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# Normal anatomy and variations of sinoatrial nodal artery (SANA) in north Indian population: A study by 64 slice computed tomographic (CT) coronary angiography

**Sushma Tomar, Punita Manik, P.K. Sharma, PallaviAga, A.K Srivastava**

**Abstract**
This prospective study was done to evaluate the anatomic characteristics and the variations of the Sino-Atrial Nodal Artery (SANA) in the North Indian population using an electrocardiographic (ECG)-gated Multi-Detector Computed Tomographic (MDCT) coronary angiography. The ECG-gated MDCT coronary angiograms of 50 subjects [32 males (14-75 years) &18 females (12-70 years); mean age 51.36 ± 14.07 years, age range 12-75 years] were analyzed . Each angiogram was visualized to see the origin of SANA and to determine its number. The correlation of origin of SANA with coronary dominance was also established. Single Sino-atrial nodal artery was seen in *45 (90%)* cases and two Sino-atrial nodal arteries were seen in *2 (4%)* cases. In *3 (6%)* cases, SANA was not visualized. Out of 45 subjects having single SANA, *36 (72%)* subjects had origin of SANA from the right coronary artery (RCA), in *2 (4%)* cases; the SANA was seen arising from anterior aortic sinus (AAS) and in *7 (14%)* cases the SANA arose from left circumflex (LCX) artery. *In one case of SANA arising from AAS, it was anomalous and aneurysmally dilated, forming a fistulous tract communicating with the right atrial cavity*. In subjects having two Sino-atrial nodal arteries, one arose from RCA and second from LCX artery. SANA was a branch of the dominant artery in 70% cases. This study can provide basic data on normal anatomy and variations of SANA in the North Indian population.

**Keywords:** Sino-atrial nodal artery (SANA), SA node, ECG-gated MDCT, North Indian Population.

## 1. Introduction
Several authors had published the reports of their studies regarding the origin and course of Sino-Atrial Nodal Artery (SANA). In the present study, number and origin of SANA were explored in the North Indian population with the help of multidetector CT coronary angiography. Many anatomical variations of SANA have been reported in previous studies performed by various methods such as anatomical dissection, catheter angiography, computed tomographic angiography etc. Sino-atrial Node (SAN) is the *pacemaker of the heart*, so it is very important to know its accurate arterial supply. Any anatomic variation in the SANA can influence its catheterization and surgical procedures done in the vicinity of SA node. The unusual course and proximity to the left atrial wall predispose this vessel to injury during cardiac interventions [12].
Ischemia of SAN due to iatrogenic occlusion or injury of SANA during surgery, coronary stent insertion or balloon inflation can cause arrhythmia such as atrial flutter or sick sinus syndrome [3, 11]. Thus the information regarding the origin and the number of SANA is very crucial for the cardiologists and the cardiothoracic surgeons during surgery and catheter-related procedures.
In the past decades, several new surgical techniques were explored for the treatment of arrhythmias especially the atrial fibrillation, therefore knowledge of the normal anatomy and its variations of atrial branches, particularly SANA have gained a great importance.

## 2. Materials and methods
A prospective analysis of MDCT coronary angiograms of 50 subjects who were referred for suspicion of having coronary artery disease (CAD) was conducted. ECG gated 64-slice CT coronary angiographic examinations of all the subjects were performed between June 2010 and June 2011, using a 64-Slice Multidetector Computed Tomographic (MDCT) scanner (BRILLIANS$^{TM}$CT, Version 2.45.22042, manufactured by Philips).
The scan field extended from the carina to the diaphragm. The imaging parameters were: slices/detector collimation of *64×0.625 mm*, effective temporal resolution (with 180°algorithm) of *165 ms*, tube voltage of *120 kV*, tube current of *800 mA*, gantry rotation time was *400 ms*, pitch of *0.2*, slice thickness of *0.90 mm* and reconstruction interval of *0.45mm*, Field of view (FOV)

was *220mm*, Isotropic voxel resolution of *0.4×0.4×0.4 mm*. A single inspiratory breath-hold of approximately *10-12 seconds* (scanning time) completed the examination.

### 2.1 Pre-procedure precautions

- The subjects were enquired, to rule out the presence of any drug allergy to avoid the occurrence of any untoward anaphylactic reaction during the procedure.
- The subjects were advised to avoid the intake of fatty food two days prior to the procedure.
- They were advised to drink only water just prior to the procedure.
- Blood urea and creatinine levels were evaluated.

### 2.2 Procedure

The subjects were laid supine. Their heart rate was stabilized with an oral dose of 50-100 mg Metoprolol one hour before the scan. If heart rate was not stabilized with an oral dose, then intravenous (IV) Metoprolol was given. Electrocardiogram (ECG) and pulse rate were monitored half an hour prior to the procedure. The subjects were counseled to reduce their anxiety.

