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Prevalence of Coronary Artery Anomalies in Adults Discovered at MDCT

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Abstract

To assess the prevalence of Coronary artery anomalies (CAAs) and their subtypes in symptomatic, but stable adults with Multi-Detector CT Coronary Angiography (MDCT-CA). 50 patients were scheduled for multidetector computed tomography – coronary angiography (MDCT-CA) which enables detailed visualization of coronary arteries and heart anatomy, (clinically suspected patients with CAD & others with suspected congenital cardiac anomalies). Coming fasting, non-contrast cardiac CT scan for calcium score was carried, after intravenous injection of contrast material & ultra-thin cardiac scanning. Images were analyzed with MPR, cMPR, MIP & VR. The data of coronary artery anomalies were reported. Among the study patients, the incidence of congenital anomalies was 10.1%. Myocardial bridging was the most frequent reaching 38.5% among all anomalies**.** The 2nd most common coronary artery anomalies found at our study was Anomalous location of coronary ostium at improper sinus (ACOIS), being of about 15.4 % of total anomalies The prevalence of CAAs in our study was relatively similar or near to previous studies and the literature data**.** Thus, CTA is a non-invasive method and an excellent tool to diagnose and guide the management of CAAs. It enables excellent three-dimensional visualization and provides a clear delineation of the origin, course, relation to the adjacent structures, and termination compared with invasive coronary angiography.

Keywords: Coronary artery anomalies, MDCT-CA, ACOIS, Myocardial bridging.

1. Introduction

Systemic Coronary artery anomalies (CAAs) are groups of congenital anomalies that have many diverse types, different clinical symptoms and variant patho-physiologies [**1**]. As regards definition, classification, diagnostic tools and their treatment, many ongoing developments are occurring [**2**]**.** Despite being uncommon, CAA is nonetheless crucial due to the related association with sudden cardiac death. MDCT-CA is well dedicated to assessing CAAs with excellent non-invasive 3D images of coronary arteries. Understanding illness burden and relative association with cardiovascular diseases can be achieved through understanding the prevalence, varieties, sexual distribution and age of presentation of CAA [**3**].

In general population, prevalence of CAAs diagnosed by MDCT-CA was 7. 9 % – 18 .4 % depending on various inclusion criteria [**4**].

2. Patients and Methods

This randomized prospective study involved 50 patients; 42 males (84%) and 8 females (16%). The age ranged between 20–81 years with mean age about 50 years. They were scheduled for multidetector computed tomography (MDCT) between October 2018 and September 2020. The CT was clinically requested for coronary assessment & exclusion of coronary heart disease. They were referred to the CT unit at National heart institute and one of the radiological centers. MDCT was done to enable detailed visualization of coronary arteries and heart anatomy.

2.1 Preparation

Patients were properly prepared before undergoing the dedicated CCTA examination. All patients were instructed to fast 6 h prior to the examination with no discontinuity of their medications. Repeated test breath hold technique was performed. Those with heart rate above 75 bpm were given beta blockers (about 50 mg Atenolol) 45 min prior to the examination (unless contraindicated), to prolong the diastole phase time of the cardiac cycle, which facilitates acquisition process.

2.2 Procedure

Examinations were performed using a 64 Multi-detector Computed Tomography (Toshiba, Aquilion Prime) using examination parameters as follows: 120 kv, 165 ms, slices/collimation 64/0.6, slice thickness 0.6 mm, images reconstruction increment 0.6 mm, field of view (FOV) was 140–180 mm. Imaging started with a scout image and then a calcium score scan, a non-contrast ECG gated thin sections carried through the coronary arteries to detect and calculate the coronary calcium score. Using bolus tracking technique, non-ionic contrast material, about 80 mL, was applied in the cubital vein at a flow rate of 4.0–5.0 mL/s. A 50 mL bolus of normal saline was given after administering the contrast material. An appropriate CCTA protocol was performed according to the heart rate, body mass index (or body weight), as well as the age of the patient. Most of the exams were performed using retrospective ECG-gating. Post-processing and evaluation were done on a workstation, where all images were transferred. All data were analyzed with post-processing tools such as multiplanar reconstructions (MPR), curved MPR (cMPR), maximum intensity projections (MIP) and volume rendering (VR) to three-dimensionally image of the complex anatomy of the coronary artery tree. Anomalies of origin and course, intrinsic coronary anomalies and termination anomalies were checked, all were classified based on Angelini et al's anatomical classification.

