JACC: CASE REPORTS VOL. 28, 2023

CASE REPORT

CLINICAL CASE: DAVINCI CORNER

Understanding Cardiac Anatomy and Imaging to Improve Safety of Procedures

The Sinus Node Artery

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ABSTRACT

The sinus node artery can originate from either the right or the left coronary arteries, or even both, and follows a variable course. Being aware of these important variations is of clinical significance during open heart surgery and catheter ablation procedures to avoid injury to the artery. (J Am Coll Cardiol Case Rep 2023;28:102124) © 2023 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

The sinus node artery perfuses the sinus node, the heart's pacemaker. In humans, its arterial supply can originate from either the right or the left coronary arteries, or even both, and follow a variable course to reach the sinus node.[1-5] These variations are of clinical significance for surgical approaches to the mitral valve[2,6] and catheter ablation procedures involving both atria,[3,7,8] wherein atrial incisions and ablations can damage the artery.[9] Inadvertent damage to the artery can be anticipated and avoided by careful review of preprocedural imaging when available and being aware of this possibility. In this report, we provide comprehensive anatomical and clinical images of the sinus node artery and quantitative data from the Wallace A. McAlpine MD Collection (**Figures 1 to 10**).

LEARNING OBJECTIVES

- To appreciate the variations in the course of the sSNA.
- To understand the frequency of each variation of the SNA.
- To recognize the risk of injury to the SNA during cardiac surgery or catheter ablation.

ACKNOWLEDGMENTS The authors thank the individuals who donated their bodies and tissues to advance education and research. The authors thank the OneLegacy Foundation and the NIH SPARC Program, which formed the basis for obtaining donor hearts for research and for funding this effort. They are also grateful to all the staff members of Translational Pathology Core Laboratory at UCLA for their support for histological preparation. They appreciate their research operations manager, Amiksha S. Gandhi, for her dedication to support their projects.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received August 20, 2023; revised manuscript received October 11, 2023, accepted October 17, 2023.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2023.102124

