Quantification of Left Ventricular Function with Thallium-201 and Technetium-99m-Sestamibi Myocardial Gated SPECT

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Myocardial gated SPECT with ^{99m}Tc-sestamibi has been used to quantify left ventricular function. The purpose of this study was to determine if myocardial gated SPECT with ^{201}Tl was possible and reliable to quantify left ventricular function. **Methods:** One hundred and four patients referred for a myocardial perfusion study were included. Myocardial gated SPECT acquisition was performed 15 min after the intravenous injection of 111 MBq (3 mCi) ^{201}Tl and at 1 hr postinjection of 925 MBq (25 mCi) ^{99m}Tc-sestamibi. A commercially available automated myocardial gated SPECT processing software was used. Parameters evaluated were left ventricular ejection fractions (LVEF), end-diastolic volumes (EDV), end-systolic volumes (ESV) and stroke volumes (SV). **Results:** The correlation between gated SPECT with ^{201}Tl and gated SPECT with ^{99m}Tc-sestamibi was: r = 0.93 for LVEF, 0.92 for EDV, 0.96 for ESV and 0.68 for SV. **Conclusion:** Myocardial gated SPECT quantification of left ventricular function with ^{201}Tl was possible and as reliable as gated SPECT with ^{99m}Tc-sestamibi. There was excellent correlation between gated SPECT with ^{201}Tl and gated SPECT with ^{99m}Tc-sestamibi. In addition to assessment of myocardial perfusion, myocardial function and viability can be quantified in a single gated ^{201}Tl study.

Key Words: myocardial gated SPECT; left ventricular function; thallium-201; technetium-99m-sestamibi

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Myocardial gated SPECT with ^{99m}Tc-sestamibi has been applied to assess left ventricular function, providing both perfusion and function information in a single study (*1–5*). However, many institutions use ^{201}Tl to assess myocardial perfusion. The purpose of this study was to determine if myocardial gated SPECT with ^{201}Tl was possible and reliable to quantify left ventricular function.

MATERIALS AND METHODS

Myocardial Gated SPECT Acquisition

We evaluated 107 consecutive patients referred to the University of Maryland Medical System for a myocardial perfusion study between July 1995 and September 1995. Myocardial gated SPECT was performed 15 min after the intravenous injection of 111 MBq (3 mCi) ^{201}Tl at rest and 1 hr poststress injection of 925 MBq (25 mCi) ^{99m}Tc-sestamibi on the same day.

SPECT acquisition was performed on a dual-head DST camera (SMV America) equipped with low-energy, high-resolution, parallel-hole collimators. The two heads were placed in an L-shaped configuration. Three standard ECG electrodes were placed in the right and left supraclavicular areas just lateral to the mid clavicular lines and at the junction of the left lateral chest and abdomen. SPECT acquisition was gated to the best R wave on lead I or II. Thirty-two projections (16 per head) over 180° were collected, from RAO to LPO. The matrix size format was 64 × 64. The stop conditions were 50 sec per step for ^{201}Tl and 40 sec per step for ^{99m}Tc-sestamibi. The cardiac cycle was divided into eight segments, and the acceptance window was 50%.

Data Processing

A commercially available automated myocardial gated SPECT processing software (SMV America) was used. Images were reconstructed with filtered backprojection using a bandpass filter. The bandpass filter produced the most distinct endocardial edges as compared to other filters tested. The endocardial edges were defined as the maxima of the first derivatives of the squared activity profiles, searching from the center of the myocardial cavity. Let A(l) be the activity profile for a given search vector, the endocardial edge distance D was defined as:

$$D_{endo} = \text{maxima}[dA^2(l)/dl].$$

The volumes were calculated from the endocardial surfaces for each time segment. Functional parameters evaluated were left ventricular ejection fractions (LVEF), end-diastolic volumes (EDV), end-systolic volumes (ESV) and stroke volumes (SV).

The first 15 patients were processed twice for each tracer, to assess intraobserver variability.

