonary actinomycosis ++

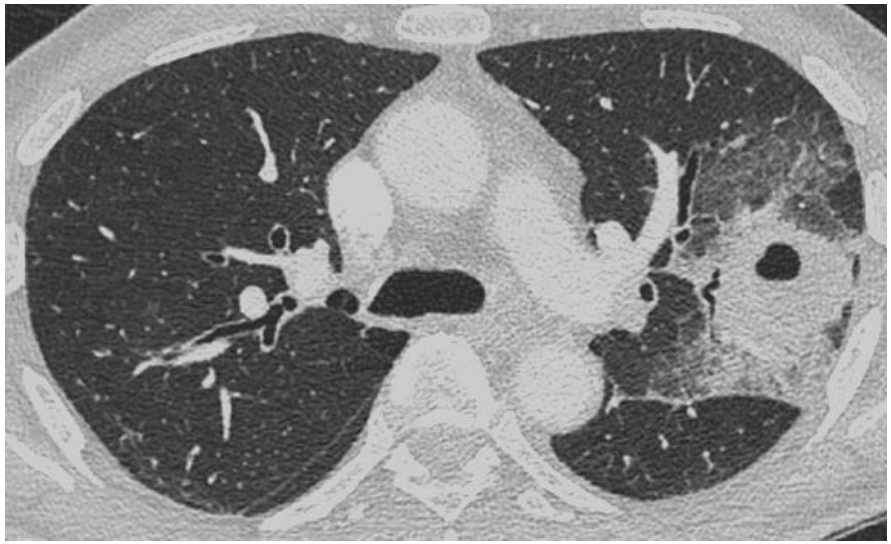
- **Consolidation** (periphery, lower lobes, sometimes multifocal)
- Can invade pleura / wall ++ (***empyema necessitans***)
- **Hypodensity ++, cavitation**
- **Peripheral enhancement ++**
- Adjacent pleural thickening, pleural effusion
- Hilar adenomegaly

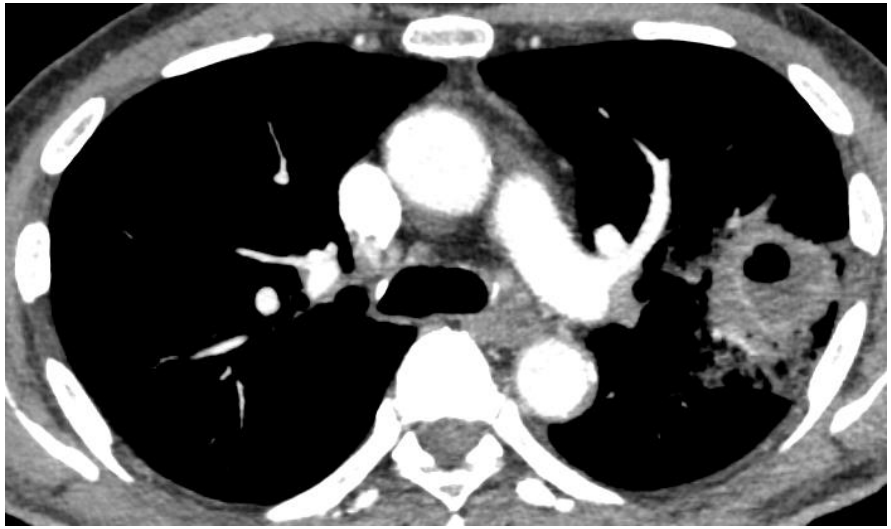
Bronchiectasic form

- Colonization of a devitalized lobe or segment with bronchiectasis (sequelae of KB or bacterial infection)

Endobronchial actinomycosis with broncholithiasis or foreign body (rare)

Biblio: Mabeza GF, Macfarlane J. Pulmonary actinomycosis. Eur. Breathing. J. 2003





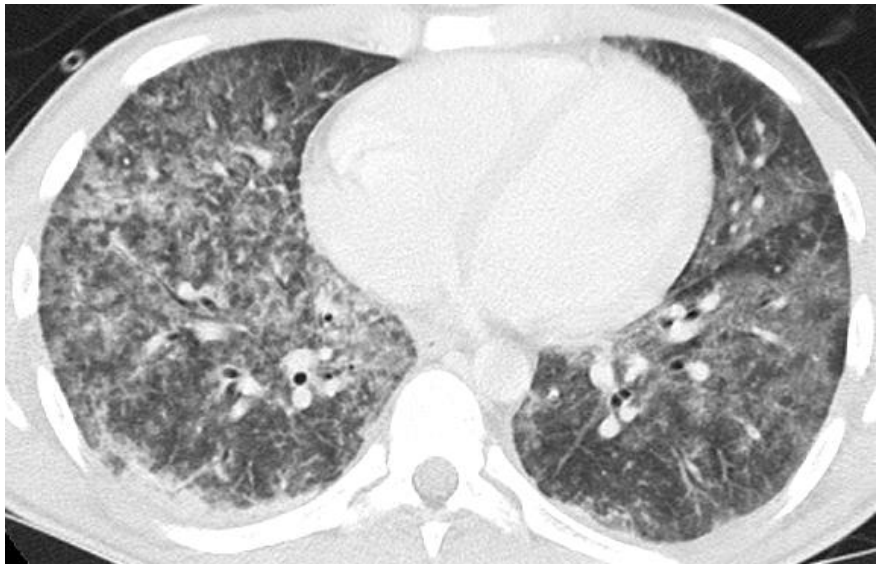
Actinomycosis

Excavated consolidation with peripheral **enhancement**
(granulation tissue with leukocytes containing "sulfur granules")

Leptospirosis

General

- *Spirochete leptospira*
- Vector: **rats**
- **Tropical, subtropical environment, contaminated water**
- **Fever, jaundice** (liver damage), nephritis (kidney damage), meningitis
- **Hemorrhagic syndrom++**



CT

- **Centrolobular micronodules ++** (hemorrhagic petechiae)
- **GGO** and **consolidation** (bleeding areas)

Viral infections

Immunocompetent patient

- Influenza virus
- Hantavirus
- EBV
- Adenovirus
- Measles

Immunosuppressed patient

- HSV
- VZV
- CMV

Cause of Pneumonia	Centrilobular Nodules	Ground-Glass Attenuation with Lobular Distribution	Segmental Consolidation	Thickened Interlobular Septa	Diffuse Ground-Glass Attenuation
Influenza virus	+++	+++	+	. . .	+
Measles virus	++	+	+	. . .	+
Hantavirus	. . .	. . .	++	+	+++
Adenovirus	++	+	+++	. . .	. . .
Herpes simplex virus	+	+++	+++	. . .	+
Varicella-zoster virus	+++	+	. . .	. . .	. . .
Cytomegalovirus	++	++	+	+	++
Epstein-Barr virus	+	+	+	. . .	+

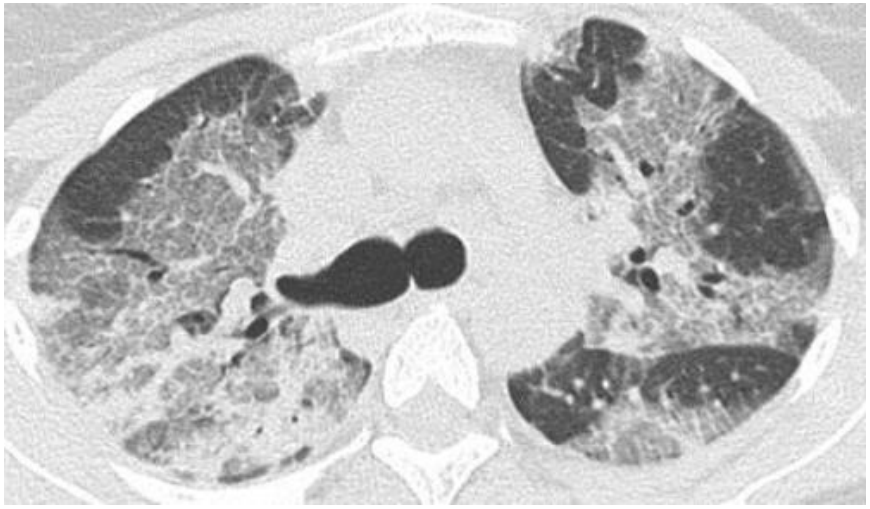
Influenza virus

General

- Influenza A
- Numerous subtypes depending on H and N antigens
- **H1N2 currently endemic in humans and pigs**

Imaging

- Bronchogenic pathway → descending evolution,
- **Broncho-alveolitis**

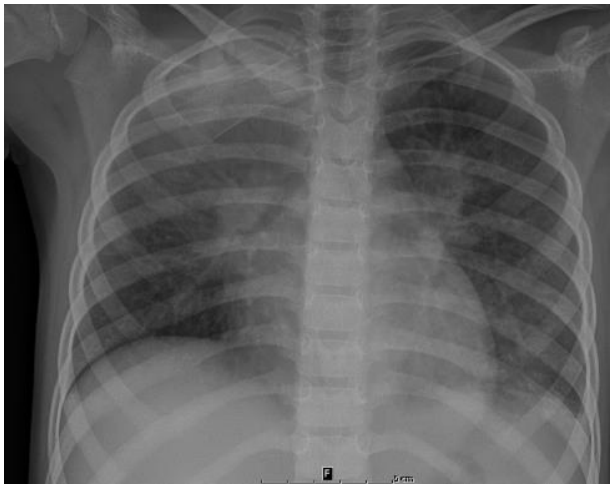


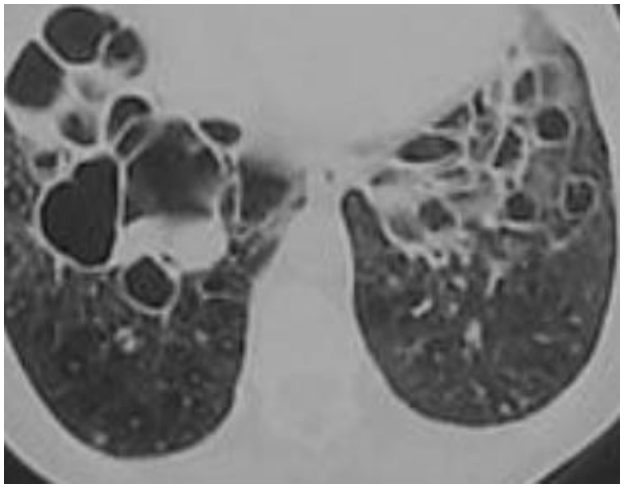
Measles

- Paramyxovirus
- **Poor children**
- Pneumonia within one month of rash

Imaging
- **Lymphadenopathy**
- **Bronchial thickening**
- **Pneumoniae**

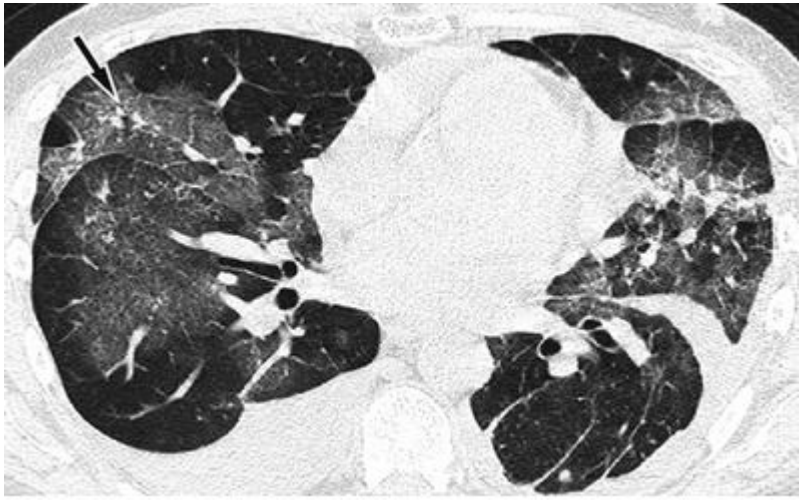
Complications
- **Follicular bronchiectasis and bronchiolectasis**
- Abscess, cysts due to inflammatory necrosis



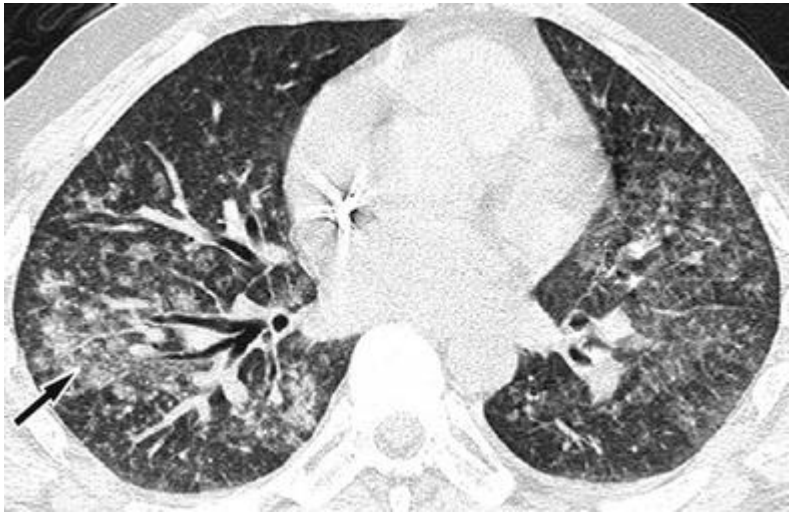


CMV infection

Affects the **immunosuppressed**, especially after **bone marrow transplant +++**



Courtesy Marius S, Horger - AJR



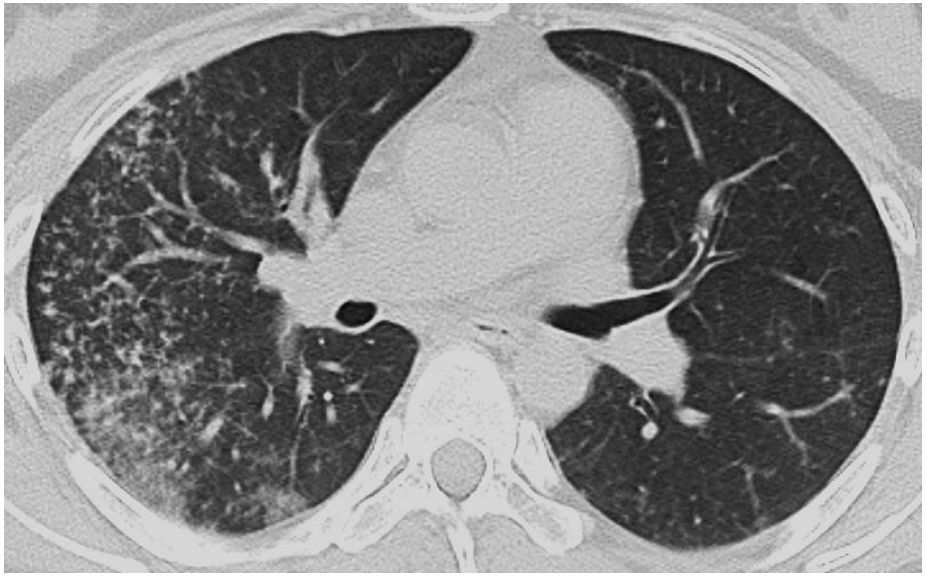
Courtesy Marius S, Horger - AJR

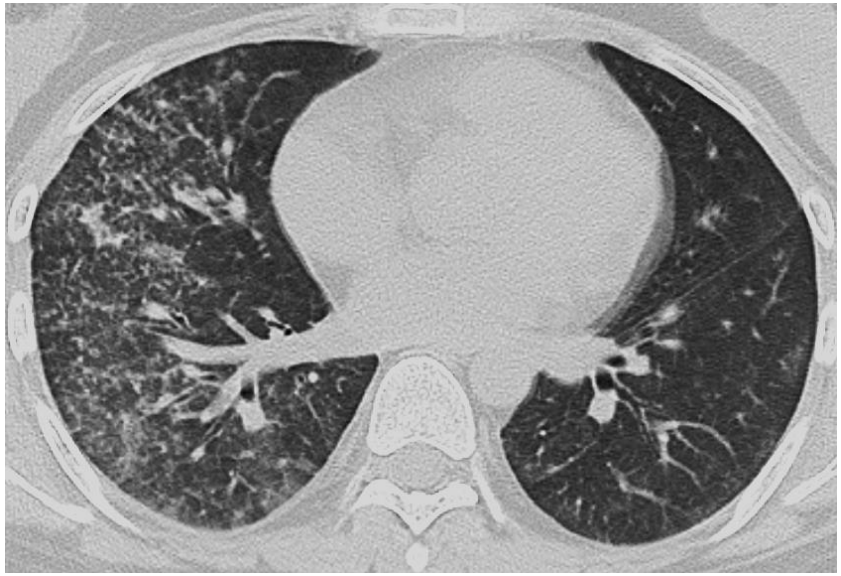
Imaging
- **GGO**
- **Centrolobular micronodules**
- **Consolidation**
- Bronchiectasis
- Bilateral, asymmetrical

Horger MS, Pfannenberg C, Einsele H et-al. Cytomegalovirus pneumonia after stem cell transplantation: correlation of CT findings with clinical outcome in 30 patients. AJR Am J Roentgenol. 2006

CMV pneumonia

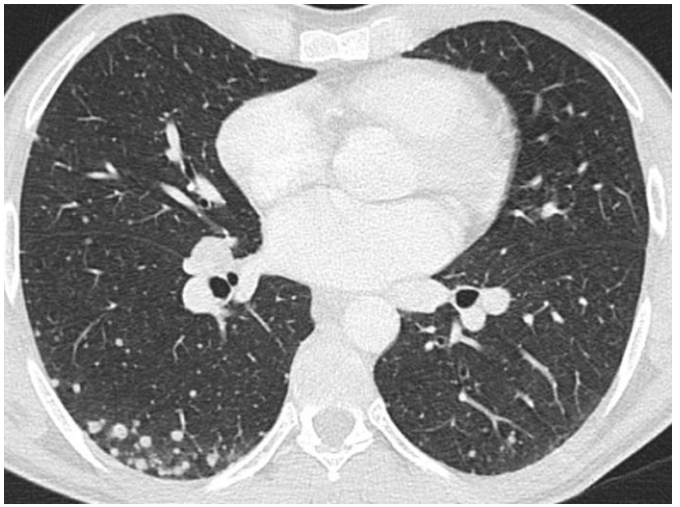
- Multitude of centrolobular ill defined micronodules
- LBA documented

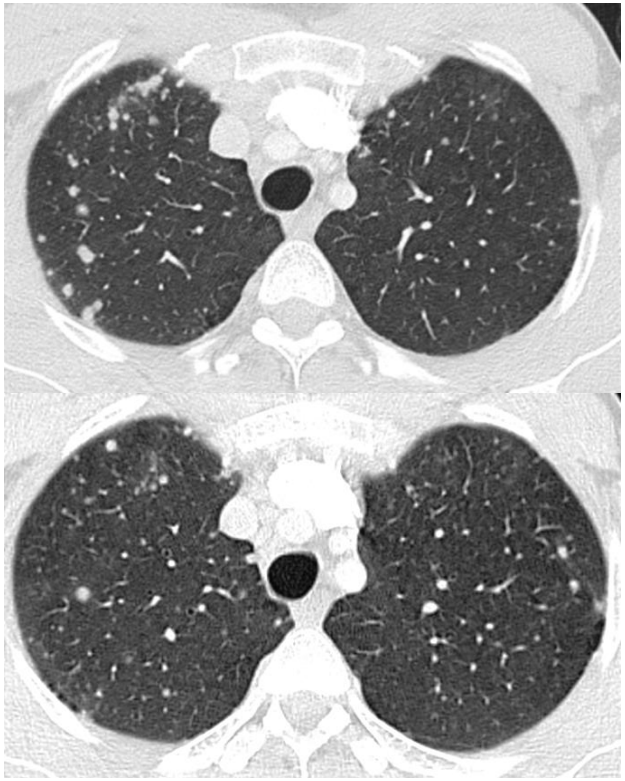




VZV pneumonia

- **The most frequent complication of chickenpox** (14%), concerns 50% of hospitalizations for chickenpox in adults.
- **Immunosuppression (especially HIV) promotes the** development of varicella pneumonia.
- **Skin lesions**



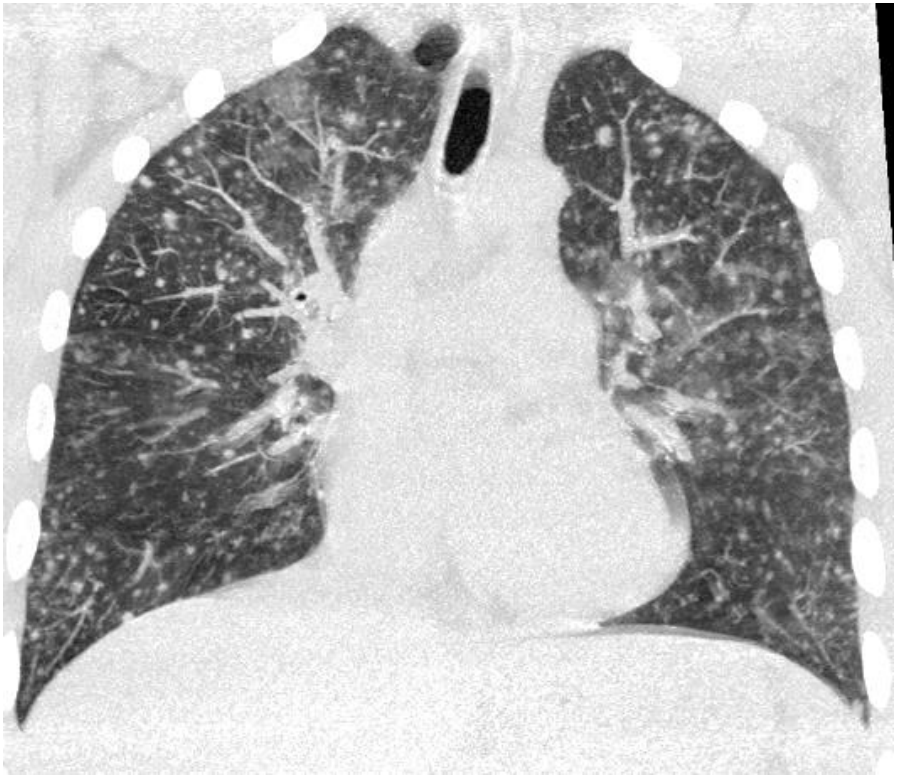


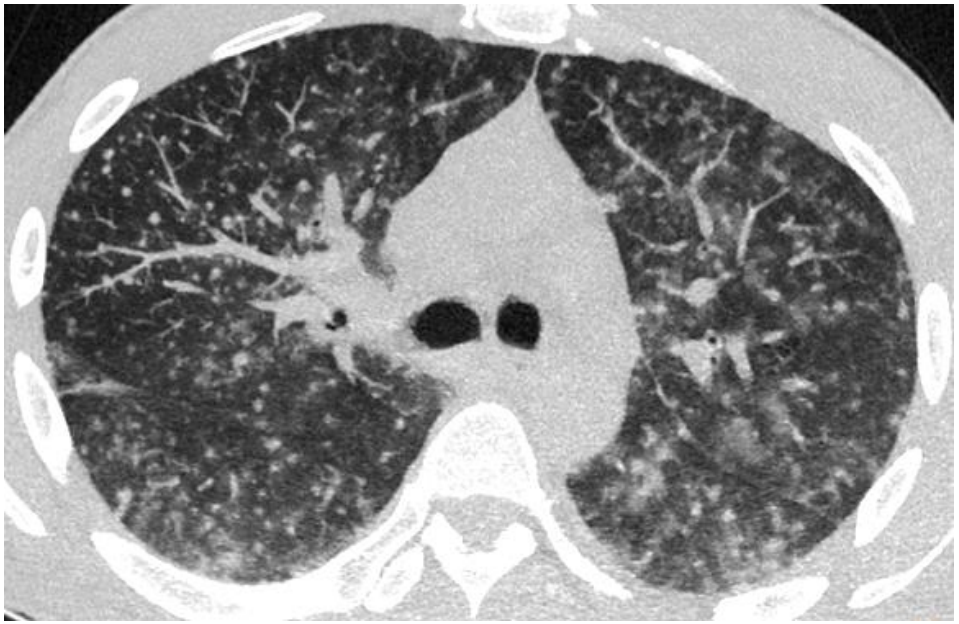
Imaging

Multiple micronodules / nodules (5 to 10 mm)

- **Centrolobular distribution**
- Or **random**
- **Poorly defined** ,with blurred edges (**halo sign**)
- May be confluent
- Disappear within a week (up to 1 month) after the skin lesions disappear
- For some patients, evolution into 2-3mm calcified micronodules.

Kim JS, Ryu CW, Lee SI, Sung DW, Park CK. High-resolution CT findings of varicella-zoster pneumonia. AJR 1999

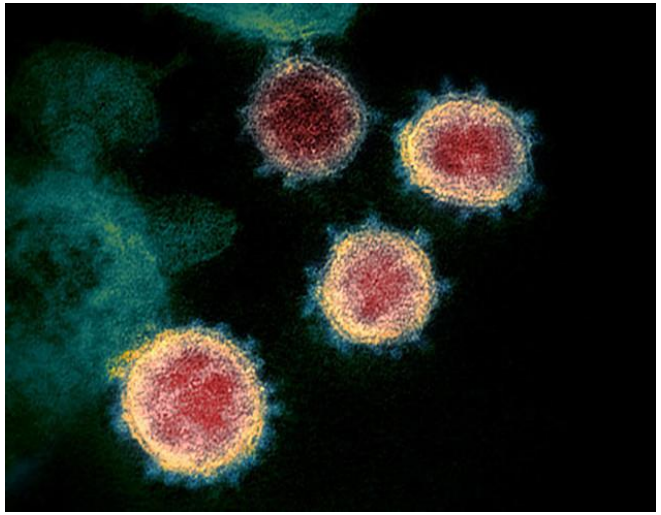




Varicella pneumonia

Multitude of random and centrolobular micronodules

Coronavirus - COVID 19



- Infection caused by a **coronavirus**: **SARS** coronavirus 2 (**SARS-Cov-2**) or 2019 novel coronavirus (**2019-nCoV**)
- First case in Wuhan, China in December 2019, followed by rapid expansion, currently recognized as a **pandemic infection.**

Diagnostic Test

RT-PCR blood or sputum = Gold standard BUT

- low sensitivity (60%)
- significant delays (at least 4 hours, even 24 hours in some center)

Place of CT:

Based on a Chinese cohort of 1014 patients suspected of COVID-19: Among PCR + patient : 97% have a CT scan +Among PCR - patients : 75% have a CT scan + of which more than ¾ were considered probably infected.

Ability of CT to detect lesions before symptoms appear

Overall: CT sensitivity = 97%; specificity = 25%.

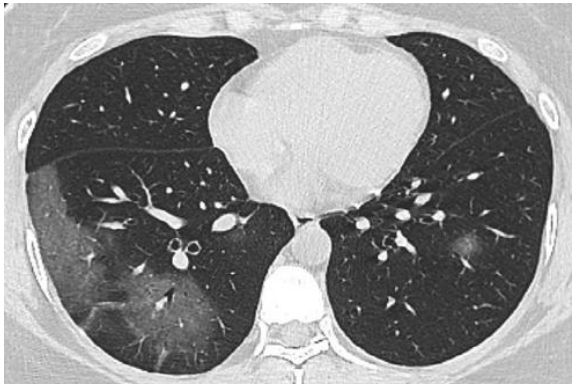
CT

- *Early phase*
  - **GGO** opacities, multifocal, asymmetrical
  - **Peripheral, posterior and lower regions**
  - Or sometimes **round and central** shape
- *Negative signs*
  - **No lymphadenopathy**
  - **No pleural effusion** (except severe forms)
  - **No micronodule**
- *Late phase*
  - **Crazy paving** (secondary appearance of intralobular reticulation) (peak around D10)
  - **Areas of subpleural condensation**, more extensive in severe forms
  - **ARDS +++** (wide declive consolidation) (**20%** of hospitalized patients)
  - **Organizing pneumonia** (reverse halo, curvilinear bands under pleura ...)
  - **Architectural distortions** (traction bronchiectasis): severity sign+++
  - **Pulmonary embolism** (association discussed)
  - *Slow regression of abnormalities in one month, possible fibrous sequelae*

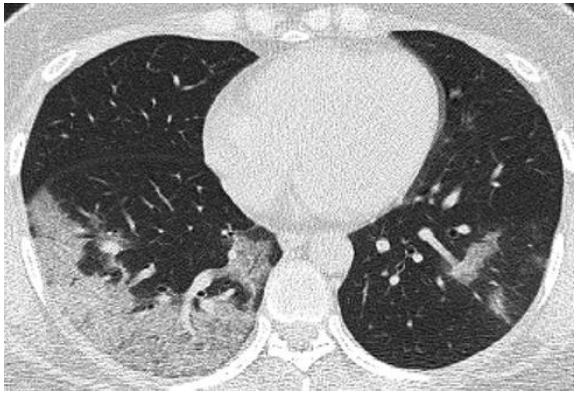
Some messages

- French radiologic society recommandations
  - Chest Xray not indicated
  - CT scan indicated
    - If **signs of severity** (desaturation)
    - If **fragile patients** with comorbidities
- There is currently **no indication to perform a chest CT scan for screening purposes** in patients without signs of severity and co-morbidities.
- **The CT scan is normal in 56% of cases for patients seen between D0 and D2.**
- **Suspect** a **pulmonary embolism** if parenchymal lesions are minimal and there is a need for oxygen.
- **In Covid-19-positive ICU patients** with **worsening**
  - ARDS?
  - Pneumothorax?
  - PE? (injection!!)
- **Suspect** myocarditis and confront troponin if there are signs of pulmonary oedema (**septal lines**)

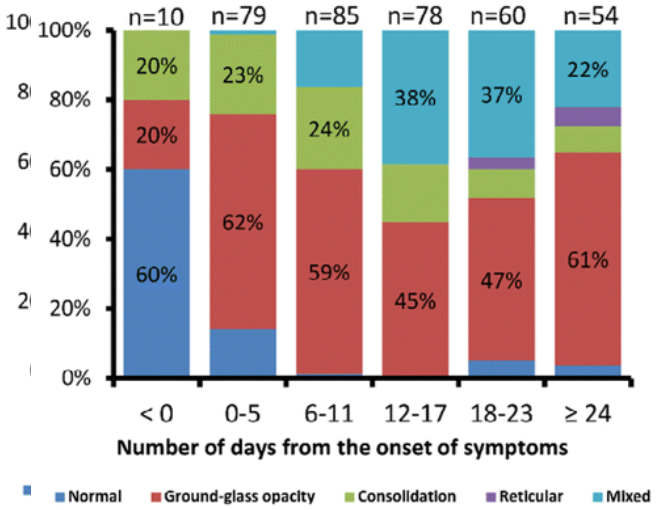
Evolution of lesions

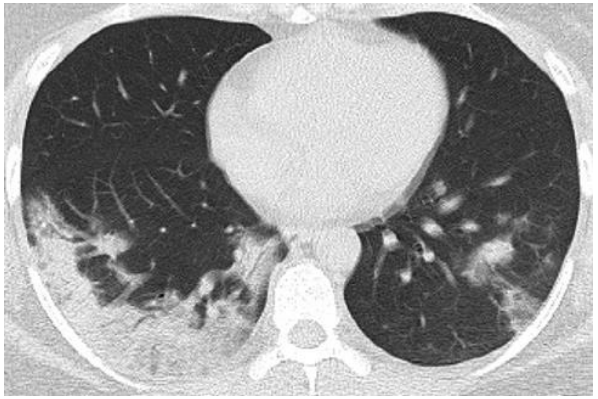


Day 1 of symptoms

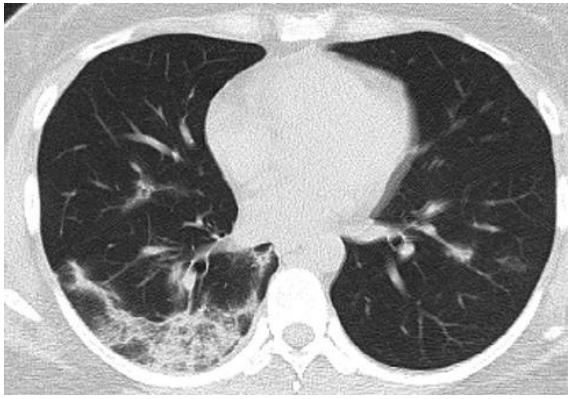


Day 5 of symptoms





Day 11

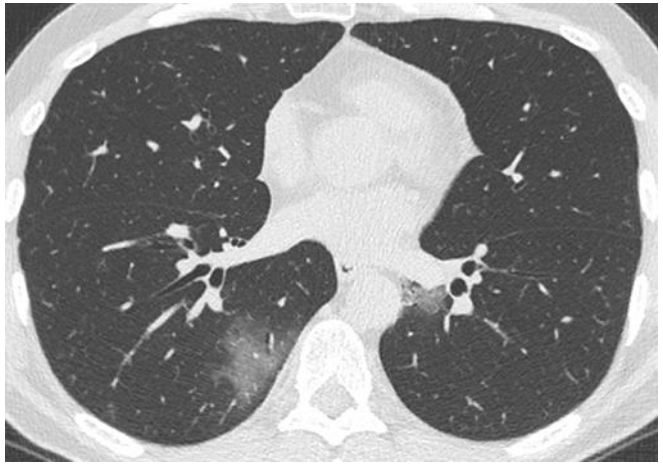


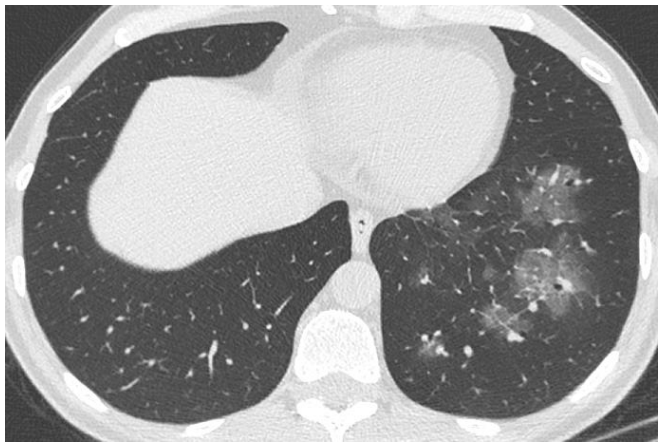
Day 15

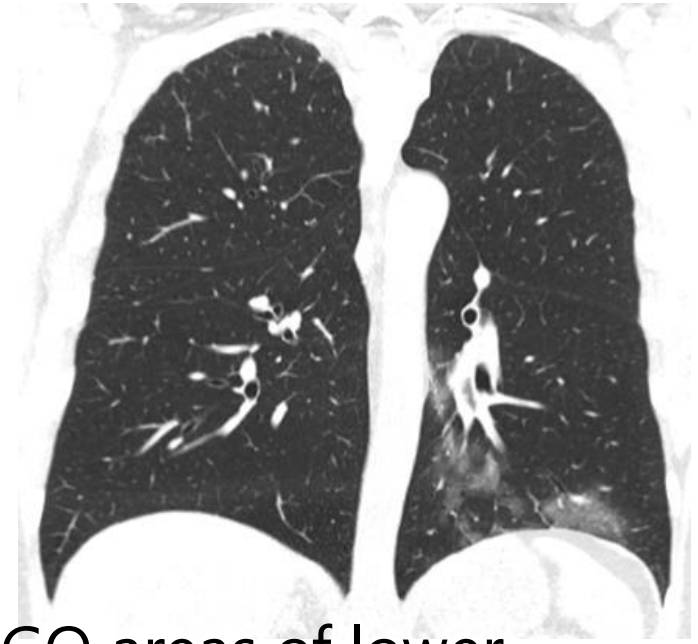
Temporal Changes of CT Findings in 90 Patients with COVID-19 Pneumonia: A Longitudinal Study
Yuhui Wang et al, March 19, 2020, Thoracic imaging

Early stage:

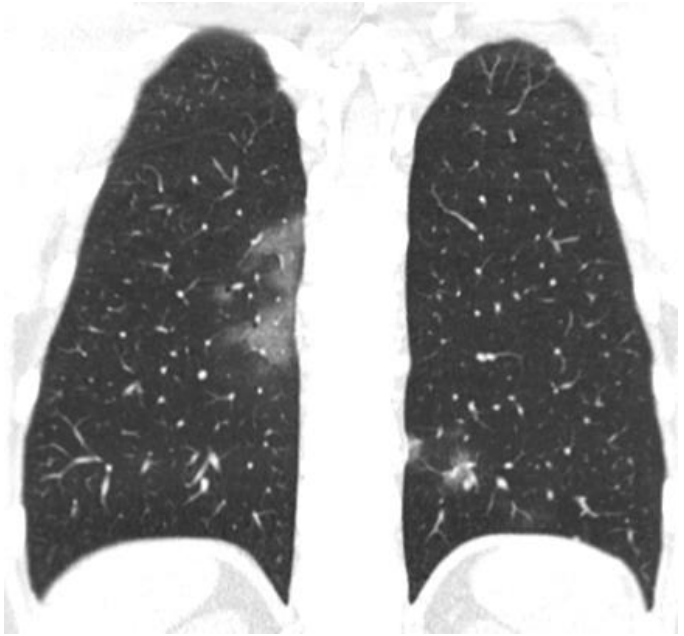
- **GGO** opacities, multifocal, asymmetrical
- **Peripheral and posterior, Lower regions**
- Sometimes **rounded** shape





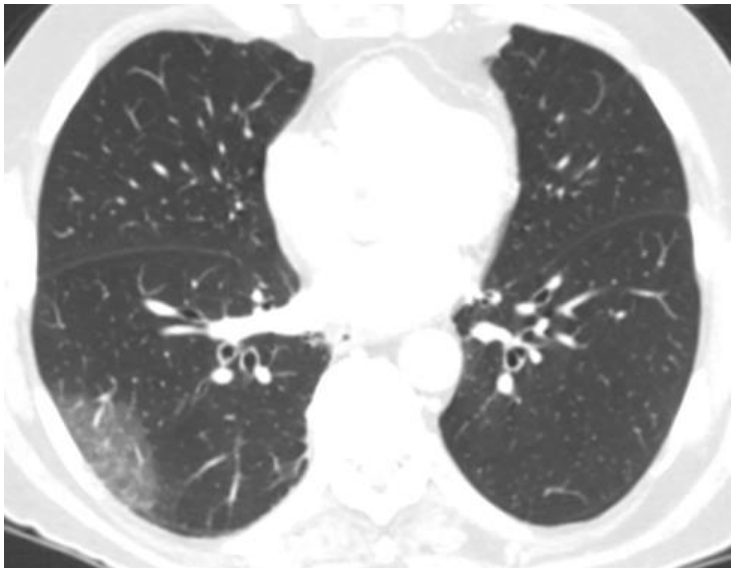


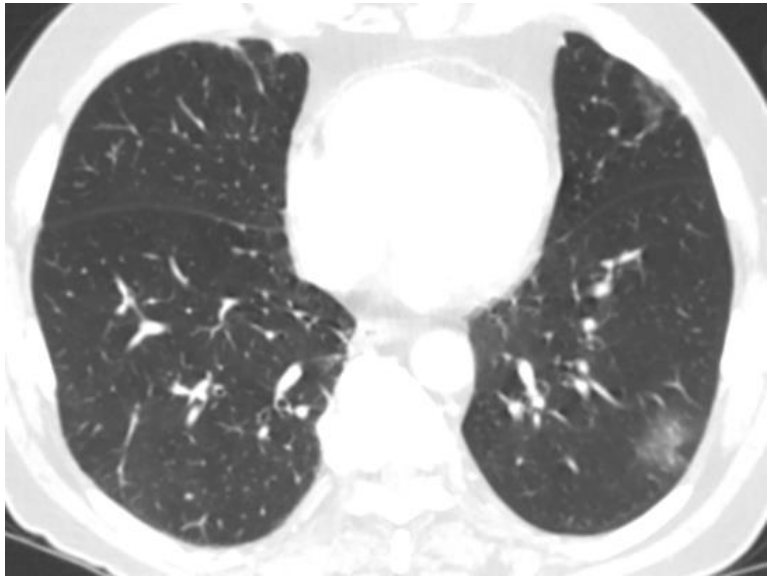
GGO areas of lower distribution

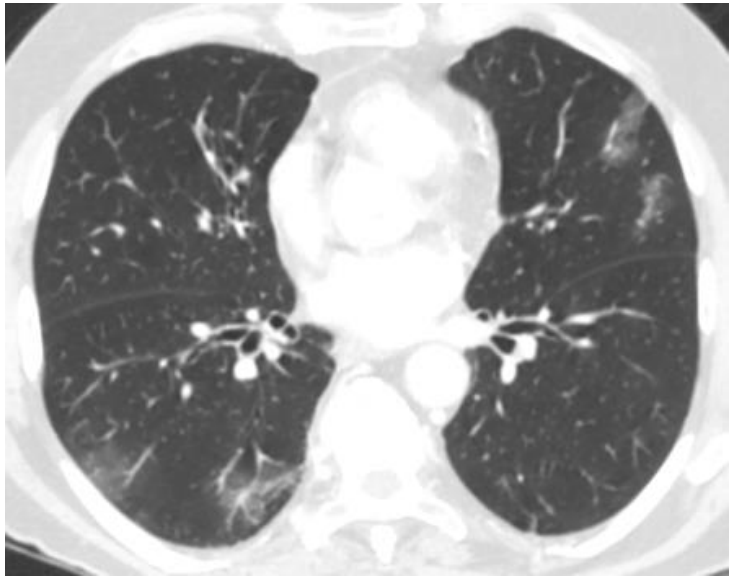


Early stage:

- **GGO** opacities, multifocal, asymmetrical
- **Peripheral and posterior, Lower regions**
- Sometimes **rounded** shape

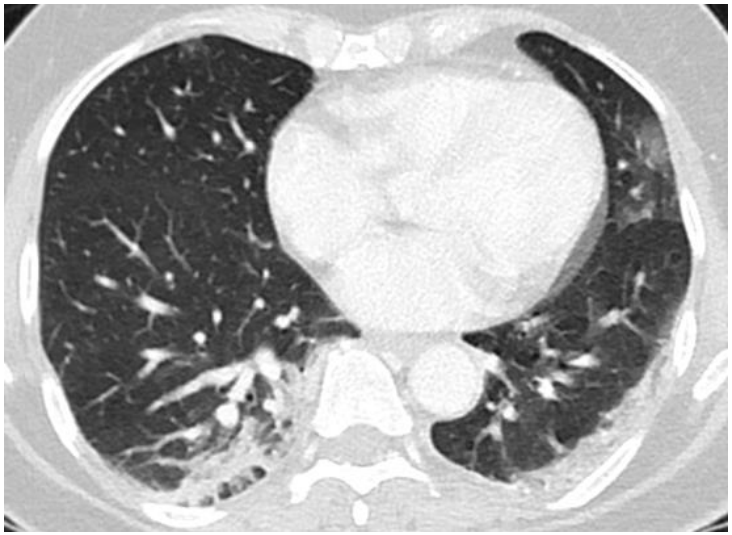


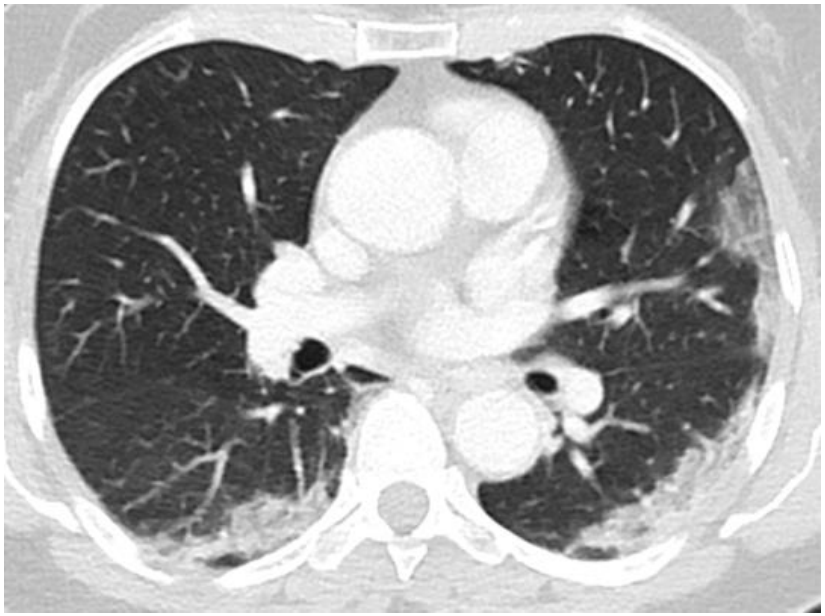


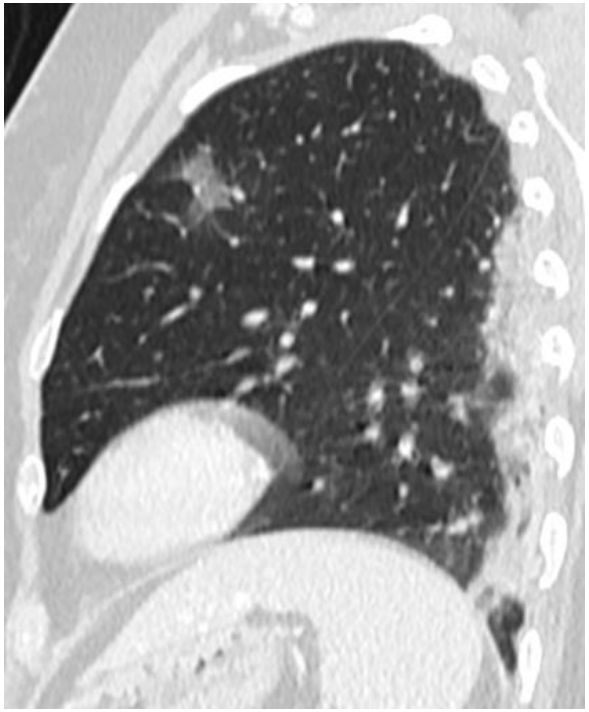


Late phase

- **Crazy paving**
- **Areas of subpleural consolidation**, more extensive in severe forms
- ARDS +++
- Organizing pneumonia
- Architectural Distortions
- Pulmonary embolism

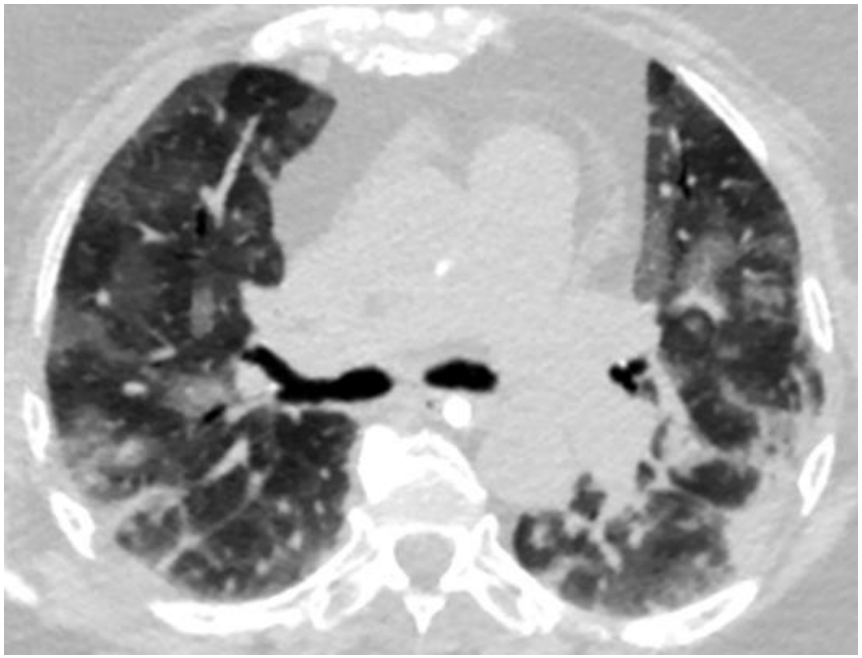


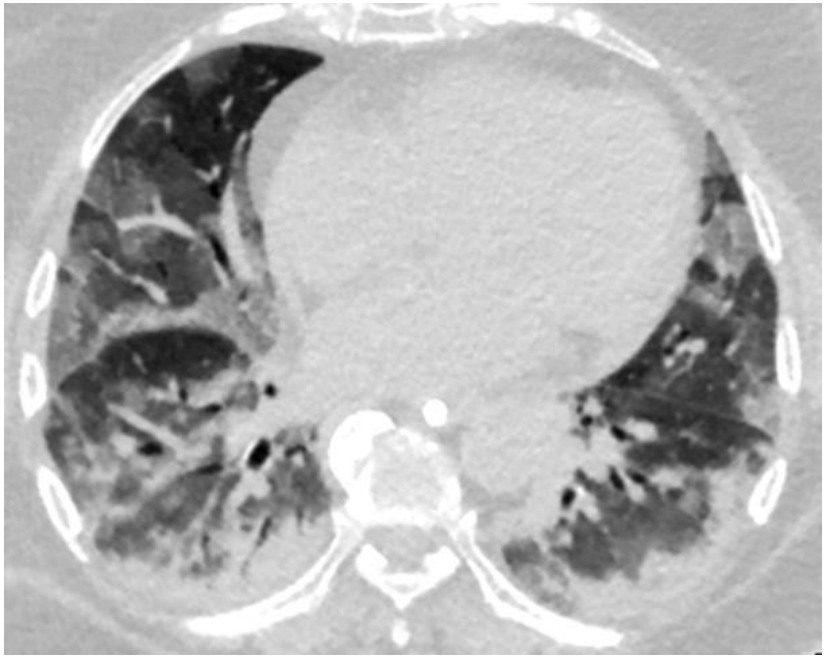




Late phase

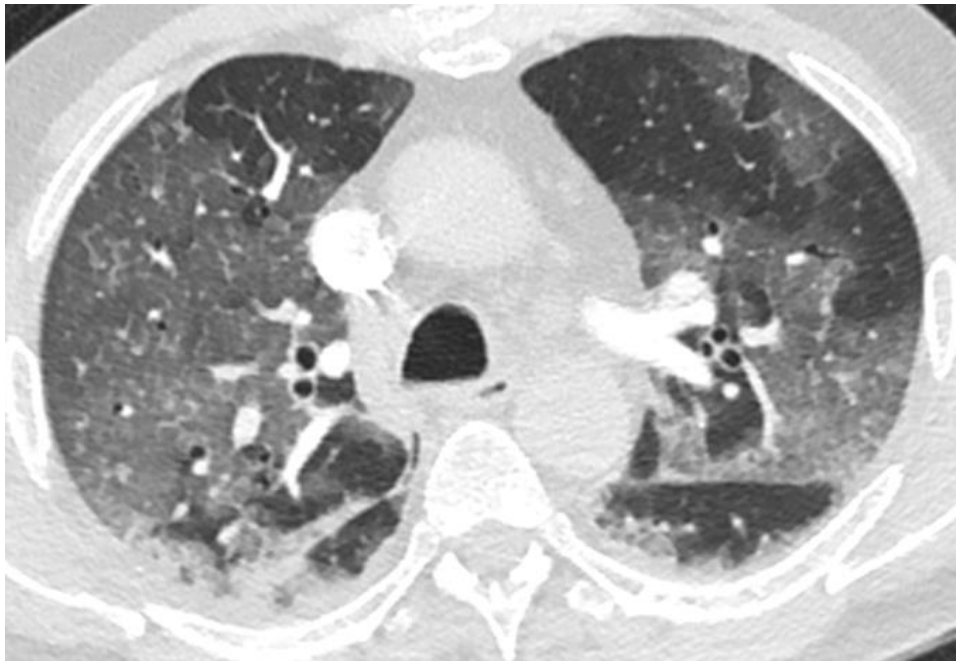
- Crazy paving
- Subpleural consolidation
- Early ARDS
- Organizing pneumonia
- Architectural Distortions
- Pulmonary embolism

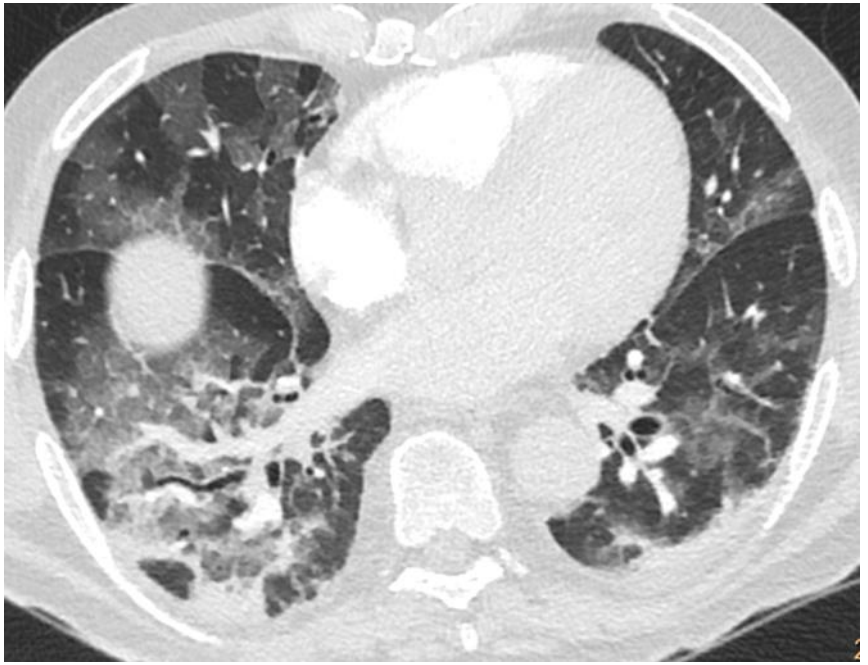




Late phase

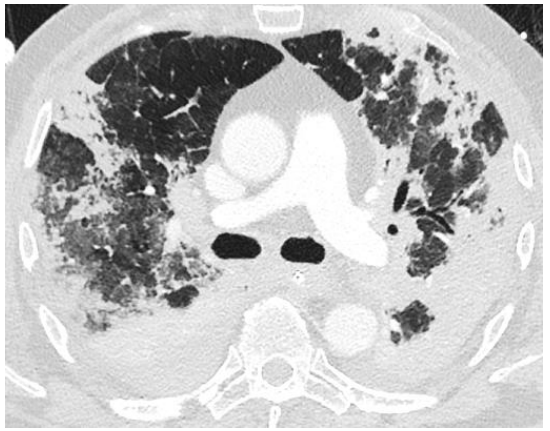
- Crazy paving
- Subpleural consolidation
- ARDS
- Organizing pneumonia (reverse halo sign , perilobular opacities...)
- Architectural Distortions
- Pulmonary embolism

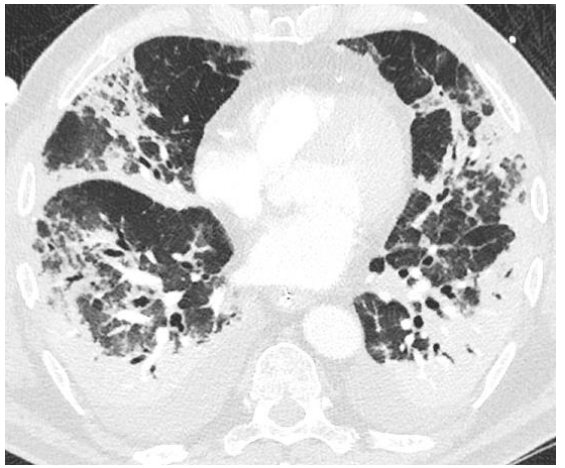




Late phase

- Crazy paving
- Subpleural consolidation
- ARDS
- Organizing pneumonia
- **Architectural distortions** (traction bronchiectasis): severity factor
- **Pulmonary embolism** (association discussed)



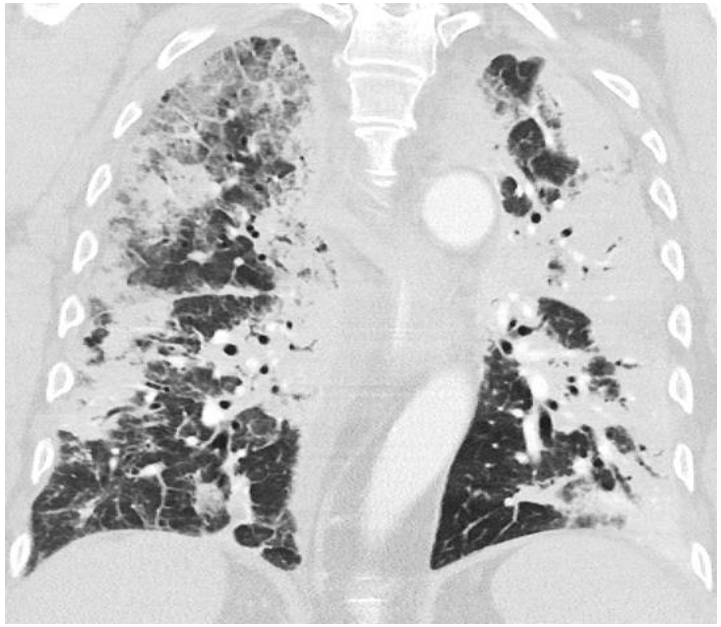


In Covid-19-positive patients in intensive care and resuscitation with **aggravation,**

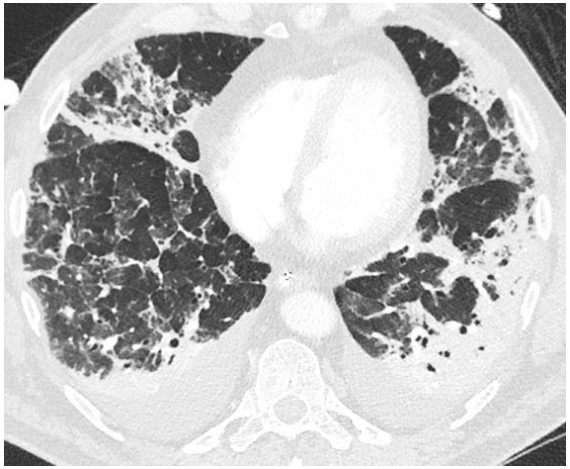
→ look for worsening of lesions with progression to ARDS

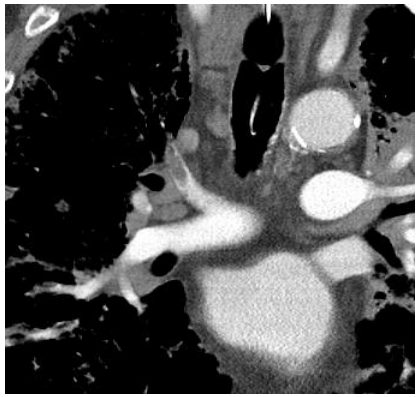
→ but also a ventilated pneumothorax

→ or a **thromboembolic complication** and → **injection (angio CT)**



ARDS

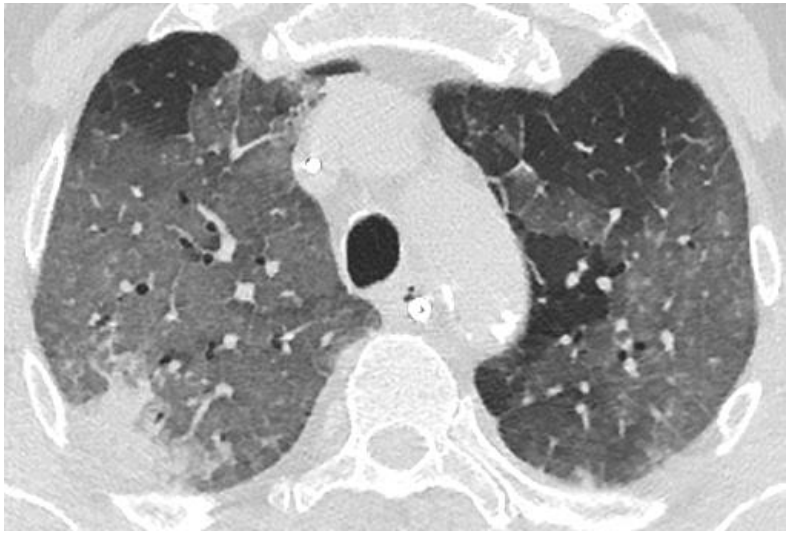




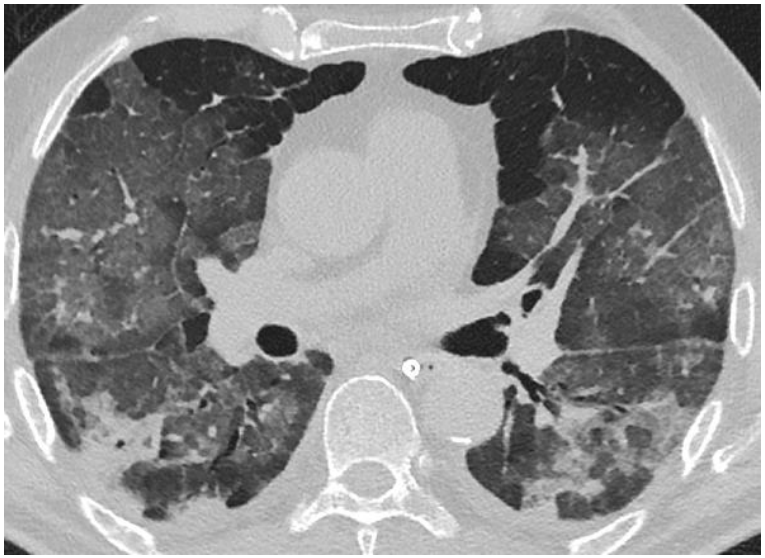
Pulmonary embolism

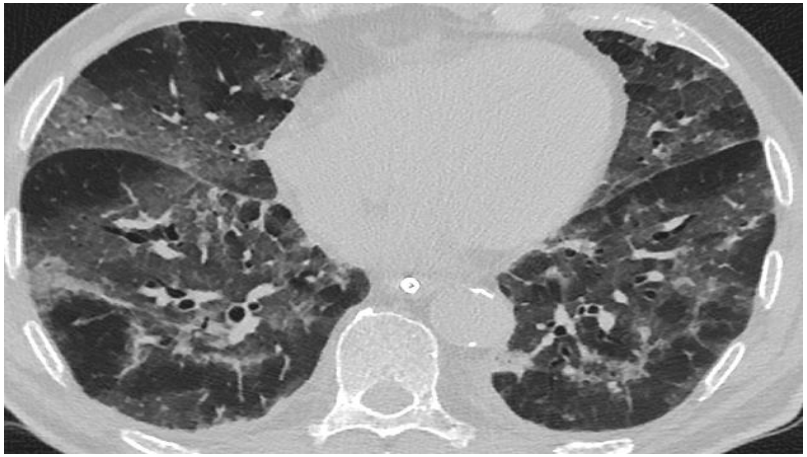
Late phase

- Crazy paving
- Subpleural consolidation
- ARDS
- Organizing pneumonia (reverse halo, perilobular opacities, ...)
- Architectural Distortions
- Pulmonary embolism

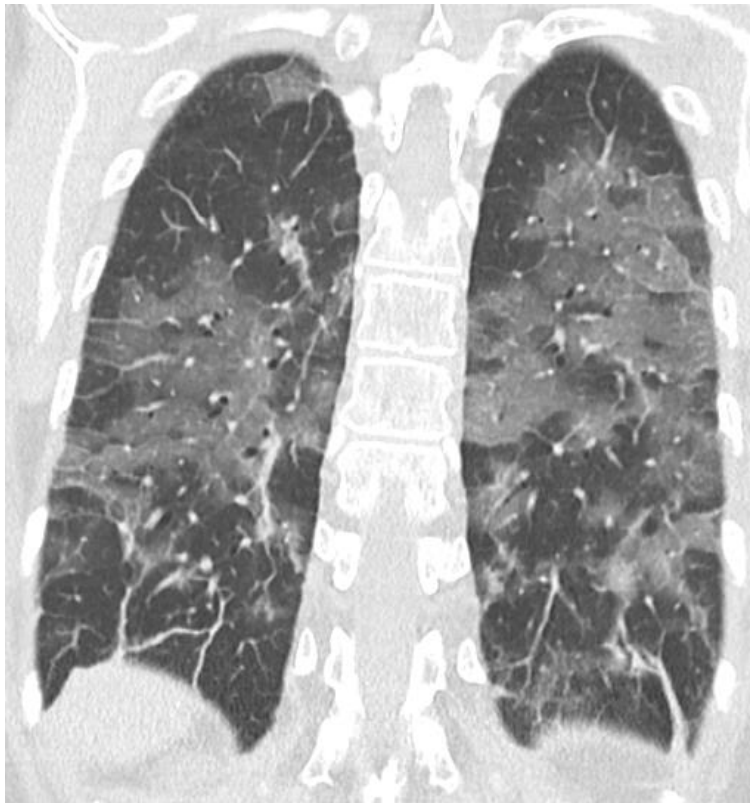


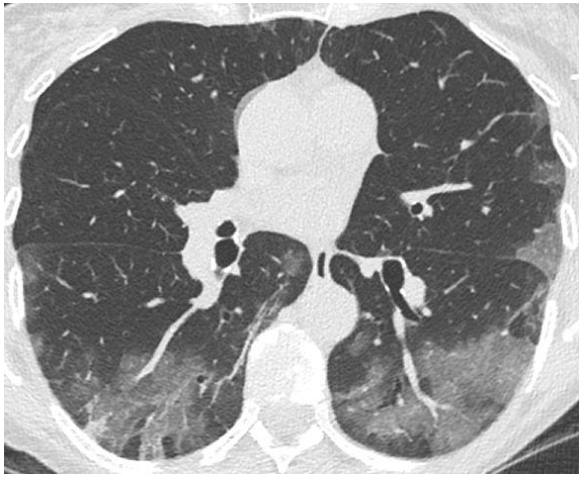
Crazy paving with the appearance of declive consolidation

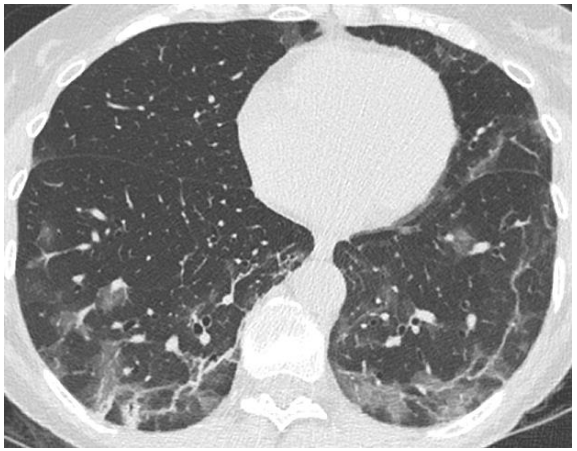


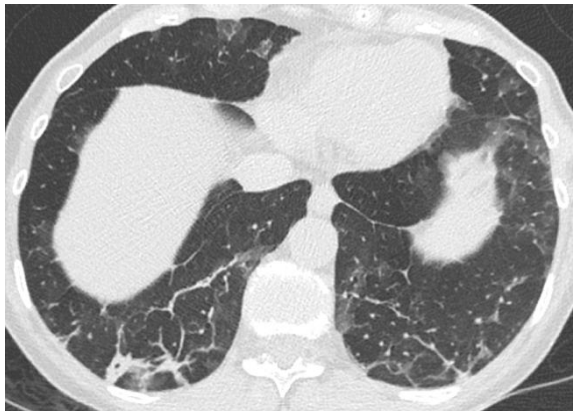


Subpleural curvilinear opacities







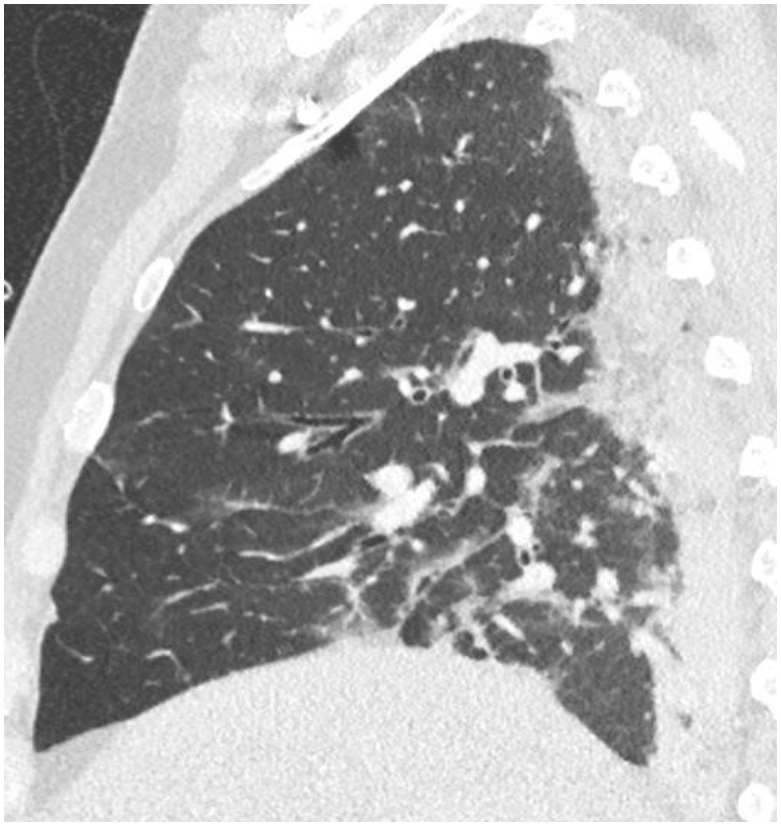


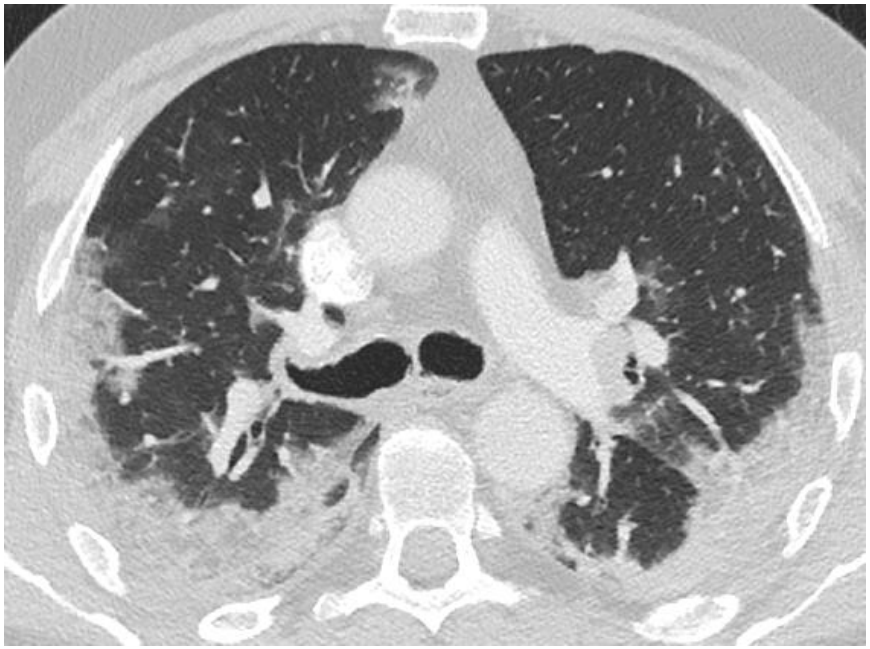
Late phase

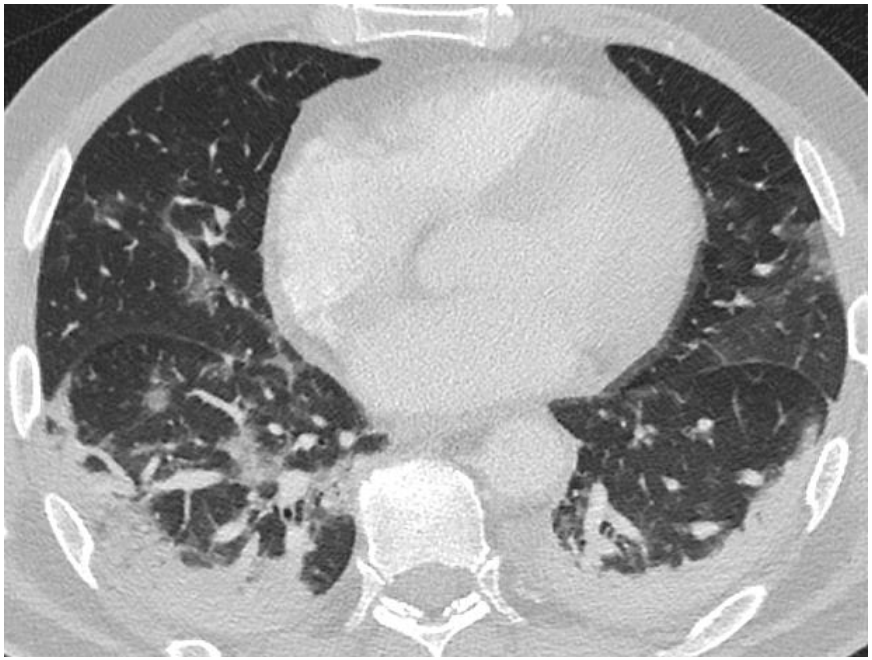
- Crazy paving
- Subpleural consolidation
- ARDS
- Organizing pneumonia (reverse halo, perilobular opacities, ...)
- Architectural Distortions
- Pulmonary embolism

Late phase

- Crazy paving
- Sub pleural consolidation +++
- Early ARDS?
- Organizing pneumonia
- Architectural Distortions
- Pulmonary embolism

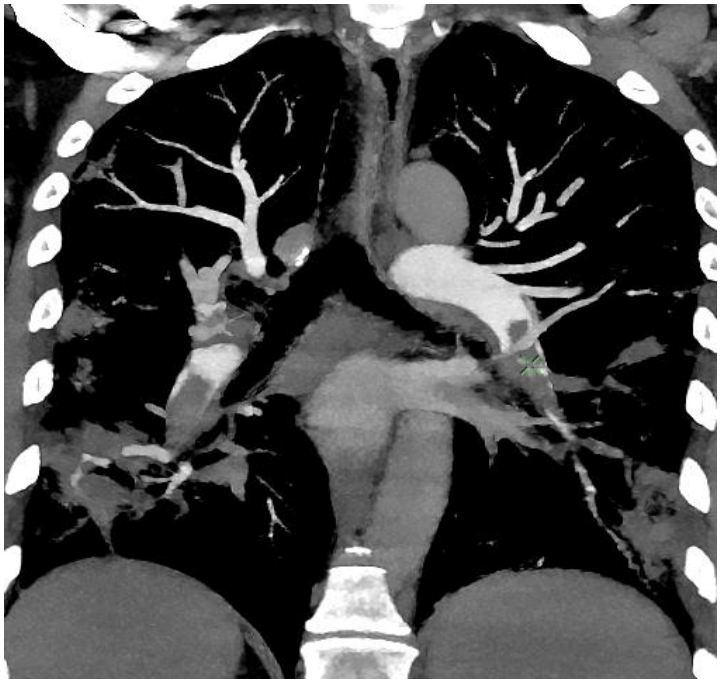




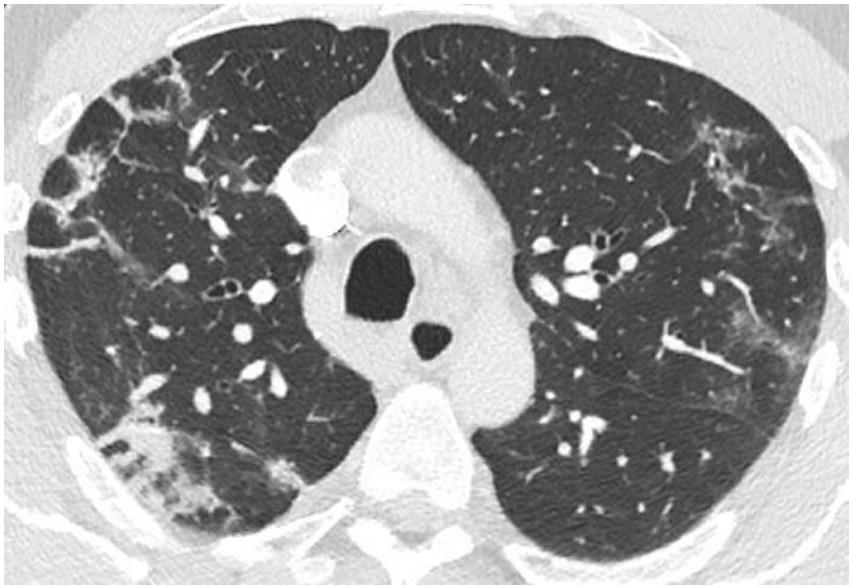


Late phase

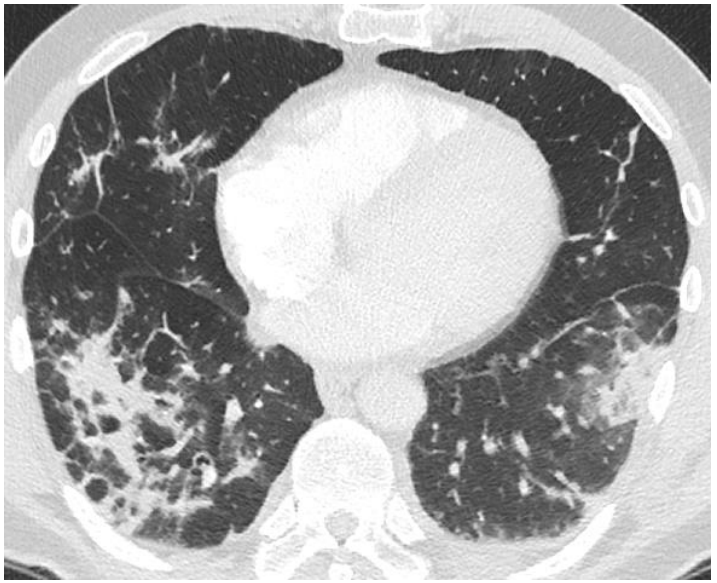
- Crazy paving
- Subpleural condensation zones
- Early ARDS
- Organizing pneumonia (perilobular opacities) +++
- Architectural Distortions
- Pulmonary embolism

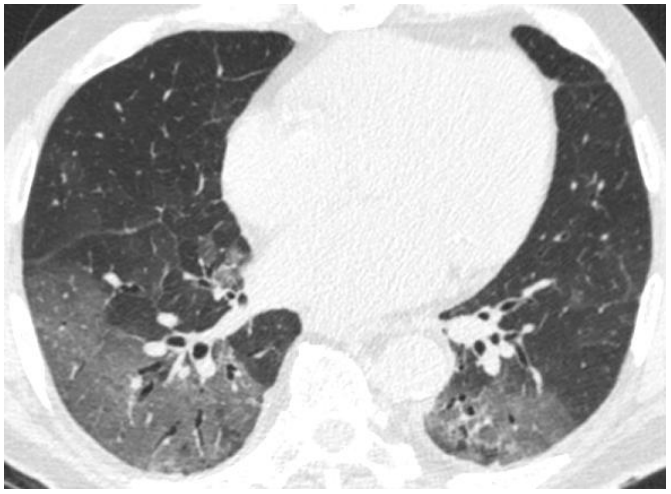


Lobar pulmonary embolism
+ left base infarction

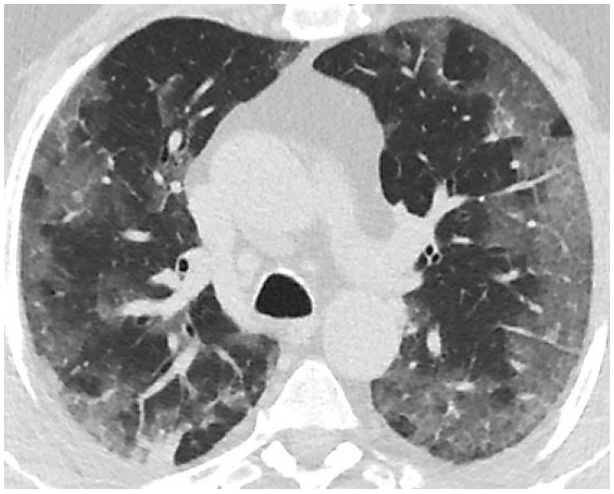


Perilobular arcade opacities ++



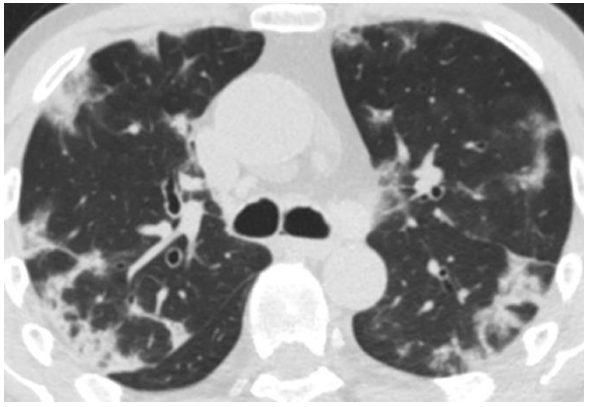


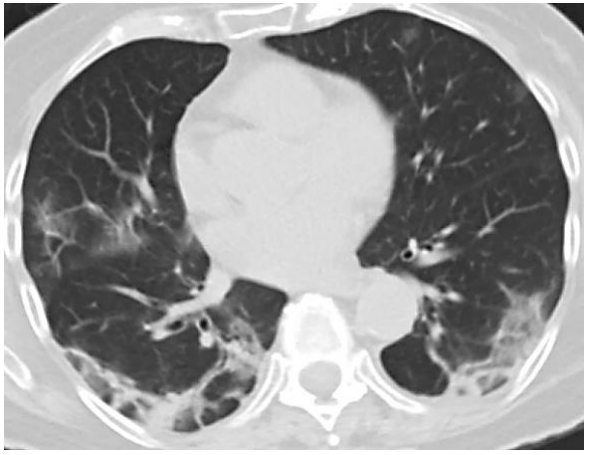
Bilateral and lower regions GGO

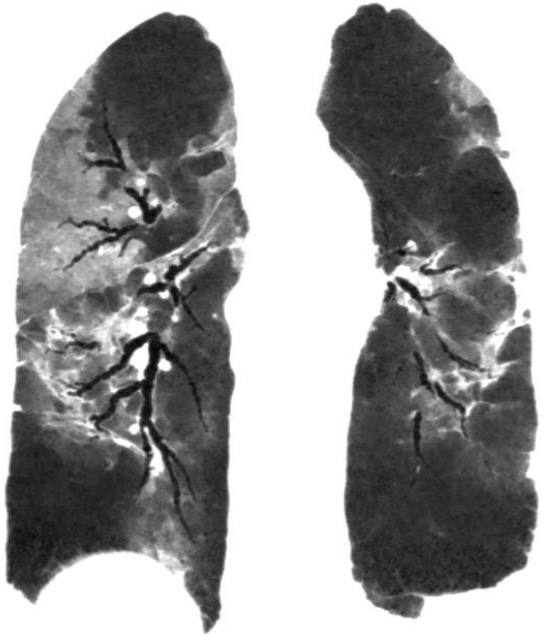


Crazy paving

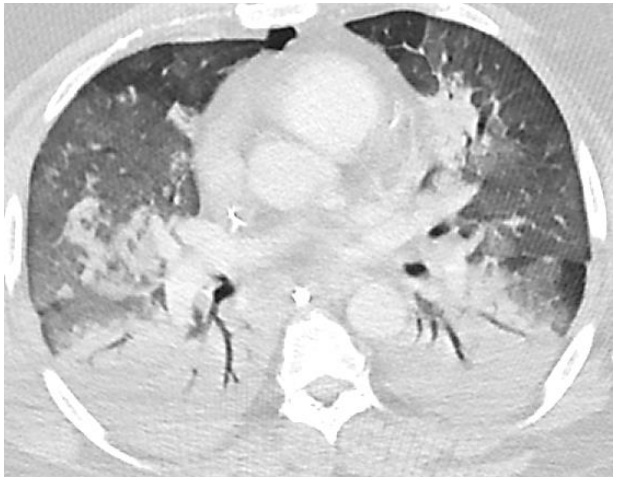
Organized pneumonia
Perilobular opacities



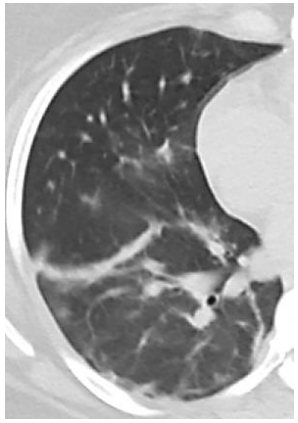


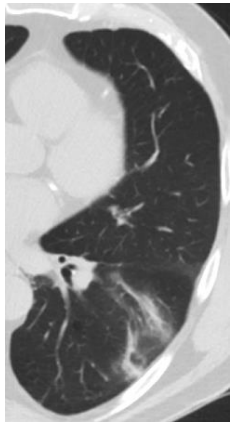


Traction bronchectasia



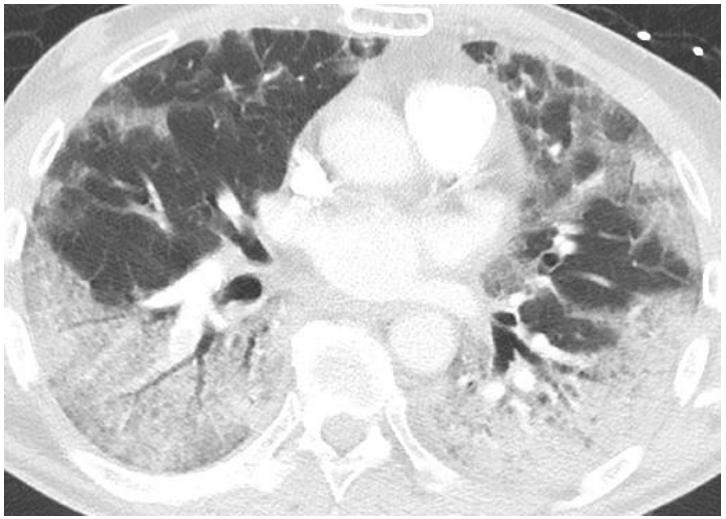
ARDS
Declive consolidation

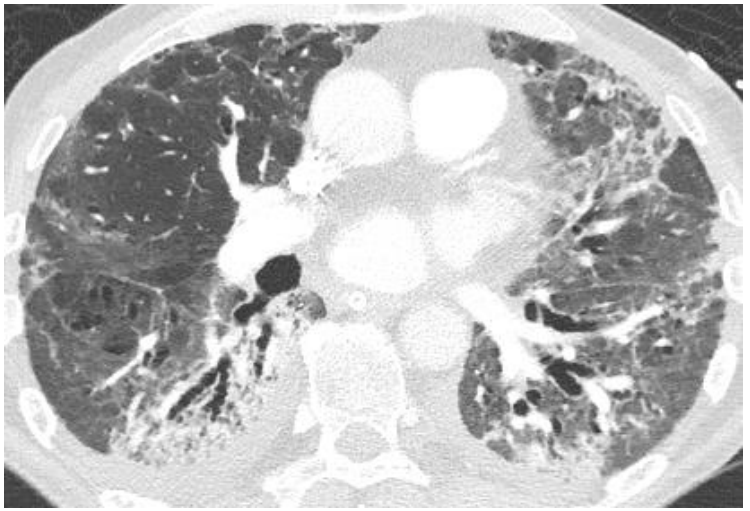


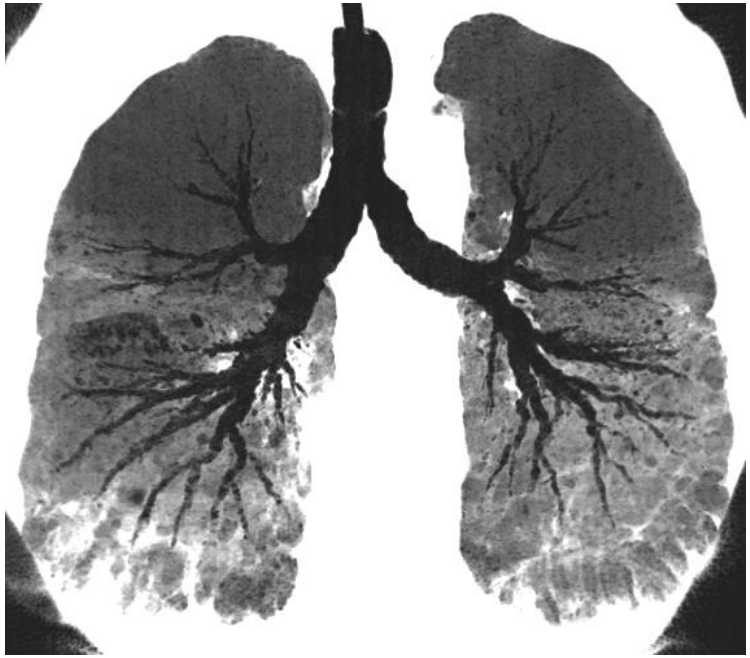


Hilo peripheric bands

COVID : **rapid fibrosing evolution +++ (15 days)**
Traction bronchectasia +++



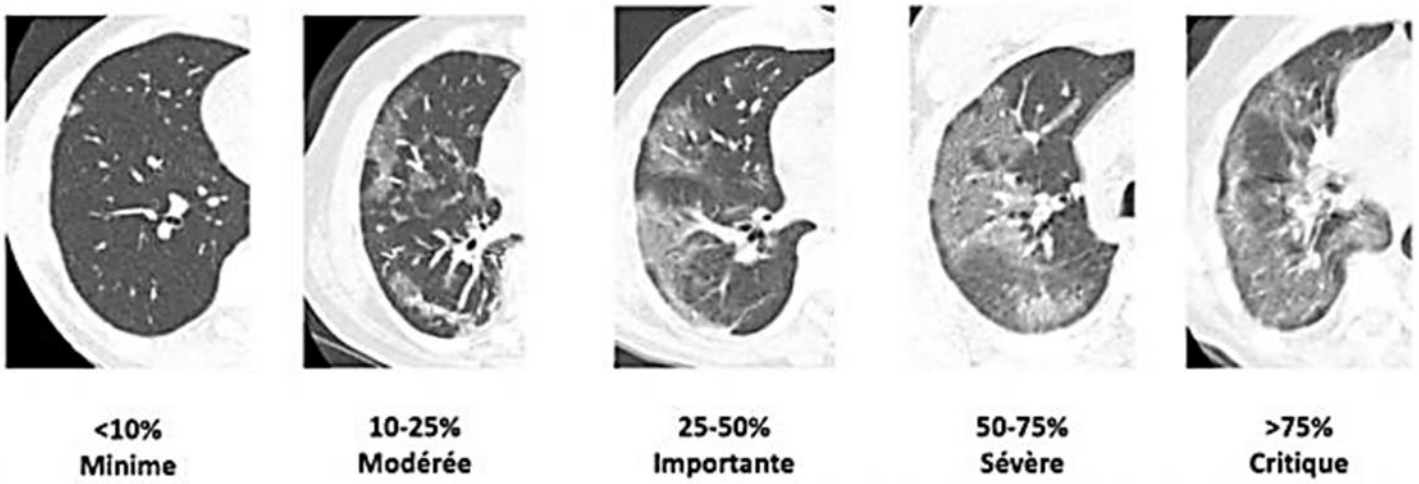




Clinical worsening → watch for signs :

1) Grading of lesions (SIT)

- Devant un cas typique ou compatible COVID-19, il est recommandé de grader l'étendue des lésions



2) Argument for added infection

- Unilateral consolidation
- Pleural effusion
- Lymphadenopathy

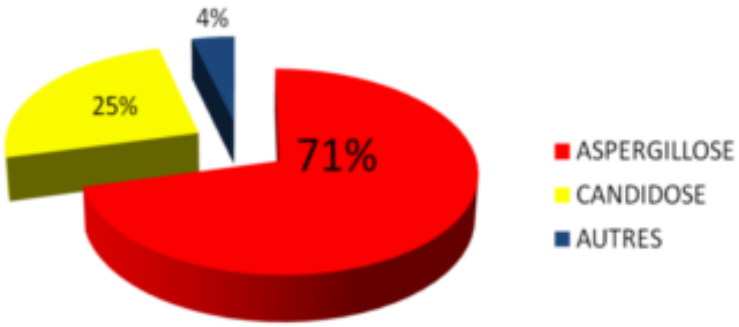
3) Pneumothorax?

