

Anatomical Study of the Variations of Sinuatrial and Atrioventricular Nodal Arteries in Human Heart

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Abstract

Introduction: The conducting system of the heart is supplied mainly by Sinuatrial nodal artery and Atrioventricular nodal artery. Generally, in 60% subjects, Sinuatrial nodal artery arise from Right Coronary Artery and in remaining 40% it arise from Left circumflex branch of Left Coronary Artery. Similarly, the atrioventricular nodal artery arises from Right Coronary Artery in 80% and from Left Coronary Artery in 20% subjects. The aim of the present study is to observe the variation of Sinuatrial & Atrioventricular nodal arteries in human hearts for gathering adequate information study which may be helpful for cardiovascular surgeries. **Material and Method:** Present study included 50 human hearts. Heart specimens obtained from department of Anatomy of Netaji Subhash Chandra Bose medical College, Jabalpur, India. The course of Sinuatrial nodal and Atrioventricular nodal arteries were traced by micro dissection under water method. **Results:** In the present study Sinuatrial nodal artery arose from RCA in 52% cases, from LCA in 24% cases and in 24% cases it arose from both RCA & LCA. Likewise, Atrioventricular nodal artery arose from RCA in 88% cases and in 12% cases it arose from LCA. **Conclusion:** Considering the necessity of Open heart surgeries it becomes necessary to have a deep knowledge of origin and variation of Sinuatrial nodal and Atrioventricular nodal arteries. Knowledge of variation in the blood supply of conducting system may help cardiac surgeons in taking due cautions during various cardiac surgeries, atrial surgical interventions and surgery related to certain valvular disorder and congenital malformation.

Key words: Sinuatrial Nodal Artery, Atrioventricular Nodal Artery, Sinuatrial Node, Atrioventricular Node, Coronary Artery.

Introduction

The Sinuatrial node, Atrioventricular node and networks of the specialized myocardial cells constitute the cardiac conduction system. The SA node is elliptical mass of histologically distinct myocardial cells. It is 10-20 mm long subepicardially situated in the wall of the right atrium, just below the superior vena cava, at the top of the sulcus terminalis. It has no macroscopic or palpable features that indicate its location [1].

The main pacemaker rhythm of the heart is generated at SA node & transmitted specifically from atria to ventricles through AV node and bundle of his, within the ventricles, to all their musculature. AV node lies subendocardially in the triangle of Koch between the anteromedial margin of the coronary sinus ostium, the

base of the septal cusp of the tricuspid valve and the tendon of Todaro, which lies between the central fibrous body or the right fibrous trigone (trigonum fibrosum dextrum) and the medial border of the Eustachian valve (valvula venae cavae inferioris). The tendon of Todaro is a subendocardial connective tissue band that connects the commissure of the Eustachian and Thebesian valves [2].

The artery of the SA node is an atrial branch, thus, 'nodal' artery usually passes back in the groove between the right auricular appendage and aorta. Generally in 60% subjects the SA nodal artery arises from right coronary artery & in 40% subjects it comes from the circumflex branch of the left coronary [1]. When this is the case, this branch travels upward along the left atrium, behind the aorta to the anterior interatrial sulcus, and continues rightward to partially encircle the lower portion of the superior vena

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cava. The SA nodal artery usually gives branches around the base of the superior vena cava, typically as an arterial loop from which small branches supply the right atrium. The dual supply of SA node from coronary system becomes a protective anatomical substrate for any atheromatosis processes involving these vessels that can alter sinus rhythm.

The largest posterior septal artery, usually arises from the inverted loop of right coronary artery at crux, supplies AV node in 80% heart & from the circumflex artery in 20% subjects [3].

As per Halsted, a pioneer American surgeon, the best way to avoid injury to a blood vessel is to know about its course and branching pattern. Hence, Anatomists bear a great responsibility of research, understanding and spreading the knowledge of arterial variations.

The aim of the present study is to observe the variation of Sinuatrial & Atrioventricular nodal arteries in human hearts for gathering adequate information study which may be helpful for cardiovascular surgeries.

Material & Methods

The heart specimens for this study were obtained from cadavers in the department of Anatomy of NSCB medical college, Jabalpur, India. The sample size for this study was 50 heart specimens.

The ribs and sternum were cut, thus opening the thoracic cavity. All the great vessels were ligated by thread at two places and cut in between. The parietal pericardium was incised and the heart was taken out of the pericardial cavity.

