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(Research Article)

Evaluation of the inter-arm blood pressure difference in subjects with hypertension in Nnewi North Local Government Area, Anambra state

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Abstract

Hypertension is defined as a sustained elevated blood pressure with a systolic blood pressure (SBP) of 140mmHg or more and a diastolic blood pressure of 90mmHg or more. The evaluation of the inter-arm blood pressure difference in subjects with hypertension in Nnewi North Local Government Area, Anambra state was done via sampling techniques. The study population was obtained using convenience sampling method and comprised of male and female hypertensive patients aged 25 to 90 years, from the cardiology unit NAUTH Nnewi. Normotensive subjects of the same age range and gender were used as control. The sample size was determined to be 70 subjects using this formula: n= (z2pq)/d2). The result of the finding showed that there was a significant increase in the mean age when the control was compared to the hypertensive group, and no significant difference in their weight, height and BMI. Furthermore, the findings of this research also supported a significant increase in the left arterial systolic and diastolic blood pressure in the control compared to the hypertensive groups. Also, the mean right systolic and diastolic blood pressure showed a significant increase when the control was compared to the hypertensive group. The inter-arm systolic and diastolic blood pressure had no significant difference when control was compared to the hypertensive group.

Keywords: Inter-arm; Blood pressure; Hypertension; Systolic and diastolic blood pressure

1. Introduction

One often measured clinical metric used in patient assessments is blood pressure. It is the force that blood applies laterally to the walls of arteries as a result of the blood vessel muscles contracting and relaxing. Clinicians can learn more about a patient's baseline cardiovascular status by measuring it (Madubuagwu et al., 2018). For survival, blood pressure must remain normal. Oxygen and nutrients would not reach the tissues and organs without the pressure that compels blood to circulate throughout the circulatory system (MacGill, 2019).

Hypertension is defined as a sustained elevated blood pressure with a systolic blood pressure (SBP) of 140mmHg or more and a diastolic blood pressure of 90mmHg or more (Chobaian *et al.*, 2003). It is a leading risk factor for cardiovascular diseases worldwide with relatively higher number of cases in low and middle – income countries including Nigeria (Adeloye *et al.*, 2021). According to Kearney *et al.* (2005), it is estimated that 26% of the world's population (972 million people) have hypertension and that the prevalence is expected to increase to 29% by 2025 especially in low- and middle-income countries. According to Mills, Stefanescu, and He (2020), the high prevalence of hypertension has emerged as a significant public health issue and is the primary cause of cardiovascular illness and early death globally. It has been seen that hypertension causes the heart to adapt structurally and functionally. These adaptations include the development of myocardial fibrosis and microvascular endothelial dysfunction, which together

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lead to left ventricular hypertrophy, diastolic dysfunction, and eventually heart failure. An accurate measurement of blood pressure is essential for the early diagnosis of hypertension and proper treatment (Balushi, Jahan, Jahdhami and Bhargava, 2018). International guidelines recommend that blood pressure should be checked in both arms during the first visit, after which subsequent monitoring of the blood pressure should be done with the higher reading arm (National Institute for Health and Care Excellence (NICE), 2019; Whelton et al., 2018; Williams et al., 2018). It is crucial to measure blood pressure in both arms during the initial visit to avoid misdiagnosing hypertension because there are typical variations in blood pressure between the two arms. (Sharma and Ramawat, 2016). The last ten years have seen an increase in interest in measuring blood pressure in both arms due to inter-arm blood pressure difference. An inter-arm blood pressure difference of a few millimeters of mercury is normal, but any difference more than 10 mmHg could significantly increase the risk for adverse cardiovascular outcomes especially in previously diagnosed hypertensive or vascular disease patients (Do, Raiciulescu and Leggit, 2019; Ojo *et al*., 2020).

Aim

The aim of this study was to evaluate the inter-arm blood pressure difference in subjects with hypertension in Nnewi North Local Government Area of Anambra state.

1.1. Study area

This study was conducted at Nnamdi Azikiwe University Teaching Hospital Nnewi in Nnewi North Local Government Area, Anambra state, Nigeria. Nnewi comprises of four autonomous villages: Otolo, Umudim, Nnewichi and Uruagu. Nnewi is the second largest city in Anambra State and is popularly known for its high commercial activity. It has an estimated population of 391,227 people according to the Nigerian census of 2006. The city spans over 1,076.9 square meters (2,789km^2) in Anambra state, which is in the Southeastern part of Nigeria and is located between latitudes 6˚017´N and 6˚1´N and longitudes 6˚55´E and 6˚917´E.

2. Material and method

2.1. Materials used

- Stadiometer
- Two Digital sphygmomanometers (Omron M1 Basic)
- Recording files

2.2. Sampling technique

The study population was obtained using convenience sampling method and comprised of male and female hypertensive patients aged 25 to 90 years, from the cardiology unit NAUTH Nnewi. Normotensive subjects of the same age range and gender were used as control.

