



## Evaluation of Left Ventricle Performance in Patients with Ischemic Heart Disease Using Single Photon Emission Computed Tomography (SPECT) in Comparison with Echocardiography

Marrwa K. Mohammed<sup>1</sup>, Satar M. Kadam<sup>2</sup>, Samar I. Essa\*<sup>1</sup>

<sup>1</sup>Department of Physics, College of Science University of Baghdad, Baghdad, Iraq

<sup>2</sup>Surgery Department, College of Medicine, University of Baghdad, Baghdad, Iraq

Received: 10/10/2020

Accepted: 3/2/2021

### Abstract

Background: Ischemic heart disease is a major cause of the diastolic heart failure. Risk of heart failures was increased with microvascular coronary disease, which is characterized by left ventricular stiffness with impaired relaxation and reduced compliance. Aim of this study is to estimate the effect of the severity of myocardium ischemia on the left ventricle ejection fraction and left ventricular volume using SPECT with <sup>99m</sup>Tc MIBI and to compare the results with the echocardiography. The study included 117 subjects with ischemic heart disease were examined using SPECT and echocardiography techniques. The following parameters were measured: left ventricular end systolic volume (LVESV), left ventricular end diastolic volume (LVEDV), and left ventricular ejection fraction (LVEF). Results show that the change difference in EDV between the two technique was (98.79%) with insignificant ( $p > 0.05$ ). While the change in the LVEF% between both groups was (105.40%) with significant ( $p < 0.05$ ). On the other hand, the difference in ESV and EDV/ESV ratio for both groups were (95.52%), and (103.61%) respectively with insignificant ( $p > 0.05$ ). It was concluded that SPECT with <sup>99m</sup>Tc MIBI had a good relation with the echocardiography technique for evaluation of the left ventricular ejection fraction and the left ventricular volumes. The results showed that LVEF was decreased in patients with severe ischemic disease.

**Keywords:** Ischemia severity, SPECT, echocardiography, left ventricular function and volumes.

قياس اداء البطين الايسر في المرضى الذين يعانون من امراض نقص التروية باستخدام طيف التصوير المقطعي المحوسب بانبعث فوتون واحد (SPECT) بالمقارنة مع تخطيط صدى القلب

مروة خالد محمد<sup>1</sup>، ستار مجيد كاظم<sup>2</sup>، سمر عمران عيسى\*<sup>1</sup>

<sup>1</sup> قسم الفيزياء، كلية العلوم، جامعة بغداد

<sup>2</sup> قسم الجراحة، كلية الطب، جامعة بغداد

### الخلاصة

مرض نقص التروية هو سبب رئيسي لفشل القلب الانبساطي. يزداد خطر الإصابة بفشل القلب مع مرض الشريان التاجي الدقيق، والذي يتميز بتصلب البطين الأيسر مع ضعف الاسترخاء وانخفاض المرونة. الهدف من هذه الدراسة هو قياس تأثير شدة نقص تروية عضلة القلب على تقليل جزء المقذوف من البطين الأيسر

باستخدام طيف التصوير المقطعي المحوسب بانبعثات فوتون واحد مع  $^{99m}\text{Tc}$  MIBI ومقارنتها مع تخطيط صدى القلب. تم فحص 117 شخصاً يعانون من مرض نقص تروية القلب باستخدام تقنيات طيف التصوير المقطعي المحوسب بانبعثات فوتون واحد (SPECT) و تخطيط صدى القلب، وتم قياس المعلمات التالية ، حجم البطين الأيسر عند نهاية انقباض عضلة القلب (LVESV) ، وحجم البطين الأيسر عند نهاية انقباض عضلة القلب (LVEDV) ، والجزء المقذوف للبطين الأيسر (LVEF). أظهرت النتائج أن فرق التغير في EDV بين الجهازين كانت (98.79%) مع عدم وجود فروق معنوية احصائياً ، قيمة  $p > 0.05$ . بينما كان التغير في LVEF بين المجموعتين (105.40%) مع وجود فروق معنوية احصائياً  $p < 0.05$ . من ناحية أخرى ، كان الفرق في ESV و النسبة  $\text{EDV} / \text{ESV}$  لكلا المجموعتين (95.52%) و (103.61%) على التوالي مع عدم وجود فروق معنوية احصائياً قيمة  $p > 0.05$ . نستنتج من الدراسة ان SPECT مع  $^{99m}\text{Tc}$  لها علاقة جيدة بتقنية تخطيط صدى القلب لتقييم الجزء المقذوف للبطين الأيسر وأحجام البطين الأيسر. وأظهرت النتائج أن LVEF ينخفض في المرضى الذين يعانون من مرض نقص تروية الشديده.

## Introduction

Heart failure is a complex clinical syndrome caused by cardiovascular disease, resulting from any functional or structural impairment of ventricular ejection or filling of blood. Diastolic heart failure is characterized by abnormal left diastolic function [1].

Left ventricular diastolic function includes left ventricular function during relaxation and filling. The primary mechanisms of diastolic dysfunction are diastolic stiffness, and reduced relaxation. Many factors lead to impairment in diastolic function including hypertrophy, aging, and ischemia. The degree of left ventricular abnormalities permits to evaluate the myocardial performance [2]

Left ventricular ejection fraction (LVEF) was used to measure the left ventricular systolic function and it is helpful in the management of the cardiovascular diseases. LVEF represents the percentage of blood volume ejected in each cardiac cycle . It is calculated from the (end-diastolic volume - end-systolic volumes)/ end-diastolic volume [3].

Recently , multiple diagnostic techniques have been used to measure left ventricular function, perfusion, and volumes including two-dimensional echocardiography, cardiac magnetic resonance imaging (cMRI), and radionuclide ventriculography (RNV) [4].

Single-photon emission computed tomography (SPECT) with  $^{99m}\text{Tc}$  MIBI has become one of the most clinical technique used to assess myocardial perfusion. Several studied have shown that this method is accurate and reproducible for measuring LVEF, regional wall motion and thickening [5].

The aim of this study is to assess the accuracy of SPECT for evaluation of left ventricular end-diastolic volume (EDV), end-systolic volume (ESV) and LVEF compared with echocardiography.

patients and methods

The study consisted of 117 patients (49 females and 68 males), their age range between 25 to 75 year old with mean age of  $48.19 \pm 10.02$ , The study was conducted according to the medical ethics rules. All the patients have given their consent. The study was carried out during the period between December 2019 and July 2020 , at Iraqi German Functional Imaging Clinic/Baghdad, and echocardiography unit at Baghdad Teaching Hospital/ Medical City/ Baghdad.

All patients with coronary artery bypass graft surgery, acute myocardial infarction, arrhythmias, left bundle branch block, and implanted pacemakers were excluded from this study. In this study only ischemia severity patients were chosen whose clinical data were recorded along with history.

A dose of (370 -700) MBq  $^{99m}\text{Tc}$  methoxyisobutyl- isonitrile (MIBI) was given to the patients at least 3 ml of normal saline through the intravenous catheter, and rest SPECT was started (45-75)min following the injection.

Myocardial SPECT images were obtained with a 90° configuration double-head gamma camera (Double-Head Gamma Camera, GE Medical Systems Millennium IPS, model ASM001145, SER . No. 1034 ). A total 64 of projections (step-and shoot mode) thirty two per each detector, matrix size (64 ×64) were acquired over a 180° anterior arc, divided into eight frames/ cardiac cycle. End systolic and diastolic volume, and left ventricular ejection fraction were assessed using available automated software program; Quantitative Gated SPECT (QGS) (XELERIS6200 SOFTWARE), used to estimate three dimensional image.

Echocardiography examination was performed by the use 2-5 MHz probe of (SONOACE X8/ PS 3.1-3.18, 2007, South Korea made supplied by Medicine Company). M-mode recordings with 2 dimensional guided were taken from the standard parasternal, short-axis and apical (four and two chamber views), while end-systole, end-diastole, and LVEF were derived.

#### Statistical analysis

All the results were presented as mean values  $\pm$  standard deviation (SD), and the difference as a percentage. Test for significance was carried out using t test, and p value less than 0.05 was statistically significant. All the results were collected and analyzed using Microsoft Excel 2010.

#### Result

Data of the 117 patients as shown in Table 1.

The results showed change differences between two techniques in EDV and ESV of 98.79% and 95.52% respectively with insignificant ( $p > 0.05$ ). The difference in EF% was 105.40% with a highly statistically significant ( $p < 0.05$ ), while the change difference in EDV/ESV ratio was 103.61% with insignificant ( $p > 0.05$ ), Table 2.

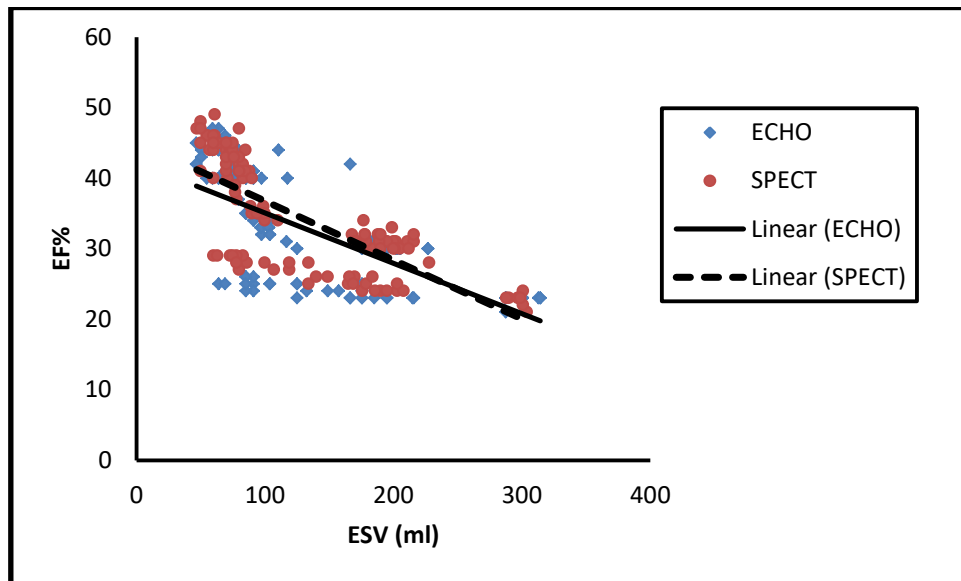
The mean  $\pm$  SD for EDV(ECHO)/EDV(SPECT) and ESV(ECHO)/ESV(SPECT) were  $1.01 \pm 0.06$ , and  $1.06 \pm 0.19$ , respectively, Table 2.

**Table 1**-Characteristics for study population Data expressed as mean  $\pm$  SD and as %

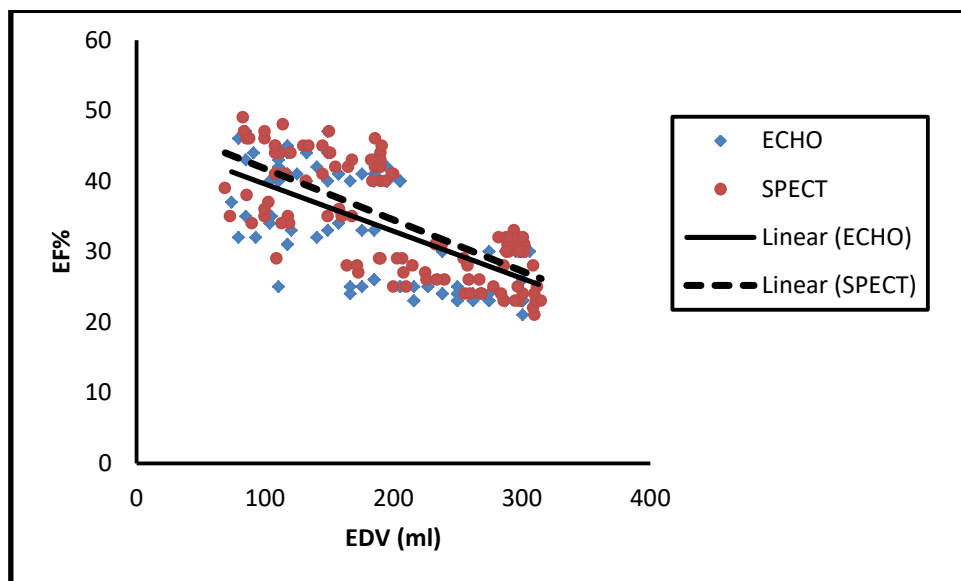
Parameter	Patient
Age (mean $\pm$ SD)	48.19 $\pm$ 10.02
Female	49 ( 41.88%)
Male	68 ( 58.12%)
Height (cm)	164.58 $\pm$ 7.66
Weight( Kg)	77.10 $\pm$ 8.29
Diabetes mellitus	15 (12.82%)
Hypertension	18 (15.38%)
Smoking	10 (8.54%)

**Table 2-**The measured parameters for ESV,EDV, and LVEF using rest SPECT and echocardiography .

Variable	Patient (ECHO) Mean ±SD	Patient (SPECT) Mean ±SD	$\frac{\text{change\% Patient (SPECT)}}{\text{Patient (ECHO)}} \times 100\%$	p-value
LV EDV (ml)	210.82 ± 76.17	208.29 ± 77.85	98.79%	>0.05
LV ESV (ml)	140.43 ± 71.71	134.15 ± 70.56	95.52%	>0.05
EF%	32.17 ± 7.55	33.91 ± 7.72	105.40%	<0.05
EDV/ESV	1.66 ± 0.54	1.72 ± 0.54	103.61%	>0.05
EDV(ECHO)/EDV(SPECT)	1.01 ± 0.06		-	-
ESV(ECHO)/ESV(SPECT)	1.06 ± 0.19		-	-



**Figure 1-**Relationship between ESV ( Rest ) and EF% in ECHO and SPECT.



**Figure 2-** Relationship between EDV ( Rest ) and EF% in ECHO and SPECT.

## Discussion

Coronary arterial stenosis has possibility clinical importance when they produce an imbalance between myocardial oxygen supply and demand. Myocardial oxygen demand depends on the amount of blood oxygen that the heart requires. The balance between myocardial oxygen supply and demand is used to assess the ability of myocardial to contract provides a very useful functional measure of importance of coronary artery lesions [6].

Since flow limiting coronary lesions causes localized dysfunction of the regions of myocardium supplied by the vessel disease. Narrowed coronary arteries that carry sufficient oxygenated blood to supply myocardial demand and permit normal regional and global contractile function may be incapable of permitting of sufficient flow to support normal function during the increased oxygen demands imposed by any myocardial stress [7,8]. Therefore, to complete assessment of the physiologic importance of coronary artery lesions requires some type of intervention that will test the functional reserve capacity of coronary arteries [9].

The results showed that the change in the end systolic volume (ESV), and the end diastolic volume (EDV) appeared on the EDV/ESV ratio in two techniques, in addition to which parameter the change is more related, this may be indicate that the ischemia is related with structural changes, such as arterial dilatation, reduced LV diastolic distensibility, and an increase in the elastic stiffness of the myocardium.

Results also showed that the reduction in EF% may be related to an increase in LVESV rather than an increase in LVEDV, because systolic dysfunction and may associated with an increase in the myocardial oxygen demand to the myocardium to perform an extra work including increased heart beats and increased blood pressure.

The results showed a slight change between echocardiography and SPECT for assessment of LVEF, EDV, and ESV. This study had good agreement with Choragudi et al. [10], they have calculated LVEF using echocardiography and GSPECT, reported showed that the two methods good correlation. Cwajg et al, showed highly significance between echocardiography technique and <sup>99m</sup> sestamibi-gated SPECT [11]. Fatma Berk, et al., showed good correlations between LV volume measurements with gated SPECT and echocardiography [12].

The results also showed that SPECT technique had a good relation with echocardiography for assessment of LV volume and LVEF in patients with ischemic disease.

Echocardiography is a safe, low cost, and easy to use method for evaluation of filling pressures and myocardial viability. We believe that both echocardiography and SPECT techniques complement each other.

SPECT is used as an alternative for patients suffering from poor echocardiographic visualization. Furthermore, SPECT is able to distinguish between ischemic and non-ischemic dilated cardiomyopathy.

The two techniques still show a good relation although some technical limitation in patients suffering perfusion defects.

The gated SPECT technique is quick, mostly automated and highly reproducible, whereas echocardiography techniques that are widely used to evaluate LV volumes and LVEF depend on the operator

## References

- [1] Ichiro, N., Shinro, M., Terue, K., Kenichi, M., Minoru, H. "Left ventricular systolic/diastolic function evaluated by quantitative ECG-gated SPECT: comparison with echocardiography and plasma BNP analysis". *Annals of Nuclear Medicine*, vol. 19, no. 6, pp. 447-454, 2005.
- [2] Nathaniel, D., David, S., Brian, P. S., Harvey, S. H. "Quantitative left ventricular systolic function: from chamber to myocardium". *Crit Care Med.*, vol. 35, no. 8, pp. 330-95, 2007.

- [3] Gregg, C. F., and Jeffrey, J. H. “Left Ventricular Ejection Fraction”. *JAC : Heart failure*, vol. 4, no. 6, pp. 511-3, 2016.
- [4] Hoffmann, R., Bardeleben, S., Folkert ten Cate, F. ten, Borges, A.C., Kasprzak, J., Firschke, C., Lafitte, S., Al-Saadi, N., Kuntz-Hehner, S., Engelhardt, M., Becher, H., Vanoverschelde, J.L. “Assessment of systolic left ventricular function: a multi-centre comparison of cineventriculography, cardiac magnetic resonance imaging, unenhanced and contrast-enhanced echocardiography”. *Eur Heart J.*, vol. 6, pp. 607-16, 2005.
- [5] Fleming, R.M. 2002. A Tête-à-Tête comparison of ejection fraction and regional wall motion abnormalities as measured by echocardiography and gated sestamibi SPECT. *Angiology*, vol. 53, pp. 313-21, 2002.
- [6] Paulo, C. R., Fernando, F. R., Carlos, V. S. , Whady, H. “Clinical significance of chronic myocardial ischemia in coronary artery disease patients”. *J Thorac Dis*, vol. 11, no. 3, pp. 1005-1015, 2019.
- [7] Braunwald, E., Kloner, R.A. “The stunned myocardium: prolonged, postischemic ventricular dysfunction”. *Circulation*, vol. 66, no. 6, pp. 1146-9, 1982.
- [8] Jaume, C.R., Josep, M.C., Javier, E. “Physiologic Evaluation of Coronary Circulation. Role of Invasive and Noninvasive Techniques”. *Rev Esp Cardiol*, vol. 55, no. 3, pp. 271-91, 2002.
- [9] Vijayan, S., Barmby, D. S., Pearson, I.R., Davies, A.G., Wheatcroft, S.B., Sivananthan, M. “Assessing Coronary Blood Flow Physiology in the Cardiac Catheterisation Laboratory” *Curr Cardiol Rev.*, vol. 13, no. 3, pp. 232–243, 2017.
- [10] Choragudi, N.L., Prakash, A.M., Sun, Y., Prasad, P., Chiaramida, S.A., Lucariello, R.J.” Comparison of echocardiography with technetium 99m-gated single photon emission computed tomography as diagnostic tools for left ventricular ejection fraction”. *Echocardiography*, vol. 18, pp. 627-32, 2001.
- [11] Cwajg, E. , Cwajg, J., He, Z.X., Hwang, W.S., Keng, F., Nagueh, S. F., Verani, M. S. “Gated myocardial perfusion tomography for the assessment of left ventricular function and volumes: Comparison with echocardiography”. *J Nucl Med.*, vol. 40, pp.1857–1865, 1999.
- [12] Fatma, B., Serkan, I., Hakan, D., Guliz, K., Dilek, U., Baki, K. “Evaluation of left ventricular function and volume in patients with dilated cardiomyopathy: gated myocardial single-photon emission tomography (SPECT) versus echocardiography”. *Ann Saudi Med.*, vol. 25, no. 3, 2005.