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Research Article

Inter-Arm Blood Pressure Difference Among Nigerian Primary Care Patients—the Need for Dual Arm Blood Pressure Measurement

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ABSTRACT

Background: For many decades, hypertension guidelines have recommended dual-arm blood pressure measurement. However, the practice is poor in Nigerian primary care and its significance largely unidentified. Hence, the need to determine the significance of detecting inter-arm blood pressure difference among primary care patients in our local population. This study was done to determine the point prevalence of inter-arm blood pressure difference and its relationship with hypertension and diabetes mellitus.

Methods: A cross-sectional study was conducted among 214 respondents at the general outpatient clinic of a tertiary hospital in Nigeria. Demographic characteristics and anthropometric indices were obtained. Blood pressure readings were obtained through sequentially repeated measurements in respondents' arms.

Results: One hundred and eighty-six respondents had complete data given a completion rate of 86.9%. Systolic blood pressure was higher on the right and left arm in 102 (54.8%) and 56 (30.1%) of the respondents respectively. Diastolic blood pressure was higher on the right and left arm in 73 (39.2%) and 63 (33.9%) of the respondents respectively. The overall prevalence of significant systolic inter-arm difference ($\geq$ 10 mmHg) and diastolic inter-arm difference ($\geq$ 10 mmHg) were 24.2% and 18.8% respectively. Significant systolic inter-arm difference (p=0.033) and diastolic inter-arm difference (p=0.01) were significantly more among respondents with hypertension and/or diabetes mellitus.

Conclusion: The blood pressure readings in both arms were different among majority of the respondents, being higher on the right arm in more of them. The prevalence of significant inter-arm difference was high in the unselected primary care patients studied especially among patients with hypertension and/or diabetes mellitus. Blood pressure measurement in both arms should become a routine practice during initial patients' visits in primary care.

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Introduction

Blood pressure (BP) is the most widely measured medical metric in primary care [1]. Accuracy in its measurement is vital to prevent mismanagement of patients. This is particularly important during patients' initial visits because the decision to commence anti-hypertensives or not depends on accurate BP measurement. Aside from the human and instrument-related errors that may affect BP measurement, acknowledgement of the fact that patients may have different blood pressures in both arms (inter-arm difference) is essential for the accurate diagnosis and continuous management of hypertension in primary care. This formed the basis for the advocacy by various hypertension guidelines for sequential or simultaneous BP checks in both arms at the initial patients' visits and the use of the arm with a higher reading for immediate and subsequent clinical judgements [2-4].

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The measurement of BP in both arms has received growing attention in the last decade because inter-arm difference has also been associated with peripheral vascular disease, increased cardiovascular and all-cause mortality [5-7]. An IAD of a few millimetres of mercury (mmHg) are quite normal, but any difference more than 10 mmHg could significantly increase the risk for adverse cardiovascular outcomes [5-7].

Unfortunately, these research findings have largely not translated into an expanded routine dual arm BP measurement in Nigerian primary care settings [8, 9]. Reports have shown that BP measurements at initial clinic visits in Nigerian primary care settings are taken using one arm [8, 9]. Although, there had been no previous research on why health care workers do not follow dual arm BP measurement, an anecdotal report has suggested time constraints and lack of awareness.

Majority of the studies on inter-arm BP difference were done in the developed world among respondents with or without cardiovascular risk factors [1, 5-7, 10, 11]. The few Nigerian studies were among secondary care patients and they pointed in no direction [8, 9, 12]. The true prevalence of IAD in Nigerian primary care settings is unknown. The paucity of studies on this subject among Nigerian primary care patients may be one reason why Nigerian primary care health workers have not adhered to dual arm BP measurement. A review of major guidelines on BP measurement by Parker *et al.* showed that most General Practitioners are aware of the recommendations to measure BP in both arms at initial visit, but they are wary of the recommendations unless justification together with evidence is provided on the importance of detecting IAD [13]. Perhaps, a study on this theme among primary care patients in Nigeria may give more insights on this topic and sensitize Nigerian General Practitioners and other primary care health workers on the relevance of dual arm BP measurement. This prompted the investigators to carry out this study among a heterogeneous general practice population in Nigeria. This study was done to determine the point prevalence of IAD and its relationship to hypertension and diabetes.

