Coronary Sinus Morphology in Patients with Posteroseptal Atrioventricular Accessory Pathways

Sou Takenaka MD, Yukiko Nakano MD, Hidekazu Hirao MD, Hiroki Teragawa MD, Tetsuji Shingu MD, Kazuaki Chayama MD

Department of Cardiology, Kurashiki Central Hospital, Kurashiki, Japan
Department of Medicine and Molecular Science, Division of Frontier Medical Science, Programs for Biomedical Research, Graduate School of Biomedical Sciences, Hiroshima University, Hiroshima, Japan
Department of Cardiology, Tsuchiya General Hospital, Hiroshima, Japan

Background: There have been numerous reports about coronary sinus (CS) anomalies related to posteroseptal accessory pathways (APs). The purpose of this study was to explore the diameter and morphology of CS in patients with posteroseptal APs.

Methods: We performed direct CS angiography in 105 patients with 22 posteroseptal APs and 83 APs in other regions, and 25 control subjects. We compared the diameter of the CS ostium in all subjects, and assessed the correlation of the local activation time in the patients with posteroseptal APs.

Results: The proximal size (diameter) of the CS in the patients with posteroseptal APs (13.6 ± 1.1 mm) was larger than that in the patients with other types of APs (10.2 ± 1.8 mm [p < 0.001]) and that in the control subjects (9.6 ± 1.5 mm [p < 0.001]). Dilatation of the CS in the patients with posteroseptal APs extended up to 20 mm inside the CS. In 15 (68%) of the patients with posteroseptal APs, the proximal site of the CS demonstrated a windsock appearance.

Conclusions: We concluded that the larger size and the wind cone appearance of proximal CS were unique structural characteristics in most patients with posteroseptal APs.

(J Arrhythmia 2006; 22: 149–154)

Key words: Wolff-Parkinson-White syndrome, Radiofrequency catheter ablation

Introduction

There have been numerous reports about coronary sinus (CS) anomalies related to posteroseptal accessory pathways (APs). Chiang CE et al. reported that some patients with APs in the left-free wall and posteroseptal area have CS abnormalities, such as an angulation, hypoplasia or diverticulum. Sun et al. showed that CS diverticula were found in 21% of patients with posteroseptal and epicardial

Received 5, January, 2006; accepted in final form 12, September, 2006.
Address for correspondence: Sou Takenaka MD, Department of Cardiology, Kurashiki Central Hospital, 1-1-1 Miwa, Kurashiki, 710-8602, Japan. Tel: 086-422-0210 Fax: 086-422-9551 E-mail: soutakenaka@yahoo.co.jp
In addition, in patients with atrioventricular nodal reentrant tachycardia, the CS ostium is prone to be larger than in those with other types of supraventricular tachycardias.\(^{10,11}\)

The purpose of this study was to explore the diameter and morphology of the CS in patients with posteroseptal APs.

**Methods**

**Patient selection**

The subjects of this study consisted of 105 patients (mean age 44 ± 18 years; 67 males and 38 female) with a single AP. Of these 105 patients, 22 had an AP located in the posteroseptal region (PSAP group). The posteroseptal accessory pathway location was defined as the pathway located around the CS over the inferoposterior one-third of Koch’s triangle, within 1 cm adjacent to the CS ostium over the inferomedial aspect of the right atrium or 2 cm to the left of the CS ostium at the crux area over the posterior medial mitral annulus.\(^{12–14}\) The other 83 patients (other AP group) was comprised of 63 patients with APs in the left free wall, 13 in the right free wall, and 7 in the anteroseptal wall. Twenty-five control subjects (control group; 15 males and 10 females; mean age: 45 ± 17 years) consisted of patients admitted for the evaluation of chest pain, or ventricular tachycardia. Written informed consent for participation was obtained from all patients before the procedure, and all procedures were carried out according to the protocol approved by the Ethics Committee of the Hiroshima University Faculty of Medicine.