4) Pulmonary embolism ?

Invasive fungal infections

- **Severe**
  - 45% at 12 weeks
  - High ICU mortality (aspergillosis 75-95%, candidemia 50%)

Etiologies

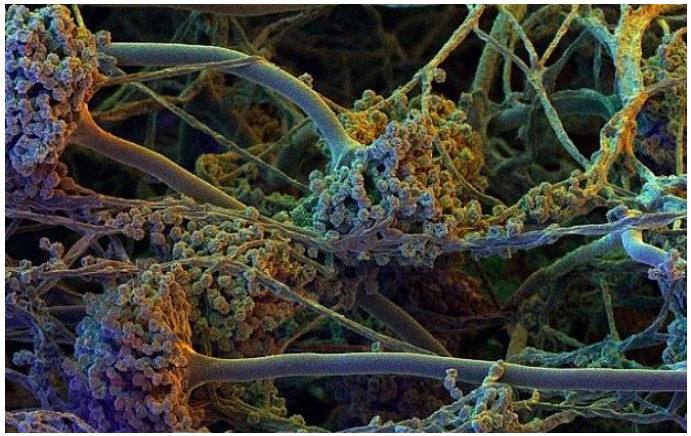


En Onco hématologie, *Pagano L et al, Clin Infect Dis 2007*

Autres : Zygomycose (rhizopus, mucor, absidia, rhizomucor…), Cryptococcose.

Pulmonary aspergillosis

- Aspergillus fumigatus: **saprophytic and ubiquitous fungus**
- Spore concentration in the air increases when **work is carried out**
- The factors that expose to the development of pathology are
  - Atopy / asthma → allergic reaction to aspergillar antigens → ABPA
  - Airway involvement (DDB, cystic fibrosis) → Colonization (60% of cystic fibrosis patients)
  - Immune Deficiency → Chronic Necrotizing Aspergillosis or Invasive Aspergillosis
  - Chronic pulmonary cavities (caverns, bubbles, ...) → absence of intracavitary macrophages → Aspergilloma



Biology

<u>Sputum / BAL, bronchial aspiration</u>

- **Direct examination +++:** confirms at least one "colonization"
- **Antigen testing** (BAL)
- **Culture** (deferred result)

<u>Blood</u>

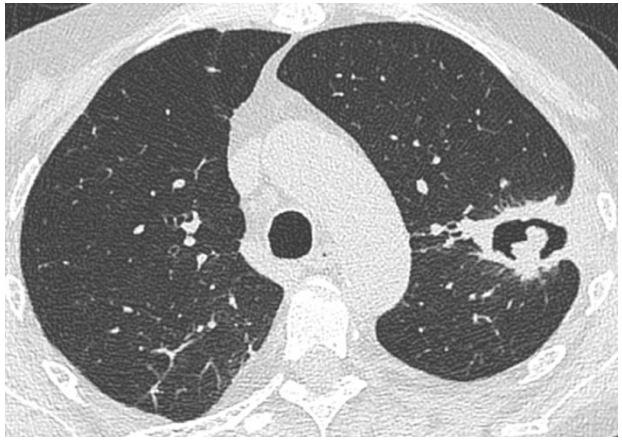
- <u>Immunocompetent</u> (capable of producing Ac) → Western Blot, Elisa, immunoelectrophoresis
- <u>Immunocompromised</u> (unable to produce Ac) → <u>antigenemia</u> (indicates invasive disease)
  → **Galactomananne+++**: positive before clinical, radiological and earlier than cultures. Se 92 and spe 96%,
  → **PCR**: VPN 100%, VPP 15%

Poster JFR- Pulmonary Aspergillosis: What the Radiologist Should Know- A. Goracci
Franquet T, Müller NL, Giménez A et-al. Spectrum of pulmonary aspergillosis: histologic, clinical, and radiologic findings. Radiographics 2001

Aspergilloma

Aspergilloma = "fungus ball" = a bundle of mycelial filaments.

- Develops in a **pre-existing cavity**
- Immunocompetent or immunocompromised patients



Saprophytic infection

Aspergillar infection **without tissue invasion** (colonization by conglomerate of filaments, mucus and cellular debris)

- Pathological airways (COPD, bronchectasia, cystic fibrosis)
- Chronic lung cavities (all types): **aspergilloma**

Imaging

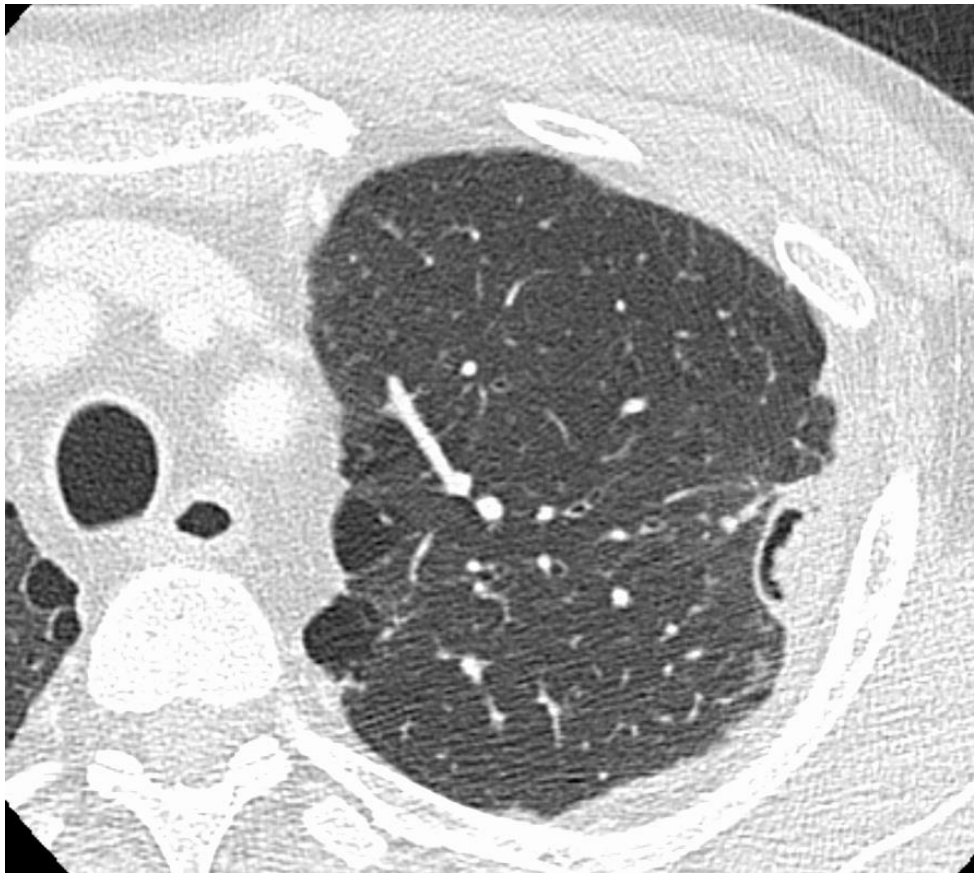
Filling of a pre-existing lung cavity with a "fungal ball" +++

- Pre-existing cavity
  - Tuberculous cavity
  - Excavated fibrosis blocks in sarcoidosis
  - Emphysema Bubbles
  - Honeycomb lesions
  - Post-radiofrequency excavation
  - (any chronic lung cavity tends to be colonized by aspergillus)
- **Variable** degree of cavity filling
- **Mobility of the** fungus ball
- **Crescent sign +++** (CT +++) (non-specific because also present in angio-invasive or chronic necrotizing aspergillosis)

Complications

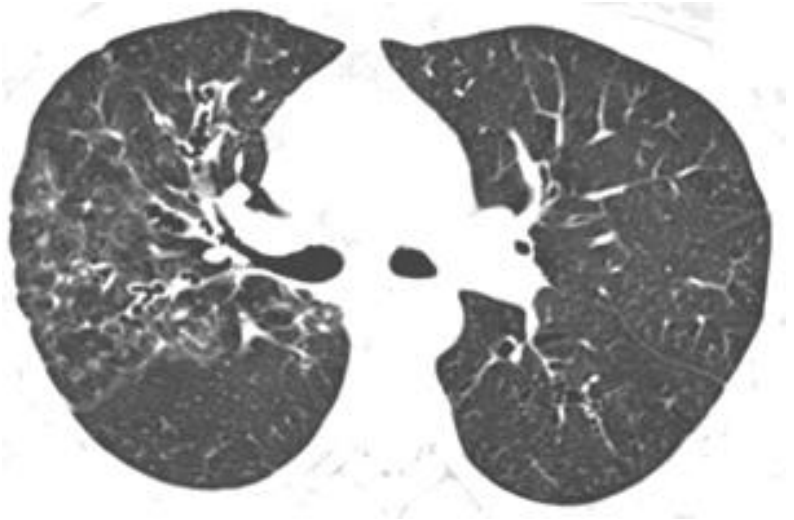
- **Hemoptysis ++**
- Superinfection (hydro-aerial level)

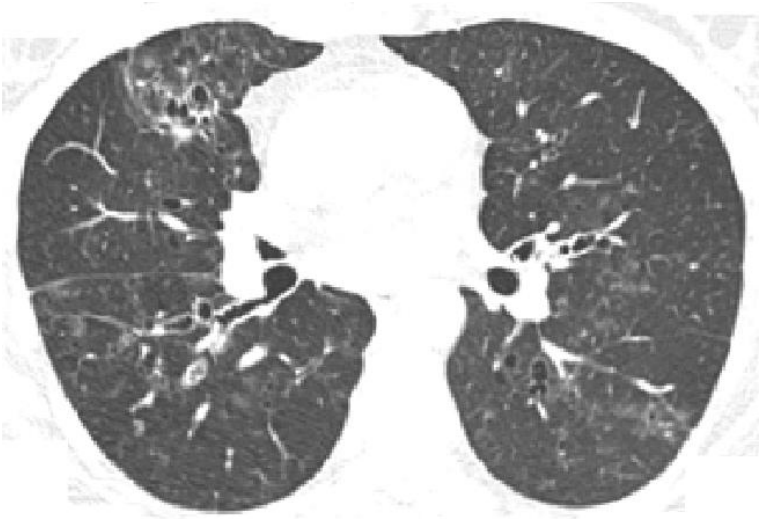
Aspergilloma



ABPA Allergic bronchopulmonary aspergillosis

- **Long-term asthma** or **cystic fibrosis** (ABPA in 10% of cases)
- **Allergic reaction to aspergillar antigens**
  - ✓Local **inflammatory reaction** with influx of eosinophils, hypersecretion, alteration of bronchial wall
  - ✓**Filling of** (often dilated) airways with plugs of mucus, aspergillus and eosinophils





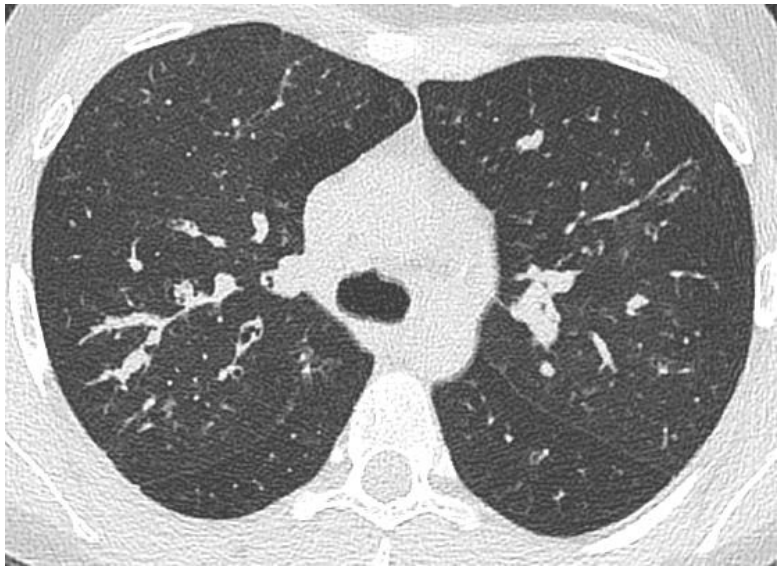
Imaging

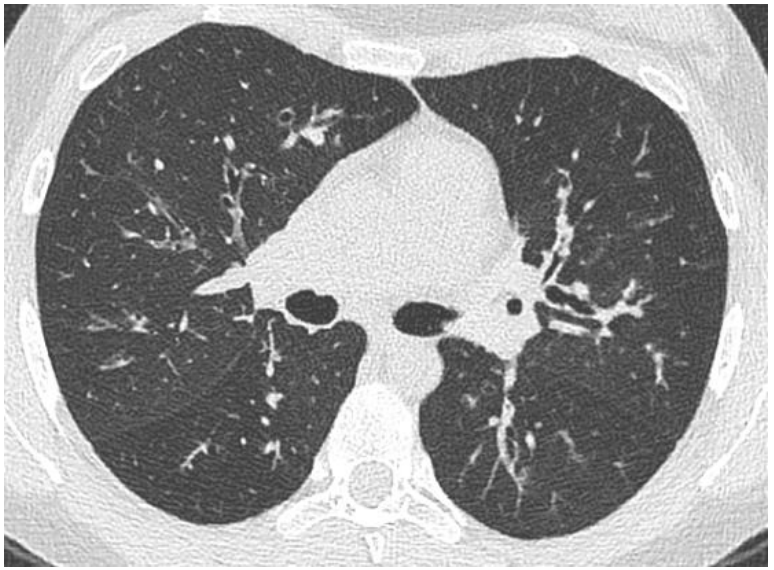
Bronchiectasis filled with mucus+++

- **Dilatation of segmental** or **sub-segmental bronchi**
- **Mucoid impactions** (Y- or V-shaped appearance) +/- calcifications or **hyperdensity** of mucous plugs

+/- Lobar or segmental atelectasis

+/- Spontaneous pneumothorax or effusion





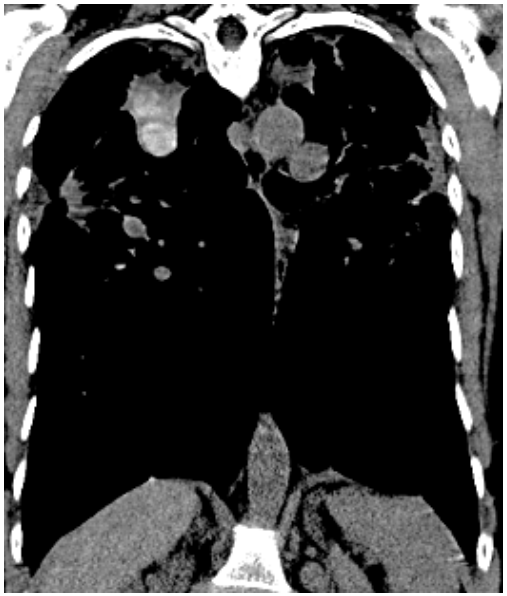
New criteria (ABPA working group 2013)

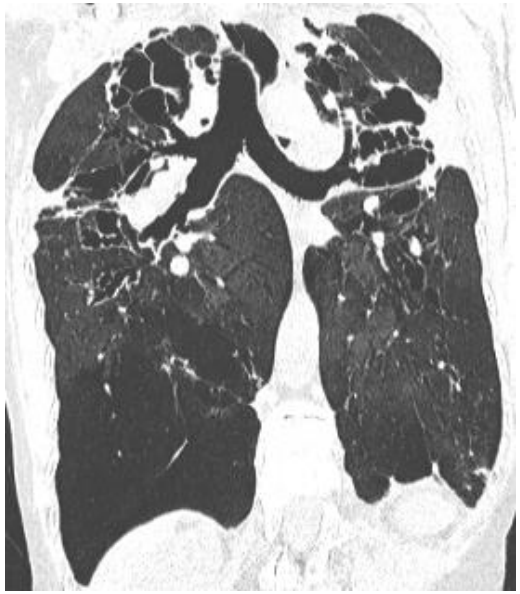
- **Predisposing condition: asthma or cystic fibrosis**
- **Mandatory criteria**
  - Presence of **immediate hypersensitivity to aspergillar skin test** or **aspergillar sp IgE > 0.35 kUA/L**
  - Total Ig E > 1000 IU/ml
- **Other criteria** (at least 2 of the 3)
  - Presence of **precipitating antibodies or IgG positive** to *aspergillus fumigatus*
  - ABPA-related **radiological infiltrates** (transients/persistents/bronchial dilatations)
  - **Hypereosinophilia** > 500 elements/mm³ in the absence of current or prior corticosteroid therapy

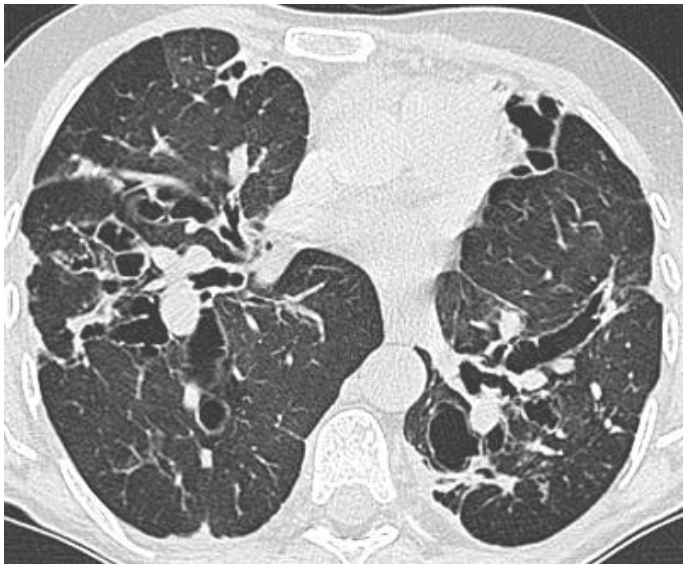
Differential diagnosis

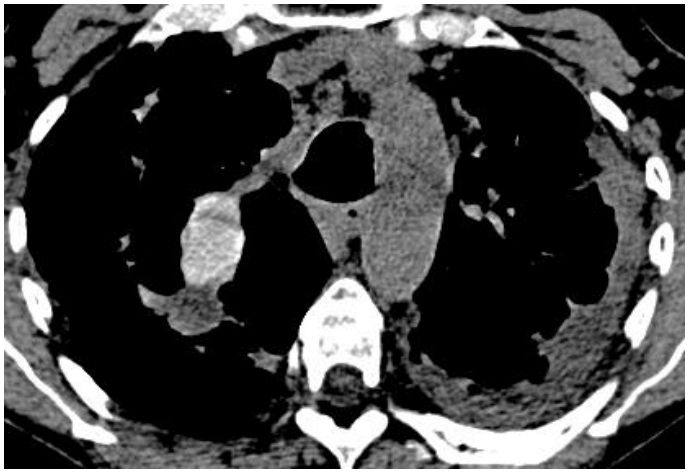
- Cystic fibrosis
- Asthma
- Congenital bronchial atresia

ABPA in a patient with **cystic fibrosis**









Spontaneously dense mucous plugs are characteristic images of ABPA

- Visible in 30% of patients
- In connection with calcium and/or metal ions giving hyperdense mucus
- Their presence is correlated with the severity of the disease.

W. Richard Webb, Nestor L. Muller, David P. Naidich, High-resolution CT of the Lung, Fifth edition

Chronic Necrotizing Pulmonary Aspergillosis

- **Rare and unknown form that** can simulate other chronic lung infections (tuberculosis, etc.).
- Patients with **chronic disease** or **moderate immunosuppression** (diabetes, undernutrition, alcoholism, COPD)
- Histologically: necrosis and granulomatous inflammation.
- Chronic symptoms: productive cough, fever, hemoptysis

Imaging

Lung consolidation (consolidation+ fibrosis)

- **Upper lobe ++**, single or bilateral
- **Progressive excavation**
- **Pleural thickening**
- Bronchiectasis

Denning Criteria (2003)

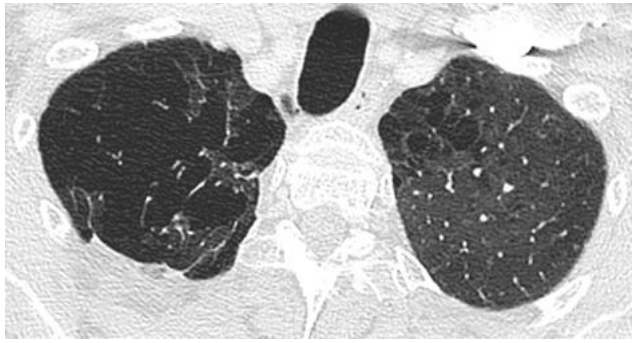
- General or respiratory **symptoms** > 3 months
- Pulmonary **cavity lesion** + para-cavitary infiltrate, new cavity formation or increase in size
- Detection of **aspergillus** or serology +
- **Biological inflammatory signs**
- **Exclusion** (cultures) of other pathogens giving similar tables
- No severe immune impairment

Bronchial necrotizing aspergillosis

- Occlusive endobronchial mass + atelectasis

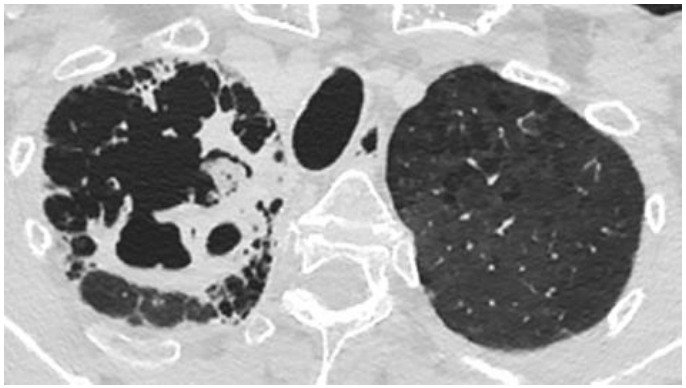
Evolution of chronic necrotizing pulmonary aspergillosis

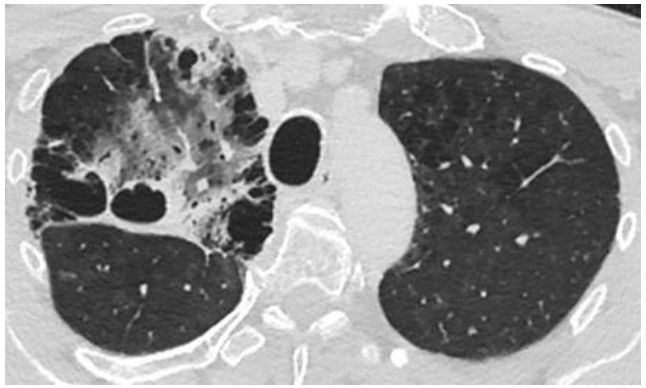
Initially (J0):
Emphysema lesions



One month later (M1) :

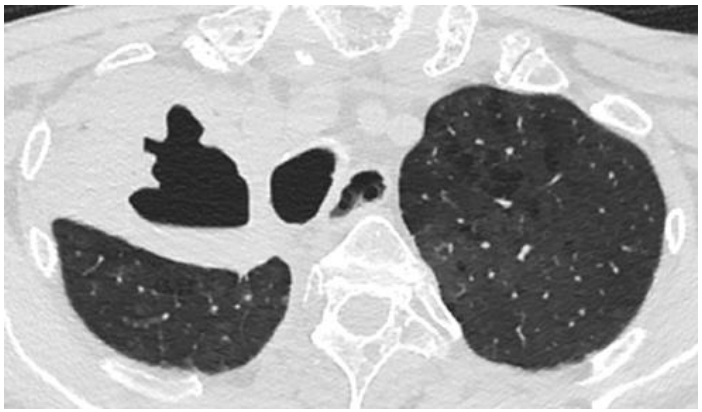
- **Fungus ball** in emphysema bubble
- **Consolidation around the edges of the emphysematous lesion** (formation of a cavity)
- And **GGO** under the cavity related to an outbreak of invasive aspergillosis (hemorrhage)

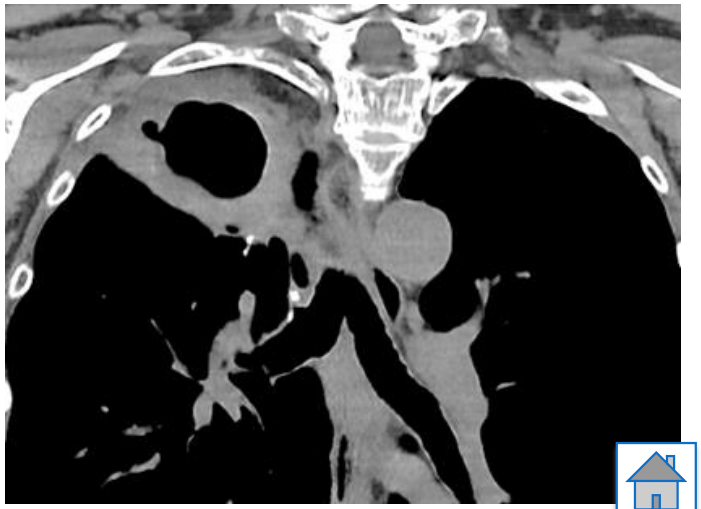




Six months later (M6):

- **Chronicization** with
- Development of a **right apical cavity**
- and **pleural thickening of the apical cuff** around the cavity





Invasive aspergillosis

Broncho-invasive form

Invasion through the bronchial wall to the **basal membran ++**

Most often, **immunosuppressed patients**
- **Immunocompromised neutropenic**
- **AIDS**

Angio-invasive form

Invasion of the small and medium **pulmonary vessels ++**
→ infarction, necrosis and pulmonary haemorrhage

Almost exclusively immunocompromised patients +++ with severe neutropenia +++
- **Bone marrow transplant**
- **Intensive chemotherapy** for solid neoplasia, some lymphomas, leukemias, myelomas
- **Immunosuppressive drugs** (functional neutropenia)
  - Organ transplantation (**lung transplantation**)
  - Autoimmune disease

But also **critical care patients**, in the **absence of the immunosuppressive factors conventionally described**
- Incidence: **7%, difficult to diagnose** (EORTC criteria not very applicable because of concomitant bacterial infections...)
- Risk factors: **corticosteroids**, **COPD**, kidney failure, liver failure

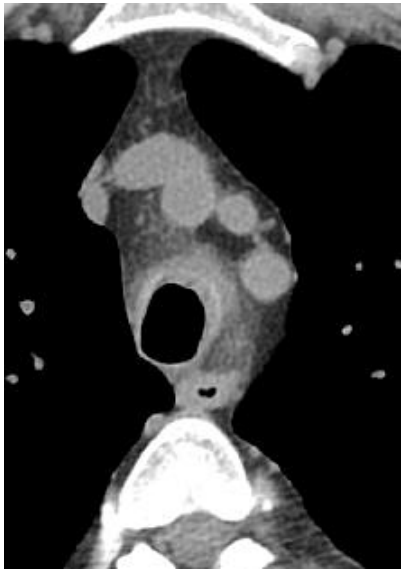
EORTC/MSG 2008 criteria

Established criteria for the diagnosis of invasive aspergillosis

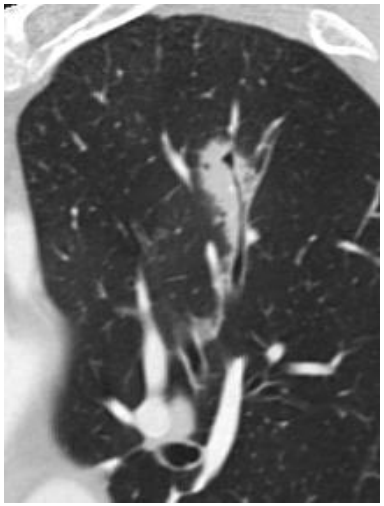
- Host
  - Neutropenia < 500/mm3 since >10d
  - Bone marrow transplant
  - Corticosteroid therapy >0.3mg/kg/d pdt >3 weeks
  - Ttt immunosuppressant
  - Acquired immunodeficiency
- Clinic
  - Lung infection: dense lesion +/- halo, crescent sign, excavated lesion
  - Tracheobronchitis
  - Sinus infection
  - CNS
  - Disseminated candidiasis: candidemia + hepatic/splenic abscess
- Microbiology
  - Direct examination, culture or cyto (ECBC, LBA,...)
  - Galactomannan (Ag aspergillar)
  - Beta D glucan

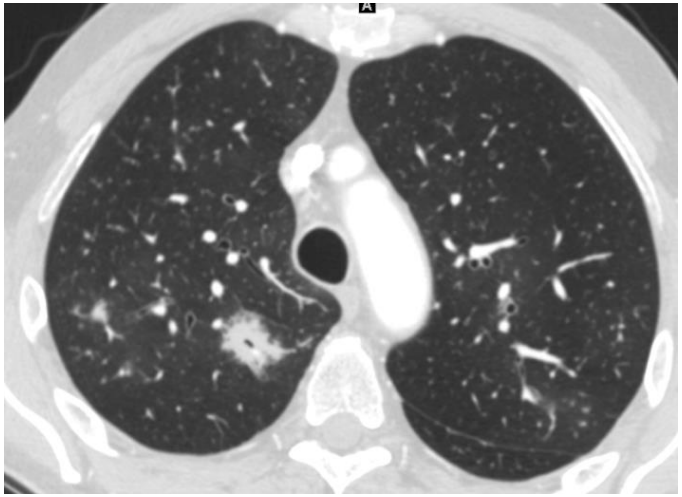
Broncho-invasive form

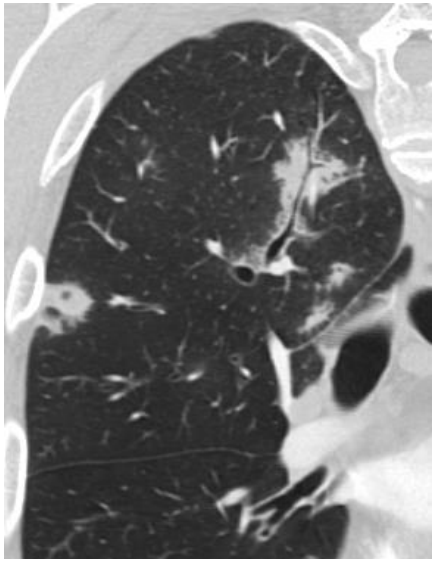
- Tracheobronchitis
  - Imaging often **normal** in the acute phase
  - **Tracheal/bronchial wall thickening**
- Aspergillar Bronchiolitis
  - Centrolobular nodules / **tree in bud**, patchy
- Aspergillar bronchopneumonia
  - **Similar to bacterial BP** (infiltration of bronchial walls and adjacent parenchyma)
  - **Peri-bronchial consolidation +++** (only specific sign)

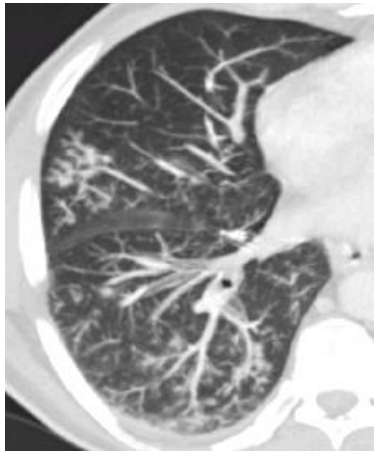


Tracheobronchitis



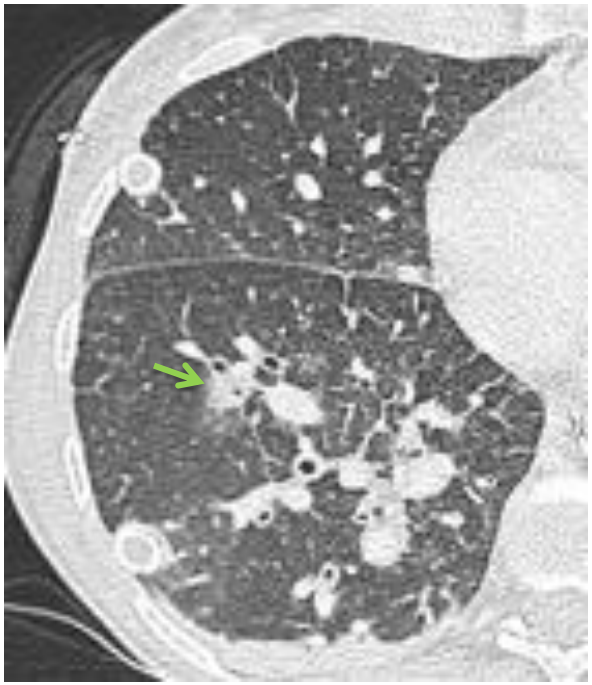
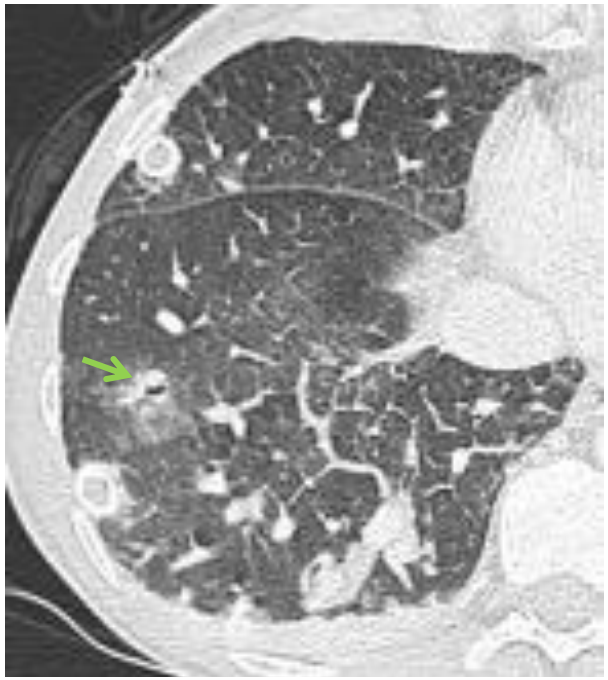
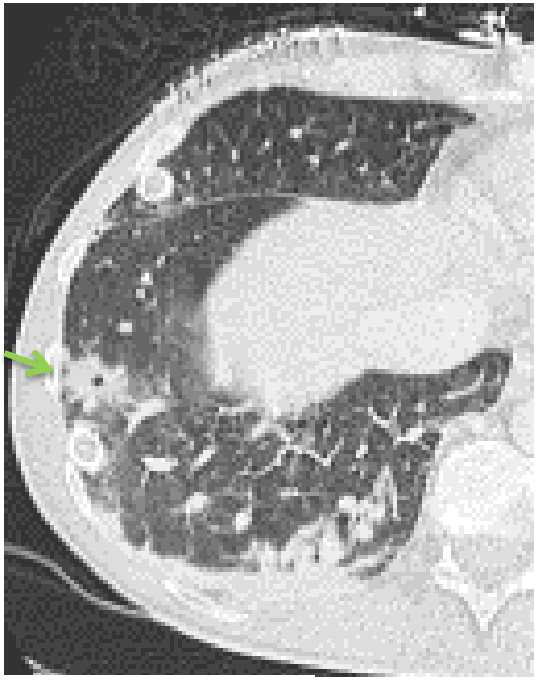






Tree in bud

Peri-bronchial consolidations+++

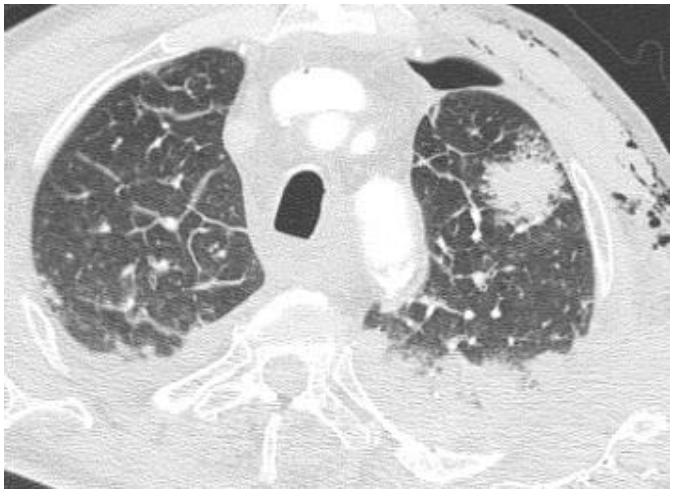




Peri-bronchial consolidation

- **Peri-bronchial consolidation**
- In an **immunosuppressed** patient
  → Consider **broncho-invasive aspergillosis**

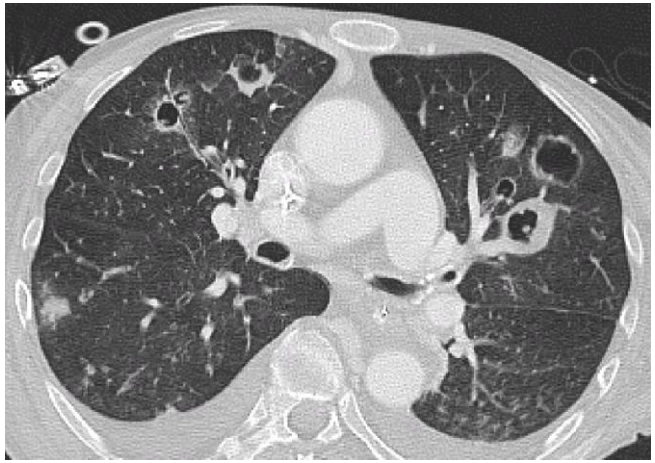
Aspergillosis: **angio-invasive form**

- **Nodules with halo +++**
  - Early sign (D0-J5)
  - Halo of GGO= bleeding
- **Infarct like opacities**
  - Wide base for pleural and quadrangular implantation
- **Excavation of nodules** and **consolidations areas (4 -16%)** at **J10-J20** at the end of aplasia (PNN>500/mm3) (2ndary-coagulation necrosis with vessel infiltration by mycelial filaments)
  - **Hypodensity sign ++** (pre-excavation) within the nodule or condensation
  - **Crescent sign +++**



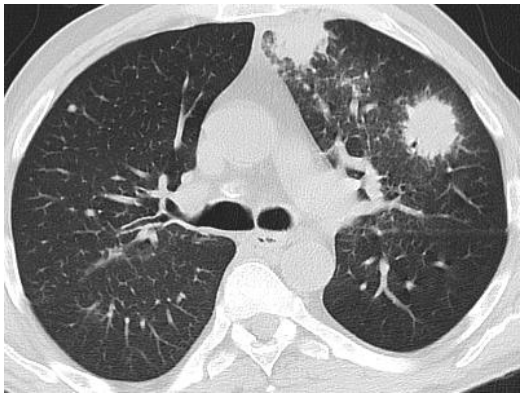
Halo sign

Nodule with **halo sign**
→ **Hypodensity**
→ **Crescent sign**
→ **Excavation +/- fungus ball**

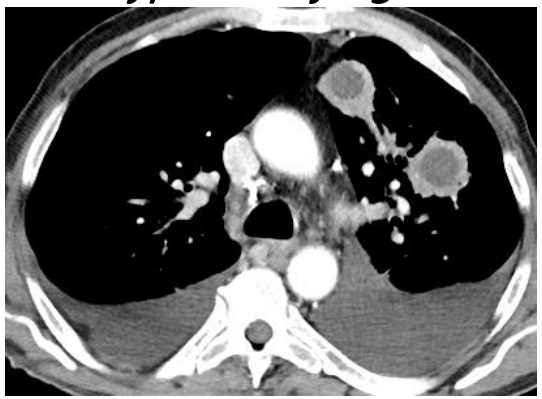


Excavated nodules +/- fungus ball

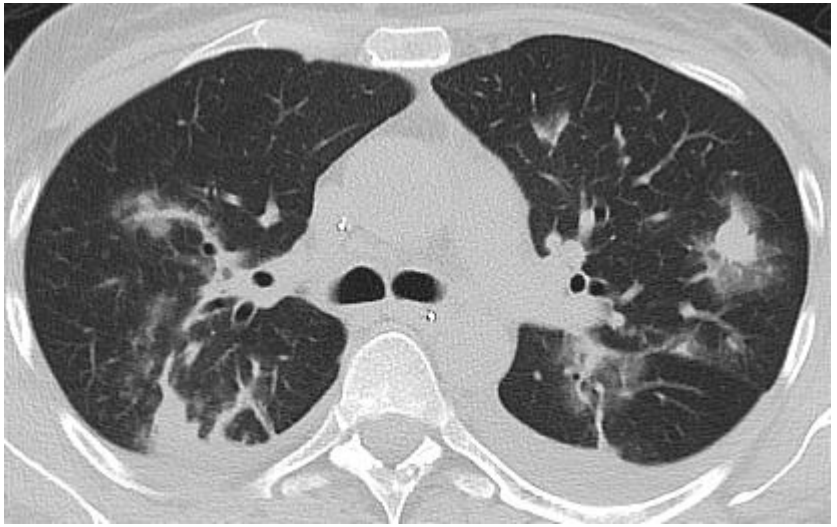
Halo sign



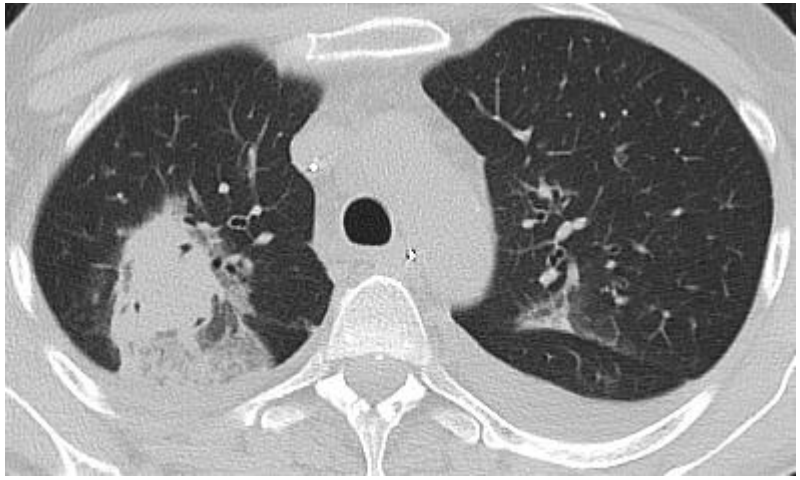
D15 : hypodensity sign

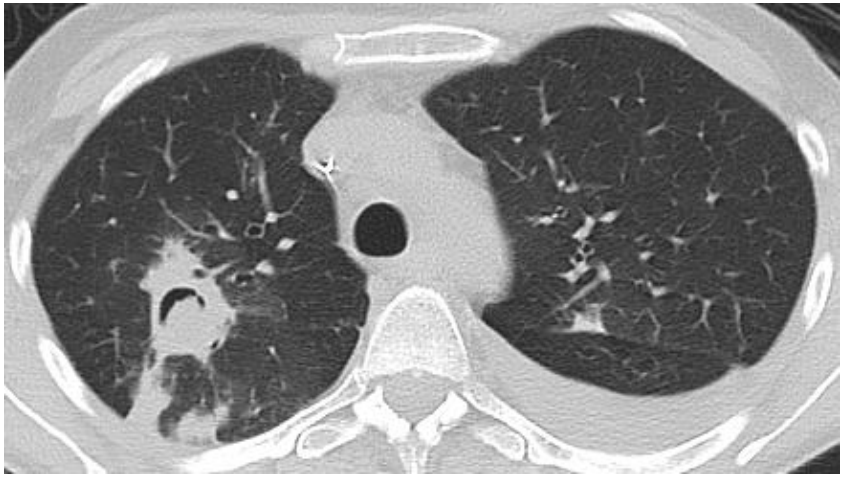


Aspergillosis
Angio-invasive form

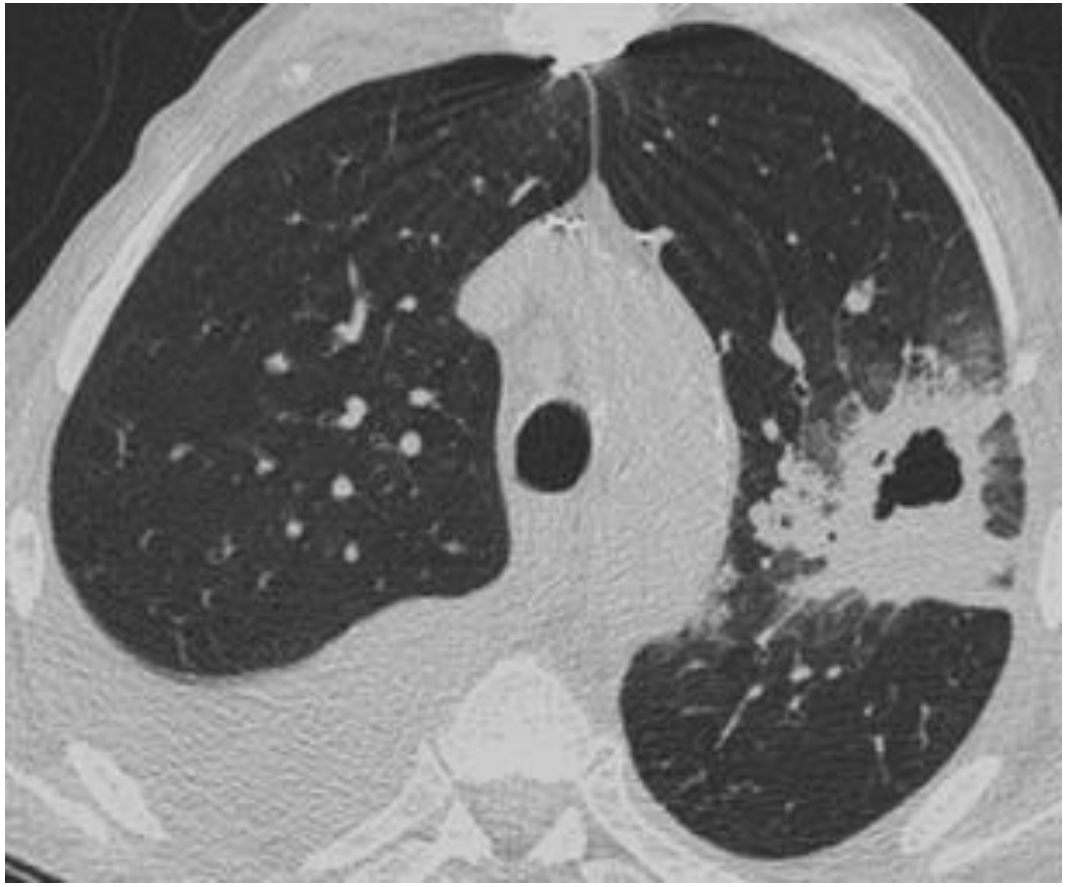


Nodule with **halo sign**
→ **Hypodensity**
→ **Crescent sign**
→ **Excavation +/- fungus ball**



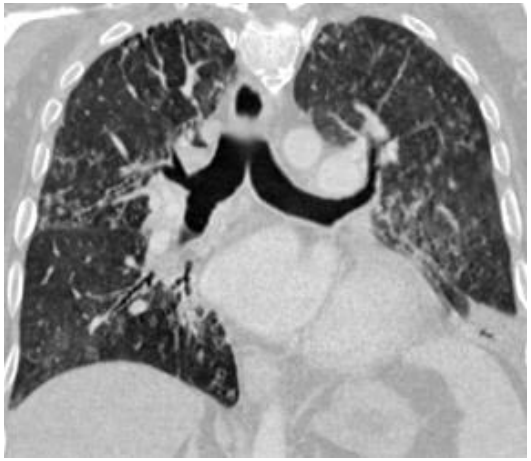


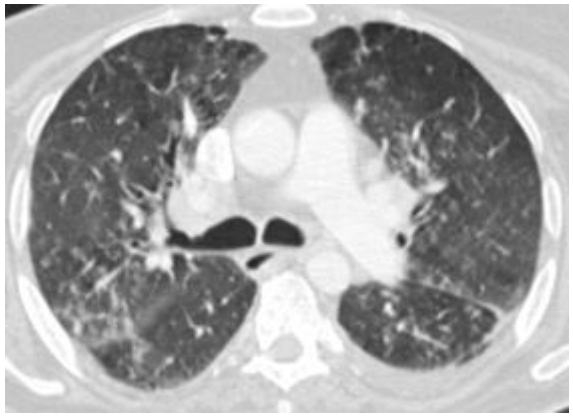
Invasive aspergillosis
(acutisation of LLC)
Excavation + halo



Candidosis pneumonia

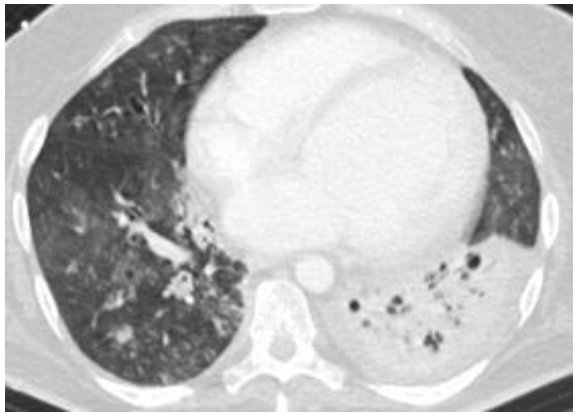
- **Severe and prolonged neutropenia**, leukemia context, lymphoma
- Pathogen isolated (+) but often associated with other fungal pathogens (++)
- **Multisystemic spread**





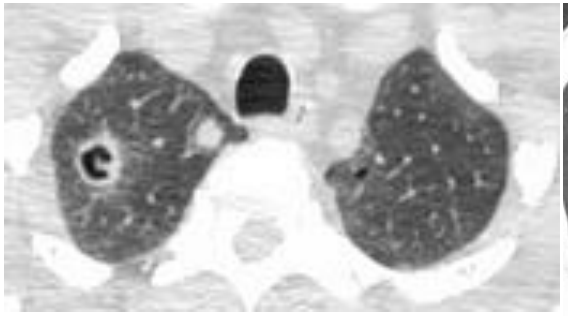
Imaging

- **Nodules** (with **halo** in 1/3 of the cases)
- **GGO**
- **"Tree in bud« micronodules**

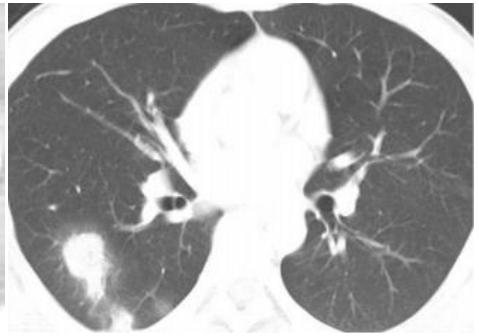


Cryptococcosis

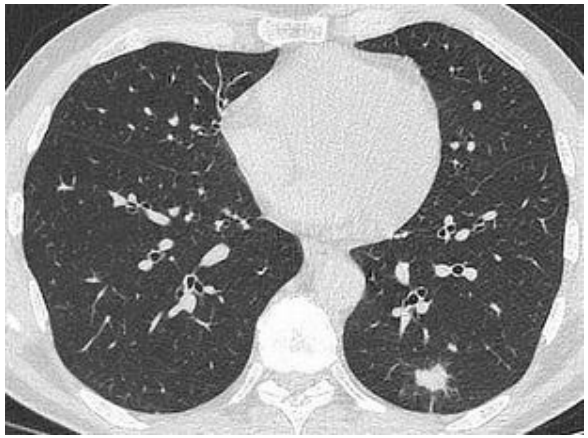
- *Cryptococcus neoformans*
- **Cosmopolitan**, soil contaminated by pigeon droppings, organic debris
- **Inhalation** contamination
- **Immunosuppressed +++**: AIDS, transplantation, haematological cancers
- Immunocompetents: rare



Case courtesy of Dr Praveen Jha, Radiopaedia.org, rID: 18688



Courtesy Song and al-Korean J Radiol

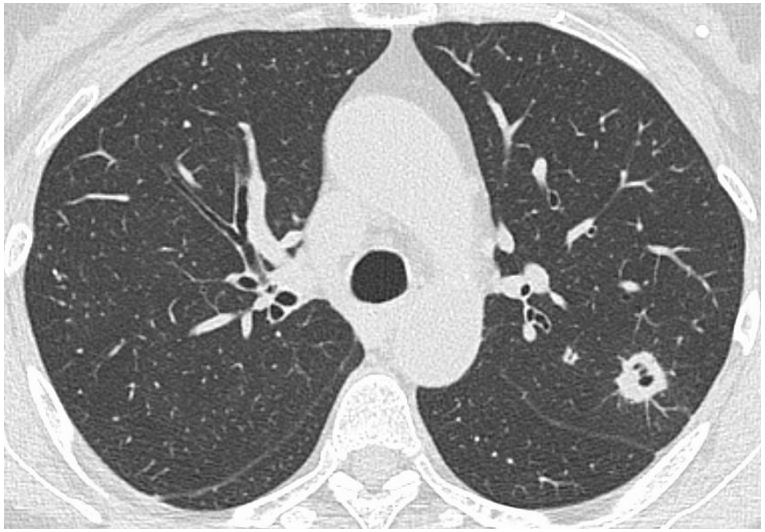


Case courtesy of Dr Jörgen Strömberg, Radiopaedia.org, rID: 46121

Imaging

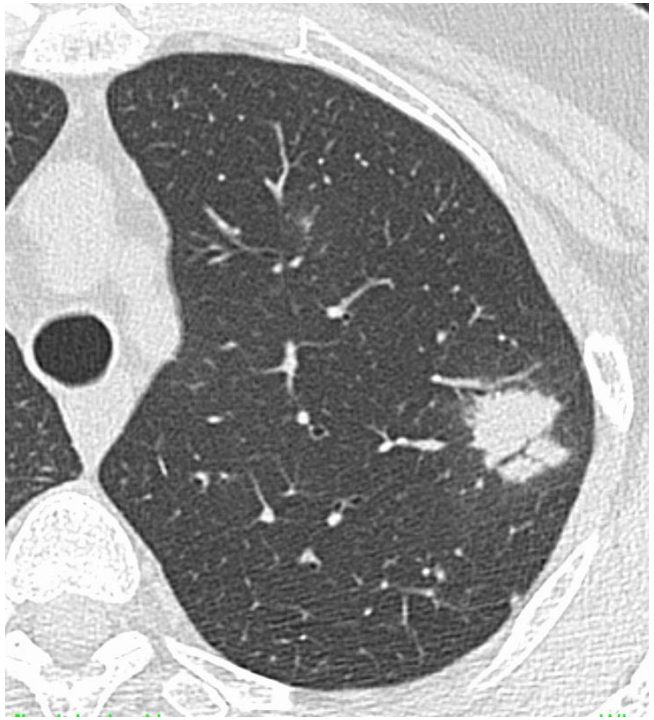
- Immunosuppressed AIDS
  - Disseminated thoracic spread with **interstitial syndrome and lymphadenopathy**
- Immunocompetent/ Non-AIDS ID (neoplasia) (more indolent)
  - **Nodules** (single+ or **multiple++**) **/ mass**
    - **Cluster ++ of nodules in the same lobe**
    - +/- halo sign +/- excavation +/- bronchogram
  - **Slow evolution / resolution**
  - TEP scan : fixation
    → Differential diagnosis with neoplasia

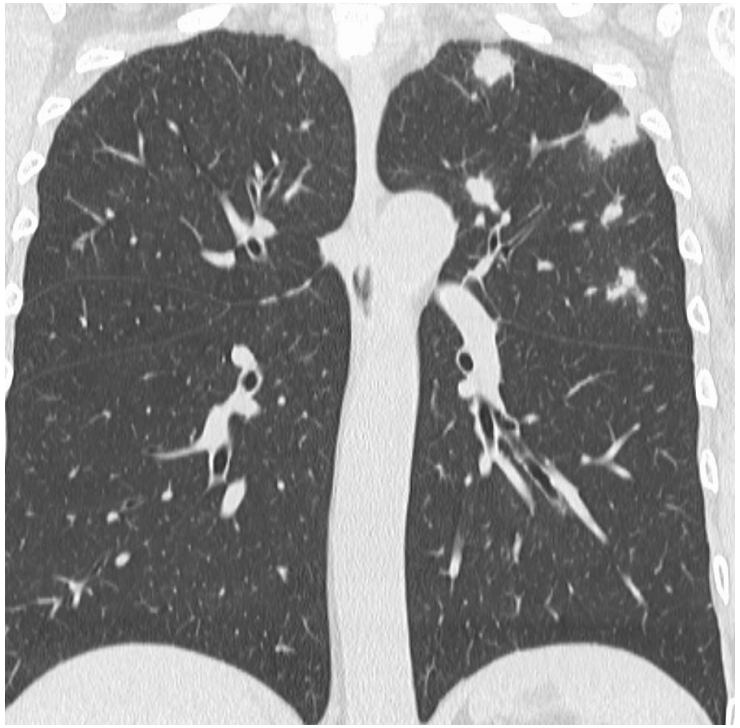
- *Song KD, Lee KS, Chung MP, Kwon OJ, Kim TS, Yi CA, Chung MJ. Pulmonary cryptococcosis: imaging findings in 23 non-AIDS patients. Korean J Radiol. 2010*
- *Lindell RM, Hartman TE, Nadrous HF, Ryu JH. Pulmonary cryptococcosis: CT findings in immunocompetent patients. Radiology. 2005*

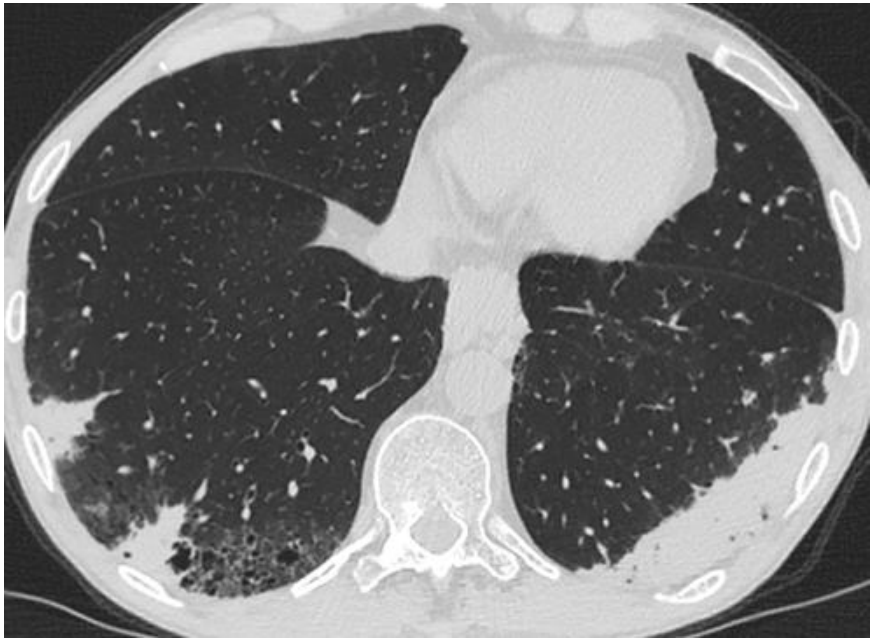


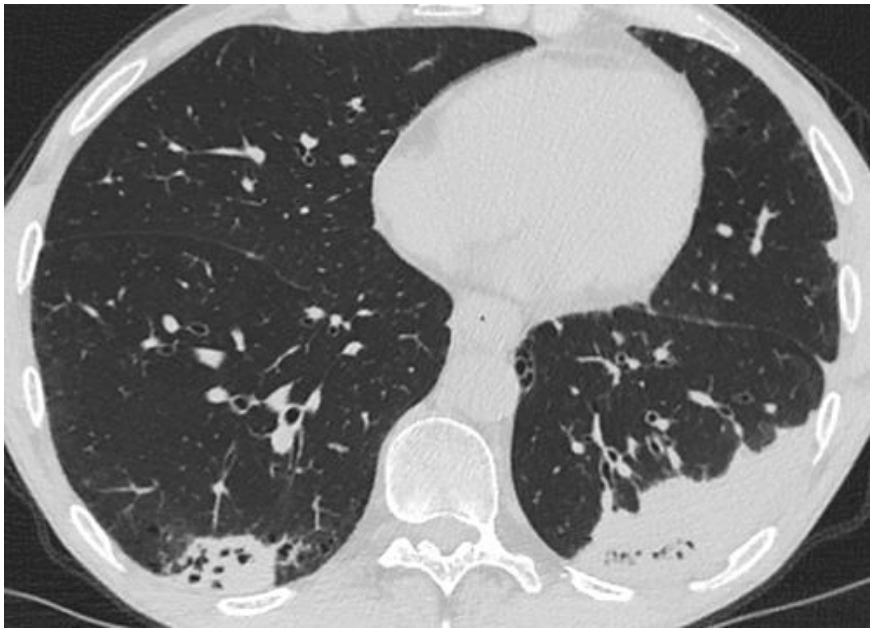
Cryptococcosis

- Note the distribution of nodules in the **cluster** characteristic of the disease (here in the upper left lobe)
- **Some excavated nodules**
- **Moderately immunocompromised** patient
- Bronchogram









Cryptococcosis

- Immunosuppressed liver transplant patient
- **Chronic bi-basal subpleural opacities**, partly excavated

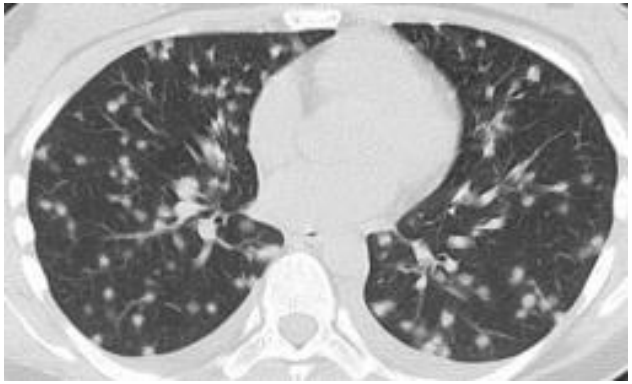
Histoplasmosis

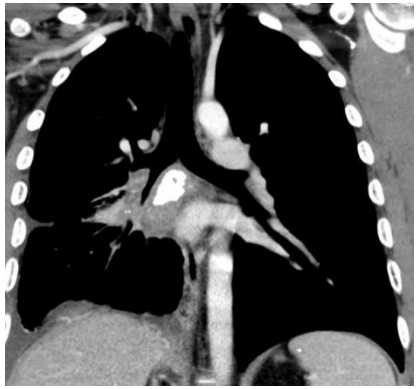
Fungus Histoplasma capsulatum

- All over the world, North and South America, the Caribbean, West Africa, South East Asia. Humid soils, caves
- Inhalation of spores
- 95% to 99% asymptomatic (symptoms with high exposure)
- **Immunocompromised: severe pulmonary or systemic damage, possibility of reactivation of latent focus**
- Diagnosis: serology, antigen, cyto/histo, cultures, antigenuria
- Treatment: antifungal agents

- ***Acute form*** (Massive inhalation of spores)
  - **Miliary or reticulonoid + ill- defined nodules + lymphadenopathy**
  - Resolution
  - **Histoplasmoma** (granuloma, nodule with central calcifications in target)
  - Calcified nodes → bronchiolithiasis, splenic calcifications
- ***Chronic form*** (emphysematous ++)
  - **Cavitations apex ++** (idem BK)
- ***Acute disseminated form*** (**ID** and child)
  - Lung involvement: **diffuse, miliary or reticular infiltrate**
  - **Hepato-splenomegaly**

Acute immunocompetent histoplasmosis

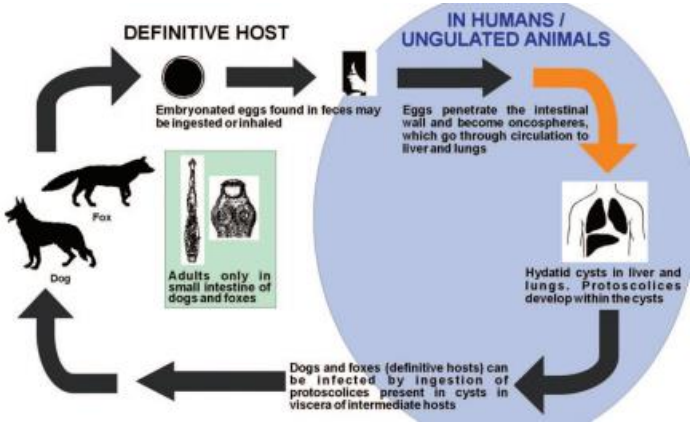




Fibrosing mediastinitis

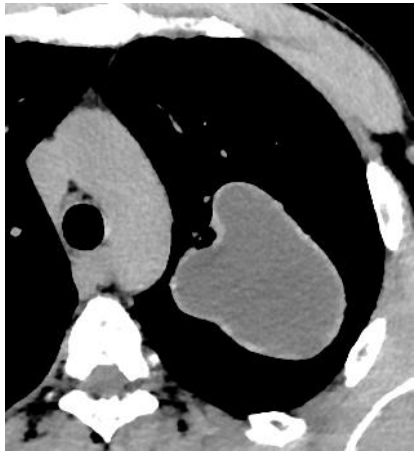
- **Classical sequelae** with excessive production of fibrous tissue → invasion and compression
- CT :**infiltration + calcifications**

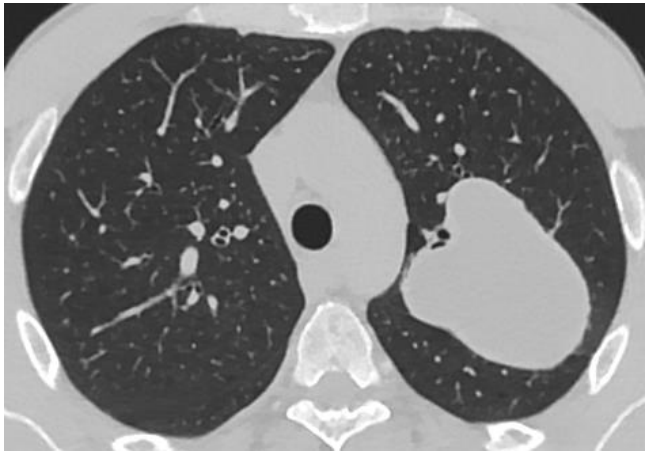
Hydatid cyst

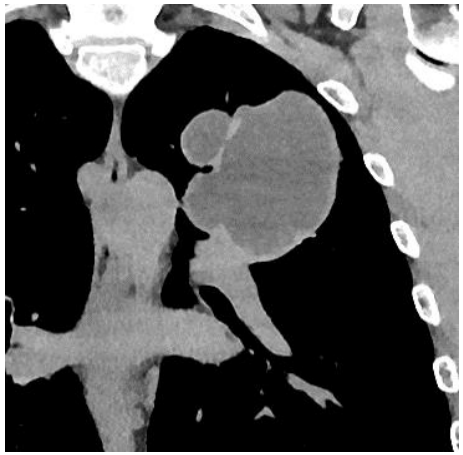


- *Echinococcus granulosus*
- Lung: 2nd most frequently **affected organ** (10-30% of cases) after the liver
- Dissemination by transdiaphragmatic (0.6-16%) or haematogenic route++.

Echinococcus granulosus
(multilocularis in black)



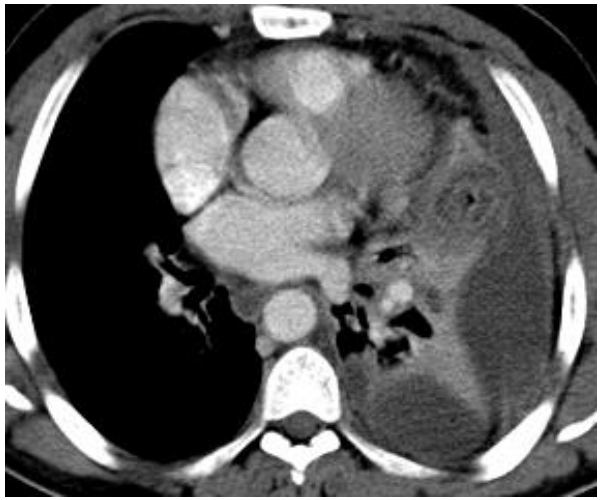




Non complicated cyst

- **Solitary or multiple cyst** (30%), well-defined contours, round, oval or polycyclic mass, 1 to 20 cm
- Hypodense content, capsule, very rare calcifications
- Single or bilateral (20%)
- **Lower lobe** ++ (60%)

Martnez S, Restrepo CS, Carrillo JA, et al. Thoracic Manifestations of Tropical Parasitic Infections: A Pictorial Review. RadioGraphics 2005

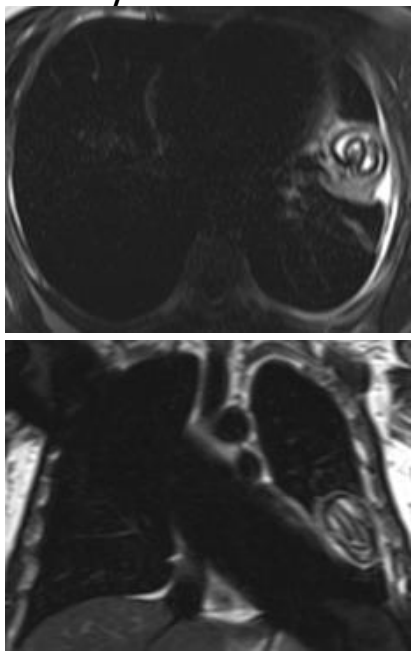


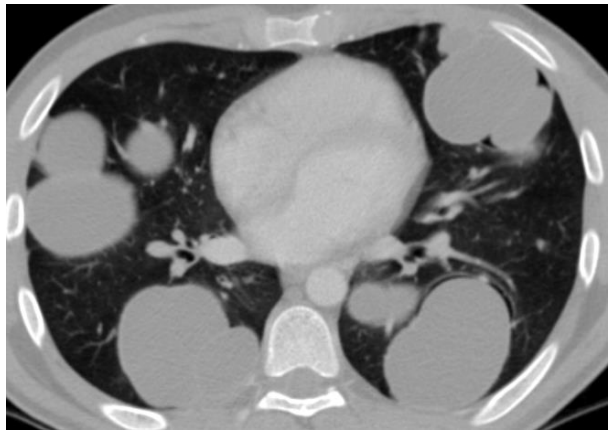
Complicated cyst

- **Intrabronchial rupture**
  - Air between pericyst and endocyst (**sign of crescent**) with floating endocyst (**sign of snake** or **water lily**)
  - Then air enters the endocyst (cumbo sign).
- **Rupture within the pleura**
- **Allergic episode** when rupture

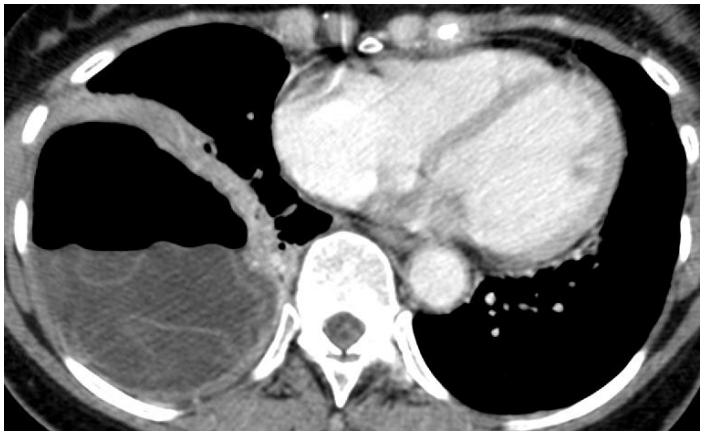
Ruptured hydatid cysts in the pleura

trufisp MRI





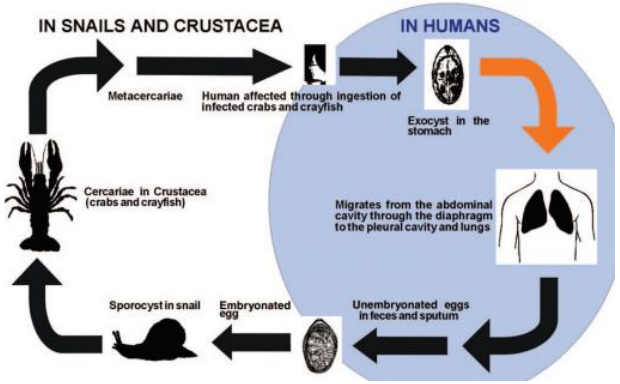
Crescent sign

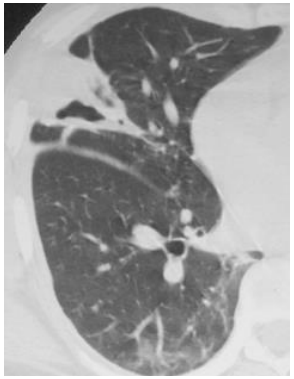


Water lily sign.

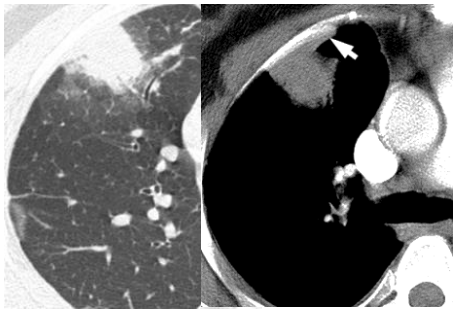
Paragonimiasis

- Trematode ***Paragonimus Westermani*** or other *paragonimus* species
- Contamination by ingestion of **raw or partially cooked freshwater crabs or crayfish** infected with *metacariae*
- East, South-East, South **Asia,** South America (Peru), Africa (Nigeria)
- Target organ: lung
- Clinic: fever, chest pain, cough, hemoptysis
- Diagnosis: detection of parasite eggs (sputum, pleural effusion, faeces) or larvae by bronchial brushing

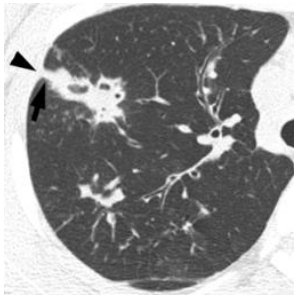




Courtesy Martenez S. Radiographics



Courtesy Kim TS - AJR



Imaging: well correlated with different stages of evolution

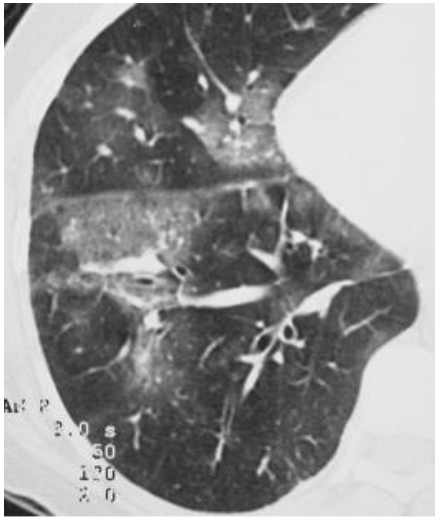
1) Penetration of juvenile worms through the diaphragm into the pleural cavity → **pleural effusion or pneumothorax**
2) Lung damage
   - **Consolidation/nodule(s) of** approx. **2cm,** poorly defined contours (GGO)
   - **Juxta-pleural or juxta-scissural +++**
   - **One or more central cystic zone(s)**
   - **Cyst(s):** single/multiple, 0.5 to 1.5 cm, best visible when consolidation disappears, liquid/water/aerial content
   - **Focal pleural thickening ++**
   - **Linear path ++** (often nodule → pleura): migration path of the worm.
   - +/- bronchiectasis

Martnez S, Restrepo CS, Carrillo JA, et al. Thoracic Manifestations of Tropical Parasitic Infections: A Pictorial Review. RadioGraphics 2005
Kim TS, Han J, Shim SS, et al. Pleuropulmonary paragonimiasis: CT findings in 31 patients. RDA 2005
JG Im et al. Pleuropulmonary paragonimiasis: radiologic findings in 71 patients. AJR 1992

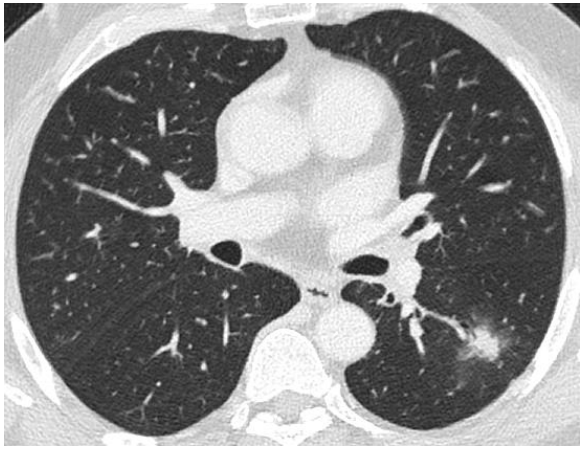
Other parasitic diseases

Martnez S, Restrepo CS, Carrillo JA, et al. Thoracic Manifestations of Tropical Parasitic Infections: A Pictorial Review. RadioGraphics 2005
Kim TS, Han J, Shim SS, et al. Pleuropulmonary paragonimiasis: CT findings in 31 patients. RDA 2005

- Amoebiasis
  - Transdiaphragmatic passage from hepatic abscess ++ (hematogenous route also possible) → effusion, **RIL++ excavated condensation,** hepato-bronchial fistula. Sometimes VCI, pericarditis
- Malaria
  - **ARDS +++**, OP
- Trypanosomiasis (Chagas++)
  - **Acute myocarditis, dilated cardiomyopathy** +/- PAO
  - Achalasia
- Ascariasis
  - **Patchy alveolar infiltrates, migratory, resolving** in 10 days +/- consolidation/alveolar bleeding
- Anguillulose (*Strongyloides Stercolaris*)
  - Same as ascariasis, patchy migrating patchy alveolar infiltrates.
  - "Hyperinfection syndrom" (AIDS, corticosteroids): severe, extensive pneumonia, alveolar hemorrhage, ARDS
- Filariasis
  - → Pulmonary v., infarction →nodule ≤ 3cm (asymptomatic++)
- Echinococcosis
  - *Echinococcus granulosus* → **hydatid cyst**
  - *Echinococcus multilocularis* → **alveolar echinococcosis**: pseudotumoral mass in the liver → lung affected by metastatic spread or direct extension.
- Schistosomiasis
  - Early: immunological damage, eosinophilic lung, ill defined nodules, diffuse GGO
  - Chronic: PAH (often preceded by liver damage and portal hypertension)



Ascariasis
Courtesy Martnez S Radiographics



Anguillulosis

Immunocompromised infections

- **Frequent** and **severe**
- Prognosis related to treatment rapidity
- CT essential for early positive diagnosis
- Difficult etiological diagnosis but clinical correlation is helpful, especially type and degree of immunosuppression.

