

MRI susceptibility measurement of hepatic iron concentration: demonstration of feasibility

Z. Chu^{1,2}, B. U. Mueller^{1,2}, D. H. Mahoney^{1,2}, K. L. McClain¹, S. J. Harpen^{1,2}, R. Muthupillai^{1,3}, T. Chung^{1,2}, R. Krishnamurthy^{1,2}, Z. J. Wang^{1,2}

¹Baylor College of Medicine, Houston, Texas, United States, ²Texas Children's Hospital, Houston, Texas, United States, ³Clinical Science, Philips Medical Systems, Cleveland, Ohio, United States

Introduction:

Managing iron-chelation therapy in an iron-overloaded patient requires accurate assessment of the hepatic iron concentration to avoid the adverse effects of excess chelator administration. The susceptibility measurement of the liver is considered as a direct measurement of hepatic iron concentration [1]. The MRI susceptometry has been validated with phantom studies, and has also shown a reasonable iron level in normal control subjects [2-4]. In patients, particularly in pediatric patients, it is difficult to estimate the phase change along the vessel in the presence of respiratory motion. Real-time navigator guided acquisition has been an effective tool in combating respiratory motion. The purpose of this work is to test the feasibility of applying real-time navigator guided MR acquisition to measure liver susceptibility in pediatric patients without the need for breathholding.

Material and Methods:

The study was approved by the Institutional Review Board, and informed written consent was obtained from all subjects. All measurements were done at 1.5T using a 4 element surface coil for signal reception. The sequence consisted of three modules, a T2 preparation pulse, a navigator pulse, and a segmented T1 weighted gradient echo readout (T1-TFE). Data acquisition occurred in diastole: FOV=288*230.4 mm, acquisition voxel =1.5*1.5*1.5 mm, TR/TE=7.1/4.0 ms and flip angle = 30. Immediately preceding the T1-TFE module, a 2d-selective RF pencil beam (diameter 3.0 cm) was used to monitor the motion of lung-diaphragmatic interface due to respiration, and any TFE data acquired within 3 mm of the mean diaphragmatic position was accepted. If data acquisition fell outside this acceptance window, the data was rejected and reacquired. The acquisition proceeded until all necessary phase encoding steps were acquired. The navigator beam excitation was specifically modified for this application to get sufficient signal in the patients with severe iron loading. The navigator beam diameter was increased to 5.0 cm and 2DRF cycles were decreased from 16 to 6 or 8. In addition, the T2 preparation duration was reduced from 70 msec (for patients with low or normal iron loading) to 20 msec for those with severe iron loading. This offered a right tradeoff between having minimal partial volume effect and sufficient signal necessary for reliable phase estimation. The raw data was saved and transferred to Sun Blade 1000 for post-processing by the home-developed software written in IDL. The phase map image was generated from a dataset collected from the coil element that is the closest to the liver. The background phase caused by an inhomogeneous field was calculated by a 3D complex curve fitting within the liver volume. The centerline of vessel was semi-automatically traced by using internally developed seed growing software [5].

Results:

The reduction of echo time of T2 preparation significantly increases tissue signal with slight decrease of contrast between vessel and tissue. With adjustment of TE' the susceptibility measurement extended to the heavily iron overloaded patients with about 19.0 Fe mg /g dry tissue. Datasets with acceptable levels of motion artifact have been successfully acquired from 5 patients (1 male and 4 female, age range 7 to 19 years, median age 9 years). Three patients had sickle cell disease, one had thalassemia and one had Blackfan Diamond syndrome. The susceptibility vs. biopsy results are shown in figure 1. The MRI measurement is linearly correlated with the biopsy result (n=5, r=0.964).

Conclusion:

The study demonstrates the feasibility of measuring hepatic magnetic susceptibility in patients with iron overload. In the future a large sample size will be studied in order to increase the statistical power and to test the clinical potential of this non-invasive technique.

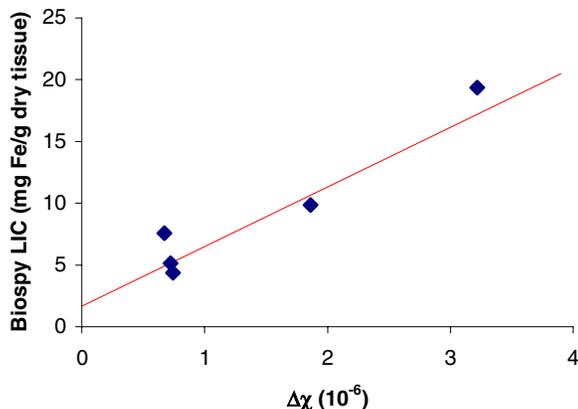


Figure 1. Correlation of MRI liver susceptometry and biopsy determined liver iron concentration. All biopsies were performed within 4 months of the MRI measurement (n=5, r = 0.964).

Reference:

1. G.M. Brittenham, et al., N Engl J Med 307 (1982), 1671-1675
2. Z. Chu, et al., MRM. 52 (2004) 1318-27.
3. Z.J. Wang, et al, in Proceedings of the 9th international conference on oral chelation. 199. Hamberg, Germany.
4. Z. Chu, et al, Proceedings of ISMRM, 2003, p998.
5. Z. Chu, et al, Proceedings of ISMRM, 2004, p2219.