QIBA 2017 CT Volumetry Biomarker Committee: Overview and Status Update

Marthony Robins, BS; Gregory Goldmacher, MD, PhD, MBA; Jenifer Siegelman, MD, MPH; Jayashree Kalpathy-Cramer, PhD; Qin Li, PhD; Benjamin Berman, PhD; Rudresh Jarecha, MBBS, DNB, DMRE; Maria Athelogou, PhD; Andrew Buckler, MS; Kevin O'Donnell, MASc; Nancy Obuchowski, PhD; Nicholas Petrick, PhD; Berkman Sahiner, PhD; Ehsan Samei, PhD

Quantitative Imaging Biomarkers Alliance RSNA

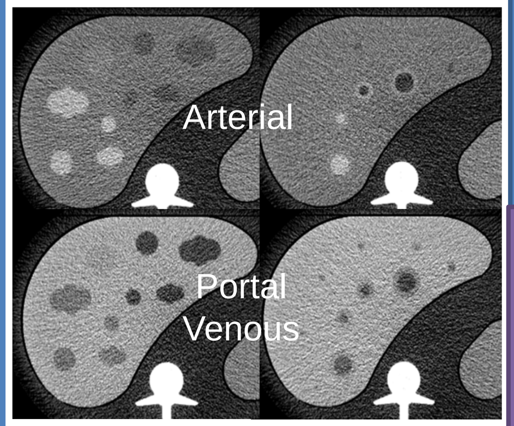
Volumetry in Dynamic Contrast-Enhanced Liver CT

Clinically accurate and precise liver lesion sizing depends on local anatomical complexity, underlying disease, patient physiology, contrast injection, and CT technical acquisition

Aims: To create a phantom emulating clinical conditions for evaluating sizing of low contrast hepatic lesions and to use it to investigate hepatic lesion sizing error as a function of:

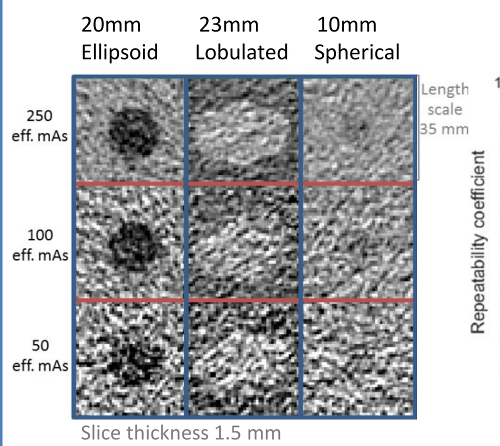
• Acquisition • Reconstruction • Lesion Size/Shape/Contrast

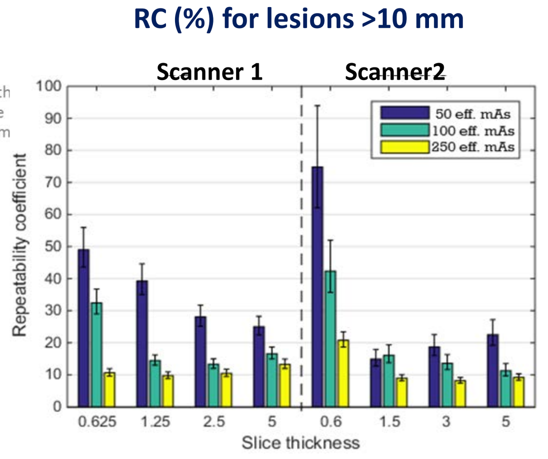
Study 1: impact of acquisition and lesion characteristics



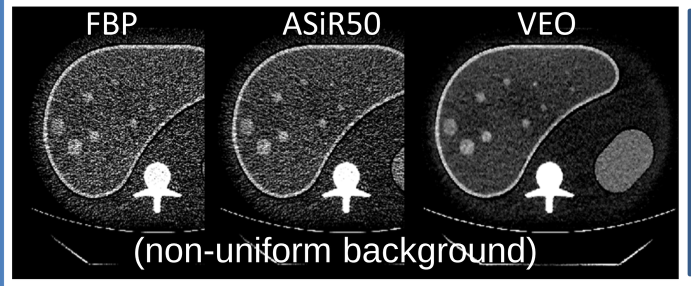
2 scanners, 3 doses, 4 slice thickness; 38 lesions; Lesion volume estimated with a segmentation and a low-bias 3D template matching algorithm

Conclusion: Poor measurability for lesions ≤10mm. Good repeatability for slice thicknesses between 1.5-5 mm and lesions >10 mm.

