



Solitary Pulmonary Nodule

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Conference



Outline

1. Definition
2. Demographic risk factors
3. Radiological signs
4. Diagnostic techniques
5. Algorithm of benign vs. malignant lesion
6. Conclusion



Goals

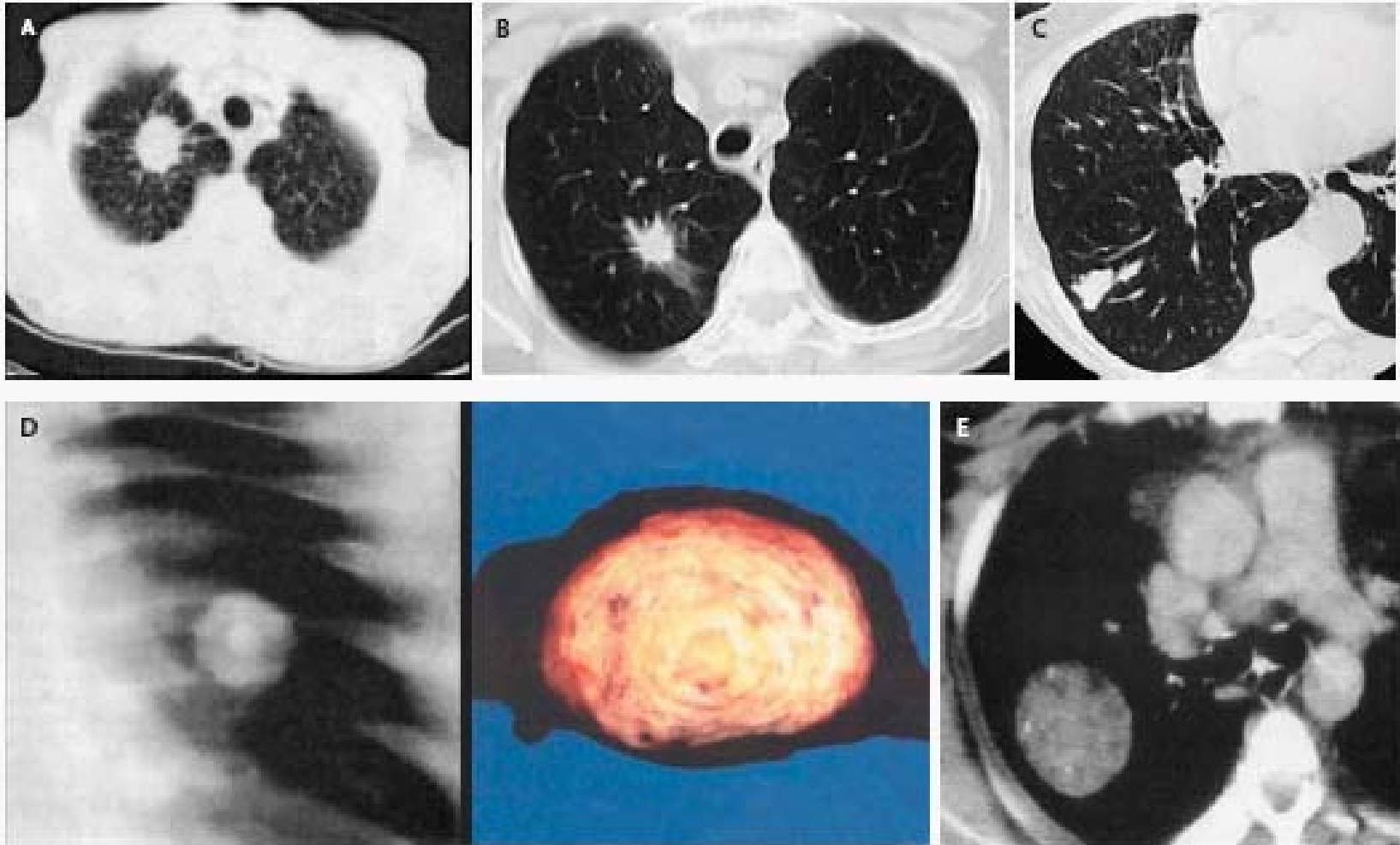
- To be able to identify a solitary pulm. nodule
- To understand various techniques to diagnose a SPN



Solitary Pulmonary Nodule (SPN)

- Also called coin lesion
- Lesion less than 3 cm and surrounded by lung parenchyma without other abnormalities
- 0.20% of all CXR have SPN
- 150,000 nodules per year identified

Solitary pulmonary nodules



1. Ost D, Fein AM, Feinsilver SH. The solitary pulmonary nodule. *N Engl J Med* 2003;348:2535-2542

Table 1. DIFFERENTIAL DIAGNOSIS OF A SOLITARY PULMONARY NODULE

Neoplasm	Benign	Hamartoma
	Malignant	Inflammatory pseudotumor Bronchogenic carcinoma Carcinoid tumor Lymphoma (Non-Hodgkin's) Metastasis
Infection	Granuloma	Mycobacteria Fungi
	Septic embolus Abscess	Bacteria (anaerobes, Staphylococcus, gram-negative) Nocardia
	Round pneumonia Parasitic	Pneumococcus Echinococcus Dirofilaria (dog heartworm)
Inflammatory	Connective tissue	Wegener's granulomatosis Rheumatoid (necrobiotic) nodule
Vascular	Sarcoidosis (rare)	
	Arteriovenous malformation	
	Hematoma	
	Pulmonary infarct	
	Pulmonary artery aneurysm	
Airway	Pulmonary venous varix	
	Congenital lesion	Bronchogenic cyst Bronchial atresia
	Mucocele Infected bulla	

Leef JL, and Klein JS. The solitary pulmonary nodule. Radiologic Clinics of North America 2002; 40:123-143



Composition of SPN

- Retrospective study at Mayo clinic:
- 65% of lesions are benign
(79% were granulomas, 7% hamartoma)
- Of the malignant lesions:
- 49% adenocarcinoma
- 29% squamous cell ca
- 8% large cell ca



Demographic risk factors

- Age
- Smoking history
- History of prior malignancies
- Environmental exposures



Radiological features of benign and malignant nodules

- Nodular size



Nodular Size

- 80% of benign nodules are <2 cm
- Only 15% of malignant lesion <1 cm

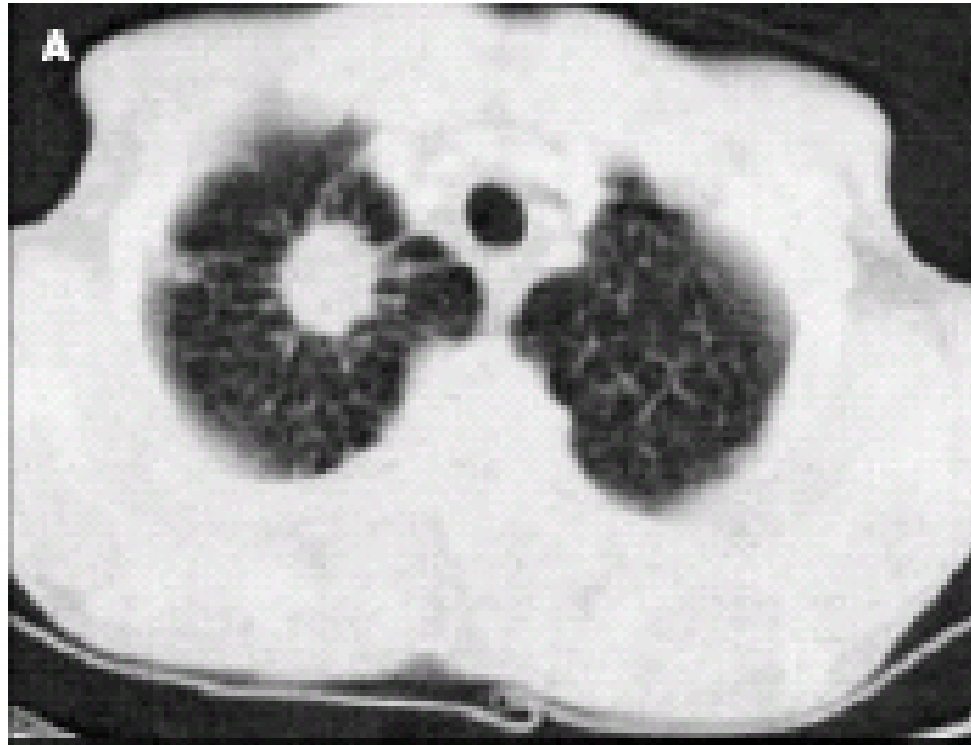


Radiological features of benign and malignant nodules

- Nodular size
- Spiculation (corona radiata sign)



