

Anatomical Variants and Anomalies of Coronary Artery Tree as Seen in Slice Multidetector Computed Tomography (MDCT)

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Received on: 25 July 2022; Accepted on: 25 November 2023; Published on: xx xx xxxx

ABSTRACT

Abstract cardiovascular diseases, especially coronary heart disease (CHD), are an epidemic in India. So, early diagnosis of coronary artery disease is necessary. There is an emerging need for the assessment of anatomical variants and anomalies of the coronary artery tree for early diagnosis of coronary artery disease. With rapid advancement of non-invasive imaging like computed tomography coronary angiography, the complex anatomy of the coronary tree is assessed. The most common type of dominant system was the right coronary dominance. The most commonly encountered variant was ramus intermedius branch. In majority, most patients with anomalies are asymptomatic and anomalies were an incidental finding on coronary angiography. Anomalous origin and course of the coronary artery were the commonly encountered of which most are benign; however, few of these anomalies were associated with sudden cardiac death (interarterial course). Other anomalies associated with sudden cardiac death included anomalous origin of the left coronary artery from the pulmonary artery, atresia of the left main stem and coronary fistulae. The aim of this article is to provide an overview of the various normal anatomy, variants, and anomalies with a brief about their clinical presentations.

Keywords: Computed tomography, Coronary artery disease, Coronary computed tomography angiography.

Annals of SBV (2023); 10.5005/jp-journals-10085-9129

INTRODUCTION

Cardiovascular illnesses, particularly coronary illness coronary heart disease (CHD), are on an ascent in India.¹ Late examinations show that the commonness of patients giving coronary vein sickness (computer-aided design) old enough lesser than 45 years to be 1.2%.² In India, concentrates on³⁻⁵ show that there has been expansion in the pervasiveness of CHD in both metropolitan and rustic populace.

The new advances permit the clinician presently approaches a scope of imaging modalities with which they examine patients with intense coronary conditions and those with constant heart symptoms.⁶ Computed tomography angiography of coronaries (CTAC) has acquired prominence in the field of imaging and has been progressively subbing the obtrusive coronary angiography in computer-aided design diagnosis.⁷ The early finding of computer-aided design involving the CTAC in patients with gentle side effects has cleared a way for early mediation and the board of these patients.

Normal Anatomy of the Coronary Arteries

The coronary conduits are evaluated concerning their starting point, course and branches. The aortic root is partitioned into three coronary sinuses. The right sinus of Valsalva of the aortic root brings about the right coronary corridor (RCA). The left coronary ostium leads to the left fundamental coronary corridor (LMCA) and the back sinus is known as the "noncoronary sinus."⁸

Normally, the right ventricle (RV) is supplied by the right coronary conduit, and the foremost part of the left ventricle (LV) and ventricular septum is provided by the left coronary course. The left circumflex (LCx) supplies the horizontal mass of the left ventricle. The vessels that supply the rest of the LV change contingent upon the coronary dominance.⁸

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How to cite this article: Ronda P, Prabhu CS, Kumar LT. Anatomical Variants and Anomalies of Coronary Artery Tree as Seen in Slice Multidetector Computed Tomography (MDCT). *Ann SBV* 2023;xx(x): xx-xx.

Source of support: Nil

Conflict of interest: None

- **Right coronary corridor life structures:** The right conus sinus leads to the RCA, back to the aspiratory supply route and courses underneath the atrial extremity on the right after which it runs along the atrioventricular (AV) groove.⁹ Majorly, the conus branch is the main part of the RCA. In different cases, it is from the aorta.¹⁰ It supplies the pneumatic surge plot. Rarely, it is seen beginning from the labor condition application (LCA), or from the RCA ostia or could have numerous branches.
- In 79% of cases, next part of the RCA is the sinoatrial nodal corridor. It could likewise emerge from the proximal LCx artery.¹⁰ The sinoatrial nodal corridor generally courses toward interatrial septum where the sinoatrial hub (SAN) is arranged.
- The RCA goes in the right AV furrow and afterward courses posteriorly and poorly along the interventricular septum. Along the course, it radiates different branches that supply the myocardium of the right ventricle, for the most part the front wall and are classified "intense or RV marginals." It is seen flowing in the front AV groove around the border of the right

heart and toward the substandard viewpoint or base of the heart.

