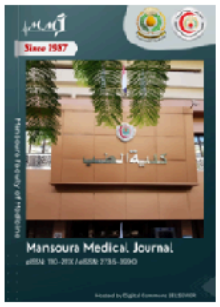
MANSOURA MEDICAL JOURNAL

ISSN - Print: 1110-211X - Online: 2735-3990

journal homepage: mmj.mans.edu.eg



Volume 52 | Issue 3 Article 6

Evaluation of Congenital Coronary Arteries Anomalies on Cardiac Computed Tomography Angiography (CTA) for Congenital Heart Diseases

Zainab A. Ramadan

Department of Diagnostic and Interventional Radiology- Faculty of Medicine - Mansoura University - Mansoura - Egypt,

zainabahmed87@mans.edu.eg

Recommended Citation

Ramadan, Zainab A. (2023) "Evaluation of Congenital Coronary Arteries Anomalies on Cardiac Computed Tomography Angiography (CTA) for Congenital Heart Diseases," *Mansoura Medical Journal*: Vol. 52 : Iss. 3 , Article 6.
Available at: https://doi.org/10.58775/2735-3990.1402

Evaluation of Congenital Coronary Arteries Anomalies on Cardiac Computed Tomography Angiography (CTA) for Congenital Heart Diseases

Cover Page Footnote

Acknowledgements: Deep gratitude to the patients who contributed to this study.

ORIGINAL STUDY

Evaluation of Congenital Coronary Arteries Anomalies on Cardiac Computed Tomography Angiography (CTA) for Congenital Heart Diseases

Zainab A. Ramadan

Department of Diagnostic and Interventional Radiology, Faculty of Medicine, Mansoura University, Elgomhoria St., 35516, Mansoura, Egypt

Abstract

Background and purpose: **Coronary arteries anomalies (CAA) are generally rare but more common to co-exist with congenital cardiac anomalies. These include several congenital conditions either origin, course, or termination. This study aims to emphasize that the accurate evaluation of CAA on cardiac computed tomography angiography (CTA) is a must before proper surgical intervention in congenital heart diseases (CHD) to prevent unnecessary procedures or vascular injury of these vital arteries.**

Methods: **Cardiac CTA scans for patients with suspected cardiac anomalies or diseases were retrospectively reviewed by radiologists for the presence of CAA between February 2020 and March 2023. CAA was found in 162 patients of the cardiac CTA reports done for CHD. They were categorized according to anomalies of origin, course, location of sinuses, or termination.**

Results: **A total of 900 reports were scanned for CAA. After the exclusion of unfit and repeated reports, CAA was detected in 162 patients, 103 (63.6 %) males. Three (1.9 %) patients had anomalous origin of left coronary artery from pulmonary artery, while 27 (16.6 %) patients had common origin of left coronary artery (LCA) or its branches from right coronary ostium, 16 (9.8 %) patients had origin of LCA or its branch from opposite or noncoronary sinus. Thirteen (8 %) patients had ectasia of the right coronary artery and one (0.6 %) had both ectasia and aneurysm. Six (3.7 %) patients had right coronary artery fistula.**

Conclusions: **Meticulous evaluation for the presence of CAA on cardiac CTA done for assessment of CHD is mandatory to avoid surgical and long-term morbidity and mortality.**

Keywords: Cardiac computed tomography angiography, Congenital, Coronary anomalies, Heart

1. Introduction

Cardiac computed tomography angiography (CTA) and magnetic resonance imaging are noninvasive techniques for cardiac imaging, producing excellent image quality particularly the heart (Sapiano and Borg, 2020).

Congenital anomalies of the coronary arteries are not common, only generally occurring in about 1 % of the population. On the contrary, there is an increased incidence of up to (11 %) in association with congenital heart diseases (CHD) (Chen et al., 2007).

CHD in adults, including coronary arteries anomalies (CAA), may be asymptomatic and incidentally detected. Also, anatomical variations of the coronary arteries are common and mostly not clinically significant (Gupta et al., 2019).

Recent guidelines from the American Heart Association and the American College of Cardiologists have recommended that the accurate evaluation of the origin and course of coronary arteries is mandatory as anomalies of the origin or course may predispose to myocardial infarction, arrhythmias, or sudden cardiac death (Writing Committee Members et al., 2022).

Received 16 October 2023; revised 13 November 2023; accepted 10 December 2023.
Available online 23 January 2024
E-mail address: zainabahmed87@mans.edu.eg.

https://doi.org/10.58775/2735-3990.1402

Patients with CAA could be surgically corrected if they have alarming criteria such as symptoms clearly attributed to ischemia, positive functional test, or high-risk anatomy like the long intramural or inter-arterial course and ostial abnormalities, despite symptomatology (Molossi et al., 2019).

Coronary artery anomalies involve several varieties characterized by abnormal origin or course of any of the three main coronary arteries [right coronary artery (RCA), left coronary artery (LCA) and left circumflex artery (LCX)]. Due to the presence of multiple inter-individual varieties that are considered normal variants, the term CAA has been limited to those occurring in less than 1 % of the general population (Gentile et al., 2021).

Some of these anomalies are associated with high morbidity and mortality. Anomalous origin of the left coronary artery from the pulmonary artery (ALCAPA) can lead to myocardial ischemia, heart failure, and arrhythmias during the early neonatal period. The anomalous origin of a coronary artery with the inter-arterial or intramural course is another less severe but still possibly fatal condition (Secinaro et al., 2011).

