Peripheral Pulmonary Lesions :

Radial Endobronchial Ultrasound – rEBUS

and
Future Diagnostic Modalities

Definitions

- ***Peripheral Pulmonary Lesions*** are focal radiographic opacities not detectable beyond the visual segmental bronchi by flexible bronchoscopy-typically located in the outer third of the lung

- ***Solitary Pulmonary Nodule*** is a well defined radiographic opacity up to 30mm in diameter surrounded by unaltered aerated lung, anywhere in the lung parenchyma

- **ACCP and NCCN (National Comprehensive Cancer Network)** recommendations suggest using the least invasive modality to obtain an adequate amount of tissue to perform molecular and PD-L1 testing in the evaluation of lung cancer

- Diagnosis and management of lung cancer, 3rd ed:ACCP evidence-based clinical practice guidelines. Chest 2013;143:e93Se120S
- NCCN Guidelines Insights :NSCLC,Version5.2018.J Natl Compr Canc Netw 2018;16:807-21

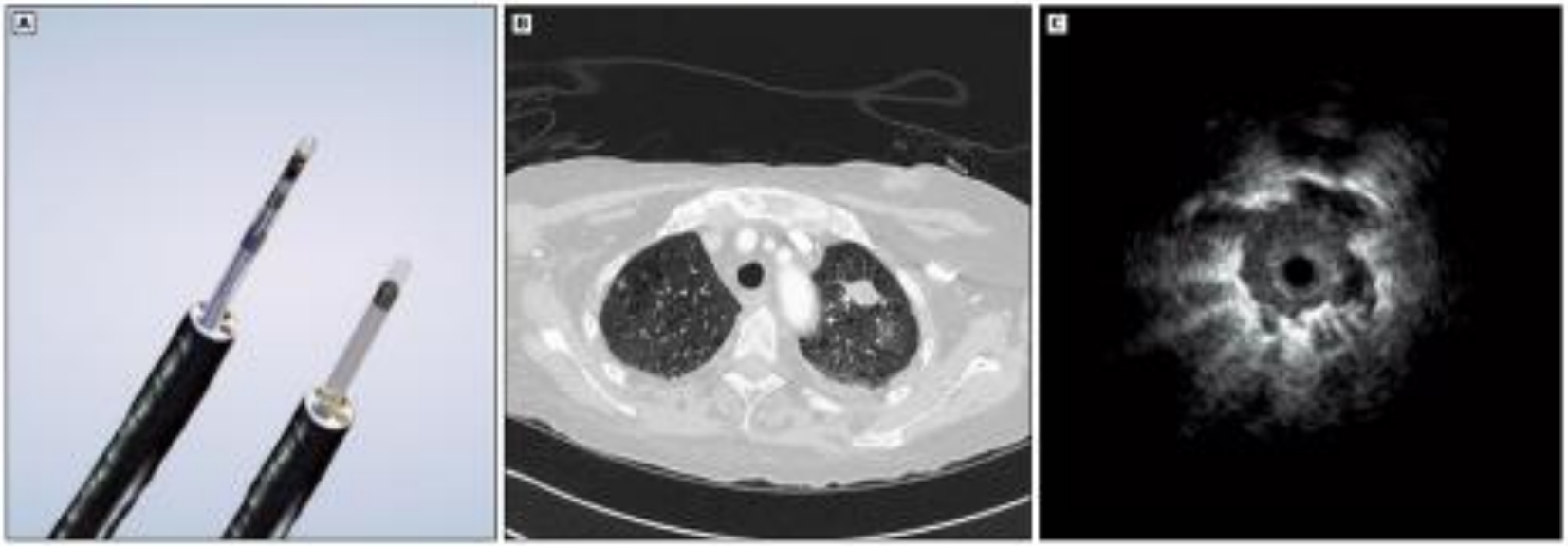
Technical approaches

- Thin/Ultrathin bronchoscopes
- Fluoroscopy
- **Radial probe endobronchial ultrasound (r-EBUS)**
- Virtual Bronchoscopy
- Electromagnetic Navigation Brobchoscopy (ENB)
- Cone Beam CT
- Augmented Fluoroscopy (LUNGVISION)
- Robotic Assisted Bronchoscopy (RAB)

Types of bronchoscopes

Bronchoscopes in increasing size are displayed. An ultrathin bronchoscope is shown on the left while an endobronchial ultrasound (EBUS) scope is shown on the right. The remaining pieces of equipment are routine bronchoscopes of two different sizes. The ultrathin and routine bronchoscopes have a light source, a camera, and a suction port seen at the tip.

Radial endobronchial ultrasound of a peripheral pulmonary lesion



Panel A shows a representative image of a bronchoscope with a radial endobronchial ultrasound probe (left) and sheath (right). Panels B and C show a computed tomographic (B) and corresponding radial ultrasound (C) image of a peripheral pulmonary lesion. The radial ultrasound image demonstrates a fairly well circumscribed echoic lesion with the hyper echoic (brighter white) boundary between the aerated lung and the lesion.

