VA PARTNERSHIP Increase ACCESS to LUNG SCREENING

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Technical Co-PI: Rick Avila, MS

Sponsored by the Bristol-Myers Squibb Foundation and the VA Office of Rural Health
Disclosures

• I am a named inventor on a number of patents and patent applications relating to the evaluation of pulmonary nodules on CT scans of the chest which are owned by Cornell Research Foundation (CRF).

• As of April 2009, I signed away any financial benefit including royalties and any other proceeds related to the patents or patent applications owned by CRF.

• I am the President of the Early Diagnosis and Treatment Research Foundation
Initial VA Screening Program

• It was started as a pilot project at multiple VA centers
• The results were very varied
• Many problems due to insufficient infrastructure and management system
  – Wrong scanning protocol
  – Too many false positives

VA-ELCAP Management System for VA-PALS

In process of being launched at the Phoenix VA, followed by St. Louis VA, and then 8 other VA centers

Early Diagnosis and Treatment Research Foundation is providing the ELCAP Management System to the VA for this purpose
Largest CT Screening Cohort in the World
ELCAP to NY-ELCAP to International-ELCAP

Individualized CT screening depends on indicators of risk
e.g., current smokers, former smokers, never smokers

Study design
Screening protocol
Pathology protocol
Regimen of screening
Lung cancer size, stage, cure rate

I-ELCAP
100+ investigators

75 institutions in 10 countries
80,000+ participants

NY-ELCAP

Israel
Switzerland
Spain
Italy

Japan
China
Taiwan

Brazil
Canada
United States

SUNY-Downstate
SUNY-Stonybrook
Roswell Park
SUNY-Upstate
Mount Sinai
NY Medical
North Shore
Long Island Jewish
Our Lady of Mercy
MSKCC

Nodule growth and detection
Mediastinal masses
Emphysema
Coronary Artery Ca++
Breast Diseases

Conferences @ 6 months
Computer analytics
Continuous Quality Improvement
Publications 200+

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Conferences @ 6 months
Further areas:
Liver
Adrenals
Thyroid

IELCAP Database

Other CT Findings
Breast mass
Breast density
Axillary LNs
Vascular CAC
Lung Cancer
COPD
Emphysema
Chronic bronchitis
Bronchiectasis
Focal pneumonia
Interstitial disease
Hypertension
Stenosis
Aorta
Peripheral/vascular
Atherosclerosis

Image processing software
VA-ELCAP Management System for VA-PALS

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QA Needed for Processes

• Scanner
• Scanning
• Protocol
• Readers
• Recommendations
Scanner

- Scanner type and model will be collected
- Protocol reviewed
- QIBA small nodule conformance
Scanning

- Dose monitoring
- Scan monitoring (overscanning)
- Scan quality
NELSON Conclusion

• Volume CT screening results in a low referral rate (2.3%) and a very substantial reduction in lung cancer screening mortality

• However, volumetric assessment is still in its infancy and needs further standardization
Volumetrics

• We introduced it in 1999

• Showed results and images to NLST and NELSON starting in 1999

• NELSON started to use it in its trial
Measurement Uncertainty
Within seconds, 44% change: 172 VDT

Problem

• Precise Quantitative CT Measurements Are Often Needed
  – CT Lung Nodule Follow-Up, Cardiac Calcification Scoring

• CT Scanners/Software Do NOT have The Tools To Support This
  – Fundamental CT Scanner Performance Varies Widely – Even Within A Single Image
  – Multiple Scanners Are Often Used At A Clinical Site With Different Properties
  – Setting Up a High Quality Imaging Protocol Is Error Prone Due to Large Numbers of Scan Parameters and Continuously Changing Technology

• Clinical Sites Are Now Able To Use a New Low-Cost Phantom and Online Phantom Analysis Tools To Consistently Achieve The Needed CT Image Quality For Specific Clinical Tasks
CT Image Quality Issues

3D Resolution

3D Spatial Warping

Noise

Image Quality Variability
CT Image Quality Control

• Using Low-Cost Phantoms and Cloud-based Services Will Help Clinical Sites and Studies To:

  – Understand the quality of their CT imaging studies in terms of expected clinical task performance and fundamental image quality properties.

