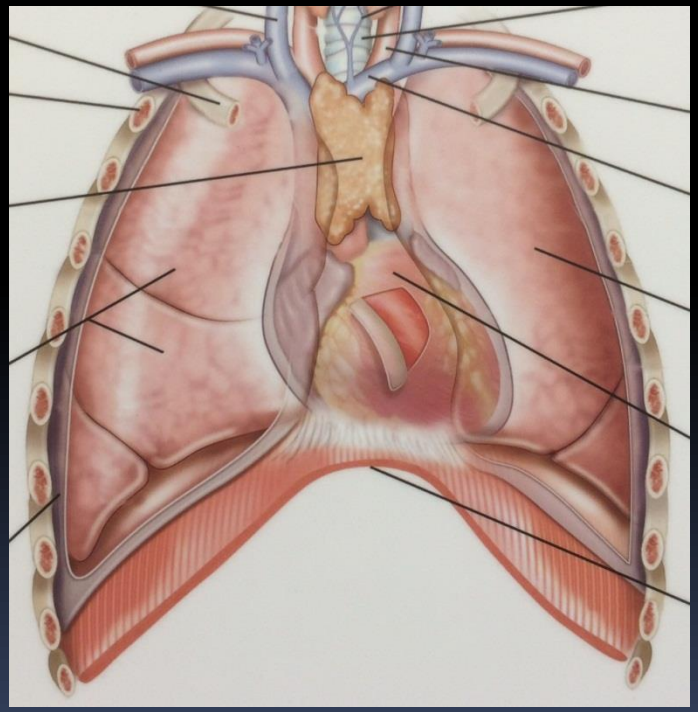
Interventional Pulmonology

From Diagnostic to Therapeutic

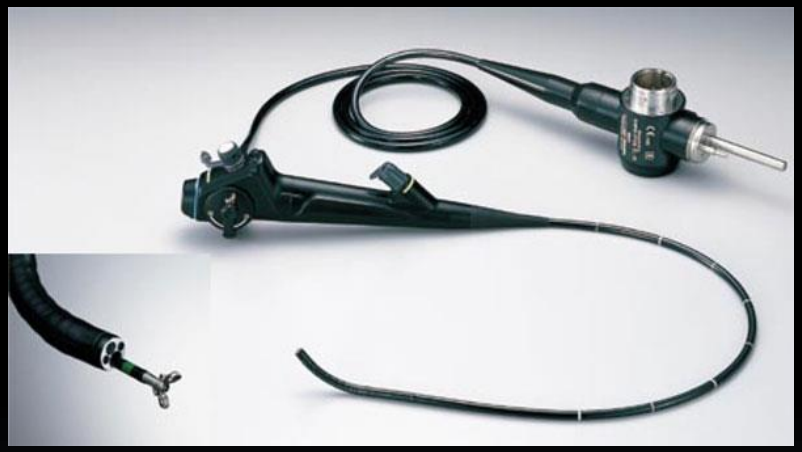
Dr. CHAN Wai Man Johnny
MBBS, MRCP, MSc, MHA, FRCP (Edin, Glasg & Lond), FHKCP, FHKAM(Med)

Consultant and Head of Respiratory Division
Department of Medicine
Queen Elizabeth Hospital

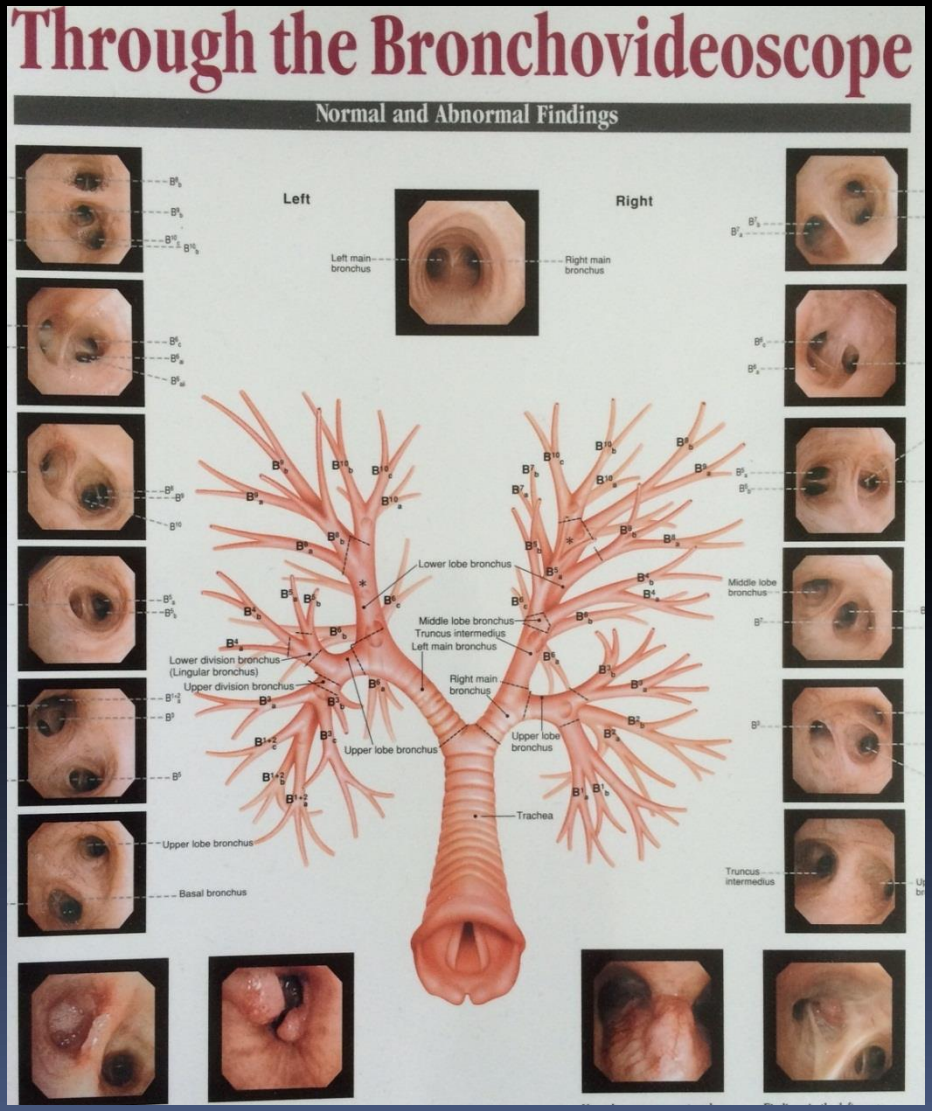
Respiratory Diseases: basic tools



Flexible Bronchoscopy



Mainly diagnostic



“Surgical” interventions

Rigid bronchoscopy:
Airway stents
Laser…etc.

Video-assist thoracoscopy:
Lung resection
Surgical pleurodesis..etc.

General Anaesthesia + Operation Theatre + Rigid instruments

- Diagnosis of pulmonary lesions
  - Peripheral lung lesion
    - Electromagnetic navigation
    - Radial endobronchial ultrasonography
  - Mediastinal adenopathy
    - Linear endobronchial ultrasonography
  - Early detection of lung cancer
    - Autofluorescence bronchoscopy
    - Narrow band imaging
    - Confocal bronchoscopy
- Central airway obstruction
  - Mechanical debulking and dilation
    - Rigid bronchoscopy
    - Balloon bronchoplasty
    - Microdebridement
    - Stent placement
  - Ablation therapies
    - Endobronchial laser
    - Argon plasma coagulation
    - Electrocautery
    - Cryotherapy
    - Brachytherapy
    - Photodynamic therapy
- Artificial airway
  - Percutaneous tracheostomy
  - Minitracheostomy
  - Transtracheal oxygen catheter
- Pleural disease
  - Medical pleuroscopy and pleurodesis
  - Indwelling pleural catheter
  - Thoracic ultrasonography
- Other diseases
  - Asthma
    - Bronchial thermoplasty
  - Emphysema
    - Endobronchial valve

Hsia D and Musani AI
Med Clin N Am (2011)

Rapidly-growing interventional options

- Transbronchial needle aspiration (TBNA) and endobronchial ultrasound-guided (EBUS) TBNA
- Electrocautery/diathermy
- Argon plasma coagulation (APC)
- Laser
- Cryotherapy
- Cryoextraction
- Photodynamic therapy (PDT)
- Brachytherapy
- Tracheobronchial stents
- Electromagnetic navigation bronchoscopy (ENB)
- Endobronchial valves for emphysema
- Bronchial thermoplasty for asthma

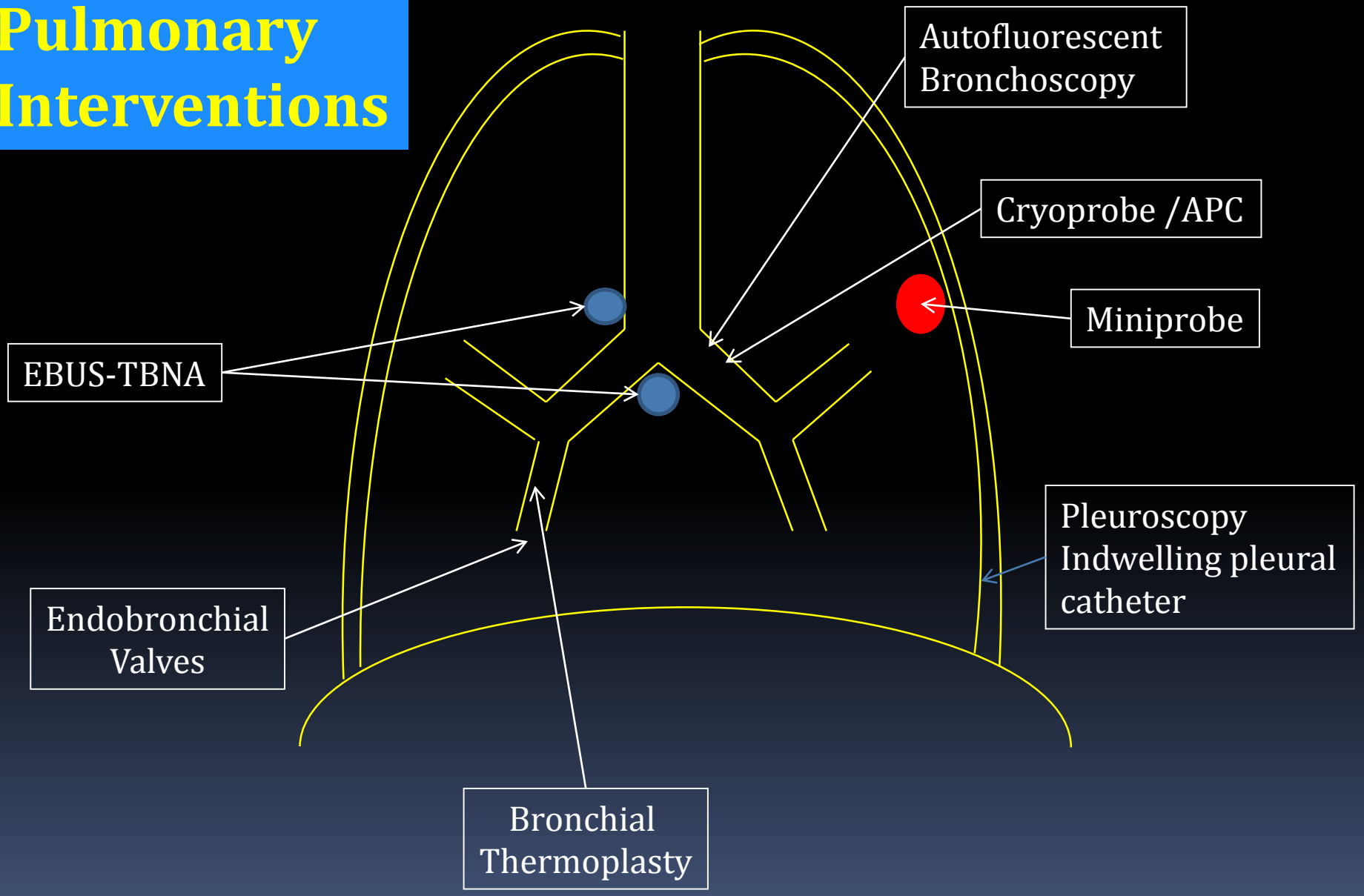
BTS guidelines for Advanced Diagnostic and Therapeutic Flexible Bronchoscopy (2011)