The subjects were connected to a cardiac monitor. For venous access, an upper extremity vein (antecubital vein) and a 20-gauge intravenous canula was used. 80-85 ml of non-ionic contrast Iohexol (Omnipaque, GE, GE Healthcare Ireland, Cork) containing iodine concentration of 350 mgI/ml, injected with a flow rate of 5.5ml/sec, followed by a 20 ml saline flush at a rate of 4ml/sec with a pressure injector (PSI-325). The scan timing was determined with automated bolus tracking technique by placing the region of interest over mid ascending aorta and setting the trigger threshold to 180 Hounsfield (Hu). The subjects were asked to lie still on the "scanning bed" for a period of 5-10 minutes. The instruction was given to the subjects to maintain an inspiratory breath hold during which CT data and ECG tracings were taken. Computed Tomographic Coronary Angiography (CTCA) was performed 5 seconds after aortic peak density. Scanning coverage was from the level of carina to the diaphragm. Raw spiral CT data of coronary arteries were reconstructed in various phases of cardiac cycle on a work station (Brilliance 64 version 4.5) to obtain images with the highest quality (without motion artifact). This work station enabled generation of the images of coronary arteries in the standard and in various other anatomical planes. Reconstruction performed at 75% of R-R interval was found to be optimal for image analysis in most of the subjects. In some, if heart rate could not be stabilized properly, then reconstructions were performed at 45% of R-R interval. The reconstructed images were interpreted with the help of a cardiac radiologist. Subjects with previous bypass surgery and also those with suboptimal study due to breath hold artifacts were excluded.

All images were reviewed first in axial projection and then with post processing tools such as Multiplanar Reconstruction (MPR), Curved Planar Reformation (CPR), thin-slab Maximum Intensity Projection (MIP), and Volume-Rendering Technique (VRT) with transparent background display. MIPs were obtained using various thicknesses (5–30 mm). Volume-rendered images were also obtained using various orientations. The statistical analysis was performed by using software SPSS (Statistical Package for Social Sciences) version 15.0. The values were represented in Number (%) and Mean ± Standard Deviation (SD).

## 3. Results

In the present study, SANA was observed for its number and origin. Single SANA was seen in 45 (90%) subjects [27 (84.38%) males and 18 (100%) females] (Table 1, Fig.1 & 2). In 2(4%) cases [2(6.25%) males] two SANA were observed (Table 1, Fig.1 & 3). SANA was not visualized in 3(6%) cases [3(9.38%) males] (Table 1, Fig.1)

SANA arose from the RCA in 36 (72%) cases [21 (65.63%) males and 15 (83.33%) females] (Fig. 2(a) & (b), Fig. 3(a) & Fig.4, Table 2). In 2 (4%) cases [2(11.11%) females] it was found to take origin from anterior aortic sinus (Table 2, Fig.4 & 5)**.** None of the male had origin of SANA from anterior aortic sinus. SANA took origin from LCX artery in 7 (14%) cases [6 (33.33%) males and 1 (5.56%) female] (Fig.2(c) & (d), Fig. 3(b) & (c) Fig.4 & 6, Table 2)**.** In 2(4%) cases [2 (6.25%) males] with two Sino-atrial nodal arteries, one SANA arose from RCA and the second SANA arose from LCX artery (Fig.3). In this way SA node was supplied by both the RCA and LCX artery. No such finding was seen in females (Table 1).

The origin of the Sino-atrial nodal artery was also correlated with the coronary dominance. In this correlation seven cases (5 males and 2 females) were excluded, which were three males with non-visualization of SANA, two males with dual origin of SANA and two females having origin of SANA from AAS. The Sino atrial nodal artery was a branch of the dominant artery in 70% cases (Table 3).

In one case of SANA arising from AAS, it was anomalous and aneurysmally dilated, forming a fistulous tract communicating with the right atrial cavity (Fig. 5 (b), (c) & (d)).

## 4. Tables and Figures

**Table 1:** Gender wise distribution of number of SANA

| SANA | Male(n=32) | Female(n=18) | Total(n=50) |
|---|---|---|---|
| Single | 27 (84.38) | 18 (100) | 45 (90) |
| Double | 2 (6.25) | 0 | 2 (4) |
| Not visualized | 3 (9.38) | 0 | 3 (6) |

