Assessment of liver fat using magnetic resonance spectroscopic imaging (MRSI)

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Introduction

Fatty liver as a common disease in modern life that affect up to 30% in adults can be associated with a variety of disorders. Currently quantification of liver fat content relies on liver biopsy which is highly invasive method [1]. Recently it has been shown that MR spectroscopy (MRS) technique can be used as an alternative method to measure and quantify the liver fat [2]. Other than other noninvasive tools such as CT, ultrasound and MRI, MRS is more reliable in quantification of fat content [1]. However, breathe holding is usually required to avoid artifacts from respiratory motion. This limits the acquisition time of single scan in less than tens of seconds which is even lower for clinical applications. Therefore only single voxel MRS has been reported for the measurement of liver fat in specific volume of interest. In this study a fast magnetic resonance spectroscopic imaging (MRSI) technique, proton echo planar spectroscopic imaging (PEPSI) [3], is proposed to quantify spatial distribution of fat content in liver. Compared with conventional MRSI technique PEPSI can reduce the acquisition time of single MRSI data set in less than 20 seconds such that subjects can hold their breath during scans. In this preliminary report the feasibility and reproducibility of liver MRSI were investigated.

Methods

8 normal subjects were recruited (all male, averaged age: 24.5 years, range: 23-31 years; body mass index (BMI) range, 20.7-32.7 kg/m2). All experiments were performed on a 3.0T MR system (Trio, Siemens Medical Solutions, Erlangen, Germany). 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 as in previous reports [3] with experiment parameters: TE/TR = 35/1000ms, matrix size 16x32, FOV ranging from 220x320~300x400 mm^2 according to subject size, slice thickness = 15 mm. The scan time is 17 seconds for one acquisition and all subjects were instructed to hold breath during the period of single scan. For each subject PEPSI scans were repeated 8 times to observe the reproducibility. Regular reconstruction process was carried out first for PEPSI data as described in the previous report [3]. Then LCModel was used to quantify the fat content for each spectrum. The derived fat contents were normalized to water signal to remove the influence of system gain which was presented in percentage. To ensure the reliability of fitting of fat signal spectra with the uncertain fat quantification (Cramér–Rao lower bounds (CRLB) higher than 100) were excluded from the ROI analysis. For each subject ROI of liver were selected on T1-weighted images (Figure 1), averaged liver contents of each scan from each subject were then calculated.

Results and Discoussion

The lipid contents were successfully detected in all subjects. For the reproducibility study, normalized liver fat fraction (LFF) maps calculate from 8 scans of one subject were shown in Figure 2. The original curves and LCModel fitted curves were shown in Figure 3. The resemblance of each scan can be clearly seen. The LFF variations of each subject were ranged from 0.46%-3.91%. The averaged and standard deviation values of LFF for each subject were shown in Table 1. We can notice that there was obvious individual difference in lipid content for different subjects, but the LFF values were all in reasonable range comparing with previous study [4]. The variations were around 1% except 2 subjects with LFF values higher than 30%. The averaged CRLB was 7.3%, and the CRLB values increases as LFF decreases.

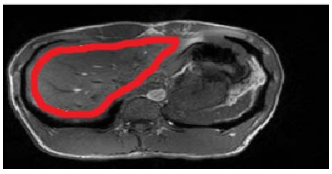
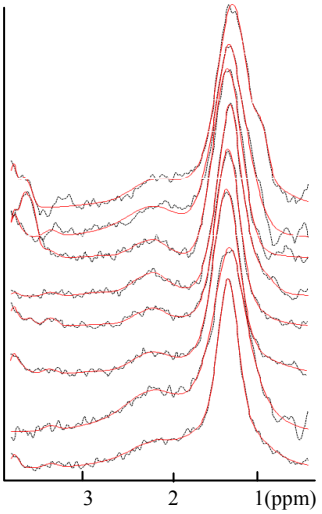


Figure 1 (a) Liver ROI localization in T1-weighted gradient echo imaging.



Conclusions

To our knowledge, only single voxel MRS has been reported for the measurement of liver fat. This is the first study to investigate the application of MRSI on liver. In our study, we have shown that PEPSI is able to detect liver fat content within a short acquisition time. And the measured lipid fat fraction is highly reproducible. Measurement of metabolites other than lipid such as choline compound is under further investigation.

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References

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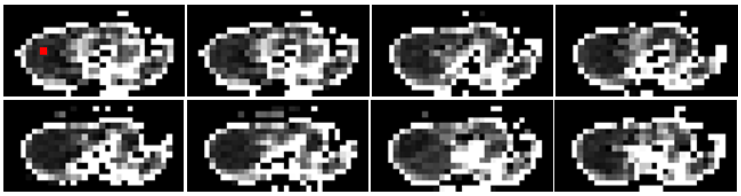

Figure 2 LFF maps of eight scans

Figure 3 Original spectra (in black) and LCModel fitted spectra (in red) of 8 scans. The voxel position was markd in Figure 2.

Table 1 List of eight subjects

Subject No.	1	2	3	4	5	6	7	8
Age	23	31	23	23	24	24	25	23
BMI (kg/m²)	29.1	30.1	32.7	25.6	24.8	20.7	25.4	26.8
LFF (au)	24.84±0.46%	47.90±3.91%	33.73±1.65%	6.42±0.62%	4.06±1.29%	2.46±0.51%	5.31±0.96%	9.04±1.05%