



Lung Cancer Screening: The Who What When Where Why

Ella A Kazerooni MD MS

Chair, National Lung Cancer Roundtable

ellakaz@umich.edu

Professor of Radiology & Internal Medicine

Department of Radiology University of Michigan Medical School

Associate Chief Clinical Officer for Diagnostics & Clinical Information Management

University of Michigan Medical Group

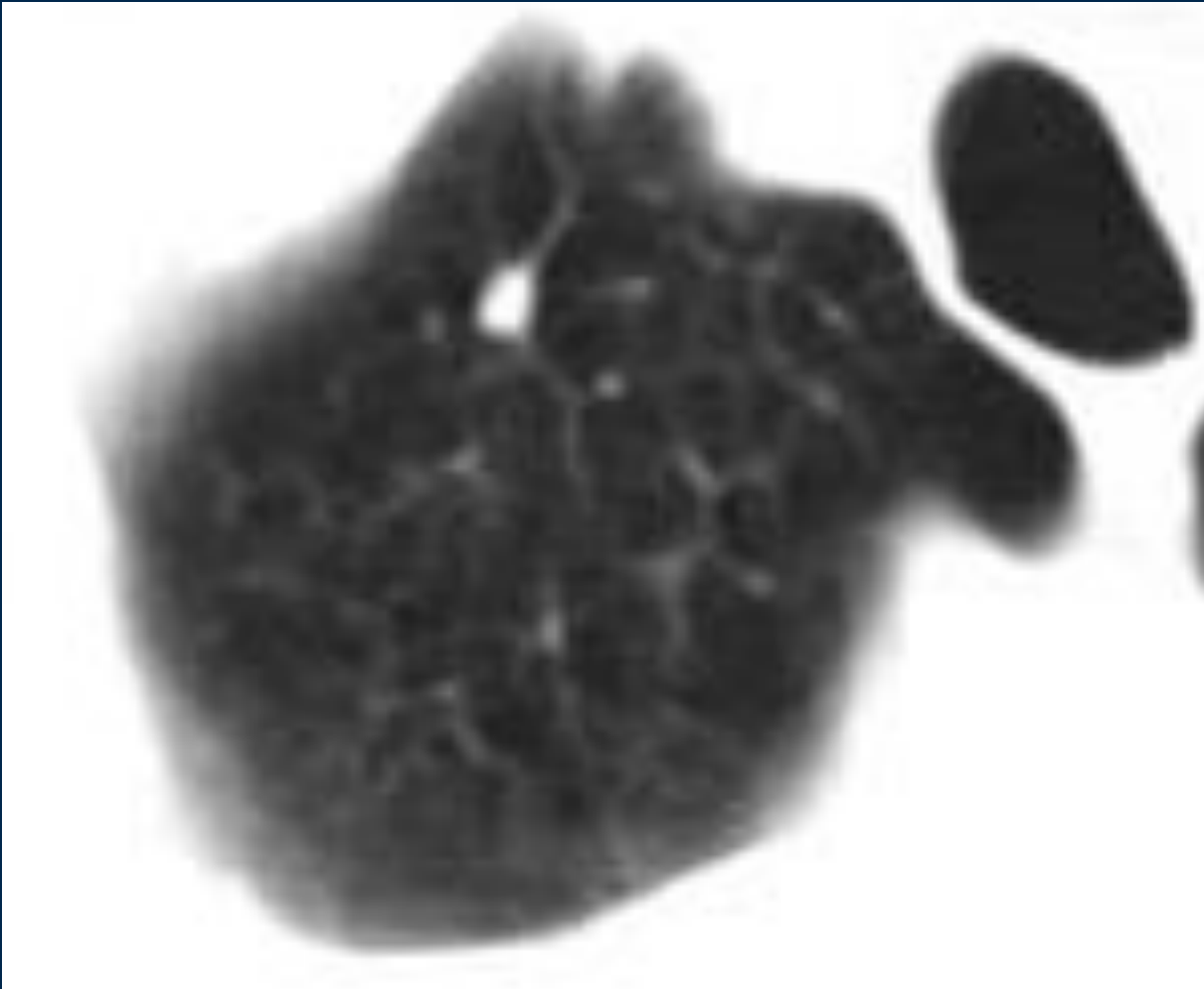
Lung Cancer Screening – Building for Success

Goal: To Create Lung Cancer Survivors

Safe, high quality and effective lung cancer screening practices

- Appropriate patient selection & education
- Tobacco consultation
- Shared decision making
- Imaging technique
- Finding management
- Results Communication
- Nurse navigator / coordinator

Lung Cancer



*early stage
screen detected*



*late stage
symptom detected*

Lung Cancer at a Glance

EVEN NON-SMOKERS ARE AT RISK

Risk Factors



228,190 Estimated new lung cancer cases in the U.S. in 2013

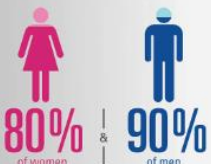
159,480 Estimated lung cancer deaths in the U.S. in 2013

Women 13x

Men 23x

Smokers are more likely to **develop lung cancer** compared to never-smokers. Even if you are a never-smoker, you may still develop lung cancer.

Smoking contributes to lung cancer in



Secondhand Smoke



3,400 lung cancer deaths each year among never-smokers

20–30% greater chance of **developing lung cancer from secondhand smoke** as compared to someone with no secondhand smoke

“Lung Cancer Is the Biggest Cancer Killer in Both Men and Women”

LUNG CANCER

is the biggest cancer killer in both men and women.

Every year, about **200,000** people are diagnosed and **150,000** people die.



