

Origin of the Sinoatrial and Atrioventricular Nodal Arteries in South Indians: an Angiographic Study

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Summary

Background: To study the arterial supply of the conducting system and its correlation with the dominance of the coronary arteries in the South Indian population.

Objective: To determine angiographically the origins of the sinoatrial nodal artery (SA_{na}) and atrioventricular nodal artery (AV_{na}) in Indians.

Methods: The study included 300 consecutive patients (114 females, 186 males; mean age, 55 years) living in the southern coastal region of India, who underwent coronary angiography either for the symptoms of chest pain, angina pectoris or positive Treadmill Test. The angiograms contained both coronary arteries (right and left) in the right and left anterior oblique position. The origin of SA_{na} and AV_{na} from the coronary arteries was observed and correlated with the arterial dominance.

Results: The SA (sinoatrial) node was supplied by the right coronary artery (RCA) in 53% of the cases, by the circumflex (Cx) branch of left coronary artery (LCA) in 42.66%, and by both coronary arteries in 4.33% of cases. The AV (atrioventricular) node was also more often supplied by the RCA (72.33% of cases) than by the Cx branch of the LCA (27.66%), and surprisingly in none of the cases was this node supplied by both coronary arteries.

Conclusion: The results of the present study may help cardiac surgeons, particularly in surgeries related to certain valvular disorders, due to the proximity of the nodal branches to the valve complex. (Arq Bras Cardiol 2009;92(5):314-319)

Key words: Coronary vessels; sinoatrial node; atrioventricular node; angiography.

Introduction

Anterior atrial branches of the RCA are arranged in anterior, lateral and posterior groups to supply the corresponding surfaces of the right atrium. One important atrial branch is the SA nodal artery which is usually the second branch of the RCA and supplies the SA node in 65% of the cases; in the remaining 35%, the SA node is supplied by a branch of the Cx artery¹. According to April, SA_{na} also arises from Kugel's artery (when an atrial branch of the circumflex communicates with the similar branch of the right coronary artery, such an anastomotic branch is called Kugel's artery)². The arterial supply of the AV node arose in 80% of the hearts from the RCA in the posterior atrioventricular sulcus at a point just beyond the origin of the posterior interventricular artery. In 20% of the hearts the AV node arose from the terminal part of the Cx at the crux of the heart [1]. The study on the arterial supply of the SA node will benefit clinical knowledge and surgical

procedures as well as methods of cardiac examination and treatment. Proper precautions should be taken to preserve the main arterial supply to the SA node during surgery³.

Sokolov and Vargin⁴, Krupa⁵, DiDio et al⁶, Sow et al⁷ and Onciu et al⁸ studied the origin of SA_{na}. Krupa⁹, Sow et al¹⁰, Arid et al¹¹ studied the origin of AV_{na}. Hutchinson¹, Vieweg et al¹², Futami et al¹³ studied the origin of both SA_{na} and AV_{na}. We studied the origin of both SA_{na} and AV_{na} and also the coronary dominance with the help of coronary arteriography.

The aim of the present study was to identify the origin of SA_{na} and AV_{na} from different coronary arteries and to determine the correlation of both arteries above with the artery of dominance. In this study, angiographic analysis of the coronary arteries was the preferred method of study as it is most commonly used in today's clinical setting and such a study would be of more clinical significance than studies done on cadaver hearts.

Methods

The present study included 300 consecutive patients (114 females, 186 males; mean age, 55 years) living in the southern

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costal region of India, who underwent coronary angiography either for the symptoms of chest pain, angina pectoris or positive Treadmill Test at Kasturba Medical College, Mangalore, India. The coronary angiograms selected were recorded on CDs. These were then studied using Cardiac SoftView (a software program to read coronary angiogram). The angiograms contained both coronary arteries (right and left) in various views, but to visualize the AVna and the SA na from either of the two coronary arteries, the preferred projections that were used here were the left anterior oblique view of the right coronary artery and the right anterior oblique view of the left coronary artery. The SA na when arising from the RCA can be recognized as its second branch after the conus artery that runs dorsally and extends over the upper portion of the atrial septum to terminate in the region of the ostium of the superior vena cava after arching laterally in front of the later. When the SA na is supplied by the circumflex branch of the LCA it passes to the right over the left auricle and reaches the SA node after encircling the superior vena cava.

