QIBA CT Volumetrics - Cross-Platform Study (Group 1C)

June 17, 2009

Interclinical Comparison of CT Volumetry

Quantitative Imaging Biomarker Alliance

Dr. Charles Fenimore, NIST

Charge

1. To agree on the scanner settings and other protocol elements under which imagery is to be collected.
2. To agree on requirements of phantoms to be imaged/measured.
3. To agree on the platforms and centers to be selected for imagery collected.
4. To identify the measurements and the algorithms for use in image processing.
5. To specify the analysis of the measurements.

Goals

1. Measure the volume of nodules on CT imagery collected from several CT scanners and sites (may include multiple settings on single scanners).

1. Measure image noise and other image quality factors and determine their impact on the measurement of volume.

2. Compare the accuracy and precision of volume measurements for these phantom datasets.

3. Determine the minimum detectable level of change that can be achieved when measuring nodules in phantom datasets.

Goal 1

1. Measure nodule volume on CT imagery collected from several CT scanners/sites (including single scanners with varying settings). Determine the systems to be used and the system settings to be varied.
    (a) kVp may be specified.
    (b) mAs may be specified.
    (c) collimation fixed (+)
    (d) field of view (skin-to-skin = closest possible view)-
    (e) reconstruction filters – follow-up Wendy & radiologists
        - Find "equivalent" filters.

    Site selection – poll the team for potential image collection sites.

Goal 2

2. Measure “image noise” and determine its impact on the measurement of volume. Facilitates inter-comparison of scanner results.

    (a) Follow existing reference protocol

    (a) Characterize / specify image quality

QIBA CT 1-C Protocol

Acquisition

- The phantom
- Image datasets
- The imaging sites
- System parameters

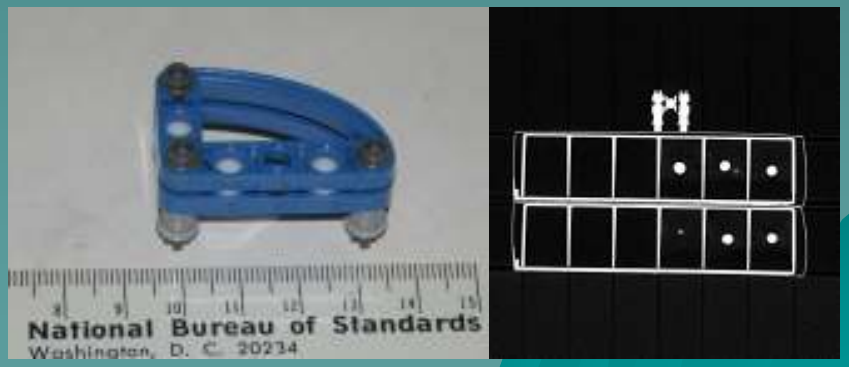
Markup

QIBA CT 1-C Acquisition Protocol

Acquisition phantom:

FDA lung phantom + NIST pocket phantom

- 10 attached nodules
  - -10 & +100HU, 10, 20 mm spheres (@ 20mm can fit in
  - 8 nodules) Left: 10 & 20 mm spheres @ - 10 & +100 HU
  - Right: 10 & 20 mm spiculated @ - 10 & +100 HU
  - 10 mm ovoid, lobulated, spiculated
  - Graded nodules coming @ 9 mm – giving 5, 8, 9, 10 mm.
- NIST pocket phantom is free standing Lego structure with teflon balls ~ 6 mm.



QIBA CT 1-C imaging sites

Potential imaging sites (focused in Washington area)

- FDA, Philips 16 row detector, agreed
- UM-MC, Sensation 64 Siemens interested
- Duke interested
- Siemens (Germany), offered multiple scanners
- Johns Hopkins – Siemens, Toshiba
- Georgetown – Toshiba

QIBA CT 1-C Markup Procedure

Adapt the Rad-Pharm process used in QIBA volume-CT 1-A and -B getting RECIST (1D), WHO (2D), & volume (3D).

- 6 readers
- 2 reads for each nodules (1 repeat)
- – can we avoid doing a full set of repeats?
- The 1A study should provide prior estimates
- of intra-rater variability. Is it possible to
- reduce the number of reads?

