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Original Research Article

INTERESTING OBSERVATIONS ON SINOATRIAL NODAL ARTERY: A CLINICAL PERSPECTIVE

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ABSTRACT

Introduction: The knowledge of anatomy of coronary arteries and their branches is a self-evident pre-requisite for better understanding of coronary artery disease or for more intelligent planning of surgery. The anatomy of sinoatrial node and its blood supply play an important role in the normal activity of the heart. The sinoatrial nodal artery has variations in origin, course and collaterals. The angle that the artery makes with its parent artery at its origin is clinically important as this angle interferes with the circulation and nourishment.

Materials and Methods: Sixty hearts obtained from the Department of Anatomy, Mysore Medical College, Mysore, over the period of two years, were studied by dissection method (37 hearts), corrosion cast (16 hearts) and arteriography (7 hearts).

Observation and Results: The origin, the angle at the origin with parent artery, course in relation to the root of the superior vena cava and demonstrable collaterals or anastomoses of sinoatrial nodal artery were studied. In 57% of hearts the sinoatrial nodal artery arose from right coronary artery, in 25%, from left circumflex artery and in 17% it was given by both right and left coronary arteries. In 1.6% of cases, it was coming from the right aortic sinus close to the right coronary artery origin. In 23% hearts there was acute angle, in 35% it was at right angle and in 48% there was obtuse angle at the site of origin from parent artery. In 50% of hearts the course of sinoatrial nodal artery was anterior, in 39% of hearts it was posterior and in 16% of hearts the course was both anterior and posterior to the root of superior vena cava. These observations could not be made in corrosion casts as the relation with superior vena cava could not be appreciated. The demonstrable collaterals or anastomoses were observed only in two cases.

Conclusion: The sinoatrial nodal artery is the main nourishing channel for the sinoatrial node of the conducting system of heart. The variations in origin, course, the angle it makes with the parent trunk and the collaterals or anastomoses play an important role in functioning of heart. No references were available for the angle of sinoatrial nodal artery at its origin from the parent trunk which is the original work.

KEY WORDS: Sino atrial node, sinoatrial nodal artery, right coronary artery, left circumflex artery, left coronary artery.

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INTRODUCTION

The conducting system of heart is the main component in the normal functioning of the heart. Increased interest in the disorders of the conducting system, together with vulnerability of the sinoatrial and atrioventricular nodes, to surgical injury has reawakened the inquisitiveness for the knowledge of its anatomy, histology, normal aging and vascular supply. The sino- atrial node is the pace maker of the heart. The right coronary artery gives of anterior, lateral and posterior branches. The lateral branch is also called right marginal artery. Posterior branch supplies both atria. The origin of sinoatrial nodal artery is variable and but frequently it arises as the anterior atrial branch. But in about 35% of cases it arises from circumflex branch of left coronary artery. Very rarely from right marginal artery and least from posterior atrioventricular part. It passes posteriorly in the groove between right auricle and ascending aorta [1].

The knowledge of the anatomical pattern of coronary arteries goes hand in hand with that of coronary heart disease itself. Galen, very precisely allotted the coronary arteries for nutrition; the function of blood supply to the heart muscle was based on his observation that these vessels came down from the left part into the substance of the heart. The coronary circulation has been referred to as third circulation. The coronary arteries have been considered as the end arteries which have been identified or renamed as functional end arteries. As stated by Ayer A.A., the left coronary artery predominantly supplies the heart and they studied finer details of anastomoses, variations in individual coronary arterial pattern and localizations of blood supply to various parts of heart [2]. It has also been stated that the left coronary artery is constant in its origin and course than the right coronary artery. It has also been stated that, the left coronary artery is preponderant in virtually all normal human hearts. In most of the hearts, the atrioventricular nodal arterial supply is by right coronary artery [3, 4].

In more than half the cases, the sino atrial node and atrioventricular node are supplied by the branches of right coronary artery and in small number of cases; these are supplied by left coronary artery. In some of the cases the sinoatrial node is supplied by right coronary artery and atrioventricular node by the other in either combination [5]. According to various authors, the sinoatrial nodal artery arises from proximal portion of the right coronary artery in about 50% to 70% of hearts. In about 25% - 45% of cases it arises from left circumflex artery and in about 2% - 8% of hearts, it arises from both right and left coronary arteries [6]. In less than 1% of humans, the artery has an anomalous origin directly from the aortic sinus, descending aorta, or distal right coronary artery [7, 8].

