Annals of Nuclear Medicine Vol. 17, No. 1, 15–22, 2003

Comparison of gated planar Tc-99m tetrofosmin scintigraphy with radionuclide ventriculography and echocardiography in the evaluation of left ventricular wall motion

Fevziye CANBAZ,* Tarik BASOGLU,* Ozcan YILMAZ,** Mustafa YAZICI** and Murathan SAHIN*

*Departments of *Nuclear Medicine and **Cardiology, Ondokuz Mayis University Hospital, Samsun, Turkey*

Assessment of ventricular function is an important diagnostic and prognostic tool in coronary heart disease (CHD). The objective of this study was to compare radionuclide ventriculography (RVG), echocardiography (ECHO) and gated planar tetrofosmin myocardial scintigraphy (GPTF) in patients with CHD. Radionuclide ventriculography in left anterior oblique (LAO) and left lateral (LLT) projections was performed in 44 patients. Two days later, rest tetrofosmin perfusion tomoscintigraphy (SPECT) and rest GPTF in RVG identical parameters and projections were acquired. Within the two following days, the patients underwent two-dimensional ECHO. GPTF studies were processed and interpreted in original (NI-GPTF) and image inverted, RVG like form (I-GPTF). All visual interpretations were evaluated with a semi-quantitative scoring system. Quantitative analysis was performed on parametric images by means of segmental regions of interest. Linear regression and contingency analysis were carried out in overall analysis and on a segmental basis separately by accepting the RVG as the standard for the whole investigation. In overall cine-mode evaluation, NI-GPTF ($r = 0.77$, $p < 0.001$, complete agreement (CA) = 84%) was superior to I-GPTF ($r = 0.73$, $p < 0.001$, CA = 82%) and ECHO ($r = 0.39$, $p < 0.001$, CA = 78%), compared to RVG. On a segmental basis, NI-GPTF showed the best RVG-correlations except for inferoapical, mid-inferior, mid-anterior and anterobasal segments. In visual analysis of functional images, the best RVG-agreement was observed in I-GPTF ($r = 0.72$, $p < 0.001$, CA = 77%). On a segmental basis, I-GPTF showed the best RVG-correlations except for posterolateral, mid-inferior, mid-anterior and anterobasal segments. In overall quantitative evaluation, amplitude values in both I-GPTF ($r = 0.76$, $p < 0.001$) and NI-GPTF ($r = 0.75$, $p < 0.001$) studies were well correlated with RVG amplitude. I-GPTF gave the best RVG-correlation of phase ($r = 0.59$, $p < 0.001$). The mean phase and standard deviation RVG-correlations of I-GPTF were $r = 0.92$, $p < 0.001$ and $r = 0.53$, $p < 0.001$ respectively. In segmental quantification, amplitude values of all segments in I-GPTF were better RVG-correlated than in NI-GPTF. In conclusion, GPTF could be a time saving alternative to ECHO in the evaluation of wall motion by the nuclear medicine physician. Because of differing segmental RVG correlations, NI-GPTF and I-GPTF should be both interpreted to improve the diagnostic value of the method. Cine-mode and parametric image interpretations in GPTF studies should be done simultaneously since the former is more closely correlated to RVG.

Key words: left ventricular wall motion, planar gated scintigraphy, Tc-99m-tetrofosmin

INTRODUCTION

ASSESSMENT of left ventricular function is an important diagnostic and prognostic tool in coronary heart disease (CHD).[1] Contrast ventriculography yet remains the gold standard in the evaluation of ventricular function. For many years radionuclide ventriculography (RVG) has

Received March 7, 2002, revision accepted October 28, 2002.
For reprint contact: Fevziye Canbaz, M.D., Ondokuz Mayis University Hospital, Department of Nuclear Medicine, 55139 Kurupelit/Samsun, TURKEY.
E-mail: fcanbaz@omu.edu.tr

Table 1 The interpretation and scoring results of parametric images

Kinetics	Score	Amplitude	Phase
Normal	0	(0)	(0)
Mild hypokinesis	1	Slightly to moderate reduced (1)	Normal (0)
Severe hypokinesis*	2	Markedly reduced (2)	Normal (0)
akinesis*	3	Markedly reduced or defective (2)	Normal or delayed (0, 1)
dyskinesis	4	Variable (0, 1, 2)	Markedly delayed (2)

*In subjects with normal phase, distinguishing between severe hypokinesis and akinesis was only possible with the simultaneous assessment of cine images.

been successfully used in ventricular function analysis.[2–4] Electrocardiography (ECG)-gated perfusion tomoscintigraphy (SPECT) is a currently well accepted technique in the evaluation of left ventricular function, particularly in the assessment of wall motion.[5–8] Although gated planar imaging has largely been replaced by gated SPECT in well developed countries, advanced gamma camera technology such as the use of multi-headed gamma cameras and high capacity storage facilities cannot be used in many centers.