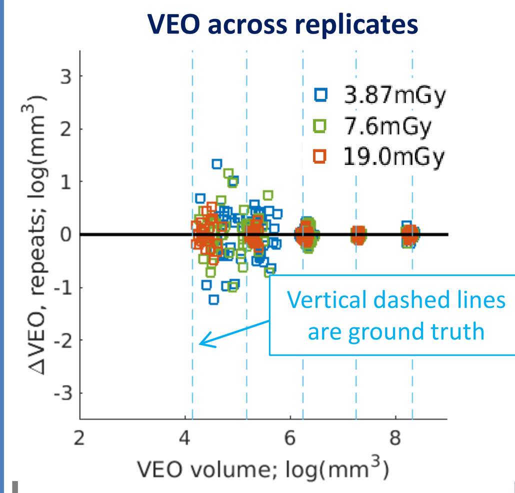


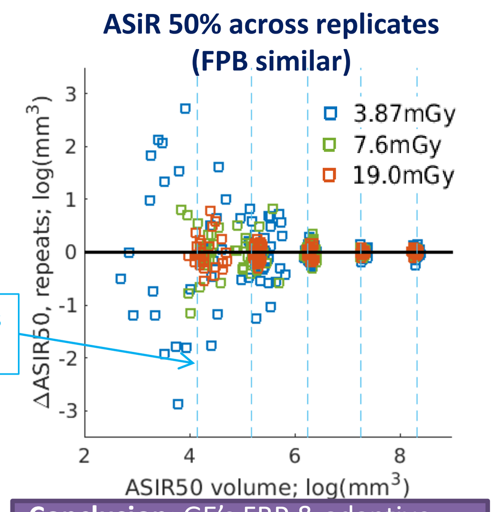


Study 2: impact of recon algorithm



5 recons: FBP, ASiR 30%,50%,70%, VEO; 3 doses, slice thickness ≥ 1.25; background (60-70HU) with focal fat (30HU); template matching estimator



