

Imaging of pulmonary infectious diseases and airway diseases

台北榮總胸腔部 馮嘉毅醫師

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Common pulmonary infection in Taiwan

- Bacterial pneumonia
 - Typical bacterial infection
 - Atypical bacterial infection
 - Tuberculosis
 - Non-tuberculosis mycobacterium
- Viral pneumonia: Influenza, CMV, measles, COVID-19
- Fungal infection
 - Candidiasis
 - Cryptococcosis
 - Aspergillosis
 - Pneumocystis jiroveci



CHEST X-RAY

Always start from PATTERN

Patterns in CXR

- Chest wall/pleural lesions ✓
- Mediastinum lesions ✓
- Hilar enlargement ✓
- Air space diseases (alveolar process) ✓
- Atelectasis ✓
- Interstitial pattern ✓
- Solitary/multiple pulmonary nodules ✓
- Hyperlucent lung ✓
- Solitary/multiple lucent defects ✓

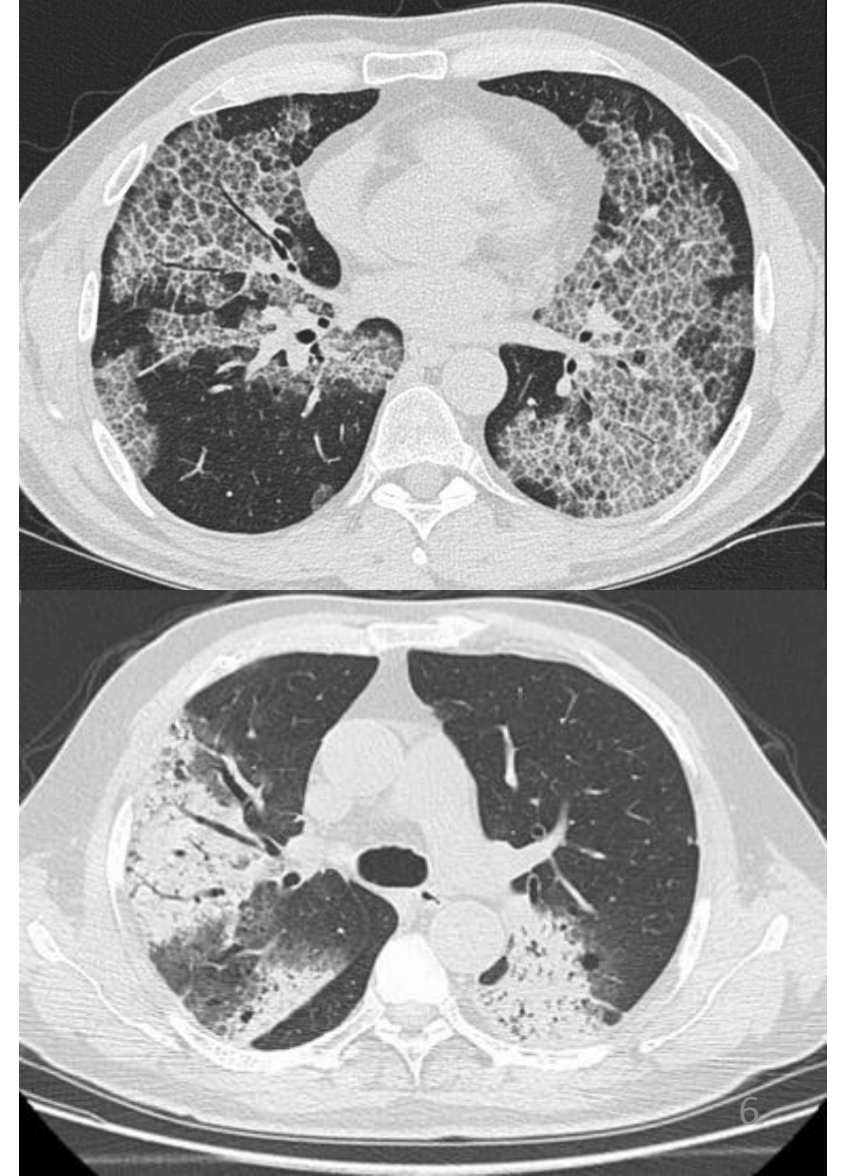
Common Patterns of lung infection

- Alveolar process (consolidations)
- Ground glass opacities
- Nodules
- Cavities
- Pneumatoceles
- Other associated findings: pleural effusion, rib destruction

Airspace Filling

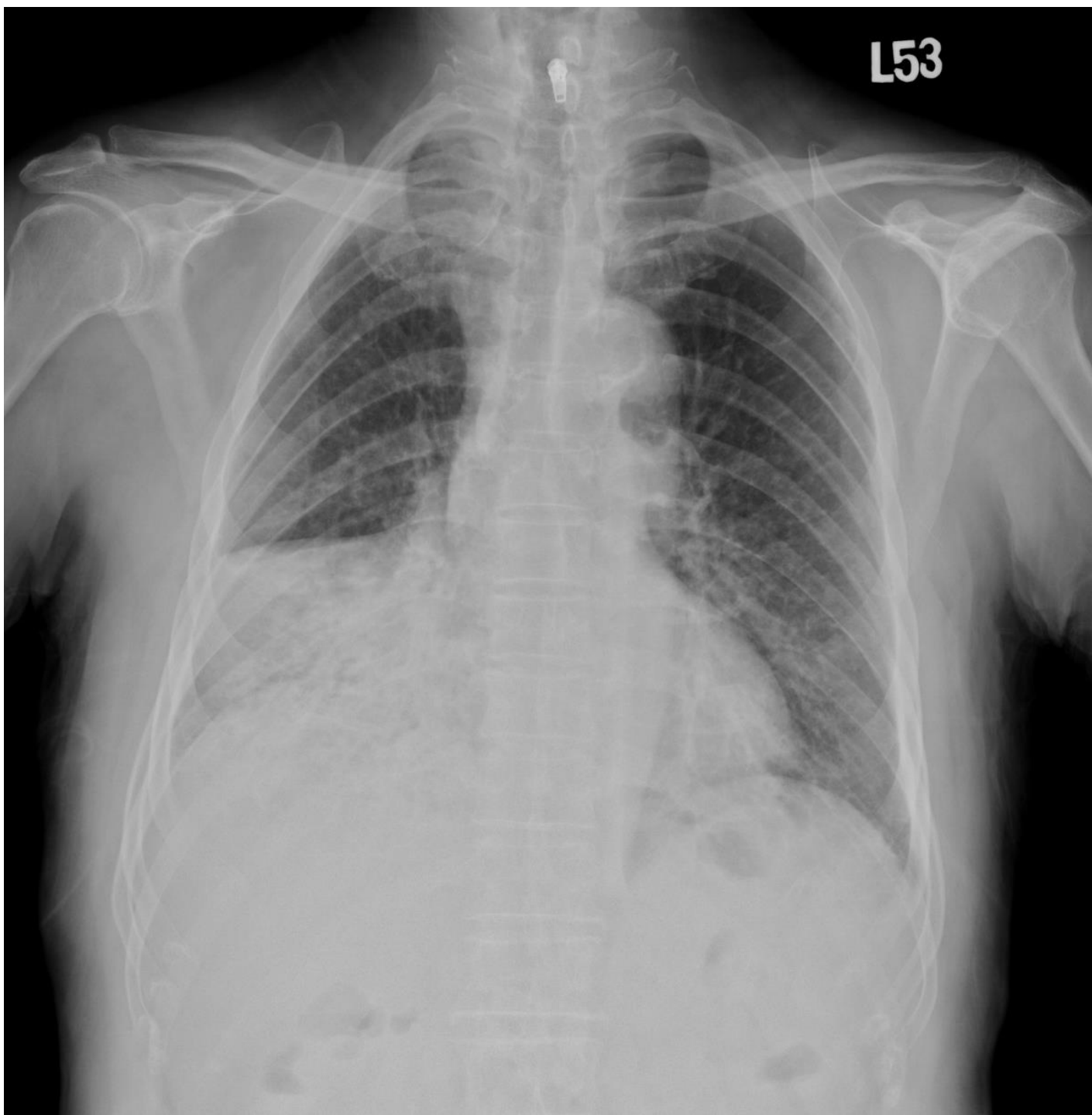
- Incomplete filling
 - Ground-glass opacity
 - Comes from inflammatory cells, exudates, fluid
- Complete filling
 - Consolidation

血、膿、水、細胞、蛋白質

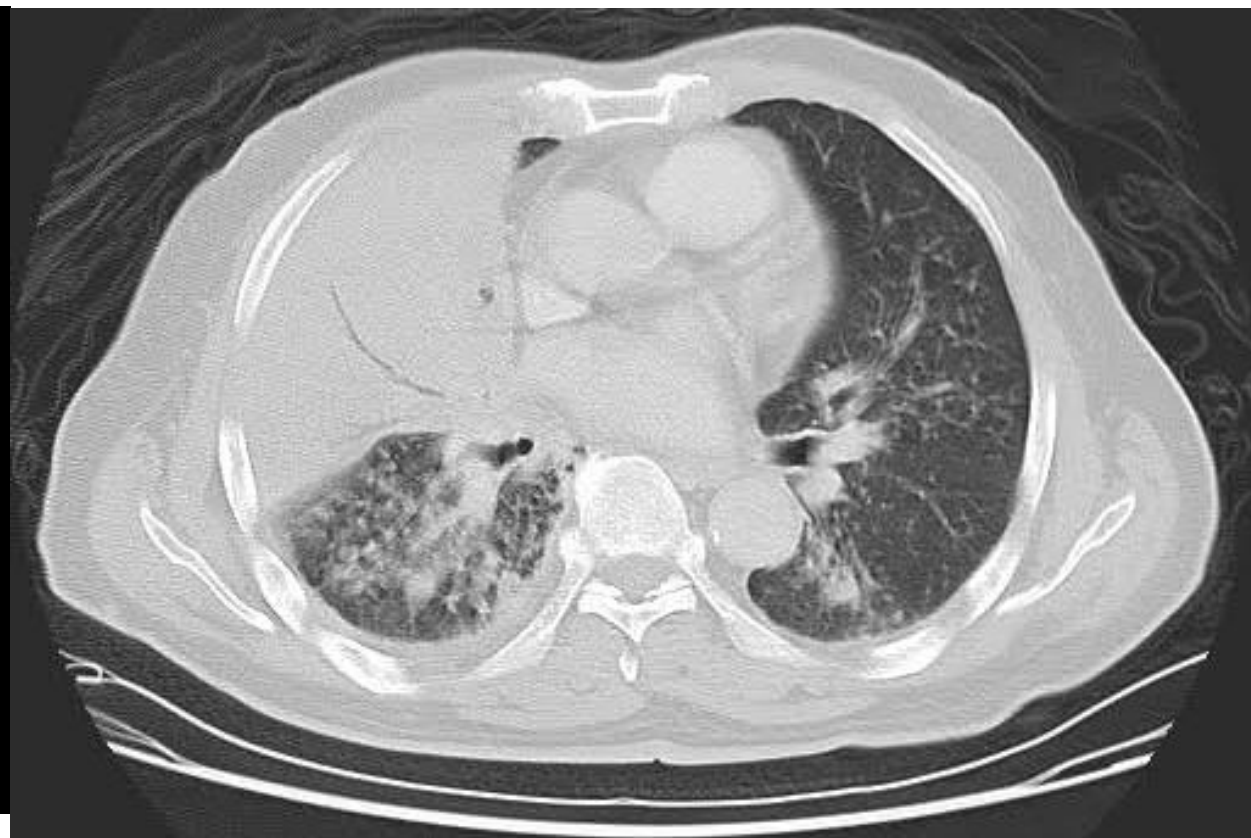
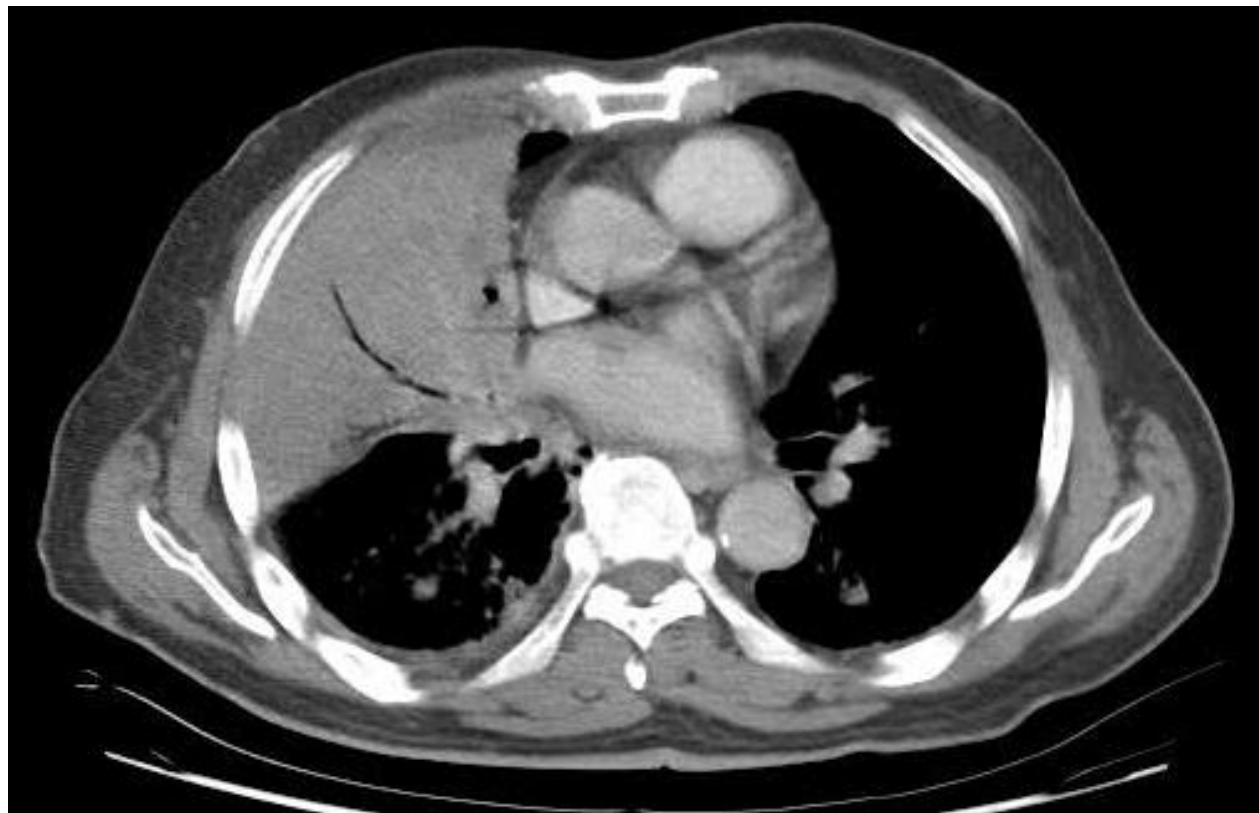


Chronicity of the Alveolar Process

- Acute: **HEEP**
 - Hemorrhage
 - Edema
 - pul. Embolism
 - **Pneumonia**
 - Bacterial
 - Viral
 - Fungal
- Chronic: **BALLS**
 - BAC
 - Alveolar proteinosis (PAP)
 - Lymphoma
 - Lipoid pneumonia
 - Sarcoidosis
 - **Subacute infection**
 - TB, fungal



- 81 y/o male
- Dyspnea and productive cough for 2 weeks
- WBC: 37600, band: 4%, CRP; 13.56
- Sputum Gram stain: GPC

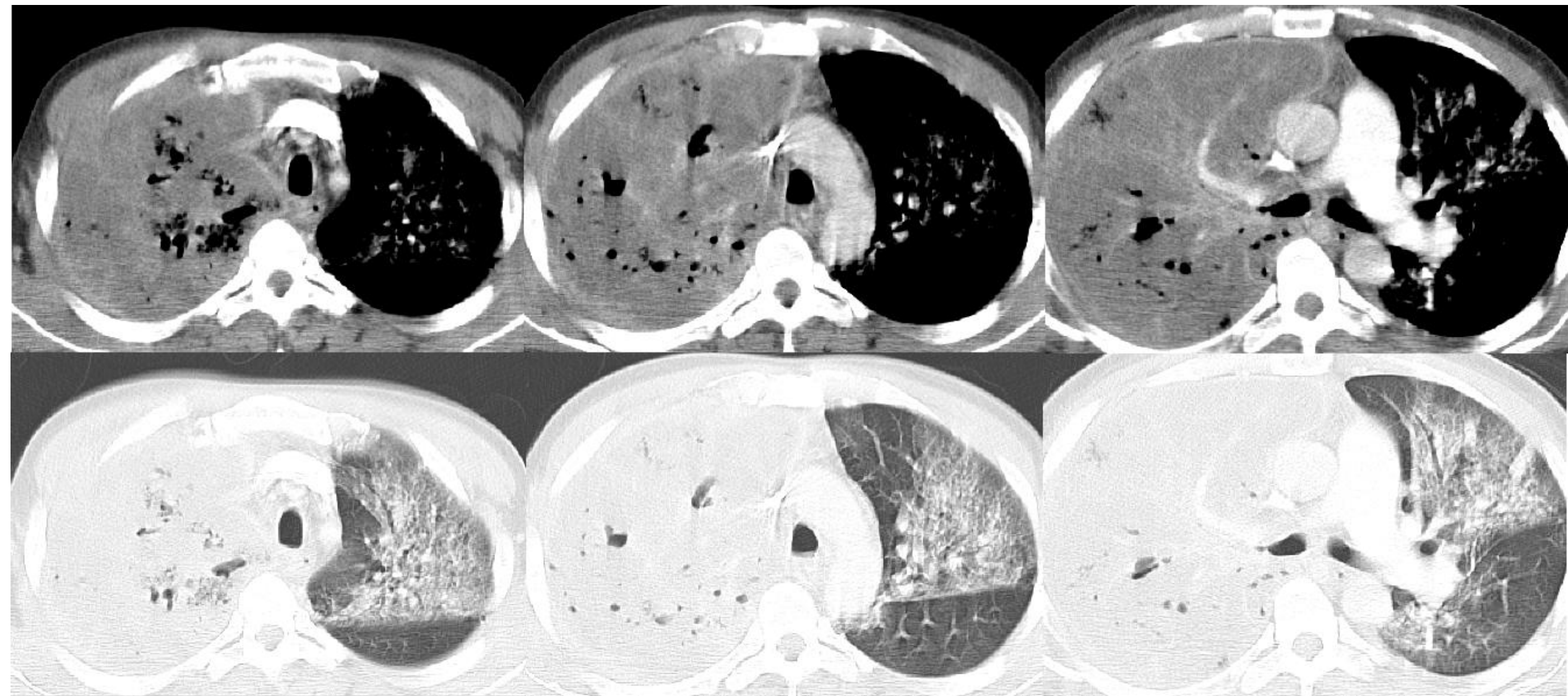


Dx:
Community Acquired MRSA

L53



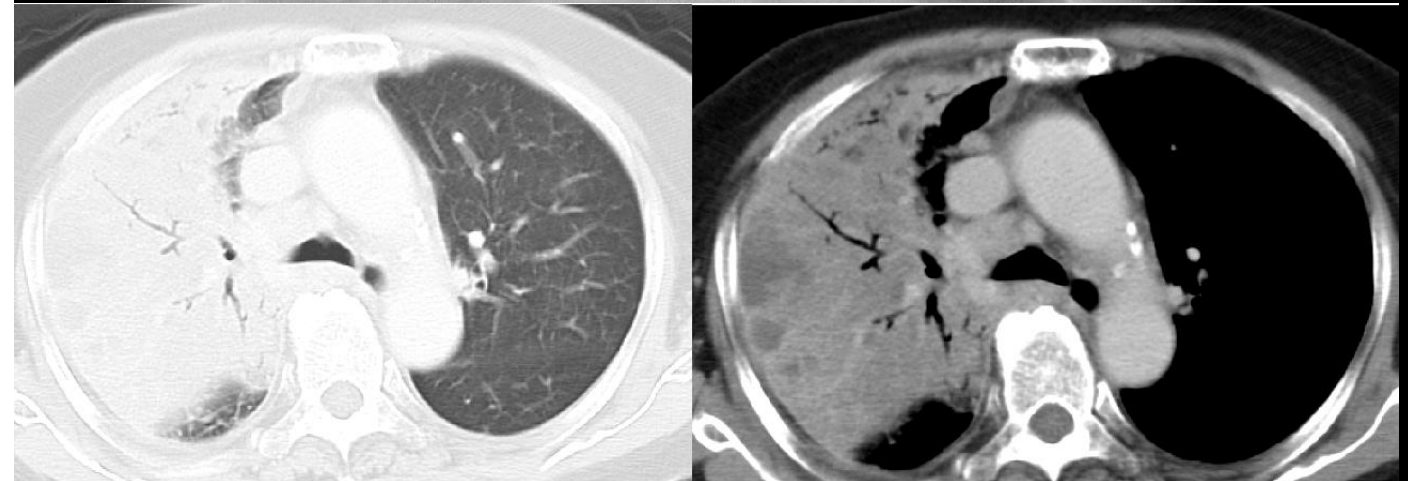
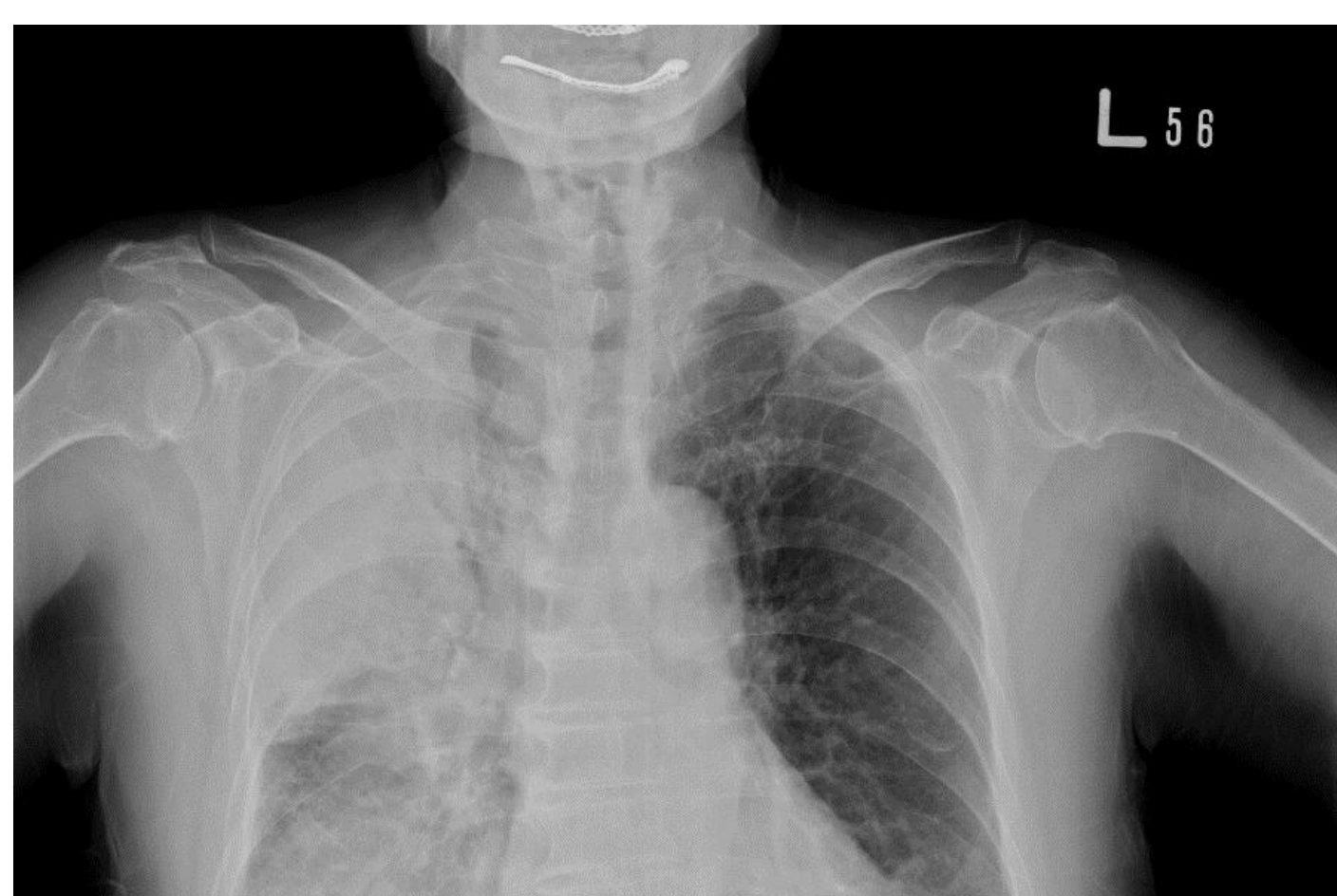
- 33 y/o male
- Dyspnea and productive cough for 1 weeks
- Chronic alcoholism
- Sputum Gram stain: GNB



Sputum culture: KP
Blood culture: KP

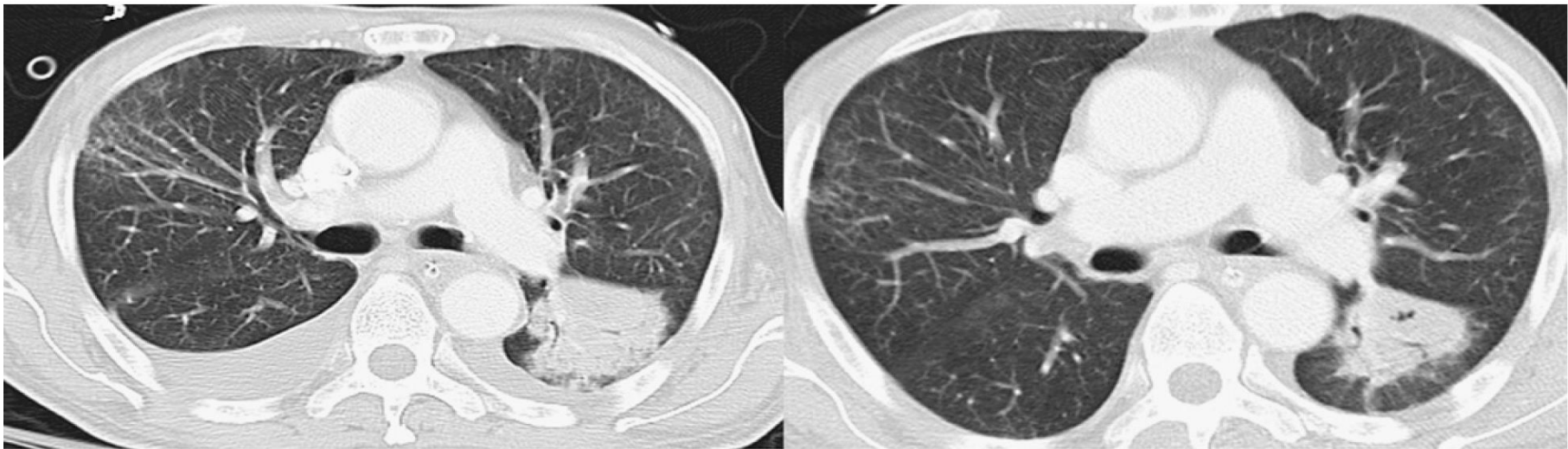






- 75 y/o female
- Low grade fever and dyspnea for 3 weeks
- T2DM
- Sputum Gram stain/culture: negative
- AFB: 2+, culture: MTBC

Invasive Pulmonary Aspergillosis in a patient after liver transplantation



(a)

(b)



Invasive Pulmonary Aspergillosis

2020 Revised EORTC-MSG criteria for invasive pulmonary aspergillosis

Clinical features

Pulmonary aspergillosis

The presence of 1 of the following 4 patterns on CT:

Dense, well-circumscribed lesions(s) with or without a halo sign

Air crescent sign

Cavity

Wedge-shaped and segmental or lobar consolidation

Common image findings in IPA

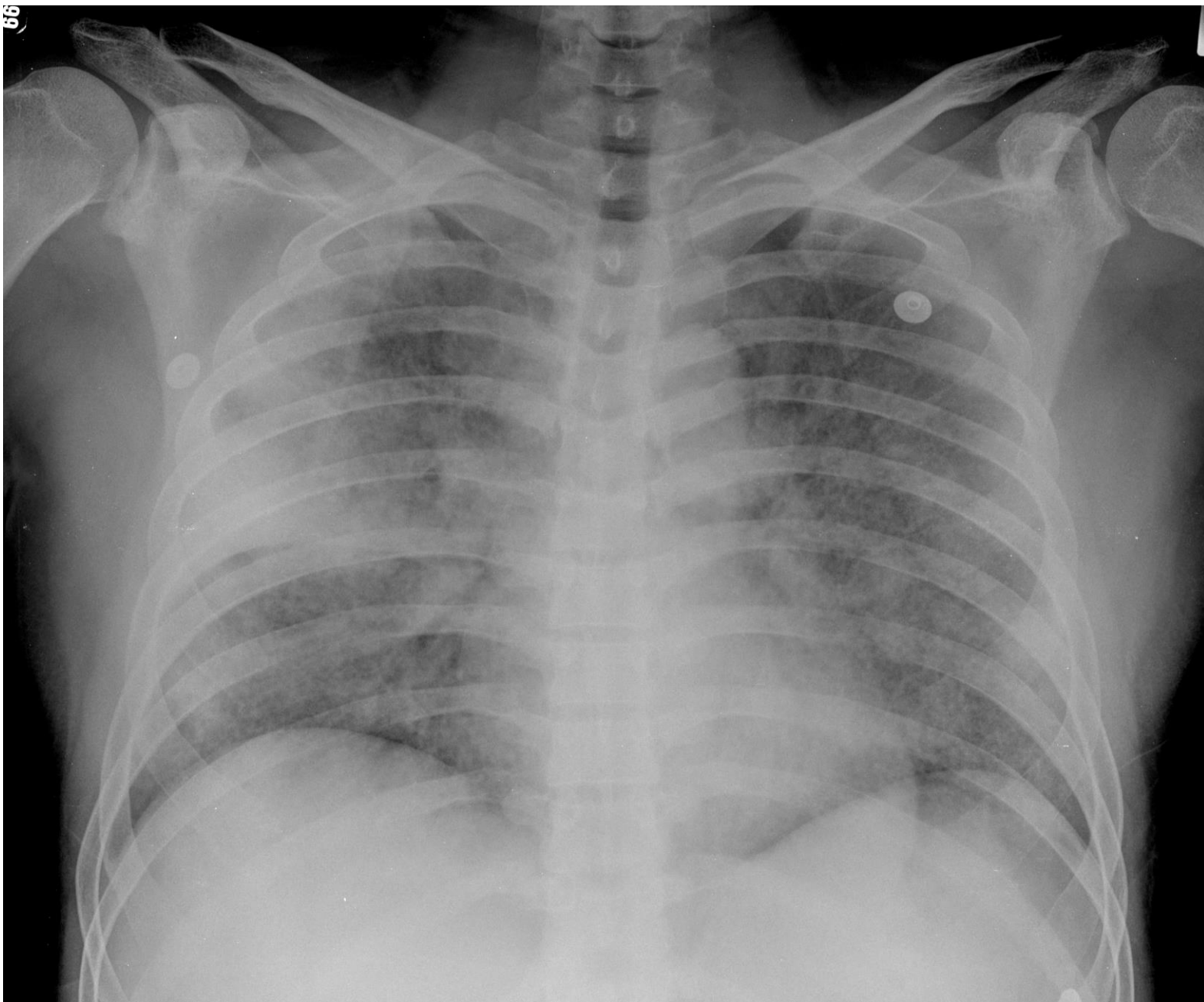
Imaging finding	No. (%) of patients (N = 235)
Macronodule (≥ 1 cm in diameter) ^a	222 (94.5)
Halo sign ^b	143 (60.9)
Consolidation ^c	71 (30.2)
Macronodule, infarct shaped	63 (26.8)
Cavitary lesion ^d	48 (20.4)
Air bronchograms	37 (15.7)
Clusters of small nodules (<1 cm in diameter)	25 (10.6)
Pleural effusion	25 (10.6)
Air crescent sign	24 (10.2)
Nonspecific ground-glass opacification	21 (8.9)
Consolidation, infarct shaped	18 (7.7)
Small-airway lesions ^e	16 (6.8)
Atelectasis	7 (3.0)
Hilar/mediastinal lesion	4 (1.7)
Pericardial effusion	2 (0.9)

Chronic Pulmonary Aspergillosis

Category	Immune status	Duration	Symptoms	Radiology	Mycology
Simple aspergilloma	Immuno-competent	≥ 3 months	Minor or no symptoms	Single cavity with a fungal ball without progression (stable)	Aspergillus IgG or Culture Histology (Hyphae within cavity)
CCPA			Pulmonary +/- systemic symptoms	≥ 1 cavities +/- aspergillomas with overt progression	
CFPA			Major impairment of respiratory function	Severe fibrosis ≥ 2 lobes + CCPA	
Aspergillus nodule			Minor or no symptoms	≥ 1 nodules (< 3 cm) +/- central cavity	
SAIA	Moderate immuno-suppression	1 – 3 months	Pulmonary + systemic symptoms	Progressive consolidation w/ abscess formation	Histology (Hyphae tissue invasion) Serum galactomannan or Aspergillus IgG

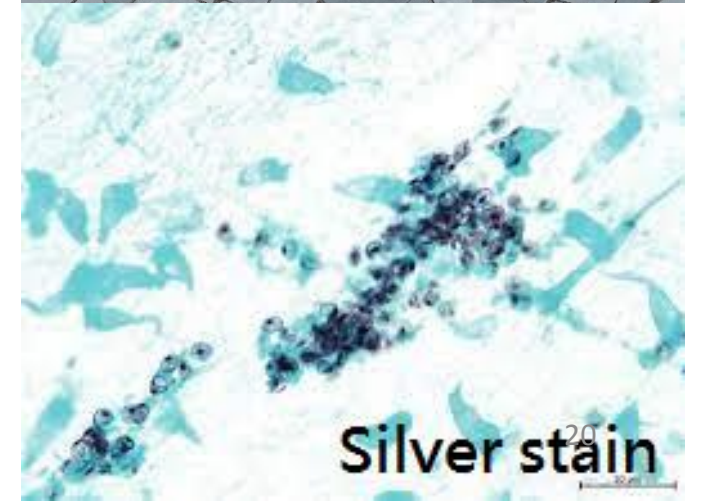
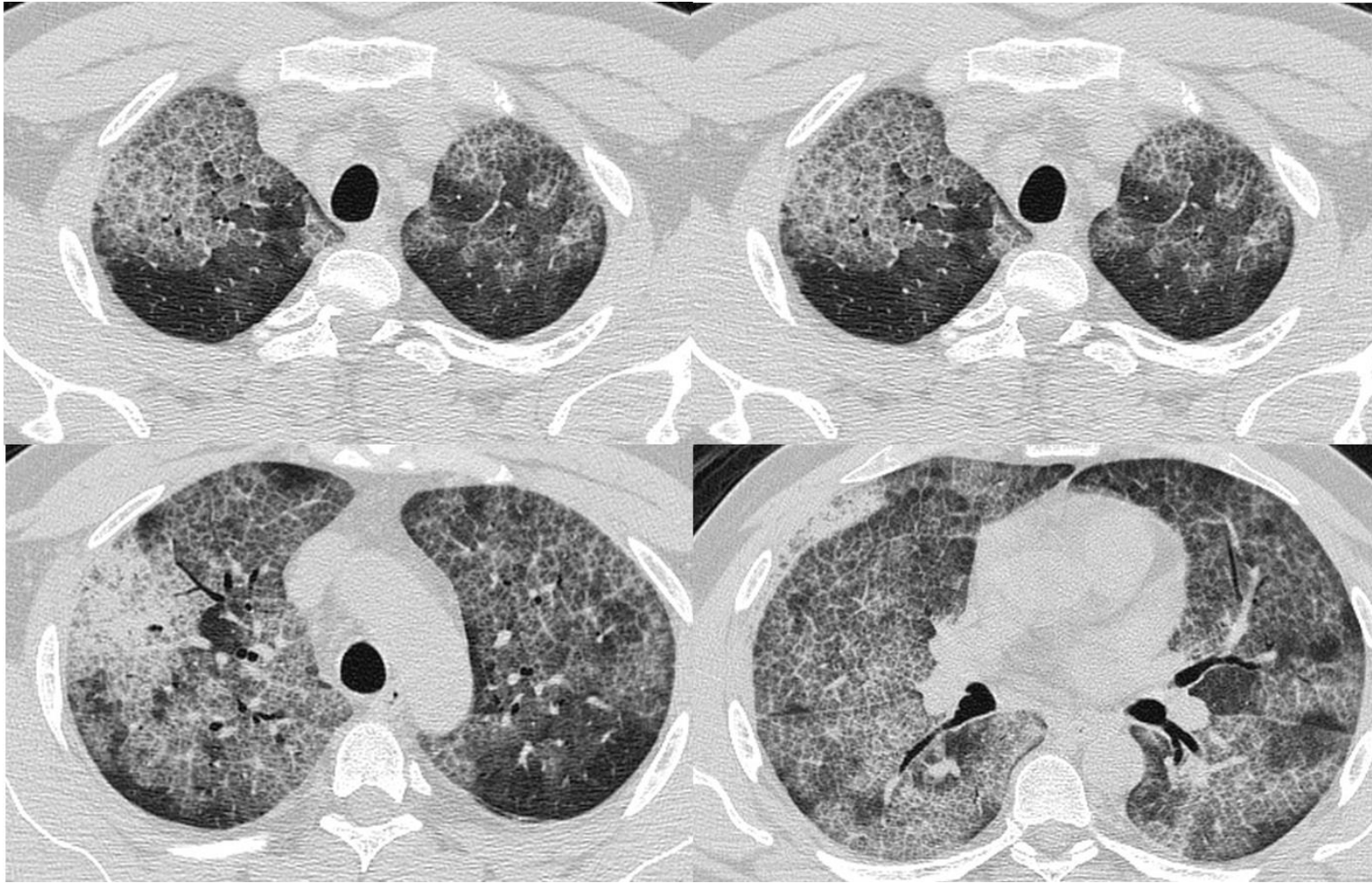
Ground glass opacities

- Lung opacity with visible bronchovascular markings
- Partial filling of alveolar spaces
- Cellular infiltrate in alveolar septa or peribronchovascular interstitium
 - Interlobular septal thickening
- Usually seen in mycoplasma, PJP, CMV, HSV, and COVID-19

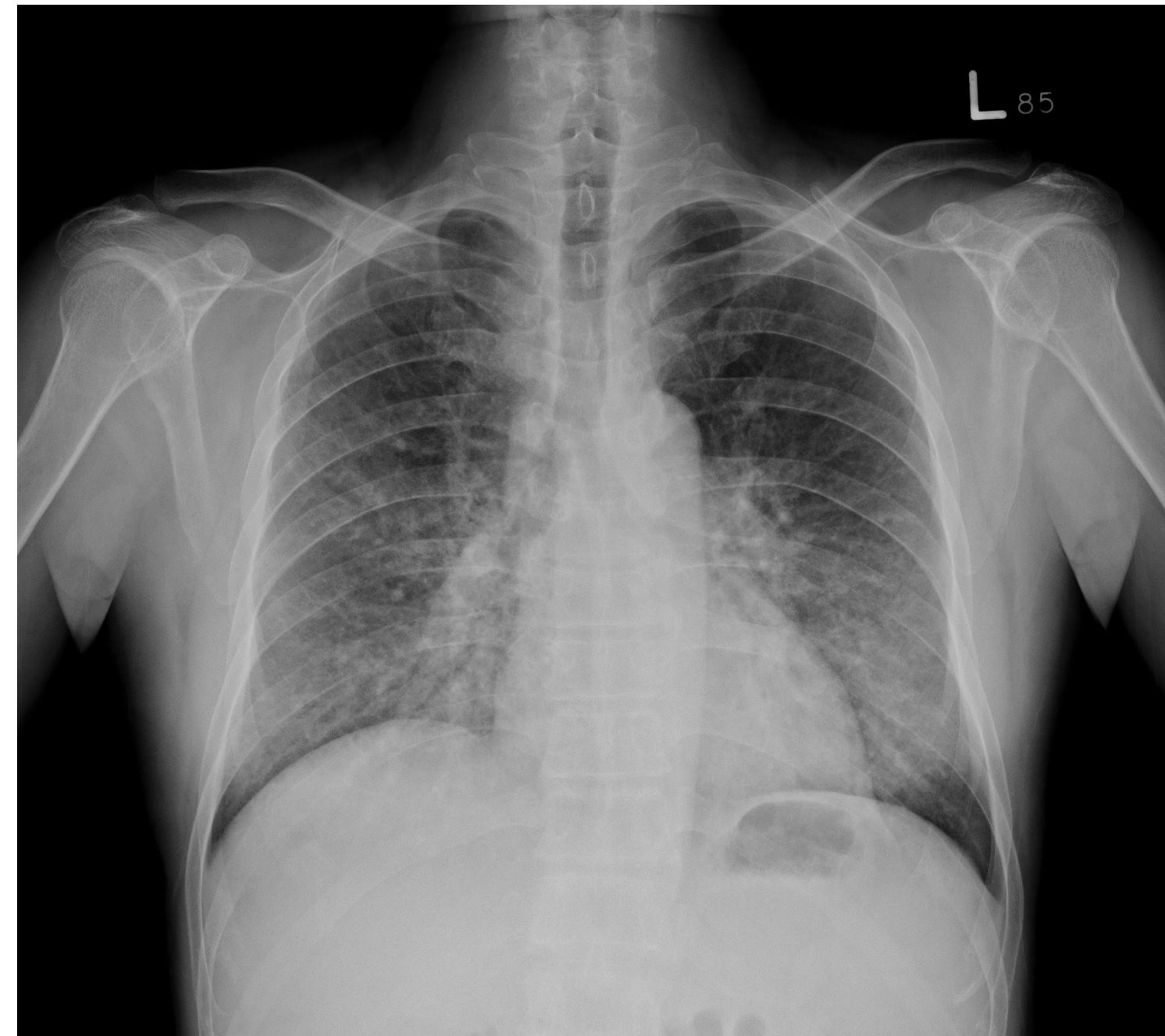


- 42 y/o male
- Cough with fever for 2 weeks
- Desaturation+
- CD4 100
- Anti-HIV +

Crazy-Paving pattern

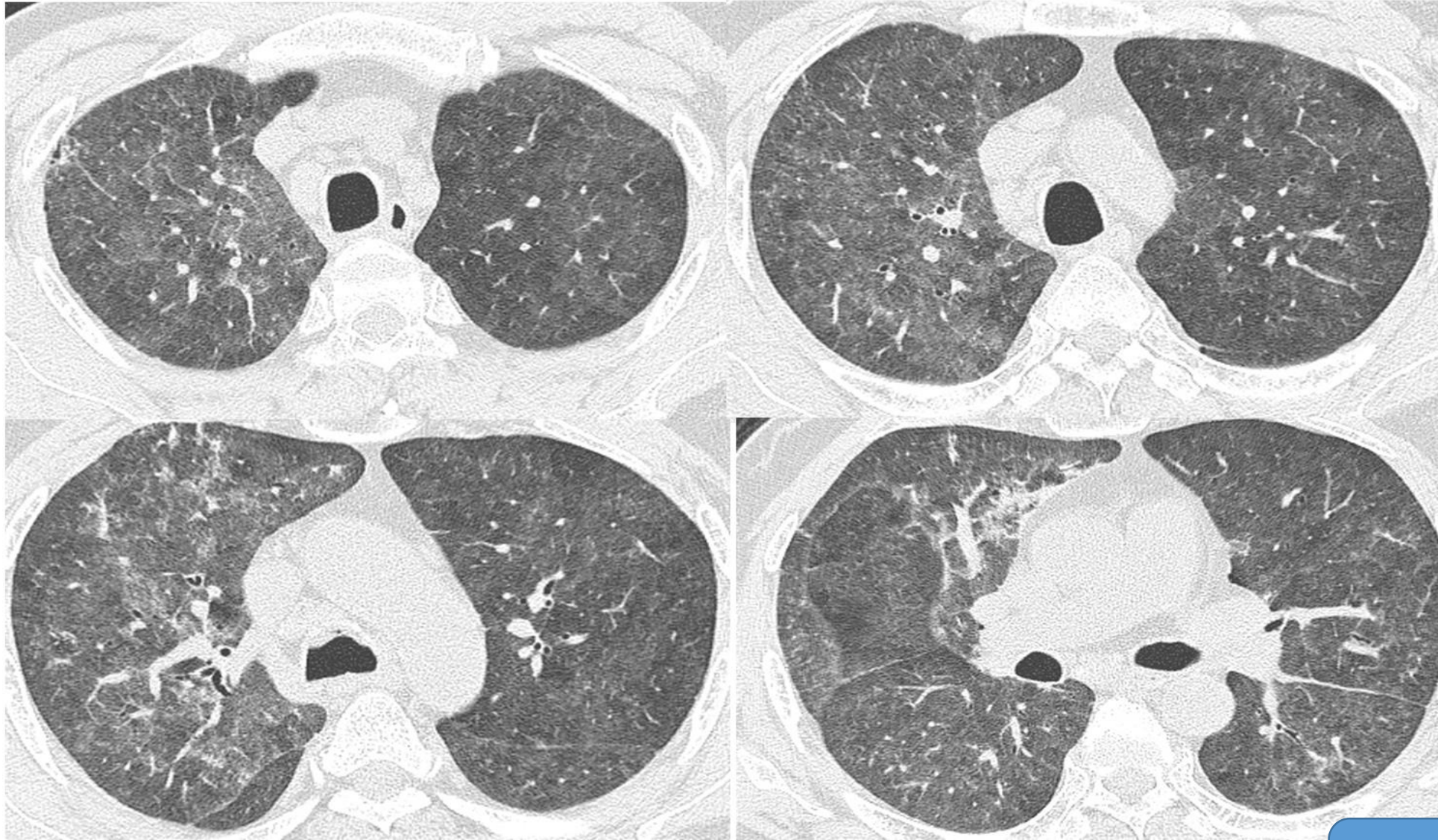


Dx: PJP



- 49 y/o male
- Cough with fever for 2 weeks
- Alcoholic liver cirrhosis
- Liver transplant 1 yr ago
 - Cellcept, Prograf, prednisolone
- WBC 8200, CRP 10.72
- Bacterial culture, AFB smear, fungal culture, galactomannan: negative

Diffuse GGO Pattern



Dx: PJP₂₂

Table 2. Occurrence of Image Patterns and Characteristic Findings on CT

	Malignancy (n=21)	AIDS (n=17)	p value [†]
Image patterns			
Type A	1* (5%)	0 (0%)	} <0.01
Type B	10 (48%)	17 (100%)	
Type C	10 (48%)	0 (0%)	
Characteristic findings			
Consolidation along the bronchovascular bundle	9 (43%)	1 (5%)	<0.02
Transverse parenchymatous band	8 (38%)	3 (18%)	0.17
Subpleural curvilinear opacity	1 (5%)	1 (5%)	0.88
Peripheral sparing of GGO	7 (33%)	10 (59%)	0.12
Centrilobular nodules	5 (24%)	1 (5%)	0.13
Septal line thickening	8 (38%)	2 (12%)	0.07
Intralobular reticular opacity	2 (10%)	3 (18%)	0.46
Cyst formation	3 (14%)	3 (18%)	0.78

- Type A
 - Sharply demarcated GGO

- Type B
 - Diffuse GGO with inhomogeneous distribution

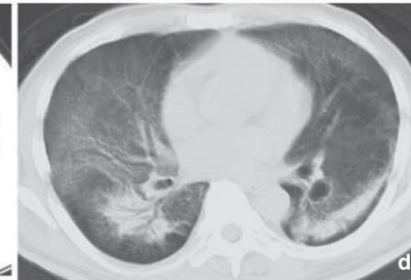
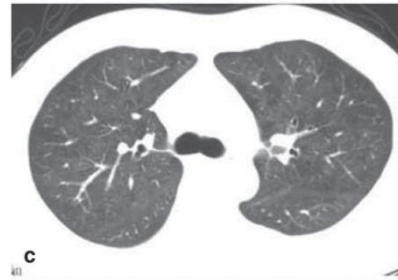
- Type C
 - Consolidation with GGO

GGO lesion with peripheral sparing-**41%**



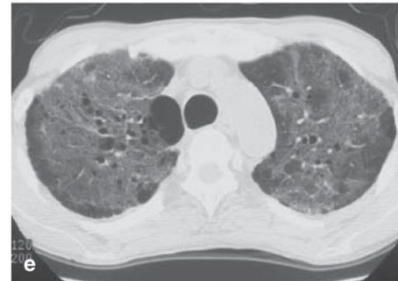
GGO lesion in mosaic pattern-**29%**

Homogeneous GGO lesion-**24%**



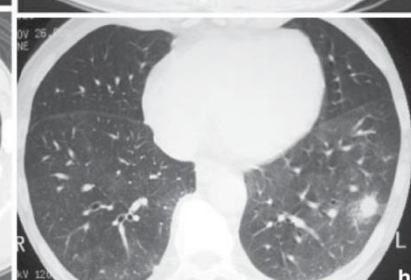
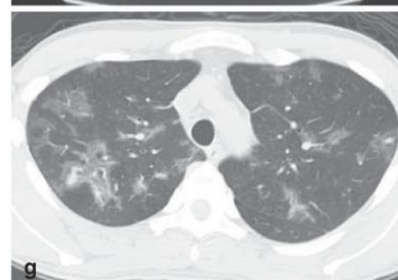
Air space consolidation-**21%**

Cystic formation-**21%**



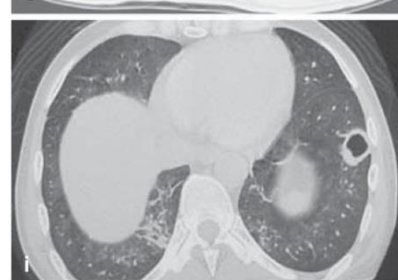
Linear-reticular opacity- **18%**

Patchy distributed GGO- **15%**

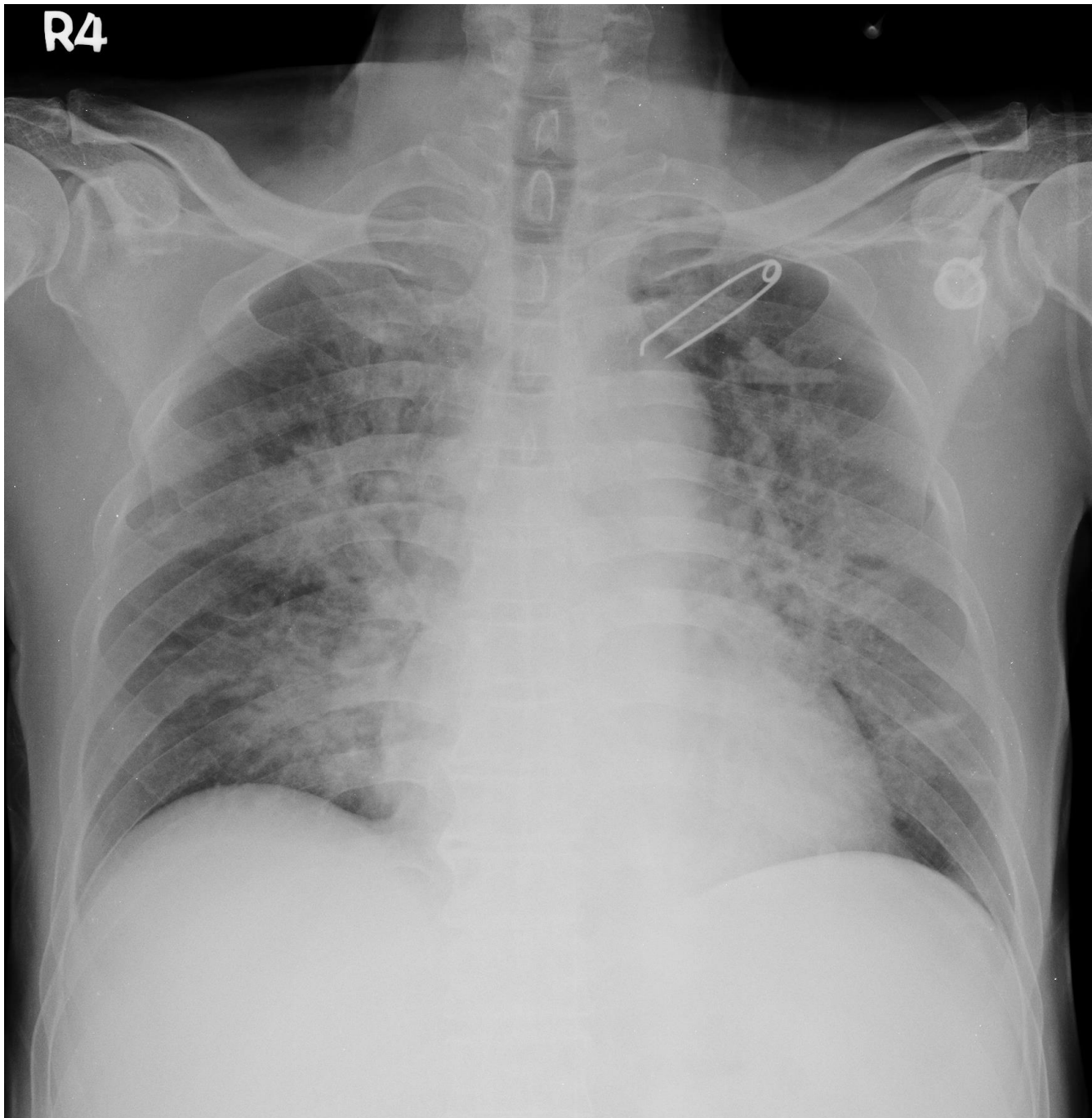


Solitary and multiple nodule-**9%**

Cavitary lesion-**6%**

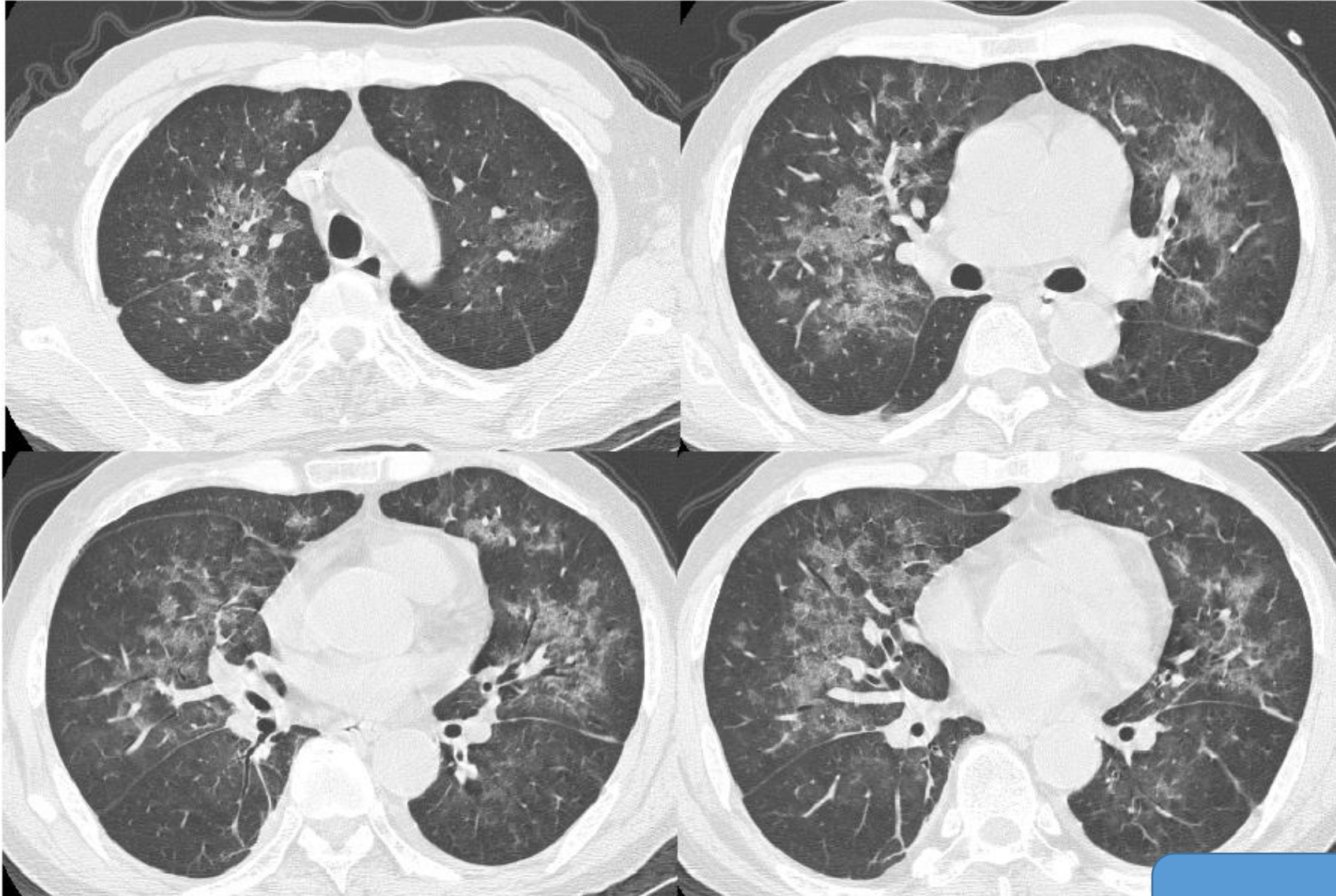


R4



- 62 y/o male
- Refractory diarrhea for 2 weeks
- Malignant lymphoma, follicular type
 - s/p chemotherapy for 4 years
 - Last chemotherapy 1 M ago
- Severe diarrhea for 2 weeks with weight loss 6kg
- Shortness of breathe also noted
- Colonoscopy
 - General edematous change
 - Biopsy: CMV colitis