- **LCA anatomy:** Its starting point is from the left coronary sinus. It is short which courses to one side of the aspiratory trunk and along its back viewpoint after which it branches into the left foremost plunging (Chap) and LCx arteries. Once in a while, the fundamental conduit might trifurcate into the LCx and fellow supply route, and one more branch which is called as the ramus intermedius course.
- **LAD artery:** The LAD artery runs in the anterior interventricular sulcus along the ventricular septum. Commonly, the LAD artery may be embedded within the anterior myocardium forming a myocardial bridge. The LAD artery has branches that supply the anterior ventricular septum. It also has diagonal arteries that course over and supply the anterior wall of the LV.
- **Left circumflex artery:** The LCx artery runs in the posterior (left) AV groove. The lateral wall of the left ventricle is supplied by the branches of LCx and is called as obtuse marginals (OMs). They are numbered sequentially from proximal to distal.⁸
- **Coronary dominance:** Still up in the air by the conduit supplies the back diving corridor (PDA) and the posterolateral branch (PLB). The PDA runs along the back interventricular sulcus to the summit of the heart. The PLB supplies the postero-parallel piece of the right ventricle.
- On the off chance that the PDA and PLB emerge from the RCA, it is supposed to be correct prevailing and when it seen emerging from the LCx corridor, being left dominant is said. At the point when the right situation brings about the PDA and the left framework leads to the then the framework is called codominant.
- The nondominant framework is generally lesser in type than the prevailing framework. This distinction in type can be utilized as an extra sign to decide if the coronary life structures are correct or left dominant.⁸
- **Kugel's artery:** It arises from the proximal LCx artery or from its branches, coursed through the lower part of the interatrial septum, and in most cases it anastomosed directly or through its branches with the distal right coronary artery (RCA). In the remainder cases, it anastomoses with the proximal RCA (26%) or with branches from the anterior portion of the LCx and RCA and the posterior portion of the LCx (8%).¹¹ Due to its large caliber, it is called "arteria anastomotica auricularis magna."

Coronary Artery Variants

Coronary supply route stretching stays comparable in the majority of the patients with gentle varieties. Varieties are characterized in light of beginning, stretching example, strength and presence of ramus intermedius branch.

Angelini et al.¹² has characterized ordinary as any component which was found in over 1% of a populace; a typical variation, is a somewhat uncommon, morphological element which is likewise found in over 1% of the populace; and a peculiarity is the point at which a morphological component is seldom experienced.

Pattern of Origin of Right Conus Artery

The conus vein supplies the conus of the really aspiratory trunk, consequently the name. It ordinarily has a place with the right coronary flow. It starts from the right fundamental coronary supply route for the most part.

- **The ordinary anatomic variations include:** Right conus corridor starting from the right coronary supply route – this is the most

widely recognized variation in most populace. The conus corridor emerges from the proximal piece of the right coronary trunk.

- **A normal beginning of right coronary supply route and right conus corridor:** In this variation, the conus vein and the right coronary course have normal site from the aortic sinus.
- **Aortic beginning of right conus conduit:** The conus course and the right coronary corridors are seen autonomously emerging from the aorta.

The evaluation of the conduit is significant as its impediment is one of the expected entanglements of RCA stenting and can mirror foremost STEMI morphology on ECG.¹³

Patterns of Variations of the Sinoatrial Node Artery

The SAN is an electrically dynamic tissue pack that is situated at the predominant vena cava and upper right chamber intersection. It is the essential pacemaker in typical sinus cadence. The sinoatrial nodal course artery (SANa) basically supplies this SAN.

The SANa is a part of the coronary flow, that provisions blood to the, crista terminalis, Bachmann's group, the left and right atrial free walls and the SAN).⁹ The variable beginning of the branch to SA hub from circumflex coronary course is seen in 35% of cases.¹⁴

A meta-analysis on variants of the sinoatrial artery showed:¹⁵

- **Number of the sinoatrial nodal artery:** It is usually present as a single vessel with prevalence of around 95.5%. Rarely, duplication and triplication of the artery were observed with a pooled prevalence of 4.3 and 0.3%, respectively.¹⁵
- **Origin of the sinoatrial nodal artery:** The SANa was seen mostly found to originate from the RCA with a pooled prevalence of 68.0% followed by its origin from the LCx with a pooled prevalence of 22.1%, followed by origin of the artery from the LCA with a pooled prevalence of 2.7%.¹⁵

Other types of rare origin of the SANa such as from the aorta or the bronchial artery were equally rare with a pooled prevalence of 0.3%. When a double origin of the SANa which was rare, when present, the artery most commonly originated from the RCA and LCx with a pooled prevalence of 2.0%.

