

A CINEANGIOCORONARIOGRAPHICAL STUDY OF THE IRRIGATION OF THE SINUATRIAL NODE AND PERINODAL AREA IN HUMAN HEARTS

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ABSTRACT

Since the initial description of the sinuatrial node and its vascularization, numerous studies have shown the importance of the sinuatrial nodal branch (SNA). In this work, we examined the anatomy of this atrial branch using cineangiography. We reviewed the records of 100 cineangiocoronariographies done between October 1991 and November 1992 in the teaching hospital of the Faculty of Medicine of Triângulo Mineiro. The records of patients with artificial pacemakers or who had undergone cardiac surgery were not included. All the records showed left anterior oblique and right anterior oblique projections of both coronary arteries. In 65% of the cases, the SNA occurred as a branch of the right coronary artery, and in 33% it derived from the left coronary artery. Double irrigation of the sinuatrial area was seen in 1% of the cases, and in 1% of the cases the SNA originated from the aorta. In 76.9% of the cases, the branch was of the medial anterior type and became less frequent in the distal part of the coronaries. There were no significant sex-related ($\chi^2 = 0.0092$), or racial ($\chi^2 = 0.1241$) differences. These findings were similar to those of studies based on anatomical or angiographic approaches. We conclude that the SNA can arise from any coronary artery, with no single, specific origin, and that there are no gender or race-related differences in this pattern.

Key words: cardiac stimulation, cineangiocoronariography, human anatomy, irrigation, sinuatrial node

INTRODUCTION

In 1906, Wenckebach affirmed that the electrical stimulus of the heart originated in the insertion area of the superior vena cava [10]. This observation subsequently led to the discovery of the sinuatrial node by Koch in 1906 [4] and was confirmed later by Keith and Flack, in 1907 [3]. The latter authors stated that the irrigation of this node originated from a specific arterial branch.

Although the irrigation of this region has been very well studied by various methods, in this work we investigated the arterial irrigation of the sinuatrial node and perinodal area in human hearts, using images obtained from cineangiocoronariographies of patients attended at hemodynamic service of the teaching hospital of the Faculdade de Medicina do Triângulo Mineiro (FMTM). This method allowed trace the irrigation profile of the sinuatrial node faster and more efficiently way.

MATERIALS AND METHODS

The cineangiocoronariographies used were done between October 1991 and November 1992 by the hemodynamic service of the teaching hospital of the Faculdade de Medicina do Triângulo Mineiro (FMTM). This study was approved by the institutional ethics committee. The 35 mm films were analyzed using a model 35 AX TAGARNO projector. One hundred films were selected, 62 of which were from male patients while 38 were from female patients. Eighty-four of the 100 films were from white patients, 14 were from dark-skinned mixed race (here called mulatto) the patients and two from black patients, as classified by the hospital patients registry.

The main interest in this investigation was to identify the atrial branches that terminated in the sinuatrial node and perinodal areas. For this, the following principles were used:

- a) The only films analyzed were of patients who had not undergone any cardiac surgery, heart pacemakers implantation or angioplasty. The patients included in this study had experienced no cardiac trauma and no atrial cardiopathies.
- b) Since, in most cases, the investigated arteries stemmed from the right or left coronary arteries, or from one of their branches, we did not use all of the films if there was evidence of total blockage in some of these arteries or branches.
- c) Recognition of the sinuatrial nodal branch and perinodal branches required the use of the left anterior oblique and right anterior oblique incidences for both coronary arteries. Any film that did not show these incidences was excluded.

