Magnetic Resonance Spectroscopy in Living-Donor Liver Transplantation

H.-J. Chiang[a], W.-P. Chang[a], H.-W. Chiang[a], M.Z. Lazo[a], T.-Y. Chen[a], H.-Y. Ou[a], L.L.-C. Tsang[a], T.-L. Huang[a], C.-L. Chen[b], and Y.-F. Cheng[a,*]

[a]Department of Diagnostic Radiology, Kaohsiung Chang Gung Memorial Hospital and Chang Gung University College of Medicine, Niao-Sung, Kaosiung, Taiwan; and the [b]Department of Surgery, Kaohsiung Chang Gung Memorial Hospital and Chang Gung University College of Medicine, Niao-Sung, Kaosiung, Taiwan

ABSTRACT

Objective. The purpose of this study is to evaluate the accuracy rate of the one breath-hold single voxel hydrogen-1 magnetic resonance spectroscopy (MRS) in comparison with intraoperative biopsy for liver fat quantification in living-donor liver transplantation.

Materials and Methods. A total of 80 living liver donors participated in this study. Each patient underwent both MRS and intraoperative biopsy for evaluation of liver fatty content. MRS was performed using 1.5-T magnetic resonance imaging and placed in segments 2–4, 5–8, and left lateral segment for each donor. Accuracy was assessed through receiver operating characteristic curve analysis. Sensitivity and specificity of MRS fat fractions were also calculated.

Results. Eighty living-donor liver transplantation donors were enrolled in this study. There was no fatty liver in 59 subjects (73.8%), 5% to 10% fatty liver in 17 subjects, 11% to 15% fatty liver in 3 subjects, and >16% fatty liver in 1 subject. MRS fat fraction showed excellent parameters to predict between normal liver and fatty liver groups (1.85% ± 0.98, 8.13% ± 3.52, respectively; $P < .0001$). Linear regression between MRS fat fraction and pathology grading showed high correlation ($R^2 = 0.7092$). Pearson correlation revealed high correlation between MRS and pathology results ($r = 0.936$), poor correlation between body mass index and pathology results ($r = 0.390$). The sensitivity and specificity for detection of liver steatosis in MRS fat fraction were 95.2% and 98.3%, respectively.

Conclusion. ^{1}H MRS fat fraction is a highly precise and accurate method in quantification of hepatic steatosis for the living donor and can be finished in a single breath-hold.

LIVER transplantation is the best treatment modality for end-stage liver disease [1]. Because of the shortage of deceased donors, living-donor liver transplantation (LDLT) has become a primary treatment method. The most important ethical concern about LDLT is donor safety, as it has both surgical and health risks. Hepatic steatosis quantification is critical for donor selection in LDLT because graft steatosis is associated with an increased risk of complications after liver transplantation for both donor and recipient [2]. Hepatic steatosis, which is a common finding in living liver donors, not only influences the outcome of liver transplantation for the recipient but it also affects the recovery of the living donor after partial hepatectomy [3]. Therefore, many noninvasive imaging analysis methods are used to quantify hepatic steatosis for preoperative living-donor evaluation [4].

This work was supported by a grant from the Ministry of Health and Welfare, Taiwan (MOHW104-TDU-B-212-124-004 to Chen CL), and health and welfare surcharge of tobacco products. and grant CMRPG8C0011 from the Chang Gung Memorial Hospital research grant, Taiwan, and a Chang Gung Medical Foundation Institutional Review Board. Taiwan approval has been obtained (101-3673B).

*Address correspondence to Yu-Fan Cheng, MD, Department of Diagnostic Radiology, Kaohsiung Chang Gung Memorial Hospital, 123 Ta-Pei Road, Niao-Sung, Kaosiung 833, Taiwan. E-mail: cheng.yufan@msa.hinet.net

360 Park Avenue South, New York, NY 10010-1710

0041-1345/16
http://dx.doi.org/10.1016/j.transproceed.2015.10.068

Medical imaging has progressed rapidly in recent years. Several noninvasive methods have been developed for quantification of fat content, one of those is acoustic structure quantification of ultrasonography, which allows detection of hepatic steatosis that is 10% or greater in living liver donors [5]. This new technique has increased sensitivity in quantification of hepatic steatosis [6]; but there is still need for more precise quantification for living donor selection. Dual energy computed tomography (CT) fat analysis provides a noninvasive technique for identifying hepatic steatosis and has strongly correlated with histopathologic results [7]. However, radiation exposure has become a major problem in CT. Another limitation in CT imaging is that occasionally, pathologic abnormalities of the hepatic parenchyma are encountered such as iron overload that can influence the hepatic attenuation [8], and lead to masking or underestimation of hepatic steatosis in CT images.

