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RESEARCH ARTICLE

Raised inter-arm difference in blood pressure: Association with family history of hypertension, anthropometric parameters, and mean arterial blood pressure

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ABSTRACT

Background: Raised inter-arm difference (IAD) in blood pressure (BP) has been found to be associated with increased risk of cardiovascular events. Relation of raised IAD in BP with family history (FH) of hypertension, mean arterial BP (MABP), and anthropometric parameters are not well addressed in most of the previous studies. **Aims and Objectives:** Primary objective was to find the association of raised IAD in BP with FH of hypertension, stroke, coronary artery disease, and peripheral vascular disease. The secondary objective was to find a correlation of raised IAD in BP with anthropometric parameters and MABP. **Materials and Methods:** A cross-sectional study was carried out among 284 medical students. BP was measured twice in each arm, using an automatic device (OMRON-Model-HEM-7130) that was calibrated according to the manufacturer's recommendations, and the values were averaged. IAD in BP is defined as the difference between average BP in the right arm and average BP in the left arm. FH of hypertension, coronary artery disease (CAD), peripheral vascular disease, and stroke were obtained using questionnaire. Height and weight were measured using standard equipment. **Results:** Raised IAD in BP shows a statistically significant association with FH of hypertension ($P = 0.002$). Systolic IAD and diastolic IAD (DIAD) in BP in both males and females show positive correlations with right arm MABP. The results were also statistically significant ($P < 0.05$). DIAD in BP shows a statistically significant negative correlation with height in females ($P = 0.002$). **Conclusion:** The presence of raised IAD in BP in patients with FH of hypertension warrants follow-up of these patients for disease development in future.

KEY WORDS: Cardio Vascular Diseases; Inter-arm Difference in Blood Pressure; Mean Arterial Blood Pressure; Peripheral Vascular Disease

INTRODUCTION

A difference in blood pressure (BP) readings between arms can be observed in various general populations, healthy women during the antenatal period and also in population with an increased risk of cardiovascular disease (CVD) such as people with hypertension, diabetes mellitus, chronic renal disease, or peripheral vascular disease. Systolic inter-arm differences (SIADs) in BP are associated with increased risk of cardiovascular events, including mortality, in a large cohort of people free of preexisting vascular disease.[1]

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The WHO has predicted that by 2030 almost 23.6 million people will die from CVD, mainly from heart disease and stroke.[2] Over 80% of CVD deaths occur in low- and

middle-income countries. Most of the risk factors for CVD are high in young adults,[3] which support the fact that nearly half of the deaths due to CVD are occurring in young- and middle-aged individuals.

Raised IAD in BP has been found to be associated with hypertension. Hypertension is a risk factor for coronary heart disease and the single most important risk factor for stroke. Young adults with a family history (FH) of hypertension have increased the risk of developing hypertension. Compared to normotensive offsprings of normotensive parents, normotensive offsprings of hypertensive parents had increased BP and impaired arterial properties.[4] So, the relation of FH of hypertension with raised IAD in BP has to be addressed. Raised IAD in BP in patients with FH of hypertension, stroke, peripheral vascular disease, or myocardial infarction may predict future disease development.

Increased arterial stiffness is associated with an increase in cardiovascular morbidity and mortality.[5] An increase in arterial stiffness is associated with progression of BP increase and an increase in incident hypertension.[6] A study by Liao et al.[7] suggests that lower arterial elasticity is related to the development of hypertension. Mean arterial BP (MABP) was an independent predictor of arterial stiffness in a study by Gunarathne et al.[8] done in South Asians. Decreased elasticity of large and medium-sized arteries has been postulated to be associated with cardiovascular disorders. So, relation of MABP with raised IAD in BP should be evaluated. Relation of raised IAD in BP with FH of hypertension MABP is not well addressed in most of the previous studies.

Height and weight had a direct relationship to systolic BP (SBP) and diastolic BP (DBP).[9] The relations of raised IAD in BP to anthropometric parameters have to be evaluated as the effects are not well addressed in other studies.

So, the primary objective of the study was to find the association of raised IAD in BP with FH of hypertension, stroke, CAD, and peripheral vascular disease. The secondary objective was to find a correlation of raised IAD with anthropometric parameters and mean BP.

MATERIALS AND METHODS

A medical institution-based cross-sectional study was conducted among MBBS students in a tertiary care center in central Kerala, during the period July 2015-November 2015 after approval by the Institutional Ethics Committee.

The study population consisting of 300 MBBS students enrolled for the course during the academic years 2013, 2014, and 2015.

Sample size was estimated using the formula $n = 4 \times p \times q/d^2$.

n = Sample size, p = The prevalence,

q = 100–p,

d = The relative precision.

The calculated sample size was 265, but annual intake of students of this institution is 100, and it was decided to cover three batches of medical students.

