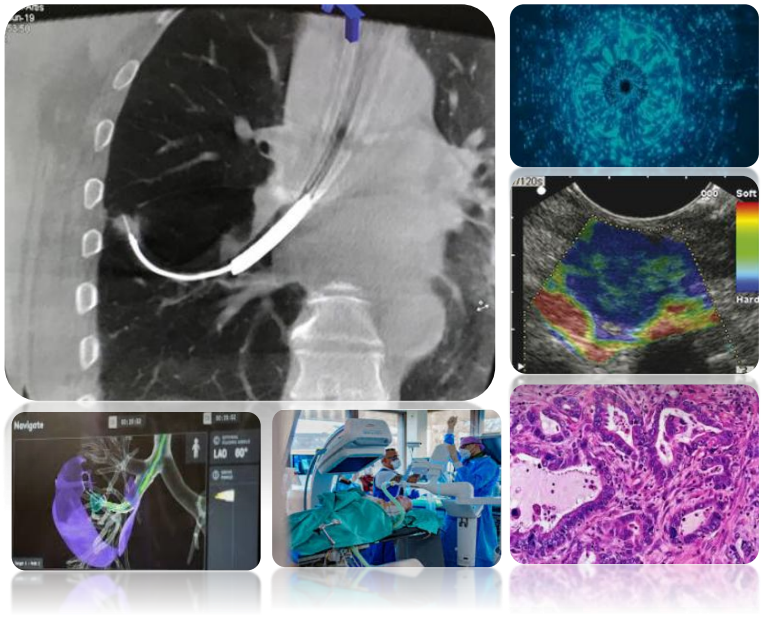
Doctors of Thoracic Surgery

Revolution or Ongoing Quest for the Holy Grail – Update in Minimally Invasive Bronchoscopic Procedures



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Division of Thoracic Surgery
Division of Respirology
Toronto General Hospital

50th Thoracic Refresher Conference

June 13, 2026

UHN Toronto General Toronto Western Princess Margaret Toronto Rehab
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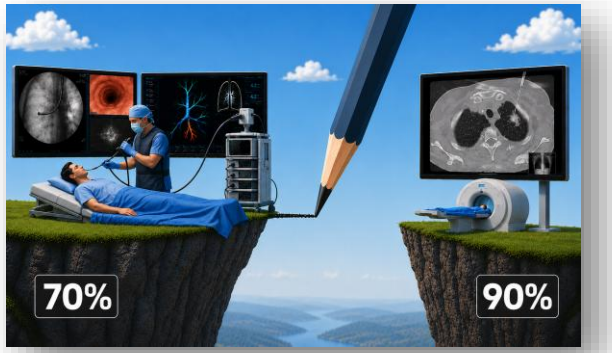
Questions we will explore

Bridging the gap…



1. Has Robotic Assisted Bronchoscopy fulfilled its promise?
2. Cryobiopsy – Ready for a comeback?
3. AI mediastinal lymph node staging: science fiction or clinical reality?

Doctors of Thoracic Surgery

Disclosures

- Consultant to
  - Astra Zeneca
  - Merck

Robotic bronchoscopy platforms

2018



2019



2023



Robotic bronchoscopy platforms - China

2018

MONARCH™
PLATFORM POWERED BY AURIS

2019

INTUITIVE ION

MEDBOT
NaviBot



2023

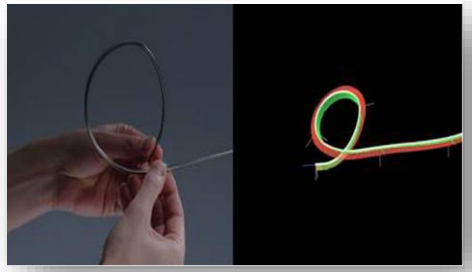
Noah Medical

朗合医疗
LungHealth MedTech

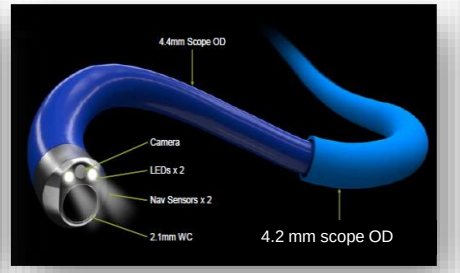


Robotic assisted bronchoscopy

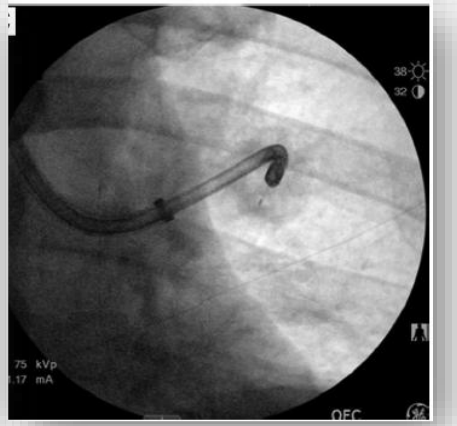
INTUITIVE ion

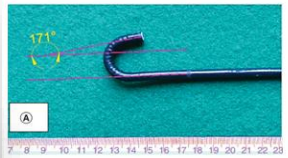


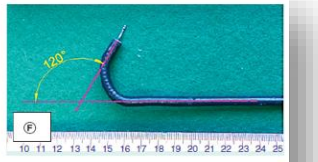
MONARCH™ PLATFORM POWERED BY AURIS





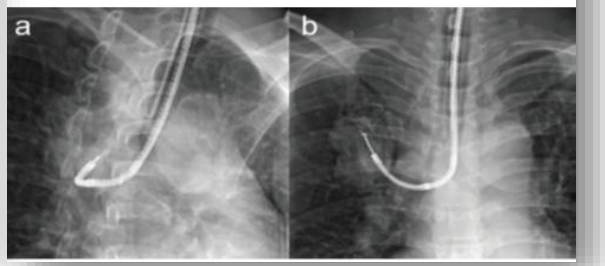






Scope	Working channel	Up/Down angulation
BF-P190	2.0 mm	210° / 130°
BF-MP190F	1.7 mm	210° / 130°
BF-XP190	1.2 mm	210° / 130°

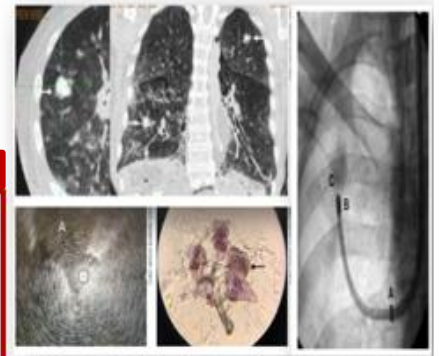
Tool	Angle reduction (°)
Needle	29.5
Forceps	68.6
Cryoprobe (1.9mm)	88.1



Accuracy of a Robotic Endoscopic System in Cadaver Models with Simulated Tumor Targets: ACCESS Study

Silvestri et al. Respiration. 2020;99:56-61.

- **Design:**
  - 8 human cadavers
  - 67 targets 10-30mm in size
  - R-EBUS, fluoroscopy, ENB used
- **Results:**
  - Mean nodule 20.4mm (9.6-28.3)
  - **Diagnostic yield 97% (66/67)**
  - Yield not impacted by:
    - nodule size
    - location
    - relationship with airway (concentric vs. eccentric)
  - No complications



Current RAB NIH studies - 2023

Study	NIH #	Status
RAB + Cone beam CT (Precise)	NCT05358041	Enrolling
RAB for pulmonary nodules	NCT03727425	Completed
RAB for pulmonary nodules (Target)	NCT04182815	Enrolling
RAB for pulmonary nodules	NCT05426213	Enrolling
RAB for pulmonary nodules	NCT03893539	Enrolling
RAB for pulmonary nodules	NCT05867953	Enrolling
RAB vs. ENB for pulmonary nodules (RELIANT)	NCT05705544	Enrolling
RAB with confocal microscopy	NCT04441749	Enrolling
RAB with confocal microscopy	NCT05231278	Enrolling
RAB with cryoprobe	NCT05399082	Enrolling
Optimizing RAB (ventilation)	NCT05714033	Enrolling
ENB Robotic ICG guided surgery (REPLACING)	NCT04987281	Enrolling