**CS morphology**

Direct CS angiography was performed prior to the electrophysiological study. The CS was cannulated with a 7 Fr RESPONSE\(^{\text{TM}}\) decapolar CS electrode catheter with a lumen (St. Jude Medical, Daig Division, MN, USA) or a 6 Fr Goodale-Lubin catheter (Medtronic, MA, USA) via the right subclavian vein or right jugular vein. About 8 ml of contrast medium was injected into the CS. Images of the CS were obtained in the projections (30° right anterior oblique and 50° left anterior oblique views) during sinus rhythm and stored on cine film. The size and shape of the CS were measured in all patients with APs and in the control subjects.\(^{15}\)

We analyzed and compared the shape and diameter of the CS. (1) Shape of the CS: We closely investigated the presence of CS abnormalities, such as an angulation, hypoplasia, or diverticulum of the CS\(^1\). In addition, the shape of the CS was classified into the 2 groups (windsock and tubular appearance), previously described by Doig et al.\(^{10}\) (2) CS diameter: We measured the diameter at 5 mm and 10 mm locations inside the CS ostium and subsequently at 10-mm intervals along the rest of the CS and great cardiac vein, up to the origin of the anterior interventricular vein, based on previous published criteria.\(^{13}\) The orifice of the CS was defined as the point at the atrial septum above and below the ostium, which was outlined by contrast flowing out of the vessel and the long axis of the proximal portion of the CS as it entered the right atrium. Measurements were made in a frame that provided the clearest image of the CS ostium at the ventricular end-systolic phase of the angiogram.

**Electrophysiological study**

An electrophysiological study was performed in all patients during the baseline, drug-free and unsedated state. Under local anesthesia, four standard electrode catheters were placed at the high right atrium, His bundle region, and the right ventricular apex, and into the CS. Intracardiac electrograms were simultaneously recorded and stored digitally on a Cardiolab system\(^{\text{TM}}\) (Prucka Engineering Inc., TX, USA). We then performed the diagnostic electrophysiologic study. Intravenous isoproterenol, atropine, or both were used to facilitate the induction of tachyarrhythmias if necessary. Paradoxical capture, parahisian pacing and/or an ATP injection were used to rule out atrioventricular nodal tachycardia.\(^{11,15}\)

We also collected and compared the antegrade/retrograde effective refractory periods and the local activation time. The local activation time was defined as the atrioventricular or ventriculoatrial conduction time at the successful site.

**Radiofrequency catheter ablation**

Radiofrequency catheter ablation (RFCA) was conducted immediately after the diagnostic electrophysiologic study. Successful results were defined as the disappearance of the AP conduction. The successful ablation sites were stored on cine film, and the AP location was classified.

**Statistical analysis**

All values are expressed as mean ± SD. The CS diameter was compared by using the unpaired t test. The baseline characteristics and comparisons of the shape of the CS among the PSAP group, other AP group and control group were performed with the chi-square test. \(P\) values less than 0.05 were considered statistically significant.
Results

Clinical characteristics
The clinical characteristics of the patients with APs is shown in Table 1. There were no significant differences between the PSAP group and other AP group. In the control subjects, 15 patients had angina pectoris, 2 hypertrophic cardiomyopathy, 4 idiopathic ventricular tachycardia, and the others chest pain syndrome.

CS anomaly
Major CS anomalies were identified in 6 (6%) of all patients with APs. Two patients had an angulation of the CS, 2 localized narrowing, 1 a CS-left atrial fistula, and 1 a diverticulum of the CS, all of which had a nice correlation between their locations and the successful ablation site. Five of those patients had left lateral APs and 1 had a posteroseptal AP. In this study, the control subjects had no CS anomalies.

CS diameter
The CS angiographic measurements are shown in Table 2. The proximal CS in the PSAP group was larger than that in the other AP group and control (13.6 ± 1.1 mm vs. 10.2 ± 1.8 mm [p < 0.001], and 9.6 ± 1.5 mm [p < 0.001], respectively). The dilatation of the CS in the PSAP group extended up to 20 mm inside the CS. There were no differences in these distal diameters (more than 20 mm inside the CS ostium, Table 2).

Table 1  Clinical characteristics.

<table>
<thead>
<tr>
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<th>PSAP n = 22</th>
<th>other AP n = 83</th>
<th>control n = 25</th>
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<tr>
<td>Male/Female</td>
<td>17/5</td>
<td>50/33</td>
<td>15/10</td>
</tr>
<tr>
<td>Age (years)</td>
<td>41 ± 18</td>
<td>45 ± 18</td>
<td>52 ± 20</td>
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<tr>
<td>Height (cm)</td>
<td>165 ± 10</td>
<td>167 ± 10</td>
<td>163 ± 14</td>
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<tr>
<td>Weight (kg)</td>
<td>72 ± 15</td>
<td>73 ± 12</td>
<td>76 ± 20</td>
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<td>Left Venticular Ejection Fraction (%)</td>
<td>62 ± 5</td>
<td>61 ± 6</td>
<td>53 ± 10</td>
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<tr>
<td>Coronary artery disease</td>
<td>2</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Hypertrophic cardiomyopathy</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Atrial septal defect</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Orthodromic reentrant tachycardia</td>
<td>17</td>
<td>78</td>
<td>—</td>
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<tr>
<td>Atrial fibrillation</td>
<td>3</td>
<td>15</td>
<td>2</td>
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<td>0</td>
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<tr>
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<tr>
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<td>0</td>
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<td>4</td>
</tr>
<tr>
<td>Syncope</td>
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Table 2  CS angiographic measurements.

<table>
<thead>
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<th></th>
<th>PSAP n = 22</th>
<th>other APs n = 83</th>
<th>control n = 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS os (mm)</td>
<td>13.6 ± 1.1*</td>
<td>10.2 ± 1.8</td>
<td>9.6 ± 1.5</td>
</tr>
<tr>
<td>CS 5 mm (mm)</td>
<td>10.5 ± 1.0*</td>
<td>8.4 ± 1.7</td>
<td>8.1 ± 1.8</td>
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<tr>
<td>CS 10 mm (mm)</td>
<td>8.7 ± 1.2*</td>
<td>7.2 ± 1.5</td>
<td>7.1 ± 1.5</td>
</tr>
<tr>
<td>CS 20 mm (mm)</td>
<td>6.9 ± 1.2*</td>
<td>6.0 ± 1.4</td>
<td>6.0 ± 1.3</td>
</tr>
<tr>
<td>CS 30 mm (mm)</td>
<td>5.8 ± 1.2</td>
<td>5.2 ± 0.9</td>
<td>5.4 ± 1.0</td>
</tr>
<tr>
<td>CS 40 mm (mm)</td>
<td>5.2 ± 0.9</td>
<td>5.2 ± 1.0</td>
<td>5.4 ± 0.8</td>
</tr>
<tr>
<td>CS 50 mm (mm)</td>
<td>5.0 ± 0.6</td>
<td>5.0 ± 0.7</td>
<td>5.1 ± 0.5</td>
</tr>
</tbody>
</table>

*: p < 0.05 vs other APs and control

CS morphology
The CS morphology is shown in Figures 1 and 2. In 15 patients (68%) in the PSAP group, the proximal CS had a windsock appearance (Figure 2A and 2B). This morphology was found in 16% of subjects in the other AP group (p < 0.001). In 96% of the control subjects, the CS was tubular (p < 0.001).

Electrophysiological study
Four patients of the PSAP group and 9 patients of the other AP group had multiple (more than 2 components) APs. During electrophysiological study, orthodromic reentrant tachycardia was induced in 13 patients of the PSAP group and in 78 of the other AP group (Table 1). The antegrade/retrograde effective refractory period of accessory pathway (327 ± 64 ms vs. 330 ± 50 ms; 296 ± 53 ms vs. 305 ± 82 ms) and the antegrade local activation time (45 ± 12 ms vs. 38 ± 13 ms) were no different between the 2 groups. The retrograde local conduction time was longer in the PSAP group than in the other AP group (39 ± 22 ms vs. 25 ± 10 ms, p = 0.02).

Radiofrequency catheter ablation
Successful ablation was achieved from CS diverticulum in 1 patient with posteroseptal AP, and from the endocardial approach in the other patients.

Correlation between the diameter of CS ostium and the local activation time
In the PSAP group, there was no correlation between the diameter of CS ostium and the antegrade (r = −0.13) and retrograde (r = 0.26) local activation time (Figure 3).

Discussion
The present study revealed a unique morphology of the CS in the patients with posteroseptal APs. The
proximal CS in those patients was significantly larger than in those with other types of APs and the control. In addition, those patients were prone to having a CS with a windsock appearance.

