

# Preoperative work up for Lung Cancer Surgery



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# 무엇을 확인할 것인가?

- 환자는 어떤 증상을 호소하는가?
- 환자의 몸 상태는 수술을 견딜 수 있는가?
- 병의 진행 정도는 수술이 합당한가?

Clinical presentation on Lung Cancer Patients

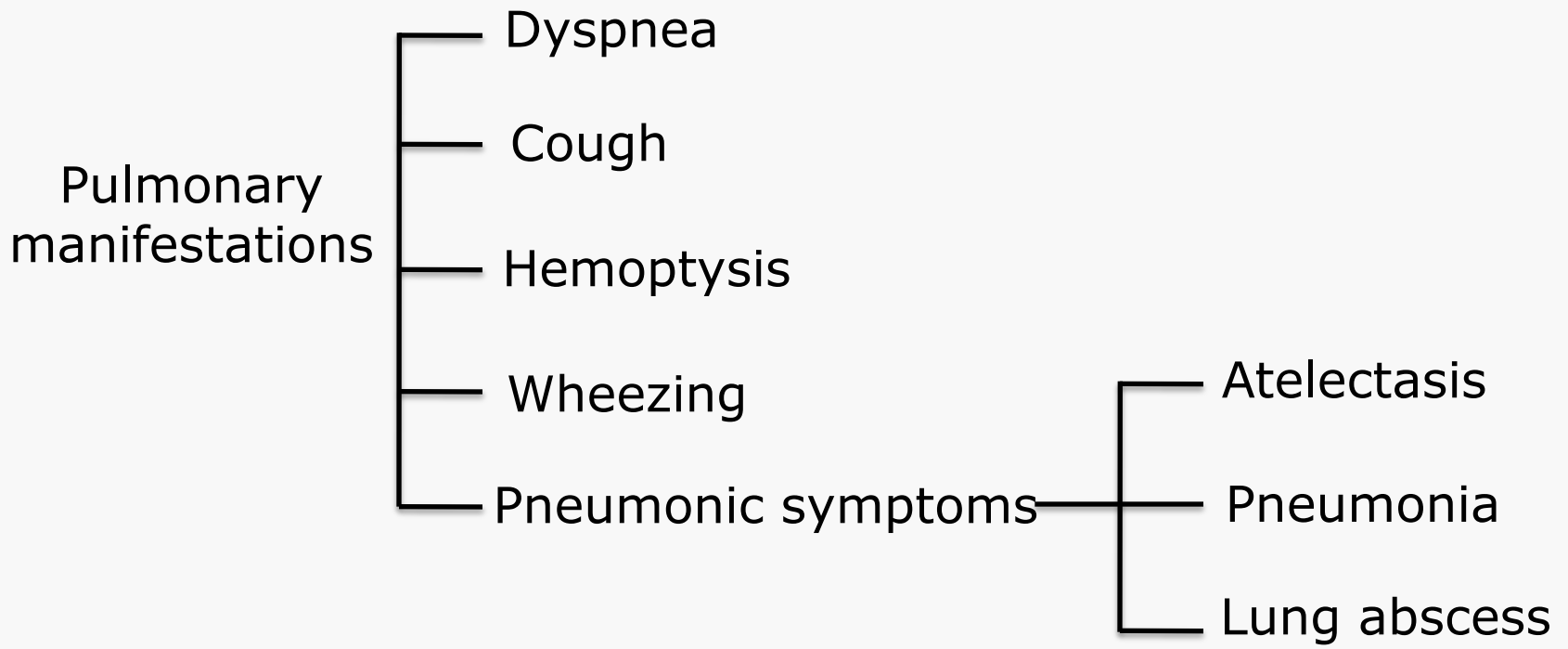
Anatomical staging of Lung cancer

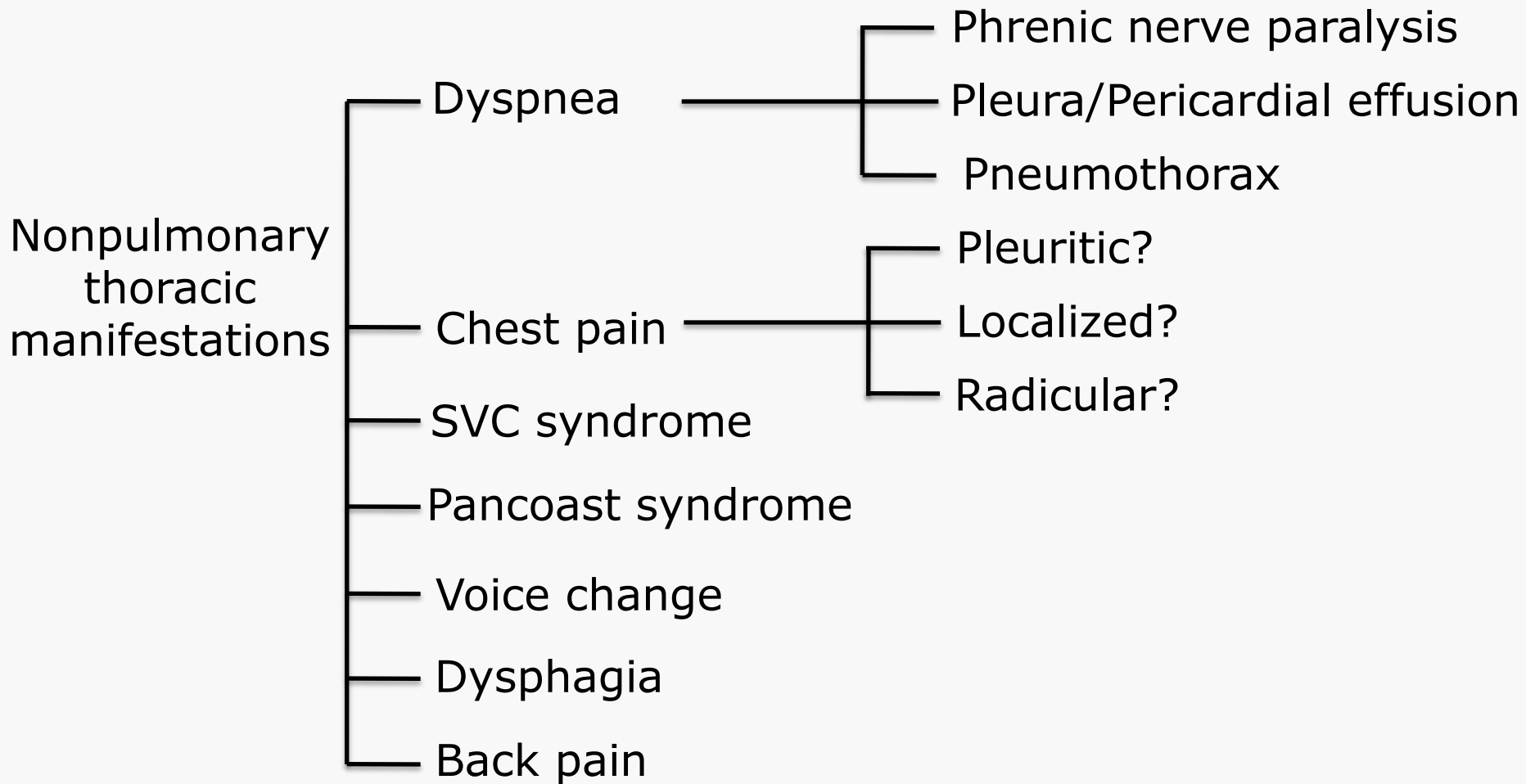
Physiologic staging of Lung cancer



# Clinical presentation

- Symptomatic lung cancer: 95%
  - 27% primary cancer related,
  - 32% metastatic related,
  - 34% non specific
- Asymptomatic: 5%
- Caustic factor: stage at presentation
  - tumor anatomic location
  - tumor histology
  - tumor biology