Diffuse GGO pattern



Dx: CMV pneumonitis

PJP vs. CMV pneumonitis in chest CT

No significant difference

With significant difference

	PJP (n = 78)	CMV-P (n = 34)	P-value
GGO, n (%)	100	100	NS
Mosaic perfusion, n (%)	25 (32.05)	10 (29.41)	0.78
Crazy-paving pattern, n (%)	7 (8.97)	3 (8.82)	0.98
Cons/GGO predominance, n (%)			0.82
Cons	2 (2.56)	2 (5.88)	
GGO	75 (96.15)	32 (94.12)	
Equal	1 (1.28)	0	
Cons/GGO distribution, n (%)			0.06
Segmental	6 (7.69)	5 (14.71)	
Non-segmental	6 (7.69)	7 (20.59)	
Lobular	66 (84.62)	22 (64.71)	
Reticulation, n (%)	45 (57.69)	18 (52.94)	0.64
Pleural effusion, n (%)	8 (10.26)	8 (23.53)	0.07
Cyst, n (%)	13 (16.67)	4 (11.76)	0.51

	PJP (n = 78)	CMV-P (n = 34)	P-value
Nodule, n (%)	7 (8.97)	16 (47.06)	<0.001
Nodule-size, n (%)			<0.001
Micro	1 (1.28)	5 (14.71)	
Small	5 (6.41)	11 (32.35)	
Large	1 (1.28)	0	
Nodule-distribution, n (%)			<0.001
Centrilobular	3 (3.85)	8 (23.53)	
Perilymphatic	1 (1.28)	0	
Random	3 (3.85)	8 (23.53)	
Consolidation, n (%)	28 (35.90)	21 (61.77)	0.01
Halo sign, n (%)	9 (11.54)	11 (32.35)	0.01

CT features of Viral Pneumonia

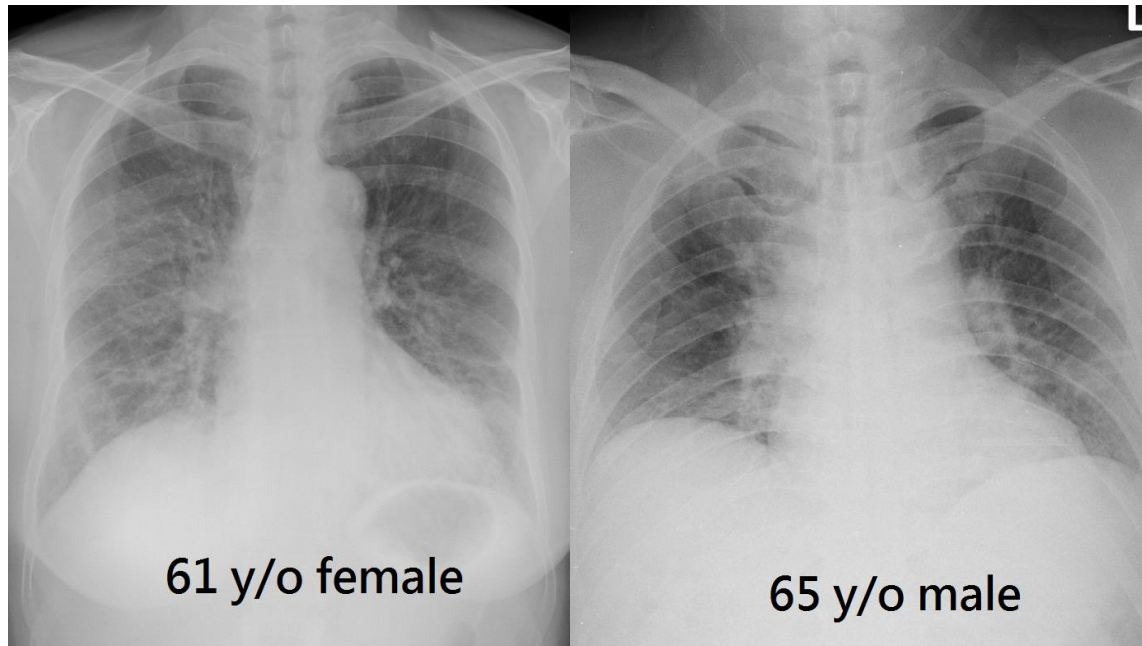
Typical CT Findings

Common Name	Distribution	Consolidation	GGO	Nodule	Bronchial Wall Thickening	Pleural Effusion	Systemic Involvement
Varicella-zoster virus	Multifocal	Rare	Surrounding halo	1–10 mm (in late phase, calcification)	UC	Rare	Skin rash
CMV	Diffuse	++	++++	++	UC	Rare	Not definite
Measles	Multifocal	Rare	+	+	UC	C	Hilar LAP, gastroenteritis, encephalitis
Influenza	Airway, multifocal	+	+	++	C	UC	Not definite
Human coronavirus	Peripheral, multifocal	+++	+	Rare	UC	Rare	Not definite

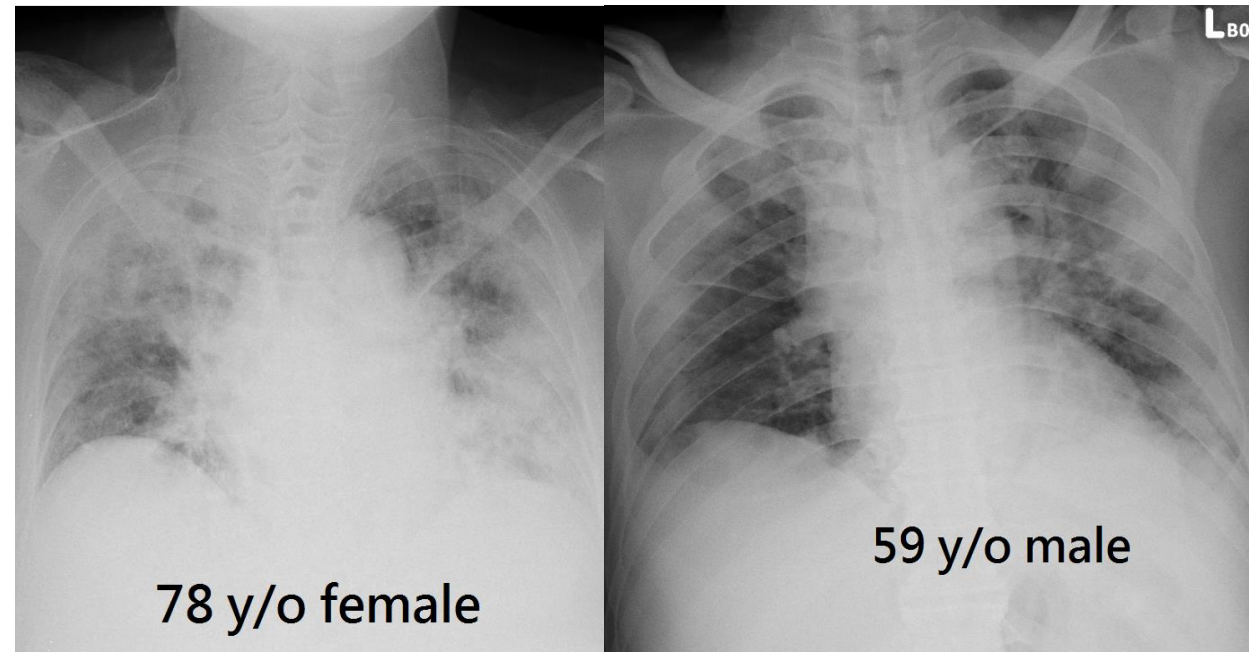
Chest X-ray Features of COVID-19 in ED

diverse and non-specific

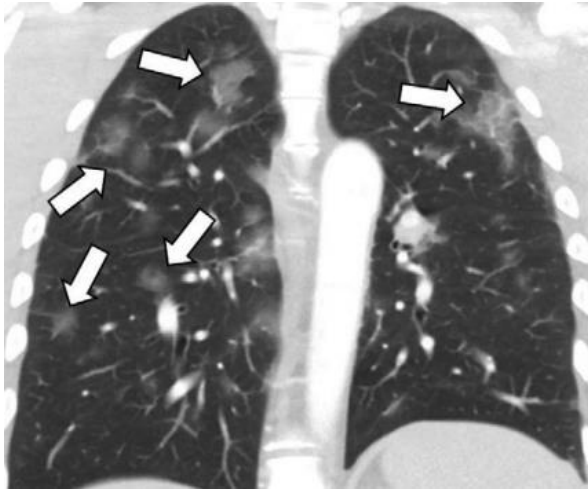
Interstitial Pattern



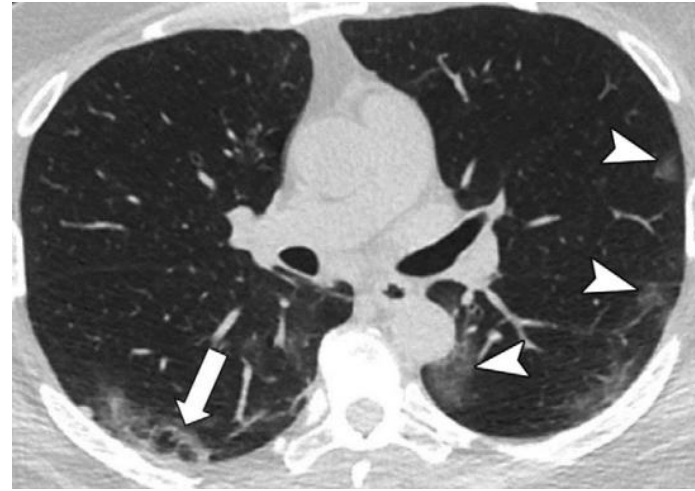
Alveolar Pattern



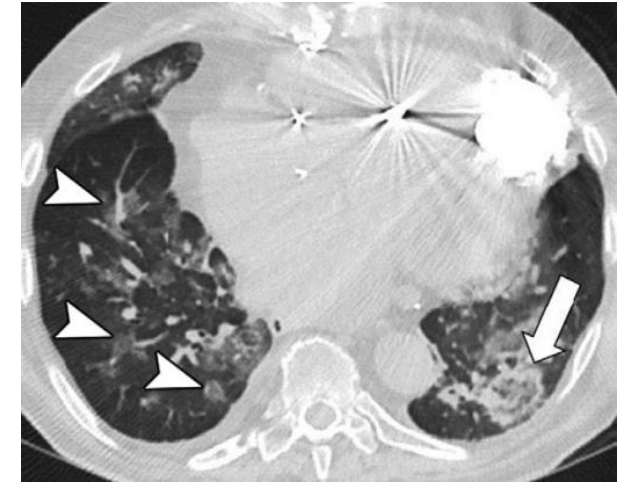
CT Features of COVID-19



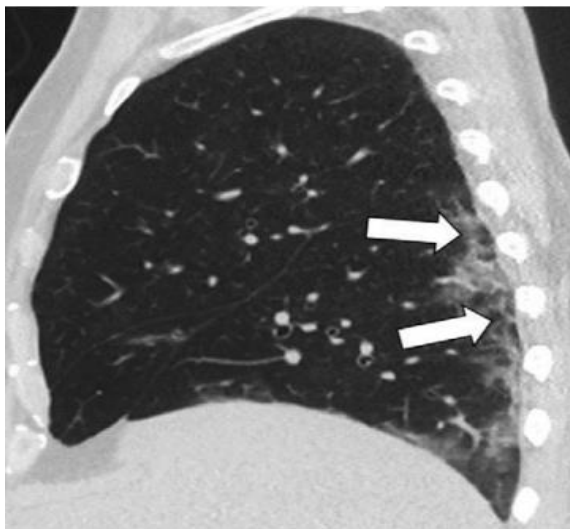
Bil. multifocal GGO



Peripheral subpleural GGO



**GGO and dense consolidation
Reverse halo sign (organ. Pneumonia)**



**Subpleural
reticulation**



Crazy-Paving

Radiological Features of COVID-19

Category and Description **North America Consensus**

Typical appearance

Peripheral, bilateral GGO with or without consolidation or visible intralobular lines (crazy paving)

Multifocal GGO of rounded morphologic presentation with or without consolidation or visible intralobular lines (crazy paving)

Reverse halo sign or other findings of organizing pneumonia (seen later in the disease)

Indeterminate appearance

Absence of typical features AND presence of:

Multifocal, diffuse, perihilar, or unilateral GGOs with or without consolidation that lack a specific distribution; that are nonrounded or nonperipheral and lack a specific distribution; or that are nonrounded or nonperipheral

Atypical appearance

Absence of typical or indeterminate features AND presence of:

Isolated lobar or segmental consolidation without GGO

Discrete small nodules (centrilobular, “tree-in-bud”)

Lung cavitation

Smooth interlobular septal thickening with pleural effusion

Category and Description **British**

Classic COVID-19: 100% confidence

Lower lobe predominant, peripheral predominant, multiple, bilateral foci of GGO, with or without:

Crazy paving

Peripheral consolidation

Reverse halo or perilobular pattern

Probable COVID-19: 71%–99% confidence

Lower lobe predominant mix of bronchocentric and peripheral consolidation

Reverse halo or perilobular pattern

GGOs scarce

Indeterminate: <70% confidence for COVID-19

Does not fit into definite, probable, or non-COVID-19

Non-COVID-19: 70% confidence for alternative

Lobar pneumonia

Cavitating infections

Tree-in-bud or centrilobular nodularity

Lymphadenopathy, effusions

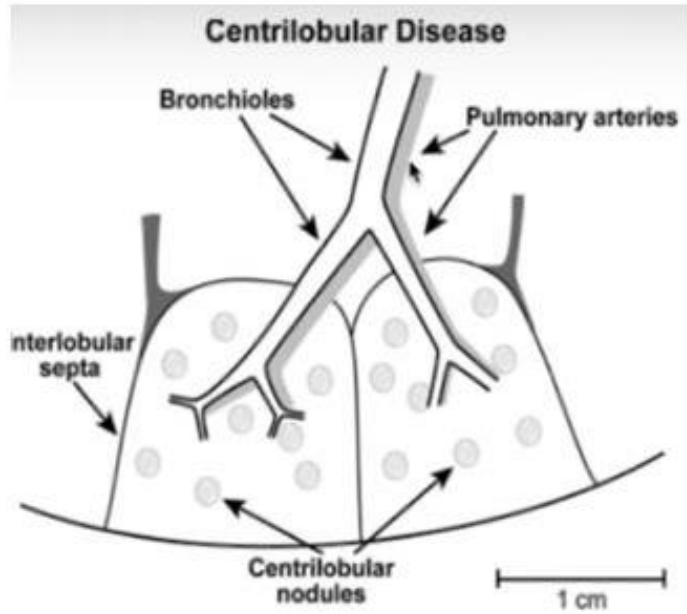
Established pulmonary fibrosis

Nodules

- Round to oval opacities less than 3cm
- Wide ranges of differential diagnosis
- Solitary nodules vs. multiple nodules
- Secondary changes
 - Cavitation, calcification, surrounding GGO
- Major causes of infective nodules
 - Mycobacterium (MTB, NTM), fungus, nocardiosis, septic emboli

Cavity

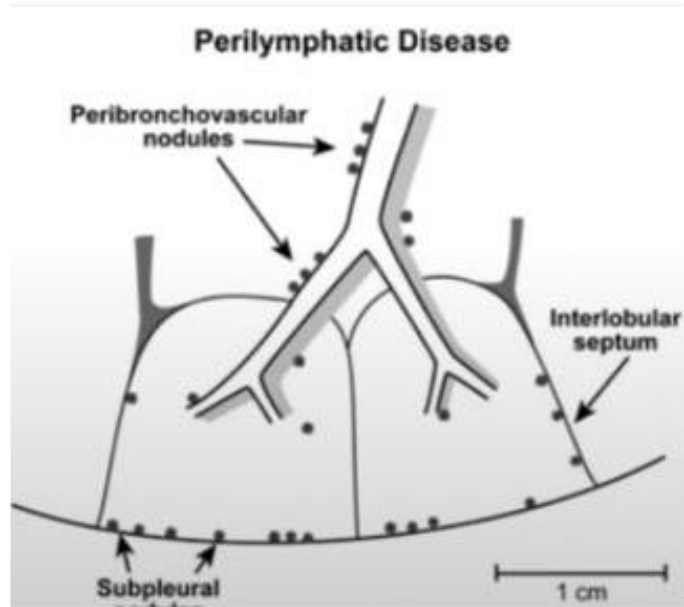
- Thick-walled, gas-filled areas
- Within a mass/nodule or consolidation
- Bacterial infection
 - Lung abscess
 - Septic emboli
 - MTB
 - NTM
- Fungal infection
 - Aspergillus



Centrilobular Disease

Airway spread

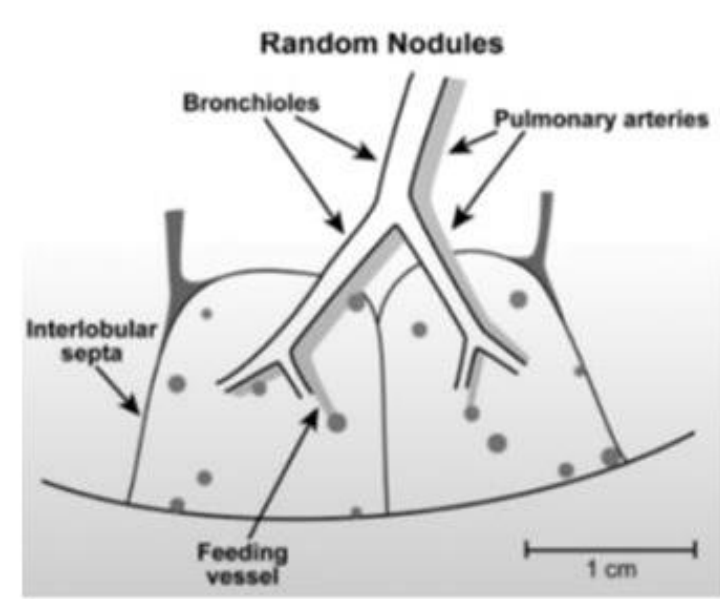
- TB
- Fungal Infection
- Virus
- Bacterial
- Aspiration
- Primary pulmonary cancers



Perilymphatic Nodules

Lymphatic spread

- Sarcoidosis
- Silicosis
- Lymphangitic spread of cancer
- Coal worker pneumoconiosis
- Leukemia/Lymphoma



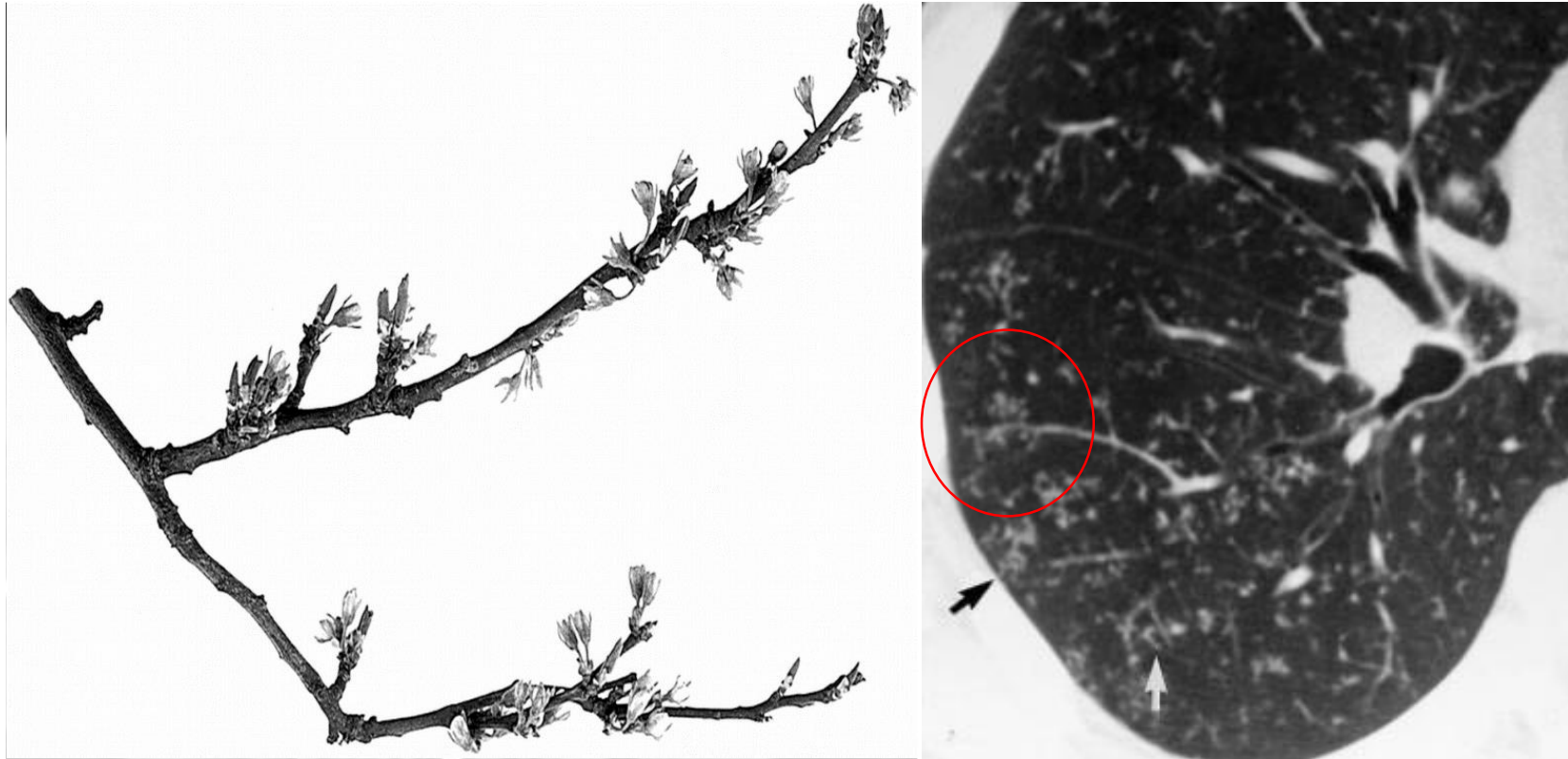
Random Nodules

Blood stream spread

- Disseminated fungal infection
- Miliary Tuberculosis
- Septic emboli (vegetations)
- Metastatic diseases
- Langerhan cell histiocytosis

