PRACTICAL APPROACH TO LUNG NODULES

Dr Lokesh Yagnik

Interventional Pulmonologist

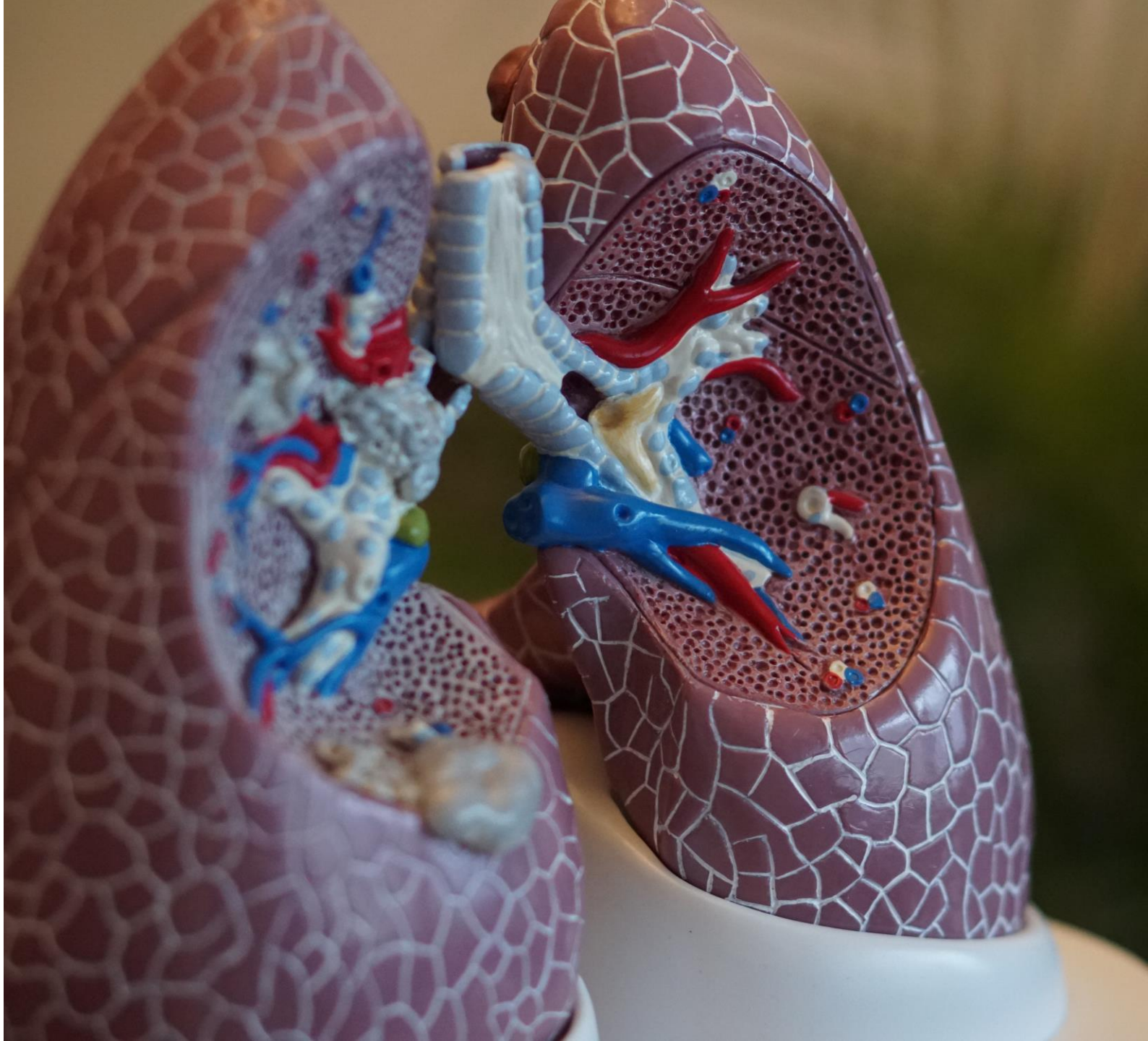
2026

FIONA STANLEY hospital

INTERVENTIONAL Pulmonology Clinic

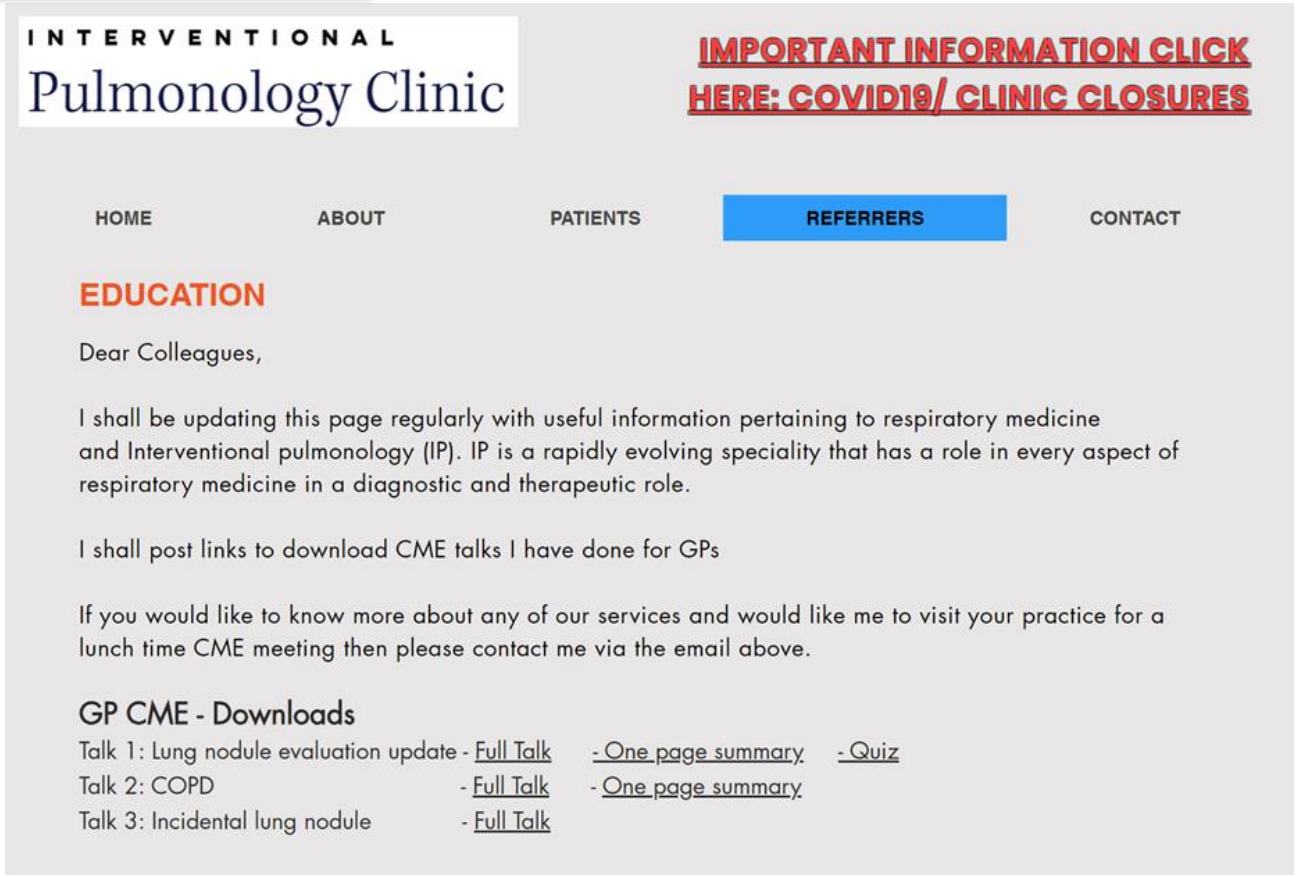
Disclosures

I do not have any financial or other disclosures



PDF of previous talks are available for download at

www.lokeshyagnik.com/education



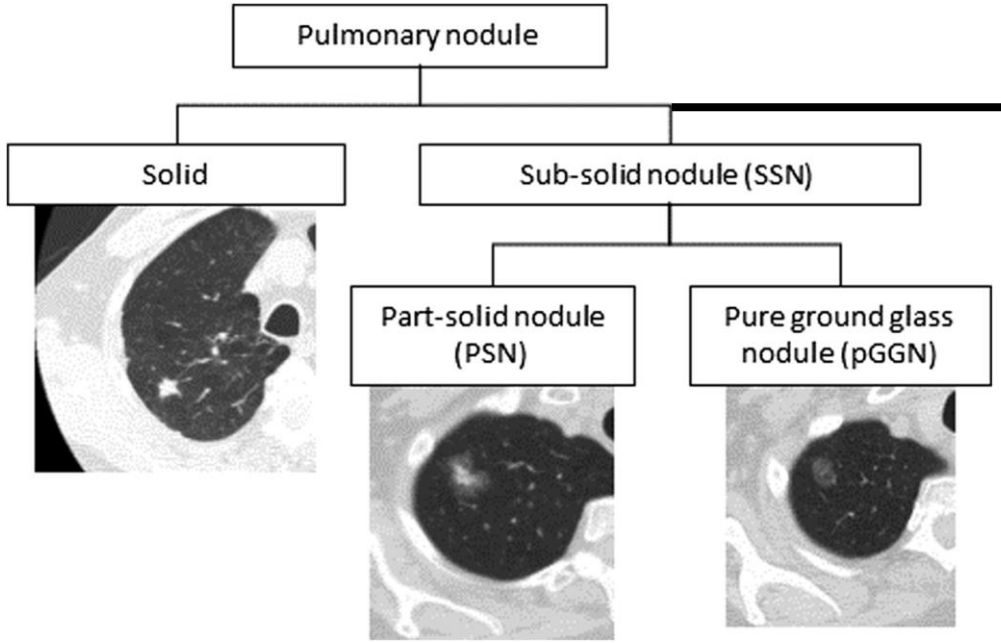
Topics

A. What is a lung nodule?
B. What are they important?
C. Initial Clinical assessment
D. Diagnostic Approach and Management update

What is a lung nodule?