The AVna is usually seen as a branch of the dominant artery. The artery arises from the crux, and is said to be a branch of the first posterior interventricular artery. It is consistent with the inverted U turn that is seen at the crux in the case of the RCA and a smooth curve seen at the crux in the case of the circumflex branch of the left coronary artery.

The following parameters were chosen for the study:

(i) Origin of the posterior interventricular artery to determine the coronary dominance.

(ii) The origin of SA na and AVna from the coronary arteries.

(iii) The origin of the nodal arteries were then correlated with dominance

These parameters were then tabulated and analyzed.

Results

In the present study, 161 (53.66%) of our 300 patients had a right dominant coronary arterial system (posterior descending artery originating from the right coronary artery), 67 (22.33%) had a left dominant coronary arterial system (posterior descending artery originating from the left circumflex), and 72 (24%) showed codominance. The SA node was supplied by the RCA [Fig. 1] more frequently (53% of cases) than by the Cx branch of LCA [Fig. 2] (42.66%), and in 4.33% of the cases this node was supplied by both coronary arteries. The AV node was supplied by the RCA (72.33% of the cases) [Fig. 3] more frequently than by the Cx branch of the LCA (27.66%) [Fig. 4], and surprisingly in none of the cases was this node supplied by both coronary arteries [Table 1]. It was found that (i) in 35% of the cases both the SA and AV nodal arteries originated from the RCA, (ii) in 11% of the cases both the SA and AV nodal arteries originated from the Cx branch of LCA, and (iii) in 54% of the cases both the SA and AV nodal arteries originated from different coronary arteries [Table 2]. The AV nodal artery was a branch of the dominant artery in 71.66% of the cases [Table 3] in comparison to the SA nodal artery which was a branch of the dominant artery only in 36% of the cases [Table 4]. The source of arterial supply of the SA

node and AV node, as found by various authors and in the present study, is shown in Table 5.

Discussion

Hutchinson found that in 50% of the hearts, both the SA and AV nodes were supplied by branches of the right coronary artery. In 7%, both were supplied by branches from the left coronary artery¹.

The SA na of the coronary arteries is anatomically regarded as a significant artery since it is used as a landmark to identify

Table 1 - Arteries giving rise to the S.A nodal and A.V nodal branches

Coronary artery /branches	No of SA na arising from	No of AV na arising from
RCA	159 (53%)	217 (72.33%)
Cx	128 (42.66%)	83 (27.66%)
RCA-Cx	13 (4.33%)	-
Total	300 (100%)	300 (100%)

SA - sinoatrial, AV - atrioventricular, SA na - sinoatrial nodal artery, AV na - atrioventricular nodal artery, RCA - right coronary artery, Cx - circumflex artery.

Table 2 - Arterial supply to the S.A node and A.V node

Node	Arterial supply	No of cases
S.A & A.V	RCA	105 (35%)
	Cx	33 (11%)
	RCA-Cx	162 (54%)

SA - Sinoatrial, AV - Atrioventricular, RCA - right coronary artery, Cx - circumflex artery.

Table 3 - Relation between A.V nodal supply and dominance

AV nodal supply in the case of	From RCA	From Cx
Right dominance	156	4
Left dominance	7	59
Co dominance	54	20

AV - arterioventricular, AV na - arterioventricular nodal artery

Table 4 - Relation between S.A nodal supply and dominance

SA na in the case of	From RCA	From Cx	From RCA-Cx
Right dominance	81	75	8
Left dominance	43	25	-
Co dominance	35	28	5

SA - sinoatrial, SA na - sinoatrial nodal artery

Table 5 - Arterial supply of the SA node & AV node as reported by various authors

Authors / Reference N ^o .	Arterial supply of the SA node by (%)			Arterial supply of the AV node by (%)		
	RCA	LCA	RCA & LCA	RCA	LCA	RCA & LCA
Berdaj et. al ¹⁴	66%	34%	–	–	–	–
Berdaj et. al ¹⁵	–	–	–	73%	27%	–
Didio et. al ⁶	58%±4.9%	42%±4.9%	–	–	–	–
Futami et al ¹³	73 %	3%	23%	80%	10%	10%
Hutchinson ¹	47%	27%	--	80%	–	–
Krupa ⁹	–	–	–	90%	10%	–
Kyriakidis et al ¹⁹	59 %	38 %	3%	-	-	-
Sow et al ⁷	64.45 %	24.44%	-	-	-	-
Present study	53%	42.66%	4.33%	72.33%	27.66%	-

