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Outcomes of Ablations Performed from the Coronary Venous System for Childhood Arrhythmias Using an Electroanatomic Mapping Method

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Abstract

Objective: In this study, we aim to share the outcomes of our ablation procedures conducted for childhood arrhythmias through the coronary venous sinus. Our experience highlights the effectiveness and potential of this approach in managing pediatric arrhythmias.

Methods: This is a single-center retrospective cohort study. Of the 2450 ablations performed in our center, 52 were carried out using the coronary venous system in pediatric patients between January 2014 and August 2024. Fifty-two consecutive patients with accessory pathways, atrial and ventricular tachycardia were included, and ablation through the coronary venous system was performed using EnSite® precison system.

Results: The patients had a mean age of 11.6 ± 4.5 years and a mean weight of 48.3 ± 16.2 kg. Out of them, 33 had manifest accessory pathways, 11 had concealed accessory pathways, 5 had atrial tachycardia, and 3 had ventricular tachycardia. Among the 44 patients with accessory pathways, 39 had a single accessory pathway, while five patients had multiple accessory pathways, two of which were associated with Ebstein anomaly. Regarding coronary venous sinus ablations, 37.5% were performed from the proximal side, 31.3% from the middle cardiac vein, 25% from the mid coronary venous system, and 6.2% from the great cardiac vein. Seven cases had a coronary venous system diverticulum. Cryoablation was used in 11 patients. The mean procedure time was 186 ± 38.7 minutes. The acute success rate was 100%. The follow-up duration was 56.2 ± 23.8 months. Two patients experienced recurrences, but successful reablation was performed in these cases, and there were no further recurrences. Major comlications were not detected.

Conclusion: Transcatheter ablation using three-dimensional mapping via the coronary sinus demonstrates promising results, achieving high acute success rates and minimal complications in patients with accessory pathways, as well as atrial and ventricular tachyarrhythmias.

Keywords: Transcatheter Ablation; Coronary Sinus; Accessory Pathway; Ventricular and Atrial Tachycardia

Introduction

In pediatric patients, endocardial ablations are commonly performed. However, accessory pathways originating from the posteroseptal region, as well as certain atrial tachycardias and ventricular arrhythmias, can rarely be localized in the epicardium. Posteroseptal accessory pathways account for 34.5% of the total. Of these, 36% are located within the coronary sinus [1-4]. The aim of this study is to evaluate the effectiveness of using electroanatomic mapping for ablating accessory pathways and arrhythmias in pediatric patients, particularly those originating from the coronary venous system, including the coronary sinus, without requiring epicardial puncture.

Material and Method

Patient Population

This is a single-center retrospective cohort study. Of the 2450 ablations performed in our center, 52 were carried out using the coronary venous system in pediatric patients between January 2014 and August 2024. A total of 52 consecutive patients with accessory pathways, atrial tachycardia, and ventricular arrhythmias who underwent ablation through the coronary venous system were included in this study. Out of the 52 patients, 44 had structurally normal hearts. Among the remaining four patients, three had Ebstein anomaly, and one had an ostium primum atrial septal defect. Patients with abation sites situated less than 5mm from the coronary arteries were excluded from undergoing ablation via the coronary venous system. In 81.8% of patients with an accessory pathway, the indication for treatment was palpitation,while the others exhibited asymptomatic preexcitation. Three patients experienced atrial tachycardia, and one had ventricular tachycardia. Six of the patients with accessory pathways had previously undergone unsuccessful endocardial ablation from the right and left posteroseptal regions in another center. All procedures were performed at a single center and approved by the local ethics committee. Written informed consent was obtained from all patients prior to the procedure. Clinical and periprocedural data were collected from electronic medical records and the electrophysiology laboratory database. Before the ablation, all patients underwent a physical examination, 12-lead electrocardiography, 24-hour Holter monitoring and transthoracic echocardiogram. Antiarrhythmic medication was discontinued at least five half-lives prior to the electrophysiologic study.

