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Original Research Article

Relationship between inter-arm blood pressure differences and predicted future cardiovascular risk in hypertensive patients

Abu S. M. O. Faroque[1]*, Prabir K. Das[1], Asish Dey[1], M. Sawkat Hossan[2], Evana Ibrahim[3], Sayem B. Latif[4]

[1]Department of Cardiology, Chittagong Medical College Hospital, Chittagong, Bangladesh
[2]Department of Otolaryngology and Head and Neck Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh
[3]Department of Dermatology, Chittagong Medical College Hospital, Chittagong, Bangladesh
[4]Ibrahim Cardiac Hospital and Research Institute, Dhaka, Bangladesh

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***Correspondence:**
Dr. Abu S. M. O. Faroque,
E-mail: sayemrobin84@gmail.com

ABSTRACT

Background: Hypertension stands as a widely recognized significant risk factor for cardiovascular disease. In clinical practice, it is advisable to measure blood pressure (BP) in both arms. The increasing attention on inter-arm blood pressure difference (IABPD) stems from its association with cardiovascular disease. This study aimed to assess the relationship between inter-arm blood pressure differences and predicted future cardiovascular risk in hypertensive patients.
Methods: This cross-sectional study was conducted at the department of cardiology, Chittagong Medical College Hospital from July 2020 to June 2021. The study included 428 cases of previously or newly diagnosed hypertension, selected through convenient sampling. Data analysis was conducted using Microsoft Office tools and statistical package for the social sciences (SPSS) version 23.0.
Results: In this study, 8.2% of patients exhibited noteworthy systolic IAD, and 2.3% demonstrated notable diastolic IAD. Median 10-year cardiovascular risk, assessed by Framingham and ASCVD calculators, was 21% and 11% respectively. A positive correlation was observed between sIAD and 10-year cardiovascular risk (p=0.003) and sIAD and 10-year ASCVD risk (p=0.041). Patients with significant sIAD had a higher incidence of ischemic heart disease compared to those without (p=0.041). Multiple regression analysis revealed a significant correlation between 10-year Framingham cardiovascular risk and sIAD (p=0.003).
Conclusions: A significant difference in systolic blood pressure between arms is linked to a higher 10-year cardiovascular risk and the presence of cardiovascular disease in well-managed hypertensive patients. So, monitoring sIAD could be an additional factor in predicting future cardiovascular events in patients receiving hypertension treatment.

Keywords: Inter-arm, Blood pressure, Cardio-vascular risk, Hypertension, ASCVD calculators

INTRODUCTION

Under normal physiological circumstances, blood pressure readings are typically consistent between both arms. However, a blood pressure difference between both arms is frequently encountered in various general populations.[1] This difference in mean blood pressure between the right arm and left arm is termed inter-arm blood pressure difference (IABPD). Systolic inter-arm blood pressure difference (sIAD) is defined as the absolute difference in

mean systolic blood pressure between the left and right arms. Diastolic inter-arm blood pressure difference (dIAD) is defined as the absolute difference in mean diastolic blood pressure between the left and right arms. sIAD and dIAD ≥10 mm Hg were considered significant.[1] This phenomenon of IABPD was first recognized more than 100 years ago.[2] Arm blood pressure is generally higher on the right side than the left because the left subclavian artery originates from the aorta, making an acute angle, unlike the right artery. This acute angle leads to turbulent flow that reduces blood flow and blood pressure, thereby resulting in an IABPD.[3] Hypertension, defined as a SBP ≥140 mmHg and/or DBP ≥90 mmHg, is a persistent condition with potential complications affecting vital organs.[4,5] Early detection through measuring blood pressure in both arms is crucial, yet not all practitioners follow this guideline, possibly due to clinical inertia or a lack of relevant evidence in primary care.[6-8] Atherosclerosis, peripheral vascular disease, and left ventricular hypertrophy can contribute to increased IABPD.[9] Meta-analyses indicate that an elevated IABPD is associated with adverse cardiovascular outcomes.[10] In individuals without major cardiovascular disease, a sIAD of 10 mmHg or more is independently linked to mean SBP and C-reactive protein.[11] Atherosclerotic cardiovascular disease (ASCVD) is a leading global cause of morbidity and mortality, with estimated annual mortality reaching 25 million by 2030, predominantly in low- and middle-income countries.[12] ACC/AHA ASCVD risk score, QRISK2, Joint British Society calculator-3, and Framingham coronary heart-disease risk score are among the widely used online calculators, providing risk scores in numeric values, while the WHO/ISH model presents risks in categories.[13] A recent review highlights a high and increasing prevalence of hypertension in Bangladesh, emphasizing the need for preventive strategies to address the associated morbidity and mortality.[14] The objective of this study was to assess the relationship between inter-arm blood pressure differences and predicted future cardiovascular risk in hypertensive patients.

