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Article

The Left ventricular ejection fraction and left ventricular volumes assessed from ^{99m}TC single photon emission tomography technique during stress and rest in relation to age in normal volunteer students.

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ABSTRACT

The heart is subject to structural and functional changes with advancing age. Left ventricular compliance appears to decline with age, which could explain why the elderly have such a high rate of heart failure. Changes in heart function with age are associated with an increased risk of cardiovascular death and morbidity. Various techniques have been used to measure the impact of age on heart structure and function. Subject and methods: The study included 221 healthy adult male and female volunteers (160 females and 61 males, 20–80 years of age). All healthy subjects volunteered to participate in this study. They were classified according to their age. All healthy subjects enrolled in the study underwent myocardial perfusion imaging following the 2-day rest–stress ^{99m}Tc sestamibi (GSPECT) protocol. At rest and during stress, end-diastolic volume, end-systolic volume, and ejection fraction using the GSPECT software were assessed both at rest and during stress for comparison. The following parameters were measured: left ventricular end-systolic volume (LVESV), left ventricular end-diastolic volume (LVEDV), and left ventricular ejection fraction (LVEF). The results show that the change in left ventricular ejection fraction (LVEF) decreased during rest and stress in all age groups. In contrast, the change in left ventricular end-systolic volume (LVESV) increased during stress and rest compared with the left ventricular end-diastolic volume (LVEDV) for all ages. Results show a significant change in EDV, ESV, and EF% (16.49%, 30.35%, -7.49%) with p-value < 0.05 for the groups (20- 49). Also a significant change in EDV, ESV, and EF% (12.13%, 24.86%,-1.62%), respectively, with p-value <0.05. for age range (50-80) years. In conclusion, in people with no cardiac functional or structural problems, the aging process is linked to considerable alterations in left and right ventricular EF, ESV, and EDV. When assessing SPECT with ^{99m}Tc investigations, our findings highlight the need to adopt age-adapted data as a reference standard.

Keywords: SPECT with ^{99m}TC, Age, Hemodynamics, Rest and Stress

INTRODUCTION

The left ventricle diastole function is a complex process that comprises ventricular relaxation and filling. Several factors can lead to reduced left ventricular compliance and impaired left ventricular (LV) diastolic function, including hypertrophy and ischemia. There is much evidence in the literature that fibrosis can cause stiffening of the left ventricle's vasculature as people age [1,2]. The left ventricular ejection fraction is commonly used to determine myocardial contractile performance, systolic function, and the left ventricle capacity to empty. With reduced LVEF, impaired systolic function increases left ventricular end-systolic and end-diastolic volume [3]. Ischemia and hypertrophy are two conditions that can cause impaired left ventricular compliance and impairment in left ventricular diastolic function. There is a lot of evidence in the literature that aging causes the left ventricle's vasculature to stiffen due to the development of fibrosis [4]. This stiffness is involved in the pathogenesis of several common cardiovascular system dysfunctions, such as left ventricular hypertrophy, atrial fibrillation, and heart failure (HF), particularly in the elderly [5]. There is a series of functional changes that the heart of older adults undergoes, which reduces the reserve capacity and reduces the response to increased workload. All factors to consider are end-systolic and diastolic volume, contractility, prolonged systolic contraction, and prolonged diastolic relaxation [6]. Multiple diagnostic tools, such as two- or three-dimensional echocardiography (ECHO), cardiac magnetic resonance imaging (CMSI), radionuclide ventriculography (RNV), computed tomographic angiography (CTA), and gated myocardial perfusion single-photon-emission-tomography, have recently been used to measure left ventricular volumes (LVC) and ejection fraction (EF) (GSPECT) [7]. Global and regional left ventricular function, myocardial perfusion from stress and rest, left ventricular volumes, and wall motion anomalies are all assessed by single-photon-emission computed tomography (SPECT) [8,9]. MIBI (99mTc sestamibi) has greater photon energy, is lipophilic, and depends on the potentials of both the mitochondrial and plasma membranes. The liver has a rapid absorption after injection and a rapid clearance in roughly an hour, with excretion into the small intestine dependent on both mitochondrial and plasma membrane potentials. ^{99m}Tc MIBI has several advantages, including being better suited for gamma camera systems than 99mTc, the "workhorse" isotope for nuclear medicine imaging. Furthermore, it has a significantly more prominent radiation profile with a shorter half-life, allowing higher doses to be supplied and "fixed" in the myocardial after injection, allowing the strict time between injection and imaging to be uncoupled [10,11]. This study aimed to assess the effect of age on the changes in the left ventricular structure and function.

