QIBA Newsletter

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IN MY OPINION

QIBA MISSION Improve the value and practicality of quantitative imaging biomarkers by reducing variability across devices, patients and time.

QIBA CONNECTIONS

QIBA Wiki

Contact us Comments & suggestions welcome

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The Value of Phantoms for Industry-wide Standardization

BY ANDY MILKOWSKI, MS

Phantoms play an important role ensuring imaging devices meet necessary standards or performance criteria. For example, the American College of Radiology's (ACR) Mammography Accreditation Program, with its use of phantoms, is regarded as a very successful quality improvement program. [1] The RSNA's Uniform Protocols for Imaging in Clinical Trials (UPICT) group facilitates the development of widely acceptable, consistent imaging protocols and includes phantoms in quality control procedures.[2] Phantoms will increase in importance as imaging equipment increases its role in providing imaging biomarkers in clinical trials.[3]

The value of phantoms for standardization for industry is not as well known. The FDA Innovation or Stagnation: Challenge and Opportunity on the Critical Path to New Medical Products report identifies the industrialization of medical device design as a challenge to delivering innovative medical therapies. In particular, "innovators are put in the position of having to invent standards in addition to inventing new products." [4] This is true for industrial vendors with commercially available ultrasound products that would like to see shear wave speed (SWS) used as an imaging biomarker for staging liver fibrosis.

The QIBA Ultrasound SWS Technical Committee took the challenge of establishing a biomarker standard for liver fibrosis. An early committee goal was to conduct a pilot study with a simple, new phantom constructed of commercially used material. The study would allow a multidisciplinary group to work through the complexity of multicenter data collection and analysis. Figure 1 illustrates statistically significant differences in SWS measurements among six different industrial and research systems. Figure 2 is a subset of the same data illustrating three different industrial and research systems as a function of measurement depth in the phantom, demonstrating a difference in depth dependency between systems. The differences in bias and linearity variation have not been explained and the phantom is essential in showing the differences. Academic and industry scientists are performing analyses to explain and eliminate these differences.

This initial QIBA ultrasound effort has already affected industry. For example, resources have been re-allocated to determine sources of bias and variation as opportunities for improvement. Industry has engaged research universities to eliminate differences between algorithms or implementations. Internal acceptance criteria derived from the original phantoms will tighten—especially as QIBA efforts improve phantoms. Additionally, internal procedures will test for potential misuse to ensure robust results. While the current QIBA phantom design is focused on liver fibrosis, new transducers enabled with SWS will be automatically tested against all phantoms and acceptance criteria. For industry, the creation of phantoms and standards create a new baseline going forward.

It is my opinion that differences between ultrasound systems will slowly disappear. Consequently, future consumers of ultrasound equipment will not have to worry about the repeatability or reproducibility of SWS—something not true of other ultrasound modes like Doppler. QIBA has provided a process where leaders can come together and establish an ultrasound biomarker, such as assessing liver tissue fibrosis with SWS, to the benefit of both industry and patients.

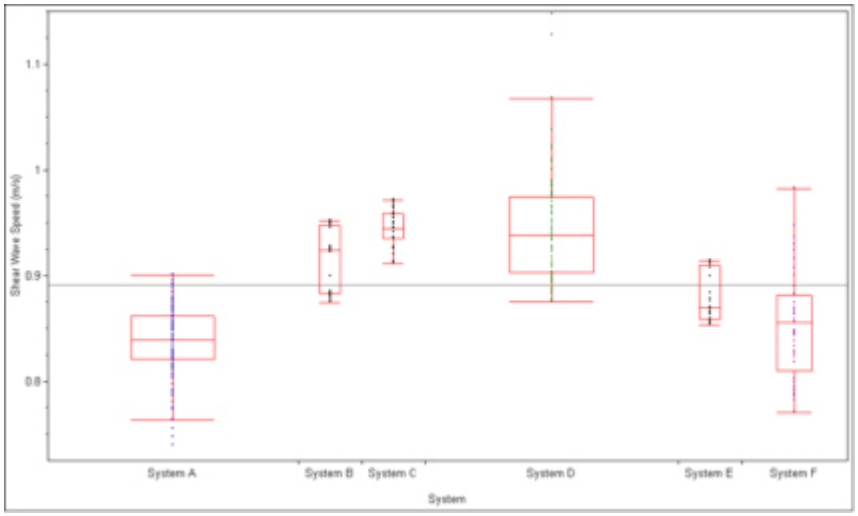

Figure 1. *A quantile plot showing statistically significant differences among six different commercial and research ultrasound systems measuring shear wave speed in pilot QIBA phantoms.*

