Original

Safety and Efficacy of Catheter Ablation for Pediatric Ventricular Tachyarrhythmia

Kentaro Ikeda[1–3], Takumi Takizawa[3], Shigeto Naito[1], Kohki Nakamura[1], Takehito Sasaki[1], Koji Kumagai[1], Tomio Kobayashi[2] and Hirokazu Arakawa[3]

1 Gunma Prefectural Cardiovascular Center, 3-12 Kameizumi-machi, Maebashi, Gunma 371-0004, Japan
2 Gunma Children's Medical Center, 779 Shimohakoda, Hokkitsu-machi, Shibukawa, Gunma 377-8577, Japan
3 Department of Pediatrics, Gunma University Graduate School of Medicine, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan

Abstract

Background & Aims: Ventricular arrhythmias, including premature ventricular contraction (PVC) and ventricular tachycardia (VT), are commonly observed in pediatric patients. Radiofrequency catheter ablation (RFCA) has come to be recognized as the first-line therapy for ventricular arrhythmias in adult patients. However, indications for the RFCA of pediatric ventricular arrhythmias remain controversial. The aim of this study was to elucidate the outcomes of catheter ablation for pediatric ventricular arrhythmias. **Methods:** Twenty-nine consecutive pediatric patients (age, 2–15 years; 12 male and 17 female) who underwent RFCA for ventricular arrhythmia at Gunma Prefectural Cardiovascular Center between March 2006 and December 2014 were included in this study. Detailed patient medical histories were reviewed from the medical records provided. **Results:** The success rate of primary RFCA was 83% (24 of 29), with an overall success rate of 93% (27 of 29) including secondary ablations. No major complications, such as cardiac tamponade or atrioventricular block, were noted. The outcomes observed were comparable to those previously established in adult patients. **Conclusions:** RFCA for pediatric ventricular arrhythmias exhibited a good success rate and few complications. RFCA could be a viable therapeutic option for pediatric ventricular arrhythmias, even in cases of frequent PVC.

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Corresponding author:
Takumi Takizawa
Department of Pediatrics, Gunma University Graduate School of Medicine, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan
Tel: +81-27-220-8205
E-mail: takizawt@gunma-u.ac.jp

Introduction

Radiofrequency catheter ablation (RFCA) has become increasingly recognized as the first-line therapy for a variety of tachyarrhythmias not only in adult patients, but also in pediatric patients. RFCA exhibits high success rates, low complication rates, and few cases of recurrence when applied to pediatric supraventricular tachycardias (SVTs), including atrioventricular node reentry (AVNRT) and atrioventricular reentry tachycardia (AVRT).[1] Frequent premature ventricular contraction (PVC) in adults can lead to an increased risk of left ventricular (LV) dysfunction, even in the context of an otherwise normal heart.[2] RFCA can decrease the risk of LV dysfunction and is indicated in cases of frequent PVC in adults. Ventricular arrhythmias, including PVC and ventricular tachycardia (VT), are commonly observed in pediatric patients. However, the prognosis associated with these ventricular arrhythmias is generally not considered poor, and the PVCs or monomorphic short duration VTs in otherwise disease-free hearts naturally disappear in 23–80% of cases.[3,4] In contrast, a previous study reported that frequent PVCs might also result in LV dysfunction in pediatric patients.[5]

Indications for the use of RFCA in pediatric ventricular arrhythmias remain controversial, and very little has been published regarding the safety and efficacy of RFCA for PVC and VT in children. Herein, we have retrospectively reviewed pediatric

cases of PVC and VT that underwent RFCA in order to elucidate the outcomes of RFCA for pediatric ventricular arrhythmias.

