의료에 신뢰를 더하다. JBUH+

Optimal management of subsolid pulmonary nodules

SeungYong Park, MD, PhD

Clinical Professor

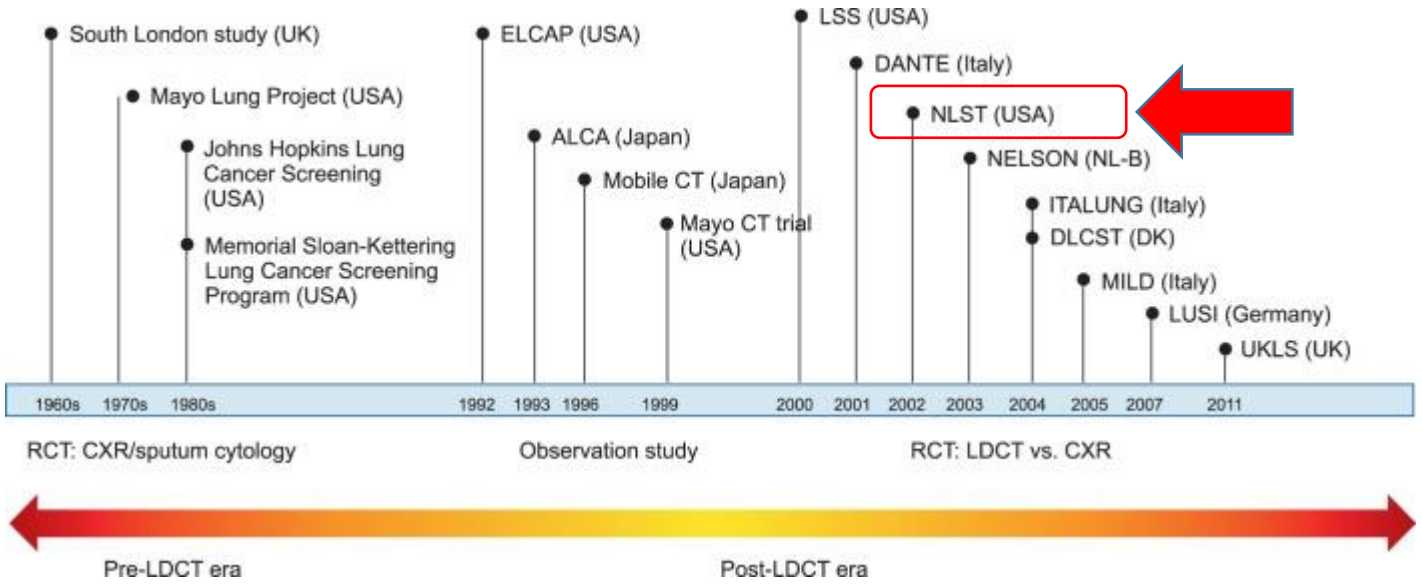
Division of Pulmonary, Allergy and Critical Care Medicine

Department of Internal Medicine

Jeonbuk National University Hospital

전북대학교병원
JEONBUK NATIONAL UNIVERSITY HOSPITAL

Hx of Lung Cancer Screening



- Chest PA
- Chest PA + sputum cytology
- Tumor marker
  - CEA(Carcinoembryonic antigen), SCC Ag(Squamous cell carcinoma antigen), CYFRA 21, Neuron specific enolase

Am J Respir Crit Care Med 1997;133:320
Respir Med 1995;89:587

- LDCT(low-dose chest CT)

RCTs on LDCT screening for lung cancer

Study	Country	Start	Control	No.	Enroll criteria		
					Age (yr)	Smoking	Others
LSS[13]	USA	2000	CXR	3318	55–74	>30PY, quit<10 yr	-
DANTE[14]	Italy	2001	Obs.	2472	60–74	>20PY, quit<10 yr	Only male subjects?
NLST[6]	USA	2002	CXR	53000	55–74	>30PY, quit<15 yr	-
NELSON[15]	NL-B	2003	Obs.	15822	50–75	>15PY, quit≤10 yr	-
ITALUNG[16]	Italy	2004	Obs.	3206	55–69	>20PY, quit<10 yr	-
DLCST[12]	DK	2004	Obs.	4104	50–70	>20PY, quit<10 yr	-
MILD[17]	Italy	2005	Obs.	4099	≥49	>20PY, quit<10 yr	-
LUSI[18]	Germany	2007	Obs.	4052	50–69	Heavy	-
UKLS[19]	UK	2011	Obs.	32000	50–75	-	Risk>5%/5 yr

LSS: Lung Screening Study; CXR: chest X-ray; DANTE: Detection and Screening of Early Lung Cancer; NLST: National Lung Screening Trial; UKLS: UK Lung Screen; PY: pack years.

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 4, 2011 VOL. 365 NO. 5

Reduced Lung-Cancer Mortality with Low-Dose Computed Tomographic Screening

The National Lung Screening Trial Research Team*

Table 2. Results of Three Rounds of Screening.*

Screening Round	Low-Dose CT				Chest Radiography			
	Total No. Screened	Positive Result	Clinically Significant Abnormality Not Suspicious for Lung Cancer	No or Minor Abnormality	Total No. Screened	Positive Result	Clinically Significant Abnormality Not Suspicious for Lung Cancer	No or Minor Abnormality
			no. (% of screened)				*no. (% of screened)*	
T0	26,309	7191 (27.3)	2695 (10.2)	16,423 (62.4)	26,035	2387 (9.2)	785 (3.0)	22,863 (87.8)
T1	24,715	6901 (27.9)	1519 (6.1)	16,295 (65.9)	24,089	1482 (6.2)	429 (1.8)	22,178 (92.1)
T2	24,102	4054 (16.8)	1408 (5.8)	18,640 (77.3)	23,346	1174 (5.0)	361 (1.5)	21,811 (93.4)

* The screenings were performed at 1-year intervals, with the first screening (T0) performed soon after the time of randomization. Results of screening tests that were technically inadequate (7 in the low-dose CT group and 26 in the radiography group, across the three screening rounds) are not included in this table. A screening test with low-dose CT was considered to be positive if it revealed a nodule at least 4 mm in any diameter or other abnormalities that were suspicious for lung cancer. A screening test with chest radiography was considered to be positive if it revealed a nodule or mass of any size or other abnormalities suspicious for lung cancer.

N Engl J Med 2011;365:395-409.

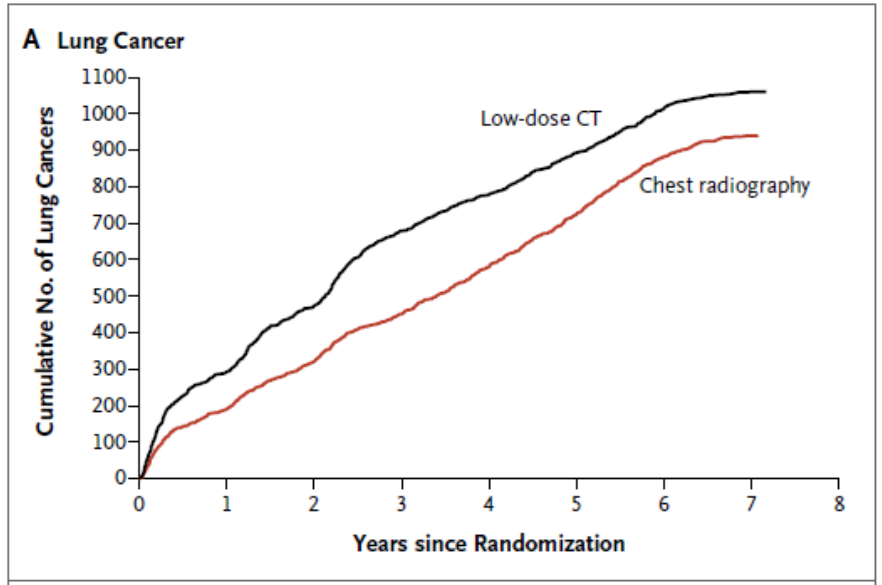


Figure 1. Cumulative Numbers of Lung Cancers and of Deaths from Lung Cancer.

The number of lung cancers (Panel A) includes lung cancers that were diagnosed from the date of randomization through December 31, 2009. The number of deaths from lung cancer (Panel B) includes deaths that occurred from the date of randomization through January 15, 2009.

- Relative reduction in <u>lung cancer mortality</u>
  - 20% (95% CI, 6.8 to 26.7; *P=0.004*)
- Relative reduction in <u>any cause mortality</u>
  - 6.7% (95% CI, 1.2 to 13.6; *P=0.02*)

N Engl J Med 2011;365:395-409.

보건복지부

보 도 자 료

12월 19일(수) 위원회 종료 후

배 포 일	2018. 12. 19. / (총 6매)	담당부서	질병정책과
과 장	김 기 남	전 화	044-202-2510
담 당 자	장 은 섭		044-202-2515

2019년부터 국가암검진 6종(폐암 추가)으로 확대

[별표1] 암의 종류별 검진주기와 연령 기준 등 (제8조 제2항 관련)

암의 종류	검진 주기	연령 기준 등
위암	2년	40세 이상의 남·여
간암	6개월	40세 이상의 남·여 중 간암 발생 고위험군
대장암	1년	50세 이상의 남·여
유방암	2년	40세 이상의 여성
자궁경부암	2년	20세 이상의 여성
폐암	**2년**	**54-74세** 남·여 중 폐암 발생 고위험군

❖비고: "간암 발생 고위험군"이란 간경변증, B형간염 항원 양성, C형간염 항체양성, B형 또는 C형 간염 바이러스에 의한 만성 간질환 환자를 말한다.

"**폐암 발생 고위험군**"이란 **30갑년**(하루 평균 담배소비량(갑)×흡연기간(년)) 이상의 흡연력을 가진 **현재 흡연자**와 폐암 검진의 필요성이 높아 보건복지부 장관이 고시로 정하는 사람을 말한다.

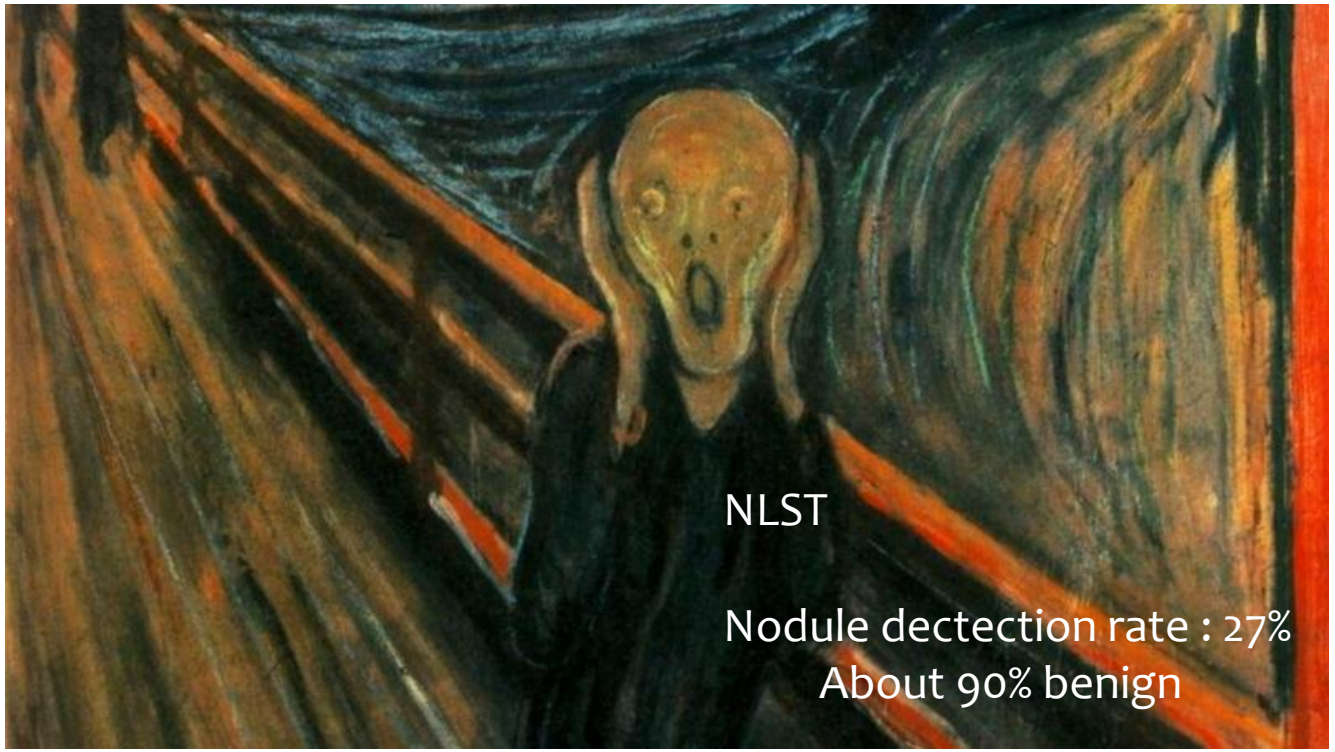
폐암검진 검사항목, 검진비용, 대상자 및 검사방법

구분	검사항목	검진비용 (분류번호)	대상자	검사방법
폐암	**1. 저선량 흉부CT 검사**		만 54-74세, 30갑년 이상 흡연력을 가진 폐암 발생 고위험군	**16열 이상의** CT검사 장비를 이용하여 **3.0mGy 이하**의 방사선량으로 **1.5mm 미만 절편** 두께로 검사를 시행하여야 한다.
	-촬영 및 판독료 -Full PACS	HA434 방사선영상 진단료	-해당 연도 전 2년내 일반건강검진(생애전환기 건강검진 포함) 또는 건강보험 금연치료 참여자의 **흡연력 문진표**로 흡연력이 확인되는 자	저선량 흉부CT 검사 결과는 반드시 검진기관에 상근하는 **영상의학과 전문의**가 판독하여야 하며, 해당 전문의는 **관련 교육**을 이수하여야 한다.
	2. 사후 결과 상담		저선량 흉부CT 검사를 받은 수검자	**결과 상담의사**는 **관련 교육**을 이수하고 폐암검진에 대한 **결과 상담** 및 **금연 상담**을 제공해야 한다.

관련교육 운영: **국립암센터**
교육실시기관: 영상의학전문가-대한영상의학회, **결과상담의사-대한폐암학회**
교육 미이수 의사가 검진을 실시했을 경우 **해당 항목 검사비용을 삭감함**

암검진 실시기준

Lung nodules… Rush… to the hospital



Which method is the best ?

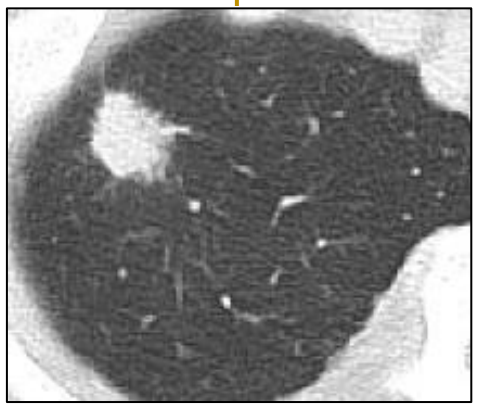
Pulmonary nodule

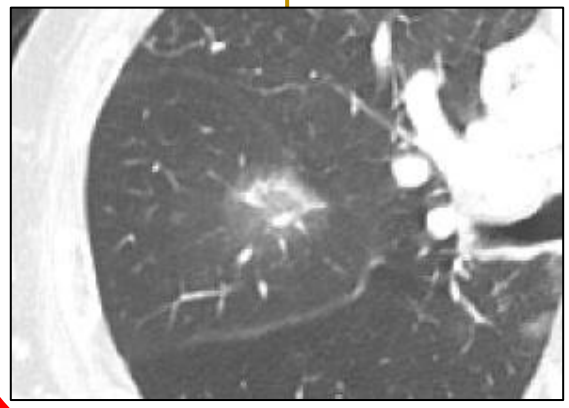
고형 결절
(Solid nodule)

반고형 결절
(Sub-solid nodule)

부분 고형 결절
(Part-solid nodule)

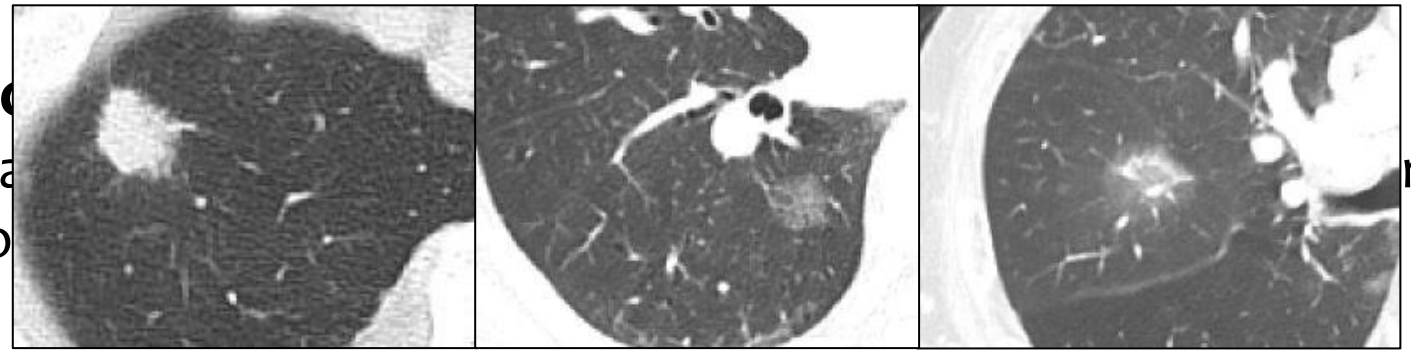
순수 간유리 결절
(Pure ground glass nodule)





Definitions of Subsolid nodules

- **A pulm**
  - a sma
  - Lesio



ry parenchyma

- **Solid nodules**
  - typically dense and homogeneous on imaging.
- **Subsolid nodules**
  - **Pure ground glass nodule (pGGN) :** a well-circumscribed nodular lesion in the lung parenchyma with attenuation less than adjacent pulmonary parenchymal structures, such as airways and vessels.
  - **Part-solid nodule :** a nodule that has both a ground glass component and one or more solid components, defined by having density visually equal to that of adjacent pulmonary parenchymal structures.

Incidences of Subsolid nodules

- Incidences of Subsolid nodules
  - ~ 9% in lung cancer screening patients.
    - **GGN :** 0.7 ~ 4.2%
    - **Part-solid nodule :** 0.8 ~ 5.0%
  - Female nonsmokers, particularly in Asian populations

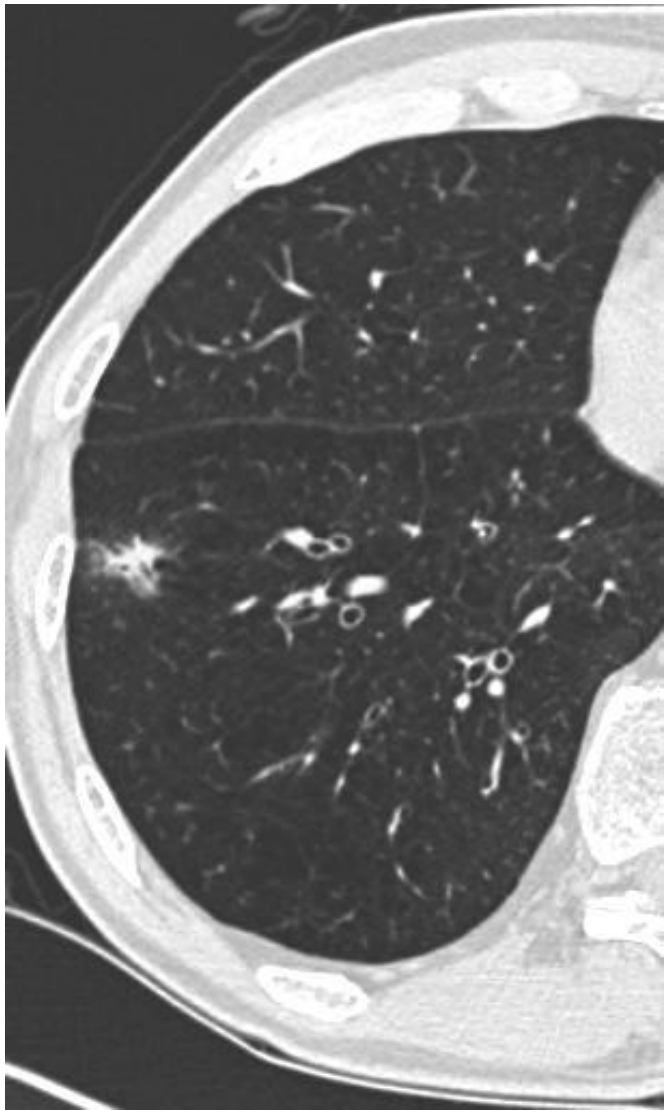
D.F. Yankelevitz, et al., Radiology 2015;277(2):555–564.
C.I. Henschke, et al., AJR Am. J. Roentgenol. 2016;207(6):1176–1184.

