
UNC Lineberger Cancer Network
Research to Practice
Live Webinar
May 28
Jason Akulian, MD, MPH, MBA
Advances in the Early Detection of Lung Cancer
UNC Lineberger Cancer Network
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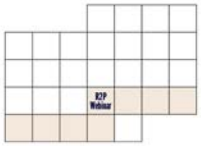

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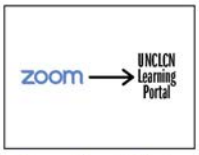

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Our Presenter

Jason Akulian,
MD, MPH, MBA

Jason Akulian, MD, MPH, MBA, focuses his research on the early detection and diagnosis of lung cancer and immune responses to malignant pleural disease with the goal of developing novel cellular therapeutics to cure advanced stage lung cancer.

As Director of Interventional Pulmonology, Carolina Center for Pleural Diseases and UNC Pleural Fluid Registry at UNC, he is dedicated to the development of immunologically directed therapeutics aimed at leveraging the ease with which we can both sample and treat the tumor microenvironment via the pleural space.

His research is geared toward better understanding the tumor-immune microenvironment and how it changes over time in response to tumor progression and/or systemic/local therapy.

He also leads and collaborates in preclinical, clinical, and translational work focused on the early detection and diagnosis of lung cancer.

Finally, his team is actively pursuing blood-based biomarker research aimed a risk stratification of patients with suspected and/or known early-stage lung cancer.

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Our Presenter

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Our Presenter

5. Jason Akulian, MD, MPH, MBA, works hard to mentor junior faculty locally and nationally after being the recipient of good mentorship in his career

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4. He served as president of the Association of Interventional Pulmonary Program Directors

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3. He chaired the American College of Chest Physicians Thoracic Oncology and Chest Procedures Network

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3. He chaired the American College of Chest Physicians Thoracic Oncology and Chest Procedures Network
2. Dr. Akulian completed his MBA during the COVID-19 pandemic and served as front line staff of the MICU
1. He has now graduated 9 interventional pulmonary fellows from the UNC IP fellowship

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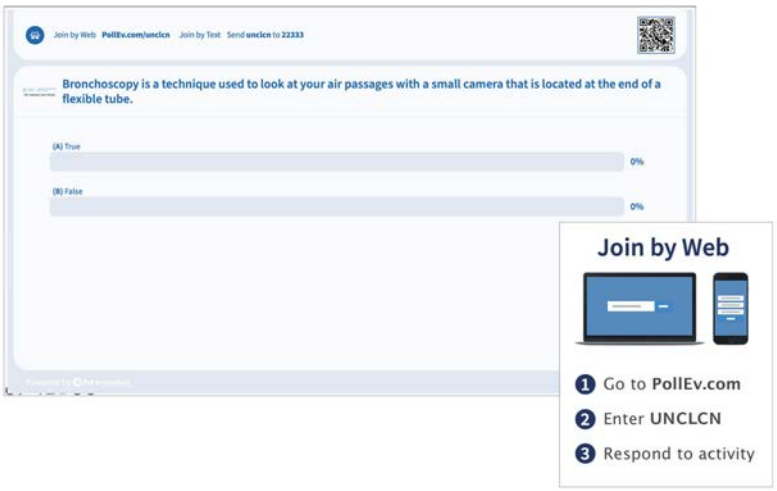
Sample Poll Everywhere Question



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ACPE Pharmacist **ACPE Pharmacy Tech**

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Disclosures

ACCME:
This activity has been planned and implemented under the sole supervision of the Course Director, Stephanie Wheeler, PhD, MPH, in association with the UNC Office of Continuing Professional Development (CPD) and Emily Ray, MD, of the UNC School of Medicine. Dr. Wheeler received research support from AstraZeneca (ended June 2023) and Pfizer Medical Foundation (ended December 2023). These financial relationships have been mitigated. Dr. Emily Ray has no relevant financial relationships with ineligible companies as defined by the ACCME. CPD staff have no relevant financial relationships with ineligible companies as defined by the ACCME.

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The presenter received speaker fees from Olympus; consulting fees from Olympus, Intuitive, Becton Dickinson, Lung Therapeutics, Boston Scientific, Cook Medical, and NanOlogy; and research support from Biodesix, NanOlogy, Veracyte, Intuitive, and Tempus.

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Relevant Financial Relationship: No one with the ability to control content of this activity has a relevant financial relationship with an ineligible company.

Criteria for Activity Completion: Criteria for successful completion to claim CE Certificate requires attendance at the NCPD activity, and submission of an evaluation within 7 days.

Approved Provider Statement: UNC Health is approved as a provider of nursing continuing professional development by the North Carolina Nurses Association, an accredited approver by the American Nurses Credentialing Center's Commission on Accreditation.

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Robotic bronchoscopy is a technique that automates a procedure to look in your air passages with a small camera that is located at the end of a flexible tube.

True 0%

False 0%

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Advances in the Early Detection (and Treatment) of Lung Cancer

Jason Akulian MD MPH MBA FCCP ATSF
Associate Professor of Medicine
Section Chief, Interventional Pulmonology and Pulmonary Oncology
Lineberger Comprehensive Cancer Center
Division of Pulmonary and Critical Care
UNC Chapel Hill School of Medicine

UNC HEALTH

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Disclosure of Financial Relationships

Consulting/Advisory Board: Intuitive, Becton Dickinson, Lung Therapeutics, Boston Scientific, Cook Medical, Olympus, NanOlogy, Pleural Dynamics

Research Grants/Trials: Intuitive, Becton Dickinson, Lung Therapeutics, Olympus, Biodesix, NanOlogy, Tempus, Pleural Dynamics

NIH/NCI: NIH R01 EB028283
NIH R01 EB024864

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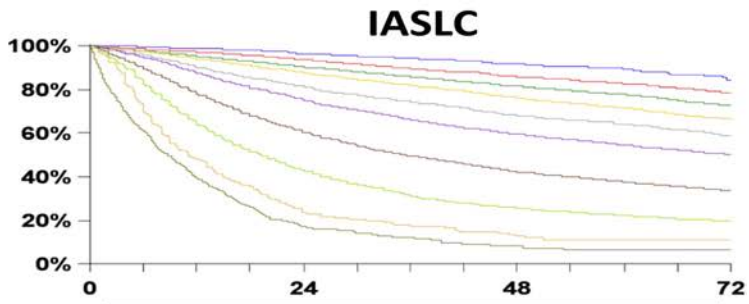
Setting the stage...



TNM	Events / N	MST	24 Month	60 Month
IA1	173 / 1765	NR	96%	89%
IA2	923 / 6127	NR	94%	82%
IA3	931 / 4606	NR	90%	78%
IB	1726 / 6400	NR	87%	71%
IIA	583 / 1700	NR	81%	64%
IIB	2307 / 5537	72.0	75%	55%
IIIA	4703 / 7779	35.0	60%	37%
IIIB	2553 / 3473	19.0	43%	22%
IIIC	873 / 1026	11.0	23%	11%
IV	665 / 883	8.7	17%	6%

at CHAPEL HILL

J Thorac Oncol. 2017 Jul;12(7):1109-1121

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Setting the stage...EBUS-TBNA

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Image courtesy of Dr. David Feller-Kopman

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EBUS-TBNA cont.

- 572 nodes in 502 patients
  - patients confirmed by thoracotomy, VATS or clinical f/u
- Diagnosis in 535 of punctures (94%)
- No ROSE
- 37 non-diagnostic
  - sarcoid in 2, CA in 35 on surgical Bx
- Sens. 94%, Spec. 100%, PPV 100%
- No complications

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Herth et al, Thorax 2006; 61(9):795-8

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EBUS vs. MED

- 190 Patients underwent EBUS f/b MED
- Mean LN size 6.9 ± 2.9mm

TABLE 4. Agreement in mediastinal lymph node staging between endobronchial ultrasound-guided transbronchial needle aspiration and mediastinoscopy

	Mediastinoscopy		
EBUS N stage	N stage	Final N stage	No. of cases
Staged correctly by both EBUS and mediastinoscopy			
0 or 1	0 or 1	0 or 1	100
2	2	2	28
3	3	3	8
Staged incorrectly			
0 or 1	0 or 1	2	4
2	0	2	5
3	2	3	2
0	2	2	5
0	3	3	1

The specificity and positive predictive value of both tests were 100%. The sensitivity, negative predictive value, and diagnostic accuracy rate of EBUS-TBNA and mediastinoscopy were 81%, 91%, 93%, and 79%, 90%, 93%, respectively. *EBUS*, Endobronchial ultrasound.

