

A Tale of 2 Lungs: Interventional Pulmonology in Lung Nodule Diagnosis and COPD Management

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Robotic Assisted Bronchoscopy

- Background, Screening, and Evolving Biopsy Strategies



Lung Cancer: Why screening matters

- Lung cancer is the leading cause of cancer-related death in the US
- ~238,000 new cases and ~127,000 deaths annually (2023)
- 5-year survival rates by stage at diagnosis:
 - Stage I: ~60-92%
 - Stage II: ~30-55%
 - Stage III: ~10-35%
 - Stage IV: ~6-10%
- Key message: Early detection dramatically improves outcomes

9th Edition TNM Descriptors and Stages						
T/M	Categories and Descriptors	N0	N1	N2		N3
				N2a	N2b	
T1	T1a ≤1 cm	IA1	IIA	IIB	IIIA	IIIB
	T1b >1 to ≤2 cm	IA2	IIA	IIB	IIIA	IIIB
	T1c >2 to ≤3 cm	IA3	IIA	IIB	IIIA	IIIB
T2	T2a Visceral pleura / central invasion	IB	IIB	IIIA	IIIB	IIIB
	T2a >3 to ≤4 cm	IB	IIB	IIIA	IIIB	IIIB
	T2b >4 to ≤5 cm	IIA	IIB	IIIA	IIIB	IIIB
T3	T3 >5 to ≤7 cm	IIB	IIIA	IIIA	IIIB	IIIC
	T3 Invasion	IIB	IIIA	IIIA	IIIB	IIIC
	T3 Same lobe separate tumor nodules	IIB	IIIA	IIIA	IIIB	IIIC
T4	T4 >7 cm	IIIA	IIIA	IIIB	IIIB	IIIC
	T4 Invasion	IIIA	IIIA	IIIB	IIIB	IIIC
	T4 Ipsilateral separate tumor nodules	IIIA	IIIA	IIIB	IIIB	IIIC
M1	M1a Contralateral tumor nodules	IVA	IVA	IVA	IVA	IVA
	M1a Pleural / pericardial effusion, nodules	IVA	IVA	IVA	IVA	IVA
	M1b Single extrathoracic metastasis	IVA	IVA	IVA	IVA	IVA
	M1c1 Multiple metastases in 1 organ system	IVB	IVB	IVB	IVB	IVB
	M1c2 Multiple metastases in >1 organ systems	IVB	IVB	IVB	IVB	IVB

e-Table 1: 5-year Overall Survival (%) by Stage Group and TNM Edition

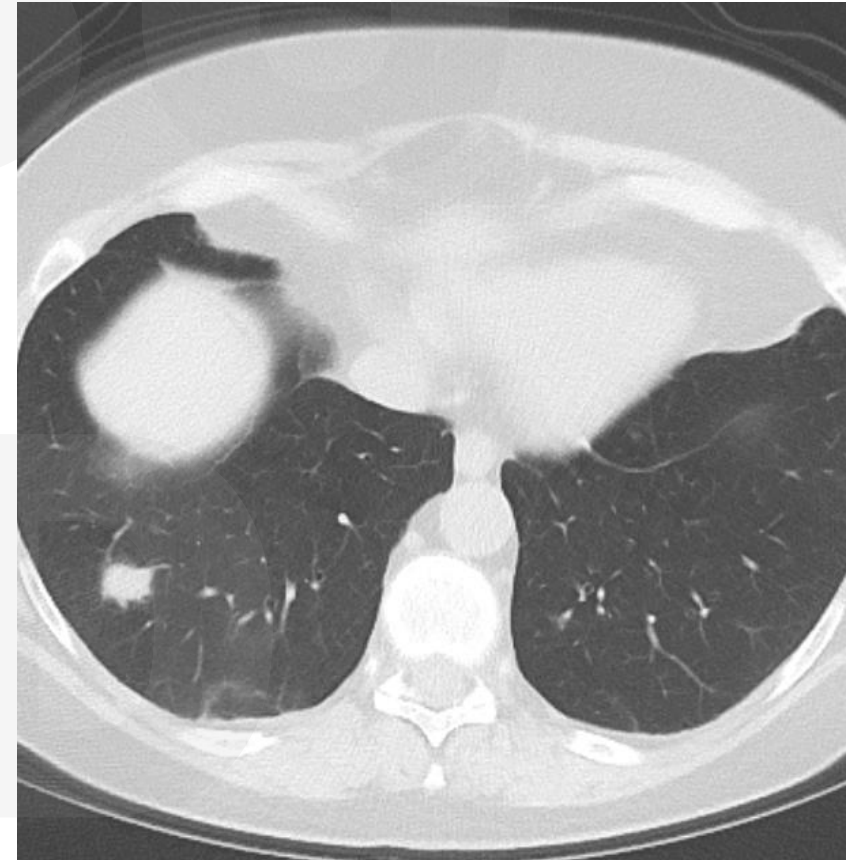
DB (years) / Staging Context	IA1	IA2	IA3	IB	IIA	IIB	IIIA	IIIB	IIIC	IVA	IVB
9 th ed DB (2011-2019)											
Clinical, 9 th ed TNM	92	84	76	69	62	54	44	31	21	18	7
Pathologic, 9 th ed TNM	94	89	83	77	67	59	50	35	19	-	-
8 th ed DB (1999-2010)											
Clinical, 8 th ed TNM	92	83	77	68	60	53	36	26	13	10	0
Pathologic, 8 th ed TNM	90	85	80	73	65	56	41	24	12	-	-
7 th ed DB (1990-1999)											
Clinical, 7 th ed TNM	50			43	36	25	19	7	2		
Pathologic, 7 th ed TNM	73			58	46	36	24	9	13		

Screening guidelines

- Annual low-dose CT (LDCT) recommended for high-risk adults:
 - Age 50-80 years
 - 20 pack-year smoking history
 - Currently smoke or quit within the past 15 years
- NLST (2011): LDCT reduced lung cancer mortality by 20% vs. CXR
- NELSON trial (2020): 24% mortality reduction in men, 33% in women
- Challenge: Screening identifies nodules that require tissue diagnosis

The Nodule Dilemma

- Up to 60% of screened patients have pulmonary nodules detected
- Most are benign - but how do we safely triage?
- Fleischner Society Guidelines / Lung Rads guide management:
 - Size, morphology, and growth rate determine follow-up vs. biopsy
- When tissue is needed, biopsy approach matters:
 - Location (central vs. peripheral)
 - Size and proximity to vessels/airways
 - Patient comorbidities and surgical risk



Biopsy options

- Bronchoscopic biopsy
- TTNA
- Surgical resection

CT-TTNA

Advantages:

- High diagnostic yield for peripheral nodules (~80-90%)
- Well-established, widely available

Limitations:

- Pneumothorax rate: 15-25% (chest tube required in ~5%)
- Cannot stage mediastinum simultaneously
- No therapeutic capability at time of procedure
- Contraindicated in poor lung function (COPD, poor reserve)



Surgical Biopsy

Advantages:

- “Gold standard” diagnostic yield
- Therapeutic and staging

Limitations:

- Higher complication and morbidity rate
- Too aggressive for nodules of unclear diagnostic significance
- Higher cost

Conventional bronchoscopy

- Standard bronchoscopy: poor yield for peripheral nodules
- Diagnostic yield ~20-30% for lesions <2 cm
- The “bronchus sign” predicted accessibility - most nodules lacked it
- Radial EBUS + fluoroscopy: improved yield ~40-70%
- Still limited by CT-to-body divergence and real-time guidance



The unmet need

- A safe, accurate, minimally invasive route to peripheral lung lesions - without the risks of TTNA

Robotic-Assisted Bronchoscopy

- Stability in distal airways
- Real-time positional feedback with shape-sensing fiber
- Ability to reach lesions without a bronchus sign





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ORIGINAL ARTICLE



Navigational Bronchoscopy or Transthoracic Needle Biopsy for Lung Nodules




Authors: Robert J. Lentz, M.D., Katherine Frederick-Dyer, M.D. , Virginia B. Planz, M.D., Tatsuki Koyama, Ph.D., Matthew C. Aboudara, M.D., Sameer K. Avasarala, M.D., Jonathan D. Casey, M.D. ,  +21, for the Interventional

Table 3. Safety Outcomes.

Outcome	Navigational Bronchoscopy (N=121)	Transthoracic Needle Biopsy (N=113)	Difference (95% CI)*	P Value
Any complication — no. (%)	6 (5.0)	33 (29.2)	24.2 (15.0 to 35.6)	<0.001
Pneumothorax				
Any grade — no. (%)	4 (3.3)	32 (28.3)	25.0 (15.3 to 34.8)	<0.001
Grade 1 or 2†	3 (2.5)	19 (16.8)	14.3 (6.0 to 22.6)	<0.001
Grade 3 or 4‡	1 (0.8)	13 (11.5)	10.7 (3.7 to 17.6)	<0.001
Median duration of chest tube in place (IQR) — days	1.0 (1.0 to 1.0)	1.0 (1.0 to 2.0)	0	0.65
Respiratory failure resulting in hospital admission — no. (%)	1 (0.8)	1 (0.9)	0.1 (−2.5 to 2.4)	0.96
Hemorrhage resulting in medical intervention — no. (%)	0	0	0	—
Acute coronary syndrome — no. (%)	1 (0.8)	0	0.8 (−1.6 to 3.3)	0.33

TTNA VS RAB

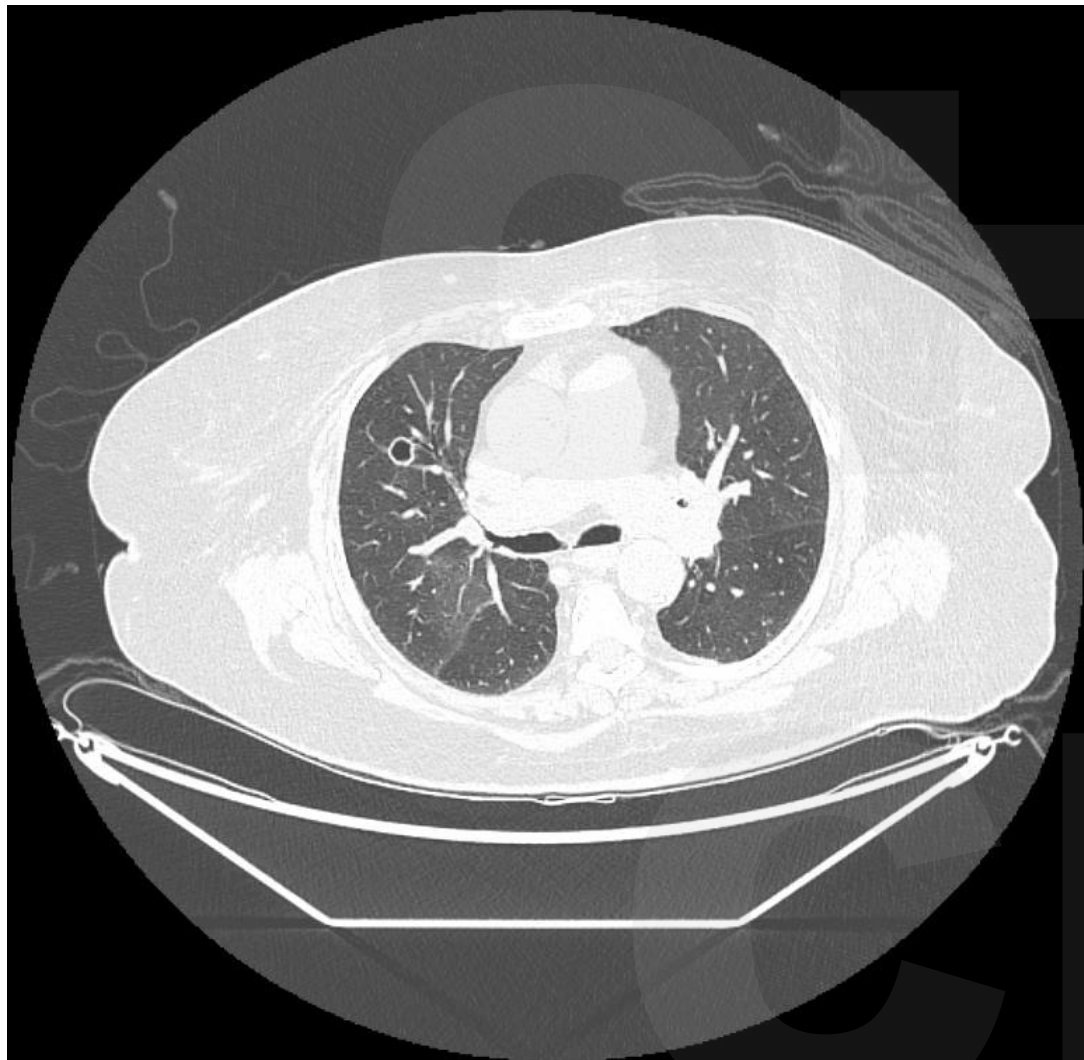
- Comparable diagnostic yield
- Safety profile strongly favors RAB:
 - Pneumothorax: RAB <5% vs. TTNA 15-25%
 - Major bleeding: RAB <1% vs. TTNA 1-5%
 - No chest tube requirement in vast majority
- Additional advantage: same-session mediastinal staging
 - EBUS-TBNA during RAB procedure (N staging)
 - Avoids second procedure under anesthesia

