

Update on Fleischner Criteria for Pulmonary Nodules

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Disclosures

- None pertaining to the talk

Objectives

1. Review the history of the Fleischner guidelines
2. Discuss the changes found in the 2017 edition
 - a. the changes in nodule size criterion for follow up and the follow up schedules
 - b. expanded list that the recommendations “do not apply to”
 - c. is a patient “High Risk” if they have only one “Lung Cancer Risk Factor”
3. What are the current guidelines for lung cancer screening and Lung-RADS assessments and how they differ from the Fleischner guidelines

History of Fleischner Society

- The Fleischner Society is named after Felix Fleischner, M.D., a pioneer in the pathogenesis and diagnosis of lung disease using the chest radiograph.



History of Fleischner Society

- Felix Fleischner was born in Vienna in 1893 and received his medical degree in 1919 from the University of Vienna.
- He came to US in 1938 and spent his first 2 years at the Massachusetts General Hospital followed by 2 years in private practice.
- He was appointed to the staff at Boston's Beth Israel Hospital in 1942 as their first full time radiologist, serving as dept chair from 1945-1960

History of Fleischner Society

- In November 1969, a group of 8 radiologists including Doctors Robert Fraser, Leo Rigler, Benjamin Felson, George Simon, Norman Blank, Richard Greenspan, Eric Milne, and Morris Simon first met to form a new society to study chest disease.
- Dr Fleischner was invited to the meeting, but when he suddenly died of a heart attack while swimming on August, 3 months before the meeting.
- The group dedicated and named the new organization, the Fleischner Society.

History of Fleischner Society

- Mission statement
 - develop a better understanding of chest diseases
 - to foster chest radiology as an art and a science, and
 - to stimulate all aspects of teaching and research.
- The Fleischner Society is now 50 years young.
- It has 65 active members (and 35 less active senior members) of varying disciplines.

History of Fleischner Society



Lung Nodules

Radiology

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Guidelines for Management of Small Pulmonary Nodules Detected on CT Scans: A Statement from the Fleischner Society¹

Lung nodules

- Since the introduction of helical CT in the early 1990s and multi-detector row CT in the late 1990s, the detection of nodules has become routine.
- A vast majority these nodules are <7 mm in diameter and most of them are benign.
- Guidelines for the management of the SPN were published in 2003 by the American College of Chest Physicians

Lung nodules

- ACCP recommended 3, 6, 12, and 24 month CT follow-up intervals, also without any specified lower size limit.
- Likelihood of malignancy in a lung nodule increases with size.
- Nodules smaller than 4mm that will eventually turn into lethal cancers is very low (1%)

Original 2005 guidelines

Recommendations for Follow-up and Management of Nodules Smaller than 8 mm Detected Incidentally at Nonscreening CT

Nodule Size (mm)*	Low-Risk Patient†	High-Risk Patient‡
≤4	No follow-up needed§	Follow-up CT at 12 mo; if unchanged, no further follow-up¶
>4–6	Follow-up CT at 12 mo; if unchanged, no further follow-up¶	Initial follow-up CT at 6–12 mo then at 18–24 mo if no change¶
>6–8	Initial follow-up CT at 6–12 mo then at 18–24 mo if no change	Initial follow-up CT at 3–6 mo then at 9–12 and 24 mo if no change
>8	Follow-up CT at around 3, 9, and 24 mo, dynamic contrast-enhanced CT, PET, and/or biopsy	Same as for low-risk patient

Note.—Newly detected indeterminate nodule in persons 35 years of age or older.

* Average of length and width.

† Minimal or absent history of smoking and of other known risk factors.

‡ History of smoking or of other known risk factors.

§ The risk of malignancy in this category (<1%) is substantially less than that in a baseline CT scan of an asymptomatic smoker.

¶ Nonsolid (ground-glass) or partly solid nodules may require longer follow-up to exclude indolent adenocarcinoma.

Limitations

- These guidelines exclude
 - GGO and subsolid nodules
 - Patients <35 years of age
 - Patients with known malignancy
 - Non incidental and screen detected nodules
 - Immunosuppressed patients
 - Nodules > 8mm
 - Solitary vs multiple nodules

Subsolid nodules

Recommendations for the Management of Subsolid Pulmonary Nodules Detected at CT: A Statement from the Fleischner Society¹

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This report is to complement the original Fleischner Society recommendations for incidentally detected solid nodules by proposing a set of recommendations specifically aimed at subsolid nodules. The development of a standardized approach to the interpretation and management of subsolid nodules remains critically important given that peripheral adenocarcinomas represent the most common type of lung cancer, with evidence of increasing frequency. Following an initial consideration of appropriate terminology to describe subsolid nodules and a brief review of the new classification system for peripheral lung adenocarcinomas sponsored by the International Association for the Study of Lung Cancer (IASLC), American Thoracic

