Characterization of myocardial T_1 and partition coefficient as a function of time after gadolinium delivery in healthy subjects

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Introduction: Diffuse myocardial fibrosis is associated with myocardial infarction[1], heart failure[2] and dilated cardiomyopathy[3]. Conventional T_1-weighted late gadolinium enhancement (LGE) imaging highlights focal scaring in contrast to remote reference tissue, but it cannot detect global changes in T_1 associated with diffuse fibrosis. Quantitative T_1 imaging does not use reference tissue, permits assessment of diffuse fibrosis, and allows for the calculation of the blood-tissue partition coefficient (lambda), the ratio of contrast concentration in tissue divided by contrast concentration in blood. A gadolinium bolus injection followed by a continuous infusion has been proposed to establish contrast concentration equilibrium[4], but requires additional preparation time per subject. Here, we determine blood and myocardial T_1 values as a function of time following a standard single bolus injection of contrast (t_{post}) and the resulting dependence for the blood-tissue partition coefficient on t_{post}.

Methods: Nine healthy subjects (22.0±5.5 yrs, 6 male) were imaged using a Siemens Avanto 1.5T MRI. T_1 mapping was performed on a mid-ventricular short-axis slice using a custom saturation recovery single-shot TrueFISP sequence at baseline and one-minute intervals for 15 minutes following a bolus injection of gadopentetate dimeglumine (0.1 mmol/kg). At each time point, one "no-saturation" image and nine images with varying saturation recovery times spanning the cardiac cycle (minimum 116–121 ms, maximum 400–960 ms) were acquired during a single breath-hold. Imaging parameters were: 70º flip angle, 1.27–1.33 ms echo time, 108×192 matrix, (262–300)×(350–400) mm field of view, (1.8–2.0)×(1.8–2.0) mm resolution, 10 mm slice thickness. The myocardium was divided into 18 segments and mean signal intensities were fitted to a 3 parameter saturation recovery curve to determine T_1 values for each segment at every time point. Blood T_1 values were computed using a region of interest within the left ventricular cavity and lambda (λ) was derived using:

$$\lambda = \frac{R_1(myocardium_{post}) - R_1(myocardium_{pre})}{R_1(blood_{post}) - R_1(blood_{pre})}, \text{ where } R_1 = 1/T_1$$

Results: Figure 1 shows myocardial T_1, blood T_1, and lambda values averaged over all segments and subjects as a function of t_{post}. At 15 min t_{post}, average myocardial $T_1$was 719.1±38.1 ms and lambda was 0.393±0.050. Average within-subject standard deviations of T_1 and lambda for t_{post} from 3–15 min were 34.1 ms and 0.046 respectively. Linear regression for lambda and t_{post} (3–15 min) shows an increase in lambda of 0.001 min^{-1} (R^2=0.75). Quantitative T_1 imaging is likely to be added to a clinical protocol following LGE imaging (t_{post} 10–15 min), where T_1 values increase by 5.9±1.6% and lambda increase by 1.1±2.7%. Derived lambda is smaller than values previously reported using a continuous injection technique[4], likely reflecting a systematic underestimation of the true lambda. However, the technique presented here shows minimal changes in lambda over t_{post} with no changes to current practices of gadolinium injection.

Conclusion: Saturation recovery SSFP T_1 mapping can be performed in a single breath-hold with derived blood-tissue partition coefficient (lambda) values in good agreement with previous measurements with single bolus contrast[3]. In the post-LGE window of 10-15 min after contrast bolus, derived lambda values show less time dependence than myocardial T_1.

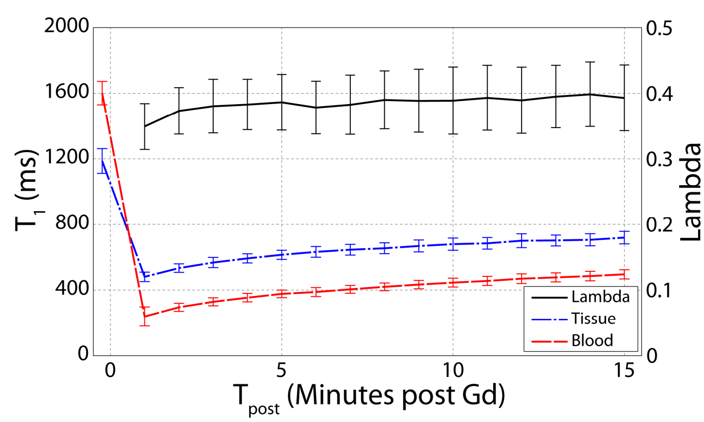

Figure 1. T_1 (myocardium, blood) and lamba following contrast injection.

References:

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