QIBA Volumetric Study 3A

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BACKGROUND

NIST

- National Institute of Standards and Technology
- Founded in 1901
- Non-regulatory federal agency within the U.S. Department of Commerce
- Mission
  - To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life

QIBA

- **Q**uantitative **I**maging **B**iomarkers **A**lliance
- Organized by the Radiological Society of North America (RSNA) in 2007
- Unites researchers, healthcare professionals, and industry
- Promotes:
  - Advancement of Quantitative Imaging
  - Use of biomarkers in clinical trials and practice

QIBA Mission

- Improve value and practicality of quantitative imaging biomarkers
- Reduce variability across
  - Devices
  - Patients
  - Time
- “Measuring devices” rather than “Imaging devices”

QIBA Process

1. Identify Error and Variation Sources in Quantitative Results from Imaging Methods
2. Specify Potential Solutions and Document as QIBA Profiles
3. Test Solutions
   - Vendors and Researchers Implement and Assess
4. Promulgate Solutions
   - Disseminated and Implemented via
     - Vendor Adoption
     - Research Integration
     - Clinical Education

QIBA Profiles

- Document specific performance claims and how stakeholders can achieve them
- Stakeholders
  - Users
  - Vendors
- Consist of
  - Claims
    - (Users) What can be accomplished by following Profile
  - Details
    - (Vendors) What must be implemented in products
    - (Users) What procedures are necessary

Snippet from a QIBA Profile

QIBA Profile. Computed Tomography: Change Measurements in the Volumes of Solid Tumors Version 2.0 28 July 2011

SPECIFICATION

Parameter	Specification
Common Lesion Selection	The Image Analysis Tool shall allow a common set of lesions to be designated for measurement, which are then subsequently measured by all readers.
Lesion Volume Change	The Image Analysis Tool shall measure lesion volume change (according to Figure 1) with variability less than +/- 15%.
Multiple Lesions	The Image Analysis Tool shall allow multiple lesions to be measured, and each measured lesion to be associated with a human-readable identifier that can be used for correlation across time points.
Recording	The Image Analysis Tool shall record actual model-specific Analysis Software set-up and configuration parameters utilized to achieve compliance with these metrics shall be recorded. Image Analysis Tools shall record in (and reload for review from) region specification (e.g., lesion segmentation boundary) and volumetric measurement as well as metadata in standard formats including one or more of the following output formats: DICOM Presentation State, DICOM Structured Report; DICOM RT Structure Set; DICOM raster or surface segmentation.

Some QIBA VolCT Groups/Studies

- Group 1A
  - Measure intra/inter-reader variability for lung nodule volume measurements
- Group 1B
  - Measure minimum detectable change in patient datasets under a “No Change” condition?
- Group 1C
  - Model Sources of variability from a systems engineering analysis
- Group 3A
  - Characterize variability due to algorithm using phantoms and clinical data
- Group 3B
  - Characterize clinical utility/efficacy with respect to clinical endpoints
- Colorado Group
  - Characterize clinical utility/efficacy with respect to clinical endpoints

IMAGING BIOMARKERS

Software and Systems Division
National Institute of Standards and Technology/U.S. Department of Commerce

Imaging Biomarkers

- Imaging Biomarkers
  - Anatomic, physiologic, biochemical, or molecular parameters detectable with imaging methods used to establish the presence or severity of disease
    - John J. Smith, MD, JD, A. Gregory Sorensen, MD and James H. Thrall, MD, Biomarkers in Imaging: Realizing Radiology's Future, June 2003 Radiology, 227, 633-638.

Imaging Biomarker Uses

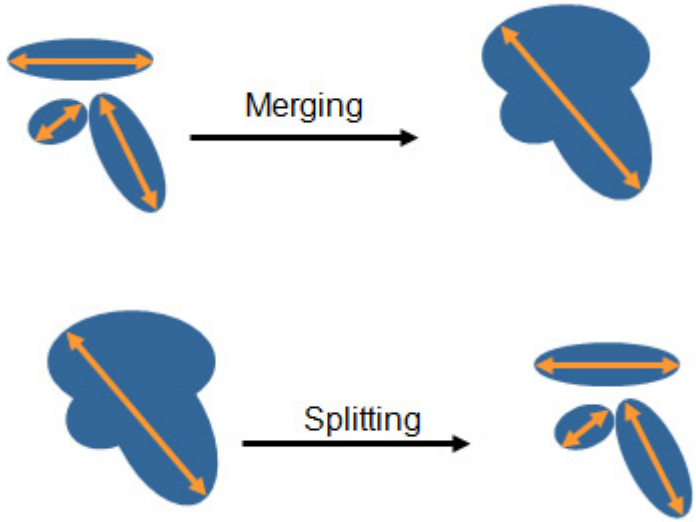
- Clinical care of patients
  - Detect and characterize disease
  - Predict course of disease
- Conduct of clinical trials
  - Define endpoints
- Adoption requires
  - Demonstration of ability to standardize
  - Assessment of reproducibility