Well defined pulmonary parenchymal opacity < 3cm in size

Consolidation/other terminologies have specific radiological definitions



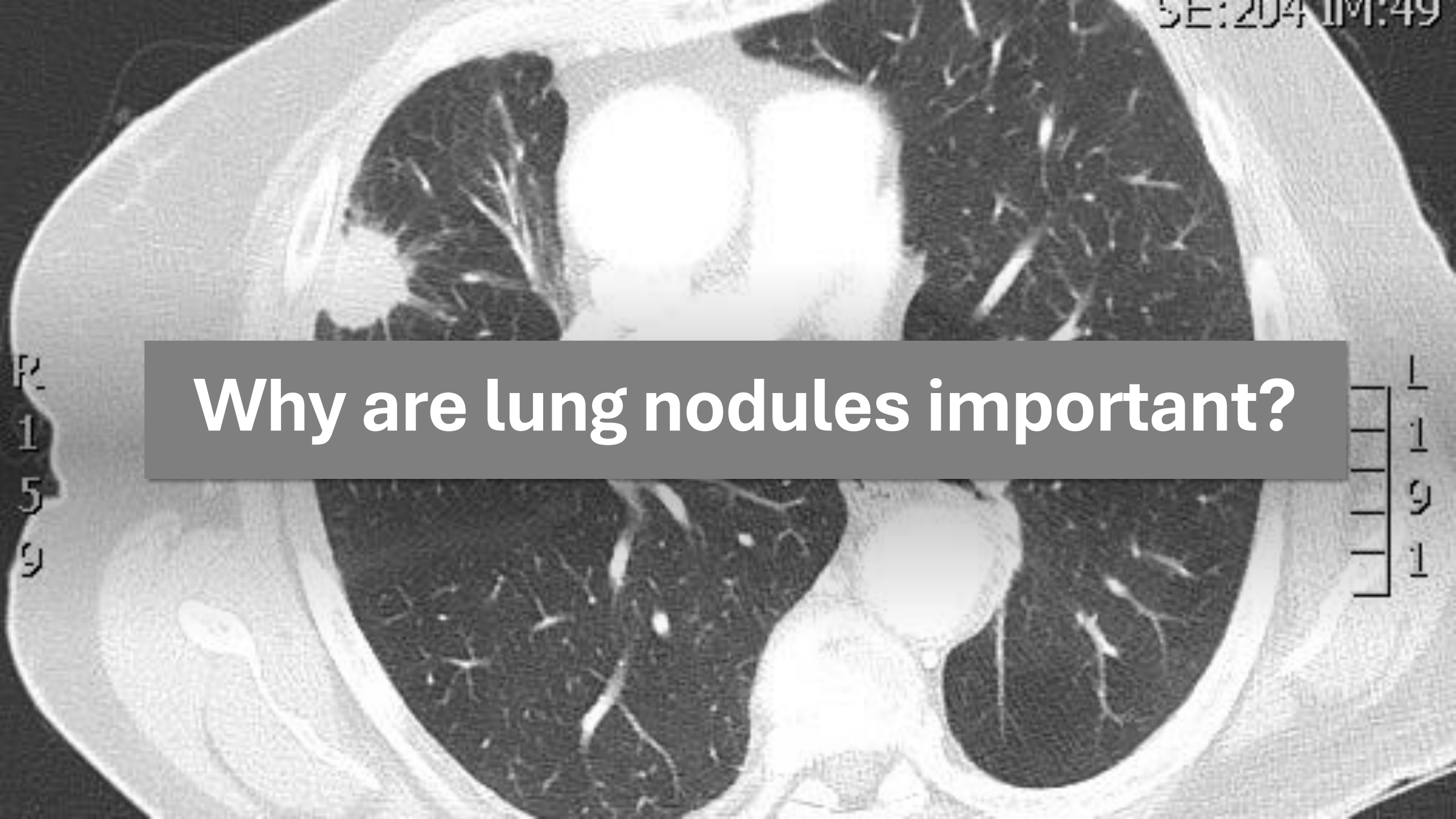
Type 1 exophytic solid nodule
Type 2 endophytic solid nodule
Type 3 asymmetrical or circumferential wall thickening
Type 4 multilocular cystic lesion

Perifissural nodules are benign representing intrapulmonary lymph nodes*

Lung cancer associated with cystic air spaces (LC-CAS)

Guidelines for Management of Incidental Pulmonary Nodules Detected on CT Images: From the Fleischner Society 2017 MacMahon et al Radiology: Volume 284: Number 1—July 2017

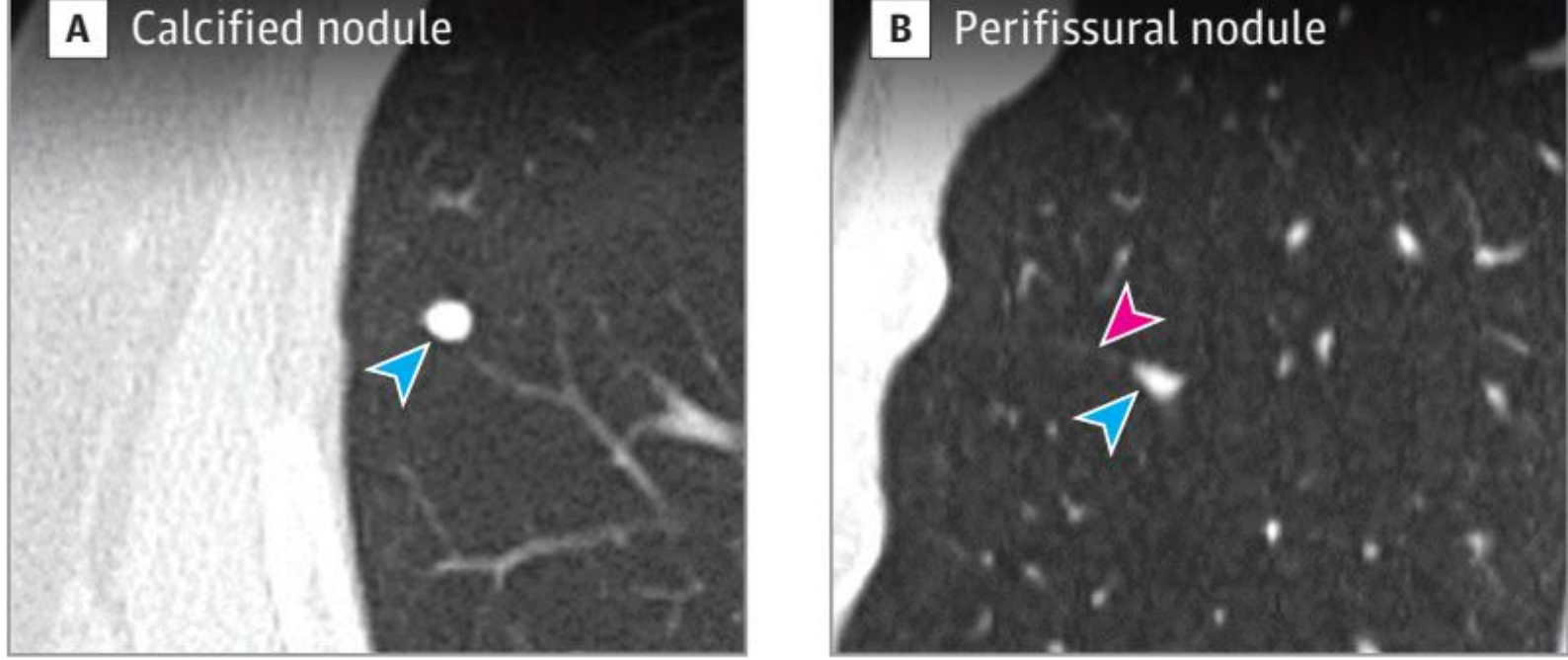
Snoeckx et al J Thorac Dis 2019;11(3):987-1004
Mets et al Eur Respir Rev 2018; 27: 180079

