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ORIGINAL ARTICLE

Association between Interarm Systolic Blood Pressure Difference and Coronary Artery Disease in Patients Undergoing Elective Coronary Angiography

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ABSTRACT

Background: An elevated risk of cardiovascular events, such as stroke, coronary artery disease (CAD), and all-cause mortality, may be linked to interarm systolic blood pressure difference (IASBPD). In the present study, we aimed to detect accurate risk association of interarm systolic blood pressure difference with coronary artery disease among patients who underwent elective coronary angiography.

Methods: A total of 80 patients who underwent elective coronary angiography and their systolic blood pressure measurement was between 90 and 200 mmHg were included in this cross sectional study. Forty-one patients did not have significant coronary artery disease while 39 patients had it. We examined the relationship between coronary artery disease and IASBPD in this well-defined patient sample.

Results: Among studied patients, systolic blood pressure in the right arm was (130 ± 19.58 mmHg), in the left arm was (113.63 ± 19.81 mmHg), and inter-arm blood pressure difference was (15.88 ± 8.49 mmHg). Inter-arm blood pressure difference (IRBP Difference) did not differ significantly between patients with significant coronary artery disease and those without (16.67 ± 10.34 vs. 15.12 ± 6.27, P= 0.4192). Gender distribution showed notable disparities, with a higher percentage of males in the significant artery disease group compared to those without significant artery disease (89.74% vs. 58.54%, P<.05). Ejection fraction (EF) differed significantly between both groups among cases without significant artery disease having a higher EF compared to cases with significant artery disease (62.12% ± 6.73% vs. 62.12% ± 6.73%, P<.05).

Conclusion: While we have observed significant gender-based disparities and a clear correlation between reduced ejection fraction and the incidence of significant artery disease, our study suggests that the predictive value of the inter-arm blood pressure difference in CAD patients appears limited.

Keywords: Elective Coronary Angiography; Coronary Artery Disease; Interarm Systolic Blood Pressure Difference.

INTRODUCTION

On a global scale, coronary artery disease (CAD) ranks as the leading cause of mortality. The death rate in Egypt due to coronary artery disease is rising. World Health Organization (WHO) data shows that CAD has one of the highest age-standardized mortality rates globally [1]. When it comes to screening for coronary artery disease in asymptomatic individuals and those in the early stages of the disease, simple and non-invasive parameters are highly beneficial and effective, especially considering the high prevalence of cardiovascular diseases (CVD) [2]. Several studies have demonstrated that the interarm difference of the systolic blood pressure can predict the risk of cardiovascular morbidity and mortality [3].

As such, the most practical, economical, and straightforward method for identifying peripheral vascular disease (PVD) and predicting the presence of CAD is to take blood pressure readings from both arms and then calculate the difference [4].

However, one of the most recent studies concerned with investigating the relation between incidence of cardiovascular diseases and inter-arm systolic blood pressure difference reported that people who had readings of 15 mmHg or more of interarm systolic blood difference (IASBPD) were at a greater risk for stroke and peripheral arterial disease (PAD). The risk was also higher for those with a maximum absolute IASBPD of 25 mmHg or more for other cardiovascular diseases. However, the risk for total cardiovascular disease was only increased for those with a maximum absolute IASBPD of 25 mmHg or more. Accordingly, measuring blood pressure between arms may help to recognize people who are at risk for cardiovascular disease [5].

It was found by Tokitsu et al. [6] that patients with CAD had a higher IASBPD level compared to those without CAD. People whose IASBPD was more than 10 mmHg had far more severe coronary artery stenosis than those whose IASBPD was less than 10 mmHg. Moreover, compared to other prevalent risk factors of cardiovascular disease, those with IASBPD ≥10 mmHg had a substantially higher chance of future cardiovascular events, and this index had a more independent and stronger predictive value.