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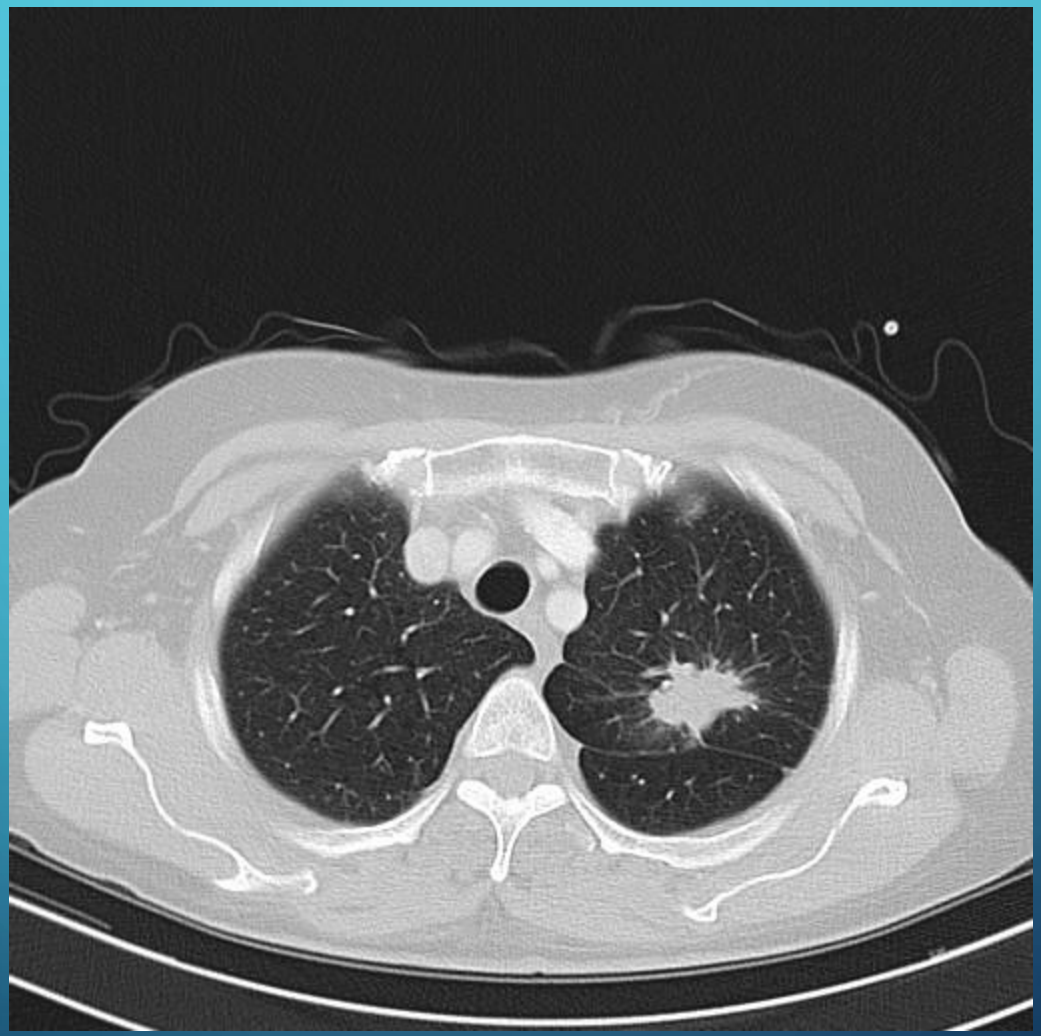
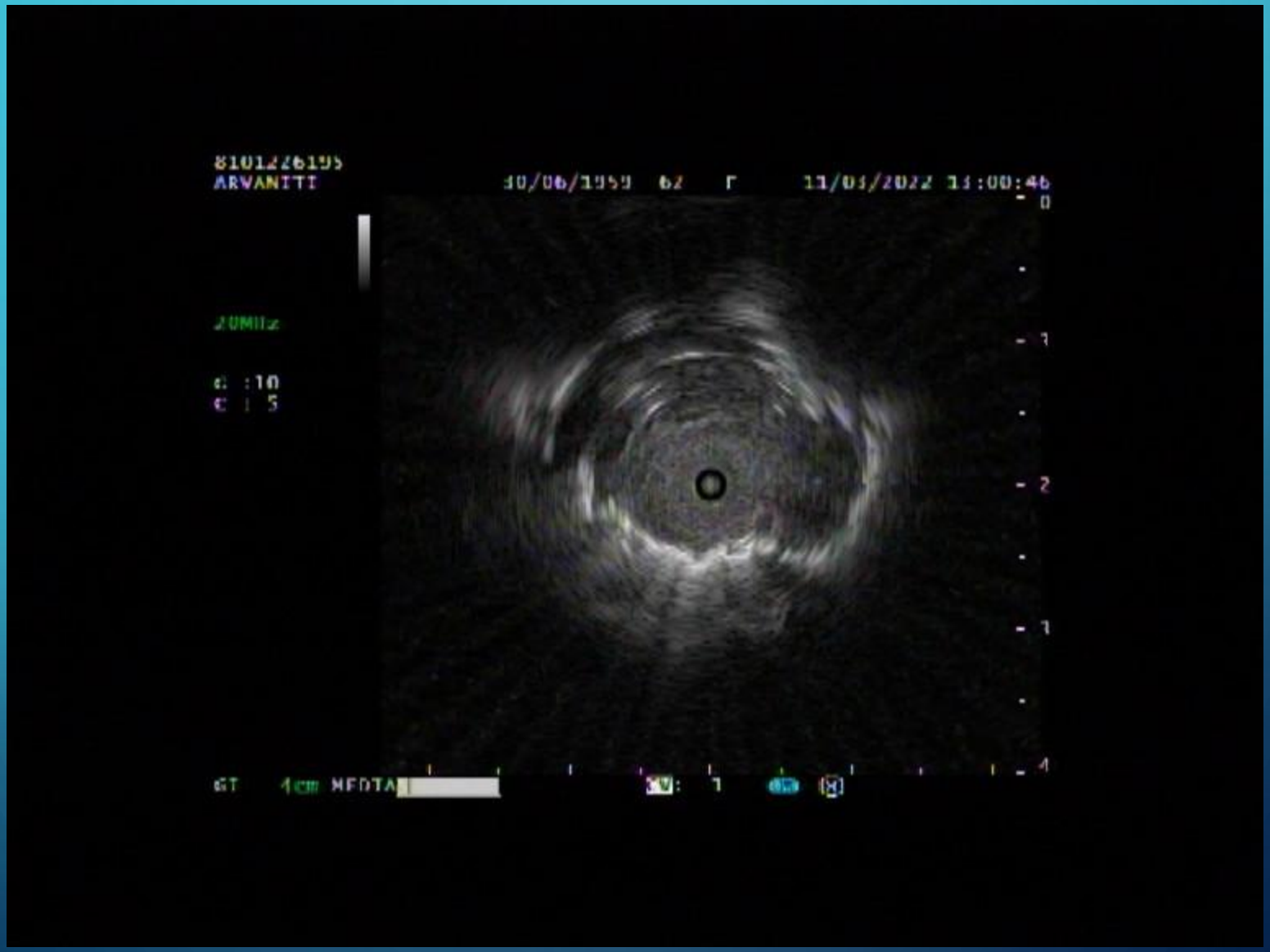