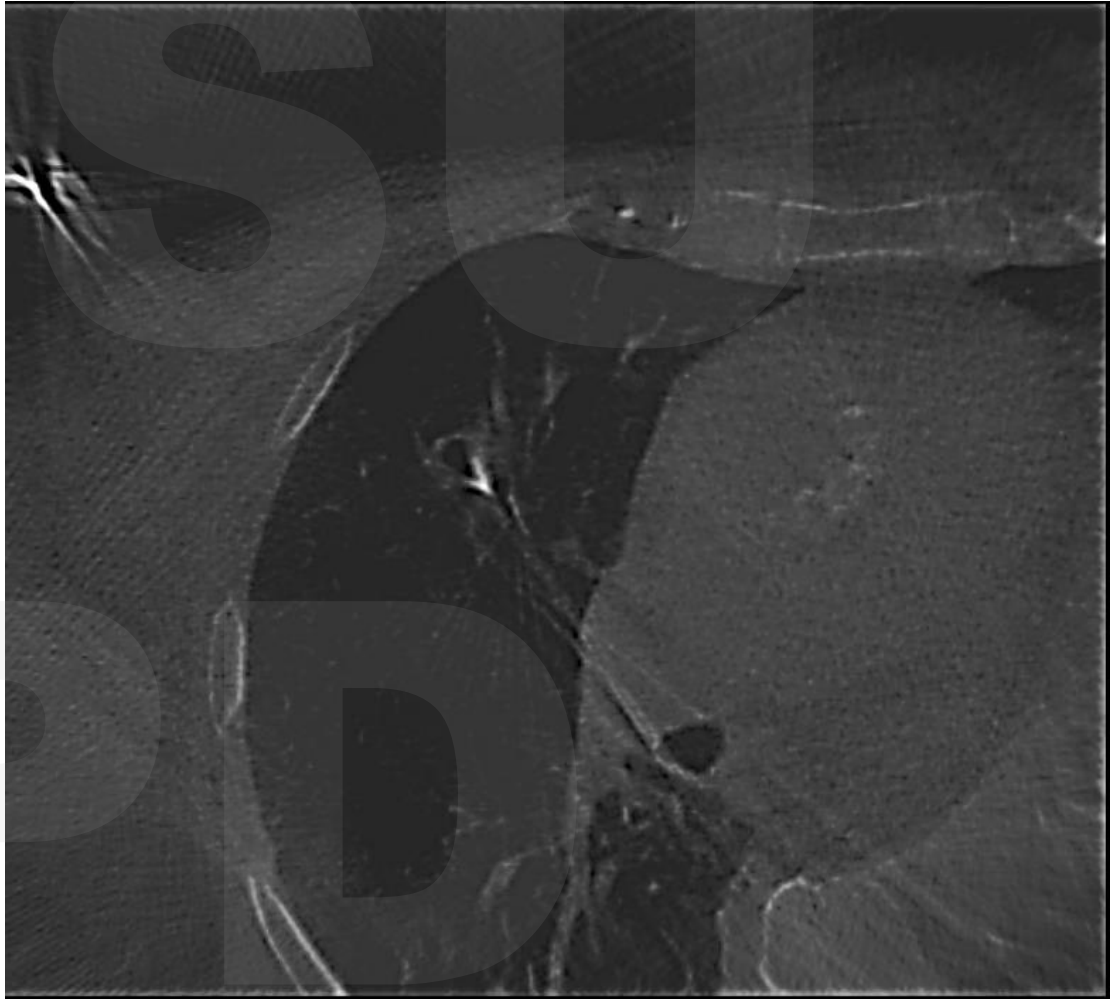
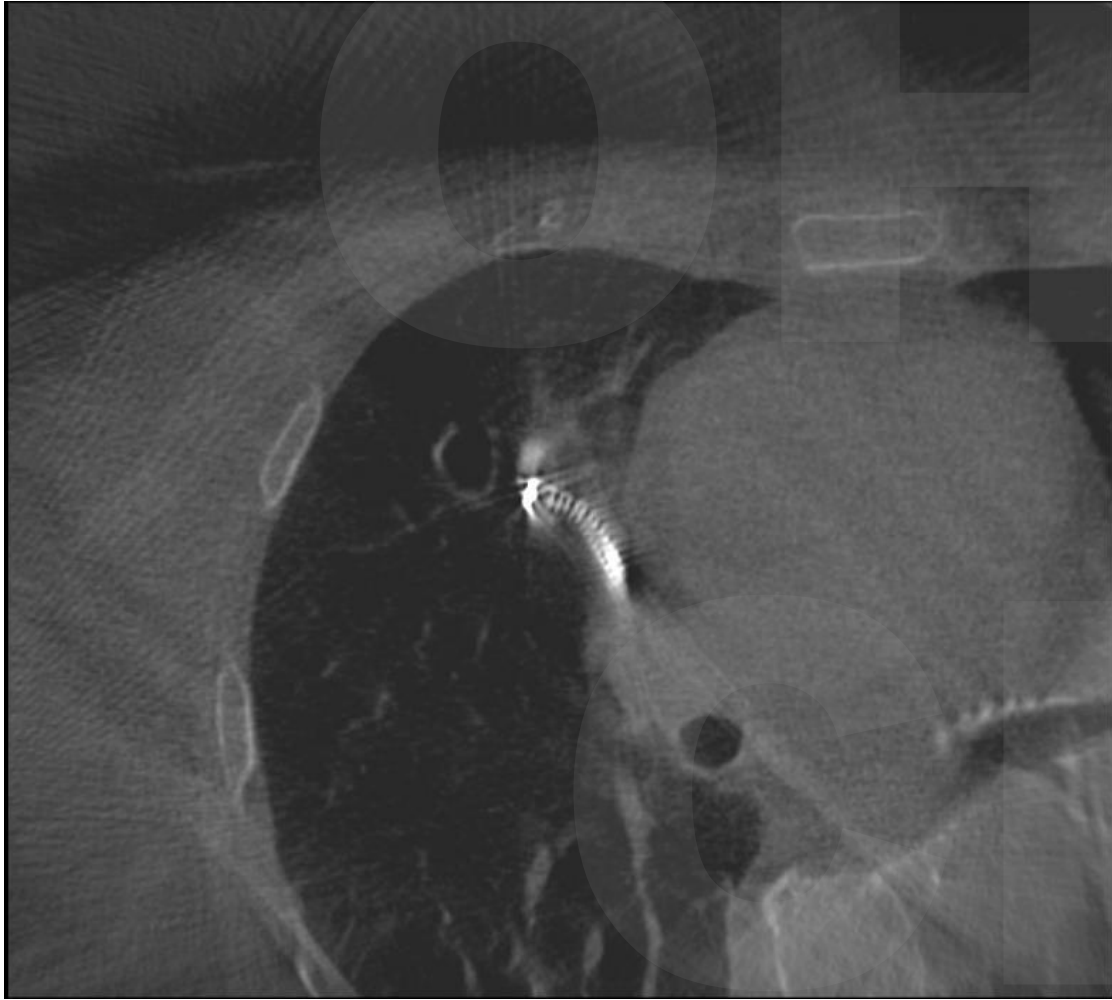
The future: From diagnosis to treatment

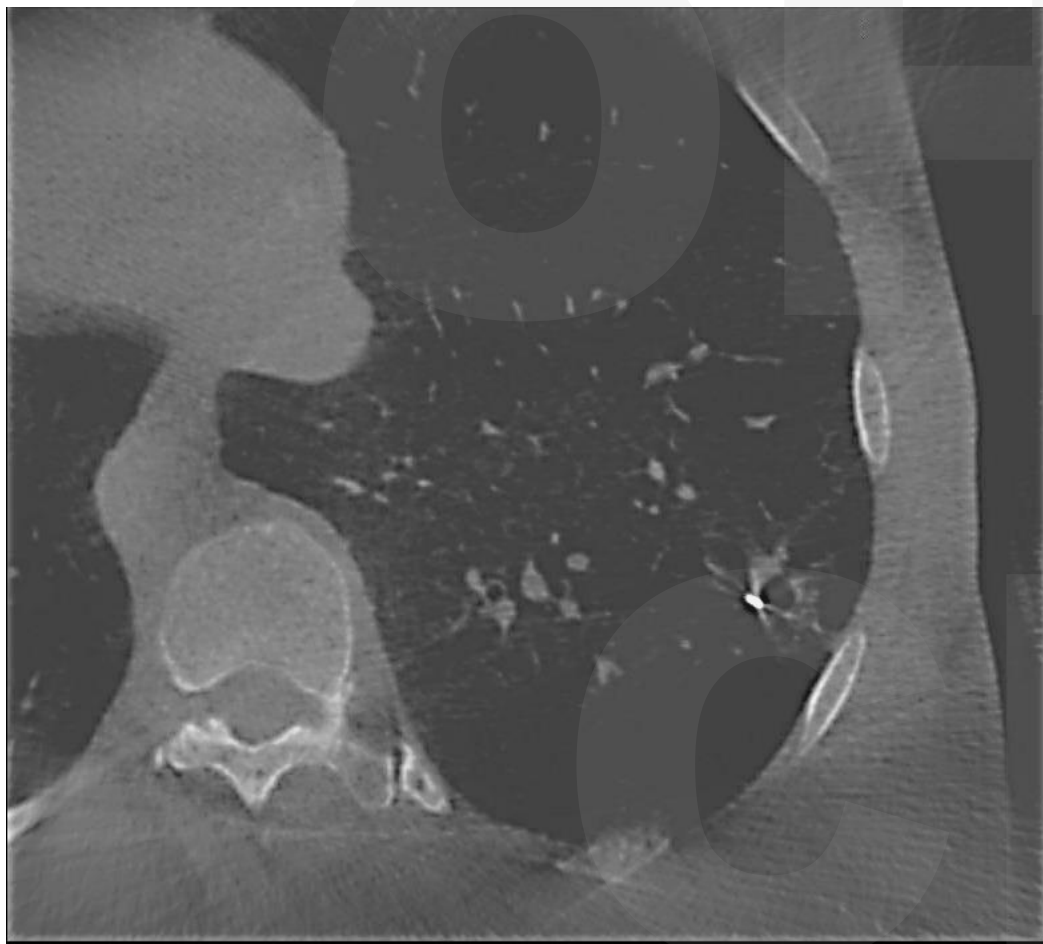
- Current RAB workflow:
 - Peripheral biopsy + EBUS mediastinal staging = same session
 - Reduces time to treatment decision
- Emerging: Same-session ablative therapy (investigational)
 - Bronchoscopic microwave ablation (Neuwave, J&J)
 - Bronchoscopic thermal vapor ablation
 - Target: Stage I NSCLC in patients unfit for surgery

Ms. H

- 78 yo F
- Hx of endometrial cancer 5 years ago, on remission
- Identifies as catholic and goes on several missions to South America and Southeast Asia
- Cough, fever and sputum





