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Scientific Research

Congenital Coronary Variants and Anomalies: Prevalence in Cardiovascular Multislice Computed Tomography Studies in a Single Center

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Abstract

In the era of Multislice Computed Tomography (MSCT), few studies have been dedicated to the evaluation of coronary anomalies and variants. We aim to present, describe and assess the prevalence of congenital coronary variants and anomalies (CVA) in the MSCT coronary angiographic studies performed in our department. All the MSCT coronary angiographies performed in our department, between April 1, 2007 and May 31, 2012 were reviewed. Coronary anomalies and variants were characterized and grouped according to their type: origin, course (including myocardial bridging) and distal ending. A total of 663 patients underwent a MSCT coronary evaluation during this period. A total of 84 anomalies and variants were identified in 80 individuals: 12.1% of the population (80/663). The most frequent variant was the myocardial bridging of the anterior descending artery. Four (4.7%) of the anomalies were considered malignant, corresponding to a prevalence of 0.6% (4/663) in the population. Congenital coronary anomalies and variants are relatively common. In our study, the prevalence was 12.1%, myocardial bridging being the most common. This fact may explain the higher prevalence compared to some series based on the cardiac catheterization studies. Few of these anomalies were considered malignant, with prevalence rates similar to those found in the cardiac catheterization studies.

Keywords

Coronary Angiography, Congenital Anomalies, Diagnosis, Epidemiology, Imaging, Computed Tomography

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1. Introduction

The normal coronary anatomy includes the left coronary artery or left main stem (LC) that arises from the left coronary sinus and the right coronary (RC) artery arising from the right coronary sinus. The left coronary artery usually bifurcates into the left anterior descending artery (LAD) (providing septal and diagonal branches) and the circumflex coronary artery (LCx) (providing marginal obtuse branches); sometimes a third branch—the intermediate or *ramus* branch can be identified. The RC artery gives rise to a pulmonary cone branch, a sinusal node branch and marginal branches. In approximately 85% of cases, the RC artery is dominant and passes along the posterior atrioventricular groove, leading to the posterior descending artery and at least one posterolateral artery [8] (**Figure 1** and **Figure 2**).

There are some studies exploring the prevalence and characteristics of coronary variants and anomalies (CVA), but most of them are based on cardiac catheterization studies [1]-[5]. MSCT coronary angiography has proven to be effective not only in the identification and characterization of coronary artery disease, but also in the evaluation of the anatomical coronary details [6] [7]. The aim of this study was to evaluate the prevalence and characteristics of coronary variants and anomalies (CVA) in the MSCT studies performed at our department.

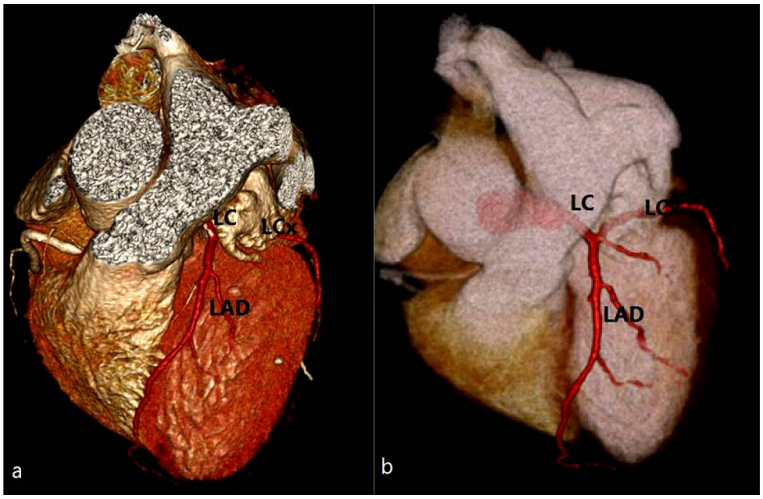

Figure 1. Volumetric reconstruction showing the left coronary normal anatomy (LC-Left coronary; LCx-Left circumflex artery; LAD-Left anterior descending).

