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Radiofrequency catheter ablation of accessory pathways at the site of prior valve surgery

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Abstract

Background: Radiofrequency catheter ablation (RFCA) for accessory pathways (APs) at the site of prior valve surgery (VS) remains challenging. We aimed to clarify the factors associated with successful RFCA for such APs.

Methods: Upon reviewing a RFCA registry and previous case reports, we included nine patients who underwent RFCA of APs at the site of prior VS (total-VS group; age, 34.0 [24.5-45.0] years; men, 4/9) and 196 patients who underwent RFCA of APs with no history of VS (no-VS group; age, 40.5 [23.0-54.0] years; men, 114/196). Electrophysiological features, procedural details, and outcomes were examined.

Results: Accessory pathway exhibited decremental conduction in four of nine patients in the total-VS group. The number of RFCA attempts was significantly higher in the total-VS group than in the no-VS group (10.0 [4.5-14.5] vs 2.0 [1.0-3.0]; $P < 0.001$). In four patients who underwent mitral VS, successful RFCA was achieved using the transaortic approach, coronary sinus (CS) approach, or bipolar ablation. In three patients who underwent tricuspid VS, successful RFCA was achieved using the above-prosthetics or trans-prosthetics approach. In two patients, RFCA failed. The trans-prosthetics approach and bipolar ablation technique were effective. The transaortic and CS approaches were occasionally effective. The transseptal approach was ineffective.

Conclusions: Successful RFCA of APs at the site of prior VS can be achieved by detailed mapping of the areas both above and below the prosthetic valve, as well as by ensuring effective radiofrequency energy delivery using various catheter approaches and RFCA techniques.

Jae-Sun Uhm and Jun Kim contributed equally to this work.

KEYWORDS
accessory pathway, catheter ablation, Ebstein anomaly, prosthetic valve, Wolff-Parkinson-White syndrome

1 | INTRODUCTION

Accessory pathways (APs) can be arrhythmogenic and contribute to a reentry circuit of atrioventricular reentrant tachycardia (AVRT). In most cases, APs can be successfully treated by radiofrequency catheter ablation (RFCA). However, in patients with valvular heart disease, RFCA of APs is challenging, especially if the AP is located at a valve annulus that has undergone replacement or repair. The optimal strategy for RFCA of APs at the site of prior valve surgery (VS) remains unclear, as very few case reports on this have been published to date.[1–5] We aimed to clarify the factors associated with successful RFCA for such APs. In this context, the specific goals of the present study were: (a) to elucidate the electrophysiological features and RFCA outcomes of APs at the site of prior VS; and (b) to identify useful catheter approaches and RFCA techniques for successful ablation of such APs.

2 | METHODS

2.1 | Patients

The study design was approved by the institutional review board of our hospital (IRB Number: 4-2018-0649). The study was conducted in compliance with the Declaration of Helsinki. The institutional review board waived the need for informed consent of the patients to be included in the analysis, as well as the need for review by a critical event committee because this was a retrospective study and no patient identification data are presented.

The study included a group of patients who received RFCA for APs located at an annulus previously involved in mitral or tricuspid VS (total-VS group, based on registry and case report data), as well as a control group consisting of RFCA recipients with structurally normal heart and without a history of VS (no-VS group) (Figure 1). To select suitable patients, we retrospectively reviewed the RFCA registry data of patients (age ≥ 15 years) with APs treated between January 2004 and June 2018 at Severance Hospital or Asan Medical Center, which are large-volume university hospitals in Seoul, Korea; patients who received RFCA for APs at the site of previous VS were included in the registry-VS subgroup. In addition, we searched the literature for case reports describing patients who received RFCA for APs at the site of previous VS,[1–5] and included such patients in the historical-VS group of the total-VS group. The no-VS group included patients with structurally normal heart and without a history of VS, who underwent RFCA for APs during the year leading up to the study in the same electrophysiological laboratory as the patients in the registry-VS subgroup.

