Myocardial blood flow measurement using DCE-MRI: comparison of region-of-interest and voxelwise analysis

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INTRODUCTION Measurement of myocardial blood flow (MBF) with DCE-MRI is conventionally performed on a region-of-interest (ROI) basis: time curves are averaged over a ROI, and tracer kinetic analysis is applied to the ROI curve to derive the MBF [1, 2]. In principle, a voxelwise analysis is more attractive since it produces higher resolution images of MBF and may thus increase the diagnostic power. On the other hand, the lower SNR of single-voxel curves may reduce the accuracy or precision of the measurement. The aim of this study was to investigate whether MBF values from a voxelwise analysis were significantly different from an analysis on ROI basis.

METHODS 25 patients were randomly selected from a recent study of 750 patients suspected of suffering from coronary heart disease [3]. DCE-MRI studies were carried out at 1.5 T (Intera, Philips) using an ECG-triggered turbo gradient echo sequence acquiring 3 short axis slices (matrix 144x144, FOV 320-460 mm, slice thickness 10 mm, TE 1.0 ms, TR 2.7 ms, flip angle 15°) in breath hold. 0.05 mmol/kg Gd-DTPA (Magnevist, Bayer) was injected at 5 ml/s. Measurements were performed at stress (during the administration of adenosine at 140 μg/kg/min) and after a 15 minute delay repeated at rest. Data were processed off-line in the software PMI 0.4 [4]. After manual motion correction, MBF maps were generated for each patient both at rest and stress using a one-compartment model. A ROI covering the myocardium was identified semi-automatically on this map (figure 1, left), and a histogram and mean MBF value were calculated for this ROI (figure 1, centre). The analysis was repeated on ROI basis (figure 1, right), and resulting MBF values were correlated against the mean MBF values from the voxelwise analysis.

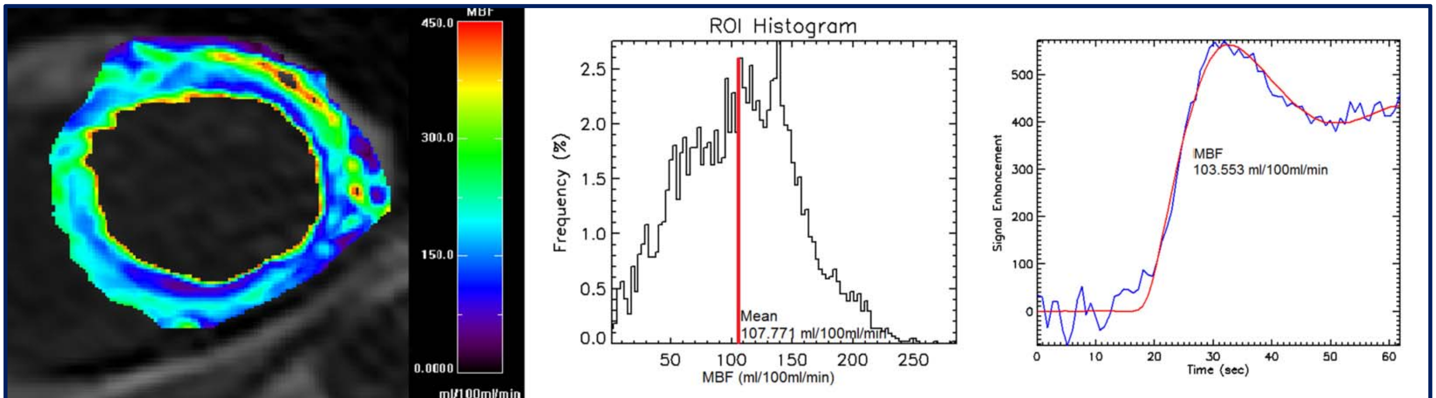

Figure 1. (Left) MBF map of the myocardium of a patient under stress. A dark blue ring in the endocardium shows reduced perfusion. (Centre) Histogram of MBF values of the myocardium in the same image. (Right) ROI analysis of MBF agrees well with the mean pixel values of the myocardium. The measured data are plotted in blue, the one-compartment model fit in red.

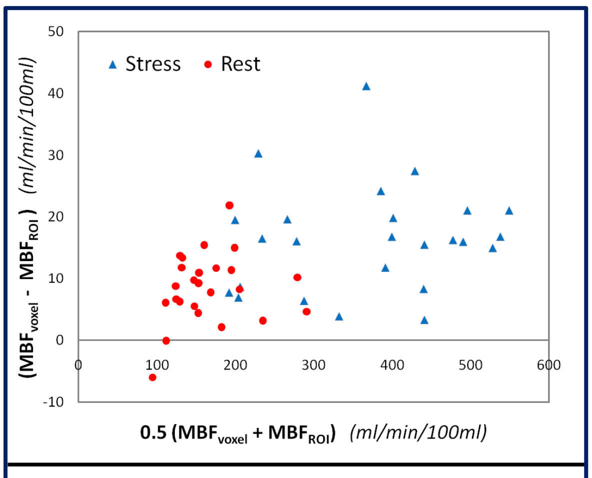

Figure 2. Bland-Altman plot of all MBF values in rest (red) and stress (blue).

RESULTS The MBF values calculated using the two methods are strongly and linearly correlated (R^2=0.997), without major outliers (fig 2). The slope of the best linear fit shows that voxelwise MBF is, on average, slightly higher (4.3%). A paired t-test ($p<0.001$) and the Bland-Altman plot (fig 2) show that this difference is significant.

DISCUSSION In view of the large difference in SNR between voxelwise and ROI curves, the strong correlation between MBF values by voxelwise and ROI analysis is unexpected, and implies that a voxelwise analysis does not cause a strong difference in precision. The small systematic difference of 4.3% does imply that a voxelwise analysis causes a difference in accuracy, but it cannot be concluded from these data whether this constitutes an error or an improvement. The origin of this systematic difference is currently unclear, but a possible explanation is that a one-compartment model is a better model for small homogeneous regions (like voxels) than for large heterogeneous ROIs. However, since the systematic effect is small compared to the spread in values (fig 2), it is not likely to be clinically relevant.

CONCLUSION Voxelwise MBF values are in very good, though not perfect, agreement with those determined on ROI basis. Since a voxelwise analysis offers additional information on the heterogeneity of myocardial perfusion, these results provide a strong case for the voxelwise approach in clinical applications of cardiac DCE-MRI.

REFERENCES [1] Jerosch-Herold (2004) *JMRI* **19**: 758-770; [2] Schwitter (2001) *Circulation* **103**: 2230-2235; [3] Greenwood (2009) *Trials* **10**: 62-70; [4] Sourbron (2009) *MRM* **62**: 205-217.