Myocardial Fat Quantification Using Two-point Water-Fat Imaging with simultaneous T2* correction

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Introduction: Cardiac dysfunction has been associated with excessive lipolysis in myocardium in animal models. Myocardial fat content is significantly elevated within the myocardium of diabetic, obese, and human immunodeficiency virus (HIV) infected individuals (1). Measurement of the ectopic fat deposition in the myocardium may provide a useful index of the degree of lipid overload. Proton MR spectroscopy (^{1}H MRS) (2) has been used for in-vivo quantification of intracellular triglycerides within the sarcolemma. However, the spatial distribution of the fat deposition cannot be accessed by ^{1}H MRS due to its single voxel characteristics. We studied whether the dual-echo Dixon MRI could quantify the fatty content of the myocardium. The fat fraction was also quantified directly with ^{1}H MRS as an independent method.

Materials and Methods: All MRI/MRS studies were performed using a 3T MR scanner (Siemens TIM Trio) on twenty individuals. Dixon images of a water phantom were studied to test the accuracy of this technique. Three parallel short-axis images were acquired by using a breath-hold dual-echo spoiled gradient-recalled echo sequence with TR/TE (In, Out)=6.3/2.46, 3.69ms, flip angle=15^o (to reduce T_1 bias) in late diastole. Four chamber views were obtained with the same protocol at ten different echo times (2.46-16ms) for the estimation of T_2*. Fat (F) and water (W) images were reconstructed using Matlab and corrected for T_2* decay. The short-axis water image was used as a reference to contour the epi- and endo-myocardial borders. Epicardial fat was carefully excluded. Contours were transposed to the fat fraction images, defined as 1-W/(F+W) to reduce noise bias (3). Fat fraction was averaged over myocardial segments.

Myocardial ^{1}H MRS was obtained with a 6-ml voxel positioned in the septum with water suppressed, ECG gated, single voxel PRESS, TR/TE =1R-R/30ms, also gated to a navigator across the liver-lung interface to reduce breathing effects. Fat content was quantified with Amares (4) and related to water in unsuppressed spectra. The fat fractions from the average of infero- and anteroseptal segments were correlated with the results of MRS.

Results: The water phantom exhibits 0.3% fat fraction after T_2* correction. This residual value shows the inaccuracy of the dual-echo Dixon techniques due to off-resonance. 12 subjects (out of 20) had successful cardiac spectra analyzed. Fig. 1(left) demonstrates decomposed fat fraction image with anterior and anteroseptal lipomatous metaplasia from a participant with prior myocardial infarction (MI). The fat fractions from six sectors of the myocardium are shown in Fig. 1 (right). Note the fat deposition extends from the apical to the mid ventricular level of the anterior wall and also the heterogeneous lipid distribution. The fat fraction based on the Dixon images was significantly (r=0.64, $p<0.05$) related to that of spectra (Fig. 2). The average fat percent (12 subjects) is 1.35% and 0.87% for MRI and MRS respectively.

Discussion: The dual echo technique showed higher estimates of fat fraction compared to the ^{1}H MRS technique. Some discrepancy is to be expected as the MRS selected voxels differ from the sectors used for determining fat fractions with the Dixon method. To accurately quantify the fat fraction, four major issues should be addressed: the effect of tissue relaxation (T_1, T_2*) and image noise. T_1 bias is small however for low fat fraction that we observed. T_2* and noise were also carefully corrected in our study. The fourth issue is the off-resonance that results in a shift of in- and out-phase echo times. Even in a pure water phantom this effect can lead to fat fractions of up to 0.3%. Off-resonance can be corrected by three-point Dixon techniques. Future work will focus on the development of the three-point Dixon method.

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. 2007;58:354-364. 4.Vanhamme L, et al. JMR 2000;143(1):1-16. **Acknowledgements:** Supported by Toshiba Medical Systems and Ultrasound Diagnostics/MESA

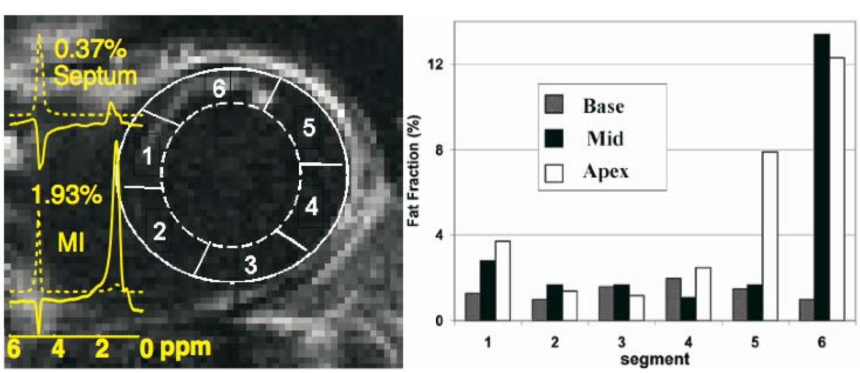

Fig. 1. *Decomposed fat fraction images and fat fractions in a 71yr. old male with a history of MI. Data from six segments of the basal, middle, and apical SA views. A fat deposit due to prior MI is evident in sector 6 (anterior) from apex to mid ventricle of the anterior wall. ^{1}H-MRS data were collected from the septum and additional region encompassing the MI yellow insert spectra with (solid scaledx200) and without (dashed) water suppression.*

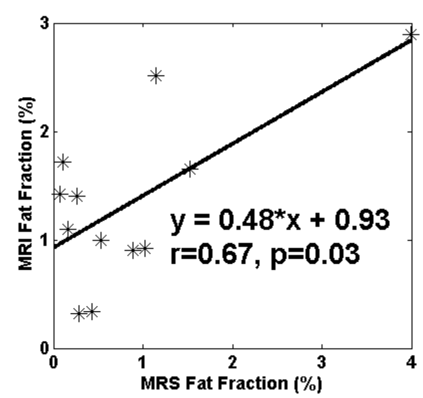

Fig.2. *Fat faction based on MRI correlated to that of MRS.*