*Figures in parentheses represent percentage.*

$\chi^2$=3.125; p=0.2096

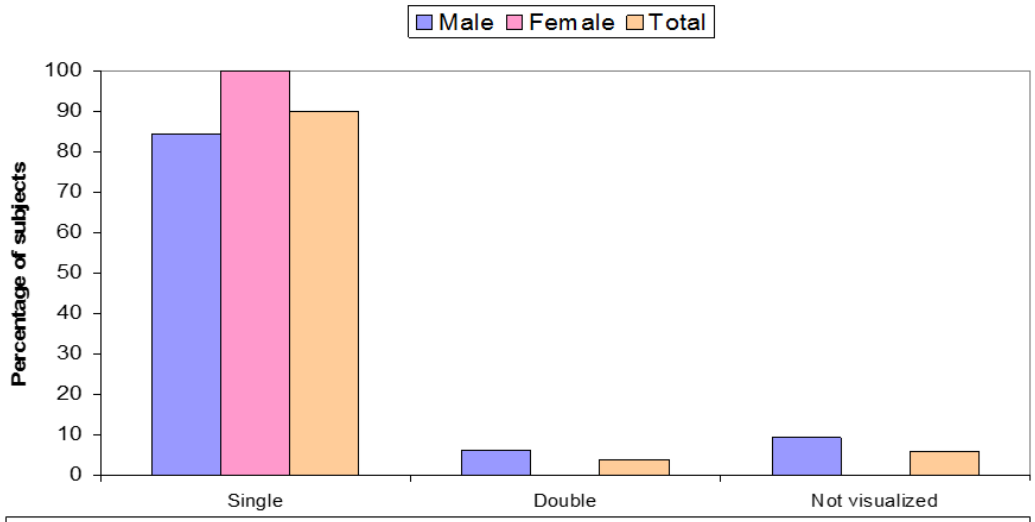


**Fig. 1** Bar Diagram showing Gender wise distribution of number of SANA

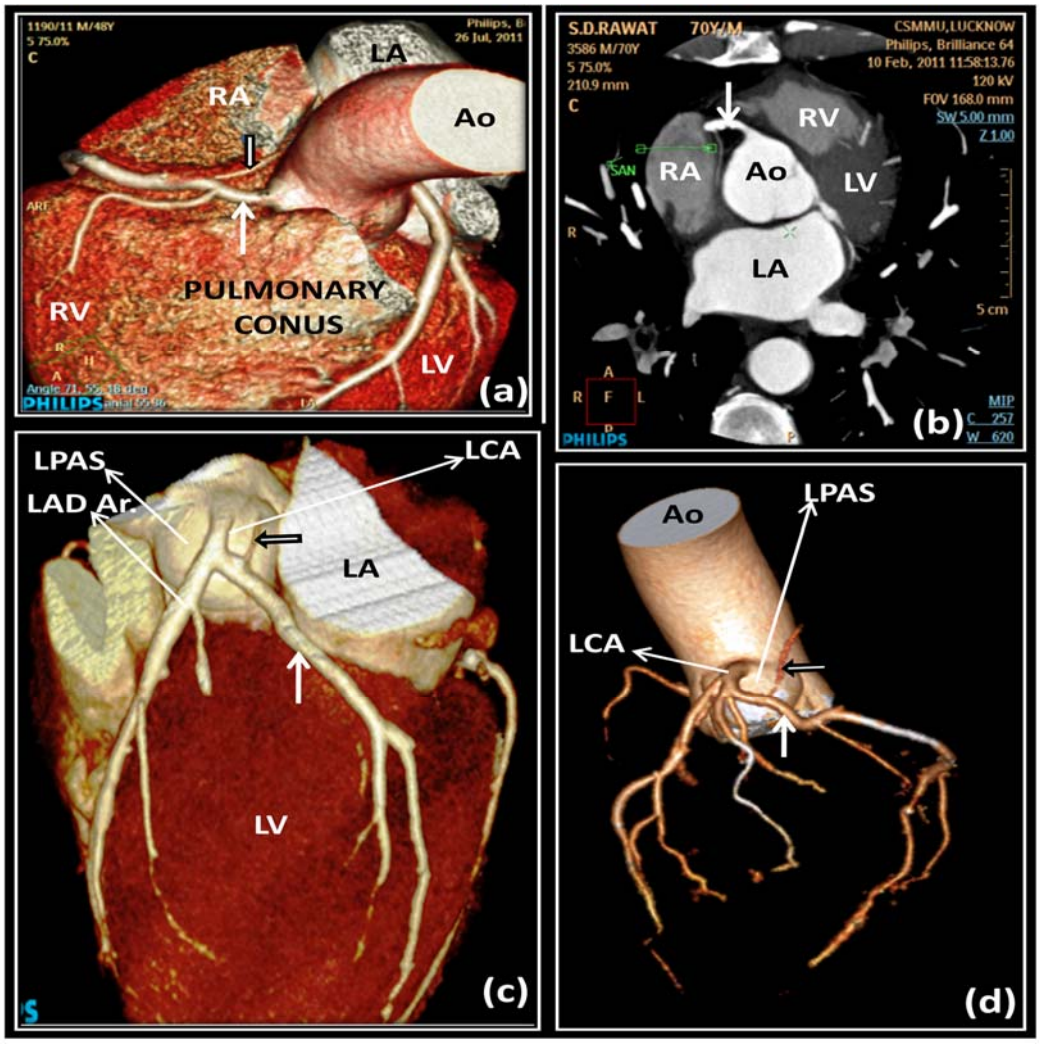


**Fig. 2-** Single Sino-Atrial Nodal Artery (SANA)
(a) 3D VR (three dimensional volume rendered) image showing SANA (*outlined arrow)* arising from RCA (*arrow*).
(b) Axial MIP image showing SANA (SAN ARTERY) arising from RCA (*arrow*).
(c) 3D VR image showing SANA (*outlined arrow*) arising from LCX (Left Circumflex) artery (*arrow*).
(d) Contrast Vessel Tracking Tree showing SANA (*outlined arrow*) arising from LCX (Left Circumflex) artery (*arrow*).
Ao- Aorta, RA- Right Atrium, RV- Right Ventricle, LA- Left Atrium, LV- Left Ventricle. LCA- Left Coronary Artery, LAD Ar. - Left Anterior Descending Artery, LPAS-Left Posterior Aortic Sinus.