The location of the sinoatrial node and its blood supply were studied in detail and it was concluded by Anderson that the sinoatrial nodal artery reaches the node with an anterior approach in relation to the root of the superior vena cava in nearly half the cases and with posterior approach in relation to root of superior vena cava in some cases and both anterior and posterior approaches, in relation to root of superior vena cava, in the remaining. The meta analysis also states variations in the relation to the Superior Vena Cava [9,10]. The observations on the angle at the origin from the parent artery are not reported in literature so far and therefore this observation has also been made in the present study as it is an important factor in the circulation of blood in the arteries, supplying the node, as these arteries are narrow.

The present study, therefore, has been taken up, to know the variations in the origin, course, angle at the origin from parent artery and its collateral branches anastomosing with the sinoatrial nodal artery.

MATERIALS AND METHODS

Sixty human hearts were collected from the Department of Anatomy, Mysore Medical College, Mysore, from 1983 to 1985. The age and sex of each case were noted. Age varied from few months to 75 years. There were 31 hearts belonging to males and 29 hearts belonging to females. The hearts were washed thoroughly to remove clots by using saline and 40% Borax solution. The coronary ostia in the ascending aorta were identified and carefully dissected. The cause of death was not known.

In 37 hearts, the arteries were studied by meticulous dissection method after embalming in formalin. 16 hearts were used to prepare corrosion casts by using butyl butyrate and 07 hearts were studied radiographically (arteriography) by injecting radio opaque material, which consisted of finely triturated 20% aqueous solution of red lead (15 gm %) and starch (5gm %), in to the coronary arterial system. These 07 hearts were embalmed in 10% formalin and preserved in 07% formalin solution.

OBSERVATIONS

After visualizing the course of the artery supplying the sinoatrial node, the observations were carried out under the following categories: Origin of sinoatrial nodal artery, Angle of origin from the parent trunk, Relation to the root of the superior vena cava and Presence of grossly demonstrable anastomoses (collaterals).

The origin of sinoatrial artery was further classified into Type A, B, C and miscellaneous.

The angles observed were:

a) Acute angle (b) right angle and (c) obtuse angle

Based on the relation to the root of superior vena cava they were further classified into

i) Group 1 (ii) group II (iii) group III. The presence or absence of grossly demonstrable collateral vessels anastomosing with sinoatrial nodal artery also were observed.

Table 1: Sinoatrial nodal artery - origin from various sources.

S.No	Type	Description	Method of study			Total	%
			Dissection	Corrosion cast method	Arteriography		
1	A	Origin from right coronary artery	22	10	2	34	57%
2	B	Origin from left coronary artery	10	3	2	15	25%
3	C	Origin from both right and left coronary arteries	4	3	3	10	17%
4	D	Miscellaneous (Origin from other sources) – Right aortic sinus	1	-	-	1	1.60%

Table 2: Sinoatrial nodal artery – Angle of origin from the parent trunk. The observations are in 96% of hearts. The remaining were arising from both right and left coronary arteries at different angles from their parent trunks.

S. No	Angle of origin	Method of study			Total	%
		Dissection	Corrosion cast method	Arteriography		
1	Acute	11	-	3	14	23%
2	Right angle	11	7	3	21	35%
3	Obtuse	16	9	4	29	48%

Table 3: The course of the sinoatrial nodal artery in relation to the root of the superior vena cava. These observations were made in 46 hearts as the observations could not be made in corrosion casts.

S.No	Group	Course around Superior Vena Cava	Method of study			Total	%
			Dissection	Corrosion cast method	Arteriography		
1	I	Anterior	17		5	22	50%
2	II	Posterior	15		2	17	39%
3	III	Both anterior & posterior	6		1	7	16%

Table 4: The origin of the sinoatrial nodal artery – Comparison with other authors.

S.No	Author	Name of the artery	From Right coronary artery	From left circumflex artery	From both right and left coronary arteries.
1	Gross L. (1921)	Superior vena cava osteal artery	60%	40%	Never present
2	James T.N.(1961)	Sinus node artery	54%	42%	2% (and 2% from unknown source)
3	Joseph Thomas Robert (1961)	Artery of S.A. node	More than 70%	25%	Some cases
4	Baroldi and Scomazzani (1967)	Sinus node artery	51%	41%	8%
5	Hutchinson (1978)	S-A nodal artery	65%	35%	-
6	Anderson and Becker (1980)	S-A nodal artery	55%	45%	-
7	Pejković B, et al (July 2008).	S-A nodal artery	60%	40%	-
8	Present study	S-A nodal artery	57%	25%	17% (origin from other source – 1%)

Fig. 1: Arrow indicating the origin from Right coronary artery - Viewed from above. Superior vena cava is outlined in blue (SVC).