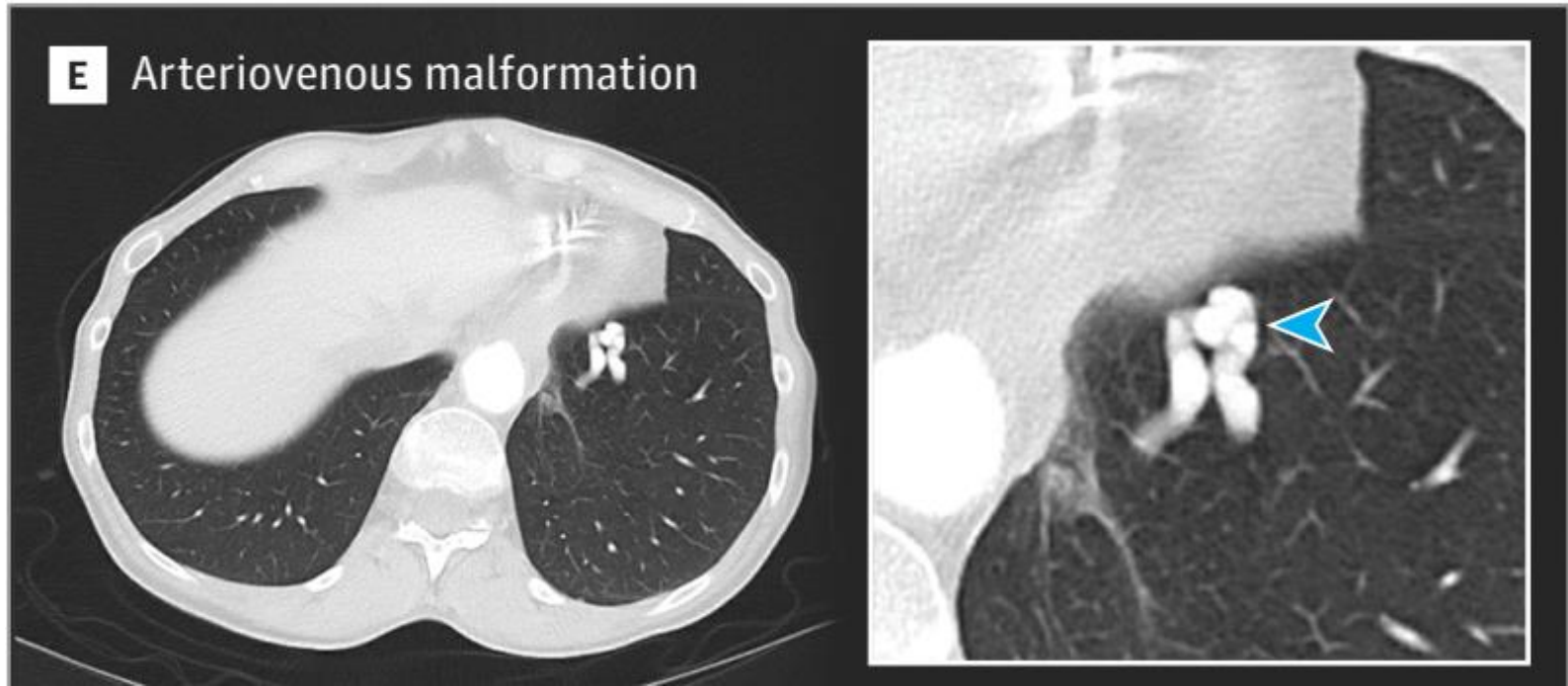


Why are lung nodules important?

1. Lung nodules are common

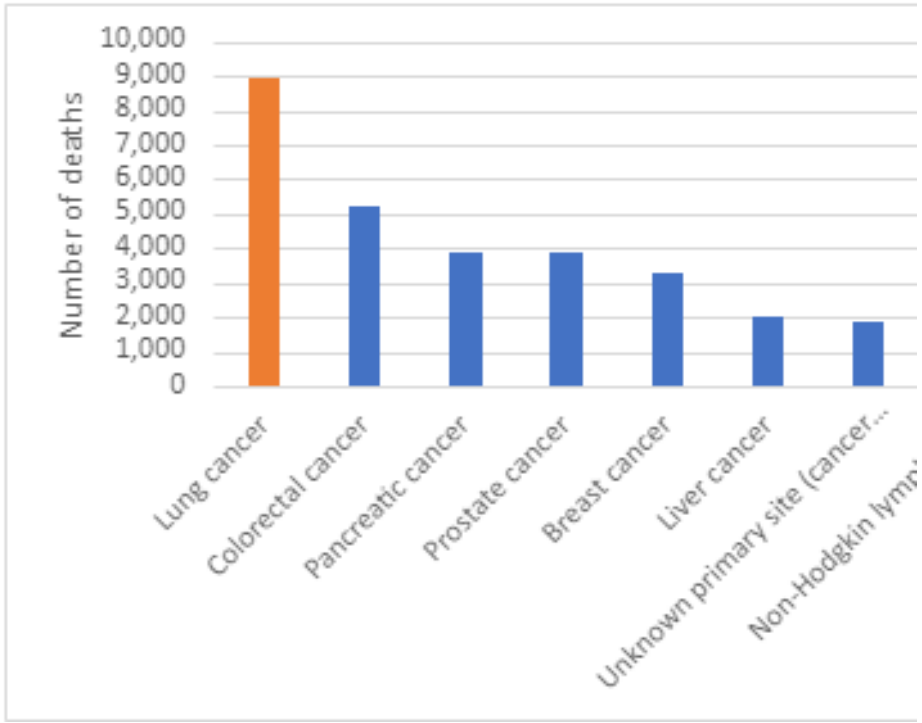
- USA: 1.6 million people /year
- 95% of detected lung nodules are benign
- Incidental findings ~ 30% of all CT chest