Technetium-99m methoxyisobutylisonitrile (MIBI) had been proposed during its introduction period as an appropriate agent for gated planar myocardial studies and has been investigated by several authors.[9–13] Since significant gastrointestinal activity in the close neighborhood of the myocardium has been a disadvantage in the interpretation of gated MIBI studies, we found it justifiable to investigate ventricular function by using the alternative new myocardial perfusion agent tetrofosmin with more rapid hepatic clearance and lower mesenteric activity.[14–16] To the best of our knowledge, this is the second reported planar gated myocardial perfusion study with Tc-99m tetrofosmin in the assessment of left ventricular function and the first including the echocardiography (ECHO) as an additional parameter.

Our aim was to investigate the correlation and agreement between gated planar tetrofosmin myocardial scintigraphy (GPTF), RVG and ECHO in the evaluation of left ventricular kinetics. A segment-to-segment comparison of GPTF and RVG by means of linear regression analysis was an important part of this prospective study.

MATERIALS AND METHODS

Radionuclide ventriculography, GPTF and ECHO were carried out in 424 myocardial segments of 44 patients including 15 women (mean age 58 ± 6.8 years) and 29 men (mean age 54 ± 8.8 years). Twenty patients with proven myocardial infarction (MI) (19 acute MI and 1 old MI), 2 patients with inferior MI diagnosed in ECG, 6 patients with unstable angina pectoris and 16 patients with suspected ischemic heart disease were examined. Because of the non visualization of large infarcted areas involving sixteen myocardial segments of a single patient with left anterior descending artery (LAD) + circumflex artery (Cx) disease, they could not be evaluated and were excluded from the study.

All patients underwent RVG examinations after *in vivo* red blood cell labeling with 925 MBq Tc-99m pertechnetate. Left anterior oblique (LAO) (30°–45°) with best septal identification and left lateral (LLT) (90°) projections were used. The data were obtained by dividing a cardiac cycle into 24 frames of 64 × 64 matrices in 2× zoom during 1000 cardiac cycles for each projection. Within the next two days, the patients were evaluated with two-dimensional ECHO. Rest perfusion SPECT was performed by using 925 MBq (25 mCi) Tc-99m tetrofosmin. Immediately thereafter, rest GPTF studies in RVG identical acquisition parameters and projections were carried out. All radionuclide studies were performed with a single-headed gamma camera equipped with a parallel-hole, low-energy, high-resolution collimator. Rest perfusion SPECT scintigraphy results were assessed by using a 3 grade scoring system (0 = normal, 1 = hypoperfusion and 2 = defective).

In visual and quantitative assessment, GPTF studies were interpreted in the non-inverted (NI-GPTF) and in the inverted (I-GPTF) mode separately. Inverted tetrofosmin images were created by the method described by Nakajima et al.[16] Visual cine scoring and functional image quantitation results obtained from NI-GPTF and I-GPTF were compared in overall analysis and for each segment separately (10 myocardial segments) to those of RVG, the accepted standard of the investigation. In left anterior oblique (LAO) projection; proximal-septal, distal-septal, inferoapical, inferolateral, posterolateral segments and in left lateral (LLT) projection anterobasal, mid-anterior, apical, mid-inferior, inferobasal segments were separately examined. Wall motion was analyzed in cine mode display, by using a semiquantitative scoring system with 5 grades (0 = normal, 1 = hypokinesis, 2 = severe hypokinesis, 3 = akinesis, 4 = dyskinesis) in RVG and GPTF studies. Movement of the inner edge of the myocardium and wall thickening were the most impressive visual interpretation factors as it was already mentioned by Nakajima et al.[16]

In echocardiographic evaluation, wall motion analysis was carried out in the parasternal long axis, the parasternal

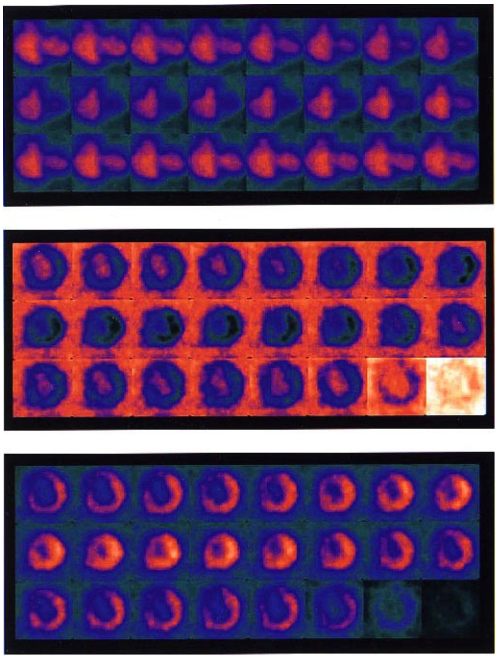

Fig. 1

Fig. 1 Serial loop images of RVG, I-GPTF and NI-GPTF (from top to the bottom, LAO projection) of a normal subject.