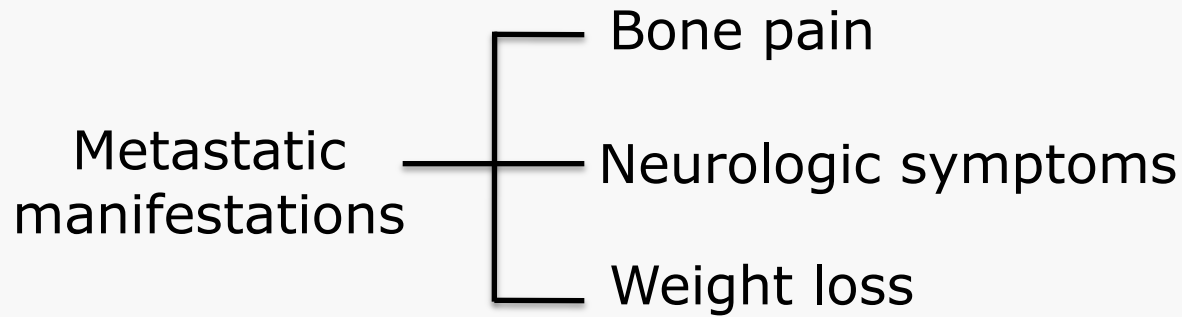
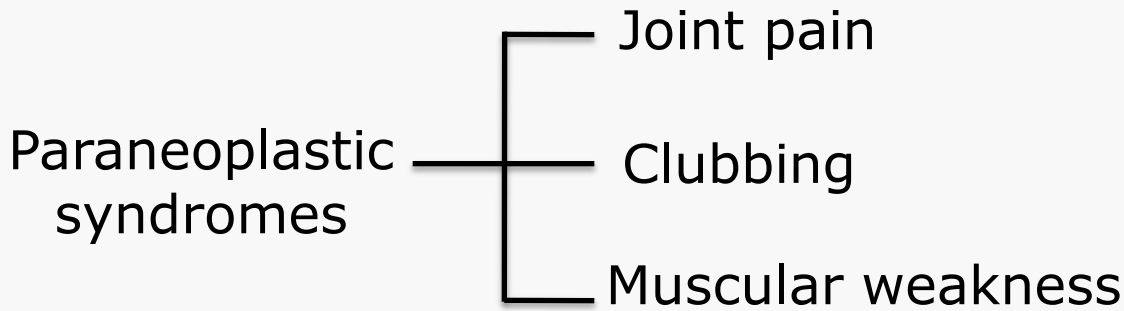


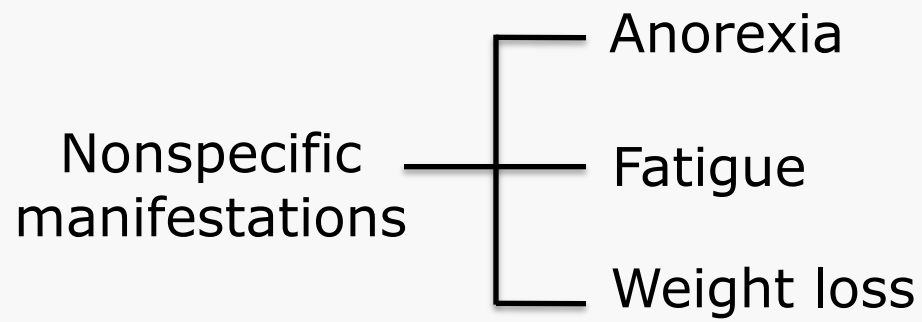




## **Pancoast syndrome ← Superior sulcus tumor**

- Shoulder pain ← direct invasion of rib and muscle
- Radicular arm pain ← invasion of C8/T1 nerve root of brachial plexus
- Horner's syndrome (enophthalmos, ptosis, miosis, anhidrosis by satellite ganglion invasion)









# TNM staging

## T 병기

- T0 원발종양의 증거가 없는 경우
- TX 원발종양에 대해 평가할 수 없거나, 객담 또는 기관지내시경 세척검사에서 악성종양 세포를 증명하였지만 영상검사나 기관지내시경검사에서 보이지 않는 경우
- TIS 상피내암종(carcinoma in situ)
- T1 종양의 장경이 3 cm 이하이면서 폐실질이나 내장쪽 흉막으로 둘러 싸여 있고 기관지내시경검사에서 엽기관지보다 근위부(주기관지)로 침범의 증거가 없는 경우
- T1a 종양의 장경이 2 cm 이하
- T1b 종양의 장경이 2 cm 보다는 크고 3 cm 이하
- T2 종양 크기가 3 cm보다 크고 7 cm 이하 또는 종양이 다음 경우 중 한 가지를 만족할 때: 주기관지를 침범했으나 기관분기부(carina)로부터 2 cm 이상 떨어져 있을 때; 내장측 흉막을 침범했을 때; 폐문까지 도달하였으나 전폐에 걸치지 않는 무기폐나 폐쇄성 폐렴을 동반했을 경우
- T2a 종양의 장경이 3 cm 보다 크고 5 cm 이하
- T2b 종양의 장경이 5 cm 보다 크고 7 cm 이하
- T3 종양의 크기가 7 cm보다 크거나 종양이 다음 중 한 가지를 직접 침범했을 때: 흉벽(상고랑종양 포함), 횡격막, 종격동 흉막, 심장막; 기관분기부 2 cm 이내로 주기관지를 침범했으나 기관분기부를 침범하지는 않았을 경우; 전폐를 침범한 무기폐나 폐쇄성폐렴을 동반한 경우; 원발종양과 같은 폐엽(lobe)에 존재하는 종양결절(들)이 있을 때
- T4 크기에 상관없이 종양이 다음 중 한 가지를 침범했을 때: 종격동, 심장, 대혈관, 기관, 성대 신경(recurrent laryngeal nerve), 식도, 척추체, 기관분기부; 종양결절(들)이 원발종양과 다른 폐엽(different ipsilateral lobe)에 있는 경우



## M 병기

M0 원위부 전이가 없는 경우

M1 원위부 전이가 있는 경우

M1a 원발종양과 반대편 폐엽(contralateral lobe)의 종양결절(들)이 있거나 종양과 관련이 있는 늑막 결절들이 있거나 악성흉수 또는 악성심낭액이 있는 경우<sup>a</sup>

M1b 원격전이가 있는 경우

<sup>a</sup> 폐암과 동반된 대부분의 흉막삼출은 종양에 의한 것이다. 그러나 여러 차례 검사에서 혈성이 아니고, 삼출액이 아니며 세포병리학적으로 음성이 나온 경우는 종양과 관련이 없는 것이며 이 경우 병기판정에서 M0으로 분류한다.

