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Original Article

Evaluation of coronary anomalies in patients undergoing coronary angiography and their clinical significance

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Abstract

Aim: Coronary artery anomalies (CAAs) occur in less than 1% of the general population and may be concomitant with other major congenital cardiac defects. Although most cases are asymptomatic, they can be associated with myocardial ischemia (MI), angina, syncope, myocardial infarction, or sudden cardiac death. CAAs are usually discovered incidentally during coronary angiography or at autopsy.
Material and Methods: We retrospectively reviewed the coronary angiography reports of 11,376 patients who underwent coronary angiography in our institution between March 2002 and December 2011 to determine the incidence of CAAs and evaluate their clinical significance.
Results: The incidence of CAAs was 1.5% (including myocardial bridging) and 1% (excluding myocardial bridging). Among the 170 patients with CAAs identified, 67.6% were male (n=115, mean age 58.4 years) and 32.4% were female (n=55, mean age 60.3 years); the overall mean age was 59.1 years. Risk factors included hypertension (45.2%, n=66), diabetes mellitus (26%, n=38), hyperlipidemia (24%, n=35), smoking (23.3%, n=34), family history of coronary artery disease (10.3%, n=15), obesity (13%, n=19), and prior myocardial infarction (20.5%, n=30). Concomitant coronary artery lesions were present in 65.3% (n=111) of patients with CAAs.
Conclusion: Coronary artery anomalies are relatively common in patients undergoing coronary angiography and may have significant clinical implications. Accurate identification and systematic classification of CAAs are essential for safe procedural planning during coronary interventions and contribute to improved clinical outcomes.

Keywords: Coronary artery anomalies, coronary angiography, myocardial bridging, coronary artery disease

INTRODUCTION

The widespread use of coronary angiography has led to the more frequent detection of coronary artery anomalies and a better understanding of their clinical significance. Although most coronary artery anomalies (CAAs) are detected incidentally and do not cause significant consequences, approximately 20% of them are reported to carry a potential risk of coronary ischemia leading to myocardial infarction (MI), arrhythmia, and sudden cardiac death (SCD) (1-3).

Angeli's definition, which states that normal coronary anatomy covers 99% of the population and that anatomical differences in the coronary arteries are considered anomalies only if they occur in at least 1% of the population or less, has been widely accepted (4). Despite CAAs are rare, they remain among the most common congenital cardiovascular anomalies (5).

Various classifications have been proposed for coronary artery anomalies, but the most widely accepted and used classification is the systematic anatomical classification developed by Angelini

(6). This classification also divides CAAs into 4 main groups: anomalies of origin and course, anomalies of intrinsic coronary arterial anatomy, anomalies of coronary termination, and abnormal anastomotic vessels (6).

In this study, we aimed to evaluate the incidence and clinical significance of CAAs detected in our clinic by retrospectively reviewing the coronary angiography (CAG) reports of 11,376 patients who underwent CAG in our catheterization laboratory between March 2002 and December 2011. We believe that this study will contribute to determining the incidence of CAAs.

MATERIAL AND METHODS

The study was based on de-identified coronary angiography data from 11,376 patients who underwent the procedure between March 2002 and December 2011. This study was approved by the Pamukkale University Non-Interventional Clinical Research Ethics Committee (Number: 60116787-020/6612, Date: 12.04.2010).

Coronary angiography reports from the catheterization laboratory of the Cardiology Clinic of our tertiary hospital were systematically reviewed. Coronary angiography (CAG) reports were separated for patients with reported CAAs and those with suspicious CAG reports. The diagnoses of patients with suspicious findings were confirmed by reviewing their coronary angiography images independently by two experienced cardiologists. Any disagreements in interpretation were resolved by consensus.

Coronary anatomy in CAG reports drafted using the Judkins technique was defined as follows: left main coronary artery (LMCA); left anterior descending coronary artery (LAD); circumflex coronary artery (Cx); right coronary artery (RCA); LAD diagonal branches (D1–3); Cx obtuse marginal branches (OM1–3); RCA acute marginal branch (AM); myocardial bridging (MB); posterior descending artery (PDA); posterolateral artery (PLA); internal mammary artery (IMA); left anterior oblique position (LAO); right anterior oblique position (RAO).

The systematic anatomical classification developed by Angelini was used to classify patients with coronary artery anomalies (6).