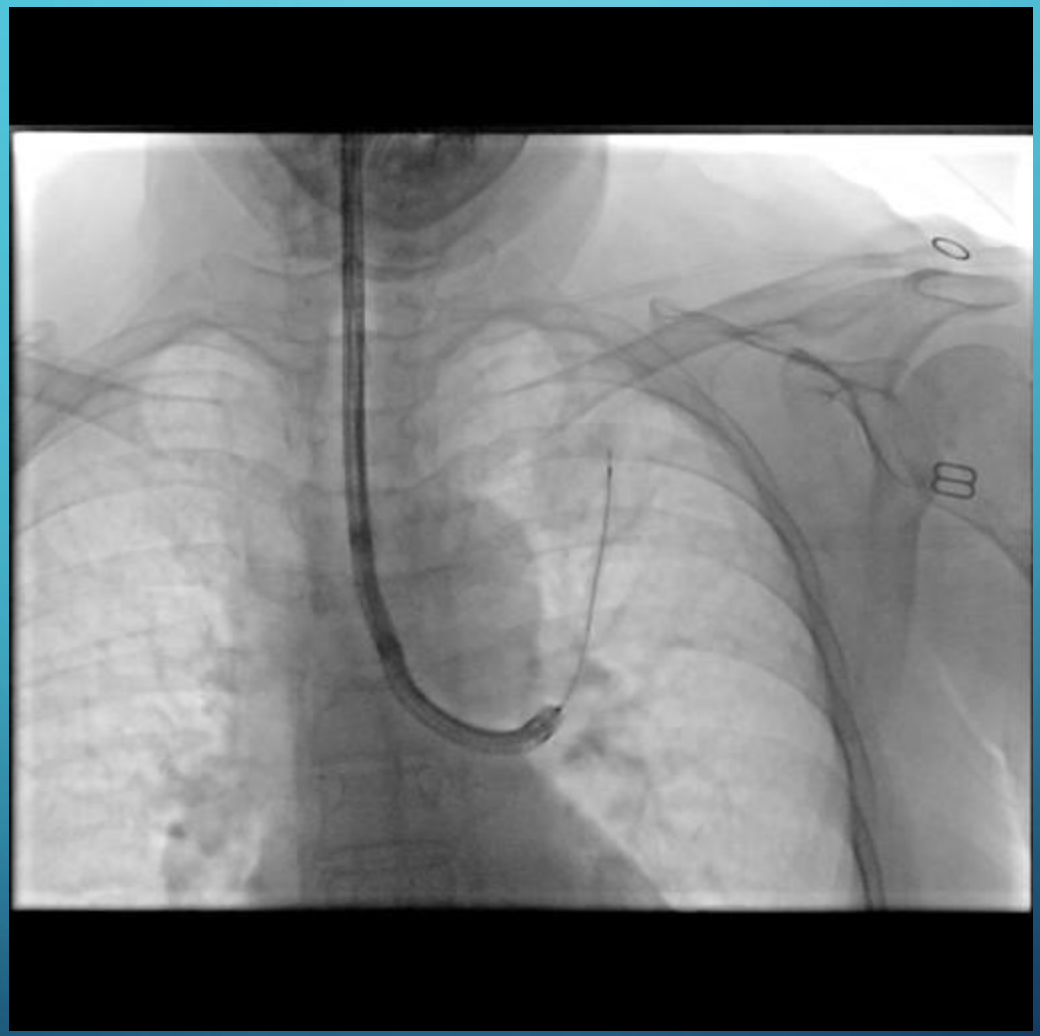
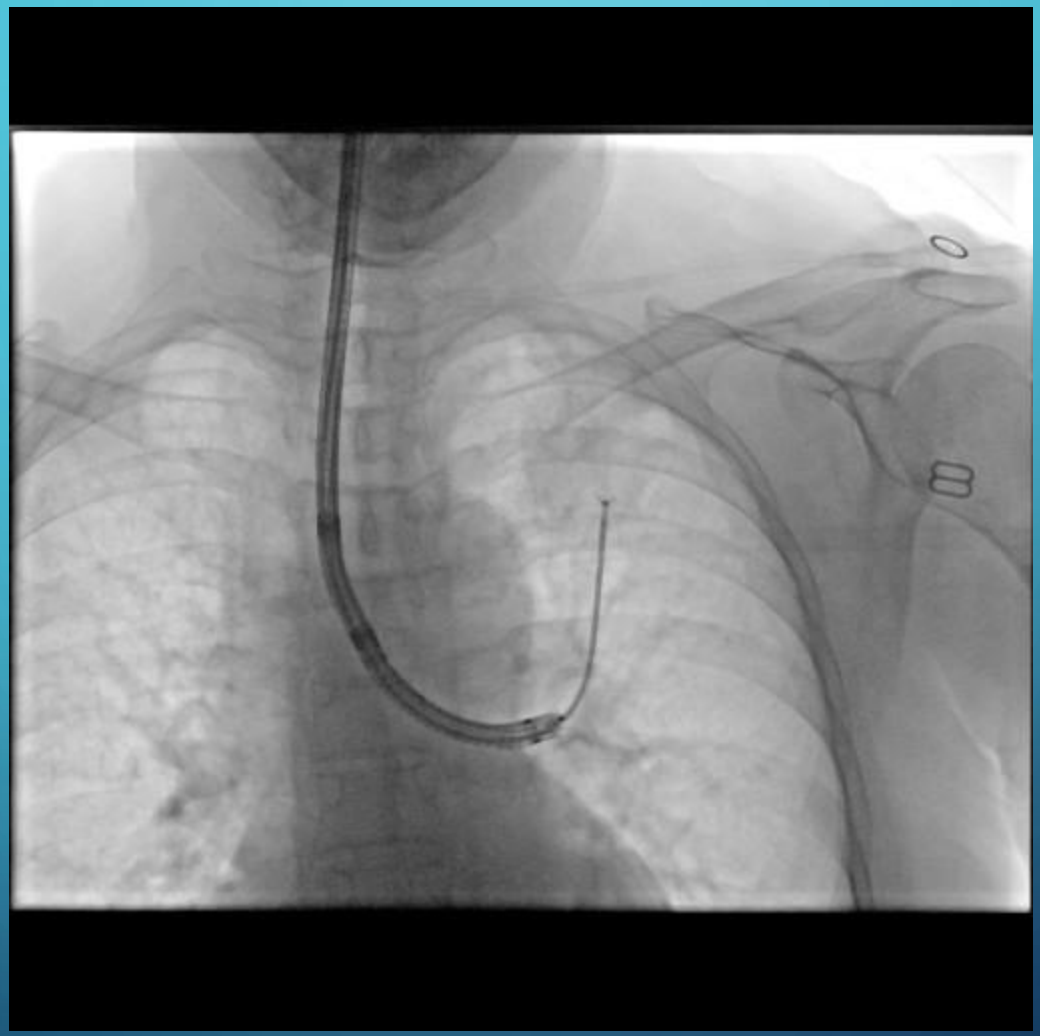
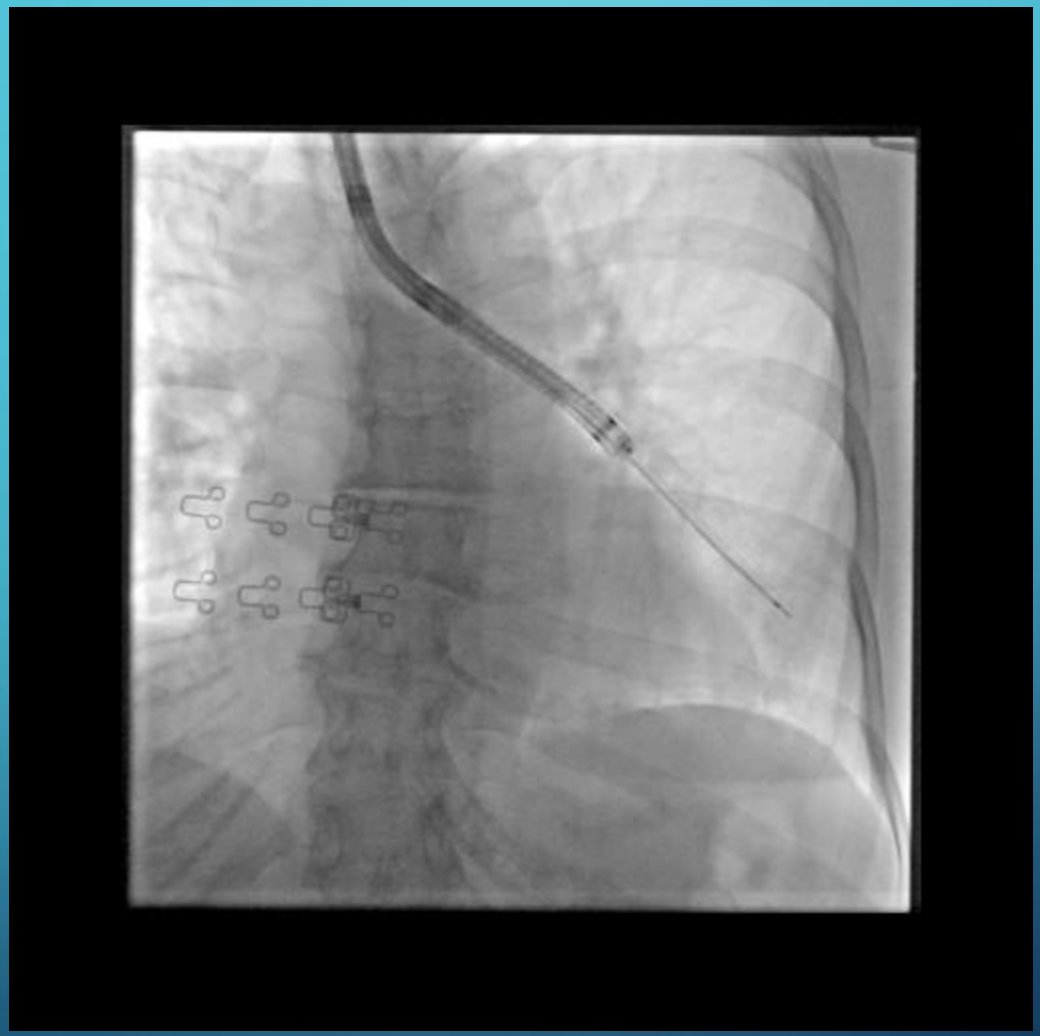
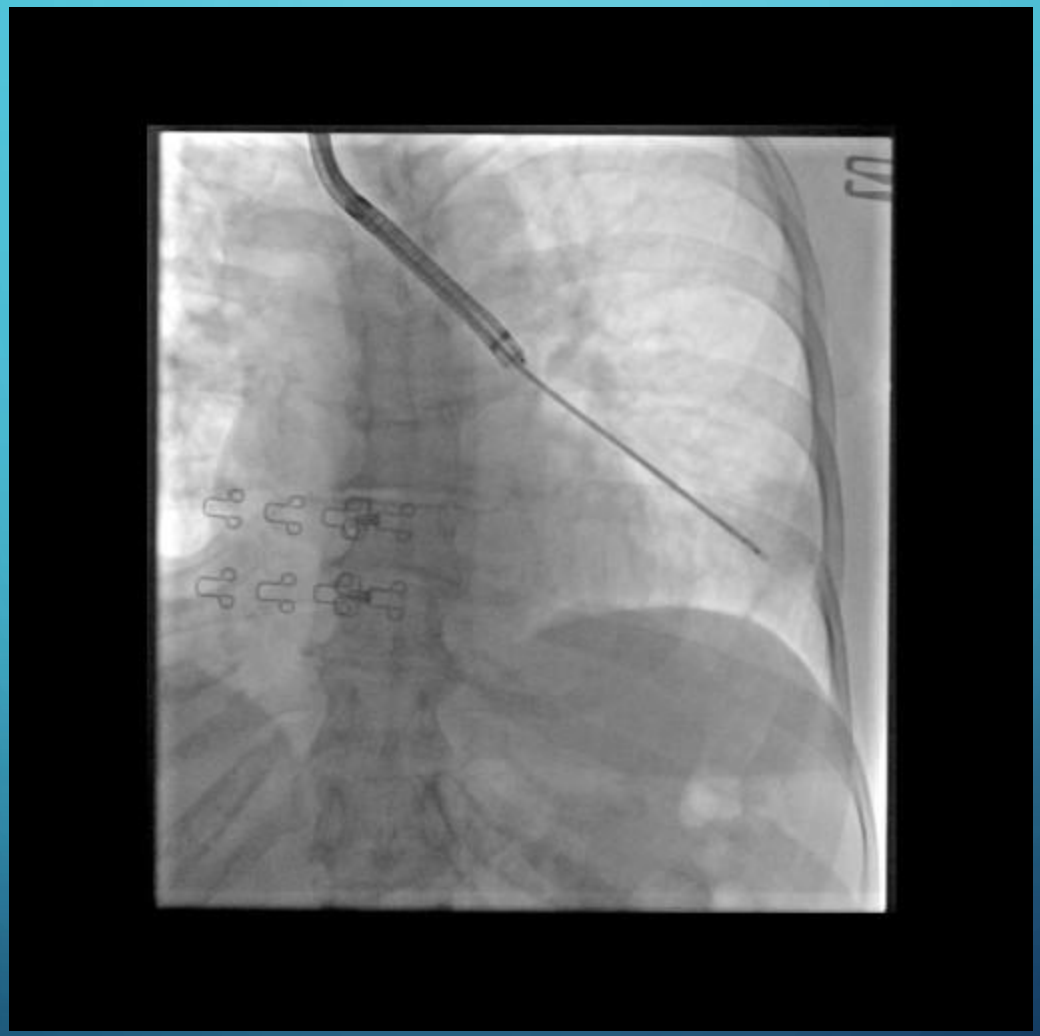