MATERIALS AND METHODS

The study consisted of 221 participants (160 females and 60 males), with an age range between 20 to 80 years old, with a mean age of 54.93 ± 11.97. The study was conducted according to the medical ethics rules. All the participants have given their consent. The study was conducted between December 2019 and February 2021 at Iraqi German Functional Imaging Clinic/Baghdad.

Control individuals' heights and weights were measured. A portable height/length measuring station with a scale was used to determine the height. Portable electronic weighing equipment was used to determine weight. All of the participants in this study received a two-day stress-rest gated SPECT 99mTc MIBI protocol. This began with GSPECT for rest and next with GSPECT for stress the next day. 650–800 MBq 99mTc-sestamibi was given with a 3-5 ml dilution of normal saline on the first day of rest perfusion imaging. After 45-90 minutes of intravenous administration, rest GSPECT acquisition began.

The participant performed a Bruce protocol maximum treadmill stress test 370–700 MBq of 99mTc sestamibi for the second-day stress perfusion imaging protocol, which was delivered in the same manner as the rest protocol for the patients and control subjects. GSPECT pictures of stress were taken starting 15 minutes after injection. GSPECT data for Myocardial rest was collected using a 90° double-head gamma camera (GE Medical Systems Millennium IPS, model ASM001145, SER. No. 1034) with a LEHR collimator. The 20 percent window was used, with an energy peak of 140 keV. For each head, over 1800 arcs were projected from the right anterior oblique to the left posterior oblique view, totaling 32 projections (step-and-shoot mode, 25 sec per view).

Perfusion volumes EDV and ESV were calculated by adding 30 projections every eighth of a cycle, whereas contraction images were calculated by adding eight projections every cycle. With a Zoom factor of 1.33, 32 projections (step-and-shoot mode) were acquired over a 180° circular orbit from 45° right anterior oblique to 45° left posterior oblique views. There was no attenuation or scatter correction applied. The data was saved in a 64×64 matrix on the computer and reconstructed using a Butterworth filter and filtered back-projection with a matrix size of 64×64

Microsoft Office Excel 2013 was used to calculate all of the data. To compare variables between the two age groups, the Student's t-test was utilized. A p-value of less than 0.05 was statistically significant. The mean ± standard deviation (SD) was used to express the data.

RESULTS

Table 1 demonstrates the clinical characteristics of the control group, where the Physical characteristics of the participants were: mean age (39.22 ± 7.10) years, height (163.87 ± 10.59) cm, weight (78.85 ± 8.07) kg, the data, for age range 20-49 years. The characteristics for the age range 50-80 years for participants were: mean age (60.04 ± 8.18) years, height (166.45 ± 6.44) cm, weight (76.81 ±7.86) kg.

Data	Age range from 20 to 49 years **(*n*= 54)**	Age range from 50 to 80 years **(*n*= 167)**
Age in years (mean ± SD)	39.22 ± 7.10	60.04 ± 8.18
Female	74.07% (40/54)	71.85% (120/167)
Male	25.92% (14/54)	28.14% (47/167)
Height (cm)	163.87 ± 10.59	166.45 ± 6.44
Weight(Kg)	78.85 ± 8.07	76.81 ± 7.86
Smoking	-	-

Table 1. Characteristics of the study population

As our work is concerned with the study of age and its influence on many cardiac parameters, including those related to cardiac performance, whether diastolic or systolic, we will start with parameters used to calculate changes in left ventricular volume and ejection fraction.

Table 2 shows that the significant change in left ventricular end-diastolic and systolic volume and ejection fraction was (16.49%,30.35%, and -7.49%) respectively, between (rest and stress), in age ranges (20-49).

The change between (rest and stress) in left ventricular end-diastolic volume, end-systolic volume, and ejection fraction was (12.13%,24.86%, and -1.62%), respectively; the difference percent in both is significant, p-value <0.05, for age range (50-80 years). The relation between ESV (rest and stress) with the EF% was shown in Fig. (1) for age range (20-49) years. In these figures, it can clearly be seen that there is a gap between both curves, i.e., a difference in the EF% between both rest and stress, starting at a low value of ESV. The difference between the slopes of the graphs for both groups stays virtually unchanged with the increase of ESV.