The hospital record system and hospital archive files were searched to access the clinical admission and follow-up information of 170 patients with detected coronary artery anomalies. The records of 24 patients could not be accessed; however, considering that 146 patients whose information was accessed had CAA, the clinical information of these patients was re-evaluated.

It is still controversial whether myocardial bridgings can be considered as CAAs. However, in this study, MBs were included within the CAAs. For myocardial bridgings, two or more consecutive MBs on the same coronary artery were defined as a single MB.

In rare cases where a patient has multiple anomalies belonging to two separate groups (e.g., MB and dual RCA or coronary fistula and dual RCA), the patient was counted as a single patient in the overall calculations, but additional necessary explanations were provided within the CAA groups.

The percentage distribution of each different CAA was calculated based on the total number of CAA cases. For the overall CAA incidence, the percentage within the CAGs performed by taking the total number of CAA cases was examined. The incidence of each CAA group was determined by calculating the percentage of patients with that anomaly within the CAGs performed. Calculations were performed with methodological concerns in mind to achieve the most accurate classification and numbers possible.

The files of patients with detected coronary artery anomalies were reviewed, and the patients' basic characteristics (age, gender, hypertension (HT), diabetes mellitus (DM), hyperlipidemia (HL), smoking, family history, obesity, history of myocardial infarction (MI), presence of concomitant coronary lesions) were examined.

Statistical Analysis

Descriptive statistical methods were used for the statistical analysis of the findings obtained in the study. Data analysis was conducted using SPSS version 15.0 (IBM Corp., Armonk, NY, USA).

Continuous variables (such as age) were presented as mean ± standard deviation (mean ± SD), and categorical variables (such as gender, risk factors, anomaly types, and the presence of concomitant coronary lesions) were presented as numbers (n) and percentages (%).

The incidence and distribution of coronary artery anomalies in general and in their subgroups were calculated as percentages.

RESULTS

Between March 2002 and December 2011, CAAs were detected in a total of 170 cases (1.5%) among 11,376 patients who underwent CAG according to the systematic anatomical classification. 67.6% of the patients were male (n=115, mean age = 58.4 years), and 32.4% were female (n=55, mean age = 60.3 years). The overall mean age was 59.1 years.

Data were available for 146 out of the 170 patients with coronary artery anomalies. When the 146 patients whose data were available were divided into two groups, under 50 years of age and over 50 years of age, 20.5% (n=30) of the patients were under 50 years of age, and 79.5% (n=116) were over 50 years of age. When the data of the 146 patients whose files were accessed were examined, 45.2% of the patients (n=66) had HT, 26% (n=38) had DM, 24% (n=35) had HL, 23.3% (n=34) were smokers, 10.3% (n=15) had a family history, 13% (n=19) were obese, and 20.5% (n=30) had a history of MI. Coronary artery lesions were detected in 65.3% (n=111) of the 170 patients with CAAs (Table 1).

Table 1. Demographic data of patients with detected coronary artery anomalies

Variables	n	%
Male	115	67.6
Female	55	32.4
<50 Years	30	20.5
>50 Years	116	79.5
Hypertension	66	45.2
Diabetes	38	26
Hyperlipidemia	35	24
Smoking	34	23.3
Family History	15	10.3
Obesity	19	13
History of MI	30	20.5
Concomitant Lesion	111	65.3

Data was available for 146 of the 170 patients. Other data, except for gender, was calculated by examining the characteristics of the 146 patients

The anomalies detected in our study were classified into four main groups based on the classification created by Angelini, which is based on a systematic anatomical foundation (6). In our study, the rates of coronary artery origin and course anomalies (n=73, 42.94%) and anomalies related to the coronary artery itself (n=72, 42.35%) were found to be similar. In our study, coronary artery termination anomalies were detected at a rate of 14.70% (n=25), while no abnormal collateral vessel anomalies were encountered (Table 2).

