QIBA CT Coordinating Committee Update

Wednesday, May 5, 2015

National Institute of Biomedical Imaging and Bioengineering

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

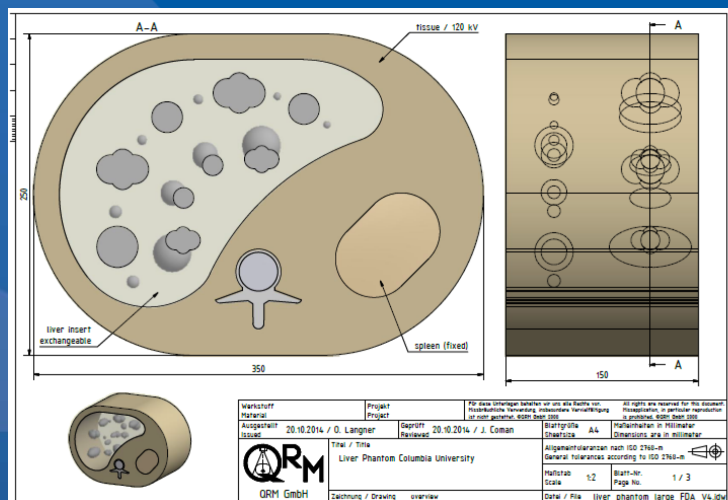
Liver Phantom

- Binsheng Zhao, PhD
- Nicholas Petrick, PhD

- Current profile based entirely on lung data

Liver Phantom Project

Abdomen Phantom Design



Liver Phantom Project

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

Liver Phantom Project

- Nodules to be created

Index	Equivalent diameter	Shape	portal venous phase (bk=110HU)		arterial phase (bk = 80HU)	
			Lesion density	Lesion-bk difference	Lesion density	Lesion-bk difference
1	20 mm	Spherical	80HU	-30 HU	95HU	+15 HU
2	20 mm	Spherical	95HU	-15 HU	110HU	+30 HU
3	14 mm	Spherical	80HU	-30 HU	95HU	+15 HU
4	14 mm	Spherical	95HU	-15 HU	110HU	+30 HU
5	10 mm	Spherical	80HU	-30 HU	95HU	+15 HU
6	10 mm	Spherical	95HU	-15 HU	110HU	+30 HU
7	7 mm	Spherical	80HU	-30 HU	95HU	+15 HU
8	7 mm	Spherical	95HU	-15 HU	110HU	+30 HU
9	5 mm	Spherical	80HU	-30 HU	95HU	+15 HU
10	5 mm	Spherical	95HU	-15 HU	110HU	+30 HU

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

	Dose L	Dose M	Dose H
Uniform background	10 repeat x 2 recon	10 repeat x 2 recon	10 repeat x 2 recon
Vessel attachment	10 repeat x 2 recon	10 repeat x 2 recon	10 repeat x 2 recon
Vessel attachment & fat infiltration	10 repeat x 2 recon	10 repeat x 2 recon	10 repeat x 2 recon

Dose H ~ clinical dose level
Dose M ~ (1+mu)/2*Dose H
Dose L ~ mu*Dose H
mu is about 0.4

Virtual Lesions

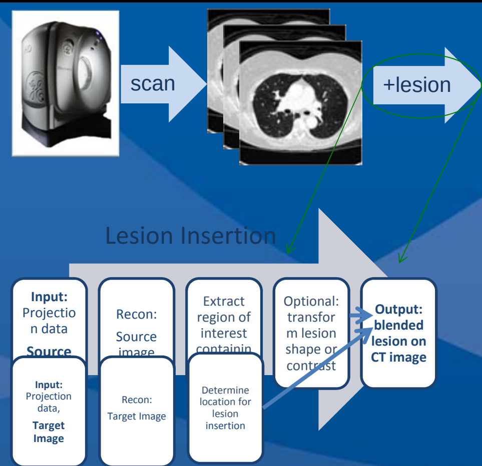
- Ehsan Samei, PhD
- Berkman Sahiner, PhD