The specimens were numbered from 1 to 50 and preserved in 10% formaldehyde solution. The dissection was done under water. The visceral pericardium was removed and by micro dissection the RCA and LCA was exposed. Then SA nodal & AV nodal arteries were traced from their origin & their course, the branching pattern & variations were noted. Red acrylic colour was used to paint the SA & AV nodal arteries to give contrast in photographs. Photographs of specimen were taken by Sony digital camera of 20.2 megapixels and labelled.

Results

Table-I: Blood Supply of SA Node

Source	Number and percentage of specimens (N=50)	
	No.	%
RCA	26	52
LCA	12	24
Both	12	24

In the present study, Right coronary artery supplied to SA node in 26 specimens i.e. 52% (See fig.I). Similarly, Left coronary artery supplied to SA node in 12 specimens i.e.24% (See fig.II). However, SA node was supplied by both the arteries in 12 specimens (See fig. III).

Table-II: Origin of AV Nodal Artery

Source	Number and percentage of specimens (N=50)	
	No.	%
RCA	44	88
LCA	6	12

In the present study, in 44 specimens (88%) AV nodal artery was branch of Right coronary artery (See fig. IV). However, in six specimens, i.e. 12%, AV nodal artery was branch of Left coronary artery (See fig. V).

Discussion

Coronary artery variation is being examined by Clinicians and Anatomists from a long time. Since 1960, when the selective coronary angiography began, the total numbers of investigations in this field have increased. However, there is still no consensus on the normality or abnormality of coronary artery rather variation in the branching pattern of coronary artery is the peculiarity of coronary artery.

Research Article

They were Keith & Flack who, in 1907, described SA node for first time [4]. It is a pacemaker and considered very important structure in the heart. Due to its functional importance, the blood supply of this important structure has great value. The nature of the blood supply to the SA node influences the clinical expression of sinuatrial nodal ischemia and related diseases.

Vascular descriptions of nodal arteries have been reported in several published articles in literature and we agree that in majority of hearts nodal arteries are given by right coronary artery (52% in our study),(See table-III) but in present study we find high incidence (24%) of dual blood supply of SA node (See photo.-I). The dual supply of SA

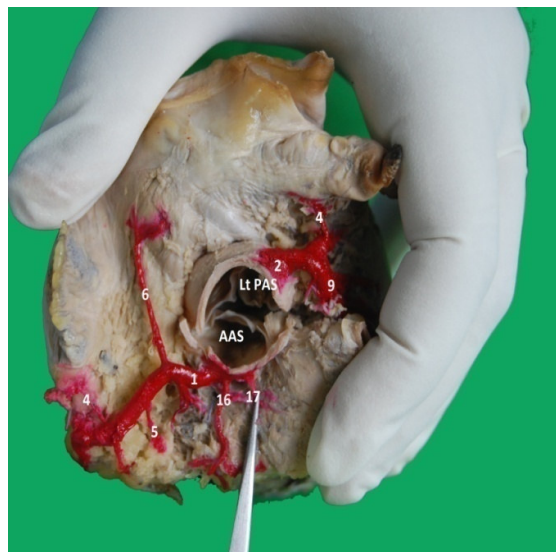


Figure-I: Origin of SA nodal artery (6) from RCA (1)

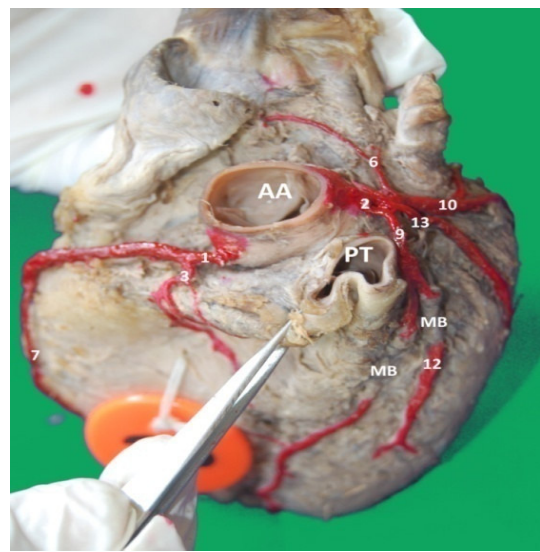


Figure-II: Origin of sinuatrial nodal artery (6) from Lt Circumflex Artery (10) (Anterosuperior View)

