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Coronary Artery Origin Anomalies on Coronary CT Angiography: A Single-Center Tertiary-Care Cohort

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ABSTRACT

Objective: In this single-center, tertiary-care coronary CT angiography (CCTA) series, we aimed to report the prevalence of coronary origin anomalies and describe the characteristics of their proximal course.

Materials and Methods: This retrospective study included 3,181 consecutive CCTA examinations performed between January 1, 2020, and June 30, 2025. All scans were acquired using a 64-slice multidetector CT system (SOMATOM Definition AS+, Siemens Healthineers) with retrospective ECG gating. Two radiologists reviewed the studies, and examinations with suspected coronary origin anomalies were re-evaluated by consensus. Anomalies were classified according to the Angelini framework, and the proximal course was categorized as interarterial, retroaortic, transseptal/intraseptal, or prepulmonic.

Results: Coronary artery origin anomalies were identified in 41 of 3,181 patients (1.29%). The largest subgroup was opposite-sinus origin (n=24, 0.76%), which included the right coronary artery (RCA) originating from the left sinus (n=12, 0.38%), the left circumflex artery (LCX) originating from the right coronary sinus (n=8, 0.26%), and the left main coronary artery (LMCA) originating from the right coronary sinus (n=4, 0.13%). An absent LMCA configuration—defined by separate left-sinus ostia for the left anterior descending artery (LAD) and LCX—was identified in 5 patients (0.16%). Single coronary artery anatomy was observed in 3 cases (0.09%), all of which had a common origin from the right coronary sinus. In one case (0.03%), the RCA arose from the noncoronary sinus. High take-off coronary artery origins were observed in 8 patients (0.26%). Regarding the course patterns, interarterial courses were observed in 20 patients, retroaortic courses in 10, and prepulmonic courses in 2. The interarterial LAD and LCX cases also demonstrated a transseptal/intraseptal segment.

Conclusion: CCTA reliably delineates coronary ostial origin and proximal trajectory, supporting a comprehensive anatomic assessment of suspected congenital coronary variants.

Keywords: Computerized tomography, congenital anomalies, coronary angiography, coronary vessel anomalies, coronary vessels.

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INTRODUCTION

Coronary artery anomalies are a diverse group of congenital variants that involve atypical coronary origin, proximal course, or termination. While most of these variants are benign and discovered incidentally, some anomalous patterns—especially those in which the left coronary arteries arise from the contralateral sinus and follow a malignant interarterial course between the aorta and the main pulmonary artery—pose a risk of myocardial ischemia and, in rare cases, sudden cardiac death.[1,2]

The prevalence of coronary artery origin anomalies reported in studies varies significantly depending on participant characteristics and assessment methods. Autopsy series show relatively low incidence rates, ranging from approximately 0.17% to 0.3%. In contrast, angiographic studies of large cohorts evaluated for coronary artery disease generally report higher incidence rates, ranging from approximately 0.6% to 1.2%.[1,3-7]

In studies based on coronary CT angiography (CCTA), reported frequencies are slightly higher, with prevalence rates ranging from approximately 1.04% to 2.33%, depending on the cohort examined.[8,9]

Identifying the origin and course of anomalous coronary arteries with invasive coronary angiography (ICA) can be challenging, particularly when selective catheterization is difficult or the vessel follows an unusual trajectory. In contrast, CCTA, with its inherent three-dimensional data acquisition, is exceptionally well-suited to detect anomalous coronary origins and determine their anatomic course and spatial relationship to adjacent cardiac and non-cardiac structures.[8,10-12] Therefore, CCTA has become the preferred first-step imaging technique for defining coronary origin anomalies when they are known or clinically suspected.

In this study, we examined CCTA studies conducted at our institution to determine the frequency of coronary artery origin anomalies and the types of anomalies observed in our population.

MATERIALS AND METHODS

Study Site and Design

This retrospective, single-center study, conducted at a tertiary-care institution, evaluated the prevalence and anatomic patterns of coronary artery origin anomalies using CCTA.

