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Meeting abstract

2011 Quantitative cardiac magnetic resonance perfusion imaging at 3 Tesla in patients with suspected coronary artery disease

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Background

Recent studies have shown that 3 T CMR perfusion imaging is superior to 1.5 T for prediction of significant coronary artery disease (CAD) when using qualitative (visual) analysis. However, there is limited clinical data on the accuracy and feasibility of absolute quantification of myocardial blood flow (MBF) at 3 T. Quantification of MBF is particularly crucial in multi-vessel CAD, where perfusion reserve can be globally reduced, and hence qualitative and semi-quantitative methods that detect regional differences of perfusion reserve may underestimate disease severity. The aims of this study were 1) to investigate the feasibility of quantitative CMR perfusion imaging at 3 T and 2) to compare (at 3 T) the diagnostic accuracy of absolute quantification against visual analysis, in patients with suspected CAD.

Methods

Forty patients (30 men; mean age 64 ± 9 years) referred for diagnostic cardiac catheterization for suspected CAD were recruited. All patients underwent perfusion CMR imaging at 3 T (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 – with parallel imaging). Images were acquired first during adenosine infusion (0.14 mg/min/kg for 4 min) and then at rest during the first pass of 0.04 mmol/kg of contrast agent (Gadodiamide, Omniscan™, GE Healthcare). Three short-axis planes were imaged, covering the left ventricle from the base to the apex. Perfusion CMR scans were visually interpreted by two observers acting in consensus, blinded to all clinical data and using the AHA 17-segmentation model (excluding the apical segment 17). A third blinded observer generated endocardial and epicardial contours (QMass, Medis). Signal intensity-time curves were determined for the left ventricular cavity of each slice and for each myocardial segment. Absolute MBF was determined for each myocardial segment in ml/min/g by deconvolution of signal intensity curves, with an arterial input function measured in the LV blood pool. Myocardial perfusion reserve index (MPRI) was calculated by dividing hyperemic MBF by the rate-pressure-corrected resting MBF values. Receiver operating characteristic (ROC) curve analyses were performed to compare the diagnostic performance, using either visual or quantitative assessment. Any segments with MPRI less than the defined cut-off value were classified as ischemic. If more than one segment within the territory of a coronary artery was classified as ischemic, CMR was regarded as positive for that region. Significant CAD was defined by quantitative coronary angiography (QCA) as the presence of at least one stenosis of > 50% diameter.

Results

Significant CAD was present in 65% (26/40) of the patients (12 single-vessel, 14 multi-vessel disease). Of the 640 myocardial segments 255 were graded as normal (segments subtended by normal coronary arteries), 236 as ischemic and 149 as remote to ischemia [segments sub-

tended by the non-critically diseased vessel(s)] according to QCA. A significant difference in MPRI between ischemic and combined normal/remote segments (1.73 ± 0.67 and 2.92 ± 1.25, $p < 0.01$) was found that resulted in a cut-off value of 2.44. Table 1 shows the corrected resting and hyperemic MBF, and the MPRI classified by segmental QCA characterization. Hyperemic MBF and MPRI differed significantly amongst the three groups of segments ($p < 0.001$), whereas corrected resting MBF values were similar ((Figure 1). Quantitative assessment of CMR perfusion imaging (using the determined MPRI cut-off value of 2.44) provided similar sensitivity and slightly lower specificity for the detection of CAD and the determination of disease location compared with visual analysis (Table 2).

Conclusion

Quantitative assessment of CMR perfusion at 3 T is clinically robust and, compared with visual assessment, has higher sensitivity in detecting multi-vessel disease, and higher specificity for single-vessel disease reflecting the ability of quantitative analysis to detect differences in myocardial tissue enhancement that might not be apparent when using visual assessment.

Table 1: Corrected resting, hyperaemic myocardial blood flow (MBF), and corrected myocardial perfusion reserve index (MPRI) classified by QCA segmental grading.

	MYOCARDIAL SEGMENTS			**P-value ANOVA**
	Normal *n* = 255	Ischemic *n* = 236	Remote *n* = 149	
Corrected Resting MBF [ml/min/g/(mmHg.bpm/10^4)]	1.19 ± 0.34	1.21 ± 0.33	1.14 ± 0.33	NS
Hyperemic MBF (ml/min/g)	3.41 ± 1.09†	2.06 ± 0.89*†	2.71 ± 0.98	< 0.001
Corrected MPRI	3.15 ± 1.32†	1.73 ± 0.61*†	2.52 ± 0.99	< 0.001

*p < 0.01 for comparison with normal
†p < 0.01 for comparison with remote
Resting MBF corrected by division by the respective rate-pressure product/10,000.

Table 2: Corrected resting, hyperaemic myocardial blood flow (MBF), and corrected myocardial perfusion reserve index (MPRI) classified by QCA segmental grading.