Fig. 2 The parametric images obtained from RVG, I-GPTF and NI-GPTF (from top to the bottom) in a normal subject (column A) and in a patient with suspected stunned myocardium (column B) in LAO projection. Each parametric image panel consists of amplitude and end-diastolic smoothed acquisition data in the upper row; phase histogram and phase images in the lower row, from left to right respectively. Note the lateral wall in the patient with suspected stunned myocardium (column B). Despite normal appearing perfusion in end-diastolic acquisition data of I-GPTF and NI-GPTF, impaired amplitude is observed in corresponding I-GPTF and NI-GPTF images similar to RVG amplitude in this region.

Fig. 3 Normal LLT functional images (column A) and images demonstrating inferoapical aneursym (column B) are shown. RVG, I-GPTF and NI-GPTF images are illustrated from top to the bottom. Each parametric image panel consists of amplitude and end-diastolic smoothed acquisition data in the upper row; phase histogram and phase images in the lower row, from left to right respectively. Note the phase delay in the apical aneurysm region in corresponding I-GPTF and NI-GPTF images similar to RVG phase in this region.

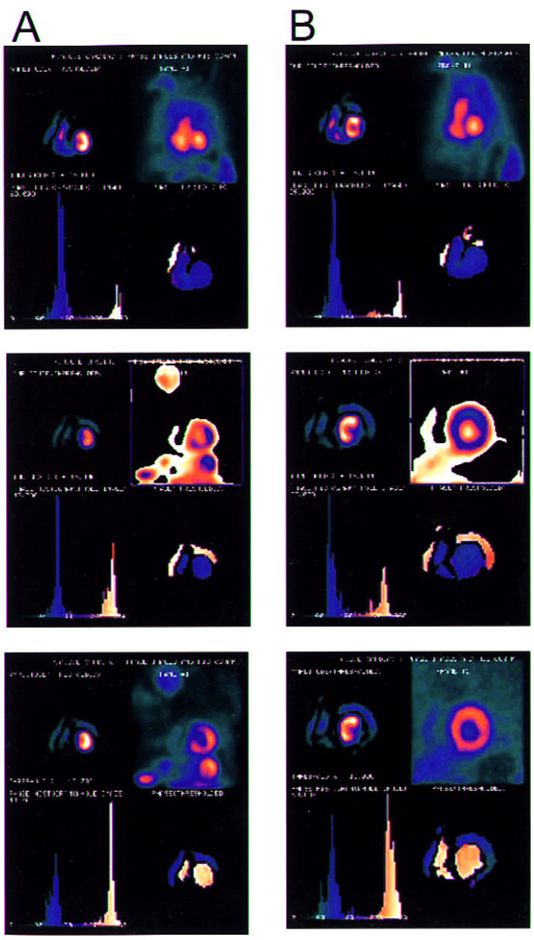

Fig. 2

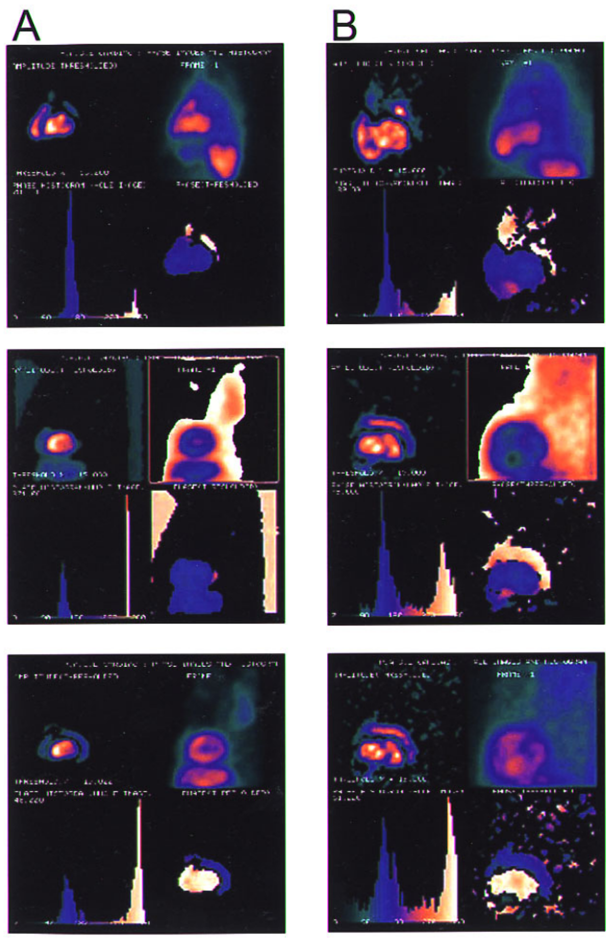

Fig. 3

Table 2 Segmental myocardial perfusion distribution in all patients obtained from the rest perfusion SPECT studies

