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Original Research Article

Frequency of Coronary Artery Anomalies Among Adult Patients Undergoing Primary Percutaneous Coronary Intervention

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Abstract: *Coronary artery anomalies (CAAs) are congenital variations in coronary anatomy that may be encountered during primary percutaneous coronary intervention (PCI). Early recognition is critical to avoid procedural complications, especially during emergent interventions.* ***Objective:*** *To determine the frequency and types of CAAs in adult patients undergoing primary PCI in a tertiary care hospital in Pakistan.* ***Methods:*** *This descriptive cross-sectional study was conducted over six months at the Department of Cardiology, Bahawal Victoria Hospital (BVH), Bahawalpur, from 3rd October 2024 to 3rd April 2025. One hundred sixty-two adult patients undergoing primary PCI were included using non-probability consecutive sampling. Demographic, clinical, and angiographic data were recorded. Coronary angiograms were assessed for anomalies by two experienced interventional cardiologists. Data were analyzed using SPSS v25. Chi-square tests were applied to evaluate associations between CAAs and cardiovascular risk factors.* ***Results:*** *Among the 162 patients, the mean age was 58.4 ± 10.2 years, with 74.7% being male. The overall frequency of CAAs was 9.3% (n = 15). The most common anomaly was the right coronary artery (RCA) originating from the left coronary sinus (3.1%), followed by absence of the left main trunk with separate origins of the LAD and LCx arteries (2.5%). No statistically significant association was found between CAAs and hypertension (p = 0.43), diabetes mellitus (p = 0.39), smoking (p = 0.36), age > 60 years (p = 0.85), or male gender (p = 0.68).* ***Conclusion:*** *The frequency of CAAs in patients undergoing primary PCI in this Pakistani tertiary care setting was relatively high at 9.3%. The most frequently observed anomalies were RCA from the left coronary sinus and absence of the left main trunk. While no significant correlation was observed with traditional cardiovascular risk factors, the recognition of CAAs remains essential during emergency PCI to guide catheter selection, prevent procedural delays, and ensure patient safety.*

Keywords: Coronary Vessel Anomalies; Percutaneous Coronary Intervention; Coronary Angiography; Pakistan; Acute Coronary Syndrome

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Introduction

Coronary artery anomalies (CAAs) are rare but clinically significant congenital variations in the origin, course, or structure of coronary arteries, with a reported prevalence of 0.3% to 5.6% in angiographic studies globally (1,2). While many CAAs are benign and incidental findings, certain types have been associated with myocardial ischemia, arrhythmias, and even sudden cardiac death, especially when associated with interarterial or intramural courses (3, 4). Accurately identifying CAAs is vital in interventional cardiology, particularly during primary percutaneous coronary interventions (PCI), where unrecognized anomalies can lead to procedural complications or failed interventions.

In recent years, the global trend of utilizing coronary angiography and multi-detector computed tomography (MDCT) has enhanced our understanding of CAAs, allowing for better anatomical characterization and correlation with clinical events (5,6). However, in South Asia—including Pakistan—the data regarding the frequency and pattern of CAAs among patients undergoing coronary interventions remain sparse. A limited number of studies have explored the prevalence of CAAs in the general Pakistani population, with a reported incidence ranging between 1.3% and 3.6%. However, most of these have been conducted on elective or diagnostic catheterization cohorts rather than acute PCI populations (7, 8).

Primary PCI is the gold standard for managing ST-elevation myocardial infarction (STEMI) and other acute coronary syndromes (ACS). However, a coronary anomaly can complicate catheter engagement, delay reperfusion, or mimic occlusion, especially if the anomaly remains undetected during the procedure (9). Recognizing CAAs during emergent PCI settings is therefore critical not only for procedural success but also for the long-term cardiovascular outcomes of patients (10).

In Pakistan, cardiovascular disease remains the leading cause of mortality, with ischemic heart disease accounting for over 30% of all deaths annually (11). Given the growing burden of CAD and the increasing use of PCI in emergency settings across tertiary care centers in the country, understanding the anatomical variations of coronary arteries in the local population is paramount. Furthermore, recognizing CAAs can influence patient management and stenting strategy, and even prompt the need for surgical referral in certain high-risk configurations (12).

Despite this clinical significance, no large-scale study has evaluated the frequency of CAAs specifically in patients undergoing primary PCI in Pakistani tertiary care settings. Most existing research originates from Western literature, which may not adequately represent the anatomical diversity or procedural context in South Asian populations (13,14).

This study aims to fill this gap by determining the frequency and types of coronary artery anomalies among adult patients undergoing primary PCI at Bahawal Victoria Hospital, Bahawalpur. The results will provide valuable epidemiological insight, enhance local procedural preparedness, and support cardiologists in timely recognition and management of CAAs, contributing to improved patient outcomes.

