110年胸部影像判讀繼續教育課程

# *Chest CT reading principles and common signs*

## 胸部CT影像判讀原則與常用徵象


張允中
台大醫院 影像醫學部
台大醫學院 放射線科

*Yeun-Chung Chang, MD, PhD*
*Department of Medical Imaging, National Taiwan University Hospital*
*Department of Radiology, National Taiwan University College of Medicine, Taipei, Taiwan*

# Goals

- The CT reading principles
- Important CT findings and signs

# Modern CT scanners

- Faster rotation of the gantry: ultra-short rotation time, fastest about 360 degree <0.3 sec
- Wider coverage: Multi-detectors: from 4 slices to 640 slices (16 cm wide detectors), organs
- Contrast enhancement: dynamic
- Lower radiation dose: FBP, IR
- Spectral images: mono- vs. poly-chromatic

# Modern CT scanners

- NTUH routine
- Pre-contrast
  - 5mm soft tissue kernel (algorithm)
  - thin section 1mm lung kernel (algorithm): HRCT
- Post-contrast
  - 5mm soft tissue kernel
  - Coronal 3mm
  - Sagittal 3mm (optional)

# CT parameters

- kVp
- mAs
- Slice thickness
- Reconstruction algorithms (kernels)
  - Standard (soft tissue)
  - Lung,
  - Bone

# CT dose

- Effective dose: the millisievert (mSv)
- The relative sensitivities of the different tissues exposed
- Dose Length Product (DLP): CTDIvol * length of scan (mGy*cm)

| CENTRAL NERVOUS SYSTEM  | Procedure | Approximate effective radiation dose | Comparable to natural background radiation for: |
|---|---|---|---|
| | Computed Tomography (CT)–Brain | 1.6 mSv | 7 months |
| | Computed Tomography (CT)–Brain, repeated with and without contrast material | 3.2 mSv | 13 months |
| | Computed Tomography (CT)–Head and Neck | 1.2 mSv | 5 Months |
| | Computed Tomography (CT)–Spine | 8.8 mSv | 3 years |

| CHEST  | Procedure | Approximate effective radiation dose | Comparable to natural background radiation for: |
|---|---|---|---|
| | Computed Tomography (CT)–Chest | 6.1 mSv | 2 years |
| | Computed Tomography (CT)–Lung Cancer Screening | 1.5 mSv | 6 months |
| | Chest X-ray | 0.1 mSv | 10 days |

https://www.radiologyinfo.org/en/info/safety-xray

# Important CT anatomy

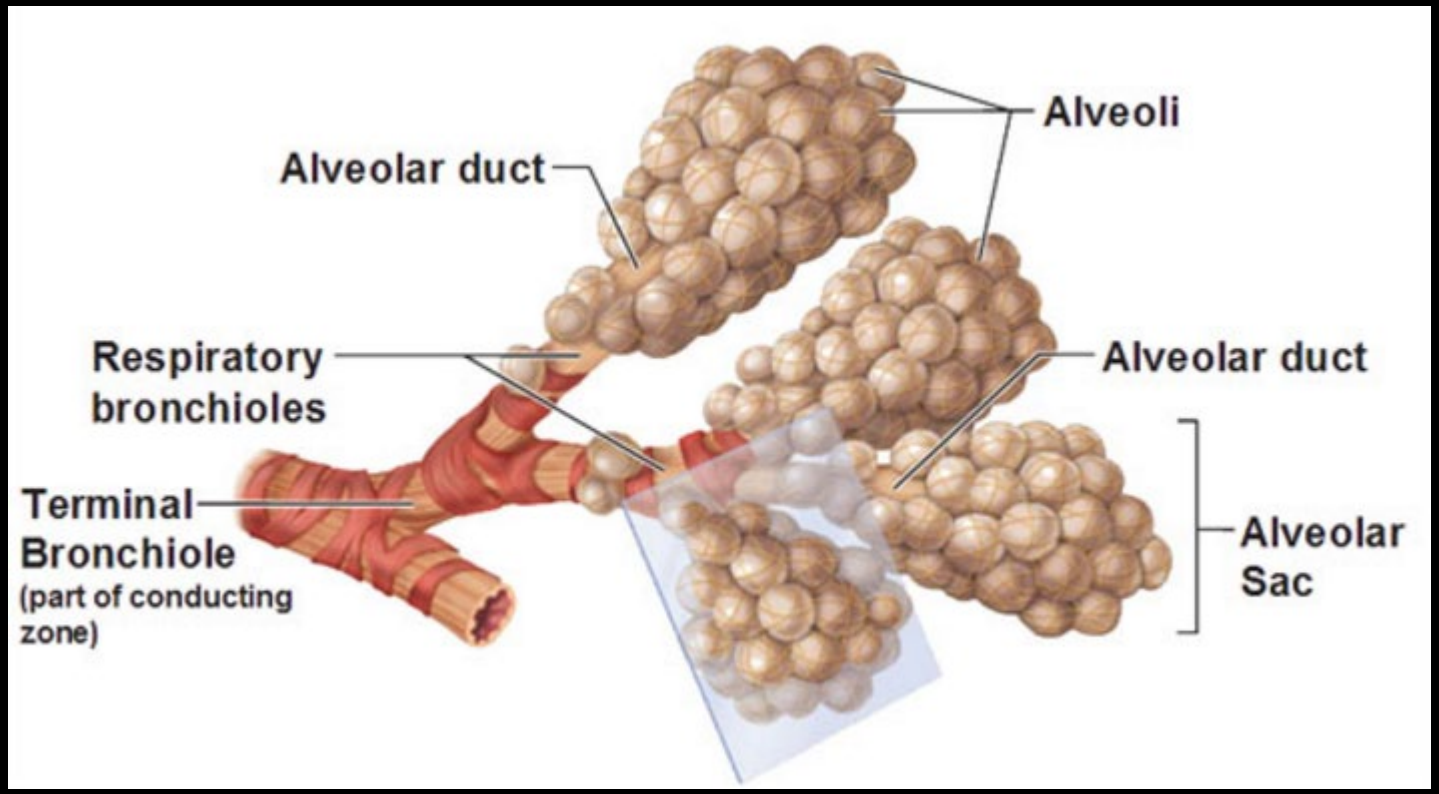
- Airway
- Lung parenchyma
- Fissures
- Vessels
- Pleura
- Mediastinum
- Bone

# Principle of reading CT

- Understanding the clinical question(s) or suspicion
- Clinical history and chief complaints
- Systemic approach
- Comparison with prior studies available

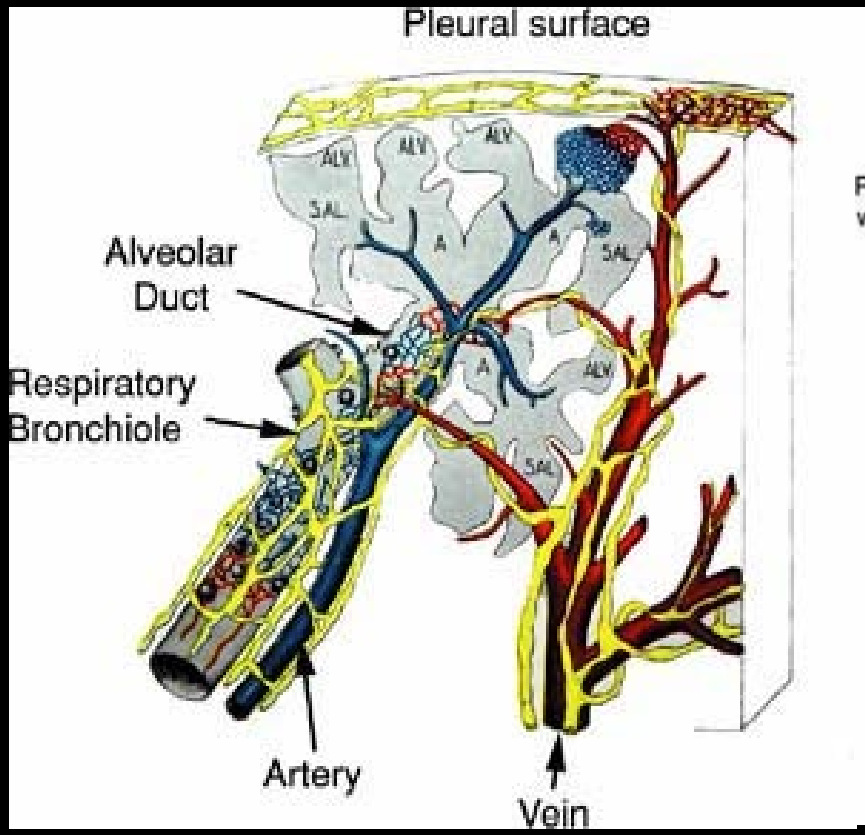
# Common CT signs

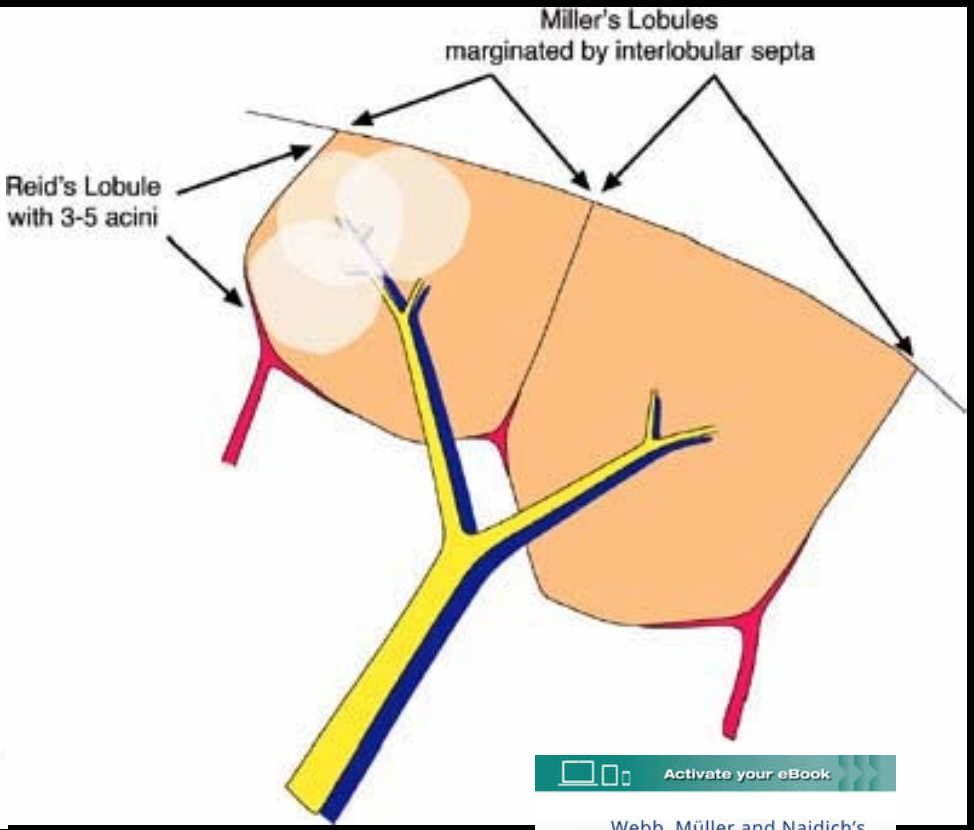
- Air crescent sign (vs. Monad sign)
- Atoll sign
- Beaded septum sign
- Crazy-paving pattern
- Halo sign
- Headcheese sign
- Honeycombing
- Signet ring sign
- Tree-in-bud pattern



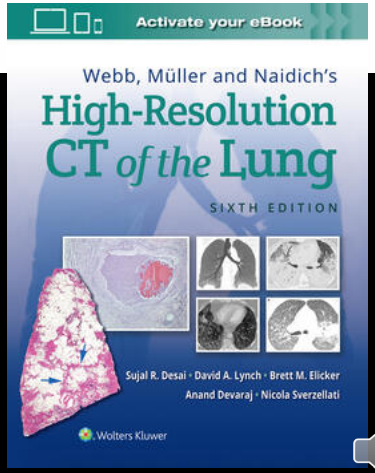

- the terminal bronchioles. This is the end of the conducting zone (remember the conducting zone is just the *transport* of air, not an exchange).
- the **respiratory bronchioles** and everything distal to it are microscopic structures

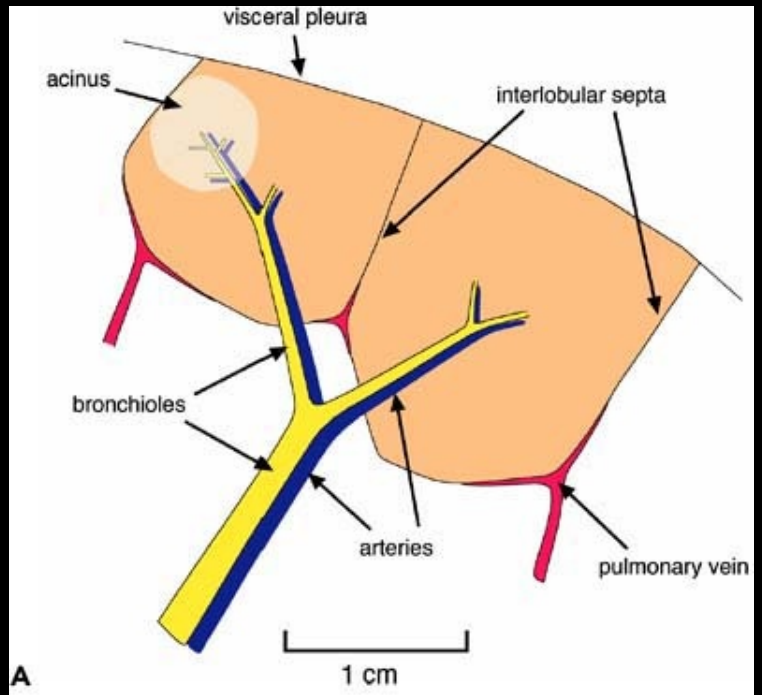
http://antranik.org/the-respiratory-system/

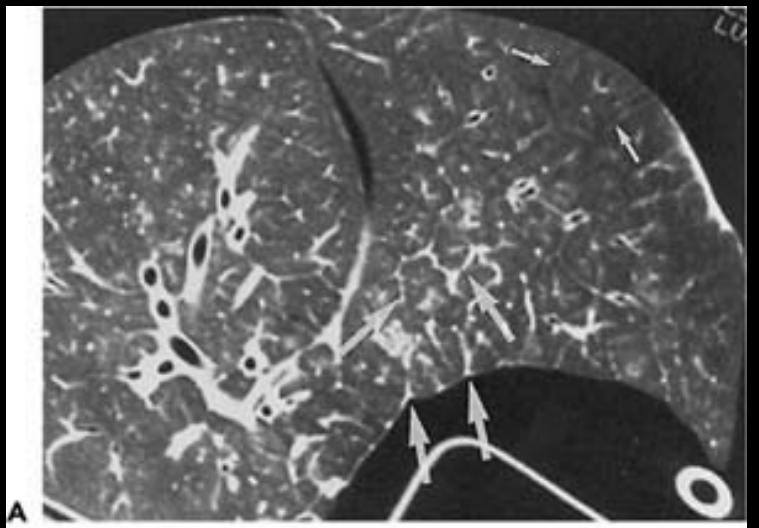



The primary pulmonary lobule. Miller defined the primary pulmonary lobule as all alveolar ducts, atria (A), alveolar sacs (SAL), and alveoli (A) distal to the last respiratory bronchiole, along with their associated blood vessels, nerves, and connective tissues. (From Miller WS. *The lung*. Springfield, IL: Charles C Thomas; 1947:75.)




visceral pleura
acinus
interlobular septa
bronchioles
arteries
pulmonary vein
1 cm
A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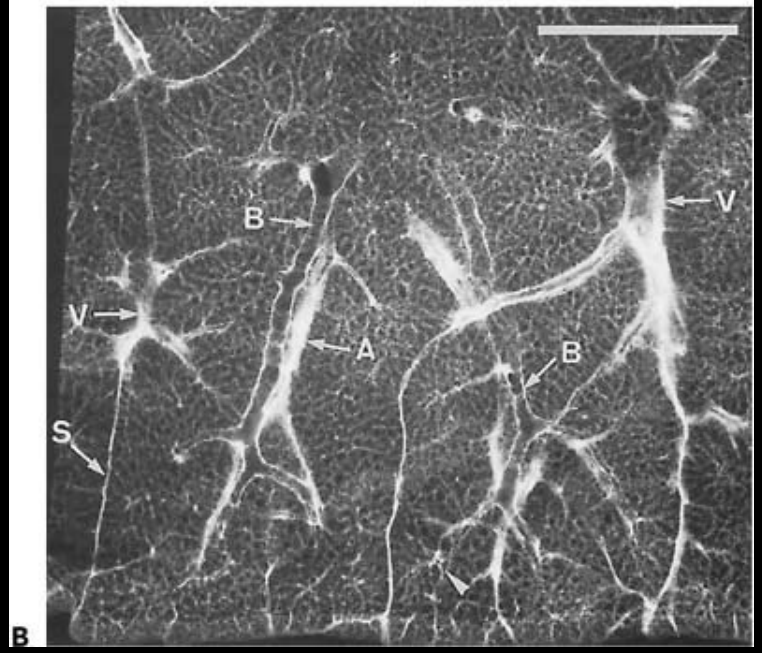
B
V
V
A
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B
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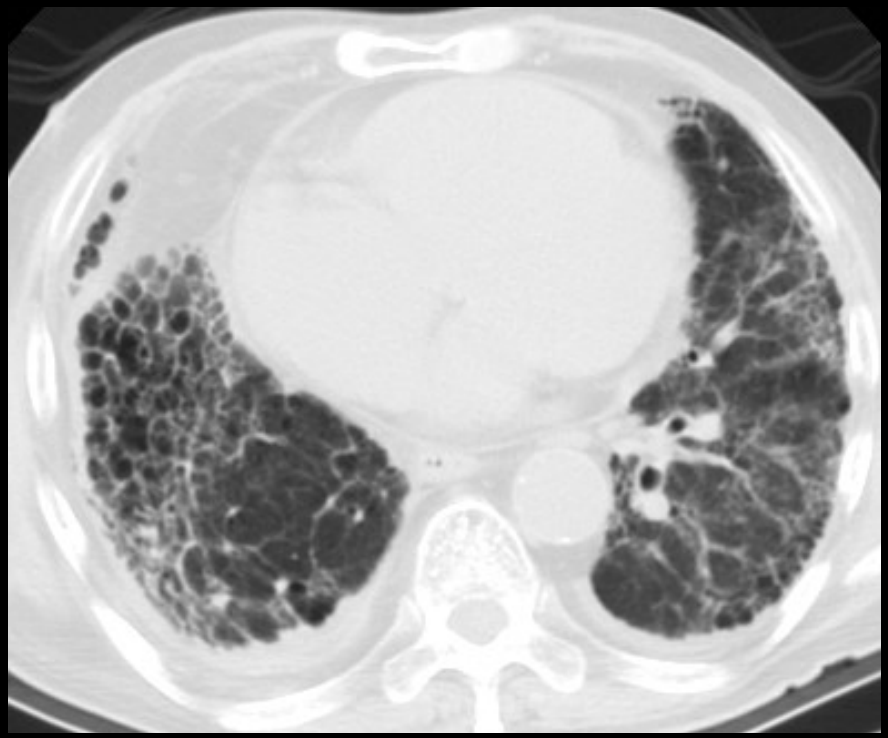
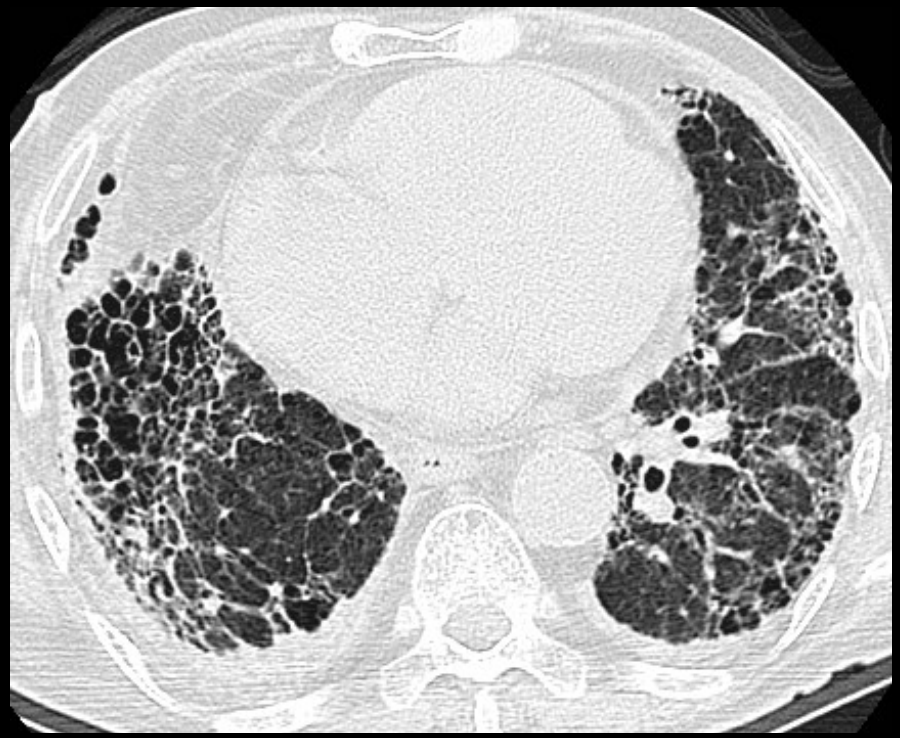
B

- Standard kernel



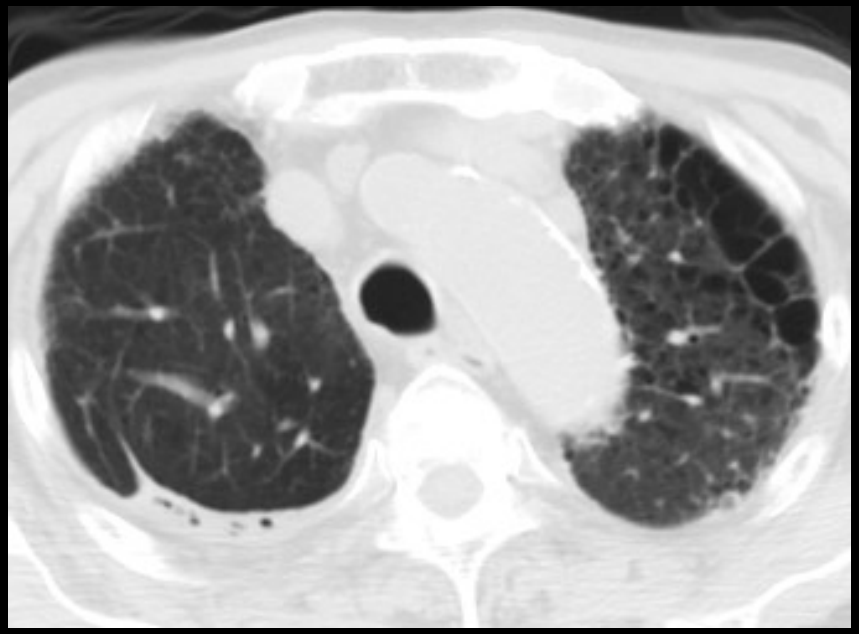
- 5mm slice collimation

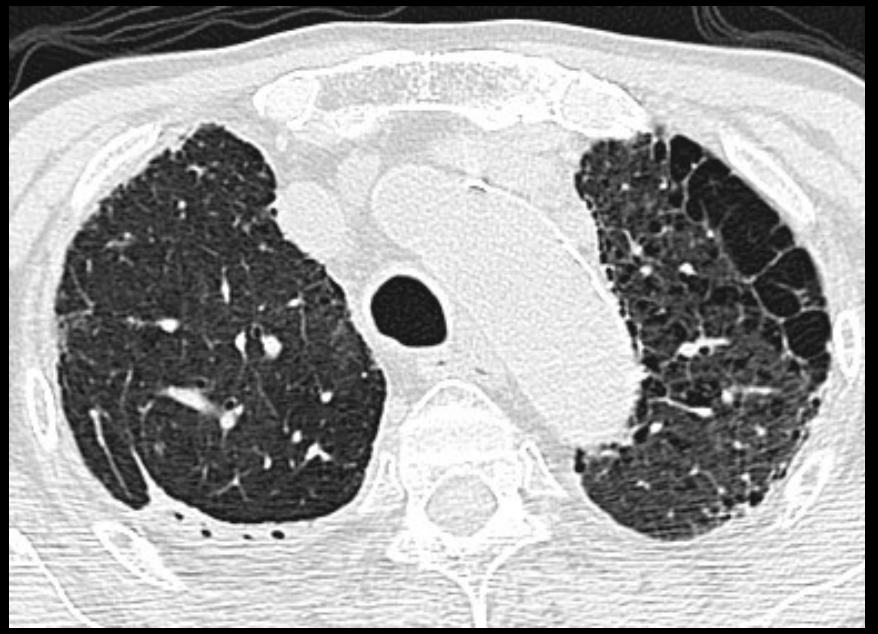
- High resolution lung kernel



- 1 mm slice collimation

- Standard kernel
- High resolution lung kernel

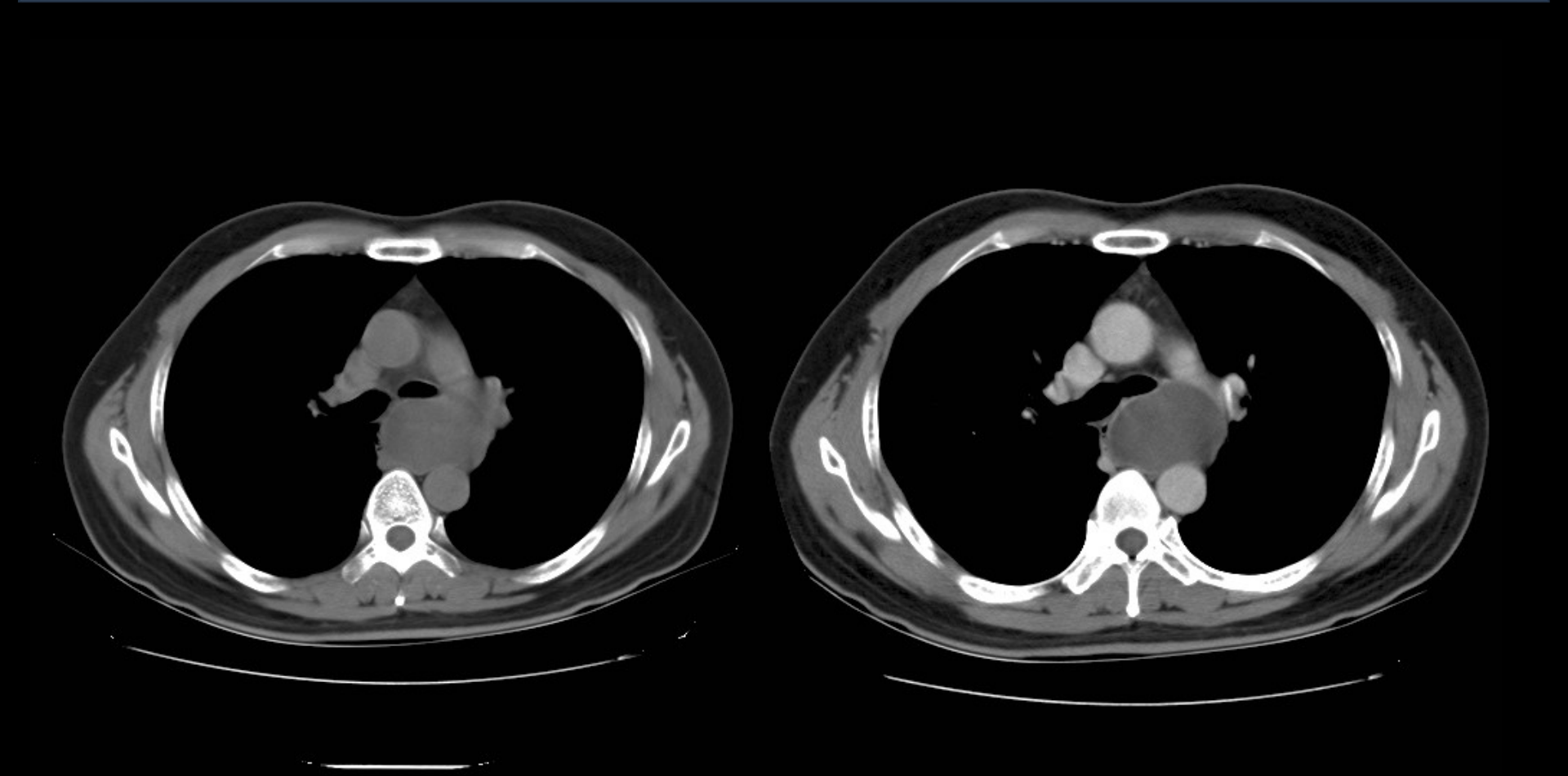




- 5mm slice collimation
- 1 mm slice collimation

Bullae at the peripheral left upper lobe in the background of centrilobular emphysema

# bronchogenic cyst



# Radiological-pathological correlation

Excellent radiological-pathological correlation between HRCT and gross pathologic findings

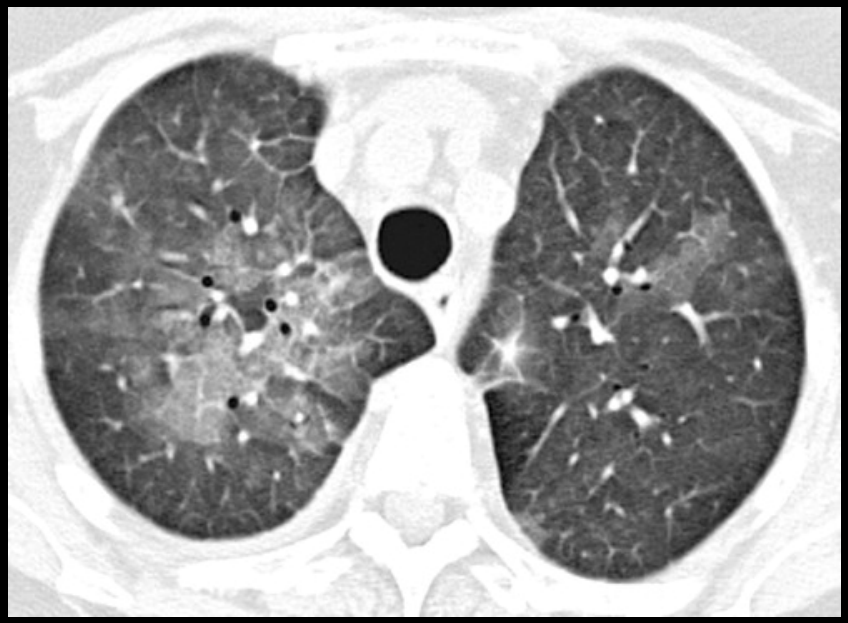
Limitation between histopathologic and HRCT findings due to different scales of resolution (microscopic honeycombing is beyond HRCT resolution)

Clinical information is important

# Non-mass lung opacities

- Ground glass opacity (GGO)
- Consolidation
- Crazy paving pattern

# Ground glass opacity (GGO)

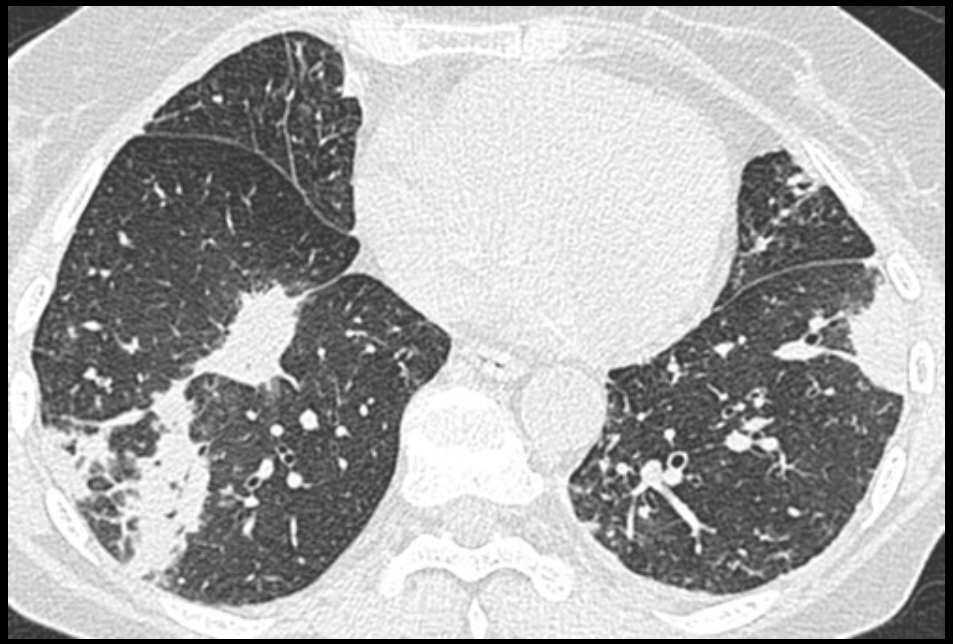


- On CXR, ground-glass opacity appears as an area of hazy increased lung opacity, usually extensive, within which margins of pulmonary vessels may be indistinct.
- On CT, it appears as hazy increased opacity of lung, with preservation of bronchial and vascular margins. It is caused by partial filling of airspaces, interstitial thickening (due to fluid, cells, and/or fibrosis), partial collapse of alveoli, increased capillary blood volume, or a combination of these, the common factor being the partial displacement of air. Ground-glass opacity is less opaque than consolidation, in which bronchovascular margins are obscured.

# Consolidation

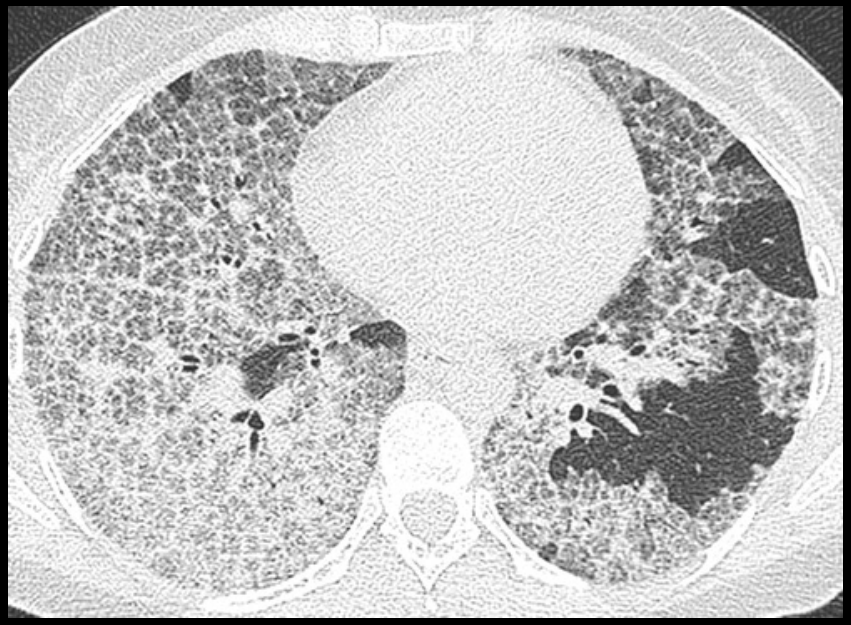
- A pattern of air space disease
- Fillings of the lung parenchyma, i.e. air space, alveoli, by fluid or solid materials, including
- Blood, pus, cells, fluid, fibrosis, etc.
- Presence of airbronchogram
- Obscured underlying vessels
- DDx. GROUND GLASS OPACITY (GGO)

# Consolidation



- *Pathology.*—Consolidation refers to an exudate or other product of disease that replaces alveolar air, rendering the lung solid (as in infective pneumonia).
- Consolidation appears as a homogeneous increase in pulmonary parenchymal attenuation that obscures the margins of vessels and airway walls.
- An air bronchogram may be present. The attenuation characteristics of consolidated lung are only rarely helpful in differential diagnosis (eg, decreased attenuation in lipoid pneumonia and increased in amiodarone toxicity).

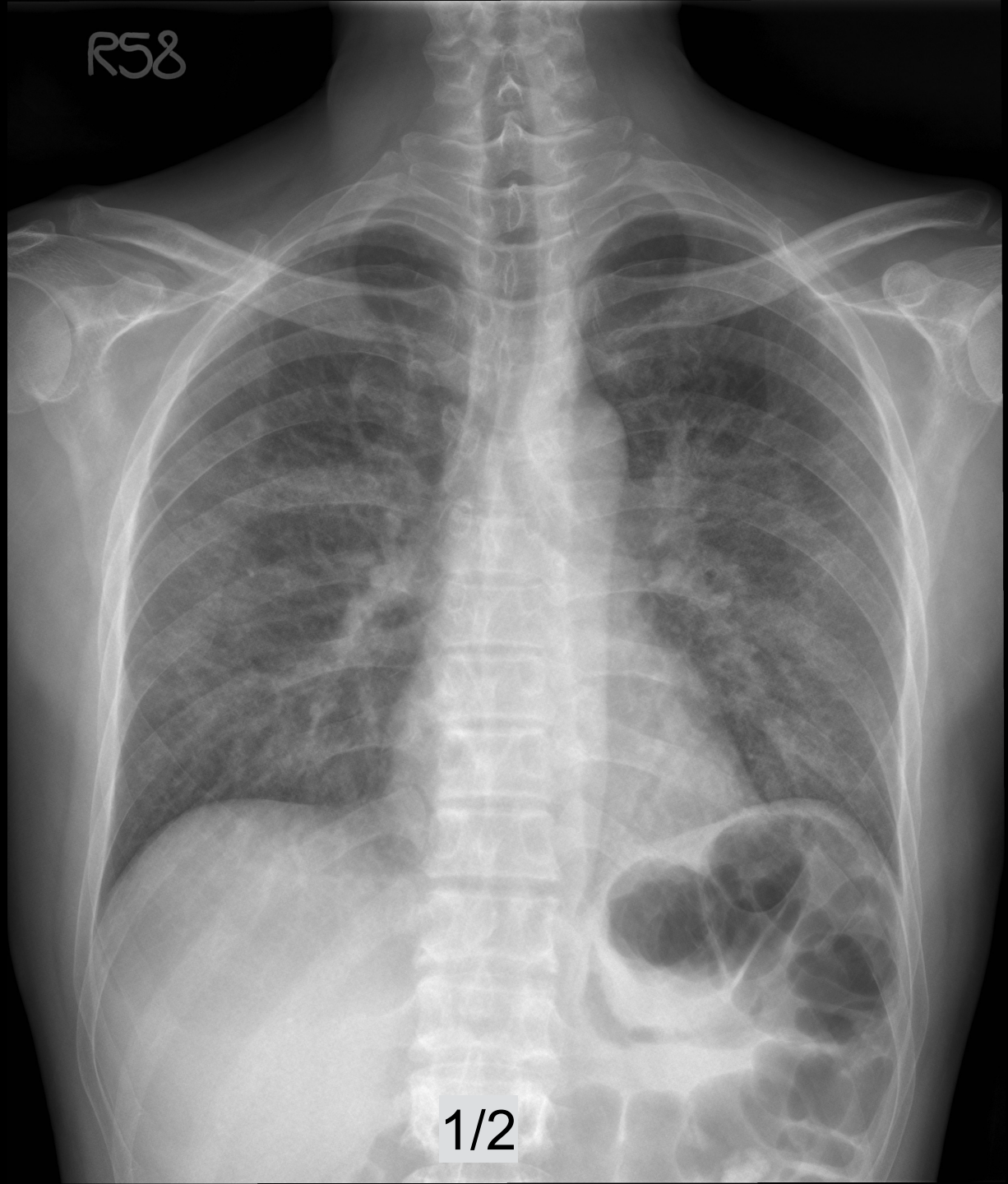
# Crazy-paving pattern



- thickened interlobular septa and intralobular lines superimposed on a background of GGO, resembling irregularly shaped paving stones. The crazy-paving pattern is often sharply demarcated from more normal lung and may have a geographic outline.
- It was originally reported in patients with alveolar proteinosis and is also encountered in other diffuse lung diseases that affect both the interstitial and airspace compartments, such as lipoid pneumonia.

# Case demonstration

- 51 y/o male businessman, came back from China with dyspnea and fever.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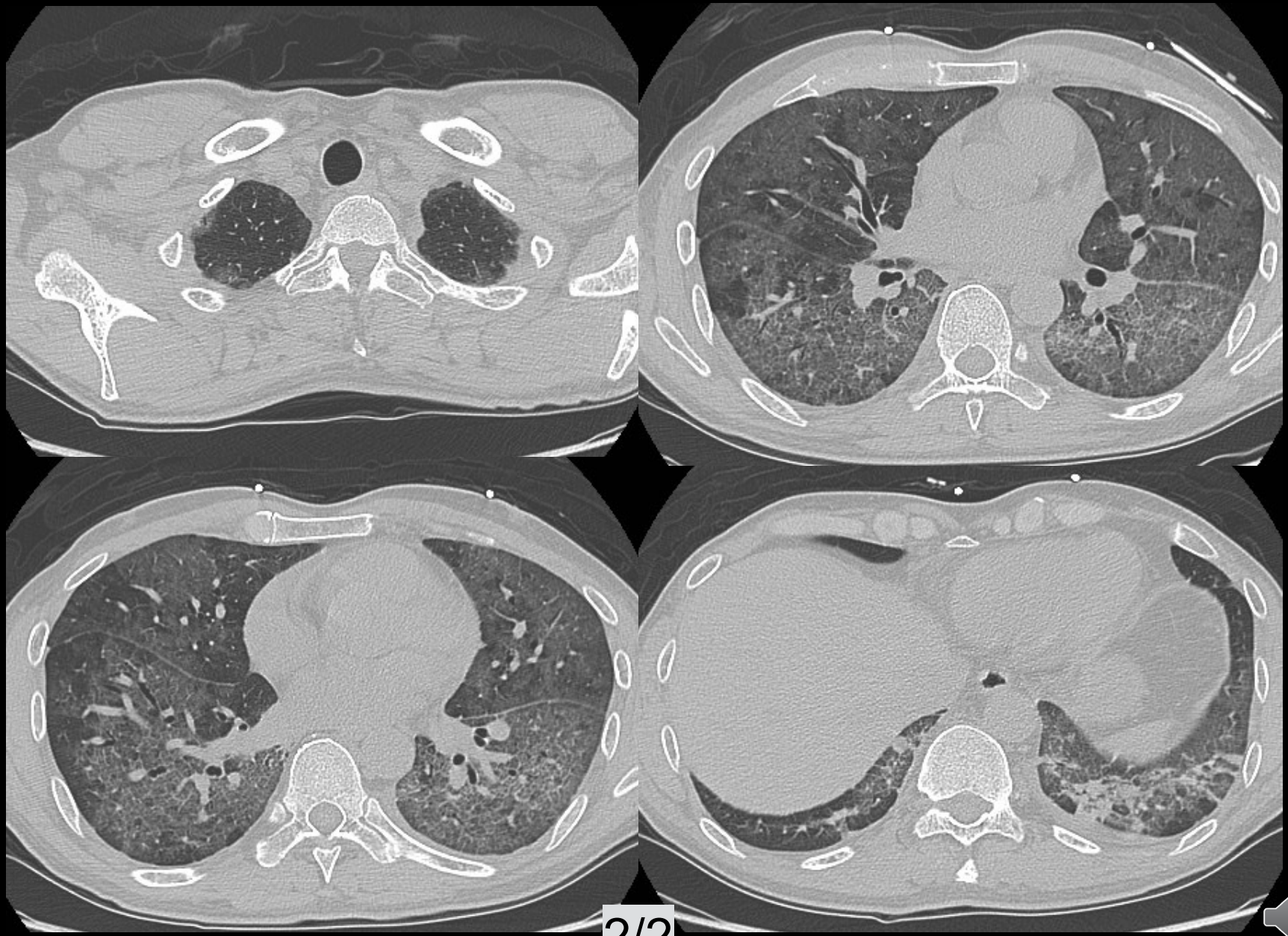


# PJP

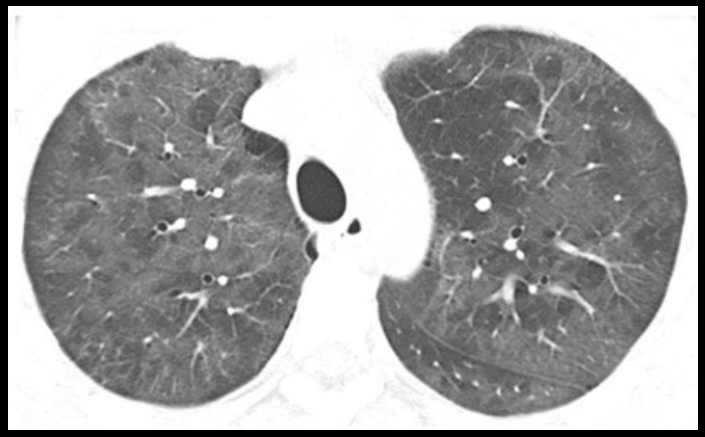
- *Pneumocystis jiroveci* is an atypical fungus that causes pneumonia in immunocompromised human hosts (esp. cell-mediated immunity)
- CXR: non-specific
- HRCT: extensive GGO is the principal finding in PJP, reflecting accumulation of intraalveolar fibrin, debris, and organisms

AJR Am J Roentgenol. 2012 Jun;198(6):W555-61

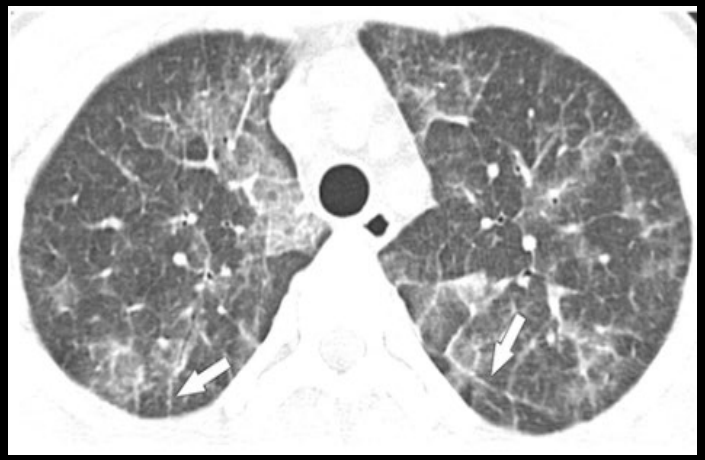
# Distribution

- Central distribution of ground-glass opacity with relative peripheral sparing: 41% of patients
- Diffuse distribution: 24%
- Mosaic pattern: 29%

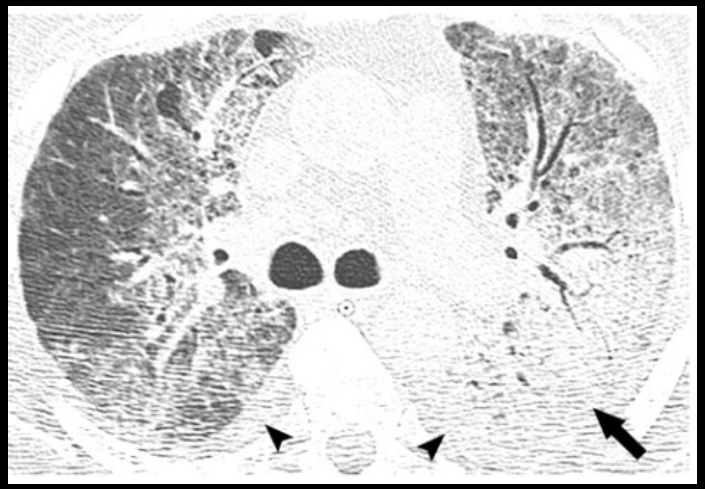
AJR Am J Roentgenol. 2012 Jun;198(6):W555-61



extensive GGO with
diffuse distribution

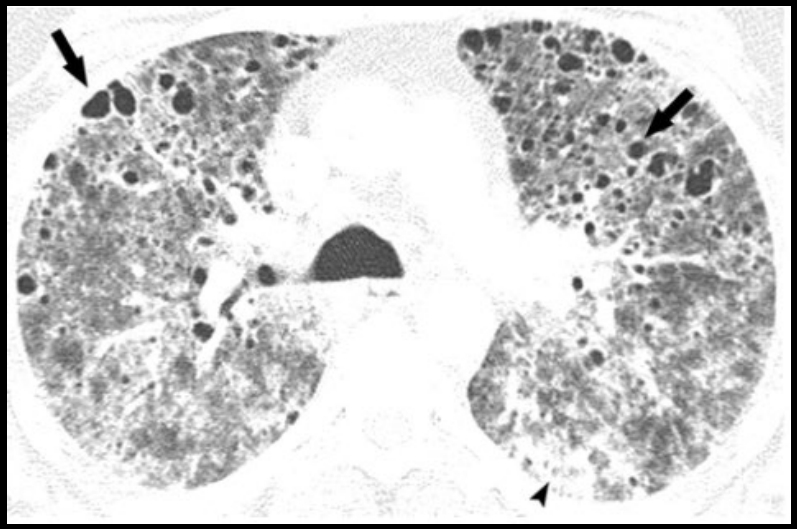


with interlobular thickening
(more advance disease)

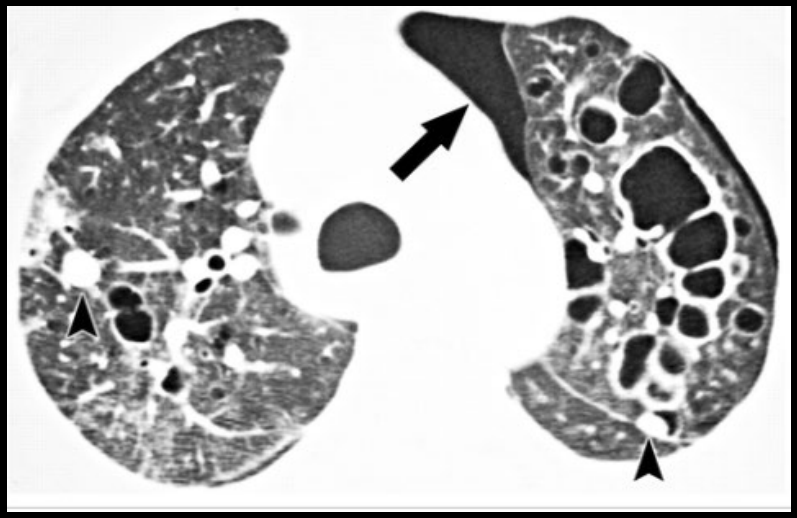


sometimes with pleural effusion
and dense consolidation

**Pulmonary cysts of varying shape, size, and wall thickness occur in as many as one third of patients with PJP. Cysts may resolve after treatment and clearing of infection**



**extensive GGO with numerous cysts**

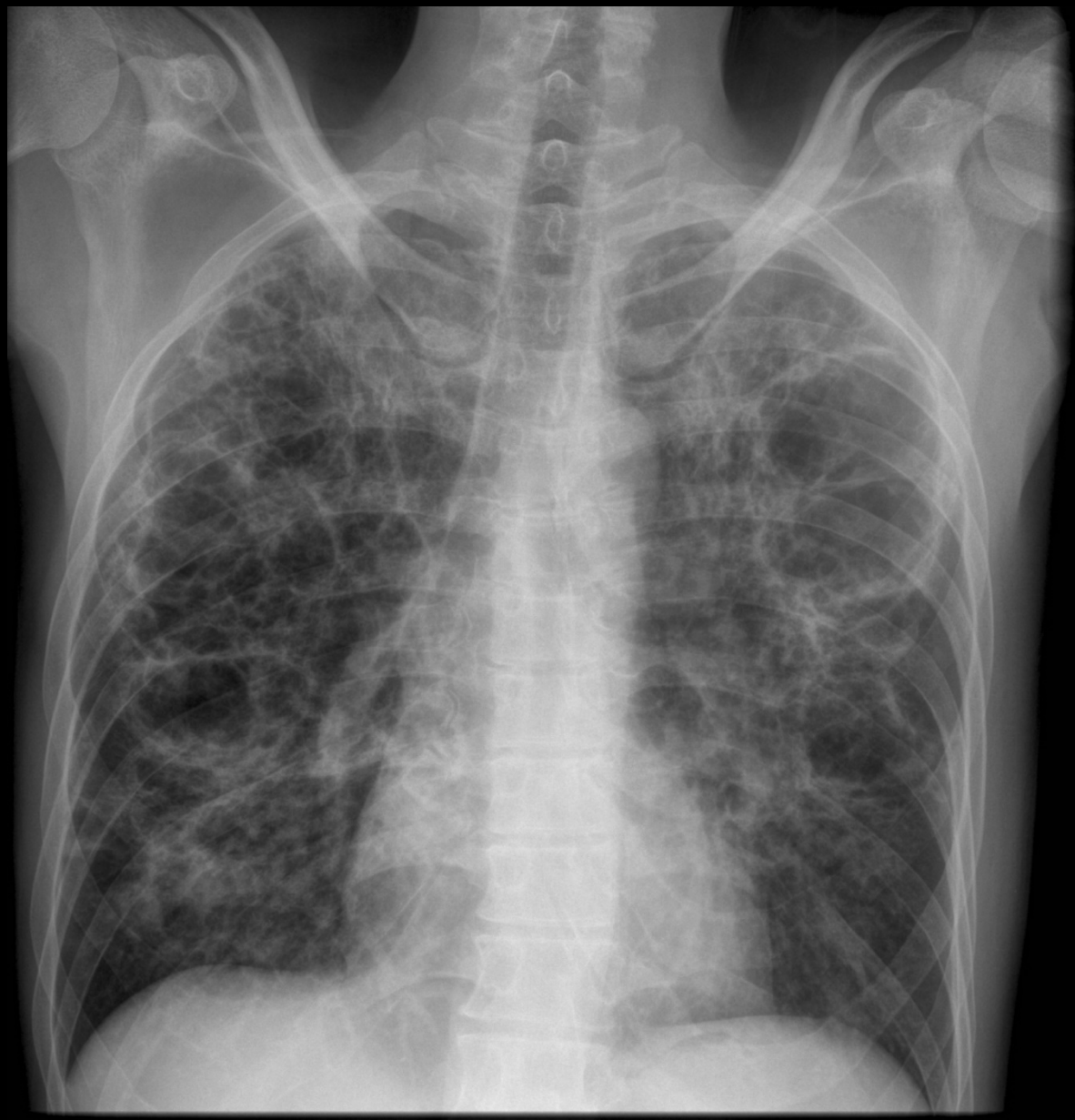


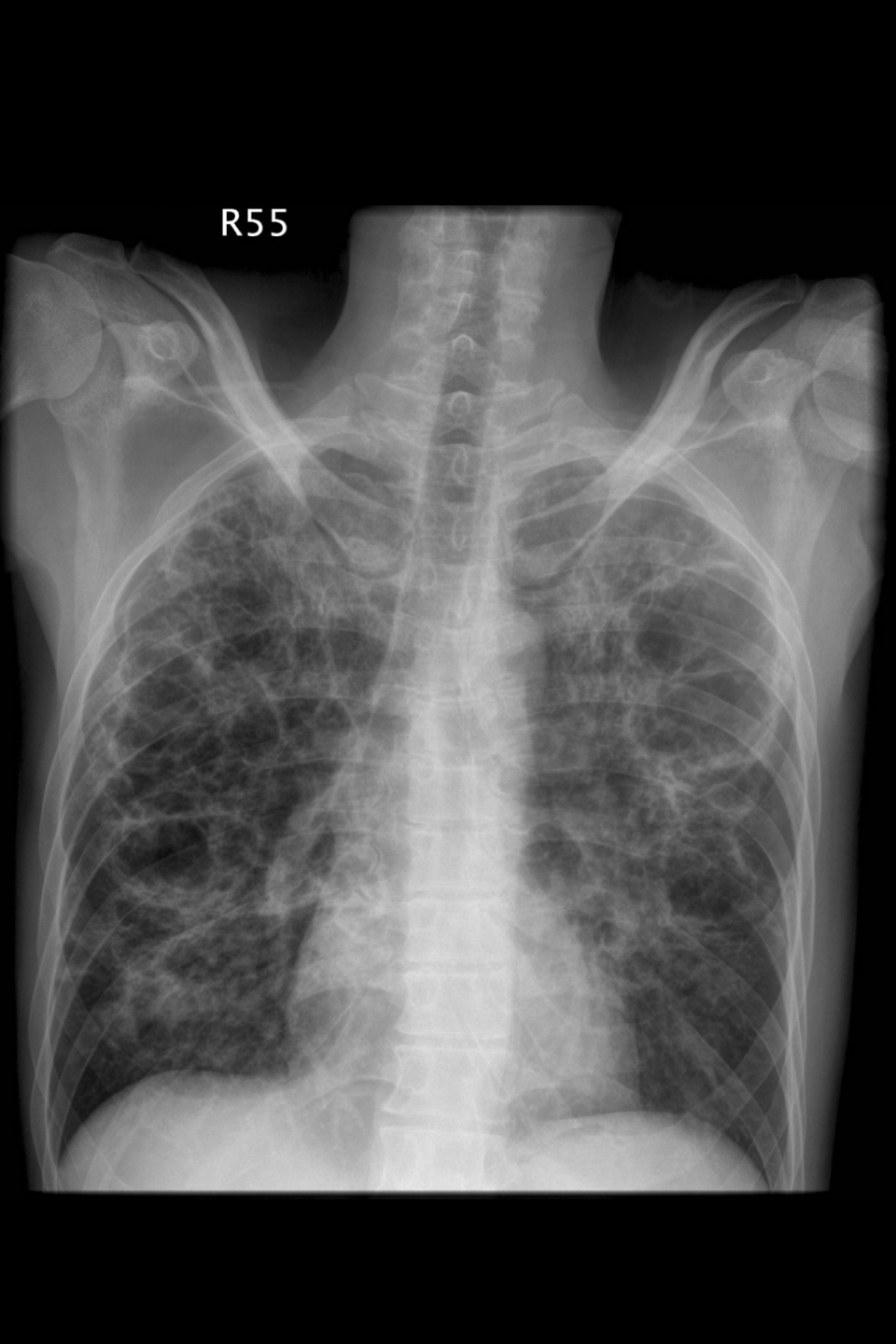
**various-sized cysts pneumothorax**

# Case demonstration

- A 40-year-old male
- Fever, night sweating, loss of body weight in 3 months
- Underlying disease :
  HIV with AIDS
  (CD4 count = 9.8 / μL)