2.2 | Electrophysiological studies

Complete electrophysiological data were only available for the patients included in the RFCA registry, and not for those described in the case reports. Therefore, we only analyzed electrophysiological data for patients in the RFCA registry (i.e., the registry-VS group and the no-VS group), and described the protocol followed in the centers participating in the RFCA registry. After the electrophysiological catheters were positioned, programmed electrical stimuli were applied, with or without isoproterenol infusion. After tachyarrhythmia was induced, the mechanisms of tachycardia were elucidated using conventional differential pacing maneuvers. In patients with a concealed AP, the AP potentials were mapped during ventricular pacing and AVRT. In patients with a manifest AP, the AP potentials were mapped during sinus rhythm, ventricular pacing, and AVRT. The precise AP location was confirmed, and RFCA was performed. The end points of RFCA were no evidence of AP and no inducibility of tachycardia. Follow-up electrocardiography (ECG) was performed at 1 day, 1-2 weeks, and 3-6 months after RFCA.

2.3 | Data acquisition and statistical analyses

The medical records, operation records, echocardiographic reports, electrophysiological reports, intracardiac electrograms and fluoroscopic images stored in the RFCA registry were reviewed. For patients in the historical-VS group, we carefully reviewed all information included in the published case reports.[1–5] Major complications were defined as atrioventricular block; cardiac perforation or tamponade; stroke or transient ischemic attack; and vascular access complications such as hematoma, pseudoaneurysm, and arteriovenous fistula that required transfusion or

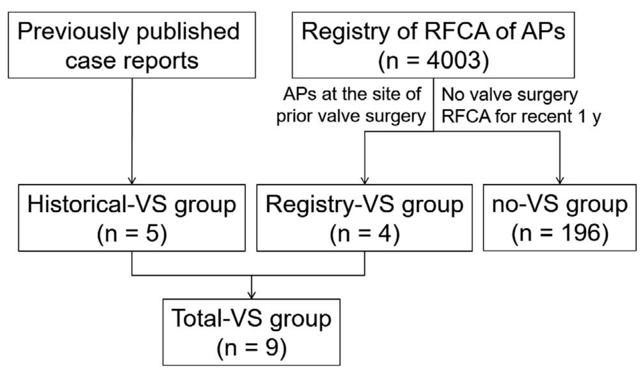

FIGURE 1 Flow diagram and numbers of patients. AP, accessory pathway; RFCA, radiofrequency catheter ablation; VS, valve surgery

surgical procedures. The baseline characteristics, electrophysiological features, and number of RFCA attempts were compared between the total-VS group and the no-VS group. The catheter approaches and RFCA techniques used in the total-VS group were examined in detail in order to clarify the technical requirements for RFCA success. Success, recurrence, and complication rates were not statistically compared between the two groups because publication bias could not be excluded.

The results are expressed as median (interquartile range) for continuous data and as frequency (percentage) for categorical data. To compare the clinical parameters between the two groups, we used the Mann-Whitney *U* test for continuous data and Fisher's exact test for categorical data, as all datasets were nonnormally distributed. A *P* value <0.05 was considered to indicate statistical significance. The data were analyzed using the Statistical Package for the Social Sciences, version 24.0 (IBM Corporation, Armonk, NY).

3 | RESULTS

3.1 | Baseline characteristics and outcomes (total-VS group vs no-VS group)

Upon screening the RFCA registry, we identified 4003 patients who underwent RFCA for APs at one of the participating centers during the study period. The registry-VS subgroup included four patients (prevalence, 0.1%; age, 37.0 [25.8-47.5] years; men, 3/4) who underwent RFCA for APs at the site of prior VS and were listed in the RFCA registry. The historical-VS subgroup included five patients (age, 32.0 [20.5-44.5] years; men, 1/5) who underwent RFCA for APs at the site of prior VS and were described in previously published case reports.[1–5] The no-VS group included 196 patients (age, 40.5 [23.0-54.0] years; men, 114/196) without a history of VS who underwent RFCA for APs during the year leading up to the study at the same electrophysiological laboratory as the patients in the RFCA registry.

Table 1 summarizes the baseline characteristics, electrophysiological features, and RFCA outcomes of the patients in the total-VS and no-VS groups. In the total-VS group, mitral valve replacement (MVR), mitral valve repair (MVr), and tricuspid valve replacement (TVR) were performed in five, one, and three patients, respectively. Manifest APs, APs with decremental conduction property, and antidromic AVRT were significantly more frequent in the total-VS group than in the no-VS group. APs with slow and decremental conduction were found in all three patients who had undergone TVR for Ebstein anomaly, as well as one patient who had undergone MVR. In the total-VS group, the rates of acute success, major complications, and recurrence were 77.8%, 0%, and 0%, respectively. In the registry-VS group, the success rate was 2/4 (50.0%). The number of RFCA attempts was significantly higher in the total-VS group than in the no-VS group (*P* < 0.001). There were no significant differences between the two groups regarding age, gender, location of the APs, or duration of follow-up.