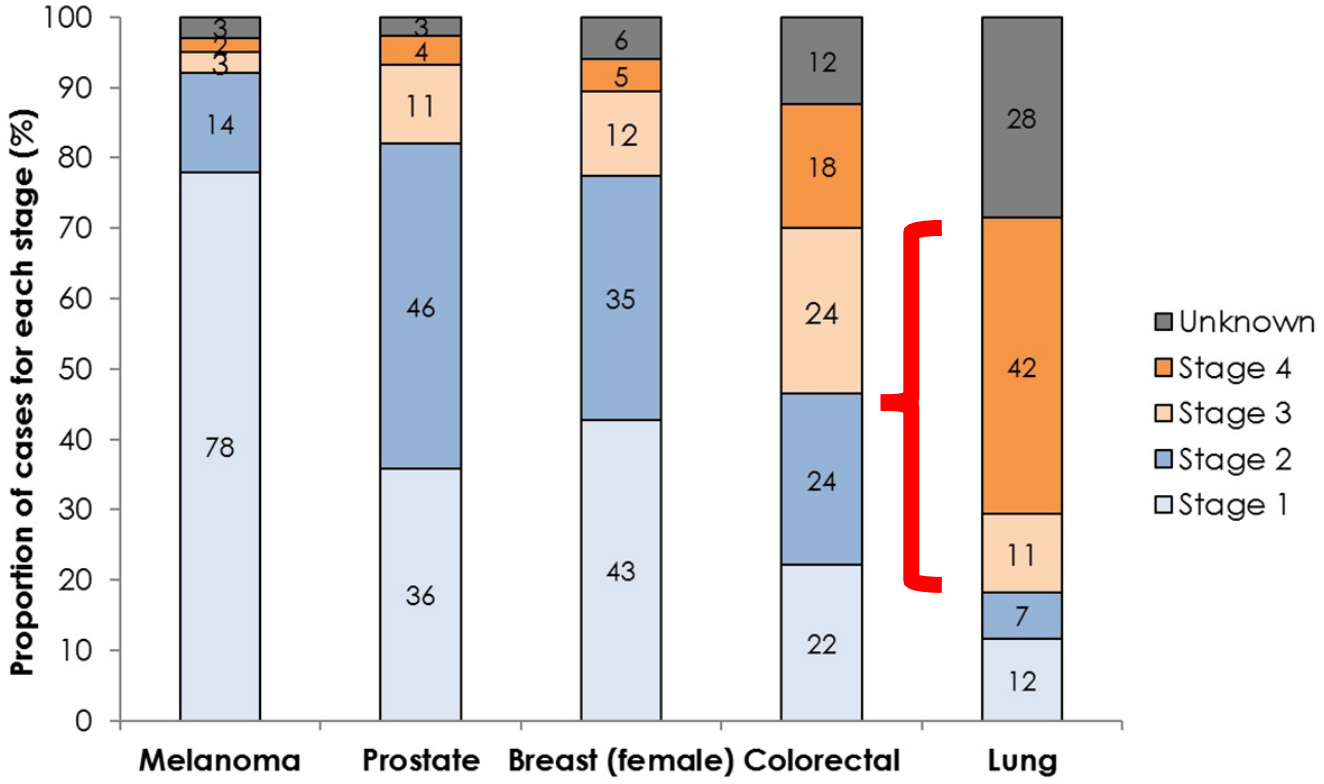


Mazzone et al JAMA January 18, 2022 Volume 327, Number 3

2. Lung nodule may be an early stage lung cancer



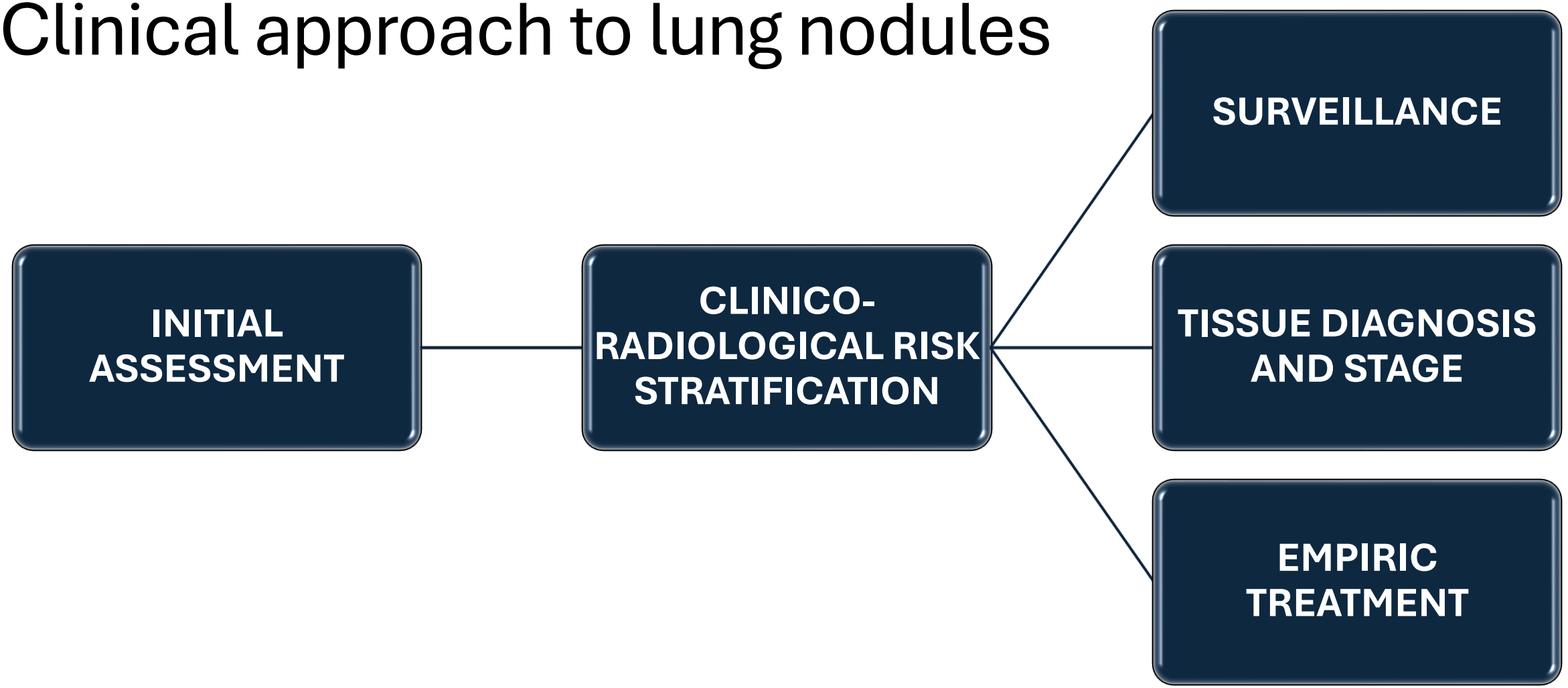
Most common cause of cancer death in Australia



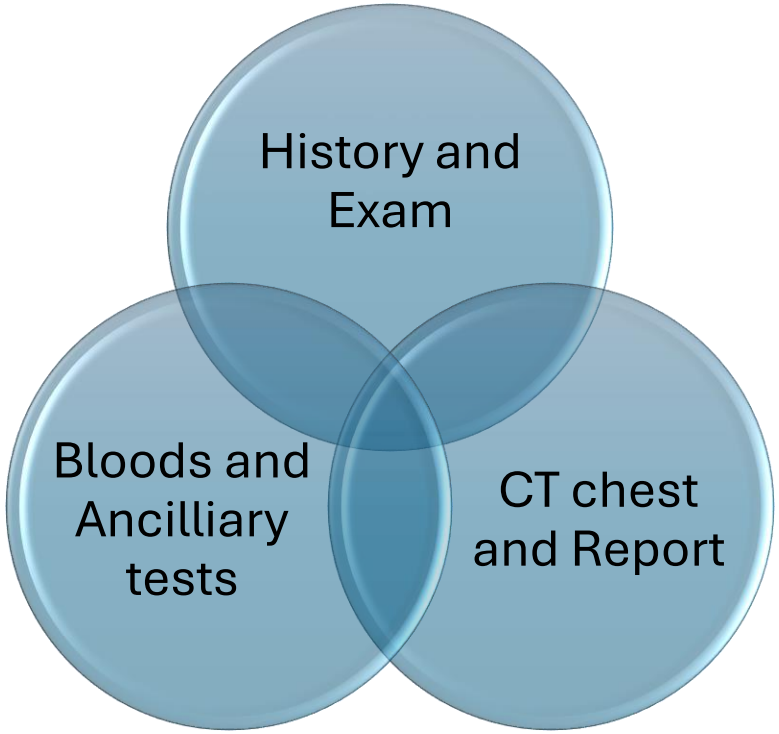
Majority are Stage 3 or 4 at diagnosis

Cancer Australia

Clinical approach to lung nodules



Initial clinical assessment



- High Suspicion for Lung cancer
- Clinical Case
- Incidental Lung nodule
- Screen detected Lung nodule

History and exam

Risk factors	Past History
- Cigarette Smoking history - Second hand smoke - Vaping, THC, ECigarettes - Asbestos exposure - Family history - Travel and TB exposure	- Any previous presentations that may resulted in CT imaging - History of solid organ malignancy - Immunosuppression - Autoimmune conditions
Clinical Presentation	**Exam**
- Asymptomatic - Clinical symptoms - Cognitive and mental status - Physical performance status	- Usually no specific findings - Signs of “Risk factors” and “Past history” - Signs of systemic disease

Blood Work and ancillary tests

Bloods	Ancilliary tests
FBC – Anaemia, cytopenia, inflammatory picture UEC/LFT – Systems involvement CRP – Inflammatory/Infectious process Coags – pre-procedure	Depends on the presentation - ECG - Echo - Urine testing - Brain/liver imaging etc

CT chest and Report

Partial CT Chest

- Partial CT
  - Cardiac CT, head and neck CT, Aortic CT, Abdominal CT

  - May miss other nodules
  - May miss key findings which aid management planning
  - Inaccurate for nodule size measurement

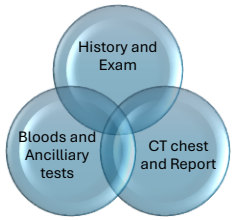
  - **First step is to request a CT chest**

CT chest

- CT chest
  - **CT chest (+/- contrast) – Thin slices**
  - NOT HRCT – this is for ILD

Analysing a CT Chest report

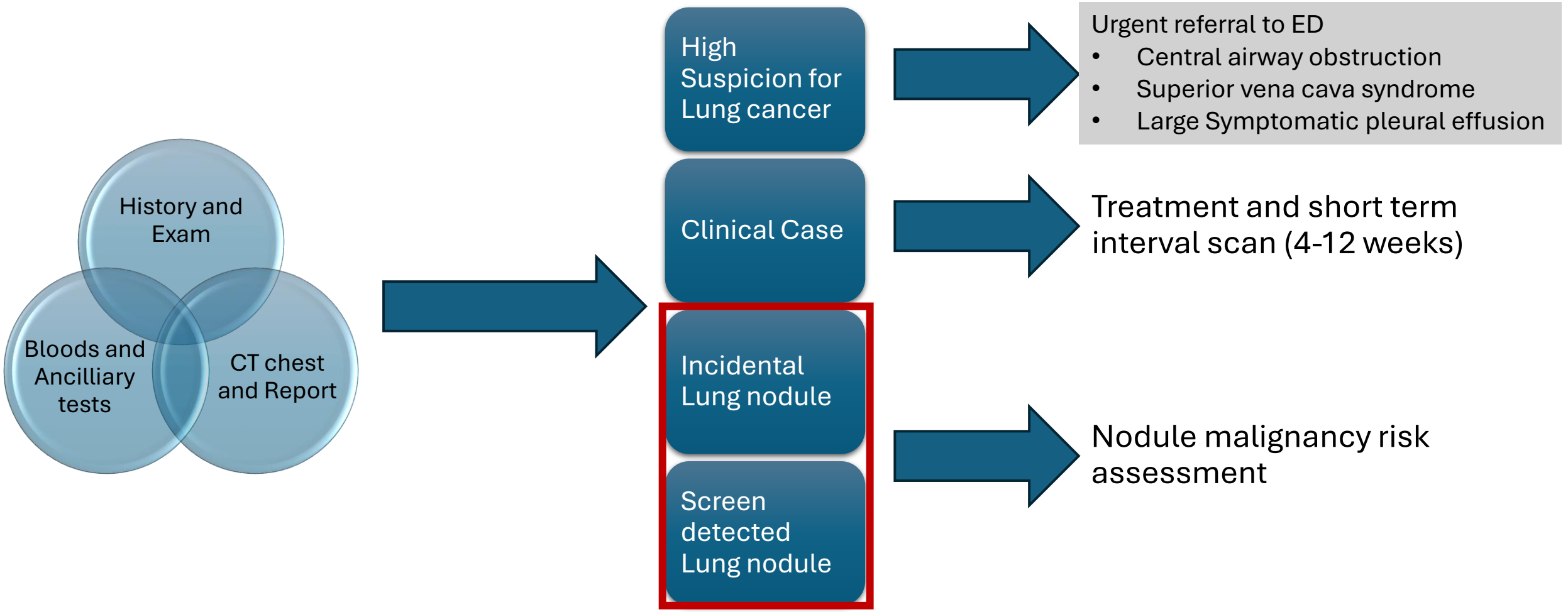
Clinical history	Clinical context
CT acquisition protocol	Is it appropriate for lung nodule assessment ? slice thickness
Comparison	How far back has the comparison been made?
Body of the report	Is there systematic organ specific reporting of radiological findings? Is the nodule fully described? What are the features?
Conclusion and recommendation	Are any findings from the report body missing ? Is there a differential ?
Reporting Radiologist	Is it a chest radiologist?
Fine details	Radiation dose, Volumetry, Screen shots



Initial Clinical Assessment

High Suspicion for Lung cancer	Lung mass (>3cm) Lung nodule with thoracic lymphadenopathy, effusion, atelectasis
Clinical Case	Acute clinical presentation Findings may reflect alternative non neoplastic pathology eg pulmonary infarct, pneumonia, organising pneumonia
Incidental Lung nodule	Detected on scan performed for an unrelated reason Patient does not meet criteria for screening Asymptomatic/Symptoms due to other disease process
Screen detected Lung nodule	Detected on formal or ad hoc lung cancer screening CT Incidental nodule but patient meets criteria for screening Asymptomatic