In children with CHD, the most important conditions to consider include tetralogy of Fallot (TOF) and transposition of great arteries (TGA). Surgical correction of TOF involves incision at the level of the right ventricular outflow tract (RVOT). So, preoperative exclusion of a prepulmonic course of a coronary artery is crucial (Yu et al., 2013). TGA has a typical coronary pattern with the LCA arising from the left anteriorly facing sinus and the RCA originating from the right-posteriorly facing sinus, but other categories with high take-off and inter-arterial/intramural course of the coronary arteries are frequently encountered, and are associated with significantly increased short and long-term morbidity and mortality (Ciancarella et al., 2020).

Thus, preoperative identification of CAAs is clinically important because their presence could result in modification of surgical procedures. Some of these anomalies could lead to severe operative morbidity and mortality and can therefore influence strategies of management (Yu et al., 2013).

2. Aim

This study aims to address the most common CAA identified by cardiac CTA done for CHD and their significance especially in decision of operative procedures and emphasize that their accurate evaluation is a must before proper surgical intervention of CHD to prevent unnecessary procedures or vascular injury of these vital arteries.

3. Patients and methods

The study was approved by the Institutional research board (code number: R.23.08.2322) and informed consent was waived because this was a retrospective study.

3.1. Patients

This retrospective study involved 162 patients with variable CHD associated with CAA.

For this study, a total of 900 cardiac CTA reports were reviewed. From which patients with Kawasaki disease 11 cases were excluded as the study is solely dedicated to congenital CAA. Repeated reports of repeated examinations for the same patient were excluded 12 cases and only one examination/patient was reviewed. CTA examinations with technical problems interfering with evaluation of coronary arteries as motion artifacts 50 cases were excluded. Also, patients with rotated aortic root as in cases of dilated aortic root e.g., in TOF 49 patients were excluded.

So, the exact number of examinations that were considered valid was 778, and the final number of patients with CAA involved in this study was 162 patients.

4. Methods

For this study, 900 cardiac CTA reports of the period from February 2020 to March 2023 were reviewed for scanning for CAA. The previously mentioned categories were excluded. So, the exact number of valid examinations was 778 CTA reports.

Out of them, CAA were encountered in 162 (20.8 %) reports that constituted from the reviewed studies. Cardiac CTAs were reported by consultants' cardiac radiologists with an average of 10 years of experience.

Cardiac CTA was done using a multi-detector CT scanner (Philips Ingenuity Core128, Philips Healthcare, the Netherlands) for patients with proven or suspected congenital heart disease. The field of view extended from the base of the neck to the upper abdomen. The examination was retrospective ECG-gated. The patients were examined in the supine position, they were instructed to fast for at least 6 h before the examination. Intravenous contrast material was injected (through an automatic injector) at a dose of 1–2 ml/kg.

The patients with CAA were classified according to anomalies of origin, anomalies of course, anomalies of termination, and abnormal location of sinuses for LCA and/or its branches and RCA and/or it branches.

5. Results

Out of 162 patients, [103 (63.6 %) were males and 59 (36.4 %) were females] had variable CAA. 70 (43.2 %) were less than 1 year old, 62 (38.3 %) were in the age group between 1 and less than 10 years, while 21 (12.9 %) were in the age group between 10 years and less than 18 years, and 9 (5.6 %) were 18 years old and more (Table 1).

Of the patients in this study, 35 (21.6 %) had double outlet right ventricle (DORV) as the major diagnosis, 27 (16.8 %) had TOF while D-TGA was diagnosed in 27 (16.8 %), and 11 (6.8 %) had intra or extracardiac shunts. Double inlet left ventricle and TGA was diagnosed in 9 (5.7 %), while isolated L-TGA was the major diagnosis in 7 (4.3 %) patients. The right side (pulmonary, tricuspid) valvular stenosis or atresia was detected in 16 (10 %) patients.

5.1. LCA and its branches

Three (1.9 %) patients had ALCAPA (Fig. 1), while 27 (16.6 %) had a common origin from the right coronary ostium, 16 (9.8 %) had an origin of LCA or its branch from opposite or NCS, 4 (2.5 %) had multiple osteal origins [separate origin of left anterior descending (LAD) and LCX] and 10 (6.2 %) had high take off origin.

Eleven (6.8 %) patients had prepulmonic course of LCA or its branches, 5 (3.1 %) had a retro-aortic course, 5 (3.1 %) had an inter-arterial course, and 5 (3.1 %) had a pre-aortic course 2 (1.2 %) had septal (subpulmonic) course another two (1.2 %) had a retrosternal course.

One (0.6 %) patient had myocardial bridging of the LAD, while three (1.9 %) duplication of the LAD (Fig. 1). 13 (8 %) had ectasia of the LCA or its branches and three (1.9 %) had both ectasia and aneurysm (Fig. 2). Four (2.5 %) patients had a coronary fistula (Table 2).

Table 1. Demographic data and major diagnosis of the patients.

	Number = 162 (%)
Sex	
Male	103 (63.6)
Female	59 (36.4)
Age groups	
Less than 1 y	70 (43.2)
1–less than 10 years	62 (38.3)
10– less than 18 years	21 (12.9)
18 years and more	9 (5.6)
Major diagnosis	
DORV	35 (21.6)
TOF	27 (16.8)
D-TGA	27 (16.8)
Intra or extra cardiac shunts	11 (6.8)
DILV and L-TGA	9 (5.7)
Isolated L-TGA	7 (4.3)
PA/PS and/or TA/TS[a]	16 (10)
Others	29 (18)

[a] PA/PS: Pulmonary atresia or stenosis, TA/TS: Tricuspid atresia or stenosis.

5.2. RCA and its branches

Nine (5.6 %) patients had a common origin from left coronary ostium, 9 (5.6 %) had origin of RCA or its branch from the opposite or noncoronary sinus [NCS] (Fig. 3) and 13 (8 %) had high take off origin.