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Yasufuku et al. J Thorac Cardiovasc Surg. 2011. 142(6):1393-400

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Addressing The Burden of Lung Cancer

- #1 – Cancer related death in NC and the nation
- More annual cancer deaths than breast, prostate and colon combined

The Game Changer – National Lung Screening Trial NLST
20% reduction in lung cancer deaths in patients screened with low dose CT

- **Stage shift is the key!**
  - Caveat emptor! – Incidence of lung cancer in NLST – 1%
  - Highlights the need for a multidisciplinary and minimally invasive approach to diagnosis
    - Conduit to definitive endpoints
      - » Surgery
      - » Radiosurgery
      - » Medical Oncology

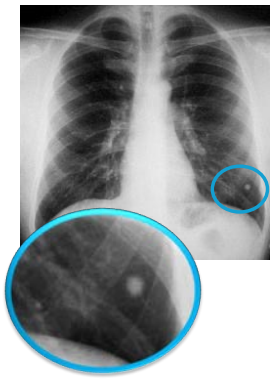

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Image courtesy of Dr. David Feller-Kopman

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NLST

Complication	Lung Cancer Confirmed				
	Thoracotomy, Thoracoscopy, or Mediastinoscopy	Bron-choscopy	Needle Biopsy	No Invasive Procedure	Total
	number (percent)				
Low-dose CT group					
Positive screening results for which diagnostic information was complete	509 (100.0)	76 (100.0)	33 (100.0)	31 (100.0)	649 (100.0)
No complication	344 (67.6)	69 (90.8)	26 (78.8)	26 (83.9)	465 (71.6)
At least one complication	165 (32.4)	7 (9.2)	7 (21.2)	5 (16.1)	184 (28.4)
Most severe complication classified as major	71 (13.9)	2 (2.6)	0	2 (6.5)	75 (11.6)
Most severe complication classified as intermediate	81 (15.9)	5 (6.6)	7 (21.2)	2 (6.5)	95 (14.6)
Most severe complication classified as minor	13 (2.6)	0	0	1 (3.2)	14 (2.2)
Death within 60 days after most invasive diagnostic procedure†	5 (1.0)	4 (5.3)	1 (3.0)	0	10 (1.5)

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NLST Research Team. NEJM 2011; 365(5):395-409

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Patients eligible for lung cancer screening should have which of these based on USPSTF criteria?

At least a 20 PYH tobacco history 0%

Age 50-80 years old 0%

Actively or quit smoking in the past 15 years 0%

All of the above 0%

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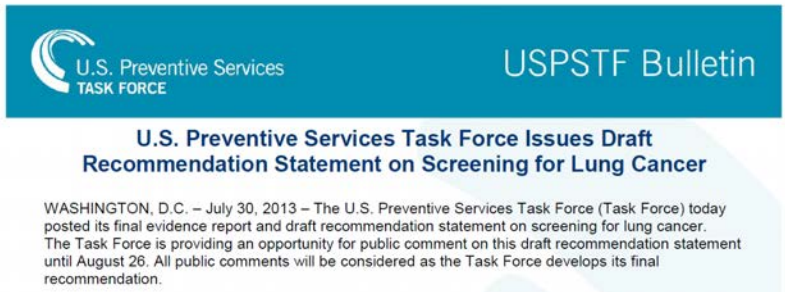

CT lung cancer screening for those who:

- Are 50 to 80 years old
- 20-pack-year history of smoking
- Smoke or quit smoking within the past 15 years

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JAMA. 2021;325(10):962-970

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Progress made with 2021 USPSTF Recommendations

- 14.5 million US adults eligible for LCS, an increase of 81% (6.4 million adults)
  - *Landy R, et al. J Natl Cancer Inst. January 5, 2021*
- Higher relative increase in eligibility of women vs. men and of Blacks, Hispanics, Native American vs. Whites
- Greater gains in lung cancer deaths averted and life-years gained in women compared with men
  - *Meza R, et al. JAMA. Published March 9, 2021*

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*Slide adapted from Drs. Rivera & Henderson presentation

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UNC Early Detection of Lung Cancer – Progress Made

- Consists of parallel programs, conceived in 2022:
  - Lung Cancer Screening Program (LCS)
  - Incidental Pulmonary Nodule Management (IPN)
- Nurse Navigator hired in 2022
  - Michelle Ottersbach, RN
- Monthly meetings with Multi-D group
- Weekly Nodule Board
- LCS BPA developed and active
- LCS Dashboard developed and active
- Streamlined/Intuitive LCS Epic order set update

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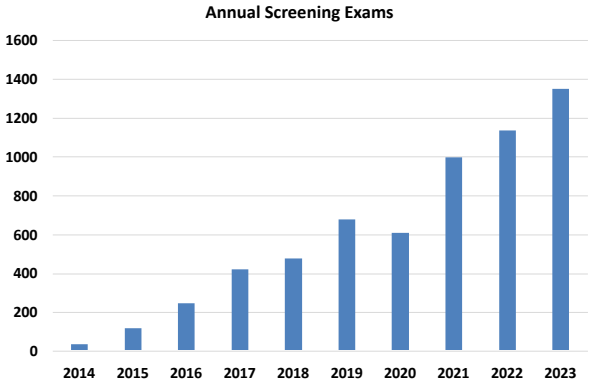
UNC Early Detection of Lung Cancer – Progress Made and now it gets interesting…



CURRENT STATE

- Currently perform ~180 LDCTs monthly
- ACR Lung Cancer Screening Center
- **GO2 Center of Excellence**

NEXT PHASE

- Develop a hybrid model of LCS
- System wide deployment/collaboration
- Begin **active** patient identification and tracking
  - Improve adherence
  - Increase % of eligible population
  - Improve lung cancer survival in NC

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NORTH CAROLINA Lung Screening Registry

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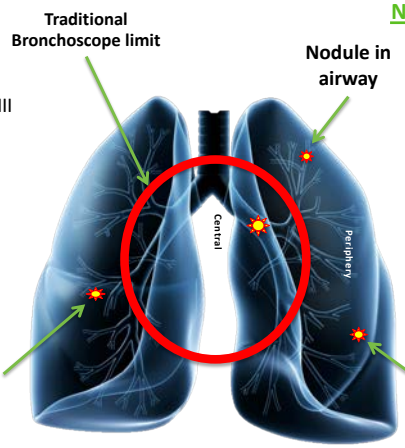
The Shifting Landscape of Lung Cancer

Old Challenge

- 78% diagnosed in stage III or IV
- Patients present with symptoms
- Poor patient outcomes



New Challenge – Phase Shifting The Diagnosis

- 40+% of nodules are outside of the airway
- >60% of lesions are **medium** pre-test probability for cancer
- Targets are smaller
- >80% benign, non-symptomatic patients
- Increased need for accurate early-stage diagnostics

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Image courtesy of Dr. Jason Akulian

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You Want Me to Biopsy What?