3. Results

A sum of 493 patients was sent to the CT unit at National heart institute and one of the private radiological centers for coronary CT angiography, 441 of them showed variable coronary artery affection, while 52 of them were normal cases. Of the 441 affected cases, 391 were non-anomalous coronary artery diseases while 50 cases showed CAAs, with a total incidence about 10.1 %. The 50 coronary artery anomaly cases were 8 females (16%) and 42 males (84%), with age ranged from 20 to 81, and median age around 55.20±11.99. The found 50 CAAs showed 17 (34%) having abnormalities of origin and course, 33 (66%) with abnormalities of intrinsic anatomy, 0 (0%), with abnormalities of termination, and 0 (0%) had anomalous anastomotic vessels. According to Angelini et al's categorization, our studies detected CAA were detailed and described at (Table 1 & 2).

The most common among anomalies of intrinsic anatomy, and total anomalies, was myocardial bridging (MB) being detected in 20 patients with a 38.5% prevalence ***(figure 1).***

Of these MB cases, the most common affected artery was the LAD mid-segment, by an incidence of about 85% of the MB cases. OM bridging was found in 2 cases by an incidence of about (10%) of the MB cases while RCA bridging was found at 1 case by an incidence of about (5%) of the MB cases.

The 2nd most common CAAs detected in our study was ***Anomalous location of coronary ostium at improper sinus (ACOIS),*** being found at about 8 cases with a (15.4 %) of total anomalies. Of these, RCA arising from LCS was found in 3 cases, by an incidence of (5.8%) total anomalies and (37.5%) of the *ACOIS* cases**.** LMCA arising from RCS was also found at 3 cases, by an incidence of (5.8%) total anomalies and (37.5%) of the *ACOIS* cases ***(figure 2)***. LCX arising from RCS was found at 2 cases, by an incidence of (3.8%) of total anomalies and (25%) of the *ACOIS* cases.

Coronary artery ectasia was detected at about 5 cases, with a prevalence of about 9.6%) among total anomalies. Of these cases, RCA ectasia was found at all the 5 cases by a prevalence of about 100% among coronary ectasia cases, while LCX ectasia was found in combination with RCA ectasia at 2 cases by an incidence of about 40 % among coronary ectasia cases.

Coronary artery hypoplasia was found at about 5 cases, with a prevalence about (9.6%) among total anomalies. Of these, the RCA was found affected at 3 cases by a prevalence of about 60% among hypoplasia cases, while LCX was found affected at 2 cases with incidence of 40% among hypoplasia cases.

Separate ostia of the LAD and LCX with absence of (LMCA) was found at 4 cases with a prevalence of about 7.7% among total anomalies ***(figure 3).***

Abnormal site of coronary ostium near the related coronary sinus or within the aortic root was found at about 4 cases with a prevalence of about 7.7% among total anomalies. Among these cases, 3 cases showed ***high origin of RCA*** from the aorta ***(figure 4)*** by a prevalence of about 5.8 % among total anomalies, while ***commissural RCA*** ostium was found at one case by an incidence of about ***1.9%*** among total anomalies**.**

Single coronary artery (SCA) was found at one case by an incidence of about 1.9% among total anomalies.

Split LAD was found at 3 cases by an incidence of about 5.8% among total anomalies, while ***split LCX*** was found at 1 case by an incidence of about 1.9 % among total anomalies.

Absent LCX was found at 1 case by an incidence of about 1.9 % among total anomalies ***(figure 5).***

Anomalous site of the coronary ostium away from the usual coronary sinus was found at 0 cases**,** and ***Congenital ostial stenosis/atresia*** was found at 0 cases**.**

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Table 1: Classification of coronary artery anomalies among these study cases, illustrating number of each anomaly among total anomaly cases and their percentage.