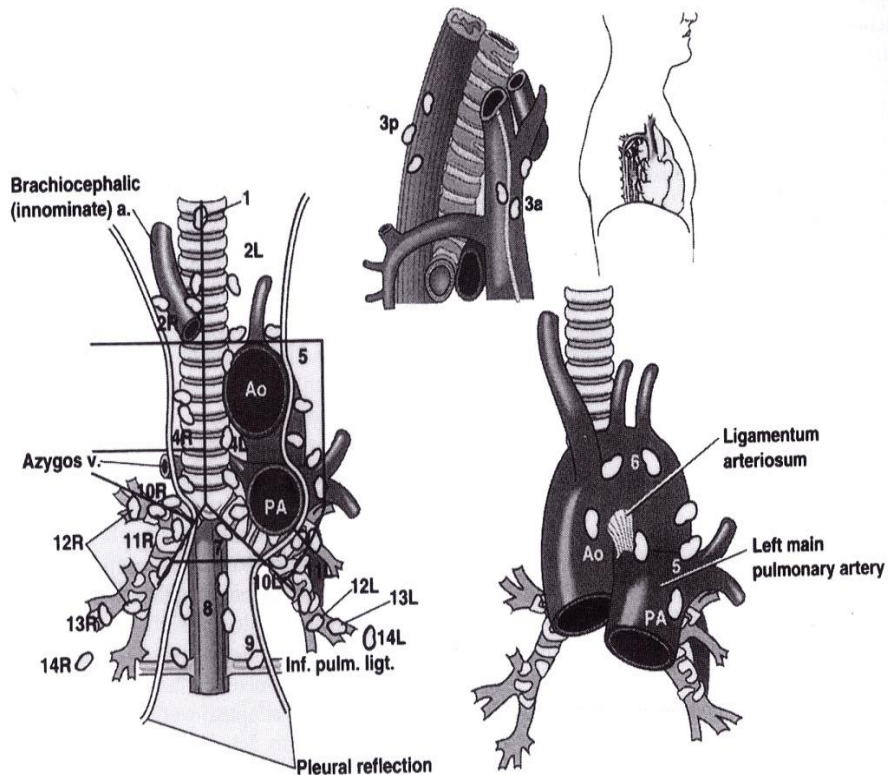


Sixth Edition T/M Descriptor	Seventh Edition T/M
T1 ( $\leq 2$ cm)	T1a
T1 ( $> 2 \sim 3$ cm)	T1b
T2 ( $\leq 5$ cm)	T2a
T2 ( $> 5 \sim 7$ cm)	T2b
T2 ( $> 7$ cm)	T3
T3 invasion	
T4 (same lobe nodules)	
T4 (extension)	T4
M1 (ipsilateral lung)	
T4 (pleural effusion)	M1a
M1 (contralateral lung)	
M1 (distant)	M1b

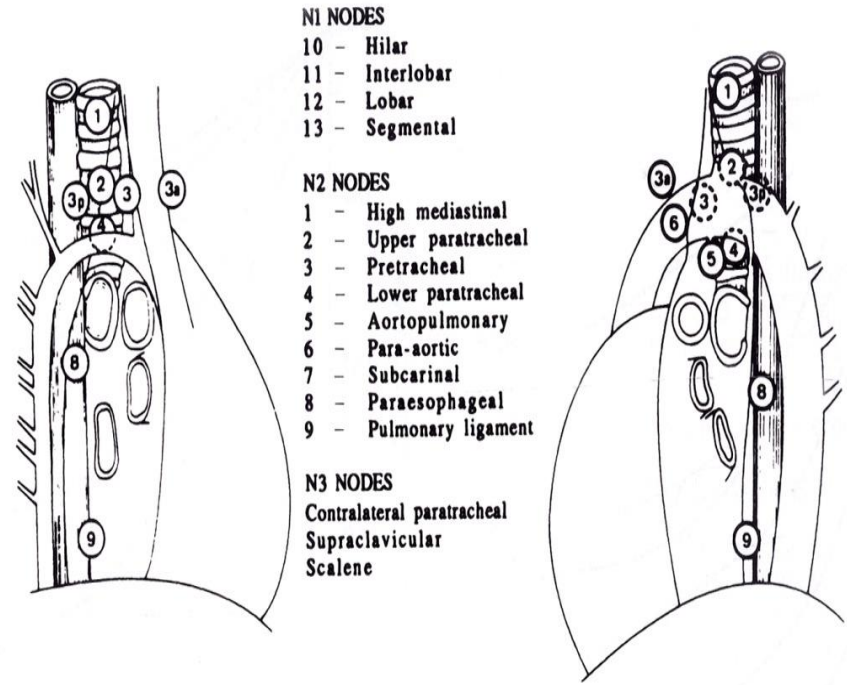




# Lymph node mapping



■ American College of Surgeons Oncology Group lymph node mapping schema showing anatomic boundaries of each lymph node station. (Reprinted with permission from the American College of Surgeons.)



■ Union Internationale Contre Cancer map. Sites of pulmonary lymph node drainage with numeric designations for each site. (From Naruke T, Suemasu K, Ishikawa S: Lymph node mapping and curability at various levels of metastasis in resected lung cancer. J Thorac Cardiovasc Surg 76:832, 1978.)



임상병기

IA기, IB기, IIA기  
IIB기(T3 병변: >7cm,  
같은 엽 내 위성병변)  
IIIA기(T4N0-1:  
동측 폐 위성병변)

치료 전 검사

기관지내시경\*  
PET/CT  
EBUS\*\*  
종격동내시경\*\*\*  
뇌 MRI  
(II기 이상인 경우)