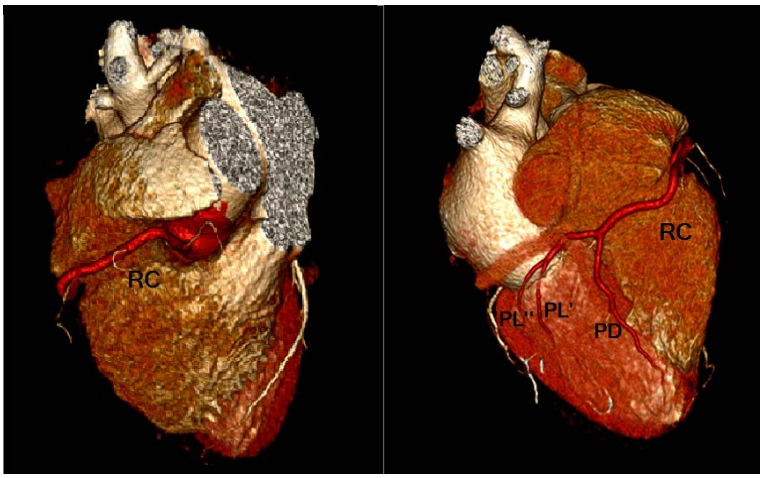

Figure 2. Volumetric reconstruction showing the right coronary artery normal anatomy (RC-Right coronary; PD-Posterior descending; PL-Postero-lateral branch).

2. Methods

A retrospective study was conducted based in all MSCT coronary angiography performed in our department during the period from April 1, 2007 and March 31, 2012. Coronary artery disease screening in patients with low or intermediate risk and atypical chest pain, questionable stress test or contradictory results in previous cardiac studies was the clinical indication for performing MSCT angiography. Severe renal disease, documented contrast allergy, pregnancy, uncontrolled heart beat rate (greater than 70 beats/minute) and inability to perform apnea for at least 10 - 12 s were contraindications for the MSCT angiography.

In each study, all patients received a sublingual vasodilator (5 mg isosorbide dinitrate). In patients with a heart rate greater than 60/70 pulses/minute, a beta-blocker was orally administered (50 mg metoprolol or atenolol 100 mg). Heart rate and blood pressure were monitored in all patients.

The MSCT angiographical studies were performed with a 64-slices (AS 64 Somaton Definition, Siemens Medical Solutions, Erlangen, Germany) and 16-slices (Brilliance 16 CT Scanner, Philips Healthcare, USA) equipment. The acquisition was ECG-synchronized. In most cases, an initial prospective pre-contrast acquisition for calcium score evaluation was performed, followed by a post-contrast retrospective acquisition with dose modulation. The following acquisition parameters were used: tube voltage 120 kV and tube current 20 - 600 mA; in 64-slice MDCT a collimation of 0.6 mm, 0.33 seconds per rotation and 0.2 pitch was used, and in the 16-slice MDCT a collimation of 0.75 mm, 0.5 seconds per rotation and 0.2 pitch.

In all studies, 80 - 100 cc of intravenous contrast (Ultravist® 370 (Bayer Healthcare)-Iopramida 370 mg I/ml) at a flow of 4/5 ml/s was administered. The studies were performed in inspiratory apnea.

Imaging analysis was performed in Cardiac Viewer® (Phillips Healthcare Products, USA) and Vitrea Advanced® (Toshiba Medical Systems, Japan). Coronary arteries were evaluated on axial images, multiplanar reconstructions (MPR), maximum intensity projection (MIP) and volumetric reconstructions. Reconstructions were mainly preformed using a diastolic phase (60% to 70% R-R interval), in order to obtain a higher coronary volume and lower cardiac motion artifact.

All coronary anomalies and variants were characterized, and grouped according to their type. A simplified anatomic classification that divides anomalies in three main groups: origin, course and (distal ending) termination variants or anomalies, and its subtypes [8]-[10] was used (**Table 1**). CVA associated with a higher risk of sudden death (malignant), were better characterized due to their greater clinic relevance.

Prevalence results are presented in absolute number and percentage.

3. Results

During this period, 663 patients underwent coronary MSCT angiographic study. Coronary anomalies or variants

Table 1. Coronary anomalies and variants classification (adapted from Kim *et al.*).