Corona Radiata Sign



1. Ost D, Fein AM, Feinsilver SH. The solitary pulmonary nodule. *N Engl J Med* 2003;348:2535-2542

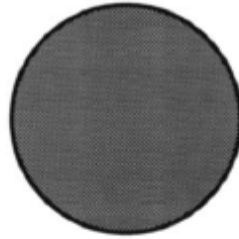


Radiological features of benign and malignant nodules

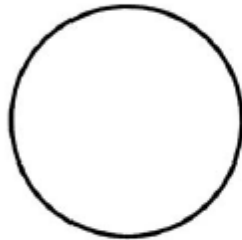
- Nodular size
- Spiculation (corona radiata sign)
- **Calcifications**



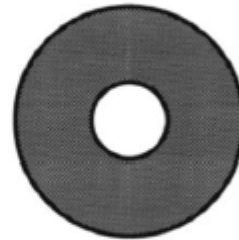
Benign Patterns of Calcifications



Non-calcified (indeterminate) SPN



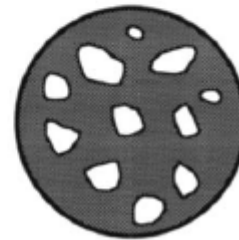
Complete calcification



Central calcification



Laminated calcification



Popcorn calcification

Leef JL, and Klein JS.
The solitary pulmonary
nodule. Radiologic Clinics
of North America 2002;
40:123-143



Noninvasive Diagnostic Techniques

- CT scan
- PET scan
- PET/CT scan



CT Scan

- Limit of detectable change is 0.3mm
- Contrast enhances a nodule
- Bronchus sign

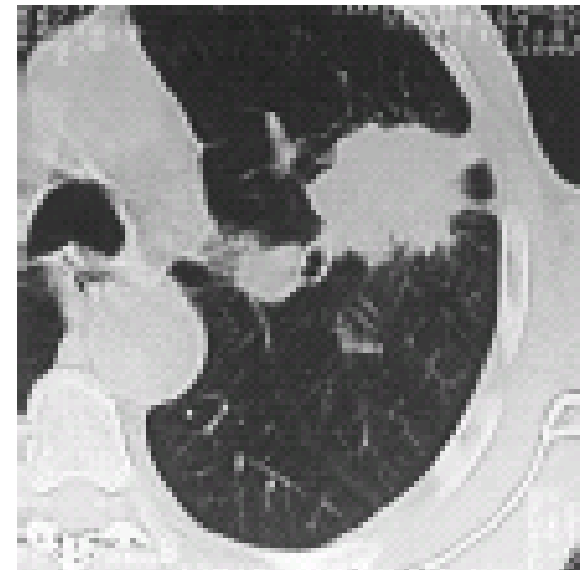
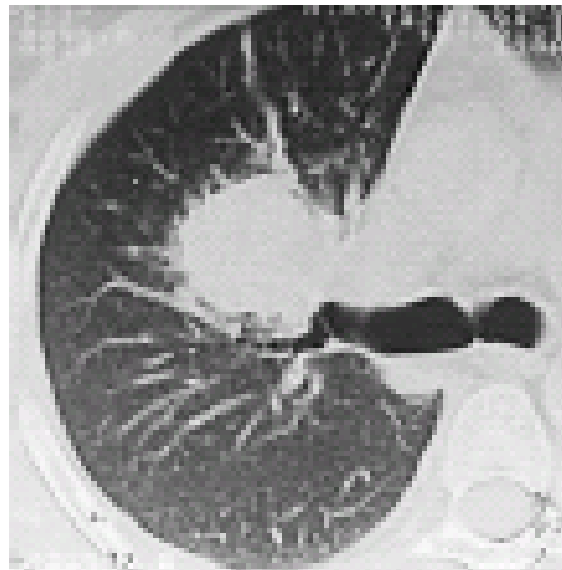
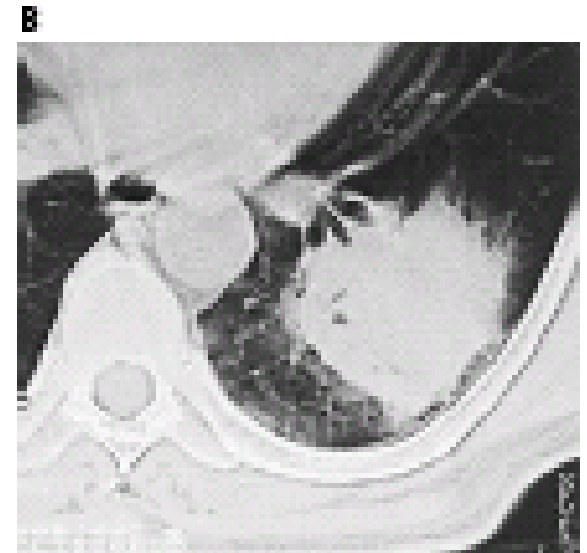
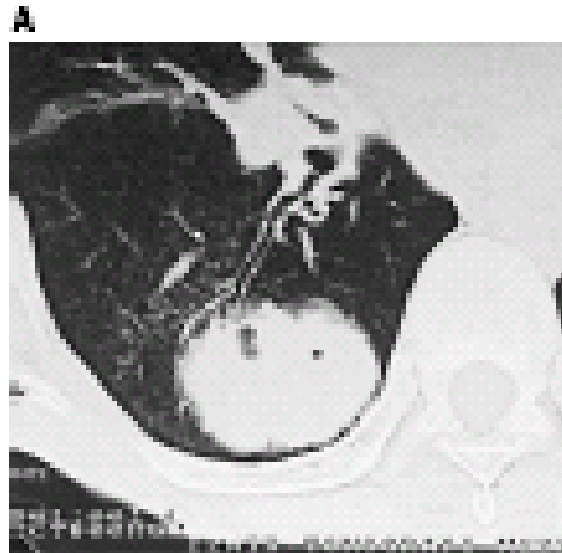


Bronchus sign

- Increases the yield of a bronchoscopy from 44% to 82%

Bronchus Sign

Fig. 1. The types of bronchus sign depicted by 2-mm thick CT sections in 4 patients whose resected specimens were examined and proven for mass-bronchus relationship. **A** A fifth-order bronchus cut-off by a 5-cm Tsuboi type 1 mass in the right lower lobe superior segment. **B** Three segmental bronchi contained within a 5-cm Tsuboi type 2 mass in the posterior basal segment of the left lower lobe. **C** A 4.5-cm mass compressing the posterior segmental bronchus (Tsuboi type 3) and also narrowing and thickening the anterior segmental bronchus of the right upper lobe (Tsuboi type 4). **D** A 5-cm mass thickening and slightly narrowing two fourth-order bronchi in the posterior segment of the left upper lobe (early-stage Tsuboi type 4).



