A Comparison of Left Ventricular Geometric Patterns in Hypertensives and Normotensives in South-South Nigeria

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ABSTRACT

Left ventricular hypertrophy defined as increased left ventricular mass is an important surrogate marker for cardiovascular morbidity and mortality and manifests diverse geometric patterns in hypertensive individuals. This study was aimed at determining the patterns of left ventricular geometry among hypertensives compared with normotensives. The study found a high prevalence of concentric hypertrophy by two different Echo criteria among hypertensives. Echocardiography should thus be a vital tool for the initial evaluation and risk stratification of hypertensive patients.

Keywords: Electrocardiographic, Ventricular Hypertrophy

INTRODUCTION

Cardiovascular disease constitutes a major cause of death across the world, representing a significant public health threat in both developed and developing countries. [1] Left ventricular hypertrophy defined as increased left ventricular mass and left ventricular geometrical abnormalities are significantly associated with cardiovascular risk factors, and independently predict myocardial ischemia, [2] coronary disease, [3] congestive heart failure, [4] ventricular arrhythmias, [5] cardiac mortality, [6,7] sudden cardiac death [8] and ischemic stroke. [9] The left ventricular (LV) geometric pattern thus represents a critical prognostic factor in cardiovascular disease**.** [10]

Left ventricular (LV) geometry, a critical determinant of cardiac function, manifests diverse patterns in hypertensive individuals, reflecting the complex interplay between hemodynamic stress and myocardial remodeling.[2] Based on echocardiography data, LV geometric patterns are classified into four types according to left ventricular mass index (LVMI) and relative wall thickness (RWT): normal geometry, concentric remodeling, eccentric hypertrophy, and concentric hypertrophy, which represent progressive stages of geometric impairment. [11]

The left ventricle (LV) remodels over the life course as an adaptive response to aging, exposure to cardiovascular disease (CVD) risk factors, and myocardial injury. [12] Echocardiography plays a key role in managing the hypertensive patient. Unlike electrocardiographic criteria, echocardiography enables the direct measurement of wall thicknesses and ventricular diameters enabling calculation of LV mass, which determines whether LV hypertrophy is present. [13] Both increased LV mass [14] and abnormal LV geometry patterns [15] adversely affect prognosis and are associated with impaired cardiac systolic and diastolic dysfunction.[16]

A previous study using the Devereux formula had shown that echocardiographically detected LV hypertrophy has a sensitivity of 93% and a specificity of 95%.[17] The prognostic relevance of left ventricular geometry has been well established for some time and has been demonstrated in numerous studies.[12,18,19] The different geometric patterns are used as a risk stratification tool, especially in hypertensive patients, and have been incorporated into most guidelines for managing the hypertensive patient. [7,20]

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Several studies have been done in Nigeria to evaluate the left ventricular patterns in hypertensive patients. Akintunde et al [21] in Ogbomosho had initially found that the majority of the hypertensive subjects (60%) in their study had concentric remodeling. Adebayo et al [22] in Ife also found that concentric remodeling was the most common LV geometric pattern in their cohort of hypertensive patients. In a study of the pattern of left ventricular geometry among newly diagnosed essential hypertensives by Aje et al [23] in UCH Ibadan documented that 28% of newly diagnosed subjects had concentric hypertrophy. Dada et al [24] in an earlier work in Ibadan had found a similar majority of concentric hypertrophy. Adamu et al [25] in Ilorin also found that concentric hypertrophy occurred in (38%) of the hypertensive individuals. Isa et al [26] in Zaria found than 75 % of the hypertensives had altered left ventricular geometry with Concentric left ventricular hypertrophy being the commonest geometric pattern constituting (37%) seen in their untreated hypertensives.

Norbert et al [27] in Port Harcourt found a majority (65.2%) of the hypertensives in their study had concentric LV hypertrophy. Karaye et al [28] in contrary had found (36.6%) had eccentric hypertrophy as the most common geometric pattern.

