Robotic-Assisted Bronchoscopy (RAB)

Dongil Park
Division of Pulmonary and Critical Care Medicine
Chungnam National University College of Medicine

A history of IP innovation…

Laser therapy (Dumon) 1982

Flexible bronchoscopy (Ikeda) 1966

Rigid bronchoscopy (Killian) 1897

TBNA (Wang) 1983

Videobronchoscope 1985

Cryotherapy 1986

1990 Silicon and metallic airway stents

Radial miniprobe 2002

Electromagnetic navigation 2004

EBUS linear array hybrid scope
Endoscopic lung volume reduction
Bronchial thermoplasty 2006

Combined EBUS/EUS-B 2010

Targeted lung denervation for COPD 2015

Archimedes image-guided navigation 2016

Robotics 2018

1890 // 1960 // 1980 1990 2000 2010 2020 The future ???

(Killian)

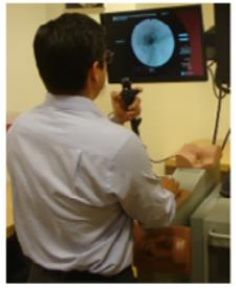
(Ikeda)

1978 WABIP founded

1980s Bronchoscopy manikins

Bronchoscopy International established www.Bronchoscopy.org

2001 Computer based bronchoscopy simulators



2007 Dedicated IP fellowships (USA)

2010 Establishment of AIPPD

Disposable bronchoscopes

2013 Train the trainer workshops

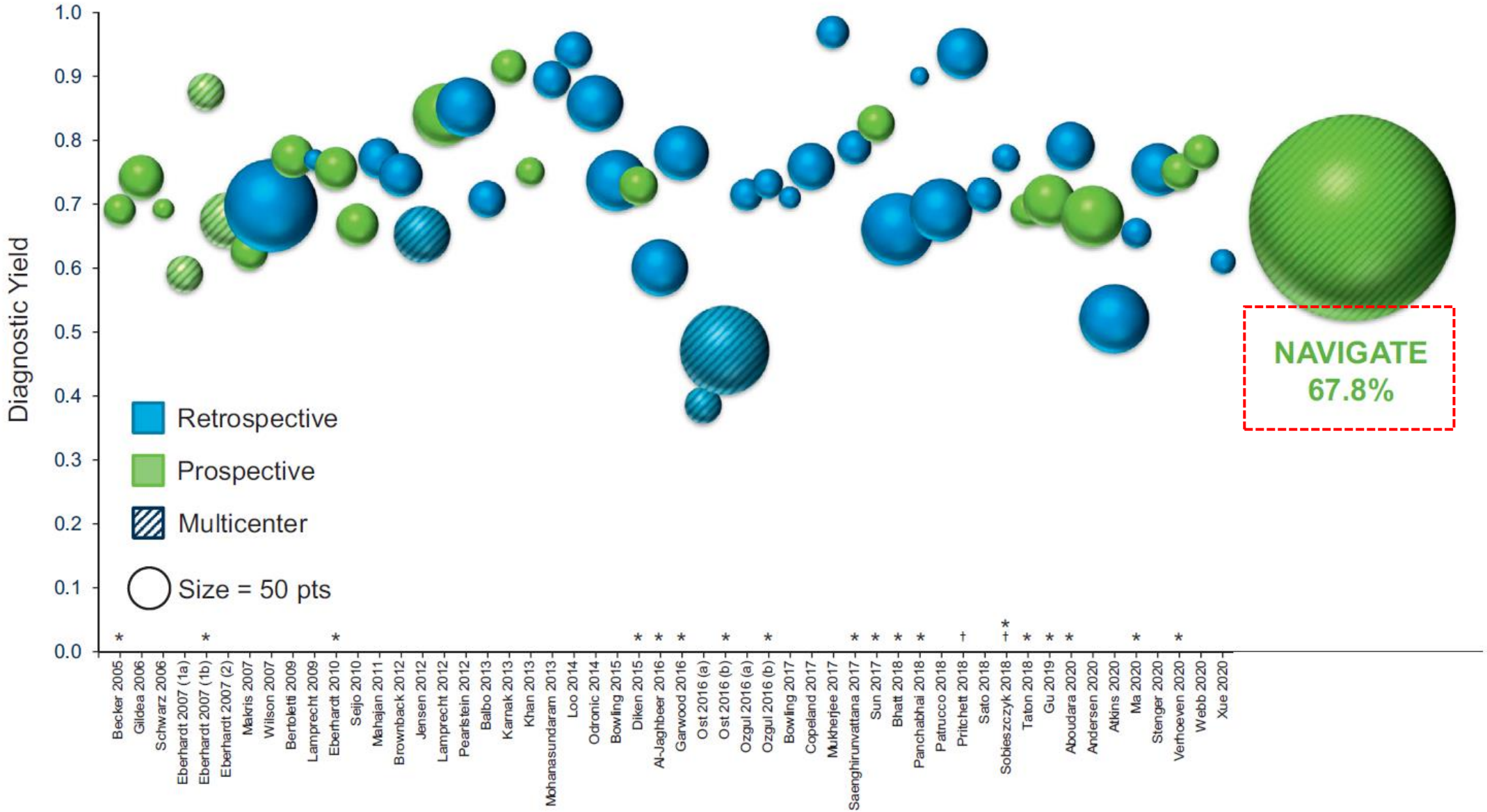
2016 EBUS certification program (ERS)

2017 Joint IP Fellowship Accreditation Committee (North America)

2018 IP Masters Program (Italy)

Education and training milestones…

Respirology **2020**, *25* (9), 997–1007.



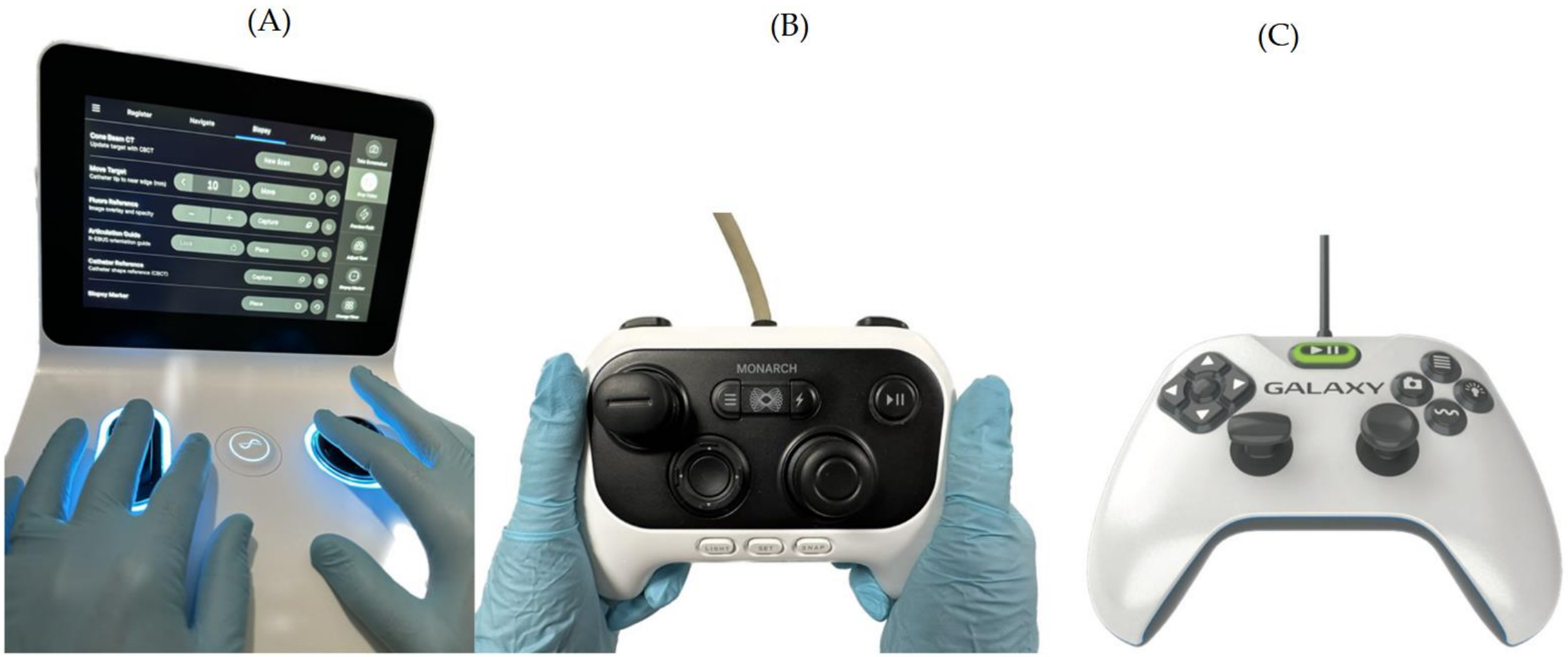
Folch EE, et al. NAVIGATE 24-Month Results: Electromagnetic Navigation Bronchoscopy for Pulmonary Lesions at 37 Centers in Europe and the United States. *J Thorac Oncol*. 2022;17(4):519-531.

Auris Health Announces First MONARCH® Robotic-Assisted Bronchoscopy Procedure Performed Outside the U.S.