Clinical assessment



Nodule Malignancy risk ASSESSMENT

- **Radiological characteristics:** Type, size, spiculation, architectural distortion
- **Clinical characteristics:** Smoking history, radiation exposure, family and past history
- **CT indication characteristics:** Incidental vs Symptomatic vs Screen detected

Radiologist recommendation are based on nodule radiological characteristics

- Size
- Spiculation
- Persistence
- Enlargement
- Architectural distortion
- Calcification pattern

A. Benign nodule
B. Surveillance
C. Referral

Guidelines for Management of Incidental Pulmonary Nodules Detected on CT Images: From the Fleischner Society 2017 MacMahon et al Radiology: Volume 284: Number 1—July 2017

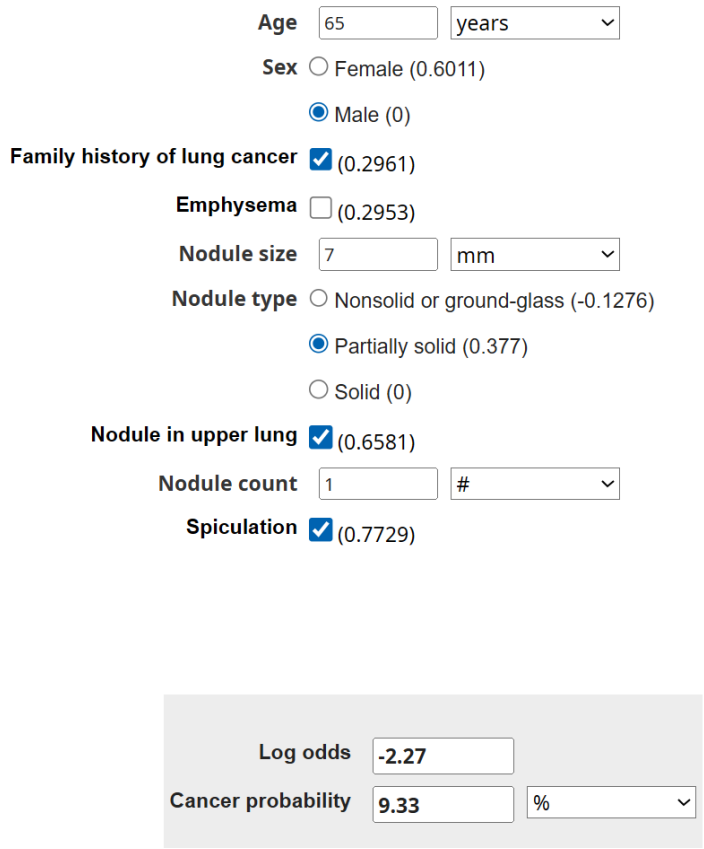
Clinician assessments - Risk calculators

RISK PREDICTION MODEL	MAYO CLINIC MODEL	HERDER MODEL	VA MODEL	BROCK UNIVERSITY MODEL	CLEVELAND CLINIC MODEL
YEAR	1997s	2005	2007	2013	2019
TOTAL PATIENTS	629	106	375	1871	301
NODULE DETECTION	Incidental on CXR	Incidental on CXR + PET	Incidental on CXR + CT +/- PET	LDCT as part of screening	Incidental nodule referred to biopsy/ resection
MALIGNANT NODULES IN DEVELOPMENT COHORT	23%	57%	54%	5.5%	66.5%
VARIABLES	Age, Smoking, Hx extrathoracic malignancy, nodule size, spiculation, UL	Mayo clinic model + FDG PET	Age, smoking, time since quitting smoking, nodule size	Age, gender, nodule size, type, location, count, emphysema, family history,	Age, smoking, UL, solid and irregular/ spiculated edges, Emphysema, PET, Hx non lung ca
AREA UNDER THE CURVE	0.83	0.88	0.79	0.94	0.75-0.82

Choi et al 2019 Annals of ATS

Clinical risk calculators

RISK PRED MODEL	Solitary pulmonary nodule malignancy risk in adults (Brock University cancer prediction equation)	BROCK UNIVERSITY MODEL	CLEVELAND CLINIC MODEL
YEAR		2013	2019
TOTAL PAT		1871	301
NODULE D		LDCT as part of screening	Incidental nodule referred to biopsy/ resection
MALIGNAI NODULES DEVELOPI COHORT		5.5%	66.5%
VARIABLE		Age, gender, nodule size, type, location, count, emphysema, family history,	Age, smoking, UL, solid and irregular/ spiculated edges, Emphysema, PET, Hx non lung ca
AOC		0.94	0.75-0.82



Choi et al 2019 Annals of ATS

Category	Malignancy Risk	LDCT Finding	Recommendation
1	**<1.5%**	Normal finding, benign calcification, perifissural nodule, hamartoma, nodule risk index	Biennial screening
2	**1.5-6%**	Low risk	Annual repeat Screen
3	**6-30%**	Moderate risk	Short term re-scan/Active surveillance in 3 months - No growth, annual screen - Growth, refer for diagnosis - 10-30% risk can be considered for definitive diagnosis
4	**>30%**	High Risk	Work up for definitive diagnosis
5	**>30%**	Suspicious for lung cancer: Mass lesion with non infectious cause, lymphadenopathy irrespective of nodule size	Work up for definitive diagnosis

*ILST Trial

Tammemagi et al BMJ 2014

PET scan not useful in nodule malignancy risk assessment

New England Journal of Medicine 2009;361:32-9

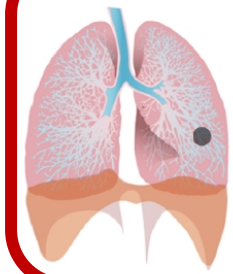
- FDG PET scan is useful for detection of extrathoracic metastasis and prevent unnecessary surgery
- PET/CT is associated with clinically **relevant false positive** lymph nodes
  - DDx Granulomatous disease (TB, Histoplasmosis, Sarcoidosis), Anthrasilicosis

Darling et al J Thorac Oncol. 2011;6: 1367–1372

- Not very useful in
  - Determination of nodule is benign or malignant
  - Small nodules < 8mm
  - Ground glass nodules
  - Thoracic lymph node metastasis

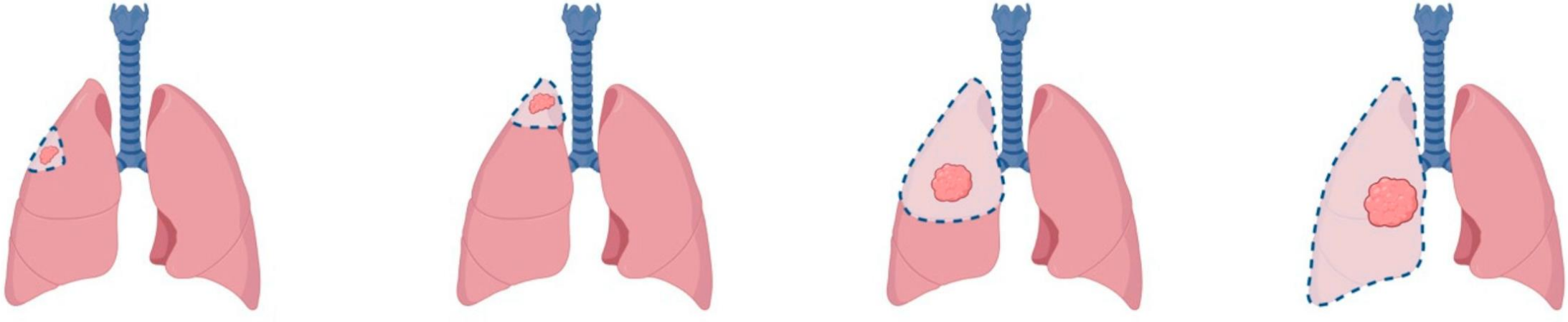
What next ? Establish a diagnosis, stage and treatment plan

Update 1: Resectable Stage 1 NSCLCa



AJCC Stage	Stage grouping (Lung TNM 8th edition)[7]	Frequency at diagnosis[10] (unknown 6%)	Treatment[32,33]	5-year survival for clinical staging[7]
IA1	T1miN0M0 T1aN0M0	30%	Surgery or definitive radiation (for medically inoperable patients)	92%
IA2	T1bN0M0			83%
IA3	T1cN0M0			77%
IB	T2aN0M0		Surgery followed by adjuvant systemic therapy Or Neoadjuvant ICI-chemotherapy followed by surgery For unresected stage III: definitive concurrent chemoradiation followed by consolidation PD-L1 inhibitor	68%
IIA	T2bN0M0	9%		60%
IIB	T1a-T2bN1M0 T3N0M0			53%
IIIA	T1a-T2bN2M0 T3N1M0 T4N0 or N1M0	18%		36%
IIIB	T1-T2N3M0 T3N2M0 or T4N2M0		For unresected stage III: definitive concurrent chemoradiation followed by consolidation PD-L1 inhibitor	26%
IIIC	T3N3M0 or T4N3M0			13%
IVA	AnyTAnyNM1a or M1b	37%	Palliative systemic therapy	10%
IVB	AnyTAnyNM1c			0%

Sublobar resection is non inferior to lobectomy



Wedge resection

Removal of a small section of lung containing the tumor along with a margin of healthy tissue

Segmental resection

Removal of a larger portion of the lung, but not an entire lobe (Right apical segmental resection illustrated)

Lobectomy

Removal of the entire lobe of one lung (Right upper lobe resection illustrated)