ABBREVIATIONS AND ACRONYMS

SNA = sinus node artery

FUNDING SUPPORT AND AUTHOR DISCLOSURES

This work was made possible by support from National Institutes of Health grants OT2OD023848 and P01 HL164311 to Dr Shivkumar and supported by the Amara Yad Program (https://www.uclahealth.org/medical-services/heart/arrhythmia/about-us/amara-yad-project). The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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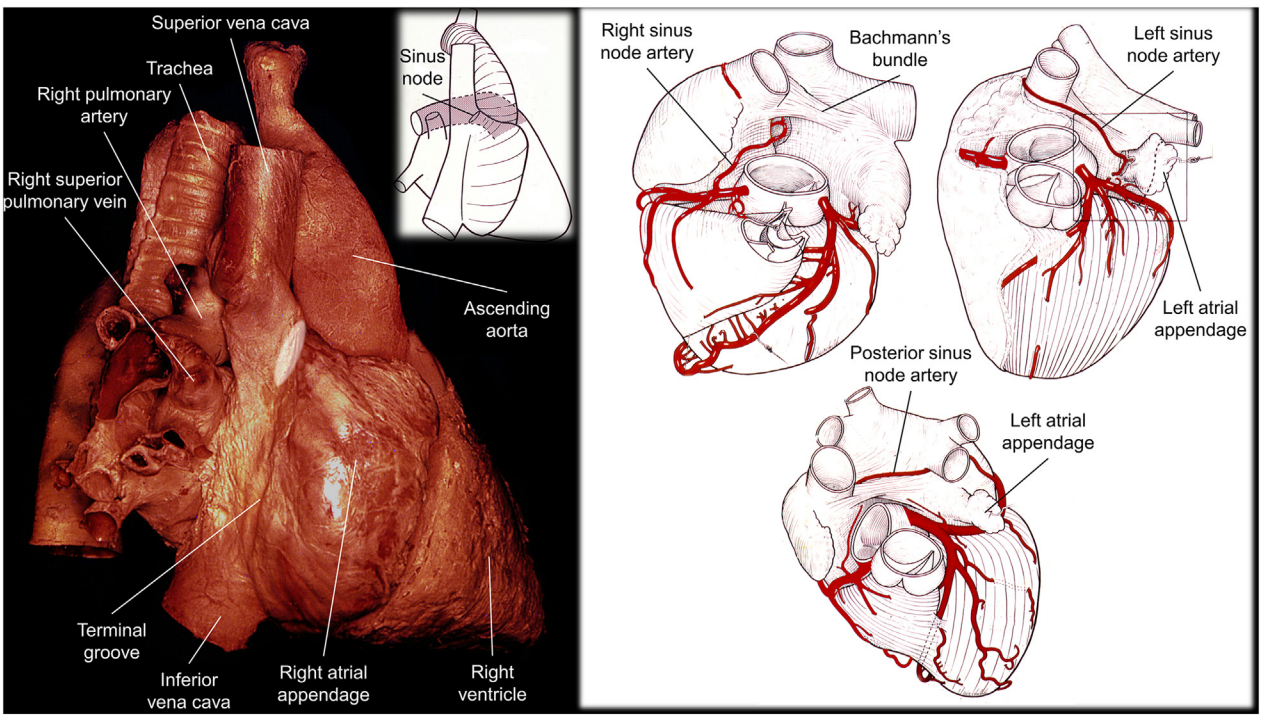
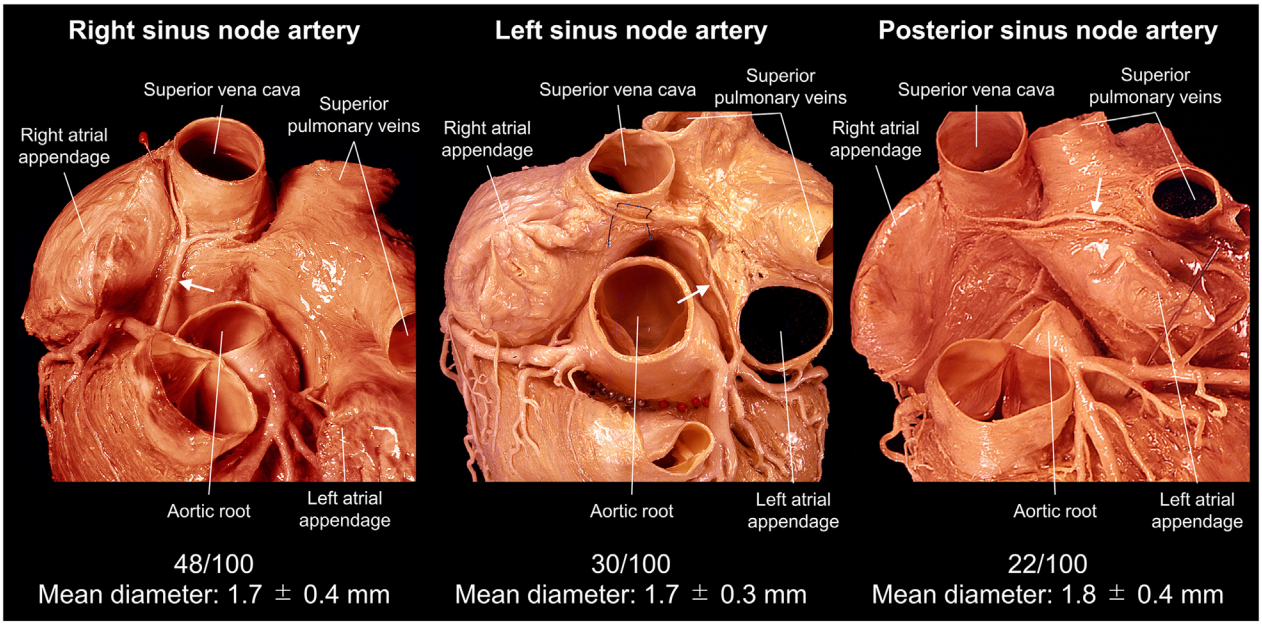
FIGURE 1 Location of the Sinus Node and the 3 Patterns of the Sinus Node Artery



