

Comparison between Gated SPECT and Echocardiography in Evaluation of Left Ventricular Ejection Fraction.

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ABSTRACT

Gated SPECT myocardial perfusion imaging has become an established routine procedure in almost all nuclear medicine departments. It has many advantages: it allows evaluation of myocardial wall motion, wall thickening, and calculation of left ventricular ejection fraction. This information helps to differentiate attenuation artifacts of breast tissue or diaphragm from true ischemic changes. The degree of wall thickening and increase in count density reflect myocardial viability.

Objective: To test the validity of LVEF by Gated SPECT and correlate it with echocardiographic results.

Methodology: 63 patients (39 males 24 females) were imaged according to the following protocol. Detectors are 90° angle, cardiac leads and gated device activated, 64 x 64 x 16 matrix, 8 slices per cardiac cycle. 16 projections per detector for a total of 32 projections, covering from right anterior oblique to the left posterior oblique. Time of acquisition per projection is 40 seconds. We gated both early and delayed thallium studies. Early images began within 5-10 minutes of dose injection. Gated SPECT study, was usually completed in 20 minutes. The first part of the study was usually finished in less than 40 minutes from the time of injection.

Results: We correlated end diastolic volume, end systolic volume and LVEF calculated from gated thallium SPECT with echocardiography done immediately following thallium study. For gated SPECT, the mean LVEF was 51.4±9, LV EDV of 96±22ml and ESV of 47.3±9ml. These were comparable to Echo result with correlation coefficient of 0.89 for LVEF. Gated SPECT changed the result of the test by 14% (from positive to negative) in 9/63 patients, 7 cases due to diaphragmatic attenuation and 2 due to breast artifact, and increasing the overall accuracy of the test.

Conclusion: Gated SPECT is a good reproducible method to assess LVEF. Correlation of LVEF with 2D Echo is very high (0.89). This proves the validity of GSPECT technique. Since thallium-201 chloride is preferred for myocardial imaging because it is more physiological and one injection is required in the presence of new true digital detectors gamma camera systems.

Key Words: Thallium 201 - Gated SPECT

INTRODUCTION

Left ventricular (LV) function and volumes, along with myocardial perfusion, have major diagnostic and prognostic importance in patients with coronary artery disease [4,11,13,14, 18,20,27]. Myocardial perfusion scintigraphy is a well-established technique for evaluation of myocardial perfusion [16,26,37,38]. Electro - cardiographic gating during the acquisition of SPECT perfusion images has become possible to simultaneously assess LV perfusion, function and volumes. Both ^{99m}Tc and ²⁰¹Tl, the most commonly used tracers for perfusion scintigraphy, can be used for gated SPECT purposes [5, 7,8,9,22, 25,28].

The aim of this study is to test the validity of gated SPECT, using thallium 201 protocol with two-dimensional echocardiography, with respect to determination of LV volumes and LV ejection fraction (EF).

MATERIAL AND METHODS

Sixty three consecutive patients, who underwent both myocardial perfusion SPECT and a two-dimensional echocardiogram, were selected for the study. They included 39 males and 24 females with mean age of 57±8 years. Exclusion criteria were any change in clinical status between acquisition of the gated SPECT and two-dimensional (2D) echocardiographic studies, acute myocardial infarction or unstable angina occurring less than 7 days before the study. Patients with significant arrhythmia that compromised the gating technique were also excluded.

Thallium 201 gated SPECT protocol:

The criteria used in our laboratory for selection of the perfusion agent were the following: ^{201}Tl (111 MBq{3 mCi}) stress 3 hours redistribution was used in all patients. 7(11%) patients underwent pharmacological stress with persantin, 56/63 (89%) with Bruce exercise protocol. Arterial blood pressure and heart rate were measured immediately before the stress, during and in recovery.

Gated myocardial SPECT images were acquired at a 90° configuration dual-head SPECT system equipped with a low-energy, high-resolution collimator. Thirty two projections matrix size 64 x 64 were acquired over a 180° anterior arc, divided into 8 frames per cardiac cycle. Acquisition commenced 6-10 min after injection of ^{201}Tl at (peck stress) and again 3h. later (redistribution images). The acquisition lasted 40 sec. per projection. Raw data were reviewed for each patient to avoid motion artifacts.

Gated Images:

Gated myocardial SPECT images with ^{201}Tl with a matrix size of 64 x 64 pixels were reconstructed using back projection algorithm with Butterworth filter of cutoff frequency 0.42 cycles per pixel (Nyquist frequency) and order 5. The transaxial gated tomography slices were then re-oriented into short, horizontal long axis and vertical long axis views.

The LVEF, end-diastolic volume (EDV) and end-systolic volume (ESV) were assessed with the commercially available automatic "Cedars Quantitative gated SPECT" software (Autoquant)-Cedars Sinai, Los Angeles, CA). The algorithm operates in three-dimensional space. It segments the left ventricle, estimates and displays endocardial and epicardial surfaces for all eight images in the cardiac cycle, calculates the relative LV volumes and drives the LVEF.

