Myocardial Blood Flow Can Be Quantified in Sub-gram Regions of Interest in Clinical MR First Pass Perfusion Studies

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Introduction

A dual-bolus first pass MR perfusion method was shown previously to correlate with microspheres in animals with regions of interest that averaged 0.85 g [1]. The purpose of this study was to determine the minimal size region of interest needed to quantify myocardial blood flow in clinical perfusion studies with strict statistical confidence. This sized region of interest was then used to quantify rest and stress blood flow in healthy subjects and in patients with known coronary artery disease.

Methods

8 normal volunteers underwent both rest and stress perfusion. 8 patients with correlative coronary angiography underwent an identical protocol. Dipyridamole (0.56 mg/kg over 4 minutes) perfusion utilized a dual-bolus first pass contrast technique (Gadolinium-DTPA 0.005 and 0.1 mmol/kg). Image acquisition included a saturation prepared gradient echo-planar sequence on a 1.5 T scanner. Typical imaging parameters were 90° prep, 20° readout, TR 6.6 ms, TE 1.6 ms, 8 mm slice, acquisition matrix 128x80, and FOV 360x270mm^2. Each raw image pixel in the myocardium translates to approximately 0.08 g. All images were post-processed to correct spatial motion and to ensure proper propagation of time-signal intensity of the myocardial pixels. Surface coil intensity correction was then applied on each image to adjust intensity drop-off due to surface coil profile. Next, each pixel was median-smoothed with neighboring myocardial pixels using an incremental kernel size ranging from 0.08 g to 0.96 g. Perfusion in ml/g/min was then estimated with model-constrained deconvolution on the time-signal curve of each myocardial pixel to determine the minimal achievable spatial resolution for fully quantitative flow analysis [2]. Mean and standard deviation values were then used to assess the optimal size of spatial smoothing kernel needed to achieve homogeneous flow estimation within normal hearts. This minimal required filter size for spatial smoothing was used in quantifying myocardial blood flow in ischemic hearts on a pixel-by-pixel basis.

Results

Myocardial blood flow could be measured in regions of interest down to 0.5 g (equivalent to approximately 6 raw pixels for spatial smoothing) without dropping the mean by more than one standard deviation below the largest regions studied. The coefficient of variation for myocardial pixels averaged 8% during stress and 7% at rest in normal hearts. Myocardial perfusion reserve was 4.5 ± 1.7 at this spatial resolution. Pixel-wise perfusion maps in units of ml/min/g, displayed on a calibrated color scale, easily differentiated rest and stress perfusion studies in normal subjects and showed perfusion defects in regions correlating spatially to moderate stenosis by coronary angiography (Fig.1).

Conclusion

Myocardial blood flow can be quantified by first pass MR perfusion in regions of interest as small as 0.5 g of myocardium. A spatial filter at this size produced a high resolution quantitative blood flow pixel map in patients with coronary artery disease that appears promising for diagnosing coronary artery disease.

Reference

[1] Christian TF, et al. Radiology 2004, p.677–684. [2] Hsu L, et al. Proc. ISMRM 2005, p.514.

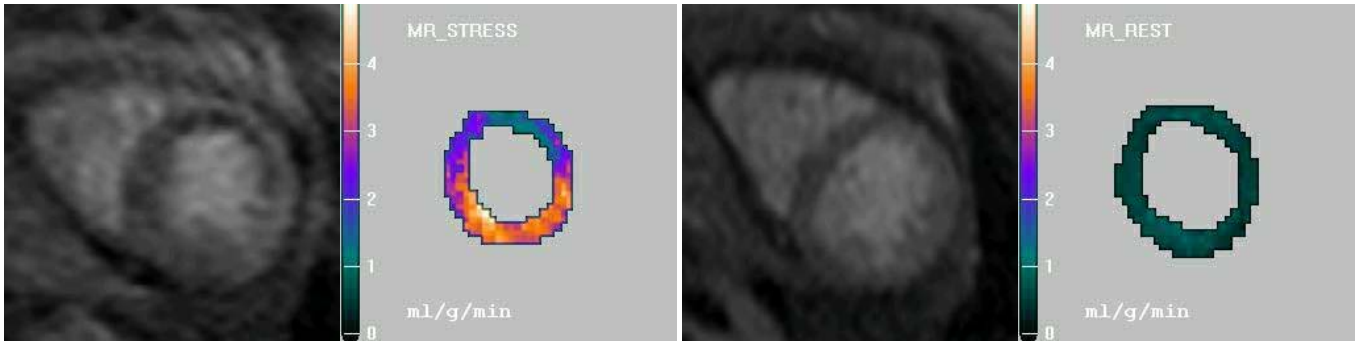

Figure-1. Pixel-wise perfusion flow map shows a moderate subendocardial defect in the mid anterior wall during stress study but a homogeneous resting blood flow.