Echocardiographic Left Atrial and Ventricular Structural Changes in Nigerian Obese Hypertensive Patients seen in Clinical Practice

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ABSTRACT

Objective: The objective was to investigate the structural changes in the left atrium (LA) and left ventricle (LV) of obese hypertensive patients. **Materials and Methods:** A total of 381 hypertensive subjects were divided into normal weight, overweight, and obese groups based on their body mass index (BMI). Clinical information and echocardiographic measurements of LA and LV were compared in the three groups. **Results:** Mean age was 52.4 ± 13.3 years (male:female ratio of 1.3:1). LA size was significantly higher in obese hypertensives (4.4 ± 0.6 cm) compared with overweight (3.8 ± 0.7 cm) and normal weight hypertensives (3.4 ± 0.6 cm). Majority of the obese hypertensives (80.5%) had various degrees of LA abnormalities when compared with overweight (31.1%) and normal BMI subjects (18.3%). The prevalence of left ventricular hypertrophy (LVH) was 29.1%, 22.6%, and 13.9% in the obese, overweight, and normal BMI subjects, respectively. Concentric LV geometry was found in the majority of the obese subjects (79.6%). **Conclusion:** There are significant differences in the prevalence and severity of abnormalities of LA as well as the degree and prevalence of LVH in obese hypertensive patients compared with the non-obese counterparts. Concentric LV geometry is the dominant phenotypes seen the obese patients.

Keywords: Hypertension, left atrium, left ventricular hypertrophy, obesity

INTRODUCTION

Obesity increases adverse cardiac events by both indirect and direct ways.[1,2] Indirectly, it is strongly associated with the development of the major risk factors for atherosclerotic disease such as dyslipidemia, hypertension, and diabetes mellitus. Obesity is also associated with increased incidence of sleep apnea/hypoventilation syndromes, which can affect the heart in many ways. There are also many direct effects of obesity on the heart and the cardiovascular system. These are not mediated through components of the atherosclerotic risk factors or through the associated effects of sleep disorders. Evidence shows that obesity is associated with structural and functional changes in the heart in both humans and animal models.[3,4] Many of these changes, such as left ventricular hypertrophy (LVH), left atrial (LA) enlargement and subclinical impairment of left ventricular (LV) systolic and diastolic functions are believed to be precursors of more overt forms of cardiac dysfunction and heart failure. LA size is of clinical relevance in the occurrence of atrial fibrillation, stroke, and congestive heart failure.[5-7]

There are divergent opinions about the type and degree of LVH as well as geometry patterns in obesity.[8-11] While earlier studies suggested that eccentric LV geometric pattern predominate in obesity, other recent ones tended to suggest concentric geometric pattern in them.[11-14] There is an increased left atrial dimension (LAD) in obese subjects compared with normal-weight controls, which had been postulated as a reason for increased atrial fibrillation in obese individuals.[5]

There are few data on the echocardiographic structural changes seen in obese hypertensive patients, especially in Nigeria, a country of the population of Black Africans.

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In view of this, we examined echocardiographic features of obese hypertensive patients compared with their non-obese counterparts with particular emphasis on LA and ventricular structural differences in Nigerian patients.

MATERIALS AND METHODS

A cross-sectional survey of 381 hypertensive subjects in sinus rhythm who were on different antihypertensive medications was carried out in the echocardiography Laboratory of a Tertiary Health Institution in Southwest Nigeria. This study was conducted between January 2009 and December 2012. Ethical clearance for the study was approved by the Ethics and Research Committee of the hospital in conformity with ethical guidelines of the 1975 declaration of Helsinki, and all participants gave written consent to participate.

Demographic parameters of subjects were noted and recorded. All subjects were clinically examined to evaluate their body mass index (BMI)(weight [kg]/height^2 [m]), body surface area (BSA) calculated using the formula of Dubois.[15] The cardiovascular status of the subjects was also evaluated. Subjects were considered hypertensive if they had a resting systolic blood pressure (SBP) >140 mmHg and/or diastolic blood pressure (DBP) >90 mmHg on two occasions measured after at least 3 min of rest with a mercury sphygmomanometer or if they were on antihypertensive therapy.[16] Korotkoff Phase 1 was used for systolic and Phase 5 for DBP. Excluded were patients with evidence of valvular abnormality, congestive heart failure, ischemic heart disease, renal failure, hemoglobinopathy, and diabetes mellitus.