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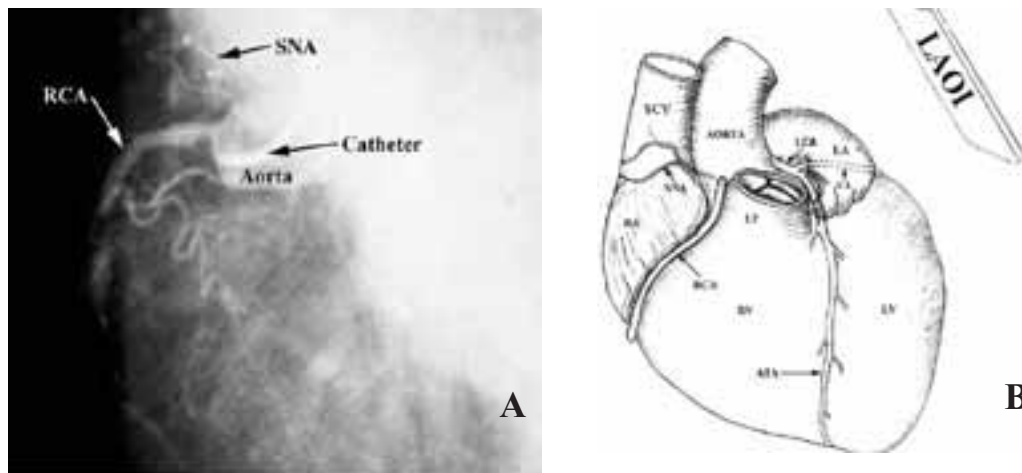


Figure 1. View from the left (A) and a scheme from the right (B) of the heart, in the left anterior oblique incidence (LAOI), showing the origin of the sinus node artery (SNA) that derives directly from the aorta. This artery crosses the transversal sinus of the pericardium to reach the anterior wall of the right atrium (RA), the cavo-atrial angle and the terminal furrow, the latter two formed by the junction of the superior vena cava vein (SVC) and the right atrium (RA). The SNA passes through the upper third part of the terminal furrow to irrigate the sinus node. AIA - anterior interventricular artery, CA - circumflex artery, LA - left atrium, LCA - left coronary artery, LT - lung trunk, LV - left ventriculium, RCA - right coronary artery, RV - right ventriculium, SVC - superior vena vein.

d) According to Lienhard *et al.* [6], and Verhaeghe and Hauwaert [7], the sinuatrial nodal branch is an important atrial branch with a highly inconsistent itinerary. However, when this branch reaches the proximities of the insertion of the superior vena cava it curves anterior or posterior in relation to this vein. Upon reaching the sinuatrial node, the caliber of this vessel decreases drastically and gives off small branches. This pattern was used to identify the sinuatrial nodal branch in the analyzed films.

e) The atrial branch was identified as the sinuatrial nodal branch only after its visualization in both incidences.

f) As also done by Kyriakidis *et al.* [5] and Viewge *et al.* [8], who studied cineangiogramographies, and Verhaeghe and Hauwaer [7] and Busquet *et al.* [1], who used anatomical sections, we did not discard the possibility of a double irrigation of the sinuatrial node and perinodal area when identifying the branches of the right and left coronary arteries that reached the sinuatrial node area simultaneously and fulfilled the established criteria.

The atrial branches implicated in the irrigation of this node were classified according to Wakefield and Didio [9], with slight modifications to simplify the nomenclature.

Statistical analysis of the data was done using frequency counts, comparison of the test of proportions and the chi-square test. A value of $p < 0.05$ indicates significance.