종격동림프절  
평가

종격동림프절  
음성

수술가능

수술  
고위험군<sup>+</sup>

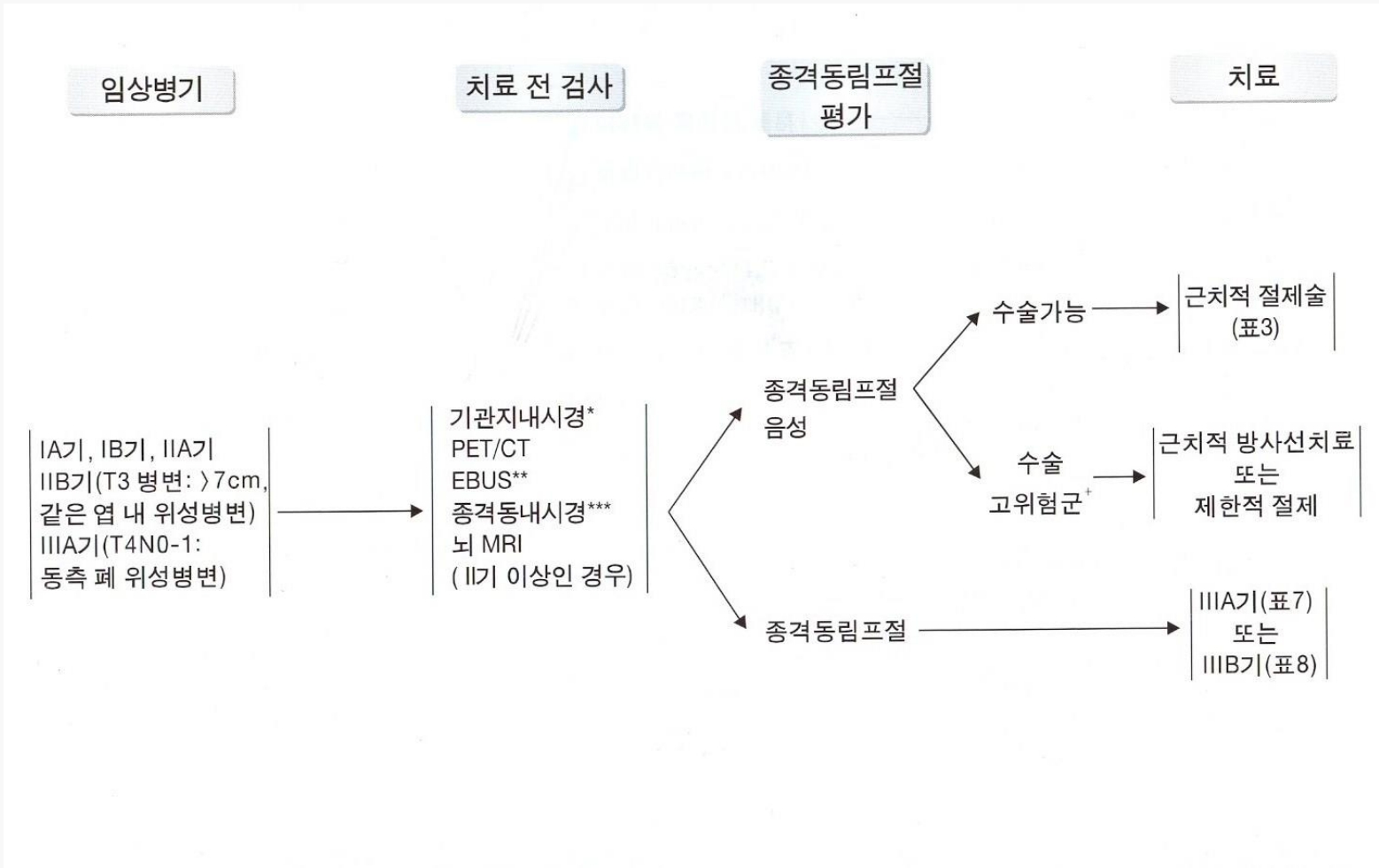
종격동림프절

치료

근치적 절제술  
(표3)

근치적 방사선치료  
또는  
제한적 절제

IIIA기(표7)  
또는  
IIIB기(표8)





# Diagnostic Tools

- T stage: chest x-ray, chest CT, bronchoscopy, PET-CT, (MRI)
- N staging: chest CT, PET-CT  
TBNA, EBUS-TBNA,  
mediastinoscopy, mediastionotomy
- M staging: physical exam, bone scan,  
brain CT(MRI), PET-CT



# Enlarged L.N. on chest CT

- Positive CT result( $> 1\text{cm}$ ): 70% actual metastasis  
→ histological confirm
- False-negative rate less than 10% in negative CT result( $< 1\text{cm}$ )  
→ T1/T2 + negative CT result: histologic confirm(?)  
(mediastinoscopy?)  
*cf.* 28% false-negative rate on central T3  
→ histological confirm(Daly et al. JTCS 94;664 1987)
- cf.* High rate of early metastasis in T1 adenoca, large cell ca



# Mediastinoscopy/Mediastinotomy

Histologic diagnosis

Accurate determine the N2

Identify extranodal extension of tumor/  
involvement of contiguous structure(trachea/ aorta)

Identify N3

## Indication

1. L.N. enlargement more than 1cm on preop CT
2. Potential entry to neoadjuvant therapy protocol
3. Negative CT result in T2, T3 tumor and T1 adenoca/large cell ca(relative)





# Mediastinoscopy/Mediastinotomy

## **Routine mediastinoscopy (with negative CT scan)**

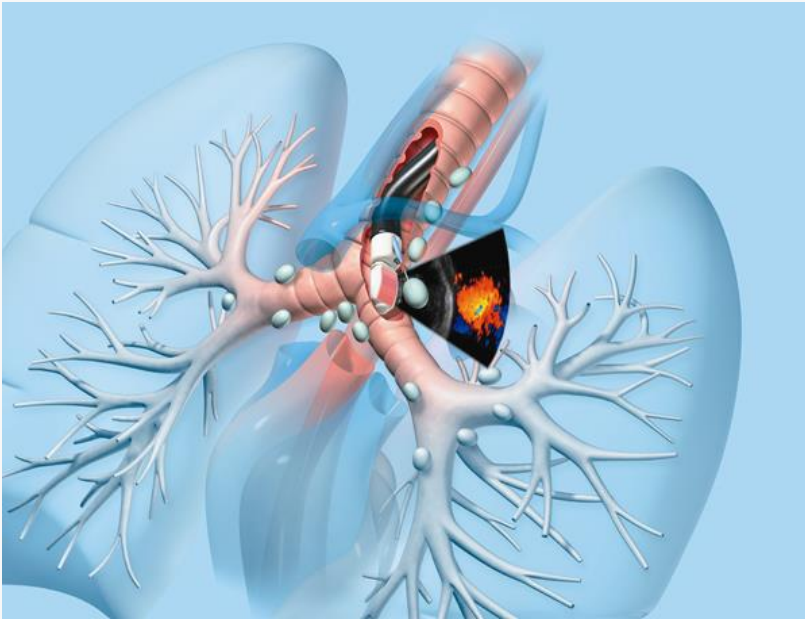
- Low complication rate
- Resectable N2 without neoadjuvant Tx(single station, ipsilateral, lower paratracheal, no extracapsular extension)
- High rate of thoracotomy(curative resection)
- 10-15% false negative rates on chest CT

## **Selective mediastinoscopy**

- High rate of negative mediastinoscopic examination(70%)
- Possible complete resection of unsuspected N2
  - ★ unsuspected N2: 8.9%(mostly inaccessible site; post subcarinal, periesophageal, anterior mediastinal\_)



# EBUS(+TBNA)



- 2007 ACCP:  
invasive staging  
mediastinoscopy 대체 in  
stage II or central cancer
- 2009 NCCN:  
IIIB 치료전 종격동검사  
방법으로 권유
- Node: 1R, 1L, 2R, 4R, 7,  
10, 11(+)  
5, 6, 8, 12(-)
- Sensitivity 95%, specificity  
100%



# EBUS(+TBNA) 적용

- 폐암의 진단.  
peripheral lung cancer  
central parenchymal lung cancer, bronchoscopy(-)
- 폐암의 림프절 병기결정  
PET N2(+) lung cancer: 민감도 93%, 정확도 97%, 음성예측율 91%  
PET N2(-) lung cancer: 민감도 89%, 음성예측율 98.9%  
→ adenocarcinoma / >5mm mediastinal node
- **Restaging the mediastinum after CCRT**  
민감도 76%, 정확도 77%, 음성예측율 20%로 치료전 시행된 것에 비해 낮은 민감도와 정확도 → 추가적 수술확인 필요
- 원인 불분명한 **hilar, mediastinal Lymphadenopathy**
- **Mediastinal mass**



# EBUS(+TBNA)

EBUS-TBNA 에서 림프절을 몇 회까지 흡인하는 것이 적절한가?

Table 7. Cumulative Diagnostic Values of EBUS-TBNA Shown by the Number of Aspirations

Variables	Aspirations, No.			
	1	2	3	4
Sensitivity	69.8 (30/43)	83.7 (36/43)	95.3 (41/43)	95.3 (41/43)
Specificity	100 (83/83)	100 (83/83)	100 (83/83)	100 (83/83)
PPV	100 (30/30)	100 (36/36)	100 (41/41)	100 (41/41)
NPV	86.5 (83/96)	92.2 (83/90)	97.6 (83/85)	97.6 (83/85)
Accuracy	89.7 (113/126)	94.4 (119/126)	98.4 (124/126)	98.4 (124/126)

\*Data are presented as % (No./total). We considered inadequate samples as negative results.

종격종 림프절의 최대한의 정확도를 얻기 위해서는 3회의 흡인이 필요하고 tissue core를 획득한 경우는 2회의 흡인이 필요하다.



