High resolution measurement of hepatic fat volume fraction in a single breathhold

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Introduction: Excess accumulation of fatty acids and triglycerides in tissues such as muscle, liver, and pancreas (ectopic fat accumulation) is believed to be a major etiologic factor leading to the Metabolic Syndrome (dyslipidemia, hypertension, fasting glucose intolerance or insulin resistance) and eventual development of type 2 diabetes mellitus. Observations of ectopic hepatic fat in severely overweight patients may provide important insights into the differential expression of the various components of MetS in one overweight person compared to another and hence, mechanisms underlying MetS.

Single voxel MR spectroscopy is currently the gold standard for quantification of intrahepatic fat (1-3). Typical MR spectroscopy imaging times range from a single breathold to several minutes (1,2), yielding a single measurement of fat volume fraction in a single large voxel within the liver.

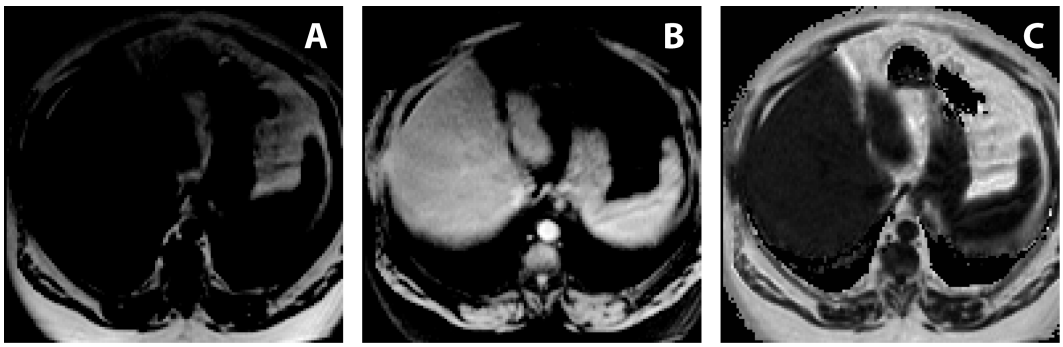

Figure 1: A) Fat-only, B) water-only, and C) computed fat volume fraction images for an axial abdominal slice from a multislice study encompassing a fatty liver.

We have implemented the three-point Dixon method (4) to perform multi-slice hepatic fat volume fraction imaging encompassing the entire liver with typical imaging time of 13 seconds, well within a single breathhold. Measurements of hepatic fat volume fraction appear to be highly correlated with body mass index (BMI) in a small series of obese patients.

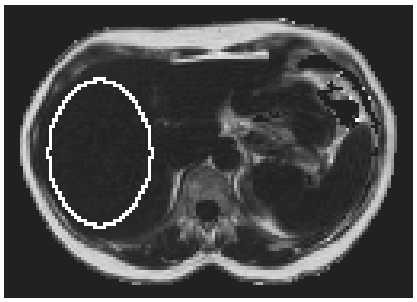

Figure 2: Typical ROI used to calculate fat volume fraction

Methods: Measurements were performed on a 1.5 Tesla Siemens Espree system. A gradient recalled echo sequence with 20 degree flip angle was used to acquire three echoes during a single 120 ms TR with echo times 4.2ms, 6.3ms, and 8.4ms over a typical field of view of 36 x 36 cm, at a resolution of 128 x 128 with 75% partial k-space acquisition. Ten axial slices were obtained with slice thickness of 1cm, with 5mm gap between slices. Unipolar readout gradients insured that the fat shift due to chemical shift artifact was in the same direction for all three echo times. Total imaging time was about 13 seconds. The three-point Dixon method was used to create simultaneous B0 maps and separate fat and water images. Signal intensity of the fat- and water-only images was corrected for T1 weighting via the signal equation for GRE imaging, using values of 663ms and 236ms for the T1 of the water- and fat-resonance components of liver (1). Signal intensity was then used to calculate fat volume fraction with the algorithm outlined in (1).

Results: Figure 1 shows typical fat-only (A), water-only (B), and calculated fat volume fraction (C) images for a single axial slice in the abdomen at the level of the liver. Fat volume fraction ranges from 0% (black) to 100% (white). Figure 2 shows a typical region of interest used to obtain single values of fat volume fraction. Single values of fat volume fraction are plotted vs. BMI for five obese volunteers in Figure 3, showing strong correlation.

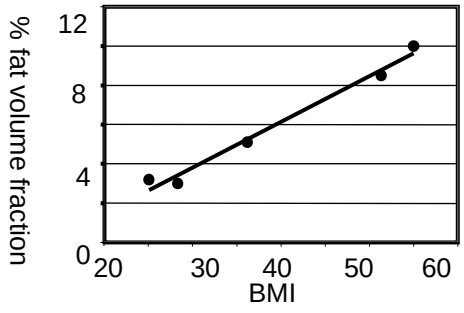

Figure 3: Fat volume fraction vs. BMI

Conclusion: Single acquisition three-point Dixon imaging allows rapid acquisition of fat volume fraction maps encompassing the entire liver in a single short breathhold. Calculated hepatic fat volume fraction appears to be strongly correlated with BMI in a small group of obese subjects.

References: 1) Longo R *et al., J Magn Reson Imaging* 1995; 5:281-285. **2)** Szczepaniak L *et al., Am J Physiol Endocrinol Metab* 2005; 288:E462-E468. **3)** Thomsen C *et al., Magn Reson Imaging* 1994; 12:487-495. **4)** Glover G *et al., Magn Reson Med* 1991; 18:371-383.