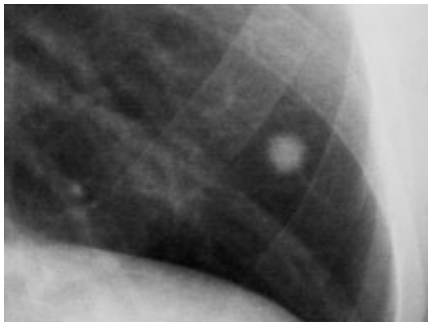

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Image courtesy of Dr. David Feller-Kopman

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A little history of bronchoscopic peripheral lung sampling methods

- Conventional bronchoscopy +/- fluoroscopy
- Radial EBUS
  - First used to eval mediastinal adenopathy and airway wall invasion
  - Adapted to peripheral use
  - +/- Guide sheath
- Electromegnetic navigation
  - Catheter based
  - Tip-tracked instruments

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Conventional Bronchoscopy

- Peripheral lesions
  - sensitivity
    - **< 2cm 33% ≥2cm 62%**

Table 6—*Sensitivity of Flexible Bronchoscopic Diagnosis of Bronchogenic Carcinoma by Size of Lesion

Study/Year	< 2 cm Lesion				> 2 cm Lesion			
	Patients, No.	Pos	Neg	Sens	Patients, No.	Pos	Neg	Sens
Baaklini et al[38]/2000	16	4	12	0.25	135	93	42	0.69
Gasparini et al[74]/1995	195	82	113	0.42	300	169	131	0.56
Naidich et al[72]/1988	15	4	11	0.27	46	26	20	0.57
Wallace and Deutsch[73]/1982	65	3	62	0.05	78	24	54	0.31
McDougall and Cortese[56]/1981	9	1	8	0.11	36	21	15	0.58
Radke et al[57]/1979	21	6	15	0.29	76	49	27	0.64
Stringfield et al[58]/1977	3	1	2	0.33	26	13	13	0.50
Hattori et al[25]/1971	17	13	4	0.76	182	150	32	0.82
Summary	341	114	227	0.33	879	545	334	0.62

*Neg = negatives; Pos = positives; Sens = sensitivity.

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Schreiber et al. Chest 2003; 123(1 Suppl):115S-128S

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Conventional Bronchoscopy

- Peripheral lesions
  - sensi
    - <

Table 6—Se ...e of Lesion*

Study/Year	Neg	Sens
Baaklini et al[38]/2000	42	0.69
Gasparini et al[74]/1995	131	0.56
Naidich et al[72]/1988	20	0.57
Wallace and Deutsch[73]	54	0.31
McDougall and Cortes	15	0.58
Radke et al[57]/1979	27	0.64
Stringfield et al[58]/1977	13	0.50
Hattori et al[25]/1971	32	0.82
Summary	334	0.62

*Neg = negatives; Pos

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Schreiber et al. Chest 2003; 123(1 Suppl):115S-128S

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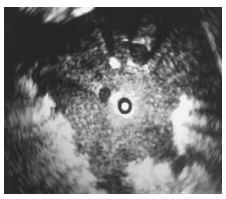
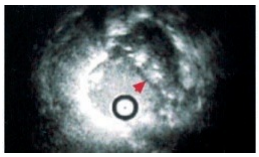
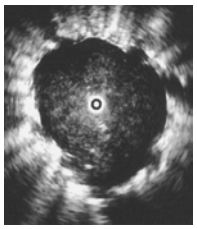
Improving the Yield: EBUS in the Parenchyma

- EBUS c/w CT and histology in 69 patients
  - 92% of the type I lesions (homogenous pattern) were benign
  - 99% of the type II (hyperechoic dots and linear arcs) and type III (heterogeneous pattern) lesions were malignant







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Kurimoto et.al., Chest 2002; 122:1887

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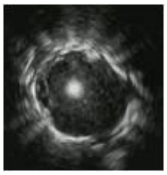
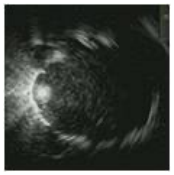
Radial EBUS

- 467 cases performed between 2008 and 2012
- Nodules were categorized by size
  - 1-2cm, 2.1-3cm, 3.1-4cm, 4.1-5cm and >5cm
- Radial EBUS views were classified as "concentric" when the probe was surrounded by lesion or "eccentric" when lesion was adjacent to the probe

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Chen et al, Ann Am Thorac Soc 2014; 11(4):578-82

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Results

- Diagnosis with concentric view: 84%
- Diagnosis with eccentric view: 48% (p<.0001)
- Diagnostic yield using guide sheath: 72% (203/283)
- Diagnostic yield using 4mm bronchoscope and no guide sheath: 70% (16/23)
- Diagnostic yield of TBNA compared to TBBx: 80% vs 77%

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Chen et al, Ann Am Thorac Soc 2014; 11(4):578-82

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Radial EBUS

- Peripheral pulmonary lesions can be successfully identified using radial probe EBUS
- Radial probe EBUS is safe
- There is a discordance between the ability to locate peripheral lesions and the ability to obtain diagnostic material
- Radial probe position relative to the target lesion significantly influences diagnostic yield

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Catheter Based Navigation bronchoscopy

- Uses a previously performed thinly cut non-contrast CT.
- Tip-tracked locatable guide (LG) through a catheter system.
- LG removed and biopsies are done through the catheter working channel.
- Longest tenure/track record of navigation systems.

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Lamprecht et al. Respir Med 2012; 106(5):710-5
Gildea et al. Am J Respir Crit Care Med 2006; 174(9):982-9
Eberhardt et al. Am J Respir Crit Care Med 2007; 176(1):36-41

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Catheter based system

	N	Size	Yield (N)
Eberhardt et al. (2007)	118	< 20 mm	75% (4)
		20-30 mm	50% (50)
		>30 mm	69% (69)
Gildea et al. (2006)	54	< 20 mm	74.1% (31)
		< 30 mm	72.1% (43)
		>30 mm	81.8% (11)
Lamprecht et al. (2012)	112	<20 mm	75.6% (45)
		> 20mm	89.6% (67)

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Lamprecht et al. Respir Med 2012; 106(5):710-5
Gildea et al. Am J Respir Crit Care Med 2006; 174(9):982-9
Eberhardt et al. Am J Respir Crit Care Med 2007; 176(1):36-41

43

EBUS & ENB

TABLE 5. DIAGNOSTIC YIELDS BY SIZE, LOCATION, AND DISEASE TYPE, AND PNEUMOTHORAX RATE

	EBUS, n (%)		ENB, n (%)		EBUS and ENB, n (%)		p
Overall diagnostic yield	27/39 (69)		23/39 (59)		35/40 (88)		0.02*
Yield by lesion size							0.02*
≤ 20 mm	7/9 (78)	p = 0.80	3/4 (75)	p = 0.50	9/10 (90)	p = 0.99	
20–30 mm	16/23 (70)		11/22 (50)		21/24 (88)		
> 30 mm	4/7 (57)		9/13 (69)		5/6 (83)		
Yield by lobar location							0.01*
Bilateral upper lobes	16/27 (59)	p = 0.18	17/22 (77)	p = 0.01*	17/20 (85)	p = 0.99	
Right middle lobe	3/3 (100)		2/3 (67)		2/2 (100)		
Bilateral lower lobes	8/9 (89)		4/11 (29)		16/18 (89)		
Yield for malignant disease							
Sensitivity	23/32 (72)		16/29 (55)		28/31 (90)		0.009*
Specificity	7/7 (100)		10/10 (100)		9/9 (100)		—
Positive predictive value	23/23 (100)		16/16 (100)		28/28 (100)		—
Negative predictive value	7/16 (44)		10/23 (44)		9/12 (75)		0.16
Yield for benign disease							
Sensitivity	4/7 (57)		7/10 (70)		7/9 (78)		0.79
Specificity	32/32 (100)		29/29 (100)		31/31 (100)		—
Positive predictive value	4/4 (100)		7/7 (100)		7/7 (100)		—
Negative predictive value	32/35 (91)		29/32 (91)		31/33 (94)		0.90
Pneumothorax rate	2/39 (5)		2/39 (5)		3/40 (8)		0.99

For definition of abbreviations, *see* Table 3.
* $p < 0.05$.

at CHAPEL HILL

Eberhardt et al. Am J Respir Crit Care Med 2007; 176(1):36-41

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Tip Tracked instruments for Navigation bronchoscopy + EMTTNA

- Currently a same-day scan with *expiratory planning*
- No room mapping limitations
- Thin bronchoscope based utilizing tip tracked instruments
- Allows for EMTTNA

