Optimization of T2 and T2* Measurement in Myocardium at 3.0 T

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INTRODUCTION

High field clinical scanners are increasingly available to researchers and clinicians and possess a significant SNR advantage over 1.5T scanners. New accelerated imaging techniques designed to optimize spatial and temporal acquisition may allow researchers to detect subtle changes in myocardial tissue, including changes that may be indicators of differences in oxygen utilization such as variations in T2 and T2*. In pursuit of this goal, we developed optimized breath hold scans to measure T2 and T2* in the myocardial septum at 3.0T.

METHODS

Seven healthy volunteers underwent safety screening and provided written informed consent. Subjects were imaged using a 3.0T MR scanner with a six-channel cardiac imaging coil (Philips Achieva 3T, Philips Medical Systems). Black-blood double-inversion preparation was used prior to late diastolic image acquisition to null signal from blood in the ventricles. To facilitate breath holding, most scans were limited to 13-15 cardiac cycles.

Table 1: TSE Methods and Parameters

TSE Method	RO Points	TSE Factor	Shots (cardiac cycles)	Echo Images	PE Lines / Image
2 echo	256	14	13	2	91
4 echo	160	16	14	4	56
8 echo	128	16	22	8	44

Three multi-echo turbo spin-echo (TSE) T2-measurement methods were tested. The first acquired an interleaved pair of 2-echo TSE scans with effective echo times of 20, 40, 60, and 80ms. The same transmitter and receiver gains were used for each scan. The second was a single 4-echo TSE scan with effective echo times of 6, 30, 54, and 78ms. The third method used a single 8-echo TSE scan. This method resulted in echo times of: 6, 18, 30, 42, 54, 66, 78, and 90ms. Phase encoding (PE) and readout (RO) parameters are given in Table 1. Parameters common to all TSE methods include: TR = 1 RR interval, FOV = 320 x 256 mm, matrix interpolation to 256 x 256, slice thickness = 6mm, flip angle = 90°, half-scan = 0.8, SENSE factor = 1.5.

Three multi-echo turbo field echo (TFE) T2*-measurement methods were tested. The first method used was a series of three 2-echo TFE sequences. The first echo was fixed at 2.3ms and second echoes were set at 6.9, 11.5, and 18.4ms. The same transmitter and receiver gains were used for each scan. A 4-echo TFE sequence was then used with echoes set to 2.3, 6.9, 11.5, and 16.1ms. The last method utilized an 8-echo TFE sequence with the first echo set at 2.3ms and later echoes incremented, in-phase, with a ΔTE of 2.3ms, up to 18.4ms. Relevant scan parameters include: FOV = 320 x 256 mm, Acquired matrix = 192 x 120, interpolated to 256 x 256. Echo train length = 8, shots = 15, TR = 25ms, flip angle = 25°, slice thickness = 6mm.

Signal values were taken from regions of interest (ROIs) in the mid-ventricular septum to compute T2 and T2* by fitting the data to monoexponential decay curves. Maps of T2 and T2* were generated using software written in MATLAB using each pixel as an ROI (The MathWorks, Inc., Natick, MA). T2 and T2* values, signal-to-noise ratios, and acquired voxel sizes were evaluated for the different methods.

RESULTS

T2 for the ventricular septum was 52.7 ± 11.1 ms (N=6) with R^2's averaging 0.959 for the monoexponential fits. A first echo SE image is given in Figure 1a. A map of T2 created via the 4-echo method is given in Fig. 1b. T2* for the ventricular septum was 37.1 ± 12.1 ms (N = 7) with R^2's averaging 0.967 for the monoexponential fits. A first echo TFE image is given in Fig. 1c and a map is given in Fig.1d. The 8-echo method of T2 measurement provided the smallest standard deviations of mean T2 values across subjects while the interleaved T2 pair method gave the highest SNR and sharpest images. The 4-echo method of T2* measurement provided the smallest standard deviations of mean T2* values across subjects and second highest SNR while the interleaved T2* pair gave the sharpest images.

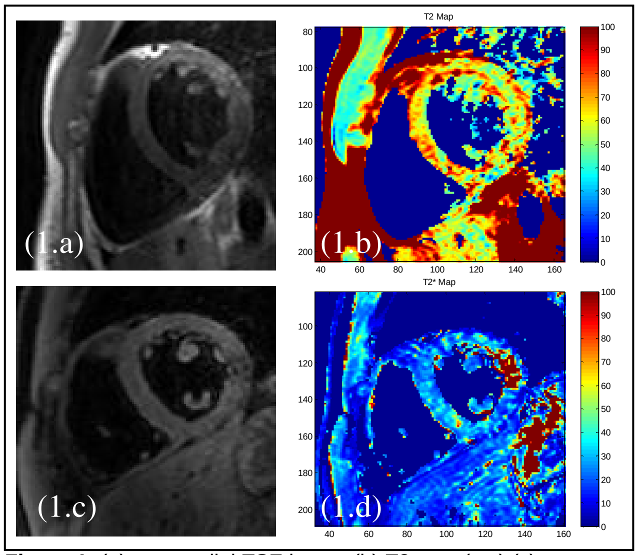

Figure 1: (a) myocardial TSE image (b) T2 map (ms) (c) myocardial TFE image (d) T2* map (ms).

DISCUSSION AND CONCLUSIONS

Due to the extreme difficulty of obtaining consistent results in high-field cardiac MRI, there exists a scarcity of published T2 and T2* values in the myocardium, a problem remedied by this ongoing work. These results suggest the 8-echo method for optimal T2 sampling and the 4-echo regime T2* measurements in the mid ventricular septum. Other research reports values for T2 (*in vivo* T2 = 41 ms for N=1[1] and *in-vitro* T2 = 47± 11ms[2]) and slightly shorter values for T2*[3]. In conclusion, the reported work presents consistent T2 and T2* measurements with optimized techniques for myocardium at 3T.

REFERENCES (1) Schar et al, Magn Reson Med 2004; 51:799-806, (2) Stanisz et al, Magn Reson Med 2005; 54:507-512, (3) Noeske et al, Magn Reson Med 2000; 44:978-982.