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Accuracy of Fully Quantitative CMR Myocardial Perfusion in Detection of Coronary Disease as Measured by Quantitative Coronary Angiography

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Abstract:
Background: The detection of coronary disease by contrast enhanced MRI is traditionally performed by qualitative assessment. Although semi-quantitative measures of perfusion are well described, fully quantitative myocardial perfusion by MRI is less well established and has the potential to enhance the assessment of coronary disease in clinical settings and serve as an important research tool. A dual bolus method for quantifying first pass perfusion studies has been validated in an animal model and in normal humans.
Objective: Our objective was to determine the sensitivity, specificity, and accuracy of fully quantitative analysis of dual bolus stress perfusion studies in patients with known or suspected coronary disease versus a reference standard of coronary stenosis as measured by conventional quantitative coronary angiography (QCA).
Methods: Sixty-seven patients were referred for MRI stress testing utilizing dipyridamole (0.56 mg/kg over 4 minutes) and dual bolus first pass gadolinium enhanced imaging (0.005 mmol/kg followed by 0.1 mmol/kg). CMR was performed on either a GE or Siemens 1.5T scanner with either a 4-element or a 12-element phased array surface coil. A saturation recovery, hybrid echoplanar perfusion sequence obtained 3 images every heart beat. The 3 imaging slices per patient were divided into 12 radial sectors and analyzed as endocardial, epicardial, and transmural regions. Myocardial perfusion (ml/min/g) was quantified using Fermi function constrained deconvolution methods. Qualitative assessment of the perfusion exam was performed by our standard protocol and also with a published algorithm from Duke Universtity. All perfusion results were correlated to cardiac catheterization studies obtained within 90 days of the MRI. A cardiologist blinded to the MRI results performed QCA by standard means. A 60% diameter stenosis by QCA was determined by ROC analysis to be the optimal threshold. Statistics are presented as mean +/- SD.
Results: Patients averaged 60 +/- 11 years, 45 were men (67%), 5 had 3-vessel disease (VD), 6 had 2-VD, and 25 had 1-VD.
Clinical qualitative assessment of dipyridamole stress perfusion images yielded a sensitivity of

81% and specificity of 84%. The Duke qualitative interpretation method, which starts with delayed enhancement images, had a sensitivity of 89% but a specificity of only 71%. Quantitative analysis of dual bolus stress perfusion yielded a sensitivity and specificity of 81% and 81%. The overall accuracy of all three methods ranged from 81-82%.

The optimal threshold for quantitative stress perfusion was a 20% or greater endocardial flow reduction relative to a user selected normal segment. This agreed well with the optimal threshold predicted by the coefficient of variation (standard deviation / mean) which averaged 0.10 +/- 0.2 for the three slices. Based on these results, a 2 standard deviation threshold should correspond to a 20% reduction in myocardial perfusion and define the normal limits.

In segments identified as normal, myocardial blood flow averaged 2.70 +/- 0.76 ml/min/g while true positive perfusion defects averaged 1.51 +/- 0.65 ml/min/g ($p<0.001$). Owing to intersubject variablilty, intrasubject flow was best distinguished by the ratio of ischemic to normal (remote) flow which averages 0.57 +/- 0.17.

Conclusion: Quantitative analysis of stress perfusion images reproduced the accuracy of clinical interpretation methods of two experienced centers. The advantage of quantitative perfusion analysis revolves around the objective determination of normal and abnormal. Overall results for any of these three interpretation methods are very encouraging in light of the high proportion of single vessel disease in this study.

Sensitivity and specificity of dipyridamole stress perfusion compared with QCA

Interpretation Method	Sensitivity (%)	Specificity (%)	Accuracy (%)
Clinical Interpretation	81%	84%	82%
Duke Qualitative	89%	71%	81%
Dual Bolus Fermi Function	81%	81%	81%