Current RAB NIH studies - 2026

Study	NIH #	Status
RAB + Cone beam CT	NCT05358041	Unknown
RAB for pulmonary nodules (BENEFIT)	NCT03727425	Completed
RAB for pulmonary nodules (Target)	NCT04182815	Completed
RAB for pulmonary nodules	NCT05426213	Withdrawn
RAB for pulmonary nodules (Precise)	NCT03893539	Completed
RAB for pulmonary nodules	NCT05867953	Completed
RAB vs. ENB for pulmonary nodules (RELIANT)	NCT05705544	Completed
RAB with confocal microscopy	NCT04441749	Completed
RAB with confocal microscopy	NCT05231278	Completed
RAB with cryoprobe	NCT05399082	Completed
Optimizing RAB (ventilation)	NCT05714033	Completed
ENB Robotic ICG guided surgery (REPLACING)	NCT04987281	Withdrawn
RAB MVA in lung cancer (POWER)	NCT05299606	Terminated

RAB- RCTs update

- **PRECiSE**
- Multicenter (6 centers)
- ssRAB+ radial probe + fluoroscopy
- 305 patients, median (IQR) nodule size: 17mm (14-23)

Diagnostic yield: 74.1% [95%CI 68.8%-78.9%]

Model variables	Reference	Odds Ratio	95% CI	P-Value
BMI	By 1 unit increase	**0.94**	0.90, 0.98	0.002

6%↓

Ost el at. Ann Am Thorac Soc. 2026

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Lung lesion location, lower lobe	Upper lobe	**0.52**	0.3, 0.89	0.02

6%↓

48%↓

Ost el at. Ann Am Thorac Soc. 2026

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Semisolid nodule	Solid	**0.39**	0.19, 0.78	0.01	61%↓

Ost el at. Ann Am Thorac Soc. 2026

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Semisolid nodule	Solid	**0.39**	0.19, 0.78	0.01	61%↓
Largest nodule diameter	By 1 mm increase	**1.05**	1.0, 1.11	0.06	5 %↑

Ost el at. Ann Am Thorac Soc. 2026

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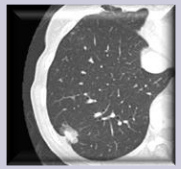
Largest nodule diameter	By 1 mm increase	**1.05**	1.0, 1.11	0.06	5 %↑
# of cases performed in 2 mths prior	By 1 unit increase	**1.03**	0.97, 1.1	0.09	3% ↑

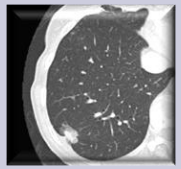
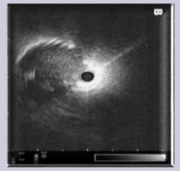
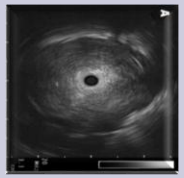
Ost el at. Ann Am Thorac Soc. 2026

RAB Yield

	Lesion size (~ 40% difference)	
	≤ 2cm	> 2cm
		
Yield	56.2 - 67.6%	68.8 - 85.2%

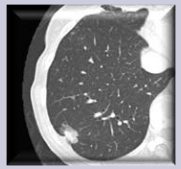
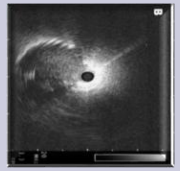
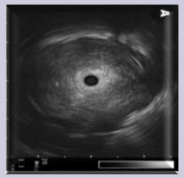
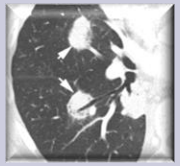
Ost el al. CHEST. 2026 RECiSE
Murgu et al. CHEST. 2025 TARGET
Low et al. CHEST. 2023

RAB Yield

	Lesion size ~ 40% difference		Radial probe view ~ 40% difference	
	≤ 2cm	> 2cm	eccentric	concentric
				
Yield	56.2 - 67.6%	68.8 - 85.2%	**41.5 - 78%**	**70.9 - 86%**

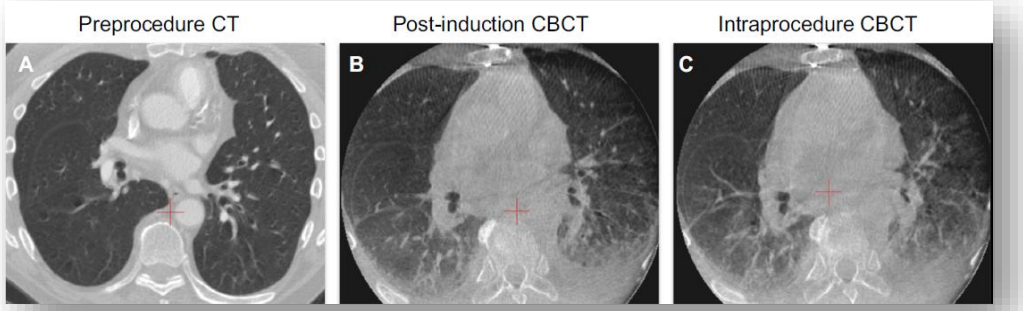
Ost el al. CHEST. 2026 RECiSE
Murgu et al. CHEST. 2025 TARGET
Low et al. CHEST. 2023

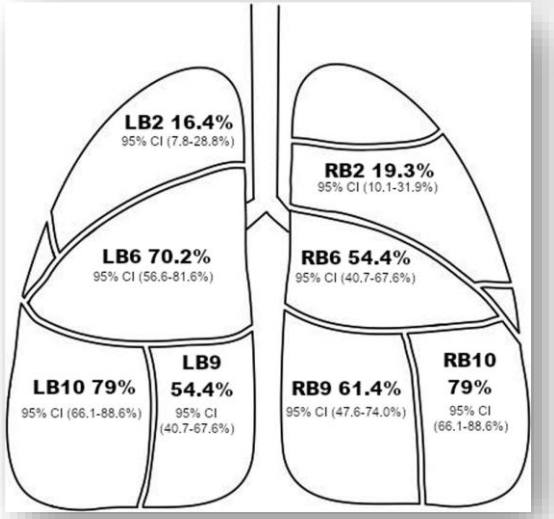
RAB Yield

	Lesion size ~ 40% difference		Radial probe view ~ 40% difference		Air-bronchogram ~ 20% difference	
	≤ 2cm	**> 2cm**	**eccentric**	**concentric**	**absent**	**present**
						
Yield	56.2 - 67.6%	68.8 - 85.2%	41.5 - 78%	70.9 - 86%	**61.1 - 76.9%**	**66.7 - 84%**

Ost el al. CHEST. 2026 RECiSE
Murgu et al. CHEST. 2025 TARGET
Low et al. CHEST. 2023

