Echocardiography Evaluations for Asymptomatic Patients with Severe Obesity

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Objective: To study the systolic and diastolic function of asymptomatic patients with severe obesity using a Doppler echocardiography.

Methods: Thirty candidates for bariatric surgery, with an average BMI of 49.2 ± 8.8 Kg/m2 and no previous history of heart disease were evaluated through transthoracic echocardiography.

Results: Enlarged left chambers were observed in 42.9% of the sample, diastolic dysfunction in 54.6% and left ventricular hypertrophy in 82.1%, of which 50% of the cases presented the geometric pattern of eccentric hypertrophy. Indexation of left ventricular mass to height resulted in a significantly higher number of diagnoses for hypertrophy than indexation to body surface area ($p = 0.0053$), demonstrating that this index is more appropriate to determine ventricular hypertrophy in obese people. Correlations between left ventricular hypertrophy with obesity duration and pressure levels were positive as well as correlations between body mass index and diastolic dysfunction indicators.

Conclusion: This study demonstrated that echocardiograms performed on asymptomatic severely obese patients can detect alterations in the cardiac structure that are common in cases of obesity cardiomyopathy and can be associated with the development of heart failure, arrhythmias and sudden death, enabling the identification of patients with greater cardiovascular risk.

Key words: Left ventricular hypertrophy, obesity cardiomyopathy, severe obesity, echocardiography.

Severe obesity is defined as a body mass index (BMI) ≥ 40Kg/m^2. It is a condition that can cause left ventricular dysfunction, even in the absence of structural heart disease or systemic hypertension[1-3]. Hemodynamic adaptations are required to support the intense adipose tissue metabolism and increased oxygen consumption.

Physiopathological alterations associated with severe obesity can virtually compromise all body systems and can hinder clinical diagnosis, making the process much more difficult[4]. Cardiovascular semiology, in conjunction with more precise diagnostic methods, can identify apparently healthy, high risk patients for cardiovascular events who have structural cardiac alterations that could lead to life threatening situations or the development of incapacitating diseases[5].

In severe obesity, cardiac output is elevated due to the increased blood volume causing a chronically elevated pre-load condition which in turn increases ventricle size, wall stress and left ventricular mass, leading to the development of eccentric ventricular hypertrophy (EVH)[6-9].

The objective of the present study is to describe the morphological and functional characteristics of the left ventricle (LV) in severely obese patients, found during an echocardiography and to analyze the risk factors associated with the development of EVH.

Methods

Thirty male and female candidates for bariatric surgery were evaluated using a transthoracic echocardiography, by a single observer, as part of a cross sectional study. Patients with an inadequate acoustic window were excluded in the analysis. The study protocol also included an evaluation of obesity duration and cardiovascular risk factors such as systemic hypertension, diabetes mellitus, dyslipidemia, smoking and the presence of metabolic syndrome.

Anthropometric data (weight, height and abdominal circumference) were evaluated during the examination to obtain the body mass index[10] (BMI: weight in Kg / height squared) and body surface area[11] [BSA: $0.0001 \times 71.84 \times (\text{weight in Kg})^{0.425} \times (\text{height in cm})^{0.725}$]. Blood pressure measurements were conducted in accordance with the recommendations of the Sociedade Brasileira de Hipertensão[12] (Brazilian Hypertension Society) using the appropriate size cuff in relation to arm circumference. Systemic hypertension was defined as systolic pressure ≥ 140mmHg and/or diastolic pressure ≥ 90mmHg or by the use of anti-hypertensive medication. Diabetes mellitus was defined according to the Consenso Nacional sobre Diabetes, 2000[13] (Brazilian Diabetes Consensus, 2000). Dyslipidemia was defined according to the laboratory classification proposed by the III Diretrizes Brasileiras sobre Dislipidemias, 2000[14] (Brazilian Dyslipidemia Guidelines

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Third Edition, 2000). LDL cholesterol was calculated using the Friedewald formula[14] (LDL = total cholesterol – HDL cholesterol – TG/5; valid if TG < 400mg/dl).