Cigarette smoking is the **#1 cause of lung cancer.** It is linked to **80% to 90%** of all lung cancers.

Quitting smoking at any age can lower the risk of lung cancer.



U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Lung Cancer Screening

#1 Who should be screened & Why?

US Lung Cancer Screening Journey



1000 patient single arm cohort study
Lancet 1999



> 50K patient RCT
NEJM 2011

International Studies Reinforce This

NELSON trial – Dutch Belgian Trial *NEJM* 2020

<https://www.nejm.org/doi/full/10.1056/NEJMoa1911793>

MILD trial - Multicentric Italian Lung Detection – *Ann Oncol* 2019

<https://www.ncbi.nlm.nih.gov/pubmed/30937431>

National Lung Cancer Screening Trial



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

N Engl J Med 2011; 365:395-409 | August 4, 2011

The National Lung Screening Trial Research Team*

20% lung cancer mortality reduction

6.9% all cause mortality reduction

screen 320 individuals to save 1 from lung cancer death

8 yrs & > 50,000 subjects randomized to LDCT vs CXR

55-74 yo, 30 pk-yr smokers, current or quit in last 15 years

National Lung Cancer Screening Trial



ORIGINAL ARTICLE

Cost-Effectiveness of CT Screening in the N Screening Trial



The NEW ENGLAND
JOURNAL of MEDICINE

William C. Black, M.D., Ilana F. Gareen, Ph.D., Samir S. Soneji, Ph.D., JoRean D. Sicks, M.S., Emmett B. Keeler, Ph.D., Denise R. Aberle, M.D., Arash Naeim, M.D., Timothy R. Church, Ph.D., Gerard A. Silvestri, M.D., Jeremy Gorelick, Ph.D., and Constantine Gatsonis, Ph.D. for the National Lung Screening Trial Research Team


N Engl J Med 2014; 371:1793-1802 | [November 6, 2014](#) | DOI: 10.1056/NEJMoa1312547

\$81,000 / QALY

...but we also determined that modest changes in our assumptions would greatly alter this figure. The determination of whether screening outside the trial will be cost-effective will depend on how screening is implemented.

Lung Cancer Screening Program

#1 Who should be screened?



U.S. Preventive Services Task Force

Screening for Lung Cancer

This topic page summarizes the U.S. Preventive Services Task Force (USPSTF) recommendations on screening for lung cancer.

Current Recommendation

Release Date: December 2013

- **The USPSTF recommends annual screening for lung cancer with low-dose computed tomography in adults ages 55 to 80 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years. Screening should be discontinued once a person has not smoked for 15 years or develops a health problem that substantially limits life expectancy or the ability or willingness to have curative lung surgery.**
Grade: **B recommendation.**

<http://www.uspreventiveservicestaskforce.org/uspstf/uspslung.htm>

Lung Cancer Screening Program

#1 Who should be screened?

■ CMS NCD Criteria – February 2015

- ① Age: 55 – 77
(USPSTF age 55-80 – tied to ACA & 3rd party coverage)
- ② Smoking history: ≥ 30 pack-years; current smoker or quit in the last 15 years
- ③ No signs or symptoms of lung cancer
- ④ Able to undergo curative treatment

Lung Cancer Screening Program

#1 Who should be screened?

- Are there others at similar risk for lung cancer?
 - NLST trial wide epidemiology group is modeling this, balancing outcome and cost
 - Other ages?
 - Other smoking histories?
 - Family history?
 - Occupational or radon exposures?
 - At what age should screening start?



National
Comprehensive
Cancer
Network®

Screening Guidelines

- Not for profit alliance
- 21 of the world's leading cancer centers
- Primary goal:
 - *to improve the quality, effectiveness, & efficiency of oncology practice so patients can live better lives*

NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines®)

Lung Cancer Screening

Version 1.2012

NCCN.org

<http://www.nccn.org/>

Lung Cancer Screening Guideline

V1.2020

First, risk assessment

- Age
- Smoking history
- Smoking exposure – second hand
- Radon exposure
- Occupational exposure
- Cancer history
- Family history of lung cancer
- Disease history (COPD, pulmonary fibrosis)
- Absence of signs or symptoms of lung cancer



Risk
High
Moderate
Low

Lung Cancer Screening Guideline V1.2020

**Risk
High**



**Candidates
for screening**

- Group 1: *age 55-77 years
≥ 30 pack year h/o smoking
current smoker or cessation < 15 yrs*
- Group 2: *age ≥ 50 years
≥ 20 pack year h/o smoking AND
additional risk factors (other than 2nd
hand smoke) that increase the risk
of lung cancer to > 1.3%*

The NCCN Panel recognizes there are individuals who would not have met the NLST criteria but are at similar risk to the NLST cohort and recommends lung cancer screening for these individuals. However, substantial uncertainty exists about the true benefits and harms of screening these individuals. It is reasonable to consider using the [Tammemägi lung cancer risk calculator](#) to assist in quantifying risk for individuals in this group, considering a 1.3% threshold of lung cancer risk over a 6-year timeframe was considered similar to that of the USPSTF (Tammemägi MC, Church TR, Hocking WG, et al. Evaluation of the lung cancer risks at which to screen ever- and never-smokers: screening rules applied to the PLCO and NLST cohorts. PLOS Med 2014;11:1-13).

