Status of the Quantitative Imaging Profile
Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening

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QIBA Working Group Co-Chair
Goal

• Advance the science and implementation of quantitative imaging in clinical trials and practice

• Use imaging devices as automated, reproducible measurement systems for specific tasks
Approach

• Conduct rigorous assessment of the variability inherent in image-based measurements

• Determine performance capabilities of specific imaging biomarkers and requirements for achieving them
QIBA Biomarker Committees

- CT Volumetry
- FDG-PET
- PET Amyloid
- SPECT
- CT Lung Density

- fMRI
- MR Elastography
- Ultrasound Shear Wave Speed
- Ultrasound Volume Blood Flow
Collaboration

• Imaging science experts (physicists, engineers, image processing scientists)
• Biostatisticians and metrologists
• Physicians
• Biologists, chemists
• Manufacturers
• Regulators
• Patient advocates
The QIBA Profile

Describes measurement performance achievable and conditions required

• Claims
• Specifications
• Assessment Procedures
Activities

• Literature review
• Groundwork studies
• Clinical trial data analysis
• Theoretical analysis and simulations
• Discussion and expert consensus
CT Volumetry

Advantages:

- Independent of lesion and measurement orientation
- Independent of selected slice and orientation
- Sensitive to size change in all directions
- Reproducible
CT Volumetry Biomarker Committee Profiles

- **Change Measurements in Solid Tumors (Lung ≥10 mm)**
  - Publicly reviewed 2011
    ([http://qibawiki.rsna.org/images/e/e3/2011_07_28_Profile_CT_Advanced_Disease_V2_0f.pdf](http://qibawiki.rsna.org/images/e/e3/2011_07_28_Profile_CT_Advanced_Disease_V2_0f.pdf))
  - Updated version in progress, liver lesions being addressed

- **Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening**
  - Released for Public Comment 6/2/16-8/1/16
Nodule Volume

- 95% confidence interval = ±(measured volume x 1.96 x CV)

<table>
<thead>
<tr>
<th>Nodule Diameter (mm)</th>
<th>Nodule Volume (mm³)</th>
<th>Coefficient of Variation (CV)</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 6 and &lt; 8 mm</td>
<td>≥ 113 and &lt; 268</td>
<td>0.29</td>
<td>± 57%</td>
</tr>
<tr>
<td>≥ 8 and &lt; 10 mm</td>
<td>≥ 268 and &lt; 524</td>
<td>0.19</td>
<td>± 37%</td>
</tr>
<tr>
<td>≥ 10 and &lt; 12 mm</td>
<td>≥ 524 and &lt; 905</td>
<td>0.14</td>
<td>± 27%</td>
</tr>
<tr>
<td>≥ 12 mm</td>
<td>&gt; 905</td>
<td>0.11</td>
<td>± 22%</td>
</tr>
<tr>
<td>Nodule volume</td>
<td>CV</td>
<td>95% CI</td>
<td>Corresponding diameter</td>
</tr>
<tr>
<td>---------------</td>
<td>-----</td>
<td>-------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>150 mm$^3$</td>
<td>0.29</td>
<td>65-235 mm$^3$</td>
<td>6.6 mm</td>
</tr>
<tr>
<td>500 mm$^3$</td>
<td>0.19</td>
<td>314-686 mm$^3$</td>
<td>9.8 mm</td>
</tr>
<tr>
<td>800 mm$^3$</td>
<td>0.14</td>
<td>580-1020 mm$^3$</td>
<td>11.5 mm</td>
</tr>
</tbody>
</table>

- Currently for investigational use only
Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening

Claim 2

Change in Nodule Volume (95% confidence)

- Real if measured % change > 2.77 x CV1 x 100
- Amount of change ± 1.96 x √(Y1 x CV1)^2 + Y2 x CV2)^2

<table>
<thead>
<tr>
<th>Nodule Diameter (mm)</th>
<th>Nodule Volume (mm^3)</th>
<th>Coefficient of Variation (CV)</th>
<th>% Change Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 6 and &lt; 8 mm</td>
<td>≥ 113 and &lt; 268</td>
<td>0.29</td>
<td>80%</td>
</tr>
<tr>
<td>≥ 8 and &lt; 10 mm</td>
<td>≥ 268 and &lt; 524</td>
<td>0.19</td>
<td>53%</td>
</tr>
<tr>
<td>≥ 10 and &lt; 12 mm</td>
<td>≥ 524 and &lt; 905</td>
<td>0.14</td>
<td>39%</td>
</tr>
<tr>
<td>≥ 12 mm</td>
<td>&gt; 905</td>
<td>0.11</td>
<td>30%</td>
</tr>
</tbody>
</table>
### Claim 2 Examples

#### % Change in Volume

<table>
<thead>
<tr>
<th>Change</th>
<th>% Change</th>
<th>Min required (2.77xCVx100)</th>
<th>Real change? (95% confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>524 - 917 mm³</td>
<td>75% (20%)</td>
<td>2.77 x 0.14 x 100 = 39%</td>
<td>Yes (149-637 mm³)</td>
</tr>
<tr>
<td>(10.0 - 12.0 mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>180 - 270 mm³</td>
<td>50% (14%)</td>
<td>2.77 x 0.29 x 100 = 80%</td>
<td>Uncertain</td>
</tr>
<tr>
<td>(7.0-8.0 mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Currently for investigational use only
Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening Profile Conditions

- Solid nodules close to spherical (shortest dimension is at least 60% of longest dimension)
- Nodule segmented without manual editing
- Subject handling, acquisition, reconstruction, analysis specifications followed
- Volume: Zero measurement bias and covariance
- Change: Measurement system components same at both time points
- CT scanner meets conformance requirements
Solid, Spherical, Isolated
Attached, Non-spherical
Subsolid/Ground Glass
Semisolid/Mixed
Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening Specifications

- **Subject selection and handling**
  - Symptoms, positioning, breath holding

- **Image Data Acquisition**
  - kVp, mAs, collimation, pitch

- **Image Data Reconstruction**
  - Slice thickness and interval, kernel

- **Image analysis**
  - Software, reading paradigm
Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening

Assessment Procedures

- **CT Equipment**
  - ACR and manufacturer guidelines
- **Technologist, Radiologist, Image Analyst**
  - ACR guidelines, relevant training
- **Image Analysis Software**
  - TBD
QIBA Profile: Lung Nodule Volume Assessment and Monitoring in Low Dose CT Screening Post-comment period


- Address issues raised and finalize
- Verify in practice and modify as needed
- Update with technical improvements
- Assess clinical value
Acknowledgements

- Profile Co-Chairs: Sam Armato and Jim Mulshine
- Claims: Rick Avila, Nancy Obuchowski, David Yankelevitz
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Thank You!