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# STUDY OF PATTERNS OF CORONARY ARTERY ANOMALIES IN A TERTIARY CARE SETTING: A RETROSPECTIVE ANALYSIS

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**ABSTRACT:**

**Background:** Coronary artery anomalies (CAAs) are rare congenital disorders that can have significant clinical implications, including myocardial ischemia, arrhythmias, and sudden cardiac death. This study aimed to determine and characterize the patterns of CAAs encountered in our tertiary care cardiovascular center.

**Methods:** This retrospective observational study was conducted at the S.S. Narayana Heart Centre, S.S. Institute of Medical and Research Centre, Davanagere, Karnataka. Data from patients who underwent coronary angiography between July 13, 2013, and May 4, 2024, were reviewed. CAAs were identified and classified based on their origin, course, intrinsic anatomy, and termination. The prevalence of CAAs and the distribution of different types were analyzed.

**Results:** Out of 20,410 patients who underwent coronary angiography during the study period, 100 (0.49%) were found to have CAAs. The mean age of patients with CAAs was 58.81±5.04 years, with a male predominance (61%). Anomalies of origin were the most common type, particularly anomalous aortic origin of the coronaries (44 cases). The right coronary artery (RCA) was most frequently affected, with abnormally high origin being the most common subtype (30 cases). Myocardial bridging was observed in 4 cases, and coronary artery fistulas in 2 cases. The majority of patients with CAAs had associated

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

coronary artery disease, with single vessel disease being the most frequent (39%). Right coronary artery dominance was observed in 85% of cases.

**Conclusions:** This study provides insights into the prevalence and patterns of CAAs encountered in a tertiary care setting in India. The findings are largely consistent with global data but highlight some unique features in our population. These results emphasize the importance of accurate diagnosis and management of these rare congenital anomalies, which can have significant clinical implications.

**Keywords:** Coronary artery anomalies, Anomalous origin, Anomalous course, Anomalous termination of coronary arteries

## INTRODUCTION

Coronary artery anomalies (CAAs) are a diverse group of congenital disorders involving the origin, course, and termination of the coronary arteries. These anomalies are relatively rare, with an estimated prevalence ranging from 0.3% to 1.3% in the general population.[1,2] However, their clinical significance lies in their potential to cause myocardial ischemia, arrhythmias, and even sudden cardiac death, particularly in cases of anomalous coronary artery origins from the opposite sinus of Valsalva.[3]

CAAs can be broadly classified into anomalies of origin, anomalies of intrinsic coronary arterial course, and anomalies of coronary termination.[4] The most common anomaly is the aberrant origin of a coronary artery from the opposite sinus, which can lead to an interarterial course between the aorta and the pulmonary artery, predisposing to compression and myocardial ischemia.[5] Other anomalies include coronary artery fistulas, coronary artery aneurysms, and myocardial bridging, all of which can have varying clinical implications.[6]

The diagnosis of CAAs has traditionally relied on invasive coronary angiography, which remains the gold standard for evaluation.[7] However, with the advent of advanced non-invasive imaging techniques such as computed tomography coronary angiography (CTCA) and cardiac magnetic resonance imaging (CMR), the detection and characterization of CAAs have become more accessible and accurate.

Despite their clinical significance, the epidemiology and patterns of CAAs in specific populations remain poorly understood, largely due to their rarity and the variability in diagnostic modalities employed. Tertiary care centers, serving as referral hubs for complex cardiovascular cases, provide a unique opportunity to study the prevalence and spectrum of CAAs encountered in clinical practice.

This retrospective study aims to determine the prevalence and characterize the patterns of CAAs among patients evaluated at a tertiary care cardiovascular center. By

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

analyzing data from a large cohort of patients undergoing advanced cardiac imaging, this study seeks to contribute to the understanding of the epidemiology and clinical implications of CAAs, ultimately aiding in the development of appropriate diagnostic and management strategies for these coronary artery anomalies.

## MATERIALS AND METHODS:

This was a retrospective observational study conducted at the S.S. Narayana Heart Centre, S.S. Institute of Medical Sciences and Research Centre, Davanagere, Karnataka, a tertiary care center for cardiovascular diseases. The study protocol was approved by the Institutional Ethics Committee.

