The prognostic significance of microvascular obstruction after myocardial infarction as defined by cardiovascular magnetic resonance

Christopher M. Kramer*

Departments of Medicine and Radiology, University of Virginia Health System, Lee Street, PO Box 800170, Charlottesville, VA 22908, USA

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This editorial refers to "Sequelae of acute myocardial infarction regarding cardiac structure and function and their prognostic significance as assessed by magnetic resonance imaging" by V. Hombach et al., on page 549.

Cardiac magnetic resonance imaging (CMR) has evolved into an important imaging tool in the assessment of patients with myocardial infarction (MI), with or without reperfusion. CMR is a gold standard technique for measuring left ventricular volumes and global function. The technique of delayed contrast enhancement has been carefully validated in animal markers as a measure of infarct size. The presence of hypo-enhanced regions at the core of hyper-enhanced infarctions is a marker of microvascular obstruction (MO) and a predictor of lack of functional recovery in the infarct zone and poor cardiovascular outcome in the patient post-MI.

The paper by Hombach et al. is the largest report to date of these CMR techniques used in sequential fashion in patients with acute MI and thus is quite instructive regarding prognostic factors derived from CMR. These authors studied 110 patients at a mean of day 6 after acute MI, which is a relatively late initial time point as patients currently are typically discharged before day 6. Of the original 110 patients, 89 returned for follow-up imaging at an average of ~9 months after MI. The remainder died (n = 7), refused follow-up (n = 11), or had inadequate imaging at follow-up (n = 3). The authors should be commended for obtaining quality imaging follow-up data in ~90% of eligible patients in this relatively large cohort.

Hombach et al. defined MO as persistent MO (PMO) on delayed contrast enhanced imaging, rather than on imaging in the first few minutes after contrast infusion as defined in several previous papers. Interestingly, they found that 46% of their patients demonstrated MO as per their definition, a surprisingly high percentage. This may reflect the predominance of anterior MI in their population (53%) and the proportion of patients without TIMI 3 flow after reperfusion (12%).

There are a number of findings in the present study that confirm and extend previous observations in CMR studies of acute MI and left ventricular (LV) remodelling. A principle finding was that predictors of LV remodelling, defined as an increase in end-diastolic volume of 20%, included total infarct size, PMO, and the transmural extent of infarction. These are interrelated risk factors as the amount of PMO correlates with infarct size. This finding makes pathophysiological sense because the size of no reflow is a predictor of ultimate infarct size. The second principle finding was that predictors of major adverse cardiac events (MACE) were end-diastolic volume, ejection fraction (EF), and PMO. PMO was a more powerful predictor of survival than was infarct size, as the latter showed only a trend. This finding is consistent with the results of the study of Wu et al., which showed that MO was a better discriminator of cardiovascular outcome than infarct size.

Another important confirmatory finding in the study by Hombach et al. was the demonstration of the change in infarct size over time. The authors found that absolute infarct size as determined by the extent of delayed contrast enhancement decreased from 11.4 ± 7.2 to 7.8 ± 5.3% (a decline of 32%) from day 6 to month 9 post-MI. These findings are consistent with those of two recently published studies using contrast-enhanced CMR. Inkangisorn et al. found a 31% decrease in infarct size.
size > 2 months after acute MI. Similarly, Choi et al.\textsuperscript{8} found a 27% decrease in infarct size over the same time period. In the studies of Hombach and Choi, the decrease in infarct size was greatest in those with greater PMO, who also have a larger total infarct size. This change in infarct size over time has important implications for the use of delayed contrast enhanced CMR in clinical trials of therapies that may alter infarct size. Clearly, the time after MI that is used as an endpoint is important to define prospectively, because the absolute infarct size changes as infarcts involute over time.

Interestingly, PMO is not seen at the 9 month imaging time point. This is likely due to the fact that infarcts with PMO show greater apoptosis and cellular loss, leading to involution, wall thinning, and infarct expansion. Regions with PMO are those that are truly non-viable.\textsuperscript{4} From early infarct expansion comes increased wall stress in non-infarcted regions and, subsequently, the late increase in LV size or LV remodelling.\textsuperscript{9} It should follow therefore, as shown by Hombach et al., that PMO is a risk factor for late remodelling.

The increase in ejection fraction after MI is of interest. The authors demonstrate, as can be seen in other contemporary CMR studies of reperfused MI,\textsuperscript{8} that ejection fraction improves regardless of PMO or infarct size. This is due to recovery of stunning in the infarct zone and improvement in function in adjacent non-infarcted regions.\textsuperscript{9} Initial EF does predict MAC, but does not predict late LV remodelling. Thus, PMO is an even more powerful predictor than EF. The increase in EF and decrease in infarct size over time in these studies of contemporary therapy of MI including reperfusion\textsuperscript{6,8} raise questions of recent uncontrolled studies of the benefits of stem cell therapy in acute MI, in which similar findings are shown using contrast enhanced CMR.\textsuperscript{10} The authors of the TOPCARE-AMI study demonstrate an increase in EF and decline in infarct size and claim this as a benefit of stem cell therapy. This demonstrates the importance of controls in studies of new and exciting therapies that may alter infarct size and impact LV remodelling after MI.

There are some additional descriptive findings of interest from the study of Hombach et al. that raise more questions than they answer. Papillary muscle infarction was seen in 26% of cases. How frequently was that associated with mitral regurgitation, and for that matter, significant mitral regurgitation? Only 6 of 18 patients with right ventricular (RV) infarction had evidence of reduced RV function. Thus, RV infarction as demonstrated by CMR may or may not have prognostic importance. There were 18 additional patients with reduced RV function. What was the aetiology of reduced RV function in these patients? Pericardial involvement was quite common with pericarditis seen in 40% of patients and pericardial effusion in 66%. Both were seen more frequently in larger infarcts with greater PMO and thus do not have prognostic implications beyond this.

The most important findings in the study by Hombach et al. is that PMO has more prognostic importance than EF in predicting late LV remodelling and survival after MI. Other techniques including contrast echocardiography have pointed out the significance of microvascular integrity after MI. As the cardiovascular community develops novel methods of impacting infarct size and late prognosis after MI, newer imaging techniques including CMR should play a significant role in their study and validation.

References