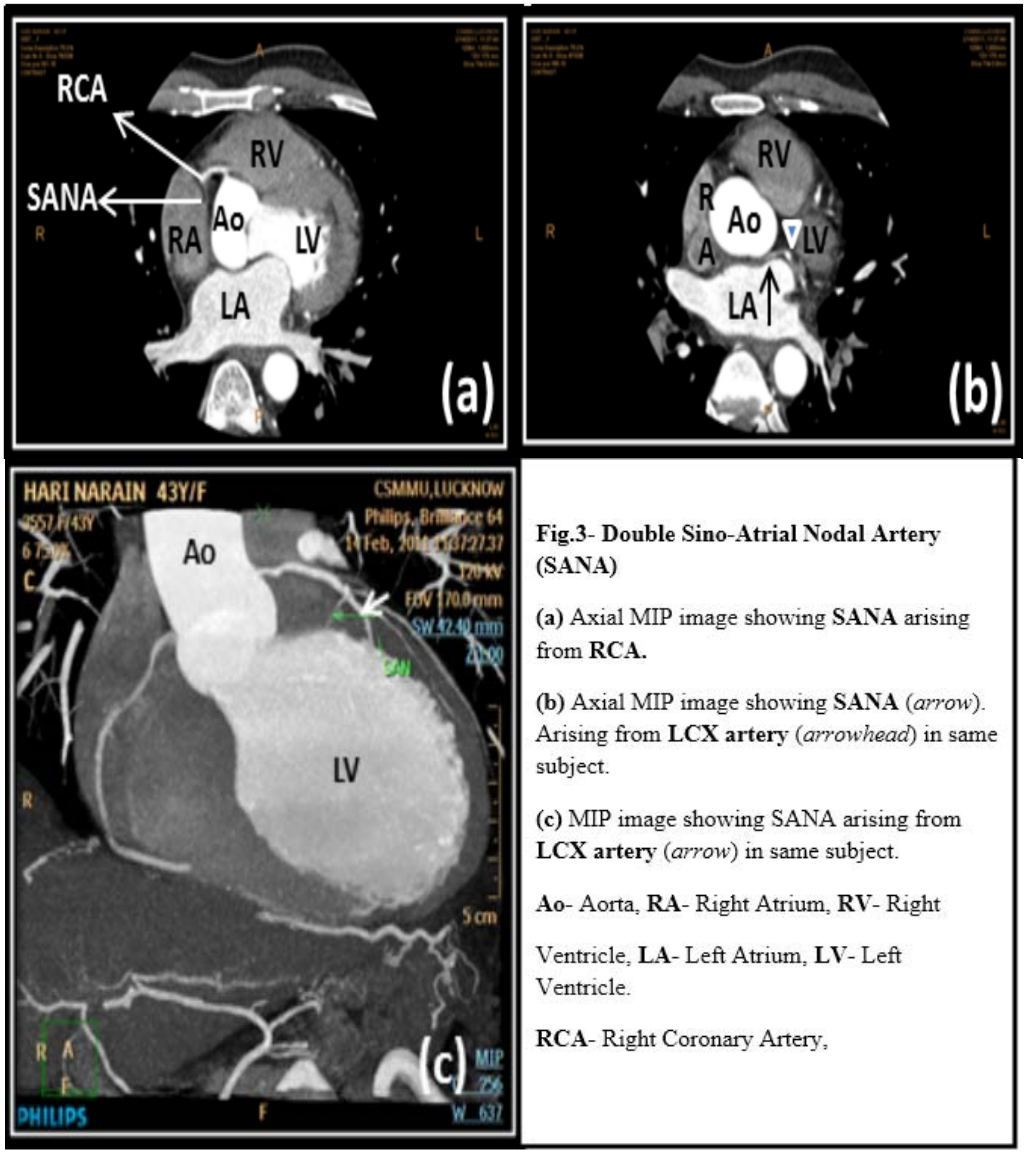


**Fig.3- Double Sino-Atrial Nodal Artery (SANA)**

**(a)** Axial MIP image showing **SANA** arising from **RCA.**

**(b)** Axial MIP image showing **SANA** (*arrow*). Arising from **LCX artery** (*arrowhead*) in same subject.

**(c)** MIP image showing SANA arising from **LCX artery** (*arrow*) in same subject.

**Ao**- Aorta, **RA**- Right Atrium, **RV**- Right Ventricle, **LA**- Left Atrium, **LV**- Left Ventricle.

**RCA**- Right Coronary Artery,

**Table 2:** Gender wise distribution of the origin of SANA

| Site of origin of SANA | Males (n=32) | Females (n=18) | Total (n=50) | $\chi^2$ | 'p' value |
|---|---|---|---|---|---|
| RCA | 21 (65.63) | 15 (83.33) | 36 (72) | 0.739 | 0.390 |
| Anterior aortic sinus | 0 | 2 (11.11) | 2 (4) | 3.365 | 0.067 |
| LCX artery | 6 (33.33) | 1 (5.56) | 7 (14) | 2.007 | 0.157 |
| Both RCA & LCX artery | 2 (6.25) | 0 | 2 (4) | 1.297 | 0.255 |
| Not visualized | 3 (9.38) | 0 | 3 (6) | | |