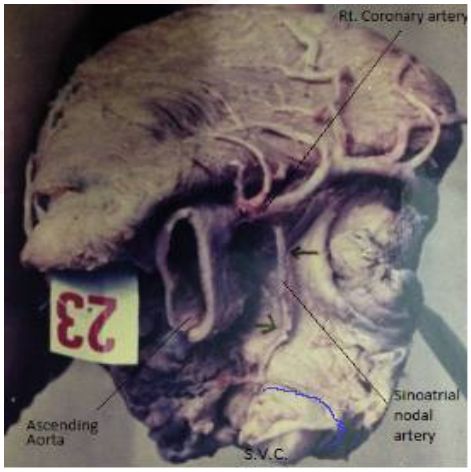


Fig. 2: Origin of sinoatrial nodal artery from Left Circumflex artery- Viewed from above.

Fig. 3: Sinoatrial nodal branches arising from both right and left coronary arteries seen in the casts of the arteries –Viewed from behind.

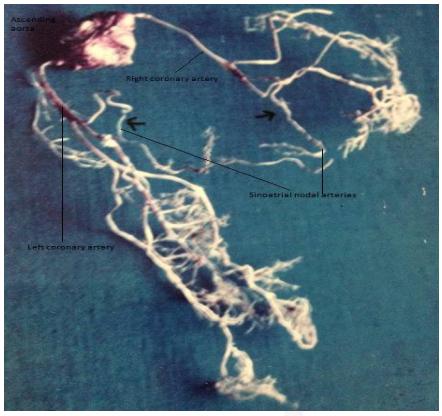


Fig. 4: Origin of sinoatrial nodal artery from the right aortic sinus close to the origin of right coronary artery –viewed from above.

Fig. 5: Acute angle at the site of origin from Parent trunk. Viewed from above.

Fig. 6: Sinoatrial nodal artery arising from parent trunk at right angle. Viewed from above.

Fig. 7: Sinoatrial nodal artery arising from the parent trunk at obtuse angle, seen in the cast. Viewed from above.

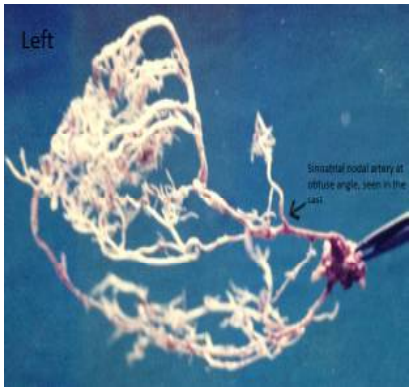


Fig. 8: Course of the S-A nodal artery is anterior in relation to root of Superior Vena Cava. Viewed from above. (Group I)

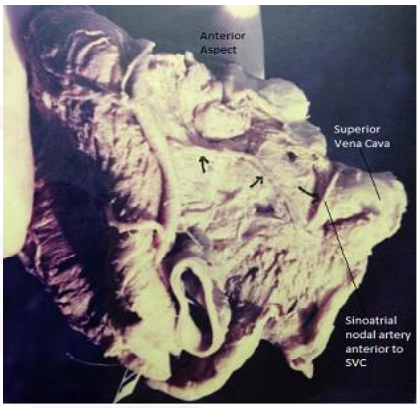


Fig. 9: Course of the S-A nodal artery is posterior in relation to root of Superior Vena Cava. Viewed from above.(Group II)

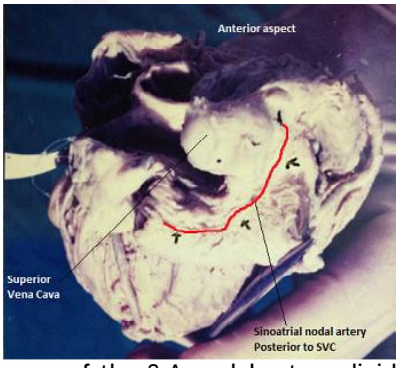


Fig. 10: Course of the S-A nodal artery dividing in to anterior (A) and posterior (B) branches which lie respectively in relation to root of Superior Vena Cava. Viewed from above. (Group III)

Fig. 11: The sinoatrial nodal artery arising from right aortic sinus running between root of the ascending aorta and anterior surface of atria is continuous with Kugel's artery arising from the left circumflex artery. Viewed from Above. (R.C.A. – Right Coronary Artery & L.C.A. – Left Coronary Artery, S.A.N.A- Sino Atrial Nodal Artery).

