MR perfusion imaging. What will be its impact for detection of coronary disease in the future?

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This editorial refers to ‘MR-IMPACT: comparison of perfusion-cardiac magnetic resonance with single-photon emission computed tomography for the detection of coronary artery disease in a multicentre, multivendor, randomized trial’ by J. Schwitter et al.,† on page 480

Revealing stress-induced myocardial ischaemia is a well-established method for evaluating the presence and pathophysiological severity of coronary artery disease. In clinical practice, exercise or pharmacological stress nuclear imaging are the most widely used techniques for this purpose. According to two meta-analyses, exercise⁴ and dipyridamole and adenosine stress¹ single-photon emission computed tomography (SPECT) have respectively 87, 89, and 90% sensitivity and 64, 65, and 75% specificity for detection of angiographically significant coronary artery disease. Detection of myocardial ischaemia by nuclear imaging also has prognostic value for predicting cardiac events³,4 such as death or myocardial infarction. Nevertheless, nuclear imaging has several significant limitations: indeed the test is quite lengthy, since it usually requires a stress and a rest study to be performed in separate sessions. In addition, conventional cardiac nuclear imaging has poor spatial resolution and lacks the ability to perform quantitative measurement of perfusion. It also suffers from attenuation artefacts. More importantly, it exposes patients to significant doses of ionizing radiation, with the potential risk of radiation-induced cancer. Finally, nuclear imaging is far from being a perfect test for detection of coronary artery disease. As indicated above, the test lacks specificity for detection of coronary disease. Therefore, alternatives for conventional nuclear perfusion imaging would be clearly desirable.

Although positron emission tomography perfusion imaging can overcome many of the limitations of conventional nuclear imaging,² its complexity and cost, and the requirement to have either a cyclotron or a rubidium generator on-site, have prevented widespread use of the technique. Cardiac magnetic resonance (cMR) may be another more practical alternative for stress perfusion imaging. Indeed, improvements in temporal resolution have allowed acquisition of several slices of the heart within one cardiac beat. Such dynamic cMR multislice imaging thus allows the myocardial enhancement after intravenous bolus injection of a gadolinium-based contrast agent to be followed, and also allows the detection of myocardial ischaemia, by demonstrating perfusion defects during pharmacological vasodilation induced by intravenous infusion of either adenosine or dipyridamole. Since the physiological half-life of gadolinium-based contrast agents is short, it is possible to repeat a rest perfusion scan several minutes after the stress study. Theoretical advantages of cMR perfusion imaging over nuclear SPECT are its significantly higher spatial resolution, allowing detection of subendocardial ischaemia; the possibility to combine evaluation of myocardial ischaemia with evaluation of contractile function and myocardial viability all within ~30 min; and, most importantly, the absence of radiation exposure.

Several single-centre studies and two smaller multicentre trials, involving only three highly selected centres and employing exactly the same cMR hardware, have so far been performed for the clinical evaluation of cMR perfusion imaging. The results of 12 of these single-centre and the two multicentre trials were recently summarized in a meta-analysis.⁷ In a total of 1183 patients (after exclusion of 50 patients secondary to unsuccessful cMR studies), cMR perfusion imaging was found to have a sensitivity of 91% [95% confidence interval (CI) 88–94%] and a specificity of 81% (95% CI 77–85%) for detection of coronary artery disease. The major limitation of all these current cMR perfusion trials was, however, their small size. Even the two largest multicentre trials included only 99 and 94 patients, respectively, which is too few for evaluation of diagnostic accuracy on a per-patient basis. Furthermore, there remains a lot of uncertainty and variation among doses of contrast agents, scanner hardware, and perfusion sequences. This limited the generalization of the findings.

The MR-IMPACT study presented by Schwitter et al.,⁷ is an important step forward, warranting the more widespread use of perfusion cMR for detection of coronary artery disease. This prospective double-blind randomized study had two purposes: first, it compared the effect of five different contrast doses on image quality and diagnostic accuracy of perfusion cMR. Secondly, it compared the diagnostic accuracy of perfusion cMR at the best dose vs. SPECT for detection of significant coronary artery disease using quantitative angiography as the reference standard. cMR and SPECT data were analysed visually by three readers in...
an independent core laboratory, and a semi-quantitative perfusion score was given in a 16 segment model. The average perfusion score of the three readers for SPECT and cMR for detection of significant coronary artery disease was compared using receiver operating characteristic (ROC) curves and with quantitative angiography as reference. The study demonstrated that perfusion cMR at the optimal contrast dose was similarly good as SPECT in the considered patients. Perfusion cMR was better than SPECT when the entire SPECT population was considered.

The study has significant strengths: by including 234 patients, it is the largest cMR perfusion study to be published thus far. In addition, the study was performed in 18 different centres, which had variable experience in the technique. Also images were acquired on several different cMR platforms of different vendors with different pulse sequences. Thus the results of this study reflect not only those of expert centres in the technique, but also those of a general population of typical cMR centres. Analysis was performed in a core laboratory by several readers completely blinded to all patient-relevant information. This ensured unbiased evaluation of the data. Most importantly, this study compared perfusion cMR with the clinical reference standard for cardiac perfusion imaging: gated $^{99m}$Tc-MIBI-SPECT. Thereby it is only the third study to carry out such a comparison of cMR perfusion with SPECT. Indeed the two previous studies were very small, considering 40 and 77 patients only, and reported conflicting results. More interestingly, this is also the largest multicentre SPECT trial ever published.

The trial also has, however, some limitations: indeed, only stress cMR perfusion images were used for evaluation. Although acquired, rest cMR perfusion or late enhancement images were not considered for interpretation. Yet the use of rest perfusion or late enhancement images may help to distinguish commonly occurring dark ring artefacts from true perfusion defects, and inclusion of late enhancement data might have further improved the results of perfusion cMR. Another limitation is also that the sensitivity and specificity for such an optimal cut-off value would be. Finally, it would have been better if the comparison of the optimal contrast dose by cMR with SPECT had been performed in a larger population than 42 patients. This would have allowed it to be specified whether cMR perfusion is superior rather than only equivalent to SPECT imaging.

Thus, in conclusion, this present study has a significant impact for promoting perfusion cMR. It provides important data supporting the use of adenosine stress perfusion cMR for detection of coronary artery disease. The test was found to be safe and fast, and appears to be as accurate as SPECT for this purpose. Considering the important advantages of perfusion cMR over SPECT, I expect that with further experience and improvements this technique has the potential to replace nuclear imaging for evaluation of myocardial ischaemia in the near future. Despite these enthusiastic prospects, let us not forget that, similarly to all other tests, perfusion cMR also has limitations and contraindications, which will prevent unrestricted use in every patient. Patients with devices such as pacemakers and AICDs cannot undergo cMR. Perfusion cMR will also not be tolerated well by claustrophobic patients. Finally, gadolinium-based contrast media have been associated with the development of nephrogenic systemic sclerosis in patients with renal failure. Therefore, perfusion cMR should not be used to evaluate patients with renal failure for myocardial ischaemia.

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References