# Anatomy and variations of the arterial supply to the sinoatrial node: Imaging with dual-source cardiac multidetector CT angiography

*Sinoatriyal noda arteryel desteğinin anatomisi ve varyasyonları: Çift tüplü multidedektör BT anjiyografi ile görüntüleme*

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***Background:*** In this study, our aim is to describe the sinoatrial node (SAN) artery and to define the typical course and variations of it in a Turkish population.

***Methods:*** We retrospectively examined cardiac computed tomography (CT) images of 107 cases acquired with a dual-source multidetector system. Using special software; three-dimensional, maximum intensity projection and curved multiplanar images were generated and evaluated. After depiction of the SAN arterial supply: firstly, the trace of the artery was defined; secondly, calibration at the origin measured and then percentages of different types were calculated.

***Results:*** A single SAN artery which originated from the proximal 35 mm of the right coronary artery (RCA) was detected in 97 (91%), from the proximal left circumflex artery in four (4%), directly from the RCA sinus in three (3%) and from the conal branch of the RCA in two (2%) cases. Only one (1.02%) encircling SAN artery was detected.

***Conclusion:*** The arterial blood supply to the SAN artery can be imaged easily with dual-source multidetector CT examination by processing the routine cardiac CT sections. Awareness of these features (supply to the SAN) is important before invasive procedures like surgery or catheter angiography to prevent potential damages. Compared with the literature, our findings suggest variability between different races, concerning the percentages of the different types of arterial supply to the SAN.

*Key words:* Angiography; coronary artery; dual-source computed tomography; sinoatrial node arterial supply.

***Amaç:*** Bu çalışmada, sinoatriyal nod (SAN) arteri açıklandı ve Türk toplumundaki tipik seyri ve varyasyonları tanımlandı.

***Çalışma planı:*** Çift tüplü bir multidedektör sistem ile incelemeleri gerçekleştirilmiş 107 olgunun kardiyak bilgisayarlı tomografi (BT) görüntüleri geriye dönük olarak incelendi. Özel yazılım programı kullanılarak sistemin üç boyutlu, maksimum intensite projeksiyon ve multiplanar düzlem görüntüleri oluşturuldu ve değerlendirildi. Sinoatriyal nod arteryel desteği tespit edildikten sonra, öncelikle trasesi tanımlandı; ikincil olarak ise orijine yakın kalibrasyonu ölçülerek, değişik formların oranları hesaplandı.

***Bulgular:*** Olguların 97'sinde (%91) sağ koroner arter (SağKA)'in proksimal 35 milimetrelik segmentinden kaynaklanan tek SAN arteri bulundu, tek SAN arteri dördünde (%4) proksimal sol sirkümfleks arterden, üçünde (%3) doğrudan sağKA sinüsünden ve ikisinde (%2) ise sağKA'nın konal dalından kaynaklanmakta idi. Sadece birinde kuşatılmış SAN arteri tespit edildi.

***Sonuç:*** Sinoatriyal noda sağlanan arteryel kan desteği, çift tüplü multidedektör BT sistemleri ile elde edilmiş rutin kardiyak BT kesitlerinin işlenmesi ile kolaylıkla görüntülenebilir. Bu arteryel desteğin özelliklerinin daha önceden bilinmesi, cerrahi veya kateter anjiyografi gibi invaziv işlemlerde yaralanmanın engellenmesi açısından önemlidir. Literatür ile karşılaştırıldığında, bulgularımız SAN arteryel desteğinin farklı ırklar arasındaki değişkenliği farklı tiplerinin ve yüzdelerinin bulunduğunu göstermektedir.

*Anahtar sözcükler:* Anjiyografi; koroner arter; çift tüplü bilgisayarlı tomografi; sinoatriyal nod arteryel desteği.

Many reports of angiographic studies, about the shape and course of the sinoatrial node (SAN) artery, can be seen in the literature.[1-6] The unusual course and proximity to the left atrial wall predispose this vessel to injury during cardiac interventions. Our basic aim is to describe the SAN artery and to define the typical

*Received:* June 1, 2009 *Accepted*: March 3, 2010

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anatomy and rare variations of this arterial supply in the Turkish population noninvasively by dual-source computed tomography (CT). Accurate anatomic imaging of this blood supply can influence planning for catheter based or surgical interventions to this site.[7]

## PATIENTS AND METHODS

We conducted a retrospective analysis in 107 consecutive patients who were referred for suspicion of having coronary artery disease. All patients had electrocardiographically gated multidetector CT coronary artery angiography examinations between January 2006 and January 2008 and all these examinations were performed with a dual-source CT scanner (Somatom Definition, Siemens Medical Solutions, Germany).