Biomarkers and Tests

- Biomarkers are defined in part by the “class” of available tests
  - Not defined by a single test or implementation
  - Defined by aggregated understanding of results for the class of tests
- Necessary to determine how the class performs

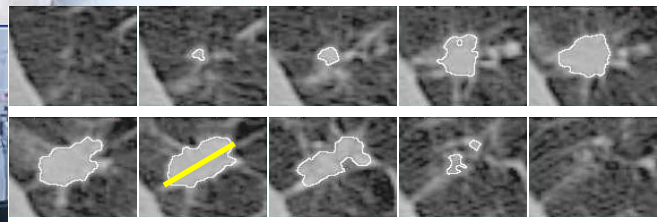
RECIST

- Response Evaluation Criteria In Solid Tumors
  - Published rules that define when cancer patients improve, stay the same, or worsen
- "The quantitative components of RECIST, the lesion size measurements, are measurable characteristics reflecting disease and response to treatment, and it seems reasonable to consider it alongside other imaging biomarkers."
  - Bleavins et al., Biomarkers in Drug Development: A Handbook of Practice, Application, and Strategy, Wiley, 2011

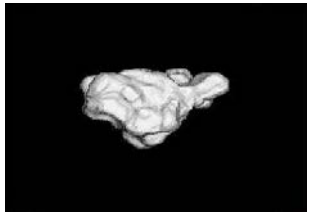


Source: http://www.recist.com

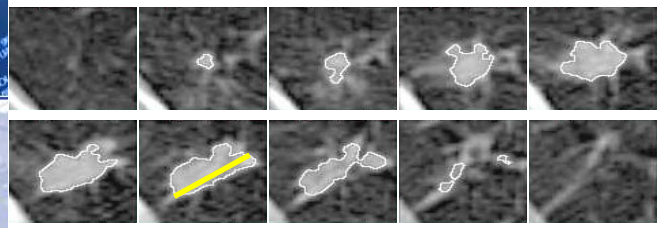
RECIST vs. Volume



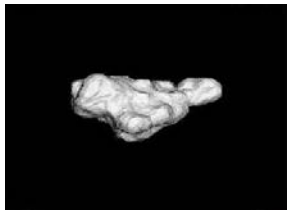
Diameter=17.7 mm



Volume=886 mm³

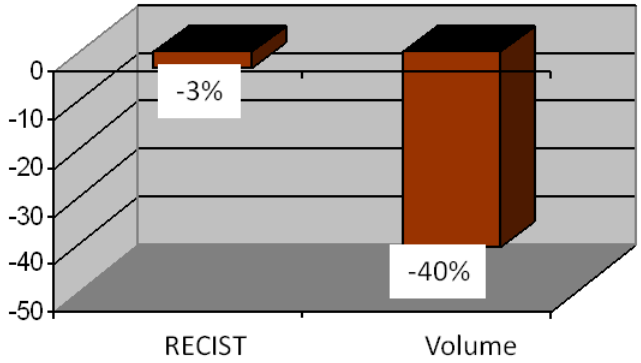


Diameter=17.1 mm



Volume=525 mm³

Complete	Partial	Progressive	Stable
Disappear	30% decrease	20% increase	Small change



Source: Orhan Suleiman, Technical Problems in Imaging Based Trials, FDA

STUDY OVERVIEW

Motivations

- Nodule volume change is important
  - Diagnosis, therapy planning, response evaluation
- Measuring volume change requires accurate absolute volume measurement
- Phantom nodule volume can be measured with accuracy
- Use phantoms to quantify algorithm performance (for this part of study)

Goals

- Estimate inter- and intra-algorithm variability by the volume estimation from CT scans
  - Inform QIBA Volumetric CT Profiles
  - Provide context with incentives for participation and cooperation
  - Not which algorithm is the best

