

Echocardiographic assessment of left ventricular function in centenarians

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Acronyms

DM: diabetes mellitus

DT: deceleration time

ESV: end-systolic volume

EDV: end-diastolic volume

HT: hypertension

IVS: interventricular septum

LVH: left ventricular hypertrophy

LV: left ventricle

LA: left atrium

LVDD: LV diastolic diameter

LVSD: LV systolic diameter

LVEDV: LV end-diastolic volume

LVEF: LV ejection fraction

PW: posterior wall

RPT: relative parietal thickness

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ABSTRACT

Introduction: Population aging is a global phenomenon and an achievement of mankind.

Objective: To characterize left ventricular function by echocardiography in ambulatory patients over 100 years old in Plaza de la Revolution Municipality, between September 2009 and September 2010.

Method: A descriptive cross-sectional study was carried out with 20 long-lived people, in the Department of Echocardiography of General Calixto García University Hospital, to whom echocardiography was performed to assess left ventricular function.

Results: The mean age was 102 years old, females were predominant with 15 patients (75%) and 50% had white skin color. The most prevalent coronary risk factor was hypertension (40%); diabetes mellitus type 2, dyslipidemia, and smoking followed in this order. Centenarians had preserved systolic function of the left ventricle (90%) with little tendency to supernormality, one patient had segmental contractility disorders in the underside, which corresponded to a history of myocardial infarction. Four centenarians had normal filling pattern, 11 had impaired ventricular relaxation and five pseudonormal patterns.

Conclusions: In the centenarians studied, the left ventricular systolic function as assessed by echocardiography is maintained within normal parameters, with signs of mild diastolic dysfunction.

Key words: Centenarians, Echocardiography, Risk factors, Left ventricular function

Evaluación ecocardiográfica de la función ventricular izquierda en centenarios

RESUMEN

Introducción: El envejecimiento poblacional es un fenómeno mundial y constituye un logro de la humanidad.

Objetivo: Caracterizar ecocardiográficamente la función ventricular izquierda de pacientes ambulatorios mayores de 100 años del municipio Plaza de la Revolución, en el período de septiembre del 2009 a septiembre del 2010.

Método: Se realizó un estudio descriptivo de corte transversal con 20 longevos, en el Departamento de Ecocardiografía del Hospital Universitario "General Calixto García", a los cuáles se les realizó ecocardiograma para evaluar la función ventricular izquierda.

Resultados: La edad media fue de 102 años, predominó el sexo femenino con 15 pacientes (75 %) y el 50 % tenía color de piel blanco. El factor de riesgo coronario de mayor prevalencia fue la hipertensión arterial (40 %); la diabetes mellitus tipo 2, el tabaquismo y la dislipidemia le sucedieron en orden. Los centenarios tenían conservada la función sistólica del ventrículo izquierdo (90 %) con poca tendencia a la supernormalidad, una paciente presentó trastornos segmentarios de la contractilidad en cara inferior, lo que correspondía a antecedentes de infarto de miocardio. Cuatro centenarios tenían patrón de llenado normal, 11 presentaron alteración de la relajación ventricular y cinco patrones pseudonormales.

Conclusiones: En los centenarios estudiados se mantiene una función sistólica del ventrículo izquierdo evaluada por ecocardiografía, dentro de parámetros normales, con signos de disfunción diastólica leve.

Palabras clave: Centenarios, Ecocardiografía, Factores de riesgo, Función ventricular izquierda

INTRODUCTION

Population aging is a global phenomenon and an achievement of mankind, but societies must be prepared to face it successfully, and this problem can only be achieved with the integration of all levels of care for the elderly.

According to data of the United Nations, in 1950 there were 200 million people over 60 years old in the world, in 1975 it increased to 350 million; in 2000 it was 590 million and it is estimated that by 2025 there will be 1,100 million elderly people on the planet, which constitute 13.7% of the world population¹.

At the beginning of the XXI century, the "Region of the Americas" had about 2,228,900 people of 90 years or more, of which 90,400 were centenarians. By mid-century, these figures will have risen to about 13,903,000 and 689,000, respectively².

The maximum allowed life expectancy generally ranges in the 125 years for women and less for men. The subgroup of centenarians worldwide, the so-called "old old" is growing at a relatively faster way and is expected to increase from 57,000 people in 1996 to 447,000 in 2040^{3,4}.

In Cuba, 80 % of people die after 60 years. Records show a rate of 16.6 % –aging above 12 % is considered high–, representing more than 1.9 million elderly people, therefore it is stated there is an increase of the so-called "old, old" according to official figures. In Havana, until 2010, there were 289 centenarians, including 14 super centenarians (105 years or more), the

oldest with 125 years. Of the total, 77.7 % were females⁵.