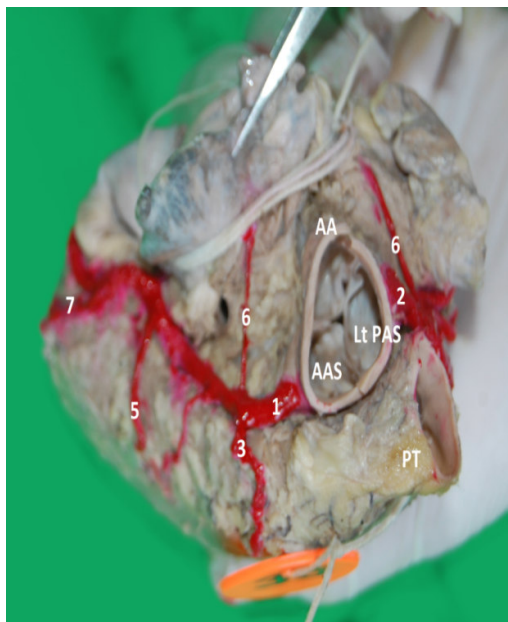
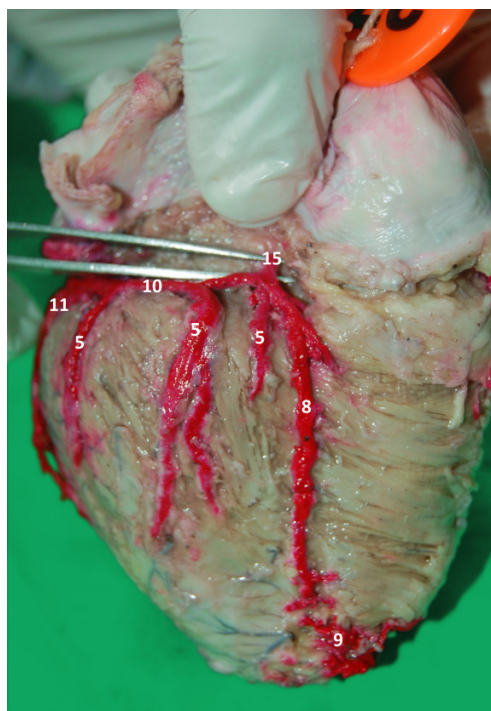


Figure-III: Origin of sinuatrial nodal artery (6) from RCA (1) & LCA (2) both (Superior View)



Figure-IV: Origin of AV nodal artery (15) from RCA (1). (Posterior view)

node from both RCA & LCA becomes a protective anatomical substrate for any atheromatosis processes involving these vessels that can alter sinus rhythm. Futami [5] also reported the double origin of SA nodal artery in 23% cases of Japanese population. Thus percentages of SA node supplied by both coronary arteries as noted by various scholars ranges between 3.3 to 23%.



Keys to Photographs

1-Right Coronary Artery, 2-Left Coronary Artery, 3-Right Conus Artery, 4-Atrial branch, 5-Ventricular branch, 6-Sino-atrial Nodal Artery, 7-Right Marginal Artery, 8-Posterior Interventricular Artery, 9-Left Anterior descending Artery, 10-Left Circumflex Artery, 11 -Left Marginal Artery, 12 -Left Diagonal Artery, 13-Median artery, 14-Posterior Right Diagonal Artery, 15-Atrio ventricular Nodal Artery, 16-Third Coronary Artery, 17-Fourth Coronary Artery, RA-Right Atrium, LA-Left Atrium, AA-Ascending Aorta, PT-Pulmonary trunk, AAS-Anterior Aortic Sinus, PAS-Posterior Aortic Sinus

Table-III: Comparison of variations in blood supply of SA and AV nodes as reported in literature

S. No.	Study done by	SinuatrialNode			Atrioventricular Node		
		RCA (%)	LCA (%)	Both (%)	RCA (%)	LCA (%)	Both (%)
1.	Baroldi and Scmazzonei (1956) ⁶	51	41	8	-	-	-
2.	James (1961) ⁷	54	42	4	-	-	-
3.	Futami C (2003) ⁵	73	3	23	80	10	10
4.	Kalpana R (2003) ⁸	56	35	8	82	18	-
5.	K.V. Venkateshu (2006) ⁹	96.3	-	3.3	86.5	13.3	-
6.	Pejkovic B (2008) ²	63	37	-	90	10	-
7.	Anjali S Sabnis (2012) ¹⁰	90	10	-	70	29	0.9
8.	Present study (2014)	52	24	24	88	12	-