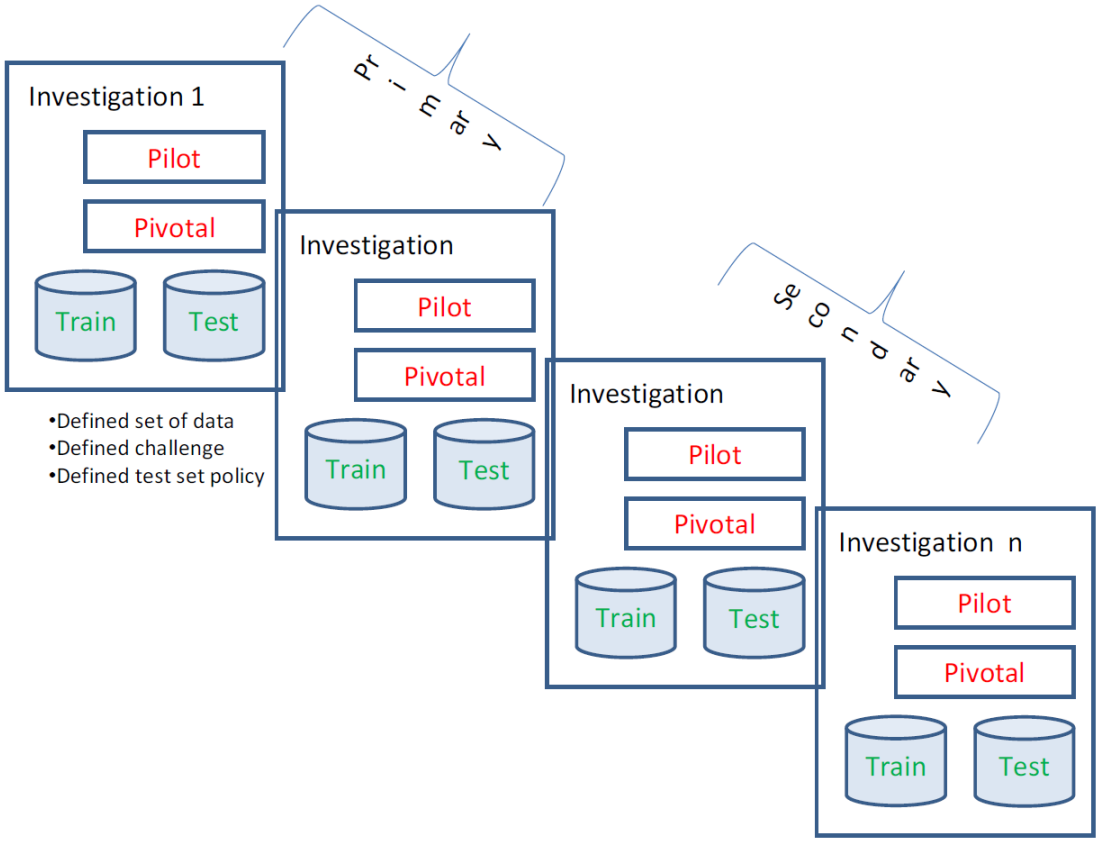
Participants

- Academic and commercial algorithm developers
- Radiologists and researchers with access to volumetric CT tools

Scope

- Automated segmentation algorithms which do not require user intervention
- Semi-automatic algorithms which require minimal user input

Overall Structure of Study

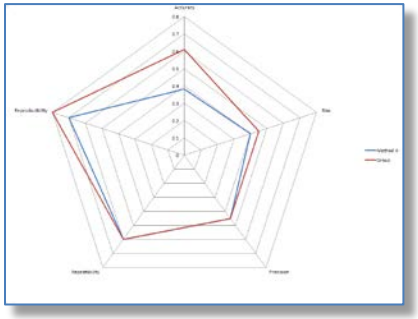


Primary Endpoint

- Pilot Study
  - Smaller study
  - Sandbox for participant practice
  - Input for power study
- Pivotal Study
  - Publishable results
  - Number of cases determined by Pilot results

Benefits to Participants/Community

- Low-risk feedback to developers/users about algorithm performance
  - Relative to other algorithms
  - With respect to ground truth
- Improve overall understanding of algorithm performance in support of biomarkers
- Larger set of data for grant proposals
- Great training exercise for radiologists
- Easy way to evaluate available systems



Participant Effort

- Depends on time required to measure and record volume
- Approximately 100 lesions available for Pilot Study

STUDY DATA

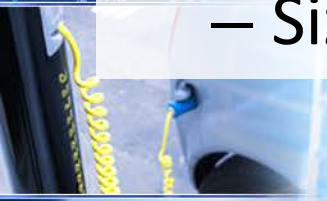
FDA CDRH Phantom Data

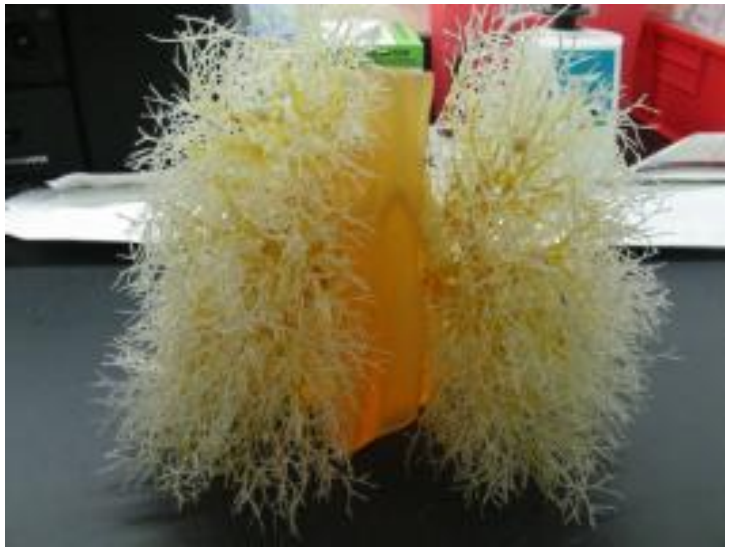
- Data for Volumetric Study 3A
- CT scans available via the NBIA for lung nodule size estimation assessment and image analysis software development
  - https://imaging.nci.nih.gov/ncia/login.jsf
- Reference
  - Marios A Gavrielides, Lisa M Kinnard, Kyle J Myers, Jenifer Peregoy, William F Pritchard, Rongping Zeng, Juan Esparza, John Karanian, and Nicholas Petrick , "A resource for the assessment of lung nodule size estimation methods: database of thoracic CT scans of an anthropomorphic phantom", *Optics Express* , vol. 18, n.14, pp. 15244-15255, 2010.