Ethical Approval

The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee at Kayseri City Training and Research Hospital (Approval Number: 553, Date: 26.08.2025).

KEY MESSAGES

- In 3,181 CCTA examinations from a single-center tertiary-care cohort, coronary artery origin anomalies were identified in 1.29% of patients.
- The clinical significance of origin anomalies is primarily determined by the proximal course; interarterial trajectories were most frequently observed in RCA-related opposite-sinus variants.
- Opposite-sinus anomalies predominated (0.76%); all cases of RCA originating from the left coronary sinus and all cases of LMCA originating from the right coronary sinus showed an interarterial course, whereas all LCX-from-right-sinus cases were retroaortic.

Informed consent was not required, as the study retrospectively analyzed anonymized CCTA datasets. The conduct of the study adhered to the ethical principles outlined in the Declaration of Helsinki.

Patients and Data Collection

All CCTA examinations performed at our institution between January 1, 2020, and June 30, 2025, were reviewed. A total of 3,755 CCTA examinations were identified during the study period. After excluding repeated examinations from the same individuals, 3,388 examinations remained.

Inclusion Criteria

Examinations were included when the image quality allowed reliable assessment of the coronary ostia and proximal coronary segments.

Exclusion Criteria

Examinations were excluded if they showed severe motion artifacts, inadequate contrast opacification, significant flare artifacts due to widespread calcification, or if the patient had prior aortic root or congenital heart surgery that could alter the natural coronary anatomy. After applying these criteria, the final study cohort consisted of 3,181 patients.

Clinical, Surgical, and Laboratory Investigations

Not applicable. This study was based solely on CCTA-derived anatomic evaluation.

CCTA Acquisition Protocol

All CCTA studies were performed using a 64-slice multidetector CT system (SOMATOM Definition AS+, Siemens Healthineers) with retrospective ECG gating. Scan protocol parameters are summarized in Table 1. For contrast enhancement, iodinated contrast material (≥350 mg I/mL) was administered

Table 1. Scan protocol parameters for CCTA

Parameter	Value
Acquisition type	Spiral
ECG gating	Retrospective
Tube voltage	120 kV
Tube current	ECG-based tube current modulation
Nominal single collimation width	0.6 mm
Nominal total collimation width	38.4 mm
Gantry rotation time	0.33 s
Reconstruction increment	0.33 mm

ECG: Electrocardiogram; kV: Kilovolt; mm: Millimeter; s: Second.

intravenously at a flow rate of 5 mL/s, with a total volume ranging from 50 to 70 mL. This was followed by a 20–30 mL saline flush to optimize coronary arterial opacification.

Image Reconstruction and Post-Processing

For image reconstruction, a slice thickness of 0.6 mm and a 0.33-mm overlap were used to create near-isotropic volumes. The coronary tree was then analyzed using workstation-based post-processing.

Diagnostic Criteria and Definitions

Coronary origin anomalies were classified according to the framework proposed by Angelini et al.[1] The absence of the left main coronary artery (LMCA) was defined as the separate ostial origins of the left anterior descending (LAD) and left circumflex (LCX) arteries. A high take-off origin was defined as the location of the coronary ostium above the sinotubular junction. In anomalous cases, the proximal course was classified as retroaortic, interarterial, transseptal/intraseptal, or prepulmonic/precardiac.

Image Evaluation

All eligible CCTA examinations performed between January 1, 2020, and June 30, 2025, were evaluated for coronary artery origin anomalies on a dedicated post-processing workstation (syngo.via, Siemens Healthineers). CCTA examinations were distributed to two radiologists experienced in cardiovascular imaging, who independently reviewed their assigned studies. All cases suspected of coronary artery origin anomalies were subsequently re-evaluated, and consensus classification and proximal course assignments were made. As part of the descriptive dataset, we recorded coronary dominance, the ramus intermedius variant, and a separate origin of the conus artery.