Segments	Normal (0)	Hypoperfusion (1)	Defect (2)
Basalseptal	36	6	2
Distalseptal	32	7	5
Inferoapical	23	9	12
Inferolateral	32	2	10
Posterolateral	40	2	2
Posterobasal	21	8	15
Mid-inferior	19	8	17
Apical	32	10	2
Mid-anterior	37	5	2
Anterobasal	38	5	1
Total	310	62	68

Table 3 Comparison of gated blood pool with ECHO and GPTF studies with cine mode display

A. Cine mode display: RVG vs. I-GPTF

Cine mode by RVG	Cine mode by NI-GPTF			
	N	H	A-Dys	Totals
N	285	38	3	326
H	18	52	8	78
A-Dys	1	9	10	20
Totals	304	99	21	424

B. Cine mode display: RVG vs. NI-GPTF

Cine mode by RVG	Cine mode by NI-GPTF			
	N	H	A-Dys	Totals
N	289	35	2	326
H	15	55	8	78
A-Dys	0	9	11	20
Totals	304	99	21	424

C. Cine mode display: RVG vs. ECHO

Cine mode by RVG	Cine mode by NI-GPTF			
	N	H	A-Dys	Totals
N	301	24	1	326
H	47	31	0	78
A-Dys	8	12	0	20
Totals	356	67	1	424

Statistics	A	B	C
Complete agreement	82	84	78
Chi-square p-value: p <	0.001	0.001	0.001
Contingency coefficient	0.60	0.63	0.40
Kappa	0.55	0.60	0.33

N, normokinesis; H, hypokinesis; A-Dys, akinesis or dyskinesis

Table 4 Segmental correlation values of RVG cine mode evaluation with I-GPTF, NI-GPTF and ECHO. The values for segments 1 to 5 were obtained from LAO projection; segments 6–10 belong to LLT projection

	Segments	I-GPTF	NI-GPTF	ECHO
1	Basalseptal	r = 0.76 p < 0.001	r = 0.83 p < 0.001	r = 0.64 p < 0.001
2	Distalseptal	r = 0.75 p < 0.001	r = 0.81 p < 0.001	r = 0.46 p = 0.002
3	Inferoapical	r = 0.83 p < 0.001	r = 0.82 p < 0.001	r = 0.60 p < 0.001
4	Inferolateral	r = 0.84 p < 0.001	r = 0.92 p < 0.001	r = 0.33 p = 0.027
5	Posterolateral	r = 0.88 p < 0.001	r = 0.88 p < 0.001	r = 0.08 p = 0.589
6	Posterobasal	r = 0.79 p < 0.001	r = 0.81 p < 0.001	r = 0.38 p = 0.013
7	Midinferior	r = 0.57 p < 0.001	r = 0.55 p < 0.001	r = 0.55 p < 0.001
8	Apical	r = 0.38 p = 0.013	r = 0.39 p = 0.010	r = 0.10 p = 0.521
9	Midanterior	r = 0.39 p = 0.011	r = 0.36 p = 0.017	r = 0.03 p = 0.828
10	Anterobasal	r = 0.56 p < 0.001	r = 0.56 p < 0.001	r = 0.70 p < 0.001

short axis, apical four chamber and apical two chamber echocardiographic windows, by using the same 5-grade system as in RVG and GPTF studies.

Functional images were created with a standard RVG software. Visual assessment of phase and amplitude images were performed with the same interpretation criteria as applied in RVG studies. Amplitude images were evaluated in a 3 (0 = normal, 1 = minimally decreased, 2 = severely decreased or defective) and phase images in 4 a grade (0 = normal, 1 = delayed, 2 = reverse and 3 = defective) scoring system.

After the simultaneous interpretation of amplitude and phase images, a general function score, varying between 0 and 5, was determined for each segment as described by Nakajima et al.[16] (Table 1). Quantitative evaluation of functional images in GPTF studies was done by using 10 regions of interest of 4 × 4 pixels for each segment in LAO and LLT projections.

The mean and standard deviation values of the phase for the whole left ventricule were calculated from the LAO projection.

Contingency analysis (CA) and linear regression were performed in the statistical evaluation of the study.

