Quantification of the regional myocardial function after dobutamine in rat using cine and tagged MRI

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Background: Experimental models on rodent aiming to reproduce myocardial hibernation require an accurate quantification of the cardiac function after dobutamine. MRI using both cardiac cine and tagged images has been recognized as a robust method to assess the cardiac function in rat. However, the respective advantage of both MRI methods regarding dobutamine challenge has never been investigated. Therefore, the purpose of this study was to measure the regional contractile function using cardiac cine and tagged images during incremental doses of dobutamine in the normal rat and in an occlusion-reperfusion model.

Methods and results: Five adult rats with a single 30 minutes episode of coronary artery occlusion followed by reperfusion and five normal rats were imaged on a clinical 1.5T MR system using a segmented turbo field echo cine sequence (11-16 phases per cycle, acquired voxel size 0.28/0.28/2 mm, TR/TE 12/4.9 ms, FA 30°, acquisition time per slice 2'52") and a C-SPAMM tag preparation segmented cine fast field echo sequence (18-25 phases per cycle, acquired voxel size 0.63/1.79/3 mm, tag spacing 1.25 mm, TR/TE 7.8/3.6 ms, FA 10°, acquisition time per slice1'25"). After imaging at rest, three doses of dobutamine were injected for normal group (IV): 2.5, 5 and 10 µg/min/kg. For two short axis views per animal, wall thickening using manual contour definition, circumferential strains using semi-automated tracking software were calculated as well as inter-observer variability. Infarct size was assessed using delayed enhancement and TTC studies.

Results: High quality cine and tagged images were obtained in all the rats even at high dose of dobutamine (fig 1). Ejection fraction increased significantly (+19.3±9.3%, p<0.001) in the normal group after dobutamine perfusion due to a significant decrease of left ventricle end-systolic volume (-62.4±23.2%, p<0.001). In the normal group, both wall thickening and circumferential strains improved for each dose of dobutamine (p<0.001) (fig 2). For the infarct group, wall thickening and endo-mid-epicardial circumferential strain measurements were significantly decreased in the infarct sectors (p<0.05) (fig 3 & 4). However, no significant response to dobutamine was observed with both techniques in the infarct group. Finally, an inter-observer analysis demonstrated a two fold decreased in variability for tag measurements (6.7 %, 0.9% and 4.2% for endo-mid-epicardial levels) by comparison to cine analysis (13.2%) (p<0.01)

Conclusion: Both cardiac cine and tagged MRI can quantify the effect of incremental doses of dobutamine and infarct induced changes on the regional cardiac function in rat. Cine imaging with an increased spatial resolution allows in addition an accurate measurement of end diastolic and end systolic volume as well as cardiac mass. Tag MRI, despite a lower spatial resolution, yields more reproducible measurements as an subendocardial analysis. Therefore, both methods needs to be performed in the cardiac function assessment on rat to improve the robustness of cardiac MRI

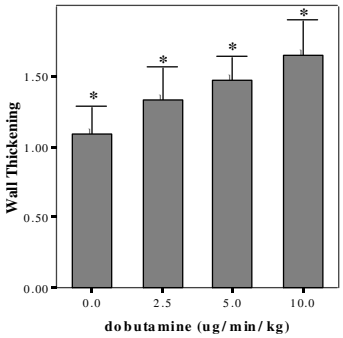

Figure 2: Wall thickening values in normal group at rest and stress. All measurements under dobutamine stress are significantly different from the values obtained at rest (* p<0.001).

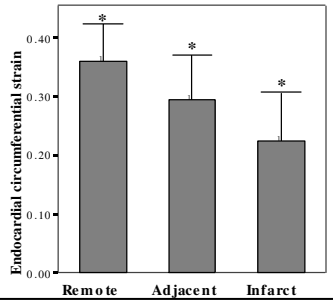

Figure 3: endocardial circumferential strains, two days after a single 30' coronary occlusion, exhibit a significant discrimination between remote, adjacent and infarcted sectors (p<0.05).

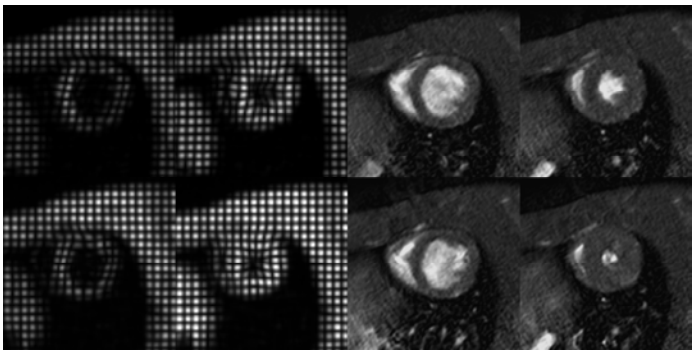

Figure 1: Representative example of tagged and cine images at rest (first row) and stress under dobutamine (2nd row) in diastolic and systolic phases obtained in normal heart

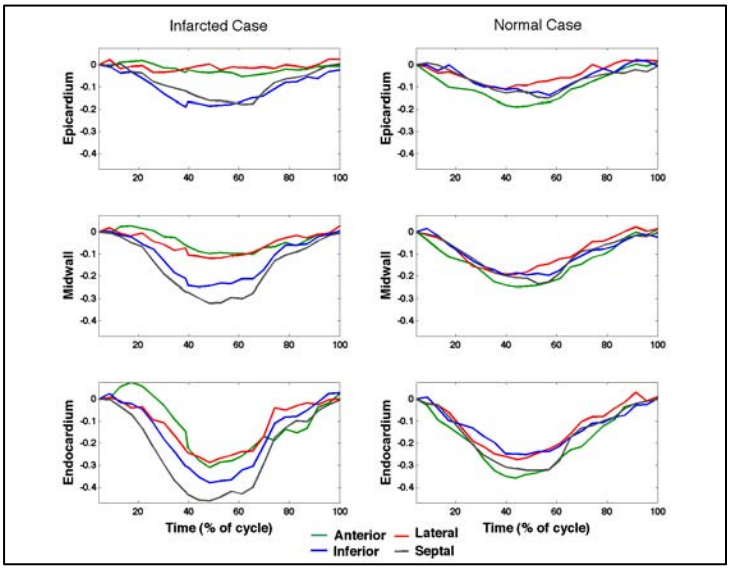

Figure 4: Representative example of circumferential strain curves obtained in an infarcted and a normal rat. Infarct area was located after TTC staining in antero-lateral sectors and exhibits a clear contraction deficit compared to the remote sector and to the antero-lateral sectors in a normal heart.