

# Bronchoscopic Navigation

## Tools and Techniques

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# Background – the need for better diagnostics

- More CT scans being performed in clinical medicine than ever
- CT screening for lung cancer is being implemented
- >>> higher number of indeterminate pulmonary nodules
  
- Diagnostic challenge!
  - Nodule management algorithms
  - Malignancy risk probability calculators
  - Other modes of imaging e.g. PET-CT
  - But.....a biopsy is still often required

# Background – the need for better diagnostics

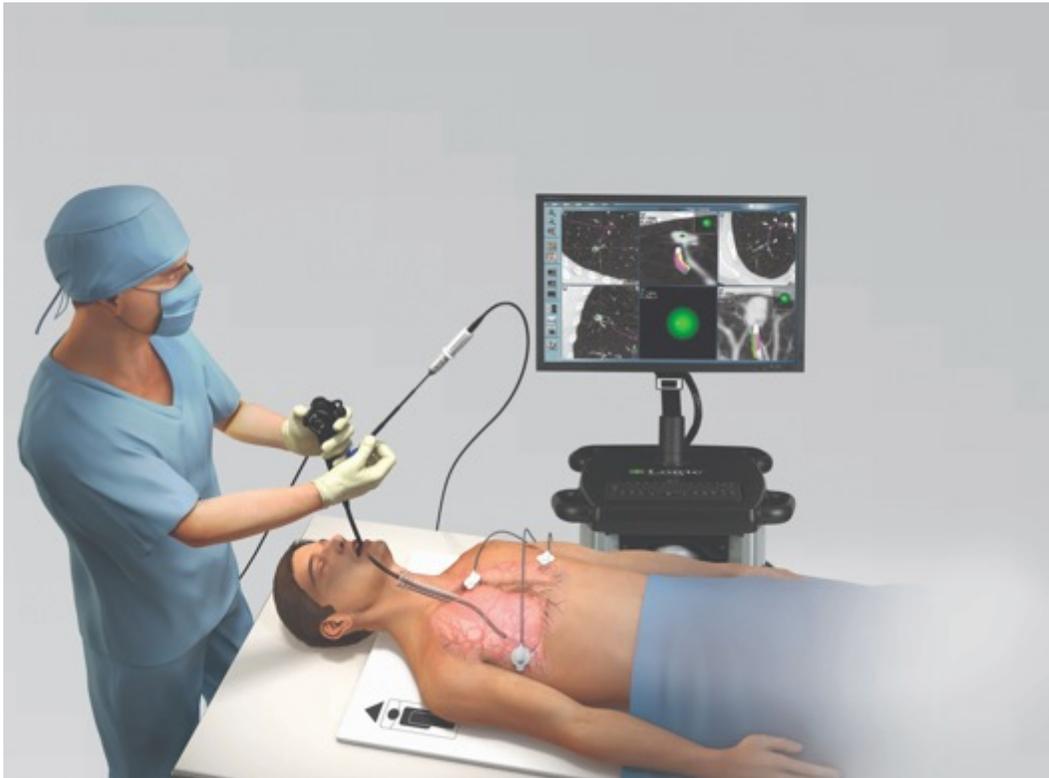
- Transthoracic Needle Aspiration (TTNA)
  - The gold standard for peripheral lesions
  - Diagnostic yield of >90%<sup>1</sup>
  - But...
    - Not always feasible
    - Variable false negative rate (3-29%)<sup>2</sup>
    - High complication rate – pneumothorax rates of 20-40%<sup>3</sup>
- Surgery
  - More costly
  - More invasive with increased morbidity & mortality
  - Risk of benign resections

# Background – the need for better diagnostics

- Bronchoscopy
  - Widely available
  - Very safe – pneumothorax rate <1%<sup>1</sup>
  - But...
    - Unable to reach the peripheries
    - Poor for smaller lesions (<2cm)
    - Diagnostic yield as low as 14% for small peripheral lesions<sup>2</sup>

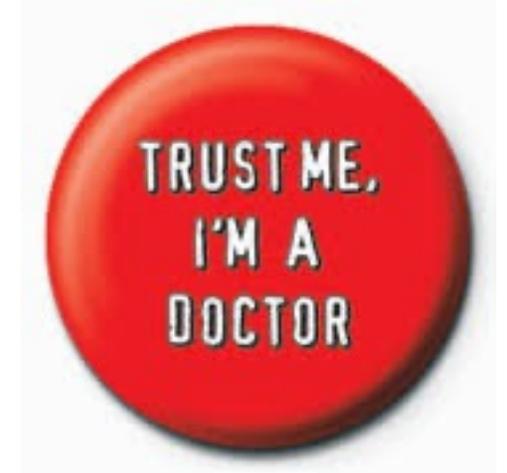
1. Du Rand, IA et al. Thorax 2013
2. Gex, G et al. Respiration 2014
3. Heerink, WJ, et al. Eur Radiol 2017

# Navigational Bronchoscopy



# Conclusions from the data

- Better diagnostic yield than standard bronchoscopy
- Yield is better when combined with other adjuncts
- Much safer than TTNA
  
- Data often from small single centre series
- Procedures often performed by limited number of experienced practitioners
- Likely selection bias with more difficult cases being selected for VB





# What is a “Nav Bronch”?

(aka a ‘*Navae*’ in Manchester)

# 1: Virtual Bronchoscopic Navigation (VBN)

- Simulated 3D 'sat nav' route to the lesion
- Thin-sliced CT images reconstructed to highlight a path
  
- Advantages (vs ENB)
  - Lower cost
  - Easier set-up
  - Relatively simple to use
  