Lung Cancer Screening Guideline V1.2020

Risk
Moderate or Low



**Screening not
recommended**

Moderate: *> 50 years of age
> 20 pack years smoker
or second hand exposure
No additional risk factors*

Low: *Age < 50 and/or
< 20 pack years smoker*

Lung Cancer Screening Program

#2 Tobacco Consultation

Lung Cancer Screening Program

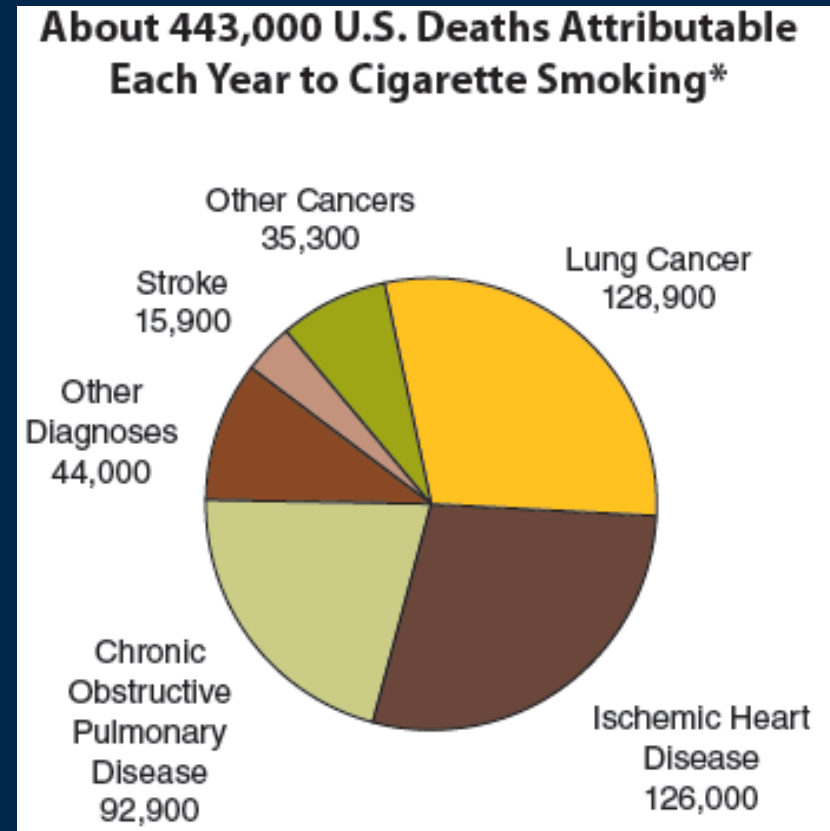
#2 Tobacco Consultation

Smoking cessation guidance & consultation

- **Key element of any lung cancer screening program**
- **Screening for lung cancer is a teachable moment**
- **Smoking cessation is the best way to reduce lung cancer risk**
- **Makes screening more cost effective**
- **Improves health and reduces other leading cause of death including cardiovascular disease and COPD**

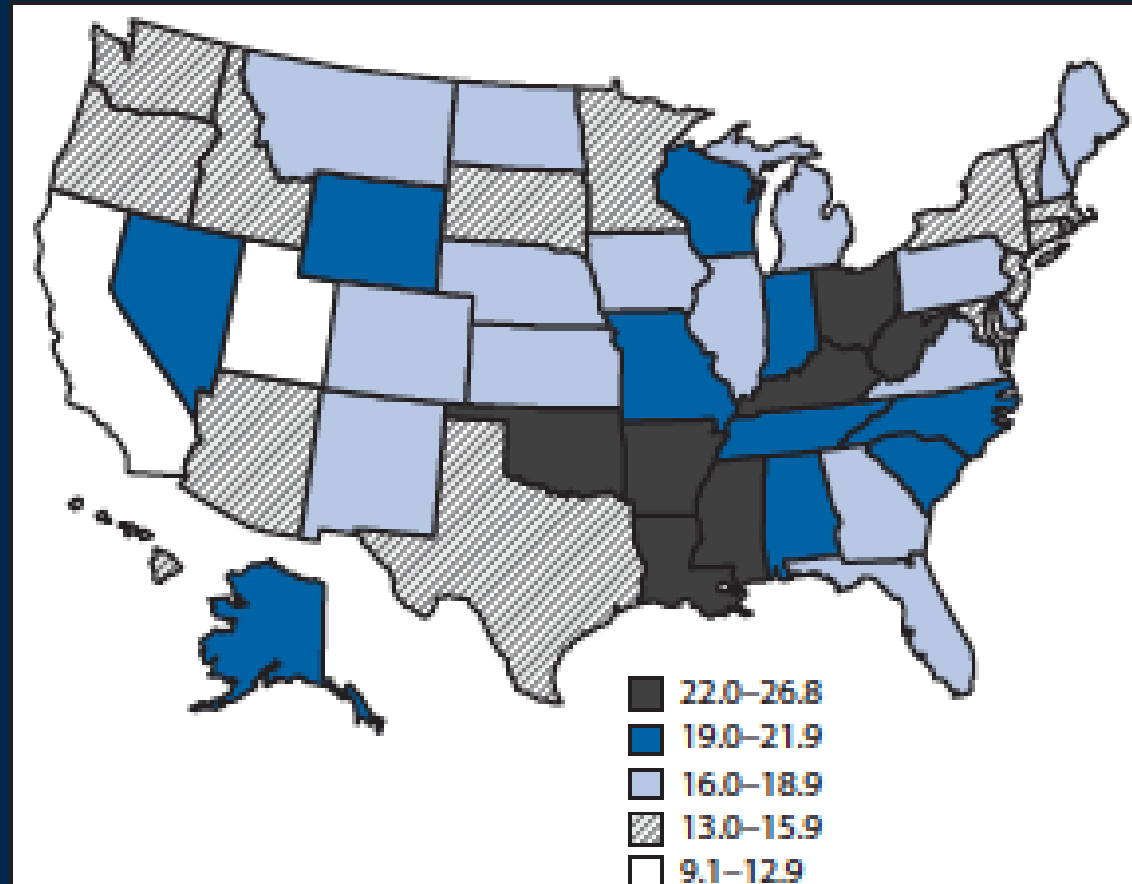
Smoking in the U.S.