Materials and Methods

I Study Setting

This study was carried out in the General outpatient clinic (GOPC) of the Family Medicine department of a tertiary hospital in South-West Nigeria. All adult patients excluding those who need emergency treatment are first seen at the GOPC, where diagnoses are made. Patients who require primary care are managed and followed up in the clinic, while those who need further care are referred to the appropriate linear specialist clinics. The GOPC attendance was 14,016 adult patients in the year 2016 and this translates to a monthly average of 1,168.

II Study Design

This was a hospital-based, cross-sectional study.

III Study Population

All adult patients aged 18 years and above attending the GOPC.

IV Inclusion Criteria

Patients aged 18 years and above with or without a prior history of hypertension who consented to participate in the study.

V Exclusion Criteria

Patients with one arm, patients with an upper limb deformity, patients with severe illnesses that make it difficult for them to follow the study protocol and patients with major psychiatric illness were excluded from the study.

VI Sample Size

The sample size was estimated using the formula, $n = z^2 pq/d^2$; where n = sample size; p= proportion of respondents in previous Nigerian studies with IAD ≥ 10 mmHg which was 14.9% (0.149)[8], q = 1-p (0.851); and d= the relative precision (0.05) [14]. The estimated minimum sample size was 194.84. However, in order to allow for missing data, an attrition value (10% of the estimated minimum sample size) was added. This gave a sample of 214 participants for the study.

VII Sampling Technique

Two hundred and fourteen respondents were selected from the patients that attended the GOPC using a systematic random sampling technique. The sampling interval 'k' of 6 (1168/214 = 5.5 ≈ 6) was used. The first person was selected from the first six patients arriving on each clinic day by balloting at the beginning of each clinic day. Thereafter, every consenting sixth person was recruited until the required number (214) was achieved.

VIII Data Collection

Data were obtained from patients who were eligible for the study. Data was collected using a questionnaire that consisted of socio-demographic variables, clinical variables, and physical examination. It contained information regarding patients' demographic factors, co-morbid conditions like hypertension and diabetes mellitus, anthropometric variables and BP readings of the respondents. Hypertension was defined as the use of antihypertensive medication or one prior BP reading of ≥140/90 mmHg in addition to recruitment BP of ≥140/90 mmHg [15]. Patients were said to have diabetes mellitus if they were receiving oral hypoglycemic agents or insulin. Height (cm, converted to meter) and weight (kg) were measured according to the standard protocol [16, 17]. The body mass index (BMI) was calculated using the formula weight (kg)/height^2 (m^2) and stratification using the World Health Organization (WHO) classification of BMI was used: Normal 18.5-24.99kg/m^2, Overweight 25.0-29.99kg/m^2, and obese ≥ 30.0kg/m^2 [16]. The waist circumference was also measured following the WHO protocol. A waist circumference of more than 40 inches (102 cm) in men and greater than 35 inches (88 cm) for women was considered abnormal [17].

BP measurement was done after the patient had rested for five minutes. The participants were made to sit comfortably in 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. Both palpatory and auscultatory methods were used to sequentially record the BP twice in each arm using a validated standard mercury sphygmomanometer. BP

was first measured in one arm twice (with at least 2 minutes' interval) without asking the patient which arm to start from. The cuff was then swapped to the other arm and two BP readings were also taken. The average of the two measurements for systolic and diastolic BP in each arm was calculated and recorded. The inter-arm systolic BP difference was the difference between average right arm systolic BP and the left. The inter-arm diastolic BP was also calculated. The IAD in blood pressure was taken as the absolute numeric character. Significant systolic and diastolic IAD were taken as systolic and diastolic blood pressure IAD of ≥10 mmHg [18].

IX Statistical Analysis

Data were analysed using the Statistical Package for Social Sciences™ (IBM Corp, Armonk, NY, USA) version 22.0. They were presented with tables and charts. Continuous variables were expressed as means±standard deviations. Categorical variables were described as frequencies and percentages. The comparison of patients' parameters between patient groups divided by significant IAD (systolic/diastolic IAD ≥ 10mmHg) versus non-significant IAD (systolic/diastolic IAD < 10mmHg) was performed using the t-test or chi-squared test as appropriate. The difference in the mean blood pressures of the left and right arms was evaluated using the t-test. Statistical significance was defined as a p-value ≤ 0.05.