Origin
High origin
Multiple ostia
Single coronary artery
Pulmonary origin
Contralateral or non coronary sinus origin with a anomalous course (retroaortic, interarterial, prepulmonary, septal)
Course
Myocardial bridging
Duplication
Distal ending
Fistula
Arcade
Extracardiac

were found in 80 patients, 50 women and 30 men, with a mean age of 65, 4 years (range 20 - 85 years). In 4 cases, two CVA were found in the same patient, in all of them at least one of the CVA was a myocardial bridging.

The distribution of CVA is described in **Table 2**.

Most of the CVA were course type CVA. They were identified 64 cases of miocarddial bridging (**Table 3**) in 62 patients. The majority located in the middle and distal segments of the LAD artery (**Figure 3**). Two patients had two distinct myocardial bridging in different arteries and two patients had a myocardial bridging and a concomitant coronary origin abnormality. In one patient, there was identified a LAD duplication (**Figure 4**).

Some origin abnormalities were identified (**Table 4**): three cases of high arterial origin (**Figure 5**), three cases of multiple ostia—two separate origin of the LAD and LCx (**Figure 6**) and a case of an obtuse marginal artery originating directly from the coronary sinus, six contralateral sinus origin with anomalous course (**Figure 7** and

Table 2. Coronary variants and anomalies distribution by type and its prevalence.

Type	Number	Percentage	Patients	Prevalence
Course	65*	77.4% (65/84)	63*	9.5% (63/663)
Origin	14	16.7% (14/84)	14	2.1% (14/663)
Distal ending	5	5.9% (5/84)	5	0.8% (5/663)
Total	84		80**	12.1%** (80/663)

*Two (2) patients with more than one course CVA; **Two (2) patients with more than one type CVA.

Table 3. Characterization and prevalence of coronary course variants and anomalies.

	Artery	Segment		Nr	%	Patients	Prevalence
Myocardial bridging	LAD	Medial	27	58	89.2	58	8.7% (58/663)
		Distal	29				
	Obtusal	Medial	2	3	4.6	3	0.45% (3/663)
		Distal	1				
	Ramus	Medial	2	3	4.6%	3	0.45% (3/663)
		Distal	1				
Duplication		LAD		1	0.6%	1	0.15% (1/663)
Total				65		63*	9.5% (63/663)

*Two (2) patients with more than one course CVA.

Table 4. Characterization and prevalence of coronary origin variants and anomalies.

Anomaly type	Artery		Nr	Prevalence
High origin	Left coronary		1	0.15% (1/663)
	Right coronary		2	0.3% (2/663)
Multiple ostia	LAD and LCx		3	0.45% (3/663)
	Obtusal with proper origin		1	0.15% (1/663)
Contralateral sinus origin	Right coronary	Interarterial course	4	0.6% (4/663)
	LCx	Retroaortic course	2	0.3% (2/663)
Single artery	Right coronary sinus origin		1	0.15% (1/663)
Total			14	2.1% (14/663)

Figure 3. Multiplanar reconstruction (a) and (b) and volumetric reconstructions (c) showing myocardial bridging examples of the left anterior descending artery.

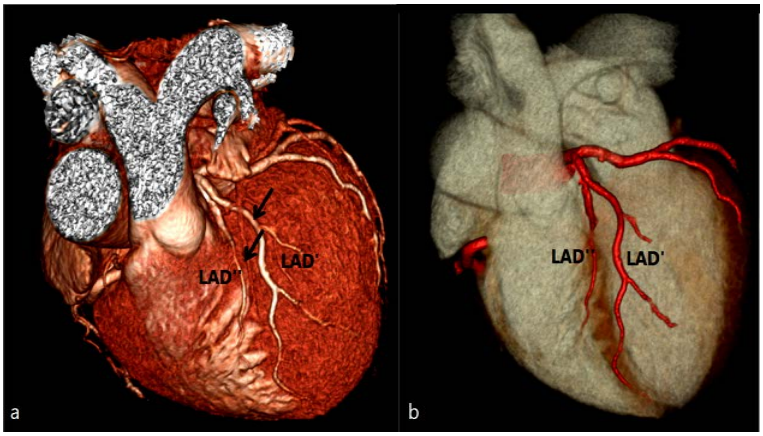

Figure 4. Volumetric reconstruction showing a left anterior descending duplication (arrows) (LAD-Left anterior descending).