- Large population at risk due to cigarette smoking and second hand smoke exposure
 - ≈ 60 million current smokers (19.3% of U.S. adults in 2010; 3 million fewer than 20.9% in 2005)
 - ≈ 30 million former smokers
 - Tobacco: leading cause of preventable death & illness; responsible for 1 in 5 deaths



Smoking in the U.S.

CDC. Vital Signs: Current Cigarette Smoking Among Adults Aged ≥ 18 Years — United States 2005-2010. Morbidity and Mortality Weekly Report 2011;60(35):1207-1211



Low: Utah & California

High: Kentucky & West Virginia

Second Hand Smoke in U.S.

2006 US Surgeon General Report: The Health Consequences of Involuntary Exposure to Tobacco Smoke; and ACS Facts & Figures 2010

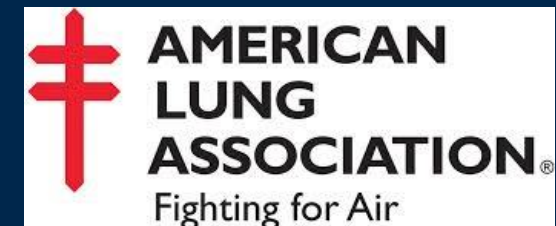
- **> 126 million are exposed to SHS**
- **3,400 lung cancer deaths / year**
- **46,000 heart disease deaths / year**
- **SHS exposure is declining**
 - 84% in 1988-94 to 46% in 1999-2004
- **74% of population is covered by smoke free policies in work places and restaurants/bars**

Lung Cancer Screening Program

Tobacco Consultation

Smoking cessation guidance & consultation

- Know your resources
 - Local: clinic, hospital, health system, cancer centers
 - Gov't: city, county, state health departments including quit lines
 - Chapters of national organizations



Lung Cancer Screening Program

Shared Decision Making

Lung Cancer Screening Program

Shared Decision Making

- Shared decision making – required by ordering provider for CMS coverage & is a good practice

What is Shared Decision Making?

Shared decision making (SDM) is a collaborative process that allows patients and their providers to make health care decisions together, taking into account the best scientific evidence available, as well as the patient's values and preferences.

SDM honors both the provider's expert knowledge and the patient's right to be fully informed of all care options and the potential harms and benefits. This process provides patients with the support they need to make the best individualized care decisions, while allowing providers to feel confident in the care they prescribe.



Lung Cancer Screening Program

Shared Decision Making

What information should individuals considering CT lung cancer screening be made aware of when making a decision to be screened?

- *What is a (+) screen?:* non calcified nodule 6 mm or larger
- *Likelihood of a (+) screen?* 10%
- *Likelihood of (+) screen being lung cancer?* 2-3%
- *What is the most common finding?* small nodules
- *And how is it usually managed?* LDCT follow up
- *Other risks?* Low radiation exposure
Low likelihood of invasive testing

Lung Cancer Screening Program

Shared Decision Making

What information should individuals considering lung cancer screening with CT be made aware of when making a decision to be screened?

- *What if an invasive procedure is needed?*

Complication rate low; 1.4% in NLST

- 28% among those determined to have lung cancer
- 0.35% determined to not have lung cancer

10 invasive procedures per life saved in NLST

16 deaths due to medical interventions

- hastened the death of 16 people
- of these 16, 10 had lung cancer and 6 did not

risk of death in non-cancer patients 0.024%

Lung Cancer Screening Program

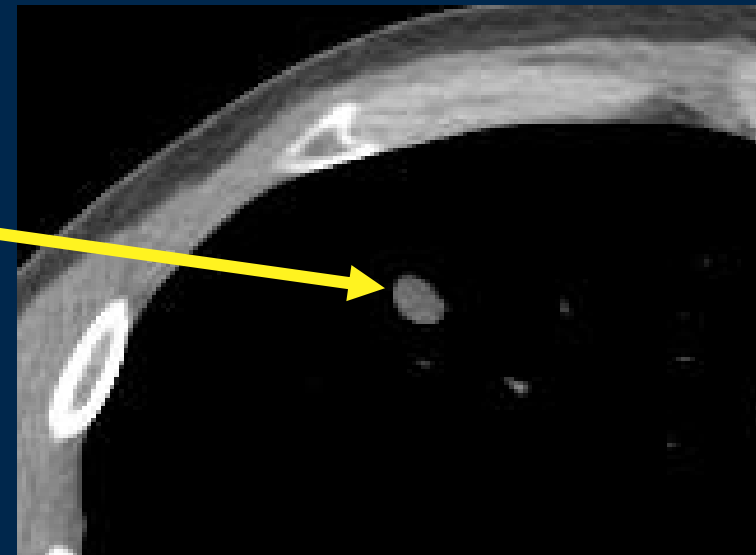
Shared Decision Making

What information should individuals considering lung cancer screening with CT be made aware of when making a decision to be screened?