QIBA CT 1-C Protocol
1st branch = a standard protocol

Scan 3 – 5 times. Readers do not to read more than 1 or 2.

Use the QIBA protocol (in current development) or ACRIN 6678 to specify kVp, slice thickness, mAs, rotation time, pitch, reconstruction kernel (affects MTF). Use (water and ACR) phantoms to characterize the resolution and noise levels under this branch of the protocol.

Sample Protocol Chart for ACRIN 6678

ACRIN™
AMERICAN COLLEGE OF RADIOLOGY IMAGING NETWORK

ACRIN 6678

Quality Control Parameters for CT Scan Tumor Volumetric Measurements

DICOM Tag #	Parameter	GE			Philips		SIEMENS			TOSHIBA
		Ultra 8-slice/0.5 sec.	LS 16 16-slice/0.5 sec.	VCT(64) 64-slice/0.5 sec.	Brilliance 16 16 slice/0.5 sec. 16 X 0.75	Brilliance 64 64 slice/0.5 sec. 64 X 0.75	Sensation 16 16 X 0.75	Sensation 40 40 X 0.6 (beam collimation 20 X 0.6)	Sensation 64 64 X 0.6 (beam collimation 32 X 0.6)	Aquilion 16-slice/0.5 sec.
0018,0050	Nominal Reconstructed Slice Width[1]	1 – 1.5 mm			1 – 1.5 mm		1 – 1.5 mm			1 – 1.5 mm
0020,1041	Reconstruction Interval[1]	0 – 20% overlap			0–20% overlap		0–20% overlap			0–20% overlap
0028,0030	Voxel Size[1]	0.55 – 0.75 mm			0.55 – 0.75 mm		0.55 – 0.75 mm			0.55–0.75 mm
--	[illegible]	None			None		None			None
--	[illegible][1]	None			None		None			None
Scanner dependent	mAs (Regular–Large)[2]	X-ray Tube Current x Exposure time			Exposure		Exposure			X-ray Tube Current X Exposure time
		135-230	95-245	95-245	130-310	100-260	130-310	100-260	100-260	130-310
0018,0060	KVP[1]	120			120		120			120
0018,1210	Reconstruction Algorithm[2]	STD			B		B30			FC10

[1] Violation of values/value ranges disqualifies CT scan series.

[2] Violation of values/value ranges may not disqualify CT scan series (unless violation is excessive).

If there were a minor violation of the recommended range that would not disqualify the series, the follow-up series should use the same parameters used for the previous series. For example, a KVP of 140 is NOT recommended, but if used for the first series (and the series could not be repeated with the appropriate KVP), the same KVP of 140 should, therefore, be used for the follow-up of the same subject.

QIBA CT 1-C Profiles
2nd branch = performance specified

Specify PERFORMANCE metrics such as simple spatial resolution and noise metrics.

- kVp (affects contrast difference between materials)
- Slice thickness, recon interval (affects z-axis resolution & noise)
- Rotation time and pitch (coverage, breath hold, etc.)
- Recon kernel OR recon kernel performance - EXAMPLE:
  - Choose kernel such that you can see 6 or 7 (but no more than 7) lp/cm on ACR phantom….or
  - 10% MTF should be between 6 and 7 lp/cm
- mA level performance
  - Choose effective mAs level so that std dev is between 20 and 30 HU in a 20 cm water phantom

Goal 3

Compare the accuracy and precision of radiologists' measurements of RECIST and Volume for these phantom datasets. (image mask?)

a) RECIST vs. volume.
b) Investigate variance & bias.
c) Inter-system variation.
d) Intra-system variation.

Goal 4

4. Determine the minimum detectable level of change that can be achieved when measuring nodules in phantom datasets.

Required resources

- Use of FDA phantom, water and ACR phantoms. Also NIST pocket phantom.
- Select clinical image collection sites through QIBA-CT group: Offers from Duke, UMBMC, MSKMC, Siemens.
- Use QIBA CT 1-A mark-up procedures at Rad-Pharm, generating
  - RECIST (1D)
  - WHO (2D)
  - Segmented volume.

Future steps

- Refine Questions and Experimental Design.
- Select participating clinics. Share and discuss plans with associated medical physicists.
- Confirm availability and discuss reading with Rad-Pharm.
- Confirm availability and schedule FDA phantom.