- Disadvantages (vs ENB)
  - No real-time position
  - No additional guidance beyond bronchoscope reach
  - No remote steering

# 1: Virtual Bronchoscopic Navigation (VBN)

- Other advantage/disadvantage:
  - Need excellent bronchoscopy skills
  - Need ability to use Radial EBUS (mini-probe)
  - Need access and skill in using slim & ultra-slim scopes

# Virtual Bronchoscopic Navigation (VBN)



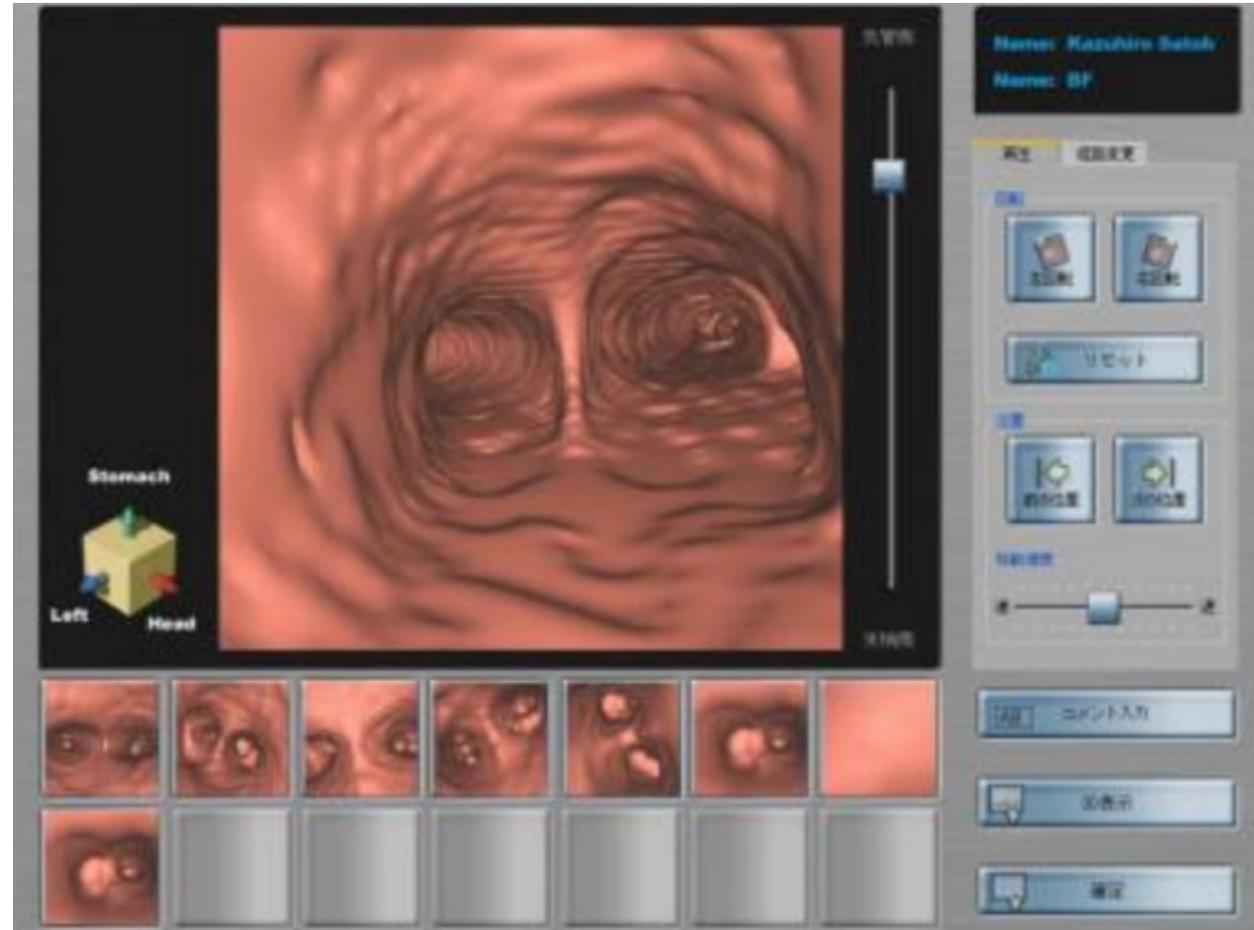
**BRONCUS**

**'LungPoint'** (aka Archimedes)

# Virtual Bronchoscopic Navigation (VBN)

**OLYMPUS**

**'Bf-Navi'**



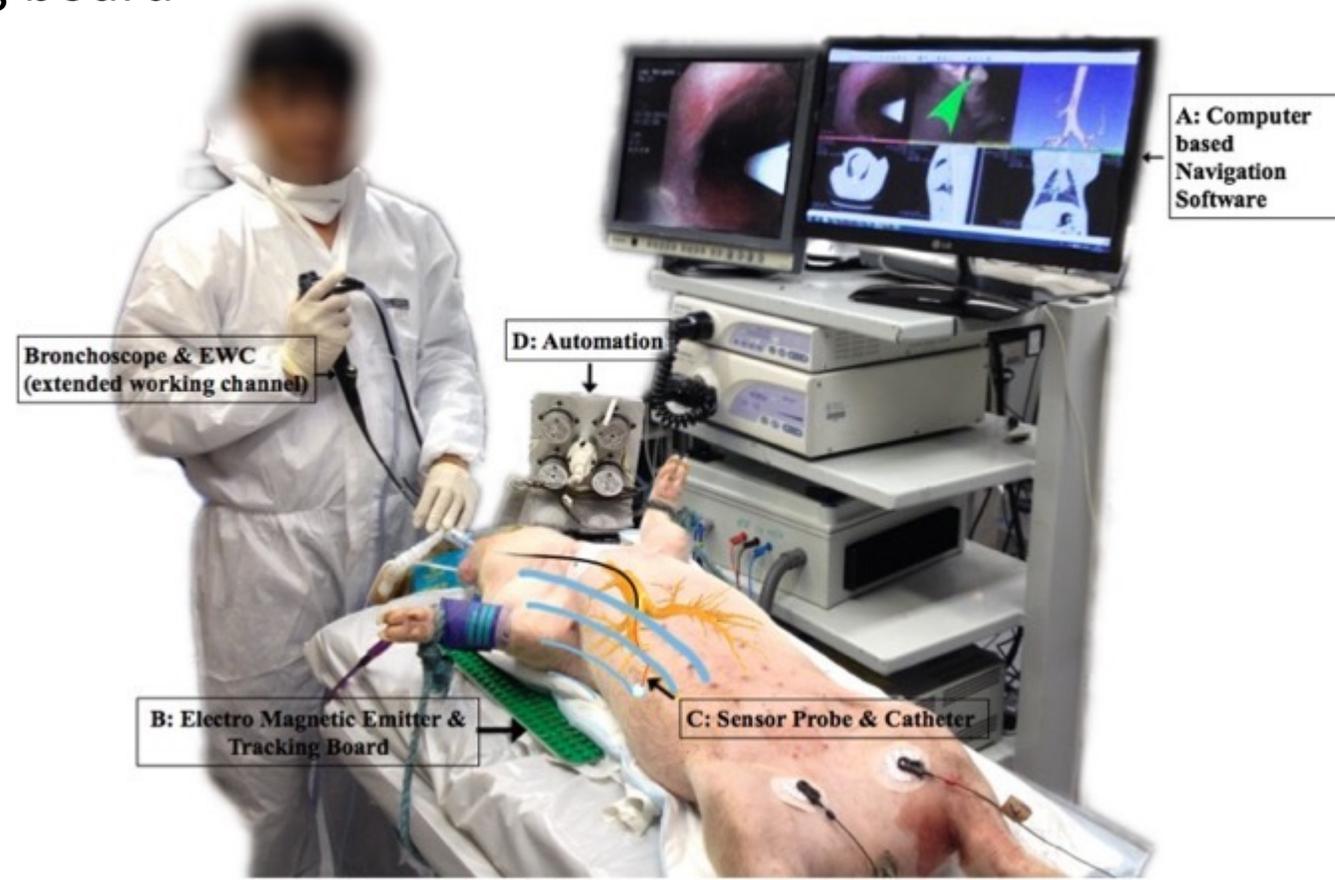
## 2: Electromagnetic Navigational Bronchoscopy (ENB)

- Creates an electromagnetic field around the patient to track devices
- Superimposes device position onto a 3D virtual bronchoscopy route
  
- Advantages (vs VBN)
  - Allows real-time position sense
  - Allows additional guide beyond bronchoscope reach
  - Allows remote steering beyond bronchoscope reach
- Disadvantages (vs VBN)
  - More expensive
  - More complex set-up including personnel
  - Longer procedure

# Electromagnetic Navigational Bronchoscopy (ENB)

ENB requires several components:

- Electromagnetic emitter and tracking board
- Sensors
- Extended working channel
- CT lung reconstruction
- Virtual bronchoscopy software