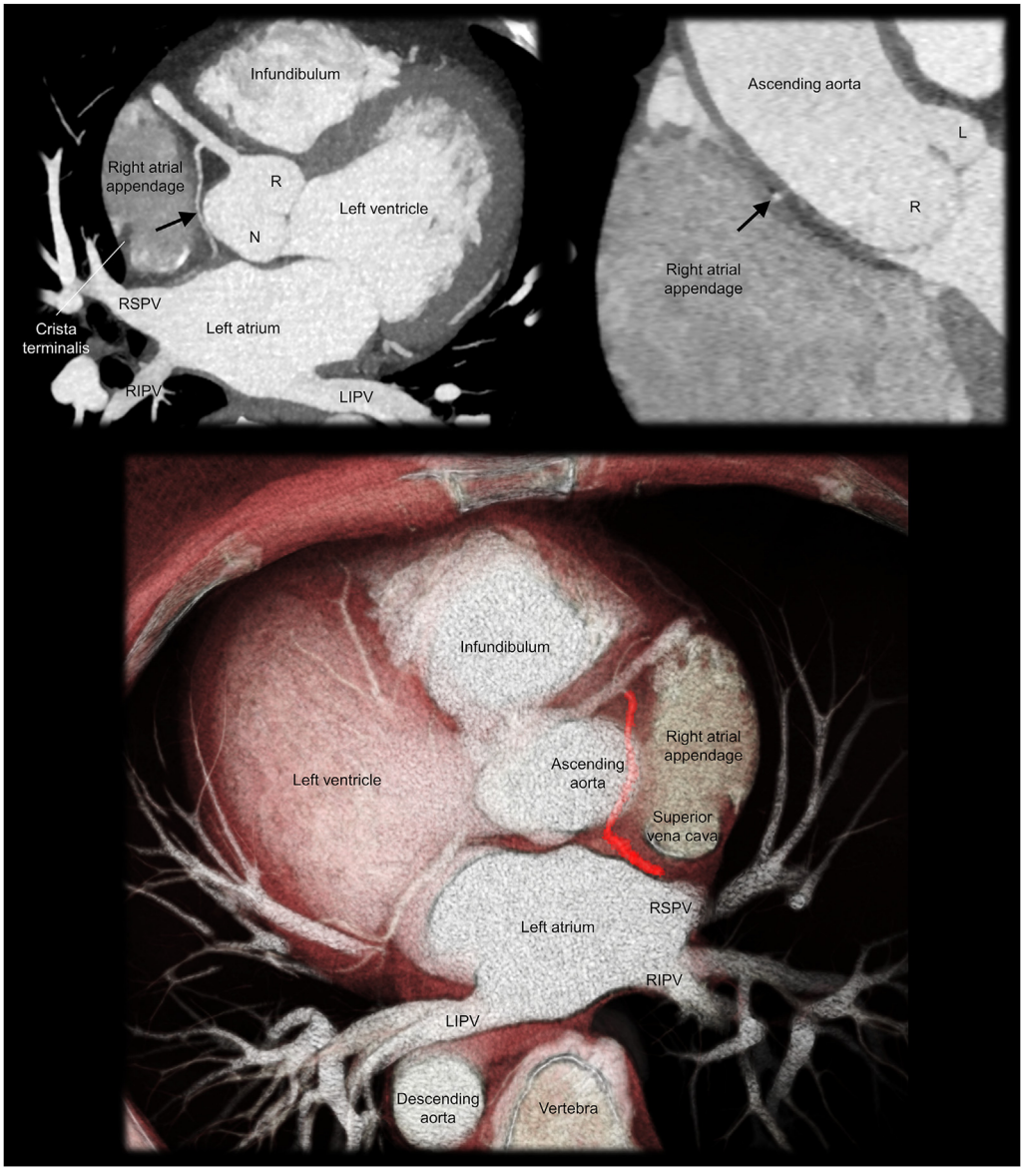
The left panel shows right lateral view and of the location of the sinus node (solid ellipse). The right panel demonstrates 3 patterns of the sinus node artery (refer to Figure 2). Images courtesy of the UCLA Cardiac Arrhythmia Center, Wallace A. McAlpine MD Collection.[1]