RESULTS

Study Population

Three patients were excluded from the study due to difficulties with ECG gating, two of them had atrial fibrillation and one had low QRS complexes. The final study population consisted of 104 patients (55 males, 49 females, age range 11–86 yr; mean age 59 ± 13 yr) (mean ± one s.d.). The average bra size was 39. The average weight was 178 pounds for women, 187 pounds for men. The average height was 63.7 in. for women, 68.9 in. for men. Eighty-two patients were referred for known or suspected coronary artery disease, nine had prior myocardial infarction, nine were referred for preoperative cardiac risk assessment, two had cardiomyopathy, one had valvular heart disease, 14 had hypertension, five had end-stage renal disease and four had chronic obstructive pulmonary disease. Fifty-one patients underwent treadmill exercise testing, and 53 had pharmacologic stress testing. Out of 104 patients, 39 had perfusion defects (26 fixed, 24 reversible), and 65 had normal scans or minimal perfusion abnormalities.

Intraobserver Variability

The intraobserver correlation was: r = 0.96 for LVEF, 0.96 for EDV, 0.96 for ESV and 0.83 for SV.

Left Ventricular Function

The correlation between myocardial gated SPECT with ^{201}Tl and myocardial gated SPECT with ^{99m}Tc-sestamibi was: r = 0.93 for LVEF, 0.92 for EDV, 0.96 for ESV and 0.68 for SV (Fig. 1-4). The means and s.d. of calculated LVEF and volumes in our study population are listed in Table 1. Forty-five patients had LVEF obtained with ^{99m}Tc-sestamibi that was <50%. The

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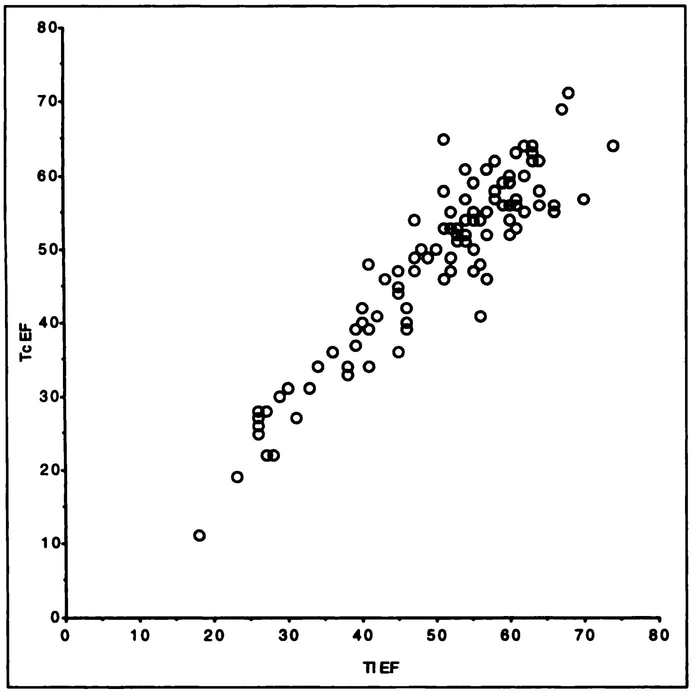

FIGURE 1. Correlation between left ventricular ejection fractions obtained with ^{201}Tl myocardial gated SPECT and ^{99m}Tc-sestamibi myocardial gated SPECT: r = 0.93.