Advantages of FDA Phantom

- Ability to generate scans with clinically-relevant
  - Locations
  - Shapes
  - Sizes

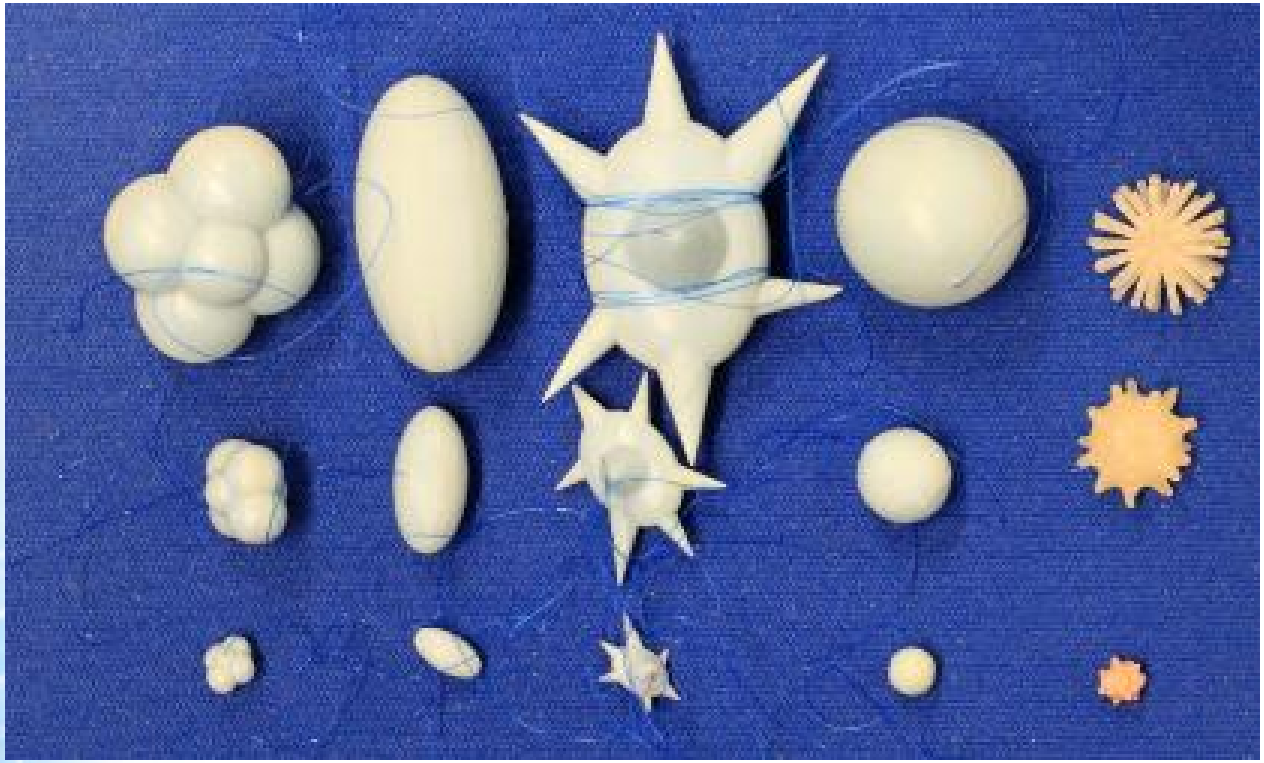




Anthropomorphic Phantom

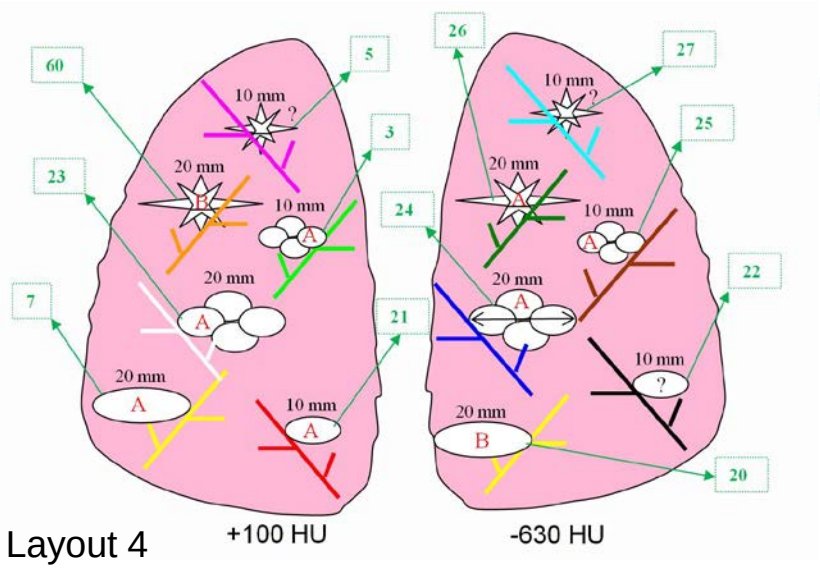
The anthropomorphic thoracic phantom and the vasculature insert on which synthetic nodules were attached before CT imaging