Tree-in-bud Lesions

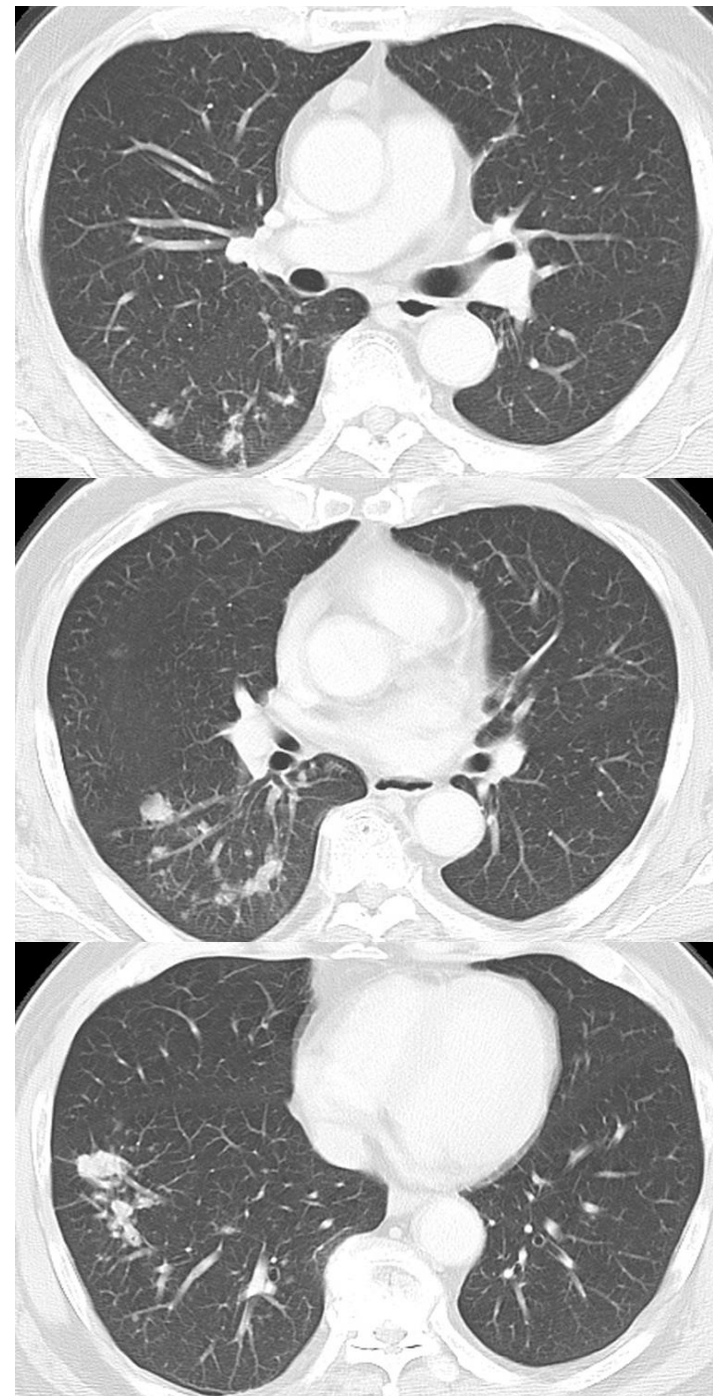
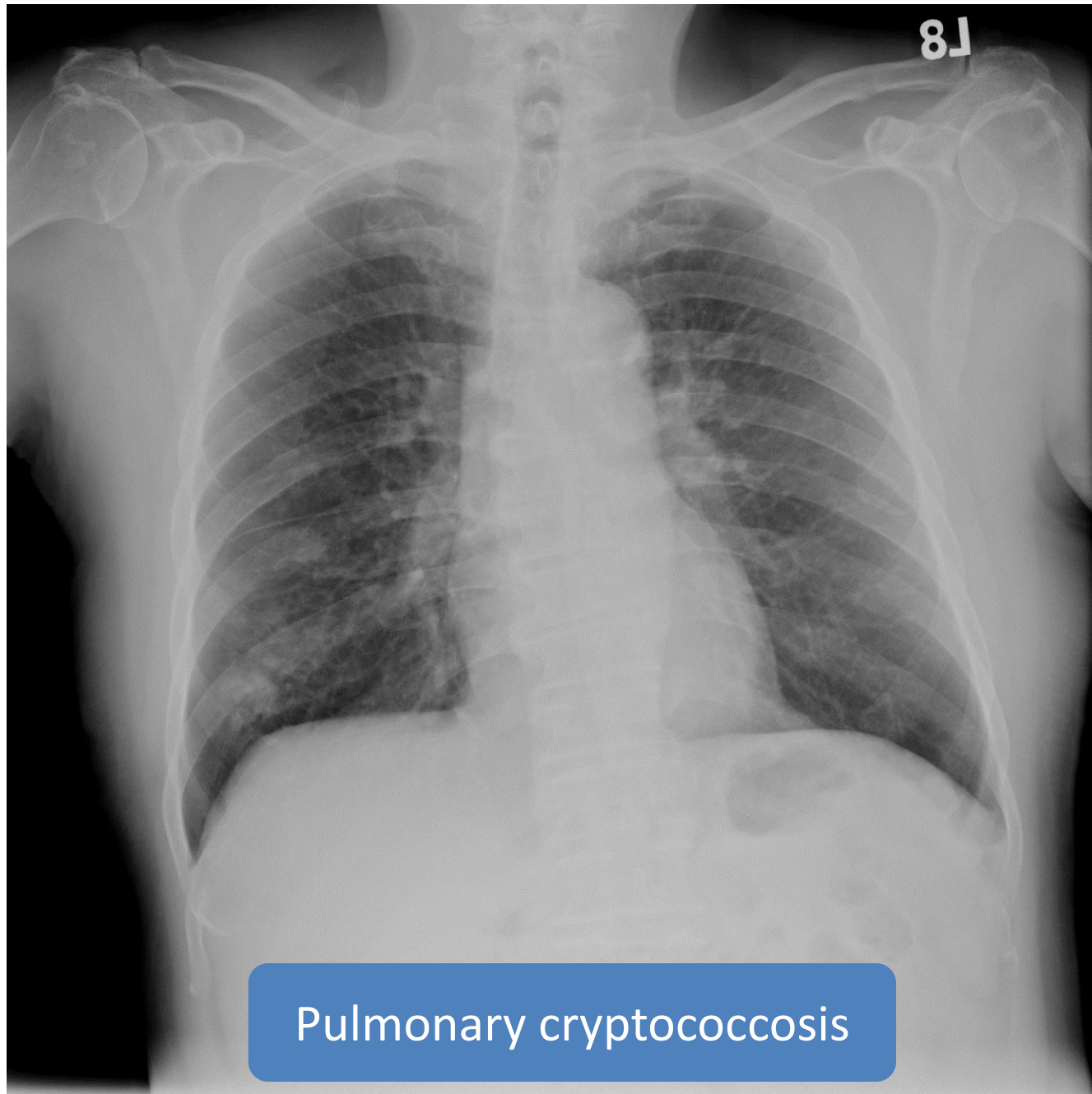
bronchocentric distribution





Early PTB

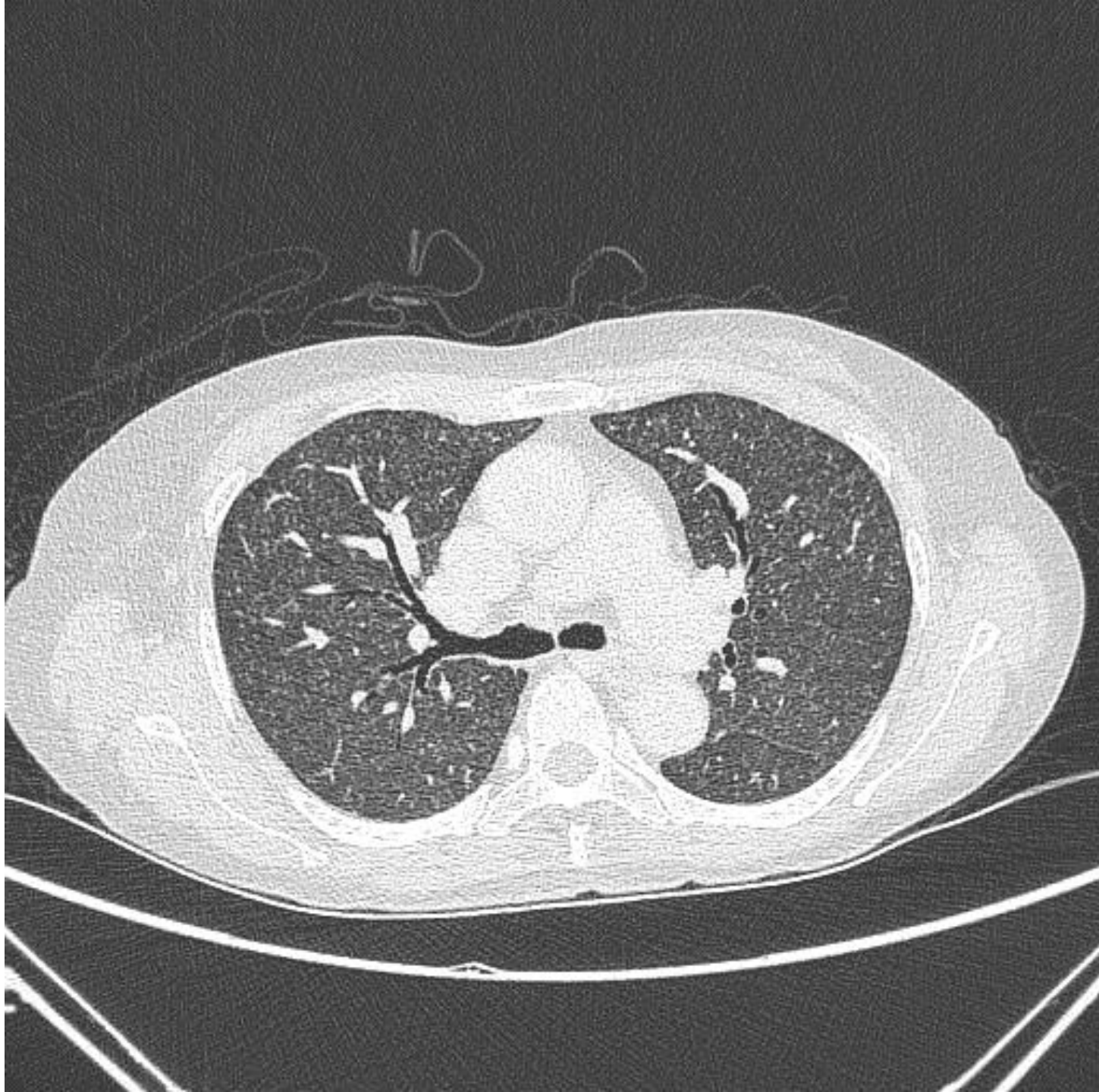
- Nodular and linear opacity in LB6 in LB6
- Sputum smear (-), BAL AFB (+), TB culture (+), ID: MTB



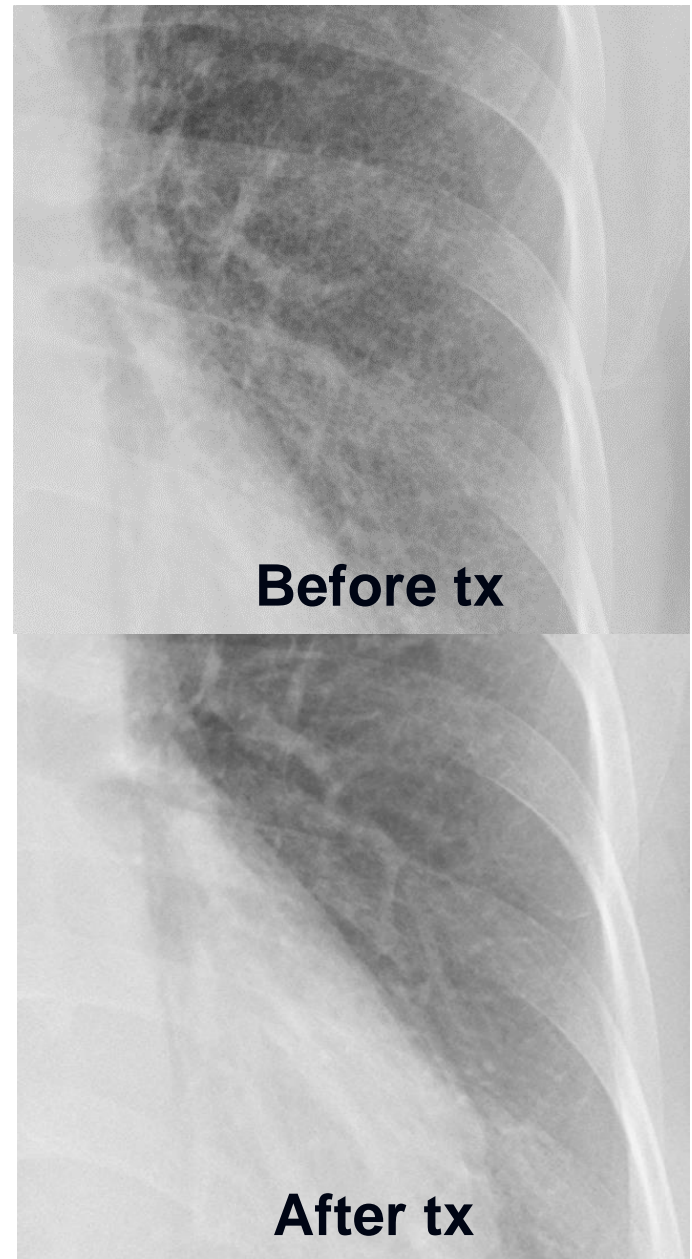
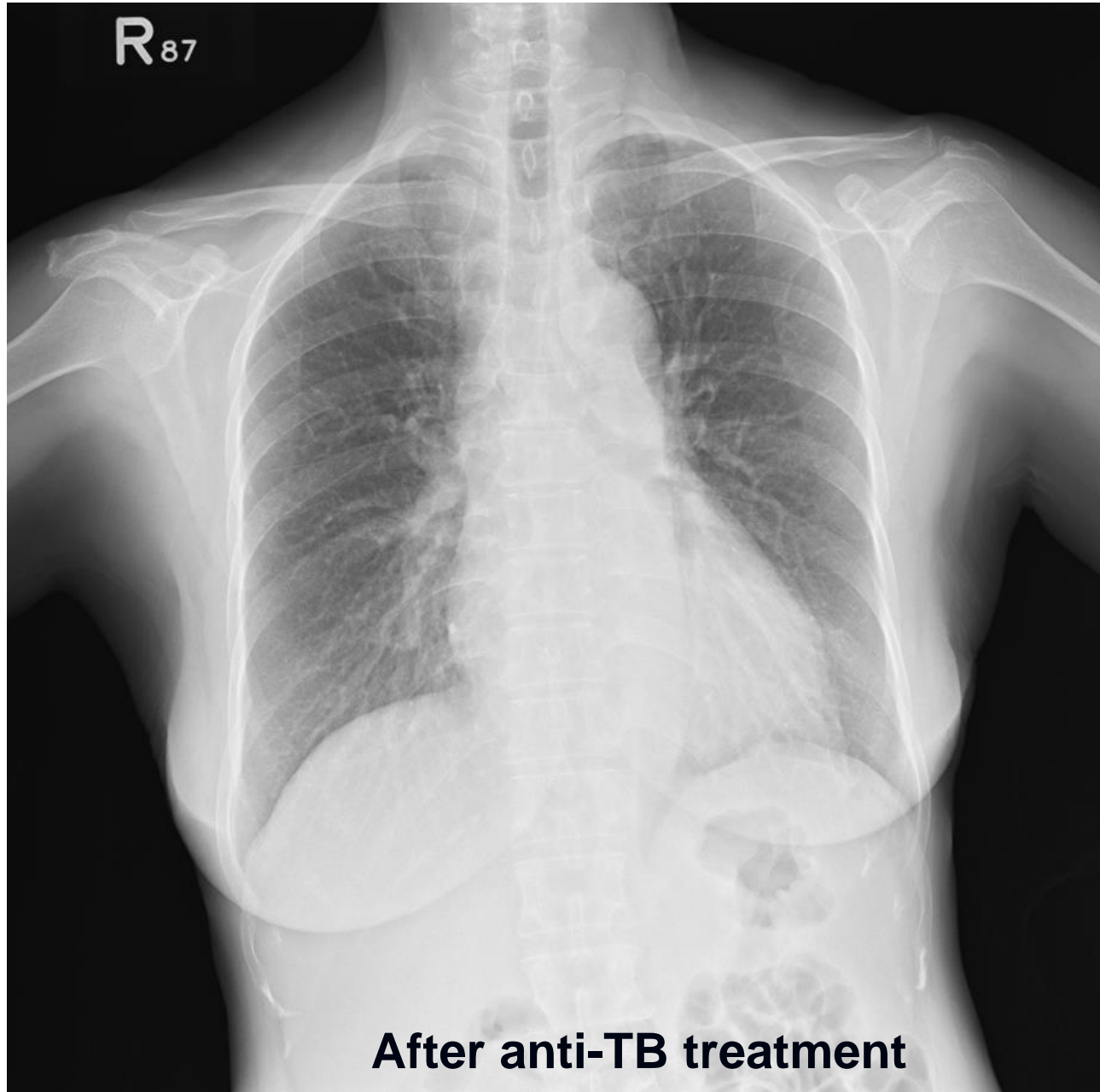


- 65 y/o female
- s/p renal transplant
2 yrs
- s/p LTBI tx

Low grade fever for 1
week

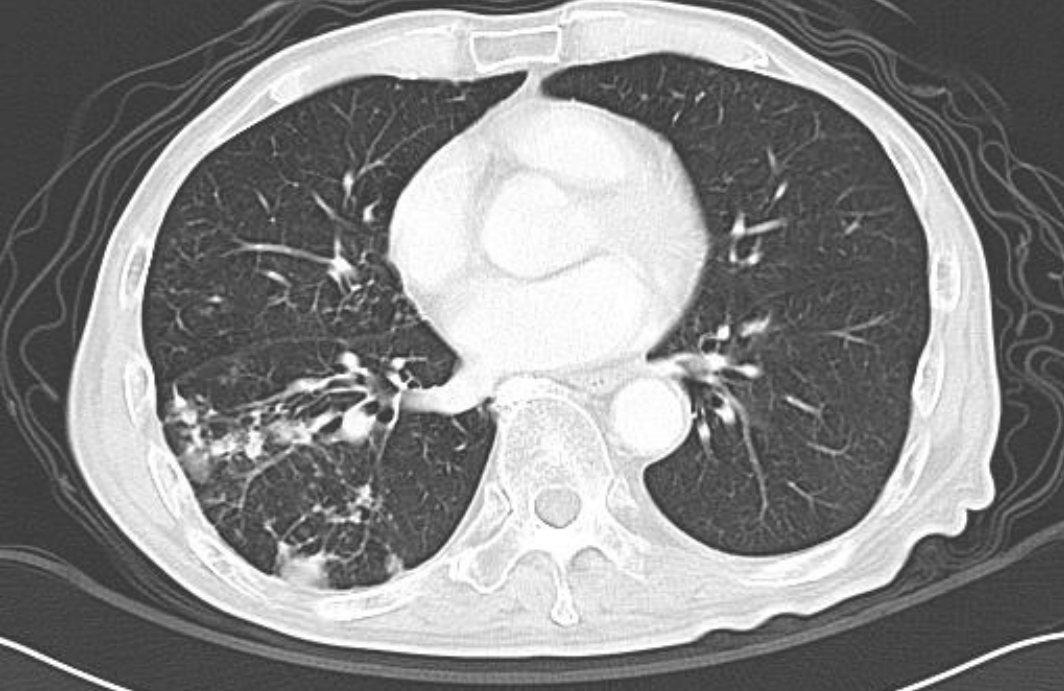


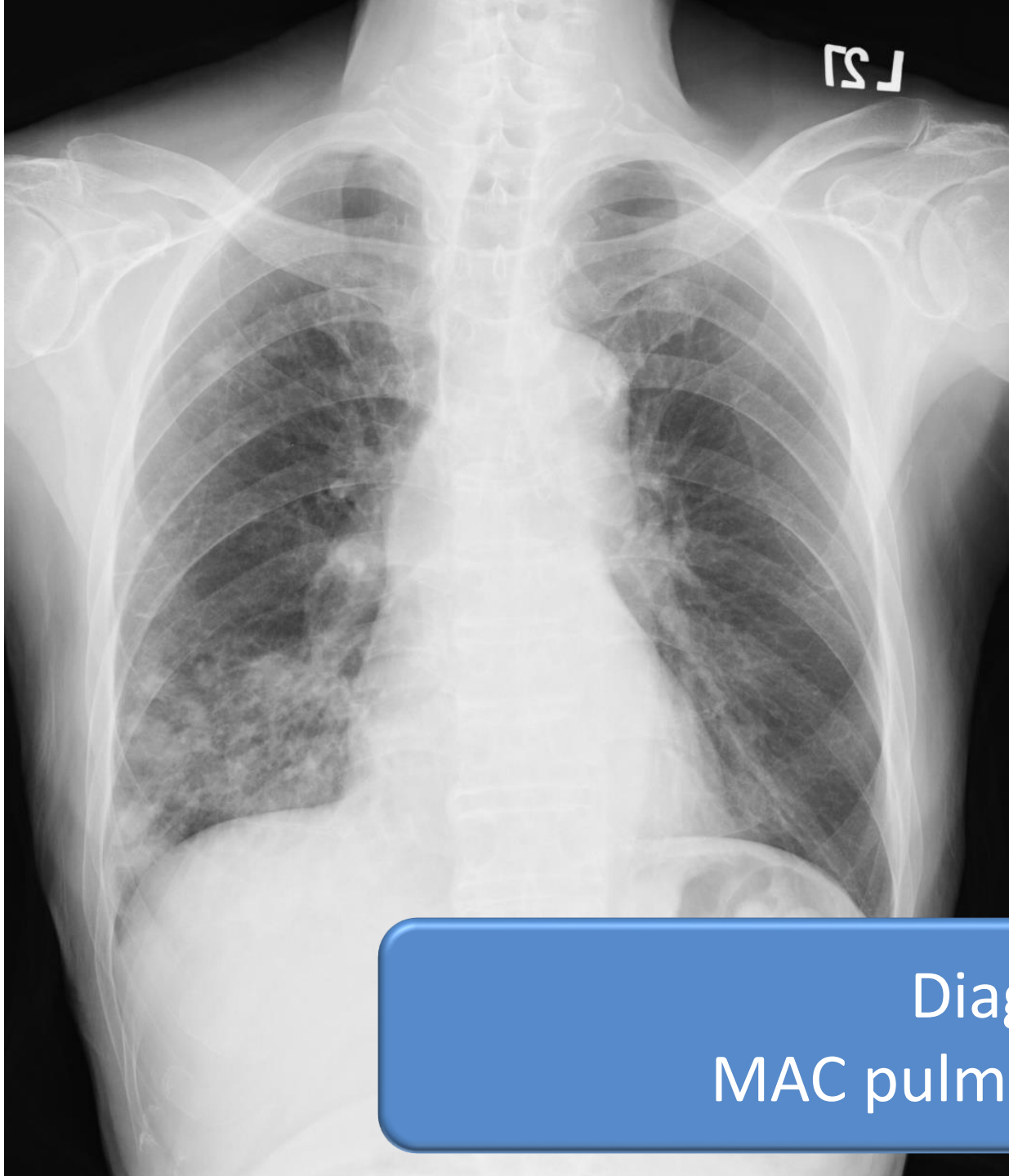
Miliary TB proofed by
bronchoscopic biopsy





- 77 y/o male
- productive cough and general malaise for 1 month
- Referred from LMD for AFB+ in sputum





Diagnosis:
MAC pulmonary disease

How do we define NTM-LD cases

ATS/IDSA statement 2007

Clinical/Radiological Criteria

1. Pulmonary symptoms
2. Nodular or cavitory lesions in CXR
3. Multifocal BXSIS or nodules in HRCT
4. Exclusion of other diseases

Microbiological Criteria

1. ≥ 2 positive sputum culture, or
2. ≥ 1 positive BAL/washing culture
3. Typical histologic features and positive biopsy culture, or
4. Typical histologic feature and ≥ 1 positive culture from sputum or lavage

BTS statement 2017

Clinical/Radiological Criteria

1. Pulmonary symptoms
2. **Nodular or cavitory** lesions in CXR
3. **Multifocal BXSIS or nodules** in HRCT
4. Exclusion of other diseases

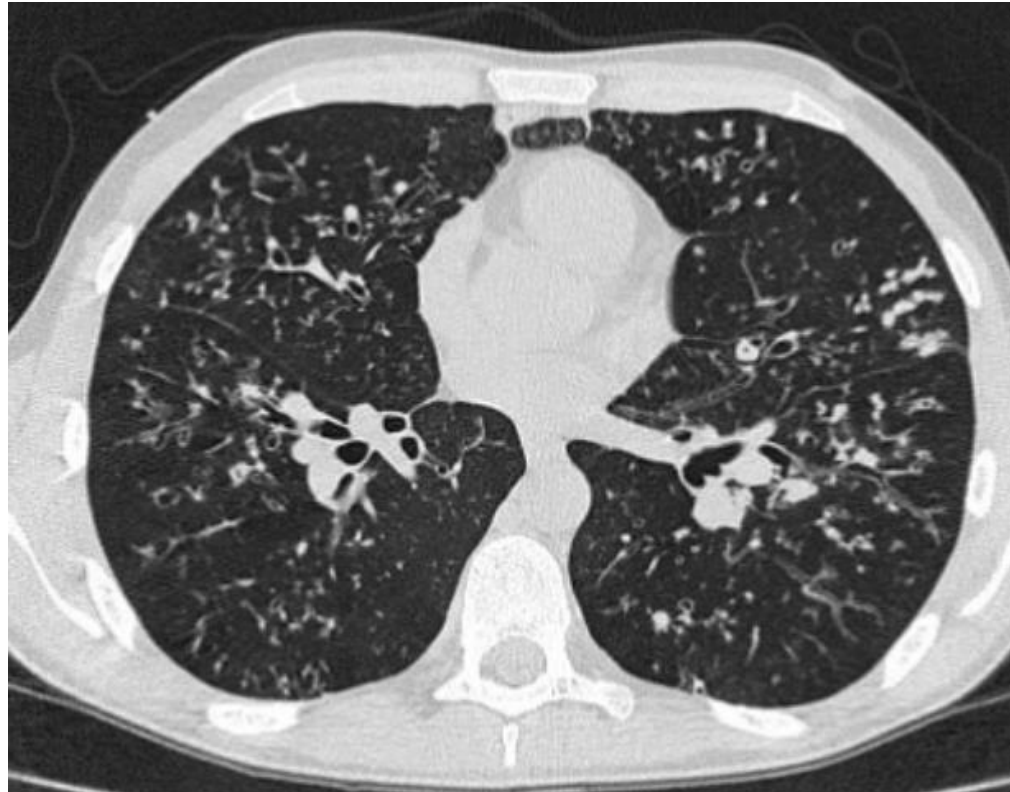
Microbiological Criteria

1. ≥ 2 positive sputum culture, or
2. ≥ 1 positive BAL/washing culture
3. Typical histologic features and positive biopsy culture, or
4. Typical histologic feature and ≥ 1 positive culture from sputum or lavage

Typical radiological presentations

Nodular-bronchiectasis pattern

MAC



M. abscess



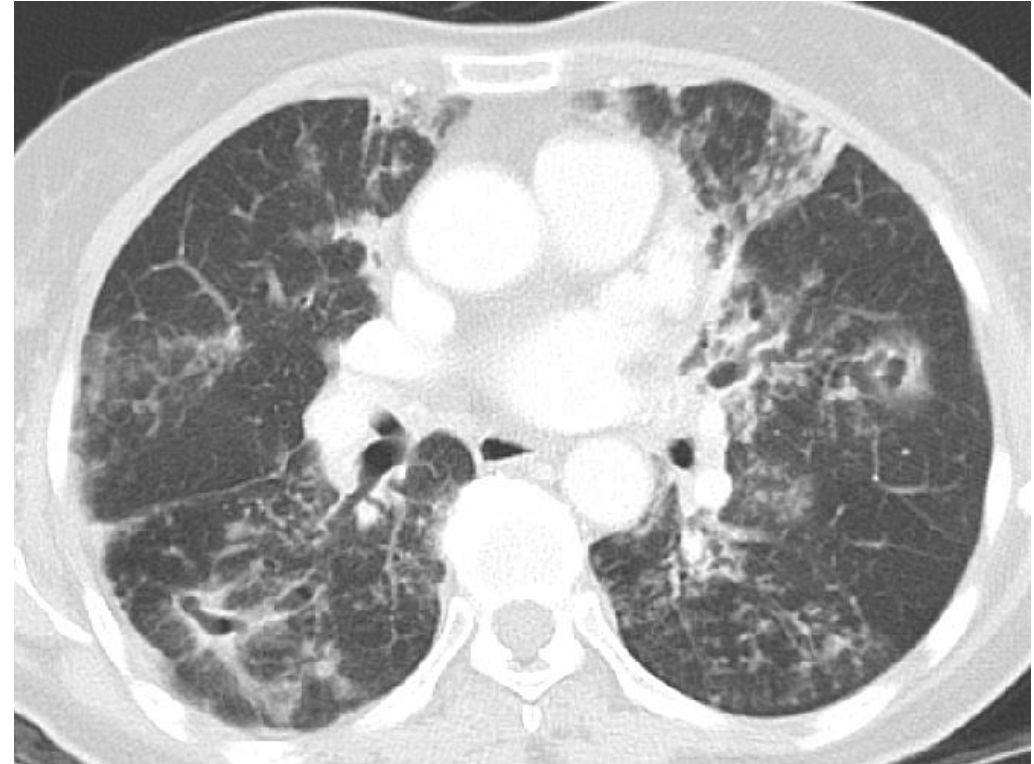
Typical radiological presentations

Fibro-cavitary pattern

M. kansasii



MAC



Differential Diagnosis- Cavity

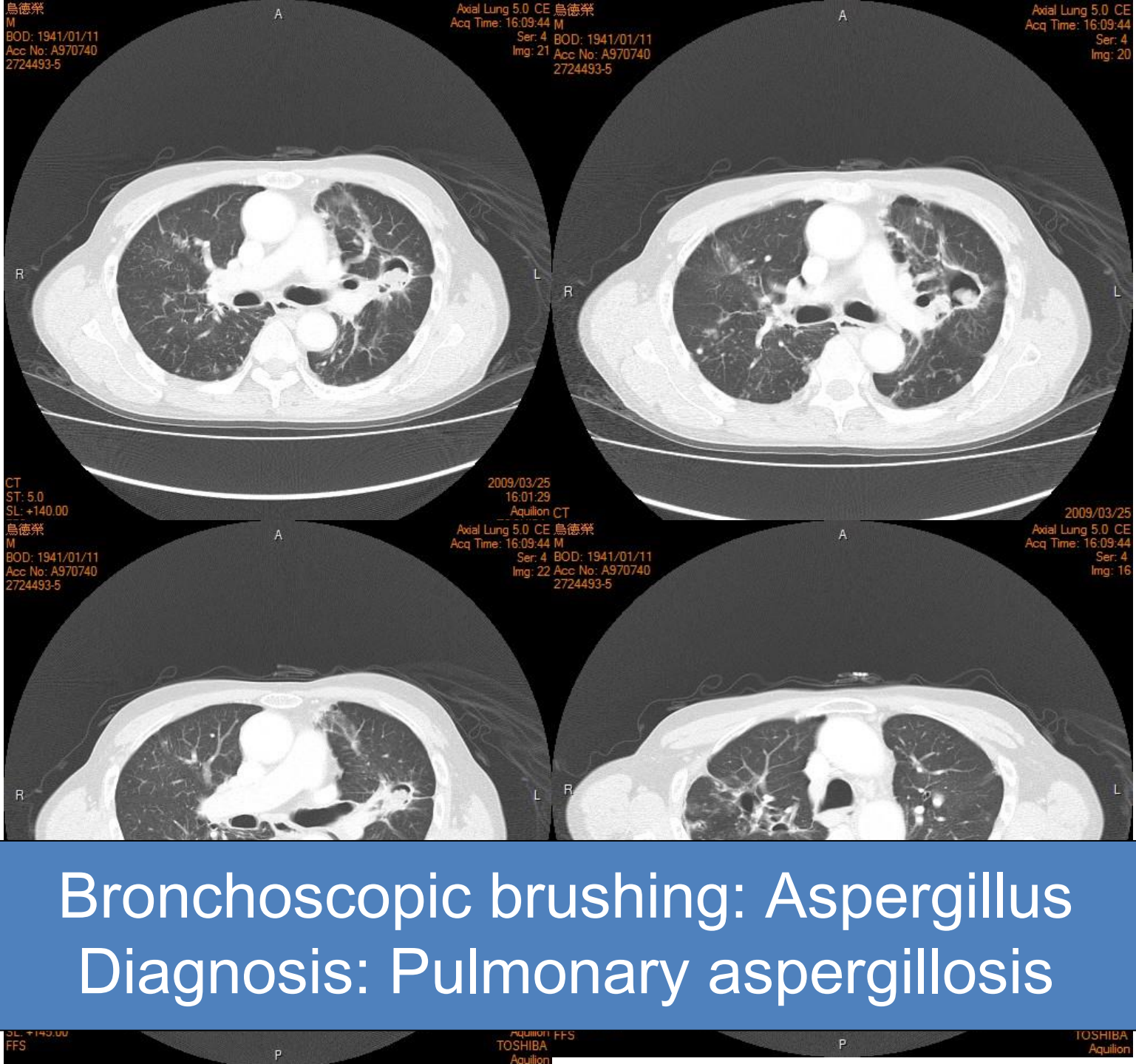
- Cavitory wall: **thickness**
 - Thick: favor lung abscess, primary lung ca, metastasis, Wegener's granulomatosis.
 - Thin: favor chronic infection (Coccidioidomycosis, Paragonimiasis).
- Wall thickness: (measure thickest part)
 - < 4 mm favor benign.
 - 4-15 mm inconclusive.
 - > 15 mm favor malignancy.

