Clinical Myocardial Perfusion PET/CT*

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The field of nuclear cardiology is witnessing growing interest in the use of cardiac PET for the evaluation of patients with coronary artery disease (CAD). The available evidence suggests that myocardial perfusion PET provides an accurate means for diagnosing obstructive CAD, which appears superior to SPECT especially in the obese and in those undergoing pharmacologic stress. The ability to record changes in left ventricular function from rest to peak stress and to quantify myocardial perfusion (in mL/min/g of tissue) provides an added advantage over SPECT for evaluating multivessel CAD. There is growing and consistent evidence that gated myocardial perfusion PET also provides clinically useful risk stratification. Although the introduction of hybrid PET/CT technology offers the exciting possibility of assessing the extent of anatomic CAD (CT coronary angiography) and its functional consequences (ischemic burden) in the same setting, there are technical challenges in the implementation of CT-based transmission imaging for attenuation correction. Nonetheless, this integrated platform for assessing anatomy and biology offers a great potential for translating advances in molecularly targeted imaging into humans.

Key Words: myocardial perfusion imaging; PET/CT; CT angiography; cardiac PET

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PET has contributed significantly to advance our understanding of heart physiology and pathophysiology for >25 y. Initially, it emerged as a powerful investigative tool that allowed in vivo quantification of physiologic processes, including myocardial perfusion and metabolism, neuronal and receptor function, and, more recently, molecularly targeted oncologic imaging. Despite its success in research applications, the limited availability of this technology, its increased cost, and the limited data supporting its use and reimbursement have all contributed to the relatively limited clinical acceptance of this imaging technology. Fortunately, there are now clear signs that change is under way. Indeed, the exponential growth in the number of PET/CT systems—attributable primarily to the technology's widely accepted role in clinical oncology—along with the Food and Drug Administration's approval of PET radiopharmaceuticals for cardiac imaging, changes in reimbursement, and the increasing documentation of PET's clinical efficacy have all contributed to help advance its clinical role in cardiovascular medicine.

The emergence of integrated PET/CT technology as the dominant configuration of clinical scanners also holds great promise for cardiac imaging as it provides a potential opportunity to delineate the anatomic extent and physiologic severity of coronary atherosclerosis in a single setting. However, the recent rapid growth of PET/CT is now opening a considerable gap between the most sophisticated users of the technology and those with a more limited knowledge base and fewer training opportunities; this includes cardiologists, as well as nuclear medicine specialists, and radiologists, who frequently lack clinical experience in performing and interpreting these cardiovascular procedures. The objective of this review is to provide trainees and practicing imaging specialists with a practical review of how to perform and interpret myocardial perfusion imaging with PET/CT in the clinical setting.

RADIOPHARMACEUTICALS

Although several tracers have been used for evaluating myocardial perfusion with PET, the most widely used in clinical practice are ^{82}Rb and ^{13}N-ammonia.

^{82}Rb

^{82}Rb is a potassium analog that is a generator product with a physical half-life of 76 s and kinetic properties similar to those of ^{201}Tl (*1*). Because of the distinct advantage of not requiring an on-site cyclotron, ^{82}Rb is the most widely used radionuclide for assessment of myocardial perfusion with

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*NOTE: FOR CE CREDIT, YOU CAN ACCESS THIS ACTIVITY THROUGH THE SNM WEB SITE (http://www.snm.org/ce_online) THROUGH MAY 2008.

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Representative Results:

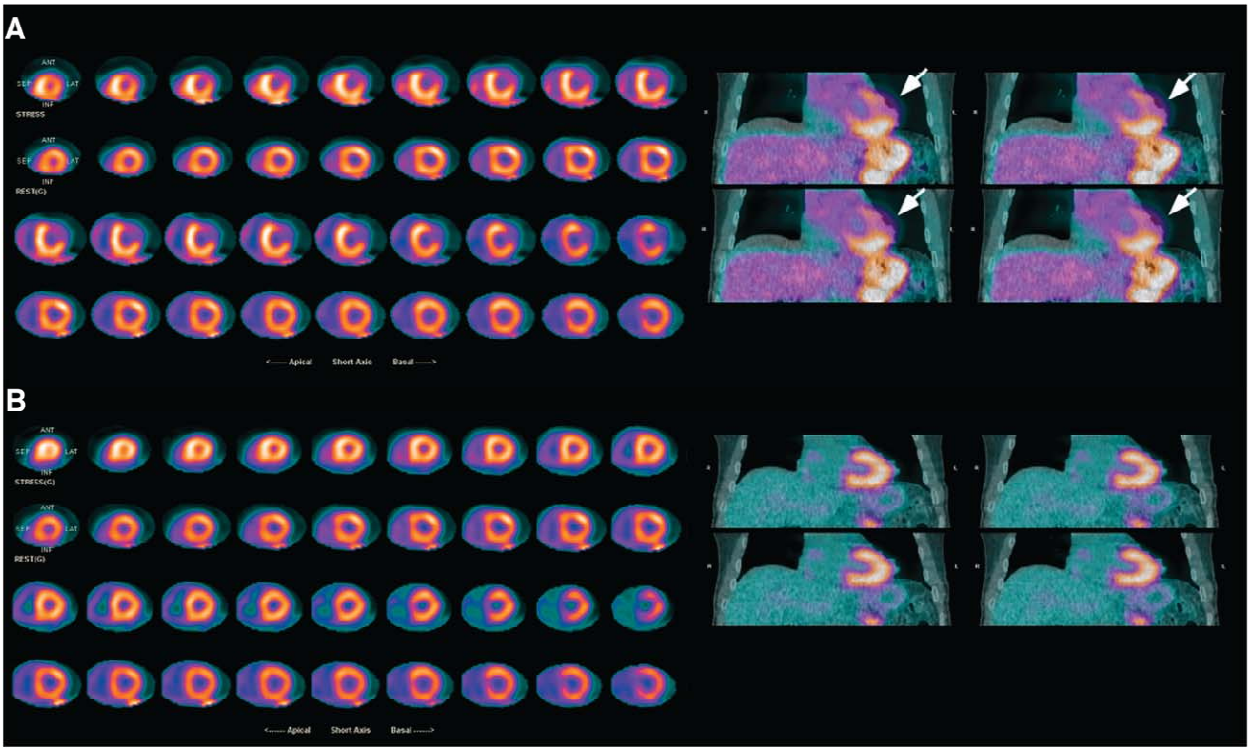


FIGURE 2. Transmission–emission misalignment. (A) Misaligned CT transmission and ^{82}Rb images (right) and resulting anterolateral perfusion defect on stress–rest ^{82}Rb PET (left). Perfusion defect results from applying incorrect attenuation coefficients during tomographic reconstruction to area of LV myocardium overlying lung field on CT transmission scan (arrows). (B) Correction of emission–transmission misalignment (right) and resulting normal perfusion study.

