MRI PERFUSION DISCRIMINATES STUNNED MYOCARDIUM ADJACENT TO FOCAL INFARCT FROM MICROEMBLIZED INFARCTED MYOCARDIUM

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Target Audience: Clinicians and cardiac researchers whose interest lies in imaging myocardial viability and coronary artery pathology.
Purpose: To assess myocardial perfusion and function in stunned myocardium with minor infarction caused by microemboli using MRI sequences and postmortem characterization method.
Methods: A fixed landmark on the left anterior descending (LAD) coronary artery (distal to second diagonal) was used for fluoroscopic positioning of the angioplasty balloon catheter, LAD occlusion, and microemboli delivery to create a reproducible area at risk. Eight pigs served as controls (Group I) and 16 were subjected to brief (45min) coronary artery occlusion (group II, n=8) or 45 min occlusion/reperfusion followed by 32mm^3 microemboli (group III, n=8). A 1.5T MR scanner was used at 3 days and 5 weeks to acquire ECG-gated cine MRI in all groups and perfusion in groups II and III. Steady state free precession cine was used for measuring global and regional LV function. The imaging parameters were: TR/TE/flip angle=3.5ms/1.8ms/70°, slice thickness=6mm without gap, FOV=26×26cm; matrix size=160x152; NEX=1 and cardiac phases=16. First-pass perfusion MR images were acquired after administration of 0.1 mmol/kg gadoterate meglumine in four short-axis sections with a saturation-recovery gradient-echo sequence TR/TE/flip angle= 4.5/2.2/20°, Slice thickness=10mm, FOV=26×26cm, matrix size=128×128, NEX=1 and two R-R intervals per dynamic acquisition). The injection rate of MR contrast media was 3mL/sec.
At 5 weeks, the hearts were excised and sliced and each LV ring was then incubated in triphenyltetrazolium chloride (TTC) to visualize myocardial infarct. Left ventricular slices were fixed by 10% formalin then stained with Masson trichrome for microscopy. Cine MR imaging was used to measure LV volumes (ejection fraction and stroke volume), systolic wall thickening and mass by delineating the endocardium and epicardium in all short-axis sections at end diastole and end systole. Using first-pass perfusion MR images, three ROIs in the LV chamber, LAD territory and remote myocardium, were measured as a function of time to determine maximum upslope, time to peak and maximum signal intensity. Paired and unpaired Student *t*-test was performed to assess the significance. The following parameters were compared: LV volumes, ejection fraction, microinfarct size, systolic wall thickening, max upslope, max signal and time to peak for perfusion. A *P*-value less than 0.05 was considered significant.
Results: Groups II and III animals showed impairment in LV function compared with group I at both time points (Table 1). Increase in LV end systolic volume and decrease in ejection fraction were more pronounced in group III than II. On the regional level, systolic wall thickening was persistently depressed in groups II and III compared with group I. However, the severity of regional dysfunction was significantly greater in group III than II. Group III, but not group II, demonstrated regional perfusion deficits at 3 days and 5 weeks (Figs 1,2), which was reflected by the perfusion indices (max upslope, time to max signal intensity and max signal intensity). Unlike group II, group III animals showed persistent perfusion deficits over the course of 5 weeks (Figs 1,2). The mismatch between regional dysfunction and perfusion indices over the course of 5 weeks suggests that the myocardium in group II animals was stunned. Postmortem TTC confirmed the presence and absence of myocardial damage in groups III and II, respectively.

	3 days	5 weeks
Group I	51±1%	50±1%
Group II	45±2%*	47±2%
Group III	36±2%*+	39±2%*+

Table 1. Ejection Fraction from Cine MRI for all groups (n=8 per group).
* P<0.05 compared with group I,
+ P<0.05 compared with group II

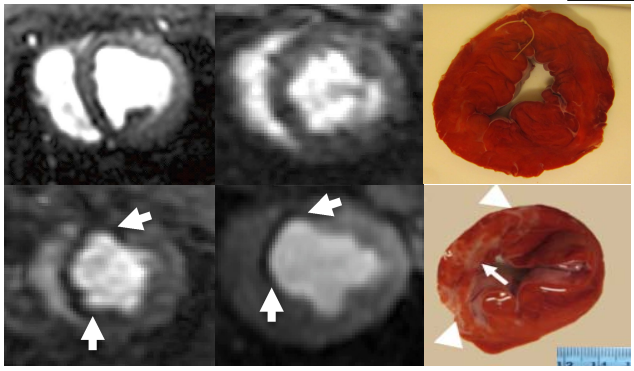

Figure 1. First pass perfusion images of Group II (top) and Group III animals (bottom) at 3 days (left) and 5 weeks (middle) demonstrate persistent perfusion deficits (white arrows) in group III but not II. Unlike group II, group III showed persistent decline in perfusion. TTC (right) shows myocardial infarct.

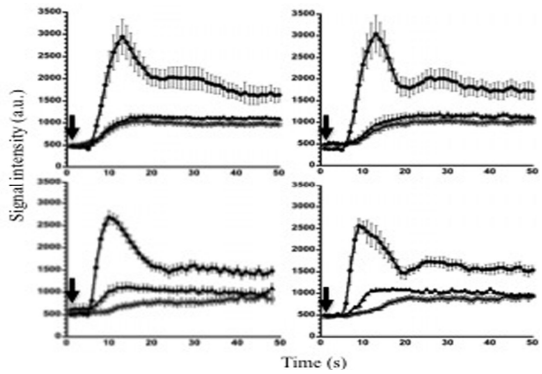

Figure 2. MR first pass perfusion plots showing the normal perfusion in the LAD territory in group II and persistent perfusion deficits in group III. The arrow indicates the time of injection of Gd-DTPA.

Conclusion: Perfusion MRI has the ability to differentiate mildly ischemic from microembolized ischemic myocardium, while cine MRI demonstrated the severity of myocardial injury at regional and global levels. It also demonstrated the effects of microemboli on vascular and cellular integrity. The combination of cine and perfusion MRI showed persistent myocardial stunning and perfusion deficits in mildly ischemic myocardium with minor infarction.