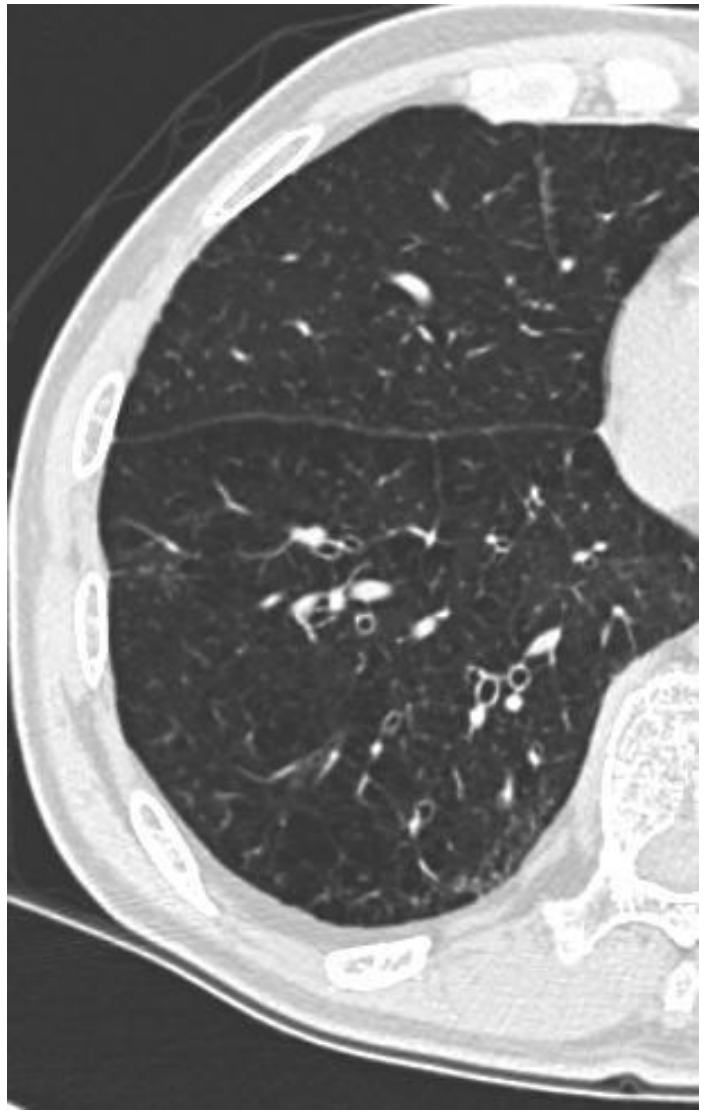
Differential diagnosis of Subsolid nodules

- **Infection or inflammation**
  - Esp. in malignancy or immunocompromised state
- **Focal lung hemorrhage**
- **Simple eosinophilic pneumonia**
- **Premalignant to Malignancy**
  - **AAH, AIS, MIA, invasive adenocarcinoma.**

01

62/M
high blood eosinophilia (15.0%)
history of eating raw cow's liver. (ELISA for toxocariasis: +)





Transient nGGO

- **38-70%**
  - Resolving either spontaneously or antibiotics
  - pGGNs : 37.6%, mGGNs : 48.7%

- **Predicted as transient lesion**
  - Young age, blood eosinophilia, lesion multiplicity, polygonal shape, ill-defined borders, lubular GGOs, mixed attenuation and large degree of solid component

Radd R. Radiol Clin N Am 2014;52:47.

Characteristics of Subsolid nodule

- **Natural course**
  - A higher risk of malignancy than solid nodules
    - Subsolid nodules, particularly part-solid nodules
  - More indolent behavior than purely solid malignancies.
  - Less likely to develop lymph node and distant metastases

Characteristics of Subsolid nodule

- **Natural course**
  - A higher risk of malignancy than solid nodules
    - Subsolid nodules, particularly part-solid nodules

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Probability of Cancer in Pulmonary Nodules Detected on First Screening CT

Data from two cohorts;

participants in the Pan-Canadian Early Detection of Lung Cancer Study (PanCan)
and participants involved in chemoprevention trials at the British Columbia Cancer Agency (BCCA)

Table 2. Prediction Models for the Probability of Lung Cancer in Pulmonary Nodules.*

Predictor Variables	Model 1a: Parsimonious Model, No Spiculation			Model 2a: Full Model, No Spiculation		
	Odds Ratio (95% CI)	P Value	Beta Coefficient	Odds Ratio (95% CI)	P Value	Beta Coefficient
Age, per yr				1.03 (0.99–1.07)	0.11	0.0321
Sex, female vs. male	1.79 (1.13–2.82)	0.01	0.5806	1.76 (1.09–2.83)	0.02	0.5635
Nodule size		<0.001†	−5.8616		<0.001†	−5.6693
Nodule type						
Nonsolid or with ground-glass opacity				0.74 (0.40–1.35)	0.33	−0.3005
Part-solid				1.40 (0.72–2.74)	0.32	0.3395
Solid				Reference		Reference

Predictors of cancer;

older age, female sex, family history of lung cancer, emphysema, larger nodule size, location of the nodule in the upper lobe, part-solid nodule type, lower nodule count, and spiculation.

Nodule size		<0.001†	−5.5537		<0.001†	−5.3854
Nodule type						
Nonsolid or with ground-glass opacity				0.88 (0.48–1.62)	0.68	−0.1276
Part-solid				1.46 (0.74–2.88)	0.28	0.3770
Solid				Reference		Reference
Nodule location, upper vs. middle or lower lobe	1.82 (1.12–2.98)	0.02	0.6009	1.93 (1.14–3.27)	0.02	0.6581
Nodule count per scan, per each additional nodule				0.92 (0.85–1.00)	0.049	−0.0824
Spiculation, yes vs. no	2.54 (1.45–4.43)	0.001	0.9309	2.17 (1.16–4.05)	0.02	0.7729
Model constant			−6.6144			−6.7892

Characteristics of Subsolid nodule

- **Natural course**
  - More **indolent** behavior than purely solid malignancies.

Original Article

The impact of histology and ground-glass opacity component on volume doubling time in primary lung cancer

Kai Obayashi[1,2], Kimihiro Shimizu[1,2], Seshiru Nakazawa[1,2], Toshiteru Nagashima[3], Toshiki Yajima[1,2], Takayuki Kosaka[1,2], Jun Atsumi[1,2], Natsuko Kawatani[1,2], Tomohiro Yazawa[4], Kyoichi Kaira[5], Akira Mogi[1,2], Hiroyuki Kuwano[1,2]

Original Article

The impact of histology and ground-glass opacity component on volume doubling time in primary lung cancer

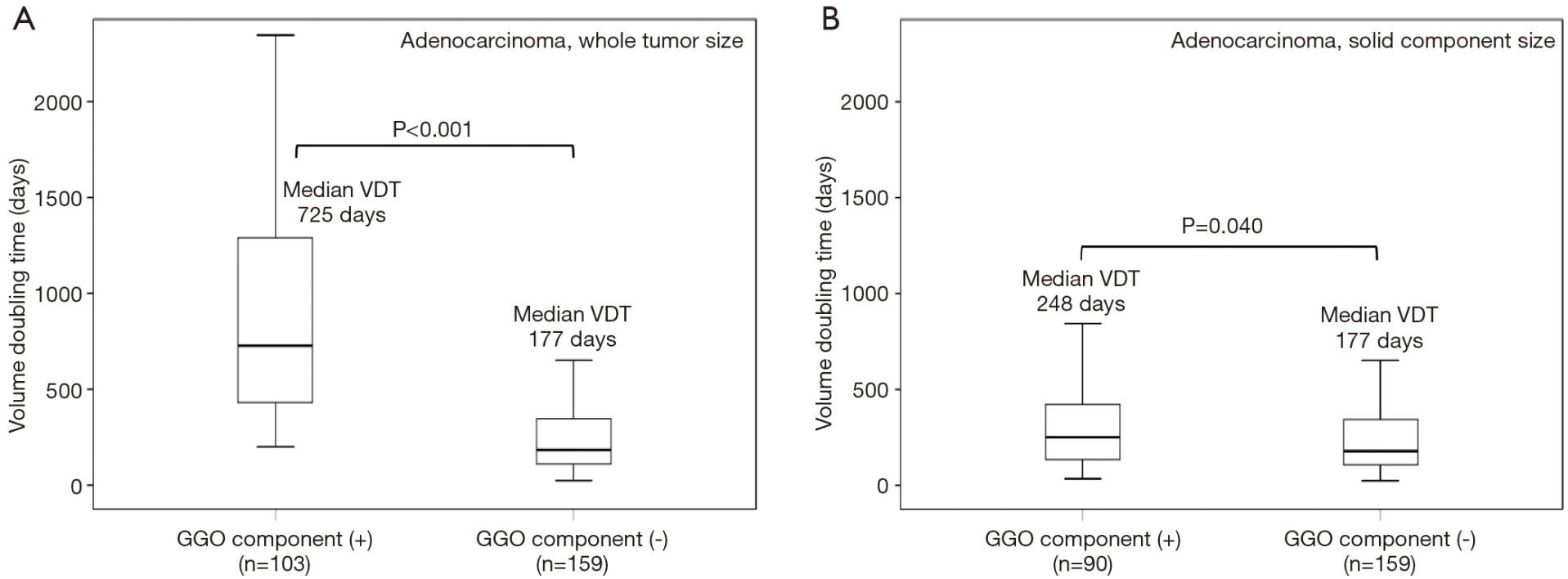


Figure 3 Box plots of VDT calculated from entire tumor (A) and solid component diameters in adenocarcinomas according to GGO component (B). VDT, volume doubling time; GGO, ground glass opacity.

Characteristics of Subsolid nodule

- **Natural course**
  - Less likely to develop lymph node and distant metastases

Table 3. Patterns of Recurrence in Patients with c-N0 Subcentimeter NSCLC Based on the Findings of Thin-Section Computed Tomography

Recurrence Sites	Pure GGO (n = 139)	Part Solid (n = 123)	Pure Solid (n = 66)	*p* Value
Locoregional recurrence	0 (0%)	0 (0%)	7 (10.6%)	<0.0001
Only hilar LN			1	
Only mediastinal LN			1	
Hilar and mediastinal LNs			3	
Malignant effusion			1	
Ipsilateral PM			1	
Distant recurrence	0 (0%)	1 (0.8%)	1 (1.5%)	
Adrenal grand			1	
Contralateral PM		1		
Both local and distant recurrence	0 (0%)	1 (0.8%)	2 (3.0%)	
Hilar and mediastinal LNs and brain metastasis			1	
Hilar and mediastinal LNs and multiple PMs			1	
Hilar LN and multiple PMs		1		
Total	0 (0%)	2 (1.6%)	10 (15.1%)	

Note: p Value in the chi-square test.
GGO, ground glass opacity; LN, lymph node; PM, pulmonary metastasis.

Hattori et al. J. Thoracic Oncol. 12 (6) (2017) 954–962.

Characteristics of Subsolid nodule

- Solid(consolidation) portion of Subsolid nodule
  - Invasiveness
  - LN metastasis
  - Recurrence after operation
  - Recurrence free survival
  - Overall survival

J Thorac Cardiovasc Surg 2012;144:1365-1371
J Thorac Cardiovasc Surg 2012;143:607-612
Eur J Cardiothorac Surg 2013;43:925-932
J Thorac Cardiovasc Surg 2013;1461:17-23
J Thorac Cardiovasc Surg 2013;146:24-30
J Thorac Oncol 2011;6:751-756
Radiology 2001;220:803-809
Clin Lung Cancer 2007;8:327-330
J Comput Assist Tomogr 2008;32:792-798
Eur Radiol 2015;25:558-567
Eur Radio 2015;25:558-567

Characteristics of Subsolid nodule

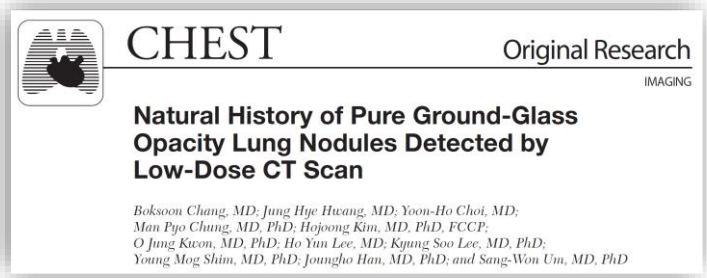
- **Natural course**
  - More **indolent** behavior than purely solid malignancies.

ORIGINAL ARTICLE

Long-Term Surveillance of Ground-Glass Nodules

Evidence from the MILD Trial

Silva Mario, MD, Sverzellati Nicola, MD, PhD,* Manna Carmelinda, MD,* Negrini Giulio, MD,* Marchianò Alfonso, MD,† Zompatori Maurizio, MD,‡ Rossi Cristina, MD,* and Pastorino Ugo, MD§*

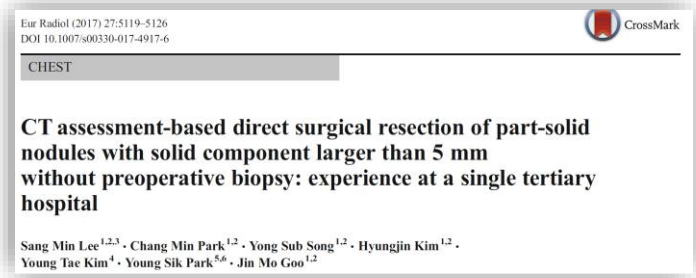


CHEST Original Research

IMAGING

Natural History of Pure Ground-Glass Opacity Lung Nodules Detected by Low-Dose CT Scan

Boksoon Chang, MD; Jung Hye Hwang, MD; Yoon-Ho Choi, MD; Man Pyo Chung, MD, PhD; Hojoong Kim, MD, PhD, FCCP; O Jung Kwon, MD, PhD; Ho Yun Lee, MD; Kyung Soo Lee, MD, PhD; Young Mog Shim, MD, PhD; Joungho Han, MD, PhD; and Sang-Won Um, MD, PhD



Eur Radiol (2017) 27:5119–5126
DOI 10.1007/s00330-017-4917-6

CrossMark

CHEST

CT assessment-based direct surgical resection of part-solid nodules with solid component larger than 5 mm without preoperative biopsy: experience at a single tertiary hospital

Sang Min Lee[1,2,3] · Chang Min Park[1,2] · Yong Sub Song[1,2] · Hyungjin Kim[1,2] · Young Tae Kim[4] · Young Sik Park[5,6] · Jin Mo Goo[1,2]

Progression

Pure GGNs : 9.8 ~ 16.7% (50-59 months)

Part-solid nodule : 40 ~ 46.2% (35-39 months)

J Thorac Oncol. 2012;7: 1541-1546
Chest 2013;143:172-178
J Thorac Oncol. 2008;3:1245-1250

F/U guidelines of Subsolid nodule

- **CT surveillance**
  - Fleischner guideline
  - Lung-RADS version 1.1 -> 2022
  - 폐암진료지침

- **PET(positron emission tomography)**

CT surveillance

- Individualizing the approach

B: Subsolid Nodules*

Nodule Type	Size	
	<6 mm (<100 mm^3)	≥6 mm (>100 mm^3)
Single		
Ground glass	No routine follow-up	CT at 6–12 months to confirm persistence, then CT every 2 years until 5 years
Part solid	No routine follow-up	CT at 3–6 months to confirm persistence. If unchanged and solid component remains <6 mm, annual CT should be performed for 5 years.
Multiple	CT at 3–6 months. If stable, consider CT at 2 and 4 years.	CT at 3–6 months. Subsequent management based on the most suspicious nodule(s).

Fleischner Society 2017 Guidelines

03 CT surveillance

Lung-RADS™ Version 1.1

Assessment Categories Release date: 2019

Category Descriptor	Lung-RADS Score	Findings	Management	Risk of Malignancy	Est. Population Prevalence
Incomplete	0	Prior chest CT examination(s) being located for comparison Part or all of lungs cannot be evaluated	Additional lung cancer screening CT images and/or comparison to prior chest CT examinations is needed	n/a	1%
Negative No nodules and definitely benign nodules	1	No lung nodules Nodule(s) with specific calcifications: complete, central, popcorn, concentric rings and fat containing nodules	Continue annual screening with LDCT in 12 months	< 1%	90%
Benign Appearance or Behavior Nodules with a very low likelihood of becoming a clinically active cancer due to size or lack of growth	2	**Solid nodule(s)**: < 6 mm new < 4 mm **Part solid nodule(s):** < 6 mm total diameter on baseline screening **Non solid nodule(s) (GGN):** <30 mm **OR** ≥ 30 mm and unchanged or slowly growing **Category 3 or 4 nodules unchanged for ≥ 3 months**			
Probably Benign Probably benign finding(s) - short term follow up suggested; includes nodules with a low likelihood of becoming a clinically active cancer	3	**Solid nodule(s):** ≥ 6 to < 8 mm at baseline **OR** new 4 mm to < 6 mm **Part solid nodule(s)** ≥ 6 mm total diameter with solid component < 6 mm **OR** new < 6 mm total diameter **Non solid nodule(s)** (GGN) ≥ 30 mm on baseline CT or new	6 month LDCT	1-2%	5%
Probably Suspicious Findings for which additional diagnostic testing is recommended	4A	**Solid nodule(s):** ≥ 8 to < 15 mm at baseline **OR** growing < 8 mm **OR** new 6 to < 8 mm **Part solid nodule(s:** ≥ 6 mm with solid component ≥ 6 mm to < 8 mm **OR** with a new or growing < 4 mm solid component **Endobronchial nodule**	3 month LDCT; PET/CT may be used when there is a ≥ 8 mm solid component	5-15%	2%
Suspicious Findings for which additional diagnostic testing and/or tissue sampling is recommended	4B	**Solid nodule(s)** ≥ 15 mm **OR** new or growing, and ≥ 8 mm **Part solid nodule(s) with:** a solid component ≥ 8 mm **OR** a new or growing ≥ 4 mm solid component	Chest CT with or without contrast, PET/CT and/or tissue sampling depending on the *probability of malignancy and comorbidities. PET/CT may be used when there is a ≥ 8 mm solid component. *For new large nodules that develop on an annual repeat screening CT, a 1 month LDCT may be recommended to address potentially infectious or inflammatory conditions*	> 15%	2%
	4X	Category 3 or 4 nodules with additional features or imaging findings that increases the suspicion of malignancy			
Other Clinically Significant or Potentially Clinically Significant Findings (non lung cancer)	S	**Modifier - may add on to category 0-4 coding**	As appropriate to the specific finding	n/a	10%
Volumetric measurements	1.5 mm = 1.8 mm^3 4 mm = 33.5 mm^3 6 mm = 113.1 mm^3 8 mm = 268.1 mm^3		10 mm = 523.6 mm^3 15 mm = 1767.1 mm^3 20 mm = 4188.8 mm^3 30 mm = 14137.2 mm^3		

IMPORTANT NOTES FOR USE:

1) Negative screen: does not mean that an individual does not have lung cancer
2) Size: To calculate nodule mean diameter, measure both the long and short axis to one decimal point, and report mean nodule diameter to one decimal point
3) Size Thresholds: apply to nodules at first detection, and that grow and reach a higher size category
4) Growth: an increase in size of > 1.5 mm
5) Exam Category: each exam should be coded 0-4 based on the nodule(s) with the highest degree of suspicion
6) Exam Modifiers: S modifier may be added to the 0-4 category
7) Lung Cancer Diagnosis: Once a patient is diagnosed with lung cancer, further management (including additional imaging such as PET/CT) may be performed for purposes of lung cancer staging; this is no longer screening
8) Practice audit definitions: a negative screen is defined as categories 1 and 2; a positive screen is defined as categories 3 and 4
9) Category 4B Management: this is predicated on the probability of malignancy based on patient evaluation, patient preference and risk of malignancy; radiologists are encouraged to use the McWilliams et al assessment tool when making recommendations
10) Category 4X: nodules with additional imaging findings that increase the suspicion of lung cancer, such as spiculation, GGN that doubles in size in 1 year, enlarged lymph nodes etc
11) Solid nodules with smooth margins, an oval, lentiform or triangular shape, and maximum diameter less than 10 mm (perifissural nodules) should be classified as category 2
12) Category 3 and 4A nodules that are unchanged on interval CT should be coded as category 2, and individuals returned to screening in 12 months
13) LDCT: low dose chest CT

Additional resources available at - https://www.acr.org/Clinical-Resources/Reporting-and-Data-Systems/Lung-Rads

Link to Lung-RADS calculator - https://brocku.ca/lung-cancer-screening-and-risk-prediction/risk-calculators/