FIGURE 2 **3 Patterns of the Sinus Node Artery**



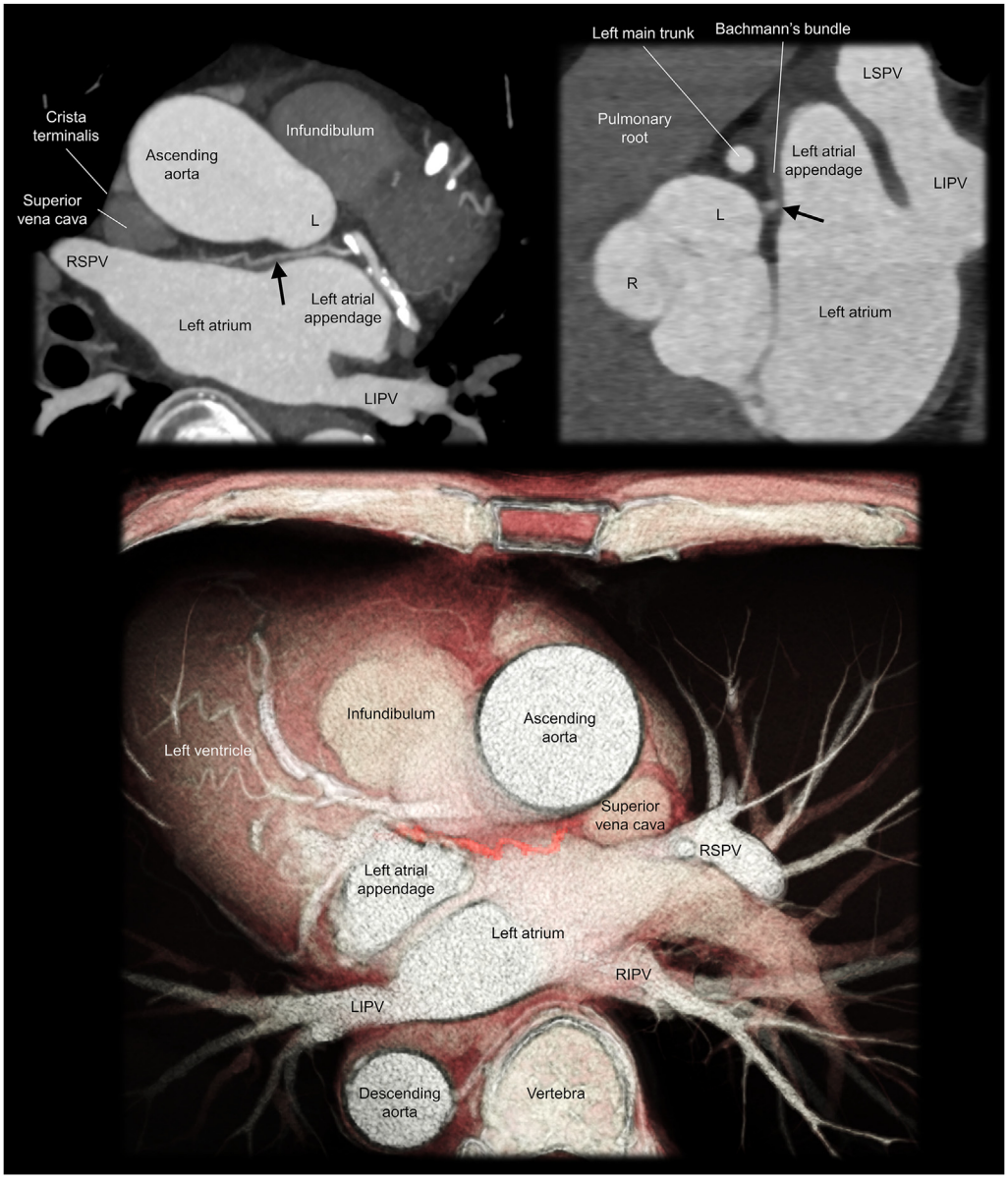
McAlpine described 3 patterns of the sinus node artery (arrows) from the100 hearts he analyzed and provided the prevalence of each pattern. Subsequent studies using cardiac computed tomography reported more right dominance; right sinus node artery (58.2% to 65.7%), left sinus node artery (21.5% to 30.7%), posterior sinus node artery (5.9% to 6.5%), and dual supply (4.2% to 5.9%). The termination of the sinus node artery is classified into retrocaval (47.5% to 49.4%), precaval (42.6% to 44.8%), and pericaval (5.8% to 9.9%).[4,5] Although both of the left and posterior sinus node arteries originate from the left circumflex artery, posterior sinus node artery with a S-shaped course[4,5] runs behind the left atrial appendage. Note that termination mode of the sinus node artery shows pericaval (right sinus node artery) and precaval (left and posterior sinus node arteries) patterns. Images courtesy of the UCLA Cardiac Arrhythmia Center, Wallace A. McAlpine MD Collection,[1] preserved and digitized at the University of California-Los Angeles. Demographic details of the persons/individual specimens were not available as a part of the collection.