METHODS

This was a cross-sectional study that was conducted at the department of cardiology, Chittagong Medical College Hospital from July 2020 to June 2021. A total of 428 cases of hypertension were enrolled using a convenient sampling technique, and simultaneous bilateral BP measurements were obtained. The IABPD was defined as the absolute difference in averaged BPs between arms, with an IABPD ≥10 mm Hg considered significant. Framingham and ASCVD risk scores were calculated for each patient using online calculators, and the study was ethically approved with written consent obtained from participants. Patients over 20 years old, diagnosed with primary hypertension and receiving antihypertensive medication, or those with SBP ≥140 mm Hg or DBP ≥90 mmHg without a previous diagnosis of hypertension, were included. Exclusion criteria comprised patients refusing to participate, those with cardiac arrhythmia, systolic heart failure, chronic kidney disease with hemodialysis, and those with other known causes of significant IABPD. Data analysis was performed using Microsoft Office and statistical package for the social sciences (SPSS) version 23.0, with a significance threshold set at $p<0.05$.

RESULTS

This study included 428 participants with a demographic distribution of 63.6% male and 36.4% female, with an average age of 53.6±10.8 years (range: 30-79). The majority (97.9%) were right-handed, while only nine individuals (2.1%) were left-handed. Among the 428 hypertensive patients analyzed, the frequency of dyslipidemia, obesity, and a history of ischemic heart disease (IHD) were 59.1%, 50.7%, and 50.0%, respectively. Diabetes mellitus was present in 40.2% of patients. Additionally, 25% reported a family history of coronary artery disease (CAD), and 21.5% were current smokers. The study showed that the frequency of the arm with the highest blood pressure readings, both systolic and diastolic, was higher in the right arm. Only in 4.6% and 3.7% of cases, respectively, were the systolic and diastolic blood pressures equal. In analyzing the distribution of systolic inter-arm blood pressure differences, the study reported a prevalence of 8.2% (35/428) for significant systolic inter-arm blood pressure difference (≥10 mm Hg) in hypertensive patients. Additionally, 117 (27.3%) patients had a systolic inter-arm blood pressure difference of <10 mmHg to ≥5 mmHg, and 276 (64.5%) patients had a systolic inter-arm blood pressure difference of <5 mmHg. According to the distribution of dIAD by mean blood pressure, the study found a prevalence of 2.3% (10/428) for significant diastolic inter-arm blood pressure difference (≥10 mm Hg) in hypertensive patients. Additionally, 108 (25.2%) patients had diastolic inter-arm blood pressure difference <10 mmHg to ≥5 mmHg, and 310 (72.4%) patients had diastolic inter-arm blood pressure difference <5 mmHg. The study calculated the 10-year cardiovascular risk using both the Framingham risk score and ASCVD risk calculator, along with the lifetime ASCVD risk. The median 10-year cardiovascular risk was 21% (10-30%) by the Framingham risk score and 11% (7-21%) by the ASCVD risk score calculator. Additionally, the median lifetime risk of ASCVD was 50% (39-69%), and more than 50% of the patients were classified as having high 10-year cardiovascular risk by the Framingham risk score. The study found a significant positive correlation between sIAD and 10-year cardiovascular risk ($r=0.144$; $p=0.003$). The study revealed a positive and statistically significant correlation ($r=0.141$, $p=0.018$) between lifetime ASCVD risk score and hypertensive patients. Subgrouping hypertensive patients by a 5-mm Hg increase in sIAD revealed significant increases in Framingham cardiovascular risk score (18.4%, 21.5%, and 30.0%, respectively, $p=0.016$). However, differences in ASCVD risk score (both 10 years and lifetime) were not statistically significant among the subgroups of sAID. Similarly, subgrouping by dIAD did not show significant differences in Framingham and