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Needle Aspiration Screenshot

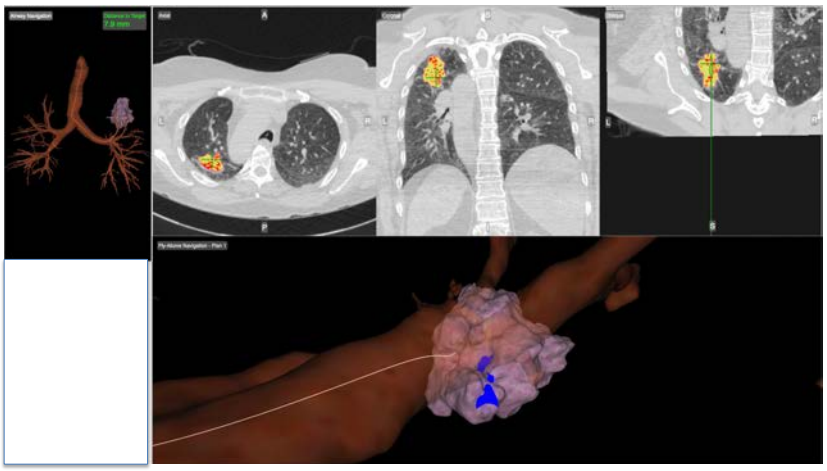

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Image courtesy of Dr. Jason Akulian

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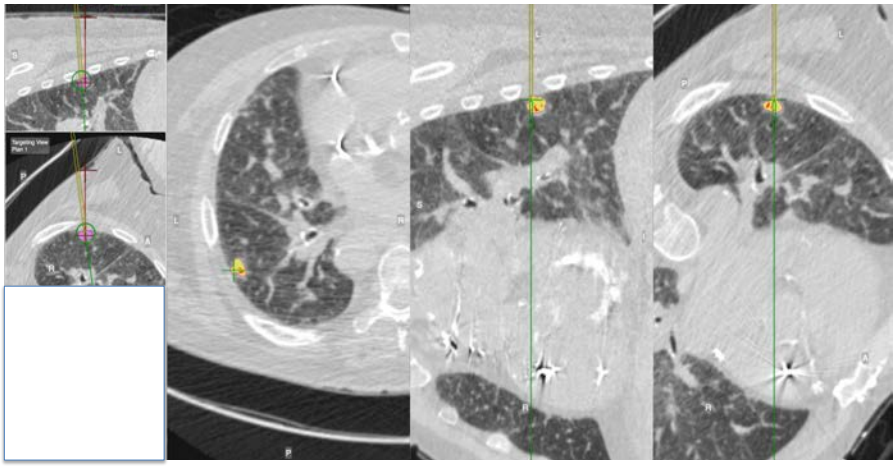
Electromagnetic TTNA



THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Image courtesy of Dr. Jason Akulian

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Tip-Tracked instrument pilot

- 24 patients with a peripheral pulmonary nodule & radiographically normal mediastinum/hilum
- EBUS ➡ Navigation ➡ EMTTNA
- Mean nodule size – 20.3 mm (12-29mm)
- Combined Yield:
  - Nav + EMTTNA – 87%
  - + EBUS – 92%
- PTX 5/24,
  - 2 chest tubes

- Non-Dx Cases: Melanoma, Carcinoid
- All Non-Dx cases diagnosed by VATS
- All benign study cases confirmed by VATS or 6 months of CT f/u showing either decrease (50%) or stability (50%)
- Final Yield including VATS in Non-dx cases = 100%

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Yarmus et al. J Thorac Dis 2016. 8(1):186-94

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Prospectively didn't look so good

- Multicenter prospective single-arm observational trial of a tip-tracked navigation platform

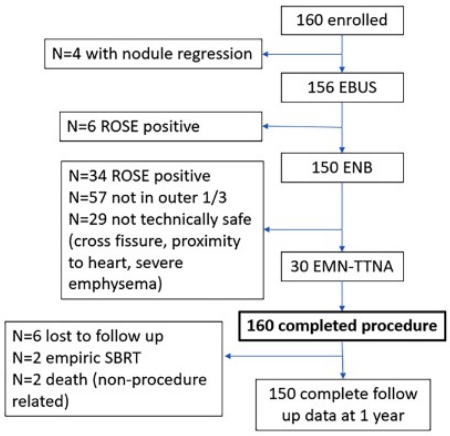

Table 2. Diagnostic Yield by Intervention

Intervention	Yield
Nodule regression	4/160 (2.5)
EBUS	11/156 (7.1)
ENB	74/150 (49.3)
EMN-TTNA	8/30 (26.7)
ENB + EMN-TTNA	79/150 (52.7)
Overall	94/160 (58.8)

Values in parentheses are percentages.
Definition of abbreviations:
EBUS = endobronchial ultrasound; EMN-TTNA = electromagnetic navigational transthoracic biopsy; ENB = electromagnetic navigational bronchoscopy.

Thiboutot J. et al. Am J Respir Crit Care Med. 2023 Oct 15;208(8):837-845.

49

The struggle was real!

- Navigation bronchoscopy

Table 2—*Inverse Weighted Diagnostic Yield Overall and by Modality*

Technology	Studies, No.	Weighted Proportion, %	95% CI	Q Statistic	Q *P* Value
VB	10	72.0	(65.7-78.4)	21.0	.01
ENB	11	67.0	(62.6-71.4)	13.3	.21
GS	10	73.2	(64.4-81.9)	63.8	<.0001
U	11	70.0	(65.0-75.1)	15.2	.12
R-EBUS	20	71.1	(66.5-75.7)	84.2	<.0001
All	39	70.0	(67.1-72.9)	119.4	<.0001

See Table 1 legend for expansion of abbreviations.

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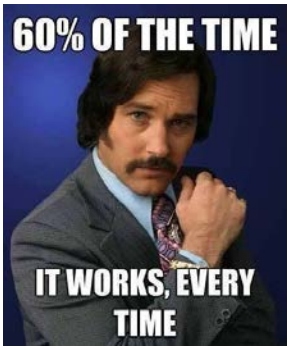
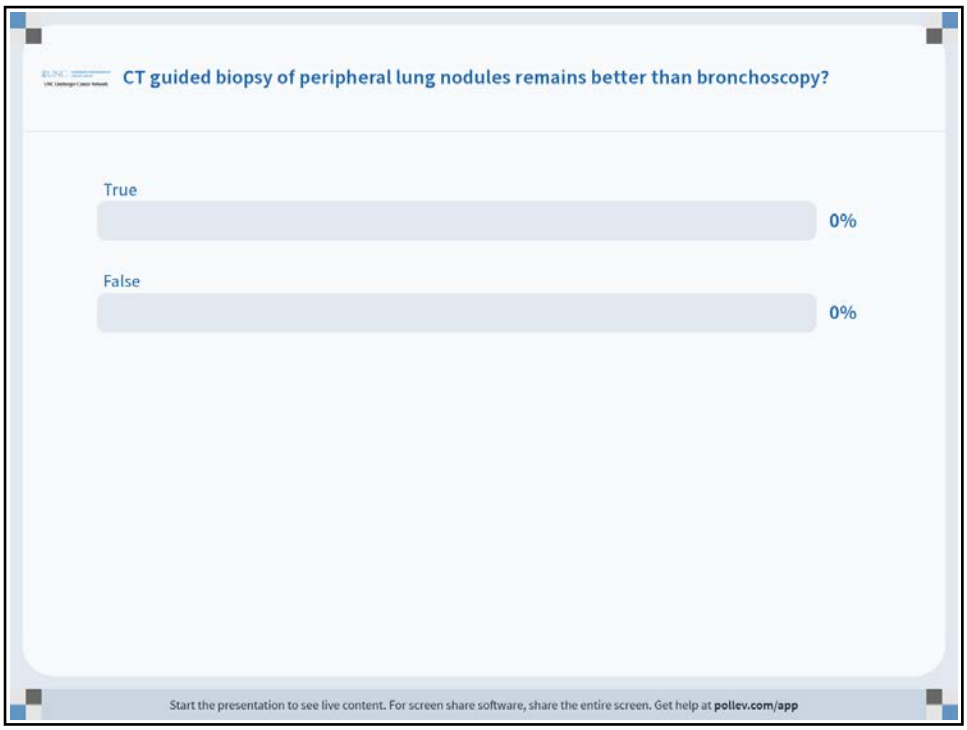


Wang Memoli JS,et al. *Chest*. 2012
Image courtesy of menandthemountains.com

50



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The robots are here!