2.3. Sample size

The sample size was determined using the formula: $n= (z^2pq)/d^2$

Where d= level of precision required 5% (0.05)

z is the standard normal deviate at 95% confidence level= 1.96

p is the proportion of persons in the population with factors under study that is, the proportion of respondents in previous Nigerian studies with IAD ≥ 10 mmHg which is 0.043 (Ojo *et al*., 2020)

And q is 1- p = 1- 0.043 = 0.957

n= (z2pq)/d2

n= (1.96)2 x 0.043 x 0.957/ (0.05)2

= 3.8416 x 0.0412/ 0.0025

= 0.1581/0.0025

n= 63.24

However, 10% attrition rate of sample size is 10/100 x 63.24

= 6.32

Therefore, total sample size= 63.24 + 6.32 = 69.56

= 70 subjects

However, 74 subjects were recruited over a period of four months, using convenience sampling technique, 33 hypertensive subjects with complete data were used for the study while 32 normotensive subjects were used as control.

2.4. Ethical clearance/ Informed consent

Ethical clearance was sought and obtained from the Ethics Committee Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus before the commencement of the research. The research procedure was thoroughly explained to the participants and each voluntarily signed an informed consent form in line with the human research ethics guidelines.

2.5. Inclusion and Exclusion Criteria

Apparently healthy adults aged 20 – 90 years who have been previously diagnosed of hypertension for about one to twenty years were included in the study, while apparently healthy adults of the same age range without a prior history of hypertension were selected as controls.

Pregnant women, children, people with one arm, or with an upper limb deformity were excluded from the study population. People with other acute or chronic diseases aside from hypertension, such as diabetes mellitus, malignancies, thyroid disease, congestive cardiac failure or cardiomyopathies were also excluded from the study population.

2.6. Laboratory procedure

2.6.1. Data Collection

Data was obtained from subjects who were eligible for the study. Biodata and medical history were obtained from each subject.

2.6.2. Body Weight and Height Measurements

The subjects were asked to stand on a stadiometer on bare feet with minimal clothing. The weight was measured in kilograms, and height was measured in meters avoiding error due to parallax. Body Mass Index of the subjects was calculated using the formula; BMI=Weight (Kg)/Height (m2) and stratification based on the World Health Organization (WHO) classification of BMI was used: underweight (BMI <18.5kg/m^2), Normal 18.5-24.99kg/m^2, Overweight 25.0-29.99kg/m^2, and obese ≥ 30.0kg/m^2 (Kifle *et al.*, 2021).

2.6.3. Blood Pressure (BP) Measurement

BP measurement was taken after each subject had rested for five minutes. The subjects were made to sit comfortably on a chair with back support and both feet flat on the floor. The appropriately sized BP cuff was applied 2.5 centimeter above the ante-cubital fossa. BP was measured thrice, simultaneously on both arms using the digital sphygmomanometer, being the most widely acceptable for research purposes (Clark and Aboyans, 2015; Clark, 2017). The average of the three readings was taken, then the difference between the average systolic BP and diastolic BP in the left and right arms was calculated. BP was measured in the normal and hypertensive subjects.

2.7. Statistical Analysis

Data was collated and managed in Microsoft Excel sheet and was analyzed using the Statistical Package for Social Sciences (SPSS) software version 25. The results were presented as mean and standard error of mean. Independent samples t-test was used for comparison of the results, one-way analysis of variance (ANOVA) followed by post Hoc Fishers Least Significant Difference (LSD) test was used for multiple comparisons. The results were considered statistically significant at p≤0.05.

3. Results

Table 1 Demographic data of the subjects

Health status	Age(years) MEAN±SEM	Weight(Kg) MEAN±SEM	Height(m) MEAN±SEM	BMI(kg/m2) MEAN±SEM
Male				
Control n=14	45.43±4.23	81.07±6.19	1.72±0.02	27.24±1.61
Hypertension n=17	62.47±4.17*	83.76±4.72	1.65±0.01	30.55±1.52
Female				
Control n=18	44.88±3.48	66.05±2.97	1.63±0.01	24.69±1.10
Hypertension n=16	58.12±2.75*	77.25±4.40*	1.56±0.02*	31.29±1.70*

Data was analyzed using one-way ANOVA followed by post Hoc Fishers LSD multiple comparison, and data were considered significant at $p \leq 0.05$, *: significant when compared to the control group,

Table 1 result showed that there was a significant difference in age of hypertensive male subjects when compared to the age of the control group. There was a significant difference in age of hypertensive females when compared to the age of the control group.

