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Echocardiographic Features of Patients with Stroke in Port Harcourt, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author RCE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author STDM managed the analyses of the study. Both authors managed the literature searches, read and approved the final manuscript.

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ABSTRACT

Stroke is a major challenge to physicians worldwide, with a high incidence, mortality, disability rates and costs. Systemic hypertension (SH) is the most dominant risk factor for the development of stroke. It results in left ventricular hypertrophy (LVH) which is a strong risk factor for cardiovascular events. Cardiac structural and functional abnormalities have been associated with cardioembolic stroke, which has a relatively high likelihood of recurrence, hence secondary prevention is important. Transthoracic echocardiogram (TTE) is a non-invasive procedure that can be performed to screen for cardiac structural abnormalities and sources of emboli in stroke patients.

Aim: The aim of the study was to determine the echocardiographic structural abnormalities in stroke patients.

Methods: A cross sectional study of cardiac structural abnormalities in 100 stroke patients using echocardiography was carried out. Healthy normotensive controls matched for age and sex were

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selected for comparison. Patients who were less than 40 years, hemodynamically unstable or pregnant were excluded.

Results: One hundred patients (61 males and 39 females) and 80 healthy controls (51 males and 29 females) were enrolled. There were more males than females in a ratio of 1.6:1 for the patients and 1.3:1 for the controls. Mean age of patients was 57.7 ± 8.4 years and 57.1 ± 8.8 years for controls. Mean body mass index was 27.8 ± 5.48 kg/m^2 in patients and 27.6 ± 4.72 kg/m^2 in controls. Left ventricular mass index of > 110 g/m^2 in females and > 134 g/m^2 in males was considered abnormal. The mean left ventricular mass index was higher in patients than in controls (140.3 ± 43.1 g/m^2 versus 88.1 ± 24.3 g/m^2; $p < 0.001$). Left ventricular hypertrophy was present in 60% of patients and 7.5% of controls ($p < 0.001$). Potential cardiac sources of embolism was found in 47% of the patients which includes left atrial dilatation (27%), left atrial dilatation with spontaneous echocardiographic contrast (3%), atrial fibrillation (7%), intracardiac thrombus (6%) and valvular heart disease (4%).

Conclusion: Stroke patients have a high prevalence of LVH and potential cardiac sources of embolism which can be identified by echocardiography.

Keywords: Stroke; systemic hypertension; left ventricular hypertrophy; transthoracic echocardiogram.

1. INTRODUCTION

The global burden of disease (GBD) study has estimated that the prevalence of stroke was 62 million globally in 2005 with a projected increase in burden to 67 million in 2015 and 77 million in 2030 [1]. Stroke is the second leading cause of all deaths [2] and of serious long term disability worldwide [3]. In Nigeria the prevalence of stroke is estimated to be 11.4% [4]. Systemic hypertension is a well known modifiable risk factor that plays a major role in the pathogenesis of atherosclerotic vascular disease [5] and in the development of stroke [6-8]. Systemic hypertension plays an important role in the development and progression of LVH which is a strong risk factor for cardiovascular events [9]. The development LVH significantly increases the risk of coronary artery disease (CAD), congestive heart failure (CHF), stroke, cardiac arrhythmia and sudden cardiac death [10].

Stroke caused by heart disease is primarily due to embolism of thrombotic material formed on the atrial or ventricular wall or the left heart valves and these thrombi then detach and embolize into the arterial circulation [11]. This accounts for 15% to 30% of ischemic stroke in developed countries, [12,13] while atrial fibrillation(AF) accounts for more than 50% of cardioembolic strokes [14]. Other cardiac structural and functional abnormalities that have been associated with cardioembolic stroke are left atrial (LA) dilatation, poor LV systolic function, valvular heart diseases, cardiac tumors, patent foramen ovale and atrial septal defect (ASD) [15-17]. Once stroke due to cardiac embolism has occurred, the likelihood of recurrence is relatively high, consequently secondary prevention becomes very important [18]. In patients who suffered stroke and survived, it is important to identify these possible sources of thrombus in order to reduce the risk of recurrent stroke by secondary preventive measures.

The aim of this study is to determine the echocardiographic cardiac structural abnormalities among adult patients with stroke and to compare it with that of healthy adult Nigerians in Port Harcourt, Southern Nigeria.

2. METHODOLOGY

A cross sectional study was undertaken among stroke patients admitted into both the male and female medical wards and those attending the Medical Out-Patient Department of the University of Port Harcourt Teaching Hospital. All stroke patients aged 40 years and above and were hemodynamically stable and who gave informed consent were recruited into the study. Eighty apparently healthy adults matched for age and sex were recruited for comparison. Ethical approval was obtained from the Hospital's Ethical Committee before commencement of the study. Written informed consent was obtained from all subjects and controls before enrollment into the study. Height in meters was measured using a Standiometer with subjects standing feet together without shoes or headgear, back and heel together against a vertical ruled bar to which a movable attached horizontal bar was brought to the vertex of the patients head and reading taken to the nearest 0.5 centimeter(cm). Weight was taken using a weighing scale with the subjects wearing only light clothing. The scale

used was standardized against a fixed weight every ten readings.