Six (3.7 %) patients had prepulmonic course of RCA or its branches, 3 (1.9 %) had retro-aortic course, 3 (1.9 %) had inter-arterial course and 2 (1.2 %) had a preaortic course (Fig. 3), (1.9 %) had retrosternal course.

Thirteen (8 %) patients had ectasia of the RCA and one (0.6 %) had both ectasia and aneurysm. Six (3.7 %) patients had coronary fistula.

Three (1.9 %) patients had a coronary arcade. Thirteen (8 %) patients had abnormal locations of the right of coronary sinus, while 18 (11.2 %) had abnormal location of the left of coronary sinus and 36 (22.2 %) had abnormal location of both sinuses (Table 2).

6. Discussion

Congenital CAA are usually incidentally discovered. Until recently, angiography was the standard for diagnosis of CAA. Their exact course in complex CHD may be difficult to determine, and misdiagnosis is relatively common. This could be attributed to (1) lack of experience with rare disorders; (2) a lack of specific angiographic projections; and (3) anatomic factors. Moreover, the coronary arteries may exhibit several anatomical variations in complex CHD, which may be difficult to image (Chen et al., 2007).

This study involved 162 patients [103 (63.6 %) males and 59 (36.4 %) females], this came by D'Alto, M et al. (D' et al., 2019) who stated that males outnumber females in most CHD. Also, this came in accordance with Simon et al. (2022) who reported that ~ 66 % of the patients were males.

Out of the patients in this study, 70 (43.2 %) patients were less than 1 year old, 62 (38.3 %) patients were in the age group between 1 year and less than 10 years, while 21 (12.9 %) patients were in the age

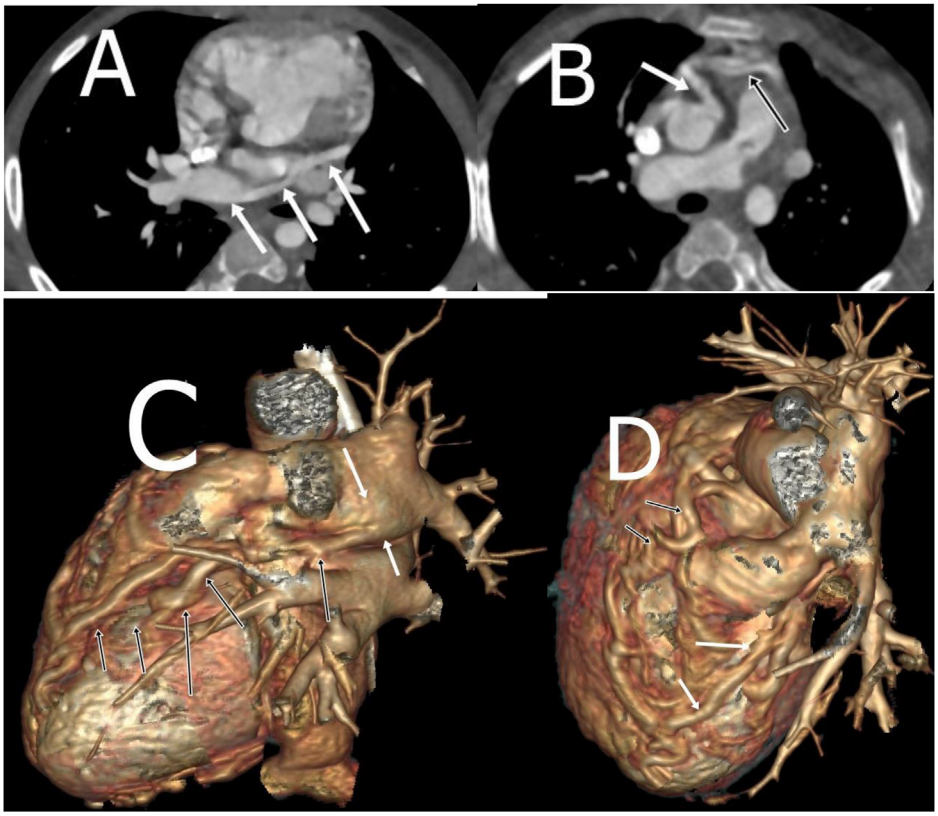


Fig. 1. Anomalous origin of left coronary artery from pulmonary artery (ALCAPA) with duplication of left anterior descending (LAD) on computed tomography angiography (CTA). (A) Axial computed tomography angiography image showing the left coronary artery (LCA) (arrows) arising from the RPA. (B) Axial oblique computed tomography angiography showing right coronary artery (RCA) (white arrow) from which an accessory left anterior descending is arising (black arrow). (C) Volume rendering (VR) image showing left coronary artery (black arrows) arising from right pulmonary artery (white arrows). (D) VR image showing left anterior descending (white arrow) and accessory left anterior descending (black arrows).

group between 10 years and less than 18 years and nine (5.6 %) were 18 years old and more. This is explained as that the study is dedicated to investigating CHD which are often diagnosed early in pediatric life.

Of the patients in this study, 35 (21.6 %) patients had DORV as the major diagnosis, CAAs are usually associated with complex CHD. Yu et al. (2013) reported that the prevalence of CAAs in DORV was relatively high, ~21.43 %.

Twenty-seven (16.8 %) patients had TOF, this conformed with Koppel, C. J. et al. (Koppel et al., 2020) who reported that anomalous origin of coronary arteries is more prevalent in patients with TOF than the general population with incidence about (2%–23 %) as opposed to less than or equal to 1 % in the general population.

