Myocardial Blood Oxygenation Level Dependent MRI at 3T for Detection of Significant Coronary Disease

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Background: In principle, elevated deoxyhaemoglobin levels seen downstream from a stenotic coronary vessel can be assessed by blood oxygenation level-dependent (BOLD) MRI. Previous animal studies have identified a T2-prepared SSFP sequence as a promising method to determine BOLD signal in the myocardium[1,2], and human studies indicate the feasibility of BOLD in patients[3,4]. We sought to apply this method in a population of patients with suspected coronary artery disease and compare it to coronary angiography and first pass perfusion MRI results.

Methods: 14 patients with exercise induced chest pain and a positive stress ECG comprised the study population. All patients were imaged with a T_2-prepared steady-state free-precession (SSFP) MRI pulse sequence. This sequence has the same sensitivity to T_2 as a spin echo sequence with a T_E of approximately 70ms, and is sensitive to BOLD contrast. 18 images were acquired at the mid-ventricular level at intervals of between 30 and 60s; at rest, during stress by adenosine infusion and in recovery. Following this, a mid-ventricular short axis (SA) first pass perfusion image was acquired during adenosine stress and rest using a saturation recovery turboFLASH sequence, with low-dosage Gd-DTPA bolus injection. All studies were performed at 3T (Siemens Trio). BOLD images were registered and mean signal intensities (SI) were sampled over 6 myocardial regions according to the standard clinical 16-segment model. Registration was performed by FLIRT[5] using optimized affine transforms for each of a set of 4 (+/-1) different masks over a reference image chosen from each set of resting images, the quality of each registration being measured by the mean intensity variance in a region around the heart. Images with visually obvious artefacts were discounted and image intensities at different levels of adenosine were normalized to the mean intensity within each segment at rest before plotting against the time of acquisition. Myocardial perfusion reserve index (MPRI) was calculated from the perfusion images. Correction methods for changes in T_1weighting owing to heart rate were evaluated.

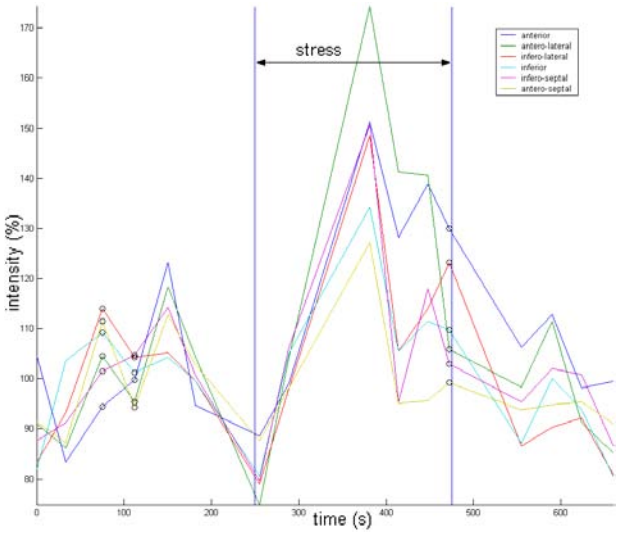

Figure 1: Example of normalised mean segment intensities through rest, stress and recovery (circles indicate artefacts, very slight in this case)

Results: 12/14 (86%) patients had at least one coronary vessel stenosis >70% (CAD). During adenosine, a mean SI decrease of 4% +/- 2% was observed for myocardial segments related to severe CAD, whereas segments without significant CAD had a mean SI increase of 6 +/- 2% (p=0.02). Including all segments and using an SI increase cutoff value of 1%, BOLD-MRI had a sensitivity of 82% and a specificity of 72% to correctly classify severe CAD. Overall comparison of BOLD-MRI data and MPRI (n=12) showed a moderate correlation (r=0.5; p=0.01) but there was substantial variability in some patients.

Conclusion: T2-prepared SSFP BOLD imaging at 3 Tesla is robust and has moderate diagnostic accuracy for the detection of significant CAD. It may have clinical applicability to detect regional variations in myocardial blood flow without the use of exogenous contrast.

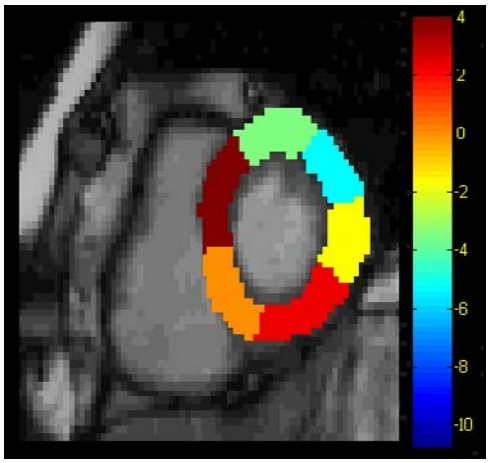

Figure 2: Example of BOLD signal changes between rest and stress

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[4] M. G. Friedrich et al, Circulation 108:2219-23 (2003)
[5] M. Jenkinson et c. Med. Im. Anal 5:143-56 (2001)