Airway → Pleural space
Diagnostic → Therapeutic

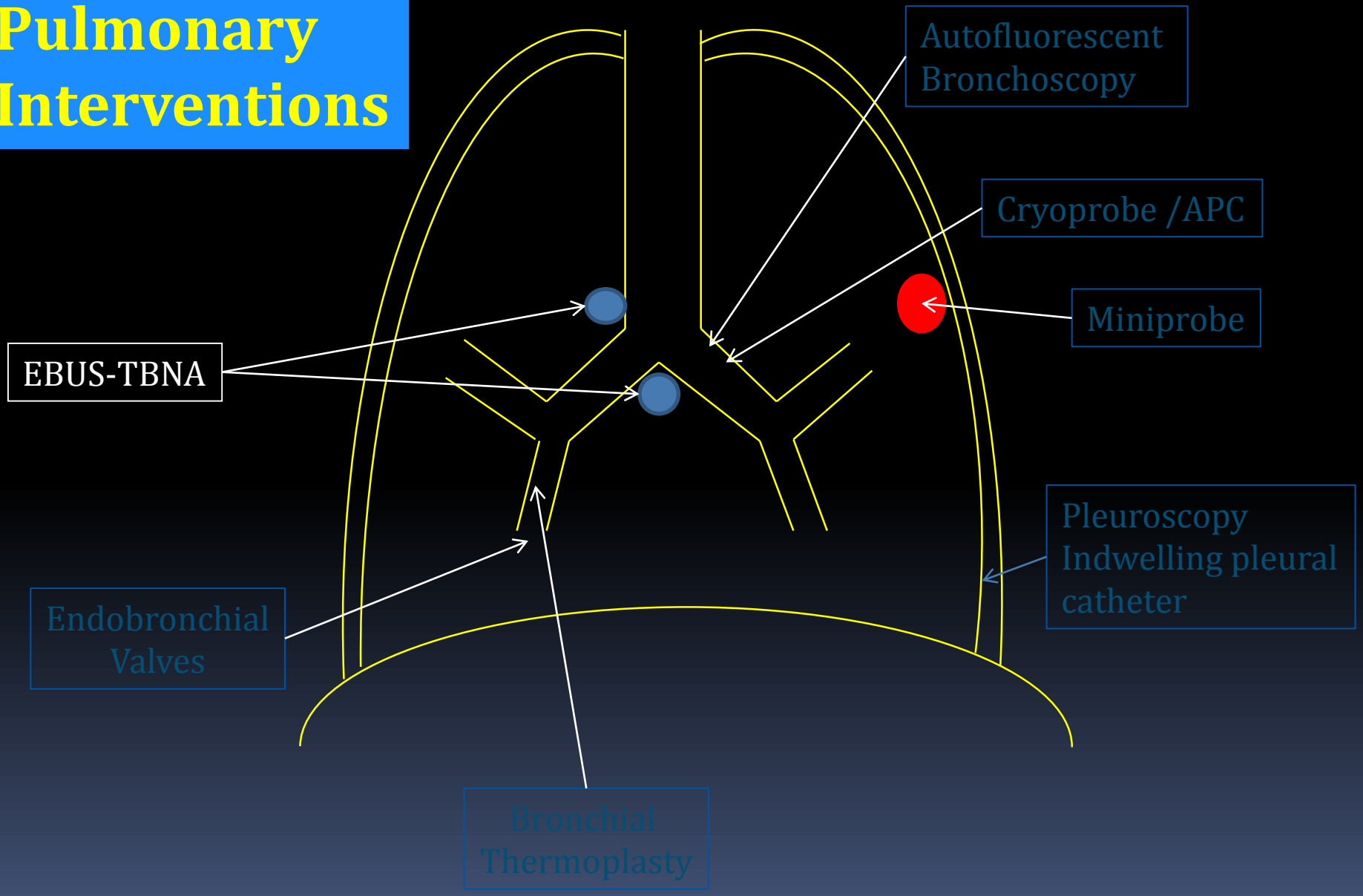
Just “New Toys”?

- Minimally invasive alternative(s)
- Flexible instruments
- Many can be performed as “day procedures”
- Local anaesthesia + conscious sedation
- Endoscopic suites

Pulmonary Interventions

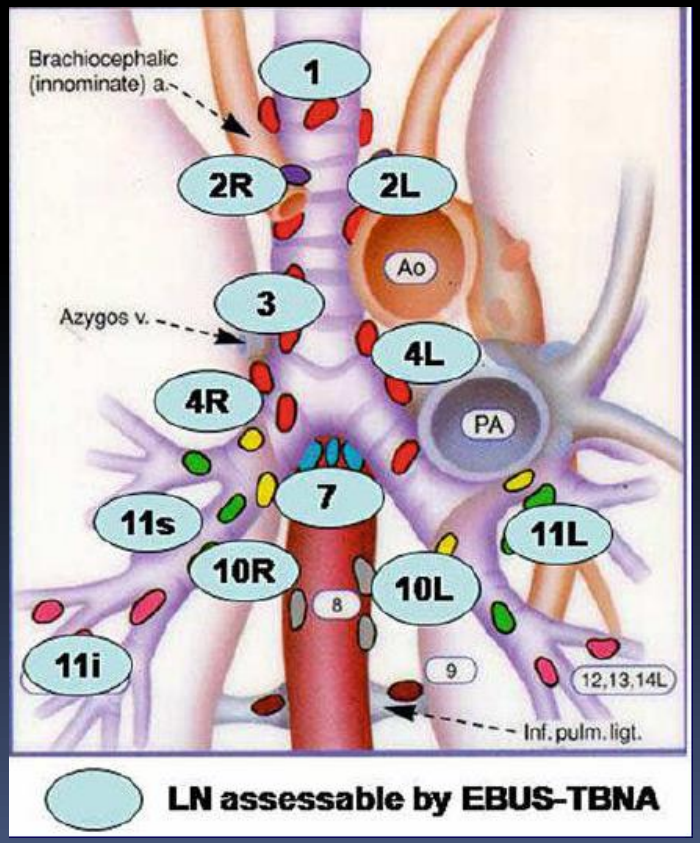


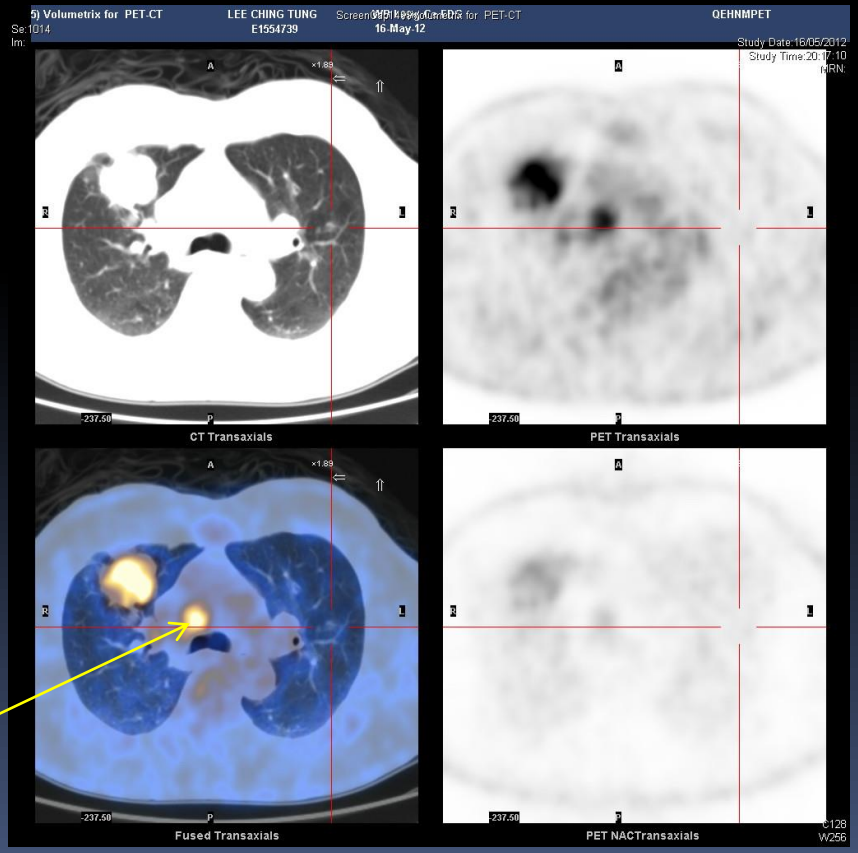
Pulmonary Interventions



Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration

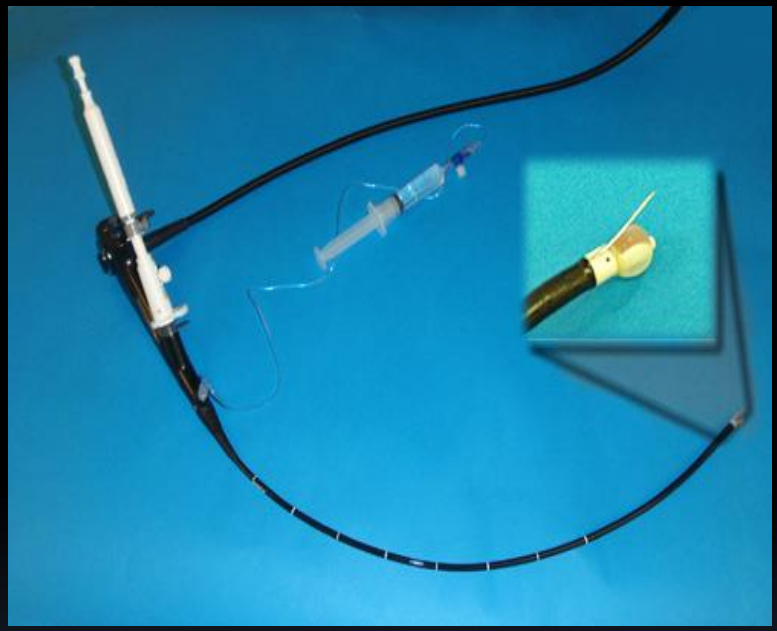
Access beyond airway walls



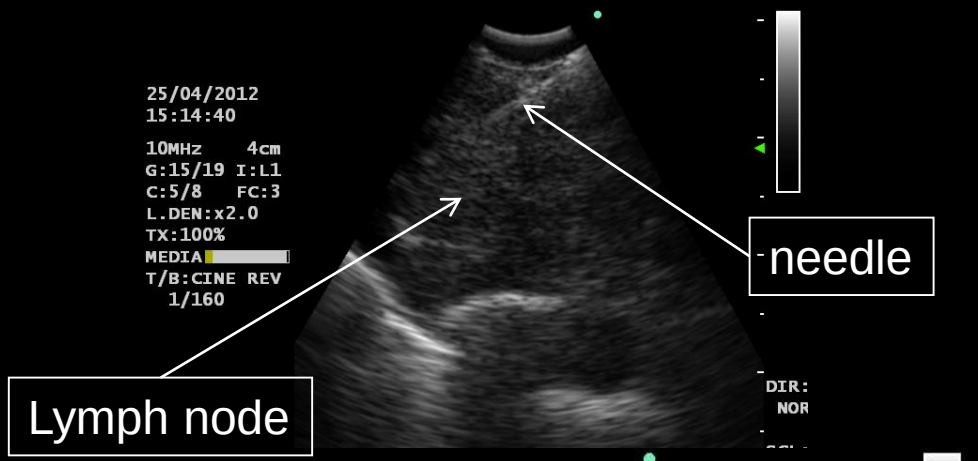


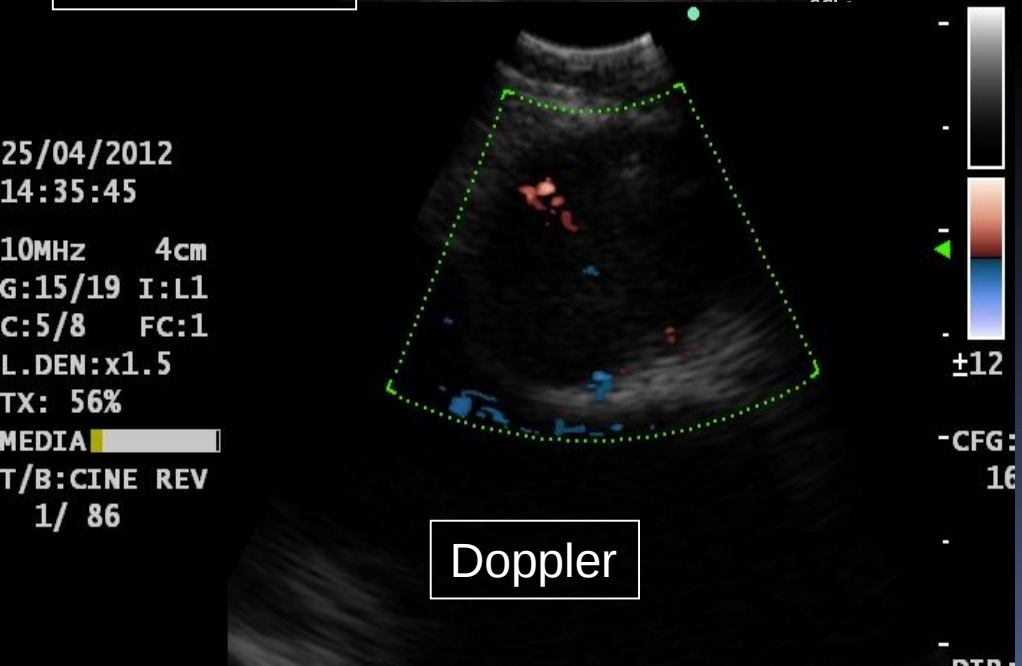
The Equipment

- 6.9mm scope with 2mm instrument channel
- Hybrid: USG/Doppler + video-bronchoscope
- Real-time USG-guided sampling with 22G needle



Simultaneous Dual Display





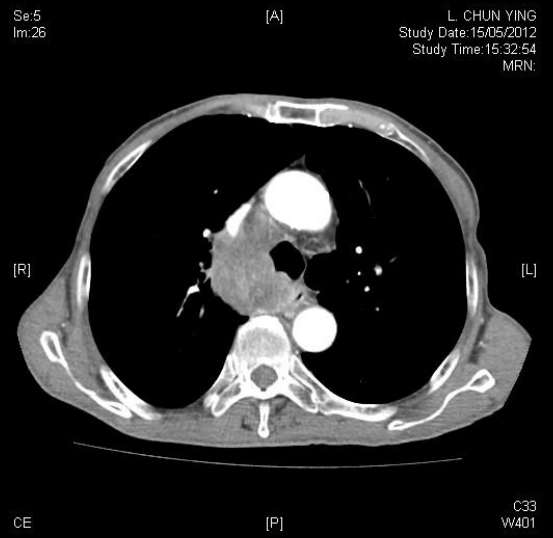
Conscious sedation + LA

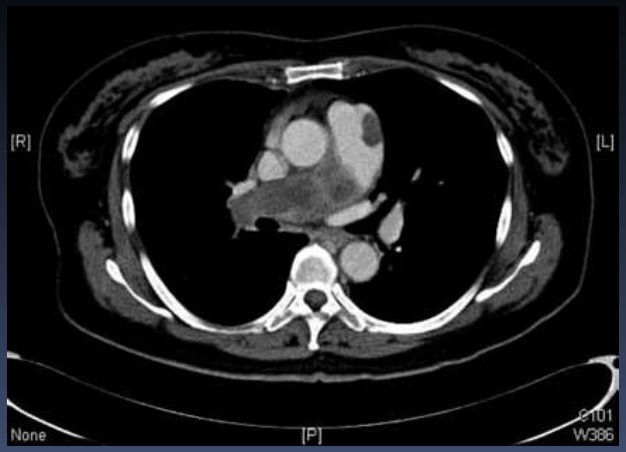
Indications

1. Staging of NSCLC
   - Sampling of mediastinal and hilar lymph nodes (stations: 2-4, 7, 10-12)

2. Diagnosis of mediastinal lesions
   - Lymphoma
   - Sarcoidosis (Wong M et al. ERJ 2013)
   - Tuberculosis

3. Tumours adjacent to the airways (Chan JW et al. Hong Kong Med J 2014)





EBUS: a reliable diagnostic tool

Table 4—*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

*Data are presented as %. When the results of the three modalities were analyzed using χ^2 tests describing the correct prediction of the lymph node status, the outcome was highly significant ($p < 0.00001$).