FIGURE 3 Cardiac Computed Tomographic Imaging of the Right Sinus Node Artery



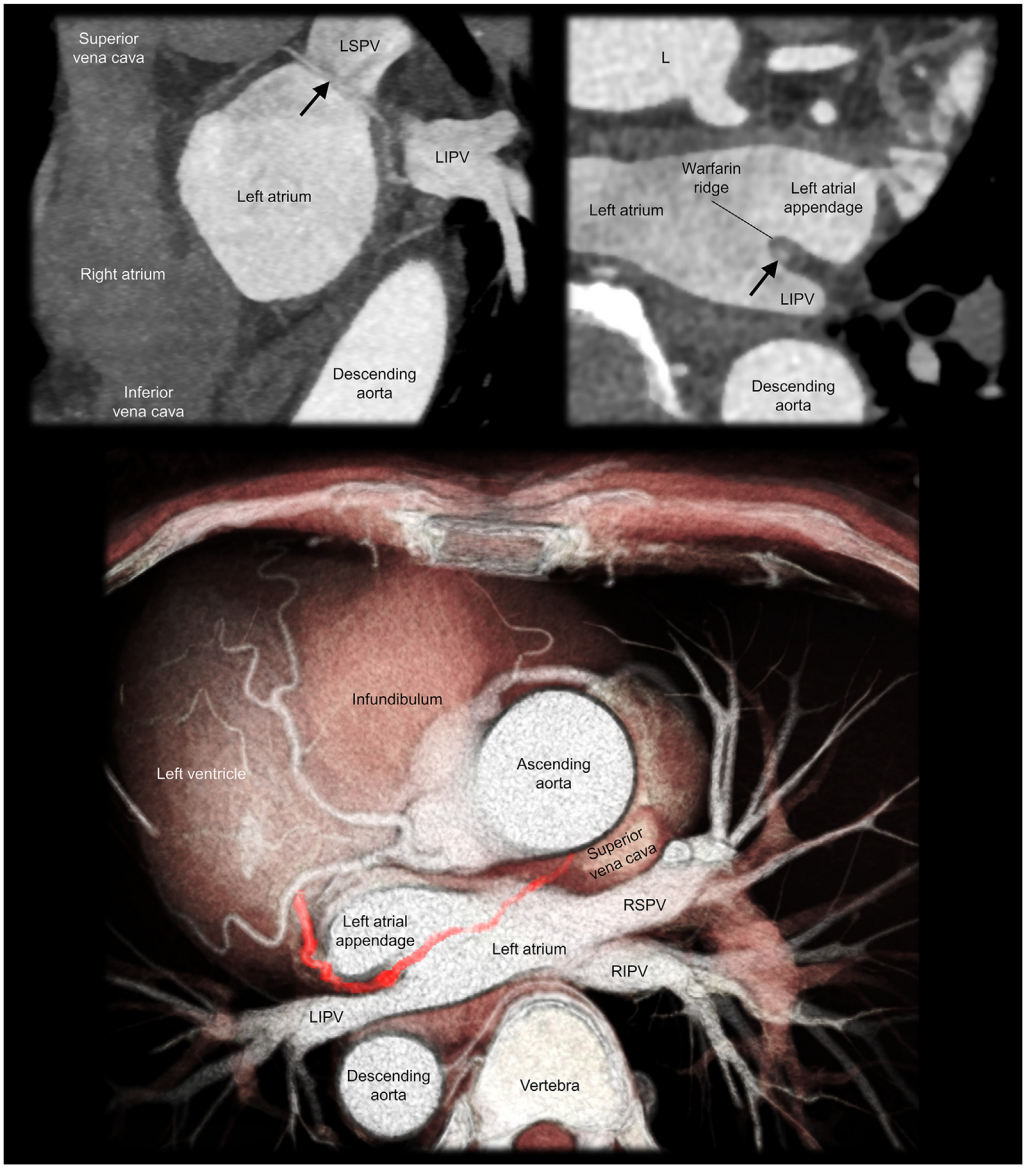
The right sinus node artery (arrows in upper panels) runs within the epicardial fat on the medial wall of the right atrial appendage. It is adjacent to the ascending aorta intervened by right side entrance/exit to the transverse sinus. Lower panel shows the right sinus node artery (red) with volume-rendered reconstruction (refer to Figure 2). L = left coronary aortic sinus; LIPV = left inferior pulmonary vein; N = noncoronary aortic sinus; R = right coronary aortic sinus; RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein.

FIGURE 4 **Cardiac Computed Tomographic Imaging of the Left Sinus Node Artery**



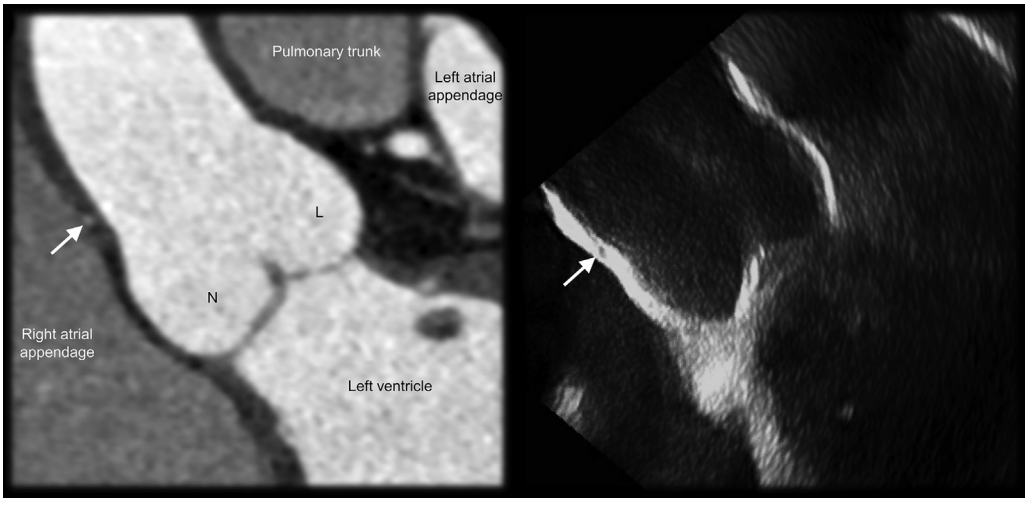
The left sinus node artery (arrows in upper panels) from the proximal left circumflex artery is located on the anterior wall of the left atrium. It is behind the aortic root intervened by the transverse sinus. Lower panel shows the left sinus node artery (red) with volume-rendered reconstruction (refer to Figure 2). Abbreviations as in Figure 3.