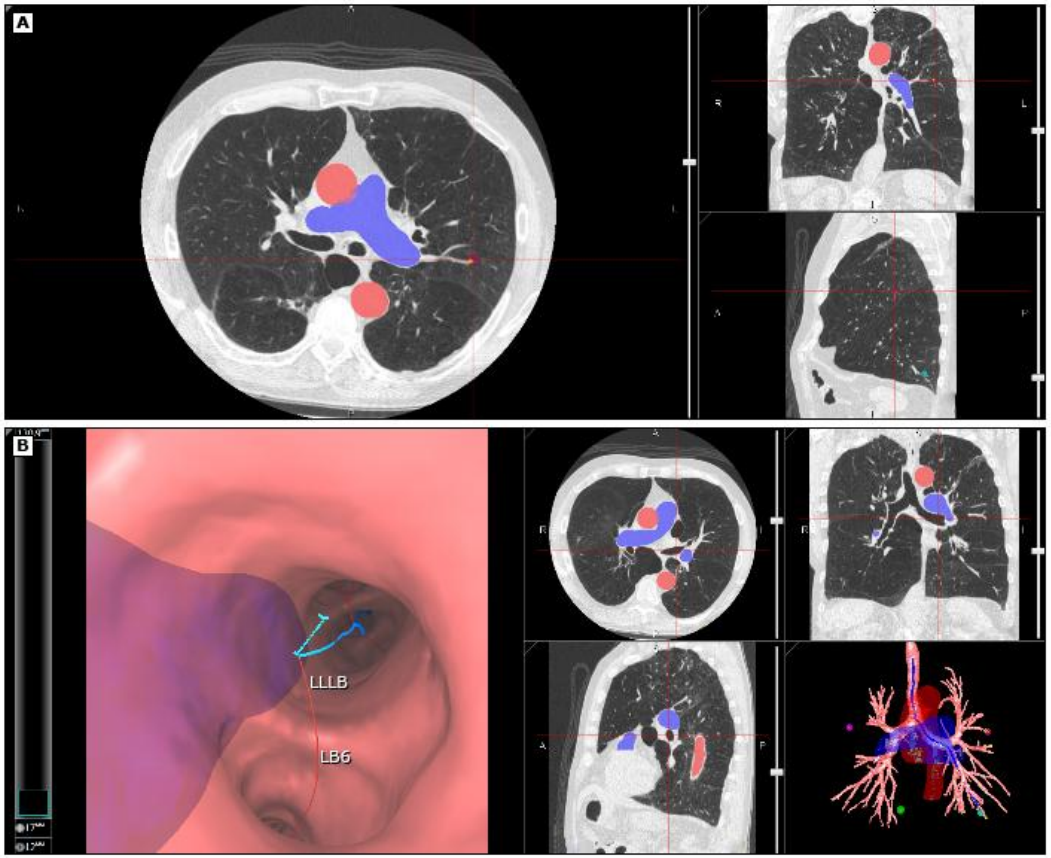






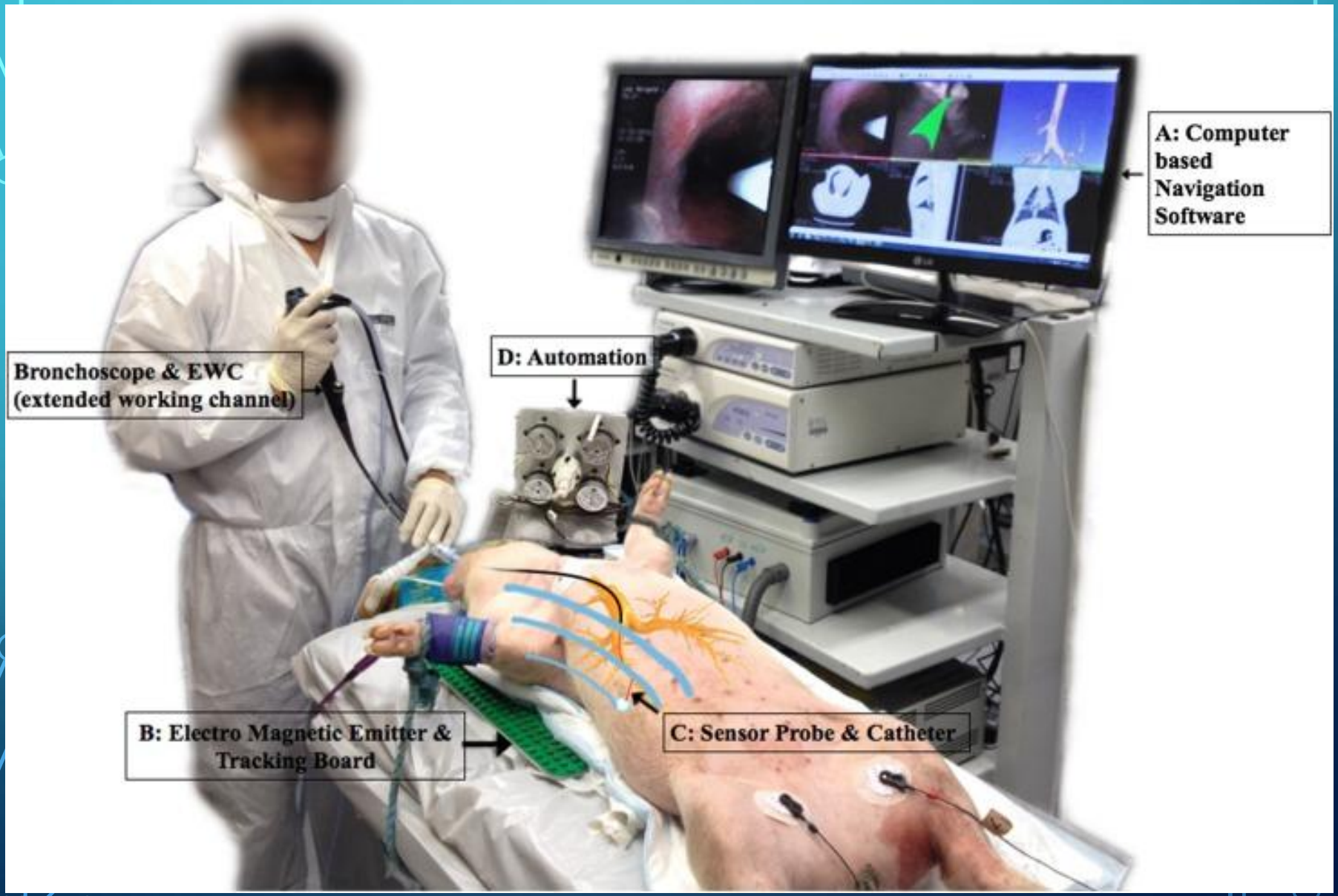


Planning and procedural views for virtual bronchoscopic navigation



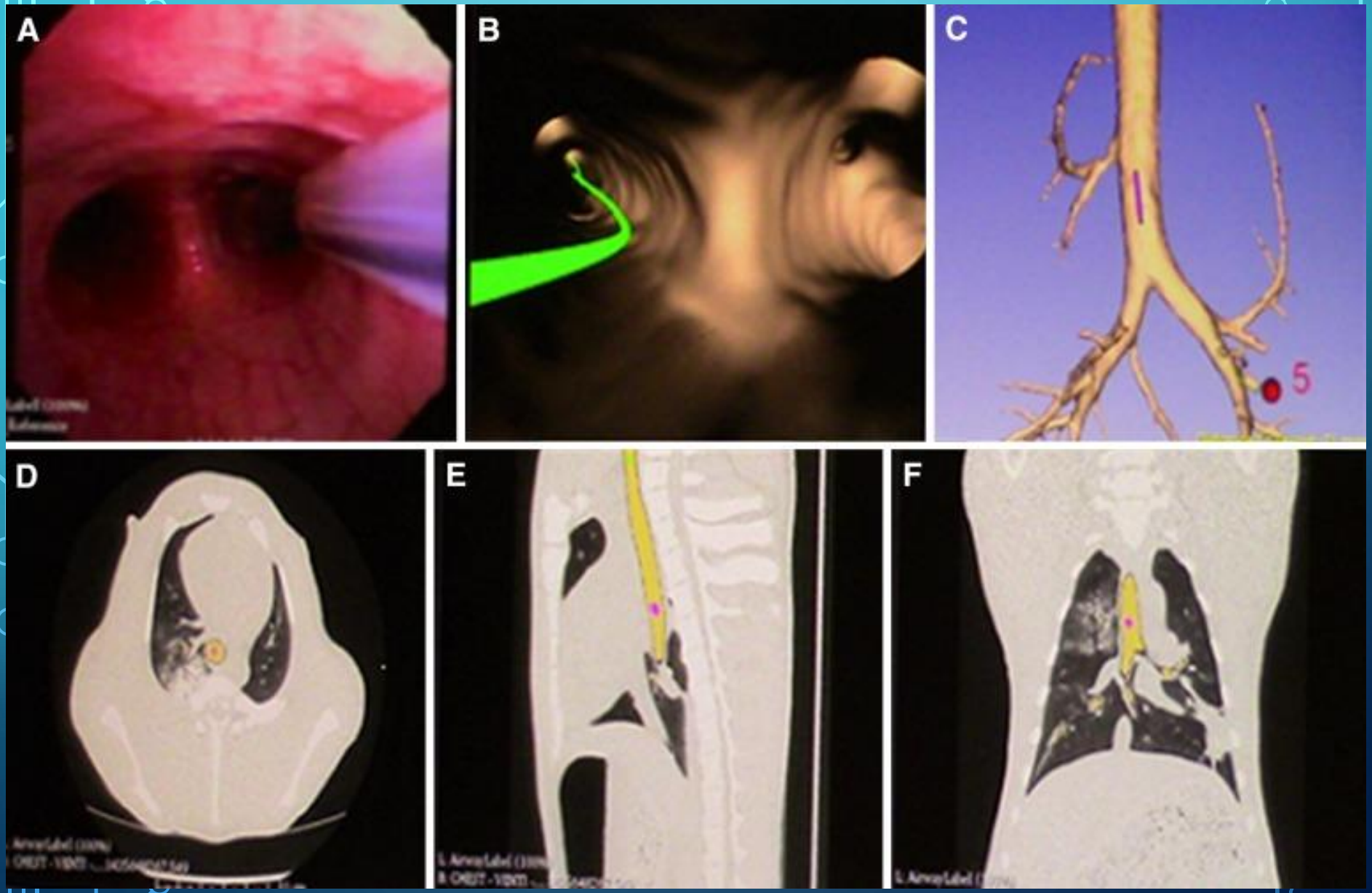
Panel A shows axial, coronal, and saggital images generated using a specific protocol with target selected by placing the red cross hairs on the lesion in all three planes. Major blood vessels are highlighted in red and blue. Panel B shows the virtual bronchoscopic view and pathway used during the procedure to navigate to the lesion.

A: anterior; P: posterior; R: right; L: left; LLB/LB6: LLB and LB6 indicate segments of the left bronchial tree.

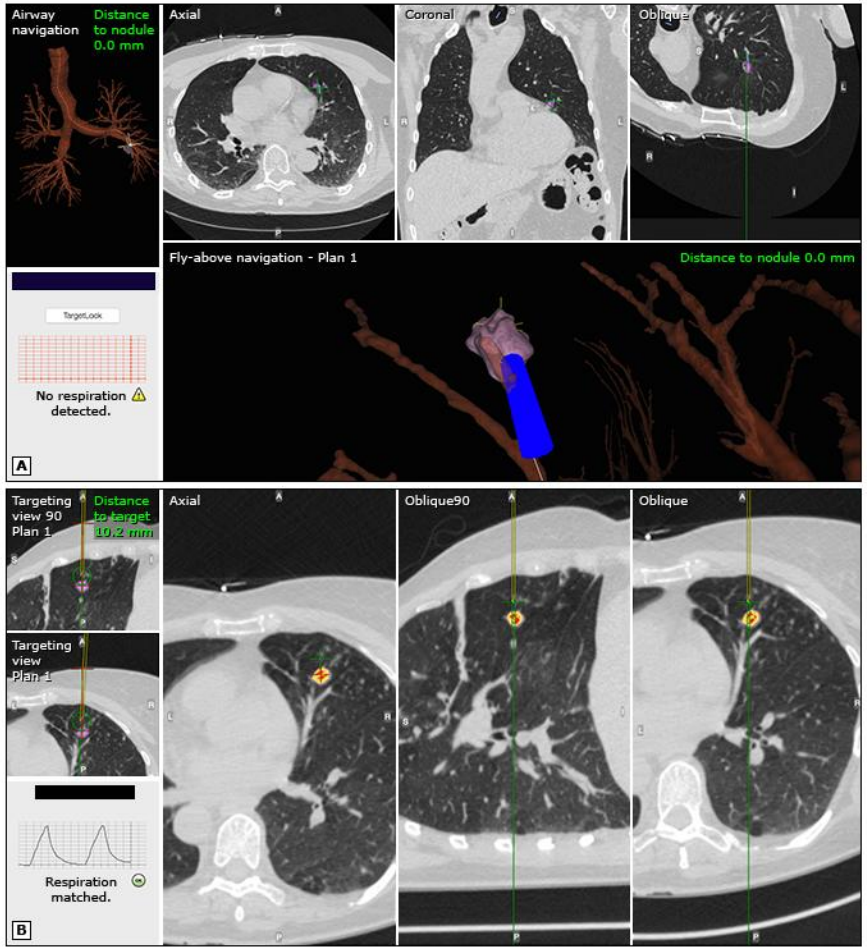


Pre-procedure planning view of electromagnetic navigation system

This graphic shows axial, saggital, and coronal computed tomographic (CT) views generated using a specific CT protocol prior to the procedure. It also shows a three dimensional (3D map) virtual bronchoscopic image of the tracheobronchial tree that the bronchoscopist can use to gain closest access to a target lesion. The bronchoscopist can, in real-time, follow where they are as they proceed through the patient's bronchi towards a nodule.



Electromagnetic navigational bronchoscopic and transthoracic biopsy