- *What is the likelihood that clinically significant abnormalities other than lung cancer will be detected?*
 - 7.5% NLST
 - 14.2% in a recent systematic review
 - cardiac, vascular (aneurysms), masses
 - 0.5% extrathoracic malignancy (renal cell ca ,lymphoma)

Lung Cancer Screening False Positives

- NLST: 40% of subjects had at least one FP over the 3 years
- among patients with a positive screen who underwent a diagnostic procedure, approximately 1.4% experienced a complication



Lung Cancer Screening Program

Shared Decision Making

Shared decision making aid:

Should I Screen

<http://www.shouldiscreen.com/>


**web-based publically available shared decision making aid
with a risk calculator**

Created by University of Michigan using the risk prediction model developed by
Tammemägi et al. (2013). **Selection criteria for lung-cancer screening.**
New England Journal of Medicine, 368(8): 728-736, 2013

Lung Cancer Screening Program

Shared Decision Making

[HOME](#) [ABOUT LUNG CANCER & SCREENING](#) [CALCULATE MY LUNG CANCER RISK](#)




LUNG CANCER CT SCREENING.

Should I get screened?

[CLICK HERE TO LEARN MORE](#)

We can help you.


Deciding whether or not to go through lung cancer CT screening is not easy. Here, there is up to date information provided by doctors to help you make an informed choice.



BENEFITS AND HARMS OF SCREENING

Find out about lung cancer CT screening and how it can help you decrease your chances of having lung cancer.

[LEARN MORE →](#)



LUNG CANCER RISK CALCULATOR

Do you want to know if you should be screened? Use our calculator to see your personalized lung cancer risk.

[USE IT →](#)

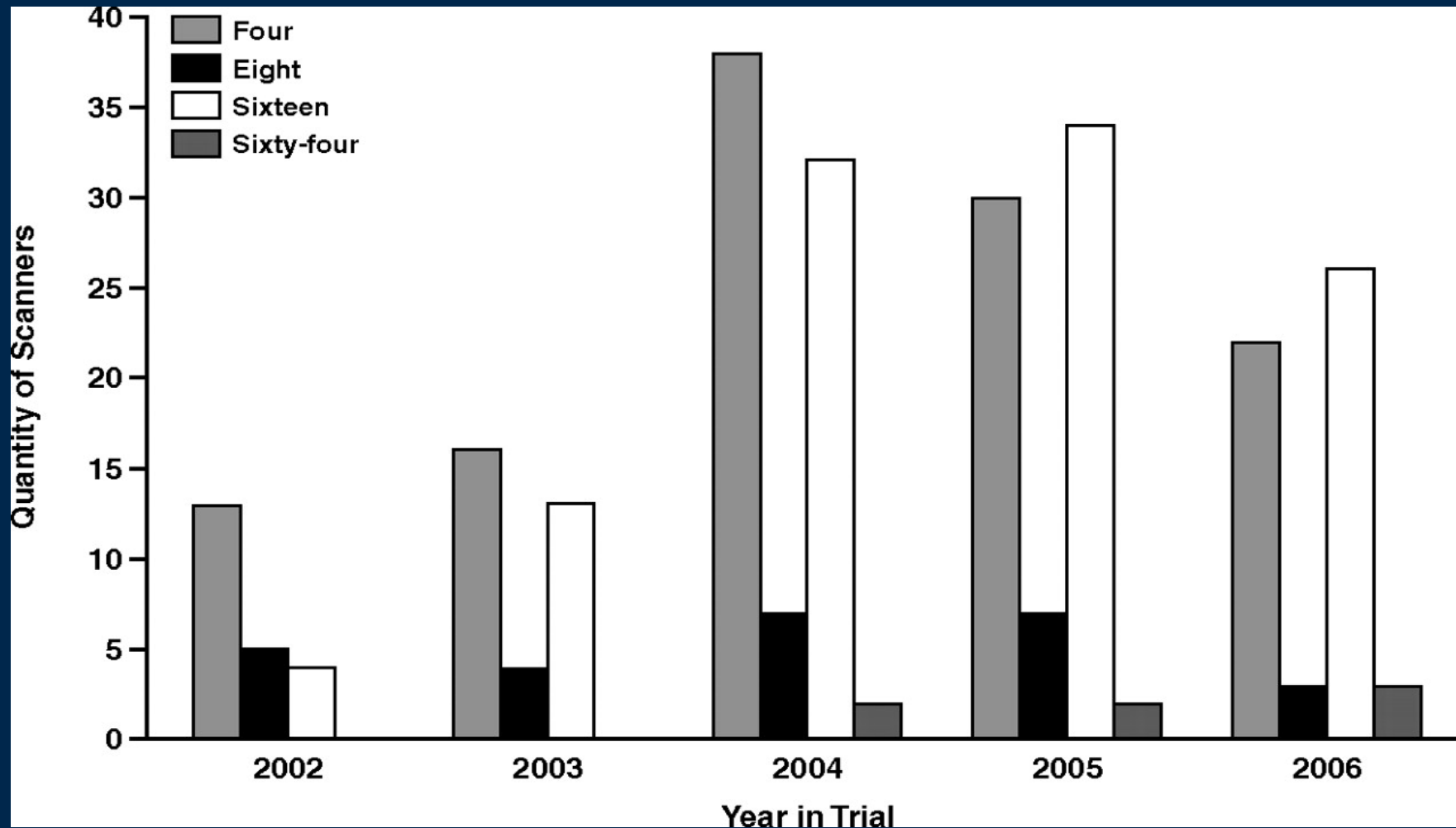
Lung Cancer Screening Program

What should we screen with?

- What do you screen with? CT. Not CXR.
- Technique: Low Dose
- What do you f/u most screen detected nodules with? CT
- Technique: Low Dose

CT Scanners in NLST: # of Detectors

Cody DD et al. American Journal of Roentgenology 2010;194:1539-1546



Lung Cancer Screening: CT Technique

- AAPM reference protocols
- ACR-STR practice parameter for the performance and reporting of lung cancer screening thoracic computed tomography (CT)
- NCCN Guideline
- Low dose technique for both screening CT & for interval follow up CT exams for (+) screens

Lung Cancer Screening LDCT

How should CT examinations be performed?