Issues in RAB affecting yield - Atelectasis

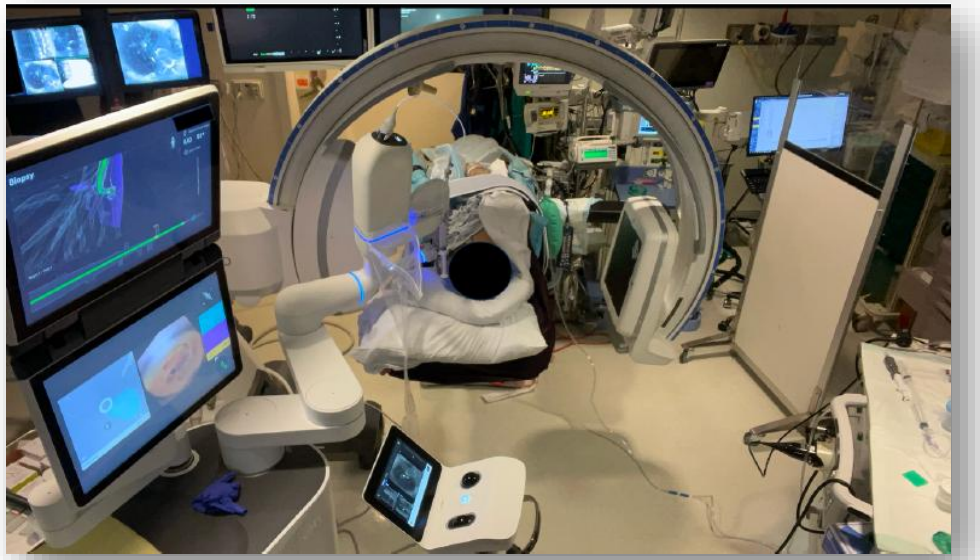




- 89%, 95% CI 78% - 96% during bronchoscopy
- Associated factors:
  - **BMI**

    OR 1.13 /unit Δ; 95% CI 1.0-1.2
  - **Time to survey**

    OR 1.064/min; 95% CI 1.03-1.1

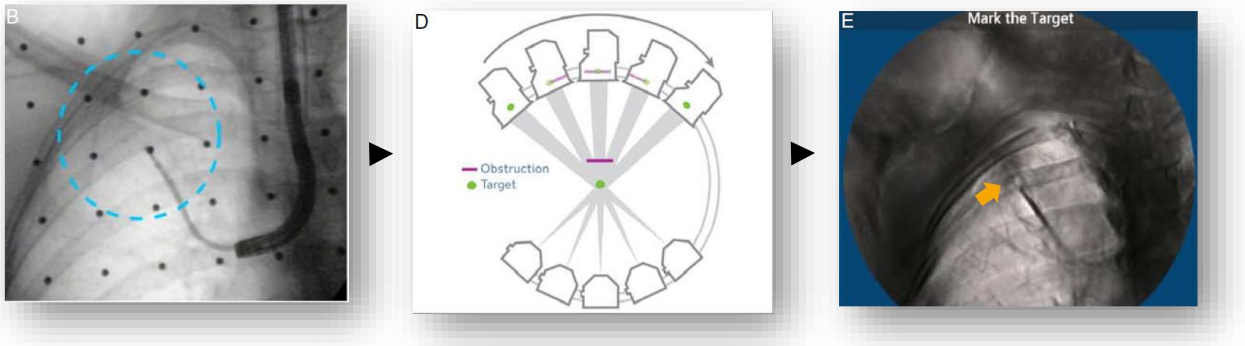


- 0% atelectasis in decubitus position
- Yield:
- **86.2%** (95% CI, 68.3% - 96.1%) decubitus vs.
- **57.6%** (95% CI, 39.2% - 74.5%) supine

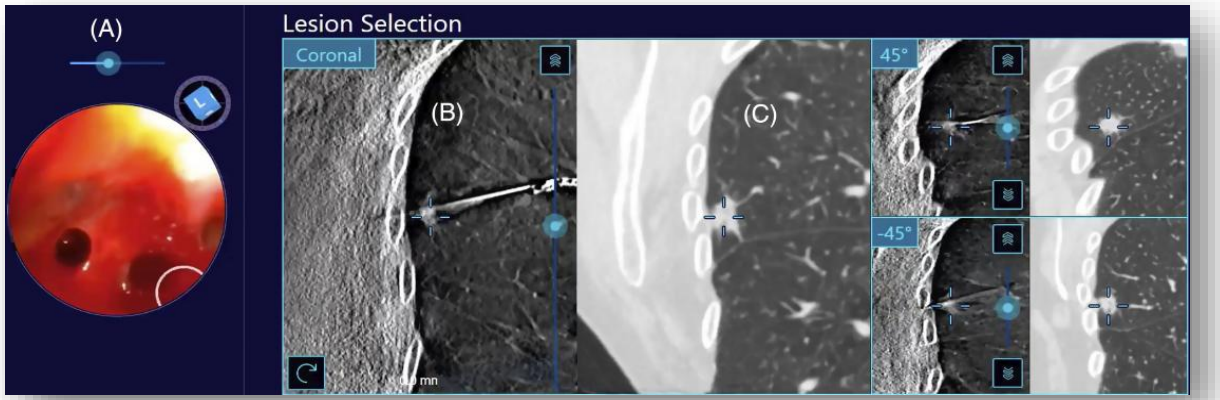
Pritchett et all. BMC Pulm Med. 2021.
Sagar et al. CHEST. 2020.
Boster et al. CHEST 2026.

Issues in RAB affecting yield – Not a real time biopsy

Variable	DT-ENB	ssRAB (Ion)+ fluoroscopy
Diagnostic yield	158 (80%)	110 (77%)
Cancer prevalence	107 (54%)	78 (54%)



Variable	Galaxy RAB
Diagnostic yield	17/19 (89.5%)
Cancer prevalence	14/19 (73.4%)



DT-ENB – Digital Tomosynthesis Electromagnetic Navigation Bronchoscopy
ssRAB – shape sensing Robotic Assisted Bronchoscopy

Shaller et al. JOBIP 2024 CBCT and RAB
Shagaie et al. Respirology. 2024 TiLT
Low et al. CHEST. 2023.

Issues in RAB affecting yield – Not a real time biopsy

Variable	RAB+CBCT	FB-CBCT
Diagnostic yield % (95%CI)	90 (82.6-94.5)	88 (80.2-93)



FB-CBCT – Flexible Bronchoscopy Cone Beam CT
RAB-CBCT– Robotic Assisted Bronchoscopy - Cone Beam CT

Shaller et al. JOBIP 2024 CBCT and RAB
Shagaie et al. Respirology. 2024 TiLT

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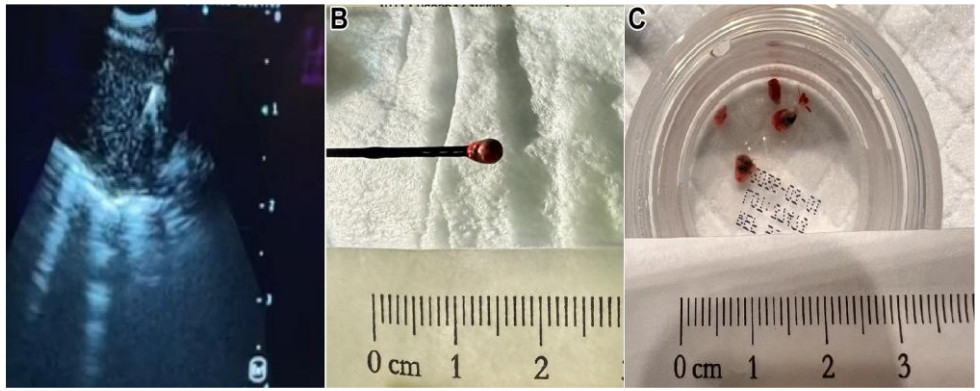
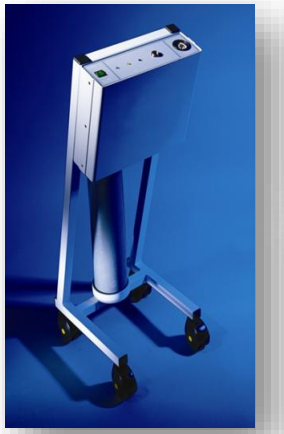
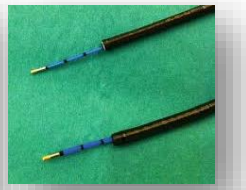
Biopsy tool selection – Cryoprobe?



PATH PLANNING	MANEUVER TO LESION	CONFIRM DESTINATION	BIOPSY TOOLS	SAMPE PROCESSING
• Axial CT • Virtual Bronchoscopy • ENB	• Ultrathin scopes • Curettes • ENB steerable device • Robotic bronchoscopy	• Fluoroscopy • Tomosynthesis • CT fluoroscopy • r-EBUS • CBCT	• Forceps • brush • TBNA needle • Wash/BAL • cryobiopsy	• Formalin • Cytolyt • Saline • ROSE







- Flexible Cryo Probe
  - –2.4mm O.D. fiber
  - –1.9mm O.D. fiber
  - –1.1mm O.D. fiber (2019)

↑15-20%

	Cryoprobe	Biopsy forceps
Diagnostic yield (%)	95 - 97.2	77.8- 85.1

Zhang et al. Respiration. 2024.
Mathew et al. J Thor Dis. 2024.
McNierney et al. JOBIP. 2025.
Oberg et al. Lung. 2022.

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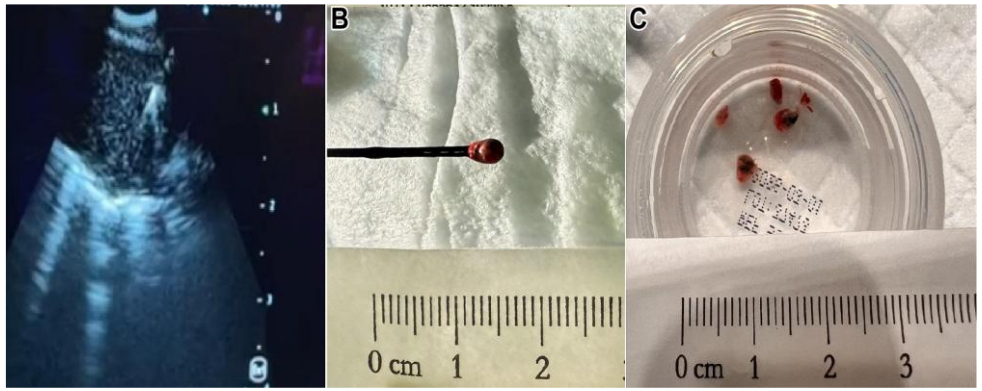

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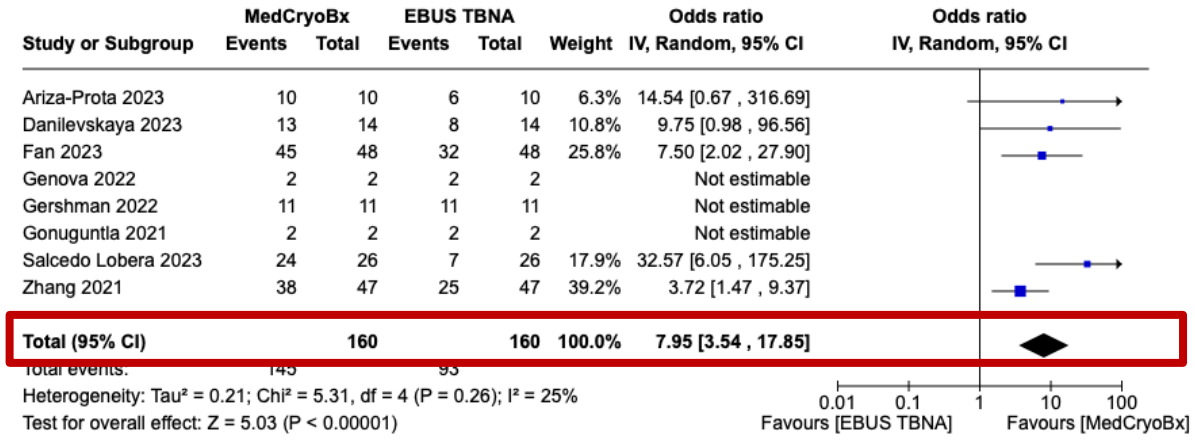
Benign conditions



Zhang et al. Respiration. 2024.
Mathew et al. J Thor Dis. 2024.

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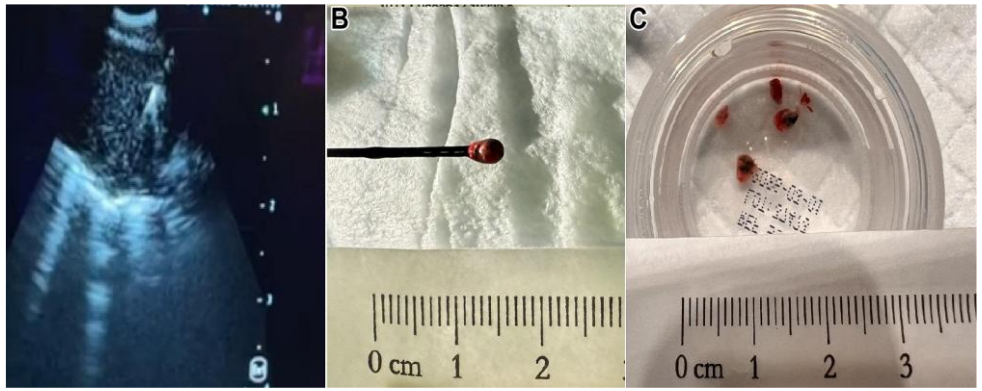

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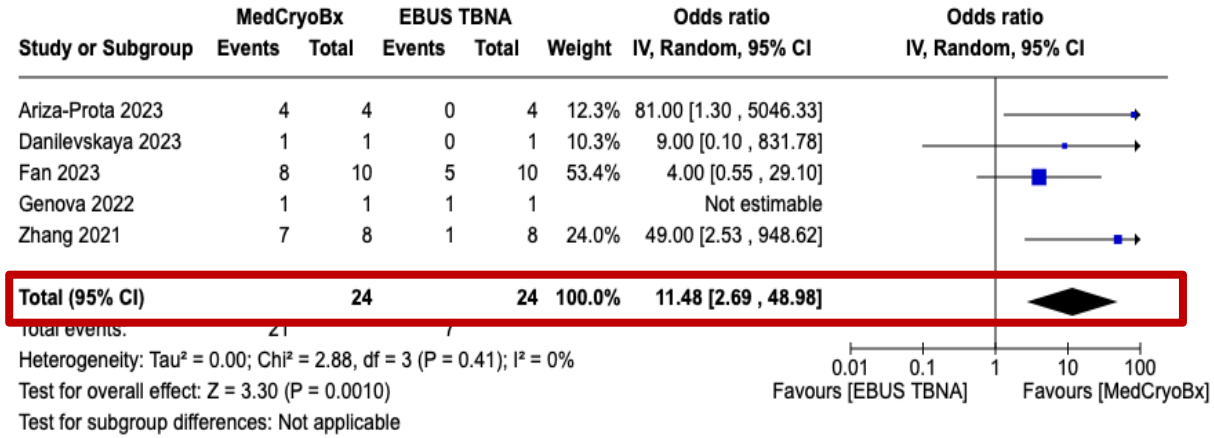
Lymphoma



Complications	Mediastinal bx Rate (%)
Bleeding requiring local therapy	0.7
Pneumothorax	0.4
Pneumomediastinum	0.4

Zhang et al. Respiration. 2024.
Mathew et al. J Thor Dis. 2024.
Oberg et al. Lung. 2022.
Husnain et al. Diagnostics. 2023.

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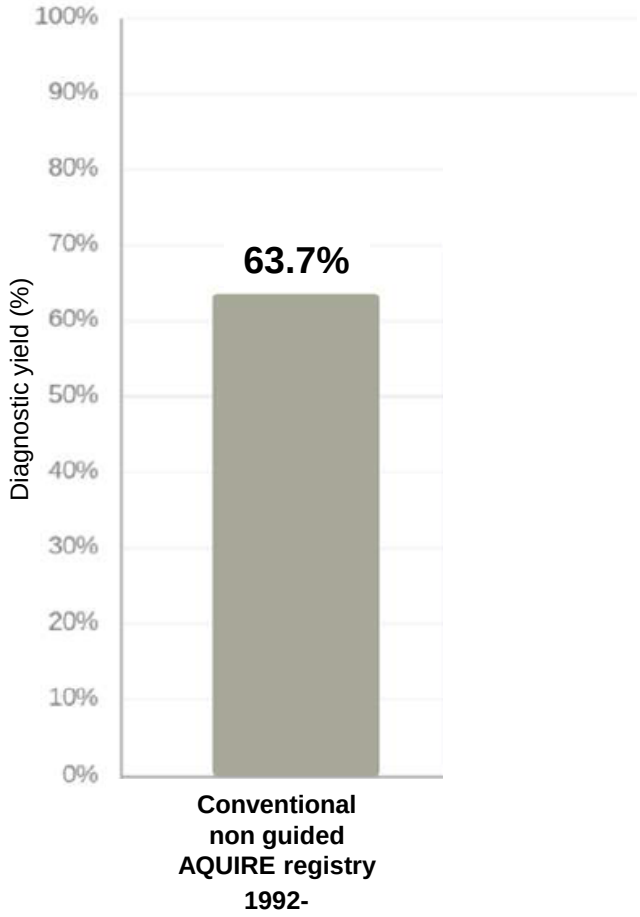
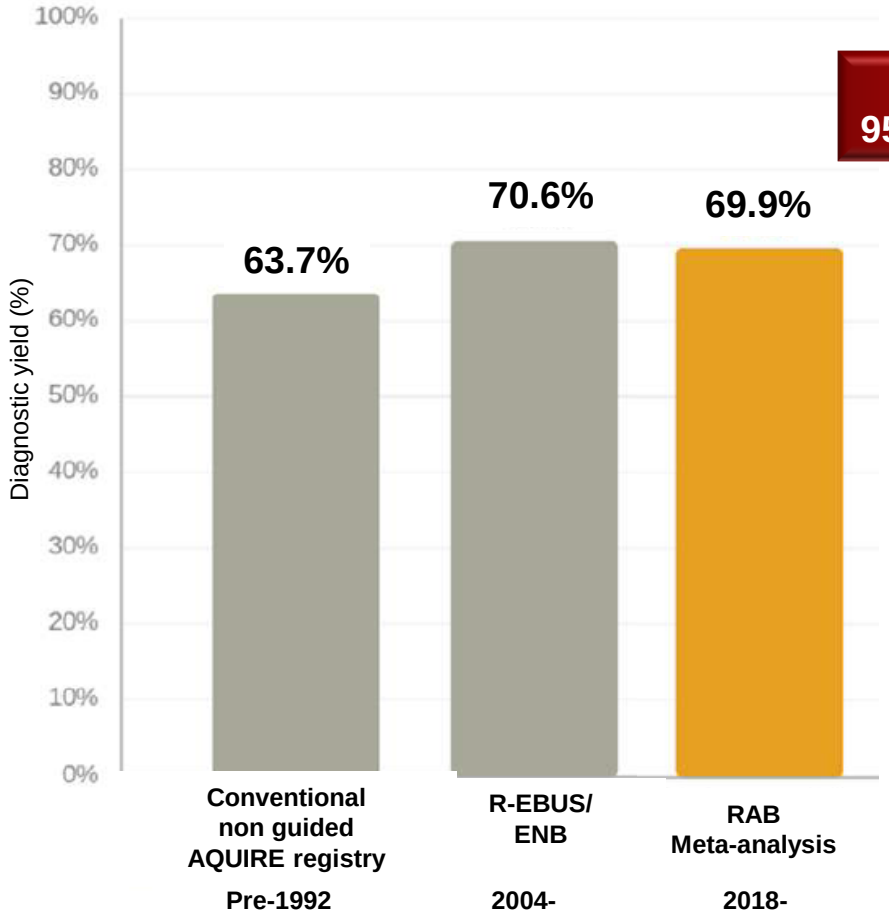
Evolution of bronchoscopic lung biopsy



