Post-Contrast T1 Measurements of Blood, Infarct and Normal Myocardium at 1.5T and 3T

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Introduction: There is growing interest in exploring the potential for cardiac imaging at 3T [1]. However, the spin-lattice relaxation time (T1) of most biological tissues is known to increase from 1.5T to 3T, increasing the degree of magnetization saturation in short-TR pulse sequences. Despite these concerns, the higher signal-to-noise ratio and potential for greater spatial resolution afforded by high field MRI may provide particular benefits in delayed enhancement imaging, where small subendocardial infarcts are not easily distinguishable. Since the observed signal intensity in delayed enhancement images is predominantly T1-weighted, initial estimates of tissue contrast at 3T can be simulated with knowledge of post-contrast T1 relaxation times.

Purpose: The purpose of this investigation was to compare T1 measurements in blood, infarcted myocardium (MI), and remote normal myocardium at 1.5T and 3T following contrast administration.

Methods: Six subjects with known MI were examined in this study. Each individual gave written informed consent prior to the study. Imaging was first performed at 1.5T (Philips Intera, Best, The Netherlands) followed at least three days later by imaging at 3T (Philips Intera or Siemens Trio, Erlangen, Germany). The imaging parameters used for T1 measurements were made as similar as possible between 1.5T and 3T, while taking into account SAR limitations and gradient performance. Baseline T1 values were measured at each field strength in the short-axis plane using an inversion recovery (IR), single-shot, gradient echo pulse sequence with a 350mm field-of-view (FOV), 128 matrix (60 phase encode lines acquired), TR/TE/α = 3.9/1.9ms/15°, 8mm slice thickness, and 500Hz/pixel bandwidth. The inversion time was interactively varied from 400ms to 1400ms, with an additional reference image also acquired without inversion. T1 was determined from a least-squares fit of the data to a mono-exponential curve. Each subject was given 0.2mmol/kg Gd-DTPA-BMA (Omniscan, Amersham, Oslo, Norway) and post-contrast T1 measurements were made between 5minutes and 30 minutes post-injection. For these measurements, a modified "Look-Locker" sequence [2] with a FLASH-EPI hybrid readout was used to obtain estimates of T1. The scan parameters were 320mm FOV, 128 matrix (reconstructed to 256), TR/TE/α = 8.0/4.1ms/10°, 8mm slice thickness, 5 α-pulses/frame with an EPI factor of 5 (temporal resolution = 41ms), 2 signal averages, and a bandwidth of 250 Hz/pixel. The total acquisition window covered several heartbeats (~55 frames), with an additional heartbeat used to allow further magnetization relaxation before the next image segment. The measured signals from blood, MI, and normal myocardium were fit to a mono-exponential relaxation curve, from which an observed T1 value, T1*, was obtained. Corrections were made to evaluate the true T1 using previous methods [3].

Results: Table 1 lists the T1 values calculated for blood, MI, and normal myocardium. The *difference* in T1 between 1.5T and 3T seen prior to contrast injection is substantially reduced following contrast administration, and is not significantly different from zero for all tissues, especially early after contrast injection. Therefore, the inversion time to null normal myocardium is not expected to change drastically at 3T. The average difference in T1 between infarcted and normal myocardium, which is predictive of image contrast in delayed enhancement, is approximately equal at 1.5T and 3T (0.15 vs. 0.14, respectively), suggesting similar expected image quality at both fields. Furthermore, the average blood-to-infarct T1-ratio, which is important for subendocardial infarct distinction, was also very similar between 1.5T and 3T (1.00 vs. 1.06, respectively). Due to the limited subject number in this present study, the data did not reach statistical significance.

Conclusions: This preliminary data suggests that, despite a small increase, the T1 values post-contrast are very similar between 1.5T and 3T, which contrasts the difference seen pre-contrast. This implies that similar image contrast can be obtained with delayed enhancement at 3T. With improved SNR at 3T, it is believed that 3T delayed enhancement may allow increased visualization of small infarcts with similar image contrast as 1.5T.

Table 1. Comparison of T1 values between 1.5T and 3T

	Blood		Normal		Infarct	
Time (min)	1.5T	3T	1.5T	3T	1.5T	3T
0	1.55±.10	1.64± .07	1.15± .06	1.26± .06	1.04± .06	1.30± .06
5	0.21±.03	0.23± .02	0.33± .04	0.34± .05	0.23± .04	0.25± .02
10	0.26±.02	0.28± .03	0.38± .02	0.38± .05	0.28± .02	0.26± .02
15	0.27±.02	0.31± .03	0.41± .04	0.41± .06	0.26± .02	0.30± .03
20	0.30±.03	0.35± .03	0.44± .03	0.48± .04	0.29± .05	0.33± .03
25	0.31±.03	0.37± .01	0.46± .03	0.51± .06	0.30± .05	0.35± .02
30	0.32±.04	0.35± .02	0.46± .04	0.56± .07	0.32± .05	0.37± .02

References

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