Update

American College of Radiology

Lung-RADS® v2022

Release Date: November 2022

Lung-RADS	Category Descriptor	Findings	Management
0	**Incomplete** Estimated Population Prevalence: ~ 1%	Prior chest CT examination being located for comparison (see note 9)	Comparison to prior chest CT;
		Part or all oflungs cannot be evaluated	Additional lung cancer screening CT imaging needed;
		Findings suggestive of an inflammatory or infectious process (see note 10)	1-3 month LDCT
1	**Negative** Estimated Population Prevalence: 39%	**No lung nodules OR** **Nodule with benign features:** • Complete, central, popcorn, or concentric ring calcifications **OR** • Fat-containing	12-month screening LDCT
2	**Benign** - Based on imaging features or indolent behavior Estimated Population Prevalence: 45%	**Juxtapleural nodule:** • < 10 mm (524 mm^3) mean diameter at baseline or new **AND** • Solid; smooth margins; and oval, lentiform, or triangular shape	
		Solid nodule: • < 6 mm (< 113 mm^3) at baseline **OR** • New < 4 mm (< 34 mm^3)	
		Part solid nodule: • < 6 mm total mean diameter (< 113 mm^3) at baseline	
		Non solid nodule (GGN): • < 30 mm (< 14,137 mm^3) at baseline, new, or growing **OR** • ≥ 30 mm (≥ 14,137 mm^3) stable or slowly growing (see note 7)	
		Airway nodule, subsegmental - at baseline, new, or stable (see note 11)	
		Category 3 lesion that is stable or decreased in size at 6-month follow-up CT **OR** Category 4B lesion proven to be benign in etiology following appropriate diagnostic workup	
3	**Probably Benign** - Based on imaging features or behavior Estimated Population Prevalence: 9%	**Solid nodule:** • ≥ 6 to < 8 mm (≥ 113 to < 268 mm^3) at baseline **OR** • New 4 mm to < 6 mm (34 to < 113 mm^3)	6-month LDCT
		Part solid nodule: • ≥ 6 mm total mean diameter (≥ 113 mm^3) with solid component < 6 mm (< 113 mm^3) at baseline **OR** • New < 6 mm total mean diameter (< 113 mm^3)	
		Non solid nodule (GGN): • ≥ 30 mm (≥ 14,137 mm^3) at baseline or new	
		Atypical pulmonary cyst: (see note 12) • Growing cystic component (mean diameter) of a thick-walled cyst	
		Category 4A lesion that is stable or decreased in size at 3-month follow-up CT (excluding airway nodules)	
4A	**Suspicious** Estimated Population Prevalence: 4%	**Solid nodule:** • ≥ 8 to < 15 mm (≥ 268 to < 1,767 mm^3) at baseline **OR** • Growing < 8 mm (< 268 mm^3) **OR** • New 6 to < 8 mm (113 to < 268 mm^3)	3-month LDCT; PET/CT may be considered if there is a ≥ 8 mm (≥ 268 mm^3) solid nodule or solid component
		Part solid nodule: • ≥ 6 mm total mean diameter (≥ 113 mm^3) with solid component ≥ 6 mm to < 8 mm (≥ 113 to < 268 mm^3) at baseline **OR** • New or growing < 4 mm (< 34 mm^3) solid component	
		Airway nodule, segmental or more proximal - at baseline (see note 11)	
		Atypical pulmonary cyst: (see note 12) • Thick-walled cyst **OR** • Multilocular cyst at baseline **OR** • Thin- or thick-walled cyst that becomes multilocular	
4B	**Very Suspicious** Estimated Population Prevalence: 2%	**Airway nodule**, segmental or more proximal - stable or growing (see note 11)	Referral for further clinical evaluation Diagnostic chest CT with or without contrast; PET/CT may be considered if there is a ≥ 8 mm (≥ 268 mm^3) solid nodule or solid component; tissue sampling; and/or referral for further clinical evaluation Management depends on clinical evaluation, patient preference, and the probability of malignancy (see note 13)
		Solid nodule: • ≥ 15 mm (≥ 1767 mm^3) at baseline **OR** • New or growing ≥ 8 mm (≥ 268 mm^3)	
		Part solid nodule: • Solid component ≥ 8 mm (≥ 268 mm^3) at baseline **OR** • New or growing ≥ 4 mm (≥ 34 mm^3) solid component	
		Atypical pulmonary cyst: (see note 12) • Thick-walled cyst with growing wall thickness/nodularity **OR** • Growing multilocular cyst (mean diameter) **OR** • Multilocular cyst with increased loculation or new/increased opacity (nodular, ground glass, or consolidation)	
		Slow growing solid or part solid nodule that demonstrates growth over multiple screening exams (see note 8)	
4X	Estimated Population Prevalence: < 1%	Category 3 or 4 nodules with additional features or imaging findings that increase suspicion for lung cancer (see note 14)	
S	**Significant or Potentially Significant** Estimated Population Prevalence: 10%	**Modifier:** May add to category 0-4 for clinically significant or potentially clinically significant findings unrelated to lung cancer (see note 15)	As appropriate to the specific finding

CT surveillance

판정 구분	판정 기준
기존 암환자	폐암 환자로 치료 중이거나 재발하지 아니함
이상소견 없음	폐결절이 없거나 확실한 양성 폐결절이 있음 **(Lung-RADS category 1)**
양성 결절	폐암의 가능성이 낮은 결절로 1년 후 정기검사가 **(Lung-RADS category 2)**
경계선 결절	폐결절이 양성으로 추정되지만 6개월 후 추적검사가 필요함 **(Lung-RADS category 3)**
폐암 의심	폐암이 의심되어 추가검사가 필요함 **(Lung-RADS category 4)**
기타 (폐결절 외 의미있는 소견)	폐결절 이외 폐암과 관련이 없는 폐질환 또는 기타 흉부질환 소견으로 추가검사 또는 진료가 필요함 **(Lung-RADS category S)**

폐암검진결과 양성

CT surveillance

American College of Radiology

Lung-RADS® v2022

Release Date: November 2022

Lung-RADS	Category Descriptor	Findings	Management
0	**Incomplete** Estimated Population Prevalence: ~ 1%	Prior chest CT examination being located for comparison (see note 9)	Comparison to prior chest CT;
		Part or all oflungs cannot be evaluated	Additional lung cancer screening CT imaging needed;
		Findings suggestive of an inflammatory or infectious process (see note 10)	1-3 month LDCT
1	**Negative** Estimated Population Prevalence: 39%	**No lung nodules OR**	12-month screening LDCT
		Nodule with benign features: • Complete, central, popcorn, or concentric ring calcifications **OR** • Fat-containing	
2	**Benign** - Based on imaging features or indolent behavior Estimated Population Prevalence: 45%	**Juxtapleural nodule:** • < 10 mm (524 mm^3) mean diameter at baseline or new **AND** • Solid; smooth margins; and oval, lentiform, or triangular shape	
		Solid nodule: • < 6 mm (< 113 mm^3) at baseline **OR** • New < 4 mm (< 34 mm^3)	
		Part solid nodule: • < 6 mm total mean diameter (< 113 mm^3) at baseline	
		Non solid nodule (GGN): • < 30 mm (< 14,137 mm^3) at baseline, new, or growing **OR** • ≥ 30 mm (≥ 14,137 mm^3) stable or slowly growing (see note 7)	
		Airway nodule, subsegmental - at baseline, new, or stable (see note 11)	
		Category 3 lesion that is stable or decreased in size at 6-month follow-up CT **OR** Category 4B lesion proven to be benign in etiology following appropriate diagnostic workup	
3	**Probably Benign** - Based on imaging features or behavior Estimated Population Prevalence: 9%	**Solid nodule:** • ≥ 6 to < 8 mm (≥ 113 to < 268 mm^3) at baseline **OR** • New 4 mm to < 6 mm (34 to < 113 mm^3)	6-month LDCT
		Part solid nodule: • ≥ 6 mm total mean diameter (≥ 113 mm^3) with solid component < 6 mm (< 113 mm^3) at baseline **OR** • New < 6 mm total mean diameter (< 113 mm^3)	
		Non solid nodule (GGN): • ≥ 30 mm (≥ 14,137 mm^3) at baseline or new	
		Atypical pulmonary cyst: (see note 12) • Growing cystic component (mean diameter) of a thick-walled cyst	
		Category 4A lesion that is stable or decreased in size at 3-month follow-up CT (excluding airway nodules)	
4A	**Suspicious** Estimated Population Prevalence: 4%	**Solid nodule:** • ≥ 8 to < 15 mm (≥ 268 to < 1,767 mm^3) at baseline **OR** • Growing < 8 mm (< 268 mm^3) **OR** • New 6 to < 8 mm (113 to < 268 mm^3)	3-month LDCT; PET/CT may be considered if there is a ≥ 8 mm (≥ 268 mm^3) solid nodule or solid component
		Part solid nodule: • ≥ 6 mm total mean diameter (≥ 113 mm^3) with solid component ≥ 6 mm to < 8 mm (≥ 113 to < 268 mm^3) at baseline **OR** • New or growing < 4 mm (< 34 mm^3) solid component	
		Airway nodule, segmental or more proximal - at baseline (see note 11)	
		Atypical pulmonary cyst: (see note 12) • Thick-walled cyst **OR** • Multilocular cyst at baseline **OR** • Thin- or thick-walled cyst that becomes multilocular	
4B	**Very Suspicious** Estimated Population Prevalence: 2%	**Airway nodule,** segmental or more proximal - stable or growing (see note 11)	Referral for further clinical evaluation
		Solid nodule: • ≥ 15 mm (≥ 1767 mm^3) at baseline **OR** • New or growing ≥ 8 mm (≥ 268 mm^3)	Diagnostic chest CT with or without contrast; PET/CT may be considered if there is a ≥ 8 mm (≥ 268 mm^3) solid nodule or solid component; tissue sampling; and/or referral for further clinical evaluation Management depends on clinical evaluation, patient preference, and the probability of malignancy (see note 13)
		Part solid nodule: • Solid component ≥ 8 mm (≥ 268 mm^3) at baseline **OR** • New or growing ≥ 4 mm (≥ 34 mm^3) solid component	
		Atypical pulmonary cyst: (see note 12) • Thick-walled cyst with growing wall thickness/nodularity **OR** • Growing multilocular cyst (mean diameter) **OR** • Multilocular cyst with increased loculation or new/increased opacity (nodular, ground glass, or consolidation)	
		Slow growing solid or part solid nodule that demonstrates growth over multiple screening exams (see note 8)	
4X	Estimated Population Prevalence: < 1%	Category 3 or 4 nodules with additional features or imaging findings that increase suspicion for lung cancer (see note 14)	
S	**Significant or Potentially Significant** Estimated Population Prevalence: 10%	**Modifier:** May add to category 0-4 for clinically significant or potentially clinically significant findings unrelated to lung cancer (see note 15)	As appropriate to the specific finding

	Solid	Part-solid	GGN
2	< 6mm New < 4mm	< 6 mm	< 30 mm
3	≥ 6 to < 8 mm New 4 to < 6mm	≥ 6 with solid component < 6 mm New < 6 mm	≥ 30 mm
4A	≥ 8 to < 15 mm Growing < 8 mm New 6 to < 8 mm	≥ 6 with solid component ≥ 6 to < 8 mm New or growing < 4 mm solid component	
4B	≥ 15 mm New or growing ≥ 8 mm	solid component ≥ 8 mm New or growing ≥ 4 mm solid component	

03 CT surveillance

American College of Radiology

Lung-RADS® v2022

Release Date: November 2022

Lung-RADS	Category Descriptor	Findings	Management
0	**Incomplete** Estimated Population Prevalence: ~ 1%	Prior chest CT examination being located for comparison (see note 9)	Comparison to prior chest CT;
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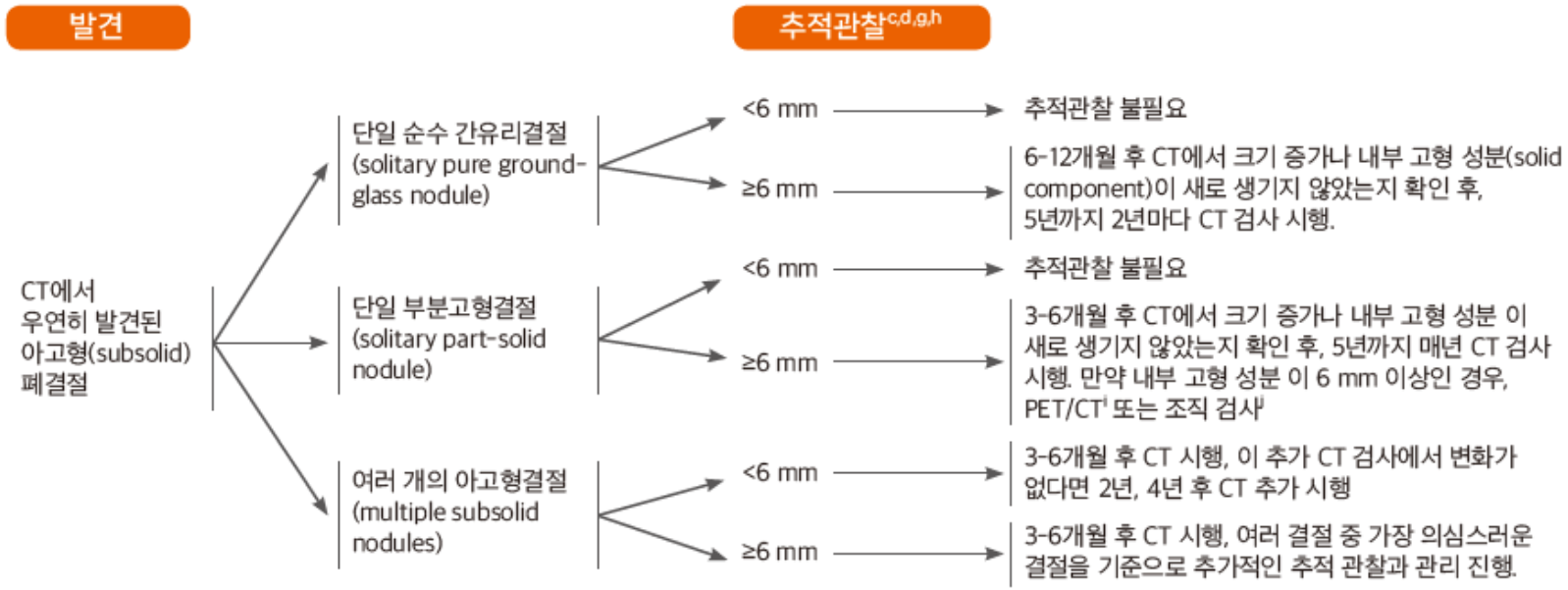
		Findings suggestive of an inflammatory or infectious process (see note 10)	1-3 month LDCT
1	**Negative** Estimated Population Prevalence: 39%	**No lung nodules OR**	12-month screening LDCT
		Nodule with benign features: • Complete, central, popcorn, or concentric ring calcifications **OR** • Fat-containing	
2	**Benign** - Based on imaging features or indolent behavior Estimated Population Prevalence: 45%	**Juxtapleural nodule:** • < 10 mm (524 mm³) mean diameter at baseline or new **AND** • Solid; smooth margins; and oval, lentiform, or triangular shape	
		Solid nodule: • < 6 mm (< 113 mm³) at baseline **OR** • New < 4 mm (< 34 mm³)	
		Part solid nodule: • < 6 mm total mean diameter (< 113 mm³) at baseline	
		Non solid nodule (GGN): • < 30 mm (< 14,137 mm³) at baseline, new, or growing **OR** • ≥ 30 mm (≥ 14,137 mm³) stable or slowly growing (see note 7)	
		Airway nodule, subsegmental - at baseline, new, or stable (see note 11)	
		Category 3 lesion that is stable or decreased in size at 6-month follow-up CT **OR** Category 4B lesion proven to be benign in etiology following appropriate diagnostic workup	
3	**Probably Benign** - Based on imaging features or behavior Estimated Population Prevalence: 9%	**Solid nodule:** • ≥ 6 to < 8 mm (≥ 113 to < 268 mm³) at baseline **OR** • New 4 mm to < 6 mm (34 to < 113 mm³)	6-month LDCT
		Part solid nodule: • ≥ 6 mm total mean diameter (≥ 113 mm³) with solid component < 6 mm (< 113 mm³) at baseline **OR** • New < 6 mm total mean diameter (< 113 mm³)	
		Non solid nodule (GGN): • ≥ 30 mm (≥ 14,137 mm³) at baseline or new	
		Atypical pulmonary cyst: (see note 12) • Growing cystic component (mean diameter) of a thick-walled cyst	
		Category 4A lesion that is stable or decreased in size at 3-month follow-up CT (excluding airway nodules)	
4A	**Suspicious** Estimated Population Prevalence: 4%	**Solid nodule:** • ≥ 8 to < 15 mm (≥ 268 to < 1,767 mm³) at baseline **OR** • Growing < 8 mm (< 268 mm³) **OR** • New 6 to < 8 mm (113 to < 268 mm³)	3-month LDCT; PET/CT may be considered if there is a ≥ 8 mm (≥ 268 mm³) solid nodule or solid component
		Part solid nodule: • ≥ 6 mm total mean diameter (≥ 113 mm³) with solid component ≥ 6 mm to < 8 mm (≥ 113 to < 268 mm³) at baseline **OR** • New or growing < 4 mm (< 34 mm³) solid component	
		Airway nodule, segmental or more proximal - at baseline (see note 11)	
		Atypical pulmonary cyst: (see note 12) • Thick-walled cyst **OR** • Multilocular cyst at baseline **OR** • Thin- or thick-walled cyst that becomes multilocular	
4B	**Very Suspicious** Estimated Population Prevalence: 2%	**Airway nodule,** segmental or more proximal - stable or growing (see note 11)	Referral for further clinical evaluation
		Solid nodule: • ≥ 15 mm (≥ 1767 mm³) at baseline **OR** • New or growing ≥ 8 mm (≥ 268 mm³)	Diagnostic chest CT with or without contrast; PET/CT may be considered if there is a ≥ 8 mm (≥ 268 mm³) solid nodule or solid component; tissue sampling; and/or referral for further clinical evaluation Management depends on clinical evaluation, patient preference, and the probability of malignancy (see note 13)
		Part solid nodule: • Solid component ≥ 8 mm (≥ 268 mm³) at baseline **OR** • New or growing ≥ 4 mm (≥ 34 mm³) solid component	
		Atypical pulmonary cyst: (see note 12) • Thick-walled cyst with growing wall thickness/nodularity **OR** • Growing multilocular cyst (mean diameter) **OR** • Multilocular cyst with increased loculation or new/increased opacity (nodular, ground glass, or consolidation)	
		Slow growing solid or part solid nodule that demonstrates growth over multiple screening exams (see note 8)	
4X	Estimated Population Prevalence: < 1%	Category 3 or 4 nodules with additional features or imaging findings that increase suspicion for lung cancer (see note 14)	
S	**Significant or Potentially Significant** Estimated Population Prevalence: 10%	**Modifier:** May add to category 0-4 for clinically significant or potentially clinically significant findings unrelated to lung cancer (see note 15)	As appropriate to the specific finding

	Management	Part-solid	GGN
2	**12- month screening LDCT**	< 6 mm	< 30 mm
3	**6-month LDCT**	≥ 6 with solid component < 6 mm New < 6 mm	≥ 30 mm
4A	**3-month LDCT;** **PET/CT may be considered if there is a 8 mm (268 mm3) solid nodule or solid component**	≥ 6 with solid component ≥ 6 to < 8 mm New or growing < 4 mm solid component	
4B	**Diagnostic chest CT with or without contrast;** **PET/CT may be considered if there is a 8 mm (268 mm3) solid nodule or solid component;** **tissue sampling; and/or referral for further clinical evaluation** **Management depends on clinical evaluation, patient preference, and the probability of malignancy (see note 13)**	solid component ≥ 8 mm New or growing ≥ 4 mm solid component	

CT surveillance

표 3 진단 3. 우연히 발견한 아고형(subsolid) 결절의 추적 관찰



폐암진료지침 (3판)

PET(positron emission tomography)

Can be avoided for nonsolid nodules(ground glass opacity or mixed nodules) !!!

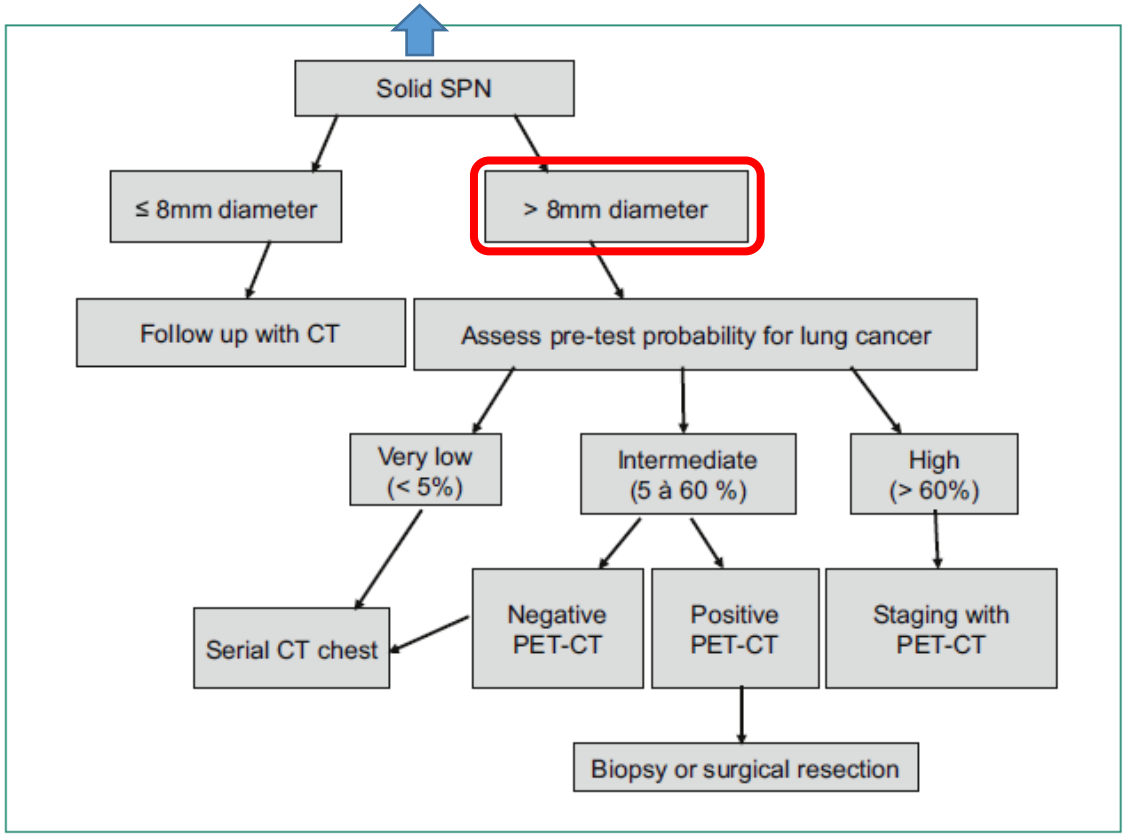


Figure 1. ACCP algorithm for assessing solid solitary pulmonary nodule.