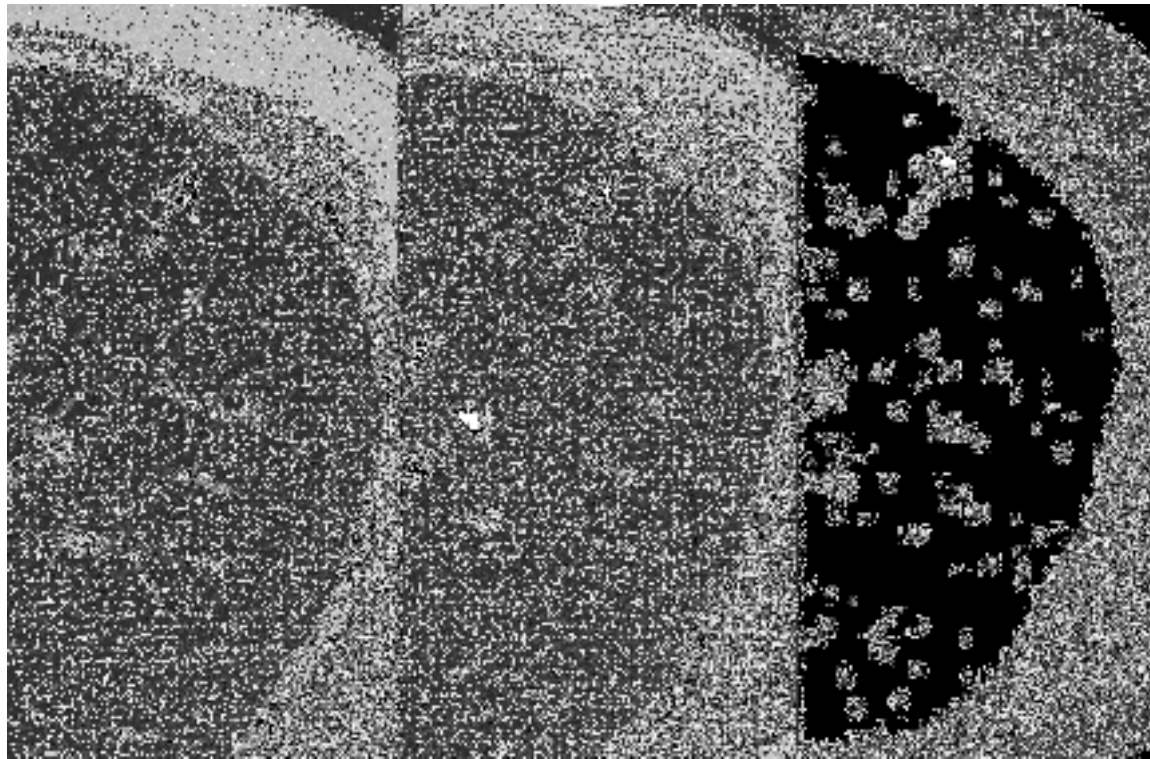
Subsolid nodules

Recommendations for the Management of Subsolid Pulmonary Nodules Detected at CT: A Statement from the Fleischner Society

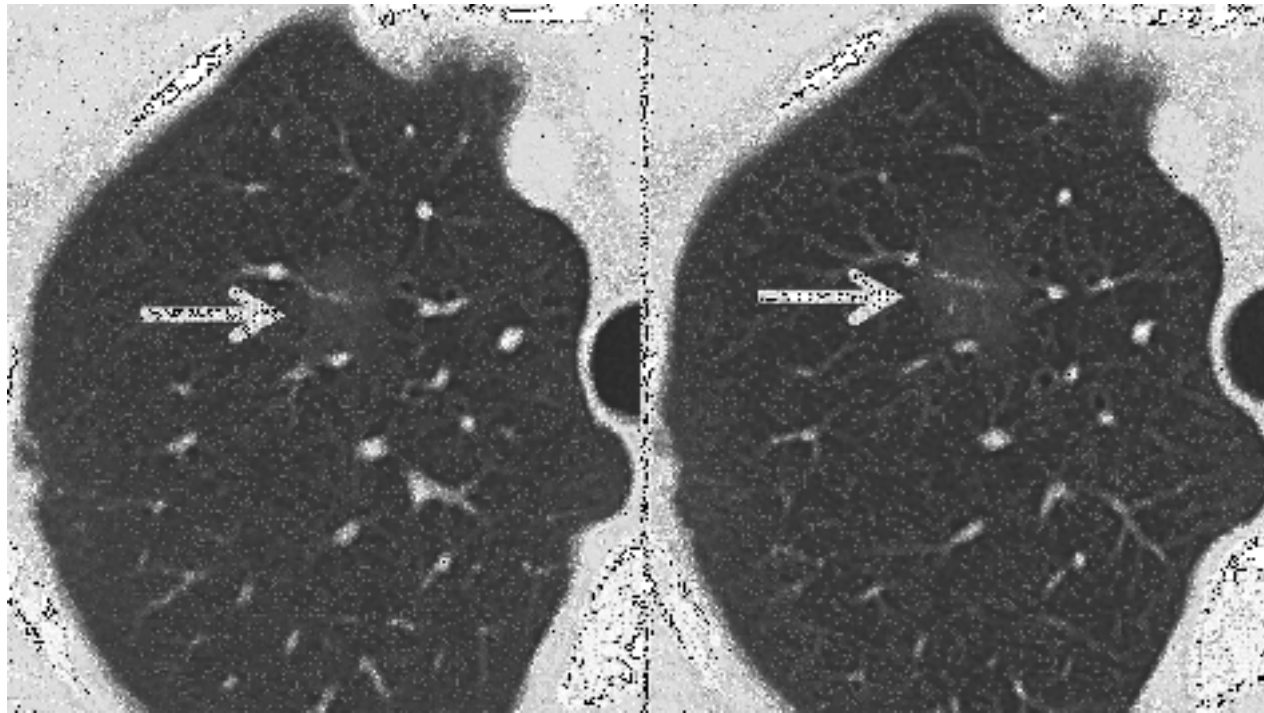
Nodule Type	Management Recommendations	Additional Remarks
Solitary pure GGNs		
≤5 mm	No CT follow-up required	Obtain contiguous 1-mm-thick sections to confirm that nodule is truly a pure GGN
>5 mm	Initial follow-up CT at 3 months to confirm persistence then annual surveillance CT for a minimum of 3 years	FDG PET is of limited value, potentially misleading, and therefore not recommended
Solitary part-solid nodules	Initial follow-up CT at 3 months to confirm persistence. If persistent and solid component <5 mm, then yearly surveillance CT for a minimum of 3 years. If persistent and solid component ≥5 mm, then biopsy or surgical resection	Consider PET/CT for part-solid nodules >10 mm
Multiple subsolid nodules		
Pure GGNs ≤5 mm	Obtain follow-up CT at 2 and 4 years	Consider alternate causes for multiple GGNs ≤5 mm
Pure GGNs >5 mm without a dominant lesion(s)	Initial follow-up CT at 3 months to confirm persistence and then annual surveillance CT for a minimum of 3 years	FDG PET is of limited value, potentially misleading, and therefore not recommended
Dominant nodule(s) with part-solid or solid component	Initial follow-up CT at 3 months to confirm persistence. If persistent, biopsy or surgical resection is recommended, especially for lesions with >5 mm solid component	Consider lung-sparing surgery for patients with dominant lesion(s) suspicious for lung cancer