Panel A shows concurrent computed tomographic and virtual images displayed to the bronchoscopist during electromagnetic navigational bronchoscopy. Real-time images and virtual images together guide the bronchoscopist to the peripheral target lesion for biopsy. Panel B shows similar computed tomographic images during navigation of a transthoracic needle to biopsy a target peripheral nodule. The biopsy needle is directed so that it is present in the lesion in the axial, coronal, and oblique CT views to ensure the best yield.

Prospective randomized controlled trial finds similar results for ENB and rEBUS

•Eberhardt Ralf, Anantham Devanand, Ernst Armin Feller-Kopman David
•Herth Felix
Multimodality Bronchoscopic Diagnosis of Peripheral Lung Lesions.
American journal of respiratory and critical care medicine. 2007; **176**: 36-41https://doi.org/10.1164/rccm.200612-1866OC

•Gex G,Pralong JA,Combescure C.,Seijo L,Rochat T
•Soccal PM
Diagnostic Yield and Safety of Electromagnetic Navigation Bronchoscopy for Lung Nodules: A Systematic Review and Meta-Analysis.
Respiration. 2014; **87**: 165-176https://doi.org/10.1159/000355710

Diagnostic Yield 69% (2005)-74% (2015)

Schwarz Y, Greif J, Becker HD, et al. Real-time electromagnetic navigation bronchoscopy to peripheral lung lesions using overlaid CT images: the first human study. Chest. 2006;129(4):988–94.