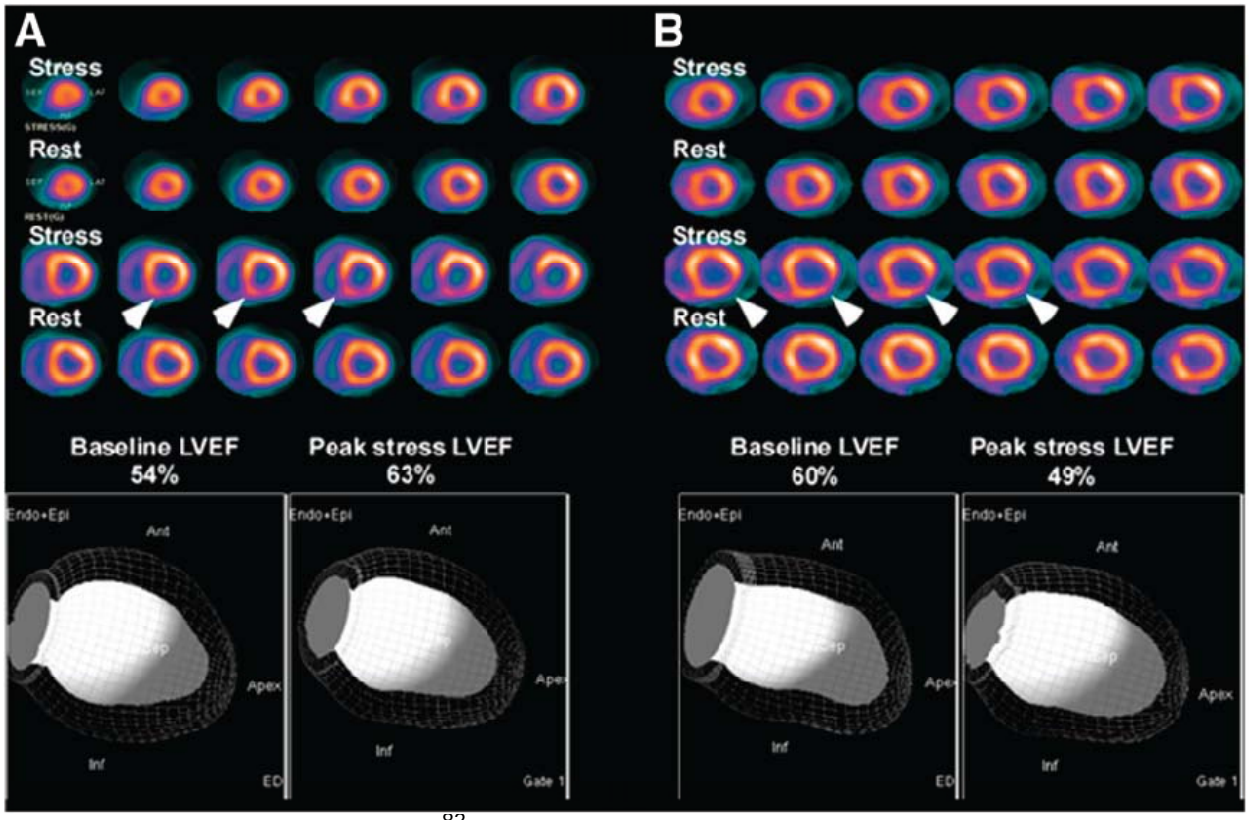
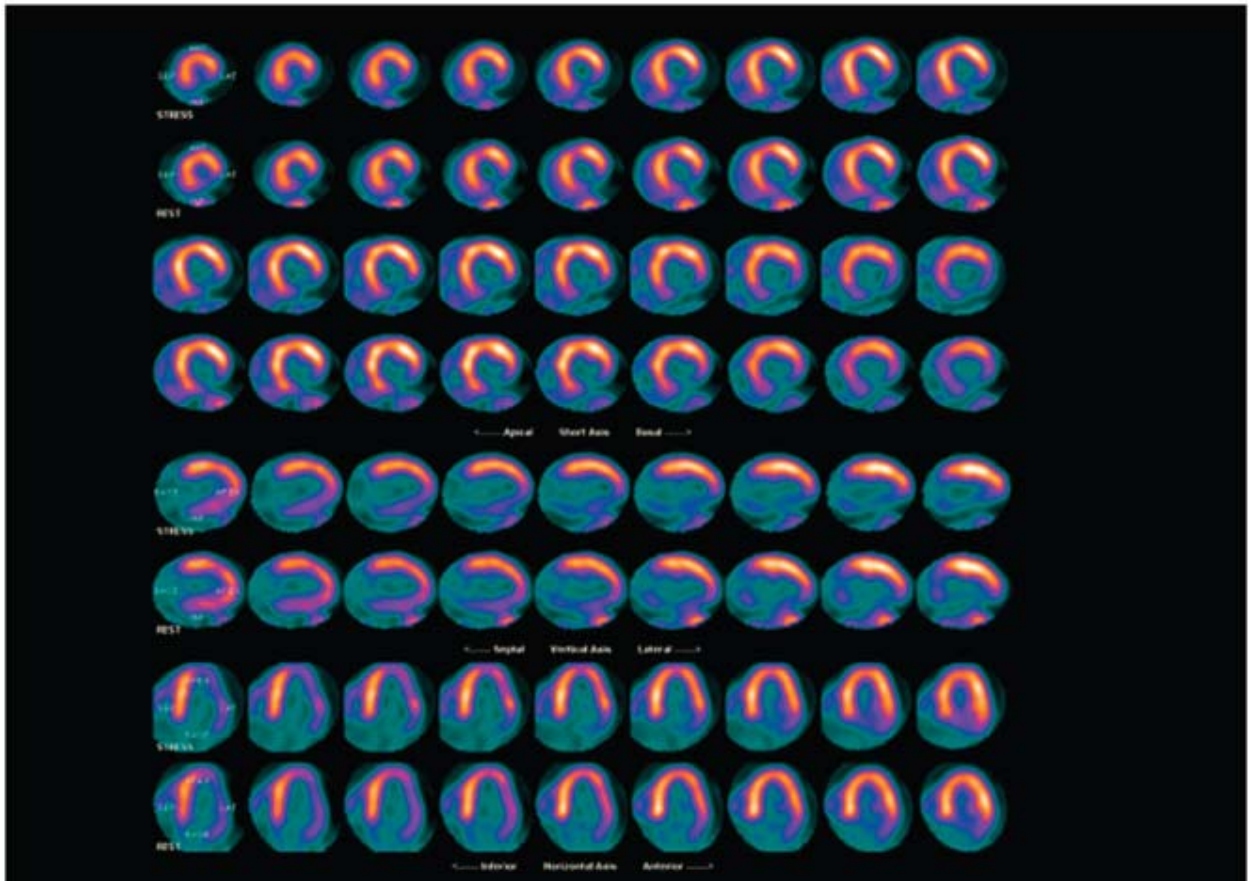