Note.—These guidelines assume meticulous evaluation, optimally with contiguous thin sections (1 mm) reconstructed with narrow and/or mediastinal windows to evaluate the solid component and wide and/or lung windows to evaluate the nonsolid component of nodules, if indicated. When electronic calipers are used, bidimensional measurements of both the solid and ground-glass components of lesions should be obtained as necessary. The use of a consistent low-dose technique is recommended, especially in cases for which prolonged follow-up is recommended, particularly in younger patients. With serial scans, always compare with the original baseline study to detect subtle indolent growth.

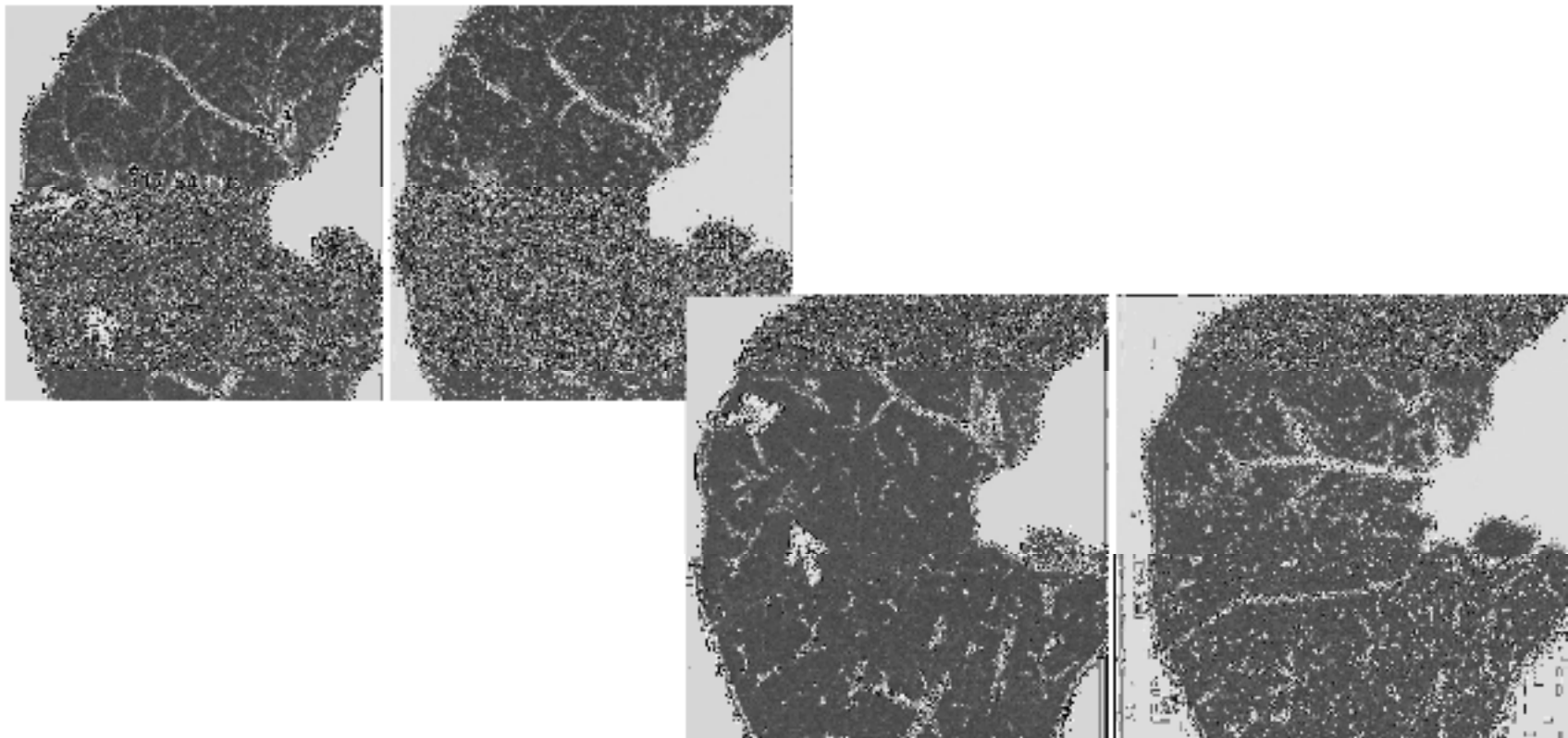
<5mm GGN



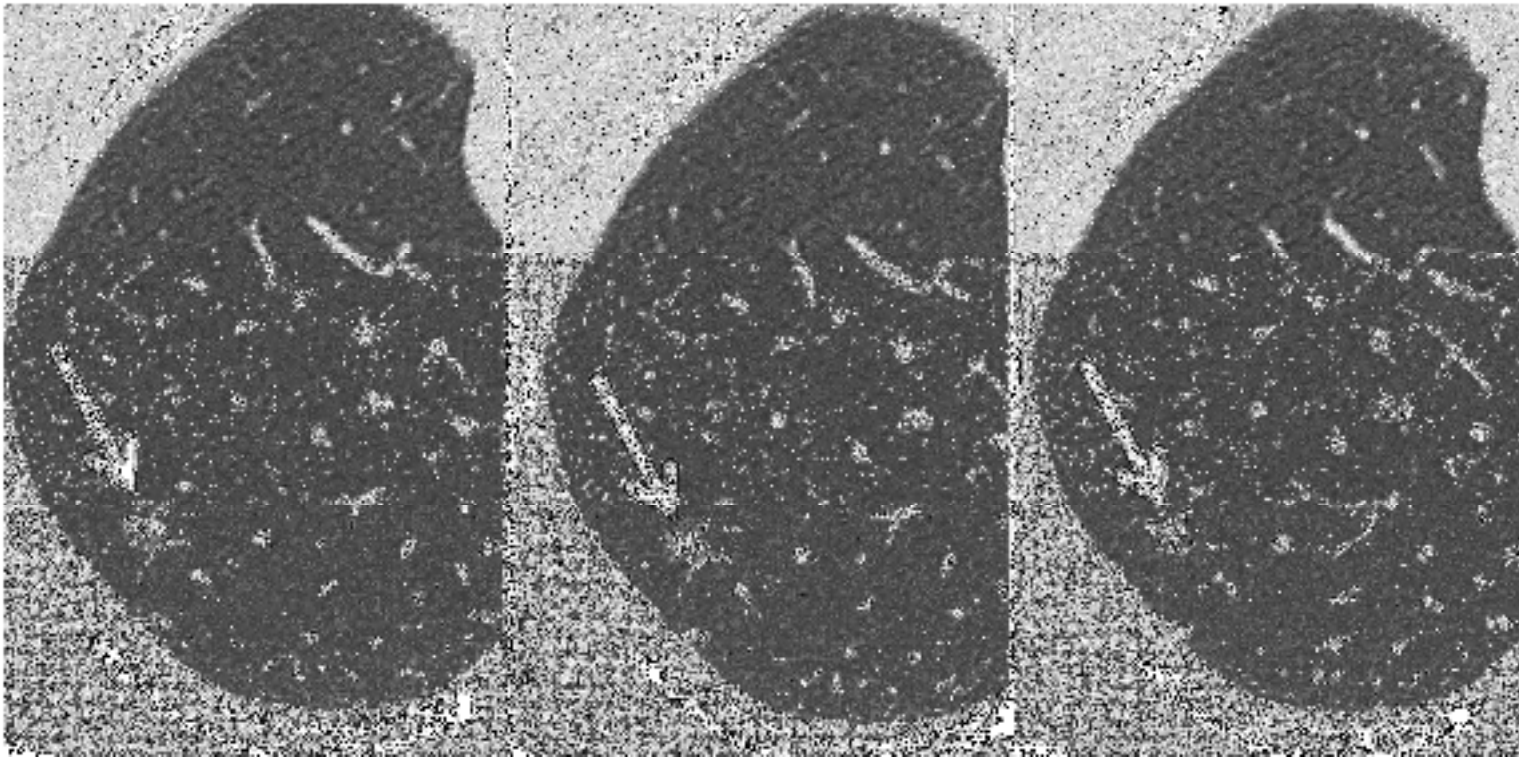
> 5mm Pure GGN



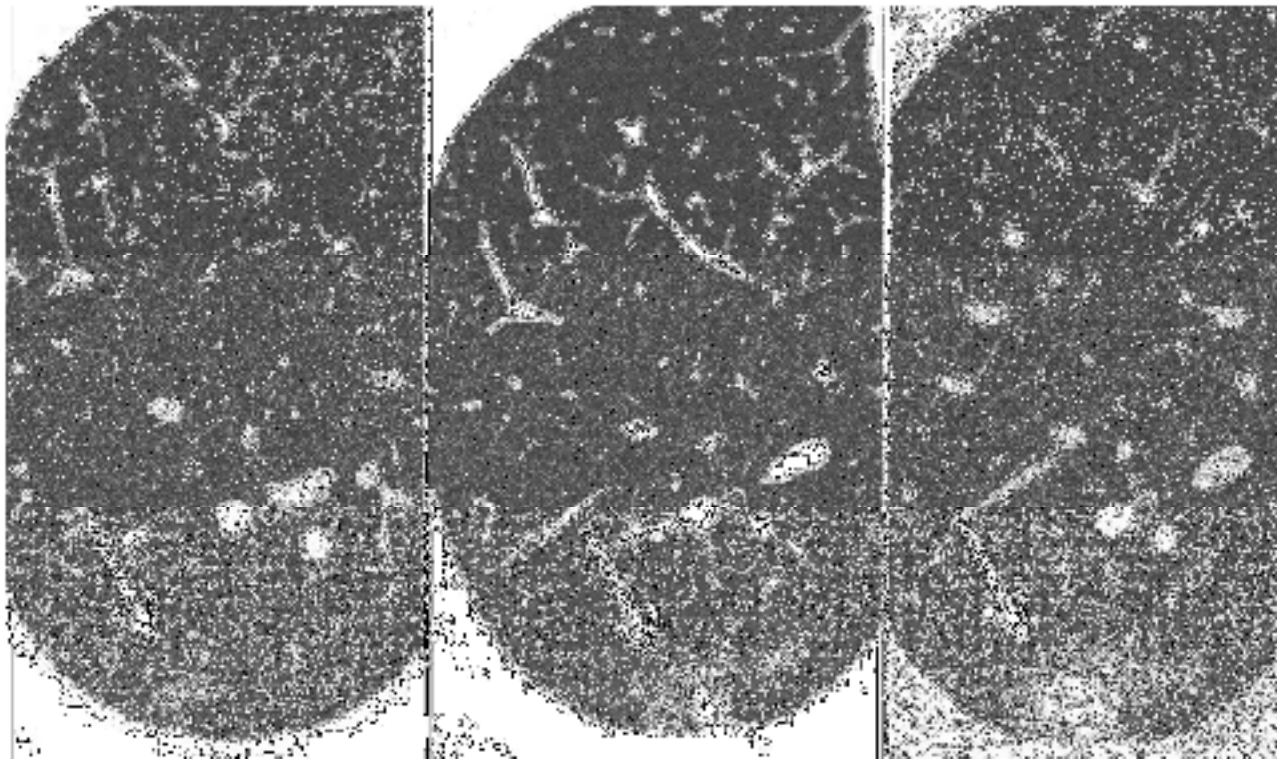
Significance of short interval follow up