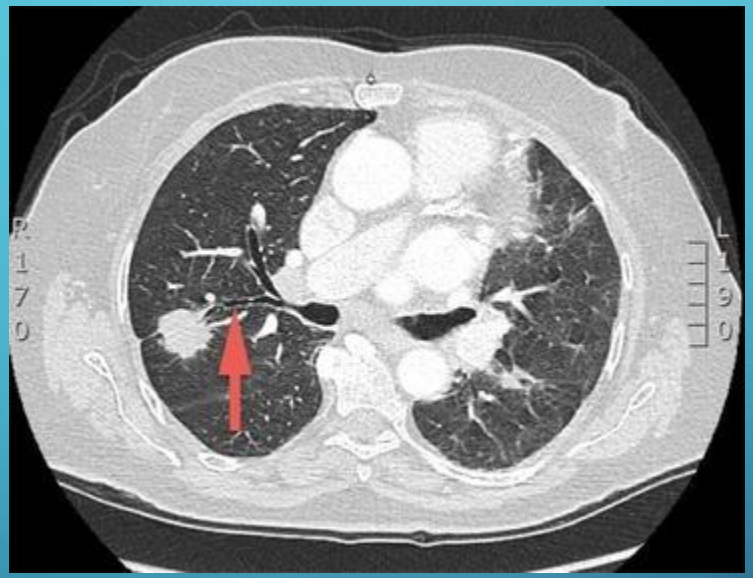
Becker HD, Herth F, et al. Bronchoscopic biopsy of peripheral lung lesions under electromagnetic guidance. A pilot study. J Bronchol Interv Pulmonol. 2005;12:9–13.

Eberhardt R, Anantham D, Ernst A, et al. Multimodality bronchoscopic diagnosis of peripheral lung lesions: a randomized controlled trial. Am J Respir Crit Care Med. 2007;176(1):36–41.

Seijo LM, de Torres JP, Lozano MD, et al. Diagnostic yield of electromagnetic navigation bronchoscopy is highly dependent on the presence of a Bronchus sign on CT imaging: results from a prospective study. Chest. 2010;138(6):1316–21.

Factors Influencing Yield

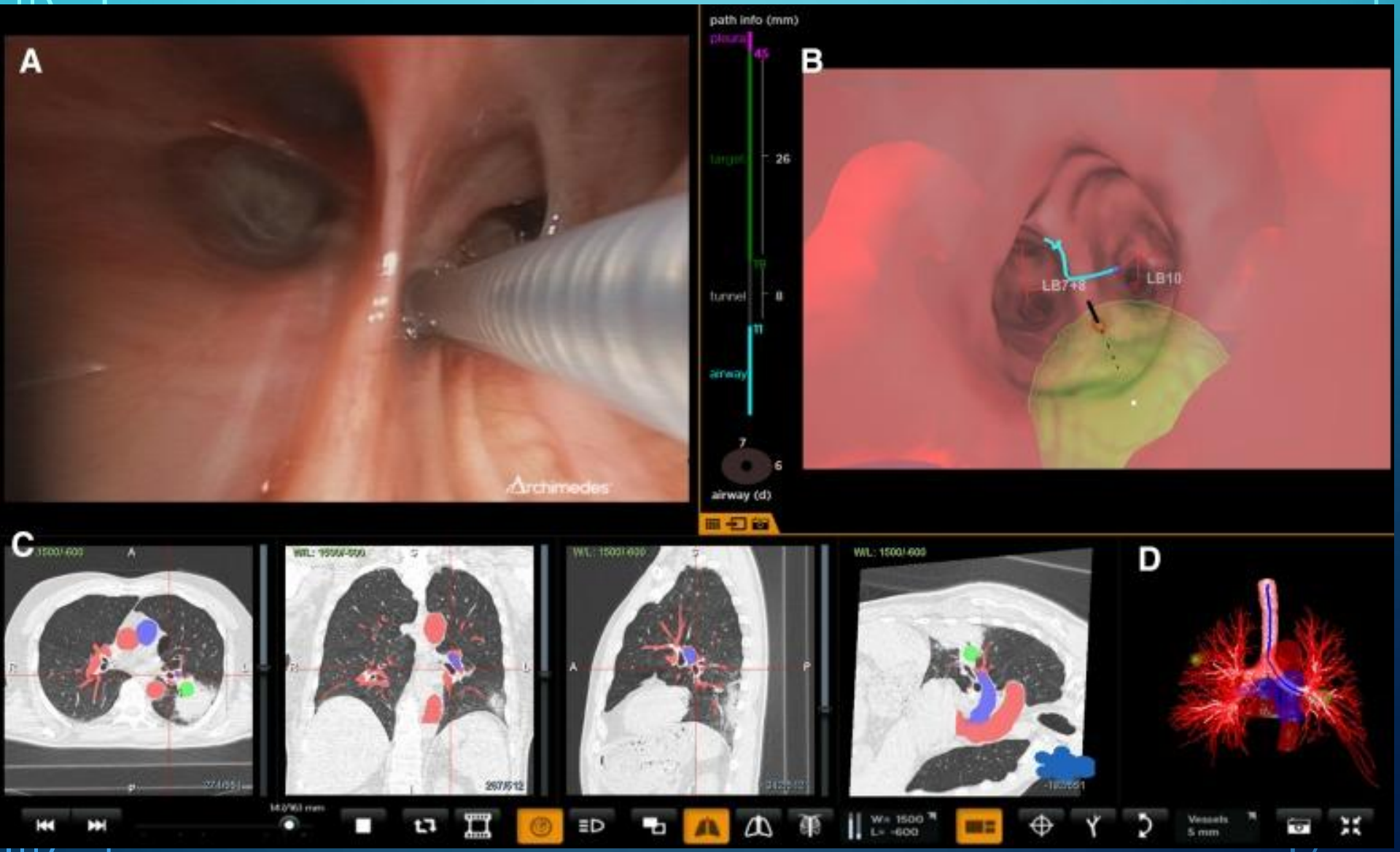
- **Bronchous sign**
- Size
- Location
- Lack of clear definition of peripheral lesion or nodule
- Anesthesia
- ROSE
- Tissue acquisition – catheter aspiration vs forceps biopsy
- Operator
- Technological factors – software, Average Fiducial Registration Error <5mm



Bronchoscopic transparenchymal nodule access – “Archimedes” Virtual Bronchoscopy Navigation

-“off-road” approach-transparenchymal tunnel

- Diagnostic yield 83%-Thorax.2015;70(4):700-7



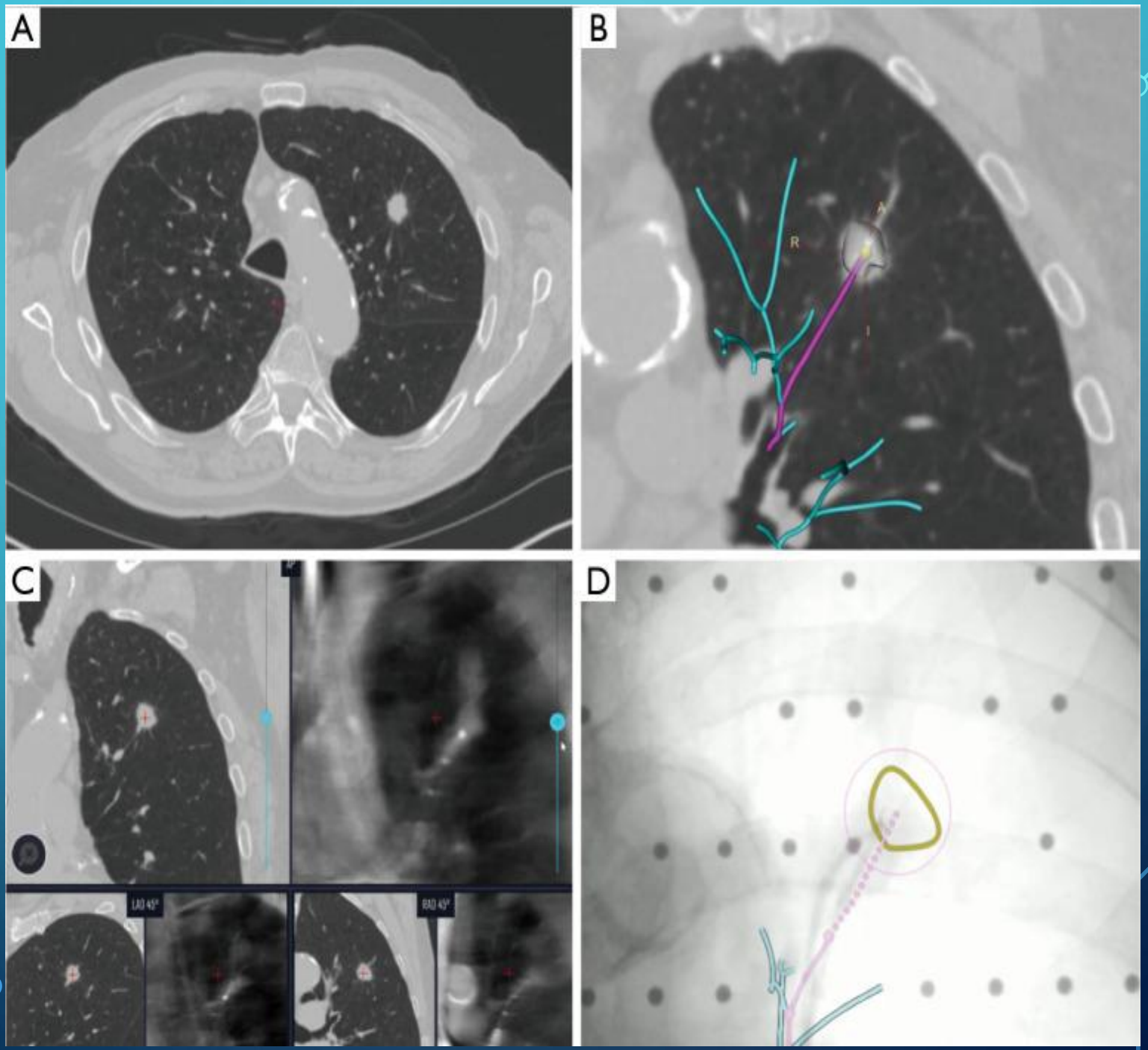
“CT-body divergence”

