EFFECT OF SYSTEMATIC T1 ERRORS ON LAMBDA CALCULATIONS: COMPARISON OF DIFFERENT T1 MAPPING TECHNIQUES

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Background  Quantitative T1 mapping is emerging as the technique of choice for imaging of fibrosis found in many cardiomyopathies. Unlike T1-weighted sequences used to identify focal scarring, myocardial T1 mapping after gadolinium has been used to characterize diffuse fibrosis. Because T1 values alone are sensitive to many factors such as contrast agent dose, it is common to calculate the blood-tissue partition coefficient (λ) using blood and myocardial T1 values at baseline and after contrast. The commonly used MOdified Look-Locker Inversion-recovery (MOLLI) sequence is known to underestimate T1 and has significant heart rate dependence, with unknown effects on derived parameters such as λ. In this abstract, the effect of these T1 inaccuracies on λ calculations will be compared between MOLLI and an alternate SAuration-recovery single-SHot Acquisition (SASHA) T1 mapping technique, previously validated on phantoms.

Methods  Healthy volunteers (n=10, 5 male, 28.8±6.6yrs) were assessed in a single exam using a Siemens Avanto 1.5 T scanner with both MOLLI and SASHA in a mid-ventricular short-axis slice prior to and every 4 minutes following 0.1mmol/kg Magnevist up to 20 minutes. Blood and myocardial T1s were calculated and λ was derived using the equation \( \lambda = \frac{R_b \text{(myocardium post)} - R_b \text{(myocardium pre)}}{R_b \text{(blood post)} - R_b \text{(blood pre)}}, \) where \( R_b = 1/T_1. \) Typical scanning parameters were: MOLLI: 2 inversion sets of 3 and 5 images, 75% partial Fourier, T1min=110ms with 80ms increment, 35° flip, TE/TR=1.03/2.4ms. SASHA: single-shot SSFP images from 10 consecutive heartbeats with incremented TI spanning the RR interval in the last 9 images (no saturation in the first image), 70° flip, TE/TR=1.3/2.6ms, full k-space.

Results  Image quality was excellent in all 10 subjects, who had an average heart rate of 63.4±8.4bpm. Average myocardial T1, blood T1, and calculated λ for both SASHA and MOLLI techniques are displayed in Table 1, for baseline and 20 minutes Post Gd. MOLLI imaging was performed 37.7±5.4s after SASHA measurements at all time points. The pooled individual results for all time points are displayed in Figure 1 for T1 measurements. The bold black line denotes unity agreement. Myocardial MOLLI T1 values are linearly and systematically underestimated compared to SASHA, while blood pool T1 are underestimated to a smaller extent. As a result, MOLLI-derived λ are consistently larger than SASHA-derived values at all times post gadolinium with similar spread (0.45±0.03 vs. 0.36±0.04 respectively, Fig. 2).

<table>
<thead>
<tr>
<th>T1, Myocardium (ms)</th>
<th>T1, Blood (ms)</th>
<th>λ</th>
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<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>20min Post Gd</td>
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<tr>
<td>SASHA</td>
<td>1175.2 ± 27.6</td>
<td>752.9 ± 48.2</td>
</tr>
<tr>
<td>MOLLI</td>
<td>935.5 ± 24.9</td>
<td>614.4 ± 33.8</td>
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Table 1: Average values for 10 healthy subjects.

Discussion and Conclusion: The results for each T1 mapping sequence presented here are in good agreement with literature values. A saturation recovery technique similar to SASHA had average pre-contrast myocardial and blood T1s of 1219 (±72) ms and 1516 (±21) ms respectively. With a MOLLI sequence using 3 inversion sets (3,5 images), pre-contrast myocardial T1s of 977 ms and 483 ms at 15 minutes post contrast (Gd-DTPA, 0.15 mmol/kg) have been reported. In a small healthy population, similar λ values (0.42±0.02) were calculated using a MOLLI sequence with 3 inversion sets (4,2, and 1 images). The data presented in this abstract confirm the systematic differences in T1 values calculated using MOLLI sequences versus saturation-recovery based T1 mapping techniques. In particular, MOLLI T1 measurements (regardless of inversion set schemes) are routinely lower than those measured with saturation recovery or SASHA-type sequences, resulting in consistently higher λ values. Additional work is necessary to characterize and correct for errors allowing for comparison between sites and studies.

References:  
3. Messroghli DR et al. JMRI 2007;26:1081-1086  
5. Piechnik SK et al. JCMR 2010;12:69  

Figure 1: Pooled data for 10 subjects pre and post contrast from MOLLI and SASHA T1 measurements.

Figure 2: λ displayed as a function of time from contrast injection.