bilateral cystic lesions and reticulonodular opacities

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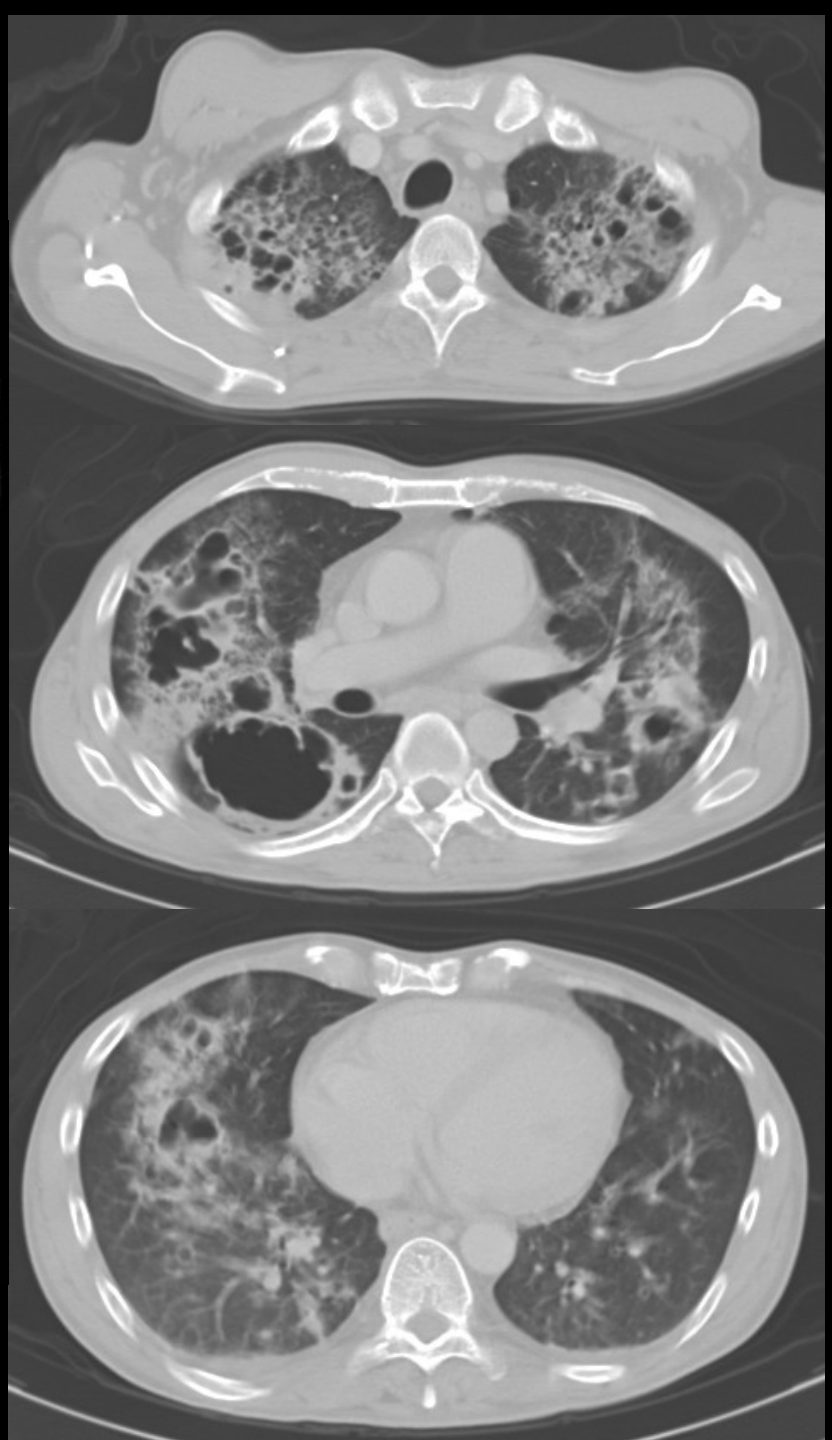
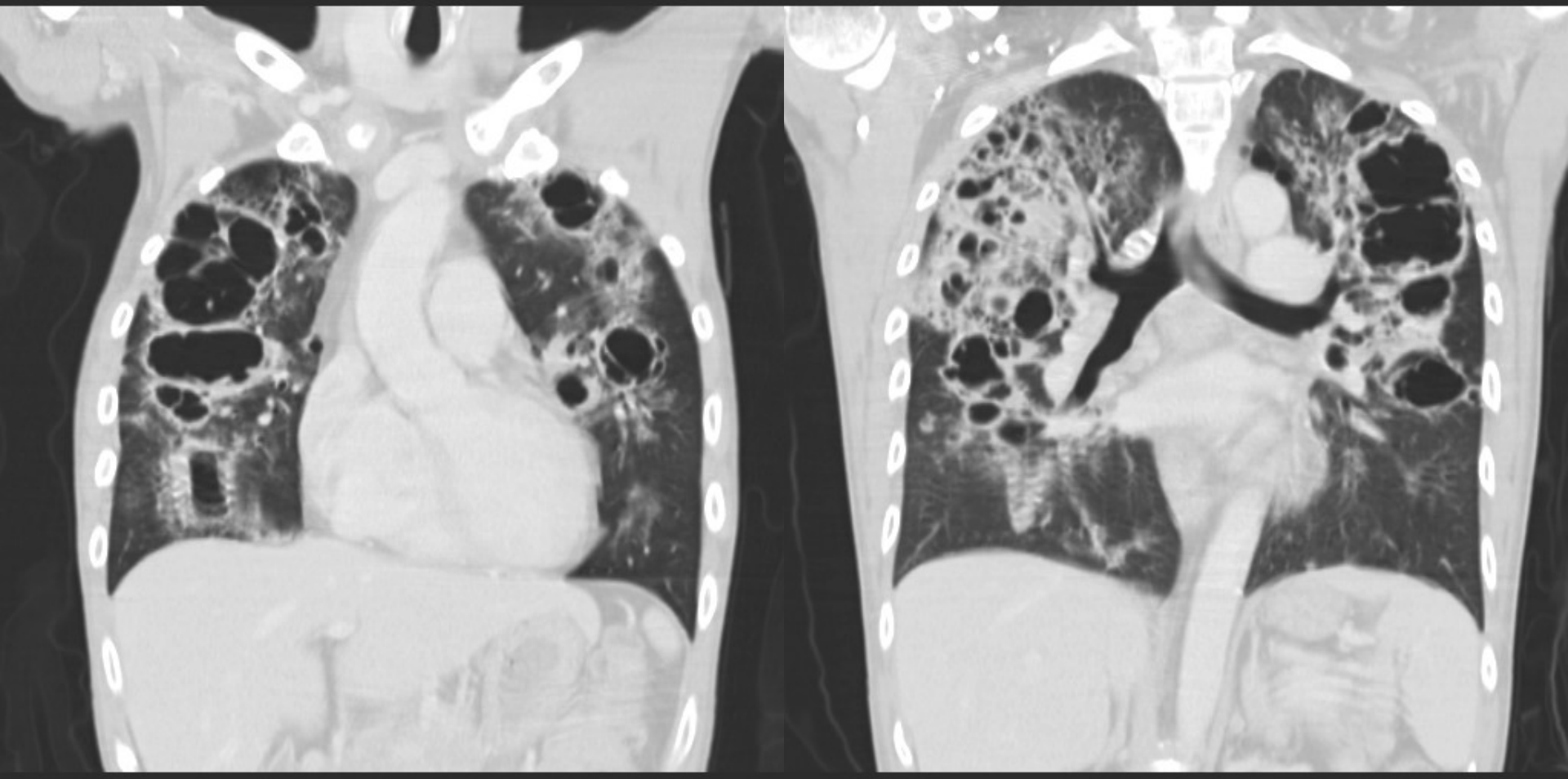
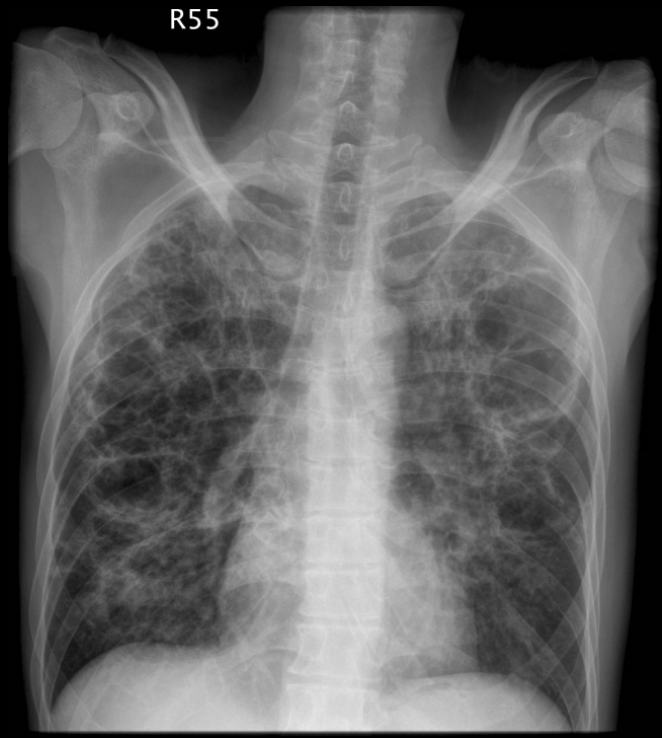
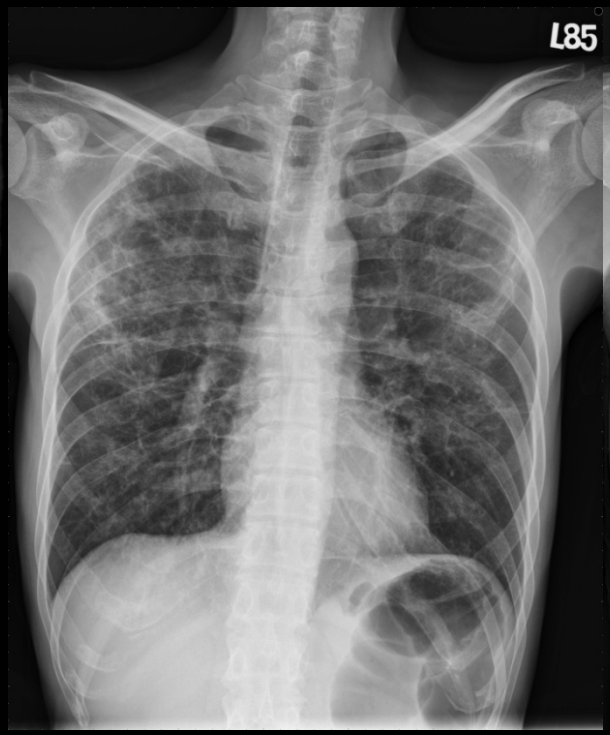




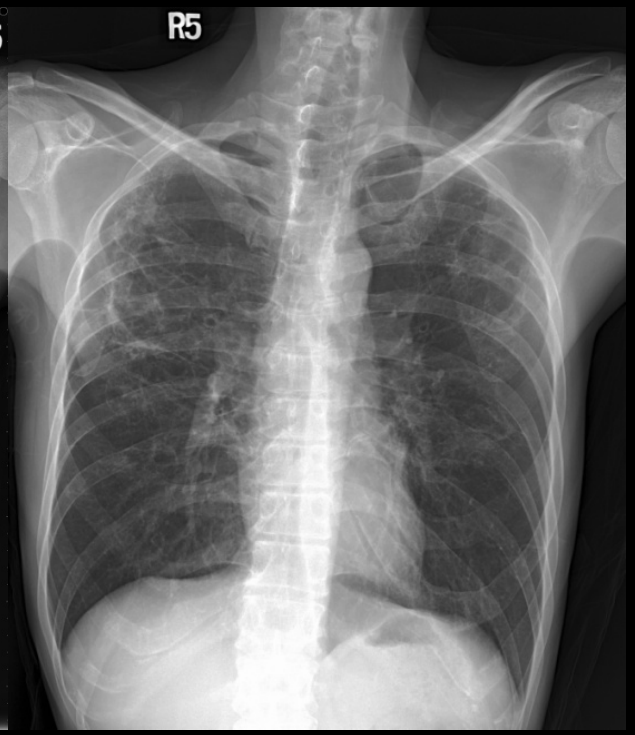
# Serial follow up CXR




2014/12/03
At presentation




2015/01/02
4 weeks later




2015/01/17
6 weeks later

# Differential Diagnosis

## Cysts, GGO, consolidation in patient with AIDS

- Infectious
  1. Bacterial pneumonia / abscess
  2. Mycobacterium
  3. Fungus
  4. Cytomegalovirus (CMV) pneumonia
- Non-infectious
  1. Lymphocytic interstitial pneumonitis (LIP)
  2. Necrotic carcinoma/ lymphoma

# Pathology Diagnosis

- Pneumocystis pneumonia, *Pneumocystis jirovecii*
  - "GMS stain show *Pneumocystis jirovecii* cysts."

# *Pneumocystis jiroveci pneumonia*

- Extensive GGO :
  - Central distribution & peripheral sparing : 41%
  - Mosaic pattern : 29%
  - Diffuse : 24%
- Cysts of varying shape, size, wall thickness : 1/3 patients
- Advance stage : septal lines / consolidation
- Granulomatous inflammation : 5%
- Interstitial fibrosis : rare,
  “chronic pneumocystis pneumonia”

Radiology. 2013 Jul;268(1):299-303

# Pulmonary findings in HIV Patients

**TABLE 1: Differential Diagnosis of Pulmonary Findings in Patients With HIV Infection**

| Pulmonary Consolidation | Ground-Glass Opacity | Cystic Lesions | Peribronchovascular Opacities |
|---|---|---|---|
| Infection | Infection | PCP (CD4 < 200 cells/$mm^3$) | Neoplastic |
| Bacterial | Viral | Lymphocytic interstitial pneumonia | Kaposi sarcoma (CD4 < 200 cells/$mm^3$) |
| CD4 < 200 cells/$mm^3$ | Atypical bacterial | | Lymphoma |
| Mycobacterial | CD4< 200 cells/$mm^3$ | | Lymphangitic carcinomatosis |
| Fungal | PCP | | |
| | CD4 < 100 cells/$mm^3$ | | Lymphocytic interstitial pneumonia |
| Neoplastic | Cytomegalovirus | | Sarcoidosis |
| Lymphoma | | | |
| Lung cancer | Interstitial lung disease | | |
| | Lymphocytic interstitial pneumonia | | |
| | Nonspecific interstitial pneumonia | | |

Note—PCP = *Pneumocystis jiroveci* pneumonia.

*AJR 2012; 198:1295–1304*

# CD4 count and Pulmonary Infections

| CD4 cell counts when infection first occurs | Pulmonary infections |
|---|---|
| >500 cells/μL | Acute pharyngitis, bronchitis, sinusitis<br>Pneumonia<br>PTB |
| 200 - 500 cells/μL | Recurrent bacterial pneumonia<br>Varicella zoster pneumonitis |
| 100 - 200 cells/μL | PCP<br>Disseminated TB |
| <100 cells/μL | Disseminated MAC<br>Fungal pneumonia (Aspergillus, Candida)<br>CMV pneumonitis<br>Herpes simplex pneumonitis |

* Most pulmonary infections occur with increasing frequency at lower CD4 cell counts.

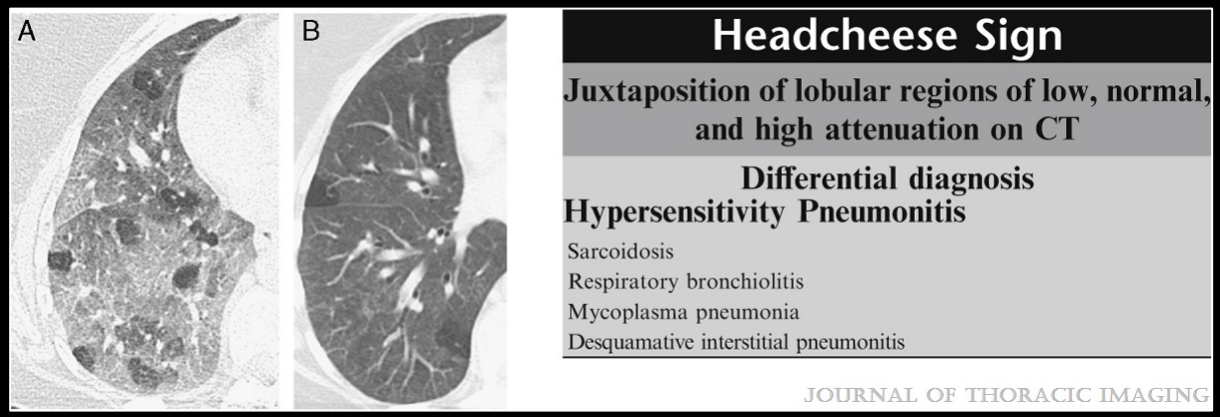
*Arch Intern Med 1995;155:1537-42.*

# Crazy-paving pattern

| Acute course of disease | Subacute/chronic course of disease |
|---|---|
| Pulmonary oedema | Usual interstitial pneumonia (UIP) |
| Pulmonary infection (bacterial, viral, pneumocystis jiroveci, mycoplasma) | Nonspecific interstitial pneumonia (NSIP) |
| Pulmonary haemorrhage | Alveolar proteinosis |
| Acute interstitial pneumonia (AIP) | Organising pneumonia |
| Adult (acute) respiratory distress syndrome (ARDS) | Vasculitis (Churg-Strauss syndrome) |
| Radiation pneumonitis | Eosinophylic pneumonia (chronic) |
| Eosinophilic pneumonia | Mucinous bronchioloalveolar carcinoma |
| | Lymphangitic spread of tumor |
| | Sarcoidosis |
| | Lipid pneumonia |

# Headcheese sign

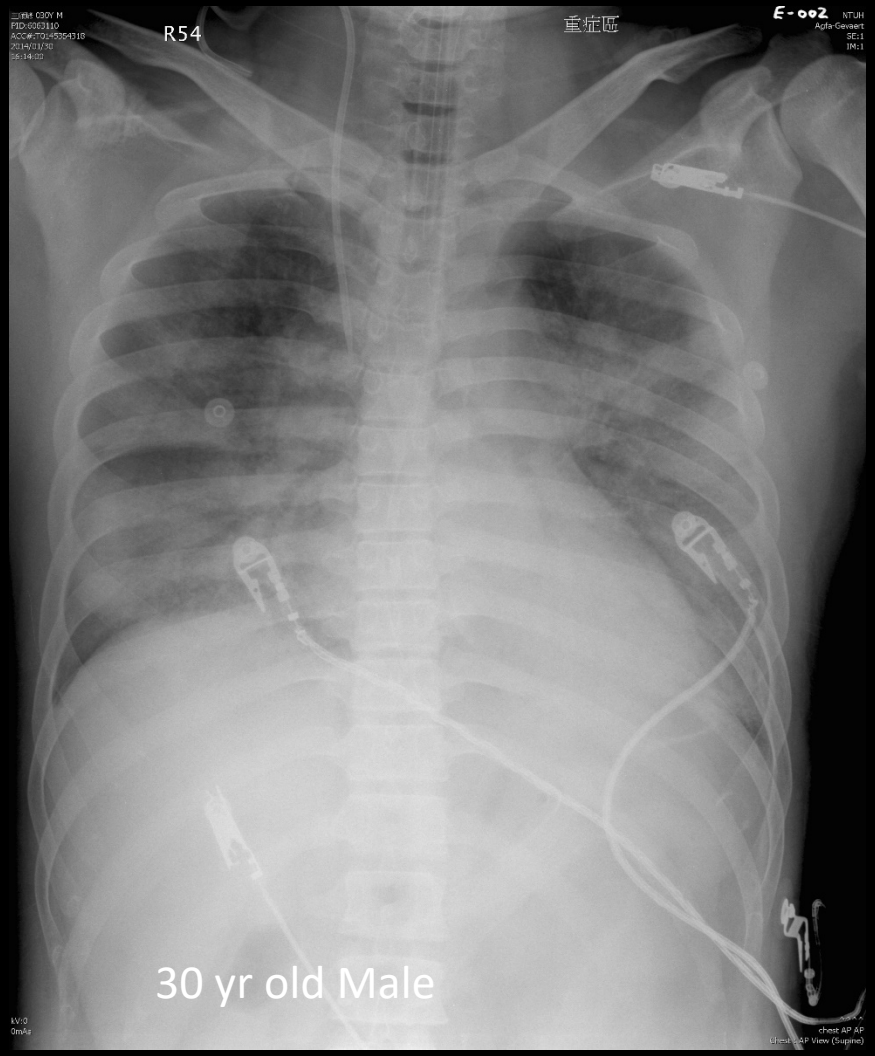
- characterized by the juxtaposition of lobular regions of low, normal, and high attenuation.

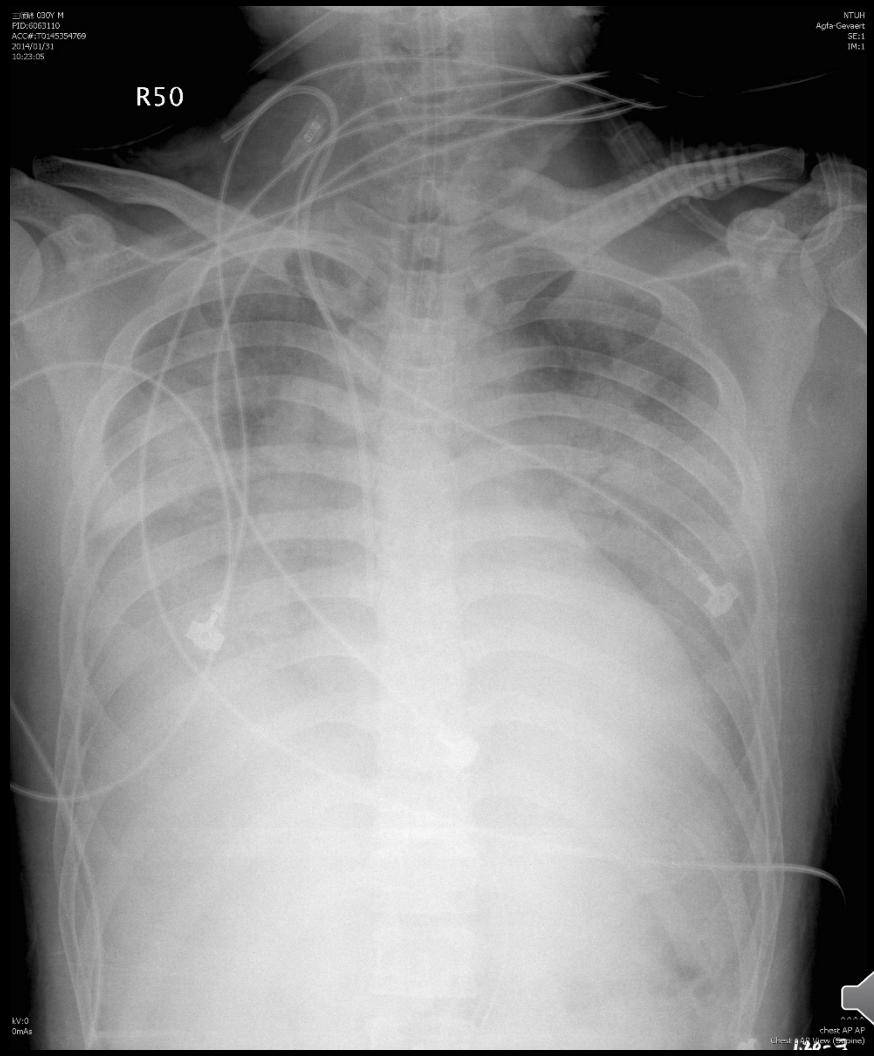



Axial image from expiratory chest CT (A) shows juxtaposition of 3 different densities with well-defined margination, consistent with the headcheese sign. The inspiratory chest CT image (B) shows mild mosaic attenuation and diffuse hazy GGO.

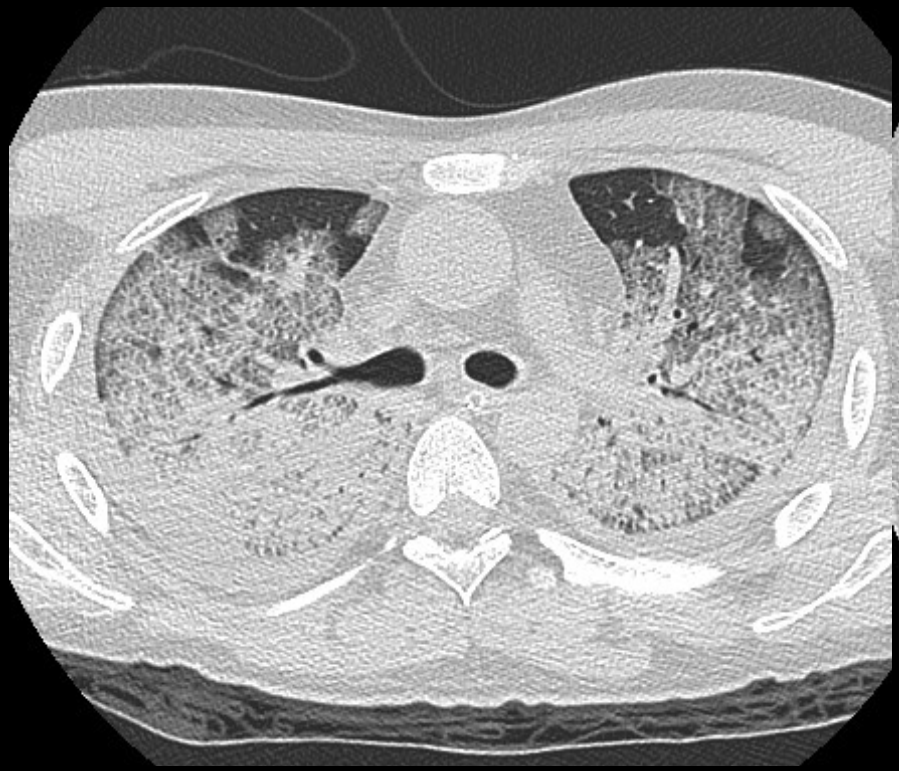
J Thorac Imaging 2014; 29 (1): W13

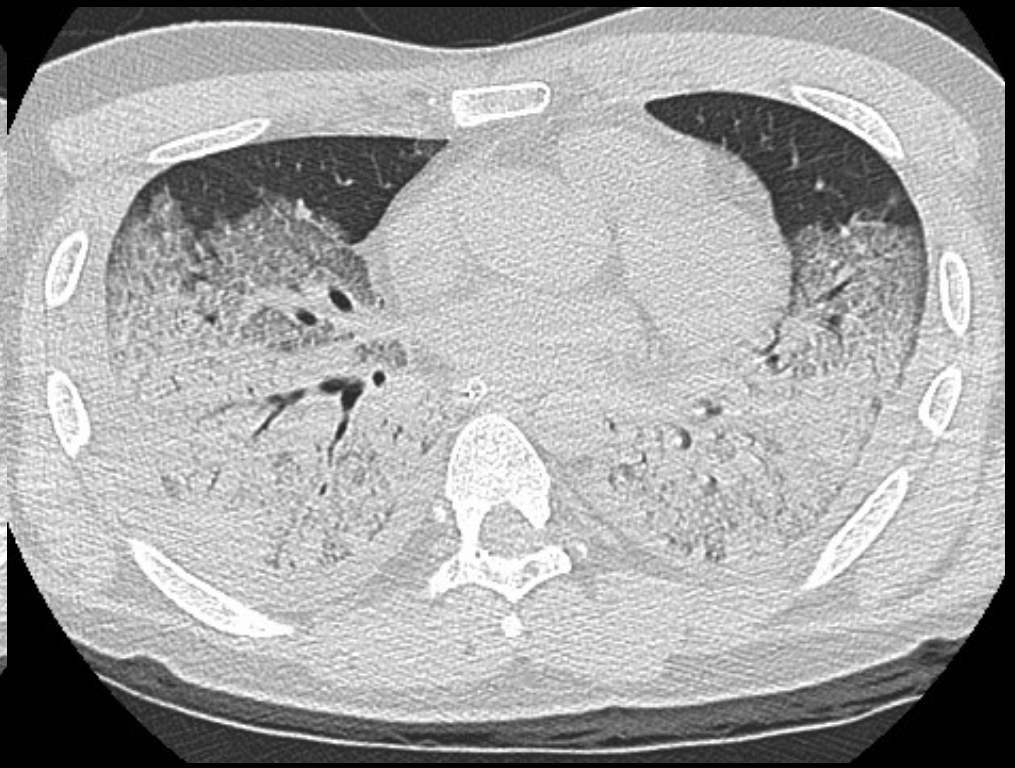
# Rapidly progressive to ARDS



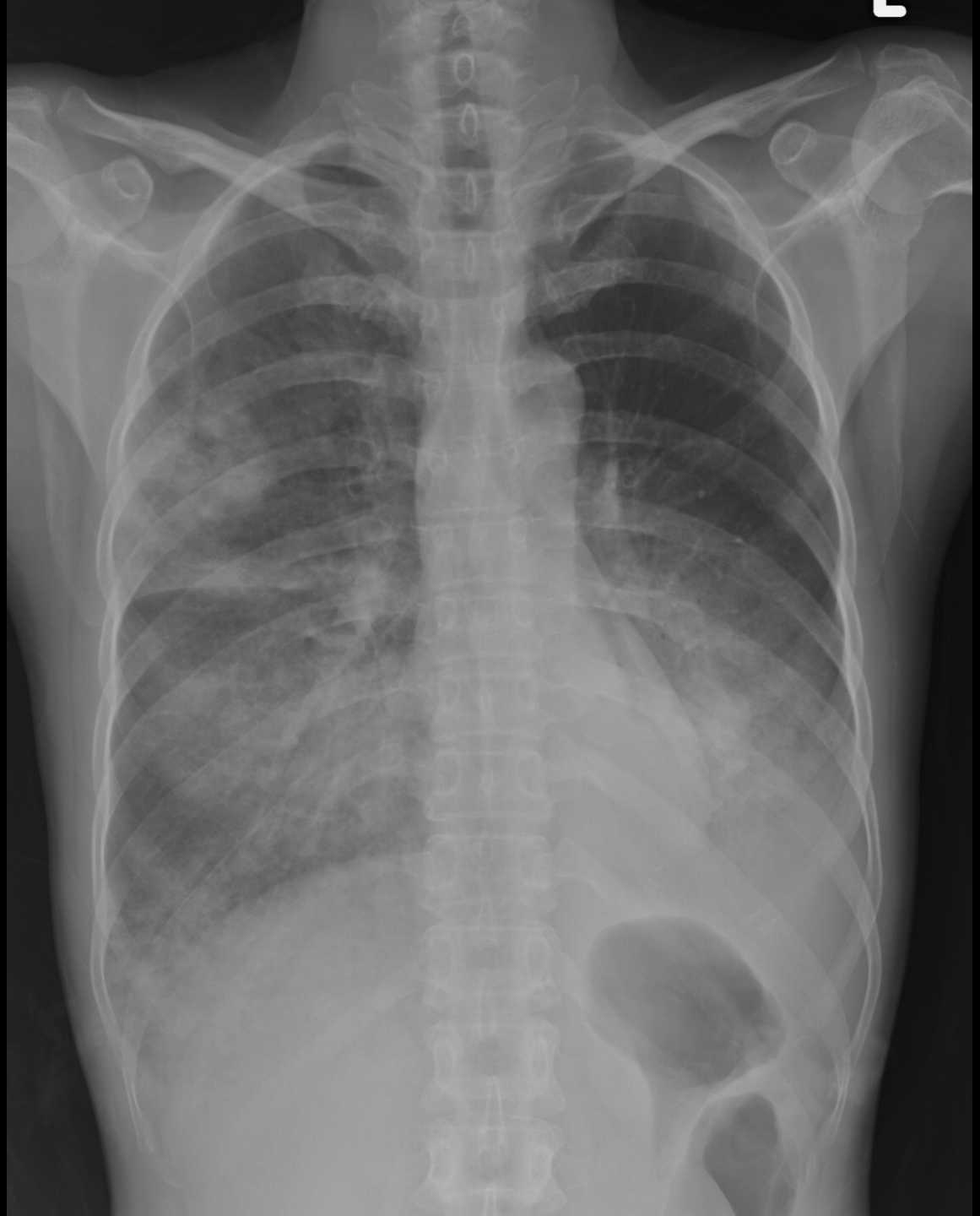
# ARDS due to influenza pneumonia

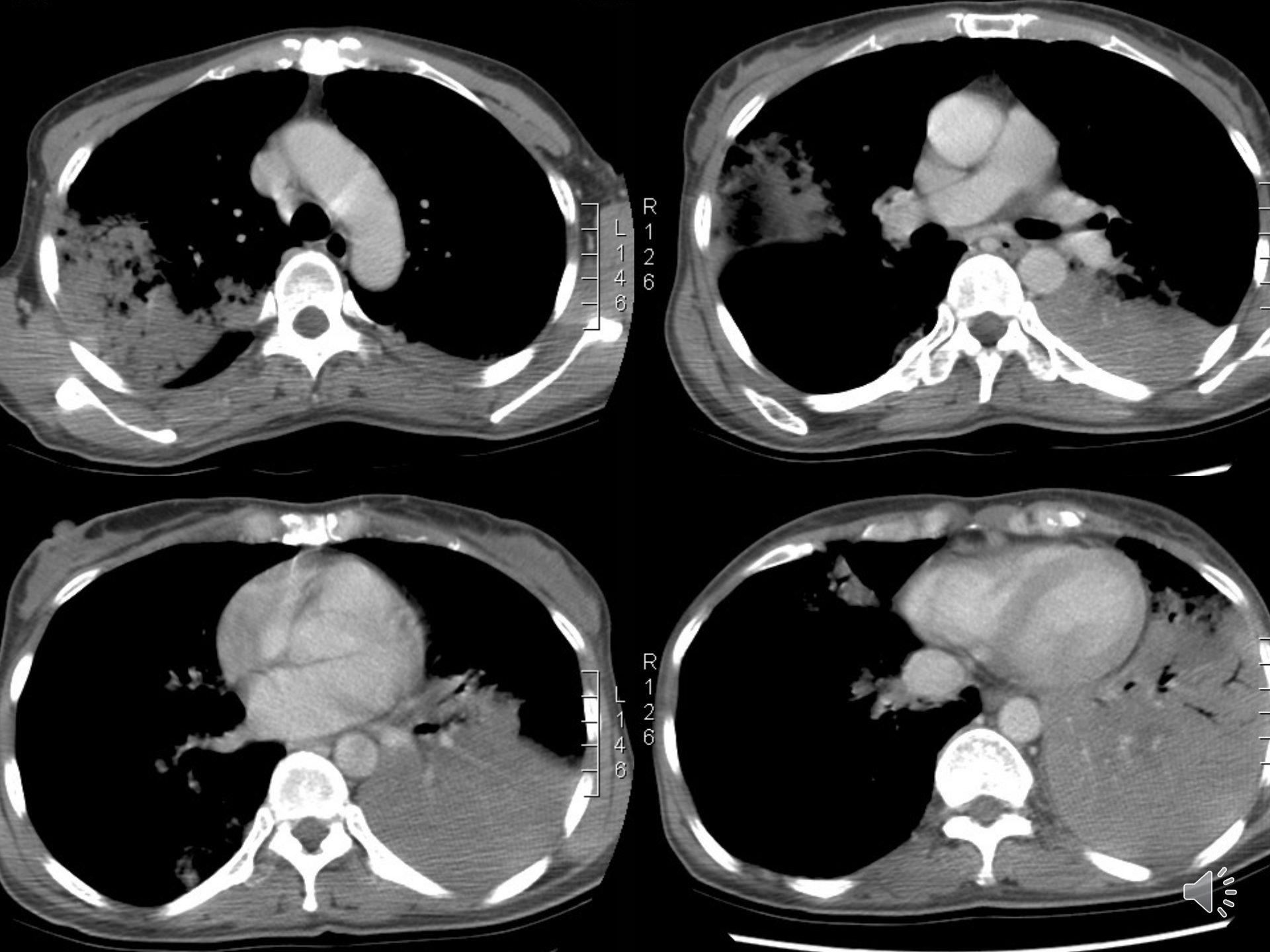




# Case demonstration

- 50 y/o women
- Chronic productive cough for 3 months
- Progressive exertional dyspnea for 2 weeks