- 3 FDA approved systems
  - JnJ/Auris – Monarch
  - Intuitive – Ion
  - Noah - Galaxy
- What are the potential benefits?
  - Control
  - Reach
  - Lock-ability
  - Reproducibility
  - Big data
- Potential pitfalls?
  - Efficacy data – lacking
  - Comparative data
  - Cost

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Robotic-Assisted Bronchoscopy Features	Ion™ Intuitive	Monarch™ Auris	Galaxy™ Noah Medical
Navigation technology	Shape sensing	Electromagnetic navigation	Electromagnetic navigation augmented fluoroscopy
Bronchoscopy	Catheter with removable vision probe (disposable after 5 uses) *	Sheath and bronchoscope with built-in camera (disposable after 2 uses) *	Bronchoscope with built-in camera (single use)
Catheter articulation	180°	180° (sheath: 130°)	180°
Catheter outer diameter	3.5 mm (catheter)	Outer sheath: 6 mm/inner scope: 4.2 mm	4.0 mm
Working channel diameter	2.0 mm	2.1 mm	2.1 mm
Irrigation and aspiration	No	Yes	Yes
CT-to-body divergence correction system	Yes (only with Cios Spin)	No	Yes
Augmented fluoroscopy	No	No	Yes
Tool-in-lesion confirmation	Yes (only when utilizing Cios Spin)	No	Yes
Tactile feedback	No	No	No

* Cleaning and recycling are carried out by Intuitive and Auris for their respective scopes.

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Diagnostics (Basel). 2024 Feb 12;14(4):399.

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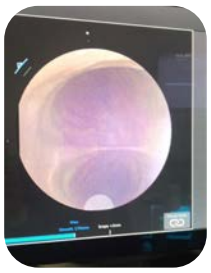
What can robotics provide?



REACH
Endoscopic Access to Peripheral Nodules

CONTROL
Precision Instrument Manipulation

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Images courtesy of Auris Medical and Intuitive

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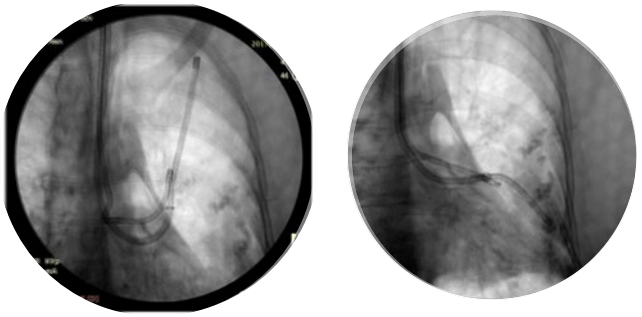
What can robotics provide?

REACH study : Robotic Endoscopic Airway CHallenge
(Monarch Endoscope vs. Olympus™ P190)



4.2cm

Incremental Reach

2.1cm

Distance to Pleura

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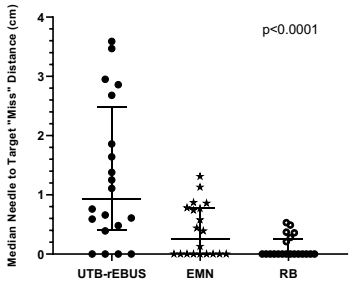
Chen AC, Gillespie CT, Ann Thora Surg 2018

55

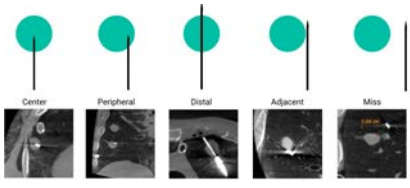
What can robotics provide?

PRECISION -1 study

- Comparison of radial EBUS vs. EMN vs. Robotic bronchoscopy
- 5 cadavers – 60 procedures (20 nodules)



- Robotic bronchoscopy significantly more accurate than radial EBUS and EMN
- 80% vs. 45% vs. 25% nodule puncture success.



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Yarmus, Akulian et al. Chest 2019

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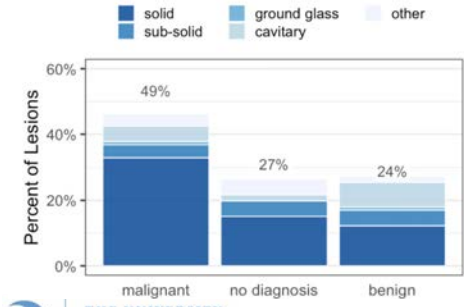
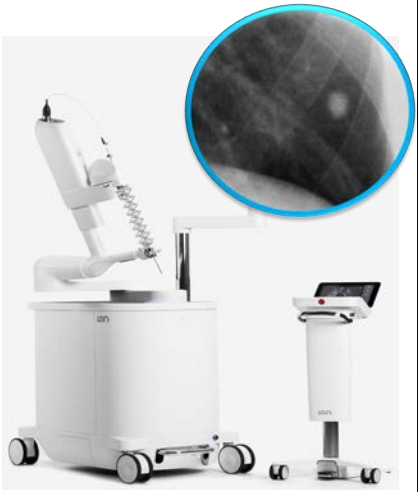
Early experience with robotic bronchoscopy

You want me to diagnose that?!
Technologic advances improve patient care

First year diagnostic success

- **Robotic – 76%**
- **Manual Bronchoscopy w/ EMN – 40%**





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Robotic System image courtesy of Intuitive Surgical

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Updated Meta-Analysis 10 years Later

TABLE 4] Study Characteristics and Diagnostic Yield, Summarized Across Types of Technology Used

Technology Used	No. of Study Arms	Proportion of Study Arms With High Bias, %	Total No. of Nodules Included	No. of Nodules Per Study, Median (range)	Diagnostic Yield, Mean (95% CI)
R-EBUS ± GS	51	78.4	5,494	83 (11-760)	70.9% (67.9%-73.9%)
ENB	24	75.0	1,952	53.5 (13-279)	74.0% (68.6%-79.4%)
ENB + R-EBUS	15	73.3	2,913	56 (26-1,329)	66.5% (59.8%-73.3%)
VB + R-EBUS	13	76.9	1,048	55 (12-334)	76.4% (72.7%-80.1%)
Ultrathin or thin + VB	10	80.0	795	63 (25-167)	69.9% (62.4%-77.3%)
Ultrathin or thin + R-EBUS	7	42.9	1,133	101 (20-467)	62.6% (55.3%-70.0%)
Other combination	7	57.1	771	63 (31-245)	64.4% (49.0%-79.9%)
Ultrathin or thin	6	50.0	770	104 (20-340)	50.2% (37.3%-63.2%)
Ultrathin + VB + R-EBUS	6	16.7	737	152.5 (32-179)	67.3% (58.4%-76.2%)
Robotic	6	66.7	483	56.5 (15-167)	77.6% (70.4%-84.8%)
VB	4	100.0	293	60.5 (50-122)	72.4% (55.1%-89.7%)

ENB = electromagnetic navigational bronchoscopy; GS = guide sheath; R-EBUS = radial endobronchial ultrasound; VB = virtual bronchoscopy.

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Nadjig et al. CHEST 2023 Jan 11; S0012-3692 (23)00030-2

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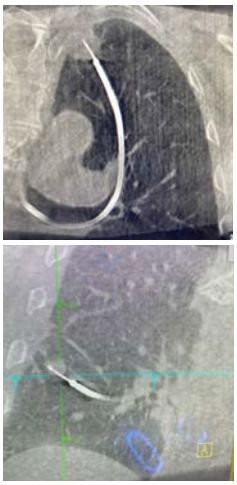
Let's get over the bar

Diagnostic success – 76% → 89%

This good but can we do better? We sure can!

