Relationship of Fatty Liver MR Spectroscopy to 7-point Gradient-echo Imaging

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Introduction: MR spectroscopy (MRS) and multiple gradient-echo (MGE) imaging are the two most common methods used to evaluate liver fat. MRS is more sensitive to low fat percentages and is more accurate, but shimming is time-consuming, and only a small part of the liver can be examined at a time. MGE imaging allows evaluation of the entire liver, but is subject to T2*-like effects from the multiple fat peaks[1], and requires a-priori knowledge, or direct estimation of fat and water T1 and T2. Perhaps both MRS, and MGE imaging together would allow better evaluation of fatty liver than either one alone. We have developed a numerical simulation model to generate MGE data directly from spectroscopic data, taking into account actual measured spectral shape, and T1 and T2 of water and fat calculated directly from those spectra[2]. This may be used to correlate spectroscopy and MGE imaging, and to validate methods of MGE imaging analysis.

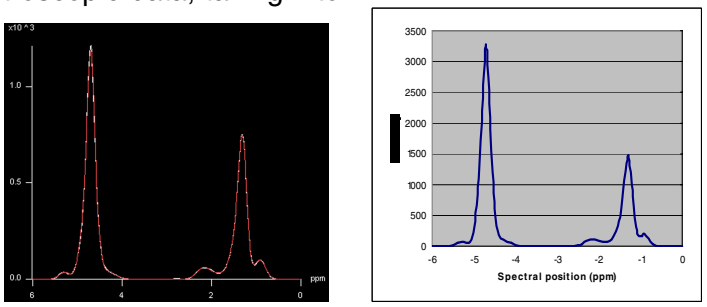

Figure 1. Actual MR spectrum (left); reconstructed MR spectrum corrected for T1 and T2 (right)

Methods: Breath-hold MRS, and MGE imaging were performed for a subject with fatty liver (with IRB approval) for 5 values of TE from 30 to 70 msec (TR = 1500 msec; to estimate T2), and for 5 values of flip angle from 10 to 90° (TR = 150 msec; to estimate T1). Breath-hold MGE images were obtained at 7 values of TE (2.2 to 8.8 msec), TR = 150 msec. MR spectra were de-convolved using Siemens software into 12 Gaussians, 4 for water and 8 for fat, and corrected for the measured T1 and T2 values of water and fat. For each of 60 spectral locations from 0-6 ppm, water and fat signals were corrected for (MGE) T1 and T2 decay, and a resultant signal magnitude generated for each value of the above 7 values of TE. These were compared to the measured ROI signal values at these values of TE for the same subject.

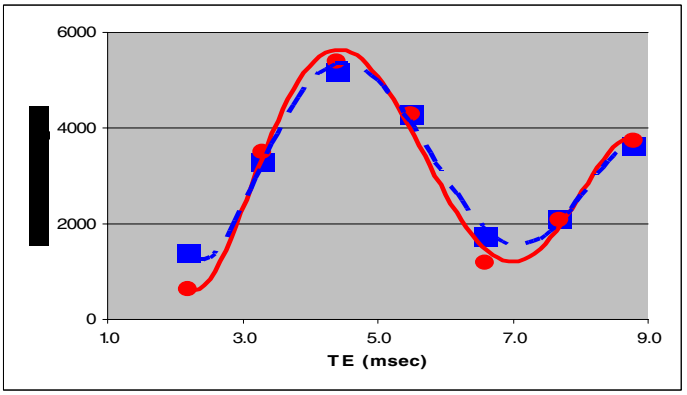

Figure 2. Normalized signal versus TE for measured (dotted blue) and calculated (solid red) MGE imaging

Results: The acquired patient MR liver spectrum, and the spectrum after correction for T1 and T2, are shown in **Figure 1** demonstrating that uncorrected MRS overestimates fat fraction (38% fat). The original measured MGE imaging signal intensities are shown in **Figure 2** (dotted blue line); the solid red line represents the data generated by our model using T1 and T2 as measured from MRS, appropriately decayed for T1 and T2 for the TR, TE's, and flip angle (70°) used in the acquired MGE images. For the parameters used in this experiment, the MR spectra are strongly T2 dependent, and the MGE images obtained are strongly T1 dependent.

Conclusion: We have constructed a numerical simulation model which can be used to generate expected MGE imaging signal intensities directly from an any simulated or acquired spectrum. This method will be used to more systematically test analysis methods to determine fat fraction from MGE fatty liver ROI data, and will hopefully allow improved analysis of the relative value of MRS and MGE imaging in the evaluation of fatty liver disease.

References

1 Middleton et al. Apparent T2* decrease of fat in liver due to fat-fat interference in Dixon-variant imaging. 2006 RSNA.

2 Middleton et al. Simultaneous T2 relaxation time and fat fraction measurement in children with nonalcoholic fatty liver disease or nonalcoholic steatohepatitis using breath-hold MR spectroscopic techniques. 2006 RSNA.