# PET-CT

- 양전자방출, 동위원소: F-18 fluorodeoxyglucose(FDG)
- 폐암세포는 정상세포보다 포도당흡수가 증가, 당분해(glycolysis)속도가 높다.
- PET-CT: CT 해부학적 구조(node size)  
+ PET 기능적 구조(metabolism)
- Granulomatous lesion(tuberculoma, histoplasmosis, rheumatoid nodule), inflammatory disease에서 양성
- 크기가 1-1.2cm보다 작을경우 확인 안될 수도 있다.  
False (+) 20%, false (-) 20%
- Carcinoid tumor, bronchioloalveolar carcinoma: PET(-)
- PET detect unexpected distant meta in 10-15% NSCLC  
& unexpected mediastinal node meta in 10%
- 종격동 PET-CT(-): 술전 mediastinoscopy시행하지 않아도 됨.  
양성인 경우는 invasive test(mediastinoscopy or EBUS) 필요



# Mediastinal staging of lung cancer: novel concepts

*Kurt G Tournoy, Steven M Keller, Jouke T Annema*

Clinical TNM staging is the standard method used to decide treatment for patients with non-small-cell lung cancer. Although integrated fluorodeoxyglucose (FDG) PET CT increases the accuracy of staging, it only guides direct tissue sampling. Histological assessment of mediastinal lymph nodes has traditionally been done with mediastinoscopy, a surgical procedure. Endobronchial and oesophageal ultrasound-guided lymph node sampling have been assessed as additions or alternatives to mediastinoscopy. We review endosonography and surgical staging, and show that both have a place in the mediastinal staging of lung cancer. We conclude that mediastinal tissue staging should preferentially start with a complete endosonographic assessment. A surgical mediastinoscopy should be reserved for those in whom the endosonography result is negative. Further refinement of this recommendation is likely in the near future because data suggest that the confirmatory mediastinoscopy is particularly useful for patients with enlarged or FDG-avid lymph nodes.

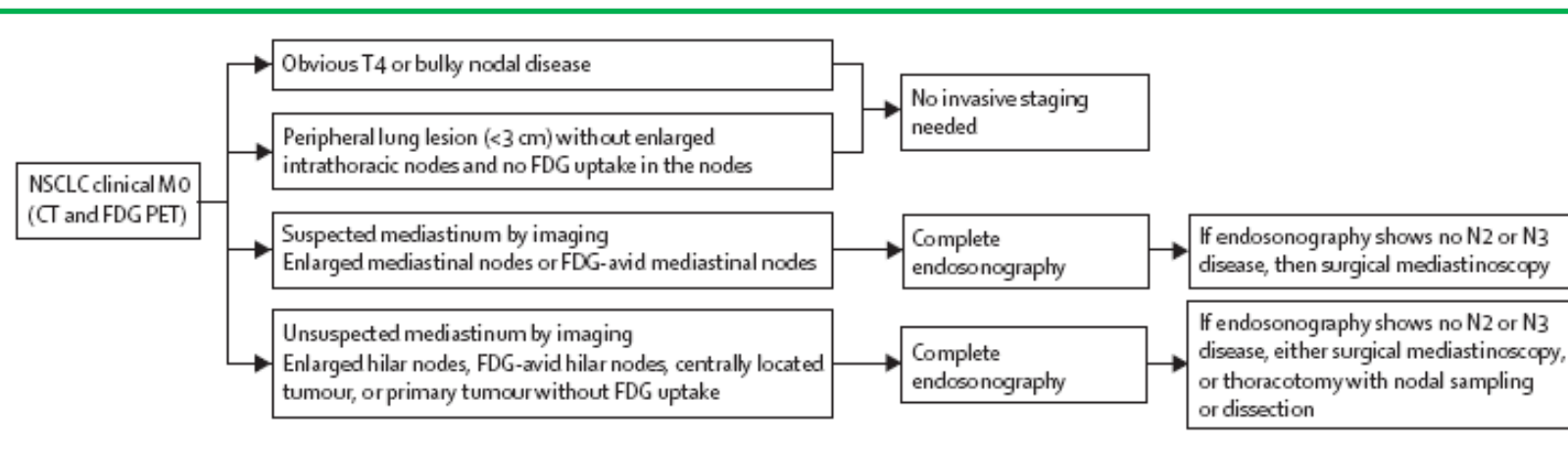
*Lancet Oncol 2012; 13: e221-29*

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	Design	Patients enrolled (n)	Received EUS-FNA and EBUS-TBNA (n)	Analysed (n)	N2 or N3 prevalence (%)	Sensitivity (%; 95% CI)	NPV (%; 95% CI)
Ohnishi, <sup>42</sup> 2011*	Cohort	120	115	110	28%	84% (67-93)	94% (87-97)
Annema, <sup>45</sup> 2010	RCT	242	123 (1 group)	123	54%	85% (74-92)	85% (75-92)
Hwangbo, <sup>44</sup> 2010†	Cohort	150	149	143	31%	91% (78-97)	96% (90-98)
Herth, <sup>43</sup> 2010†	Cohort	150	150	139	51%	96% (88-99)	96% (88-99)
Szlobowski, <sup>41</sup> 2010*	Cohort	120	120	120	23%	68% (48-84)	91% (83-96)
Wallace, <sup>40</sup> 2008	Cohort	138	138	138	30%	93% (81-99)	97% (91-99)
Rintoul, <sup>38</sup> 2005‡	Cohort	20	7	7	57%	75% (19-99)	75% (19-99)
Vilmann, <sup>39</sup> 2005‡	Cohort	33	31	28	71%	100% (83-100)	100% (63-100)

95% CIs were taken from the article, or if not provided, were calculated with binomial expansion. RCT=randomised controlled trial. NPV=negative predictive value. EUS-FNA=endoscopic ultrasound-guided fine-needle aspiration. EBUS-TBNA=endobronchial ultrasound with real-time-guided transbronchial needle aspiration. PET=positron emission tomography. CT=computed tomography. \*Prevalence of malignant nodal metastasis was low because Ohnishi<sup>42</sup> included any clinical T<4N<M0 after imaging while Szlobowski<sup>41</sup> included only patients with normal mediastinal nodes (selected with CT, no PET CT available). †EUS-FNA and EBUS-TBNA done with a single (EBUS) endoscope. ‡Feasibility reports, not trials assessing test characteristics.

**Table 1: Studies of complete endosonography to stage the mediastinum**



**Figure 4: Proposed algorithm for mediastinal staging in patients with non-metastatic non-small-cell lung cancer based on CT PET findings**  
 CT=computed tomography. PET=positron-emission topography. FDG=fluorodeoxyglucose. NSCLC=non-small-cell lung cancer.





# Investigation and Management of Nodules Less than One Centimeter in Size



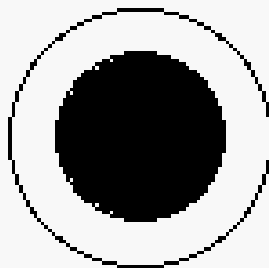


# Benign vs Malignant

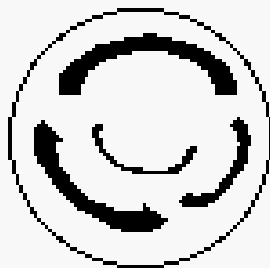
- **Most of pul. Nodules**
  - Postinflammatory change
  - Calcification is the most definitive finding for benign inflammatory lesion
  