The study population included all patients who underwent coronary angiography at the center between July 13, 2013, and May 4, 2024. During this period, a total of 20,410 patients underwent coronary angiography, and those with coronary artery anomalies (CAAs) were identified and included in the study.

Electronic medical records and coronary angiography reports were reviewed to identify patients with CAAs. The following data were collected for each patient:

1. Demographic information (age, gender)
2. Clinical presentation and indications for coronary angiography
3. Coronary angiography findings, including the type and pattern of CAA

The coronary angiograms were reviewed and analyzed by experienced interventional cardiologists to classify the CAAs according to the established anatomical classifications.

Classification of Coronary Artery Anomalies: The CAAs were classified based on the following categories:[4]

1. Anomalies of coronary artery origin
    - Anomalous origin from the opposite sinus of Valsalva
    - Anomalous origin from the non-coronary sinus
    - Anomalous origin from the pulmonary artery
2. Anomalies of intrinsic coronary arterial anatomy/ course
    - Coronary artery aneurysms
    - Myocardial bridging
3. Anomalies of coronary artery termination
    - Coronary artery fistulas
    - Coronary artery stenosis

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. The prevalence of CAAs was calculated as the number of patients with CAAs divided by the total number of patients who underwent coronary angiography during the study period. The distribution and patterns of different types of CAAs were analyzed and presented using appropriate statistical methods.

**RESULTS:**

The mean age of patients with CAAs was 58.81±5.04 years, suggesting that these anomalies are often detected in middle-aged to older adults. The male predominance (61%) aligns with previous studies that have reported a higher incidence of CAAs in males.

**Table 1: Demographic Characteristics**

| **Parameter** | **Value** |
|---|---|
| Mean age (Years) | 58.81±5.04 |
| Gender (males & females) | 61 |
| | 39 |
| Diabetes mellitus | 28 |
| Hypertension | 38 |
| Previous H/O IHD | 7 |

The study reports varying degrees of left ventricular dysfunction among patients with CAAs, with moderate dysfunction (40-50% ejection fraction) being the most common (36 cases). This suggests that CAAs may be associated with impaired cardiac function, though a causal relationship cannot be established from this data alone.

**Table 2: Left Ventricular Function**

| **LV systolic dysfunction** | **Frequency** |
|---|---|
| Normal LV systolic function | 32 |
| Mild (50 to 60%) | 22 |
| Moderate (40 to 50%) | 36 |
| Severe (<39%) | 10 |
| **Total** | **100** |

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

The right femoral artery approach was most commonly used (62 cases), followed by the right radial artery (33 cases). This reflects the standard practices in coronary angiography, with a trend towards increased use of radial access.

**Table 3: Approach of CAG**

| **Approach of CAG (Coronary Angiogram)** | **Frequency** |
|---|---|
| Left femoral artery | 3 |
| Right femoral artery | 62 |
| Right radial artery | 33 |
| Right radial and femoral artery | 2 |
| **Total** | **100** |

Right coronary artery (RCA) dominance was most common (85%), which is consistent with the general population. This suggests that CAAs do not significantly alter the pattern of coronary dominance.

**Table 4: Dominance**

| **Dominance** | **Frequency** |
|---|---|
| RCA | 85 |
| LCX | 9 |
| Co-dominant | 6 |
| **Total** | **100** |

Single vessel disease was the most frequent finding (39 cases), followed by double vessel disease (21 cases) and triple vessel disease (16 cases). Notably, 14 patients had normal epicardial coronaries despite having CAAs, indicating that not all anomalies are associated with obstructive coronary artery disease.