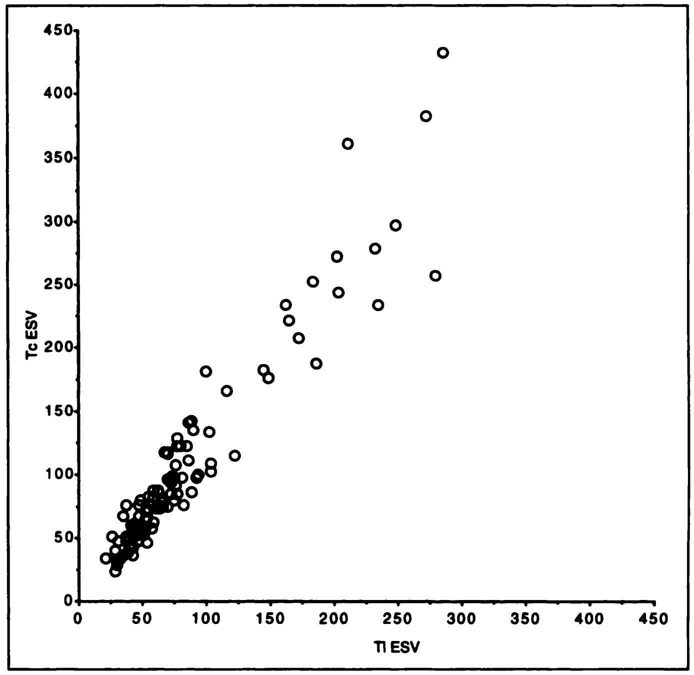

FIGURE 3. Correlation between end-systolic volumes obtained with ^{201}Tl myocardial gated SPECT and ^{99m}Tc-sestamibi myocardial gated SPECT: r = 0.96.

correlation in these patients with abnormal left ventricular function was: r = 0.91 for LVEF, 0.91 for EDV, 0.93 for ESV and 0.70 for SV. The male/female and exercise/pharmacologic subpopulation results are summarized in Table 2. Figures 5 and 6 present quality control reports obtained with ^{201}Tl and ^{99m}Tc-sestamibi myocardial gated SPECT.

Software Validation

Myocardial gated SPECT as performed in our laboratory was initially validated in a group of 67 consecutive patients. There was good correlation between myocardial gated SPECT with ^{99m}Tc-sestamibi and standard first-pass radionuclide angiography: r = 0.86 for LVEF, 0.88 for EDV, 0.93 for ESV and 0.70 for SV. Schwartz et al. (*3*) found similar results using the same hardware and software configuration.

Even in the presence of a large perfusion defect, the endocardial borders were identified by the processing software. Borders of poorly perfused myocardium, e.g., previous myocardial infarction or severe myocardial ischemia, always had some low counting rate activity that could be detected by the software algorithm. Figure 5 (^{201}Tl) and Figure 6 (^{99m}Tc-sestamibi) demonstrate the computer generated endocardial borders in a patient who had a fixed perfusion defect (quality control reports).

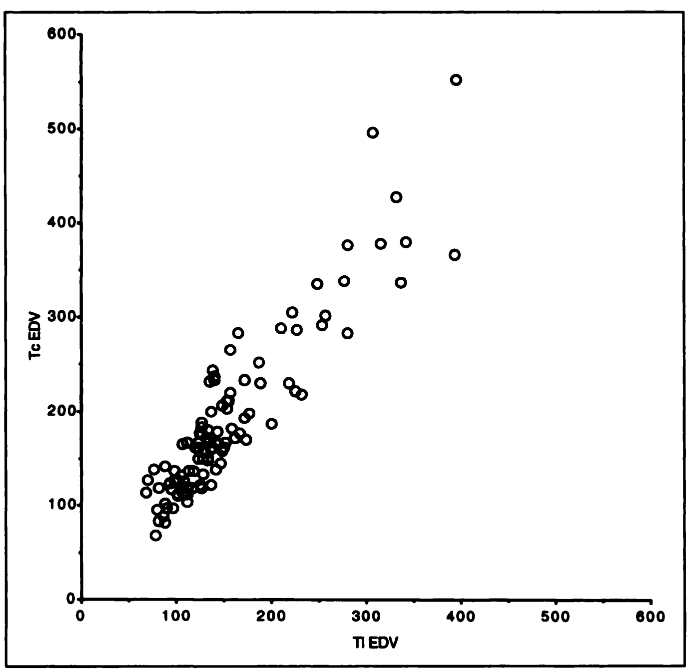

FIGURE 2. Correlation between end-diastolic volumes obtained with ^{201}Tl myocardial gated SPECT and ^{99m}Tc-sestamibi myocardial gated SPECT: r = 0.92.