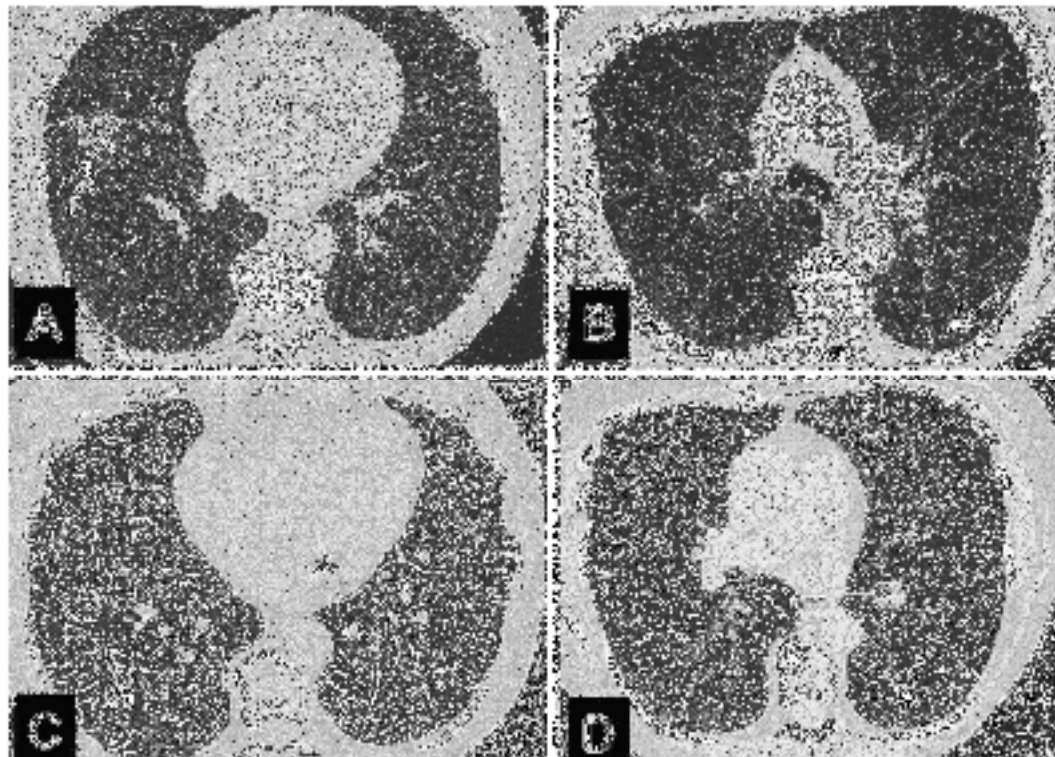
Part Solid nodule (Solid component $<5\text{mm}$)



Part solid nodules (Solid component >5mm)



Multiple subsolid nodules



Updated 2017 guidelines

Advances in Knowledge

- For solid nodules, the minimum threshold size for routine follow-up has been increased, and fewer follow-up examinations are recommended for stable nodules.
- For subsolid nodules, a longer period is recommended before initial follow-up, and the total length of follow-up has been extended to 5 years.

Implications for Patient Care

- These guidelines apply to incidental nodules, which can be managed according to the specific recommendations.
- These guidelines do not apply to patients younger than 35 years, immunocompromised patients, or patients with cancer.
- For lung cancer screening, adherence to the existing American College of Radiology Lung CT Screening Reporting and Data System (Lung-RADS) guidelines is recommended.

2017 Guidelines (Solitary Solid nodule)

A: Solid Nodules*				
Nodule Type	Size			Comments
	<6 mm (<100 mm ³)	6–8 mm (100–250 mm ³)	>8 mm (>250 mm ³)	
Single				
Low risk†	No routine follow-up	CT at 6–12 months, then consider CT at 18–24 months	Consider CT at 3 months, PET/CT, or tissue sampling	Nodules <6 mm do not require routine follow-up in low-risk patients (recommendation 1A).
High risk‡	Optional CT at 12 months	CT at 6–12 months, then CT at 18–24 months	Consider CT at 3 months, PET/CT, or tissue sampling	Certain patients at high risk with suspicious nodule morphology, upper lobe location, or both may warrant 12-month follow-up (recommendation 1A).

Recommendations for Follow-up and Management of Nodules Smaller than 6 mm Detected Incidentally at Nonscreening CT		
Nodule Size (mm) ^a	Low-risk Patients ^b	High-risk Patients ^c
<4	No follow-up needed ^d	Follow-up CT at 12 months if unchanged; no further follow-up needed ^e
4–6	Follow-up CT at 12 months if unchanged; no further follow-up	Initial follow-up CT at 6–12 months or 18–24 months if unchanged
6–8	Initial follow-up CT at 6–12 months or 18–24 months if no change	Initial follow-up CT at 3–6 months or 6–12 and 24 months if no change
>8	Follow-up CT at 3 months, 9, and 24 months if no change; PET, PET/CT, and/or biopsy	Same as for low-risk patients

*Note.—Incidentally detected indeterminate nodule in persons 35 years of age or older.
^aAverage of length and width.
^bMinimal or absent history of smoking and all other known risk factors.
^cHistory of smoking or all other known risk factors.
^dThe risk of malignancy in this category of nodules is substantially less than that in categories C, D, and E.
^eSome nodules may require longer follow-up to exclude indeterminate nodules.

- The risk of cancer in never smokers and in younger patients is significantly lower, with a RR of 0.15 when compared to heavy smokers.
- Risk of cancer in solid nodules <6 mm in patients at high risk is <1%
- Suspicious morphology, upper lobe location, or both can increase cancer risk into the 1%–5% range

- Average estimated risk of malignancy in 6-8 mm nodules in high risk patients is 0.5-2%.
- The average risk of cancer in an 8-mm solitary nodule is 3% depending on morphology and location
- As nodules become larger, their morphology becomes more distinct, and management should be strongly influenced by the appearance of the nodule rather than by size alone

N Engl J Med 2013;369(10):910–919.