TABLE 1 Baseline characteristics, electrophysiological features, and radiofrequency catheter ablation outcomes

Characteristics	Total-VS group (n = 9)	No-VS group (n = 196)	*P* value
Age, y	34.0 (24.5-45.0)	40.5 (23.0-54.0)	0.326
Male gender	4 (44.4)	114 (58.2)	0.499
Prior VS			
Mitral valve replacement	5 (55.6)	—	
Mitral valve repair	1 (11.1)	—	
Tricuspid valve replacement	3 (33.3)	—	
Manifest AP	7 (77.8)	83 (42.3)	0.045
Location of the AP			
Left	5 (55.6)	114 (58.2)	0.499
Septal	1 (11.1)	46 (23.5)	>0.999
Right	3 (33.3)	36 (18.4)	0.377
Decremental conduction property	4 (44.4)	3 (1.5)	0.001
Induced arrhythmia			
Orthodromic AVRT	5 (55.6)	162 (82.7)	0.063
Antidromic AVRT	3 (33.3)	2 (1.0)	0.010
Atrial fibrillation	2 (22.2)	24 (12.2)	>0.999
No induction	0 (0)	8 (4.1)	—[a]
Number of RFCA attempts	10.0 (4.5-14.5)	2.0 (1.0-3.0)	<0.001
Acute success	7 (77.8)	196 (100)	—[b]
Major complications	0 (0)	1 (0.5)	—[b]
Recurrence	0 (0)	8 (4.1)	—[b]
Follow-up period, mo	11.4 (3.4-86.2)	38.8 (21.1-55.1)	0.296

Data are shown as median (interquartile range) or frequency (percentage).
Abbreviations: AP, accessory pathway; AVRT, atrioventricular reentrant tachycardia; RFCA, radiofrequency catheter ablation; VS, valve surgery.
[a]Statistical comparison could not be performed because the number of patients was small.
[b]Statistical comparison was not performed because publication bias could not be excluded.

3.2 | Catheter approaches and RFCA techniques used for APs at the site of prior mitral VS

Table 2 provides detailed information regarding the nine patients in the total-VS group, among whom six had previously undergone MVR or MVr. RFCA of APs at the site of prior mitral VS was successful in four patients and failed in two patients. Among the four patients who underwent successful RFCA for APs at the site of prior mitral VS, the transaortic approach, coronary sinus (CS) approach, and bipolar ablation technique using both the transaortic and CS approaches were used in two, one, and one patient, respectively

TABLE 2 Overview of patients who underwent RFCA for APs at the site of previous VS (total-VS group)

No.	Subgroup	Age, y	Gender	VS	Valve disease	Preexcitation before surgery	Time from surgery to RFCA (y)	AP type	AP location	Decremental conduction property	Induced arrhythmia	No. of RFCA attempts	RFCA result	Successful approach or technique	Failed approach
1	R	40	M	MVR with bileaflet mechanical valve	Severe MR	Yes	6	Manifest	Left posterior	Yes	AF	15	Success	Bipolar ablation	Transseptal, CS, transaortic
2[1]	H	32	F	MVR with bileaflet mechanical valve	Severe MS and MR	No	0.75	Concealed	Left posteroseptal	No	Orthodromic AVRT	4	Success	Transaortic	Transseptal, CS
3[2]	H	52	F	MVR with bileaflet mechanical valve	Severe MR	Yes	5	Manifest	Left lateral	No	Orthodromic AVRT	1	Success	Transaortic	
4[3]	H	37	M	MVR with bileaflet mechanical valve	N/A	Yes	N/A	Manifest	Left lateral	No	Orthodromic AVRT	10	Success	CS	Transseptal
5	R	50	F	MVR with bileaflet mechanical valve	Severe MR	No	5	Concealed	Left lateral	No	Orthodromic AVRT	14	Failure	No	Transseptal, CS, transaortic
6	R	34	M	MVr with annuloplasty ring	Severe MR	Yes	6	Manifest	Posteroseptal	No	AF	10	Failure	No	Right septal, transseptal, CS
7	R	23	M	TVR with bileaflet mechanical valve	Ebstein anomaly	No	2	Manifest	Right posterior	Yes	Antidromic AVRT	5	Success	Trans-prosthetics	Above-prosthetics
8[4]	H	26	F	TVR with bioprosthetic valve	Ebstein anomaly	No	10	Manifest	Right posterolateral	Yes	Antidromic AVRT	16	Success	Trans-prosthetics	Above-prosthetics
9[5]	H	15	F	TVR with bioprosthetic valve	Ebstein anomaly	No	6	Manifest	Right posterolateral	Yes	Ortho- and antidromic AVRT	9	Success	Above-prosthetics	