- **Malignant**
  - Diffusely calcified nodule



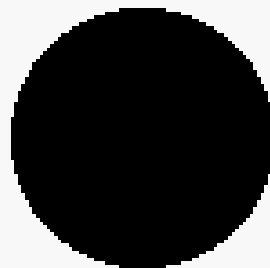
# Benign SPN Calcification Patterns



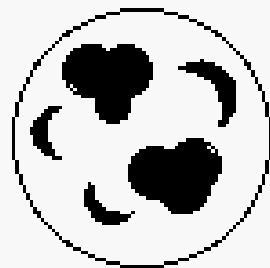
Central  
Calcification



Laminar  
Calcification

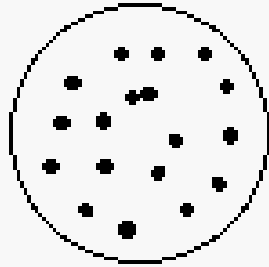


Diffuse  
Calcification

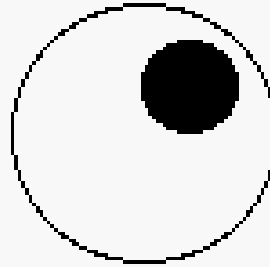


Popcorn / Chondroid  
Calcification

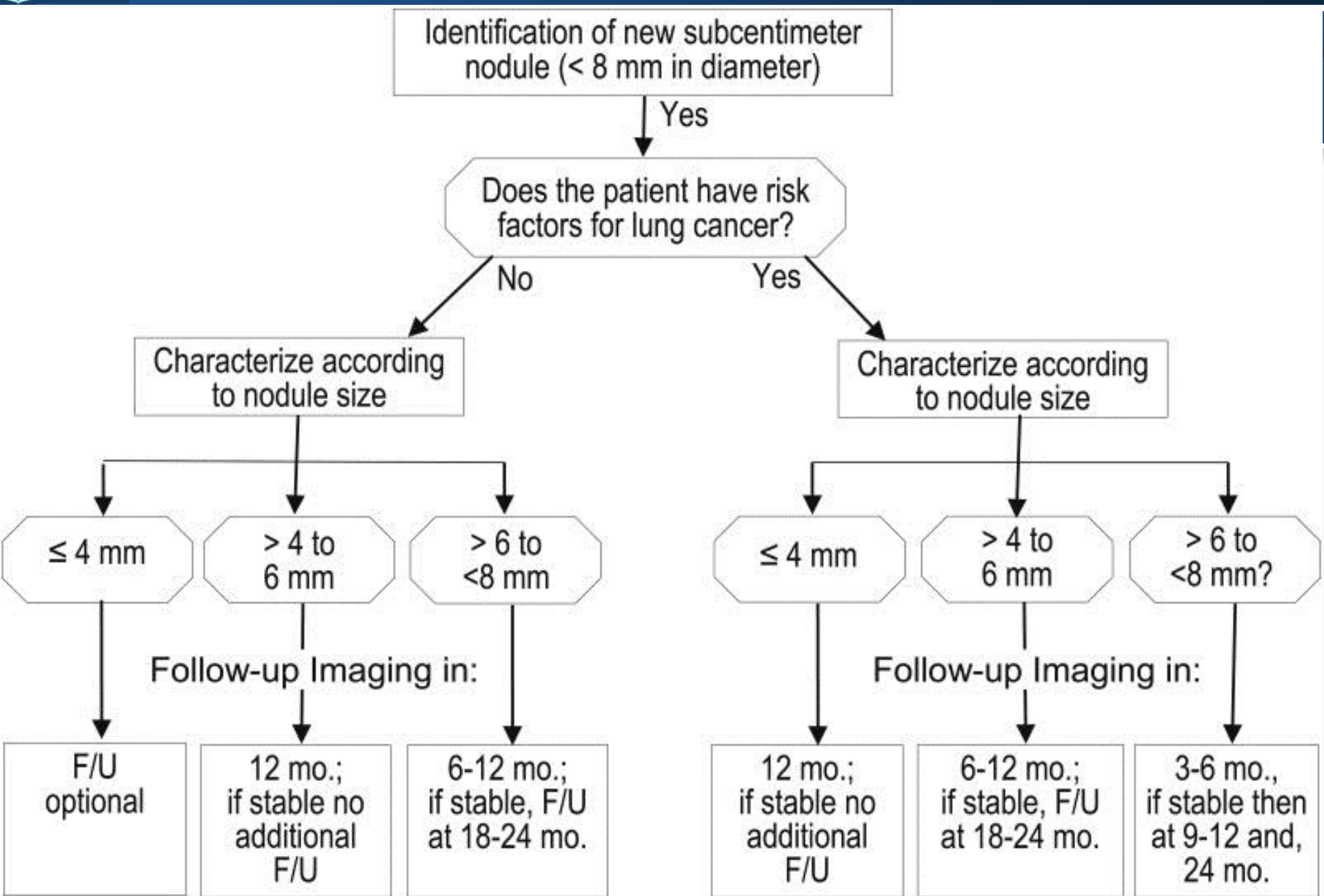
## Potentially Malignant SPN Calcification Patterns