Complications after bone marrow transplant

	Neutropenic phase < 30j	Early phase 30-100j	Late phase >100j
Infectious	Aspergillosis Candidacy Bacteria	CMV Pneumocystis	
Non-infectious	PAO HAD Hypersensitivity Medication	Aplasia exit syndrome	Constrictive Bronchiolitis (GVH) OP

T M Wah et al. Pulmonary complications following bone marrow transplantation. British Journal of Radiology (2003)

Immunocompromised infections

Alveolar consolidation

Infections	Non-infectious DD
- **Bacteria +++** - **Angio invasive aspergillosis** (neutropenia) - Atypical pneumocystis (HIV, corticosteroids, transplant recipients)	- OP - Alveolar hemorrhage - Invasive mucinous carcinoma - Lymphoma

Consolidation + necrosis

Infections	Non-infectious DD
- **Tuberculosis** - **Angio-invasive aspergillosis** - **Klebsiella** - **Pyogens: staph, BG-** - **Anaerobes**	- Cancer excavated - Lymphoma (EBV induced)

HIV/AIDS: staph, BG- ++
Aplastic: aspergillosis +++

Bronchiolitis, bronchopneumonia

Infections	Non-infectious DD
- **Common CAP germs** - **Tuberculosis**, atypical mycobacteria - **Invasive Aspergillosis, broncho invasive**	- Inflammatory bronchiolitis - Exceptional endobronchial/vascular metastases

GGO

Infections	Non-infectious DD
- **Pneumocystis** - **Viruses, CMV** - ***Mycoplasma pneumoniae***	- Pn. Medication - Alveolar Hgie - PAO - PO

HIV/AIDS: pneumocytosis +++
ID: CMV +++

Immunocompromised infections

Multiple Nodules

Infections	Non-infectious DD
- **Viruses**: CMV, HSV, VZV - **Fungi**: candidiasis, cryptococcosis, aspergillosis, mucormycosis. - **Tuberculosis**, atypical mycobacteria - **Nocardiosis** - **Septic embolism**	- Metastasis - Lymphoma - Kaposi's Sarcoma

Miliaire

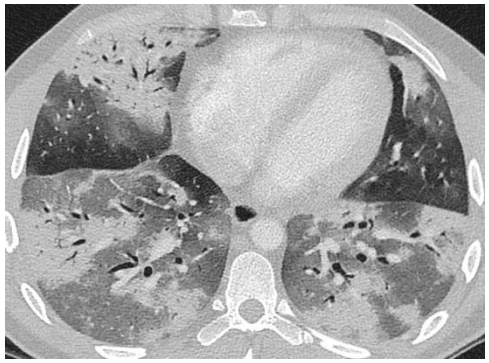
Infections	Non-infectious DD
- **Tuberculosis** - **Candidosis** - **CMV, HSV, VZV**	- Metastasis - Stage IV Lymphoma

Immunocompromised infections

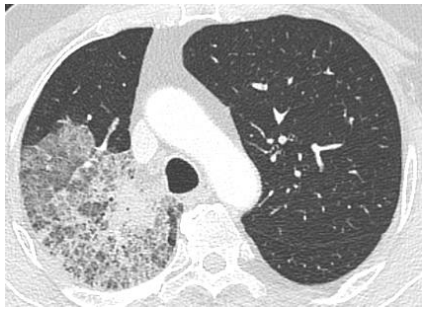
Alveolar consolidation

Infections	Non-infectious DD
- **Bacteria +++** - **Angio invasive aspergillosis** (neutropenia) - Atypical pneumocystis (HIV, corticosteroids, transplantation)	- OP - Alveolar hemorrhage - Invasive mucinous carcinoma - Lymphoma

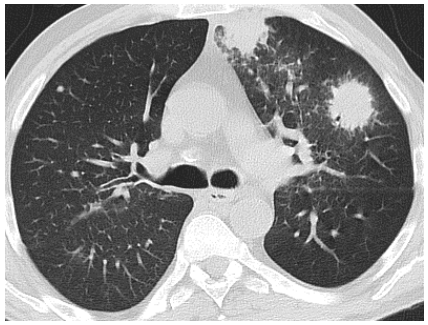
Organizing pneumonia



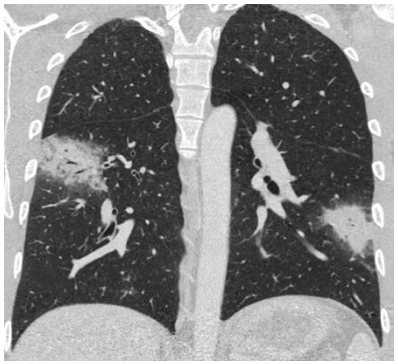
Adenocarcinoma



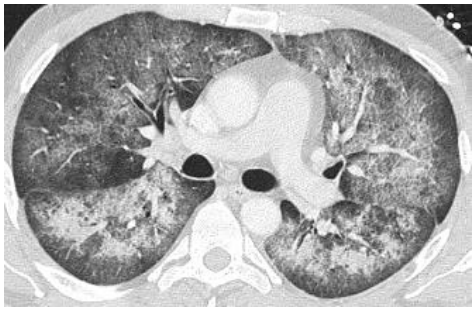
Angio-invasive aspergillosis



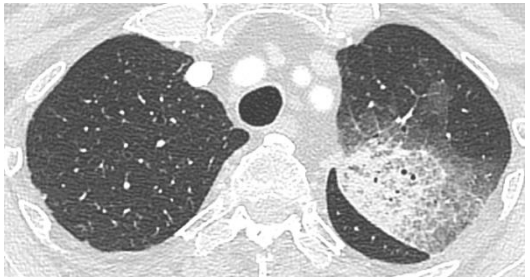
Bacteria



Pneumocystis



Lymphoma



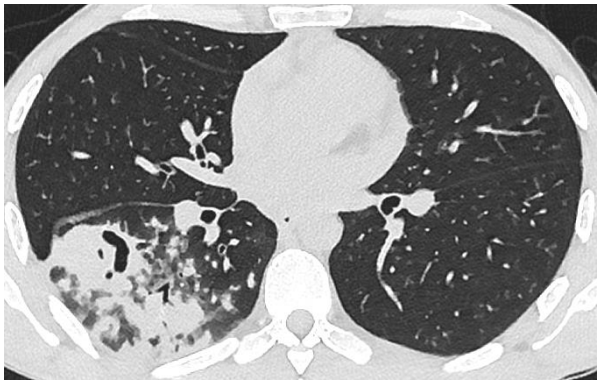
Immunocompromised infections

Consolidation + necrosis

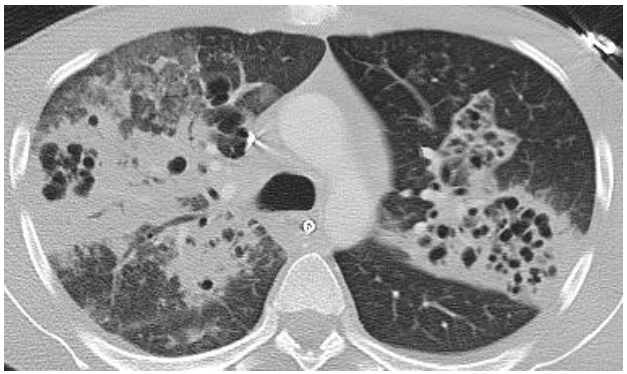
Infections	Non-infectious DDx
- Tuberculosis - Aspergillosis - Klebsiella - Pyogens: staph, BG- - Anaerobes	- Cancer excavated - Lymphoma (EBV induced)

HIV/AIDS: staph, BG- ++
Aplasia: aspergillosis +++

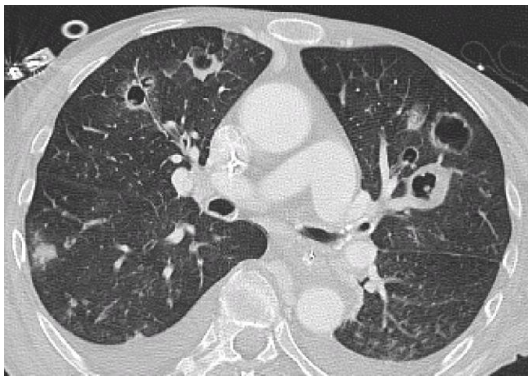
Tuberculosis



Staph



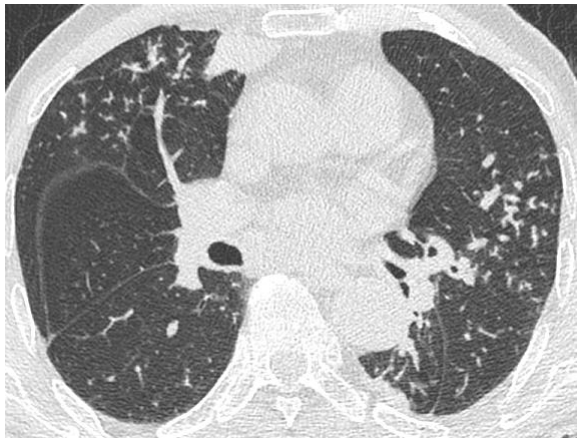
Angio-invasive aspergillosis



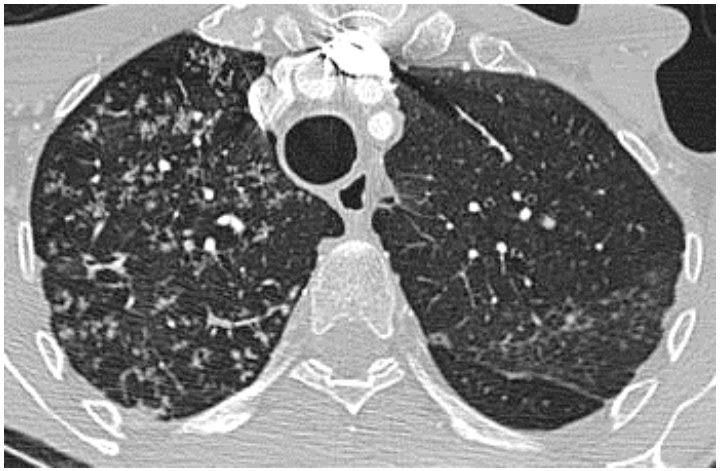
Bronchiolitis, bronchopneumonia

Infections	Non-infectious DD
- **Common CAP germs** - **Tuberculosis**, atypical mycobacteria - **Broncho invasive aspergillosis**	- Inflammatory bronchiolitis - Exceptional endobronchial/vascular metastases

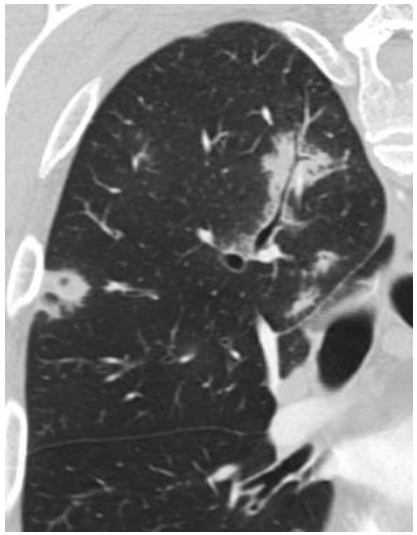
Bronchial pneumonia CAP



Tuberculosis



Broncho-invasive aspergillosis



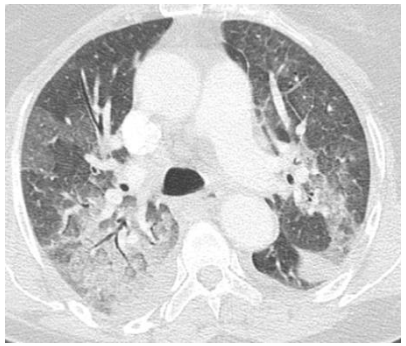
Immunocompromised infections

GGO

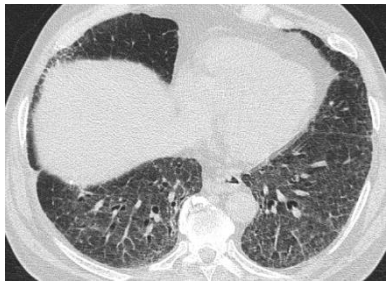
Infections	Non-infectious DD
- Pneumocystis - Viruses, CMV - *Mycoplasma pneumoniae*	- Drug toxicity - Alveolar hemorrhage - PAO - OP

HIV/AIDS: pneumocytosis +++
ID: CMV +++

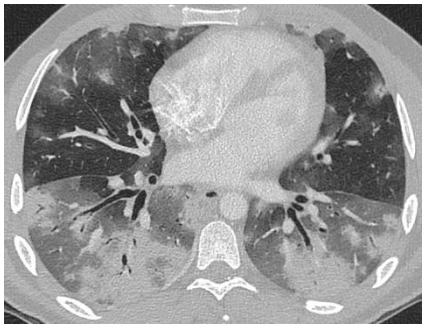
PO



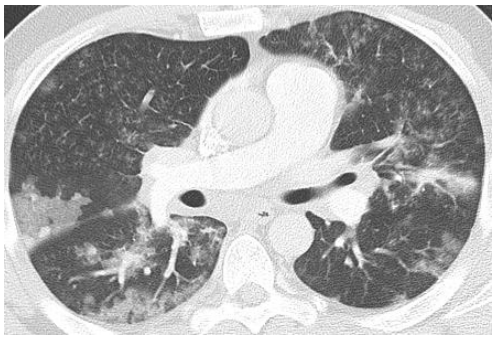
Drug toxicity



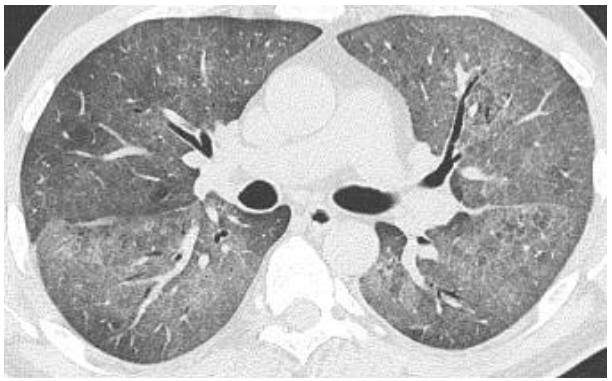
OP



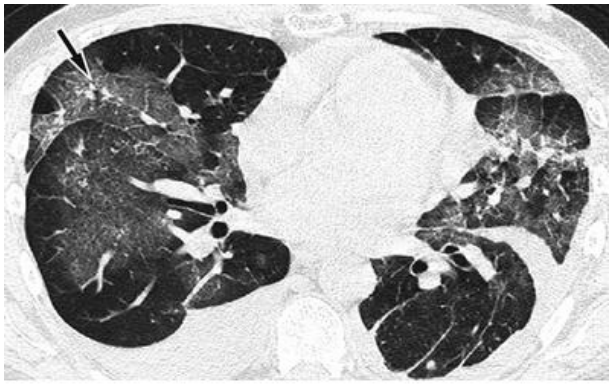
Viral



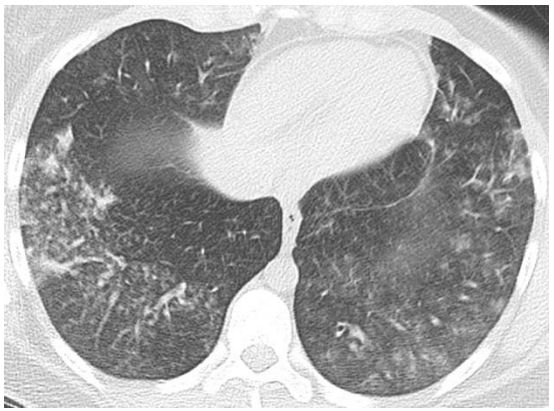
Pneumocystis



CMV



Mycoplasma



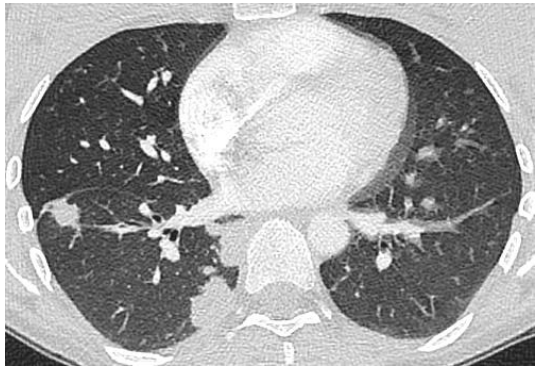
Courtesy Marius S, Horger - AJR

Immunocompromised infections

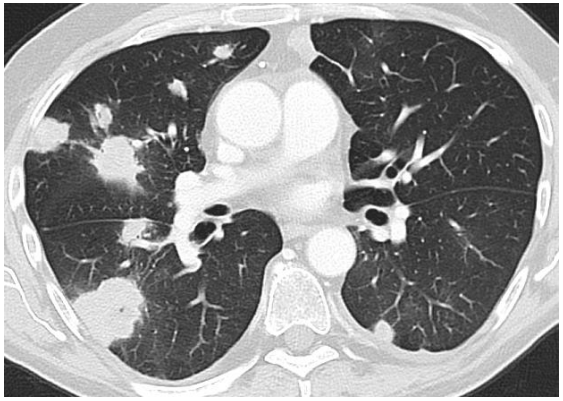
Multiple Nodules

Infections	Non-infectious DD
- **Viruses**: CMV, HSV, VZV - **Fungi**: candidosis, cryptococcosis, aspergillosis, mucormycosis. - **Tuberculosis**, atypical mycobacteria - **Nocardiosis** - **Septic embolism**	- Metastases - Lymphoma - Kaposi's Sarcoma

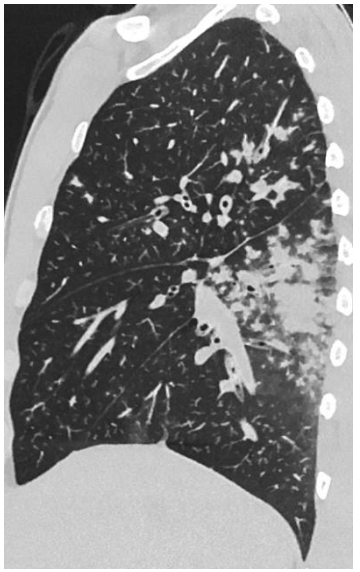
Septic embolism



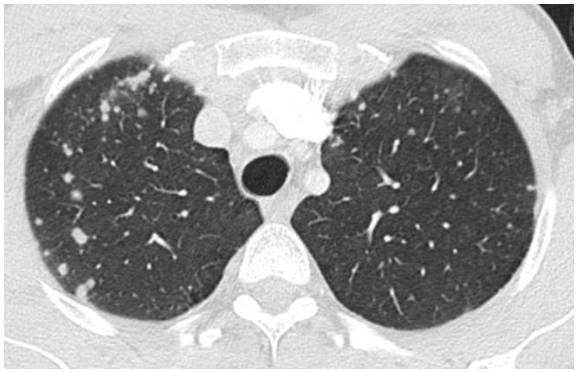
Nocardiosis



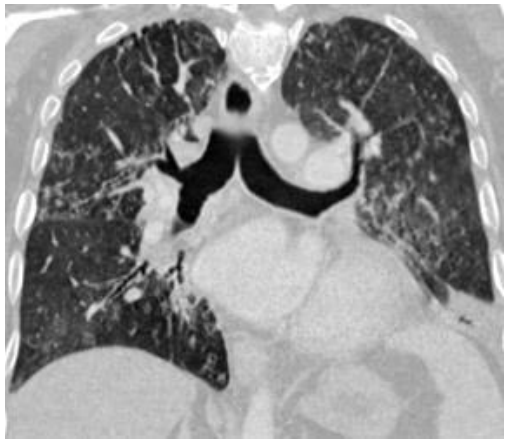
Tuberculosis



VZV



Candidosis

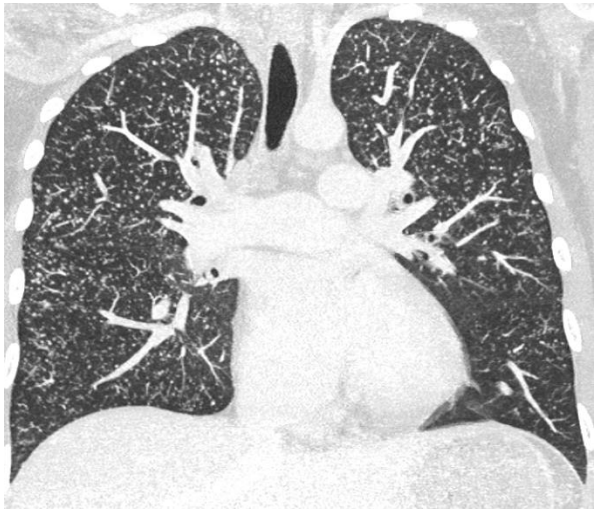


Immunocompromised infections

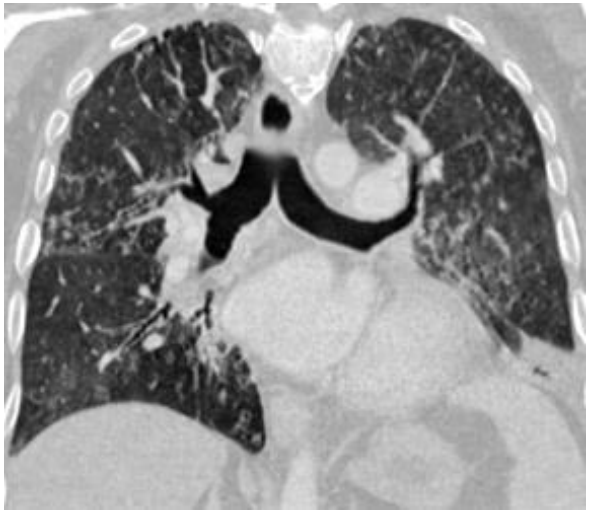
Miliary

Infections	Non-infectious DD
- Tuberculosis - Candidosis - CMV, HSV, VZV	- Metastasis - Stage IV Lymphoma

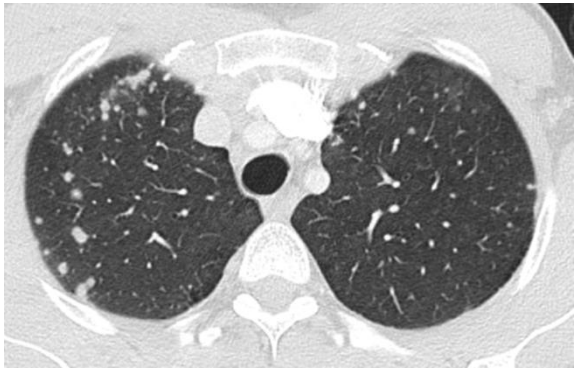
Miliary tuberculosis



Candidosis



VZV



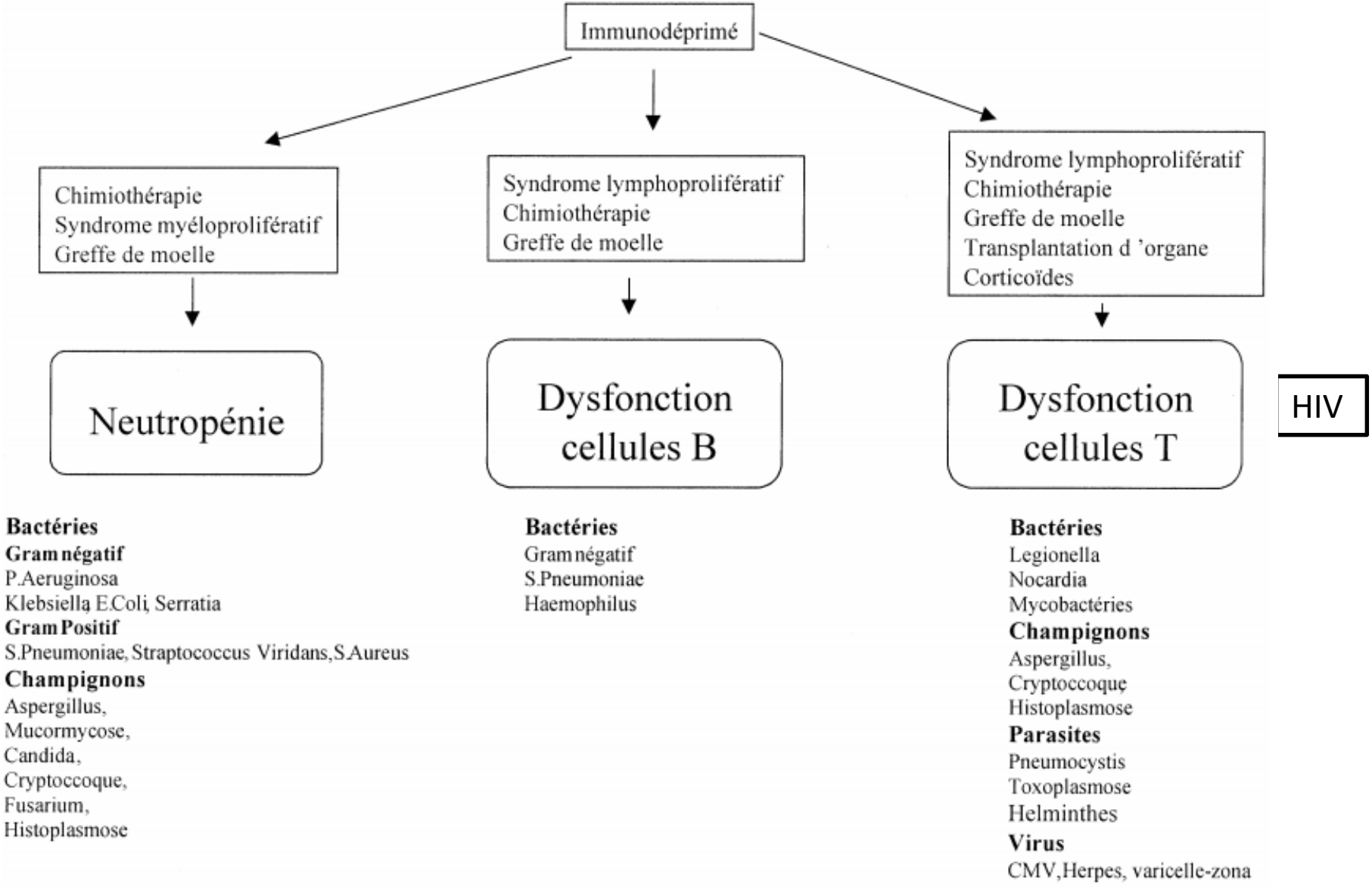
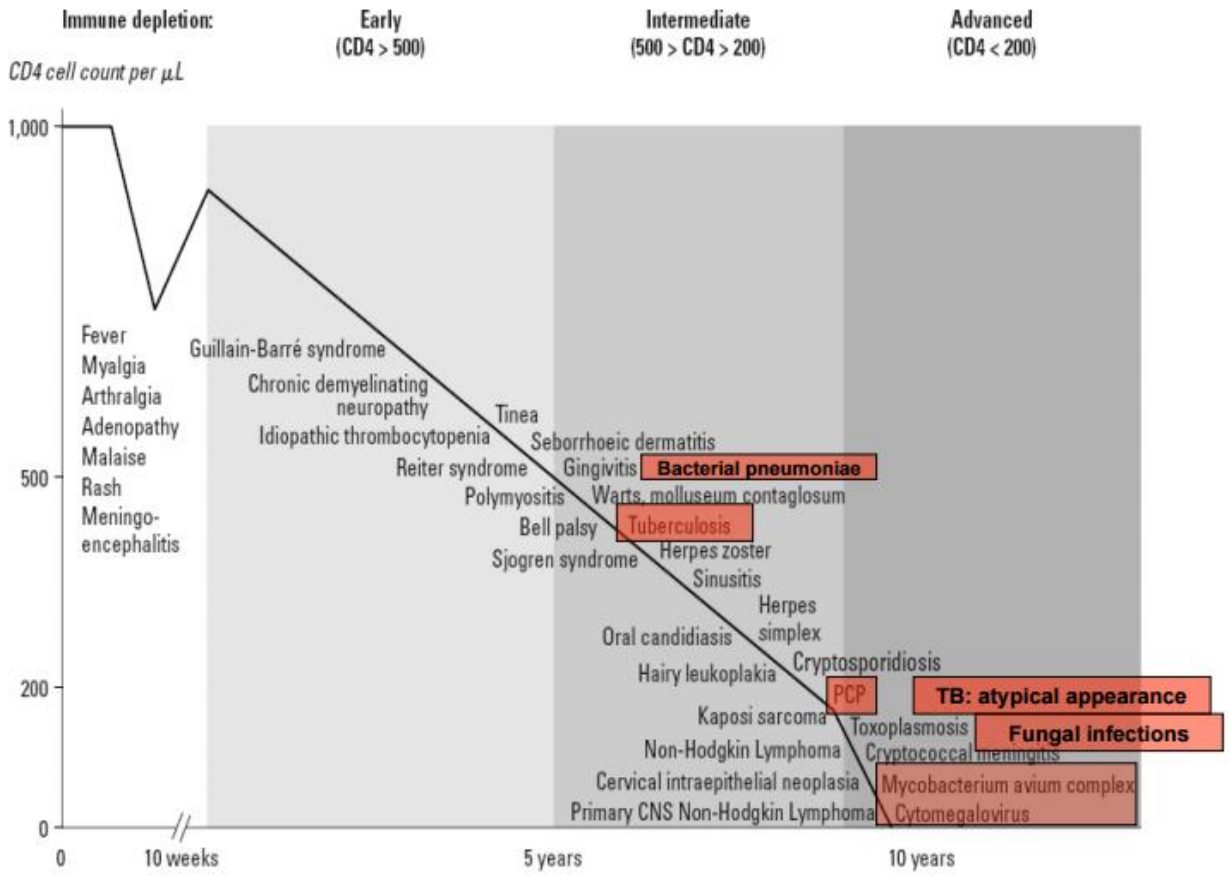


Figure 2. Déficit immunitaire et infections pulmonaires. D'après Collin [18].

HIV infections

CD4 count	Pathology
> 200	Tuberculosis Encapsulated pyogenic bacteria
< 200	Pneumocystis jiroveci
< 150	Fungal infections
< 50	CMV, MBA, HIV-related lymphomas



HIV/AIDS prevention and treatment.NIH Stefano Bertozzi and coll.

Low to moderate ID

Community-acquired bacterial pneumonia +++

- **Most frequent**
- Possible occurrence at **modest degrees of ID**
- Pneumococcus, Haemophilus, influenza, Staph aureus, pseudomonas aeruginosa ...
- Same presentation as IC

Pneumocystis +++

- *Pneumocystis carinii* (parasite), the most common early pathology of AIDS
- **CD4 < 200 mm3**
- Confluent, bilateral and symmetrical GGO+ cysts (10 to 30%)

Tuberculosis +++

- May occur at **moderate stage of ID (CD4<300/mm3)**
- **Presentation a little different** especially if CD4<200/mm3
  - **Less** apical predominance
  - Less consolidation, less excavation
  - More **blood spread**

High ID (<100CD4/mm3)

Cryptococcosis

- More frequent opportunistic fungal infections in France
- **CD4 < 100/mm3**
- Often disseminated: meningitis (^{1st}), pulmonary (^{2nd})
- CT scan: bilateral abnormalities, multiple nodules, interstitial reticular syndrome, miliary

Atypical Mycobacteria

- *Mycobacterium avium intracellulare* (disseminated disease)
- Rare: *M. Kansasii* (respiratory tropism), *M. Xenopi* (disseminated disease).
- **CD4<50/mm3,** incidence ↓ (ARV)

Invasive pulmonary aspergillosis

- Rare in HIV, favoured by **other risk factors** or **CD4 < 50/mm3**
- Consolidation +/- halo

Other germs

- Mycosis
  - **Histoplasmosis**
    - USA++, alveolar condensation sometimes migratory, mediastinal lymphadenopathy, hematogenous dissemination: liver, spleen, CT, lung (very fine miliary +/- diffuse alveolar syndrome)
  - Coccidioidomycosis
  - Candidosis
- Parasitosis
  - Toxoplasmosis (<100 CD4) (disseminated toxoplasmosis)
  - Cryptosporidiosis
- Viral
  - CMV, etc.
  - Exceptionally incriminated

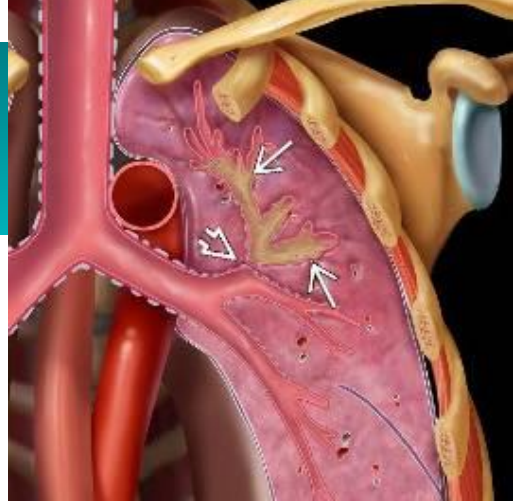
NB: Opacity of HIV/AIDS tumour appearance.
- Bronchial cancer +++
- Lymphoma++
- Kaposi+

Congenital

/ Pathology from childhood to adulthood

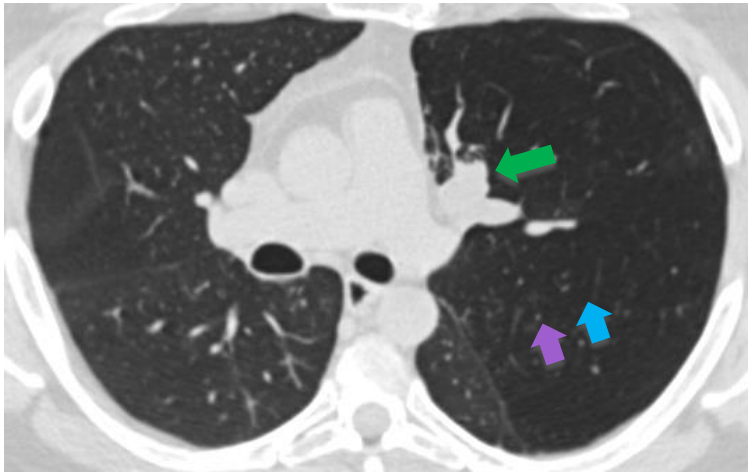
- Bronchial atresia
- Giant Lobar Emphysema
- Diffuse Pulmonary Lymphangiectasis
- Lung sequestration
- Cystic adenomatoid malformation
- Arteriovenous malformation
- Cystic fibrosis
- Primary ciliary dyskinesia
- Swyer James Syndrome
- Alpha 1 antitrypsin deficiency
- Marfan disease

Bronchial atresia



Definition

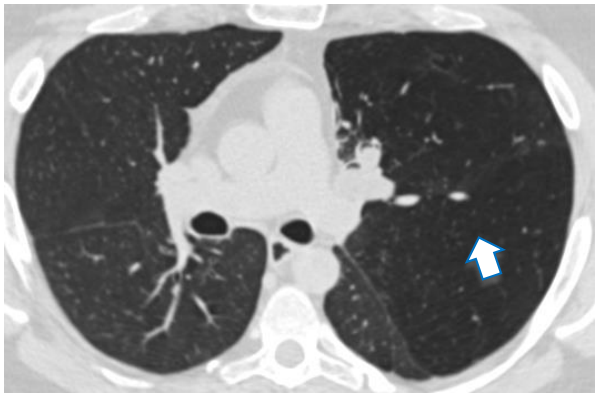
- **Congenital atresia of a segmental bronchus**
- with **normal distal architecture**

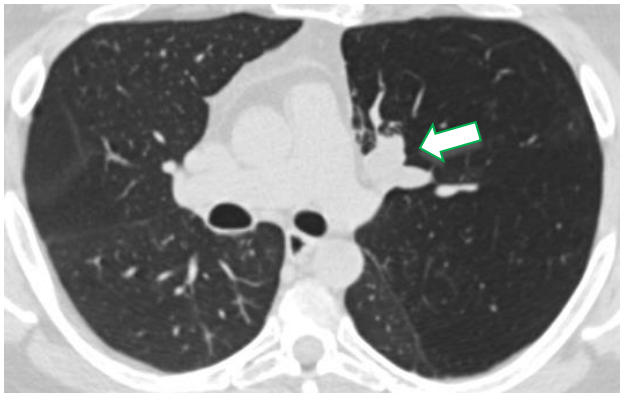


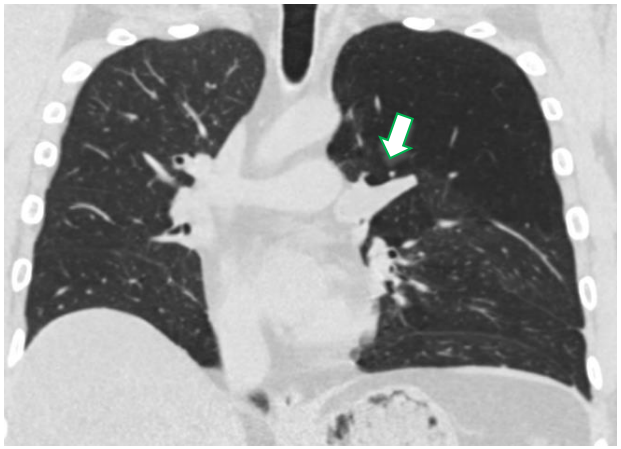
Differential diagnostis
- Mucoid Impaction
- Congenital Lobar Emphysema
- Intra-lobal sequestration

Imaging

- **Apico-posterior segment LUL** (50%), then RUL (20%), LLL and RLL (15% each)
- **Bronchocele** ➔
  - (± calcified)
  - plugged with mucus. Can give a finger-in-glove appearance. Often with bronchectasia
- **Hyperlucent lung** ➔
  - Systematized with trapping and distension of the affected segment
- **Hypoperfusion** ➔
  - Rarefaction of the vascular weave
- **Look for another cause of bronchial obstruction**: tumor, foreign body, broncholithiasis...

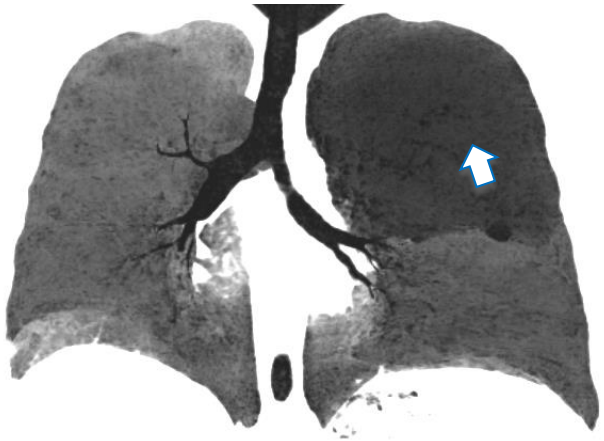






Bronchocele

Bronchial atresia

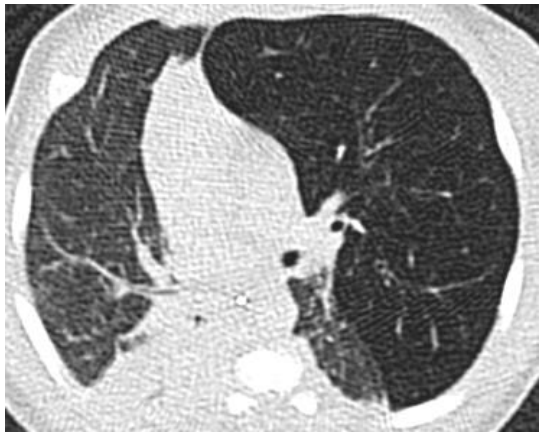


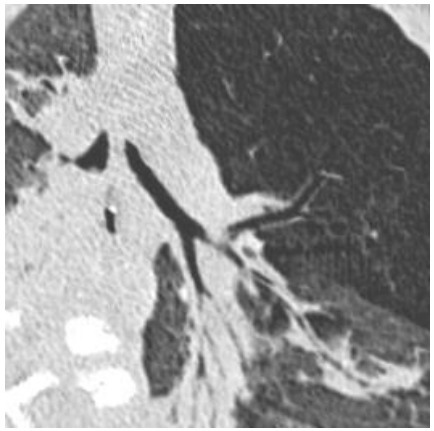
Hyperlucent lobe+ hypoperfusion

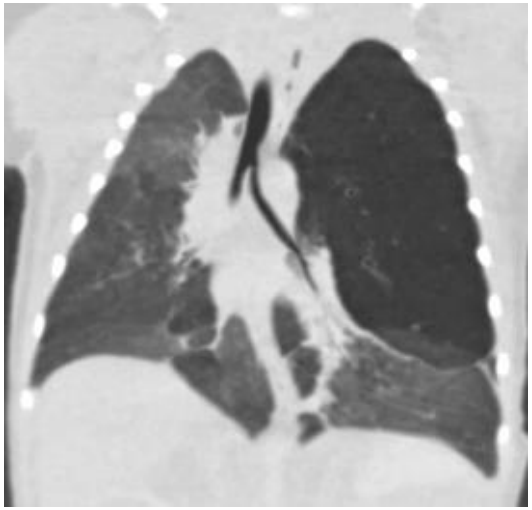
Giant Lobar Emphysema

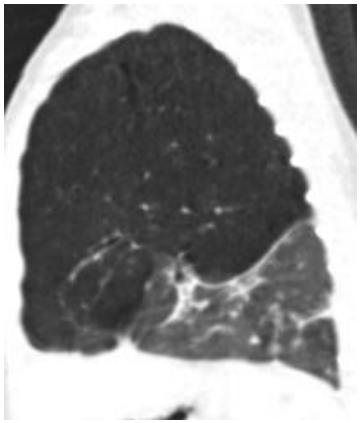
Progressive distension of a lobe due to an incomplete bronchial obstacle.

- Rare **lung malformation**
- 3 times more frequent in boys
- **Respiratory distress before 6 months of age**
- **Treatment**: lobar resection in severe cases









Radiography

- Lobar low density ,vascular frame rarefaction
- Mediastinal deviation and flattening of the homolateral diaphragmatic dome

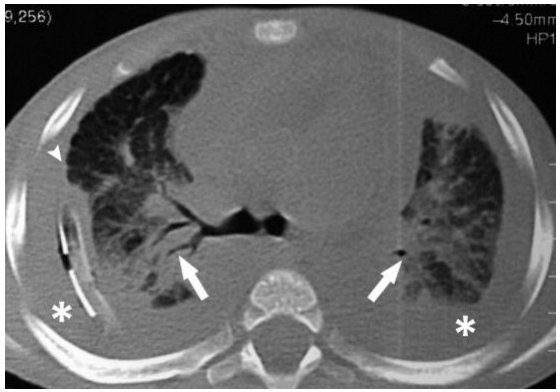
CT SCAN

- **Hyperlucent lobe**
- Rarefaction of the vascular frame
- **Compression**: +/- atelectasis of other homolateral lobes, +/- mediastinal deviation, +/- contralateral GGO by lack of expansion.

Adult Chest Imaging 3rd edition - Edited by Philippe Grenier

Diffuse Pulmonary Lymphangiectasis

- **Rare**, lymphatic disorder with **dilation of lymphatic vessels, high mortality.**
- Several types
  - **Secondary** to **cardiac** cause
  - **Primitive** +/- syndromic. No lymphatic vessel size regression after the 20th week of gestation. Dilatation of intra-pulmonary lymphatics
    - **Isolated ++**
    - Or may be part of a **generalized lymphangiectasis (lymphedema, hemi-hypertrophy).**
- Treatment: high-protein diet, triglyceride-free diet



Courtesy Bellini C
Orphanet J Rare Dis. 2009

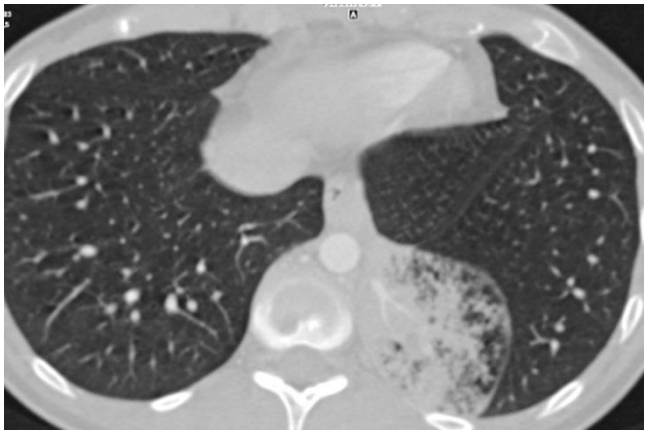
Imaging

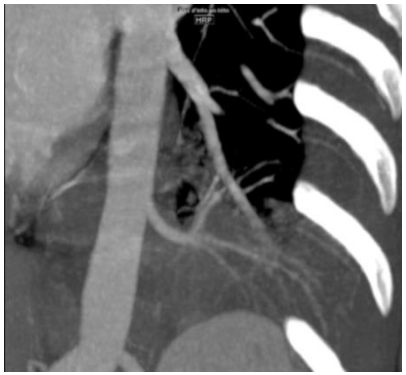
- Lung: lymphatic overload
  - **Inter-lobular septal thickening, sub-pleural**
  - **Peri-bronchial thickening**
  - Patchy GGO
  - Basal predominance
- Médiastin
  - **Infiltration of mediastinal fat**, lymphadenopathy (50%)
- Pleura
  - **Chylothorax ,** sometimes pleural calcifications

Bellini C, Boccardo F, Campisi C et-al. Congenital pulmonary lymphangiectasia. Orphanet J Rare Dis. 2009

Lung sequestration

Congenital. Lung tissue detached from the rest of the lung
Vascularized by a proper systemic artery +++: thoracic aorta (75%), abdominal (20%), intercostal...





Intra-lobular sequestration
Systemic artery vascularize LLL consolidation syndrom

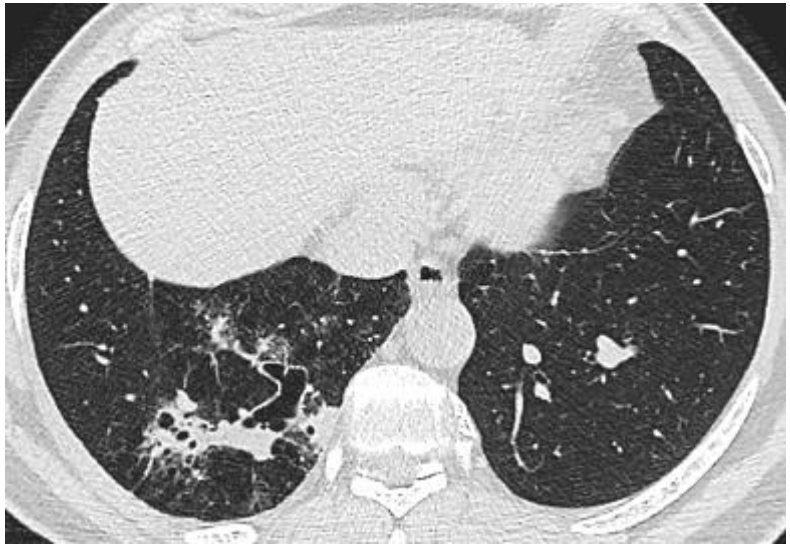
1/ Intra-lobular +++ (90%)

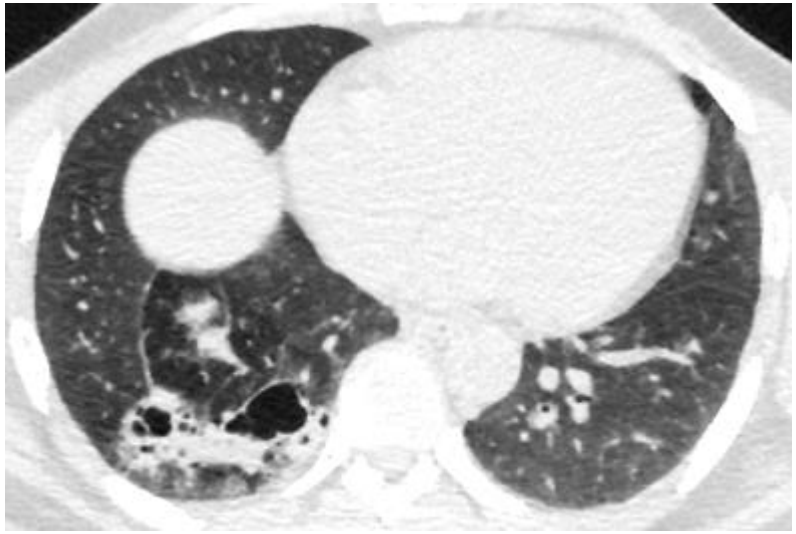
- Contained **in the visceral pleura of the** homolateral lung
- **Artery from the aorta or its branches**
- **Drainage through the pulmonary vein** (left-right shunt)
- **Lower lobes: posterior segment of the LLL +++** (2/3)
- **Complications: superinfections +++** (consolidation, hydro-aerous levels)
- Different presentations
  - **Cystic / bronchiectasis** (communication with the tracheo-bronchial tree)
  - **Pseudotumoral** (homogeneous mass, well limited, posterior in the LLL) (no communication with the tracheobronchial tree)
  - **Emphysematous**

2/ Extra-lobular (10%)

- Clean pleural envelope
- **Artery from the aorta or its branches**
- **Systemic venous return**
- Sus, intra or sub-diaphragmatic

Reflex!
Consolidation syndrom or **repetitive pneumonia** of the **lower left lobe +++**
→Look for **systemic artery** (**angioscan +++**) to diagnose a **sequestration**

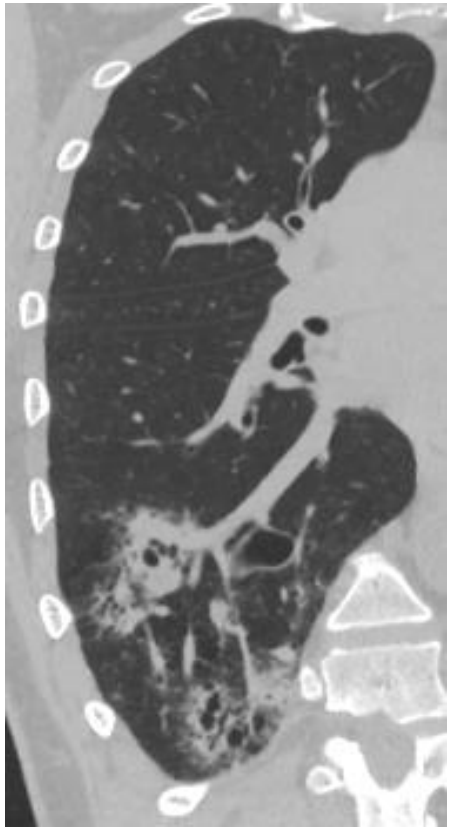


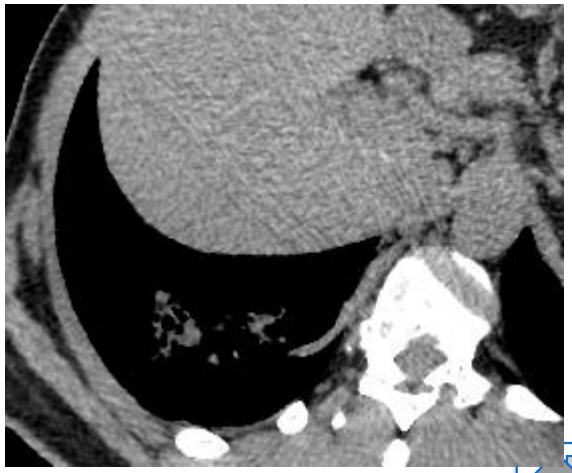


Intra-lobular sequestration

→ Hemoptysis

→ Discovery at 41



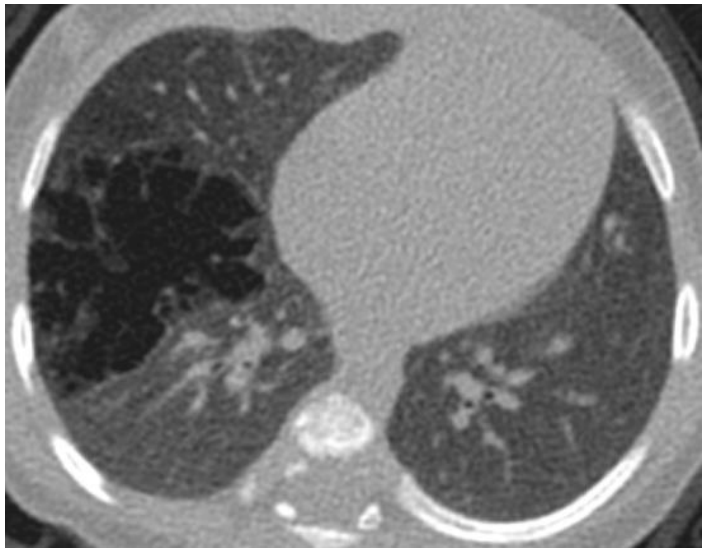


Adenomatoid malformation

Definition: **abnormal foetal development of the terminal respiratory structures of a segment of lung tissue** resulting in adenomatoid proliferation of bronchiolar elements with development of **cysts.**

- = ***MAKP****: cystic adenomatoid pulmonary malformation*
- = ***CAMC****: congenital cystic adenomatoid malformation.*

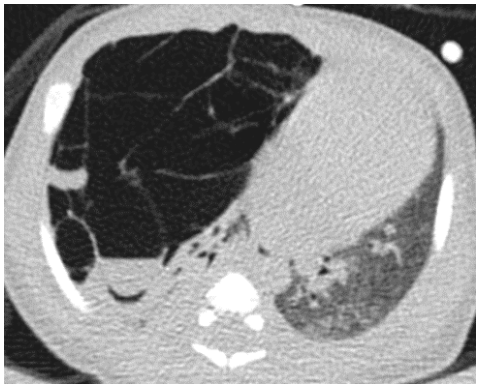
- 25% of congenital lung lesions
- 1/1500 to 1/4000, male dominated
- Treatment: Surgery if symptomatic



Complications

- Pneumothorax
- Hemopneumothorax
- Pyo-pneumothorax
- Degeneration
  - Carcinomas
  - Pleuro-pneumoblastoma
  - Rhabdomyosarcoma

Pleuro-pneumo-blastoma



Biblio: Biyyam DR, Chapman T, Ferguson MR et-al. Congenital lung abnormalities: embryologic features, prenatal diagnosis, and postnatal radiologic-pathologic correlation. Radiographics. 2010

Imaging

Diagnosis

- Antepartum/post natal (respiratory distress) → US
- Sometimes in adulthood (recurrent infections) → CT

Several types (depending on the phases of development of the tracheobronchial tree)

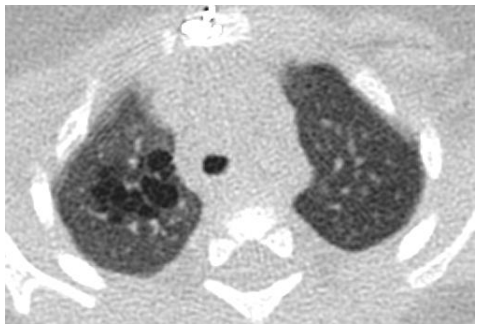
- Type 1 +++ (70%): **one or more large cysts** (2 cm to 10 cm) +/- small peripheral cysts
- Type 2 (15-20%): **multiple small cysts** (<2cm), associated with other anomalies (renal agenesis, pulmonary sequestration, cardiac malformations).
- Type 3 (10%): microcysts (<5mm) → **solid** (adenomatoid tissue), typically affects a whole lobe
- Type 4: large cyst (risk of pneumothorax, blastoma degeneration)

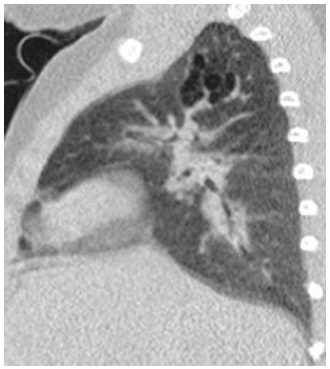
Location

- Lobar
- Unilateral

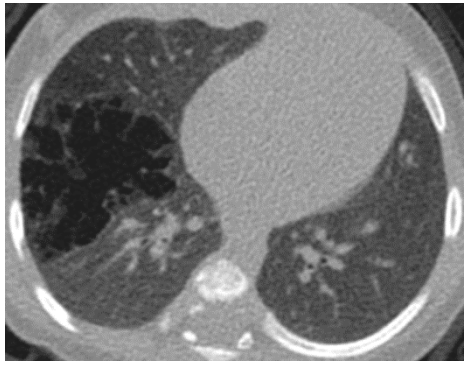
Differential diagnosis

- **Bronchogenic cyst**
- Pulmonary **sequestration** (feed artery)
- Congenital diaphragmatic **hernia**
- **Giant Lobar Emphysema**
- Cystic **Bronchiectasis**

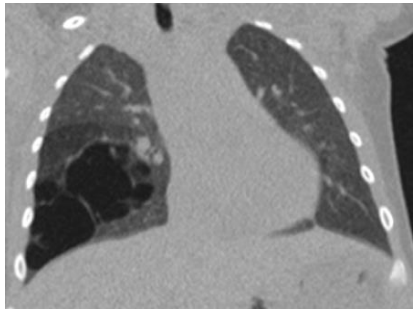


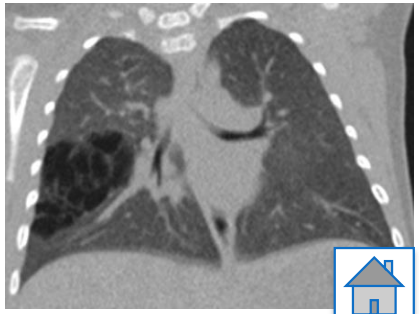


MAKP type 2, 7 months



MAKP type 1
11 months



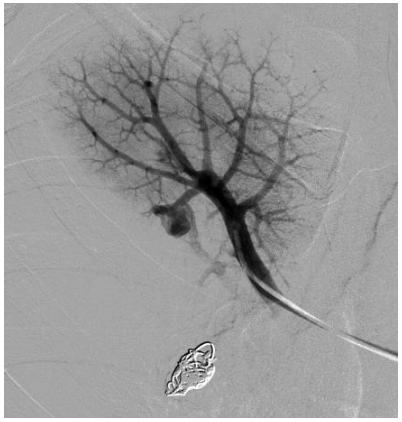


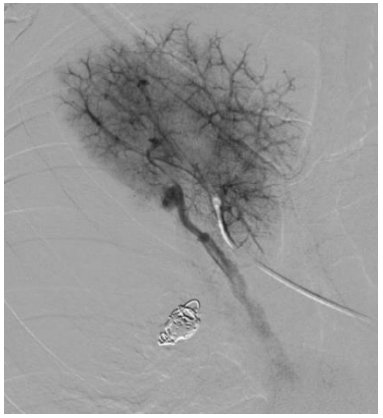
Arteriovenous malformation

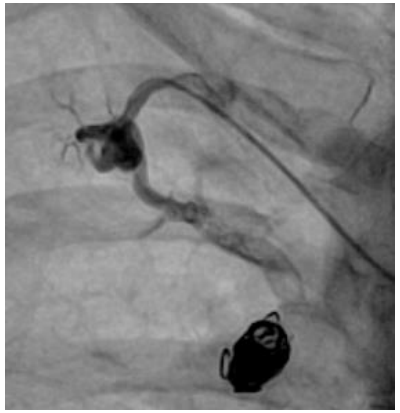
- Direct communication between artery and pulmonary vein **without capillary**
- **Osler-weber-rendu** disease **80%**
- Idiopathic 20 %

Imaging

- **Nodule** with **one or more artery(ies)** and **drainage veins** whose communication is objective (MIP)
- Round or oval
- Lobulated, well limited
- Multiple (33%), or single (66%)
- Lower lobes (50 to 70%) or 1/3 medium

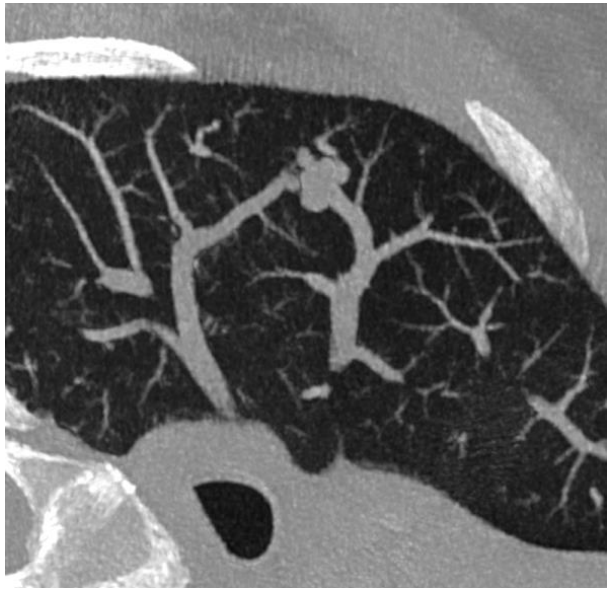






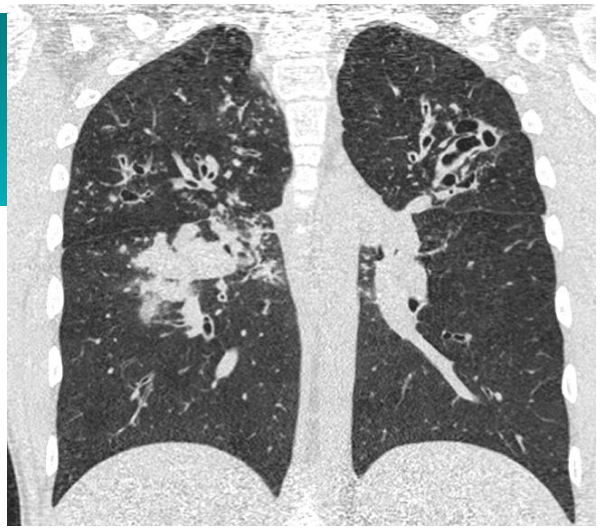
Consequences

- Shunt right / left -> hypoxemia
- **Septic**, cruoric, gaseous **emboli**: antibiotic for life
- **Risk of rupture** (especially during **pregnancy**)



Adult Chest Imaging 3rd edition - edited by Philippe Grenier

Cystic fibrosis



- The most frequent serious genetic disease in the white population in France (1/3200 births)
- **Autosomal recessive** disease
- **CFTR protein gene mutation**
- → **viscous mucus** → chronic surinfection → bronchial dilatation and parenchymal destruction

Differential diagnosis
- ABPA
- Ciliary dyskinesia
- Tuberculosis

- **Bronchectasis +++**
- **Upper** regions
- Child/young adult

→ consider **cystic fibrosis**

Radiology (Mandatory at **initial check-up** (at birth or on symptoms) and **annual check-up)**
- Hyperinflation, bronchiectasis, mucoid impactions

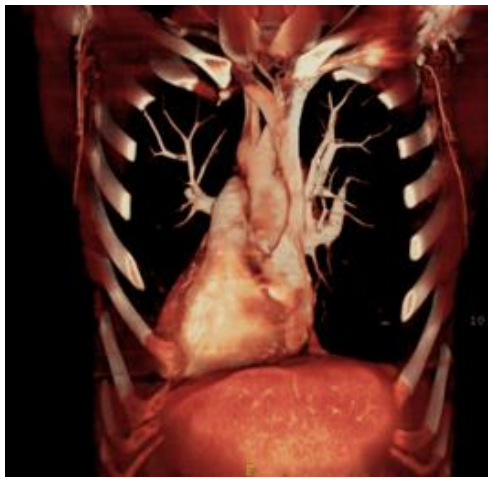
CT scan (Optional for initial symptom assessment, 6-month and annual assessment (depending on the context), low dose CT +++)
- **Cylindrical and cystic diffuse bronchiectasias** with preferential involvement of the **upper lobes +++** and **posterior segment**
- **Thickening of the bronchial walls**
- **Mucoid impactions** (normal bronchus) and **bronchocele impactions** (dilated bronchus), tree in bud
- Cysts or bubbles in the subpleural regions of the upper lobe
- Air **trapping** (mosaic lung) and atelectasis
- Thoracic **distension** with hyperinsufflation
- Emphysema
- Mediastinal nodes

- *Muller NL, Silva CS. Imaging of the Chest. Saunders 2008*
- *HAS - Cystic fibrosis National protocol for diagnosis and care of a rare disease November 2006*

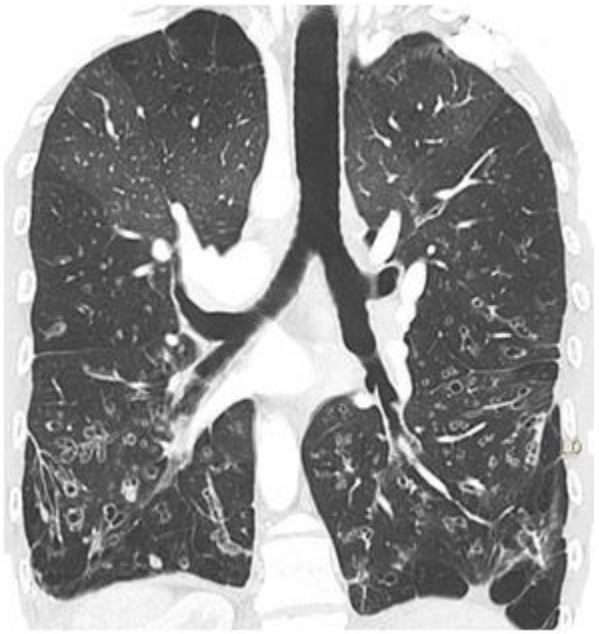
Primary ciliary dyskinesia

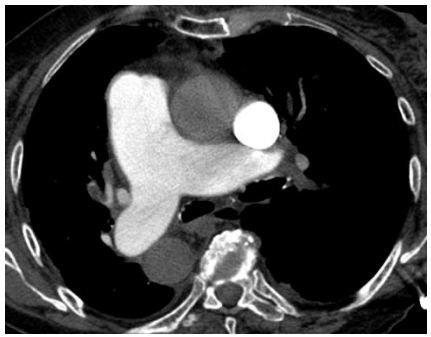
Genetic lash structure disorder
- Diagnosis: Jorissen and Bertrand test

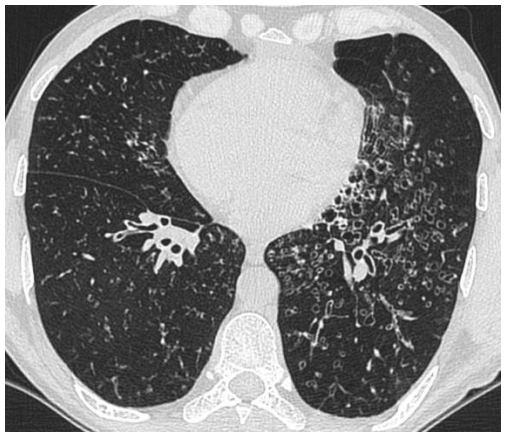
Imaging
- **Bronchiectasis** (of all types)
- **Mucoid Impactions**
- Tree in bud
- Trapping



Kartagener Syndrome
Association
- Ciliary dyskinesia
  - **Bronchiectasis**
  - **Naso-sinusal polyposis**
  - Aplasia of frontal sinus
- Situs inversus or dextrocardia (50%)



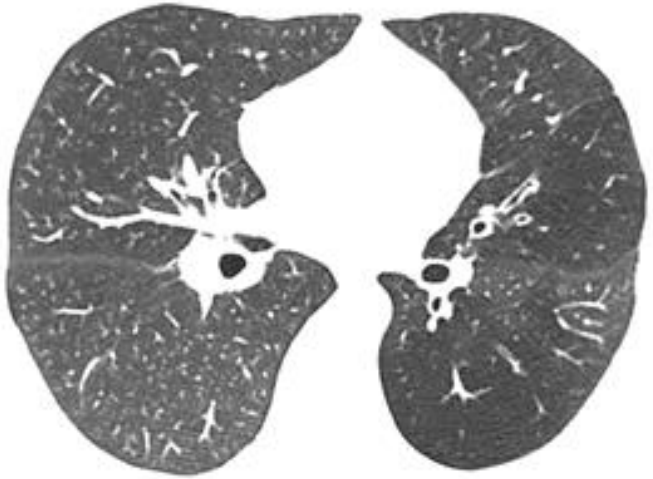


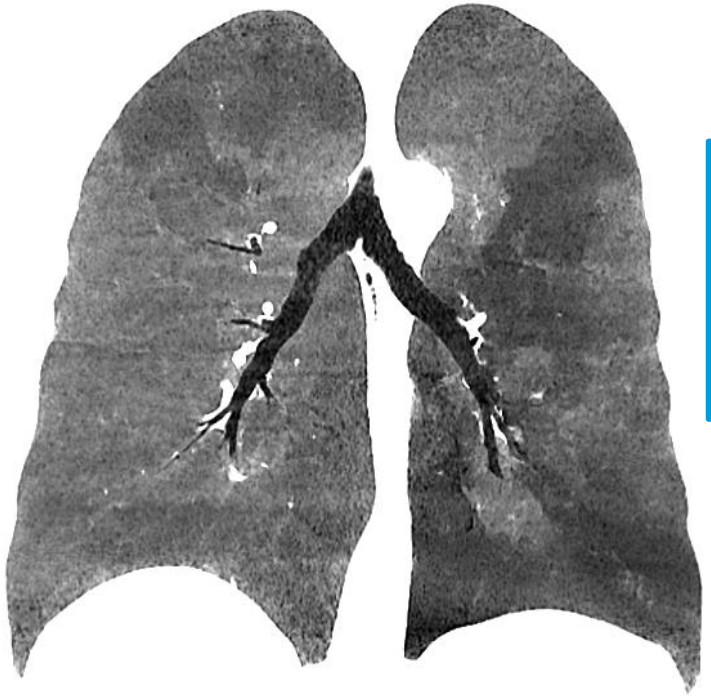


Swyer-James Syndrom

Physiopathology

- = MacLeod's syndrom
- **Hemithoracic hyperlucency** related to **constrictive bronchiolitis lesions** secondary to childhood bronchitis or bronchiolitis (adenovirus or mycoplasm)





- **Hyperlucent lung/lobe / Air trapping**
- Distribution: **lung, lobe**, ...
- **Decrease in vessel size**
- Normal or decreased volume (younger - smaller)
- Often irregular segmental bronchiectasias

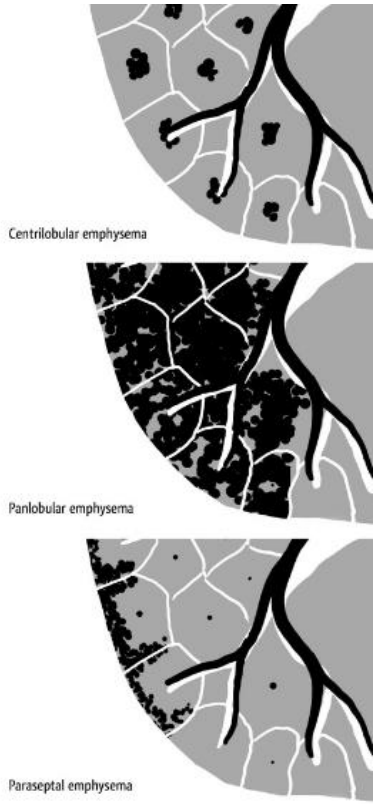
Differential diagnosis

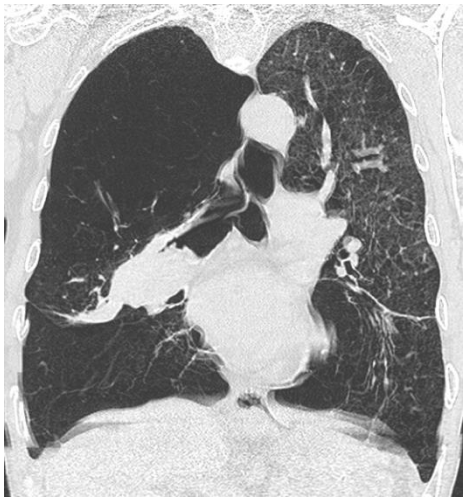
- Partially obstructive **lesion of the** main bronchus
- Chronic thrombus
- Hypoplasia of the pulmonary artery

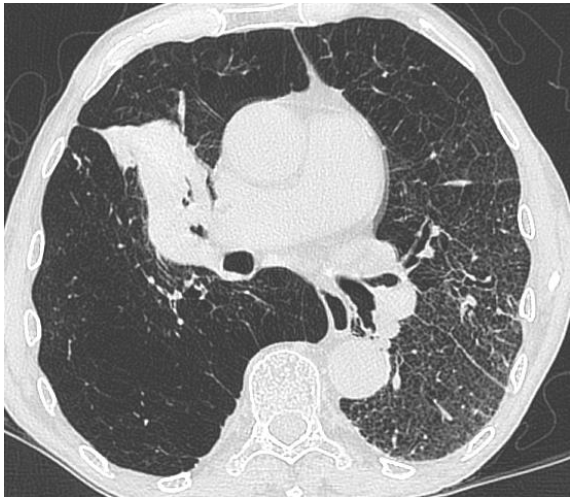
Alpha 1 antitrypsin deficiency

Physiopathology

- **Alpha1 antitrypsin** is a **protein that protects the tissues from enzymes** (elastase...).
- Associated **Cirrhosis**







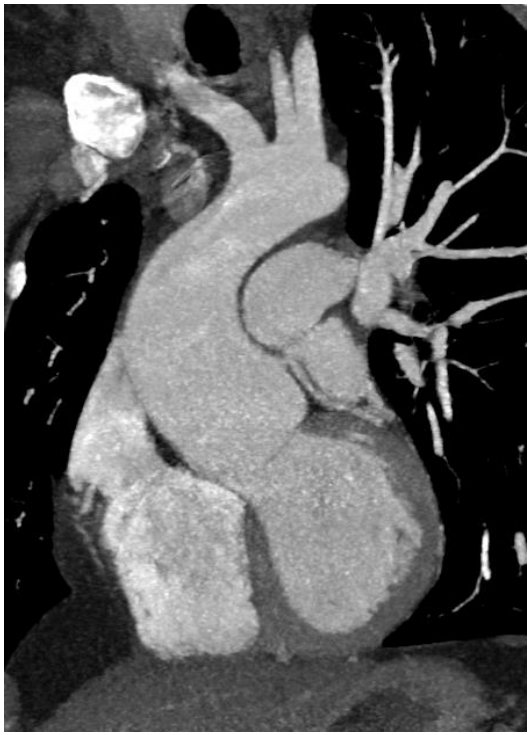
- **Panlobular Emphysema**
- **Bubbles**
- **Bronchiectasia, moderate, cylindrical** (40%)
- Bronchial parietal thickening (50%)
  - Severity proportional to emphysema
- <u>Distribution</u>
  - **Predominance in lower regions**
  - Diffuse
  - Sometimes upper regions

Courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 9674

Marfan disease

Elastic tissue system disease

- **Autosomal dominant** transmission (mutation of the fibrillin gene on chromosome 15)
- Prevalence: 2-6 / 1 000 000

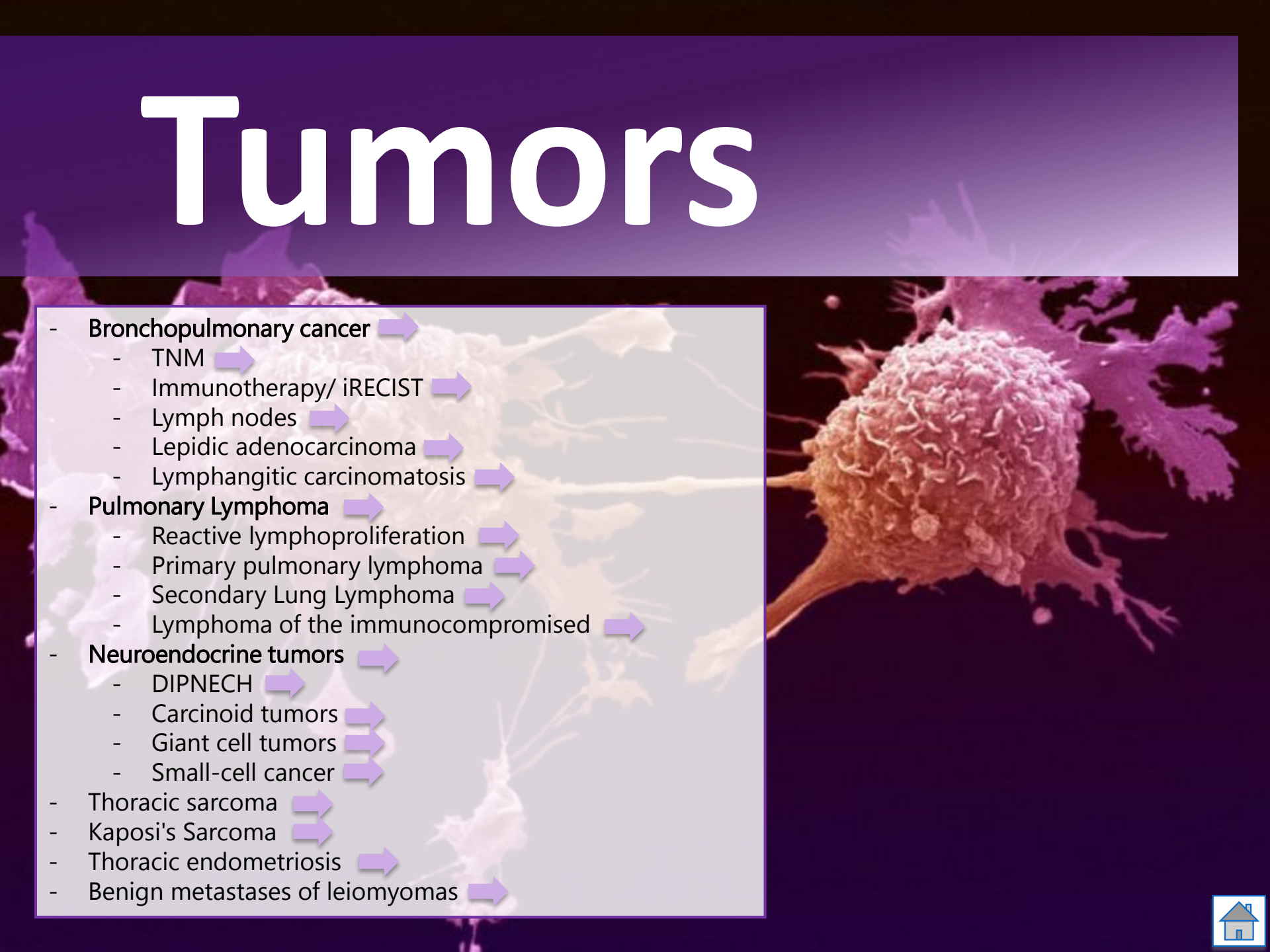


Imaging: **Multi-organ damage**

- Musculoskeletal
  - **Slender** morphotype, osteopenia, ligament **hyperlaxity,** acetabular protrusion
  - Spine: atlanto-axial subluxation, dural ectasia, kyphoscoliosis, meningocel.
  - Thorax: *pectus excavatum/ carinatum*
- Eyes
  - Myopia, lens subluxation, retinal detachment
- Cardiovascular
  - **Aortic aneurysm,** aortic insufficiency, aortic coarctation.
  - **Arterial Dissection**
- Lung
  - **Cysts** and **bubbles**, spontaneous pneumothorax

Ha HI, Seo JB, Lee SH et-al. Imaging of Marfan syndrome: multisystemic manifestations. Radiographics. 2007

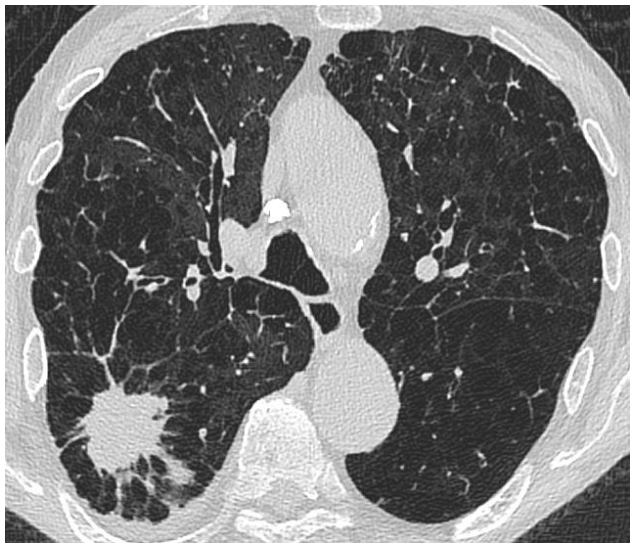
Tumors



- **Bronchopulmonary cancer**
  - TNM
  - Immunotherapy/ iRECIST
  - Lymph nodes
  - Lepidic adenocarcinoma
  - Lymphangitic carcinomatosis
- **Pulmonary Lymphoma**
  - Reactive lymphoproliferation
  - Primary pulmonary lymphoma
  - Secondary Lung Lymphoma
  - Lymphoma of the immunocompromised
- **Neuroendocrine tumors**
  - DIPNECH
  - Carcinoid tumors
  - Giant cell tumors
  - Small-cell cancer
- Thoracic sarcoma
- Kaposi's Sarcoma
- Thoracic endometriosis
- Benign metastases of leiomyomas

Bronchopulmonary cancer

- Broncho pulmonary cancer: more than **30,000 new cases/year**: 4th most frequent cancer in France
- Average age at diagnosis: 65 years
- 80-85% non-small cell
- All stages combined, relative survival at 5 years is estimated at about 14%.



