Temporal features of edema in acute myocardial infarction: T2 maps vs T2-STIR

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Background – Information on the extent of ensuing myocardial edema during acute ischemia [1], and edema-based assessment of area-at-risk (*AAR*) [2] and myocardial salvage (*MS*) [3,4] is of clinical importance in the setting of acute coronary syndrome and myocardial infarction. The temporal changes of these parameters and the effects of different MR acquisition methods are expected to be critically important in the overall interpretation of pathology; however, these factors have not been fully investigated. In an effort to bridge this gap, we investigated the temporal features of edema during ischemia and post reperfusion in a surgically controlled canine model using two different CMR methods: (a) T2-STIR imaging, most commonly employed edema approach [5]; and (b) T2 mapping, an improved method for edema detection [6,7].

Methods – Canines (n = 10) were subjected to no-flow ischemia by occluding the LAD artery for 3 hours followed by reperfusion. CMR studies were performed at baseline, during ischemia (45-90 minutes post-occlusion) and on days 2, 5, 7 and 56 post-reperfusion (1.5T Siemens). T2-prepared SSFP (TR/TE = 2.2/1.1ms; T2-prep durations = 0, 22 and 55ms; BW = 1002Hz/pixel), T2-STIR (TR = 2-3 R-R intervals; TE = 64ms; TI = 170ms; BW = 355Hz/pixel) and Late Gadolinium Enhancement (LGE; IR-prep SSFP; TR/TE = 3.5/1.75ms; BW = 1002Hz/pixel) images of contiguous short-axis slices covering the whole LV were acquired. Spatial resolution for all the scans was 1.3x 1.3 x 8.0mm^3.

Motion-corrected T2 maps were generated by fitting the multiple T2-prepared SSFP images using a validated algorithm [8]. A reference ROI was drawn in the Remote myocardium (region showing no hyperintensity on LGE images). Myocardium with mean T2 (for T2 maps) and signal intensity (for T2-STIR images) at least 2 standard deviations (SDs) higher than those of the reference ROIs were determined. Infarcted myocardium was defined on LGE images as the region with mean SI at least 5 SDs greater than that of reference ROI. Percentage edema volume ($\bar{E}$; with respect to total LV volume) during ischemia, and on days 2, 5 and 7 post reperfusion were computed and compared. Percentage infarct volume ($\bar{I}$; with respect to total LV volume) and *MS* ($\bar{E}$ post-reperfusion – $\bar{I}$) were determined for each study time point post reperfusion (days 2, 5 and 7) and compared. In addition, pre- and post-reperfusion $\bar{E}$ were normalized with mean post-reperfusion infarct volume and compared. All calculations were performed using both T2 maps and T2-STIR images and compared against one another. Statistical significance was set at p<0.05.

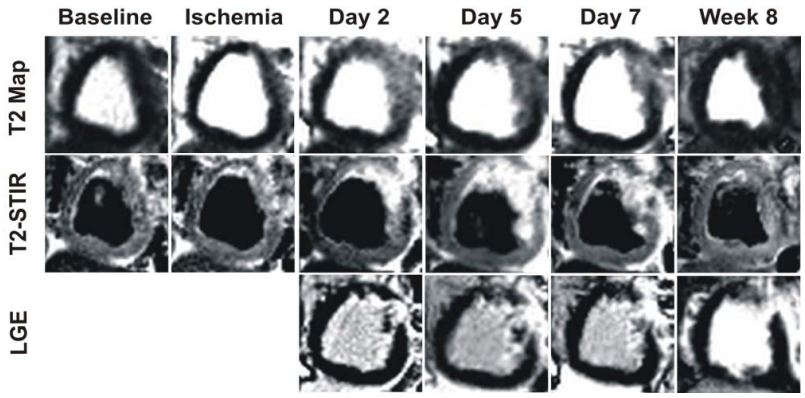

Figure 1: Representative T2 maps, T2-STIR images and LGE images at different study time points are shown.