Sensitivity : 95%
Specificity : 82%
Positive predictive value(PPV) : 91%
Negative predictive value (NPV) : 90%.

Radiology2008;246:772—82.

Diagnostic and Interventional Imaging (2016) **97**, 1003—1017

Until when….F/U

ORIGINAL ARTICLE

Long-Term Surveillance of Ground-Glass Nodules

Evidence from the MILD Trial

Silva Mario, MD, Sverzellati Nicola, MD, PhD,* Manna Carmelinda, MD,* Negrini Giulio, MD,* Marchianò Alfonso, MD,† Zompatori Maurizio, MD,‡ Rossi Cristina, MD,* and Pastorino Ugo, MD§*

GGNs in the Multicentric Italian Lung Detection (MILD) trial

A total of 48 pGGNs
15 of 48(31.3%) resolved,
4 of 48 (8.3%) decreased in size
21 of 48 (43.8%) remained stable
8 of 48 (16.7%) progressed.

Only one pGGN developed a solid component of 5 mm after 63.9 months

So… Upto 5 years

But, debate for Part-solid nodule

J Thorac Oncol. 2012;7: 1541-1546

Progression during F/U

Eur Radiol (2017) 27:195–202
DOI 10.1007/s00330-016-4364-9

CHEST

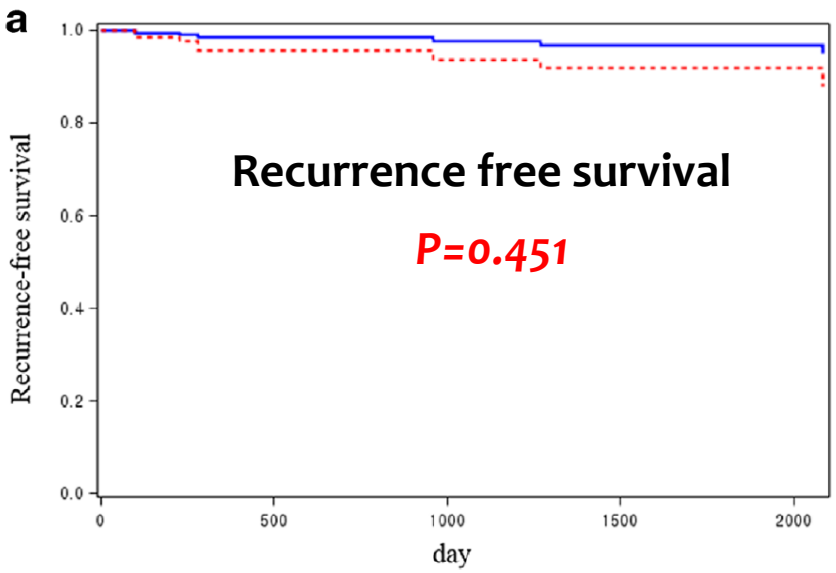
**Persistent part-solid nodules
Can the 'follow-up and surgi
policy have a negative effect**

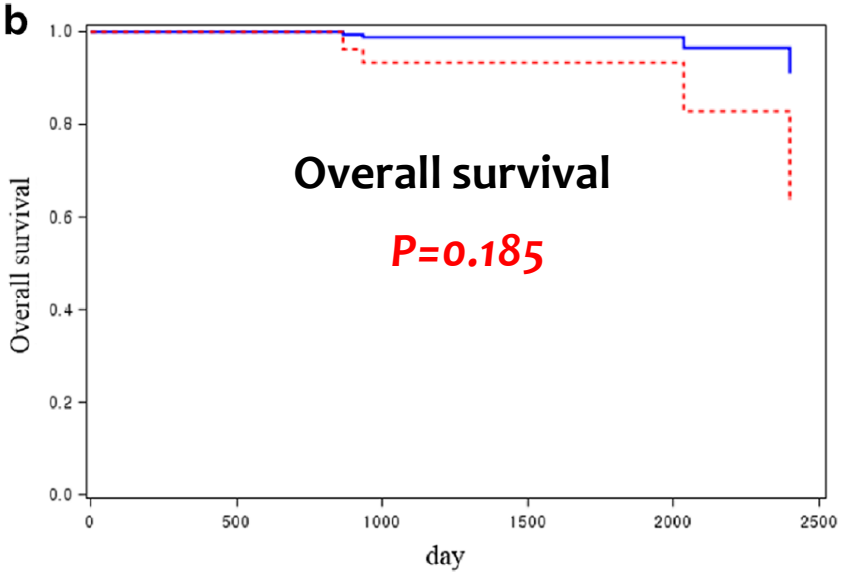
Jong Hyuk Lee[1] · Chan
Jin Mo Goo[1,2]

In the interval growth group

30 patients showed increased nodule size, 10 increased solid parts, and the remaining 14 both patterns.

5 patients showed clinical stage shifts (stage T1a, initially, to T1b after interval growth).





(n=19)

Fig. 4 Plots for time to recurrence-free survival (*a*) and overall survival (*b*) after surgical resection of a persistent part-solid nodule with solid components ≤5 mm. No significant difference is noted with respect to recurrence-free survival ($p = 0.451$) and overall survival ($p = 0.185$) between the interval growth group and the immediate surgery group

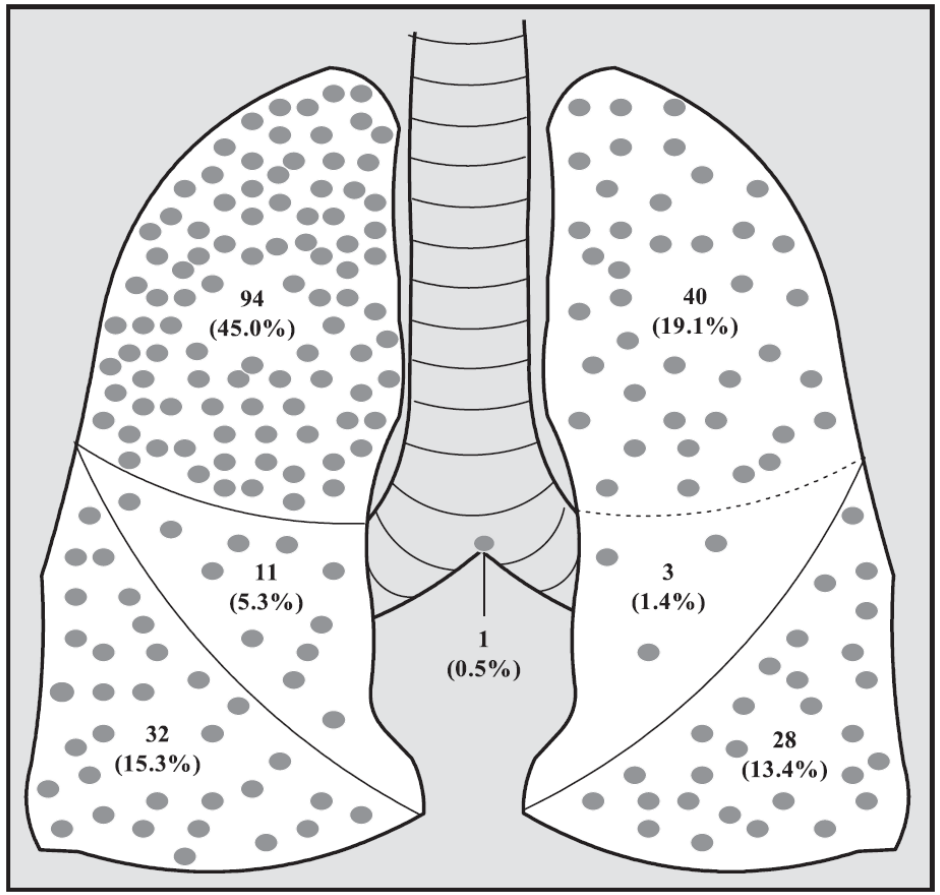
Diagnostic options of Subsolid nodules

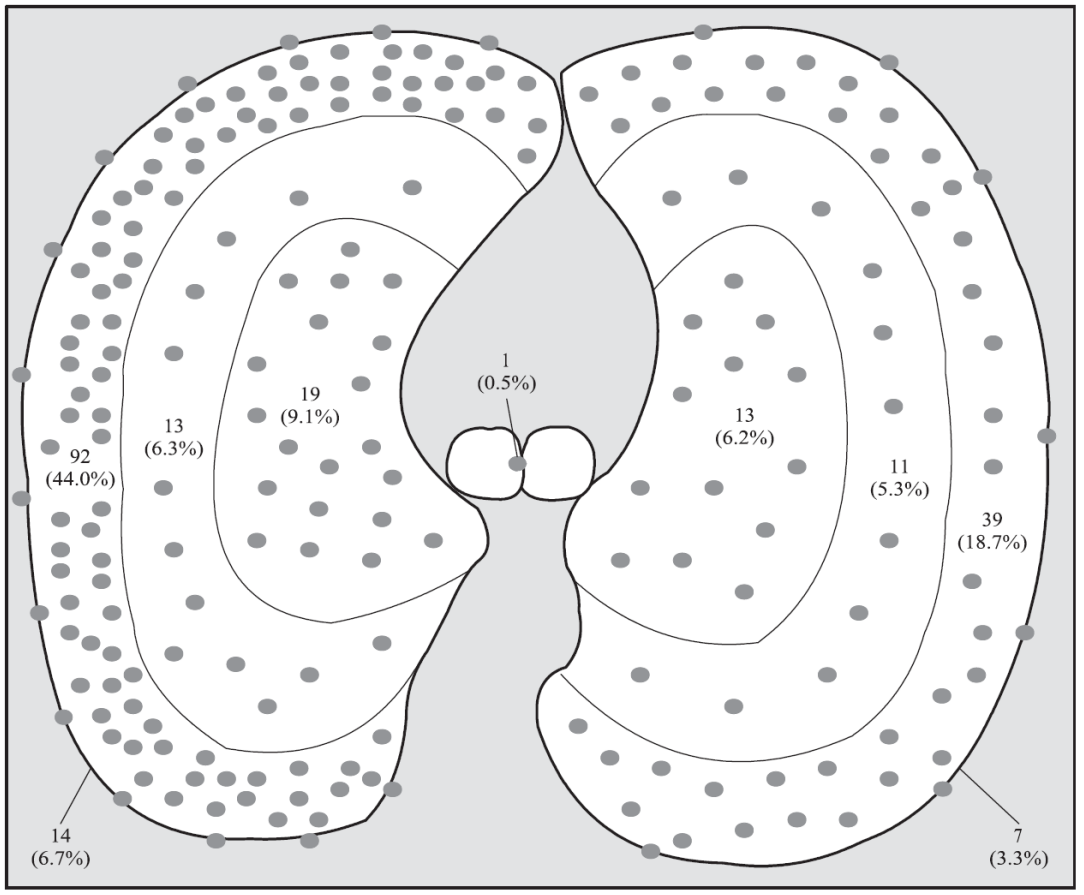
- Non-surgical biopsy
  - Transthoracic needle biopsy
  - Bronchoscopic technique

- Surgical biopsy

Characteristics of Lung Cancers Detected by Computer Tomography Screening in the Randomized NELSON Trial

Nanda Horeweg[1,2], Carlijn M. van der Aalst[1], Erik Thunnissen[3], Kristiaan Nackaerts[4], Carla Weenink[5], Harry J. M. Groen[6], Jan-Willem J. Lammers[7], Joachim G. Aerts[2], Ernst T. Scholten[8], Joost van Rosmalen[1], Willem Mali[9], Matthijs Oudkerk[10], and Harry J. de Koning[1]

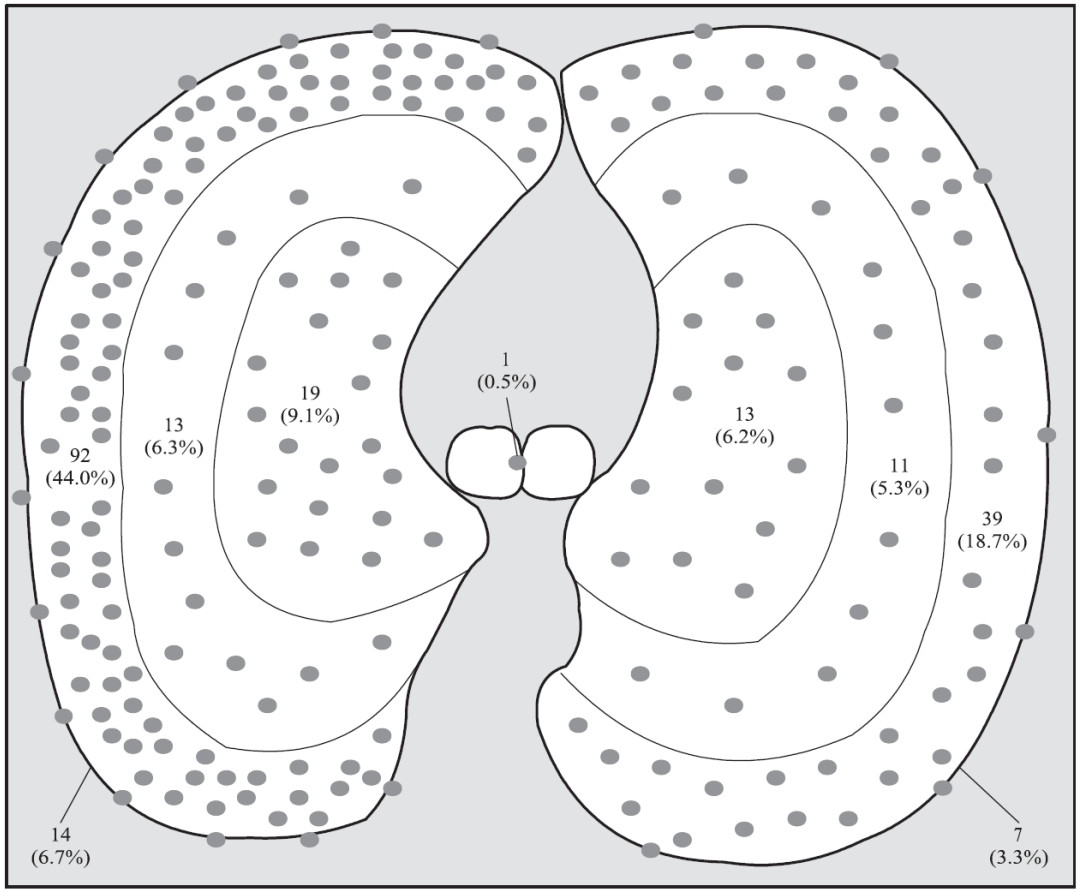




Am J Respir Crit Care Med 2013;187(8): 848–854

Diagnostic options of Subsolid nodules

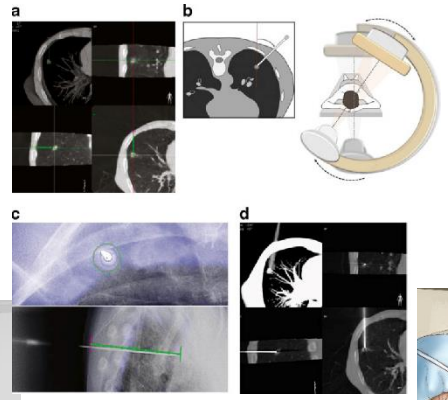
- Non-surgical biopsy
  - **Transthoracic needle biopsy**
    - **Fluoroscopy guided biopsy**
    - **CBCT guided biopsy**
      - **Virtual navigation CBCT guided biopsy**
    - **CT guided biopsy**
    - **CT fluoroscopy guided biopsy**
  - Bronchoscopic technique

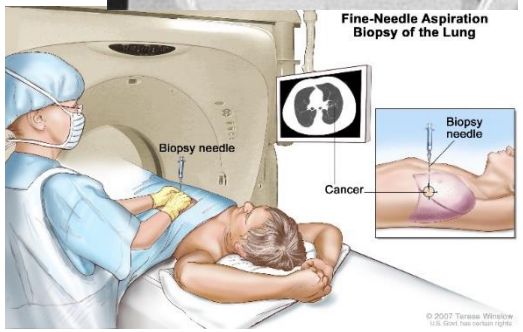


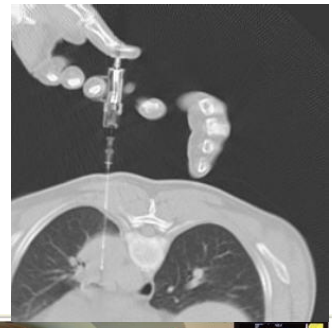
Am J Respir Crit Care Med 2013;187(8): 848–854

Diagnostic options of Subsolid nodules

Transthoracic needle biopsy







	Diagnostic rate	Complication
Fluoroscopy guided	≤ 15 mm: 70-80% > 15 mm: ~90%	**Bleeding:** 1% **Any pneumothorax:** 15% **pneumothorax with chest tube:** 6-7%
Conebeam CT guided		
CT guided or CT-fluoroscopy guided		

Diagnostic options of Subsolid nodules

- **Limitations** of Transthoracic needle biopsy
  - Severe emphysema
    - Pneumothorax(8-64%, overally 30%, 그 중에서 의미 있는 것은 1%)
  - Location
    - Central lesion, peri-fissure, main vessel, heart
  - Uncontrolled severe coagulation disorder
    - PLT <50-70K, PTT>50sec, INR >1.5
    - Anticoagulation agent
      - Aspirin, plavix: discontinue for 5 days, Plavix and aspirin: discontinue aspirin for 5 days
      - Warfarin: switch to low molecular heparin, antagonist
    - Hemothorax : 2nd most common (5-10%)
  - Un-cooperative patients

Diagnostic options of Subsolid nodules

- Non-surgical biopsy
  - Transthoracic needle biopsy

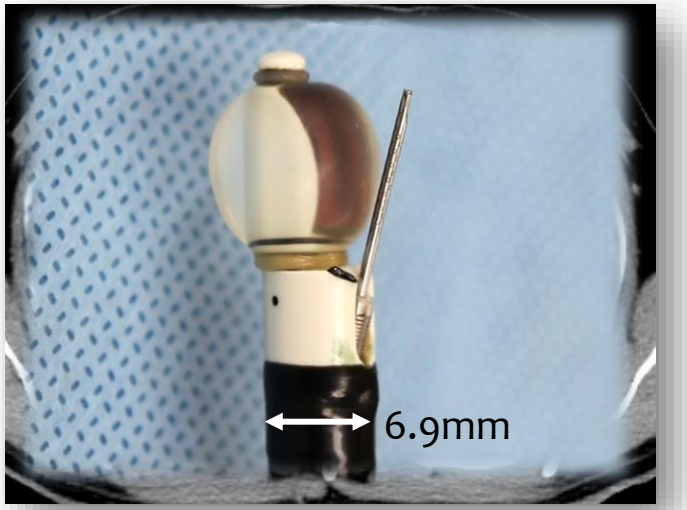
  - **Bronchoscopic technique**
    - **Conventional bronchoscopy**
      - **Fluoroscopic-guided transbronchial lung biopsy(TBLB)**
      - **Computed tomography-guided TBLB**
    - **Radial probe endobronchial ultrasound(RP-EBUS) guided transbronchial biopsy**
      - **Thin bronchoscopy(4_{mm})**
    - **Navigation-guided transbronchial biopsy**
      - **Virtual bronchoscopic navigation(VBN)**
      - **Electromagnetic navigation bronchoscopy(ENB)**

    - **Ultrathin bronchoscopy**
    - **Robotic bronchoscopy**
    - **Bronchoscopic-transparenchymal needle aspiration**

