Estimation of Liver Iron Content with Spin-Echo vs. Gradient-Echo Sequences

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Purpose. To compare two methods for noninvasively estimating liver iron content (LIC).

Methods. Thirty patients 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]. Furthermore, examinations with spin echo (SE) were performed with a protocol proposed by St. Pierre et al. [2]. For evaluation of GRE data, signal values are measured in manually drawn circular regions of interest (ROIs) in vessel-free parts of the liver and in the paraspinal muscles. Calculating the ratio of muscle reference value and liver signal, LIC can be estimated according to [1]. Spin echo data is analyzed using a more sophisticated method [ref. 2 and references cited there] based on calculation of T_2 relaxation time. For each patient, LIC values were compared. Since the GRE methods has an upper limit of 350 mmol/kg liver dry tissue, patients with values of more than 300 mmol/kg (calculated using GRE data) were excluded from analysis.

Results. Both methods correlate moderately with r=0.88. Taking into account patients with a LIC value below 230 mmol/kg determined from GRE data, this value even increases to r=0.92. However, the values do not correspond: in the range of 50…100 mmol/kg (determined with SE) the GRE values are around 100…200 mmol/kg, whereas in the range of 150-250 mmol/kg (evaluated from SE data) GRE data yield values of 250...300. Since nearly all dots in Fig. 1 are above the bisector line, GRE overestimates LIC.

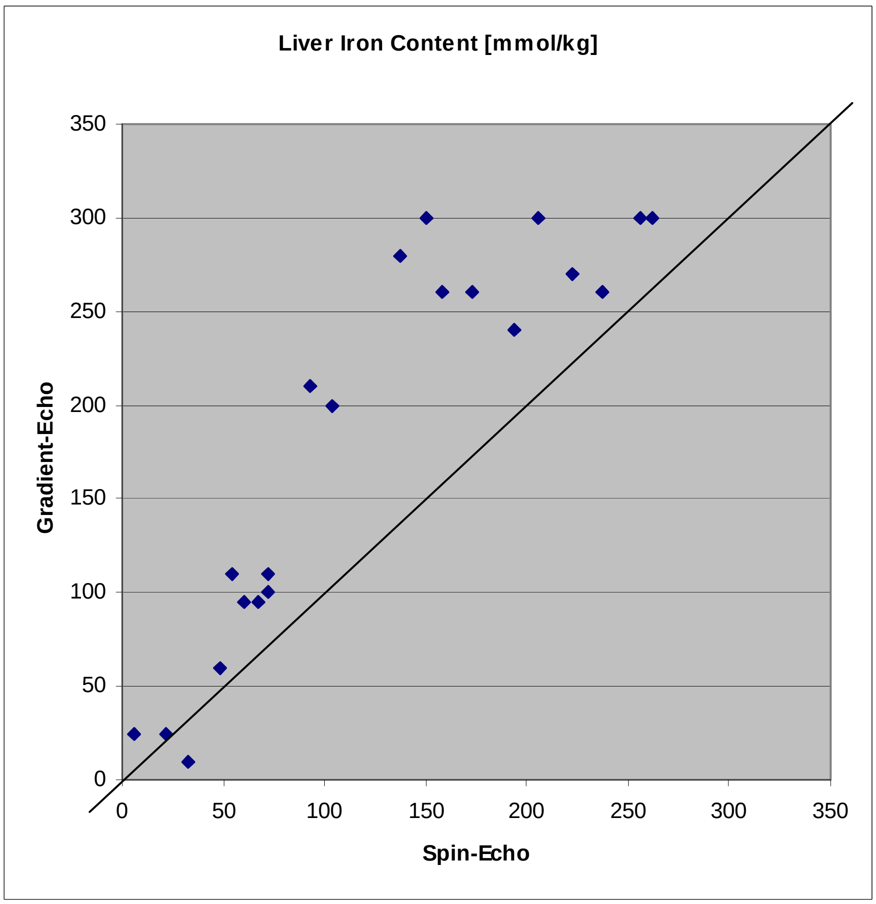

Fig. 1. Liver iron content in mmol/kg liver dry tissue determined with GRE vs. SE. The bisector line indicates identical results.

Discussion. Iron distribution in the liver is highly non-uniform on different length scales [3]. The distribution depends also on the reason for iron overload: the mechanism observed in primäry hemochromatosis differs from those in secondary transfusional hemosiderosis.

Both methods for LIC determination investigated in this work are accepted and publicly available. However, the proposed sequences address different aspects of LIC. SE refocuses spins subject to different local magnetic field strengths whereas GRE does not. Therefore, signal loss in GRE is dominated by spins around large iron compartments whereas the signal of these spins is conserved in SE acquisitions. Signal loss in SE is caused by spin-spin-relaxation and by non-stationary spins, e.g. spins diffusing around microscopic iron particles. This means that the results of the methods are difficult to compare. The SE method requires a long measurement time of 16 minutes whereas GRE can be done in a few breathhold acquisitions with paraspinal muscles as internal reference and therefore is more easily accessible in every days routine.

It can be stated that both methods are suitable for a rough estimation of LIC and to differentiate between mild (up to 90 mmol/kg) on the one hand and moderate or severe liver iron overload on the other for most of our patients which is of interest for disease management. In general, GRE tends to overestimate LIC.

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 proton magnetic resonance. Blood 2005; 105 (2): 855-61

3. Ghugre et al.: Mechanisms of Tissue–Iron Relaxivity: Nuclear Magnetic Resonance Studies of Human Liver Biopsy Specimens. MRM 2005; 54: 1185-93