In contrast, Mohamadi et al. [7] found no correlation between IASBPD and the existence or severity of coronary artery disease. They argued that the IASBPD index is not a reliable tool for determining the presence and degree of coronary artery stenosis or for making a diagnosis of coronary artery disease. Therefore, this study is to detect accurate risk association of interarm systolic blood pressure difference with coronary artery disease among patients who underwent elective coronary angiography.

PATIENTS AND METHODS

This cross-sectional study was carried out on 80 elective coronary angiography patients from June to December of 2023 in the Cardiology Department, Faculty of Medicine at Zagazig University Hospitals. Written informed consent was obtained from all participants after an explanation of the methods and medical research. The research was conducted under the World Medical Association's Code of Ethics (Helsinki Declaration) for human research. This study was carried out after the approval of the Institutional Review Board (IRB) (#10798/21-5-2023).

Study population

The following criteria were used to include cases that were eligible for elective coronary angiography: aged more than 18 years, feasibility of monitoring blood pressure from both arms, and systolic blood pressure between 90 and 200 mmHg.

We excluded patients who had history of coronary artery bypass graft, systemic thromboembolism, severe heart valve disease, congenital heart disease (determined by echocardiography), peripheral arterial disease, atrial fibrillation rhythm, second- or third-degree heart block (based on electrocardiogram), and renal failure (those who were on hemodialysis or having creatinine level higher than 2mg/dl). Patients with systemic inflammatory diseases (fever or evidence of the diseases), as well as pregnant were also excluded from the study.

Study variables, clinical assessment

All patients included in this study were subjected to complete history taking as well as clinical evaluation. Vital signs such as radial pulse rate and rhythm were assessed, along with measuring brachial blood pressure. Cardiac examination and auscultation were started in supine position. The next step was to place the patient in the lateral decubitus posture so we could listen for mitral stenosis's low-pitched diastolic murmur. Once the patient was turned upright, the stethoscope diaphragm was used to evaluate all cardiac areas, S1, S2, systolic as well as the diastolic murmurs were evaluated. Finally, with the patient leaning forward and holding their breath, the sound of murmur of aortic regurgitation or any other friction rubs were checked by the examiner.

A standard tourniquet (arm) of 35 cm in length and 12–13 cm in width was utilised in accordance with the protocols for measuring blood pressure. We also had smaller and larger tourniquets on hand in case anyone required them. On the eve of the coronary angiography (CAG), the patient had their blood pressure checked and noted. At least five minutes before to taking their blood pressure, patients were asked to lie comfortably on a height-adjustable table with their arms aligned with their heart on the bed. At least thirty minutes before to the blood pressure measurement, patients were instructed not to drink any caffeinated beverages or tea. This study's interarm difference computation informed the automatic measurement of blood pressure up to three times per minute and the subsequent determination of each hand's mean blood pressure.

A significant IASBPD value of ≥10 mmHg or more was determined by measuring blood pressure in both arms. An angiographic professional with expertise in the field injected contrast agent and used a fluoroscope and X-ray apparatus (Philips, Eindhoven, Netherlands) to perform the CAG. The CAG was used to detect if CAD was present or not. The severity and complexity of coronary artery disease were assessed in individuals using Gensini and Syntax scores. Two groups of patients were identified from the CAG results: one group had no substantial CAD (coronary artery normalcy or stenosis less than 50 percent), while the other group had significant CAD (moderate stenosis 51.0-70.0 percent, severe stenosis greater than 71.0 percent).

STATISTICAL ANALYSIS

Using SPSS 23.0 for Windows, we gathered, tabulated, and statistically analyzed all of the data (SPSS Inc., Chicago, IL, USA). The qualitative data was shown using relative percentages and frequencies. The stated difference between qualitative variables was calculated using the chi-square test ($\chi 2$). The quantitative variables in the two sets of non-normally distributed data were compared using the Mann Whitney test. Z-test for percentage: to compare percentage of outcome between the two groups.