FIGURE 5. Gated rest–stress ^{82}Rb myocardial perfusion PET images illustrate added value of LV function over perfusion information. (A) Normal rise in LVEF from rest to peak stress (bottom) in patient with angiographic single-vessel CAD, showing single perfusion defect in inferior wall on PET images (arrowheads). (B) Abnormal reduction in LVEF from rest to peak stress in patient with angiographic multivessel CAD, also showing single perfusion defect in inferolateral wall on PET images (arrowheads). Ant 5 anterior; Inf 5 inferior. (Reprinted with permission of (28).)



Coronary territory	Rest MBF (mL/min/g)	Stress MBF (mL/min/g)	CFR (stress/rest)
LAD	0.86	0.89	1.07
LCX	0.64	0.66	1.03
RCA	0.86	1.00	1.16

FIGURE 6. (Top) Stress–rest 82Rb PET scan demonstrates a large and severe perfusion defect throughout inferior and inferolateral LV walls, which was fixed. (Bottom) Results of quantitative assessment of myocardial blood flow from 82Rb PET approach developed at Brigham and Women's Hospital. Data demonstrate severely impaired dipyridamole-stimulated myocardial blood flow (MBF), resulting in a markedly reduced coronary flow reserve (CFR). Coronary angiography demonstrated total occlusion of right and left circumflex coronary arteries and severe stenosis in mid left anterior descending artery. LAD 5 left anterior descending coronary artery; LCX 5 left circumflex coronary artery; RCA 5 right coronary artery.