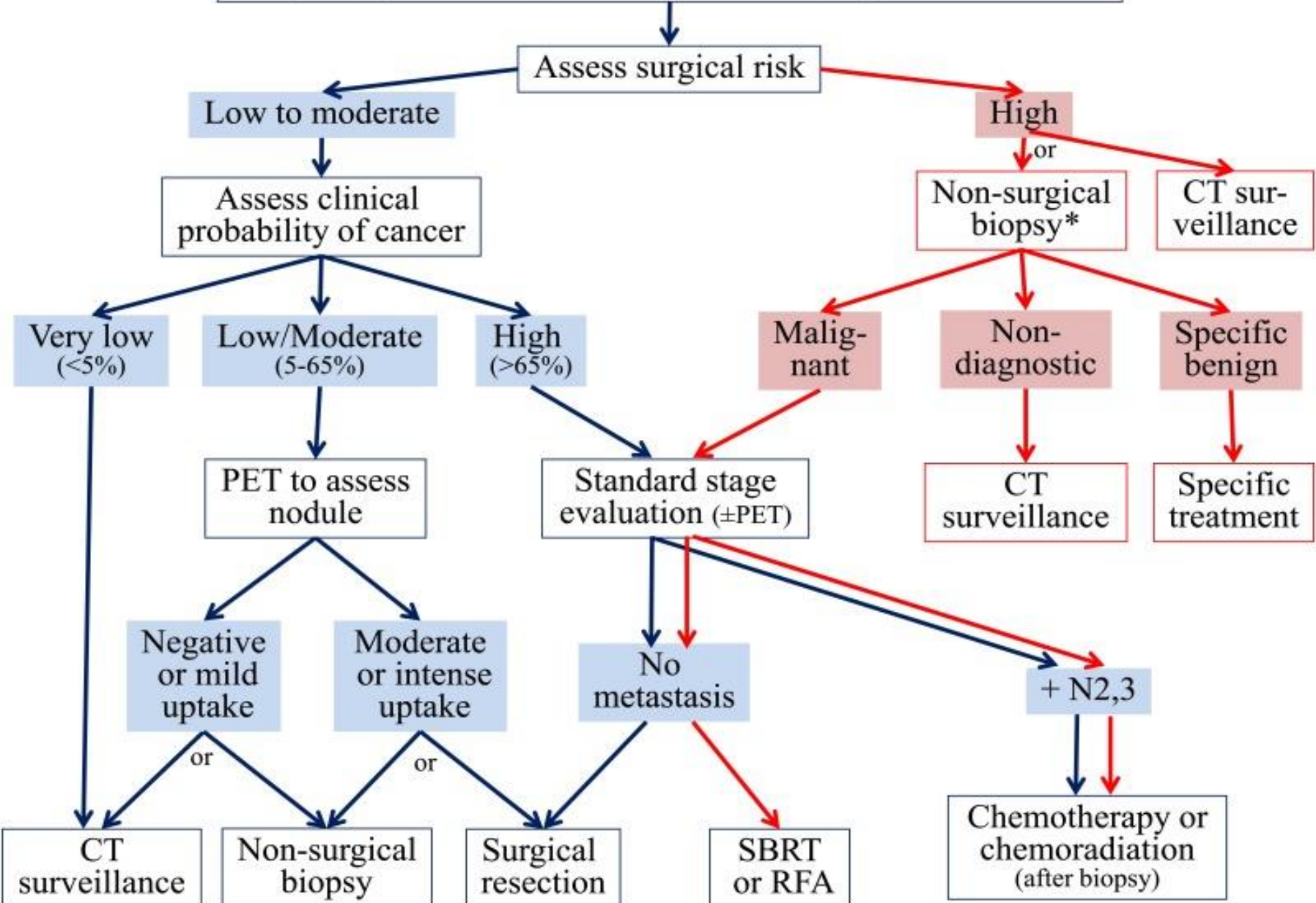
Speckled  
Calcification



Eccentric  
Calcification



New, solid, indeterminate nodule on chest CT, 8 mm to 30 mm





Assessment Criteria	Probability of Malignancy		
	Low (< 5%)	Intermediate (5%- 65%)	High (> 65%)
Clinical factors alone (determined by clinical judgment and/or use of validated model) <sup>a</sup>	Young, less smoking, no prior cancer, smaller nodule size, regular margins, and/or non-upper-lobe location	Mixture of low and high probability features	Older, heavy smoking, prior cancer, larger size, irregular/spiculated margins, and/or upper-lobe location
FDG-PET scan results	Low-moderate clinical probability and low FDG-PET activity	Weak or moderate FDG-PET scan activity	Intensely hypermetabolic nodule
Nonsurgical biopsy results (bronchoscopy or TTNA)	Specific benign diagnosis	Nondiagnostic	Suspicious for malignancy
CT scan surveillance	Resolution or near-complete resolution, progressive or persistent decrease in size, <sup>b</sup> or no growth over $\geq 2$ y (solid nodule) or $\geq 3-5$ y (subsidiary nodule)	NA	Clear evidence of growth



# Definitive Diagnosis

- **CT-guided FNAB**
- **Transbronchial Bx**
- **VATS Bx with Marking tools**
  - Needle
  - Methylene blue
  - intraoperative ultrasound (gamma probe)
  - Technetium-99m (percutaneous or transbronchial)



# Physiologic staging

- Age
- Pre-existing lung condition(lung function)
- Cardiovascular fitness
- Nutrition and performance status  
(recent weight loss)
- Smoking
- Obesity
- Patient attitude toward the disease





# Age

- Perioperative morbidity increase with advancing age → preop careful assessment of co-morbid
- Clinically stage I, II over 70yrs: same with younger patients (beyond stage II, survival is very poor)
- In Stage I, over 80 is not contraindication to lobectomy
- Pneumonectomy is higher mortality risk (6-36%) in elder, Age should be a factor in deciding suitability for pneumonectomy



**TABLE 2-1** Scales for Assessing Individual Performance Status

Grade	ECOG <sup>1</sup>	Score	Karnofsky <sup>2</sup>
0	Fully active, able to carry on all predisease performance without restriction	100	Normal, no complaints; no evidence of disease
		90	Able to carry on normal activity; minor signs or symptoms of disease
1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature (e.g., light housework, office work)	80	Normal activity with effort; some signs or symptoms of disease
2	Ambulatory and capable of all self-care but unable to carry out any work activities; up and about more than 50% of waking hours	70	Cares for self; unable to carry on normal activity or to do active work
		60	Requires occasional assistance, but is able to care for most personal needs
3	Capable of only limited self-care; confined to bed or chair more than 50% of waking hours	50	Requires considerable assistance and frequent medical care
4	Completely disabled; cannot carry on any self-care; totally confined to bed or chair	40	Disabled; requires special care and assistance
		30	Severely disabled; hospital admission is indicated although death is not imminent
		20	Very sick; hospital admission necessary; active supportive treatment necessary
		10	Moribund; fatal processes progressing rapidly
5	Dead	0	Dead

<sup>1</sup>Oken MM, Creech RH, Tormey DC, et al: Toxicity and response criteria of the Eastern Cooperative Oncology Group. *Am J Clin Oncol* 5:649-655, 1982.

<sup>2</sup>Hollen PJ, Gralla RJ, Kris MG, et al: Measurement of quality of life in patients with lung cancer in multicenter trials of new therapies. *Cancer* 73:2087-2098, 1994.



# PFT

## **Poor resp function → perioperative morbidity/mortality**

postop long term disability

poor quality of life

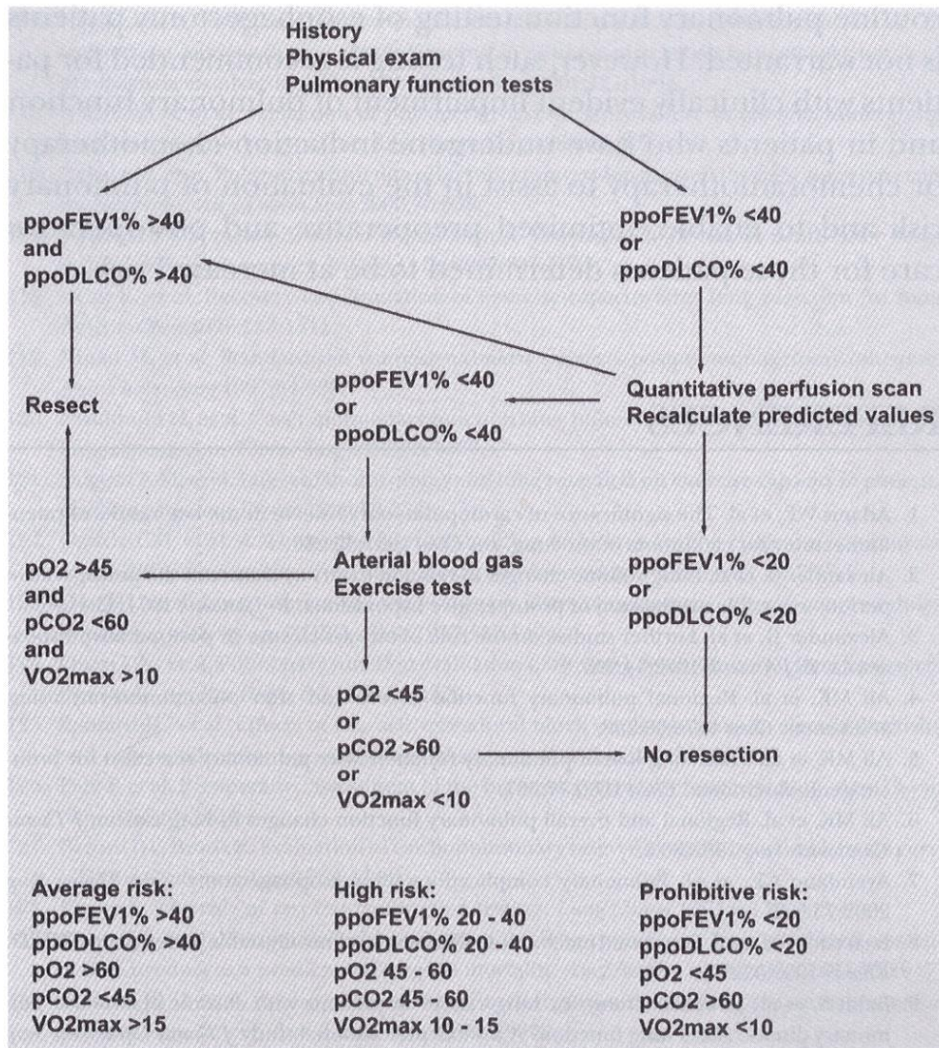
## **Additional test in poor, risk PFT test**

Ventilation/perfusion scan (ppoFEV1, ppoDLCO)