RESULTS

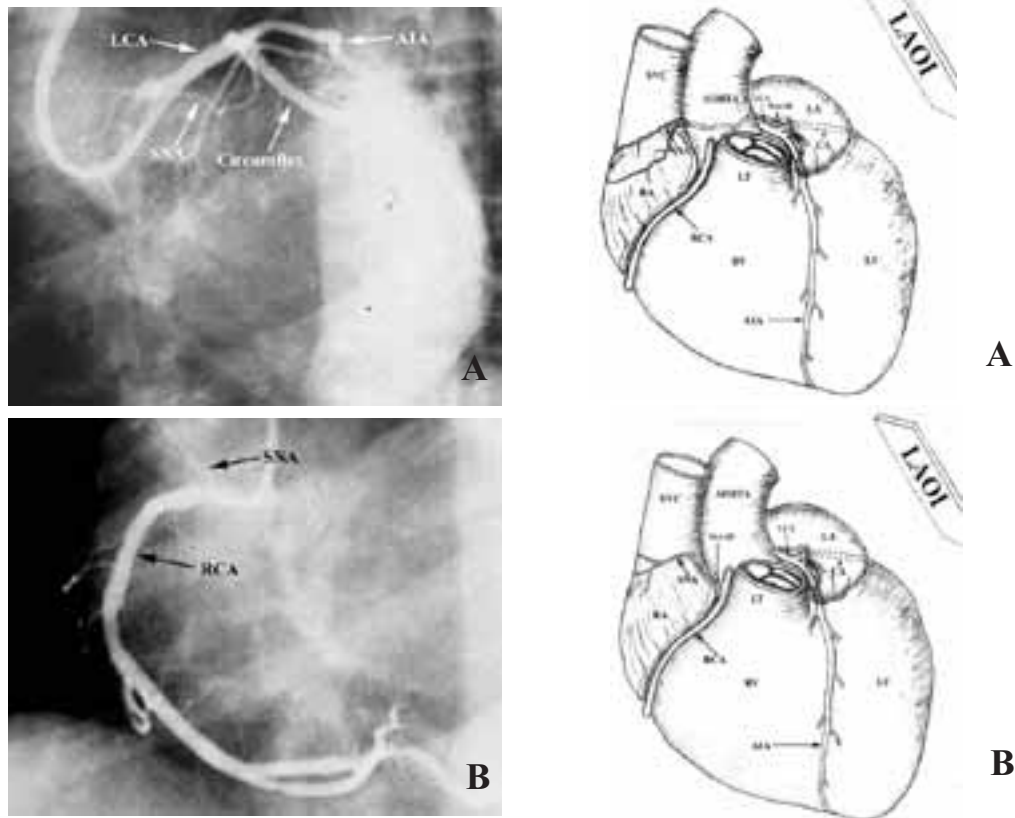
Among the 100 films analyzed, the sinuatrial nodal branch originated from the right coronary artery in 65% of the cases and from the left coronary artery in 33% of the cases; one case (1%) originated from the aortic artery (Fig. 1) and one case (1%) had double irrigation of the sinuatrial node area (Fig. 2A, B) that involved one branch each from the right and left coronary arteries.

Based on the classification of the atrial branches adopted here, the irrigation of the sinuatrial node area was as follows: in 76.9% of the cases, the irrigation involved branches that were of the medial anterior atrial type (MAAB) (Figs. 2B and 3), in 16% of the cases they were intermediate anterior atrial (IAAB) (Fig. 4), and in 7% of the cases they were lateral anterior atrial (LAAB) (Fig. 5). Branches that were of the lateral posterior atrial (LPAB) (Fig. 6) and medial posterior atrial (MPAB) (Fig 7) types each accounted for 1% of the cases.

Table 1 shows the different types of branches that irrigate the sinuatrial node area, relative to their origin from the right or left coronary arteries. Application the comparison test of proportions ($\alpha = 0.05$ and critical $Z = 1.96$) to these data yielded the following results:

a) For branches that originated from the right coronary artery: (1) Comparison of the proportions between MAAB and IAAB, yielded $Z = 7.23$, which indicated a significant difference between these branches; (2) Comparison of the proportion between IAAB and LAAB, yielded $Z = 1.46$. (no significant difference); (3) Comparison of the proportion between LAAB and LPAB, yielded $Z = 41.91$, indicating a highly significant difference between these branches; (4) Comparison of LPAB and MPAB, yielded $Z = 0$ (no significant difference).

b) For branches that originated from the left coronary artery: (1) Comparison of the proportion be-



Figures 2A and 2B. Double irrigation. **2A** - View from the left and a scheme from the right of the heart (in left anterior oblique incidence, **LAOI**) showing the double irrigation of the sinus node. The left medial anterior atrial artery (**MAAB**) derives from the circumflex artery (**CA**), of the left coronary artery (**LCA**) and passes through the anterior wall of the left (**LA**) and the right (**RA**) atrio, in the transversal sinus of the pericardium, to reach the cavo-atrial angle and the terminal furrow, both formed by the junction of the superior cava vein (**SVC**) and the right atrium (**RA**). The **MAAB** passes through the upper third of the terminal furrow to irrigate the sinus node through the sinus node artery (**SNA**). **2B** - Right medial anterior atrial artery (**MAAB**) originates from the right coronary artery (**RC**). **MAAB** passes through the anterior wall of the right atrium to reach the cavo-atrial angle to irrigate the sinus node. For other abbreviations, see Figure 1.