Virtual Lesions

Techniques

1. Image space Lesion Addition

2. Projection space Lesion Addition



Virtual Lesions

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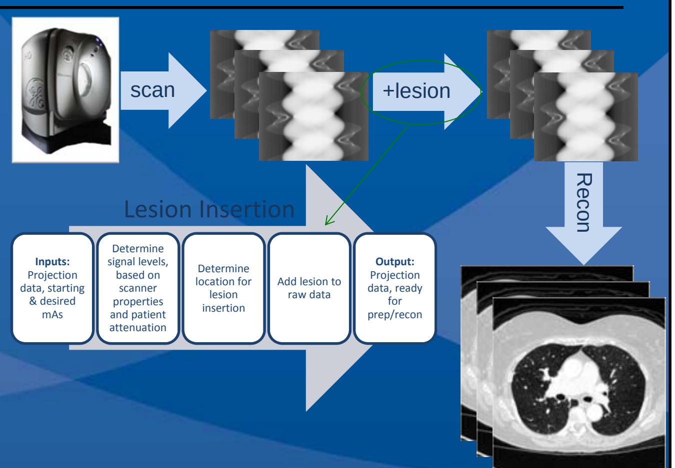


LESION MODEL

Spherical Coordinates

Contrast

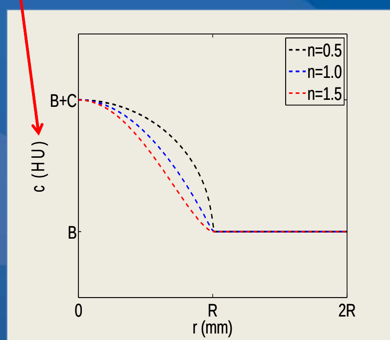
$$c(\theta,\phi,r)=B+C\left(1-\left(\frac{r}{R_{\theta,\phi}}\right)^2\right)^n$$

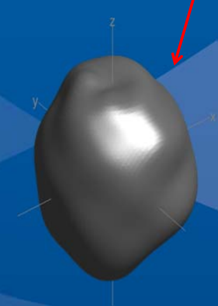
Edge Blur

Attenuation

Background

Shape

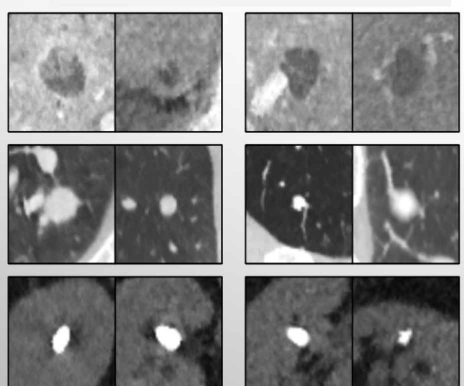


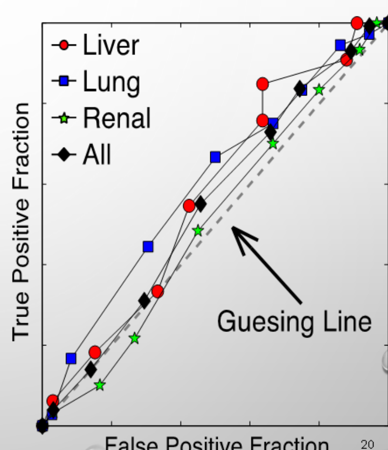


*X. Li, E. Samei, et al. Br J Radiol. 2009

19

WHICH ONE IS REAL?





20

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 (5mGy, 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

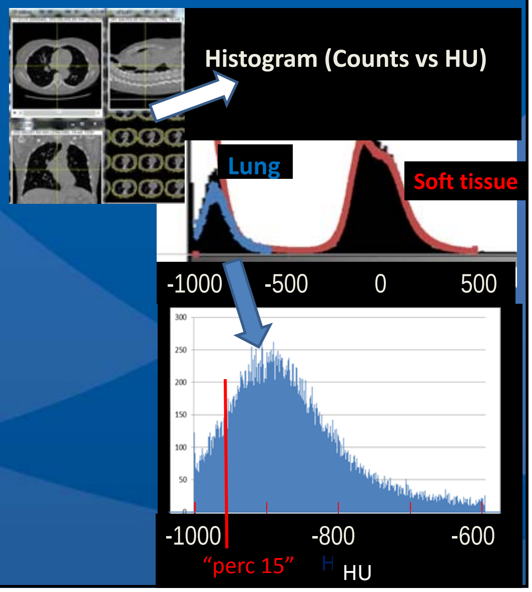
Status: Phantom identified; scans being performed

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

Different Acquisition Device				Same Acquisition Device			
Different Radiologist		Same Radiologist		Different Radiologist		Same Radiologist	
Different Analysis Tool	Same Analysis Tool	Different Analysis Tool	Same Analysis Tool	Different Analysis Tool	Same Analysis Tool	Different Analysis Tool	Same Analysis Tool
A%	B%	C%	D%	…	…	…	…

Challenges/Next Steps/Future Plans

- CT Volumetry Field Test
  - **We will need volunteer radiologists**