The origin of the SANa when it was triplicated, was also similarly rare with a pooled prevalence of 0.3%.

- **Course of the sinoatrial nodal artery:** With a pooled prevalence of 47.1%, the retrocaval course of the SANa was the most common course of the artery, followed by the precaval and pericaval courses with a pooled prevalence of 38.9 and 14.0%, respectively.¹⁵

The course of the SANa originating from the LCA or LCx, the retrocaval course of the SANa was also the most common course of the artery with a pooled prevalence of 46.5%. On the contrary, analysis on few other studies reporting the course of the SANa originating from the RCA found the precaval course to be the most common course of the SANa with a pooled prevalence of 43.1%.¹⁵

Ramus Intermedius Artery

When the left main coronary artery trifurcates into the LAD artery, LCx arteries, and an artery between them called the "ramus intermedius" artery. It can be distributed as a diagonal branch or as an obtuse marginal branch. Rarely, quadfurcation of the left main

coronary artery, i.e., double ramus medianus coronary system is also been noted.¹⁶

Coronary Artery Anomalies

Pathophysiological components might change incredibly for various inconsistencies. The clinical meaning of an irregularity is to find a system which is fit for slowing down perfusion of myocardium.¹⁷ Subsequently, the ischemic components of CAAs and their occurrence was concentrated on dissections and coronary angiographies.¹⁸

The order and meaning of coronary oddities are generally fluctuated. Might be classified as serious or inconsistencies which are huge hemodynamically vs minor ones.¹⁹

As per the most ordinarily acknowledged characterization of coronary oddities in human hearts by Angelini¹⁷ abnormalities are delegated peculiarities of characteristic coronary life structures, of beginning and course, bizarre anastomotic vessels and irregularities of end.

Anomalies of Origination and Course

- **Absence of left main stem:** It is one of the common coronary anomalies which is characterized by the absence of a common left trunk, i.e., separate ostia of LAD and LCx. It is a benign entity that usually causes no ischemic consequences or hemodynamic impairment.^{20,21}
- **Anomalous coronary ostia location:** Coronary ostia which is anomalous in location may be located outside the proper coronary sinus or within it. When the ostium is seen within the coronary sinus proper, it can originate in higher position, lower position, or may be at the level of commissure. When the artery originates from the contralateral sinus of Valsalva, it can have significant clinical implications and may finally lead to sudden death, especially when the artery is seen passing between the two great vessels, that is the aorta and the pulmonary artery (also termed as interarterial course).²²⁻²⁶
- **Anomalous origin of coronary ostium from contralateral sinus:** This type can follow various courses which include: (1) retroaortic, (2) pre pulmonic (benign course), (3) trans-septal, (4) inter-arterial, between the aorta and the pulmonary artery, and (5) retro-cardiac, in the posterior AV groove.²⁷⁻²⁹

In young athletes, there is an increased risk of sudden death if the artery has an inter-arterial. Thus, this subtype is the most clinically significant one.^{30,31} However, the pathophysiology is not clear.

The anomalous RCA from the left sinus of Valsalva has a frequency of 0.03–0.92%, and the anomalous LAD which is seen arising from the right sinus of Valsalva has an occurrence of 0.03%.²⁷ If this anomaly has an intramural inter-arterial course, it has a greater risk of sudden death. The abnormal origin of LCx where it is seen originating from the right sinus of Valsalva or proximal RCA is with an occurrence of 0.37%.^{27,32,33} It is benign condition (no hemodynamic implications) with the course of the artery being retrocardiac or retroaortic,²⁰ thus, deals with less severe symptoms.^{29,34}

Patients with RCA originating from the left sinus of Valsalva who are asymptomatic and with a negative nuclear stress test should be followed up only. Patients with a positive nuclear stress test (with or without symptoms) must undergo optical coherence tomography and when there was high risk detected, intervention was done percutaneously with stenting³⁴ or with

surgical repair should. If younger than 35 years old, should undergo surgical repair regardless of symptoms. If older patients have symptoms or a positive nuclear stress, should undergo surgery. Surgical options include osteoplasty, direct reimplantation of the ectopic artery at the aortic root and unroofing of the intramural segment.³⁵⁻³⁷ Currently, unroofing is the most widely used for these procedures.