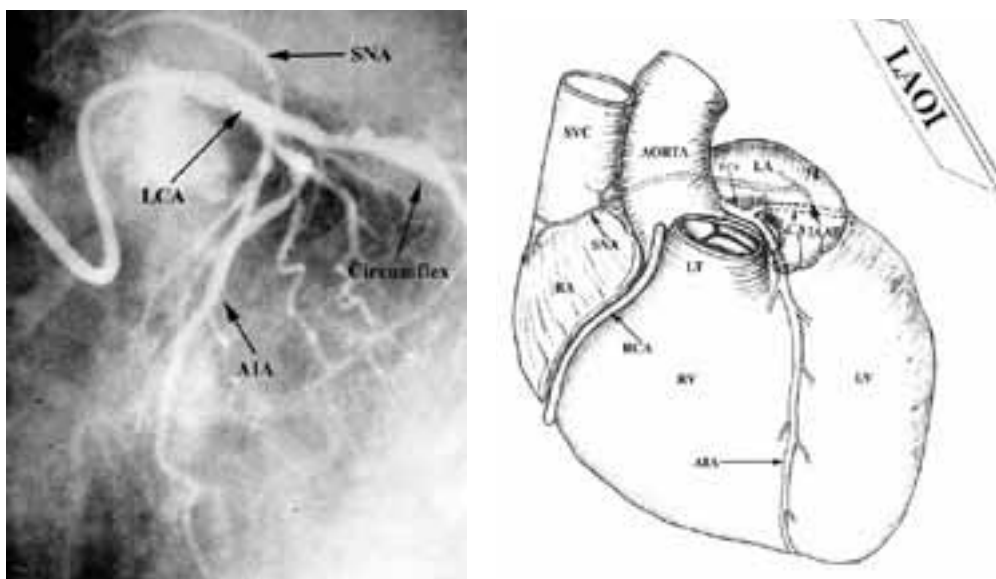


Figure 3. View from the left and a scheme from the right of the heart (in left anterior oblique incidence, **LAOI**), showing the left medial anterior atrial artery (**MAAB**), arising in the anterior wall of the right atrium (**RA**) to reach the cavo-atrial angle and the terminal furrow. For other abbreviations, see Figures 1 and 2.