In this study, D-TGA was diagnosed in 27 (16.8 %) patients. This conformed with Moll, M et al. (Moll et al., 2017) who stated that CAA are frequently present in children with TGA.

Various definitions and classifications schemes of CAAs have been suggested. However, none gained widespread adoption as there are variable anatomical variations of the coronary arteries (Yu et al., 2013; Mazine et al., 2019). So, in this study various classification systems were merged to cover various CAA encountered.

Three (1.9 %) patients had ALCAPA, two arose from the left pulmonary artery, while one arisen from the right pulmonary artery.

In the case of ALCAPA, the myocardium supplied by the anomalous coronary artery would be liable to ischemic insult and its sequelae as it carries deoxygenated blood from the pulmonary artery and has low perfusion pressure. The prognosis of symptoms depends on several variables. There is no effective conservative management for ALCAPA, and definitive treatment is surgical (Mazine et al., 2019).

Twenty-seven (16.6 %) patients had common origin of LCA from the right coronary ostium, while nine (5.6 %) patients had common origin of RCA from left coronary ostium. 16 (9.8 %), nine (5.6 %) had the origin of either LCA or RCA or one of their branches from opposite or NCS, respectively.

Eleven (6.8 %) patients had prepulmonic course of LCA or its branches, five (3.1 %) had retro-aortic course, five (3.1 %) had inter-arterial course and five

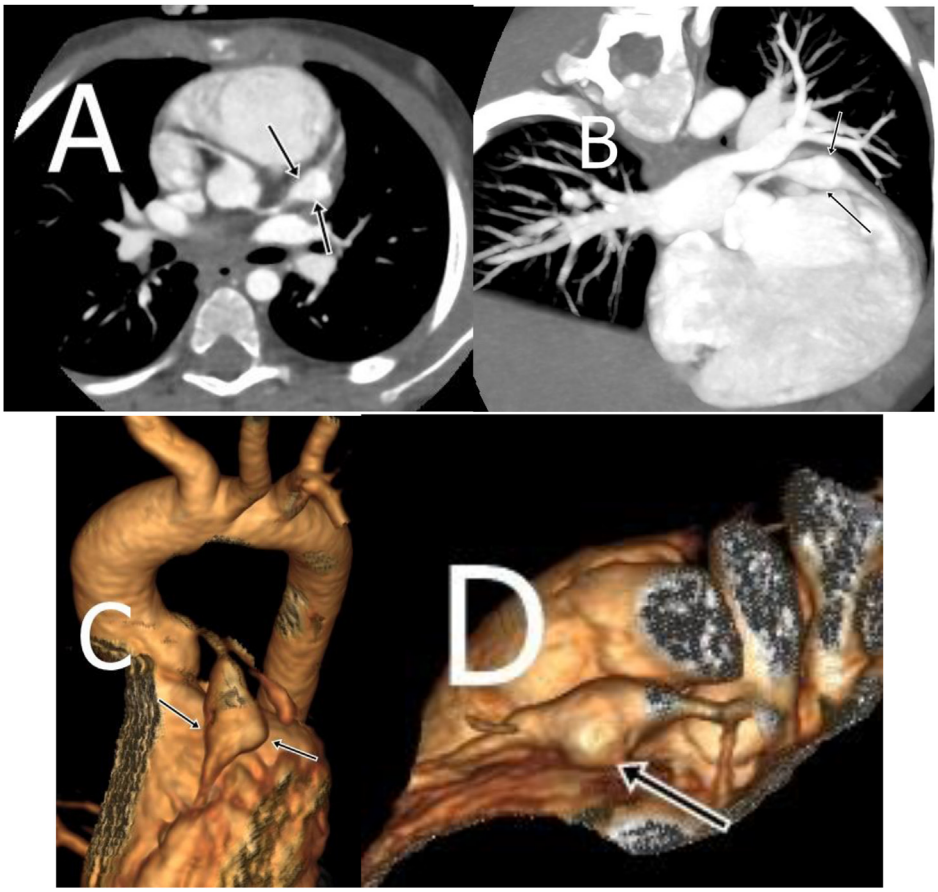


Fig. 2. (A) Axial, (B) curved planar reformatting, (C and D) volume rendering cardiac computed tomography angiography images showing fusiform aneurysm of the left anterior descending (arrows).

(3.1 %) had preaortic course two (1.2 %) had septal (subpulmonic) course another two (1.2 %) had retrosternal course.

Six (3.7 %) patients had a prepulmonic course of RCA or its branches, three (1.9 %) had retro-aortic course, three (1.9 %) had inter-arterial course and two (1.2 %) had preaortic course three (1.9 %) had retrosternal course.

The anomalous origin from the opposite sinus is the most clinically relevant as it is mostly associated with anomalous course, whereas the origin of an artery from the NCS represents an unusual finding (Gentile et al., 2021).

Dissimilar to ALCAPA, most coronary arteries' anomalous origins are benign, apart from those associated with inter-arterial course which can be associated with ischemic symptoms with significant percentage of patients' sudden cardiac death as an initial manifestation, particularly in the case of LCA arising from the right sinus. Although the estimated prevalence of these anomalies is mainly biased by a significant proportion of undetected asymptomatic cases, it is well established that inter-arterial anomalous LCA is much less common than inter-arterial anomalous RCA (0.03 vs. 0.23 %). However, it is associated with a worse prognosis (Cheezum et al., 2017). Yet, this came in discordance with the results in this study as five (3.1 %), three (1.9 %) had inter-arterial course of LCA and RCA, respectively. This could be explained as the number of cases of anomalous origin of LCA that could be associated with anomalous course 56 patients is much more common than similar cases of anomalous origin of RCA 31 patients in this study.