SRT Surgical Robotics Technology 8th, December 2021 3 min read

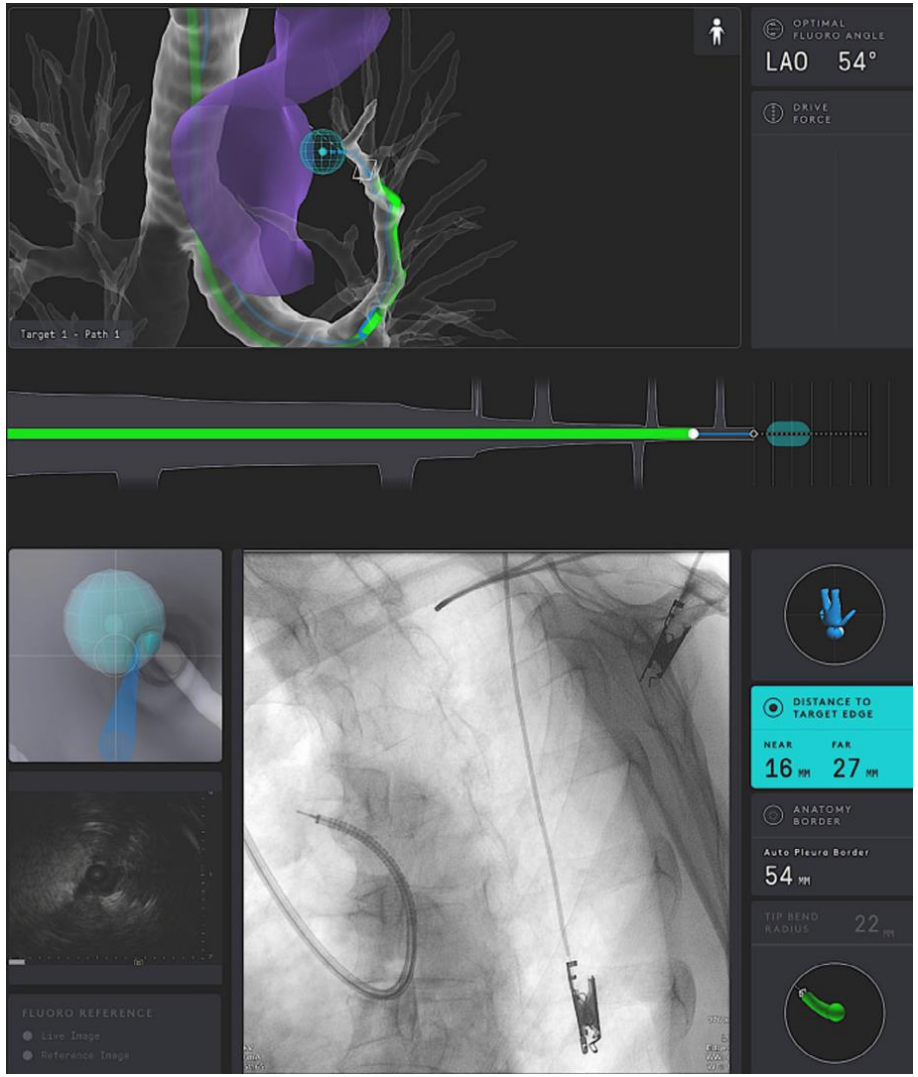
	Monarch™ Robotic Endoscopy System	The Ion™ Robotic Endoluminal System	Galaxy System™
FDA approval	March 2018	February 2019	March 2023
Bronchoscope	4.2 mm inner bronchoscope, 6 mm outer sheath	3.5 mm outer diameter fully articulating catheter with a thin 1.8 mm removable visual probe	4.0 mm outer diameter
Working channel	2.1 mm	2 mm	2.1 mm
Navigation	Electromagnetic navigation along with peripheral vision and real time input from the micro-camera at the tip of the bronchoscope	Fiberoptic shape-sensing and peripheral vision	Electromagnetic navigation with digital tomosynthesis Tool-in-Lesion+ Technology™
Scope reprocessing	Yes	Yes	No (single use disposable scope)
Vision during biopsy	Yes	No	Yes

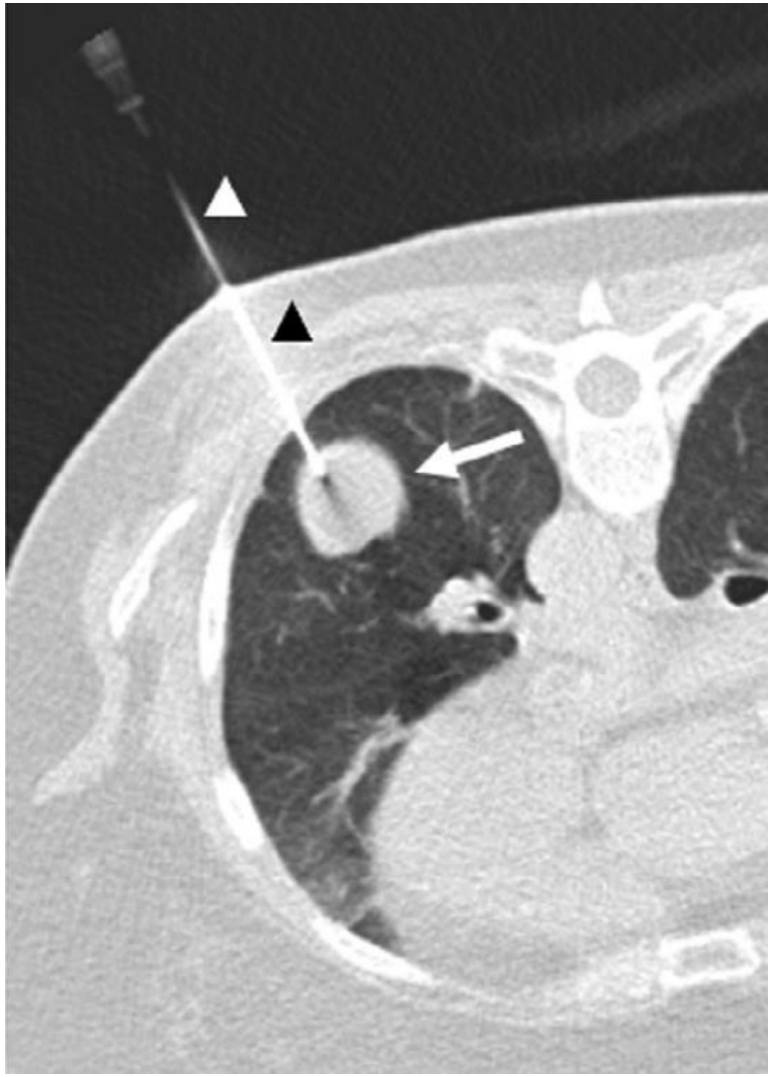
J Thorac Dis. 2024 Aug;16(8):5422–34.



Diagnostics **2024**, *14* (4), 399.

RAB vs. CT-TTNB





Respirology **2023**, *28* (1), 66–73.

	Robotic-assisted bronchoscopy ($n = 113$)	CT-guided transthoracic biopsy ($n = 112$)	p value
Age (mean, ±SD)	70.0 (±9.8)	67.4 (±12.4)	0.295
BMI (mean, ±SD)	27.9 (±6.5)	27.0 (±5.2)	0.236
Gender			
Female	56 (49.6%)	55 (49.1%)	1
Male	57 (50.4%)	57 (50.9%)	
Personal history of cancer			
Yes	54 (47.8%)	77 (68.8%)	**0.003**
No	59 (52.2%)	35 (31.2%)	
Smoking history			
Former	70 (61.5%)	57 (50.9%)	**0.03**
Never	30 (26.5%)	47 (42.0%)	
Current	13 (11.5%)	8 (7.1%)	

Respirology **2023**, *28* (1), 66–73.

	Robotic-assisted bronchoscopy ($n = 113$)	CT-guided transthoracic biopsy ($n = 112$)	p value
Target accessibility	113 (100%)	112 (100%)	—
Biopsy tool			—
Needle 18G	0 (0%)	79 (70.5%)	
Needle 19G	14 (12.4%)	0 (0%)	
Needle 20G	0 (0%)	33 (29.5%)	
Needle 21G	73 (64.6%)	0 (0%)	
Needle 23G	44 (38.9%)	0 (0%)	
Forceps	3 (2.7%)	0 (0%)	
Nodule location			0.471
RUL	39 (34.5%)	37 (33.0%)	
RML	7 (6.2%)	8 (7.1%)	
RLL	14 (12.4%)	17 (15.2%)	
LUL	32 (28.3%)	34 (30.4%)	
LLL	21 (18.5%)	26 (23.2%)	
Nodule pattern			0.136
Solid	91 (81.3%)	98 (87.5%)	
Ground glass	16 (14.3%)	5 (4.5%)	
Mixed	5 (4.5%)	8 (7.1%)	
Cystic	1 (0.9%)	1 (0.9%)	
Maximum target size (cm) (median, IQR)	1.8 (1.3–2.7)	1.6 (1.0–2.6)	0.077
Minimum target size (cm) (median, IQR)	1.4 (1.0–2.0)	1.2 (0.8–1.8)	**0.028**
Distance to chest wall (cm) (median, IQR)	1.5 (0.6–3.3)	1.3 (0.1–2.3)	0.065

Respirology **2023**, *28* (1), 66–73.

	Robotic-assisted bronchoscopy ($n = 113$)	CT-guided transthoracic biopsy ($n = 112$)	p value
Malignancy diagnosis			
True positive	64	77	
False positive	0	0	
True negative	35	22	
False negative	14	13	
Diagnostic accuracy			
Sensitivity	82.1%	88.5%	0.674
Specificity	100%	100%	—
Positive predictive value	100%	100%	—
Negative predictive value	71.4%	62.9%	0.177

Respirology **2023**, *28* (1), 66–73.

Complication Rate (Overall)

- **Total Nodules:** 225
  - **Monitoring:** Up to 7 days post-procedure
- **RAB:** 4.4% (5/113) vs. **CT-TTNB:** 17% (19/112)
  - **p-value:** 0.002 (**TTNB has significantly higher complications**)

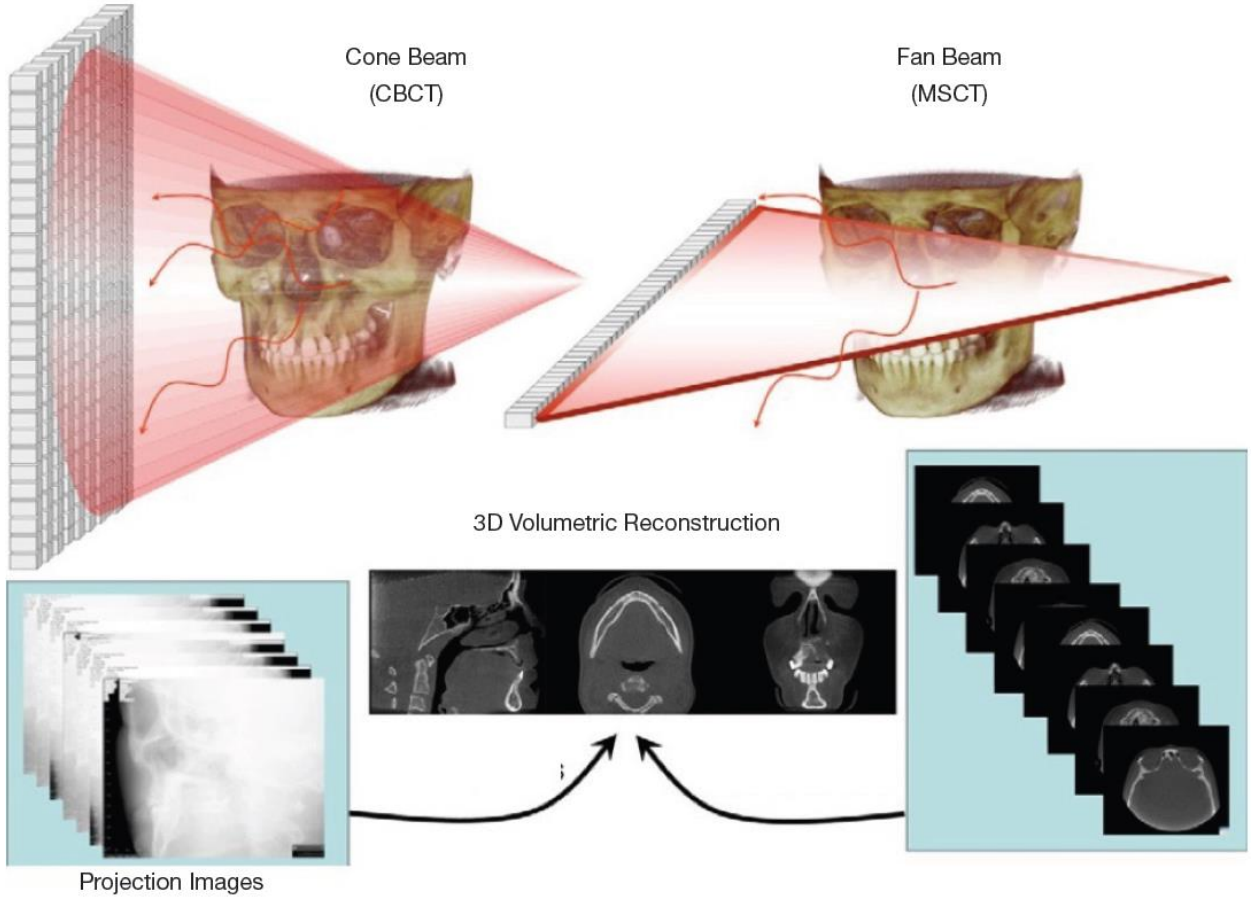
Respirology **2023**, *28* (1), 66–73.