Lancet Oncol 2014;15(12):1332–1341

Chest 2007;132(3 Suppl):1085–130S.

2017 Guidelines (Multiple Solid nodules)

Nodule Type	Size			Comments
	<6 mm (<100 mm ³)	6–8 mm (100–250 mm ³)	>8 mm (>250 mm ³)	
Multiple				
Low risk [†]	No routine follow-up	CT at 3–6 months, then consider CT at 18–24 months	CT at 3–6 months, then consider CT at 18–24 months	Use most suspicious nodule as guide to management. Follow-up intervals may vary according to size and risk (recommendation 2A).
High risk [†]	Optional CT at 12 months	CT at 3–6 months, then at 18–24 months	CT at 3–6 months, then at 18–24 months	Use most suspicious nodule as guide to management. Follow-up intervals may vary according to size and risk (recommendation 2A).

- There is an increased in risk for primary cancer, as the total nodule count increased from 1 to 4, but a decrease in risk for those with five or more nodules, most of which likely resulted from prior granulomatous infection

Updated guidelines (Solitary Subsolid nodule)

Nodule Type	Size		Comments
	<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	In certain suspicious nodules < 6 mm, consider follow-up at 2 and 4 years. If solid component(s) or growth develops, consider resection. (Recommendations 3A and 4A).
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.	In practice, part-solid nodules cannot be defined as such until ≥6 mm, and nodules <6 mm do not usually require follow-up. Persistent part-solid nodules with solid components ≥6 mm should be considered highly suspicious (recommendations 4A-4C)

Recommendations for the Management of Subsolid Pulmonary Nodules Detected at CT: A Statement from the Fleischner Society		
Nodule Type	Management Recommendations	Additional Remarks
Solitary pure GGNs		
≤5 mm	No CT follow-up required	Obtain contiguous 1-mm thick sections to confirm that nodule is truly a pure GGN
>5 mm	Initial follow-up CT at 8 months to confirm persistence then annual surveillance CT for a minimum of 3 years	FDG PET is of limited value, potentially misleading, and therefore not recommended
Solitary part-solid nodules		
	Initial follow-up CT at 3 months to confirm persistence. If persistent and solid component <5 mm, then yearly surveillance CT for a minimum of 3 years. If persistent and solid component ≥5 mm, then biopsy or surgical resection	Consider PET/CT for part-solid nodules >10 mm
Multiple subsolid nodules		
Pure GGNs ≤5 mm	Obtain follow-up CT at 2 and 4 years	Consider alternate causes for multiple GGNs ≤5 mm
Pure GGNs >5 mm without a dominant lesion(s)	Initial follow-up CT at 8 months to confirm persistence and then annual surveillance CT for a minimum of 3 years	FDG PET is of limited value, potentially misleading, and therefore not recommended
Dominant nodule(s) with part-solid or solid component	Initial follow-up CT at 3 months to confirm persistence. If persistent, biopsy or surgical resection is recommended, especially for lesions with ≥5 mm solid component	Consider lung-sparing surgery for patients with dominant, highly suspicious for lung cancer
<p>Note—These guidelines do not include evaluation of solitary, well-circumscribed, thin-walled (≤1 mm) peripheral nodules in patients with low-risk for developing lung cancer. For these nodules, the Fleischner Society recommends annual surveillance CT for a minimum of 3 years. If persistent and solid component ≥5 mm, then biopsy or surgical resection is recommended, especially for lesions with ≥5 mm solid component.</p> <p>Disclaimer—These guidelines do not include evaluation of solitary, well-circumscribed, thin-walled (≤1 mm) peripheral nodules in patients with low-risk for developing lung cancer. For these nodules, the Fleischner Society recommends annual surveillance CT for a minimum of 3 years. If persistent and solid component ≥5 mm, then biopsy or surgical resection is recommended, especially for lesions with ≥5 mm solid component.</p>		

- For GGN <6mm in size, 10% of such nodules may grow and that nearly 1% may progress to adenocarcinoma over many years.
- A solid component larger than 5 mm correlates with a substantial likelihood of local invasion
- For multiple subsolid lesions 6 mm or larger, the most suspicious nodule (which may not be the largest) should guide management

Updated guidelines (multiple subsolid nodules)

Nodule Type	Size		Comments
	<6 mm (<100 mm ³)	≥6 mm (>100 mm ³)	
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).	Multiple <6 mm pure ground-glass nodules are usually benign, but consider follow-up in selected patients at high risk at 2 and 4 years (recommendation 5A).

Other risk factors

- Pulmonary fibrosis, particularly IPF, is an independent risk factor, with a hazard ratio of approximately 4.2
- Emphysema increases likelihood of malignancy
- Family history increases likelihood of malignancy by a factor of 1.5-1.8
- Smoking confers 10- to 35-fold increased risk

Size does matter

Nodule Size	Confirmed Lung Cancer		PPV (%)
	Yes	No	
4-7 mm	18 (7%)	3642 (53%)	0.5
7-10 mm	35 (13%)	2079 (30%)	1.7
11-20 mm	111 (41%)	821 (12%)	11.9
21-30 mm	58 (22%)	137 (2%)	29.7
> 30 mm	45 (17%)	64 (1%)	41.3

Nodule Malignancy predictors

Calculator: Solitary pulmonary nodule malignancy risk in adults (Brock University cancer prediction equation)

$$\text{Logodds} = (0.0287 * (\text{Age} - 62)) + \text{Sex} + \text{FamilyHistoryLungCa} + \text{Emphysema} - (5.3854 * ((\text{NoduleSize}/10)^{0.5} - 1.58113863)) + \text{NoduleType} + \text{NoduleUpperLung} - (0.0624 * (\text{NoduleCount} - 4)) + \text{Spiculation} - 6.7892$$
$$\text{Cancerprobability} = 100 * (e^{\text{Logodds}} / (1 + e^{\text{Logodds}}))$$

