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A Novel Technique for the Avoiding Catheter Dislodgment Caused by Atrio-Ventricular Dissociation after Elimination of the Accessory Pathway

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We hypothesized that the atrio-ventricular (AV) dissociation occurring after elimination of the accessory pathway conduction during right ventricular (RV) pacing made the stability of the ablation catheter worse. We confirmed this hypothesis by using a pacing model. As a simulation model, sequential ventriculo-atrial (VA) pacing was designed and studied in 20 patients without VA conduction. Prior to the sequential VA pacing, 3 catheters were positioned in the RV, right atrium (RA) and at the tricuspid valve annulus (TVA), respectively. The sequential VA pacing consisted of continuous RV pacing at a cycle length of 600 ms and RA pacing. The RA was paced at an interval of 125 ms following the RV pacing. To induce AV dissociation, RA pacing was abruptly terminated during continuous sequential VA pacing. We observed the motion of the catheter tip on the TVA before and after RA pacing using fluoroscopy in the 30˚ right anterior oblique (RAO) and 45˚ left anterior oblique (LAO) views. The catheter tip position in the end-systolic and end-diastolic phases was confirmed in each projection, and the distance of the catheter tip between these 2 phases was measured. The mean value of the catheter tip distance between the 2 phases obtained with sequential VA pacing and fusion beats was 7.5 ± 3.2 and 21.0 ± 8.3 mm in the RAO ($P < 0.001$) and 8.0 ± 4.5 and 19.0 ± 8.6 mm in the LAO views ($P < 0.001$), respectively. Further, we proposed a new pacing maneuver to stabilize the ablation catheter position after the elimination of accessory pathway conduction. Using sequential VA pacing, we examined catheter tip movement during RF current delivery in 6 patients with the concealed Wolff-Parkinson-White syndrome. During RF current delivery, catheter dislodgment did not occur in any patients after the accessory pathway was eliminated when no fusion beats occurred. In conclusion, AV dissociation occurring after elimination of the accessory pathway conduction during RV pacing worsened the stability of the ablation catheter. Furthermore, a new pacing maneuver during the RF application provided a useful method for maintaining stable catheter position for catheter ablation of accessory pathways.

Key words: catheter dislodgment; sequential pacing; radiofrequency catheter ablation; Wolff-Parkinson-White syndrome

In the case of manifest anterograde accessory pathway conduction, radiofrequency (RF) energy is usually delivered during sinus rhythm to the site with the shortest atrio-ventricular (AV) interval and/or an accessory pathway potential (Twidale et al., 1991; Calkins et al., 1992; Silka et al., 1992; Bashir et al., 1993; Grimm et al., 1994). In the case of concealed retrograde accessory pathways, evaluation of the local electrogram is meaningful only during the retro-

Abbreviations: AV, atrio-ventricular; CS, coronary sinus; HRA, high right atrium; LAO, left anterior oblique; RA, right atrium; RAO, right anterior oblique; RF, radiofrequency; RV, right ventricle/ventricular; TVA, tricuspid valve annulus; VA, ventriculo-atrial; VCS, ventriculo-CS; VRA, ventriculo-HRA grade accessory pathway conduction occurring during either orthodromic tachycardia or right ventricular (RV) pacing, and the RF energy is delivered during either the tachycardia or RV pacing (Okumura et al., 1993; Li et al., 1994). In all cases, during RF catheter ablation of accessory pathways, once the elimination of the accessory pathway conduction is observed, the RF energy application should be continued for a prolonged length of time in order to assure a permanent cure, even if there is a prompt loss of the accessory pathway conduction within 2 to 3 s. Unfortunately, if the catheter movement occurs at the time of the elimination of the accessory pathway, in particular with concealed retrograde accessory pathways in which it is necessary to use RV pacing, the RF energy application cannot be continued and the temporary loss of accessory pathway conduction can make subsequent mapping and ablation difficult. There have been many trials attempted to avoid such an occurrence (Li et al., 1994; Okumura et al., 1993); however, the cause of this accident has not yet been reported. In this study, we hypothesized that the AV dissociation after the elimination of the accessory pathway during RV pacing made the stability of the ablation catheter worse. We confirmed this by using a pacing model that simulated the condition when RF energy is delivered to the concealed accessory pathways during the constant RV pacing. Further, we proposed new pacing maneuvers, which we called sequential ventriculo-high right atrium (VRA) pacing or ventriculo-coronary sinus (VCS) pacing, to stabilize the ablation catheter position after the elimination of the accessory pathway. Therefore, we would like to describe our preliminary experience with this technique.