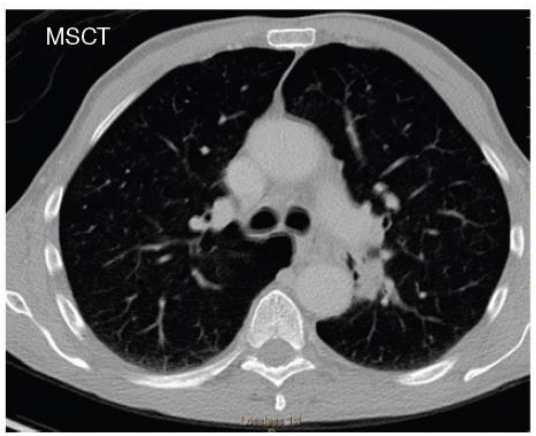
Complication Rate

- **Hemoptysis**
  - RAB: 1 moderate case
  - CT-TTNB: 1 mild case
- **Pneumothorax requiring admission or chest tube**
  - RAB: 4 cases / n=113 (3.5%)
  - CT-TTNB: 18 cases / n=112 (16.1%)
- **Multivariable Logistic Regression Analysis**
  - RAB: OR 0.19 (95% CI 0.05–0.62, p ≤ 0.001) vs. CT-TTNB: OR 5.2 (95% CI 0.06–0.75, p ≤ 0.001)

Respirology **2023**, *28* (1), 66–73.

Cone beam CT (CBCT)

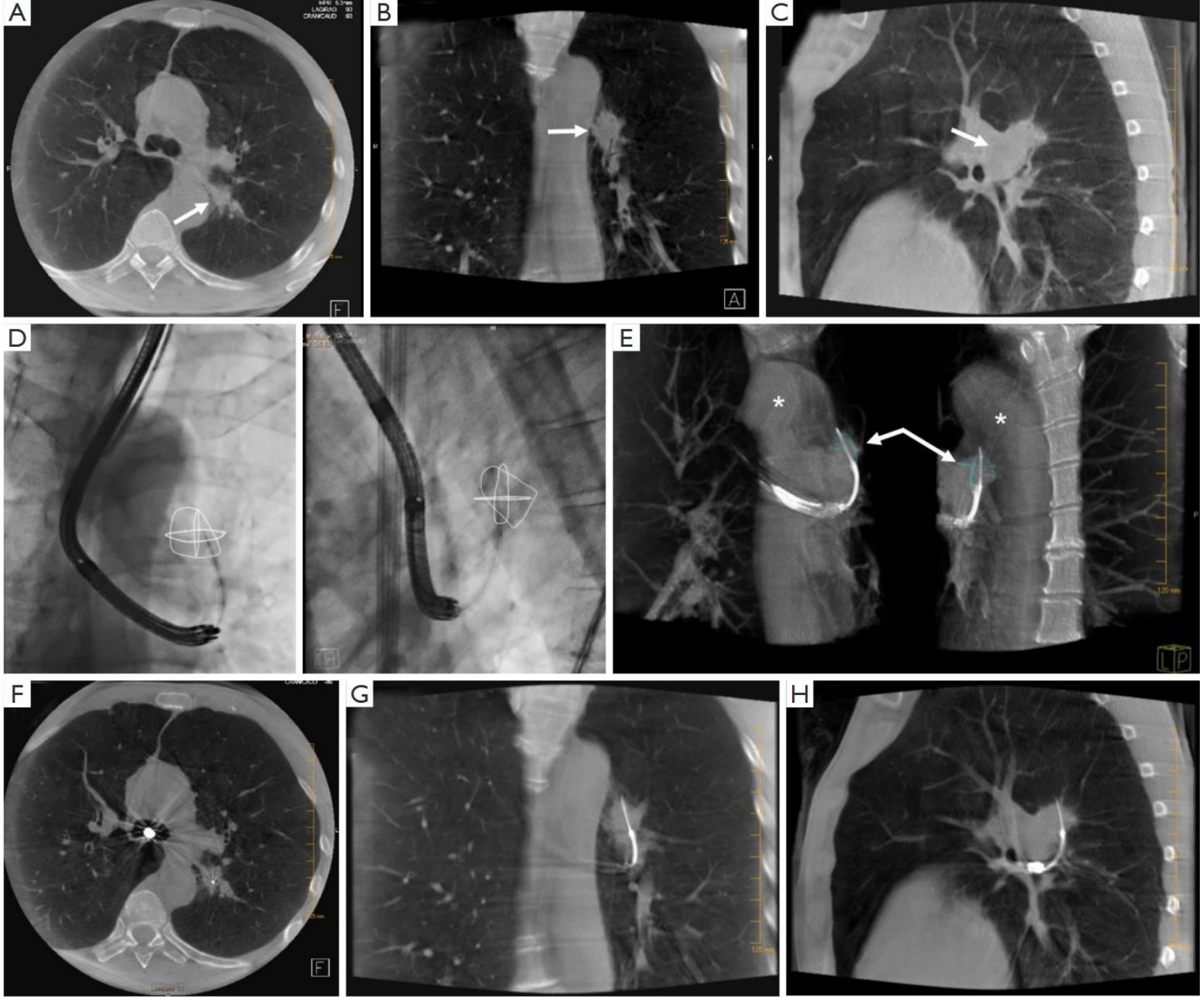




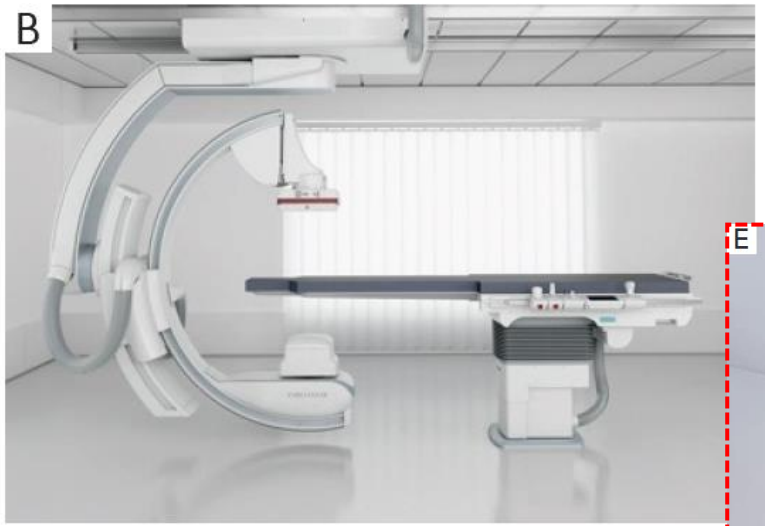
J Thorac Dis. 2020;12(12):7416-7428.

Feature	CBCT	MSCT
X-ray Beam Type	Cone-beam	Fan-beam
Detector Type	2D Flat Panel Detector	1D Detector Array
Image Acquisition	C-arm rotates around a stationary patient	Helical scan with patient table movement
Z-Dimension Definition	Defined by detector size	Defined by table movement
Scan Time	3-20 seconds	Less than 0.4 seconds per rotation
Spatial Resolution	Similar to MSCT	Similar to CBCT
Contrast Resolution	Lower than MSCT	Higher than CBCT
Image Calibration	Non-calibrated grayscale values	Calibrated Hounsfield Units (HU)
Standardized Lung Window	Not possible	Possible
Motion Artifacts	More susceptible due to longer acquisition ti me	Less susceptible due to fast acquisition
Artifacts from Metal Objects	More pronounced due to scatter radiation	Less pronounced
Radiation Dose Measurement	Air Kerma (Kar) and Dose Area Product (DAP)	Effective Dose (E)
Typical Effective Dose (mSv)	0.98 - 3.32 mSv per acquisition	Similar to CBCT low-dose protocols
Collimation for Dose Reduction	Possible; can reduce dose significantly	Not typically used
Use in Bronchoscopy	Primarily used for intraprocedural guidance	Limited use; challenging due to patient positioning in the gantry