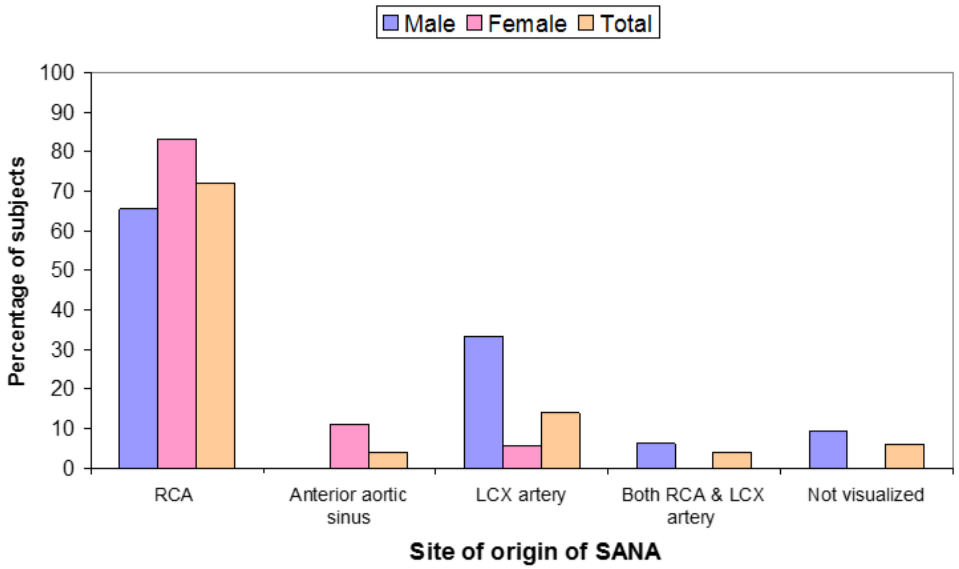


**Fig.4** Bar Diagram showing Gender wise site of origin of SANA

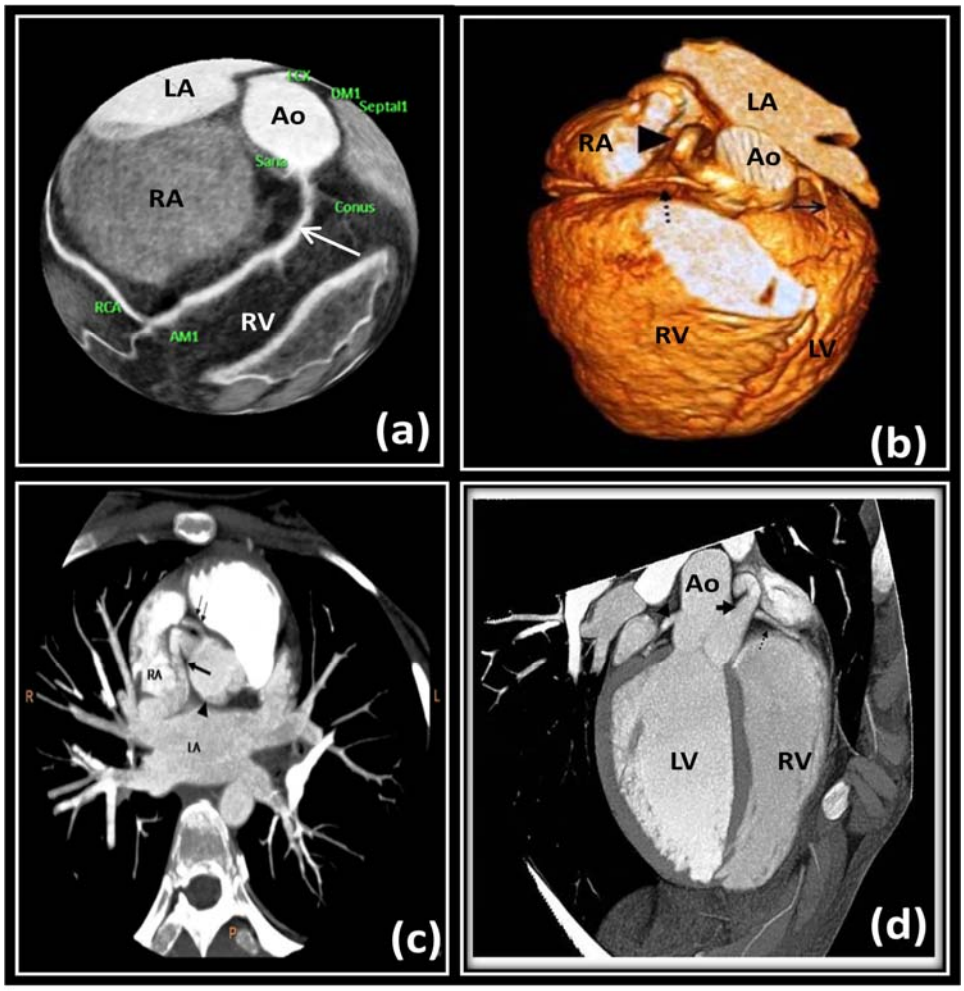


**Fig 5:** SANA arising from AAS (Anterior Aortic Sinus).
**(a)** CPR image showing normal SANA arising from AAS. Other artery arising from AAS is RCA **(***arrow***)**
**(b)** 3D VR image showing anomalous **SANA (***arrowhead)* arising *from* **AAS**. Other artery arising from AAS is RCA (*dotted arrow*)**.** LCA (*arrow*).
**(c)** Axial MIP image showing *anomalous* **SANA (***arrow)* arising from **AAS**, draining into right atrium. Other artery arising from AAS is RCA **(***double arrow*).Aorta (*arrowhead*).
**(d)** Oblique Coronal MIP image showing *anomalous* **SANA (***arrow)* arising from **AAS.** Other artery arising from AAS is RCA (*dotted arrow)* LCA (*arrowhead*). **Ao-** Aorta, **RA-** Right Atrium, **RV-** Right Ventricle, **LA-** Left Atrium, **LV-** Left Ventricle.