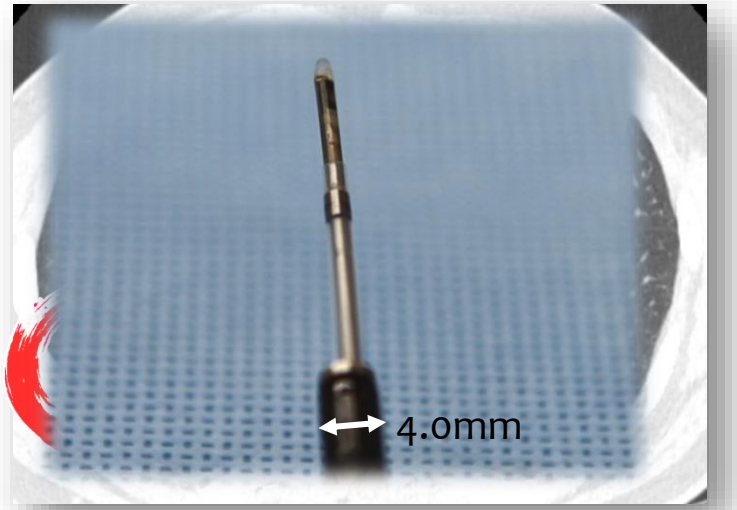
Bronchoscopic technique

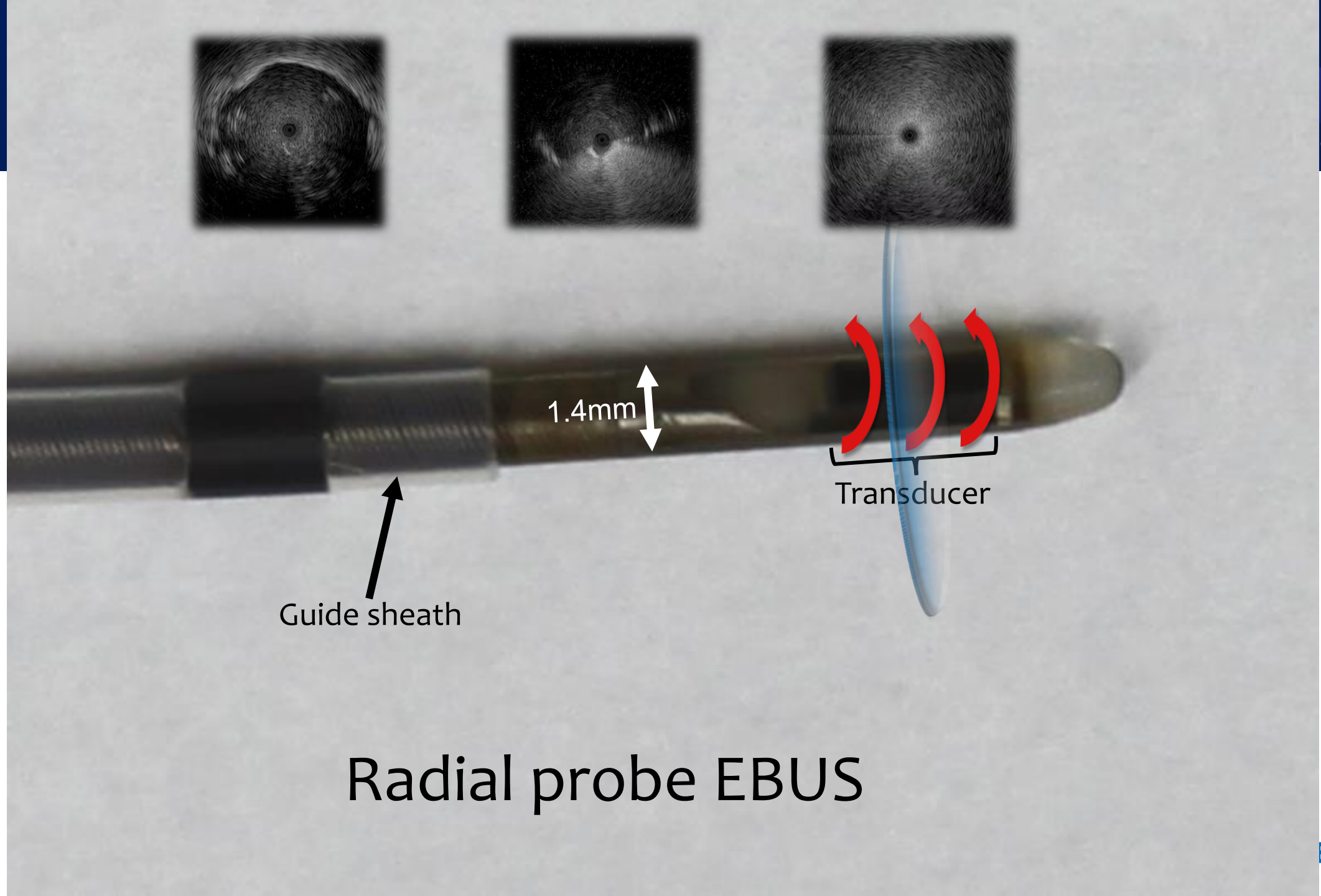
- Radial probe endobronchial ultrasound(RP-EBUS) guided trans-bronchial biopsy
  - Thin bronchoscopy(4_{mm})

TBNA
for mediastinal structures



TBLB
for peripheral lung lesion

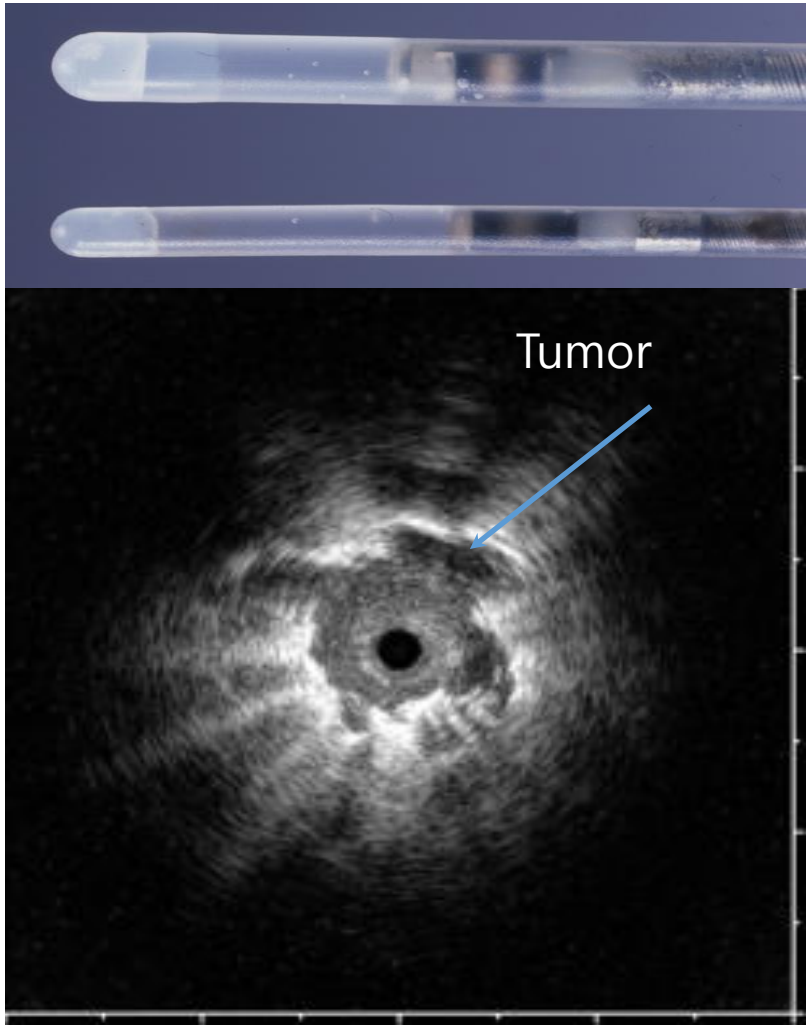


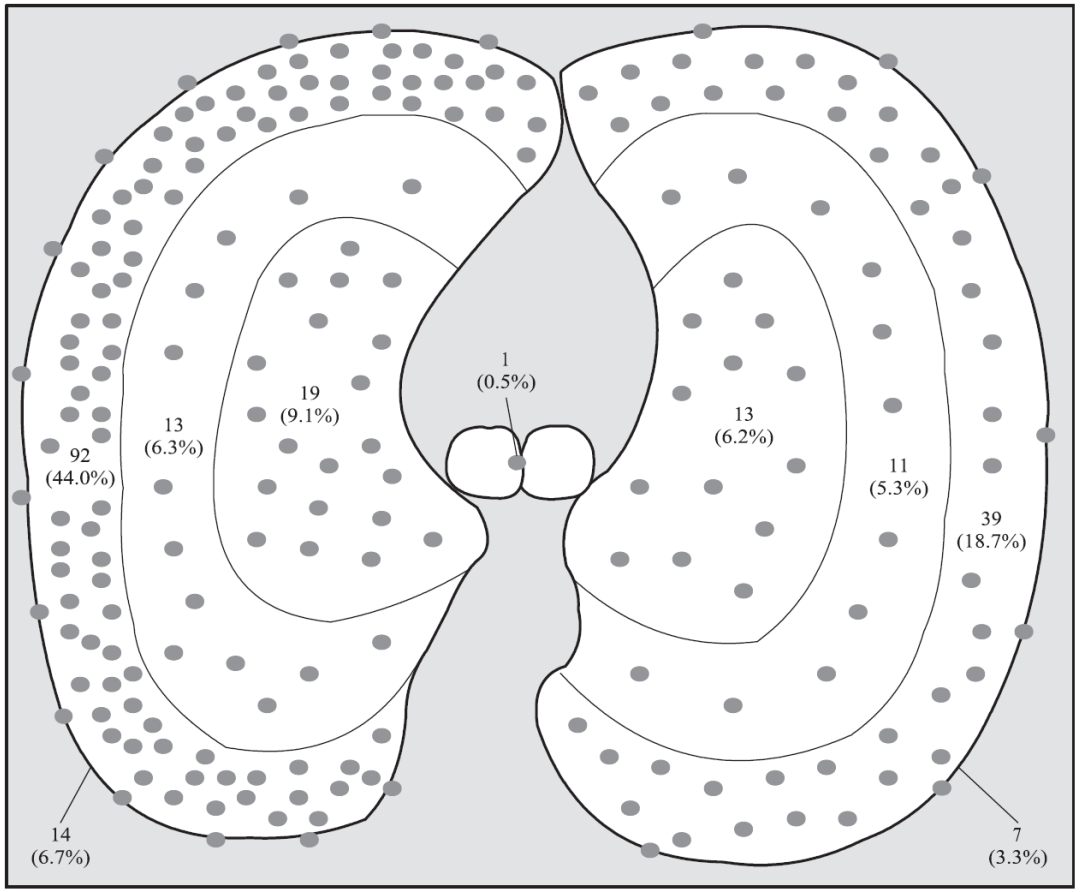


Radial probe EBUS

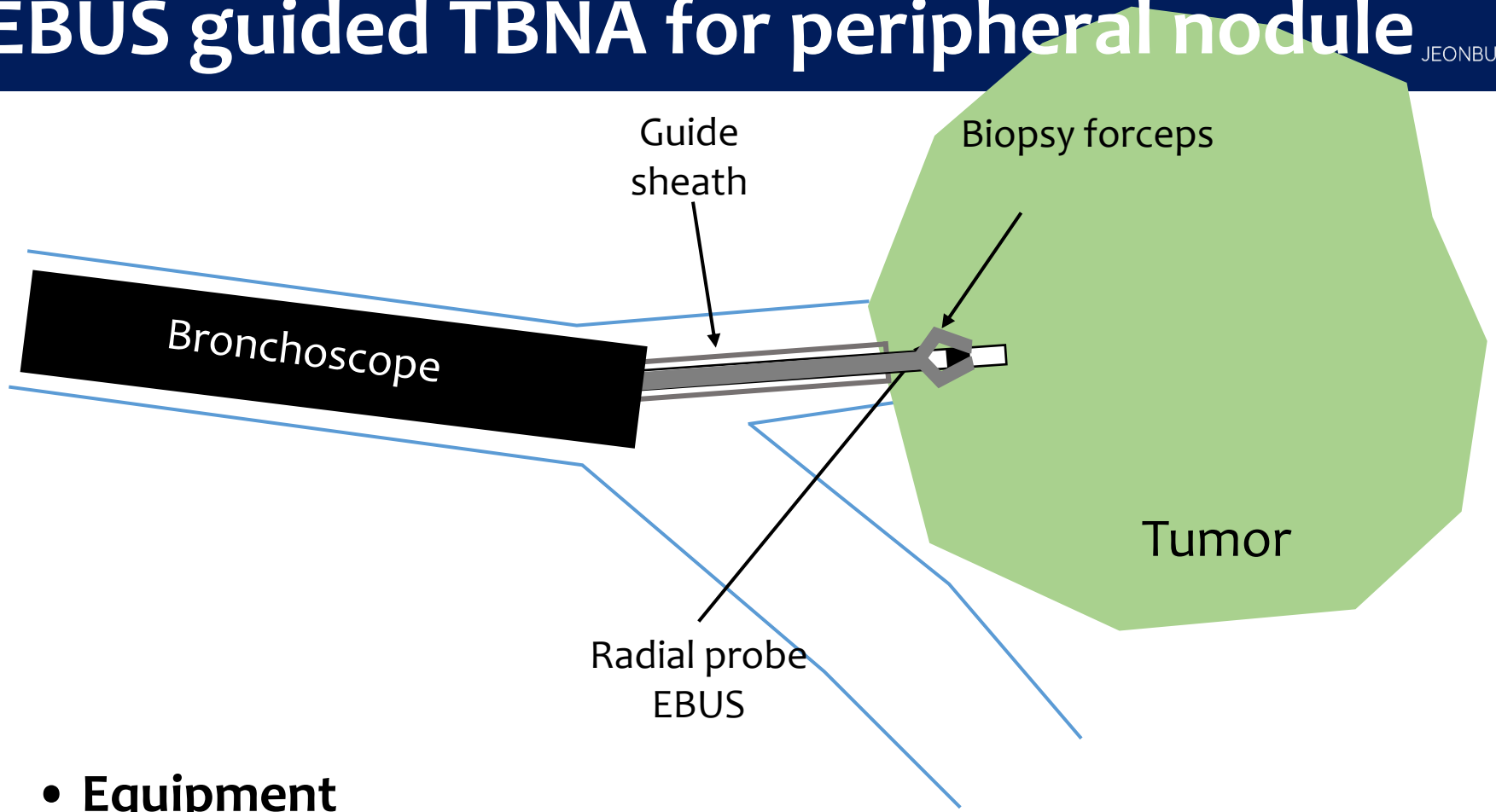
RP EBUS : Radial Probe EBUS

The 20 MHz ultra-miniature radial probe





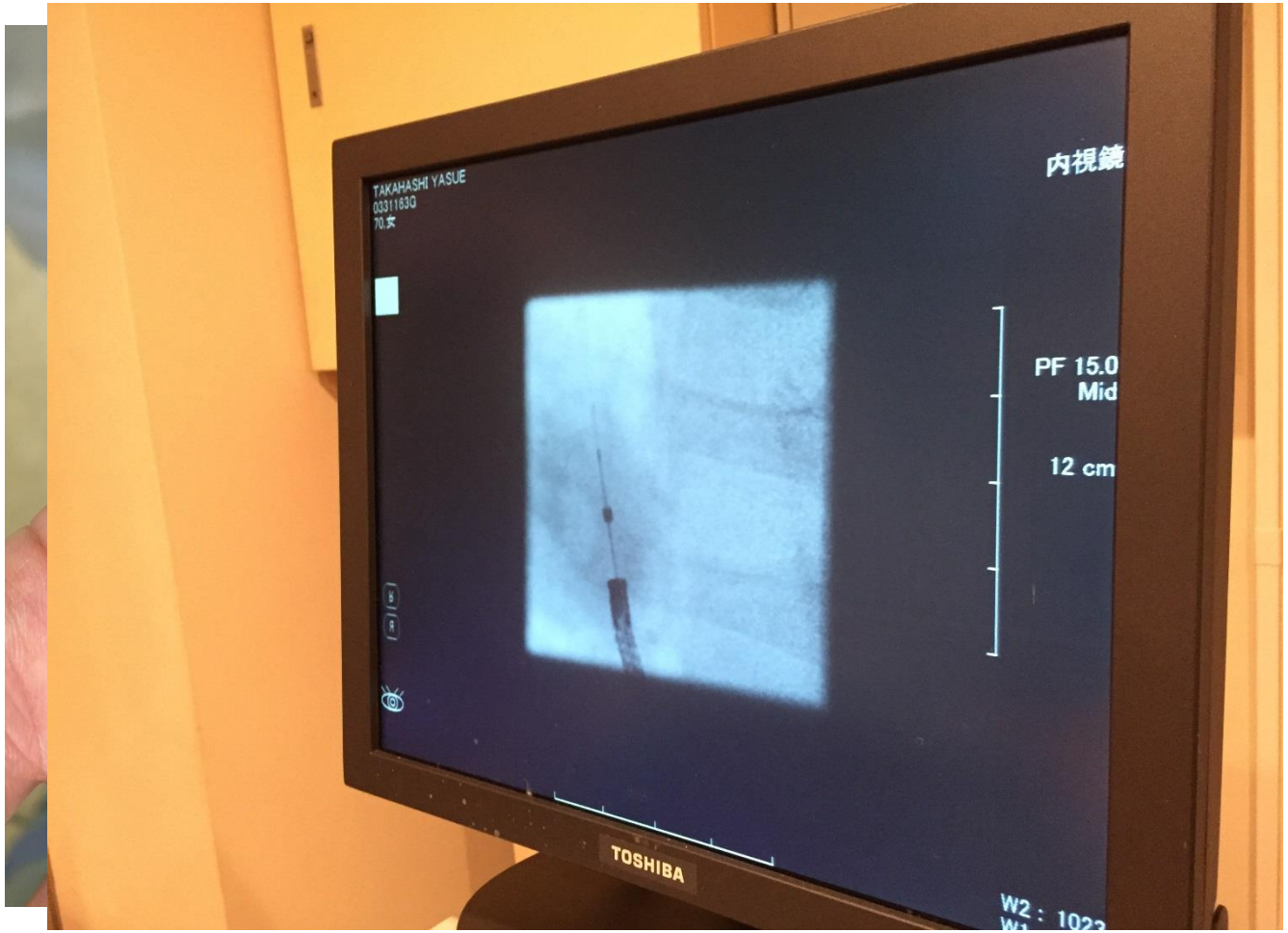
RP-EBUS guided TBNA for peripheral nodule

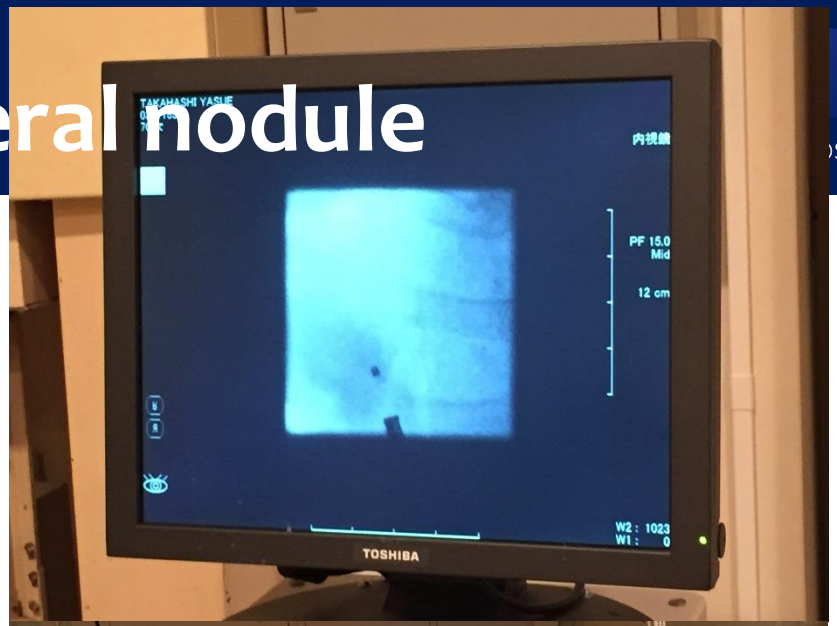


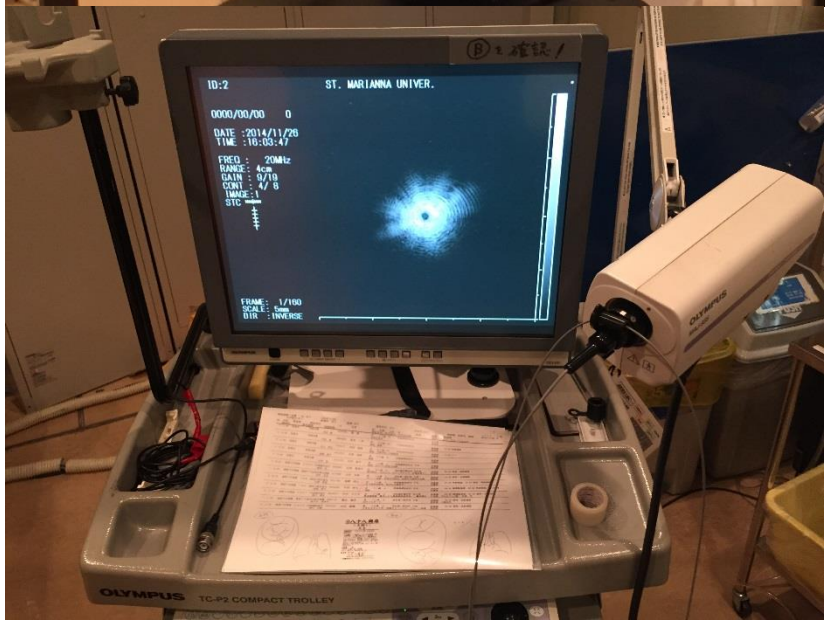
- **Equipment**

1) Bronchoscope
2) Guide sheath kit: guide sheath, cytology brush, biopsy forceps
3) Radial probe EBUS (mini-probe), driving unit, ultrasound center

