Relationship between 24-hour Blood Pressure Pattern and Left Ventricular Structure and Function in Hypertensive Nigerians

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Objective: Blood pressure variation throughout the day is known to have cardiovascular consequences. Left ventricular (LV) mass is more closely related to 24-hour blood pressure than casual blood pressure. Daytime blood pressure expectedly is higher than that of nighttime under normal circumstances. The effect of 24-hour blood pressure pattern on the left ventricular structure and function has not been examined in hypertensive Nigerians. The aim of our study was to assess the 24-hour blood pressure pattern and its relationship to the LV structure and function in newly diagnosed hypertensives in Nigeria. We hypothesized that 24-hour blood pressure was more related to left ventricular structure than casual blood pressure in hypertensive Nigerians.

Design: Cross-sectional study.

Setting: The study was carried out at the Cardiology Unit of the Department of Medicine, University College Hospital, Ibadan, South West Nigeria.

Participants: Three casual blood pressure measurements were taken, while the participants were resting, using standardized digital blood pressure machine. Mean of the 3 measurements was used to categorize the participants as hypertensives or normotensives (controls). A calibrated Schiller BR-102 ABPM machine was used to measure the 24-hour blood pressure in 210 hypertensives and 202 normotensives (controls). Daytime and nighttime systolic (SBP) and diastolic blood pressures (DBP) were acquired every 20 minutes. Left ventricular mass was indexed by the allometric power of height (height$^{2.7}$) and left ventricular hypertrophy was considered present if LVM was ≥49.2g/m$^{2.7}$ in males or ≥46.7g/m$^{2.7}$ in females.

Main Outcomes: The hypertensives and the controls were comparable in their demographic characteristics. Among the hypertensives, mean casual blood pressure and mean 24-hour blood pressure (SD) were 165(16)/96(8) mm Hg and 132(22)/84(15) mm Hg, respectively ($P<.0001$). 24-hour, day- and nighttime blood pressure were statistically related to left ventricular mass and indexed left ventricular mass in the hypertensives ($r=.40$ and .40, respectively for mean 24-hour SBP; $r=.34$ and .30, respectively for mean 24-hour DBP; $r=.33$ and .35, respectively for mean nighttime SBP, and; $r=.22$ and .24, respectively for mean nighttime DBP. The relationship was significant for mean 24-hour blood pressures but not for mean nighttime blood pressures for normal controls. There was no significant correlation between 24-hour blood pressure and indices of left ventricular function.

Conclusions: Our study has shown a stronger relationship between 24-hour mean blood pressure and left ventricular mass compared with casual blood pressure. However there is no statistical relationship between 24-hour blood pressure and indices of left ventricular systolic and diastolic function. (*Ethn Dis.* 2013;23[4]:474–479)

Key Words: 24-hr Blood Pressure, Ambulatory Blood Pressure, Left Ventricular Mass, Left Ventricular Geometry, Hypertension, Nigeria

Introduction

Blood pressure (BP) is a quantitative trait that is highly variable and is a function of the cardiac output and peripheral resistance. Hypertension is a major contributor to the rising profile of cardiovascular diseases (CVDs) globally and no meaningful control of this wave of non-communicable disease epidemic can occur without addressing it.

The heart is a major target organ for the complications of uncontrolled BP. In the absence of an underlying cardiac structural disease, high BP (hypertension) is a major contributing factor to left ventricular hypertrophy (LVH).[1,2]

The methods of blood pressure measurement have undergone tremendous advancement due to the observed short coming in the various instruments and techniques. 24-hour BP monitoring is a well recognized tool for the diagnosis and management of hypertension.[3,4] Since the introduction of ambulatory BP monitoring to medicine about three decades ago, different BP patterns have been identified and the diagnosis of hypertension made more accurately with enhancement in the care of hypertensive patients and reduction in cardiovascular morbidity and mortality from the disease. The aim of our study was to evaluate the relationship of 24-hr BP to left ventricular geometry.

Methods

Design and Setting

This was a cross sectional study carried out in the Cardiology Unit of the Department of Medicine, University College Hospital, Ibadan, South West Nigeria.