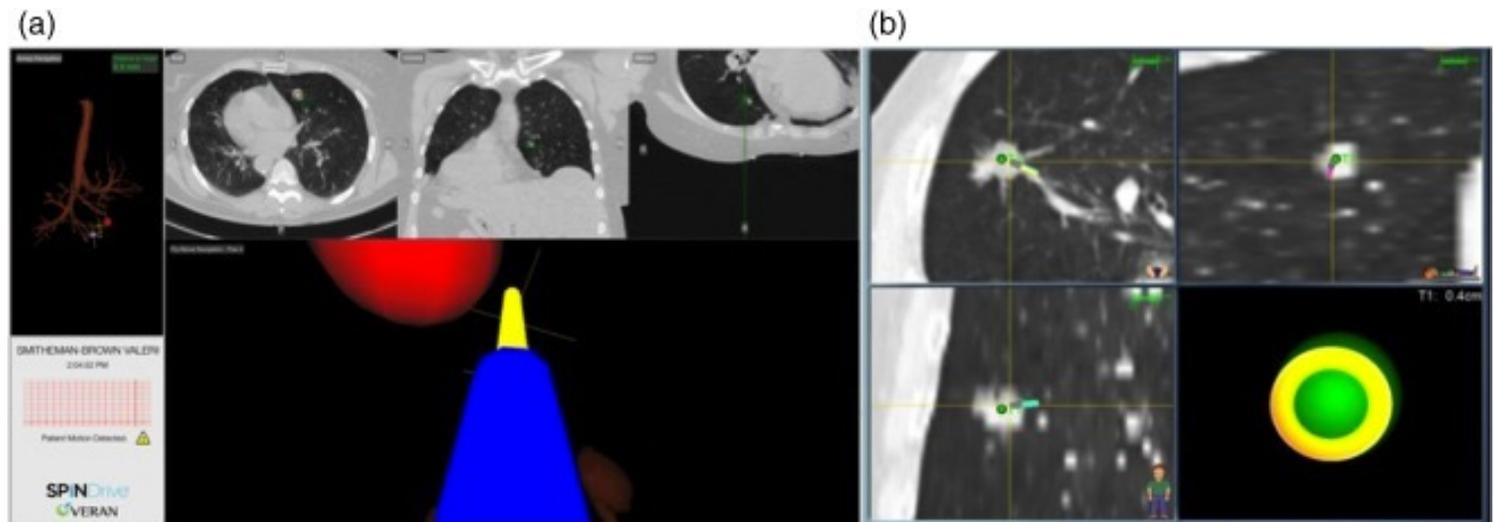


# Electromagnetic Navigational Bronchoscopy (ENB)



**'Illumisite'** (aka superDimention)

# Electromagnetic Navigational Bronchoscopy (ENB)



**‘SPiNDrive’**

# Local VBN experience in Manchester

- Manchester Thoracic Oncology Centre, Wythenshawe Hospital
- Established in 2019
- Standard bronchoscopy lists
  - Standard room setup
  - No access to GA
  - Two lists per week
- VBN (Archimedes system)

# Results - cases

- Now performed >250 cases
- 50% female
- Mean age 70.3 years
- Median midazolam dose: 2mg
- Median alfentanil dose: 350mcg

# Results – lesions

- 88% solid lesions (no pGGOs)
- 58% of lesions in upper lobes
  
- Median number of subsegments beyond carina: 5
- Mean shortest distance to pleura: 30.7mm
- Mean lesion size: 25mm

