Clinical Evaluation of a Cardiac T1 Mapping Method using a Reduced Number of Sample Times

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Introduction

T1 mapping is a quantification tool for tissue characterization. A Modified Look-Locker with saturation recovery (MLLSR) sequence can be used for this purpose [1]. Patient compliance is a significant challenge in all myocardial imaging. This is especially true for quantitative imaging where failed breath holds can result in significant data corruption. The flexibility afforded by the MLLSR sequence enables sampling the signal recovery in different breath hold times. In this work we were interested in exploring if a signal sampling pattern requiring half the previously suggested breath hold time could accurately estimate T1 values. Nine subjects were enrolled in an IRB approved study. T1 values using different signal recovery sampling patterns were measured and compared in these subjects.

Methods

The MLLSR pulse sequence uses a saturation recovery sequence with Look-Locker imaging blocks [1]. Previously we reported the application of this technique using three Look-Locker blocks requiring 2, 2 and 4 heartbeats respectively. To minimize the data acquisition window, the acquisition of each TI time is segmented across two heartbeats thus the total acquisition time is 16 heartbeats. To target cardiac patients who often have significant difficulty holding their breath, and also to address cardiac patients with relatively low heart rates (as can occur on beta-blockers) a further reduction in breath hold time is desirable. We compare the previously reported 16 heartbeat scan to an 8 heartbeat variation requiring 2 Look-Locker blocks of 1 and 3 heartbeats respectively. Note that the acquisition time per TI image is preserved so that the individual TI images have similar SNR properties. FIESTA imaging was performed at each of the TI times with the following parameters: TE/TR 1.7/3.9ms, 45° flip angle, 256x160matrix, 0.5 NEX, 38 VPS, 8mm slice thickness, 350msec trigger delay. Data was fit to a standard saturation recovery signal equation to estimate T_1. On an IRB-approved protocol, 3 patients with positive MDE (51±16yr, 3 male) and 6 healthy volunteers (57±13yr, 4 male) were evaluated. All 3 patients were scanned pre- and post-contrast. Correlations between the 16 heartbeat breath hold and 8 heartbeat breath hold acquisitions were compared.

Results

T1 estimates were made successfully in all 9 subjects. For the 16 heartbeat variation, pre-contrast T1 values were measured to be 872.17±65.61ms, post-contrast normal myocardial T1 values were 451.33±24.09ms, and post-contrast myocardial infarction T1 value were 289.67±10.41ms. For the 8 heartbeat variation, pre-contrast normal myocardial T1 values were 886.17±50.88ms, post-contrast normal myocardial T1 values were 484.33±22.59ms, and post-contrast myocardial infarction T1 values were 264.33±10.41ms. Sample images across the recovery times for the 16 heartbeat scheme is illustrated if Figure 1a and for the 8 heartbeat scheme in Figure 1b demonstrating excellent image quality from both schemes. Figure 2 compares T1 estimates between the 2 sampling schemes across all subjects and all tissues. Measurements made with both schemes are highly correlated with a correlation coefficient of 99.55%. Linear regression yielded a slope of 0.96 and a bias of 14.21. Figure 3 shows example T1 and M0 (equilibrium magnetization) maps from the fits to the data from the same subject shown in Figure 1. Both sampling schemes are able to visualize the variation in T1 and M0 resulting from a myocardial infarction present in this subject (arrows).

Conclusions

T1 mapping using two different data sampling schemes was compared in 9 subjects across a range of tissues demonstrating different underlying T1 properties (normal myocardium pre- and post-contrast and myocardial infarction post-contrast). We demonstrated that T1 estimates derived from an 8 heartbeat sampling scheme that samples 4 different signal recovery times yields equivalent values to a 16 heartbeat sampling scheme that samples 8 different signal recovery times. The achieved reduction in breath hold time should improve patient compliance and data robustness when applying T1 mapping methods to clinical myocardial characterization applications.

References [1] T. Song, et al, ISMRM 2009, pp483.

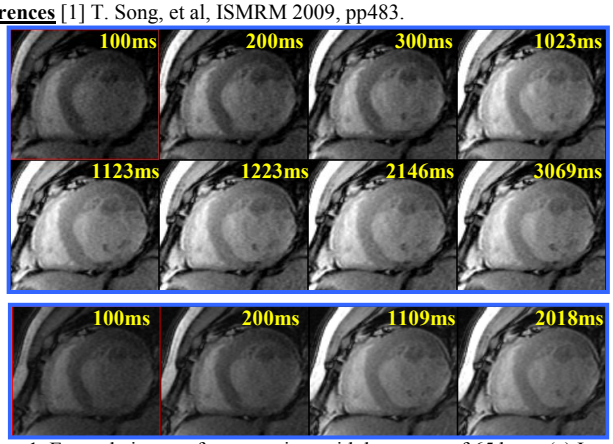

Figure 1. Example images from a patient with heart rate of 65 bpm. (a) Images from a 16 heartbeat scheme that samples 8 TI times; (b) images from an 8 heartbeat scheme that samples 4 TI times.

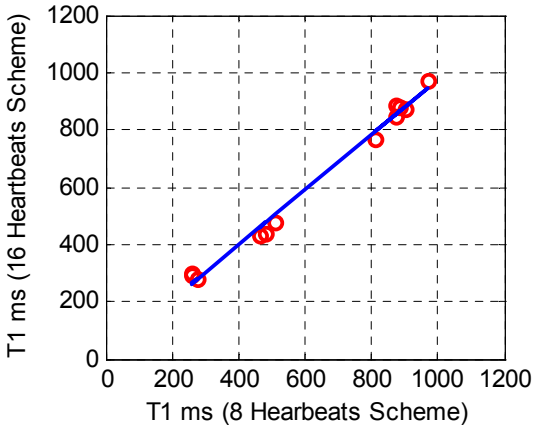

Figure 2. Scatter plot of T1 values estimated using the16 heartbeat scheme versus 8 heartbeat scheme. Correlation coefficient was 99.55%. Linear regression yielded a slope of 0.96 and a bias of 14.21.

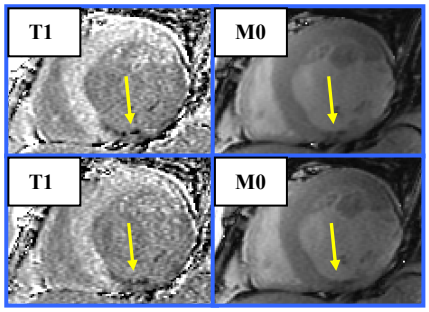

Figure 3. Quantitative maps from the patient with heart rate of 65 bpm also shown in Figure 1. T1 maps (left column) and M0 maps (right column) are shown for the (a) the 16 heartbeat scheme and (b) the 8 heartbeat scheme. Similar maps are obtained in (b) in half the time. Dark area in T1 maps demonstrates myocardial infarction (arrows).