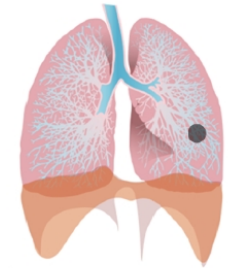
Pneumonectomy

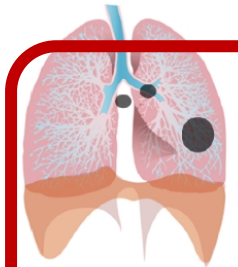
Removal of an entire lung

- Practice changing studies since Ginsberg et al in 1995 (Lobectomy > Pneumonectomy)
- Similar outcomes – DFS, OS

Saji et al Lancet 2022 Apr 23;399(10335):1607-1617, Altorki et al NEJM 2023;388:489-498, Khan et al Journal of clinical medicine 2024

Update 2: Resectable locally advanced NSCLCa





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IIIA	T1a-T2bN2M0 T3N1M0 T4N0 or N1M0		For unresected stage III: definitive concurrent chemoradiation followed by consolidation PD-L1 inhibitor	36%
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IIIC	T3N3M0 or T4N3M0			13%
IVA	AnyTAnyNM1a or M1b	37%	Palliative systemic therapy	10%
IVB	AnyTAnyNM1c			0%

STAGE	TREATMENT INTENT
I	CURATIVE
II	
III	
IV	PALLIATIVE

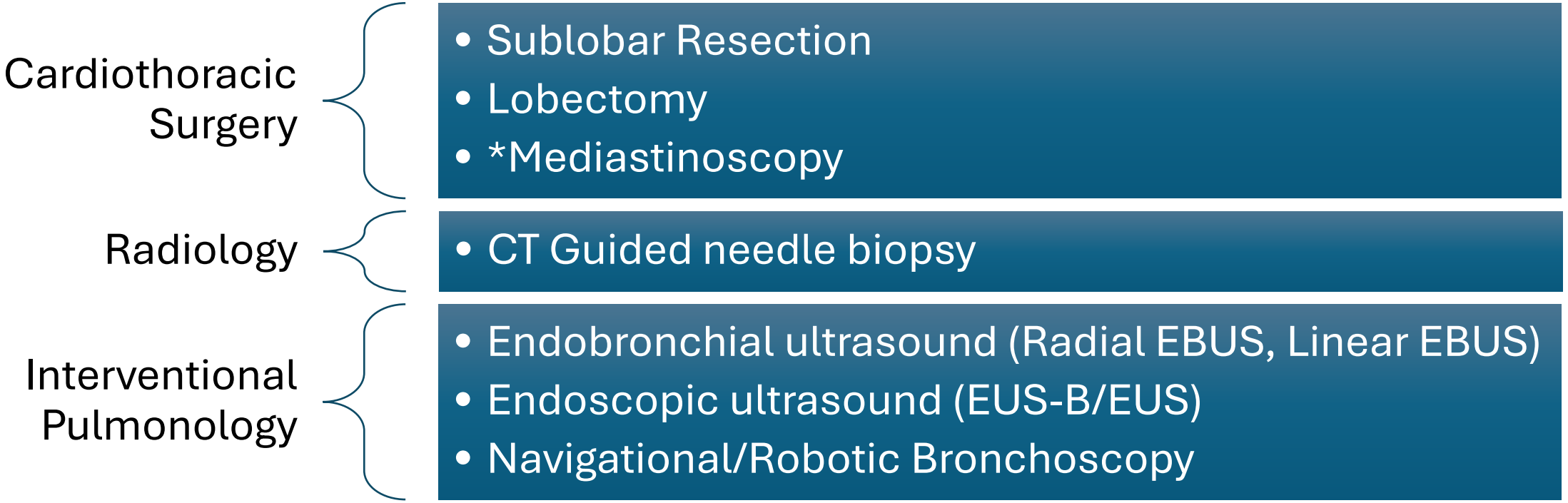
Neoadjuvant immunotherapy for resectable locally advanced disease

- Stage II-IIIA (No Distant Mets)
- Deemed Resectable
- No autoimmune disease

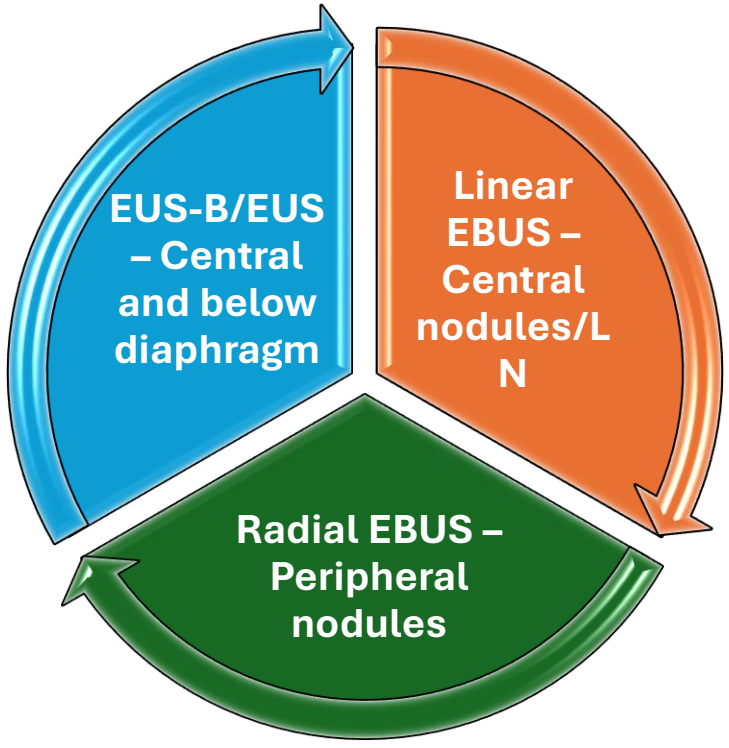
- Major pathological response (37% vs 9%)
- Better Progression free survival (2 year 63 vs 45% IO vs Chemo)

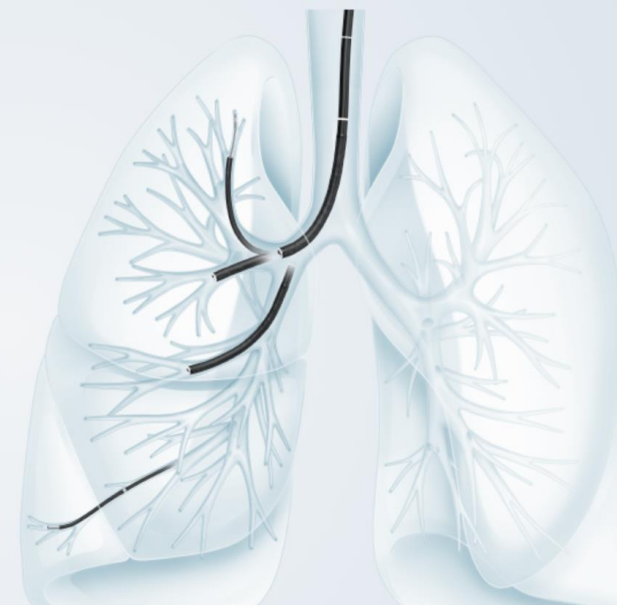
Forde et al NEJM 2022;386:1973-1985

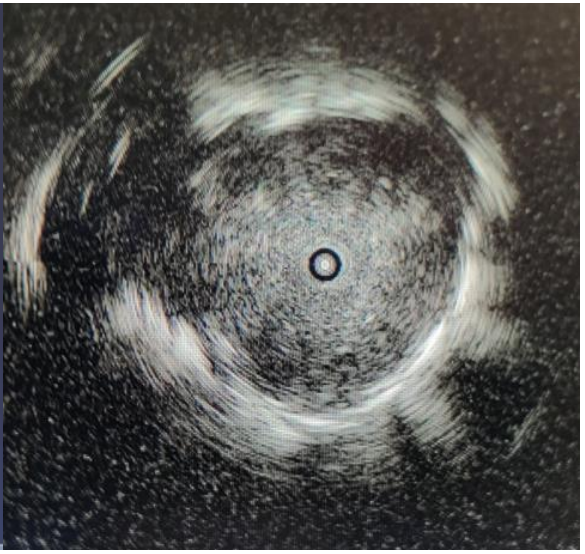
Establishing a tissue diagnosis: Peripheral lung nodule