Electrophysiologic Study and Ablation

The procedures were performed under general anesthesia. Femoral vein sheaths were inserted. EnSite Precision System (Abbot, St Paul, MN, USA) was used to facilitate mapping and to reduce or eliminate the fluoroscopy. Electrophysiological study and mapping were performed as previously defined [5]. Activation mapping was primarily conducted endocardially, followed by mapping of the coronary venous system. Selective coronary angiography and coronary venous system angiography were performed before and after the ablation procedure in all patients. Cryoablation was choosen if the ablation site was less than five mm away from the coronary artery. In other patients, ablation was applied using a cool-tip irrigation catheter. Radiofrequency ablation was performed with a minimum power of 10 Watts and a maximum power of 30 Watts, ensuring that each application did not exceed 30 seconds (21.8±5.45). Cryoablation was performed using a cryoablation catheter (Freezor Cryocath, Medtronic, Inc., Minneapolis, USA) at -70 degrees for four minutes per session. In cases where there were difficulties in reaching the planned ablation location, a long sheath was used to facilitate access.

Standard criteria has been established to determine immediate success after ablation. This criteria include the absence of anterograde pathway conduction in the case of manifest preexcitation, an adenosine test resulting in bidirectional block, and the elimination of the other targeted arrhythmogenic substrates with varying protocols of progressive bi-atrial and bi-ventricular pacing at baseline and during an isoproterenol infusion [6]. In instances of atrial and ventricular tachycardia, the procedure was deemed successful if no tachycardia is induced during atrial and ventricular extra-stimulus or burst stimulation during isopro-

terenol infusion half an hour after the procedure.

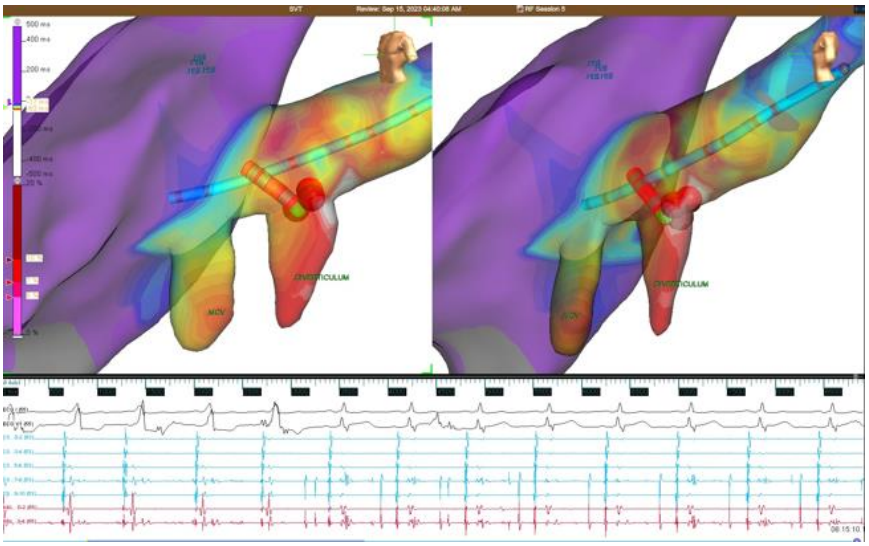

Figure 1: Ablation performed from the proximal coronary sinus, originating from the diverticulum. The ablation catheter is positioned at the mouth of the diverticulum, and after the fifth beat, the preexcitation is observed to disappear. (*MCV*: *midddle cardiac vein*)