Materials and Methods

The Ethics Committee of the Gunma Prefectural Cardiovascular Center approved our retrospective study. The medical records of 29 consecutive pediatric patients (age, 2–15 years; 12 male and 17 female) who underwent RFCA for ventricular arrhythmias at Gunma Prefectural Cardiovascular Center between March 2006 and December 2014 were reviewed. Detailed medical histories, including age at ablation, sex, symptoms such as syncope or palpitations, type of ventricular arrhythmia, medication history, origin of ventricular arrhythmia, and outcomes were obtained. Diagnosis of VT was made upon observation of at least three consecutive ventricular beats greater than 120 beats/min via electrocardiogram (ECG) or Holter monitoring. Nonsustained VT was defined as lasting from 3 beats to 30 s, and sustained VT was defined as lasting more than 30 s.[4] Frequent PVC was defined as more than 1,000 beats per day.[2] All patients underwent a medical interview, a standard 12-lead ECG, chest radiography, and echocardiography. Propofol or dexmedetomidine were used as sedatives during the catheter procedures. Electrophysiological examination was performed prior to catheter ablation. A conventional computerized electrophysiological system was used in all cases. Ventricular arrhythmias were grouped into those originating from the right ventricular outflow tract (RVOT), left ventricular outflow tract (LVOT), endocardial left ventricle (LV), and para-Hisian region, according to the site of successful ablation or the earliest activation upon electrophysiological examination. Each application of RF energy using a 4-mm tip ablation catheter (Celsius, Biosense Webster, Diamond Bar, USA) was delivered with a power of up to 50 W. Catheter ablation was considered successful when patients remained free from ventricular arrhythmias at 1 month after the procedure.

Statistics

Statistical analysis was performed using the Mann-Whitney U test or Fisher's exact test as shown in Table 1. All statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). Specifically, it is a modified version of R Commander designed to add statistical functions frequently used in biostatistics.[6]

Results

Patient characteristics

The median age at catheter ablation was 9.7 years (range: 2–15 years) for the patients with VT and 13.3 years (range: 10–15 years) for the patients with frequent PVC (Table 1). There were eight male and six female patients in the VT group, and four male and 11 female patients in the frequent PVC group. Sustained VT was observed in eight of the VT patients. None of the patients had echocardiographic evidence of structural heart disease.

Symptoms were observed in all 14 patients in the VT group and in 10 of 15 patients in the frequent PVC group. Antiarrhythmic medications, including beta-blockers, verapamil, and mexiletine were given to seven patients in the VT group and one patient in the PVC group. The number of PVCs in asymptomatic PVC patients ranged from 25,464 per day to 80,067 per day (mean: 48,525 per day). The majority of the cohort (17 of 22) aged over 10 years was prompted to visit the hospital following school-based screening. The median time between the first hospital visit and the ablation procedure was 28.2 ± 30.9 months.

The origin of PVC/VT

PVC and VT origins were estimated according to the site of successful ablation or the site of earliest activation during electrophysiological studies. VT origins included the RVOT in eight cases, LVOT in

Table 1 Clinical characteristics of patients with VT and those with frequent PVC

Clinical category (n)	VT (14)	Frequent PVC (15)	P value
Age	9.7 (2–15)	13.3 (10–15)	0.0017
Sex (M/F)	8/6	4/11	0.025
BW (kg)	35.3 (13.2–55.4)	45.3 (25.8–63.4)	0.044
Symptoms	14/14	10/15	0.042
Medication	7/14	1/15	0.14
BNP (pg/mL)	26.3 (4.0–49.2)	32.2 (12.5–148)	0.60
LVEF (%)	61.8 (42–71)	64.2 (46–75)	0.67
PVCs (beats/day)	22,880 (8,227–43,220)	30,788 (14,669–80,067)	0.49
Success			
First session	11/14	13/15	
Second session	2/3	1/1	
Total	13/14	14/15	1

BW; body weight, LVEF; left ventricular ejection fraction, VT; ventricular tachycardia, PVC; premature ventricular contraction, ABL; ablation. Mann–Whitney's U test or Fisher's exact test were used for statistical analysis.