C

D



PET Scan

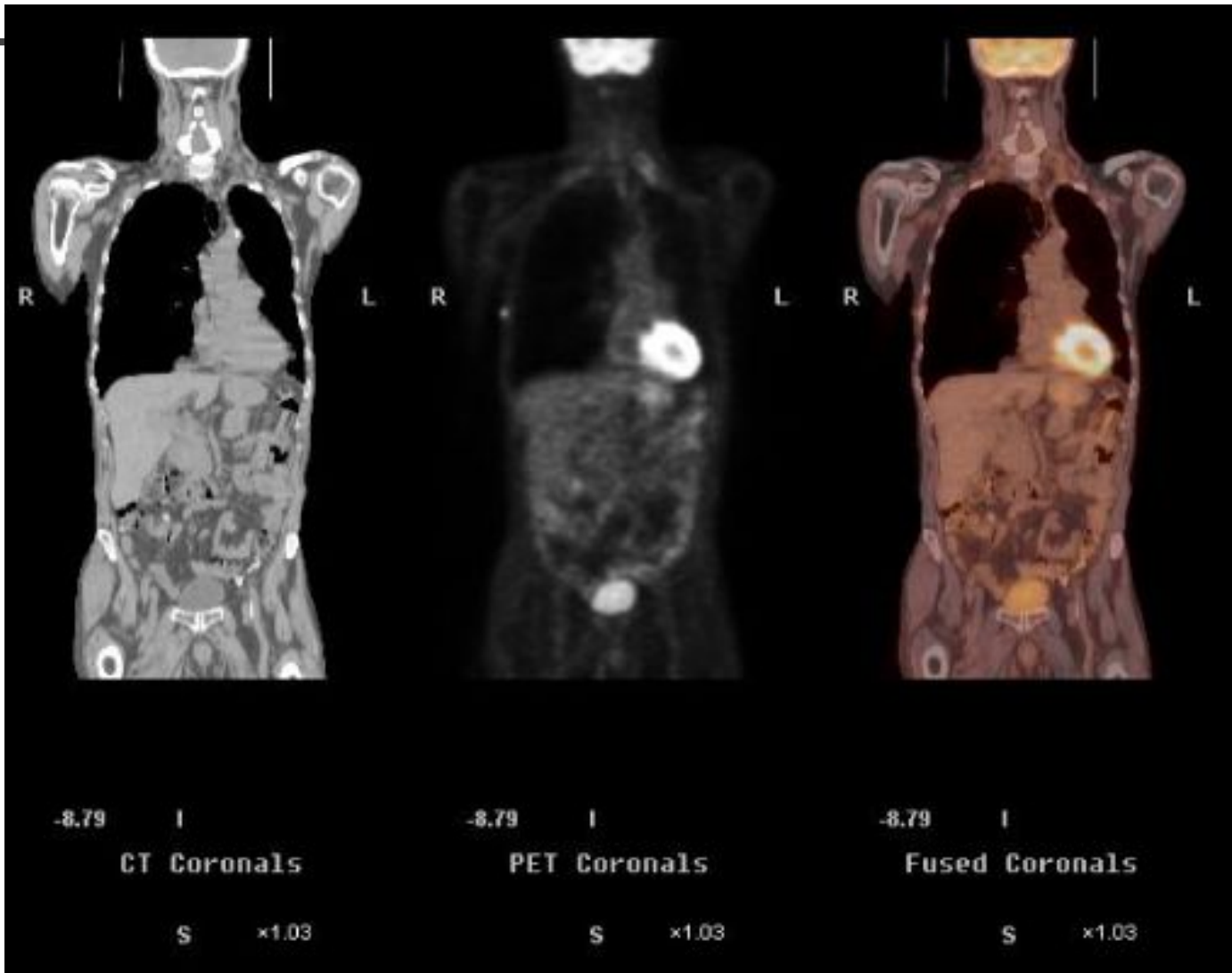
- Uptake of 18-fluorodeoxyglucose
- Metanalysis of 727 studies (1966-2000) in Medline and Cancerlit from Gould et al.
- Mean sensitivity is 93.6% and mean specificity is 85.8%



Downside of PET scan

- False (-):
 - Bronchioloalveolar Carcinoma
 - Carcinoids
 - 5% of all stage 1 lung cancer
 - Tumors less than 1 cm in diameter
- False (+) :
 - Infectious or inflammatory processes

PET/CT





PET/CT Scan

- Sensitivity to 96%
- Specificity 88%.



Invasive Diagnostic Procedures

- Bronchoscopy
- Thoracotomy versus VATS



Bronchoscopy

- Sensitivity ranges from 20-80%.
- Multiple techniques:
 - Bronchial Washing
 - Endobronchial Biopsy
 - Bronchial Brushing
 - Bronchoalveolar Lavage (BAL)
 - Transbronchial Needle Aspiration

Bronchoalveolar Lavage (BAL)

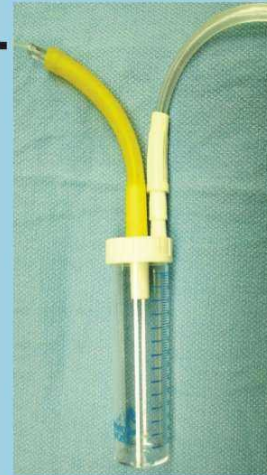
AN EXAMPLE SETUP FOR OBTAINING BRONCHOALVEOLAR



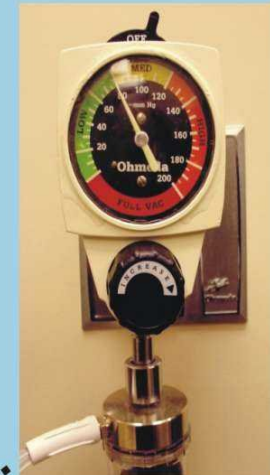
The bronchoscope is wedged at the desired location for the BAL. Tubing is connected at the instrument channel which is ...



... attached to a syringe containing the saline through a three-way stopcock. The saline is instilled into the bronchoalveolar space from here. The third port of the stopcock is ...

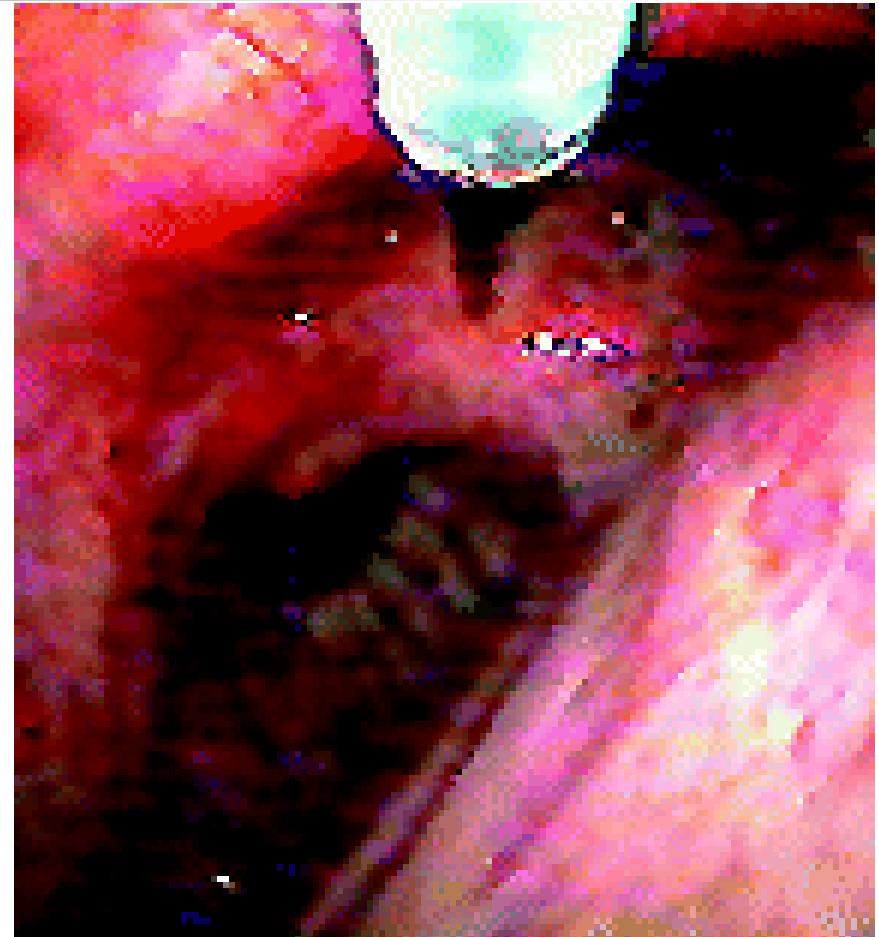
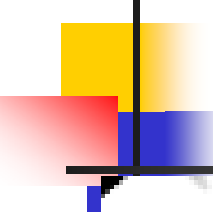


... attached to the trap that will collect the BAL effluent. The effluent is collected when the stopcock is turned off to the syringe which causes suction through the trap ...



... from the suction unit. The typical pressure used during BAL is -80 cm-H₂O. Lower pressures may be used if complete collapse of the bronchus occurs preventing collection of the lavage sample.