- General anesthesia
- Positive pressure ventilation
- Probable development of atelectasis
- In/Exp

- Augmented Fluoroscopy-

- ***Tomosynthesis***
- ***LUNGVISION-fluoroscopy plus AI***

- Cone Beam CT



Therapeutic implications

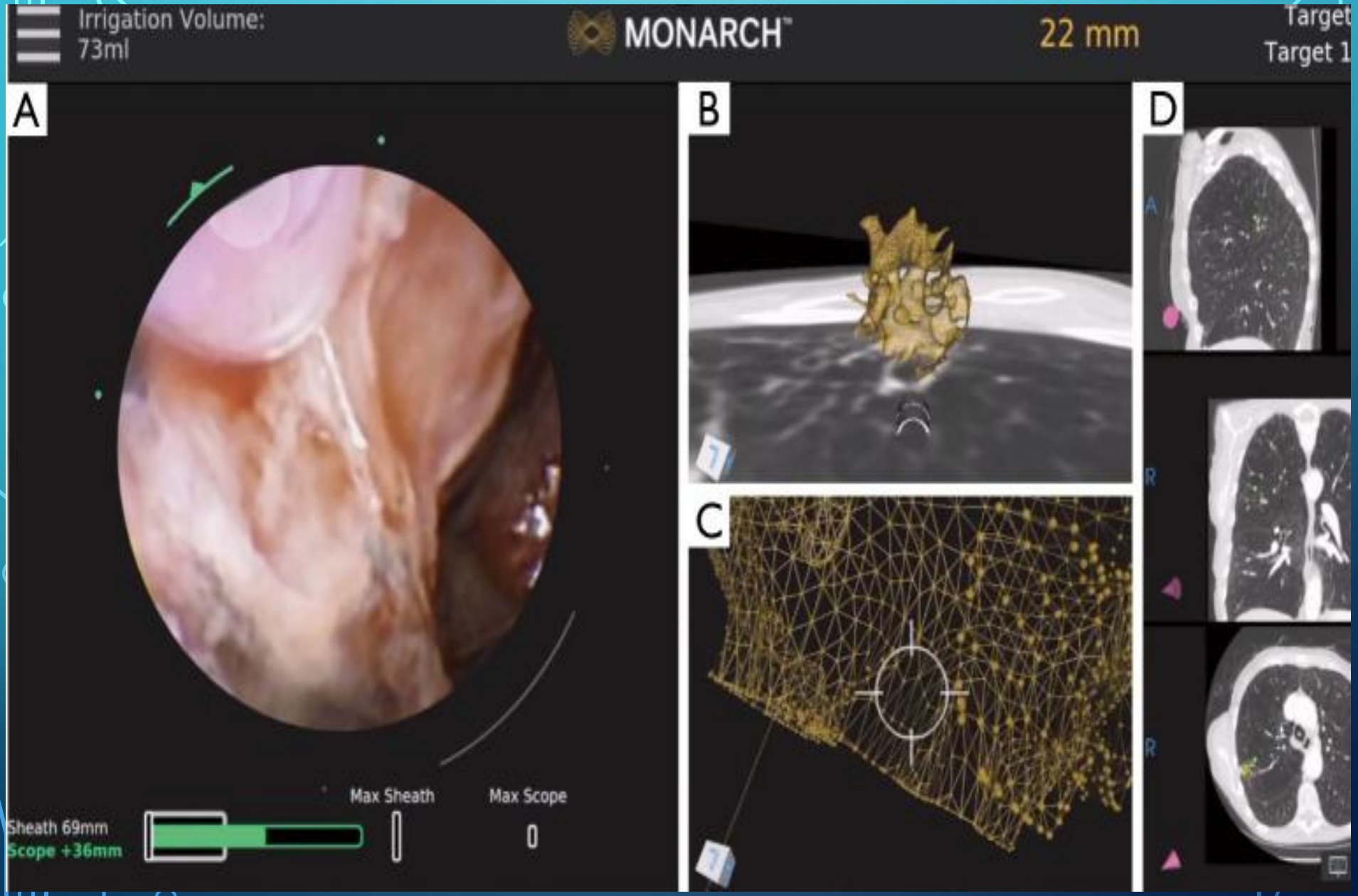
-Fiducial markers – stereotactic radiation

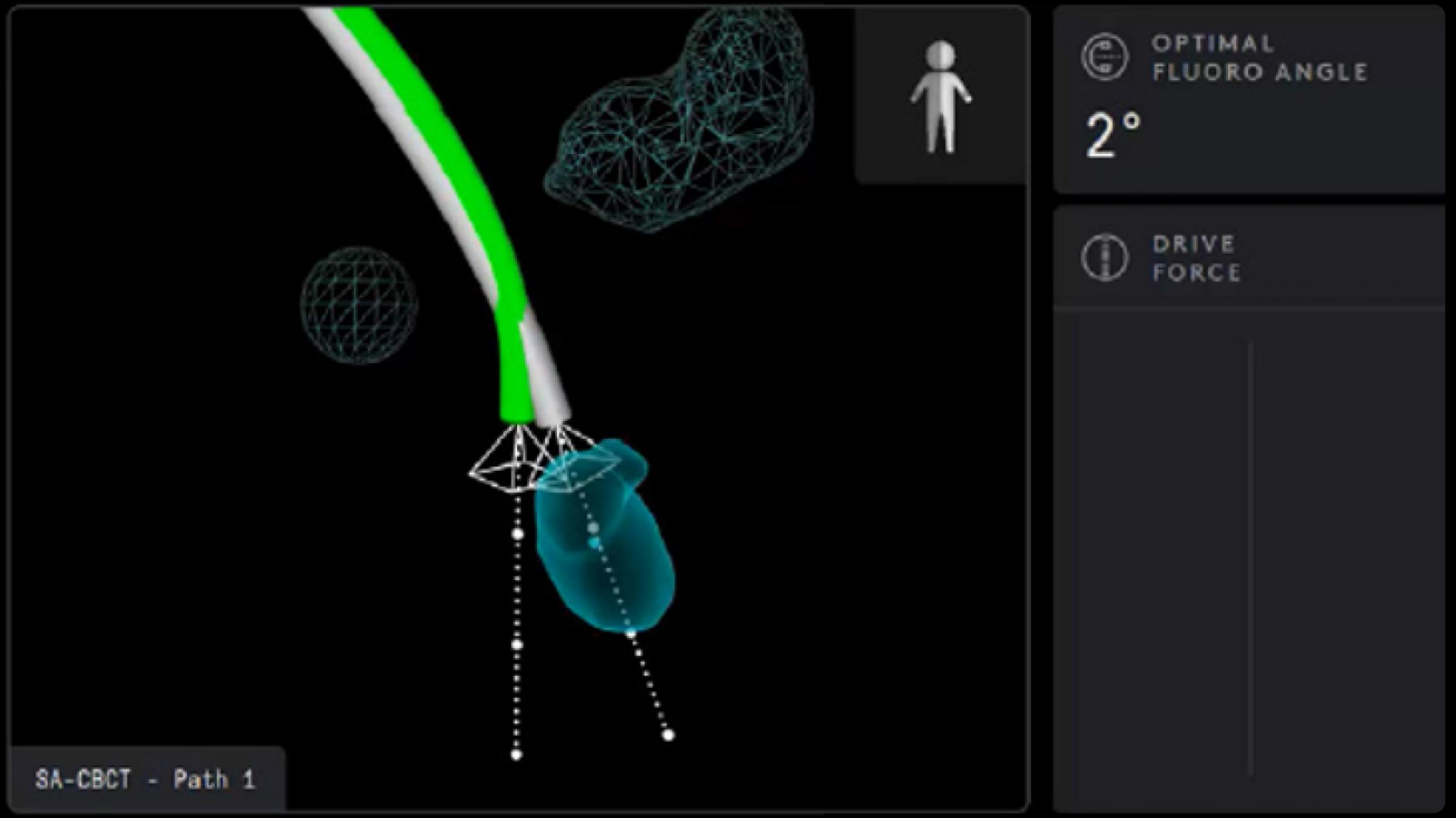
-Tumor marking pre-op (indocyanine, methylene blue dyes)