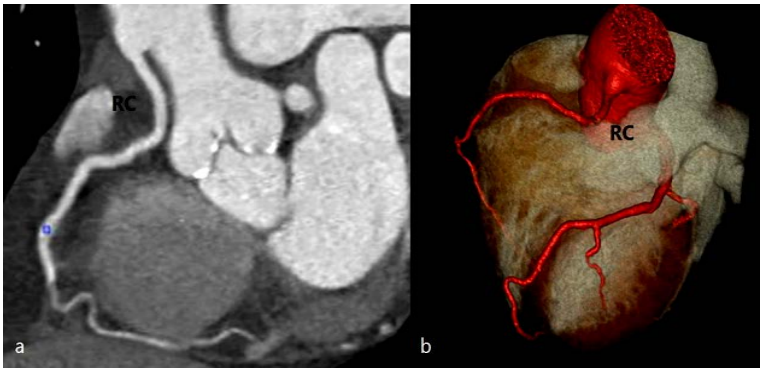

Figure 5. Multiplanar (a) and volumetric (b) reconstruction showing a high origin of the right coronary artery (RC-Right coronary).

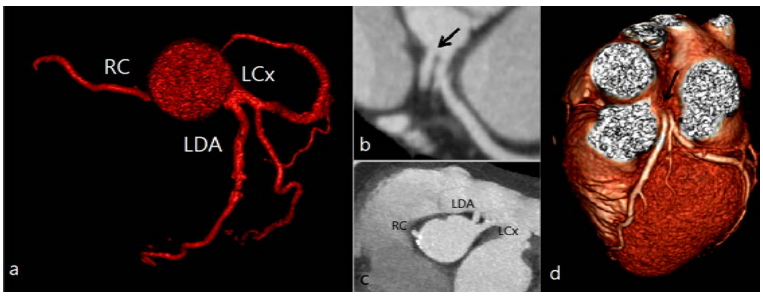

Figure 6. Volumetric (a) and (d) and multiplanar (c) and (d) reconstructions showing a separated origin of the LAD and LCx with two ostia (arrow) (RC-right coronary; LCx-Circumflex artery and LAD-Left anterior descending).

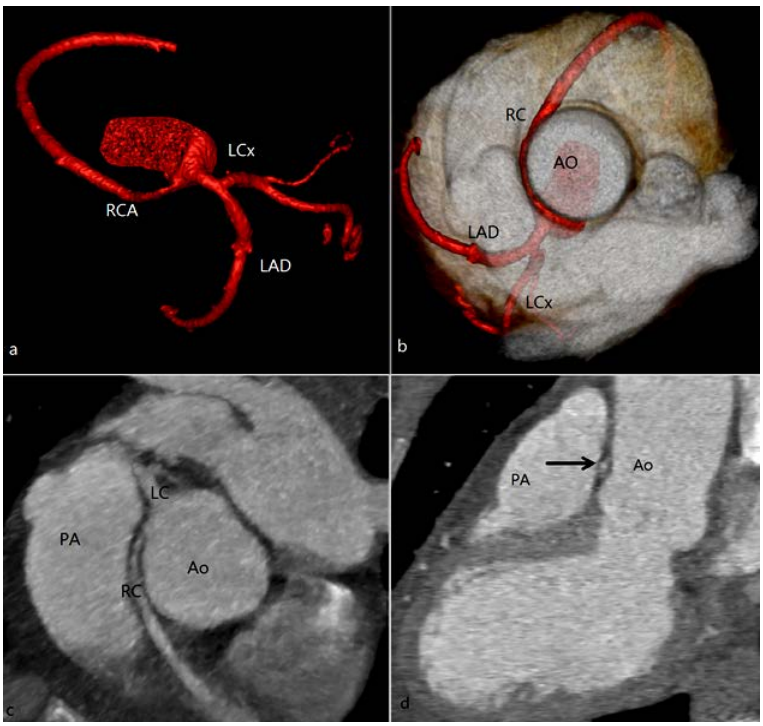

Figure 7. Volumetric (a) and (b) and multiplanar (c) and (d) reconstructions showing anomalous contralateral origin of the RC artery, with an interarterial course (arrow) (AO-Aorta; PA-Pulmonary artery; RC-Right coronary; LCx-Circumflex artery and LAD-Left anterior descending).