Not all variations of CAA are of the same clinical significance. Despite considering the other types of anomalous course benign, they must be accurately evaluated and reported. The most clinically significant course is that of an anomalous artery arising from the contralateral sinus and coursing anterior to the RVOT or prepulmonic course, or behind the RVOT and anterior to the aorta. The incidence of an anomalous artery that crosses the RVOT ranges from 6 to 14 %. This may cause significant problems, if passed unrecognized, in corrective surgery especially in cases of TOF (Koppel et al., 2020; Kapur et al., 2015).

Table 2. Descriptive data of variable congenital coronary arteries anomalies.

	Number = 162 (%)
Anomalous origin of LCA or its branches	
None	102 (63)
ALCAPA	3 (1.9)
High take off	10 (6.2)
Common origin from right coronary ostium	27 (16.6)
Multiple ostia	4 (2.5)
Origin of LCA or its branch from opposite or non-coronary sinus	16 (9.8)
Anomalous origin of RCA or its branches	
None	131 (80.8)
ARCAPA[a]	0
High take off	13 (8.)
Common origin from left coronary ostium.	9 (5.6)
Multiple ostia	0
Origin of RCA or its branch from opposite or non-coronary sinus	9 (5.6)
Anomalous course of LCA or its branches	
None	132 (81.5)
retro-aortic	5 (3.1)
Inter-arterial	5 (3.1)
Pre-pulmonic	11 (6.8)
Septal (sub-pulmonic)	2 (1.2)
Retrosternal	2 (1.2)
Pre-aortic	5 (3.1)
Anomalous course of RCA or its branches	
None	145 (89.4)
Retro-aortic	3 (1.9)
Inter-arterial	3 (1.9)
Pre-pulmonic	6 (3.7)
Septal (sub-pulmonic)	0
Retrosternal	3 (1.9)
Pre-aortic	2 (1.2)
Anomaly of course LCA or its branches	
None	142 (87.6)
Myocardial bridging	1 (0.6)
Duplication	3 (1.9)
Ectasia only	13 (8)
Coronary ectasia and aneurysm	3 (1.9)
Anomaly of course RCA or its branches	
None	148 (91.4)
Myocardial bridging	0
Duplication	0
Ectasia only	13 (8)
Coronary ectasia and aneurysm	1 (0.6)
Anomaly of termination or LCA or its branches	
None	156 (96.3)
Coronary fistula	4 (2.5)
Coronary arcade	2 (1.2)
Extra-cardiac termination	0
Anomaly of termination or RCA or its branches	
None	155 (95.7)
Coronary fistula	6 (3.7)
Coronary arcade	1 (0.6)
Extra-cardiac termination	0
Anomaly of location of coronary sinuses	
None	95 (58.6)
RCA	13 (8)
LCA	18 (11.2)
Both	36 (22.2)

(*continued on next page*)

[a] ARCAPA: anomalous origin of RCA from pulmonary artery.

Also, in TGA, these CAA markedly increase the complexity of arterial switch operations and may influence the postoperative prognosis (Moll et al., 2017). Therefore, the imaging of the origin and course of the anomalous coronary arteries preoperatively is critical for decreasing surgical morbidity (Shi et al., 2015).

In this study, four (2.5 %) patients had multiple osteal origins (separate origin of LAD and LCX from the left coronary sinus) which is usually a benign anomaly and not associated with definite anomalous course.

Angelini P (Angelini, 2007) stated that it is found in up to 0.67 % of patients and is considered a normal variant. It should be differentiated from atretic LCA, in which a fibrous tract may hinder myocardial perfusion; however, this finding is very rare (Gentile et al., 2021).

In this study, 10 (6.2 %) patients had high take off origin of LCA, and 13 (8 %) patients had high take off origin of RCA. High take-off origin of the coronary arteries is a rare anomaly that may be isolated or come in association with other CHD, more common in the RCAs (up to 84.46 % of cases) (Loukas et al., 2016; Cantinotti et al., 2021; Rosenthal et al., 2012; Frommelt et al., 2020). Although there is no global definitive definition of high take-off, many studies defined high take-off as an origin above or distal to the sino-tubular junction (Cantinotti et al., 2021). Although the use of fixed criteria in adults is preferred (like one centimeter above the sino-tubular junction), this may have limitations in children where aortic dimensions are smaller; therefore, some authors adopted relative criteria as coronary orifices that originate 120 % or more of the depth of the sinus of Valsalva or 20 % or more the depth of the sinus above the sino-tubular junction (Palmieri et al., 2018). A detailed evaluation of a high take-off coronary arteries should also involve other important criteria, like the presence or absence of slit-like ostium, stenosis, the angle at origin, the interarterial, and intramural course (Loukas et al., 2016; Frommelt et al., 2020).

In this study, one (0.6 %) patient had myocardial bridging of the LAD; this patient's major diagnosis was hypertrophic obstructive cardiomyopathy.

