QIBA Perfusion, Diffusion, & Flow MRI Technical Committee: Current Status

Edward F. Jackson1, Daniel P. Barborkia, Mark A. Rosen2, Edward Ashton3, Alexander R. Guimaraes3, Michael Boss4, Eunhiee Kim5, Richard Price6, Ryan J. Bosca1, David E. Purdy5,

1The University of Texas MD Anderson Cancer Center, 2Duke University, 3University of Massachusetts Medical School, 4Harvard - National Institute of Standards and Technology, 5Toumson, 6Princeton University, 7Siemens Medical Solutions, 8GE Global Research Center, 9The University of Chicago, 10Philips Healthcare, 11F Hoffman - La Roche, Ltd. [FM1 / GZ co-author]

Brief Summary of Activities in 2012

The RSNA QIBA Dynamic Contrast Enhanced Magnetic Resonance Imaging (DCE-MRI) Technical Committee expanded its activities in 2012. A new Executive Committee was formed, including the addition of new members to support the expansion of the committee's focus.

During 2012, the PDF-MRI Technical Committee focused primarily upon: 1) completion of the Phase I DCE- MRI projects (Digital Reference Object, QIBA DCE-MRI Phantom, Phantom Data Analysis Software); 2) release of the DCE-MRI Profile (http://rsna.org/QIBA_.aspx), adoption of a test-retest clinical trial (Phase II project); 4) initiation of a new Diffused Weighted MRI Profile, and 5) development of additional groundwork projects needed to expand the initial DCE-MRI Profile to address 3 T1 field strength and parallel imaging challenges. Details of these initiatives can be found using the PDF-MRI Technical Committee link at http://qibawiki.rsna.org/.

DCE-MRI Profile v1.0

Version 1.0 of the DCE-MRI Profile was released in public comments addressed phase following review and approval by the RSNA Steering Committee. The profile is posted at http://rsna.org/QIBA_.aspx, and addresses the following clinical projects: Quantitative imaging biomarkers reflecting microvascular properties (specifically transfer constant (Ktrans) and blood normalized initial area under the gadolinium concentration curve (AUC(0,inf))), and tourism patterns extracted from DCE-MRI data obtained at 1.5T using low molecular weight, extracellular gadolinium-based contrast agents with a 20% within-subject coefficient of variation for solid tumors at least 2 cm in diameter.

DCE-MRI Project Summaries

The original focus of our technical committee was to develop the now published Profile, provide tools (phantoms, test guidance, analysis tools) to allow users to implement and comply with the Profile recommendations, and to "field test" the Profile in a clinical trial setting. The deliverables associated with these goals are summarized in the remaining section(s) of this summary document: the initial project goals, points, and principal investigators.

Phase I Funded Project: Machine Qualification and QC

Two projects supported by Phase I QIBA funding were focused upon the development of a commercialized RSNA-QIBA DCE-MRI Phantom and associated acquisition protocol and analysis software. The DCE-MRI Phantom was based on a modified version of the Phantom Laboratory's DCE-MRI phantom poster at RSNA 2010. The phantom (Fig. 1) consists of a 36-cm diameter x 15-cm right cylindrical polystyrene shell filled with a 30 mM NaCl solution and containing two 15-cm diameter spheres filled with a 30 mM NiCl2 solution.

A total of 8 copies of the phantom, without filling solutions, were manufactured by The Phantom Laboratory (Salem, NY). The phantoms were filled with NECl solutions prepared at MD Anderson Cancer Center and the phantom relaxation rate for each copy was measured and recorded. The DCE-MRI scan was acquired using a Polarized Excitation technique (PET) to remove any water signal from the phantom. The PET scan was then converted into DICOM images using freely available utilities.

To provide a standardized data analysis environment, a second phantom-related contract was issued to ViVitroLabs, Inc. to create a Windows-based program that can generate a new Windows-based phantom consisting of 1) a body coil receive fast spoiled gradient echo scan, 2) a phased array receive matched (monochrome) 3D, 3) a variable flip angle (VFA) fast spoiled gradient echo scan, 4) a DCE-MRI scan. Optional variable TI inversion recovery (T1 saturation recovery) protocols were also developed. Specific acquisition parameters were established for scanners from GE, Philips, and one pass-on source of T1 and T2, with and without T2-weighting.

Phase II Funded Project: DCE-MRI Software Evaluation

Rationale for Dynamic Reference Object Projects

As a first step in software package evaluation, a formal evaluation of a variety of academic, open source and commercial software packages used to create T1 maps from variable flip angle MRI images began in February 2012. Software outputs from processing 1) mapping DROs (QIBA v1.1 mapping and QIBA v2.1 mapping) have been obtained from 12 software packages and several vendor-specific parameter packages. These DROs stimulated the extraction of 9, or R, and equilibration parameters from the 9, or R, and equilibration parameter packages in a low-15, 9, or R, and equilibration parameter package and slow exchange parameter packages. These images have been made available for both T1 and T2 maps and have been used to validate the software packages.

Testing of T1 mapping software packages

As a first step in software package evaluation, a formal evaluation of a variety of academic, open source and commercial software packages used to create T1 maps from variable flip angle MRI images began in February 2012. Software outputs from processing 1) mapping DROs (QIBA v1.1 mapping and QIBA v2.1 mapping) have been obtained from 12 software packages and several vendor-specific parameter packages. These DROs stimulated the extraction of 9, or R, and equilibration parameters from the 9, or R, and equilibration parameter packages in a low-15, 9, or R, and equilibration parameter package and slow exchange parameter packages. These images have been made available for both T1 and T2 maps and have been used to validate the software packages.

Figure 1: DCE-MRI Phantom

Figure 2: A) Phantom data analysis software interface, B) measured vs. known R1 measures from VIF

Figure 3: Variation in bias of R1 parameter derivation for two submitted software packages. Results from identical noise-free input data, each line represents a separate simulation. Both software packages demonstrated less than 2% bias (expressed as deviation of calculated R1 from nominal R1, as a percentage of nominal R1) for the vast majority of parameters tested (note that for both software packages, R1 bias decreases with increasing SNR and constant input data).

Figure 4: Example entry in comparative performance report, showing relative performance of software packages in two tasks. Bias expressed as mean bias over 20 test cases. Bias shown in dark grey text is for task a) in dark grey text and parallel imaging performance on the right. The example entry was extracted from a larger number of sample software packages to provide feedback for developers of Software A. For reference, superimposed in faint text are relative performance of Software B relative to Software A for this example.