Participants

Patients with the following criteria were included: aged ≥18 years; recently

The aim of our study was to evaluate the relationship of 24-hr BP to left ventricular geometry.

diagnosed hypertensive but not on anti-hypertensive therapy; and those who gave consent to participate in the study. Potential participants who had diabetes mellitus, heart failure, or structural heart diseases were excluded. Also excluded were those with presence of other chronic diseases such as chronic obstructive pulmonary disease and chronic renal failure.

Hypertensives who exhibited reduction of both systolic and diastolic BP during the night by an average of more than 10% of the daytime pressure were considered dippers and those who did not show this drop in BP were regarded as non-dippers.

Controls

These volunteers were matched for age and sex with the hypertensives. Their BPs were <140/90 mm Hg during the screening exercises and subsequent evaluations. They met the selection criteria and were recruited from the same community as the hypertensives.

Sample Size and Ethical Approval

The minimum sample size was estimated as 140 per group based on a previous study by Chamontin et al.[5] The study was 80% powered (20% beta error) and the alpha error was set 5% (.05) Ethical clearance was obtained from the Joint Ethical Committee of the University of Ibadan and University College Hospital, Ibadan.

Clinical Evaluation

Adequate and relevant history such as alcohol consumption, cigarette smoking and other cardiovascular risk factors were obtained from the study population and all clinical information obtained on demographic variables were entered in data entry proforma. Procedure and modalities of the study were duly explained and seen to be understood by the patient, then informed consent was obtained. Physical examination was performed on all participants to exclude any co-existing medical conditions.

Systolic and diastolic BPs were measured using Omron HEM-780 premium BP monitors which were calibrated and standardized. Blood pressure was taken after 5 minutes of rest in a seated position, three separate times and the average of the last 2 readings was used for our study. Height and weight were also measured while participants were in bare feet, with no head gear, in light dressing and no objects or weights on them. Body mass index (BMI) was calculated as weight/(height)^2.

Blood Pressure Measurement

A Schiller BR-102 ABPM device was applied on the less dominant arm and BP recording taken every 20 minutes over 24 hours between 9 am–10 pm for daytime and 10 pm–9 am for nighttime. Participants were instructed to keep the arm steady while recording was in progress and to note any problem they may have during the procedure. Data obtained were analyzed with respect to average 24-hour systolic and diastolic BP, daytime systolic and diastolic BP and nighttime systolic and diastolic BP.

Echocardiography

An Aloka SSD-4000 echocardiography machine was used to assess the structure and function of the left ventricle according to the American Society of Echocardiography (ASE) criteria.[6] The echocardiography was performed with participants at rest, in the left lateral decubitus position. Two-dimensional guided M-mode measurements of the left ventricular end-diastolic dimension, interventricular septal thickness and posterior wall were done at the level of the chordae tendinae just beyond the tip of the mitral valves.

The left ventricular septum in diastole, posterior wall thickness in diastole and cavity dimensions (left ventricular internal diameter in diastole and systole) were measured using leading edge to leading edge convention at both end-systole and end-diastole.

End-diastole was measured at the beginning of QRS complex on the ECG tracing. Measurements from 3 cardiac cycles were taken and averaged.

Calculation of Derived Variables

Left ventricular mass (LVM) was calculated using the formula that has been shown to yield values closely related to necropsy LV weight (r=0.90);[7] LV mass (g) = .8 (1.04 (IVSd + LVIDd + PWTd)^3 – LVIDd^3) + .6. The LVM was indexed to the allometric power of height (height)^8 and LVH was considered present if LVM was ≥49.2g/m$^{2.7}$ in males or ≥46.7g/m$^{2.7}$ in females as documented by Adebiyi et al[9] among Nigerians. Relative wall thickness (RWT) was calculated as 2 × PWTd / LVIDd.[10] Increased RWT was considered present when RWT≥.45. Left ventricular geometry was defined using LVMI and RWT. Left ventricular systolic function was calculated by using the Teichholz formula. Fractional shortening (FS) and ejection fraction (EF) of the left ventricle were calculated using the formula: FS (%) = ((LVIDd-LVIDs)/ LVIDs) × 100; EF (%) = ((EDV-ESV)/EDV) × 100, where: LVIDd is left ventricular internal diameter in diastole; LVIDs is left ventricular internal diameter in systole; EDV is end diastolic volume, and: ESV is end systolic volume.