  – Optimize CT scanner acquisition protocol performance based on best protocols identified throughout the world for a specific scanner.

  – Monitor CT scanner and protocol performance and obtain alerts when protocol performance falters.

  – Make CT scanner image acquisition from different CT scanner models and manufacturers more consistent.

RSNA/QIBA now provides a conformance certification mark demonstrating the quality of a site’s CT scanning and measurement of solid lung nodules.
Solution: RSNA QIBA CT Small Lung Nodule Profile
+ Conformance Phantom & Online Software

QIBA Profile: Lung Nodule Assessment in CT Screening Profile - 2017

Quantitative Imaging Biomarkers Alliance

QIBA Profile:
Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening

Stage: Publicly Reviewed (draft)
RSNA/QIBA Conformance Certification Pilot Project
Using Cloud-Based Computing Services

http://quality.rsna.org

Check Each Time Scanner or Protocol Changes and Once Per Year

Guidance
Webpages & FAQs
International CT Image Quality Monitoring

60 CTLX1 Phantoms Sent Out As Of 10/1/2018

Data Received & Analyzed From:

- ~30 Sites
- ~50 Unique CT Scanners
- > 200 CT Scans

- 4 Manufacturers
- Siemens, GE, Philips, Toshiba
- > 20 Different Scanner Models
The Screening Regimen: 
*Critical to Maximizing the Benefit Minimizing Harms*

The Devil is in the Details

- Low-dose CT
- Positive result
- Work-up algorithm
- Diagnosis of lung cancer

I-ELCAP and NLST Survival Rates

The benefit of having a regimen of screening with continuous updates together with a web-based electronic structured management system is shown by the results below.
Importance of Regimen:

Reduces unnecessary tests and particularly invasive procedures
Protocol

• I-ELCAP
• Lung-RADS
• European
## I-ELCAP, ACR-LungRADS, European baseline protocols

### a. Immediate workup
PET, biopsy, follow-up CT

<table>
<thead>
<tr>
<th>Solid NCN, largest</th>
<th>I-ELCAP</th>
<th>ACR-Scenario 1</th>
<th>ACR-Scenario 2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 15.0 mm</td>
<td>≥ 8 mm</td>
<td>≥ 15 mm</td>
<td>≥ 10 mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part-solid NCN, largest</th>
<th>I-ELCAP</th>
<th>ACR-Scenario 1</th>
<th>ACR-Scenario 2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td>solid component ≥ 15.0 mm</td>
<td>solid component ≥ 8 mm</td>
<td>solid component ≥ 15 mm</td>
<td>NONE</td>
<td></td>
</tr>
</tbody>
</table>

### b. 3-month LDCT

<table>
<thead>
<tr>
<th>Solid NCN, largest</th>
<th>I-ELCAP</th>
<th>ACR-Scenario 1</th>
<th>ACR-Scenario 2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 6.0 mm but &lt; 15.0 mm</td>
<td>-</td>
<td>≥ 8 mm but &lt; 15 mm</td>
<td>≥ 5 mm but &lt; 10 mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part-solid NCN, largest</th>
<th>I-ELCAP</th>
<th>ACR-Scenario 1</th>
<th>ACR-Scenario 2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td>solid component of NCN ≥ 6.0 mm but &lt; 15.0 mm</td>
<td>entire size of NCN ≥ 6 mm with solid component ≥ 6 mm but &lt; 8 mm</td>
<td>entire size of NCN ≥ 6 mm with solid component ≥ 6 mm but &lt; 8 mm</td>
<td>entire size of NCN ≥ 5 mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nonsolid NCN, largest*</th>
<th>I-ELCAP</th>
<th>ACR-Scenario 1</th>
<th>ACR-Scenario 2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 5 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### c. 6-month LDCT