# Results – technique & findings

- 85% needed a Slim/Pediatric/Ultra-slim scope
- 54% needed radial-EBUS to confirm pre-sample
  
- Findings:
  - 36% no lesions identified
  - 29% lesion identified with bronchoscope
  - 24% non-obstructing lesion seen with mini-probe
  - 11% obstructing lesion seen with mini-probe

# Results – yield

- **Overall diagnostic yield: 77%**
  - Lesion seen: 96%
  - Obstructing mini-probe lesion: 89%
  - Non-obstructing mini-probe lesion: 79%
  - Nil seen: 57%
    - but 21/23 cancers false negative
- **>3/4 of cases did not require further diagnostic**
- Adequate tissue for molecular testing in all relevant cases
- **No pneumothoraces; no major complications**

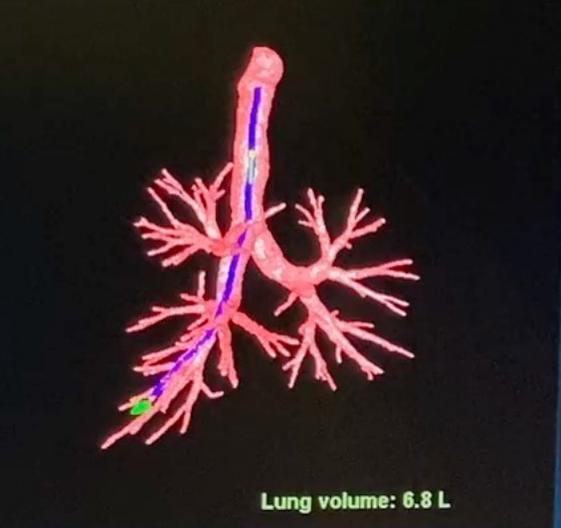
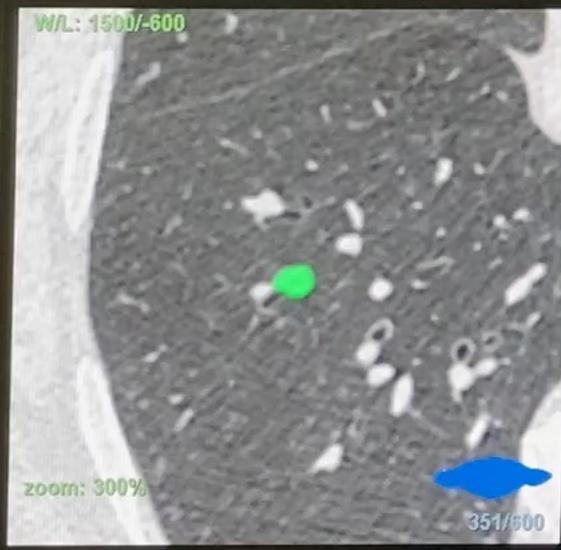
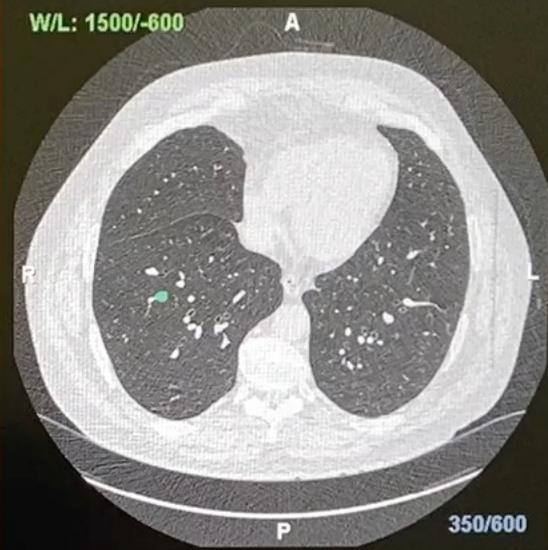
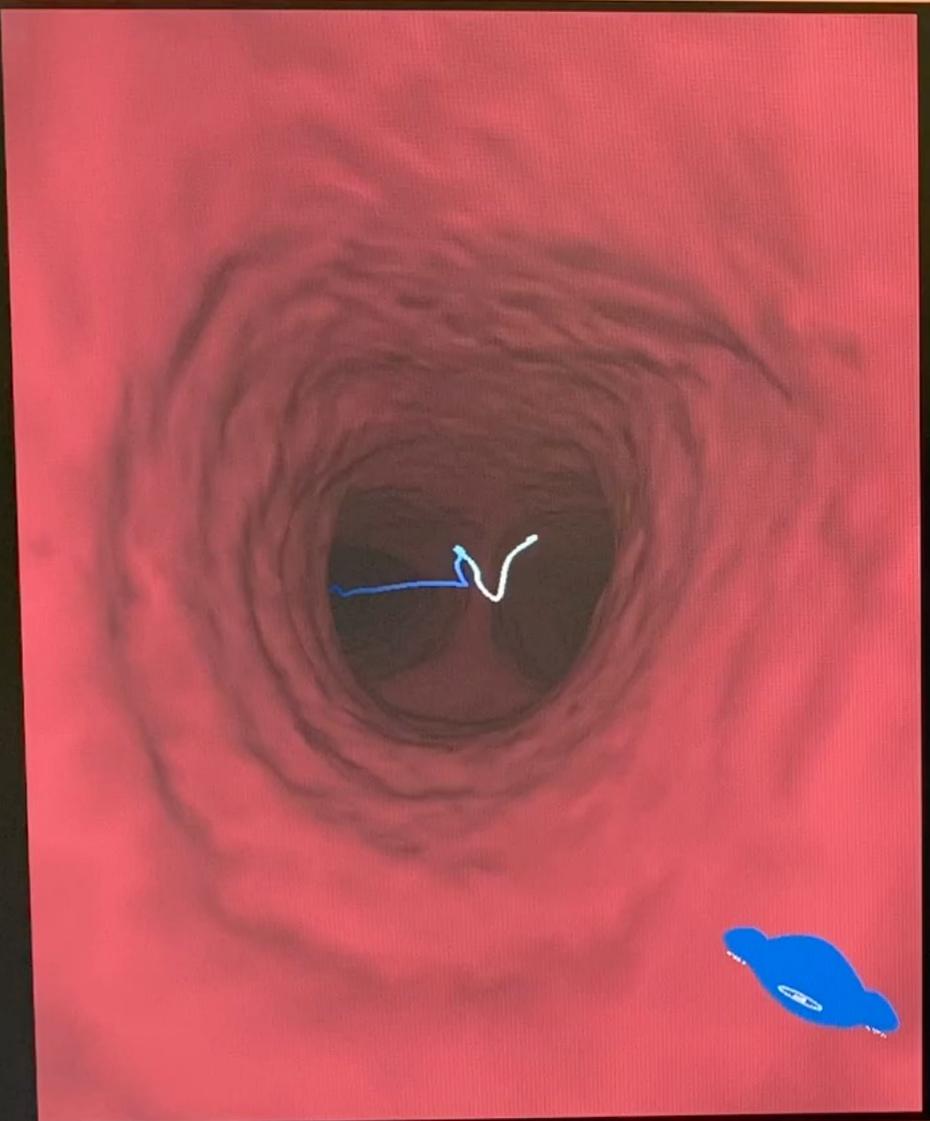
Info (mm)

