

Cardiovascular Nuclear Medicine: State-of-the-Art

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About two decades ago, radionuclide methods were introduced for noninvasive, clinical assessment of myocardial perfusion and ventricular function. The extensive research and development that ensued established the clinical role of cardiovascular nuclear procedures in modern cardiology. Cardiovascular nuclear medicine is a dynamic field; each year new applications are introduced and established ones are refined. In 1993, the Cardiovascular Council of the SNM asked me to organize a series of continuing medical education lectures on the state-of-the-art of cardiovascular nuclear medicine for the SNM's Annual Scientific Meeting. I am grateful to all the contributors who prepared this superb material under a very tight deadline; to Linda Ketchum for her efforts as the guest managing editor; and to Dr. Stanley J. Goldsmith for the opportunity to publish these articles as Continuing Medical Education material in *The Journal of Nuclear Medicine*.

This special section is comprised of three parts: (1) the role of nuclear techniques for detection and evaluation of coronary artery disease (CAD); (2) the role of radionuclide techniques in evaluation of prognosis in CAD; and (3) exercise versus pharmacologic stress in conjunction with myocardial perfusion imaging.

In part one, the role of ^{201}Tl , technetium-labeled agents (sestamibi and teboroxime) and PET are reviewed for their application in detection and evaluation of CAD. Dr. Beller presents information on the role of ^{201}Tl myocardial perfusion scintigraphy for which the largest body of literature is available. Dr. Berman and his colleagues review the advantages and disadvantages of several protocols available for rest/stress myocardial perfusion imaging with $^{99\text{m}}\text{Tc}$ -sestamibi. These protocols differ mainly in their scheduling

flexibility and their ability to detect reversibility. Gated SPECT may be added to any of the protocols and aids in identifying artifacts, defining regional wall motion and thickening and assessing ventricular function.

The simultaneous evaluation of exercise ventricular function by the first-pass technique provides additional information to that of myocardial perfusion imaging with $^{99\text{m}}\text{Tc}$ -sestamibi. Dr. Johnson reviews unique applications of $^{99\text{m}}\text{Tc}$ -teboroxime, such as rapid sequential stress-rest myocardial perfusion studies and sequential studies before and after reperfusion therapy in acute myocardial infarction to document vessel patency and success of thrombolysis. Dr. Schwaiger compares the imaging characteristics of several positron-emitting radiotracers for assessment of myocardial perfusion. He further reviews the literature to demonstrate improved diagnostic accuracy of PET in comparison to SPECT in the evaluation of CAD. This improvement is primarily related to PET's ability to provide attenuation-corrected images that improve its specificity for detection of CAD. Dr. Schwaiger also reviews the unique application of myocardial perfusion imaging with PET for quantitative assessment of regional flow reserve which allows for physiologic characterization of CAD. In the last article of this section, Dr. DePuey provides a comprehensive discussion of how to detect and avoid myocardial perfusion SPECT artifacts as a means of reducing the rate of false-positive studies.

Part two discusses one of the most important roles of cardiovascular nuclear medicine: providing prognostic information about patients with known or suspected CAD. In the first article, Dr. Brown provides an overview of the prognostic role of stress-redistribution ^{201}Tl myocardial perfusion imaging, documenting that the presence and extent of transient perfusion defects and increased lung uptake of ^{201}Tl are strong predictors of future cardiac events. In contrast, a normal exercise ^{201}Tl study predicts a benign outcome: <1% annual rate of cardiac death or myocardial infarction. This low annual cardiac event rate is also maintained in patients with angiographically documented CAD who have a normal myocardial perfusion study. Exercise ^{201}Tl myocardial perfusion parameters have a significant incremental predictive value to clinical and exercise ECG data. The presence and extent of transient myocardial perfusion defects during pharmacologically induced stress

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testing are also predictive of the perioperative risk in patients who undergo noncardiac surgery.

In the second article, the role of ^{201}Tl and PET imaging of myocardial viability is presented as a rational approach to proper management of patients with CAD and poor left ventricular function. The presence of reversible defects on rest-redistribution ^{201}Tl myocardial scintigraphy and the PET pattern of perfusion metabolism mismatch are highly accurate for identifying the presence of hibernating myocardium and thus predicting the potential for recovery of left ventricular contractile dysfunction following revascularization. The PET pattern of perfusion metabolism mismatch is also predictive of improvement in heart failure symptoms and of survival benefit after myocardial revascularization in these patients. Based on these data, treatment of patients with heart failure may be selected in a cost-effective manner; a subgroup of patients who are otherwise candidates for cardiac transplantation, but who will benefit from the more practical and less costly myocardial revascularization procedure, can be identified. Dr. Verani reviews the evidence that three parameters of myocardial perfusion imaging (presence of transient defects, the number of transient defects and increased lung uptake of ^{201}Tl) have emerged as strong predictors of future cardiac events in postmyocardial infarction patients. It appears that cardiac catheterization, for the most part, does not add to the prognostic value of radionuclide stress testing in these patients.

Pharmacologic stress myocardial perfusion imaging has provided a unique opportunity to evaluate myocardial perfusion during maximal coronary vasodilation in the early days of myocardial infarction and to substitute submaximal pre-discharge exercise testing as a method for evaluating the extent of coronary disease and risk of future cardiac events in patients who are admitted with acute myocardial infarction. The last article in this section, by Dr. Port, deals with the role of radionuclide ventriculography in the assessment of prognosis in patients with CAD. He presents data from large follow-up databases demonstrating that exercise left ventricular ejection fraction, by evaluating the total ischemic burden, is the most significant predictor of survival in patients with or suspected of CAD. The radionuclide parameters such as exercise left ventricular ejection fraction, resting end-diastolic volume and exercise-

induced change in heart rate have the same prognostic power as the catheterization data and they are more predictive of outcome than clinical and exercise electrocardiographic data.

In part three, Dr. Wackers presents exercise as the preferred method of stress testing in conjunction with myocardial perfusion imaging because the parameters of exercise testing performance and exercise-induced electrocardiographic changes, when combined with myocardial image data, provide a more comprehensive evaluation of the patient with known or suspected CAD. In patients who are unable to exercise, three pharmacologic stress agents are available that can be effectively used in conjunction with myocardial perfusion imaging. Drs. Leppo and Iskandrian provide a comprehensive review of the mechanism of action, side effects, clinical protocols and validation studies for dipyridamole and adenosine myocardial perfusion stress imaging. Dr. Verani reviews data that demonstrate comparable sensitivity and specificity of dobutamine myocardial perfusion imaging to those from perfusion studies using exercise, dipyridamole or adenosine. Patients with asthma or severe chronic obstructive pulmonary disease, who are at risk for adverse effects from either dipyridamole or adenosine, are prime candidates for dobutamine myocardial perfusion studies.

In the 1990s, cardiovascular nuclear medicine will continue to face challenges posed by competing imaging modalities and reduced procedure reimbursement. To meet these challenges effectively, one should provide the highest quality procedures, educate referring physicians and demonstrate the cost-effectiveness of cardiovascular nuclear medicine procedures in the diagnosis and management of patients with coronary artery disease. With concerted effort, cardiovascular nuclear medicine will continue to thrive as an important modality for the evaluation of patients with known or suspected cardiac disease.

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