RESULTS

The serial loop images of RVG, I-GPTF and NI-GPTF of a normal subject are shown in Figure 1. Figure 2 shows the parametric images obtained from RVG, I-GPTF and NI-GPTF in a normal subject and in a patient with suspected

Table 5 Comparison of RVG with I-GPTF and NI-GPTF with functional imaging

A) Functional image: RVG vs. I-GPTF

Functional image by RVG	Functional image by I-GPTF			
	N	H	A-Dys	Totals
N	265	41	5	311
H	20	37	15	72
A-Dys	1	15	25	41
Totals	286	93	45	424

B) Functional image: RVG vs. NI-GPTF

Functional image by RVG	Functional image by I-GPTF			
	N	H	A-Dys	Totals
N	256	42	13	311
H	18	39	15	72
A-Dys	0	19	22	41
Totals	274	100	50	424

Statistics	A	B
Complete agreement	77	75
Chi-square p-value: p <	0.001	0.001
Contingency coefficient	0.59	0.56
Kappa	0.50	0.47

N, normokinesis; H, hypokinesis; A-Dys, akinesis or dyskinesis

Table 6 Segmental correlation results of visual functional image analysis of RVG with I-GPTF and NI-GPTF. The values for segments 1 to 5 were obtained from LAO projection; segments 6–10 belong to LLT projection

	Segments	I-GPTF	NI-GPTF
1	Basalseptal	r = 0.80 p < 0.001	r = 0.80 p < 0.001
2	Distalseptal	r = 0.67 p < 0.001	r = 0.61 p < 0.001
3	Inferoapical	r = 0.82 p < 0.001	r = 0.70 p < 0.001
4	Inferolateral	r = 0.82 p < 0.001	r = 0.70 p < 0.001
5	Posterolateral	r = 0.62 p < 0.001	r = 0.64 p < 0.001
6	Posterobasal	r = 0.69 p < 0.001	r = 0.58 p < 0.001
7	Mid-inferior	r = 0.56 p < 0.001	r = 0.61 p < 0.001
8	Apical	r = 0.61 p < 0.001	r = 0.44 p < 0.001
9	Mid-anterior	r = 0.12 p = 0.45	r = 0.14 p = 0.40
10	Anterobasal	r = 0.12 p = 0.45	r = 0.14 p = 0.84

Table 7 Comparison of cine mode display and functional imaging for RVG, I-GPTF and NI-GPTF

A) RVG study: Functional image vs. Cine mode

Functional image by RVG	Cine mode by RVG			
	N	H	A-Dys	Totals
N	288	21	2	311
H	33	35	4	72
A-Dys	5	22	14	41
Totals	326	78	20	424

B) I-GPTF study: Functional image vs. Cine mode

Functional image by RVG	Cine mode by RVG			
	N	H	A-Dys	Totals
N	265	25	0	290
H	36	52	3	91
A-Dys	8	19	16	43
Totals	309	96	19	424

C) NI-CPTF study: Functional image vs. Cine mode

Functional image by RVG	Cine mode by RVG			
	N	H	A-Dys	Totals
N	255	18	0	273
H	38	56	5	99
A-Dys	17	22	13	52
Totals	310	96	18	424

Statistics	A	B	C
Complete agreement	80	79	76
Chi-square p-value: p<	0.001	0.001	0.001
Contingency coefficient	0.58	0.58	0.56
Kappa	0.49	0.49	0.50

N, normokinesis; H, hypokinesis; A-Dys, akinesis or dyskinesis

stunned myocardium in the LAO projection. Normal LLT functional images and images showing an inferoapical aneurysm are given in Figure 3. Rest perfusion SPECT results for all patients are shown in Table 2.

In visual overall wall motion (cine) analysis, there were 120 asynergic (99 hypokinetic, 21 akinetic/dyskinetic) segments in each of the GPTF studies (NI-GPTF and I-GPTF), 98 asynergic (78 hypokinetic, 20 akinetic/dyskinetic) segments in RVG and 68 (67 hypokinetic, 1 akinetic/dyskinetic) in ECHO (Table 3). Correlative statistics performed between RVG and the other methods showed that NI-GPTF ($r = 0.77$, $p < 0.001$, CA = 84%) was superior to I-GPTF ($r = 0.73$, $p < 0.001$, CA = 82%) and ECHO ($r = 0.39$, $p < 0.001$, CA = 78%). On a segmental basis, NI-GPTF showed the best RVG-correlations except for inferoapical, mid-inferior, mid-anterior and anterobasal segments. In the first three of these segments, I-GPTF was better RVG correlated. Echocardiography showed a better RVG-correlation solely in the anterobasal