Abbreviations: AF, atrial fibrillation; AP, accessory pathway; AVRT, atrioventricular reentrant tachycardia; CS, coronary sinus; F, female; H, historical-VS subgroup; M, male; MR, mitral regurgitation; MVR, mitral valve replacement; MVr, mitral valve repair; N/A, not available; RFCA, radiofrequency catheter ablation; R, registry-VS subgroup; TVR, tricuspid valve replacement; VS, valve surgery.

(Table 2). The transseptal approach was not effective in any of the five patients who underwent RFCA using this approach. We further provide an overview of these five cases.

A 40-year-old male patient (No. 1) with Wolff-Parkinson-White (WPW) syndrome had undergone MVR with a bileaflet mechanical valve. Surgical cryoablation for left posterior AP had been performed during MVR. However, the AP recurred at 8 months after surgical ablation. In a subsequent electrophysiological study, decremental conduction property was observed during ventricular pacing. The AP could not be completely ablated with an irrigated ablation catheter using the transseptal, CS, or transaortic approaches. Finally, RFCA was successfully performed using the bipolar ablation technique with one ablation catheter placed under the mechanical valve via the transaortic approach and the other ablation catheter placed in the CS which served as a dispersive electrode (Figure 2). A 32-year-old female (No. 2) who had undergone MVR with a bileaflet mechanical valve presented supraventricular tachycardia.[1] An electrophysiological study revealed a concealed left posteroseptal AP without decremental conduction property. RFCA using the transseptal approach was not successful, and mapping in the CS showed no ideal target site. Finally, RFCA for the AP was successfully performed using the transaortic approach. A 52-year-old female (No. 3) with asymptomatic ventricular preexcitation had undergone MVR with a bileaflet mechanical valve.[2] At 5 years after MVR, the patient developed narrow QRS tachycardia. An electrophysiological study revealed a manifest left lateral AP without decremental conduction property. RFCA for AP was successfully performed using the transaortic approach. A 37-year-old male patient (No. 4) who had undergone MVR was referred for WPW syndrome.[3] In an electrophysiological study, AVRT using manifest AP at the distal CS was induced. RFCA through the transseptal approach was not successful. The AP at the proximal vein of Marshall was successfully ablated through the CS. A 50-year-old female patient (No. 5) who had undergone MVR with a bileaflet mechanical valve developed narrow QRS tachycardia involving a left lateral AP. RFCA through the transseptal, transaortic, and CS approaches failed. A 30-year-old male patient (No. 6) who had undergone MVr with an annuloplasty ring developed narrow QRS tachycardia involving a manifest posteroseptal AP, RFCA through the right septal, transseptal, and CS approaches failed.

3.3 | Catheter approaches and RFCA techniques used for APs at the site of prior tricuspid VS

Radiofrequency catheter ablation of APs at the site of prior tricuspid VS was successful in all three patients (Table 2). In these three

