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Research Article

Aortic Root Dilatation in African Hypertensives Subjects: Frequency of Occurrence and Associations: A Multicentre Echocardiographic Survey

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Abstract

Background and Objectives: Anecdotal reports suggest that hypertension is associated with an increased predisposition to aortic root dilatation (ARD). Reports on epidemiology of ARD and demographic or clinical associations among African hypertensive subjects are scarce. This study aimed to describe the prevalence of ARD among Nigerian hypertensive subjects.

Methods: This was a retrospective review analysis of hypertensive subjects who had echocardiography performed. ARD was defined according to three criteria using the normograms recently proposed by Devereux et al. SPSS 17.0 was used for statistical analysis.

Results: ARD was present in 34 (7.3%) vs. 10 (2.15%) vs. 12 (2.58%) using the aortic sinus index, pHeight, pBSA respectively. The frequency of ARD using any of the three parameters was 8.37% (39 subjects). ARD was significantly more common among males (31.03% of males vs. 2.84% of females. Compared to hypertensive without ARD, those with ARD were more likely to be older, had a significantly higher systolic blood pressure, left ventricular posterior and interventricular septal thickness in diastole and left ventricular mass/index. Aortic sinus index and aortic root dimension were well significantly correlated to age, systolic blood pressure, waist circumference, interventricular septal thickness in diastole, posterior wall thickness, left ventricular mass/index and height.

Conclusion: Males are more likely to have ARD than females among African hypertensive subjects. Age, systolic blood pressure and echocardiographic parameters are determinants of aortic root dimensions. ARD seems to be associated with a more likely chance of increased cardiovascular risk in African hypertensive subjects.

Keywords

Oxidative stress; Microcirculation; Endothelium

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Introduction

Hypertension remains the most common cardiovascular risk factor worldwide [1-3]. Hypertension could manifest with aortic diseases such as aortic dissection, aortic aneurysm, aortic regurgitation, ARD, aortic sclerosis and aortic artery stiffness [4,5]. Hypertension has been shown to be present in 75% of individuals with aortic dissection [6-8]. Hypertension promotes the formation of atheromatous plaques which is the underlying pathology for many of the consequent aortic root and valvular diseases [7,8]. Hypertensive subjects with additional aortic valvular diseases have been shown to have higher cardiovascular risks compared to those without concomitant aortic valvular disease [6,8]. ARD has also been shown to be associated with left ventricular diastolic function in patients with cardiovascular risk factors including hypertension [9]. Aortic valvular diseases are not exclusively associated with hypertension. Other diseases that have been associated with them include Marfans syndrome, mitral valve prolapse, congenital heart disease and storage disorders [10-12].

Previous reports have suggested that hypertension directly predispose to aortic root enlargement and aortic regurgitation [13,14]. However, some recent echocardiographic and pathological studies have linked the relationship earlier described between hypertension and aortic root diseases as only being determined by aging alone and much less significantly blood pressure [15-16]. Traditional aortic root dimension measurements is fraught with many limitations; these include intrinsic underestimation of real aortic dimension using the M mode measurements on which most of the studies in the literature were based. Overestimation is also possible due to imperfect alignment of the ultrasound beam. Also, anthropometric factors such as age, body surface area and height which are not taken into account using the absolute values considered for the definition of aortic root dimension in the literature. To overcome these limitations, newer corrections for absolute values for aortic root dimension have been proposed. With the advent of new reference values for aortic dilatation, Milan et al. recently show that that the prevalence of ARD was higher than previously reported and suggested the necessity of a correct choice of the diagnostic criterion that has to be applied in the single patient for the definition of ARD [17].

With the presence of conflicting information on the burden of ARD among hypertensive subjects among the Caucasians for which information are available, reports are very scarce on the burden of ARD among African hypertensive subjects. This study was therefore designed to describe the prevalence of ARD using newly defined normogram of aortic root dimension correction for age, gender, height and body surface area of subjects. The clinical and demographic determinants of aortic root dimension in Nigerian hypertensive subjects were also determined.

Materials and Methods

Four hundred and sixty eight consecutive hypertensive subjects who had echocardiography performed in three cardiac units by the investigators were included in this study. It was a retrospective review. Hypertensive subjects who had no complications were included in the study. Exclusion criteria include history of diabetes mellitus, stroke, pregnancy, history of physical appearance suggestive of Marfan's syndrome and congenital heart diseases.