R
1
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6
L
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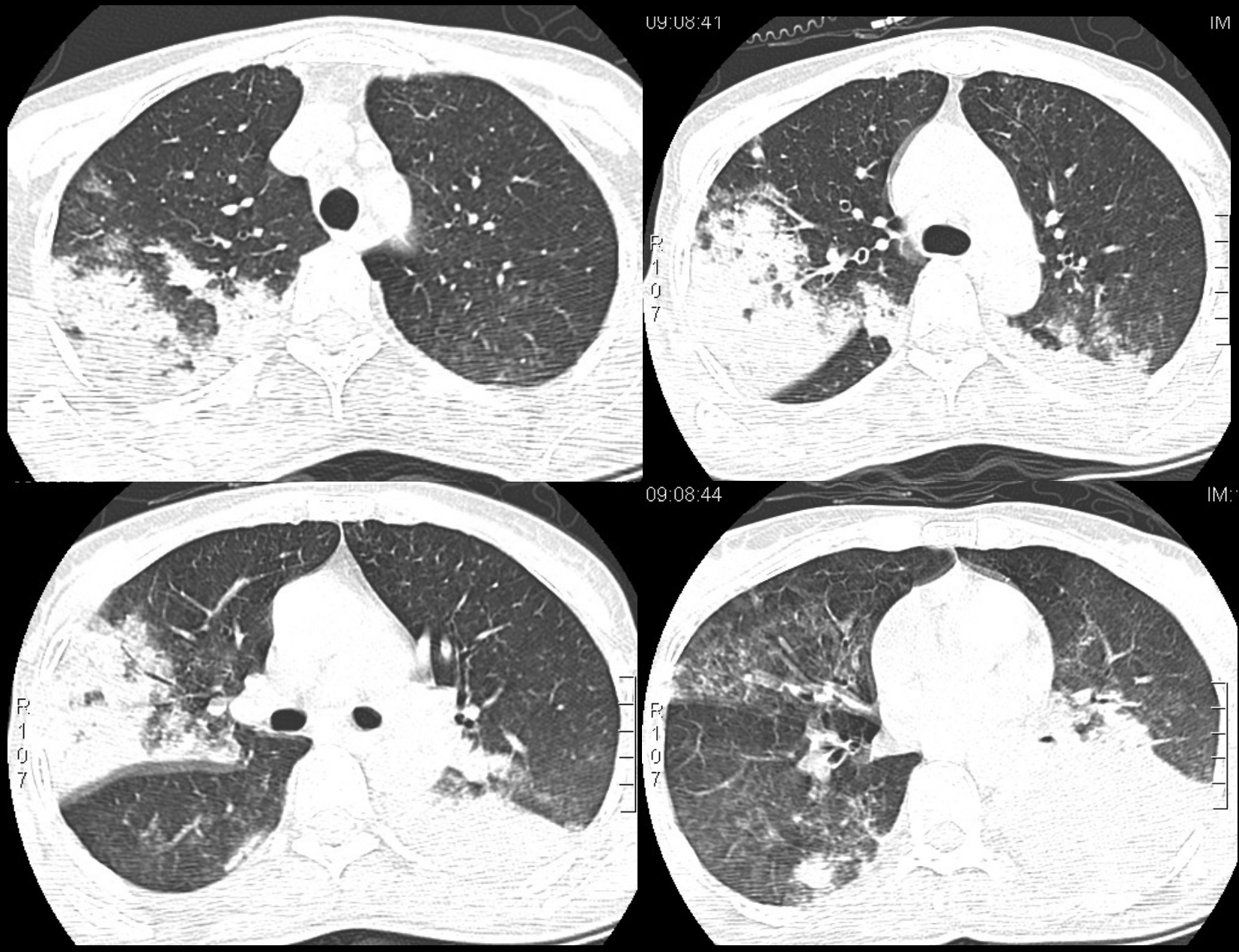
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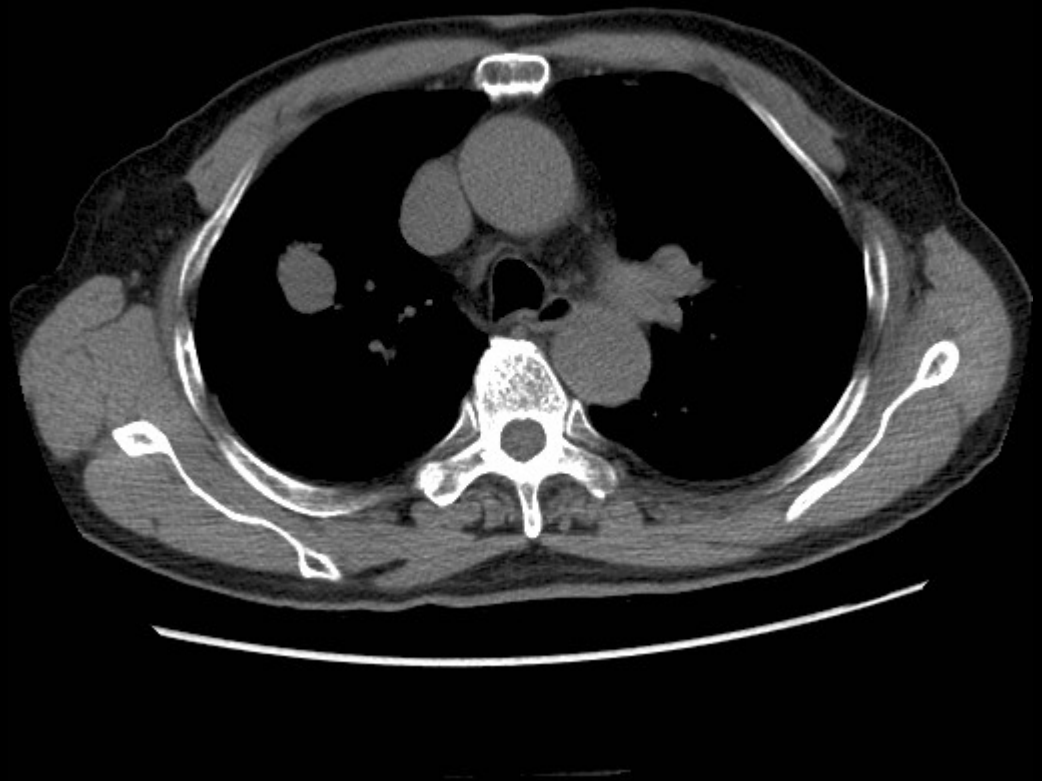
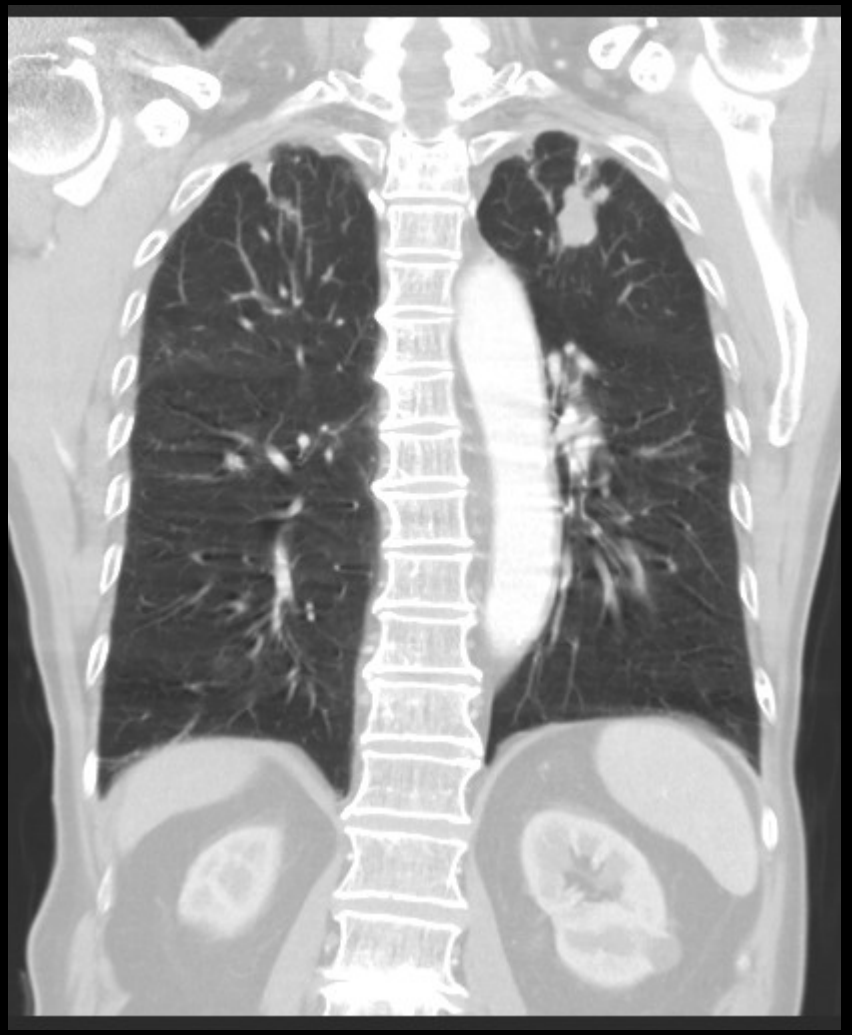
# Differential diagnoses

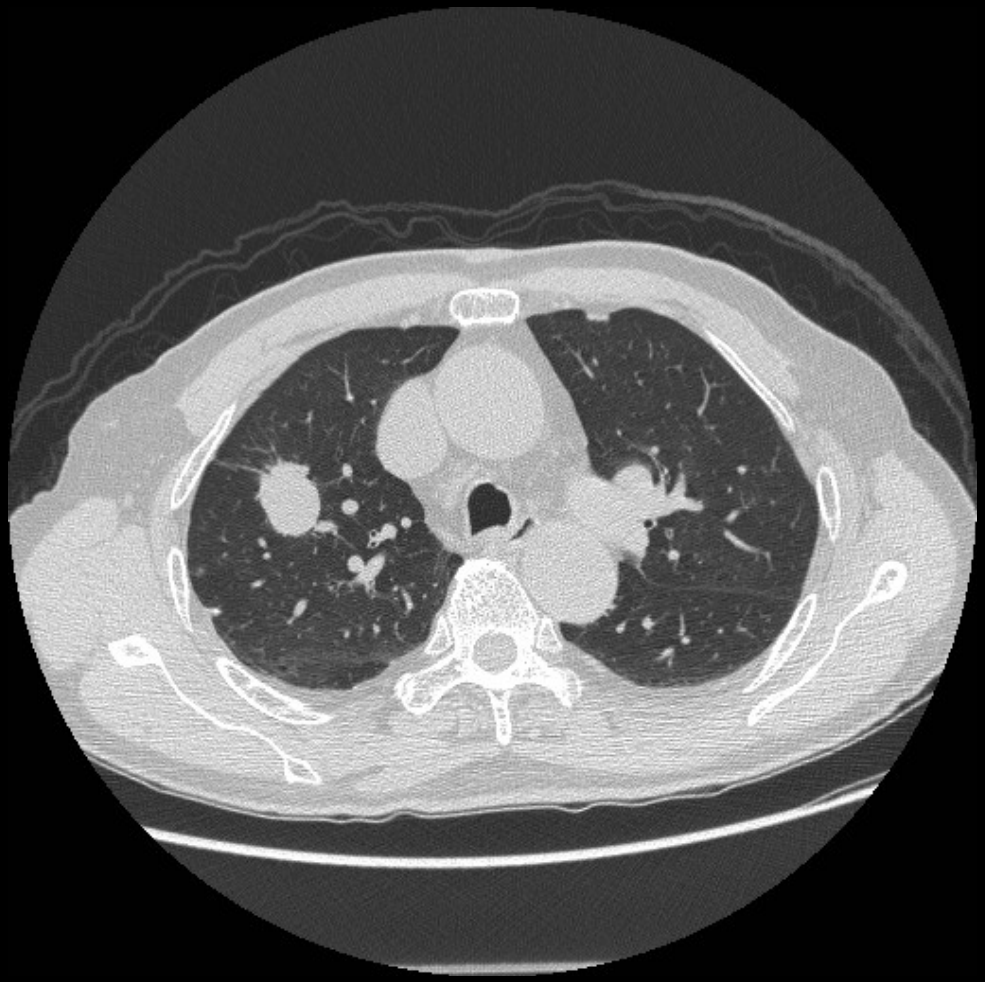
- Bronchopneumonia
- Lymphoproliferative disorder such as pulmonary lymphoma
- Lung cancer, especially mucinous adenocarcinoma

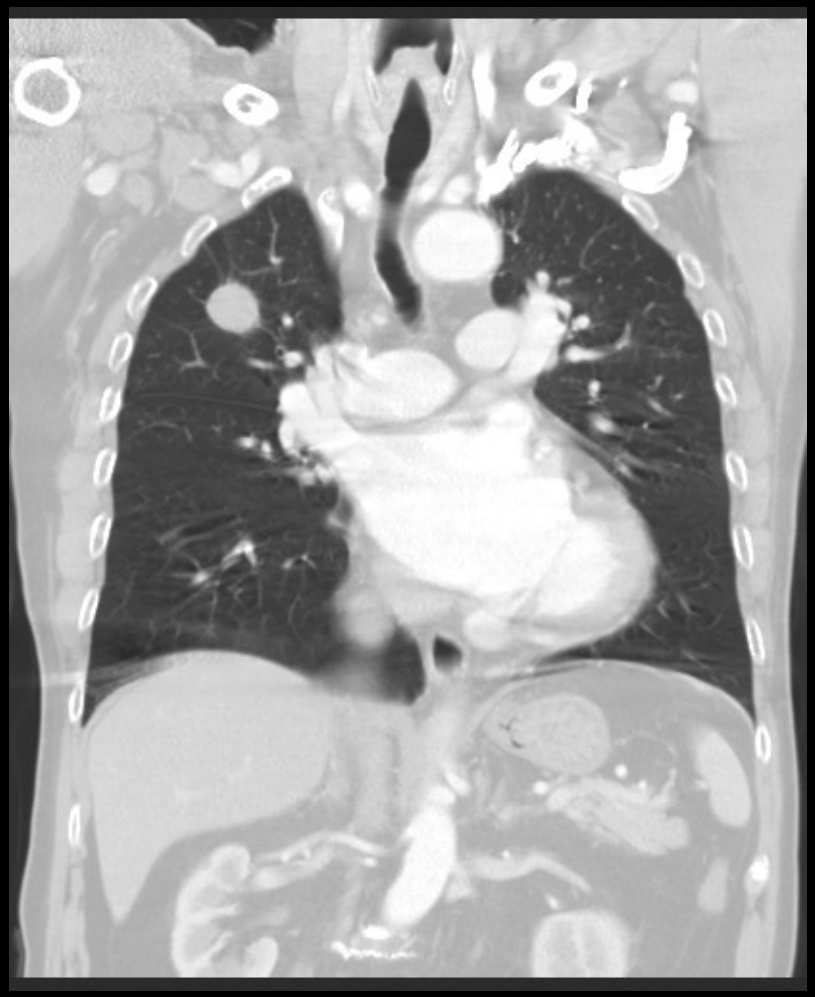
# Result

- washing cytology, culture and TBLB: negative
- s/p Echo-guided biopsy
- an adenocarcinoma of bronchioloalveolar pattern, TTF-1 (+).









Diffuse Large B-cell Lymphoma presented with bilateral nodules

# Lung cancer staging and follow up

- CT is an important clinical imaging modality for staging lung cancer and follow up lung cancer for treatment response
- Tumor
- Nodal
- Metastasis
- Response evaluation

| T/M | Subcategory | N0 | N1 | N2 | N3 |
|---|---|---|---|---|---|
| T1 | T1a | IA1 | IIB | IIIA | IIIB |
| | T1b | IA2 | IIB | IIIA | IIIB |
| | T1c | IA3 | IIB | IIIA | IIIB |
| T2 | T2a | IB | IIB | IIIA | IIIB |
| | T2b | IIA | IIB | IIIA | IIIB |
| T3 | T3 | IIB | IIIA | IIIB | IIIC |
| T4 | T4 | IIIA | IIIA | IIIB | IIIC |
| M1 | M1a | IVA | IVA | IVA | IVA |
| | M1b | IVA | IVA | IVA | IVA |
| | M1c | IVB | IVB | IVB | IVB |

# Lung cancer staging and follow up

**TABLE 1. Definitions for TNM descriptors**

| T (primary tumor) | |
|---|---|
| T0 | No primary tumor |
| Tis | Carcinoma in situ (squamous or adenocarcinoma) |
| T1 | Tumor ≤3 cm |
| T1mi | Minimally invasive adenocarcinoma |
| T1a | Superficial spreading tumor in central airways* |
| T1a | Tumor ≤1 cm |
| T1b | Tumor >1 but ≤2 cm |
| T1c | Tumor >2 but ≤3 cm |
| T2 | Tumor >3 but ≤5 cm or tumor involving: visceral pleura,† main bronchus (not carina), atelectasis to hilum† |
| T2a | Tumor >3 but ≤4 cm |
| T2b | Tumor >4 but ≤5 cm |
| T3 | Tumor >5 but ≤7 cm or invading chest wall, pericardium, phrenic nerve; or separate tumor nodule(s) in the same lobe |
| T4 | Tumor >7 cm or tumor invading: mediastinum, diaphragm, heart, great vessels, recurrent laryngeal nerve, carina, trachea, esophagus, spine; or tumor nodule(s) in a different ipsilateral lobe |

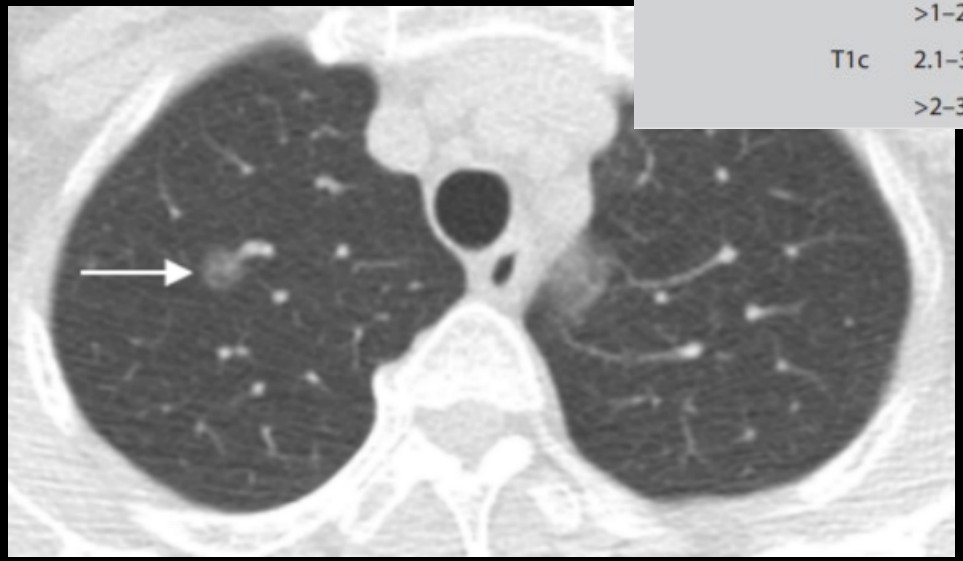
# Lung cancer staging and follow up

| N (regional lymph nodes) | |
|---|---|
| N0 | No regional node metastasis |
| N1 | Metastasis in ipsilateral pulmonary or hilar nodes |
| N2 | Metastasis in ipsilateral mediastinal or subcarinal nodes |
| N3 | Metastasis in contralateral mediastinal, hilar, or supraclavicular nodes |
| **M (distant metastasis)** | |
| M0 | No distant metastasis |
| M1a | Malignant pleural or pericardial effusion‡ or pleural or pericardial nodules or separate tumor nodule(s) in a contralateral lobe |
| M1b | Single extrathoracic metastasis |
| M1c | Multiple extrathoracic metastases (1 or >1 organ) |

*Superficial spreading tumor of any size but confined to the tracheal or bronchial wall. †Atelectasis or obstructive pneumonitis extending to hilum; such tumors are classified as T2a if >3 and ≤4 cm, T2b if >4 and ≤5 cm. ‡Pleural effusions are excluded that are cytologically negative, nonbloody, transudative, and clinically judged not to be due to cancer.

**Table 1.** T classification for appearance on chest CT for TNM 8th edition

| T classification | | T components on CT |
|---|---|---|
| Tis (AIS) | | Pure GGN ≤3 cm |
| T1 | T1mi | ≤ 0.5 cm solid part within part-solid tumor total size ≤3 cm |
| | T1a | 0.6–1.0 cm solid part within part-solid tumor total size ≤3 cm |
| | | Pure GGN >3 cm |
| | | ≤ 1 cm solid tumor |
| | T1b | 1.1–2.0 cm solid part within part-solid tumor total size ≤3 cm |
| | | >1–2 cm solid tumor |
| | T1c | 2.1–3 cm solid part within part-solid tumor total size ≤3 cm |
| | | >2–3 cm solid tumor |



pure ground-glass nodule of 0.8 cm in diameter.
adenocarcinoma in situ.
T stage: Tis

Fen SH, Yang ST. Diagn Interv Radiol 2019; 25:270–279

**Table 1.** T classification for appearance on chest CT for TNM 8th edition

| T classification | | T components on CT |
|---|---|---|
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| | T1c | 2.1–3 cm solid part within part-solid tumor total size ≤3 cm |
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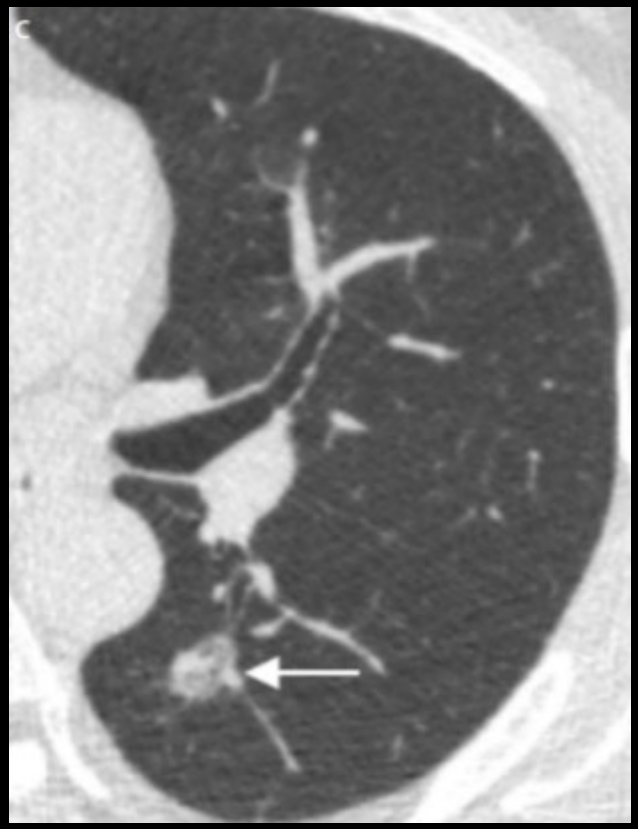
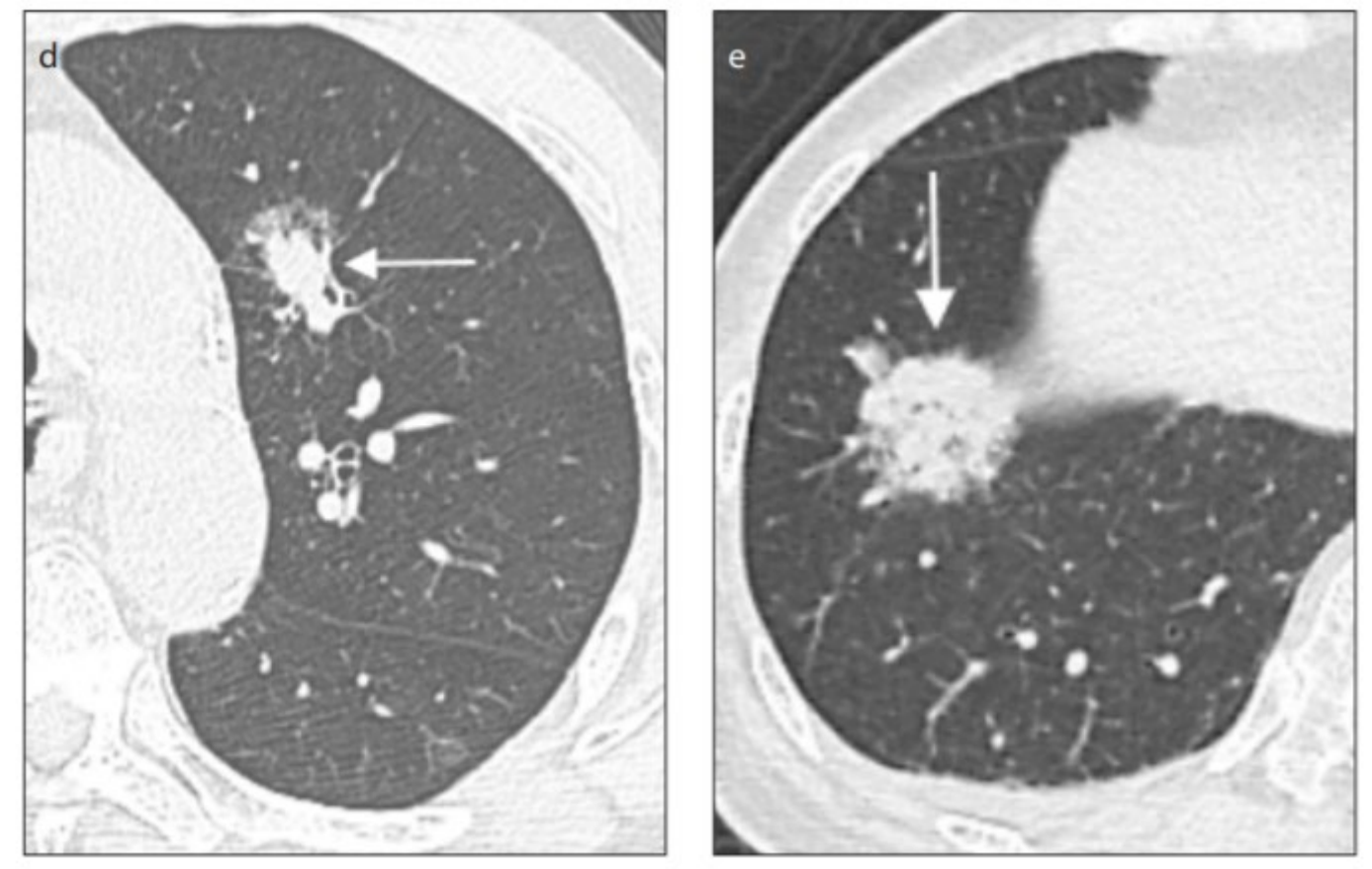


a part-solid nodule with a solid component measuring up to 0.8 cm in maximum diameter with total size of 1.8 cm (arrow), imaging staging T1a

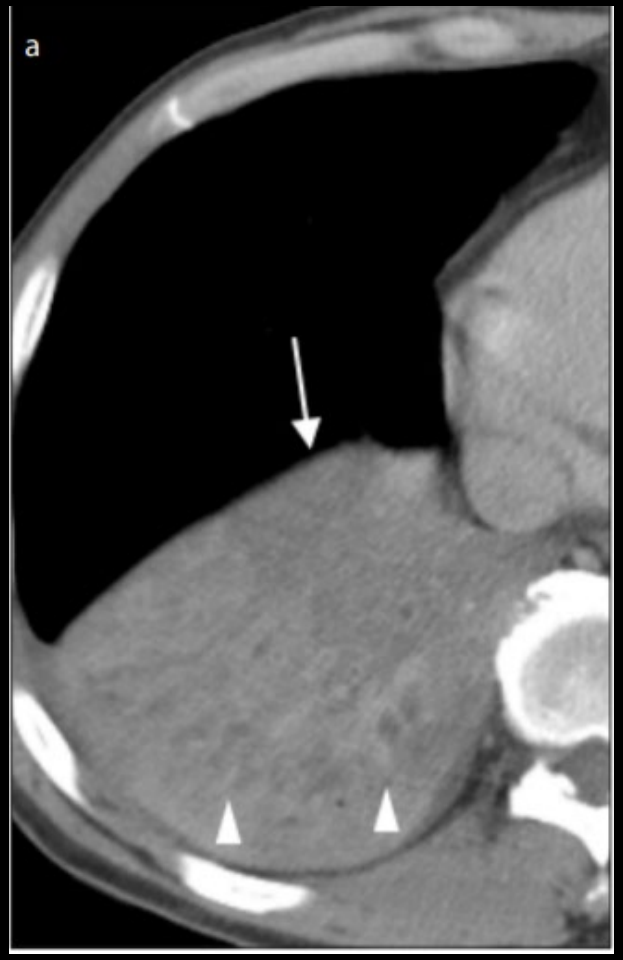
Fen SH, Yang ST. Diagn Interv Radiol 2019; 25:270–279




a 62 M, LUL: part-solid nodule up to 1.8 cm with 1.2 cm solid part (arrow)
T1a (≤2 cm) in the 7th edition and T1b in the 8th edition

A 76F, 2.8 cm part-solid tumor with a solid part measuring up to 2.7 cm,  T1c

Fen SH, Yang ST. Diagn Interv Radiol 2019; 25:270–279

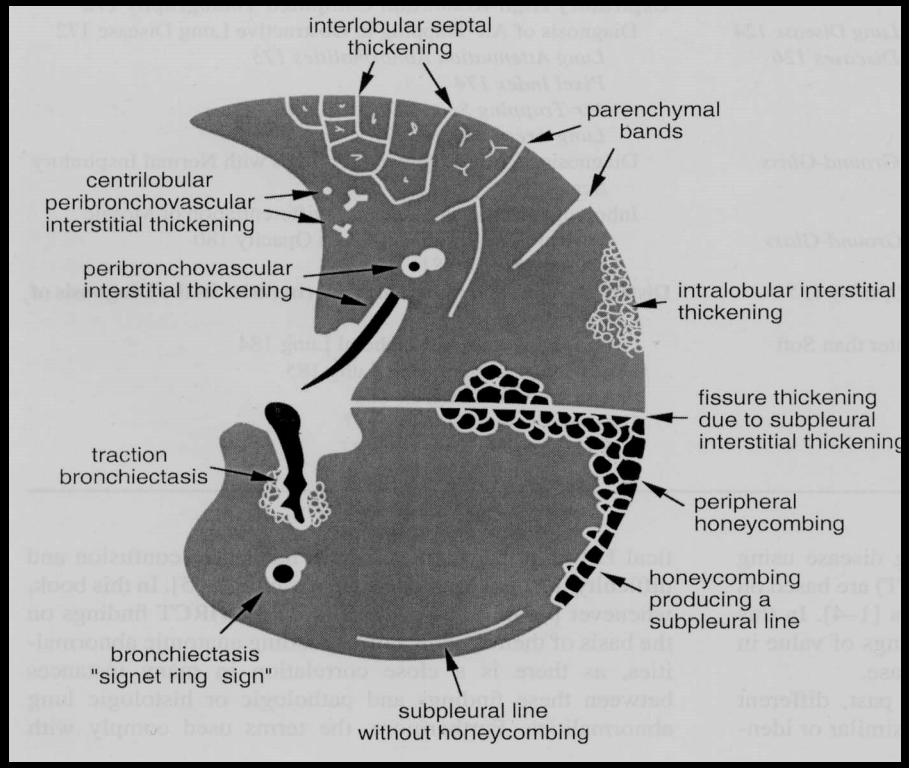


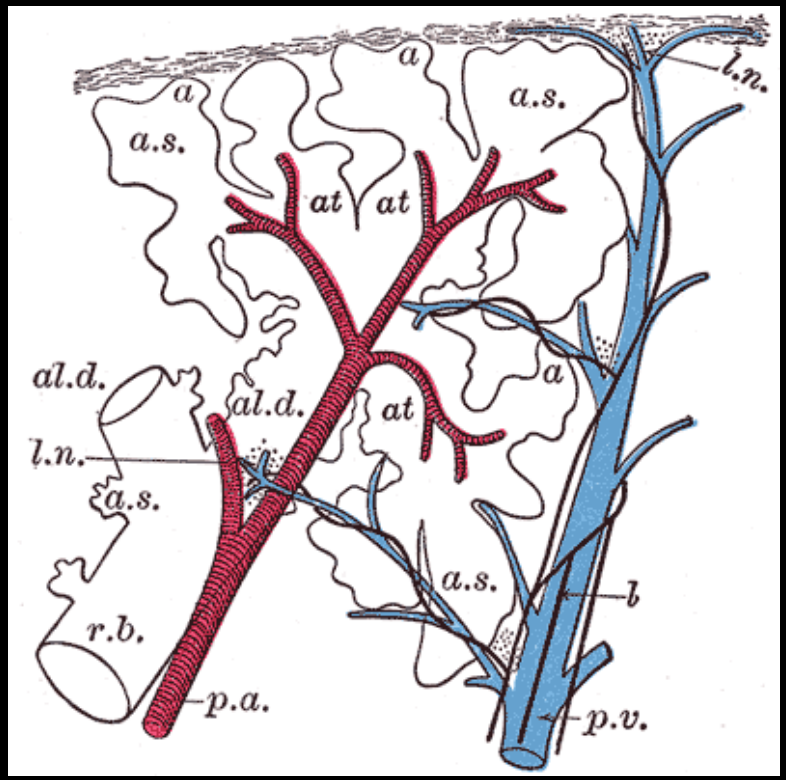

| | | | |
|---|---|---|---|
| T2 | T2a | 3.1–4 cm | Involves main bronchus without involvement of carina |
| | T2b | 4.1–5 cm | Total/partial atelectasis |
| | | | Total/partial pneumonitis |
| | | | Involves hilar fat |
| | | | Involves visceral pleura (PL1 or PL2) |
| T3 | | 5.1–7 cm | Separate tumor nodules in the same lobe as the primary |
| | | | Involves parietal pleura (PL3) |
| | | | Parietal pericardium |
| | | | Chest wall |
| | | | Phrenic nerve |

the poorly enhanced, central tumor (a, arrow) measuring 4.4 cm with distal partial atelectasis/pneumonitis (arrowheads) RLL. The stage is T2b in the 8th edition of lung cancer staging.