Only 98 patients of 107, who had adequate image quality for evaluating the SAN artery were included. Mean heart rate before data acquisition was 67 beats per minute (range; 52-89 beats per minute). Premedications for regulating heart rate or for sedation were not used. Contrast enhancement was achieved by using 80 ml of iohexol (non-iodinated contrast agent) injected at a rate of 5 ml/sec followed by an injection of 40 mL of saline flush at a rate of 4 mL/sec through an 18-gauge catheter into an antecubital vein. The CT scan parameters were as follows: collimation, 64x0.5 mm; table feed per rotation, 7.2 mm; gantry rotation time, 400 msec; tube voltage, 140 kVp; and tube current, 350-400 mA. Start delay was defined with bolus tracking in the ascending aorta at the level of the carina. Computed tomography scan start was automatically initiated after reaching the threshold of 150 HU. Retrospective electrocardiographically gated volumetric data sets were acquired during a single breath hold (mean scan time was 11.5 seconds). Transverse sections were reconstructed in synchronization with the electrocardiogram by using segmented image reconstruction algorithm. Systolic and diastolic images were reconstructed at 10, 20, 30, 40, 50, 60, 70, 80, and 90 percent of the RR-interval. Transverse sections with a thickness of 0.5 mm, were generated by primary reconstruction. The data set least affected by cardiac motion was transferred to a special workstation. Multiplanar reformations of the transverse images were rendered and evaluated in consensus by four radiologists. Depending on the individual sinoatrial nodal branch anatomy, different visualization techniques -such as curved multiplanar reformation, maximum intensity projection, and three-dimensional reconstruction with dedicated tissue sculpturing- were used (Fig. 1). Images were analyzed for the origin, anatomic course and number of vascular (arterial) supply to the SAN region. The distance of SAN artery origin from the right coronary artery (RCA) or from left circumflex (LCx) orifices, callibration at the proximal segment of it and variations were also noted.

## RESULTS

A single SAN artery which originates from the proximal 35 mm of the RCA was detected in 97 (91%) of cases. In another group; the origin was near the proximal 40 mm of LCx artery in four (4%). In 3% of cases, the SAN artery originated directly from the RCA sinus and in 2%, the SAN artery was a branch originating from the conal branch of the RCA. Only one (1.02%) encircling SAN artery was detected. Twenty one percent of the cases had a retrocaval SAN artery course while the other courses were antecaval.

## DISCUSSION

Vascular anatomic descriptions of the SAN have been reported in several published articles in the literature.[3-6] To our knowledge, our study is the first to use dual-source

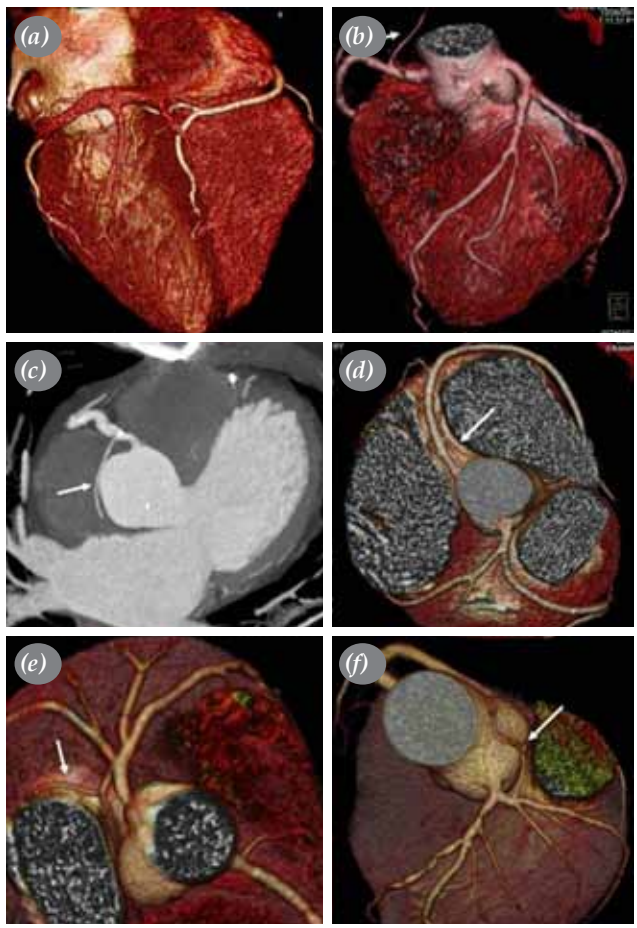


**Fig. 1.** Colored and curved planar reformat high resolution images show of the SAN supply. **(a)** It is possible to differentiate the arteries and veins of the heart in the same phase with different volume rendering color settings. **(b, c, d)** Antecaval course of the common type is seen through the anterior aspect VR, curved-planar and superior aspect VR images respectively. **(e)** circumcaval and **(f)** retroaortic (which originates from the left circumflex) are also well appreciated with high quality images. SAN artery pointed with arrow for each image. SAN: Sinoatrial node; VR: Volume rendered.