Ost et al. Am J Resp Crit Care Med. 2016.
Ali et al. 2017.
Li et al. Int J Surg. 2025.
Husta et al. Thorax. 2026 CONFIRM

Evolution of bronchoscopic lung biopsy



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Ost el at. Ann Am Thorac Soc. 2026. PRECiSE
Ost et al. Am J Resp Crit Care Med. 2016.
Ali et al. 2017.
Li et al. Int J Surg. 2025.
Paez at al. Am J Respir Crit Care Med. 2025 RELIANT
Murgu et al. CHEST. 2025. TARGET

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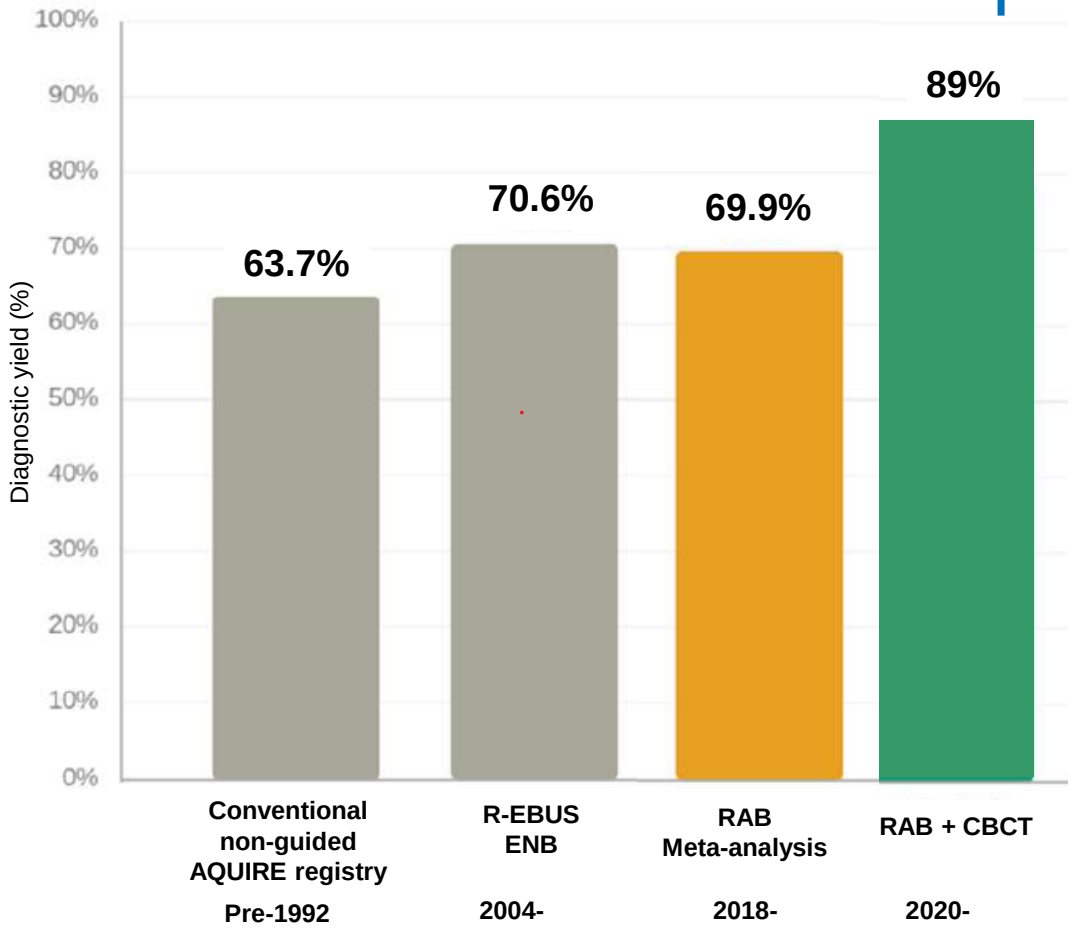
RESPIROLOGY 50 YEARS OF EXCELLENCE

Evolution of bronchoscopic lung biopsy

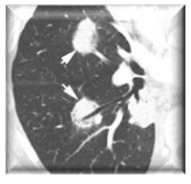
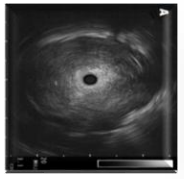
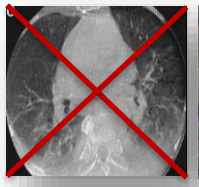
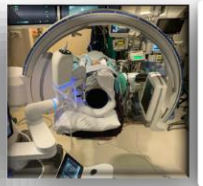


89%
95% CI (77%-93.5%)



PATH PLANNING	MANEUVER TO LESION	CONFIRM DESTINATION	BIOPSY TOOLS	SAMPE PROCESSING
• Axial CT • Virtual Bronchoscopy • ENB	• Ultrathin scopes • Curettes • ENB steerable device • Robotic bronchoscopy	• Fluoroscopy • Tomosynthesis • CT fluoroscopy • r-EBUS • CBCT	• Forceps • brush • TBNA needle • Wash/BAL • cryobiopsy	• Formalin • Cytolyt • Saline • ROSE

BMI optimal

Cancer probability > 60%

Ost el at. Ann Am Thorac Soc. 2026. PRECiSE
Ost et al. Am J Resp Crit Care Med. 2016.
Ali et al. 2017.
Li et al. Int J Surg. 2025.
Paez at al. Am J Respir Crit Care Med. 2025 RELIANT
Murgu et al. CHEST. 2025. TARGET