Classes	Anomalies	Number of anomalies in Cases	Percentage (%) among total anomalies
A: Anomalies of origin and course	1. Absent left main trunk (LMCA) with separate origins of LAD and LCX	4	7.7%
	2. Anomalous location of coronary ostium within aortic root or near proper coronary sinus (n=4)	4	7.7%
	a. High origins	3	5.8%
	b. Commissural RCA ostia/inter-arterial course	1	1.9%
	3.Anomalous location of coronary ostium outside normal coronary sinus:		
	a. Non Coronary Sinus (NCS)	0	0.0%
	b. Main Pulmonary artery (MPA)	0	0.0%
	4. Anomalous location of coronary ostium at improper sinus (ACOIS)(n=8)	8	15.4 %
	a. RCA arising from LCS, with inter-arterial course	3	5.8%
	b. LAD arising from RCS, with anomalous course	0	0.0%
	c. LCX arising from RCS, with retro-aortic course	2	3.8%
	d. LMCA arising from RCS, with retro-aortic/pre-pulmonic course	3	5.8%
	5. Single coronary artery (SCA)	1	1.9%
B: Anomalies of intrinsic anatomy	1. Congenital ostial stenosis/atresia	0	0.0%
	2. Coronary ectasia/aneurysm	5	9.6%
	3. Coronary hypoplasia	5	9.6%
	4. Intramural coronary artery (Myocardial bridging)	20	38.5%
	5. Split LAD	3	5.8%
	6. Split LCX	1	1.9%
	7. Absent LCX	1	1.9%
Grand Total		52	100.0%

Table 2: Classification of coronary artery anomalies among these study cases, illustrating the affected artery in each anomaly, number of affected arteries per anomaly and percentage of affected artery per anomaly.

Classes	Anomalies	Affected Artery	Number of affected artery in anomalies	Percentage (%) affected artery/ anomalies
A: Anomalies of origin and course	1. Absent left main trunk (LMCA) with separate origins of LAD and LCX (n=4)	Absent LMA, separate ostia of LAD, LCX	4	100%
	2. Anomalous location of coronary ostium within aortic root or near proper coronary sinus (for each artery) (n=4)			
	a. High origins	RCA	3	75%
	b. Commissural RCA ostia/intraarterial course	RCA	1	25%
	3.Anomalous location of coronary ostium outside normal coronary sinus:			
	a. Non Coronary Sinus (NCS)	Non	0	--
	b. Main Pulmonary artery (MPA)	Non	0	--
	4. Anomalous location of coronary ostium at improper sinus (ACOIS) (n=8)			
	a. RCA arising from LCS, with inter-arterial course	RCA	3	37.5%
	b. LAD arising from RCS, with anomalous course	Non	0	--
	c. LCX arising from RCS, with retro-aortic course	LCX	2	25%
	d. LMCA arising from RCS, with retro-aortic/pre-pulmonic course	LMA	3	37.5%
	5. Single coronary artery (SCA) (n=1)	LAD pre-pulmonic course	1	100%
B: Anomalies of intrinsic anatomy	1. Congenital ostial stenosis/atresia	Non	0	--
	2. Coronary ectasia/aneurysm (n=5)	LCX	2	40%
		RCA	5	100%
	3. Coronary hypoplasia (n=5)	LCX	2	40%
		RCA	3	60%
	4. Intramural coronary artery course (Myocardial bridging) (n=20)	LAD	17	85.0%
		OM1	2	10.0%
		RCA	1	5.0%
	5. Split LAD	LAD	3	100%
	6. Split LCX	LCX	1	100%
	7. Absent LCX	LCX	1	100%