254  
68  
186  
176 10  
3

ray

20  
18

way (d)



Virtual Branch Navigation controls: play, stop, back, forward buttons and a slider set to 44/218 mm.

Doppler icon and POE icon.

Window & Level Lung controls: W= 1500, L= -600.

Views icon and a window icon.

Navigation icons: home, search, and a Y-shaped icon.

Display icons: refresh and undo.

Options icon and a Vessels 5 mm icon.

Options icon and a window icon.

# The future

Thorax Online First, published on March 6, 2015 as 10.1136/thoraxjnl-2014-206211  
Lung cancer



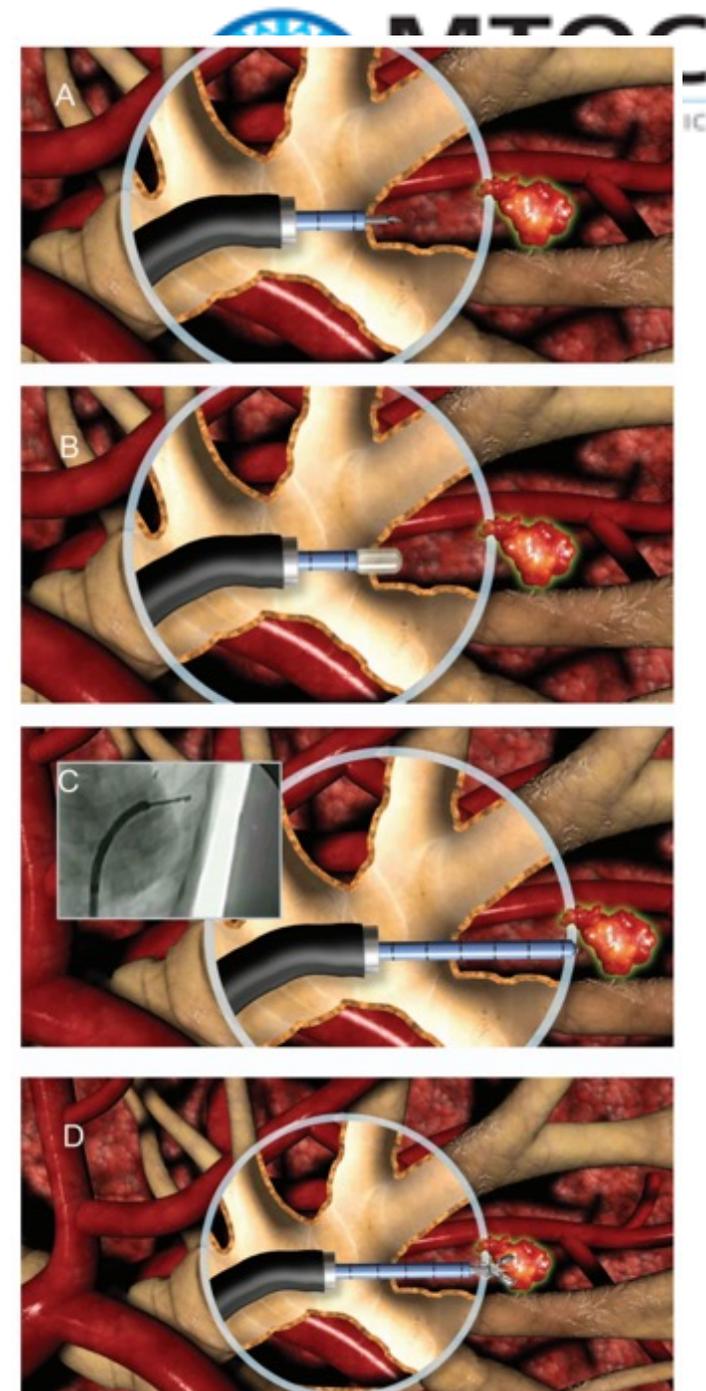
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ORIGINAL ARTICLE