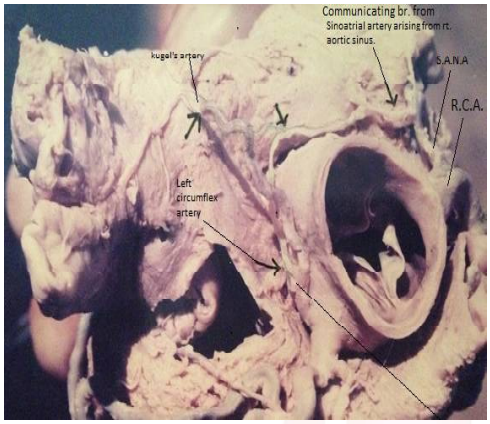
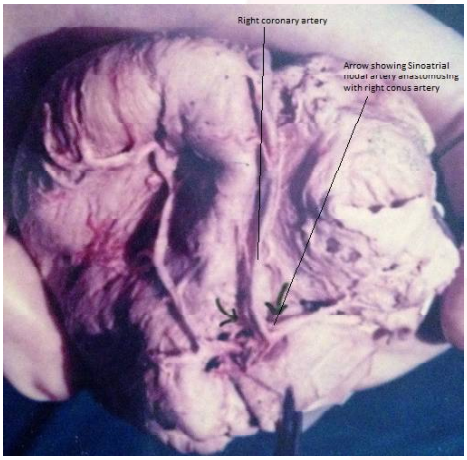


Fig. 12: The sinoatrial nodal artery arising from the right coronary artery and running deep to the artery to anastomose with right conus artery. (Appreciated in the dissection). Superior view.



DISCUSSION

The knowledge of the anatomy of the coronary arteries and their branches is a self-evident pre-requisite for the better understanding of coronary artery disease or for more intelligent planning of surgery.

The embryonic blood vessels, during development, appear in conjunction with other rudiments where there is need for blood supply. The blood vessels develop prior to the establishment of circulation. The initial phase of nourishment and drainage of the predominantly spongy wall of the heart is by the intertrabecular sinusoids. As noted earlier, the coronary arteries develop in situ and later get connected with aortic buds [11, 12, 13, 14].

The functional period of the embryo often determines the course of the blood flow and secondary changes, both structurally and functionally. Organ typical endothelio - mesenchymal inductive interactions play a great role in the development of the blood vessel, the outcome being the resultant of the heredity and environmental affects on the developing embryo. The developed arteries, in general, pursue the shortest and the most direct course so as to reach their areas of supply. But once well established, they usually retain the pathway, as seen in case of a very high origin of gonadal arteries irrespective of changes of position of target organs.

The mode of development of coronary arteries helps us to give an explanation for all known coronary artery anomalies. The coronary interarterial anastomosis has been investigated in many different ways since 1669. The vessels which carry blood to the heart come together again and communicate here and there by anastomoses. Relative cardiac anoxia appears to be a stimulus for the formation / establishment of interarterial coronary anastomosis. Collaterals present at the time of birth are not large enough to take part in collateral circulation, but gradually enlarge with age or when there is stimulus like anoxia or partial obstruction [15]. Coronary anastomoses in normal human hearts are generally straight or gently curving, regardless of their diameter, but those hearts with coronary occlusion are extensively twisted and corkscrew in shape. It seems likely that the normal anastomoses are not under much stress. While those connecting a low pressure occluded artery, with a high pressure non occluded artery, do participate in flow, the stress of higher pressure and pulsation causing them to become elongated, enlarged and tortuous. Based on these, the gross, morphologic characteristics of coronary anastomosis may be a reasonable indication of whether they were functioning for collateral flow in vivo [15].

Numbers of variations of coronary arterial pattern have been described. In the present study, origin of sinoatrial nodal artery, angle of origin, course of the artery in relation to the root of superior vena cava and grossly demonstrable anastomoses or collaterals have been observed.

Origin of Sinoatrial nodal artery is either from proximal part of right coronary artery or from

left circumflex artery or from both. It runs over the anterior surface of the right or left atrium towards interatrial groove along the anteromedial wall of right atrium and passes either in front or behind, or both in front and behind the root of superior vena cava. Occasionally it divides and the branches encircle the root of the superior vena cava to supply the sinoatrial node [9]. In rare cases there was no distinct vessel identified [4,6,13,16]. In the present study, the sinoatrial nodal artery was arising from right coronary artery in 57% of hearts [Figure 1]; it was arising from left circumflex artery in 25% of hearts [Figure 2] and from both right and left coronary arteries in 17% of hearts. [Figure 3]. In one case it was arising from right aortic sinus just posterior to the origin of right coronary artery [Figure 4]. [Tab1].