Echocardiographies were performed at the three centers: namely Cardiac Units of the Ladoke Akintola University of Technology Teaching Hospital, Ogbomoso, Ladoke Akintola University of Technology Teaching Hospital, Osogbo and Goshen Heart Clinic, Osogbo all in South Western Nigeria. Participants were included if they were ≥18 years of age.

Clinical and demographic parameters including age, gender, weight (kilogram), height (in meters) and waist circumference were measured. The waist circumference was measured at the middle of the points between the anterior iliac spine and lowermost rib at mid-expiration with the patient in light clothing. The body mass index was derived using the formula weight/(height)^2 . Body surface area was derived using the formula of DuBois and DuBois [18,19]. Echocardiographic parameters obtained form the echocardiography done include the left ventricular end diastolic dimension(LVDD), left ventricular end systolic dimension(LVSD), Posterior wall thickness in diastole (PWTd), Interventricular septal thickness in diastole (IVSd), Ejection fraction(EF), Fractional shortening (FS), Aortic root dimension obtained at the Sinuses of Valsalva, aortic cusp separation, right ventricular end diastolic dimension and left atrial dimension.

Aortic root dimension was corrected for height and body surface area. Left ventricular mass and left ventricular mass index were calculated using the Devereux modified ASE cube formula which has been shown to correlate with necropsy findings [20].

$$LVM(g) = 0.8[1.04(IVSd+LVDD+PWTd)^3 - (LVDD)^3] + 0.6$$

ARD was defined according to three criteria using the normograms recently proposed by Devereux et al. [21]

1. Predicted-BSA (pBSA) = 2.423 + Age X 0.009 + BSA X 0.461 - 0.267 X sex + 0.261 X 1.96

2. Predicted-height (pHeight) = 1.519 + Age X 0.01 + height X 0.01 - 0.247 X Sex + 0.215 X 1.96

Sex was defined as: male = 1, female = 2.

3. Aortic sinus index(ASi) = Aortic diameter/BSA (8,21)

Aortic root dilatation was defined as ASi > 2.1 cm/m^2

ARD was defined as aortic root dimension > predicted AOD corrected for body surface area or aortic sinus index > 2.1cm/m^2. Statistical analysis was done using the Statistical Package for Social Sciences (SPSS 17.0). Data were summarized as means ± standard deviation for quantitative variables and as proportions and percentages for qualitative variables. Association between aortic root dimension and echocardiographic parameters were done using the Pearson Correlation coefficient. Regression analysis was done to evaluate the determinant of aortic root dimension among clinical, demographic and echocardiographic variables. P value <0.05 was taken as statistically significant.

Table 1: Clinical and echocardiographic parameters of study participants.

	Minimum	**Maximum**	**Mean**	**Std. Deviation**	**Skewness**	
Variables	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Age(years)	19	90	56.30	16.479	-.275	.161
Waist (cm)	54.00	133.00	94.80	14.56	.074	.193
Systolic blood pressure(mmHg)	118	226	142.51	25.156	.352	.184
Diastolic blood pressure (mmHg)	64	124	84.73	14.575	.034	.19
LVDD (cm)	3.38	7.68	4.79	.71	1.222	.160
EF(%)	35	81	58.22	11.59	-1.022	.160
IVST(cm)	.80	1.86	1.22	.20	.433	.159
PWT (cm)	.76	2.30	1.22	.194586	1.533	.160
AOD (cm)	23.40	40.80	31.68	3.58	.008	.160
ME (m/s)	0.10	1.50	.59	0.20	1.242	.161
MA (m/s)	.24	1.13	.66	0.17	.163	.163
ME_A	0.30	2.83	0.96	0.51	1.76	.163
DT (msec)	45.60	276.10	145.54	45.34	-.012	.163
IVRT (msec)	18.80	142.70	79.70	25.05	.156	.206
Body mass index(kg/m^2)	15.55	44.82	26.27	5.73	0.593	.195
LVMI (g/m^2)	60.58	250.17	124.88	39.73	0.952	.192
BODY SURFACE AREA (M^2)	1.41	2.37	1.2068	.87	-0.605	.159
AOD_HT	14.01	39.22	18.9162	2.78	3.193	.190
AOD_BSA	12.44	31.64	17.55	2.70	1.480	.194
ARD [any of three] n(%)	39(8.37%)					
ASI >2.1 cm/m (n)	34 (7.30%)					
pHeight (n)	10(2.15%)					
pBSA (n)	12(2.58%)					

SBP- Systolic blood pressure, DBP-diastolic blood pressure, IVST-interventricular septal thickness, PWTd-Left Ventricular Posterior wall thickness in diastole, LAD-left atrial dimension, BMI-body mass index, LVM(I)-left ventricular mass(index), AOD-aortic root dimension, BSA-body surface area, IVRT-isovolumic relaxation time, DT-deceleration time.

