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 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.
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

MILD trial - Multicentric Italian Lung Detection – Ann Oncol 2019
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
$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?

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.
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?
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

http://www.nccn.org/
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%
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
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.


Low: Utah & California      High: Kentucky & West Virginia
Second Hand Smoke in U.S.


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


- Four
- Eight
- Sixteen
- Sixty-four

Quantity of Scanners

Year in Trial:
- 2002
- 2003
- 2004
- 2005
- 2006
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
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
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 (CTD\text{vol}) Values

- Approximate values for CTD\text{vol} are listed for three different patient sizes:

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Approx. Weight (kg)</th>
<th>Approx. Weight (lbs)</th>
<th>Approx. CTD\text{vol} (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Patient</td>
<td>50-70</td>
<td>110-155</td>
<td>0.25 - 2.8</td>
</tr>
<tr>
<td>Average Patient</td>
<td>70-90</td>
<td>155-200</td>
<td>0.5 - 4.3</td>
</tr>
<tr>
<td>Large Patient</td>
<td>90-120</td>
<td>200-265</td>
<td>1.0 – 5.6</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Small Patient (BMI ≤30)</th>
<th>Large Patient (BMI &gt;30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total radiation exposure</td>
<td>≤3 mSv</td>
<td>≤5 mSv</td>
</tr>
<tr>
<td>kVp</td>
<td>100-120</td>
<td>120</td>
</tr>
<tr>
<td>mAs</td>
<td>≤40</td>
<td>≤60</td>
</tr>
</tbody>
</table>

**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
## Lung Cancer Screening Guideline

<table>
<thead>
<tr>
<th><strong>Storage</strong></th>
<th>All acquired images, including thin sections; MIPs and CAD renderings if used</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interpretation Tools</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Platform</strong></td>
<td>Computer workstation review</td>
</tr>
<tr>
<td><strong>Image type</strong></td>
<td>Standard and MIP images</td>
</tr>
<tr>
<td><strong>Comparison studies</strong></td>
<td>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</td>
</tr>
</tbody>
</table>

BMI = body mass index; CAD = computer aided diagnostics; CT = computed tomography; MIP = maximum intensity projection.
### Low-Dose Computed Tomography Acquisition, Storage, Interpretation, and Nodule Reporting

<table>
<thead>
<tr>
<th>Nodule Parameters</th>
<th>All Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Largest mean diameter on a single image*</td>
</tr>
<tr>
<td>Density</td>
<td>Solid, ground glass, or mixed†</td>
</tr>
<tr>
<td>Calcification</td>
<td>Present/absent; if present: solid, central vs eccentric, concentric rings, popcorn, stippled, amorphous</td>
</tr>
<tr>
<td>Fat</td>
<td>Report if present</td>
</tr>
<tr>
<td>Shape</td>
<td>Round/ovoid, triangular</td>
</tr>
<tr>
<td>Margin</td>
<td>Smooth, lobulated, spiculated</td>
</tr>
<tr>
<td>Lung location</td>
<td>By lobe of the lung, preferably by segment, and if subpleural</td>
</tr>
<tr>
<td>Location in dataset</td>
<td>Specify series and image number for future comparison</td>
</tr>
<tr>
<td>Temporal comparison</td>
<td>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</td>
</tr>
</tbody>
</table>

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 too
  - 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
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
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.