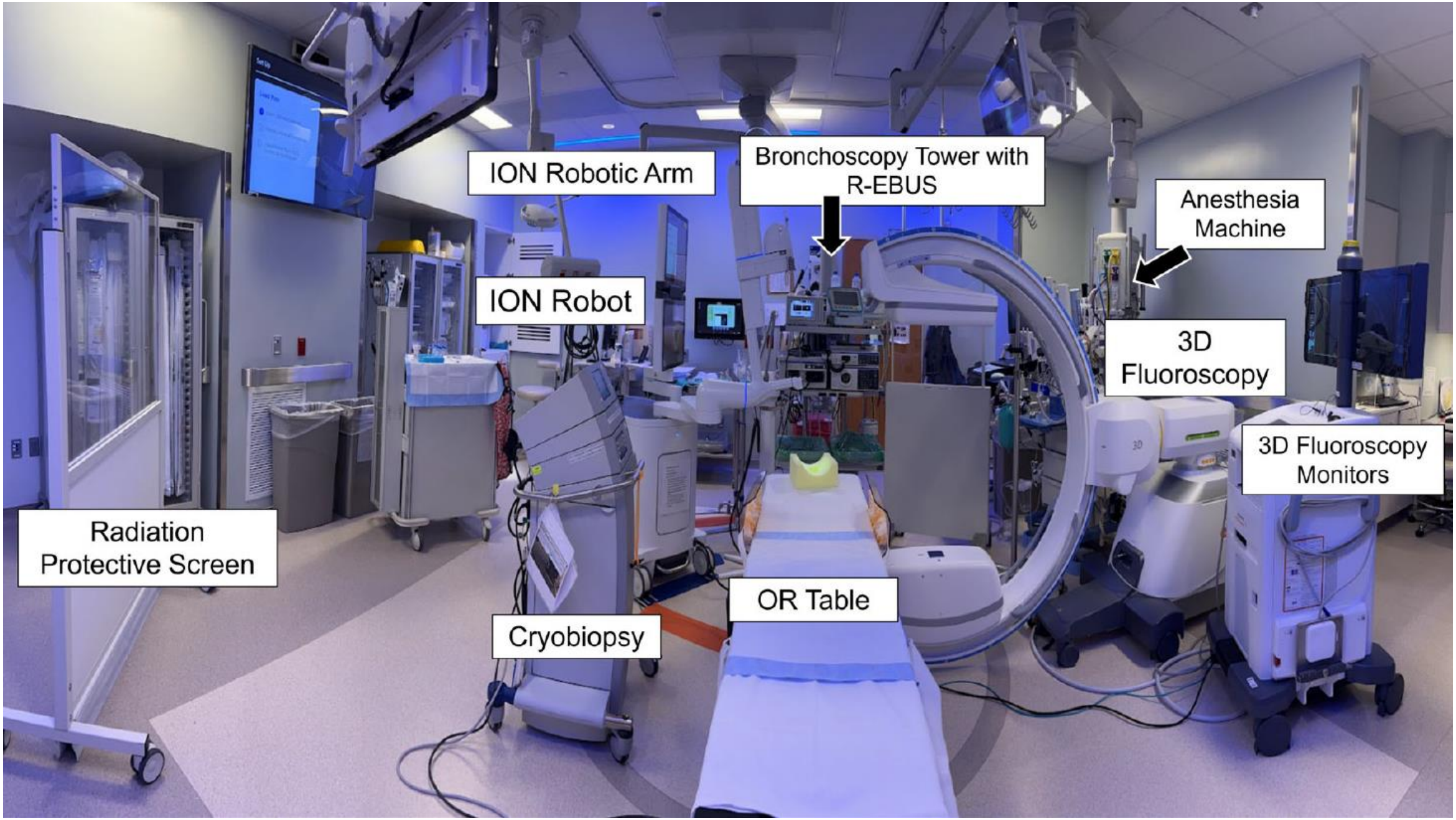
J Thorac Dis. 2020;12(12):7416-7428.



J Thorac Dis. 2020;12(12):7416-7428.



J Thorac Dis. 2020;12(12):7416-7428.

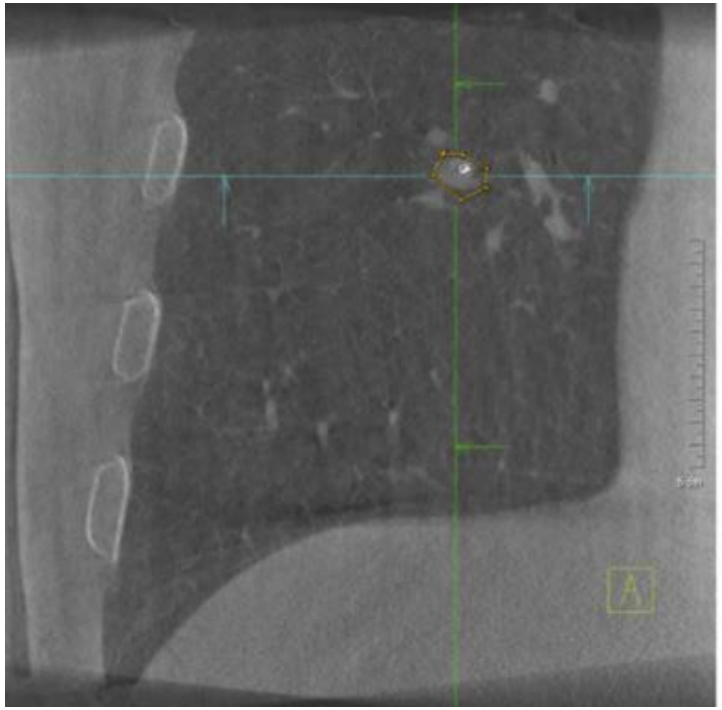


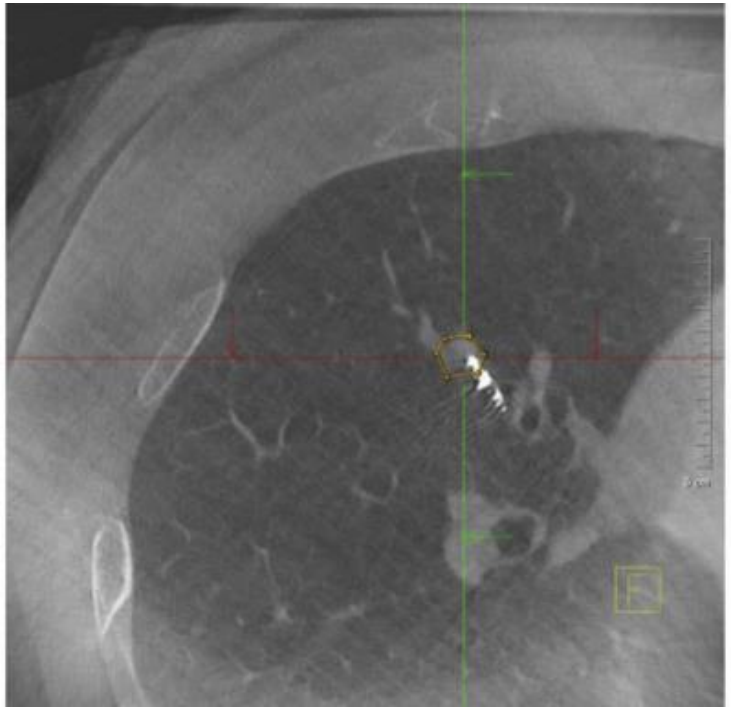
Abia-Trujillo D, et al. Mobile cone-beam computed tomography complementing shape-sensing robotic-assisted bronchoscopy in the small pulmonary nodule sampling: A multicentre experience. *Respirology*. Published online November 28, 2023.

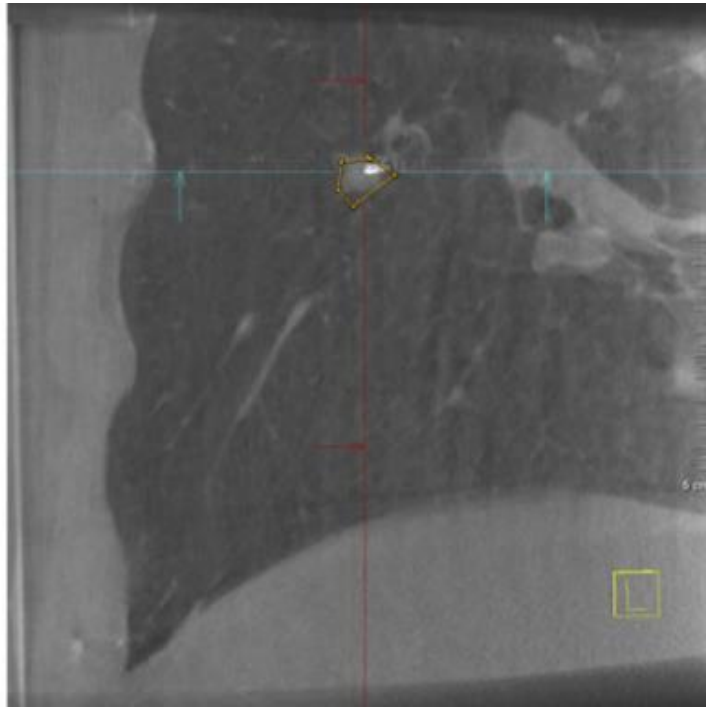
MAYO CLINIC

ORIGINAL ARTICLE

Combining Shape-Sensing Robotic Bronchoscopy With Mobile Three-Dimensional Imaging to Verify Tool-in-Lesion and Overcome Divergence: A Pilot Study







Mayo Clinic Proceedings: Innovations, Quality & Outcomes **2022**, *6* (3), 177–185.

TABLE 2. Cases of Divergence[a]

Target lesion from preprocedural and intraoperative CT with less than 10% overlap or less[b]	
Upper lobes (17)	Lower lobes (11)
Average lesion size: 16.5 mm	Average lesion size: 16.8 mm
Median divergence: 10 mm	Median divergence: 21 mm
Cases with divergence, 6 (35%)	Cases with divergence, 8 (73%)
Average lesion size: 18.5 mm	Average lesion size: 14.2 mm
Median divergence: 17.8 mm	Median divergence: 21.5 mm
Target centers from preprocedural CT and intraoperative 3D images divergent >10 mm[c]	
Upper lobes (17)	Lower lobes (11)
Average lesion size: 16.5 mm	Average lesion size: 16.8 mm
Median divergence: 10 mm	Median divergence: 21 mm
Cases with divergence, 8 (47%)	Cases with divergence, 9 (82%)
Average lesion size: 15.3 mm	Average lesion size: 17 mm
Median divergence: 17 mm	Median divergence: 22 mm

	Diagnostic yield[b]
Location	
Right upper lobe	8/9 (88.9%)
Left upper lobe	9/9 (100%)
Right middle lobe	2/2 (100%)
Right lower lobe	6/7 (85.7%)
Left lower lobe	3/3 (100%)
Bronchus sign present	12/12 (100%)
Bronchus sign absent	16/18 (88.9%)
rEBUS view	
Eccentric	18/19 (94.7%)
Concentric	4/4 (100%)
No view	6/7 (85.7%)
Lesion appearance	
Solid	22/23 (95.6%)
Semisolid	6/6 (100.0%)
Cavitary	0/1 (0%)
Size	
10 mm	3/3 (100%)
11-20 mm	13/15 (86.7%)
21-29 mm	9/9 (100%)
30 mm	3/3 (100%)

Mayo Clinic Proceedings: Innovations, Quality & Outcomes **2022**, *6* (3), 177–185.