Differential Diagnosis- Cavity

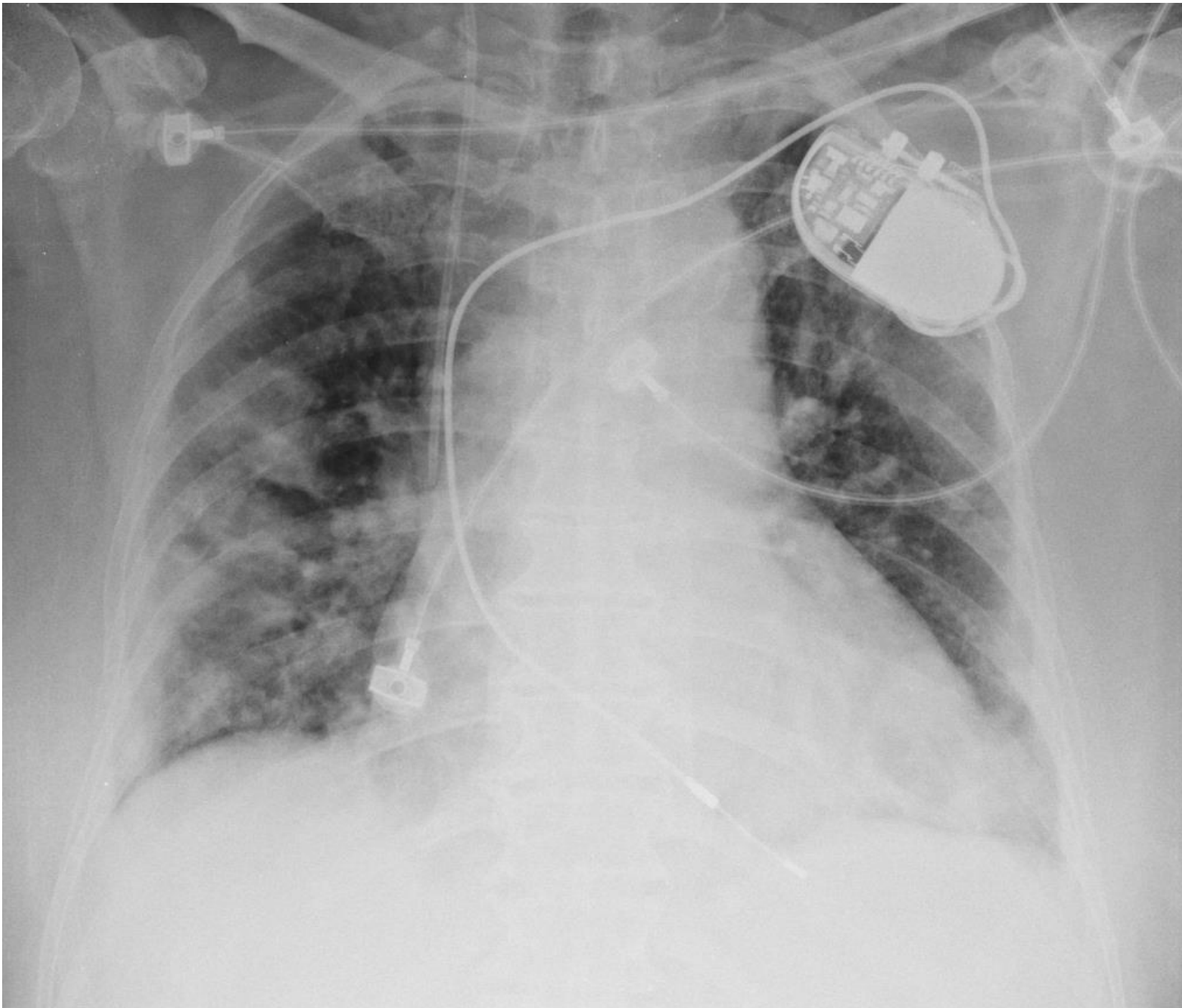
- Character of the **outer and inner lining**:
 - Nodular, Lobular, irregular: malignancy.
 - Shaggy: acute inflammatory process.
 - Smooth: favor benign process or subacute-chronic inflammatory process

- Nature of the cavity Content:
 - Fluid: in most cases, the contents are liquid.
 - Cannot d/d benign or malignant lesion
 - Fungus ball.
 - Pulmonary gangrene: irregular pieces of sloughed necrotic lung parenchyma float like icebergs in the cavity fluid.

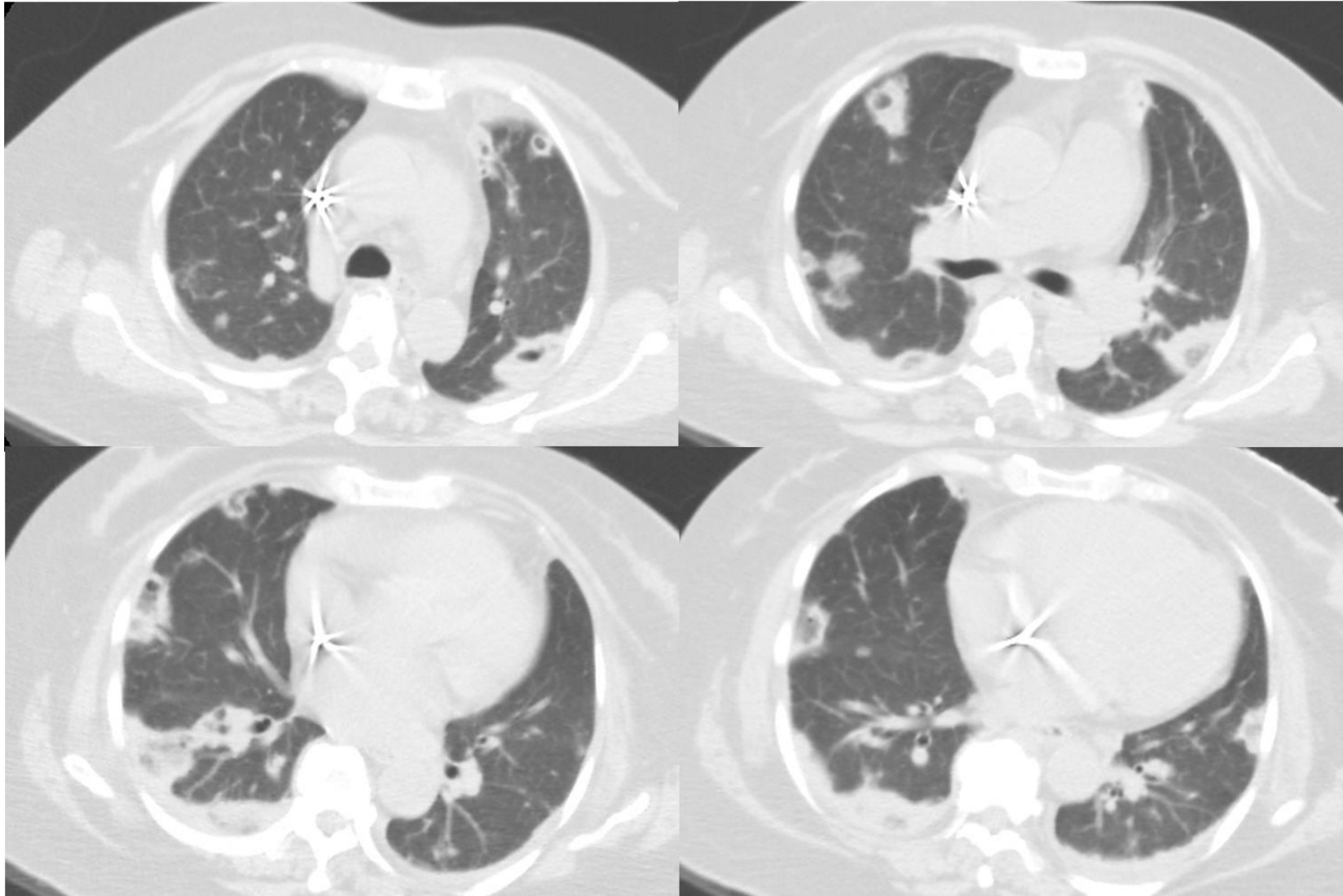




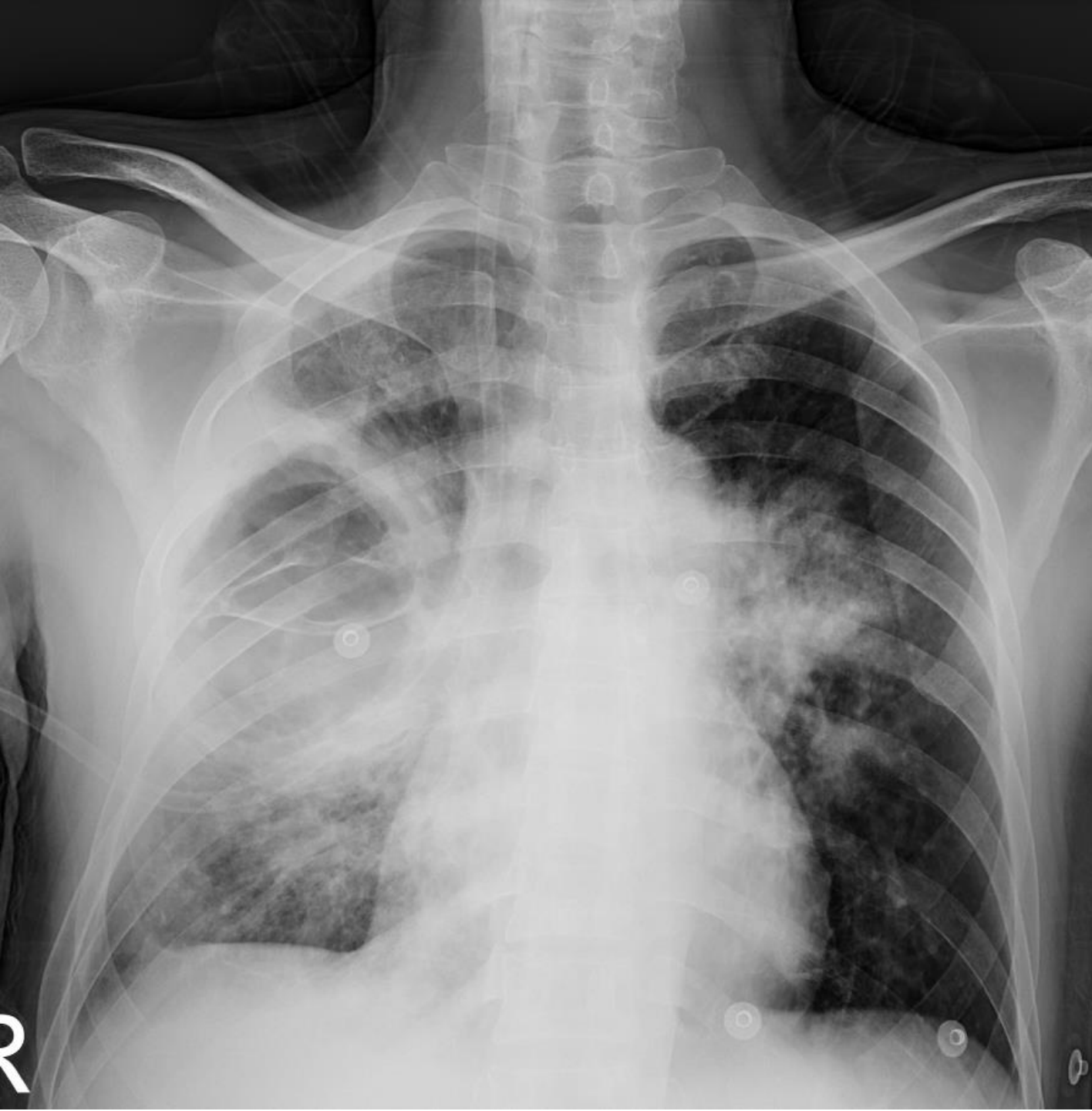
Bronchoscopic brushing: Aspergillus
Diagnosis: Pulmonary aspergillosis



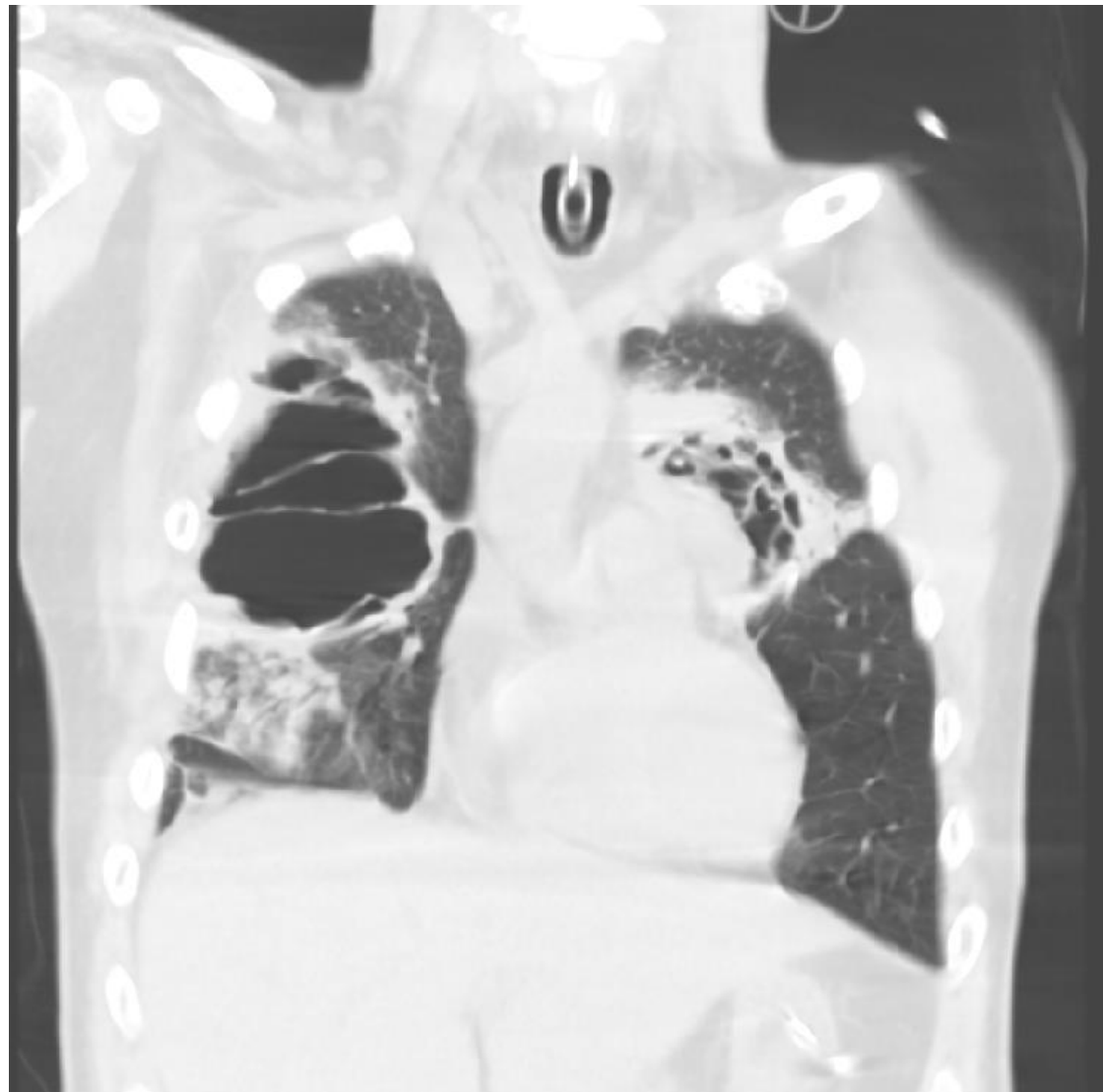
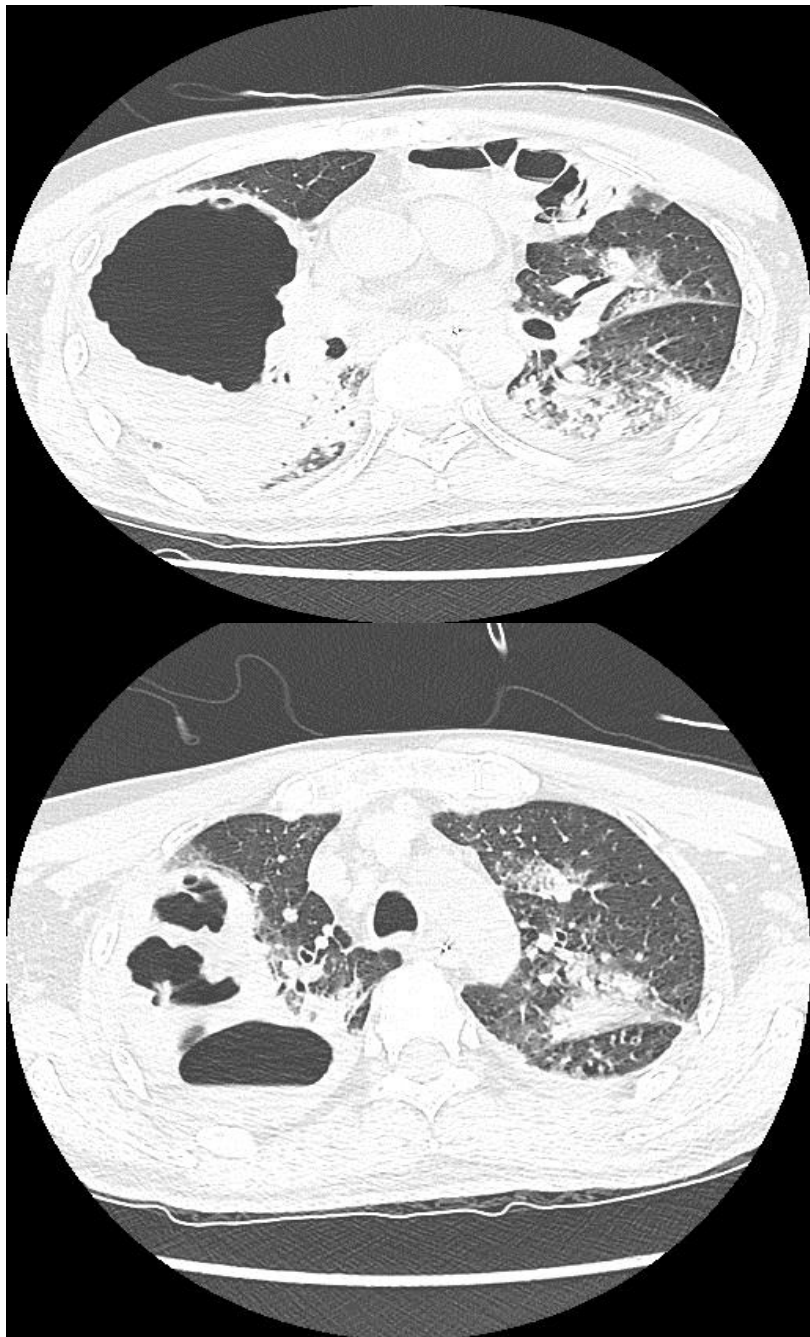
- 57 y/o female
- Intermittent fever to 2 weeks
- SSS s/p pacemaker
- Blood culture: MRSA
- TEE: Highly mobile ribbon-like structure >2 cm in length attached to pacing wire in RA



Infective endocarditis with MRSA bacteremia
and septic emboli



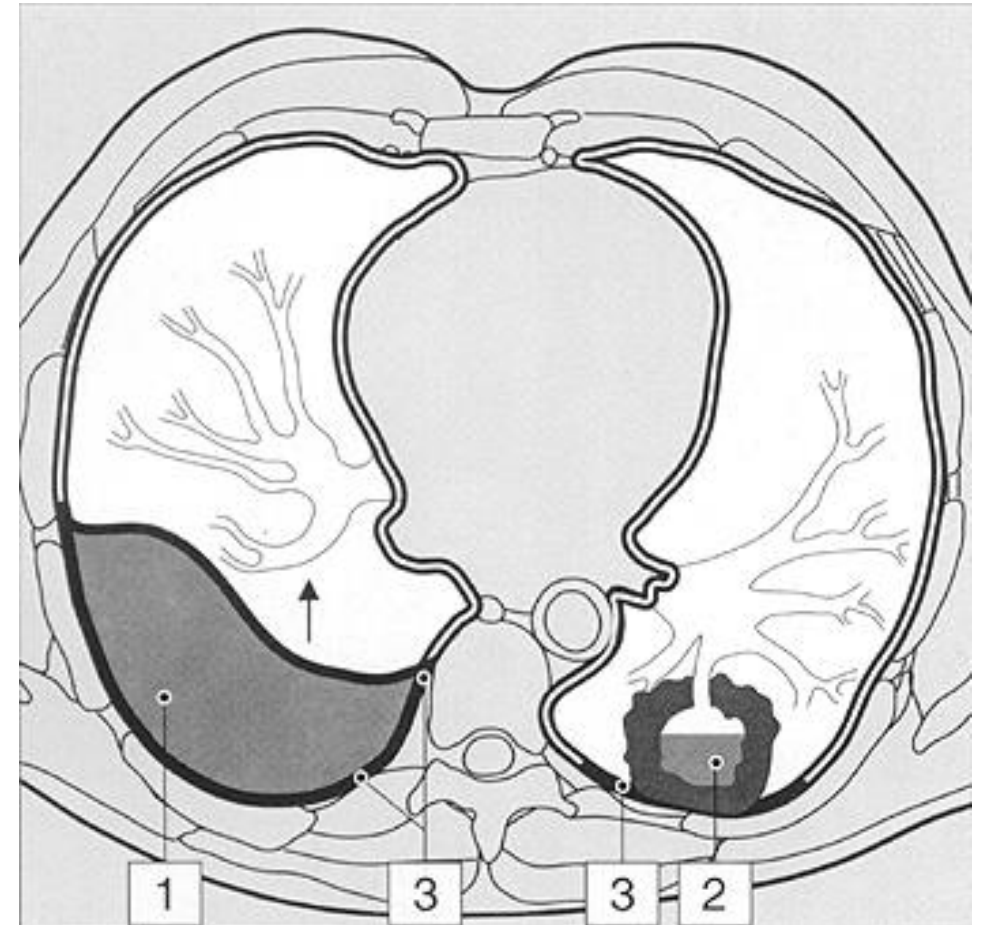
- 54 y/o male
- Used to be well
- Fever for 2 weeks with shortness of breath
- Sputum culture:
MDR-Pseudomonas,
CRAB



CRAB, MDRPA-related
necrotizing pneumonia with lung abscess

Lung abscess vs Empyema

- Lung abscess → bronchopleural fistula → hydropneumothorax (empyema)
- Lung abscess : spherical, thick wall, the air-fluid levels are equal in length
- Empyema : pleural disease, lens-shaped, ill-defined margin, longer in one view than in the other,