- **Anomalous origin of coronary ostium from contralateral sinus:** The rare origin of the RCA from the pulmonary artery is characterized by collaterals. Patients with this anomaly do not have any symptoms; however, occasionally complications like syncope, heart failure, and sudden cardiac death were reported. Anomalous origin of the LCA from the pulmonary artery (ALCAPA) is an extremely rare anomaly and has high mortality rate. It is also known as Bland-White-Garland syndrome. Collaterals to LCA are provided by the RCA which appears dilated. It may coexist with patent ductus arteriosus and aortic coarctation. It is mostly fatal and patient dies at infancy. However, some may remain asymptomatic and survive into adulthood, due to adequate collateral flow.²⁰ A few cases of accessory arteries which are seen arising from the pulmonary artery have also been identified documented.
- **Single coronary syndrome:** It is a syndrome which is characterized by single coronary artery that could either be seen originating from right Valsalva sinus or the left Valsalva sinus and may sometimes coexist with other congenital anomalies.²⁷ Erbagci et al.³⁸ proposed a classification based on location of the ostium, anatomical distribution, and course of the transverse trunk.

This anomaly is usually benign but when the artery is seen coursing between the pulmonary artery and the aorta, which could cause severe effects like ischemia and may further lead to cardiac death may occur.^{35,39,40}

Anomalies of Intrinsic Coronary Anatomy

- **Split RCA:** It is a relatively commonly occurring coronary artery anomaly and can be seen in close to 1% in general population. In this anomaly, the RCA is seen dividing earlier in its course into an anterior branch and a posterior branch. The course of the anterior branch is along the wall of the right ventricle which provides blood supply to the PDA which itself is seen coursing through the interventricular groove distally. The posterior branch courses to the right, in the AV groove which also leads to a PDA which runs in the interventricular groove but is more proximal in location.^{38,41,42}
- **Atresia of LMS:** True atresia is typically a rarely encountered congenital disorder in which there is no ostium or main trunk. The LAD and LCx which could be present mostly end blindly. It gets its blood supply through collaterals from the RCA, but is inadequate and may lead to ischemia and cardiac death. It is usually associated with stenosis of the aorta (supravalvular) and other congenital defects of the cardia. Patients usually present in infancy or early childhood but sometimes can present later in life. It could be treated with bypass grafting of the coronary artery in adults, while in children left main stem surgically reconstructed with a baffle of ascending aorta is usually preferred.⁴³
- **Hypoplasia of coronary arteries:** This condition is characterized by reduced or narrowed lumen diameter (usually <1.5 mm) in one or more of the main coronary arteries with

no branches to compensate it. Due to this narrowed lumen, there is reduced blood flow to the area supplied by the affected vessel and thus can eventually lead to myocardial infarction. There are limited options for treatment and include implantable cardioverter defibrillator and transmyocardial revascularization. However, the outcome is usually poor.⁴⁴⁻⁴⁶

Anomalies of Coronary Termination

Pathophysiological components might fluctuate enormously for various irregularities. The clinical meaning of an oddity is to find a component which is equipped for disrupting perfusion of myocardium.¹⁷ In this manner, the ischemic systems of CAAs and their frequency was concentrated on examinations and coronary angiographies.¹⁸

The arrangement and meaning of coronary abnormalities are broadly differed. Might be classified as extreme or abnormalities which are huge hemodynamically vs minor ones.¹⁹

As per the most regularly acknowledged arrangement of coronary abnormalities in human hearts by Angelini¹⁷ irregularities are named oddities of natural coronary life structures, of beginning and course, bizarre anastomotic vessels and peculiarities of end.

CONCLUSION

Anatomical variants of the coronary artery are seen around 1% of the population and are usually hemodynamically insignificant. Anomalies of the coronary artery are uncommon and may have mild to severe clinical presentations. The imaging techniques advancements have increased rapidly over the past decade. Thus, it helped us to design a diagnostic criteria for risk stratification for serious complications and also form treatment guidelines.

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