	Sensitivity	Specificity	AUC ± SE	Diagnostic accuracy
Overall detection of CAD				
Visual	92% (24/26)	79% (11/14)	0.85 ± 0.06*	88% (35/40)
Quantitative	96% (25/26)	71% (10/14)	0.84 ± 0.06*	88% (35/40)
Single-vessel Disease				
Visual	75% (9/12)	86% (24/28)	0.80 ± 0.08	83% (33/40)
Quantitative	58% (7/12)	96% (27/28)	0.77 ± 0.09	85% (34/40)
Multi-vessel Disease				
Visual	71%(10/14)	85% (22/26)	0.78 ± 0.08	80% (32/40)
Quantitative	93% (13/14)	69% (18/26)	0.81 ± 0.08	78% (31/40)
Left Anterior Descending Artery				
Visual	81% (13/16)	83% (20/24)	0.82 ± 0.07*	83% (33/40)
Quantitative	94% (15/16)	67% (16/24)	0.80 ± 0.08*	78% (31/40)
Left Circumflex Artery				
Visual	57% (8/14)	88% (23/26)	0.73 ± 0.09*	78% (31/40)
Quantitative	100% (14/14)	77% (20/26)	0.89 ± 0.06*	85% (34/40)
Right Coronary Artery				
Visual	83% (15/18)	82% (18/22)	0.83 ± 0.07*	83% (33/40)
Quantitative	100% (18/18)	64% (14/22)	0.82 ± 0.07*	80% (32/40)

AUC = Area Under the ROC Curve; SE = Standard Error; *p > 0.05 for comparison of AUC with the 2 methods of assessment.

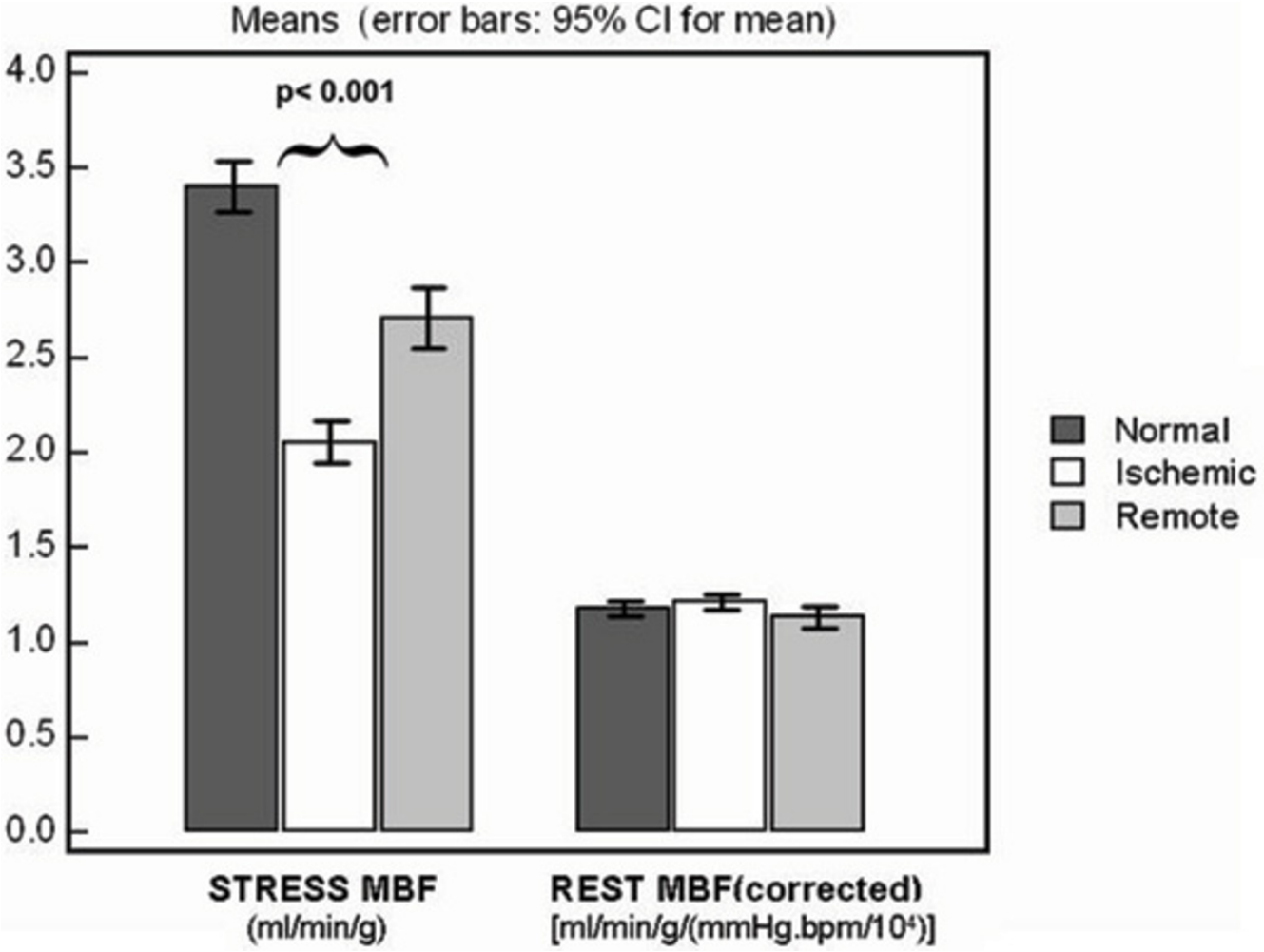

Figure 1
Corrected resting and hyperaemic myocardial blood flow (MBF), classified by QCA segmental grading.