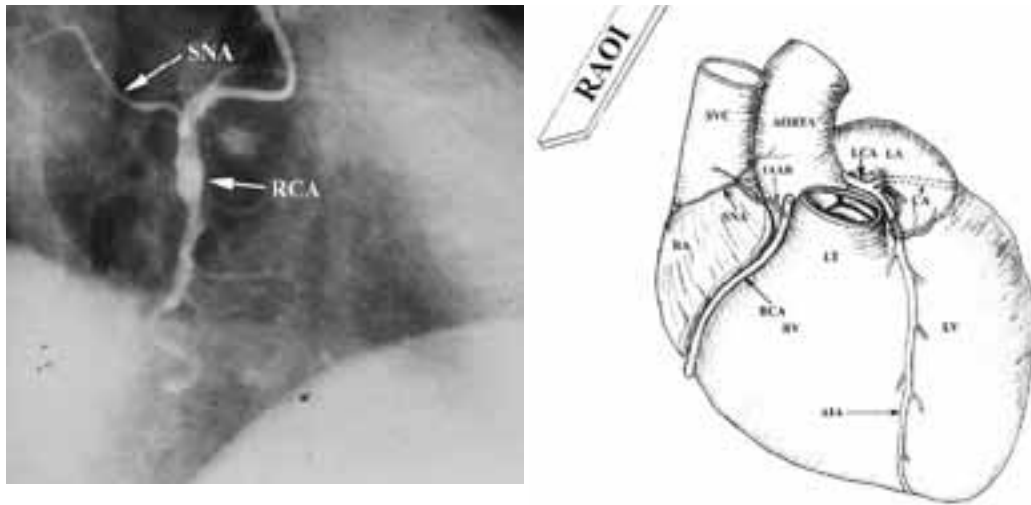


Figure 4. View from the left and a scheme from the right of the heart (in right anterior oblique incidence, (RAOI), showing the right intermediate anterior atrial artery (IAAB), which originates from the circumflex artery (CA), arising through the anterior wall of the right atrium (RA), to reach the cavo-atrial angle and the terminal furrow. For other abbreviations, see Figures 1 and 2.

tween MAAB and IAAB, yielded $Z = 3.94$, indicating a significant statistical difference between these branches; (2) Comparison of the proportion of IAAB and LAAB, yielded $Z = 14.43$, indicating a significant difference between these proportions.

Table 1. Frequencies of the different branches that irrigate the sinus node based on their origin from the right or left coronary arteries.

	Right coronary	Left coronary
MAAB	50 (76.9)	23 (69.7)
IAAB	9 (13.9)	7 (21.2)
LAAB	4 (6.2)	3 (9.1)
LPAB	1 (1.5)	-
MPAB	1 (1.5)	-

The values in parentheses refer to the percentages for a given coronary artery. **MAAB:** medial anterior atrial branch; **IAAB:** intermediated anterior atrial branch; **LAAB:** lateral anterior atrial branch; **LPAB:** lateral posterior atrial branch; **MPAB:** medial posterior atrial branch.

Table 2 shows the origin of the atrial branches that irrigate the sinuatrial node according to gender.

The chi-square test for these values, excluding the cases that originated in aorta and that showed double irrigation, yielded $\chi^2 = 0.0092$. Based on the critical value for this test (3.84), we concluded that the origin of the branches that irrigated the sinuatrial node was not influenced by gender.

Table 3 and 4 show the gender-related frequencies of the various branches that irrigate the sinuatri-

Table 2. Origin of the atrial branches according to gender.

	Female	Male
Right coronary artery	18 (47.4)	47 (75.8)
Left coronary artery	18 (47.4)	15 (24.2)
Aorta	1 (2.6)	-
Double origin	1(2.6)	-

Table 3. Frequencies of branches of the left and right coronary arteries according to gender.

	Female		Male	
	RC	LC	RC	LC
MAAB	13 (72.2)	13 (72.2)	38 (80.9)	10 (66.7)
IAAB	2 (11.1)	4 (22.2)	6 (12.8)	3 (20)
LAAB	2 (11.1)	1 (5.6)	6 (12.8)	2 (13.3)
LPAB	1 (5.6)	-	-	-
MPAB	-	-	1 (4.3)	-

RC: Right coronary; **LC:** Left coronary.