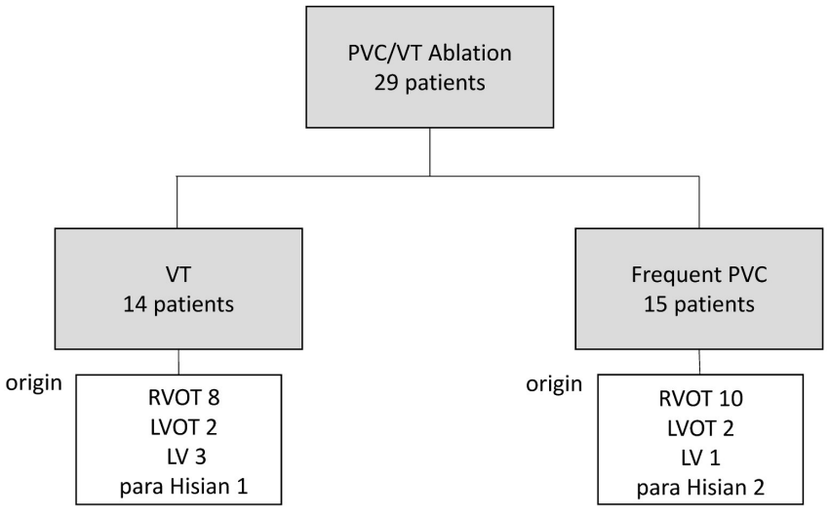

Fig. 1 Sites of PVC/VT origin
Twenty-nine patients who underwent catheter ablation due to ventricular tachyarrhythmia included 14 VT patients and 15 PVC patients. There was no difference in the variation of the sites of origin between the VT and PVC groups. RVOT; right ventricular outflow tract, LV; endocardial left ventricle, LVOT; left ventricular outflow tract, PVC; premature ventricular contraction, VT; ventricular tachycardia.

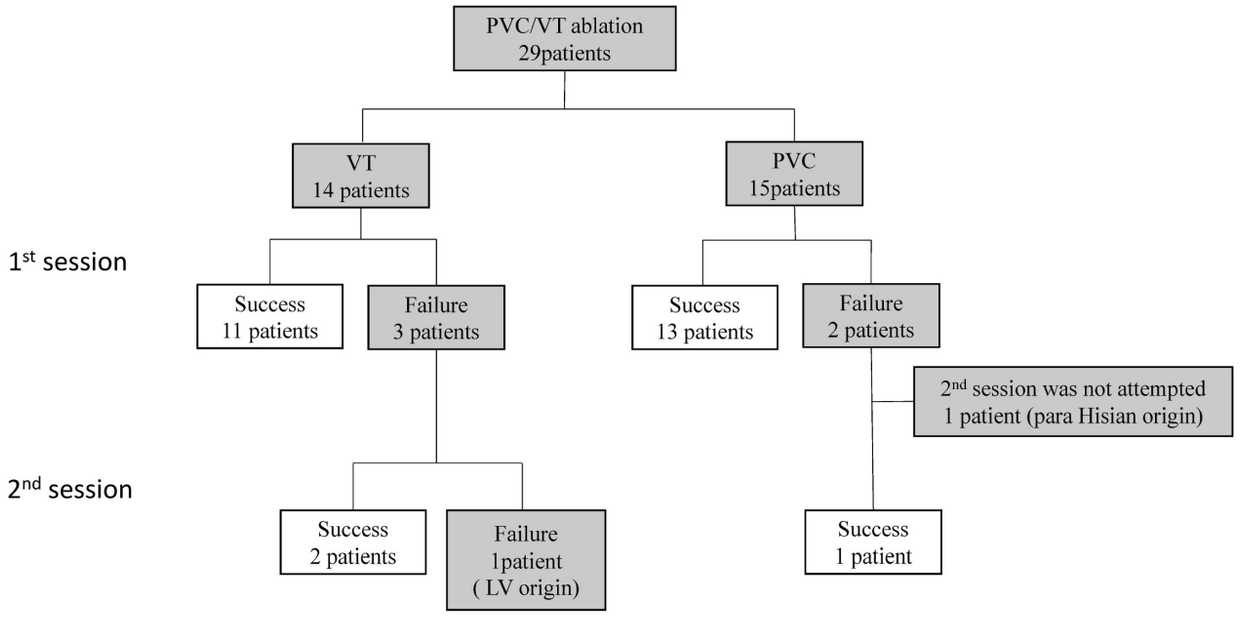

Fig. 2 RFCA outcomes
The overall success rate of RFCA was 93% (27 of 29). No significant difference in success rates was observed between the VT and PVC groups. RFCA; radiofrequency catheter ablation, PVC; premature ventricular contraction, VT; ventricular tachycardia.