Yasufuku K et al. CHEST 2006

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)

tEBUS-TBNA, endobronchial ultrasound-guided transbronchial needle aspiration; EUS-FNA, endoscopic ultrasound-guided fine needle aspiration.

Toloza EM, et al. CHEST 2003
Detterbeck FC, et al. CHEST 2007
Medford AR, et al. Respirology 2010

EBUS-TBNA: Evaluations

- Pros
  - Daycase
  - no GA required
  - In endoscopy suite
  - ↓ procedural time
  - Even ↑ diagnostic value if combined with EUS

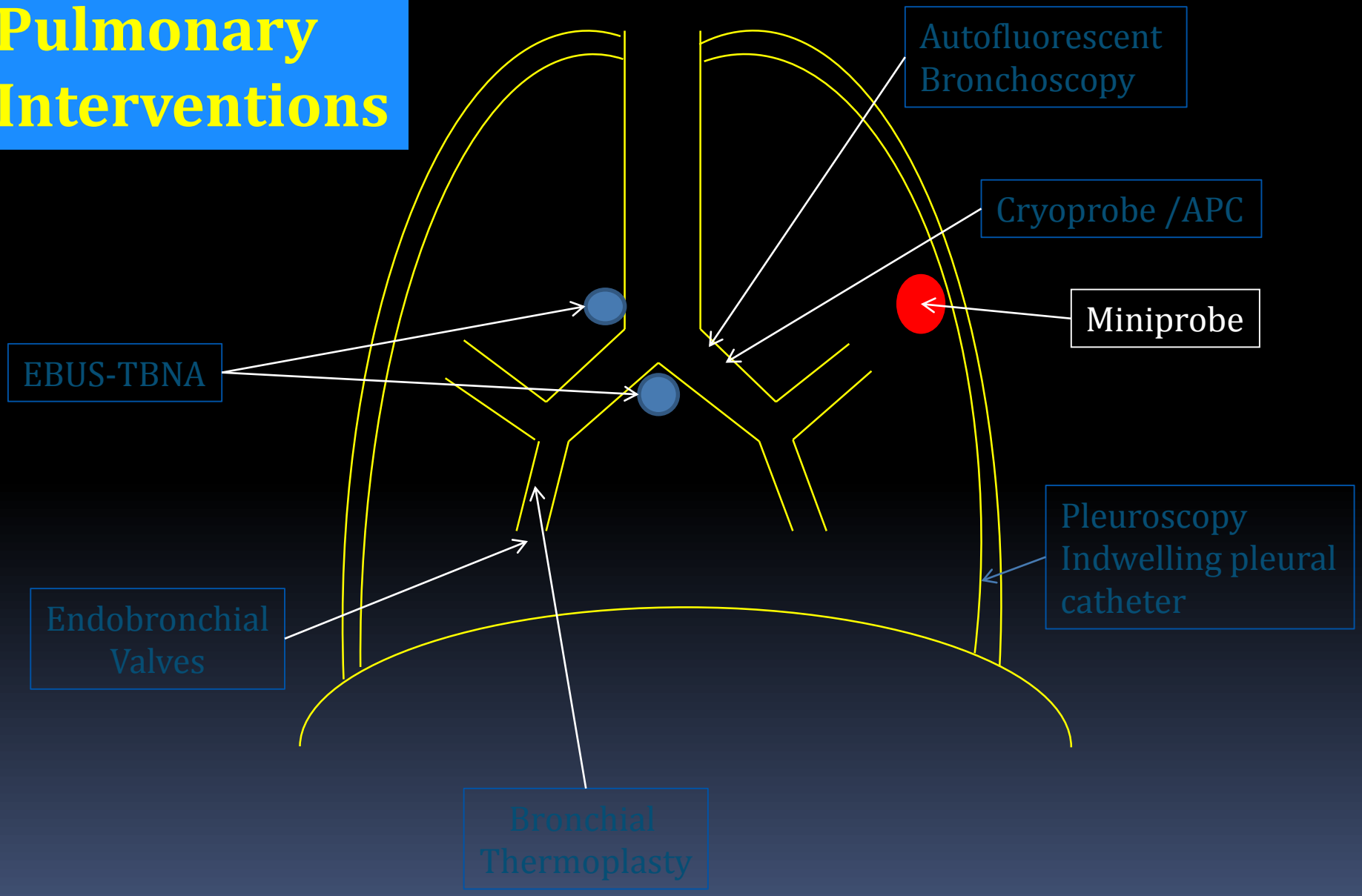
    Rintoul RC et al. ERJ 2005

    Lee YT et al. HKMJ 2010
  - Safe:
    - overall complication rate~1%

      Shah A et al. CHEST 2011

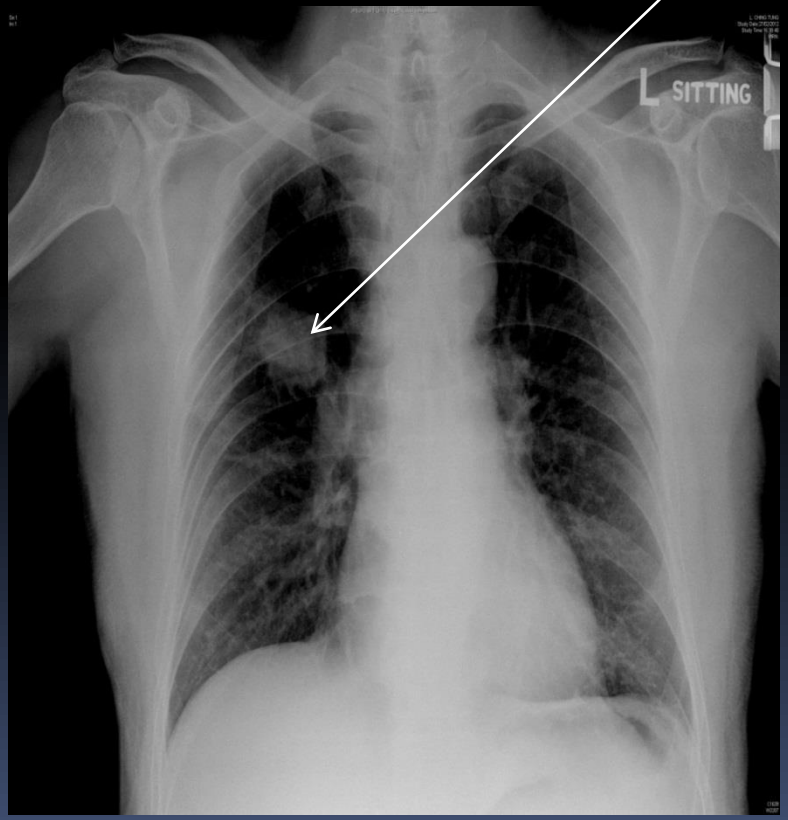
- Cons
  - ↓ Negative predictive value than mediastinoscopy
  - Smaller sample size
  - ↑ initial setup costs

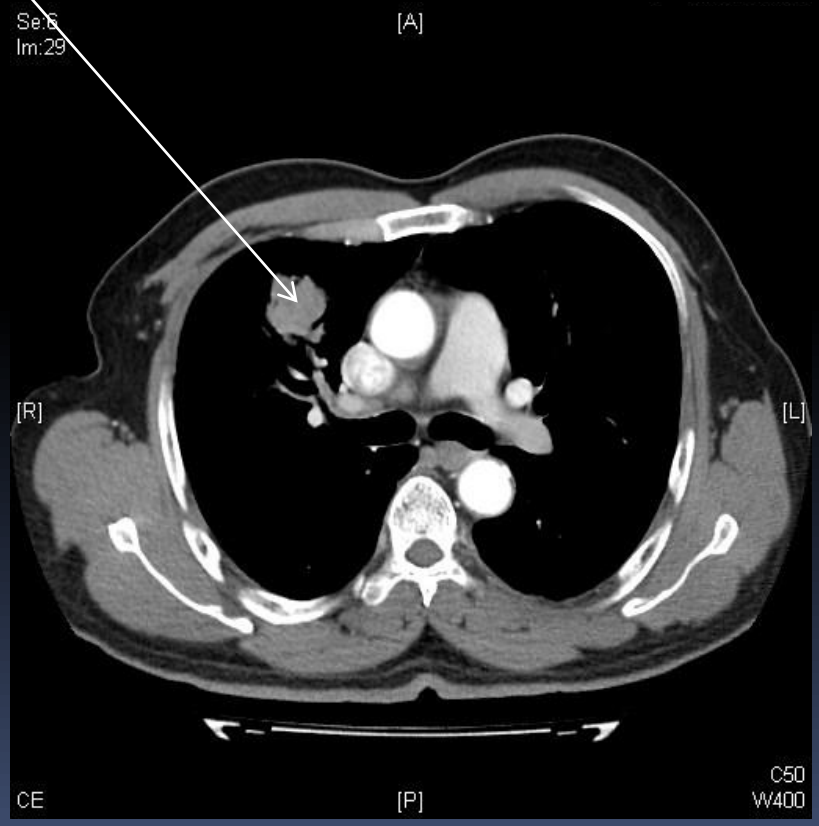
Pulmonary Interventions



Endobronchial USG for peripheral lesions

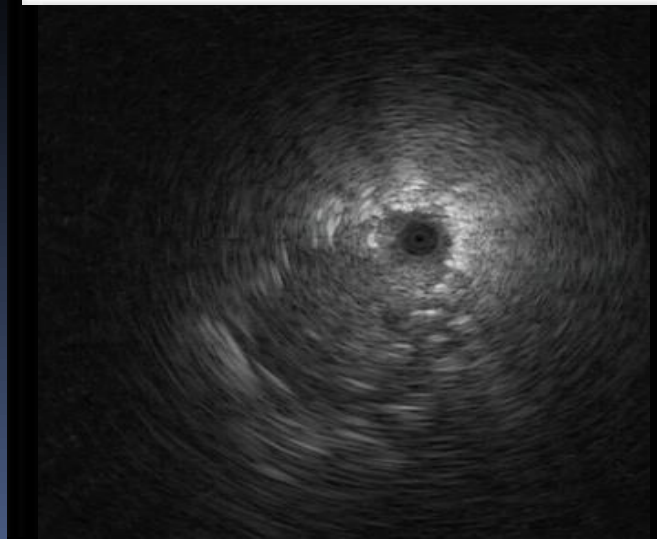
Yield for conventional flexible bronchoscopy only ~ 30%





EBUS radial probe (miniprobe)

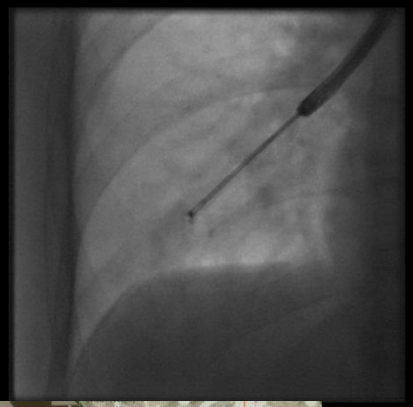
- A small radial USG probe inserted via bronchoscope (+/-) guide sheath
- "Extended working channel" to lesions along or adjacent to small airways
- Enable biopsy, brush, bronchial aspirate, needle aspiration and curette

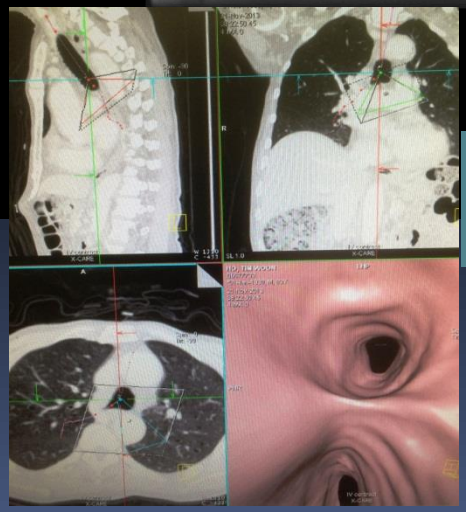


Peripheral lesions: "Additional guides"