Bronchopulmonary tumor

Anatomopathology

- Common forms 95%
  - Adenocarcinoma 46%
  - Squamous cell carcinoma 26%
  - Large cell carcinoma 10%.
  - Small Cell Carcinoma 13

  } NPC
- Non-common forms 5%
  - Carcinoid 80%
  - Bronchial tumors
  - Others

8th edition of the TNM

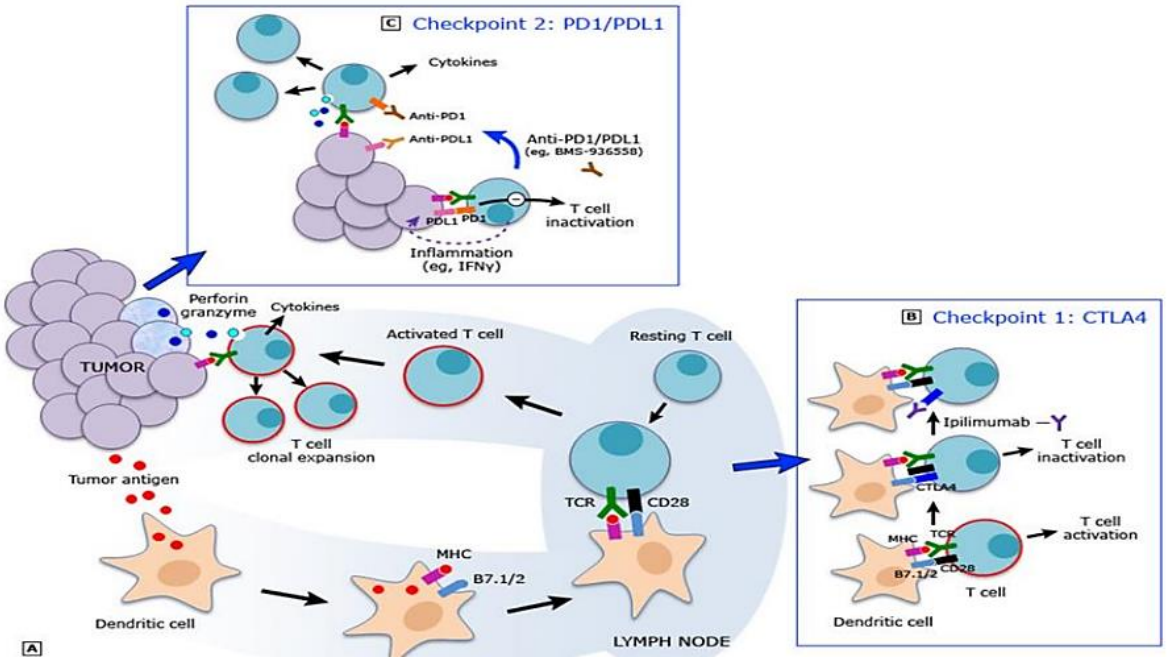
Descriptor	Definition
T descriptor	
TX	Primary tumor cannot be assessed or tumor proven by the presence of malignant cells in sputum or bronchial washings but not visualized with imaging or bronchoscopy
T0	No evidence of primary tumor
Tis	Carcinoma in situ
T1	Tumor ≤ 3 cm in greatest dimension, surrounded by lung or visceral pleura, without bronchoscopic evidence of invasion more proximal than the lobar bronchus
T1a	Tumor ≤ 1 cm in greatest dimension
T1b	Tumor > 1 cm but ≤ 2 cm in greatest dimension
T1c	Tumor > 2 cm but ≤ 3 cm in greatest dimension
T2 descriptor	
T2	Tumor > 3 cm but ≤ 5 cm or tumor with any of the following features: involvement of a main bronchus regardless of the distance from the carina; invasion of the visceral pleura; associated with partial or complete lung atelectasis or pneumonitis
T2a	Tumor > 3 cm but ≤ 4 cm in greatest dimension
T2b	Tumor > 4 cm but ≤ 5 cm in greatest dimension
T3	Tumor > 5 cm but ≤ 7 cm in greatest dimension or one that directly invades any of the following structures: parietal pleura, chest wall (including superior sulcus tumors), phrenic nerve, parietal pericardium; or separate tumor nodule or nodules in the same lobe
T4	Tumor measuring >7 cm in greatest dimension that invades any of the following structures: mediastinum, diaphragm, heart, great vessels, trachea, recurrent laryngeal nerve, esophagus, vertebral body, carina; or separate tumor nodule or nodules in a different lobe of the same lung

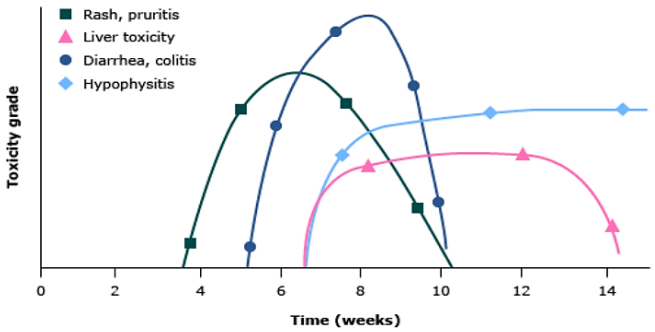
8th edition of the TNM

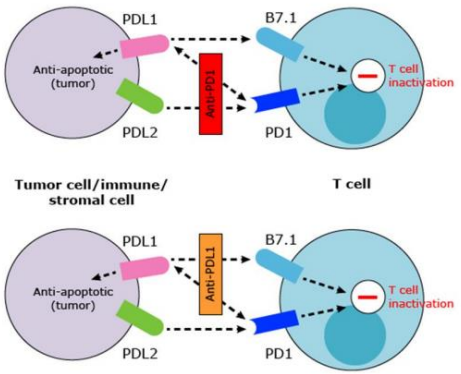
N descriptor	
NX	Regional lymph nodes cannot be assessed
N0	No regional lymph node metastasis
N1	Metastasis in ipsilateral peribronchial and/or ipsilateral hilar lymph nodes and intrapulmonary nodes, including involvement by direct extension
N2	Metastasis in ipsilateral mediastinal and/or subcarinal lymph nodes
N3	Metastasis in contralateral mediastinal, contralateral hilar, ipsilateral or contralateral scalene, or supraclavicular lymph nodes
M descriptor	
M0	No distant metastasis
M1	Distant metastasis
M1a	Separate tumor nodule or nodules in contralateral lung; malignant pleural effusion or pleural thickening or nodules or masses; malignant pericardial effusion or pericardial thickening or nodules or masses
M1b	Single distant (extrathoracic) metastasis in a single organ
M1c	Multiple distant (extrathoracic) metastases in a single organ or multiple organs

Immunotherapy

- **Stimulate the immune response** (T-lymphocytes) **to destroy tumor cells**
- Pembrolizumab, Nivolumab, Atezolizumab
- Side effects +++ (auto immune), toxicity
  - Cutaneous 16%.
  - Digestive 12%
  - Pneumology 7%
  - Endocrine 6%
  - Hematologic, hepatic, neuromuscular...
- **Sometimes pseudo-progression** on the 1st control (by **immune inflammatory** reaction) **while response**
- <u>Criteria i RECIST</u> for immunotherapy







i RECIST

- i RECIST was developed in patients receiving this type of treatment because of the different cinetic response compared to conventional chemotherapy. **In patients treated with immunotherapy, a "flare" or "pseudoprogression" effect is sometimes observed, i.e. an initial increase in the size of the lesion followed by a response in a second stage.**

- To assess tumour response, RECIST 1.1 criteria are used up to the progression. Then the iRECIST criteria are used. The challenge is to wait and rescan the patient at 4 to 8 weeks :
    - to confirm progression
    - or pseudo-progression /response if lesions are decreasing

- The **iUPD** (unconfirmed PD) criteria is therefore used initially if the lesions are progressing and then at the reassessment scan:
    - i CPD if **progress is confirmed**: stop treatment
    - i UPD again when the patient **maintains baseline progression criteria** but without worsening from the previous scan
    - i SD / i PR: if the **stability (i SD)** or **partial response (i PR)** criteria with **respect to the baseline** are met
    - i CR when it is a **complete response**
    In the i SD, i PR, i CR, the next time you progress, you start again on an i UPD

Criteria i RECIST

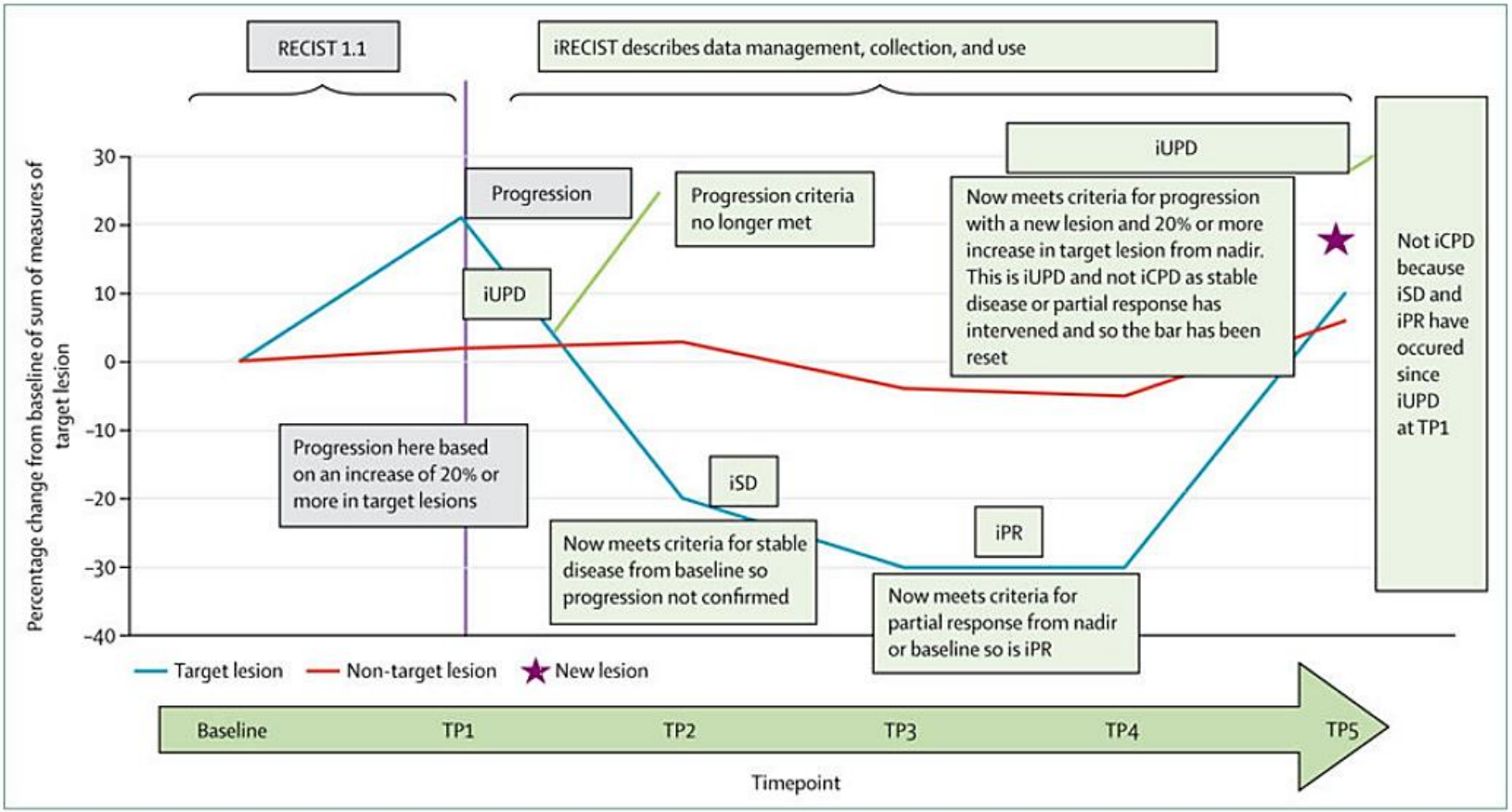
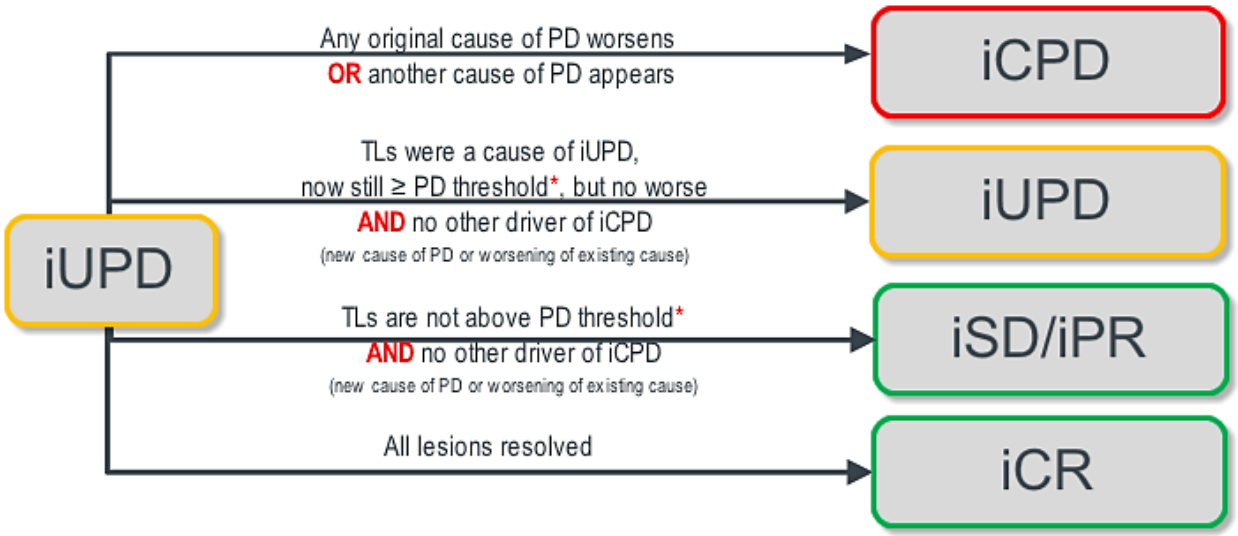


Figure 2. RECIST 1.1 and iRECIST: an example of assessment

Prefix "i" indicates immune responses assigned using iRECIST; others without "i" are confirmed by RECIST 1.1. RECIST=Response Evaluation Criteria in Solid Tumours. iCR=complete response. iCPD=complete progression. iPR=partial response. iSD=stable disease. iUPD=unconfirmed progression. TP=timepoint.

NB: **hyperprogression**: increase in tumour growth rate by a factor ≥ 2 after the introduction of immunotherapy.

Possibilities After Initial iUPD



Stop treatment

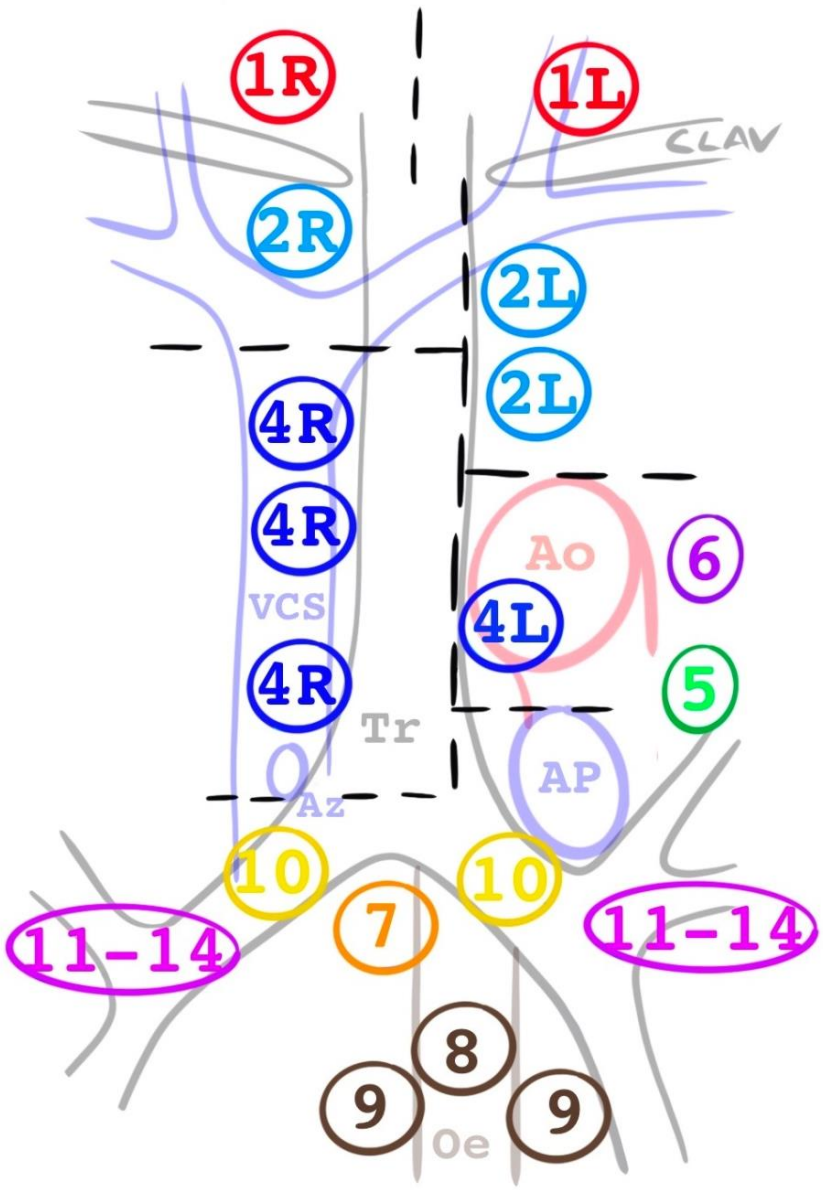
Continued treatment

Continued treatment
Bar reset
Next progression iUPD

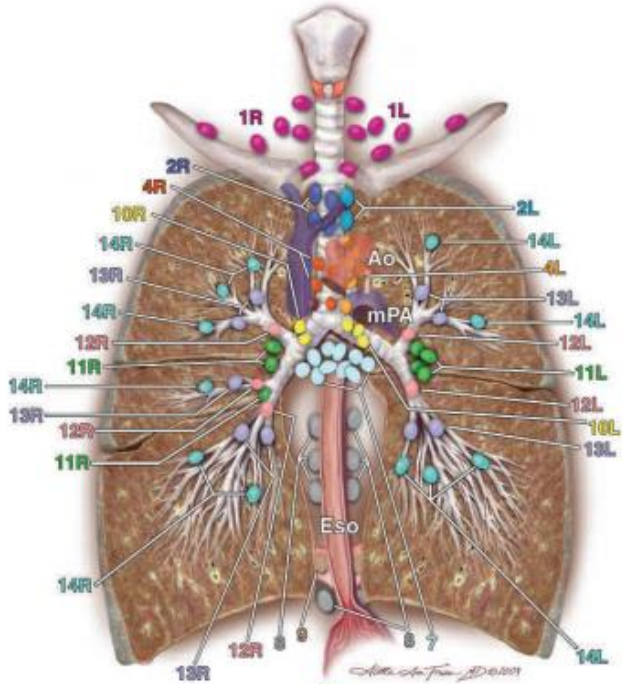
Note: Only target lesion PD, if present at iUPD, must resolve to achieve iSD/iPR.
e.g. PR in TLs + unequivocal PD of NTLs + new lesions → unchanged = iPR

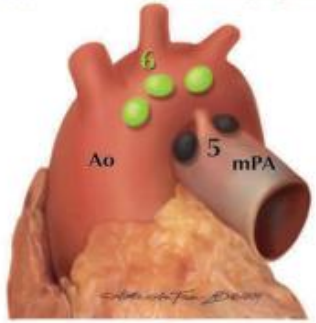
* PD threshold = 20% & 5 mm ↑ from nadir

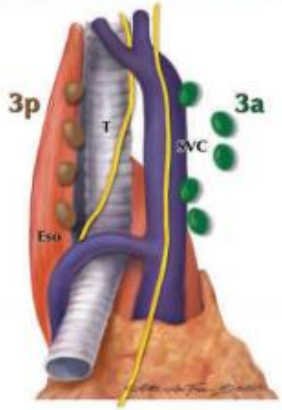
Nomenclature of mediastinal lymph nodes



Area GG	Common Name
1	Supra-clavicular
2R	Upper right para-tracheal
4R	Lower right para-tracheal
2L	Upper left para-tracheal
4L	Lower left para-tracheal
3A	Pre-vascular
3P	retrotracheal
5	Sub-aortic
6	Para-aortic
7	Sub carinal
8	Posterior infra-mediastinal (or para-esophageal) space
9	Pulmonary ligament
10	Hilar
11, 12, 13, 14	Interlobar, lobar, segmental, sub-segmental







Supraclavicular zone

1 Low cervical, supraclavicular, and sternal notch nodes

SUPERIOR MEDIASTINAL NODES

Upper zone

- 2R Upper Paratracheal (right)
- 2L Upper Paratracheal (left)
- 3a Prevascular
- 3p Retrotracheal
- 4R Lower Paratracheal (right)
- 4L Lower Paratracheal (left)

AORTIC NODES

AP zone

- 5 Subaortic
- 6 Para-aortic (ascending aorta or phrenic)

INFERIOR MEDIASTINAL NODES

Subcarinal zone

- 7 Subcarinal

Lower zone

- 8 Paraesophageal (below carina)
- 9 Pulmonary ligament

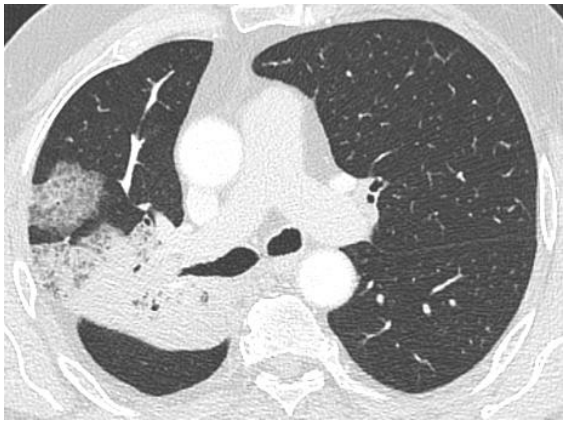
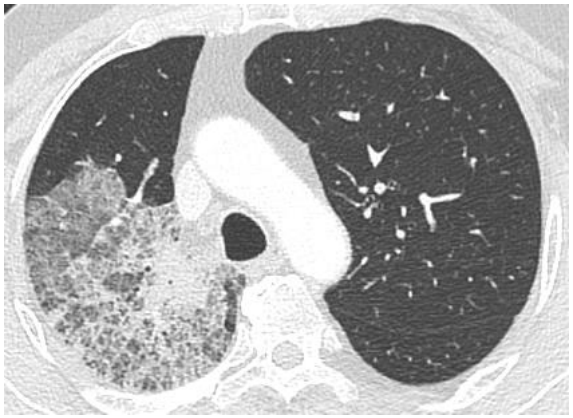
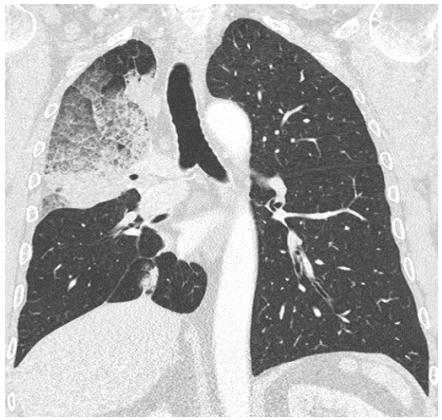
N1 NODES

Hilar/Interlobar zone

- 10 Hilar
- 11 Interlobar

Peripheral zone

- 12 Lobar
- 13 Segmental
- 14 Subsegmental

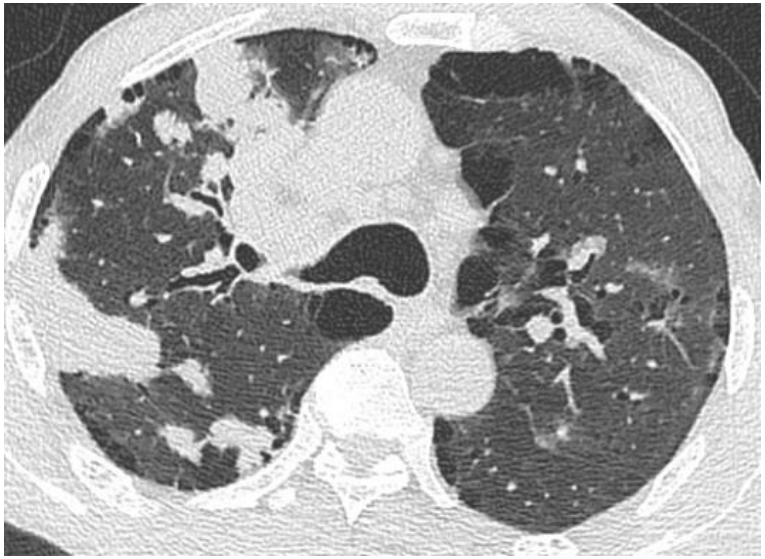
LPAL
- *Consolidation*
- *Crazy paving*
- *Scissural bulging +++*

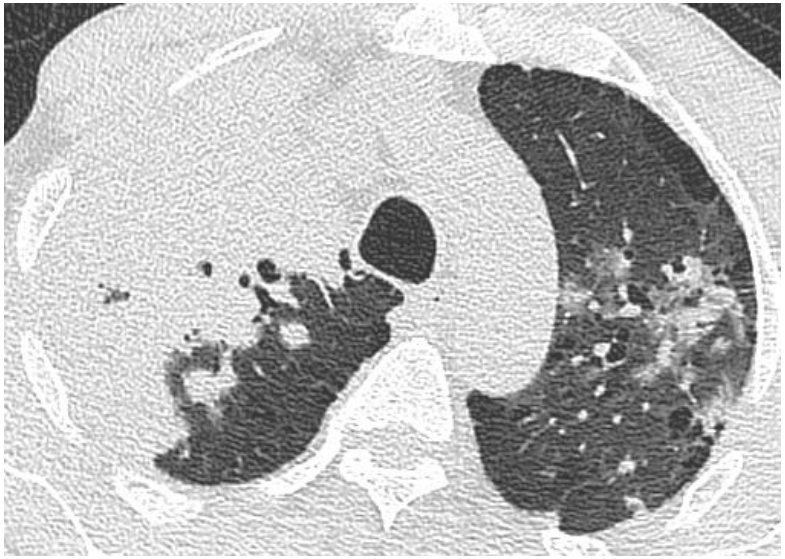
Lepidic predominant adenocarcinoma of the lung (LPAL)

- Proliferation of cylindrical cells **lining the alveolar walls** and respecting the alveolar architecture . Former " **bronchiolo-alveolar adenocarcinoma ".** Mucinous (80%: diffuse++) or non-mucinous (localized++).
- **Bronchogenic progression** to other lobes / controlateral lung, or lymphatic/hematogenic spread
- Presentations
  - Early form: **GGO nodule +/- mixed** (sometimes the transformation of an atypical adenomatous hyperplasia (AAH) which is a possible precursor)
  - **GGO +/- crazy paving** (consolidation)
  - **Consolidation**
    - **Lobar** , **asymmetrical** with **scissural bulging** **+++** and **stretched bronchogram**
  - **Nodules**
  - **Often the 3 signs together +++**
  - DD: pneumonia

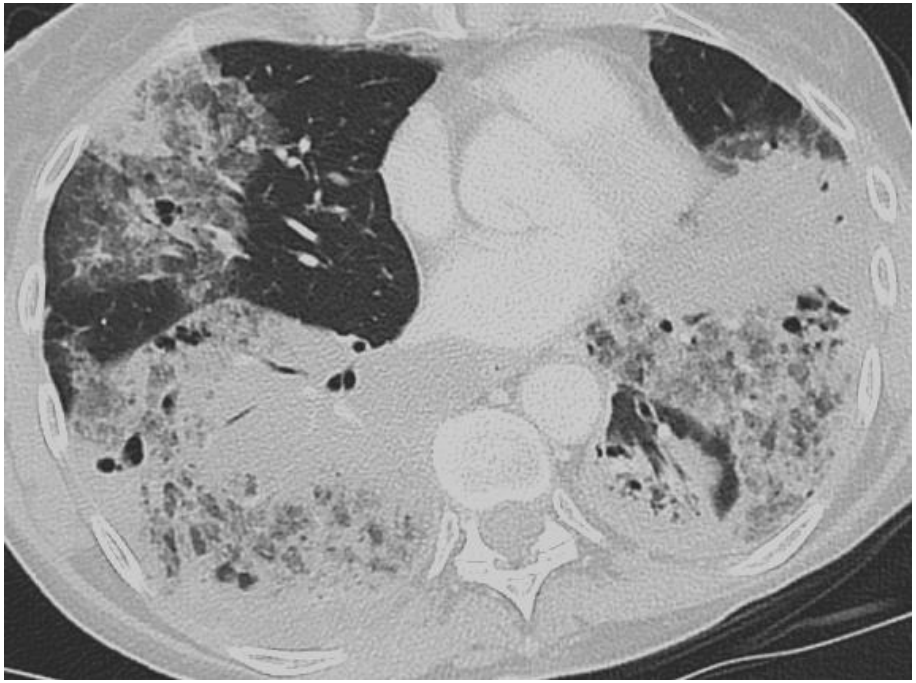
THINK to the LAPL when:
- **Chronic consolidation**
- **Resistant to broad-spectrum antibiotic therapy**

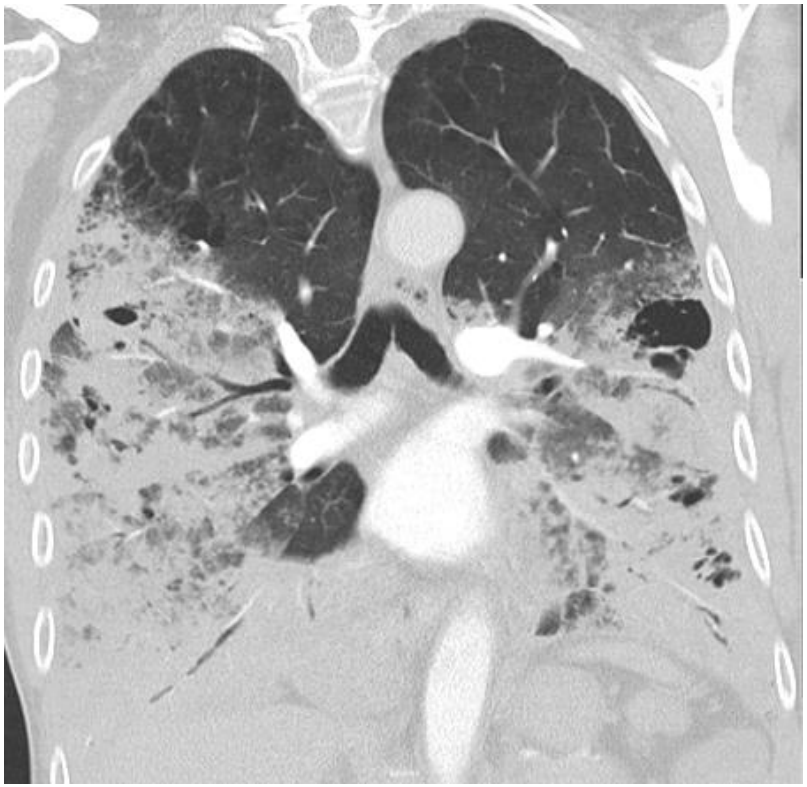
Akira M et al.High-resolution CT findings of diffuse bronchioloalveolar carcinoma in 38 patients. AJR Am J Roentgenol. 1999





LPAL

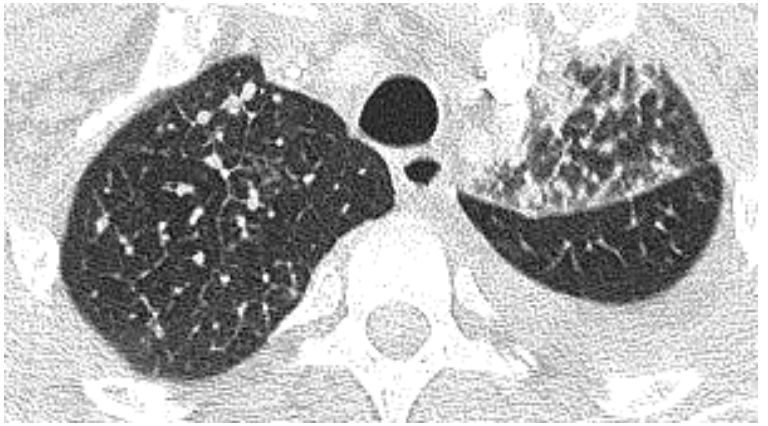


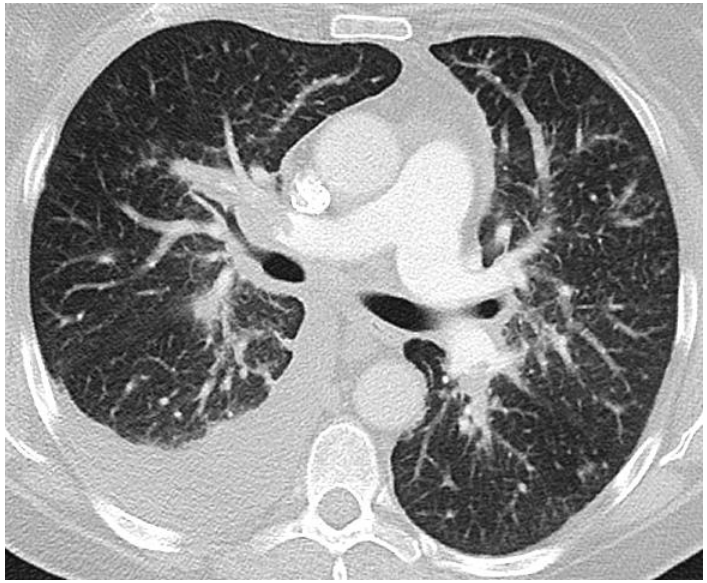


Lymphangitic carcinomatosis

Extension of a tumour to the lymphatic system of the lung

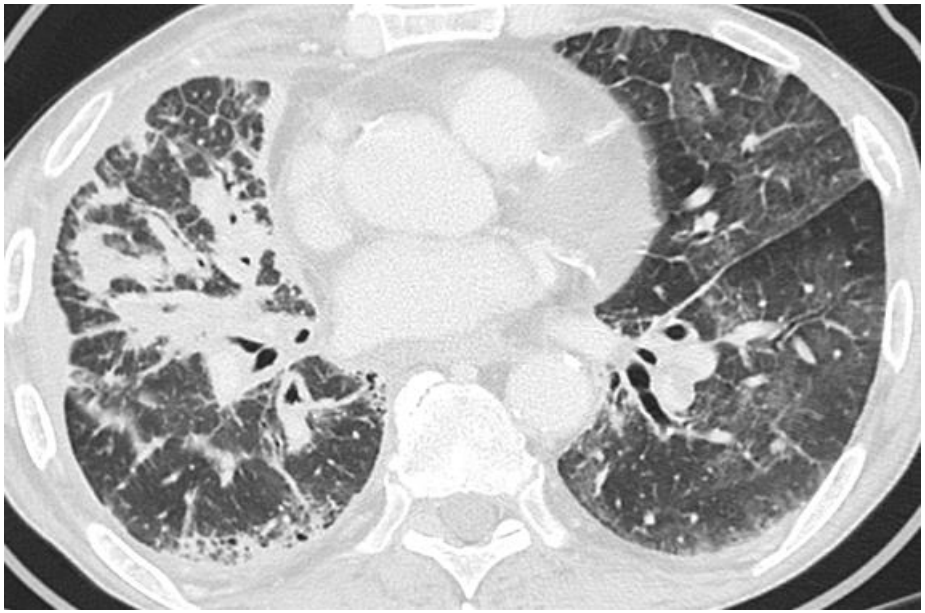
- **Adenocarcinoma +++** (**breast+++**, **lung++**, colon, stomach, prostate, ENT, thyroid)
- Dissemination :
  - Haematogen
  - Direct (pulmonary ADK)
  - or through the mediastinal lymph nodes...
- Restrictive syndrome (failure of the pulmonary lobules to expand), abnormalities in alveolo-capillary diffusion

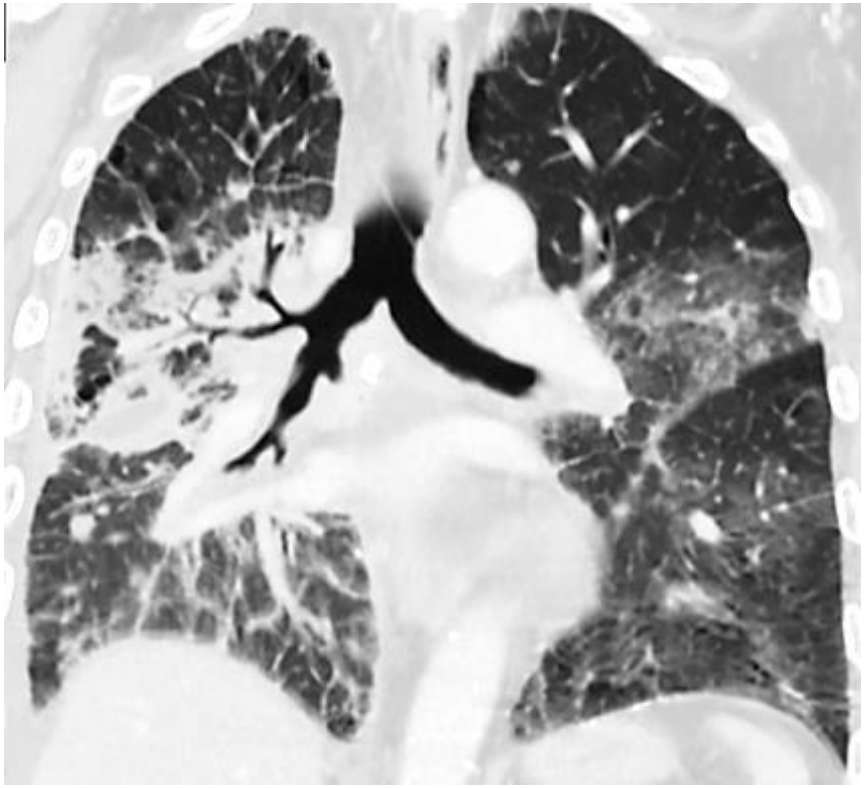




CT

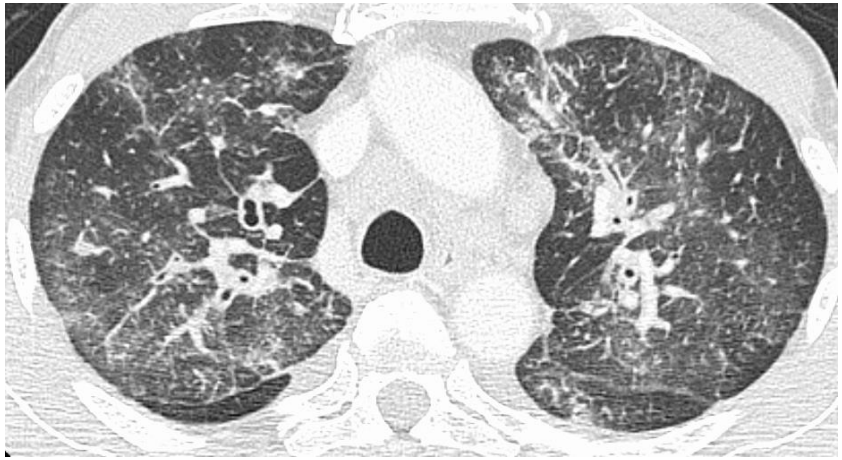
- **Septal thickening +++**
  - Regular, **nodular +++** or irregular polygonal appearance
- **Peri-broncho-vascular thickening +++**, irregular and nodular
- Homolateral (one or more lobes) or bilateral
- Respect for lung architecture
- +/- **Pleural carcinomatosis**: pleural effusion with enhanced nodules on the parietal or visceral pleura and on the scissure
- +/- Hilar and mediastinal **lymphadenopathy**

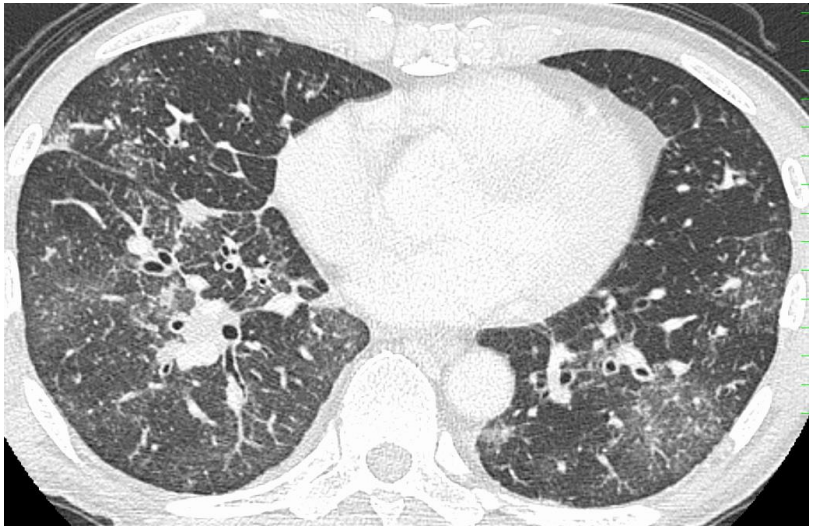


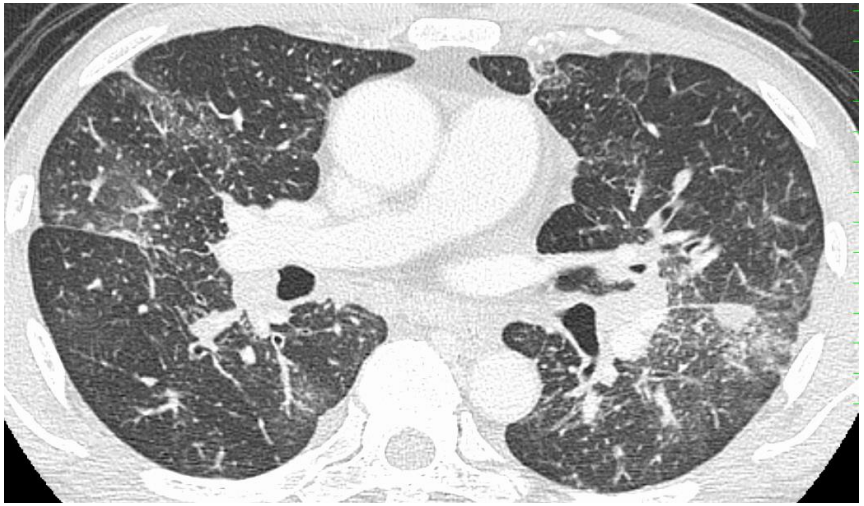


Lymphatic carcinomatosis on lung adenocarcinoma

Major peribronchovascular thickening



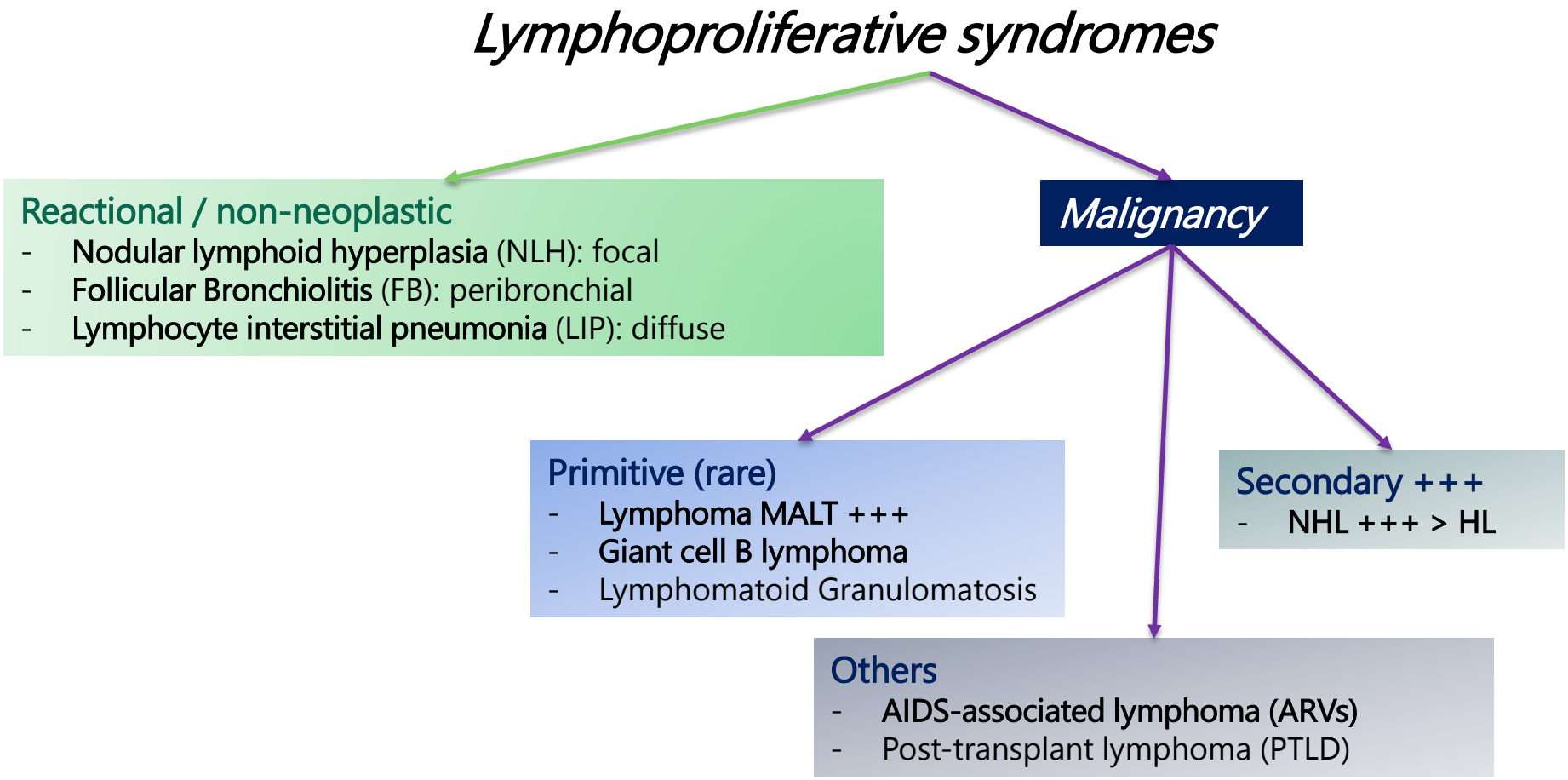




Lymphatic carcinomatosis on lepidic adenocarcinoma

- GGO= lepidic ADK
- Septic lines and micronodules = lymphangitis

Pulmonary Lymphoma



The radiological spectrum of pulmonary lymphoproliferative Disease S HARE The British Journal of Radiology, July 2012

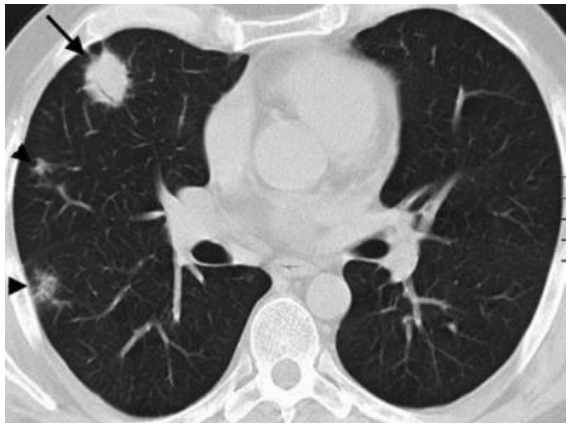
Benign lymphoproliferative disease

Nodular lymphoid hyperplasia (NLH)

- Rare, called **"Pseudolymphomas."**
- 19 - 80 years (median 65 years)
- Asymptomatic
- Histology: **polyclonal** mature lymphocyte infiltrate

Imaging

- **Nodule** or **condensation**
  - Well defined
  - **Unique ++**, average 2 cm (0,6 to 6cm)
  - Sometimes conglomerate of 2-3 nodules
  - Bronchogram
  - Discrete lymphatic dissemination



NLH

Courtesy S HARE The radiological spectrum of pulmonary lymphoproliferative Disease The British Journal of Radiology, July 2012

Follicular bronchiolitis (FB)

- Benign **polyclonal** hyperplasia of intra- and **peribronchial** MALT tissue

Etiologies

- Collagenoses (PR, Sjögren) (adult)
- Immunodeficiency (HIV ...) (younger)

Imaging : airways+++

- **Centrolobular micronodules +++**
- **Tree in bud**
- **GGO** bilateral, patchy
- **Bronchial dilatation**

Lymphoid interstitial pneumonia (LIP)

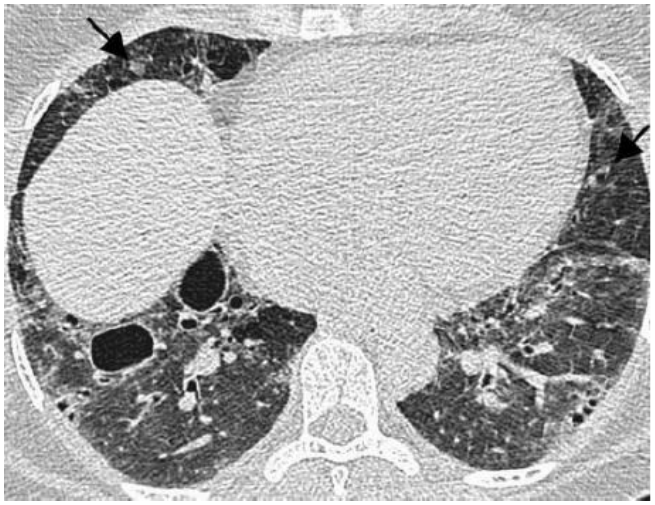
- **Polyclonal lymphocyte infiltration**

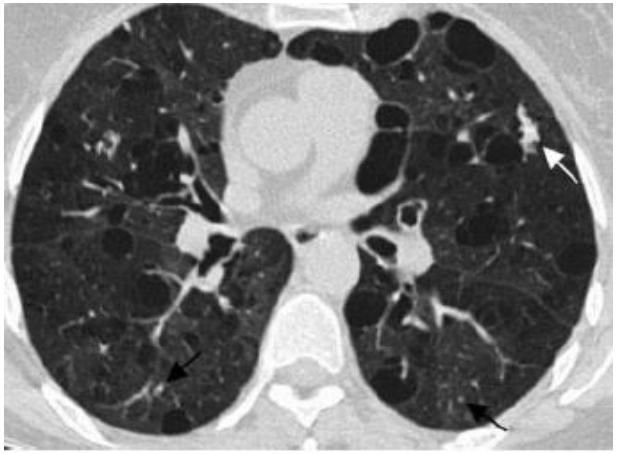
Etiologies

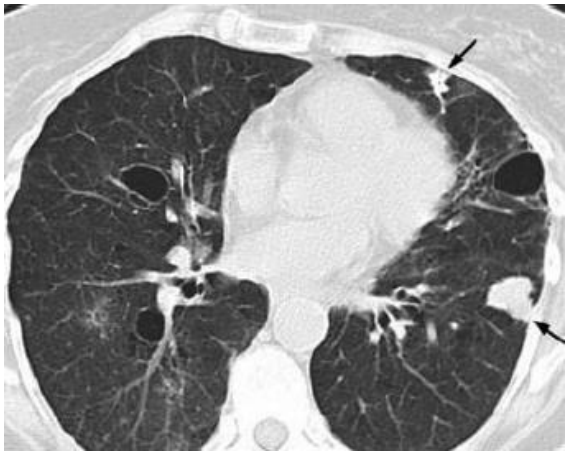
- HIV
- Connective tissue disease (Sjögren) (woman between 40 and 60 years old)

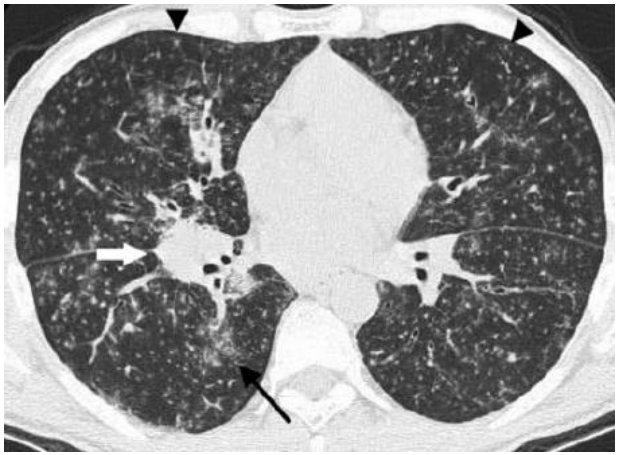
Imaging

- Diffused or patchy **GGO**
- **Perivascular cysts** 1 to 30 mm
- **Centrolobular micronodules**
- **Peribronchovascular thickening**
- Moderate septal thickening
- Adenomegalies









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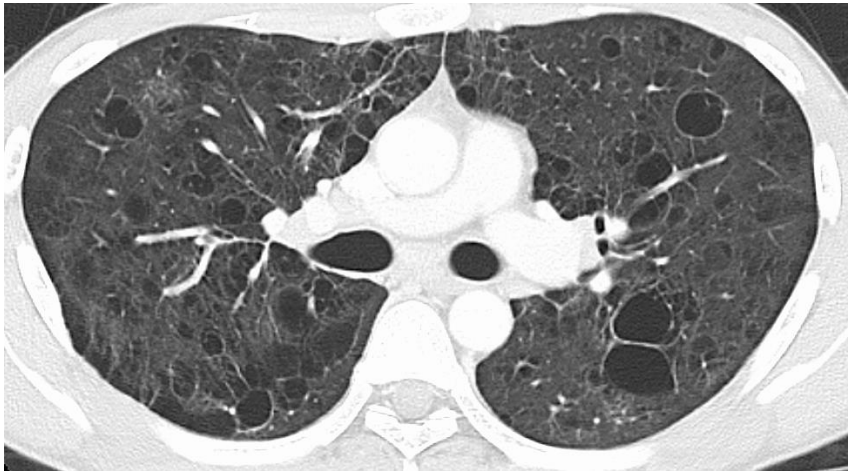
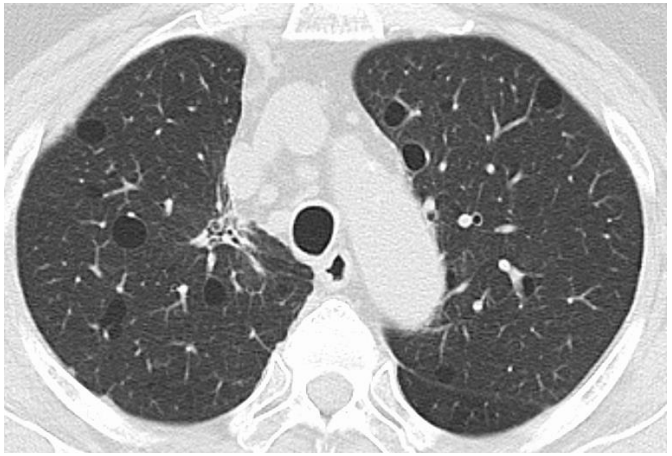
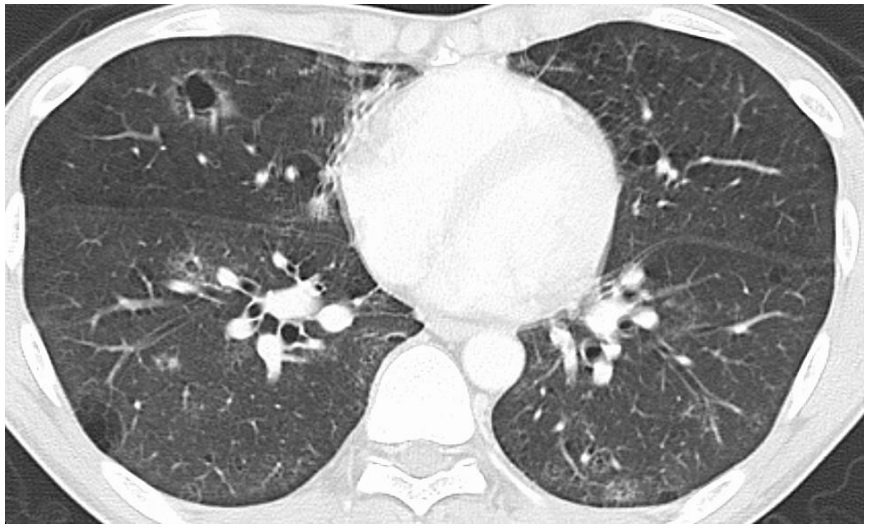
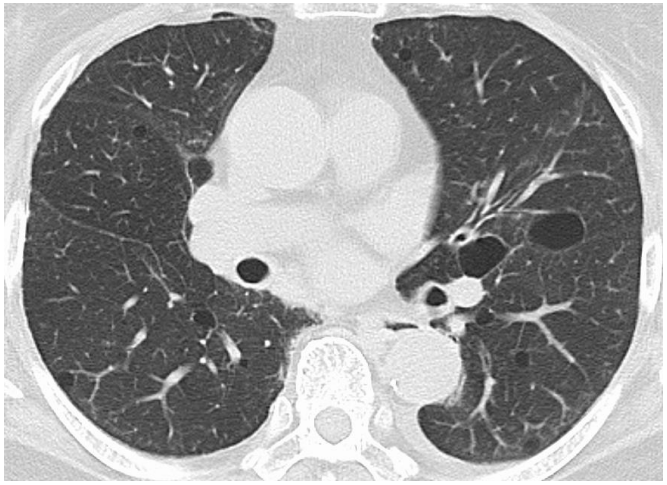
2 cases of LIP

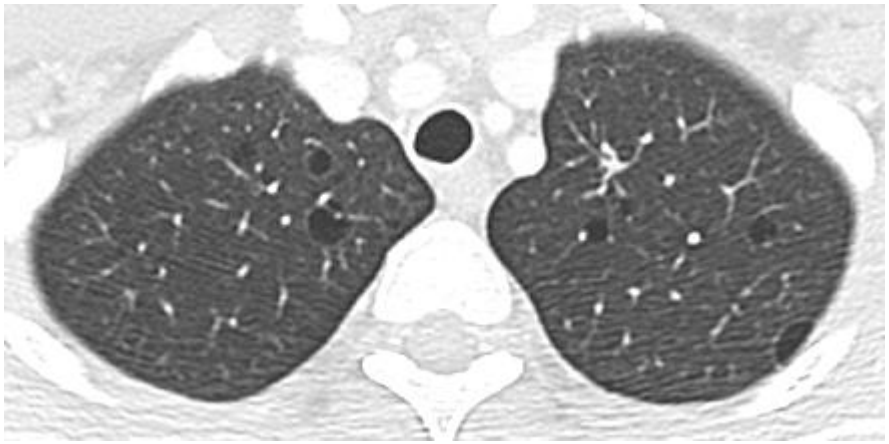


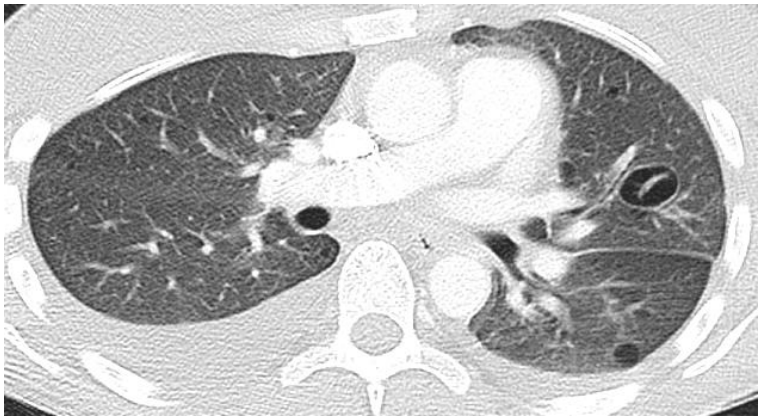




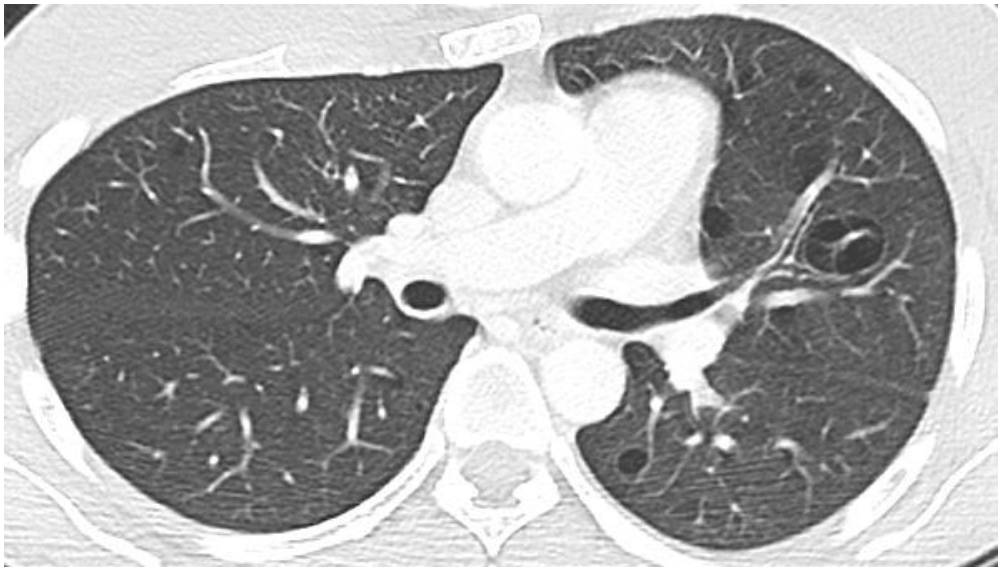


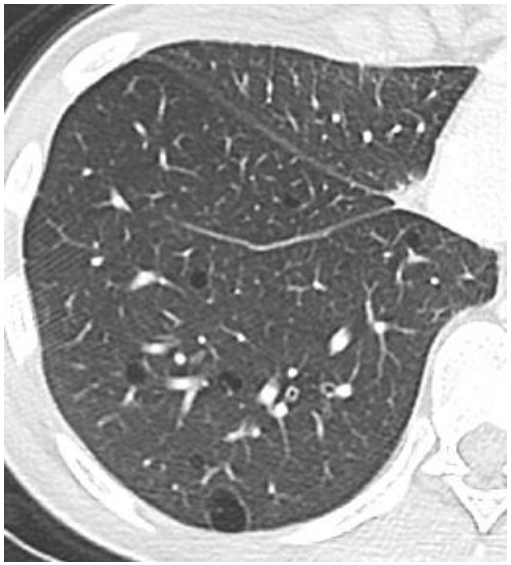
LIP
Lupus associated with Sjögren





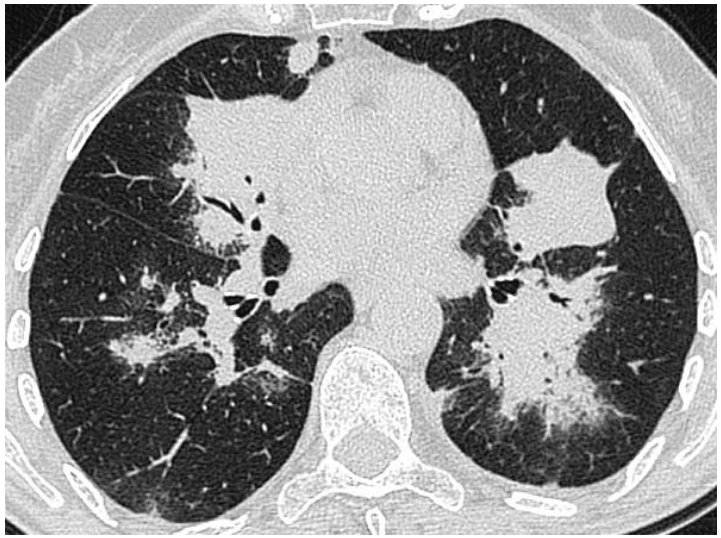
Acute episode of systemic erythematous lupus (pleural effusions)





Primary pulmonary lymphoma

- **Rare**
- **Monoclonal** proliferation in the lung
- Criteria: **no extrathoracic lymphoma found within 3 months** of initial diagnosis.
- **NHL B +++** (80%): MALTomes and Giant Cell B Lymphoma



Lymphoma MALT

MALTome

- **Autoimmune disease** associate **++**
- **Asymptomatic**
- **Good prognosis** (5-year survival: 84-94%)

Imaging

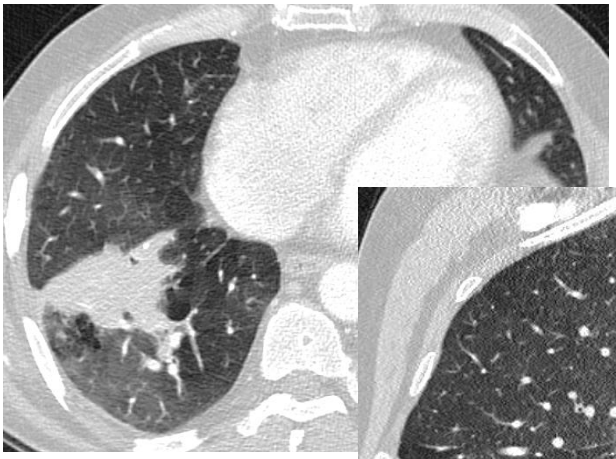
- **Nodule or consolidation**
- Single (30%) or **multiple** (>70%)
- **Bilateral** (>70%)
- **Peri bronchovascular ++**
- Bronchiectasis
- Bronchogram
- +/- Hilar or mediastinal adenopathies (30%)

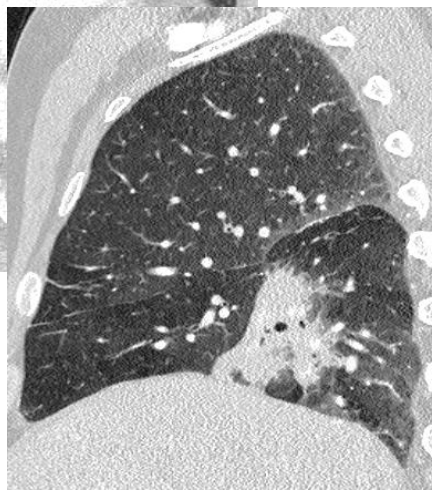
Diffuse Large Cell B Lymphoma (DLBCL)

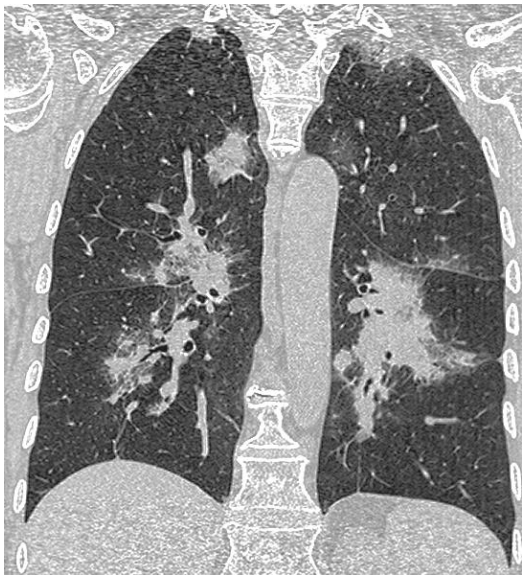
- **Immunodeficiency ++**
- **Symptomatic** (dyspnea, fever, weight loss)
- **Poorer prognosis** (5-year survival: 0 to 60%)

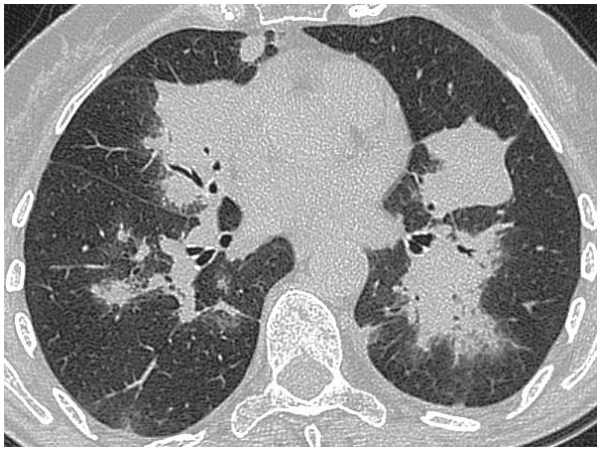
Imaging

- **One or more nodules or mass**
- **Excavation ++**
- +/- Lymphadenopathies

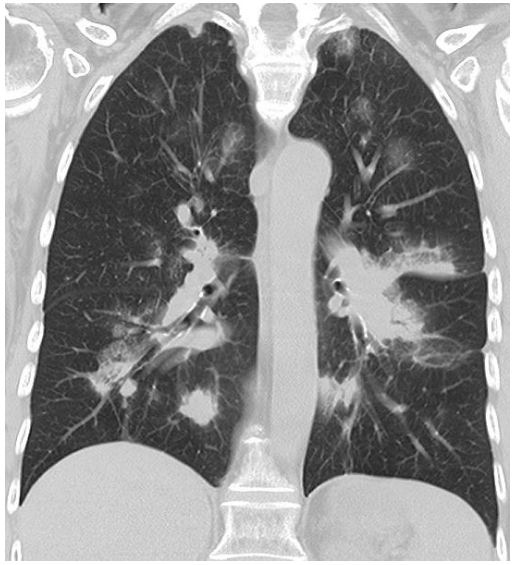




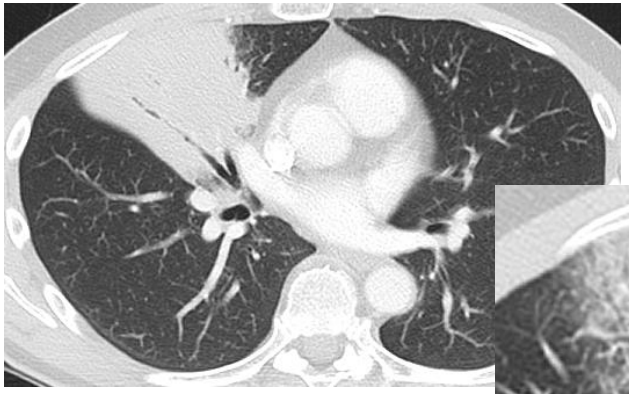


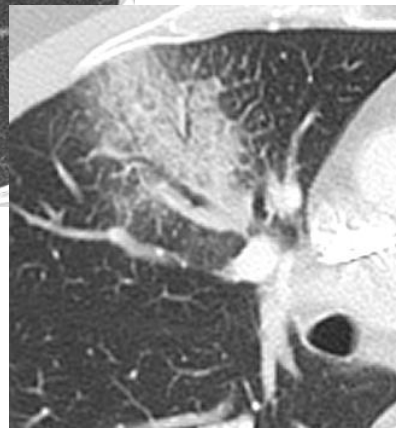


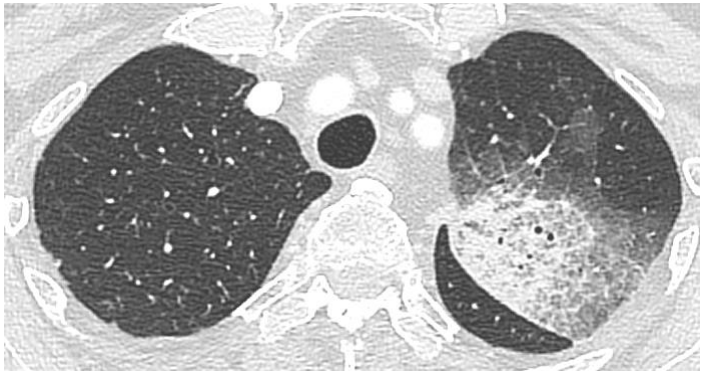
Silicosis + MALT



MALT Lymphoma







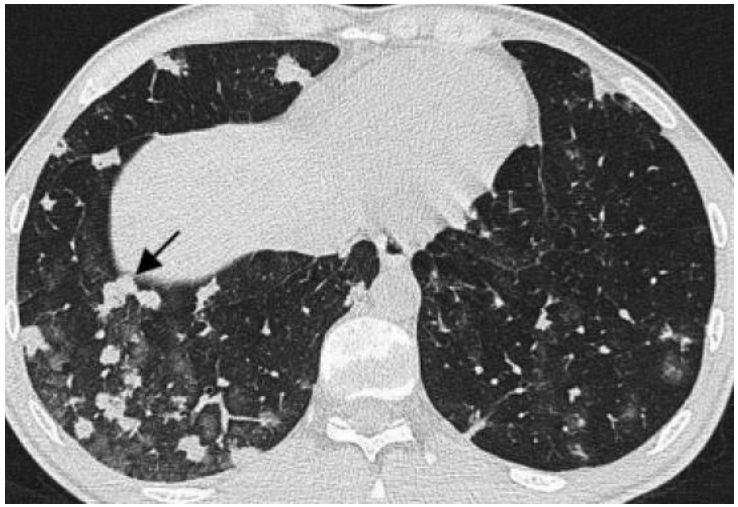
Primary pulmonary lymphoma

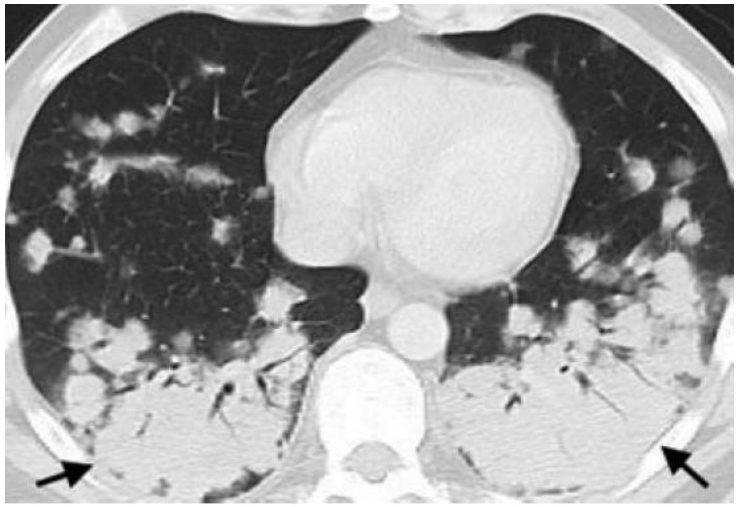
Lymphomatoid Granulomatosis

- Rare, men, 30-50 years old
- EBV, blood vessel destruction (angiocentric)
- Lung +++ (>90%) + CNS + skin
- Prognosis < 2 years

Imaging

- **Multiple nodules**, bilateral, round, **poorly limited** 0.5 to 8 cm
- Basal predominance
- Peribronchovascular distribution
- +/- confluence
- +/- excavation
- "Reverse halo sign."
- Migratory nodules





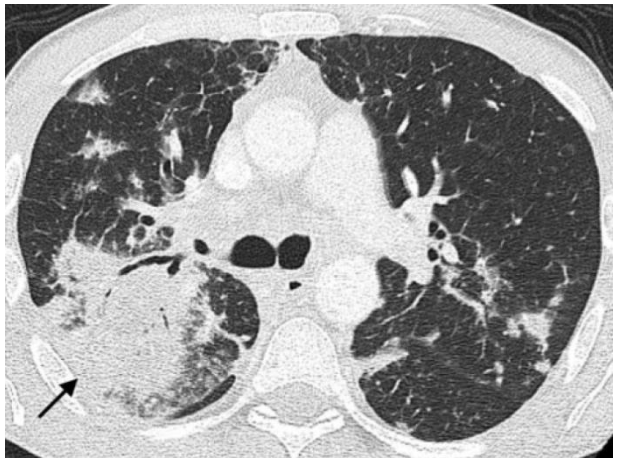
Courtesy S HARE The radiological spectrum of pulmonary lymphoproliferative Disease The British Journal of Radiology, July 2012

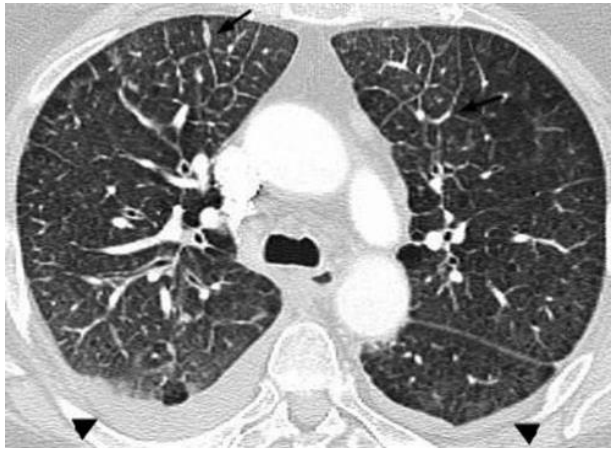
Pulmonary 2ndary Lymphoma

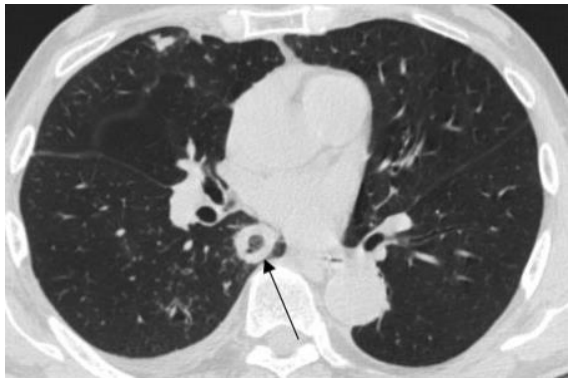
- **All type of lymphoma** can affect the lung.
- **Mature B lymphoma ++ : HL (12%)** > NHL (4%) but **NHL** more frequent

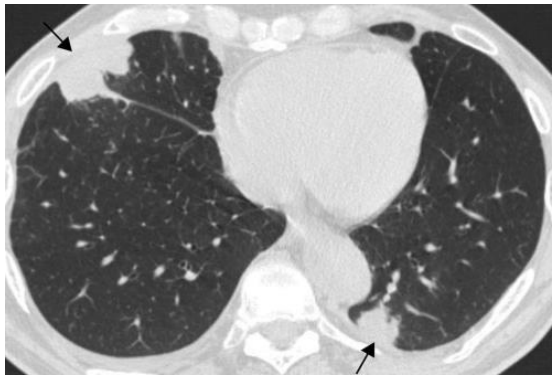
Non-specific imaging++++++

- <u>Nodule -> interstitial involvement</u>
  - **Nodules < 1cm, single or multiple ++**
  - **Consolidation/ mass ++**
    - +/- excavation, bronchogram
  - **Peribronchovascular thickening**
  - **Lymphangitic spread** (thickened and nodular septal lines)
  - Pleural effusion
- <u>Mediastinal Lymphadenopathy</u>
  - **LH++** > NHL

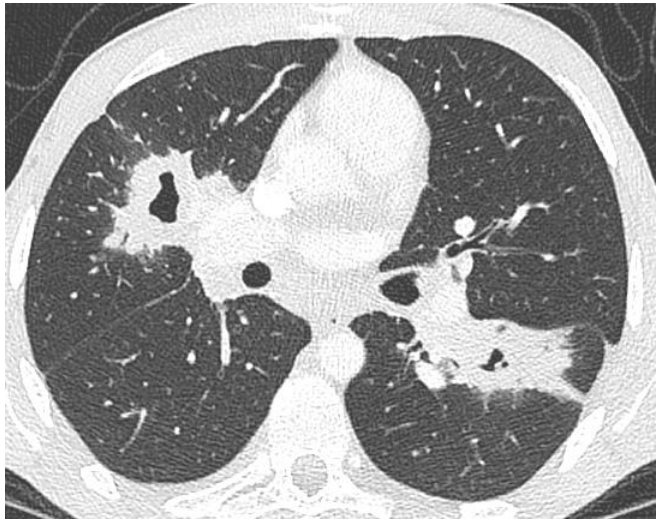


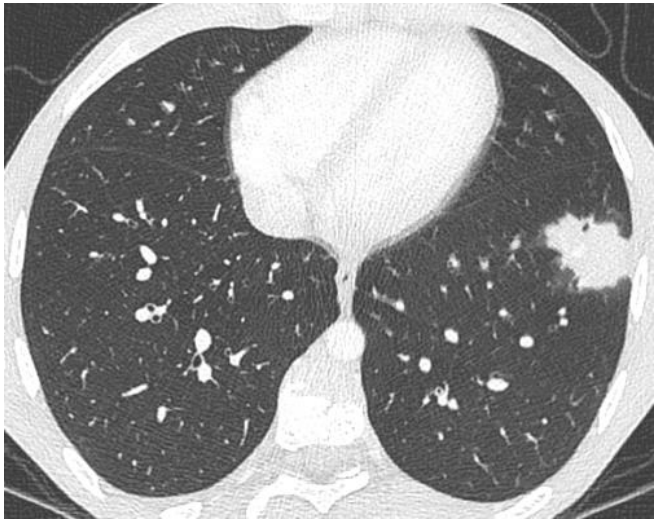






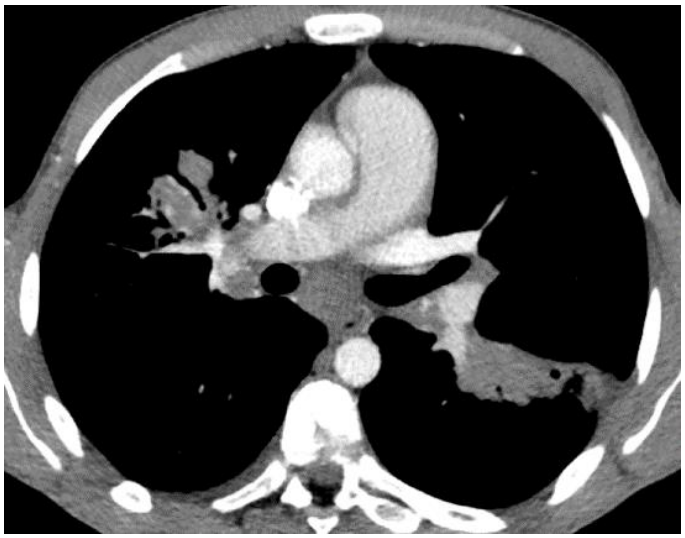
Courtesy S HARE The radiological spectrum of pulmonary lymphoproliferative Disease
The British Journal of Radiology, July 2012

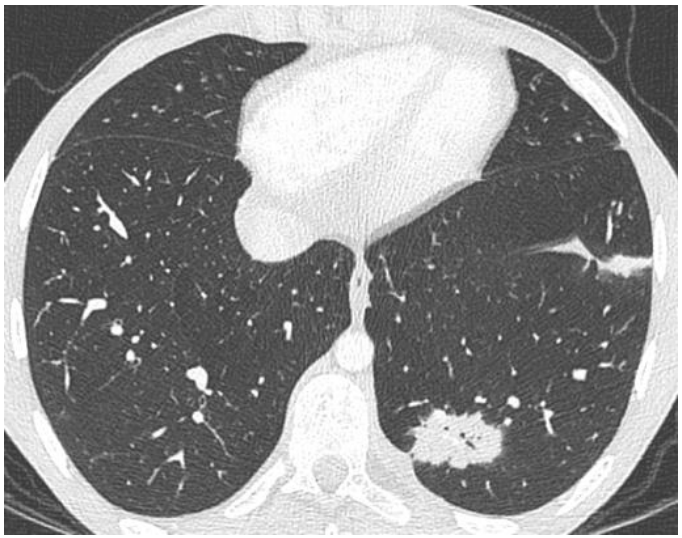




Pulmonary Hodking Lymphoma

Bilateral excavated mass





Lymphoma in immunocompromised patient

AIDS-related lymphoma (ARVs)