Patients and Methods

Pacing model

Sequential ventriculo-atrial (VA) pacing was designed as a model to simulate the condition when RF energy is delivered to concealed accessory pathways during constant RV pacing. The study population consisted of 20 consecutive patients (12 males, 8 females; mean age, 42 ± 24 years) who underwent electrophysiological examination between July1996 and September 1997 in the Division of Cardiology, First Department of Internal Medicine, Faculty of Medicine, Tottori University. Out of the 20 patients, 7 had the sick sinus syndrome and 13 were successfully ablated Wolff-Parkinson-White syndrome patients. In this examination, we confirmed that no patients had VA conduction or structural heart disease. Antiarrhythmic drugs were discontinued for at least a 5-fold period of their half-life in all patients. The research was performed after completion of the diagnostic study in the sick sinus syndrome patients and after successful ablation in the Wolff-Parkinson-White patients.

Prior to the sequential VA pacing, two 5-Fr quadripolar (5 mm interelectrode spacing) catheters (Cordis Webster, Baldwin Park, CA) were introduced via the inferior vena cava and positioned in the right atrium (RA) and RV. A 7-Fr quadripolar catheter with a large tip electrode (electrode length 4 mm; Cordis Webster) was introduced via the inferior vena cava and positioned on the tricuspid valve annulus (TVA). One indicator that the catheter on the TVA, which represented the RF catheter, was satisfactorily positioned, was the presence of clear and discernible equal atrial and ventricular components of the local electrogram recorded from the distal pair of electrodes of the catheter. Simultaneously performed right coronary artery angiography supported the existence of satisfactory positioning. The sequential VA pacing consisted of continuous RV pacing at a cycle length of 600 ms and RA pacing. The RA was paced at an interval of 125 ms following the RV pacing. Both pacing impulses constantly collided in the normal conduction system (Fig. 1 A). RV pacing was obtained by abrupt termination of the RA pacing during continuous sequential VA pacing. The sinus node function recovered due to the termination of the RA pacing. The different rates of the sinus rhythm and RV pacing prevented constant collision of the impulses (Fig. 1B). In this manner, we were able to simulate the same condition as that observed during