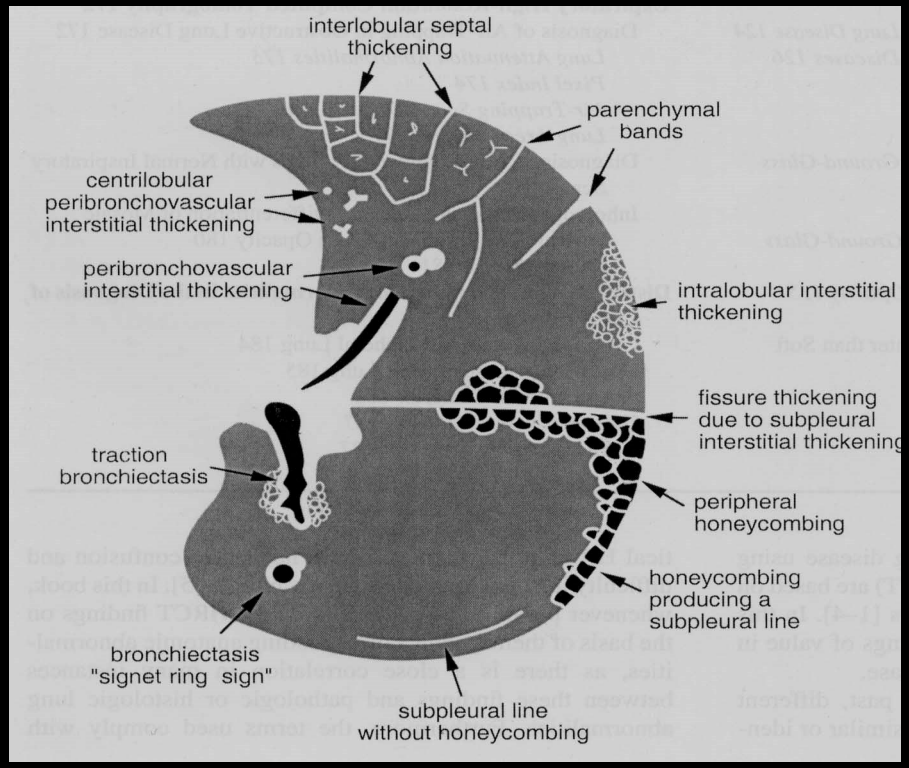
Fen SH, Yang ST. Diagn Interv Radiol 2019; 25:270–279

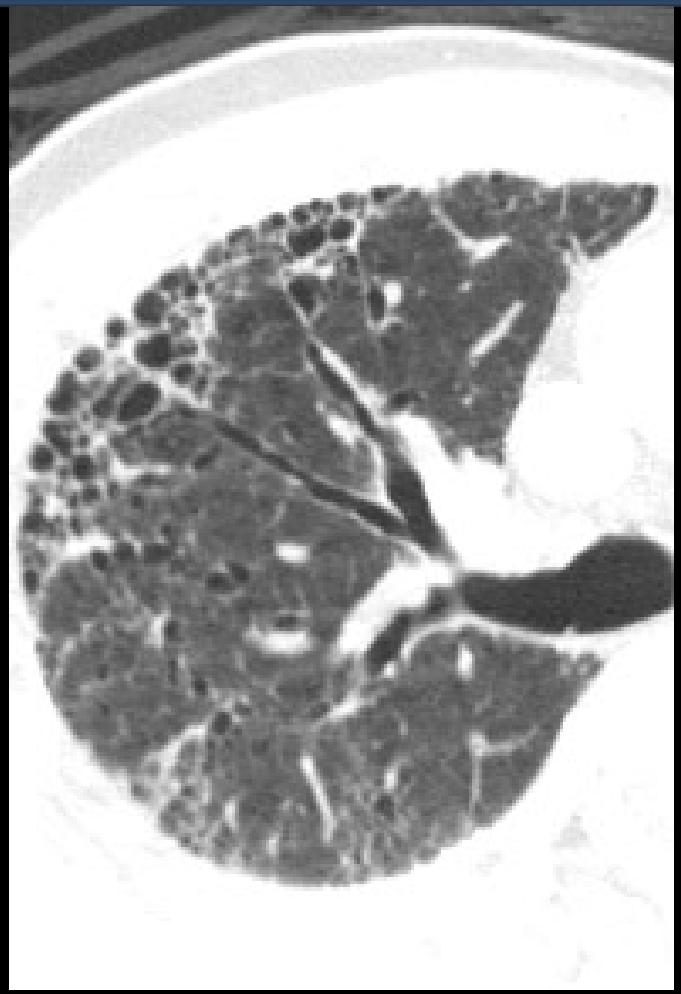
# HRCT classification of lung parenchymal pattern



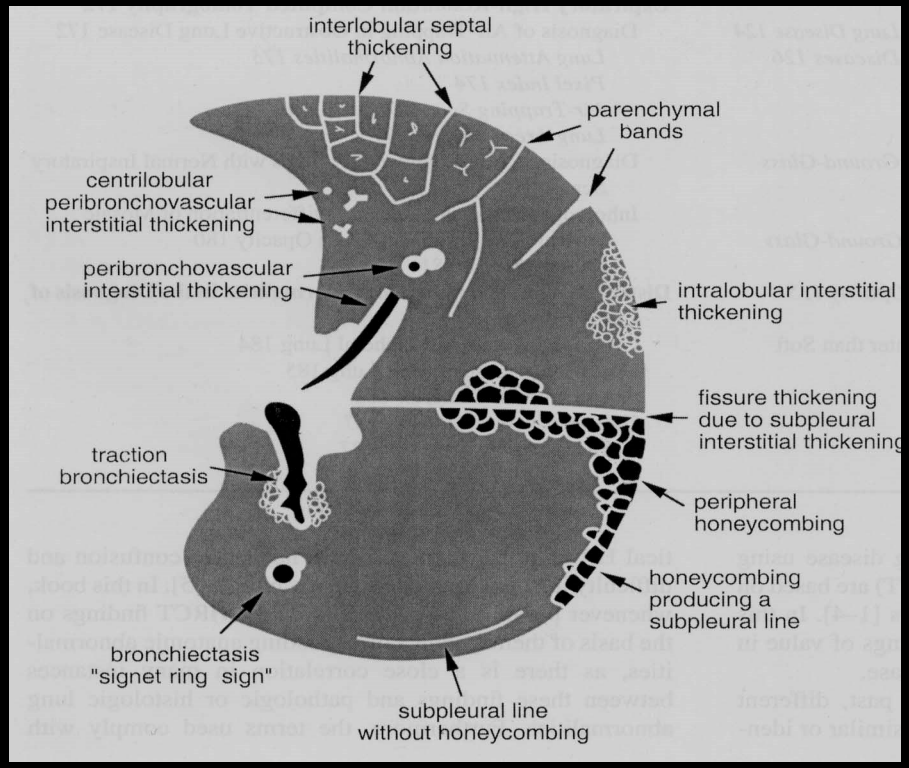



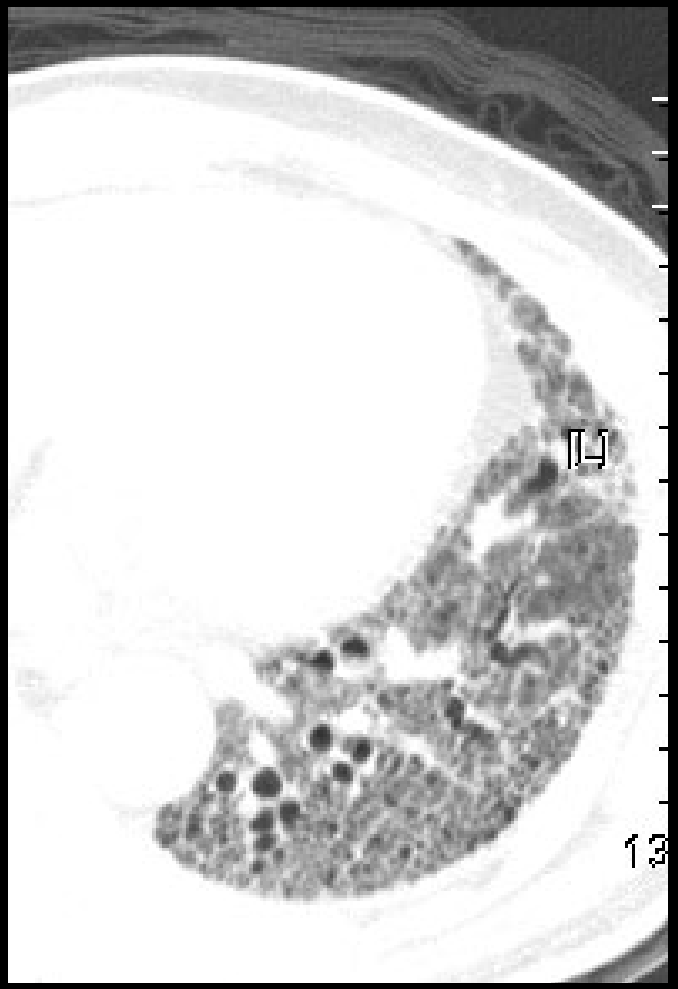
# Honeycomb Pattern in UIP



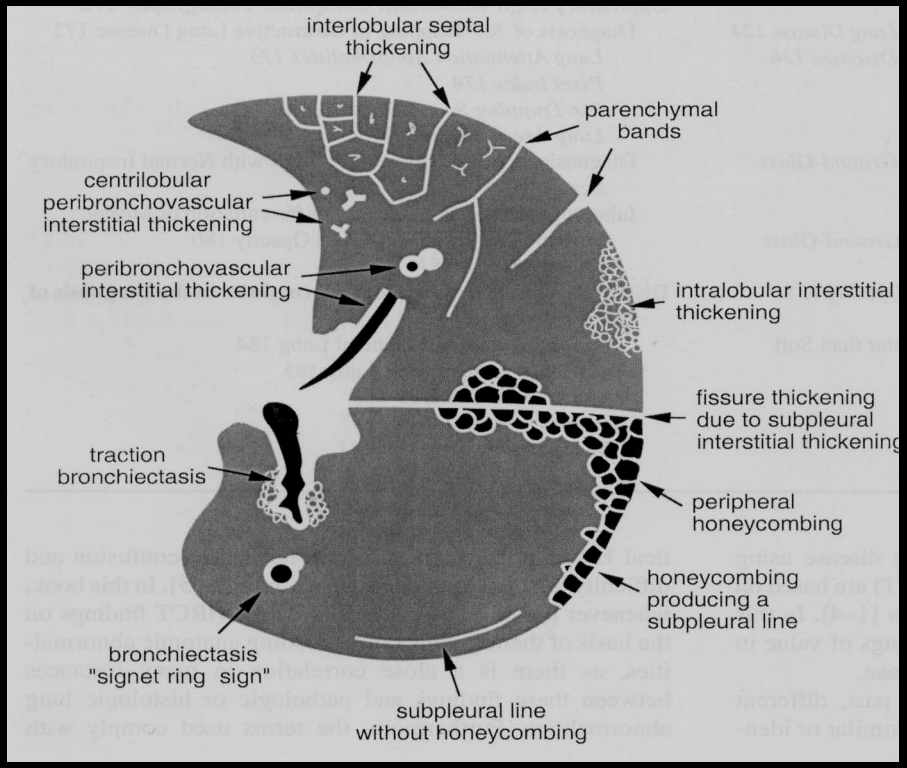



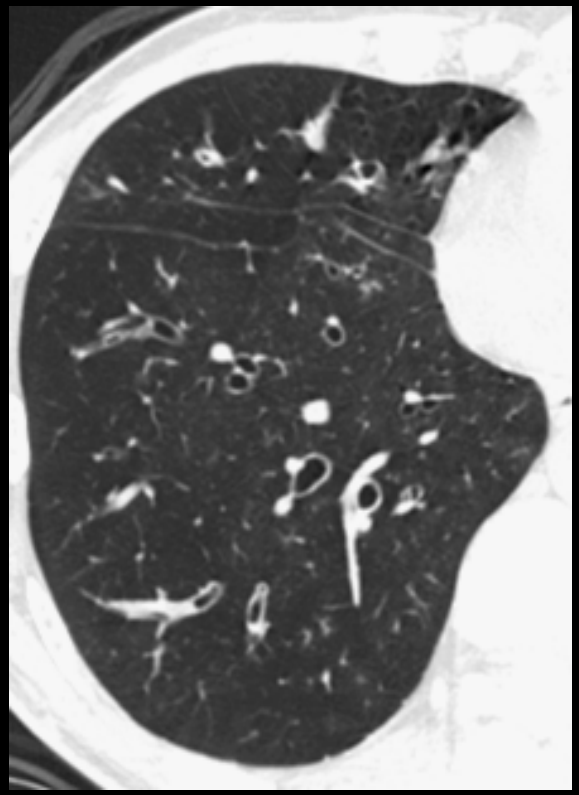
# Idiopathic Pulmonary Fibrosis



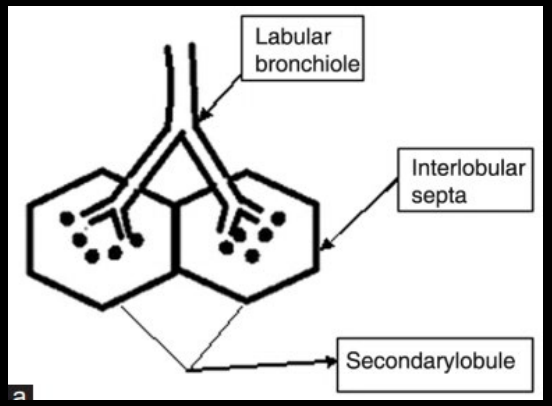
# Signet ring sign



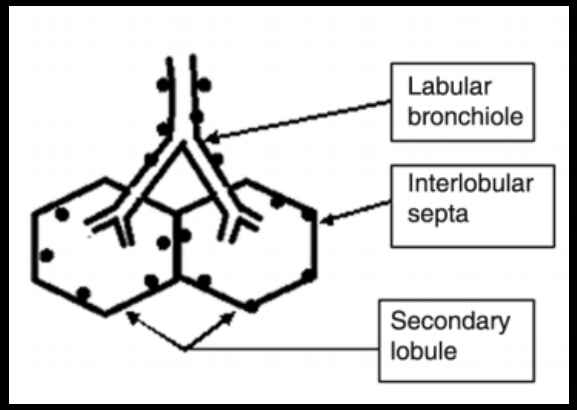
Bronchiectasis

# Patterns of nodule distribution



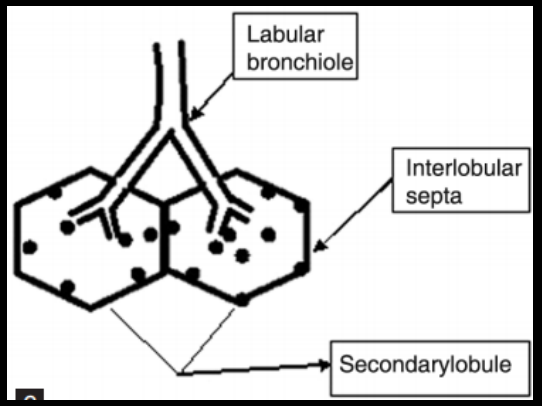

## Centrilobular nodules

- Infectious bronchiolitis including tuberculosis.
- Pneumoconiosis
- Diffuse panbronchiolitis.
- Vasculitis and vascular metastases.
- Respiratory bronchiolitis-interstitial lung disease.
- Hypersensitivity pneumonitis




## Perilymphatic nodules

- Sarcoidosis
- Silicosis, coal worker's pneumoconiosis
- Lymphangitic carcinomatosis
- Amyloidosis
- Lymphoid interstitial pneumonia

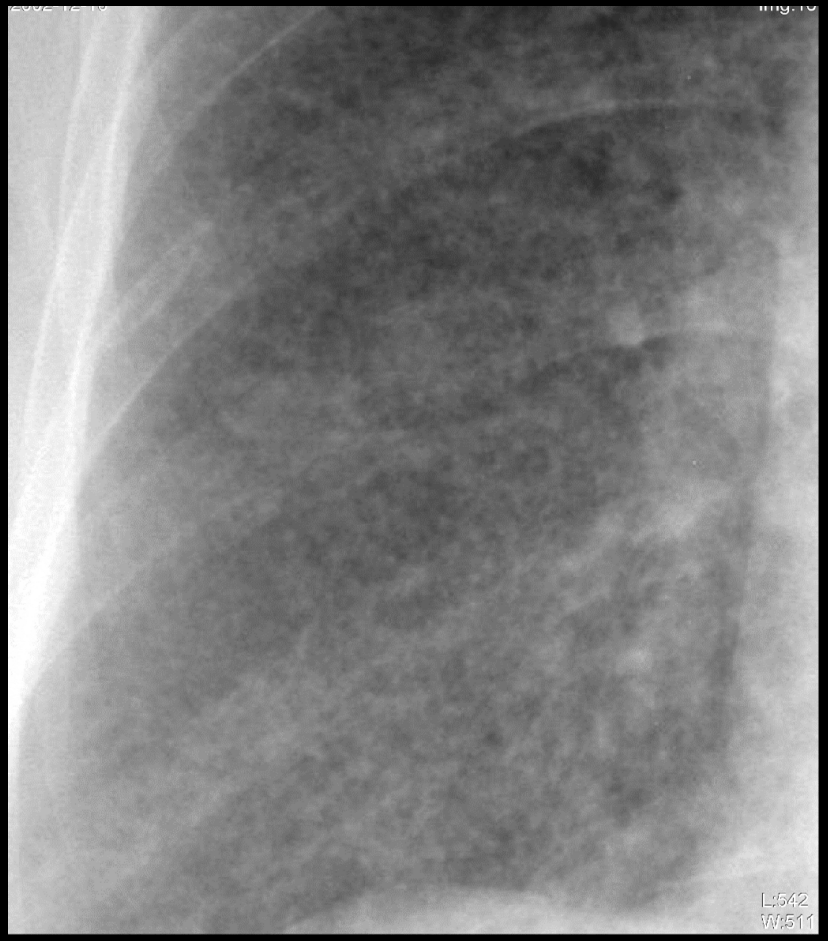


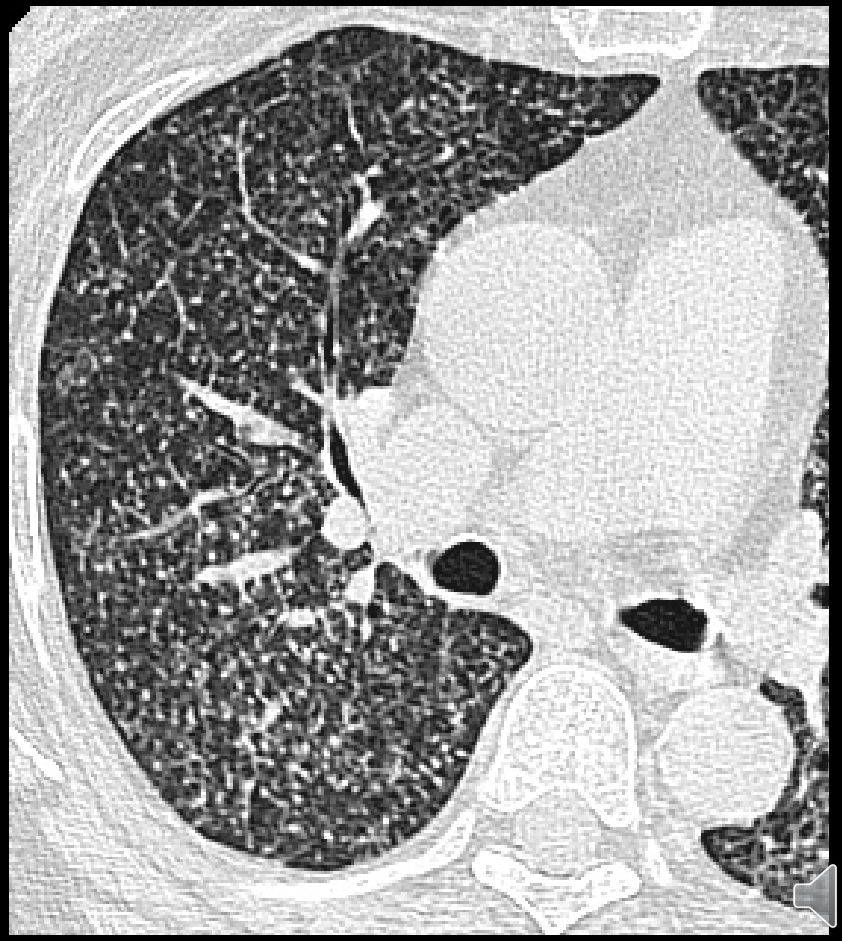

## Random nodules

- Miliary tuberculosis
- Fungal infection
- Metastasis

# Random distributed nodules

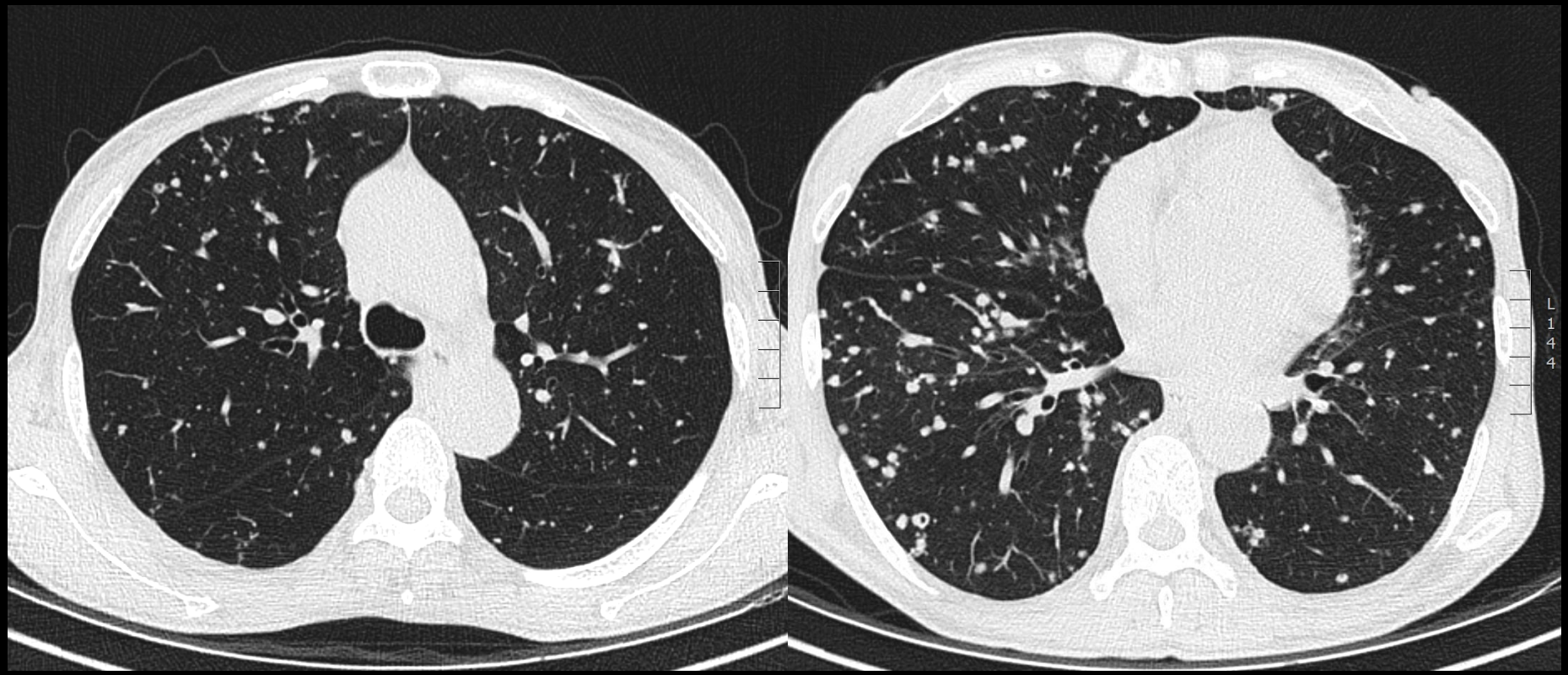
Miliary Nodules in Miliary Pulmonary Tuberculosis





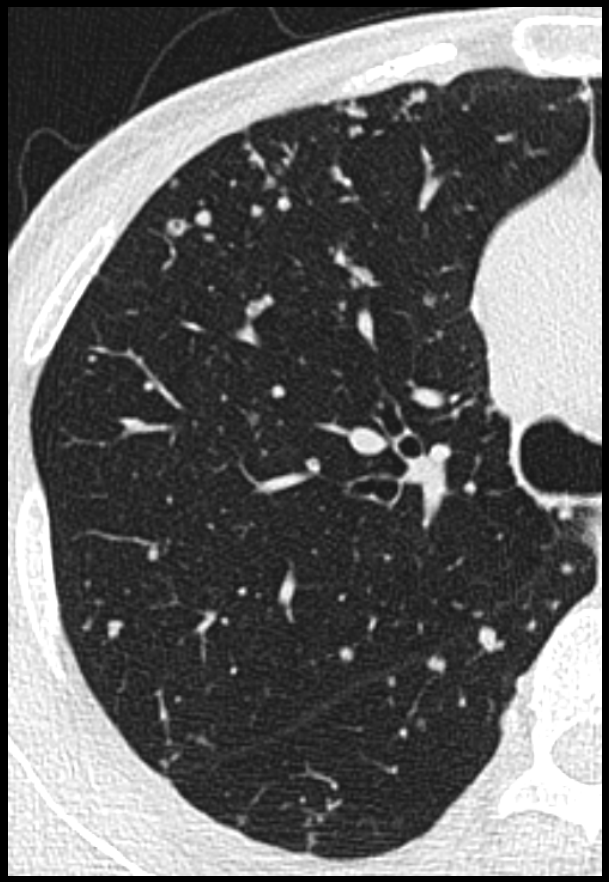
# Random distributed nodules

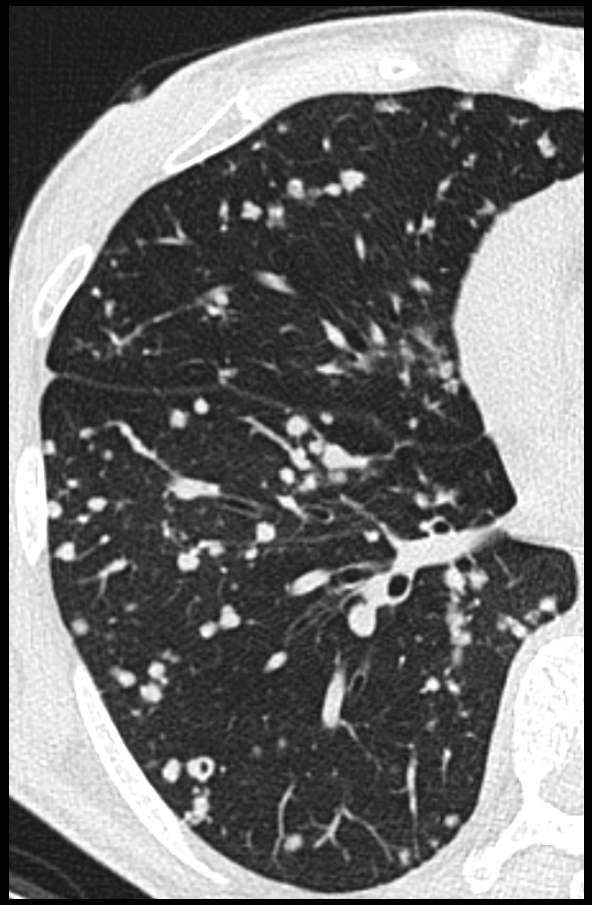
colon cancer with multiple lung metastases