+

=



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Select images courtesy of Intuitive Surgical

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CT: Body Divergence

- Discrepancy between the location of a nodule on static imaging and in the dynamic lung itself
  - Local atelectasis
  - Poor CT scan resolution
  - Airway distortion from scope
  - Hemorrhage
  - Other factors such as pleural effusion

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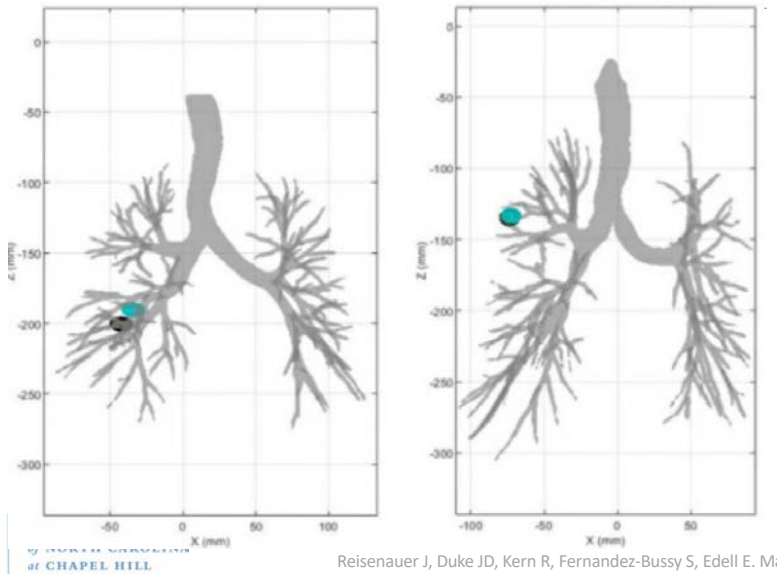
Bhadra et al. J Bronchology Interv Pulm. 2022
Pritchett et al. J Thorac Dis. 2020
Picture from Noah Medical website

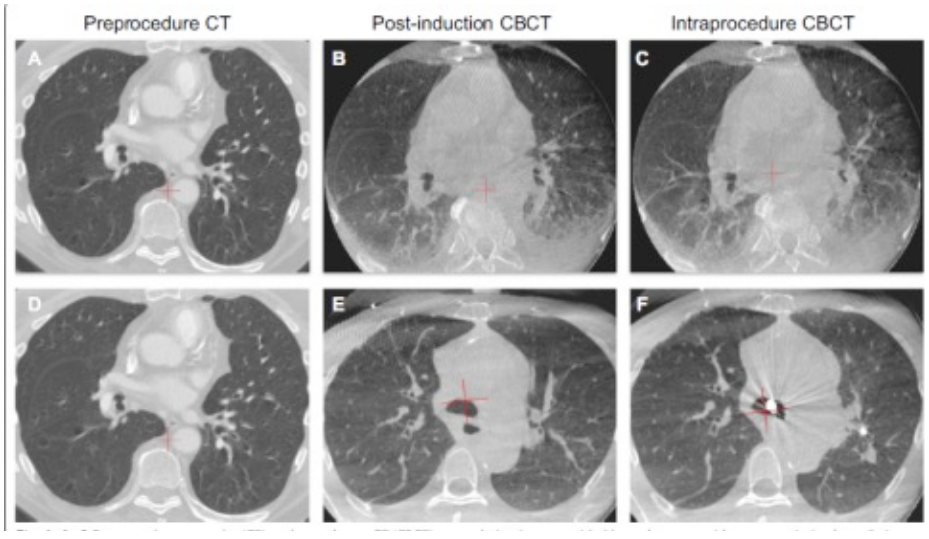
60

How common is CT-Body divergence in RAB?



Reisenauer J, Duke JD, Kern R, Fernandez-Bussy S, Edell E. Mayo Clin Proc Innov Qual Outcomes. 2022 Apr 23;6(3):177-185

61



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Pritchett et al. BMC Pulm Med (2021) 21:240
Abdelmalak et al, Curr Opin Anesthesiol 2021, 34:455–463

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Video courtesy of Dr. Christine Argento at The Johns Hopkins Hospital

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Video courtesy of Dr. Christine Argento at The Johns Hopkins Hospital

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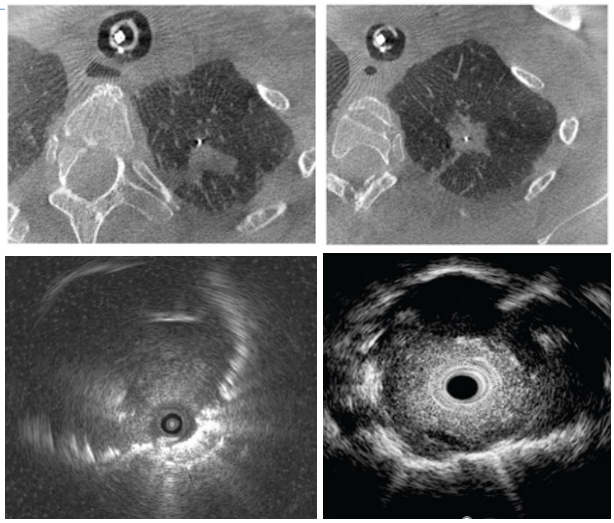
Lets start a revolution

- 'Near' real time guidance
- Yields reported 75-79%
- Conebeam CT integration to robotic bronchoscopy
- Paired with traditional and/or robotic-assisted bronchoscopy



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Casal et al. J Thorac Dis 2018
J Bronchol Intervent Pulmonol 2018;25:274–282
Salahuddin et al. Diagnostics 2023

65

Shape-Sensing Robotic-Assisted Bronchoscopy with Concurrent use of Radial Endobronchial Ultrasound and Cone Beam Computed Tomography in the Evaluation of Pulmonary Lesions

Kim Styrvoky[1] · Audra Schwalk[1] · David Pham[1] · Hsienchang T. Chiu[1] · Anastasiia Rudkovskaia[1] · Kristine Madsen[2] · Stephen Carrio[3] · Elizabeth M. Kurian[4] · Luis De Las Casas[4] · Muhanned Abu-Hijleh[1]

Table 4 Diagnostic test outcomes (disease prevalence of malignancy 64.1%)

Statistic	Value (%)	95% CI
Diagnostic accuracy	91.4	86.7% to 94.8%
Sensitivity	87.3	80.5% to 92.4%
Specificity	98.7	92.8% to 100.0%
Positive likelihood ratio	65.5	9.3 to 459.3
Negative likelihood ratio	0.13	0.08 to 0.20
Positive predictive value	99.2	94.3% to 99.9%
Negative predictive value	81.3	73.6% to 87.2%

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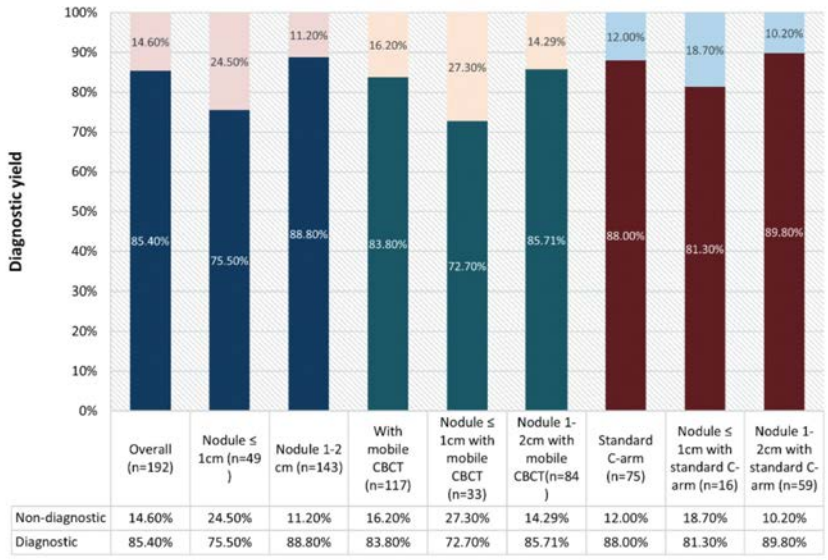
Mobile cone-beam computed tomography complementing shape-sensing robotic-assisted bronchoscopy in the small pulmonary nodule sampling: A multicentre experience