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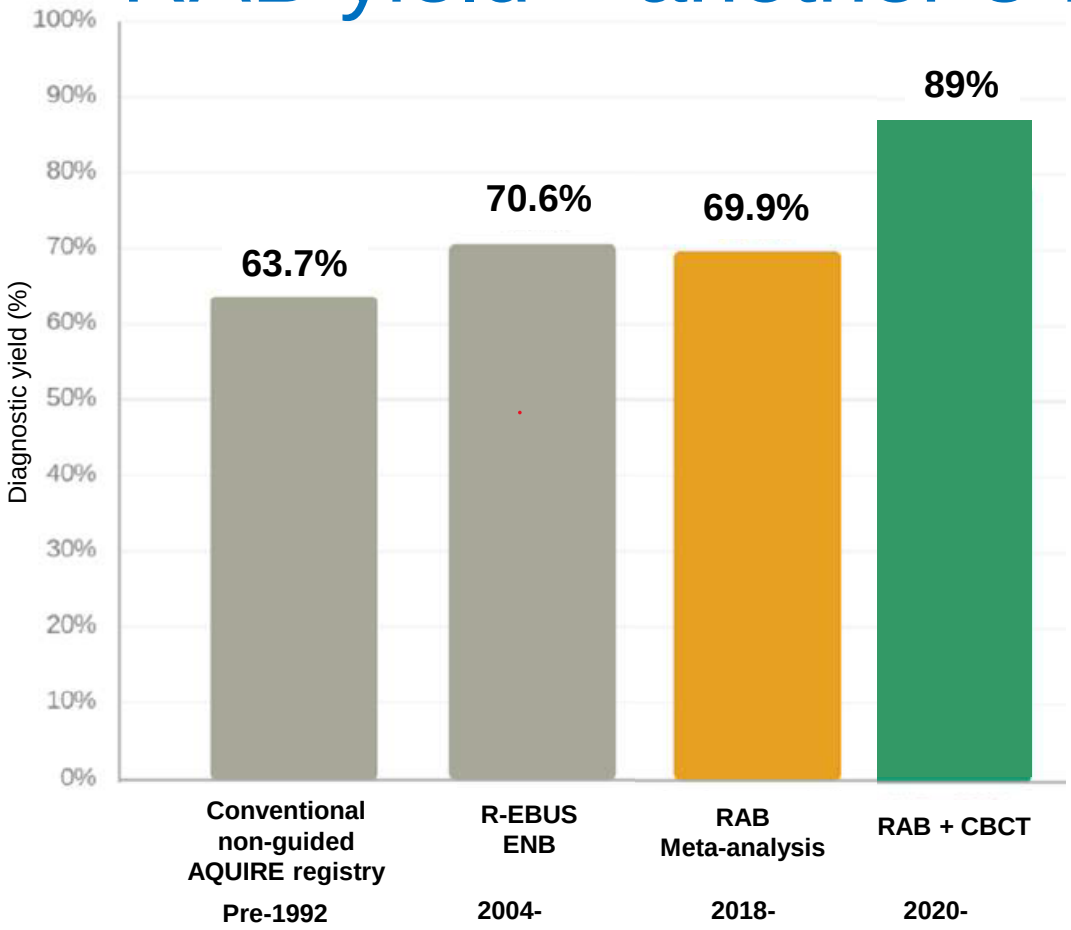
RAB yield – another 3-body problem?





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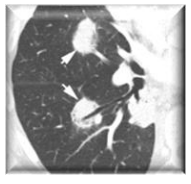

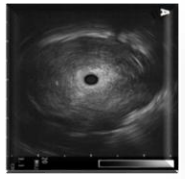

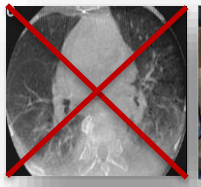

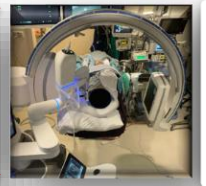

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RAB - economic analysis

- **10-15% ↑ in diagnostic sensitivity for malignancy**

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Physician directed lung nodule workup



	Bronchoscopic biopsy first	Transthoracic biopsy first	p

Ishiwata, Czarnecka-Kujawa et al. JOBIP. 2026

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Physician directed lung nodule workup



	Bronchoscopic biopsy first	Transthoracic biopsy first	p
Diagnostic yield %	**77.8** n=108	**89.9** n=99	**0.02**
Total work up cost Mean (95%CI) (US)	**1,791 (1,274-2,612)** n=108	**1,658 (954-2,875)** n=99	**0.677**

Ishiwata, Czarnecka-Kujawa et al. JOBIP. 2026

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Patients with pathologic nodal staging (95%CI) (US)	**2,122 (1,724-2,875)** n=63	**3,022 (2,384-3,459)** n=28	**0.0002**

Ishiwata, Czarnecka-Kujawa et al. JOBIP. 2026
Muench et al. ISPOR. 2024
Guiance and Kapp. Breathe. 2025

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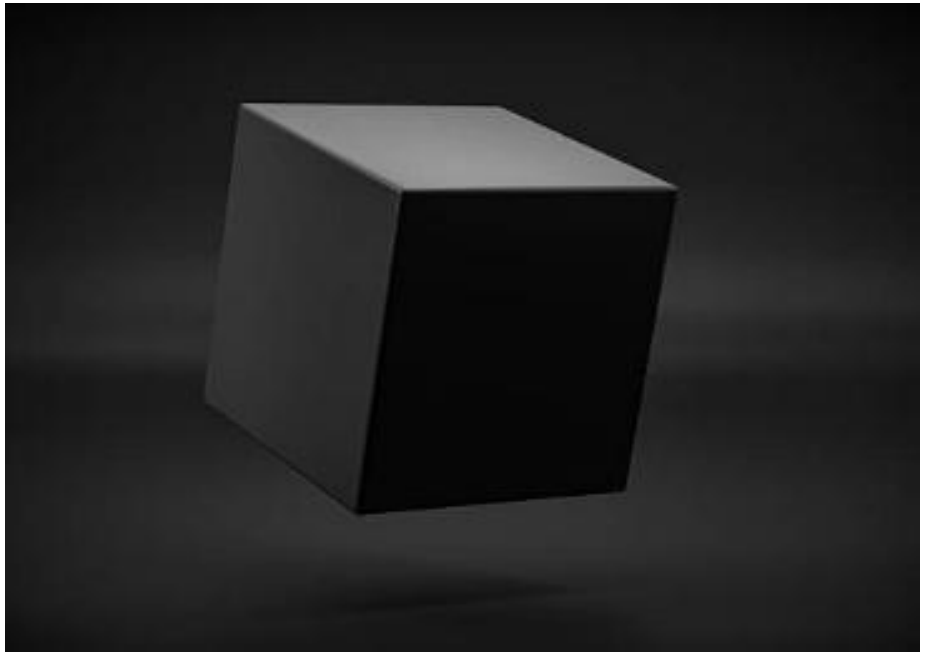
Economic analysis of RAB

- **10-15% ↑ in diagnostic sensitivity for malignancy**



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Improved diagnostic care with RAB



- Capital costs of RAB (~700,000 US)
- Capital costs CBCT (>250,000 US)

	ENB (Illumisite)	ssRAB (Ion)
Fixed costs/y Mean (US)	281,625	632,749
Procedure cost (US)	2,077	2,360 – 4,500

5y cost difference: 436,959 US - 757,118 US

Ishiwata, Czarnecka-Kujawa et al. JOBIP. 2026.
Muench et al. ISPOR. 2024.
Guiance and Kapp. Breathe. 2025.
Harrell et al. CHEST Oct. 2024.
Kanchustambham. Preprints.org. 2026. Accessed: May 26, 2026.

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Give up hope?

Respiration. 2025;104(5):332-340. doi: 10.1159/000542966. Epub 2024 Dec 10.

First in Human Evaluation of a Novel Thin Convex Probe Endobronchial Ultrasound System

Nicholas J Pastis [1], Vidhya Y Aroumougame [2], Christopher R Gilbert [2], Adam H Fox [2], Nichole T Tanner [2], Travis L Ferguson [2], Gerard A Silvestri [2]