The objective of this study was to assess the prevalence and patterns of left ventricular geometry among hypertensive patients and normotensive controls in Calabar, South-South Nigeria.

METHODOLOGY

A comparative cross-sectional study was conducted among normotensive individuals and hypertensive patients, including both newly diagnosed and those on treatment. The sample size was calculated using Pocock's formula. [29]

Formula: $n = [P1(1-P1) + P2(1-P2)] (Z\alpha/2 + Z\beta)2 (P1-P2)2$

Where:

n = minimum sample size
p =proportion of LVH in hypertensives
d = difference to be detected at the end of the study
Zα - 95% confidence = 1.96
Zβ – 90% power = 1.98

A study done in University College Hospital Ibadan by Dada et al [24] was one of the earliest works in Nigeria to compare LVH criteria and found the prevalence of Echocardiographic LVH indexed for height was 34% and 1.67% in the hypertensive and controls respectively.

Assuming a difference to be detected at the end of the study is 20%.

$n = [0.34(1 - 0.34) \times (1.96 + 1.98)^2 \times 2] / (0.20)^2$

$n = [0.2278 \times 10.4976 \times 2] / 0.04 = 119$

The calculated sample size was 119.

To improve power and allow for subgroup analysis, 240 participants were recruited 120 hypertensive patients and 120 controls.

Recruitment of Study Participants, Inclusion and Exclusion criteria

Study participants were recruited from the Cardiology and Medical Out-Patients Department (MOPD) of University of Calabar Teaching Hospital. All who consented to participate in the study were recruited. Both newly diagnosed hypertensives and those already on treatment were included. Controls for the study were healthy normotensive subjects, drawn from hospital staff and patient's relatives.

Inclusion criteria: All who consented to participate in the study were recruited aged 18 years and above. Both newly diagnosed hypertensives and those already on treatment were included. Controls for the study were healthy normotensive subjects, drawn from hospital staff and patient's relatives

Exclusion criteria: Those excluded included: Patients less than 18 years of age, Structural heart disease (i.e. Myocardial Infarction, Significant Valvular Heart disease, Cardiomyopathy and Chronic Pericardial diseases), Concomitant Diabetes Mellitus, Congestive Cardiac Failure, Chronic Renal Failure, technically inadequate echocardiograms, the presence of the following ECG abnormalities: uncontrolled atrial fibrillation, atrial flutter, bundle branch block, and pacemaker use.

Data Collection - Questionnaire

Baseline clinical and socio-demographic characteristics were obtained from the subjects using an interviewer- administered structured questionnaire. These included date of birth, age, gender, marital status, level of education, history of hypertension and diabetes, and a history of smoking and alcohol use. A standard mercury sphygmomanometer (Accosson, London) was used, and the systolic blood pressure

(SBP) and diastolic blood pressure (DBP) taken as Korotkoff sound phases I and V, respectively. A cuff of appropriate size was applied to the exposed right upper arm and was gently inflated to 30 mmHg above the level at which the pulse disappeared and then deflated gradually. Blood pressure 140/90mmHg and above was taken as hypertension and individuals already on medication, were noted. [30]

Transthoracic Echocardiography

M-mode, 2D, and Doppler echocardiography were performed by the researcher alone on all 240 subjects using an ALOKA SSD–4000 machine (Aloka Co. Ltd., Tokyo, Japan) with a 3.5 MHz transducer, following the American Society of Echocardiography (ASE) guidelines. [31]

LV internal dimension, posterior wall thickness and interventricular septal thickness was measured at end-diastole and end-systole. When M-mode imaging was suboptimal, 2D measurements were used per ASE criteria. [31]

LV systolic performance (fractional shortening and ejection fraction) was calculated using the Teichholz's formula.[32]

Left ventricular mass (LVM) was calculated using the Devereux-modified ASE cube formula. [17]

LVmass (ASE) = 0.8 x 1.04 x ([LVIDD + PWTD + IVSTD]^3- [LVIDD]^3)) + 0.6 g.