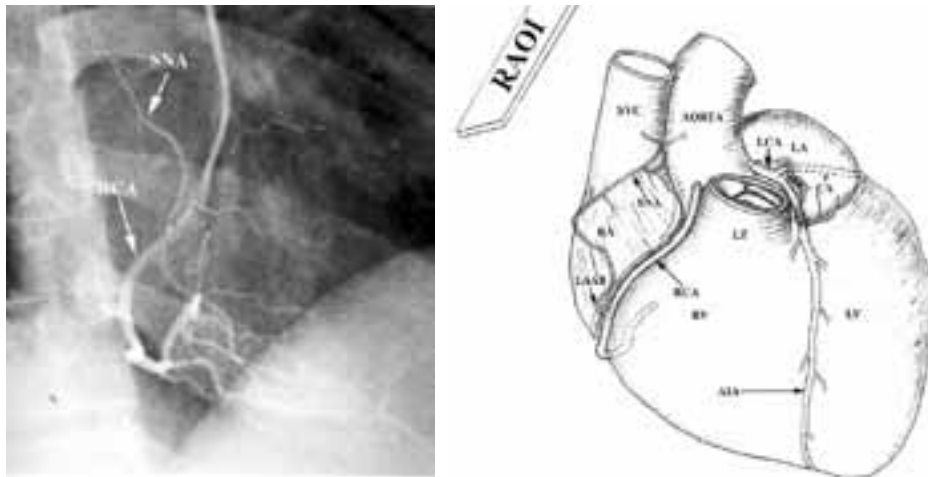


Figure 5. View from the left and a scheme from the right of the heart (in right anterior oblique incidence, (RAOI), showing the lateral anterior atrium artery (LAAB), which originates from the right coronary artery, rising through the lateral wall of the right atrium to reach the terminal furrow. The LAAB passes through it until the cavo-atrial angle, to irrigate the sinus node, via the SNA. For other abbreviations, see Figure 1.

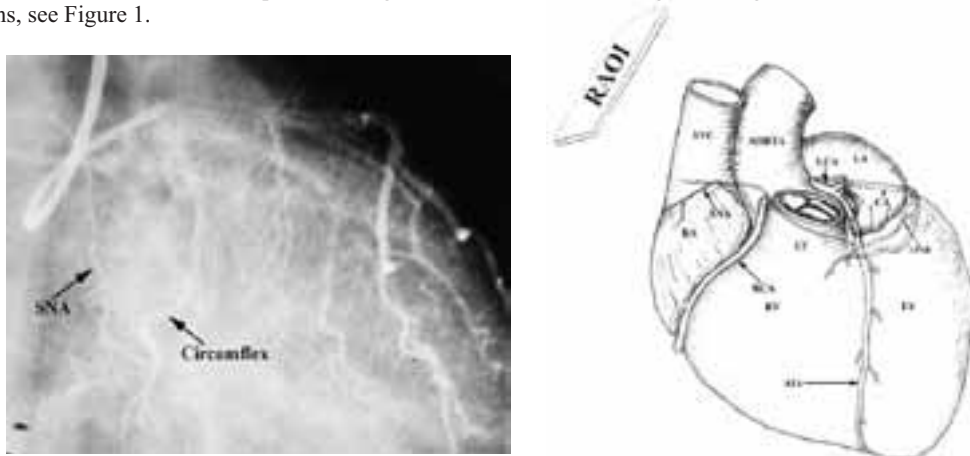


Figure 6. View from the left and a scheme from the right of the heart (in right anterior oblique incidence, (RAOI), showing the left posterior lateral atrial artery (LPAB), which originates from the circumflex artery (CA) crossing the posterior wall of the left (LA), and right (RA) atriums, through the antecava branch, reaching the cavo-atrial angle to irrigates the sinus node via the SNA. For other abbreviations, see Figure 1.