Figure 2 shows the change between EDV (rest and stress) and EF%. It shows that there was almost no change in the slope during rest, with a jump between stress and rest. The EF% curve decreased during rest, and the figure shows that the EF% decreased with an increasing degree of ESV.

Figure 3 shows the change in ESV (rest and stress with EF% for the age range (50–80). The graph shows that there is almost no change in the slope during the rest and a decrease in the graph during the stress.

The graph of EDV (rest and stress) versus EF% started almost from the same point. For the age range between (50 – 80) years, the curve during stress slightly decreases with increasing EDV and becomes higher than the rest, as shown in Figure 4.

Parameter	**Rest**	**Stress**	***Change%**	**p-value**
Age range from 20 to 49 years				
LVEDV (ml)	74.10 ±18.10	86.32 ± 27.045	16.49%	<0.05
LVESV (ml)	27.06 ±11.91	35.27 ±16.14	30.35%	<0.05
EF%	73.94 ±10.00	68.40 ± 9.43	-7.49%	<0.05
Age range from 50 to 80 years				
LVEDV (ml)	72.25 ±27.97	81.02 ±25.25	12.13%	<0.05
LVESV (ml)	29.44 ±13.22	36.76 ±11.026	24.86%	<0.05
EF%	69.05 ±11.12	67.93 ±9.69	-1.62%	<0.05

$$Change\% = \frac{stress-rest}{rest} \times 100$$

Table 2. The LVEDV index, LVESV and LVEF measured using SPECT in the control group. Data are expressed as mean ±SD and as percentage.

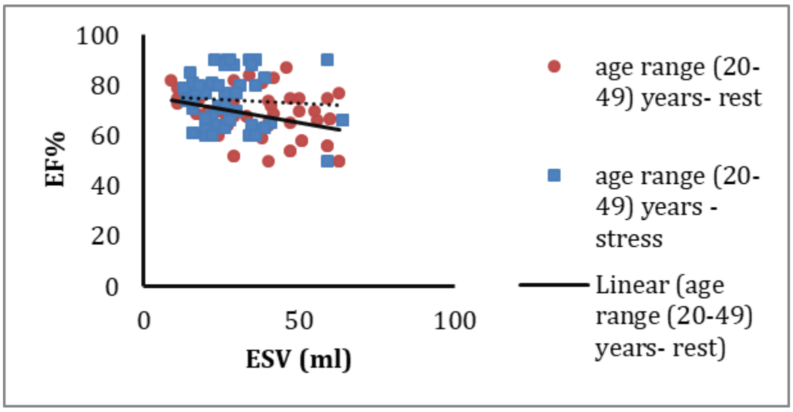

Figure 1. Relationship between ESV (Rest, stress) and EF%.

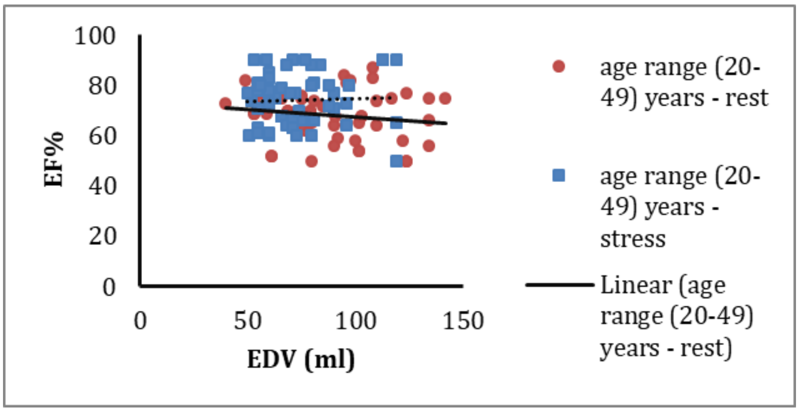

Figure 2. Relationship between EDV (Rest, stress) and EF%.