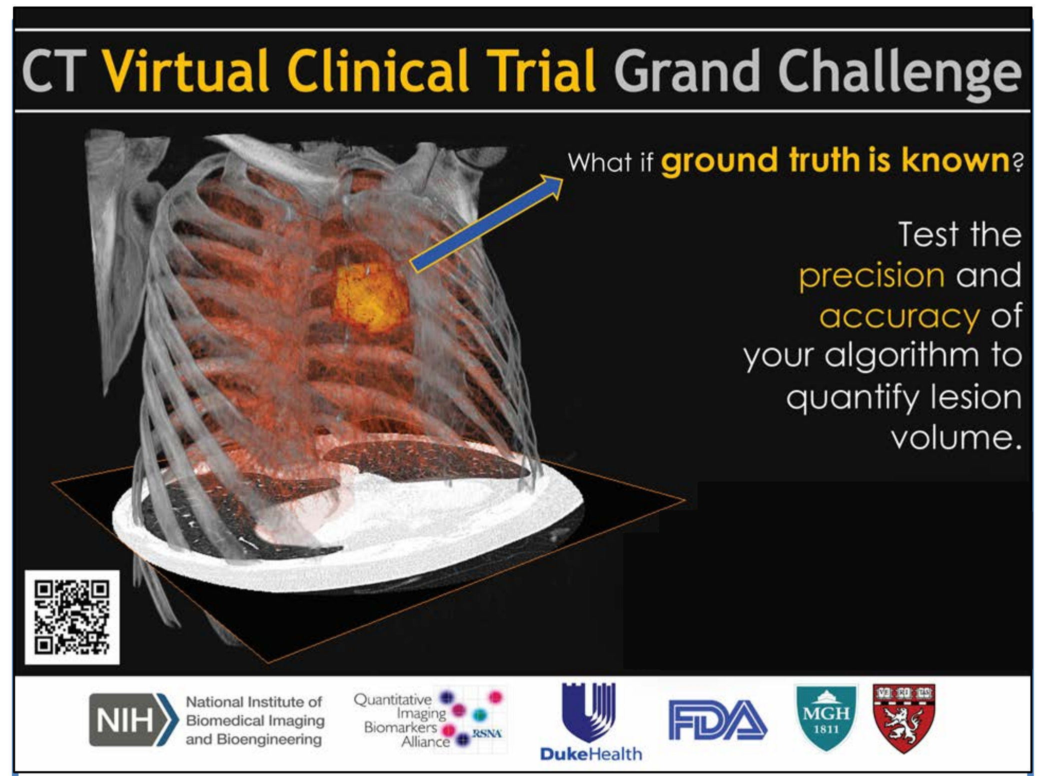


Detectability of 10mm low contrast lesion @ Slice thickness=2.5 mm, Dose=3.87mGy

AUC of FBP	0.90
AUC of ASiR 50	0.95
AUC of VEO	0.98*

Conclusion: GE's FBP & adaptive statistical IR (ASiR) behave similarly; GE's model-based IR (VEO) had lower variability but higher positive bias for small lesions; All recons perform similarly for lesions ≥10mm; IR showed improvement in detection of low-contrast small lesions

Volumetry of Pulmonary Lesions in Thoracic CT



Aims:

- To quantitatively benchmark volume estimation performance of image analysis tools
- To provide a quantitative understanding of differences between approaches.

Methods:

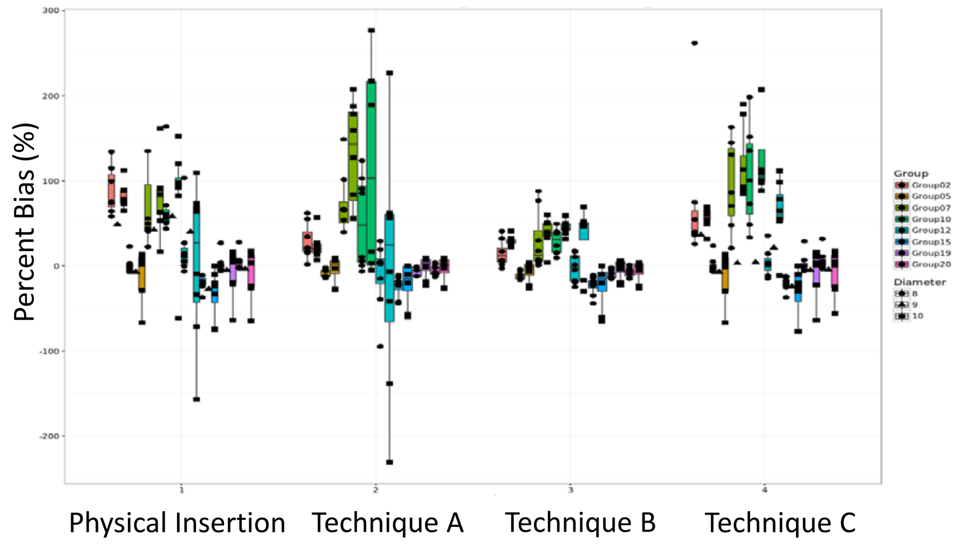
Image-based segmentation on datasets generated using

(1) an anthropomorphic phantom with synthetic and virtually inserted nodules

(2) clinical images containing real lung lesions and virtually inserted lesion models.

Nodules virtually inserted using three methods:
Technique A is a projection-domain insertion method
Techniques B and C are image-domain insertion methods.

Results: Data from 21 national and international participants were analyzed for bias and precision of estimated volumes. Aggregate data will be published and used as a gauge of quantitative variability across segmentation methods.



Conclusions:

1. Four of 21 participants meet QIBA compliance criteria
2. Equivalence of insertion method (compliant groups): No statistical difference in bias of virtual insertion methods compared to physical insertion
3. Equivalence of insertion method (non-compliant groups): No statistical difference in bias of virtual insertion methods compared to physical lesions for Techniques A and C.

Defining Standard for CT Tumor Volume Change for Advanced Disease (CTVAD) Profile

Moving from Consensus Stage to Technically Confirmed Stage

The Consensus version of the CTVAD Profile was published in late Nov 2016. Since then it has been field tested at:

- **Duke University School of Medicine**
- **Rush University Medical Center**
- **Columbia University Medical Center**

Field testing focused on confirming that the requirements and procedures in the Profile were practical/feasible when executed in a normal imaging environment. Feedback was collected from all three sites and corresponding revisions and simplifications to the Profile are being completed.

The Technically Confirmed version of the CTVAD Profile is expected to be published in the next few months.

The following stage is Claim Confirmed, which involves field testing the profile again with a focus on confirming it is possible to achieve the performance stated in the Claim by conforming to the Profile requirements and procedures.