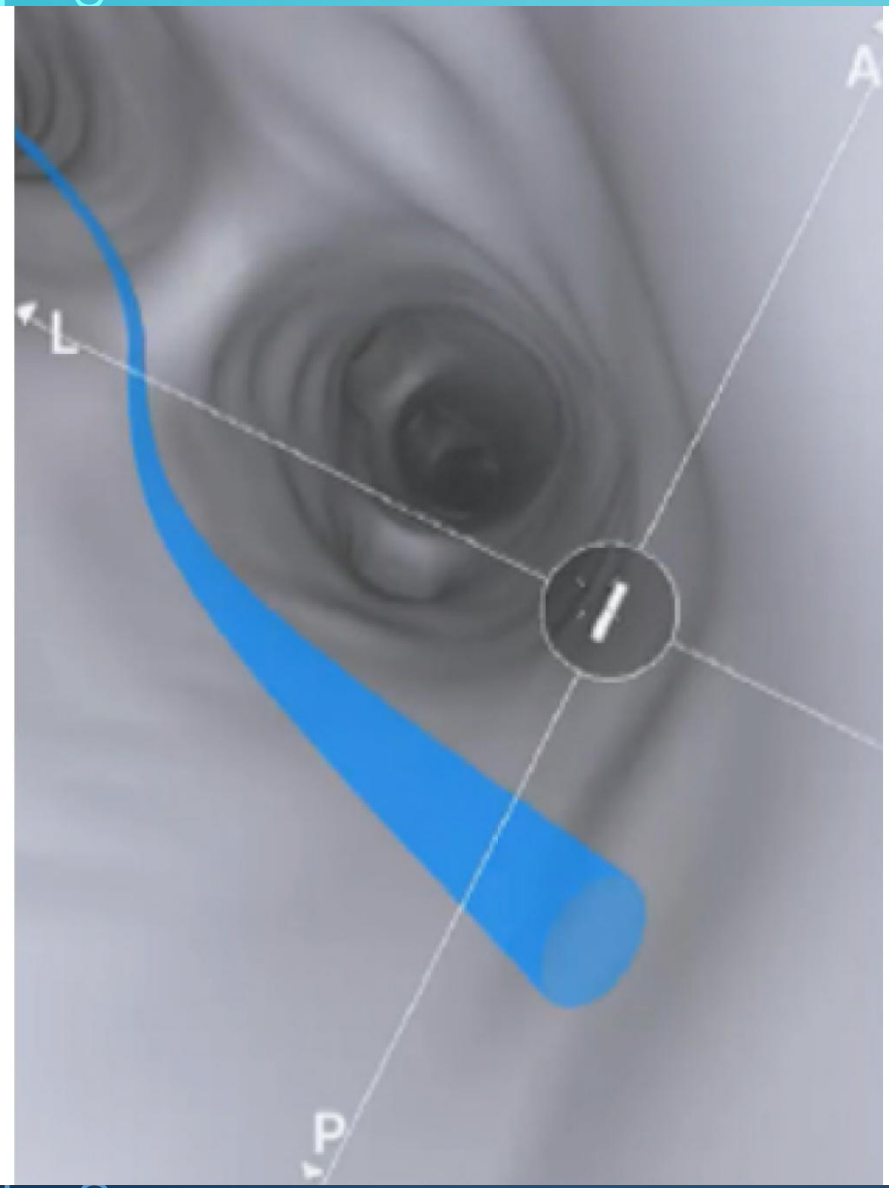
-Brachytherapy microwave ablation

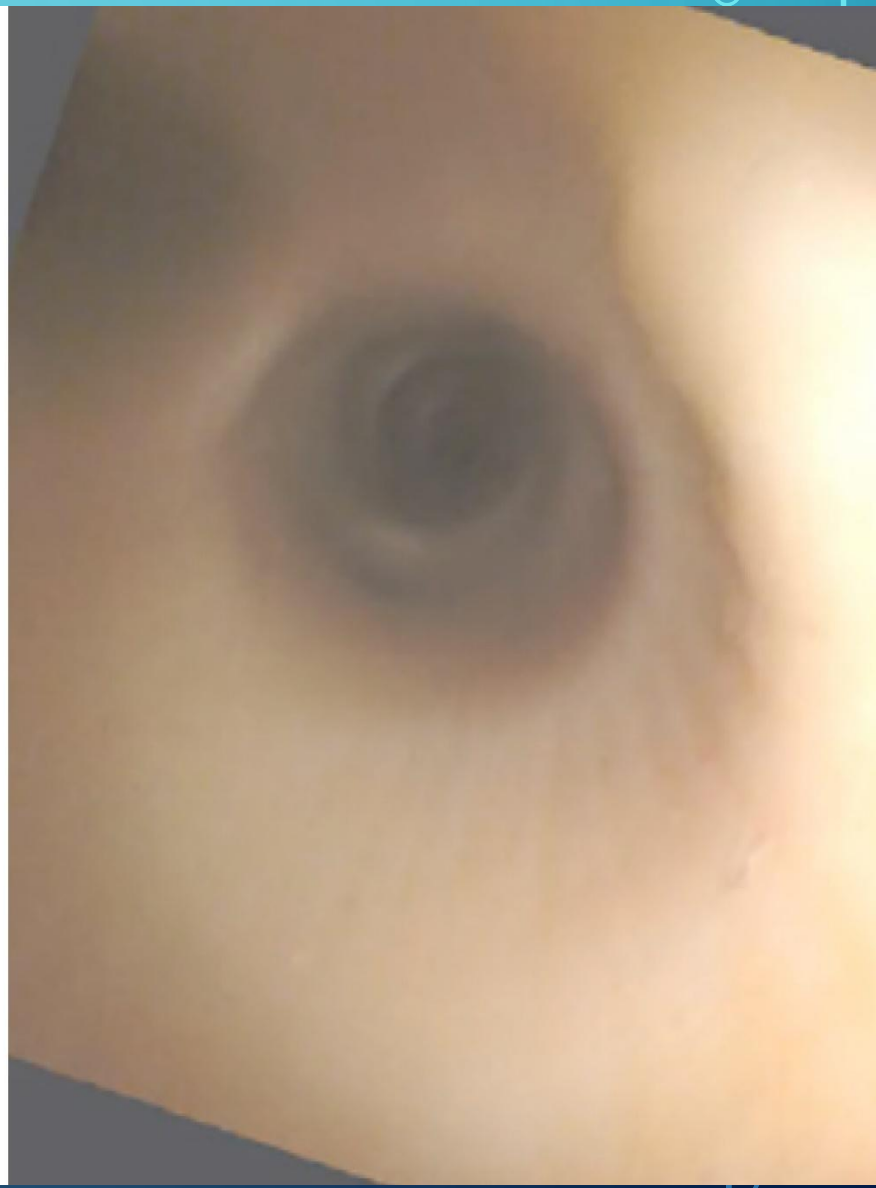
-Radiofrequency ablation

Monarch and Auris Health, Inc.









Early studies/trials demonstrating the localization, diagnostic yield, and complications of the robotic platforms.

Robotic Platform	Trial	# pts enrolled	Ability to reach target/Localize	Pathologic Diagnostic Yield	Adverse Events/Complications
Monarch™	Rojas-Solano *et al*, 2018	15	93.3%	93.3%	none reported
	Chen *et al*, 2019	46	95.6%	-	4.3% pneumothorax; 2.1% tube thoracostomy
	Chaddha *et al*, 2019	165	97.6%	69-77%	3.6% pneumothorax, 2.4% tube thoracostomy, 2.4% airway bleeding
Ion™	Fielding *et al*, 2019	29	96.6%	79.3%	0%