**Table 5: Impression of CAGs**

| **Impressions of CAGs** | **Frequency** |
|---|---|
| Normal Epicardial coronaries | 14 |
| Minor CAD | 4 |
| Single vessel disease | 39 |
| Double vessel disease | 21 |
| Triple vessel disease | 16 |

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

| | |
|---|---|
| Recanalised CAD | 4 |
| Patent stent with branch vessel disease | 1 |
| Native vessel disease with patent grafts | 1 |
| **Total** | **100** |

Table 6 provide detailed information about anomalies in each major coronary artery:

- LMCA: 10 cases of LMCA anomalies were found, all of which were anomalies of origin. Eight cases arose from the Right Coronary Cusp (RCC), and two were found on the side of the right ostium. All these cases had RCA dominance. Associated coronary artery disease was common, with 8 cases showing single vessel disease and 2 cases showing recanalized RCA with proximal 50% lesion. Treatment plans varied, including stenting and medical management.
- LAD: Eight cases of LAD anomalies were reported. Four were anomalies of origin (arising from RCC), and four were anomalies of course (myocardial bridging). All cases showed RCA dominance. The coronary angiography (CAG) impressions were evenly split between single vessel disease and normal epicardial coronaries. Treatment plans included stenting and medical management.
- LCX: Twenty cases of LCX anomalies were identified, all being anomalies of origin. Nine arose from the RCA, and eleven from the RCC. All cases showed RCA dominance. CAG impressions varied, with single vessel disease being the most common (9 cases), followed by double vessel disease (5 cases) and normal epicardial coronaries (6 cases). Treatment plans included various stenting procedures and medical management.
- RCA: This was the largest group with 62 cases of RCA anomalies. The majority (30 cases) had abnormally high origin, 19 arose from the Left Coronary Cusp (LCC), 6 from the LMCA, and 5 from the LAD. Two cases showed anomalous termination with coronary cameral fistula. Most cases (52) showed RCA dominance, with some showing LCX dominance (4) or co-dominance (6). CAG impressions varied widely, with single vessel disease being the most common (24 cases). Treatment plans were diverse, including CABG, various stenting procedures, and medical management.

**Table 6a: LMCA anomalies**

| **LMCA** | | **Frequency** |
|---|---|---|
| Anomalous Origin | Arising from RCC | 8 |

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

| | | |
|---|---|---|
| | Side of right ostium | 2 |
| Anomalous Course | - | 0 |
| Anomalous Termination | - | 0 |
| Dominant coronary among patient with anomalous LMCA | RCA | 10 |
| Impression & diagnosis of CAG of patients with anomalous LMCA | Single vessel disease | 8 |
| | Recanalized RCA with proximal had 50% lesion | 2 |
| Treatment Plan of the patients post CAG with anomalous LMCA | Primary PTCA with Stenting to RCA | 2 |
| | PTCA with Stenting to RCA | 2 |
| | PTCA with Stenting to LAD | 4 |
| | Medical Management | 2 |
| Associated other coronary artery anomalies seen in patient with anomalous LMCA | LMCA,LAD And LCX : Anomalous origin, Arising from right coronary sinus | 2 |

**Table 6b: LAD anomalies**

| **LAD** | | **Frequency** |
|---|---|---|
| Anomalous Origin | Arising from RCC | 4 |
| Anomalous Course | Myocardial bridging | 4 |
| Anomalous Termination | ___ | 0 |
| Dominant coronary among patient with anomalous LAD | RCA | 8 |
| Impression of CAG of patients with anomalous LAD | Single vessel disease | 4 |
| | Normal epicardial coronaries | 4 |
| Treatment Plan of the patients post CAG with | PTCA with Stenting to LAD | 2 |
| | Primary PTCA with Stenting to RCA | 2 |

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

| | | |
|---|---|---|
| anomalous LAD | Medical Management | 4 |
| Associated other coronary artery anomalies seen in patient with anomalous LAD | LMCA, LAD And LCX: Anomalous origin, Arising from right coronary sinus | 2 |