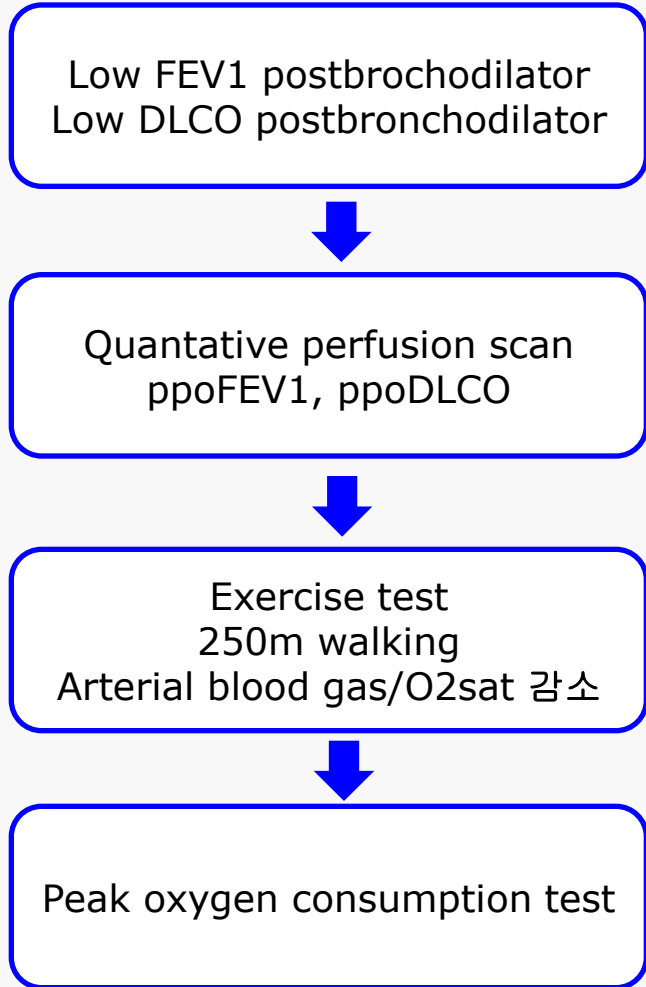
VO<sub>2</sub>max

SaO<sub>2</sub> after exercise

## **3 most important predictors of severe pul complications: $D_{LCO}$ , FEV1/FVC, A-aDO<sub>2</sub>**



Suggested algorithm for evaluating patients for their suitability for major lung resection (ppoFEV<sub>1</sub> %: predicted postoperative FEV<sub>1</sub> expressed as a percent of normal; ppoDLCO%: predicted postoperative diffusing capacity expressed as a percent of normal; PO<sub>2</sub>: PO<sub>2</sub> in mm Hg; PCO<sub>2</sub>: PCO<sub>2</sub> in mmHg; VO<sub>2</sub>max: VO<sub>2</sub>max in mL/kg per minute).



## Absolute contraindication for resection

- ppoFEV<sub>1</sub> < 0.8 L
- VO<sub>2</sub>max < 10ml/kg/min
- ↑CO<sub>2</sub>(cor pulmonale) in pneumonectomy



# Cardiovascular Fitness

- All patients for lung resection should have preop ECG
- All patients with audible cardiac murmur should have echocardiogram
- After MI, operation for lung resection should not be done within 6 weeks
- MI within 6 months, ask cardiology opinion
- CABG should not preclude lung resection
- Pt with significant lesion on coronary angiography should be considered for CABG before lung resection
- All patients with history of stroke, TIA, carotid bruits, should be assessed with carotid doppler

# Cardiovascular Fitness

*Table 3 Importance of multiple risk factors*

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Risk factors:	High risk surgery (includes intrathoracic) Ischaemic heart disease Congestive heart failure Insulin dependent diabetes Creatinine >177 $\mu\text{M/l}$
Number of factors*	Major cardiac complications**
1	1.1%
2	4.6%
$\geq 3$	9.7%

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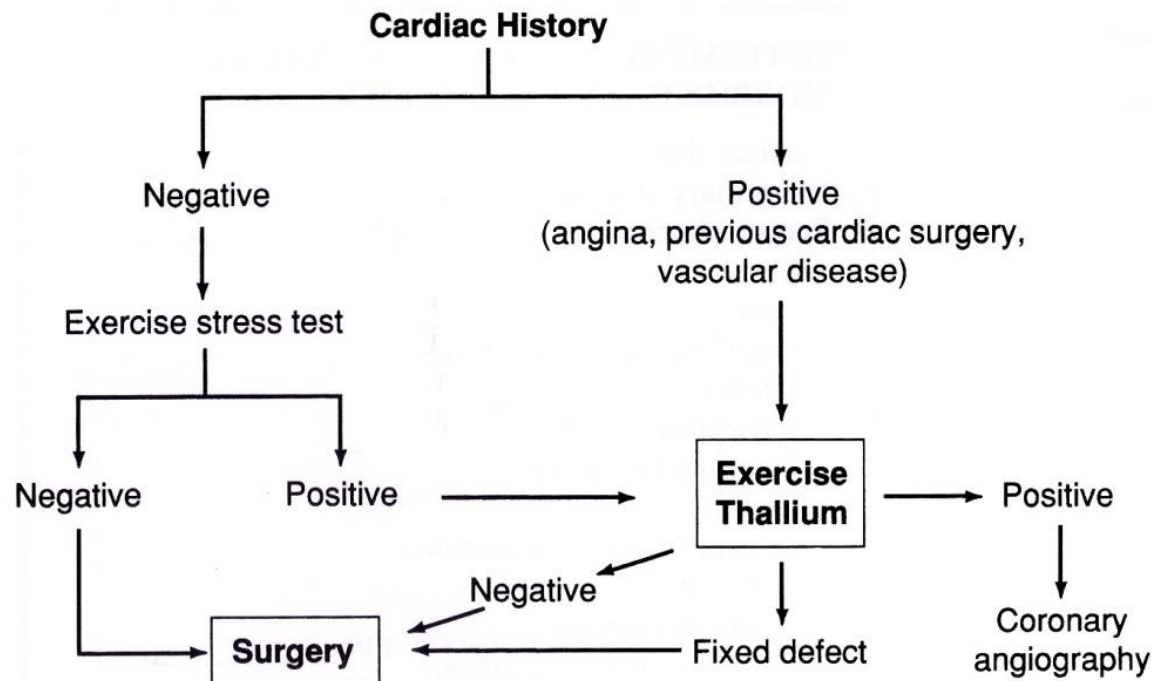
\*As intrathoracic surgery is classified as a risk factor, all patients undergoing surgery for lung cancer have at least one factor.

\*\*Myocardial infarction, pulmonary oedema, ventricular fibrillation or primary cardiac arrest, complete heart block.





# Cardiovascular Fitness



A suggested algorithm for investigating the cardiac status of all patients over the age of 45 or those with significant risk factors undergoing major thoracic surgery. (Adapted from Miller JI: Preoperative evaluation. Chest Surg Clin North Am 4:701, 1992.)



# Weight loss, Performance status, Nutrition

- Patient with preop wt loss  $>10\%$  or more
- And/or WHO 2 or worse  $\rightarrow$  particular care staging assessment
- Measure of nutritional status( body mass index, serum albumin level)



## DETERMINANTS OF POSTOPERATIVE MORBIDITY AND MORTALITY\*

Cardiac disease

Pulmonary disease

Tumor characteristics

Stage

Type

General medical conditions

Diabetes

Creatinine level

Hemoglobin level

Serum albumin level

Immunosuppressed status

Steroids

Chemotherapy

Other chronic illnesses

Weight loss >10%

Age >70

Anticipated surgery

Extent of resection

Additional procedures

Side of pulmonary resection (R > L)

Previous surgery

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\*Significant cardiopulmonary disease, late tumor stage, and extent of resection appear to be the most significant determinants.