

Myocardial Magnetic Resonance Stress Perfusion Imaging at 3T using a 1-molar contrast agent

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Background: MR-stress perfusion imaging (MRSPI) is a well established technique for the detection of hemodynamically relevant coronary artery disease (1). At our institution, MRSPI at 1.5T renders a sensitivity of 90% and a specificity of 74% for coronary artery stenoses >70%. However, image quality is compromised by limited SNR and image contrast at 1.5T (2). Due to the high clinical impact of stenosing coronary artery disease for patient treatment, further improvement of techniques enabling the detection of coronary artery disease at an early stage is desirable. One approach is an increase in field strength and contrast agent concentration providing higher SNR and image contrast (3). Due to prolonged longitudinal relaxation at 3T especially strongly T1 weighted sequence techniques relying on the application of gadolinium based contrast agents including myocardial perfusion and viability imaging will take advantage from increased signal intensity at higher field strength (4). Yet, additional problems including reduced field homogeneity and artefacts due to magnetic resonance effects occur at higher field strength. Moreover established sequence techniques at 1.5T cannot be implemented on 3T systems without prior modifications for physical and technical reasons. Aim of our study was the evaluation of the diagnostic capability of myocardial stress perfusion imaging under optimized conditions at 3T using a 1-molar contrast agent.

Method and Materials: 57 patients with clinical symptoms of coronary artery disease scheduled for invasive coronary angiography were examined on a 3T whole body MR system (Magnetom Trio, Siemens Medical Solutions, Erlangen, Germany). Myocardial perfusion was assessed using a 2D saturation recovery gradient echo sequence in short axis orientation after pharmacological stress induction by adenosine infusion (TR 1.9 ms, TE 1.0 ms, flip 12°, matrix 115 x 192, slice thickness 6 mm, GRAPPA 2, voxel size 2.1 x 1.7 x 6 mm, 0.1 mmol Gadobutrol / kg BW at 4 ml/s, 140 µg adenosine / kg BW / min / 4 min). Myocardial function was assessed by SSFP-sequences in standard angulations. 10 minutes after stress perfusion, resting perfusion images were acquired using identical sequence parameters. For the detection of myocardial infarction, delayed enhancement images were acquired 10 min after resting perfusion using an inversion recovery gradient echo sequence in standard angulations. Standard of reference for the presence of hemodynamically relevant coronary artery stenoses (>70%) was invasive coronary angiography performed in all patients. Analysis of the perfusion images based on the AHA 17-segment model included visual image analysis by two experienced observers, measurement of peak signal intensity and upslope of the signal over time curve during the first pass normalized to the arterial input function and calculation of the myocardial perfusion reserve index. Sensitivity, specificity and diagnostic accuracy for the detection of hemodynamically relevant coronary artery stenoses were calculated.

Results: Stress induced myocardial hypoperfusion was found in 43 patients, myocardial infarction in 27 patients. According to the AHA 17-segment model, stenoses were suspected in 25 patients in the LAD, in 24 patients in the LCX and in 29 patients in the RCA. Invasive coronary angiography revealed hemodynamically relevant coronary artery disease in 41 patients with 24 stenoses located in the LAD, 23 in the LCX and 26 in the RCA. MRSPI provided in comparison with in vasive coronary angiography a sensitivity of 97%, specificity of 81% and diagnostic accuracy of 93% for stenoses of more than 70%. Semiquantitative perfusion analysis revealed a significantly reduced myocardial perfusion reserve index with 1.3 ± 0.2 in segments supplied by stenosed coronary arteries compared to 2.6 ± 0.7 in regularly perfused myocardium ($p < 0.05$).

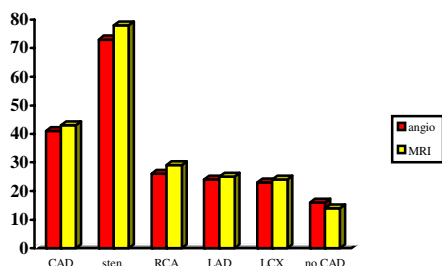


Fig.1

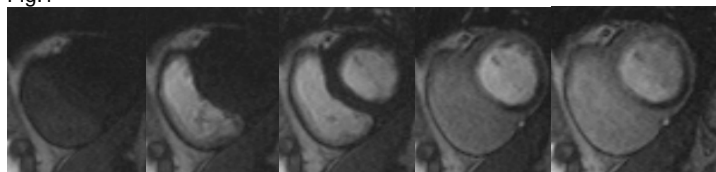


Fig. 2

Fig 1: Correlation of MRSPI and invasive coronary angiography regarding presence of coronary artery disease, number of stenosed coronary arteries and location of detected stenoses and myocardial hypoperfusion respectively.

Fig. 2: MRSPI of a patient with RCA occlusion and 75% stenosis of the LCX revealing stress induced myocardial hypoperfusion of the inferior and lateral wall.

Conclusion: MRMSPI under optimized conditions provided by 3T and highly concentrated contrast agent renders improved sensitivity, specificity and diagnostic accuracy for hemodynamically relevant coronary artery stenoses compared to results at 1.5T. Compared to established sequence techniques at 1.5T spatial resolution could be improved by 62% (voxelsize 21 mm³ vs 57 mm³).

References:

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