QIBA CT Coordinating Committee Update

Wednesday, May 5, 2015

Modality Structure

• CT Volumetry Biomarker Committee
  Gregory Goldmacher, MD, PhD, MBA
  Samuel Armato III, PhD
  Jenifer Siegelman, MD, MPH
  • Volumetry Algorithm Challenge Task Force
    Maria Athelogou, PhD
  • Small Lung Nodule Task Force
    David Gierada, MD
    James Mulshine, MD
    Samuel Armato III, PhD

• Lung Density Biomarker Committee
  Philip Judy, PhD
  • Airway Measurement Task Force
    Sean Fain, PhD
Current Status: Profile Development

• Profile(s) in progress: CT Volumetry
  • Claim revised to match metrology
  • Years of commentary incorporated
  • Conformance procedures provisionally defined
  • Breakout session today – finalize this version
  • Ready for field test!

Current Status: Profile Development

• Profile(s) in progress: Small Nodule Volumetry
  • Claim numbers supported by groundwork
  • Claim wording matches main volumetry profile
  • Specifications completed
  • Compliance to be aligned with main profile
Current Status: Profile Development

- Profile(s) in progress: Lung Density
  - Working draft completed
    - Acquisition/reconstruction specs will be revised this week
  - Precision claim finalized
    - Volume correction method undetermined → Round 5 project

Activities/Projects

- Volumetry
  - Algorithm challenges
  - Liver phantom
  - Virtual lesions
  - Field test!

- Lung Density
  - Vendor COPDGene Phantom
  - AEC evaluation
  - Dose reduction effects
  - Volume correction methods
Algorithm Challenges

- Maria Athelogou, PhD
- Andrew Buckler, MS
- Phantom and clinical data analyses complete
- Publications in process

Liver Phantom

- Binsheng Zhao, PhD
- Nicholas Petrick, PhD
- Current profile based entirely on lung data
Liver Phantom Project

Abdomen Phantom Design

CT images of the liver phantom

Portal venous phase

Arterial phase
Liver Phantom Project

Lesion size measurements

- CU algorithm:
  Based on a marker-controlled watershed transformation
- FDA algorithm:
  Matched-filter based volume estimator

Preliminary statistical analysis

- Accuracy
  Bias/linearity (w Cis)
- Precision
  Repeatability
  Reproducibility
  Bland-Altman comparison of algorithms

Liver Phantom Project

- Received liver insert for complex liver
Liver Phantom Project

- Identified vascular materials & background technique for arterial/portal phase simulation
  - Working on simulating fatty infiltration

<table>
<thead>
<tr>
<th>Index</th>
<th>Equivalent diameter</th>
<th>Shape</th>
<th>Portal venous phase (bk=110HU)</th>
<th>Lesion density</th>
<th>Lesion-bk difference</th>
<th>Arterial phase (bk=80HU)</th>
<th>Lesion density</th>
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Liver Phantom Project

- Proposed imaging protocol
  - 3 phantom x 3 dose x 10 repeats = 90 acquisition
  - 90 acquisition x 2 recon algorithm = 180 set of images
  - 180 x 20 nodules = 3600 measurements

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<thead>
<tr>
<th></th>
<th>Dose L</th>
<th>Dose M</th>
<th>Dose H</th>
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<td>Uniform background</td>
<td>10 repeat x 2 recon</td>
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<tr>
<td>Vessel attachment</td>
<td>10 repeat x 2 recon</td>
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<tr>
<td>Vessel attachment &amp; fat infiltration</td>
<td>10 repeat x 2 recon</td>
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Dose H ~ clinical dose level
Dose M ~ (1+\mu)/2 * Dose H
Dose L ~ \mu * Dose H
\mu is about 0.4

Virtual Lesions

- Ehsan Samei, PhD
- Berkman Sahiner, PhD
Virtual Lesions

Techniques

1. Image space Lesion Addition

2. Projection space Lesion Addition

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Virtual Lesions

Techniques

1. Image space Lesion Addition

2. Projection space Lesion Addition
LESION MODEL

\[ c(\theta, \phi, r) = B + C \left( 1 - \left( \frac{r}{R_{\theta, \phi}} \right)^{2^n} \right) \]

**Attenuation**

**Background**

**Contrast**

**Spherical Coordinates**

**Edge Blur**

**Shape**

WHICH ONE IS REAL?