Input:

Age years

Sex ☐ Female (0.6011)
☒ Male (0)

Family history of lung cancer ☒ (0.2961)

Emphysema ☒ (0.2953)

Nodule size mm

Nodule type ☐ Nonsolid or ground-glass (-0.1276)
☐ Partly solid (0.377)
☒ Solid (0)

Nodule in upper lung ☒ (0.6581)

Nodule count #

Spiculation ☒ (0.7729)

Results:

Log odds

Cancer probability %

Decimal precision

Nodule Malignancy Predictors

Solitary Pulmonary Nodule Malignancy Risk (Mayo Clinic model)

Input

Age: yr

Smoker: ☒ Current or former (1)
☐ Never smoker (0)

Cancer: ☐ Extrathoracic cancer more than 5 years prior (1)
☒ None (0)

Nodule Diameter: mm

Spiculation: ☒ Yes (1)
☐ No (0)

Upper Lobe: ☒ Yes (1)
☐ No (0)

Results:

X: 0.24

Malignancy Probability: %

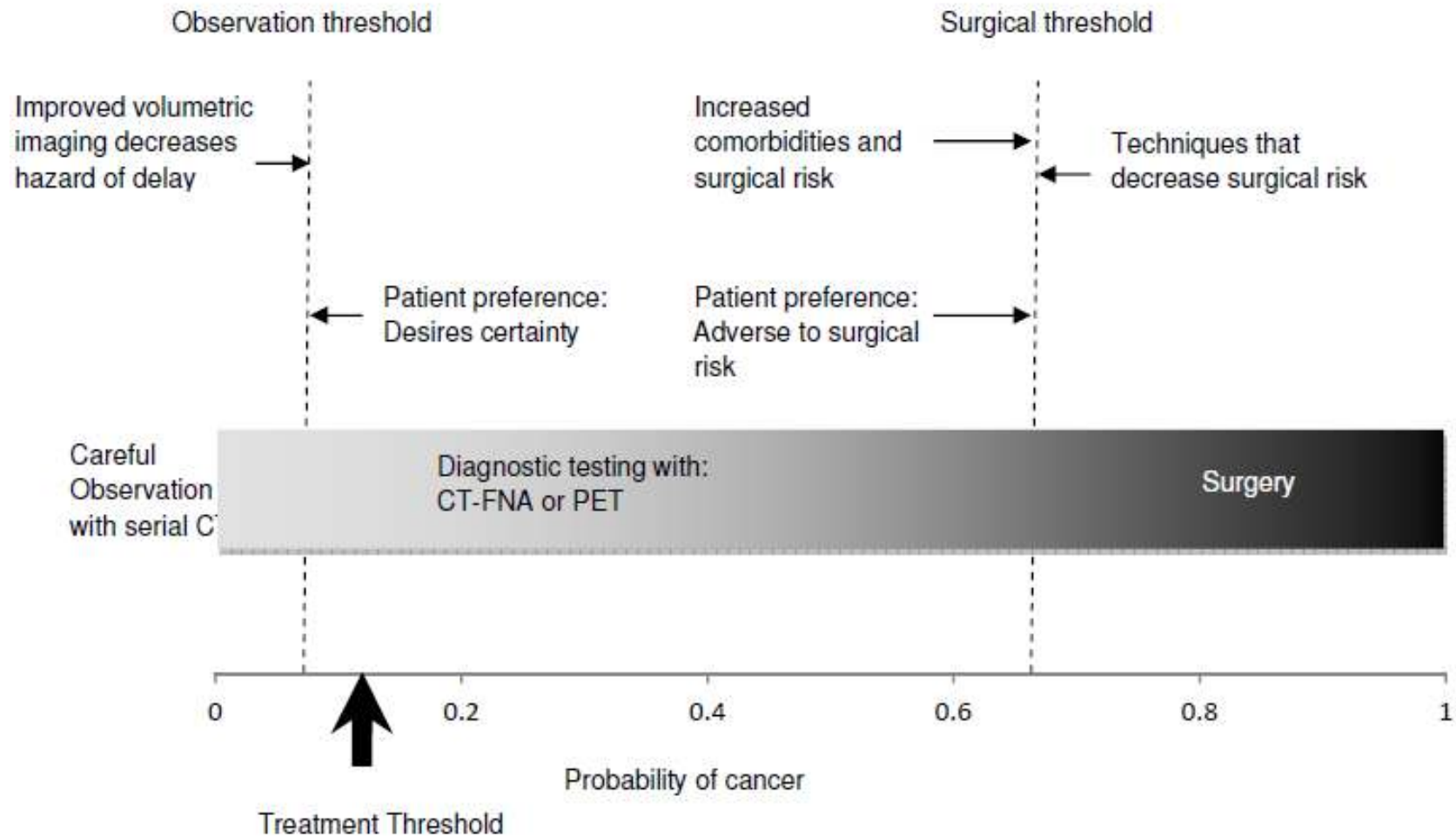
Decimal Precision:

Formula: Notes: References:

$$X = (0.0161 * Age) + (0.7517 * Smoker) + (0.3355 * Cancer) + (0.0274 * NoduleDiameter) + (0.0407 * Spiculation) + (0.7835 * UpperLobe) - 6.8272$$

$$MalignancyProbability = 100 * e^X / (1 + e^X)$$

Risk stratification



What about screen detected nodules?