Results

Sequential pairs of BP readings were taken from 214 participants. One hundred and eighty-six of them had complete data giving a completion rate of 86.9%. The mean age of the respondents was 48.16±14.59 years. Majority of them were female [n=112 (60.2%)]. The BMI (p<0.001) and waist circumference (p=0.031) were significantly higher in female respondents (Table 1). For the entire sample, the mean systolic BP and mean diastolic BP were higher in the right arm than the left arm. However, only the difference between the mean systolic BP readings in the 2 arms was significant (p=0.004) (Table 2). Systolic BP was higher in the right arm in 102 (54.8%) participants while 56 (30.1%) had higher left arm systolic BP readings. Twenty-eight (15.1%) had equal systolic BP in both arms. Seventy-three (39.2%) participants had higher right diastolic BP readings while 63 (33.9%) had higher left diastolic BP readings. The diastolic BP readings were equal in both arms in 50 (26.9%) participants (Figure 1).

Table 1: Baseline characteristics of the respondents.

Variables	All patients N=186	Male N=74	Female N=112	p-value
Age (years)	48.16±14.59	47.28±14.36	48.74±14.77	0.506
Height (meter)	1.64±0.09	1.71±0.08	1.60±0.06	0.349
Weight (kilogram)	71.03±14.55	72.21±12.68	70.25±15.27	p<0.001
Body mass index(kg/m^2)	26.38±5.37	24.78±4.42	27.43±5.70	p<0.001
Waist circumference (cm)	90.00±13.10	87.57±11.27	91.61±14.00	0.031
Right arm systolic blood pressure (SBP) (mmHg)	130.35±23.99	126.53±20.16	132.88±25.99	0.077
Right arm diastolic blood pressure (DBP) (mmHg)	81.10±14.09	80.76±13.61	81.32±14.45	0.790
Left arm systolic blood pressure (mmHg)	128.79±24.37	124.18±20.04	131.84±26.50	0.035
Left arm diastolic blood pressure (mmHg)	80.52±13.57	80.68±12.94	80.42±14.03	0.900
SBP inter-arm difference(mmHg)	5.54±5.19	5.07±4.88	5.85±5.39	0.317
DBP inter-arm difference(mmHg)	4.35±4.53	3.38±3.53	5.00±4.99	0.010
Diabetes mellitus	18 (9.70%)	4 (5.41%)	14 (12.50%)	0.109
Hypertension	80 (43.01%)	25 (33.8%)	55 (49.1%)	0.039

Table 2: Comparison of blood pressure measurement in both arms.

Blood pressure	Right arm	Left arm	T	P
Systolic BP (mmHg)	130.35±23.99	128.79±24.37	2.957	0.004
Diastolic BP (mmHg)	81.10±14.09	80.52±13.57	1.282	0.201

Table 3: Prevalence of inter-arm blood pressure difference (IAD) among different groups.

Population	Significant sIAD		Significant dIAD	
	No	Yes	No	Yes
No hypertension or diabetes (N=100)	82 (82.0%)	18 (18.0%)	88 (88.0%)	12 (12.0%)
Hypertension only(N=67)	46 (68.7%)	21 (31.3%)	53 (79.1%)	14 (20.9%)
Diabetes mellitus only (N=5)	4 (80.0%)	1 (20.0%)	3 (60.0%)	2 (40.0%)
Hypertension coexisting with diabetes mellitus (N=14)	9 (64.3%)	5 (35.7%)	7 (50.0%)	7 (50.0%)
All respondents (N=186)	141 (75.8%)	45 (24.2%)	151 (81.2%)	35 (18.8%)

The mean absolute sIAD was 5.54±5.19 mmHg while the mean absolute dIAD was 4.35±4.53 mmHg (Table 1). Forty-five (24.2%) respondents showed significant sIAD (≥10 mmHg) while 35 (18.8%) respondents showed significant dIAD (≥10 mmHg). The prevalence of significant sIAD (18.0%) and dIAD (12.0%) was least among respondents without hypertension and diabetes mellitus (Table 3). Respondents with sIAD of ≥10 mmHg had a significantly higher mean right arm systolic BP than respondents with sIAD of < 10 mmHg (p=0.011) (Table 4).

