INVITED COMMENTARY

Gated Cardiac SPECT: Has the Addition of Function to Perfusion Strengthened the Value of Myocardial Perfusion Imaging?

The clinical practice of cardiology places great value on left ventricular (LV) function. Many treatment algorithms in cardiology use the LV ejection fraction (LVEF) as an initial measure in clinical decision making. For example, the Coronary Artery Surgery Study stratified patients according to the extent of coronary disease on coronary angiography and the LVEF on radionuclide cineangiography (*1*). The data revealed that patients with proximal left anterior descending artery disease of ≥70% and an LVEF of <50% and patients with 3-vessel disease and an LVEF of <50% had a statistically significant survival benefit if treated with surgical revascularization versus medical therapy. The Multicenter Automatic Defibrillator Implantation Trial is another clinical study using the LVEF to stratify patients (*2*). This study investigated patients with an LVEF of ≤35% as assessed by radionuclide scanning; contrast angiography or echocardiography; prior myocardial infarction; and asymptomatic, unsustained ventricular tachycardia. These patients had improved survival with an implanted defibrillator compared with conventional antiarrhythmic therapy.

In addition to clinical decision making, LV function and ventricular volumes are powerful independent prognostic variables (*3*–*8*). The ability to combine function with myocardial perfusion has brought incremental value to nuclear cardiology and has broadened the clinical relevancy of the modality. In 1983, a report in *The New England Journal of Medicine* indicated the value of the LVEF in patients after myocardial infarction (*3*). Univariate analysis showed an increase in cardiac mortality over 1 y when the LVEF, as measured by radionuclide cineangiography, fell below 40%. This variable was also an independent predictor of mortality.

Further studies confirm the value of the LVEF in evaluation of coronary artery disease. Hachamovitch et al. (*4*) showed the enhanced prognostic value of myocardial perfusion imaging. Mildly abnormal perfusion studies are associated with a low risk of cardiac death or myocardial infarction, whereas markedly abnormal scans are associated with a high risk of cardiac events. These high-risk patients should be considered for coronary angiography and early revascularization. Analyzing a similar database and adjusting for the type of stress performed, Hachamovitch et al. (*5*) applied a Cox proportional hazards model and revealed a statistically significant increase in incremental value of the gated SPECT ejection fraction over that of the prescan likelihood of events and perfusion SPECT data. Additionally, the same study revealed that patients with normal perfusion scans and abnormal gated SPECT ejection fractions had a 30% annual risk of cardiac death or myocardial infarction.

Assessment of LV volumes has equal importance in determining prognosis. A major determinant of survival after recovery from a myocardial infarction is LV end-systolic volume as measured by contrast ventriculography (*6*). Using an automated gated SPECT algorithm, Sharir et al. (*7*) showed that an LV systolic volume of ≤70 mL was related to a low mortality rate even in patients with severe perfusion abnormalities. LV systolic volumes of >70 mL were related to a high death rate in patients with mild-to-moderate or severe perfusion defects. Survival benefits were shown when the LVEF, as measured by the gated SPECT technique, was ≥45%.

Risk stratification with LV volumes also applies to valvular heart disease (*8*). Preoperative end-systolic volumes from cineangiography can predict postoperative LV performance in patients with aortic regurgitation and mitral regurgitation. Additionally, a preoperative end-systolic volume of >60 mL/m^2 predicts a high risk for perioperative cardiac death. In a study by Borrow et al. (*8*), the preoperative LVEF and end-diastolic volume were less strong predictors of surgical outcome compared with end-systolic volume.

In this issue of *The Journal of Nuclear Medicine*, Daou et al. (*9*) compared 3 methods for ejection fraction and volume estimations from electrocardiographically gated blood-pool SPECT images. The authors made a thorough analysis of various processing methods to determine the LVEF and measure LV volumes. A limitation of current commercially available software for cardiac gated SPECT is overestimation of the LVEF and underestimation of LV end-systolic volumes in small ventricles, particularly in patients with hyperdynamic LV function. Both the automatic geometric method developed by Kriekinge et al. (*10*) and the semiautomatic activity method of Mariano-Goulart et al. (*11*) may be subject to this error. Daou et al. compared their more time-consuming technique with these 2 processing methods

Received Feb. 26, 2001; revision accepted Mar. 8, 2001.

For correspondence or reprints contact: Jean M. Cacciabaudo, MD, Division of Adult Cardiology, Rm. 2135, Long Island Jewish Medical Center, New Hyde Park, NY 11040.

TABLE 1
Relative Advantages and Disadvantages of SPECT, Echocardiography, CT, and CMR

Modality	Advantages	Disadvantages
Gated SPECT	Simultaneous perfusion and function	Moderate temporal resolution
	Widely available	Poor spatial resolution
	3-Dimensional	Uses radiation
	Good image contrast	Relatively long scanning time
	Clinically validated	
	Robust	
	Automatic quantitation	
Echocardiography	Widely available	Geometric assumptions
	Economic	Echo window needed
	No radiation	Operator dependent
	Moderate spatial resolution	Subjective analysis
		Mostly 2-dimensional
CT	3-Dimensional	Needs contrast agent
	Quantitative	Need to move imaging gantry
	Wider bore scanner than CMR	Short-axis approximation only
	High spatial resolution	Uses x-rays
CMR	3-Dimensional	Expensive
	No radiation	Limited availability
	Quantitative	Limited expertise
	Good spatial resolution	Developmental

CMR = cardiovascular MRI.

and showed an enhanced accuracy of their method in determining the LVEF and LV end-systolic volumes in small ventricles.