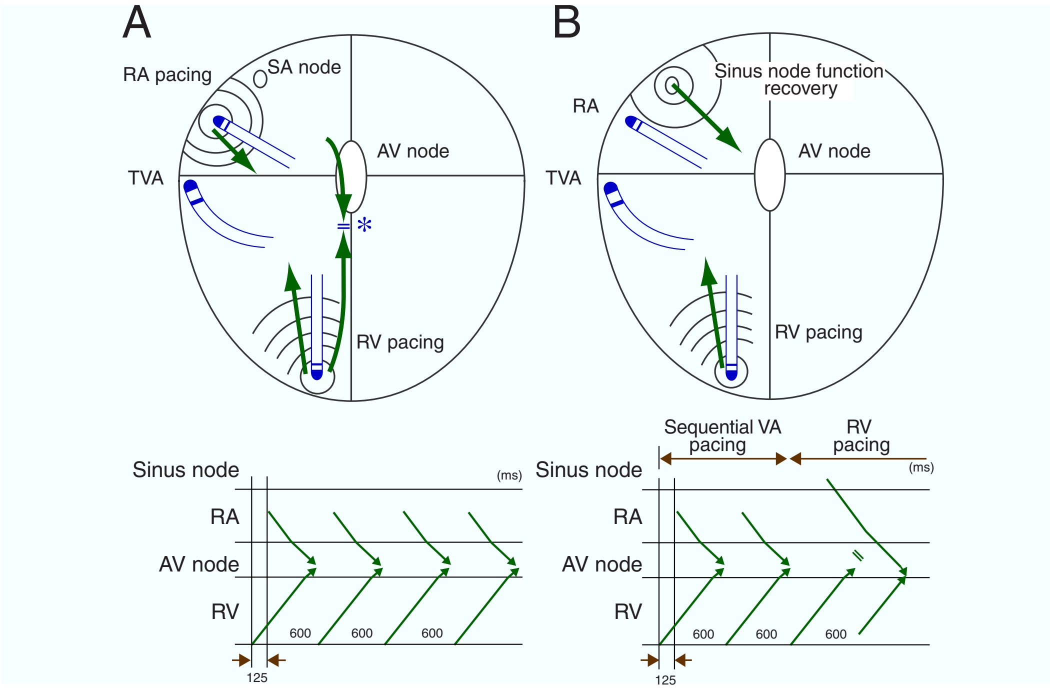

Fig. 1. Illustrations showing the method of sequential ventriculo-atrial (VA) and right ventricular (RV) pacings, with the conduction patterns during sequential VA pacing (**A**) and during RV pacing (**B**). See the text for details. AV, atrio-ventricular; SA, sinoatrial; RA, right atrium; TVA, tricuspid valve annulus.

elimination of accessory pathways. In other words, sequential VA pacing was the condition before the elimination of accessory pathway, and sequential RV pacing, after the elimination. During sequential VA or RV pacing, the movement of the catheter tip on the TVA, was observed using fluoroscopy in the 30° right anterior oblique (RAO) and 45° left anterior oblique (LAO) views. The position of this catheter tip during the end-systolic and end-diastolic phases was confirmed in each projection, and the distance between the position of the catheter tip in these 2 phases was measured. Body surface and intracardiac electrograms were monitored and recorded with an EP Amp and EP Lab (Quinton, Seattle, WA). Pacing was performed with a cardiac stimulator (SEC-3102, Nihon Kohden, Tokyo, Japan) using rectangular stimuli at twice the diastolic threshold and a pulse width of 2 ms. The distal pair of electrodes of RV and RA were used for stimulation, while the proximal pair of electrodes were used for recording the local bipolar electrogram.

RF ablation under sequential VRA or VCS pacing

The pacing technique was used in 6 patients in whom either right or left concealed accessory pathways was electrophysiologically diagnosed. Out of the 6 patients (4 males, 2 females; mean age, 42 ± 24 years), 4 patients had left-sided and 2 right-sided accessory pathways. Using this sequential VA pacing, we were able to design a method that would mimic the VA conduction, that occurs with accessory pathways during RV pacing, even after the elimination of the accessory pathway conduction. When the accessory pathway was located on the left side, RF ablation was performed using an RF generator (CAT 500, Central Inc., Ichikawa, Japan) while delivering sequential VRA pacing. The RV-high RA (HRA) pacing interval was programmed to be the maximum interval in which the atrial wave front propagating from the HRA pacing site did not hide the earliest activation of the left atrium through the accessory pathway.