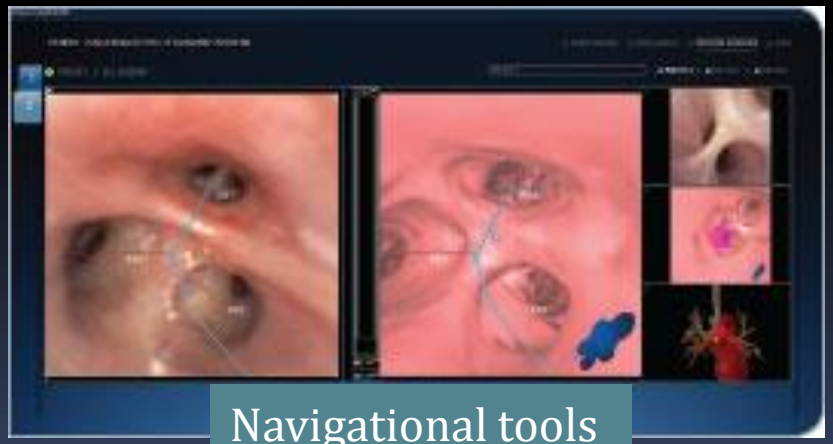
Se:3
Im:300 (F1/1)

Fluoroscopic guidance



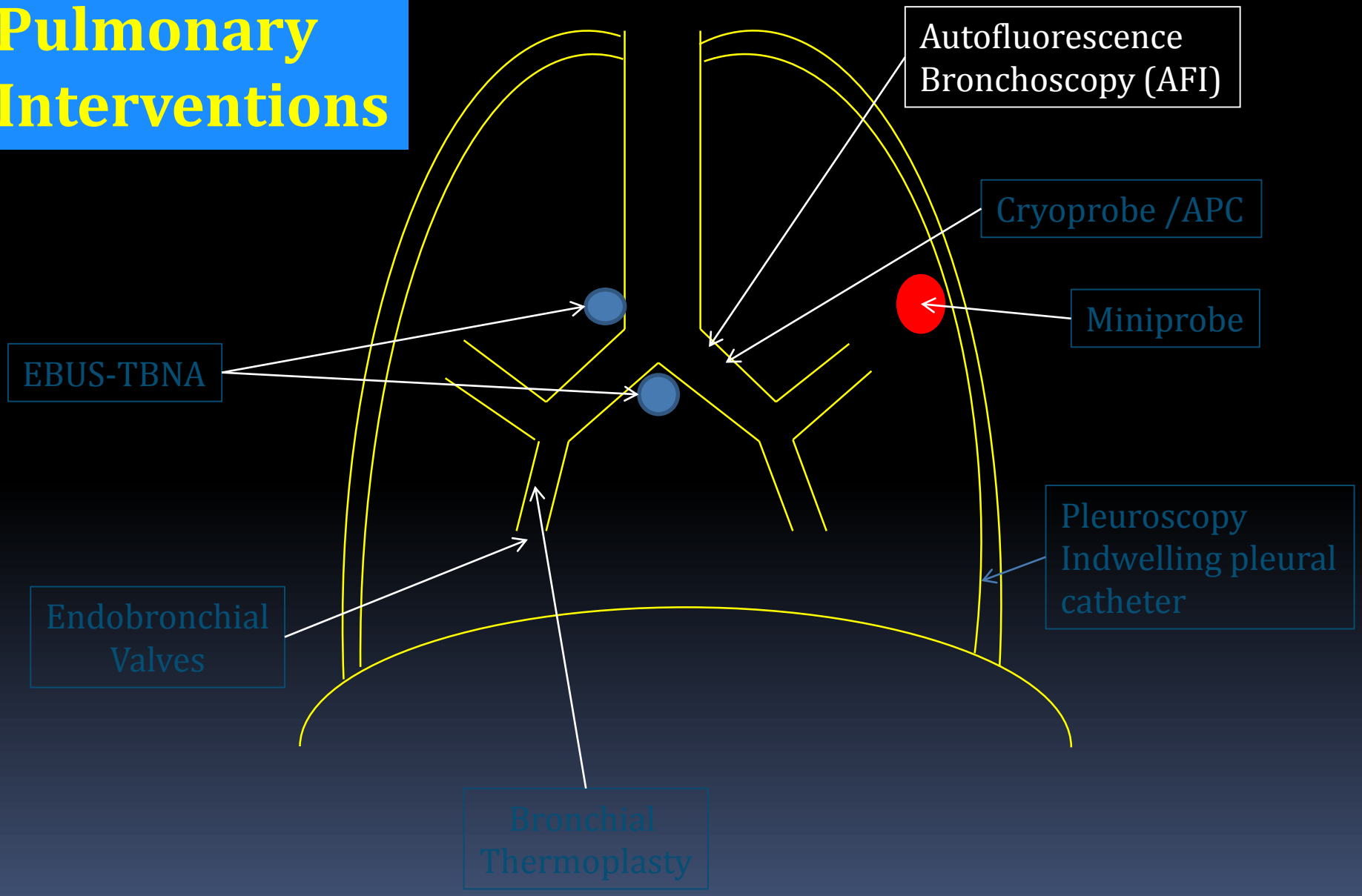


Virtual Bronchoscopy

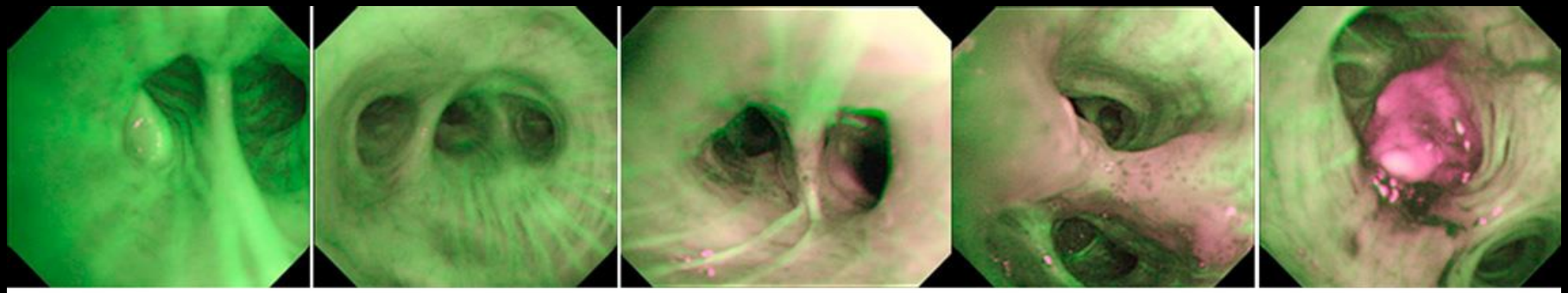


Navigational tools

Pulmonary Interventions



Mechanisms of AFI



Normal Bronchitis Dysplasia C.I.S. Cancer

green magenta

	Display color (Detection Light)	R (G' Reflected light)	G (Auto Fluorescence)	B (G' Reflected light)	
Light intensity	normal				⇨
	Cancer, Dysplasia				⇨
	Bronchitis				⇨

Yasufuku K. Clin Chest Med 2010

Potential indications of AFI

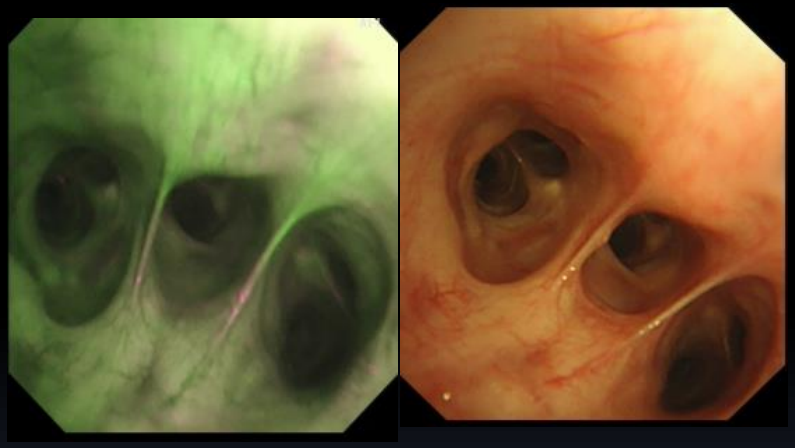
1. Detection of early lung cancer with abnormal sputum cytology
2. Surveillance after curative resection of lung cancer
3. Guidance to endoscopic ablative procedures like Cryotherapy

	WLB	AFB
Sputum atypia group[#]		
Sensitivity	57.1 (20–88)	85.7 (42–99)
Specificity	44.9 (31–60)	26.5 (15–41)
PPV	12.9 (4–31)	14.3 (6–29)
NPV	88.0 (68–99)	93.0 (64–100)
Suspicious sputum cells group[¶]		
Sensitivity	60.0 (17–93)	100 (46–100)
Specificity	58.8 (32–81)	35.3 (15–61)
PPV	30.0 (8–65)	31.3 (12–59)
NPV	83.3 (57–97)	100 (52–100)
Whole group[+]		
Sensitivity	58.3 (29–84)	91.7 (60–100)
Specificity	50.0 (38–62)	26.4 (17–38)
PPV	16.3 (7–31)	17.2 (9–29)
NPV	87.8 (73–95)	95.0 (73–100)

Lam B et al. ERJ 2006

AFI: limitations

- ↓ specificity
- ↓ central tumours
- Varying accuracies with different pre-cancerous lesions
- Addition of Narrow Band Imaging (NBI) might improve the performance

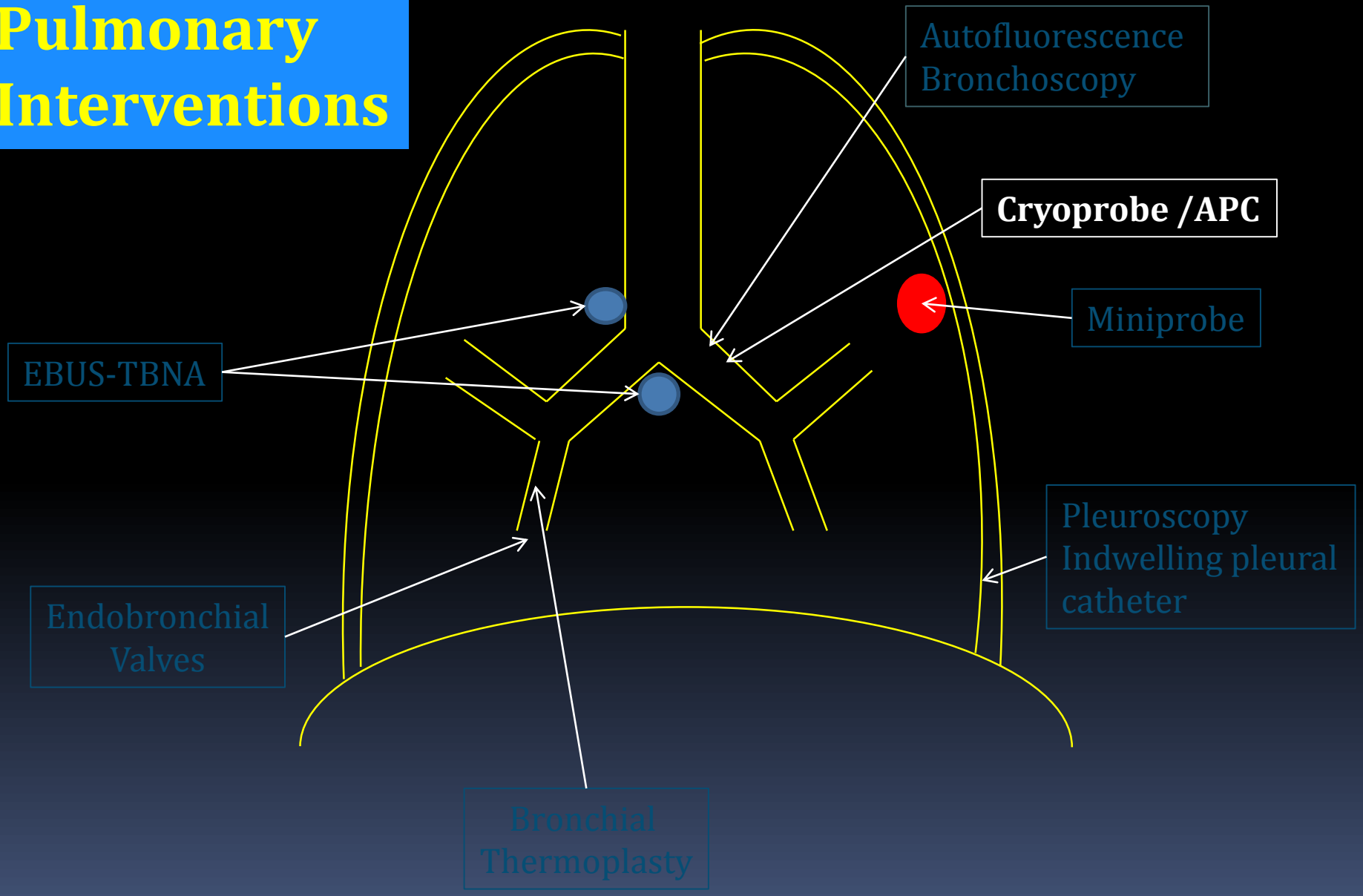


Technique	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
WLB	26.5	63.9	34.4	54.9
AFI	52	79.6	64.4	69.9
NBI	66	84.6	75.4	77.7
AFI+NBI	86.1	86.8	84.4	88

WLB = White light videobronchoscopy, AFI = Autofluorescence imaging videobronchoscopy, NBI = Narrow band imaging videobronchoscopy, PPV = Positive predictive value, NPV = Negative predictive value

