MR-VOLUMETRY OF THE LIVER AND THE SPLEEN IN CORRELATION TO LIVER IRON CONCENTRATION DETERMINED BY MRI-R2* AND BIOSUSCEPTOMETRY

Sarah Keller[1], Björn Schönnagel[1], Charlotte Pfeifer[1], Zhiyue Jerry Wang[2], Roland Fischer[3], Christoph Berliner[1], Moritz Brehmer[1], Gerhard Adam[1], and Jin Yamamura[1]

[1]Diagnostic and Interventional Radiology, University Medical Center Hamburg-Eppendorf, Hamburg, Hamburg, Germany, [2]Department of Radiology, Children's Medical Center Dallas, Dallas, Tx, United States, [3]Department for Biochemistry, University Medical Center Hamburg-Eppendorf, Hamburg, Hamburg, Germany

Target Audience

Clinicians dealing with chronic and acute hematological and gastroenterological diseases, which require frequent follow up examinations of organ involvement to evaluate disease progression or response to medical treatment.

Introduction/Purpose

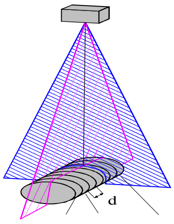
In many diseases, liver and spleen size assessment is an important task of clinical examination. Especially in patients with iron loading anemias such as thalassemia or with genetic hemochromatosis, a precise volume estimation of these main iron storage organs is essential for evaluating the total body iron load and the efficacy from iron depletion therapy. Patient with iron loading diseases usually need regular blood transfusions. The consequence of this therapy is an increased iron accumulation in a variety of organs, especially in the liver. Due to the increased iron stores, first in the macrophages of the reticuloendothelial system and then after redistribution into the parenchymal cells, these patients eventually develop hepato- and splenomegaly. The purpose of this study was 1.) to investigate the accuracy of liver volumen measurements using MR-volumetry and ultasonic planimetry and 2.) to correlate liver volume with liver iron concentration assessed with MR-R2* relaxometry in patients with iron overloading diseases.

Material and Methods

46 patients with iron overloading diseases were examined. Subsequently to cardiac iron measurements, breathhold retrospective ECG-gating on a 1.5T MRI was applied. For liver iron measurements, a mid-vertebral slice (thickness = 10 mm, pixel resolution 1.25x1.25 mm^2) was selected covering the major part of the liver, spleen, and bone marrow. All MRI-scans were performed as breathhold prospective ECG gated MRI sequences with data from typically 9 heartbeats in end-diastole on a 1.5 T imager (Siemens) with 12 bipolar echo times TE= 1.3 to 25.7 ms (□t= n·1.16 ms, TR = 244 ms, flip angle = 20°, band width 1955 Hz/pixel). The signal averaging used the fit method (Marquardt algorithm) to derive R2* from the model function,

$$S(TE) = S(0)\cdot EXP(-R2^*\cdot TE) + SLO$$

with the signal amplitude (S(0)) and signal level offset (SLO). The in-vivo liver iron concentration (LIC) was assessed by the biomagnetic liver susceptometry (BLS) used as reference method. Besides the MR-volumetry, ultra-sound (US) based volumetry was also performed.



Single Liver Volume was defined as:

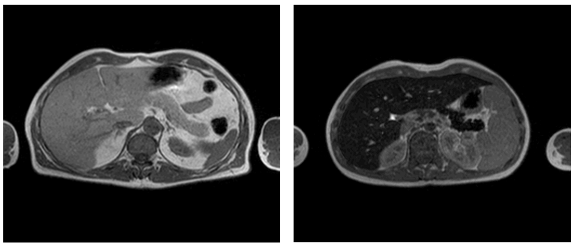
$$V_i = d * A_i$$

Where d = thickness of the slices and

A_i= surface area

In order to calculate the total liver Volume:

$$V = d * (A_1 + A_2 + \ldots A_n)$$



Normal: LIC = 180 µg/g-liver Thal. Maj.: LIC = 2270 µg/g Liver

Signal intensity data were assessed by CMRtools (Cardiovascular Imgaing Solutions Ltd). Cardiac and liver ROI based R2* were determined in the interventricular septum of a mid-papillary short axis slice and in a mid-vertebral slice covering the whole liver. A mono-exponential model for the proton signal intensities as function of echo time T_E was applied. In order to fit the unknown signal amplitude SI (T_E=0), the transverse relaxation rate R_2*, and the constant signal level offset SI_o. Levenberg-Marquardt algorithm was used for curve fitting:

$$SI(T_E) = SI(0)\cdot \exp(-R_2^*\cdot T_E) + SI_o$$

Statistical analysis:

Linear regression was performed to estimate the relationship between the iron loading within the liver and the voulme. The relationship between volume measurement (US and MRI) and hepatic iron loading was estimated by Spearman correlation.

Results

LIC was between 57-7681mg/g wet-weight (median 1718□g/g). The Spearman-Rank-Correlationcoefficient was rs= 0.94 ($p<10^{-4}$) with a highly significant correlation between LIC-BLS and MRI-R2*. The median volume of the liver measured with US was 1593cm^3 (range 604-3216cm^3) and that of the spleen 366cm^3 (range 50-930cm^3), and correlated significantly with MR volumetry (rs= 0.85, p<10-3 and rs=0.88, $p<10^{-3}$) (**Figure 1**). A significant correlation of rs=0.32 (p=0.006) between liver volume and R2* was given **(Figure 2)**, whereas there was no significant correlation between the volume and R2* in the spleen.

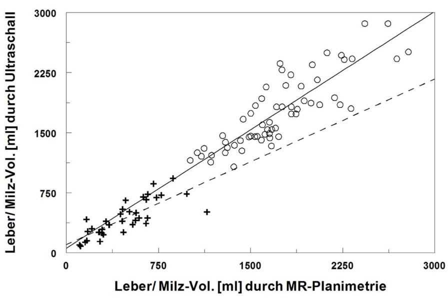


Figure 1

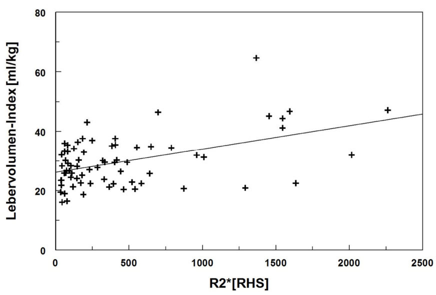


Figure 2

Discussion/Conclusion

There was a correlation between hepatomegalie and iron concentration within the liver. The liver seems more affected by iron overload than the spleen. Both the hepatosplenomegalie and iron overload can be adequately assessed with MRI. Hepatomegalie could be the first sign of iron accumulation within the liver. **Key words:** T2*, R2*, Iron, Relaxometry, MR-Volumetry, Liver