Where:

LVIDD = left ventricular internal dimension,

IVSTD = intraventricular septum thickness in diastole, and

PWTD = posterior wall thickness in diastole.

Left ventricular mass when derived by the above formula was normalized to both body surface area and height$^{2.7}$ (where height was in meters) to correct for the effect of overweight. [33] Echocardiographic patterns were thus determined as: normal geometry, concentric remodeling, eccentric and concentric hypertrophy in the subjects.

Relative wall thickness was measured at end diastole as the ratio of the posterior wall thickness plus septal thickness divided by LV internal dimension.[148]

Relative wall thickness (RWT) = ([IVSd +PWTd]/LVIDd) and a value of <0.45 was defined as normal.[11]

Left ventricular geometric patterns were defined as follows:

1. Normal geometry, when LVMI and RWT were normal;
2. Concentric remodelling, when LVMI was normal and RWT increased;
3. Eccentric hypertrophy, when LVMI was increased but normal RWT; and
4. Concentric hypertrophy, when both LVMI and RWT were increased [7]

Statistical analysis: Analysis was done using the SPSS version 28.0 software (SPSS, Chicago, IL, USA).

Categorical variables were expressed as proportions and percentages while continuous variables were expressed as means ± standard deviation.

Comparisons of continuous variables between groups was performed with the independent samples t-test.

Comparison between categorical variables was performed with the chi- square test.

Level of statistical significance was fixed at $p<0.05$.

ETHICAL CONCERNS

Ethical clearance was obtained from Ethical committee of the University of Calabar Teaching Hospital, Calabar. All patients who participated in the study gave voluntary written informed consent. Non-consenting patients were excluded from the study. Participants confidentiality was maintained: Personal information is protected to ensure privacy by using initials only. The echocardiography was done at no cost. The results and implications were discussed with the patient. There was no harm from the tests and Echocardiography study. The participants' physical and psychological well-being were prioritized. Those who declined participation were not unduly punished or discriminated against.

RESULTS

A total of 120 hypertensives and 120 controls made up the study population. Majority were females 132 (55%). Of the 120 hypertensives, there were 52 males and 68 females. Majority of the study participants had received some form of education up to post-secondary level. Majority 161(72.5%) were married and 85.4% lived in the urban areas.

Table 1: Characteristics of All Respondents

	Characteristic	Number (n=240)	Percentage (%)
Age	<30	9	3.8
	30-59	176	73.3
	60 and above	55	22.9
	Mean ± SD	49.7 ± 12.2	
Sex	Male	108	45.0
	Female	132	55.0
Marital status	Single	39	16.3
	Married	161	67.1
	Divorced	5	2.1
	Widow/Widower	35	14.6
Educational status	None	13	5.4
	Primary	34	14.2
	Secondary	31	12.9
	Post-Secondary	82	34.2
	Graduate	80	33.3
Ethnicity	Efik	89	37.4
	Ibibio	41	16.7
	Ekoi	30	12.6
	Annang	30	12.2
	Igbo	14	6.1
	Others	36	15.0
Residence	Urban	205	85.4
	Rural	35	14.6
HTN history	No HTN	120	50.0
	Newly diagnosed HTN	24	10.0
	Pre-existing HTN	96	40.0

Table 1 shows the demographics of all the respondents.