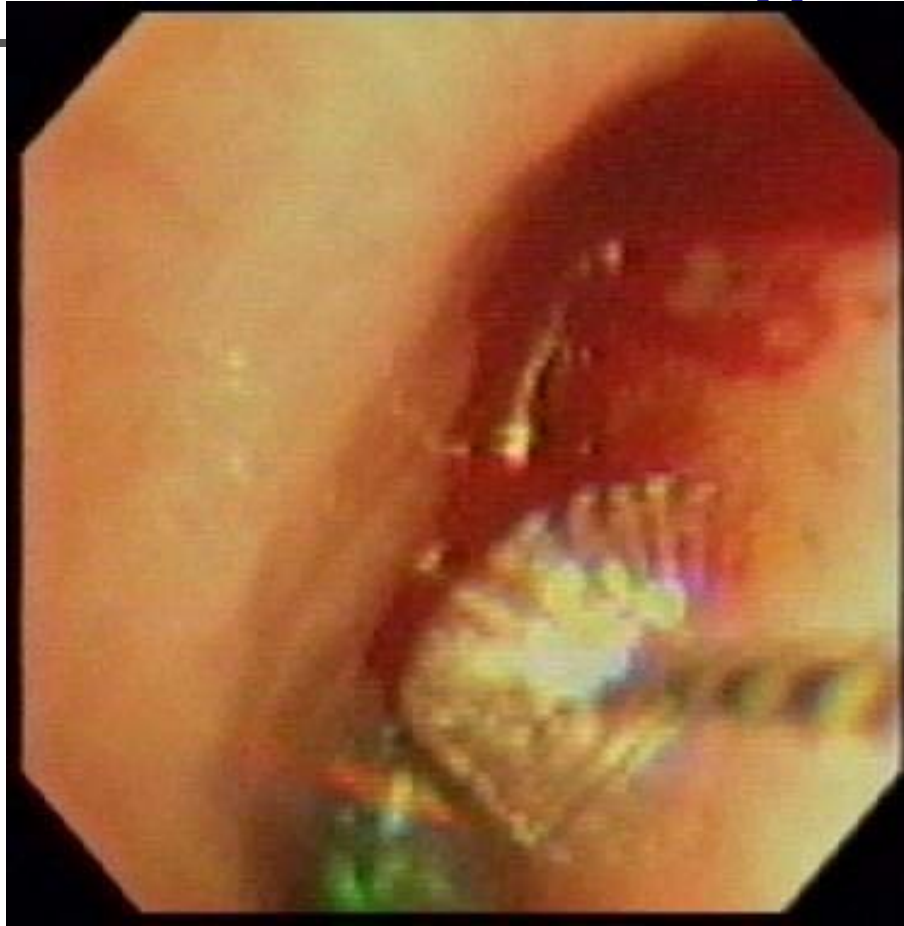
Transbronchial fine Needle Aspiration (TBNA)



Transbronchial needle aspiration biopsy. Retrieved on September 15, 2007.

website:<http://www.webio.hu/broncho/album/album7.php>

Bronchial Brushing



Lung Cancer. Retrieved on September 15, 2007.
website:<http://www.tobacco-facts.info/bronchoscopy.htm>



Houston VA Medical Center Study

- Retrospective analysis of 177 men (active or ex smokers) with pulmonary nodule evaluated by bronchoscopies over a 4 year period
- Diagnostic yield of malignancy is 64%, and of benign lesions is 35%

Table 3—Bronchoscopy Yield by Distance From the Hilum*

Location	Malignant	Benign	Total
Central	18/22 (82)	0/0	18/22 (82)
Intermediate	40/64 (62)	6/12 (50)	46/76 (61)
Peripheral	39/65 (60)†	3/14 (21)	42/79 (53)†

*Data are presented as No. of lesions/total lesions (%).

†p = 0.2, χ^2 analysis across diagnostic yields of malignant lesions in three elliptical locations around the hilum.

‡p = 0.05, χ^2 analysis across diagnostic yields of all lesions in three elliptical locations around the hilum.

Baaklini WA, Reinoso MA, Gorin AB, Sharafkaneh A, Manian P. Diagnostic yield of fiberoptic bronchoscopy in evaluating solitary pulmonary nodules. *Chest* 2000;117:1049-1054

Table 5—Bronchoscopy Yield by Bronchopulmonary Segment*

Segments	Total	Malignant	Benign
RUL	46/78 (59)	42/70 (60)	4/8 (50)
RML	10/12 (83)	9/11 (82)	1/1
RLL	18/28 (64)	16/20 (80)	2/8
LUL	20/37 (54)	19/33 (58)	1/4
Lingula	4/6 (67)	4/5 (80)	0/1
LLL	8/16 (50)	7/12 (58)	1/4

*Data are presented as No. of lesions/total lesions (%); RLL = right lower lobe; LUL = left upper lobe; LLL = left lower lobe.

Baaklini WA, Reinoso MA, Gorin AB, Sharafkaneh A, Manian P. Diagnostic yield of fiberoptic bronchoscopy in evaluating solitary pulmonary nodules. *Chest* 2000;117:1049-1054



Bronchoscopy Complications

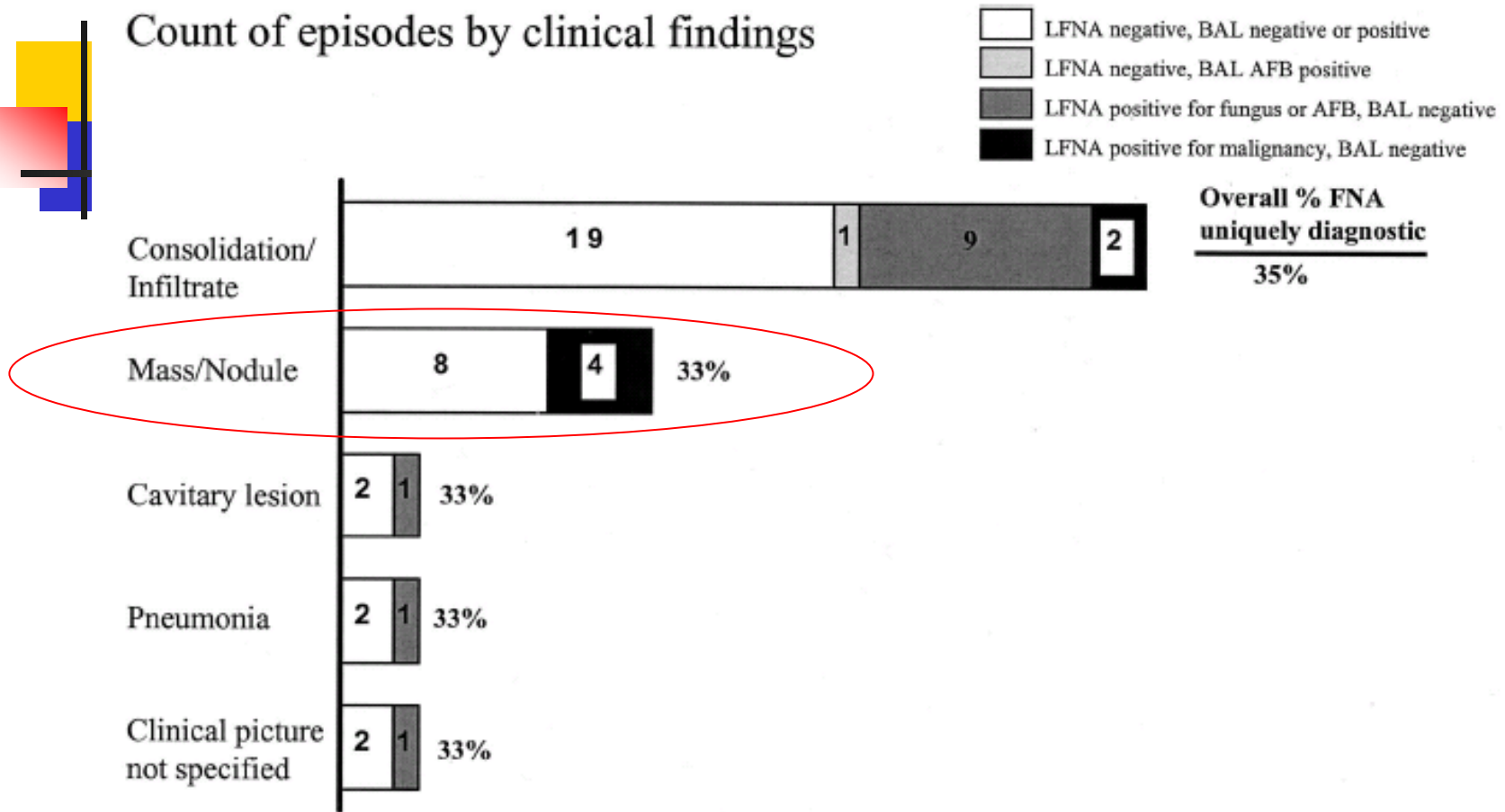
- Complication rate approximately 2%
- Most common complications:
 - Hemorrhage
 - Pneumothorax



BAL vs. Fine Needle Aspiration

- Retrospective study
- 45 pts pulmonary disease evaluated by both BAL and fine needle aspiration
- Resulted: 35% of the time fine needle aspiration was positive while the BAL was negative.

