

Endobronchial Ultrasound

Dr. Aditya Jindal

7/10/11

- Endobronchial ultrasound (EBUS) was first introduced in 1992 when endovascular probes were introduced through the bronchoscope
 - Endobronchial sonography: feasibility and preliminary results. Hurter T, Hanrath P. *Thorax* 1992;47:565-567
- The radial probe EBUS (RP EBUS) was introduced in the 1990s
- The convex probe or linear probe EBUS (CP EBUS) was introduced in 2005

- Initially considered as a toy, EBUS has grown to the stage where it is replacing mediastinoscopy as the staging procedure in lung cancer
 - Endobronchial ultrasound - Expensive toy or useful tool? Becker HD. Proceedings of the 8th World Congress for Bronchology and the 8th World Congress for Bronchooesophagology. Munich. 1994. (abstract No 237)
 - Mediastinoscopy: an endangered species? *J Clin Oncol.* 2005 Nov 20;23(33):8283-5. Epub 2005 Oct 11

Equipment

- Standard bronchoscope

- External diameter → 4 – 6.3 mm

- Ultrathin → 2.7 mm

- Internal diameter → 1.3 – 3.2 mm

- Field of view

- Anteflexion → 180°

- Retroflexion → 130°

- Optical fibre based or charge coupled device (CCD) based

- Bronchoscopes of the Twenty-First Century. Yarmus et al. *Clin Chest Med* 31 (2010)

- Endobronchial ultrasound bronchoscope

1. Radial probe (RP EBUS)

- Rotating mechanical probe
- Produces 360° images

- a) UM-BS20-26R (Olympus)

- 20 Mhz
- Fitted with a 2.6 mm balloon sheath with a water inflatable balloon at the tip
- Needs a bronchoscope with a working channel of at least 2.8 mm
- Resolution of <1 mm and depth of penetration = 5 mm

b) UM-S-3020R (Olympus)

- 30 MHz
- 1.7 mm external diameter

c) UM-S20-20R (Olympus)

- 20 MHz
- External diameter 1.7 mm
- Can be combined with guided sheath (2.8 mm)

- d) UM-S20-17R (Olympus)
 - Ultra miniaturized probe
 - External diameter 1.4 mm
 - Can be combined with guided sheath (2 mm)
 - Used with regular adult bronchoscope
 - 20 MHz

Current clinical applications of endobronchial ultrasound . Yasufuku K. *Expert Rev. Resp. Med.* 4(4), (2010)

2. Convex probe or linear probe

- A flexible bronchoscope integrated with a convex transducer on the tip
 - Tip diameter 6.9 mm
 - Working tube external diameter 6.2 mm
 - Working channel 2 mm
 - Direction of view 35° forward to long axis
 - Angle of view 90° forward
 - 7.5 MHz
 - Color Doppler
 - BF-UC160F-OL8 (Olympus)

- BF-UC180F-OL8 (Olympus)
 - 2.2 mm working channel
 - Can be connected to the universal ultrasound system

- EB01970UK (Pentax)
 - EBUS scope with a charge coupled device integrated into the distal end
 - 7.4 mm external diameter
 - 2 mm working channel / 100° field of view
 - Up/down 120°/90°
 - Better visual quality
 - Depth of field 2 – 50 mm
 - Coupled with Hitachi ultrasound system

Technique

- The ultrasound probe consists of a transducer and a processor
 - Transducer → sends and receives ultrasound waves
 - Processor → integrates the sound waves and converts them into images

RP EBUS

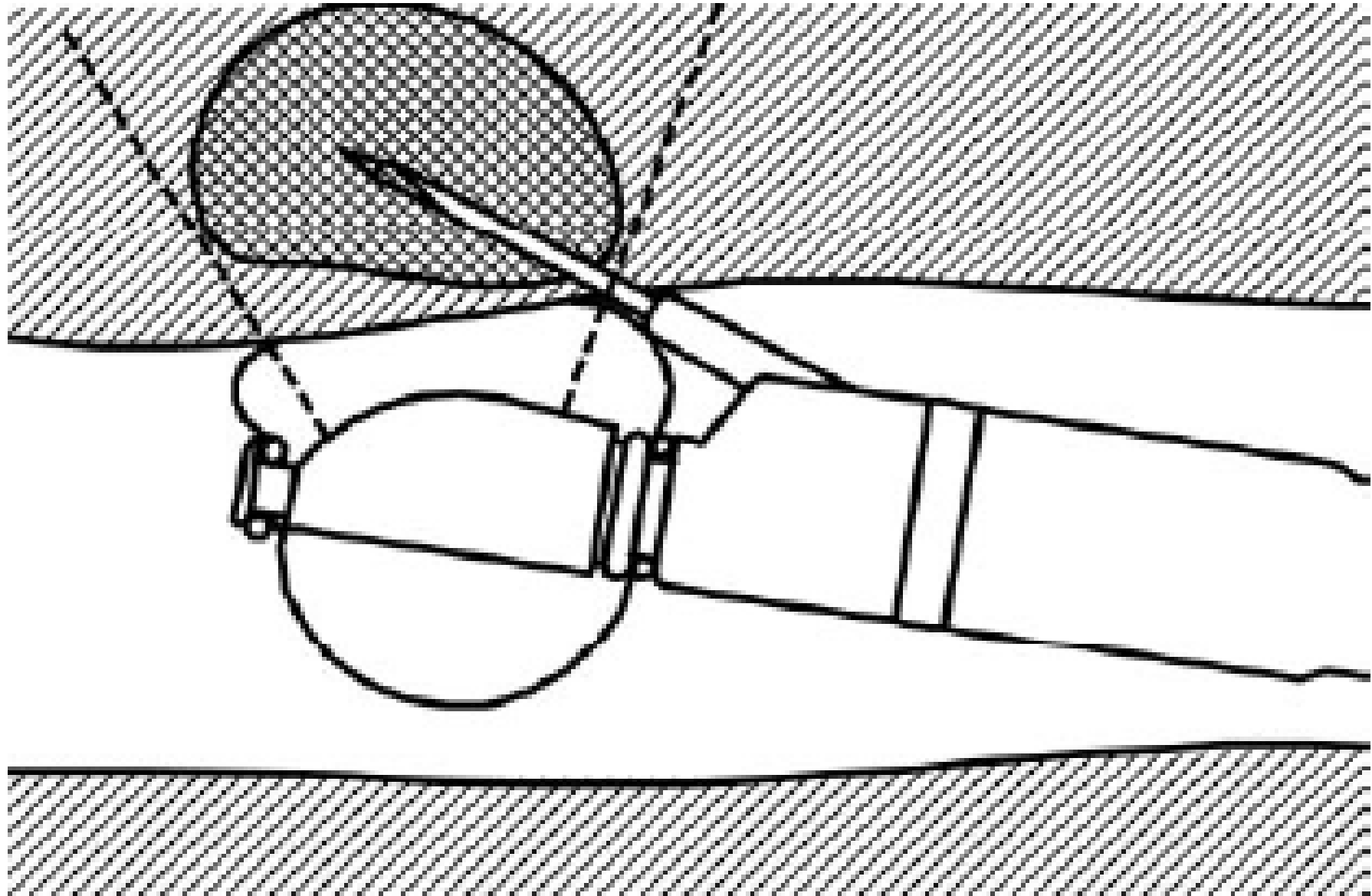
- Consists of a probe which can be introduced through the working channel of a routine bronchoscope, with or without a guide sheath
- The probe is used to locate the lesion and is then withdrawn
- The guide sheath can be left in place to localize the lesion and biopsy forceps or a brush introduced through it