The subjects also had transthoracic two-dimensional (2D), and 2D derived M-mode echocardiography performed according to standard procedure,[17] while in the left lateral decubitus position using the SonoScape 1000 ultrasound imaging system with 4-2 MHZ transducer. LV end-diastolic measurements were taken during at least three cardiac cycles according to American Society of Echocardiography convention.[18] These included the left ventricular internal diameter in diastole (LVIDD), posterior wall thickness (PWT) and interventricular septal thickness (IVST). LV mass was estimated from the Deveureux's formula[19] = 0.80 (1.04 [LVIDD + PWT + IVST]^3-[LVIDD]^3)+0.6 g and normalized to height$^{2.7}$ (ht$^{2.7}$).

Upper normal limits for left ventricular mass index (LVMI) were >48 g/m$^{2.7}$ in men and >44 g/m$^{2.7}$ in women[20] to define LVH. Relative wall thickness (RWT) was defined as (2 × PWT)/LVIDD.[21] A partition value of 0.42 for RWT was used for both men and women.[20] Patients with increased LVMI and increased RWT were considered to have concentric hypertrophy, and those with increased LVMI and normal RWT were considered to have eccentric hypertrophy. Those with normal LVMI and increased or normal RWT were considered to have concentric remodeling or normal geometry, respectively.[20] Aortic root dimension was obtained from the parasternal long-axis with measurement at the maximal diameter in the sinuses of valsalva and gender-specific cut-off points of 4.0 cm in men and 3.8 cm in women were used to define aortic root dilatation.[21]

LA anteroposterior linear dimension obtained from the parasternal long-axis view was taken from the trailing edge of the posterior aortic wall to the leading edge of the posterior LA wall at the end-ventricular systole when the LA chamber was at its greatest dimension.[20]

LA changes were defined as: (1). LA diameter >4.0 cm and >3.8 cm in males and females, respectively. Gender-specific thresholds 4.1-4.6/3.9-4.2 cm, 4.7-5.2/4.3-4.6 cm, and ≥5.2/4.7 cm were used to grade severity of abnormality as mild, moderate, and severe in men/women, respectively.[20] (2). LA diameter indexed to BSA (LAD/BSA)>2.3 cm/m^2 in men and women and severity of abnormality graded as 2.4-2.6 cm/m^2 (mildly abnormal), 2.7-2.9 cm/m^2 (moderately abnormal) and ≥3.0 (severely abnormal)[20] and (3). LAD in relation to aortic root diameter (AOD) to define disproportionate LA enlargement as LAD/AOD >1.4.[22]

Statistical analysis

The subjects were stratified to three groups according to their BMI, i.e., 120 subjects in normal BMI hypertensive group (BMI 18.5-24.9 kg/m^2), 148 subjects in overweight hypertensive group (BMI 25-29.9 kg/m^2) and 113 subjects in obese hypertensive group (BMI ≥30 kg/m^2) (Table 1).

Data are expressed as mean ± standard deviation and frequency expressed as a percentage. Analysis of variance was used to compare the three groups of normal BMI, overweight, and obese. Spearman's rho correlation was used to investigate the correlation of severity of abnormality of LA and other variable factors. All statistical analyses were performed with commercially available computer program SPSS 13.0 (SPSS Inc., Chicago, IL USA). $P < 0.05$ was considered as statistically significant.

RESULTS

A total of 381 hypertensive patients comprising 216 males and 165 females (male:female ratio = 1.3:1) were assessed.

The mean age of the population was 52.4 ± 13.3 years. The population was divided into three groups using their BMI as normal weight, overweight, and obese and as shown in Table 2, their mean ages matched.

The subjects in the obese group were shorter in height and significantly weighed more than the subjects in normal and overweight groups (Table 2). There were no significant differences in the mean SBP, DBP, and pulse pressure among three groups.

Increased LAD and LAD/BSA was found in 37.6% and 20.3% of the study population, respectively. Males (39.5%) had a higher prevalence of abnormal LAD compared with females (35.5%). LA changes as measured by LA diameter and LAD/BSA were significantly higher in the obese group than the non-obese groups. Majority of the obese hypertensives (80.5%) had various degrees of LA abnormalities in contrast to overweight subjects (31.1%) and normal BMI subjects (18.3%), a trend that was followed when LAD was indexed to aortic root. No subject with normal BMI had severely abnormal form of LAD while 5.4% and 15.9% of normal weight and obese subjects respectively had LAD considered severely abnormal. Aortic root dilatation was seen in 1.3% of the study population with rates in males and females being 1.9% and 0.6%, respectively. There was a stepwise decrease in the prevalence of aortic root dilatation from normal weight hypertensives (1.7%) to overweight hypertensives (1.4%) and obese hypertensives (0.9%). However, disproportionate LA in relation to aortic root was found more commonly in obese subjects (49.6%) compared with overweight (21.6%) and normal BMI subjects (16.7%).