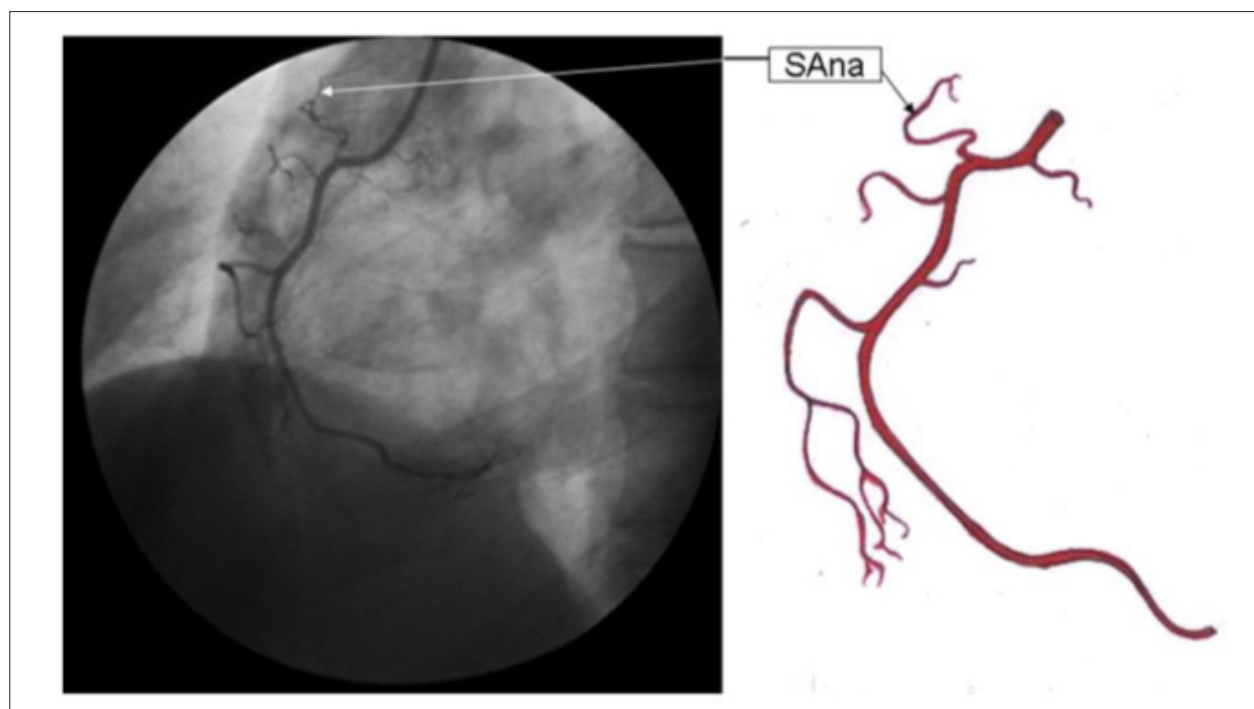


Figure 1 - Right coronary artery in the left anterior oblique position showing the sinoatrial nodal branch. SAna, sinoatrial nodal artery.

the SA node, in addition to its clinical significance. Berdajs et al¹⁴ reported that the SAna crosses the superior posterior border of the interatrial septum in 54% of the cases. From these data they concluded that the risk for intraoperative damage to the sinus node artery during the superior transeptal approach to the mitral valve is high¹⁴. Berdajs et al¹⁵ studied the AVna by coronary angiogram; they found that the SAna originated from the RCA in 73% of the examined cases, and from the LCA in 27% of the cases. The left AVna was closely related to the mitral valve attachment, especially at the area of the left proximal part of the posterior leaflet. By comparing their data with the available literature, they reported that there is a high risk of intraoperative damage to the left AVna during manipulation of

the mitral valve annulus fibrosus¹⁵. In the present study, only in 27.66% of the cases did the AVna originate from the LCA. In addition to being an excellent guide to the location of the sinoatrial node, the topic investigated demands further study due to its application in cardiac surgery³.

Nerantzis et al¹⁶ observed that the SAna played a major role in the blood supply of the atrial myocardium and atrial septum in the majority of the cases (59%). In 37% of the cases, the vessel supplying the SA node was not the main continuation of the SA nodal artery. In 22% of the cases, the SAna supplied the entire atrial myocardium, and in 19% the SAna supplied the right atrium and part of the atrial septum¹⁶.