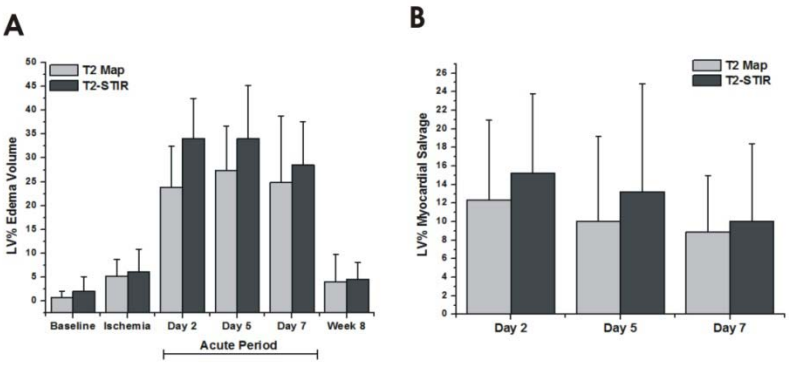

Figure 2: Percentage edema volume and myocardial salvage (with respect to total LV volume) measured using T2 maps and T2-STIR images at different study time points are shown.

Results – Figure 1 shows representative T2 maps, T2-STIR and LGE images at the different study time points. Relative to baseline, a small but significant $\bar{E}$ was apparent during ischemia (T2 maps: 0.83 ± 1.26% at baseline vs 5.25 ± 3.51% during ischemia; T2-STIR: 2.09 ± 3.01% at baseline vs 6.19 ± 4.71% during ischemia; p=0.04). $\bar{E}$ post-reperfusion was significantly higher than that of pre-reperfusion (p<0.001), but remained constant across days 2, 5 and 7 (p = 0.78). Edema regressed completely and returned to baseline levels by day 56 (p = 0.42). There was no significant difference between $\bar{E}$ measured by T2 maps and T2-STIR images (p = 0.56). Mean ischemic $\bar{E}$ normalized with mean $\bar{I}$ was significantly lower than the mean post-reperfusion $\bar{E}$ normalized by $\bar{I}$ (T2 maps: 0.5 ± 0.4 pre-reperfusion vs 1.8 ± 1.1 post-reperfusion; T2-STIR: 0.6 ± 0.4 pre-reperfusion vs 1.8 ± 0.8 post-reperfusion; p<0.001). Both normalized ischemic and post-reperfusion edema volumes were not different between T2 maps and T2-STIR images (p = 0.41). Both $\bar{I}$ and MS remained unchanged across days 2, 5 and 7 (p = 0.99 and 0.72 respectively). There was no significant difference between MS measured by T2 maps and T2-STIR images across all study time points (p = 0.74).

Conclusions – A small but significant relative edema volume was apparent during ischemia, as determined from T2 maps and T2-STIR images. However, relative edema volume increased significantly post reperfusion. Relative edema volume during ischemia is not truly indicative of relative edema volume post-reperfusion, and may underestimate area-at-risk. In fact, mean ischemic $\bar{E}$ is less than mean $\bar{I}$ but greater than mean post-reperfusion $\bar{E}$. Both post-reperfusion relative edema volume (with respect to total LV volume) and *MS* remained unchanged during the acute period of reperfused myocardial infarction. T2 mapping and T2-STIR imaging appear to provide equivalent information on relative edema volume and *MS*.

References – [1] Abdel-Aty et al, *JACC*, 2009; [2] Arai et al, *Circ CV Imaging*, 2010; [3] Friedrich et al, *JACC*, 2008; [4] Eitel et al, *JACC CV Imaging*, 2010; [5] Friedrich et al, *JACC*, 2009; [6] Giri et al, *JCMR*, 2009; [7] Thavendiranathan, *Circ CV Imaging*, 2011; [8] Giri et al, *SCMR*, 2010.