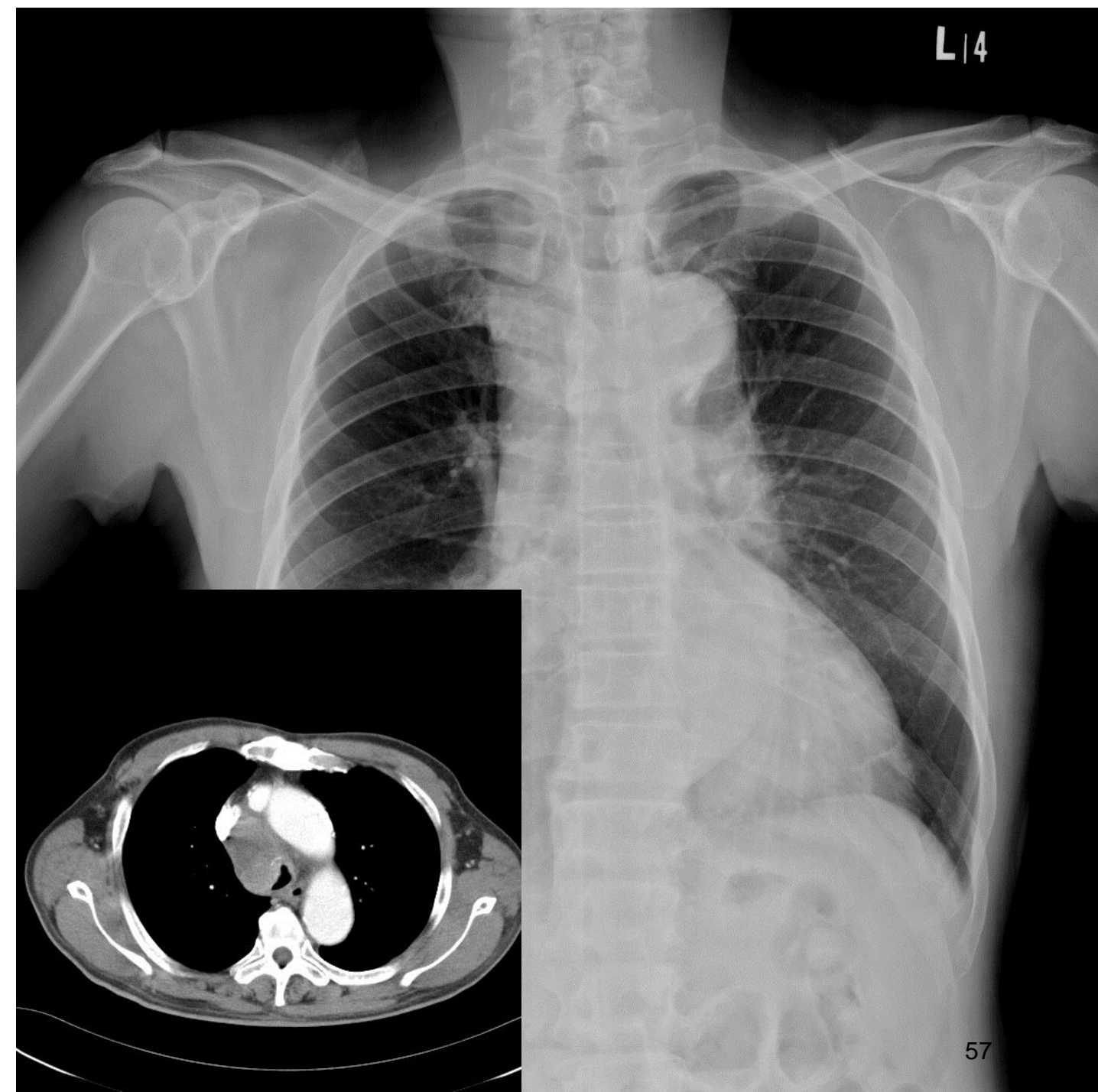


Empyema

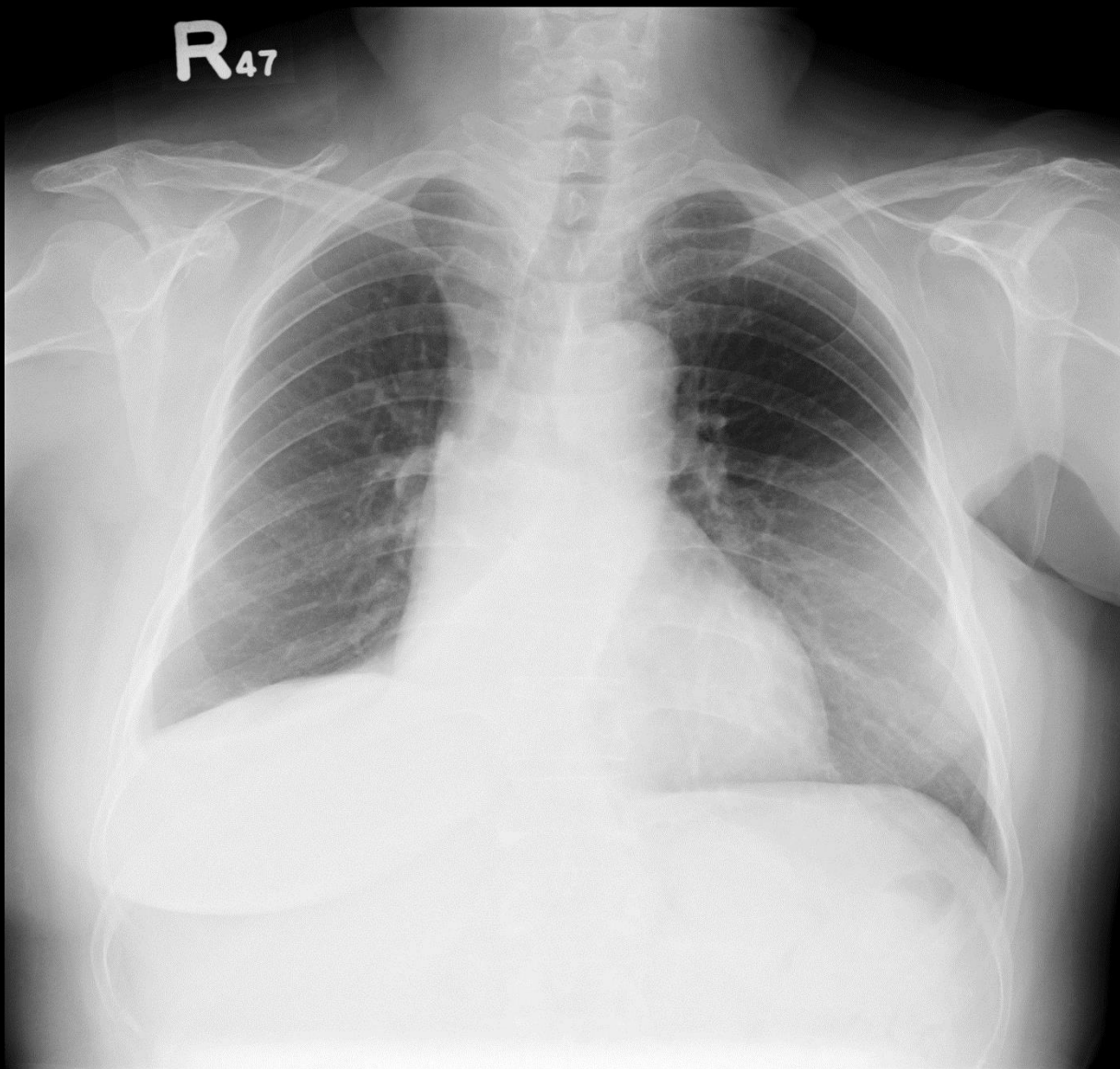


Airway Disease

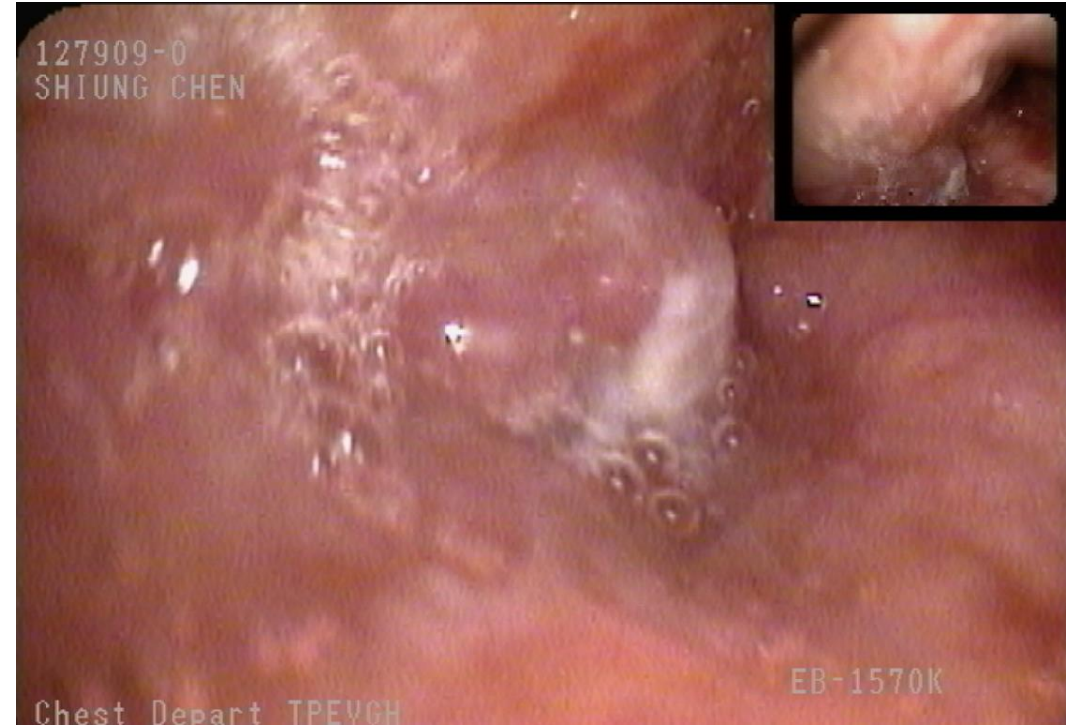
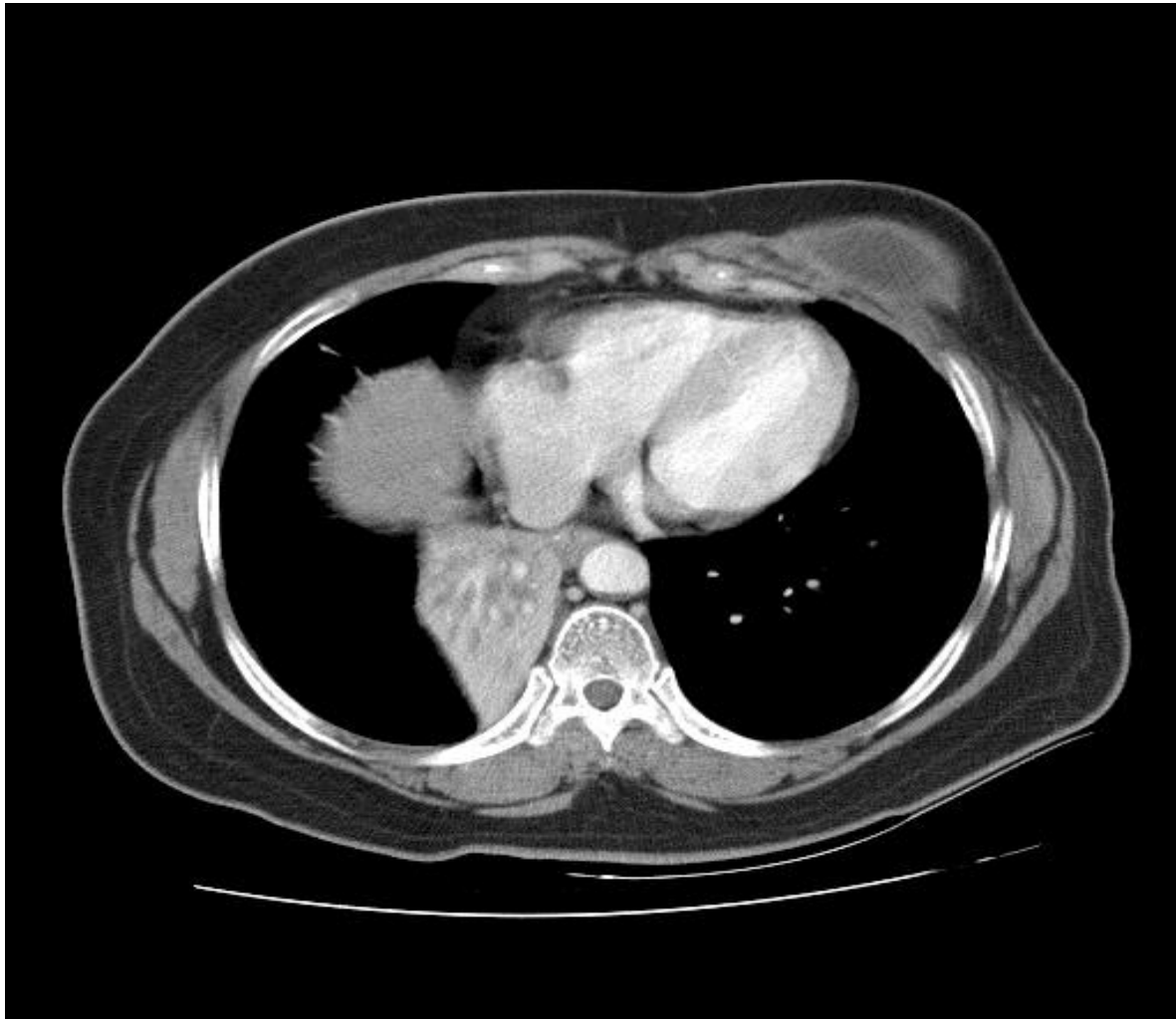
- Tracheal narrowing
- Bronchiectasis



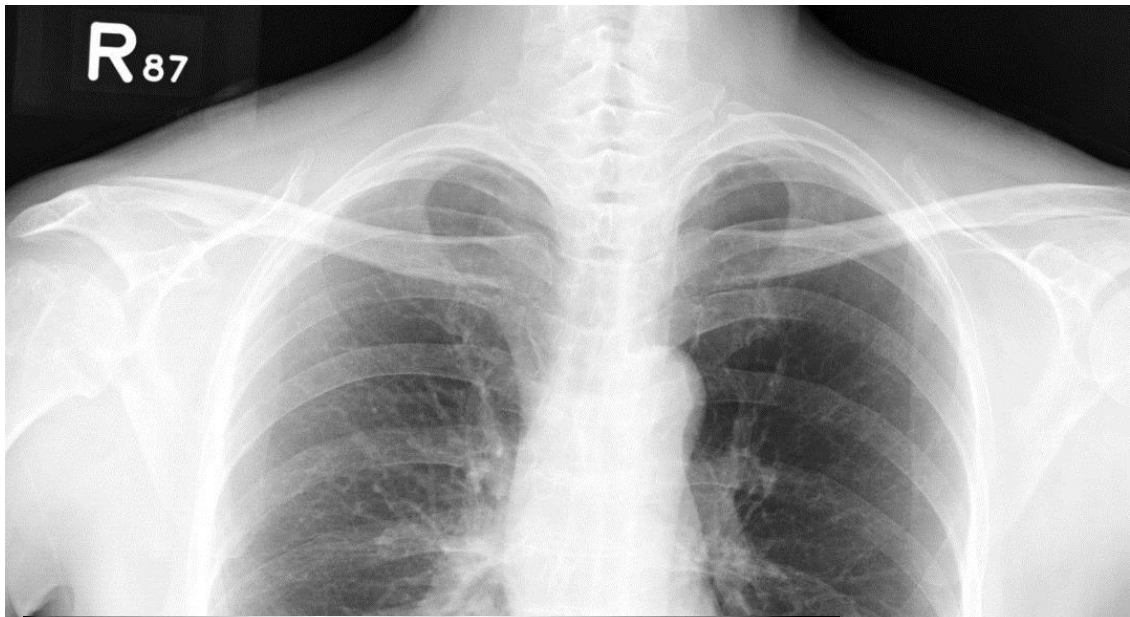
- 64 y/o male
- Current smoker
- Shortness of breath with hoarseness



- 66 y/o female
- Breast cancer s/p MRM and reconstruction
- Cough with fever for 1 week



Breast CA with endobronchial meta
RML/RLL atelectasis

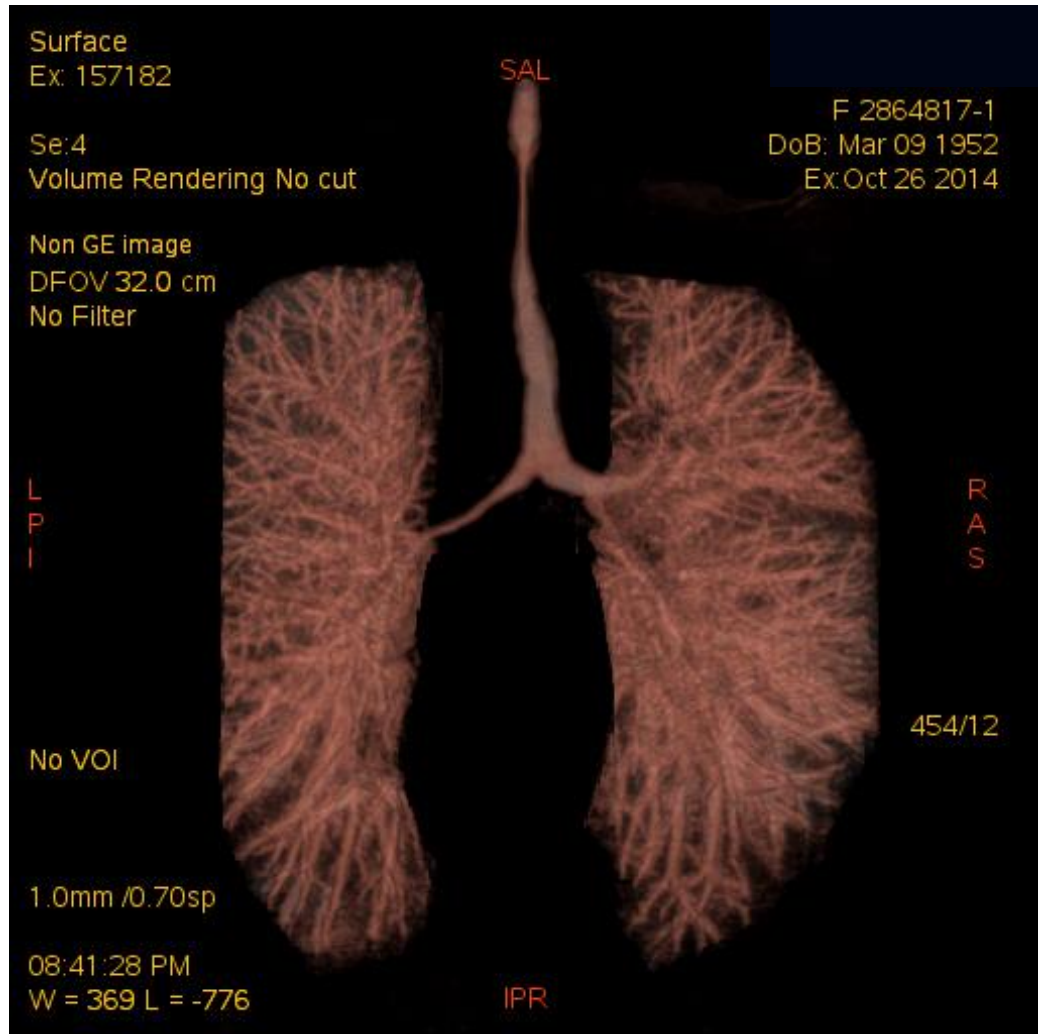


- 68 y/o female

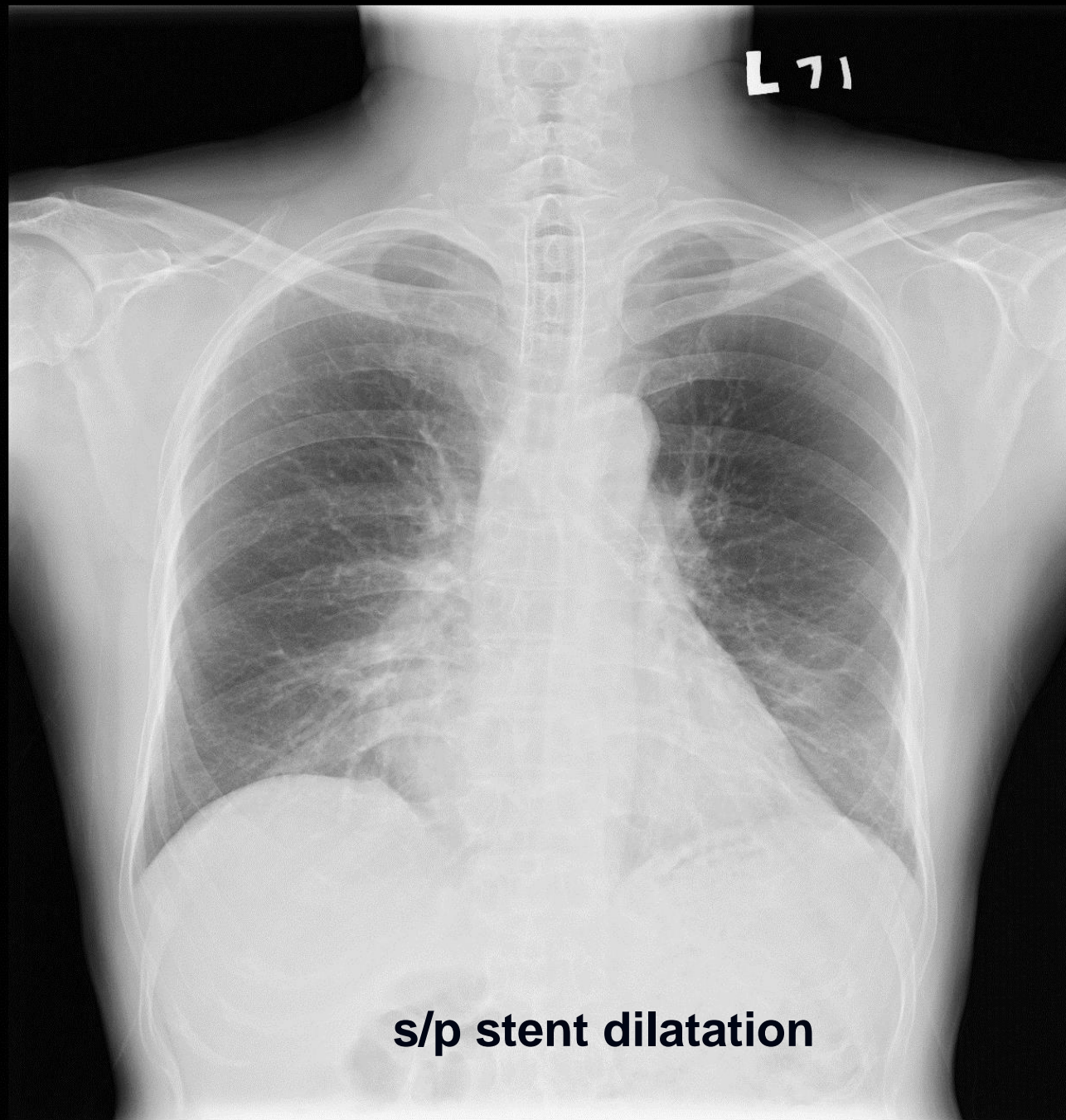
- progressive dyspnea for 6 months



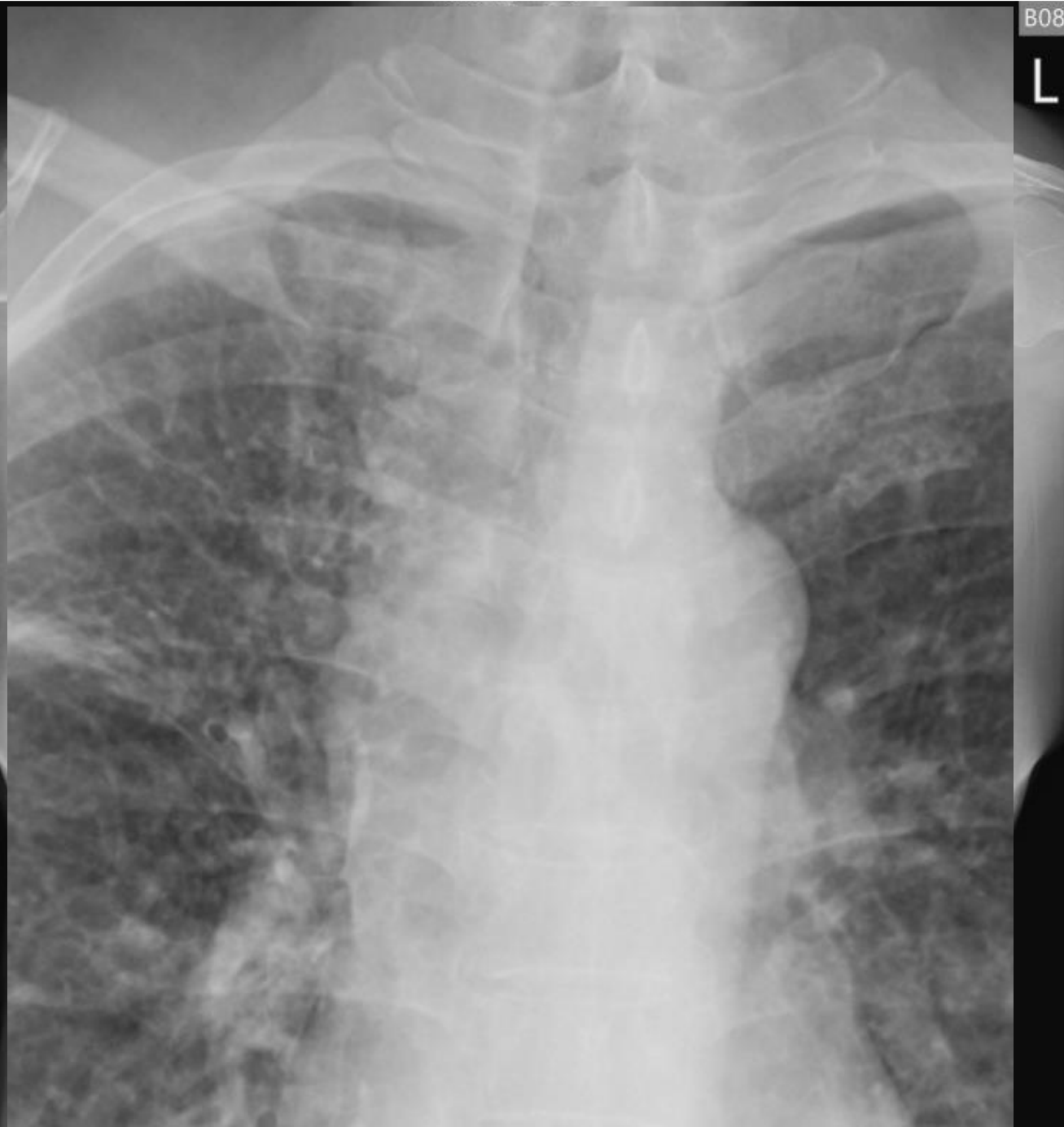
■ sarcoidosis



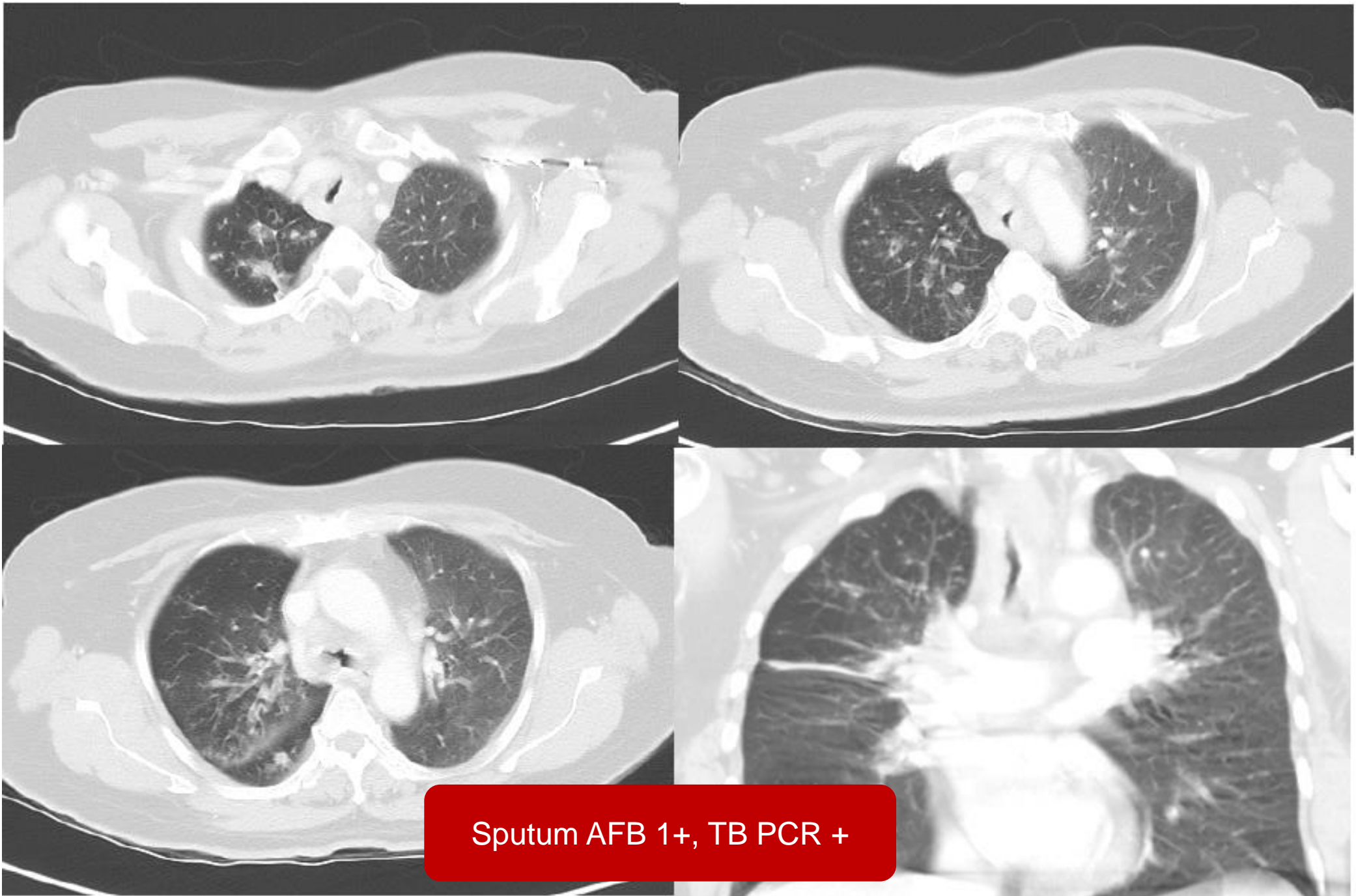
Relapsing polychondritis
with tracheostenosis



s/p stent dilatation



- 57 y/o female
- Refractory cough and progressive dyspnea for 3 months
- Used to be well