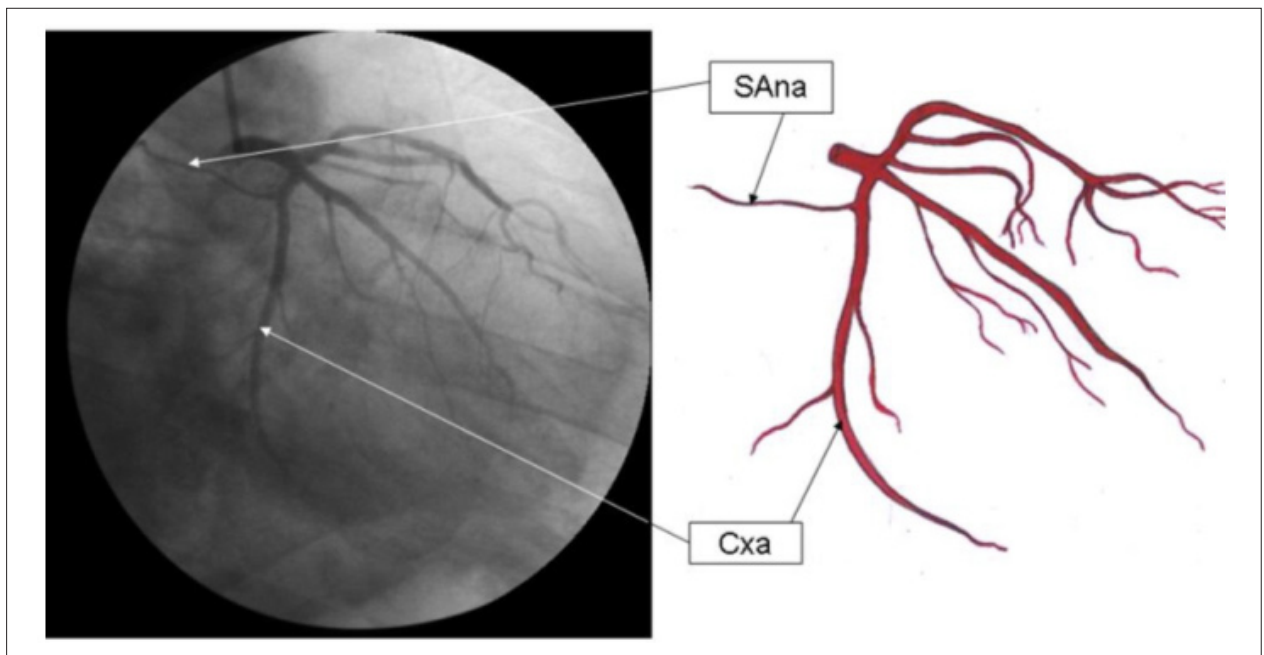


Figure 2 - Left coronary artery in the right anterior oblique position showing the sinoatrial nodal branch from the circumflex artery; SAAna - sinoatrial nodal artery; Cxa - circumflex artery.