Table 2: Comparing characteristics of all Hypertensives and Controls

	HTN (n=120)	Control (n=120)	Test statistic /p-value
Age			
<30	4 (44.4)	5 (55.6)	Fishers exact = 0.183
30-59	88 (50.0)	88 (50.0)	*p*=1.000
60 and above	28 (50.9)	27 (49.1)	
Sex			
Male	58 (53.7)	50 (46.3)	Chi = 1.077
Female	62 (47.0)	70 (53.0)	P= 0.364
Marital status			
Single	8 (20.5)	31 (79.5)	Fishers exact = 19.350
Married	90 (55.9)	71 (44.1)	P <0.001
Divorced	1 (20.0)	4 (80.0)	
Widow/Widower	21 (60.0)	14 (40.0)	
Educational status			
None	8 (61.5)	5 (38.5)	Chi = 22.325
Primary	29 (85.3)	5 (14.7)	P <0.001
Secondary	14 (45.2)	17 (54.8)	
Post-Secondary	32 (39.0)	50 (61.0)	
Graduate	37 (46.3)	43 (53.8)	

Ethnicity			
Efik	21 (23.6)	68 (76.4)	
Ibibio	20 (48.8)	21 (51.2)	Fishers exact = 55.398
Ekoi	17 (56.7)	13 (43.3)	P <0.001
Annang	26 (87.6)	4 (13.3)	
Igbo	8 (57.1)	6 (42.9)	
Others	28 (77.8)	8 (22.2)	
Residence			
Urban	100 (48.8)	105 (51.2)	Chi = 0.836
Rural	20 (57.1)	15 (42.9)	P= 0.465

Table 2 shows the characteristics of the matched participants in the study. The two groups were comparable in all parameters being statistically significant except place of residence.

Table 3: Comparing characteristics of respondents with newly diagnosed hypertension, pre-existing hypertension, and Controls

	Newly diagnosed HTN (n=24)	Pre-existing HTN (n=96)	Control (n=120)	Test statistic /p-value
Age				
<30	3 (33.3)	1 (11.1)	5 (55.6)	Fishers exact = 6.517
30-59	15 (8.5)	73 (41.5)	88 (50.0)	*p*=0.140
60 and above	6 (10.9)	22 (40.1)	27 (49.1)	
Sex				
Male	6 (5.6)	52 (48.1)	50 (46.3)	X = 7.677
Female	18 (13.6)	44 (33.3)	70 (53.0)	P= 0.021
Marital status				
Single	5 (12.8)	3 (7.7)	31 (79.5)	Fishers exact =
Married	13 (8.1)	77 (47.8)	71 (44.1)	25.910
Divorced	0 (0.0)	1 (20.0)	4 (80.0)	P <0.001
Widow/Widower	6 (17.1)	15 (42.9)	14 (40.0)	
Educational status				
None	2 (15.4)	6 (46.2)	5 (38.5)	Fishers exact =
Primary	3 (8.8)	26 (76.5)	5 (14.7)	31.884
Secondary	0 (0.0)	14 (45.2)	17 (54.8)	P <0.001
Post-Secondary	7 (8.5)	25 (30.5)	50 (61.0)	
Graduate	12 (15.0)	25 (31.3)	43 (53.8)	
Ethnicity				
Efik	2 (2.2)	19 (21.3)	68 (76.4)	
Ibibio	4 (9.8)	16 (39.0)	21 (51.2)	Fishers exact =
Ekoi	5 (16.7)	12 (40.0)	13 (43.3)	59.132
Annang	8 (26.7)	18 (60.0)	4 (13.3)	P <0.001
Igbo	1 (7.1)	7 (50.0)	6 (42.9)	
Others	4 (11.1)	24 (66.7)	8 (22.2)	
Residence				
Urban	19 (9.3)	81 (39.5)	105 (51.2)	Chi = 1.254
Rural	5 (14.3)	15 (42.9)	15 (42.9)	P= 0.555

Table 3 shows the characteristics of respondents with newly diagnosed hypertensives, pre-existing hypertensives and controls

