Multi-echo R2* Technique in the Quantification of Hepatic Iron

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Background

Quantification of liver iron has been previously demonstrated using T2* weighted gradient-recalled echo (GRE) sequences and calculation of signal intensity ratios to other structures [1]. This approach is based on the relative increase in T2 or T2* relaxation rate seen with increasing hepatic iron. More recently investigators have evaluated a multi-echo T2* technique for cardiac thalassemia [2]. The purpose of this abstract is to review our preliminary experience in the performance of an R2* mapping sequence in the liver for quantification of hepatic iron where R2* = 1/T2* and is proportional to the iron concentration; higher iron levels correspond to larger R2* values. We will review the technique, show examples and discuss limitations in imaging of the liver.

Methods

Five normal volunteers, two patients with thalassemia and one patient with mild hemochromatosis (3307 ug/g dry weight of liver) underwent imaging of the liver with an R2* mapping sequence at 1.5T on a GE Signa LX 1.5 T EXCITE system using a multi-echo GRE sequence (mfgre) capable of acquiring up to sixteen echoes (TE of 2.4-65.4 msec) in a single breath-hold. Two patients also underwent imaging on a Signa LX 3T scanner to assess field strength related differences. Patients were scanned with a torso phased array coil with the following parameters: TR of 175msec, 10 mm slice thickness, 192 x 128 matrix, a 45^0 flip angle, and a bandwidth of ±32 kHz. R2* maps were generated by fitting the pixel data at each TE time to the function $s(n) = s0 * \exp(-TEn * R2^*)$ where n is the echo number and TEn is the corresponding echo time. Regions of interest were drawn over the right lobe of the liver and the cursor was placed over liver parenchyma to avoid inclusion of blood vessels and areas of susceptibility artifacts. Three R2 * measurements were calculated and averaged.

Results

The R2* values were 30.4-47.7 Hz for normal volunteers, 326.3-367.4 Hz for the patients with thalassemia and 113.3-133.4 Hz for the patient with hemochromatosis. Patients with hemochromatosis and thalassemia had higher R2* values than those without any history of liver disease. For the two cases done at 3T, R2* values increased by 75% and 123% compared to 1.5T. Limitations with the technique included susceptibility artifacts that occurred at air-liver (lung, bowel) interface, and the limited coverage in the z-axis.

Discussion and Conclusion

In this small feasibility study, our multiecho R2* mapping sequence demonstrated increased R2* values in the liver in patients with clinically suspected or confirmed elevated hepatic iron concentration in comparison to normal volunteers and the values as expected showed a nearly linear increase at 3T. This is a promising technique to obtain rapid quantification of liver iron in a single breath-hold. The R2* maps are independent of local signal variations due to surface coil penetration but are sensitive to susceptibility effects. The reproducibility of these measurements and accuracy compared to gold standard histologic assessment will need to be confirmed in larger studies. In the future, this technique may be able to replace diagnostic liver biopsies and be used for follow-up studies after treatment.

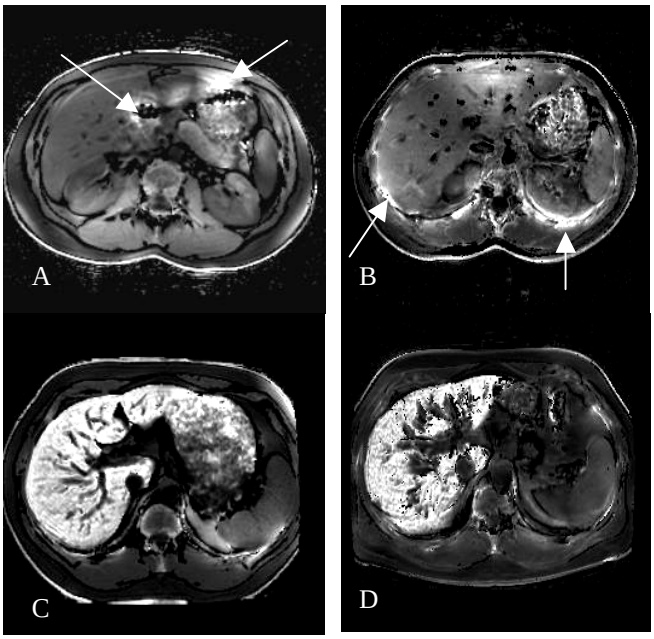

Figure 1. Examples of R2* maps in a normal volunteer at 1.5T (A) and 3T (B).
For comparison, note the higher signal intensity (R2*) in a patient with hemochromatosis at 1.5T (C) and 3T (D). Note the susceptibility artifact (arrows) at the interface of the liver and the air-filled stomach (A) and lung (B).

References

1. Bonkovsky HL, Rubin RB, et al. Hepatic Iron Concentration: Noninvasive Estimation by Means of MR Imaging Techniques. Radiology 1999; 212: 227-234.
2. Anderson LJ, Holden S, Davies B et al. Cardiovascular T2* magnetic resonance for the early diagnosis of myocardial iron overload. Eur Heart J 2001; 95: 1229-1236