Variations in Myocardial T1 with Cardiac Cycle at 1.5T

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Introduction

T1 mapping is a powerful tool for characterizing myocardial tissue, with many potential clinical applications. T1 maps are typically created from images acquired either at end-diastole [1,2], to minimize cardiac motion artifacts, or throughout the cardiac cycle to reduce scan time (e.g. Look-Locker [3]). An underlying assumption of these methods is that T1 is constant throughout the cardiac cycle. However, a recent study [4] reported cyclic variation of myocardial T1 (at 3T) of 70% in the septum and 43% in the lateral wall from end-diastole (ED) to end-systole (ES) in healthy volunteers. In the current study, we evaluated T1 values at different points in the cardiac cycle to determine whether similar cyclic T1 variation is seen at 1.5T.

Methods

Healthy volunteers (n=5, 3M/2F, age 37±12 years), were imaged at 1.5T (Achieva XR, Philips) using a 16 element phased-array coil (SENSE Torso XL, Philips). T1 mapping was performed using MOLLI (Modified Look-Locker Inversion-recovery) at 2 left ventricular (LV) short axis levels and 3 separate cardiac time points: ES, ED and mid-diastole (MD). MOLLI was performed as described previously [1,2], with 3 inversion-recovery (IR)-prepared experiments split over 15 heartbeats to collect 3+3+5 images (with 2 pause cycles). T1 maps were created using custom software (IDL, RSI International). Image data was sorted by inversion time and three-parameter nonlinear curve fitting using a Levenberg-Marquardt algorithm was performed pixel-wise using the equation: $y = A - B \exp(-t/T1^*)$. T1 was then calculated from effective T1 (T1*) using $T1 = T1^* [(B/A) - 1]$ [1].

Results

The figure shows representative T1 maps from a volunteer at ES (top), MD (middle) and ED (bottom). Regional T1 values are shown in the table for the different time points. T1 variation between time points was greatest in the lateral wall (6% from MD to ED); variations between other time points ranged from 0 to 4%. There was no statistically significant T1 difference between regions, but the difference between time points was statistically significant (p=0.02), with T1 at ED significantly higher than at MD. The difference in T1 between ED and ES was not significant. In addition, the range of measured T1 values (847-1012 ms) in this study was consistent with those previously reported in the literature measured at end diastole (862-1105 ms) [2].

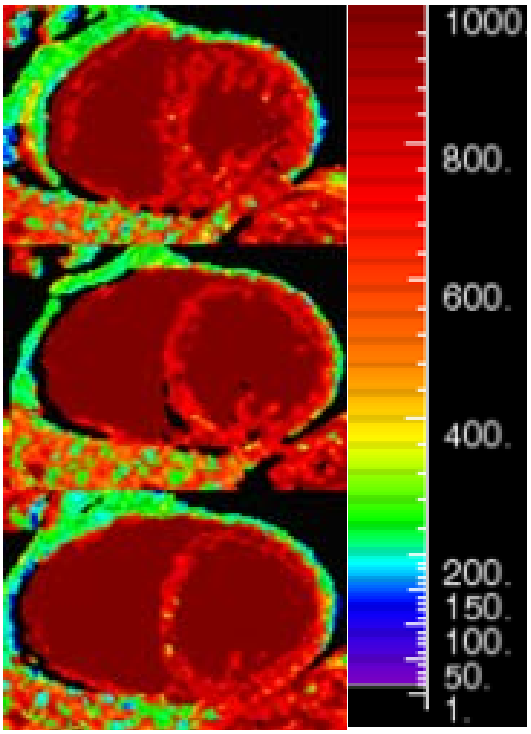

Figure. T1 maps at 3 points in the cardiac cycle from a volunteer. The trigger delays were 360 ms (ES, top) 600 ms (MD, middle) and 836 ms (ED, bottom).

Table. Regional T1 (ms) measured at different points in the cardiac cycle (±standard deviation)

	Septum	Inferior	Lateral	Anterior
ES	926±38	930±32	911±65	939±57
MD	931±51	930±41	886±65	926±60
ED	960±32	957±43	938±71	954±65

Discussion and Conclusions

In this study, we have measured myocardial T1 values at different portions of the cardiac cycle. Our results demonstrate that cyclic variation of T1 is negligible at 1.5T. (Note that the small, but significant difference between T1 at MD and ED is likely related to the small sample size.) These results suggest that the magnetic properties of myocardial tissue are fairly constant throughout the cardiac cycle, and T1 quantification methods such as Look-Locker should be valid at 1.5T. Our results contradict the large T1 variation observed by others at 3T [4]; however, it is not known whether this is caused by differences in field strength or differences in image acquisition technique. The T1 values of the heart are of particular importance for the diagnosis of myocardial diseases, as well as for the development and optimization of clinical T1 mapping sequences. Such significance warrants further investigation of the myocardial T1 values at different stages of the cardiac cycle and at different magnetic field strengths.

References

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