

Blood Oxygen Level-Dependent Cardiovascular Magnetic Resonance Imaging (BOLD-CMR) in Assessment of Transmural Perfusion Effect

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Background: BOLD-CMR has successfully been used for the diagnosis of myocardial perfusion defects. New SSFP based BOLD-CMR sequences show improved image quality for assessing myocardial oxygenation with excellent spatial resolution, offering a distinct advantage over other image modalities. We hypothesized that these new BOLD-CMR techniques can detect differences in oxygenation throughout the myocardial wall.

Objective: To investigate the epicardial and endocardial oxygenation with a new BOLD-CMR sequence in healthy volunteers compared to patients with suspected coronary artery disease (CAD).

Methods: 11 healthy volunteers (mean age 29±4 years) and 11 patients with suspected CAD (mean age 59±8 years) who all had abnormal perfusion results on nuclear imaging (SPECT) were recruited for scanning. Using a clinical 1.5 T MRI system (MAGNETOM Avanto, Siemens Healthcare, Erlangen, Germany), BOLD-CMR was performed on a mid left ventricular short axis slice at baseline and during adenosine infusion (140 µg/kg). Scan parameters: Field-of view (FOV) 138x340 mm; matrix size 66x192; in-plane resolution 2.1x1.8 mm; slice thickness 5 mm; T_R/T_E 7.6/4.3 ms; flip angle 25°; typical breath-hold duration 14 s. Images were analyzed using clinically validated software (cmr⁴², Circle Cardiovascular Imaging Inc., Calgary, Canada). After automatic definition of the subendocardial 50% and the subepicardial 50% of the wall thickness, the BOLD signal intensity (SI) for each was analyzed and the relative change to baseline during adenosine infusion calculated. Late enhancement was performed to ensure that patients did not have an infarct in the selected slice for analysis.

Results: In most studies excellent image quality was achieved. Three patients were excluded due to motion artifacts on the stress portion of the exam. Results are illustrated in Figure 1 and summarized in Table 1 as means and standard error means (SEM). Heart rate (HR) increased from baseline with the infusion of adenosine. The mean HR increase was 48±7% for the suspected CAD patients, and 26±9% for the healthy volunteers. The increase in BOLD-SI of the whole myocardium from baseline to adenosine was similar in CAD patients (19.6±4.7%) and in healthy volunteers (21.3±3.4%). In healthy volunteers there was only a marginal difference between the BOLD-SI increase in the endocardium only, and epicardium only (mean difference 0.2±1.6%, p=0.88). However, in the suspected CAD patients, the endocardial BOLD-SI increases were significantly lower than epicardial BOLD-SI increases (mean difference 5.7±2.2%, p=0.03).

Conclusion: The latest BOLD-sensitive SSFP sequences, with its improved image quality and excellent spatial resolution can detect differences in epicardial and endocardial myocardial oxygenation and are proving feasible for the clinical setting.

Table 1:

Table 1: Adenosine induced changes in BOLD SI and HR

	<i>SI re. to BL whole myocardium (%)</i>	<i>SI rel. to BL endocardium (%)</i>	<i>SI rel. to BL epicardium (%)</i>	<i>HR relative to baseline (%)</i>
Patients with susp. CAD (n=9)	117.6 (4.7)	114.8* (4.6)	120.4* (5.0)	142.6 (7.3)
healthy volunteers (n=11)	121.3 (3.4)	121.2 (4.1)	121.4 (2.9)	126.4 (9.1)

*p<0.05 compared to whole myocardium

Figure 1:

