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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Multidetector computed tomographic anatomy of the coronary sinus in patients with supraventricular reentrant tachycardia

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Abstract

Background: In a number of previous studies it has been observed that coronary sinus (CS) ostium was larger and cannulation was easier in patients with atrioventricular nodal reentrant tachycardia (AVNRT).

Aim: To investigate the size and morphology of CS in AVNRT patients and compare them to those of atrioventricular reentrant tachycardia (AVRT) patients and a control group using multidetector computed tomography (MDCT), which is a non-invasive technique.

Methods: Eighteen consecutive patients with AVNRT who were scheduled for catheter ablation in our institution constituted the study population. Sixteen patients with AVRT and 16 patients without supraventricular arrhythmia who underwent MDCT for other indications comprised the control group. A conventional transthoracic echocardiography was performed to all patients. The diameter of the CS at ostium as well as at 5, 10, and 15 mm inside the CS were measured on MDCT images. The CS was also categorised according to its morphology, as to whether it had a windsock shape or a tubular shape.

Results: The AVNRT, AVRT and control groups were similar with regard to age, gender, body surface area and echocardiographic parameters. The size of the CS ostium was 10.9 ± 3.0, 11.1 ± 3.9 and 12.5 ± 3.6 mm for the AVNRT, AVRT and control groups, respectively ($p = 0.393$). There was no significant difference in the size of the CS from the ostium until 15 mm into the CS between the AVNRT, AVRT and control groups. The number of patients with windsock or tubular CS morphology were also similar between the three groups.

Conclusions: Contrary to previous reports, the CS size and morphology of patients with AVNRT did not differ from that of AVRT or control patients.

Key words: coronary sinus, reentry tachycardia, computed tomography

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INTRODUCTION

Atrioventricular (AV) nodal reentrant tachycardia (AVNRT) accounts for about 60% of the patients presenting with paroxysmal supraventricular tachycardia. It is the result of functional dissociation of AV nodal conduction into a so-called 'fast pathway' and a 'slow pathway' [1]. Therefore dual AV nodal physiology is the electrophysiologic substrate of AVNRT, but the anatomic basis for this arrhythmia remains unknown [2, 3].

The coronary sinus (CS) has become a clinically important structure, especially through its role in providing access for different cardiac procedures [4]. Although not studied to the same extent as the coronary arteries, the coronary venous

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system is important in many electrophysiological procedures, including arrhythmia ablation, biventricular pacing, and deployment of cardiac devices [5–7]. There is heightened interest in the CS as an access point for interventionalists for ablation procedures of an arrhythmia source and for mapping [8, 9]. It has been observed in patients with AVNRT that the CS ostium is close to where a His-bundle electrocardiogram can be recorded and that CS cannulation from the femoral vein is easier than in patients with other forms of supraventricular tachycardia [10, 11]. The easier cannulation may be due to a larger size or a different morphology of the CS ostium. A larger CS ostium may stretch the normal atrial tissue around it, modifying the conduction characteristics of the periostial tissue and creating a potential zone of slow conduction and thus giving rise to dual AV nodal physiology or anisotropic conduction [12]. Consequently, the relationship between CS and AVNRT has been of interest to clinicians, and several studies into this topic have been published. Angiographic visualisation and intracardiac echocardiography were used to demonstrate CS anatomy in these previous studies, which showed conflicting results.

In this paper we aimed to investigate the relationship between CS morphology and AVNRT using a noninvasive visualisation technique, i.e. multidetector computed tomography (MDCT). This was proved to be as appropriate as other conventional imaging methods for demonstrating the coronary venous system.

METHODS

Study groups

The study population consisted of 18 consecutive patients with clinically documented AVNRT, who were scheduled for catheter ablation in the cardiology clinic of our hospital between April 2008 and April 2009. Sixteen patients with atrioventricular reentrant tachycardia (AVRT) and 16 patients without supraventricular arrhythmia who underwent MDCT for other indications comprised the control group. Neither the patient nor the control group had any structural heart disease. This study conforms with the Declaration of Helsinki and the local ethics committee of Ankara Numune Education and Research Hospital approved the study. Written informed consent was obtained from all patients. Electrophysiologic study was performed to all AVNRT (18 total, 13 female, mean age 45.8 ± 14.1) and AVRT (16 total, eight female, mean age 39.6 ± 10.9 years) patients. Curative therapy could be achieved by successful radiofrequency catheter ablation in all of the patients. Sixteen patients who underwent MDCT for other indications made up the control group (16 total, ten female, mean age 48.4 ± 13.3 years). The size and morphology of the CS were compared between these three groups. Sixteen (88.9%) patients had typical and two (11.1%) patients had atypical AVNRT. The localisation of accessory AV connections were as follows: four — left lateral wall, two — left posterior, two — right posteroseptal, one — left posterolateral, four — free left wall, one — right lateral, one — anteroseptal and one — para-hisian.

Multidetector computed tomography

Before MDCT, 100 mg metoprolol succinate was given to patients orally to maintain a heart rate of below 70 bpm. Intravenous bolus 5 mg of metoprolol was applied to patients who still had a heart rate above 70 bpm at the time of MDCT. The diameter of the CS ostium as well as the diameter at 5, 10 and 15 mm inside the CS, were measured. The CS was also defined according to its morphology whether it had a windsock shape or a tubular shape. CS morphology was defined as either a windsock shape if there was sudden tapering of the vessel (defined as tapering after 10 mm inside CS) or a tubular shape if there was gradual tapering of the vessel.

All MDCT examinations were performed with a 16-row MDCT scanner (Aquillion system, Toshiba Medical Systems, Otawara, Japan) during a single end-expiratory breath-hold of 46.3–39.5 s (median 42.3 s) in a supine position. A standardised examination protocol with 16 × 0.75 mm collimation, 1.5-mm table feed per rotation (normalised pitch: 0.375), and a gantry rotation time of 420 ms was used. Tube voltage was 120 kV with a tube current of 350 mA. Contrast material was administered via an 18-gauge needle in the right cubital vein. The scanning delay was determined by injection of a 20-mL test bolus with a flow rate of 4.5 mL/s and repeated scanning at the level of the aortic root. The time to peak enhancement plus 5 s was chosen as delay time. For vessel enhancement, 120 mL of nonionic contrast material (Ultravist 370 [iopromide], Schering) was injected at a flow rate of 4.5 mL/s. Both injections were followed by a 50-mL saline chaser injected at the same flow rate. The amount of contrast media was equal to the amount used in conventional MDCT coronary imaging. Average heart rate during the MDCT examination was 55.3 ± 3.6 bpm. Axial image series were reconstructed at 0–100% of the R-R interval in steps of 5% with an effective slice thickness of 1.25 mm and a reconstruction increment of 0.5 mm. All image series were transferred to an external workstation (Vitrea®) and analysed using the standard software package (Vital Images, Plymouth, MN, USA). From the image series presenting with the least motion artifacts, multiplanar reconstructions (MPR) and maximum intensity projections (MIP) along the course of the coronary veins and three-dimensional volume-rendering technique images (3D-VRT) were obtained. Image analysis was performed by an experienced radiologist blinded to the diagnoses of the patients, during ventricular end-systolic phase in which the CS had the maximal diameter [13], using all of the described image-display techniques (Fig. 1A, B). The imaging protocol exposed no extra amount of radiation compared to conventional MDCT coronary imaging, which is estimated to be 6.4 ± 1.9 mSv [14].

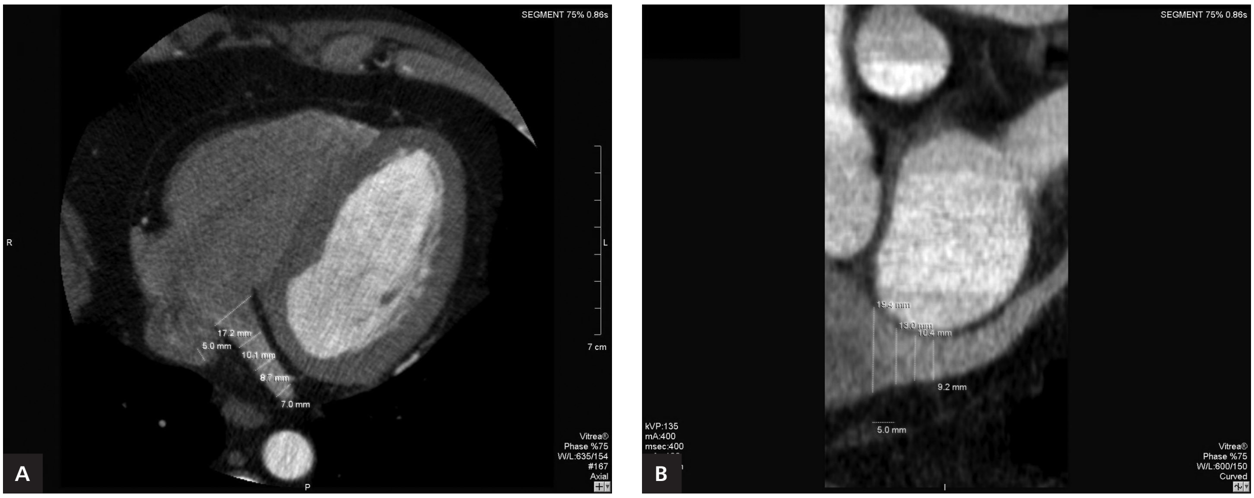

Figure 1. **A**, **B**. Multiplanar reformatted multidetector computed tomography images showing measurement technique of coronary sinus diameter

Table 1. Baseline characteristics and coronary sinus morphology in patients with AVNRT, AVRT and controls

	AVNRT (n = 18)	AVRT (n = 16)	Control (n = 16)	P
Age [years]	45.8 ± 14.1 (range 29–70)	39.6 ± 10.9 (range 25–71)	48.4 ± 13.3 (range 27–69)	0.147
Gender: female	13 (72.2%)	8 (50%)	10 (62.5%)	0.534
Body surface area [m²]	1.71 ± 0.17 (1.42–2.07)	1.83 ± 0.25 (1.44–2.28)	1.71 ± 0.19 (1.53–1.95)	0.274
Diabetes mellitus	3 (16.7%)	0	1 (6.30%)	0.244
Hypertension	5 (27.8%)	2 (12.5%)	5 (31.3%)	0.847
Coronary artery disease	2 (11.1%)	3 (18.8%)	5 (31.3%)	0.144
Thebesian valve	2 (11.1%)	1 (6.30%)	0	0.174
CS morphology:				
Windsock	9 (50%)	7 (43.8%)	9 (56.2%)	0.731
Tubular	9 (50%)	9 (56.2%)	7(43.8%)	
Left atrium [mm]	35.4 ± 3.8 (30–44)	35.8 ± 3.1 (31–39)	37.8 ± 3.4 (32–43)	0.295
LV EDD [mm]	46.6 ± 2.3 (44–50)	45.8 ± 4.4 (40–51)	48.4 ± 5.4 (40–56)	0.323
LV ESD [mm]	29.4 ± 2.9 (25–34)	29 ± 2.6 (24–32)	32.4 ± 6.8 (23–46)	0.170
LVEF [%]	66.8 ± 4.4 (60–75)	65.7 ± 3.0 (61–70)	62.3 ± 11.9 (30–75)	0.316

AVRT — atrioventricular reentrant tachycardia; AVNRT — atrioventricular nodal reentrant tachycardia; CS — coronary sinus; EDD — end-diastolic diameter; ESD — end-systolic diameter; LV — left ventricular; LVEF — left ventricular ejection fraction; PAP — peak systolic pulmonary artery pressure

Transthoracic echocardiography

Transthoracic echocardiographic evaluations were performed by an experienced observer using a standard sonographic system (Vivid 7 Pro, GE Vingmed Ultrasound, Horten, Norway) equipped with a 1.5–3.3 mHz phased-array sector probe. Left atrial size was measured at end-systole from the parasternal long-axis view. All echocardiographic measurements were made according to American Society of Echocardiography recommendations [15].

Statistical analysis

Statistical analysis was performed using SPSS version 11.0 (SPSS Inc, Chicago, IL, USA). Data was presented as mean ± standard deviation for continuous variables and differences between groups were assessed by unpaired samples t-test. Categorical variables were presented as percentages and were compared using Fisher exact test or χ^2 test. A p value < 0.05 was accepted as significant.

RESULTS

The baseline characteristics of the patients are shown in Table 1. There were 13, eight, and ten female patients and five, eight and six male patients in the AVNRT, AVRT and control groups, respectively. There was no difference in age, gender, frequency of diabetes mellitus, hypertension, echocardiographic parameters and basal surface area

Table 2. Comparison of coronary sinus diameters at different levels

	AVNRT (n = 18)	AVRT (n = 16)	Control (n = 16)	P
CS0 [mm]	10.9 ± 3.0	11.1 ± 3.9	12.5 ± 3.6	0.393
CS5 [mm]	8.3 ± 2.6	7.8 ± 2.7	8.9 ± 2.8	0.473
CS10 [mm]	6.9 ± 1.7	7.3 ± 2.3	7.9 ± 2.2	0.435
CS15 [mm]	6.4 ± 1.2	6.8 ± 2.2	7.1 ± 1.8	0.562

AVRT — atrioventricular reentrant tachycardia; AVNRT — atrioventricular nodal reentrant tachycardia; CS — coronary sinus

among the three groups. The ostial diameter of the CS did not change according to gender (10.9 ± 3.3 mm in females vs. 12.2 ± 3.9 mm in males, $p = 0.2313$). However, the ostial CS diameter of patients ≥ 40 years was significantly bigger than patients < 40 years (12.4 ± 3.2 mm vs. 9.9 ± 3.5 mm, $p = 0.0125$). The size of the CS ostium detected by MDCT was 10.9 ± 3.0 mm; 11.1 ± 3.9 mm and 12.5 ± 3.6 mm for AVNRT, AVRT and control groups, respectively ($p = 0.393$). There was no statistically significant difference between groups. Table 2 also shows the measurements of the CS diameter 5 mm, 10 mm and 15 mm into the CS. We did not find any statistically significant difference between the three groups in any part of the CS along ostium to 15 mm distance. The CS morphology (whether it was windsock or tubular shape) was also compared between the AVNRT, AVRT and control groups. Nine of the 18 patients in the AVNRT group had windsock CS, while the number of patients with windsock-shaped CS was seven in the AVRT group that consisted of 16 patients. Also nine out of 16 control patients had windsock morphology. Table 1 shows that no significant difference exists between the three groups with regard to CS morphology ($p = 0.731$). Two patients in the AVNRT group and one patient in the AVRT group had Thebesian valve. Thebesian valve was not seen in any patient in the control group ($p = 0.174$).

DISCUSSION

The aim of this study was to investigate the size and morphology of the CS in patients with AVNRT and to compare these findings to those of the AVRT and control groups. We found no significant difference in the size of CS from the ostium until 15 mm into CS between AVNRT, AVRT and controls. Age and body surface area were similar between the three groups to exclude other confounders that can affect the size and shape of coronary ostium. Furthermore, the CS morphology (windsock shape or tubular shape) did not differ between three groups.

Several studies have been published about this issue, and they have found conflicting results. Retrograde venography and intracardiac echocardiography were the methods of imaging in these studies. Doig et al. [11] compared 15 patients with AVNRT to controls. They found that the mean ostial diameter was 44% larger in patients with AVNRT than in the controls and that dilatation persisted at least 10 mm into the CS by using angiographic evaluation. The number of windsock shaped CS was also significantly higher in the AVNRT group. In contrast, Hummel et al. [16] observed no difference in the diameter of the CS os and morphology of the CS in a fluoroscopic comparison. DeLurgio et al. [17] used intracardiac echocardiography to evaluate the CS in patients with AVNRT. They compared the anatomy of the proximal CS and posteroseptal space in 11 patients with AVNRT to that in nine patients with other mechanisms of tachycardia and showed that CS anatomy did not differ between patients with and without AVNRT. However, the posteroseptal space was wider in patients with AVNRT. On the other hand, Okumura et al. [18] also studied the same topic by using intracardiac echocardiography and found that the area of the CS ostium was significantly larger in patients with AVNRT than in those without. In this study, there was also a strong evidence that atrial flutter was more inducible in patients with AVNRT. The remaining two studies also studied the relationship between AVNRT and CS by using selective CS angiography. Ong et al. [12] compared CS size and morphology in patients with typical AVNRT, atypical AVNRT and AVRT and showed that there was significant difference in the size of the CS from the ostium until 15 mm into the CS between typical AVNRT and AVRT and also between typical AVNRT and atypical AVNRT. Typical and atypical AVNRT patients had more windsock morphology CS compared to AVRT. On the other hand, Hiraoka et al. [19] demonstrated that patients with AVNRT had large CS ostial diameters compared to patients with AVRT and controls while there were no differences in distal diameters. As mentioned there have been six major studies about this topic which had conflicting results; the imaging methods used were either retrograde venography or intracardiac echocardiography.

To the best of our knowledge, this is the first study into the relationship between AVNRT and size and morphology of the CS to have used an alternative noninvasive technique: MDCT angiography. The usefulness of MDCT for visualisation of the coronary veins has already been shown. Mühlenbruch et al. [20] showed that MDCT was as effective as conventional angiography and was also less invasive in monitoring cardiac venous system [21]. In the previous studies there has been criticism that washout of contrast material from the proximal CS and an oblique fluoroscopic projection may result in underestimation of ostial diameter in conventional angiography. The MDCT technique used to measure CS diameter is adequate;

it is definitely better that performing direct CS angiography by direct contrast injection or late phase of contrast injection to dominant coronary artery, as the latter technique exposes patients to a significant amount of contrast medium and radiation. On the other hand, intracardiac echocardiography, which is an invasive procedure, seems to be more observer-dependent compared to MDCT. Therefore we designed this study to use an alternative method that has recently been shown to be as good as conventional angiography [20].

Our study showed similar results to that of Hummel et al. [16] and DeLurgio et al. [17]. CS size and anatomy did not differ between patients with and without AVNRT.

Limitations of the study

Our study has some limitations. First of all, a larger population of patients and controls could be enrolled. Confirmatory evidence of the measurements of CS by use of another imaging technique would have also been helpful, but the effectiveness of MDCT had already been shown and it would have been unethical to cannulate the CS in the patients who comprised the control group. Determining more anatomic structures like posteroseptal area or others around the CS also would help us to investigate relationships between mechanism of the tachycardia and the anatomic structure. Lastly, defining a morphology (wind-sock or tubular shape) could be subjective.

CONCLUSIONS

In patients with AVNRT, the CS size and morphology were similar to that in patients with AVRT and controls by using MDCT. Although in recent studies the morphologic variation of the CS was thought to be the anatomic substrate for dual AV nodal physiology in patients with AVNRT, the results of our study do not support this hypothesis. Further studies including a larger population of patients are needed. More interest in the anatomic structures around the CS will help us to identify the mechanism of the tachycardia patients with AVNRT.

Conflicts of interest: *none declared*

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Ocena budowy zatoki wieńcowej w wielodetektorowej tomografii komputerowej u chorych z nawrotnym częstoskurczem nadkomorowym

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Streszczenie

Wstęp: W wielu wcześniejszych badaniach obserwowano, że ujście zatoki wieńcowej (CS) było większe (co wiązało się z łatwiejszą kaniulacją) u pacjentów z nawrotnym częstoskurczem węzłowym (AVNRT).

Cel: Celem badania była ocena wymiarów i morfologii CS przy użyciu nieinwazyjnego badania metodą wielodetektorowej tomografii komputerowej (MDCT) u chorych z AVNRT oraz u pacjentów z nawrotnym częstoskurczem przedsionkowo-komorowym (AVRT) i u osób z grupy kontrolnej oraz porównanie uzyskanych wartości.

Metody: Grupa badana liczyła 18 kolejnych chorych z AVNRT skierowanych na przezcewnikową ablację do ośrodka autorów. Do badania włączono ponadto 16 pacjentów z AVRT i 16 osób bez nadkomorowych zaburzeń rytmu, u których istniały inne wskazania do przeprowadzenia MDCT; stanowili oni grupę kontrolną. U wszystkich pacjentów wykonano konwencjonalną echokardiografię przezprzełykową. Na podstawie obrazów MDCT określono wymiary CS na wysokości ujścia oraz 5, 10 i 15 mm w głąb. Autorzy określili kategorie budowy CS w zależności od tego, czy miała kształt stożkowaty, czy cylindryczny.

Wyniki: Grupy chorych z AVNRT i AVRT oraz grupa kontrolna były podobne pod względem wieku, płci, powierzchni ciała i parametrów echokardiograficznych. Wielkość ujścia CS wynosiła 10,9 ± 3,0; 11,1 ± 3,9 i 12,5 ± 3,6 mm, odpowiednio w grupach AVNRT, AVRT i w grupie kontrolnej (p = 0,393). Nie stwierdzono istotnej różnicy w wymiarach CS na odcinku od ujścia do 15 mm w głąb między poszczególnymi grupami. Liczba chorych, u których CS miała kształt stożkowaty lub cylindryczny, była również zbliżona we wszystkich grupach.

Wnioski: W przeciwieństwie do wcześniejszych doniesień, w niniejszym badaniu nie zanotowano różnic w zakresie wymiarów i budowy CS między chorymi z AVNRT a pacjentami z AVRT oraz osobami z grupy kontrolnej.

Słowa kluczowe: zatoka wieńcowa, reentry, częstoskurcz, tomografia komputerowa

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