Figure 8)—four cases with anomalous origin of the LCx artery and retroaortic coure and two cases of anomalous origin of the RC and interarterial course, and a case of single coronary artery originating from the right coronary (**Figure 9**).

Fistulas were the only distal ending abnormalities identified (**Table 5**). Most originating from the LAD and leading to the pulmonary trunk (**Figure 10**).

Four patients had malignant abnormalities: all due to an anomalous origin in the contralateral sinus with anomalous interarterial course (**Table 6**), corresponding to 0.6% prevalence in the population under study.

4. Discussion

The prevalence of CVA based in coronary MSCT studies varies widely in the literature from 2.69% to 24.5% [11]-[15]; in our study, prevalence was 12.1% (n = 663) which is located within the limits of the values described. However, this value was larger than most series based on the cardiac catheterization studies, which

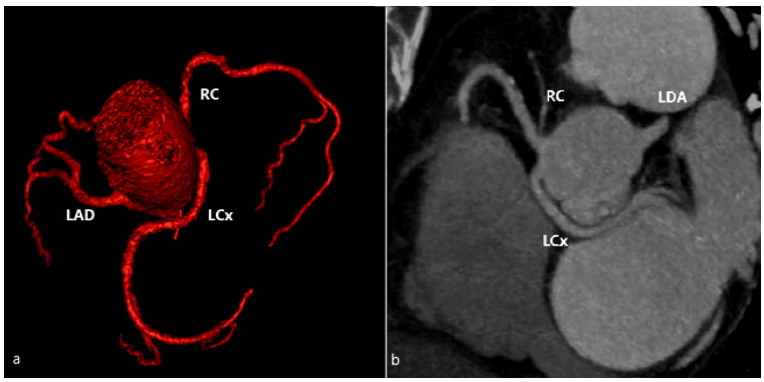

Figure 8. Volumetric (a) and multiplanar (b) reconstructions showing anomalous origin of the LCx artery in the contralateral sinus with a retroaortic course (arrow). (AO-Aorta; RC-Right coronary; LCx-Circumflex artery and LAD-Left anterior descending).

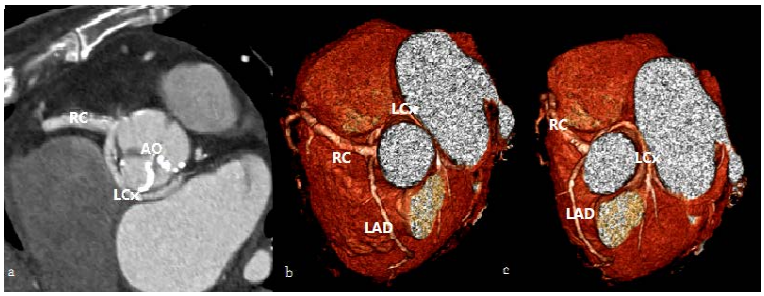

Figure 9. Multiplanar (a) and volumetric (b) and (c) reconstructions showing a single coronary artery with a right sinus origin (RC-Right coronary; LCx-Circumflex artery and LAD-Left anterior descending).

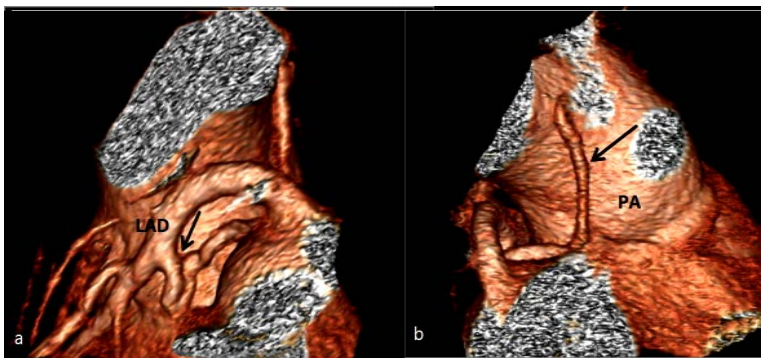

Figure 10. Volumetric reconstructions showing a LAD and pulmonary artery fistula (arrow) (PA-pulmonary artery and LAD-Left anterior descending).