Zaric B et al. Ann Thorac Med 2013

Pulmonary Interventions



Mechanism of Cryotherapy

- N_2O vaporizes at the metal tip of the cryoprobe with ↓↓ pressure
- → cooling (Joule- Thomsen) effect (-89°C)
- "Cryo-destruction": freeze/thaw action + vascular damage
- Cartilage is cryo-resistant: ↓↓ bronchial perforation
- "Cryo-adhesive" effect

(CHEST 1996; 110:718-23)

Vergnon JM et al. ERJ 2006

Indications

- Relief of malignant major airway obstruction: de-bulking +/- "cryo-recanalization"

  Schumann C et al. J Thorac Cardiovasc Surg 2010; Asimakopoulos G et al. Chest 2005

- Treatment of early superficial carcinoma or carcinoma-in-situ Deygas N et al. Chest 2001; Vergnon

- Cryo-biopsy: bronchial / transbronchial

  Babiak A et al. Respiration 2009;Franke KJ et al. Lung 2009

- Removal of foreign bodies

Cryotherapy: evaluations

- Safe
- Few adverse effects:
  - cough
  - fever
  - airway oedema
  - Bleeding
- Delayed effects
- Multiple sessions

Argon Plasma Coagulation(APC)

- High-frequency electrical current via ionized argon delivered to target tissue
- Self-limiting depth (≤5mm)
- Flexibility: Direction determined by the shortest distance between the jet and tissue (not direction of applicator)

A: Desication
B: Coagulation
C: Devitalization

Indications

- Haemoptysis Morice RC et al. Chest 2001
- Symptomatic airway obstruction Morice RC et al. Chest 2001
- Others:
  - Benign tumours (e.g. carcinoid) Miller SM et al. J Bronchol Interv Pulmonol 2013
  - Stent overgrowth or ingrowth (malignancy or granulation tissue) Colt HG. J Bronchol 1998
  - Cicatricial stenosis Yasuo M et al. Respirology 2006
- Not much evidence for treatment of early superficial cancer

APC: Potential risks

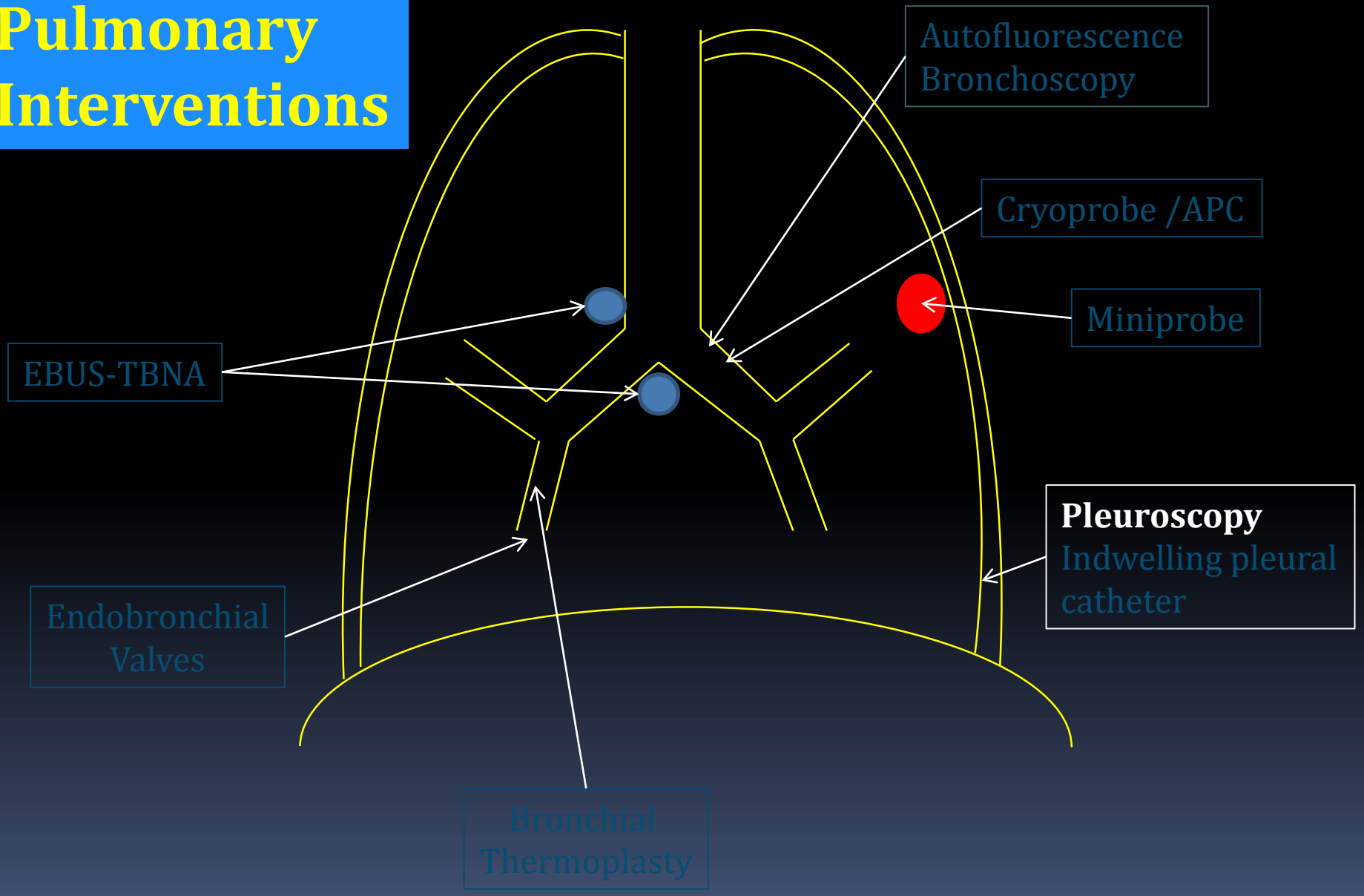
- Uncommon
- Airway wall perforation
  - Leading to mediastinal and subcutaneous emphysema
- Burnt bronchoscopic tips
- Endobronchial burn (airway fires)
- MI, Stroke
- Gas embolism (rare) Goldman Y et al. J Bronchol 2007; Reddy C et al. Chest 2008

Table 2 Advantages and Disadvantages of Bronchoscopic Techniques for Treating Early-Stage Cancer in the Central Airways[6,12-14]

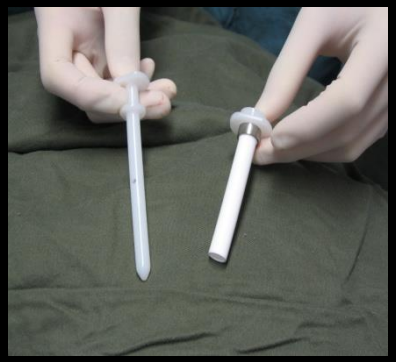
Techniques	Advantages	Disadvantages
Mechanical Removal	• Standard biopsy forceps	• Bleeding may cause less accurate management
Nd-YAG Laser	• Deep necrosis • Immediate result	• Relatively expensive • Skill & expertise needed • "Overkill," fibrosis, and scarring
Electrocautery and Argon Plasma Coagulation	• Simple & inexpensive facility • Immediate visible result • Flexibility (angulation)	• Superficial necrosis • Thermal fibrosis and scarring
Cryotherapy	• Simple & inexpensive facility • Lethal effect (mm) • Safe for cartilage	• Special equipment • Multiple sessions • Unpredictable secondary effect
High-Dose-Rate Brachytherapy	• Simple treatment • Short sessions • "Accurate" dosimetry calculation	• Expensive facility • Normal tissue damage • Multiple treatment sessions • Lack feedback dosimetry for catheter movement during irradiation
Photodynamic Therapy	• Simple treatment • Deep necrosis • Vascular thrombosis • Safe for cartilage	• Relatively expensive, elaborate facility • Complex dosimetry • Late necrosis, cleanup bronchoscopy • Skin photosensitivity (hematoporphyrin)

Sutedja T et al. Clinical Lung Cancer, Vol. 2, No. 4, 264-270, 2001

Pulmonary Interventions



Pleuroscopy (Medical Thoracoscopy): Semi-rigid instrument



- Handing ~ flexible bronchoscope
- 1 port of entry
- flexible trocar

Distal 5 cm: 160° up/130°down
Outer diameter: 7mm
Working channel: 2.8mm

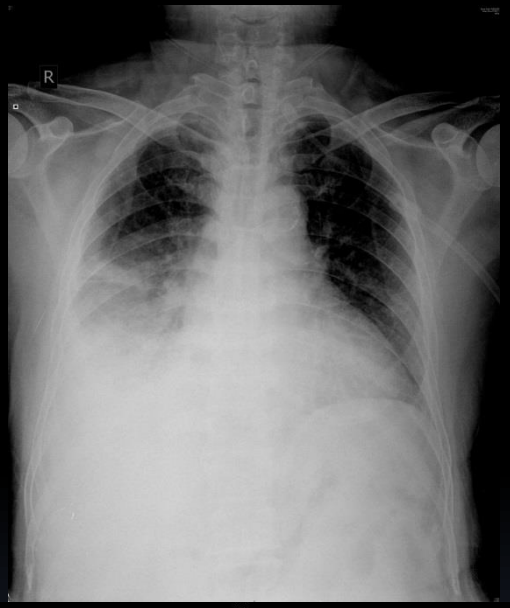
Common Indications

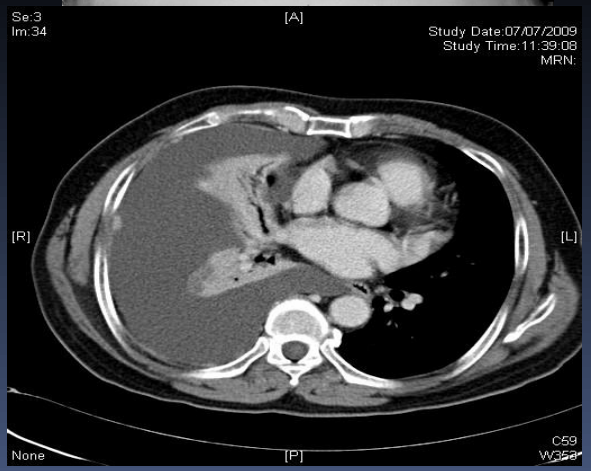
Diagnostic

- Exudative pleural effusions of unknown origin
- Suspected pleural secondaries (staging)