ASCVD risk scores. Patients with significant sIAD had a higher BMI and were more likely to have diabetes mellitus (DM), ischemic heart disease (IHD), and dyslipidemia, with the proportion of IHD reaching statistical significance. They were also more likely to receive statins, aspirin, and beta-blockers. Serum HDL-C median value was significantly lower in patients with significant sIAD compared to those without sIAD. Regarding patients with significant dIAD, they were significantly less likely to receive beta-blockers compared to patients without dIAD. Serum HDL-C median value was significantly lower in patients with significant dIAD compared to those without dIAD.

Table 1: Demographic status of patients (N=428).

Characteristics	Mean (±SD)/n (%)
Age (year)	
Mean ±SD	53.6 (±10.8)
Gender	
Male	272 (63.6)
Female	156 (36.4)
Handiness	
Right	419 (97.9)
Left -	9 (2.1)

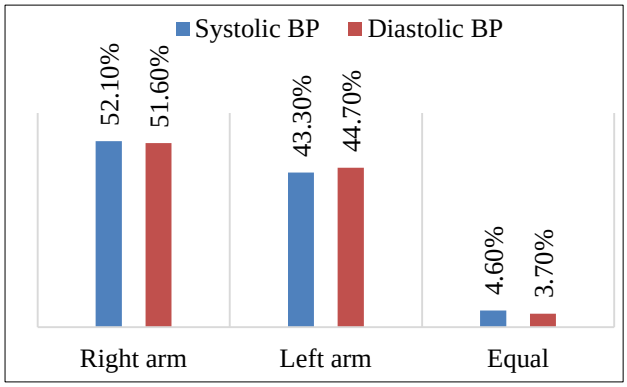

Figure 1: Frequencies of the arm with the highest BP readings.

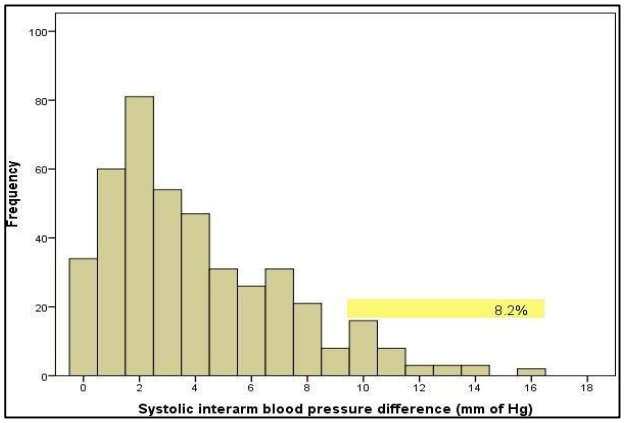

Figure 2: Distribution of systolic inter-arm blood pressure differences.

Table 2: Risk factors of hypertension and CAD.