**Table 6c: LCX anomalies**

| **LCX** | | **Frequency** |
|---|---|---|
| Anomalous Origin | Arising from RCA | 9 |
| | Arising from RCC | 11 |
| Anomalous Course | - | 0 |
| Anomalous Termination | - | 0 |
| Dominant coronary among patient with anomalous LCX | RCA | 20 |
| Impression of CAG of patients with anomalous LCX | Single vessel disease | 9 |
| | Double vessel disease | 5 |
| | Normal epicardial coronaries | 6 |
| Treatment Plan of the patients post CAG with anomalous LCX | PTCA with Stenting to LAD | 5 |
| | PTCA with Stenting to RCA and LCX | 3 |
| | PTCA with Stenting to RCA and LAD | 2 |
| | PTCA with Stenting to RCA | 4 |
| | Medical Management | 6 |
| Associated other coronary artery anomalies seen in patient with anomalous LCX | | 0 |

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

**Table 6d: RCA anomalies**

| **RCA** | | **Frequency** |
|---|---|---|
| Anomalous Origin | Abnormally high origin | 30 |
| | Arising from LCC | 19 |
| | Arising from LMCA | 6 |
| | Arising from LAD | 5 |
| Anomalous Course | - | 0 |
| Anomalous Termination | coronary cameral fistula | 2 |
| Dominant coronary among patient with anomalous RCA | RCA | 52 |
| | LCX | 4 |
| | Co-dominant | 6 |
| Impression of CAG of patients with anomalous RCA | Single vessel disease | 24 |
| | Double vessel disease | 16 |
| | Triple vessel disease | 6 |
| | Recanalized LAD/RCA | 4 |
| | Insignificant disease | 2 |
| | Minor disease | 2 |
| | Patent Stent with Branch Vessel Disease | 2 |
| | Patent Stent with Branch Vessel Disease | 2 |
| | Normal epicardial coronaries | 4 |
| Treatment Plan of the patients post CAG with anomalous RCA | CABG / Revascularization | 11 |
| | PTCA with Stenting to LCX | 12 |
| | PTCA with Stenting to LAD | 10 |
| | PTCA with Stenting to RCA | 8 |
| | PTCA with Stenting to Ramus | 1 |
| | PTCA with Stenting to LAD and LCX | 2 |
| | PTCA with Stenting to LAD and Ramus | 2 |
| | Medical Management | 16 |
| Associated other coronary artery anomalies seen in patient with anomalous LCX | | 0 |

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

Table 7 provides a comprehensive overview of the coronary artery anomalies (CAAs) found in the study, categorized by type and affected artery. The most common anomalies were those of origin, with 94 cases total, including 44 cases of anomalous aortic origin, 30 cases of anomalous high origin (all in the Right Coronary Artery [RCA]), and 20 cases of anomalous origin from another coronary artery. The RCA was the most frequently affected, showing various types of origin anomalies and 2 cases of coronary fistulas. Myocardial bridging was observed in 4 cases, all affecting the Left Anterior Descending (LAD) artery. Notably, no cases of anomalous pulmonary origin, coronary aneurysms, or congenital atresia of the left main artery were found. This table highlights the prevalence of origin anomalies, particularly in the RCA, and the relative rarity of course and termination anomalies in this study population. It provides a clear picture of the distribution of CAAs across different coronary arteries, which is crucial for understanding their patterns and potential clinical implications.

**Table 7: Coronary Artery anomalies**

| **Coronary Artery Anomaly** | | **LMCA** | **LAD** | **LCX** | **RCA** | **TOTAL** |
|---|---|---|---|---|---|---|
| Anomalies of origin | Anomalous pulmonary origin of the coronaries | - | - | - | - | 0 |
| | Anomalous aortic origin of the coronaries | 10 | 4 | 11 | 19 | 44 |
| | Anomalous high origin | - | - | - | 30 | 30 |
| | Anomalous origin of the coronaries from another coronary artery | - | - | 9 | 11 | 20 |
| | Congenital atresia of the left main artery | - | - | - | - | 0 |
| Anomalies of course | Myocardial (or coronary) | - | 4 | - | - | 4 |

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

| | | | | | | |
|---|---|---|---|---|---|---|
| | bridging | | | | | |
| | Coronary aneurysm | - | - | - | - | 0 |
| Anomalies of termination | Coronary arteriovenous fistula (coronary cameral fistula) | - | - | - | 2 | 2 |
| | Coronary stenosis | - | - | - | - | 0 |