Table 2. Number and percentages of patients identified in our study according to systematic anatomical classification

Classification	Anomaly group	n	%
A	Coronary artery origin and course anomalies	73	42.94
B	Anomalies related to the coronary artery's own anatomy	72	42.35
C	Coronary artery termination anomalies	25	14.70
D	Abnormal collateral vessels	0	0
TOTAL		170	100

Patients with detected CAAs were grouped according to anomaly types and frequency of occurrence. In our study, MB was identified as the most common anomaly among all anomalies (32.35%). The anomaly characterized by the left anterior descending artery originating from the left main coronary artery (LMCA), the left circumflex artery (Cx) originating from separate ostia, or the absence of the LMCA was found to be the second most common anomaly type with a prevalence of 25.88% (Figure 1). Other anomaly types, in order of incidence, were coronary fistula (14.70%) (Figure 2), Cx originating from the right sinus of Valsalva (RSV) (14.11%) (Figure 3), dual RCA (3.5%) (Figure 4), absence of RCA (2.35%), absence of Cx (2.35%), dual LAD (1.76%), LMCA originating from RSV (1.76%) (Figure 5), RCA originating from the left sinus of Valsalva (LSV) (0.58%) (Figure 6), and single coronary artery (0.58%) (Figure 7) (Table 3).

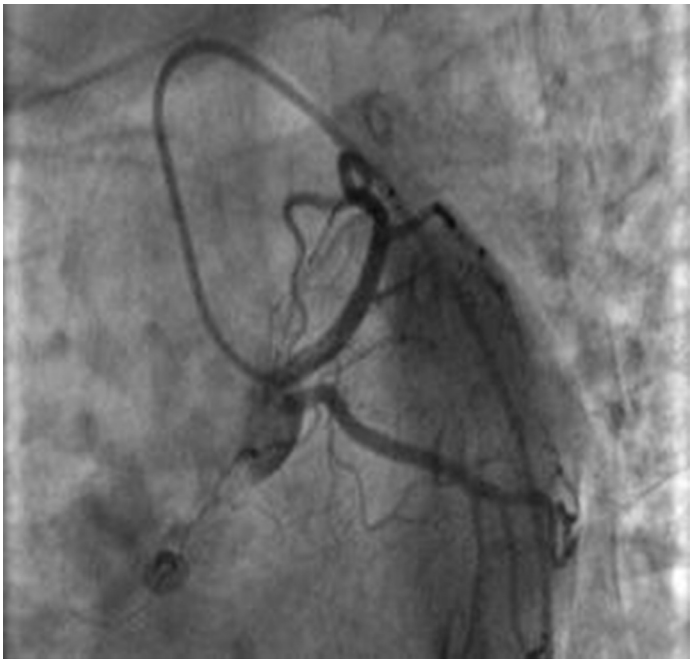

Figure 1. Absence of the LMCA (LAD and CX originating from separate ostia)