David Abia-Trujillo[1] | Erik E. Folch[2] | Alejandra Yu Lee-Mateus[1] | Prasanth Balasubramanian[3] | Fayez Kheir[2] | Colleen M. Keyes[2] | Regina Villalobos[2] | Ryan M. Chadha[4] | Britney N. Hazelett[1] | Sebastian Fernandez-Bussy[1]



	Overall (n=192)	Nodule ≤ 1cm (n=49)	Nodule 1-2 cm (n=143)	With mobile CBCT (n=117)	Nodule ≤ 1cm with mobile CBCT (n=33)	Nodule 1-2cm with mobile CBCT(n=84)	Standard C-arm (n=75)	Nodule ≤ 1cm with standard C-arm (n=16)	Nodule 1-2cm with standard C-arm (n=59)
Non-diagnostic	14.60%	24.50%	11.20%	16.20%	27.30%	14.29%	12.00%	18.70%	10.20%
Diagnostic	85.40%	75.50%	88.80%	83.80%	72.70%	85.71%	88.00%	81.30%	89.80%

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New reach brings new opportunities

Single Anesthetic Bronchoscopy and Resection Event (SABRE)

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Select images courtesy of Intuitive Surgical

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Single Anesthetic Bronchoscopy and Resection Event (SABRE)

Table 1. Nodule Characteristics

	RATS			VATS		
Characteristic	Marked N=38	Unmarked N= 45	P value	Marked N=33	Unmarked N=75	P value
Nodule Size (mm)	13.6 ± 0.8	16.8 ± 0.9	.01	10.9± 0.8	12.6 ± 0.7	.18
Distance from pleural to proximal nodule border (mm)	10.6 ± 1.5	7.9 ± 1.5	.23	12.4 ± 2.1	7.9 ± 1.1	.03
Distance from pleural to distal nodule border (mm)	22.2 ± 1.8	22.5 ± 1.6	.89	22.4 ± 2.1	18.7 ± 1.3	.20
Nodule Location, no. of nodules (%)			.53*			.50*
RUL	12 (32)	17 (38)		12 (36)	21 (28)	
RML	1 (2.6)	4 (8.9)		0 (0)	4 (5)	
RLL	8 (21)	10 (22)		8 (24)	13 (17)	
LUL	13 (34)	9 (20)		8 (24)	23 (31)	
LLL	4 (11)	5 (11)		5 (15)	14 (19)	
Nodule Consistency, no. of nodules (%)			.144*			.03*
Solid	24 (63)	37 (82)		25 (76)	69 (92)	
Semi-Solid	11 (29)	6 (13)		4 (12)	5 (7)	
Ground Glass	3 (8)	2 (4.4)		4 (12)	1 (1)	

*P values from Chi square test

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Single Anesthetic Bronchoscopy and Resection Event (SABRE)

Table 1. Nodule Characteristics

	RATS			VATS		
Characteristic	Marked N=38	Unmarked N= 45	P value	Marked N=33	Unmarked N=75	P value
Mean length of stay, days (SD)	3.5 (2.1)	3.9 (2.6)	0.44	3.4 (2.6)	3.3 (2.4)	.93
Marking Time, min (SD)	39 (14)	n/a		39 (13)	n/a	
Persisent air leak (%)	2 (5)	9 (20)	.06	3 (9.1)	7 (9.3)	.97
Incision to closing time, hr:min (SD)	3:07 (65 min)	2:59 (63 min)	.56	1:57 (75)	1:40 (54)	.45
Marking failure (%)	2 (5)	n/a		1 (3)	n/a	
Localization failure (%)	5 (13)	4 (9)	.73	1 (3)	4 (5)	.60
Conversion to open (%)	4 (11)	4 (9)	>.9	3 (9)	8 (11)	.80

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Other developments!

Navigational Bronchoscopy or Transthoracic Needle Biopsy for Lung Nodules

- Prospective randomized trial comparing:
  - CT guided needle biopsy
  - Navigation bronchoscopy + digital tomosynthesis
- Noninferiority trial design

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Lentz RJ eta al. N Engl J Med. 2025 May 18. doi: 10.1056/NEJMoa2414059. Epub ahead of print. PMID: 40387025.

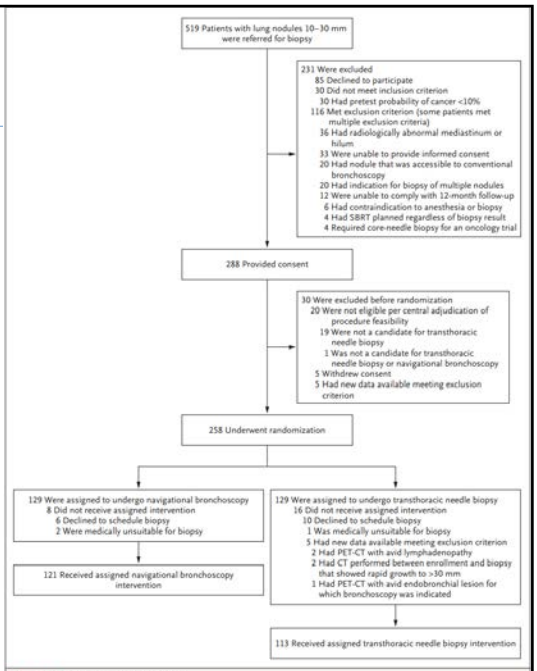

Figure 1. Screening and Randomization.
PET-CT denotes positron-emission tomography with computed tomography, and SBRT stereotactic body radiation therapy.

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Navigational Bronchoscopy or Transthoracic Needle Biopsy for Lung Nodules

Table 2. Primary and Secondary Outcomes.

Outcome	Navigational Bronchoscopy (N = 121)	Transthoracic Needle Biopsy (N = 113)	Difference (95% CI)*
Primary outcome: diagnostic accuracy — no./total no. (%)†			
Accurate	94/119 (79.0)	81/110 (73.6)	5.4 (−6.5 to 17.2)‡
Inaccurate	25/119 (21.0)	29/110 (26.4)	—
False negative	0	4/110 (3.6)	—
Initially nondiagnostic	25/119 (21.0)	25/110 (22.7)	—
Lost to follow-up	2/121 (1.7)	3/113 (2.7)	—
Secondary outcome: diagnostic yield — no. (%)§			
Diagnostic¶	96 (79.3)	88 (77.9)	1.5 (−9.9 to 12.8)
Malignant‖	78 (64.5)	61 (54.0)	—
Specific benign	16 (13.2)	17 (15.0)	—
Granulomatous	6 (5.0)	10 (8.8)	—
Organizing pneumonia	1 (0.8)	5 (4.4)	—
Acute neutrophilic inflammation	3 (2.5)	1 (0.9)	—
Other specific benign**	6 (5.0)	1 (0.9)	—
Same-day regression††	2 (1.7)	10 (8.8)	—
Nondiagnostic	25 (20.7)	25 (22.1)	—
Nonspecific inflammation	10 (8.3)	8 (7.1)	—
Normal lung or airway	9 (7.4)	3 (2.7)	—
Atypia	4 (3.3)	2 (1.8)	—
No biopsy specimens obtained‡‡	2 (1.7)	6 (5.3)	—
Proceduralist declined to perform procedure§§	0	6 (5.3)	—
Additional secondary outcomes			
Underwent procedure — no. (%)¶¶	119 (98.3)	97 (85.8)	12.5 (4.8 to 20.2)
Median duration of procedure (IQR) — min	36 (28 to 48)	25 (13 to 36)	11 (8 to 18)
Median radiation exposure (IQR)‖‖	9800 (7190 to 18,850)	659 (253 to 1276)	NA
Intraprocedural rapid onsite cytologic assessment — no./total no. (%)	114/119 (95.8)	7/97 (7.2)	88.6 (81.4 to 95.8)
Subsequent invasive diagnostic procedure — no. (%)	16 (13.2)	15 (13.3)	0.1 (−8.8 to 8.7)