Please see below for opportunities to get involved in the effort

Doctor/ Technologist/ Physicist:
Participate in clinical testing of the Advanced Disease Profile and get the inside track on QIBA compliant protocols.

Startup/ Vendor/ Researcher: time needed 8-40 hrs
Evaluate feasibility of profile steps from your commercial/ research perspective.

Government / CRO/ Pharma: time needed 6-8 hrs
Determine if QIBA Profiles are useful for clinical trial design.

All Interested:
Join QIBA, Meet Virtually, Create Consensus Profiles

Attend Live Sessions at RSNA

1. QIBA Challenge report (SSC03-5): Mon 11/27 11:10
2. "Industrializing Quantitative Imaging Biomarkers" (SPSI23B): Mon 11/27 4:30-6:00pm

We acknowledge the contributions of committee participants and RSNA Staff:
Joseph Koudelik, Julie Lisiecki, Fiona Miller

For supplemental materials, and to add your name for consideration as a test site, find us at:
http://qibawiki.rsna.org/index.php/Invitation_to_Participate

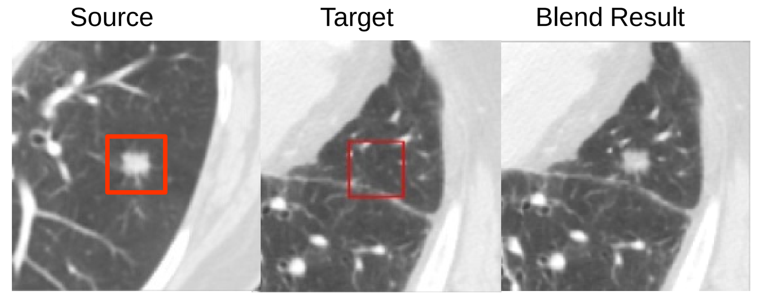
Various QIBA projects and activities have been funded in whole or in part with Federal funds from the National Institute of Biomedical Imaging and Bioengineering, National Institutes of Health, Department of Health and Human Service, under Contracts Nos. HHSN268201000050C, HHSN268201300071C, and HHSN268201500021C.

Hybrid Data for CT Volumetry Testing

Creation of a set of blended CT scans that "look and feel" like actual clinical scans of patients with tumors. Will allow testing of algorithms for measurement of tumors with known volumes.

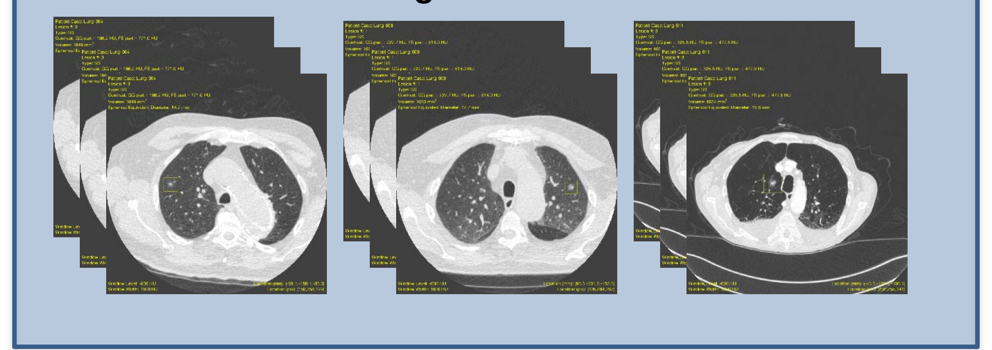
1. Use projection and image-domain lesion insertion tools to **virtually insert** lung and liver lesions of known shape, volume, and texture into clinical CT images