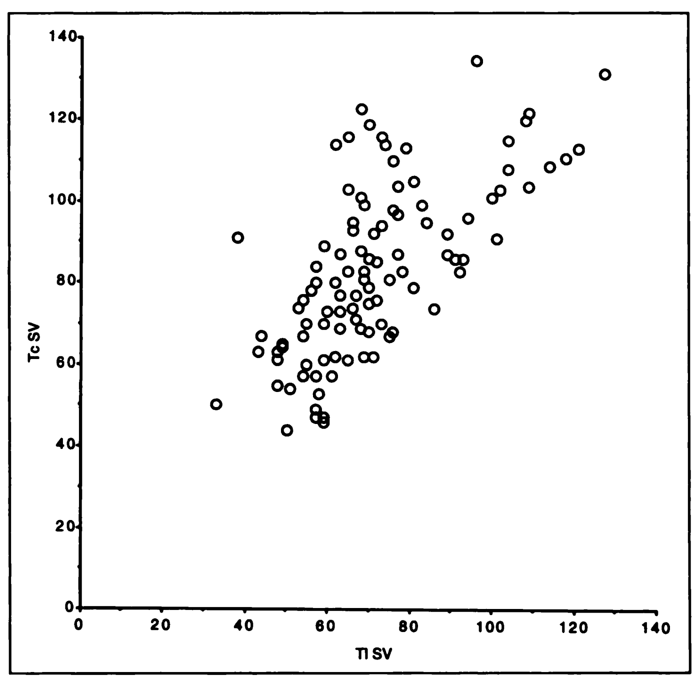

FIGURE 4. Correlation between stroke volumes obtained with ^{201}Tl myocardial gated SPECT and with ^{99m}Tc-sestamibi myocardial gated SPECT: r = 0.68.