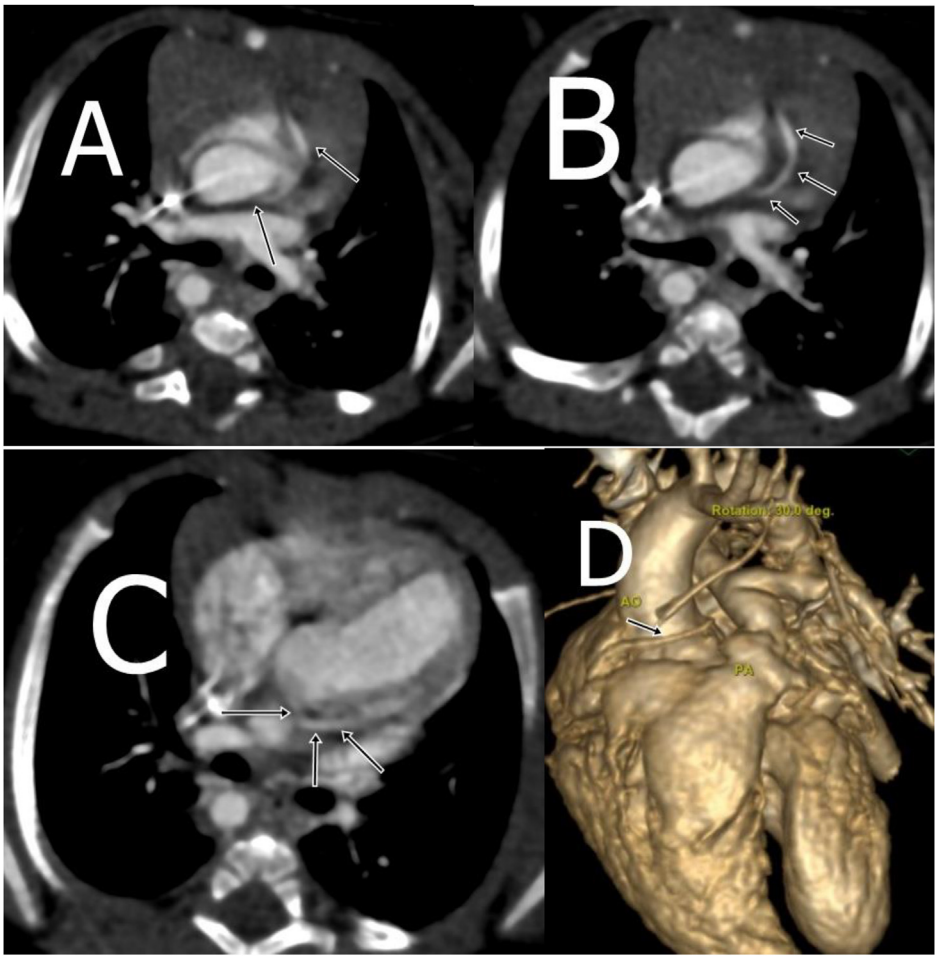


Fig. 3. Anomalous origin of right coronary artery from left coronary sinus on computed tomography angiography. (A) Axial computed tomography angiography image showing origin of right coronary artery (arrow) arising from the left coronary sinus. (B) Axial oblique computed tomography angiography showing right coronary artery (black arrows) with pre-aortic course. (C) Axial computed tomography angiography image showing normal origin of left coronary artery. (D) VR image showing anomalous origin of right coronary artery with pre-aortic course (arrow).

Myocardial bridging is an anatomical variant that can be benign as evidenced by the high rates of incidental findings. However, myocardial bridging is linked to numerous complications as myocardial infarction, arrhythmias, and sudden cardiac death. The decreased perfusion detected in patients with myocardial bridging is mainly due to compression of the artery and occlusion of flow on systole. The depth of bridging is considered much more important than its length (Roberts et al., 2021).

Three (1.9 %) patients had duplication of the LAD in which the accessory LAD arises from the RCA and hence crossing anterior to the RVOT to reach its normal course. This is mandatory to be delineated prior to surgical intervention especially in TOF cases to avoid surgical complications.

In this study, 13 (8 %), 13 (8 %) patients had ectasia, and three (1.9 %), one (0.6 %) had both ectasia and aneurysm of the LCA, RCA or their branches, respectively. These cases were not diagnosed as Kawasaki disease. Coronary artery aneurysm is defined by a focal enlargement of the artery more than the 1.5-fold diameter of the nearby normal segment, while ectasia is similar but diffuse involving greater than or equal to 50 % of the arterial length (Matta et al., 2021). Patients may present with myocardial ischemia and scar, sudden cardiac death, thrombosis, embolism, fistula, rupture, hemopericardium, tamponade, or heart failure (Sheikh et al., 2019). So, the accurate diagnosis and interpretation is highly indicated.

Four (2.5 %) patients had left coronary fistula, one from the LCA to the right atrium associated with atrial septal defect, one from the mid LAD to RV associated with pulmonary atresia, the third between the distal LAD and RV apex (Fig. 4) associated with valvular pulmonary stenosis, and the last one had two fistulous tracts: one from the proximal LAD to RV and the other from RCA to right atrium associated with pulmonary atresia.

