Hybrid Positron emission tomography/magnetic resonance imaging in viability assessment

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In the current issue of the Journal, Kiko et al.[1] have used a hybrid scanner with positron emission tomography (PET) and magnetic resonance imaging (MRI) to evaluate the presence of myocardial viability in patients with left ventricular dysfunction secondary to a chronic total occlusion of a coronary artery. The patients had moderately reduced left ventricular ejection fraction (LVEF 43.0 ± 15.1%), while 60% of the 255 myocardial segments were dysfunctional.

Moreover, based on tissue characterization (viability assessment), the authors aimed to predict recovery of function after percutaneous coronary intervention. PET and MRI are the ''high-end imaging tools'' that one can use in cardiovascular disease and they provide a wealth of information. In this specific study, the authors used resting MRI to assess the function before and (6 months) after revascularization to define functional recovery (contractile improvement) as the ''gold standard'' for viability. In order to characterize the tissue before revascularization (and predict recovery after revascularization), the authors used MRI with delayed contrast enhancement, which permits the delineation of dead myocardium (scar tissue), with very high resolution, and the highest accuracy to predict no recovery after revascularization. To further characterize the dysfunctional myocardium, Kiko et al.[1] have used PET with F18-fluorodeoxyglucose (FDG), which permits the assessment of residual glucose metabolism (and thus alive myocardium) and probably has the highest sensitivity to predict functional recovery.

Some issues in this study deserve attention. First, the use of hybrid PET/MRI scanners for assessment of viability is an important step forward. In the past, comparative imaging with (delayed enhancement) MRI and PET has been performed,[2] but this was always based on separate MRI and PET scanners, potentially introducing misalignment of myocardial regions. With the introduction of hybrid PET/MRI scanners, co-registration will be significantly improved, resulting in increased diagnostic accuracy.

Next, resting MRI was used to assess left ventricular function before and 6 months after revascularization. Most previous studies relied on echocardiography to assess left ventricular function before and after revascularization, and although the MRI images before and after revascularization were interpreted visually, MRI clearly provides superior resolution, resulting in increased accuracy of wall motion assessment (the standard of viability assessment in the current study). Kiko et al.[1] have used a 5-point scoring system, ranging from normokinesia, to hypokinesia, akinesia and dyskinesia, thereby further improving diagnostic accuracy of assessing functional recovery after revascularization. One note of caution, hypokinesia was divided in mild–moderate versus severe hypokinesia which may be challenging at times when visual scoring is used. And more specifically,

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when wall motion improves from severe hypokinesia to mild–moderate hypokinesia, the clinical relevance of this change may be debated.

The study population consisted of 38 patients with a chronic total occlusion on coronary angiography, and percutaneous coronary revascularization was attempted in 23 patients, which was not guided by the presence of viability. Functional follow-up was obtained in 15 patients and this constituted the final study population. A highly debated topic is the protocol that is used for viability assessment. Kiko et al.[1] used an ''FDG only'' protocol; dysfunctional segments were considered viable when FDG uptake was more than 50%; the remaining segments were considered non-viable. The earliest FDG PET study compared FDG uptake with perfusion (assessed with N13-ammonia), and areas with hypoperfusion but preserved FDG uptake were considered viable (''perfusion-FDG mismatch''), probably representing areas of hibernation, which improved in function after revascularization.[3] Conversely, areas with concomitantly reduced perfusion and FDG uptake (''perfusion-FDG match'') were considered scar tissue, which did not improve in function post-revascularization. Over the years, the ''FDG only'' approach (without comparison to perfusion imaging, as used by Kiko et al.[1] in the current issue of the Journal) was used to assess viability.[4] Both approaches appeared adequate in prediction of functional recovery after revascularization, but in theory, the combined ''perfusion-FDG'' approach may permit to distinguish ''jeopardized,'' hibernating myocardium from nontransmural scar tissue, which is also viable, but will not improve in function after revascularization.[5] In the clinical practice, however, both approaches have been used.

Another important issue of the current study concerns the metabolic conditions during FDG imaging, which are relevant for promoting glucose (and FDG) uptake in the myocardium, to ensure that the areas that do not take up FDG are truly scar tissue. These metabolic conditions can be completely standardized by using hyperinsulinemic euglycemic clamping, but this approach is very time-consuming. The alternative approach that is used by Kiko et al.[1] in the current study is providing a glucose load (75 g) prior to FDG injection. For clinical evaluation of viability, this approach is a good practical alternative.

Besides these various methodological issues, the diagnostic accuracy of the current approach was very good. On a segmental basis, the agreement between FDG PET and contrast-enhanced MRI was good: regional FDG uptake decreased gradually in parallel to an increasing transmurality of scar tissue on contrast-enhanced MRI. More specifically, of the 152 dysfunctional segments, viability on both PET and MRI was present in 106 segments (69.7%), whereas both imaging techniques showed non-viability in 11.2%. This resulted in an agreement of 80.9% of both techniques for viability/scar tissue. The disagreement between the 2 techniques may be related to the differences in resolution, and the inherent differences between MRI providing (anatomical) scar imaging, and PET providing (metabolic) functional imaging. Moreover, scar segments on PET and MRI had significantly worse wall motion score at baseline (1.60 ± 0.71 and 1.56 ± 0.68, respectively) as compared to viable segments (1.90 ± 0.77 and 2.00 ± 0.77, respectively). At 6 months follow-up (after revascularization), 94 of the 152 (61.4%) dysfunctional segments improved in function (which is a relatively high percentage, but may be related to development of collaterals). Importantly, recovery of function occurred in 67.8% of the PET viable segments and in 71.5% of the MRI viable segments. Conversely, recovery of function occurred only in 23.5% and 20.7% non-viable segments on PET and MRI, respectively. However, significant improvement in diagnostic accuracy occurred with the hybrid PET/MRI scanner: 77.4% of the viable segments improved in function and only 11.8% in the non-viable segments. These results highlight the use of hybrid PET/MRI scanners for future viability assessment. The strength of the PET/MRI scanners relates to the integrated, high-resolution ''anatomical'' assessment of tissue with MRI (ventricular scar assessment) and high-resolution ''functional'' assessment of tissue with PET (ventricular glucose utilization). This improved (integrated) tissue characterization will not only improve accuracy in viability/scar assessment, but also contribute to improved assessment of systemic diseases with cardiac involvement (e.g., sarcoidosis, myocarditis, and amyloidosis).

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