Variables	n	%
Family history of CAD	107	25.0
Current smoker	92	21.5
Diabetes mellitus	172	40.2
Dyslipidemia	253	59.1
History of IHD	214	50.0
History of CVD	30	7.0
Obese	217	50.7

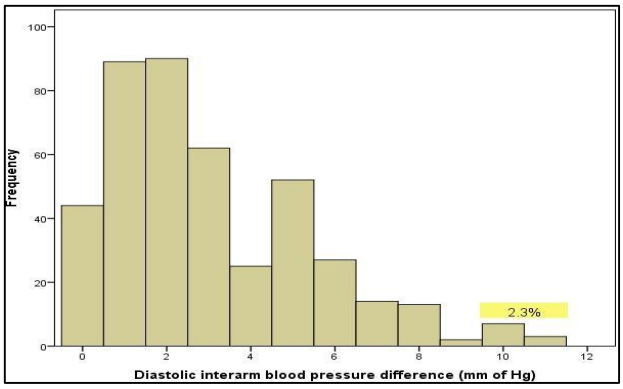

Figure 3: Distribution of diastolic inter-arm blood pressure differences.

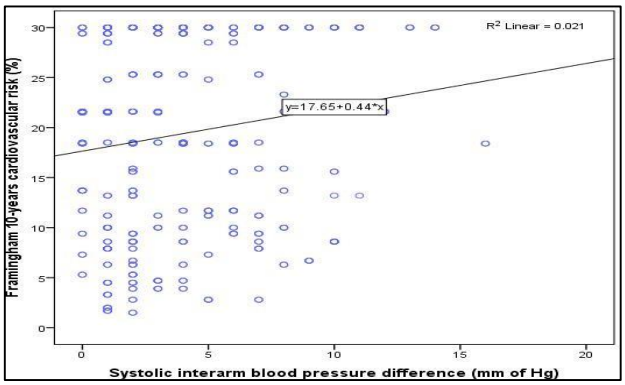

Figure 4: Correlation of systolic inter-arm BP difference with the Framingham 10-year cardiovascular disease risk.

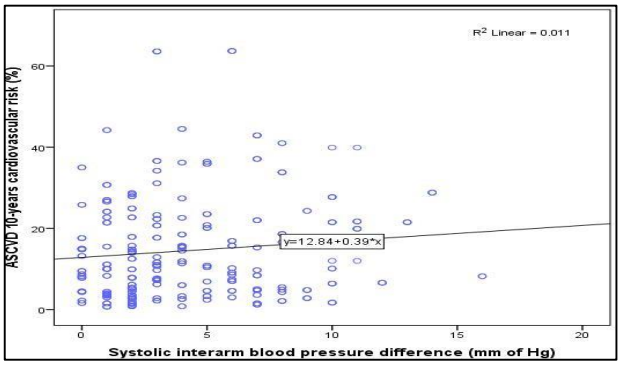

Figure 5: Correlation of systolic inter-arm blood pressure difference with the 10- years ASCVD risk.

Table 3: By Framingham and 10- years and lifetime ASCVD cardiovascular risk assessment.

Measurement tool	n	%
10-years Framingham risk		
Median (IQR)	21	10.30
Low risk	103	24.1
Intermediate risk	109	25.5
High risk	216	50.5
10- years ASCVD risk (n=383)		
Median (IQR)	11	7.21
Low risk	85	22.20
Borderline risk	55	14.40
Intermediate risk	130	33.90
High risk	113	29.50
Lifetime ASCVD risk (n=282)		
Median (IQR)	50	39.69
Low risk	17	6.00
High risk	265	94.00

Table 4: Systolic inter-arm blood pressure difference and future cardiovascular risk.

Characteristics	sIAD <5 mmHg	5<10 mmHgs IAD	sIAD ≥10 mmHg	P value
sAID, mmHg	2.1±1.3	6.6±1.3	11.3±1.7	<0.001**
FRS, %	18.4 (11.2-30.0)	21.5(9.4-30.0)	30.0 (15.6-30.0)	0.016††
ASCVD risk(10-years), %	9.1 (4.6-21.4)	11.0 (4.4-20.7)	19.9 (6.6-21.7)	0.081††
ASCVD risk	50.0 (39.0-69.0)	50.0 (39.0-69.0)	69.0 (50.0-50.0)	0.129††

ASCVD: atherosclerotic cardiovascular diseases, FRS: Framingham risk score, IAD: inter-arm blood pressure difference, sIAD: systolic inter-arm blood pressure difference, **ANOVA test, ††Kruskal Wallis test

Table 5: Diastolic inter-arm blood pressure difference and future cardiovascular risk.