The two-dimensional echocardiograms were acquired at rest with standard short axis, apical and parasternal views. LV volumes were derived with the modified Simpson's method (Fig. 1).

Statistical Analysis:

Data are represented as mean±SD or frequency. Correlation between two-dimensional echocardiography and gated SPECT variables after stress and redistribution were assessed.

RESULTS

Sixty-three patients were qualified for the study. Patients' mean age was 57 ± 8 y (range 21-78y), 39 were men and 24 were women. Twenty eight (44%) had a history of myocardial infarction, with only 8 (12%) cases with Q waves in the ECG. 35(66%) were assessed for ischaemic heart disease (IHD). Patients had gated SPECT study after stress-redistribution with two-dimensional echocardiogram done in-between. Thus, a total of 126 gated SPECT studies were available for comparison with two-dimensional echocardiography. Gated SPECT studies were processed with the semiautomatic technique. The time difference between the first gated SPECT acquisition and the echocardiographic study was 42 ± 14 min. The mean heart rates before stress GSPECT and before echocardiography were 74 ± 13 beats/min and 70 ± 13 beats/min. Meanwhile, the mean respective values for systolic blood pressure were 136 ± 26 mm Hg and 136 ± 21 mm Hg. The results of the perfusion part of the SPECT studies are shown in Table (1).

Left Ventricular ejection fraction:

There was significant linear correlation between post-stress gated SPECT studies and the rest echocardiograms with respect to EDV, ESV and LVEF. Pearson's correlation coefficients were $r = 0.85, 0.86$ and 0.89 , respectively (Fig. 2). The LV volumes and EF are shown in table (2). The EDV was larger by two-dimensional echocardiography than by post-stress gated SPECT (102 ± 31 ml versus 96 ± 22 ml), as well as the ESV. The LVEF was also significantly higher by echocardiography ($56\% \pm 5\%$ versus $51\% \pm 9\%$).

Analysis of the 63 patients who had both echocardiograms and gated SPECT after redistribution yielded similar results. There was good correlation between the two techniques with respect to determinations of EDV, ESV and LVEF.

Correlation between post-stress and redistribution gated SPECT studies in all 63 patients with complete available data were excellent for EDV ($r = 0.96$), ESV ($r = 0.94$) and LVEF ($r = 0.94$).

Futher, GSPECT data changed our results from positive to negative study in 9 patients by looking into wall motion and wall thickening

with increase in count density by 30-40%.

These patients were 4 females (2 breast artifacts and 2 diaphragmatic attenuation) and 5 males due to diaphragmatic attenuation.

Table (1): Myocardial perfusion spect data

	No. of Patients	%
<i>Perfusion agent</i>		
201Tl	63	100
<i>Type of stress</i>		
Treadmill Bruce protocol	55	87.4
Persantin	7	11
Modified Bruce	1	1.6
<i>Normal perfusion</i>		
	37	58.7
<i>Abnormal perfusion</i>		
Fixed defect	9	14.2
Reversible defect	17	26.8
<i>Defect vascular territory</i>		
LAD	9/26	34.6
RCA	14/26	53.8
LCX	3/26	11.6

LAD = Left anterior descending coronary artery;
 RCA = right coronary artery; LCX = circumflex coronary artery.

Table (2)

	Stress G - Spect	Echo
LVEF	51.4 ± 9 %	56 ± 5 %
EDV	96 ± 22 ml	102 ± 31ml
ESV	47.3 ± 9 ml	48.7 ± 7 ml

Calculation of LVEF

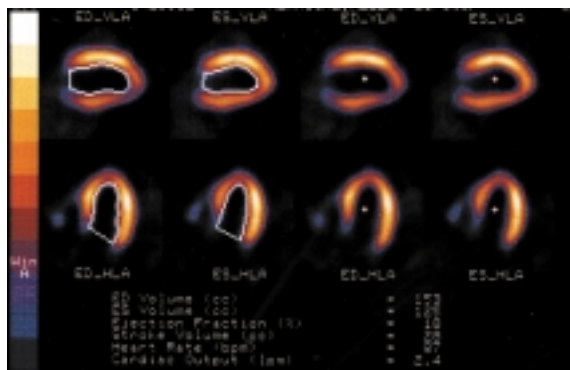


Fig. (1-A): Gated SPECT



Fig. (1-B): Echo Cardiography

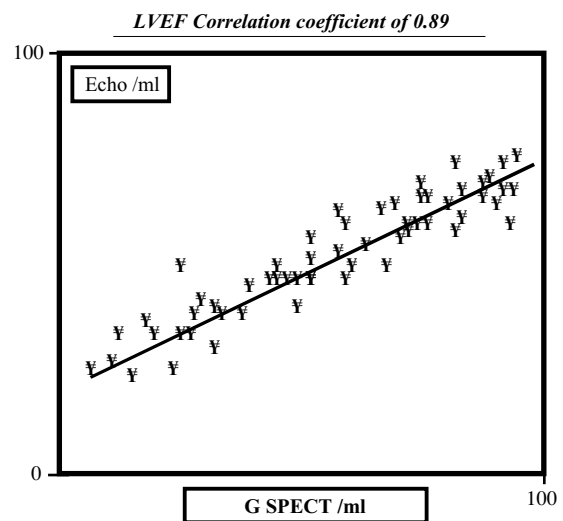


Fig. (2)