The conclusion of this study is that the enhanced accuracy of this method may soon be coupled with faster processing and a more practical usefulness. Gated blood-pool SPECT (GBPS) will be capable of accurately performing additional assessments such as the right ventricular ejection fraction and regurgitant fraction determinations. Possibly, the need to use the cumbersome first-pass technique could be eliminated. The benefit of being able to quantify right ventricular performance will allow GBPS to have further value in the clinical management of valvular heart disease and pulmonary hypertension. Borer et al. (*12*) have already shown that determination of right ventricular function is crucial to assess the timing of surgery in mitral valve regurgitation.

Given the findings of Daou et al. (*9*), GBPS uses a highly reproducible and accurate technique for assessment of the LVEF and ventricular volume. Nevertheless, as evidenced in the examples described here, clinicians use many modalities to assess the LVEF and volumes, including gated SPECT, echocardiography, fast gated CT, and cardiovascular MRI. All of these techniques have been validated and each has been shown to be reproducible, but can these modalities or GBPS be used interchangeably? All of these techniques have been validated against another modality as the gold standard, but differences are present. Table 1 lists the relative advantages and disadvantages of these modalities (*13*). Because of these differences and different resolution capabilities, is an LVEF of 45% as determined by echocardiography equivalent to the same value determined by gated SPECT? An ejection fraction of 45% by echocardiography implies mild to moderate dysfunction, whereas the same value by gated SPECT suggests low normal function. Perhaps GBPS may provide more accurate information than that from gated SPECT. However, the real goal should be achievement of measurement agreement among the various imaging modalities.

Daou et al. (*9*) have produced a technically important paper. Validation of the LVEF and volume measurements from GBPS, with the consequent impact on clinical decision making and management, will further enhance the value of combined perfusion and function from nuclear techniques as the major tool for the practice of cardiology. The next step is to demonstrate the interchangeability and interrelativity of the various imaging modalities and compare the information provided so that GBPS becomes more clinically relevant. Once this is accomplished, the union of perfusion and function in gated myocardial perfusion imaging will become even more valuable and powerful.

Jean M. Cacciabaudo
Massimiliano Szulc
Long Island Jewish Medical Center
New Hyde Park, New York
New York Presbyterian Hospital
New York, New York

REFERENCES

1. Chaitman BR, Ryan T, Kronmal RA, et al. Coronary Artery Surgery Study (CASS): comparability of 10 year survival in randomized and non-randomized patients. *J Am Coll Cardiol.* 1987;16:1071–1078.
2. Moss AJ, Hall WJ, Cannon DS, et al. Improved survival with an implanted defibrillator in patients with coronary disease at high risk for ventricular arrhythmia. *N Engl J Med.* 1996;335:1933–1940.
3. Anonymous. Risk stratification and survival after myocardial infarction. *N Engl J Med.* 1983;309:331–336.

4. Hachamovitch R, Berman DS, Shaw LJ, et al. Incremental prognostic value of myocardial perfusion single photon emission computed tomography for the prediction of cardiac death: differential stratification for risk of cardiac death and myocardial infarction. *Circulation*. 1998;97:535–543.
5. Hachamovitch R, Berman DS, Lewin H, et al. Incremental prognostic value of gated SPECT ejection fraction in patients undergoing dual isotope exercise or adenosine stress SPECT [abstract]. *J Am Coll Cardiol.* 1998;31(suppl):41A.
6. White HD, Norris RM, Brown MA, et al. Left ventricular end-systolic volume as the major determinant of survival after recovery from myocardial infarction. *Circulation*. 1987;76:44–51.
7. Sharir T, Germnao G, Kavanagh PB, et al. Incremental prognostic value of post-stress left ventricular ejection fraction and volume by gated myocardial perfusion single photon emission computed tomography. *Circulation*. 1999;100: 1035–1042.
8. Borrow KM, Green LH, Mann T, et al. End-systole volume as a predictor of post-operative performance in volume overload from valvular regurgitation. *Am J Med.* 1980;68:655–663.
9. Daou D, Harel F, Helal BO, et al. Electrocardiographically gated blood-pool SPECT and left ventricular function: comparative value of 3 methods for ejection fraction and volume estimation. *J Nucl Med.* 2001;42:1043–1049.
10. Kriekinge SD, Berman D, Germano G. Automatic quantification of left ventricular ejection fraction from gated blood pool SPECT. *J Nucl Cardiol.* 1999;6:498–506.
11. Mariano-Goulart D, Collet H, Kotzki PO, Zanca M, Rossi M. Semi-automatic segmentation of gated blood pool emission tomographic images by watersheds: application to the determination of right and left ejection fractions. *Eur J Nucl Med.* 1998;25: 1300–1307.
12. Borer JS, Wencker D, Hochreiter C. Management decisions in valvular heart disease: the role of radionuclide-based assessment of ventricular function and performance. *J Nucl Cardiol.* 1996;3:72–81.
13. Bellenger NG, Pennell DJ. Comparison of nuclear and non-nuclear techniques for the combined assessment of perfusion and function. In: Germano G, Berman D, eds. *Clinical Gated Cardiac SPECT*. New York, NY: Futura Publishing; 1999:349–377.

SOCIETY OF NUCLEAR MEDICINE