Table 4: Association between participants' characteristics and significant IAD (continuous data).

Variables	Significant sIAD			Significant dIAD		
	No (N=141)	Yes (N=45)	p-value	No (N=151)	Yes (N=35)	p-value
Mean age (years)	48.01±14.19	48.62±15.94	0.808	47.63±14.18	50.46±16.24	0.303
Mean height (m)	1.64±0.09	1.64±0.08	0.580	1.65±0.09	1.62±0.07	0.065
Mean weight (kg)	71.56±14.64	69.38±14.28	0.382	71.78±14.22	67.80±15.67	0.145
Mean BMI (kg/m^2)	26.52±5.44	25.95±5.20	0.534	26.47±5.26	25.98±5.91	0.622
Mean waist circumference (cm)	90.39±12.83	88.80±13.98	0.479	90.00±13.01	90.01±13.66	0.996
Mean left arm SBP (mmHg)	126.96±22.97	134.51±27.82	0.070	127.94±24.13	132.46±25.41	0.344
Mean right arm SBP (mmHg)	127.84±22.79	138.22±26.13	0.011	129.15±23.63	135.54±25.18	0.156
Mean left arm DBP (mmHg)	80.06±13.35	81.98±14.31	0.410	80.74±13.56	79.57±13.78	0.647
Mean right arm DBP (mmHg)	80.06±13.66	84.36±15.04	0.075	80.98±13.84	81.60±15.33	0.815

Table 5: Association between participants' characteristics and significant IAD (categorical data).

Variable		Significant sIAD			Significant dIAD		
	Categories	No (N=141)	Yes (N=45)	p-value	No (N=151)	Yes (N=35)	p-value
Age grouped	Young	40 (75.5)	13 (24.5)	0.996	42 (79.2)	11 (20.8)	0.115
	Middle age	72 (75.8)	23 (24.2)		82 (86.3)	13 (13.7)	
	Adult	29 (76.3)	9 (23.7)		27 (71.1)	11 (28.9)	
Gender	Male	61 (82.4%)	13 (17.6%)	0.086	66 (89.2%)	8 (10.8%)	0.023
	Female	80 (71.4%)	32 (28.6%)		85 (75.9%)	27 (24.1%)	
Presence of hypertension or diabetes	Yes	59 (68.6%)	27 (31.4%)	0.033	63 (73.3%)	23 (26.7%)	0.01
	No	82 (82.0)	18 (18.0%)		88 (88.0%)	12 (12.0%)	
JNC 7 stage of high blood pressure	Normal	52 (83.9%)	10 (16.1%)	0.028	53 (85.5%)	9 (14.5%)	0.422
	Prehypertension	41 (82.0%)	9 (18.0%)		42 (84.0%)	8 (16.0%)	
	Stage 1	31 (68.9%)	14 (31.1%)		35 (77.8%)	10 (22.2%)	
	Stage 2	17 (58.6%)	12 (41.4%)		21 (72.4%)	8 (27.6%)	
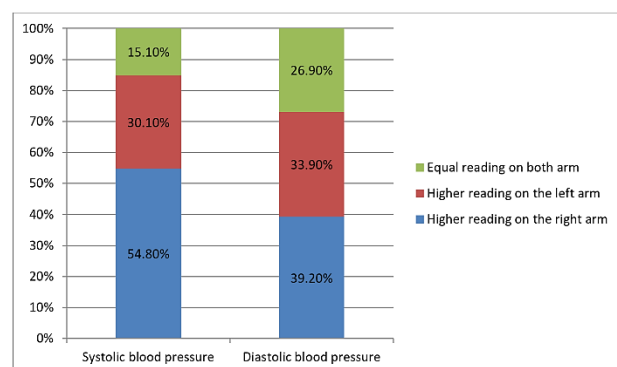
Figure 1: Systolic and diastolic blood pressure measurement of both arms (Bar chart showing the systolic and diastolic blood pressure measurement of both arms).