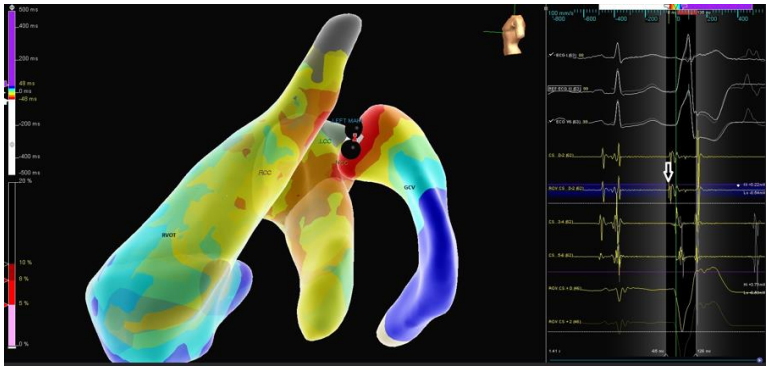

Figure 2: An ablation originating from the summit region and performed through the graet cardiac vein in observed.

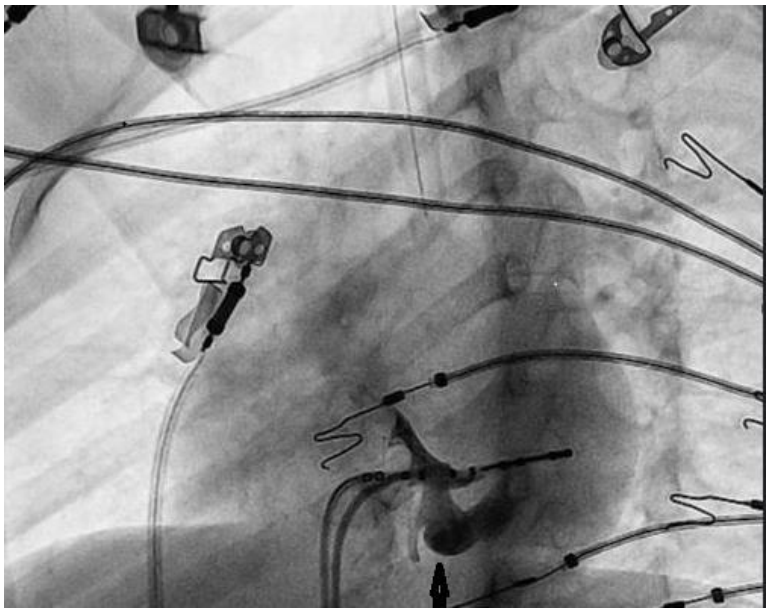

Figure 3: The coronary venous diverticulum is demonstrated with contrast injection .

Statistical Analysis

Statistical analysis was performed using SPSS 22.0 (IBM Corporation, Armonk, New York, United States). Quantitative data were expressed as mean ± standard deviation or median range (minimum-maximum) values. Categorical values were presented as n (number) and % (percentage).

Results

The study comprised a group of 27 males and 25 females with a mean age of 11.6 ± 4.5 years. Among them, 33 had manifest accessory pathways, 11 had concealed accessory pathways, five had atrial tachycardia, and three had ventricular tachycardia. Out of the 44 patients with accessory pathways, 39 had a single accessory pathway, while five had multiple accessory pathways. Two of these cases were associated with Ebstein's anomaly

Regarding coronary venous sinus ablations, 37.5% were performed from the proximal side, 31.3% from the middle cardiac vein, 25% from mid coronary venous system, and 6.2% from the great cardiac vein. Cryoablation was used in 11 patients. Ablation was performed on three patients under 2 years of age due to tachycardia-induced cardiomyopathy, and their median ejection fraction was 38% (33-42). Coronary venous system diverticulum was present in seven cases (Fıgure 1-3). Three of the patients with coronary sinus diverticulum underwent cryoablation, rest of them irrigated radiofrequency ablation. In the selective coronary angiography performed prior to ablation, the proximity of the ablation site to the coronary artery was found to be an average of 7.1 ± 2.9 mm (range: 2.5-10.8). The mean procedure time was 186 ± 38.7, and the fluoroscopy time was 6.4 ± 3.8 minutes.. Only one patient had a self-limiting minimal pericardial effusion detected after transseptal puncture. No coronary artery complications were encountered.