Table 2. Distribution of coronary artery origin anomalies detected on CCTA (n=3,181)

Type of coronary anomaly	n	%
Coronary ostium from non-coronary sinus		
RCA from non-coronary sinus	1	0.03
Anomalous origin from opposite sinus		
RCA from left sinus	12	0.38
LCX from right sinus	8	0.26
LAD from right sinus	0	0
LMCA from right sinus	4	0.13
Absent LMCA (separate LAD & LCX origin from left sinus)	5	0.16
Single coronary artery		
From right coronary sinus	3	0.09
From left coronary sinus	0	0
High take-off coronary artery origins		
High take-off LMCA	1	0.03
High take-off RCA	6	0.18
High take-off LMCA and RCA	1	0.03
Total number of anomalies	41	1.29

CCTA: Coronary computed tomography angiography; RCA: Right coronary artery; LCX: Left circumflex artery; LAD: Left anterior descending artery; LMCA: Left main coronary artery.

Statistical Analysis

Statistical analyses were performed using SPSS (version 24.0; IBM, Armonk, NY, USA). Numerical variables are expressed as mean±standard deviation or median (range), while categorical data are presented as frequencies and percentages. Prevalence estimates were calculated for the entire cohort, and no inferential statistical tests were applied.

RESULTS

A total of 3,181 patients formed the study population: 2,187 (68.7%) were men, and 994 (31.3%) were women. The average age was 45.5±15.9 years, with a median of 46 years (range: 0–96). Among the 3,181 patients, 86.1% (2,738 patients) had right coronary dominance, 10.9% (347 patients) had left coronary dominance, and 3.0% (96 patients) had co-dominance. A separate conus artery was present in approximately 493 patients (15.5%), and a ramus intermedius was identified in approximately 1,001 patients (31.5%).

Coronary origin anomalies were detected in 41 patients, corresponding to 1.29% of the cohort. The distribution of these anomalies is summarized in Table 2.

An RCA origin from the left coronary sinus was observed in 12 patients; all of these cases displayed an interarterial (malignant)

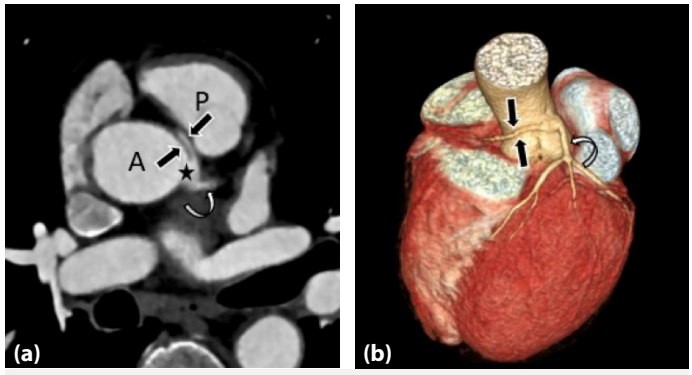

Figure 1. CCTA in a 62-year-old man demonstrates an anomalous origin of the right coronary artery (RCA) (arrows) from the left coronary sinus (asterisk). A) (axial oblique multiplanar reformat) shows the RCA coursing interarterially between the ascending aorta **(a)** and the pulmonary trunk (P). **(b)** (three-dimensional volume-rendered image) demonstrates the same anomalous origin and proximal interarterial trajectory. The left main coronary artery (LMCA) arising from the left coronary sinus is indicated by the curved arrow.

proximal trajectory (Fig. 1). Separately, one patient had an RCA arising from the noncoronary sinus, with a unique course.

The absence of LMCA was observed in 5 patients; in these cases, the LAD and LCX followed a normal proximal course (Fig. 2).

The LMCA ostium was located in the right coronary sinus in four patients, distinct from the RCA ostium in all cases. The proximal LMCA then followed an interarterial course (Fig. 3).

Eight patients had an LCX origin in the right coronary sinus, and all demonstrated a proximal retroaortic course.