The largest arterial branch, arising from the first or second centimeter of the main vessel is usually the SA nodal artery which forms a vascular ring in the right atrium and auricle below the superior venacaval opening. This supplies the SA node in almost 60% of hearts and may arise directly from the anterior aortic sinus adjacent to the

right coronary itself. Among 110 autopsy cases Anjali s Sabnis et al [10] found that, in one heart right marginal artery was arising from right coronary artery much proximally. Instead of right coronary artery, SA nodal artery took origin from right marginal artery. Schlesinger et al [11] and James [7] have described the origin of SA

nodal artery directly from the aortic sinuses in some instances. The anatomic features of the SA nodal artery are very important in cardiac surgery. The base of the superior vena cava at the superior atriocaval junction, the anterior and lateral walls of the right or left atria, particularly opposite the proximal segments of the RCA, the roof of the atria, the interatrial septum are some regions at which major risks of damaging or dividing the SAN exists [12].

In the current study the blood supply to the SA node was found from the left coronary artery in 24% cases; this compares with previously reported incidences which ranges between 3 to 41%(See table-III). It has been found to be a branch of the Lt.Circumflex branch either just distal to division of main trunk of LCA or from proximal part of Lt. circumflex artery, but, sometimes arises directly from the left coronary artery [13]. It then usually ascends the left atrial wall behind the aorta, reaches the anterior interatrial groove and then takes the same course as when originating from the right coronary artery. B Pejko^{vi}cet *al.* [2] noted that in 2% cases the SA node artery has been found to arise from the distal portion of the circumflex branch of the left coronary artery as the left lateral (intermediate) atrial branch or as the posterior atrial branch parallel to the circumflex branch.

AV node was first described by Tarawa⁴ in 1906. The main function of AV node is modulation of atrial impulse transmission to the ventricles, there by coordinating atrial and ventricular contractions. It delays the impulse received from S.A node and protect ventricles from atrial arrhythmia. The largest posterior septal artery from right coronary artery which is given at crux enters the interatrial septum and supplies AV node. This artery is important vessel in the pathogenesis of heart block.

Any variation in point of origin, course may provide information prior to catheter based interventional cardiac procedure¹⁴. The origin of AV nodal artery is related to coronary artery dominance. In right dominance it usually arises from RCA and in left dominance it arises from Lt. circumflex branch of LCA. We found that AV nodal artery is arising from RCA in 88% specimens (See photo.- III); this compares with previously reported incidences ranges between 70 to 90%. It arises from LCA in 12% specimen (see photo. – IV) and in 10 to 29% specimens by other authors (see table – III). Futami [5] and Anjali S Sabnis [10] also noted origin of AV nodal artery from both LCA and RCA but we did not find such type of variation. The close proximity of the AV node artery to the mitral valvular ring explains the rhythm disorders that can occur during mitral valve surgery. In such cases the risk of injuring the AV node artery is increased.

Awareness of anatomical variants of SA nodal & AV nodal arteries may guide the Cardiac surgeons during cardiac procedures and reduces the risk of damaging them.

Conclusion

Now-a-days open hearts surgeries are being performed widely. It needs precaution to maintain existing anastomosis for normal functions of heart. Considering the necessity of these surgeries it becomes necessary to have a deep knowledge of origin and variation of Sinuatrial nodal and Atrioventricular nodal arteries.

Knowledge of variation in the blood supply of conductive system may help cardiac surgeons in taking due cautions during various cardiac surgeries, atrial surgical interventions and surgery related to certain valvular disorder and congenital malformation.

It may also be beneficial for methods of cardiological examination and treatment to have detailed knowledge of the arterial supply of the SA & AV nodes. Proper precautions may be taken to preserve the main arterial supply to the sinus node during surgery through this knowledge.

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Abbreviations

AV	-	Atrioventricular
SA	-	Sinuatrial
RCA	-	Right Coronary Artery
LCA	-	Left Coronary Artery
Lt	-	Left
Rt	-	Right

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