Therapeutic

- Talc pleurodesis for malignant pleural effusion

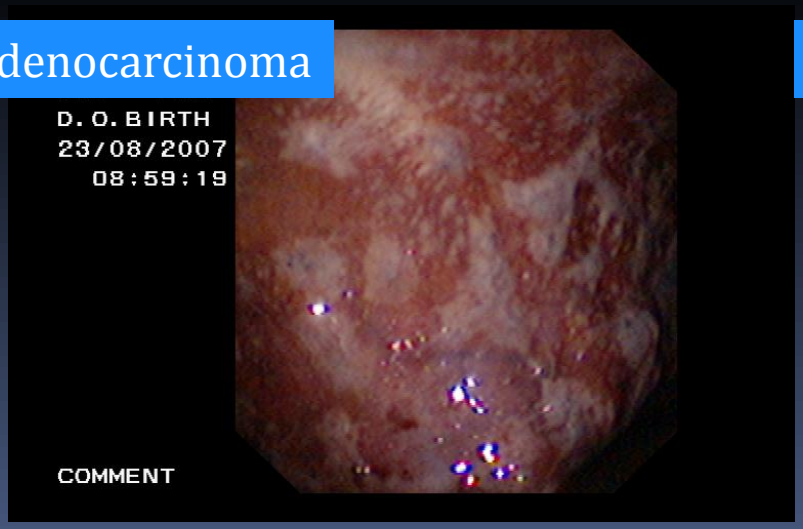




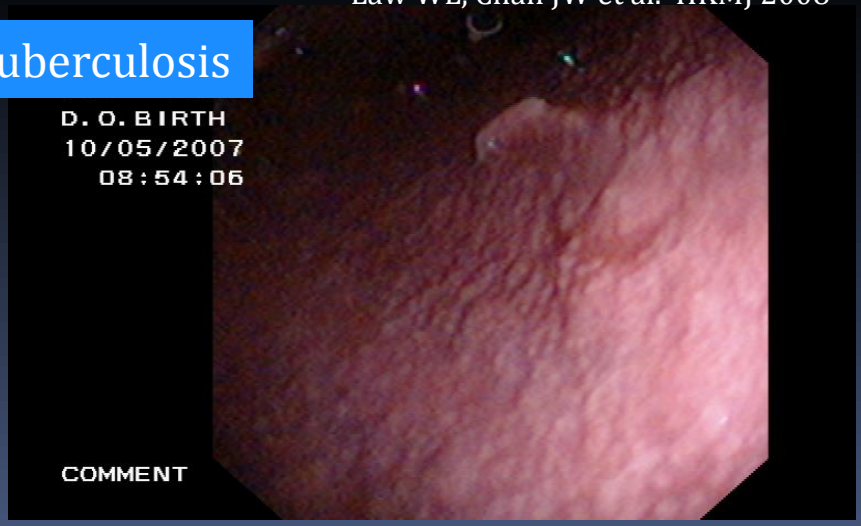
The procedure

Law WL, Chan JW et al. HKMJ 2008

Adenocarcinoma



Tuberculosis



Pleuroscopy: evaluation

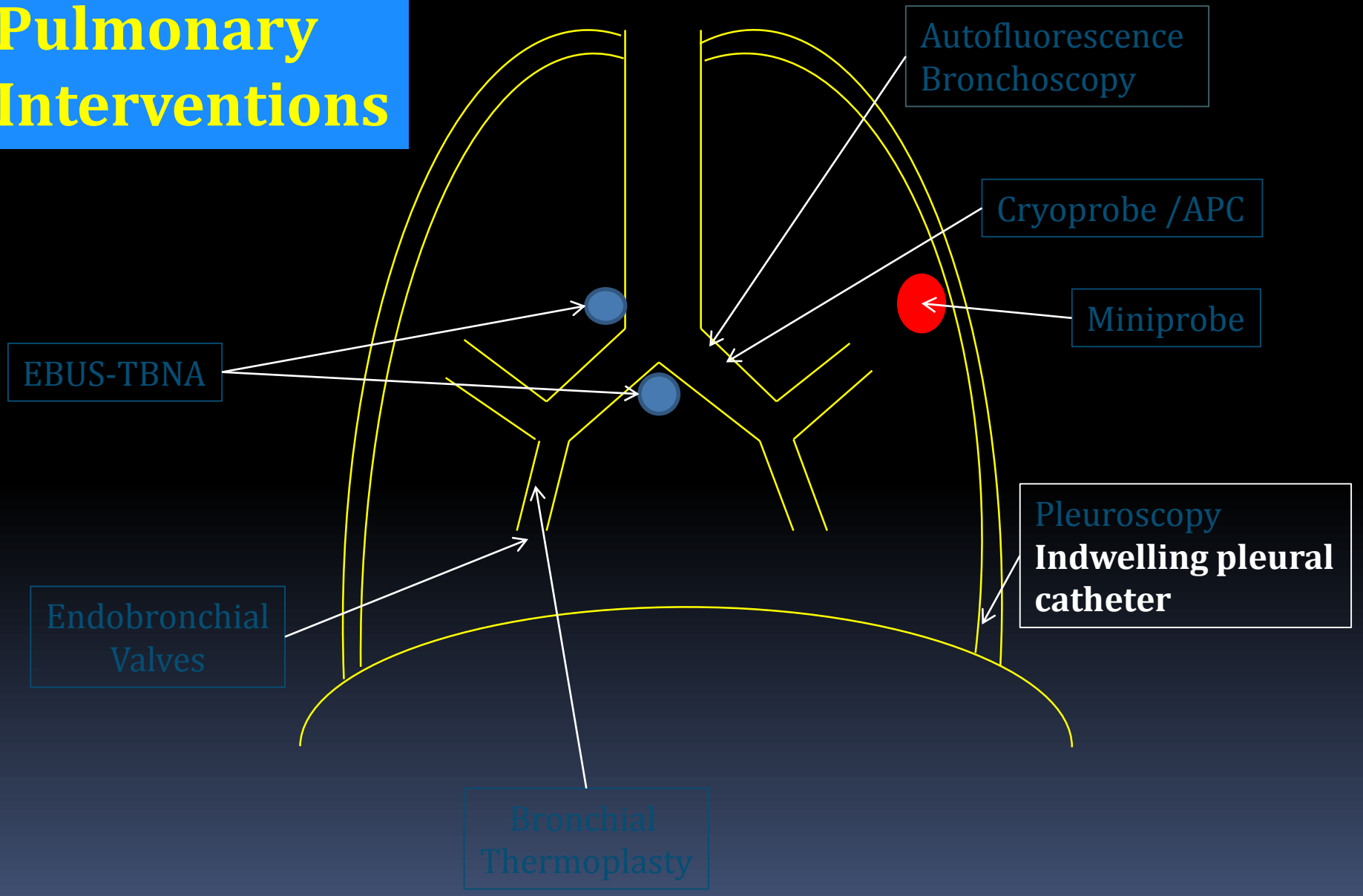
Pros:

- Yield 79-96%
  - rigid ~ semi-rigid
    [Lee et al. 2007; Munavvar et al.2007; Law WL, Chan JW et al. 2008]
  - Superior to pleural biopsy and pleural tapping
    [Harris RJ et al. Chest 1995; Blanc FX et al. Chest 2002]
- Safe
  - Mortality (0.09-0.24%)
  - Complications: mild and self-limiting
  - Commonest: Fever and SC emphysema
    [Law WL, Chan JW et al. HKMJ 2008]

Cons: (semi-rigid pleuroscope)

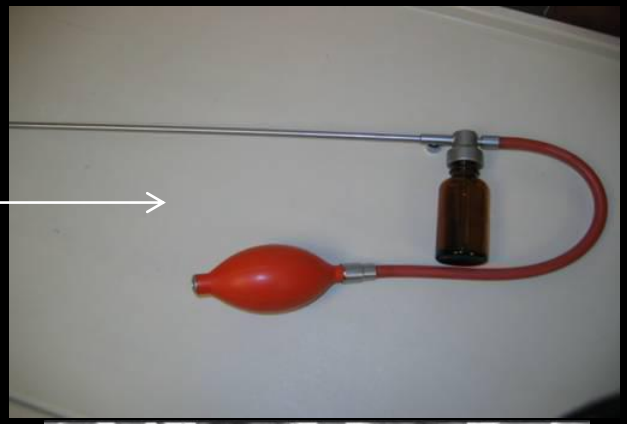
- Possibly ↓ yield with mesothelioma or lymphoma
- Difficulty with dense adhesions or loculations
- ↓ Bleeding control

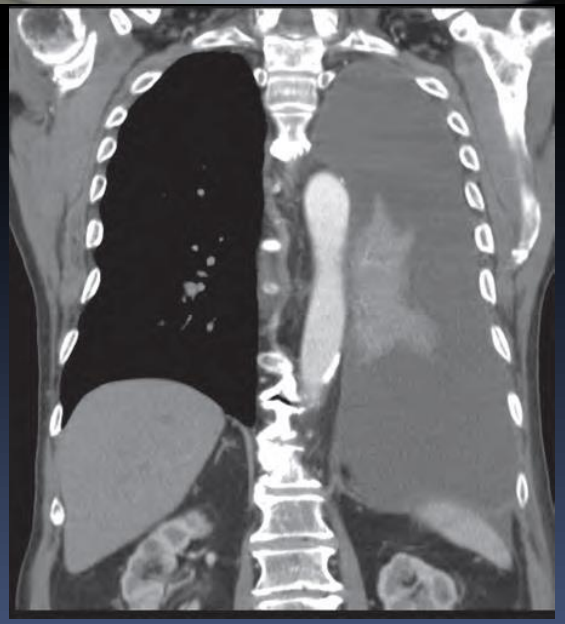
Pulmonary Interventions



Malignant Effusions: pleurodesis

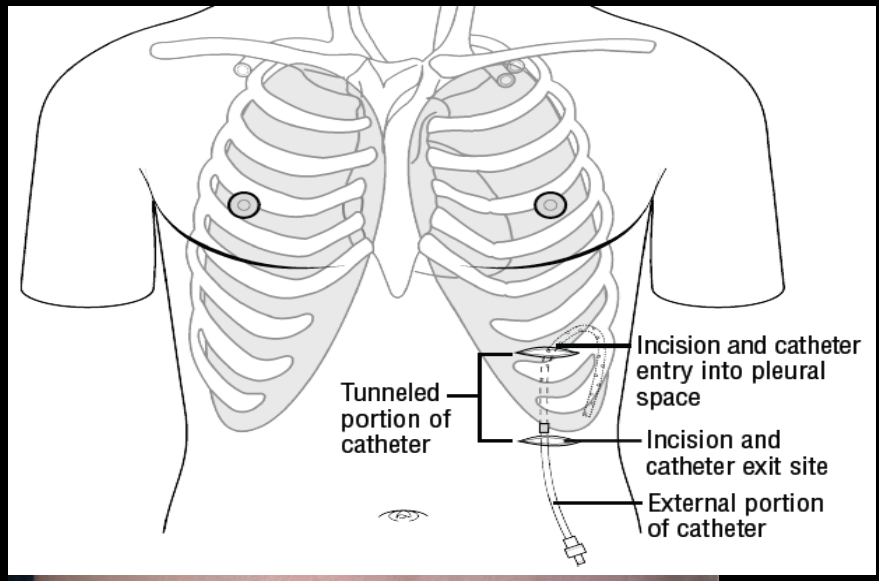
- Symptom relief with drainage + prevention of recurrence
- Might not be the best solution:
  - "trapped lung"
  - Inability to tolerate surgical procedure
  - Significant failure rate
  - Adverse reactions
  - Hospitalizations

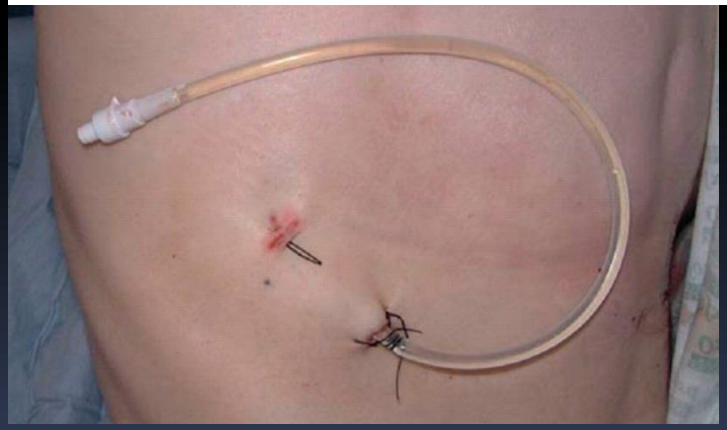




Davies HE and Lee GYC. Curr Opin Pul Med 2013

Indwelling (Tunneled) Pleural Catheter (IPC)





- Day procedure and ambulatory drainage
- Tunneled catheter connected to vacuum containers

IPC Outcomes

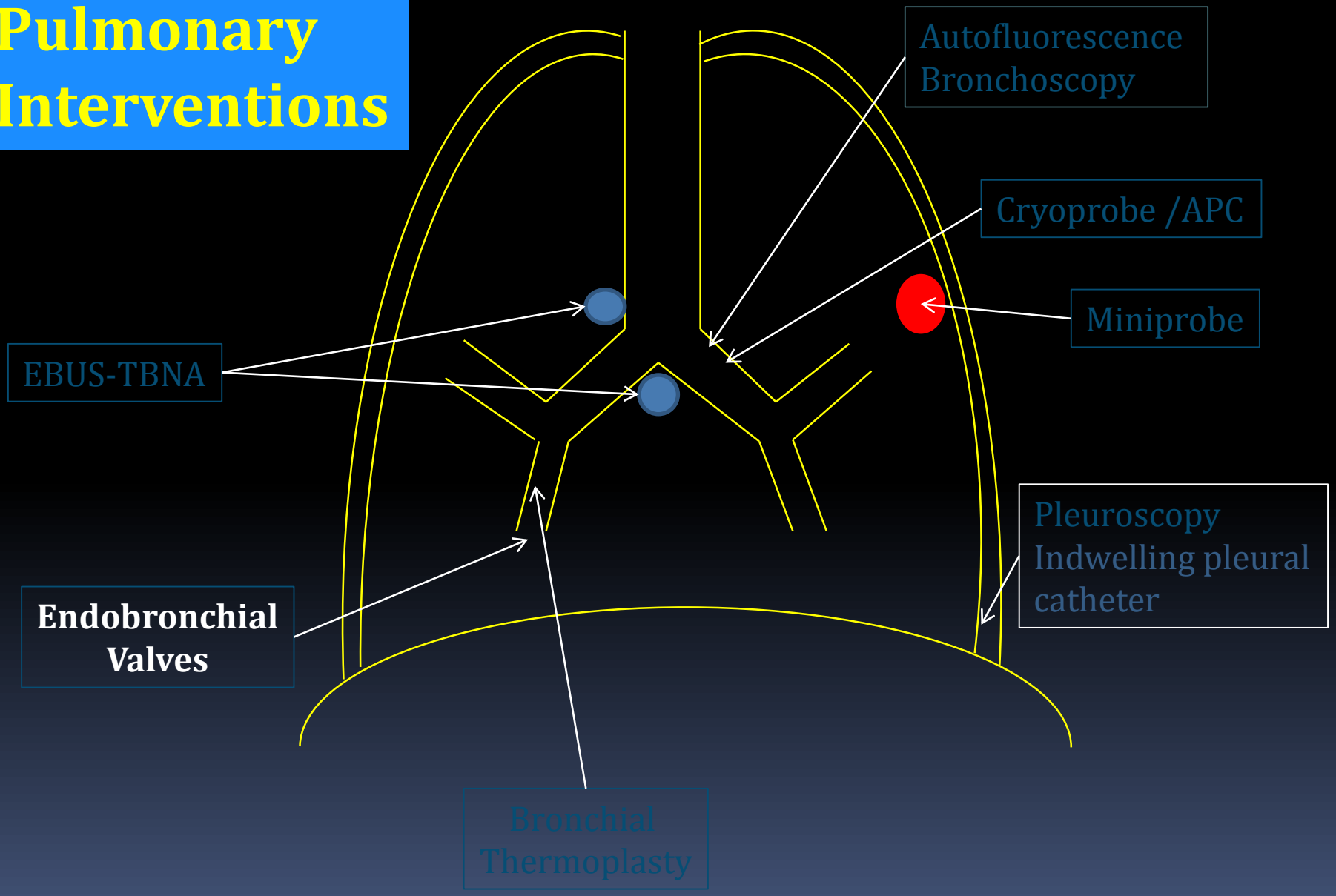
- 90% symptoms-free at 30-D without additional interventions
- ~50% "auto-pleurodesis" at 2-6 weeks

  Temblay A et al. Chest 2006
- Non-inferior to talc pleurodesis for dyspnoea control and QOL Davies HE et al. JAMA 2012
- More cost-effective Puri V et al. Ann Thorac Surg 2012
- Lower direct costs: ↓ hospitalizations