- 2nd tumor after Kaposi
- Chronic stimulation HIV + EBV
- **B-cell NHL aggressive +++**
- Prevalence multiply per 40-100
- Advanced HIV, low CD4 count (average : 55/mm3)

Imaging

- **Nodules** (0.5 to 5cm), +/- excavated
- Or **single lung mass** (2 to 5cm)
- **Pleural** +/- pericardial **effusion**
- Consolidation, GGO

Nodules + effusions + lymphadenopathy + HIV = lymphoma +++

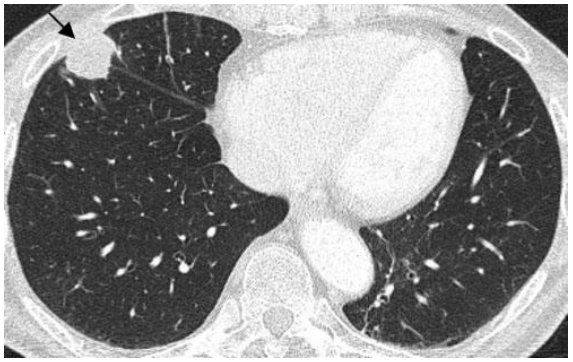
Post-transplant pulmonary lymphoma (PTLD)

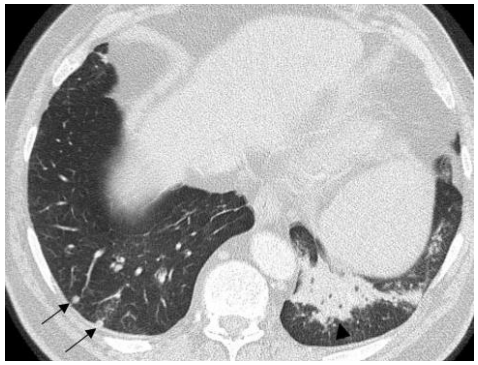
- Within 2 years ++ (> 60 days) after organ or hematopoietic transplant. EBV, Type B++, T+
- 2% transplants (lung +++, heart ++), children ++

Imaging

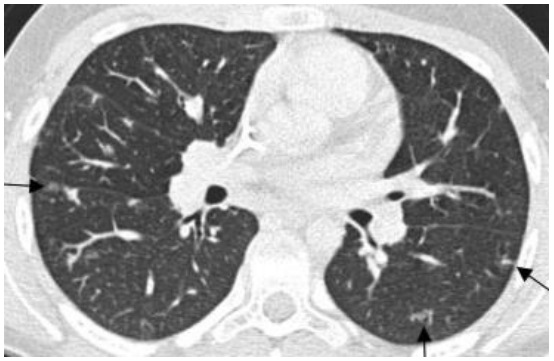
- **Single or multiple nodules** 0.3 to 5 cm
- **Well defined** > ill defined
- **Halo sign**
- Consolidation or patchy GGO
- Peribronchial / sub-pleural
- Lymphadenopathy (30-60%)

ARV





PTLD



Biblio et images: The radiological spectrum of pulmonary lymphoproliferative Disease S HARE The British Journal of Radiology, July 2012

Neuroendocrine tumors

- Comes from **Kulchitzky cells** normally present in the bronchial mucosa.
- 25% of pulmonary neoplasia

Classification (1991, Travis et al)
- **Typical Carcinoid** (low grade)
- **Atypical carcinoid** (moderate grade)
- **Large cell neuroendocrine carcinoma** (high-grade)
- **Small cell carcinoma** (high grade)

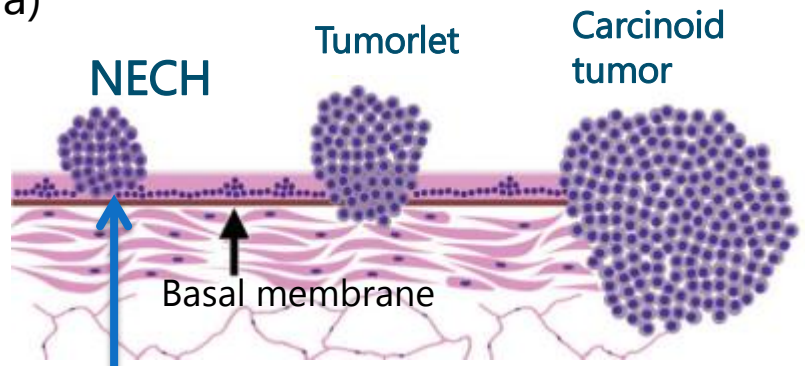
Prognosis ↓

Biblio: Neuroendocrine tumors of the lung: clinical, pathologic, and imaging findings. Chong S, Radiographics 2006

DIPNECH

- DIPNECH = Diffuse idiopathic neuroendocrine cell hyperplasia
- **Idiopathic diffuse neuroendocrine hyperplasia** (**pre-invasive** lesion)
  --> Carcinoid tumor
- **Elderly woman** (50 to 70 years **old)**
- Asymptomatic or respiratory symptoms (asthma)

- **Good prognosis** (83% at 5 years)
- **Long-term follow-up by scanner** (nodule/nodes)
- If symptomatic: corticosteroids, chemotherapy, surgical resection, even transplantation



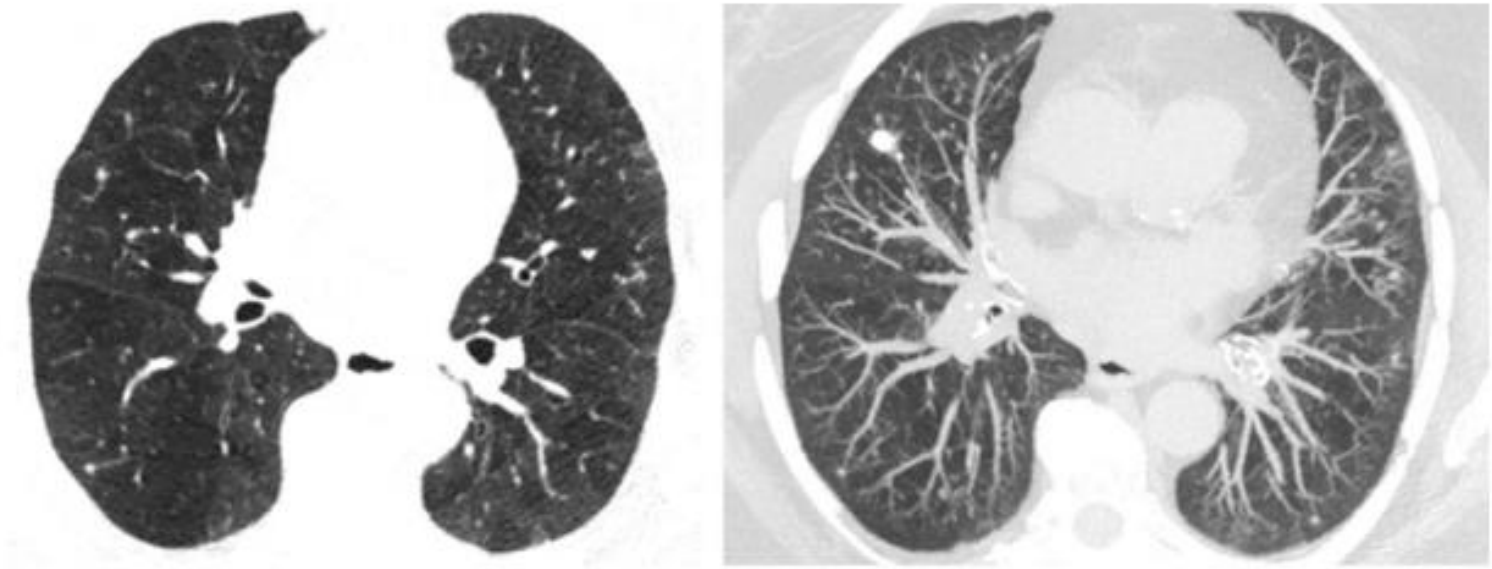
Courtesy radiographics

<u>Belong the group of neuroendocrine cell hyperplasia (NECH)</u>
- NECH
- PNECH (NECH + carcinoid tumor)
- **DIPNECH** (diffuse NECH)

Spectrum of pulmonary neuroendocrine proliferations and neoplasms
Ryo E. Benson - Radiographics 2013

CT

- **Multiple Micronodules**
- GGO with **trapping** = **constrictive bronchiolitis**
  → Suggests diagnosis
  → Surgical biopsy for certain diagnosis



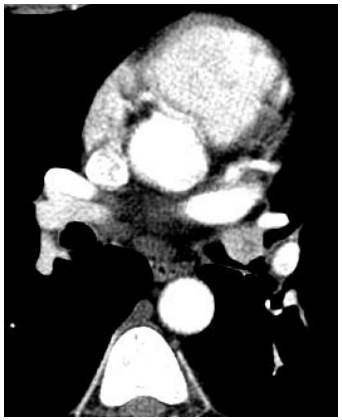
DIPNECH

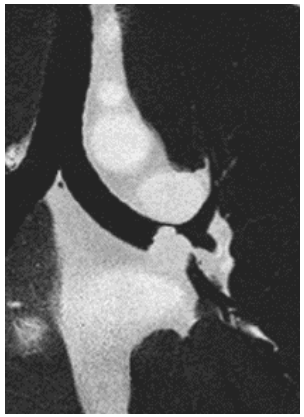
Courtesy Ryo E. Benson - Radiographics

Spectrum of pulmonary neuroendocrine proliferations and neoplasms
Ryo E. Benson - Radiographics 2013

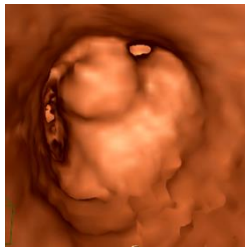
Carcinoid tumors

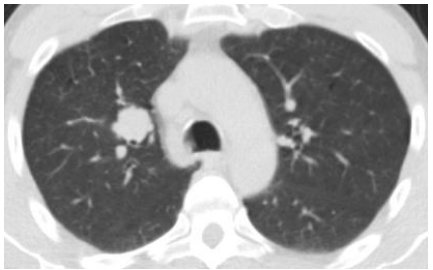
- **1/4 of** neuroendocrine tumors
- **1 to 2% of pulmonary neoplasia**
- 80 - 90% typical and **10 - 20% atypical**
- Median age: **46 years, variable+++++.**
- (Very rare carcinoid syndrom)
- 5-years survival: 87% (typical), 56% (atypical)
- Histology: atypical: + necrosis + mitosis
- Treatment: **surgical resection +++**

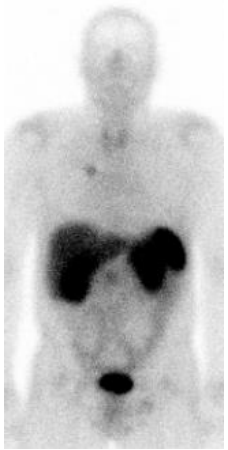




Typical central carcinoid tumor







Imaging (**typical** and **atypical** shape)

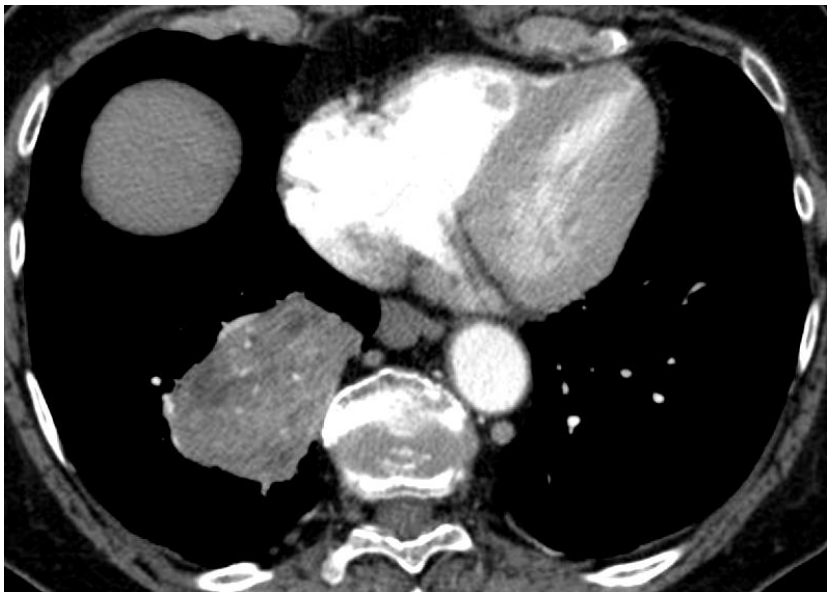
- **Nodule or mass** (2 to 5 cm)
  - **Central** location (hilar or peri-hilar) (85%) (typical++), peripheral (20%)
  - **Well-defined , discreetly lobulated, round or ovoid** or **elongated shape** along the bronchial tubes.
  - +/- Endoluminal
  - **Calcification (30%)** punctuated / excentric / diffuse
  - **Enhancement+++** (> 30UH)
  - +/- atelectasis / pneumonia / trapping
  - +/- lymphadenopathy : reactive or metastatic (atypical)
  - Atypical: bigger and more peripheral
- Octreotide scan (receptor for somatostastine)
- **PET scan : typical low fixation** (if fixation : atypical)

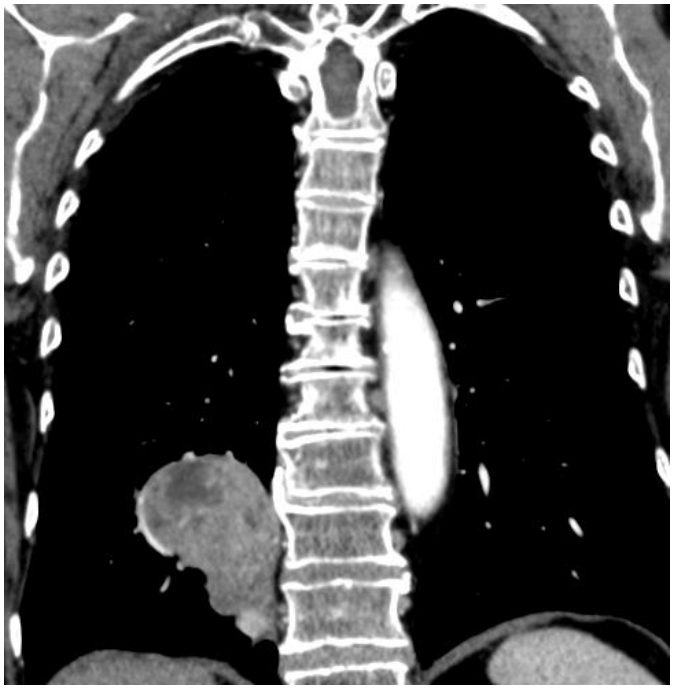
Differential diagnosis of a **solitary lung tumor with intense enhancement**

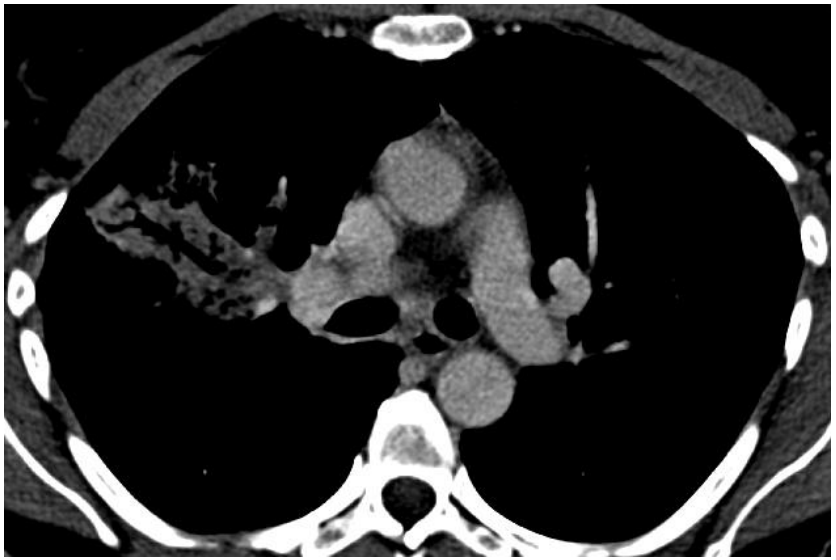
- Sclerosing hemangioma
- Intrapulmonary Castelman
- Solitary intrapulmonary fibrous tumor
- Metastasis
- Primary bronchopulmonary cancer

Typical carcinoid tumor
CT scan + Octreotide scan

Atypical carcinoid tumor







Biblio: Neuroendocrine tumors of the lung: clinical, pathologic, and imaging findings. Chong S, Radiographics 2006

Giant cell NE tumours

Epidemiology

- **65 years old, men ++**
- Tobacco +++
- **3%** of pulmonary neoplasia
- Survival at 5 years: 13% - 45%, Average : **21%.**

Histology

- Neuroendocrine characteristics
- NE markers (chromogranin...)
- Mitosis +++
- Necrosis ++
- Giant cells

Imaging

Non-specific: similar to non-small cell tumour imaging

- **Nodule or mass**
- 13-92 mm (avg = 37 mm)
- **Well defined, lobulated** or sometimes spiculate
- **Peripheric** (84%)
- Large necrotic tumor, heterogeneous enhancement
- Pleural effusion
- PET scan: fixing

Biblio: Neuroendocrine tumors of the lung: clinical, pathologic, and imaging findings. Chong S, Radiographics 2006

Small-cell lung cancer

Epidemiology/ histology

- **20% of** lung carcinoma
- **Smoking +++**
- Histology: small cells, cellularity +++, mitosis+++
- 2 stages
  - **Limited** : hemithorax + regional and supraclavicular lymphadenopathy
    ->chemo + radiotherapy on lymphadenopathy
  - **Extensive** chemo
- Prognosis
  - Survival at 2 years: 10%.
  - Median survival: 15-20 months

Imaging

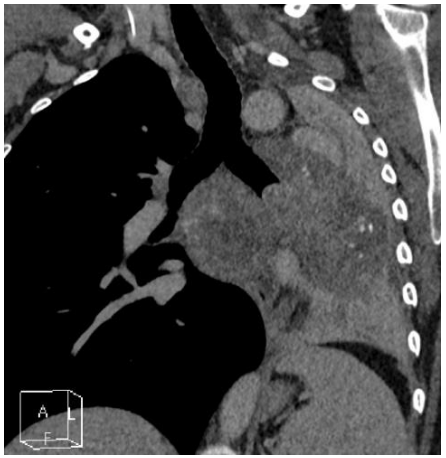
- **Central** topography **+++**
- **Voluminous hilar or mediastinal lymphadenopathy , confluent**
- The primary tumor may not be seen...
- **Displacement / compression**
  - Tracheo-bronchial tree
  - Large vessels (VCS, pulmonary arteries etc...)
- **Lobar atelectasis**
- Pleural effusion
- Calcification (23%)
- 5 - 10%: nodule/peripheral mass, lobulated, peripheral GGO, spiculated: non-specific (idem CNPC)
- Secondary location: bone +++, liver +++, adrenal gland++, brain ++.

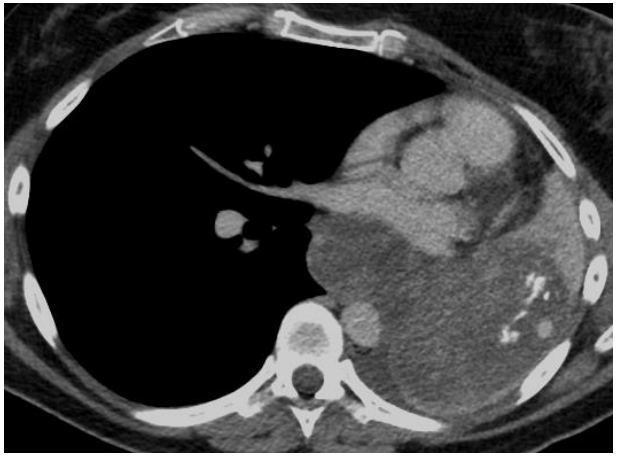
Biblio: Neuroendocrine tumors of the lung: clinical, pathologic, and imaging findings. Chong S, Radiographics 2006

Thoracic sarcoma

Malignant soft tissue tumour (**mesenchymal** cells with epithelial differentiation potential)

- contain a heterogeneous pannel of tumours
- **0.1-0.5% of primary pulmonary malignancies**
- **<45 years of age, H=F**
- risk factor unknown (radiation? asbestos?)





Evolution

- Metastases (rare): Bone, liver, skin, CNS, breast.
- **75% of local recidive at 2 years**
- **50-80% survival at 5 years**

Treatment

- **Surgical resection if possible**
- Neoadjuvant / adjuvant radiotherapy
- Chemotherapy

Imaging: non-specific

Tissue mass

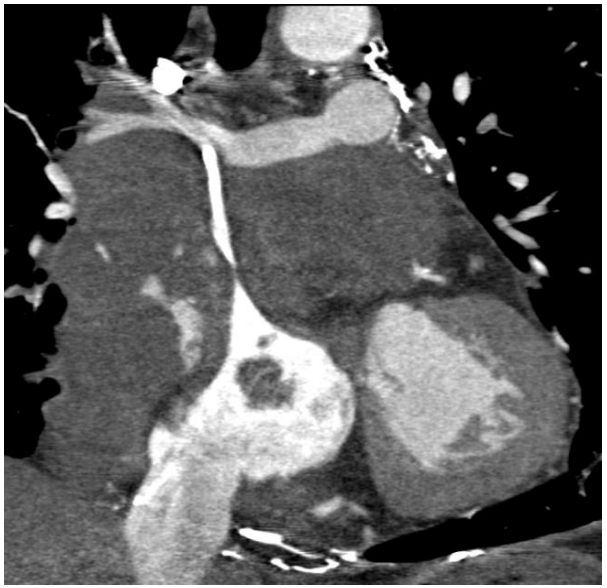
- +/- well circumscribed
- Rounded, ovoid or lobulated
- **Heterogeneous**
  - **Tissue area**
  - **Cystic area:** necrosis, haemorrhage, myxoid material.
- **Stovepipe**
- **Peripheral**, para-scissural, pleural base with obtuse angle of connection with the pleura
- +/- encapsulated

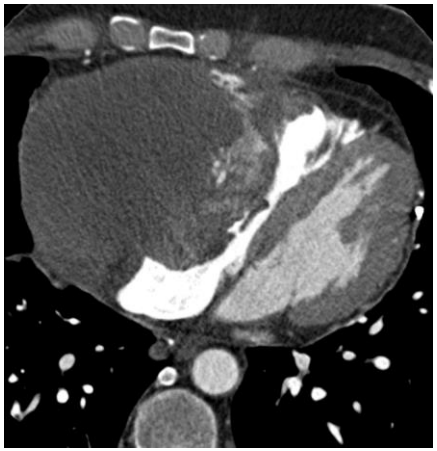
- MRI: isoT1, hyperT2, same intensity as muscle, peripheral enhancement
- CT scan: fibrosis bands
- PET scan: fixation
- +/- homolateral pleural effusion, adenomegaly (rare), pleural adhesions

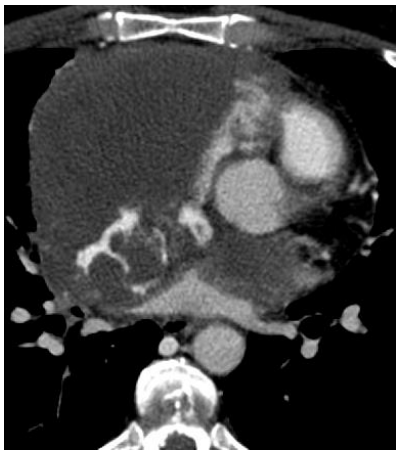
Gladish, G., Primary thoracic sarcomas, RadioGraphics, RSNA, May 2002
Frazier, A., Pleuropulmonary synovial sarcoma, RadioGraphics, RSNA, May 2006
Murphey, M., Imaging of synovial sarcoma with radiologic-pathologic correlation, RadioGraphics, RSNA, Sep 2006

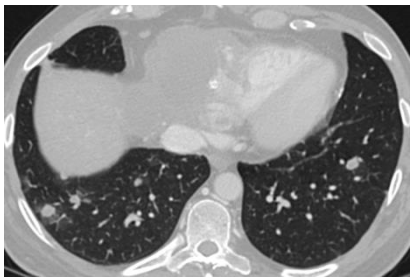
	Epidemiology	Clinic	Imaging features
Angiosarcoma	Middle-aged adult Risk factors **radiotherapy/chemical** exposure	- Lung: hemoptysis - Mediastinum: vascular compression - Cardiac: arrhythmia, RVI	- Lung: bilateral nodules - Mediastinum: anterior mediastinal mass around the vessels - Cardiac: **RA mass** or diffuse parietal thickening
Leiomyosarcoma	- Lung, mediastinum: ≥ 50 years old, M>F - Pulmonary artery: 50 years old	- Lung: a∑ - Mediastinum: mass effect - Cardiac: CI - Pulmonary artery: pain, dyspnea, RVI	- Lung: nodules or large necrotic mass - Mediastinum: bulky necrotic mass - Cardiac: LA mass - Pulmonary artery: **mass into the pulmonary artery. Gd+**
Rhabdomyosarcoma	Heart and mediastinum: child Other sites: bimodal (child, 5th-7th decades), M>F	- Cardiac: arrhythmia, CI (L or D) - Mediastinum/wall - Lung	- Cardiac: **hypodense valve mass** - Wall: muscular origin - Lung: bulky mass, cystic/necrosis.
Sarcomatoid mesothelioma	- 7th decade, M>>F - **Asbestosis**	- Pain, shortness of breath, cough, fatigue	**Focal mass** > Diffuse nodular thickening

According to Gladish, G., Primary thoracic sarcomas, RadioGraphics, RSNA, May 2002.









Mediastinal angiosarcoma

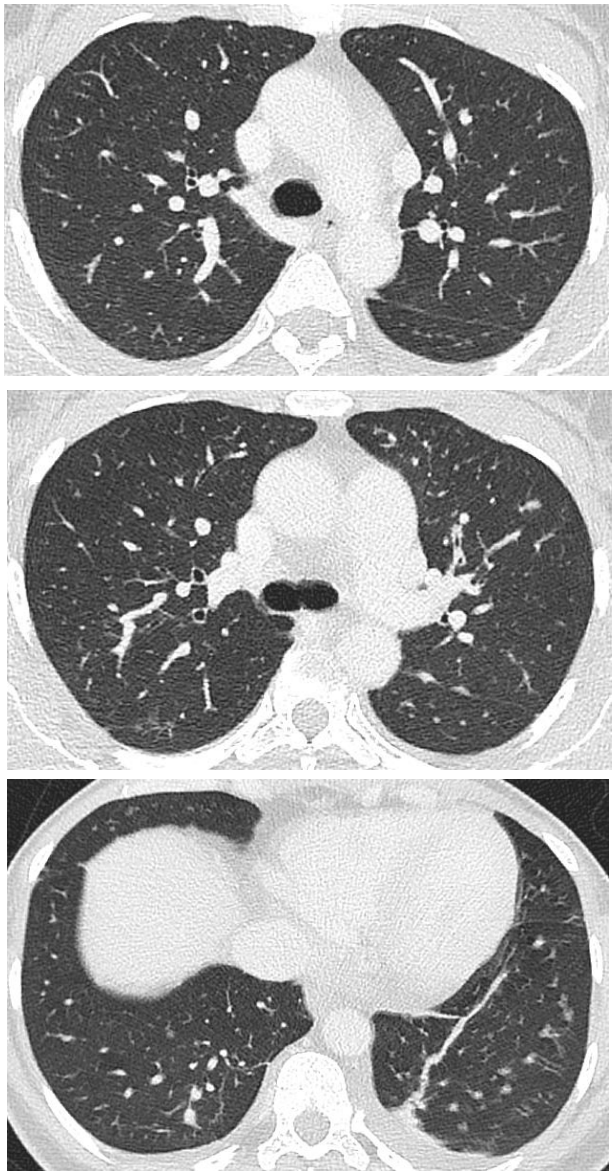
Parietal mass of right cavities

Kaposi's Sarcoma

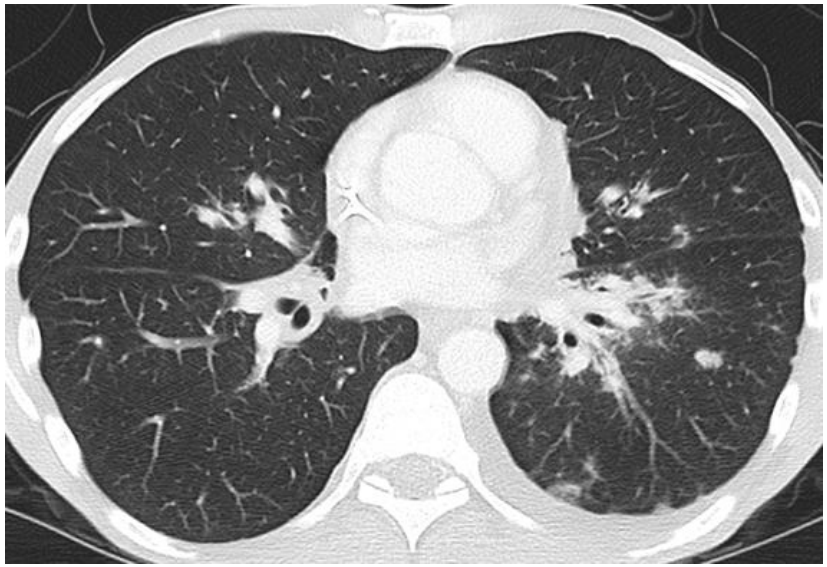
- Decreasing incidence (ARVs)
- Most often on untreated patients
- Patients with **severe ID**
- Already having a **mucocutaneous or digestive disorder**

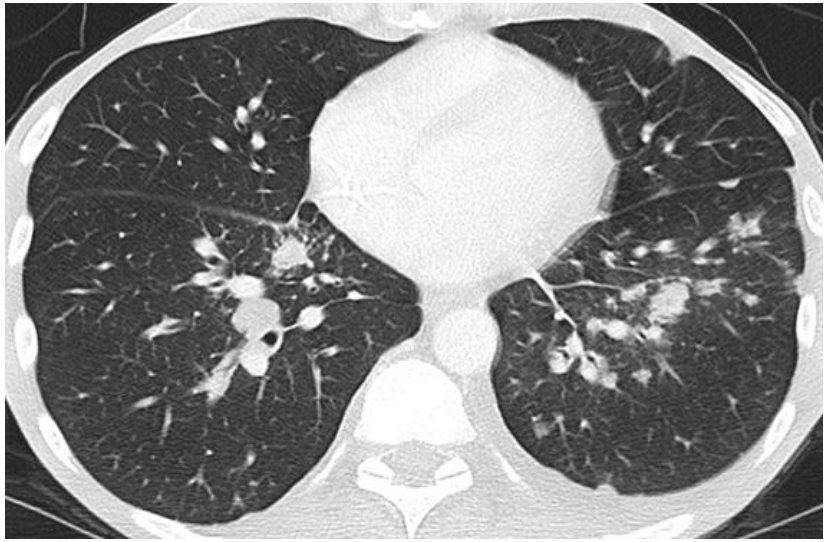
Imaging: 2 CT forms

- Nodular shape
  - **Multiple irregular**, **spiculate nodules**
  - **+/- halo**
  - Predominantly **peri-hilar**, peri-bronchovascular distribution, frequent aerial bronchogram
- Infiltrating form
  - Peribronchovascular thickening, **septal thickening,** sometimes nodular septal thickening



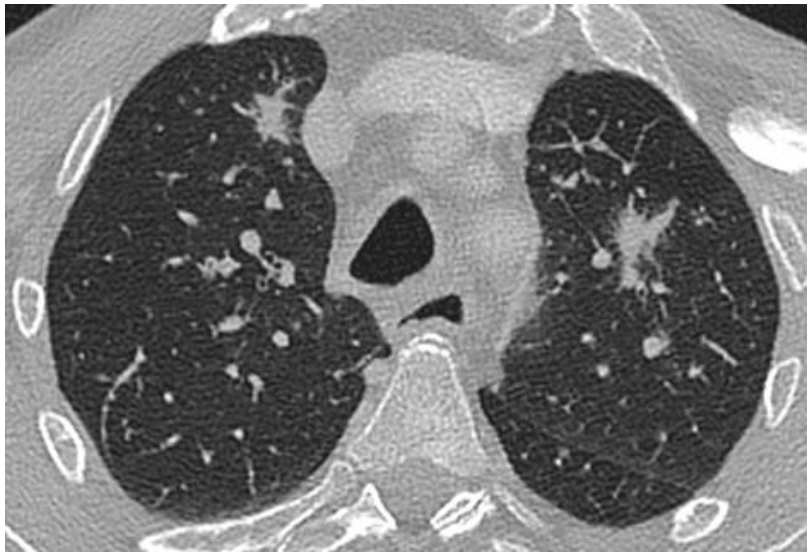
Suspected kaposi's sarcoma, CD4 =0
40-year-old woman with esophageal Kaposi

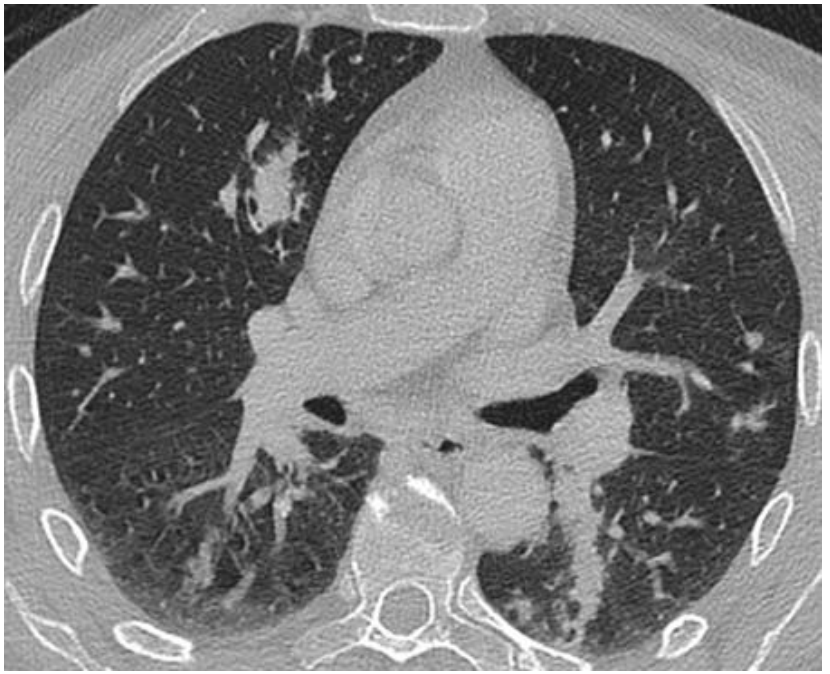


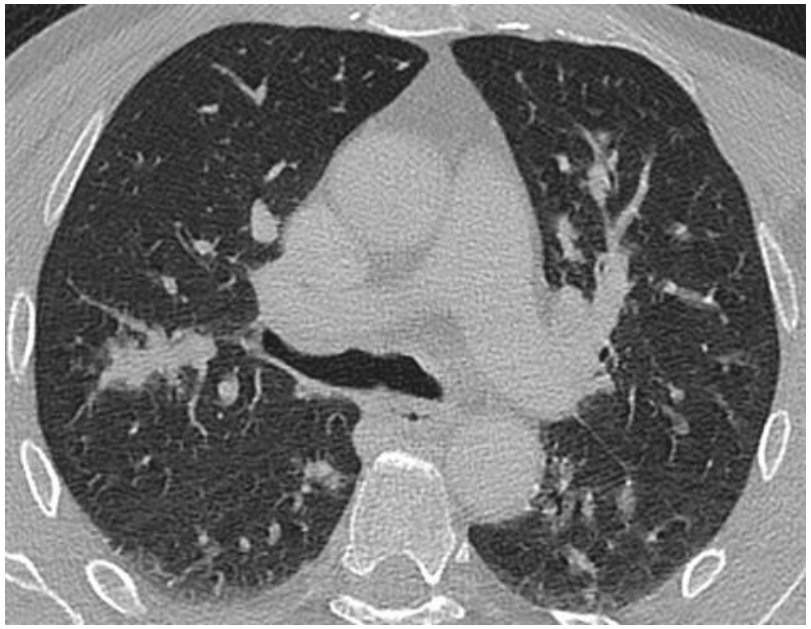


Pulmonary Kaposi's disease (+ skin lesions) in a HIV patient

Multiple bilateral lower lung nodules and peribronchovascular thickening of the left hilum





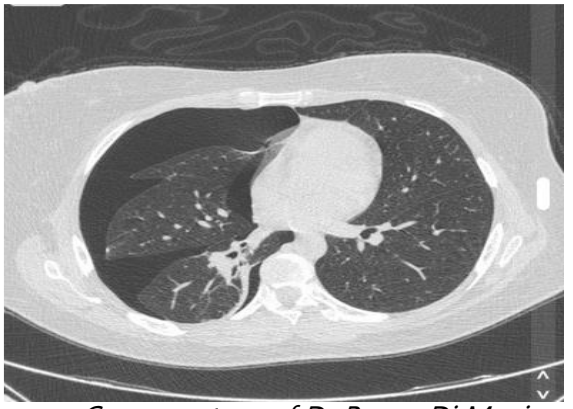


Kaposi's disease

Multiple bilateral **irregular peribronchovascular nodules** with some associated **septal lines** (upper left lobe)

Thoracic endometriosis

- **Symptoms 24-48 hours after menstruation**
  - **Pleural**: **pneumothorax or catamenial hemothorax** with chest pain and dyspnea, right-sided predominance.
  - **Parenchyma** : micro embolism of endometrial tissue, endometriotic pulmonary nodules, **catamenial hemoptysis.**
- **Rare**, **35 years old** on average (20 to 30 years old), later onset than pelvic endometriosis. Exact prevalence difficult to establish, underestimated: 5 to 10%.
- Treatment: hormonal (GnRH agonists), surgical resection



Case courtesy of Dr Bruno Di Muzio, Radiopaedia.org, rID: 30293

Diaphragmatic implant
Courtesy P. Rousset - Clinical radiology

Imaging

- **Lesions varying in size during the menstrual cycle.**
- **Pneumothorax or catamenial hemothorax** +++
  - **Right +++** (90%)
  - **Hypodense diaphragmatic implants ++** (posterior superior part) (+/- isodense component), non-enhanced
  - MRI ++: **hyperintense T1 (hemorrhagic)**
  - Sometimes associated pneumoperitoneum
  - Pleural lesions
- **Catamenial hemoptysis** (rare)
  - **Nodule(s)** (implant or hematoma) **+/- excavation**
  - +/- signs of old or recent bleeding (**GGO**)

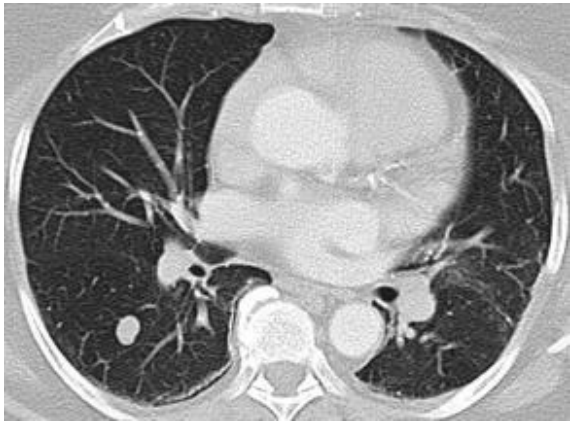
Thoracic endometriosis syndrome/ CT and MRI features – P. Rousset – Clinical Radiology 2014

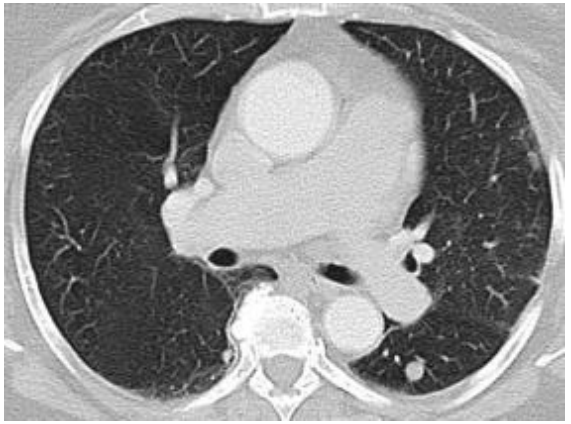
Benign metastases of leiomyoma

- **Rare,** lung = 1st site of metastases
- **Hysterectomy for leiomyomas ++**
  - Asymptomatic, incidental finding
  - Nodules can be seen 3 months to 20 years after hysterectomy
- The clinical course is **generally indolent**

CT

- **Multiple nodules** (a few mm → several cm)
- Sometimes **miliary**
- Absence of calcification
- No enhancement
- **No uptake in PET scan**





Case courtesy of Dr Paul Leong, Radiopaedia.org, rID: 26803

References:

- *di Scioscio V. et al. J Thorac Imaging. 2009;24:41-4 Benign metastasizing leiomyoma of the lung: PET findings*
- *Abramson S. et al. Benign Metastasizing Leiomyoma Clinical, Imaging, and Pathologic Correlation. Am J Roentgenol. 2001*

Lung transplantation and GVH

Complications of lung transplantation

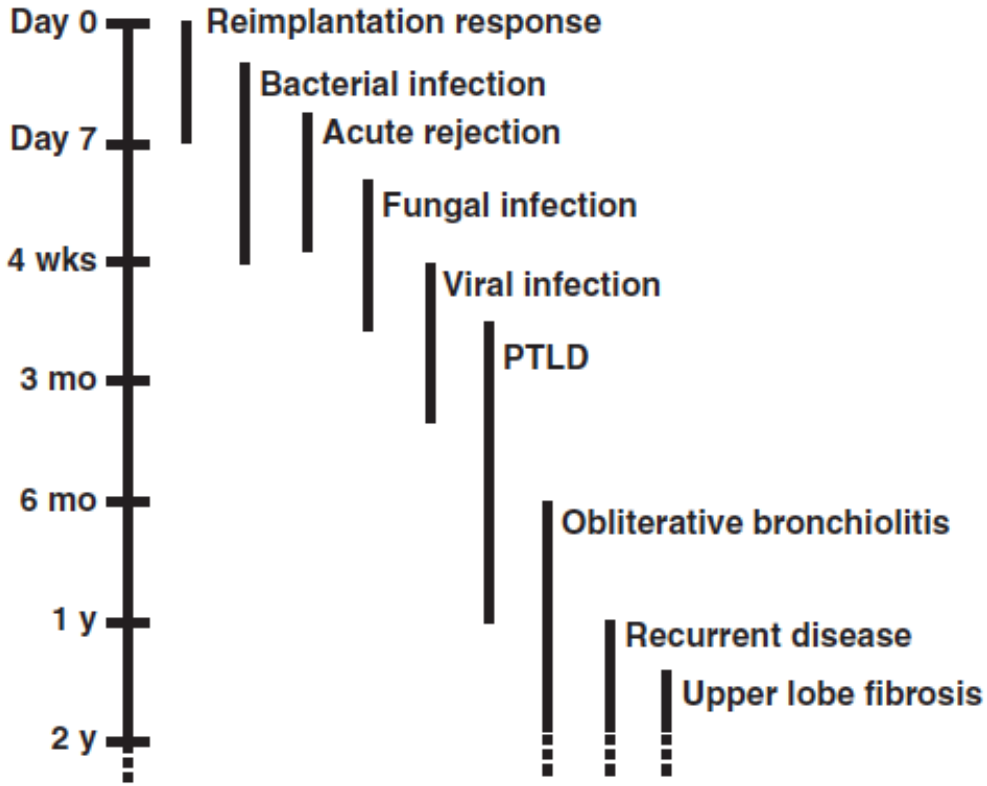
- Hyperacute rejection
- Primary Graft Dysfunction (PGD)
- Acute rejection
- Chronic Rejection
- Other Complications

Allograft complication

- Complication of allograft marrow transplantation
- GVH

Lung Transplant Complications

Time tree of complications



Hyperacute rejection

- **Rare** complication following lung transplant (vs. other transplants)
- Deadline: **first 24 hours**
- **Sensibilized patient** (antibodies following transfusion, anterior transplant)

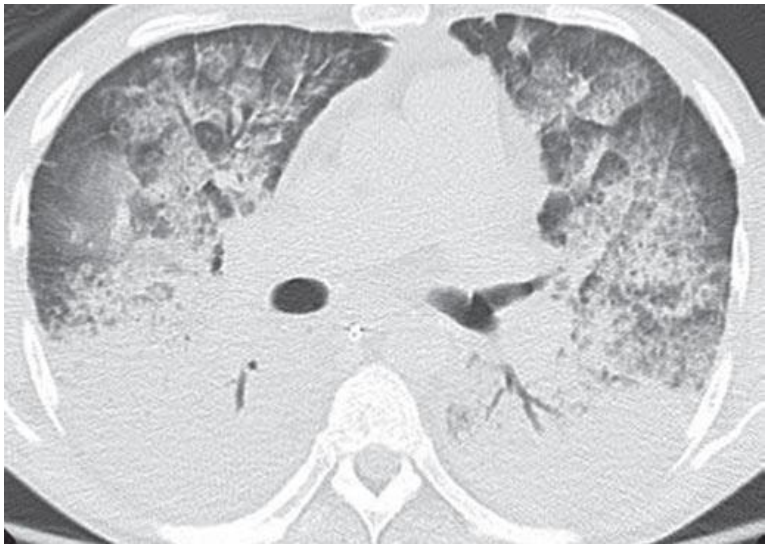
Imaging
Xray: **lung consolidation** (like **unilateral PO**)

Imaging of complications of lung transplantation - PB O'Donovan - Radiographics 1993

PGD Primary Graft Dysfunction

= **Reperfusion edema**, reimplantation **edema** (11-57%)

- Increased **capillary permeability**, **alveolar damage**
- Following surgery, ischemia, graft preservation, lung denervation, lymphatic vx damage.
- Delay: **first 48 hours**, **max day 3-4,** up to 2 months before resolution
- Definition idem ARDS
  - **Diffuse alveolar opacities** in transplanted lung appearing within the **first 72 hours.**
  - **Hypoxemia**, PaO2/FiO2<200 persistent>48h after surgery
  - **Exclusion other causes** (PO, rejection, infection, venous obstruction)
- Severe PGD persists in 15% = ARDS



Imaging

- **Peri-hilar alveolar opacities and lower lobes**
- **Peri-bronchovascular thickenings**
- **Septal Lines**
- Pleural effusion

Acute rejection

Cell-mediated immune response, lymphocyte activation
Perivascular lymphocyte infiltration +/- bronchial invasion

- From the **3rd to 5th day after grafting** (DPG earlier)
- Increased incidence in the **first 3 months** with about **2 to 3 episodes**

Imaging

Grade 1 and 2

- Xray and CT can be normal

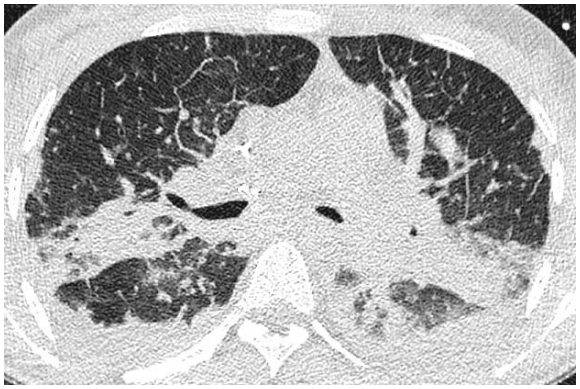
Grade 3 and 4

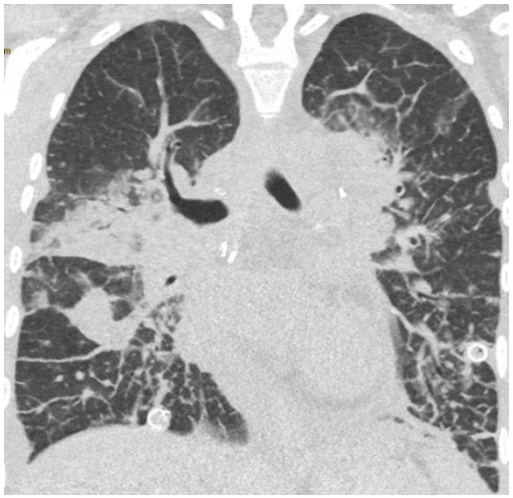
- Focal or diffused **GGO**
- Peri-hilar or lower lobe **consolidation**
- **Reticulo-nodular opacities**
- **Bronchial wall thickenings**
- Pleural effusion

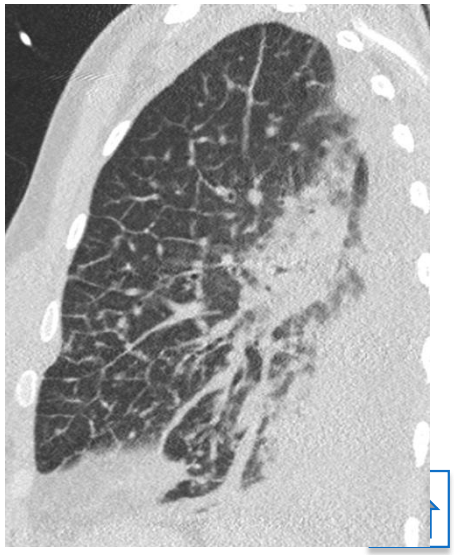
Differential diagnosis

- PO
- DPG
- Infection

Acute rejection at D15







Other complications

Anastomotic complications

- **Incidence 4%**
- Pathophysiology: **ischemia ++**
- Types
  - **Bronchial anastomosis dehiscence** (1st month) (posterior wall more significant)
  - Bronchovascular, bronchopleural, bronchomediastinal **fistulas**
  - **Bronchial stenosis** (long term)
  - **Bronchomalacia** (long term)

Infections

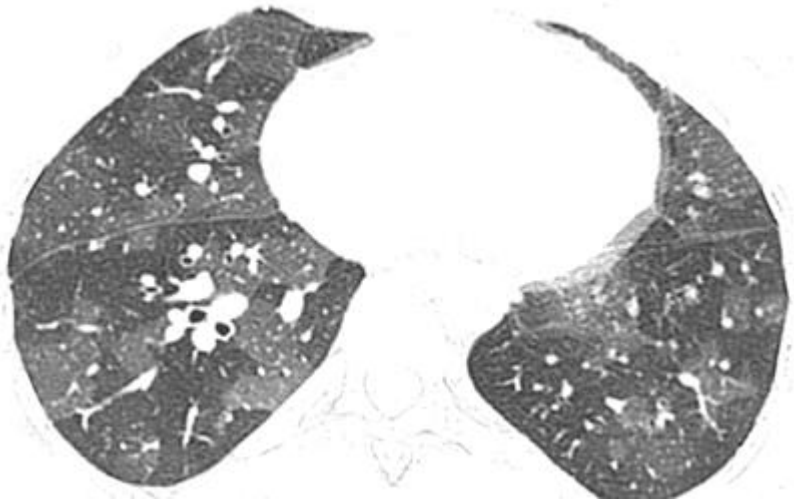
- Lung transplant: highest incidence of infection
- Pathogens
  - **Bacterial** and **fungal** (aspergillosis, candida) (1st month)
  - **Virus** (CMV++, RSV, HSV, Varicella, adenovirus) (2nd and 3rd month)
  - **Mycobacteria**

Pleural complications

- **Incidence 22%.**
- **Pneumothorax ++**
  Small 10%: resorption, if persistent: look for dehiscence anastomosis, bubble rupture
- **Pleural effusion**, **chylothorax** (defect of lymphatic vessel regeneration). Persistent effusion: chylothorax, acute rejection, aspergillosis, tuberculosis
- Empyema: 4%, after 6 weeks post-transplantation
- Hemothorax

Chronic Rejection

- **Peri-bronchiolar fibrosis** (alloimmune response + non-immune factors)
- **16-20 months** after transplantation
- Constrictive bronchiolitis (50% of patients) (higher than in other transplants)



Imaging

- **Constrictive bronchiolitis**: expiratory trapping (**forced expiration +++**)
- Bronchiectasis
- Bronchial parietal thickening
- Mosaic appearance
- Vessel reduction in periphery
- Septal thickening
- Peri-bronchovascular opacities

Allograft complications

Early / neutropenic phase

- **Pulmonary edema**
- **Engraftment syndrom**: diffuse capillary leakage with pulmonary lesions and oedema, 7 days after transplantation, CT scan: GGO and perihilary consolidation with septal thickening.
- **Diffuse alveolar hemorrhage** (mortality 70-100%, 1st month, incidence =10-20%)
- **Drug Toxicity**

Early (<100 days)

- **Idiopathic Pulmonary Syndrome** (DAD J30-180, elimination diagnosis, mortality> 70%)
- **Acute GVH** (see next slide)
- Pericardial effusion and veno-occlusive damage to the hepatic veins

Late

- **Chronic GVH** (see next slide)
- **Post-transplant neoplasia**

Franquet T, Müller NL, Lee KS et-al. High-resolution CT and pathologic findings of noninfectious pulmonary complications after hematopoietic stem cell transplantation. AJR Am J Roentgenol. 2005

Pulmonary GvHD

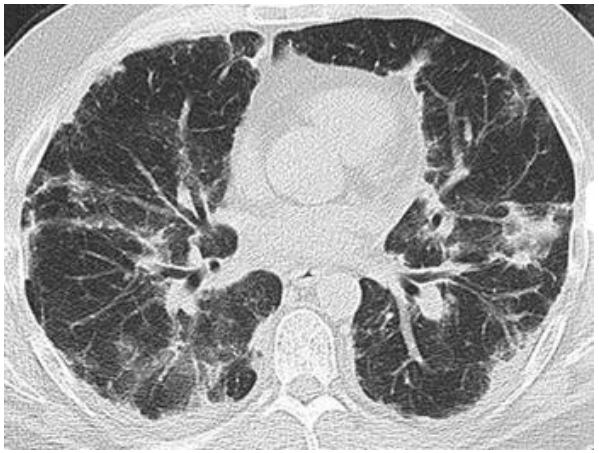
- GvHD = one of the **complications of hematopoietic cell transplantation.**
- Can be divided into acute and chronic GVH

Acute GvHD

- Lung involvement is **rare**
- Onset of respiratory symptoms is 5 months.
- Imaging
  - Moderate perihilar or diffuse interstitial fibrosis
  - Cyst
  - Nodules

GvHD chronic +++

- **Constrictive Bronchiolite**
- **Organizing pneumonia**



Organizing pneumonia in chronic GVH

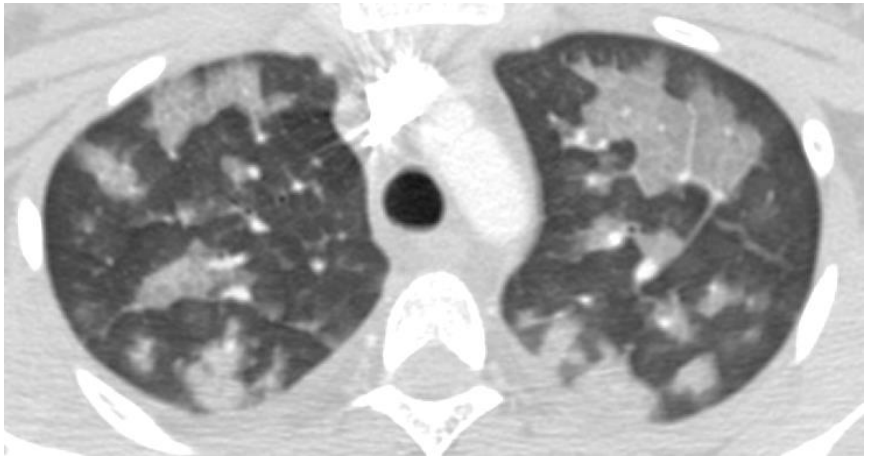
Case courtesy of Royal Melbourne Hospital Respiratory, Radiopaedia.org, rID: 21990

Franquet T, Müller NL, Lee KS et-al. High-resolution CT and pathologic findings of noninfectious pulmonary complications after hematopoietic stem cell transplantation. AJR Am J Roentgenol. 2005

Fat embolism

Clinic: classic triad

- Hypoxia
- Petechiae
- Neurological deterioration

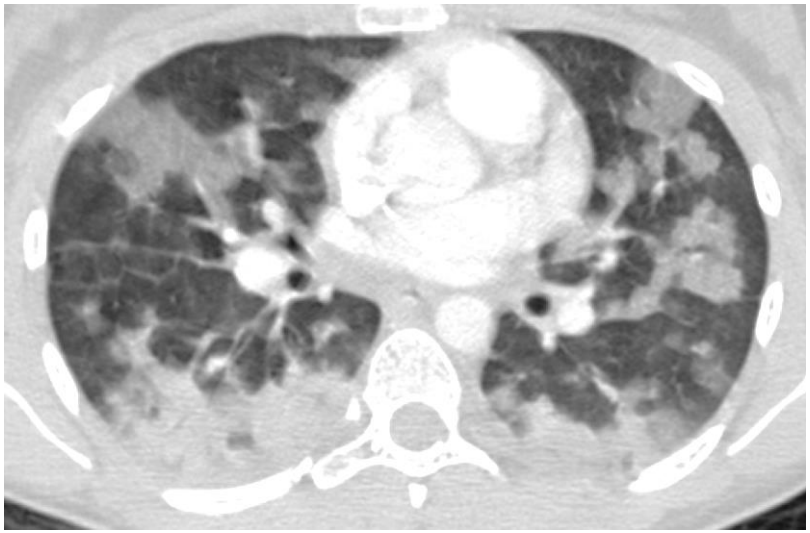


Differential diagnosis

- PO / ARDS / neurogenic edema
- Pneumonia
- Alveolar hemorrhage

Imaging

- **Bilateral GGO**
- **Septal thickening**
- **Centrolobular micronodules**
- Resolution of the CT scan signs in about 2 weeks
- No visible or rare fat embolism
- Scintigraphy: several sub-segmental peripheral defects



Lipid pneumonia

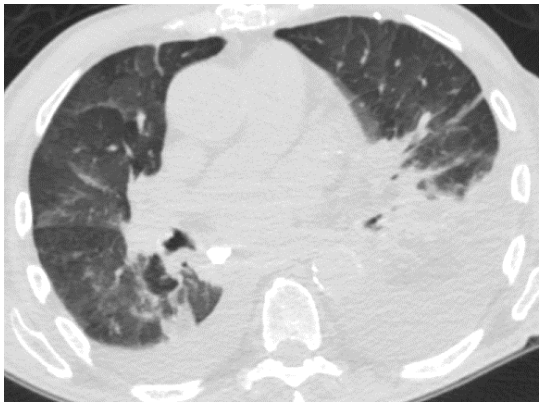
Accumulation of lipids in the alveoli
→ alveolar **macrophages** phagocyte lipid
→ interstitium

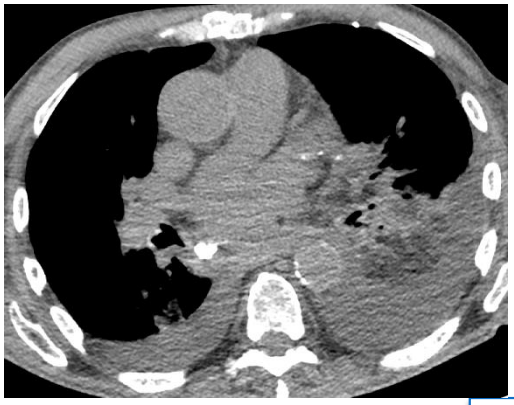
- **Exogenous form +++**
  - **Inhalation** of mineral, animal, vegetable **oil**
  - Favored by **swallowing disorders**, neuromuscular pathology, **oesophageal pathology**, **elderly/children**
  - Acute/Chronic form
- **Endogenous form**: obstructive pneumonia secondary to bronchial obstruction ++ (histological diagnosis, non-specific imaging)

CT : **Acute** and **chronic form :**

In **acute form**: radiological manifestations **30 min to 24 hours** after exposure.

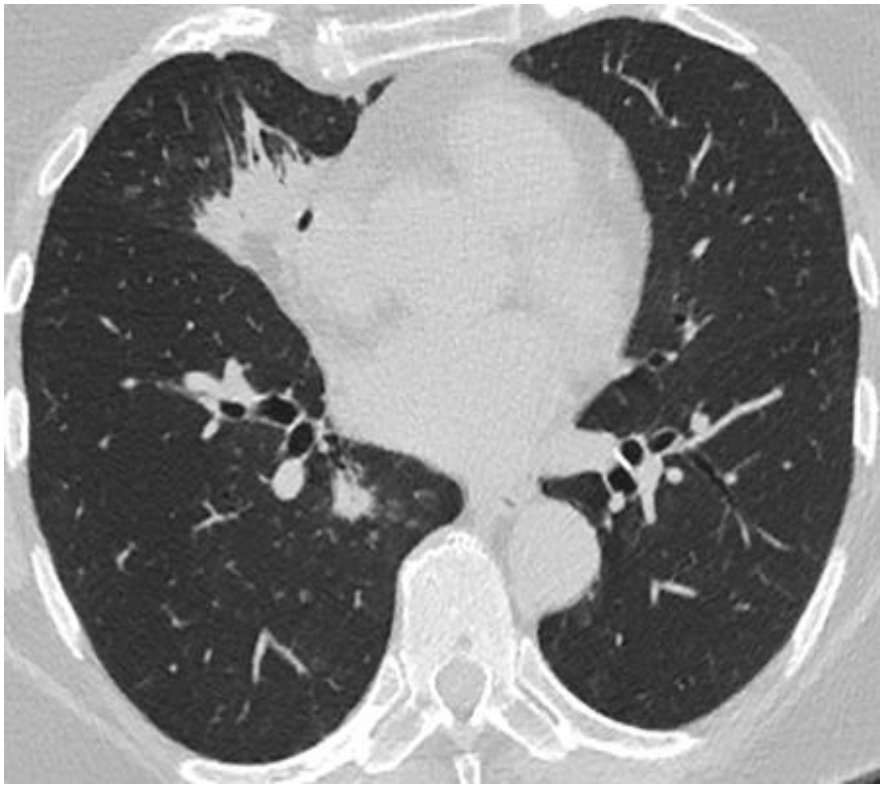
- **Geographic GGO / consolidation**, segmental/lobal, bilateral
- **Crazy paving** (passage of macrophages into the interstitium)
- **Declive regions ++** (lower middle lobe/lobe)
- **Fat density +++** (-10 to -150 HU) but can be hide by reactive inflammation (dense)
- **Nodule(s) / mass(es)** with fat content, spiculated contours (reaction fibrosis) (chronic form)

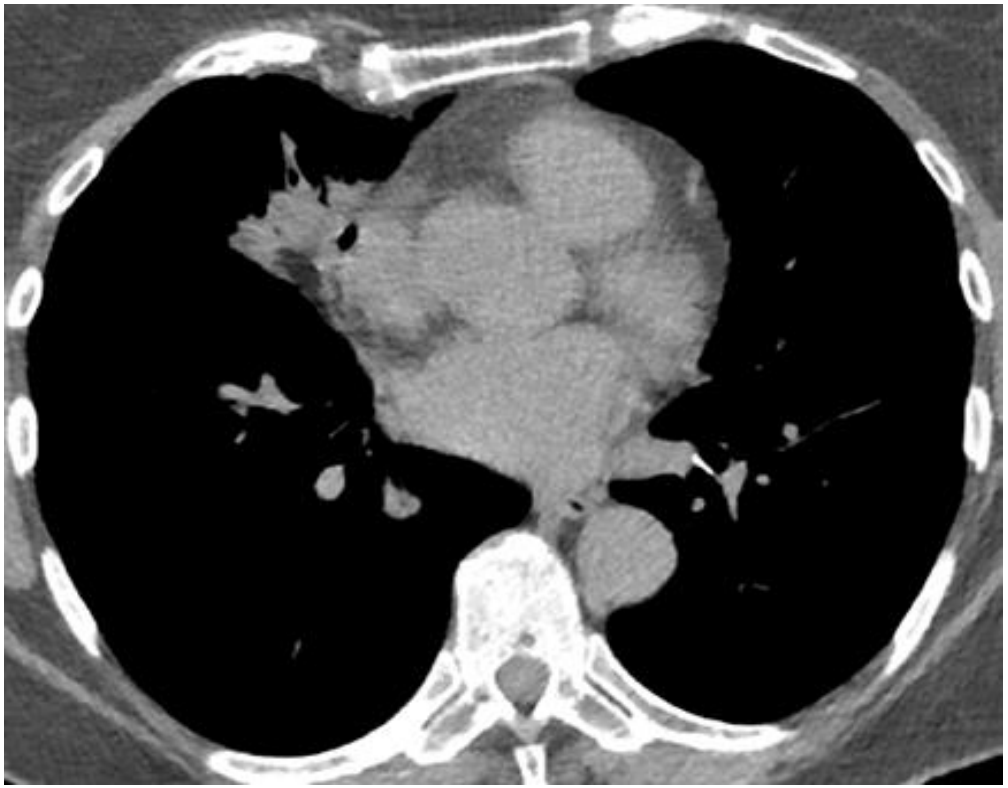




Lipid pneumopathy *with left lower lobe* ***fat density*** *condensation syndrome*

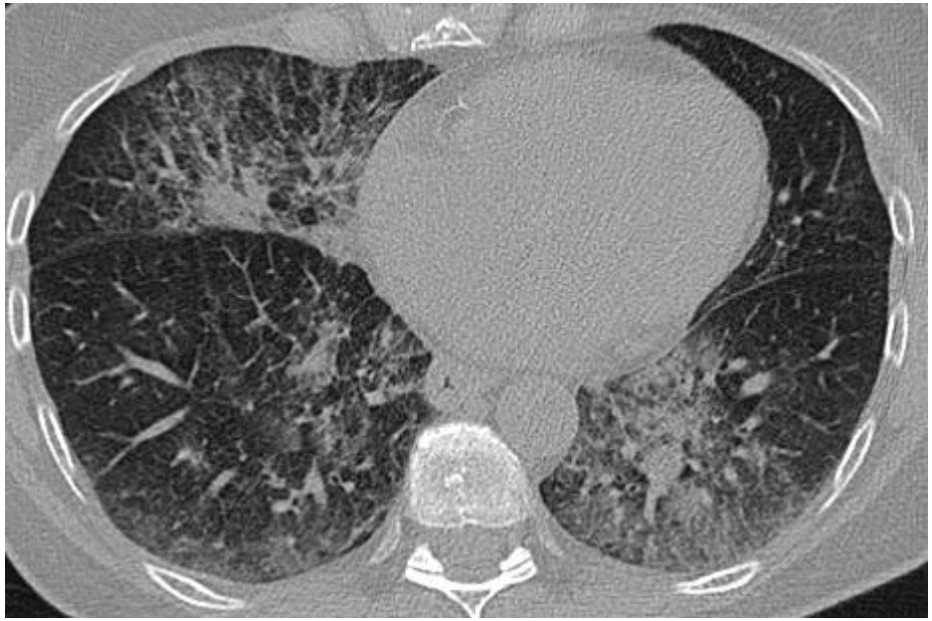
Biblio: Lipoid pneumonia: spectrum of clinical and radiologic manifestations - Sonia L. Betancourt, AJR 2010

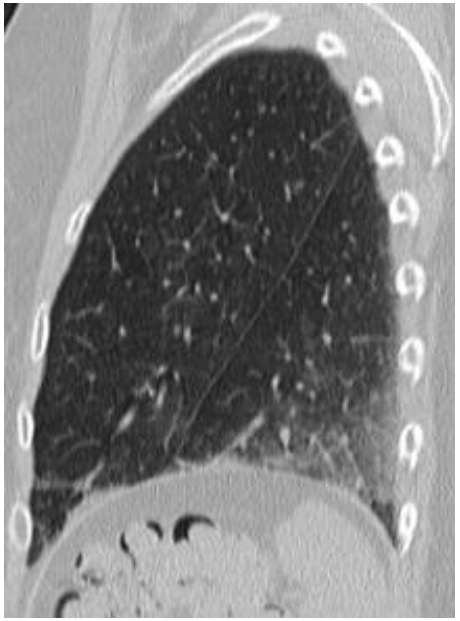


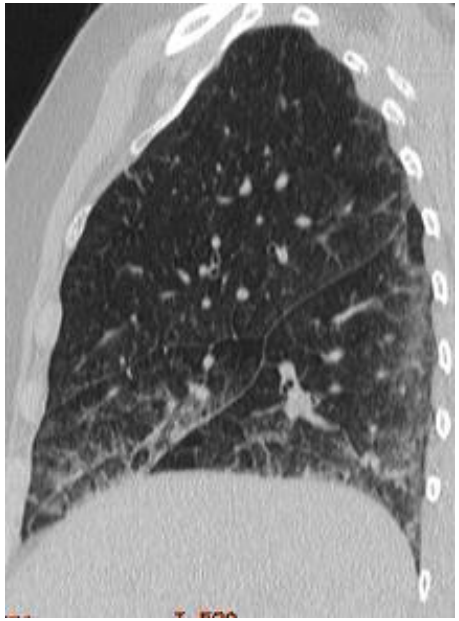


Middle lobe lipid pneumonia

- Parenchyma window: consolidation
- Mediastinal window: **fat component** into the consolidation

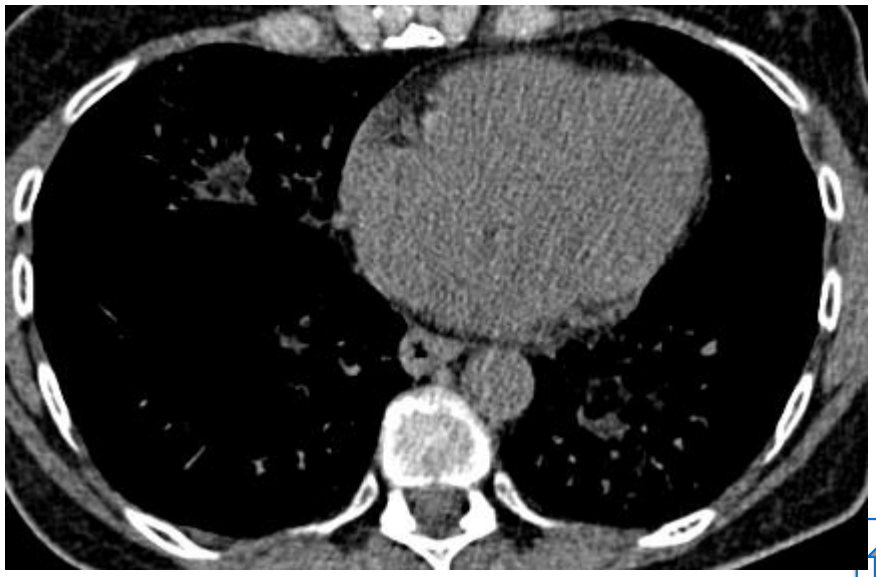


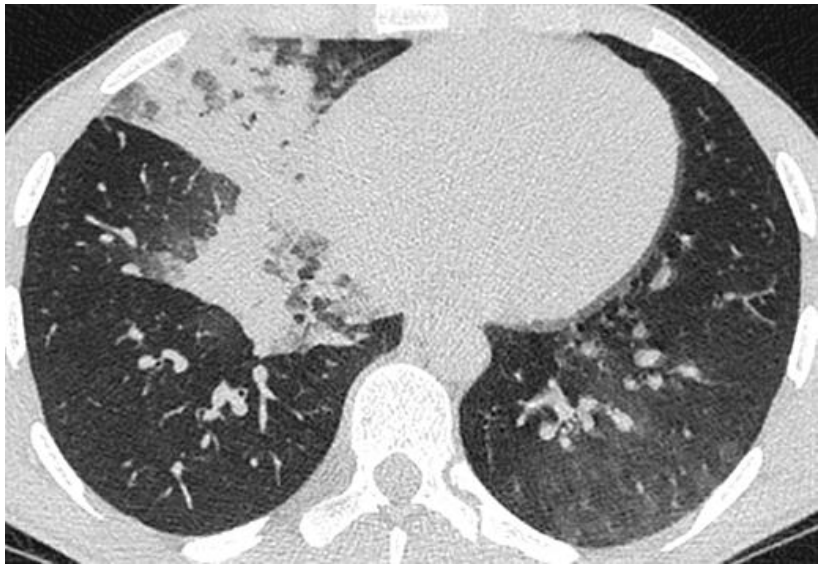


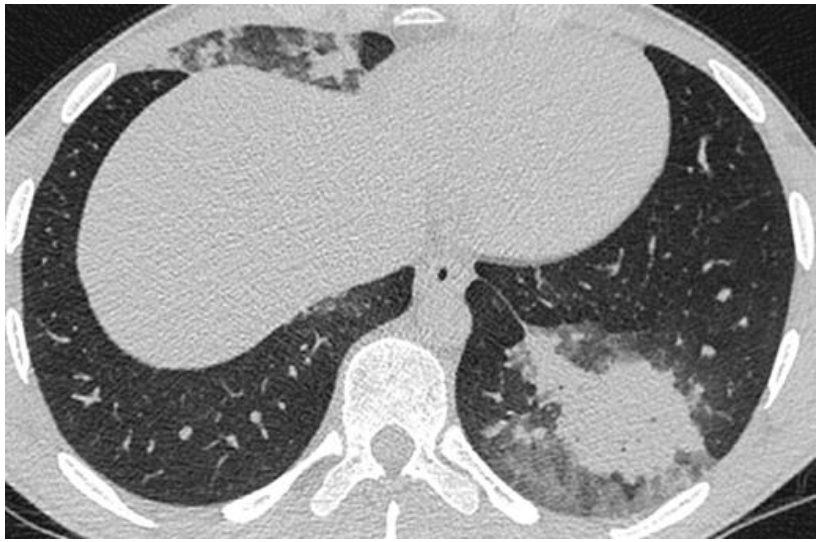


Lipid pneumonia

- GGO bi-basal opacities
- Fat density (medium lobe)







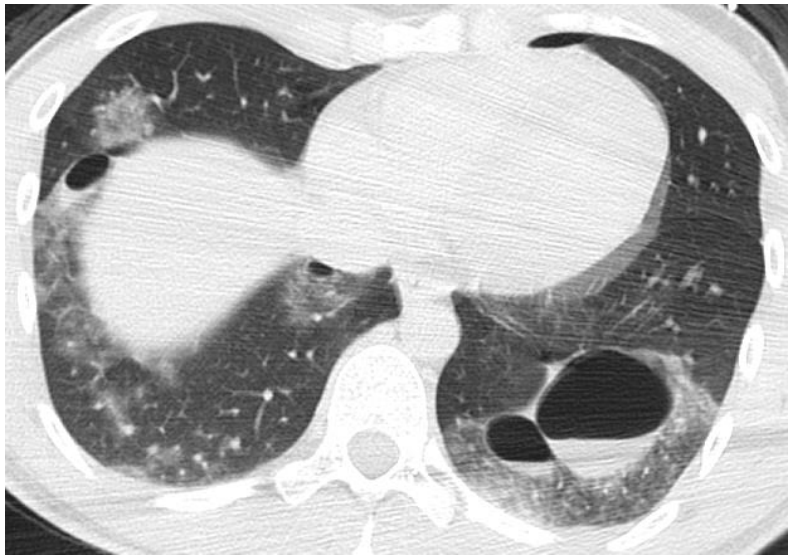
Petroleum pneumonia

(inhalation of hydocarbons in a fire-eater)

Pneumatocele

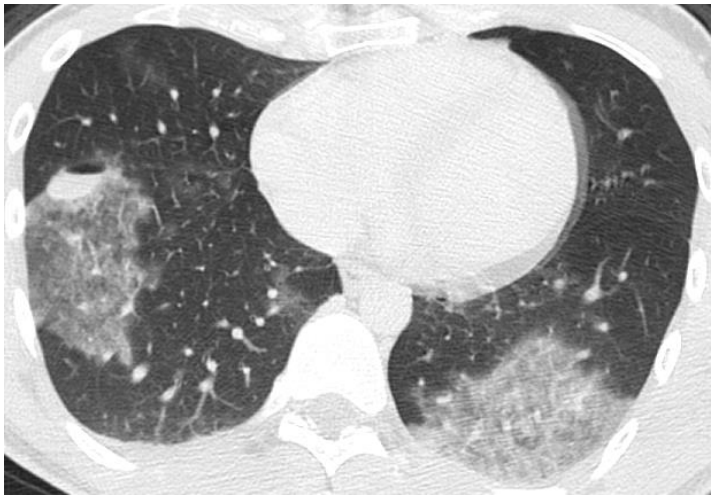
Cyst with air or hydro-aeric content **secondary** to parenchymal aggression

- **Thin and regular wall**
- **Persistent**



Etiologies

- **Post-infectious** (staph+++, strepto, *haemophilus*, *E. Coli…)*
- Post-ventilation newborn
- Road accident …

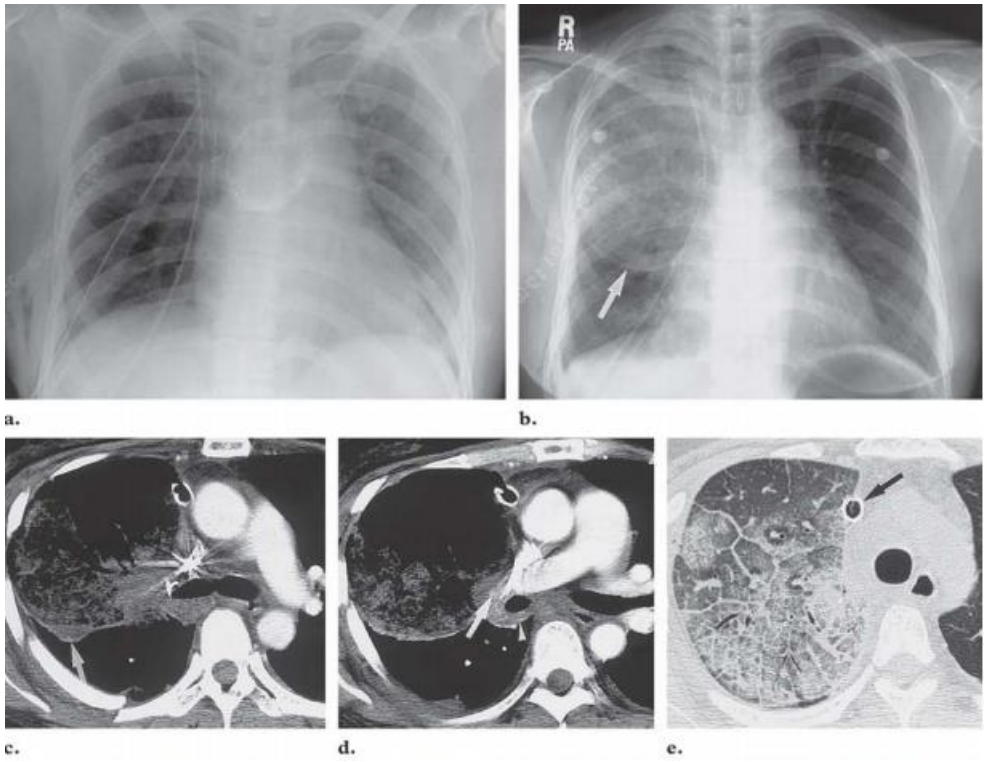


Post-traumatic hematopneumatoceles

- *Post car crash accident*
- *GGO: **pulmonary contusions***
- *Hematopneumatoceles*

Post-op middle lobe torsion

- **Thoracic surgery complication**, incidence: **0.1%.**
- **URL lobectomy++** (70%) **ULL**
- Medium lobe vulnerable due to small size occupying large space
- Mortality: 10-20% if undiagnosed.



