T2*-weighted cardiovascular magnetic resonance imaging detects reperfusion hemorrhage in a dog model of myocardial infarction

A. Kumar[1], J. D. Green[1,2], J. M. Sykes[3], P. Ephrat[3], J. J. Carson[3], A. J. Mitchell[3], G. Wisenberg[3], and M. G. Friedrich[1]

[1]Stephenson CMR Centre, University of Calgary, Calgary, AB, Canada, [2]Siemens Medical Solutions, Calgary, AB, Canada, [3]Imaging Division, Lawson Health Research Institute, London, ON, Canada

Background

Hemorrhage is a known complication of reperfusion therapy in acute myocardial infarction, but there is currently no accepted imaging method to assess reperfusion hemorrhage in vivo. T2*-weighted MR sequences sensitively detect hemorrhage in stroke patients. It is known that about 50% of the areas with myocardial no-reflow contain hemorrhage. We hypothesized that, in areas of no-reflow, a T2*-weighted gradient echo EPI sequence sensitively detects hemorrhage in a dog model of acute reperfused myocardial infarction.

Methods

Ten mongrel dogs (all female, weight 19-22kg) underwent thoracotomy and transient occlusion of the left anterior descending coronary artery distal to the first diagonal branch. After three hours (n=6) or four hours (n=4) of no-flow ischemia, coronary arteries were re-opened and the dogs were allowed to recover. At day 3 post infarction, a cardiovascular magnetic resonance (CMR) imaging study was performed using a 1.5T system (Avanto®, Siemens Medical Solutions, Germany) with a cardiac coil. A gradient echo EPI sequence (TE=35ms) was applied in contiguous short axis slices covering the entire left ventricle (slice thickness 10mm no spacing). After contrast injection (0.1mmol/kg Gadolinium-DTPA), an IR-prepared gradient echo sequence ("late enhancement") was applied in contiguous short axis slices covering the entire left ventricle 2 minutes (assessment of no-reflow) and 10 minutes (infarct visualization) after Gd-DTPA. Image analysis was performed with custom-made software using a modified 17-segment model. Segments that showed a signal deviation of more than 2 standard deviations from remote myocardium were defined as abnormal. The dogs were sacrificed; the hearts were sliced and assessed for infarction and hemorrhage using Tetrazolium-Chloride staining (TTC). Correlation statistics were performed to compare findings consistent with hemorrhage on T2*-weighted imaging to TTC staining and no-reflow.

Results

288 GE-EPI segments were assessed but 20 (7%) had to be excluded because of significant artifacts. 15/39 segments with no-reflow showed a T2* signal consistent with hemorrhage, and only 4/225 segments without no-reflow showed a T2* signal abnormality consistent with hemorrhage. Comparing T2* imaging for hemorrhage with the ex-vivo results for hemorrhage using TTC staining, a significant correlation was found with a Kappa value of 0.78.

Conclusion

T2*-weighted GE-EPI detects reperfusion hemorrhage in no-reflow areas of reperfused acute myocardial infarcts in a dog model. This pattern is consistent with previously described pathology findings. T2*-weighted CMR may thus serve as a clinical tool to visualize myocardial hemorrhage.

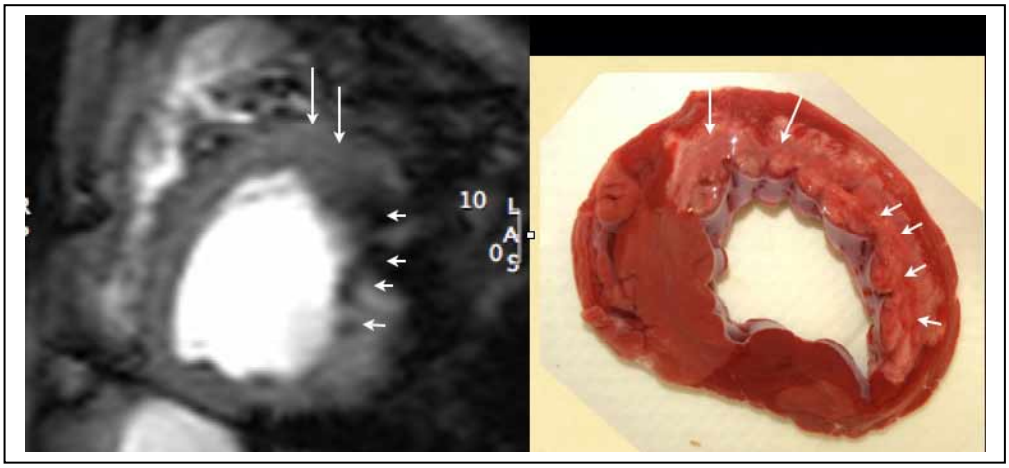

Figure: TTC stained heart slice (right image) showing myocardial infarction without hemorrhage (long arrows) and with hemorrhage (short arrows). The T2* MRI image (left) shows a signal drop only in the hemorrhagic zone (short arrows), but not in the area of non-hemorrhagic infarction (long arrows).