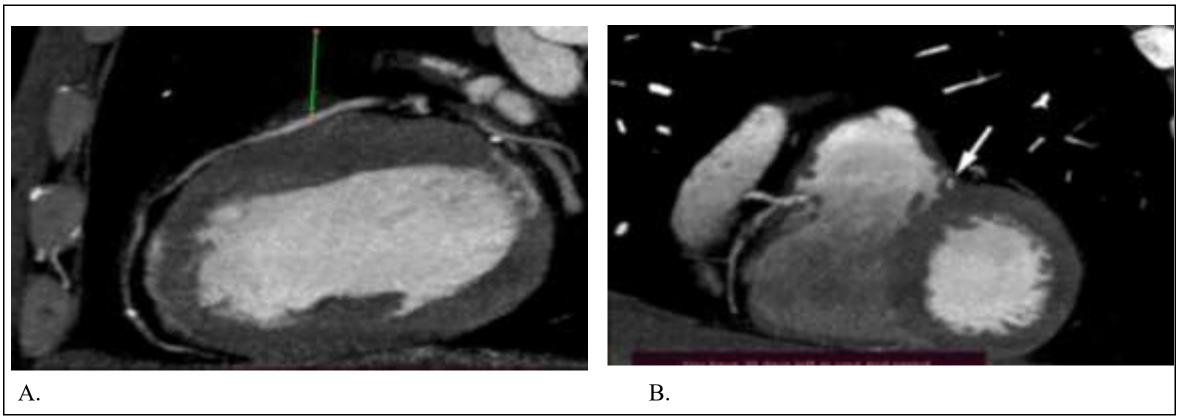


Figure 1: 38 years old male patient presented by atypical chest pain. pain. **A)**: 3D VR image, **B)**: Coronal MIP image shows absent LMA and separate ostia of LAD and LCX from LCS. The white arrow at A refers to the LAD origin from the LCS, while the green arrow at A refers to LCX origin from LCS. The green arrows at B refer to the separate origin of LAD and LCX from the LCS.

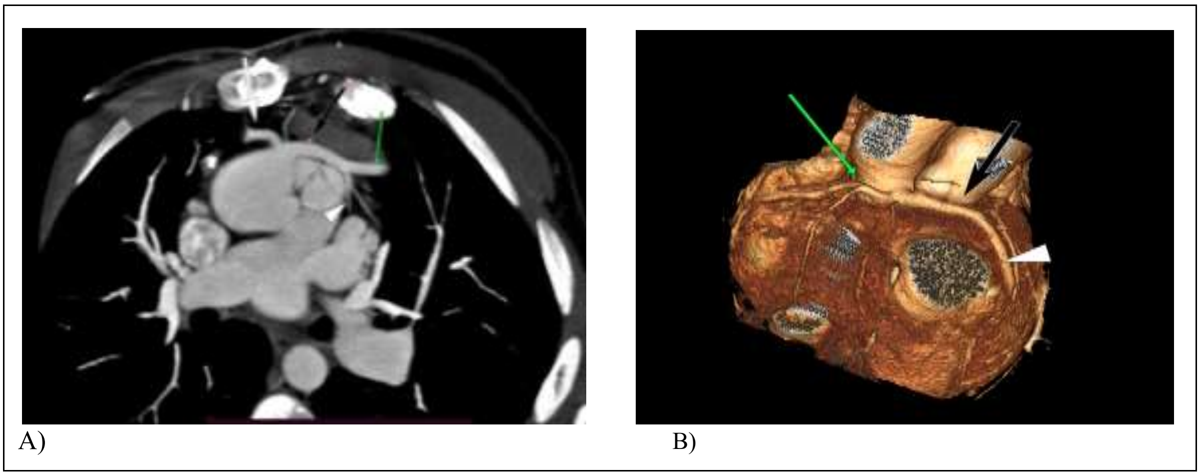


Figure 2: 50 years old male patient presented by arrhythmia. **A)** curved axial MIP image, **B)** 3D VR image showing ectopic origin of LMCA ostium from RCS with pre-pulmonic course. White arrow at A: RCA, black arrow at A: LMA, green arrow at A: LAD, white arrowhead at A: LCX, green arrow at B: RCA, black arrow at B: LMCA, while white arrowhead at B: LAD.