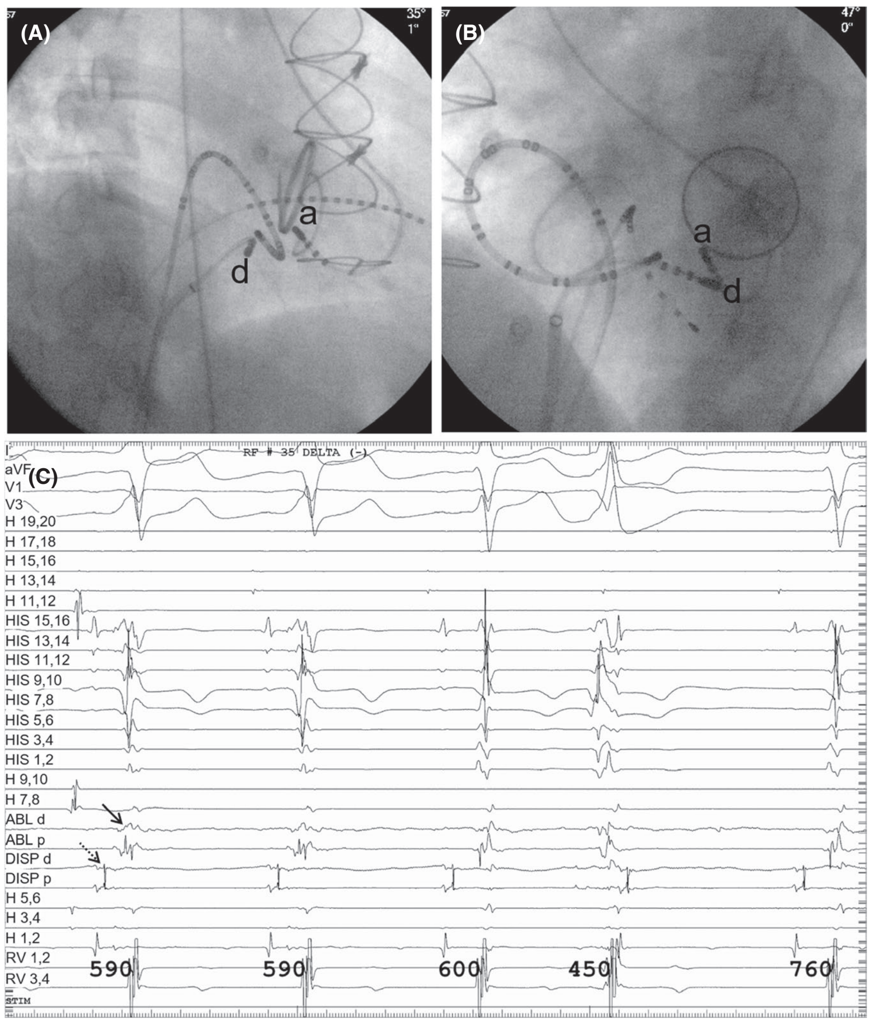

FIGURE 2 Radiofrequency catheter ablation (RFCA) using the bipolar ablation technique in a patient with left posterior accessory pathway who underwent mitral valve replacement with a bileaflet mechanical valve. Fluoroscopic images of the RFCA site in the right (A) and left (B) anterior oblique views. The ablation catheter (a) was placed under the mechanical valve, and the dispersive catheter (d) was placed in the coronary sinus. C, Intracardiac electrogram during RFCA for the accessory pathway. Ventricular signals (arrow with solid line) with far-field atrial signals are observed at the ablation catheter (ABL d) and the atrial signals (arrow with dotted line) are observed at the dispersive catheter (DISP d)