Three patients exhibited a single coronary artery configuration, each with a solitary ostium in the right coronary sinus and variable proximal courses. In the first case, the left main coronary artery originated from a right-sided common trunk and reached the left side via a prepulmonic route before dividing into the LAD and LCX. In the other two cases, the common trunk gave rise to the LAD and LCX on the right side of the heart. In the second patient, the LAD demonstrated a proximal interarterial course, followed by a transseptal/intraseptal trajectory, whereas the LCX coursed retroaortically (Fig. 4). In the third patient, the LAD followed a prepulmonic trajectory, while the LCX followed an interarterial proximal course, followed by a transseptal/intraseptal course.

High take-off origins of the coronary arteries were identified in eight patients. One patient demonstrated simultaneous

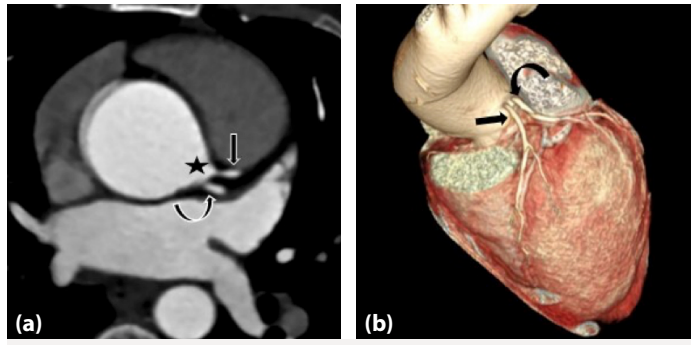

Figure 2. CCTA in a 38-year-old woman demonstrates the absence of the left main coronary artery. **(a)** (axial oblique multiplanar reformat) shows the separate origins of the left anterior descending artery (LAD) (arrow) and the left circumflex artery (LCX) (curved arrow) from the left coronary sinus (asterisk). **(b)** (three-dimensional volume-rendered image) confirms the absence of a common left main trunk and the independent ostial origins of the LAD and LCX.

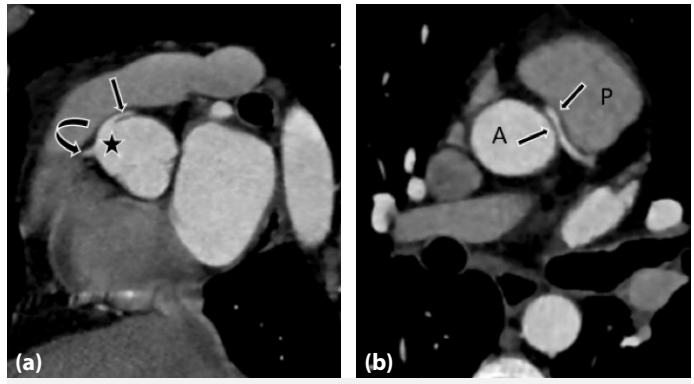

Figure 3. CCTA in a 40-year-old man demonstrates an anomalous origin of the left main coronary artery (LMCA) (arrows) from the right coronary sinus (asterisk) with an interarterial course between the ascending aorta (A) and the pulmonary trunk (P). **(a)** (axial oblique multiplanar reformat) depicts the separate ostial origins, with the LMCA arising from the right coronary sinus and the right coronary artery indicated by the curved arrow. **(b)** (axial oblique multiplanar reformat) highlights the interarterial trajectory of the LMCA between the ascending aorta and the pulmonary trunk.

high take-off origins of both the LMCA and RCA; the RCA originated at the level of the right–left commissural junction, just above the sinotubular junction, and followed a proximal interarterial course, while the LMCA maintained a normal trajectory. Another patient had an isolated high take-off