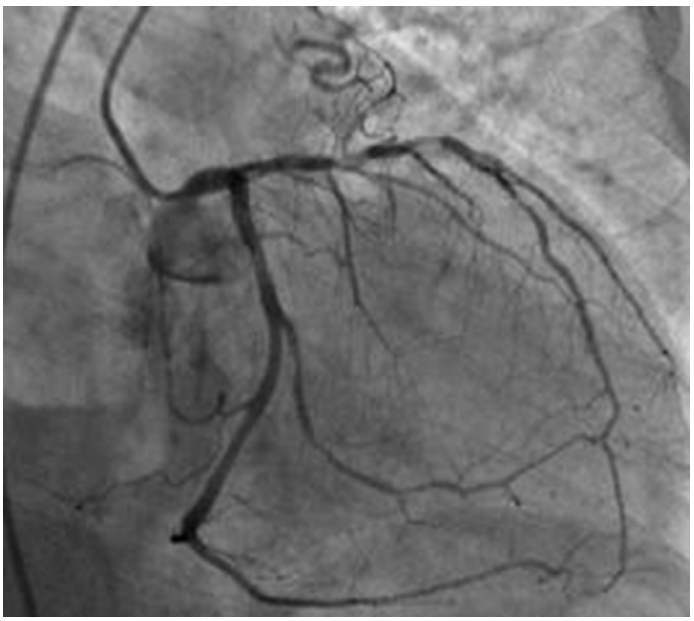

Figure 2. Coronary fistula

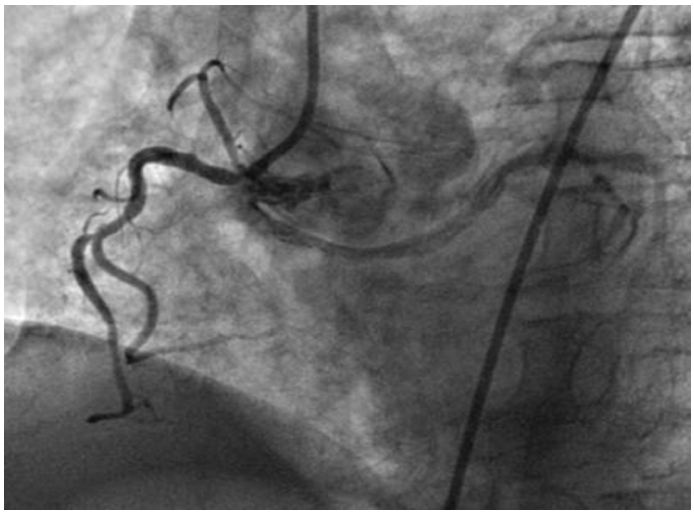

Figure 3. Origin of the CX from the RSV

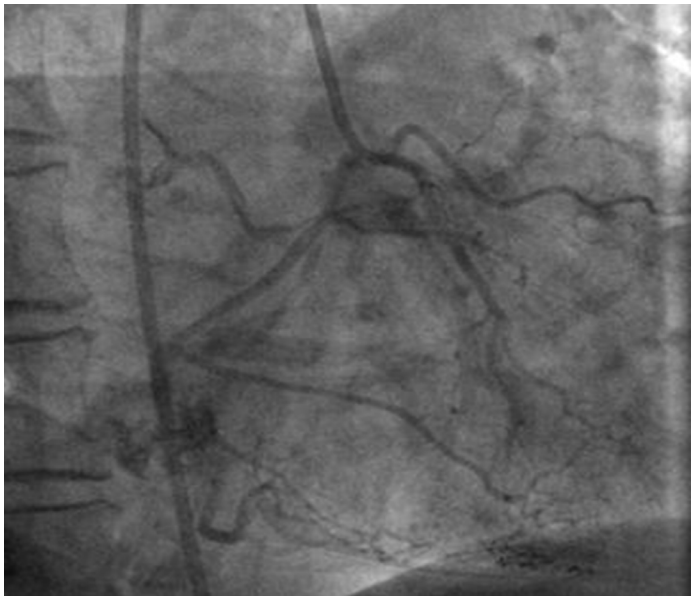

Figure 4. Dual RCA, fistula in the right ventricle

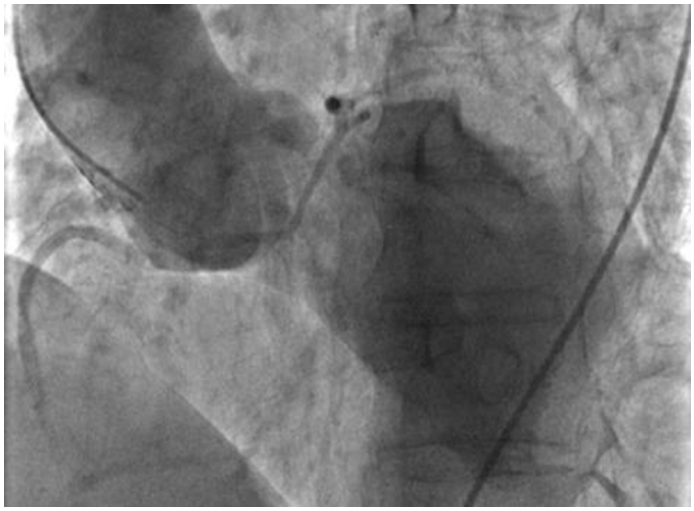

Figure 5. LMCA originating from the RSV

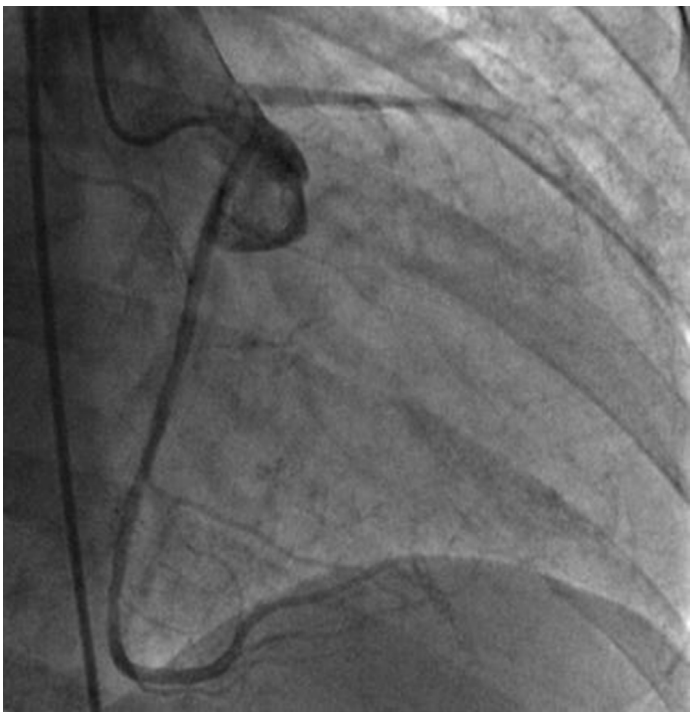

Figure 6. RCA originating from the LSV

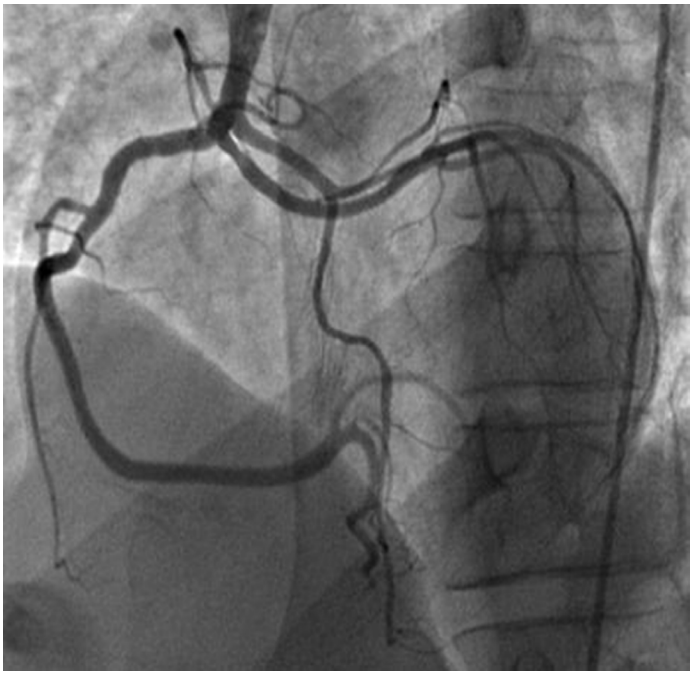

Figure 7. Single coronary artery

Multiple anomalies were detected in three patients, and these patients were included in a single anomaly group. One of the two patients who were found to have dual RCA had concomitant MB, and the other one had concomitant coronary fistula. The third patient was found to have RCA originating from the LSV and concomitant MB.

Table 3. Classification of patients with coronary artery anomalies detected in our study according to anomaly type and gender

Group Nr.	Type of Anomaly	Male		Female		Total	
		n	%	n	%	n	%
1	Myocardial bridging	37	21.76	18	10.58	55	32.35