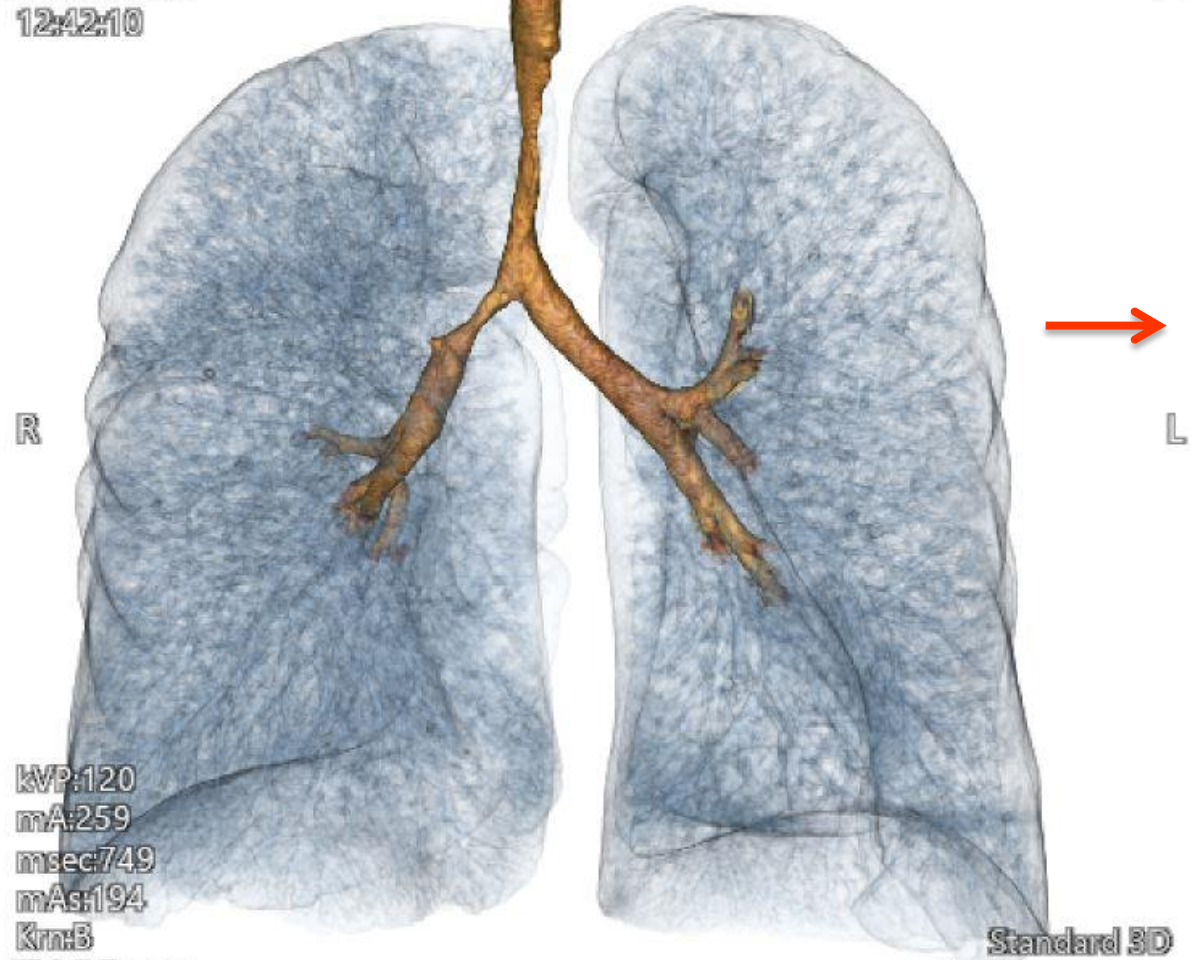


Sputum AFB 1+, TB PCR +

TSAI Y-J
4445464-0
56y
F
09 Feb 2021
12:42:10

202102/09
12:42:10.285

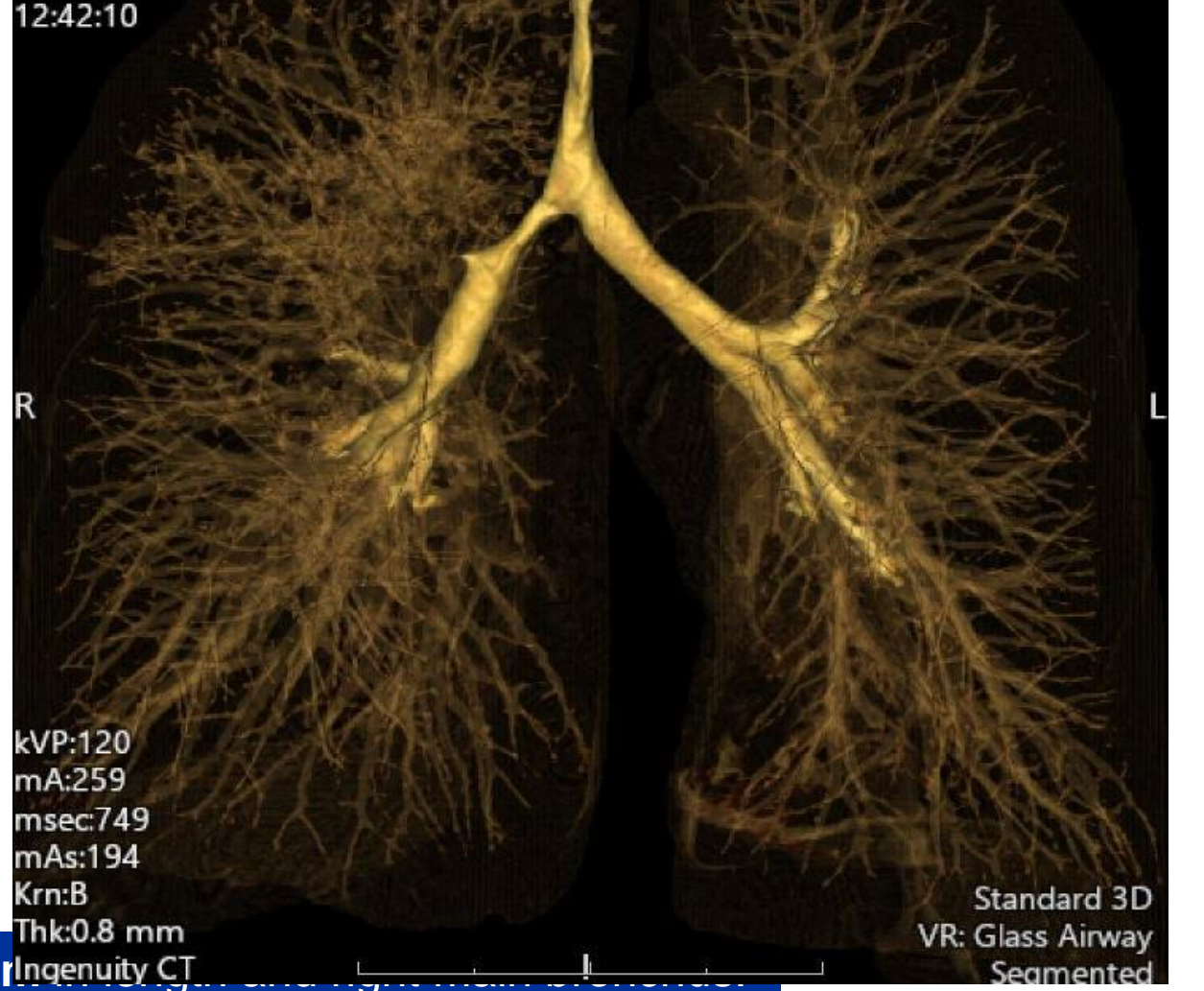
VGH TAIPEI
Ref:DOC57458
S-D IMAG
CT
HRCT HELICAL /Thorax
C 3D, iDose (3)



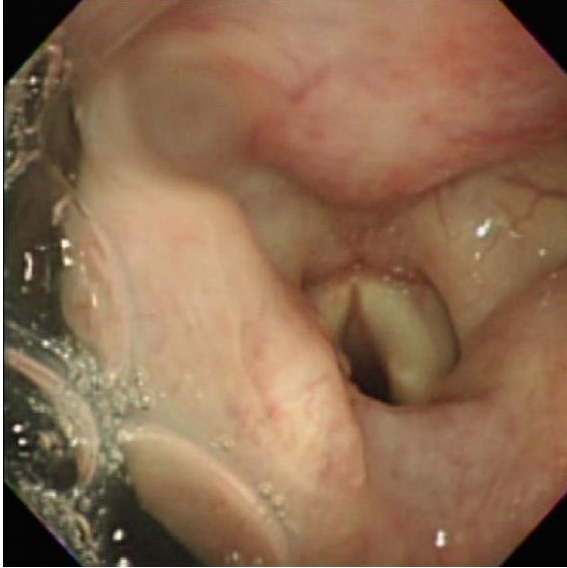
TSAI Y-J
4445464-0
56y
F
09 Feb 2021
12:42:10

202102/09
12:42:10.285

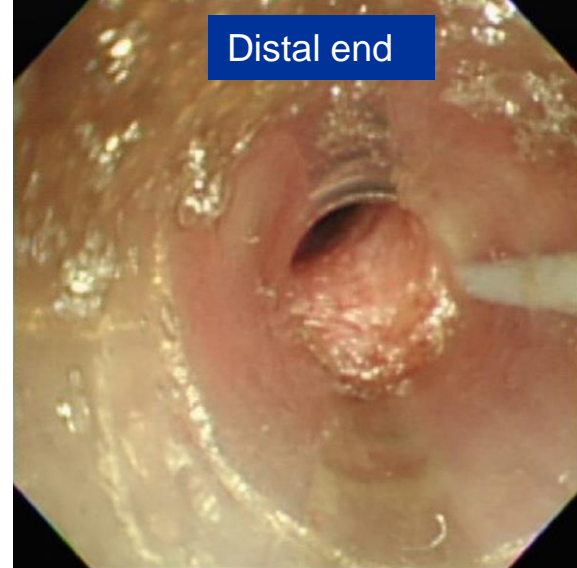
VGH TAIPEI
Ref:DOC57458
S-D IMAG
CT
HRCT HELICAL /Thorax
C 3D, iDose (3)



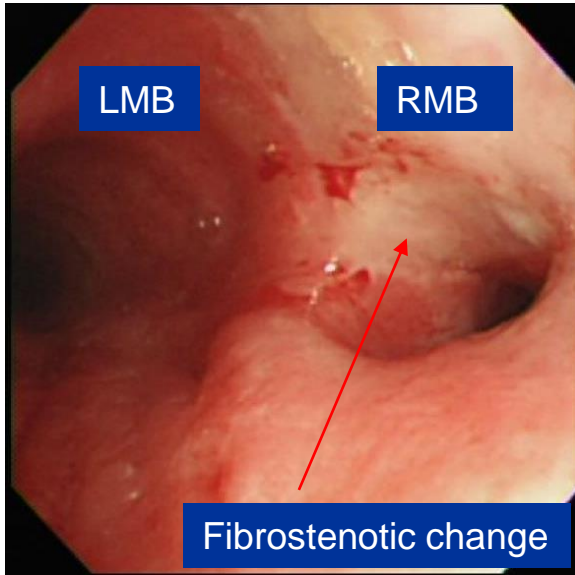
Stenosis of trachea above carina about 3cm
Most stenosis site about 2.9 mm in diameter



Tracheostomy tube



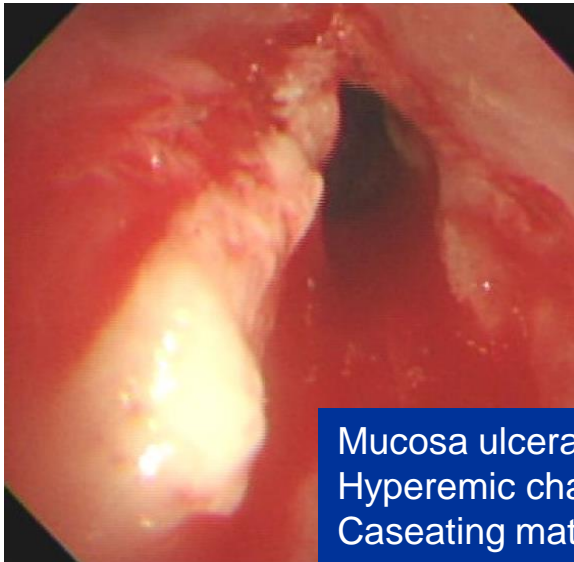
Distal end



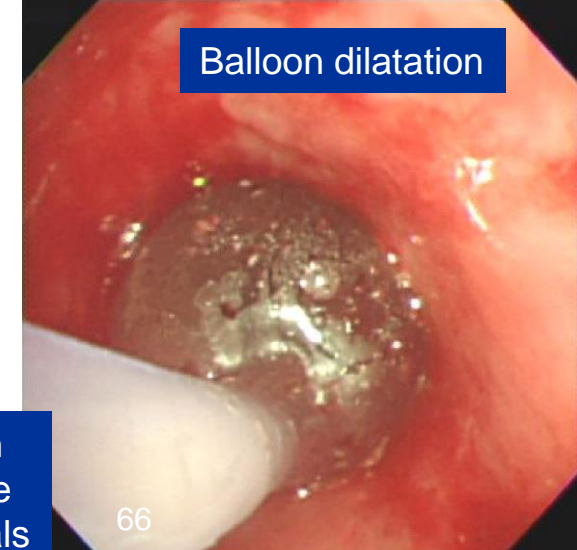
LMB

RMB

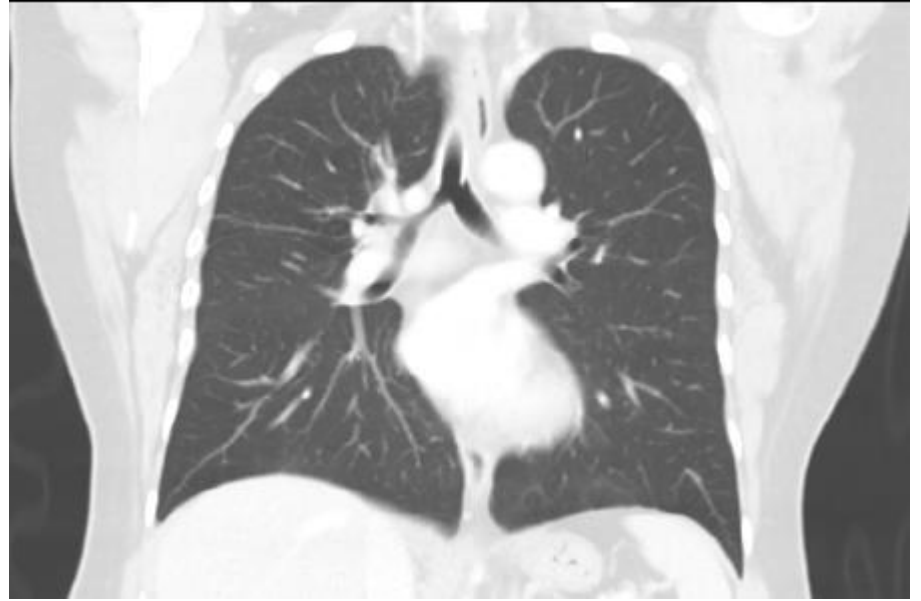
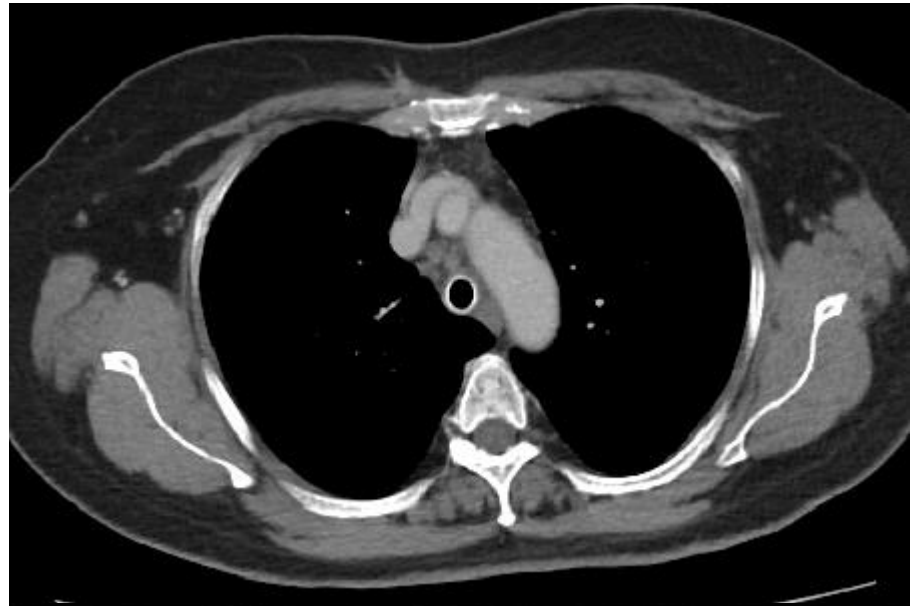
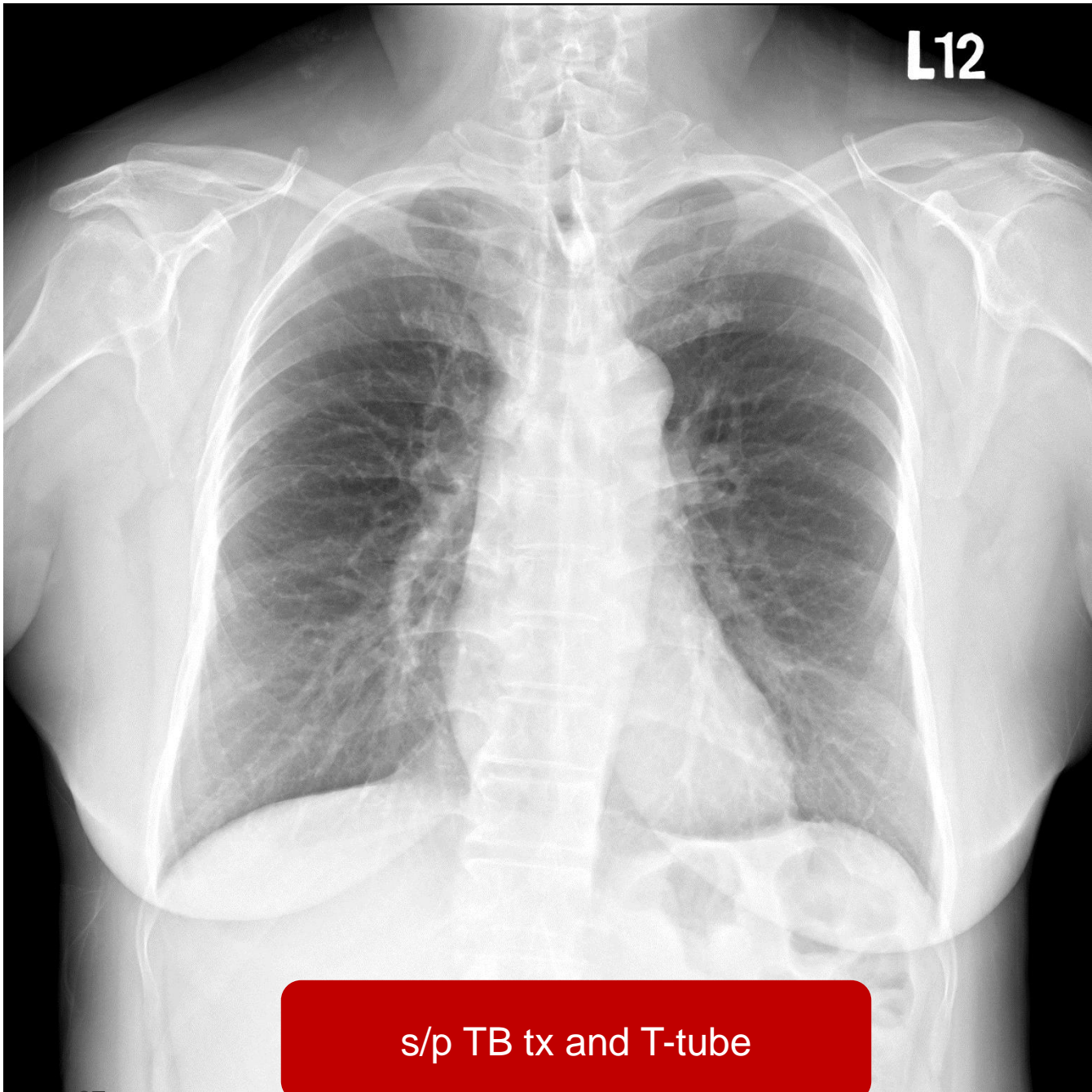
Fibrostenotic change



Mucosa ulceration
Hyperemic change
Caseating materials

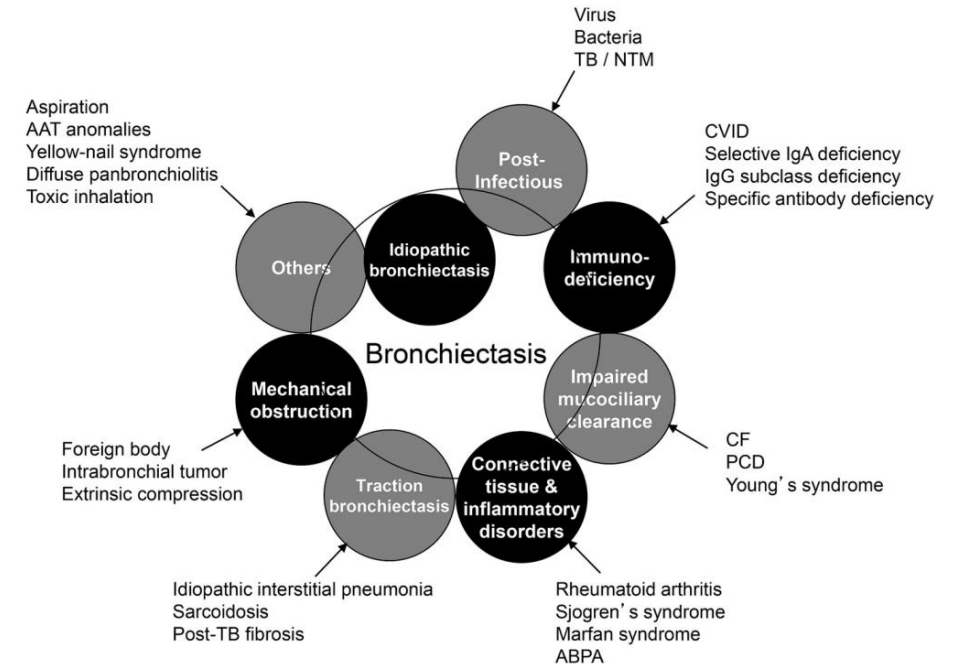


Balloon dilatation

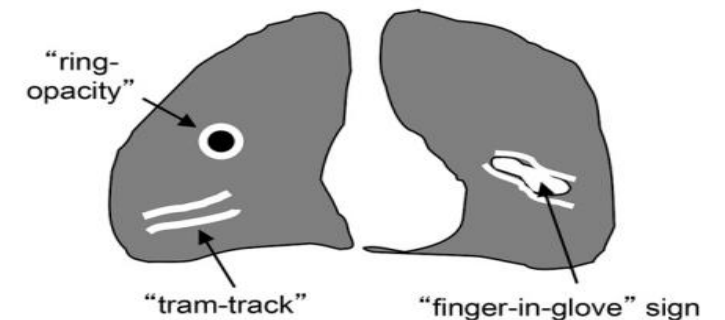


Bronchiectasis

- Definition: irreversible dilatation of bronchi
 - Great range of causes
- Chest X-ray
 - Relatively insensitive
 - “Tram-track” parallel density
- Chest CT
 - Standard investigation tool
 - Beware of false-positive in cases with pulmonary hypertension

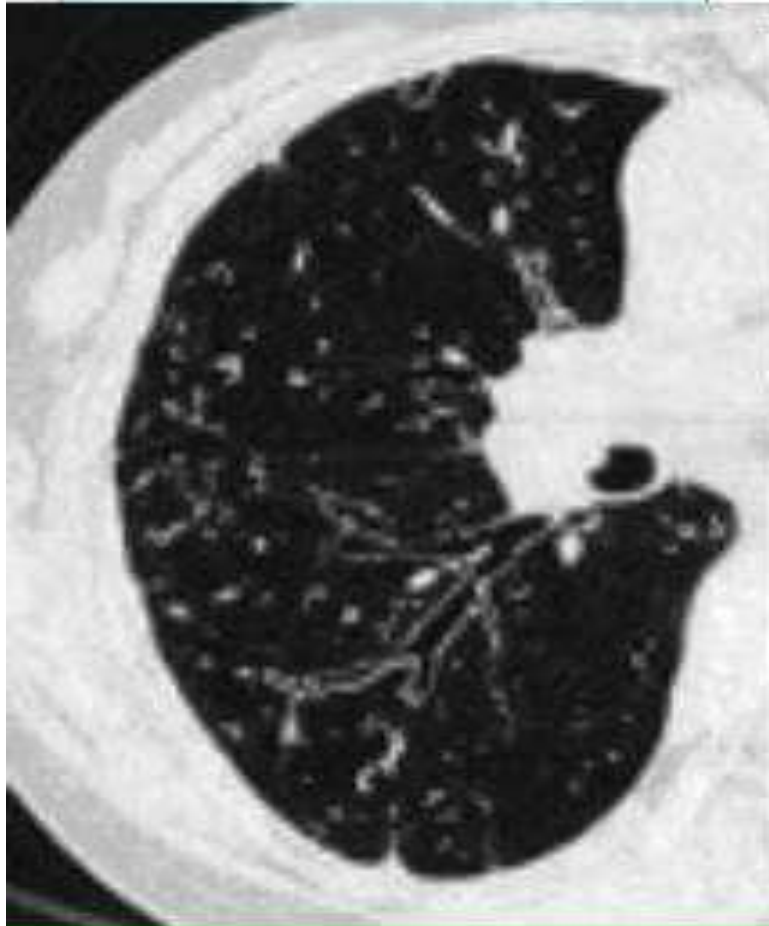


A) Chest X-ray (frontal view)