RESULTS

The mean age of the participants was 57.68 years, 73.75% were male (59 patients), while 26.25% were female (21 patients). Among the patients, 41.25% had a history of smoking, 45% had a history of diabetes mellitus (DM), and 41.25% had a history of hyperlipidemia. Additionally, 26.25% had a family history of heart disease. The mean body mass index (BMI) of the participants was 30.46 kg/m2, the systolic blood pressure (SIABPD) measurements were evaluated for both the left and right arms, with the mean systolic blood pressure in the right arm (SBP.RT.ARM) being 130 mmHg ± 19.58 mmHg, and the mean systolic blood pressure in the left arm (SBP.LT.ARM) being 113.63 mmHg ± 19.81 mmHg, inter-arm blood pressure difference (IRBP Difference) had a mean of 15.88 ± 8.49 mmHg.

The mean ejection fraction (EF) was 59.9% ± 8.85%. The left ventricular end-systolic diameter (LVES) had a mean value of 35.05 cm ± 9.79 cm, and the left ventricular end-diastolic diameter (LVED) had a mean value of 50.98 cm ± 7.95 cm. The mean severity score by Gencini was 26.2 ± 33.41, reflecting the severity of coronary artery disease, and the complexity of coronary artery lesions, as assessed by the syntax evaluation, had a mean value of 8.88 ± 10.24.

On average, each participant had approximately 1.16 ± 1.23 diseased vessels. The distribution of significant lesions in the coronary arteries varied, with 46.25% of patients having no significant lesions (0), 12.5% with one lesion, 20% with two lesions, and 21.25% with three lesions. In total, 48.75% of the participants exhibited significant artery disease (Figure 1).

Patients were subdivided into two groups, first group including 39 patients with significant coronary artery disease and second group including 41 patients without significant coronary artery disease. Gender distribution showed notable disparities, with a higher percentage of males in the significant coronary artery disease group (89.74%) compared to the group without significant artery disease (58.54%) ($p = 0.00152$) (Table 1).

The group without significant artery disease had a higher percentage of patients with normal blood pressure (46.34%) compared to the significant artery disease group (28.21%). The inter-arm blood pressure difference (IRBP Difference) showed a substantial difference, with cases without significant artery disease having a mean difference of 15.12 ± 6.27 mmHg and those with significant artery disease having a considerably higher mean difference of 16.67 ± 10.34 mmHg, although this difference was not statistically significant (p = 0. 4192). (Table 1).

Ejection fraction (EF) differed significantly among cases without significant artery disease having a higher mean EF of 62.12% ± 6.73% compared to cases with significant artery disease, which had a mean EF of 57.56% ± 10.21% ($p = 0.0203$) (Table 2). Non statistically significant association was found between IRBP Difference and any other parameters (Table 3).

Table (1): Demographic data and clinical examination among cases with and without significant coronary artery disease

		No Significant coronary artery disease (N = 41)	Significant coronary artery disease (N = 39)	P. Value
Age (Years)		57.49 ± 10.81	57.87 ± 10.69	0.8736
Gender				
Male		24 (58.54%)	35 (89.74%)	0.00152*
Female		17 (41.46%)	4 (10.26%)	
Smoking				
History		14 (34.15%)	19 (48.72%)	0.18572
History of DM		17 (41.46%)	19 (48.72%)	0.51445
History of hyperlipidemia		16 (39.02%)	17 (43.59%)	0.67843
Family history of heart disease		8 (19.51%)	13 (33.33%)	0.16021
BMI (Kg/m^2)		30.45 ± 6.8	30.48 ± 3.63	0.9818
Stages of Hypertension	Normal	19 (46.34%)	11 (28.21%)	0.09397
	High normal	11 (26.83%)	11 (28.21%)	0.89043
	Stage 1	9 (21.95%)	13 (33.33%)	0.25444
	Stage2	4 (9.76%)	3 (7.69%)	0.74402
IRBP Difference		15.12 ± 6.27	16.67 ± 10.34	0.4192

DM: diabetes mellitus, BMI: Body mass index, IRBP Difference: inter-arm blood pressure difference

