

Quantitative assessment of iron overload in liver of patients with thalassemia major using ultra-short T2*

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Background: Iron accumulation in organs such as heart and liver can cause morbidity and mortality in transfusion-dependent patients with β -thalassemia major. MRI T2* relaxometry has been increasingly used in clinical practice for quantitative assessment of iron overload in heart and liver. For a heavily iron loaded liver, T2* is ultra-short (<1ms). In this scenario, conventional gradient echo sequence is limited because the initial echo time (TE) and echo spacing are usually more than 1ms due to hardware limit. Ultra-short T2* (<1ms) measurement would give more accurate assessment of iron deposition in the liver, which can lead to improved diagnosis and optimized iron-chelation treatment of patients in need.

Methods: All studies were conducted on a 1.5T MRI scanner (Siemens Avanto) with a cardiac phase array coil. The newly developed sequence was obtained by minimizing duration of RF pulse and shortening the ramp times and duration of field gradients. This sequence was tested on a dedicated phantom and then compared with a validated conventional T2* sequence. The phantom consists of 13 bottles with various concentrations of MnCl₂ ranging from 0.05mM to 24mM. The initial echo time was reduced to 0.8ms and echo spacing to 0.6ms for the new sequence. All remaining parameters were close to the conventional sequence.

Liver images were acquired from 7 patients with thalassemia major. The conventional and the optimized sequences were used for patient scan each within a breath-hold. Echo spacing of 1.9ms was used for the conventional sequence and 1ms for the optimized one. The rest of the parameters were kept the same for both sequences. A typical acquisition time was 15ms.

All data were analyzed using FDA approved Thalassemia Tools (www.cmrttools.com) where T2* were measured using a truncation model (1). R^2 was used for representing the goodness of fitting, and paired t-test was conducted to test for agreement between two measurements.

Results and discussion: For phantom study, the new sequence was able to measure T2* values of all 13 bottles while the conventional sequence failed to measure 2 of the bottles. Example image and T2* curve fitting for the last bottle was shown in Fig. 1. The curve did not fit using the conventional sequence even after truncation (Fig. 1, a) while a reasonable fitting was obtained using the new sequence, Fig. 1, (c) (R^2 of 0.99).

Similar to the phantom study, liver T2* measurement using the optimized sequence demonstrated an improved curve fitting (figure 2). According to the paired t-test on patient studies, there is no significant difference between measurements using the new and conventional sequences (P = 0.13).

Figure 1: (a) Phantom data fitting using the conventional sequence. (b) Corresponding image showing ROI in green. (c) The same phantom data fitting using the optimized sequence.

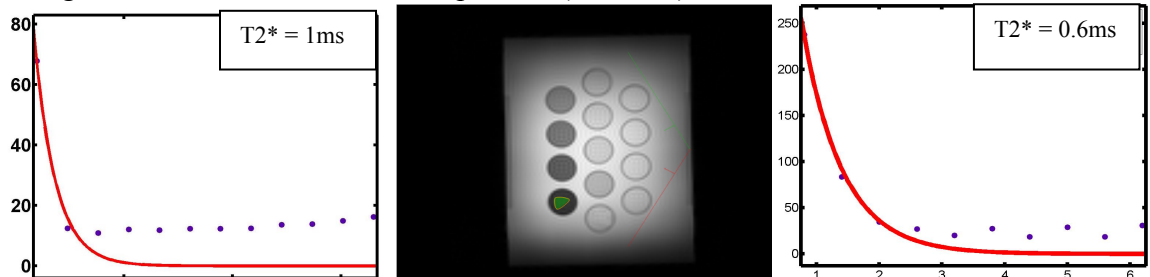
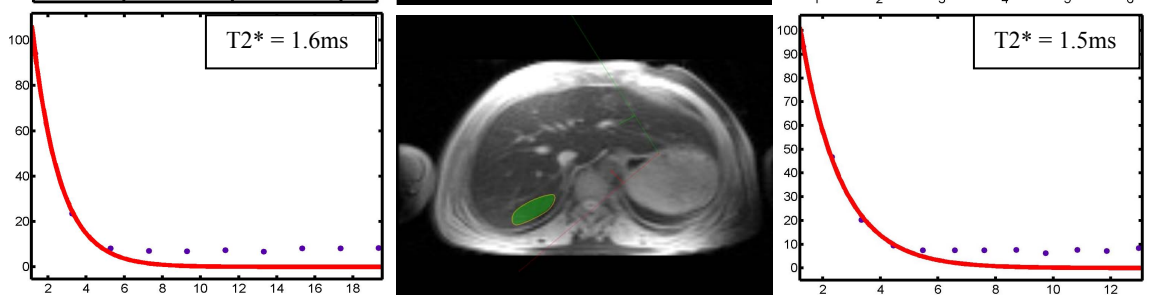


Figure 2: (a) Liver data fitting using the conventional sequence. (b) Corresponding image showing ROI in green. (c) The same liver data fitting using the optimised sequence.



Conclusion: This work has demonstrated the feasibility of measuring ultra-short T2* values in phantoms and in liver of patients with thalassaemia major by an improved multi-echo gradient echo sequence. The sequence needs further validation with more clinical studies.

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Reference: 1. He T, et al. Myocardial T2* measurement in iron-overloaded thalassemia: An ex vivo study to investigate optimal methods of quantification. MRM 2008; 60: 350-356.