Data Management and Statistical Analysis

Data was entered into a Microsoft Excel spreadsheet and statistical analysis performed using SPSS 16.0 (SPSS Chicago Inc.). Continuous variables were expressed as means (SD), categorical variables were expressed as proportions. Categorical variables were compared with chi-square while means were compared with t-test. Pearson's correlation analysis was performed to test the relationship between the various BP forms and indices of left ventricular structure. A P <.05 was considered statistically significant.

Table 1.   Social characteristics of hypertensives and normotensives (controls)

Variables	Hypertensive (*n*=210)	Control (*n*=202)	*P*
Sex			
Male	100 (47.6%)	100 (49.5%)	NS
Female	110 (52.4%)	102 (50.5%)	NS
Age, years (SD)	46.05 (12.2)	44.30 (12.5)	.036
Weight, kg (SD)	73.65 (13.1)	69.40 (13.8)	.022
Height, cm (SD)	167.40 (8.7)	166.9 (7.8)	.586
BMI (SD)	26.30 (4.6)	24.90 (14.0)	.004
Casual BP			
SBP, mm Hg, (SD)	165.1 (15.6)	127.7 (11.2)	<.0001
DBP, mm Hg , (SD)	95.5 (8.0)	75.6 (8.7)	<.0001
Number of ABP measurements			NS
Total, (SD)	64.8 (20.4)	66.3 (20.5)	
Daytime, (SD)	36.4 (12.8)	37.0 (11.4)	
Nighttime, (SD)	28.7 (15.9)	29.1 (18.5)	
Cigarette smoking (>5 sticks/day)	12 (5.7%)	17 (8.4%)	NS
Alcohol consumption			
(>15u/wk in females, >20u/wk in males)	57 (27.1%)	47 (23.3%)	NS
Added salt to meals	134 (63.8%)	59 (29.2%)	<.0001
Family history of hypertension	16 (7.6%)	16 (7.9%)	NS

SD= standard deviation.
Data are *n* unless indicated otherwise.

RESULTS

Baseline Demographic and Clinical Characteristics

A total of 412 participants were studied: 210 newly diagnosed hypertensives and 202 normotensive controls. (Table 1) The mean age (SD) of the participants was 46.1 (12.2) years and 44.3 (12.5) years for the controls. The sex distribution was similar for the participants and controls. The mean BMI (SD)of the hypertensives was 26.30 (4.57) whereas it was 24.90 (14.0) in the normotensive group *P*=.004. The participants were predominantly housewives, traders and civil servants. Addition of salt to meals was more common among the hypertensives than controls. As expected, the casual BP was higher in the hypertensives than in the normotensive controls.

24-hour Blood Pressure and Echocardiographic Characteristics of Hypertensives and Controls

The different 24-hour BP characteristics between the hypertensives and the controls are depicted in the Table 2. The differences in left ventricular parameters of hypertensives and controls are shown in Table 3. The left ventricular geometry in most hypertensives was concentric hypertrophy while most normotensives expectedly had normal left ventricular geometry. No statistically significant differences were noted between the LV diastolic indices of the hypertensives and the controls. Table 4 shows the strong correlation that exists between the main indices of LV structure and function and the mean 24-hour BP. Left ventricular dimensions, cardiac output and LVM were generally higher in the hypertensives than in the controls. In a multiple regression analysis, the total

Table 2. Twenty-four hour blood pressure characteristics of hypertensives and controls

Variables	Hypertensives (*n*=210)	Controls (*n*=202)	*P*
Average 24hr BP, mm Hg (SD)			
Systolic	131.7 (22.6)	111.8 (13.1)	.000[a]
Diastolic	83.6 (14.9)	69.9 (10.0)	.000[a]
Daytime BP, mm Hg (SD)			
Systolic	134.6 (21.9)	115.3 (14.8)	.000[a]
Diastolic	87.2 (13.4)	72.8 (9.3)	.000[a]
Nighttime BP, mm Hg (SD)			
Systolic	124.4 (30.6)	104.1 (24.9)	.000[a]
Diastolic	77.62 (19.56)	63.9 (17.0)	.000[a]
Heart rate, BPM (SD)			
Mean 24-hr	73.0 (9.0)	70.4 (8.2)	.003[a]
Daytime	76.56 (10.48)	73.5 (8.8)	.001[a]
Nighttime	68.1 (14.2)	63.3 (15.3)	.001[a]

[a] Statistically significant.
BP, blood pressure; hr, hour; BPM, beats per minute.