- Gives 360° images and also details the structure of the airway wall
- The normal airway wall has 7 layers on USG
 - 1 – 2 → mucosa and submucosa
 - 3 – 5 → cartilage
 - 6 – 7 → loose and dense connective tissue respectively
 - External layers taper off and disappear peripherally
- Can be reused upto 75 times
 - Endobronchial Ultrasound. Sheski FD, Mathur PN. *Chest* 2008;133;264-270

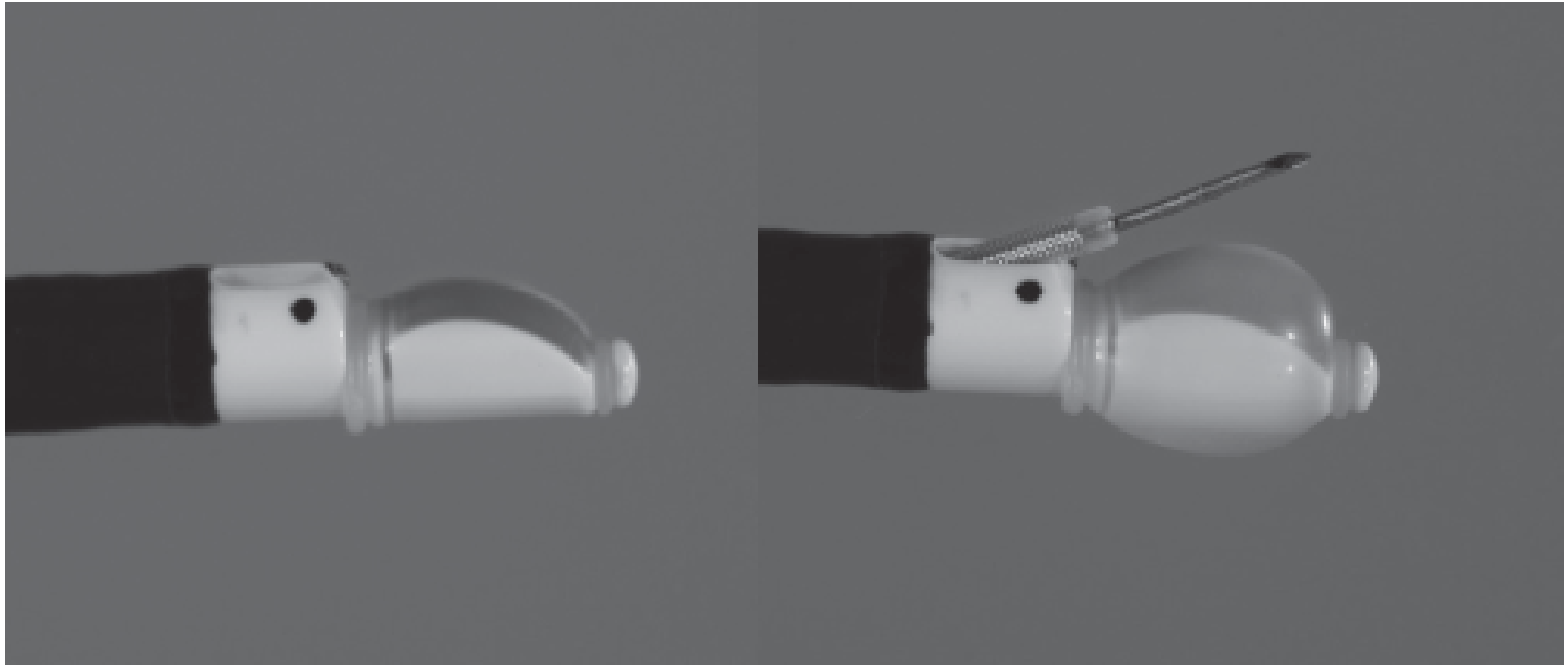
- Uses
 - To assess the structure of the airway wall and invasion by early stage lung cancer
 - To assess the length of stenoses
 - To identify the proximity of blood vessels to the airway
 - To biopsy peripheral and mediastinal lesions
 - To assist in decision making regarding intraluminal therapy
- Disadvantages
 - Real time guidance not possible
 - Steep learning curve

CP EBUS

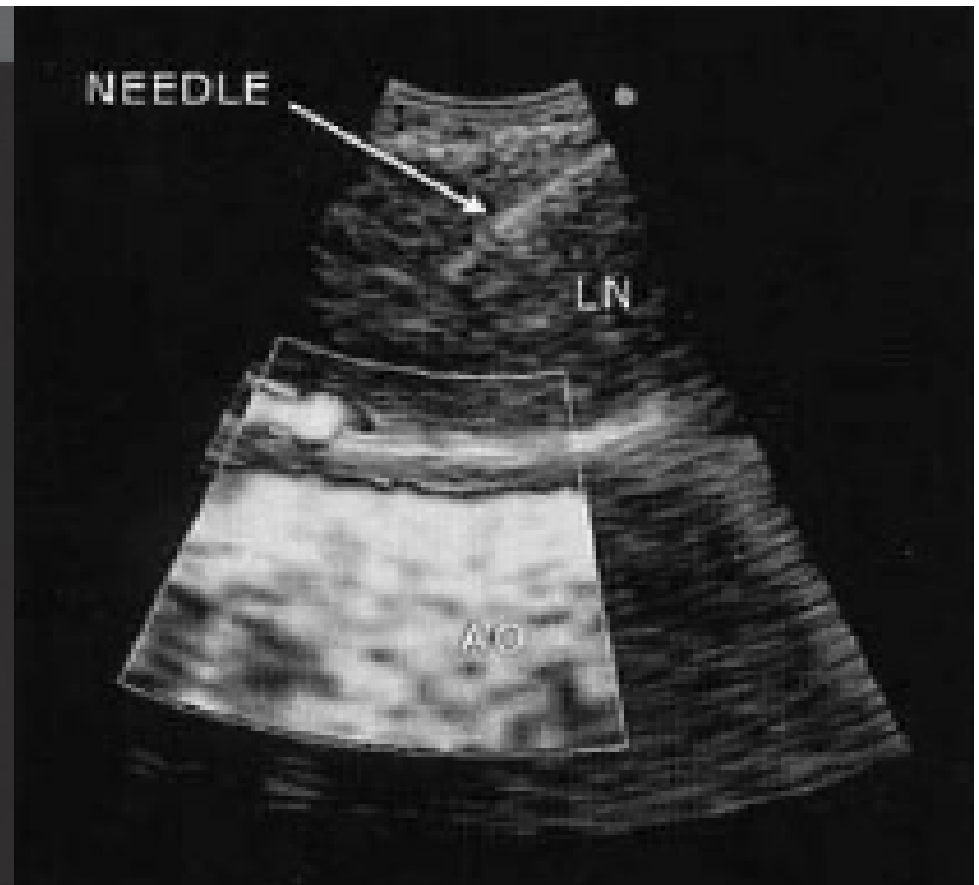
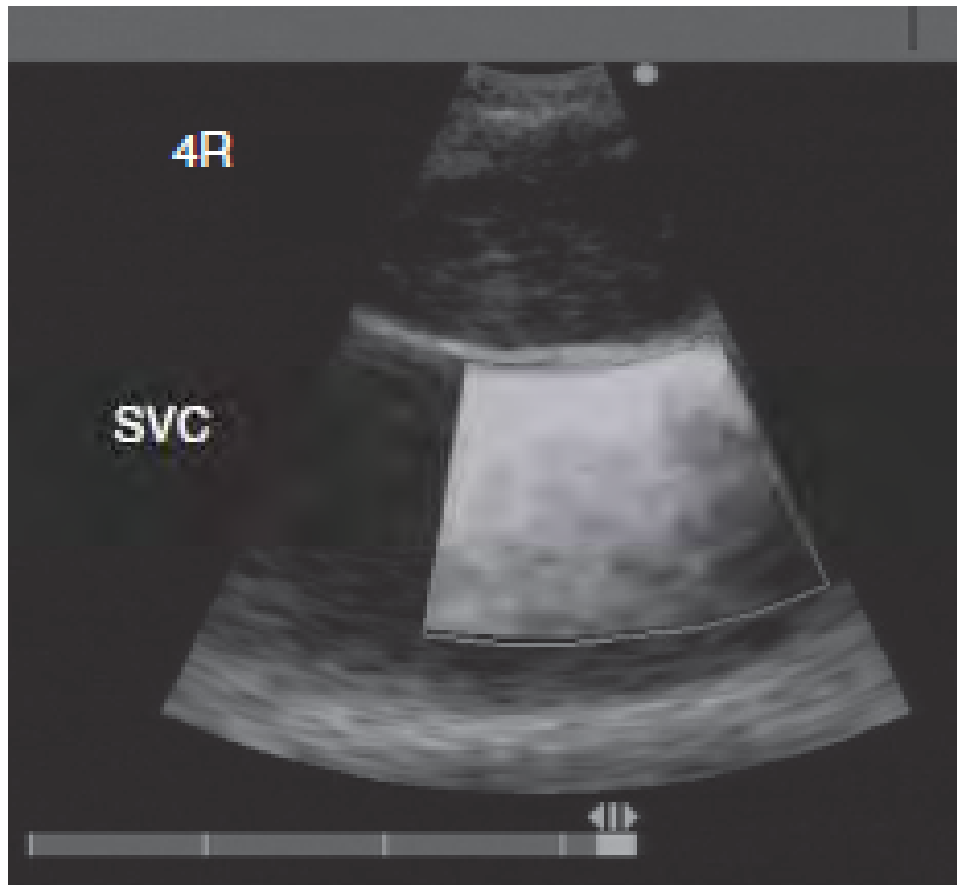
- Designed to perform real time EBUS guided transbronchial needle aspiration (TBNA)
- Consists of a bronchoscope with the ultrasound probe attached to the tip
- EBUS scope is inserted through the mouth under local anesthesia and conscious sedation
- The lesion is localized with the ultrasound and adjacent blood vessels are also visualized
- The tip is apposed to the bronchial wall and a needle passed through the working channel into the lesion