Body mass index was defined as weight in kilograms divided by the square of the height in meters (kg/m^2). Waist and hip circumference were measured in cm using a tape measure. Waist circumference was taken at the part of the trunk located midway between the costal margin and the iliac crests with the subject standing with feet about 25-30 cm apart. The tape was fitted snugly without compressing underlying soft tissue and circumference was measured to the nearest 0.5 cm at the end of a normal expiration. Hip circumference was taken at the level of the greater trochanters. The waist to hip ratio was calculated. The diagnosis of stroke was confirmed using neuroimaging (BRAIN CT SCAN/MRI) or the WHO stroke scoring system. Fasting blood sugar was analyzed using glucose oxidase method.

All patients and control subjects had transthoracic echocardiographic evaluation using a Mindray DC-N6 diagnostic ultrasound machine. Echocardiography was done in standard views and measurements taken in accordance with the American Society of Echocardiography (ASE) guidelines [19]. The views and measurements were undertaken by two observers conversant with echocardiographic procedures. Left ventricular mass index (LVMI) was also assessed and LVMI of >134 g/m^2 in males and >110 g/m^2 in females was considered abnormal [20]. A conventional resting 12 lead electrocardiogram (ECG) was performed on all patients and control subjects using a MAC 1200ST GE Medical Systems Electrocardiography machine. All data obtained were analyzed using SPSS version 17.0 (IBM Corporation, Armonk, NY, USA). The results are presented as means ± standard deviations, median, percentages and tables. Continuous variables were compared using the Students t-test, while categorical parameters were analyzed with the chi-square test. Relations among continuous variables were assessed using Pearson correlation test. A p-value of 0.05 or less was considered to be statistically significant.

3. RESULTS

There were 100 patients (61 males and 39 females) with a male to female ratio of 1.6:1 and 80 controls (51 males and 29 females) with a male to female ratio of 1.3:1. The age range of the patients was 40-74 years with a mean age of 57.7 ± 8.4 years. The age range of the controls was 40-75 years with a mean age of 57.1 ± 8.8 years. There was no significant difference between the mean ages of the patients and controls (p=0.65). The mean duration of stroke was 5.85 ± 3.2 months and 7% (n=7) of patients having had a stroke for 1 month or less, while 93% (n=93) have had a stroke for more than 1 month. Systemic hypertension either alone (58%) or in association with diabetes mellitus (40%) was the commonest risk factor identified for stroke in the patients studied. Other risk factors include dyslipidemia, atrial fibrillation, obesity and rheumatic heart disease (Table 1). The mean body mass index (BMI) in both groups showed that they were overweight and obese but there was no statistical significant difference between the two groups (Table 2). The mean systolic and diastolic blood pressures were significantly higher in the patients than in the controls (Table 2).

Table 1. Clustering of risk factors in the patients with stroke

Risk factors	Number (%)
SH	8 (8.0)
SH+DM+DYS+PHX+FHX	40 (40.0%)
SH+AF+DYS+OBESITY+FHX	11 (11.0%)
SH+OBESITY	2 (2.0%)
SH+DYS+SMOKING+PHX	19 (19.0%)
SH+OBESITY+FHX	18 (18.0%)
RHDX	2 (2.0%)
Total	**100 (100.0%)**

Abbreviations: SH, systemic hypertension; DM, diabetes mellitus; DYS, dyslipidemia; PHX, previous history of stroke; FHX, family history of stroke; AF, atrial fibrillation; RHD, rheumatic heart disease

The patients had a significantly thicker interventricular septal diameter in diastole (IVSd) than the controls (12.2 ± 2.2 mm versus 11.8 ± 1.4 mm, respectively; p=0.036) as shown in Table 3. The mean left ventricular posterior wall thickness in diastole (LVPWd) in the patients was 14.8 ± 3.1 mm and 13.1 ± 1.3 mm in the controls. The mean relative wall thickness (RWT) was higher in patients than controls 0.65 ± 0.17 gm versus 0.49 ± 0.12 gm, respectively; and this difference was statistically significant (p<0.001). The mean LVMI was significantly higher in patients (140.7±43.1 g/m^2) compared to controls (88.1±24.3 g/m^2; p<0.001). Sixty (60%) patients had abnormal LVMI while 6 (7.5%) controls had abnormal LVMI and this difference was statistically significant (p<0.001; Table 3).

