Noninvasive Assessment of Coronary Artery Bypass Graft Disease
The Potential Role of Contrast-Enhanced Cardiac Magnetic Resonance*

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Recurrent or persistent angina pectoris in patients with previous coronary artery bypass graft (CABG) surgery is a common diagnostic and therapeutic challenge. In 2005, 469,000 CABG operations were performed in the U.S. alone (1). Many of these patients require reassessment once or several times after their initial operation because of symptom recurrence. Early after surgery, this is usually caused by technical graft failure or graft thrombosis, whereas in the long term, degenerative graft disease and progression of atherosclerosis in nongrafted vessels are responsible. The scale of this clinical problem is illustrated by the fact that 15 years after CABG, 50% of vein grafts and as many as 20% of arterial grafts are occluded, and many nonoccluded vein grafts have developed significant atherosclerotic disease (2,3).

The management of graft disease is complicated in that all interventional therapies are technically challenging and have poor long-term outcomes. Patients with previous CABG are usually of advanced age, have significant comorbidities, and often have diffuse atherosclerosis. Re-do CABG, therefore, carries a substantially higher perioperative mortality and complication rate than the initial procedure and risks damage to any remaining functional grafts, in particular the internal mammary conduits (4). Percutaneous graft angioplasty, while increasingly performed, is fraught with challenges such as distal embolization, high rates of restenosis, and new lesion development as high as 50% at 1 year (5), although the combination of drug-eluting stents with embolic protection devices may eventually improve these outcomes.

In light of the challenges in treating bypass graft disease, revascularization decisions need particularly careful strategic planning and risk assessment. Because basic diagnostic tests such as exercise tolerance testing are usually unhelpful in this patient group due to abnormal resting electrocardiograms, guidelines recommend the early use of imaging tests (6). The clinician is already spoiled for choice with regard to available imaging modalities, and myocardial perfusion scintigraphy or stress echocardiography can detect, localize, and quantify ischemia after CABG surgery and have prognostic value (7,8). More recently, cardiac computed tomography (CCT) has matured into a highly accurate test to visualize graft stenosis with sensitivities and specificities in excess of 95% (9). Although that makes CCT by far the most accurate noninvasive test to detect graft disease, the method remains limited by the lack of the all-important functional assessment of any observed stenosis.

In this issue of iJACC, Klein et al. (10) propose myocardial perfusion cardiac magnetic resonance (CMR) imaging as another potential noninvasive test for the detection of graft disease (10). The use of CMR for graft assessment is itself not new, and as long as 20 years ago, CMR was used for noninvasive graft angiography and flow assessment, albeit with limited diagnostic performance (11). Perhaps surprisingly, though, myocardial perfusion CMR has hitherto not been used for graft assessment. In the present study, Klein et al. (10) studied 78 patients with a disease prevalence of 69% at a
mean of 8 years after CABG. In this high-risk population, perfusion CMR had a sensitivity of 77% and specificity of 90% to identify patients with significant graft or native vessel stenosis on subsequent X-ray angiography. CMR was equally accurate in localizing disease to vessel territories. These results are very much in line with the existing literature of perfusion scintigraphy and stress echocardiography, and thus provide a first indication that perfusion CMR could be an alternative test for the detection of ischemia after CABG.

However, similar diagnostic accuracy as established tests is not sufficient justification to adopt a new test for clinical application—unless it provides some other unique diagnostic information. With its focus on diagnostic accuracy of the perfusion analysis, the study by Klein et al. (10) can give merely a glimpse of what makes CMR unique in the assessment of patients with previous bypass surgery. CMR is the most versatile imaging modality currently available and can be used to interrogate many facets of myocardial and coronary morphology and function. With the late gadolinium enhancement (LGE) method in particular, CMR provides the most detailed delineation of myocardial scar of any current imaging modality (12). This method is now widely regarded as the reference test for viability assessment and, as in the study by Klein et al. (10), LGE can be very usefully combined with stress perfusion imaging. This combination is of particular relevance for patients with previous CABG surgery, because they have more complex disease and a high incidence of previous infarction; in the study by Klein et al. (10), it was 63% (49 of 78 patients). Importantly, the current study has demonstrated for the first time that peri-infarct ischemia can be detected by perfusion CMR with an impressive sensitivity of 88% in this cohort. Furthermore, 7 of the 54 patients with significant stenosis had transmural LGE, suggesting that revascularization to these territories would be inappropriate. This combined assessment of ischemia and scar, with substantially higher spatial detail than with other imaging tests, is likely to be the main motivation for using CMR for assessing patients with coronary artery disease in general and for those with complex disease or previous bypass surgery in particular.

But the appealing combination of perfusion CMR with LGE, and with it the study by Klein et al. (10), has limitations. Contemporary perfusion CMR methods typically cover 3 myocardial slices. While this is sufficient to evaluate 16 myocardial segments, the LGE method covers the entire heart so that the extent of peri-infarct ischemia may not be fully appreciated on CMR. Furthermore, conventional perfusion CMR affords only half the spatial resolution compared with LGE, so that the spatial correlation of scar and ischemia within each section can be challenging. Recent innovations that permit high-resolution or 3-dimensional perfusion CMR with whole-heart coverage have been proposed and tested in feasibility studies (13,14). With these methods, the current limitations of perfusion CMR may soon be overcome, creating a powerful new tool for the precise correlation of scar and the presence and degree of peri-infarct ischemia.

In summary, the work by Klein et al. (10) gives a first indication that CMR can be used to detect and localize ischemia in high-risk patients with symptom recurrence late after CABG surgery. However, CMR promises more than noninvasive gate-keeping for X-ray angiography, which can probably be most reliably delivered by CCT, and combined with LGE assessment of scar, perfusion CMR can provide a detailed guide to revascularization decisions for this challenging patient group.

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