Endobronchial Ultrasound. Sheski FD, Mathur PN. *Chest* 2008; 133; 264-270



Current clinical applications of endobronchial ultrasound . Yasufuku K.
Expert Rev. Resp. Med. 4(4), 2010



Current clinical applications of endobronchial ultrasound .
Yasufuku K. *Expert Rev. Resp. Med.* 4(4), 2010

Endobronchial Ultrasound. Sheski FD, Mathur PN. *Chest* 2008; 133; 264-270

- Material aspirated is smeared onto slides
- Core from the mass/lymph node is sometimes aspirated
- Advantages
 - Real time guidance possible
 - High sensitivity
 - Safety

- Disadvantages

- Larger size of scope → greater difficulty in crossing vocal cords
- White light image is below par → airway inspection has to be done with a separate bronchoscope
- Difficulty in adjusting to the angle of view
- Cost
- Training requirement

Comparison of the two types of EBUS

	Radial probe EBUS	Linear probe EBUS
Transducer	Rotating mechanical transducer	Fixed array of electronic transducer aligned in a curvilinear pattern
View	360° to the long axis of scope	60° parallel to the long axis of the scope
Frequency	20 MHz (12, 30 also available)	5-12 MHz
Tissue penetration	4-5 cm	5 cm
Image quality	Very good. Allows airway layers to be identified	Currently not possible to identify airway layers
Real time TBNA	Not possible	Possible
Doppler to indentify blood vessels	Not possible	Possible

Balamugesh T, Herth FJ. Endobronchial ultrasound: A new innovation in bronchoscopy. Lung India [serial online] 2009 [cited 2011 Sep 27];26:17-21. Available from: <http://www.lungindia.com/text.asp?2009/26/1/17/45199>

Uses

1. Lung cancer

- a. Staging of potentially operable non small cell lung cancer
- b. Restaging after induction chemotherapy
- c. Diagnosis of peripheral lung nodules
- d. Assessment prior to intraluminal therapy

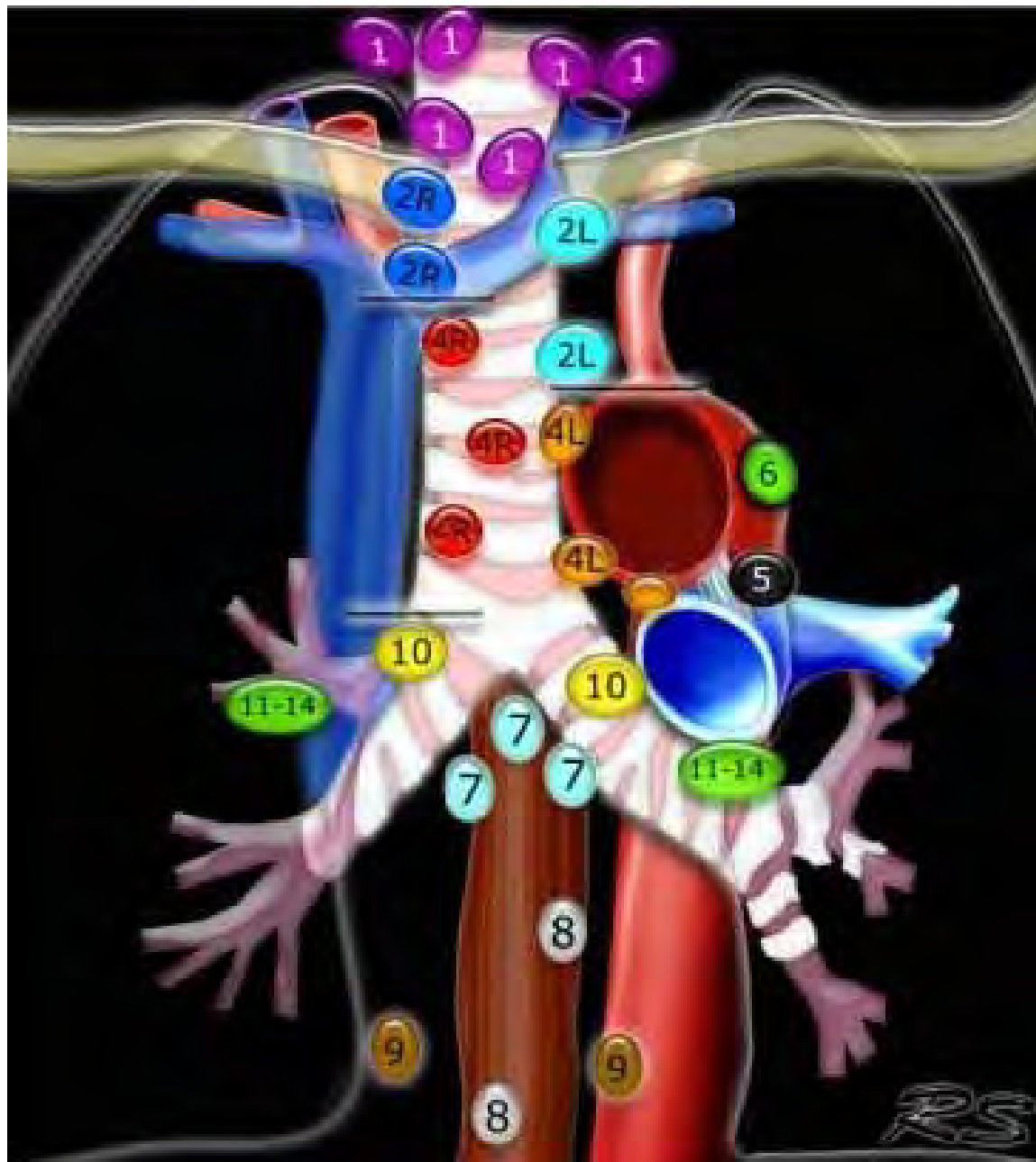
2. Diagnosis of mediastinal masses of unknown etiology

