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Blood oxygen level-dependent magnetic resonance imaging at 3 Tesla in coronary artery disease: validation using quantitative coronary angiography and cardiovascular magnetic resonance perfusion imaging

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Background

By exploiting the paramagnetic properties of deoxyhemoglobin, blood oxygen level-dependent (BOLD) MRI can be used to determine myocardial oxygenation. In this study involving human subjects, we used BOLD and perfusion MRI at 3 Tesla to investigate the relationship between coronary artery stenosis, myocardial perfusion and tissue oxygenation. We sought (1) to define a threshold for BOLD MRI to identify myocardium subtended by coronary stenosis, and (2) to determine its diagnostic accuracy in patients with suspected CAD.

Methods

Subjects were studied at 3 Tesla (Trio, Siemens Medical Solutions). Ischemic thresholds for BOLD and first-pass perfusion imaging were determined in 25 patients (age 61 ± 7) with known CAD and 20 normal volunteers (age 53 ± 7). These thresholds were then applied in a consecutive series of 60 patients with suspected CAD, in whom diagnostic angiography was scheduled to investigate exertional chest pain.

For BOLD MRI, mid-ventricular short-axis images were acquired at rest and stress (4-5 minutes intravenous adenosine, 140 μg/kg/min) using a T2-prepared SSFP sequence (echo time 1.43 ms, repetition time 2.86 ms, T2 preparation time 40 ms, matrix 168 × 192, slice thickness 8 mm, flip angle 44°). First-pass perfusion imaging was then performed in the same slice locations following intravenous Gadolinium-DTPA bolus injections (0.04 mmol/kg, Gadodiamide, Omniscan™, GE Healthcare) using a T_1-weighted fast gradient echo sequence (echo time 1.04 ms, repetition time 2 ms, voxel size 2.1 × 2.6 × 8 mm^3). Absolute quantification of perfusion was performed using model-independent deconvolution. For BOLD analysis, stress signal intensity (SI) was indexed to resting SI using a segmental approach. Quantitative coronary angiography was used to evaluate segmental coronary stenosis: a reduction in luminal diameter of > 50% was deemed significant.

Results

In the validation arm, taking QCA as the gold standard, cut-off values to define ischemic segments were derived for hyperemic myocardial blood flow (<2.1 ml/min/g -

AUC 0.72) and BOLD SI change (<5.2% - AUC 0.64). In the prospective arm, the complete imaging protocol was performed in 57 individuals (age 61 ± 9, CAD prevalence 68%). On a per subject basis, applying the BOLD SI threshold provided diagnostic accuracy 83%, sensitivity 94% and specificity 56% for the detection of CAD (compared with 84%, 95% and 61%, respectively for perfusion imaging). On a per subject basis, agreement between BOLD and perfusion imaging was 81%.

Conclusion

BOLD imaging at 3 Tesla is comparable with first-pass perfusion imaging, and yields favorable diagnostic accuracy in the detection of significant CAD.