  Boshuizen RC et al. Respiration 2013
- Few complications: infections (<5%)

  Fysh ET et al. Chest 2013

Pulmonary Interventions



A ONE-WAY VALVE:

Isolate the lobe→

Lobe shrinkage →

Complete collapse →

Volume reduction

Advance housing into target segment, confirm sizing using gages

Confirm Zephyr EBV positioning and sizing

Zephyr EBV allowing air to exit from during expiration

Zephyr EBV preventing air from entering during inspiration

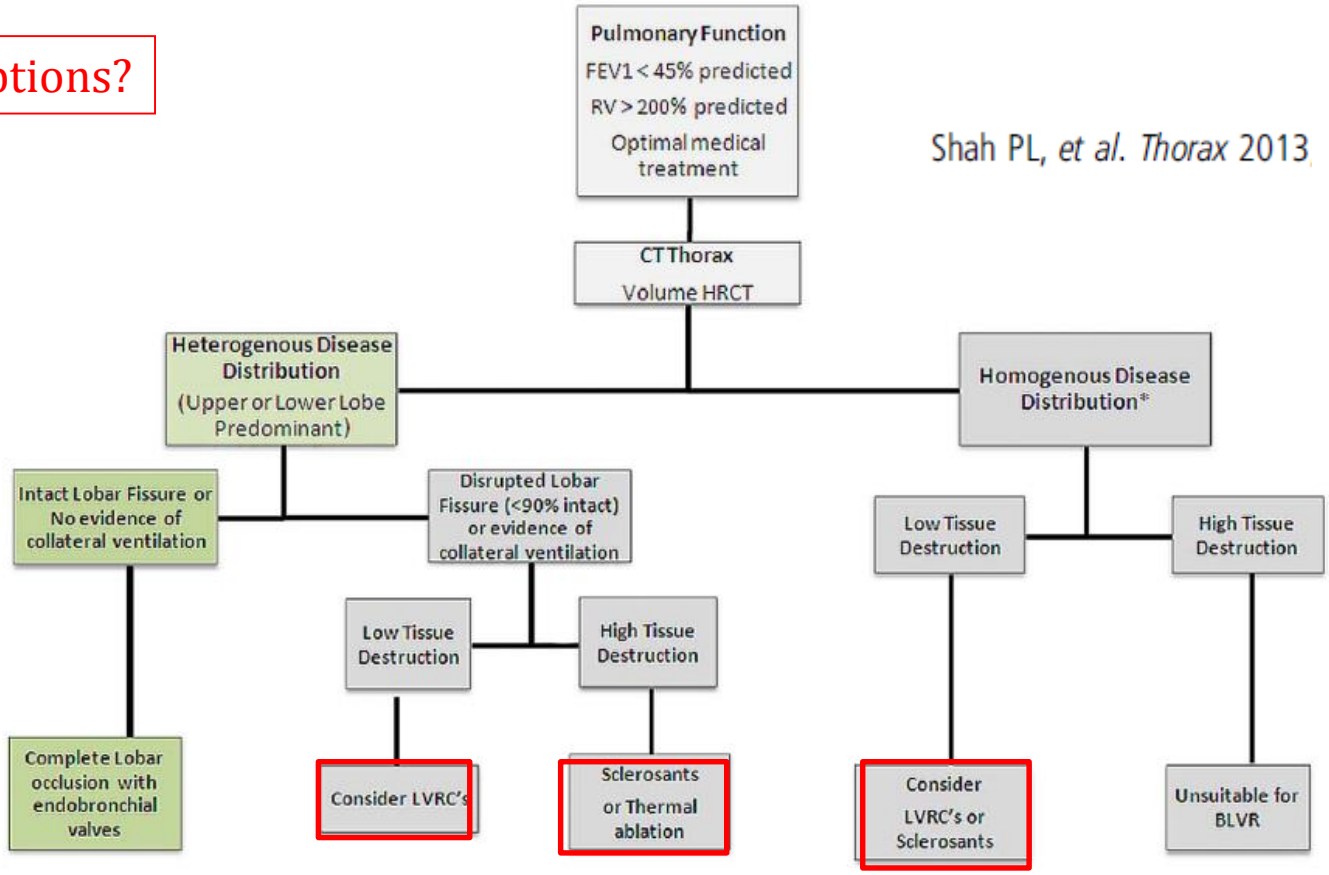
Lung volume reduction (LVR) in emphysema

- Hyperinflation in emphysema:
  - ↓ chest wall compliance
  - ↓ function respiratory muscles
  - Leading to SOB, ↓ exercise tolerance and QOL
- LVR surgery [Fishman A et al. NEJM 2003]
  - Improves functional capacity and survival in a subgroup
  - Upper lobe predominant disease and poor baseline lung function
  - Substantial operative risks

EBV for emphysema (Bronchoscopic Lung Volume Reduction)

- Modest ↑ lung function, exercise tolerance and symptoms [Sciurba FC NEJM 2010; Herth FJ ERJ2012]
  - ↑ success rate with heterogeneous emphysema, lobar exclusion (with complete lobar fissure) and -ve collateral ventilation
- ↑adverse events [Sciurba FC NEJM 2010; Herth FJ ERJ2012; Ninane V ERJ 2012]
  - EBV-related events: pneumothorax > 7 days (2.2%), "distal" pneumonia (1.9%); haemoptysis (0.6%)

Other Options?

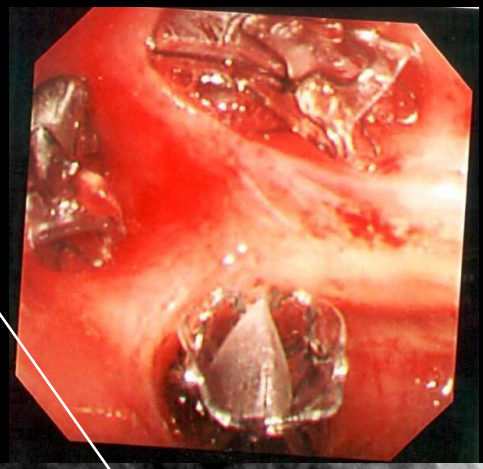


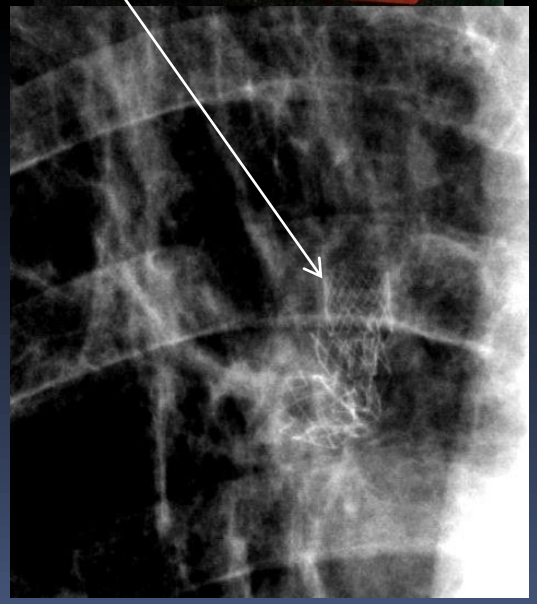
Shah PL, *et al. Thorax* 2013

Figure 5 Algorithm for bronchoscopic lung volume reduction in patients with severe emphysema. BLVR, biological lung volume reduction; FEV_1, forced expiratory volume in 1 s; HRCT, high-resolution CT; LVRC, lung volume reduction coil; RV, residual volume.

Herth FJ et al. Respiration 2011 (Sealant)
Snell G et al. ERJ 2012 (thermal vapour ablation)
Shah PL et al. Lancet Resp 2013 (endobronchial coils)

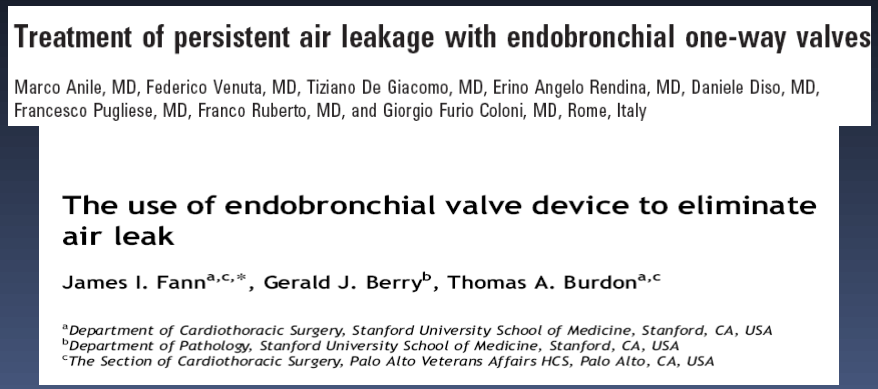
EBV for persistent air leaks in pneumothorax





EBV in persistent air leaks: the evidence

- Mostly case series or reports
- Shorten LOS
- Relatively safe and non-invasive
- Air leaks reduced or resolved in >90% (Travaline JM et al. Chest 2009)
  - Mean time from EBV placement to drain removal: 21 days (median 7.5; IQR 3-29)



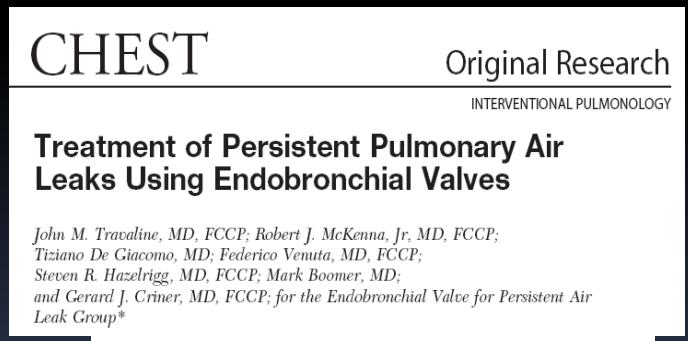
Treatment of persistent air leakage with endobronchial one-way valves

Marco Anile, MD, Federico Venuta, MD, Tiziano De Giacomo, MD, Erino Angelo Rendina, MD, Daniele Diso, MD, Francesco Pugliese, MD, Franco Ruberto, MD, and Giorgio Furio Coloni, MD, Rome, Italy

The use of endobronchial valve device to eliminate air leak

James I. Fann[a,c,*], Gerald J. Berry[b], Thomas A. Burdon[a,c]

[a]Department of Cardiothoracic Surgery, Stanford University School of Medicine, Stanford, CA, USA
[b]Department of Pathology, Stanford University School of Medicine, Stanford, CA, USA
[c]The Section of Cardiothoracic Surgery, Palo Alto Veterans Affairs HCS, Palo Alto, CA, USA

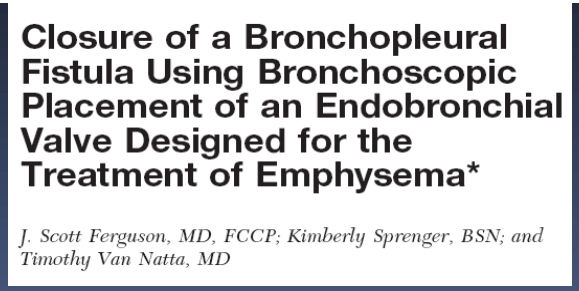


CHEST Original Research

INTERVENTIONAL PULMONOLOGY

Treatment of Persistent Pulmonary Air Leaks Using Endobronchial Valves

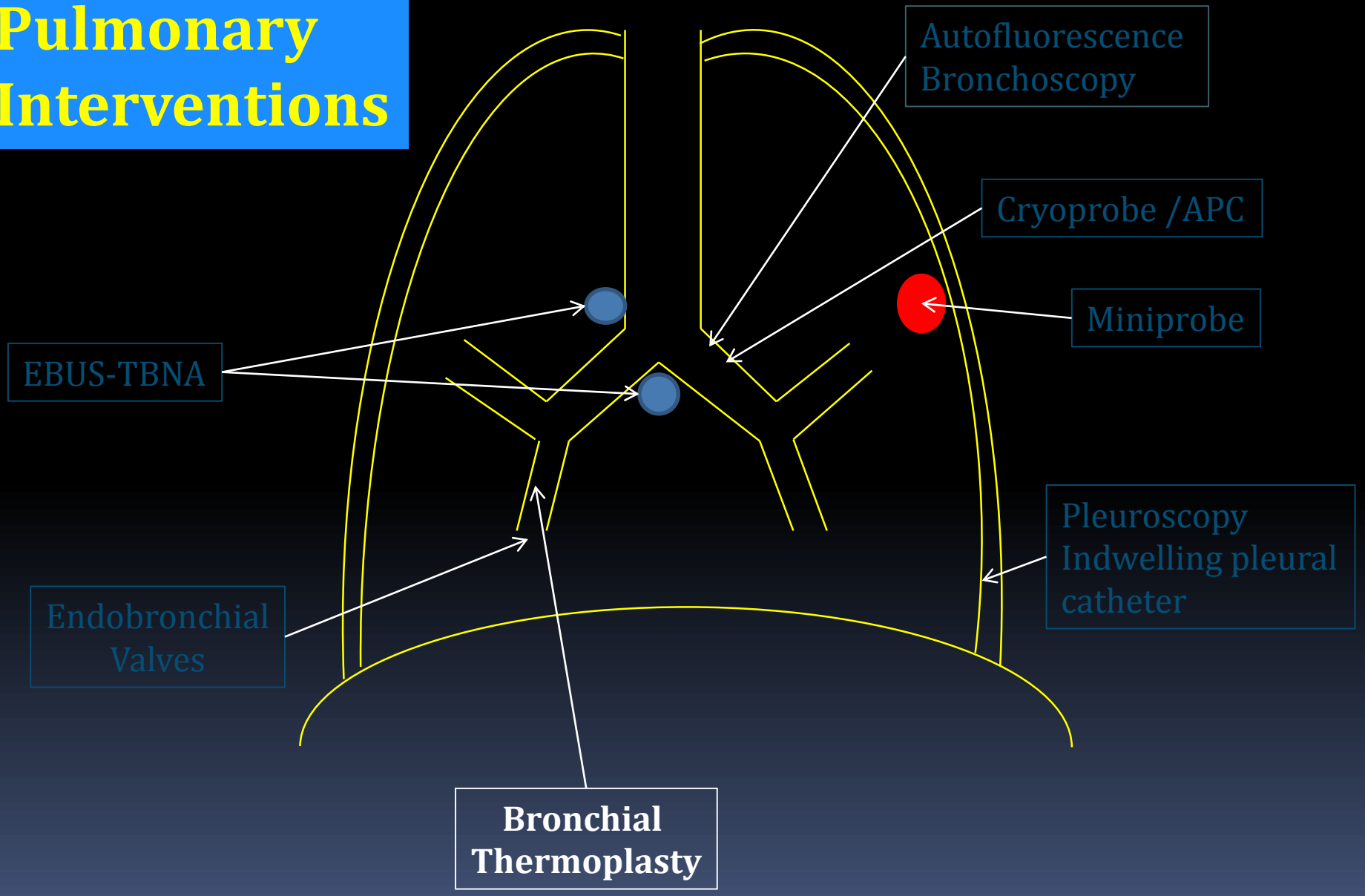
*John M. Travaline, MD, FCCP; Robert J. McKenna, Jr, MD, FCCP; Tiziano De Giacomo, MD; Federico Venuta, MD, FCCP; Steven R. Hazelrigg, MD, FCCP; Mark Boomer, MD; and Gerard J. Criner, MD, FCCP; for the Endobronchial Valve for Persistent Air Leak Group**



