Multivendor, Multisite DCE-MRI Phantom Validation Study

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INTRODUCTION

The QIBA initiative seeks to advance quantitative imaging (QI) and the use of imaging biomarkers in clinical trials and clinical practice by: 1) collaborating to identify needs and solutions to develop and test consistent, reliable, validated, and achievable QI results across imaging methods [1]. The QIBA DCE-MRI technical committee has initially focused on item 1) above by initiating a multivendor, multicenter, test-retest phantom assessment building upon the previous efforts of the Imaging Response Assessment Teams (IRAT) DCE-MRI phantom studies [2]. Initial results from this initiative are summarized in this exhibit.

METHODS & MATERIALS

Phantom: Two matched 20-cm internal diameter spherical phantoms were purchased from The Phantom Laboratory (funded by National Cancer Institute contracts N01-DC-12400 and 27XS112). For this particular application, the key component of the phantom design was the inclusion of eight 3-cm diameter spheres filled with CuSO4-doped H2O to yield T1 relaxation times ranging from ~300–960 ms. The remainder of the phantom was identical to the ADNI Magphan phantom [3, 4], including a 6-cm diameter central sphere filled with pure water. A 17-cm by 11-cm “cuboid”, also filled with 30 mM NaCl water, was used to appropriately load the radiofrequency coil. This phantom design differed from that used by the IRAT MR Committee [2] in the use of 30 mM NaCl water in the flood section of the phantom and cuboid and no D2O was used in the 6 contrast spheres. Otherwise, the phantom components and positioning were identical for the IRAT and QIBA DCE-MRI initiatives.

Scanners and Sites: The phantom studies are initially being performed at five sites (M.D. Anderson Cancer Center, University of Chicago, University of Pennsylvania, Duke University Medical Center, and University of California Davis) utilizing 1.5T scanners from GE, Philips, and Siemens. (Figure 1)

Scan Protocol: Initial phantom characterization (inversion recovery T1 measurements, phantom cross-comparison scans, initial QIBA protocol scans) were performed at M.D. Anderson Cancer Center. At each subsequent site, the phantom was scanned twice, with one week between the scans. During each scanning session, the phantom was rotated 90° four times and rescanned at each position. This provides data necessary for a “coffee break” test-retest analysis as well as a one-week interval test-retest analysis. The phantom and cuboid were positioned in a phased-array receive coil as shown in Figure 2. The phantom position at each of the five rotations was identified as A, B, C, D, and A’. Table 1 summarizes the data obtained at each rotation. All data were acquired using a 3D fast spoiled gradient echo sequence with all acquisition parameters matched, vendor-to-vendor, as closely as possible. The same protocol was used to obtain data one week later. The inversion recovery (IR) based T1 measurements were only performed once and the results used as “ground truth” for the subsequent variable flip angle (VFA) T1 measurements.

PRELIMINARY RESULTS

Current Status: Thus far, complete data sets have been obtained from two sites (two MR vendors) and partial data obtained from one site (third vendor). DCE Mean Signal Intensity vs. IR: Figure 3 shows the uncorrected and corrected DCE signal intensity vs. Inversion recovery R1 measurements. Figure 4 shows the VFA-derived R1 measurements vs. the inversion recovery R1 measurements for data obtained at a single site, but on two subsequent weeks. The left figure shows the linear regression while the right figure shows the Bland-Altman plot.

CONCLUSIONS

Results obtained thus far demonstrate, with appropriate choices of pulse sequences and acquisition parameters across vendors, 1) signal intensity measurements, when corrected for receiver coil sensitivity variations, correlate well with R1, 2) VFA R1 measures correlate well with IR R1 measures, 3) these findings are consistent over short times (“coffee break”) and longer times (1 week), 4) such phantom-based assessment of scanner performance is critical to validate imaging biomarker data from multivendor, multicenter applications.

REFERENCES


Figure 2: Phantom and cuboid positioned in a 4-channel torso phased-array coil. The phantom is scanned five times, before and following each of four 90°-rotations.