

The Delayed Hyperenhancement Patterns for Occlusive and Reperfused Myocardial Infarct at Different Healing Stage

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Introduction:

The delayed contrast-enhanced MRI (ceMRI) has often been used to access the myocardial viability in recent years. However, the mechanism of the delayed enhancement in infarcted myocardium and the enhancement pattern throughout the infarct healing are not yet fully understood. In this study, we used pig model to investigate the MR enhancement pattern in different healing stage of myocardial infarct with and without reperfusion.

Methods:

12 pigs were studied with 6 pigs subjected to permanent RCA occlusion and the other 6 pigs subjected to transient 90 min RCA occlusion. In vivo MRI exam was performed at a few time points: 4 hours, 8 hours, 12 hours, 24 hours and 8 days after the artery occlusion. Pigs were scanned in the lateral decubitus position using a GE 1.5T SIGNA CV/i MRI system. An inversion recovery-prepared fast gradient recalled echo sequence was employed in the ceMRI exam which was performed 30 min after the injection of 0.2mmol/kg Gd-DTPA. The ceMRI scan parameters were TR=7.2ms, TE=3.2ms, TI=200ms, flip angle=20°, FOV=360mm×270mm, 256×192 matrix. Contiguous 8-mm-thick short-axis image were acquired from apex to base. 2 pigs with occlusive infarct and 2 pigs with reperfused infarct were sacrificed after the in vivo imaging at 4 hours. Four pigs were sacrificed following in vivo MRI at 24 hours. The rest of pigs were sacrificed following in vivo MRI at 8 days. With each sacrificed pig, the heart was sectioned into 8-mm-thick short axis slices perpendicular to ventricular septum from apex to base using a commercial rotating meat slicer. All slices were stained with 2% TTC and photographed under room light to determine infarct size. A transmural block of tissue was obtained from both infarcted and normal myocardium. Each tissue specimen was stained with hematoxylin and eosin (H&E) and examined under light microscopy. An additional small piece of tissue was obtained from the infarcted and normal myocardium nearest the endocardium for electron microscopy exam.

Results:

For all 6 pigs with permanent artery occlusion, in vivo image at 4 hours after ligation did not exhibit delayed hyperenhancement; images at 8 hours started to show delayed enhancement and the spatial extent of the hyperenhancement gradually increased, from the infarct border to center and from epicardium to endocardium; the transmural hyperenhancement appeared at 8 days. However, for the pigs with reperfusion, the significant hyperenhancement exhibited at every stage from 4 hours to 8 days. The SI of hyperenhanced region was $507.57 \pm 142.31\%$ of remote, normal myocardium. In the myocardial territory supplied by occluded artery irrespective of reperfusion status, the pathologist identified the full range of histologic features characteristic of infarcts at various stages of healing, including coagulation and contraction band necrosis, neutrophils and macrophages in infarcts 4 hours to 24 hours, granulation tissue in 8-day-old infarct.

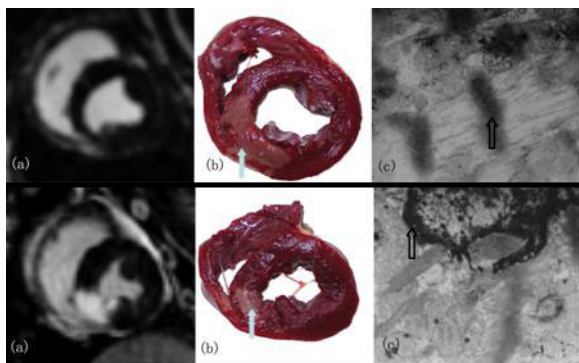


Figure 1: a pig heart with occlusive infarct 4hours after interruption of blood flow. (a) in vivo T1 weighted MR image acquired 30 min after the Gd-DTPA injection; (b) TTC staining photograph identified irreversible injury (arrow); (c) electron microscopy showed contraction bands (hollow arrow).

Figure 2: a pig heart with reperfused infarct 4hours after blood flow restored. (a) in vivo T1 weighted MR image acquired 30 min after the Gd-DTPA injection; (b) TTC staining photograph identified irreversible injury (arrow); (c) electron microscopy showed the nucleus clumped chromatin along the membrane and large lucent areas (hollow arrow).

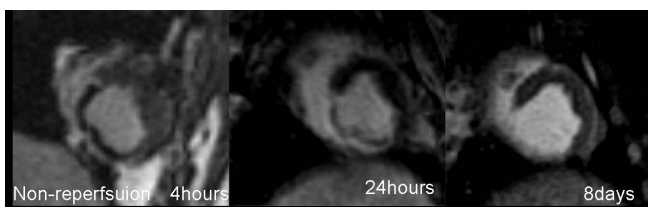


Figure 3: The in vivo images of a pig's heart with occlusive infarct scanned at 4 hours, 24 hours and 8 days respectively.

Conclusion:

Our investigation showed that the delayed hyperenhancement pattern in the occlusive infarct is different from that in reperfused infarct. The occlusive infarct did not exhibit hyperenhancement within first few hours after the ligation while reperfused infarct exhibited hyperenhancement throughout whole healing period. It indicates that the delayed ceMRI may not be able to identify the nonviable myocardium at hyperacute stage when reperfusion is not established. Our MRI finding in occlusive infarct is different from previous report in dog model (1). This might be due to that the pig has less collaterals than the dog. Nevertheless, Pigs have similar coronary circulation and similar heart to body weight ratio as in human.

Reference:

1. Fieno et al. J Am Coll Cardiol 2000; Vol 36, No.6, 1985-1991.