## Bronchoscopic transparenchymal nodule access (BTPNA): first in human trial of a novel procedure for sampling solitary pulmonary nodules

Felix JF Herth,<sup>1,2</sup> Ralf Eberhardt,<sup>1,2</sup> Daniel Stermann,<sup>3</sup> Gerard A Silvestri,<sup>4</sup>  
Hans Hoffmann,<sup>5</sup> Pallav L Shah<sup>6,7,8</sup>

- A novel bronchoscopic technique for accessing nodules through a transparenchymal approach which is not dependent on the need to have an airway leading into the lesion.
- Twelve patients were recruited, and a tunnel pathway created in 10 patients.
- There were no adverse events during the procedures. Adequate biopsies were obtained from 10 patients (83%), which correlated with the histological findings from the surgical resection.
- Inspection of the resected lobes did not raise any safety concerns and indicated appropriately tunnelled pathways to the nodule

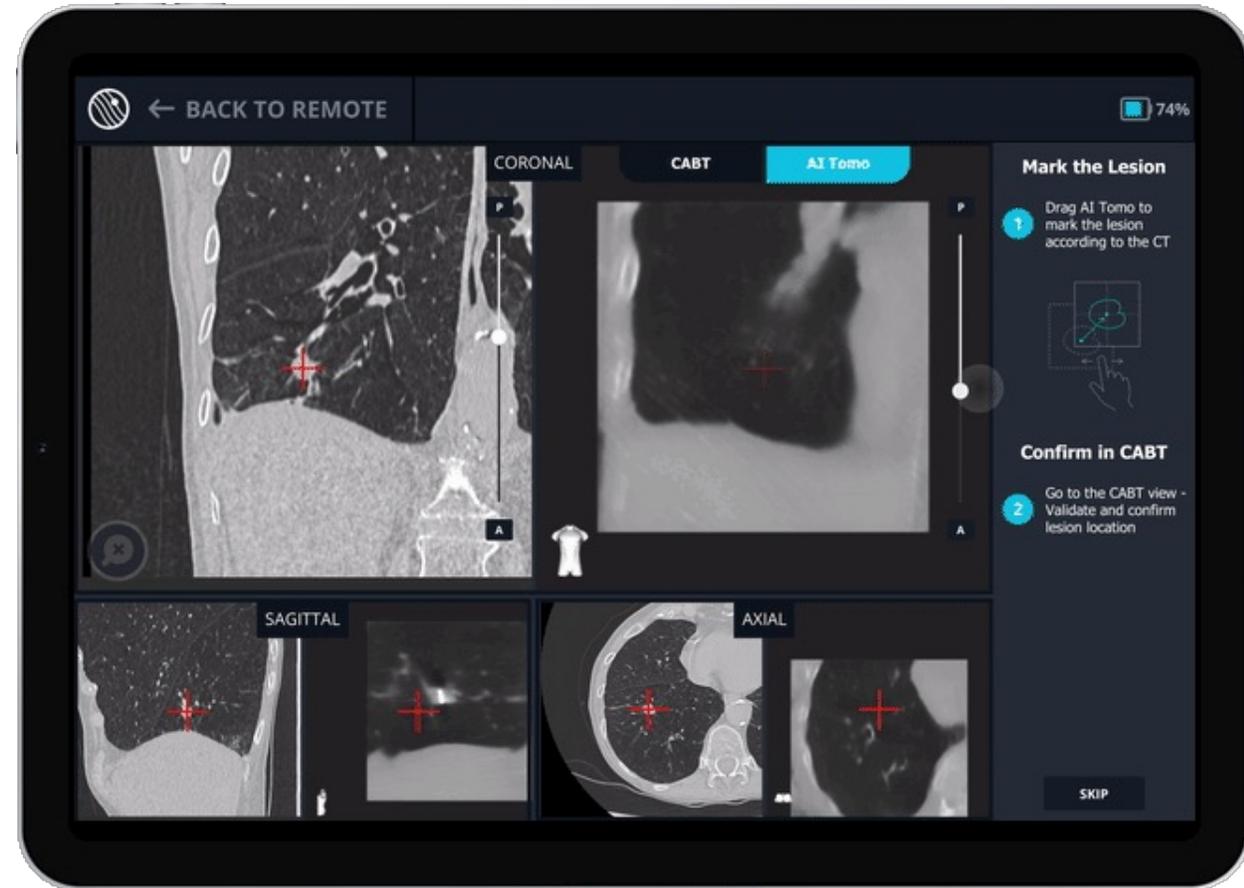


# Image guidance: augmented fluoroscopy

## LungVision System

(Body Vision Medical Ltd)

