Robustness of a hybrid magnitude/complex method for liver fat quantification in the presence of a hepatobiliary contrast agent

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Target Audience

Clinical radiologists; abdominal MR radiologists

Purpose

Quantification of hepatic lipid content is an important emerging technique which holds promise for staging the disease as well as assessing response to treatment. The contrast agent gadoxetate (Eovist/Primovist, Bayer) is being increasingly used for structural and functional assessment of the liver, and adding lipid quantification sequences to these examinations may provide important, complementary metabolic information. In order to provide efficient clinical workflow, it would be advantageous to be able to perform lipid quantification after contrast administration, since there is typically a 20-minute waiting period between contrast administration and the acquisition of the final post-contrast sequences. The purpose of this study was to assess the reproducibility of hepatic fat fraction measurements obtained using a hybrid magnitude/complex MRI method in the presence and absence of gadoxetate.

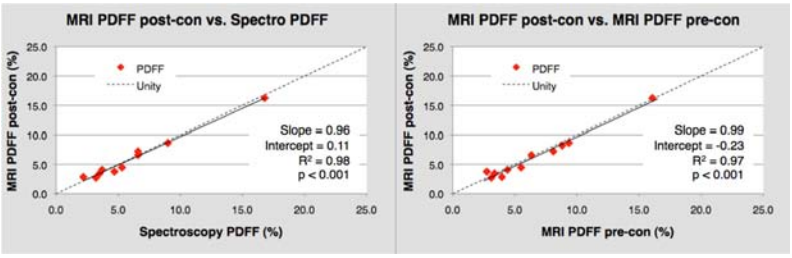

Figure 1: Correlation between proton density fat fraction (PDFF) as measured using the MRI technique post-contrast and both the precontrast single voxel spectroscopy and pre-contrast MRI measurement.

Methods

The local institutional review board approved this prospective study. Abdominal MRI examinations from 10 consecutive subjects were performed on a 3 T MR system (Skyra, Siemens Healthcare) prior to and at 15-20 minutes post-injection of 10 mL of gadoxetate intravenously. The imaging method was a 3D technique with: FA 4°, TR 8.9 ms, first TE 1.23 ms, 6 echoes collected with ΔTE 1.23 ms. Single voxel spectroscopy (high-speed T_2-corrected multiecho – HISTO) was performed prior to contrast administration using a 20x20x20 mm^3 voxel placed in the liver, avoiding large vessels, and five echoes were collected (TE 12-72 ms) to perform T_2 correction. A cubic ROI was chosen on the image data sets to co-localize with the spectroscopy (SVS) voxel.

The details of the image reconstruction method are reported in a separate abstract. Briefly, the image reconstruction includes T_2* correction, multi-fat-peak modeling, and provides separate solutions for the R_2* values of fat and water. It uses a two-point Dixon method with flexible echo times to obtain initial guesses for the fat and water signal fractions, and a seed value of 30 s^{-1} for each of the R_2* values. Using these initial guess values, Levenberg-Marquardt non-linear fitting is performed in two additional steps to update the fat fraction, water fraction, and R_2* values until a stable solution is reached.

For statistical analysis, linear regression was performed to determine the relationship between the proton density fat fraction (PDFF) measurements obtained using the post-contrast imaging and spectroscopic techniques as well as the post-contrast and pre-contrast imaging methods. The Wilcoxon signed-rank test was used to determine whether there were significant differences between the measured values, with a p-value of < 0.05 considered significant.

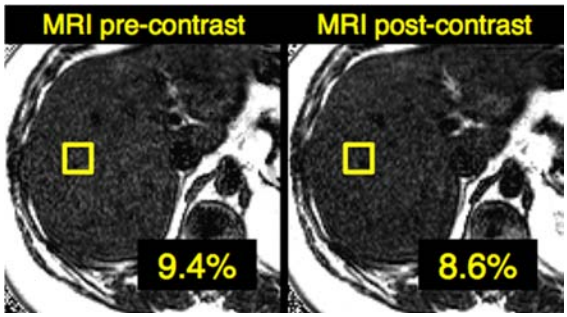

Figure 2: Example of excellent agreement between PDFF measured using the MRI method following contrast administration (8.6%), and pre-contrast by single voxel spectroscopy (9.0%) and the MRI method (9.4%).

Results

Results of the regression analysis are shown in Figure 1. There was excellent correlation between the PDFF values measured post-contrast compared with both SVS (R^2 = 0.98, slope = 0.96, intercept = 0.11, $p < 0.001$) and the pre-contrast MRI method (R^2 = 0.97, slope = 0.99, intercept = -0.23, $p < 0.001$). The slope was not significantly different from 1 and the intercept not significantly different from 0 for either comparison. The Wilcoxon signed-rank test showed no statistically significant difference between the post-contrast measurement and either pre-contrast measurement ($p > 0.2$ for both comparisons).

Representative fat fraction images from one patient are shown in Figure 2, with PDFF of 8.6% measured after contrast administration by the MRI method, and precontrast measurements of 9.0% by spectroscopy and 9.4% by the MRI method.

Discussion

The addition of lipid quantification to contrast-enhanced MR abdominal examinations would likely provide an efficient evaluation of hepatic metabolism, particularly if this could be accurately obtained following IV contrast administration without adding scan time to each individual patient. Our results demonstrate a very strong agreement between the PDFF measured after contrast administration using the MRI method and both pre-contrast measurements.

Conclusion

The PDFF measured after contrast administration agreed well with both pre-contrast PDFF measurements. Fat quantification can be performed accurately using this MRI-based method after administration of gadoxetate during the period spent waiting for the 20-minute delayed image, so that this measurement does not add to the total examination time.

References

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