2	Absence of LMCA	25	14.70	19	11.17	44	25.88
3	Coronary Fistula	16	9.41	9	5.29	25	14.70
4	Cx originating from RSV	20	11.76	4	2.35	24	14.11
5	Dual RCA	6	3.52	0	0	6	3.5
6	Absence of RCA	2	1.17	2	1.17	4	2.35
7	Absence of CX	3	1.76	1	0.58	4	2.35
8	Dual LAD	2	1.17	1	0.58	3	1.76
9	LMCA originating form RSV	3	1.76	0	0	3	1.76
10	RCA originating from LSV	0	0	1	0.58	1	0.58
11	Single coronary artery	1	0.58	0	0	1	0.58
TOTAL		115	67.6	55	32.4	170	100

LMCA: Left main coronary artery, LAD: Left anterior descending coronary artery, Cx: Circumflex coronary artery, RSV: Right sinus of Valsalva, RCA: Right coronary artery, LSV: Left sinus of Valsalva

DISCUSSION

Although CAAs are generally asymptomatic and mostly diagnosed incidentally in the adult population, they should be included in the differential diagnosis of anginal symptoms, myocardial infarction, arrhythmia, and heart failure, particularly in young patients (3,7,8). Increased awareness of these pathologies will enable earlier diagnosis and treatment of patients having these anomalies (3).