Lesion blending in image domain

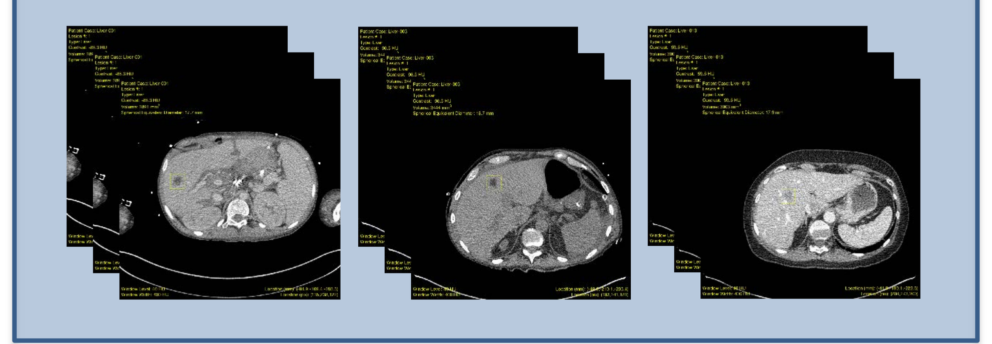


2. Develop datasets of clinical CT scans with virtually inserted lesions and disseminate lesion insertion software

Lung Datasets

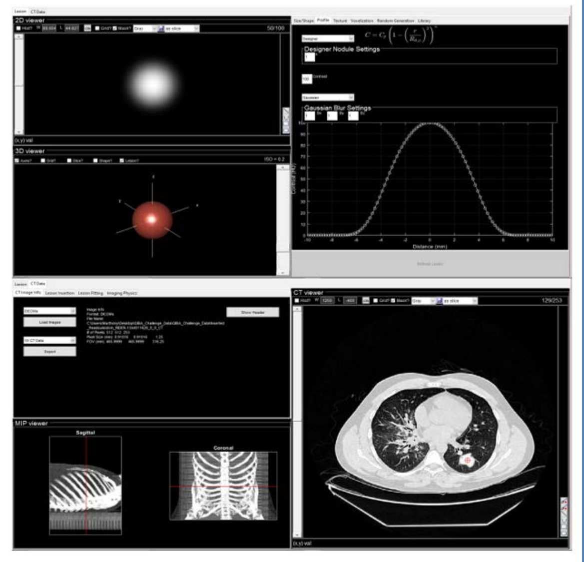


Liver Datasets



3. Disseminate lesion insertion software

Provision is made to provide a resource to generate dynamic datasets based on a priori statistical definitions for the formation of variable datasets using the Duke Lesion Tool. These reference datasets are designed to be used to conduct evaluation of quantitative performance across commercial and research software packages for lesion volumetry, texture and morphology analysis. The database will be made publically available so institutions can benchmark their volumetry, texture and morphology software using a validated reference clinical dataset without the need for additional image acquisition.

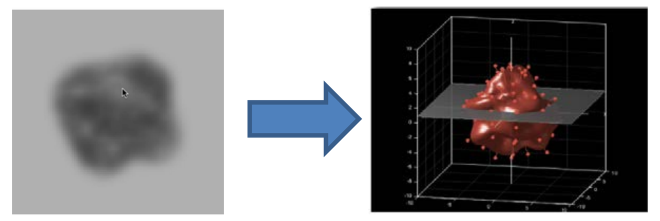


Duke Lesion Tool: used for modeling lesions and providing a platform for lesion insertion for creating a dynamic hybrid dataset.

CT Quantification Beyond Volume: Texture, Morphology

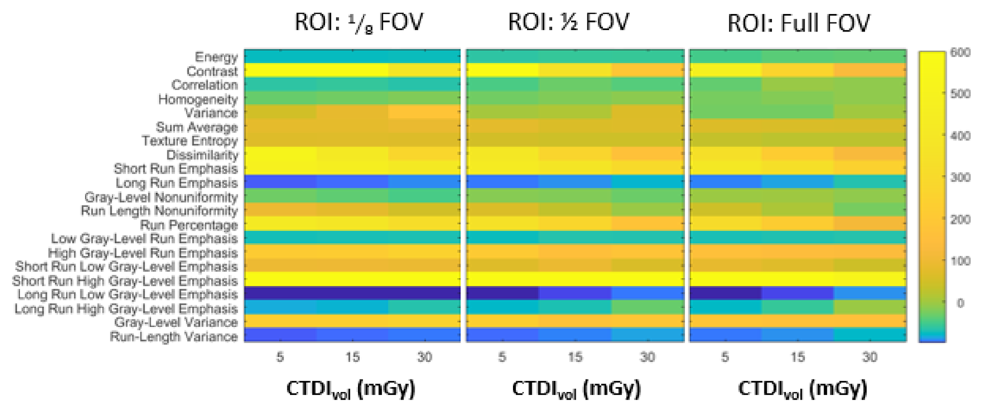
Creation of a library of anthropomorphic lesion simulations with a priori internal texture, morphology, and volumes.

