Rationale for lung cancer screening seemed obvious, but lack of mortality specific evidence

NIH funded National Lung Screening Trial (NLST) through:
- Lung Screening Study (LSS)
- American College of Radiology Imaging Network (ACRIN) ~$250 Million

Imaging study – very large (goal 50,000 subjects), complex

Heavy involvement with biostats & IT
National Lung Screening Trial (NLST)

53,456 participants, 55-74 years, w 30+ pack year smoking history
Baseline exam + 2 subsequent annual exams (3 total per subject)

ACRIN
n = 18,842 subjects
CT vs CXR

LSS
n = 34,614 subjects
CT vs CXR

Data eventually pooled, analyzed
Results showed real benefit for CT screening
"20% reduction in lung cancer mortality in the CT arm"
US Preventive Services Task Force statement
CT Lung Screening now performed in increasing numbers

US Preventive Services Task Force

The USPSTF recommends annual screening for lung cancer with low-dose computed tomography (LDCT) in adults aged 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.

December, 2013

U.S. Preventive Services Task Force

NLST Sites

US Preventive Services Task Force

The USPSTF recommends annual screening for lung cancer with low-dose computed tomography (LDCT) in adults aged 55 to 80 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years.

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December, 2013

U.S. Preventive Services Task Force

NLST Sites

ACRIN sites
LSS sites
Way back when, once upon a time, at the start….

Concept of NLST was very controversial
Anticipated lots of scrutiny no matter what the trial result
Wanted to be sure that the images would not be a target:
• quality
• consistency (opposite of variability)
Also – radiation dose was a BIG concern (Screening!)

Timeline…

Launched September 2002
Recruitment halted April 2004 (target 50,000)
Follow up continued
~90% of all subjects completed all 3 exams

Physicists included in budget 2002 - 2010 (consultants)

Medical Physics NLST Publications -

2006 Academic Radiology (Cagnon) – QC program for NLST
2010 AJR (Cody) – CTDI of NLST scanners
2011 AJR (Larke) – Effective Dose of NSLT subjects
2017 AJR (Lee) – Organ dose estimates of NLST subjects

CT Physicists…

ACRIN
- Dianna Cody (Chair)
- Christopher Cagnon
- Phil Judy
- Michael McNitt-Gray

LSS
- Fred Larke (Chair)
- Randell Kruger
- Michael Flynn
- Xizeng Wu
CT Physics Team

Needed to find a balance between:
- Excellent & consistent quality (QC)
- Reasonable for site personnel to execute
- Team approach – find that sweet spot

Divided up the monitoring duties

Regular t-cons to discuss data/issues

NLST overall goals/design

Multi-slice CT scanners ONLY – thin sections, fast “Low-Dose” (~1/4 routine chest dose)
- Effective mAs ~ 20-30 mAs
- Lung masses ≥ 4mm
  - Solid, part-solid, ground glass
- Positive screens → follow-up
- Blood, urine, sputum specimens
  - 15 sites
  - ~10,000 subjects
  - + lung tumor pathology blocks
- Primary endpoint: mortality

CT Physics Requirements

Phantom images submitted for review:
- Verify protocol parameters being applied
- Confirm acceptable IQ using that parameter set

Annual dosimetry measurements:
- Confirm radiation exposure values using parameter set
Physics ACRIN/NLST QC paper

Image Acquisition Parameters – 4 manufacturers, 14 scanner models (n = 96)
Initial ‘certification’ submission
Annual performance tests
CTDvol on 32cm phantom with NLST scan protocol
Water phantom (0±4 HU) w/NLST scan protocol
Image noise – std deviation in water phantom 15-40 HU w/NLST scan protocol
Field Uniformity in water phantom w/NLST protocol ≤7 HU
Artifact assessment (water phantom scanned w/NLST protocol)
Bimonthly water phantom image submission


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Image Acquisition Parameters - Example

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AAPM CT Protocol website (+ TCM)

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Radiation dose papers (3)


What we did well

Acquisition parameter sets by CT model
Guide for study personnel at sites
Very specific
Helped provide image quality consistency

Looked for water QC images
Not useful for intended purpose (water CT#)
Very useful for checking connectivity of individual sites to archive system

What I wish we had done better:

Implement new technology somehow
Tube Current Modulation!

Use of DICOM monitoring real-time to confirm protocol was being followed

Current challenge - New CT options

Tube Current Modulation (versions, parameters)
Iterative Reconstruction (many versions, parameters)
Organ dose modulation
CAD (lung)
Dose Notification values
Dual Energy? (LOTS of parameters/post processing options)
Post processing options:
Metal artifact reduction
Multi-planar reformats
Maximum intensity projection images
Report templates (structured reports)?
Hanging protocol standards?
Ongoing QC?...

Consider if an accreditation program or other standard may suffice for following established processes?

(Don’t reinvent the wheel…)

May have been sufficient for:
- Equipment certification
- Annual performance submission

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General CT Pointers in Clinical Trials:

Budget must include Medical Physics assistance!
- Ballpark: $10-15K per year per physicist (need team)
- May need help well after image acquisition has ended
- Last payment for 2010, acquisitions stopped 2006
- Nail down acquisition and reconstruction parameters on a per scanner model basis
- Include a method for confirming image transfer is ok
- Have a plan for implementing new technology as it becomes released during the trial (it WILL happen)