FIGURE 5 Cardiac Computed Tomographic Imaging of the Posterior Sinus Node Artery



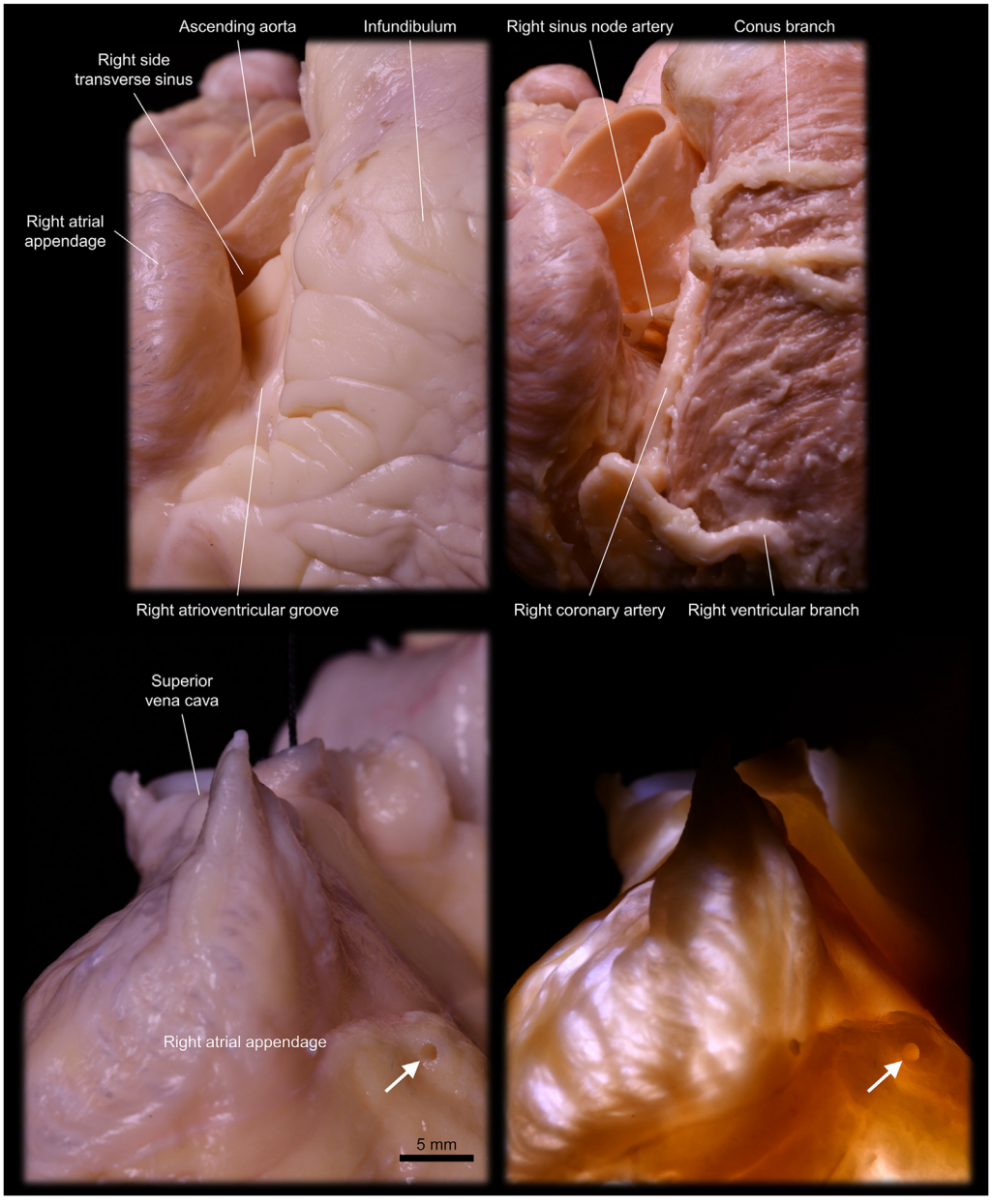
The posterior sinus node artery (arrows in upper panels) from the distal left circumflex artery is wedged in the warfarin ridge between the left atrial appendage and the left superior pulmonary vein. Lower panel shows the posterior (S-shaped) sinus node artery (red) with volume-rendered reconstruction (refer to Figure 2). Abbreviations as in Figure 3.