Table 5. Characterization and prevalence of coronary distal ending variants and anomalies.

	Artery	Communication	Nr	Prevalence
Fistulas	LAD	Pulmonary trunk	3	0.45% (3/663)
	Right coronary	Right auricula	1	0.15% (1/663)
	RC, LCx and ramus	Pulmonary trunk	1	0.15% (1/663)
Total			5	0.8% (5/663)

Table 6. Characterization of the malignant coronary anomalies.

	#1	#2	#3	#4
Type	Origin	Origin	Origin	Origin
Characteristic	Contralateral sinus	Contralateral sinus	Contralateral sinus	Contralateral sinus
Artery	Right coronary	Right coronary	Right coronary	Right coronary
Course	Interarterial	Interarterial	Interarterial	Interarterial
Dominant	Yes	No	Yes	No
Plaques	No	No	Yes	No
Age (years)	20	79	70	68
Gender	M	F	F	F
Symptomatic	No	Yes	No	No

demonstrated a prevalence around 1.3% [2]-[5]. Meanwhile, several studies have shown that only 50% of coronary anomalies identified in CT studies are identified by catheterism [6] [7].

The most common variant was myocardial bridging of the left anterior descending artery, corresponding to 69% (58/84) of all anomalies and variants described, and a prevalence of about 9% (58/663). This result was similar to those described in series based on MSCT coronary angiographic studies [12] [16], but less than those described in autopsy series, in which the prevalence ranges from 16% to 80%.

Origin anomalies prevalence was about 2%, higher than the one described in a study in the Portuguese population based cardiac catheterization studies: 0.54% [5]. The anomalous origin in the contralateral sinus was the most common origin anomaly, with a prevalence of 0.9% (6/663), most commonly the right coronary artery, similar to other series based on tomography studies [6] [13]-[15] and some based on catheterism [17]. In some studies, the anomalous origin of the circumflex artery was the most frequent origin anomaly [1] [3]. In some series based in cardiac catheterization, the absence of a left coronary artery, with separated origin of the anterior descending artery and circumflex arteries was the most common origin anomaly [2] [5], this may be due to an overestimation in the cardiac catheterization studies, caused by the presence of a short left coronary stem.

Some CVA are considered malignant as they have an increased risk of sudden death, [2] [18]. Four abnormalities were identified as malignant in our study: all corresponding to an anomalous origin in the contralateral sinus, with an interarterial path. This is indeed the most common malignant anomaly described in the literature [2] [5] [13] [14] [18].

A case of single coronary artery was also identified, a very rare anomaly, corresponding to a prevalence of 0.15% (1/663) in our population. In the literature, the reported prevalence is lower (0.024%) [19] [20], which is mainly due to the small size of our population. The single artery identified was classified as R (origin from the right coronary sinus), group III: separate origin of the ADA and the CCA, which held a retroaortic course [20].

Some anomalies were not found: origin in the pulmonary artery, arcade and extra heart termination, all very rare. Pulmonary artery origin is usually associated with death in the first year of life (childhood type), but there is also described an adult type [21].

5. Conclusion

MSCT coronary angiographic studies are able to identify and characterize effectively anomalies and variations of the coronary arteries, including those associated with an increased risk of sudden death (malignant) and are the actual first line imaging study. The prevalence of anomalies and variations of the coronary arteries in our sample was higher than the series based on cardiac catheterization, and comparable to the series based on tomography.

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Abbreviations

CVA	Coronary Variants and Anomalies
LCx	Left Circumflex
ECG	Electrocardiogram
LAD	Left Anterior Descending
LC	Left Coronary
MSCT	Multislice Computed Tomography
RC	Right Coronary