Table 8 Segmental correlation values of cine mode display and functional imaging for RVG, I-GPTF and NI-GPTF. The values for segments 1 to 5 were obtained from LAO projection; segments 6–10 belong to LLT projection

	Segments	RVG	I-GPTF	NI-GPTF
1	Basalseptal	r = 0.66	r = 0.67	r = 0.73
		p < 0.001	p < 0.001	p < 0.001
2	Distalseptal	r = 0.67	r = 0.64	r = 0.66
		p < 0.001	p < 0.001	p < 0.001
3	Inferoapical	r = 0.81	r = 0.81	r = 0.70
		p < 0.001	p < 0.001	p < 0.001
4	Inferolateral	r = 0.84	r = 0.81	r = 0.88
		p < 0.001	p < 0.001	p < 0.001
5	Posterolateral	r = 0.72	r = 0.62	r = 0.74
		p < 0.001	p < 0.001	p < 0.001
6	Posterobasal	r = 0.72	r = 0.70	r = 0.56
		p < 0.001	p < 0.001	p < 0.001
7	Mid-inferior	r = 0.84	r = 0.68	r = 0.67
		p < 0.001	p < 0.001	p < 0.0001
8	Apical	r = 0.50	r = 0.68	r = 0.81
		p = 0.001	p < 0.001	p < 0.001
9	Mid-anterior	r = 0.26	r = 0.028	r = 0.16
		p = 0.09	p = 0.86	p = 0.32
10	Anterobasal	r = 0.56	r = 0.27	r = 0.12
		p < 0.0001	p = 0.08	p = 0.44

segment (Table 4).

In overall visual analysis of functional images, the I-GPTF results ($r = 0.72$, $p < 0.001$, CA = 77%) were better correlated than the NI-GPTF results ($r = 0.68$, $p < 0.001$, CA = 75%) with the corresponding RVG values (Table 5). On a segmental basis, I-GPTF showed the best RVG-correlations except for posterolateral, mid-inferior, mid-anterior and anterobasal segments (Table 6).

In overall analysis (LAO + LLT projections), cine to functional image correlation was found to be slightly higher in RVG studies ($r = 0.75$, $p < 0.001$, CA = 80%) than in I-GPTF and NI-GPTF studies ($r = 0.72$, $p < 0.001$, CA = 79%; $r = 0.72$, $p < 0.001$, CA = 76%) (Table 7). In segmental assessment, RVG showed the better results except for basalseptal, inferolateral, posterolateral and apical segments (Table 8). In overall (LAO + LLT projections) quantitative evaluation, amplitude values in both I-GPTF ($r = 0.76$, $p < 0.001$) and NI-GPTF ($r = 0.75$, $p < 0.001$) studies were well correlated with RVG amplitudes. I-GPTF gave the best RVG-correlation of phase ($r = 0.59$, $p < 0.001$). The mean phase and standard deviation RVG-correlations of I-GPTF were $r = 0.92$, $p < 0.001$ and $r = 0.53$, $p < 0.001$ respectively. In segmental quantification, amplitude values of all segments in I-GPTF were better RVG-correlated than in NI-GPTF.

DISCUSSION

The evaluation of left ventricular function with non-invasive methods plays an important role in the assessment of coronary artery disease. Ultrafast computed tomography (CT), magnetic resonance imaging (MRI), ECHO, RVG and gated-SPECT are the currently proposed methods, where the first two methods still remain domains of scientific and clinical research for this purpose.

Radionuclide ventriculography is the most commonly used radionuclide method in the evaluation of left ventricular function. In the daily routine of a nuclear medicine department, a good half of RVG examinations are performed after myocardial perfusion SPECT studies. In the case of RVG demand, the patient must be reinjected, and in patients who have had perfusion SPECT studies with Tc-99m agents, this must be done on a separate day. Regarding the myocardial gated-SPECT method, the availability of advanced gamma camera equipment limits the common use of this novel and elegant method in some countries.

The usefulness of gated planar perfusion scintigraphy in clinical practice has already been reported by different authors.[9–13,16–23] One of the most recent studies was performed by Nakajima et al. with Tc-99m tetrofosmin.[16] The complete agreement between cine RVG and functional RVG was calculated to be 70% by Nakajima et al. In our study this agreement value was 80%. Nakajima and co-workers calculated the complete agreement values for: cine RVG/cine GPTF, cine GPTF/functional GPTF, functional RVG/ and functional GPTF as 78%, 69% and 86%, respectively. The corresponding I-GPTF values for complete agreement in our study were 82%, 79% and 77%, respectively. In NI-GPTF mode, these values were found as 84%, 75% and 75%. In cine mode interpretations, our agreement values for RVG and GPTF studies were about 4–6% higher than those of Nakajima et al. An objective interpretation of this difference is, in our opinion, not easy because of a certain subjective character of cine mode evaluation. The comparison of the functional interpretation results showed lower values (≅10%) in our study. In GPTF studies, left ventricular wall thickening and ejection fraction (EF) were not determined considering the unreliability of the results already reported by Nakajima et al.[16]

