Signal Intensity Ratio between Liver and Muscle Reference in Highly Iron Overloaded Patients: comparing 1.5 T to 3 T

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Target Audience. Clinicians and scientists interested in MRI based liver iron content (LIC) determination with simple data analysis.

Purpose. To study signal intensity ratio (SIR) between liver and paraspinal muscle in iron overloaded patients at 1.5 vs. 3 T and its dependence on Liver Iron Content (LIC).

Theory. It can be shown that the logarithm of SIR between liver and muscle tissue depends linearly on the R_2* difference of both tissues. Since liver R_2* is a linear function of LIC, the same is expected for R_2* difference and therefore the logarithm of SIR.

Methods. 71 highly transfused patients with liver iron overload were enrolled in the study approved by our ethics committee. After giving informed written consent, 37 patients (age 8 … 75 years, mean age 26 y) were scanned at 1.5 T (Siemens Avanto), 48 patients (age 8 … 72 years, mean age 28 y) were examined at 3T (Siemens Skyra). This means that 14 patients were scanned at both scanners. Breathhold RF spoiled GRE sequences were performed with TE/TR 4.76/120 ms at 1.5 T and 2.5/250 ms at 3 T. All protocols were acquired with four flip angles (FA) of 20°, 30°, 50° and 90°. Note that TEs were chosen for fat and water signal to be in phase. Signal intensity values were measured as median of voxel intensities in three manually drawn regions of interest (ROI) in the liver and two in paraspinal muscles as described in [1]. Ratio of median ROI signal intensity in liver to muscle was calculated to give SIR.

For all 71 patients, five single-echo spin echo sequences with different TE were acquired at 1.5 T for commercial analysis (Ferriscan®, cf. [2]). Results are referred to as LIC in the following. Patients exceeding the upper limit for this method (769 mmol Fe/kg liver dry tissue) were excluded.

Dependence of SIR on LIC was determined by evaluating R² for linear correlation between ln (SIR) and LIC. Also, corresponding p values were calculated.

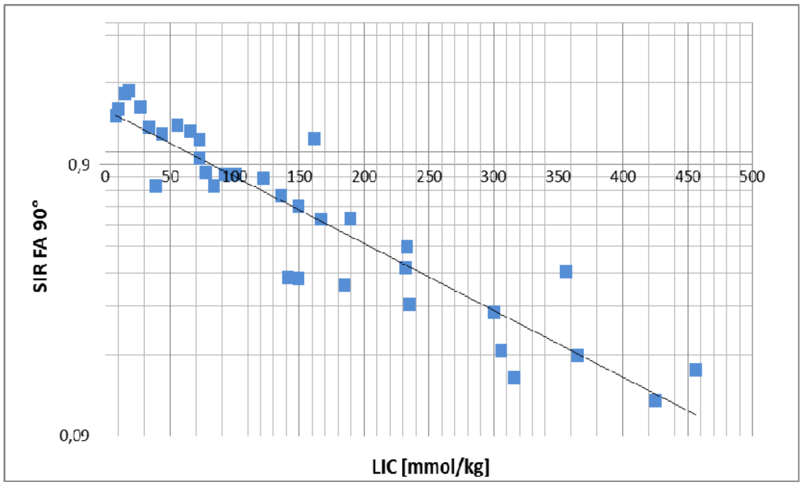

Fig. 1. SIR (logarithmic scale) vs. LIC for 1.5 T at FA 90°. The solid line shows the linear regression between ln (SIR) and LIC.

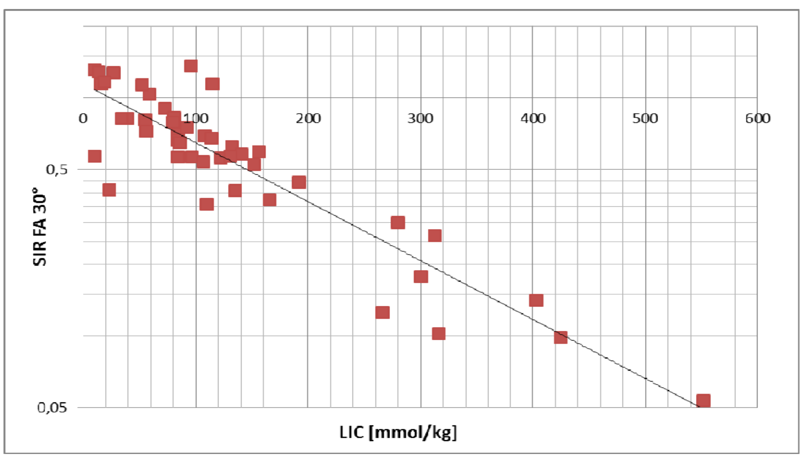

Fig. 2. SIR (logarithmic scale) vs. LIC for 3 T at FA 30°. The solid line shows the linear regression between ln (SIR) and LIC.

Results. Two patients exceeded the limit for LIC determination and were excluded. As expected from theory, ln (SIR) shows a linear dependence on LIC (Fig. 1,2) for both field strengths at a significance level $p<0.001$. R² was best for 90° with R²=0.85 at 1.5 T and 30° at 3 T with R²=0.83.

Discussion.. We were able to show that the SIR method proposed by Gandon [1] has the potential for reliable LIC determination with no substantial difference between field strengths of 1.5 and 3 T. Median value of ROIs was taken to minimize influence of liver vessels sometimes hardly seen due to partial volume effects. This was a methodological deviation from [3] where mean ROI values were taken and deviations from linearity were observed at LIC above 300 mmol/kg. Therefore, we now hypothesize that taking median value of voxels within an ROI has advantages over mean value. This effect has to be studied further using data from identical patients.

Conclusion. Using the SIR analysis for GRE data and its theoretic dependence on LIC, we were able to show that this approach avoiding complex mathematics performs equally at 1.5 and 3 T. We see good chances to determine LIC from GRE acquisitions with SIR.

References. 1. Y. Gandon et al.: Non-invasive assessment of hepatic iron stores by MRI. Lancet 2004; 363: 357–62
2. T. G. St. Pierre et al.: Noninvasive measurement and imaging of liver iron concentrations using magnetic resonance. Blood 2005; 105 (2): 855-61
3. A. Wunderlich et al.: Liver Iron Content determined with minimal MR scan time. Proc. 19th ISMRM (2012)