Explanatory Legend for Figure 1: Participants with systolic and diastolic BP greater than 140 mmHg and 90 mmHg were regarded as having hypertension. Among the 214 participants, 54.8% of the participants had a higher systolic BP in the right arm, whereas 30.1% had higher systolic BP in the left arm. 15.1% had equal systolic BP in both arms. 39.2% participants had higher right diastolic BP readings while 33.9% had higher left diastolic BP readings. The diastolic BP readings were equal in both arms in 26.9% participants.

Respondents with hypertension and diabetes mellitus have significant sIAD (p=0.033) and significant dIAD (0.01) compared to respondents without hypertension and diabetes mellitus. The proportion of respondents with significant sIAD increases with increasing severity of hypertension (p=0.028). Significant dIAD was more common among female respondents (p=0.023) (Table 5). The sIAD and dIAD were unrelated to age and anthropometric variables (Tables 4 & 5).

Discussion

The mean systolic BP and diastolic BP readings on the right arm were higher than those of the left arm and the difference was significant in the case of systolic BP. The previous reports on this subject are conflicting [9, 19-22]. Similar to this study, several studies have also reported higher BP readings in the right arm compared to the left [19-21]. On the other hand, Clark and others systematically reviewed studies on IAD and found no overall evidence in favour of a higher BP on the right arm [22]. A previous Nigerian study also showed no significant difference between the BP readings of the right and left arm [9]. Hence, the finding that higher BP readings are more frequent in one arm than the other may be for educational purpose with no clinical significance because there is still a chance of higher BP reading in any of the arms for every BP measurement especially across a population. The possibility of higher BP reading in either arm further justifies the guidelines' recommendation of dual arm BP measurements at the initial visit, and subsequent measurement of BP in the arm with higher reading [2-4].

This study showed that significant IAD is a common finding in a population of unselected primary care patients. The present study reported an overall prevalence of 24.2% and 18.8% for significant sIAD and dIAD respectively. The clinical implication of this finding is that almost a quarter of unselected primary care patients may have their BP underestimated by 10 mmHg if IAD is not specifically excluded. It is noteworthy though that the reduction in the BP of 10 mmHg can prevent

fatal and non-fatal coronary events and stroke [15]. Thus, significant IAD should be sought out for during clinical assessment of BP.

There was no previous study on the prevalence of inter-arm BP difference in unselected general practice population in Nigeria to compare our findings with. The prevalence of significant IAD in the present study was, however, higher than those stated in a Nigerian study conducted among secondary care hypertensive and normotensive adult Nigerians, which reported a prevalence of 14.9% and 9.1% for significant sIAD and dIAD respectively [8]. A literature searches on the prevalence of significant IAD in developed and developing countries showed a range of 5.0-39% for a significant sIAD and 3.8-23.2% for significant dIAD [1, 8, 19, 22, 23]. Although, the prevalence of significant sIAD and dIAD in this study is comparable to previously reported prevalence, the higher prevalence found in this study is interpreted with caution because of the sequential BP measurement protocol used. Clark and others in their systematic review reported that the prevalence of IAD is overestimated threefold by sequential measurement compared to repeated simultaneous BP measurement protocol [24].

In spite of the risk of overestimation that may occur with the use of sequential BP measurement protocol, the sequential measurement with standard mercury sphygmomanometer may still be the most feasible and practical way of dual arm BP measurement during a routine clinic in resource-poor countries when one considers the cost implication of simultaneous BP measurement protocol. In addition, a single sequential pair of measurements has also been shown to rule out significant IAD with a high negative predictive value [20, 24]. Furthermore, the consistent finding of a relationship between significant IAD and cardiovascular events using the sequential approach further showed that sequential protocol of measuring IAD is still relevant [20, 24].