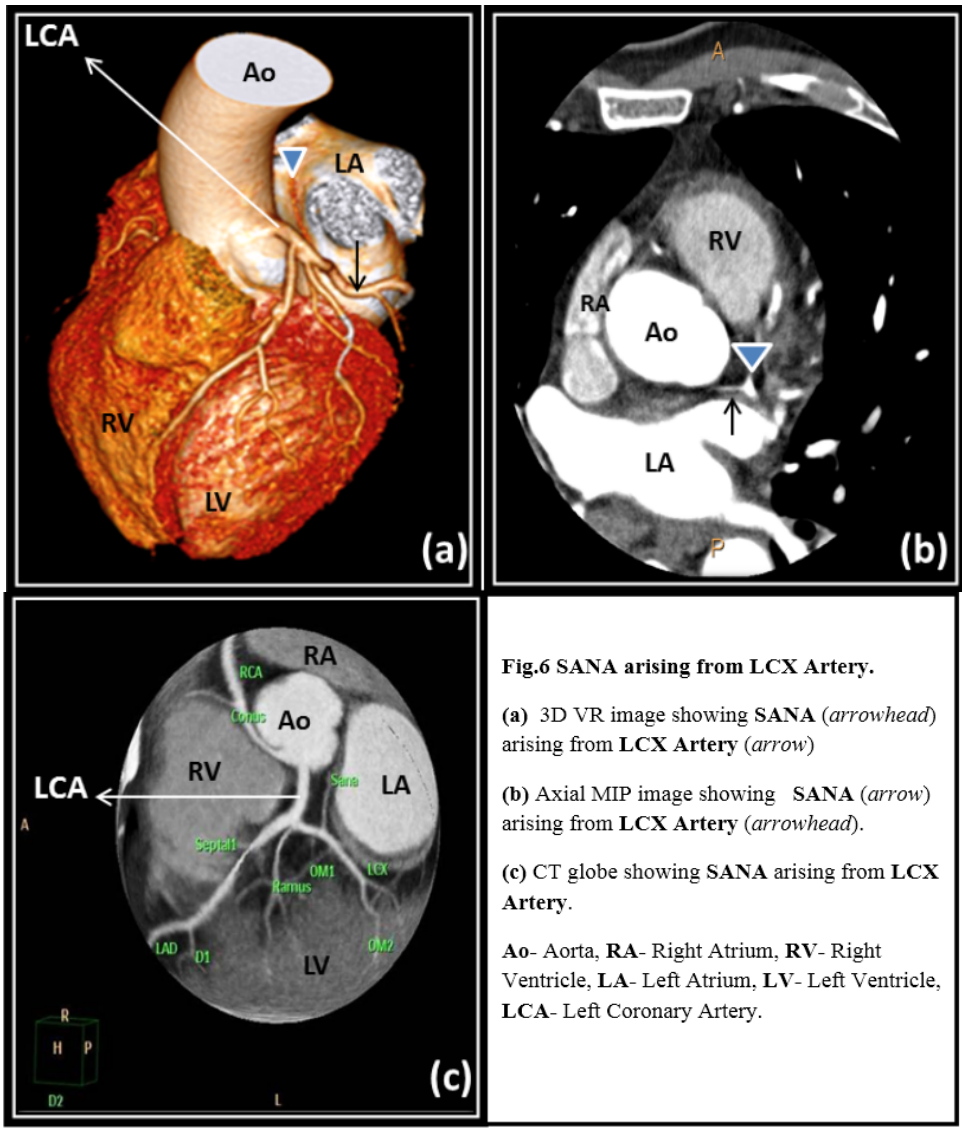


**Fig.6 SANA arising from LCX Artery.**

**(a)** 3D VR image showing **SANA** (*arrowhead*) arising from **LCX Artery** (*arrow*)

**(b)** Axial MIP image showing **SANA** (*arrow*) arising from **LCX Artery** (*arrowhead*).

**(c)** CT globe showing **SANA** arising from **LCX Artery**.

**Ao**- Aorta, **RA**- Right Atrium, **RV**- Right Ventricle, **LA**- Left Atrium, **LV**- Left Ventricle, **LCA**- Left Coronary Artery.

**Table 3:** Correlation between origin of SANA and coronary dominance

| Site of origin of SANA | Right dominance (n=31) | Left dominance (n=9) |
|---|---|---|
| RCA | 26 | 7 |
| LCX | 5 | 2 |

## 5. Discussion

The sinus node artery (SNA) is an integral part of the sinus node (SN), which is the natural pacemaker of the heart [6].

Anatomic descriptions of the blood supply to the SA node have been reported in several published articles of cadaveric dissections and angiographic studies in the literature (Table 4 & Table 5). As pointed out by *James and Burch, 1958*, the sinus node artery is the largest atrial coronary branch; it originates from the right or left coronary artery and encircles the orifice of the superior vena cava in either a clockwise or a counterclockwise direction [20]. In the present study we found that SANA arises mainly from RCA. This finding is similar to the findings of some authors referred in Table 5.

The artery, that followed the RCA in frequency of giving origin to SANA is LCX artery [4,5,8,14,1524,25,26,29,30,35,36]. Some studies reported a minor difference in the number of SANA originated from RCA and from LCA or one of its terminal branches [14, 19,24, 36]. This difference in the site of origin may be due to ethnic diversity among different population groups in the studies.

According to the reports of most of the studies conducted so far, the origin of the SANA from the LCX artery is more frequent than the origin from main trunk of the LCA. We didn't find any case with a SANA originating from the trunk of the LCA, or with an extracardiac origin, this finding is similar to *Onciu M et al* [28]. But *José Roberto Ortale et al* and some other authors reported extracardiac origin of SANA [22]. *James (1961)* had described the origin of the SA nodal artery directly from the aortic sinuses in some instances [19]. Awareness of the presence of multiple ostia in anterior aortic sinus is important because they may cause problems in interventional procedures. Presence of multiple ostia in the anterior aortic sinus may also lead to surgical problems in cases requiring right ventriculotomy for ventricular septal defect or pulmonary stenosis [27].

In our study, we found dual origin of SANA from both RCA and LCX artery in 4% cases which is consistent with findings of *C Nerantzis & D Avgoustakis*, *Lakshmi Ramanathan*, *Fares G Altaii et al & Luis Ernesto Ballesteros et al* [14,19, 24, 36]. This incidence is higher than that is reported by *Yong Sub Song et al* [36] and lower than that is reported by *Futami C et al*, *Saremi F et al*, *Cademartiri F et al* and *Yobany Quijano-Blanco et al* [8, 15, 30, 35]. A much higher incidence of double

Sino-atrial nodal artery is reported in Japanese population by *Futami C et al* [15]. It is probable that the higher frequencies shown for the presence of two branches of the Sinuatrial node reported by *Futami et al* is an anatomical variation associated with a particular ethnic group Brazilians of European and African descendent on the one hand and Japanese on the other [22].

