Myocardium structural remodeling with relation of infarct location and size in porcine model using DTI

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Introduction

Myocardial infarction (MI) usually causes an altered myocardium geometry and mechanical function of left ventricle (LV). Infarct size and location have been recognized as the determinants of LV remodeling [1]. However, the effect of infarct location on cardiac remodeling is still controversial. Some researchers reported that infarct size, not the location, is the dominant determinant of LV remodeling [2-3]. However, others believed that anterior MI was associated with greater LV remodeling compared with non-anterior infarctions [4-5]. In this study, CMR and DTI were performed to investigate the influence of infarct location and size on myocardium structural and fiber architectural alterations in porcine models.

Method

Imaging experiments were conducted on a 3T Philips MR imager. LAD and LCX ligations were performed on two porcine groups with infarctions induced at septum near apex and lateral wall around base, respectively (Fig.1; N=6 for each infarct group; control N=6). 13 weeks later, in vivo CMR study, including CINE sequence and Gd delay enhancement, was performed to calculate ejection fraction (EF) and infarct size. Then, hearts were excised and fixed with formalin. DTI was performed along the short-axis of LV using SE-EPI: TR/TE=4000/45ms; diffusion b=800 s/mm^2; 15 gradient directions; ~40 slices with 0mm gap; and NEX=40 with isotropic resolution of 1.13mm^3. The scan time was ~50 min per sample. Ten slices covering infarction were chosen and, together with corresponding controls, were segmented into infarct, adjacent and remote regions [6]. For each slice, infarct size in terms of epicardium circumferential length of infarction was measured. Fiber quality, described by FA, mean ADC, axial and radial diffusivities, together with fiber orientation were measured from DTI data. Three groups of fibers were categorized: left-handed helical fiber (LHF) with helix angle within -90º to -30º, circumferential fiber (CF) within -30º to 30º, and right-handed helical fiber (RHF) within 30º to 90º [7]. Fiber quality and fiber architecture were compared in 3 regions. Correlation of infarction size and fiber quality in infarct regions were performed. Masson's trichrome stain was performed on an adjacent region of one piece of infarct sample. Student's t-test was applied with values of p<0.01 regarded as significance.

Results

EF decreased with increase of infarct size (Fig. 2). Two infarct groups did not show significant difference of EF and infarct size. Student's t-test of FA values in MI groups was summarized in Table 1. Note that difference was detected between adjacent and remote regions while histology revealed substantial tearing of the myocardial fiber bundles with extended formation of fibrosis in adjacent region (Fig.3). Significant decrease of FA was observed in infarct region, but not in adjacent and remote regions. Between the two infarct groups, no significant difference was obtained in all three regions (Fig.4). Mean ADC was found to increase significantly only in infarct region. No significant difference was observed in all three regions between two infarct groups (not shown). Similar results were obtained for axial and radial diffusivities (not shown). Fig.5 correlates the FA values with infarct size in infarct region, yielding negative correlations in both MI groups. But positive correlations were exhibited for mean ADC, axial and radial diffusivities with infarct size (not shown). Figs.6 and 7 illustrate the percentages of LHF, CF, and RHF. In adjacent region, LHF and CF of LAD-related MI group were significantly different from control and LCX-related MI group (Fig.6). But no substantial changes of three groups of fibers were found in LCX-related MI group. In remote regions, no significant fiber distribution change was observed in both MI groups (Fig.7).

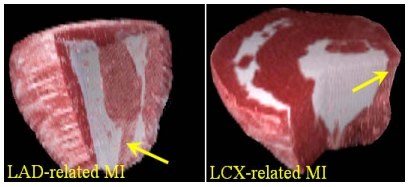

Fig.1 Infarct locations (arrows).

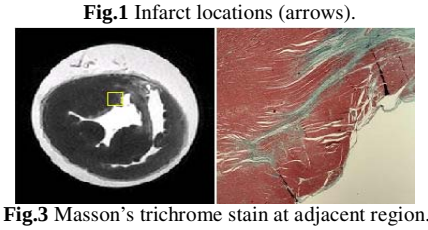

Fig.3 Masson's trichrome stain at adjacent region.