Study	Robot	Publication	Type	Time Frame	Analysis	Total Patients	Average Age (*yr*)	Average Size (*mm*)	3D Imaging	Total Lesions	Diagnosed	DY (%)
Styrvoky *et al.* (2022)	SS-RAB	Manuscript	Retro	12/2020 to 2/2022	DY and safety	198	67.1	22.6	CBCT	209	192	91.9
Low *et al.* (2022)	SS-RAB	Manuscript	Retro	11/2021 to 5/2022	DY and safety	133	64	17	No	143	110	76.9
Oberg *et al.* (2022)	SS-RAB	Manuscript	Retro	10/2021 to 8/2022	DY and safety	112	71	22	No	120	108	90
Naaman *et al.* (2022)	SS-RAB	Abstract	Pros	1/2022 to 3/2022	Safety only	11	62.9	15.8	No	12	8	66.7
Folch *et al.* (2022)	SS-RAB	Abstract	Pros	3/2019 to 5/2021	DY and safety	129	NR	16	No	129	104	80.6
Lee-Mateus *et al.* (2022)	SS-RAB	Manuscript	Retro	1/2019 to 3/2021	DY and safety	113	70	18	No	113	99	87.6
Chambers *et al.* (2022)	SS-RAB	Manuscript	Retro	9/2020 to 7/2021	DY and safety	75	65	20	O-arm	79	61	77.2
Reisenauer *et al.* (2022)	SS-RAB	Manuscript	Pros	2/2021 to 8/2021	DY and safety	30	69.3	17.5	Cios Spin	30	28	93.3
Tavakoli *et al.* (2022)	SS-RAB	Abstract	Retro	8/2020 to 12/2021	Safety only	65	NR	21.2	No	65	56	86.2
Al Taq *et al.* (2022)	SS-RAB	Abstract	Retro	NR	Safety only	20	NR	14	No	20	19	95
Kalchiem-Dekel *et al.* (2022)	SS-RAB	Manuscript	Pros	10/2019 to 7-2020	DY and safety	130	69	18	Cios Spin	159	130	81.8
Ross *et al.* (2021)	SS-RAB	Abstract	Pros	8/2020 to 3/2021	Safety only	40	NR	15	No	49	43	87.8
Pritchett *et al.* (2021)	SS-RAB	Abstract	Retro	1/2020 to 4/2021	DY and safety	192	NR	15	CBCT	230	212	92.2
Ghosh *et al.* (2021)	SS-RAB	Abstract	Retro	2/2020 to 4/2021	DY and safety	95	NR	19	No	103	82	79.6
Verga *et al.* (2021)	SS-RAB	Abstract	Pros	1/2020 to 10/2020	Safety only	40	67	NR	No	57	NR	NR
Bajwa *et al.* (2021)	SS-RAB	Abstract	Retro	3/2020 to 11/2020	DY and safety	76	68.4	17	No	76	68	89.5
Benn *et al.* (2021)	SS-RAB	Manuscript	Retro	9/2019 to 6/2020	DY and safety	52	68	21.9	CBCT	59	51	86.4
Fielding *et al.* (2019)	SS-RAB	Manuscript	Pros	9/2016 to 7/2017	DY and safety	29	63.2	14.8	No	29	23	79.3
Hedstrom *et al.* (2022)	EN-RAB	Abstract	Retro	2/2021 to 11/2021	DY and safety	45	NR	16.9	AF	45	41	91.1
Cumbo-Nacheli *et al.* (2022)	EN-RAB	Manuscript	Retro	NR	DY and safety	20	70	22	CBCT	20	18	90
Agarwal *et al.* (2022)	EN-RAB	Manuscript	Retro	6/2018 to 12/2019	DY and safety	124	68	24	No	124	95	76.6
Manley *et al.* (2021)	EN-RAB	Abstract	Retro	NR	DY and safety	17	NR	NR	No	17	14	82.4
Ekeke *et al.* (2021)	EN-RAB	Manuscript	Retro	8/2020 to 2/2021	DY and safety	25	71	10-20	No	25	20	80
Chen *et al.* (2021)	EN-RAB	Manuscript	Pros	NR	DY and safety	54	67.1	23.2	No	54	40	74.1
Rojas-Solano *et al.* (2018)	EN-RAB	Manuscript	Pros	NR	DY and safety	15	67	26	No	15	13	86.7

Definition of abbreviations: 3D = three-dimensional; AF = augmented fluoroscopy; CBCT = cone-beam computed tomography; DY = diagnostic yield; EN = electromagnetic navigation; NR = not reported; Pros = prospective; RAB = robotic-assisted bronchoscopy; Retro = retrospective; SS = shape-sensing.

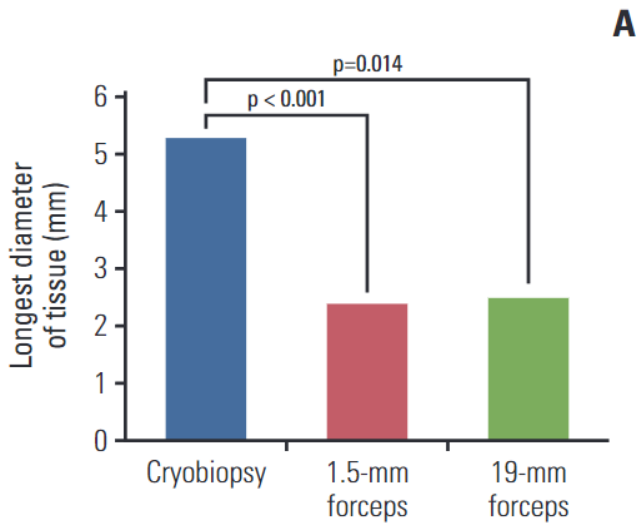
Factor	Studies	Number of Studies	Pooled Diagnostic Yield (%) (95% CI)	I^2 (%)
Lesion size	Studies with average lesion size ⩽ 18 mm	9	85.5 (81–89.5)	69.2
	Studies with average lesion size > 18 mm	9	83.3 (77.8–88.2)	71.3
Study design	Prospective studies	6	81 (77–84.6)	7.3
	Retrospective studies	14	85.2 (81.4–88.7)	70.2
Publication type	Manuscript	14	83.4 (79.4–87)	63.9
	Abstract	6	86.1 (80.2–91)	69
Robot type	SS-RAB	13	85.2 (81.6–88.6)	71.7
	EN-RAB	7	80.1 (75.1–84.4)	19.4
3D imaging	Studies with 3D imaging	8	87.6 (83.1–91.5)	65.7
	Studies without 3D imaging	12	81.8 (78.2–85.1)	44.2
Sample size	Sample size (⩽100 lesions)	11	83.7 (80.0–86.9)	23.3
	Sample size (>100 lesions)	9	84.5 (79.9–88.7)	80.6
Diagnostic yield definition	Stringent	5	79.4 (74.3–83.9)	26.2
	Liberal	15	85.0 (81.5–88.2)	67.0

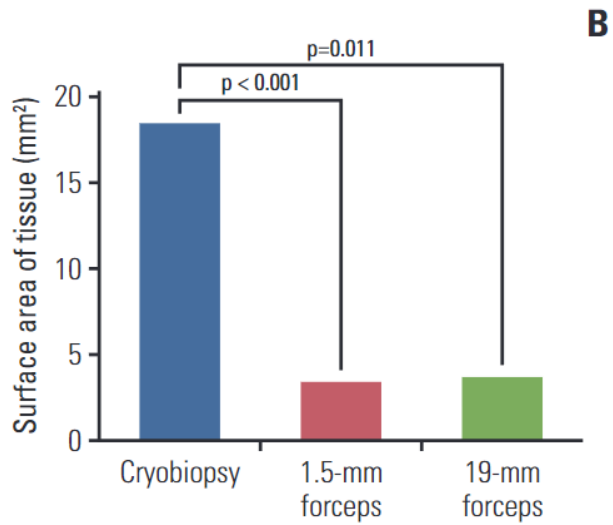
Annals of the American Thoracic Society **2023**, *20* (12), 1801–1812.

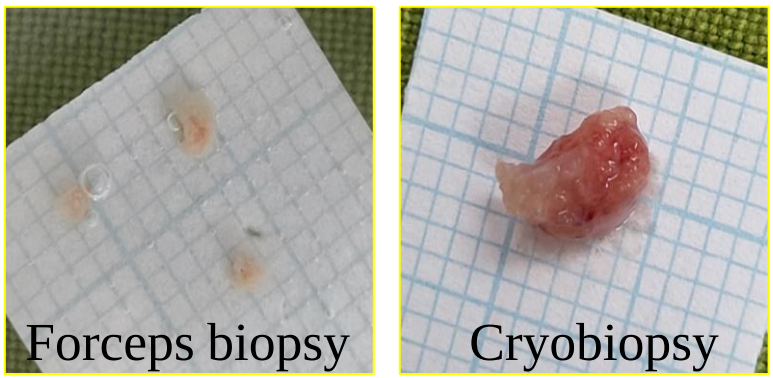
Cryobiopsy

Transbronchial lung cryobiopsy (TBLC)

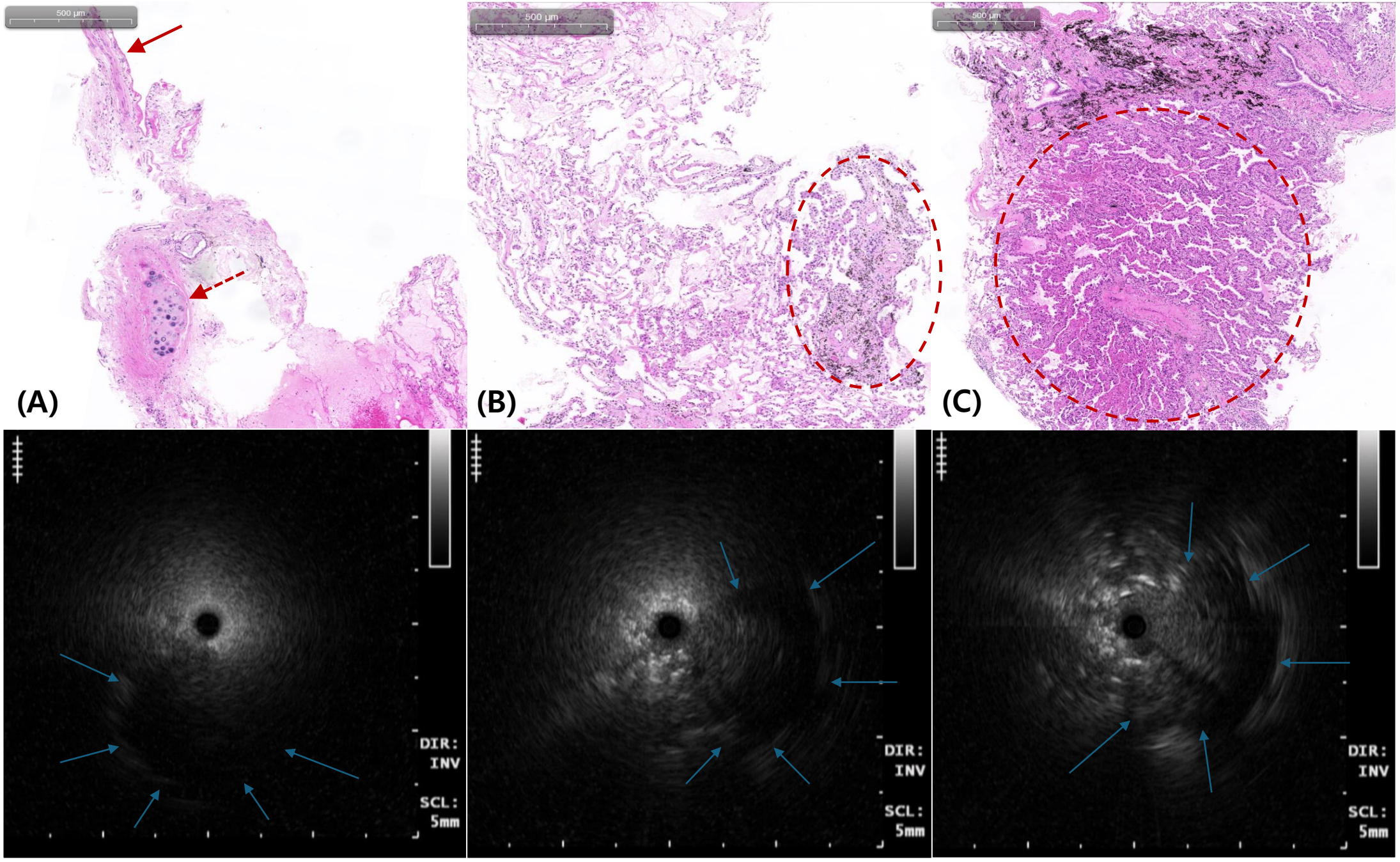
- Forceps TBLB vs. Transbronchial lung cryobiopsy (TBLC)
  - Larger tissues / Less crushing artifact
  - Additional diagnostic yield for peripheral pulmonary lesions (PPLs)
- 1.1 mm cryoprobe
  - Excellent flexibility
  - With 1.95 mm guide sheath (GS) in 2.0 mm working channel