The acute success rate was 100%. No patient required coronary angiography after ablation. Three patients developed temporary first-degree block due to catheter manipulation. No major complications were encountered.

The details of patient characteristics and procedural aspects are provided in Table.

Table 1: Patient characteristics and Procedural data

Age (year)	11,6±4.5
Gender (M/F)	27/25
Weight (kg)	28,3±14,2
Procedure Time (minute)	186.4±38.7
Flororoscopy time (minute)	6.4+3.8
Number of total radiofrequency lesion	3.3+2.8
Total lesion duration (second)	58.3+.33.2
Arrhythmia disappearance time (ms)	2,8+1.5
Catheter Type İrrigated RFA, n Cryoablation, n	 41 11
Acute procedural success , %	100

Abbreviatons: RFA-Radiofrequency ablation catheter; ms-milisecond; n-number

Follow up

Follow-up was conducted through either inpatient or outpatient visits, or through phone communication without a pre-scheduled follow-up period. All patients participated in these regular follow-up activities, with an average follow-up duration of 62.2 ± 36.8 months. During this period, two patients experienced arrhythmia recurrences. The first recurrence was in a 7.5-year-old patient, occurring at the 1st month. For this patient, cryoablation was performed to successfully address the recurrence, and no further issues were observed in subsequent follow-ups. The second recurrence occurred at the 3rd month in a 9-year-old patient with Ebstein anomaly. This patient underwent irrigated radiofrequency ablation, effectively resolving the recurrence, and no further recurrences were noted during later follow-up visits.

Discussion

The use of 3D Electroanatomical Mapping (EAM) has significantly reduced the need for fluoroscopy during cardiac procedures. By visualizing catheters and cardiac anatomy from various angles, obtained through 3D EAM, physicians can navigate with accuracy and perform interventions more precisely. With increasing experience, clinicians have achieved further reductions in both procedural and fluoroscopy durations. This advancement not only minimizes patient exposure to radiation but also improves procedural efficiency. 3D EAM has revolutionized cardiac procedures, offering safer and more effective treatment options while advancing interventional cardiology.

The ablation of some posteroseptal accessory pathways, atrial, and ventricular tachycardias can be performed through the coronary venous system. However, there are certain challenges involved that include a susceptibility to complications [7]. These include proximity to the coronary arteries, slow blood flow, and a semi-closed system. Determining when and how arrhythmias originating from this location will undergo ablation requires making clear-headed decisions that balance the current arrhythmia risk against the risk of ablation. Additionally, the frequency of vascular dilatations and diverticula varies in different studies, with an incidence of around 25% [8]. During the ablation low blood flow and vascular nature of the structure lead to an increase in impedance [9]. Despite attempts to overcome this issue using irrigation catheters and cryoablation, the procedure becomes more challenging due to the difficulty of catheter manipulation and limited range of motion. However, the use of long sheaths can overcome these difficulties and facilitate the manipulation of the catheter within the coronary sinus. So far, no complications related to coronary sinus and coronary artery have been reported with cryoablation. In our study, we were able to overcome this challenge in four cases by using a long sheath.

Ablations performed through the coronary venous system predominantly involve posteroseptal accessory pathway ablation in children [10]. Accessory pathways, especially those originating from the proximal and middle portions of the coronary sinus, are one of the common sites for ablation [3]. Dilatations and diverticula within the coronary venous system contribute to the increased complexity of the procedure. The study by Patrick Leitz and colleagues highlights the challenges posed by coronary sinus diverticula in complicating catheter ablation procedures, emphasizing the importance of properly identifying these anatomical variations. In their research, they found that 0.36% of the 2245 patients analyzed had a CS diverticulum. This small percentage significantly impacted the ablation process, as conventional ablation methods were often unsuccessful. Their findings demonstrated that venographic assessment of these diverticula is crucial, particularly in cases where previous ablation attempts have failed. Additionally, the study reveals that long-term prognosis is excellent following successful ablation, with patients remaining free of recurrences over a mean follow-up period of 8.9 ± 6.4 years [11].