Count of episodes by clinical findings



* Interval of days between BAL and FNA per patient per clinical diagnosis not exceeding 8 days.
BAL – Bronchoalveolar lavage; LFNA – Lung fine needle aspiration

FIGURE 1. Episodes of closely timed BAL and LFNA procedures, January 1989 to June 2000.

Clark BD, Vezza PR, Copeland C, Wilder AM, Abati A.
Diagnostic sensitivity of bronchoalveolar lavage versus
lung fine needle aspirate. Mod Pathol 2002;15:1259-1265



TBNA

- Study in Switzerland
- 172 patients underwent diagnostic bronchoscopy for a peripheral pulmonary lesion
- Bronchoscopist determines which patients have bronchial washings, bronchial brushing, or transbronchial needle aspiration



Results

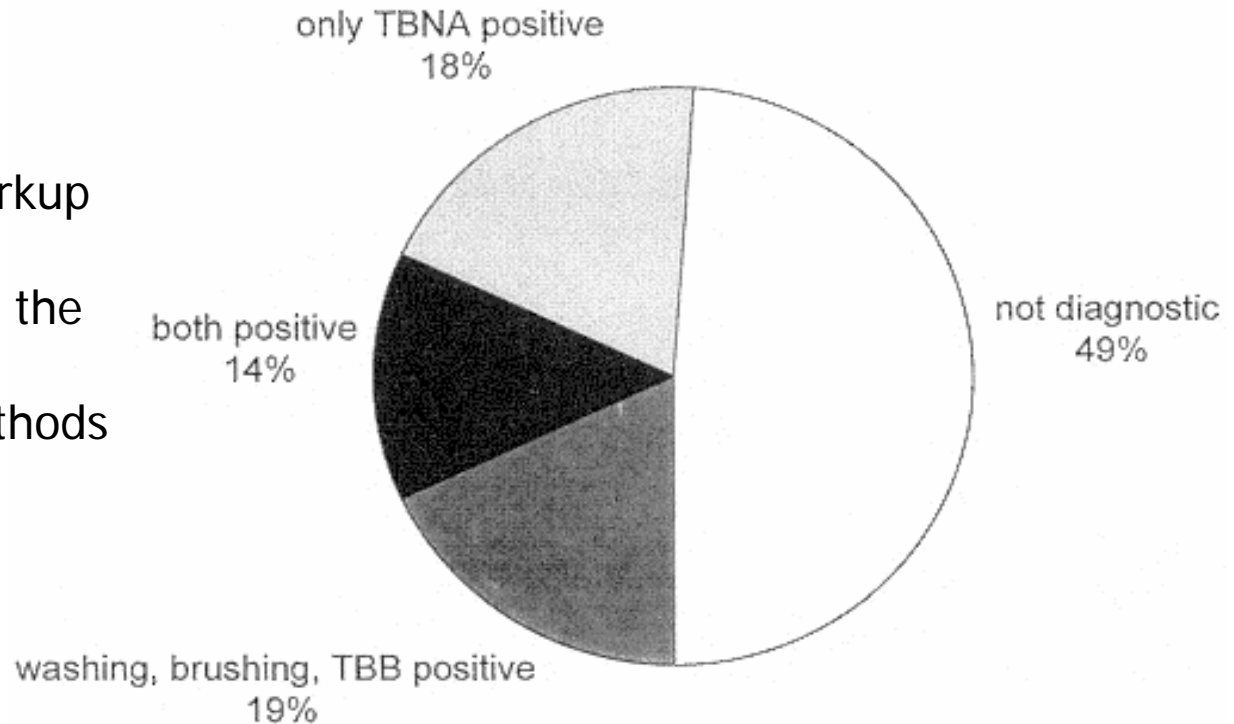
Procedures	No. of Lesions	Malignant	Benign	
Bronchoscopy	87	81	6	50%
Sputum after bronchoscopy	2	1	1	
CT-guided TNB	16	13	3	
Thoracotomy	39	24	15	22%
FNA of extrathoracic lesions	3	3	—	
Autopsy	2	2	—	
TB clinically	1	—	1	
History, CXR, and follow-up	22	2	20	
Total	172	126	46	

*FNA = fine needle aspiration; CXR = chest radiograph.

Reichenberger F, Weber J, Tamm M, Bolliger CT, Dalquen P, Perruchoud AP, Soler M. The value of transbronchial needle aspiration in the diagnosis of peripheral pulmonary lesions. Chest 1999;116:704-708

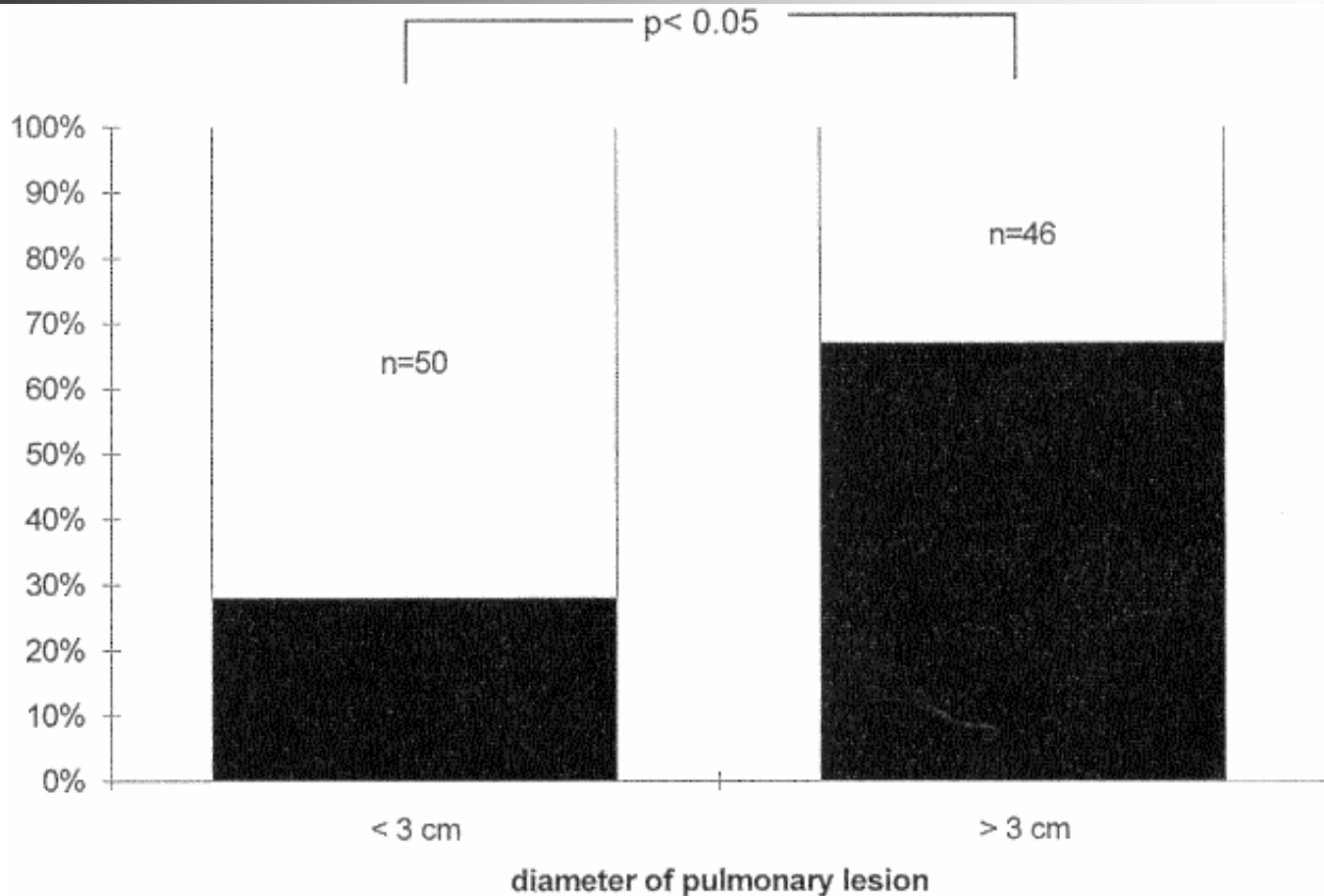
TBNA increase diagnostic yield of bronchoscopy by 50%.

