

Quantification of Myocardial Triglycerides: Ex-Vivo and In-Vivo Evaluations by Two-point Water-Fat Imaging and ¹H Spectroscopy

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Introduction: Proton MR spectroscopy (1H-MRS) has been used for in-vivo quantification of intracellular triglycerides within the sarcolemma of myocardium (1, 2). While the accuracy and reproducibility have been validated, the spatial distribution of the fat deposition cannot be accessed by 1H-MRS due to its single voxel characteristics (typically 6 to 8ml voxel for the heart). We studied whether the dual-echo Dixon MRI could quantify the fatty content of the myocardium. Experiments were performed on transplant native heart autopsies and patients using Dixon method and correlated with 1H-MRS.

Materials and Methods: All MRI/MRS studies were performed using a 3T MR scanner (TIM Trio, Siemens). Three fixed explanted hearts (due to transplantation) were examined: one with myocardial infarction (MI), and two with dilated cardiomyopathy (Myo1, 2). Explants were immersed in water for scanning. 1H-MRS was obtained with 6-8ml voxels positioned in the samples (Fig.1) with water suppressed and unsuppressed PRESS, TR/TE =550/30ms, both 64 averages (ave.). Non-gated dual-echo spoiled gradient-recalled echo sequence with TR/TE (In, Out)=6.3/2.46, 3.69ms, flip angle=5° was performed with 10 signal averages. The same view was also obtained with multi-echo gradient echo sequences at eight different echo times (1.2-12.4ms) with 10 averages for the estimation of T₂*. For in-vivo study, 37 subjects including patients with HIV and cocaine use (n=27), and normal controls (n=10) were examined using the same scanner and sequences. Four-chamber view in late diastole was acquired with cardiac gated dual-echo Dixon and multi-echo protocols with flip angle=15°. PRESS, TR/TE =1R-R/30ms ¹H spectra were obtained from a 6-ml voxel positioned in the septum with and without water suppression (32 and 4 ave respectively). Motion effects were reduced with gating to ECG and to a signal from a navigator across the liver-lung interface. Fat (F) and water (W) images were reconstructed using Matlab and corrected for T₂* decay and noise. Fat content was quantified with Amares/jMRUI (3) and resonance frequency of lipids at 0.9 and 1.3 ppm were summed to quantify myocardial triglycerides content and related to water in unsuppressed spectra. The fat fractions, 100*F/(F+W), from MRI were correlated with the results of MRS.

Results: Fat fractions measured in the autopsies by MRS were strongly correlated with those from the corresponding regions in MRI (Fig.2). As a control, background water showed 0.0% fat by MRS, and 0.06% by MRI. The septum in the MI slice had 8.45% of fat deposition by from MRS and 4.7% from MRI due to partial fatty replacement within a chronic scar. The scar was excluded from the comparison in Fig.2, because the goal is to quantify the intracellular triglycerides. Fat distributions were heterogeneous in MI and Myo2, while relatively uniform in Myo1. The results from 37 subjects showed good correlation between the Dixon images and MRS (Fig.3) (r₂=0.77, p< 0.01).

Discussion: MRI and MRS results were well correlated, with discrepancies likely due to a limitation of the spectral model that is implicitly assumed for the fat signal (single peak at 1.3ppm) in this Dixon water-fat separation technique (3). Other more elaborate spectroscopic models can be employed in the multipoint, multipeak imaging method (4) and may yield a correspondence between MRI and MRS closer to unity. However, linearity, which is highly desirable for clinical applications, is clearly demonstrated in our study.

References: 1. Szczepaniak LS, et al. *Circ. Res.* 2007;101:759-767. 2. van der Meer RW, et al. *Diabetes.* 2007;56:2849-2853. 3.Liu CY, et al. *MRM*, submitted Aug. 2009, accepted, in press. 4. Reeder SB, *JMRI*, 2009;29:132-1339.

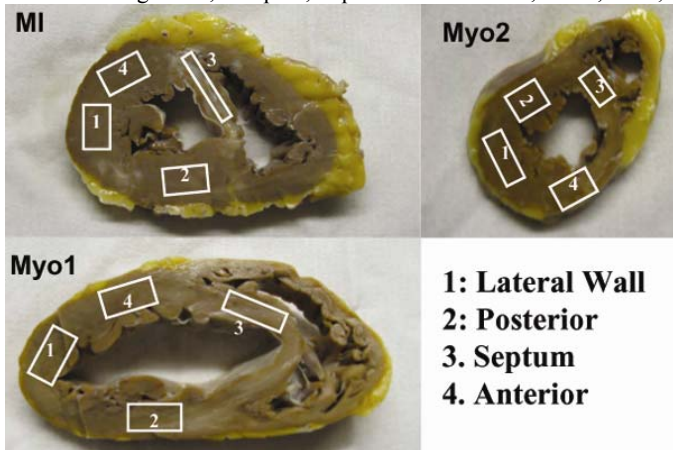


Fig.1. Position of voxels in the autopsies for MRS.

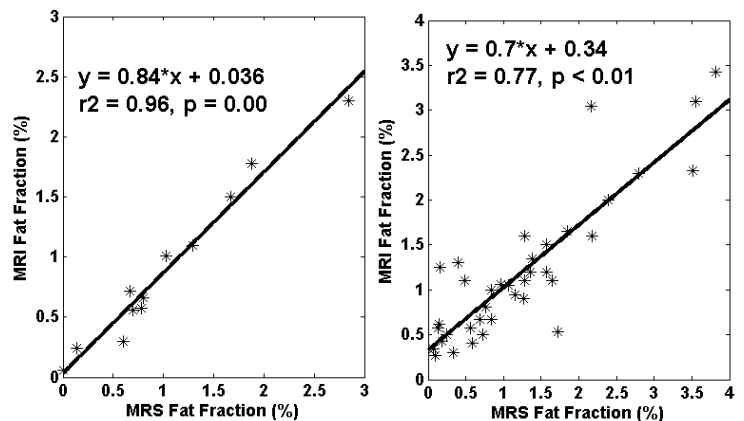


Fig.2. From autopsies, MRI results correlated well to that of MRS.

Fig.3. MRI-MRS correlations from 37 subjects.