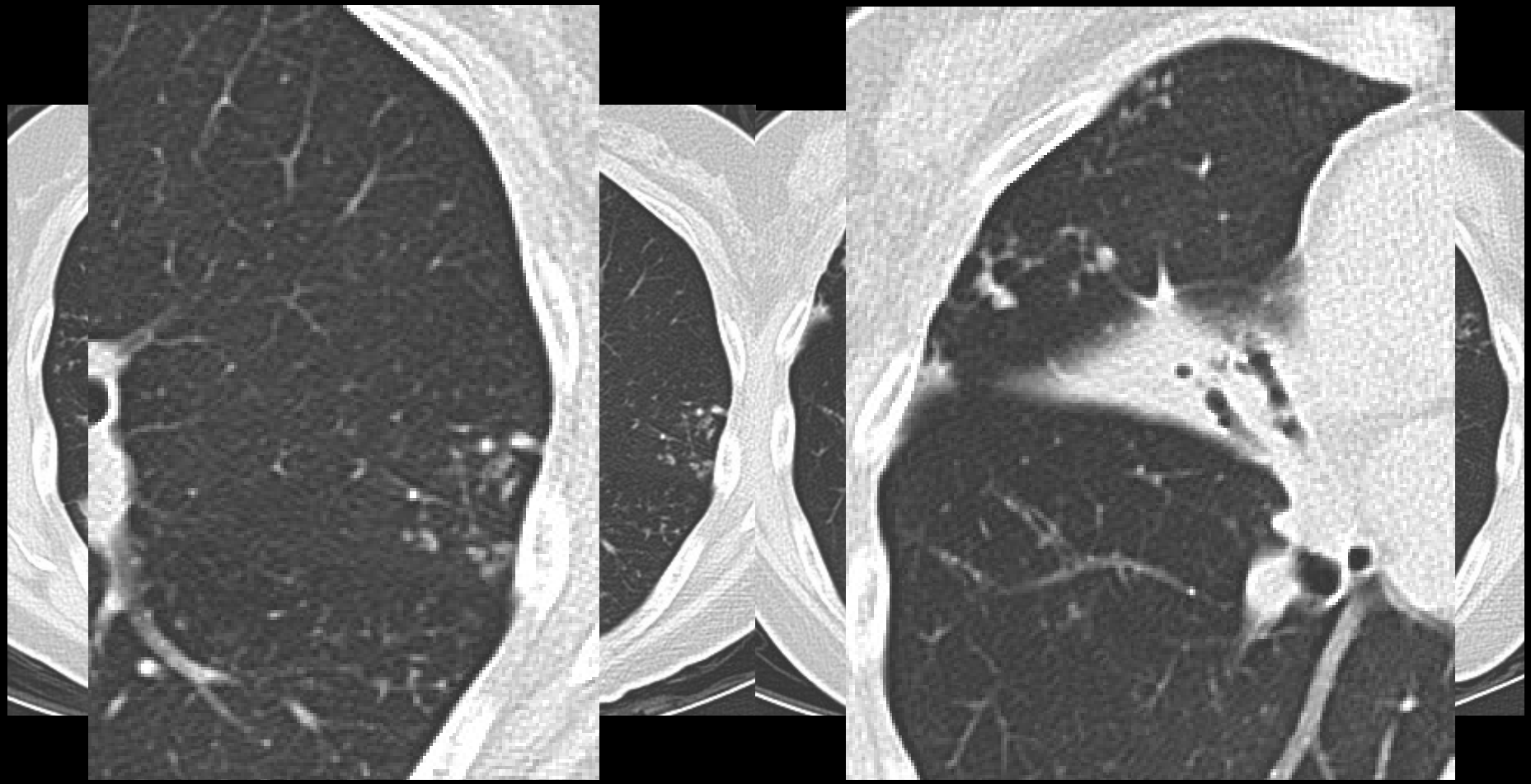
# Random distributed nodules

colon cancer with multiple lung metastases



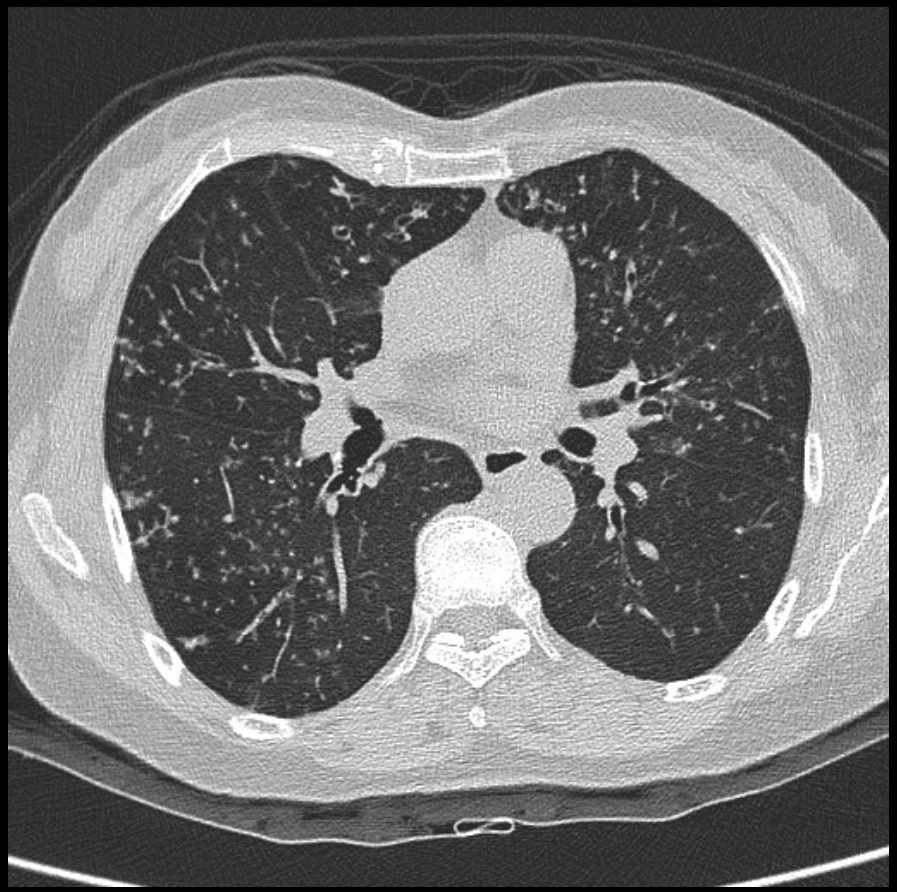


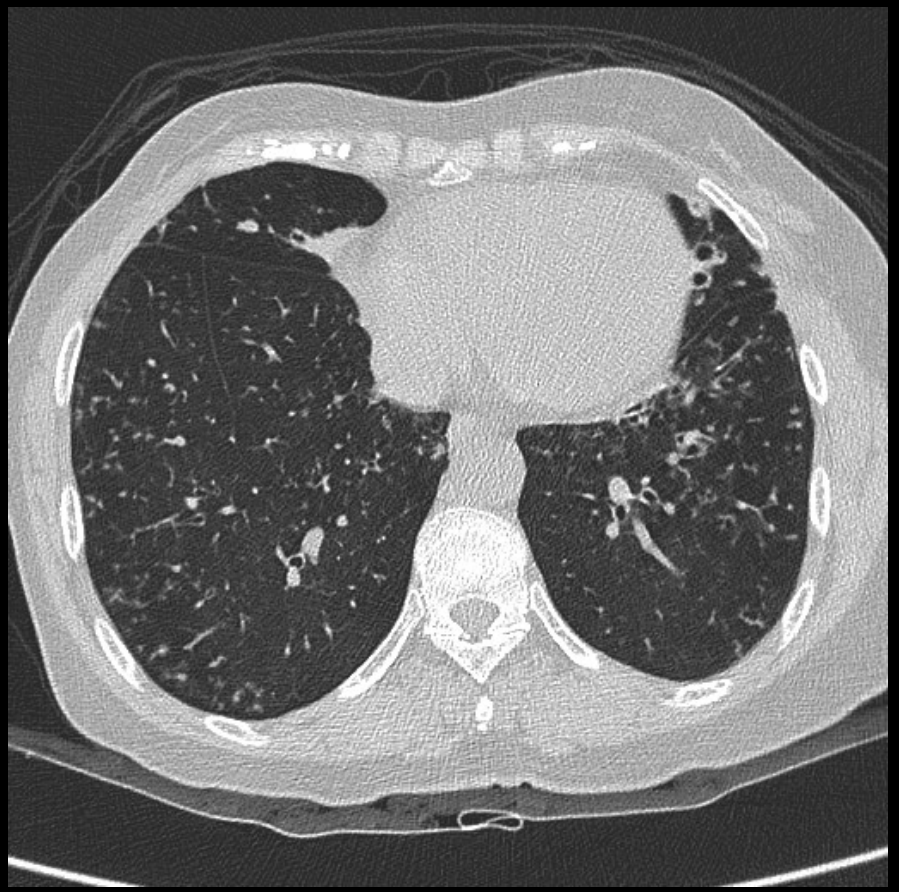
# Tree-in-bud pattern



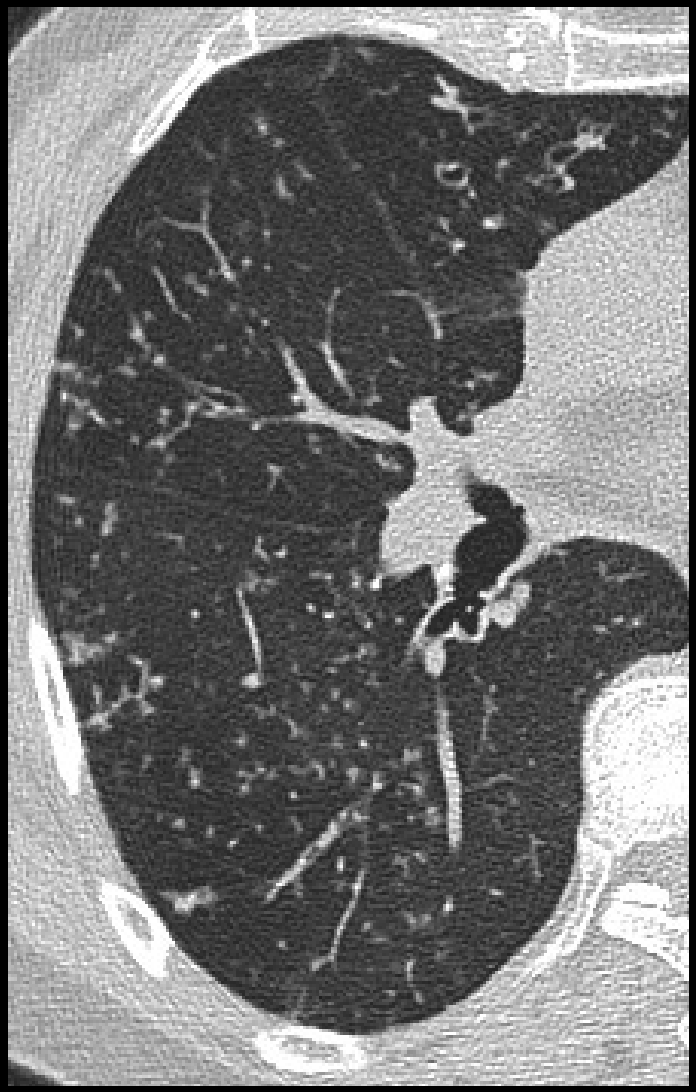
NTM pulmonary infection

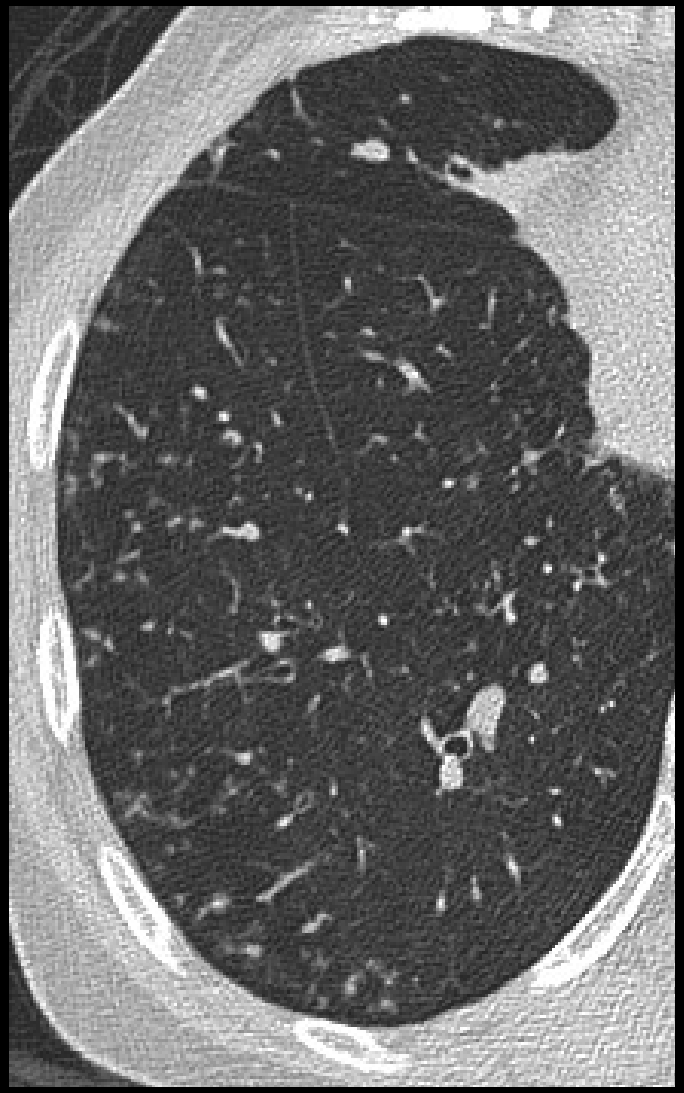
# Diffuse panbronchiolitis (DPB)





# Diffuse panbronchiolitis (DPB)



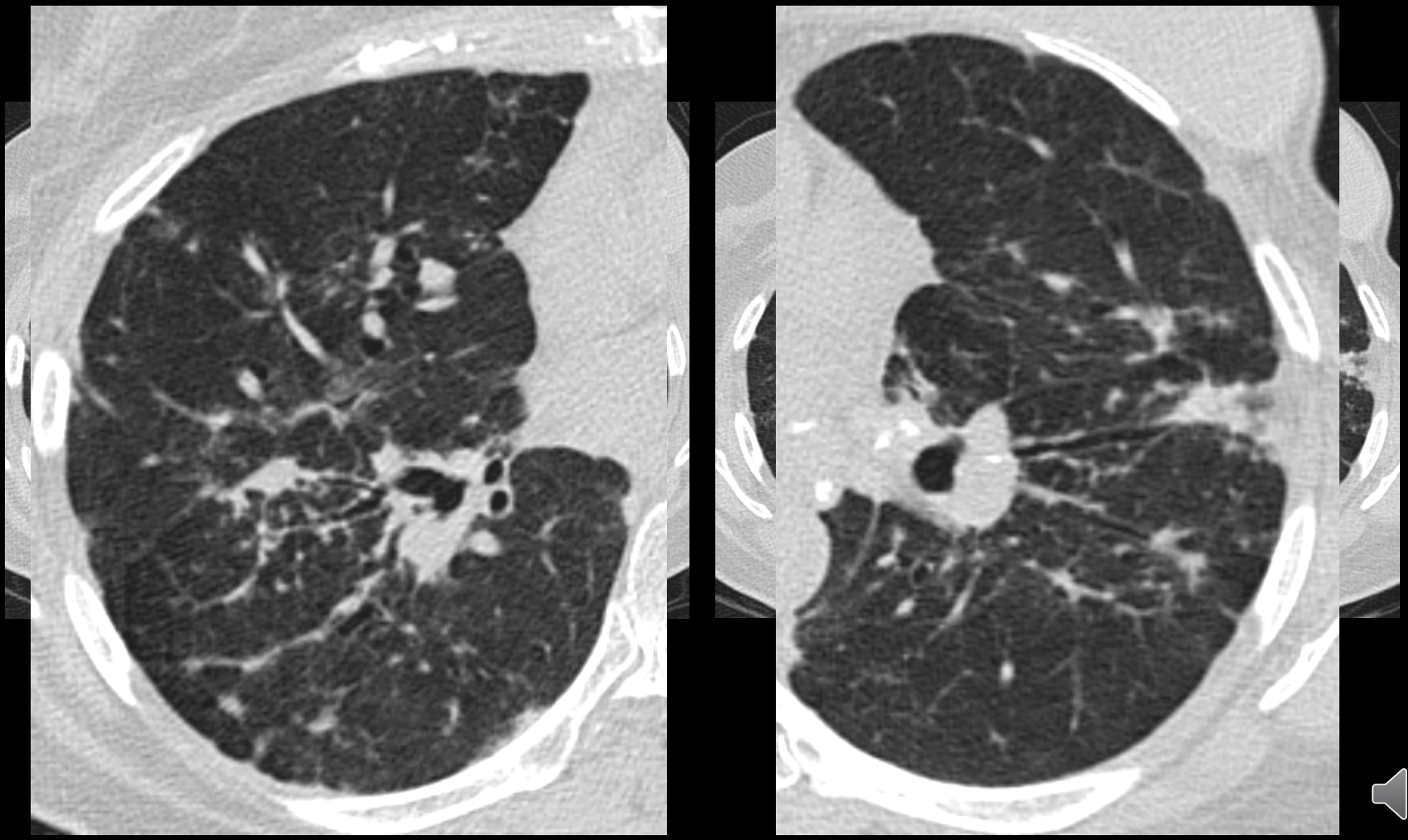


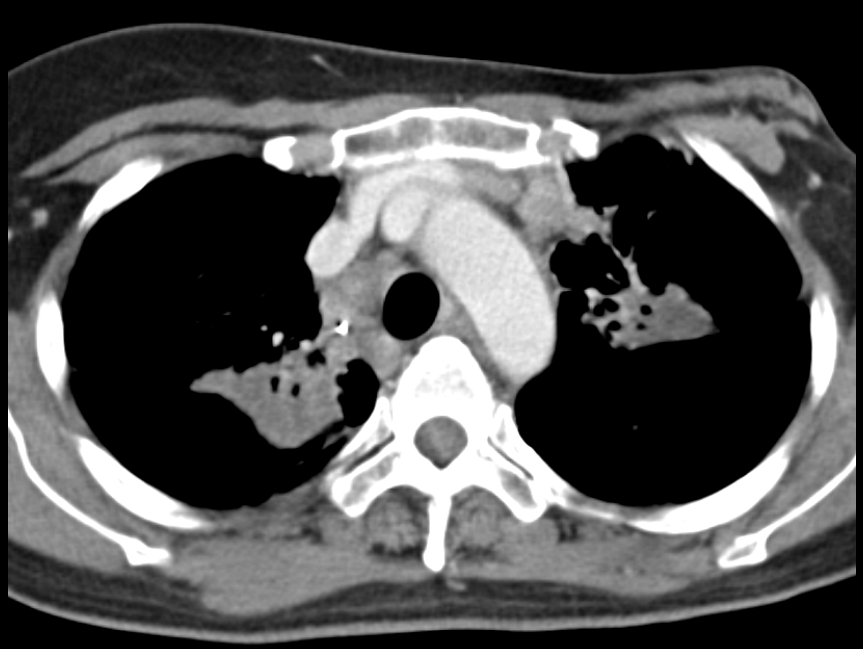
# Tree-in-bud pattern

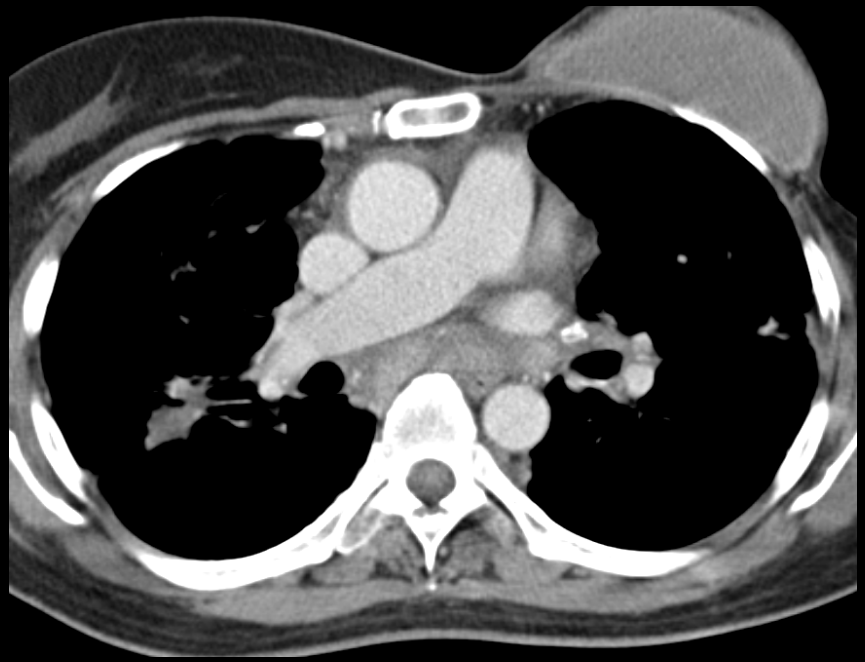
- Peripheral airway disease
  - Infection
    - Bacterial
      - Mycobacterium tuberculosis
      - M avium-intracellulare complex
      - Staphylococcus aureus
      - Haemophilus influenzae
    - Fungal
      - Aspergillus
    - Viral
      - Cytomegalovirus
      - Respiratory syncytial viruscv
  - Congenital disorders
    - Cystic fibrosis
    - Kartagener syndrome
  - Idiopathic disorders
    - Obliterative bronchiolitis
    - Diffuse panbronchiolitis
  - Aspiration
  - Inhalation
    - Toxic fumes and gases
  - Immunologic disorders
    - Allergic bronchopulmonary aspergillosis
  - Connective tissue disorders
    - Rheumatoid arthritis
    - Sjo¨ gren syndrome
- Peripheral pulmonary vascular disease
  - Neoplasms
  - Gastric cancer
    - Breast cancer
    - Ewing sarcoma
    - Renal cancer

# Peri-lymphatic distibution

sarcoidosis



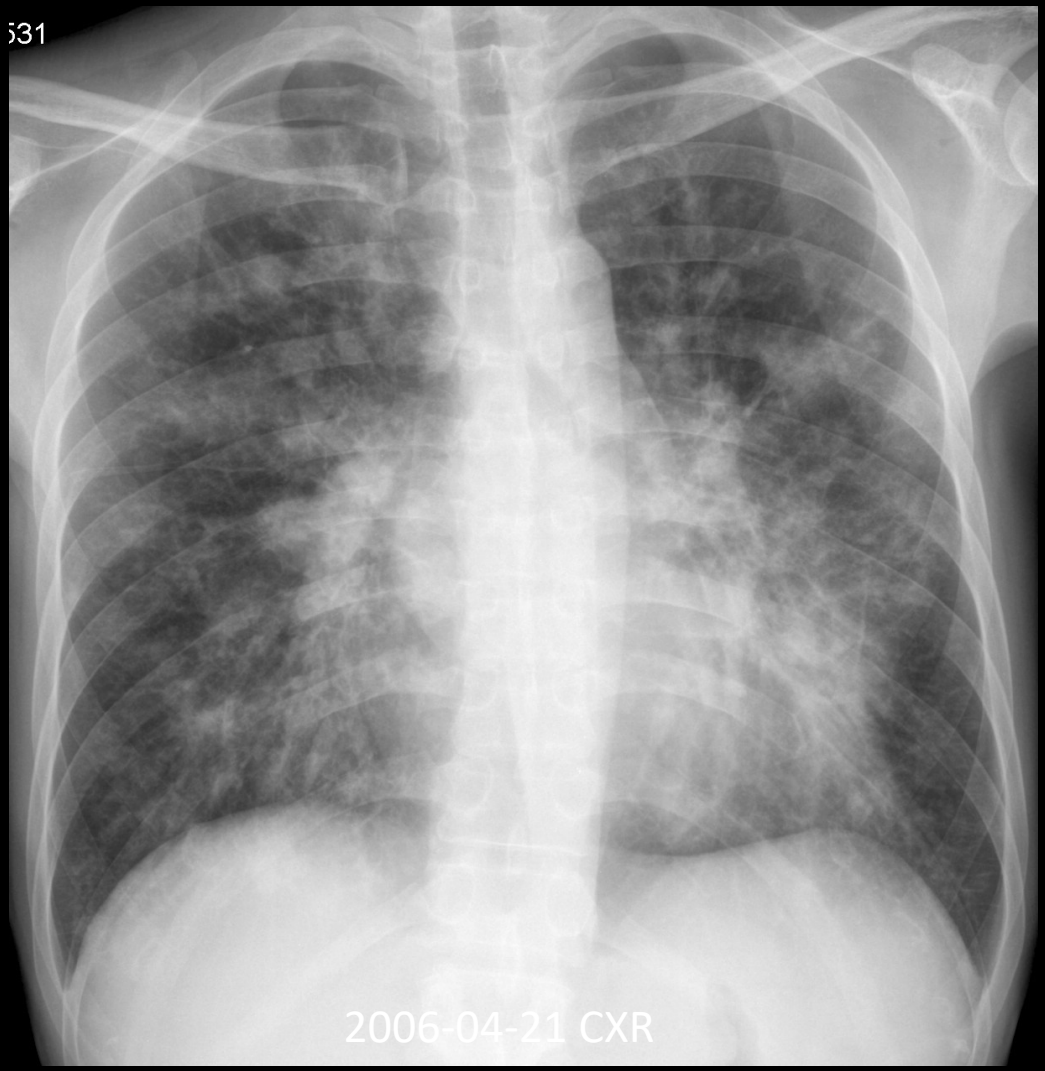




# Case demonstration

- 36-year-old male

- productive cough with blood-tinged sputum for 10 days and admitted in Apr. 2006.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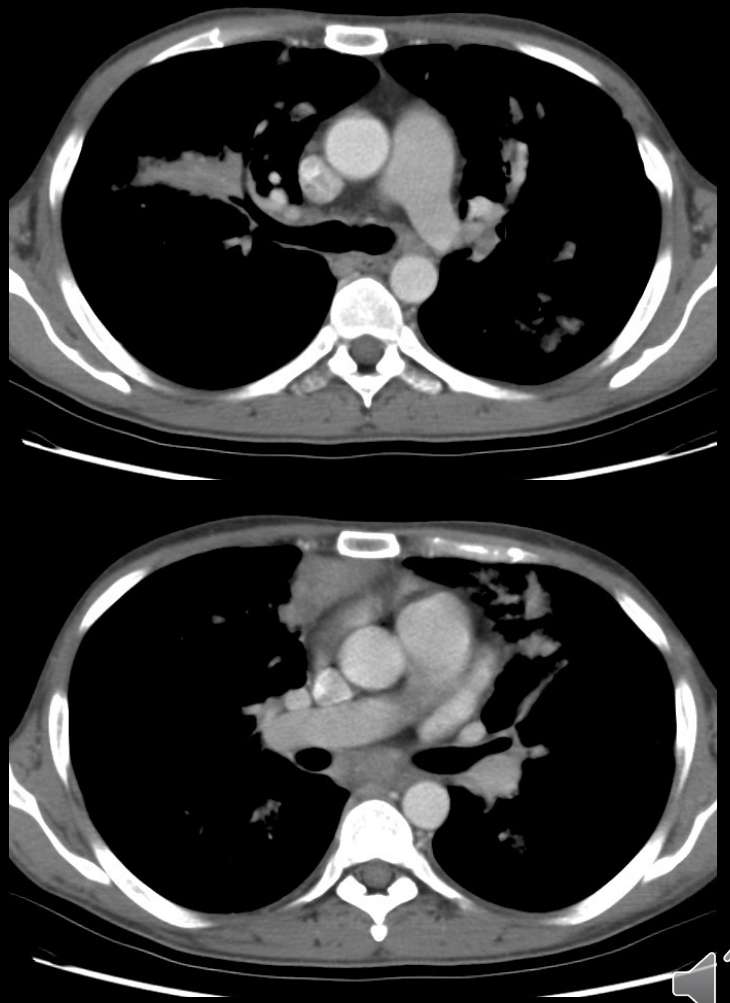
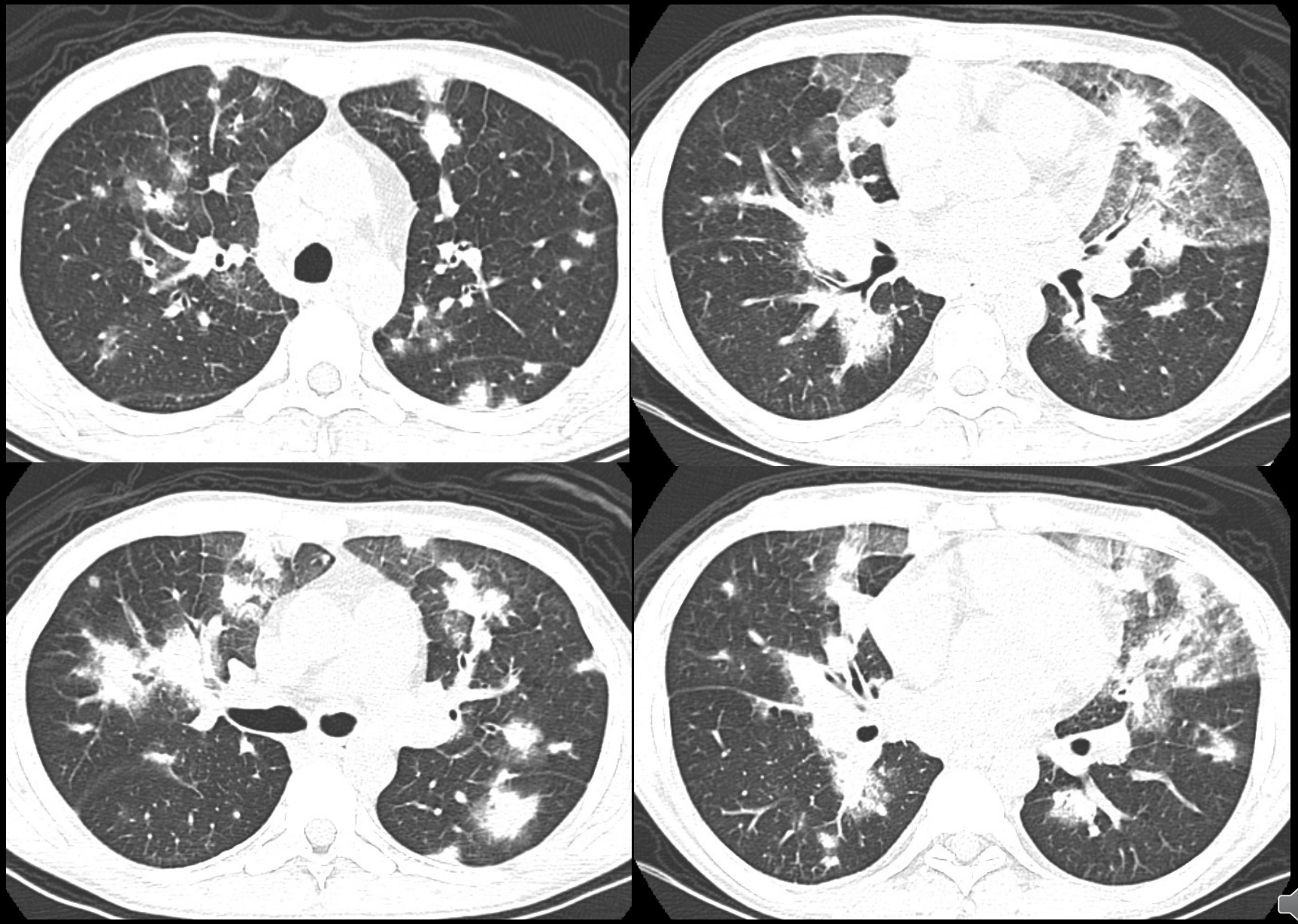
2006-04-21 CXR





# Peribronchial infiltration

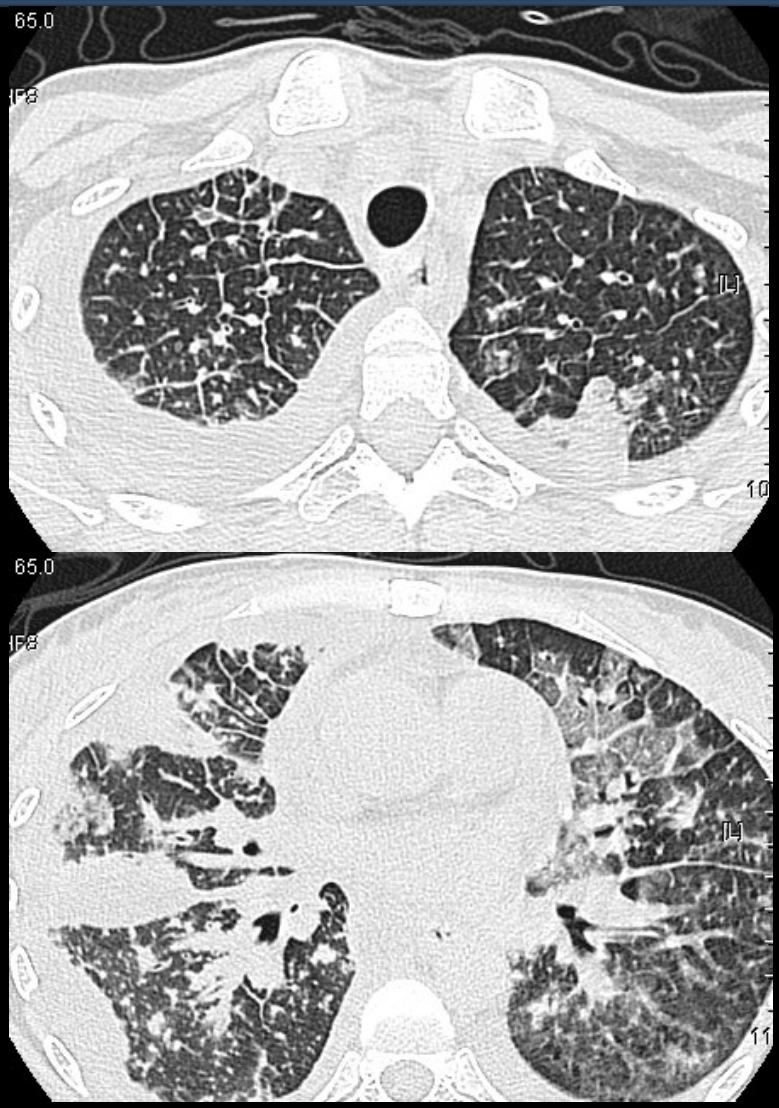
- Prominent ill-defined opacities predominantly located bilateral perihilar regions along the bronchovascular bundles.

