Assessment of Liver Fat With T2 Correction Using Magnetic Resonance Spectroscopic Imaging

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Introduction

Non-alcoholic fatty liver disease (NAFLD) prevalence is increasing world-wide in recent decades. Early detection of NAFLD can prevent the further complications such as steatohepatitis, fibrosis and cirrhosis [1]. Among all noninvasive imaging techniques such as ultrasound, computed tomography, magnetic resonance imaging (MRI) and magnetic resonance spectroscopy (MRS) have been used to detect hepatic steatosis [2-4], MRS is known to be the most accurate method for the quantification of lipid contents for hepatic steatosis [5]. Previous we have shown that fast magnetic resonance spectroscopic imaging (MRSI) technique, proton echo planar spectroscopic imaging (PEPSI) [3], is able to detect the spatial distribution of liver fat content with around 3 c.c. in-plane resolution. With PEPSI, one acquisition can be finished in less than 20 seconds [6]. In this study, we will extend our work to further consider the quantification errors from relaxation effects [7]. The aim of this study is to investigate the influence of T2 relaxation effects and the accuracy of quantification on the measurement of hepatic fat content.

Methods

A total of 6 subjects without history of hepatitis or other liver diseases participated in this study (all male, averaged age: 25.4, range: 22~33, body mass index (BMI) range: 25.1~32.7 kg/m2). Subjects were in supine position using an abdominal surface array coil along with spine array coil. Before PEPSI a set of T1-weighted anatomic images were acquired for localization. Non-water suppressed liver spectra were obtained using PEPSI sequence. Experiment parameters include: matrix size 16x32, FOV ranging from 270x360~300x400 mm^2 according to subject size, slice thickness = 15 mm, TR=1000ms, and TE varied from 15 to 55 ms (5 steps). The scan time is 17 seconds for one acquisition and all subjects were instructed to hold breath during the period of single scan. Regular reconstruction process was carried out first for PEPSI data as described in previous report [3]. For each spectrum, signal from water and lipid were quantified by Lorentzian function curve fitting with baseline correction. In this preliminary study, only signal from methylene ($-(CH_2)_n-$, 1.3ppm) group were fitted for lipid. T2 relaxation times of water and Lipid were calculated by nonlinear exponential curve fitting and water and lipid signal without T2 relaxation were acquired by extrapolating the fitting curve . Hepatic fat content (Fat%) was defined as $\text{Fat\%} = S_{fat}/S_{water}$. Only voxels with both fitting reliability (R^2 values) of water and lipid larger than 0.8 were included for analysis. The averaged Fat% and T2 values were then obtained from a manually selected ROI within liver. To exclude the influence of subcutaneous fat, ROI is chosen to be smaller than boundary of liver. PEPSI scans were repeated 8 times for each subject to observe the reproducibility of T2 correction.

Results and Discussion

The lipid contents were successfully detected in all subjects. Figure 1 showed the original spectra and fitted spectra of 5 TEs of the same voxel from one subject. It can be observed that water and lipid peaks progressively decreased as TE increased. Representative T2 relaxation plot of water and lipid signal were shown in Figure 2. The spatial distribution of Fat% and T2 values were shown in Figure 3. Table 1 listed quantified T2 values of water and fat and the T2-corrected Fat%. Measured T2 values ranged from 20.52 to 27.81 ms for water, and from 41.75 to 61.69 ms for fat. We also listed uncorrected Fat% measured from TE=15, 35, and 55ms in Table 1 for comparison. It is obvious that the overestimation of Fat% becomes more crucial as TE becomes longer. However, even for the shortest TE, there were still 1~23% overestimation. The standard deviation of Fat% between scans were less than 1.4% for all subjects, indicating high reproducibility.

In conclusion, PEPSI as a fast MRSI method is a reliable method for the quantification of liver fat content. With our protocol, hepatic fat content distribution with T2 correction can be achieved in less than 3 minutes. And the measured fat content is highly reproducible. In addition to better accuracy for quantification of fat content, T2 relaxations of fat and its potential spatial variation may be also useful information, which is under further investigation.

References

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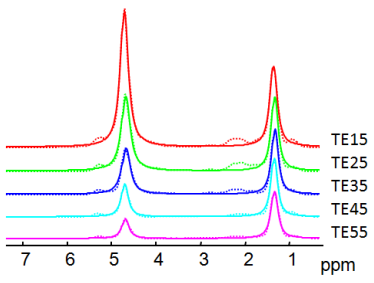

Figure1 Representative spectra of 5 TEs from one subject

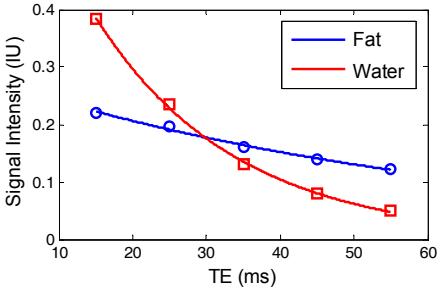

Figure2 Signal intensity vs. TE for fat and water

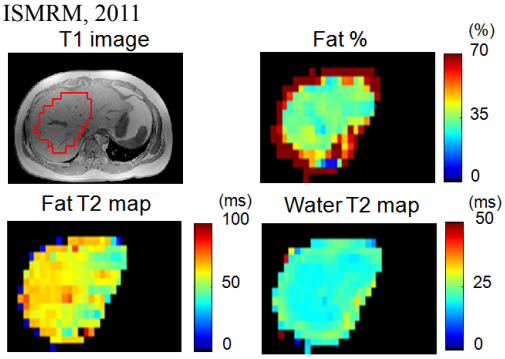

Figure3 Fat% map and T2 maps

	Age	BMI(kg/m^2)	$T2_{Fat}$ (ms)	$T2_{Water}$ (ms)	Fat%	$Fat\%_{TE15}$	$Fat\%_{TE35}$	$Fat\%_{TE55}$
S1	24	32.7	45.84 ± 5.53	21.91 ± 0.70	10.40 ± 0.68	14.9 ± 1.22	22.94 ± 1.47	41.98 ± 3.92
S2	23	27.4	41.75 ± 9.07	25.49 ± 0.92	6.58 ± 0.76	7.79 ± 0.58	9.93 ± 0.51	14.97 ± 2.28
S3	33	30	61.69 ± 4.61	27.81 ± 0.34	34.23 ± 1.38	57.38 ± 1.56	116.6 ± 2.35	230.92 ± 4.18
S4	27	28.7	42.14 ± 5.24	23.96 ± 0.38	7.3 ± 0.61	8.77 ± 0.44	12.12 ± 0.64	18.15 ± 1.16
S5	25	25.2	43.62 ± 8.10	23.77 ± 1.44	7.61 ± 0.80	8.54 ± 0.27	12.72 ± 2.31	16.35 ± 2.19
S6	29	32.2	59.42 ± 6.85	20.52 ± 1.46	17.53 ± 0.95	28.49 ± 0.76	54.92 ± 2.57	116.53 ± 17.58

Table1 The averaged and standard deviation of T2 values and Fat% for all 6 subjects