Table 1 Severity of LA abnormality

Parameters	Normal (*n*=120)	Overweight (*n*=148)	Obese (*n*=113)	*P* value
LAD				<0.001
Normal *n* (%)	98 (81.7)	102 (68.9)	22 (19.5)	
Mildly abnormal *n* (%)	15 (12.5)	29 (19.6)	46 (40.7)	
Moderately abnormal *n* (%)	7 (5.8)	9 (6.1)	27 (23.9)	
Severely abnormal *n* (%)	0 (0)	8 (5.4)	18 (15.9)	
LAD/BSA				0.115
Normal *n* (%)	95 (79.2)	127 (85.8)	81 (71.7)	
Mildly abnormal *n* (%)	16 (13.3)	12 (8.1)	16 (14.2)	
Moderately abnormal *n* (%)	6 (5.0)	5 (3.4)	12 (10.6)	
Severely abnormal *n* (%)	3 (2.5)	4 (2.7)	4 (3.5)	
LA size in relation to aortic root				<0.001
Normal *n* (%)	100 (83.3)	116 (78.4)	57 (50.4)	
Disproportionate *n* (%)	20 (16.7)	32 (21.6)	56 (49.6)	

BSA: Body surface area, LAD: Left atrial dimension

The prevalence rate of LVH in the study population was 65.6% comprising 29.1% (obese), 22.6% (overweight) and 13.9% (normal BMI) subjects, respectively. Within group analysis of LVH in the three groups is shown in Figure 1. Concentric LV geometry was found in the majority of the obese subjects (79.6%) and the overweight subjects (35.1%) while concentric remodeling geometric pattern was found in majority (33.3%) of the normal BMI subjects. Eccentric LV geometric pattern was not as common in the hypertensive obese subjects compared with hypertensive subjects who were either normal weight or overweight. The prevalence of combined LA enlargement and LVH in our study population was 18.4% (70/381). Among the subjects who had LA enlargement and LVH, 27.1%, 27.1%, and 45.7% were normal weight, overweight, and obese hypertensives, respectively. Figure 2 shows the prevalence

Table 2 Clinical and echocardiographic variables in the study population

Parameters	Normal (*n*=120)	Overweight (*n*=148)	Obese (*n*=113)	*P* value
Age (years)	50.6±13.3	53.4±14.0	53.4±13.3	0.197
Sex				0.655
Male *n* (%)	70 (58.3)	86 (58.1)	60 (53.1)	
Female *n* (%)	50 (41.7)	62 (41.9)	53 (46.9)	
Weight (kg)	61.0±7.9	77.1±7.4	92.6±12.2	<0.001
Height (cm)	167.7±6.6	167.6±7.9	164.8±11.0	0.012
BMI (kg/m)	21.7±2.3	27.4±1.4	34.3±5.6	<0.001
BSA (m^2)	1.7±0.1	1.9±0.1	2.0±0.2	<0.001
Hypertension duration (years)	4.5	4.9	4.6	0.643
SBP (mmHg)	136.0±23.0	135.1±20.4	140.8±21.4	0.127
DBP (mmHg)	83.7±13.0	84.6±11.9	87.3±11.6	0.088
Pulse pressure (mmHg)	52.6±18.4	50.5±15.3	53.5±16.1	0.381
LVIDD (cm)	4.8±1.1	4.8±0.9	5.5±1.0	<0.001
LVIDS (cm)	3.3±1.0	3.3±1.0	4.1±1.2	<0.001
PWD (cm)	1.1±0.2	1.1±0.2	1.5±0.3	<0.001
IVST (cm)	1.1±0.3	1.2±0.3	1.6±0.3	<0.001
AOD (cm)	3.0±0.7	3.0±0.4	3.1±0.4	0.367
LAD (cm)	3.4±0.6	3.8±0.7	4.4±0.6	<0.001
LAD/AOD	1.2±0.3	1.3±0.3	1.5±0.3	<0.001
RWT	0.5±0.2	0.5±0.2	0.6±0.2	<0.001
LVMI (g)	49.5±23.3	53.8±19.9	110.5±52.1	<0.001
LV geometry				<0.001
Normal *n* (%)	27 (22.5)	34 (23.0)	0 (0)	
Concentric hypertrophy *n* (%)	29 (24.2)	52 (35.1)	90 (79.6)	
Concentric remodeling *n* (%)	40 (33.3)	30 (20.3)	6 (5.3)	
Eccentric hypertrophy *n* (%)	24 (20.0)	32 (21.6)	17 (15.0)	

