A Comparative Study of Different CMR Methods for Detecting Myocardial Edema Associated with Acute Myocardial Infarction

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Introduction: A number of CMR imaging approaches have been proposed for detecting myocardial edema accompanying acute myocardial infarctions (AMI). T1 [1] and T2 [2] maps, T2-prepared SSFP [3] and cine SSFP (bSSFP) [4,5] are potential alternatives to the most commonly employed T2-weighted STIR (T2-STIR) [6] imaging. However, the relative sensitivities of the various approaches in relation to the routinely used T2-STIR method is not fully known. This work aims to assess the sensitivity of T1 and T2 maps, as well as T2-prep SSFP and bSSFP methods against T2-STIR, in detecting myocardial edema using an animal model with AMI.

Methods: Animal Preparation and Imaging: Dogs (n=4) subjected to an ischemia-reperfusion injury (LAD occlusion for 3 hours followed by reperfusion) were studied 2-hours post reperfusion (day 0), and on days 2, 5, and 7. Multiple breath-held and ECG-triggered T2-STIR, T2-prep SSFP, and bSSFP images and the corresponding T2- and T1-maps were acquired using a Siemens 1.5T system. All acquisitions, except bSSFP, were acquired in mid-diastole; bSSFP images were acquired in the cine mode. Scan parameters for the various edema-weighted acquisitions are summarized in Table 1. All scans were terminated with a late-enhancement acquisition to confirm the presence of LAD infarction. Data Analysis: On the bSSFP images and the relaxation maps, the edematous territories were identified as regions with pixel values that are 2 standard deviation greater than the mean value of the remote (healthy) territories. The mean signal intensity of the edematous (E) and healthy (remote) territories (H) were computed. Myocardial edema contrast (MEC) on each slice was computed as, MEC=(E-H)/H. Normalized MEC was computed by dividing MEC obtained from the different methods by MEC of T2-STIR images, to assess relative contrast. This was performed on a slice-by-slice basis and averaged across all studies. A one-way ANOVA was used to compare the normalized contrast between the different methods. Statistical significance was set at $p<0.05$.

	Scan parameters
T1 map[7]	IR with 11 TI from approximately 80ms to 4000ms; SSFP readout (TR/TE=2.4/1.2ms, Flip angle=35°, BW=1000Hz/pixel, resolution=1.3X1.3X8.0mm^3)
T2 map[2]	T2 Prep. Time=0,24 and 55ms; SSFP readout (TR/TE=2.2/1.1ms, Flip angle=70°, BW=1490Hz/pixel, resolution=1.9X1.9X8.0mm^3)
STIR[6]	TI=170ms, TSE readout (echo train length=15, TE=64ms, BW=235Hz/pixel, resolution=0.9X0.9X8.0mm^3)
T2-Prep[3]	T2 Prep. Time=55ms; SSFP readout (TR/TE=2.2/1.1ms, Flip angle=70°, BW=1490Hz/pixel, resolution=1.9X1.9X8.0mm^3)
bSSFP[5]	TR/TE=3.5/1.7ms, Flip angle=70°, BW=930Hz/pixel, resolution=1.25X1.25X8.0mm^3

Table 1. Imaging parameters for the various CMR approaches used for the detection of myocardial edema.

Results: Myocardial edema was detected as regions of hyperintensity from all CMR methods used (Figure 1). Relative to T2-maps, T1-maps had significantly lower MEC. However, both T1 and T2 maps had lower MEC relative to T2-STIR. Normalized MEC between T2-STIR, T2-Prep, and bSSFP were not statistically different. T2-STIR normalized MEC among the different methods are shown in Figure 2.

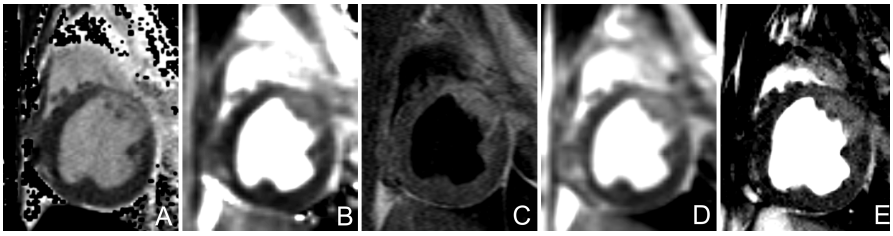

Figure 1. Representative short-axis T1 (A) and T2 (B) maps and T2-STIR (C), T2-prep SSFP (D), and bSSFP (E) images obtained from a canine with ischemia-reperfusion injury (day 0, 2 hours post reperfusion). Note that both relaxation maps and edema-weighted images delineate the edematous territory as regions of hyperintensity.

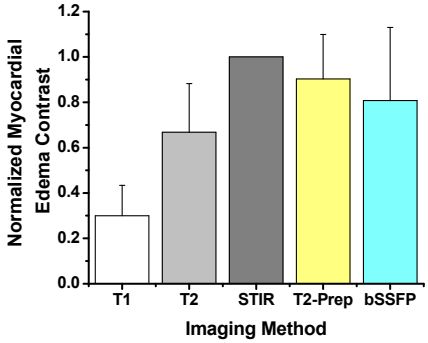

Figure 2. T2-STIR normalized myocardial edema contrast over all imaging studies in canines with AMI.

Conclusion: T1 and T2 maps appear to have lower sensitivity for identifying myocardial edema compared to T2-STIR, while no sensitivity differences were found among T2-STIR, T2-Prep, and bSSFP methods. In addition to the sensitivity consideration, the most robust CMR method for identifying myocardial edema will also require a comparative assessment of the specificity of the different methods.

References: [1] Goldfarb *et al* Radiology 2007, [2] Giri *et al* SCMR 2009, [3] Kellman *et al* MRM 2007, [4] Dharmakumar *et al* ISMRM 2008, [5] Kumar *et al* ISMRM 2008, [6] Abdel-Aty *et al* Circulation 2004, [7] Messroghli *et al* MRM 2004.