Table 3. Echocardiographic characteristics of hypertensives and controls

Variables	Hypertensives	Controls	*P*
Aorta, cm	3.0 (.3)	2.8 (.3)	.001[a]
LA, cm	3.9 (.5)	3.6 (.5)	<.0001[a]
IVSTd, cm	1.1 (.2)	.9 (.1)	<.0001[a]
PWTd, cm	1.1 (.2)	.9 (.1)	<.0001[a]
LVIDd, cm	4.8 (.4)	4.5 (.5)	<.0001[a]
LVIDs, cm	3.0 (.4)	2.8 (.5)	.001[a]
FS, %	38.7 (6.3)	39.2 (6.6)	.574
EF, %	68.4 (8.1)	69.2 (7.8)	.462
CO	5.5 (1.6)	4.8 (1.5)	.001[a]
LVM, g	202.1 (48.4)	140.8 (33.9)	<.0001[a]
LVMI, g/m	50.3 (11.6)	35.5 (8.6)	<.0001[a]
Relative wall thickness	.5 (.1)	.4 (.1)	
Mitral a, vel	.7 (.2)	.6 (.2)	.869
Mitral e/a	1.0 (.4)	1.31 (.5)	.159
DT, ms	205.8 (35.6)	202.1 (29.3)	.410
LV geometry normal	16 (15.2%)	57 (60%)	
Concentric remodeling	27 (25.7%)	26 (27.4%)	
Eccentric hypertrophy	18 (17.1%)	8 (8.4%)	
Concentric hypertrophy	44 (41.9%)	4 (4.2%)	

[a] Statistically significant.

LA, left atrium; IVSTd, interventricular septal thickness in diastole; PWTd, posterior wall thickness in diastole; LVIDd(s), left ventricular internal diameter in diastole (systole); FS, fractional shortening; EF, ejection fraction; LVM(I), left ventricular mass (index); CO, cardiac output.

Values in parenthesis are standard deviation unless indicated otherwise.

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of hypertension in those communities.[17] Lifestyle and dietary habits have been recognized as major contributors to cardiovascular well-being. The association between obesity and hypertension as well as other CVDs is well recognized.[18–22] In our study the mean BMI (SD) of the hypertensives was 26.30 (4.57) whereas it was 24.90 (14.0) in the normotensive group, *P*=.004.

Casual Blood Pressure and Left Ventricular Mass

The relationship between casual BP and LVM has been investigated by Devereux,[23] Rowland,[24,25] Drayer,[26–28] and Verdecchia.[29,30] We found the correlation coefficient between casual BP and LVM were similar to the findings by Verdecchia and Rowlands whereas Devereux had a lower result as against the higher ones found by

mean 24-hour SBP was only significantly related to the LV septal wall thickness (Beta=.323, *P*=.002).

DISCUSSION

Our study demonstrated the usefulness of ambulatory BP monitoring for proper diagnosis of hypertension and evaluation of its relationship with left ventricular geometry in native Africans where such data is lacking.[3–4,11–16] O'Brien had posited that it would be a great error to manage hypertension without 24-hour BP monitoring.[3] Our study supports this view as many of the participants whose BP was elevated during the screening processes were subsequently found to have normal BP.