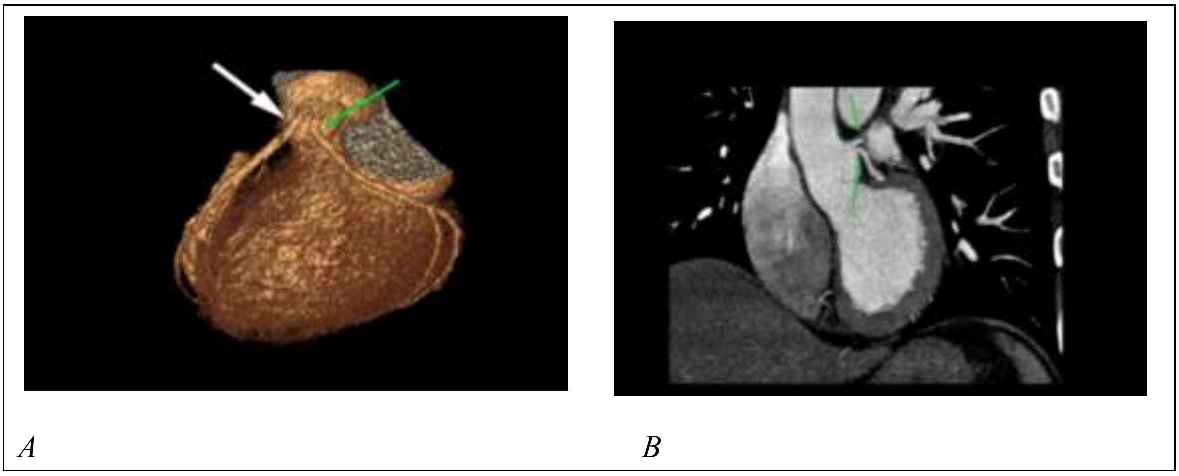
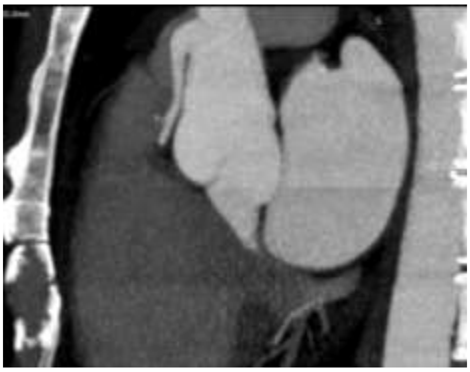
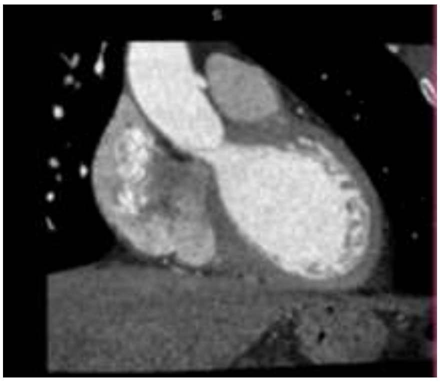


Figure 3: 58 years old male patient presented by atypical chest pain. **A)** Sagittal oblique MIP image, **B)** coronal oblique MIP image shows mid-LAD superficial myocardial bridge. Green arrow at A and the white arrow at B refer to the bridged segment of LAD surrounded by myocardial tissue.



A



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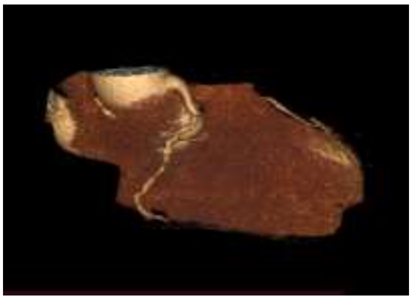

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Figure 4: *50 years old male patient presented with frequent attacks of chest pain increased at stress.* ***A.*** *Sagittal MIP image,* ***B.*** *coronal oblique image,* ***C.*** *VR 3d image of CT CA showing high origin of the RCA from the ascending aorta a distance above the sino-tubular junction.*

A

B

Figure 5: *60 years old male patient presented with dyspnea and chest pain.* ***A.*** *Axial MIP image,* ***B***. *3D VR image of CTCA showing absence of LCX with LMCA giving off LAD only. The arrowhead refers to the LMCA, the black arrow refers to the LAD, while the white arrow refers to the D1 branch.*