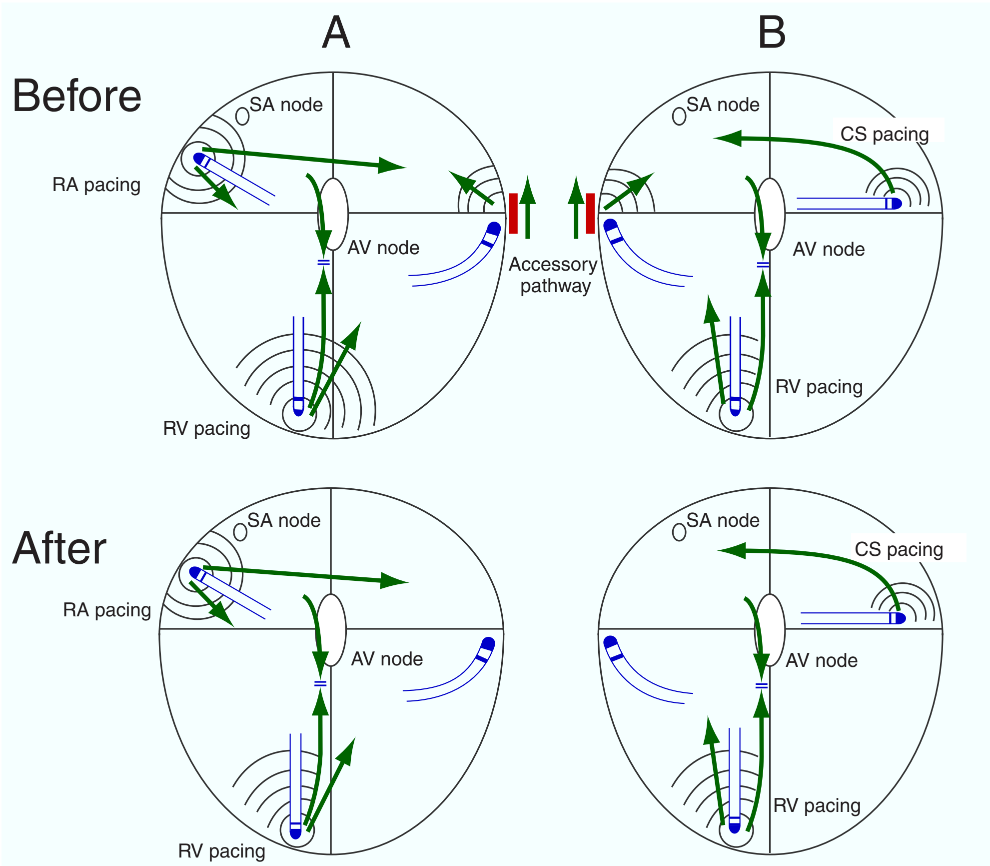

Fig. 2. Illustration showing the activation sequences before and after the elimination of accessory pathway conduction when sequential ventriculo-high right atrium pacing (**A**) or ventriculo-coronary sinus (CS) pacing (**B**) is applied during the radiofrequency application. **A:** A left-sided accessory pathway case. **B:** A right-sided accessory pathway case. See the text for details. AV, atrio-ventricular; RA, right atrium; RV, right ventricular; SA, sinoatrial.

In other words, the VA interval was programmed in order to minimize the atrial activation through the accessory pathway to just only local activation (minimum atrial activation) (Fig. 2A). If the accessory pathway was located on the right side, we performed RF ablation during sequential VCS pacing (Fig. 2B). If elimination of the accessory pathway conduction was observed, the RF energy application was continued for 60 s at 20 W. Before and after elimination of the accessory pathway, the movement of the ablation catheter tip on the mitral or tricuspid valve annulus, was observed using fluoroscopy in the 30˚ RAO and 45˚ LAO views. The position of this catheter tip during the end-systolic and end-diastolic phases was confirmed in each projection, and the distance between the position of the catheter tip in these 2 phases was measured over 5 consecutive beats. All patients gave written informed consent to participate in this study.

Data and Statistical Analysis

All data were presented as mean ± SD. Continuous variables were compared using Student's *t*-test for paired samples. A probability of < 0.05 was considered statistically significant.