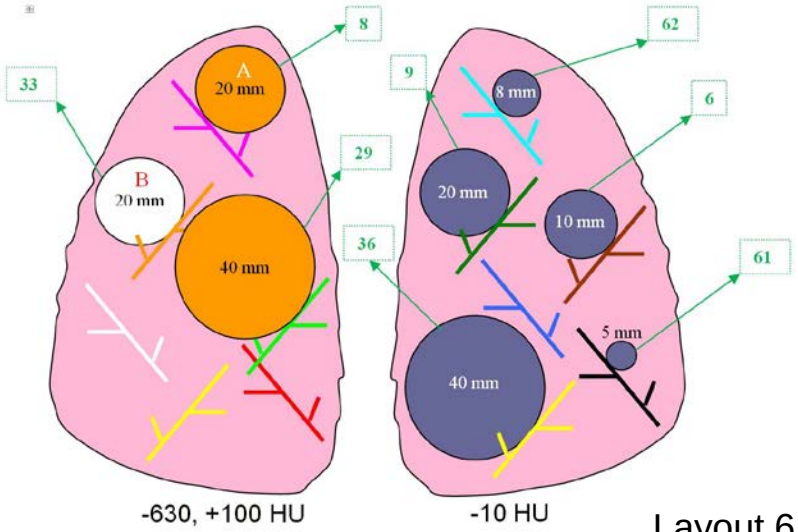
Synthetic Lesions

The synthetic lung nodules vary in size (5, 8, 10, 12, 20, & 40 mm), shape (spherical, elliptical, lobulated, & spiculated), and density (-800, -630, -10, & +100 HU)

Layouts



Layout 4



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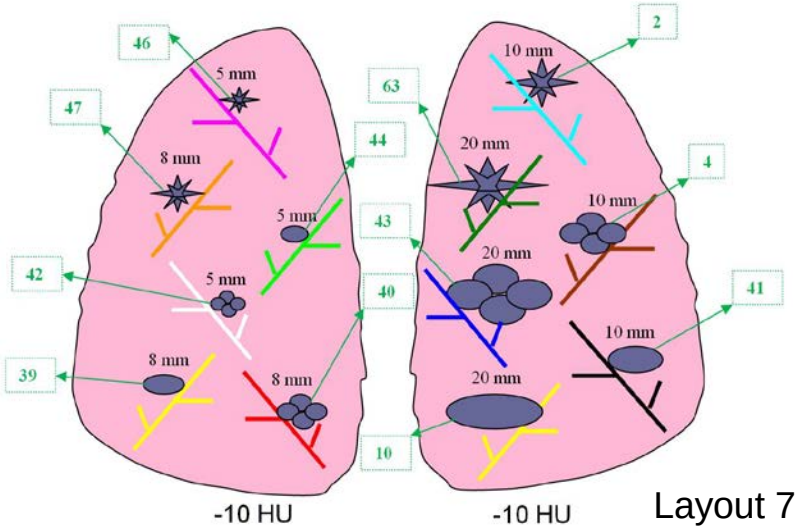
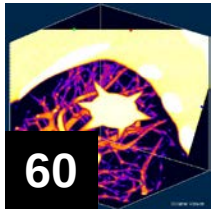
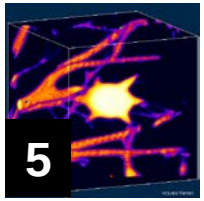