![Image of lesion model with various graphs and examples of different tissues](image-url)

*X. Li, E. Samei, et al. Br J Radiol. 2009*
Next Steps

• Demonstrate statistical exchangeability
• Generate static data set
• Create dynamic platform

Lung Density Biomarker Committee Activities

1. Vendor COPDGene phantom study
   • Mathew Fuld and Bernice Hoppel
2. Automatic Exposure Control (AEC) evaluation
   • Sean Fain
3. Dose reduction effects on emphysema metrics
   • Philip Judy
4. Volume correction
   • Heather Chan-Mayer
Vendor COPDGene Phantom Study

• **Purpose**: Acquisition and reconstruction specs to control lung density measurement bias

• Task Group of CT vendor scientists
  – Develop a compliance checklist
  – Suggest changes to acquisition and reconstruction parameter Profile specification

COPDGene Phantom Study

• Phantom scanning
  – Same COPDGene phantom
  – Three dose levels (5 mGy, 3 mGy, 1.5 mGy)
  – 8-10 sec acquisition time for 40 cm z-coverage
  – Several kVps (80 - 140)
  – Five scans for variability
  – Each of 4 vendors will use two different models

• Measurements
  – Noise levels
  – Resolution measurements
  – HU variability

• Status:
  – Scans completed
  – Preliminary report at today’s breakout session
AEC Evaluation

Goal:
Evaluate quantification impact of different AEC methods

Task:
Identify appropriate phantom and compare AEC methods

Status: Phantom identified; scans being performed

Dose reduction effects on emphysema metrics

- COPDGene study may lower mAs for 10 year inspiration exams (200 mAS => 50 mAs).
  – QIBA Lung Density Profile draft specifies 50 mAs
- Estimate bias differences created by change to 50 mAs.
- Compare results of volume corrected 50 mAs expiration exam
Volume Correction

• Rationale:
  – Natural progression: after age 50, lung density declines about 1.5 g/L 1.5 HU per year.
  – Current repeatability coefficient (within-subject variance) is 10 times higher.
  – Perc15 value changes depending on state of inflation

Volume correction using duplicate COPDGene exams

• Meta-analysis for precision claim: lung volume correction will improve repeatability
  
• Two possible methods

• Use duplicate exams from COPDGene Study to compare methods
CT Volumetry Field Test

• Goals:
  – Determine feasibility/usability
  – Run the profile end to end, measure precision
  – Expand profile data beyond lung
  – Provide sequestered data for conformance testing

CT Volumetry Field Test

• Protocol:
  – Test / re-test (“coffee break”)
  – Same scanner and different scanners
  – Segmentation by at least 5 readers
  – Using 3 software systems

  – Issues still under discussion
    • PI, IV contrast, analysis plan
CT Volumetry Field Test

• Timelines:
  – Year 1: 4 sites scanning 22 subjects each
  – Year 2: Scan segmentation and statistical analysis
    • Collaboration with QIN on structure

CT Volumetry Field Test

• Deliverables:
  – Public data set (n=72) for algorithm development
  – Sequestered data (n=16) for conformance testing
  – Support for precision values in claim

<table>
<thead>
<tr>
<th>Different Acquisition Device</th>
<th>Same Acquisition Device</th>
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<tbody>
<tr>
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<tr>
<td>Different Analysis Tool</td>
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<tr>
<td>A%</td>
<td>B%</td>
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Challenges/Next Steps/Future Plans

- CT Volumetry Field Test
  - We will need volunteer radiologists