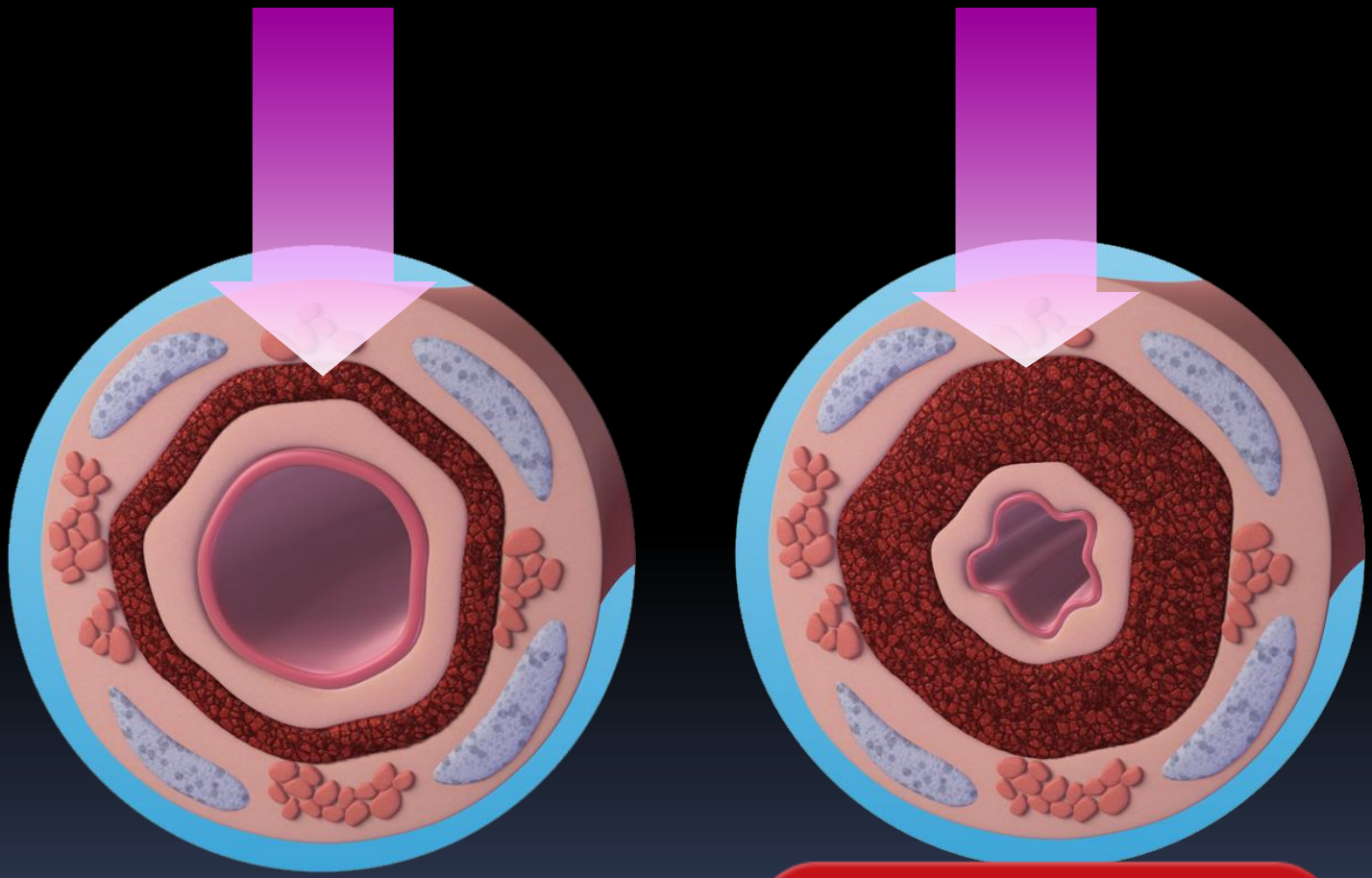
Closure of a Bronchopleural Fistula Using Bronchoscopic Placement of an Endobronchial Valve Designed for the Treatment of Emphysema*

J. Scott Ferguson, MD, FCCP; Kimberly Sprenger, BSN; and Timothy Van Natta, MD

Pulmonary Interventions



Airway Smooth Muscle (ASM) on Asthma



Normal Airway

Asthma Attack

Bronchial Thermoplasty: Actions and effects

Reduces Airway Smooth Muscle

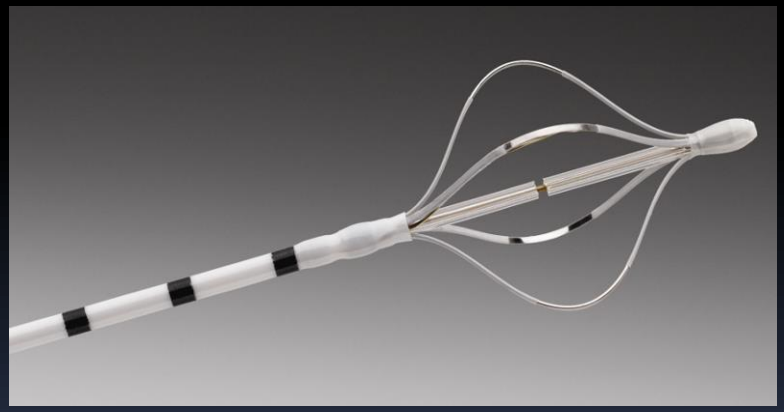
Reduces Bronchoconstriction

Reduces Asthma Exacerbations

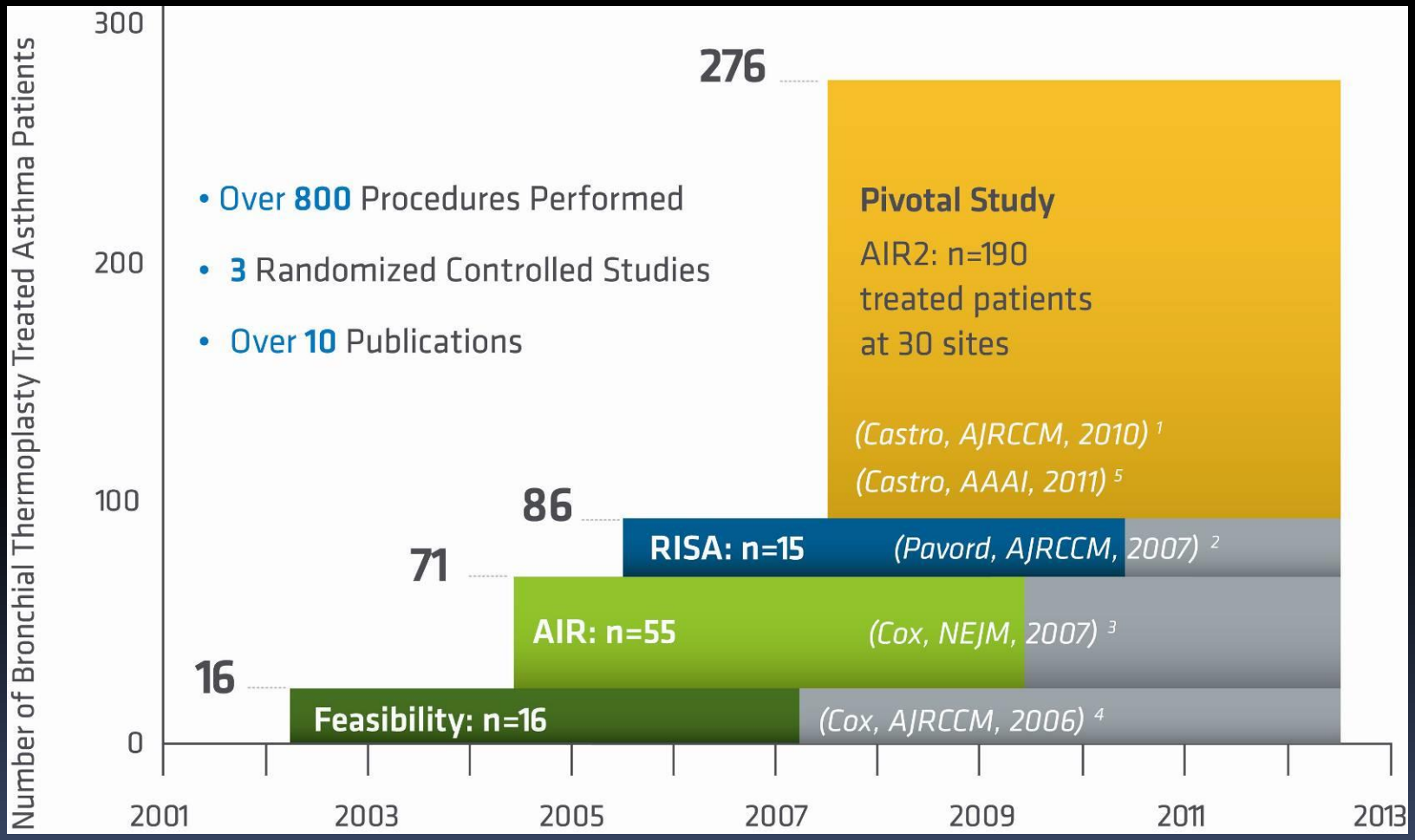
Improves Asthma Quality of Life

Bronchial Thermoplasty : Catheter and RF Controller

- **Catheter** – a flexible tube with an expandable wire array at the tip (introduced through a standard bronchoscope)
- **Radiofrequency (RF) Controller** – supplies energy via the Catheter to heat the airway wall



Clinical Studies



AIR = Asthma Intervention Research Study
RISA = Research in Severe Asthma Study

Clinical Outcomes

- **Improved asthma-related quality of life**
- **Improved clinical outcomes:**
  - 32% ↓ severe exacerbations
  - 84% ↓ ER visits
  - 73% ↓ hospitalization
  - 66% ↓ days off work / school /other daily activities

Castro et al. AJRCCM 2010
Cox et al. NEJM 2007
Pavord et al. AJRCCM 2007

- **Slightly short-term asthma related morbidities**
- **No device-related serious adverse events or deaths**

Castro, Am J Respir Crit Care Med. 2010;181(2):116-24

- **No complications + stable lung fx at 5 years**

Thomson NC et al. BMC Pul Med 2011

Pavord ID et al. AJRCCM 2011

Potential therapeutic option in severe asthmatics

Step 1	Step 2	Step 3	Step 4	Step 5
Asthma education environmental control				
As needed rapid-acting $ß_2$-agonist	As needed rapid-acting $ß_2$-agonist			
Controller options***	Select One	Select One	Add one or more	Add one or both
	Low-dose inhaled ICS*	Low-dose ICS plus long-acting $ß_2$-agonist	Medium or high-dose ICS plus long-acting $ß_2$-agonist	Oral glucocorticosteroid (lowest dose)
	Leukotriene modifier**	Medium-or high-dose ICS	Leukotriene modifier	Anti-IgE treatment
		Low-dose ICS plus leukotriene modifier	Sustained release thephylline	
		Low-dose ICS plus sustained release thephylline		

*ICS = inhaled glucocorticosteroids
** = Receptor antagonist or synthesis inhibitors
*** = Preferred controller options are shown in shaded boxes

GINA 2012

Interventional Pulmonology: Conclusions

- A growing field
  - From airway to pleura
  - From diagnostic to therapeutic
- Attractive alternatives for patients with borderline performance status
  - ↓ invasiveness
  - ↓ risks
  - ↓ hospitalization
  - ↑Cost-effectiveness

Acknowledgments

- Dr. David CL Lam (QMH)
- Dr. WL Law (QEH)
- Members of the Special Interest Group of Bronchology and Interventional Pulmonology of HKTS/ACCP (HK & Macau Chapter)

THANK YOU!