CT scanner to describe the anatomy of the SAN artery in the Turkish population.

In a study performed by Busquet et al.[8] a variable course of the sinoatrial nodal artery was found. That study also suggested a new classification schema of the SAN artery anatomy. According to the results of the mentioned study; precaval (58%), retrocaval (36%), and encircling (6%) SAN artery configurations were established. In our study; 21% of the cases had retrocaval SAN artery course and the other courses were all established as antecaval. The other literature data were also consistent with these mentioned ratios.[6,8] As a difference, a single SAN artery which originating from the proximal 35 mm of the RCA was detected in 89 (91%) of cases in our study. This course, which is the most common form detected in studies, was named as "typical course of SAN" and others were accepted as variations. In another group; the origin was in the proximal 40 mm of LCx artery in four (4%). Besides; in 3% of cases, the artery to SAN originated directly from the RCA valsalva sinus and in 2% of cases origination from the first conal branch were available. Only one (<1%) encircling SAN artery was detected.

The reason for the difference of our findings from the literature is thought to be inheritance. Considering that SAN arterial course may vary in different populations, dual-source multidetector CT depiction of the variable arterial blood supply to the SAN and the atrioventricular node may provide important information prior to planned surgical or catheter-based interventional cardiac procedures in patients.

As it is known, retrocaval and relatively pericaval sinoatrial nodal arteries are prone to surgical trauma.[9-11] In our study, the rate of retrocaval course of sinoatrial nodal artery was less common (21%) compared to the literature (36%). The low ratio of retrocaval course, which is more prone to trauma, may be accepted as a good luck for the Turkish population.

In conclusion, dual-source cardiac CT imaging enables depiction of the anatomic course of the arterial blood supply to the SAN with excellent anatomic detail. Being variable between races, it is crucial to know the course of this artery especially prior to planning surgery or ablation related with the left atrial wall.

### Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

### Funding

The authors received no financial support for the research and/or authorship of this article.

## REFERENCES

1. Tanaka S, Lee HY, Mizukami S, Nakatani T, Chung IH. Posterior sinus node artery and accessory atrioventricular node artery arising by a common origin: a case report. Clin Anat 1998;11:106-11.
2. Kyriakidis M, Vyssoulis G, Barbetseas J, Toutouzas P. A clinical angiographic study of the arterial blood supply to the sinus node. Chest 1988;94:1054-7.
3. Berdajs D, Patonay L, Turina MI. The clinical anatomy of the sinus node artery. Ann Thorac Surg 2003;76:732-5.
4. Anderson KR, Ho SY, Anderson RH. Location and vascular supply of sinus node in human heart. Br Heart J 1979;41:28-32.
5. Sow ML, Ndoye JM, Lô EA. The artery of the sinuatrial node: anatomic considerations based on 45 injection-dissections of the heart. Surg Radiol Anat 1996;18:103-9.
6. Ortale JR, Paganoti Cde F, Marchiori GF. Anatomical variations in the human sinuatrial nodal artery. Clinics (Sao Paulo) 2006;61:551-8.
7. Saremi F, Channual S, Abolhoda A, Gurudevan SV, Narula J, Milliken JC. MDCT of the S-shaped sinoatrial node artery. AJR Am J Roentgenol 2008;190:1569-75.
8. Busquet J, Fontan F, Anderson RH, Ho SY, Davies MJ. The surgical significance of the atrial branches of the coronary arteries. Int J Cardiol 1984;6:223-36.
9. Nerantzis C, Avgoustakis D. An S-shaped atrial artery supplying the sinus node area. An anatomical study. Chest 1980;78:274-8.
10. Abuin G, Nieponice A, Martinez S, Fernando C. The role of atrial vessels in aortic root and mitral valve operations. Ann Thorac Surg 2000;70:1234-7.
11. Futami C, Tanuma K, Tanuma Y, Saito T. The arterial blood supply of the conducting system in normal human hearts. Surg Radiol Anat 2003;25:42-9.