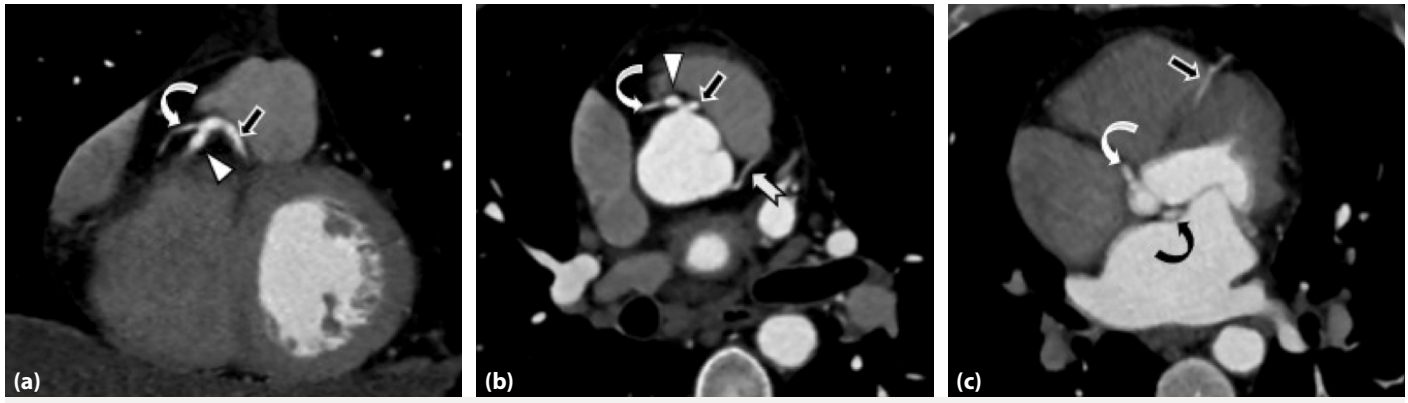

Figure 4. CCTA in a 35-year-old man demonstrates a single coronary artery arising from the right coronary sinus. **(a)** (coronal oblique multiplanar reformat) shows the common right-sided origin (asterisk) with trifurcation: the LAD (arrow), the LCX (curved arrow), and the RCA (arrowhead). **(b)** (axial oblique multiplanar reformat) demonstrates the LAD (arrow) with an interarterial proximal course; a thin accessory diagonal branch arising from the left coronary sinus is also noted (notched arrow), while the RCA (arrowhead) follows a normal course. **(c)** (axial oblique multiplanar reformat) shows the LCX (curved arrow) coursing retroaortically, and the LAD (arrow) continuing with an intraseptal course at the midlevel.