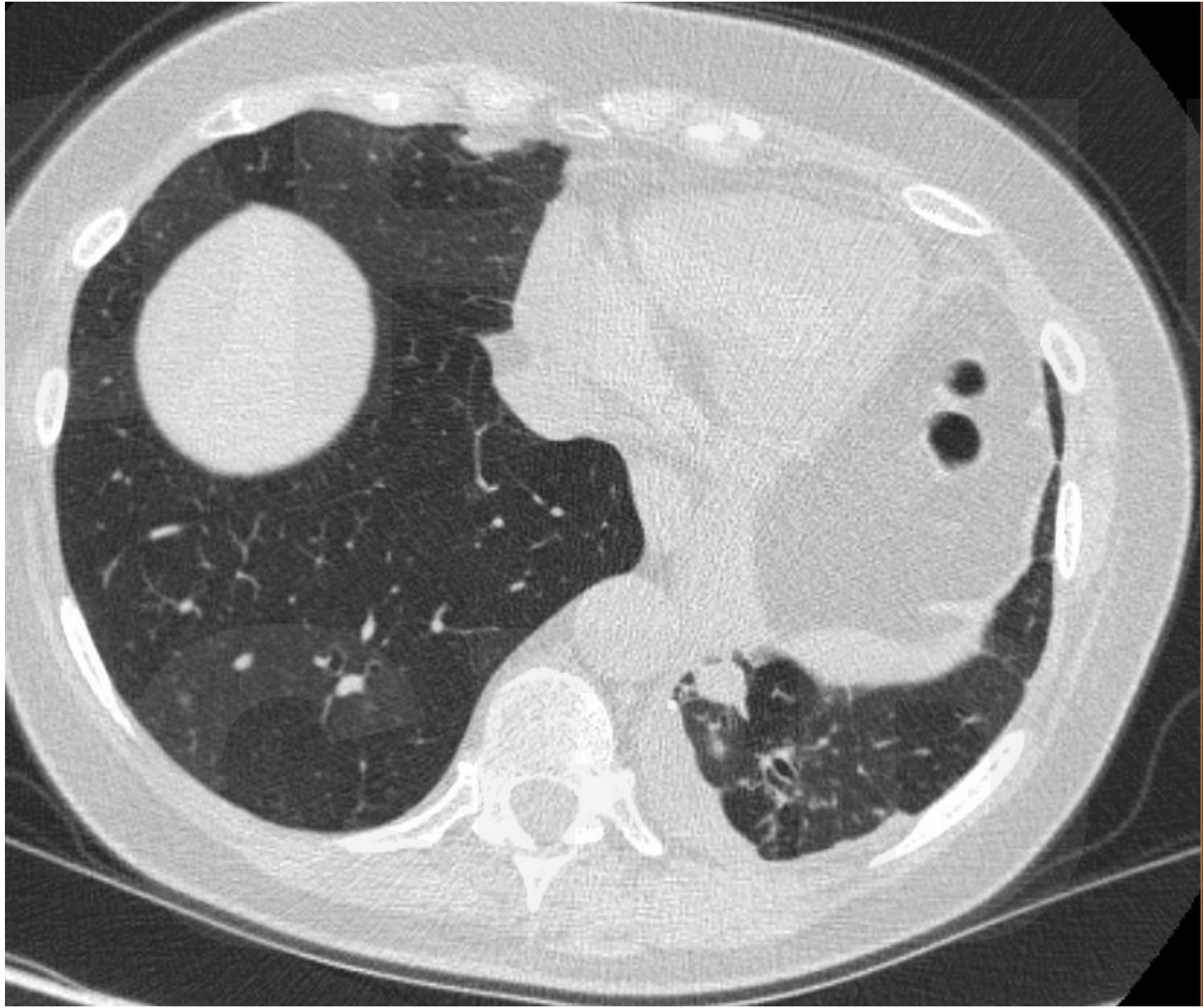


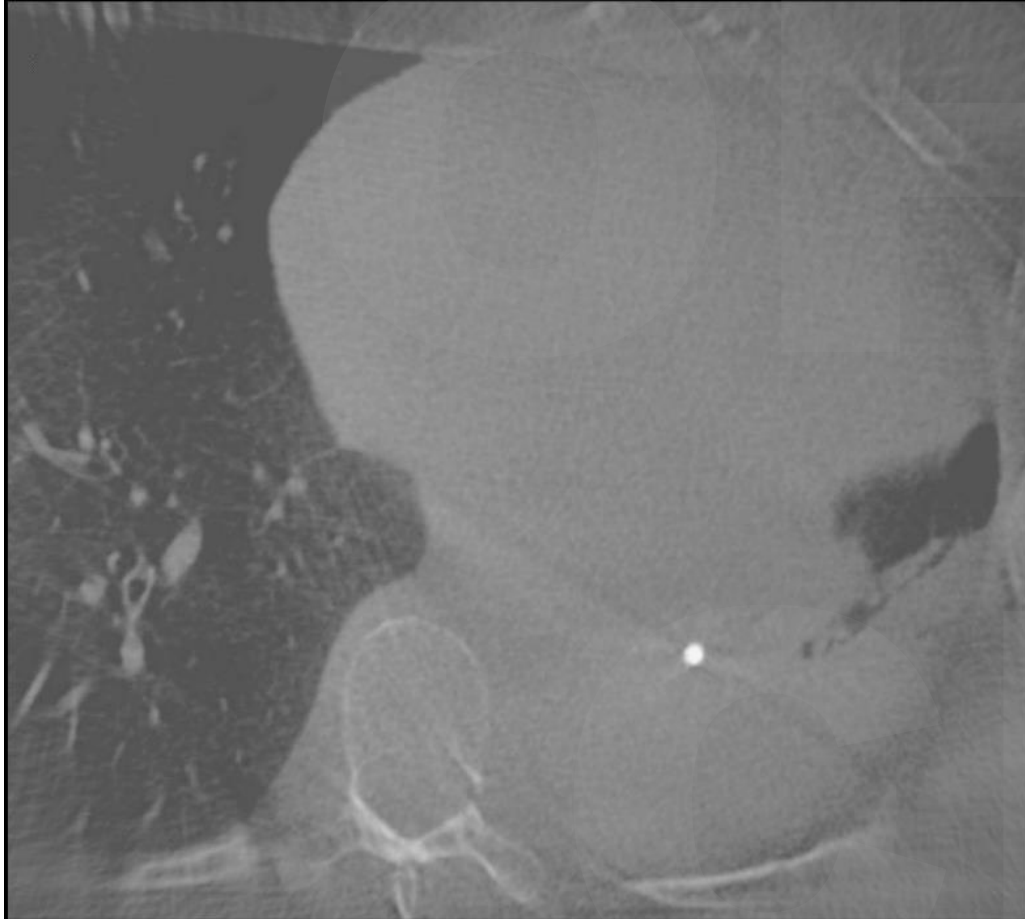
• Biopsy:

- Adenocarcinoma, consistent with endometrial primary

Ms. A

- 65 yo F
- NSCLC s/p LLL lobectomy on remission









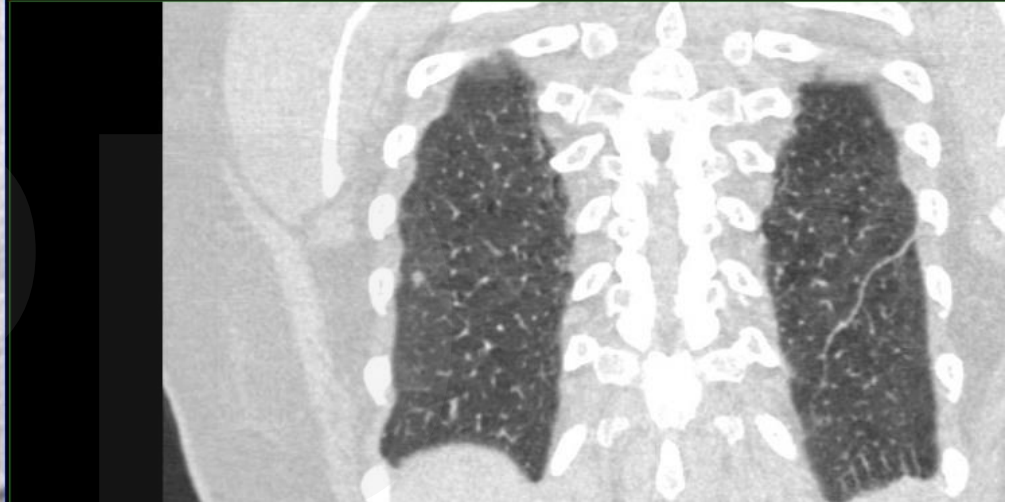
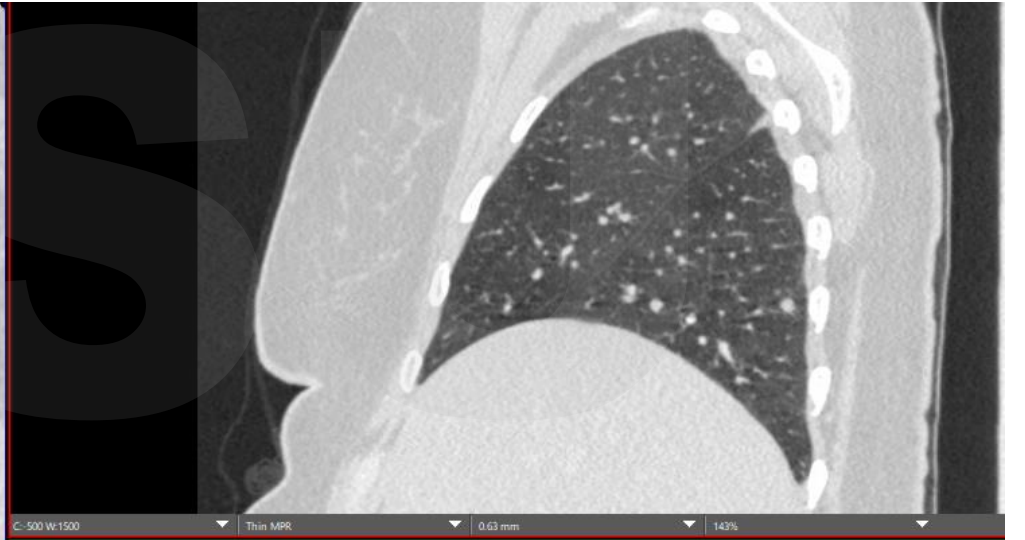
• Biopsy:

- Non-caseating granulomas, consistent with sarcoidosis

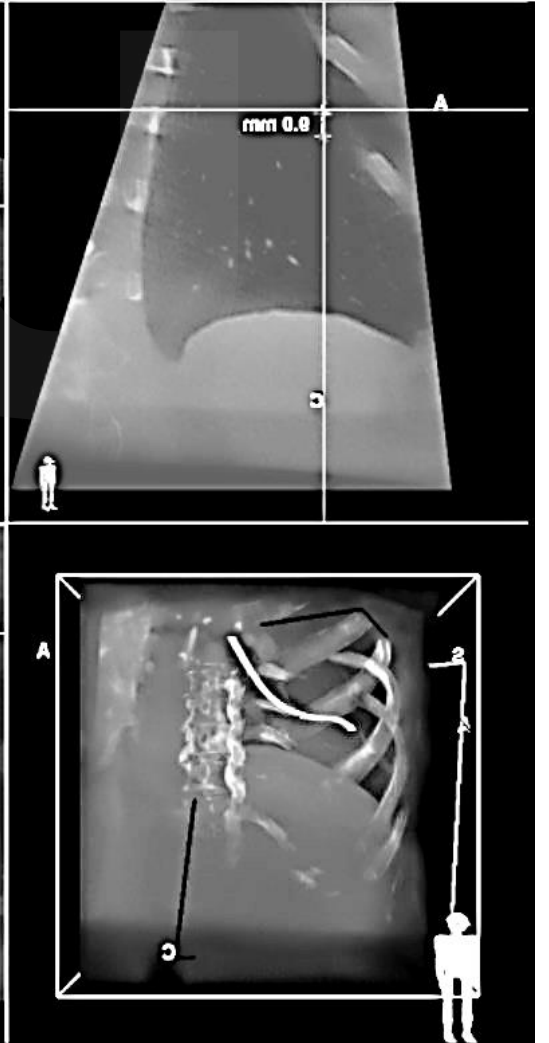
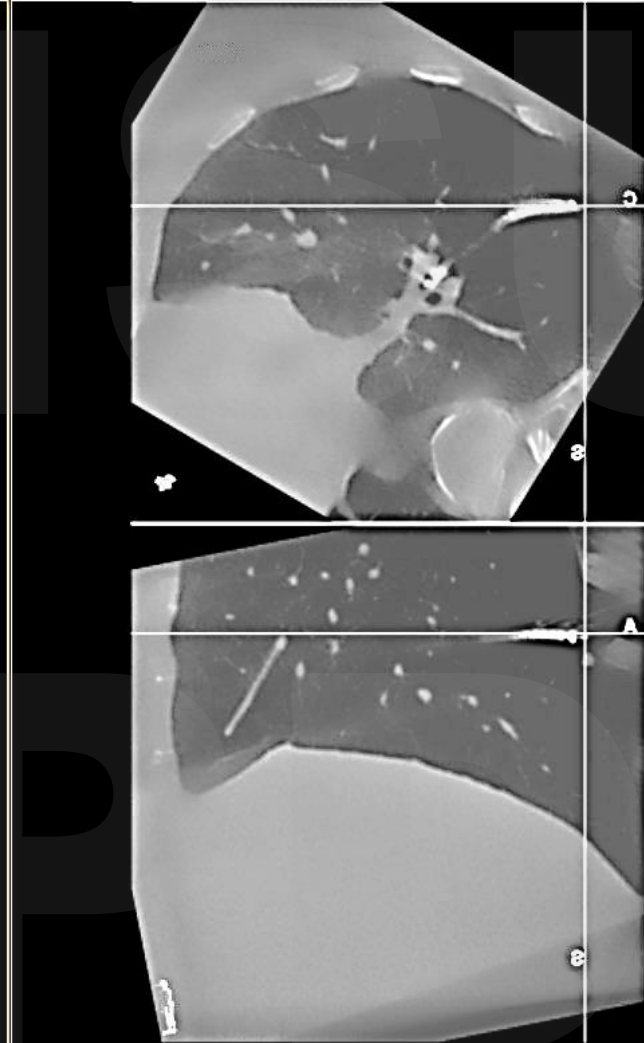
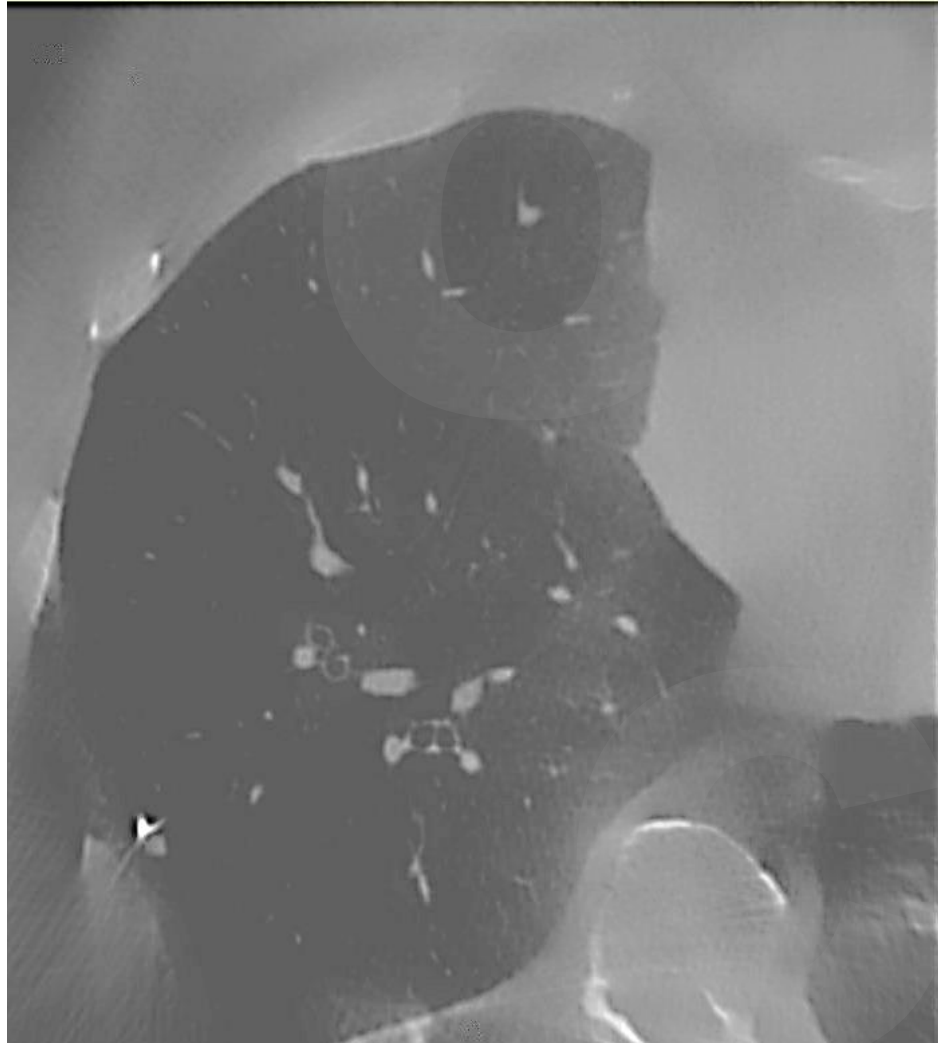
CPD

Ms. R

- 63 y.o. female
- Recent diagnosis of mucinous carcinoma of endometrium
- Planned for surgical staging and possible adjuvant chemo



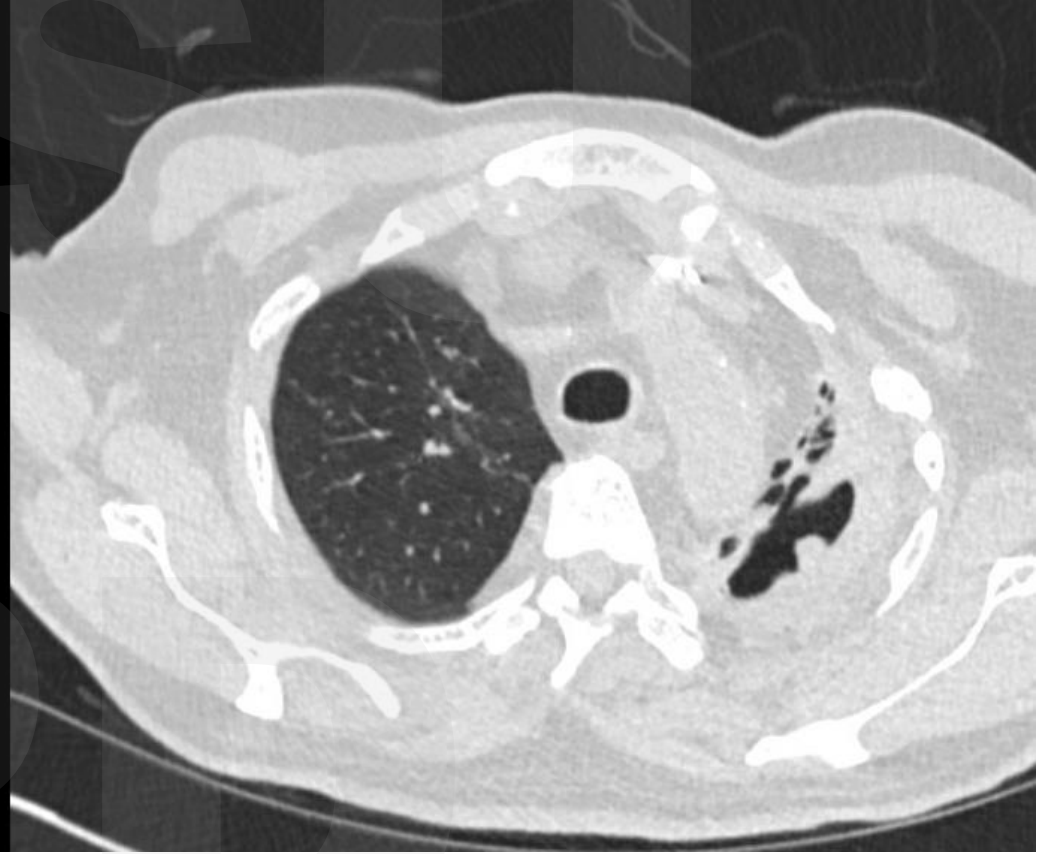
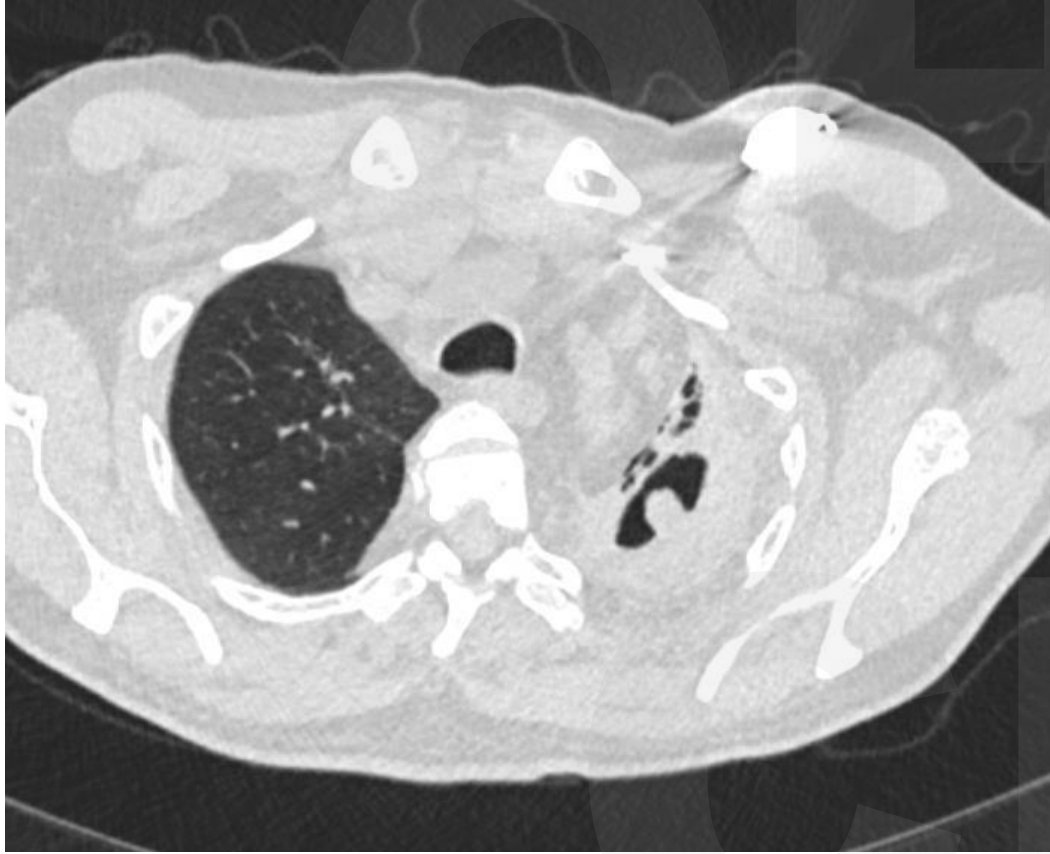
C-500 W:1500 Thin MPR 0.63 mm 143%