FIGURE 6 Representative Image of the Right Sinus Node Artery



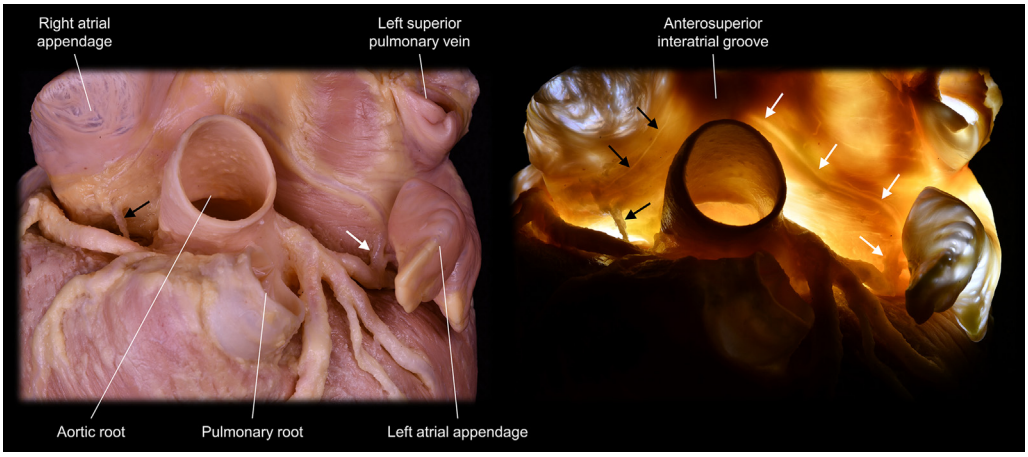
Comparative frontal section images obtained from the preprocedural cardiac computed tomography (left) and intraprocedural intracardiac echocardiography (right) showing the right sinus node artery (arrows). The echocardiographic probe is placed in the right atrial appendage. Basic anatomical knowledge (**Figures 1 and 2**) and preprocedural imaging (**Figures 3-5**) help select appropriate strategy before the planned procedure. Intraprocedural real-time imaging assures further safety for procedural guidance. In this regard, intracardiac echocardiography can visualize the sinus node artery with/without color Doppler capabilities, depending on the location of the probe. Visualization of the right sinus node artery is straightforward. It is expected to be located between the ascending aorta and right atrial appendage. Its presence or absence will inform operators about potential patterns of the sinus node artery (**Figures 1 to 5**). Absence of the right sinus node artery in this view should prompt the search for the left or posterior sinus node arteries, which guides subsequent procedural steps if the anterior wall of the left atrium is targeted for ablation. Visualization of the left and posterior sinus node artery patterns are challenging from the right atrium using intracardiac echocardiography and may require advancement of the probe into the left atrium. Abbreviations as in **Figure 3**.

FIGURE 7 The Sinus Node Artery Buried in Epicardial Fat of the Right Atrioventricular Groove



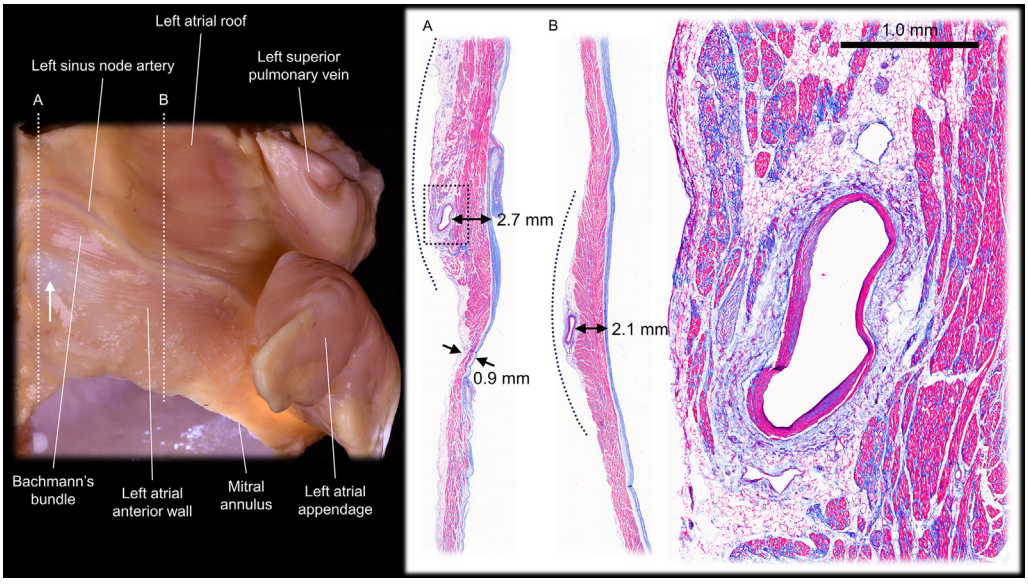
The left upper panel shows epicardial fat intact. The right sinus node artery from the proximal right coronary artery is exposed after extensive removal of the epicardial fat between the right atrial appendage and the right ventricular outflow tract (right upper panel). Lower panels with (right) and without (left) transillumination are the frontal view of the right atrial appendage. They demonstrate cross section of the right sinus node artery (arrows) running within the thin epicardial fat located on the medial wall of the right atrial appendage. Thus, the right sinus node artery faces to the ascending aorta intervened by the right-side entrance to the transverse sinus (Figure 6).

