EDITORIAL

Fluorodeoxyglucose Imaging to Assess Myocardial Viability: PET, SPECT or Gamma Camera Coincidence Imaging?

Over the past 25 y, the ability of revascularization to reverse chronic ischemic left ventricular (LV) dysfunction has become clear (*1*), although not every patient benefits from revascularization. The high risk of performing revascularization procedures in this subset of patients (*1*) mandates careful preoperative selection. Functional recovery after revascularization depends on the presence or absence of jeopardized yet viable tissue in the dysfunctioning area. Various techniques have been developed to identify viable myocardium, namely PET with ^{18}F-fluorodeoxyglucose (FDG), SPECT with ^{201}Tl or ^{99m}Tc-sestamibi and dobutamine echocardiography (*2*). Currently, FDG PET is considered most accurate in patients with severe LV dysfunction. However, widespread application has been hampered by the relatively high cost and limited availability of the technique. Consequently, substantial effort has been invested in the development of high-energy SPECT imaging using 511-keV collimators (*3,4*). The advantages of this approach include the widespread availability of SPECT systems and the option of using dual-isotope imaging (making possible the assessment of both perfusion and FDG uptake in one session) (*3,4*). The major disadvantages of this approach are its low resolution and low counting sensitivity. Coincidence imaging using a gamma camera was introduced to overcome these limitations (*5*). In this issue of *The Journal of Nuclear Medicine*, Hasegawa et al. (*6*) report a direct comparison between FDG PET, FDG SPECT (without attenuation correction) and FDG coincidence imaging using a gamma camera for the assessment of myocardial viability. The clinical value of these different modalities is discussed below.

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For correspondence or reprints contact: Jeroen J. Bax, MD, PhD, Department of Cardiology, Leiden University Medical Center, Rijsburgerweg 10, 2333 AA Leiden, The Netherlands.

FDG PET

More than 10 y ago, Tillisch et al. (*7*) showed that FDG PET enabled prediction of improvement in the regional LV dysfunction of patients undergoing coronary bypass surgery. Since then, many studies have evaluated the usefulness of FDG PET in predicting improvement in LV function after revascularization. Pooling of the available data (11 studies, 302 patients) resulted in a sensitivity of 88% and a specificity of 73% (*8*). Clinically more important is the prediction of improvement in global LV function. In the study by Tillisch et al. (*7*), FDG PET showed mean LV ejection fraction (EF) to improve from 30% ± 11% to 45% ± 14% in patients with two or more viable, dysfunctional segments but not to improve in patients with one or no viable segments. Another FDG PET study also indicated that preoperative viability determined improvement in functional status after revascularization (*9*). Di Carli et al. (*9*) showed that the extent of viable tissue seen on FDG PET was linearly related to improvement in symptoms of heart failure. Another important issue is long-term prognosis. Five FDG PET studies (549 patients) have consistently shown that the presence of viable but jeopardized tissue in patients who are treated medically is associated with high morbidity and mortality (*10–14*) (Fig. 1).

FDG SPECT

Five studies have directly compared FDG PET with FDG SPECT in patients with chronic coronary artery disease (*15–19*) (Table 1). These studies consistently showed good agreement between PET and SPECT in the assessment of viable myocardium, although their protocols and methods of analysis varied widely. In the study by Hasegawa et al. (*6*) agreement between PET and SPECT was only 67%. This poor agreement may in part be explained by the use of a visually assessed five-point scoring system that amplifies subtle differences in tracer activity. When the comparison focused on the infarct-related territories, SPECT detected viability in 96% of the regions that PET had shown to be viable. Similarly, when only akinetic regions were evaluated, SPECT detected viability in 94% of the regions that PET had shown to be viable. Unfortunately, Hasegawa et al. did not systematically address functional outcome after revascularization. However, one report indicated that FDG SPECT had a sensitivity of 85% and a specificity of 75% in predicting improvement in regional LV function after revascularization (*20*). Prediction of improvement in global LV function was also evaluated: mean LVEF increased from 25% ± 6% to 32% ± 6% ($P < 0.01$) in 14 patients with three or more viable segments, whereas in 8 patients with two or fewer viable segments, LVEF remained unchanged (24% ± 6% before revascularization versus 25% ± 6% after revascularization, not statistically significant) (*20*). Preliminary data indicated that viability on FDG SPECT also predicted improvement in symptoms of heart failure after revascularization (*21*).