Exclusion Criteria

Students <18 years of age, with any major illness, on any regular drugs and found to have hypertension on clinical examination were excluded. On clinical examination, 9 students were found to have hypertension and were hence excluded. 7 students did not participate in the study.

Around 284 students participated in the study and response rate was 94%. Height and weight were measured using standard equipment.

Body weight

This was measured in the erect position without footwear with the patient lightly clothed. Measurements were taken with the same instrument and were done in kilograms, which were rounded off to the nearest half a kilogram.

Height

After removing the shoes, the patient was asked to stand upright on the flat floor keeping the feet parallel to heels, buttocks, and shoulder and back of the head touching a hard surface. The head was held comfortably erect with the lower border of the orbit in the same horizontal plane as the external auditory meatus. The arms were positioned by the side of the body. Measurements were taken to an accuracy of half a centimeter.

Body mass index (BMI)

This was calculated as weight (in kilograms) divided by height (in meters) BP measurement was done in a quiet room with the patient in sitting position following at least 5 min of rest. The patient was refrained from taking food or drinks half hour before BP measurement. The apparatus was kept at the level of heart and hands were supported during BP measurement.

BP was measured twice in each arm. BP was measured first in the arm first presented without prompting, using an automatic device (OMRON-Model-HEM-7130) that was calibrated according to the manufacturer's recommendations, and the values were averaged. Cuff was then swapped to the

other arm, and two readings were taken with 5 min interval. Inter-arm BP difference is defined as the difference between average BP in the right arm and average BP in the left arm.

FH of hypertension, stroke, peripheral vascular disease, and CAD were obtained using questionnaire.

Operational Definitions Used

Raised systolic inter-arm BP difference: ≥10 mm of Hg difference between average SBP in the right arm and average SBP in the left arm.

Raised diastolic inter-arm BP difference: ≥10 mm of Hg difference between average DBP in the right arm and average DBP in the left arm.

Statistical Methods

The data were coded and entered in Microsoft Excel and analyzed using SPSS version 16.0. Continuous variables were summarized as arithmetic mean and standard deviation. Chi-square test was used to find the relation between categorical variables. Correlation between inter-arm BP difference, BMI, height, weight, right and left arm MABP were done by Pearson's coefficient of correlation analysis. For all statistical analysis, the significance level was set at $P < 0.05$.

RESULTS

SIAD in BP ≥10 mm of Hg was present in 15.4% (44) patients. Diastolic IAD (DIAD) ≥10 mm of Hg was present in 1.7% (5) patients. Mean SIAD in BP was 5.915 (±3.81) mm of Hg, and mean DIAD in BP was 3.18 (±2.44) mm of Hg.

Descriptives of anthropometric parameters and BP are described in Table 1. All variables were normally distributed.

FH of hypertension was present in 143 patients and 33 (23.1%) among them had raised IAD in BP, whereas 14 (9.9%) patients with no FH of hypertension had raised IAD in BP. The result was statistically significant ($P = 0.002$). FH of CAD, stroke, and peripheral vascular disease did not show a statistically significant association with raised IAD in BP (Table 2).

SIAD and DIAD in BP in both males and females show positive correlations with right arm MABP. The results were also statistically significant ($P < 0.05$) (Tables 3 and 4).

In the present study, both SIAD and DIADs in BP show a negative correlation with height in males and females. DIAD in BP shows a statistically significant ($P = 0.002$) negative correlation with height in females (Table 4). Both SIAD and DIAD in BP show a positive correlation with BMI and weight in males and females, but the results were not statistically significant.

Table 1: Descriptives of anthropometric parameters and BP of study patients

Clinical/anthropometric measures	Mean±SD (*n*=284)
Height	162.97±10.386
Weight	54.43±11.752
BMI	20.249±3.094
SIAD	5.915±3.81
DIAD	3.18±2.44

BMI: Body mass index, SIAD: Systolic inter-arm difference, DIAD: Diastolic inter-arm difference, BP: Blood pressure

Table 2: Association of family history of hypertension, stroke, CAD, and PVD with IAD status

Family history status	IAD status		Value
	Present %	Absent %	
Hypertension			
Yes	33 (23.1)	110 (76.9)	0.002
No	14 (9.9)	127 (90.1)	
CAD			
Yes	14 (14.1)	85 (85.9)	0.26
No	33 (17.9)	151 (82.1)	
Stroke			
Yes	9 (18)	41 (82)	0.46
No	38 (16.2)	196 (83.8)	
PVD			
Yes	2 (13.3)	13 (86.7)	0.53
No	45 (16.7)	224 (83.5)	

CAD: Coronary artery disease, PVD: Peripheral vascular disease, IAD: Inter-arm difference

