Reproducibility of a cardiac magnetic resonance derived myocardial perfusion reserve index

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Myocardial perfusion imaging has an important and expanding role, predominantly in the management of patients with coronary artery disease. Cardiovascular magnetic resonance (CMR) perfusion imaging is particularly valuable as it does not use ionising radiation and is multiparametric—i.e., perfusion imaging is routinely combined with an assessment of myocardial structure, function and scar. Qualitative analysis of CMR perfusion images is the current clinical standard and this has repeatedly been shown to be accurate (1,2). However, quantification of perfusion should result in more reproducible and precise measurements and has potential advantages in a number of patient subsets. This includes patients with multivessel disease, where perfusion imaging frequently underestimates the number of ischaemic territories compared to invasive anatomic (3) and functional assessments (4), patients with left ventricular impairment and after CABG. Furthermore, quantification of perfusion may assist in the evaluation of patients with angina and normal epicardial coronary arteries, who are often poorly understood and managed.

A number of post processing software programmes which provide semi-quantitative data from CMR perfusion imaging have been commercially available for some years. These techniques make use of the changes in signal intensity within a region of interest over time-the time intensity curve. The myocardial time intensity curve is compared during stress and rest first pass perfusion imaging to calculate an index of perfusion reserve (MPRI). The upslope of this curve is usually used for this calculation but the initial area under the curve and the amplitude have also been used. These methods have been validated in animal models (5,6) and can improve the diagnostic accuracy over visual analysis alone in humans (7). However, in order for measurements of MPRI to be useful both clinically and for research studies they must be robust which includes a requirement for results to be reproducible. Knowledge regarding a tests reproducibilty is key when interpreting differences between cohorts of patients and in determing sample sizes required in trials. The study by Goykhman *et al.*, (8) published in this issue provides us with valuable data on the inter and intra-observer reproducibility of MPRI measurements. The study subjects were all female and included both healthy volunteers and patients with angina, abnormal stress testing and normal coronaries (and therefore presumably abnormal perfusion in at least some). The authors present comprehensive results and demonstrate very good intra and inter-observer reproducibility of MPRI in these female subjects. For the entire myocardium inter-observer intraclass correlation coefficient 0.80 (95% CI, 0.57-0.92) and coefficient of variation 7.5%, and intra-observer intraclass correlation coefficient 0.89 (95% CI, 0.77-0.95) and coefficient of variation 3.6%. Reproducibility was consistently high for the subepicardial and subendocardial layers of the myocardium as well as for the entire heart. Unsurprisingly the mid myocardial slice MPRI was most reproducible and intra-observer reproducibilty was superior to inter-observer results. Their results are also ressuringly comparable to previous findings in this area using different post processing software (9).

However, whilst the relatively small variations in measurements is encouraging, as the authors acknowlege, the findings can only confidently be applied when similar methods of data acquisition and analysis are used. This includes the scanner, imaging pulse sequence, contrast agent regimen as well as the post processing software and methods. The lack of standardisation with CMR perfusion imaging can make transferability of results problematic. Furthermore, calculation of MPRI still requires significant user interaction including verifying myocardial contours on a frame-by-frame basis, correcting these contours as required, and manually precisely defining the onset and end of the time intensity curves. Such interactions are both very time-consuming and are likely to reduce reproducibility if performed less rigourosly than a research study allows. Until these limitations are adequately addressed measurement of MPRI is

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unlikely to enter widespread routine clinical practice. Finally, for many, the ultimate goal in quantitative perfusion imaging is the ability to quantify perfusion in absolute terms with the perceived added benefits this could provide. However, for the time being, accurate and reproducible absolute quantification continues to be even more of a challenge (10).

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