Table (2): ECHO data among cases with and without significant coronary artery disease

	No Significant coronary artery disease (N = 41)	Significant coronary artery disease (N = 39)	P. Value
Mild valve disease			
MR	6 (14.63%)	3 (7.69%)	0.32601
TR	4 (9.76%)	3 (7.69%)	0.74402
AR	1 (2.44%)	1 (2.56%)	0.97143
Moderate valve disease			
MR	1 (2.44%)	0	0.99
TR	0	1 (2.56%)	0.98
EF (%)	62.12 ± 6.73	57.56 ± 10.21	0.0203*
LVES (Cm)	33.29 ± 5.74	36.9 ± 12.56	0.0997
LVED (Cm)	50.32 ± 7.86	51.67 ± 8.08	0.4495

MR: Mitral Regurgitation, TR: Tricuspid Regurgitation, AR: Tricuspid Regurgitation, LVES: left ventricular end-systolic diameter, LVED: left ventricular end-diastolic diameter

Table (3): Correlation between IRBP Difference and other parameters

	R	P .value
Age	-0.20844	0.0635
BMI	-0.09494	0.4022
EF	0.002788	0.9804
LVES	-0.07174	0.5272
LVED	-0.11312	0.3178
Severity by Gencini	0.017879	0.8749
Complexity by syntax	-0.07714	0.4964

BMI: Body mass index, EF: Ejection fraction, LVES: left ventricular end-systolic diameter, LVED: left ventricular end-diastolic diameter,

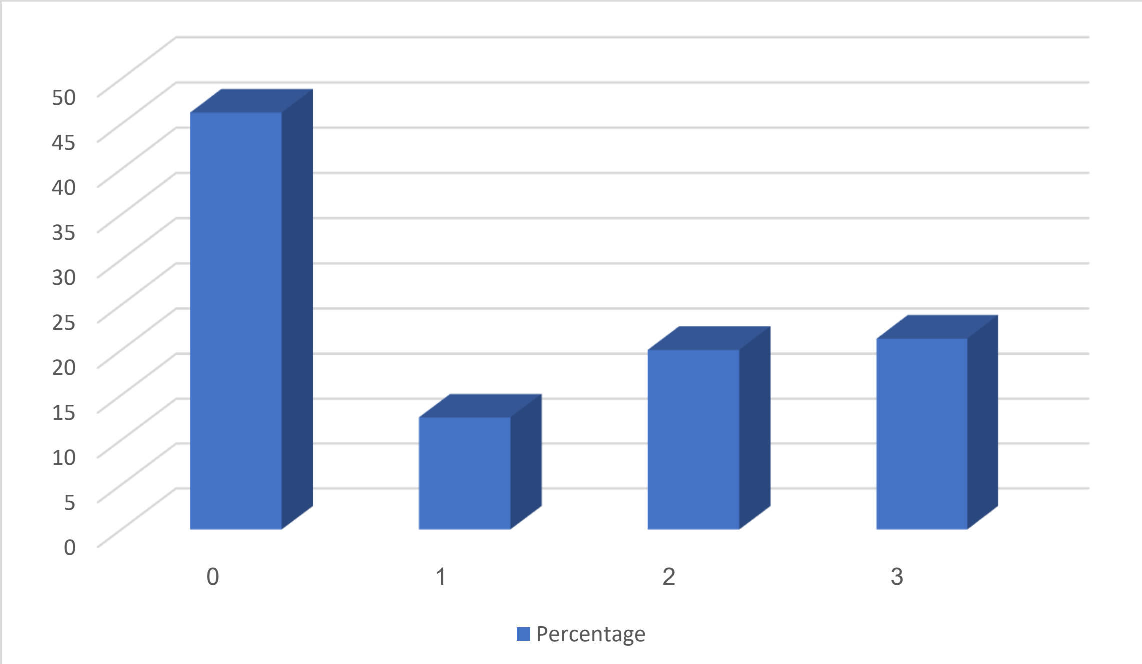

Figure (1): Number of diseased vessels among included patients.