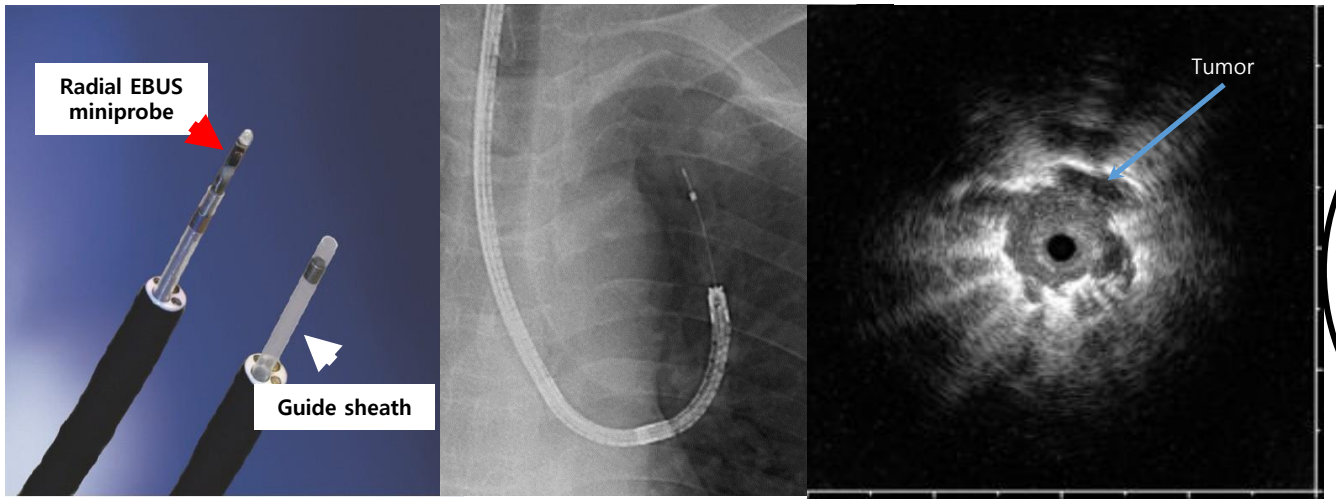
04 RP-EBUS guided TBNA for peripheral nodule

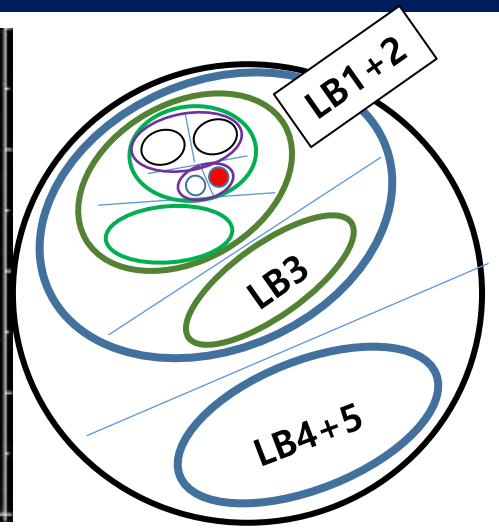






Diagnostic options of Subsolid nodules

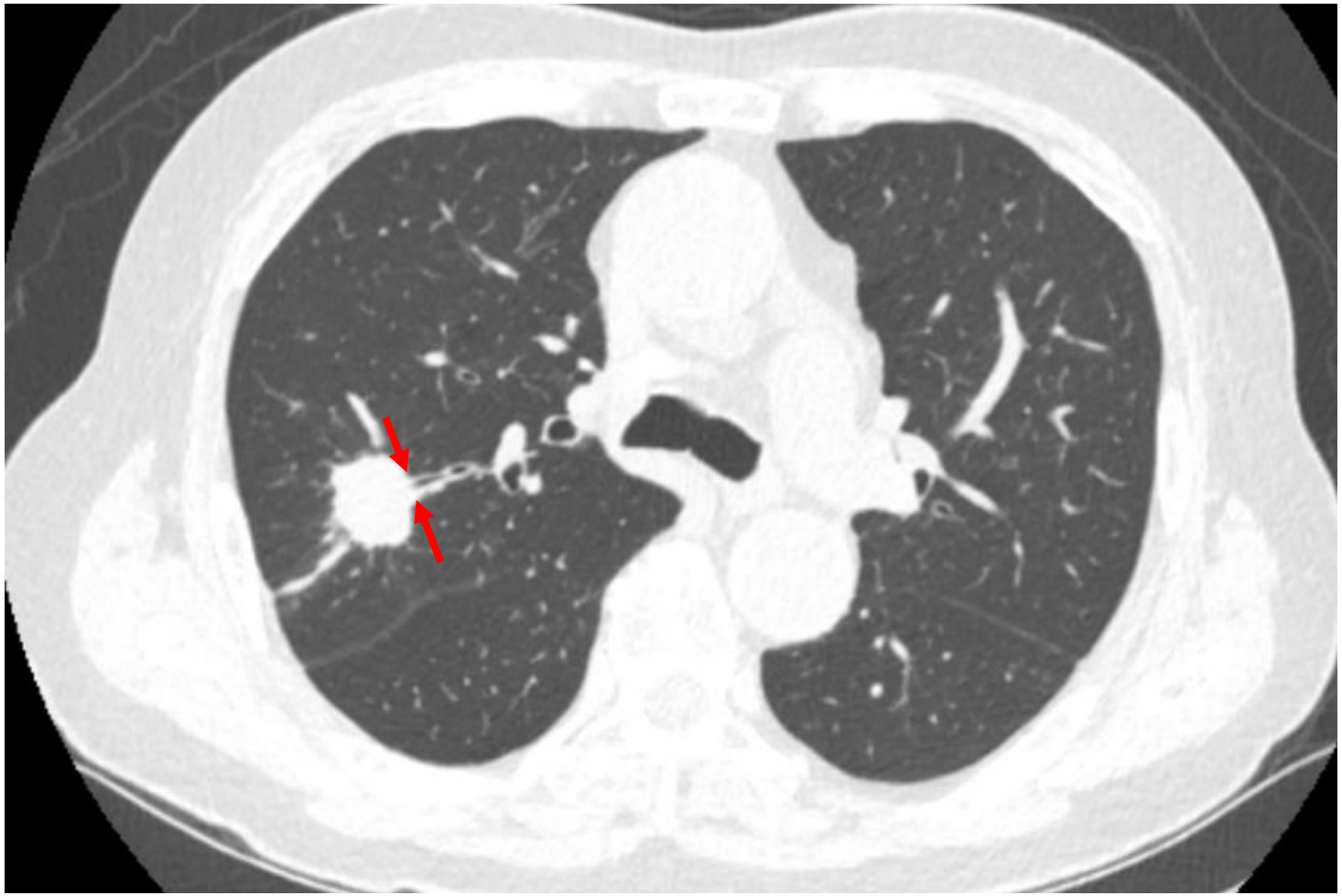




Targeting

	Diagnostic rate		Complication
CT-guided TBLB	67%	A mean of 4.1 (range 2–8) CT scans was performed to localize the lesion.	
Radial EBUS(GS)	<20mm : 53.3-60.5% >20mm : 66.7-75.7%		Pneumothorax : 0.3% Significant hemorrhage : 0%

Where to go ?



Where to go ?

CT Scan

Versus

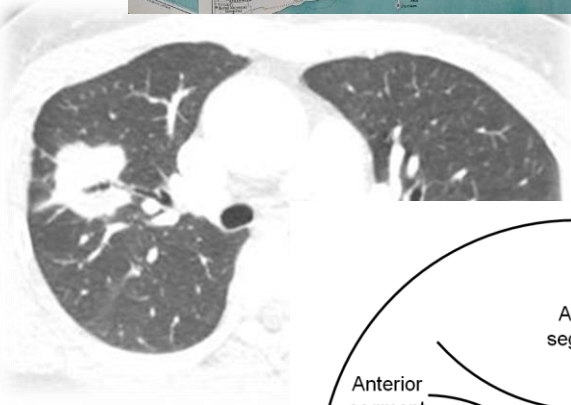
VBN

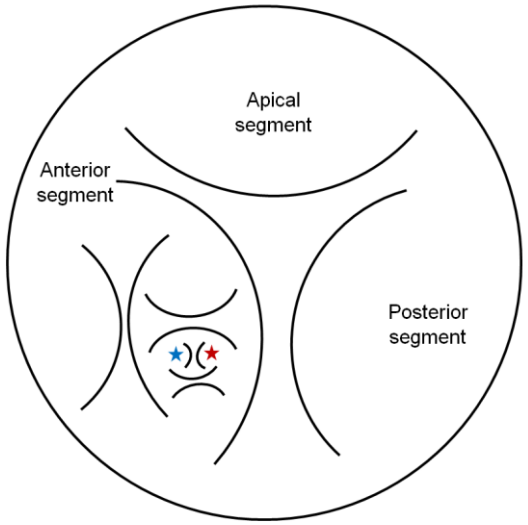
Google map

Versus

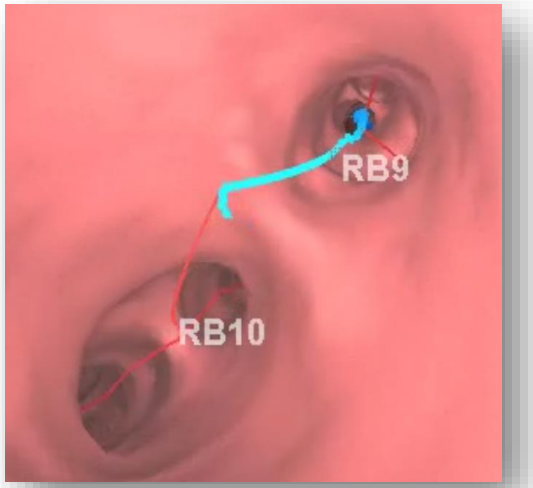
ENB

Navigation System





Drawed by 박승용



LungPoint® Bf-Navi® Synapse 3D®

SuperDimension®

SPiN system®

Diagnostic options of SPN

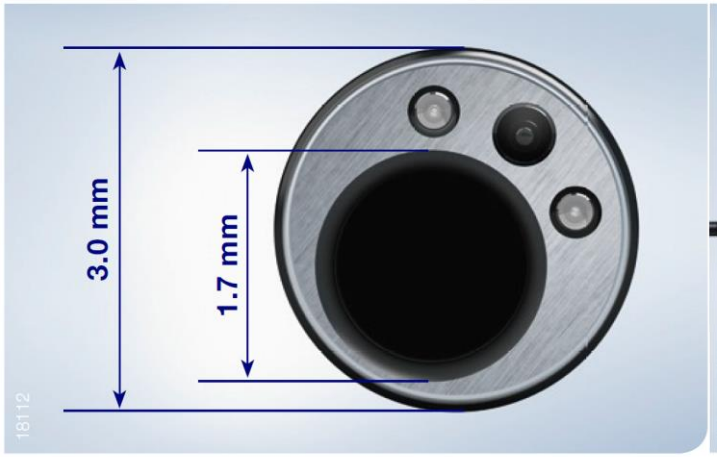
- Diagnostic yield by modality

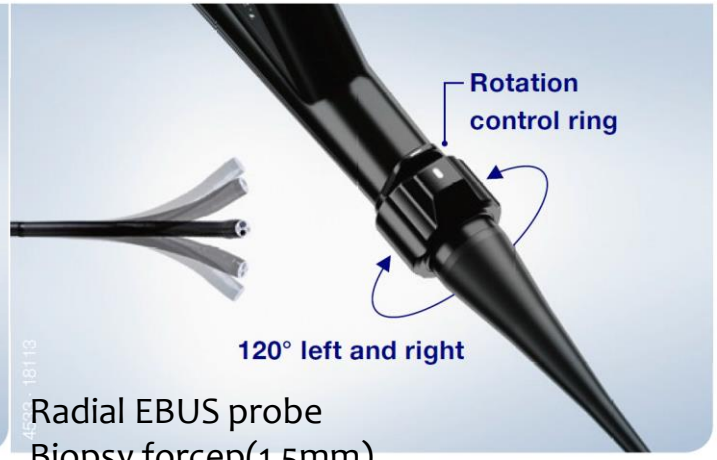
Technology	Study No.	95% CI	Q static	Q *P*-value
Virtual bronchoscopy	10	66-78	21.0	0.01
ENB	11	63-71	13.3	0.21
Guide sheath	10	64-82	63.8	< 0.001
Ultrathin bronchoscope	11	65-75	15.2	0.12
Radial probe EBUS	20	67-76	84.2	< 0.001

ENB = electromagnetic navigation bronchoscopy
EBUS = endobronchial ultrasound using guide sheath

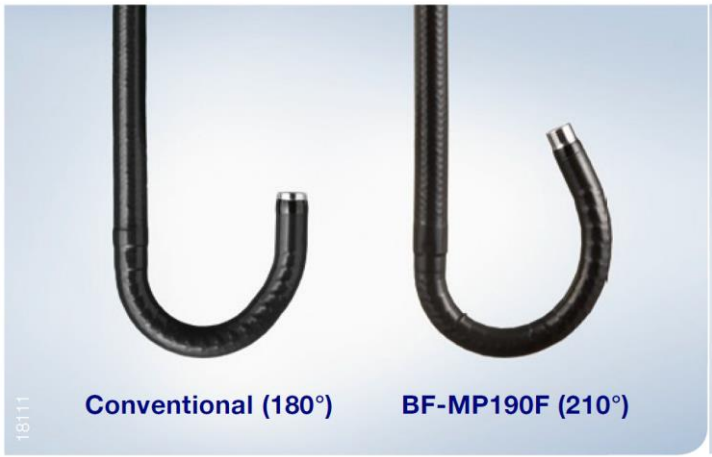
Wang Memoli JS, et al. Chest. 2012 Aug;142(2):385-93.

Ultrathin bronchoscope



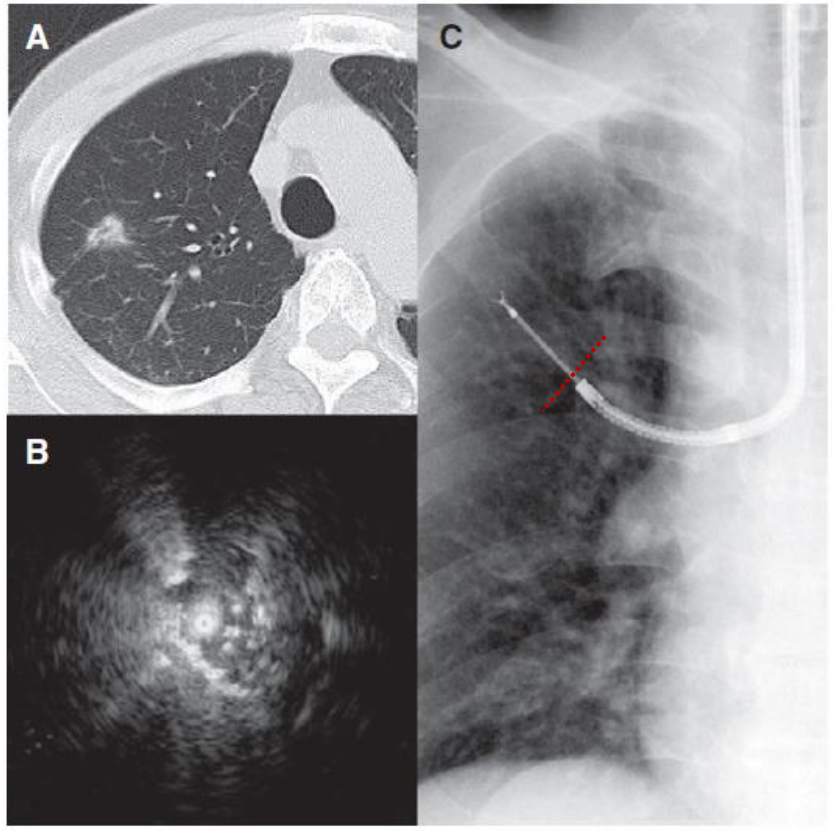


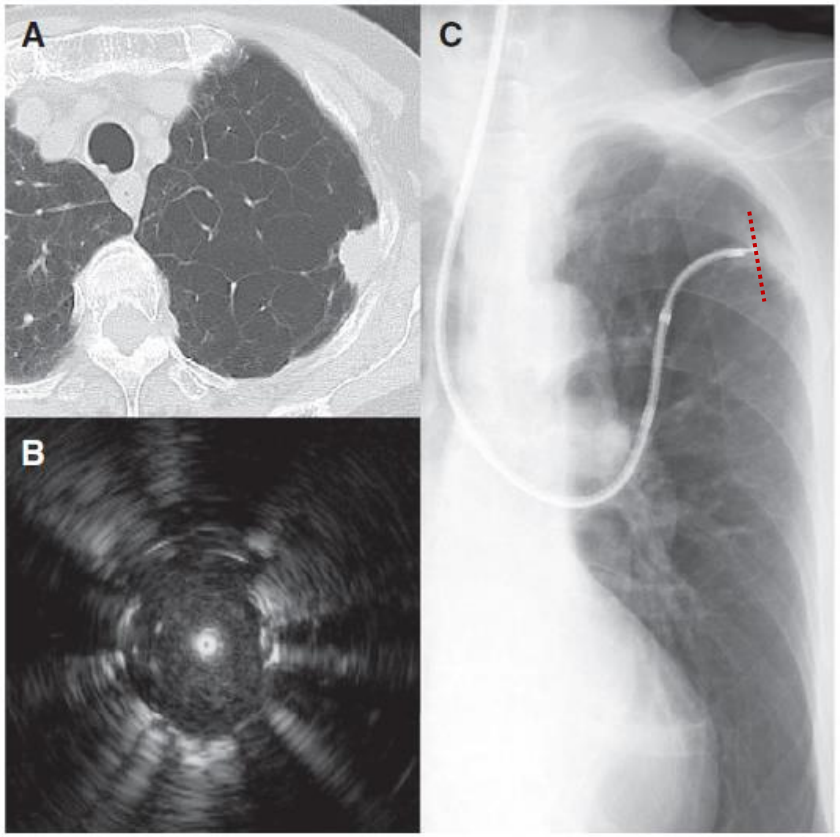
Radial EBUS probe
Biopsy forcep(1.5mm)
Cytology brush
PeriView FLEX TBNA needle



Ong PG, et al. J Thorac Dis. 2016 Dec;8(12):3808-3817.

Ultrathin bronchoscope





Thin bronchoscope Versus Ultrathin bronchoscope

Oki M, et al. Am J Respir Crit Care Med. 2015 Aug 15;192(4):468-76.

Diagnostic yield

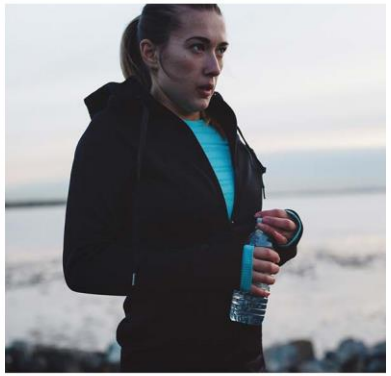
310 patients, 4 centers, suspected peripheral pulmonary nodule < 30mm

Lesion size, mm	UTB	EBUS-GS	*P*-value
≤ 20	65%	49%	0.037
20~30	84%	71%	0.061
Total	74%	59%	0.044

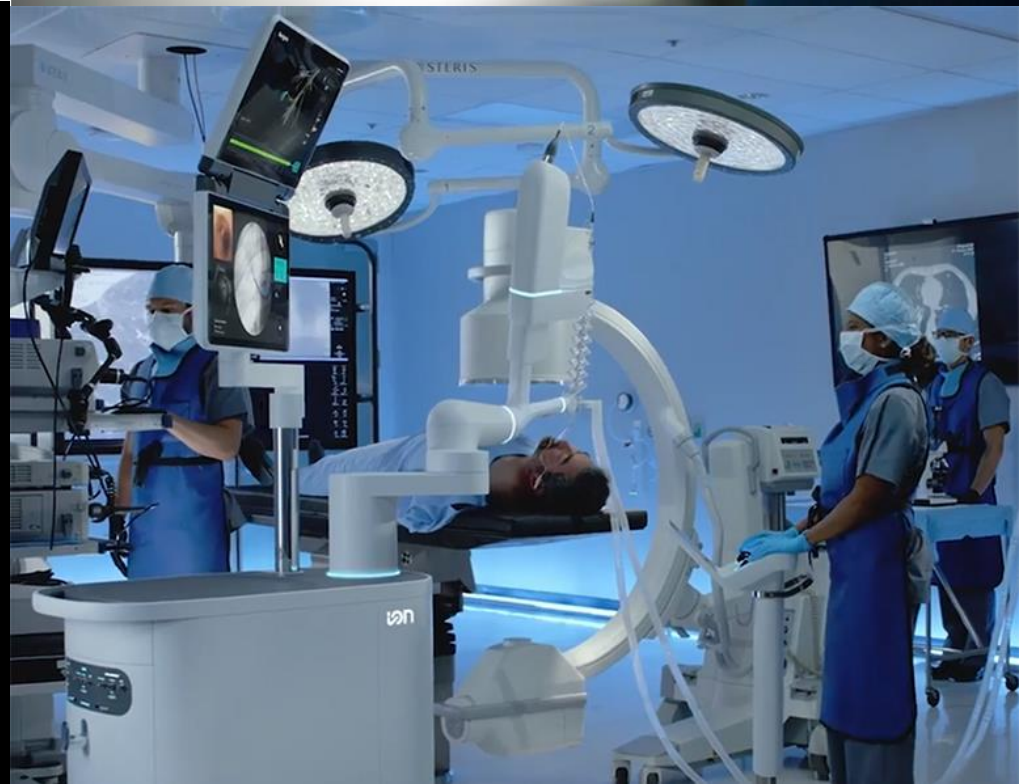
UBT = ultrathin bronchoscopy
EBUS-GS = endobronchial ultrasound using guide sheath

Oki M, et al. Am J Respir Crit Care Med. 2015 Aug 15;192(4):468-76.