Table 8 provides a concise summary of the total types of coronary artery anomalies reported in the study. The most common anomaly was anomalous origin from the opposite sinus, with 44 cases, followed by abnormally high origin of coronary artery with 30 cases. Anomalous origin from another coronary artery was observed in 20 cases. Less common anomalies included myocardial bridging (4 cases) and coronary artery fistula (2 cases). Notably, some types of anomalies were not observed in this cohort, including anomalous origin from the non-coronary sinus, anomalous origin from the pulmonary artery, coronary artery aneurysm, absent coronary artery, and coronary artery hypoplasia. This distribution highlights the predominance of origin anomalies in the study population, particularly those involving abnormal aortic origin or high takeoff. The table provides a clear overview of the frequency of different types of coronary artery anomalies, which is valuable for understanding their relative prevalence and potential clinical significance in this patient population.

**Table 8: Total types of coronary artery anomalies reported**

| **Coronary Artery Anomaly** | **N** |
|---|---|
| Anomalous origin from opposite sinus | 44 |
| Anomalous origin from another coronary artery | 20 |
| Anomalous origin from non-coronary sinus | 0 |
| Abnormally high origin of coronary artery | 30 |
| Anomalous origin from pulmonary artery | 0 |
| Myocardial bridging | 4 |
| Coronary artery aneurysm | 0 |
| Coronary artery fistula | 2 |
| Absent coronary artery | 0 |

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

| | |
|---|---|
| Coronary artery hypoplasia | 0 |

**DISCUSSION:**

This retrospective study analyzed the prevalence and patterns of coronary artery anomalies (CAAs) in a large cohort of patients undergoing coronary angiography at a tertiary care center in Karnataka, India. The prevalence of CAAs in our study population was 0.47%, which falls within the range reported in previous studies (0.3% to 1.3%).[1,8]

Our findings indicate that anomalies of origin were the most common type of CAA, particularly anomalous aortic origin of the coronaries. This is consistent with several other studies in the literature.[3,4] Specifically, we found that anomalous origin of the right coronary artery (RCA) was the most frequent anomaly, with an abnormally high origin being the most common subtype. This finding aligns with a study by Yamanaka and Hobbs, which also reported RCA anomalies as the most prevalent.[8]

The prevalence of myocardial bridging in our study (4%) was lower than that reported in some other angiographic studies, which have shown rates ranging from 5% to 12%.[9] This discrepancy could be due to differences in diagnostic criteria or the inherent limitations of conventional angiography in detecting subtle cases of myocardial bridging.

Interestingly, the prevalence of coronary artery fistulas or aneurysms in our cohort was 2%. This contrasts with some studies that have reported prevalences of coronary artery fistulas ranging from 0.1% to 0.2%.[10] The presence of these anomalies in our study population may be due to regional variations in the prevalence of specific types of CAAs.

The clinical presentation and management of patients with CAAs in our study varied widely, reflecting the diverse nature of these anomalies. This heterogeneity in presentation and treatment approaches is consistent with observations from other studies.[5,11] Our findings underscore the importance of individualized assessment and management strategies for patients with CAAs.

The majority of patients with CAAs in our study were male (61%), which is in line with previous reports suggesting a male predominance in CAAs.[12] However, the reasons for this gender disparity remain unclear and warrant further investigation.

One limitation of our study is its retrospective nature and reliance on conventional coronary angiography for diagnosis. Advanced imaging techniques such as computed tomography coronary angiography (CTCA) have been shown to provide superior visualization of coronary anatomy and may detect subtle anomalies that could be missed on

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 07, 2024

conventional angiography.[7] Future studies incorporating these advanced imaging modalities could provide more comprehensive insights into the prevalence and patterns of CAAs.

**CONCLUSION:**

In conclusion, our study provides valuable data on the prevalence and patterns of CAAs in a large Indian cohort. The findings largely align with previous studies from other populations, suggesting a degree of consistency in the global distribution of CAAs. However, some differences were noted, particularly in the prevalence of certain subtypes of anomalies. These observations highlight the need for population-specific data to inform clinical practice and guide appropriate management strategies for patients with CAAs.

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