DISCUSSION

The interarm systolic blood pressure difference has recently gained attention as a non-invasive parameter that could hold significant value in assessing CAD risk. IASBPD represents the systolic blood pressure difference between the left and right arms, and it has shown promise as an indicator of cardiovascular risk. Elevated IASBPD values have been linked to adverse cardiovascular outcomes, making it an intriguing candidate for further investigation [8].

The present research aimed to shed light on the prognostic or risk-stratification implications of IASBPD in the context of coronary artery disease among those undergoing elective coronary angiography at Zagazig University Hospital

In our study, we conducted an assessment of blood pressure among the participants and found that the distribution of hypertension stages included 37.5% with normal blood pressure, 27.5% with High Normal blood pressure, 27.5% in Stage 1 hypertension, and 8.75% in Stage 2 hypertension. Notably, the mean inter-arm blood pressure difference (IRBP Difference) was measured at 15.88 mmHg ± 8.49 mmHg.

In our study, we conducted a comparison between cases with and without significant coronary artery disease. However, a notable gender disparity was observed, with a higher proportion of males in the significant coronary artery disease group compared to those without significant coronary artery disease respectively (89.74% vs. 58.54%, p = 0.00152*).

In this study, the interarm systolic blood pressure difference (IASBPD) showed a non-significant variation between the two groups, with 46.34% in the no significant coronary artery disease group and 28.21% in the significant coronary artery disease group having normal blood pressure, 26.83% and 28.21% having high-normal blood pressure, 21.95% and 33.33% having stage 1 hypertension, and 9.76% and 7.69% having stage 2 hypertension, respectively. The mean IASBPD was 15.12 ± 6.27 in the no significant coronary artery disease group and 16.67 ± 10.34 in the significant coronary artery disease group, with no significant difference observed (p = 0.4192).

This suggests that the variation in blood pressure between the arms, as measured in our study, may not be a distinguishing factor in identifying or predicting significant artery disease in these particular groups.

However, our results were inconsistent with Sadasivam et al. [11] who reported a significant finding in their study, indicating that a notably elevated systolic inter-arm blood pressure difference (IAD) is prevalent in subjects with coronary artery disease (CAD). Their research further revealed that this increased IAD is positively correlated with the severity of CAD. Remarkably, this association remained robust even after controlling for other cardiovascular disease (CVD) risk factors, underlining the potential value of IAD as an indicator of CAD severity and its independence from other common risk factors.

Similarly, our results were inconsistent with Durmuş et al. [13] as they stated that when coronary angiography was done, it revealed an association between the IASBPD and the severity of coronary artery disease.

In a prospective study conducted by Clark et al. [14], they examined 230 hypertensive patients over a median follow-up period of 9.8 years in a primary care setting. Their findings revealed a significant association between an inter-arm systolic blood pressure difference of ≥10 mmHg and the incidence of cardiovascular (CV) events. Furthermore, this inter-arm systolic blood pressure difference was linked to all-cause mortality. Notably, the study also reported that for each 1 mmHg increase in the inter-arm systolic blood pressure difference, there was a corresponding increase of 5–6% in the incidence of mortality. These findings underscore the clinical importance of inter-arm systolic blood pressure differences as predictors of CV events and mortality in hypertensive patients.

Similarly, Tokitsu et al. [6] reported that the presence and severity of IADs were associated with an increase in CAD patients. Future cardiovascular events were independently linked to IAD levels greater than 10 mmHg.

The inconsistency between our study and other investigations be attributed to several key factors. Firstly, variations in geographical, regional characteristics, lifestyle habits, dietary patterns, and genetic predispositions that can significantly influence the relationship between inter-arm blood pressure differences (IAD) and the presence and severity of CAD. These regional discrepancies underline the importance of considering the unique attributes of our study population in Egypt compared to other regions, such as India as in Sadasivam et al. [11] study, when interpreting research findings. Additionally, variations in sample sizes among the studies are pivotal, given that investigations with larger cohorts, such as Sadasivam et al. [11] with 106 subjects, Durmuş et al. [13] with 104 patients, and Clark et al. [14] with 230 hypertensive patients, may yield increased statistical power. This augmented statistical power enhances their capability to detect associations that might remain elusive in our relatively smaller scale study.