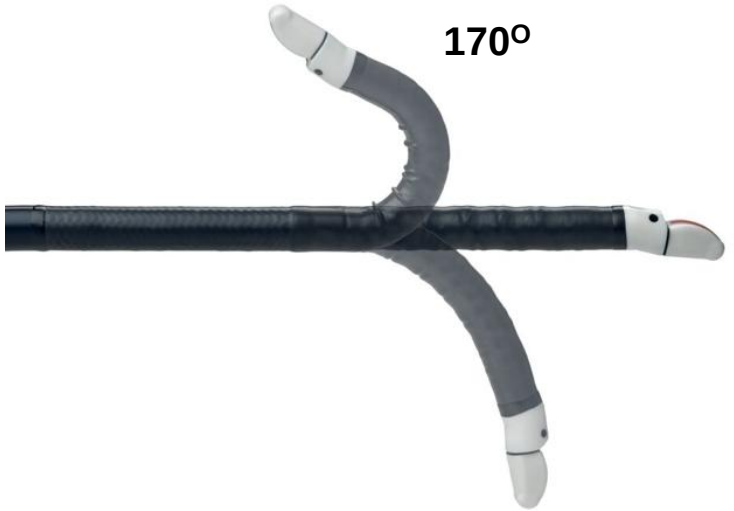
BF-UCP190F
D: 5.9mm

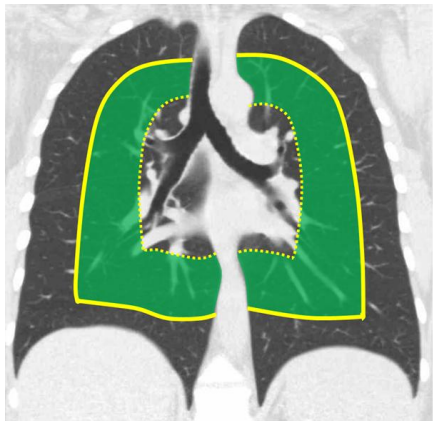


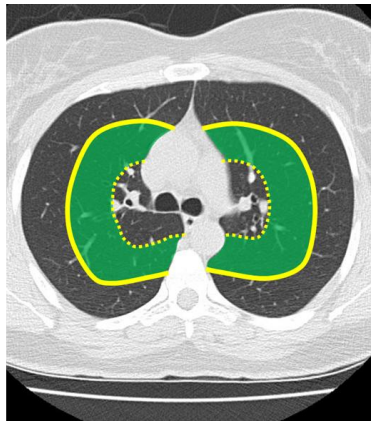
BF-UC190F
D: 6.6mm

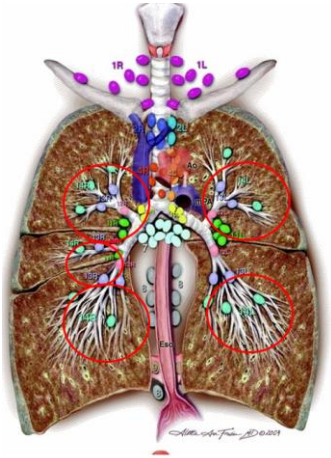


BF-UC180F
D: 6.9mm









LN not assessable by EBUS

N1 LNs
part of 12, 13, 14

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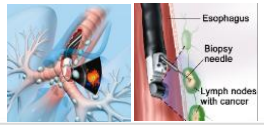
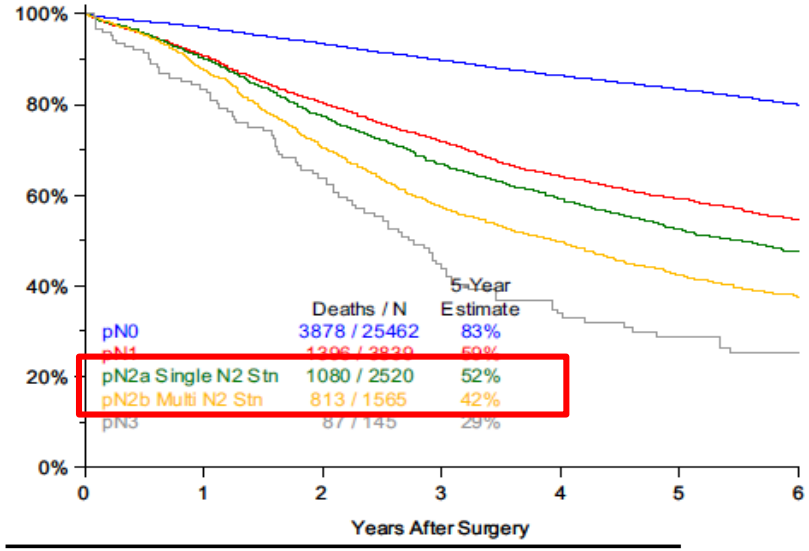
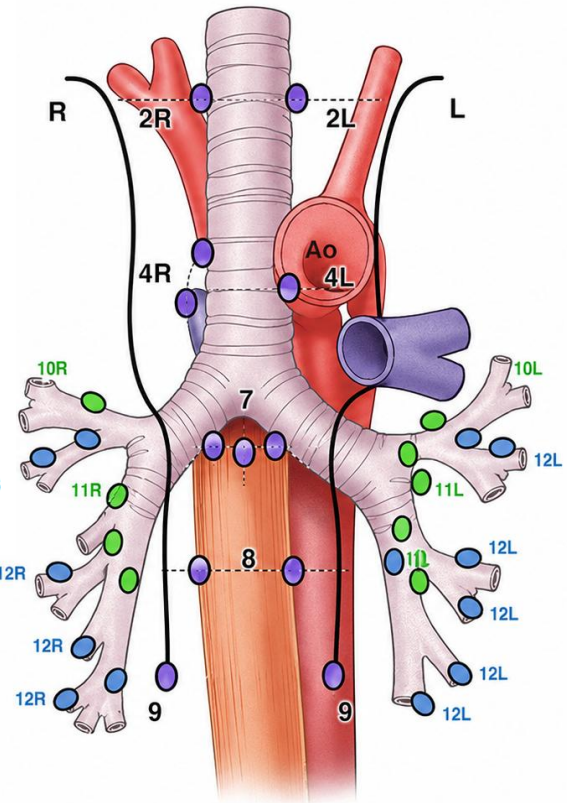
Growing importance of nodal staging in NSCLC

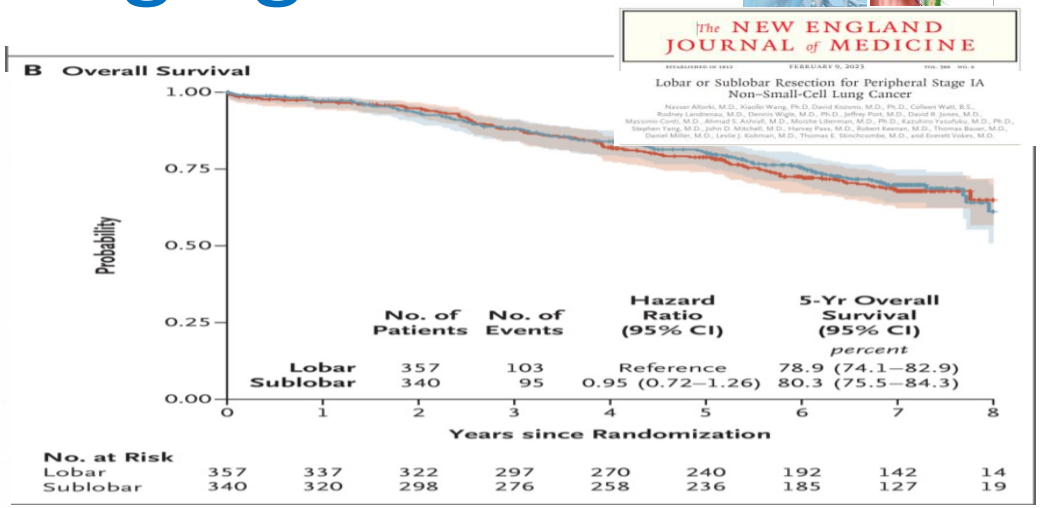


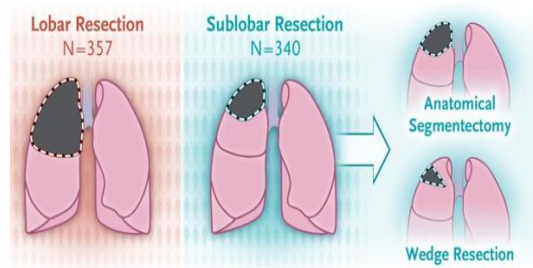


Comparison	cN *p* Value	pN *p* Value
N1 vs. N0	<0.0001	<0.0001
N2a vs. N1	<0.0001	<0.0001
N2b vs. N2a	<0.0001	<0.0001
N3 vs. N2b	<0.0001	0.0042

cN, clinical node; pN, pathologic node.







Stage I NSCLC

- **N1-N2 prevalence 4.4% - 18.5%**
- **cT1a - pN1 3.5%**
  - pN2 4.9%

Huang et al. JTO. 202319 (5):766-785.
Altorki et al. NEJM. 2023.
Kohman et al. VTCVS. 2017.
Boffa et al. Ann Thor Surg. 2012
Licht et al. Ann Thor Surg 2013.
Wilson et al. Ann Thora Surg. 2014.