Courtesy Eun A, Kim, Radiographics

Xray:

Main scissure under the hilum and **rapid post-op consolidation**

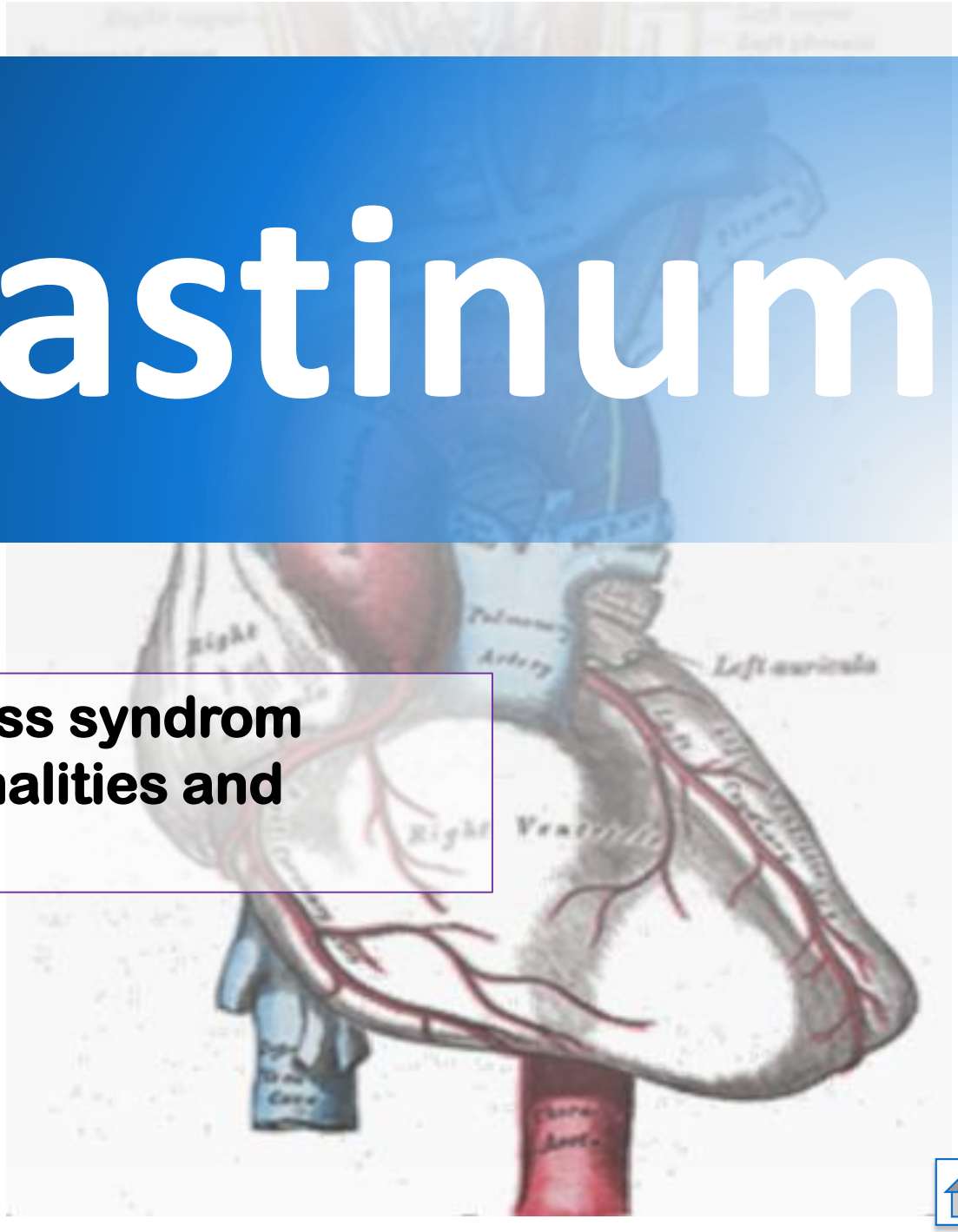
CT :

- **Occlusion of** the **pulmonary artery** and **bronchi**
- **Amorphous** hilum **mass syndrome**
- Lobe
  - **Consolidation GGO ,** inter and intra-lobular reticular opacities
  - **Lobe distension**
  - Low enhancement

Kim EA et al. Radiographic and CT Findings in complications following pulmonary resection. Radiographics. 2002

Mediastinum

1 / Tumours and mass syndrom
2 / Vascular abnormalities and variants



Mediastinal -
Tumours and mass syndrom

Study of a mediastinal mass

- Location: compartiments
  - Anterior ➡
  - Middle ➡
  - Posterior ➡
- Density
  - Cystic ➡
  - Fat ➡
- Contrast enhancement ➡

Location

ANTERIOR MEDIASTINAL MASS

- Thymus
  - Thymic hyperplasia
  - Epithelial tumors: **Thymoma +++ and thymic carcinoma**
  - Thymic cyst
- Germ cell tumor
  - **Teratoma +++**
  - **Seminome (TGS)**
  - **Non-Seminomatous Tumor (NST)**
- Neuroendocrine tumors
- Ganglion
  - **Lymphoma +++**, metastasis
- Thyroid/ parathyroid
  - **Thyroid goiter** or thyroid nodule, ectopic parathyroid gland
- Miscellaneous
  - Lymphangioma, hematoma, mediastinal fibrosis, pericardial cyst, thymolipoma

MIDDLE MEDIASTINAL MASS

- **Lymphadenopathies +++**
- **Bronchogenic cysts +++**
- Esophageal injury
  - **Tumor**, diverticulum, megaoesophagus...
  - Hiatus hernia or traumatic diaphragmatic hernia
  - Esophageal varices
- Vascular
  - **Aneurysm** of the aorta or supra-aortic trunks
  - Aortic arch abnormality
- Retrotracheal endothoracic goiter
- Less frequent
  - tracheal lesion, Castelman's disease, mediastinitis, pancreatic pseudocyst, neurofibroma, sarcomas, paragangliomas

POSTERIOR MEDIASTINAL MASS

- **Nervous Tumours +++** (63%)
  - T. peripheral nerves
    - **Neurinoma+++**
    - **Neurofibroma**
  - T. sympathetic chain
    - Ganglioneuroma
    - Ganglio neuroblastoma
    - Neuroblastoma
  - T. para GG cells
    - **Paraganglioma**
- Meningocele
- Neuroenteric cyst
- Extra-medullary haematopoiesis

Anterior mediastinal mass

- Thyroid/ parathyroid
  - **Thyroid goiter** or thyroid nodule, ectopic parathyroid gland
- Thymus
  - Thymic hyperplasia
  - Epithelial Neoplasms
    - **Thymoma +++**
    - **Thymic carcinoma**
  - Thymic cyst
- Neuroendocrine tumors
- Germ cell tumor
  - **Teratoma +++**
  - **Seminome (TGS)**
  - **Non-Seminomatous Tumor (NST)**
- Ganglion
  - **Lymphoma (Hodgkin's, NHL) +++**
  - Metastasis
- Miscellaneous
  - Lymphangioma, hematoma, mediastinal fibrosis, pericardial cyst, thymolipoma

Necrotic appearance
- Tuberculosis
- Hodgkin (sclerotic or mixed cell form) (21% of cases)

Hopper KD, Diehl LF, Cole BA, et al. The significance of necrotic mediastinal lymph nodes on CT in patients with newly diagnosed Hodgkin disease. AJR 1990

Thyroid/ parathyroid gland mass

Goiter

- **Thyroid tissue**: spontaneously hyperdense (100UH), enhancement+++ and prolonged
- Anterior (in front of the venous plane, 80%, F++) or posterior (behind the trachea and vascular plane, D++)
- Heterogeneous++, well-defined contours, **Link to the thyroid gland +++** (multi-planar reconstructions)

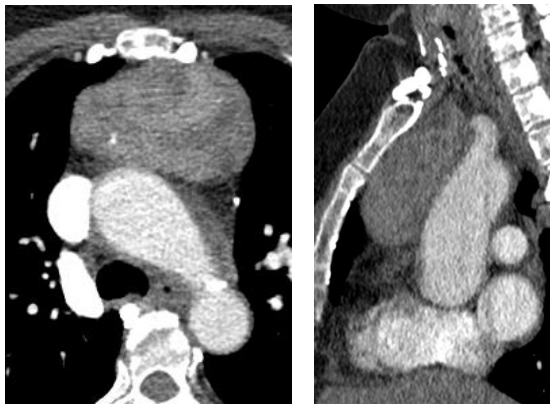
Thyroid adenoma/carcinoma

- Density, variable enhancement
- Look for continuity with the thyroid gland +++

Ectopic parathyroid adenoma/carcinoma

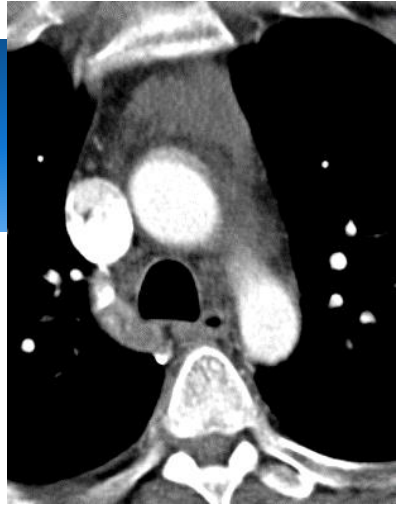
- Nodule 0.3 to 3cm, intense enhancement
- Mostly inferior parathyroid in the anterior mediastinum.
- Scintigraphy 99mTc Sestamibi +++
- CT SCAN
  - Without injection: > 80 HU: thyroid, <80 **HU: adenoma.**
  - **45s: adenoma >130 HU (GG<130** HU).
  - Late 70s: **wash out >20 HU:** adenoma (node: late enhancement)
- MRI: isoT1, hyperT2, wash-out enhancement++

New methods for parathyroid imaging: sonography, 4D CT, MRI
Boury S. Ann Endrocrinology 2015



Thyroid goiter
Multinodular goiter
ATCD operated

Thymic hyperplasia



Thymus

- Growth until puberty, then fat and fibrous involution with age, residual until 40-45 years old.
- Maximum thickness
  - 18 mm before 20 years, 13 mm after 20 years
- Triangular shape, straight or concave edges

2 types of hyperplasia

- True thymic hyperplasia
  - normal histology
  - = **Thymic rebound** after stress-related atrophy, immunosuppression (chemo, steroids, irradiation)
  - Increased size, **normalization in 9 months**
- Lymphoid hyperplasia
  - Medullary Lymphoid Proliferation
  - Normal (45%) or increased (30%) size or thymic mass (25%)→ **MRI++: in/out** sequence (signal drop)
  - **Myasthenia gravis**
  - **AI disease** (scleroderma, PR, Basedow, Addison, acromegaly)

Imaging

No distinction between the two types of hyperplasia → « **thymus hyperplasia** »

Criteria

- **Respected shape**
- **Two-lobulated shape**
- **Fat infiltration**
  - **MRI: drop in T1 in/out signal ++** (fat infiltration indicator: differential diagnosis lymphoma, thymoma…)

Myasthenia gravis Association

- 65%: **lymphoid hyperplasia**
- 15%: thymoma
- 20%: normal thymus

Thymic epithelial tumors

WHO histological classification

- **Thymoma**
  - Benin:
    - **A** (medullary)
    - **AB** (mixed)
  - Signs in favour of malignancy (histo/CTD)
    - **B1** (predominantly cortical)
    - **B2** (cortical)
    - **B3** (well-differentiated thymic carcinoma)
- **Thymic carcinomas** C

Metastases

- 5% metastasis if thymoma
- 50 to 65% if thymic carcinoma

Masaoka's classification

Based on degree of extension on postoperative staging

- **I**: no capsular effraction
- **II**: Invasion of fat tissue
  →additional radiotherapy
- **III**: invasion of close organs (lung, aorta, VCS)
- **IVa**: pleural or pericardial metastasis
- **IVb**: hematogenous or lymphatic metastasis
  →chimio/chir/Rx

Prognostic factors

- **WHO and Masaoka classifications**
- **Complete surgical resection**
- **Size > 8cm**

→ Median survival: 24 months for carcinomas

→ Median 10-year survival median for all stages of thymomas

- 76% if complete resection
- 28% if incomplete resection

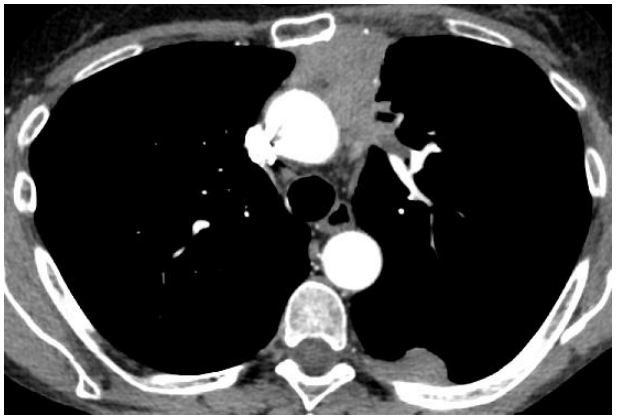
Treatment

- **Surgery**
- +/- chemotherapy
- +/- radiotherapy

CT+ / MRI++: difficult to distinguish type of thymic epithelial tumors in imaging but some Key point help…

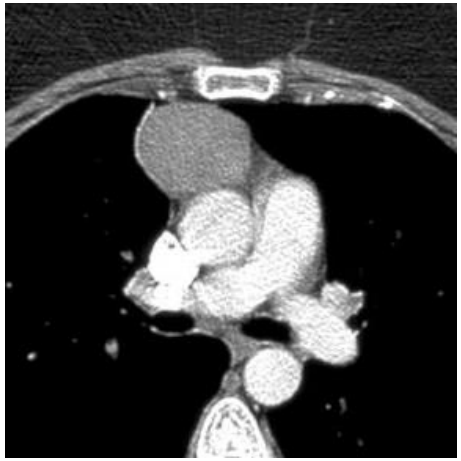
Carcinoma +++

- Irregular borders
- Necrosis
- Vascular invasion
- Heterogeneous enhancement
- Lymphadenopathies



Low-grade thymoma

- Homogeneous enhancement
- Regular borders
- Thin capsule hypoT1 MRI
- Fibrous Septas



No discriminating value

- Calcification
- Hemorrhagic
- Pleural effusion
- Encaspulated

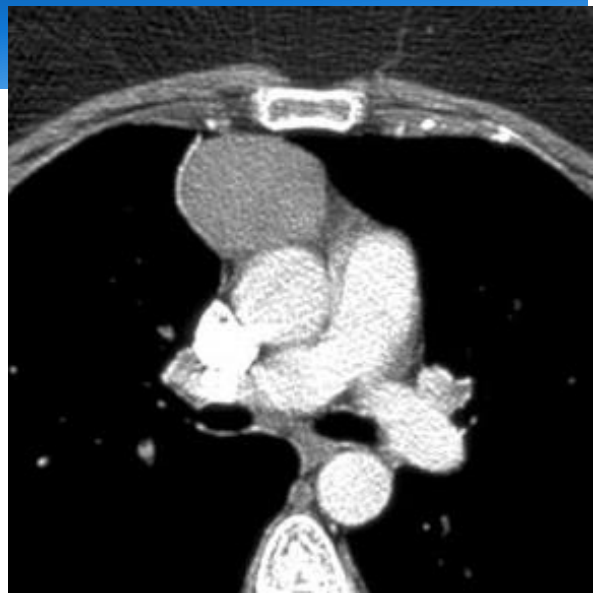
Thymoma

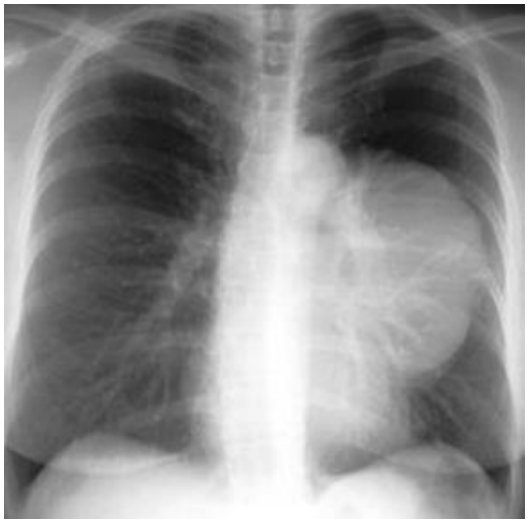
- The most common of the primitive masses of the anterior mediastinum. 15% of mediastinal tumors
- Epithelial tumor +/- lymphocytes
- 40-50 years

Myasthenia gravis and thymoma

- 1/3 thymoma → myasthenia
- 10 to 15% myasthenia → thymoma

  Myasthenia Association
  - 65%: lymphoid hyperplasia
  - 15%: thymoma
  - 20%: normal thymus

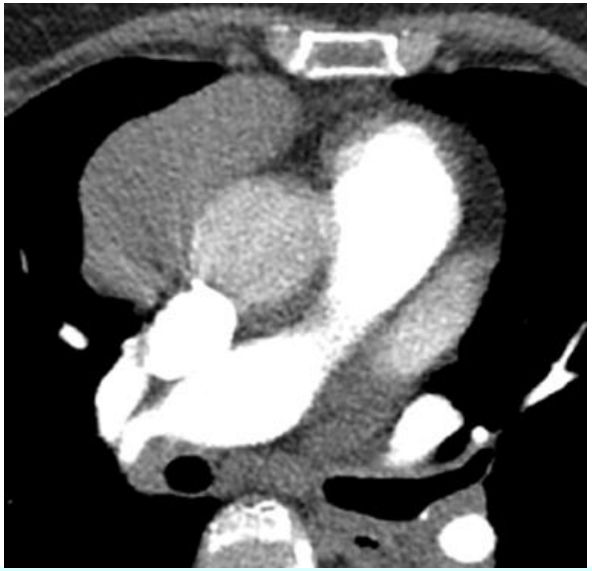




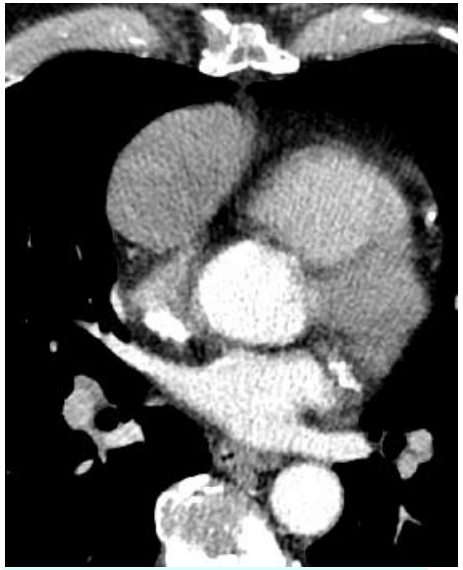
Imaging: CT+++

- Tissular mass
  - Oval or lobulated
  - Enhancement
    - Homogeneous for small tumors
    - Heterogeneous (cystic, necrotic zones) for the largest 20%.
  - Calcifications: 20% (fine, linear, in capsule)
  - Sometimes cystic form
- Anterior mediastinum
- No sign of invasion, regular border+++
- Look for signs of high grade or thymic carcinoma.

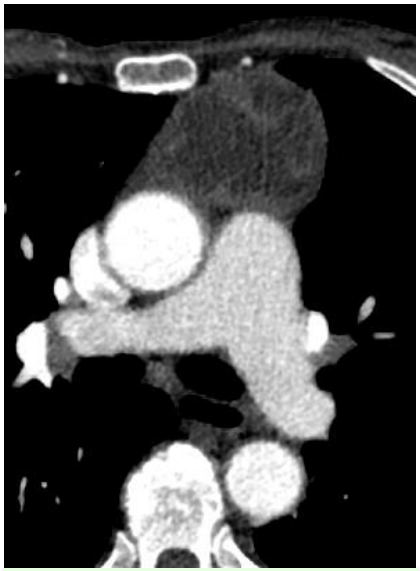
The imaging workup aims to distinguish between local, ***stage I or II forms of*** *Masaoka-Koga →* ***surgery,*** *and more invasive,* ***stage III and IV*** *forms, warranting* ***neo-adjuvant chemotherapy***



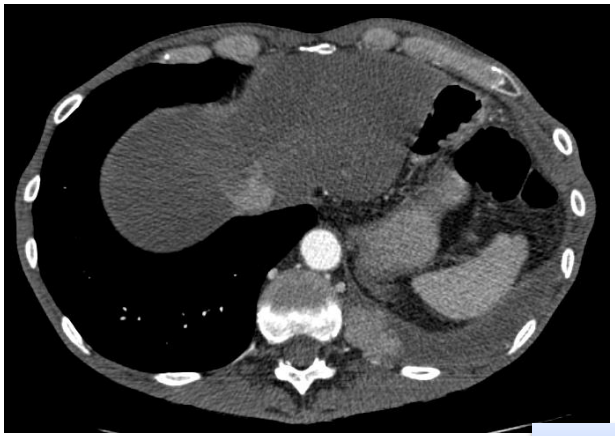
Low-grade thymoma

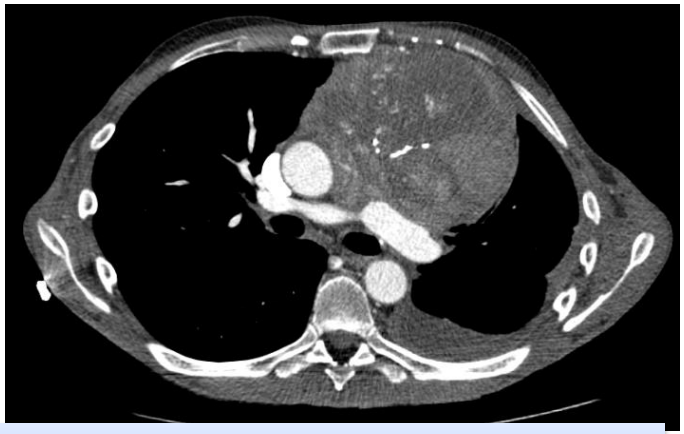


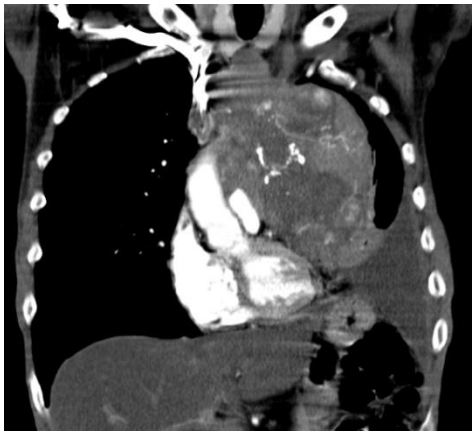
Thymoma AB



Thymoma B1





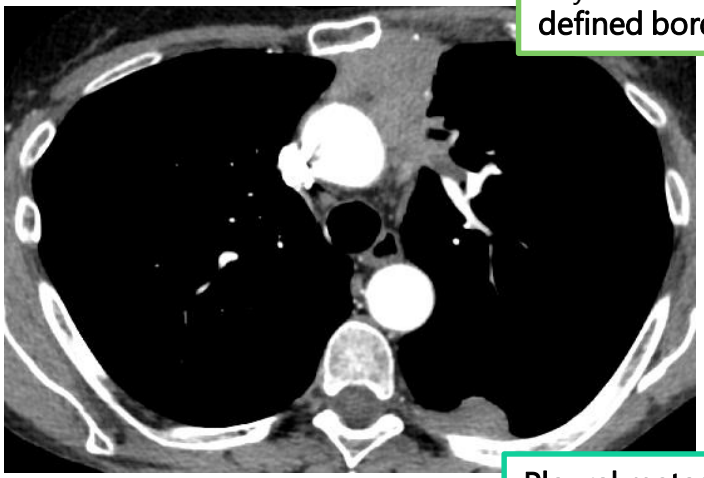


High grade thymoma

Thymic carcinoma

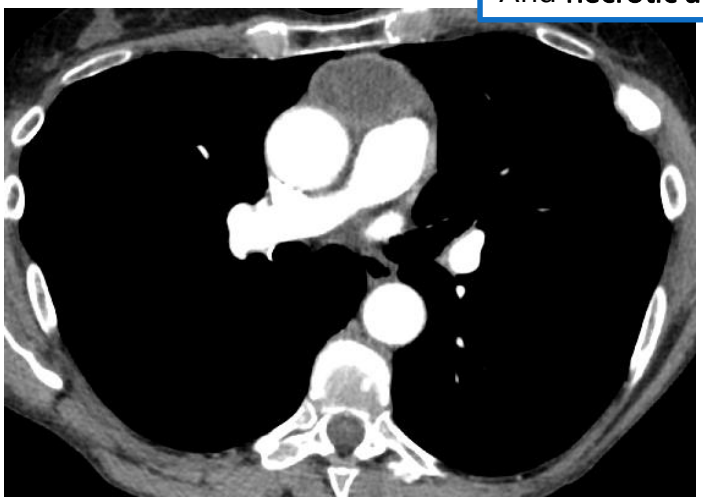
Imaging

- **Heterogeneous enhancement** mass with **areas of necrosis**
  - Calcifications 10 to 40%
- <u>Invasive nature</u>
  - **Fat infiltration**
  - **Invasion of large vx** and mediastinal structures: 40%.
  - **Lymphadenopathies**
  - Extension to **pleura** and pericardium
  - Metastases



Thymic mass with **ill-defined borders**

Pleural metastasis



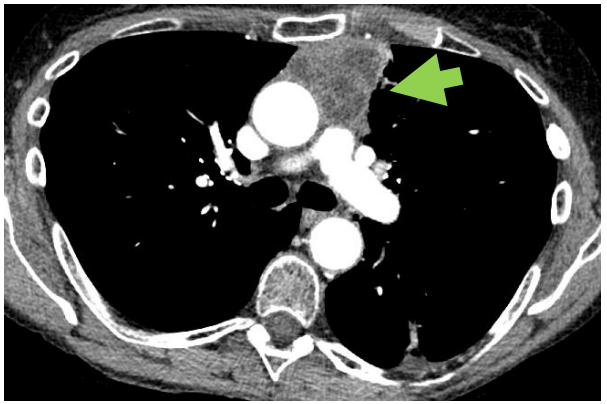
And **necrotic areas**

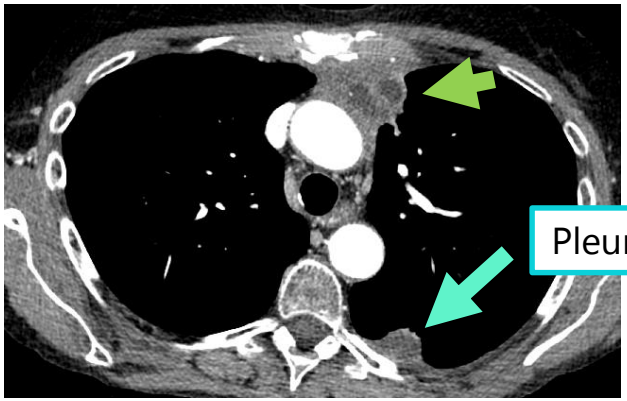
Neuroendocrine tumors

- **= Carcinoid tumor**
- **Very rare**, H, 40 to 60 years old
- **Cushing's syndrome (paraneoplastic secretion)**
- **Association with NEM1**
- Other syndrom
- Metastases at diagnosis: 20% (bone, GG, kidney, brain, lung, skin)
- **Recurrence after resection: 70%.**
- Survival at 5 years: 30%.
- Identical management as for other neuroendocrine tumours

Association
- Anterior mediastinal mass
- Cushing's or NEM1

→ **Thymic Carcinoid**





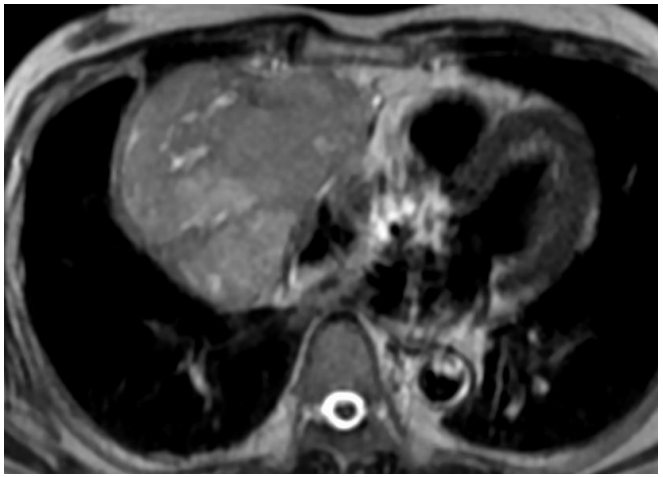
Pleural metastasis

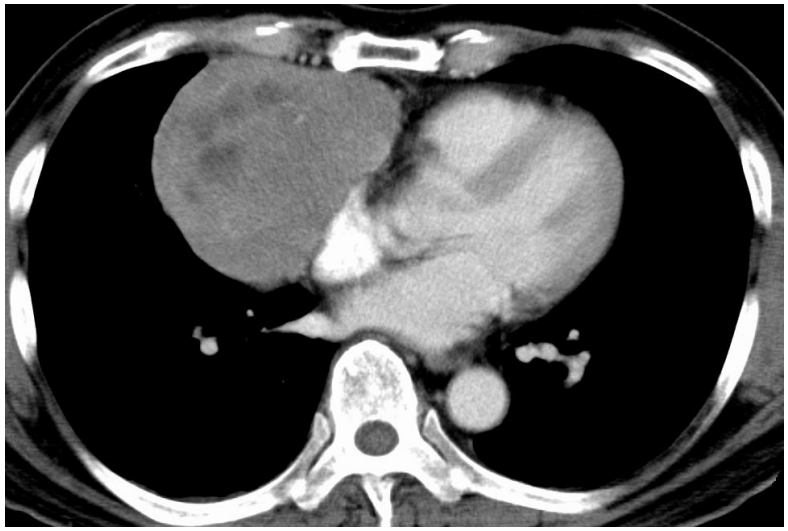
Imaging
- **Enhancement +++ heterogeneous**
- Calcifications
- Necrosis
- Invasion of adjacent tissues

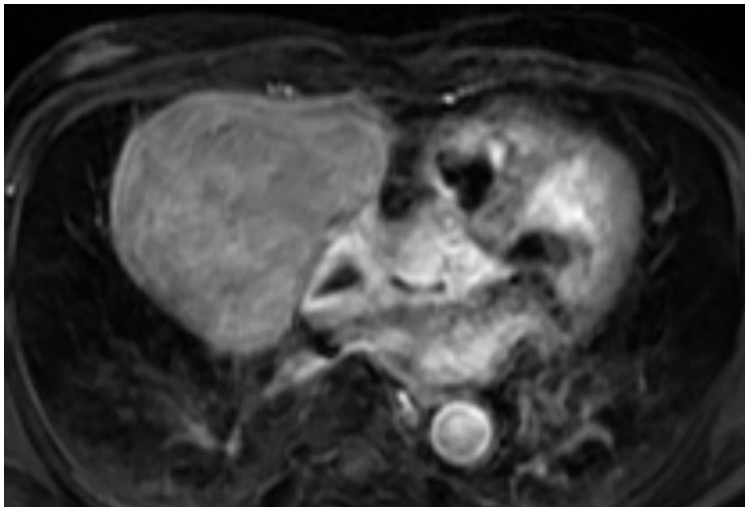
→ *difficult to differentiate from a thymic carcinoma in morphological imaging +++*

- Scinti octreotide + but not specific

Mediastinal carcinoid tumor







Germ Cell Tumours

Classification

- Extra-gonadal germ cells
- Extra-embryonic Differentiation: **Teratoma** (70%)
  - Mature teratoma

Benin

  - Immature teratoma
  - Teratoma with malignant transformation
- Embryonic differentiation
  - Seminomatous germ cell tumors **SGCT** (10 to 20%)
  - Non-seminomatous germ cell tumours **NSGCT** (10 to 20%)
    - Choriocarcinoma
    - yolk sac tumor
    - embryonal cell carcinoma

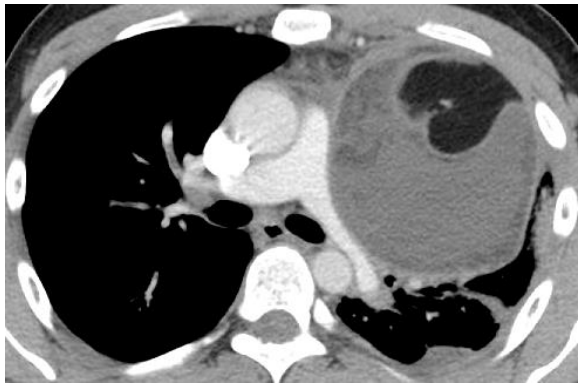
Malignant

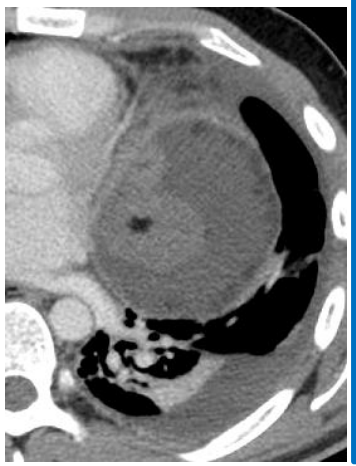
- < 10% of mediastinal tumors...
- 2/3 extragonadic locations
  - 80%: mature teratomas
  - 20%: malignant germinal tumor
- Young adult, Klinefelter's syndrome

Teratoma

Most common germ cell tumor. 15% of anterior mediastinal masses (25% in children)

- Elements of the **3 embryonic layers**: endoderm, mesoderm, ectoderm
- Age of presentation:
  - **20-40 years old**
  - < 1 year (immature)
  - Immature: almost exclusively male





Mature teratoma
Rupture in the pleura

1) Mature (75%)

- H = F
- **Well defined mass**, encapsulated, 3 to 25 cm
- Generally **cystic** 90% (single or multilocular)
- +/- wall / septal contrast enhancement
- Several components
  - **Fat** (75%)
  - **Cystic** (90%)
  - **Liquid-fat levels** (10%)
  - **Homogeneous tissue density**
  - **Calcification** (26%) +/- tooth / bone (8%)
- **Rupture**: 35% (lung, bronchus, pleura, pericardium, Vx)
  → pleuritis, pneumonia, fat/liquid level

2) Immature

- Solid

(3) Malignant: teratocarcinoma

- **Irregular border**
- **Tissue component +++**, necrosis
- **Thick wall , enhancement**
- Compression

Biblio: Ueno T, Tanaka YO, Nagata M et-al. Spectrum of germ cell tumors: from head to toe. Radiographics 2004

SGCT (seminoma) and NSGCT

SEMINOMA

- **Male+++ (90%)**, 30-40 years old
- The most common malignant germ cell tumor
- Biology: βHCG normal or ↑, αFP normal+++
- **Better prognosis than NSGCT**
- Treatment: Rx and chemo

Imaging

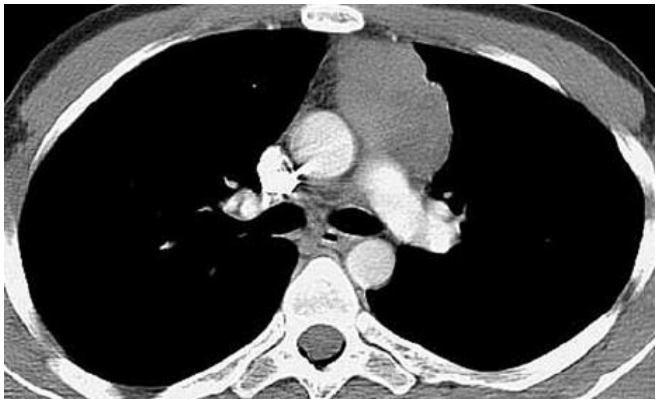
- **Massive tissue mass**
- **Well limited**, **lobulated**
- **No calcification**
- **Homogeneous** moderate late enhancement
- No or little necrotic area+++

NSGCT

- M, 15- 35 years old
- **Embryonal cell carcinoma (↑ αFP)**
- **Choriocarcinoma (↑ βHCG)**
- **Yolk sac tumor (↑ αFP)**

Imaging

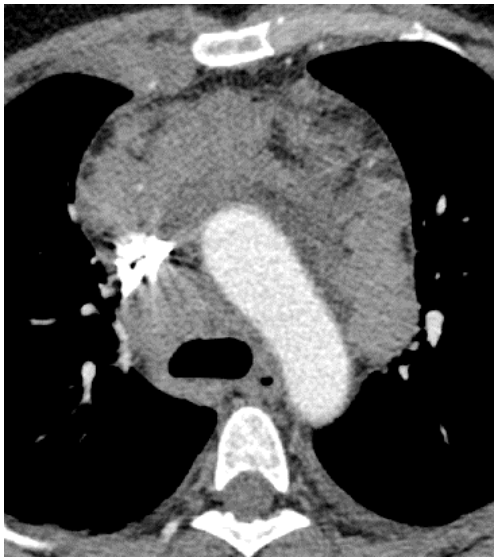
- **Large size++++.**
- **Invasive +++, poorly limited**
- Heterogeneous
- **Necrosis**
- Hemorrhage

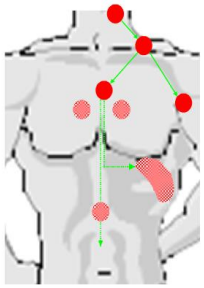


Seminome
DU Nancy

Hodgkin's Lymphoma

- The most common tumor of the anterior mediastinum
- In USA, 0,2 % of people are affected at some point in their life, 1% of all cancers
- Bimodal distribution : young adult (15-34 years) and older patient (>55 years)
- Curable in 90% of cases
- Clinic: inflammatory syndrome, fever, sweating, pruritus, weight loss

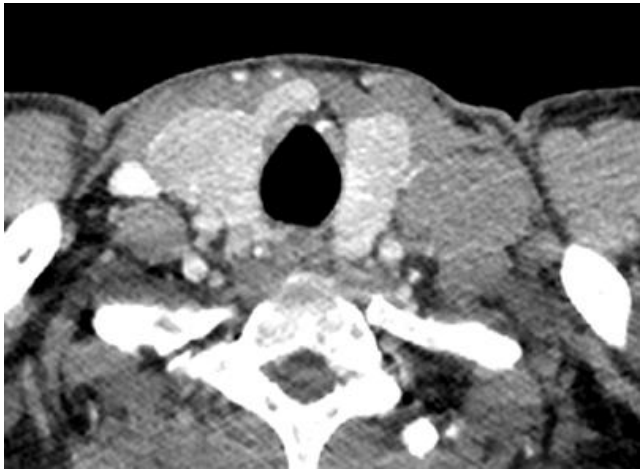


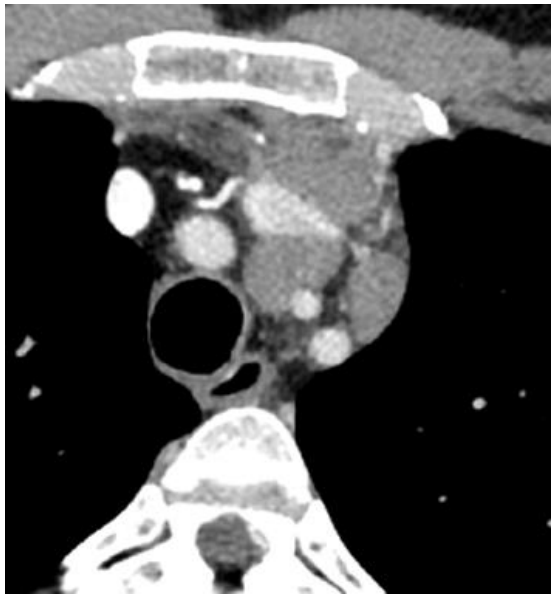


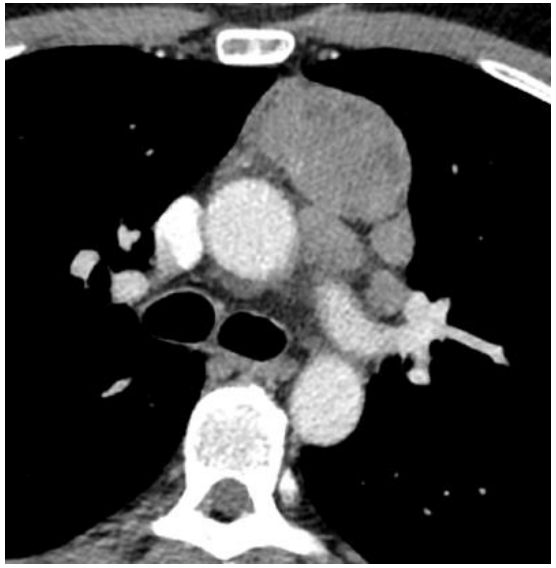
	Hodgkin	NHL
Mediastinal	**65%-80%**	20-40%
Anterior mediastinum	**++**	+
Latero-tracheal	**++**	+
Hilaire	**++**	+
Internal mammary gland	**+++**	+
Paracardiac	+	+++
Posterior mediastinum	+	+++

Imaging

- **Thoracic +++ (85%)**
  - **Anterior** mediastinum **++ and superior ++**
  - +/- para-tracheal chains
- **Progression by contiguity +++**
- **Rarely compressive ++**
- +/- parenchymal, pleural, cardiac, parietal, thymic involvement
- Pet-scan needed for stage

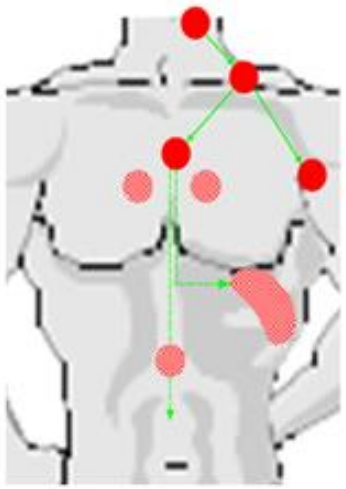




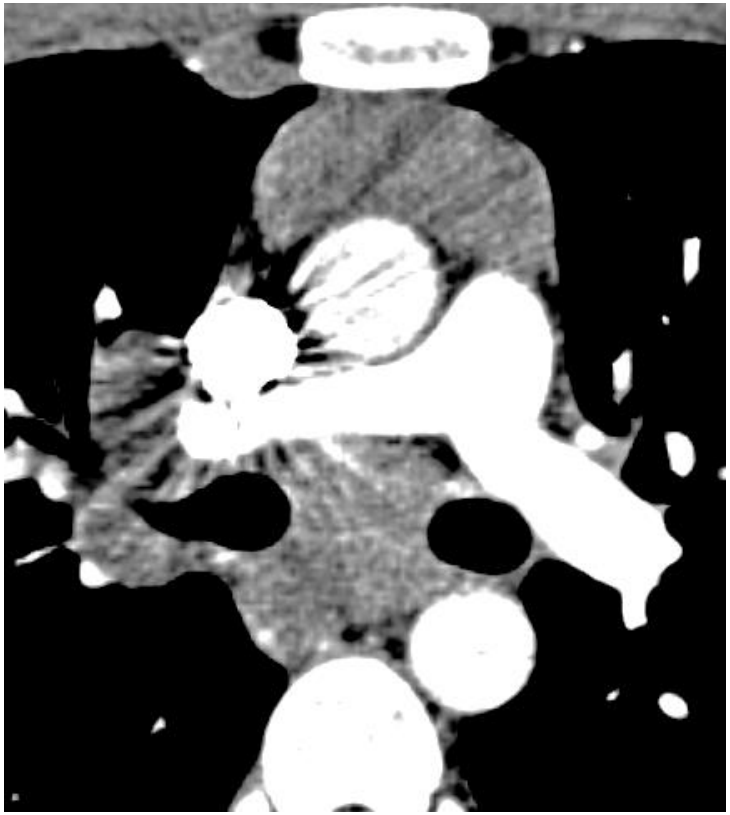


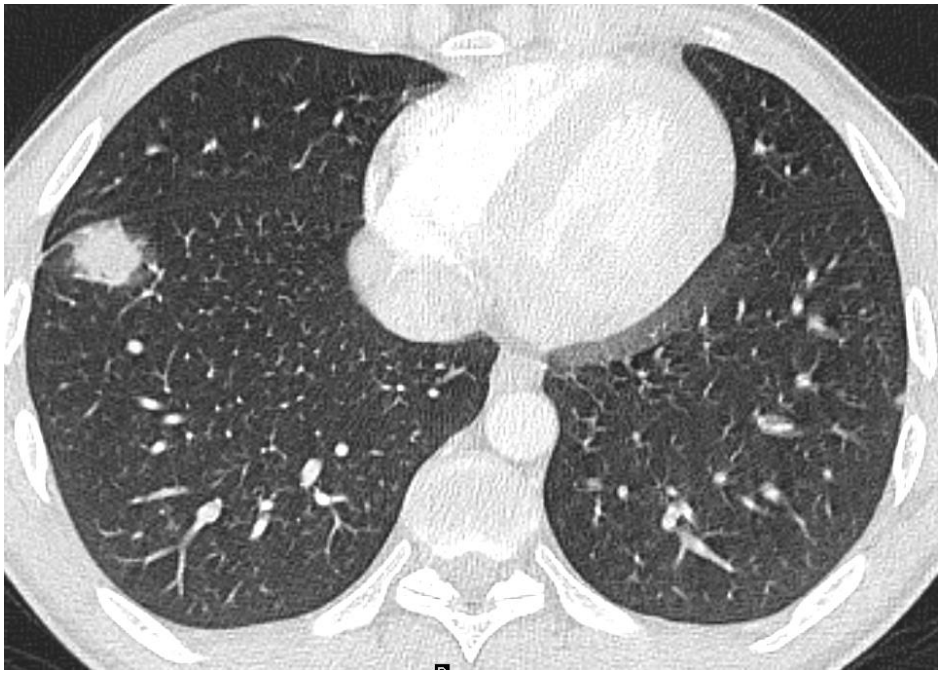
Hodgkin's Lymphoma

- Anterior mediastinal and left supraclavicular lymphadenopathies
- **Contiguous adenopathies** characteristic of Hodgkin's lymphoma (affecting relatives close to the lymph node chains) in contrast to non-Hodgkin's lymphoma



Hodgkin's Lymphoma





NHL

- In USA, 2,1 % of people are affected at some point in their life (vs 0,2 % for HL)
- 7th cancer in annual incidence
- **Large histological variety**
- Good prognosis for B lymphoma

Imaging
- **Diffuse spread without contiguous extension**
- +/- Compressive
- +/- Parenchymal, pleural...

	Hodgkin	NHL
Mediastinal	65%-80%	20-40%
Anterior Mediastin	++	+
Tracheal Latero	++	+
Hilaire	++	+
Internal mammary gland	+++	+
Paracardiac	+	**+++**
Posterior mediastinum	+	**+++**

Non-Hodgkin's Lymphoma

Primary mediastinum B Lymphoma

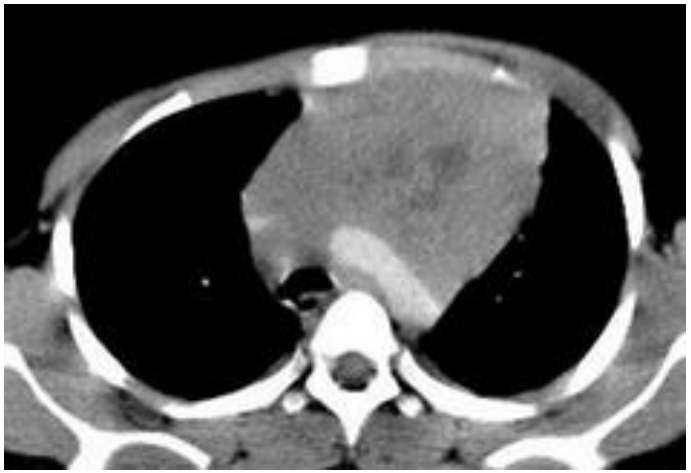
- 6 to 10% of adult NHL
- 2nd mediastinal tumor after Hodgkin's.
- **Large diffuse B cell** subtype
  - Median age: **37 years**
  - Predominantly female
  - Thoracic location: 70%, bulky++

Mediastinal involvement in lymphoma

- 20 to 40% of cases
- Ubiquitous

Lymphoblastic Lymphoma

- **Medical emergency +++** (cave syndrome, obstructive dyspnea, high mass)
- **young** male+++
- Sometimes CBC: hyperlymphocytosis, LDH elevation, cell lysis...
- non-invasive biopsy + myelogram before steroids



Case courtesy of Dr Ayush Goel, Radiopaedia.org, rID: 25431

Middle mediastinal tumor

- **Lymphadenopathies**
  - Latero-tracheal, subcarinary, latero-esophageal chains
- **Esophageal lesion**
  - Malignant tumor
  - Leiomyoma
  - Diverticule
  - Achalasia/ megaoesophagus
  - Hiatus hernia or traumatic diaphragmatic hernia
  - Esophageal varices
- **Vascular**
  - Aneurysm of the aorta or supra-aortic trunks
  - Aortic arch abnormality
- **Bronchogenic cysts +++**
- Retrotracheal endothoracic goiter

Less frequent

- Tracheal disease
- Castelman's disease
- Médiastinitis
- Pancreas Pseudocyst
- Neurofibroma
- Sarcomas
- Paragangliomas

…

Lymphadenopathies

Malignant

- Lymphoma
- Secondary malignant
  - Bronchial carcinoma
  - Esophagus
  - Extra-thoracic primitive tumors
- CLL, myeloma, Waldenström (rare)

Infectious origin

- Tuberculosis
  - Primary infection, clinical context, KB in sputum/BLA, IDR+, risk of abscess and fistula
- Bacterial, viral, parasitic, fungal: rare.

Benin

- Sarcoidosis
  - The most frequent, young adult. Asymptomatic. IDR-, biopsy: giganto-cellular granuloma without caseous necrosis
- Silicosis
  - Calcifications, parenchymal damage
- Amylose
  - Calcification

Lymphadenopathies

Look out! Look out!

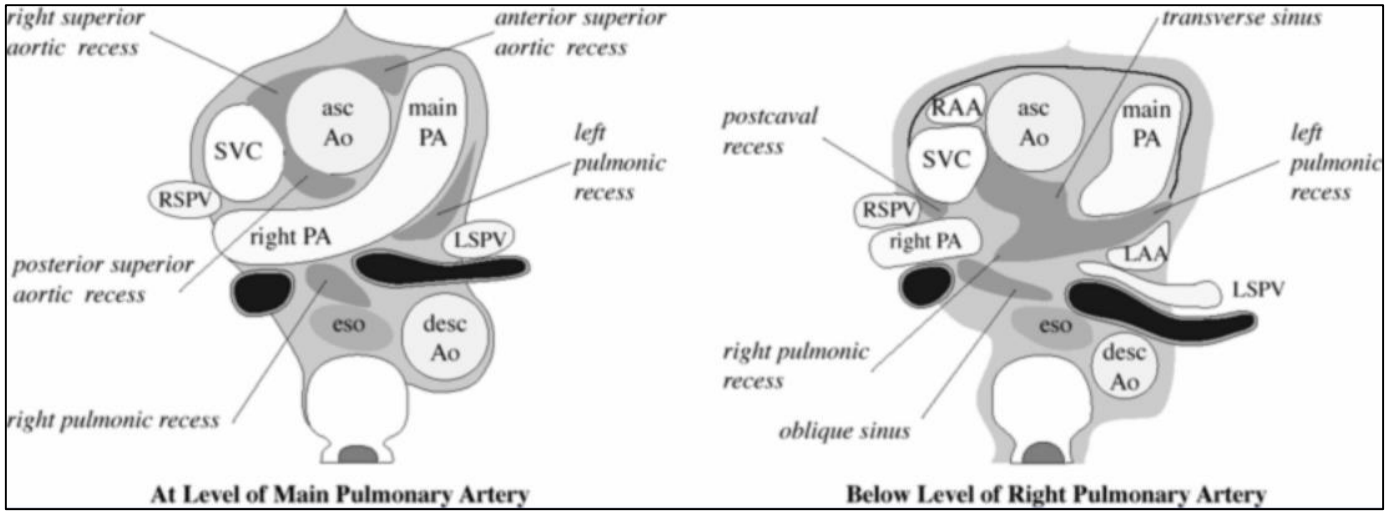
Don't confuse a **mediastinal node** with..:

- A **pericardial recess**
- An **azygos vein**
- The **oesophagus** (in sub carinary)

Lymph node vs. pericardial recess

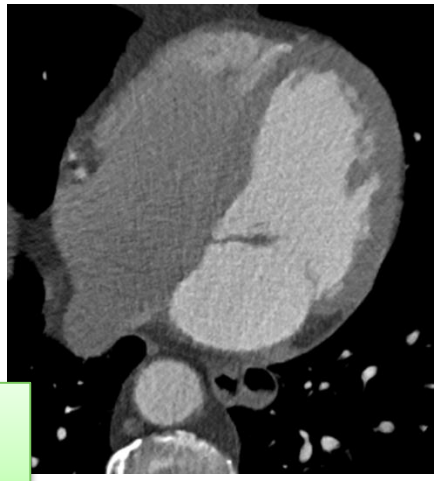
Pericardial recess:

- **Water** density
- **No enhancement**
- Interest of **reformat reconstruction** (continuity ++)



Esophageal diverticulum

Mucosal hernia without muscular wall



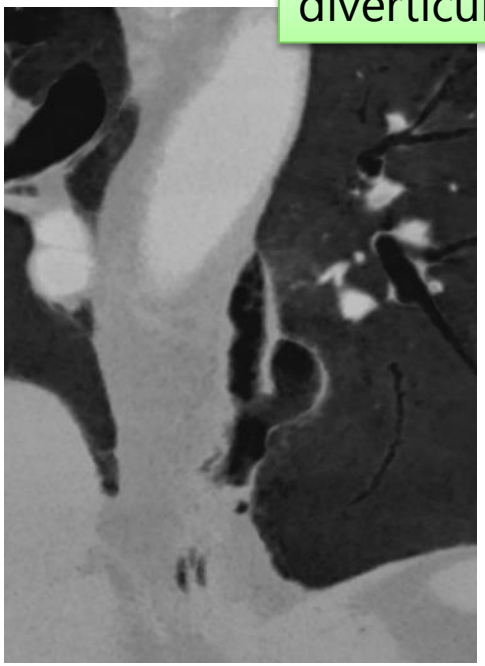
Epiphrenic diverticulum

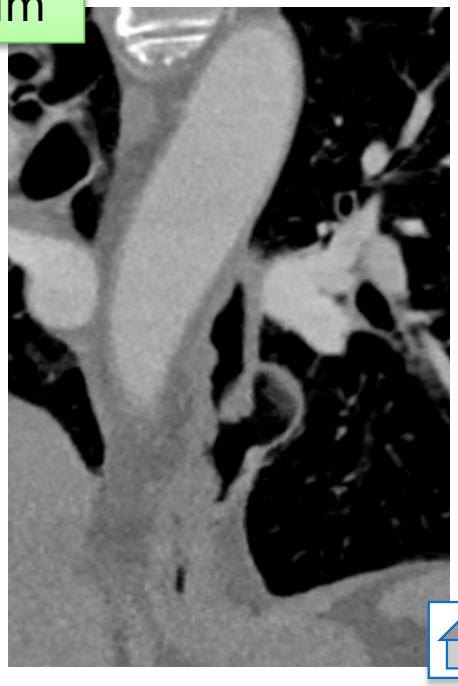
CT SCAN

- **Thin wall**
- **Air** or **hydro-aerial content++++.**
- Not visible on an empty stomach (except stenosis or achalasia)

Classification

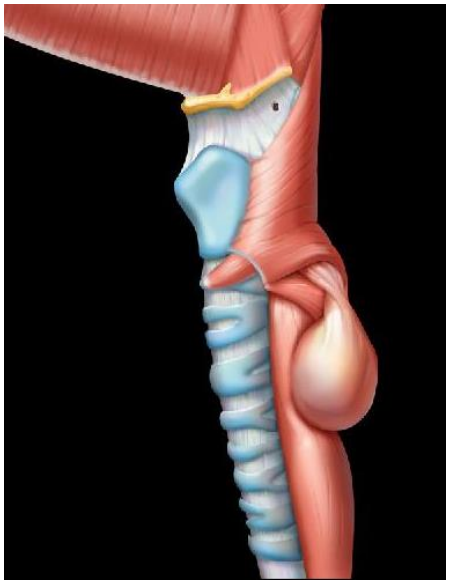
- **Zenker ++**: pharyngeal-esophageal junction
- **Middle esophagus**
- **Epiphrenic**: above the hiatus

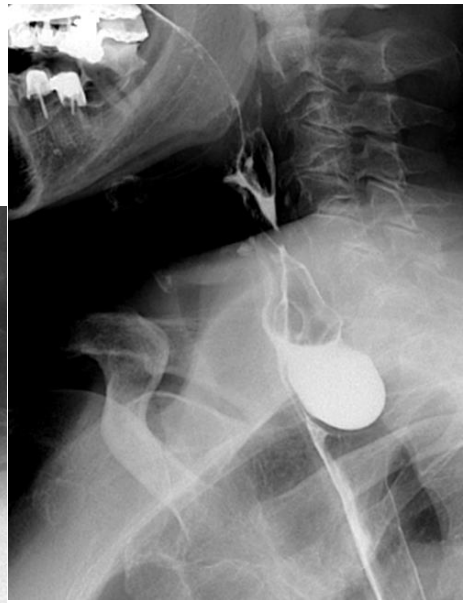


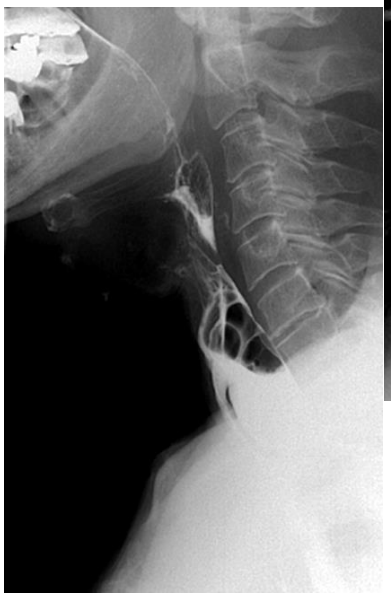


Zenker's Diverticulum

- Hernia through an anatomical weakness in the region of the crico-pharyngeal muscle
- Imaging
  - **Large diverticulum either lateralized to the left or posteriorly compressing the cervical oesophagus.**
  - Sac posterior to the cervical oesophagus
  - Orifice just above the crico-pharyngeal muscle (which can be thickened).
  - Narrowing lumen of pharyngo-esophageal junction
  - Association with esophageal mobility disorder, hiatus hernia...
- Complications
  - High dysphagia
  - Regurgitations
  - Inhalation pneumonia
  - Perforation during surgery
- Treatment
  - Diverticulectomy
  - or endoscopic (laser) treatment



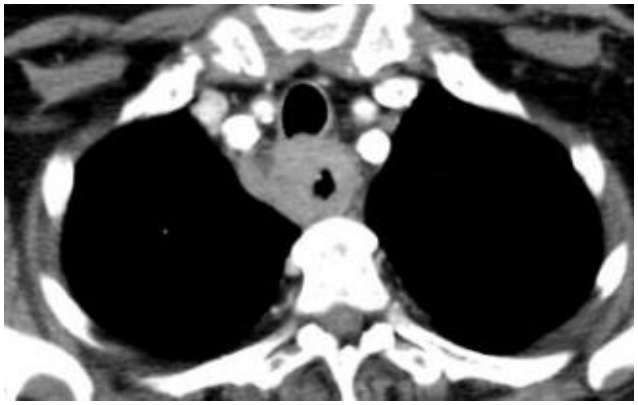




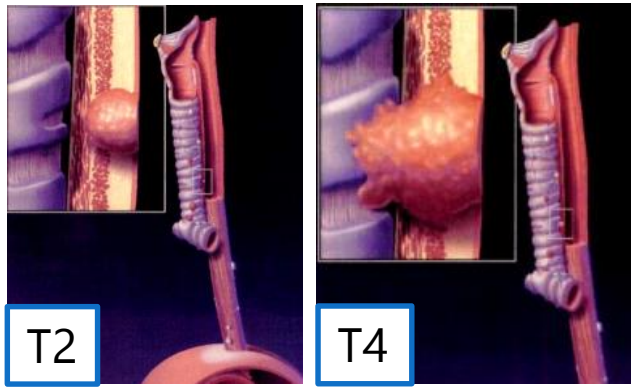
Esophageal malignant tumor

Histology

- **Squamous cell carcinoma** (81-95%)
- Adenocarcinoma (4-19% (Barrett's esophagus, esogastic junction)
- Others: Mucoepidermal, cystic adenoid, sarcomas, lymphoma...



Case courtesy of Dr Roberto Schubert, Radiopaedia.org, rID: 17673



TNM

- Tis = carcinoma in situ
- T1 = lamina propria or submucosa
- T2 = muscular
- T3 = adventis
- T4 = adjacent structures

CT SCAN

- **Eccentric or circumferential wall thickness >5mm**
- **Peri-esophageal infiltration**
- Hydro-aerial retention above the tumor
- Tracheobronchial tree / aorta displacement/ invasion

Extension

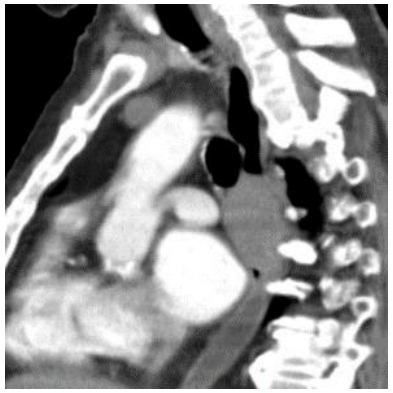
- Mediastinal nodes
- Liver, lung, adrenal gland...

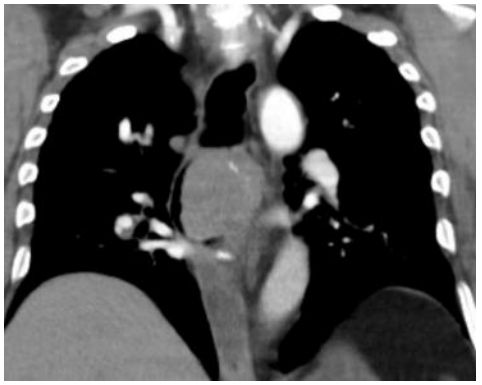
Kim TJ, Kim HY, Lee KW et-al. Multimodality assessment of esophageal cancer: preoperative staging and monitoring of response to therapy. Radiographics. 2009

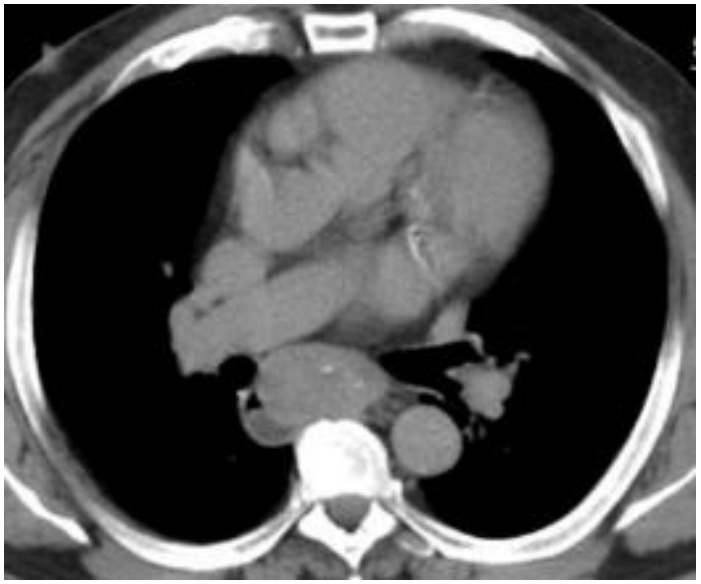
Esophageal leiomyoma

Benign smooth muscle tumour

- 45-73% benign esophageal tumours, **20 - 50 years old**
- **Often asymptomatic** when < 5 cm
- > 5 cm: sometimes **dysphagia** ...







Case courtesy of Dr Vitalii Rogalskyi, Radiopaedia.org, rID: 29503

TOGD

- **Regular stenosis** by intramural lesion

CT

- **Smooth, round, well-limited submucosal tumour**
  - Rarely exophytic or intraluminal
- **Moderate enhancement**
- **+/- Calcifications (quasi pathognomonic)**
- No soft tissue invasion

Location

- **1/3 lower esophagus: 60%.**
- 1/3 middle: 30%.
- 1/3 upper: 10%.

Winant AJ, Gollub MJ, Shia J et-al. Imaging and clinicopathologic features of esophageal gastrointestinal stromal tumors. AJR Am J Roentgenol. 2014

Pulmonary artery sarcoma

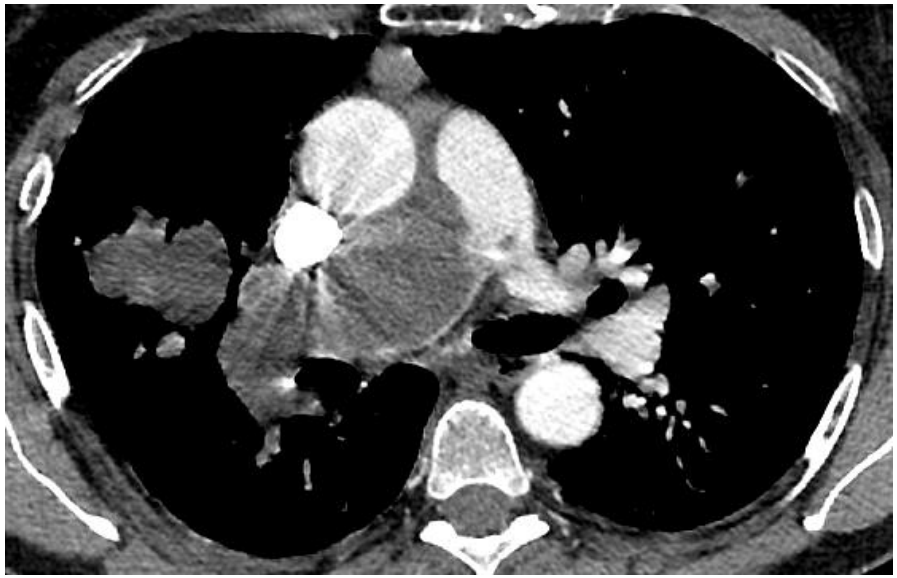
- **Extremely rare** (0.001%-0.03%)
- Origin: intimal mesenchymal cells

Imaging

CT
- **Hypodense process** occupying the entire arterial lumen
- **Expansive character**
- **Extraluminal extension**

PET scan
- **Fixation**

MRI
- **Very specific** because **enhancement +++** compared to thrombus



Pulmonary artery sarcoma

Differential diagnosis +++: often mistaken for **pulmonary embolism** (trap)

Treatment and prognosis

- **Highly malignant** tumor
- Average survival of 12-18 months
- Surgical resection +/- chemotherapy, radiotherapy

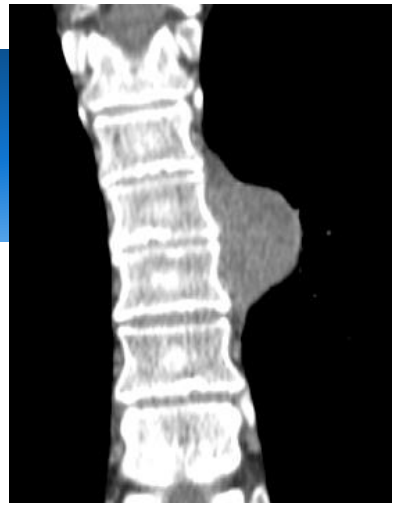
Yi CA, Lee KS, Choe YH et-al. Computed tomography in pulmonary artery sarcoma: distinguishing features from pulmonary embolic disease. J Comput Assist Tomogr. 2004

Posterior mediastinal tumor

Etiologies

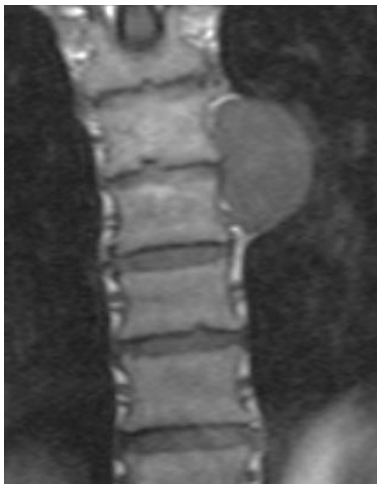
- Peripheral nerve sheath tumor (PNST) +++ (63%)
  - Peripheral nerve tumors
    - Neurinoma +++
    - Neurofibroma
  - Sympathetic chain tumors
    - Ganglioneuroma
    - Ganglio-neuroblastoma
    - Neuroblastoma
  - Paraganglia neoplasms
    - Paragangliomas
- Meningocele
- Neuroenteric cyst
- Extra-medullary haematopoiesis
- Teratomas (3-8% of teratomas in posterior mediastinum)

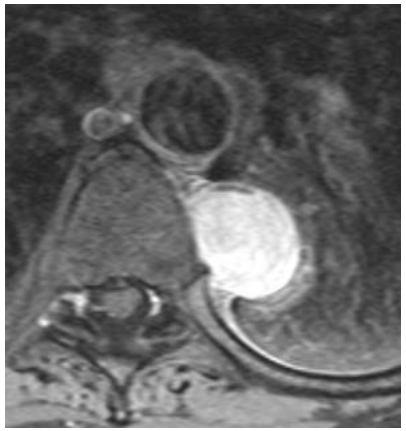
Schwannoma



Benign tumour developed from the sheath cells→ The tumour pushes nerve fibres away

- Encapsulated
- 2 cell patterns: ordered cell component (Antoni type A) and loose myxoid component (Antoni type B)
- Slow growth
- Clinical: asymptomatic ++, root pain
- Treatment: Surgical removal





CT

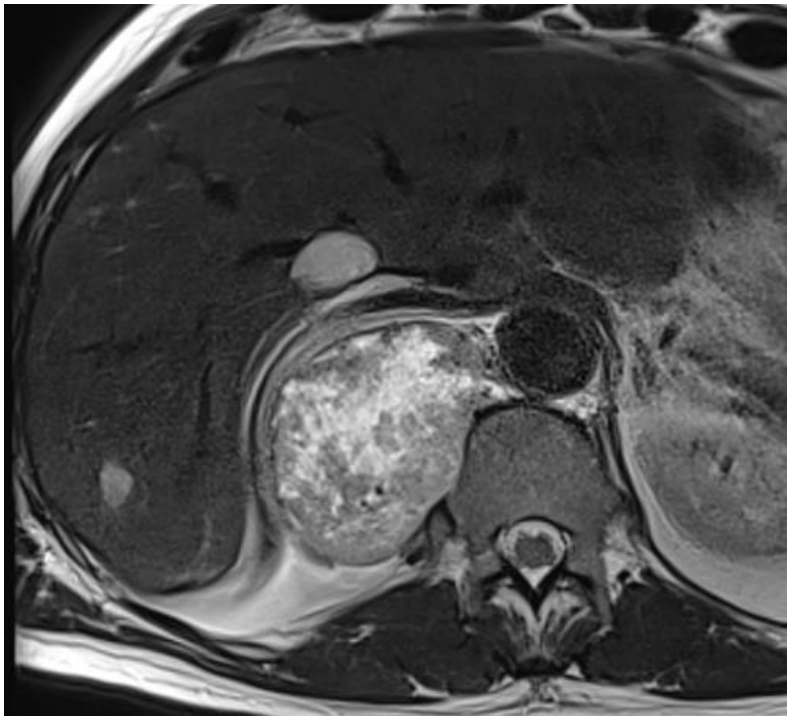
- **Tissular mass, hypodense, well limited**
- **Hourglass**: 10% (if intracanalar portion)
- Round or elongated (intercostal direction)
- **Para-spinal**: scalloping
- **Cystic form**
- Calcification: 10%.
- If voluminous: heterogeneous (haemorrhage, necrosis)

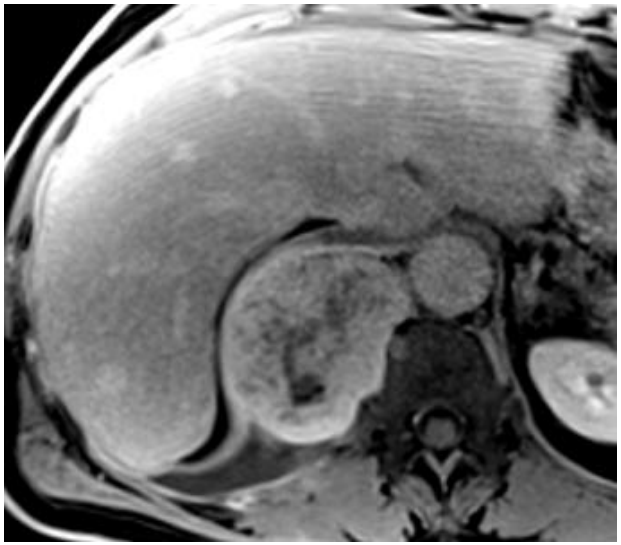
MRI

- T1: intermediate
- **T2: intermediate to high**
- **Enhancement**

Topography

- **Posterior mediastinum ++**
- Along the **vagus nerve** or **phrenic nerve**





Schwannoma
(pathological confirmation)

Neurofibroma

- 10% of neurogenic tumours
- Mixed tumour: sheath cells + nerve
- 20 to 40 years old
- **NF1 Association (40%)**

3 types have been described

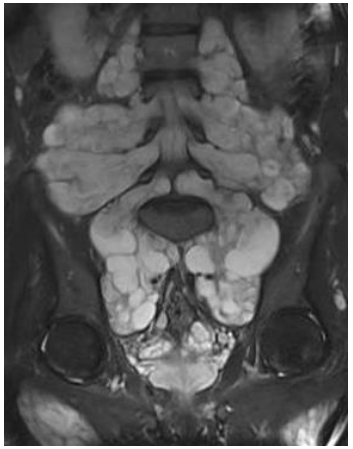
- Localized +++ (90%)
  - **≈ idem schwannoma**
  - CT scan: spontaneously hypodense mass in relation to muscles (15 to 20 HU) (73% of cases), little contrast enhacement
  - MRI: hypoT1, hyperT2, heterogeneous enhancement
- Diffuse
- Plexiform
  - **Pathognomonic NF1**

NF1

- Genetics, autosomal dominant
- Prevalence: 1/4000
- Skin lesions: coffee-milk spots, subcutaneous neurofibromas
- Neuro: Optic nerve glioma...
- Thorax: neurofibromas **paravertebral** regions, **vagus nerve, phrenic** nerve, **recurrent laryngeal nerve, intercostal** nerve

Plexiform NF

Thick mass infiltrating the entire nerve trunk and its branches (in a rosary), encompassing the rib



Case courtesy of Dr Vinay Shah, Radiopaedia.org, rID: 19700

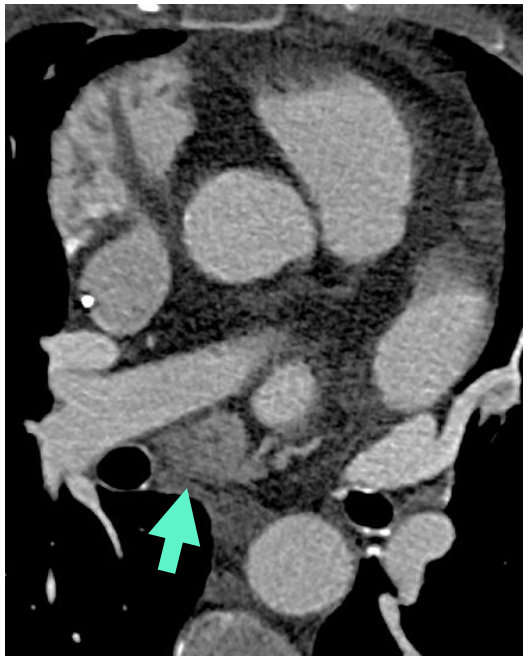
Risk of degeneration into MPNST *(malignant peripheral nerve sheat tumor).*

- 40-60% of MPNST: NF1. 4% malignant transformation in NF1
- Criteria: **size, rapid increase in size of a neurofibroma +++,** +/- irregular edges
- **MRI** (heterogeneous T1, **hypoT2**), Galium scinti67

Pilavaki M, Chourmouzi D, Kiziridou A et-al. Imaging of peripheral nerve sheath tumors with pathologic correlation: pictorial review. Eur J Radiol. 2004

Mediastinal paraganglioma

- **Paraganglioma = extra adrenal pheochromocytoma**
- 1/3: non-secreting
- 2 types
  - Non-chromaffinic and non-secreting P.
    - = Chemodectoma
    - Middle mediastinum, difficult resection
  - P chromaffins and secreting agent
    - = Extra adrenal pheochromocytoma.
    - Posterior mediastinum, easy resection
    - catecholamine secretion → HT, diabetes, headache, palpitation, sweating



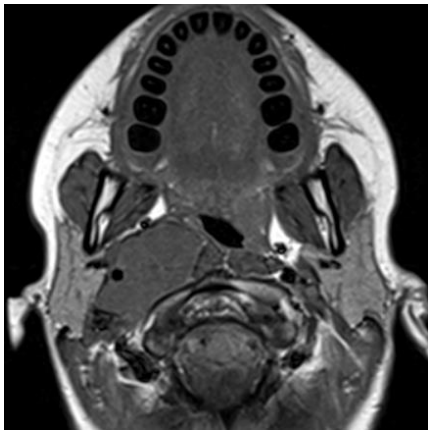
Paracardial paraganglioma

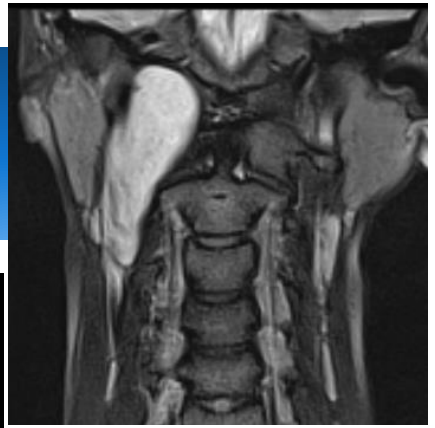
CT scan
- **Round mass**
- **Hypervascular +++**
- Calcifications ++
- MRI: "salt and pepper" aspect in T2 (**flow voids**), **dynamic MRI ++.**
- Blush (angio)
- MIBG

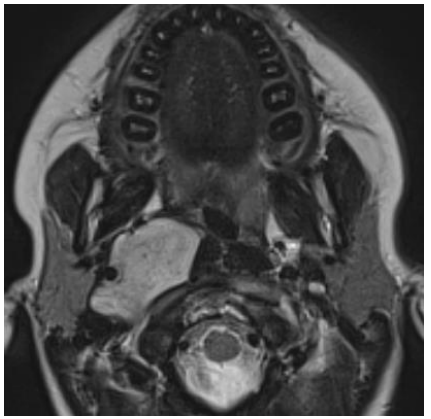
Site
- Abdomen > Thorax (rare,1 to 2% pheo)
- **Posterior mediastinum**: costo-vertebral gutter (sympathetic chain)
- **Middle mediastinum**: aortic arch, pulmonary artery, adjacent or in the heart

Ganglioneuroma

- **Rare, adolescents and young adults (< 20 years of age)**
- Tumours from **ganglion cells of** the sympathetic nervous system
  - ❖ **Ganglioneuroma (benign)**
  - ❖ Ganglioneuroblastoma
  - ❖ Neuroblastoma (malignant)
- **Posterior mediastinum** (32%), **neck** (8%)
- Encapsulated Tumor
- Treatment: curative resection



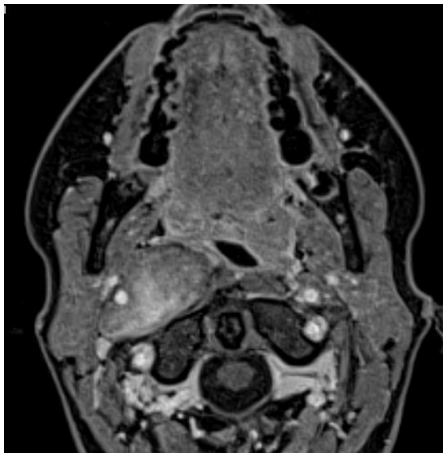


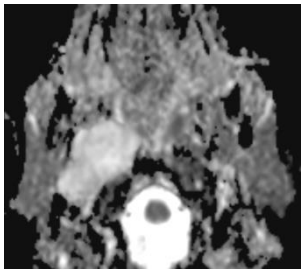


Imaging

- **Round or oval mass**
- **Regular borders**
- **Hypodense**
- **Absence (20%) or low (80%) contrast enhancement**
- Punctiform calcification (20%)
- Heterogeneous hypersignal in T2
- Dynamic: no early enhancement, **progressive enhancement**
- If atypical: think GNB (<10 years old, calcif + frequent), NB, pheo

Cervical ganglioneuroma

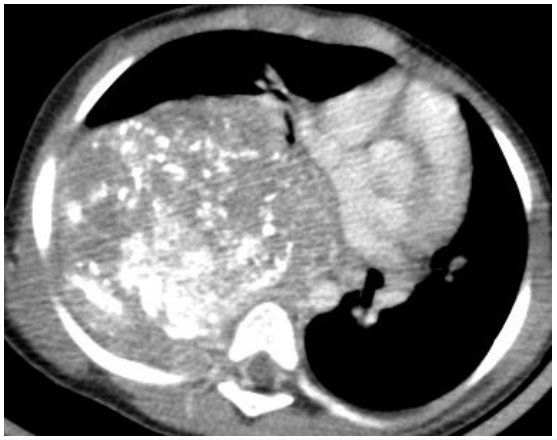


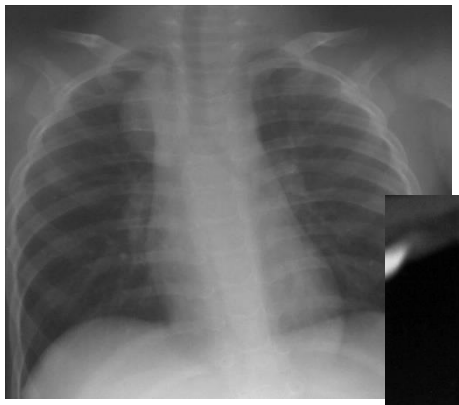


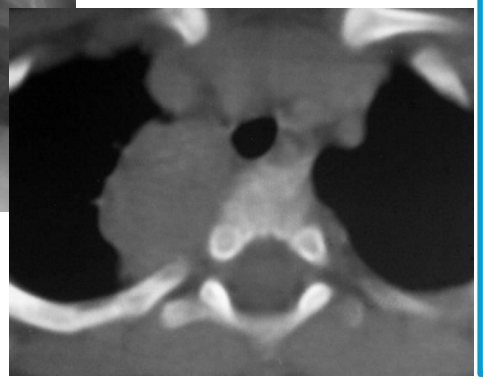
ADC between 1.7 and 2

Neuroblastoma

- **Neoplasms of neuroblastic origin**
- **Kid < 10 years +++,** pain, palpable mass...
- 3rd most common tumour after brain tumours and leukaemia
- **Huntchinson's syndrome**: bone metastasis
- **Pepper's syndrome**: liver metastasis
- Location
  - Adrenal glands 35 %
  - Retroperitoneum 35%.
  - **Posterior mediastinum 20%** ...







CT SCAN
- **Posterior mediastinum mass**
- **Heterogeneous**, **calcifications** (80-90%), hypodense areas (necrosis)

MRI
- T1: heterogeneous, iso to hypointense
- T2: heterogeneous, hyperintense, very hyperintense necrosis, flow voids
- Gd: variable enhancement, heterogeneous

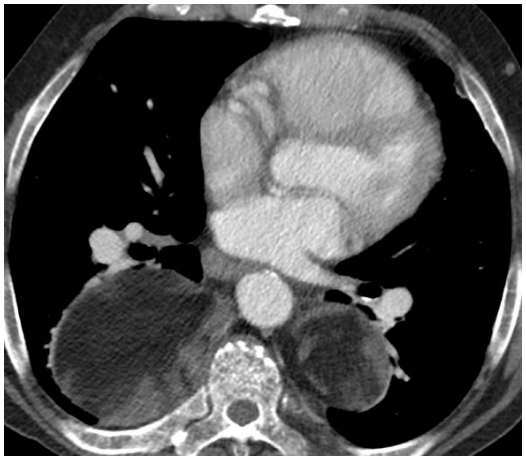
MIBG
- **Fixation** with Se:88%, Sp:99% (fixation in ganglioneuroblastoma, ganglioneuroblastoma, carcinoid, pheochromocytoma)

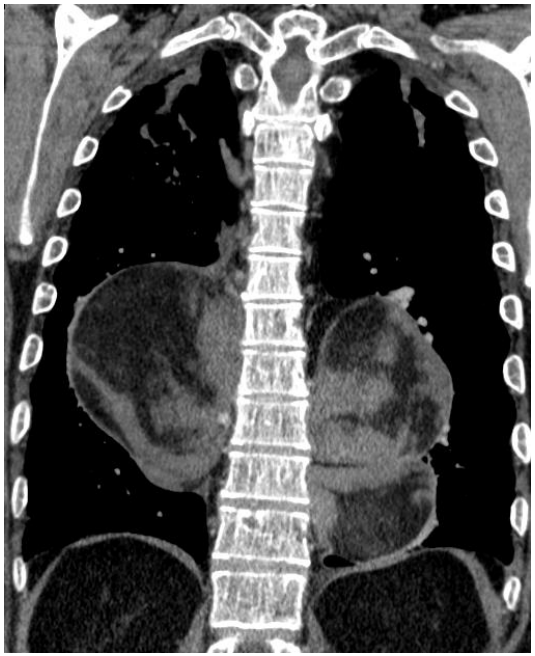
Lonergan GJ, Schwab CM, Suarez ES et-al. Neuroblastoma, ganglioneuroblastoma, and ganglioneuroma: radiologic-pathologic correlation. Radiographics 2002

Extramedullary hematopoiesis

Extra-medullary tissue proliferation in response to **insufficient production of hematopoietic cells**

- **Rare**, asymptomatic
- Secondary to
  - **plenectomy**
  - **Chronic anemia** (thalassemia, sickle cell disease, myelofibrosis...)





Imaging

- **Posterior mediastinal mass**
  - **Multiple ++, bilateral and symmetrical in contact with the vertebral bodies**
  - T6-T12
  - = Herniation of myeloid tissue through a fine cortex
- **Fat density +++**
- **Remodelling of bone in contact**
- Medullary rarefaction, coarse appearance of the weft
- No aggressive criteria
- Biopsy or scintigraphy to confirm if doubt

Biblio: Yahya M. Berkmen and Benjamin A. Zalta. Case 126: Extramedullary Hematopoiesis Radiology 2007

DENSITY

Cystic DENSITY

Congenital cysts

- **Bronchogenic cysts +++**
- Esophageal Duplication
- Neuroenteric cyst
- Pleuropericardial cysts

Cystic or cystitic tumors

(favored by Rx/chimio)

- Congenital/acquired thymic cyst
- Germ Cell Tumours
- Neurogenic tumor (schwannoma, neurofibroma)
- Cystic Lymphangioma
- Lymphoma

Miscellaneous

- Meningocele
- Pancreatic pseudocyst

FAT DENSITY

Fat-containing lesions

- **Teratoma**
- Thymo-lipoma

Fatty lesions

- Lipoma
- Liposarcoma
- Lipoblastoma

- Mediastinal Lipomatosis
- Extramedullary hematopoiesis
- Hernias

CONTRAST ENHANCMENT +++

- Thyroid or parathyroid mass
- Castelman's disease
- Paraganglioma
- Carcinoid tumor
- Ganglion metastasis (thyroid, sarcoma, melanoma...)
- Extramedullary hematopoiesis

Necrotic nodes

- Hodgkin
- Large B cell lymphoma

Biblio

- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
- *Adult Chest Imaging 3rd edition - Edited by Philippe Grenier*

Cystic density

Congenital cysts

Derivatives of the anterior primitive intestine +++

- **Bronchogenic cysts +++**
  - 1/5 mediastinal masses, 90% in mediastinum, subcarinary++, right paratracheal
- **Esophageal Duplication**
  - Adjacent to esophagus, vertical tubular form, often right, sometimes thick-walled
- **Neuroenteric cyst**
  - Posterior mediastinum, right, vertical tubule, vertebral anomalies (above, hemi-vertebrae...), upper thorax ++.