Characteristics	dIAD <5 mmHg	5<10 mmHgs IAD	dIAD ≥10 mmHg	P value
dAID, mmHg	1.8±1.2	5.9±1.1	10.3±0.5	<0.001**
FRS, %	21.6 (10.0-30.0)	18.4 (9.4-29.4)	29.4 (22.0-30.0)	0.061††
ASCVD risk (10-years), %	11.4 (5.0-22.6)	9.8 (3.6-16.9)	10.1 (4.7-20.6)	0.062††
ASCVD risk	50.0 (50.0-69.0)	50.0 (39.0-69.0)	39.0 (36.0-69.0)	0.190††

ASCVD: atherosclerotic cardiovascular diseases, FRS: Framingham risk score, IAD: inter-arm blood pressure difference, sIAD: systolic inter-arm blood pressure difference, **ANOVA test, ††Kruskal Wallis test

Table 6: Comparison of demographic and clinical characteristics by the presence of significant inter-arm systolic blood pressure difference.

Characteristics	<10 mm Hg (n=393)	≥10 mm Hg (n=35)	P value
Age, years			
Mean ±SD	53.5±10.9	54.5±9.1	0.571*
Sex			
Male	245 (62.3)	27 (77.1)	0.081†
Female	148 (37.7)	8 (22.9)	
BMI	25.0±4.1	26.4±4.1	0.045*
SBP, mm of Hg	138.1±23.3	144.5±20.7	0.117*
DBP, mm of Hg	85.6±12.2	88.1±17.8	0.271*
Associated diseases			
DM	154 (39.2)	18 (51.4)	0.083†
IHD	189 (48.1)	25 (71.4)	0.041†
Dyslipidemia	229 (58.3)	24 (68.6)	0.235†
CVD	27 (6.9)	3 (8.6)	0.877†

Continued.

Characteristics	<10 mm Hg (n=393)	≥10 mm Hg (n=35)	P value
Medication			
Aspirin	76 (19.3)	11 (31.4)	0.089†
Statin	84 (21.4)	14 (40.0)	0.012†
ACEB/ARB	257 (65.4)	17 (48.6)	0.047†
Beta blocker	143 (36.4)	14 (40.0)	0.671†
CCB	101 (25.7)	6 (17.1)	0.263†
Diuretics	62 (15.8)	3 (8.6)	0.255†
Laboratory findings			
FBS, mg/dl	107 (94-151)	98 (95-124)	0.194‡
Total cholesterol	170 (148-195)	164 (146-223)	0.820‡
LDL-C, , mg/dl	105 (83-70)	90 (70-158)	0.352‡
HDL-C, mg/dl	35 (31-40)	32 (31-36)	0.041‡
Triglyceride, mg/dl	168 (125-216)	192 (148-270)	0.104‡
Creatinine, mg/dl	1.0 (0.9-1.2)	1.1 (0.9-1.2)	0.189‡

ACEB/ARB=angiotensin-converting enzyme blocker, angiotensin receptor blocker, CCB=calcium channel blocker, CVD=cerebrovascular diseases, dIAD=diastolic inter-arm blood pressure difference, DM=diabetes mellitus, IHD=ischemic heart disease, *Independent sample t test; †Chi- square test; ‡Mann-Whitney U test

Table 7: Comparison of demographic and clinical characteristics by the presence of significant inter-arm diastolic blood pressure difference.