Furthermore, variations in measurement techniques can significantly affect the accuracy and interpretation of IAD, which further underscores the importance of methodological consistency in comparative research. These variations may be represented in the inclusion of the ankle-brachial pressure index (ABI) in some studies such as Sadasivam et al. [11] and Tokitsu et al. [6] who used a combination of ABI and IAD values, can also contribute to the disparity in outcomes. Research populations should be taken into account in terms of their differences in heterogeneity. For example, while many of the people in our study had normal blood pressure, there were also people in different stages of hypertension. Consistent relationships between IAD and CAD may be more challenging to establish due to the variation in blood pressure categories. In addition, some studies, like the one by Clark et al., only included hypertensive patients, whereas our research included a wider range of blood pressure categories. Different results may be expected due to the fact that the patient population is distinct. Differences in results could also be explained by the fact that different studies set out to evaluate different variables, such as the predictive power of IAD for coronary events or its function as a predictor of coronary artery disease

In this study, we found that cases without significant coronary artery disease had a significantly higher ejection fraction (EF) compared to cases with significant coronary artery disease. This difference in ejection fraction (EF) reflects the impact of significant coronary artery disease on cardiac function. This is due to the absence of significant arterial blockages, allowing for more efficient blood flow. In contrast, cases with significant artery disease experience reduced blood flow to the heart muscle, particularly during periods of increased demand, leading to a lower EF [15].

Moreover, we explored the correlation between inter-arm blood pressure difference (IRBP Difference) and other clinical parameters included age, body mass index (BMI), as well as cardiac parameters encompassing left ventricular end-systolic volume (LVES), left ventricular ejection fraction (EF), as well as left ventricular end-diastolic volume (LVED). Additionally, the severity of cardiac conditions was evaluated using the Gencini scale, while The Syntax score was used to measure the complexity of coronary artery disease. It was

found that there was no significant correlation between IRBP Difference and any other parameters. Our results were in agreement with Grossman et al. [16] who revealed that heart rate, body mass index, or age had no correlation with interarm BP difference.
Our findings contradicted those of a prior study by Kimura et al. [17], which found a correlation between body mass index (BMI) and systolic interarm systolic blood pressure (SIBP) greater than 10 mm Hg. Our results showed a non-significant connection between BMI and both IASBPD and IADBPD, which differed from the previous study. In addition, they found a positive and statistically significant correlation between age and absolute IASBPD.

Limitations:
Several limitations should be acknowledged in our study. First, the sample size, though adequate for initial insights, may not fully represent the diversity of patients with coronary artery disease. Additionally, the single-center nature of the study could introduce selection bias. The observational design of the research restricts our ability to establish causal relationships, and confounding variables that were not considered in this analysis may influence the results. Furthermore, the cross-sectional design limits our ability to assess temporal relationships. The reliance on elective coronary angiography patients may not capture individuals with less advanced or symptomatic forms of coronary artery disease. Moreover, we didn't use other invasive assessment techniques like Intravascular ultrasound (IVUS) or the instantaneous wave-free ratio (iFR) relying solely on angiography which might limit the depth of our analyzed data.

CONCLUSION

In conclusion, our study provides valuable insights into the relationship between inter-arm blood pressure differences and coronary artery disease (CAD). While we have observed significant gender-based disparities and a clear correlation between reduced ejection fraction and the presence of significant artery disease, our study suggests that the predictive value of the inter-arm blood pressure difference in CAD patients appears limited.

Conflict of interest

The authors declare that they have no conflict of interest with respect to the authorship and/or publication of this article.

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Figure legend

Figure 1: Number of diseased vessels among included patients.

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