Ablation of atrial and ventricular arrhythmias through the coronary sinus has been reported with increasing frequency [12,13]. The myocardial sleeve around the coronary sinus has been shown to be composed of bands of muscle from the left atrium as well as the right atrium. Focal atrial tachycardias originate predominantly from the right atrium along the crista terminalis and

less commonly from the left atrium. Rarely, atrial tachycardia can originate from the coronary sinus musculature and require ablation inside the coronary sinüs [14,15]. Apart from a few isolated case reports the largest series of atrial tachycardia within coronary sinus are from Badhwar et al who reported a set of eight patients out of a consecutive series of 283 patients undergoing radiofrequency ablation for atrial tachycardia [16]. Min Guo and colleagues presented a rare case of focal atrial tachycardia originating from the proximal middle cardiac vein (pMCV). Their report demonstrates that low power and short-duration radiofrequency ablation can effectively treat atrial tachycardia arising from specific sites like the coronary sinus ostium and pMCV, offering valuable insights into the management of such uncommon cases [17].

When there is lack of earlier signals at the aortic cusps, coronary sinus is the best route for ablation of left ventricular outflow tract ventricular tachycardia. An S wave in lead I, tall R wave in the inferior leads, MDI > 0.55 and precordial transition zone near leads V1-3 have been reported as the electrocardiography findings of idiopathic ventricular tachycardias arising from the distal portion of coronary venous system [18]. According to Santangelli et al, the three ECG criteria for successful epicardial ablation are: 1) Absence of q in V1, 2) R/S > 2 in V1, and 3) Q in aVL/aVR > 1.85 [16]. The left ventricular summit, positioned amidst the great cardiac vein, left anterior descending artery, and circumflex artery, plays a significant role in generating epicardial arrhythmias. Ablation procedures that target this region can be particularly challenging due to the dense presence of adipose tissue. In a case report by Mesterovic and colleagues, the potential of pulsed-field ablation (PFA) in treating arrhythmias is demonstrated. They successfully used PFA to ablate epicardial premature ventricular contractions (PVCs) from the coronary venous system (CVS) in a patient after traditional radiofrequency ablation (RFA) had failed, highlighting PFA's promise in expanding treatment options within electrophysiolog [19]. Cryoablation is considered a safer alternative to radiofrequency ablation due to its reduced risk of thrombosis and perforation.

Coronary artery stenosis is a documented complication of catheter ablation, often occurring as a late complication after 12–24 months [4]. The high complication rate in coronary sinus ablations is influenced by the thin tissue and slow blood flow in the region. In our cases, the average distance between the ablation site and the coronary artery was found to be 7.1 ± 2.9 mm (range: 2.5-10.8).

In this area, particularly in children weighing less than 15 kg, we initiate ablation at low values like 10 watts and gradually increase it if the desired effect is not achieved. We do not exceed 30 watts in any of the patient. The use of an irrigated catheter does not cause thrombus formation. We did not encounter any major complications in our patients. We used a 7 mm irrigation radiofrequency ablation catheter due to the unavailability of 5F irrigation options. We optioned for cryoablation in locations near the coronary artery. So far, no complications have been reported specifically related to cryoablation of the coronary sinüs [20]. However, it is worthnoting that cryoablation catheter manipulation is generally more challenging compared to radiofrequency catheters.

Conclusion

The coronary venous system is an importatnt route in ablations originating from the epicardial surface. We believe that the use of 3D mapping with limited fluoroscopy allows safe and effective ablation of accessory pathways, atrial tachycardia and ventricular tachycardia in children.

Study Limitations

This study was limited by its retrospective design. Our study was performed in a small number of patients. More reliable results may be obtained if the study is performed in a larger patient group.

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Conflict of Interest

None

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