Table 4: Patterns of LV Geometry by the different Echo criteria

	Hypertensives (n=120)	Controls (n=120)	Test statistic; p-value
±LV GeomHT2.7			
Concentric Hypertrophy	45(76.2)	14 (23.8)	Chi = 51.098
Concentric remodeling	24 (51.0)	23 (49.0)	P<0.0001
Eccentric hypertrophy	24(75.0)	8 (25.0)	
Normal geometry	27(26.5)	75 (73.5)	
±LV Geom BSA			
Concentric Hypertrophy	44 (69.8)	19 (30.2)	Fishers exact = 42.367
Concentric remodeling	25 (58.1)	18 (41.9)	P<0.0001
Eccentric hypertrophy	18(81.8)	4 (18.2)	
Normal geometry	33(29.5)	79 (70.5)	

Table 4 shows the patterns of LV Geometry by the different Echo criteria between hypertensives and controls

Table 5: Relationship between Patterns of Geometry and Hypertension

	Newly diagnosed HTN (n=24)	Pre-existing HTN (n=96)	Controls (n=120)	Test statistic; p-value
±LV Geom HT2.7				
Concentric Hypertrophy	6 (25.0)	39 (40.6)	14 (11.7)	Chi = 51.098
Concentric remodeling	6 (25.0)	18 (18.8)	23 (19.2)	P<0.0001
Eccentric hypertrophy	7(29.2)	17 (17.7)	8 (6.7)	
Normal geometry	5 (20.8)	22 (22.9)	75 (62.5)	
±LV Geom BSA				
Concentric Hypertrophy	8 (33.3)	36 (37.5)	19 (15.8)	Fishers exact =
Concentric remodeling	4 (16.7)	21 (21.9)	18 (15.0)	42.367
Eccentric hypertrophy	6 (25.0)	12 (12.5)	4 (3.3)	P<0.0001
Normal geometry	6 (25.0)	27 (28.1)	79 (65.8)	

Table 5 shows the patterns of LV Geometry by the different Echo criteria in the newly diagnosed hypertensives, pre-existing hypertensives and controls

±± LV Geom HT 2.7- Left Ventricular Geometry indexed to Height 2.7
±± LV Geom BSA- Left Ventricular Geometry indexed to body surface area

DISCUSSION

This study aimed to determine the patterns of Left ventricular geometry in hypertensive patients and normotensive controls.

In this study all echocardiographic parameters were significant in the hypertensives compared to the controls. On indexing for both Echo LVH HT $^{2.7}$ and Echo LVH BSA there was no significant difference in the results. Concentric hypertrophy being the most predominant left ventricular geometric pattern among the pre-existing and newly diagnosed hypertensives followed by concentric remodeling then eccentric hypertrophy and the minority had normal geometry. For controls, the majority had normal geometry.

This finding contrasts with Ganau et al. [11] who reported a much lower prevalence of concentric hypertrophy (8%) in untreated hypertensives. Instead, eccentric hypertrophy (27%) and normal geometry (52%) were more common in their cohort. Furthermore, Ganau's study was conducted in a European population, which raises the possibility that racial/ genetic as well as environmental factors may influence LV geometric responses to hypertension.

Wacthtell et al [34] found that hypertensive patients had a high prevalence of geometric abnormalities, especially eccentric hypertrophy, irrespective of method of indexation of LV mass indexation by body surface area or height[2.7] and Cuspidi et al [35] working in Milan, Italy performed Echocardiographic examinations on 640 consecutive hypertensives referred to the outpatient's hypertension unit and also found that eccentric hypertrophy was the most frequent type of LVH independently of the criteria used. This may also be explained by the higher incidence of coronary artery disease in the populations in Europe and the Americas than Africa.

The LIFE Study investigators led by Zogabolita et al [36] had found that eccentric LV hypertrophy predominated but the Coronary Artery Disease (CAD) group had a greater prevalence of eccentric LV hypertrophy than those without CAD.

African - Americans in the study by Fox et al. [9] were found to have more of concentric hypertrophy as we observed in our study. This brings to the fore the possibility of a genetic factor triggering concentric left ventricular hypertrophy in those of African descent.