Patients who reported during the interview that they currently smoked and had smoked more than 100 cigarettes in their lifetime were classified as smokers[15]. Obesity duration was obtained from the patient's medical history and confirmed by medical records, when available. Obesity duration, in years, was calculated using the patient's current age minus the onset age. The presence of metabolic syndrome was defined according to the diagnostic criteria of NCEP ATPIII[16], which includes the presence of at least three of the following five criteria: abdominal circumference >102cm for men and >88cm for women; fasting glucose >110mg/dl; triglycerides >150mg/dl; HDL cholesterol <40mg/dl in men and <50mg/dl in women; systolic blood pressure >130mmHg or diastolic blood pressure ≥ 85mmHg.

The echocardiographs were performed by the same technician, using an ATL, model HDI machine with a second harmonic and a 2.25 MHz mechanical transducer. Direct measurements obtained using the mono-dimensional mode were diastolic aortic diameter (AoD) and left atrial systolic diameter (Las), using the parasternal long axis view; LV diastolic diameter (LVDD); LV systolic diameter (LVSD); LV posterior wall in diastole (LVPWD); and interventricular septum in diastole (IVSD) using the parasternal short axis view at the papillary muscle level. Volume measurements calculated indirectly using the Teicholz formula were LV systolic and diastolic volumes (LVSV and LVDV), ejection fraction (EF) and ventricular fractional shortening during systole (delta D%). Other measurements calculated indirectly included relative wall thickness, left ventricle mass indexed to the body surface area (LVM / BSA) and left ventricle mass indexed to height (LVM / $height^2$).

LVM was calculated using the American Society of Echocardiography formula modified by Devereux[17]: $0.8 [1.04 (IVSD + LVDD + LVPWD)^3 – (LVDD)^3] + 0.6$. Two criteria were used for ventricular mass indexation and to calculate the presence of EVH. LVM was indexed to BSA using the Du Bois[18] formula, resulting in the LVM / BSA parameter. According to the recommendations for obese patients LVM was also indexed to height, using height squared, as proposed by Rosa and associates[19], resulting in the LVM / $height^2$ parameter. When the LVM / $height^2$ ratio was elevated, EVH was diagnosed. The LV geometric classification was based on the evaluation of LVM and relative wall thickness (IVSD + LVPWD / LVDD) as shown in Figure 1.

Diastolic function was assessed by analyzing transmitral flow using the pulsatile Doppler echocardiography described by Nishimura and associates[20], evaluating the peak velocities of the E and A waves, E/A ratio and E-wave deceleration time (EDT). Using the M-mode color imaging Doppler, diastolic dysfunction was determined when the flow propagation velocity towards the apex was less than 45cm/s[21].

The reference values used for the echocardiography evaluation are shown in Table 1[21,22].

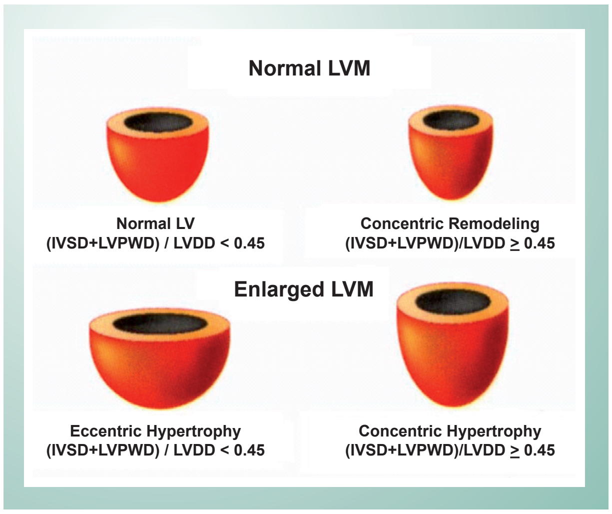

Fig. 1 - *Left ventricle geometric patterns. Adapted from Denmeaux G and associates[37]. LVM (left ventricular mass)*