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

The National Lung Screening Trial Research Team*

It is not uncommon to find lung nodules

	Total No. Screened	Positive Result	Clinically Significant Abnormality Not Suspicious for Lung Cancer <i>no. (% of screened)</i>	No or Minor Abnormality
T0	26,309	7191 (27.3)	2695 (10.2)	16,423 (62.4)
T1	24,715	6901 (27.9)	1519 (6.1)	16,295 (65.9)
T2	24,102	4054 (16.8)	1408 (5.8)	18,640 (77.3)

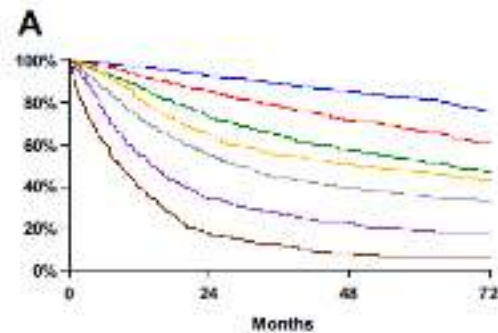
Most nodules are non malignant

Total positive tests	7191 (100.0)	6901 (100.0)	4054 (100.0)	18,146 (100.0)
Lung cancer confirmed	270 (3.8)	168 (2.4)	211 (5.2)	649 (3.6)
Lung cancer not confirmed†	6921 (96.2)	6733 (97.6)	3843 (94.8)	17,497 (96.4)
Positive screening results with complete diagnostic follow-up information	7049 (100.0)	6740 (100.0)	3913 (100.0)	17,702 (100.0)

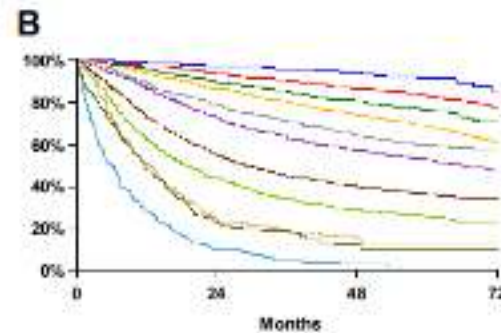
Most cancers will be early stage

Stage and Histologic Type	Low-Dose CT			
	Positive Screening Test (N = 649)	Negative Screening Test (N = 44)†	No Screening Test (N = 367)‡	Total (N = 1060) <small>What about screen detected no...</small> <i>number/total n</i>
Stage				
IA	329/635 (51.8)	5/44 (11.4)	82/361 (22.7)	416/1040 (40.0)
IB	71/635 (11.2)	2/44 (4.5)	31/361 (8.6)	104/1040 (10.0)
IIA	26/635 (4.1)	2/44 (4.5)	7/361 (1.9)	35/1040 (3.4)
IIB	20/635 (3.1)	3/44 (6.8)	15/361 (4.2)	38/1040 (3.7)
IIIA	59/635 (9.3)	3/44 (6.8)	37/361 (10.2)	99/1040 (9.5)
IIIB	49/635 (7.7)	15/44 (34.1)	58/361 (16.1)	122/1040 (11.7)
IV	81/635 (12.8)	14/44 (31.8)	131/361 (36.3)	226/1040 (21.7)

Lung cancer survival based on stage



7 th Ed.	Events / N	MST	24 Month	60 Month
IA	1119 / 6303	NR	93%	82%
IB	768 / 2492	NR	85%	66%
IIA	424 / 1008	66.0	74%	52%
IIB	382 / 824	49.0	64%	47%
IIIA	2139 / 3344	29.0	55%	36%
IIIB	2101 / 2824	14.1	34%	19%
IV	664 / 882	8.8	17%	6%



Proposed	Events / N	MST	24 Month	60 Month
IA1	68 / 781	NR	97%	92%
IA2	505 / 3105	NR	94%	83%
IA3	546 / 2417	NR	90%	77%
IB	560 / 1929	NR	87%	68%
IIA	215 / 585	NR	79%	60%
IIB	605 / 1453	66.0	72%	53%
IIIA	2052 / 3200	29.3	55%	36%
IIIB	1561 / 2149	19.0	44%	26%
IIIC	831 / 986	12.8	24%	13%
IVA	336 / 494	11.5	23%	10%
IVB	328 / 398	8.0	10%	0%

5-Year Survival (%)

Type	IA1	IA2	IA3	IB	IIA	IIB	IIIA	IIIB	IIIC	IVA	IVB
Clinical	92	83	77	68	60	53	36	26	13	10	0
Pathologic	90	85	80	73	65	56	41	24	12	-	-

Lung RADS

Lung-RADS Category	Baseline Screening	Subsequent Screening
1	No nodules; nodules with calcification	No nodules; nodules with calcification
2	Solid/part solid: <6 mm GGN: <20 mm -	Solid/part solid: <6 mm GGN: <20 mm or unchanged/slowly growing Category 3-4 nodules unchanged at ≥3 mo
3	Solid: ≥6 to <8 mm Part solid: ≥6 mm with solid component <6 mm GGN: ≥20 mm	Solid: New ≥4 to <6 mm Part solid: New <6 mm GGN: New ≥20 mm
4A	Solid: ≥8 to <15 mm Part solid: ≥8 mm with solid component ≥6 and <8 mm	Solid: Growing <8 mm or new ≥6 and <8 mm Part solid: ≥6 mm with new or growing solid component <4 mm
4B	Solid: ≥15 mm Part solid: Solid component ≥8 mm	Solid: New or growing and ≥8 mm Part solid: ≥6 mm with new or growing solid component ≥4 mm
4X	Category 3 or 4 nodules with additional features; imaging findings that increase suspicion of cancer	Category 3 or 4 nodules with additional features; imaging findings that increase suspicion of cancer

Lung RADS

Lung-RADS Category	Cancer Present, <i>n</i> (%)	Cancer Absent, <i>n</i> (%)	Indeterminate Cancer Status, <i>n</i> (%)
1	13 (3.2)	25 149 (52.2)	39 (53.4)
2	73 (18.2)	20 505 (42.5)	28 (38.4)
3	10 (2.5)	578 (1.2)	0 (0.0)
4A	39 (9.7)	810 (1.7)	2 (2.7)
4A or 4B	41 (10.2)	239 (0.5)	0 (0.0)
4B	210 (52.4)	683 (1.4)	3 (4.1)
4X	15 (3.7)	233 (0.5)	1 (1.4)
All	401 (100)	48 197 (100)	73 (100)

THANK YOU