BMI: Body mass index, BSA: Body surface area, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, LVIDD: Left ventricular internal dimension in diastole, LVIDS: Left ventricular internal dimension in systole, PWD: Left ventricular posterior wall thickness in diastole, IVST: Interventricular septal thickness in diastole, AOD: Aortic root diameter, LAD: Left atrial dimension, RWT: Relative wall thickness, LVMI: Left ventricular mass index

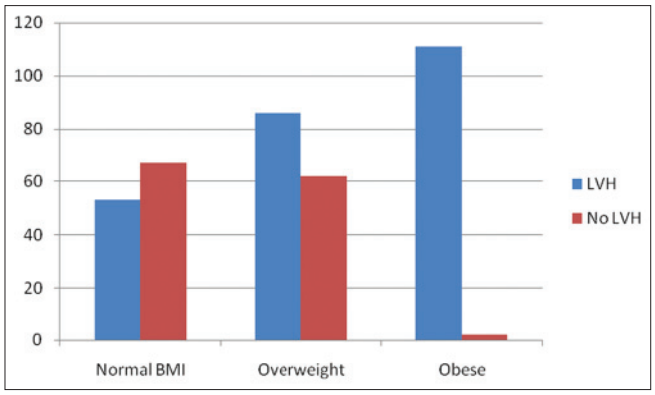

Figure 1. Prevalence of left ventricular hypertrophy in the study population.

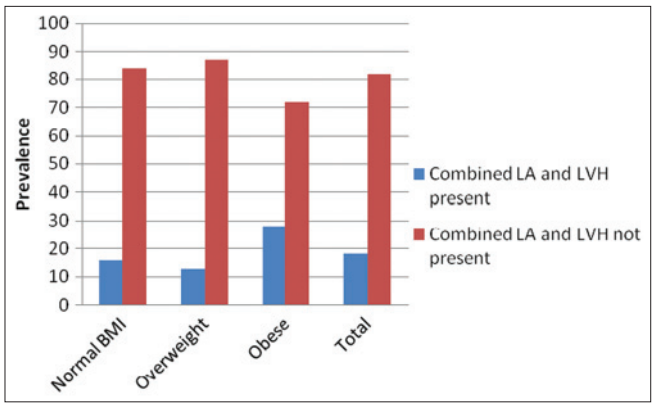

Figure 2. Prevalence of combined left atrial enlargement and left ventricular hypertrophy in the study population.

of combined LA enlargement and LVH among the three strata of BMI in the 381 studied subjects.

Significant correlates of severity of LAD and their correlation coefficients (*r*) at the 0.01 level of significance were: BMI (r = 0.483), weight (r = 0.430) and BSA (r = 0.326). Others were left ventricular internal dimension in systole (r = 0.487), LVIDD (r = 0.465), PWT (r = 0.263) and IVSTD (r = 0.249).

DISCUSSION

The main findings of this study can be summarized as follows: Firstly, structural LA abnormalities are common in hypertensive subjects, but more prevalent and severe in the obese hypertensives compared with hypertensive subjects with BMI in the normal and overweight range. Secondly, LVH is common with concentric LVH geometric pattern being the most prevalent LV alteration in obese hypertensives. The third point is that subjects' body weight and LV internal dimensions are factors that correlate with severity of LA abnormalities in hypertensive subjects.

From a clinical point of view, presence of LA enlargement has been shown to be a significant predictor of cardiovascular outcomes.[5-7] Among the factors that influence LA size, body size is the most important anthropometric determinant,[23,24] with LA size increasing with increasing body size. Pathophysiologically, LA enlargement is mostly the result of either pressure or volume overload or both. Obesity, independent of hypertension causes increased cardiac output as a result of increased stroke volume in order to meet the metabolic demand of the adipose tissue. The LA enlarges in response to the increased blood volume and venous return initially, and the LA alteration worsens when other factors like LVH and diastolic dysfunction set in. In the same vein, hypertension independent of other factors causes an increase in cardiac output and peripheral vascular resistance thereby leading to changes in LV wall stress, poor LV wall compliance in diastole and elevated diastolic filling pressure, which may ultimately lead to alteration in LA structure and function. Therefore, in obese hypertensive individuals, combination of factors converges to produce LA structural abnormalities as seen in our study.