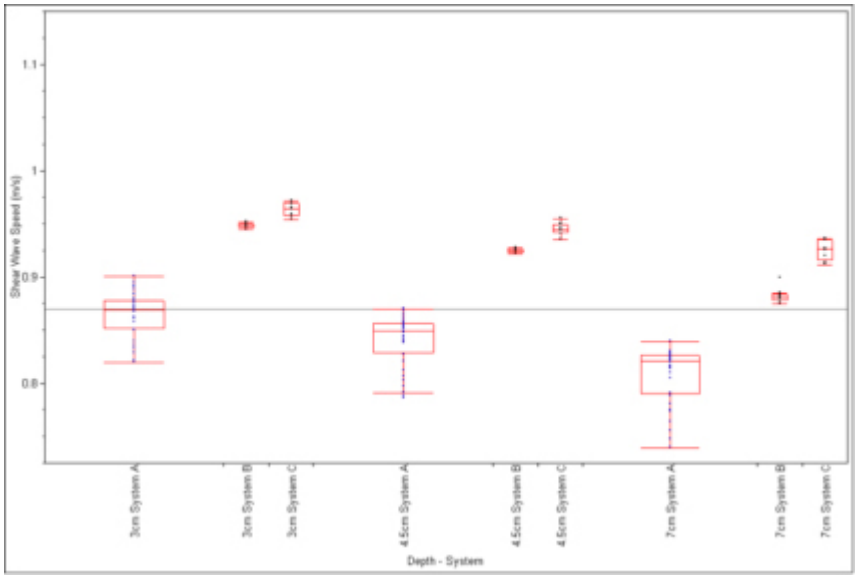

Figure 2. *A. quantile plot showing statistically signficant differences among three different ultrasound systems (A,B & C) measuring shear wave speed over three depths (3, 4.5 & 7cm) on pilot QIBA phantoms.*

REFERENCES:

[1] Destouet et al. ACR Mammography Accreditation Program.
J Am Coll Radiol 2005;2:585-594.

[2] QIBA Wiki [online reference]

[3] Erickson B, Buckner J. Imaging in Clinical Trials. Cancer Inform. 2007; 4: 13-18 [online]

[4] FDA Challenges and Opportunities Report,March 2004. Innovation or Stagnation: Challenge and Opportunity on the Critical Path to New Medical Products. [online reference]

Each issue of QIBA Newsletter features a link to a dynamic search in PubMed, the National Library of Medicine's interface to its MEDLINE database. Link to articles on: "The Value of Phantoms for Industry-wide Standardization" here.

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Reducing Radiation Dose in Quantitative CT of Obstructive Lung Disease BY SEAN B. FAIN, PHD

Chronic obstructive pulmonary disease (COPD) and asthma are the most common chronic lung diseases, affecting an estimated 38 million people in the U.S. Noninvasive imaging of lung disease using X-ray CT has long been the clinical standard for diagnosing lung diseases and their regional expression. Clinical lung CT uses a standard scale of Hounsfield units (HU) making it feasible to set thresholds to identify low density lung parenchyma. Typically alveolar tissue loss in emphysema is best seen during full inspiration with regional patterns reflecting COPD subtypes. Similarly, small airway disease in asthma leads to low density as a result of hyperinflation and air trapping. In both diseases, increased central airway thickening due to bronchiectasis and remodeling are also important indicators of disease subtypes. [1]

Several quantitative CT (qCT) measures have been introduced in the radiology and pulmonary medicine literature to numerically characterize phenotypic expression and severity of both COPD and asthma. The fractional extent of air in the lung volume below a HU threshold, typically -950 or -910 HU, has been shown to correlate with degree of emphysema on histology [2]. More recently, measures of airway wall thickness have been shown to correlate with histology from bronchoscopic biopsy in asthma [3]. However, several confounding factors can influence both HU and airway dimension measurements including varying lung inflation volume, image noise from poor photon statistics, and differing reconstruction and scatter correction methods used by CT vendors. The QIBA COPD-Asthma Technical Committee is charged with understanding the sources of bias and variance in these measurements and developing methods that are comparable across imaging systems and system configurations.