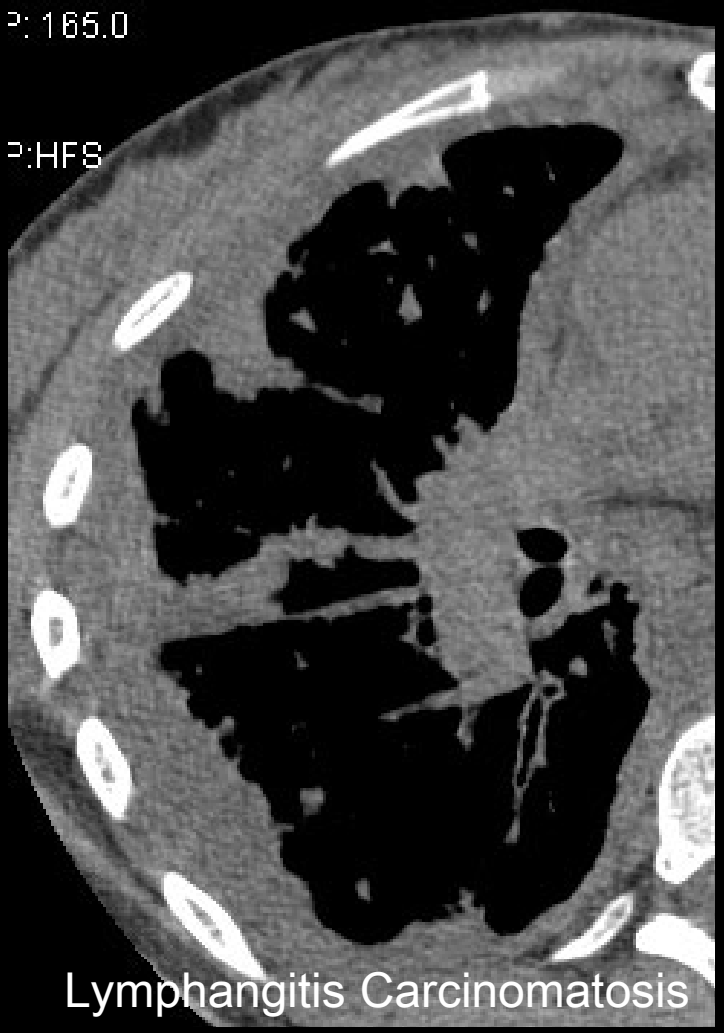
- DDX:
  - Kaposi's sarcoma
  - Sarcoidosis
  - Lymphoma
  - Lymphangitic carcinomatosis
  - Multicentric Castleman's disease

# Diagnosis

- Homosexual, multiple sexual partners
- Several red-purplish nodules over his legs in recent 1 year
- K.S. with lung involvement.

# Beaded septum sign

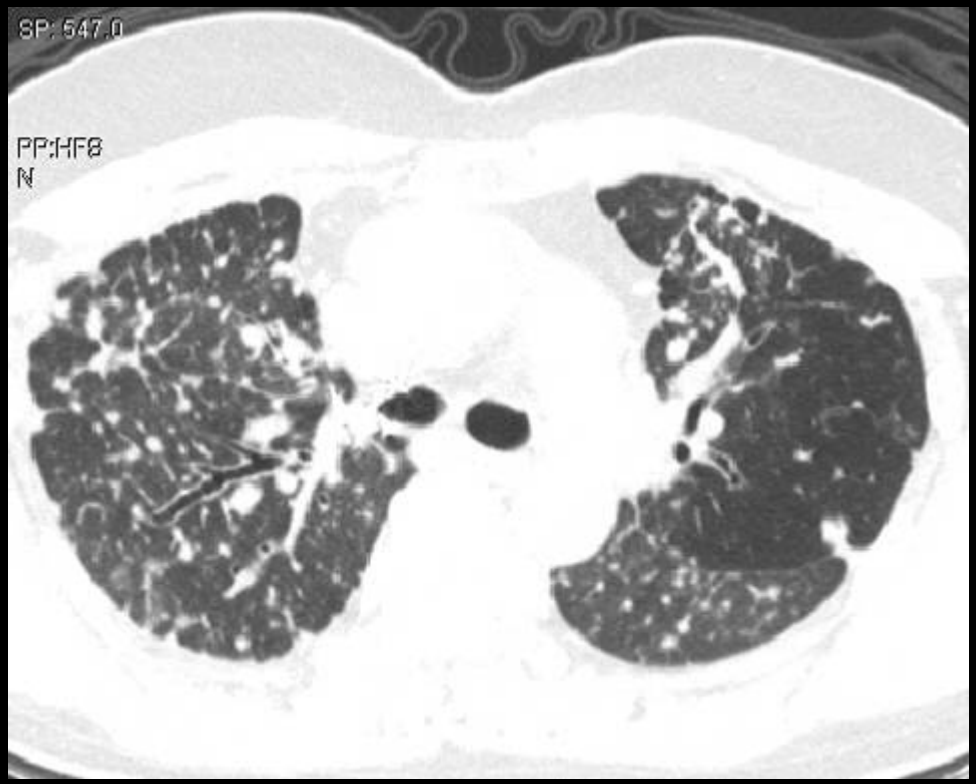


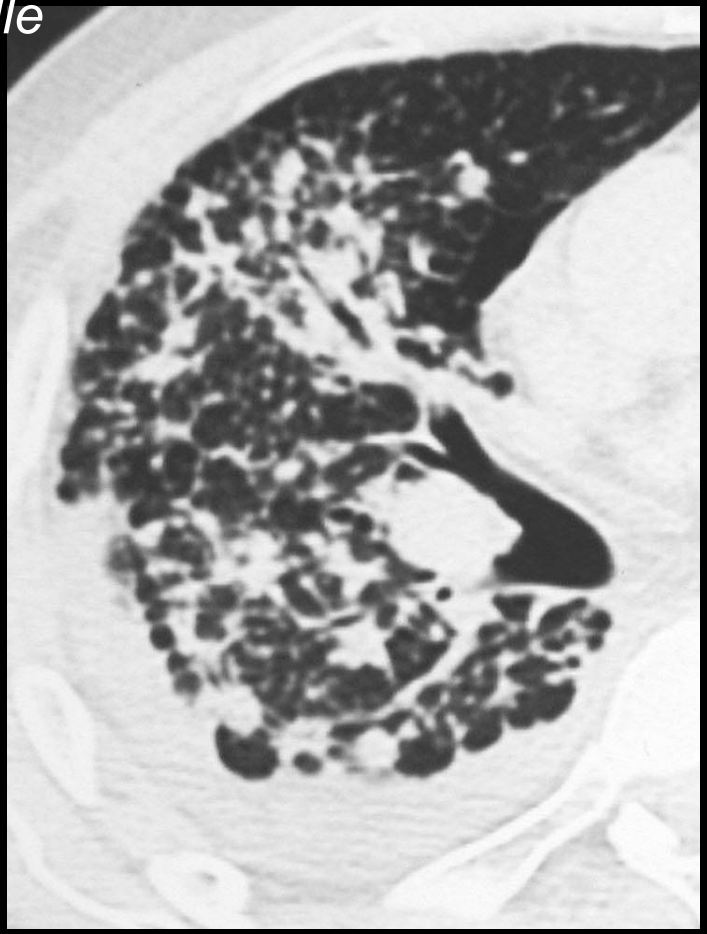

Lymphangitis Carcinomatosis

# Lymphangitis Carcinomatosis

- *Thickening of the bronchovascular bundle*
- *Beaded interlobular septa*



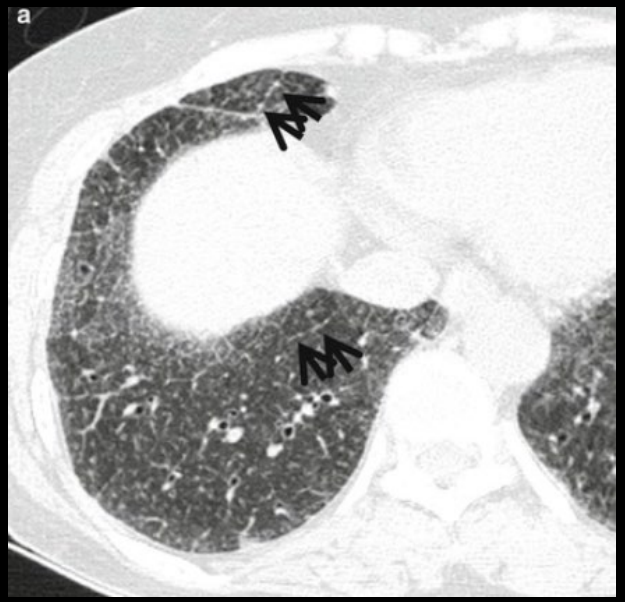

**Lung cancer**

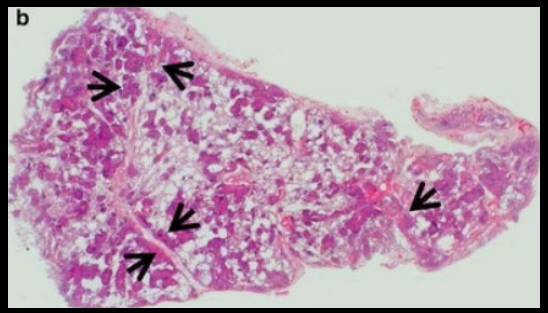


**Gastric cancer**

# Beaded septum sign

- The sign consists of irregular and nodular thickening of interlobular septa reminiscent of a row of beads.
  - Lymphangitis carcinomatosis
  - Sarcoidosis

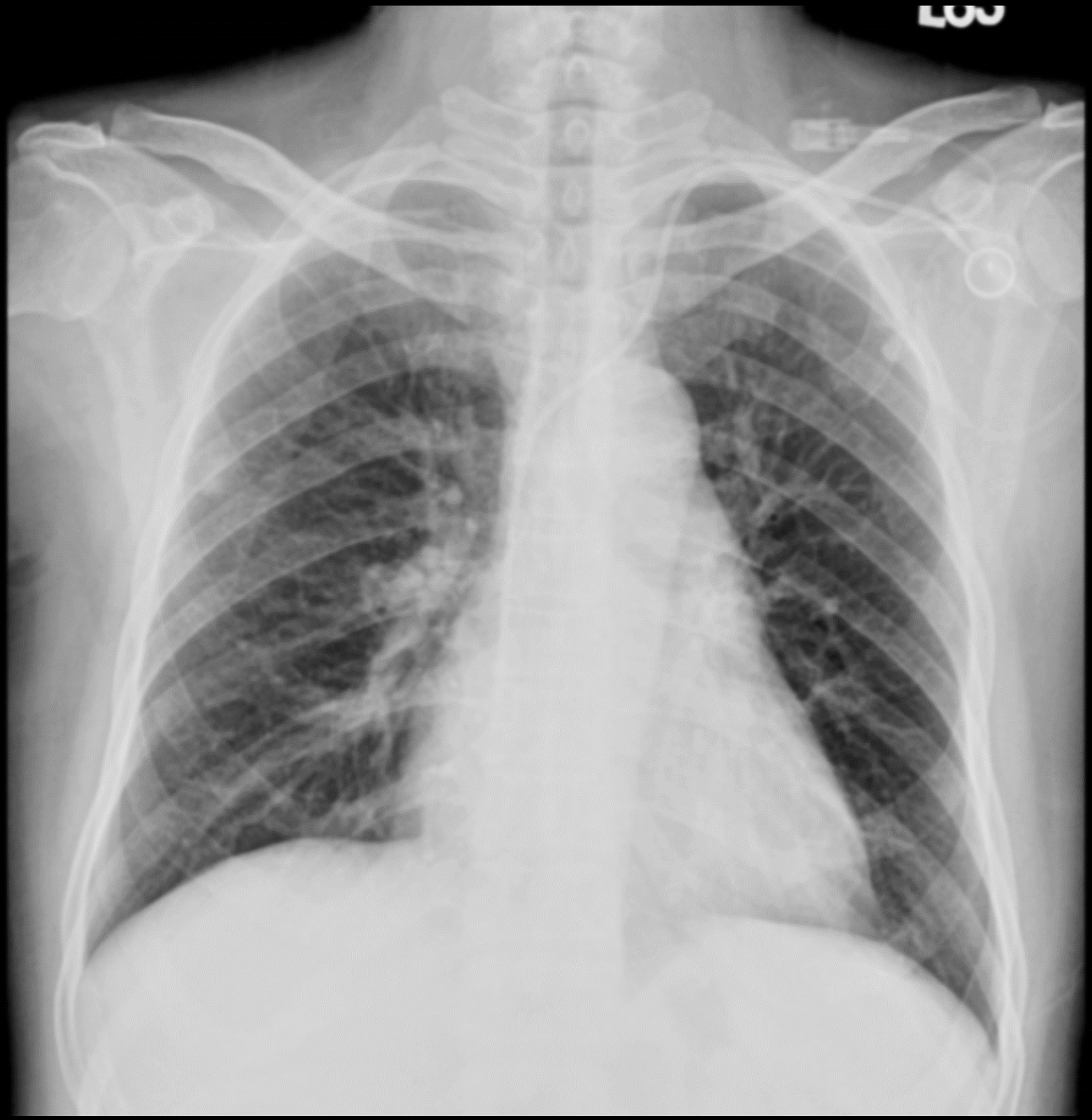


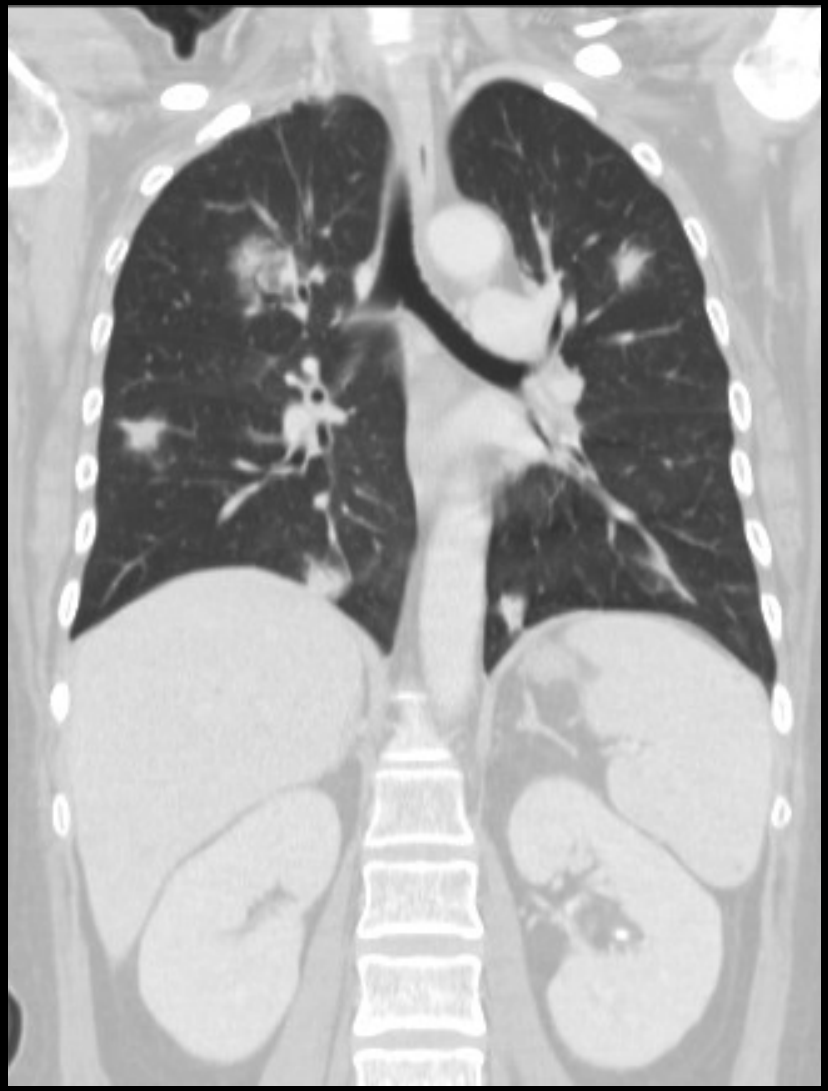



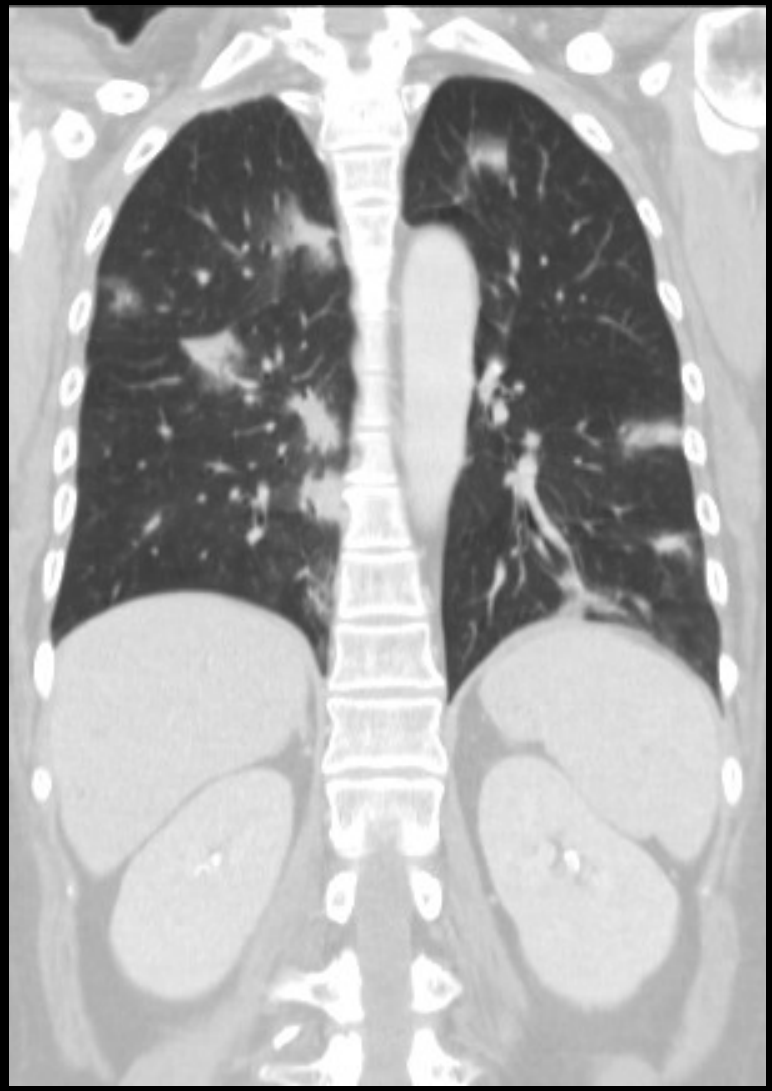

Pulmonary sarcoidosis showing beaded septum sign in a 57-year-old woman with Sjögren's syndrome. (**a**) Targeted view of thin-section scan obtained at level of liver dome shows thickened interlobular septa (*arrows*) with string of bead appearance. Also note diffuse GGO in both lungs. (Joungho Han https://radiologykey.com/beaded-septum-sign/)

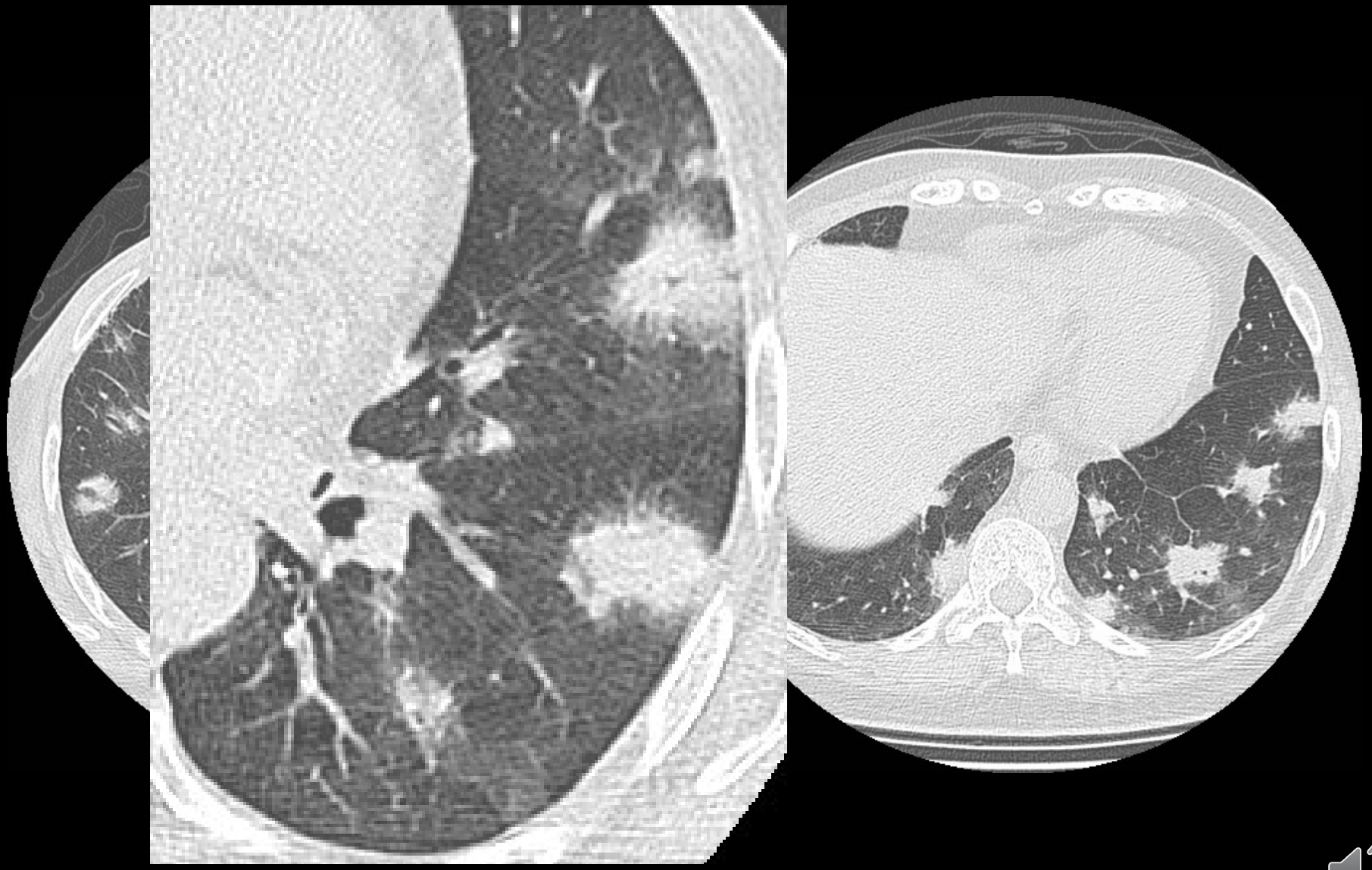
# Case demonstration

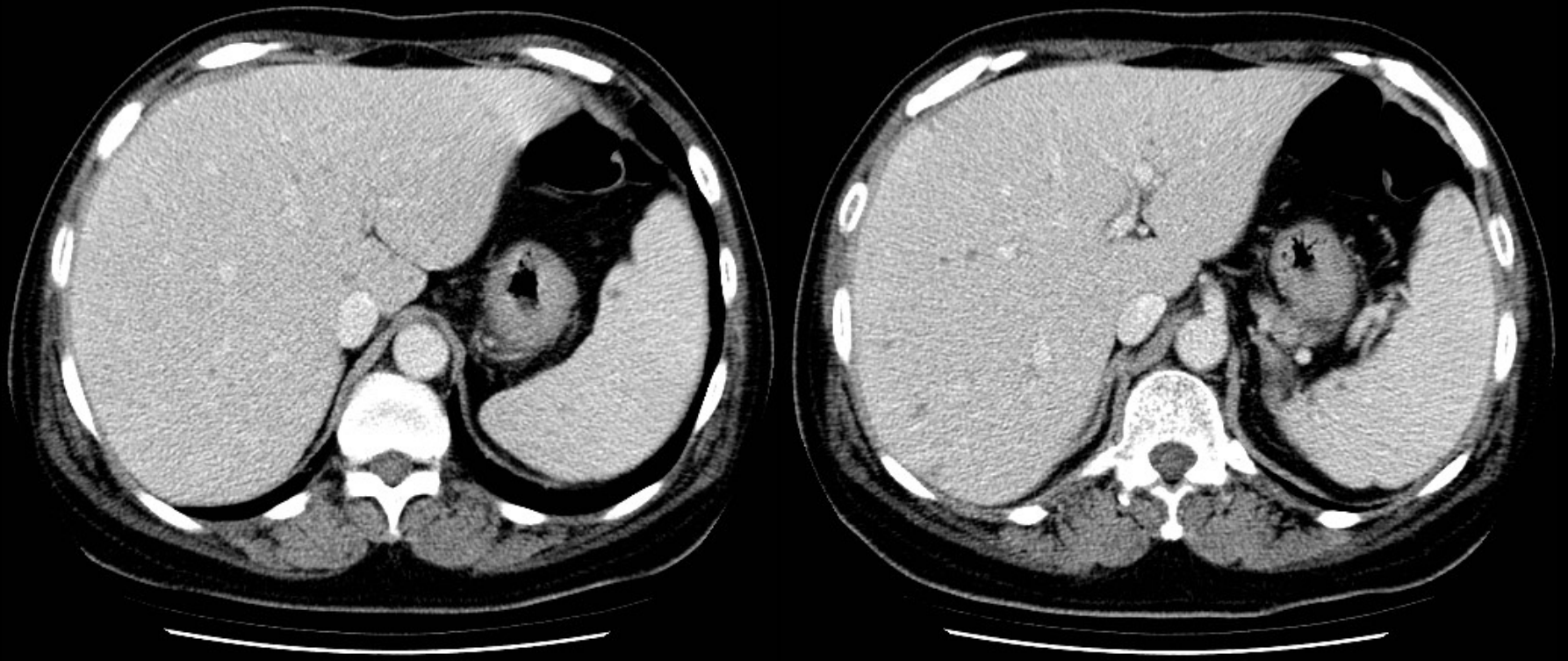
- 48-year-old woman
- Acute myeloid leukemia
- Neutropenic fever









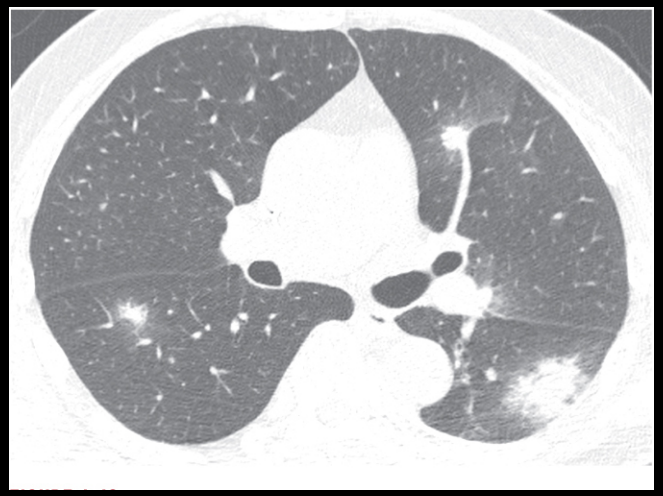


# Radiological findings

- Multiple bilateral lung nodules with some surrounding ground glass opacity (Halo sign)
- Multiple small low density nodules or abscesses in the liver and spleen

Suggestive imaging diagnosis: fungal infection, especially Aspergillosis

# Halo sign



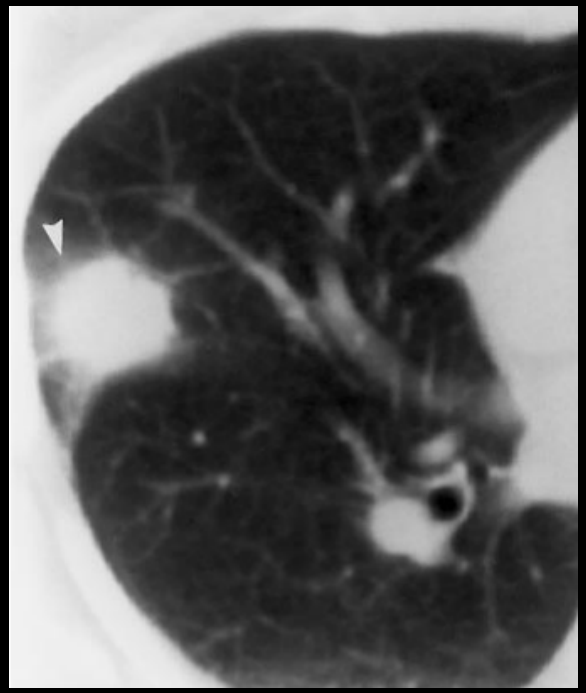
Nodules with a surrounding halo of GGO
(= the “halo sign”)

Angioinvasive aspergillosis. Several large nodules/masses are seen, each of which has a halo of surrounding GGO. Although this finding is nonspecific, in the setting of neutropenia, angioinvasive aspergillosis is the most likely diagnosis.

The ground-glass opacity represents hemorrhage surrounding infarcted lung and is caused by vascular invasion by the fungus. The halo sign is typically seen early in the course of the infection

# Air crescent sign

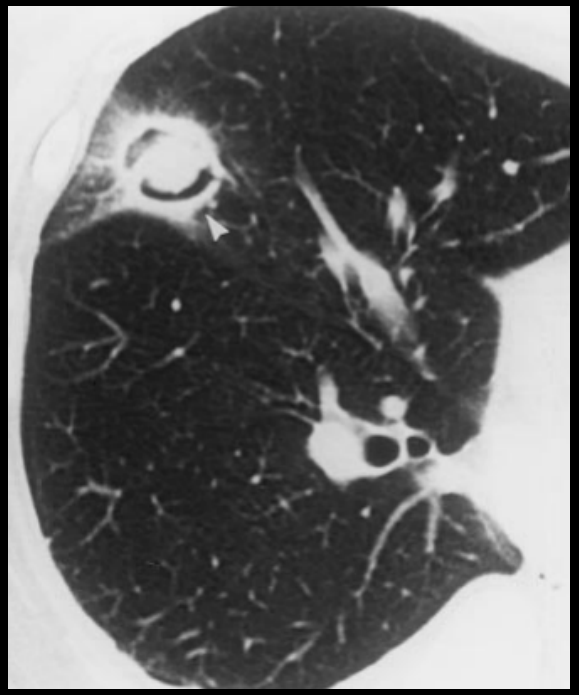
Invasive aspergillosis in a 58-yearold woman with acute myelocytic leukemia



CT halo sign

4 days later

the recovery phase of infection and which coincided with white blood cell count recovery.