The aging of the cardiovascular system is associated with characteristic changes at the biochemical, histological and morphological level. At a vascular level, there is an increase in the rigidity of the arterial wall, with increased speed of the pulse wave, endothelial dysfunction and impaired vasodilation mediated by β -adrenergic stimulation. At rest, the cardiovascular system is able to develop efficient adaptive mechanisms, but in times of stress such as exercise, the changes associated with aging are evident. Therefore, the elderly must maximize the Frank-Starling mechanism to keep cardiac output⁶.

Echocardiography provides information regarding cardiac structure and function, allows accurate quantification of the dimensions, atrial and ventricular volumes, and intracardiac velocities, from which systolic and diastolic parameters are measured⁷.

Researches on cardiac function in centenarians are rare and there are fewer than a dozen groups working on them around the world. In Cuba, even though this population has greatly increased, no studies provide information on the characteristics of the heart in centenary adults regarding left ventricular function parameters.

The aim of this study is to characterize left ventricular function by echocardiography in ambulatory patients over 100 years old in Plaza de la Revolution Municipality, between September 2009 and Septem-

ber 2010.

METHOD

A descriptive, cross-sectional study was performed with 20 long-lived ambulatory patients, in Plaza de la Revolution Municipality, in the Department of Echocardiography of General Calixto García University Hospital, between September 2009 and September 2010.

Registry of patients yielded the following information: name, address, age, sex, coronary risk factors and personal medical history.

Echocardiogram

A transthoracic Doppler echocardiography was performed with an Aloka ALPHA 10 Prosound Premier and with a 2.5 MHz transducer. With the patient in left lateral decubitus, images in parasternal and apical view were obtained from 2 and 4 chambers with simultaneous electrocardiogram recording. End-diastolic volume (EDV) and end-systolic volume (ESV) of the left ventricle (LV) were measured using the modified Simpson's method, for that purpose the synchronization of the equipment, with the peak of the R wave of electrocardiogram (EDV) and the T end of the time from the R wave to the closure of the aortic valve in M-mode (ESV), was used. The volume and ejection fraction were calculated by formulas incorporated into the computer using a software, and the values obtained in 3 beats were averaged⁸⁻¹¹.

Variables

To assess regional contractility the anatomical M-mode technique was used, where temporal changes of wall thickening were recorded, aided by two-dimensional images, and the various tomographic planes of the image through the 17-segment model proposed by the American Society of Echocardiography, where Normal = 1, hypokinesia = 2, akinesia = 3; dyskinesia = 4 and aneurysm = 5. Regional wall motion score index was calculated, scores for each segment of movement were added and divided by the number of visualized segments⁸⁻¹¹.

LV morphology was analyzed by ventricular mass index (VMI) and relative parietal thickness (RPT) obtained by the formula $RPT = 2 \left[\frac{\text{diastolic thickness of the posterior wall}}{\text{LV diastolic diameter}} \right]$. Left ventricular hypertrophy (LVH) was considered when the VMI was greater than 134 g/m² in men and 110 g/m² in women, normal RPT ≤ 0.44 . According to these

values, patients were classified into four types: type I (normal LV: Normal VMI and normal RPT), type II (concentric remodeling: normal VMI and RPT > 0.44), type III (concentric hypertrophy: LVH and RPT > 0.44) and type IV (eccentric hypertrophy: LVH and RPT ≤ 0.44)⁸.

The assessment of LV diastolic function was performed by pulsed Doppler patterns of transmitral flow, the annular tissue Doppler and left atrium (LA) volume¹².

To minimize measurement variations with the respiratory cycles, the samples were taken in expiratory apnea, and an average of 3 consecutive beats was taken. LA study was performed in apical view of 4 and 2 chambers, with increased LA and image adjustment for good edge definition. Manually, using the modified Simpson's method and excluding left atrial appendage and pulmonary veins measurements, the endocardial border from the LA was drawn and its volume was obtained, which was indexed by dividing it between the m² of body surface. As normal cutoff value < 34ml/m²¹²⁻¹⁴ was used.

Statistical analysis

Quantitative variables were expressed in mean values and standard deviation, and qualitative or categorical variables in absolute and relative frequencies. Statistical analysis was performed with SPSS version 16.

Ethical aspects

Participants were told what the research was all about and that its essential purpose would be purely scientific, and their informed consent and that of their families to participate voluntarily was asked. This was done with all the ethical and methodological rigor, by respecting all opinions or individual criteria and the four basic ethical principles.