4. Discussion

Any coronary arterial feature involving any of origination, course, or termination and rarely seen in the general population is defined as CAA **5.** In our thesis we followed Angelini et al. anatomical classification of CAAs. MDCT use for the evaluation of CAAs, according to the current guidelines is suggested **6.** Multiple previous studies revealed that MDCT- CA is a reliable non -invasive technique to identify CAAs **7.** Among the world population, according to different inclusion criteria, the prevalence of CAAs found by MDCT-CA ranged from 7.9% to 18.4% and when MB was excluded, it ranged from 1.029% to 2.88% **8.** Conventional Coronary angiography (CCA) was the ‘‘gold standard” for coronary artery assessment. Selective coronary catheterization & its assessment was difficult in CCA, if the operator was unaware about the atypical vessel orifice site. 3D images that assist detailing the coronary anatomy cannot be provided by CCA**9.** MSCT- CA provides excellent spatial resolution and high diagnostic accuracy level as well as produces informative post-processing images**10**. **Over a period of 2 years, we performed** a sum number of 493 patients that were referred to the CT unit at National heart institute and one of the private radiological centers for **diagnostic CTCA studies using 64 slices MSCT.** 441 of these cases showed variable coronary artery affection, while 52 of them were normal cases. Of the 441 affected cases, 391 were non-anomalous coronary artery disease while 50 cases showed coronary artery anomalies, with a total incidence of about 10.1 %. The 50 coronary artery anomaly cases were 8 females (16%) and 42 males (84%), ranging in age between 20 and 81 years with mean age of about 55.20±11.99. Among 50 CAAs, 17 (34%) were anomalies of origin and course, 33 (66%) were anomalies of intrinsic anatomy, 0 (0%) were anomalies of termination and 0 (0%) cases of anomalous anastomotic vessels. Talking about congenital anomalies, the incidence is 10.1 % (when myocardial bridge is included as an anomaly among our study population as compared to 18.4% found by **Cademartiri et al. 11.** Myocardial bridging was found the most common CAA in our study group (38.5 % of the congenital anomalies). This prevalence makes it a variant (according to incidence) rather than a congenital anomaly, agreeing with **Mehta and Agarwal** who found myocardial bridge in 11.3% of their population **12.** 85% of the myocardial bridges in our study were found in LAD involving the mid segment. 10 % of the myocardial bridges in our study were found in OM branch while 5 % were found in RCA. **Ghadri et al. 4** found that MB was involving the LAD in 88% with stating that the most affected portion is the mid segment**.** In anomalous origin of the coronary artery from the opposite sinus, the coronary artery arises from the opposite sinus and then takes one of four paths: (1) an inter-arterial course (2) transseptal (subpulmonic); (3) retroaortic; and (4) prepul-monic (anterior to the Pulmonary Artery or right ventricle). The most common anomalous origin is the RCA arises from the left SV **13.** Anomalous location of coronary ostium at improper sinus (ACOIS) was the second most common anomaly, being found in 8 patients with a prevalence of 15.4% of our cases (three of them (37.5 %) with ectopic RCA from LCS, three (37.5%) with ectopic LMCA from the RCS and two (25%) with ectopic LCX from the right coronary sinus). Absence of left main trunk with the separate origin of LAD and LCx origin from a left coronary sinus in our study was found in 4 patients (an incidence of 7.7% of all anomalies) as compared to **Abdelrahman SF et al. 14,** who found it in 4.8 % of their study total anomalies**.** Anomalous location of coronary ostium within the aortic root or near proper aortic sinus of Valsalva was found in 4 patients (with an incidence of about 7.7% of all anomalies). Three of them (about 75%) were of high origin (high take off) with an incidence of 5.8 %

among total anomalies, all were seen affecting RCA). One of them (25%) was of commissural origin with an incidence of about 1.9 % among total anomalies and it was seen affecting RCA. A single CA was found in one patient in our study group with an incidence of about 1.9 % among total CAA as compared to **Abdelrahman SF et al. 14,** who found it in 2.1% of their study total anomalies**. Smettei OA et al. 15** also found single coronary artery in about 1 % of their study total anomalies. **Coronary artery ectasia** was found in 5 patients in our study group with an incidence of 9.6 % among total anomalies as compared to **Smettei OA et al. 15** who found it in 6% of their study total anomalies**. Coronary artery hypo-plasia** was also found in 5 patients in our study group with an incidence of 9.6 % among total anomalies as compared to **Naidu SC et al. 16** who found it in about 0.23 % of their study total anomalies**. Split LAD** was found in 3 patients in our study group with an incidence of 5.8 % among total anomalies as compared to **Naidu SC et al** who found it in about 0.59 % of their study total anomalies **16. Split LCX** was found in 3 patients in our study group with an incidence of 5.8 % among total anomalies. **Absent LCX** was found in one patient in our study with an incidence of about 1.9 %.

5. Conclusion

The prevalence of CAAs in our study was relatively similar or near to previous studies and the literature data. Most CAAs are asymptomatic and have no clinical significance, but some can be symptomatic and even life threatening. The most common anomaly is myocardial bridging followed by anomalous origin of the coronary artery. CTA is a noninvasive method and an excellent tool to diagnose and guide the management of CAAs. It enables excellent three-dimensional visualization and provides a clear delineation of the origin, course, relation to the adjacent structures, and termination compared with invasive coronary angiography. In the future, with attempts to reduce radiation dose, CTA can overcome the current limitation and may become the screening test of choice for CAAs.

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