Cardiac Magnetic Resonance Imaging Permits Visualization of Coronary Microembolization in Swine

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Background: Coronary microembolization (ME) is a frequent event in ischemic heart disease, occurring either spontaneously in acute coronary syndromes or artificially during coronary interventions. The experimental pathophysiology and the post-mortem morphological alterations of coronary ME are well characterized. In animal models experimental ME results in regional myocardial dysfunction as well as inflammatory edema and focal scar formation. However, whereas myocardial dysfunction can easily be analysed in vivo edema and scar formation had to be investigated using post-mortem histology.

Purpose: Our study aimed to visualize the effects of experimental ME in-vivo using contrast-enhanced cardiac magnetic resonance imaging (cMRI).

Methods: In 12 minipigs a 2F microcatheter was placed into the distal portion of the left anterior descending coronary artery (LAD) under x-ray guidance and ME was performed by injection of microspheres (42µm in diameter, approximately 4500 microphores per mL/min coronary flow). In the first three animals, only ex-vivo-measurements of the explanted heart were performed 8 hours after ME. In 9 animals repetitive in-vivo cardiac exams were performed. The in-vivo MR protocol included SSFP-Cine sequences (TR 3 ms, TE 1.5 ms; FA 60°, spatial resolution 1.9 x 1.9 x 6 mm) for the assessment of regional wall motion and T2-weighted TSE sequences (TR 2 x RR, TE 59 ms, FA 180°, resolution 1.3 x 1.7 x 5 mm) to visualize myocardial edema. Thereafter, a dose of 0.2 mmol/kg Gd-DTPA (Magnevist, Schering AG Berlin) was applied and IR-turboFLASH sequences (TR 700-800 ms, TE 4.6-4.9 ms, TI 180-300 ms, FA 25-30°, resolution 1.3 x 1.7 x 5 mm) were performed for the detection of late enhancement. The animals were scarified at 2, 4 or 8 hours after ME. Finally, the heart was explanted and ex-vivo MR measurements were performed. Ex-vivo imaging protocol included high-resolution 2D and 3D IR-turboFLASH sequences (TR 800, TE 4.85 ms, TI 300, resolution 0.5 x 0.5 x 3 mm). All experiments were followed by histomorphologic characterization of myocardial damage.

Results: In-vivo cine MRI demonstrated ME-induced regional wall motion abnormalities of the target area in all but one animal (3/3 after 8 hours, 3/3 after 4 hours, 2/3 after 2 hours), whereas myocardial edema was detected in 6 animals (2/3 after 8 hours, 3/3 after 4 hours, 1/3 after 2 hours). The in-vivo MR measurements showed focal areas of late enhancement in 2 animals only (0/3 after 8 hours, 2/3 after 4 hours, 0/3 after 2 hours). However, ex-vivo-measurements showed patchy and streaky areas of late enhancement in the target area (segments 7,8,13,14 and/or 17 in 11 of 12 pigs (6/6 after 8 hours, 3/3 after 4 hours, 2/3 after 2 hours) [Figure 1a]. The corresponding histology confirmed patchy microinfarcts with leukocyte infiltration at 8 hours after ME, whereas at 2 and 4 hours only beginning evidence of oncoming microinfarction with infiltrating leukocytes [Figure 1b] could be detected by histology.

Conclusion: Our data suggest that cMRI permits visualization of experimental ME in an animal model, even prior to histologic demarcation. However, areas of late enhancement could only reliably be detected at high-resolution ex-vivo imaging. Therefore, high-field MRI resulting in an improved spatial resolution of in-vivo-measurements might be helpful to visualize microinfarcts in-vivo.

(a) (b)

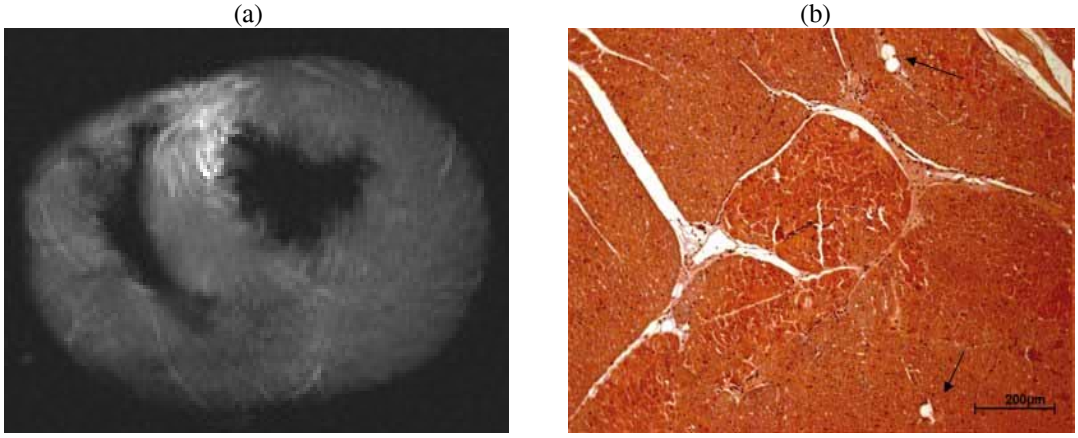

Figure 1: Ex-vivo demarcation of patchy to streaky hyperenhancement 4 hours following experimental ME (a) and corresponding histology demonstrating discrete hypereosinophily and leukocyte infiltration as a hint for oncoming microinfarction beside the presence of microspheres [arrow] (b).