Diagnostic Performance of Native T1 Maps at 3T for Characterizing Chronic Myocardial Infarctions

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Target Audience – Scientists and clinicians studying myocardial infarction

Purpose – Semi-automatic thresholding applied to native T_1 mapping at 3T has been previously shown to be a reliable alternative to Late Gadolinium Enhancement (LGE) imaging for characterizing chronic myocardial infarctions (cMIs)[1]. The purpose of this study is to (a) establish the sensitivity and specificity of automatic, semi-automatic and visual methods; and (b) identify the optimal approach for characterizing cMIs on the basis of native T_1 maps at 3T.

Methods – Canines (n=23) subjected to myocardial infarction (MI) underwent MRI at 3T at 4 months post-MI. Native T_1 maps (MOLLI-bSSFP; 8 TIs with 2 inversion blocks of 3+5 images; minimum TI=110ms; ΔTI=80ms; TR/TE=2.2/1.1ms) and LGE images (IR-prepared FLASH; optimal TI to null remote myocardium; TR/TE=3.5/1.75ms) of contiguous short-axis slices covering the entire LV were acquired. Infarcted myocardium detected using the Mean+5SD criterion on LGE images was considered the gold standard. Infarcted myocardium was detected on T_1 maps using visual delineation, automatic thresholding (Otsu's), and semi-automatic thresholding (Mean+*n*SD, where n = 2, 3, 4, 5, 6; Full Width at Half Maximum (FWHM)) methods. Infarct size (% of LV volume, as well as on the basis of AHA 17-segment model), transmurality (% of LV wall thickness), and diagnostic performance of the different detection methods applied to T_1 maps were compared to the standard LGE measurements. ROC analysis was performed to compare the diagnostic performance of the different detection methods. For this purpose, presence of >1% of infarct volume in a given AHA segment on LGE images was considered positive for infarction, and the AHA-segmental infarct size measured on T_1 maps was used as the predictor variable.

Results – Mean infarct size and transmurality measured from native T_1 maps were significantly over-estimated by Mean+2SD (10.5±6.1% and 68.9±14.9% respectively), Mean+3SD (8.8±5.1% and 61.9±15.4% respectively), Mean+4SD (7.1±4.3% and 54.4±14.8% respectively), and FWHM (8.44±5.25% and 63.2±14.7% respectively) methods ($p<0.001$, for all cases), compared to the standard LGE measurements (5.8±3.6% and 46.9±15.1% respectively). Infarct size and transmurality were significantly under-estimated by Mean+6SD criterion (4.8±3.4%, $p<0.001$ and 42.7±14.9%, $p=0.01$ respectively) and visual delineation (4.1±3.0% and 38.3±14.8% respectively, $p<0.001$ for both cases) on T_1 maps. Otsu's method showed no difference for measuring infarct size on T_1 maps (6.7±3.8%, $p=0.06$) compared to LGE images, but it over-estimated the infarct transmurality (59.3±16.2%, $p<0.001$). Mean+5SD criterion showed no difference for measuring either infarct size (5.8±3.8%, $p=0.98$) or transmurality (47.9±14.8%, $p=0.57$) on T_1 maps relative to LGE images. Mean+5SD criterion for detecting chronic MIs on T_1 maps at 3.0T showed the strongest diagnostic performance (area-under-curve=0.981, $p<0.001$), while visual delineation showed the weakest diagnostic performance (area-under-curve=0.886, $p<0.001$).

Conclusion – Threshold-based analysis using Mean+5SD criterion can accurately and precisely estimate the location, size and transmurality of chronic MIs on native T_1 maps as reliably as LGE at 3T.

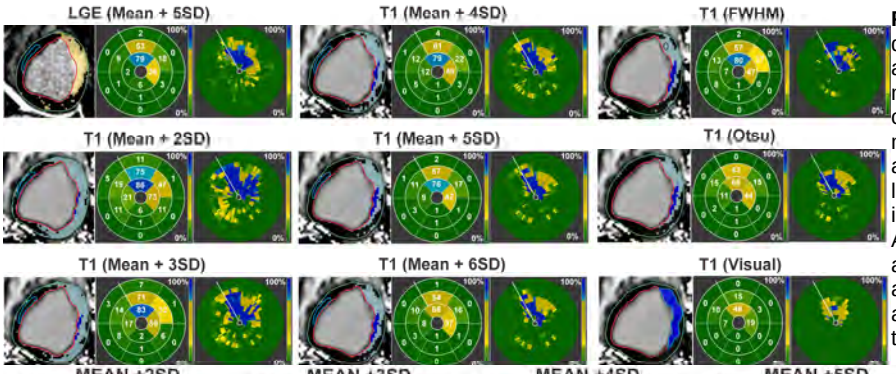
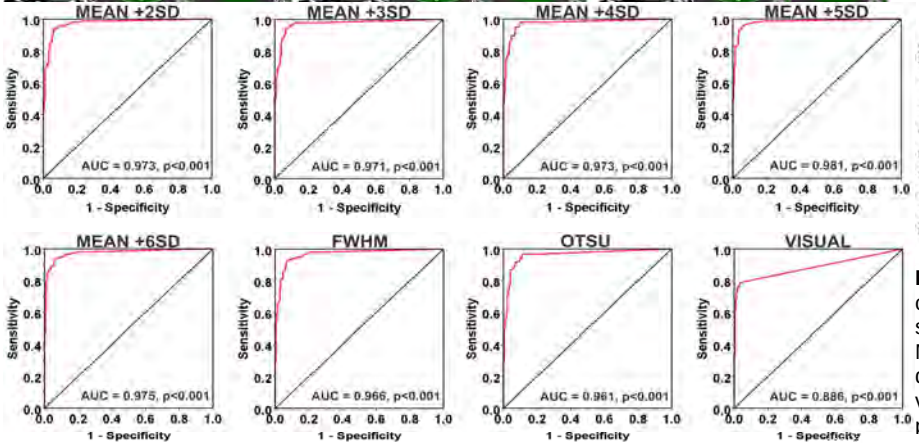


Figure 1: Infarcted myocardium (highlighted pixels) detected using the Mean+5SD criterion on LGE images, and various (automatic, semi-automatic, and visual) methods on T_1 maps are shown. Hypointense cores of chronic iron deposition that was not detected as infarcted myocardium on T_1 maps by an automatic or semi-automatic detection method (dark blue pixels within the light blue highlighted pixels on T_1 maps) was manually included in the final analysis. Bulls-eye plots depicting the AHA-segmental infarct size and transmurality distribution are also shown for the respective methods. Infarct location and spatial extent observed on LGE images generally agreed well with those observed on native T_1 maps using the different detection methods.



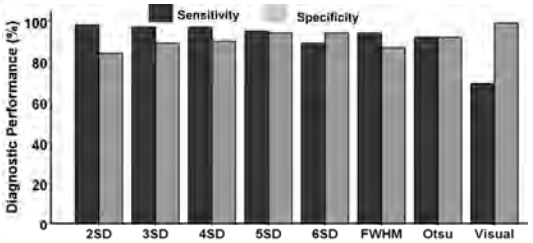


Figure 2: ROC curves of different methods for detecting cMIs on native T_1 maps are shown. Bar-plots show the sensitivity and specificity of the different methods. Mean+5SD criterion on T_1 maps showed the best diagnostic performance relative to LGE images, while visual delineation showed the weakest diagnostic performance.

References: 1. Kali A et al, Circulation Cardiovascular Imaging, 2014.