Characteristics	<10 mm Hg (n=418)	≥10 mm Hg (n=10)	P value
Age (year)			
Mean±SD	53.4±10.7	58.4±10.6	0.149*
Sex			
Male	266 (63.6)	6 (60.0)	0.813†
Female	152 (36.4)	4 (40.0)	
BMI	25.5±4.2	24.4±2.9	0.414*
SBP, mm of Hg	137.1±19.4	138.7±23.2	0.832*
DBP, mm of Hg	85.7±12.7	97.0±13.7	0.048*
Associated diseases			
DM	169 (40.4)	3 (30.0)	0.506†
IHD	209 (50.0)	5 (50.0)	0.981†
Dyslipidemia	245 (58.6)	8 (80.0)	0.174†
CVD	30 (7.2)	0 (0)	0.184†
Medication			
Aspirin	87 (20.8)	0 (0)	0.106†
Statin	98 (23.4)	0 (0)	0.081†
ACEB/ARB	270 (64.6)	4 (40.0)	0.109†
Beta-blocker	157 (37.6)	0 (0)	0.015†
CCB	105 (25.1)	2 (20.0)	0.712†
Diuretics	61 (14.6)	4 (40.0)	0.027†
Laboratory findings			
FBS, mg/dl	107 (94-151)	98 (95-124)	0.952‡
Total cholesterol	170 (148-195)	164 (146-223)	0.086‡
LDL-C, mg/dl	105 (83-132)	90 (70-158)	0.932‡
HDL-C, mg/dl	35 (31-40)	32 (31-36)	0.005‡
Triglyceride, mg/dl	168 (125-216)	192 (148-270)	0.073‡
Creatinine, mg/dl	1.0 (0.9-1.2)	1.1 (0.9-1.2)	0.113‡

*Independent sample t test; †Chi- square test; ‡Mann-Whitney U test

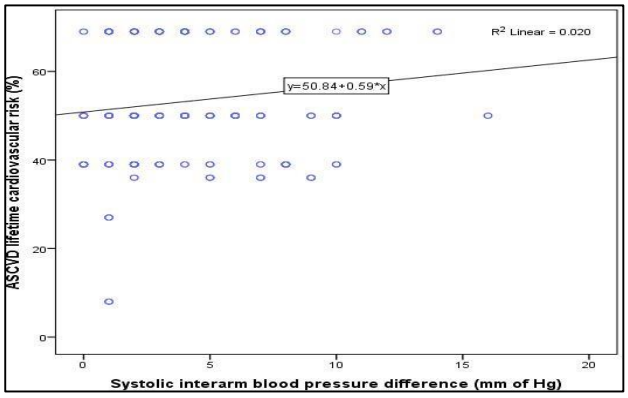

Figure 6: Correlation of systolic inter-arm blood pressure difference with the lifetime ASCVD risk.

DISCUSSION

This study aimed to assess the relationship between inter-arm blood pressure differences and predicted future cardiovascular risk in hypertensive patients. In this study, the average age of the patients was 53.6 (±10.8) years.[15] This finding was similar to a study in another tertiary care hospital in Bangladesh. It was comparatively lower than in other studies; Kim et al from Korea reported an average age of 61±11 years, and Yu et al from China reported an average age of 62.3±13.6 years.[16,17] Regarding sex distribution, this study demonstrated a male predominance (63.6% males, 36.4% females). The frequency of dyslipidemia, obesity, and a history of IHD were 253 (59.1%), 217 (50.7%), and 214 (50.0%), respectively. Diabetes mellitus was present in 40.2% of patients, with 25% reporting a family history of coronary artery disease, and 21.5% of participants were current smokers. Most commonly used antihypertensive medications were angiotensin Receptor blockers or ACE inhibitors, similar to other studies conducted in Bangladesh and other countries.[15,16] A relatively large proportion of patients had several cardiovascular comorbidities, including diabetes mellitus, coronary artery disease, and cerebrovascular disease, similar to the study of Kim et al.[16] The present study reported a prevalence of 8.2% for significant sIAD (≥10 mmHg). In terms of systolic inter-arm difference (sAID), 27.3% of patients had sAID <10 mmHg to ≥5 mmHg, and the majority (64.5%) had sAID <5 mmHg. Regarding diastolic pressure, the present study reported a prevalence of 2.3% for significant dIAD (≥10 mmHg), followed by 25.2% of patients with dAID <10 mmHg to ≥5 mmHg, and the majority (72.4%) had dAID <5 mmHg. The magnitude of IABPD >10 mmHg varies considerably among studies; frequencies of 3.4–40.7% have been found in sIAD and from 1.4 to 40% in dIAD.[9,16,18] Differences of more than 20 mmHg, although less intense, are also common, with systolic frequencies ranging from 1.1 to 23% and diastolic frequencies ranging from 0 to 3.8%.[18,19]