Table 3: Correlation of SIAD with anthropometric parameters and mean arterial BP

IAD	Anthropometric parameters and mean arterial BP	Correlation coefficient	*P* value
SIAD in BP (males)	Height	−0.091	0.407
	Weight	0.186	0.08
	BMI	0.045	0.683
	LAM	0.107	0.328
	RAM	0.396	0.000
SIAD in BP (females)	Height	−0.041	0.565
	Weight	0.048	0.505
	BMI	0.091	0.201
	LAM	0.038	0.59
	RAM	0.265	0.000

BMI: Body mass index, LAM: Left arm mean arterial BP, RAM: Right arm mean arterial BP, IAD: Inter-arm difference, SIAD: Systolic inter-arm difference, BP: Blood pressure

Table 4: Correlation of DIAD with anthropometric parameters and mean arterial BP

IAD	Anthropometric parameters and mean arterial BP	Correlation coefficient	*P* value
DIAD in BP (males)	Height	−0.21	0.849
	Weight	0.054	0.622
	BMI	0.02	0.983
	LAM	0.043	0.695
	RAM	0.285	0.008
DIAD in BP (females)	Height	−0.217	0.002
	Weight	0.129	0.070
	BMI	0.34	0.636
	LAM	0.004	0.953
	RAM	0.162	0.022

BMI: Body mass index, LAM: Left arm mean arterial BP, RAM: Right arm mean arterial BP, DIAD: Diastolic inter-arm difference, IAD: Inter-arm difference, BP: Blood pressure

DISCUSSION

A recent study[10] found that participants with higher inter-arm SBP difference were at much higher risk for future CVD than those with <10 mm difference between arms. Hypertension is a risk factor for coronary heart disease and the single most important risk factor for stroke. It causes about 50% of ischemic strokes and increases the risk of hemorrhagic stroke.

There is an increase in future disease incidence for all ages with increasing FH score values.[11] The prevalence of hypertension was significantly higher in those with an FH of hypertension.[12] Raised IAD in BP is found to be associated with hypertension. In this study, raised IAD in BP shows a statistically significant association with FH of hypertension. Therefore, recording of inter-arm BP difference showing raised IAD may be a predictor of the development of hypertension in future among those with FH of hypertension. Definite lifestyle modifications can be implemented to reduce BP for primary prevention of development of hypertension.

In this study, SIAD and DIAD in BP in both males and females show a positive correlation with right arm MABP. The result was statistically significant also ($P < 0.05$). MABP is one of the principal modifiable factors, which contribute to arterial stiffness. Inter-arm differences are associated both with wider pulse pressures[13] and with increased pulse-wave velocities.[14] Thus, indirect evidence exists to suggest that arterial stiffening has a role in the etiology of IAD.[6] Arterial stiffness is a major determinant of SBP in central vessels and left ventricular load. Increased arterial stiffness increase SBP in two ways, first by increasing amplitude of the initial pressure wave generated by ventricular ejection and second by causing reflected waves from periphery to return during systole and so augment the initial wave. Average SBP, DBP, and MABP strongly predict CVD among younger men in a study by Sesso et al.[15]

Anthropometric parameters such as height and weight were found to be associated with BP in several studies.[16,17] Aboyans et al.[18] and Su et al.[19] in their studies found a significant correlation between high BMI and SIAD in BP. Direct relation between DBP and height was found in a study by Song et al.[20] while inverse relation with DBP and height was found in a study by Davey Smith et al.[21] In the present study, both SIAD and DIADs in BP show a negative correlation with height in males and females. In females, DIAD shows a statistically significant negative correlation with height ($P = 0.002$). No other anthropometric parameters showed a significant correlation with SIAD and DIAD in either males or females. Differences in SBP between arms can predict an increased risk of cardiovascular events and all-cause mortality over 10 years in people with hypertension.[21] Our study shows a significant association between raised IAD in BP and FH of hypertension. FH of hypertension is a cardiovascular risk factor accounted in the inter heart study. Recent evidence as shown by a large cohort study[1] could strengthen our study findings, and these individuals have to be evaluated for concurrent cardiovascular risk factors.

Limitations

Influence of mid arm circumference on IAD in BP was not considered in the study. The study used the sequential method of BP measurement which might have resulted in higher values of BP.

CONCLUSION

Hypertension guidelines have recommended that BP should be assessed in both arms at the initial visit. Assessment of BP in both arms should become a routine clinical practice in initial BP measurement in primary care. Raised IAD in BP along with raised MABP necessitates follow-up of these individuals for future cardiovascular events development. Measures should be initiated to prevent the development of hypertension and future CVD. FH of hypertension is a non-modifiable risk factor for the development of hypertension. However, detection of raised IAD in BP and associated FH of hypertension warrants lifestyle modifications and regular follow-up of these patients for disease development in future.

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