	Mean	Variation	Absolute Value
Aorta (mm)	26	20-32	
Left atrium (mm)	34	28-40	
IVSD (mm)	8.5	6-11	
LVPWD (mm)	8.5	6-11	
LVDD (mm)	46.5	35-58	
LVSD (mm)	29	22-40	
LVDV (ml)	108.5	62-155	
LVSV (ml)	43	16-70	
Delta d%	34	27-42	
E wave (cm/s)	86	70-102	
A wave (cm/s)	56	43-69	
E/A ratio	1.6±0.5	1-2	
EDT (ms)		160-220	
EF (%)	65±10		>55%
LVM / BSA (g/ m2):			
Males	148±26		134
Females	108±21		110
LVM / height2 (g/m2):			
Males			77.7
Females			69.8
RWT (relative wall thickness)			<0.45

Table 1 - Normal echocardiography values for adult men and women. Adapted from Quiñones and associates[21] and Schiller and associates[22]

The database was created in Excel and the analyses were performed using the program SPSS (Statistical package for social science), version 8.0. A descriptive analysis was performed to demonstrate the results obtained. The measured variables were presented using tables or graphs and also included some descriptive measures (mean and standard deviation). The comparative analysis of the qualitative variables was conducted using the independent chi-square test. Simple linear regression was used for the quantitative variables. Statisticaly significant correlations were established as $p \leq 0.05$.

The research protocol was approved by the institution's Ethics Committee and the patients selected for the study signed a free and informed consent form.

Results

The mean age was 37.8 ± 10.48 years. Eighteen of the patients were male. The BMI varied from 40.2 to 70.7 kg/m^2, with an average of 49.2 ± 8.8 kg/m^2. Seven patients (23.3%) were classified as super-obese (BMI >55 kg/m^2). Abdominal circumferences varied from 106 to 170cm, with an average of 139.9 ± 17.5.

Twenty-five patients (83%) were hypertensive, of which 19 (63.3%) were using ati-hypertensive medication and had their pressure levels under control at the time of the interview. The average systolic blood pressure (SBP) was 133.4 ± 16.2 mmHg and average diastolic blood pressure (DBP) was 85.6 ± 10.1 mmHg. Twenty-three patients (76%) met at least one of the criteria established for the diagnosis of dyslipidemia and eight (26%) were diabetics. Two patients were smokers (6.6%) and 19 (63%) had been obese for more than 15 years. The metabolic syndrome diagnosis was established for 70% of the sample.

None of the patients evaluated, presented clinical signs compatible with heart failure. For 56.2% of the sample, the physical examination was insignificant. The most common findings during the cardiovascular system semiology were: hyper-resonant sounds during cardiac auscultation, imperceptible *ictus cordis* and edema in the lower limbs. Auscultation of heart murmurs and fourth heart beats were only found in 9.3% of the sample, while 21.9% presented refluxes during the echocardiogram (tricuspid, pulmonary or mitral).

All patients underwent a two dimensional color Doppler echocardiography. An interpretable examination could not be obtained in two female patients with a BMI > 55Kg/m2 and large breasts. Therefore, these patients were excluded from the analysis leaving a group of 28 patients who had satisfactory echocardiograms for the variables analyzed. Technical difficulties to obtain images were reported in 57.1% of the tests, mainly in the case of the female patients and for evaluation of right chambers. It was not possible to use the Simpson method to measure ejection fraction due to difficulties in defining the endocardial edges for a large part of the sample. The echocardiography variables evaluated, comprising averages and standard deviations, are shown in Table 2.

Fifty-four percent of the patients had enlarged left atriums and 42.9% had enlarged LV. The average IVSD thickness was 12.6 ± 2.5mm and LVPWD was 11.9 ± 2.1mm. LVSV and LVDV were above normal limits in 25% and 42.8% of the cases, respectively, but the average values were within normal limits. Systolic dysfunction was found in 10.7% of the cases