The detailed segmental comparison between GPTF and RVG has not been sufficiently investigated in the reported studies. We, in our study, tried to analyze in particular the segmental wall motion interpretation by GPTF. The aim of this type of interpretation was to select patients, which could eventually benefit from a GPTF study after the perfusion SPECT. Accepting the RVG method as the gold standard of radionuclide left ventricular function evaluation, selecting patients who could benefit from a GPTF study could be done on the basis of the results of a trial such as ours. In other words, if the dyskinesia suspected myocardial segment in a SPECT examination can be comparably evaluated by GPTF or RVG (good segmental correlation) according to the results of the present study, a GPTF study could be performed. In the case of insufficient segmental correlation, one can always perform an RVG study.

It must be emphasized that patients with extensive myocardial defects are not suitable for evaluation with GPTF due to the nonvisualization of the related segments. In these patients, assessment of the normal or ischemic myocardial tissue motion in the neighborhood of the defective area may be helpful in certain cases.

In a GPTF study we evaluate left ventricular function by examining the movement of myocardial walls and not the blood pool activity. The nearest equivalent of such a diagnostic approach in the daily routine of cardiologic practice is echocardiography in which the physician estimates the ventricular function by observing the myocardial wall motion itself. In this comparative trial versus RVG, it was clearly shown that GPTF was superior to ECHO in visual wall motion analysis. As shown in Tables 3 and 4 the complete agreement and correlation values calculated for RVG versus GPTF and ECHO indicate that GPTF should be considered as an alternative method to ECHO.

The diagnostic limits of RVG in the evaluation of left ventricular wall motion justify the search for other methods for routine practical use. One of the disadvantages of RVG is the difficulty in evaluating the wall motion in all left ventricular wall segments because of right ventricular activity superimposition in some oblique and lateral projections. This especially applies to the inferior wall. Therefore, in the interpretation of the infero-basal segments, the RVG may even not constitute a standard for GPTF to evaluate its diagnostic value. Prospective comparative studies including contrast ventriculography or gated-MRI could be performed to clarify this particular issue.

Non-inverted GPTF and I-GPTF should be both interpreted, and, depending on the best segmental RVG correlation obtained in our study, the final diagnosis concerning the affected myocardial segment could be made on the related NI-GPTF and/or I-GPTF images to obtain the best RVG-correlated results. In other words, when NI-GPTF and I-GPTF give different results from each other, the result of the better RVG-correlated method should be preferred for the myocardial segment examined (see Tables 4 and 6). Since the highest overall agreement values were found between cine RVG and cine GPTF, simultaneous evaluation of cine and functional images could be useful in the case of questionable functional findings.

To conclude, the results of the present study indicate that echocardiographic wall motion evaluation is generally worse correlated with RVG than with GPTF studies. This new finding accentuates the value of the method as reported by Nakajima et al.[16] The additional evaluation of non-inverted images and detailed segmental analysis could further help the nuclear medicine physician in accurate utilization of the GPTF method.