RESULTS

During the period studied, there were 20 centenarian patients in the municipality of Plaza de la Revolution. **Figure 1** shows their distribution by sex. Half of them were white patients.

Hypertension (HT) was the risk factor (**Figure 2**) which represented the highest percentage of the sample (40%), followed by diabetes mellitus (DM) with 30%, a history of quitting smoking (15%) and dyslipidemia (10%). It is important to note that 40% of subjects had no cardiovascular risk factors and none of

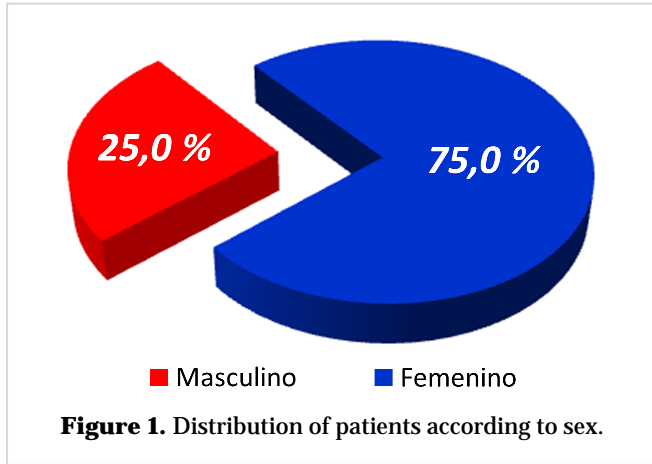


Figure 1. Distribution of patients according to sex.

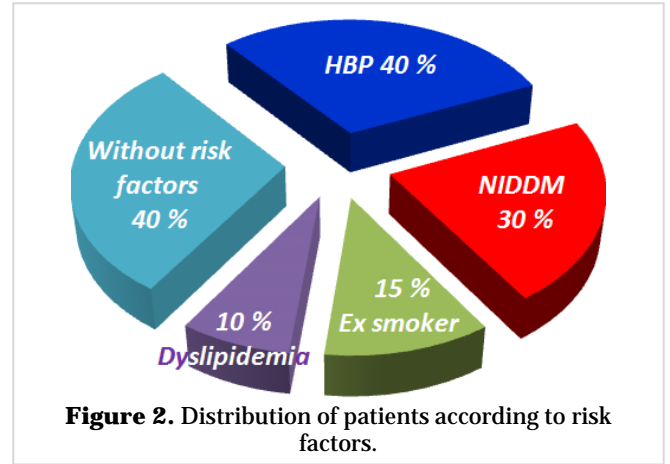


Figure 2. Distribution of patients according to risk factors.

them were obese.

Table 1 shows the distribution of centenarians, according to echocardiographic variables of LV systolic function. The interventricular septum (IVS) had a mean of 11.4 ± 1.82 mm, and the posterior wall (PW) 10.1 ± 1.86 mm. The mean of left ventricular diastolic diameter (LVDD) was 40.9 mm and systolic diameter (LVSD), 26.9 ± 5.92 mm. Left ventricular end-diastolic volume (LVEDV) was 42.5 ± 13.96 ml and ejection fraction (LVEF) values, calculated using Teich and modified Simpson's methods, were 62.1 ± 7.05 and $61.4 \pm 8.58\%$, respectively.

Four patients (20.0 %) showed LVEF considered supernormal (LVEF > 75 %) calculated using the modified Simpson's method (Table 2). This parameter was decreased in only one individual of the series (5.0%) and the remaining 15 (75.0 %) had normal LVEF.

The distribution of centenarians according to LV geometric patterns (LVGP) showed that, in the study sample (Table 3) 85.0 % had LVH, concentric type 10 patients (50.0 %) and eccentric 7 (35 %), also only one patient (5.0%) was considered normal.

The distribution of centenarians, according to echocardiographic variables of LV dias-

tolic function is shown in Table 4. As for the values of mitral transvalvular flowchart, E wave mean was 78.4 ± 29.12 cm/s and A wave 99.0 ± 19.28 cm/s, hence the mean E/A ratio was 0.8 ± 0.27 cm/s. The deceleration time (DT) of E wave was 170 ± 8.70 ms, which allowed categorizing diastolic function values in grades 1, 2, 3 and 4.

On the lateral annulus, the mean E' wave velocity was 8.5 ± 2.78 cm/s and A' wave was 11.1 ± 3.31 cm/s. Meanwhile, the E'/A' ratio had a mean of 0.8 ± 0.39 and the mean E/E' ratio was 9.9 ± 4.54 .