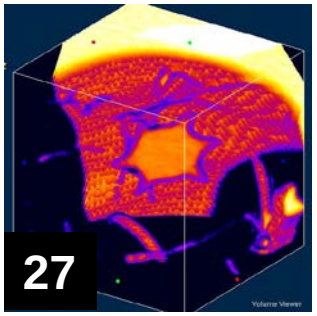
Layout 7

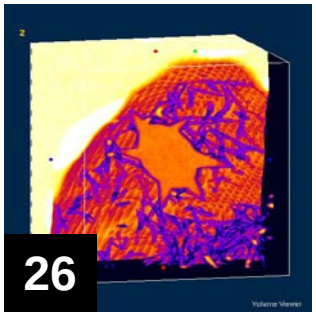
Lesions

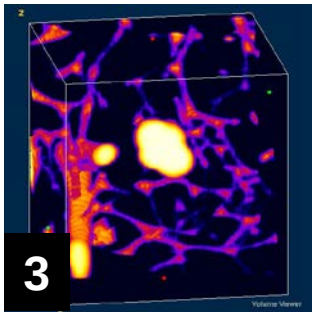
Series 1114 – FDA Layout 4

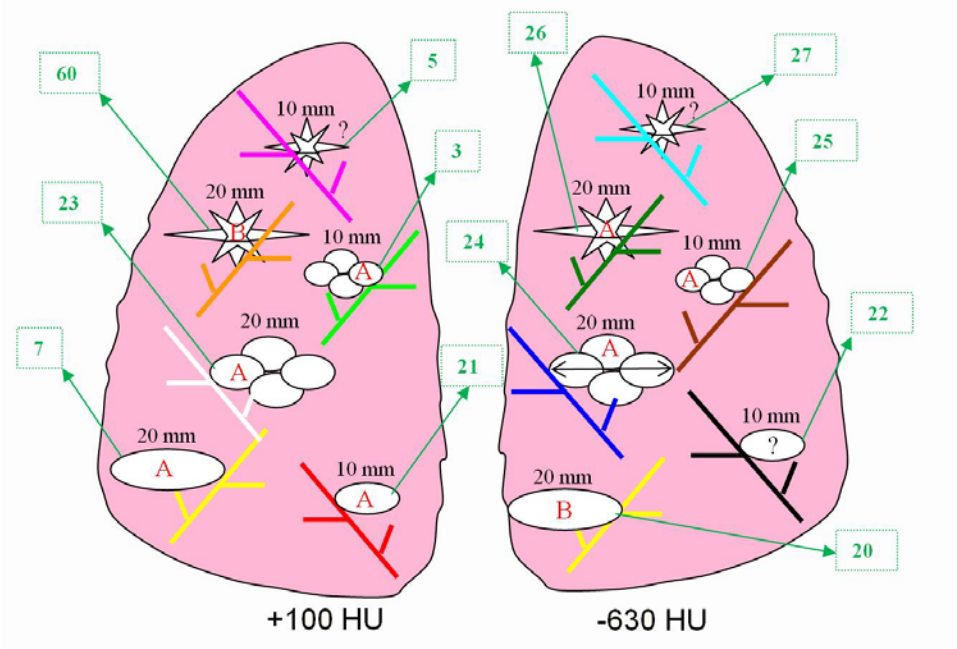


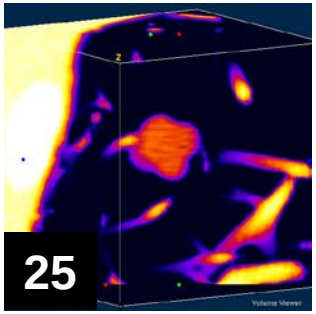


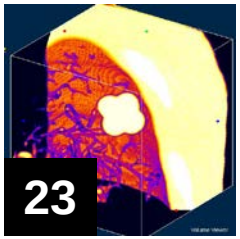


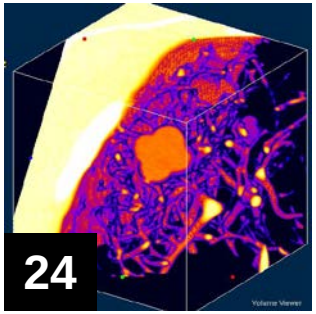


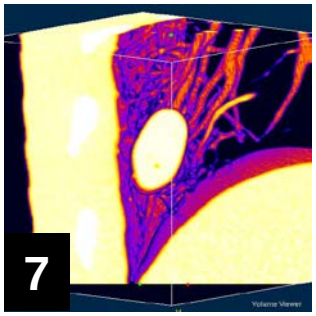


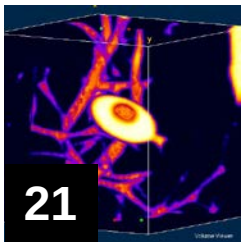


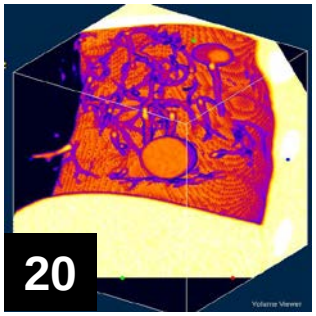


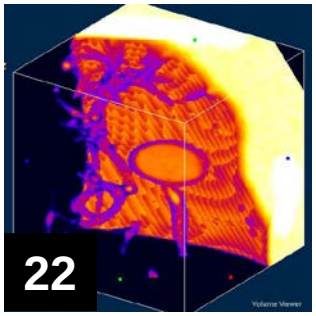






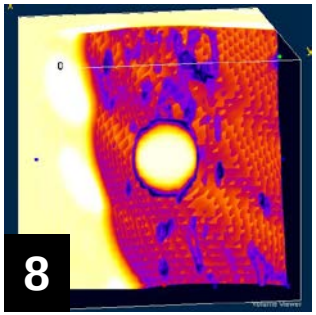


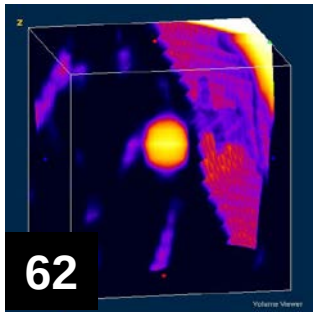


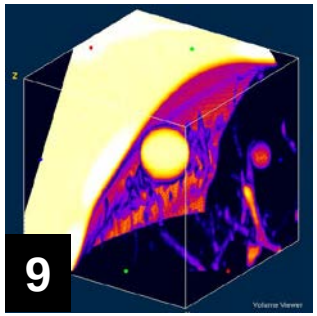