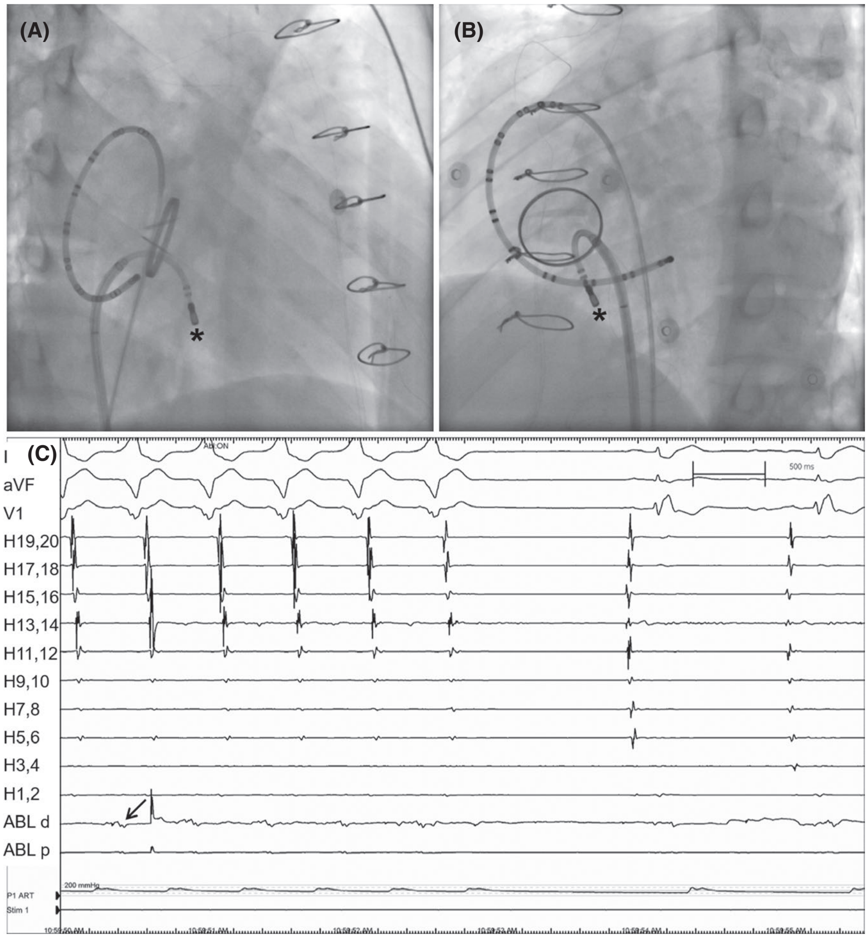

FIGURE 3 Radiofrequency catheter ablation (RFCA) with the trans-prosthetics approach in a patient with right posterior accessory pathway who underwent tricuspid valve replacement with a bileaflet mechanical valve. Fluoroscopic images of the RFCA site (*) in the right (A) and left (B) anterior oblique views. C, Intracardiac electrogram during RFCA for the accessory pathway. The earliest ventricular signals (arrow) at the ablation catheter (ABL d) are observed during antidromic atrioventricular reentrant tachycardia

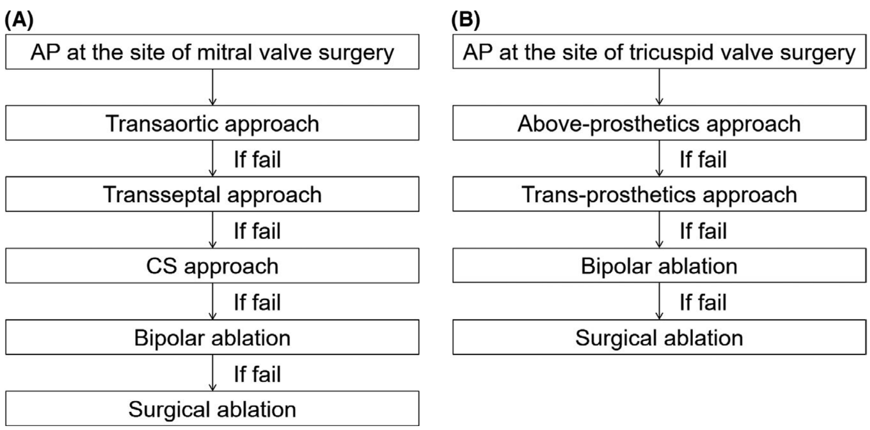

FIGURE 4 Suggested stepwise approach to radiofrequency catheter ablation of accessory pathways at the site of prior valve surgery. Approach to the site of mitral (A) and tricuspid (B) valve surgery. AP, accessory pathway; CS, coronary sinus

patients, who had Ebstein anomaly and WPW syndrome, delta waves were detected on post-TVR ECG; moreover, all three patients had APs with slow and decremental conduction. The trans-prosthetics and above-prosthetics approaches were used in two and one patient, respectively. We further provide an overview of these three cases.

A 23-year-old male patient (No. 7) with WPW syndrome had undergone TVR with a bileaflet mechanical valve for Ebstein anomaly. ECG showed no delta wave before surgery. Just after surgery, narrow QRS tachycardia and a delta wave were noted. RFCA for right posterior AP was attempted four times before the patient was referred to our hospital. RFCA failed on the first three attempts. Upon the fourth attempt, RFCA was successful but the AP recurred. The fifth electrophysiological study revealed antidromic AVRT involving a right posterior AP with slow and decremental conduction property. Right coronary angiogram findings confirmed that the true tricuspid annulus was located under the mechanical valve. After the irrigated ablation catheter was meticulously passed through the mechanical valve under fluoroscopic guidance, RFCA for the AP was successfully performed (trans-prosthetics approach; Figure 3). Following RFCA, no change regarding the motion of the mechanical valve was noted. A 26-year-old female patient (No. 8) had undergone TVR with a bioprosthetic valve for Ebstein anomaly.[4] She had no evidence of preexcitation before and after surgery. She presented palpitation and syncope. In an electrophysiological study, antidromic AVRT involving a right posterolateral AP with slow and decremental conduction property was induced. Mapping above the bioprosthetic valve showed no ideal target site. RFCA for AP was successfully performed under the bioprosthetic valve using the trans-prosthetics approach. A 15-year-old female patient (No. 9) had undergone TVR with a bioprosthetic valve for Ebstein anomaly.[5] ECG showed no preexcitation before surgery. Six years later, the patient presented paroxysmal supraventricular tachycardia and delta waves were noted on ECG. An electrophysiological study revealed ortho- and antidromic AVRT involving a right posterolateral AP with decremental conduction property. The AP was successfully ablated above the bioprosthetic valve.