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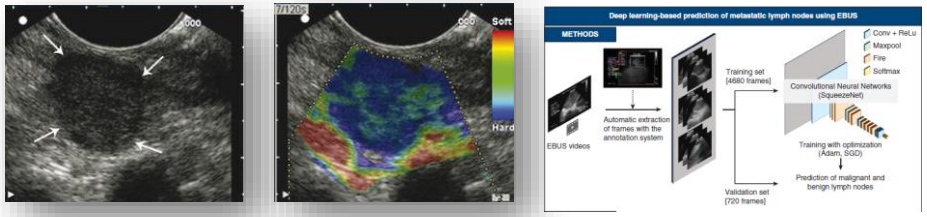
AI detection of intrathoracic nodal metastasis

- Meta analysis (12 studies, 16 cohorts)
- Different AI models
  - Machine learning (ML)
  - Convolutional Neuronal Networks (CNN)
- Retrospective and prospective



Performance characteristic		Performance characteristic	Prospective	Retrospective
Sensitivity (95%CI)	0.75 (0.60-0.86), I^2 =97%)	Sensitivity	0.42	0.87
Specificity (95%CI)	0.88 (0.83-92, I^2 = 96%)	Specificity	0.80	0.93

Cold et al. Eir Respir rev. 2025.
Tang et al. BMC Pulm Med. 2025.
Nakajima et al. Cancers. 2024.
Ishiwata et al. JTCVS Techniques. 2024.
Patel et al. Respiration. 2024.

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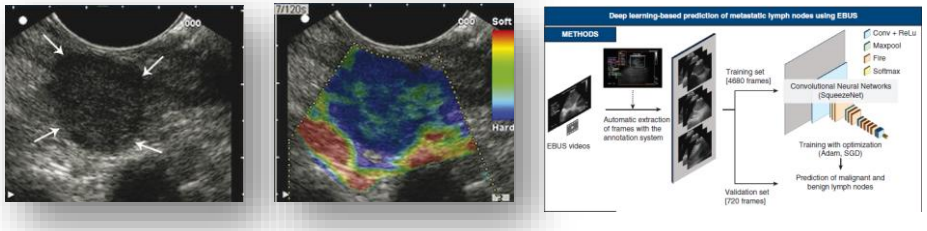

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+ve LR (95%CI)	**6.34 (4.41-9.08)**
- ve LR (95%CI)	**0.28 (0.17- 0.47)**

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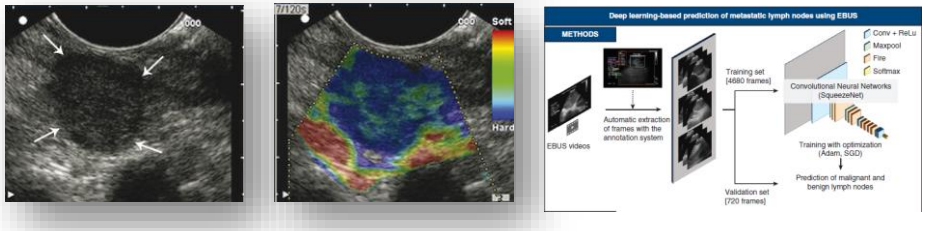

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- **<u>NSCLC: N2 pre-test probability: 20%</u>**
  - +ve AI: post-test probability: **63%**
  - -ve AI: post-test probability: **~ 6-7%**

Cold et al. Eir Respir rev. 2025.
Tang et al. BMC Pulm Med. 2025.
Nakajima et al. Cancers. 2024.
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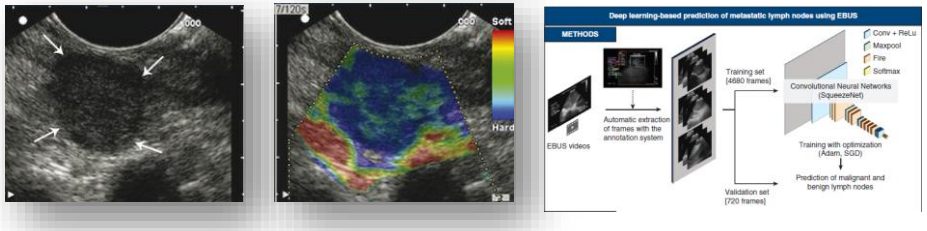

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- **NSCLC: N1-2 pre-test probability: 6%**
  - +ve AI: post-test probability: **29%**
  - -ve AI: post-test probability: **~ 1.8%**

Cold et al. Eir Respir rev. 2025.
Tang et al. BMC Pulm Med. 2025.
Nakajima et al. Cancers. 2024.
Ishiwata et al. JTCVS Techniques. 2024.
Patel et al. Respiration. 2024.

Challenges with current AI technology in LN diagnosis

- I^2 = 97%
- Retrospective vs. prospective
  - Selection bias
- Training test leakage
- Overfitting
- Selection bias
  - NSCLC patients only

> 60% excluded

Cold et al. Eir Respir rev. 2025.
Tang et al. BMC Pulm Med. 2025.
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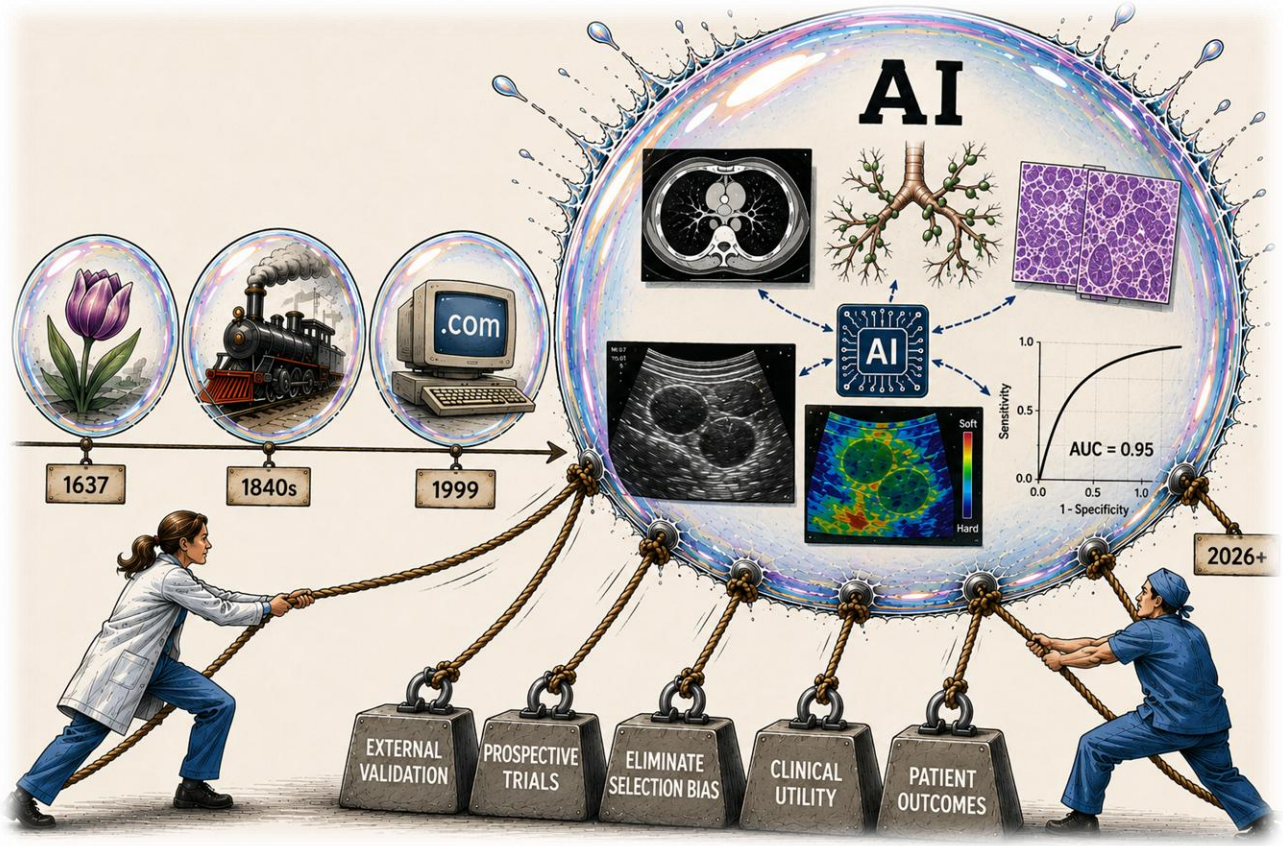
Challenges with current AI technology in LN diagnosis

- Future of AI in LN analysis
  - Prospective cohorts
  - Externally validated
  - No selection bias
    - Include other pathologies
  - Multimodal AI models



Summary

- RAB may improve diagnostic yield when combined with optimal imaging confirmation and sampling strategies
- The best diagnostic approach integrates available technologies rather than relying on any single platform
- AI lymph node assessment remains investigational and is not yet ready for routine clinical practice




Toronto General Hospital
University Health Network




Thank you