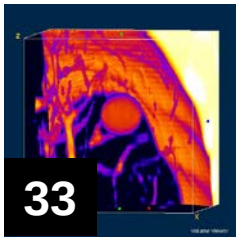
Lesions

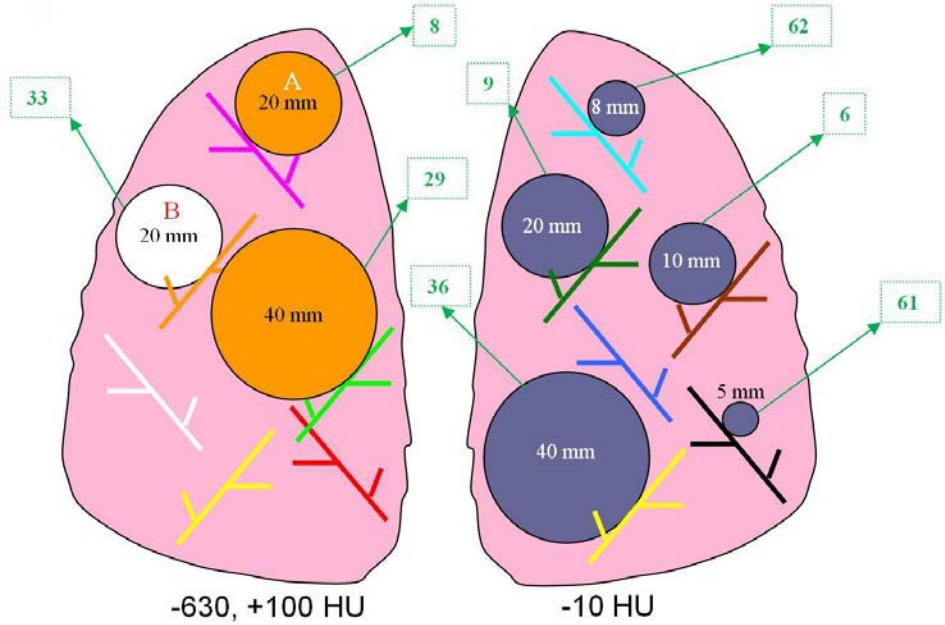
Series 9559 – FDA Layout 6

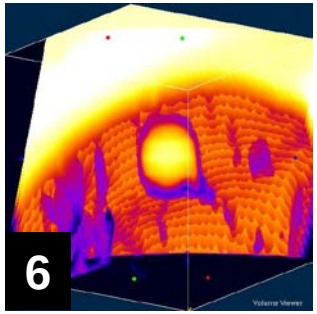


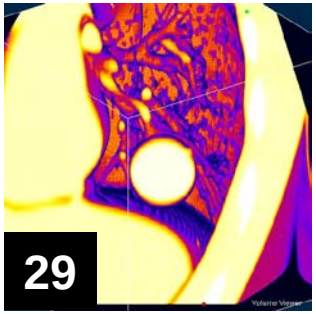


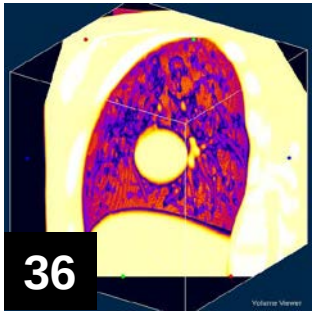


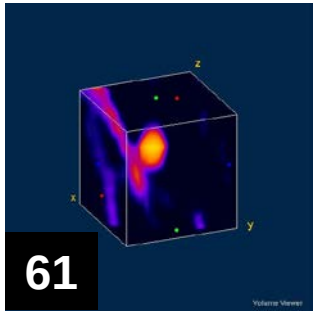






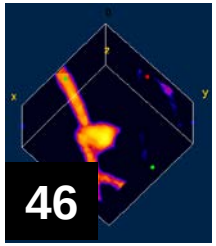


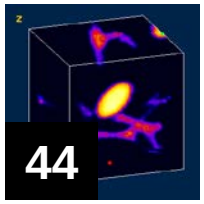


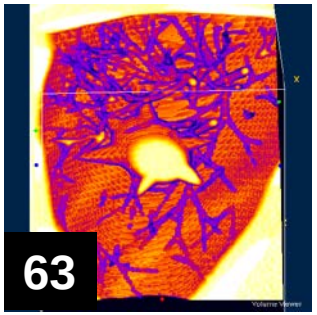


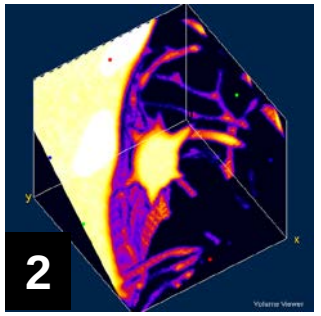
Lesions

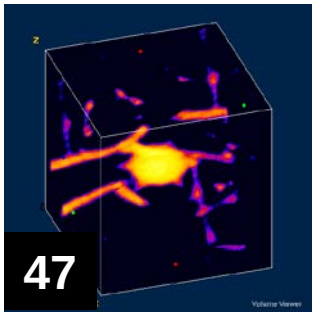
Series 39 – FDA Layout 7

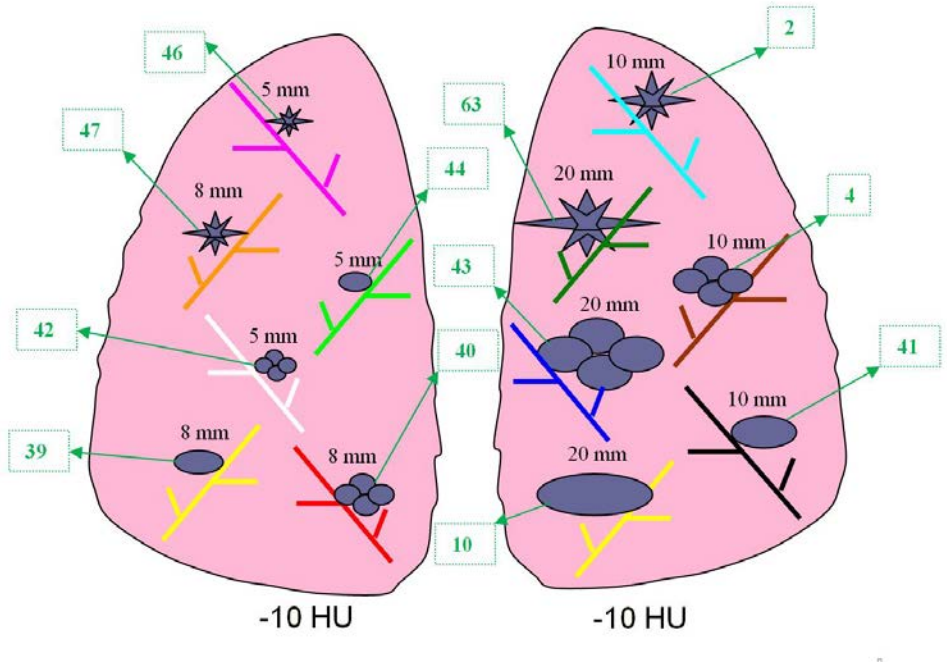


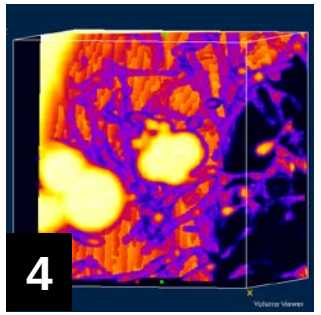


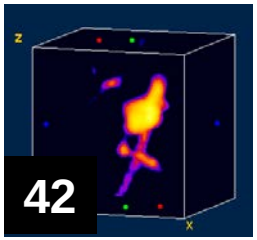