FIGURE 8 **Dual Sinus Node Artery**



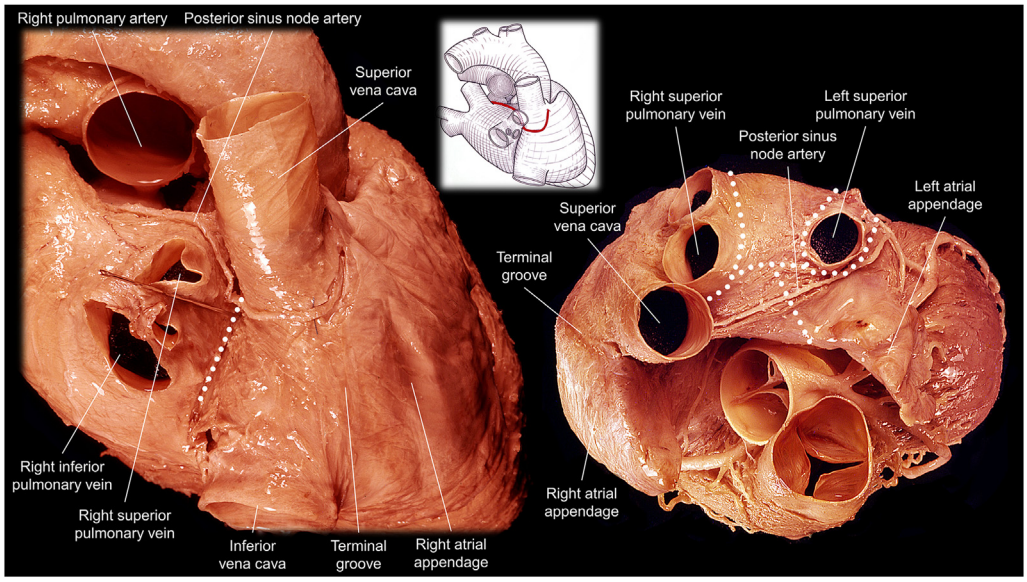
The left and right panels show the gross anatomical specimen and its transilluminated image, respectively. Black arrows and white arrows indicate the right and left sinus node arteries, respectively. The left sinus node artery is dominant in this heart. Both sinus node arteries run on/within the atrial wall facing to the transverse sinus behind the arterial trunks and direct toward the anterosuperior interatrial groove.

FIGURE 9 **Relationship of the Left Sinus Node Artery to the Left Atrial Wall**



The left panel shows the gross anatomical specimen (Figure 7), and the right panel shows the histological sections (Masson-Trichrome) along the white dotted lines A and B (left). The right panel also shows the magnified portion of the left sinus node artery (black dotted rectangle within section A). This short distance (<3.0 mm) from the endocardium to the left sinus node artery is within the zone of destruction of almost all ablative technologies that are used for catheter ablation of the left atrium, explaining the clinical occurrence of acute sinus node dysfunction following catheter ablation procedures in the left atrium. In addition to the simple distance from the endocardium, several other factors may either predispose or play a protective role in periprocedural sinus node artery injury. These include atrial wall thickness, relative location of the artery within the atrial wall, the caliber of the artery (heat sink effect), and fibrosis and epicardial fat around the artery. Black dotted curves denote area of the Bachmann's bundle. White arrow indicates the unprotected area[1] beneath the Bachmann's bundle where the wall thickness measures only 0.9 mm (myocardial thickness, 0.4 mm).

FIGURE 10 **Risk of Injury to the Sinus Node Artery During Surgery and Catheter Ablation**



The left panel shows the posterior sinus node artery (retrocaval termination pattern) originating from the left circumflex artery, where it could be injured by a surgical incision made along the posterior interatrial (Waterston's) groove (white dotted line) between the right pulmonary veins and sinus venarum. The right panel also shows the posterior sinus node artery from the left circumflex artery, where it could be damaged by some ablation lines (white dotted lines), including the one across the anterior wall and the one near the fold between the left atrial appendage and left superior pulmonary vein. Surgical maze procedure[9] can also injure any of the sinus node arteries. Around the orifice of the left atrial appendage (**Figures 4 and 5**), pulmonary vein isolation and percutaneous occlusion or surgical ligation of the left atrial appendage can injure the left and posterior sinus node artery. These images indicate the importance of pre- and intraprocedural assessment of the variable course the sinus node artery can take in order to personalize the approach for each procedure (refer to **Figure 5**). Images courtesy of the UCLA Cardiac Arrhythmia Center, Wallace A. McAlpine MD Collection.[1]

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KEY WORDS **Amara Yad Project, anatomy, McAlpine collection, sinus node artery**