3. Diagnosis of sarcoidosis

4. Miscellaneous uses

Lung cancer

- Requires rapid diagnosis and treatment
- Current staging methods
 - Computed tomography (CT) of the thorax and upper abdomen
 - Positron Emission Tomography (PET)
 - Mediastinoscopy
 - Conventional transbronchial needle aspiration (TBNA)
 - Endoscopic ultrasound (EUS) TBNA
 - EBUS TBNA



1. Low cervical, supraclavicular and sternal notch
- 2R. Upper Paratracheal
- 2L. Upper Paratracheal
- 3A. Pre-vascular
- 3P. Pre-vertebral
- 4R. Lower Paratracheal
- 4L. Lower Paratracheal
5. Subaortic nodes
6. Para-aortic nodes
7. Subcarinal
8. Paraesophageal
9. Pulmonary Ligament
10. Hilar
11. Interlobar
12. Lobar
13. Segmental
14. Subsegmental

Lung cancer - Lymph Node Map – Update. Smithuis R.
<http://www.radiologyassistant.nl/en/4646f1278c26f>

- ***Computed tomography***

- Stages 50% of patients correctly, with a further 25% overstaged and the remainder understaged

- Endobronchial Ultrasound Today. Amat et al. *Clin Pulm Med* 2011;18:34–38

- ***Positron emission tomography (PET)***

- Sensitivity of 84%

- Negative predictive value of 0.93

- Specificity of 89%

- Positive predictive value of 0.79

- Endobronchial Ultrasound Today. Amat et al. *Clin Pulm Med* 2011;18:34–38

- Negative PET findings should be verified by cytohistologic lymph node sampling, before excluding surgical resection
 - The noninvasive staging of non-small cell lung cancer: the guidelines. Silvestri et al. *Chest*. 2003;123:147s–156s
 - Invasive Mediastinal Staging of Lung Cancer. ACCP Evidence-Based Clinical Practice Guidelines (2nd Edition). Detterbach et al. *Chest* 2007; 132:202S–220S

Characteristics of CT, PET, and EBUS TBNA in the Correct Prediction of Mediastinal Lymph Node Staging

Tests	Sensitivity	Specificity	PPV	NPV	Accuracy
CT	76.9	55.3	37.0	87.5	60.8
PET	80.0	70.1	46.5	91.5	72.5
EBUS-TBNA	92.3	100	100	97.4	98.0

Comparison of Endobronchial Ultrasound, Positron Emission Tomography, and CT for Lymph Node Staging of Lung Cancer. *Yasufuku K et al. Chest 2006; 130:710-718*

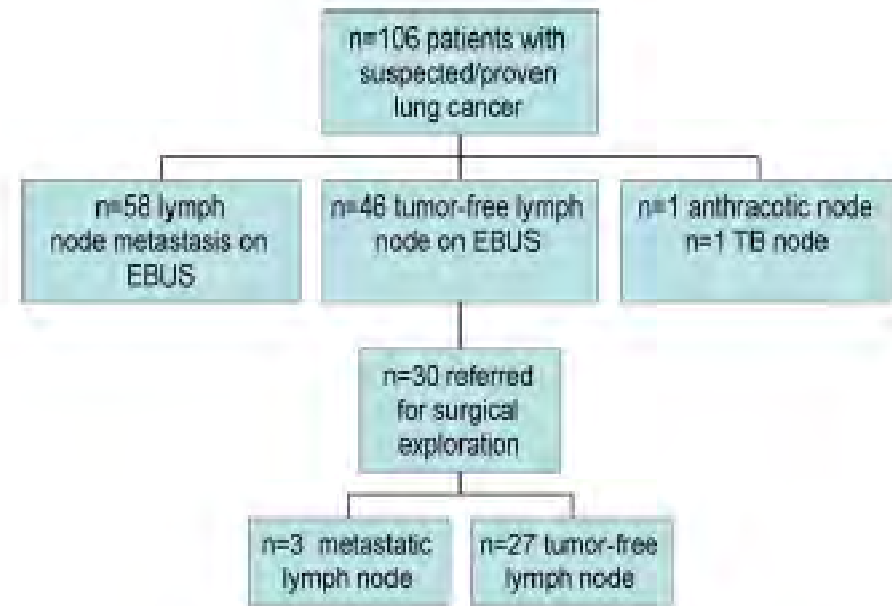
- Combined PET and EBUS

- EBUS TBNA of PET positive lymph nodes

- Sensitivity 95%

- Accuracy 97%

- NPV 91%



- Surgical procedures were avoided in 56% of the patients

- Endobronchial ultrasound and value of PET for prediction of pathological results of mediastinal hot spots in lung cancer patients. Bauwens et al. *Lung Cancer* (2008) 61, 356—361

- ***Integrated PET-CT***

- 117 patients
- PET-CT followed by EBUS TBNA

Diagnostic Values of Integrated PET/CT Scanning and EBUS-TBNA in the Detection of Mediastinal Metastases

Patient Groups and Procedures	Sensitivity, %	Specificity, %	PPV, %	NPV, %	Accuracy, %
Total (n = 117)					
PET/CT scan	70.0	59.8	37.5	85.2	62.4
EBUS-TBNA	90.0	100	100	96.7	97.4
p Value	0.052	< 0.001	< 0.001	0.011	< 0.001
Adenocarcinoma (n = 55)					
PET/CT scan	70.0	60.0	50.0	77.8	63.6
EBUS-TBNA	90.0	100	100	94.6	96.4
p Value	0.114	< 0.001	< 0.001	0.044	< 0.001
Squamous cell carcinoma (n = 53)					
PET/CT scan	85.7	56.5	23.1	96.3	60.4
EBUS-TBNA	85.7	100	100	97.9	98.1
p Value	1.0	< 0.001	< 0.001	0.689	< 0.001

Application of Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration Following Integrated PET/CT in Mediastinal Staging of Potentially Operable Non-small Cell Lung Cancer. Hwangbo et al. *CHEST* 2009; 135:1280–1287

- ***Mediastinoscopy***

- Gold standard for staging
- Lymph node stations 2 – 4 and 7 are accessible; stations 5 and 6 are also accessible via a separate port

- Sensitivity of 80%
- False negative rate of 10%
- Specificity of 100%
- False positive rate of 0%

- Invasive Mediastinal Staging of Lung Cancer. ACCP Evidence-Based Clinical Practice Guidelines (2nd Edition). Detterbach et al. *Chest* 2007; 132:202S–220S

- General anaesthesia and hospitalization
- Invasive
- Does not target all the lymph node groups
- Morbidity and mortality rate of 2% and 0.08% respectively