Angle of origin of the sinoatrial nodal artery was observed in the present study. This is a very important aspect clinically because of the current and direction of blood flow. The risk of thrombotic blockage of sinoatrial nodal artery with its lethal consequences, increases with acuteness of branching from its parent trunk. It has been said that the stresses of torsion, shearing and buckling, particularly at the right angle branching, where the elements of coronary artery breakup and enter myocardium may present forces, which, either damage the vessel wall or make it unduly susceptible to the development of atherosclerosis [17]. In the present observation, in about 23% of hearts, there was acute angle, in 35% of hearts, there was right angle at origin and in 48% of hearts the artery had an obtuse angle with its parent trunk [Figures 5, 6, 7 & TABLE 2]. The discrepancy in the percentage mentioned above is because, in some specimens, the sinoatrial nodal arteries arising from both right and left coronary arteries, arise at different angles at the origin from their parent trunks. There are no observations by other authors to note or to compare. There was no relation between age and angulation at origin from the parent artery.

Course of the sinoatrial nodal artery, noted in relation to the root of the superior vena cava, has been observed in the present study. This observation was done only in dissection method and in arteriograms. It was difficult to note down in corrosion casts. Thus the observations were conducted in 46 hearts and statistically analysed accordingly. The sinoatrial nodal artery may course anterior or posterior or both anterior and posterior to the root of superior vena cava [9]. The artery, in majority of hearts, is part of an anastomotic ring around the atriocaval junction [16]. It is possible that the development of an anastomotic ring is an aging feature as majority of subjects were in the 5th and 6th decades [9]. In the present study the arteries were grouped into - groups I, II and III depending upon their course. The anterior course was grouped as group I, posterior course as group II and both anterior and posterior as group III. 50% of specimens belonged to group I, [Figure 8], 39% to group II [Figure 9] and 16% to group III. Our observations coincided with the observations made by Anderson et al, in which 40% belonged to group I, 44% belonged to group II and 16% belonged to group III [Figure 10] [9] . It can be opined that the location of the artery supplying the Sinoatrial node near the base of the superior vena cava, is less predictable and if a surgical trauma is to be prevented, then the entire atriocaval junction should be avoided.

The collaterals or the anastomoses occur between the other atrial arteries, the sinoatrial nodal artery, Kugel's artery and atrioventricular nodal artery, but as in other coronary arteries, they are usually inadequate [18]. In the present study, only gross demonstration of anastomotic channels was taken up. In two specimens, the anastomotic arteries have been demonstrated. In one of the specimens the cause may be anoxia, because the heart belonged to subject whose age was approximately 75 years and the vessels were tortuous [Figure 11]. In another specimen, the vessels were not tortuous and the age of the individual was approximately 35 years [Figure 12]. The anastomosis between the sinoatrial nodal artery and conus artery appears to be associated with congenital heart diseases [17].

CONCLUSION

The sinoatrial node is about 10 – 20 mm long elliptical structure, situated at the junction of anterior and posterior walls of right atrium close to the opening of superior vena cava.

The sinoatrial nodal artery usually arises from the right coronary artery or circumflex branch of left coronary artery or from both right and left coronary arteries. In the present study of sixty hearts, 37 were subjected to simple dissection; 16 hearts were studied by resin cast method and 07 specimens were studied by arteriography by injecting radio opaque dye in to the artery. The artery was arising from right coronary artery in 57% of cases, from left circumflex artery in 25 % of cases, from both right and left coronary arteries in 17% of cases and in one case (1.6%) it was from right aortic sinus close to the origin of right coronary artery. The angle at the origin from the parent trunk was also studied in which there was acute angle in 23%, right angle in 35% and obtuse angle in 48% of hearts. The angle of sinoatrial nodal artery at its origin with the parent trunk plays a very important role in the blood flow and any obstruction or lower pressure in the arteries, the nourishment to the sinoatrial node and functioning of the node are affected. The course of the sinoatrial nodal artery in relation to the root of the superior vena cava was studied in which the artery was running anterior to the root of superior vena cava in 50%, posterior in 39% and both anterior and posterior to the root of superior vena cava in 16%. The course may be sinuous and again causing reduced pressure in these minute arteries. The collaterals do occur but only the demonstrable anastomoses were noted. This was observed in two cases. In one specimen there was tortuosity in the collateral artery and the age of the heart was about 75 years and in another case the heart belonged to 35 years of age and the artery was not tortuous. Therefore it can be correlated with age. All these observations help in understanding and analysing the cause of malfunctioning of the sinoatrial node.

Conflicts of Interests: None

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