Assessment of Irreversible Myocardial Damage by Delayed Hyperenhancement MRI in the Hyper-Acute Stage

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Introduction: Delayed hyperenhancement magnetic resonance imaging (MRI) can be used as a noninvasive method to assess the size of myocardial infarction[1]. The accuracy of this imaging method has been validated by direct comparison with postmortem cardiac tissue stained with tetrazolium as a gold standard. However, a characteristic pale appearance of necrotic region from tetrazolium staining is fully developed only after the complete depletion of dehydrogenase and other intracellular cofactors; and an incomplete depletion will result in a non-characteristic pink color[2, 3]. This study was to examine delayed hyperenhancement MRI in the acute phase of reperfusion from two aspects: First, does the hyperenhanced region correlate to tetrazolium staining at 1 and 2 hours after reperfusion? And second, does image acquisition need a different delay after contrast agent administration, at 1 or 2 hr compared to 24 hr reperfusion?

Materials and Methods: Male Sprague-Dawley rats (270-370 g) were anesthetized with Sodium Pentobarbital (50 mg/kg, I.P.), intubated and respiration was maintained with a rodent ventilator. Thoracotomy was performed to expose the heart, and the left coronary artery was occluded with a 6-0 suture for 30 minutes, followed by 1 (n=4), 2 (n=5) and 24 hr (n=6) reperfusion. All MRI images were obtained on a Bruker BIOSPEC 3T/60 system, using a homemade cylindrical local gradient coil, which, at 100 A, produced gradient fields of 21.30 Gauss/cm, 20.83 Gauss/cm, and 41.20 Gauss/cm in the X, Y, and Z directions, respectively. A custom made 4.5 cm i.d. birdcage coil was used for excitation and reception. As the purpose of this study was to quantitatively compare the infarct area assessed by MRI and tetrazolium staining, we selected a spin echo sequence to maximize spatial resolution. ECG gated short-axis spin echo images (TE = 15.2 ms, TR = 320 ms, FOV = 5 cm, Matrix = 192 x 192, slice thickness = 2 mm) were acquired at an average of 17.5 min after Gd-DTPA injection (0.1 mmol/kg). The heart was immediately excised after collecting MR images, and short-axis slices of myocardium were stained with 1% triphenyltetrazolium chloride (TTC) to determine the exact infarct size. The size of delayed hyperenhanced region of each MR image, and the TTC negative infarct region, including the pink regions, in histology, were determined independently by drawing regions of interest (ROI) on digitized images by an observer. We particularly avoided using automated image analysis software due to the complications from the no reflow phenomenon at the necrotic centers in the MR images and the non-characteristic pink regions in histology. The infarct area as a percentage of the left ventricle from each MR image was compared with that of corresponding TTC-stained section.

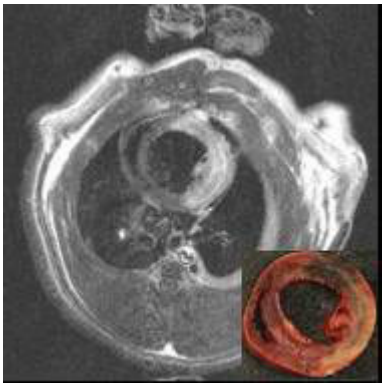

Figure 1. *Short-axis spin echo image of the rat heart at 6 mm from the apex, acquired at 17.5 min after injection of Gd-DTPA. Infarct area appears to be hyperenhanced. The insert is thea photograph of the corresponding tissue slice stained with TTC.*

Results: Figure 1 demonstrates a representative short-axis spin echo image of the rat heart at 6 mm from the apex, acquired at 17.5 min post Gd-DTPA injection. The hyperintense region in the anterior wall of the left ventricle was identified as the infarct region. In this particular case, it is a transmural infarction, with regions of no-reflow at the necrotic core. The insert in Figure 1 is the corresponding tissue section stained with TTC, where the pale region is dead myocardium being TTC negative. The anterior region of the infarct area appears to be black, which was caused by the local hemorrhage as a consequence of cardiac injury. The hyperenhanced region of the left ventricle in the MR image registers with the pale TTC-negative infarct region in the histological section. Figure 2 demonstrates the infarct area determined by MRI as a percentage of the true infarct area by TTC, for 24, 2 and 1 hr reperfusion. The mean percentages are 100.1 ± 2.3, 100.1 ± 1.7, and 100.6 ± 5.4%, for 24, 2 and 1 hr of reperfusion, respectively.

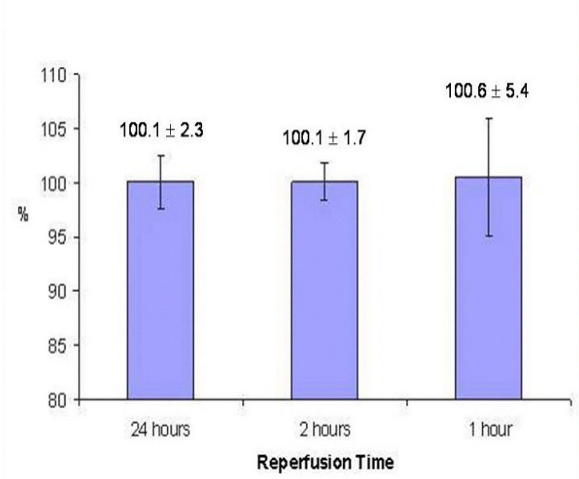

Figure 2. *Infarct area determined by del hyperenhancement MRI as a percentage of infarct area by TTC, for 24, 2 and 1 hr of reperfu*

Conclusion: Irreversible myocardial damage in acute infarction, as confirmed by TTC staining, can be imaged as early as 1 hr after reperfusion with delayed hyperenhancement MRI. Regardless of the reperfusion length from 1 to 24 hr, image acquisition at 17.5 min post Gd-DTPA injection resulted in infarct area best correlated to TTC staining. This result is in agreement with that delayed hyperenhancement detects irreversible myocardial damage. While the data were acquired at the hyper-acute stage of infarction, they provide a large safety margin for the early diagnosis of myocardial damage.

References:

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