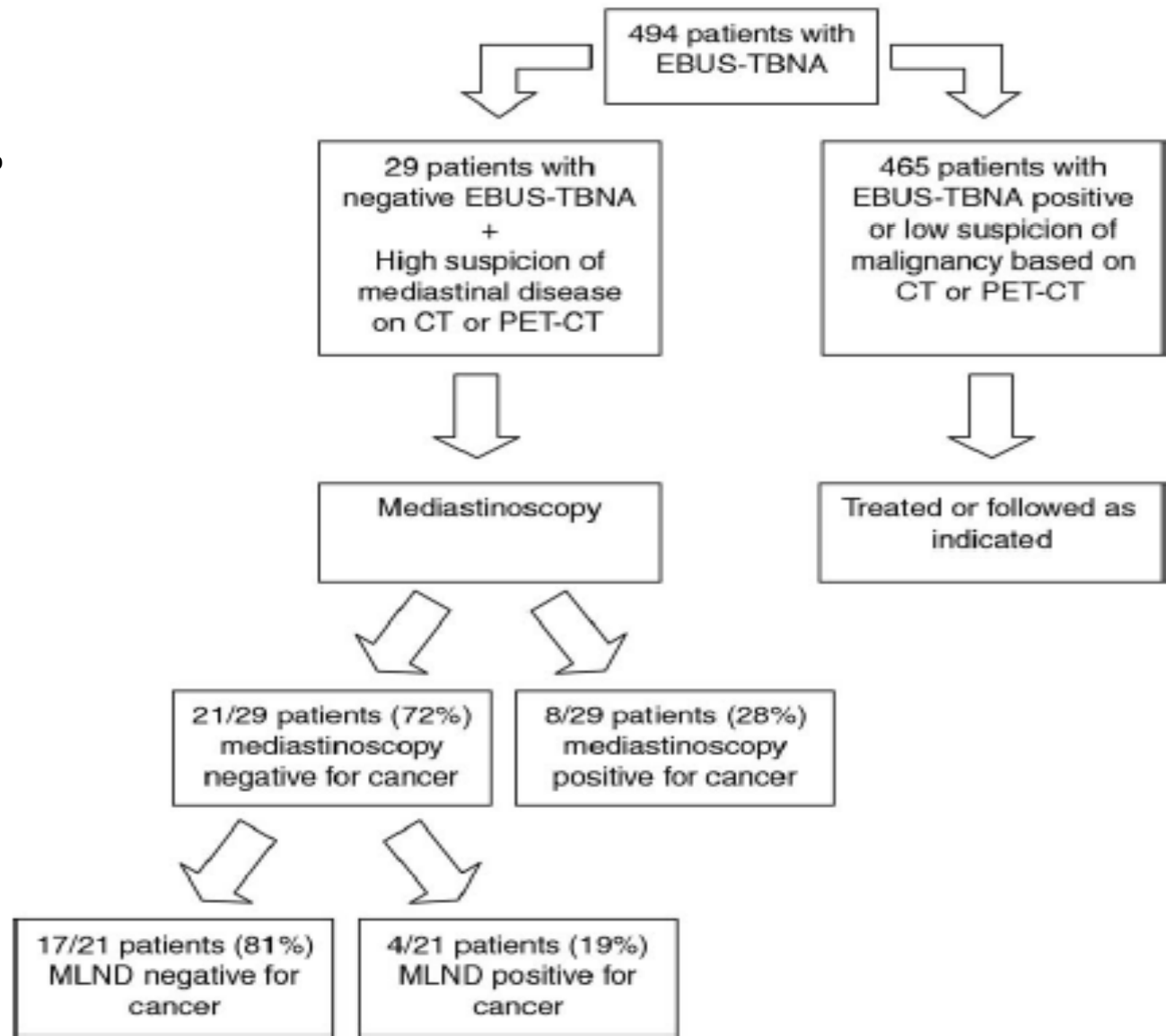
Endobronchial ultrasound versus cervical mediastinoscopy

Study	Number	Design; criteria	Sensitivity		Negative predictive value		Prevalence
			EBUS	Cervical mediastinoscopy	EBUS	Cervical mediastinoscopy	
Ernst <i>et al.</i> [20 ^{••}]	66	Prospective cross-over trial; suspected NSCLC	87%	68%	78%	59%	89%
Yasufuku <i>et al.</i> [21]	33 ^a	Prospective controlled trial; suspected or confirmed NSCLC	76.9%	84.6%	85.9%	90.4%	39.4%

Yasufuku K, Quadri M, dePerrot M, et al. A prospective controlled trial of endobronchial ultrasound guided transbronchial needle aspiration compared to mediastinoscopy for mediastinal lymph node staging of lung cancer. In: Western Thoracic Surgical Association, 33rd Annual Meeting abstract; 2007; Santa Ana Pueblo, New Mexico

- A randomized controlled trial (ASTER trial) is due for publication in 2012
- Will compare mediastinoscopy versus EBUS and Endoscopic ultrasound (EUS) staging of NSCLC
 - <http://www.ncchta.org/project/1603.asp>. Assessment of Surgical sTaging versus Endobronchial and endoscopic ultrasound in lung cancer: a randomised controlled trial (ASTER) 2008–12

NPV of EBUS-TBNA of 72%



Mediastinoscopy in Patients With Lung Cancer and Negative Endobronchial Ultrasound Guided Needle Aspiration. Defranchi et al. *Ann Thorac Surg* 2010;90:1753– 8

- ***Conventional TBNA***

- Sensitivity of 78% (14 - 100%)

- False negative rate of 28% (0 - 66%)

- Specificity 100%

- False positive rates 0%

- Invasive Mediastinal Staging of Lung Cancer. ACCP Evidence-Based Clinical Practice Guidelines (2nd Edition). Detterbach et al. *Chest* 2007; 132:202S–220S

- According to a meta analysis published in 2005 pooled sensitivity and specificity were 39% (95% CI 17 to 61) and 99% (95% CI 96 to 100), respectively

- Accuracy of transbronchial needle aspiration for mediastinal staging of non-small cell lung cancer: a meta-analysis. Holty et al. *Thorax* 2005;60:949–955

- Yield of conventional TBNA versus EBUS TBNA
 - 58% vs 84% in 200 patients
 - Significant in all lymph node stations except the subcarinal node
 - Conventional vs Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration. Herth et al. *Chest* 2004; 125:322–325
 - Another study of 30 patients each
 - Overall diagnostic yield of conventional TBNA was 33.3% vs 66.7% with EBUS-TBNA (p= 0.010)
 - In subcarinal lymph nodes 33.3% vs 62.5%(p= 0.362)
 - In other mediastinal lymph nodes 33.3% vs. 68.2% (p= 0.028)
 - Conventional vs. endobronchial ultrasound guided transbronchial needle aspiration in the diagnosis of mediastinal lymphadenopathies. Arslan et al. *Tüberküloz ve Toraks Dergisi* 2011; 59(2): 153-157

- ***EUS***

- 1L, 2L, 4L, 7, 8, 9

- Can sample subdiaphragmatic disease also

- Sensitivity 84%

- False negative rate was 19% (0 - 61%)

- Specificity 99.5%,

- False positive rate 0.4%

- Invasive Mediastinal Staging of Lung Cancer. ACCP Evidence-Based Clinical Practice Guidelines (2nd Edition). Detterbach et al. *Chest* 2007; 132:202S–220S

- Complementary procedure
- Medical mediastinoscopy
 - EUS + EBUS for staging the mediastinum
 - Accuracy of EUS–FNA + EBUS–TBNA for the diagnosis of mediastinal cancer was 100% (95% CI, 83±100%)
 - Vilmann P et al. EUS–FNA and EBUS–TBNA in Mediastinal Lesions . *Endoscopy* 2005; 37: 833±839
 - Combining both approaches produced successful biopsies in 97% and diagnoses in 94% of patients
 - Herth et al. Transbronchial versus transesophageal ultrasound-guided aspiration of enlarged mediastinal lymph nodes. *Am J Respir Crit Care Med.* 2005;171: 1164–1167

