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Comparison of ECV measurements during equilibrium between IR- and SR-based Cardiac T_1Mapping

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Background

Cardiac T_1 and extracellular volume fraction (ECV), derived from pre- and post-contrast cardiac and blood T_1 measurements, are emerging imaging biomarkers of diffuse cardiac fibrosis. The most frequently used cardiac T_1 mapping pulse sequence is MOLLI [1]. However, MOLLI is known to be sensitive to rapid heart rate and irregular rhythm, because it is based on inversion-recovery (IR) of magnetization preparation. In response, we developed an arrhythmia-insensitive-rapid (AIR) cardiac T1 mapping pulse sequence based on B_1-insensitive saturation-recovery (SR) of magnetization preparation [2]. Our prior study [2] showed that AIR (scan time = 2-3 heart beats) is faster and yields more accurate cardiac T_1 measurements than MOLLI (scan time = 17 heart beats). We sought to compare ECV measurements between SR-based AIR and IR-based MOLLI cardiac T_1 mapping at 3T.

Methods

Sixteen mongrel dogs with normal myocardium were imaged at 3T (Verio, Siemens). Cardiac T_1 maps were acquired in a mid-ventricular short-axis plane using both AIR and MOLLI cardiac T_1 mapping at baseline and during equilibrium of Gd-BOPTA (Multihance; 30 min after slow infusion at 0.002 mmol/kg/min). Note that equilibrium ensures identical concentration of Gd-BOPTA for a fair comparison of cardiac and blood T_1 measured by two different pulse sequences. Both AIR and MOLLI acquisitions with b-SSFP readout were performed with the following relevant imaging parameters: spatial resolution = 1.4 × 1.4 × 7.0 mm, temporal resolution = 217 ms, flip angle = 35°, and SR time = 600 ms. The AIR acquisition was performed with "paired" consecutive phase-encoding steps in centric k-space ordering to minimize image artifacts due to eddy currents. Blood samples were drawn during MRI for hematocrit calculation. AIR and MOLLI cardiac T_1 maps were manually segmented to calculate the myocardial and blood T_1 values and subsequently ECV=(1-hematocrit)x($\Delta R_{1,\ myocardium}/\Delta R_{1,\ blood}$), where R_1 is T_1^{-1}, and Δ is the difference between post- and pre-contrast. Paired-wise t-test and Bland-Altman analyses were performed to compare the results.

Results

Figure 1 shows representative AIR and MOLLI cardiac T_1 maps which exhibit similarly high image quality. In the 16 dogs studied (mean heart rate = 100 ± 19 BPM), compared with MOLLI, AIR yielded higher T_1 measurements (mean difference = 185 ms; $p < 0.0001$) and lower ECV measurements (mean difference = -0.018; $p < 0.0001$).

Conclusions

Our study suggests that MOLLI and AIR cardiac T_1 mapping pulse sequences yield significantly different T_1 and ECV measurements. ECV measurements derived from SR-based AIR and IR-based MOLLI cardiac T_1 mapping pulse sequences may need to be adjusted for comparison

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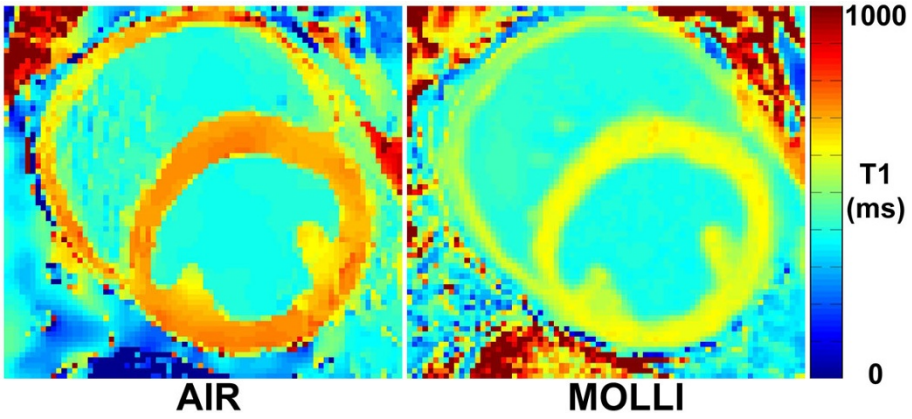

Figure 1 Example SR-based AIR and IR-based MOLLI cardiac T_1 maps of the same animal acquired during equilibrium.

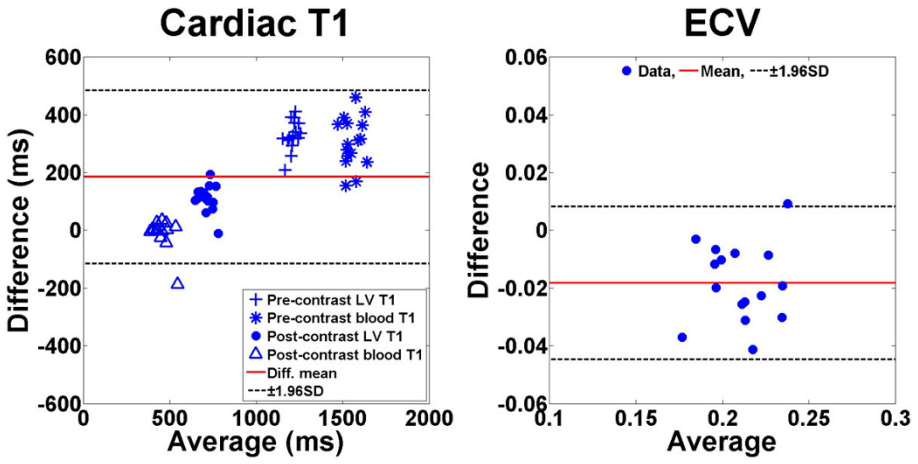

Figure 2 Bland-Altman plots comparing (left) cardiac T_1 and (right) ECV measurements derived from SR-based AIR and IR-based MOLLI cardiac T_1 mapping.

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