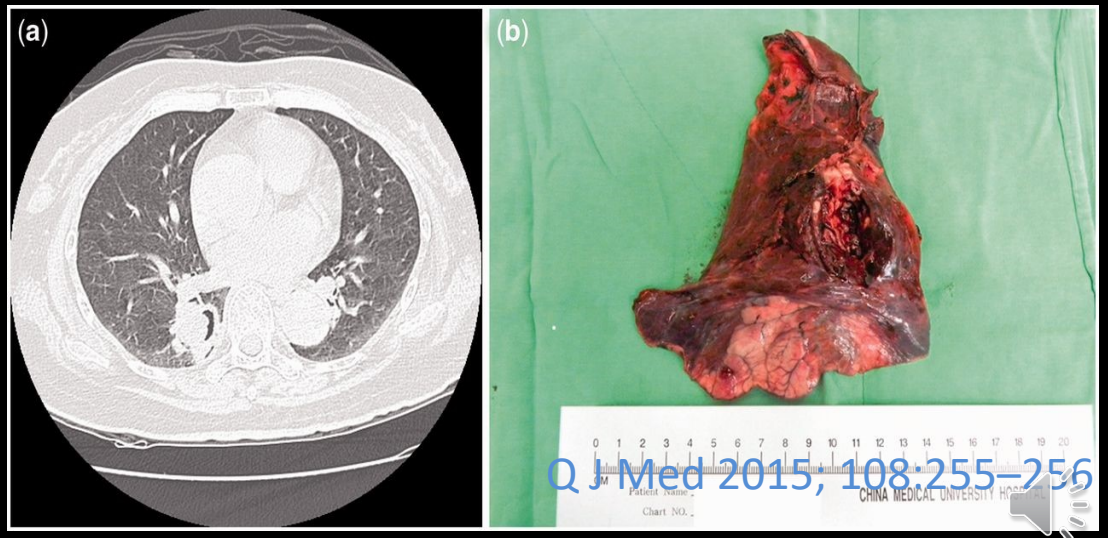
air crescent sign

Radiology 2001; 218:230–232

# Air crescent sign

The air crescent sign is not specific for Aspergillus infection and can be seen in other conditions, such as cavitating neoplasm, intracavitary clot, and Wegener granulomatosis

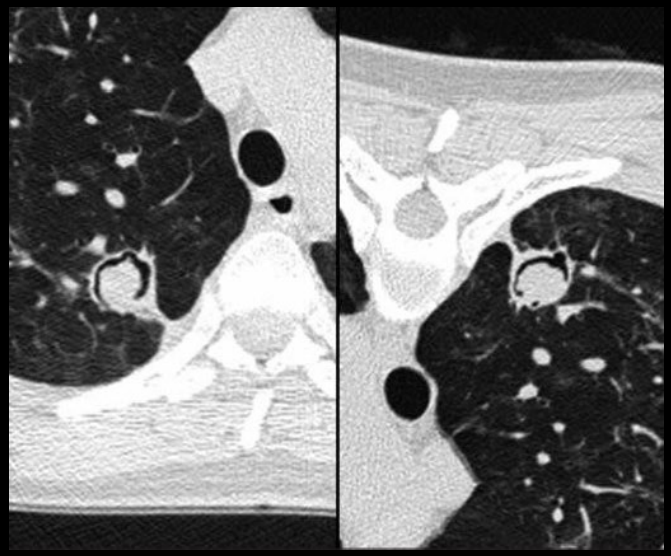
poorly differentiated adenocarcinoma with focal squamous cell carcinoma




Q J Med 2015; 108:255–256

# Monad sign

- Caution is advised not to mistake the Monad sign of aspergilloma with the air crescent sign of invasive aspergillosis.
- Monad sign develops in immunologically competent patients with structural lung disease. The radiographic appearance is that of a gravity dependent mass within a preexisting cavity



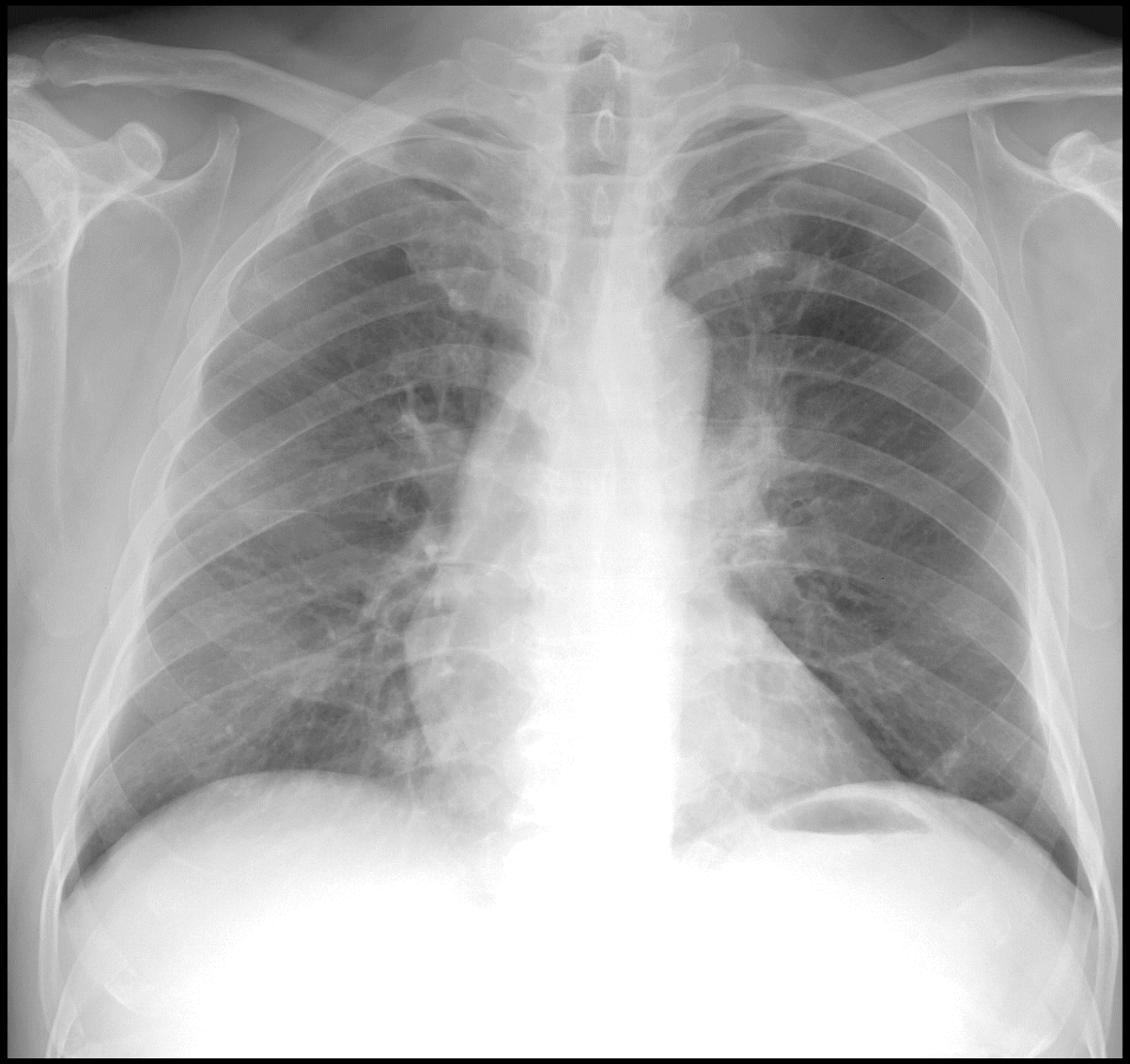
A 65-year-old woman with intracavitary mycetoma. Example of Monad sign.

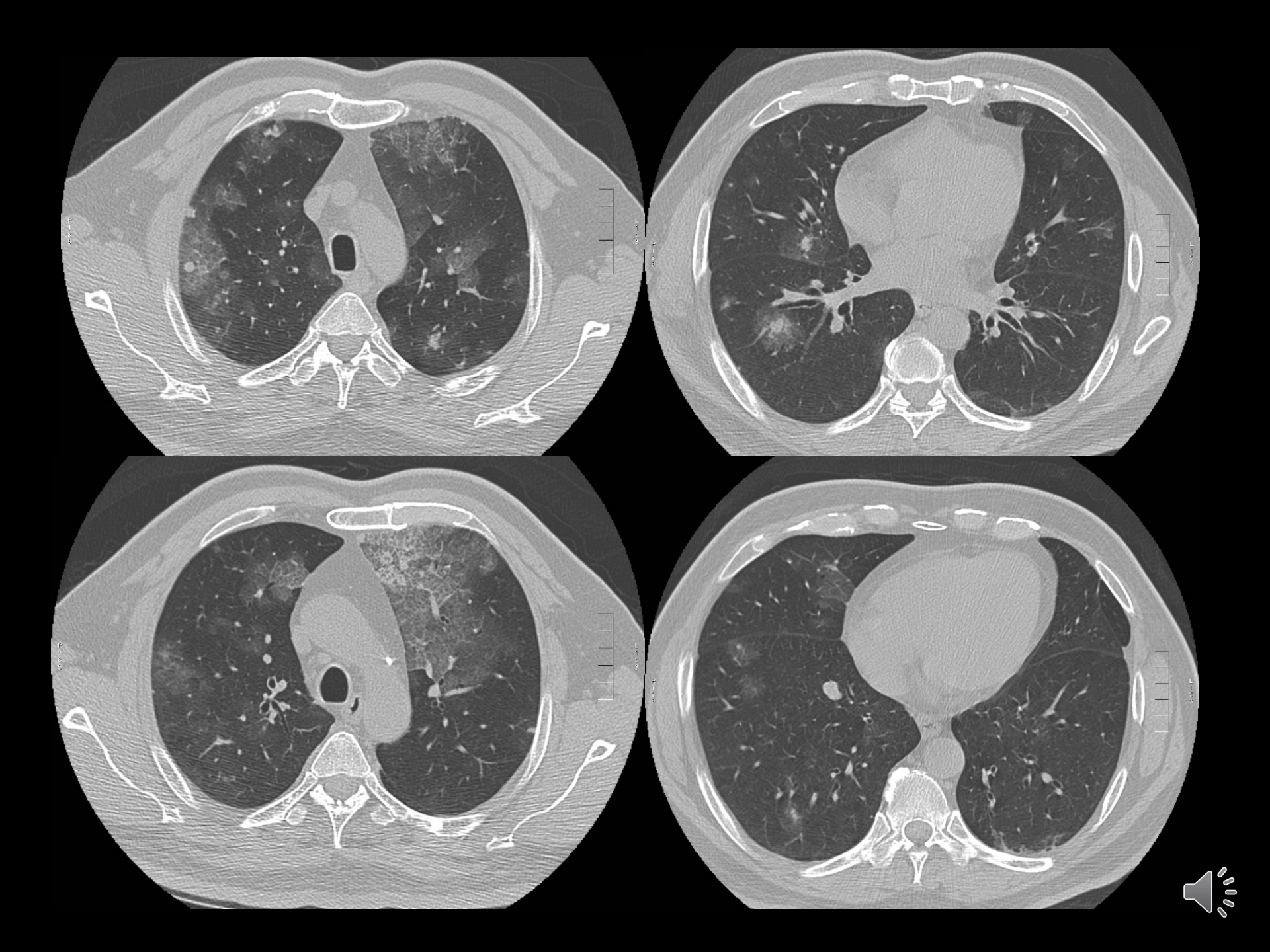
AJR 2014; 202:479–492

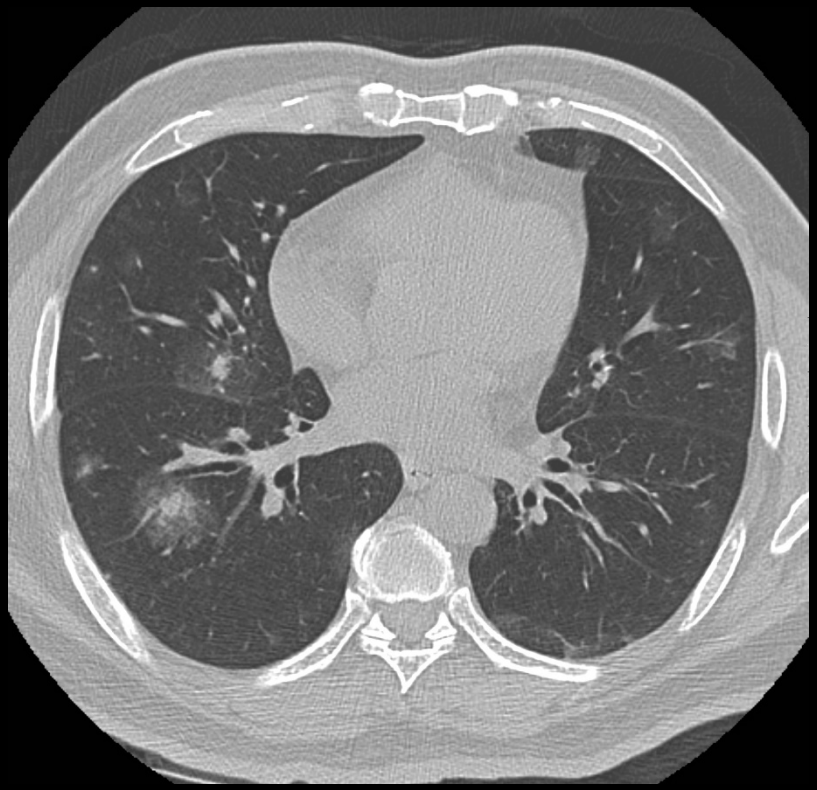
# Case demonstration

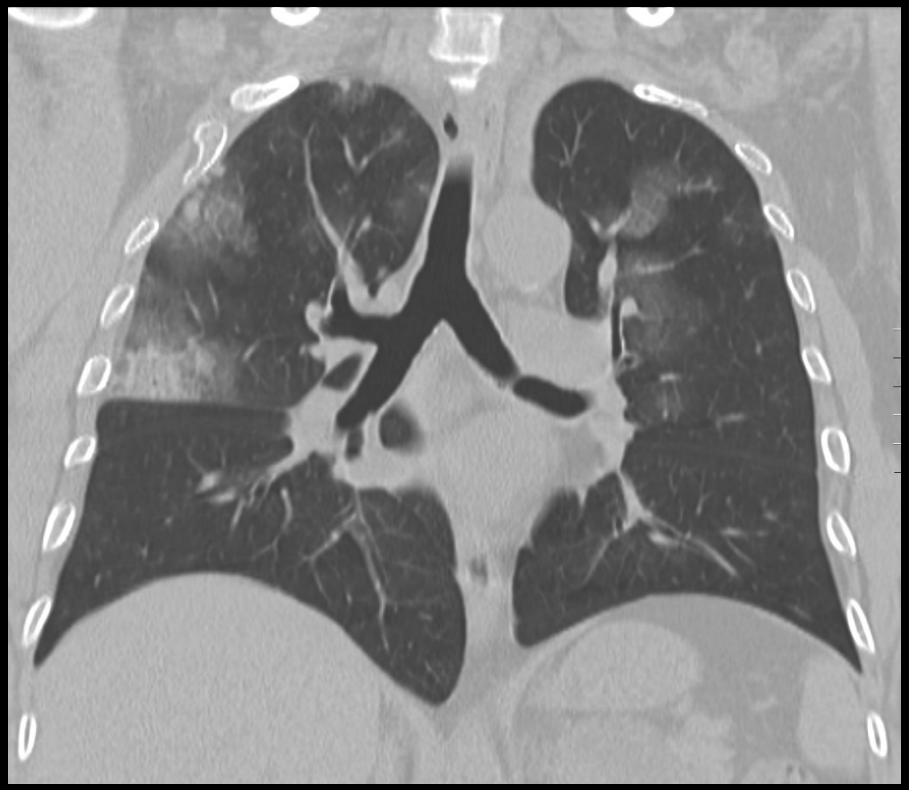
- 52-year-old male
- DM under OHA control
- Left shoulder pain
- Blood-tinged sputum

- DM: Diabetes mellitus OHA: Oral hypoglycaemic agents.









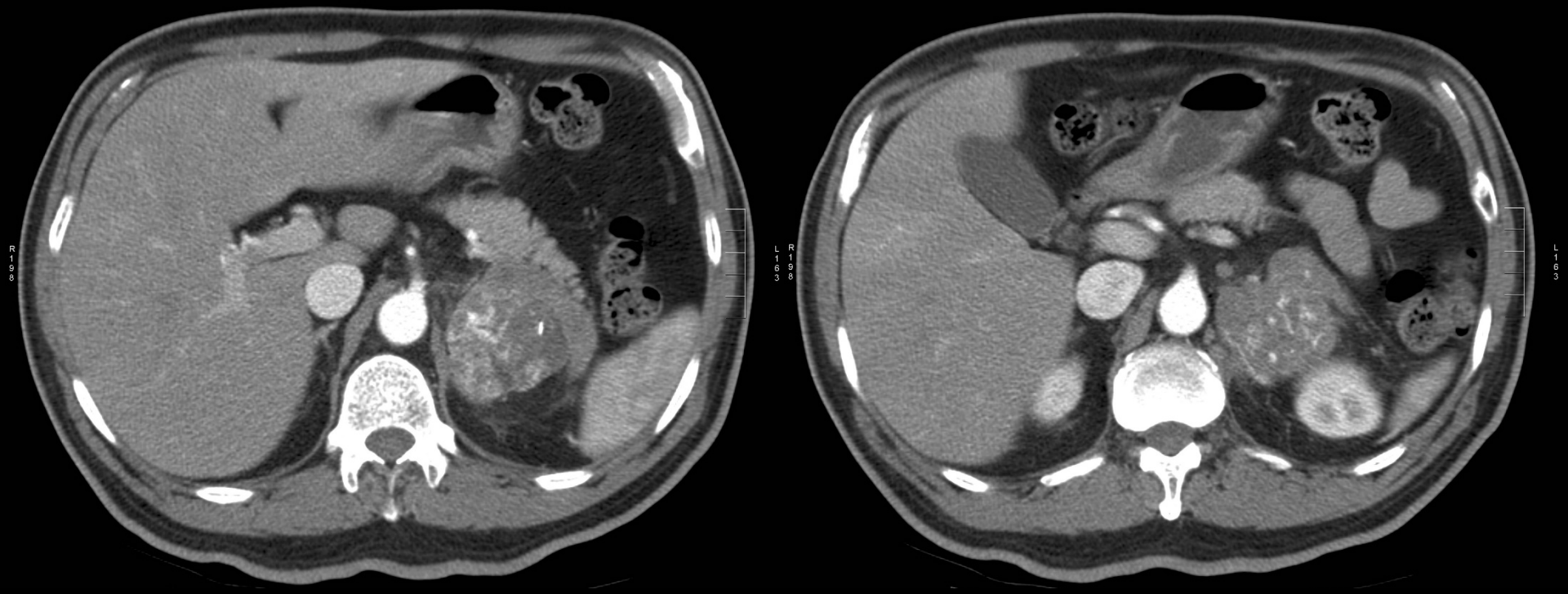
# CT findings

- Bilateral lung nodules, some with halo sign
- Bilateral patchy GGO with septal thickening, more evident at the LUL

- LUL: Left upper lobe; GGO: Ground-glass opacity.

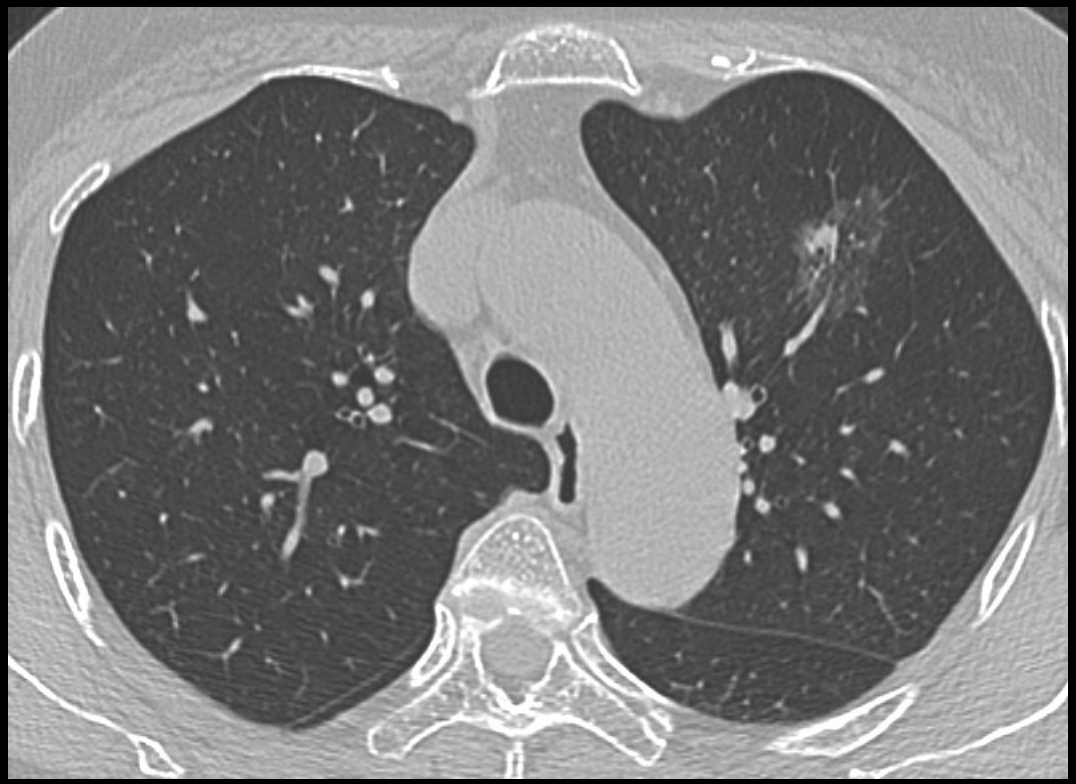
# *What do you think?*

# Adrenal angiosarcoma, multiple metastases



# Another case: Part solid nodule (PSN)

Lung adenocarcinoma



# CT Halo Sign

**Table 1.** List of diseases showing the CT halo sign

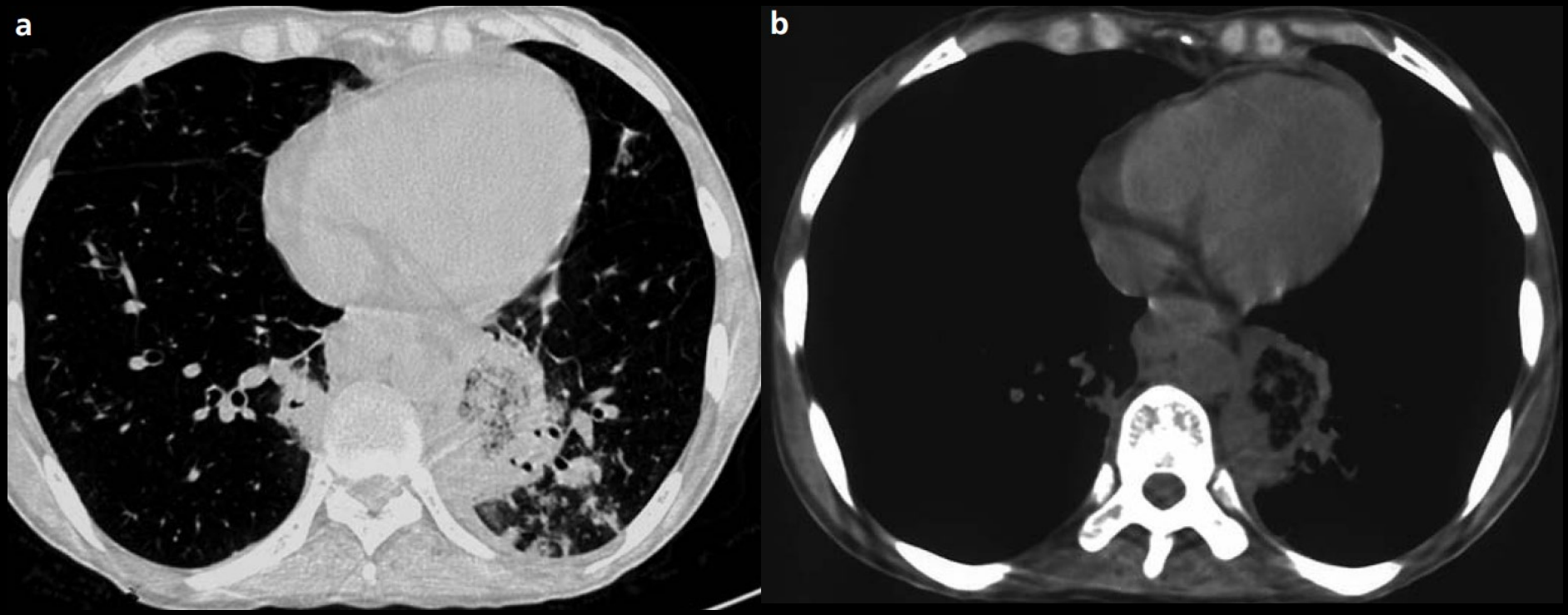
| |
|---|
| Infectious diseases |
| Fungus; aspergillosis[a], mucormycosis, candidiasis, coccidioidomycosis, cryptococcosis |
| Septic embolism |
| Mycobacteria; tuberculosis, *Mycobacterium avium* complex |
| Rickettsia; *Coxiella burnetti* |
| Virus; herpes simplex virus, varicella-zoster virus, cytomegalovirus, myxovirus |
| Neoplastic diseases |
| Primary tumours; squamous cell carcinoma, Kaposi sarcoma, bronchioloalveolar carcinoma[b], adenocarcinoma |
| Metastatic tumours; angiosarcoma, choriocarcinoma, osteosarcoma, melanoma, hydatidiform mole, metastatic tumours from gastrointestinal malignancies |
| Lymphoproliferative disorders |
| Non-neoplastic, non-infectious, inflammatory diseases |
| Wegener's granulomatosis |
| Eosinophilic lung disease; parasitic infestation (schistosomiasis), simple pulmonary eosinophilia, hypereosinophilic syndrome |
| Pulmonary endometriosis |
| Organizing pneumonia |
| Hypersensitivity pneumonitis |
| Iatrogenic injury; transbronchial lung biopsy, catheter-induced pulmonary pseudoaneurysm |

[a]The most common condition showing the CT halo sign in immunocompromised patients.
[b]The most common condition showing the CT halo sign in immunocompetent patients.

- Specific CT signs: important
- Not all lesions with air crescent sign or halo sign are fungal infection
- Clinical data, history, disease course
- High clinical suspicious index
- HRCT/ thin section CT
  - Lesion detection and characterization
- Tissue proof: Bronchial alveolar lavage (BAL) with microbiologic study, PCR; Percutaneous biopsy; VATS

Lee YR. *Br J Radiol* 2005; 78: 862–5

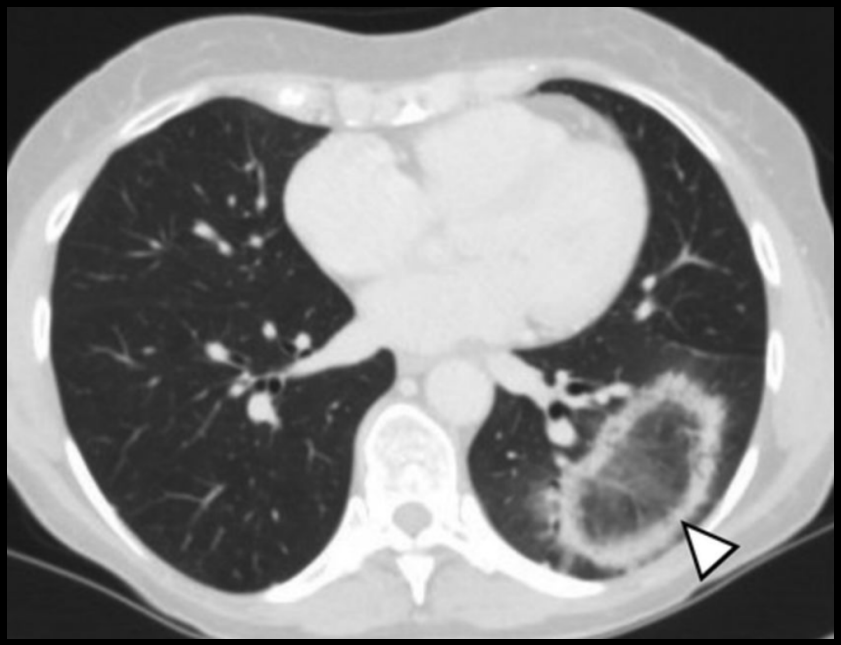
# Reverse halo sign



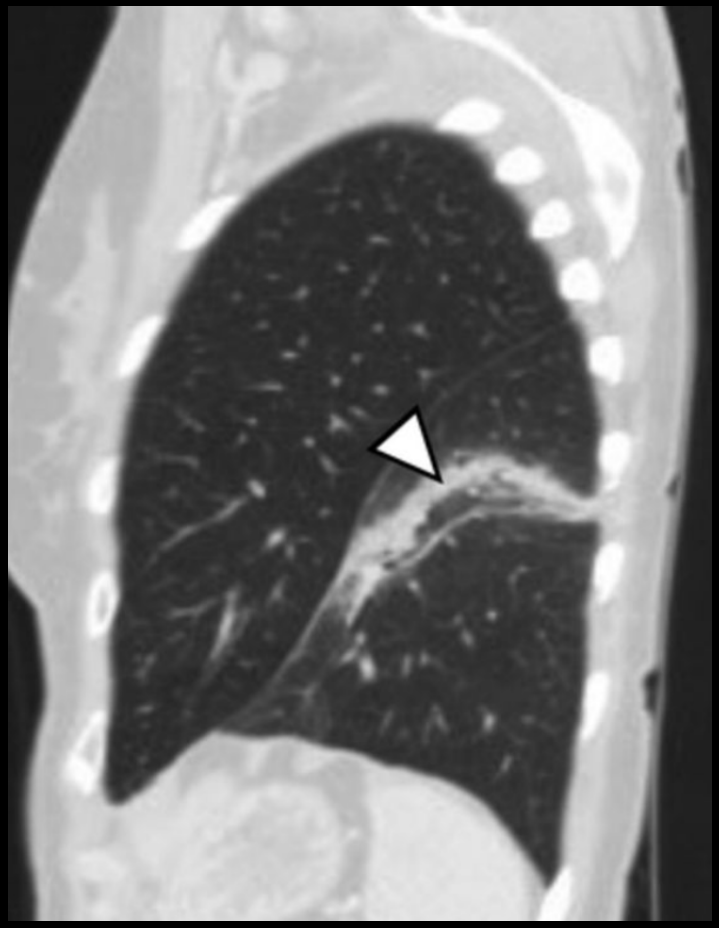

invasive pulmonary fungal infection

Algin O, et al. Diagn Interv Radiol 2011; 17:18-29

# Reverse halo sign



cryptogenic organising pneumonia



•Findings of reversed halo sign and COP may lead to further examination of the underlying cause of its presence, as COP may have multiple aetiologies.

Davidsen JR, et al. BMJ Case Rep 2016.
doi:10.1136/bcr-2015-213779

# Reversed halo sign (atoll sign)

- a focal round area of GGO and surrounding air-space consolidation of crescent or ring shapes
- relatively specific to a diagnosis of cryptogenic organizing pneumonia (COP)
- Also found in
  - Lymphomatoid granulomatosis (LG),
  - Sarcoidosis,
  - Pulmonary paracoccidioidomycosis,
  - Other pulmonary fungal infections

# Reversed halo sign (atoll sign)

Table 2. Disorders Manifesting With the Reversed Halo Sign on Computed Tomography of the Chest

| | No. |
|---|---|
| Infectious diseases | |
| Pulmonary mucormycosis[20,25,36,44,45,50,54,55,65] | 23 |
| Invasive pulmonary aspergillosis[20,65] | 8 |
| Histoplasmosis[41] | 1 |
| Cryptococcosis[46] | 1 |
| Paracoccidioidomycosis[8,46] | 27 |
| *Pneumocystis jirovecii* pneumonia[31,46] | 2 |
| H1N1 ARDS[48] | 3 |
| Tuberculosis[12,46,58] | 30 |
| Psittacosis[17] | 1 |
| *Legionella pneumophila* pneumonia[18] | 2 |
| Noninfectious diseases | |
| Cryptogenic organizing pneumonia[1,2,4,10,13,23,24,26,28,34,39,53,65] | 36 |
| Secondary organizing pneumonia[5,6,9,10,15,27,32,33,35,37,40,43,47,65] | 30 |
| Vasculitis[7,11,46] | 4 |
| Sarcoidosis[3,22,46] | 7 |
| Lymphomatoid granulomatosis[14,21] | 2 |
| Idiopathic nonspecific interstitial pneumonia[19,38] | 2 |
| Lipoid pneumonia[16] | 1 |
| Pulmonary thromboembolism[46,49] | 19 |
| Pulmonary tumor embolus[52] | 1 |
| Pulmonary edema[46] | 3 |
| Bronchoalveolar carcinoma[46] | 3 |
| Hypersensitivity pneumonitis[57] | 1 |
| Tuberous sclerosis complex[56] | 1 |
| Lymphocytic interstitial pneumonia[51] | 1 |
| Total | 209 |

The two most commonly associated diseases are the organizing pneumonias and invasive fungal pneumonias (especially mucormycosis).

Respir Care 2014;59(9):1440–1449


Thanks for your attention