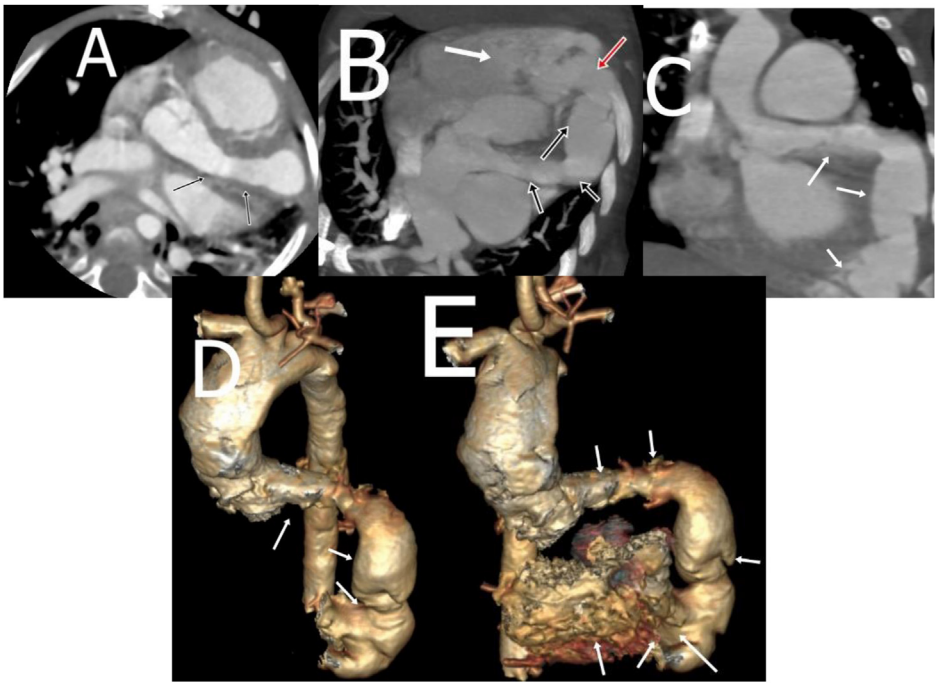


Fig. 4. Left anterior descending right ventricle (LAD-RV) fistula (A) axial oblique computed tomography angiography image showing dilated left coronary artery and left anterior descending, (B) curved planar reformatting image showing dilated left anterior descending (black arrows), fistulous opening (red arrow) communicating with RV (white arrow), (C) coronal oblique, (D) VR cardiac computed tomography angiography showing dilated left anterior descending along its course. (E) VR cardiac computed tomography angiography image showing left anterior descending right ventricle fistula.

Six (3.7 %) patients had RCA fistula, the first was mentioned above, two from RCA to RV one in a case of L-TGA and a case of combined tricuspid atresia and pulmonary atresia, fourth one from RCA to right atrium at the cavo-atrial junction with superior vena cava in a case of otherwise structurally normal heart, the fifth from conal branch to RV in a case of pulmonary atresia, and the last one from RCA to right atrial appendage in a case of TOF.

The right coronary artery is more commonly affected by congenital fistulas and the majority ~90 % communicate with right heart structures, including pulmonary arteries, coronary sinus, and the vena cava (Burch and Sahn, 2001).

Four out of the ten patients of coronary fistula were associated with pulmonary atresia. This conformed with Goo, H. W (Goo, 2021) who reported that ventriculo-coronary fistulas are present in ~40.0 % of cases of pulmonary atresia with intact interventricular septum. These communications occur in cases with severely hypoplastic and hypertrophied RV. It may lead to RV steal phenomenon if the affected coronaries are patent, while in cases of occluded coronary arteries, it may lead to myocardial ischemia or infarction.

In this study, three (1.9 %) patients had coronary arcade. Inter-coronary communication or coronary arcade is a rare CAA. The significance of this variant is not clear, but it may lead to decreased myocardial perfusion by coronary steal or act as a natural bypass (Abreu et al., 2014; Ku et al., 2022).

Thirteen (8 %) patients had abnormal location of the right of coronary sinus, while 18 (11.2 %) had abnormal location of the left coronary sinus and 36 (22.2 %) had abnormal location of both sinuses.

D-Transposition of the great arteries is commonly associated with anomalous coronary artery origin including abnormal location of sinuses. Identification of such anomalies is clinically significant as the arterial switch operation became the method of choice in infants with D-TGA (Burch and Sahn, 2001).

6.1. Limitations

There were some limitations in this study. First, this study discussed the different CAA, future dedicated studies to each category and each of the epicardial coronary arteries is recommended. Second, multicentric study is recommended to increase the number of cases, so numbers of variable anomalies are increased to promote accuracy. Lastly, a dedicated study on adults only with diagnosed CAA coexisting with CHD in infants to evaluate the long-term prognosis.

6.2. Conclusions

Meticulous evaluation of CAA on cardiac CTA done for assessment of CHD is mandatory to avoid surgical and long-term morbidity and mortality.

Conflicts of interest

None declared.

References

Abreu, G., Nabais, S., Enes, V., Marques, J., Costa, J., Correia, A., 2014. Coronary arcade: a rare anomaly of coronary circulation. Rev. Port. Cardiol. (English Edition) 33 (4), 241.e1.

Angelini, P., 2007. Coronary artery anomalies: an entity in search of an identity. Circulation 115, 1296–1305.

Burch, G.H., Sahn, D.J., 2001. Congenital coronary artery anomalies: the pediatric perspective. Coron. Artery Dis. 12, 605–616.

Cantinotti, M., Giordano, R., Assanta, N., Koestenberger, M., Franchi, E., Marchese, P., et al., 2021. Echocardiographic screening of anomalous origin of coronary arteries in athletes with a focus on high take-off. Healthcare 9 (2), 1–14.

Cheezum, M.K., Liberthson, R.R., Shah, N.R., Villines, T.C., O'Gara, P.T., Landzberg, M.J., et al., 2017. Anomalous aortic origin of a coronary artery from the inappropriate sinus of Valsalva. J. Am. Coll. Cardiol. 69 (12), 1592–1608.

Chen, S.J., Lin, M.T., Lee, W.J., Liu, K.L., Wang, J.K., Chang, C.I., et al., 2007. Coronary artery anatomy in children with congenital heart disease by computed tomography. Int. J. Cardiol. 120 (3), 363–370.

Ciancarella, P., Ciliberti, P., Santangelo, T.P., Secchi, F., Stagnaro, N., Secinaro, A., 2020. Noninvasive imaging of congenital cardiovascular defects. La radiologia medica 125, 1167–1185.

D'Alto, M., Budts, W., Diller, G.P., Mulder, B., Assenza, G.E., Oreto, L., et al., 2019. Does gender affect the prognosis and risk of complications in patients with congenital heart disease in the modern era? Int. J. Cardiol. 290, 156–161.