There have been several reports about cases of Wolff-Parkinson-White syndrome with posteroseptal APs associated with CS diverticula. Those anomalies included an angulation, hypoplasia, localized narrowing, fistula and diverticula, but did not include dilatation (windsock appearance) of the CS. In this study, we first demonstrated the relationship between the dilatation of the CS and the posteroseptal APs.

CS diameter and morphology
Recent studies have reported the relationship between the pathogenesis of arrhythmias and the structural characteristics of the human heart. Ebstein’s anomaly is often associated with APs. Chiang et al. reported that 2.9% of patients with supraventricular tachycardias had major CS abnormalities. In our study, 6% of the patients had major CS abnormalities. All of them had left lateral or posteroseptal APs. This finding suggested that some disarrangement during cardiogenesis might have created the CS abnormalities and/or the APs. APs are vestigial remnants of embryonic structures.

Figure 1 Coronary sinus (CS) morphology.
In 68% of the PSAP group, the proximal CS had a windsock appearance. This morphology was found in 16% of the other AP group (p < 0.001). In 96% of the control subjects, the CS was tubular (p < 0.001).

Figure 2 Coronary sinus (CS) angiography.
(A, B) A case with a posteroseptal accessory pathway. The CS ostium had a windsock appearance. (C, D) A case with a left lateral accessory pathway. The CS ostium had a tubular appearance. (A, C) 30° right anterior oblique. (B, D) 50° left anterior oblique.
mammals, the right extension of the primitive sinus venosus, or cuvierian duct, becomes the cardiac end of the superior vena cava, and the left extension becomes the CS. When the CS progresses into an intimate anatomical relation with the ventricles, it remains possible that extensions of the sinus venosus muscle could be responsible for a physiological connection.20) Not only CS abnormalities, but also CS dilatation, as shown in the present study, could occur during this development.

In atrioventricular nodal reentrant tachycardia (AVNRT), the CS ostium was found to be larger and to remain more dilated to at least 10 mm from the ostium.10,11) The appearance of the CS is like a windsock in AVNRT patients. In our study the CS ostium in patients with posteroseptal APs was also large and remained dilated at least 20 mm from the ostium and had a windsock appearance. These findings were similar to those of AVNRT patients.

In an anatomical study, Davis et al.13) reported that APs located in the proximal 15 mm of the CS were almost always in the posteroseptum. In our study, for at least 10 mm from the CS ostium, the diameter of the CS was larger in the patients with posteroseptal APs than in the other AP group. This suggested that posteroseptal APs may be related to the dilatation of the CS ostium.

Clinical implications
In the patients with posteroseptal APs, the ostium of the CS is large and shaped like a windsock. These findings mean that the RFCA catheter can drop easily into the CS. Not only chest pain22) during the application, but also complications following RFCA in the coronary venous system, such as an occlusion18) or thrombosis formation, have been reported.22) The posteroseptal accessory pathway location included the area around and into the CS. CS angiography could be useful to understand the catheter position in this area. During RFCA in the right posteroseptal region, especially into CS and the coronary venous system, we should carefully control the catheter and check the impedance and power output23) to avoid damaging the coronary venous system.

Study limitations
This study had several limitations. First, the two-dimensional measurements of the CS diameter may not have accurately presented the true distance of the three-dimensional structure of the CS. However, this is the first important study to characterize the morphology of the CS ostium in patients with APs. Second, the criteria for the CS abnormalities were not available in the past. We defined them ourselves more appropriately for the patients with supraventricular tachycardias and the control population.

Takenaka et al.24) reported that a longer local activation time is characteristics of left free-wall epicardial APs. There was only one patient with epicardial AP in this study, and we could not characterize the electrophysiological difference between the endocardial and epicardial APs.

In conclusion, the larger size of the proximal CS was a unique structural characteristic in patients with posteroseptal APs. The appearance of proximal CS was like a wind cone in these patients. These findings may give some clues to trace arrhythmic pathogenesis to its origin.

Acknowledgment
We wish to thank Fumiharu Miura, MD, Togo Yamagata, MD, and Hideo Matsuura, MD for their continued and invaluable assistance, and Yuko Omura for her secretarial assistance.

References