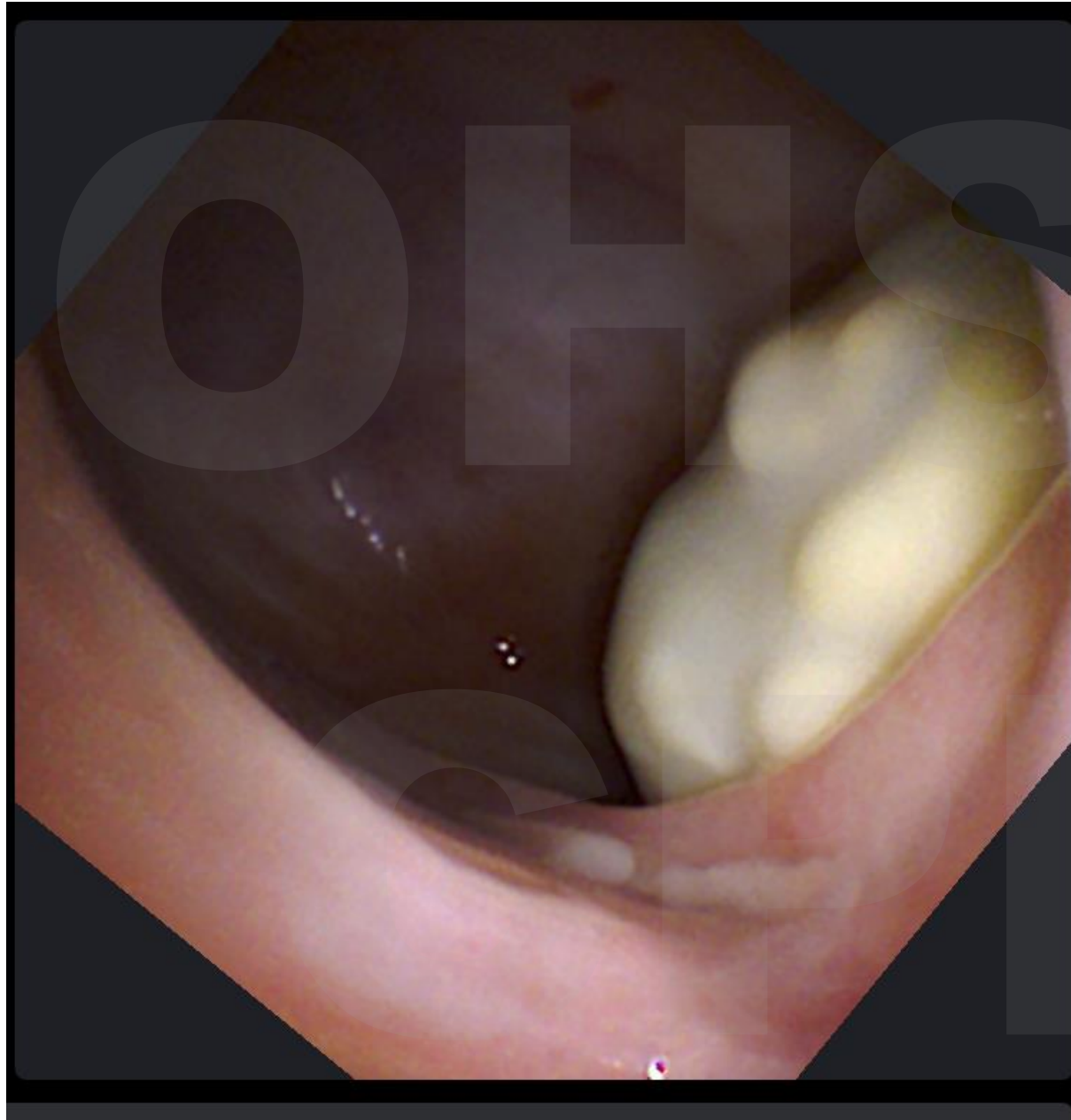


- Biopsy:
 - Mucinous adenocarcinoma, consistent with endometrial primary

Mr. B

- 70 y.o. male
- History of treated TB, pulmonary aspergillosis and actinomyces
- IA NSCLC 2013 s/p wedge resection on remission.





Distance To Target Edge

Near	Far
12 mm	18 mm

Anatomy Border

-- mm

Reference Area

Near	Far	Point
-- mm	-- mm	-- mm

Bend Radius **13** mm



Part II: Bronchoscopic Lung Volume Reduction

- Endobronchial Valves for Severe Emphysema
- History, Evidence, and Patient Selection

Zephyr® Endobronchial Valve



Spiration® Valve System



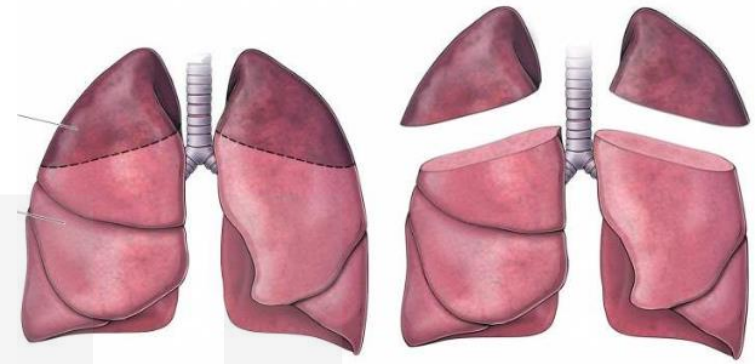
COPD and Emphysema: The burden

- COPD affects ~16 million Americans
- Hyperinflation drives symptoms:
- Increased residual volume (RV) and total lung capacity (TLC)
- Flattened diaphragm reduces mechanical efficiency
- Dynamic hyperinflation with exertion causes dyspnea

- Pharmacotherapy improves symptoms but does not reverse hyperinflation
- Most severe patients (GOLD III-IV) remain highly symptomatic



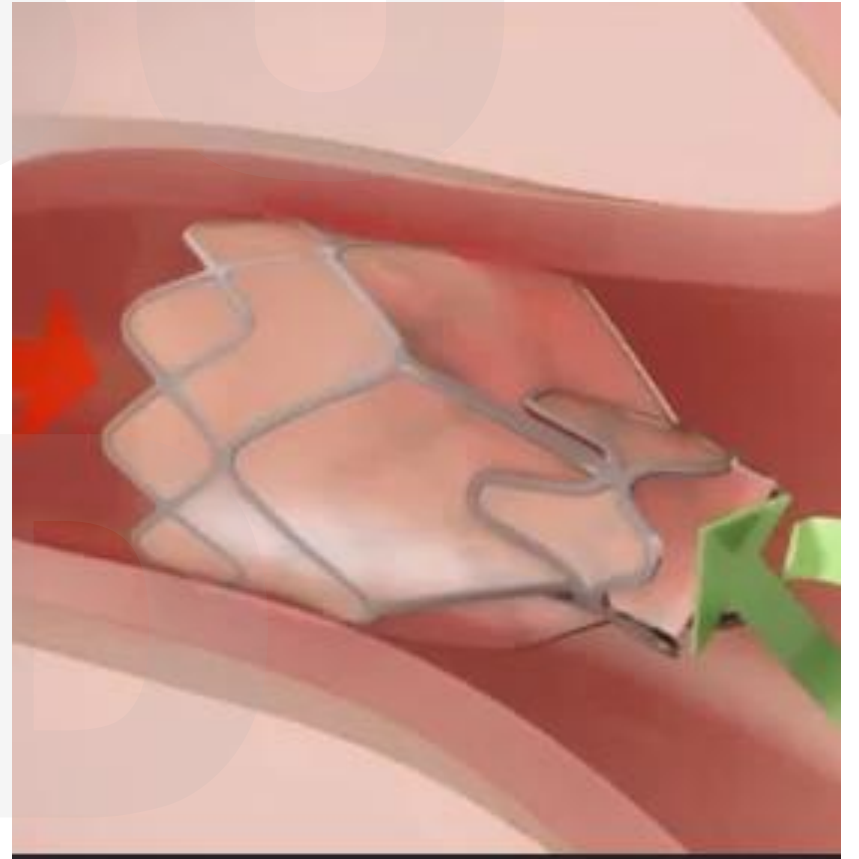
Lung Volume Reduction Surgery



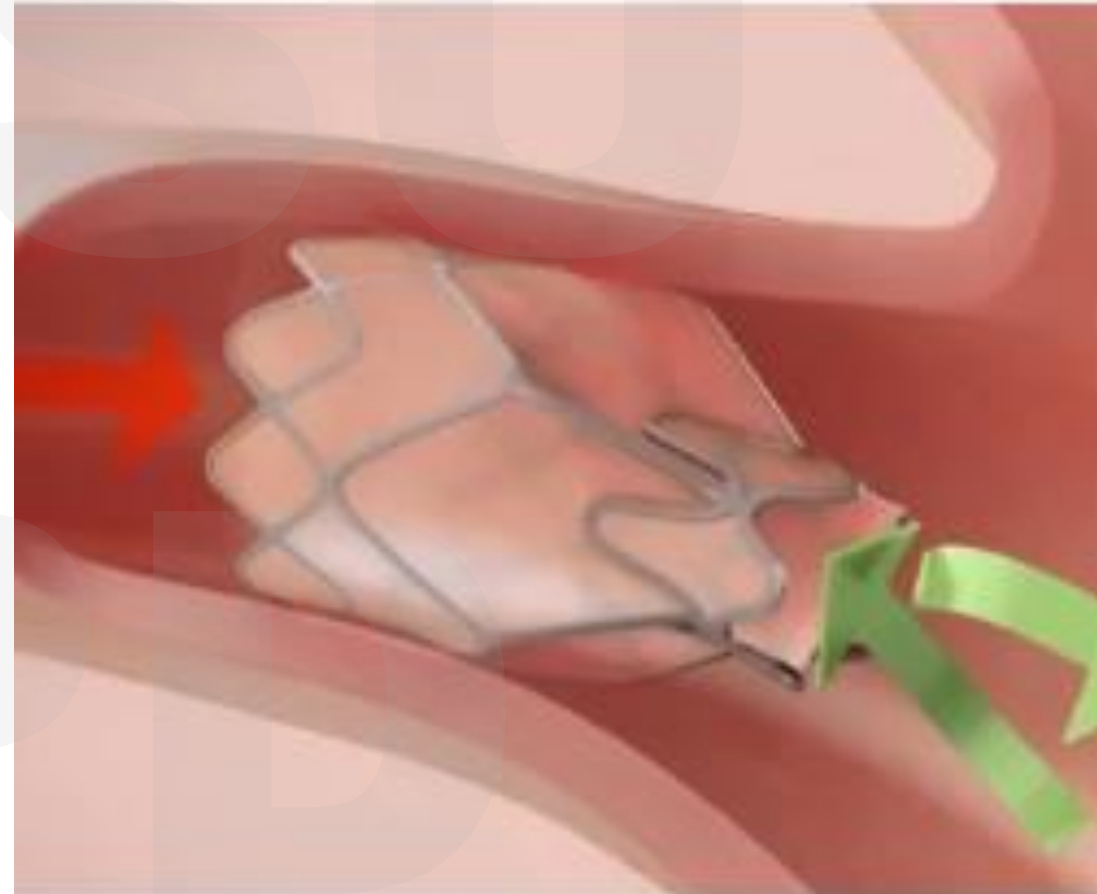
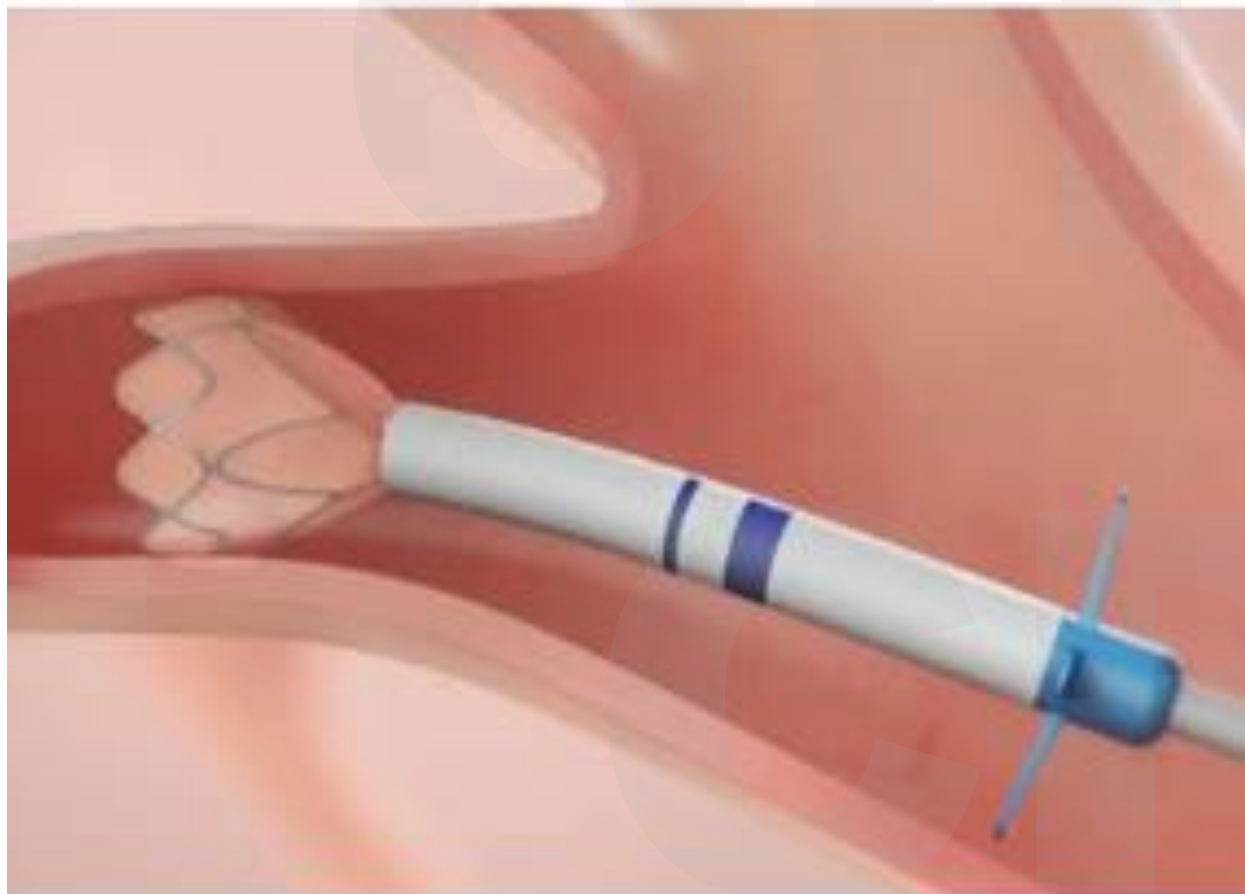
- NETT Trial (2003): landmark RCT, LVRS vs. medical therapy
- Key findings:
 - Upper-lobe predominant emphysema + low exercise capacity: significant survival benefit and improved FEV1, 6MWD, and quality of life
- However, LVRS has significant limitations:
 - 30-day mortality ~5% in high-risk groups
 - Prolonged air leak (most common complication)
 - Not feasible for patients with homogeneous disease or poor reserve
 - Only ~5% of patients with severe emphysema are sur