In a study carried out by Kadiri et al, it was established that the encroachment of a Western life style to rural communities in Africa increased the prevalence

Table 4. Correlation of BP patterns to derived echocardiographic data of hypertensives and controls

Variables	Hypertensive				Controls			
	LVM	LVMI	RWT	EF	LVM	LVMI	RWT	EF
Casual SBP, mm Hg	.094	.049	.271[a]	.242	.126	.152	.010	.037
Casual DBP, mm Hg	.051	.021	.204	.156	.089	.136	.061	.037
Mean 24-hr SBP, mm Hg	.395[a]	.401[a]	.182	.051	.397[a]	.370[a]	.038	−.053
Mean 24-hr DBP, mm Hg	.342[a]	.298[a]	.198	.109	.326[a]	.331[a]	.034	.073
Daytime SBP, mm Hg	.384[a]	.408[a]	.196	.038	.333[a]	.295[a]	.106	.116
Daytime DBP, mm Hg	.340[a]	.312[a]	.206	.091	.258[a]	.266[a]	.066	.034
Nighttime SBP, mm Hg	.331[a]	.354[a]	.223[a]	.006	.060	.117	.038	.092
Nighttime DBP, mm Hg	.273[a]	.242[a]	.239[a]	.090	.053	.079	.032	.150

[a] Statistically significant.

LVM(I), left ventricular mass (index); RWT, relative wall thickness; EF, ejection fraction; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Drayer. The findings in our study were similar to those of Devereux as casual BP showed poor correlation with LVMI (Table 4).

Casual systolic BP showed significant correlation with EF in hypertensive but not in the controls. This supports the possibility of increased sympathetic drive producing increased demand on the heart as being responsible for white-coat hypertension and this may not necessarily translate to LV structural changes at an early stage.[31–33] Therefore accurate assessment of the relationship between hypertension and LV structure can best be done with ABPM.

Day- and Night-time Blood Pressure and Left Ventricular Mass

Some researchers have reported that daytime BP showed closer correlation with LVM than nighttime BP while others argue that daytime and night time BP showed equal correlation to LVM.[23,30] Our study showed that the entire 24 hour BP profile was significantly higher in the hypertensives than normotensives and that this correlated with the LVM and LVMI (Table 4).

The clinical implication of nighttime BP has been of great interest to researchers. In the Ohasama study it was noted as a prognostic factor even in the normotensives, however, other studies were equivocal.[34–37] The statistically significant differences between the night time BP profile of hypertensives and normotensives, as widely reported in the literature, was also demonstrated in our study.

Blood Pressure Patterns and Systolic and Diastolic Function

Systolic dysfunction is well recognized as one of the late complications of hypertension after diastolic dysfunction.[38,39] In our study, systolic function did not show significant differences in the participants. The statistically insignificant effect of the BP patterns on the systolic function could be explained by the selection of our participants as those

with symptoms of heart failure were excluded.

The pattern of the 24-hour BP profile favors preserved left ventricular functions since dysfunction follows uncontrolled hypertension over a long time or sudden assault on the myocardium as occurs in coronary artery diseases which may not have yet occurred in our study population.

The results of diastolic function evaluation in our study show that peak left ventricular filling (E-wave), mitral a wave, E/A ratio and deceleration time, (diastolic velocity) were not significantly different for the groups. This insignificant difference may be due to differences in left ventricular geometric pattern following hypertension which could cancel out the effects of the morphologic changes on the functions; this has been demonstrated in other studies.[9,40,41]

Limitations of Our Study

Our study population was from an urban area where the influence of environmental factors on BP could not be completely eliminated. This was a hospital-based study, which is not very representative of the ideal ambulatory BP. The cases and controls were also not well matched.

The majority of our participants were predisposed to a sedentary lifestyle as housewives, civil servants and traders constituted a large proportion of the sample. Although less than 10% of the study population admitted to sleep disturbance, an objective monitoring would have been more useful. The device compensated for disturbances by repeat measurements which disrupted the set measurement intervals in some patients.

Some indices of left ventricular function could not be evaluated, for example midwall shortening fraction and circumferential end systolic stress, which have been shown to be better

indices for left ventricular systolic function than myocardial shortening fraction. Other diastolic indices and isovolumic relaxation time would have been additional support for the assertions concerning the diastolic functions in the sub-groups.

CONCLUSIONS

Our study has shown a stronger relationship between 24-hr mean BP and LVM compared with casual BP. However there is no statistical relationship between 24-hr BP and indices of LV systolic function.

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