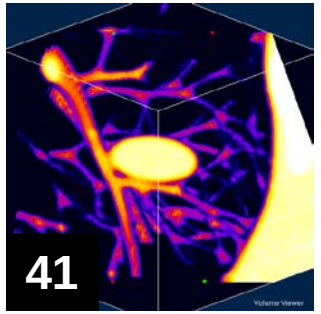


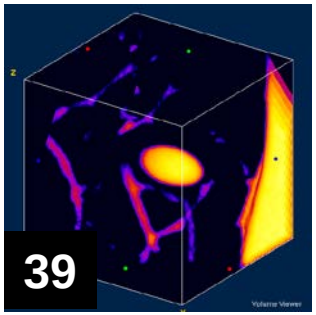


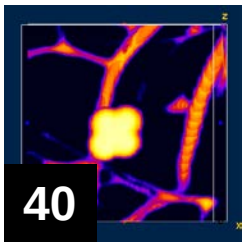


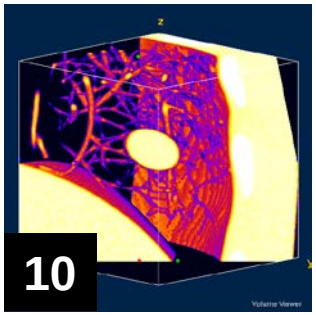


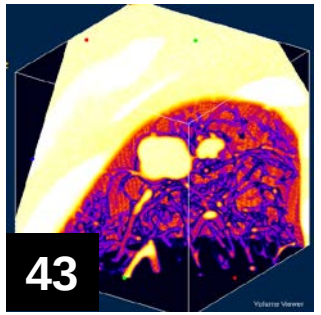















Series

Series	Layout	Slice Thickness
39	7	0.8
51	7	0.8
526	7	5
1114	4	0.8
1120	4	0.8
1126	4	0.8
7531	4	5
7537	4	5
7543	4	5
9076	6	0.8
9082	6	0.8
9088	6	0.8
9547	6	5
9553	6	5
9559	6	5

Study Description File

- Excel Spreadsheet
  - Provides study data to participants
    - Seed points
    - Bounding boxes
    - Some ground truth
  - Captures participants results for analysis
    - Lesion Volume
  - Study Description Pilot 3A 1.0 for Participants