Bronchoscopic Lung Volume Reduction (BLVR)

- Hypothesis: Achieve the physiologic benefit of LVRS without surgery
- Endobronchial valves (EBV) - the leading BLVR approach:
 - One-way valves placed bronchoscopically
 - Allow air/secretions to escape but prevent re-entry
 - Target lobe deflates over days to weeks
 - FDA approved 2018



BLVR



Data

- LIBERATE Trial (NEJM 2019) - Zephyr EBV:
 - RCT vs. sham bronchoscopy
 - Primary endpoint: FEV1 improvement >15% at 12 months
 - EBV: 47.7% achieved endpoint vs. 16.8% sham ($p < 0.001$)
 - Improved 6MWD, St. George QOL, and SGRQ
- EMPROVE Trial (CHEST 2019) - Spiration Valve:
 - Significant improvement in FEV1, RV, and exercise tolerance
- Meta-analyses: EBV superior to sham in heterogeneous emphysema with complete fissures

Patient selection

- Inclusion criteria:
 - Severe emphysema: FEV1 15-45% predicted
 - Significant hyperinflation: RV >175%, TLC >100%
 - CT: heterogeneous or upper-lobe predominant emphysema
 - 6MWD >100m (some functional reserve)
 - Optimized medical therapy, pulmonary rehab completed
 - Critical requirement: Complete interlobar fissure
 -
- Exclusion criteria:
 - Active infection or significant bronchiectasis
 - DLCO <20% predicted
 - Pulmonary hypertension (mPAP >35 mmHg)

Complications

- COPD exacerbation (post-valve placement) - ~25% within first 6 weeks
- Pneumothorax: 20-30% (major complication, often requires intervention)
- Valve expectoration: ~5%
- Valve migration: rare

Mr. C

- 64 yo M
- Emphysema
- Decreased exercise tolerance and severe limitation on ADLs
- “I just want to be able to walk back on the beach again, doc”

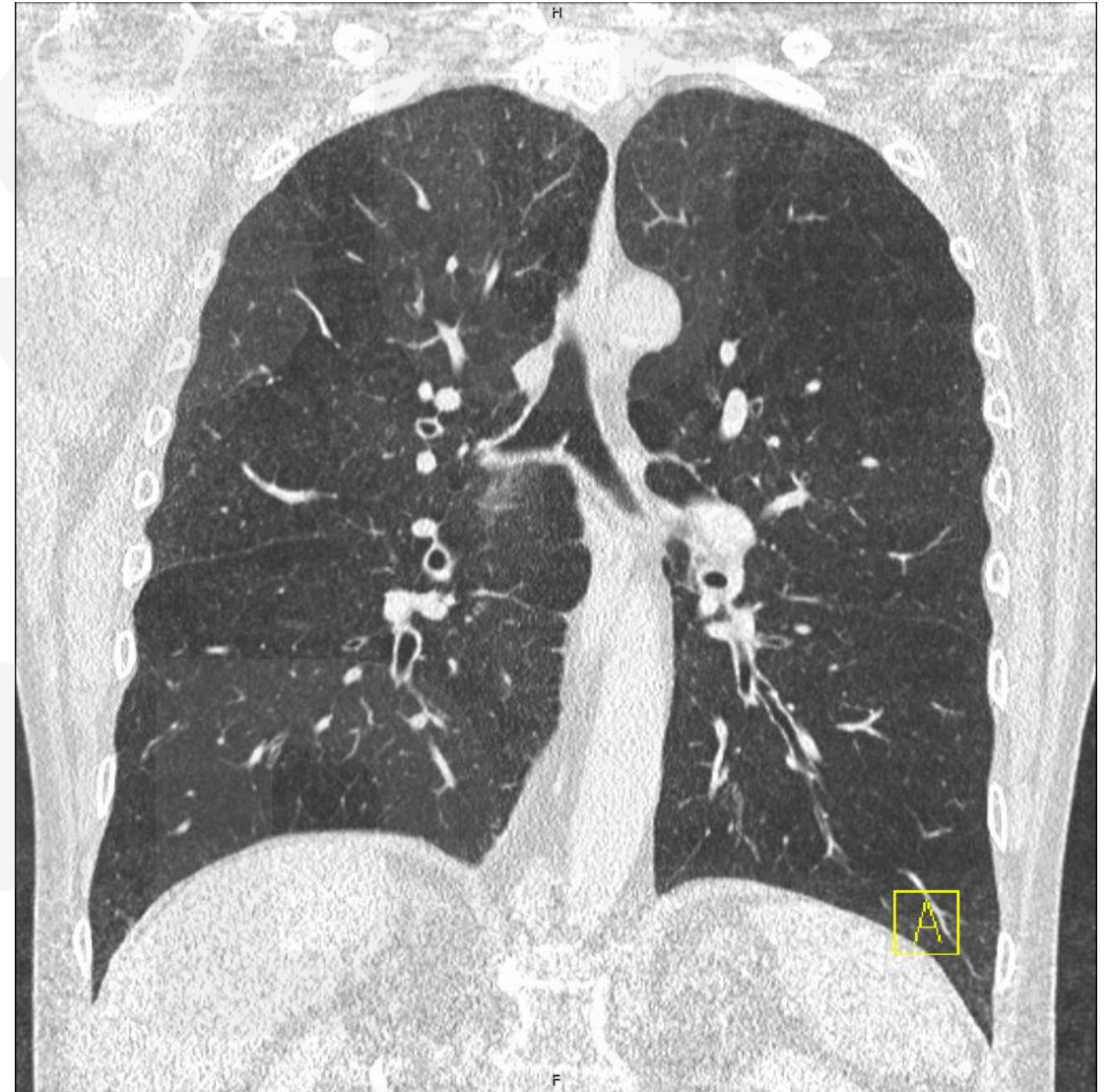
Parameter	Units	Pre-Bronchodilator				Post-Bronchodilator			
		Result	LLN	Z-score	% Pred	Result	Z-score	% Pred	% Chg
FVC	L	2.27	2.02	-1.09	82	2.36	-0.89	86	4
FEV ₁	L	0.60	1.62	-4.07	27	0.60	-4.07	27	0
FEV ₁ / FVC	%	26	69	-4.54		25	-4.56		-4
FEF ₂₅₋₇₅ [ISO]	L/s	0.18	1.22	---	8	0.20	---	9	11
FEF ₇₅	L/s	0.10	0.28	-3.34	15	0.11	-3.19	16	10
PEFR	L/s	1.95	4.51	---	32	1.75	---	29	-10
PIFR	L/s	2.56	0.00	---	63	3.03	---	75	18
FET	s	15.55	6.00	---		15.37	---		-1
FeNo				---			---		
SVC	L		2.55	-2.30			---		
MVV	L/min	22.4	61.8	---	24		---		
CPF	L/s		6.65	---			---		
MIP	cmH ₂ O		42	---			---		
MEP	cmH ₂ O		49	---			---		

Reference: GLI 2017 Test Quality: Pre BD: FEV1 = A, FVC = A Post BD: FEV1 = A, FVC = A

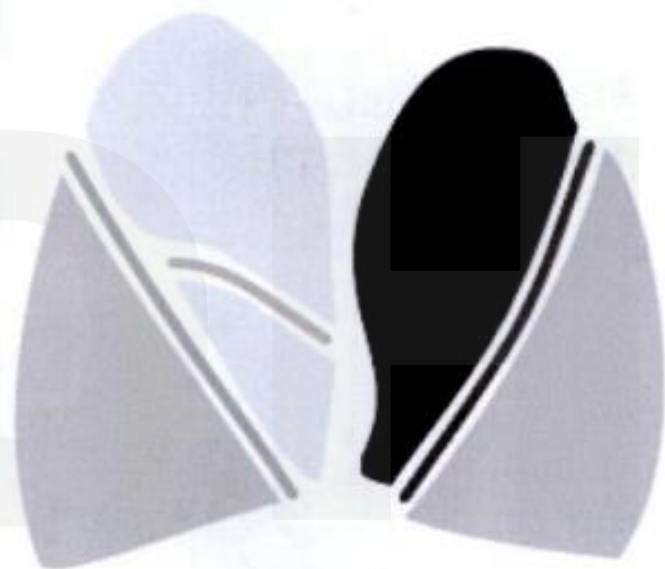
Lung Volumes Box

Parameter	Units	Pre-Bronchodilator				
		Result	LLN	ULN	Z-score	%Pred
TLC	L	5.25	3.82	5.68	0.94	112
VC	L	2.27	2.55	3.91	-2.30	70
RV	L	2.98	0.91	2.27	2.89	199
RV/TLC	%	57	21	43	3.47	178
FRC	L	4.58	1.72	3.30	3.53	189
ERV	L	1.60	0.30	1.53	1.78	200

