Comparison of MOLLI and AIR cardiac T1 mapping pulse sequences in a clinical population of cardiomyopathies

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Purpose: While late gadolinium enhancement (LGE) cardiovascular magnetic resonance (CMR) is considered the gold standard test for focal fibrosis[1], it is ill-suited for imaging diffuse fibrosis. Cardiac T1 mapping is emerging as a promising method for assessment of diffuse cardiac fibrosis. The most widely used method to date is Modified Look-Locker inversion recovery (MOLLI)[2], but its accuracy is known to depend on cardiac rhythm and a prolonged breath hold is required for even single slice imaging. To overcome such limitations, an arrhythmia insensitive rapid (AIR) cardiac T1 mapping[3, 4] pulse sequence has been developed, having the advantage of a shorter breath hold and insensitivity to rate and rhythm that broaden its application in a clinical cardiac population. This study was conducted to compare the performance of AIR and MOLLI T1 mapping acquisitions in a clinical population.

Methods: 10 patients (1F, 9M, mean 46.6y, range 19-74y; mean heart rate = 63 bpm) who had undergone clinical CMR including T1 mapping were identified retrospectively. CMR was performed for: dilated cardiomyopathy, n=2; hypertrophic cardiomyopathy, n=4; infiltrative disease, n=1; myocarditis, n=1; hemochromatosis, n=1. Utilizing a balanced SSFP readout based on prototype sequence implementations, MRI parameters at 1.5T (MAGNETOM Avanto, Siemens Healthcare) were as follows: a) **MOLLI** TR/TE 2.7/1.1ms, matrix 256 x166, SL 6 mm, FA 35°, FOV 360 mm x 270 mm, R = 2 (GRAPPA), BW 1028 Hz/pixel, temporal resolution 167 ms, imaging over one breath hold over 11 heart beats acquiring 7 single-shot images with different inversion times (i.e., 5-2 MOLLI); b) **AIR** TR/TE 2.4/1ms, matrix 192 x144, SL 10 mm, FA 55°, FOV 360 mm x 270 mm, R = 2 (GRAPPA), BW 930 Hz/pixel, temporal resolution 201 ms, 3 slices, imaged over three heart beats in a single breath hold acquiring T1-weighted (T1W) and proton density (PD) images, with T1 calculated from the ratio of T1W to PD images[3]. A 6-channel phased array body coil and posterior spine array were used for signal reception. Images were obtained in the mid-ventricular short axis plane pre-contrast and at 5 minutes after administration of 0.2 mmol/kg of gadoterate meglumine (Dotarem®, Aspen Pharmacare). Post-processing of T1 MOLLI/AIR maps was conducted using customized software (Matlab®) to calculate T1 values in myocardium and the blood pool. Areas of LGE as identified on phase sensitive IR imaging performed at 8 minutes post injection were excluded from segmentation. Partition coefficients were also calculated from derived T1 values as an estimate of myocardial extracellular volume. Pearson's correlation was performed to calculate the association between methods, Bland-Altman analysis was conducted to evaluate the agreement between methods, and paired t-test was performed to test whether there is significant difference between methods.

Table 1: Measured T1 (mean ± STD) for MOLLI and AIR

Tissue	MOLLI (ms)	AIR (ms)	p*
Native myocardial	1002.4 ± 24.6	1094.6 ± 27.5	**<0.0001**
Native blood	1550.6 ± 78.4	1609.4 ± 129.4	**<0.0256**
Post-contrast myocardial	355.6 ± 31.1	423.3 ± 23.6	**<0.0001**
Post-contrast blood	225.2 ± 30.7	224.3 ± 39.2	0.8221

Results: Figure 1 shows representative MOLLI and AIR T1 maps acquired from one patient, with both methods generating good data quality. For T1 measurements, there was near perfect correlation (0.997, p<0.0001) between MOLLI and AIR. However, T1 values calculated from MOLLI were slightly but statistically significantly lower than those from AIR for native myocardium, native blood pool and post contrast myocardium (Table 1). Bland-Altman analysis demonstrated a mean difference in measured T1 values of 54.4ms (upper and lower 95% limits of agreement 152.7ms and -43.9ms respectively) with poorest agreement observed for native blood pool T1 values (Fig 2). For partition coefficient, there was strong correlation between the two sequences (0.7313, p<0.016). The mean partition coefficient was significantly different (p < 0.001) between MOLLI (0.47 ± 0.03) and AIR (0.37 ± 0.06). According to the Bland-Altman analysis, the mean difference in partition coefficient was -0.10 (upper and lower 95% limits were -0.02 and -0.18, respectively).

Discussion/Conclusion: This study shows that AIR and MOLLI produce significantly different T1 and partition coefficient measurements in this diverse cohort. These findings are consistent with previous studies[4,6] which reported that different cardiac T1 mapping pulse sequences yield significantly different T1 and extracellular volume fraction even in normal hearts. Awareness of these differences is important for clinical interpretation of results with potential management implications. Further clinical experience in a larger clinical population, including patients with high and irregular heart rates is warranted.

References:

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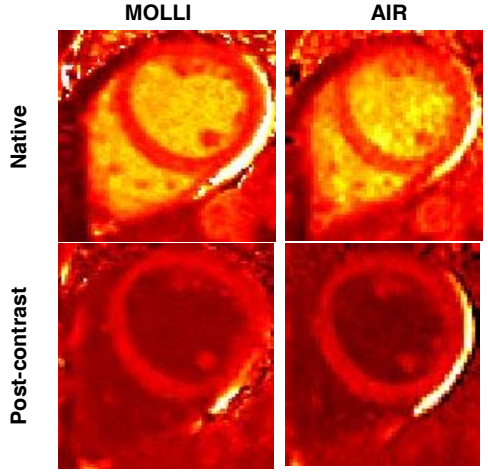

Figure 1. *50 yr old male with suspected sarcoidosis. Native and post contrast T1 maps for MOLLI and AIR*

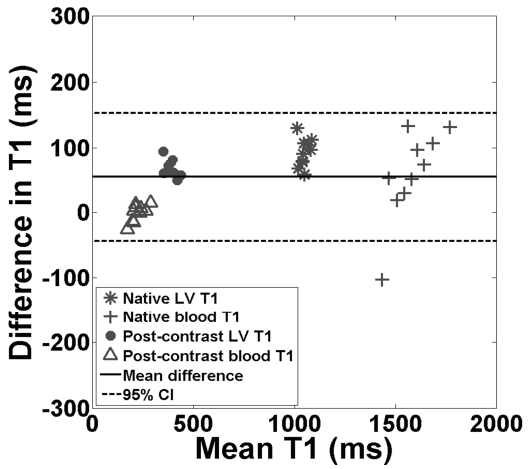

Figure 2. *Bland Altman analysis comparing MOLLI and AIR T1 values*