Table 5 shows the distribution of centenarians, according to LA indexed volume and LV diastolic func-

Table 1. Distribution of centenarians, according to echocardiographic variables of LV systolic function.

Variables	Mean	DE	Minimum	Maximum	Reference values
IVS (mm)	11,4	1,82	8	15	8-12
PW (mm)	10,1	1,86	7	13	8-12
LVDD (mm)	40,9	6,66	28	50	39-53
LVSD (mm)	26,9	5,92	19	36	variable
LVEF Teich(%)	62,1	7,05	48,7	74,5	≥ 55
LVEDV (ml)	42,5	13,96	26	74	56-104
LVESV (ml)	16,4	8,30	6	34	19-49
LVEF Simpson(%)	61,4	8,58	46,6	79,5	≥ 55
LV mass (g)	192	53,72	78	286	131
Relative wall thickness (mm)	0,52	0,13	0,36	0,84	< 0,45

Source: Spreadsheet of the echocardiographic study.

Table 2. Distribution of centenarians, according LVEF modified Simpson's method.

LVEF Simpson	Nº	%
Slight decrease	1	5,0
Normal	15	75,0
Supernormal	4	20,0
Total	20	100

Table 3. Distribution of centenarians according to LVGP.

LVGP	Nº	%
Concentric hypertrophy	10	50,0
Eccentric hypertrophy	7	35,0
Concentric remodeling	2	10,0
Normal	1	5,0
Total	20	100

tion. 75.0 % of them had a lower LA indexed volume of 34 ml/m² and only 4 of the subjects studied (20 %) had a normal diastolic function pattern. Grade I diastolic dysfunction was demonstrated in 11 patients (55.0 %), and grade II in 5 (25.0 %). There were no centenarians with grade III-IV diastolic dysfunction.

Table 4. Distribution of centenarians according to echocardiographic variables of LV diastolic function.

Echocardiographic variables	Mean	DE	Maximum	Minimum	Reference values in > 60 years	
Transvalvular mitral flowchart	E	78,4	29,12	140,1	39	71 ± 11 cm/s
	A	99,0	19,28	142	61	138 ± 19 cm/s
	E/A	0,800	0,271	1,251	0,531	0.96 ± 0.18
	DT	170	8.70	337	120	200 ± 29 ms
Lateral annulus	E'	8,5	2,78	15,1	4,7	12.9 ± 3.5 cm/s
	A'	11,1	3,31	18	5	-
	E'/A'	0,8	0,39	1,79	0,5	0.9 ± 0.4
	E/E'	9,9	4,54	20	4,34	< 10
LA indexed volume	26,1	13,13	59,0	9,0	22 ± 6ml/m ²	

Table 5. Distribution of centenarians according to LA indexed volume and LV diastolic function.

LA volume and LV diastolic function	Nº	%
LA indexed volume		
< 34 ml/m ²	15	75,0
> 34 ml/m ²	5	25,0
LV diastolic function		
Normal	4	20,0
Grade I dysfunction	11	55,0
Grade II dysfunction	5	25,0
Grade III and IV dysfunction	0	-
Total	20	100%

DISCUSSION

In recent decades there has been a decrease in cardiovascular mortality rates for all age groups, less marked in elderly patients and proportionally larger in women, which has contributed to an increase in life expectancy¹⁵.

Male gender presents greater cardiovascular complications, mainly due to excess male mortality and greater longevity of women, explained from a genetic point of view^{16,17}. Data from the National Bureau of Statistics in Plaza de la Revolucion in 2010 show that

the female population at that time was 82, 138 while that of men was 70, 180, for a 54% of females, little more than half of the population^{18, 19}.

The incidence of hypertension increases with age and is associated with an increased risk of atherosclerotic disease. It behaves as an independent cardiovascular risk

factor, which means there is a linear relationship between the values of systolic and diastolic blood pressures, and cardiovascular morbidity and mortality. The risk is higher in elderly than in youths and adults, especially for systolic hypertension²⁰.

According to the Framingham study²¹, 60-65% of all elderly hypertensives have isolated systolic hypertension, which is more common in females, and this is consistent with our results.

It has been stated that DM is a negative indicator of longevity in relation to the high rate of sclerodegenerative vascular complications it favors. Diabetes in centenarians usually appears after age 90 (senile DM), with no significant clinical manifestations and its control is much easier than for people with diabetes with onset at younger ages, mainly for those that start with elevated glycemia before 60 years of age²².

On the other hand, it is suggested that the progression of atherosclerotic vascular damage occurs after 10 years of suffering from the disease, and then degenerative diseases that increase cardiovascular morbidity and mortality appear, which explains the reason for the survival of senile diabetics in so advanced ages of life²³.