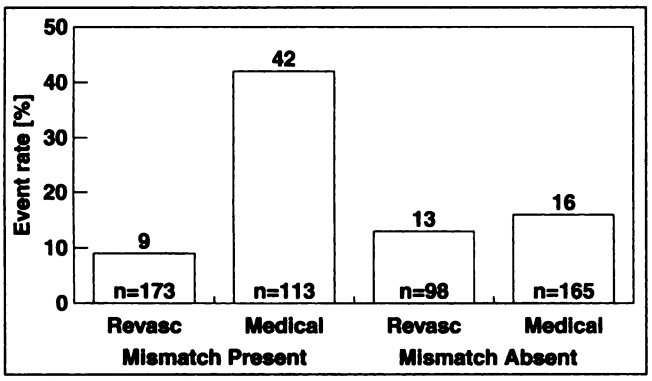

FIGURE 1. Pooled data from five FDG PET (549 patients) studies (*10–14*) evaluating prognostic value of technique. Revasc = revascularization.

Finally, preliminary data on the prognostic value of FDG SPECT indicate that patients with ischemic cardiomyopathy and residual viability are at increased risk of future cardiac events in the absence of revascularization (*22*).

GAMMA CAMERA COINCIDENCE IMAGING

Although the clinical results obtained with FDG SPECT appear to provide information similar to that provided by FDG PET, the resolution and counting sensitivity of FDG SPECT remain inferior. Superior sensitivity and resolution can be obtained with gamma camera coincidence imaging (*3–5*). Hasegawa et al. (*6*) reported the potential usefulness of coincidence imaging for the assessment of myocardial viability. They directly compared FDG PET (with and without attenuation correction), FDG SPECT and coincidence imaging (with and without attenuation correction). Image quality, expressed as target-to-background ratios, was better with coincidence imaging than with FDG SPECT. However, agreement between coincidence imaging and FDG PET for the assessment of myocardial viability was disappointingly low (31%). Disagreement was seen predominantly in the inferior and septal regions, suggesting that attenuation influenced it. In fact, with attenuation correction, agreement improved to 48%, which remained, however, lower than that between FDG PET and SPECT. When the comparison was restricted to akinetic segments, SPECT identified 94% of the segments classified as viable by FDG PET, whereas coincidence imaging identified only 56% of these segments. The results indicate that with coincidence imaging, attenuation correction is mandatory, as previously indicated (*5,23*), whereas it may not be necessary with SPECT. The reason is that both 511-keV photons need to pass through the body before entering the crystal with coincidence imaging as opposed to only one with SPECT (*5*). The fact that attenuation is less important with FDG SPECT is illustrated by comparable predictive accuracy in inferoseptal versus anterolateral myocardial regions (*20*).

Another potential advantage of coincidence imaging is superior resolution, which should permit detection of smaller viable areas compared with SPECT. However, large areas of viable tissue are needed to result in improvement of LVEF (*7,20*); thus, enhanced resolution may not be important for routine assessment of viability.

CONCLUSION

The available data from FDG PET have clearly shown the value of this technique in the assessment of myocardial viability. FDG SPECT is emerging as a promising alternative. From the instrumentation point of view, gamma camera coincidence imaging has clear theoretic advantages over SPECT; yet this study shows that gamma camera coincidence imaging is less accurate in identifying viable tissue than is PET and even SPECT. Studies addressing both the methodologic issues and the clinical outcome after revascularization are needed before coincidence imaging can join the armamentarium of nuclear cardiology.

Jeroen J. Bax
Leiden University Medical Center
Leiden, The Netherlands

William Wijns
Onze Lieve Vrouw Ziekenhuis
Aalst, Belgium

TABLE 1
Summary of Studies with Direct Comparisons Between FDG SPECT and FDG PET

Study	Year	Journal	No. of patients	LVEF (mean % ± SD)	Agreement (%) between PET and SPECT
Martin et al. (*15*)	1995	*J Nucl Med*	9	NA	93
Burt et al. (*16*)	1995	*J Nucl Med*	20	NA	100
Bax et al. (*17*)	1996	*J Nucl Med*	20	39 ± 16	76
Chen et al. (*18*)	1997	*J Nucl Med*	36	NA	90
Srinivasan et al. (*19*)	1998	*Circulation*	28	33 ± 15	94

FDG = ^{18}F-fluorodeoxyglucose; LVEF = left ventricular ejection fraction; NA = not available.

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