Reference values: GLI 2021; Test Quality: Failed



SUMMARY

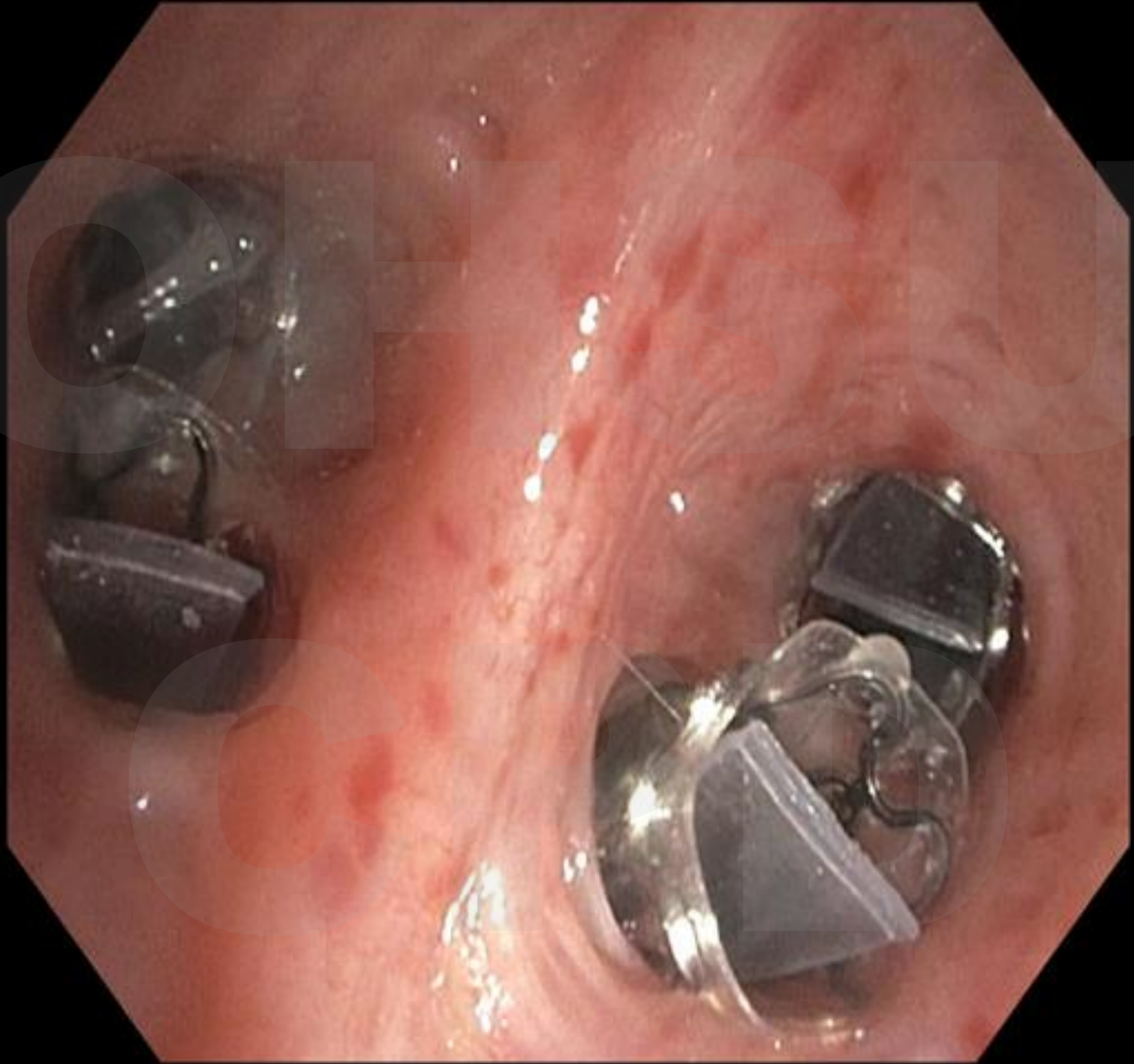


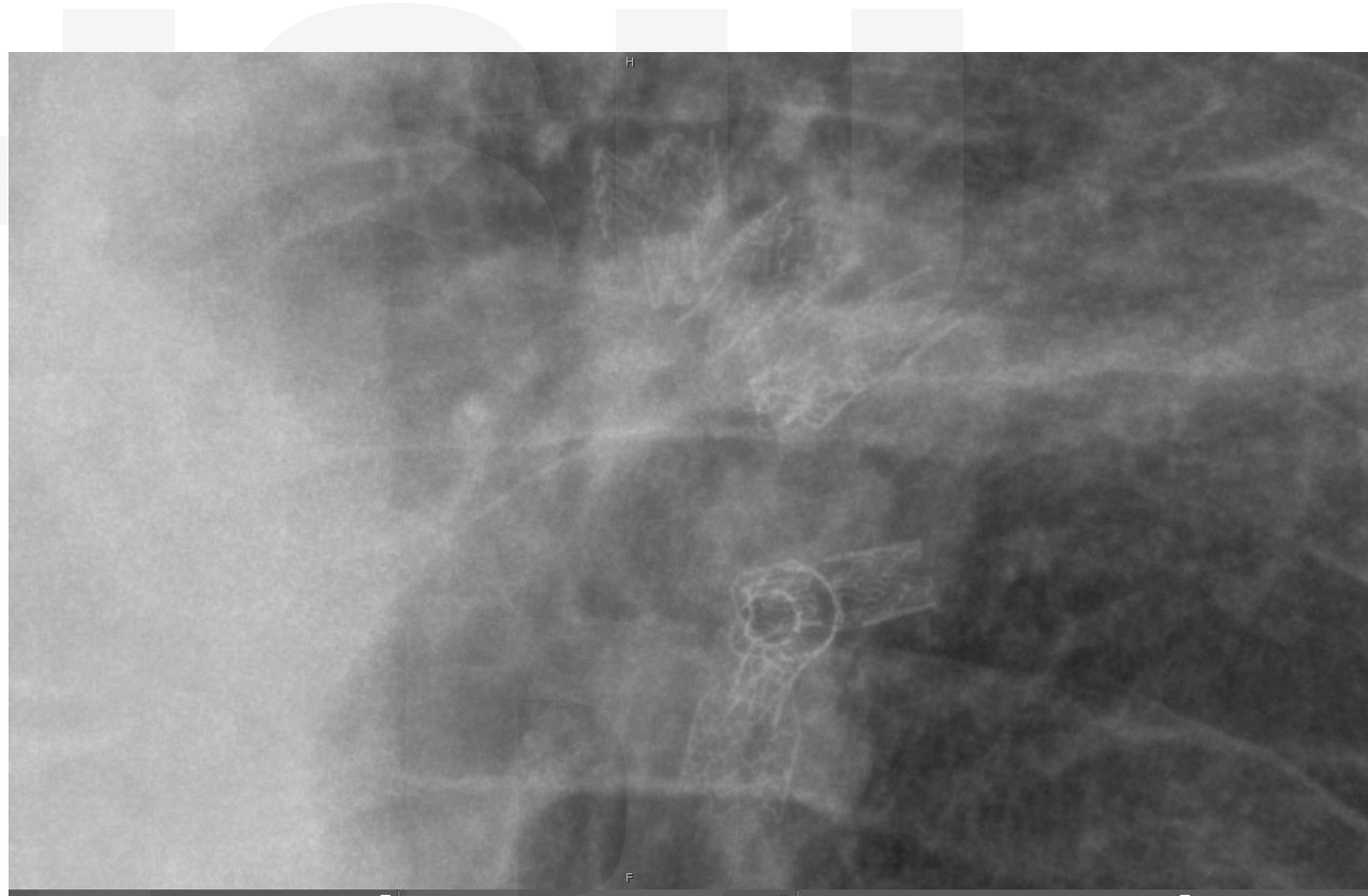
KEY

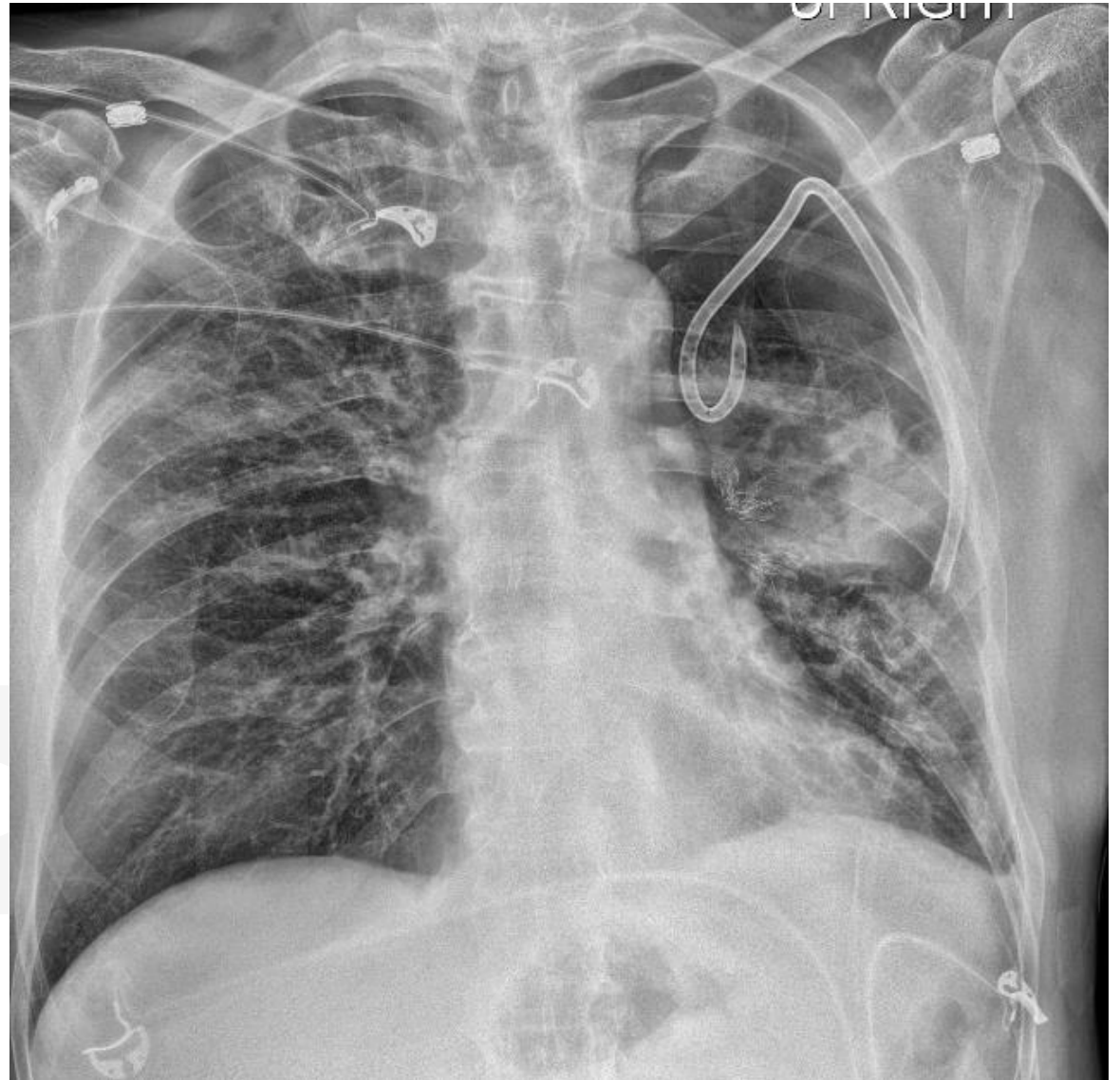
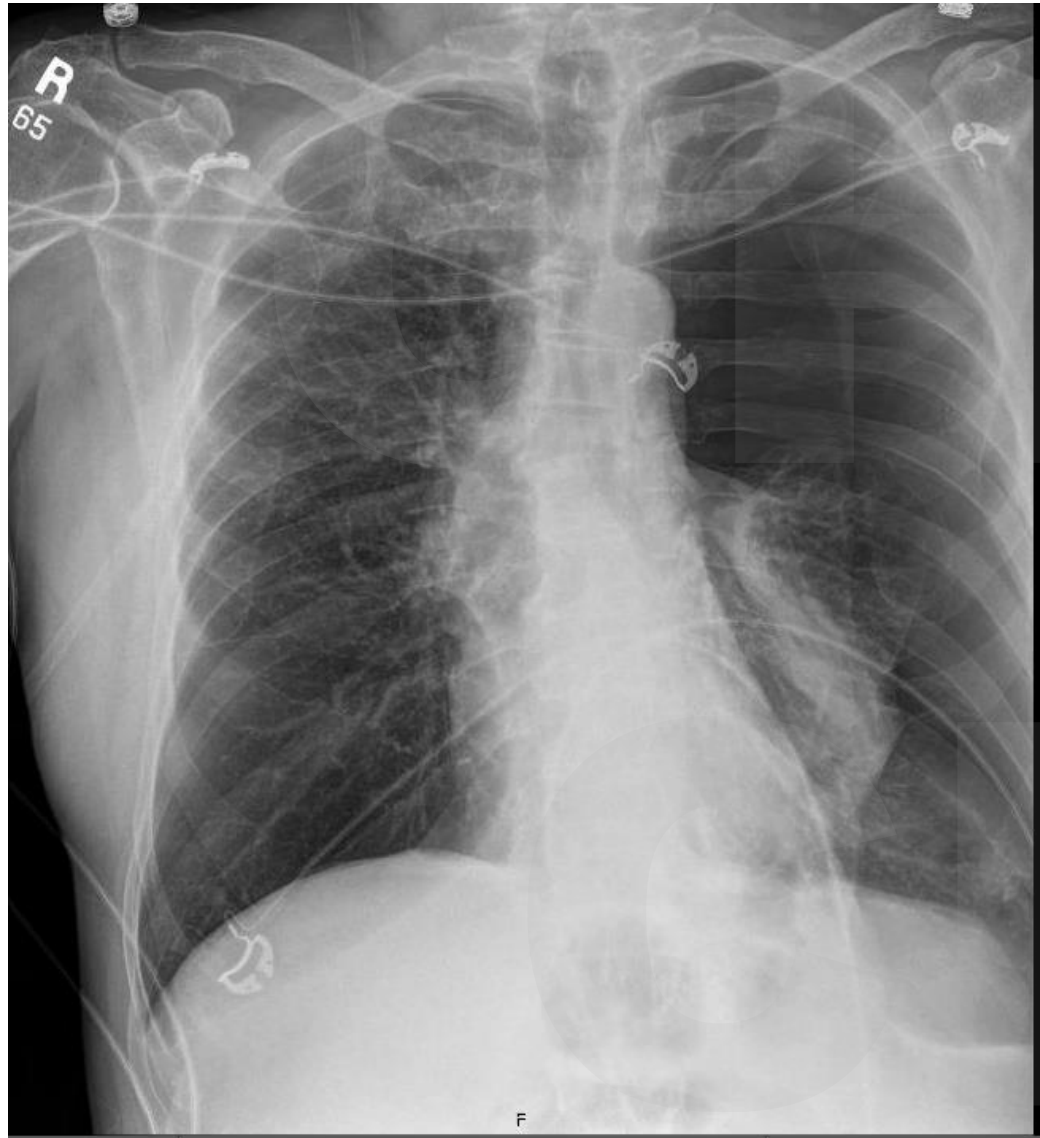
- $\geq 70\%$ Voxel Density
Less Than -910 HU
- $\geq 60 - < 70\%$ Voxel Density
Less Than -910 HU
- $\geq 50 - < 60\%$ Voxel Density
Less Than -910 HU
- $< 50\%$ Voxel Density
Less Than -910 HU
- $\geq 95\%$ Fissure Completeness
- $\geq 80 - < 95\%$ Fissure Completeness
- $< 80\%$ Fissure Completeness