Pleuropericardial cysts

- Adjacent to pericardium, cardiophrenic angles +++ (right), upper pericardial recess

Cystic or cystitic tumors (favored by Rx/chimio)

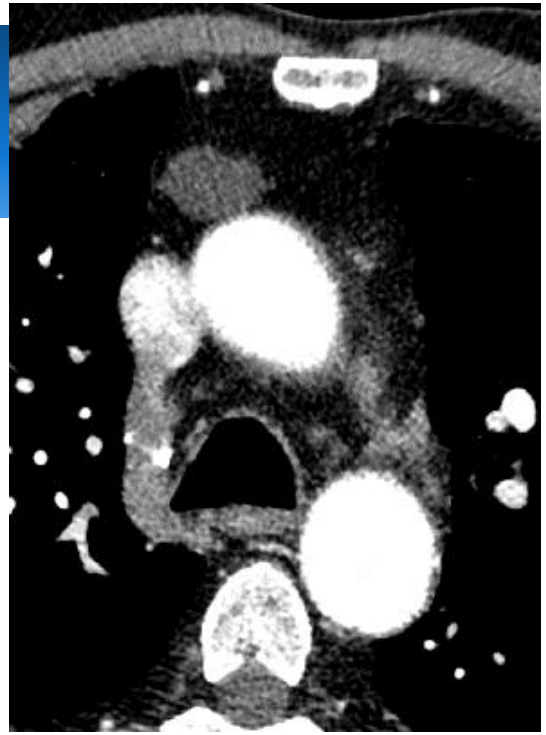
- Congenital/acquired **thymic cyst**
  - Anterior mediastinum
- **Germ Cell Tumours**
- **Neurogenic tumor** (schwannoma, neurofibroma)
- **Cystic Lymphangioma**
  - Single or multilocular, fine septal defects
    Complications: compression, infection
- Lymphoma

- **Meningocele**
  - Posterior mediastinum, associated with neurofibromatosis, myelography
- Pancreatic pseudocyst

Biblio

- *Radiographics;2002;22;579 Imaging of Cystic Masses of the Mediastinum*
- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
- *Adult Chest Imaging 3rd edition - Edited by Philippe Grenier*

Thymic cyst



- 3% of anterior mediastinal masses
- Congenital +++ typically unilocular (thymopharyngeal embryonic pathway)
- Acquired: often **multilocular**
  - Secondary to a thoracotomy
  - Lesion (thymoma, thymic carcinoma...) → chemo or irradiation
  - **Inflammatory:** multiloculate, thick fluid, thick fibrous wall, signs of inflammation on histology, diseases: Sjögren, myasthenia gravis, trauma, irradiation, AIDS

Imaging

- Cervical or mediastinal location
- Variable size: mm ->15 cm
- CT SCAN
  - **Unilocular or multilocular cyst with a well-limited wall**
  - +/- haemorrhagic
  - +/- Calcification (^{2ndaire} haemorrhagic)
- MRI ++: hypoT1, hyper T2, no enhancement

Complications

- Hemorrhage
- Infection

Differential diagnosis

- Cystic thymoma
- Cystic teratoma
- Lymphangioma
- Cystic degeneration of a seminoma
- Pericardial cyst

Biblio

- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
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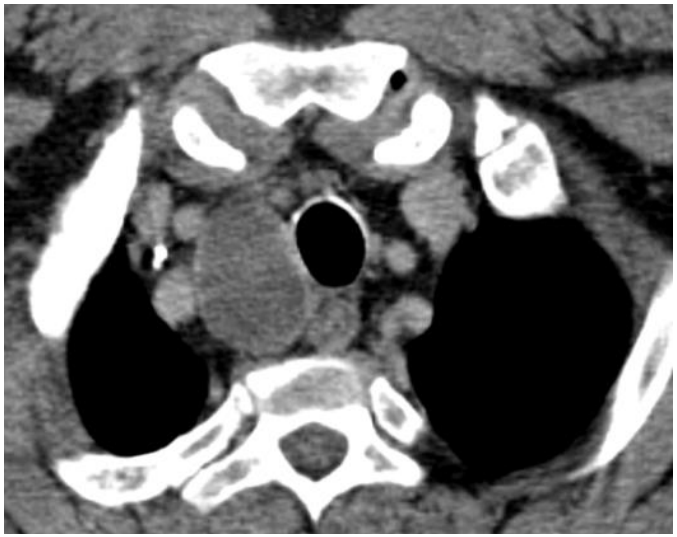
Bronchogenic cyst

Most common cystic lesion of the mediastinum (60%)

- Man > woman
- Possible Associations
  - Sequestration, lobar emphysema



Complications

- **Superinfection**
- **Hemorrhage** (↑volume)
- Obstructive compression emphysema
- Bronchial fistulation (hydroaerics level)

CT SCAN

- **Thin-walled cyst**
- Spontaneous density: **cystic to hyperdense** (50%) (mucoid content, calcium oxalate)
- Calcifications in the periphery

MRI

- Iso or hypersignal T1, **hypersignal T2,** thin wall not enhanced +++

Location

- Tracheo-bronchial contact
- **Mediastinal+++** (85%) **subcarinary** or **right paratracheal**
- Intra parenchymal (+/- mediastinum beak)

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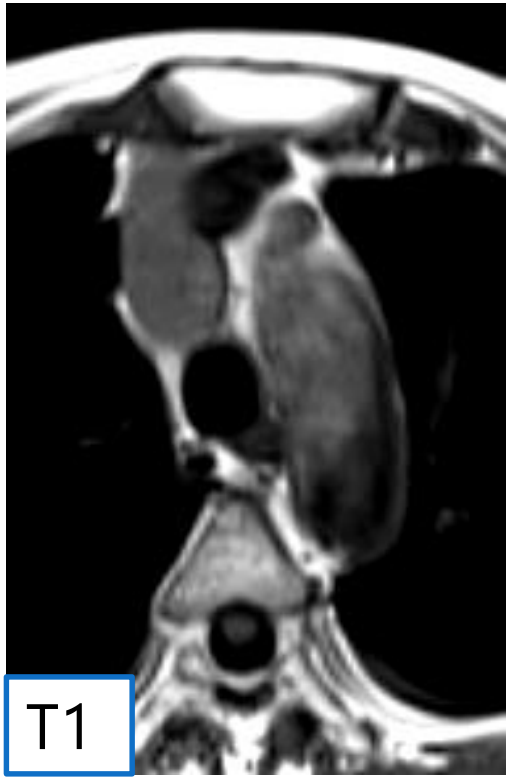
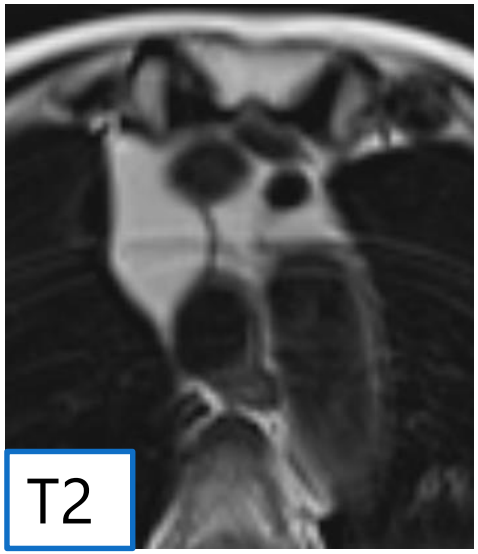
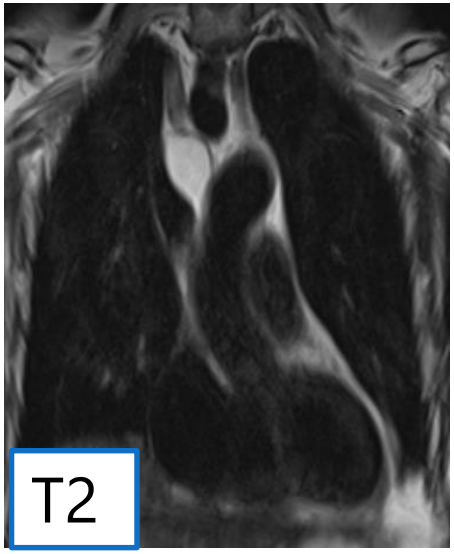
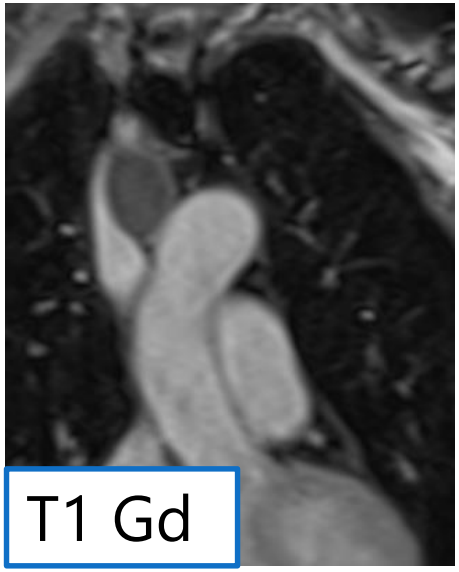






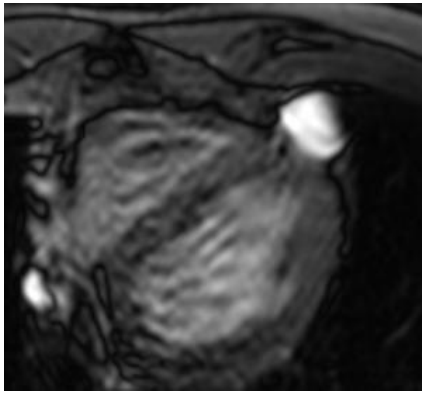


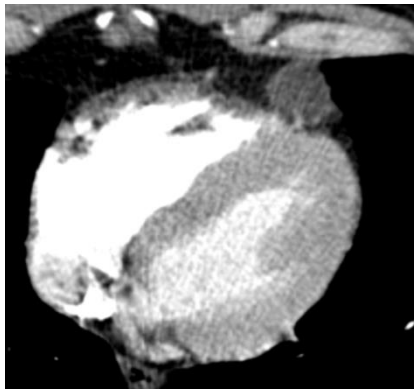
Bronchogenic cyst
Right paratracheal

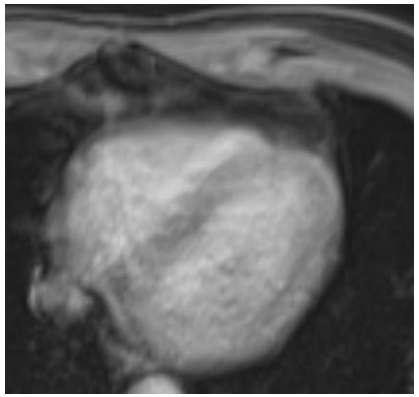
Pleuropericardial cyst

Congenital formation due to abnormal closure of the coelomic pericardial cavity

- **Asymptomatic**
- Bordered by a wall containing conjonctive tissue and a layer of mesothelial cells.







Imaging

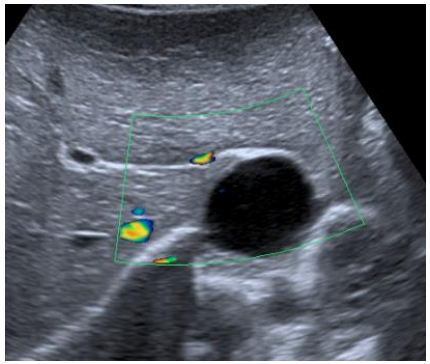
- **Oval or round, unilocular, thin-walled cyst**
- **Liquid Content**
- **Sometimes dense** if hemorrhage (but more cystic than bronchogenic cyst)
- 3 to 8 cm
- Location
    - **Right anterior cardiophrenic angle +++** (70%), left (22%)
    - Rare: pericardial recess (aortic root, pulmonary artery)

Biblio

- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
- *Adult Chest Imaging 3rd edition - Edited by Philippe Grenier*

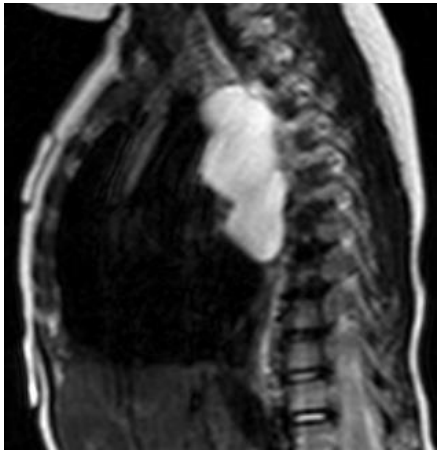
Esophageal Duplication

- **Child +++**
- **Cystic formation adjacent to the gastrointestinal tract**
- **2nd location (20%)** after the ileum (33%) but affects the whole digestive tract
- Wall: ectopic gastrointestinal mucosa, incomplete muscle layer, no cartilage
- Frequent associated malformations: vertebra, esophageal atresia

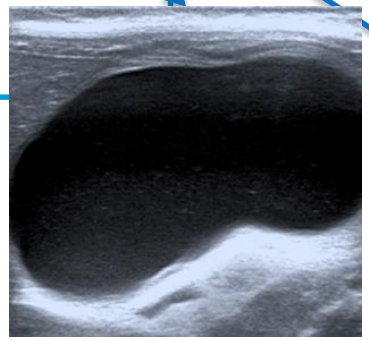


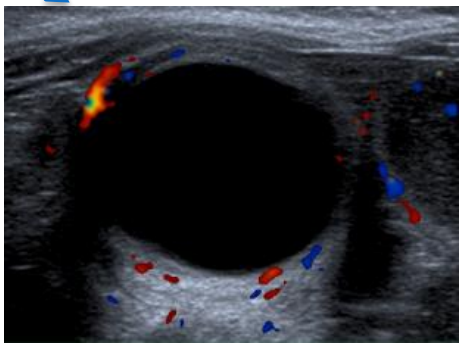
Imaging

- **Cystic** formation **adjacent to the gastrointestinal tract**
- With a **proper wall** (muscle layer)
- 2 forms
  - 82%: spherical, no communication with the IT
  - 18%: tubular form, communicate with the IT
- ***Same as bronchogenic cyst BUT***
  - ***Thicker wall***
  - ***and intimate contact with the esophagus***



Esophageal Duplication 3 year old child





Complications

- Rupture (acute mediastinitis, hemorrhage)
- Infection
- Esophageal compression (dysphagia), vessels

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Lymphangioma

Benign congenital malformation: **proliferation of lymphatic tissue** (ectasia lymphatic ducts lined with endothelial cells)

- **Rare** (0.7 to 4.5% of mediastinal tumours)
- Slow growth
- Histology
  - Capillary L.
  - Cavernous L.
  - **Cystic L. +++** (large macroscopic lymphatics)

Complications

- Infection
- Superior airway compression
- Chylothorax and chylopericardia

Imaging

- **Well limited mass, multilocular, sheathing the mediastinal structures (vessels...) without moving them.**
- Homogeneous cystic density (hyperdense if complication)
- Location:
  - Neck and axillary +++
  - 10%: Cervical extended to the mediastinum (children++)
  - **1%: Pure mediastinal (upper and middle mediastinum: right tracheal edge)**
- +/- Tissue areas, fatty areas
- +/- pleural effusion (chylous)

Biblio

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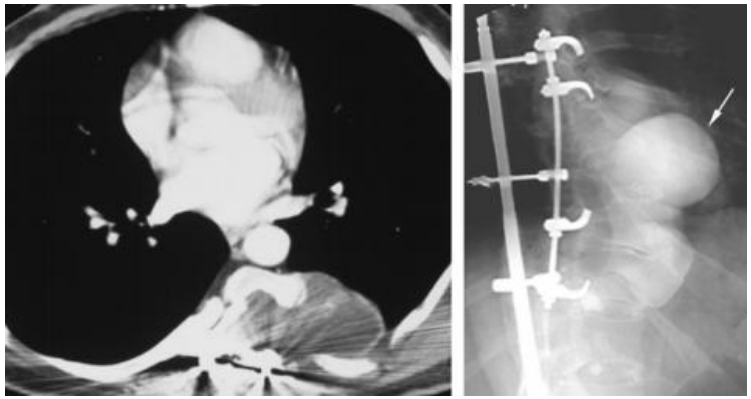
Thoracic meningocele

- **Herniation of the meninges through a conjugate foramen or a defect of the vertebral body**
- Asymptomatic
- Surgical treatment (bag closure)



Courtesy Mi-Young Jeung - Radiographics

Imaging

- **Cystic** lesion
  - **Costo-vertebral angle** (Right side ++)
  - Associated spinal abnormalities
    - **Scoliosis** (meningocele at the apex of the angulation)
    - **Enlargement of conjugate foramen**
- Association with **NF1**
- **DD: Nerve sheath tumors**
- **MRI +++**
  - **Hypersignal T2 (cerebro spinal fluid (CSF) signal)**
  - Widening of conjugate foramen
  - Vertebral "Scalloping"

Biblio

- *Mi-Young Jeung - Radiographics - 2002 - Imaging of Cystic Masses of the Mediastinum*
- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
- *Adult Chest Imaging 3rd edition - Edited by Philippe Grenier*

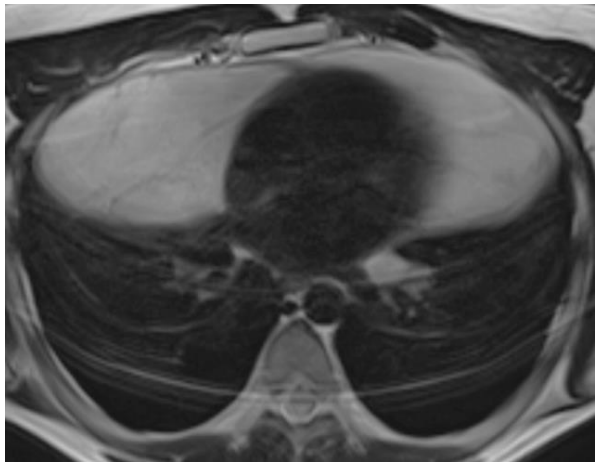
Fat Density

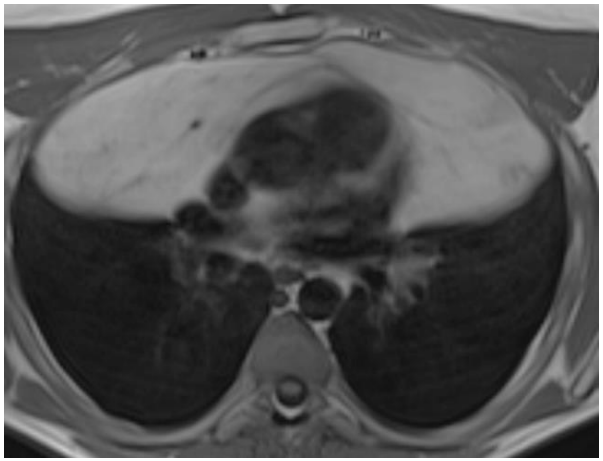
- Fat-containing lesions
  - **Teratoma** ➡
  - Thymo-lipoma ➡
- Fatty lesions
  - Lipoma
  - Liposarcoma ➡
  - Lipoblastoma ➡
- Mediastinal Lipomatosis ➡
- Extramedullary hematopoiesis ➡
- Hernias ➡

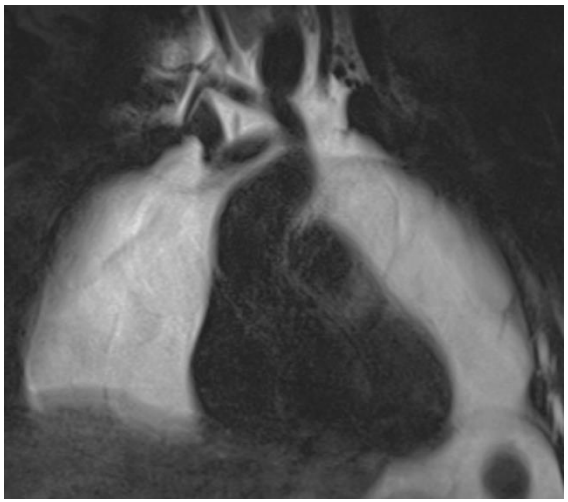
Biblio
- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
- *Adult Chest Imaging 3rd edition - Edited by Philippe Grenier*

Thymolipoma

- Epidemiology: 5% of thymic tumors
- Treatment: Surgical resection







Imaging
- **Voluminous tumor** (up to 20cm)
- **Well encapsulated**
- Repressed by neighbourhood structures
- **Fat content+++** + *septa* + thymic tissue
- Location: **cardio phrenic angle ++**
- MRI: hyperT1 and Fat Sat suppression
- Differential diagnosis
  - Mediastinal Lipomatosis
  - Liposarcoma

Biblio
- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
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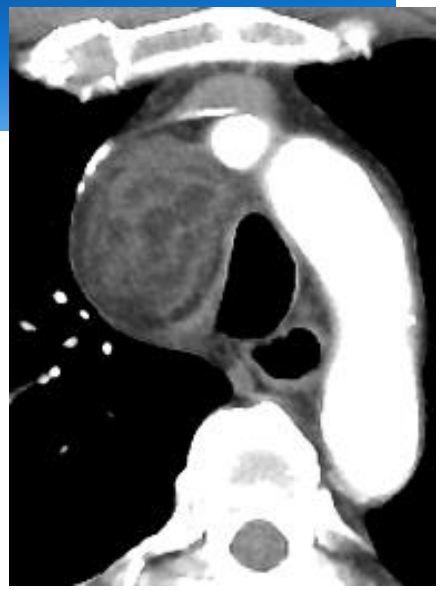
Liposarcoma

- **Rare**, 40 to 60 years old
- Long-term local aggressivity
- Clinical: weight loss, cough, pain, upper basement syndrome, asymptomatic
- Treatment: surgical (risk of recurrence) / radiotherapy



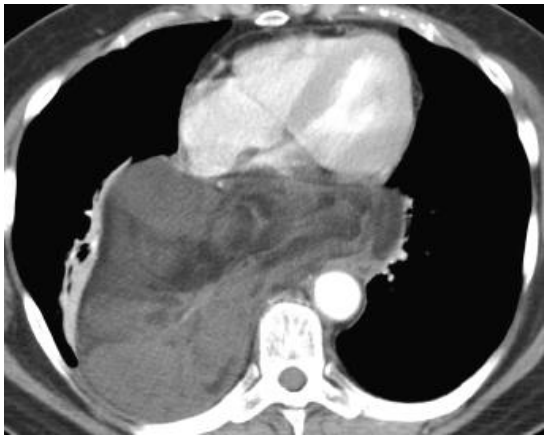
Liposarcoma "lipoma like"
Case courtesy of Dr Yune Kwong, Radiopaedia.org, rID: 32453

Imaging

- Mixed: **fat + tissue**
- Arguments for liposarcoma
  - **Tissular component / infiltration**
  - **Ill defined borders**
  - **Infiltration/invasion of** mediastinal structures

4 types

- ***Well differentiated +++ (*<50%) (low grade)
  - 4 subtypes including "lipoma like"
- ***Myxoid ++*** (intermediate grade)
- *Pleiomorphic* (high grade, metastasis++)
- *Round-cell*



Courtesy of the thorax Nancy

Biblio
- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
- *Adult Chest Imaging 3rd edition - edited by Philippe Grenier*

Lipoblastoma

- Rare
- Field: **Child+++**(90% before 3 years-75% before 12 months) / Teenager
- Topography: extremities +++ (2/3), mediastinum, retroperitoneum
- Tends to extend: neck, diaphragm
- Treatment: curative surgery

2 forms
- Lipoblastoma = encapsulated form
- Lipoblastomatosis = non-encapsulated form

Biblio
- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
- *Adult Chest Imaging 3rd edition - Edited by Philippe Grenier*

Mediastinal Lipomatosis

Abundant mediastinal fat, not encapsulated

Location
- Mediastinal (cardiophrenic angle)
- Cervicomediastinal

Enabling factors
- Cushing
- Steroids
- Obesity

Biblio
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Hibernoma

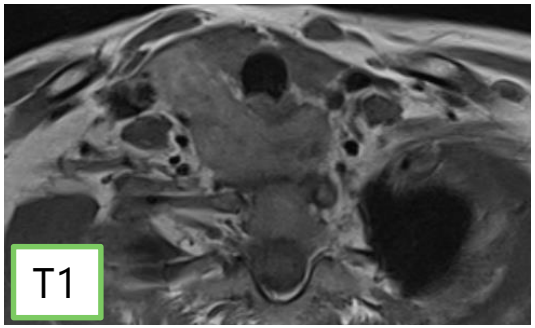
Benign fatty tumour derived from residual fetal brown fat

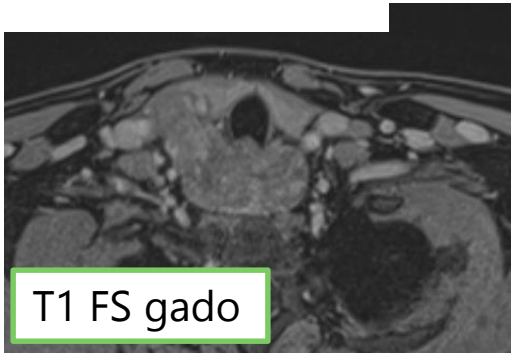
- "hibernoma" because it looks like the fat of hibernating animals...
- Location
  - Thigh ++, shoulder, back
  - Neck, Thorax
  - Arm
- Treatment: Surgical resection

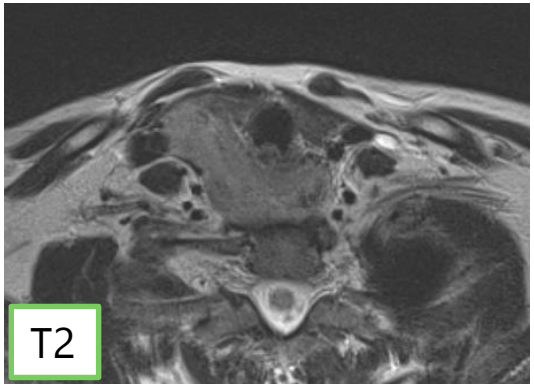
CT SCAN
- Density: **fat → muscle**
- **Well limited**
- Caspule
- **Discret enhancement**

MRI
- **Hyper T1 and T2 < subcutaneous fat**
- +/- flow voids
- Fat sat: incomplete saturation

PET scan
- **Hyperfixation +++**







Posterior cervico-thoracic hibernoma

Biblio
- *Chest Course Nancy - Mediastinal lesions Radiological aspects*
- *Adult Chest Imaging 3rd edition - edited by Philippe Grenier*

Enhancement +++

Thyroid or parathyroid mass
- 10% of mediastinal tumors
- Goiter
- Thyroid adenoma/carcinoma
- Ectopic parathyroid adenoma/carcinoma

Castelman's disease
- Ubiquitous, right paratracheal, hilar, young adult, hyaline vascular type++, single non-invasive (50%) or invasive (40%) mediastinal mass, enhancement+++

Paraganglioma
- Posterior mediastinum mass (catecholamine secretion) or medium, enhancement +++, Ca

Carcinoid tumor
- Anterior mediastinum

Ganglion metastasis
- Thyroid, sarcoma, melanoma...

Extramedullary hematopoiesis
- Anemia, asplenia, costovertebral gutter, tissue + fat+++

Biblio
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Castelman's disease

Angiofollicular node hyperplasia : benign B-cell lymphoproliferation + capillary proliferation + endothelial hyperplasia

- **Young adults ++** 20 - 40 years (but at any age)
- 2 morphological types
  - **Unicentric**
  - **Multicentric**
- 2 histological types
  - **Hyaline vascular type +++** (90%): follicular structure, small lymphocytes, vx interfolliculars++
    - Often unicentric +++
  - **Plasma cell**
    - Multicentric +++
    - Few follicular vessels
  - **Associated with HHV8**
- Location
  - **Thorax ≈ 70% +++**
  - Abdomen/pelvis and retro peritoneum (10-15%)
  - Neck (10-15%)

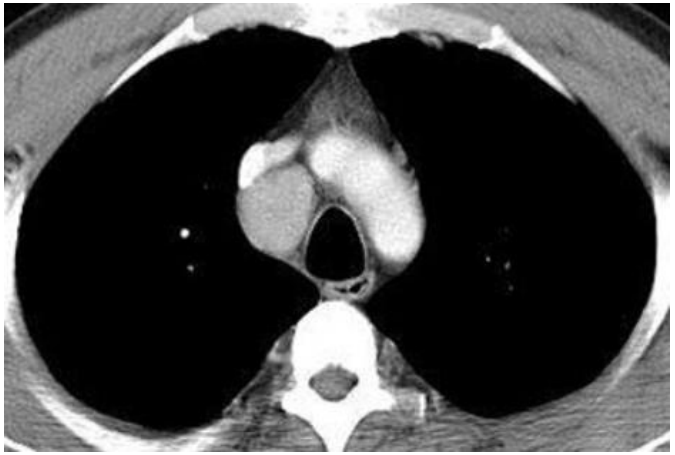
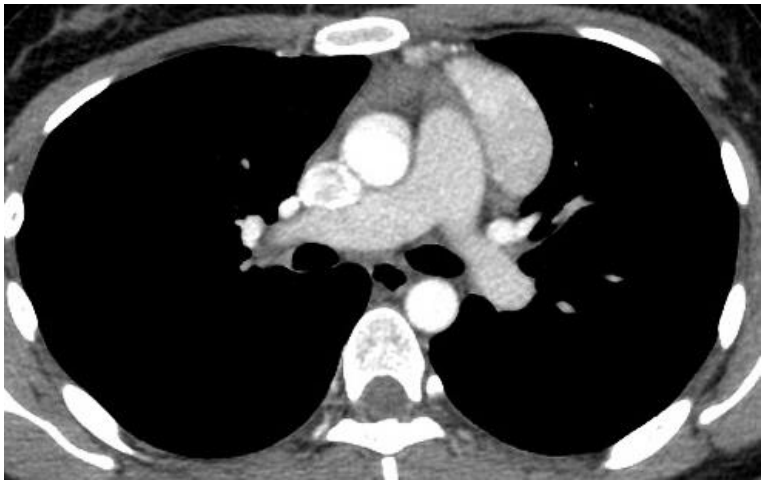


Image from Nancy's chest DU



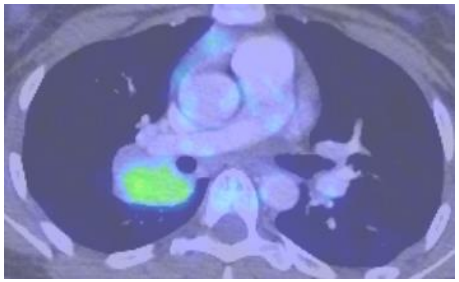
Case courtesy of Dr Vincent Tatco, Radiopaedia.org, rID: 40917

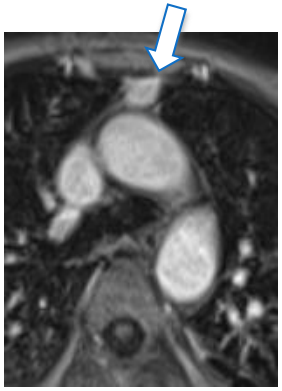
Biblio:

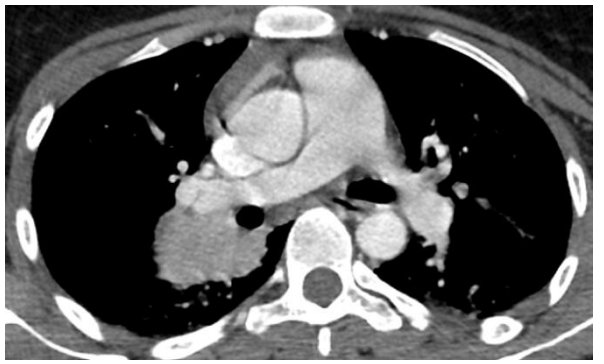
- *Bonekamp D, Horton KM, Hruban RH, et al. Castleman Disease: The Great Mimic. RadioGraphics 2011*
- *Ko SF, Hsieh MJ, Ng SH et-al. Imaging spectrum of Castleman's disease. AJR Am J Roentgenol. 2004*

Hyaline vascular type +++ (90%)

- **Unicentric +++**
- Location: right paratracheal > hilum > posterior mediastinum
- 3 presentations
  - **Single non-invasive mediastinal mass** (50%)
  - **Infiltration mass** (40%)
  - Multiple confluent adenopathies confined to a mediastinal compartment (10%)
- CT SCAN
  - Spontaneously: tissue, homogeneous
  - **Homogeneous intense enhancement +++**
  - Sometimes central hypodensity
  - Calcification (5-10%)
- MRI
  - Iso or hyper T1 /muscle, heterogeneous hyper T2 (sometimes septa to hypoT2), heterogeneous intense contrast





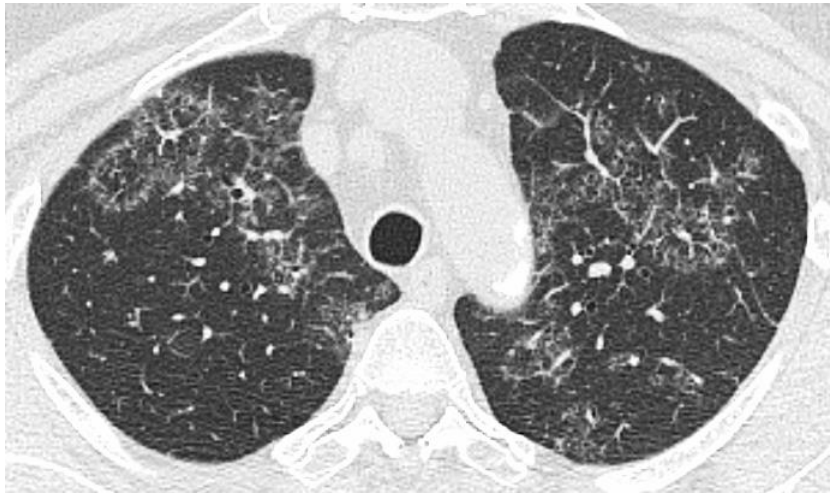


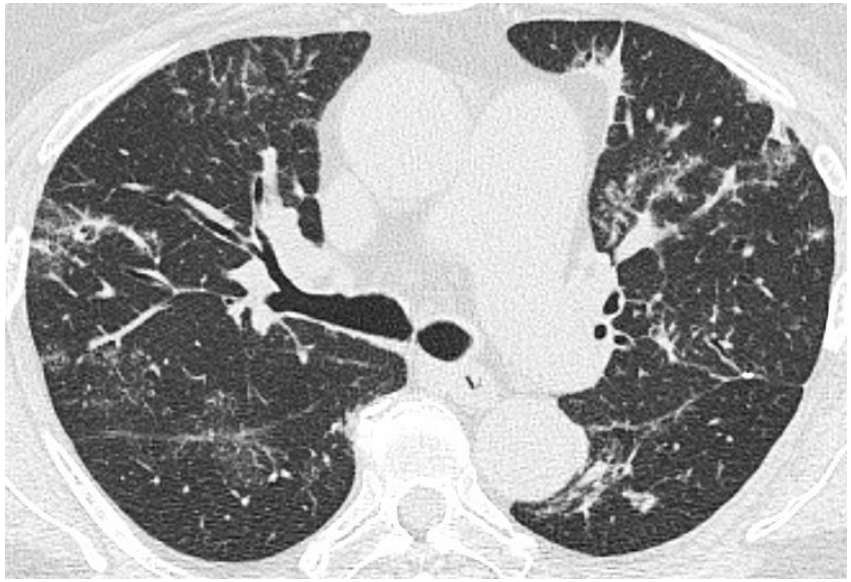
Castelman associated with HHV8

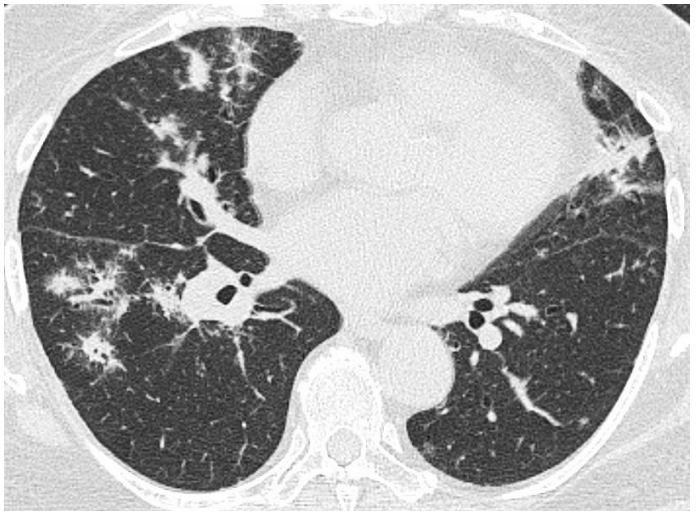
- **Multicentric**
- Plasmablastic Variant
- Low prognosis
- Immunocompromised patient, HIV

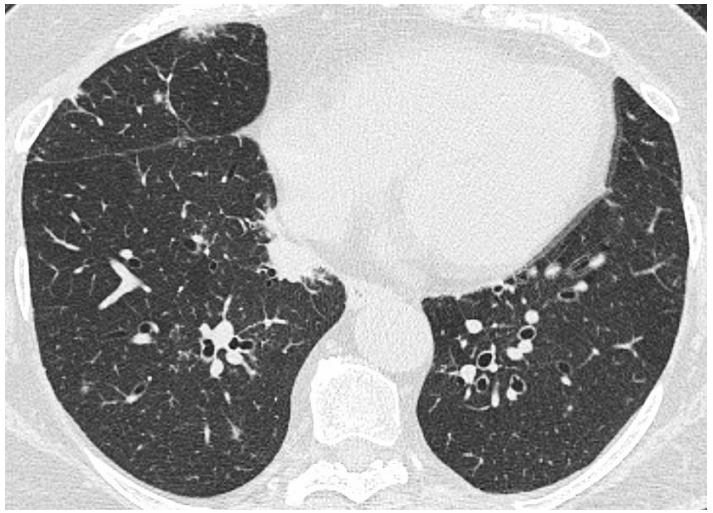
Plasma cell

- **Multicentric +++**
- Bilateral and mediastinal hilar adenopathies
- Centrolobular nodules, ggo, consolidation
- -/+ symptomatic (fever...)



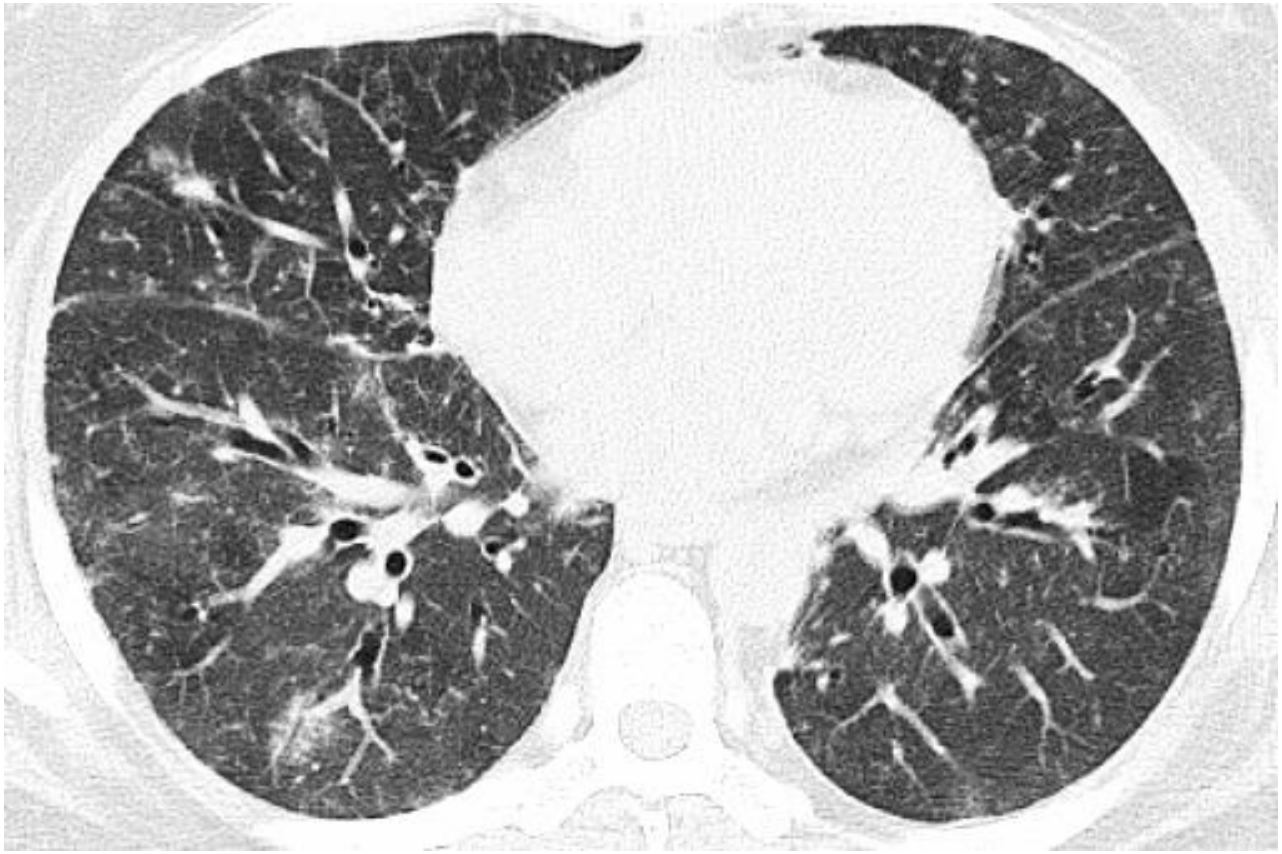






Castelman's disease

Opacity has been gradually increasing over the last 15 years and has become symptomatic in recent months.
Antecedent of MALT
Surgical Pulmonary Biospy
Probably Plasma Cell type

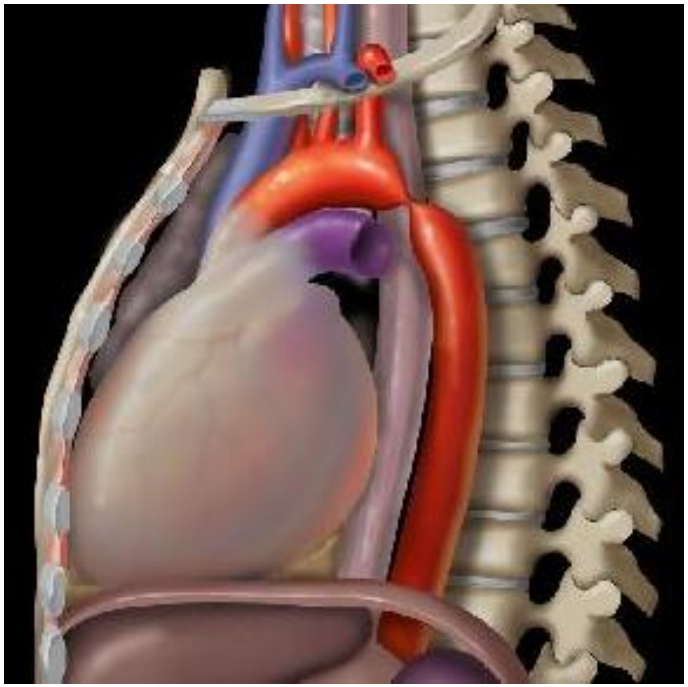


Castelman parenchymal disease

Mediastinum - Vascular abnormalities

- *Aortic Abnormalities*
  - Aortic coarctation
  - Persistent ductus arteriosus
  - Diverticulum of ductus arteriosus
  - Aortic Arc Anomalies
- *Venous abnormalities*
  - Abnormal pulmonary venous return
  - Double superior vena cava
  - Continuation azygos of the inferior vena cava

Aortic coarctation



Aortic lumen stenosis

- 2 sub-types
  - **Infantile (preductal):** diffuse hypoplasia or stenosis just after ABCT to *ductus arteriosus* → vascularization via *ductus arteriosus*
  - **Adult (ductal juxta, post ductal or medioaortic)**
- 5-8% of congenital cardiopathies (bicuspid +++, interventricular communication, transposition of large vessels...), syndromic associations (Turner...)
- Clinic: asymptomatic → chest pain, claudication

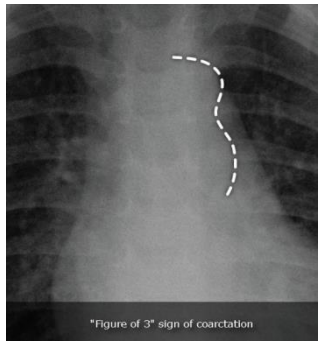
Higgins CB. Radiography of congenital heart disease. In: Webb WR, Higgins CB. Thoracic imaging: pulmonary and cardiovascular radiology (pp742-767). Lippincott Williams and Wilkins. (2011)

Xray

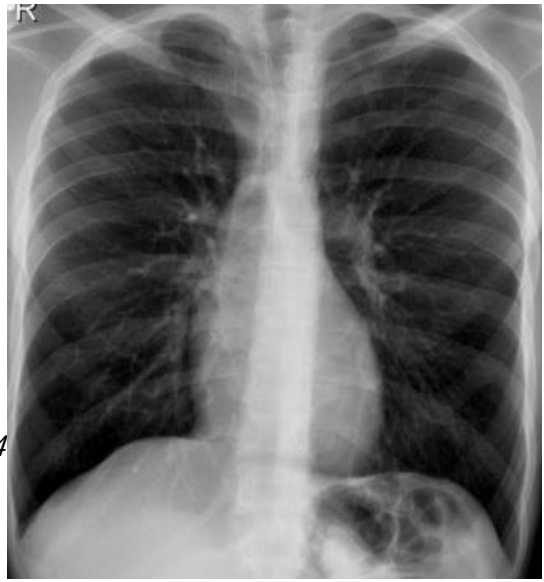
- Sign of figure "3"
- "Inferior rib notching": Roesler's sign.
  - Secondary to dilated collaterals intercostal arteries that form an impression under the ribs (child > 5 years and adult)

Angio CT/MRI, angiography

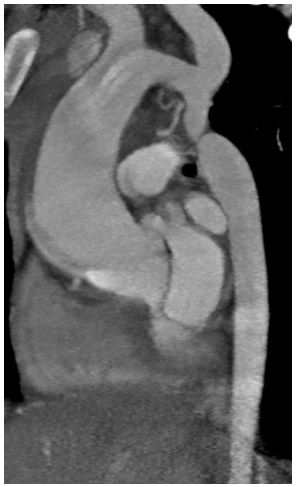
- Direct visualization of stenosis
- and the network of collaterals

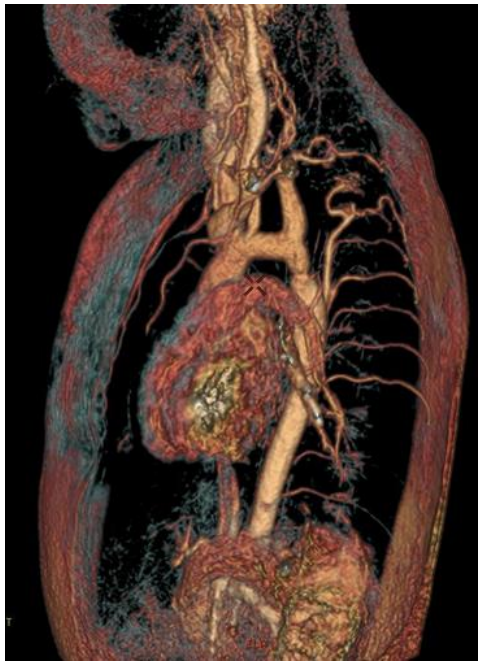


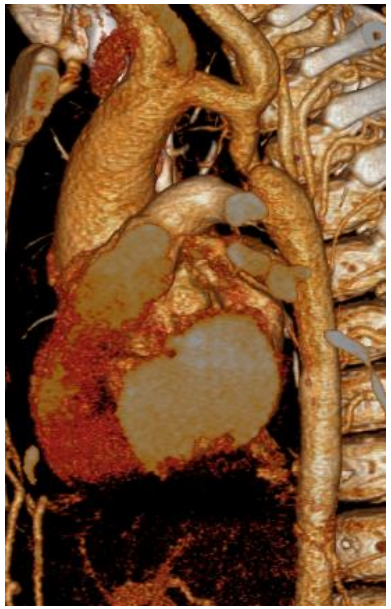
Sign of figure "3"
Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 6274



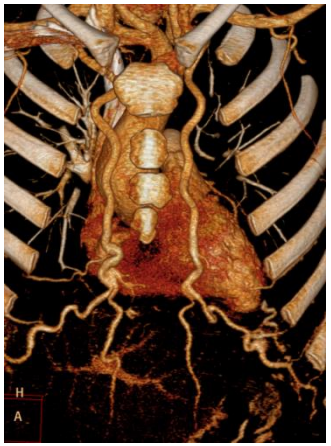
"Rib Notching"
Case courtesy of Dr Hani Al Salam, Radiopaedia.org, rID: 12461

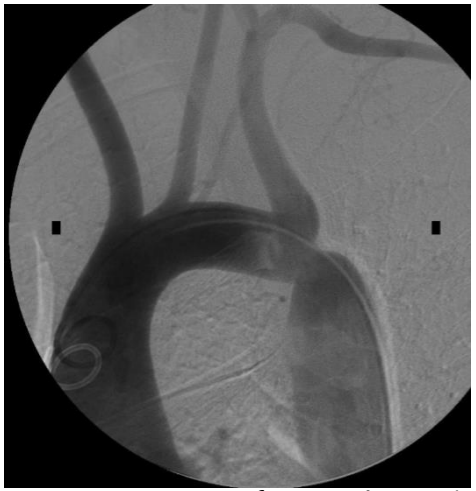






AngioTDM

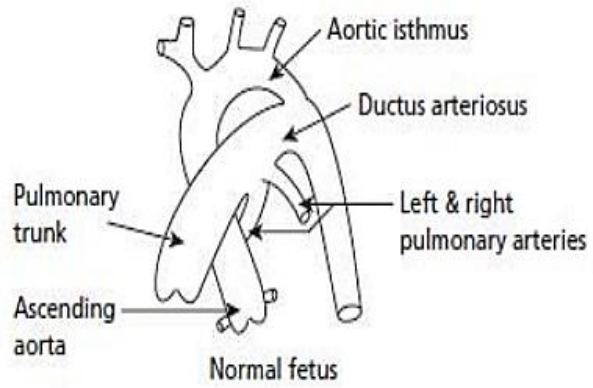




Case courtesy of Dr Andrew Dixon, Radiopaedia.org, rID: 18771

Patent ductus arteriosus

Definition ductus arteriosus: **normal connection during fetal life between the aorta and the pulmonary artery**, developed from the 6th aortic arch, during the 6th week of development, **physiological closure 48H after birth.**

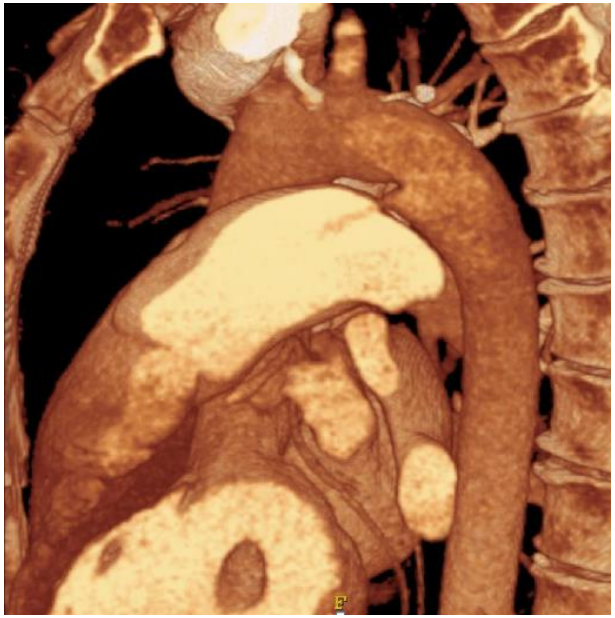


Persistent DA

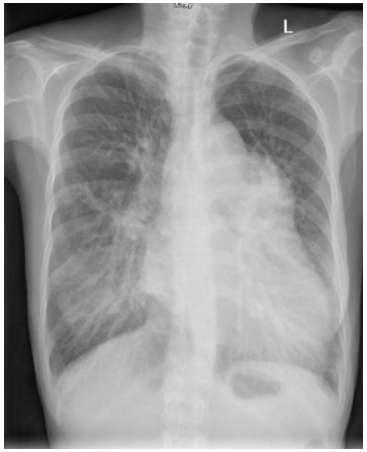
- Frequent, 5.3 to 11% of congenital heart disease, 3 F/ 1 H
- 1/3 of patients die before the age of 40.
- Pathophysiology: DA persistent isolated: Left → right / Ao → AP → Shunt post Tricuspid, volume overload left cavities and PA
- Complications
  - **Heart Failure**
  - Infectious endocarditis
  - **HTAP – Eisenmenguer syndrom**
  - Aneurysm - rupture - systemic embolism
- Treatment
  - Medical: NSAIDs in premature infants
  - Endovascular: prothesis
  - Surgical: ligature or section/suture

- **Isolated**
- **Or in association**
  - ***other congenital cardiac abnormalities***: tetralogy of Fallot, Eisenmenger's syndrome, hypoplasia of the left heart, pulmonary artery atresia.
  - ***other pathologies***: prematurity, surfactant deficiency, Trisomy 18 and 21, rubella, etc.

- *Goitein O, Fuhrman CR, Lacomis JM. Incidental finding on MDCT of patent ductus arteriosus: use of CT and MRI to assess clinical importance. AJR 2005*
- *Morgan-Hughes GJ, Marshall AJ, Roobottom C. Morphologic assessment of patent ductus arteriosus in adults using retrospectively ECG-gated multidetector CT. AJR 2003*



Radiographic signs



- Cardiomegaly (left heart)
- Dilatation of the pulmonary artery trunk
- Frequent pulmonary edema

CT Signs

Direct signs

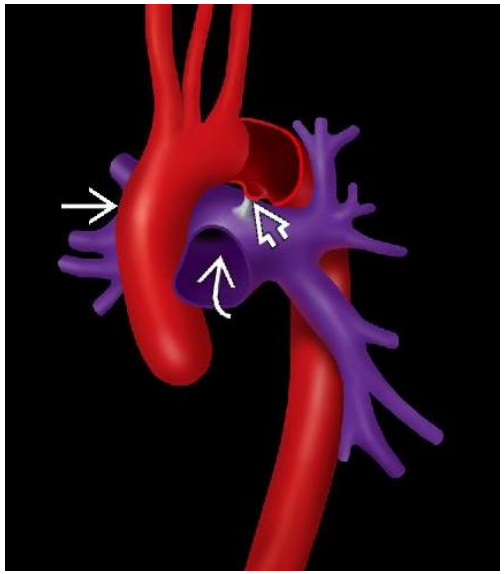
- **Visible arterial canal**
- Communication Ao - PA

Indirect signs

- **Dilatation Ao ascending + aortic isthmus**, normalization of diameter Ao descending
- **Cardiomegaly ++** (**OG + VG** dilatation)
- **Enlargement of the right ventricle**
- **Dilatation ++ of the PA trunk**

Ductus Diverticulum

- **Ductus diverticulum** (just downstream of the left subclavian artery)
- Differential diagnosis: **traumatic rupture of the isthmus**
- Enlarged *Ductus*: Aneurysm



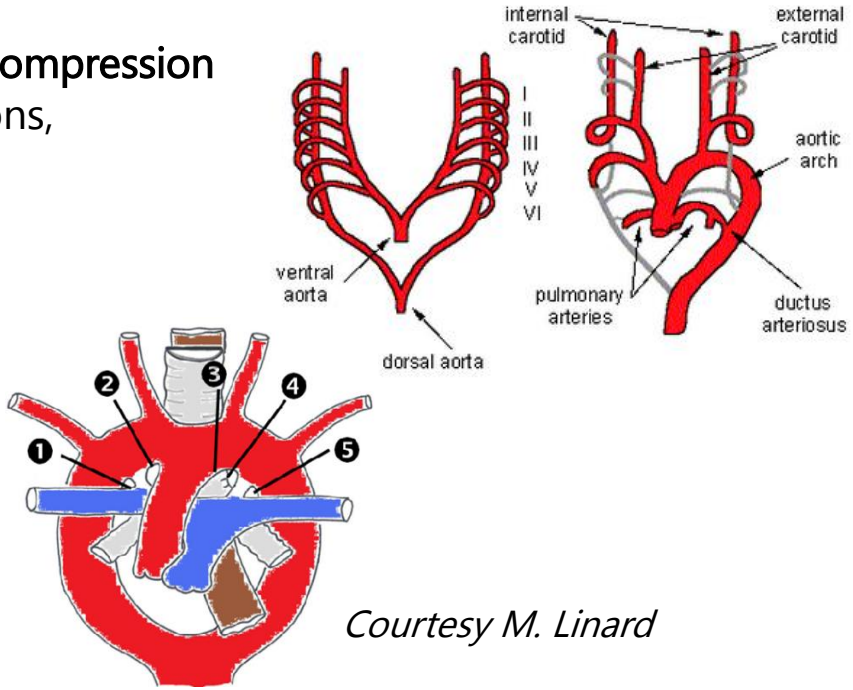
Features +++ (important for differential diagnosis of isthmus rupture)

- **Smooth edges**
- **Obtuse angles** with aortic wall (sometimes acute)
- **No intimal flap**
- **Normal mediastinum** (not hemomediastinum)

Aortic Arc Anomalies

Abnormal development of the aortic arches -> encirclement +/- complete trachea, oesophagus

Clinical: asymptomatic or **tracheo-esophageal axis compression** (-> newborn stridor, respiratory gene, pulm infections, dysphagia...).



Courtesy M. Linard

Anomalies of the 4th aortic arc

Cut-off sites

- **1** Normal aortic arch
- **2** Aberrant right artery under clavicle on left aorta
- **3** Aberrant brachiocephalic arterial trunk on right aorta
- **4** Aberrant left subclavian artery on right junction
- **5** right aorta with mirror arrangement
- Double aortic arch
- Length anomaly of the 4th aortic arch: Aorta "kingking"

6th Aortic Arc Anomalies

- Agenesis of a pulmonary artery
- Retrotracheal left pulmonary artery

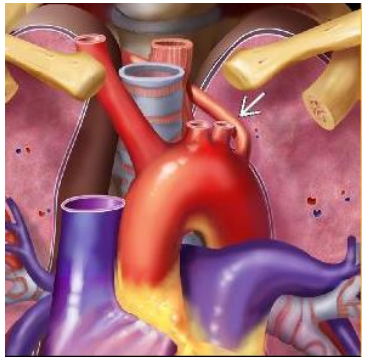
Imaging

- Chest X-ray: if right aorta -> left deviated trachea
- TOGD: Abnormal fingerprints
- Sectional imaging provides an anatomical diagnosis, objective compression and guides surgical treatment.

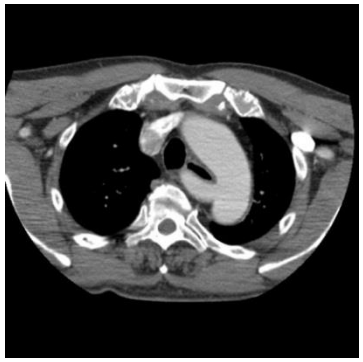
Diagnosis of 4th and 6th Aortic Arc Deformities: Contribution of the scanner.M. Linard, M. Arrot-Masson, J. Goupil, V. Pineau,F. Belloy, B. Richter- Pôle d'Imagerie, Service de Radiologie CHU CAEN

2) Retro-esophageal aberrant right subclavian artery on left aorta

- Most frequent abnormality (0.5% of subjects), mass effect on posterior face of the esophagus.
- *Dysphagia lusoria*



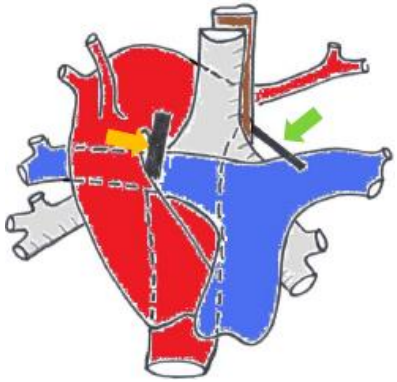
Courtesy Diagnostic imaging



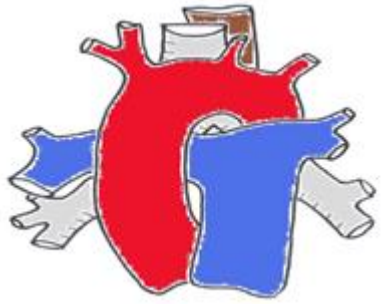
Case courtesy of Dr Mohammad A. ElBeialy, Radiopaedia.org, rID: 35607

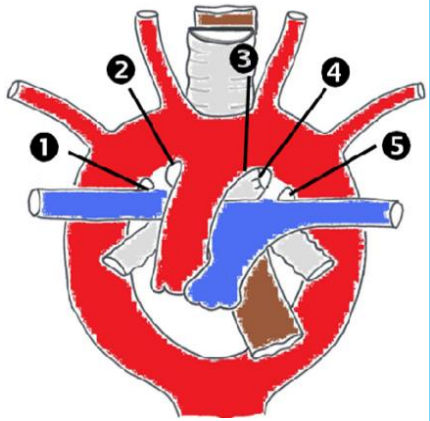
3) Aberrant brachiocephalic arterial trunk on right aorta

- Arterial ligament on the **left** (→ vasculoligamentary ring) or on the right



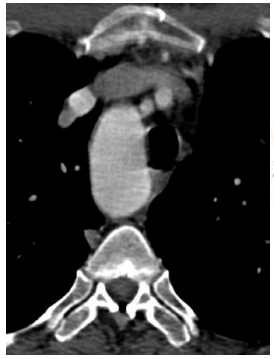
NORMAL

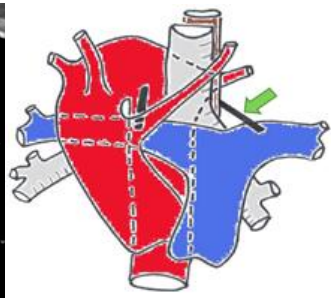


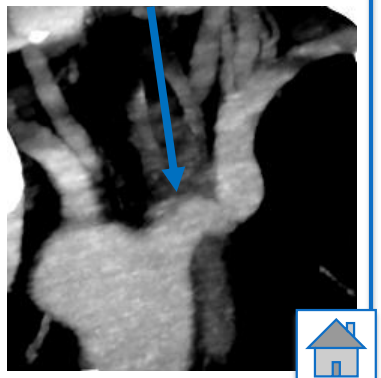


4) Aberrant left subclavian artery on right crosspiece

- Right aorta + arterial ligament (connecting the left pulmonary artery to the tranverse aorta) → vascular-ligamentary compressive ring around the trachea and oesophagus, defining a **Neuhauser's anomaly**
- The bulge at the origin of the left subclavian retroesophageal artery, where the arterial ligament is inserted, is called **Kommerel's diverticulum.**

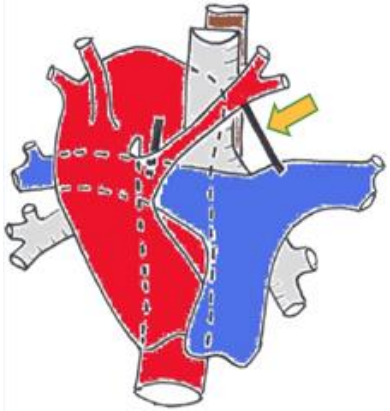


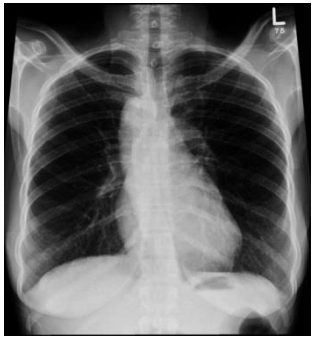




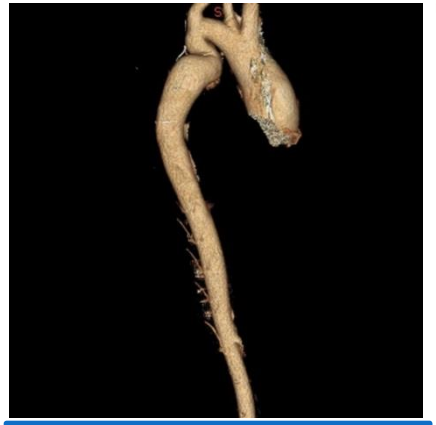
5) Straight stock with "mirrored" arrangement

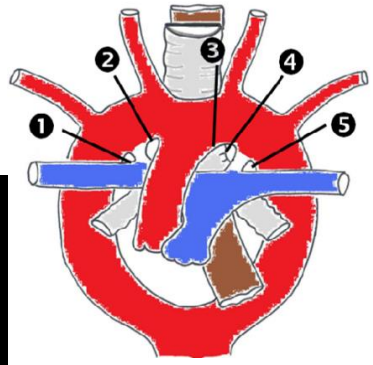
- In 98% of cases associated with congenital heart disease (tetralogy of Fallot++)





Case courtesy of Dr Hani Al Salam, Radiopaedia.org, rID: 8416



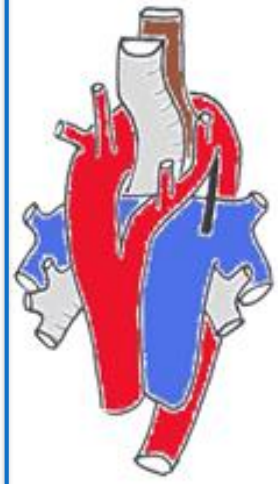


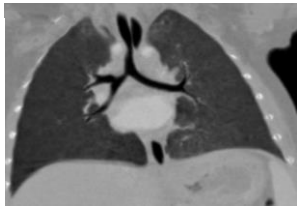
Length anomalies of the 4th aortic arc:
Aortic kinking

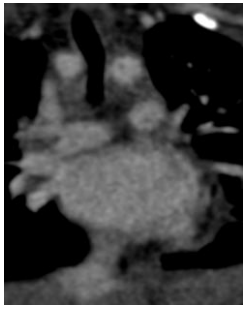
Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 8218

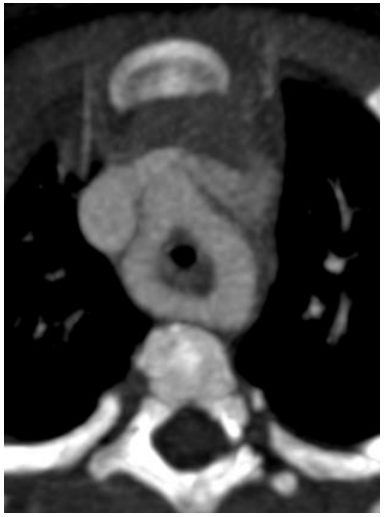
Double aortic arch

Absence of total or partial regression of the 2 arcs





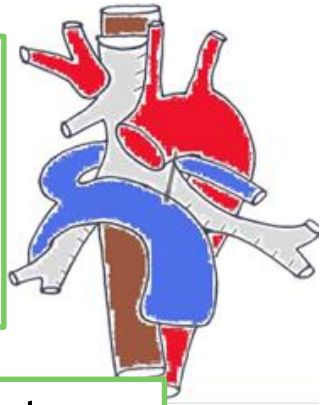




6th Aortic Arc Anomalies

Retrotracheal left pulmonary artery

- Severe, with noisy symptomatology from the neonatal period onwards



Agenesis of a pulmonary artery:
see corresponding chapter

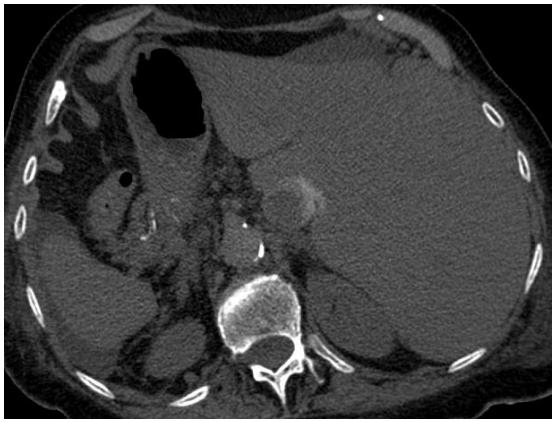
Situs inversus

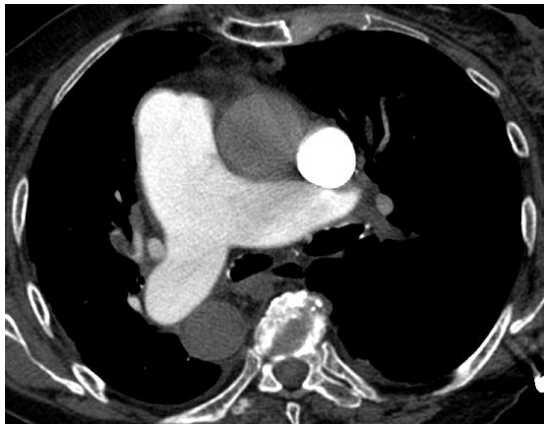
- **Reverse position of the organs.** *Total* when inversion of all abdominal + thoracic organs
- Often associated with
  - A **dextrocardia** +/- cardiac malformation (transposition of large vessels)
  - A **right thoracic aorta**

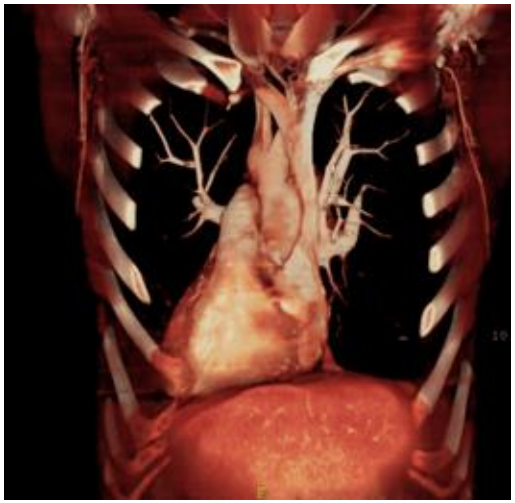
20% have **Kartagener syndrome**

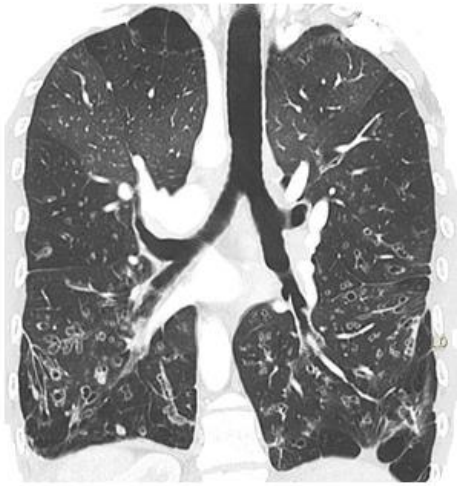
Association

- **Ciliary dyskinesia**
  - **Bronchiectasis**
  - **Naso-sinusal polyposis**
- **Situs inversus** or dextrocardia (50%)
- Aplasia of frontal sinuses





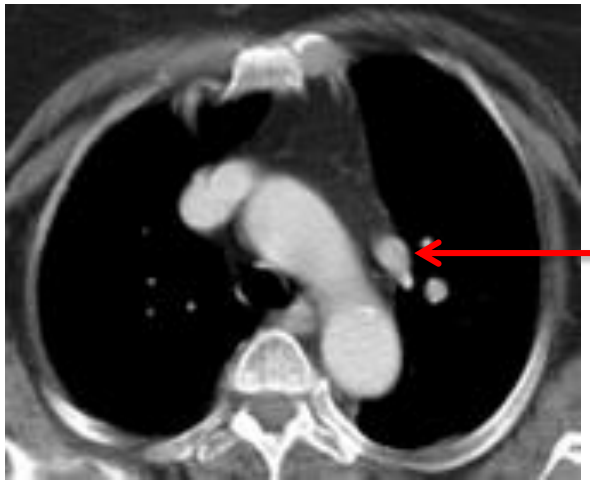




Abnormal pulmonary venous return (APVR)

Drainage of one or more pulmonary veins in the systemic venous system

- Left-right shunt
  → Hyperdebit
- Types:
  - Complete: supra-cardiac, cardiac, infra-cardiac, complex
  - Partial: Simple, Scimitar Syndrome, IAC Sinus venosus.



Case courtesy of Dr Ahmed Abd Rabou, Radiopaedia.org, rID: 34707

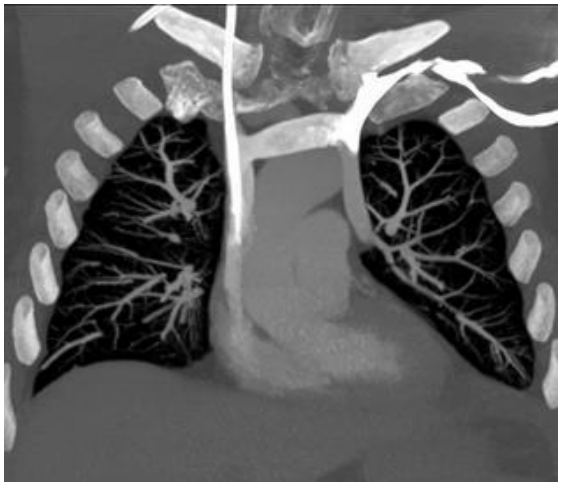
Abnormal Partial Pulmonary Venous Return Simple

Left upper pulmonary vein draining into the left brachiocephalic venous trunk

When you see a vascular structure in a left para-aortic situation

→ APVR

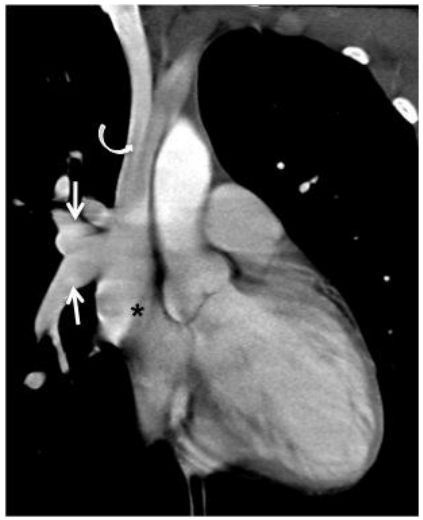
→ Double SVC

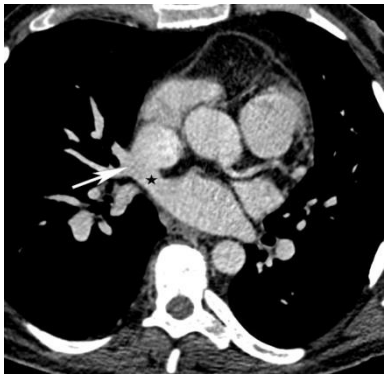


Case courtesy of Dr Cathal O'Brien, Radiopaedia.org, rID: 44093

Partial APVR: IAC / *Sinus venosus*

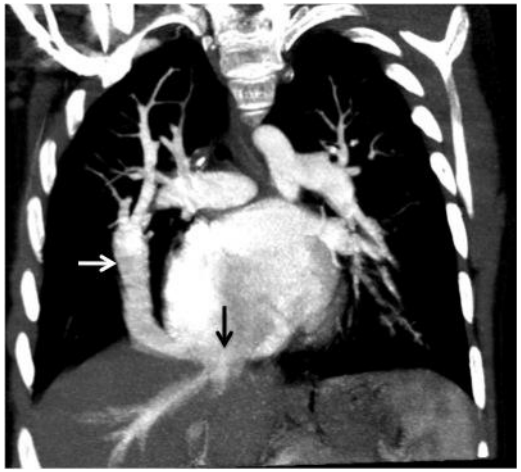
Pulmonary vein drains in front of a high IAC.

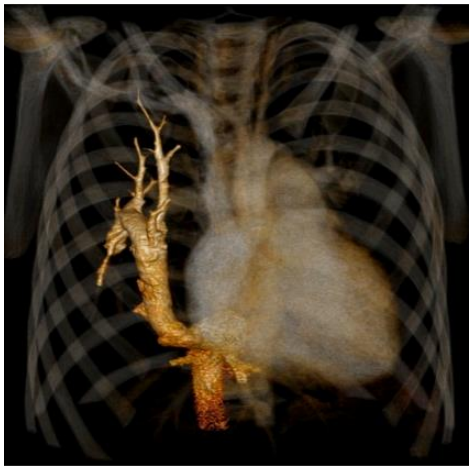




Partial APVR: Cemetery

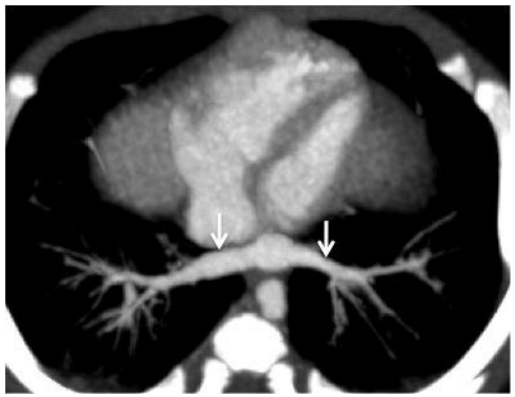
Pulmonary vein draining the right lung with drainage at the RA/IVC junction

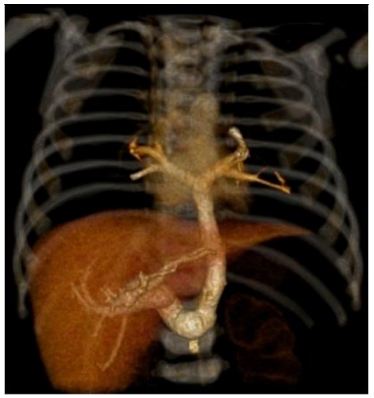




Full APVR Infra-Cardiac

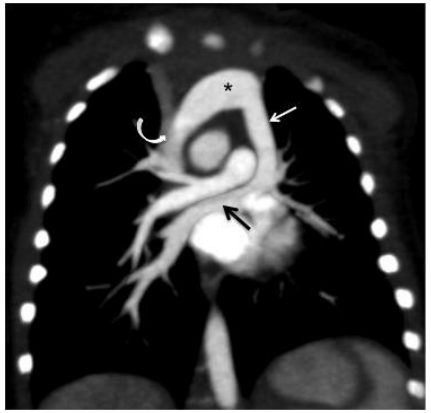
Collector draining into the trunk of the heart with infracardiac drainage

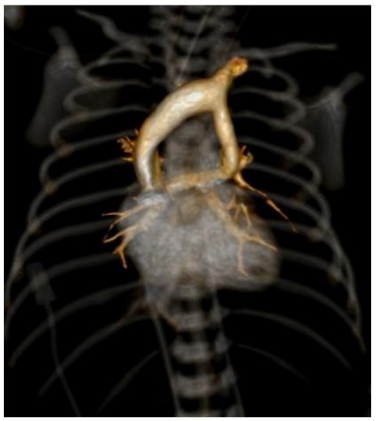




Complete Supra-Cardiac APVR

Collector draining supracardiac through the left innominate venous trunk then VCS

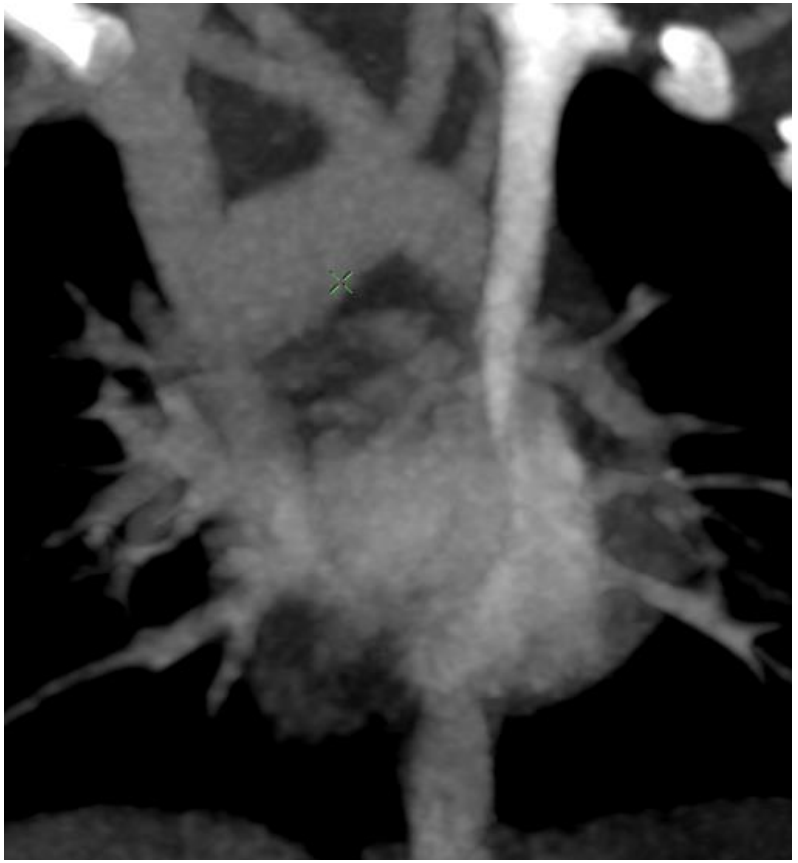




Double SVC

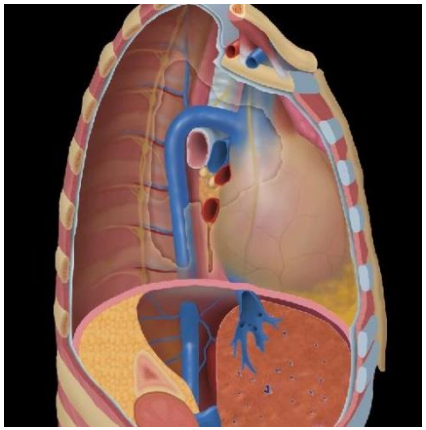
Double SVC

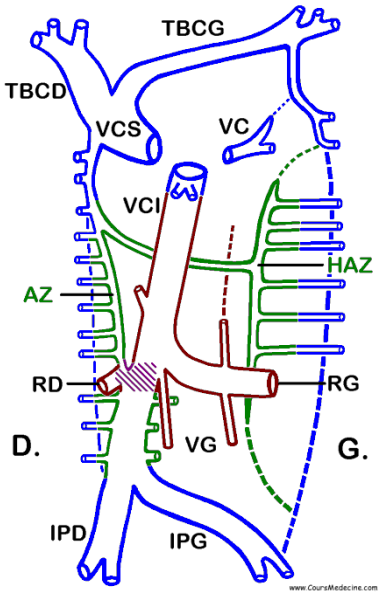
→ Left SVC draining into the coronary sinus

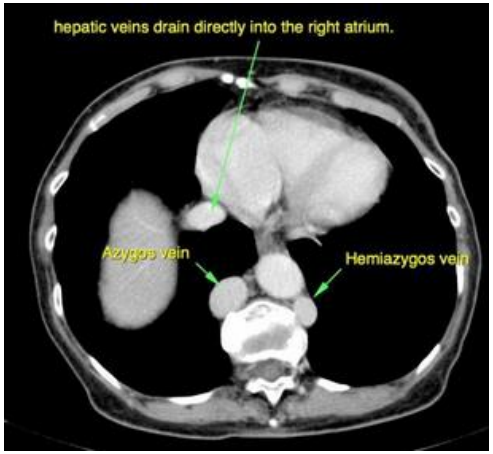


Continuation azygos of the IVC

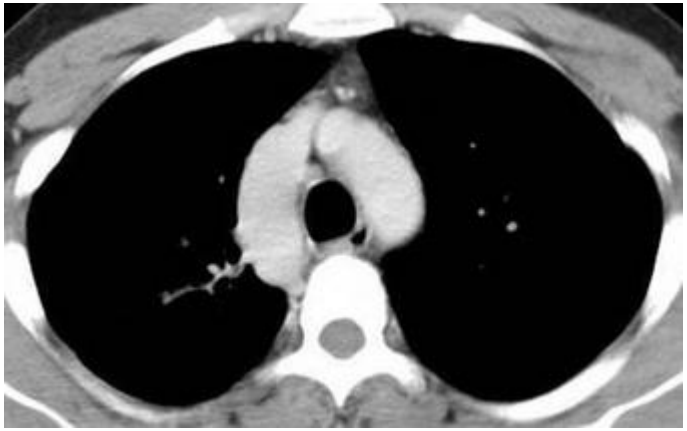
Continuation azygos of the IVC
- **Interruption of IVC above the renal veins**
- Hepatic veins → RA
- **Enlargement of the azygos vein** (right of the aorta) and the arch of the azygos.