The commonest LV geometric pattern found in this study was concentric hypertrophy and these corroborated with other studies across Nigeria. Aje et al [23] in UCH Ibadan documented that 28% of newly diagnosed subjects had concentric hypertrophy. Dada et al [24] in an earlier work in Ibadan had found a similar majority of concentric hypertrophy. Adamu et al [25] in Ilorin also found that concentric hypertrophy occurred in (38%) of the hypertensive individuals. Isa et al [25] in Zaria found than 75 % of the hypertensives had altered left ventricular geometry with Concentric left ventricular hypertrophy being the commonest geometric pattern constituting (37%) seen in their untreated hypertensives. Norbert et al [28] in Port Harcourt also found a majority (65.2%) of the hypertensives in their study had concentric LV hypertrophy.

Across Africa Chillo P et al [37] working in Tanzania also to assess prevalence, type and covariates of abnormal left ventricular (LV) geometry in untreated native Tanzanian patients with hypertension in relation to normotensive controls performed echocardiography on 161 untreated hypertensive outpatients and 80 normotensive controls at a tertiary hospital in Tanzania and found the prevalence of abnormal left ventricular geometry to be 62.1% among patients and 12.5% in controls.

However other investigators in Nigeria like Karaye et al [27] working on black Africans in Northern Nigeria also found a high prevalence of left ventricular hypertrophy with eccentric hypertrophy being the most common geometric pattern.

Akintunde et al [21] working in Western Nigeria had found on the contrary that concentric remodeling was the commonest form of geometric pattern in his study group of newly diagnosed hypertensives. Adebayo et al [22] in Ife also found that concentric remodeling was the most common LV geometric pattern in their cohort of hypertensive patients using their eight-year echo register.

These differences may be due to variations in study design, population demographics, or hypertension severity. The newly diagnosed hypertensives in this study also had a high prevalence of left ventricular hypertrophy. A few researchers like Salako et al [38] have documented a high prevalence of target organ damage among newly diagnosed hypertensives even in Nigeria There was also a high prevalence of hypertension mediated target organ damage on account of poor blood pressure control among the pre-existing hypertensives

Our study findings have demonstrated the need for early and intensive screening for hypertension as we found subclinical hypertensive disease in untreated hypertensives. This agrees with research showing that subclinical hypertensive heart disease is highly prevalent in untreated hypertensives and associated with both systolic and diastolic LV dysfunction. [39,40] This is also a call for better blood pressure control among hypertensives in Nigeria as several studies have reported poor control. In this systematic review of 53 studies on the prevalence of hypertension in Nigeria. Adeloye et al [41] found strong evidence that more than half of the hypertensive individuals in Nigeria are untreated and/or have poorly controlled blood pressure.

Thus, there is a lot of work to be done to identify the patients early and identify individuals at higher risk of cardiovascular events and assessing changes in the left ventricular structure over time to tailor interventions to

individual patient profiles as this has been shown by Sayin et al in their study to greatly improve prognosis.[42]

In view of this cardiologists and all physicians must include Echocardiography in the initial assessment of patients and ensure that antihypertensive therapy targets ventricular geometry and LV mass and not just blood pressure control.

LIMITATIONS

This was a hospital-based study and sample size of 240 was bigger than most other studies in Nigeria so far though a longitudinal study is proposed.

There was no selection bias. The higher incidence of urban prevalence is balanced by the fact that several studies have found higher blood pressures among urban than rural dwellers. Further studies will include genetic testing and speckle tracking.

CONCLUSION

This study aimed to determine the patterns of left ventricular geometry among hypertensive patients compared to normotensive controls. The findings revealed that most hypertensive participants, whether newly diagnosed or previously known, exhibited abnormal LV geometric patterns, particularly concentric hypertrophy. This supports the assertion that hypertension significantly alters cardiac structure, even in early stages. Early diagnosis and treatment of hypertension is important to reduce cardiovascular events. Regular echocardiographic testing can help in detecting abnormal LV geometry, allowing for timely interventions to mitigate associated risks.

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