1. Simulate heterogeneous structures (texture) within lesions

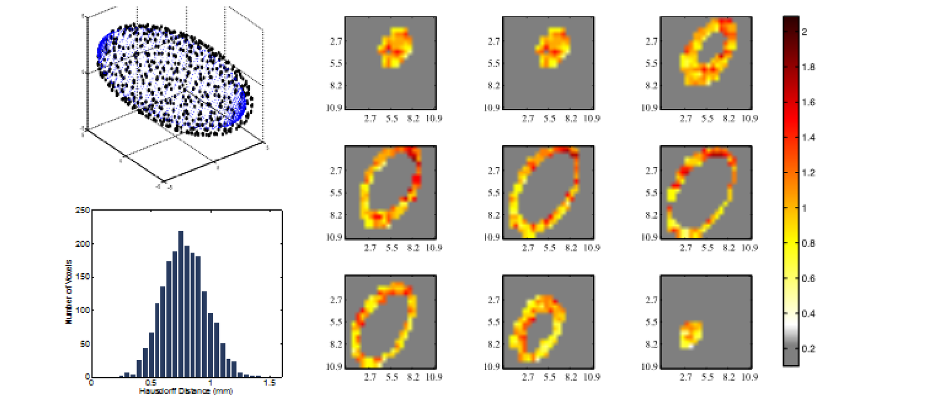


Cross-sectional view of a realistic textured lesion > 3D modeled lesion rendition.

2. Assess imaging system impact on lesion texture

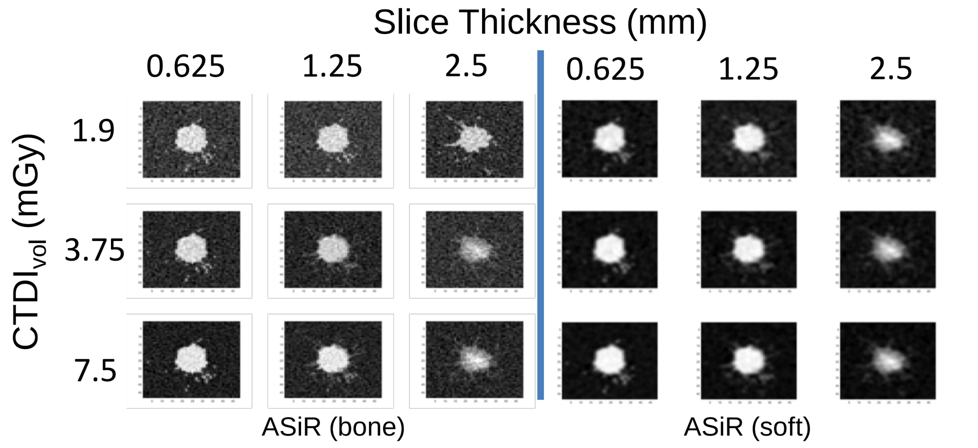


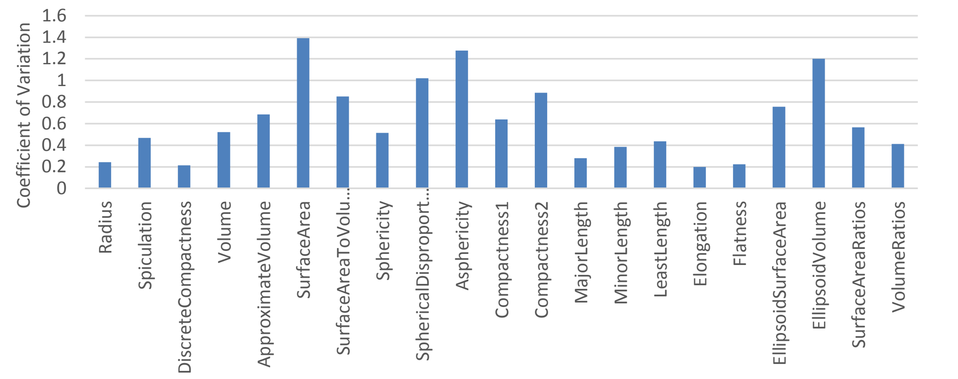
3. Develop a framework to analyze scanner-specific shape deformation



Concentric models of simulated and segmented lesions oriented at lesion center (top left), distribution of Hausdorff distances (HD) between the two lesions (bottom left), and a 3D difference map of HD for the lesions.

4. Assessing variation across imaging system & morphology





Average inter-acquisition protocol coefficient of variation for 21 morphology features measured for each lesion across 54 different imaging conditions.