Table 2. Demographic characteristic in subjects and controls

Variable	Subjects	Controls	p-value
Mean age (years)	57.7 ± 8.4	57.1 ± 8.8	0.618
Mean BMI (kg/m^2)	27.8 ± 5.4	27.6 ± 4.7	0.784
Mean SBP (mmHg)	156.6 ± 19.1	119.7± 13.6	<0.001
Mean DBP (mmHg)	96.5 ± 11.4	77.8 ± 5.85.4	<0.001

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 3. Indices of left ventricular structure and function in patients and controls

Indices	Patients	Controls	p value
IVSd	12.2 ± 2.2	11.8 ± 1.4	0.036
LVIDd (mm)	47.8 ± 6.9	46.2 ± 6.5	0.112
LVPWd (mm)	14.8 ± 3.1	13.1± 1.3	0.213
LA (mm)	38.2 ± 7.9	33.1 ± 4.4	<0.001
EF (%)	61.3± 10.8	63.7± 9.3	1.536
FS (%)	33.3 ± 7.7	34.9 ± 7.2	1.500
LVM (gm)	266.1 ± 87.7	166.4 ± 51.4	<0.001
LVMI (gm/m^2)	140.7± 43.1	88.1± 24.3	<0.001
RWT	0.65± 0.2	0.47± 0.6	<0.001
LVH (%)	60.0%	7.5%	<0.001

Abbreviations: IVSd, interventricular septal thickness in diastole; LVIDd, left ventricular internal diameter in diastole; LVPWd, left ventricular posterior wall thickness in diastole; LA, left atrium; EF, ejection fraction; FS, fractional shortening; LVH, left ventricular hypertrophy; LVM, left ventricular mass; LVMI, left ventricular mass indexed to body surface area; RWT, relative wall thickness

Table 4. Frequency of echocardiographic findings in study population

Echocardiographic finding	Subjects number (%)	Controls number (%)	p-value
LVH	60 (56.1)	6 (7.5)	<0.001
Dilated left atrium	27 (25.2)	1 (1.25)	<0.001
Dilated left atrium+ SEC	3 (2.8)	0	0.118
Atrial fibrillation	7 (6.5)	0	0.016
Left ventricular thrombus	4 (3.7)	0	0.070
Left atrial thrombus	2 (1.9)	0	0.203
Valvular heart disease	4 (3.8)	0	0.130
Normal finding	0	73 (91.2)	<0.001
Total	**107 (100%)**	**80 (100%)**	

Abbreviations: LVH, left ventricular hypertrophy; SEC, spontaneous echocardiographic contrast

The mean left atrial diameter (LAD) was significantly higher in the patients than controls (p<0.001; Table 2). Three patients had dilated left atrium with spontaneous echocardiographic contrast (SEC). Four (4%) of the patients had left ventricular thrombi and 2 (2%) had left atrial thrombi, while none of the controls had cardiac thrombi (p=0.084). Two (2%) of the patients had rheumatic mitral valve disease and another 2 (2%) had degenerative valvular disease (Table 4). The patients had a normal but lower mean ejection fraction and fractional shortening than the controls (61.3 ± 10.8% and 33.3 ± 7.68%, respectively; versus 63.7 ± 9.31% and 34.9 ± 7.19%, respectively. This difference was not statistically significant.

4. DISCUSSION

Systemic hypertension either alone (58%) or co-existing with DM (40%) was the commonest risk factor identified for stroke in this study. Studies among Nigerians and other populations in developed countries have shown that of the various modifiable risk factors for stroke, SH is one of the most powerful and prevalent factors for first stroke and also an independent risk factor for recurrent stroke [21,22,23]. Amu et al. [21] reported that SH and DM independently increased the risk for stroke by three-fold and the presence of both further increased the risk seven fold. Therefore every effort should be made to identify individuals at risk and treat them early.

Systemic hypertension leads to the development and progression of LVH [9]. The presence of LVH confers an increased risk for subsequent major cerebrovascular event, this evidence suggests that major cerebrovascular injury can be preceded by asymptomatic cerebrovascular damage, which parallels the onset of cardiac hypertrophy [24]. Systemic hypertension accelerates atherosclerosis in large arteries and causes hypertrophy and thickening of the media of the intracerebral vessels leading to hypoperfusion and ischemic rarefaction of white matter [24]. The reduction in cerebral blood flow can produce any degree of brain injury, from asymptomatic (silent) cerebral infarction to reversible or persistent loss of function such as TIA and stroke [24]. The stroke patients in our study had a significantly thicker IVSd compared to the controls (p=0.036) while the LVPWd is not significantly different from that of the controls (p=0.213). Abnormalities in the cardiac structure of stroke patients included a significant increase in LVMI and RWT compared to normal controls. The LVMI was increased in sixty (60%) of the patients compared to six (7.5%) controls (p<0.001). This is comparable to findings by other workers [22,25]. Left ventricular hypertrophy is mediated by mechanical stress of pressure overload and various neurohormonal substances that independently exert trophic effects on myocytes and non myocytes in the heart. Trophic factors such as angiotensin II, aldosterone, norepinephrine and insulin directly promote myocyte hypertrophy and stimulate production of cytokines and growth factors including transforming growth factor beta, fibroblast growth factor, and insulin growth factor that directly stimulate cardiac protein synthesis and hypertrophy [26].