- 138 patients
- Combination of EUS-FNA and EBUS FNA had higher sensitivity (93%) and NPV (97%) compared with either method alone
- Also had higher sensitivity and higher NPV for detecting lymph node in any mediastinal location and for patients without lymph node enlargement on chest CT
 - Minimally Invasive Endoscopic Staging of Suspected Lung Cancer. Wallace et al. *JAMA*, February 6, 2008—Vol 299, No. 5
- Both procedures can be performed in a single setting with the same instrument
 - Combined Endoscopic-Endobronchial Ultrasound-Guided Fine-Needle Aspiration of Mediastinal Lymph Nodes Through a Single Bronchoscope in 150 Patients With Suspected Lung Cancer. Herth et al. *Chest* 2010; 138(4):790–794

- 241 patients
- 118 to surgical staging
- 123 to endosonography followed by surgical staging in 65 if no nodal metastases found
- Sensitivity of 79% vs 85% ($P=.47$) and 94% ($P=.02$)
- Thoracotomy unnecessary in 21 patients (18%) in the mediastinoscopy group vs 9 (7%) in the endosonography group ($P=.02$)
 - Mediastinoscopy vs Endosonography for Mediastinal Nodal Staging of Lung Cancer. Annema et al. *JAMA* 2010;304:2245–52

- ***EBUS TBNA***

- CP EBUS

- All lymph node stations except 5,6, 8 and 9 are accessible

- Rapid on site evaluation (ROSE) and cell blocks increases the diagnostic yield

- Core biopsy specimens can be sent for molecular analysis

- EGFR mutations were detected in 11 out of 43 specimens (25.6%)

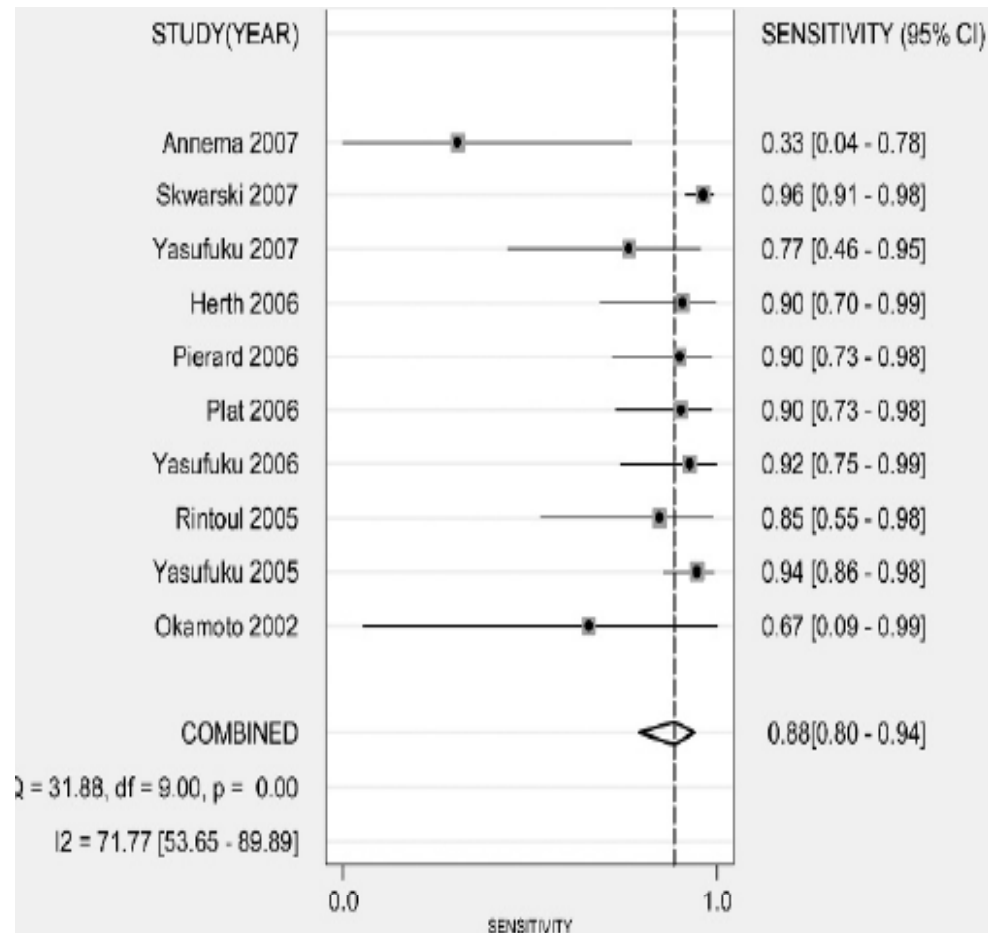
- Assessment of Epidermal Growth Factor Receptor Mutation by Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration. Nakajima et al. *CHEST* 2007; 132:597–602

Diagnostic Yield of EBUS TBNA in Lung Cancer Mediastinal Staging

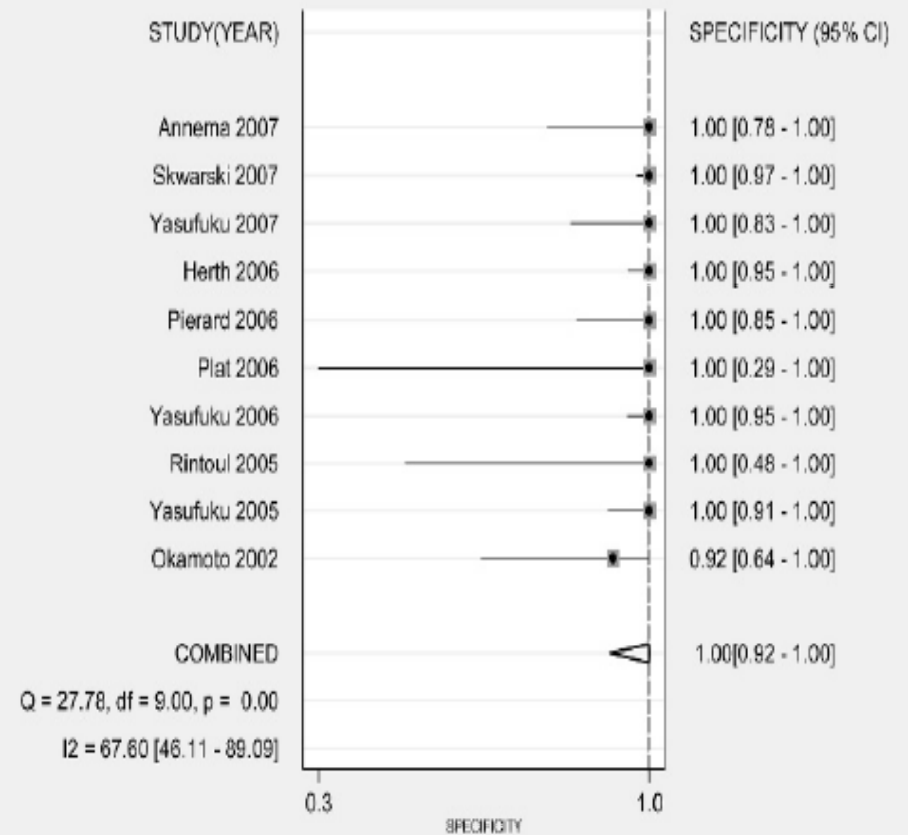
Study	Year	Patients Number	Sensitivity %	Specificity %	Prevalence %	NPV %	Accuracy %
Yasufuku et al	2004	70	95	100	67	n.s.	97
Herth et al	2006	502	94	100	98	11 [†]	94
Herth et al	2006	100	94	100	17	96.3	n.s.
Groth et al	2008	56	93.3	100	30	95	96.7
Vincent et al	2008	152	99.1	100	62.8	97	98.7
Szlubowski et al	2008	226	89	100	60.9	83.5	92.9
Hert et al	2008	97	89	100	10.3	98.9	n.s.
Ernst et al	2008	66	87	100	89	78	91
Summary		1269	92.5	100	54	91	95