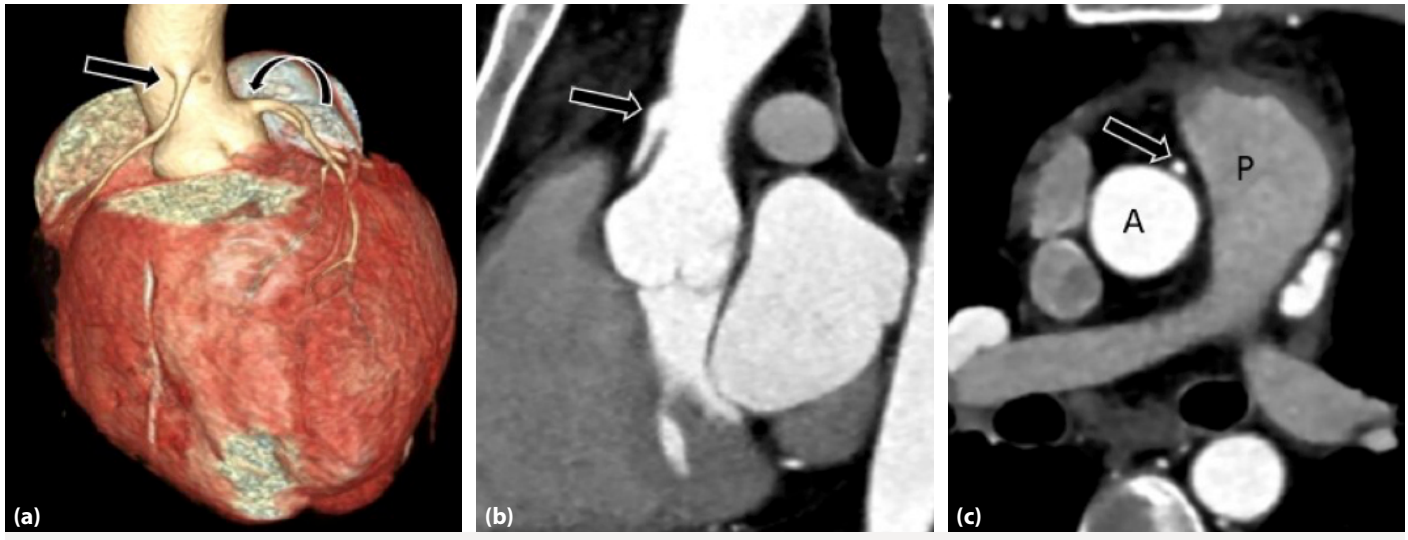

Figure 5. CCTA in a 65-year-old man demonstrates a high take-off origin of the RCA. **(a)** 3D volume-rendered image, **(b)** coronal oblique multiplanar reformat show the RCA (arrows) arising above the sinotubular junction. The LMCA originates normally from the left coronary sinus (curved arrow). **(c)** Axial oblique multiplanar reformat demonstrates the RCA (arrows) with an interarterial proximal course between the ascending aorta (A) and the pulmonary trunk (P).

LMCA arising above the left sinus and following a normal course. The remaining six patients had high take-off RCA origins: five arose above the right sinus and followed a normal proximal course, while one originated superior to the right–left sinus commissure, above the sinotubular junction, and demonstrated an interarterial proximal course (Fig. 5).

When coronary origin anomalies were stratified by proximal course, the interarterial variant was found in 20 patients: RCA (n=14), LMCA (n=4), LAD (n=1), and LCX (n=1). A retroaortic course was observed in 10 patients (LCX n=9, RCA n=1), and a prepulmonic course was seen in 2 patients (LMCA n=1, LAD n=1). In addition, the interarterial courses of the LAD and LCX included a proximal transseptal/intraseptal segment.

DISCUSSION

In this single-center, tertiary-care cohort, CCTA datasets from 3,181 patients were analyzed to define the prevalence

and proximal-course characteristics of coronary artery origin anomalies.

In cohorts evaluated with invasive coronary angiography or CCTA, reported prevalence rates generally range from 0.6% to 1.2%, whereas autopsy-based series typically report markedly lower rates of approximately 0.17% to 0.3%. This difference likely reflects the referral pattern of imaging-based cohorts, which predominantly include patients with chest pain or suspected coronary artery disease, rather than an unselected population.[1-13,14] In our study, the prevalence of coronary artery origin anomalies, including high take-off variants, was 1.29%, consistent with prior imaging-based literature.[3-12]

Origins arising from the contralateral sinus represent a clinically important subset of coronary origin anomalies. Although most courses are benign, interarterial variants are associated with an increased risk of myocardial ischemia and, in rare cases, sudden cardiac death. In contrast, origins from the non-coronary sinus are extremely uncommon and are generally considered incidental imaging findings without hemodynamic consequence.[13] A cardiac MRI study of 5,169 healthy children reported an overall prevalence of contralateral sinus origins of 0.44%, with right coronary arteries arising from the left sinus (0.33%) more frequently than left coronary arteries arising from the right sinus (0.12%).[15] Other studies similarly report that anomalous coronary arteries originating from the opposite sinus and exhibiting an interarterial course occur in less than 0.5% of the population, with the anomaly more often affecting the right coronary artery (0.23%) than the left (0.03%).[16]

In our cohort, the prevalence of contralateral or non-coronary sinus origins was 0.79%. RCA originating from the left sinus and left coronary arteries (LMCA or LCX) originating from the right sinus were each observed in 0.38% of patients. An additional case (0.03%) demonstrated the RCA originating from the non-coronary sinus and coursing retroaortically, consistent with the rarity of this variant in previous literature. In our cohort, every RCA with a left-sinus origin and every LMCA with a right-sinus origin followed a proximal interarterial course, whereas all right-sinus LCX variants followed a retroaortic course.