These tasks are complicated by increased public sensitivity to X-ray radiation dose from serial CT scans for research subjects with early lung disease. The challenge of achieving high spatial resolution while maintaining accurate measures of quantitative density argues for a new approach, in part because low-density HU values in the lung parenchyma are sensitive to noise, scatter correction, and helical artifact. Typically, qCT protocols have limited these variations by carefully controlling selection of acquisition protocol and reconstruction parameters, slowing incorporation of dose-saving algorithms such as automatic exposure control (AEC) and iterative image reconstruction (IR).

The purpose of a recently funded QIBA contract tested whether AEC and IR can reduce radiation dose while maintaining quantitative measures. Our approach uses the known reference standards in the COPDGene® phantom [4] developed in collaboration with the National Institute for Standards and Technology (NIST) [Fig. 1] on a 64-slice dual-energy CT scanner (GE 750 HD). This enables comparison to known values under controlled conditions. Among the key results are the consistency of HU values with an approximately 25% reduction in dose using AEC [Table 1], and the improved quantitative accuracy of wall thickness measures with adaptive statistical IR (ASIR). In the latter, ASIR was performed with a high frequency reconstruction kernel and increased spatial sampling—achieved by a reduced display field of view (DFOV). A combination of AEC with IR reconstruction using higher frequency kernels and reduced DFOV shows promise. We are currently testing this revised reconstruction protocol with raw projection data derived from human subjects and across multiple vendor platforms. The QIBA COPD/Asthma Technical Committee is working towards a protocol to accurately measure CT number for lung density and airway morphology with a single low-dose inspiratory helical CT scan.

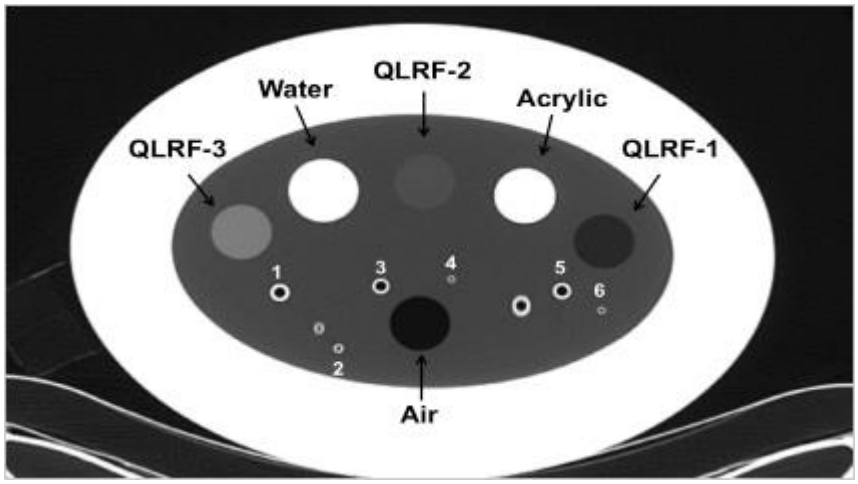

Figure 1. *COPDGene®2 test object with cylindrical foam density standards and acrylic tubes mimicking airway wall and lumen. Densities are indicted below in Table 1.*

Table 1: Summary table of density measures for azimuthal AEC (Smart mA) at equivalent noise index referenced to a 200 mA (6.55 mGy CTDIvol) manual tube current, 0.984 pitch, 40 mm collimation, and 0.5 s per rotation.

