Hepatic fat quantification in children using multi-echo gradient-echo imaging and fat spectral modeling at 1.5 T

M. Shiehmorteza[1], T. Yokoo[1], G. Hamilton[1], M. Bydder[1], M. Rodriguez[1], J. E. Lavine[2], J. B. Schwimmer[2], and C. B. Sirlin[1]

[1]Radiology, University of California San Diego, San Diego, CA, United States, [2]Pediatrics, University of California San Diego, San Diego, CA, United States

Purpose: To assess hepatic fat quantification accuracy of multi-echo gradient-recalled-echo (GRE) magnetic resonance (MR) imaging and fat spectral modeling at 1.5T in children with or at risk for fatty liver disease (FLD).

Introduction: Due to the current epidemic in childhood obesity, FLD has become the most common cause of liver disease in children, with an estimated prevalence of 12-17% in the general pediatric population [1]. To reduce the associated morbidity and mortality risks of FLD (e.g., cirrhosis, liver cancer) in this population, early diagnosis and intervention are critical. MR imaging has been shown to be the most sensitive and specific modality for noninvasive assessment of liver fat in adults. Although MR imaging assessment of liver fat has been applied to pediatric populations previously [2], the accuracy of fat quantification in this group has not been verified. Confirming that MR imaging is accurate in the pediatric population is necessary because children may not be able or willing to cooperate with MR examinations as readily as adults. Also, the histological features of pediatric FLD differ from those of adult FLD [1], and generalization of findings from adults to children may not be valid. We have recently developed a clinical MR imaging technique called *LIPO-Quant* (*L*iver *I*maging of *P*hase-related signal *O*scillation and *Quant*ification), based on a non-T1-weighted multi-echo GRE sequence and fat spectral modeling [3,4]. This technique allows rapid multi-slice liver imaging in a single breath-hold (<18 sec); fat fraction (FF) maps that display the pixel-by-pixel spatial distribution of liver fat content are generated on-line in seconds. In this first pediatric study assessing fat estimation accuracy of MR imaging, we compared FF by *LIPO-Quant* imaging to the reference FF obtained by single-voxel spectroscopy.

Materials and Methods: In this HIPAA-compliant, IRB-approved prospective clinical study, 51 children of age 8-18 years (27 with biopsy-confirmed FLD, 24 with family members with FLD) gave assent to parental informed consent and underwent MR spectroscopy and imaging of the liver at 1.5 T. Single-voxel STEAM spectroscopy was performed with long repetition time to minimize T1 effects, and data were acquired at multiple echo times to permit T2 correction in a single breath-hold of 15 sec. Spectroscopic FF was calculated from T2-corrected peak areas of water (4.7ppm) and fat (2.2, 1.3, 0.9 ppm). 2D axial GRE imaging was performed with low flip angle to minimize T1 effects, and data were acquired at multiple echo times to permit T2* correction. Field of view and matrix size were adjusted case by case to accommodate each child's breath-hold ability. The LIPO-Quant MR imaging FF was calculated based on T2*-corrected fat and water signals using a 3-peak fat spectral model (2.2 1.3, 0.9 ppm) [3,4]. The accuracy of the LIPO-Quant FF at the location of the spectroscopy voxel was assessed by linear regression analysis with spectroscopic FF as the reference standard.

Results: As shown in the age-distribution histogram of the study population sample (**Fig. 1**), at least two subjects were included at every year of age from 8 to 18 years. The linear regression analysis (**Fig. 2**) shows that the LIPO-Quant MR imaging FF closely predicted the spectroscopic FF, with minimal positive intercept (0.01, P<0.05) and slope essentially equal to unity (0.99, P=NS). On the graph, the diagonal dashed line (intercept 0, slope 1) represents equality between LIPO-Quant MR imaging and spectroscopic FFs, the solid red line the observed regression, and the curved dash lines the 95% confidence bounds of the observed regression. The FF estimation error, measured as the difference between LIPO-Quant MR imaging and spectroscopic FF, showed no meaningful trend with age (**Fig. 3**), suggesting that the LIPO-Quant technique provides stable performance across age 8-18 years.

Conclusion: *LIPO-Quant* MR imaging is clinically feasible and is highly accurate for hepatic fat quantification in children. Minimal overestimation of spectroscopy-determined FF by 1% is not likely to be clinically important.

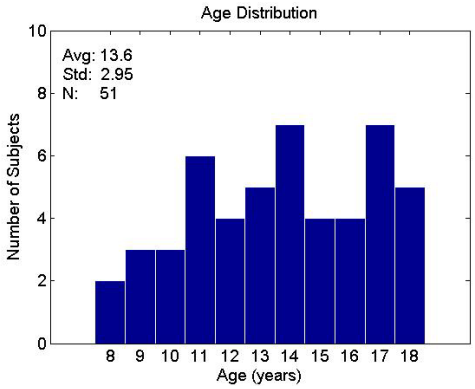

Figure 1

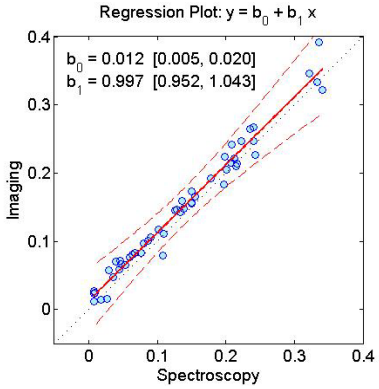

Figure 2

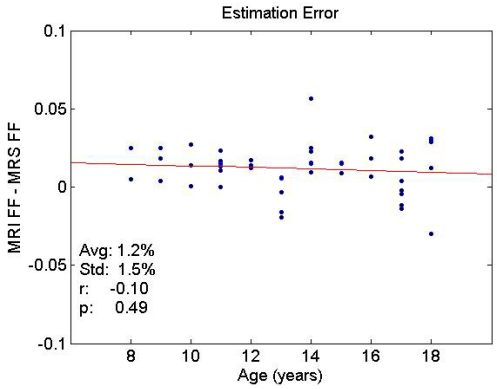

Figure 3

References:

[1] Lavine and Schwimmer. Nonalcoholic fatty liver disease in the pediatric populaiton. Clinics in Liver Disease, 2004. 8(3):549-558

[2] Fishbein et al. Relationship of hepatic steatosis to adipose tissue distribution in pediatric nonalcoholic fatty liver disease. J Pediatr Gastroenterol Nutr. 2006 Jan;42(1):83-8.

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[4] Reference accepted to Radiology, available upon request.