Variable	mean ±sd
Aorta (mm)	30.4 ± 3.4
Left atrium (mm)	40.8 ± 5.5
IVSD (mm)	12.6 ± 2.5
LVPWD (mm)	11.9 ± 2.1
LVDD (mm)	55.7 ± 7.6
LVSD (mm)	35.6 ± 6.2
LVDV (ml)	154.5 ± 53.9
LVSV (ml)	55.0 ± 22
Delta d%	35.3 ± 5.3
E wave (cm/s)	74.4 ± 22.6
A wave (cm/s)	64.4 ± 31.8
E/A Ratio	1.3 ± 0.6
EDT (ms)	220.3 ± 83.6
EF (%)	63.9 ± 6.5
LVM / BSA (g/ m2)	139.7 ± 52.
LVM / Height2 (g/ m2)	116.9 ± 44.4

Table 2 - Echocardiograph variables for the 28 severely obese patients. Recife-PE,2004

Diastolic dysfunction was observed in 54.6% of the cases. The LV geometric patterns are shown in Figure 2. Left ventricular hypertrophy was diagnosed in 46.4% of the sample using the LVM / BSA criterion, and in 82.1% using the LVM / height² criterion. A comparative analysis using the chi-square test between the variables LVM / BSA and LVM / height², revealed a significantly statistical difference (p = 0.0053).

Simple linear regression was used for comparisons between the presence of EVH with the criterion LVM / height², SBP, LVDD and obesity duration (Figs. 3, 4 and 5). Comparisons were also conducted between BMI, the presence of EVH and the diastolic dysfunction parameters (Fig. 6).

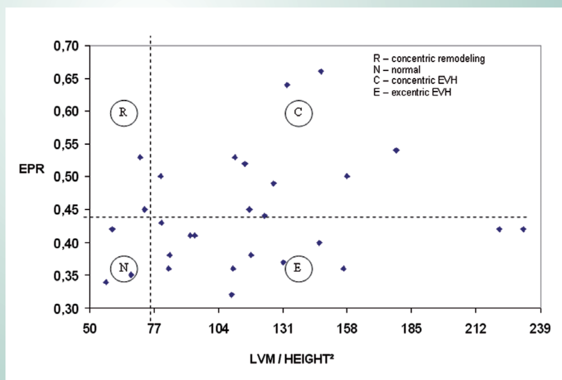

Fig. 2 - *LV geometric patterns of the 28 severely obese patients.Recife-PE, 2004.*

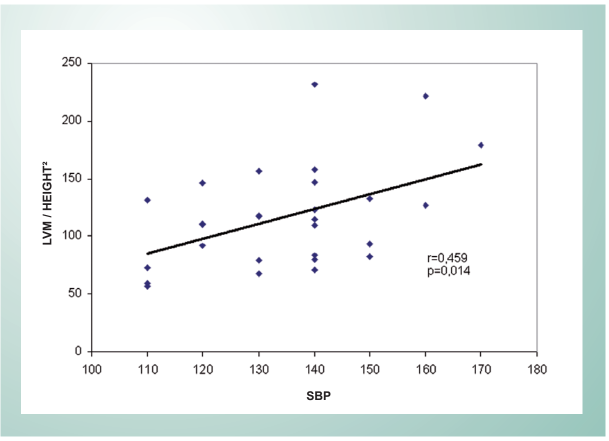

Fig. 3 - Correlation between LVM / height² and SBP for the 28 severely obese patients. Recife-PE, 2004.

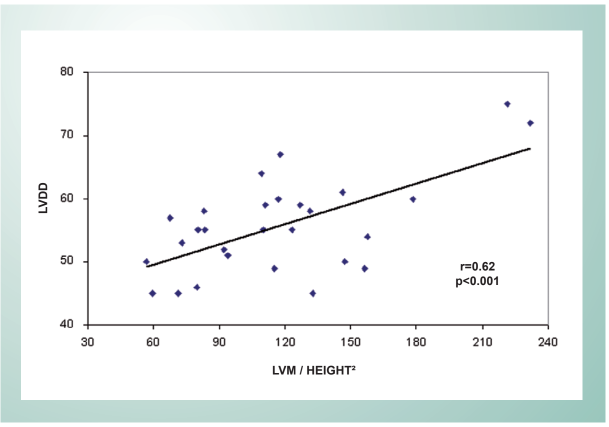

Fig. 4 - Correlation between LVDD and LVM / height² for the 28 severely obese patients. Recife-PE, 2004

