Effect of Fat Spectral Model Parameters on Hepatic Fat Quantification by Multi-Echo Gradient-Echo Magnetic Resonance Imaging

T. Yokoo[1], M. Bydder[1], G. Hamilton[1], M. S. Middleton[1], H. M. Patton[2], T. Hassanein[2], J. B. Schwimmer[3], and C. B. Sirlin[1]

[1]Radiology, UCSD, San Diego, CA, United States, [2]Medicine, UCSD, San Diego, CA, United States, [3]Pediatrics, UCSD, San Diego, CA, United States

Purpose: To assess the effect of fat spectral model parameters on hepatic fat quantification by multi-echo gradient-recalled echo (GRE) imaging.

Introduction: At last year's meeting, several groups independently proposed that accurate estimation of hepatic fat content using GRE MR imaging requires modeling of the signal interference caused by the non-dominant fat peaks as well as the dominant 1.2 ppm peak [1-3] (**Fig 1**). Our group demonstrated high fat quantification accuracy in human subjects [3,4] using *LIPO-Quant* (*Li*ver *I*maging of *P*hase-interference signal *O*scillation and *Quant*ification) with a 3-peak fat spectral model derived from empirical MR spectra of fatty livers. The performance of *LIPO-Quant*, however, may depend on the parameters of the spectral model. The purpose of this study was to assess the effect of fat spectral model parameters on liver fat quantification by multi-echo GRE imaging. To this end, we perturbed the fat model parameters in *LIPO-Quant* and assessed the variation in diagnostic and fat-grading accuracy, using MR spectroscopy as the reference technique.

Materials and Methods: As previously described [3,4], 110 human subjects (29 biopsy-confirmed fatty liver, 50 overweight, and 31 healthy volunteers) gave informed consent and underwent MR spectroscopy and imaging of the liver. Spectroscopy used long repetition time (to suppress T1 effects) and multiple echo-times (to permit T2 correction); spectroscopic fat fraction (FF) was calculated from the T2-corrected fat and water spectral peak areas. Imaging used low flip-angle (to suppress T1 effects) multi-echo GRE acquisition (to permit T2* correction); imaging FF was calculated from T2*-corrected fat and water signals using *LIPO-Quant* with the 3-component fat spectral model [3,4]. The fat signal was modeled as a weighted sum of three components (0.9, 1.2, 2.1 ppm), whose weight-parameters were derived from the peak areas of the respective frequencies (normalized by the 1.3 ppm peak), averaged over 97 spectra with FF>0.1. The imaging diagnostic accuracy was assessed by sensitivity and specificity using spectroscopic FF as the reference standard. According to previously published criterion [5], spectroscopic FF>0.0625 was considered abnormal. The imaging fat-grading accuracy was assessed by regression analysis (only for subjects with abnormal FF by spectroscopy), using slope=1 and intercept=0 as the reference. The relative weights of the minor peaks (0.9, 2.2 ppm peaks) were then varied by ± 2x standard deviation along the two principal axes of the observed relative peak-area distribution of the 97 spectra (**Fig 2**). The diagnostic and grading accuracy was re-assessed at these 5 points (*i.e.* 5 models).

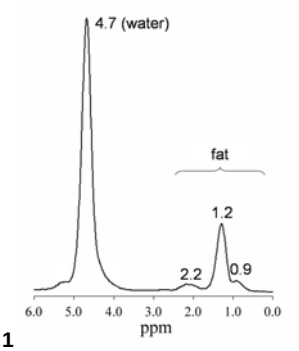

Fig 1

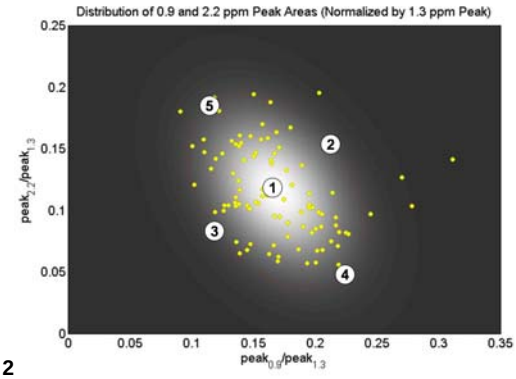

Fig 2

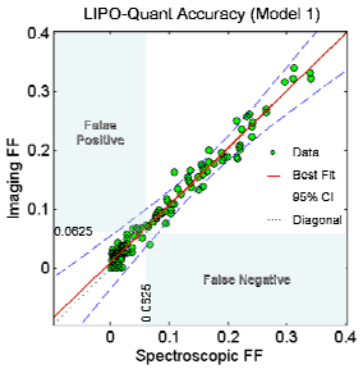

Fig 3

Table 1: Five Fat Spectral Models and Their Diagnostic and Fat-Grading Accuracy

Peak Area (normalized by 1.3 ppm peak)	Model 1		Model 2		Model 3		Model 4		Model 5	
2.2 ppm	0.115		0.151		0.079		0.045		0.186	
1.3 ppm	1.000		1.000		1.000		1.000		1.000	
0.9 ppm	0.168		0.215		0.121		0.222		0.114	
Diagnostic Accuracy										
Sensitivity	0.983		0.983		0.983		0.983		0.983	
Specificity	0.880		0.880		0.900		0.900		0.880	
Fat Grading Accuracy										
	Intercept	***Slope***	***Intercept***	***Slope***	***Intercept***	***Slope***	***Intercept***	***Slope***	***Intercept***	***Slope***
Regression	0.009	0.974	0.017	0.995	0.006	0.950	0.007	0.951	0.011	0.999
p-value	0.052	0.196	0.019	0.438	0.126	0.045	0.109	0.047	0.022	0.482
95% CI	0.020	1.034	0.023	1.056	0.017	1.008	0.017	1.009	0.022	1.060
	-0.002	0.915	0.001	0.935	-0.004	0.892	-0.004	0.893	0.000	0.938

Results: A graphical illustration is shown in **Fig 3**, which compares spectroscopic and imaging FF (*e.g.* model 1, mean spectrum). Dichotomized classification (diagnosis) and the linear regression line (fat-grading) are shown. **Table 1** shows that, under perturbation of the model parameters by ± 2x standard deviation (*not* standard error of the mean), the change in diagnostic sensitivity and specificity was minimal. No statistically significant deviation of slope away from 1 was noted. Small but statistically significant (<2%) upward shift of the regression intercept is noted when 2.2 ppm peak was modeled >15% of the main 1.3 ppm peak (models 2 and 5).

Conclusion: Under reasonable perturbation of the fat spectral model, *LIPO-Quant* MR imaging for hepatic fat quantification had minimal variability in diagnostic or fat-grading accuracy. This degree of variability is unlikely to be clinically meaningful.

References:

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