There was a significant difference in weight, height and BMI of hypertensive female subjects when compared to the weight, height and BMI of the control female subjects

Table 2 Comparisons between right and left systolic and diastolic blood pressure among male subjects

	Right arm	Left arm	P-value	T-value
	MEAN±SEM	**MEAN±SEM**		
Control n=14				
MASBP (mmHg)	125.33±2.14	123.17±2.31	0.498	0.687
MDBP (mmHg)	77.15±2.39	77.59±2.05	0.890	-0.140
Hypertension n=17				
MASBP (mmHg)	151.90±6.30	147.88±6.01	0.648	0.461
MDBP (mmHg)	90.67±4.26	91.13±4.17	0.938	-0.079

Data was analysed using independent samples t- test and values were considered significant at $p<0.05$. MASBP: mean arterial systolic blood pressure, MDBP: mean diastolic blood pressure.

Table 2 result showed that there were no significant differences between the arterial blood pressure of the right and left arms of all the male subjects.

Table 3 Comparison between right and left systolic and diastolic blood pressure among female subjects

	Right arm	Left arm	P-value	T-value
	MEAN±SEM	**MEAN±SEM**		
Control n=18				
MASBP (mmHg)	118.20±2.78	117.07±2.64	0.772	0.292
MDBP (mmHg)	75.83±1.57	77.07±2.06	0.639	-0.483
Hypertension n=16				
MASBP (mmHg)	135.97±4.45	135.17±4.49	0.648	0.128
MDBP (mmHg)	89.37±2.65	90.10±2.81	0.938	-0.189

Data was analysed using T-paired independent test and values were considered significant at *p<0.05*. MASBP: mean arterial systolic blood pressure, MDBP: mean diastolic blood pressure.

Table 3 showed no significant differences between the arterial blood pressure of the right and left arms of all the female subjects.

Table 4 Comparison of demographic characteristics between control and hypertensive male subjects

Variables	Control	Hypertensive	P-value	T-value
	MEAN±SEM n=14	**MEAN±SEM n=17**		
Age (Years)	45.42±4.23	62.47±4.17	0.01*	-2.84
Weight (Kg)	81.07±6.19	83.76±4.72	0.73[a]	-0.35
Height (meter)	1.72±0.02	1.65±0.01	0.06[a]	1.94
Body mass index (kg/m2)	27.25±1.61	30.55±1.52	0.15[a]	-1.48

Data was analysed using independent T-test and values were considered significant at *p<0.05*, SEM: standard error of mean, *: significance, a: not significant

Table 4 result showed a significant increase in the mean age when the control was compared to hypertensive group, and no significant difference in their weight, height and BMI.

Table 5 Comparison of demographic characteristics between control and hypertensive female subjects

Variables	Control	Hypertensive	P-value	T-value
	MEAN±SEM n=18	**MEAN±SEM n =16**		
Age (Years)	44.88±3.48	58.12±2.75	0.01*	-2.93
Weight (Kg)	66.00±2.97	77.25±4.40	0.04*	-2.15
Height (meter)	1.63±0.01	1.56±0.01	0.00*	3.50
BMI (kg/m2)	24.69±1.10	31.29±1.70	0.00*	-3.31

Data was analysed using independent T-test and values were considered significant at *p<0.05*, SEM: standard error of mean, *: significance, a: not significant

Table 5 result showed that the hypertensive females had a significantly higher mean age, weight, and BMI when compared to control group, and were significantly shorter than the control female group.

Table 6 Comparison of blood pressure parameters of control and hypertensive male subjects

Variables	Control	Hypertension	P-value	T-value
	MEAN±SEM n=14	**MEAN±SEM n=17**		
Mean left arterial systolic blood pressure (mmHg)	123.17±2.31	147.88±6.01	0.00*	-3.54
Mean left diastolic blood pressure (mmHg)	77.59±2.05	91.13±4.17	0.01*	-2.72
Mean right arterial systolic blood pressure (mmHg)	125.33±2.14	151.90±4.17	0.00*	-3.67
Mean right diastolic blood pressure (mmHg)	77.15±2.39	90.04±4.27	0.01*	-2.76
Inter-arm Systolic blood pressure difference (mmHg)	-2.17±1.02	-4.02±1.26	0.27[a]	1.11
Inter-arm Diastolic blood pressure difference (mmHg)	0.44±1.21	0.47±1.01	0.98[a]	-0.02

Data was analysed using independent T-test and values were considered significant at *p<0.05*, SEM: standard error of mean, *: significance, a: not significant

Table 6 result revealed a significant increase in the left arterial systolic and diastolic blood pressure in the control compared to hypertensive groups. Also, the mean right systolic and diastolic blood pressure showed a significant increase when the control was compared to hypertensive group. The inter-arm systolic and diastolic blood pressure had no significant difference when control was compared to hypertensive group.