4 | DISCUSSION

4.1 | Overview of findings

The main findings of this retrospective study were that: (a) APs at the site of prior TVR for Ebstein anomaly had decremental conduction property; (b) the transaortic approach, CS approach, and bipolar ablation technique using the transaortic and CS approaches were occasionally effective in RFCA for APs at the site of mitral VS; (c) the transseptal approach was not effective; and (d) the trans-prosthetics approach was effective in RFCA for APs at the site of tricuspid VS.

4.2 | Challenges in RFCA of APs at the site of prior VS

It is challenging to perform RFCA for APs at the site of prior VS. Several aspects contribute to this difficulty. First, the prosthetic valve or annuloplasty ring impedes the catheter approach and delivery of radiofrequency energy to the APs. It is because the sewing ring of the prosthetic valve or annuloplasty ring was sutured with the annulus.[6] Second, there is severe fibrosis around the annulus owing to the prior VS, which may obscure AP signals and impede delivery of radiofrequency energy.[7] Therefore, detailed mapping of the areas both above and below the prosthetic valve is an essential step.

4.3 | Prevalence of APs with decremental conduction property

The prevalence of APs with decremental conduction property is reported at 7.6%-9.7% in patients without structural heart disease.[8,9] The prevalence of decremental conduction APs among patients with Ebstein anomaly is comparable to that noted among patients with structurally normal heart.[10] However, decremental conduction APs are more frequent in patients with persistent left superior vena cava.[11,12] In the present study, the prevalence of APs with decremental conduction property was high in patients with AP at the site of prior VS. In particular, all three patients who had undergone TVR for Ebstein anomaly exhibited APs with slow and decremental conduction property. Although the reason for decremental conduction is unclear, two possible explanations can be suggested. (a) APs without decremental conduction property might a have higher probability of overt delta wave and performing RFCA before VS than APs with decremental conduction property. Because delta waves are not always noted on presurgery ECG in patients with APs exhibiting slow and decremental conduction, not all such patients might be indicated for RFCA before VS. This explanation was our guess based on the cases in the present study. (b) APs might be partially damaged either by the surgery itself or by prior RFCA attempts and show decremental conduction property.[13–15] The slow and decremental conduction properties could contribute to minimal or intermittent ventricular preexcitation, leading to difficulties in diagnosing WPW syndrome and mapping these APs in an electrophysiological study. Thus, slow and decremental conduction property may be the reason why none of the three patients in this study who had APs at the site of prior TVR exhibited preexcitation on preoperative ECG.

4.4 | Transaortic approach

Mapping of the areas both above and below the prosthetic mitral valve can be performed using the transseptal and transaortic approaches. For RFCA of APs at the site of mitral VS (six cases), the transaortic approach was successful in two patients but failed in another two patients, whereas the transseptal approach failed in all five patients in whom it was attempted. The position of the mechanical mitral valve may account for this discrepancy in success rate. Specially, the transaortic approach might be effective if the mechanical valve is located slightly toward the atrial side, but not if the mechanical valve is located at the true mitral annulus. In patients with a relatively small mitral valve annulus, cardiac surgeons occasionally implant the mechanical valve slightly on the atrial side from the mitral valve annulus. Because it is difficult to determine the exact position of the mechanical valve based on imaging alone, it is important to map the areas both above and below the mechanical valve.