Regarding treatment strategy for patients with CAAs, our study demonstrates that the approach has evolved significantly. In our cohort, 65.3% of patients with CAAs had concomitant coronary artery disease, which necessitates integrated treatment planning. The treatment strategy now varies by CAA type: myocardial bridging patients with symptoms receive medical therapy (beta-blockers, calcium channel blockers) as first-line treatment, with surgical intervention considered for refractory cases; anomalous coronary origin with interarterial course requires more aggressive management; and coronary fistulas are managed based on hemodynamic significance. Most importantly, accurate CAA identification is essential for safe procedural planning during PCI and CABG.

In our study, we found the incidence of CAAs to be 1.5% (including MB). This value is higher than those found in comprehensive incidence studies conducted in Türkiye (9,10). One reason for this higher incidence is the difference in the classification of CAAs. If we had not considered myocardial bridging as an anomaly and had excluded it from the classification, the incidence of CAAs would have been 1%. This rate is consistent with previous studies (9–11). Since all CAGs performed at our clinic were on patients over 18 years of age, there were no CAA cases associated with major cardiac anomalies in our patient series. The higher prevalence of certain CAA subtypes in our Turkish cohort compared to international studies may reflect regional genetic variations, differences in referral patterns and diagnostic approaches, selection bias from our single-center design, and the age distribution of our cohort (mean age 59.1 years, 79.5% over 50 years).

It remains unclear whether myocardial bridgings, the incidence and prevalence of which vary greatly depending on the diagnostic approach, should be considered within CAAs or not. It has been reported that myocardial bridging may be seen in more than 1% of cases, and therefore there has been a debate as to whether they should be included within CAAs (9,12). MBs have not been included in the percentage of CAAs in large studies (9–11). Myocardial bridging is usually detected incidentally during CAG, but patients may also present with coronary syndrome symptoms. These patients are usually male, on average 5–10 years younger than patients with symptomatic coronary artery disease, and have quite severe anginal complaints (13). Studies conclude that MB is a treatable cardiac anomaly and that a combined approach involving diagnosis, treatment, and follow-up is necessary (14). Due to the presence of cardiac risk factors and high rates of coronary lesions, it can be assumed that most

patients with MB are asymptomatic, as indicated in the literature, and are incidentally diagnosed when undergoing CAG for suspected coronary artery disease.

Myocardial bridging was the most common anomaly in our cohort (32.35%, n=55). Our strategy was to systematically identify and document myocardial bridging during coronary angiography. Two or more consecutive bridging segments on the same coronary artery were defined as a single myocardial bridging. Most myocardial bridging cases are asymptomatic and managed conservatively. Symptomatic patients typically receive medical therapy with beta-blockers or calcium channel blockers as first-line treatment. In cases refractory to medical management, surgical unroofing may be considered. The recognition of myocardial bridging is important for safe procedural planning during coronary interventions.

In extensive studies conducted on coronary artery anomalies, MBs were not included in the research, and the absence of the LMCA was reported to be the most common CAA (9–11). In our study, when MBs were excluded, the most frequently observed CAA was the absence of the LMCA, and this rate is consistent with the literature.

The prevalence of coronary artery fistulas (CAFs) has been reported in the literature as 0.08% to 0.42%, while in our study, it was found to be 0.21%, which was consistent with the literature (15,16). In our study, we determined the prevalence of coronary fistulas among all CAAs to be 14.7% (n=25).

The origin of the Cx from the LAD or one of the early branches of the RCA is the most common origin anomaly after the absence of LMCA (9-11). In our study, the incidence of this anomaly was found to be 0.21%, and its percentage among all anomalies was 14.1%. These rates are higher compared to the data of Türkiye.

D u a l RCA is a rare, benign anomaly, and only a few cases have been reported in the literature (17). In our study, this anomaly was detected in 6 patients, with a prevalence of 3.5% and an incidence of 0.05%.

In order to argue that a coronary artery is truly absent, hypoplasia must be demonstrated in the myocardial segment supplied by the relevant artery (17). In our study, we identified a total of 8 patients whom we could define as having coronary artery absence; with 4 patients without the Cx artery and 4 patients without the RCA.