Table 7 Comparison of blood pressure parameters of control and hypertensive female subjects

Variables	Control	Hypertension	P-value	T-value
	MEAN±SEM n=18	**MEAN±SEM n=16**		
Mean left arterial systolic blood pressure (mmHg)	117.44±2.57	135.16±4.49	0.00*	-3.52
Mean left diastolic blood pressure (mmHg)	76.92±1.93	90.10±2.81	0.00*	-3.93
Mean right arterial systolic blood pressure (mmHg)	118.20±2.78	135.97±4.45	0.00*	-3.46
Mean right diastolic blood pressure (mmHg)	75.83±1.57	89.37±2.63	0.00*	-4.50
Inter-arm Systolic blood pressure difference (mmHg)	-0.75±1.00	-0.81±0.90	0.96[a]	0.04
Inter-arm Diastolic blood pressure difference (mmHg)	1.09±0.84	0.72±0.96	0.78[a]	0.28

Data was analysed using independent T-test and values were considered significant at *p<0.05*, SEM: standard error of mean, *: significance, a: not significant

Table 7 result revealed a significant increase in the left arterial systolic and diastolic blood pressure in the control compared to hypertensive groups. Also, the mean right systolic and diastolic blood pressure showed a significant increase when the control was compared to hypertensive group. However, there was no significant difference in the inter-arm systolic and diastolic blood pressures between the control and hypertensive female subjects.

4. Discussion

Studies have shown that variations in blood pressure between the arms of more than 10 mmHg are linked to an increased risk of cardiovascular events, including death and cerebrovascular accidents. Clinicians in Nigeria still do not routinely take blood pressure in both arms, especially while treating hypertension patients. The study's demographic characteristic results indicated that the male hypertensive participants were older (45.42±4.23/62.47±4.17, p=0.01) than the control group. Additionally, the female hypertensive patients were older (44.88±3.48/58.12±2.75, p=0.01) than the control group. This may be explained by the general understanding that older people are more likely to have hypertension, and that studies have shown a linear increase in systolic blood pressure with age beyond 30 to 40 years, which peaks in late life (Cheng et al., 2022). The female hypertensive subjects were found to be shorter than the control female group and this finding seems in agreement with the finding of Islam *et al.* (2020) in which systolic BP was observed to decrease linearly with increasing height among only females in Bangladesh, although, no association was found between height and prevalence of hypertension. Also, in this study, the hypertensive females were shorter than the hypertensive males. This is possibly because women who are naturally shorter than men also have a smaller caliber of coronary arteries than the males. Shorter individuals have been noted to have shorter arterial length which predisposes them to hypertension (Islam *et al.* 2020). Meanwhile, Shimizu *et al.* (2022) observed an inverse association between height and incident hypertension in only males in their study and that baseline hypertension was positively associated with height loss for men but not for women, though this may be overlooked because the males (8342) in their study far outnumber the females (2812). However, the study done by Song *et al.* (2016) found an inverse association between height and systolic blood pressure in both males and females among middle aged and older Chinese population aged 37 to 94 years. These studies suggest that shorter individuals are more at risk of developing hypertension as they get older. The hypertensive females also had higher mean weight and BMI than the control group and were obese (31.29±1.71/24.69±1.10, p=0.00). The hypertensive males were also obese (BMI 30.55±1.52) even though their BMI was not significant when compared to that of the control male group. This corresponds with the result of a study done in Nigerian by Emiloju, Chinedu, Onuoha and Iheagwam (2018) in which over 75% of the hypertensive subjects studied were overweight or obese. It also agrees with the findings in a study done at China by Xiao, Wang, Sa, Qiu, and Liu (2019) in which the prevalence of hypertension increased as BMI increased suggesting that body weight and BMI could be important factors in the development of hypertension.

The mean diastolic and mean systolic arterial blood pressures in the hypertensive male and female subjects did not differ significantly, which is consistent with the results of a study conducted by Igbokwe et al. (2017) with a younger age group (16–24 years old). Though the prevalence of significant IASBPD and IADBPD in the hypertensive subjects was not significant, the author disagrees with the findings of a cross-sectional study conducted by Ojo et al. (2020) among 186 unselected subjects with a mean age of 48.16±14.59 years. In this study, the right arm's mean systolic blood pressure readings were significantly higher than the left arm's.

5. Conclusiotn

In conclusion there was no significant difference between the right and left mean arterial systolic blood pressure and mean diastolic blood pressure in the hypertensive subjects, which implies that inter-arm blood pressure difference may not be as pronounced as it has been in other studies, if it is assessed in both arms simultaneously. This study recommends that inter-arm blood pressure difference should be routinely assessed simultaneously using validated digital sphygmomanometer when a patient is being assessed for hypertension to avoid over diagnosis of an interarm blood pressure difference.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.”

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