4.5 | Trans-prosthetics approach

The above- and trans-prosthetics approach facilitated detailed mapping of areas above and below the prosthetic tricuspid valve. Generally, it is safe that the catheter is passed through a bioprosthetic valve with particular care.[4] It is not recommended to pass the catheter through the mechanical valve, as doing so carries a risk of catheter entrapment, mechanical valve damage, and acute regurgitation through the mechanical valve. However, this recommendation is based mainly on reports of cases involving caged-ball or tilting-disc valves.[16–18] In our patients, the ablation catheter was passed through the bileaflet mechanical tricuspid valve by carefully manipulating the catheter under fluoroscopic guidance. There were no complications and it was feasible to retain the ablation catheter across the mechanical valve for about 10-15 minutes.

In Ebstein anomaly, the tricuspid annulus is separated into the true (or anatomic) annulus and the functional annulus, which is displaced downward.[19,20] During TVR for Ebstein anomaly, the prosthetic valve is usually implanted on the atrial side to avoid injury to the conduction system.[20,21] In patients with Ebstein anomaly, the right APs can be successfully ablated at the true annulus.[10] Therefore, to ensure successful RFCA for right APs in patients with Ebstein anomaly, it is necessary to accurately map the area below the prosthetic valve. Right coronary angiography is helpful for recognizing the location of the true tricuspid annulus because the right coronary artery demarcates this landmark.[21] The exact lateral view of the mechanical valve leaflets is suitable for fluoroscopic guidance of the trans-prosthetics approach because this view provides helpful information about the location of leaflet hinges, as well as leaflet motion.

4.6 | Bipolar ablation technique

Ensuring effective radiofrequency energy delivery to the AP is critical because the prosthetic components and fibrotic tissue around the annulus hinder energy delivery. Using the bipolar ablation technique, a deep and transmural ablation lesion can be created.[22–24] In our patients, the second ablation catheter, which served as a dispersive electrode, was connected to the port for the dispersive patch of the radiofrequency generator and to the ECG recording system using a custom-made cable (Figure S1). To apply the bipolar ablation technique for RFCA of left APs, the ablation catheter should be placed under the mechanical mitral valve via the transaortic approach, whereas the dispersive catheter should be placed in the CS. This setup with the ablation catheter at the ventricular endocardial area and the dispersive catheter at the atrial epicardial area facilitates ablation of the AP because the AP is located between the ablation catheter and dispersive catheter. Ablation can be started at low power (10 W), followed by a gradual increase up to 30 W with impedance monitoring to avoid steam pop, which is more likely to occur at a power of ≥30 W.[23,25] Damage to the left circumflex coronary artery can occur when RFCA is performed around the CS.[26,27] Therefore, particular attention should be paid to any symptom of chest pain and to signs of ST segment deviation on ECG monitoring.

4.7 | Stepwise approach to APs at the site of prior VS

Based on the success rate and accessibility, we suggest a stepwise approach to RFCA of APs at the site of prior mitral or tricuspid VS. In patients with prior mitral VS, we recommend the following strategy: transaortic approach → transseptal approach → CS approach → bipolar ablation (an ablation catheter below the prosthetic valve via the transaortic approach and a dispersive catheter in the CS) → surgical ablation (Figure 4A). In patients with prior tricuspid VS, we recommend the following strategy: above-prosthetics approach → trans-prosthetics approach → bipolar ablation (ablation catheter below the prosthetic valve and dispersive catheter above the prosthetic valve) → surgical ablation (Figure 4B).

4.8 | Study limitations

The number of patients in the present study was small because the prevalence of AP among patients with prior mitral or tricuspid VS is generally very low. Furthermore, there were insufficient data regarding the patients described in previously published case reports and included in the present study (historical-VS subgroup), and we could not exclude publication bias. Moreover, because case reports describing failed procedures and patients with recurrence or complications may be less likely be published, we could not conduct between-group comparisons of the success, recurrence, and complication rates. Additionally, we could not validate the safety of passing the catheter across the mechanical mitral or aortic valve. As our patients only had bileaflet valves, we were not able to suggest useful catheter approaches and RFCA techniques for RFCA of APs adjacent to mechanical valves with caged-ball or tilting-disc design. Finally, we could not validate the efficacy of the bipolar ablation techniques for right APs in patients who underwent TVR. Further studies are needed to clarify the efficacy and safety of the stepwise approach for APs at the site of prior VS.

5 | CONCLUSIONS

To achieve successful RFCA of APs at the site of prior VS, it is important to conduct detailed mapping of the areas both above and below the prosthetic valve, as well as to ensure effective radiofrequency energy delivery using various catheter approaches and RFCA techniques.

CONFLICT OF INTEREST

Authors declare no conflict of interests for this article.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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