Types of bronchiectasis

Cylindrical



Varicose



Cystic

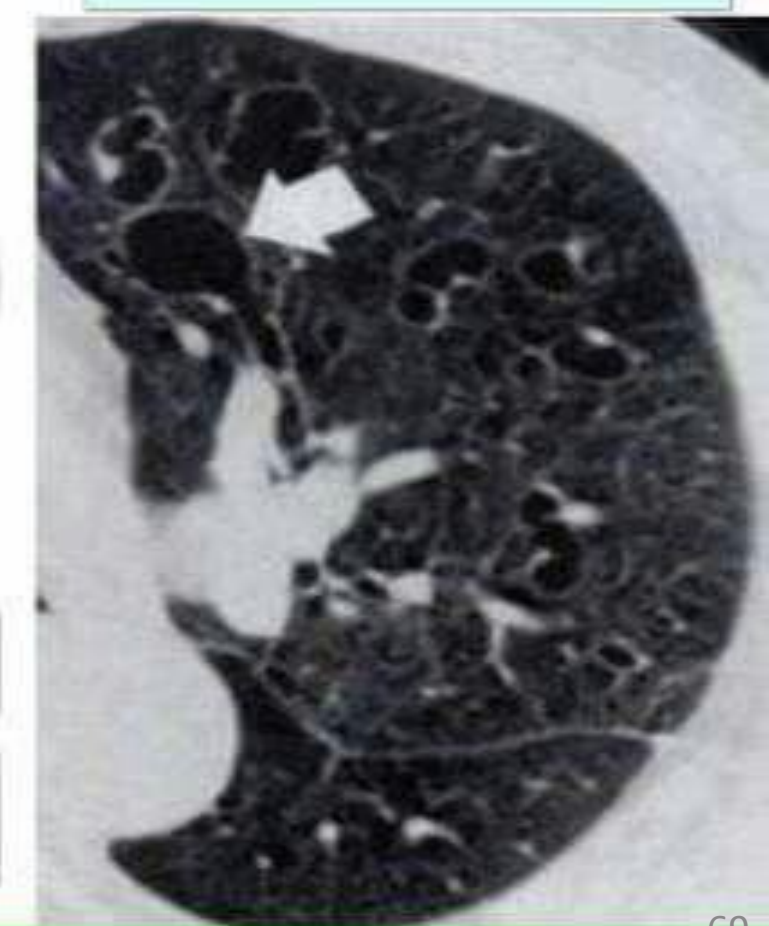


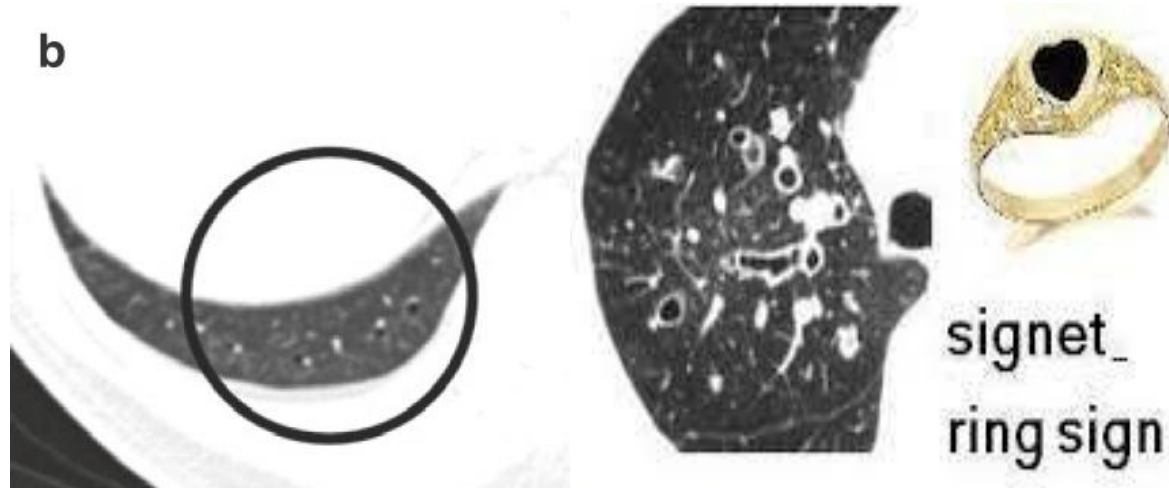
Table 2.11 HRCT signs of bronchiectasis

Primary signs

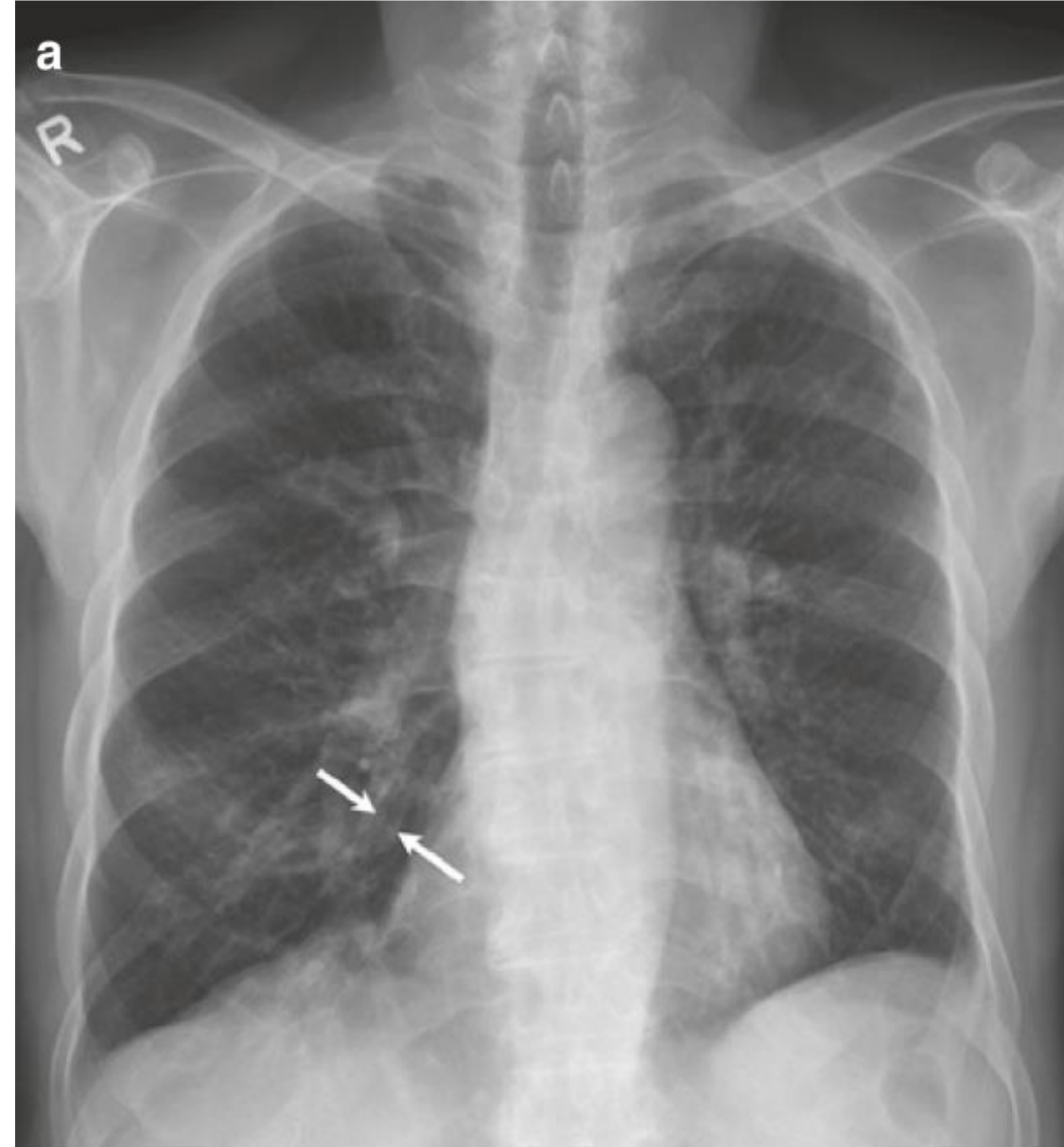
- Lack of progressive tapering of bronchi (earliest sign)
- Bronchiole diameter more than accompanying artery (“**signet ring**” sign)
- Identification of bronchi within 1 cm of pleura abutting the chest wall or mediastinal pleural surface

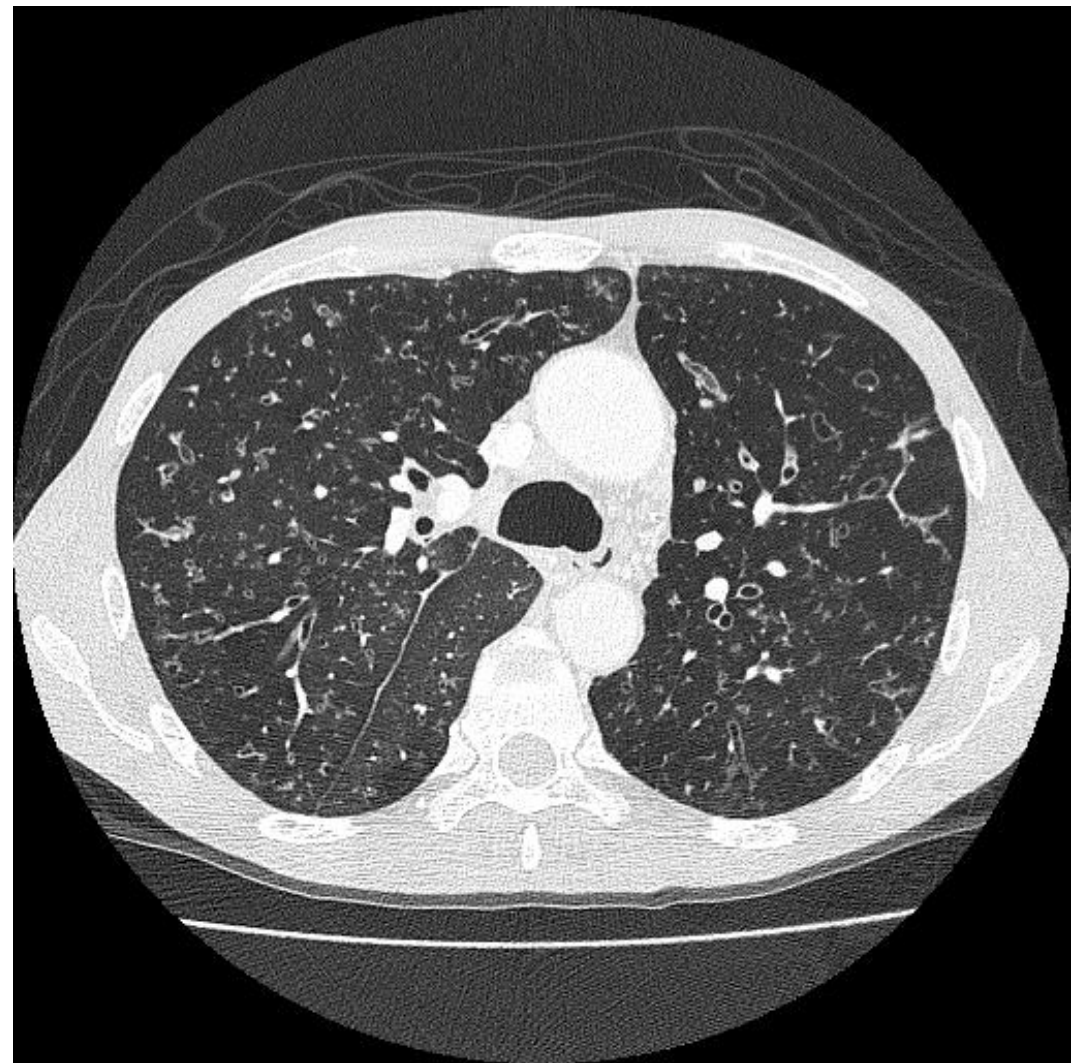
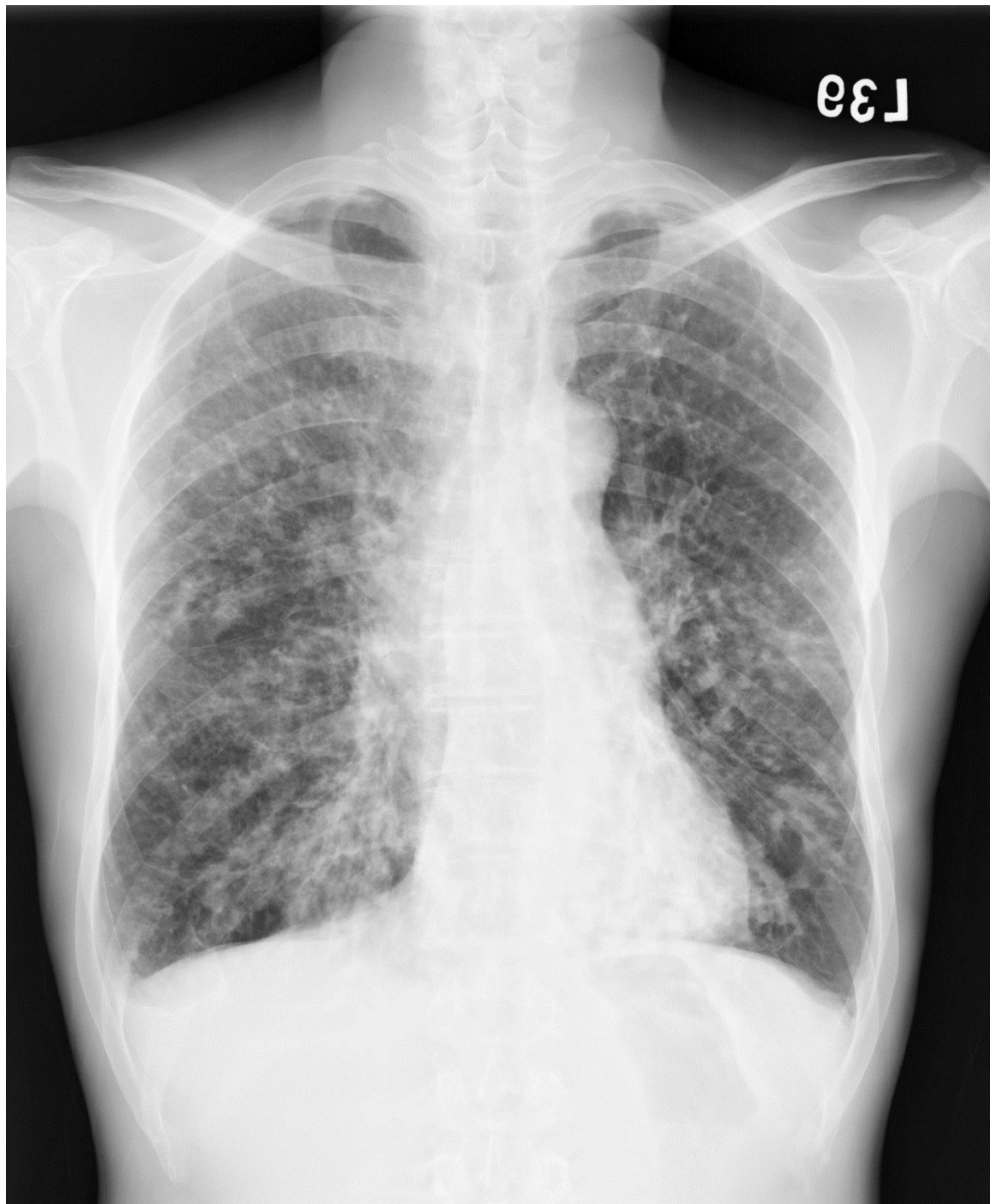
Secondary signs

- **Bronchial wall thickening**
- Mucus plugging
- Small airways disease (centrilobular nodules, tree-in-bud opacities, mosaic attenuation)
- Subsegmental atelectasis



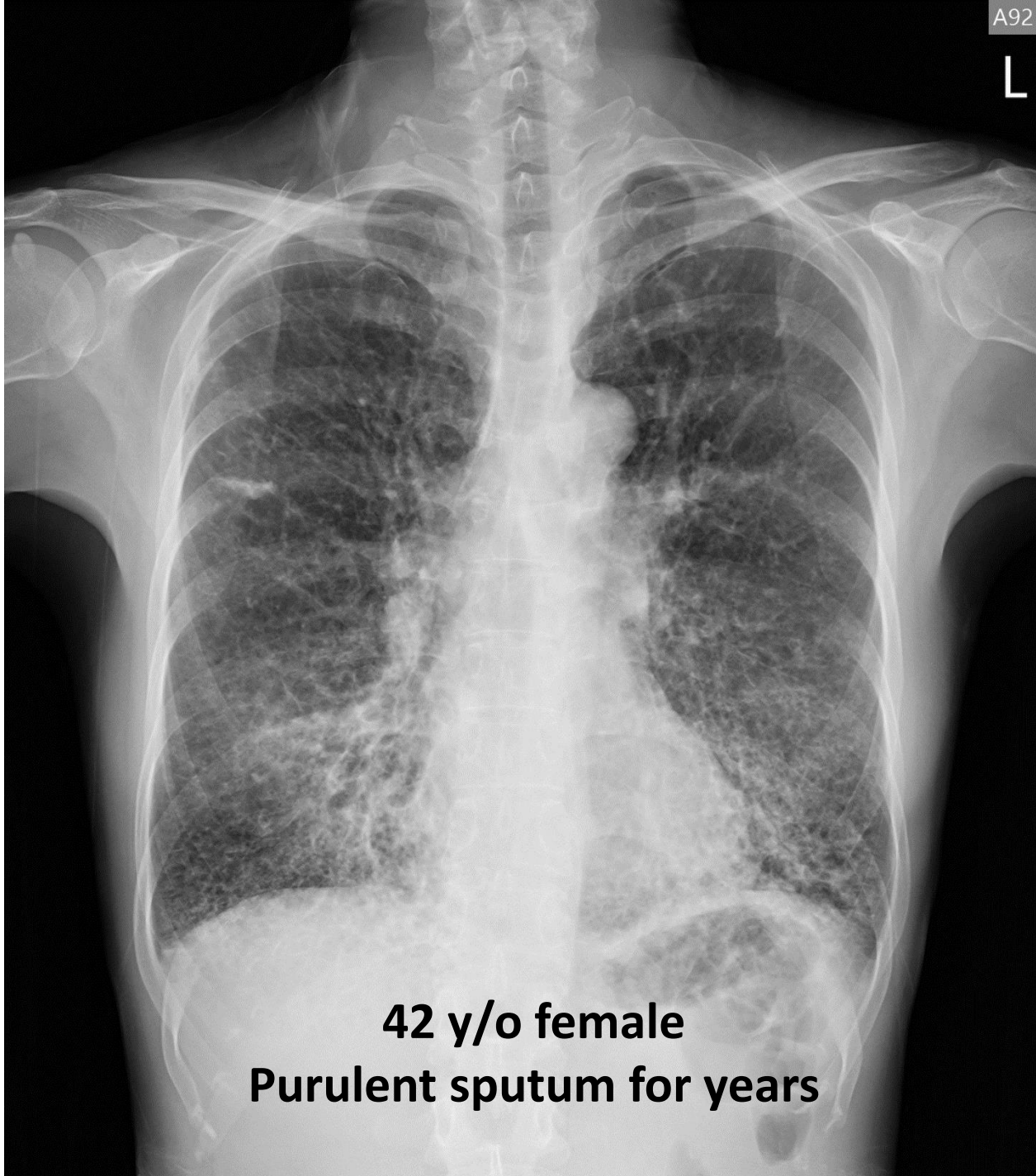
Early bronchiectasis



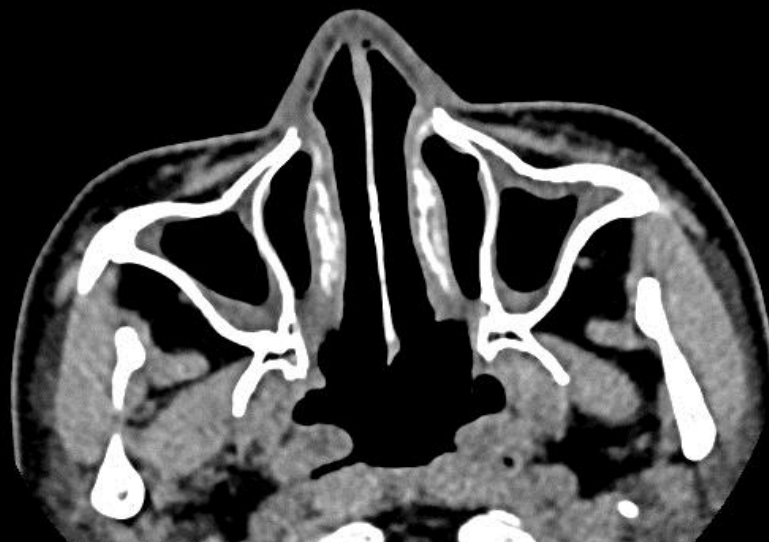


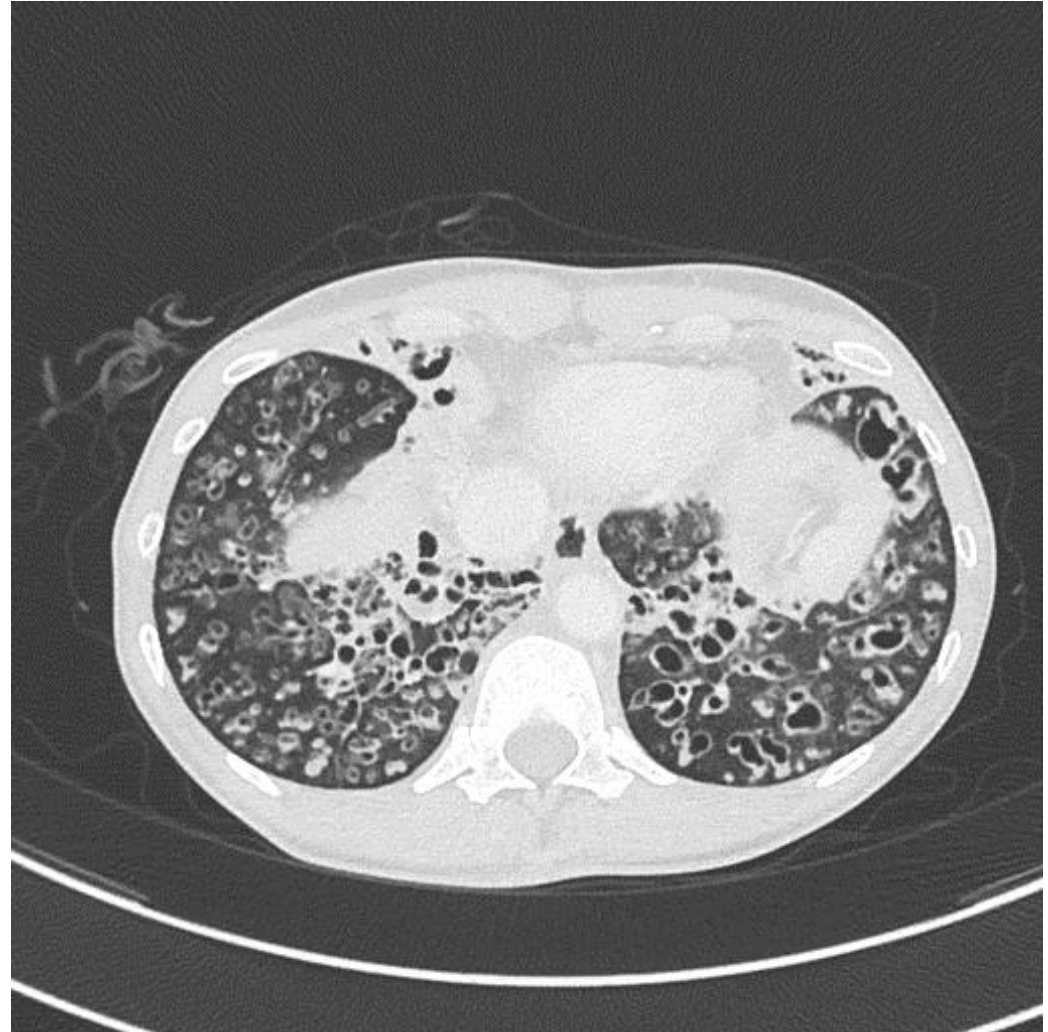
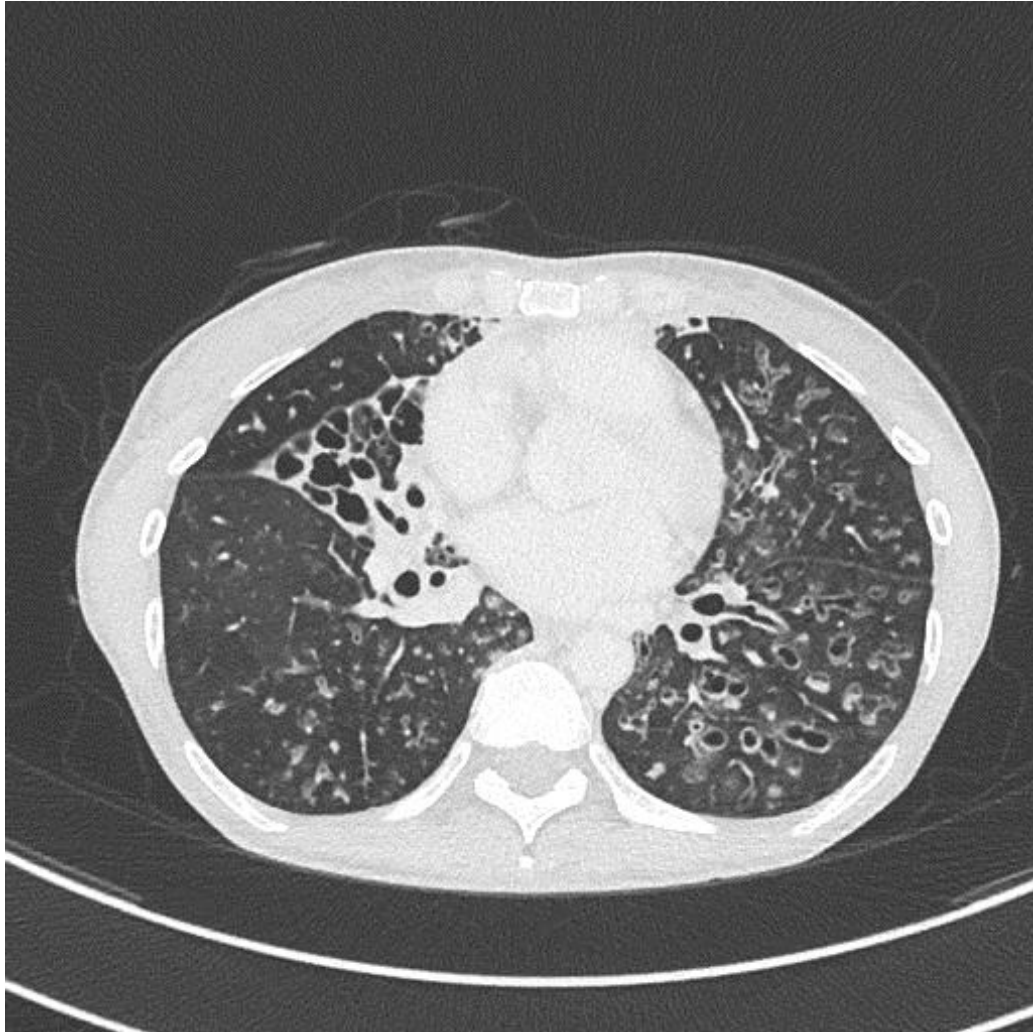
Diffuse panbronchiolitis

L



**42 y/o female
Purulent sputum for years**





Primary ciliary dyskinesia with bronchiectasis and recurrent sinusitis

Traction Bronchiectasis in ILD



The Take Away.....

- Radiological presentations of infectious disease have high variety
 - Alveolar process: bacteria, TB, fungal
 - Ground glass opacities: fungal, viral
 - Nodules: TB, fungal, viral
 - Cavities: bacteria, TB, fungal
- Associated findings and clinical information are important
- Pay attention to abnormalities in major airways to avoid missing airway disease with life threatening conditions
- Chest CT is usually required when poor response to initial management and further differentiation is needed

Learning from Reading