Endobronchial Ultrasound in Lung Cancer Staging. Rosell et al. *Clin Pulm Med* 2009;16: 275–280

Forest plot of sensitivity



Forest plot of specificity



Test performance of endobronchial ultrasound and transbronchial needle aspiration biopsy for mediastinal staging in patients with lung cancer: systematic review and meta-analysis. Adams et al. *Thorax* 2009;64:757–762

Author	Year	No. of patients	Age (Average)	Study design	Patients enrollment	Patients selection	Confirmation of EBUS-TBNA positive results	Stations examined by EBUS-TBNA	Sensitivity (%)	Specificity (%)	Prevalence ^c (%)
Krasnik ²⁰	2003	11	58	Retrospective	ND ^f	Selected ^a	-	1,2,4,7,10	100.0	100.0	90.9
Rintoul ²¹	2005	18	65	Prospective	ND ^f	Selected ^a	-	2,3,4,7,10,11	84.6	100.0	72.2
Vilmann ²²	2005	28	61	Prospective	ND ^f	Unselected ^b	-	1,2,4,5,7,10,11	85.0	100.0	71.4
Yasufuku ²³	2005	108	65	Prospective	Consecutive	Selected ^a	-	1,2,4,7,10,11	94.1	100.0	63.0
Herth ²⁴	2006	502	59	Prospective	Consecutive	Selected ^a	-	2,3,4,7,10,11	94.0	100.0	99.2
Vincent ²⁵	2008	146	60	Retrospective	Consecutive	Selected ^a	-	2,3,4,7,10,11	99.1	100.0	78.1
Wallace ²⁶	2008	138	69	Prospective	Consecutive	Unselected ^b	-	1,2,3,4,5,6,7	69.0	100.0	30.4
Herth ²⁷	2008	97	52	Prospective	Consecutive	Unselected ^b	Surgery	2,4,7,10,11	88.9	100.0	9.3
Lee ²⁸	2008	95	64	ND ^f	ND ^f	Selected ^a	-	2,4,7	93.8	100.0	33.7
Bauwens ²⁹	2008	90	64	Prospective	ND ^f	Selected ^a	-	2,4,7,10,11	95.1	100.0	67.8
Ernst ³⁰	2008	66	60	Prospective	Consecutive	Selected ^a	Mediastinoscopy and surgery	2,4,7	88.1	100.0	89.4

ND = not document.

	No. of patients	Pooled sensitivity (95% CI)	Pooled specificity (95% CI)	AUC	Likelihood ratio I ² (%)	χ ² test (p value)
Total ^f	1299	0.93 (0.91-0.94)	1.00 (0.99-1.00)	0.9796	74.40	39.03 (0.00)
Selected patients ^b	1036	0.94 (0.93-0.96) ^a	-	0.9834	48.90	13.71 (0.06)
Unselected patient ^c	263	0.76 (0.65-0.85) ^a	-	0.9436	33.40	3 (0.22)
No on-site cytopathology	1045	0.92 (0.89-0.94)	-	0.9606	70.50	27.09 (0.00)
On-site cytopathology	254	0.97 (0.94-0.99)	-	0.9969	74.50	3.92 (0.04)

Endobronchial ultrasound-guided transbronchial needle aspiration for staging of lung cancer: A systematic review and meta-analysis. Gu et al. *Eur J Cancer* 45(2009)1389-1396

Diagnostic utility of mediastinal staging investigations

Technique	Sensitivity (%)	Negative predictive value (%)	Prevalence (%) (range)
Cervical mediastinoscopy	78–81	91	39 (15–71)
Conventional TBNA	76–78	71–72	75 (30–100)
EBUS-TBNA	90	76	68 (17–98)
EUS-FNA	84–88	77–81	61 (33–85)

Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA): Applications in chest disease. Medford et al. *Respirology* (2010) 15, 71–79

Pooled sensitivities of MS, TBNA, EUS TBNA and EBUS TBNA in studies with a prevalence of mediastinal metastases below 40%

	Sensitivity	Pooled prevalence of mediastinal metastases
MS	76%	31%
TBNA	39%	34%
EUS-FNA	67%	36%
EBUS-FNA	81%	32%

Endoscopic mediastinal staging of lung cancer. Khoo KL, Ho KU. *Respiratory Medicine* (2011), 105, 515-518

Advantages and disadvantages of EBUS-TBNA compared with conventional TBNA and mediastinoscopy

Advantages over conventional TBNA	Advantages over mediastinoscopy	Disadvantages
Direct visualization of node	Minimally invasive	Inferior negative predictive value to mediastinoscopy
Superior sensitivity	Day case, no general anaesthesia	Less core tissue: relevant in benign disease, lymphoma?
Access to more nodal stations (2, 3, 10–12, see Fig. 1)	Access to hilar nodes (also stations 5, 6 and 8, 9 if use EUS-FNA too, see Fig. 1)	Training and learning curve
Real-time sampling	Cost saving: not in theatre, out patient	High initial capital costs
Less risk of major vessel puncture	Time: shorter procedure time than mediastinoscopy	Two operator procedures: physician time factors

Endobronchial ultrasound-guided transbronchial needleaspiration (EBUS-TBNA): Applications in chest disease. Medford et al. *Respirology* (2010) 15, 71–79

Lung CA Staging: overview

- ACCP Invasive mediastinal staging
 - Extensive mediastinal infiltration
 - Invasive staging not needed
 - Discrete mediastinal lymph node enlargement
 - Staging by CT or PET not sufficient
 - Invasive staging required
 - Normal sized lymph nodes → mediastinoscopy
 - Clinical N1 (Stage II) or central tumor
 - Mediastinoscopy
 - EBUS is an accepted alternative

Lung CA Staging: overview

- PET positive lymphadenopathy in Stage I
 - Invasive staging is required
 - EBUS alternative
- Overall
 - EBUS-TBNA is reasonable as long as nondiagnostic results are followed by Mediastinoscopy
 - Mediastinoscopy is still the Gold Standard

- Other uses

1. Restaging the mediastinum after neoadjuvant chemotherapy

- Current clinical applications of endobronchial ultrasound . Yasufuku K. *Expert Rev. Resp. Med.* 4(4), 2010

2. Biopsy peripheral pulmonary lesions

- The yield for RP EBUS was 76% as compared to 52% for bronchoscopy under fluoroscopic guidance
 - Diagnostic Value of Endobronchial Ultrasonography With a Guide Sheath for Peripheral Pulmonary Lesions Without X-Ray Fluoroscopy. Yoshikawa et al. *Chest* 2007; 131:1788–1793
- Useful for fluoroscopically invisible nodules also.
 - Ultrasound-guided transbronchial biopsy of solitary pulmonary nodules less than 20 mm. Eberhardt et al. *Eur Respir J* 2009; 34: 1284–1287

- A meta analysis of 16 studies with 1,420 patients found that EBUS had
 - specificity of 1.00 (95% CI 0.99–1.00)
 - sensitivity of 0.73 (95% CI 0.70–0.76)
 - positive likelihood ratio of 26.84 (12.60–57.20)
 - negative likelihood ratio of 0.28 (0.23–0.36)
 - Radial probe endobronchial ultrasound for the diagnosis of peripheral lung cancer: systematic review and meta-analysis. Steinfurt et al. *Eur Respir J* 2011; 37: 902–910

- RP EBUS was also superior to CT guided transthoracic needle aspiration and much safer