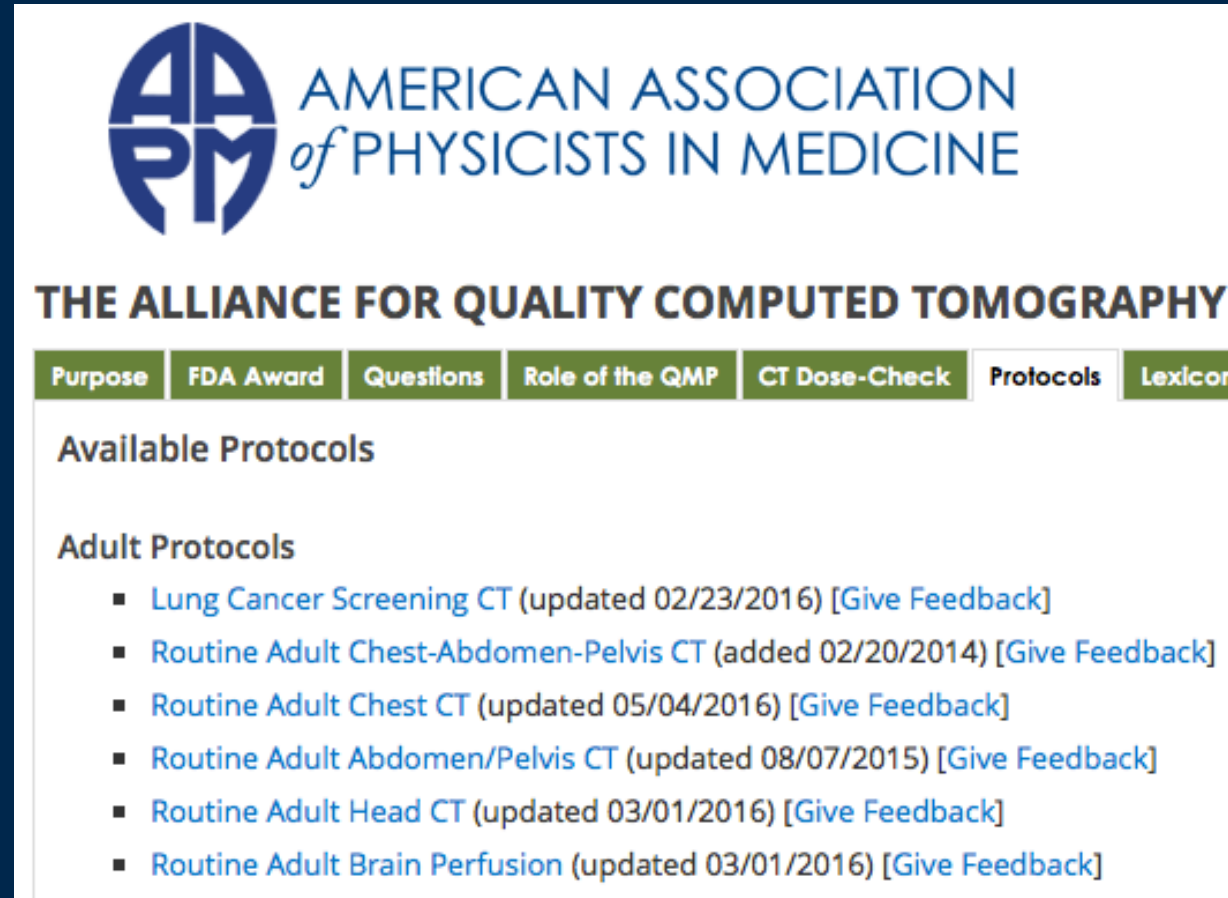
- low dose (1.5 mSv in NLST, lower with new technology)
- < 3 mm slice thickness (ideally 1-1.5 mm); overlapping reconstructions
- 40-80 mAs depending on body size (size adjusted protocols)
- Sliding slab MIPS reconstructions
- Nodule detection software
- Report should include for each nodule:
 - Size
 - Location: lobe, series/image #
 - Consistency: solid/part solid/ground glass

Lung Cancer CT Technique: *Key Elements*

- One breath-hold
- Thin image thicknesses (≤ 2.5 mm, ≤ 1.0 mm preferred); reconstruction of coronal and sagittal reformations as well as MIPS may be helpful and are encouraged
- CTDIvol < 3.0 mGy for a standard sized patient (see table), with adjustments made for smaller and larger patients.
- Typically requires a 16 detector-row (or greater) scanner to meet these requirements

<http://www.aapm.org/pubs/CTProtocols/documents/LungCancerScreeningCT.pdf>

AAPM Protocols & ACR-STR Practice Parameter



The screenshot displays the AAPM website interface. At the top is the AAPM logo, consisting of a stylized 'A' and 'P' inside a circle, followed by the text 'AMERICAN ASSOCIATION of PHYSICISTS IN MEDICINE'. Below this is the heading 'THE ALLIANCE FOR QUALITY COMPUTED TOMOGRAPHY'. A navigation bar contains several tabs: 'Purpose', 'FDA Award', 'Questions', 'Role of the QMP', 'CT Dose-Check', 'Protocols', and 'Lexicon'. The 'Protocols' tab is currently selected. Underneath, the section 'Available Protocols' is shown, followed by a sub-section 'Adult Protocols'. A list of six protocols is provided, each with a date and a link to 'Give Feedback'.