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Results

The echocardiographic, clinical and demographic parameters are as shown in Table 1. The mean age of the study participants was 56.30 ± 16.5 years. It consist of 290 males (62.2%) and 176(38.8%) females. Their age ranges between 19 and 90 years. The mean systolic and diastolic blood pressures were 142.5 ± 25.16 and 84.7 ± 14.58 mmHg respectively. The aortic root dimension ranged from 23.4 mm to 40.8 m with the mean aortic root dimension 31.68 ±3.58 mm. The mean body mass index was 26.27 kg/m2. The mean corrected aortic root dimension for height and body surface area was 18.92 ± 2.78 vs. 17.55 ± 2.70 cm respectively. ARD using any of the three criteria was present in 39 of participating subjects (8.37%) while suing the aortic sinus index was present in 34(7.30%). The frequency of occurrence using Aortic root dimension predicted for body surface area and height was 12 (2.58%) vs. 10(2.15%) respectively.

The clinical, demographic and echocardiographic differences between hypertensives with at least one positive index of aortic root dilatation compared to those with normal aortic root dimension are as shown in Table 2. Hypertensive's with ARD were more likely to be males and significantly older than those with normal aortic root dimension. The systolic and diastolic blood pressures were, though not statistically significant, higher among hypertensives with ARD than hypertensive subjects with normal aortic root dimension. The mean left ventricular mass (index) was significantly higher among hypertensive subjects with ARD compared to those without ARD. Mean left ventricular mass index among hypertensives with ARD compared to those without ARD were 231.19 ± 60.71g, 130.6 ± 48.6g/m2 vs. 207.36 ± 72.23, 118.4 ± 39.2, p<0.05 respectively.

The correlation of demographic parameters, echocardiographic and clinical with aortic root dimension, and aortic root dimension corrected for height and body surface area are shown in Table 3. Aortic root dimension was significantly correlated with age, waist circumference, systolic blood pressure, interventricular septal thickness, left ventricular posterior wall thickness and left ventricular mass (index). Aortic root dimension corrected for body surface area was significantly correlated with age, waist circumference, systolic blood pressure and body mass index as shown in Table 3. Aortic sinus index was also significantly correlated with age, waist circumference, systolic blood pressure and body mass index.

Discussion

This study shows that the prevalence of ARD in African hypertensives using the new internationally proposed normogram/diagnostic criteria is relatively low. The prevalence reported in this study is low compared to studies among Caucasians that has reported a much higher prevalence among hypertensive subjects [4,8,16-17].

Table 2: Clinical and echocardiographic parameters between hypertensive with ARD and those with normal aortic root dimension.

Variable	Hypertensives with ARD(39)	Hypertensives with normal AOD(407)	P value
Gender(M/F)	25/14	265/162	0.005*
Age (years)	63.08±12.95	55.34±16.67	0.0103*
SBP (mmHg)	148.83 ±22.95	140.87 ± 24.07	0.335
DBP (mmHg)	85.25 ± 10.98	84.30 ± 14.22	0.822
IVST (mm)	12.21 ± 1.56	12.23 ± 1.24	0.962
PWTd(mm)	12.57 ± 0.23	12.2 ±0.19	0.480
LAD (mm)	39.91 ± 7.72	39.12± 7.2	0.690
BMI (kg/m^2)	24.31 ± 2.94	26.56 ± 5.7	0.053
LVM (g)	231.19 ± 60.71	207.36 ± 72.23	0.041*
LVMI(g/m^2)	130.6 ± 48.6	118.4 ± 39.2	0.046*

* statistically significant

SBP- Systolic blood pressure, DBP-diastolic blood pressure, IVST-interventricular septal thickness, PWTd-Left Ventricular Posterior wall thickness in diastole, LAD-left atrial dimension, BMI-body mass index, LVM(I)-left ventricular mass(index).

