

Optimization and Standardization of TI-Selection in Contrast Enhanced Viability Imaging by Automated Analysis of Rapid Quantitative T1 Mapping

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Introduction Contrast enhanced viability imaging is a key feature in Cardiovascular MR (CMR), but depends on several co-founders including selection of optimal inversion time (TI). Suboptimal TI may lead to wrong clinical diagnosis. Usually a routine CMR protocol includes a TI scout (IR-prepared cine TrueFISP) for TI selection. The most suitable TI value is selected based on investigator dependent image selection and used in subsequent late gadolinium enhancement (LGE) imaging. Due to limited temporal resolution and differences in the sequence details of the TI scout (continuous TrueFISP readout) vs. LGE imaging (single phase, segmented FLASH or TrueFISP), the TI determination is often not accurate depending on the experience of the technician. A standardized approach is warranted. We propose a new robust, user-independent approach to TI optimization based on a fast T1-mapping protocol, which can also be used in combination with an automated segmentation of the left-ventricular myocardium.

Methods A modified Look-Locker inversion recovery (MOLLI) protocol [1,2] optimized for rapid T1 mapping after contrast administration was set up with a 3(2)-3(2)-1(0) heartbeats acquisition pattern (recovery heartbeats in brackets) with TE/TR 1.04/2.4ms, 192x132 matrix, FoV 360mm. 5-10 minutes after contrast injection, a standard TI scout (temp. res. 21ms, $T_{acq}=18s$) was acquired in a mid-ventricular short-axis slice within the same minute as the T1 map in consecutive patients scheduled for cardiovascular MR including LGE assessment (e.g. CAD and myocarditis). In the subsequent LGE viability imaging, the TI was adopted according to the selection of an experienced CMR technologist based on the TI scout information, blinded to the T1-mapping results. Measurements were performed on a clinical 1.5T MR scanner (MAGNETOM Avanto, Siemens AG, Erlangen, Germany). A user-independent TI time was determined from the TI scout data by carefully selecting the image with the lowest signal in the healthy myocardium. Motion-corrected [3] T1 maps were analyzed based on a ROI evaluation and the corresponding TI was calculated by $TI=T1*\ln(2)=T1*0.693$. If applicable, an additional cine TrueFISP short-axis image series with automated inline segmentation based on non-rigid registration was acquired and the segment information of the slice and timeframe was used to provide an automatic left-ventricular ROI definition in the T1 quantification for TI selection.

Results The T1 mapping protocol could successfully be applied in all patients (n=30, mean age 57y (18-86), 14 female) and allowed a significantly shorter breath-hold than the standard TI scout protocol (11s vs. 18s). The result of the automated segmentation could be used to define the contours of a ROI for T1 quantification in the T1 map (fig. 1). The T1-map-based TI times were in very good agreement with the user-selected TI-scout-based values ($266\pm40ms$ vs. $267\pm35ms$). The user-selected TI times varied from the objective TI scout values ($252\pm36ms$) due to the technologist's strategy to account for the known TI scout inaccuracies. Remarkably, the T1-map-derived TI times matched the user-defined values (av. rel. diff. -0.5%) better than the objective TI scout values (av. rel. diff. +6.6%).

Discussion and Conclusions

The proposed approach for TI determination is faster and more accurate than the apparent TI scout value and as accurate as based on TI values selected by an experienced CMR-trained technician. The segmentation from an automated inline cardiac function analysis can be used to define the ROI for TI calculation based on the T1 map. In the presence of scar, e.g. threshold-based selection of remote myocardium can be incorporated to further improve the robustness for optimal TI selection. The presented method provides a new option for standardization in clinical research and routine CMR.

References [1] Messroghli DR et al, Magn Reson Med 2004;52:141-6. [2] Messroghli DR et al, J Magn Reson Imaging. 2007 Oct;26(4):1081-6. [3] Xue H. et al, Magn Reson Med doi: 10.1002/mrm.23153.

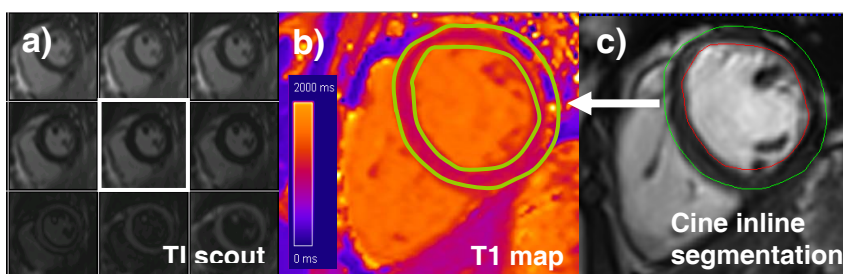


Figure 1: a): TI scout for optimal TI selection; image with lowest signal marked (9 out of 29 frames shown); b): T1 map with segmentation taken from c) cine inline evaluation.

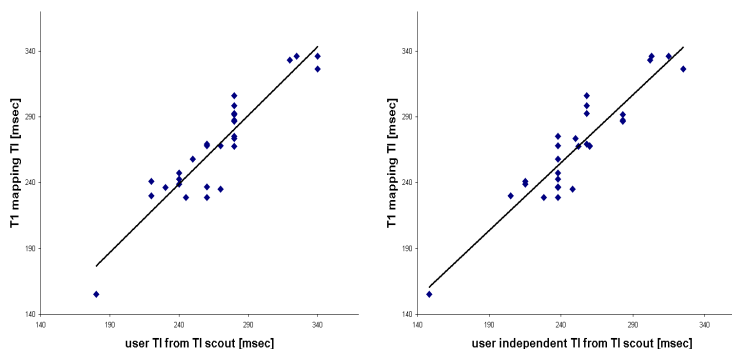


Figure 2: Plot of TI times from TI scout vs. T1 map; left: user TI from TI scout vs T1 map TI; right: user-independent TI from TI scout vs. T1 map TI.