Frommelt, P., Lopez, L., Dimas, V.V., Eidem, B., Han, B.K., Ko, H., et al., 2020. Recommendations for multimodality assessment of congenital coronary anomalies: a guide from the American Society of Echocardiography: developed in collaboration with the Society for Cardiovascular Angiography and Interventions, Japanese Society of Echocardiography, and Society for Cardiovascular Magnetic Resonance. J. Am. Soc. Echocardiogr. 33 (3), 259–294.

Gentile, F., Castiglione, V., De Caterina, R., 2021. Coronary artery anomalies. Circulation 144, 983–996.

Goo, H.W., 2021. Imaging findings of coronary artery fistula in children: a pictorial review. Korean J. Radiol. 22, 2062.

Gupta, A., Kumar, V., Gupta, R., Samarany, S., 2019. A case of anomalous origin of the right coronary artery from the left sinus of valsalva with a malignant course. Cureus 11 (9).

Kapur, S., Aeron, G., Vojta, C.N., 2015. Pictorial review of coronary anomalies in Tetralogy of Fallot. J. Cardiovasc. Comput. Tomogr. 9, 593–596.

Koppel, C.J., Jongbloed, M.R., Kies, P., Hazekamp, M.G., Mertens, B.J., Schalij, M.J., et al., 2020. Coronary anomalies in tetralogy of Fallot–a meta-analysis. Int. J. Cardiol. 306, 78–85.

Ku, L., Wang, J., Song, L., Ma, X., 2022. A rare congenital coronary arcade anomaly: distal intercoronary communication between the circumflex and right coronary arteries. J. Cardiovasc. Comput. Tomogr. 16 (3), e25–e26.

Loukas, M., Andall, R.G., Khan, A.Z., Patel, K., Muresian, H., Spicer, D.E., et al., 2016. The clinical anatomy of high take-off coronary arteries. Clin. Anat. 29 (3), 408–419.

Matta, A.G., Yaacoub, N., Nader, V., Moussallem, N., Carrie, D., Roncalli, J., 2021. Coronary artery aneurysm: a review. World J. Cardiol. 13 (9), 446.

Mazine, A., Fernandes, I.M., Haller, C., Hickey, E.J., 2019. Anomalous origins of the coronary arteries: current knowledge and future perspectives. Curr. Opin. Cardiol. 34 (5), 543–551.

Moll, M., Michalak, K.W., Sobczak-Budlewska, K., Moll, J.A., Kopala, M., Szymczyk, K., et al., 2017. Coronary artery anomalies in patients with transposition of the great arteries and their impact on postoperative outcomes. Ann. Thorac. Surg. 104 (5), 1620–1628.

Molossi, S., Martínez-Bravo, L.E., Mery, C.M., 2019. Anomalous aortic origin of a coronary artery. Methodist Debakey Cardiovasc. J. 15, 111.

Palmieri, V., Gervasi, S., Bianco, M., Cogliani, R., Poscolieri, B., Cuccaro, F., et al., 2018. Anomalous origin of coronary arteries from the "wrong" sinus in athletes: diagnosis and management strategies. Int. J. Cardiol. 252, 13–20.

Roberts, W., Charles, S.M., Ang, C., Holda, M.K., Walocha, J., Lachman, N., et al., 2021. Myocardial bridges: a meta-analysis. Clin. Anat. 34 (5), 685–709.

Rosenthal, R.L., Carrothers, I.A., Schussler, J.M., 2012. Benign or malignant anomaly? Very high takeoff of the left main coronary artery above the left coronary sinus. Tex. Heart Inst. J. 39, 538.

Sapiano, K., Borg, A., 2020. P1839 Extracardiac findings in cardiac CT and MRI-a Maltese perspective. Eur. Heart J. Cardiovasc. Imag. 21 (Suppl. ment_1), jez319–1181.

Secinaro, A., Ntsinjana, H., Tann, O., Schuler, P.K., Muthurangu, V., Hughes, M., et al., 2011. Cardiovascular magnetic resonance findings in repaired anomalous left coronary artery to pulmonary artery connection (ALCAPA). J. Cardiovasc. Magn. Reson. 13 (1), 1–6.

Sheikh, A.S., Hailan, A., Kinnaird, T., Choudhury, A., Smith, D., 2019. Coronary artery aneurysm: evaluation, prognosis, and proposed treatment strategies. Heart Views Off. J. Gulf Heart Assoc. 20 (3), 101.

Shi, K., Yang, Z.G., Chen, J., Zhang, G., Xu, H.Y., Guo, Y.K., 2015. Assessment of double outlet right ventricle associated with multiple malformations in pediatric patients using retrospective ECG-gated dual-source computed tomography. PLoS One 10 (6), e0130987.

Simon, J., Herczeg, S., Borzsák, S., Csőre, J., Kardos, A.S., Mérges, G., et al., 2022. Extracardiac findings on cardiac computed tomography in patients undergoing atrial fibrillation catheter ablation. Imaging 1, 52–59.

Writing Committee Members, Lawton, J.S., Tamis-Holland, J.E., Bangalore, S., Bates, E.R., Beckie, T.M., et al., 2022. 2021 ACC/AHA/SCAI guideline for coronary artery revascularization: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. J. Am. Coll. Cardiol. 79 (2), e21–e129.

Yu, F.F., Lu, B., Gao, Y., Hou, Z.H., Schoepf, U.J., Spearman, J.V., et al., 2013. Congenital anomalies of coronary arteries in complex congenital heart disease: diagnosis and analysis with dual-source CT. J. Cardiovasc. Comput. Tomogr 7 (6), 383–390.