The presence of two distinct coronary arteries in the anterior interventricular sulcus is referred to as Dual LAD. Both may originate from the LMCA, or one may originate from the LMCA while the other originates from the RCA (17). In our study, dual LAD was detected in 3 patients. The incidence found in our study was 0.02% and its frequency relative to other anomalies was 1.76%, which are lower than the values in the literature (4,9,11,18). Another rare anomaly is the origin of the RCA from the LSV. The right coronary artery originates from the LSV or LMCA (18). In most cases, the RCA runs between the aorta and PA (67%), while the remainder mostly runs behind the aorta (18-20). The incidence of the right coronary artery originating from the LSV has been reported to vary between 0.28% and 0.92% in several studies in the literature (2,3,6). In our study, an anomalous origin of the RCA from the LSV was detected in one patient (incidence 0.008%). Coronary artery origin anomalies are known to be the second leading cause of SCD in young athletes (3,21). The risk of SCD appears to be the highest in young individuals, particularly during or after strenuous exertion, and especially in those with abnormal interarterial and intramural left coronary artery origins. Studies that included adult cohorts with abnormal right coronary artery origin undergoing conservative treatment observed very low mortality (<1%) over approximately 1 to 5 years of follow-up (6,22).

In a study investigating whether coronary artery origin anomalies may have more severe CAD stenosis compared to coronaries with normal origin, it was demonstrated that origin anomalies do not increase the severity of CAD (23). In our study, the CAD rate was found to be 65.3%, but when cases were grouped into patients under 50 years of age and those over 50 years of age, it was found that 80% of cases were patients over 50 years of age. Therefore, due to this finding, increased coronary artery lesion rates in patients was thought to be associated with atherosclerotic CAD the incidence of which increases with age, independent of CAA. The incidence of single coronary artery anomaly, which was first described in 1941 and demonstrated on angiography in 1967, has been reported as 0.029% (10,24). In our study, single coronary artery anomaly (incidence = 0.08%) was detected in one patient. In cases with a single coronary artery, clinical features are most closely related to the course of the single coronary artery. In cases where the LMCA or RCA runs between the main PA and the aorta, particularly exercise-related acute MI and sudden death have been described (18). In our study, no other types of CAAs were encountered apart from those mentioned above.

Although the incidence of coronary artery anomalies is low and varies among different populations, detecting these anomalies and gaining greater awareness of their clinical significance and treatment options will enable better management of this anomaly group. Physicians dealing with adult cardiac pathologies should have sufficient knowledge about these anomalies, as the management of these patients requires special attention, particularly when surgical or interventional treatments are necessary.

Limitations

This study has several limitations. First, its retrospective, single-center design may limit the generalizability of the findings to other populations. Second, CAA identification was based on angiographic reports and image review, which may underestimate anomalies that are better visualized with advanced imaging modalities such as CT coronary angiography. Third, clinical data were unavailable for 24 of the 170 patients with CAAs, which may have influenced the accuracy of demographic and clinical characteristic analyses. Fourth, myocardial bridgings were included as anomalies, although their classification remains

controversial and varies across studies; this may partially account for the higher overall incidence observed. Finally, long-term clinical outcomes were not systematically assessed, preventing evaluation of the prognostic impact of individual CAA subtypes. These findings underscore the importance of population-specific epidemiological data and the need for multicenter studies across different geographic regions.

CONCLUSION

In this large retrospective cohort of 11,376 patients undergoing coronary angiography, the overall incidence of coronary artery anomalies (CAAs) was 1.5%, and 1% when myocardial bridging was excluded, which is comparable to previous population-based studies. Myocardial bridging was the most frequently observed anomaly, followed by the absence of the left main coronary artery. Although most CAAs were benign and detected incidentally, several anomalies—particularly those involving abnormal coronary origin and course—carry potential clinical importance due to their association with myocardial ischemia and, in rare cases, sudden cardiac death. Our findings underscore the importance of recognizing CAAs, accurately classifying them, and documenting their anatomical characteristics to guide procedural planning and improve clinical outcomes in patients undergoing invasive cardiac interventions.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Ethics Committee Approval: This study was approved by the Pamukkale University Non-Interventional Clinical Research Ethics Committee (Approval No: 60116787-020/6612, Date: 12.04.2010).

Informed Consent: Informed consent was waived by the ethics committee due to the retrospective nature of the study.

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