The Framingham study showed that DM is a powerful contributor to atherosclerotic disease and particularly to ischemic heart disease. In all age groups the incidence of cardiovascular disease is almost 2-3 times higher in men and women with diabetes. This impact decreases somewhat with age, suggesting that late-onset DM is less atherogenic; and this may explain, in this context, why centenarians in our sample have had a higher life expectancy²¹.

Smoking may increase mortality from cardiovascular disease up to 3 times. Cessation of this habit causes a risk reduction proportional to the time of quitting, and equals the risk of a nonsmoker after 10-15 years¹⁵.

The IMUSCE²⁴ trial, conducted in Italy in 2000, revealed a very small incidence of smokers (1.44 %) and former smokers (9.93 %) among 483 centenarians studied, these results are consistent with ours and show the favorable influence of smoking cessation on aging.

Reports based on data from the Framingham²⁵ study showed that total cholesterol is associated with increased mortality from all causes, until approximately 60 years of age, and an increase in mortality from ischemic heart disease up to 80 years of age,

although in both cases the association has dimmed in the last decades. These results confirm the importance of the care provided for people who reach an old age in relation to modifiable risk factors.

LVH has been incorporated into clinical practice as a risk marker for cardiovascular disease²⁶. Its presence is clinically important because it is associated with an increased incidence of heart failure, ventricular arrhythmias, death from myocardial infarction, decreased LVEF, sudden cardiac death, aortic root dilatation and cerebrovascular events²⁷.

Unlike the ECG criteria, echocardiography allows direct measurement of walls thickness and ventricular diameters and thus, calculation of left ventricular mass, which is the parameter that determines the presence of LVH²⁸. However, it is noticeable that in spite of that they have reached such extreme ages, if the association of the latter with the risk of cardiovascular disease is considered. Tovillas-Morán et al.²⁸, in a representative cohort of hypertensives from the general hypertensive population in the primary care setting in Spain, found no association between LVGP and the incidence of cardiovascular disease.

LVEF was measured by two methods, however the modified Simpson's was chosen because the comparisons of both methods, when using angiography as a reference, have favored it; hence it is the most frequently used in daily clinical practice²⁹.

In a study with patients over 100 years, made by Sadiq et al.³⁰, echocardiographic parameters and LV systolic function were found normal, tending to be supernormal, as in our series.

Zapata et al.¹³, in their study of 60 hypertensive patients without heart failure; measured LA volume and found a decrease in the parameters of atrial function in hypertensive patients without heart failure, with slight increments of atrial volume; however, the behavior of LA indexed volume has not been studied in the centenarian population, so there are no reference works that reflect normal values for these subjects. It is noteworthy that despite evidence from previous works in adults over 60 years, in which a LA increase with age has been detected, primarily in males; in our series atrial volumes remain within the normal range. Values above 34 ml/m² are associated with adverse cardiovascular events. This phenomenon may be related to the increased survival these patients have had.

The integration method of transvalvular mitral

flowchart, Doppler tissue imaging and LA indexed volume, allow defining LV diastolic function with greater reliability and accuracy¹².

Few studies describe the frequency of LV diastolic dysfunction of the impaired relaxation type in the elderly population. The study performed by Sytkowsky et al.³¹ demonstrated that 87 % of individuals between 70 and 87, selected as healthy, exhibited an E/A < 1 ratio, which is a diastolic dysfunction criterion, of the impaired relaxation type, recommended by the American Society of Echocardiography¹². Later, in a research with 288 normal subjects between 20 and 80 years, a gradual reduction of E wave and increase of A wave with aging was demonstrated, since in most of them waves became equal in the sixth decade of life³². If this observation is taken as a basis, an E/A ratio between 0.75 and 1.5 is assumed as a criterion of normality in the population aged over 50 years; however, the deceleration time suffers less variation with advancing age and is considered normal when it is less than 240 ms³².

In our study, the prolonged relaxation pattern of LV, which is grade I of diastolic dysfunction, was the main echocardiographic finding, which is consistent with a study performed in Cuba in patients with various degrees of hypertension, where a prevalence of 73 % was found³³.

Sánchez et al.³⁴, in a study of 205 patients admitted during the year 2008, found that those over 90 years old, had impaired diastolic function, primarily by impaired relaxation, for a 39.4%. In the other age groups, normal records were observed in 41 of the 172 patients aged between 60 and 90 years.

CONCLUSIONS

In the centenarians studied the left ventricular systolic function, as assessed by echocardiography, is maintained within normal parameters, with signs of mild diastolic dysfunction.

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