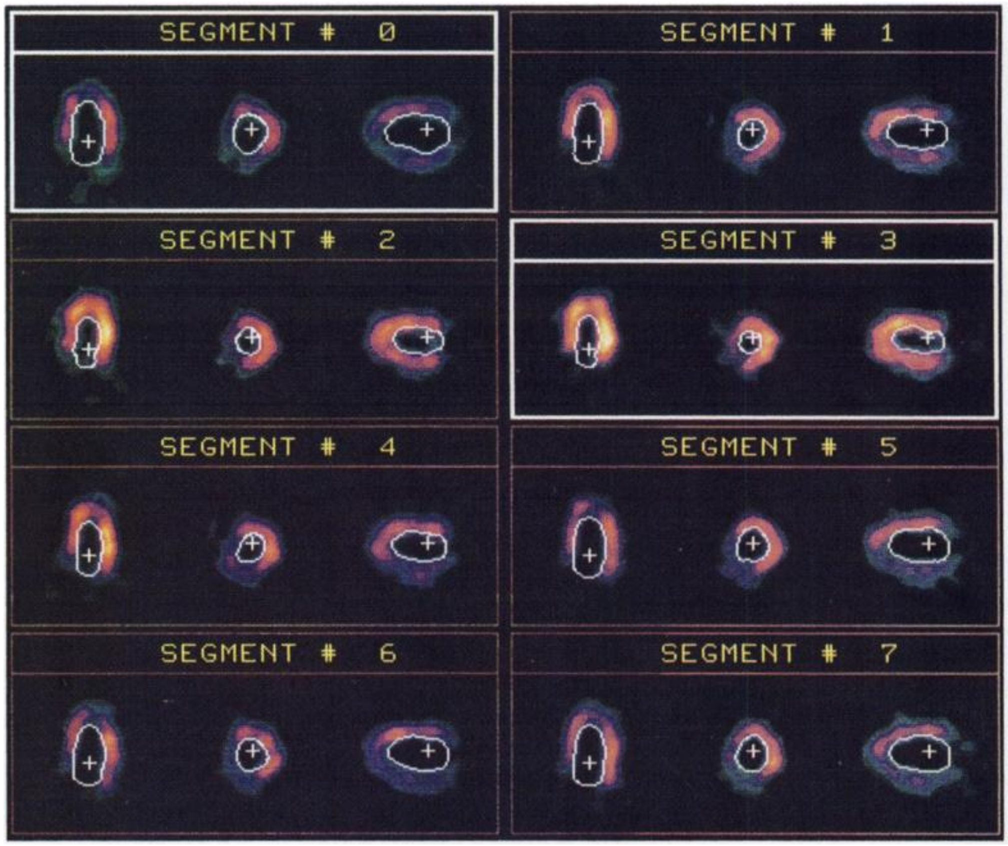

FIGURE 5. Quality control report of a ^{201}Tl myocardial gated SPECT study in a patient with a fixed perfusion defect. Highlighted segments represent end-diastolic and end-systolic regions of interest used for ventricular function calculations.

DISCUSSION

Myocardial gated SPECT quantification of left ventricular function with ^{201}Tl was possible and was as reliable as gated SPECT with ^{99m}Tc-sestamibi. There was excellent correlation between gated SPECT with ^{201}Tl and gated SPECT with ^{99m}Tc-sestamibi, even when the left ventricular function was abnormal. The results were also reproducible, even in patients with large perfusion defects. Similar to equilibrium radionuclide angiography studies, left ventricular function cannot be accurately evaluated with gated SPECT in patients with severe cardiac arrhythmias or low QRS complexes on electrocardiograms.