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Navigational Bronchoscopy or Transthoracic Needle Biopsy for Lung Nodules

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

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The Future…is not so far away

- A patient who is an ex-smoker presents a lung nodule
- The next day, you perform a robot assisted bronchoscopy with conebeam CT guidance
- The Rapid-on-Site pathology team outside the bronchoscopy room confirms adenocarcinoma
- You immediately deliver a definitive treatment with an ablative therapy, or the surgical team resects the lesion during the same anesthetic event

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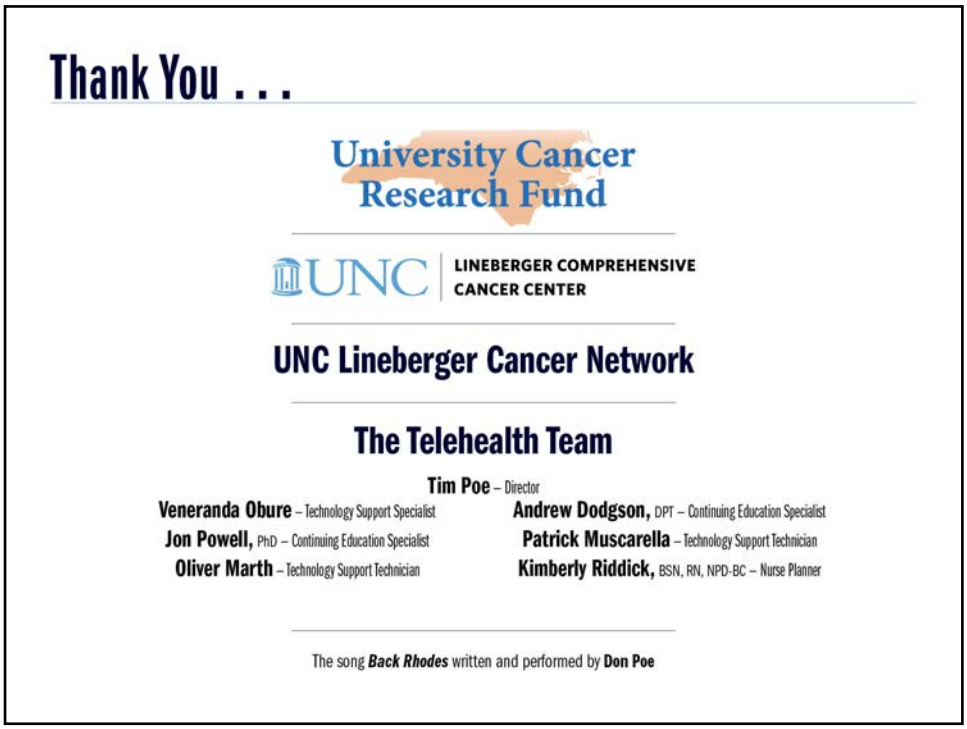
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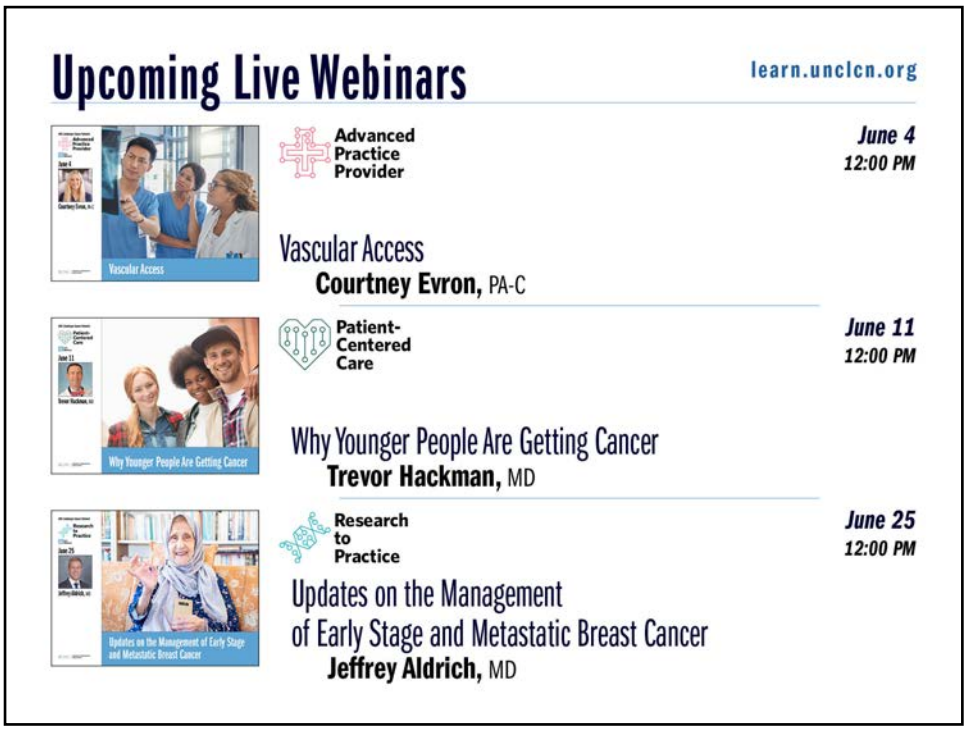
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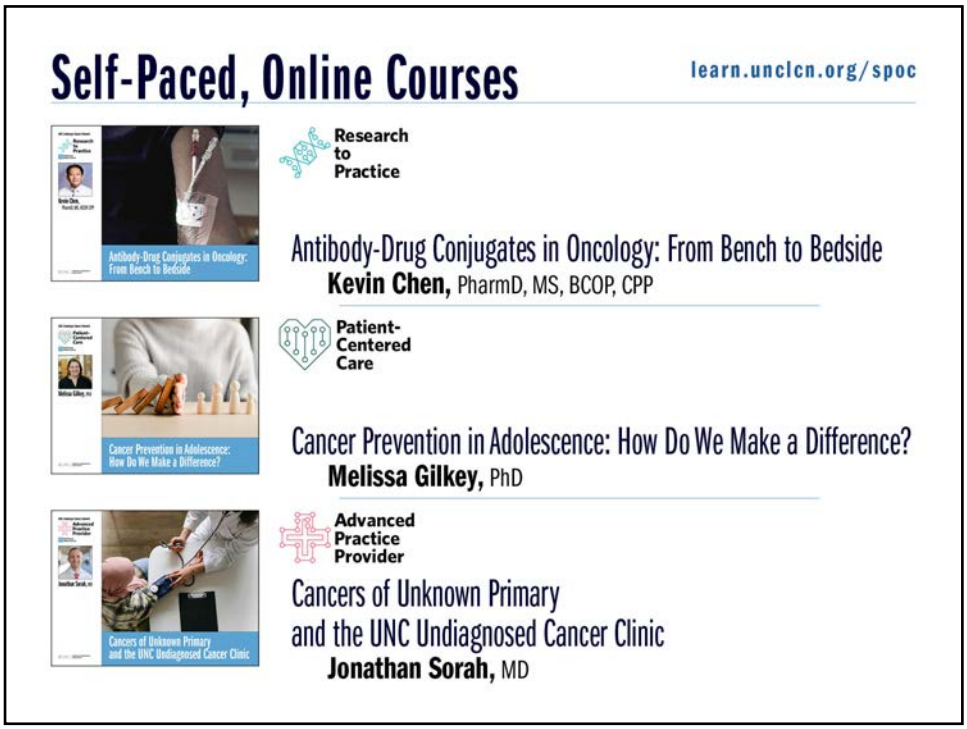
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