The prevalence of LAD in the stroke patients was 30%, the left atrium was dilated in 27% of the patients compared to 1.25% of controls (p<0.001), while 3% had LAD with SEC. Nakibuuka et al. also reported a high prevalence of 48.8% of LAD in stroke patients [27]. Left atrial enlargement increases the risk of ischemic stroke by potentiating the formation of a clot in the atrial chamber that can result in thromboembolism. LA enlargement also predisposes to atrial arrhythmias, such as AF, that can result in ischemic stroke by increasing the risk of thromboembolism [28,29]. Eleven (11%) of the stroke patients in this study had AF and this is comparable to findings by other workers [27,30]. The patients with atrial fibrillation all had cerebral infarction although a previous clinical study reported a prevalence of AF in 6 (17.1%) with dysarthria clumsy hand syndrome, 79 (14.8%) of other lacunar syndromes and 493 (32%) in non-lacunar stroke [31]. Spontaneous echo contrast which is the presence of dynamic smoke-like echoes produced by the interaction of erythrocytes and plasma proteins under conditions of stasis. These patients are at particular risk of recurrent thromboembolism, as left atrial SEC is an independent predictor of LA thrombus and/or cardiac thromboembolic events [32].

The prevalence of cardiac thrombus in the stroke patients was 6%, left ventricular (LV) thrombus was found in 4% while 2% had left atrial thrombus. A previous study of 126 stroke patients by Kolo et al reported LV thrombus in 0.8% of patients, biventricular thrombus in 1.6% and 4% had LA thrombus [22]. Once stroke due to cardiac embolism has occurred, the likelihood of recurrence is relatively high for most cardio-embolic sources, consequently secondary prevention is very important. Valvular heart disease was found in 4% of the patients, however an earlier study among stroke patients in Port Harcourt, Nigeria reported that none of the patients had valvular heart disease [23]. The prevalence of valvular heart disease is comparable to findings by other workers [22,30]. The present study demonstrated a reduced EF (<55%) in 21% of patients compared to only 2.5% of controls. The finding of systolic dysfunction in stroke patients has been previously reported [33,34]. Left ventricular dysfunction promotes increased blood stasis in both the LV and LA, increasing the chance of thrombus formation and the risk of embolic stroke. Also, transient arrhythmias especially AF could also be involved in the stroke mechanism [33]. An earlier study also showed that the presence of atrial arrhythmia and sudden onset to maximal deficit were significant predictors of embolic stroke [35].

This study demonstrated that most of the study population were either overweight or obese. Thirty one (31%) patients and 18 (22.6%) controls were obese while 35 (35%) patients and 39 (48.8%) controls were overweight. Obesity and being overweight has been found to significantly increase the risk of developing insulin resistance, [36] which results in endothelial dysfunction, chronic inflammation and a prothrombotic state. Therefore, early diagnosis and more aggressive lifestyle modification will be indicated to prevent future cardiovascular events.

In our study there was a predominance of cerebral ischemia (84%) which is similar to findings from other previous studies from Nigeria and other parts of Africa. [23,27,30], Hemorrhagic stroke was found in the remaining 16%.

5. CONCLUSION

Potential cardiac source of embolism is prevalent among stroke patients in Port Harcourt, Nigeria. Systemic hypertension and DM were identified as the most important risk factors for stroke. Transthoracic echocardiogram is therefore useful in the management of adults with SH and DM to prevent the occurrence of stroke.

6. LIMITATIONS OF THE STUDY

1. Limitations of this study included its cross-sectional design as a longitudinal follow-up would have provided further data on incidence of recurrent stroke in the subjects with cardiac abnormalities.
2. Unavailability of transesophageal echocardiogram which provides a better visualization of the LA, study of the left atrial function and diagnosis of complex atheromathosis of the aortic arch which has been implicated in cerebral ischemia of unknown cause.

7. RECOMMENDATIONS

1. All subjects with stroke should be screened for cardiac sources of embolism. Transthoracic Echocardiogram should be included as part of the initial diagnostic work up in stroke patients in order to identify patients at high risk of developing cardiovascular events.
2. All subjects with SH should be screened for LVH with TTE in order to identify subjects at higher risk of developing cardiovascular events.
3. More intensive BP and blood sugar control is advocated. Obesity and dyslipidemia should also be identified and aggressively managed in patients with SH and DM as a means of reducing their overall cardiovascular risk.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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