two, LV in three, and para-Hisian region in one case (Fig. 1). Frequent PVC origins included the RVOT in 10 cases, LVOT in two, LV in one, and para-Hisian region in two cases. No significant differences were observed between the groups with respect to the VT or PVC origins ($P = 0.78$).

RFCA outcomes

The overall success rate of RFCA was 93% (27 of 29; Figure 2). Among the 14 VT patients, 11 were successfully ablated during the first session, and two of the remaining three were successfully ablated during the second session. Similarly, among the 15 frequent PVC patients, 13 were successfully ablated during the first session, and one was successfully ablated during the second session. No significant difference in success rates was observed between the VT and PVC groups.

Arrhythmia ablation was unsuccessful in five patients during the first session (Fig. 2). Failure due to recurrence occurred in three patients with arrhythmia originating at the RVOT. Furthermore, no ablation was performed in two patients; one of these patients

had an LV Purkinje origin and exhibited arrhythmia suppression during sedation, while the other had an origin in the para-Hisian region, which is associated with a high risk of atrioventricular block with conventional ablation. Secondary ablation was performed in four of the five patients, with exclusion of the patient who exhibited the high-risk origin in the para-Hisian region. Consequently, three patients with recurrence were eventually successfully ablated. However, the patient exhibiting multiple PVCs originating from the Purkinje fibers was not completely ablated. No major complications, such as ventricular perforation, cardiac tamponade, embolism, or atrioventricular block, were observed.

Discussion

This was a retrospective study examining the implementation of RFCA for 29 cases of pediatric ventricular arrhythmias. Successful catheter ablation was achieved in 27 (93%) of 29 patients without major complications. This outcome is comparable to those previously observed in adult patients.[7] RFCA is often indicated in cases of VT, as ablation is necessary to alleviate symptoms and to prevent mortality associated with ventricular fibrillation. Indeed, all of the patients with VT in this study presented with concomitant symptoms. There have been several reports regarding the efficacy and outcomes associated with catheter ablation in cases of pediatric VT. Baksiene et al. treated 16 pediatric VT patients with RFCA, and ablation was successfully achieved in 11 patients, with one patient exhibiting a minor complication.[7] Song et al. treated 14 idiopathic VT pediatric patients with RFCA and observed successful ablation in all cases.[9]

In contrast, few studies have examined the outcomes associated with PVC ablation in pediatric patients.[10] In adult patients, even in the absence of any structural heart diseases, frequent PVC (>20,000 per day) can result in LV dysfunction and is considered an indication for catheter ablation. [2,11] Kakaband et al. described that frequent PVC may also cause LV dysfunction in pediatric patients.[5] Furthermore, a previous report has shown that even in monomorphic PVC, at least 20% of PVCs do not disappear spontaneously.[4] In this study, 14 of the 15 frequent PVC cases were successfully ablated and no serious complications were observed. Therefore, we propose that in pediatric patients with frequent PVC (>20,000 per day) who do not exhibit a decrease in PVC frequency, RFCA is a safe and effective intervention.

Limitations

This study was a retrospective analysis of patients from a single institution. Furthermore, no control group existed and the number of patients was relatively small. Therefore, it remains difficult to draw generalized conclusions from our observations.

Conclusions

RFCA for pediatric VTs exhibited a good success rate with few complications. Therefore, RFCA could be a viable therapeutic option for pediatric VTs, including cases of frequent PVC.

Conflict of interest

The authors declare no conflicts of interest associated with this manuscript.

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