Cancer Res Treat. **2023** Apr;55(2):506-512.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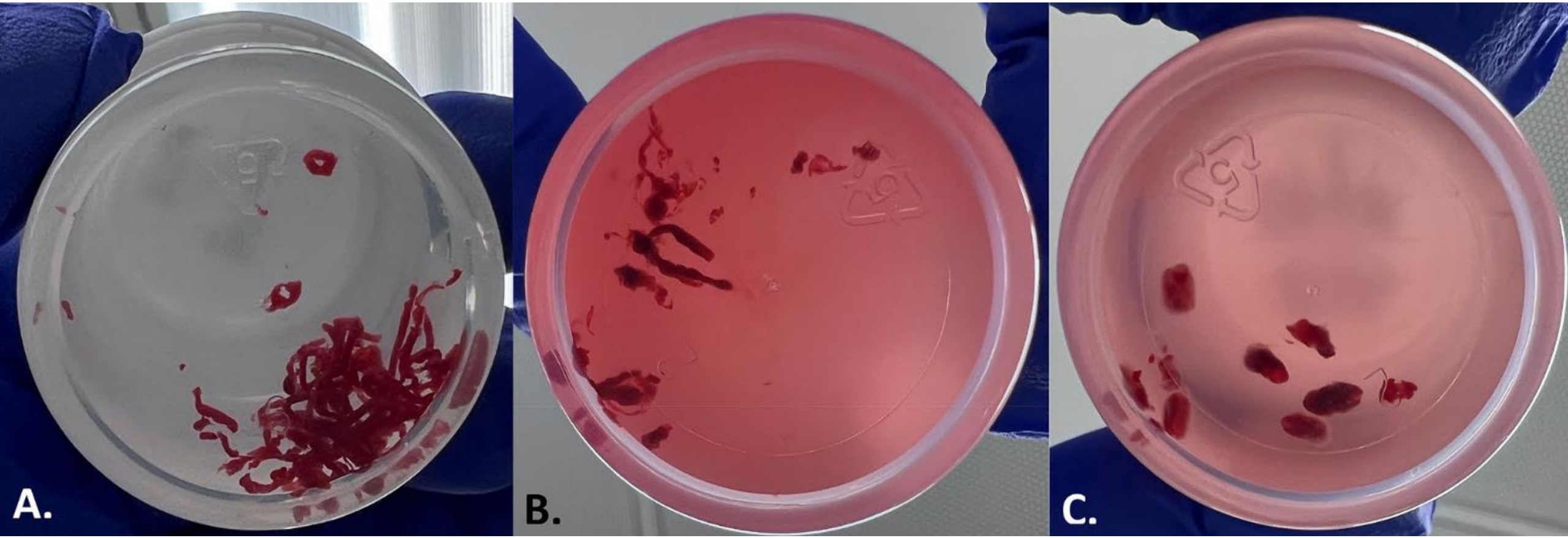
Novel Robotic-Assisted Cryobiopsy for Peripheral Pulmonary Lesions

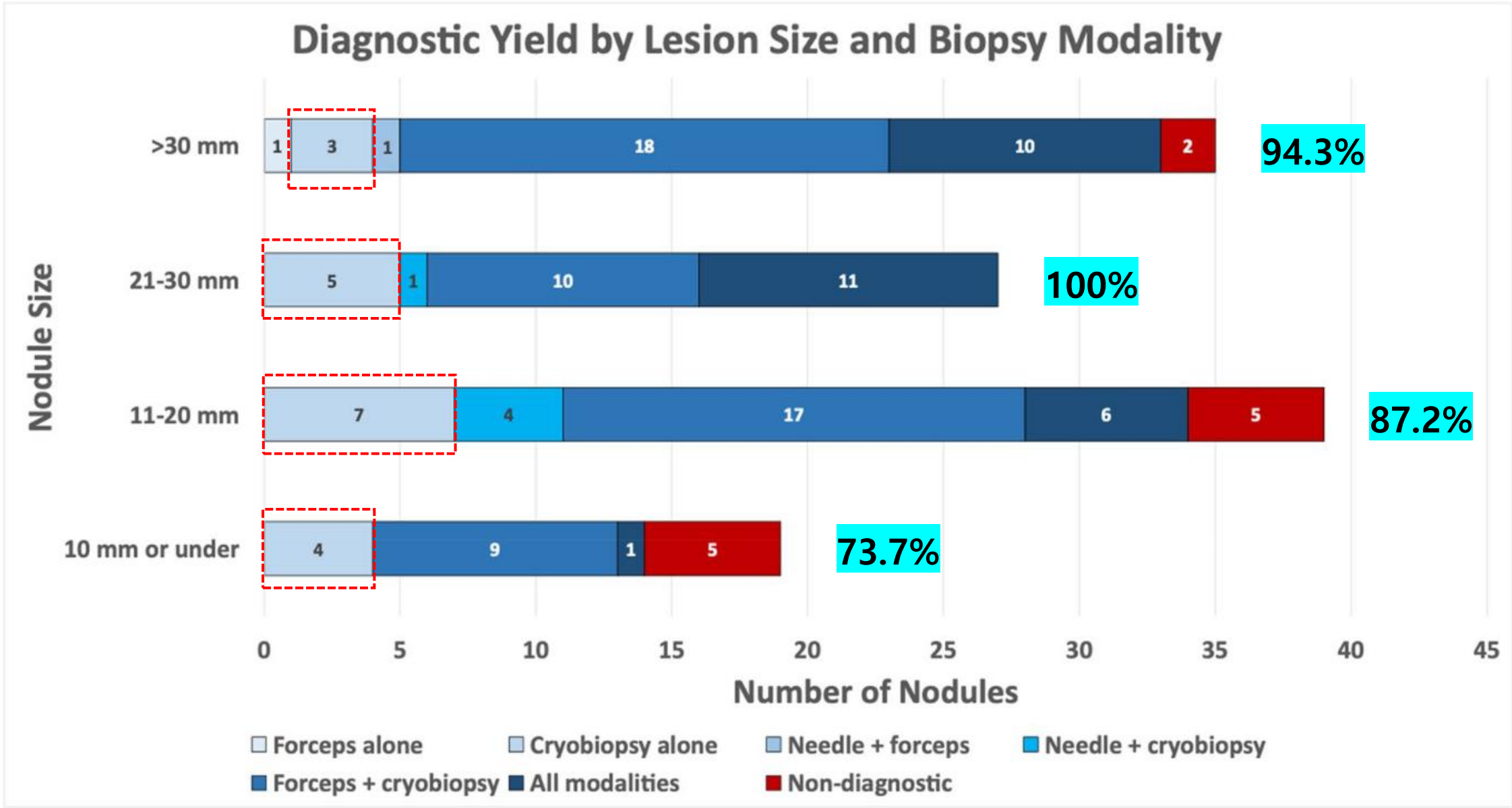
Catherine L. Oberg[1,4] · Ryan P. Lau[2] · Erik E. Folch[3] · Tao He[1] · Reza Ronaghi[1] · Irawan Susanto[1] · Colleen Channick[1] · Rodrigo Garcia Tome[1] · Scott Oh[1]

Purpose	- Importance of tissue acquisition in lung cancer - Common reasons for biopsy failure: insufficient tumor cells, inadequate tissue quality - Limitations of robotic bronchoscopy in sampling peripheral pulmonary nodules - Evaluation of the 1.1-mm cryoprobe's 360-degree tissue acquisition capability
Methods	- Study Population: 112 patients with 120 peripheral pulmonary nodules - Techniques Compared: Needle aspiration, forceps biopsy, cryobiopsy - Key Analyses: Diagnostic yield and molecular marker adequacy
Results	- Overall Diagnostic Yield: 90% - Cryobiopsy-exclusive Diagnoses: 18% - Molecular Marker Analysis: 100% adequacy in cryobiopsy samples - Digital Imaging Analysis: Cryobiopsy provided superior tissue quantity and quality compared to needle aspiration and forceps biopsy
Conclusion	- Combination of robotic bronchoscopy and 1.1-mm cryobiopsy is safe and effective - Yields more diagnostic tissue than conventional methods - Improved tissue acquisition for extraluminal lesions adjacent to the airway

Lung **2022**, *200* (6), 737–745.



Lung **2022**, *200* (6), 737–745.



Lung **2022**, *200* (6), 737–745.

Molecular analysis	$n=49$
Local IHC/FISH adequacy	49 (100%)
Needle	2 (100%)
Forceps	18 (100%)
Cryobiopsy	29 (100%)
NGS adequacy	45 (81.6%)
Needle	1 (50%)
Forceps	15 (83.3%)
Cryobiopsy	29 (100%)

Lung **2022**, *200* (6), 737–745.

Complication

Outcome	Count	Percentage (%)
Total Patients	112	-
Prolonged Intubation/Hospitalization	None	-
Post-procedure Pneumothorax	6	5.4
Chest Tube Placement & 24-h Admission	3	2.7
Major Bleeding (Grade 2 or higher)	None	-

Lung **2022**, *200* (6), 737–745.