REFERENCES

1. Massie BM, Botvinick EH, Brundage BH, Greenberg B, Shames D, Gelberg H. Relationship of regional myocardial perfusion to segmental wall motion. *Circulation* 1978; 58: 1154–1162.
2. Marcassa C, Marzullo P, Parodi O, Sambuceti G, L'Abbate A. A new method for noninvasive quantitation of segmental myocardial wall thickening using technetium-99m 2-methoxy-isobutyl-isonitrile scintigraphy—results in normal subjects. *J Nucl Med* 1990; 3: 173–177.
3. Brateman L, Buckley K, Keim SG, Wargovich TJ, Williams CM. Left ventricular regional wall motion assessment by radionuclide ventriculography: A comparison of cine display with Fourier imaging. *J Nucl Med* 1991; 32: 777–782.
4. Bartlett LM, Srinivasan G, Barker WC, Kitsiou AN, Dilsizian V, Bacharech SL. Left ventricular ejection fraction: Comparison of results from planar gated blood-pool studies. *J Nucl Med* 1996; 37: 1795–1799.
5. Narula J, Dawson MS, Singh BK, Amanullah A, Acio RB, Chaudhry FA, et al. Noninvasive characterization of stunned, hibernating, remodeled and nonviable myocardium in ischemic cardiomyopathy. *J Am Coll Cardiol* 2000; 15: 1913–1919.
6. Sharir T, Bacher-Stier C, Dhar S, Lewin HC, Miranda R, Friedman JD, et al. Identification of severe and extensive coronary artery disease by postexercise regional wall motion abnormalities in Tc-99m sestamibi gated single-photon emission computed tomography. *Am J Cardiol* 2000; 1: 1171–1175.
7. Vaduganathan P, He ZX, Vick GW 3rd, Mahmarian JJ, Verani MS. Evaluation of left ventricular wall motion, volumes, and ejection fraction by gated myocardial tomography with technetium 99m-labeled tetrofosmin: a comparison with cine magnetic resonance imaging. *J Nucl Cardiol* 1999; 6: 3–10.
8. Nichols K, DePuey EG, Krasnow N, Lefkowitz D, Rozanski A. Reliability of enhanced gated SPECT in assessing wall motion of severely hypoperfused myocardium: echocardiographic validation. *J Nucl Cardiol* 1998; 5: 387–394.
9. Massardo T, González P, Humeres P, Chamorro H, Ayala F, Yovanovich J, et al. Simultaneous assessment of function and perfusion during dipyridamole-handgrip Tc-99m sestamibi imaging in chronic coronary artery disease. *Ann Nucl Med* 1999; 13: 121–125.
10. Williams KA, Taillon LA. Gated planar technetium 99m-labeled sestamibi myocardial perfusion image inversion for quantitative scintigraphic assessment of left ventricular function. *J Nucl Cardiol* 1995; 2: 285–295.
11. Jangid DR. Quasi-3D kinematic modeling and parametric image processing of a multiframe ECG-gated planar ^{99m}Tc-SestaMIBI myocardial perfusion scintigraphic study. *J Digit Imaging* 1997; 10: 197–202.
12. Boonyaprapa S, Ekmahachai M, Thanachaikun N, Jaiprasert W, Sukthomya V, Poramatikul N. Measurement of left ventricular ejection fraction from gated technetium-99m sestamibi myocardial images. *Eur J Nucl Med* 1995; 22: 528–531.
13. Jamar F, Topcuoglu R, Cauwe F, De Coster P, Roelants V, Beckers C, et al. Exercise gated planar myocardial perfu-

sion imaging using technetium-99m sestamibi for the diagnosis of coronary artery disease: an alternative to exercise tomographic imaging. *Eur J Nucl Med* 1995; 22: 40–48.
14. Inoue Y, Machida K, Honda N, Mamiya T, Takahashi T, Kamano T, et al. Clearance of ^{99m}Tc-tetrofosmin from the myocardium and the adjacent organs. *KAKU IGAKU (Jpn J Nucl Med)* 1993; 30: 313–316.
15. Van Dongen AJ, van Rijk PP. Minimizing liver, bowel, and gastric activity in myocardial perfusion SPECT. *J Nucl Med* 2000; 41: 1315–1317.
16. Nakajima K, Taki J, Matsuyama T, Kita Y, Hwang EH, Tonami N. Functional imaging of gated Tc-99m tetrofosmin study as a simple method to quantify ventricular wall motion. *Ann Nucl Med* 1997; 11: 87–94.
17. Maddahi J, Rodrigues E, Berman DS, Kiat H. State-of-the-art myocardial perfusion imaging. *Cardiol Clin* 1994; 12: 199–222.
18. Tischler MD, Niggel JB, Battle RW, Fairbank JT, Brown KA. Validation of global and segmental left ventricular contractile function using gated planar technetium-99m sestamibi myocardial perfusion imaging. *J Am Coll Cardiol* 1994; 23: 141–145.
19. DePuey EG, Nichols K, Dobrinsky C. Left ventricular ejection fraction assessed from gated technetium-99m-sestamibi SPECT. *J Nucl Med* 1993; 34: 1871–1876.
20. Berman DS, Kiat H, Van Train K, Garcia E, Friedman J, Maddahi J. Technetium 99m sestamibi in the assessment of chronic coronary artery disease. *Semin Nucl Med* 1991; 21: 190–212.
21. Kumita S, Nishimura T, Uehara T, Shimonagata T. Evaluation of left ventricular function using gated planar myocardial imaging with Tc-99m-MIBI. *KAKU IGAKU (Jpn J Nucl Med)* 1991; 28: 591–597.
22. Smith WH, Watson DD. Technical aspects of myocardial planar imaging with technetium-99m sestamibi. *Am J Cardiol* 1990; 16: 16E–22E.
23. Holman BL, Jones AG, Lister-James J, Davison A, Abrams MJ, Kirshenbaum JM, et al. A new Tc-99m-labeled myocardial imaging agent, hexakis(t-butylisonitrile)-technetium(I) [Tc-99m TBI]: initial experience in the human. *J Nucl Med* 1984; 25: 1350–1355.