04 Robotic bronchoscope
The Monarch ® system



04 Robotic bronchoscope
The Ion ® endoluminal system(Intuituve)



Preoperative diagnosis vs. Surgery without diagnosis

Eur Radiol (2017) 27:5119–5126
DOI 10.1007/s00330-017-4917-6

CrossMark

CHEST

CT assessment-based direct surgical resection of part-solid nodules with solid component larger than 5 mm without preoperative biopsy: experience at a single tertiary hospital

Sang Min Lee[1,2,3] · Chang Min Park[1,2] · Yong Sub Song[1,2] · Hyungjin Kim[1,2] · Young Tae Kim[4] · Young Sik Park[5,6] · Jin Mo Goo[1,2]

- From January 2009–December 2014, retrospective study
- 85 PSNs with solid components > 5 mm on CT
  - Preoperative PTNBs(biopsy group) : 41 PSNs
  - CT assessment-based direct resections(direct surgery group) : 44 PSNs

- There were no significant differences in diagnostic accuracy (P = 0.559) between the two groups.

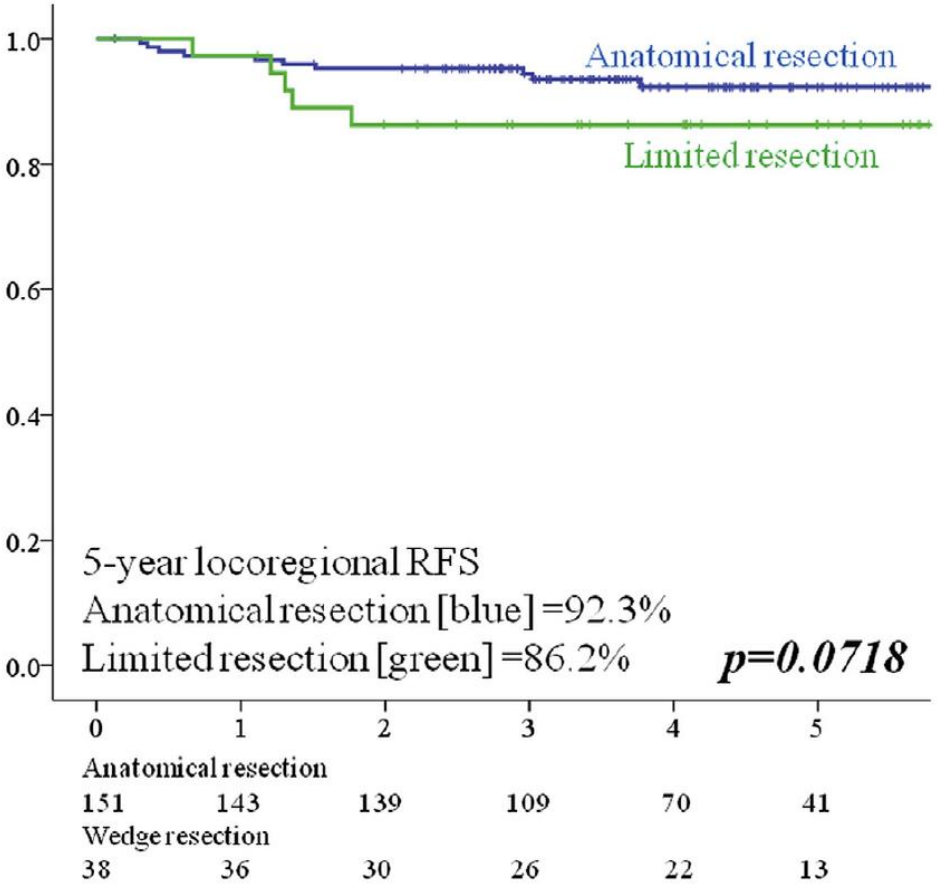
Eur Radiol (2017) 27:5119–5126

Treatment of Subsolid nodules

- Nodules that are large or exhibit progressive growth
  - Definitive therapy
    - Operable
      - Anatomic surgical resection (lobectomy); standard of care treatment
      - Limited (sub-lobar or wedge) surgical resection
    - Non-operable
      - Radiation therapy(RT); Stereotactic beam radiation therapy (SBRT) or conventional fractionation
      - Percutaneous or transbronchial ablation.

Treatment of Subsolid nodules

- Lobectomy vs. Limited (sub-lobar or wedge) surgical resection



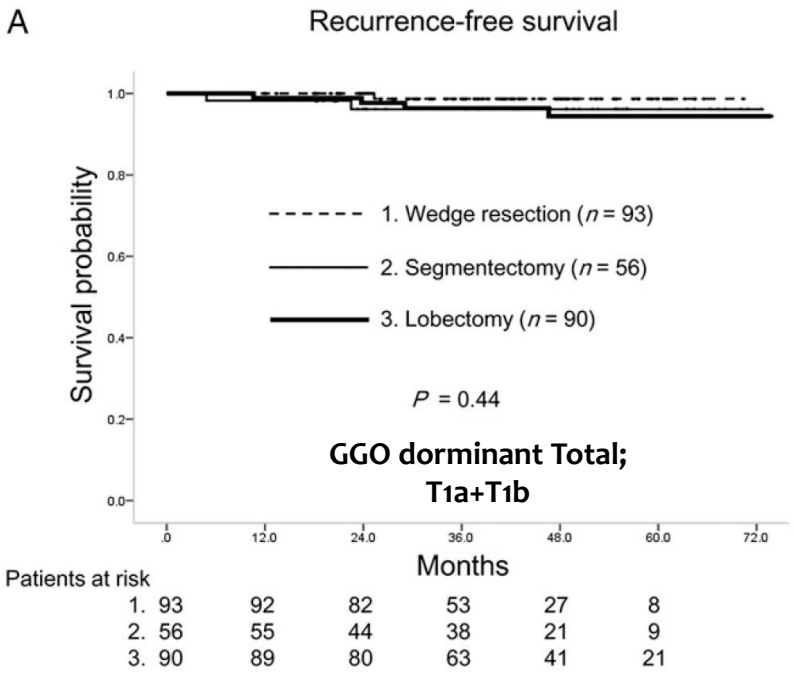
The anatomical resection (i.e., lobectomy or segmentectomy) arm

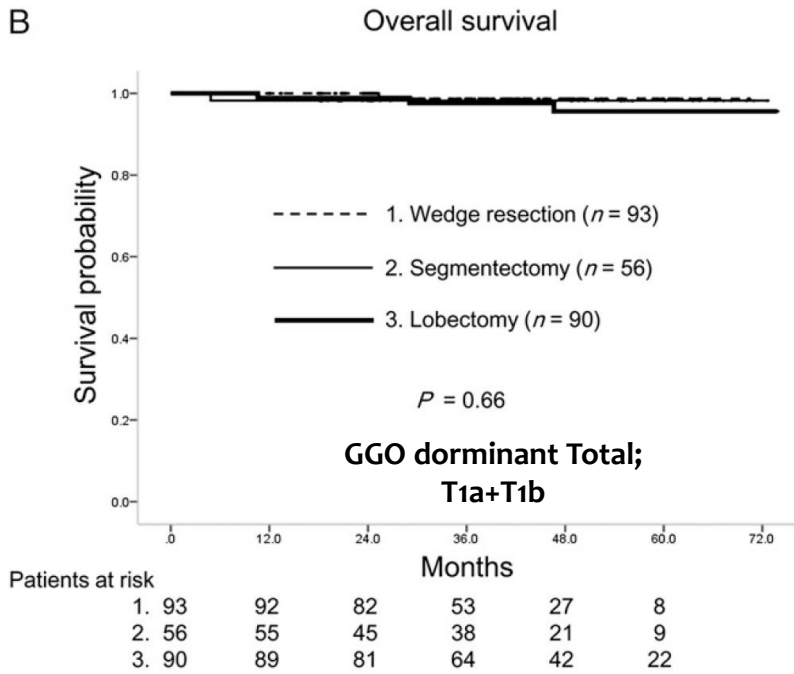
The wedge resection arm

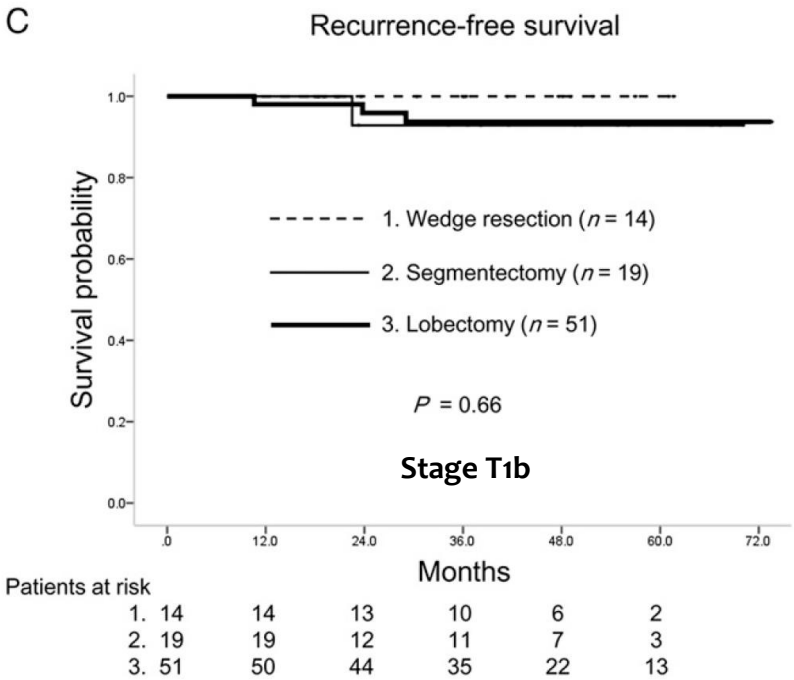
5-year locoregional RFS : no difference
P=0.0718

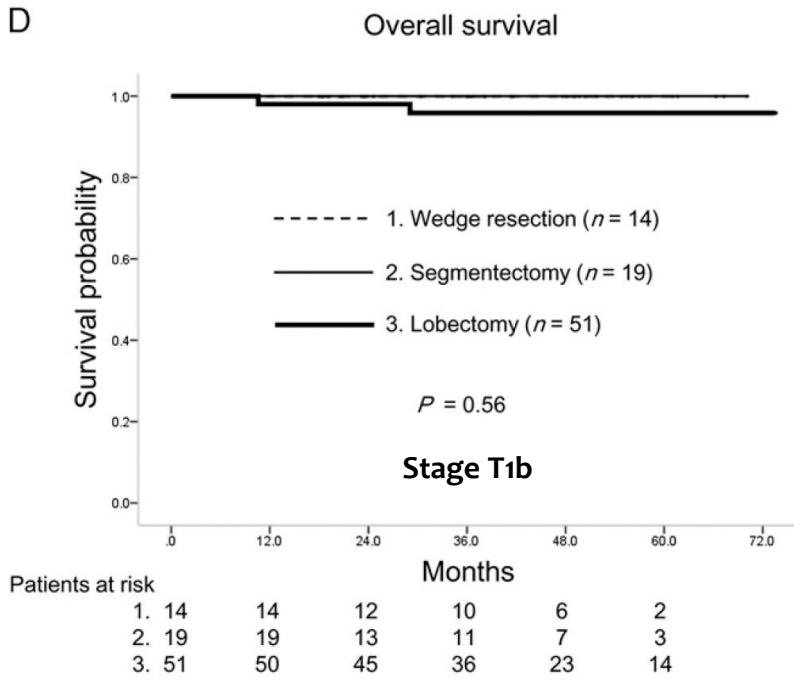
Hattori et al. J. Thoracic Oncol. 12 (6) (2017) 954–962.

- Lobe n


A
Recurrence-free survival
Survival probability
1. Wedge resection (n = 93)
2. Segmentectomy (n = 56)
3. Lobectomy (n = 90)
P = 0.44
GGO dorminant Total;
T1a+T1b
Months
Patients at risk
1. 93 92 82 53 27 8
2. 56 55 44 38 21 9
3. 90 89 80 63 41 21


B
Overall survival
Survival probability
1. Wedge resection (n = 93)
2. Segmentectomy (n = 56)
3. Lobectomy (n = 90)
P = 0.66
GGO dorminant Total;
T1a+T1b
Months
Patients at risk
1. 93 92 82 53 27 8
2. 56 55 45 38 21 9
3. 90 89 81 64 42 22


C
Recurrence-free survival
Survival probability
1. Wedge resection (n = 14)
2. Segmentectomy (n = 19)
3. Lobectomy (n = 51)
P = 0.66
Stage T1b
Months
Patients at risk
1. 14 14 13 10 6 2
2. 19 19 12 11 7 3
3. 51 50 44 35 22 13


D
Overall survival
Survival probability
1. Wedge resection (n = 14)
2. Segmentectomy (n = 19)
3. Lobectomy (n = 51)
P = 0.56
Stage T1b
Months
Patients at risk
1. 14 14 12 10 6 2
2. 19 19 13 11 7 3
3. 51 50 45 36 23 14

Treatment of Subsolid nodules

- Lobectomy vs. Limited (sub-lobar or wedge) surgical resection

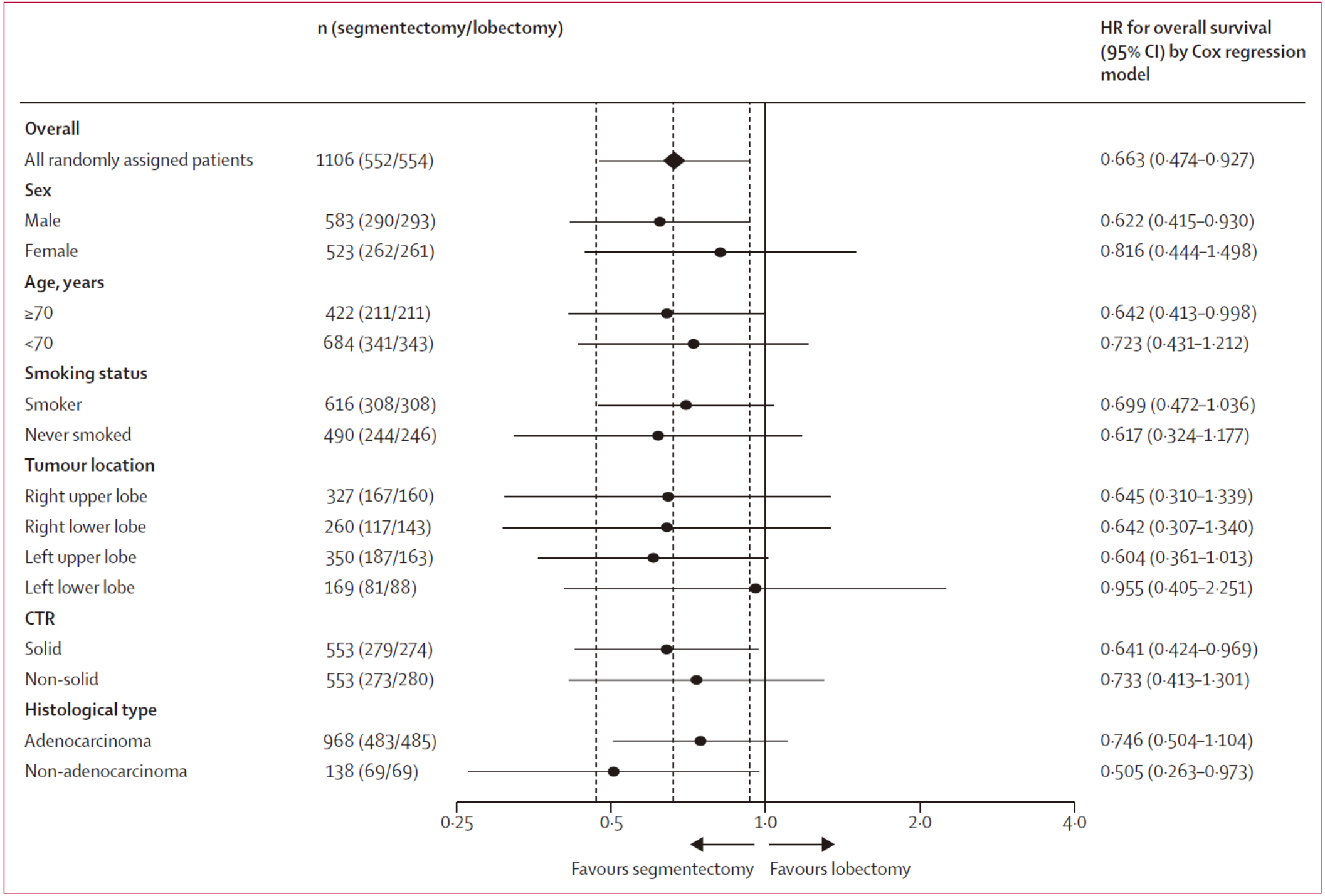
Segmentectomy versus lobectomy in small-sized peripheral non-small-cell lung cancer (JCOG0802/WJOG4607L): a multicentre, open-label, phase 3, randomised, controlled, non-inferiority trial

*Hisashi Saji, Morihito Okada, Masahiro Tsuboi, Ryu Nakajima, Kenji Suzuki, Keiju Aokage, Tadashi Aoki, Jiro Okami, Ichiro Yoshino, Hiroyuki Ito, Norihito Okumura, Masafumi Yamaguchi, Norihiko Ikeda, Masashi Wakabayashi, Kenichi Nakamura, Haruhiko Fukuda, Shinichiro Nakamura, Tetsuya Mitsudomi, Shun-Ichi Watanabe, Hisao Asamura, on behalf of the West Japan Oncology Group and Japan Clinical Oncology Group**

A randomised, controlled, non-inferiority trial at 70 institutions in Japan.

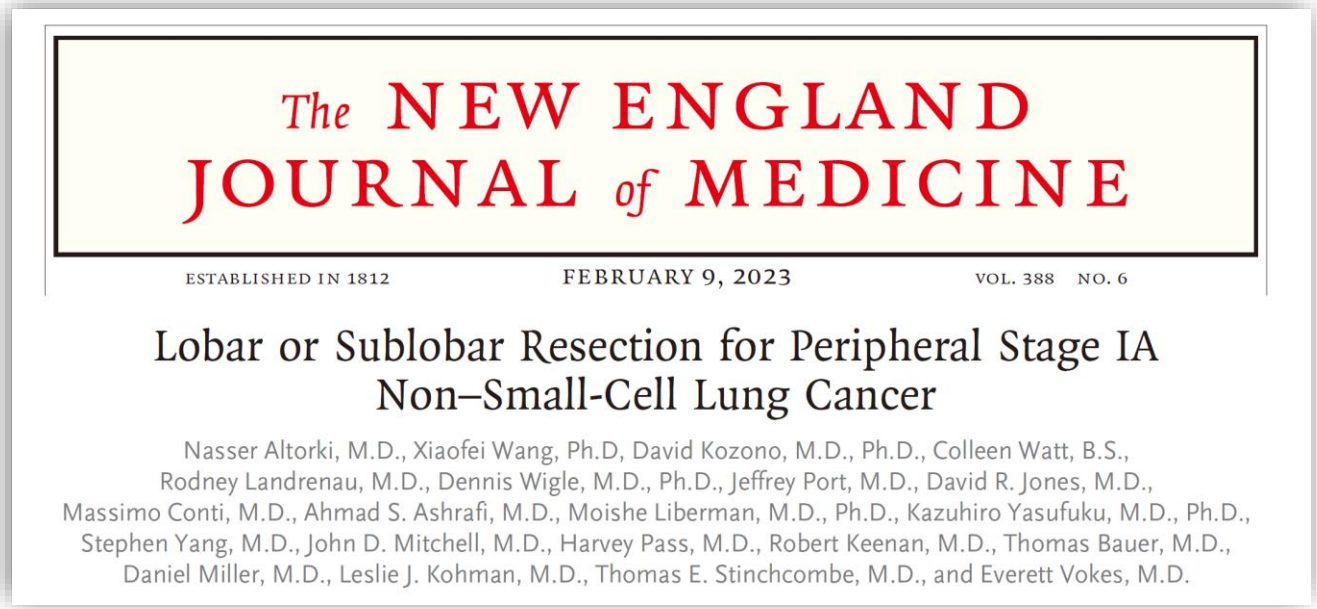
Patients with clinical stage IA NSCLC (tumour diameter ≤2 cm; consolidation-to-tumour ratio >0·5)
1:1 lobectomy or segmentectomy.