DISCUSSION

Assessment of LV volumes and function has major clinical importance in the management of patients with known or suspected coronary artery disease [19,27,30,34,35]. This study examined the performance of automatic quantitative gated SPECT in the evaluation of LV absolute volumes and LVEF using different protocols.

Echocardiography is a well-established and widely used technique for assessment of LV function and volumes, thus we chose this technique to validate our measurements. Others reported good correlation between Tc-99m sestamibi gated SPECT, 201Tl gated SPECT and first - pass radio-nuclide angiography [12]. Other investigators have compared LVEF assessed by gated SPECT and radionuclide angiography [7,8,24,31,33,36] or contrast angiography [21,36]. Good correlations were found among all these methods.

In our study, the correlation between gated SPECT and echocardiography with respect to EDV, ESV and LVEF ranged from good to excellent, whether we used the poststress or redistribution acquisition. Achtert et al. [1], using a digital phantom model, found that quantitative gated SPECT overestimated the true EF by 3-7% when the myocardial tracer activity was normal, and underestimated it by up to 9% when the myocardial tracer activity was very low. The accuracy for determining LV volumes had an average error of 12%. Germano et al. [7], using a phantom model, found that volumes estimated by a quantitative gated SPECT algorithm were within 10% of the true known volume. Recently, a group of investigators [12] observed a good correlation between Tc-99m sestamibi gated SPECT and first-pass radionuclide angiography with respect to estimation of EDV and ESV. Zanger et al. [3] reported an agreement between echocardiography and gated SPECT for determination of LVEF and volumes. Other investigators reported a good correlation between gated SPECT and cardiac MRI for the assessment of LV volumes and EF [17, 21,23,32]. In all these previous studies Tc99m sestamibi was the tracer used. Recently, Germano et al. [8] and He et al. [12] validated the accuracy of gated SPECT for the measurement of LVEF in patients who underwent TI-201 myocardial gated SPECT. In this study, we used TI-201 and the results of absolute volumes and LVEF estimates correlated well with two-dimensional echocardiography. Even in the worst possible scenario, that is gated SPECT performed during TI-201 redistribution, the performance was still good.

Generally, our patients had smaller EDV, ESV and consequently lower LVEF by gated SPECT than by echocardiography

In our study, the correlation between post-stress and redistribution gated SPECT studies for assessment of LV volumes and EF has been excellent. These results are in agreement with other recent studies using either 99mTc - agents [1,6,10,24] or TI-201 [2,12]. Other investigators, however, have demonstrated that gated SPECT performed immediately after exercise may manifest postischemic stunning in some patients [3,15,29].

Reproducibility of Gated SPECT:

The reproducibility of measurements of gat-

ed SPECT after stress and redistribution were excellent. The internal reproducibility of the algorithm was, in fact, nearly perfect. Recently, Berman et al. [3], using the same automatic quantitative gated SPECT algorithm, reported excellent inter-study reproducibility of LV volumes when studies were acquired in two different positions (prone and supine).

The use of only 8 frames per cardiac cycle by necessity reduces the resolution time for calculation of LVEF.

Although using 16 frames per cycle does improve the time resolution, it leads to either fewer counts per frame or prolongation of acquisition. Moreover, an excellent agreement has been found between acquisitions with 8 or 16 frames [7], with slightly lower values for the LVEF calculated from the 8-frame studies (3.7%). In keeping with these observations, we found slightly lower values for LVEF calculated by gated SPECT than by two-dimensional echocardiography.

In patients with small ventricles, the LVEF may be overestimated because of underestimation of volumes, particularly in end-systole, secondary to use of smoothing filters [8]. Typically, these patients have a normal heart but their LVEF may be falsely elevated.

Occasionally, the algorithm may fail to correctly track the LV edges; this occurs when a severe large defect with very low tracer activity is present. Rarely, we have seen the presence of excessive visceral activity to also compromise tracking of the endocardium.

Conclusion:

In conclusion, quantitative gated SPECT, using TI-201 tracer has a good correlation with echocardiography for the measurements of absolute LV volumes and LVEF. This automatic technique is highly reproducible and thus can be used clinically for those measurements, with the added advantage that the ventricular performance parameters are obtained from the perfusion images. Moreover, contrary to echocardiographic techniques used to assess LV volumes and LVEF, which are quite labor intensive and more observer dependent, gated SPECT technique is nearly totally automatic, fast and highly reproducible.

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