Density Reference Standard	Measured Density (HU ± SD)	
	Manual mA	Automatic Exposure Control (AEC)
QLRF-3 (20 lb. NIST Foam); -708	-706.54±11.97	-706.69±12
Water; 0	3.33±14.10	3.24±13.49
QLRF-2 (12 lb. NIST Foam); -832	-831.27±12.82	-832.35±11.33
Acrylic; 120	119.63±13.91	123.64±13.54
QLRF-1 (4 lb. NIST Foam); -942	-940.68±10.9	-941.32±11.26
Air; -1000	-1002.55±10.52	-1000.61±10.18

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[1] Thurlbeck WM, Muller NL. Emphysema: Definition, Imaging, and Quantification. *American Journal of Roentgenology*. 1994;163(5):1017-25. Epub 1994/11/01. doi: 10.2214/ajr.163.5.7976869. PubMed PMID: 7976869.

[2] Hayhurst MD, MacNee W, Flenley DC, Wright D, McLean A, Lamb D, et al. Diagnosis of Pulmonary Emphysema by Computerised Tomography. Lancet. 1984;2(8398):320-2. Epub 1984/08/11. PubMed PMID: 6146866.

[3] Aysola RS, Hoffman EA, Gierada D, Wenzel S, Cook-Granroth J, Tarsi J, et al. Airway Remodeling Measured by Multidetector CT is Increased in Severe Asthma and Correlates with Pathology. Chest. 2008;134(6):1183-91. Epub 2008/07/22. doi: 10.1378/chest.07-2779. PubMed PMID: 18641116; PubMed Central PMCID: PMC2859729.

[4] FDA Challenges and Opportunities Report,March 2004. Innovation or Stagnation: Challenge and Opportunity on the Critical Path to New Medical Products. [online reference]

[5] Sieren JP, Newell JD, Judy PF, Lynch DA, Chan KS, Guo J, et al. Reference Standard and Statistical Model for Intersite and Temporal Comparisons of CT Attenuation in a Multicenter Quantitative Lung Study. Medical Physics. 2012;39(9):5757-67. Epub 2012/09/11. doi: 10.1118/1.4747342. PubMed PMID: 22957640; PubMed Central PMCID: PMC3448623.

Sean B. Fain, PhD, is an associate professor in the Medical Physics Department at the University of Wisconsin-Madison and a member of the QIBA COPD-Asthma Technical Committee. As director of the Image Analysis Core Facility, he leads MR imaging and CT studies for quantitative assessment of asthma severity and progression.

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FOCUS ON

Quantitative Imaging Meetings & Activities 2013

QIBA Sixth Annual Working Meeting

More than 90 people attended the sixth annual QIBA meeting held in May in Leesburg, Va. The meeting provided opportunities to collaborate with federal stakeholders, for information sharing and status updates on Technical Committee projects, and time for strategic planning.

RSNA Awarded Second NIBIB Contract to Support QIBA Activities

The RSNA was recently awarded a $1.25 million, one-year contract from the National Institute of Biomedical Imaging and Bioengineering (NIBIB) to support research groundwork by the Quantitative Imaging Biomarkers Alliance (QIBA). Part of the funding has been earmarked for 13 projects that will be conducted to characterize the performance and sources of variability associated with quantitative imaging. Planning and development of digital reference objects (DROs), physical phantoms and Profile field testing are underway and will continue in the months ahead. The QIBA Technical Committees will hold working meetings during RSNA 2013.

QIBA KIOSK

Located at the front of the Lakeside Learning Center, Hall D, the QIBA kiosk provides an overview of the QIBA Technical Committees and the Profile process, and provides an area for QIBA members to meet and exchange ideas.

Individual Technical Committee posters will be on display and QIBA Poster Meet-the-Expert (MTE) sessions will be held over the noon hour, Sunday, December 1 through Thursday, December 5, providing time to interact with meeting attendees and discuss current QIBA projects.

QIBA ACTIVITIES

The ongoing work of the Technical Committees is posted on the QIBA wiki page: http://qibawiki.rsna.org. New participants in QIBA Technical Committees are always welcome; please contact QIBA@rsna.org for more information.

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QIBA AND QI/ IMAGING BIOMARKERS IN THE LITERATURE

Articles are divided into two categories:

1. *Articles that are generated by Quantitative Imaging Biomarkers Alliance (QIBA) research teams*
2. *Articles that reference QIBA*

These are articles published by QIBA members, or ones that relate to a research project undertaken by QIBA members that may have received special recognition. New submissions are welcome and may be directed to QIBA@rsna.org.

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