The large proportion of respondents with hypertension and diabetes mellitus may also contribute to the high prevalence of significant sIAD and dIAD. The prevalence of significant sIAD and dIAD was higher among respondents who had hypertension and diabetes mellitus compared to those without these diseases in the study. Aside from the finding of a high prevalence of significant sIAD and dIAD in respondents who have hypertension and diabetes mellitus, the prevalence of significant sIAD also rose with increasing severity of hypertension in this study. The finding of a direct relationship between the presence of cardiovascular disease and significant IAD in this study concurred with findings from other studies [5-7, 11, 19, 20-23]. The associations of IAD with these cardiovascular diseases may be useful in primary care in Nigeria with shrinking and finite resources. The detection of significant IAD through BP measurement may serve as a simple cost-effective tool in primary care to identify patients who may benefit from further screening for cardiovascular diseases.

Female participants had a higher prevalence of significant sIAD and dIAD than their male counterparts and this was significant in the dIAD. Similar to this study, some previous studies have reported a higher prevalence of significant IAD among female respondents, whereas others have failed to demonstrate this [1, 11, 23, 25-27]. The high prevalence of significant IAD among female participants in this study can be attributed to the higher proportion of female respondents in the study population and consequent higher prevalence of obesity, diabetes

mellitus and hypertension among the female participants in this study may also be contributory to this finding.

Our study showed that age was not associated with IAD. The association between IAD and age in previous studies is conflicting. While our finding was in consonance with some previous reports, other studies reported association between age and IAD [1, 11, 23, 26, 27]. The relationship in the later studies were either direct or inverse [11, 23, 27]. The direct or inverse relationship between age and IAD that were reported in these studies and the finding of an approximately equal prevalence of significant IAD across different age groups in the index study underscore the importance of screening everyone for IAD through dual arm BP measurement irrespective of their age.

Implications for Research and Practice

The high prevalence of significant IAD among the unselected primary care patients in this new study supports the current clinical guideline to measure BP in both arms at the initial visit and subsequently use the arm with the higher BP for continued management. The chances of getting a higher BP on either arm, though, greater on the right arm compared to left arm in this study further justifies the guidelines' recommendation of an initial dual arm BP measurement [2-4].

Unfortunately, this guideline is not routinely followed in many primary care settings in Nigeria. The non-exclusion of IAD in patients may lead to under-diagnosis of hypertension, misdiagnosis of hypotension or under-treatment of hypertensive patients. The disparity can be enormously important to certain individuals that we see at primary care who are applying for life insurance, pre-employment fitness assessment, or military/paramilitary service, particularly when only the arm with the higher pressure is used for BP measurement.

Therefore, the assessment of BP in both arms should become routine in our clinics. The incorporation of bilateral arm BP measurement into our various clinical training programmes at both undergraduate and postgraduate that lacks this practice may also improve the practice of dual arm BP measurement. The single sequential BP measurement protocol which has been shown to reliably rule patients out of the need for subsequent pair of BP measurement may be the most practical method for now [11]. The facilitators and obstacles to dual arm BP measurement should also be explored through qualitative research.

The association of an IAD with hypertension and/or diabetes mellitus makes bilateral arm blood pressure measurement in these groups of patients appropriate to prevent under-treatment. In addition, identification of IAD in patients should trigger the consideration of cardiovascular diseases which may require further screening and investigations especially in primary care settings in Nigeria with limited health resources.

Conclusion

There is a chance of getting higher BP readings on either arm, though, greater on the right arm compared to left arm in this study. The prevalence of significant IAD is high in unselected primary care patients. This is particularly more marked among patients with hypertension and/or diabetes mellitus. BP measurement in both arms should become a routine clinical practice at initial patients' visit in primary care.

Strength and Limitations

This is the first Nigerian study on IAD among unselected primary care patients. The study used the sequential method of BP measurement which might have resulted in the over-estimation of the prevalence of significant IAD. Further works that assess the prevalence of IAD among the unselected primary care patients using the simultaneous BP measurement protocol is needed. In addition, the study is a cross-sectional, one-center study; therefore, some caution may be needed in the generalization of these results. Some patients with previously undiagnosed diabetes mellitus may have been missed due to the use of self-report in determining the prevalence of diabetes mellitus among the participants.

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Ethical Consideration and Consent

Ethical approval for the study was obtained from the Health Research Ethics Committee of the hospital with protocol number FMCA/470/HREC/11/2016 and registration number FWA/Q0018660/02/28/2017.

Conflicts of Interest

None.

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