<table>
<thead>
<tr>
<th>Solid NCN, largest</th>
<th>I-ELCAP</th>
<th>ACR-Scenario 1</th>
<th>ACR-Scenario 2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td>NONE</td>
<td></td>
<td>≥ 6 mm to &lt; 8 mm</td>
<td>≥ 6 mm to &lt; 8 mm</td>
<td>NONE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part-solid NCN, largest</th>
<th>I-ELCAP</th>
<th>ACR-Scenario 1</th>
<th>ACR-Scenario 2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td>NONE</td>
<td></td>
<td>entire size of NCN ≥ 6 mm with solid component &lt; 6 mm</td>
<td>entire size of NCN ≥ 6 mm with solid component &lt; 6 mm</td>
<td>NONE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nonsolid NCN, largest**</th>
<th>I-ELCAP</th>
<th>ACR-Scenario 1</th>
<th>ACR-Scenario 2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 20 mm</td>
<td></td>
<td>≥ 20 mm</td>
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<td></td>
</tr>
</tbody>
</table>

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I-ELCAP, ACR-LungRADS, European

All protocols recommend
- 1) immediate workup, %
- 2) delayed workup, %
- 3) annual repeat screening %

All use different thresholds for recommendations
- 6.0mm for I-ELCAP, 6mm for LungRADS, 5mm European

ACR-LungRADS recommends PET scans for NCNs, 8 mm or larger, although 3 month follow-up CT is an alternative, therefore 2 scenarios:
- Scenario 1: immediate PET scan
- Scenario 2: 3 month LDCT
I-ELCAP, ACR-LungRADS, European

For each protocol option, we calculated:

Percentage of participants recommended for workup
ER = # workups/# dx cancers
I-ELCAP, ACR-LungRADS, European

Overall protocol summary:

Total number of participants recommended for workup before first annual repeat and
ER = # participants/# LC diagnosis
Comparison of Protocols

**ER** = number of people requiring dx tests for each diagnosis of lung cancer

<table>
<thead>
<tr>
<th>Workup</th>
<th>I-ELCAP</th>
<th>ACR-S1</th>
<th>ACR-S2</th>
<th>European</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Immediate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workup/L ca</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3-month</td>
<td></td>
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<tr>
<td>Workup/L ca</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>6-month</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workup/L ca</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OVERALL ER</strong></td>
<td><strong>13.9</strong></td>
<td>18.3</td>
<td>18.3</td>
<td>31.9</td>
</tr>
</tbody>
</table>

Comparison of Baseline Protocols: Estimated % requiring biopsies and # participated biopsies/LC dx

<table>
<thead>
<tr>
<th>Workup</th>
<th>I-ELCAP %</th>
<th>I-ELCAP ER</th>
<th>ACR-S1 %</th>
<th>ACR-S1 ER</th>
<th>ACR-S2 %</th>
<th>ACR-S2 ER</th>
<th>European %</th>
<th>European ER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate</td>
<td></td>
<td></td>
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<tr>
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<tr>
<td>6-month</td>
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<td></td>
</tr>
<tr>
<td>Biopsies</td>
<td>1.6%</td>
<td>2.2</td>
<td>6.0%</td>
<td>8.1</td>
<td>2.3%</td>
<td>3.2</td>
<td>3.3%</td>
<td>4.4</td>
</tr>
</tbody>
</table>

First Round of Screening

• The first screening round is not a single test, but a two-step process
  – Starts with low-dose CT scan
  – If first low-dose CT is negative or the largest noncalcified nodule (NCN) is < 6.0 mm, come back for the first annual round of screening next year
  – in 10% of screenings, come back in 3 months to assess change on another low-dose CT scan
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Conclusion

- Differences among modern protocols lead to major changes in efficiencies.
- Accumulated knowledge and data should lead to continual updating of protocols
- Mechanisms should be place to enhance such updating
IELCAP Database

OTHER CT FINDINGS

Further areas:
Liver
Adrenals
Thyroid