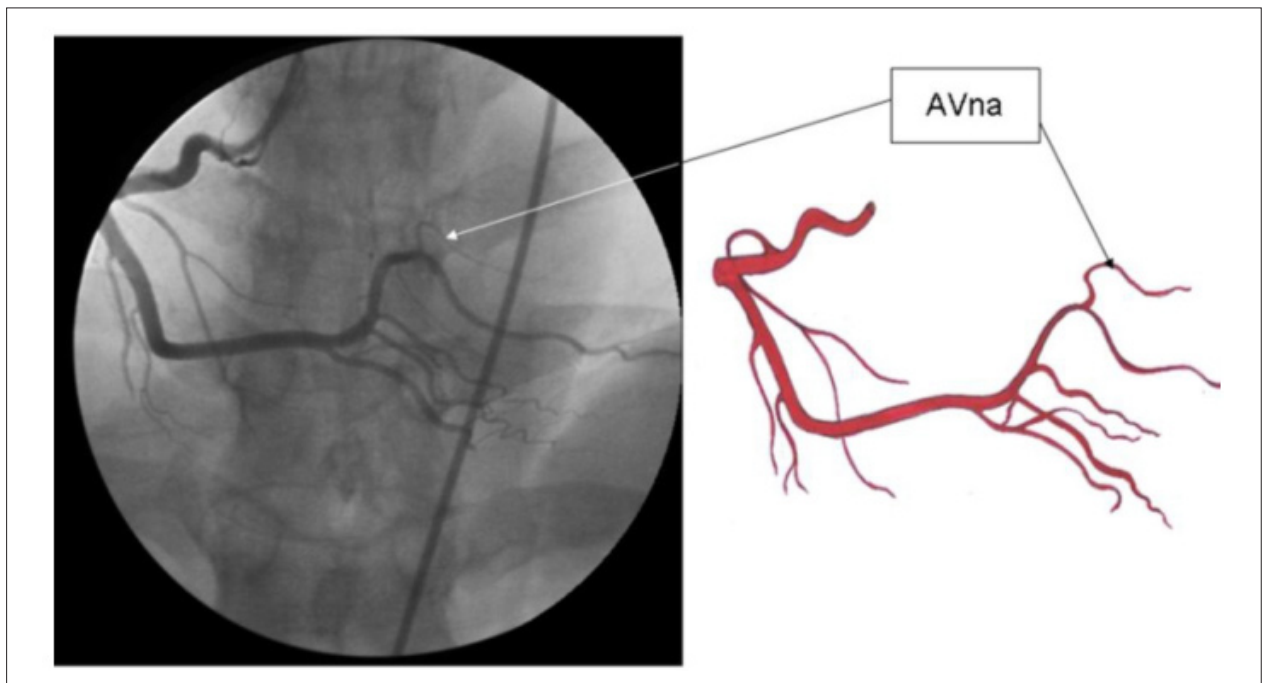


Figure 3 - Right coronary artery in left anterior oblique position showing the atrioventricular nodal branch; AVna - atrioventricular nodal artery.

A study by Bokeriya et al¹⁷ on the variations of the SAAna and AVna showed 14 different variations of the SAAna with regard to its connections with the anterior atrial sulcus and orifices of the superior vena cava, and they also identified 6 variants of the AVna with regard to its connections with the interventricular septum. The importance of these variations

was stressed because any surgery on these arteries could damage the surrounding structures¹⁷.

Krupa⁵ published a study on SAAna in human hearts, where he observed that the SAAna arose as the anterior, intermediate and posterior atrial branches of both the RCA and LCA. In 51.7% of the hearts, the SAAna forms an arterial circle at the