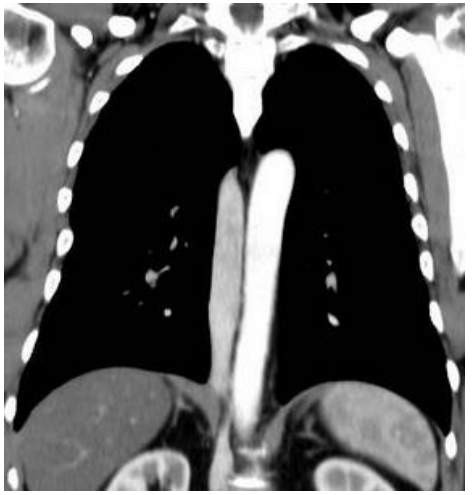




Case courtesy of Dr Bruno Di Muzio, Radiopaedia.org, rID: 22642



Case courtesy of Radiopaedia.org, rID: 11228



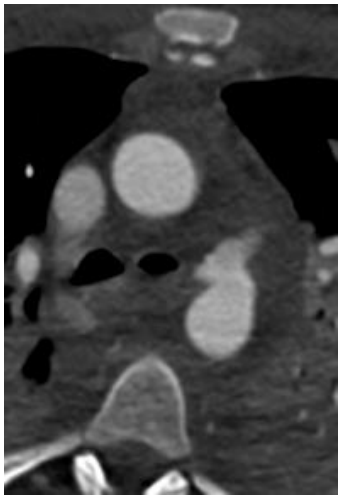
Case courtesy of Dr Abdallah Khateeb, Radiopaedia.org, rID: 44697

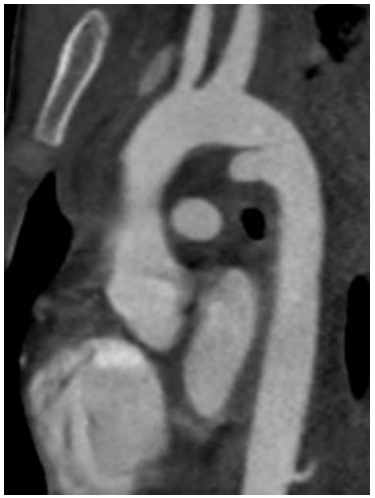
Mediastinum -
Trauma / hernia / infectious

- Rupture of the aortic isthmus
- Diaphragmatic rupture
- Diaphragm eventration
- Hernias
- Broncho-esophageal fistula
- Esophagitis
- Achalasia
- Mediastinitis
- Boerhave Syndrome
- Fibrosing mediastinitis

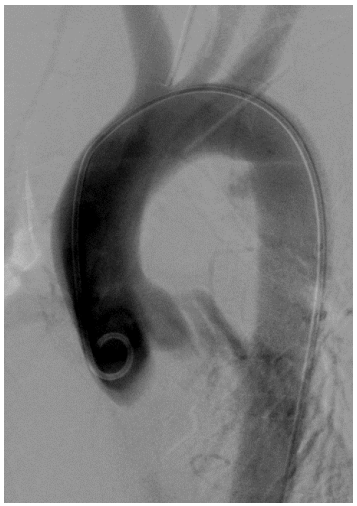
Rupture of the aortic isthmus

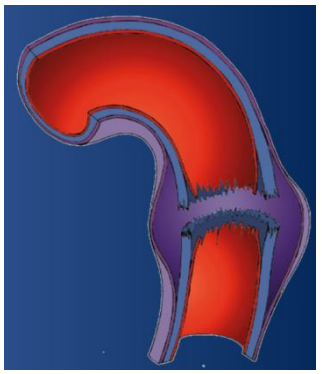
- **Sharp deceleration** (high kinetic accident +++)
- **Isthmic location (90%)** because segment 1 and 2 mobile and segment 3 fixed





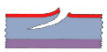
Stage 3 isthmus rupture





Stage

1/ Intimo-medial laceration
Low/no risk of aneurysm



2/ Subadventiel rupture
Emergency or delayed

3/ Total rupture(hemomediastinum)
Extreme Emergency

Differential diagnosis

Aortic diverticulum

- **Smooth edges**
- **Obtuse angles** with aortic wall (sometimes acute)
- **No intimal flap**
- **Normal mediastinum** (no hemomediastinum)

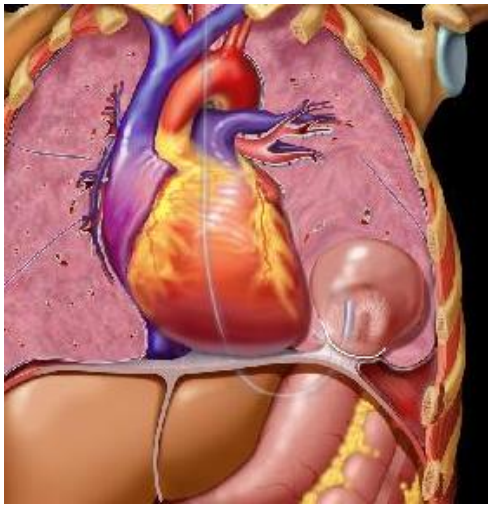
2 forms

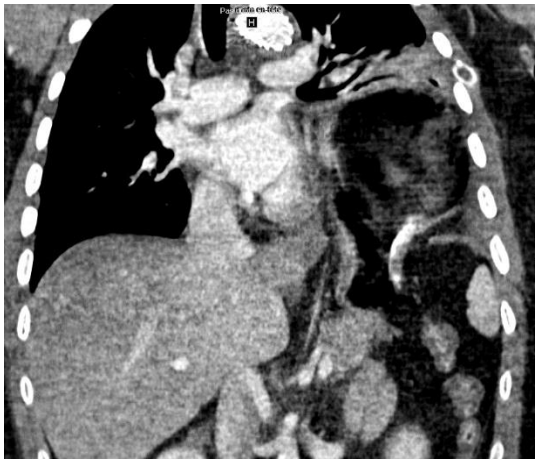
- **Round** shape
- **Spicular** shape (DD difficult): oblong or pointed addition image, directed towards the PA +/- calcification, analogy with persistent ductus arteriosus.
  → Addition image without any sign of intimate rupture ("**smooth aortic light**")

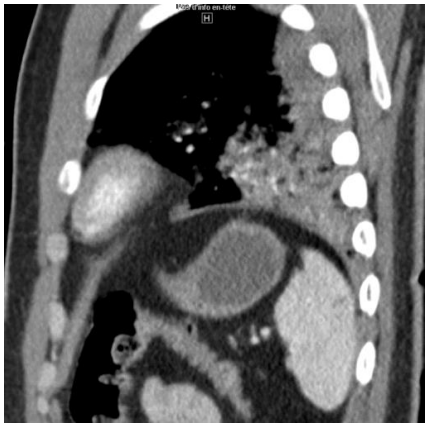
Diaphragmatic rupture

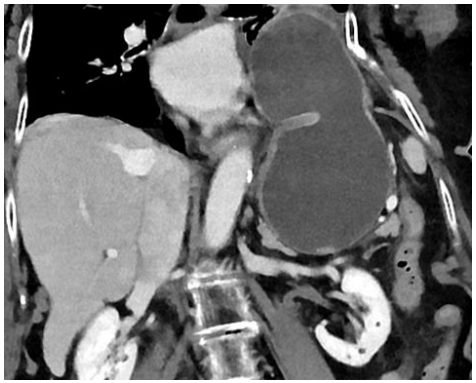
Post-traumatic hemi-diaphragm injury

- **Violent trauma** (association of lesional rupture of the aortic isthmus, ...)
- Frequency R>>L
- Clinical manifestations Left (70-80%)







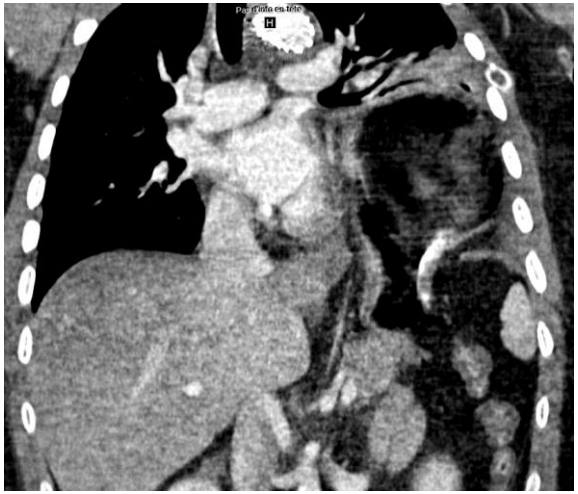


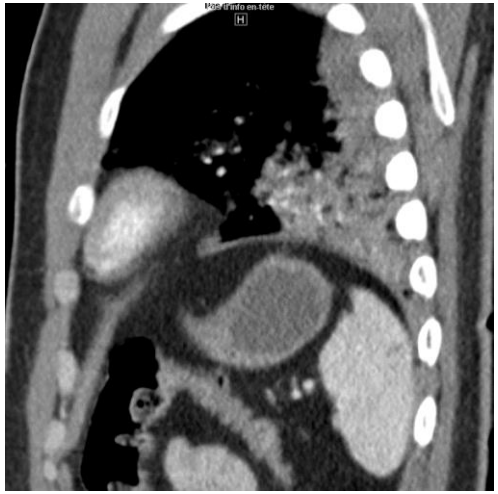
CT+++

- **Dome** (fibrous portion) ++
- **Discontinuity**
- **Thickening** (shrinkage, hematoma): 30%.
- **Hernia** (intestine, stomach, liver) with strangulation

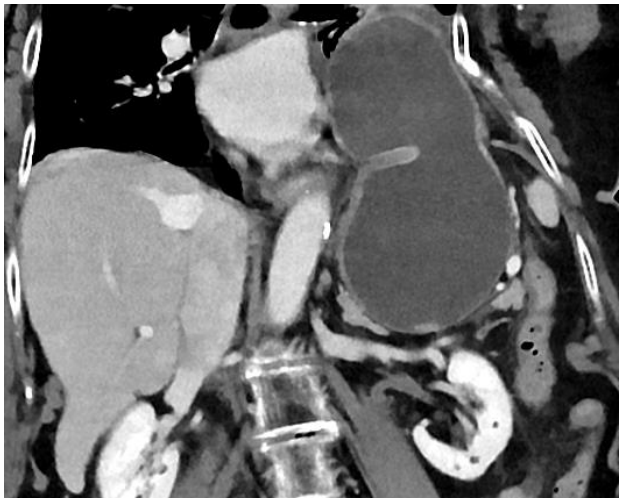
Diaphragmatic rupture

Highly kinetic polytrauma, rupture of the aortic isthmus (stent)
At D3: discovery of an intrathoracic hernia through the diaphragmatic rupture.

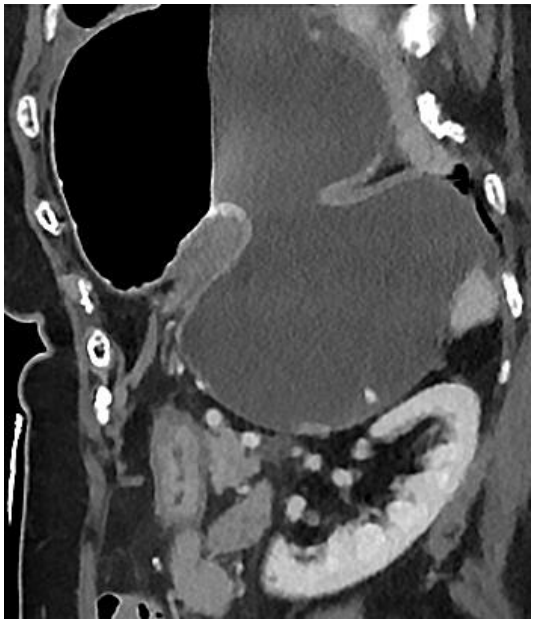




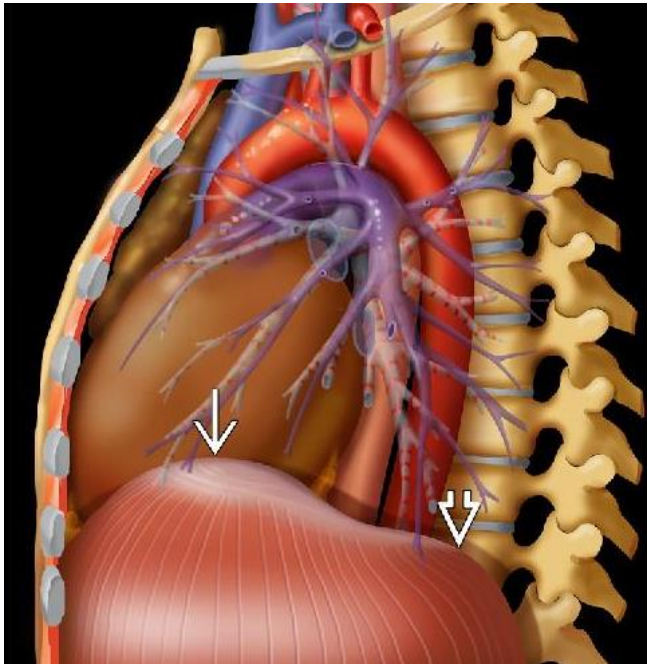
*A posteriori, **visible defect in the** anterior part of the dome at J1*



Diaphragmatic rupture
Gastric hernia
Traumatic ATCD with hemothorax



Diaphragm enventration



- **Weakness and non-paralytic thinning of the diaphragm** (anterior part and dome)
- **Normal posterior part**
- Complications: atelectasis, pneumonia.

Differential diagnosis

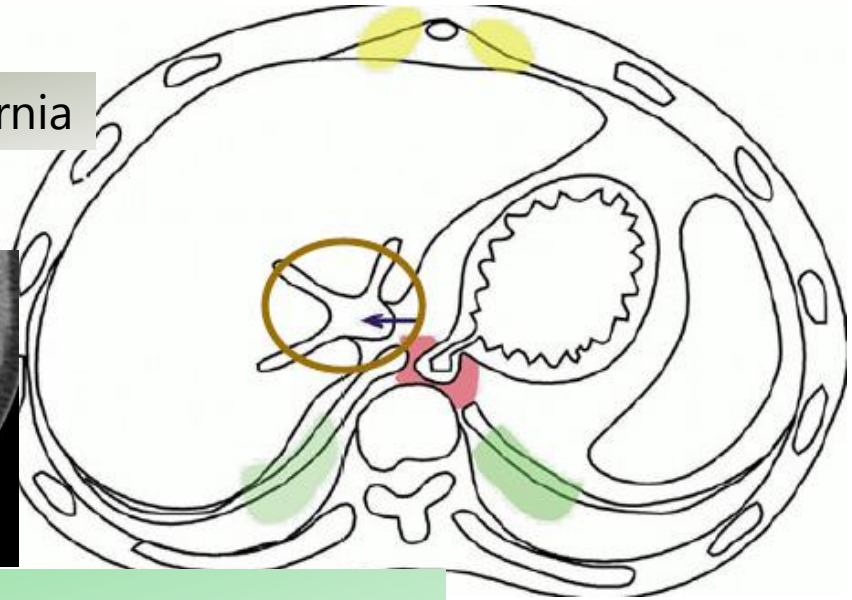
- Paralysis
- Rupture
- Morgani's Hernia

Hernias

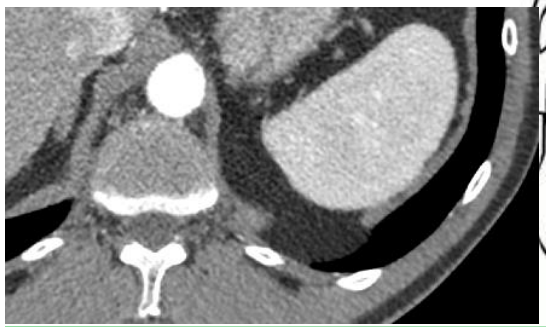
Morgani
- through the anterior parasternal hiatus
- Omentum, GIT (colon), gastric volvulus

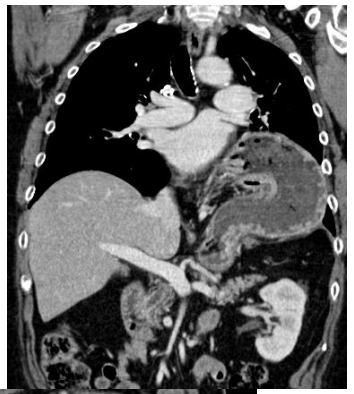
Larrey

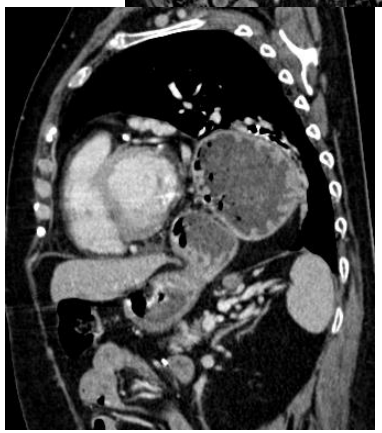
Hernia by **esophageal hiatus**



Juxta-cava hernia







Bochdalek
- Through the posterior pleuro-peritoneal hiatus
- Fat, kidney, GIT, L++,

Bronchoesophageal fistula

- In adults
  - **Malignant tumor**
  - **Iatrogenic**: EC, trauma, iatrogenic lesions
- Insidious
- Symptoms
  - **Chronic cough (++ at mealtime)**
  - Asthma
  - Recurrent infections
  - DDB
  - Hemoptysis

Esophagitis

Infectious esophagitis

- **Immunosuppressed** patient, transplantation, AIDS
- **Candida, Herpes, CMV**
- **KB** (contiguity via adenopathy++) → fistula
- **Mucosal** damage

Eosinophilic esophagitis

- **Chronic immune** disease with eosinophilic inflammation, 2nd to 5th decade, M>W, **atopy ++**
- Endoscopy: longitudinal grooves, white exudates, **rings,** contractions, oedema, stenosis.
- CT: **diffuse thickening**

Stefan L. Idiopathic Eosinophilic Esophagitis in Adults: The Ringed Esophagus. Radiology 2005;

Caustic esophagitis

Following accidental/suicidal ingestion of caustic
If acidic substance, respect stomach

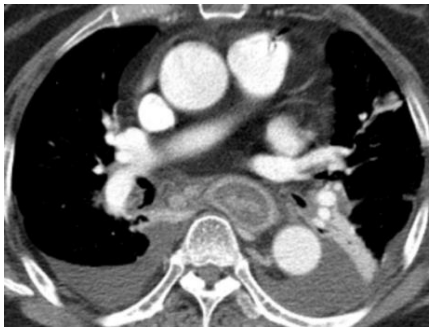
- D0-D10: **ulceration, necrosis, dilated esophagus, atonic, perforation.**
- J10-J20: same with stenosis
- After D21: fibrosis with strictions

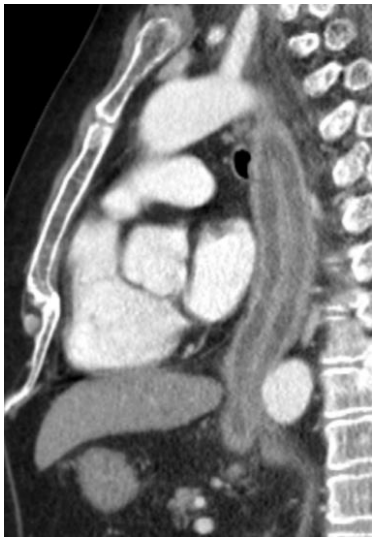
Muhletaler CA, Gerlock AJ, de Soto L and-al. Corrosive acid esophagitis: radiographic findings. AJR Am J Roentgenol. 1980

Phlegmonous esophagitis

- **Whole GI tract**, stomach++
- Submucosa, sometimes affect muscularis mucosa and serous → perforation
- Favored by **immunosuppression**, alcoholism, ulcer, neoplasia... sometimes without factors (50%)
- CT: **circumferential thickening with hypodensity and peripheral enhancement** +/- air
- DDX: dissecting hematoma, tubular duplication
- Antibiotherapy+ surgical drainage

Jung C et al. Acute Diffuse Phlegmonous Esophagogastritis: Radiologic Diagnosis. American Journal of Roentgenology. 2003



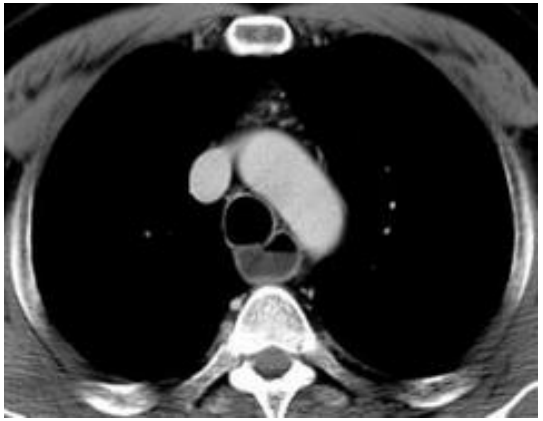


Phlegmonous oesophagitis
Case courtesy Yeonjoo Jeong, MD, PhD

Achalasia

Primary esophageal motor disorder with **lack of relaxation of the lower esophageal sphincter (LES)** due to involvement of the Auerbach's myenteric plexus++, involvement of esophageal peristalsis

- **High resolution pressure measurement +++**
- Differential diagnostics:
  - Pseudo-achalasia: neoplasia ++
  - Chagas disease
- Treatment: endoscopic dilatation++, surgery (myotomy)
- Complications: cancer (squamous cell carcinoma, ADK) (5%), mega oesophagus, inhalation pneumonia, candida oesophagitis.



Case courtesy of Dr Hani Al Salam, Radiopaedia.org, rID: 883

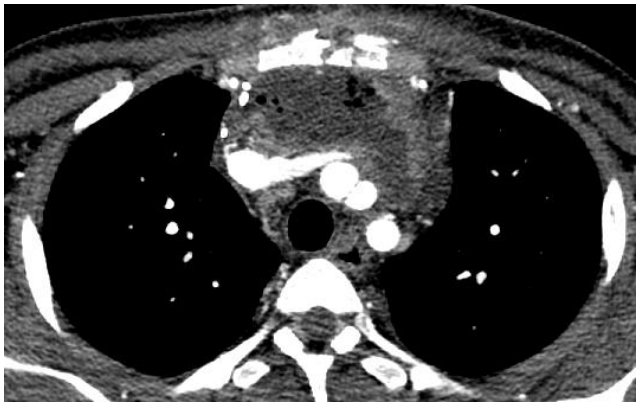
TOGD
- **« Bird's beak »** appearance
- Dilation
- Incomplete relaxation IOS
- Uncoordinated tertiary contractions

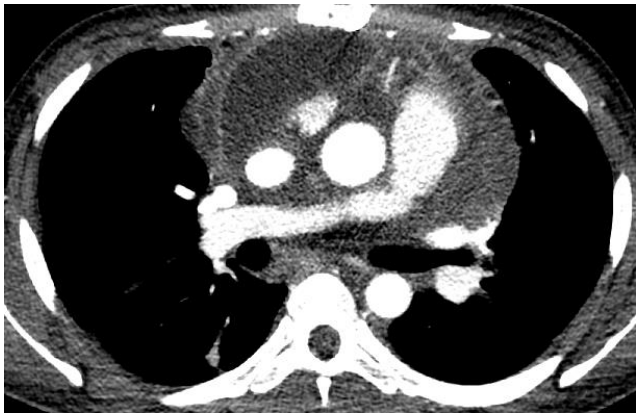
CT SCAN
- Dilated esophagus with thin wall
- Hydro-aerial level

Bird's beak" look
Case courtesy of Dr MohammadTaghi Niknejad, Radiopaedia.org, rID: 23554

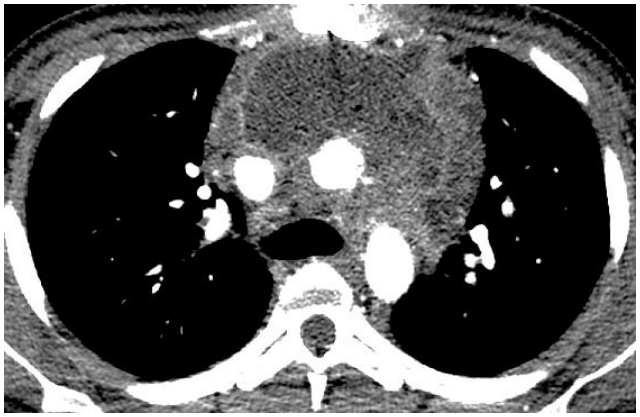
- *Mr. Andrew Murphy and A. Prof Franck Gaillard et al. Radiopediae*
- *Sophie Ribière - Hépatoweb.com*

Mediastinitis





Postoperative mediastinitis



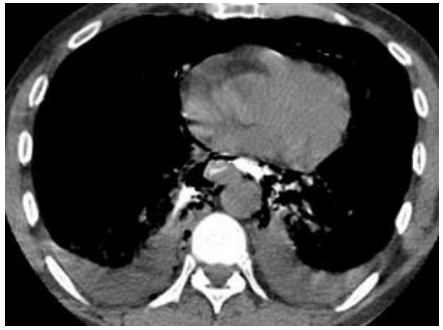
CT SCAN
- **Mediastinal widening**
- **Infiltration**
- **Abscess**

Secondary to
- **Boerhaave's syndrome** (spontaneous rupture of the esophagus on effort of vomiting)
- **Esophageal necrotic tumor**
- **Postoperative infection**
- **Diffusion from an infectious site** (tonsil abscess, dental abscess) via the **retropharyngeal space** (virtual neck + thorax space)

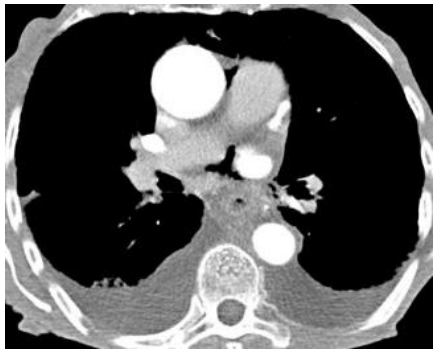
Boerhaave's Syndrome

Esophagus rupture following vomiting effort
- Sometimes other causes (convulsions, trauma...)
- M>F, ethylism, incidence 1/6000

X ray
- Pneumomediastinum
- Left pleural effusion
- Sign of the "V" of Nacerio



Case courtesy of Dr Domenico Nicoletti, Radiopaedia.org, rID: 27683



Case courtesy of RMH Core Conditions, Radiopaedia.org, rID: 26240

Perforation is usually
- Vertical
- Range from 1 to 4 cm
- On the **left posterolateral wall of the distal esophagus** just above the esophageal-gastric junction (topography due to the fact that there are fewer mediastinal structures to protect against perforation)

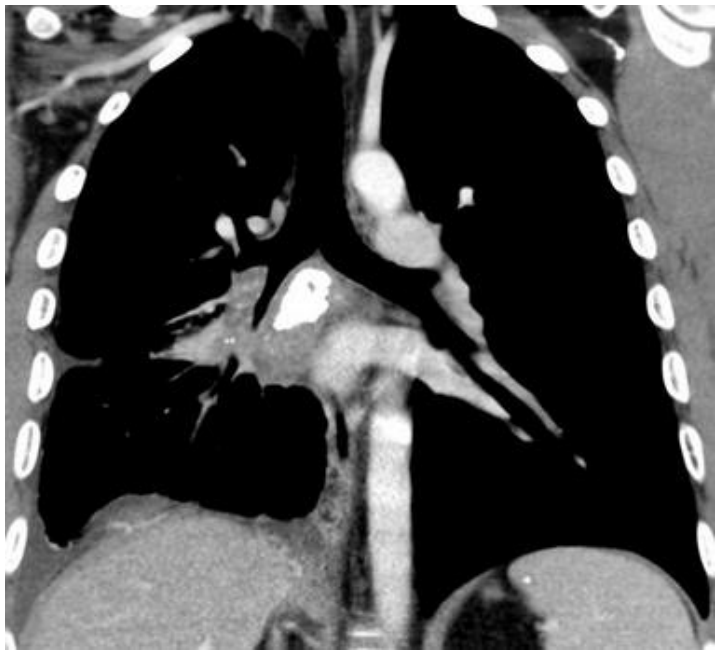
Imaging
- **Wall hematoma**
- **Perforation path**
- **Periesophageal hydroaerics collections (pneumomediastinum) → mediastinitis**
- **Pleural effusion** (pleuro-pneumothorax)
- Oral contrast extravasation

Ghanem N, Altehoefer C, Springer O et-al. Radiological findings in Boerhaave's syndrome. Emerg Radiol. 2003
White CS, Templeton PA, Attar S. Esophageal perforation. AJR 1993

Fibrotic Mediastinitis

Excessive fibrotic reaction in the mediastinum

- Rare
- **Compression/** occlusion mediastinal structures
  - Superior vena cava
  - HTPA
  - Esophageal compression



Case courtesy of Dr Darel E Heitkamp, Radiopaedia.org, rID: 13520

Etiologies

- **Idiopathic +++**
  - Without calcification
  - **diffuse**
  - Sometimes steroids-sensitivity
  - Often associated with **retroperitoneal fibrosis**, **Riedel's thyroiditis**, **orbital pseudotumor**...
- **Histoplasmosis secondary**
  - USA
  - Localize
  - **Calcifications**
- Tuberculosis
- Sarcoidosis
- Radiotherapy

Rossi SE, Mcadams HP, Rosado-de-christenson ML and-al. Fibrosing mediastinitis. Radiographics. 2001

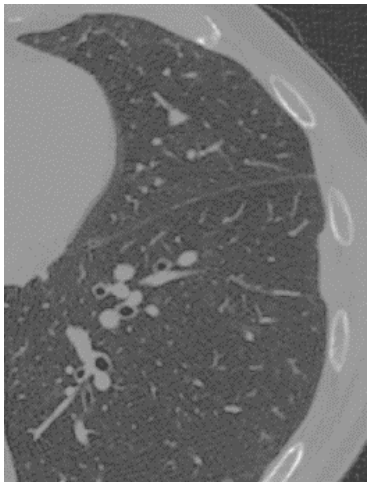
Pleura / Wall

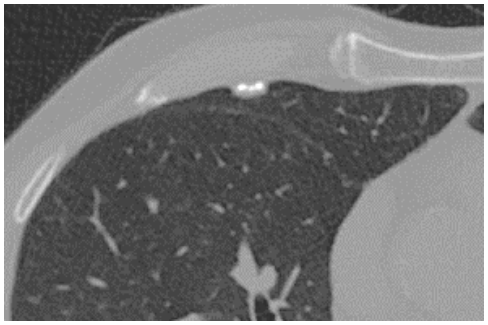
- Pleural abnormalities/ Asbestosis
- Mesothelioma
- Pleural metastasis
- Solitary fibrous tumour
- Intra-thoracic splenosis
- Empyema necessitans
- Costal tumors
  - Benign Neoplasms
  - Malignant tumors
- Elastofibroma
- Scapulo-thoracic bursitis

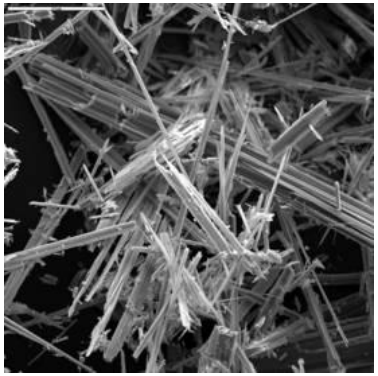
Asbestosis (Pleural abnormalities)

Pneumoconiosis due to prolonged inhalation of asbestos fibres

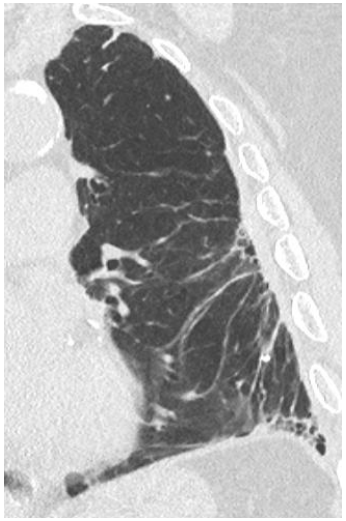
- Asbestos fibre: lg 100µm, Ø3µm bronchioles, alveoli fibrosis
- Anapath: asbestos bodies, asbestos fibres, fibrosis.







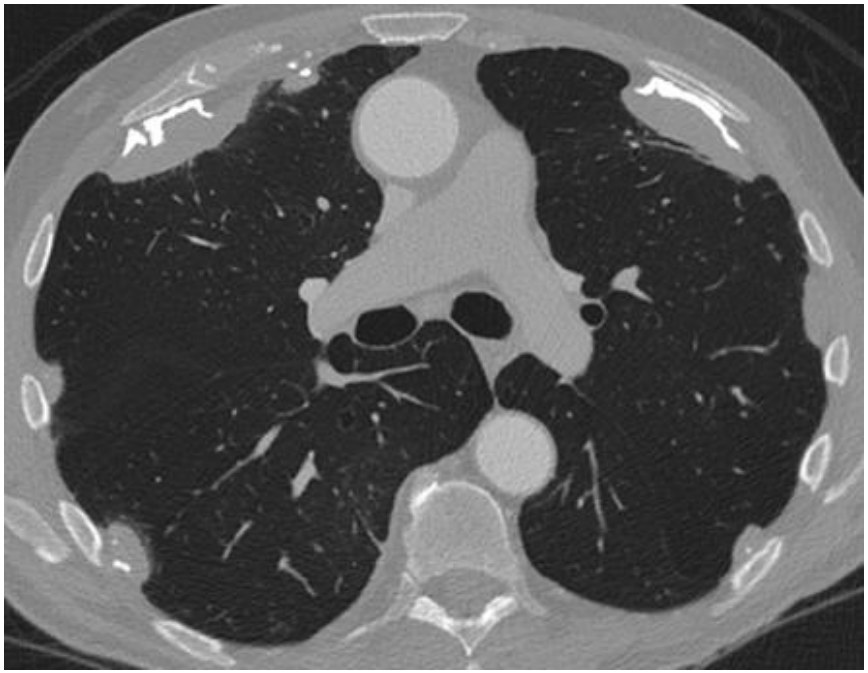
Crow's feet

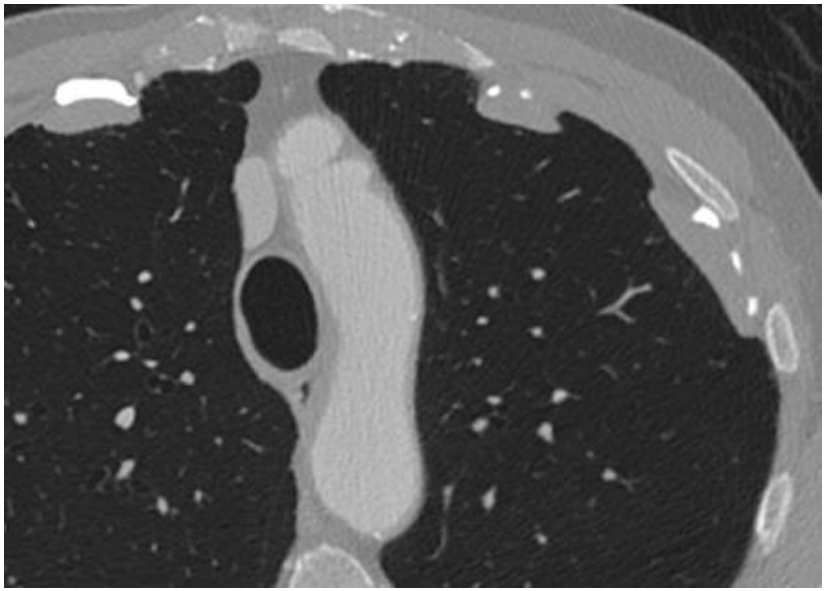


Pleural Anomalies - asbestosis!!!!

- **Pleural plaques +++:** parietal pleura, sign of asbestos exposure, > 20 years old, +/- calcified, bilateral asymmetrical
- **Pleural effusion:** 1st sign of pleural involvement, within 10 years, hemorrhagic exudate
- **Visceral pleural fibrosis:** less specific, thickening and fibrosis of the visceral pleura / fusion with parietal pleura

Computed tomographic atlas of benign asbestos pathologies - C Beigelman-Aubry, Journal of Radiology 2007

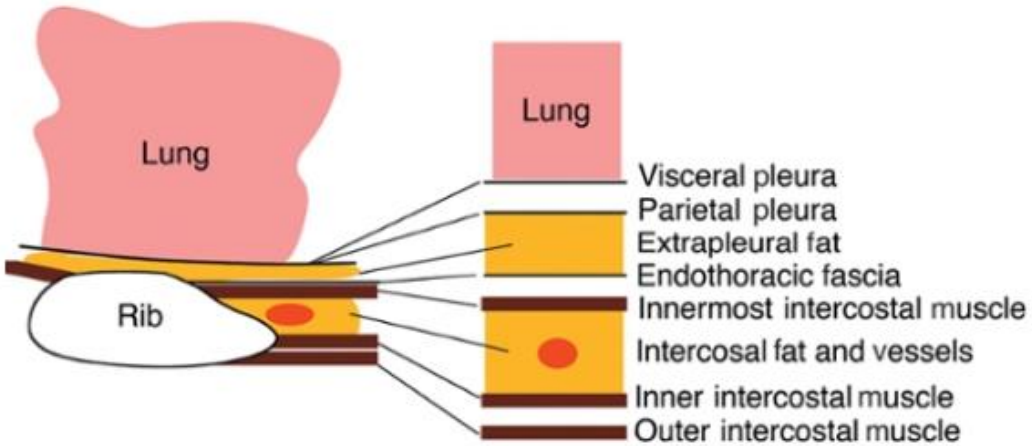


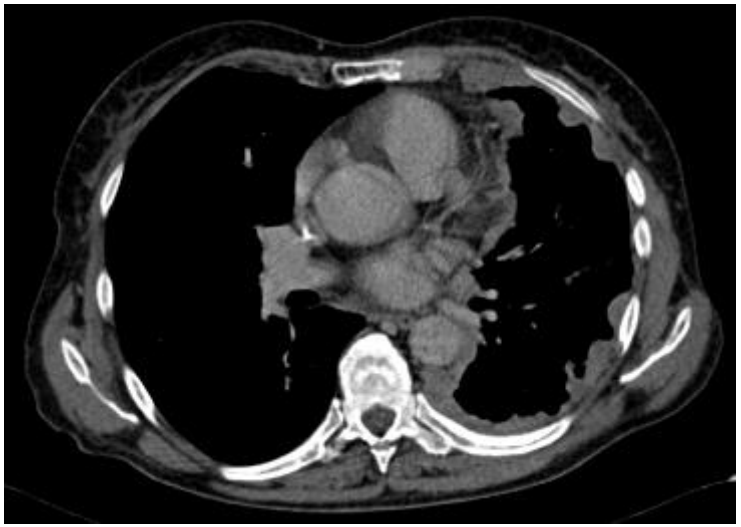


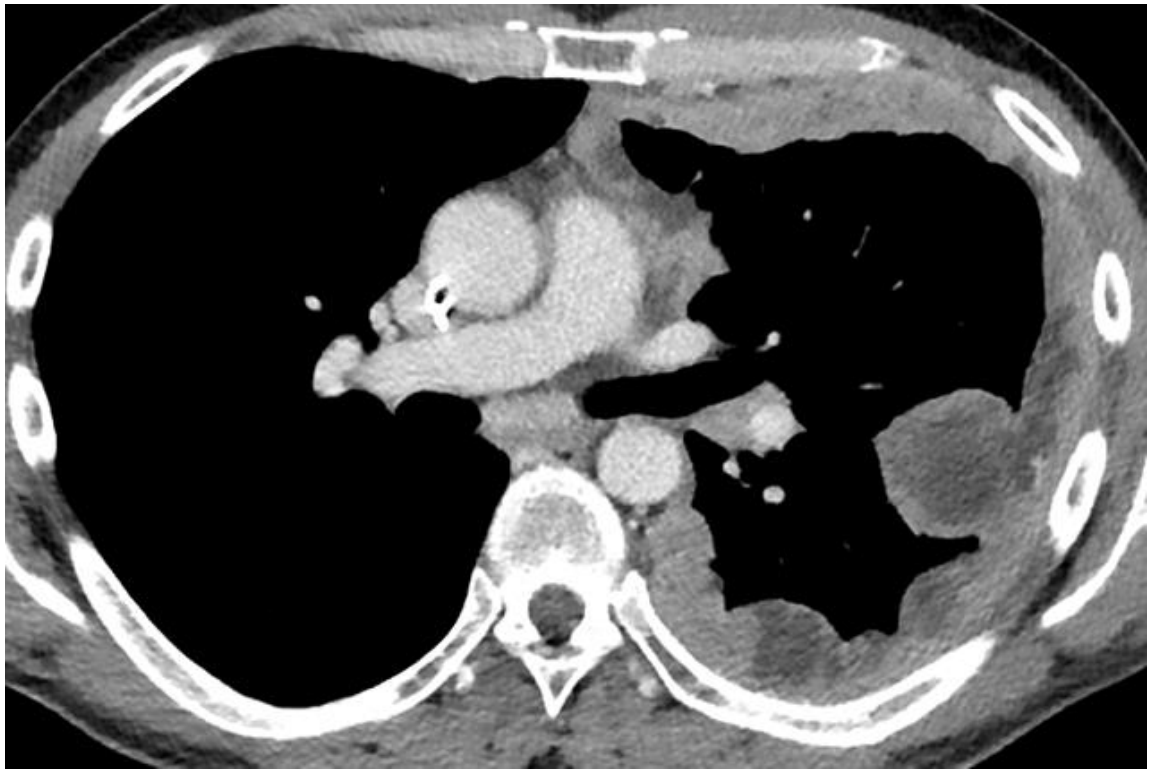
Bilateral pleural plaques :
context of asbestos exposure

Mesothelioma

- **Asbestos exposure +++**: main risk factor: 80% of cases
- **Malignant** tumor developing on the **parietal part of the pleura**
- Histological subtypes
  - Epithelioid (70%)
  - Sarcomatoid (10%)
  - Mixed
- Diagnosis: **biopsy under video-thoracoscopy**: malignancy: infiltration of fat tissue under the pleural



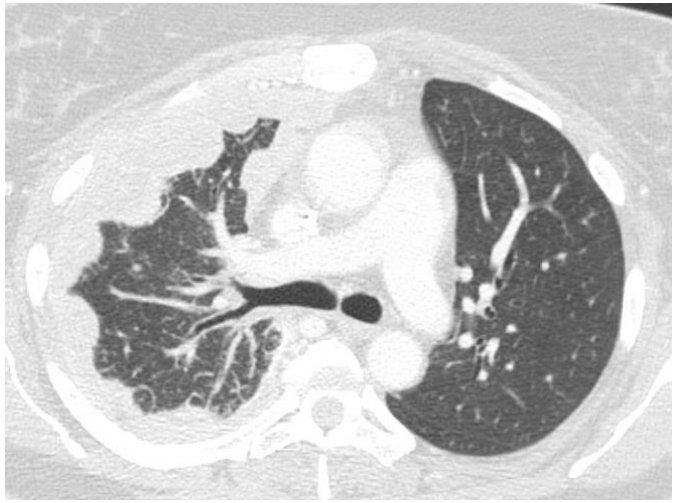


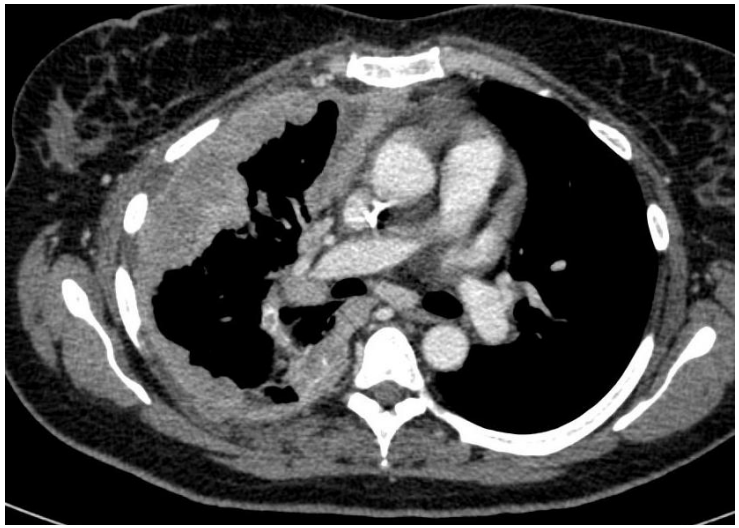


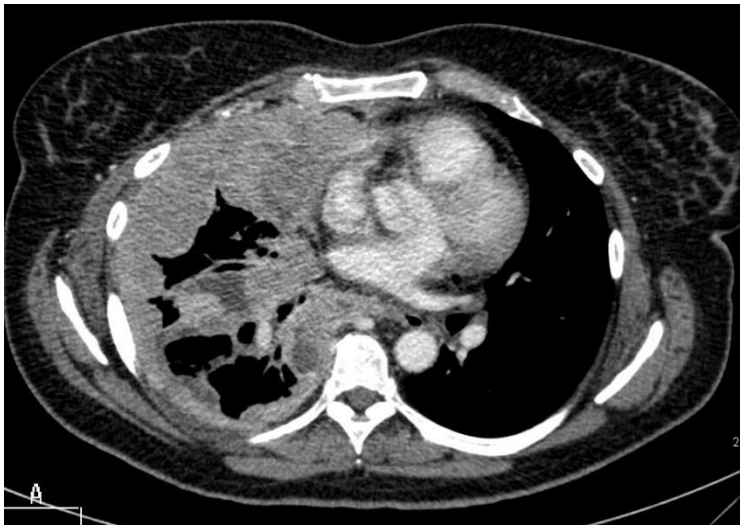
Mesothelioma: irregular, scalloping , thick left pleura

CT scan (if possible **two-phase injection**, impregnation 2 min)

- Isolated effusion
  - Find the **pleural tissue nodule**
- Pleural Carcinosis
  - **Pleural thickening**
  - **Circumferential**, mediastinal and scissural pleura
  - **Nodular** appearance, **nippled / scalloped**
  - Thickness **> 1cm** costal **pleura** = malignancy
  - **Hemithorax retraction**
  - Unilateral spread
- Localized form (very rare)
  - DD: solitary fibrous tumor, lipoma, fibrous malignant histiocytoma, hemangiopericytoma, sarcomas,...)







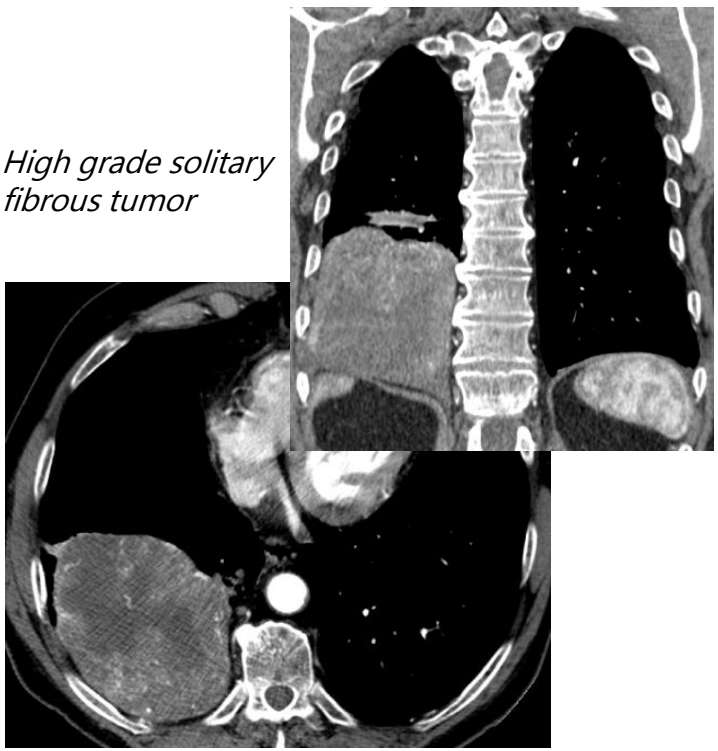
Pleural metastasis

Etiologies
- **Lung** +++
- But also breast, pancreas, stomach, ovary…

Differential Diagnosis **Multiple pleural masses + effusion**
- Pleural metastasis
- Mesothelioma
- Lymphoma

Solitary fibrous tumour

- Histology: **Mesodermal** origin, rare, < 5% of **pleural tumors.**
- **Benign +++**, **malignant (20%),** very rarely intra-parenchymatous
- Incidental discovery++, all ages (>50 years++), hypoglycemia (large tumor size by glucose consumption), hypertrophic osteoarthropathy
- **Attached to the visceral pleura** (sometimes parietal) **by a** mobile **pedicle** (fluoroscopy).



High grade solitary fibrous tumor

CT SCAN

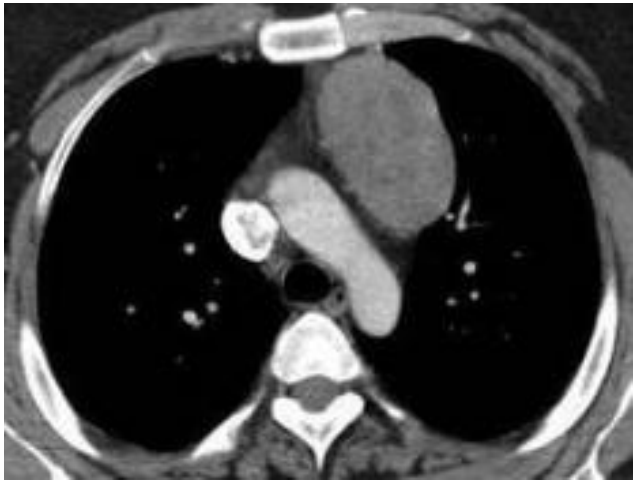
- **Tissue mass**, 1-39 cm, round or oval, sometimes lobulated, **well limited, mobile,** medium1/3 or lower
- Acute or obtuse connection angle
- Calcifications (large tumours)
- Spontaneously iso or hyperdense (collagen)
- **Intense and homogeneous enhancement**
- Non-enhancement: areas of necrosis, myxoid degeneration, haemorrhage.

MRI

- T1: hypo/iso signal
- T2: variable, **hyposignal ++** (abundant collagen stroma), "black and white" pattern
- **Intense enhancement**

- *Daniel T. G, Aqiba B, Shweta B. Imaging Features of Solitary Fibrous Tumors. AJR 2011*
- *Truong M, Munden RF, Kemp BL. Localized fibrous tumor of the pleura. AJR Am J Roentgenol. 2000*
- *Ferretti GR, Chiles C, Cox JE, Choplin RH, Coulomb M. Localized benign fibrous tumors of the pleura: MR appearance. JCAT 1997*

Surgical treatment +++
- Because 20% risk of malignancy
- And DD



Case courtesy of Dr Abdallah Khateeb , Radiopaedia.org, rID: 44946

Signs of malignancy SFT
- **>10 cm**
- **Central Necrosis**
- **Pleural effusion**
- **PET scan : high fixation**

DD
- **Mesothelioma** (multiple pleural or diffuse masses)
- Paraspinal:
  - **Neurogenic tumor** (condensation or costal erosion, rare in SFT)
- Paramediastinal
  - **Thymic, germ cell, teratoma...**
  - A mediastinal tumour compresses the lung while the SFT compresses the mediastinum (+ help from the angioTDM, feeding vessels).

Cardinale L, Ardissone F, Volpicelli G. CT signs, patterns and differential diagnosis of solitary fibrous tumors of the pleura. J Thorac Dis 2010

Intra-thoracic splenosis

Grafting of splenic tissue in abnormal locations after splenic trauma

- Area
  - Mesentery, *peritoneum*, *omentum*
  - Thoracic: less frequent but 18%.
- Asymptomatic

CT SCAN
- **One or more pleural mass(es)**
  - Implants on visceral or parietal
- **Density and enhancement identical to splenic tissue**

Diffusion
- **Diffusion : restriction**

Scintigraphy GR marked altered
- **Specific splenic tissue fixation**

DD
- **Pleural metastasis** (lung, breast, melanoma)
- **Lymphoma**
- **Solitary fibrous tumour**
- **Mesothelioma**
- Invasive thymoma

Reflex!
Pleural nodules
+ history of thoraco-abdominal **traumatic**
Or splenectomy
→ considere **intrathoracic splenosis**

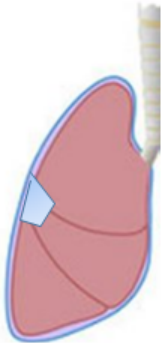
Diagnostic tree
Pleural thickening

Les plus pourvoyeurs de métastases pleurales :
- Poumon
- Sein
- Ovaire
- Lymphome
- Thymome

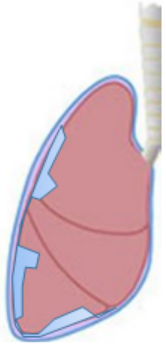
Les lésions sous-lignées peuvent avoir une présentation **bilatérale**

Lésions pleurales qui peuvent être **calcifiés** : *
N.B: après traitement les lésions du lymphome peuvent se calcifier

Epaississement pleural



Focal



Diffus

+ Epanchement
- **Pleurésie infectieuse** (dont tuberculose)
- **Mésothéliome**
- **Métastases pleurales**
- Lymphome
- Pleurésie asbestosique
- Radiothérapie
- Chirurgie

En faveur de la malignité de l'épaississement pleural :
1. Caractère **circonférentiel**
2. Caractère **nodulaire > 1 cm / irrégulier +++**
3. L'atteinte de la plèvre médiastinale

Benin
- **Plaque pleurale ***
- **Tumeur fibreuse solitaire ***
- Lipome
- Endométriose
- Splénose (gauche)

Malin
- **Mésothéliome***
- Sarcome pleural
- Métastases.
- Lymphome

Benin
- **Fibrose pleurale viscérale***
- Tuberculose pleurale
- Empyème
- Trauma/ chirurgie
- Irradiation

Malin
- **Mésothéliome pleural*** (atteinte circonférentielle ++)
- **Métastases pleurales**
- Lymphome pleural (atteinte circonférentielle rare)

Costal tumors

Benign Neoplasms

- **Fibrous dysplasia +++**
- **Chondroma ++**
- **Osteochondroma ++**
- Others
  - Aneurysmal bone cyst
  - Giant cell tumor
  - Chondroblastoma
  - Osteoblastoma
  - Brown Tumor
  - Paget
  - Osteoid osteoma
  - Postfracturnal bony callus
  - Postradic sequelae
  - Infection (tubercular osteitis)
  - Benign condensing ileum (enostosis)

- Prevalence: **3 to 8%.**
- **Metastasis** and **myeloma**: most common malignant costal tumours
- Benign lesions: **fibrous dysplasia +++**
- **Age**, sex, context, clinical +++
- **Look for arguments in favour of a benign or malignant etiology** (osteolysis, periosteal reaction, soft tissue mass).

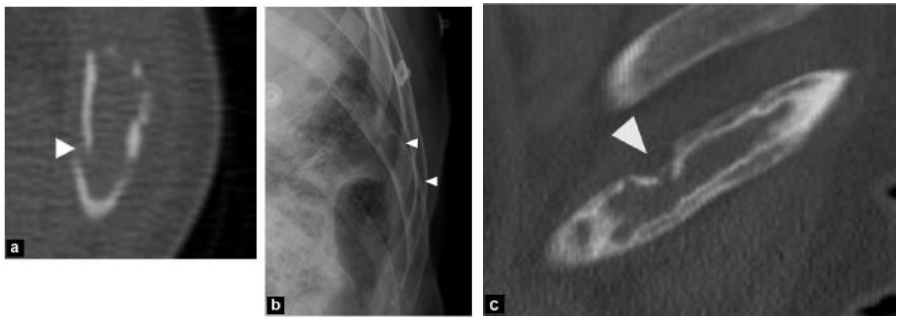
Malignant tumors

- **Metastasis +++**
- **Myeloma ++**
- **Chondrosarcoma**
- Osteosarcoma
- Ewing's Sarcoma

Benign Costal Neoplasms

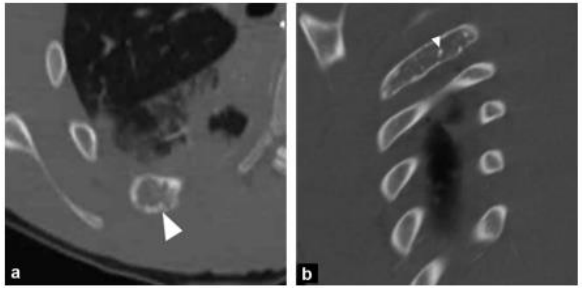
Fibrous dysplasia +++

- **The most common benign tumor**
- Congenital, fibrous tissue/immature bones
- **30-50 years**, **medium arc/posterior++, K2**
- **Medullary lesion centered, lytic, blowing, elongated in the axis of the rib,** thinning the cortical with osteocondensation border, no periosteal reaction, no soft tissue damage, **GGO areas +++** very specific
- MRI: hypoT1, T2 variable
- Sometimes pathologic fracture



Fracture on fibrous dysplasia

Chondroma

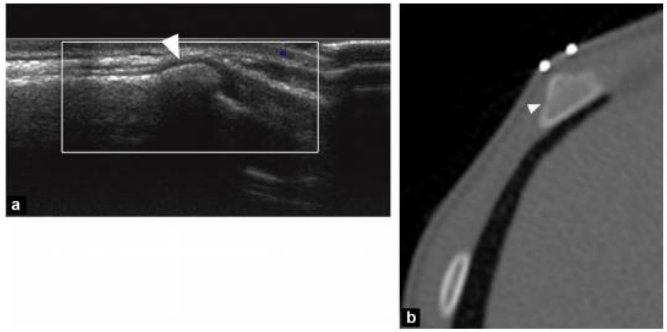


Enchondrome ++

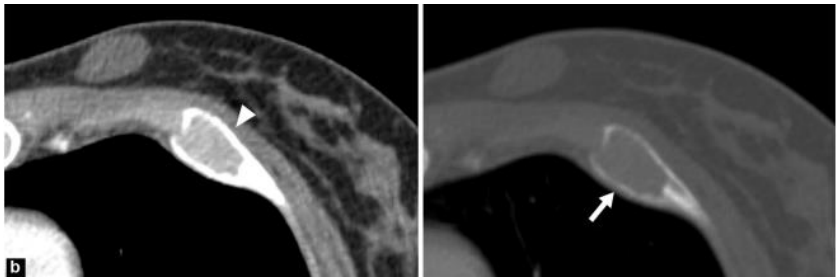
- 2nd **benign lesion**, cartilage tumor, 10-30 years old
- Anterior costal arch **near the chondro-costal ++ junction** or near the costo-vertebral joint
- **Osteolytic lesion, well limited, lobulated,** <4cm, +/- blowing, arciform calcifications in matrix
- MRI: hypoT1, high hyperT2, lobulated, septa hypoT2, peripheral enhancement

Osteochondroma ++

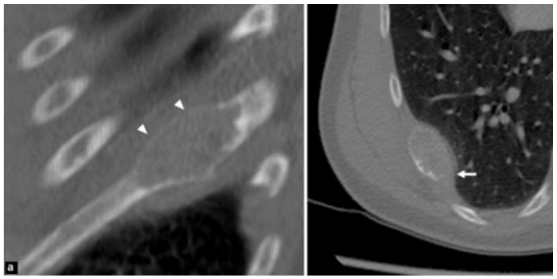
- **Anterior, chondro-costal junction,** children/adults young++
- **Well-corticalized bone excrescence with medullary and cortical/adjacent bone continuity**
- Cartilaginous cap (hyperT2) >2cm(adult), >3cm(child)→transformation into malignant if above



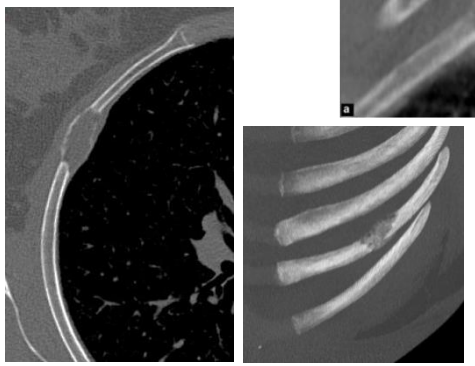
- **Aneurysmal cyst** Young, **posterior arc++**, expansive, **liquid-liquid levels**
- **Giant cell tumor** 20-40 years old, pain, +/- fracture, **lytic lesion, expansive, excentric,** sharp contours, no peripheral osteosclerosis, no periosteal reaction, no cortical interruption, no calcifications, +/- soft tissue extension (MRI), MRI: hypo/iso T1 and T2, elevation
- **Chondroblastoma** **chondro-costal junction, costo-vertebral**, **medullary edema+++**
- **Osteoblastoma** Bone matrix lesion, posterior arc
- **Brown tumour** Complication of **hyperthyroidism**, repeated micro fractures → macrophages → hypervascularised localised medullary fibrosis**, well limited lytic lesion +/- expansive,** when resolution bone reconstruction with scintigraphic fixation
- **Eosinophilic granuloma** **Histiocytosis X**, **lytic lesion**
- Rare Paget in ribs, widening, cortical thickening, rare and thickened bays
- Osteoid osteoma (rare in rib, small cortical lacuna, calcified nidus, compact periosteal reaction)
- Post-fracture bony callus +++
- Post-radiation sequelae
- Infection (tubercular osteitis)
- Benign condensing island (enostosis)



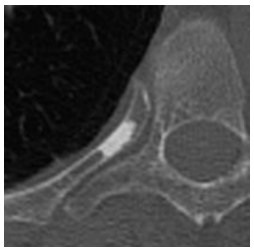
TCG



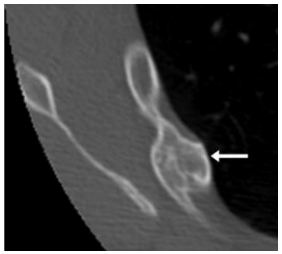
Brown T.



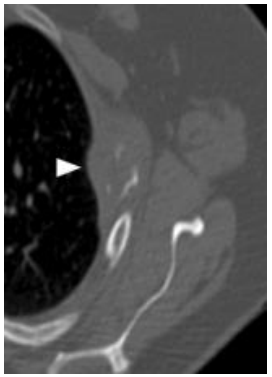
Eosinophilic Granuloma



Enostose



Bony callus

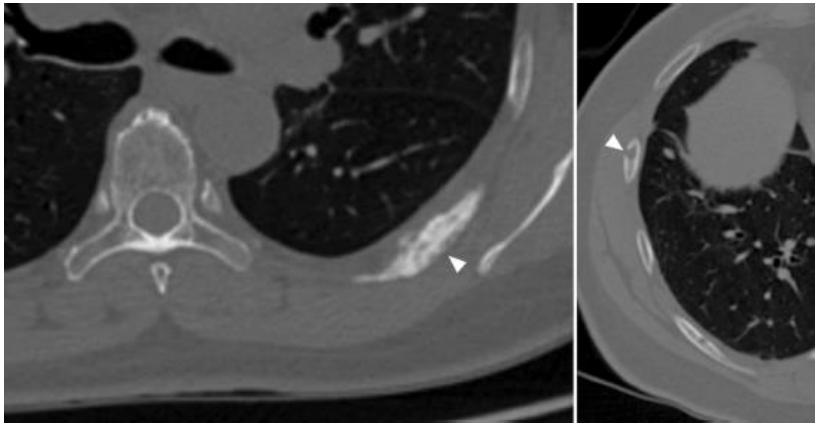


Osteitis BK

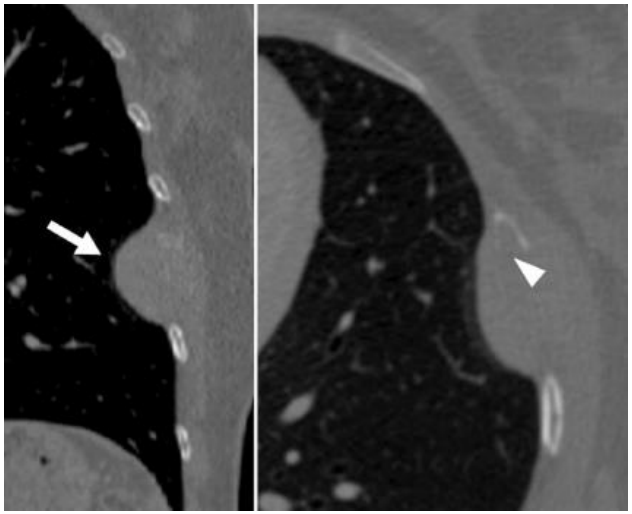
Malignant Costal Neoplasms

Metastasis +++

- 3rd location of secondary lesions after spine and femur
- Neoplasia **context**
- Single or multiple focal lesions,
- **Osteolytic** (breast, lung, thyroid, uterus)
- **Sclerotic** (prostate, breast, bronchus, stomach, thyroid, colon)
- Mixed (breast, lung)



Metastasis



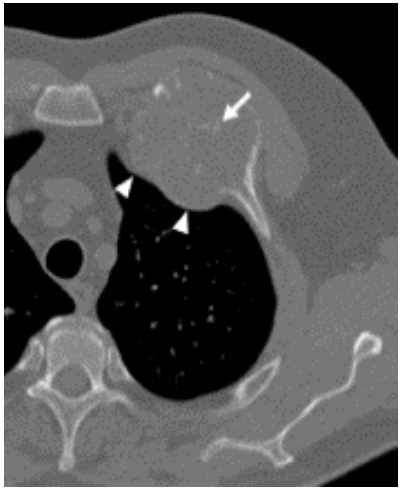
Myeloma

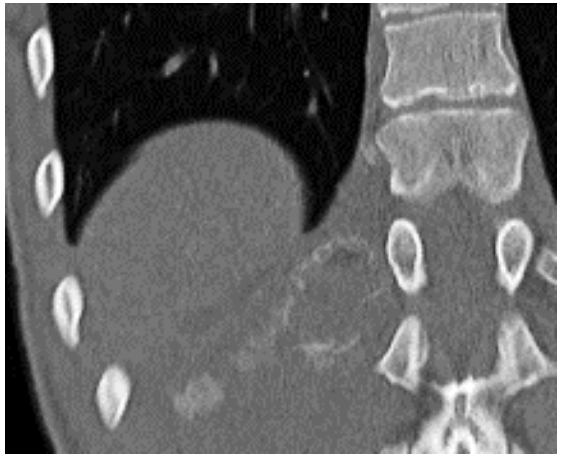
Myeloma ++

- 2nd location after the spine, in 50% of patients followed for myeloma, > 50 years of age
- CT scan: **multiple osteolytic lesions with rounded or oval-shaped, sharply contoured lacunae,** rarely surrounded by an osteosclerotic border, often with soft tissue swelling.
- Mean costal arc++

Chondrosarcoma

- 11-16% of chondrosarcomas are at the costal level → most common primary malignant tumour, 20-70 years old
- Primitive (90%) or chondrome/osteochondrome degeneration
- Anterior arch of the first 5 ribs
- Osteolysis , size > 4cm, aggressive (endosteal resorption, cortical lysis), cartilage matrix
- *DD /enchondrome: size>4cm, **endosteal resorption>2/3** cortical, MRI: **early** pdC, **intense fixation in scintigraphy***



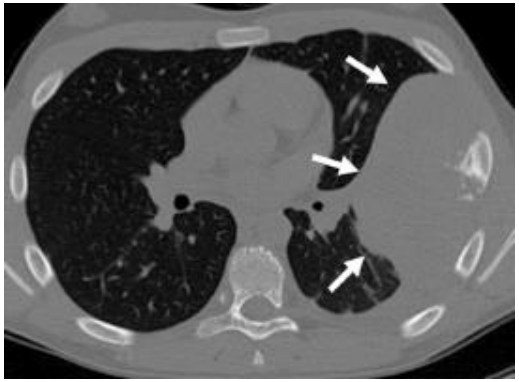


Osteosarcoma

- Reaches the ribs in 1 to 3% of cases.
- Primitive tumour young subject (15-25 years old) sometimes elderly (Paget, radiotherapy)
- Large bone matrix lesion , areas of necrosis, hemorrhage, ossifications.
- **Osteolysis with cortical interruption and significant spiculated periosteal reaction in « sunburst »**
- Invasion of soft parts

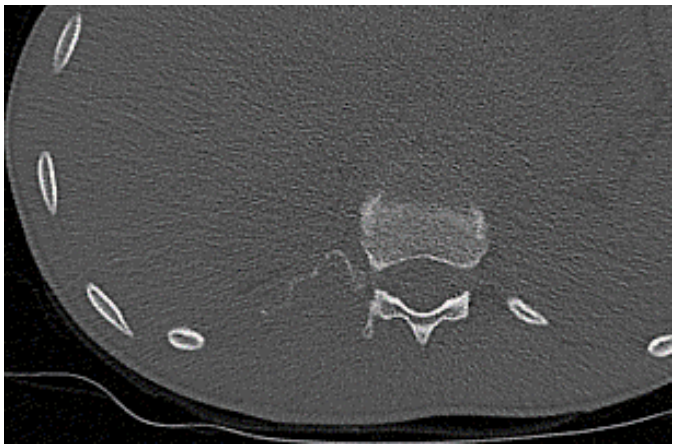
Ewing's Sarcoma

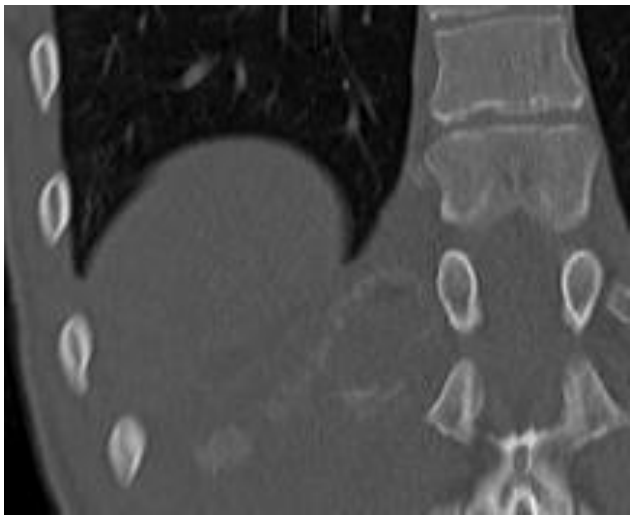
- 10 - 15 years
- Painful parietal mass, fever
- **Voluminous (> 10 cm) eccentric extrapleural mass / rib with osteolysis and spiculate or lamellar reaction** (+/- periosteal **reaction in onion bulb**)

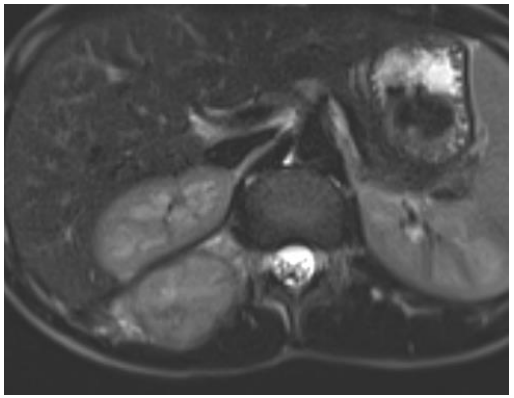


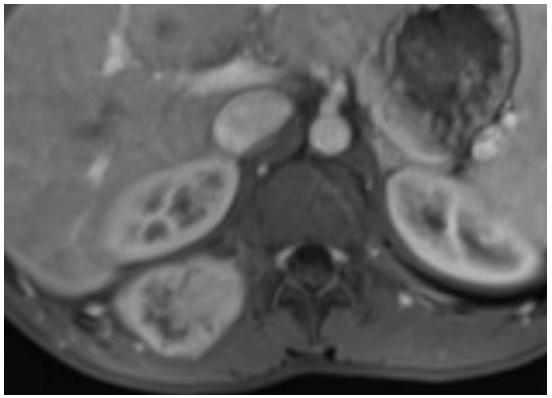
Osteosarcoma

- Lytic and blowing injury and a floating rib
- Hyper T2, heterogeneous contrast uptake









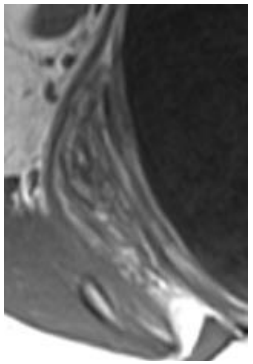
Parietal lesions

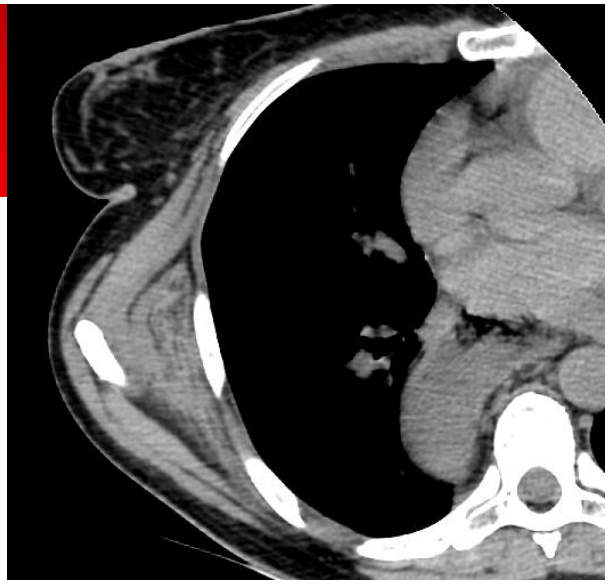
- Parietal lipoma
  - Soft tissue mass, homogeneous, well circumscribed, whose spontaneous density is negative (between -65 and -120 HU)
- With liposarcoma as the main differential diagnosis, to be discussed in front of certain criteria:
  - Size **> 5cm**
  - **> 50** years old
  - **Deep** (subaponeurotic or muscular)
  - **Tissular infiltration, enhancement, thick septa, nodules**
  - **Invasion** of adjacent structures, justifying an MRI.
- Elastofibroma
- Schwannoma **(intercostal or para-spinal)**
- Extramedullary hematopoiesis
- Others
  - Hematomas (traumatic context)
  - Ossifying myositis
  - Desmoid tumor or fibromatosis
  - Empyema *necessitans* by extension of pleural empyema to the chest wall (e.g. tuberculosis, actinomycosis), possibly associated with costal osteitis.
  - Fatty tumours: lipoma, liposarcoma, hibernoma
  - Scapulo-thoracic bursitis

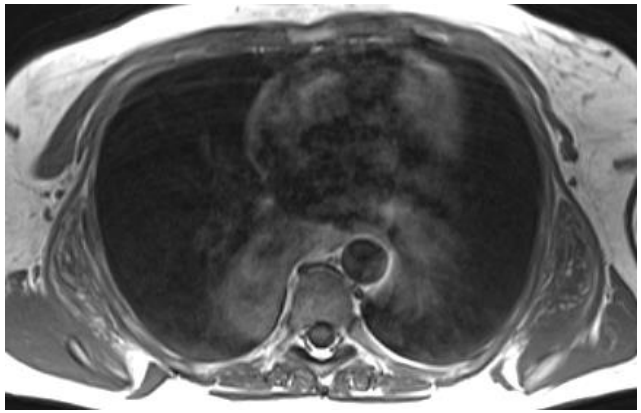
Elastofibroma

Benign fibroelastic tumor of the infrascapular space

- Right ++, 60% **bilateral**
- Older woman ++, 65-70 years old
- Asymptomatic ++ (sometimes slight pain)







CT SCAN

- Soft tissue mass of the **infrascapular space** (between ribs and anterior serratus / scapula / rhomboid muscle)
- **Ill defined**
- Isodense to muscles, heterogeneous with **fasciculate appearance** with **bands of fatty tissue** (sometimes homogeneous)

MRI

- **Hypo** T1 and T2 /muscles
- **T1 hypersignal bands** (fatty tissue)
- Variable increase

Dinauer PA, Brixey CJ, Moncur JT, Fanburg-Smith JC, Murphey MD. Pathologic and MR Imaging Features of Benign Fibrous Soft-Tissue Tumors in Adults. RadioGraphics, 2007

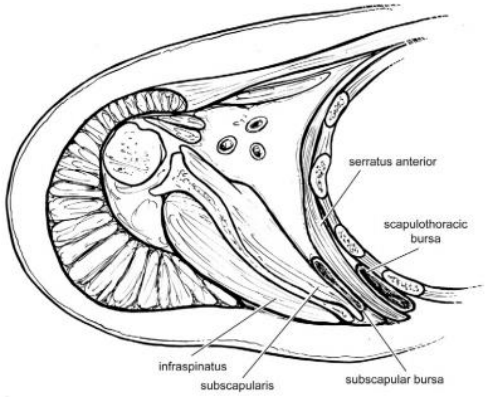
Empyema necessitatis

- Rare
- = empyema of necessity (empyema drains out through the chest wall)
- Empyema →parietal pleura → chest wall (→ skin)
- Germs
  - **BK +++**: 66%.
  - **Pyogens**
  - **Actinomycosis**
- +/- osteolysis

Scapulo-thoracic bursitis

Mechanical conflict between the scapula and the rib cage
= Snapping scapula

- = Rare cause of shoulder pain
- Female, 20-30 years old
- Clinic
  - Posteromedial shoulder **pain**
  - Audible and painful **jump**
  - +/- "winging scapula": removal of the scapula in abduction the arm.

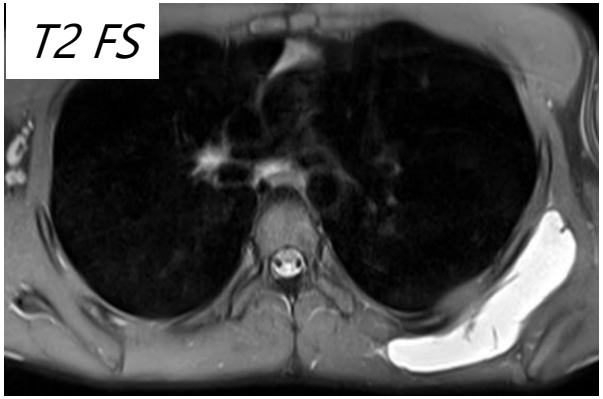


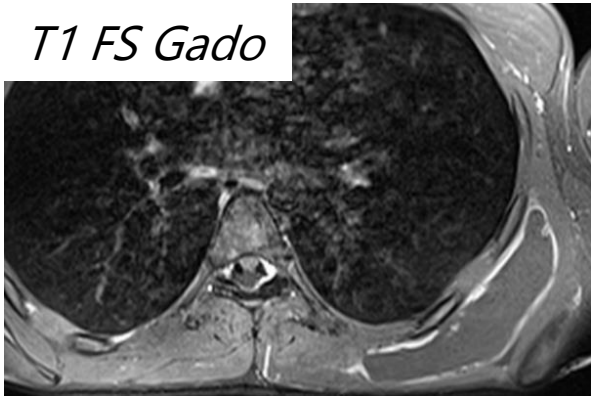
Etiologies

- **Congenital or acquired bone abnormalities**: osteochondrome, callus, Luschka's tubercle prominence...
- **ATCD thoracobrachial procession surgery**
- **Elastofibroma...**

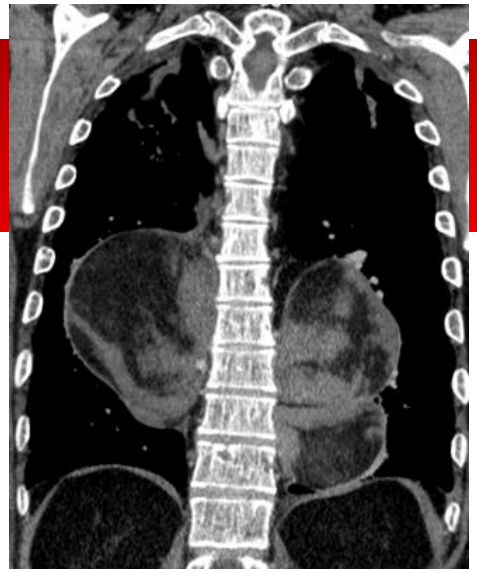
CT/MRI

- **Bursitis** between the anterior serratus muscle and the rib cage
- **Fluid** content **+/- hemorrhagic**
- **Peripheral enhancement**

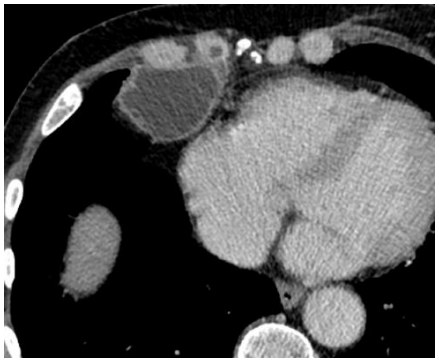


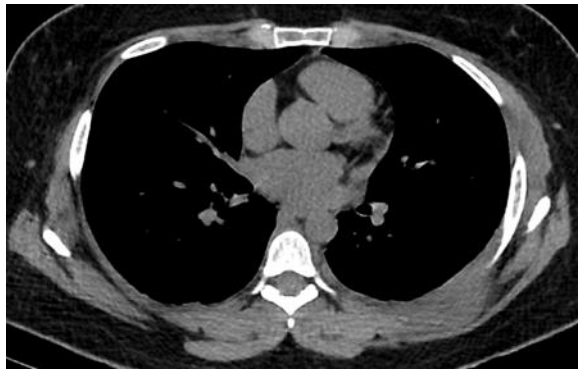


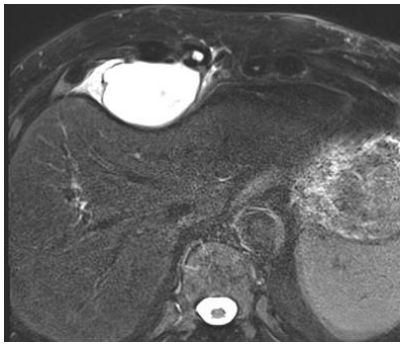
Others

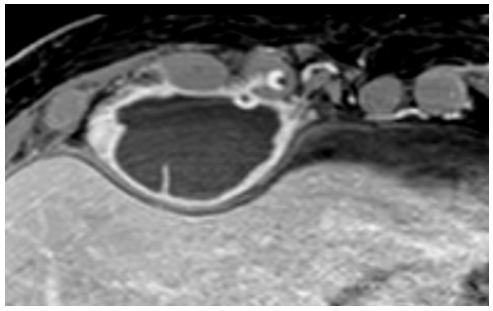


Extra-medullary haematopoiesis

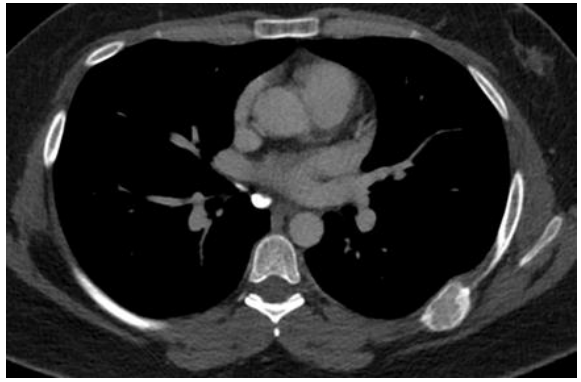








Chondrocostal tuberculosis



Ossifying myositis

Peripheral secondary calcification on a control scanner at 4 months