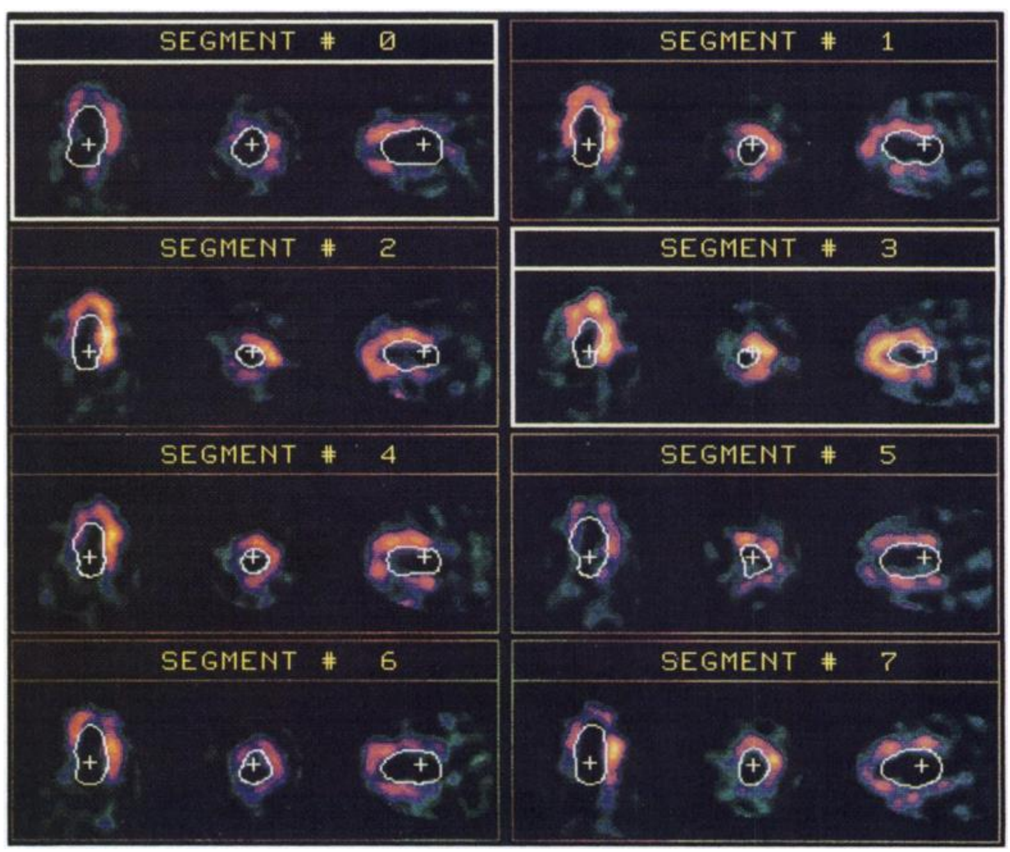

FIGURE 6. Quality control report of a ^{99m}Tc-sestamibi myocardial gated SPECT study in the same patient (Fig. 5). Highlighted segments represent end-diastolic and end-systolic regions of interest used for ventricular function calculations.

TABLE 1
Mean and Standard Deviation Values of Calculated LV Ejection Fractions and Volumes Obtained with Myocardial Gated SPECT in 104 Consecutive Patients

	^{201}Tl	^{99m}Tc-sestamibi
LVEF (%)	50.2 ± 11.9	48.4 ± 12.1
EDV (ml)	154.9 ± 70.1	189.8 ± 89.3
ESV (ml)	83.5 ± 59.9	106.5 ± 78.7
SV (ml)	71.4 ± 18.6	83.3 ± 21.1

LVEF = left ventricular ejection fraction; EDV = end-diastolic volume; ESV = end-systolic volume; SV = stroke volume.

The correlation coefficient for the SV was not as high as with EDV and ESV. This was due to the smaller magnitude of the SV, so the impact of small differences in SV was proportionally greater (Fig. 4).

The myocardial walls were slightly thicker and the cavity sizes slightly smaller in ^{201}Tl studies as compared to ^{99m}Tc-sestamibi studies (*6*). This explained why the mean calculated left ventricular volumes with ^{201}Tl were slightly smaller (Table 1).

The left ventricular function was assessed at rest for both tracers. With ^{201}Tl, patients were injected at rest, and perfusion and function were evaluated at rest. With ^{99m}Tc-sestamibi, although the injection was made during stress, providing information about myocardial perfusion at stress, function was evaluated at rest 1 hr after stress.

Many institutions prefer ^{201}Tl to assess myocardial perfusion because additional information about myocardial viability can be obtained in the same study. Gated SPECT quantification of left ventricular function with ^{201}Tl was as reliable as gated SPECT with ^{99m}Tc-sestamibi, so these institutions can continue to use ^{201}Tl and also perform myocardial gated SPECT.

Besides the quantification of the left ventricular volumes and ejection fractions, myocardial gated SPECT can provide wall motion and wall thickening information with ^{201}Tl (*7–9*) or ^{99m}Tc-sestamibi (*10–15*).

TABLE 2
Correlation Between Myocardial Gated SPECT with Thallium-201 and Myocardial Gated SPECT with Technetium-99m-Sestamibi

	Male (n = 55)	Female (n = 49)
LVEF	r = 0.95	r = 0.89
EDV	r = 0.93	r = 0.92
ESV	r = 0.97	r = 0.96
SV	r = 0.64	r = 0.71
	Exercise (n = 51)	Pharmacologic (n = 53)
LVEF	r = 0.94	r = 0.93
EDV	r = 0.93	r = 0.93
ESV	r = 0.97	r = 0.96
SV	r = 0.66	r = 0.70

LVEF = left ventricular ejection fraction; EDV = end-diastolic volume; ESV = end-systolic volume; SV = stroke volume.

CONCLUSION

Myocardial gated SPECT quantification of left ventricular function with ^{201}Tl was possible and was as reliable as gated SPECT with ^{99m}Tc-sestamibi. There was excellent correlation between gated SPECT with ^{201}Tl and gated SPECT with ^{99m}Tc-sestamibi. In addition to assessment of myocardial perfusion, myocardial function and viability can be quantified in a single gated ^{201}Tl study.

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