

Liver Iron Content determined with minimal MR scan time

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Purpose. To establish an MR method for determining liver iron content (LIC) with minimal scan time.

Methods. 173 patients (age 2 ... 88 years, mean age 28.8 y) suspected for liver iron overload were examined by MRI to evaluate the amount of LIC. All examinations were performed at 1.5 T. Gradient echo (GRE) sequences were acquired according to the protocol published by Gandon et al [1] and the supplementary protocol for higher LIC by Rose et al. [2]. Furthermore, examinations with spin echo (SE) were performed with a protocol proposed by St. Pierre et al. [3] which served as reference. Spin echo data was analyzed using a sophisticated method [ref. 3 and references cited there] based on calculation of T_2 relaxation time. This method is FDA approved under the name Ferriscan®. For evaluation of GRE data, signal values were measured in manually drawn circular regions of interest (ROIs) in vessel-free parts of the liver and in the paraspinal muscles. After calculating the ratio of liver signal and muscle reference value (L/M ratio), multiple linear regressions were performed. The best relation between L/M ratio values and reference LIC was determined by means of correlation analysis and linear regression. The SE methods has an upper limit of 769 $\mu\text{mol/g}$ liver dry tissue, so patients with values of more than 750 $\mu\text{mol/g}$ determined from SE data were excluded from analysis.

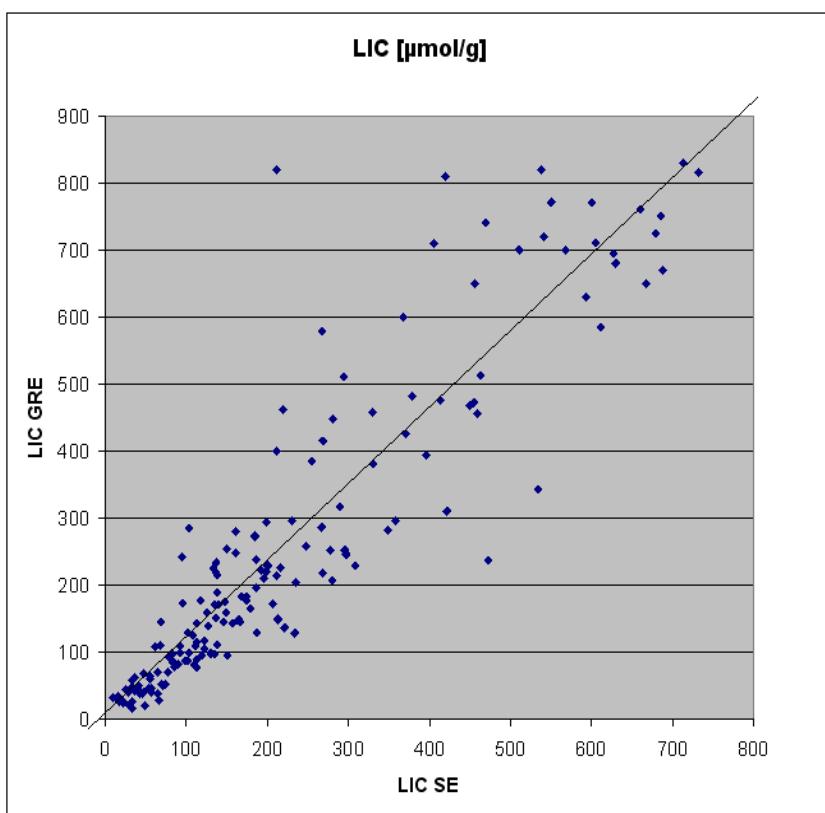


Fig. 1. Liver iron content in $\mu\text{mol/g}$ liver dry tissue determined with GRE vs. SE. The solid line indicates linear regression between both methods.

It can be stated that with our modification we can now differentiate more reliably between mild (up to 90 $\mu\text{mol/g}$) and moderate or severe liver iron overload which is of interest for disease management. This improvement is achieved using only three MR sequences. Initial therapy success in highly iron overloaded liver patients can be satisfactorily monitored with the appropriate protocol.

References.

1. Y. Gandon et al.: Non-invasive assessment of hepatic iron stores by MRI. Lancet 2004; 363: 357–62
2. C. Rose et al.: Liver iron content assessment by ... magnetic resonance imaging procedure in highly transfused patients. Eur J Haematol 2006; 77: 145–149
3. T. G. St. Pierre et al.: Noninvasive measurement and imaging of liver iron concentrations using proton magnetic resonance. Blood 2005; 105 (2): 855–61
4. Jensen et al.: Separate MRI Quantification of Dispersed (Ferritin-like) and Aggregated (Hemosiderin-like) Storage Iron. MRM 2010; 63:1201–1209
5. A. Wunderlich et al.: Estimation of Liver Iron Content with Spin-Echo vs. Gradient-Echo Sequences. Proc. 17th ISMRM (2010)
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Results. A combination of three GRE sequences shows the best correlation for the whole range of LIC values covered by our patient group (cf. Fig. 1). These are the protocol proposed by Rose et al. with a TE of 1.8 ms and two of Gandon's sequences, both with a TE of 4.8 ms. Correlation analysis gives $r=0.91$, and regression analysis yields a slope of 1.14 with an intercept of 5.4.

Discussion. While mild and moderate iron overload of up to 350 $\mu\text{mol/g}$ can be handled with echo times where water and fat signal are in phase (multiples of 4.8 ms at 1.5 T), shorter TE values have to be used to evaluate higher iron overload. This causes sensitivity to fatty liver and may account for deviations observed in the high LIC regime (LIC > 350 $\mu\text{mol/g}$). The deviations for LIC values between 200 ... 350 $\mu\text{mol/g}$ may arise from different sensitivity of SE and GRE to contributions of aggregated vs. dispersed iron as pointed out by Jensen et al [4]. These effects can be addressed with multi-echo SE sequences. For low LIC values up to 300 $\mu\text{mol/g}$, we found a relation using only one GRE acquisition which yielded good correlation similar to the values above (data not shown).

In addition to our previous work [5], we were able to improve the correlation between GRE and SE by modification of published analysis methods. Our approach was similar to that of Alustizia et al. [6], but the relation proposed by him did not work well in our patient cohort.