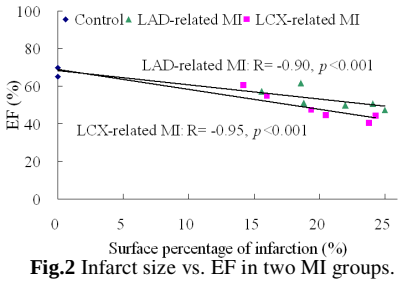

Fig.2 Infarct size vs. EF in two MI groups.

Table 1 Student's t-test of FA values in MI groups.

	LAD-related MI	LCX-related MI
Infarct vs. adjacent	*p<0.01	*p<0.01
Adjacent vs. remote	*p<0.01	p=0.02
Remote vs. infarct	*p<0.01	*p<0.01

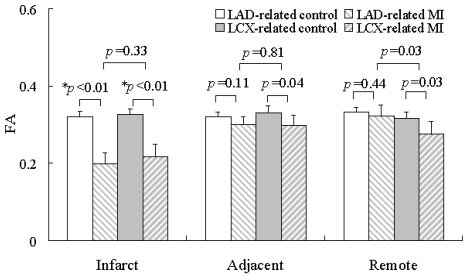

Fig.4 FA values in 3 regions.

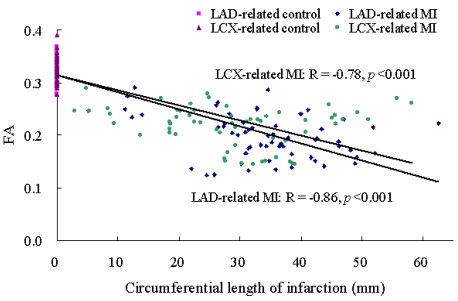

Fig.5 FA vs. infarct size in infarct region.

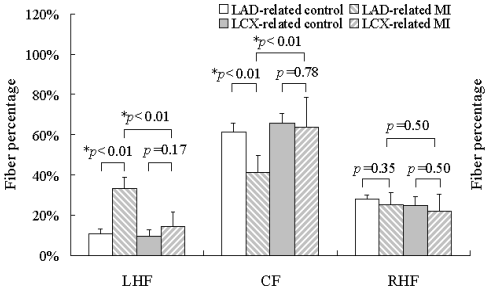

Fig.6 Fiber distribution in adjacent region.

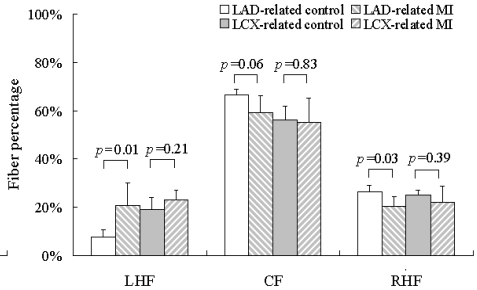

Fig.7 Fiber distribution in remote region.

Discussion

In current study, two porcine groups with different infarct locations (by LAD or LCX ligation) were studied. No significant difference of EF and infarct size was observed between two MI groups. Changes of FA, mean ADC, axial diffusivity, radial diffusivity and double-helical structure were investigated using DTI. Compared with controls, similar alteration trend of FA, mean ADC, axial and radial diffusivities in infarct, adjacent and remote regions were exhibited in both two MI groups. No significant difference was observed between the two MI groups in all 3 regions. The DTI parameters were found to be correlated well with infarct sizes. The results suggested that the degradation of myocardial fiber quality is dependent on infarct size, not infarct location. However, for myocardial fiber architecture, more left-handed shift of double–helical fiber distribution was found only in LAD-related MI group. This implies that LAD-related MI causes more fiber orientation change and that fiber architecture alteration indeed is associated with infarct location. In conclusion, infarct size is the most dominant factor in the overall functional and structural degradation after myocardial infarction. However, both infarct size and location affect the myocardium structural remodeling.

References

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