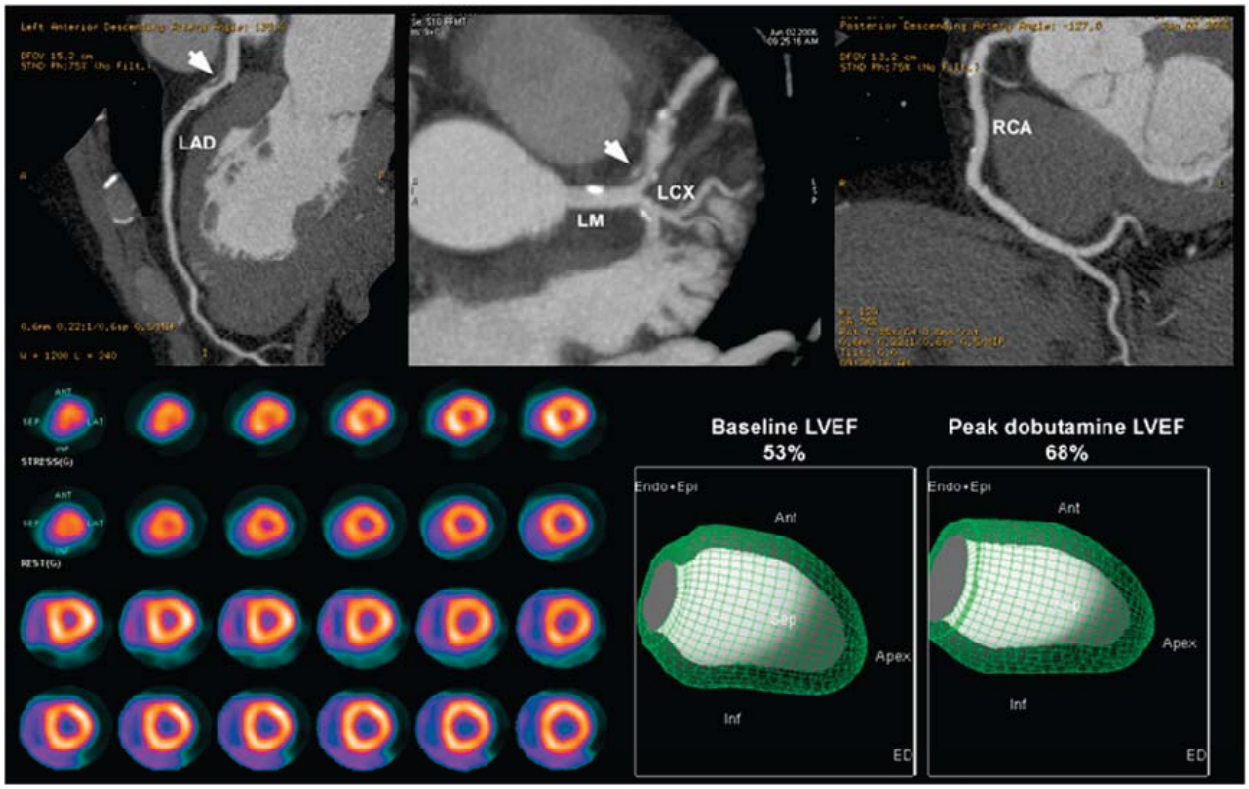


FIGURE 7. Integrated PET/CTA study. CTA images demonstrate noncalcified plaque (arrow) in proximal LAD with 50%–70% stenosis. However, rest and peak dobutamine stress myocardial perfusion PET study (bottom left panel) demonstrates only minimal inferoapical ischemia. In addition, LVEF was normal at rest and demonstrated a normal rise during peak dobutamine stress. LAD 5 left anterior descending coronary artery; LCX 5 left circumflex coronary artery; LM 5 left main coronary artery; RCA 5 right coronary artery; Ant 5 anterior; Inf 5 inferior. (Reprinted with permission of (28).)

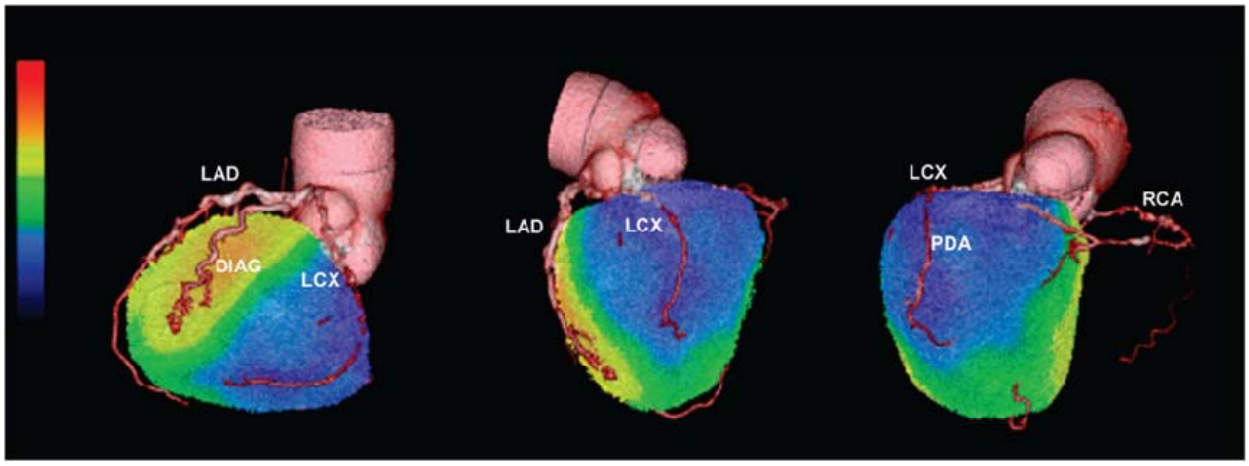


FIGURE 10. Fused 3D reconstructions of coronary CTA and stress 82Rb myocardial perfusion study obtained in same setting, assessed through integrated PET/CTA. CTA demonstrated 3-vessel CAD. Fused CTA stress myocardial perfusion images demonstrate large area of severe stress-induced perfusion abnormality (deep blue color) only in territory of dominant LCX coronary artery. LAD 5 left anterior descending coronary artery; DIAG 5 diagonal artery; LCX 5 left circumflex coronary artery; RCA 5 right coronary artery; PDA 5 posterior descending artery.