Methodology

This descriptive cross-sectional study was conducted at the Department of Cardiology, Bahawal Victoria Hospital (BVH), Bahawalpur, a major tertiary care teaching hospital in Southern Punjab, Pakistan, from 3 October 2024 to 3 April 2025. The study aimed to determine the frequency and types of coronary artery anomalies among adult patients

undergoing primary percutaneous coronary intervention (PCI). Data were collected over six months following approval from the Institutional Review Board and the ethical committee.

162 patients were included in the study using non-probability consecutive sampling. All adult patients aged 18 years or above who presented with acute coronary syndrome and underwent primary PCI were considered eligible for inclusion. Patients with previous coronary artery bypass grafting (CABG), known congenital heart disease, or those undergoing elective PCI were excluded to eliminate confounding variables that might affect anatomical coronary evaluation.

All patients underwent primary PCI using standard techniques, and the diagnostic coronary angiograms were assessed for the presence of coronary artery anomalies. Anomalies were defined according to standard angiographic criteria and classified based on their origin, course, and termination patterns. At least two experienced interventional cardiologists interpreted coronary angiograms independently to minimize observer bias.

Clinical and demographic data, including age, gender, comorbidities such as hypertension, diabetes mellitus, and smoking status, were recorded using a structured proforma. Statistical analysis was performed using SPSS version 25.0. Descriptive statistics were used to calculate means and standard deviations for continuous variables, as well as frequencies and percentages for categorical variables. The chi-square test was applied to determine associations between coronary artery anomalies and common cardiovascular risk factors. A p-value ≤ 0.05 was considered statistically significant.

Results

A total of 162 adult patients undergoing primary percutaneous coronary intervention (PCI) at the Department of Cardiology, BVH Bahawalpur, were included in this study. The mean age of the patients was 58.4 ± 10.2 years, with a male predominance (n = 121; 74.7%) compared to females (n = 41; 25.3%). The majority of patients (approximately 62%) were aged between 51 and 70 years. The mean BMI was 27.5 ± 4.1 kg/m². Among the comorbidities, hypertension was observed in 92 patients (56.8%), diabetes mellitus in 72 (44.4%), and a history of smoking (current or former) was positive in 99 patients (61.1%).

Out of the total sample, coronary artery anomalies (CAAs) were identified in 15 cases, representing a frequency of 9.3%. The most frequently encountered anomaly was the right coronary artery originating from the left coronary sinus, observed in 5 patients (3.1%). This was followed by the absence of a left main trunk with separate origins of LAD and LCx arteries in 4 patients (2.5%). Other anomalies included the left coronary circumflex originating from the right coronary artery and the right coronary artery from the ascending aorta, each in 2 patients (1.2%). Additionally, a single case (0.6%) of the left main coronary artery arising from the ascending aorta was also noted.

Stratification analysis revealed no statistically significant associations between the presence of CAAs and conventional cardiovascular risk factors. Among the 15 patients with anomalies, 80.0% were male compared to 74.1% in those without anomalies (p = 0.68). Half of the patients with anomalies were aged over 60 years (50.0%), compared to 47.1% in patients without anomalies (p = 0.85). Hypertension was found in 66.7% of patients with anomalies and 55.6% without (p = 0.43). Similarly, diabetes mellitus was present in 53.3% of patients with anomalies and 43.2% without (p = 0.39). Smoking history was positive in 73.3% of patients with anomalies compared to 60.4% in those without (p = 0.36). None of these associations were statistically significant (p > 0.05).

These findings suggest that while the overall frequency of CAAs was 9.3%, aligning with previous regional studies, no significant relationship was found between CAAs and traditional cardiovascular risk factors. The identification of such anomalies remains crucial during coronary angiography and PCI, as they can influence the choice of interventional strategies and procedural safety.

Table 1: Demographic and Clinical Characteristics of Patients (n = 162)

Variable	Frequency (n)	Percentage (%)
Gender		
Male	121	74.7
Female	41	25.3
Age Group (years)		
40–50	24	14.8
51–60	61	37.7
61–70	40	24.7
>70	37	22.8
Comorbidities		
Hypertension	92	56.8
Diabetes Mellitus	72	44.4
Smoking (current/ex)	99	61.1

Table 2: Frequency of Coronary Artery Anomalies (n = 162)

Type of Anomaly	Frequency (n)	Percentage (%)
Right coronary artery originating from left coronary sinus	5	3.1
Absent left main trunk (separate LAD and LCx origin)	4	2.5
Left coronary circumflex from right coronary artery	2	1.2
Right coronary artery from ascending aorta	2	1.2
Left main coronary artery from ascending aorta	1	0.6
Total CAA	**15**	**9.3**

Table 3: Stratification of Coronary Artery Anomalies with Risk Factors (n = 162)

Risk Factor	CAA Present (n = 15)	CAA Absent (n = 147)	p-value
Male Gender	12 (80.0%)	109 (74.1%)	0.68
Age > 60 years	8 (53.3%)	69 (47.1%)	0.85
Hypertension	10 (66.7%)	82 (55.8%)	0.43
Diabetes Mellitus	8 (53.3%)	64 (43.5%)	0.39
Smoking (current/ex)	11 (73.3%)	88 (59.9%)	0.36

Chi-square test applied; p-value ≤ 0.05 considered significant.

