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Evaluation of the effect of myocardial localisation errors on myocardial blood flow estimates from DCE-MRI

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Introduction

Dynamic contrast enhanced myocardial perfusion MRI (DCE-MRI) has the potential to be superior to other currently available imaging techniques for the assessment of myocardial ischaemia. Quantitative analysis of cardiac perfusion is currently not routinely carried out because of the time consuming process of manually segmenting the myocardium from large DCE-MRI datasets. A range of automated segmentation algorithms have been proposed which quote results in terms of distance error or estimated myocardial blood flow (MBF). However, the relationship between these two evaluation measures is not clear, making objective comparisons of algorithm performance difficult.

Purpose

The purpose of this study was to investigate the effect of errors in the placement of endocardial and epicardial contours on estimated MBF in the analysis of DCE-MRI data.

Methods

Rest and adenosine stress DCE-MRI was carried out on 10 healthy volunteers. Manually segmented epicardial and endocardial contours were radially dilated and eroded by up to three voxels. The regions described by these contours were used to estimate mean MBFs by a Fermi-constrained deconvolution algorithm.

Results

Using the manual contours the mean (+/- standard deviation) MBF at rest was 2.0 +/- 0.5 ml/g/min and at stress was 4.4 +/- 0.7 ml/g/min. The mean myocardial width (+/- standard deviation) was 7.4 +/- 1.5 voxels (9.0 +/- 2.1 mm), meaning that a contour modification of 3 voxels typically traversed just under half of the myocardial tissue. The mean MBF errors under stress conditions are plotted against contour errors in the endocardium (Fig. 1a) and epicardium (Fig. 1b). The trends of the curves are consistent with known myocardial sub-physiology, i.e. at stress the epicardium exhibits greater perfusion than the endocardium. Single contour errors of up to 3 voxels were only seen to make a statistically significant ($p < 0.05$) difference in MBF in the case of endocardial erosions of 2 or more voxels. Similarly, when endocardial and epicardial contours were changed simultaneously, estimated MBFs remained unaffected, except when the endocardial contour was eroded by 2 or more voxels. Similar results were observed in the resting data.

Conclusion

These results suggest that the current accuracy achievable by segmentation algorithms for the assessment of transmural perfusion is sufficient for MBF estimation and future work should focus on decreasing algorithm failure rates, rather than achieving marginal improvements in segmentation accuracy. The endocardium is the most critical contour and the inclusion of any blood pool voxels should be avoided.

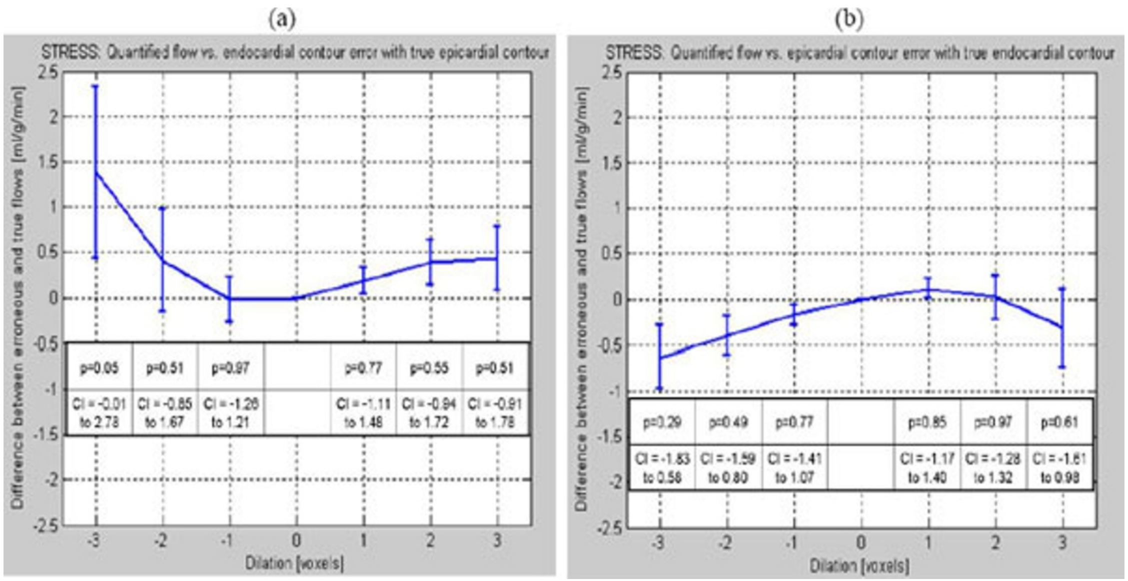

Figure 1

Plots showing the mean errors in flow at stress. Positive dilation is in the direction of the epicardium, negative towards the blood pool. (a) shows the errors induced when the endocardial contour is modified whilst holding the epicardial contour at its reference state. (b) shows the converse arrangement. Error bars show ± one standard deviation. The corresponding tables show the p-value and 95% confidence interval for the t-test (n = 10).