AMERICAN ASSOCIATION
of PHYSICISTS IN MEDICINE

THE ALLIANCE FOR QUALITY COMPUTED TOMOGRAPHY

Purpose FDA Award Questions Role of the QMP CT Dose-Check **Protocols** Lexicon

Available Protocols

Adult Protocols

- [Lung Cancer Screening CT](#) (updated 02/23/2016) [[Give Feedback](#)]
- [Routine Adult Chest-Abdomen-Pelvis CT](#) (added 02/20/2014) [[Give Feedback](#)]
- [Routine Adult Chest CT](#) (updated 05/04/2016) [[Give Feedback](#)]
- [Routine Adult Abdomen/Pelvis CT](#) (updated 08/07/2015) [[Give Feedback](#)]
- [Routine Adult Head CT](#) (updated 03/01/2016) [[Give Feedback](#)]
- [Routine Adult Brain Perfusion](#) (updated 03/01/2016) [[Give Feedback](#)]

Modeled after the ACR-STR practice parameter for the performance and reporting of lung cancer screening thoracic computed tomography (CT)

AAPM Protocols

Approximate Volume CT Dose Index (CTDIvol) Values

- Approximate values for CTDIvol are listed for three different patient sizes:

	Approx. Weight (kg)	Approx. Weight (lbs)	Approx. CTDIvol (mGy)
Small Patient	50-70	110-155	0.25 - 2.8
Average Patient	70-90	155-200	0.5 - 4.3
Large Patient	90-120	200-265	1.0 - 5.6



Lung Cancer Screening CT Protocols Version 4.0 2/23/16

INDEX OF LUNG CANCER SCREENING PROTOCOLS (by manufacturer)

[GE with Auto/Smart mA](#)

[GE with constant mA](#)

[Hitachi](#)

[Neusoft](#)

[Philips](#)

[Siemens](#)

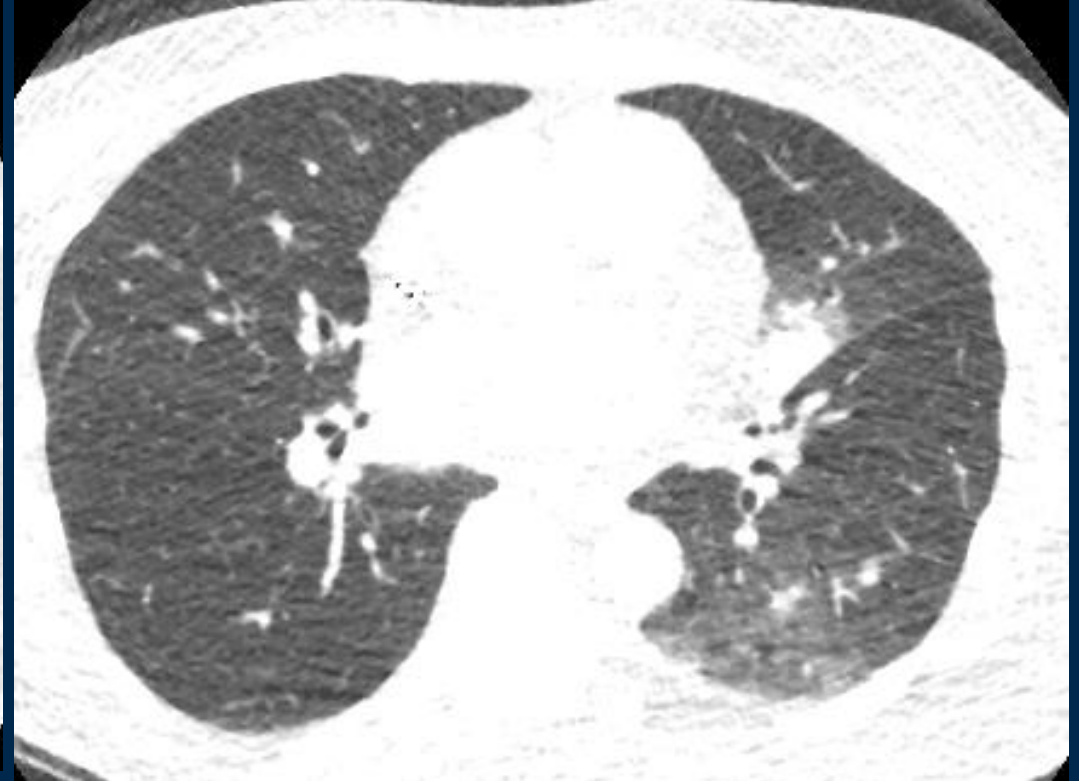
[Toshiba](#)

<http://www.aapm.org/pubs/CTProtocols/documents/LungCancerScreeningCT.pdf>

Further reductions in “low dose” CT *model based iterative reconstruction*



LDCT : 2 mSv



ultraLDCT : 0.2 mSv

Lung Cancer Screening Guideline

Table 2 Low-Dose Computed Tomography Acquisition, Storage, Interpretation, and Nodule Reporting

Acquisition	Small Patient (BMI ≤30)	Large Patient (BMI >30)
Total radiation exposure	≤3 mSv	≤5 mSv
kVp	100-120	120
mAs	≤40	≤60
	All Patients	
Gantry rotation speed	≤0.5	
Detector collimation	≤1.5 mm	
Slice width	≤3 mm; ≤1.5 mm preferred	
Slice interval	≤ slice width; 50% overlap preferred for 3D and CAD applications	
Scan acquisition time	≤10 seconds (single breath hold)	
Breathing	Maximum inspiration	
Contrast	No oral or intravenous contrast	
CT scanner detectors	≥16	



National
Comprehensive
Cancer
Network®

Lung Cancer Screening Guideline

Storage	All acquired images, including thin sections; MIPs and CAD renderings if used
Interpretation Tools	
Platform	Computer workstation review
Image type	Standard and MIP images
Comparison studies	Comparison with prior chest CT images (not reports) is essential to evaluate change in size, morphology, and density of nodules; review of serial chest CT exams is important to detect slow growth

BMI = body mass index; CAD = computer aided diagnostics; CT = computed tomography; MIP = maximum intensity projection.