SNA dual irrigation from coronary system becomes a protective anatomical substrate for any atheromatosis processes involving these vessels that can alter sinus rhythm. Equally, surgical approaches on atrial walls (atriotomy, valvular correction and congenital malformation) may injure Sinoatrial node. In case of dual arterial supply of Sino-atrial node, if one artery gets damaged during surgical procedures or blocked due to any pathological condition, than other artery can compensate the arterial blood flow.

In our study, more than two Sino-atrial nodal branches were not found in any case. But *José Roberto Ortale et al* reported 2% incidence of three Sino-atrial nodal branches in their study [22].

The SANA anatomically regarded as a significant artery since it is used as a landmark to identify the SA node, in addition to its clinical significance [24]. This knowledge may not only enrich our understanding of the spatial relationships pertaining to cardiac vascular anatomy but also could potentially influence preprocedural planning in a number of catheter-based or open surgical procedures performed near these important structures.

When SANA arose from the right coronary artery, its course varied greatly with its site of origin from the coronary vessel, either from an atrial artery. or from one of its collateral branches, and also depended on its relations with the interatrial septum. When it arose from the left coronary artery, its course was relatively uniform, except for arteries arising from the inferior atrial arteries, which characteristically involve the posterior wall of the left atrium. These findings are especially important during certain stages of cardiac surgeries like atriotomies, surgical repair of valvular disorders and congenital malformations, which expose the SANA [32].

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 [23].

The sinus node artery crosses the superior posterior border of the interatrial septum in 54% of cases, we can state that the risk for intraoperative damage to the sinus node artery during the superior transseptal approach to the mitral valve is high [6].

Sinoatrial nodal arteries, especially those arising from the LCX artery are prone to surgical trauma during superior transseptal incisions to approach the mitral valve. A superior septal approach for mitral valve surgery is directly related with the loss of normal sinus rhythm because of the section of the sinus node artery [16]. Superior trans-septal approach (STA) for the mitral valve surgery involves the transection of SANA and anterior internodal conduction pathway, therefore the sinus node (SN) function and atrial vulnerability after surgery still remain as important considerations with the STA [13].

Major atrial coronary arteries, including the SNA, were commonly found in the areas involved in Atrial Fibrillation (AF) ablation and could cause difficulties in obtaining transmural lesions and electric isolation or even lead to ischemic sinus node or atrial dysfunction [21].

No sexual or racial factor influenced the anatomical variations [9]. The side of origin of SANA was not significantly influenced by the coronary dominance [32]. However in the present study, the SANA was a branch of the dominant artery in 70% cases.

In the present study, one subject had coronary arterio-venous fistula originating from an anomalous SANA with drainage into the right atrium. Though many patients are asymptomatic, patients may also present with angina, coronary steal, congestive heart failure, infective endocarditis, rupture or compressive symptoms.

**Table 4:** Comparative percentages of number of SANA among various studies

| Authors and year of study | Type of study | Population & No. of Cases | Number of SANA | | | |
|---|---|---|---|---|---|---|
| | | | Single | Double | Three | Not visualized |
| Vieweg WV *et al*, 1975 | Catheter angiography | 118 | 88% | 11% | NIL | |
| Hadziselimović H, 1978 | Dissection, injection-corrosive, radiographic & coronarographic | 200 | 100% | | | |
| C Nerantzis & D Avgoustakis, 1980 | Autopsy (x-ray films & corrosion casting) | Greek 300 | 296 (98.67%) | 4 (1.33%) | NIL | NIL |
| Kyriakidis M *et al*, 1988 | Catheter angiography | 309 | 301 (97.41%) | 8 (2.59%) | NIL | NIL |
| Sow ML *et al*, 1996 | Injection- dissection | 45 | 88.89% | 11.11% | NIL | NIL |
| Futami C *et al*, 2003 | Cadaveric dissection | Japanese 30 | 76% | 23% | NIL | Not mentioned |
| Abadio Gonçalves Caetano *et al*, 2005 | Catheter angiography | Brazilian 100 | 99% | 1% | | NIL |
| José Roberto Ortale *et al*, 2006 | Dissection | Brazilian 50 | 47 (94%) | 2 (4%) | 1 (2%) | NIL |
| Onciu M *et al*, 2006 | Dissection, injection-corrosive | Romanian & Non-Romanian 50 | 90% | 10% | NIL | NIL |
| Saremi F *et al*, 2008 | MDCT coronary angiography | 102 | 95 (93.14) | 6 (5.88%) | NIL | 1 (0.98%) |
| Cademartiri F *et al*, 2008 | 64-slice CT coronary angiography | 543 | 446 (82.14%) | 51 (9.39%) | NIL | 46 (8.4%) |
| Pınar Koşar *et al*, 2009. | 64-slice CT coronary angiography | Turkish 700 | 700 (100%) | NIL | NIL | NIL |
| Lakshmi Ramanathan *et al*, 2009 | Catheter angiography | South Indian 300 | 95.66% | 4.33% | NIL | NIL |
| Fares G Altaii *et al*, 2010 | 64-slice CT coronary angiography | Syrian 66 | 57 (86.36) | 3 (4.55) | NIL | 6 (9.09) |
| Janua´rio Pardo Meo *et al*, 2010 | Dissection and Resin injection | Brazilian 24 | 100% | NIL | NIL | NIL |
| Luis Ernesto Ballesteros *et al*, 2011 | Autopsy | Colombian 221 | 211 (95.5%) | 10 4.5% | NIL | NIL |

| | | | | | | |
|---|---|---|---|---|---|---|
| Yong Sub Song *et al*, 2012 | MDCT coronary angiography | Korean 500 | 478 (96.4%) | 18 (3.6%) | NIL | 4 (0.8%) |
| Yobany Quijano-Blanco *et al*, 2012 | Cadaveric dissection | Colombian 60 | 90% | 10% | NIL | NIL |
| **Present study, 2011** | **64-slice CT coronary angiography** | **North Indian 50** | **45 (90%)** | **2 (4%)** | NIL | **3 (6%)** |

