Three-Dimensional k-t PCA Cardiac Magnetic Resonance Perfusion Imaging for Quantification of Myocardial Ischemic Burden in Patients with Coronary Artery Disease

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Objectives: Cardiac magnetic resonance (CMR) imaging enables noninvasive assessment of myocardial perfusion. Standard 2D multi-slice CMR perfusion techniques yield high diagnostic accuracy but lack the information of the absolute amount of ischemia. Up to now, nuclear imaging methods have been the only methods to determine the amount of myocardial ischemia. Recently, 3D CMR perfusion has proven highly diagnostic for the detection of angiographically defined coronary artery disease (CAD) and has enabled the assessment of myocardial ischemic burden (2). The present study aimed at relating significant coronary lesions as defined by fractional flow reserve (FFR) to the volume of myocardial ischemic burden (MIB) and to assess the inter-study reproducibility of 3D CMR perfusion imaging.

Methods: Sixty patients (mean age 64 ± 11 years, 12 female) with known or suspected CAD scheduled for invasive coronary angiography underwent a 1.5 Tesla (Philips Healthcare) CMR examination (TR/TE/flip angle: 1.8ms/0.7ms/15°, saturation prepulse delay: 150 ms, partial Fourier acquisition, 16 slices, voxel size: 2.3x2.3x5.0 mm³). Perfusion scans were obtained under adenosine stress (140 µg/kg/min for 6 min; 0.1mmol/kg Gd-DTPA) and at rest. FFR was recorded in all patent epicardial coronary arteries (significant stenosis <0.75). Ten patients underwent an identical repeat CMR examination for determination of inter-study reproducibility. For visual analysis, 3D CMR perfusion scans were classified as pathologic if ≥1 segment showed an inducible perfusion deficit with >25% transmurality. MIB was measured by segmentation of the area of inducible ischemia and normalized to left-ventricular myocardial volume (MIB,%).

Results: All CMR and FFR studies were completed successfully. CAD prevalence as defined by FFR (<0.75) was 55% (33 of 60 patients). 3D CMR perfusion resulted in a sensitivity and specificity of 88% and 82%, respectively. Mean MIB in percentage of left ventricular myocardium was 19.9 ± 17.5% in patients with significant coronary artery stenosis (FFR <0.75) and 1.5± 3.8% in patients without significant CAD (FFR >0.75). Inter-study reproducibility of MIB measurements showed a high correlation (Pearson's correlation coefficient, 0.97, p <0.0001). The Bland-Altman analysis (Figure 1) revealed a mean bias for inter-study measurements of 0.6 ml (95% CI: -5.9 to 7.0). Figure 2 shows a representative patient example with double vessel CAD of the right coronary artery (FFR 0.68) and the left anterior descending artery (FFR 0.72) with extensive inducible ischemia during stress perfusion in the anterior and inferior wall, resulting in a total MIB of 39%.

Conclusions: 3D k-t PCA CMR perfusion provides high diagnostic accuracy for the detection of functionally significant CAD as defined by FFR. MIB measurements were highly reproducible and allowed the assessment of CAD severity.

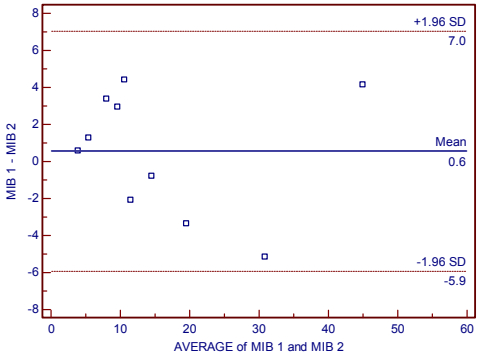

Figure 1

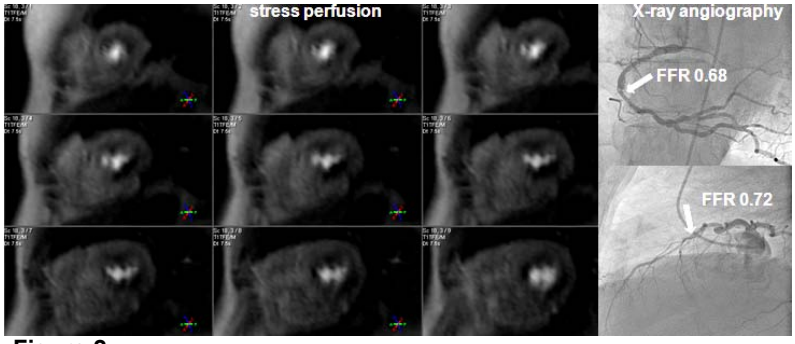

Figure 2

References

(1) Plein S et al. Eur Heart J. 2008. ; (2) Manka R et al. J Am Coll Cardiol 2011. ; (3) Vitanis V et al. Magn Reson Med 2010