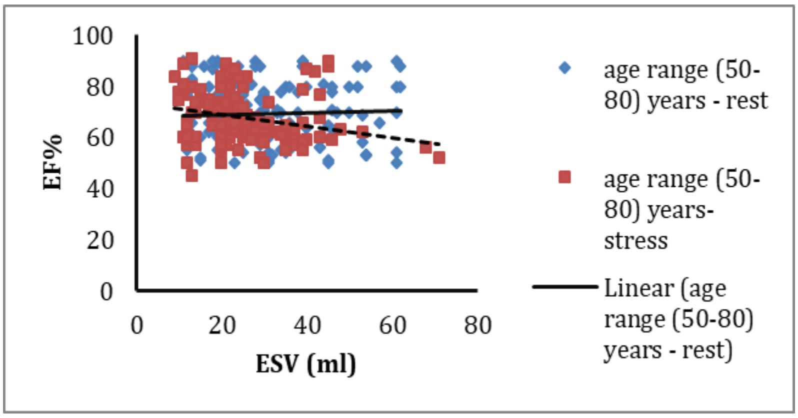

Figure 3. Relationship between ESV (Rest, stress) and EF%.

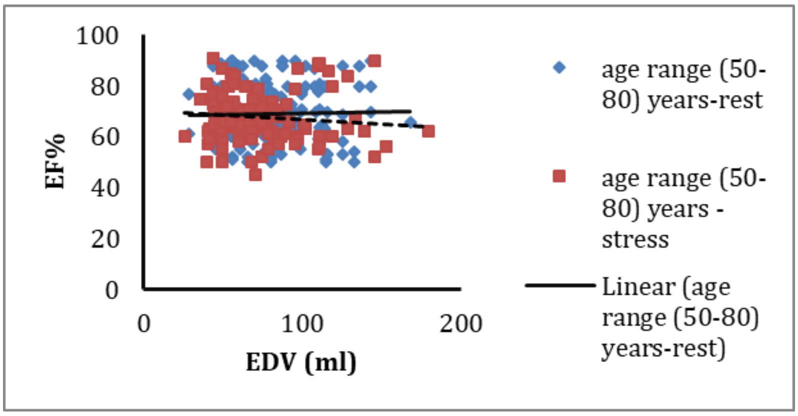

Figure 4. Relationship between EDV (Rest, stress) and EF%.

DISCUSSION

Cardiovascular disease (CVD), one cause of death worldwide, is associated with age. The main cause of CVD is increased hardening of the arterial wall and loss of compliance, called atherosclerosis. The ability of an artery to expand and contract in response to pressure changes inside the artery is known as arterial compliance [12]. Equilibrium radionuclide has significant benefits over other methods because the technique is not based on geometric assumptions, and the imaging agent has no intrinsic influence on the circulatory system; the effects of rest and exercise on the left ventricle were compared using a newly developed SPECT with ^{99m}TC that yields measures of end-diastolic and end-systolic volumes [13]. In this study, volunteers were divided into two groups according to age (20–80 years old). Hypertensive volunteers were excluded. The results of the present study showed that aging is associated with considerable changes in central cardiovascular function during exercise. During stress, myocardial contractility was increased in young subjects, while in older subjects, the end-diastolic volume increased. Furthermore, these findings reveal a considerable variation in left ventricular exercise response between the two age groups. The present results show that the increase in ESV is higher than the increase in EDV. This change may be due to increased myocardial stiffness and has also been described as impaired LV compliance and distensibility with aging [14]. The increase in the ESV corresponds to a decrease in the ejection fraction, indicating that the more the dilatation. The data indicate that the effect of myocardium weakness is more apparent during systole than in diastole since systolic stroke needs muscle strength for the heart to pump blood to the different parts of the body. When the patient exercises and the heart is under stress, the results show a modest decrease in EF % in the age range (50-80) years. This could be related to the myocardium's higher oxygen requirement. The findings of this study revealed that the myocardium has to put in more effort by pumping more vigorously, accompanied by faster heartbeats and higher blood pressure. As a result, the heart must expend more energy to meet its need as a pump to circulate blood throughout the body. As a result, the heart needs more oxygen to function properly. On the other hand, a lack of oxygen may limit the myocardium's ability to operate efficiently, resulting in a somewhat reduced EF. These findings are in complete agreement with those of other researchers [15]. The present results are in total agreement with Mor-Avi et al. found that the LV ejection changed with age, with late ventricular contraction playing a larger role in ejection [16].

CONCLUSION

In people with no cardiac functional or structural problems, the aging process is linked to considerable alterations in left and right ventricular EF, ESV, and EDV. When assessing SPECT with ^{99m}Tc investigations, our findings highlight the need to adopt age-adapted data as a standard of reference.

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