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

Sarah Keller1, Bjorn Schönagel1, Charlotte Pfeifer1, Zhiyue Jerry Wang2, Roland Fischer3, Christoph Berliner1, Moritz Brehmer1, Gerhard Adam4, and Jin Yamamura1

1Diagnostic and Interventional Radiology, University Medical Center Hamburg-Eppendorf, Hamburg, Hamburg, Germany. 2Department of Radiology, Children’s Medical Center Dallas, Dallas, Tx, United States. 3Department 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 volume measurements using MR-volumetry and ultrasonic planimetry and 2.) to correlate liver volume with liver iron concentration assessed with MR-R2* relaxometry in patients with iron overloadng diseases.

Material and Methods
46 patients with iron loading 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 mm²) 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 ( = 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 suscceptometry (BLS) used as reference method. Besides the MR-volumetry, ultra-sound (US) based volumetry was also performed.

Single Liver Volume was defined as:

\[ V_i = d \cdot A_i \]

Where \( d \) = thickness of the slices and \( A \) = surface area

In order to calculate the total liver Volume:

\[ V = d \cdot \left( A_1 + A_2 + ... A_n \right) \]

Results
LIC was between 57-7681 mg/g wet-weight (median 1718 g/g). The Spearman-Rank-Correlation coefficient was \( r_s = 0.94 \) (p<10⁻⁴) with a highly significant correlation between LIC-BLS and MRI-R2*. The median volume of the liver measured with US was 1593 cm³ (range 604-3216 cm³) and that of the spleen 366 cm³ (range 50-930 cm³), and correlated significantly with MR volumetry (rs=0.85, p<10⁻³ and rs=0.88, p<10⁻⁴) (Figure 1). A significant correlation of \( r_s = 0.32 \) (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.

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