Range of Bronchoscopy







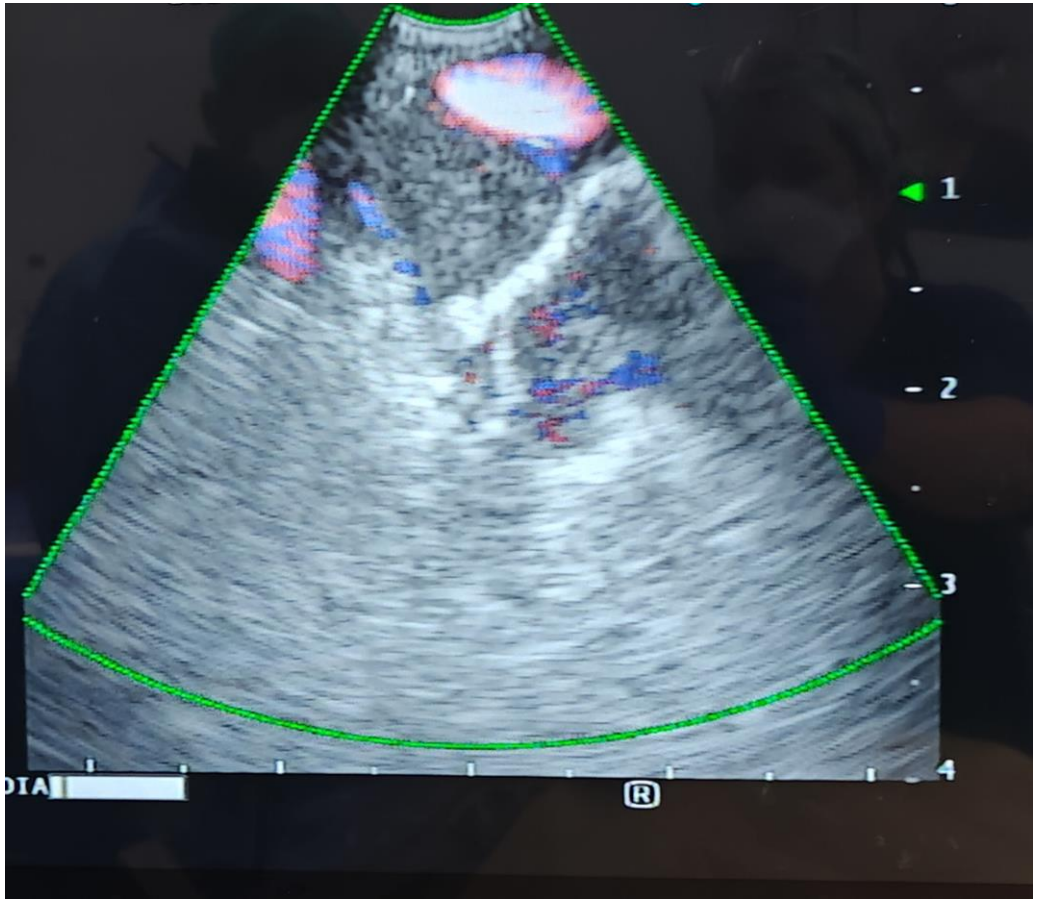
Single procedure to diagnose and stage

Multiple nodules, including bilateral

TRANSBRONCHIAL – LINEAR EBUS

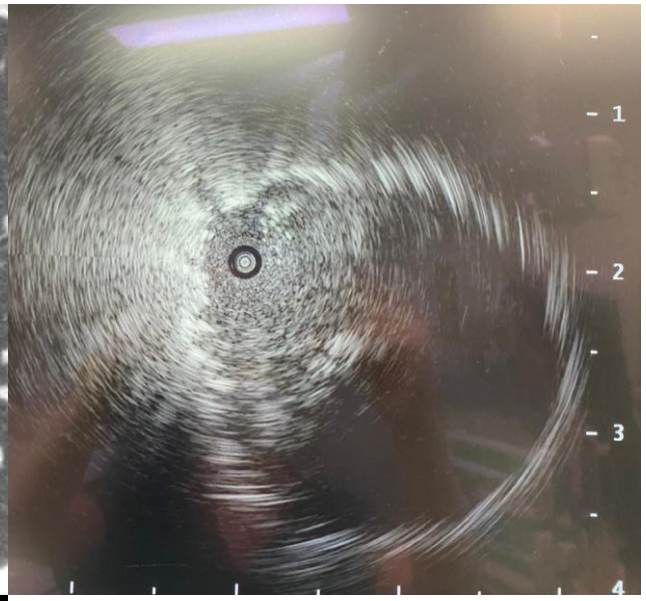
Linear/Convex Probe EBUS

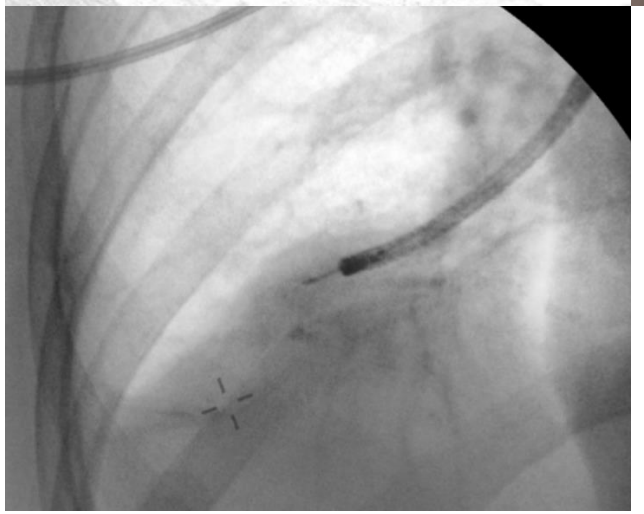
- Flexible bronchoscope with a convex ultrasound probe on the tip
- *CENTRAL LUNG*



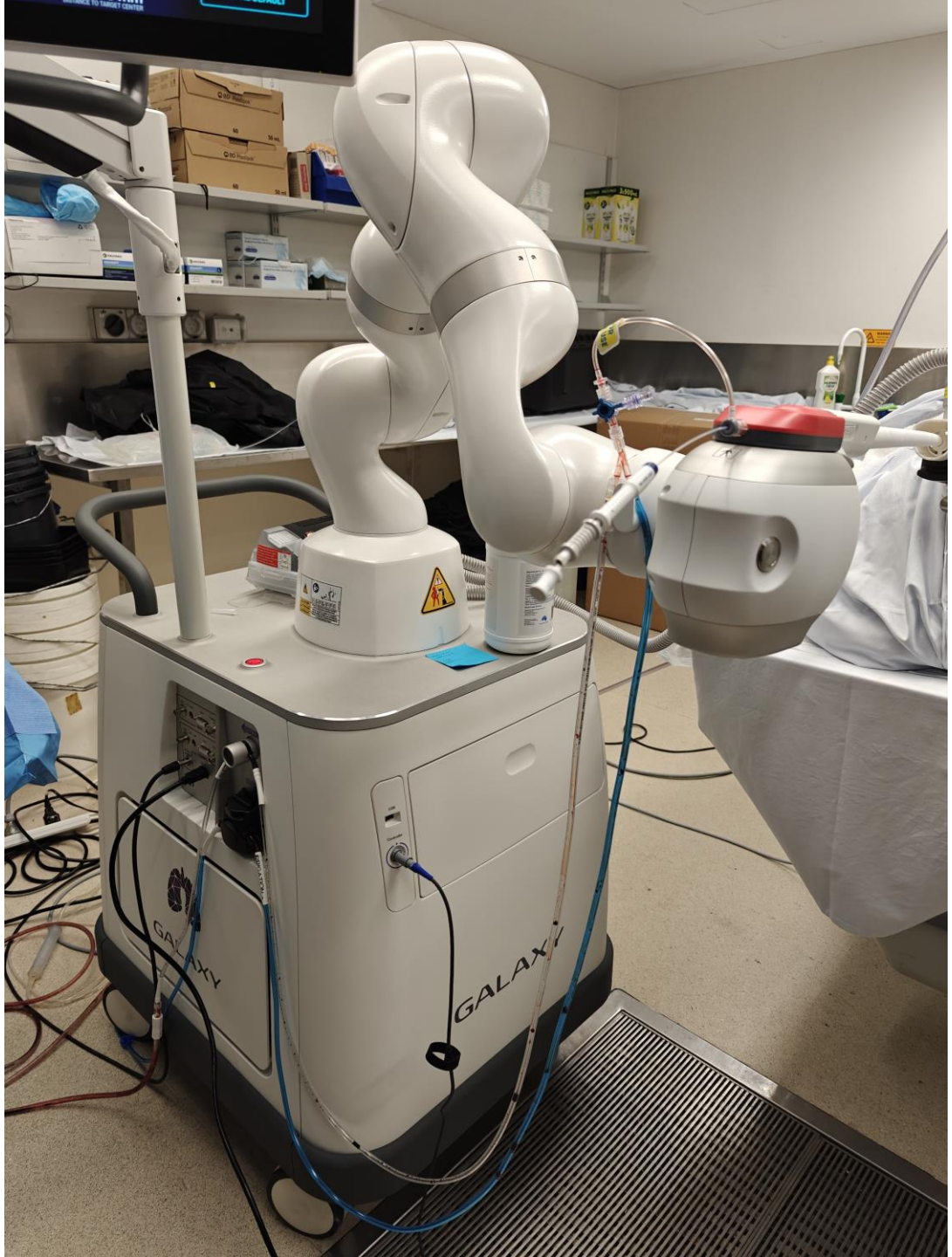
TRANSBRONCHIAL - RADIAL EBUS

- Thin (1.7mm) wire with 360° spinning ultrasound at distal tip
- *PERIPHERAL LUNG*

