Comparison between spectroscopy based fat quantification and two imaging based water-fat separation methods for the diagnosis of diffuse liver disease

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Introduction

Magnetic Resonance techniques are increasingly being used for the diagnosis of diffuse liver disease. Especially the evaluation of hepatic fat with concurrent hepatic iron overload is of special interest. The purpose of our study was to compare fat quantification of the liver based on 1H spectroscopy and two different imaging based water-fat separation methods.

Materials and Methods

After approval by our local institutional review board a total of 64 patients were included in this study. All patients were referred to our radiology department as part of the standard diagnostic procedure for hepatic iron evaluation. MR imaging was performed on a 1.5T whole body MR scanner (Magnetom Avanto, Siemens, Erlangen, Germany). For the quantification of liver T2* values a fat saturated multi-echo gradient-echo sequence with 12 echoes (TR=200ms; TE=0.99ms + n*1.41ms, flip angle: 20°) was used in transversal orientation. During one breath hold one single slice was acquired at a location with maximum liver cross-section. T2* or R2* maps were calculated off-line based on a mono-exponential fit using ImageJ (1). For fat quantification an experimental multi echo T2 corrected single voxel spectroscopy sequence (Siemens work in progress 599B) as described by N. Pineda et al. (2) was used, (TR=3000ms, TE=12/24/36/48/72ms) which enabled the acquisition of water/lipid spectra in one single breath-hold (acquisition time: 15s). Spectra were obtained for one location in the right hepatic lobe, whereby care was taken to avoid the inclusion of large vessels. For imaging based fat quantification a conventional 2D spoiled gradient echo in-phase and opposed-phase (2D IOP) imaging sequence as provided by the manufacturer was used (TR=103ms, TE=2.37ms/5.05ms, flip angle: 70°). Fat-signal fraction (FSF) maps were calculated using ImageJ based on the equation $\eta = (IP-OP)/(2*IP)$. IP and OP values were corrected for T2* bias whereby only a single average T2* value obtained with the multi-echo sequence described above was utilized. In addition, an experimental 3D multi-echo gradient echo (VIBE-DIXON) sequence with multi-step adaptive fitting and correction for relaxation and the spectral complexity of fat as described by X. Zhong et al. (4,Siemens work in progress 798A) was applied. 6 different gradient echoes (TR=9.17ms, TE=1.03/2.3/3.57/4.84/6.11/7.38ms, flip angle: 5°) were acquired in a single breathhold (typical duration; 21s), delivering in-phase, opposed-phase, separated fat and water images, as well as R2* and fat percentage maps. All parameter maps were analyzed by placing of region of interests (ROIs) into different hepatic lobe segments, whereby for all sequences correlating ROIs were used and care was taken to avoid the inclusion of large vessels.

Results and Discussion

For the 64 investigated patients T2* values ranged between 1.2ms and 37ms (mean T2*: 15.3 +/- 8.7ms), whereby T2* was lower than 10ms (5) for 20 patients and between 18ms and 10ms for another 20 patients. The normal range of T2* values was considered to be above 18ms (3). The range and variability of observed T2* values proves the necessity of applying T2* correction for reliable fat quantification. Figure 1-3 show the obtained correlations between the different fat quantification methods. For the FSF data of the experimental SVS sequence and for the experimental 3D multi-echo VIBE-DIXON sequence, one extreme outlier each was observed, most likely due to severe motion during measurement, and was removed from the analysis. Without these two outliers excellent correlations between the data were found: r=0.85 between the multi-echo SVS sequence and the 2D IOP sequence; r=0.9 between the multi-echo SVS sequence and the 3D multi-echo VIBE-DIXON sequence and r=0.9 between the 3D multi-echo VIBE-DIXON sequence and 2D IOP sequence. Comparable values were found in earlier studies (6, 7) with lower number of patients and higher mean T2* values as in our study. Without removal of the outliers the correlation coefficients were r=0.76, r=0.53 and r=0.67, respectively. For the 2D IOP sequence slightly higher FSF values as compared to the SVS sequence were observed, which might be explained by different T1 bias, and/or missing correction for the spectral complexity of fat of the former.

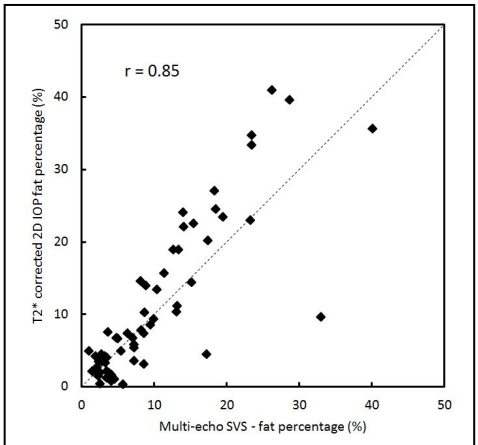

Figure 1: Correlation between FSF values obtained for the multi-echo SVS sequence and the 2D IOP sequence.

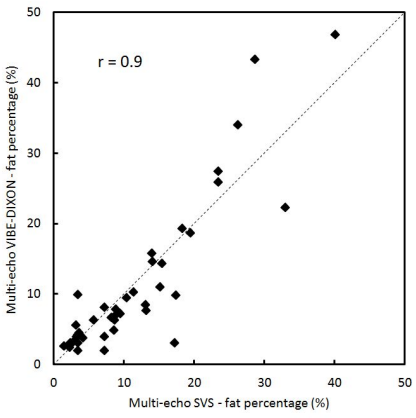

Figure 2: Correlation between FSF values obtained for the multi-echo SVS sequence and the 3D multi-echo VIBE-DIXON

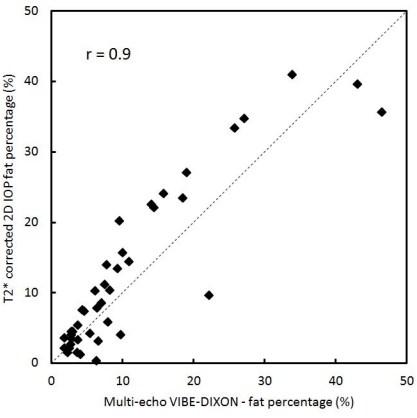

Figure 3: Correlation between FSF values obtained for the 3D multi-echo VIBE-DIXON sequence and the 2D IOP

Conclusions

In this study it is shown that for clinical purposes there is a good correlation between different fat quantification methods. In order to obtain reliable FSF estimates T2* correction is mandatory due to the wide range of T2* values observed in patients. For the used experimental multi-echo SVS and 3D multi-echo VIBE-DIXON sequences T2* values are determined and accounted for within the same measurement without the need of special off-line processing. This simplifies the routine application of these methods compared to the simple 2D IOP method, where a separate quantification of T2* and off-line processing has to be performed. Nevertheless, it was shown that even a simple T2* correction with global liver T2* estimates obtained from a few ROI measurements within a representative liver region seems to enable reliable FSF results.

References

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