Figure 1. Bronchoscopic workup of 172 pulm nodules
In regard to the impact on the diagnostic yield of
Different bronchoscopic methods



Reichenberger F, Weber J, Tamm M, Bolliger CT, Dalquen P, Perruchoud AP, Soler M. The value of transbronchial needle aspiration in the diagnosis of peripheral pulmonary lesions. Chest 1999;116:704-708

Lesion Diameter Influences TBNA



Reichenberger F, Weber J, Tamm M, Bolliger CT, Dalquen P, Perruchoud AP, Soler M. The value of transbronchial needle aspiration in the diagnosis of peripheral pulmonary lesions. *Chest* 1999;116:704-708



TBNA Complications

- Pneumothorax
- Hemoptysis/Hemorrhagic Complications
- Air Embolism or Hemothorax (rarely)

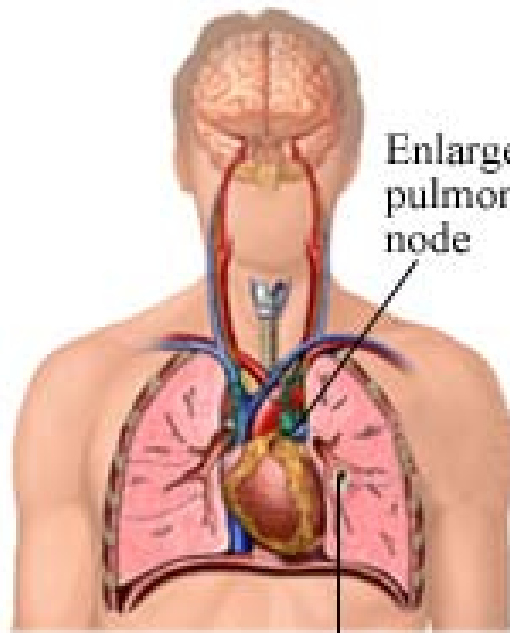


Thoracotomy vs VATS

- Annals of Thoracic Surgery
- Randomized prospective trial of VATS vs muscle sparing lateral thoracotomy.
- 44 patients with SPN: randomized into 22 patients for VATS and 22 patients with lateral thoracotomy.

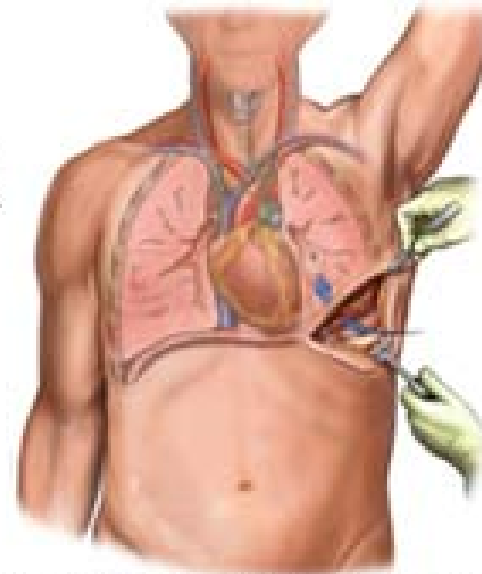


Thoracotomy



Left lung mass

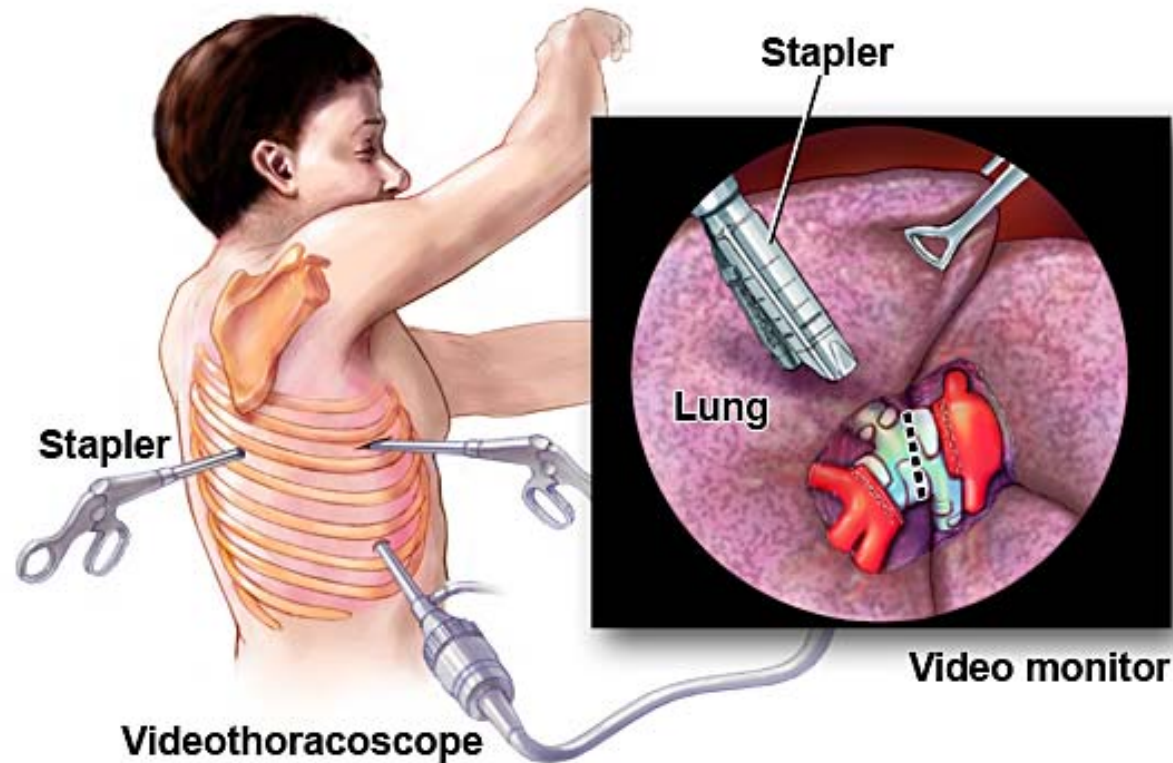
Enlarged aortico-pulmonary lymph node



- A. The pleural cavity is entered through a limited incision in the 5th intercostal space, through which the lung mass and enlarged lymph node are removed

Carson-Dewitt, R. Thoracotomy: Lung Cancer. 2007. retrieved 9.15.07 website: <http://www.thirdage.com/ebSCO/files/14870.html>

VATS



Video-Assisted Thoracoscopic Surgery (VATS) at Mayo Clinic. Retrieved on 9.15.07.
website: <http://www.mayoclinic.org/video-assisted-thoracic-surgery>



Inclusion Criteria

- Maximum nodule size 2.5cm,
- Located in peripheral third of the lung
- Nodule is classified as indeterminate after diagnostic procedures



Results

- VATS procedure:
 - Significantly less pain and hospital stay.
 - Sensitivity and specificity of both VATS and Thoracotomy is 100%

Study Result – VATS vs. Thoracotomy

Table 3. Postoperative Patient Characteristics

Characteristic	VATS	LT	p Value
Operating room time (min)	97.2 ± 32.9	130.5 ± 14.0	>0.05
Transfusion	0	0	...
Air leak > 7 days	0	0	...
Postoperative stay (days)	4.6 ± 1.08	7.8 ± 0.89	<0.01
Pain ^a	26.5 ± 11.6	48.3 ± 12.8	<0.05
Ketorolac (mg)	106.6 ± 15.7	143.3 ± 26.1	<0.05
Anxiety ^a	25.5 ± 7.44	31.7 ± 17.0	NS

^a Visual analogue scale, 0 to 100.