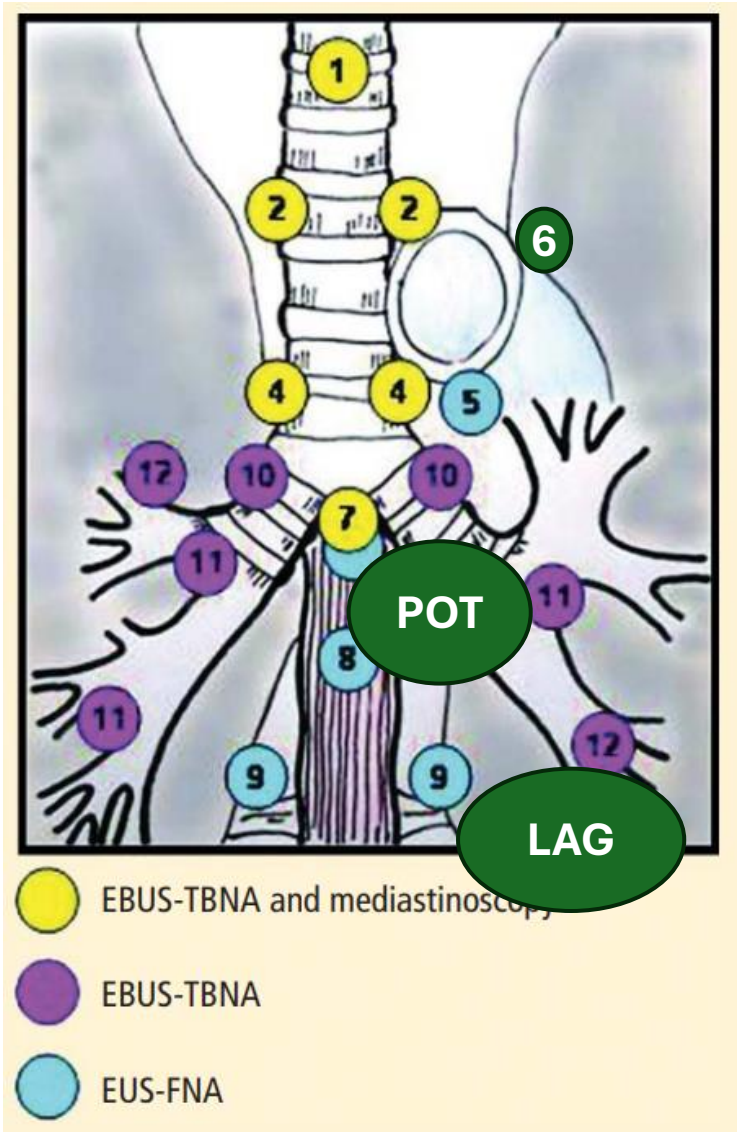


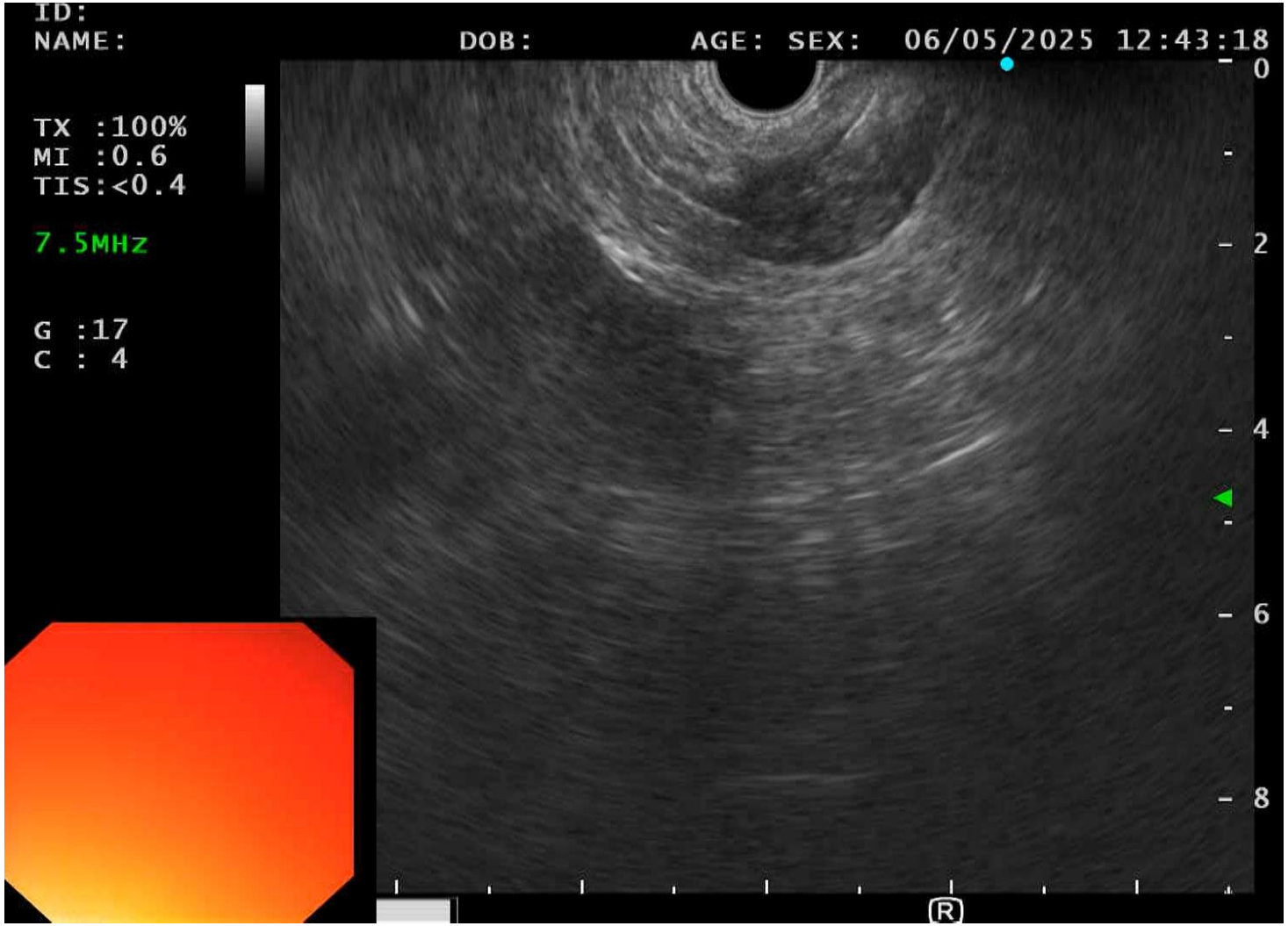


TRANSBRONCHIAL - ROBOTIC BRONCHOSCOPY



TRANSOESOPHAGEAL - EUS-B/EUS





Almeida et al Cleveland clinic JOM 2012

Safety: Flexible bronchoscopy with radial EBUS

Meta-analysis, studies from 2002-2016: 57 studies, 7872 lesions

	Radial EBUS	CT FNA
Diagnostic yield	70%	90%
Safety: **Pneumothorax** **ICC**	 **2.8% (All complications)** 0.2%	 **30%** 8%

Radial endobronchial ultrasound for the diagnosis of peripheral pulmonary lesions: A systematic review and metaanalysis Ali et al *Respirology* (2017)

Assessment of Advanced Diagnostic Bronchoscopy Outcomes for Peripheral Lung Lesions: A Delphi Consensus Definition of Diagnostic Yield and Recommendations for Patient-centered Study Designs

An Official American Thoracic Society/American College of Chest Physicians Research Statement

Anne V. Gonzalez, Gerard A. Silvestri, Daniel A. Korevaar, Yaron B. Gesthalter, Nisha D. Almeida, Alex Chen, Chris R. Gilbert, Peter B. Illei, Neal Navani, Mary M. Pasquinelli, Nicholas J. Pastis, Catherine R. Sears, Samira Shojaee, Stephen B. Solomon, Daniel P. Steinfort, Fabien Maldonado, M. Patricia Rivera, and Lonny B. Yarmus; on behalf of the American Thoracic Society Assembly on Thoracic Oncology and the American College of Chest Physicians

This Official Research Statement was approved by the American Thoracic Society December 2023 and the American College of Chest Physicians September 2023

Specific Malignant Diagnoses	Specific Benign Diagnoses	Nondiagnostic Test Results
Non–small cell lung cancer	Benign lung tumors (e.g., hamartoma, lipoma, papilloma)	Atypia/atypical cells
Adenocarcinoma	Organizing pneumonia	Acute or chronic inflammation
Squamous cell carcinoma	Granulomatosis with polyangiitis	Normal lung parenchyma
Large cell carcinoma	Fungal (e.g., *Aspergillus*, *Histoplasma*)	Insufficient tissue for diagnosis
Small cell carcinoma	*Mycobacterium* (e.g., *M. tuberculosis*)	Blood
Carcinoma metastatic to lung (e.g., melanoma, breast cancer)	Bacterial (e.g., *Streptococcus pneumoniae*)	Necrosis
Typical/atypical carcinoid tumor	Granuloma/granulomatous inflammation	—

Gonzalves et al 2024 AJRCCM

VERITAS STUDY: naVigation Endoscopy to Reach Indeterminate lung nodules VS Transthoracic needle Aspiration, a randomized controlled Study

Multicentre, randomized, controlled, non-inferiority trial

Pulmonary nodules measuring 10–30 mm. Pre-test probability of malignancy ≥10%

Navigational bronchoscopy (119 patients) vs CT-guided transthoracic needle biopsy (110 patients)

Key results

Outcome	Navigational bronchoscopy	CT-guided biopsy
Diagnostic Accuracy	79%	73.6%
Pneumothorax	**3.3%**	**28.3%**
Chest tube	0.8%	11.5%

Lentz et al 2025 NEJM

Establishing a tissue diagnosis: Peripheral lung nodule

Interventional Pulmonology

- Endobronchial ultrasound (Radial EBUS, Linear EBUS)
- Endoscopic ultrasound (EUS-B/EUS)
- Navigational/Robotic Bronchoscopy

SUMMARY

- Incidental lung nodules are a common, mostly benign but an opportunity to cure lung cancer
- Index CT is partial, first step is to request a CT chest
- Nodule malignancy risk depends on multiple clinico-radiological factors
- FDG PET scans have a place in planning a biopsy strategy than determining malignant/benign status
- Bronchoscopy is first line investigation due to versatility, range, safety and comparable diagnostic yield

INTERVENTIONAL

Pulmonology Clinic

ACCEPTING NEW REFERRALS

Unit1/158 Cambridge St, West leederville 6007
Clinic tel: 0432807009 fax: 08 61021729 email:admin@lokeshyagnik.com
Healthlink: dryagnik

Get in touch - Questions, comments etc

ly@lokeshyagnik.com

Thank you

www.lokeshyagnik.com