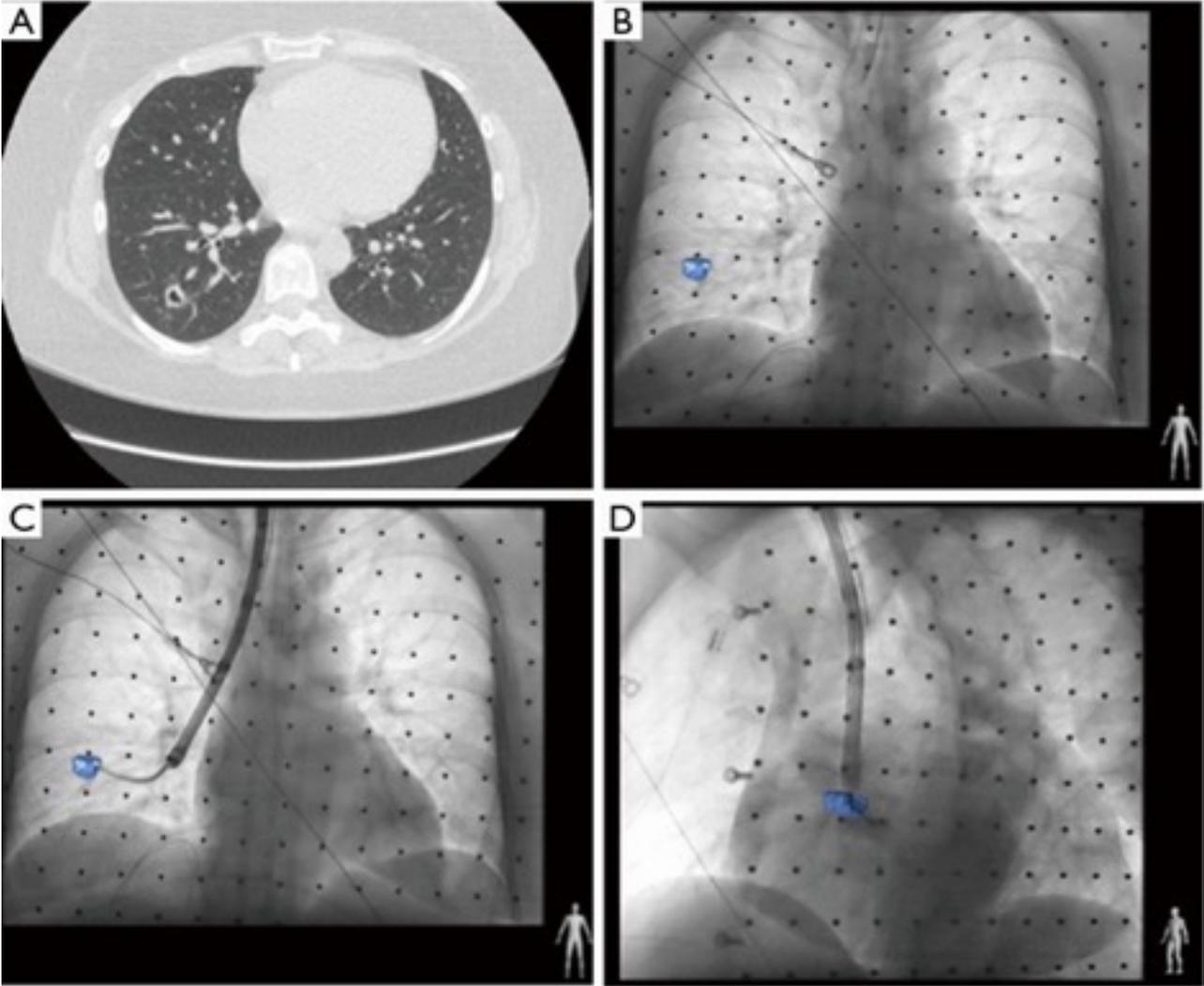
“An image navigation and guidance system that utilizes multimodal image fusion of preoperative CT and interoperative fluoroscopy to enable real-time augmented endobronchial fluoroscopic navigation and guidance.”



# Image guidance: Cone beam CT

- Already widely used in interventional radiology, interventional cardiology, neurosurgery and vascular surgery
- Produces CT like multiplanar 3D images
- Allows real-time 3D position confirmation

# Image guidance: Cone beam CT



1. Cheng, GZ et al. JTD 2020
2. Orth, RC et al. JVIR 2008
3. [usa.philips.com](http://usa.philips.com) (image)
4. [siemens-healthineers.com](http://siemens-healthineers.com)