Meta-analysis

Study	Robotic platform	Study design	Patients, *n*	Lesions, *n*	Lesion size, mm	Bronchus sign, *n* (%)	Solid lesion, *n* (%)	Auxiliary technique	Sampling method
Fielding et al. 2019[31]	Ion	Pro	29	29	12.2 ± 4.2[a]	17 (58.6)	23 (79.3)	rE, Fl, ROSE	Needle, forceps, brush, BAL/wash
Benn et al. 2021[32]	Ion	Pro	52	59	19.6 ± 10.9[a]	27 (45.8)	41 (69.5)	CBCT, ROSE	Needle, forceps
Chen et al. 2021[33]	Monarch	Pro	54	54	23.2 ± 10.8[a]	32 (59.3)	NR	rE, Fl, ROSE	Needle, forceps
Kalchiem-Dekel et al. 2022[34]	Ion	Retro	130	159	18 (13–27)[b]	100 (62.9)	116 (73.0)	rE, Fl, ROSE	Needle, forceps, brush
Oberg et al. 2022[35]	Ion	Retro	112	120	22 (13–34.3)[b]	58 (48.3)	87 (72.5)	rE, Fl	Needle, forceps, cryoprobe
Cumbo-Nacheli et al. 2022[36]	Monarch	Retro	20	20	22 ± 7[a]	10 (50.0)	17 (85.0)	rE, CBCT	Needle, forceps
Xie et al. 2022[37]	Ion	Pro	30	30	17.1 ± 4.3[a]	23 (76.7)	26 (86.7)	rE, Fl, ROSE	Needle, forceps, brush
Vu et al. 2023[38]	Ion	Retro	110	110	20 (15–24)[b]	27 (24.5)	87 (79.1)	rE, Fl, ROSE	Needle, forceps
Agrawal et al. 2023[39]	Monarch	Retro	124	124	20.5 (13–30)[b]	93 (75.0)	71 (57.3)	rE, Fl, ROSE	Needle, forceps
Manley et al. 2023[40]	Monarch	Pro	20	20	14.5 (8–28)[c]	12 (60.0)	NR	rE, Fl, nCLE, ROSE	Needle, forceps

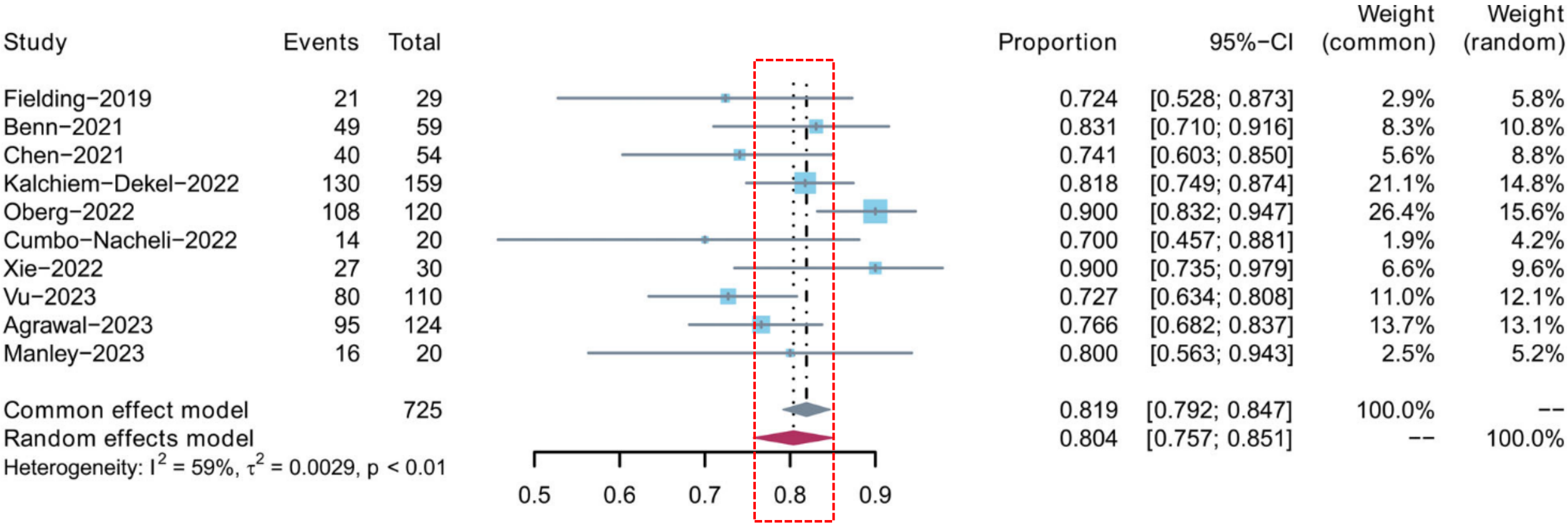


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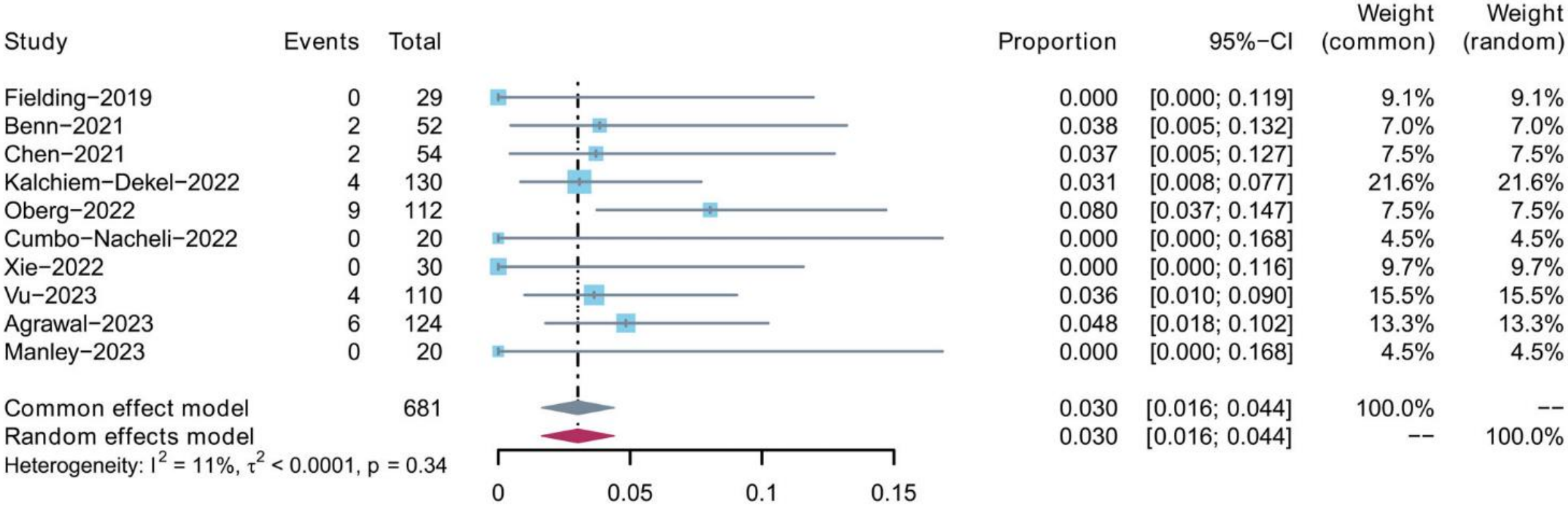
TABLE 2 Diagnostic yield by lesion characteristics.

	No. of studies (lesions)	Pooled diagnostic yield (95% CI)	Test for subgroup differences
Lesion size, mm			
≤20	4 (176)	78.0% (72.0%–84.1%)	$p = 0.09$
>20	4 (156)	88.4% (78.6%–98.1%)	
Lesion size, mm			
≤30	4 (267)	79.5% (71.7%–87.3%)	$p = 0.03$
>30	4 (90)	92.4% (86.8%–98.0%)	
rEBUS view			
Concentric	5 (169)	89.4% (84.8%–94.0%)	$p = 0.01$
Eccentric	5 (154)	79.8% (73.5%–86.0%)	
Bronchus sign			
Positive	4 (242)	82.9% (78.2%–87.6%)	$p = 0.02$
Negative	4 (124)	71.9% (64.0%–79.8%)	
Lesion appearance			
Solid	3 (210)	80.2% (74.9%–85.6%)	$p = 0.60$
Nonsolid[a]	3 (102)	77.6% (69.6%–85.7%)	
Lesion location			
Upper lobe	3 (190)	79.5% (73.8%–85.2%)	$p = 0.90$
Nonupper lobe	3 (122)	78.9% (71.7%–86.2%)	

TABLE 3 Results of subgroup analyses.

	No. of studies (lesions)	Pooled diagnostic yield (95% CI)	Heterogeneity	Test for subgroup differences
Platform				
Ion	6 (507)	82.5% (76.5%–88.5%)	$I^2 = 68\%, p < 0.01$	$p = 0.11$
Monarch	4 (218)	75.8% (70.2%–81.5%)	$I^2 = 0\%, p = 0.88$	
Study design				
Pro	5 (192)	81.4% (76.0%–86.8%)	$I^2 = 24\%, P = 0.26$	$p = 0.81$
Retro	5 (533)	79.8% (72.8%–86.8%)	$I^2 = 76\%, p < 0.01$	
Mean/median lesion size				
≤20 mm	6 (407)	80.5% (76.7%–84.3%)	$I^2 = 36\%, P = 0.17$	$p = 0.87$
>20 mm	4 (318)	79.6% (70.4%–88.8%)	$I^2 = 77\%, p < 0.01$	
Use of cryoprobes				
Yes	1 (120)	90.0% (83.2%–94.7%)	–	$p < 0.01$
No	9 (605)	79.0% (75.8%–82.2%)	$I^2 = 22\%, p = 0.25$	
Use of CBCT				
Yes	2 (79)	80.6% (72.0%–89.3%)	$I^2 = 24\%, p = 0.25$	$p = 0.89$
No	8 (646)	80.5% (75.1%–85.9%)	$I^2 = 66\%, p < 0.01$	



Pooled Complication Rate	3.0% (95% CI: 1.6%–4.4%)
Pneumothorax Incidence	1.8% (95% CI: 0.7%–2.9%)
Mortality	None reported