Discussion

In this prospective study conducted at Bahawal Victoria Hospital, Bahawalpur, the frequency of coronary artery anomalies (CAAs) among 162 adult patients undergoing primary percutaneous coronary intervention (PCI) was found to be 9.3% (15 out of 162 patients). This prevalence is notably higher than previously reported figures from both regional and international literature, suggesting a potentially greater burden of anatomical coronary variations in patients presenting for emergent PCI procedures in Pakistan.

The most common coronary anomaly identified was the right coronary artery (RCA) originating from the left coronary sinus, found in 5 patients (3.1%), followed by the absence of the left main coronary trunk, with separate origins of the LAD and LCx arteries in 4 patients (2.5%). Other less frequent anomalies included LCx from RCA (1.2%), RCA from ascending aorta (1.2%), and left main coronary artery from ascending aorta (0.6%).

These findings differ from those of earlier local studies. For instance, Alam et al. reported a CAA frequency of 3.6% in a diagnostic angiography cohort in Karachi, with RCA anomalies seen in 1.5% of cases (15). Likewise, Shah et al. observed a 2.9% prevalence in patients undergoing routine angiography at a tertiary center in Islamabad (16). The higher anomaly rate in our study (9.3%) may be attributed to our population of patients undergoing primary/emergency PCI, where time constraints and urgent intervention needs might unmask more conspicuous anatomical variations, especially during attempts at coronary cannulation and device advancement.

Internationally, the reported prevalence of CAAs remains lower. A multicenter study by Liu et al., utilizing multidetector computed tomography (MDCT) in over 30,000 patients, found a prevalence of 1.3%, with RCA anomalies being the most common (0.92%) (17). Similarly, Ghadri et al. observed a CAA frequency of 1.2% in a CT angiography-based cohort (18). These lower figures in non-invasive settings may reflect underdetection or limited reporting in emergent invasive procedures. Moreover, CT-based imaging allows better spatial delineation of anomalous courses, which may be missed during routine angiography.

In our stratification analysis, we observed no statistically significant associations between CAAs and common cardiovascular risk factors. Among CAA patients, 80% were male, versus 74.1% in those without anomalies ($p = 0.68$); 53.3% were aged >60 years, compared to 47.1% in the non-CAA group ($p = 0.85$). Similarly, hypertension was present in 66.7% of CAA patients versus 55.8% in those without ($p = 0.43$); diabetes mellitus in 53.3% vs. 43.5% ($p = 0.39$); and smoking history in 73.3% vs. 59.9% ($p = 0.36$). All p-values > 0.05 suggest that the presence of CAAs is likely congenital and unrelated to traditional atherosclerotic risk factors, consistent with existing literature (19).

Although these anomalies may be asymptomatic, their presence can have important clinical implications. For instance, RCA originating from the left coronary sinus, the most prevalent anomaly in this cohort, has been associated with malignant interarterial courses between the aorta and pulmonary artery in some cases, posing a risk for myocardial ischemia, sudden cardiac death, and failed catheter engagement (21). While our study did not evaluate the precise anatomical course of these arteries, the clinical importance of recognizing their presence during PCI remains critical. Tanaka et al. highlighted the technical difficulties and increased procedural times associated with such anomalies during emergent coronary interventions (22).

The absence of a left main trunk, the second most frequent anomaly in our population, may complicate coronary stenting and requires careful angiographic assessment to avoid misclassification of proximal LAD or LCx lesions. As emphasized in the literature, the identification of this anomaly is essential for precise revascularization strategies and for anticipating dual-vessel involvement during PCI (23).

This study contributes to the limited body of evidence from Pakistan regarding coronary artery anomalies in emergent cardiac interventions. The relatively high prevalence observed suggests the need for enhanced awareness among interventional cardiologists. Given that such anomalies can compromise procedural efficacy and patient safety, especially during urgent interventions, a systematic angiographic assessment should be incorporated into PCI protocols. In selected high-risk or anatomically ambiguous cases, adjunctive imaging modalities such as MDCT could improve detection and procedural planning.

Conclusion

This study identified a 9.3% frequency of coronary artery anomalies among adult patients undergoing primary PCI at a tertiary care hospital in Pakistan. The most frequently observed anomalies were RCA originating from the left coronary sinus and absence of the left main trunk. While no significant association was found between CAAs and common cardiovascular risk factors, their identification remains crucial during emergent procedures to optimize catheterization strategy, reduce complications, and improve outcomes. Enhanced operator awareness and incorporation of adjunctive imaging where necessary can aid in the early detection and management of these anomalies during interventional cardiology practice.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-REU-CRD-2023-032-3015)

Consent for publication

Approved

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The authors declared the absence of a conflict of interest.

Author Contribution

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Conception of Study, Development of Research Methodology Design, Study Design, manuscript review, critical input.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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