Lung Cancer Screening Guideline

Low-Dose Computed Tomography Acquisition, Storage, Interpretation, and Nodule Reporting	
Nodule Parameters	All Patients
Size	Largest mean diameter on a single image*
Density	Solid, ground glass, or mixed†
Calcification	Present/absent; if present: solid, central vs eccentric, concentric rings, popcorn, stippled, amorphous
Fat	Report if present
Shape	Round/ovoid, triangular
Margin	Smooth, lobulated, spiculated
Lung location	By lobe of the lung, preferably by segment, and if subpleural
Location in dataset	Specify series and image number for future comparison
Temporal comparison	If unchanged, include the longest duration of no change as directly viewed by the interpreter on the images (not by report); if changed, report current and prior size

BMI = body mass index; CAD = computer-aided diagnosis; CT = computed tomography; MIP = maximum intensity projection.

*Mean of the longest diameter of the nodule and its perpendicular diameter, when compared to the baseline scan.

†Mixed, otherwise referred to as part solid.

Lung Cancer Screening Program

LDCT Interpretation & Management

How should CT examinations be interpreted & managed?

- LungRADS 1.1
- ACR White Paper Incidental Cardiothoracic Findings

Lung Cancer Screening Program

LDCT Interpretation & Management

- ACR LungRADS™
 - structured reporting and management tool
 - Version 1.0 April '14; 1.1 April '19
 - User manual with image-rich guide in progress
 - Nodule size, density (solid to non solid) & temporal change drive interpretation category
 - Each category has a management recommendation

Lung Cancer Screening Program

LDCT Interpretation & Management

In what environment should screening take place and test results be managed?

- Screening is NOT just a low dose lung CT scan
- Managing positive screens (4B/4x in particular) is best done in a multidisciplinary setting including:
 - Radiology
 - Pulmonary Medicine
 - Thoracic Surgery
 - Oncology/Radiation Oncology

Lung Cancer Screening Program

LDCT Interpretation & Management

What is the proper approach to patients with a negative screen?

- It's not license to continue or restart smoking!
- NLST results were based on 3 annual screens
- *What is the likelihood that a new nodule will be detected on a subsequent annual screening CT and that the new nodule is cancer?*

ELCAP – of 27,500 individuals with a negative initial screen, 5.3% developed a new nodule; of these 1460, 5% (70) were cancer; rate of new cancers is the same with each future screen

Lung Cancer Screening Program

LDCT Interpretation & Management

- ACR White Paper Incidental Cardiothoracic Findings
November 2018
 - Thoracic Lymph Nodes
 - Mediastinal Mass
 - Coronary arterial calcification
 - Pulmonary artery size
 - Aorta size – dilated vs aneurysm

Lung Cancer Screening Program

Results Communication

To Whom and How?

- Referring physicians
- Patient
 - Letters
 - Patient portal

Lung Cancer Screening Program

Data Collection – ACR LCSR

What data should lung cancer screening programs collect?

- The more the better – hopefully for a future registry
- Demographics
- Risk factors
- Smoking status
- CT screen results
- Downstream diagnostic testing & results
- Lung cancer diagnosis
- Test dates with reminder for annual screen
- Referring provider

Lung Cancer Screening: Performance Metrics

- ACR Lung Cancer Screening Registry
 - Appropriateness of screening
 - Smoking cessation
 - Radiation exposure
 - Positive screen rate
 - Positive predictive values
 - LR 3 with 6 month recommended CT
 - LR 4A with 3 month recommended CT
 - all known biopsies with tissue diagnosis of cancer at 1 year
 - Cancer detection rate
- Access



Lung Cancer Screening Program

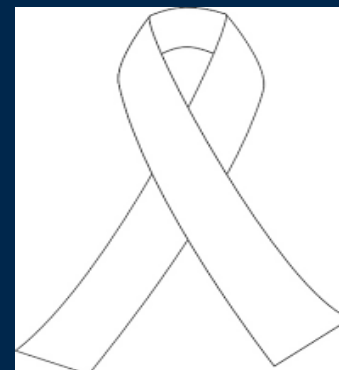
How? Navigator / Coordinator

The most important part of any screening program!!!

- Screen individuals for eligibility
- Make appointments (CT, pulmonary medicine etc)
- Follows up on positive screens
- Annual screen reminders
- Database/registry
- Focus for education and outreach
- Tobacco cessation
- ***Relationship building***

Lung Cancer Screening: Education & Advocacy

- It's early in lung cancer screening implementation, and we have a lot to learn and do
- Awareness & education among patients and providers is not at the level of breast cancer or colon cancer screening
 - October breast cancer awareness month – pink
 - February colon cancer awareness – dark blue
 - November for lung cancer awareness - white



*Thank you for helping to create lung cancer survivors,
to lower the impact of lung cancer through prevention,
early detection & assurance of optimal therapy,
and to do so in a patient-centered, evidence-based
manner that's inclusive, diverse, proactive & visionary*



Together we can create lung cancer survivors