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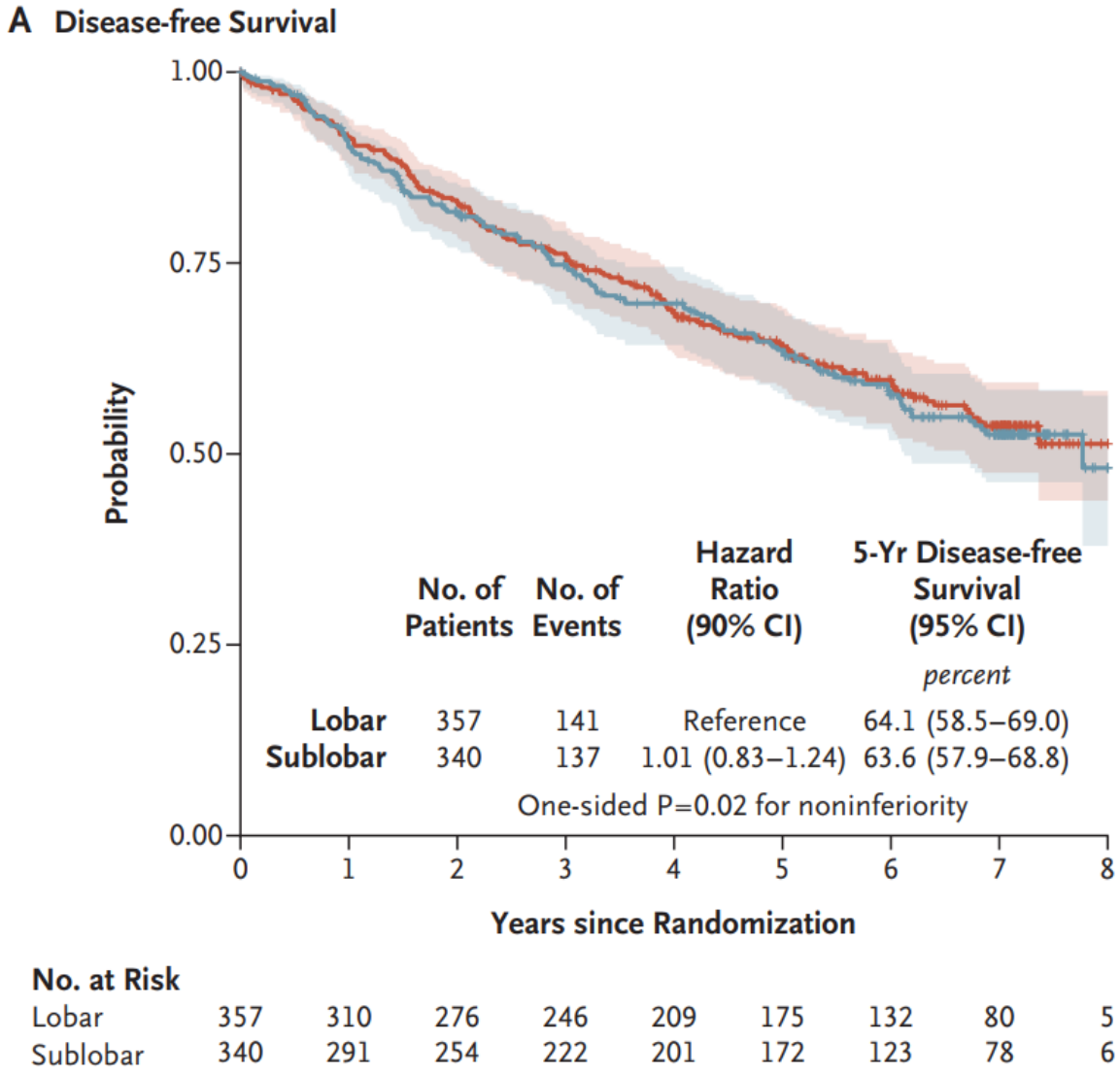
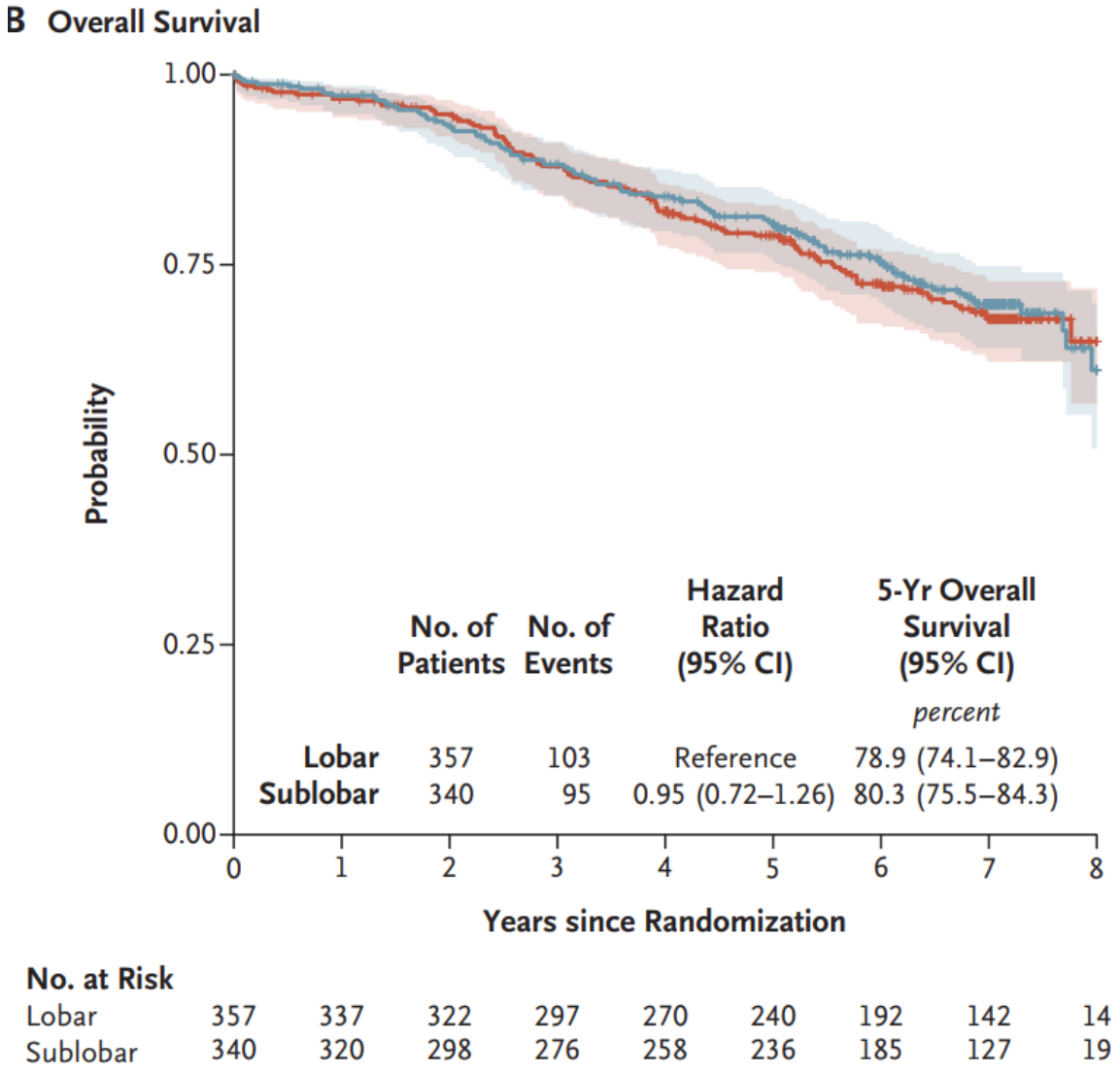
Therapeutic Applications





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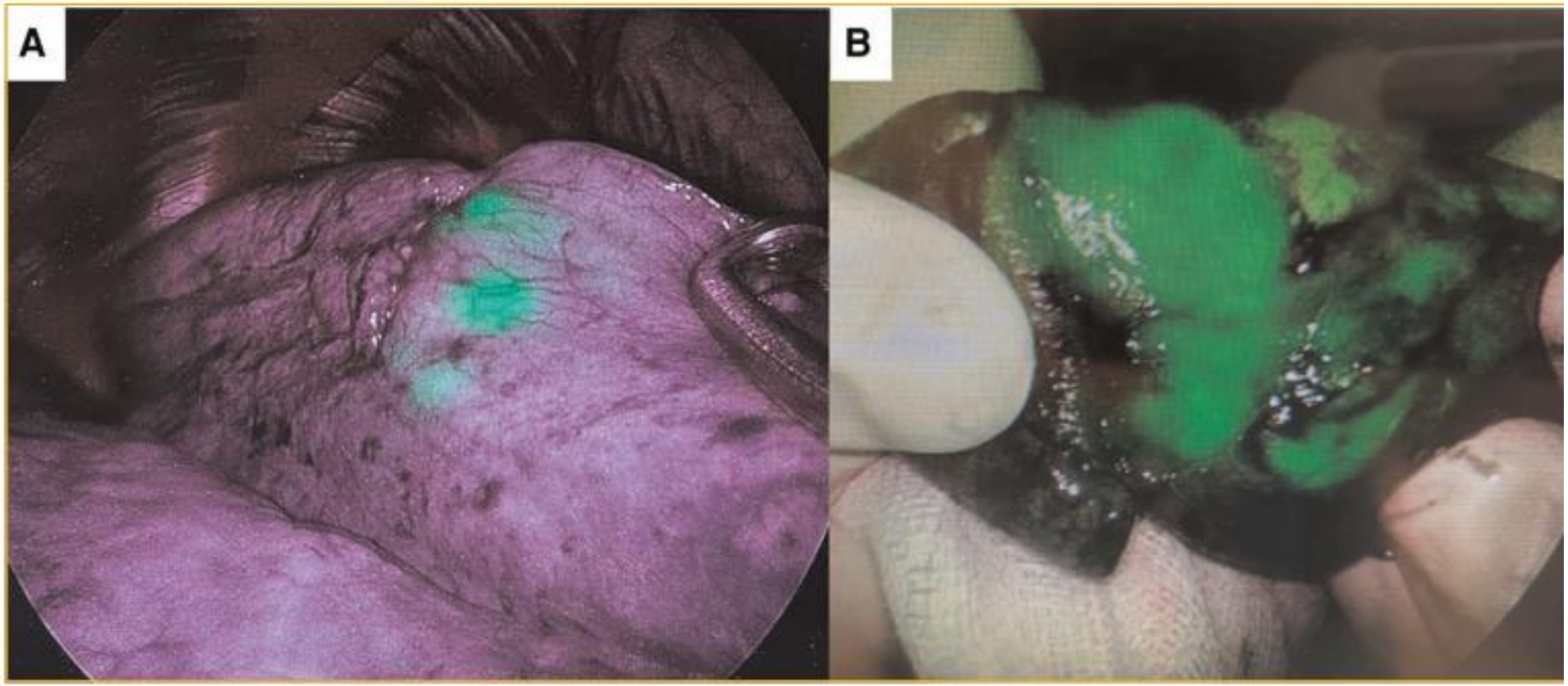

Front Surg. 2022 Jun 28:9:943531.

Summary of RAB

- **Enhanced Diagnostic Yield**
  - DY: RAB ≈ CT-TTNB
  - Safety: RAB > CT-TTNB
- **Adjunctive Techniques**
  - CBCT and aFluoroscopy: Enhances real-time navigation / Confirm biopsy device / Overcome CT-body divergence
  - 1.1-mm cryoprobe: Additional DY / Improve tissue acquisition quality
- **Therapeutic Potential**
  - Dye marking / Fiducial marker
  - Tumor ablation
- AI, ROSE…

Thank for your attention

rahm3s@gmail.com