**Table 5:** Comparative percentages of origin of SANA among various studies

| Authors and year of study | Type of study | Population & No. of cases | Origin of SANA | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | AAS or Aorta | RCA | LCX | Both RCA & LCX | Both RCA & LCA | BothLCX & *Pul.Ar. | LCA |
| Campbell, 1929 | | | NIL | 52.6% | 13.7% | NIL | NIL | NIL | 33.7% |
| James TN, 1961 | | | NIL | 55% | 45% | NIL | NIL | NIL | NIL |
| Vieweg WV *et al*, 1975 | Catheter angiography | 118 | NIL | 53% | | | 11% | | 35% |
| Hadziselimović H, 1978 | Dissection, injection-corrosive, radiographic and coronarographic | 200 | NIL | 60% | NIL | NIL | NIL | NIL | 40% |
| C Nerantzis & D Avgoustakis, 1980 | Autopsy (x-ray films & corrosion casting) | Greek 300 | NIL | 62% | 37% | 1% | NIL | NIL | NIL |
| Kyriakidis M *et al*, 1988 | Catheter angiography | 309 | NIL | 182 (58.9%) | 119 (38.51%) | 8 (2.59%) | | | |
| LJA DiDio *et al*, 1995 | Autopsy (x-ray films | Caucasian & Non-Caucasian (Negroes & Mulattoes) 100 | NIL | 58% ± 4.9% | 30% ± 4.5 | NIL | NIL | NIL | 12% ± 3.2 |
| Sow ML *et al*, 1996 | Injection- dissection | 45 | NIL | 64.45% | | | 11.11% | | 24.44% |
| Futami C *et al*, 2003 | Cadaveric dissection | Japanese 30 | NIL | 73% | | | 23% | | 3% |
| Berdajs D *et al*, 2003 | Catheter angiography | 50 | NIL | 66% | NIL | NIL | NIL | NIL | 34% |
| Abadio Gonçalves Caetano *et al*, 2005 | Catheter angiography | Brazilian 100 | 1% | 65% | | | 1% | | 33% |
| Onciu M *et al*, 2006 | Dissection, injection-corrosive | Romanian & Non-Romanian 50 | NIL | 74% | 16% | 6% | | | |
| B Pejkovi´c *et al*, 2008 | Cadaveric dissection | Austrian 150 | NIL | 63% | | | | | 37% |
| Saremi F *et al*, 2008 | MDCT coronary angiography | 102 | NIL | 67 (65.69%) | 28 (27.45%) | 6 (5.88%) | | | NIL |
| Cademartiri F *et al*, 2008 | 64-slice CT coronary angiography | 543 | 1 (0.2%) | 355 (65.4%) | 90 (16.6%) | 50 (9.2%) | | 1 (0.2) | NIL |
| Arda Şanlı Ökmen & Ertan Ökmen, 2009 | Catheter angiography | 1500 | NIL | 1292 (85.8%) | 208 (14%) | NIL | NIL | NIL | NIL |
| Lakshmi Ramanathan *et al*, 2009 | Catheter angiography | South Indian 300 | NIL | 53% | 42.66% | 4.33% | | | NIL |
| Pınar Koşar *et al*, 2009. | 64-slice CT coronary angiography | Turkish 700 | 0.4% | 79% | 20% | NIL | | | 0.4% |
| Fares G Altaii *et al*, 2010 | 64-slice CT coronary angiography | Syrian 66 | NIL | 33 (50%) | 24 (36.36%) | 3 (4.55%) | | | NIL |
| Janua´rio Pardo Meo *et al*, 2010 | Dissection and Resin injection | Brazilian 24 | NIL | 58% | 42% | NIL | NIL | NIL | NIL |
| Luis Ernesto Ballesteros *et al*, 2011 | Autopsy | Colombian 221 | NIL | 60.6% | 34.9% | 4.5% | | | NIL |
| Yong Sub Song *et al*, 2012 | MDCT coronary angiography | Korean 500 | | 265 (53.4%) | 213 (43%) | | | | |
| Yobany Quijano-Blanco *et al*, 2012 | Cadaveric dissection | Colombian 60 | NIL | 75% | 15% | 10% | NIL | NIL | NIL |
| **Present study, 2011** | **64-slice CT coronary angiography** | **North Indian 50** | **4%** | **72%** | **14%** | **4%** | **NIL** | **NIL** | **NIL** |

***** Pul.Ar. - Pulmonary Artery

## 6. Conclusions

The frequency of origin of SANA from RCA is consistent with the reports of most of the studies done for the origin of SANA. The frequency of origin of SANA from anterior aortic sinus is greater than that is reported in previous studies conducted on populations of other ethnicity than Indians. This finding can make us to consider it as characteristic of North Indian population. This study can provide basic data on normal anatomy and variations of SANA in the North Indian population.

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