LT = lateral thoracotomy; VATS = video-assisted thoracic surgery.

Santambrogio L, Nosotti M, Bellaviti N, Mezzetti M.
Videothoracoscopy versus thoracotomy for the diagnosis of the
indeterminate solitary pulmonary nodule. *Ann Thorac Surg*
1995;59:868-71



Algorithms

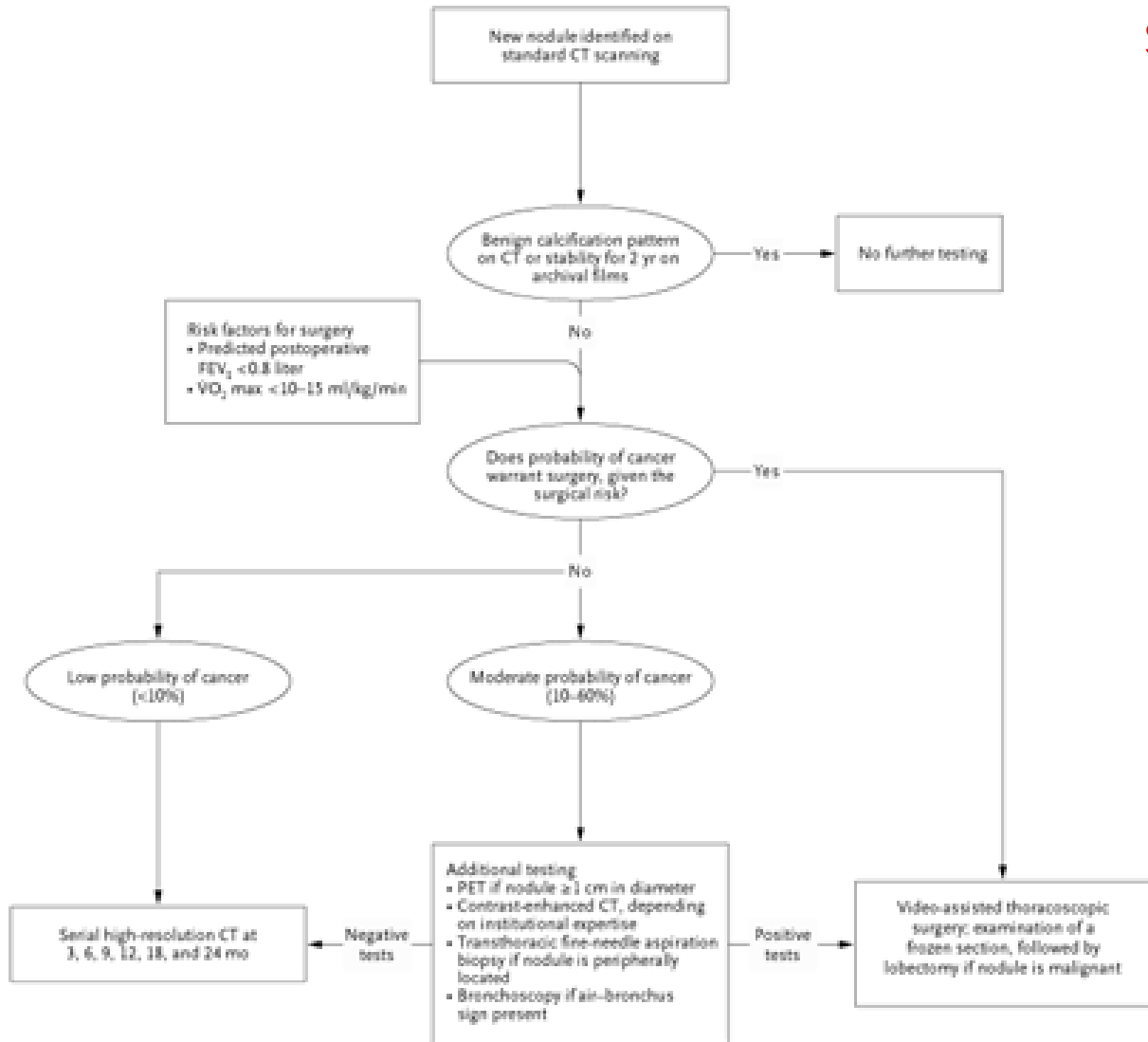
- Swenson et al. – complex model to predict probability of malignancy
- Included demographic features: age, sex, cigarette smoking status, history of asbestos exposure, extrathoracic malignant neoplasm, (COPD)
- Plain radiographic data including diameter, location, margin and cavitation.



Swenson's algorithm

- Probability of Malignancy = $e^x / (1 + e^x)$
- $x = -6.8272 + (0.0391 * \text{Age}) + (0.7917 * \text{cigarettes}) + (1.3388 * \text{Cancer}) + (0.1274 * \text{diameter}) + (1.0407 * \text{spiculation}) + (0.7838 * \text{Upper})$

