ORIGINAL ARTICLE

Evaluation of Cardiac Output, Stroke Volume and Ejection Fraction (EF) using Nuclear Cardiology

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ABSTRACT

The recognition of different heart disease was frequently scored by nuclear medicine Physician by determining the location and the extend of the disease. The measurement of the heart volume in nuclear medicine is considered one of the most crucial methods of appraisal the myocardial disorders. The aim of this paper was to study the stroke volume of the heart for patient using SPECT machine. For the scanning, the patient were injected by Technetium labeled with Sestamibi and Tetrofosmin (20 mCi) then they scanned for 45 minutes using SPECT with ECG during the examination. The sample of this study were 50 patients. The quantitative analysis included the stroke volume, cardiac output and ejection fraction. The results of the study showed the upsurge in cardiac output 6.3 $\pm$ 1.1 L/min ($p > 0.05$) and ejection fraction 66.8 $\pm$ 8.4 ($p > 0.05$). The stroke volume was decreased with increasing of the both age and body mass index.

Keywords: Nuclear cardiology, Cardiac output, stroke volume (SV), Ejection fraction (EF).

المخلص

التعرف على امراض القلب المختلفة كثيراً ما يسجل من قبل اختصاصي الطب النووي وذلك من خلال تحديد موقع وامتداد المرض. يعتبر قياس حجم القلب باستخدام الطب النووي واحد من أكثر الوسائل الحاسمة لتقييم أضطرابات عضلة القلب. كان الهدف الأساسي للورقة العلمية هو دراسة حجم السكتة القلبية والنتاج القلبي ومعدل قذف الدم للقلب باستخدام ماكينة تصوير الطب النووي. لغرض الفحص تم حقن المريض بالتكنيشيوم الموسم بمادة الاستاميبي والتيروفوزمين ومن بعد ذلك تم فحص المرضى بعد ٥٤ دقيقة باستخدام كلا من جهازي التصوير بالطب النووي وجهار تخطيط القلب. شملت الدراسة عدد ٥٠ مريض. شمل التحليل الكمي للدراسة حجم السكتة القلبية والنتاج القلبي ومعدل قذف الدم. أظهرت النتائج زيادة في النتاج القلبي بمعدل (٦٫٣ + ١٫١) ومعدل قذف الدم (٦٦٫٨ + ٨٫٤). سجل حجم السكتة القلبية انخفاض مع كلا من العمر ومعدل كتلة الجسم.

1. INTRODUCTION

The main function of the heart is preserving adequate flow of blood around the body. It consists of four-chamber pump [1]. Nuclear Cardiology has important role in heart problem diagnosis [2-3]. Gated SPECT Cardiac Quantification (GSCQ) is another method that is based on k-means cluster classification to separate the cardiac region from other extracardiac structures [4]. The myocardial surface boundaries are determined using hybrid count-geometric analysis for the calculation of the LV volumes and EF [5]. The method uses thresholding and the nongated data to determine a cutoff value that serves to separate the LV volume. More refinements and constraints are carried out to remove the small remaining volumes within the image and to accurately define and obtain a clean long axis LV binary image [6]. The long-axis images are resliced to obtain the most apical and basal slices in addition to the myocardial apex. The first apical slice is defined as the first short-axis slice containing the LV cavity, while the position of the last basal slice is defined as the last short-axis slice containing the basal limit of septum plus 10 mm toward the LV base [7]. In 1990s, the myocardial measurement was introduced into the cardiac nuclear applications. This technique was based on quantifying the 3D activity distributions within the heart into 2D polar map or bull's-eye [8]. The polar map is constructed through modelling the myocardium into a cylindrical and spherical coordinate system [9]. Another semiquantitative approach used to quantify tracer uptake is implemented by dividing the myocardium into 20 segments. An ejection fraction (EF) is the portion of blood evicted from simultaneously with cardiac beat. It is valued using the stroke and diastolic volume, and is a characteristic amount of the pumping competence of the heart [10]. Hearts that move actively but don't prosper in ousting more amount of blood are called cardiac failure. Left ventricular ejection fraction (LVEF) is a degree of the competence of impelling blood into the circulatory System, whereas right ventricular ejection fraction (RVEF) is a value of the competence of impelling into the pulmonary flow [11].

2. Materials and Methods

This study conducted to evaluate the Heart Ejection fraction (EF) Using Nuclear Cardiology segmentation. Once the patients referred for scanning, the patients asked to stopover the cardiac treatment drugs for 24 hours previously the study because it reduced the radiotracer approval. Also asked for abstaining until the administration of the radiopharmaceutical, afterward the administration patient have to wait for minutes then eat fatty rich meal in order to excrete of the gall bladder.

This study led in the Nuclear Medicine department of Elnileen Medical Center, Khartoum, Sudan. The study included 50 patients of both genders, who referred for nuclear cardiology assessment due to symptomatic heart complains that recognized by aggressive methods. During the examination patients asked to stop

the medication for one day before the study as well as abstaining afterward night which disturb the radiopharmaceutical material consumption. Then after 20 minutes post-injection patients requested to have fatty mealtime. Then One hour waiting time, patient scanned using SPECT machine with ECG apparatus. Both right and left oblique rest and stress projections were acquired. SPSS program was used for data analysis. The outcomes with $p > 0.05$ considered substantial ones. T-test used to test the significance of the relationships between the variables of the study.

The results:

The sample of this study were 50 patients with age range of 41-70 year (56.2 ± 8.5) $p > 0.05$. In the study, 14% were in 40-45 years, 20% were in 46-50 years, 12% were in 51-55 years, 16% were in 56-60 years, 14% were in 61-65 years and 24% were in 66-70 years. The body mass index (BMI) of the patients in this study were ranged of 14-30 kg/m^2 (56.2 ± 8.5) $p > 0.05$ (Table 1).

Table 1. Age group of the patients

Age group (years)	Percentage (N=50)
40-45	14 (7)
46-50	20(10)
51-55	12(6)
56-60	16(8)
61-65	14(7)
66-70	24(12)

In this study the results of EF showed that 42% of the sample were in range of 50-70 % (EF) and 58 % of the sample were above the 70% (EF) (table 2). The cardiac output were ranged from 4-8 with the mean of 6.3 ± 1.1 ($p > 0.05$). The stroke volume were ranged from 55-100 ml/beat with the mean of 80.2 ± 11.7 ($p > 0.05$) (Table 2).

Table 2. Ejection Fraction results as disturbed in the sample:

Ejection Fraction results	No. of patients (%) N
Above 70%	(42%) 21
% 50-70	(58%) 29
36-49%	-
35% and below	-

Table 3: The predicted lower, upper and mean limits for body mass index (BMI), Cardiac output (L/min), SV (ml/m^2) and EF (%).

Age (years)	BMI				Cardiac Output L/min				SV (ml/m^2)				EF (%)			
	Lower	Mean	Upper	SD	Lower	Mean	Upper	SD	Lower	Mean	Upper	SD	Lower	Mean	Upper	SD
40-45	15	22.6	28	5.0	5.2	6.5	7.7	1.0	66	76.1	88	8.6	55	67	77	8.7
46-50	19	24.1	29	3.7	4	6	7.5	1.3	62	83.4	100	10.7	57	66.7	78	6.7
51-55	14	20.3	30	6.7	4.5	6.5	7.7	1.5	57	75.8	94	12.6	52	62.5	78	9.8
56-60	15	22.3	30	5	4.9	6.4	8	1.2	73	86	99	9.7	64	71.9	80	5.6
61-65	17	19.9	24	2.5	4.7	5.9	7.1	1.0	60	73.7	96	13.9	53	63.0	79	10.2
66-70	16	20.8	27	3.9	4.3	6.4	7.8	1.1	55	80.8	98	11.9	50	68.8	80	8.6

Figure 1. Relationship between cardiac output and EF

Figure 2. Relationship between the Cardiac output and Body mass Index (BMI)

Table 4. Ejection Fraction results of related studies:

Authors	EF (mean + SD)
(Sumito et al (2016	68.5 + 9.7
(Elkader et al (2014	57.12 $\pm$ 8.6
(Yogesh et al (2016	64 $\pm$ 8
Ding et al (2016)	63.05 $\pm$ 1.84
Ogah and Bamgboye	58.9 $\pm$ 13.4

Discussion:

This study highlighted the importance of nuclear cardiology. The use of nuclear cardiology has grown-up progressively, and it contribute with a large number in myocardial diseases. Nuclear Cardiology is has also wider role as well as metabolic imaging, innervation imaging, among other technologies. This make it better than various imaging modalities use in cardiology. Nuclear medicine is beneficial in starting treatment plans in patients with myocardial disorders and CHF by displaying the perfection with pharmacological management. Coronary heart disease is one of the death leading disease in both gender because of many factors such as increased blood pressure, cholesterol consumption and smoking. The nuclear cardiology has recently gained popularity as noninvasive diagnostic tool in evaluation of heart disease. In this study discovered that the percentage of the increased ejection fraction in elderly aged group were more than younger patients, it was 54% in old whereas the younger was 14%. This finding supported by Kim et al (2002), Elkader et al (2014) and Sharief (2015) who found the same results in elderly

patients. On other hand, this study revealed that BMI and cardiac output had correlated in t-test with p = 0.001 (p > 0.05) which is considered extremely statistically significant. This results supported by Cain et al, (2009) and Mathew et al (2008). In general, both SV and EF revealed an increase with age group 56-60 years (Table 3). This results support by Nikitin et al (2006), Cain et al (2009) and Gulati et al (2013). Although differences in cardiac measurements between males and females in this study were (Cardiac output: 5.9 ± 1.1 vs 6.1 ± 1.2 L/min, p = 0.002, SV: 83 ± 12 ml vs. 81 ± 13 ml, p < 0.002; EF: 68 ± 11 vs. 65 ± 12, p = 0.018) correspondingly. This study showed that cardiac output were in normal range which 4-8 L/min (6.3 ± 1.1, p > 0.05). The SV were in normal range which 55-100 ml/beat (80.2 ± 11.7, p > 0.05) (Table 2). Veldhuisen et al (2009) and Anane et al. (2012), supported the results of this study who found that a significant upsurge in the LVEF befallen after treatment. Obesity disturbs the cardiovascular scheme straight in numerous methods, furthermore its unintended effects, and it upsurges disease and death. Several practical difficulties make cardiac studies hard to make and interpret in obese patients. Tentative this obesity prevalent is an essential obstacle that affect the populace health. This results support by many scientist such as Rider et al (2009), Boer et al (2010) and Eltayeb et al (2014). Nuclear Cardiology has exceptional described sensitivity and negative predictive significance in the revealing of heart disease in patients.

Conclusion:

This study had demonstrated a cardiac output, SV and EF of Khartoum population using the invasive nuclear cardiology techniques. Nuclear Cardiology can be used as method of choice in cardiology department as it is cheap and suitable in many centers in Sudan.

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