3. Therapeutic uses

- RP EBUS → to assess the depth of tumor invasion into the airway wall
 - Photodynamic therapy(PDT) can be used only if the tumor has not penetrated the cartilage layer
 - RP EBUS was used to target PDT in 9 of 18 patients with NSCLC with no recurrences
 - Tanaka F, Muro K, Yamasaki S, et al. Evaluation of tracheobronchial wall invasion using transbronchial ultrasonography. *Eur J Cardiothorac Surg.* 2000;17:570–574
- RP EBUS → to assess the length of stenoses and presence of adjoining vascular structures prior to stent placement

Mediastinal masses of unknown etiology

Disease Classification	Patients (n)	EBUS-TBNA	
		Final Diagnosis (%)	Alters Therapy
All patients	140	93.6	112 (80.0%)
Malignant mediastinal	40	87.5	29 (72.5%)
Benign mediastinal	100	96.0	83 (83.0%)

Utility of Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration in the diagnosis of Mediastinal Masses of Unknown Etiology. Yasufuku et al. *Ann Thorac Surg* 2011;91:831– 6

- **Lymphoma**

- Sensitivity of EBUS was 91% in 25 patients

- Kennedy MP, Jimenez CA, Bruzzi JF et al. Endobronchial transbronchial needle aspiration in the diagnosis of lymphoma. *Thorax* 63(4), 360–365 (2008)

- Sensitivity and specificity were 57% (95% CI 37–76) and 100% (95% CI 91–100) respectively in 55 patients

- Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration for the Evaluation of Suspected Lymphoma. Steinfert et al. *J Thorac Oncol.* 2010;5: 804-809

- **Sarcoidosis**

- EBUS-TBNA has a yield of 90–96%
- Superior to conventional bronchoscopic diagnostic modalities
 - Blind TBNA
 - Transbronchial lung biopsy (TBLB)
 - Bronchoalveolar lavage fluid analysis

Author and year	Type of study	Patients included	Reference/comparison test	Diagnostic performance				P	Adequate sample	Safety
				S	Sp	PPV	NPV			
Diagnosis of sarcoidosis										
Wong [27]	Prospective	65 patients with clinical and radiological findings suggestive of sarcoidosis and enlargement of lymph and/or mediastinal nodes (>1 cm)	Positive cytologies taken as final diagnosis In benign results, mediastinoscopy (n=5), thoracoscopy (n=1) and clinical follow-up (n=3)	91.8%	87.5%*	11%*	100%	95.3%	No important complications	
Oki [28]	Prospective	15 patients with clinical and radiological findings suggestive of sarcoidosis and enlargement of lymph and/or mediastinal nodes (>1 cm)	TBNA in all patients	Diagnostic performance of EBUS-TBNA 93% Diagnostic performance of TBNA 94%				93.3%	No complications	
Garwood [29]	Prospective	50 patients with suspicion of sarcoidosis (90% with clinical symptoms and adenopathy on radiographic imaging)	Positive cytologies taken as final diagnosis In benign results, histology samples (obtained by EBUS-TBNA or transbronchial lung biopsy, endobronchial biopsy or in one case supraclavicular lymph node aspiration) or follow-up	88%	100%	100%	12.5%	98%	88%	No complications

Effectiveness and safety of endobronchial ultrasound–transbronchial needle aspiration: a systematic review. Varela-Lema et al. *Eur Respir J* 2009; 33: 1156–1164

- EBUS TBNA followed by conventional bronchoscopic techniques (TBLB and endobronchial biopsy)
 - Sensitivity of EBUS-TBNA for detection of noncaseating granulomas was 85%, compared with a sensitivity of 35% for standard bronchoscopic techniques ($P < 0.001$)
 - The diagnostic yield of combined EBUS-TBNA and bronchoscopy was 93% ($P < 0.0001$)
 - Combination of endobronchial ultrasound-guided transbronchia needle aspiration with standard bronchoscopic techniques for the diagnosis of stage I and stage II pulmonary sarcoidosis. Navani et al. *Respirology* (2011) 16, 467–472

- **Analysis of internal structure of pulmonary lesions & lymph nodes**

- Kurimoto et al developed an EBUS classification system for distinguishing benign from malignant lesions

- Type I : Homogeneous pattern

- Type Ia → with patent vessels and patent bronchioles

- Type Ib → without vessels and bronchioles

- Type II : Hyperechoic dots and linear arcs pattern

- Type IIa → without vessels

- Type IIb → with patent vessels

- Type III : Heterogeneous pattern
 - Type IIIa → with hyperechoic dots and short lines
 - Type IIIb → without hyperechoic dots and short lines
- 92% of type I lesions were benign, while 99% of type II and III lesions were malignant
 - Kurimoto et al. Analysis of the internal structure of peripheral pulmonary lesions using endobronchial ultrasonography. *Chest* 122, 1887–1894 (2002)

- Logistic regression analysis revealed that shape, margin, echogenicity and CNS were independent predictive factors
- 285 of 664 lymph nodes (42.9%) having a metastatic feature in at least one of the four categories were pathologically proven metastatic
- 381 of 397 (96.0% of lymph nodes) were pathologically proven not metastatic when all four categories were determined as benign
 - Fujiwara *et al.* The utility of sonographic features during endobronchial ultrasound-guided transbronchial needle aspiration for lymph node staging in patients with lung cancer – a standard endobronchial ultrasound image classification system. *Chest* 138(3), 641–647 (2010)

Miscellaneous uses

1. Diagnosis and drainage of bronchogenic cysts
 - Drainage of the cyst can be done under real time USG guidance
 - Role of Endobronchial Ultrasound in the Diagnosis of Bronchogenic Cysts. Anantham et al. *Diagnostic and Therapeutic Endoscopy*, 2011

2. Visualization of pulmonary emboli
 - Among 32 patients CT angiography documented 101 PE, of which 97 (96%) were also detected with EBUS
 - Endobronchial Ultrasound for Detecting Central Pulmonary Emboli: A Pilot Study. Aumille et al. *Respiration*, 2009; 77:298-302

3. To assess airway wall in lung transplant recipients

- RP EBUS was used to assess the airway wall in 10 lung transplant recipients
- Relative area of layer two
 - Significantly smaller in patients with graft rejection (p 0.04) compared to patients without rejection
 - Significantly larger in patients with graft infection (p 0.02) compared to patient
 - Endobronchial ultrasonography for the quantitative assessment of bronchial mural structures in lung transplant recipients without graft infection. Irani et al. *Chest* 129(2), 349–355 (2006)

4. Asthma

- A study found that RP EBUS is as good as HRCT thorax for detecting airway remodeling in asthma
 - The Use of Endobronchial Ultrasonography in Assessment of Bronchial Wall Remodeling in Patients With Asthma. Soja et al. *Chest* 2009; 136:797–804

5. Placement of fiducial markers for stereotactic radiosurgery

- Harley et al. Fiducial marker placement using endobronchial ultrasound and navigational bronchoscopy for stereotactic radiosurgery: an alternative strategy. *Ann. Thorac. Surg.* 89, 368–374 (2010).

- **Complications**

- Tolerated as well as standard bronchoscopy with a similar complication risk
- Mortality rate → 0.01- 0.04%
- Major complication rate → 0.08 - 0.3%

- Endobronchial ultrasound-guided transbronchial needleaspiration (EBUS-TBNA): Applications in chest disease. Medford et al. *Respirology* (2010) 15, 71–79

Summary

- EBUS TBNA is safe and effective procedure with high sensitivity and specificity
- May soon replace surgical staging in lung cancer
- Negative results in lung cancer staging need to be confirmed by surgical methods
- Needs to be used within its limitations