Magnetic resonance imaging is a highly sensitive tool for detection and characterization of fatty infiltration of liver. Magnetic resonance spectroscopy (MRS) has been used for detection and quantification of fatty infiltration in liver in recent years. MRS is one of the most accurate noninvasive techniques in assessment of hepatic steatosis. In this study, the investigators describe the 1-breath-hold stimulated echo acquisition mode (STEAM) hydrogen-1 MRS for quantification of hepatic steatosis; results are compared with liver biopsy results in the living liver donor.

MATERIALS AND METHODS

This prospective study was institutional review board – approved by the human research committee of our institution.

Patients

From March 2013 to May 2014, a total of 80 living donors (35 males and 45 females) underwent both pretransplantation MRS and intra-operative liver biopsy for liver fat quantification. Demographic characteristics and body mass index (BMI) were recorded. The mean age for all patients was 30.24 ± 7.7 years (range 18 years to 47 years). The BMI ranged from 16.4 kg/m^2 to 33.3 kg/m^2 with a mean value of 23.4 kg/m^2 and standard deviation of 4.1 kg/m^2.

Image Acquisition Technique

All the ^{1}H MRSs were performed on a 1.5-T MR scanner (Discovery 450; GE Healthcare, Milwaukee, Wisconsin, United States). A body coil was used for signal excitation and an 8-channel body-phased array coil was used for signal reception.

Breath-hold single-voxel MRS was acquired using the STEAM sequence. Voxel size was 2.0 cm^3 × 2.0 cm^3 × 2.0 cm^3. The breath hold T1-weighted in/out phase images were used to locate the voxels placed in segments 2–4, 5–8, and left lateral segment for each donor; visible blood vessels or bile duct structures were avoided. Acquisition parameters for MRS are with a repetition time of 2,500 ms, an echo time of 12 ms, 2 next, 4 number of scan in each acquisition. In all cases, the quality of the shimming obtained in the voxel was controlled by the spectral line width (full width of half maximum in Hz) of the unsuppressed water, obtained by the automated optimization sequence before scanning. No water suppression was applied to calculate the fat fraction of the liver. Total scan time was 21 seconds with a single breath-hold.

^{1}H MRS Post-processing

To estimate the liver fat fraction, all magnetic resonance spectra were analyzed with the spectral analysis program (SAGE 7.0; GE Healthcare) and performed with the same operator who has received spectrum analysis training. Post-processing steps include 8-channel signal combination, apodization, zero filling, Fourier transform, automated phase correction, and Marquardt curve fitting. The lipid signal peak was defined at 1.3 ppm, and the water was at 4.7 ppm. The signal fat fraction can then be given as the fat integral signal divided by the integral of the water and fat peaks areas.

Donor Biopsy

Zero-hour biopsy specimens were obtained by wedge resection during surgery; sampling location was different for each subject, depending on the graft donated. Two independent pathologists performed histological grading of macrovesicular steatosis. For severity of fatty change and the presence of lobular inflammation, results were reported as a quantitative evaluation of the percentage of hepatocytes.

Statistical Analysis

To determine the accuracy of the ^{1}H MRS fat fraction, pathology grading was used as the gold standard. Hepatic steatosis from pathology reports in this study were divided into four groups. Group 1 included specimens normal to <5% fatty liver. Group 2 included specimens with 5% to 10% fatty liver. Group 3 included specimens with 11% to 15% fatty liver. Group 4 included specimens with >15% fatty liver. For statistical analysis, the pathology data were divided into two groups: normal (0 to <5% fatty change) and fatty liver (≥5% fatty change).

The statistical analysis was based on independent paired Student *t* test. MRS fat fraction results were used to divide the subjects into two groups. Linear regression was used to detect the correlation between MRS fat fraction and pathology data. Receiver operating characteristic curve analysis was performed to analyze sensitivity and specificity for detection of steatosis in MRS fat fraction. Pearson correlation was used for the correlation among MRS fat fraction, BMI, and pathology data.

All statistical analyses were performed using SPSS 17.0 software (SPSS Inc., Chicago, Illinois, United States). A $P < .05$ was considered significant.

RESULTS

Eighty LDLT donors were evaluated for fatty liver change by use of both MRS and intraoperative biopsy. Pathology results showed no fatty content in 73.8% (n = 59), and fatty liver content in 26.2% (n = 21). Of those with fatty liver, there were 21.2% with 5% to 10% fatty liver (n = 17), 3.8% with 11% to 15% fatty liver (n = 3), and 1.2% with >16% fatty liver (n = 1).

Independent paired Student *t* test showed that ^{1}H MRS fat fraction was an excellent parameter to predict between normal and fatty liver groups (1.85% ± 0.98%, 8.13% ±