Absolute LAD enlargement in our study increased progressively from normal weight hypertensives to overweight hypertensives and highest in the obese hypertensives in whom the prevalence of LA enlargement was 80.5%. In previous studies, Cuspidi *et al*.[25] reported prevalence of 38% in a population of hypertensive patients referred for echocardiographic evaluation and a prevalence of 46% was reported by the investigators in LIFE study.[26] In these studies, hypertensive patients with LA enlargement were more obese compared with patients without LA enlargement, even though, obesity was not assessed as predictive index of LA enlargement within the population of hypertensive patients. In a study by Gottdiener *et al*.[27] in which the influence of obesity was assessed on LA size in hypertensive men, obese hypertensive men had a greater LA size than overweight or normal weight hypertensive men and the prevalence of LA enlargement progressively decreased from obese to overweight and normal weight hypertensive men. Stritzke *et al*.[28] assessed the independent contributions of obesity and hypertension to the development of LA enlargement in a mixed population of patients and reported that the effect of obesity was almost twice the effect of hypertension.

We noted in this study that there was no significant difference in the aortic root dimension between the three groups of BMI strata, and the low prevalence of aortic root dilatation in the three groups of subjects (0.9-1.7%). However, similar to the previous report in healthy obese subjects compared to normotensive non-obese subjects,[22]

obese hypertensive patients had significantly higher LA/aortic root proportion compared with non-obese hypertensive subjects and more patients in the obese hypertensive group had LA/aortic root proportion >1.4 (disproportionate LA enlargement). In our study, 49.6% of obese hypertensive patients compared to 34% in healthy, normotensive obese subjects reported by Sasson *et al*.[22] had disproportionate LA enlargement.

The prevalence rates (total as well as gender-related) of aortic root dilation in our study population were lower than what was reported in earlier studies. Cuspidi *et al*.[21] found prevalence of 6.1% while Palmieri *et al*.[29] found prevalence of 4.2% in a population of untreated and treated hypertensive patients. In general, the prevalence of aortic root dilatation in obese hypertensive patients, like other cohorts of hypertensive patients is lower than that of the traditional markers of cardiac organ damage.

As reported in previous studies,[14] a stepwise increase in prevalence rates of LVH also occurred from normal weight to overweight and obese hypertensive patients in our study. Contrary to some reports where eccentric LVH phenotype was suggested in obesity with or without hypertension,[11-13] this study revealed that LVMI increased progressively from normal weight hypertensive to overweight hypertensive and obese hypertensive patients, concentric LVH being the predominant LV geometric phenotype in obese hypertensives and hypertensive patients with BMI in the overweight range. This finding is in agreement with the reports of Masaidi *et al*.[14] in which concentric LVH was approximately 4-fold higher in obese than lean and overweight hypertensive patients. In a population of severely obese patients (mean BMI = 43 ± 10 kg/m^2) in which 40% of them were hypertensive, Avelar *et al*.[3] had also reported a predominance of concentric LVH cardiac phenotype. One reason for this may be as a result of the IVST and PWD in our study population, which were significantly out of the range of normal compared with LV internal dimensions which though, were high but not clearly out of the range of normal, findings which may indicate that pressure overload because of the coexistence of hypertension, played a more significant role than volume overload in our study population. It is also possible that the middle age profile of our study population (mean age of 52.4 ± 13 years) is partly responsible for the predominance of this LV geometry phenotype. Theoretically, in patients with concentric remodeling or concentric hypertrophy, usually the pressure overload predominates rather than volume overload stimuli. With pressure overload the wall tension is high trying to counteract the high peripheral resistance and usually the cardiac myocyte hypertrophy typical of concentric hypertrophy. This finding of increase in walls thickness to a greater extent than cavity size was clearly demonstrated in our study as stated above. With time, the hypertrophied cardiac muscle becomes maladaptive and fatigues for reasons not known and so to overcome the volume overload, the chambers dilate and cardiac output is decreased, and resultant reduced systolic and diastolic pressure produces eccentric LVH pattern. Therefore, the relative young age of our study population may also partly explain our findings.

Finally, we found that the prevalence of combined LAE and LVH was approximately 1.7-fold higher in obese hypertensive patients compared with their overweight and normal weight counterparts. This finding is particularly important considering the adverse prognosis associated with either LAE and LVH in addition to the fact that both are potentially modifiable with medical therapy.[10,30,31]

This study has its limitations, which are worthy of note. It was carried out in a selected population of hypertensive patients who were referred for possible hypertensive cardiac damage and as such, the findings of this study may differ from what may obtain in the whole hypertensive population. Furthermore, linear measurement of anteroposterior diameter of LA was used in the assessment of LA structure, which may inaccurately represent true LA size, although, it had been shown to correlate with angiographic measurements.[32]

Conclusion

There are significant differences in the prevalence of LA and its severity of abnormalities as well as in the degree and prevalence of LVH in obese hypertensive patients referred for echocardiographic assessment compared with the non-obese counterparts. Concentric LV geometry is the dominant LV geometric phenotypes seen in these patients.

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