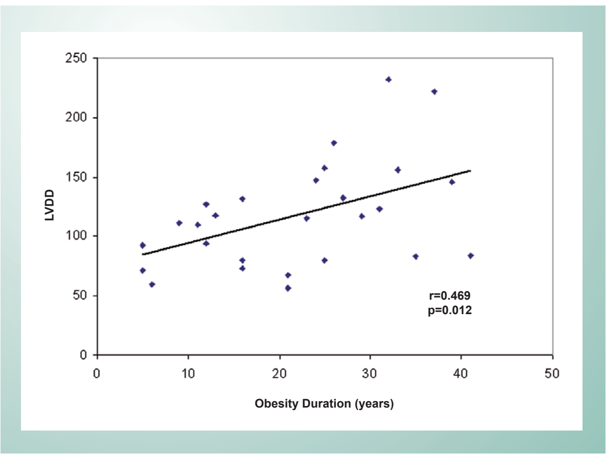

Fig. 5 - Correlation between LVM / height² and obesity duration for the 28 severely obese patients. Recife, 2004.

Discussion

There is very little information in medical literature regarding studies using an echocardiography to evaluate severely obese patients, possibly due to the operational difficulties involved in this test for these patients who often present a limited acoustic window.

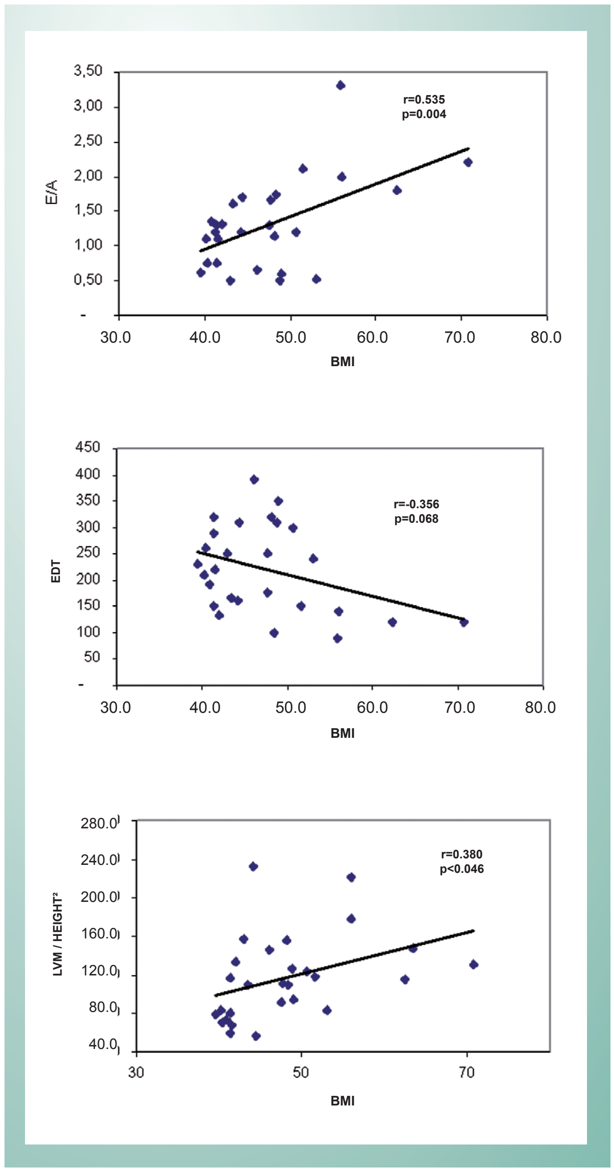

Fig. 6 - Correlation between BMI and E/A ratio, EDT and LVM / Height² for the 28 severely obese patients. Recife-PE, 2004.

