

Non Alcoholic Fatty Liver Disease (NAFLD) and Visceral Fat: Accurate spectroscopic and Volumetric determinations derived from MR

K. N. Salman¹, P. Sharma², B. Kalb¹, H. Kitajima², C. Lurie¹, M. Vos³, and D. R. Martin¹

¹Radiology, Emory University, Atlanta, GA, United States, ²Radiology, Emory Healthcare, Atlanta, GA, United States, ³Pediatrics, CHOA, Atlanta, GA, United States

Introduction: Non-alcoholic fatty liver disease (NAFLD) has become an increasingly prevalent liver condition in children and adults, which can become a precursor to more serious abnormalities, such as hepatitis and fibrosis. Since biopsy is often associated with sample measurement error and patient discomfort, non-invasive methods to predict and evaluate hepatic lipid are attractive alternatives. Direct measurement of visceral adipose tissue (VAT) using CT and MR has been shown to be an independent predictor of fatty liver; however, the standard of comparison has been limited to BMI, serum chemistry, biopsy sample and out-of-phase MR imaging, each of which have associated inaccuracies. Recently, a high speed T2 corrected (HISTO) MR spectroscopy method has been introduced for susceptibility-corrected hepatic lipid measurements within a single breath hold acquisition [1], which provides direct assessment of hepatic fat fraction.

Purpose: This study investigates the correlation between visceral and subcutaneous adipose tissue, and measurements of hepatic fat fraction using the HISTO technique.

Methods: This investigation was IRB approved and HIPPA compliant. Imaging was performed on a 1.5T Siemens Avanto system with phased array body coils. Fifteen children with variable clinical indicators of NAFLD were enrolled to undergo MR imaging of the abdomen and spectroscopic evaluation of the liver. **MRI.** Imaging of visceral and subcutaneous fat encompassing L4 vertebra was performed with either breath hold T1-weighted 3D spoiled gradient echo (TR/TE/flip = 7.0/4.4ms/12deg) with a resolution of 1.4x1.4x3mm, or T2-weighted single-shot spin echo (TR/TE/flip=1200/86ms/90deg) with a resolution of 1.7x1.7x7mm. Analyze version 6.0 (Mayo Clinic, Rochester MN) was used for image post processing of dicom images. A single slice at the level of L4 was chosen for the analysis. Semi-automatic image segmentation was performed using closed trace and flood-fill tools to delineate the visceral and subcutaneous fat, and a threshold level was chosen for fat segmentation. The number of fat pixels in the slice was calculated and area

was estimated based on the pixel size obtained from the dicom headers. **MRS.** The HISTO MRS method has been described previously [1]. The multi-echo TE set was fixed to {12, 24, 36, 48, 72}ms, with TR=3000ms, voxel=3x3x3cm³, 1024 points, and 1200 Hz bandwidth. The acquisition duration was a 15 sec breath hold, and repeated three times for reproducibility. Data was exported off-line for automatic processing with in-house software (Matlab, Mathworks,



Figure 1.

Natick, MA). Water and lipid spectra at were analyzed by determining peak area over a user-defined frequency range (water peak: 4.6ppm; lipid peak: 1.3, 2.0ppm). The integrated spectrum signals at each TE were fit to exponential T2 decay, whereby the equilibrium signal (M_0) and the relaxation rate ($R2=1/T2$) were determined by least-squares approximation. Using M_0 for water and lipid, the T2-corrected hepatic lipid fraction was calculated from: $\%HL = M_{0lipid} / (M_{0lipid} + M_{0water})$. **Regression.** VAT, SAT, VAT/SAT ratio, and VAT/(VAT+SAT) were correlated with HISTO MRS findings using linear regression (Pearson correlation). Significant correlation was set to $p < 0.05$.

Results: HISTO HL% measures were achieved with high reproducibility ($SD < 5\%$) and curve fitting ($rsq > 0.95$). The range of HL% measured by HISTO was 0 to 29.5% 0.2. VAT and SAT segmentation was successful with both T1 and T2-weighted source images. An example of one case with segmented VAT and SAT using T1 spoiled gradient echo is shown in Figure 1, with resultant

VAT/(VAT+SAT)=0.32. Adjacent is the corresponding HISTO spectrum, revealing corrected HL% of 22.8% 0.2. Figure 2 shows regression analysis for VAT/(VAT+SAT), which revealed a Pearson coefficient of 0.755 ($p=0.0011$). Table 1 provides a summary of correlation statistics between HISTO HL% and VAT and SAT measures and ratios. The greatest correlation with HISTO was achieved using VAT and SAT ratios, with Pearson correlations exceeding 0.7 ($p < 0.05$). Despite VAT measures exhibiting moderate correlation, no significant relationship was found with individual VAT and SAT measures ($p > 0.05$).

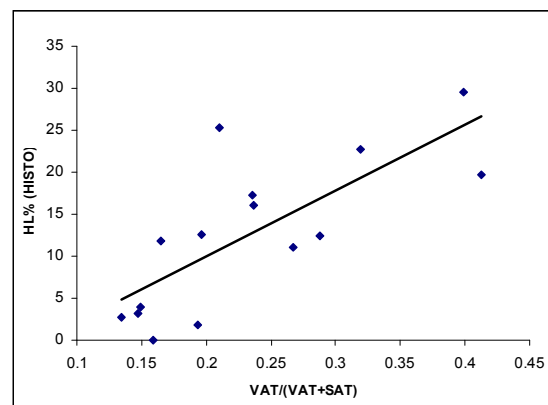


Figure 2

Table 1. Measured statistics with HISTO HL%

	VAT	SAT	VAT/SAT	VAT/total
Pearson (r)	0.50	*	0.73	0.75
p-value	0.059	0.986	0.002	0.001

*no correlation observed

Conclusions: 1. HISTO MRS provides a fast, susceptibility-corrected measure of HL%; 2. VAT and SAT can be obtained through T1 or T2-weighted imaging; 3. Ratio quantities of VAT and SAT (VAT/SAT and VAT/total) provide significant correlation with HISTO measured HL%; 4. Individual VAT or SAT measures do not provide significant correlation with HL%; 5. Direct measurement of HL% using HISTO, coupled with VAT/SAT measures, provides a feasible methodology for longitudinal assessment of hepatic and abdominal fat fraction in patients with NAFLD.

References. [1] Pineda N, et al Radiology 2009