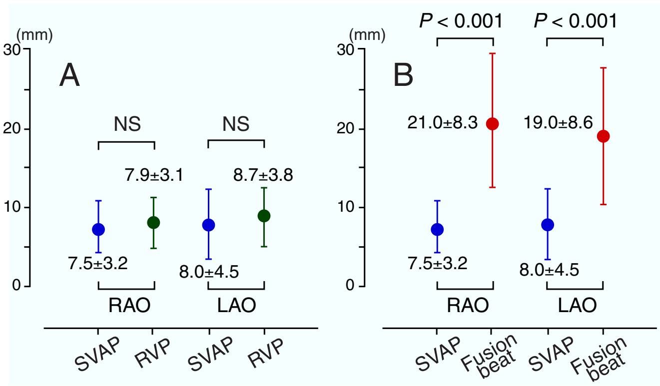

Fig. 3. The distance between the location of the catheter tip on the tricuspid valve annulus in the end-systolic and end-diastolic phases. **A** shows mean values of the distance during sequential VA pacing (SVAP) and RV pacing (RVP), not including fusion beats. **B** shows mean values of the distance during SVAP and fusion beats. LAO, 45˚ left anterior oblique view; NS, not significant; RAO, 30˚ right anterior oblique view.

Results

Sequential VA pacing

The catheter located on the TVA was positioned on the right posterior-lateral TVA in all patients. The catheter tip movement revealed that the TVA motion was weak and constant during sequential VA pacing, and had a tendency to be strong during RV pacing regardless of patients respirations. The mean value of the distance that the catheter tip moved from its position in the end-systolic phase to that in the end-diastolic phase during sequential VA or RV pacing, except during fusion beats, for 10 beats was 7.5 ± 3.2 mm and 7.9 ± 3.1 mm in the RAO projection and 8.0 ± 4.5 mm and 8.7 ± 3.8 mm in the LAO projection, respectively. However, there was no significant difference between the values obtained during sequential VA or RV pacing in either projection (Fig. 3A). However, when a fusion beat during RV pacing resulting from a supraventricular beat propagating down the normal AV conduction system occurred, there was strong and abrupt movement of the TVA catheter. The mean value of the distance the catheter moved during the fusion beats was 21.0 ± 8.3 mm and 19.0 ± 8.6 mm in the RAO and LAO projections, respectively. As a result, the distances observed with the fusion beats were substantially longer than those during sequential VA pacing ($P < 0.001$) (Fig. 3B). In 6 patients the local electrogram recorded from the distal pair of electrodes of the TVA catheter during fusion beats with RV pacing varied from that during sequential VA pacing.

Typical examples of TVA motion during sequential VA pacing and a fusion beat are shown in Figs. 4 and 5. In Fig. 4, RA pacing at an interval of 125 ms following the RV pacing was discontinued abruptly during constant RV pacing at a cycle length of 600 ms. This indicated that a fusion beat resulting from a sinus beat propagating down the normal AV conduction system occurred when the sinus node function had recovered after stopping the RA pacing (see the asterisk). The local electrogram recorded from the distal pair of electrodes of the TVA catheter altered with the fusion beats. Depicted in Fig. 5 is the fluoroscopy taken during right coronary artery angiogram in the 30˚ RAO and 45˚ LAO views during sequential VA pacing (Fig. 5A) and RV pacing when a fusion beat occurred (Fig. 5B). The 2 images of the end-systolic and end-diastolic phases were superimposed during each pacing attempt. The distance of the catheter tip movement on the TVA was measured. The distance of the catheter tip movement during sequential VA pacing was 4.9 mm and 4.2 mm in the RAO and LAO projections, respectively (Fig. 5A). On the other hand, the distance during a fusion beat was 16.7 mm and 13.9 mm in the RAO and LAO projections, respectively (Fig. 5B). This indicated that the distance of the catheter tip moved during the fusion beat was longer than that during sequential VA pacing. The above results indicate that fusion beat will play the pivotal role for the dislodgment of catheter tip.