Obesity cardiomyopathy is a distinct clinical entity that is described in necropsy studies and was first reported by Smith and Willius[23] in 1933. The first studies using echocardiographs began in 1978 and were conducted by Alexander after the technique had been improved[24]. From that time on, consistent results have been obtained for the detection of EVH, elevated ventricular filling pressures, variable incidences of systolic dysfunction and ventricular dilation[25,26].

The results of the present study show that left ventricular hypertrophy was diagnosed more often when the criterion of LVM indexed to height squared was used. The diagnosis of EVH using the LVM / BSA criterion was determined in only 46.4% of the cases, revealing a statistically significant difference in relation to the EVH diagnosis using the LVM

/ height² criterion and therefore presents a more precise correlation for the diagnosis of ventricular hypertrophy in obese persons. Hanse and associates[27] established that the indexation of LVM to height is an approach that should be used for obese patients. The Du Bois formula, used to calculate body surface area, is not suitable for patients who weigh more than 150Kg[28]. Nevertheless, this recommendation is often neglected in most echocardiograph laboratories; that could result in an under diagnosis of an entity related to higher cardiovascular risk.

Left ventricular hypertrophy presented a positive correlation with elevated BMI and obesity duration, confirming the hypothesis that severe obesity is a causal factor of hypertrophy. Alterations in the cardiac structure can be present, even without any clinical sign of heart disease, representing a sub-clinical manifestation of obesity cardiomyopathy.

The LV geometric patterns found in 50% of the patients involved in this study agree with other authors[6,7,29,30] in that eccentric EVH is the most common geometric abnormality associated with obesity. Within the physiopathological concepts established, especially in the studies of Alexander[7,31] and Alpert[6,29,32,33], excentric ventricular hypertrophy is associated with obesity. Nevertheless, in obese patients with SH, many authors agree that there is a double stimulus to develop hypertrophy that could be concentric or mixed. Regardless of the type, there is an increased risk for patients with ventricular hypertrophy to develop heart failure[34,35].

Concentric remodeling, the LV geometric pattern described in hemodynamic studies as associated with a diminished cardiac index, elevated peripheral vascular resistance and reduced plasmatic volumes[36], was only seen in two cases (7.1%), confirming the physiopathological model proposed for severe obesity, in which the blood volume is elevated and the peripheral vascular resistance is normal or low.

Systolic dysfunction was found in 10.7% of the study population. Two widely used indexes to measure the performance of the LV ejection phase were used. Other indexes that can be obtained using an echocardiogram such as, cardiac output, average velocity of circumferential shortening and systole ejection volume were not used due to the technical alignment difficulties for Doppler acquisition and the impracticability, especially in patients with a limited acoustic window. Even though these indexes are sensitive to changes in LV contractile function they are highly dependent on the LV pre and post load conditions[11].

Diastolic dysfunction was found in 54.6% of the cases, which was expected for the study population. It has been described in literature that severely obese patients have diastolic dysfunction regardless of SH development with a small correlation to EVH[37]. Evaluation using the E/A ratio had a positive correlation with BMI, while the evaluation using EDT had a negative correlation with this variable. Even though the p value was not significant ($p=0.068$), there was a tendency for EDT to diminish as the BMI increased, suggesting more severe diastolic dysfunction patterns, that is, an E/A ratio >2 and EDT <160ms, are found more often in patients with a higher BMI.

Various authors have described the association between an increased BMI and a greater prevalence of metabolic syndrome elements, indicating that obesity represents an unfavorable risk profile for cardiovascular disease. The elevated prevalence of metabolic syndrome elements in the sample, associated with alterations diagnosed during the echocardiogram, such as left ventricular hypertrophy and diastolic dysfunction, justifies a more in-depth and specific semiological evaluation for these patients, even at a younger age, especially for those who will be submitted to procedures that could cause hemodynamic instability, such as bariatric surgery.

The results of the present study demonstrate that patients with severe obesity present structural cardiac alterations that could be associated with the development of heart failure, arrhythmias and sudden death. The echocardiography study, a readily available and economical test, makes it possible to identify patients with higher cardiovascular risk, enabling the implementation of preventative measures to control the ventricular remodeling process and cardiomyopathy evolution.

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