The findings of the present study were more or less similar to the findings of the studies those included only hypertensive individuals.[20] Clark et al reported that 23% of patients had a mean difference in systolic blood pressure between arms of ≥10 mmHg and 3% had a mean difference of ≥20 mmHg.[21] Another 6% of patients had a mean difference in diastolic blood pressure between arms of ≥10 mmHg.[21] Kim et al reported a prevalence of 7.7% for significant sIAD (≥10 mmHg) in hypertensive patients with well-controlled blood pressure.[16] The IAD and the prevalence of patients with significant IAD in this study were lower than those in previous studies with Western populations, which reported a significant systolic IAD prevalence of 13% in hypertensive patients (10–19.2%).[22] Findings of the present study suggest that blood pressure is different in each arm in most individuals. The inter-arm blood pressure differences are consistent, frequent, and strong. In general, blood pressure measured simultaneously in the right and left arm is rarely the same, a finding supported by the present study (only 4.6% of all systolic blood pressure and 3.7% of all diastolic blood pressure were equal in both arms). These findings are similar to those reported by other authors who also used simultaneous measurements.[18,19] One important aspect of identifying inter-arm blood pressure differences, besides correctly establishing blood pressure categories, is its future usefulness for identifying cardiovascular risk. Patients with renal disease were reported to have 24% higher mortality for every 10 mmHg of inter-arm blood pressure difference.[23] Moreover, results from multiple regression analysis show that the 10-year Framingham cardiovascular risk was significantly correlated with systolic inter-arm blood pressure difference (sIAD) (β=0.096, p=0.003) in the present study. This finding was in agreement with another study that demonstrated a correlation between sIAD and the 10-year cardiovascular risk, as determined by the Framingham risk score.[16] In Lane et al's and Kimura et al's studies, gender was not a significant factor associated with a large inter-arm blood pressure difference.[18,24] Handedness has been examined as a possible variable in inter-arm blood pressure difference. Unfortunately, the current study group included a surprisingly low number of left-handed individuals: only nine individuals (2.1%). This low number makes it impossible to relate handedness to blood pressure differences in the arms.

However, Lane et al studied this more in detail.[18] Their sample did include a larger number of left-handed individuals compared with the present study, and they found no significance in terms of handedness. Similar results were also reported by Fonseca-Reyes and his colleagues.[20]

Limitations

This study had several limitations, including the selection of patients from a single public tertiary care hospital, a small sample size, the cross-sectional design, and the use of the ASCVD risk calculator for evaluating the 10-year cardiovascular risk in patients who have already experienced coronary artery disease.

CONCLUSION

This study indicates a positive correlation between sIAD and 10-year cardiovascular risk, with significant sIAD associated with a higher frequency of ischemic heart disease in hypertensive patients. Accurate sIAD measurements may serve as a simple and cost-effective tool for predicting cardiovascular risk. Simultaneous measurement of inter-arm blood pressure differences may offer clinical benefits for risk stratification in hypertension.

Recommendations

Large-scale, multicenter, longitudinal studies are needed to explore the clinical significance of inter-arm differences and whether tailored risk reduction strategies based on detected inter-arm differences can impact outcomes for individuals with hypertension.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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