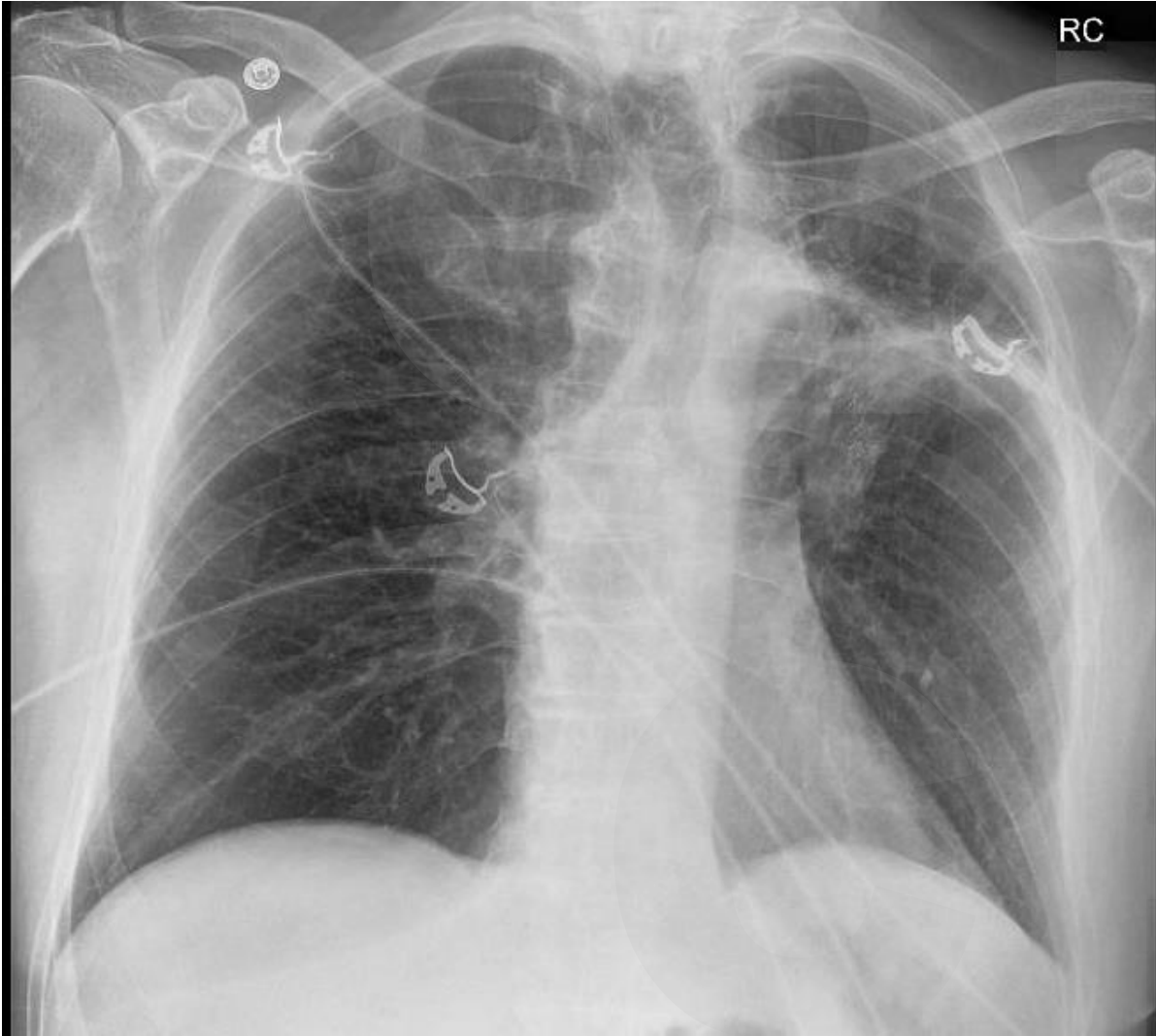
RESULTS

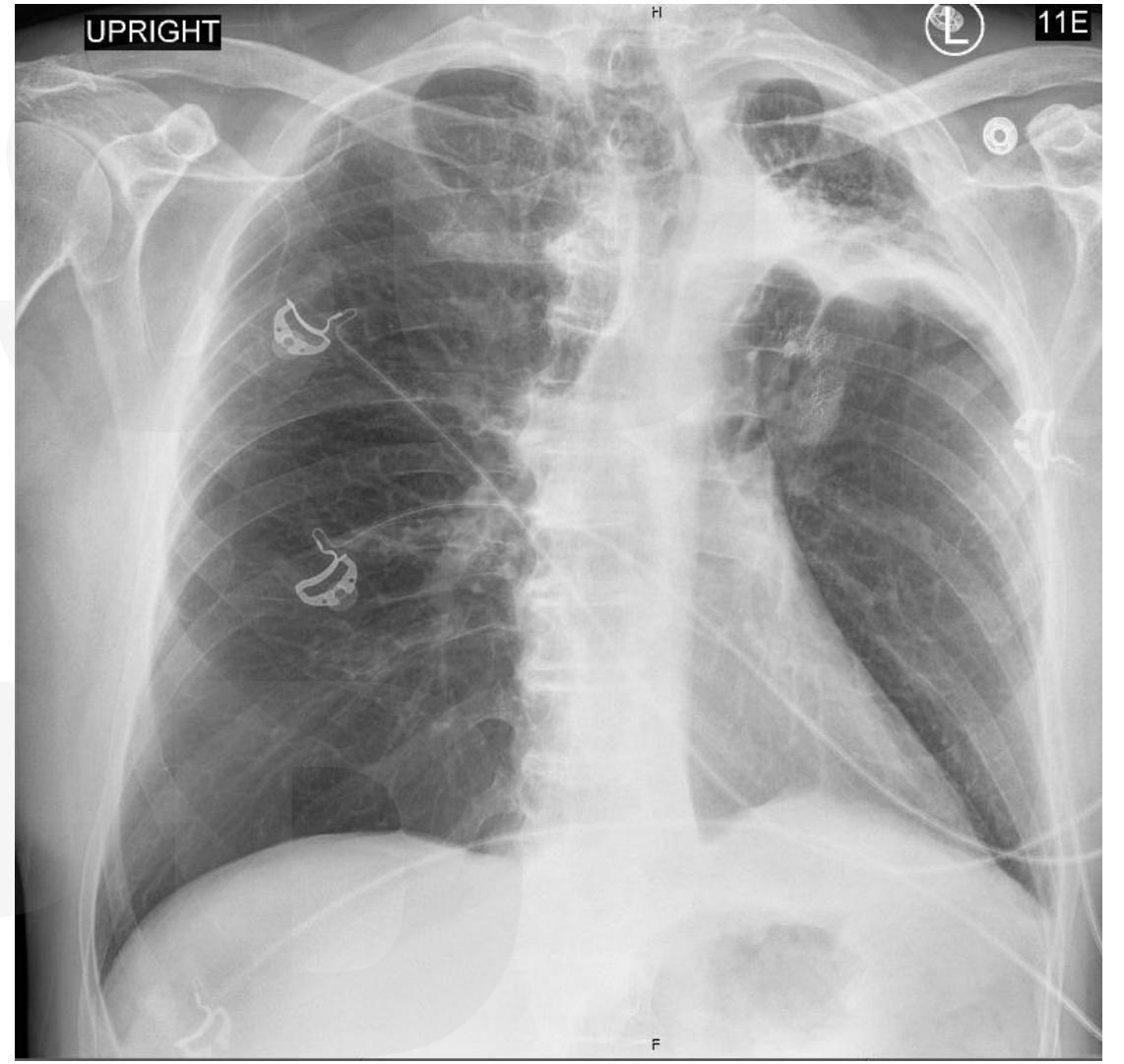
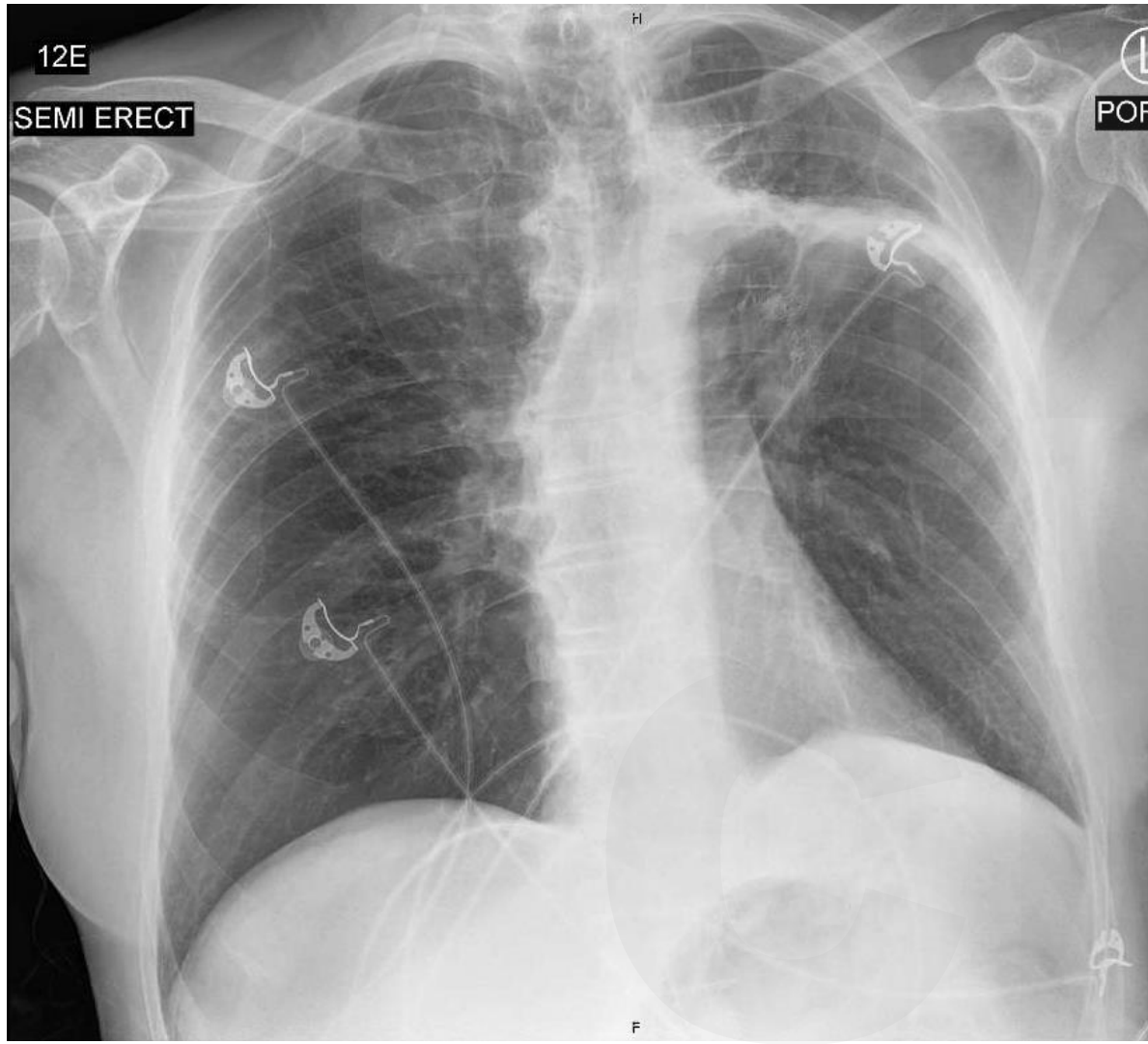
	RIGHT LUNG				LEFT LUNG	
	RUL	RUL+RML	RML	RLL	LUL	LLL
% Fissure Completeness	80	90	82	90	95	95
% Voxel Density Less Than -910 HU	56	56	57	68	73	64
% Voxel Density Less Than -950 HU	27	27	27	49	41	37
Inspiratory Volume (ml)	1521	1825	305	1766	2326	1231











OHSU

Thanks

CPD