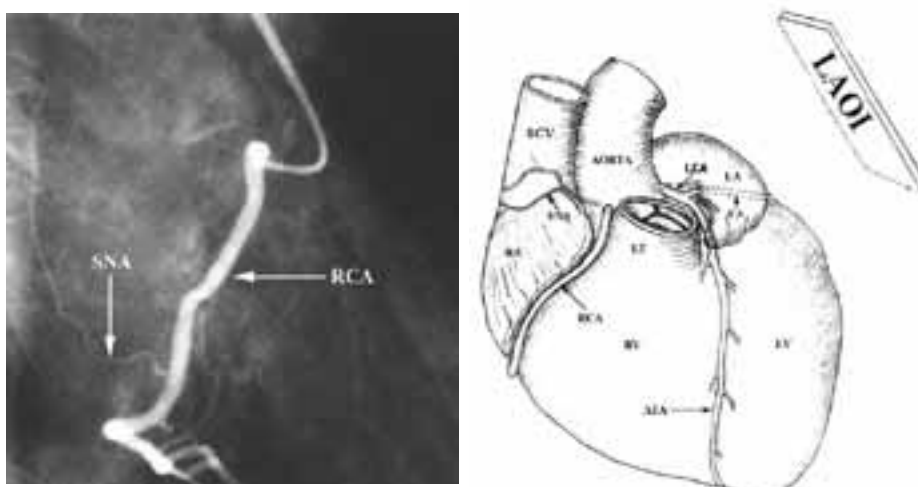


Figure 7. View from the left and a scheme from the right of the heart (in right anterior oblique incidence, (LAOI), showing the right posterior medial atrial artery (MPAB), which originates from the right coronary artery (RCA), rising through the posterior wall, and then through the lateral wall of the right atrium (RA), reaching the terminal furrow to irrigate the sinus node via the SNA. For other abbreviations, see Figure 1.

Table 4. Origin of the atrial branches according to race.

	White patients	Mulatto patients	Black patients
Right coronary artery	57 (67.9)	6 (42.9)	2 (100)
Left coronary artery	25 (29.8)	8 (57.1)	-
Aorta	1 (1.2)	-	-
Double origin	1 (1.2)	-	-

Table 5. Frequencies of branches of the left and right coronary artery according to race.

	Patients					
	White		Mulatto		Black	
	RC	LC	RC	LC	RC	LC
MAAB	43 (75.5)	17 (68.0)	5 (83.3)	5 (62.5)	2 (100)	-
IAAB	8 (14.0)	5 (20.0)	1 (16.7)	3 (37.5)	-	-
LAAB	4 (7.0)	3 (12.0)	-	-	-	-
LPAB	1 (1.8)	-	-	-	-	-
MPAB	1 (1.8)	-	-	-	-	-

RC: Right coronary; LC: Left coronary.

al node according to their origins in the right and left coronary arteries, respectively.

Table 5 shows the origin of the sinuatrial nodal branches in relation to race. The chi-square test for these values, excluding the cases that originated in aorta and that showed double irrigation, yielded $\chi^2 = 0.1241$. Based on the critical value for this test (5.99), we concluded that the origin of the branches that irrigated the sinuatrial node area was not influenced by race.

Table 6 and 7 show the race-related frequencies of the various branches that irrigate the sinuatrial node according to their origins in the right and left coronary artery, respectively.

DISCUSSION

As shown here, in 65% of the cases, the sinuatrial nodal branch originated from the right coronary artery and, in 33% of the cases, this vessel derived from the left coronary artery. These values were similar to those reported by Caetano *et al.* [2], Kyriakidis *et al.* [5], and Wakefield and Didio [9], who observed frequencies of 58%, 59% and 64%, respectively, for vessels originating from the right coronary artery and 42%, 38%, 36%, respectively, for vessels from the left coronary artery.

The branches of the coronary artery that irrigated the sinuatrial node originated mainly from the medial anterior area of arteries. Generally, the more distal the origin of the atrial artery in both of these coro-

nary arteries, the less frequent the branching to the sinuatrial node. This relationship was also reported by Caetano [2] and Wakefield and Didio [9].

The lack of an influence of gender and race on vessel branching to the sinuatrial node agreed with observations by Caetano [2]. However, there was tendency for the branch to the sinuatrial node to originate more frequently from the left coronary artery in mulatto patients.

Two unusual cases of sinuatrial node irrigation were observed. In first case, the irrigation artery originated directly from aorta and the branch to the sinuatrial node arose beside the right coronary artery and behaved like a medial anterior atrial branch.

In the second case, the node was irrigated by two vessels of different origins, namely a medial anterior atrial branch of the right coronary artery and a medial anterior atrial branch of the left coronary artery. Both vessels reached the sinuatrial node area with all of the morphological characteristics of a normal sinuatrial nodal branch. This arrangement was also notes by Kyriakidis *et al.* [5] and Vieweg *et al.* [8], based on cineangiocoronariographies, and by Verhaeghe and Hauwaert [7] and Busquet *et al.*[1], based on an analysis of anatomical sections.

Our results permit to suggest that the SNA can arise from any coronary artery, with no single specific origin, and that there are no gender or race-related differences in this pattern.

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