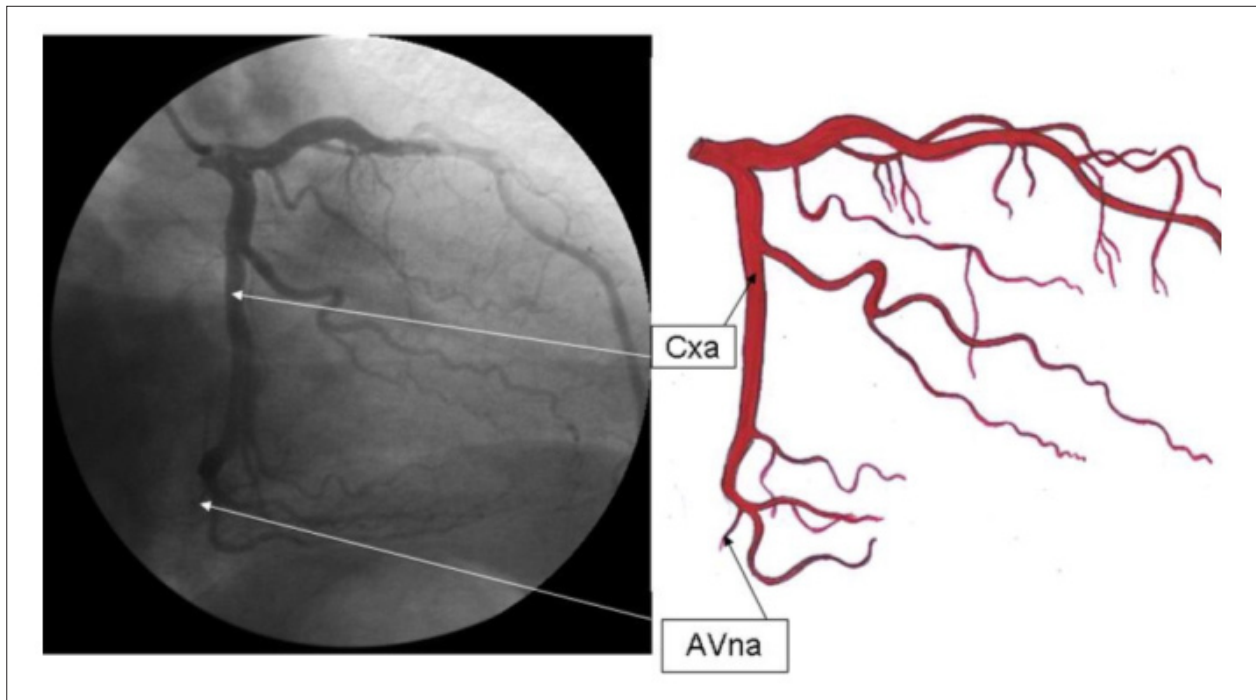


Figure 4 - Left coronary artery in right anterior oblique position showing the atrioventricular artery from the circumflex artery; AVna - atrioventricular nodal artery; Cxa - circumflex artery.

base of the superior vena cava⁵. The origin of the SAa from the proximal portion or trunk of the LCA, was less frequent ($12\% \pm 3.2$) than from the Cx ($30\% \pm 4.5$) and neither sex nor race influenced the origin of Sana⁶.

Sow et al⁷ studied the SA node artery by injection-dissection and found that it was a solitary artery in 88.89% of cases and double in 11.11%, and the artery of origin was not influenced by coronary dominance. However, in the present study the AVna was a branch of the dominant artery in 71.66% of the cases. When it came from the RCA, the course of Sana varied greatly in relation to the site of origin – from either the atrial artery or from one of its collateral branches. When it came from the Cx its course was relatively uniform. These findings are especially important during certain stages of cardiac surgeries like atriotomies, surgical repair of valvular disorders and congenital malformations, which expose the Sana⁷. The origin of the Sana from both coronary arteries in our study (4.33%) was much less frequent than in the study conducted by Futami et al¹³, but the frequency of RCA origin of the AVna found by Futami et al¹³ was quite similar to that of the present study (72.33%). Not even in a single occasion did the AVna originate from both coronary arteries in the present study, in comparison to the 10% of cases found by Futami et al¹³.

Sokolov and Varegin⁴ investigated 60 heart preparations to observe the variation in the Sana. They reported that large atrial branches of RCA or LCA usually supply the SA node and showed some variations in the site of origin from the RCA and LCA. The Sana may arise from the right

intermediate or right posterior atrial branches. In the LCA variant it can arise from the anterior left, posterior left or intermediate left atrial branches⁴. Abuin and Nieponice¹⁸ studied the origin of AVna in 20 hearts. They found that in 40% of these hearts Kugel's artery was supplying the AV node. The right descending superior artery supplied the AV node in 70% of the cases. These findings may be of major significance both in cardiology and in cardiovascular surgery¹⁸. Arid et al¹¹ aimed at studying the anatomical characteristics of the major arterial source of the AV node of 40 hearts by various anatomical and radiological techniques but they could only obtain results from 23 of them. They concluded that the most common atrial source of the AV node (21/23) was the RCA, but numerous variations in origin and topography were found¹¹.

Kyriakidis et al¹⁹ mentioned that the knowledge of the course of the arteries irrigating the sinus node is important for a better understanding of the cardiac physiology and from a surgical point of view. They studied the arterial blood supply to the sinus node area in 309 consecutive patients undergoing coronary arteriography. Of the sinus node arteries arising from the right coronary artery – the right sinus node arteries, the majority (179) arose proximally 1 to 3 cm from the aortic ostium, passed across the anteromedial wall of the right atrium, and penetrated the atrial septum below the interatrial bundle. In 87 of the 119 patients in whom the Sana arose from the left Cx, it arose from the proximal portion of the left Cx and coursed through the anterior branch of the interatrial muscle bundle and then through the bundle itself¹⁹.

Conclusion

In our study, the origin of the SAa was mainly from the RCA (53%) and LCA (42.66%); only in 4.33% cases was the SAa supplied by both coronary arteries. The AVa originated either from the RCA (72.33%) or from the Cx branch of LCA (27.66%). However, more angiographic studies of coronary arteries in different races should be performed to provide conclusive data on the origin of the SAa and AVa. The results of the present study may help cardiac surgeons, particularly during surgical correction of certain valvular disorders and congenital malformations of the coronary arteries.

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Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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