Hisashi S. et al. *Lancet* 2022; 399: 1607–17


n (segmentectomy/lobectomy)
HR for overall survival (95% CI) by Cox regression model
Overall
All randomly assigned patients 1106 (552/554) 0·663 (0·474–0·927)
Sex
Male 583 (290/293) 0·622 (0·415–0·930)
Female 523 (262/261) 0·816 (0·444–1·498)
Age, years
≥70 422 (211/211) 0·642 (0·413–0·998)
<70 684 (341/343) 0·723 (0·431–1·212)
Smoking status
Smoker 616 (308/308) 0·699 (0·472–1·036)
Never smoked 490 (244/246) 0·617 (0·324–1·177)
Tumour location
Right upper lobe 327 (167/160) 0·645 (0·310–1·339)
Right lower lobe 260 (117/143) 0·642 (0·307–1·340)
Left upper lobe 350 (187/163) 0·604 (0·361–1·013)
Left lower lobe 169 (81/88) 0·955 (0·405–2·251)
CTR
Solid 553 (279/274) 0·641 (0·424–0·969)
Non-solid 553 (273/280) 0·733 (0·413–1·301)
Histological type
Adenocarcinoma 968 (483/485) 0·746 (0·504–1·104)
Non-adenocarcinoma 138 (69/69) 0·505 (0·263–0·973)
0·25
0·5
1·0
2·0
4·0
Favours segmentectomy
Favours lobectomy

Treatment of Subsolid nodules

- Lobectomy vs. Limited (sub-lobar or wedge) surgical resection



The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 FEBRUARY 9, 2023 VOL. 388 NO. 6

Lobar or Sublobar Resection for Peripheral Stage IA Non–Small-Cell Lung Cancer

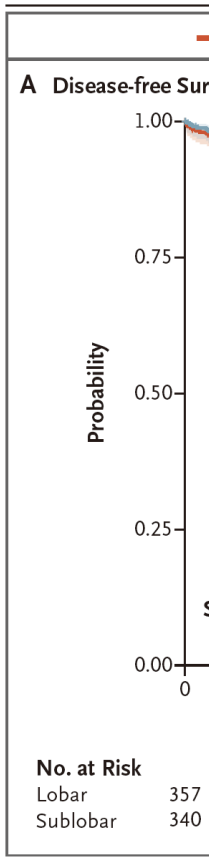
Nasser Altorki, M.D., Xiaofei Wang, Ph.D, David Kozono, M.D., Ph.D., Colleen Watt, B.S., Rodney Landrenau, M.D., Dennis Wigle, M.D., Ph.D., Jeffrey Port, M.D., David R. Jones, M.D., Massimo Conti, M.D., Ahmad S. Ashrafi, M.D., Moishe Liberman, M.D., Ph.D., Kazuhiro Yasufuku, M.D., Ph.D., Stephen Yang, M.D., John D. Mitchell, M.D., Harvey Pass, M.D., Robert Keenan, M.D., Thomas Bauer, M.D., Daniel Miller, M.D., Leslie J. Kohman, M.D., Thomas E. Stinchcombe, M.D., and Everett Vokes, M.D.

A multicenter, noninferiority, phase 3 trial

Patients with NSCLC clinically staged as T1aN0 (tumor size, ≤2 cm)
Sublobar resection or lobar resection after intraoperative confirmation of node-negative disease.

Altorki N. et al.N Engl J Med 2023;388:489-98.

- Lobectomy v resection



Subgroup	Sublobar Resection	Lobar Resection	Hazard Ratio for Disease Recurrence or Death (95% CI)
	no. of patients		
Overall	340	357	1.03 (0.81–1.30)
Age			
≤65 yr	123	131	0.96 (0.64–1.45)
>65 yr	217	226	1.07 (0.80–1.42)
Age			
≤70 yr	206	211	1.10 (0.80–1.52)
>70 yr	134	146	0.94 (0.67–1.33)
Sex			
Male	150	147	1.12 (0.78–1.59)
Female	190	210	0.97 (0.71–1.33)
Tumor location			
Right upper lobe	120	128	1.00 (0.68–1.47)
Right middle lobe	19	16	2.27 (0.71–7.26)
Right lower lobe	55	43	0.83 (0.44–1.56)
Left upper lobe	86	104	0.91 (0.59–1.41)
Left lower lobe	56	63	1.35 (0.69–2.64)
Lingula	4	3	0.93 (0.15–5.71)
Histologic type			
Squamous-cell carcinoma	45	53	0.99 (0.54–1.79)
Adenocarcinoma	218	226	1.09 (0.80–1.50)
Other	77	78	0.93 (0.60–1.46)
Smoking status			
Never	28	35	1.75 (0.65–4.71)
Former	172	177	0.91 (0.65–1.27)
Current	140	145	1.07 (0.75–1.52)
Tumor size			
<1.0 cm	28	30	0.83 (0.29–2.40)
1.0–1.5 cm	174	180	0.90 (0.65–1.25)
>1.5–2.0 cm	138	147	1.24 (0.87–1.77)
ECOG performance-status score			
0	263	250	0.96 (0.72–1.26)
1 or 2	77	107	1.31 (0.84–2.04)

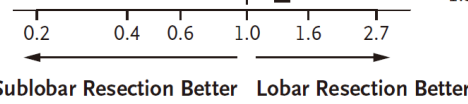
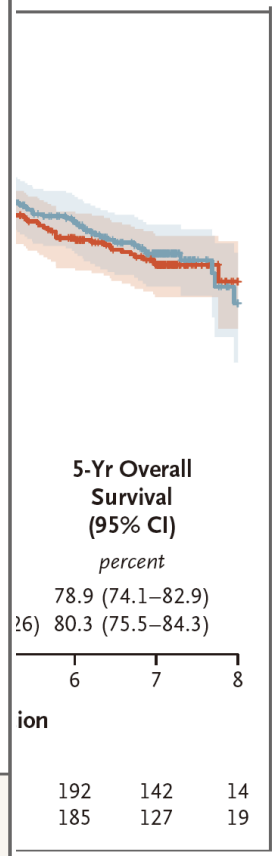


Figure 2. Exploratory Subgroup Analysis of Disease-free Survival.

Hazard ratios and 95% confidence intervals were estimated with the use of unstratified Cox proportional-hazards models. The size of the squares indicating the hazard ratios is proportional to the number of patients included in the analysis. Eastern Cooperative Oncology Group (ECOG) performance-status scores range from 0 to 5, with higher scores indicating greater disability.



-98.

Treatment of Subsolid nodules

- Lobectomy vs. Limited (sub-lobar or wedge) surgical resection

Long-Term Outcomes of Wedge Resection for Pulmonary Ground-Glass Opacity Nodules

Jong Ho Cho, MD, PhD, Yong Soo Choi, MD, PhD, Jhingook Kim, MD, PhD, Hong Kwan Kim, MD, PhD, Jae Ill Zo, MD, PhD, and Young Mog Shim, MD, PhD

Department of Thoracic Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

Conclusion

Wedge resection should be **carefully** considered for **patients with mixed GGO nodules (C/T ratio >0.25)** because of the high recurrence rate.

Radiologic noninvasiveness (C/T ratio <0.25) might be a good indicator for candidates for sublobar resection in cases of early stage lung adenocarcinoma.

JH Cho et al. Ann. Thorac Surg. 2015;99(1):218-222

Treatment of Subsolid nodules

- Nodules that are large or exhibit progressive growth
  - Definitive therapy
    - Operable
      - Anatomic surgical resection (lobectomy); standard of care treatment of NSCLC
      - Limited (sub-lobar or wedge) surgical resection; Stage IA NSCLC
    - Non-operable
      - Radiation therapy(RT); Stereotactic beam radiation therapy (SBRT) or conventional fractionation
      - Percutaneous or transbronchial ablation.

Treatment of Subsolid nodules

- Non-operable
  - **Radiation therapy(RT);** Stereotactic beam radiation therapy (SBRT) or conventional fractionation
  - Prospective phase II studies with SBRT
    - the local control rate is approximately 90 to 95 percent

Senthi S, et al. Lancet Oncol. 2012;13(8):802.
Hobbs CJ, et al. Mayo Clin Proc Innov Qual Outcomes. 2018;2(1):40.

  - SBRT vs. Standard radiotherapy
    - In a randomized trial in patients with inoperable peripherally located stage I NSCLC
      - SABR resulted in superior local control of the primary disease without an increase in major toxicity

Ball D, et al. Lancet Oncol. 2019;20(4):494.

Treatment of Subsolid nodules

- Non-operable
  - SBRT vs. surgery
    - Prior to 2010, three randomized trials were designed to compare the efficacy of SBRT with surgical resection for the operable patient population (American College of Surgeons Oncology Group Z4099, the ROSEL trial, and the Accuray trial).
      - Closed prematurely due to poor accrual.
    - Retrospective analyses of large cohorts
      - A retrospective analysis of 4065 patients with clinical stage I NSCLC
        - SBRT (n = 449) versus surgery (sublobar resection [n = 634] or lobectomy [n = 2986])
          - Cancer-specific mortality
            - SBRT >> lobectomy (HR 1.4, 95% CI 1.09-1.94).
            - SBRT > Sublobar resection; not statistically significant(HR 1.25, 95% CI 0.93-1.68).
          - Short-term mortality
            - lower in patients managed with SBRT (90-day mortality for SBRT, sublobar resection, and lobectomy 1.4, 2.5, and 3.6 percent, respectively).

Bryant AK, et al. Ann Thorac Surg. 2018;105(2):425.

Treatment of Subsolid nodules

- Non-operable
  - SBRT vs. surgery
    - Prior to 2010, three randomized trials were designed to compare the efficacy of SBRT with surgical resection for the operable patient population (American College of Surgeons Oncology Group Z4099, the ROSEL trial, and the Accuray trial).
      - Closed prematurely due to poor accrual.
    - Retrospective analyses of large cohorts
      - A retrospective analysis of 76,623 patients with clinical stage I NSCLC(cT1-T2a,N0,M0 disease)
        - Short-term mortality
          - SBRT >> surgery
        - Overall mortality at both 30 and 90 days.
          - SBRT was lower (0.7 versus 2.1 percent and 2.9 versus 3.6 percent, respectively)
          - Esp in patients more than 70 years of age.

Stokes WA, et al. J Clin Oncol. 2018;36(7):642.

JOURNAL OF CLINICAL ONCOLOGY ASCO SPECIAL ARTICLE

Stereotactic Body Radiotherapy for Early-Stage Non–Small-Cell Lung Cancer: American Society of Clinical Oncology Endorsement of the American Society for Radiation Oncology Evidence-Based Guideline

Bryan J. Schneider, Megan E. Daly, Erin B. Kennedy, Mara B. Antonoff, Stephen Broderick, Jill Feldman, Shruti Jolly, Bryan Meyers, Gaetano Rocco, Chad Rusthoven, Ben J. Slotman, Daniel H. Sterman, and Brendon M. Stiles

Recommendations

For standard operative risk patients with stage I NSCLC

1. SBRT is not recommended outside of a clinical trial.
2. Lobectomy with systematic lymph node evaluation remains the recommended treatment, although a sublobar resection may be considered in select clinical scenarios.

The use of SBRT in high operative risk patients and for inoperative patients;
challenging scenarios where tumors are: centrally located, > 5 cm in diameter, lacking tissue diagnosis, synchronous primary or multifocal, second primary after pneumonectomy, proximal to or involved with mediastinal structures, abutting the chest wall, or recurring after previous treatment.

J Clin Oncol 2017;36:710-719.

Treatment of Subsolid nodules

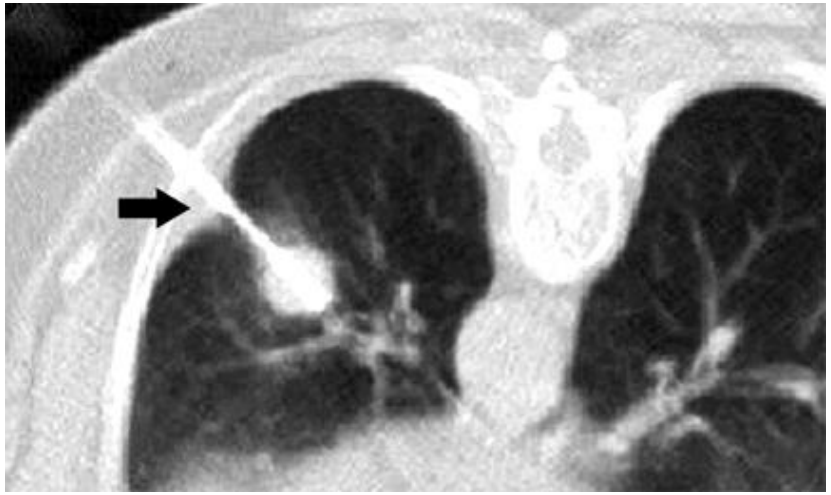
- Non-operable
  - SBRT vs. surgery
    - Now randomizing patients with operable stage I NSCLC to surgery or stereotactic ablative radiotherapy
      - the Joint Lung Cancer Trialist's Coalition STABLE-MATES trial (NCT02468024)
      - the Veterans Affairs Lung Cancer Surgery or Stereotactic Radiotherapy trial (NCT02984761)

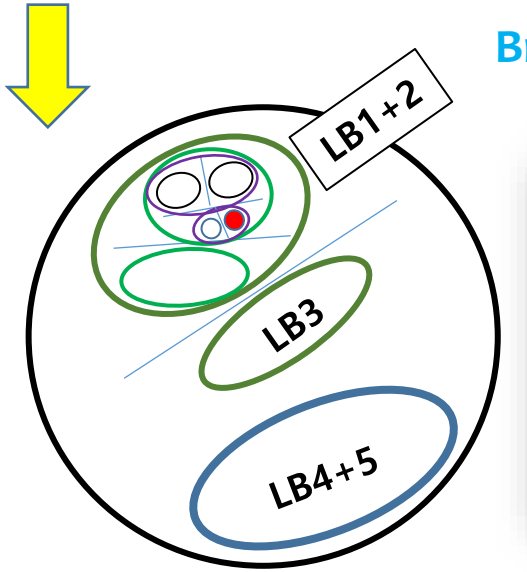
Senthi S, et al. Lancet Oncol. 2012;13(8):802.
Hobbs CJ, et al. Mayo Clin Proc Innov Qual Outcomes. 2018;2(1):40.

Treatment of Subsolid nodules

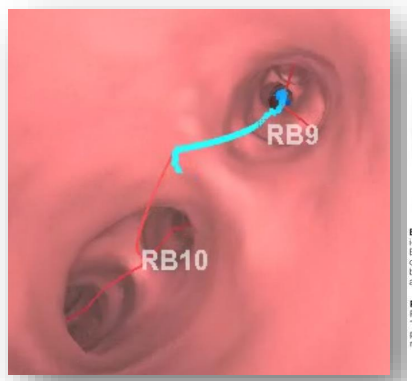
- Non-operable
  - **Other ablative techniques**
    - Both proton beam and carbon ion therapy.
      - The results suggest that these approaches yield results similar to SBRT.
    - Other image-guided ablative techniques –radiofrequency ablation, cryoablation, microwave ablation, laser ablation, and irreversible electroporation.

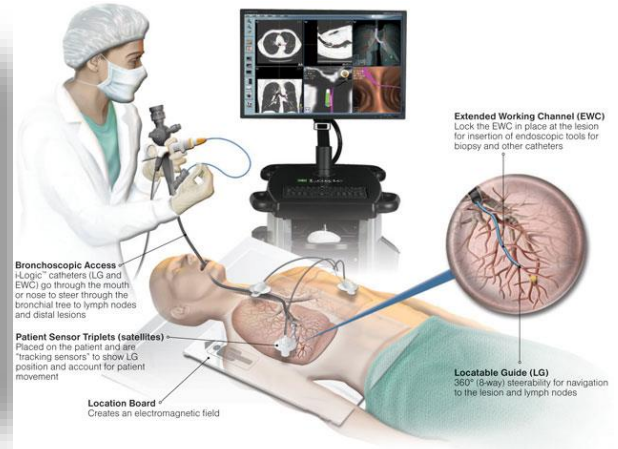
Radiologic guided…





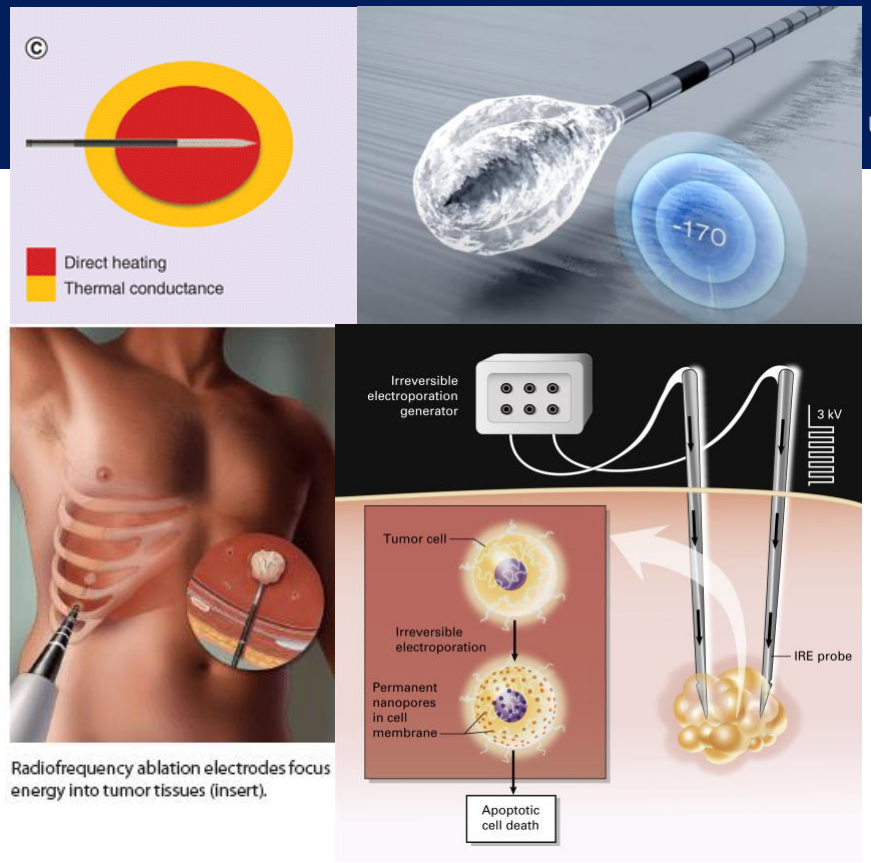
Bronchoscopic guided…





Treatment of Subsolid nodules

- Non-operable
  - **Other ablative techniques**
    - Image-guided ablative techniques
      - Radiofrequency ablation
      - Cryoablation
      - Microwave ablation
      - Laser ablation
      - Irreversible electroporation.



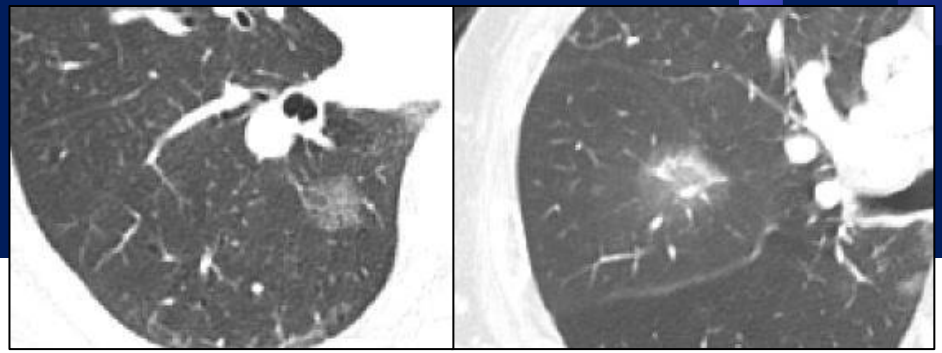
- There are inadequate long-term data with these techniques, and none of these have an established role in the routine management of stage I or stage II NSCLCs.

05 Treatment of Subsolid nodules

Image-guided ablation of lung tumors in Uptodate ®

	Overall survival rate		Complication
RFA	70-89%(I year), 48-69.8%(2 years), 59%(3 years), **40%(5 years)** Recurrence free rate : 68.9%(1 year), 59.8%(2 year) Medial survival : 33 months	- Electromagnetic energy(375-500 kHz) with 4-16 small wires deployed through 14-17 gauze needle - Good for ≤3cm mass - RFA ≠ SBRT	**Pneumothorax; 38.4%** Pneumonia : 5.7% Effusion : 4% In-hospital mortality : 1.3% Conversion to thoracoscopy/thoracotomy : 0.9%
Cryoablation	**5 Year survival rate : 68%** **5 year progression free survival : 88%**	**Liquid nitrogen, argon-based (upto -140°C)** Compared with RFA, larger tumor ablation volumes, multiple applicators, a highly visible ablation zone, less procedural pain	
MW ablation	65%(I year), 55%(2 years), 45%(3 years) Medial survival : 30.6 months	Needle-like antenna under CT guidance to **directly deliver MW energy** into a tumor	
Laser ablation	81%(I year), 59%(2 years), 44%(3 years), **27%(5 years)**	**Nd:YAG laser**; wavelength of 1064nm or a **continuous-wave infrared(820nm) diode laser** through a flexible fiberoptic cable	
IRE	61%(I year)	Novel ablation technology; **direct electrical pulses** to create nanoscale defects or pores in cell membranes	

Summary



- **Subsolid nodule : pGGN + part-solid nodule**
  - **Incidence :** ~ 9% in lung cancer screening patients(GGN : 0.7 ~ 4.2%, Part-solid nodule : 0.8 ~ 5.0%)
  - **Natural course :** A higher malignancy risk, More indolent behavior, Less likely to develop LNs and distant metastases
  - **CT surveillance :** solid component
    - Fleischner guideline, Lung-RADS 2022, 폐암진료지침
  - **Diagnosis :** Non-surgical biopsy(Transthoracic needle biopsy, Bronchoscopic technique)
  - **Treatment**
    - Operable
      - **Anatomic surgical resection (lobectomy); standard of care treatment of NSCLC**
      - Limited (sub-lobar or wedge) surgical resection; Stage IA NSCLC
    - Non-operable
      - Radiation therapy(RT); **Stereotactic beam radiation therapy (SBRT)** >> conventional fractionation
      - Percutaneous or transbronchial ablation; inadequate long-term data and no RCTs

For multiple subsolid nodules
Multidisciplinary team approach

Thank you for listening…

Special thanks to Prof. Kurimoto, Prof. Eom, Prof. Kim and Prof. Min