Flowchart from the NEJM



Step 1

Step 2

Step 3

Step 4



Step 1

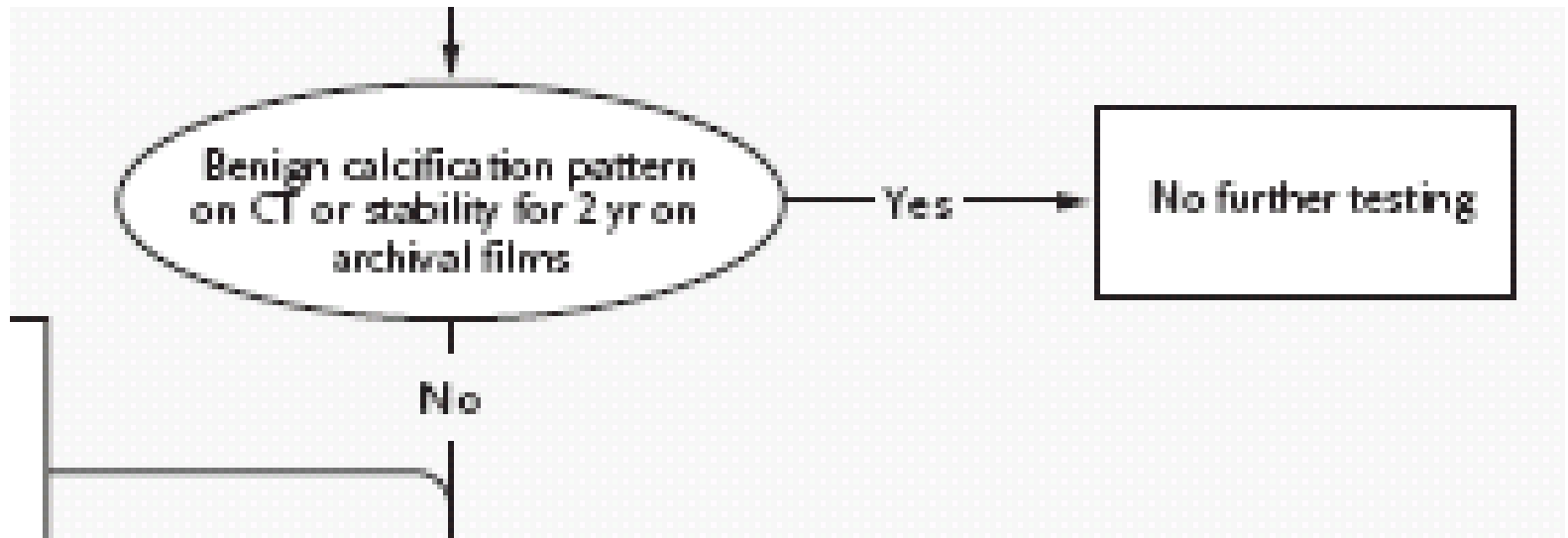


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graph TD; A[New nodule identified on standard CT scanning] --- B[ ]
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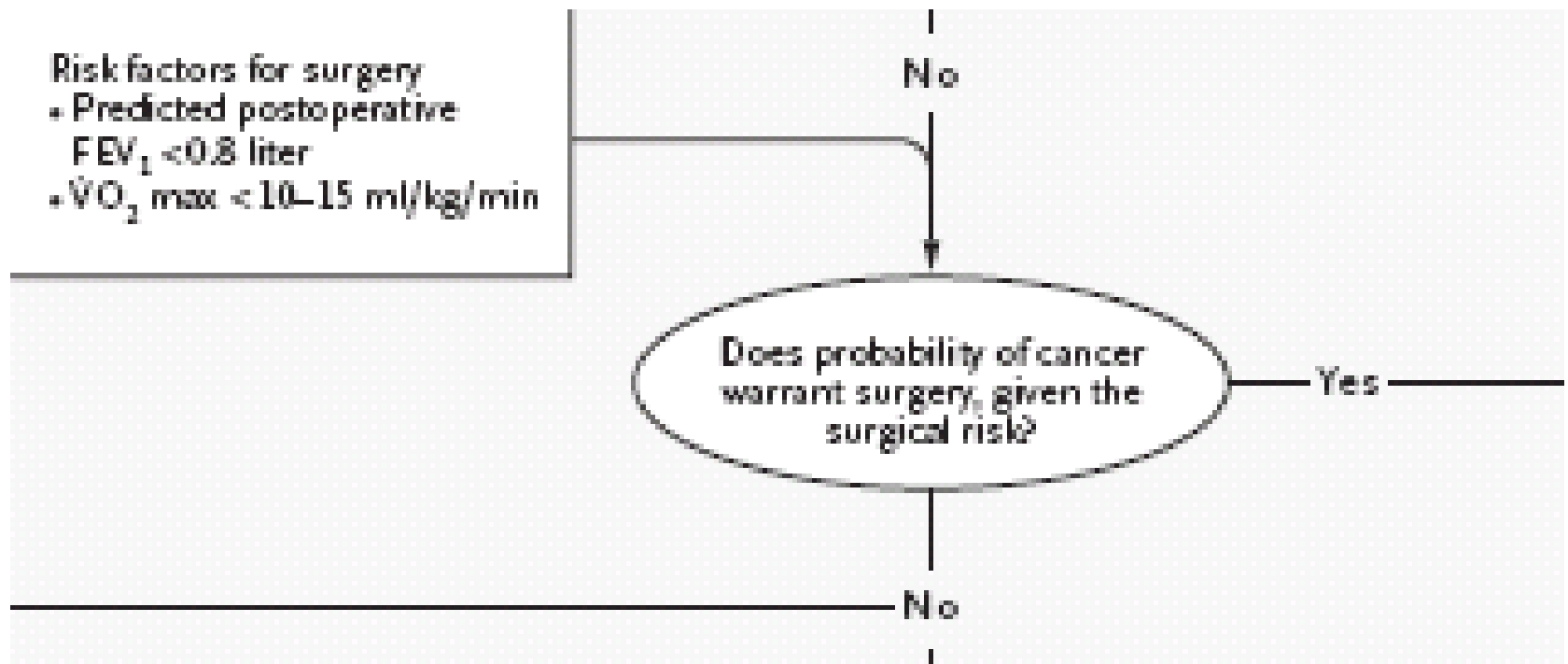
New nodule identified on
standard CT scanning



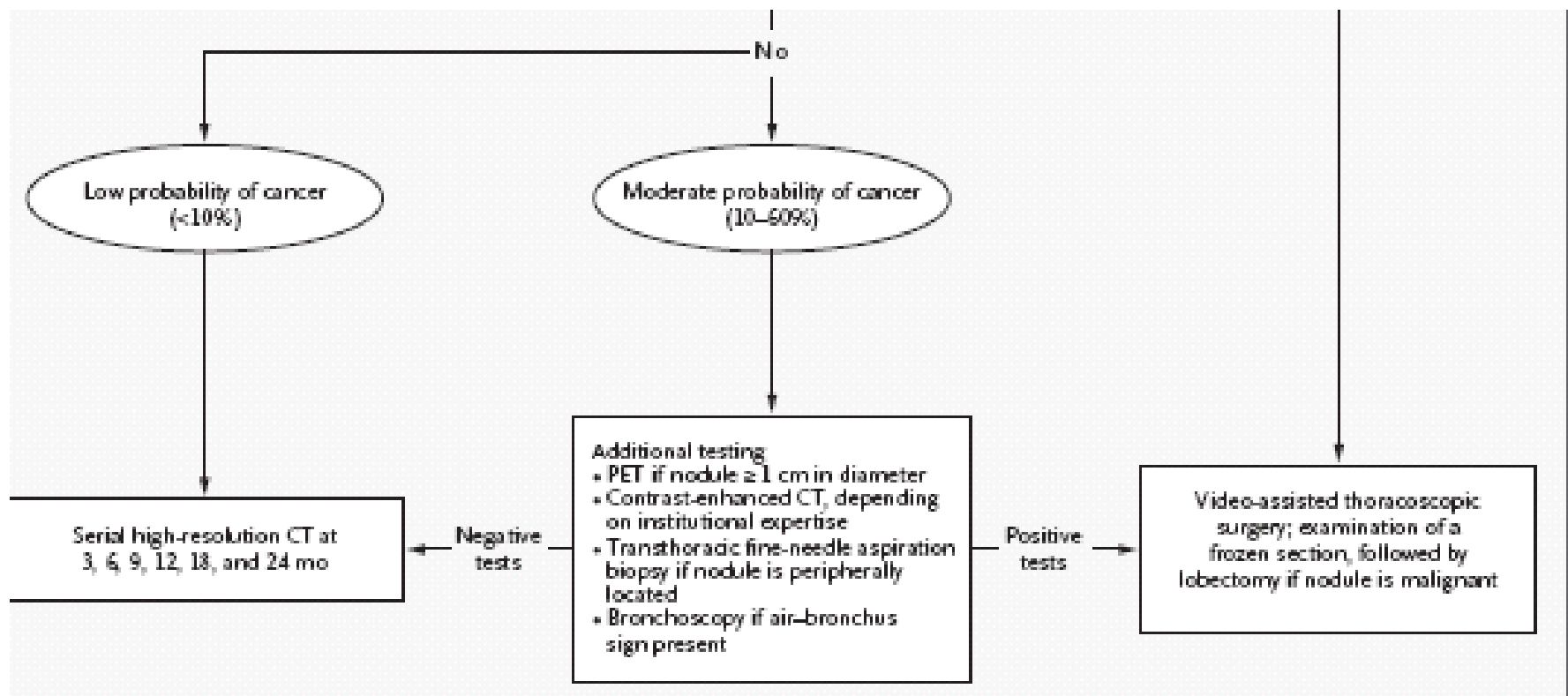
Step 2



Step 3



Step 4





American college of radiology

Table 2. American College of Radiology Recommendations for the Testing of Solitary Pulmonary Nodules.*

Level of Clinical Suspicion	Size of Nodule on Plain-Film Radiography	
	<1 cm	≥1 cm
Low		
Initial evaluation	High-resolution CT	High-resolution CT or transthoracic fine-needle aspiration biopsy
Follow-up	Follow-up CT	Follow-up CT
Moderate to high	Transthoracic fine-needle aspiration biopsy	Contrast-enhanced high-resolution CT

* The information is based on data from Henschke et al.³¹ CT denotes computed tomography.

Ost D, Fein AM, Feinsilver SH. The solitary pulmonary nodule. N Engl J Med 2003;348:2535-2542



Conclusion

- Investigation of the solitary pulmonary nodule remains an inexact science
- Medicare reimbursement for PET imaging is \$1912, noncontrast CT of the thorax \$276 and a CT guided needle biopsy is \$560



Pearls of Wisdom

- CT scan with iv contrast
- Understand radiological signs of malignancy (corona radiata, size)
- Get a pulmonary consult but also may need surgical consult



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