Liver iron content measurement using quantitative susceptibility mapping

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TARGET AUDIENCE: Researchers interested in quantification of fat, iron and magnetic susceptibility (QSM) in the liver.

PURPOSE: The liver is known to allow various degrees of iron (hemochromatosis) and triglyceride (steatosis) accumulation, which affect the MRI signal. Iron deposition is normally evaluated via R2* mapping [1]. However, R2* provides only an indirect measure of the iron content, which is relevant for liver disease treatment. By capitalizing on the difference between iron and fat susceptibilities, quantitative susceptibility mapping (QSM) may be used for the characterization of liver iron content [2].

METHODS: 1) Data acquisition: With IRB approval and informed consent, 8 healthy volunteers were scanned on a 1.5T MRI system (GE Excite HD, Milwaukee, WI), using an 8-channel cardiac coil and a 4-echo flow-compensated spiral sequence (TE = 0.6ms, ΔTE = 6.6ms, 4 echoes, TR = 25 ms, FA=30°, BW=±62.50 kHz, 48 spiral leaves, breath hold ~45 seconds and voxel size = 1.4×1.4×3mm³). As a comparison, the 2D multi-echo SPGR sequence that is currently used in our clinical practice for the estimation of R2* and iron content was performed as well. Imaging parameters were TE = 1.3ms, ΔTE = 1.5ms, 16 echoes, TR = 28 ms, FA = 20°, BW=±62.50 kHz, 5 slices. 2) Total susceptibility field estimation: A linear fitting of the signal phase was performed as a first step. Discontinuities in the field map between neighboring voxels caused by chemical shift were detected by searching for field differences of approximately \( n/\Delta\text{TE} + m f_1 \), where \( f_1 \) is the assumed chemical shift, \( n \) is an integer and \( m = 0 \) or 1. Both of these steps were repeated with a magnitude-guided field unwrapping process.

DISCUSSION AND CONCLUSIONS: The algorithm successfully reconstructed a susceptibility map in the liver, while minimizing the number of streaking artifacts typical for incomplete solutions of QSM. Features of interest, such as hepatic veins and portal vessels were well visualized, while liver susceptibility was found to correlate with liver R2*. Unfortunately, due to the limited number of volunteers, the correlation between liver R2* values and liver susceptibility relative to subcutaneous fat (A) and back muscle (B) was not significant (p<0.01).