**Table 1** CBCT combined with navigation for diagnosis peripheral pulmonary lesions

Studies	Design	Procedural modalities	CBCT used	Overall diagnostic yield	Lesions	Nodule size	Radiation information
Pritchett <i>et al.</i>	Retrospective study	CBCT + ENB + AF	Allura Xper FD20; Philips	83%	93	Median nodule size 20 (range, 7–55) mm	2.0 mSv per CBCT run, average 1.5 runs, 3.5 mSv
Sobieszczyk <i>et al.</i>	Retrospective study	CBCT + ENB + R-EBUS + TBAT	Not reported	77.2%	22	Median nodule size 21 (range, 7–52) mm	Not reported
Casal <i>et al.</i>	Prospective observational cohort study	CBCT + R-EBUS + Ultrathin Bronchoscope	Not reported	70%	20	Median nodule size 21 (range, 11–30) mm	Estimated to range between 8.6 to 23 mSv, average fluoroscopy time 8.6 minutes (range, 5–15.4 minutes)
Bowling <i>et al.</i>	Retrospective study	CBCT + ENB + TBAT	Artis Zeego; Siemens	71%	14	Median nodule size of 18 (range, 9–30) mm	4.3 mSv (range, 3 to 5 mSv), and the average fluoroscopic time was 17 minutes (range, 2 to 44 minutes)
Ali <i>et al.</i>	Prospective study	CBCT + VBN + Ultrathin Bronchoscope	Artis Zeego; Siemens	90%	40	Median nodule size 20 (range, 9–30) mm	Not reported

CBCT, cone beam computed tomography; ENB, electromagnetic navigation bronchoscopy; R-EBUS, radial endobronchial ultrasound; AF, augmented fluoroscopy; TBAT, Trans Bronchial Access Tool.

# Other abilities

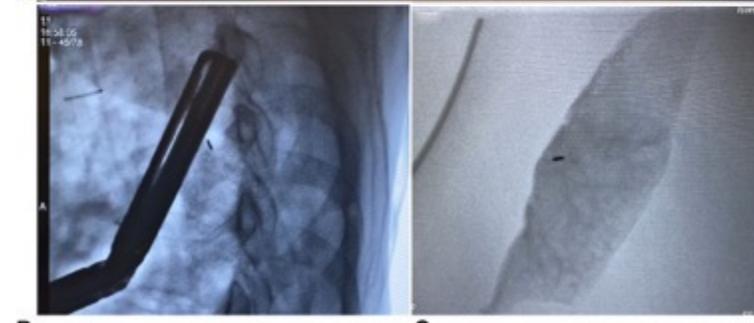
- Placement of markers for treatment
- Fiducials for SABR/localized resections
  - NAVIGATE study
  - 258 patients
  - 99.2% accurately placed, 94.1% remained in place
  - Pneumothorax rate 5.4%
- Injection of dye pre-operatively
  - Methylene blue/indocyanine green
  - Several small case series
    - ~80% success rate
    - Safe (no significant complications)



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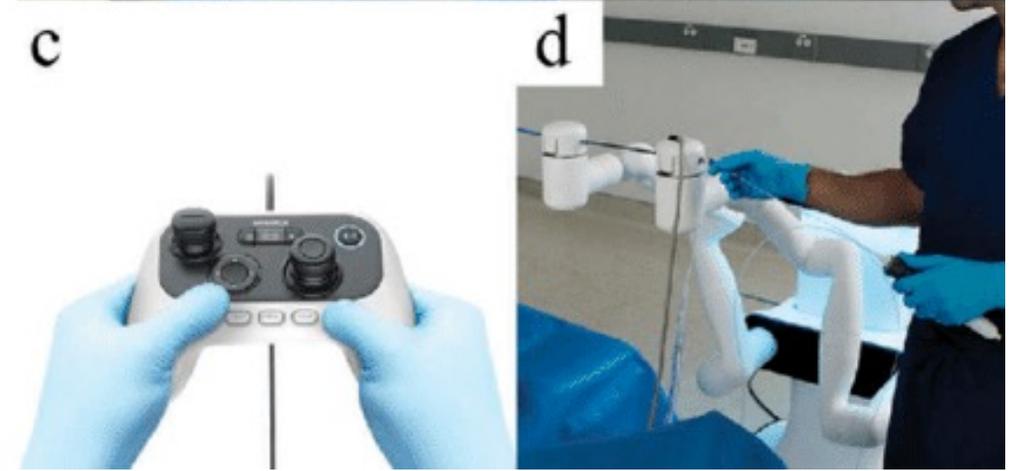
# The future: Robotic bronchoscopy

- Rationale
  - Thinner and more flexible scope
  - Further reach
    - 9<sup>th</sup> vs 6<sup>th</sup> generation airways
  - Peripheral direct visualisation
  - More stable sampling



# Roboti <sup>a</sup>

- Three FD
  - Monar
  - Ion™ I
  - Galaxy
- Evidence
  - Initial
  - Small I
  - Two la
    - BEN
    - PRE



1. Rojas-Solano, JR. et al. J Bronchol Interv Pulmonol 2018
2. Chen, AC. Et al. Respiration 2020.
3. Chen A. et al. ACCP annual conference
4. <https://clinicaltrials.gov/ct2/show/NCT03893539>

# The future – endobronchial therapy

- Accurate access to peripheral lesions allows focal treatment including:
  - Brachytherapy
  - Radiofrequency ablation
  - Microwave ablation
  - Photodynamic therapy
- Evidence mostly around small case series for now.
- Most of these show good feasibility and safety.
- This is an area of growing research and clinical interest.

1. Harms, W et al. Strahlenther Onkol 2006
2. Xie, F et al. respiration 2017
3. Chan, J et al. TLCR 2021
4. Chen, K et al. JTD 2018
5. Khan, K et al. Adv Ther 2016

# Conclusions

- The technology is already out there and in use
- Different technologies available – think about your needs
- Combination in diagnostics achieves better results
- Robotic bronchoscopy has significant potential to improve diagnostic yield
  - Combine with radial-probe/ENB/others
- *Endobronchial therapy is the future*

# Thank you

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