A single coronary artery is likewise a rare anomaly; in one report, 12 cases (0.27%) were found among 4,445 individuals.[17] We identified three patients (0.09%) with a single coronary artery, each arising from the right coronary sinus. In this subgroup, an interarterial segment with subsequent transseptal/intraseptal extension was seen in the LAD of one patient and the LCX of another (each representing 0.03% of the cohort).

Overall, the pattern of interarterial courses in our series—particularly their greater representation in RCA-related variants—paralleled previously described distributions. Notably, among patients in whom left-sided coronary arteries originated from the contralateral sinus, two patients demonstrated an interarterial proximal segment accompanied by a transseptal (intraseptal) component, a combination that may increase the clinical relevance of the anomalous origin.

Absence of the left main coronary artery, resulting in separate LAD and LCX origins from the left coronary sinus, is a well-described benign anatomical variant, with a reported prevalence ranging from 0.41% to 0.67% in previous studies.[14,18] In our cohort, this configuration was observed in 0.16% of patients, which is at the lower end of the reported range. Although usually regarded as clinically inconsequential, this variant should be recognized—particularly before invasive coronary angiography—because separate LAD and LCX ostia can influence catheter choice, ostial engagement strategy, and interpretation of the coronary origins.

Anomalous coronary origin from the pulmonary artery is exceptionally rare but represents a clinically significant congenital anomaly, most often manifesting in early life with heart failure and, in severe cases, sudden death. While the overall incidence in the general population is estimated to be approximately 0.01%,[3,16] no such cases were identified in our cohort. This absence may be related to the predominantly adult cohort studied, as these anomalies are typically detected in infancy or early childhood and frequently become symptomatic during that time.

In a large cohort of 12,899 patients, the prevalence of high take-off coronary arteries was reported to be approximately 0.20%, with the majority of cases (0.17%) originating from the right coronary artery.[19] In our cohort, high take-off anatomy was detected in 8 patients (0.26%). Of these, one had both the LMCA and the RCA with high take-off, one had an isolated LMCA with high take-off, and six had RCA origins with high take-off. Notably, two high take-off RCA cases exhibited a proximal interarterial course. This finding may increase their potential clinical significance even in the absence of additional anomalies. High take-off variants are important to consider when planning invasive coronary angiography, where catheter placement may be challenging, and in identifying high-risk proximal courses.

This study has several limitations. First, similar to other CCTA- and ICA-based investigations, our cohort does not fully represent the general population, as CCTA is predominantly performed in patients with chest pain or suspected coronary artery disease. For this reason, the frequency reported in our

series should be interpreted as representative of a CCTA-referred population rather than the general community. Furthermore, the single-center nature of the study may limit the broader applicability of the results. Third, due to the large number of examinations included, it was not feasible for both observers to review every CCTA dataset; consequently, interobserver variability could not be assessed.

CONCLUSION

Our analysis of 3,181 CCTA scans demonstrated that both the overall rate and the anatomic distribution of anomalous coronary origins were consistent with those in previously published CT angiography series. In our cohort, proximal course patterns—particularly interarterial trajectories—were common among opposite-sinus anomalies and represent an important anatomic feature to document when reporting coronary origin variants. Although most findings were incidental variants, accurate recognition remains crucial for procedural planning and for identifying anomalies with potentially high-risk proximal courses. CCTA provides noninvasive depiction of coronary ostial origin and proximal trajectory, reinforcing its role as a first-line imaging approach for suspected congenital coronary variants.

Ethics Committee Approval: Ethics committee approval was obtained from Non-Interventional Clinical Research Ethics Committee Kayseri City Training and Research Hospital (Approval Number: 553, Date: 26.08.2025).

Informed Consent: Informed consent was not required, as the study retrospectively analyzed anonymized CCTA datasets.

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