Table 3: Correlation coefficient of clinical and echocardiographic parameters with aortic parameters.

Variable	Aortic root dimension	Aortic sinus index	pBSA
Age	0.36**	0.19*	0.19*
Waist	0.32**	-0.31*	0.31*
SBP	0.17*	0.20*	0.20*
DBP	0.07	-0.013	-0.013
IVST	0.39 **	0.096	0.096
PWTd	0.31**	0.12	0.080
LAD	0.09	0.12	0.107
BMI	0.06	-0.49	0.49*
LVMI	0.24*	0.11	0.044

*- statistically significant

SBP- Systolic blood pressure, DBP-diastolic blood pressure, IVST-interventricular septal thickness, PWTd-Left Ventricular Posterior wall thickness in diastole, LAD-left atrial dimension, BMI-body mass index, LVM(I)-left ventricular mass(index).

It is also much lower compared to similar studies that have used the conventional absolute values for aortic root dimension among Italian and Brazilian hypertensive subjects [22,23]. These new definitions have taken care of the influence of demographic parameters such as height, body surface area and gender in order to classify subjects appropriately as these parameters have been shown to significantly affect the aortic root dimension [6,8,12]. ARD is often associated with many cardiovascular risk factors such as uric acid, metabolic syndrome and carotid atherosclerosis [24,25]. Progressive ARD has been closely linked with aortic regurgitation, aortic aneurysm and dissection of aorta [26]. Recently Gardin et al. showed that ARD is a good predictor of incident heart failure, stroke, cardiovascular mortality and all cause mortality in the Cardiovascular Health Study [27]. Furthermore, Kim et al. and Cuspidi et al. showed that ARD is well correlated with many cardiac and extracardiac target organ damage among hypertensive subjects. [23,28].

This study also revealed that hypertensives with ARD were more likely to be older and males than hypertensive subjects without ARD. This is in agreement with previous studies that have suggested that ARD is closely related with increasing age and male gender [6,17]. The left ventricular mass and left ventricular mass indexes were significantly higher among hypertensive subjects with ARD than those without. Left ventricular mass is an important cardiovascular risk factor among hypertensive subjects as it predicts all cause cardiovascular risk among hypertensive subjects [3].

This study further revealed that many cardiovascular risk factors were well correlated with aortic root dimension among our hypertensive patients. They include age, waist circumference, systolic blood pressure, left ventricular septal wall thickness, left ventricular posterior wall thickness, left ventricular mass/index and height. These are important cardiovascular risk determinants among hypertensive and normotensive subjects.

Reports on the prevalence of ARD among Africans are very rare. Albeit, this is the first study which aim to determine the pattern of ARD among African hypertensive subjects using the new proposed criteria. Traditional definition of ARD has been based on the absolute cut off values which are essentially influenced by the M-mode measurement and gender. However, the finding that aortic root dimension can be affected by many anthropometric factors such as height, body mass index and body surface area makes the new criteria more relevant for epidemiologic description of ARD among our hypertensive subjects where ARD is quite important to pick early so as to prevent catastrophic consequences such as acute aortic dissection. Although, case reports of acute aortic dissection in Africans are scarce in the literature, one of the authors (AA) has had an autopsy confirmed case seen in our teaching Hospital. The use of this normogram have been associated with more accurate diagnosis of ARD and avoid over diagnosis [8,16-17].

It is therefore pertinent to note that ARD seem to be associated with more cardiovascular burden among hypertensive subjects as they are more often associated with other factors which may confer such increased CV risk status. They include obesity, left ventricular hypertrophy, increasing age, male gender, metabolic syndrome, uric acid etc. therefore hypertensive subjects with ARD should be carefully followed up for progression and early institution of appropriate therapy to prevent disastrous complications. Beta blockers and Angiotensin converting enzyme inhibitors/ Angiotensin Receptor Blockers are useful drugs in preventing further worsening of ARD [17,22,23].

In conclusion, this study showed that a comparatively low prevalence of ARD among African hypertensive subjects using the new proposed criteria/normogram, a value much less than what has been documented among Caucasians. Whether this is related to the low frequency of complications due to aortic valve disease (Acute aortic dissection) among Africans is for appropriately designed studies to look at. However, we suggest that these new criteria can be adopted for use among Africans and hypertensive subjects with ARD identified should be offered prophylactic therapy including beta blockers and ACE-I/ARBs therapy.

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