# Factors Associated with Recurrence of Accessory Pathway Conduction After Radiofrequency Catheter Ablation

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**TWIDALE, N., ET AL.: Factors Associated with Recurrence of Accessory Pathway Conduction After Radiofrequency Catheter Ablation.** *Catheter ablation of 215 accessory pathways (APs) using radiofrequency current (RF) was attempted in 204 consecutive patients. Two hundred twelve of the 215 (99%) APs were successfully ablated. After a minimum follow-up period of 1 month (mean 8.5 ± 5.4 months), AP conduction had returned in 17 patients (8%). Recurrence of AP conduction was manifest by atrioventricular (AV) reentrant tachycardia in six patients, palpitations suggestive of AV reentrant tachycardia in five patients, ventricular preexcitation on electrocardiogram in five patients, and inducible AV reentrant tachycardia during a follow-up electrophysiological study in one asymptomatic patient. AP conduction returned as early as 12 hours and as late as 4.7 months, but was evident within 2 months of ablation in 15 of 17 (88%) patients. AP conduction recurred in 12%–14% of anteroseptal, right free-wall, and posteroseptal APs, but only 5% of left free-wall APs (P < 0.01). Retrograde only conducting APs (concealed APs) had recurrence of AP conduction more frequently (16%) than APs that exhibited antegrade conduction (5.5%; P < 0.01). Failure to record AP potentials from the ablation electrode, reflecting poor AP localization, was a strong predictor for recurrence of AP conduction. AP conduction returned in 19% of 48 APs when AP potentials were not recorded, compared to 5% of 164 APs where AP potentials were recorded from the ablation electrode (P < 0.01). The time to block of AP conduction from the onset of RF current application was longer in APs with recurrence of conduction (4.9 ± 6.1 sec vs 2.9 ± 3.4 sec; P < 0.02). Recurrence of AP conduction was more frequent when the stability of the ablation electrode was poor (12% of 41 APs vs 7% of 171 APs with stable electrode placement), and when the AP had multiple components (11% of 36 APs ablated at multiple sites vs 7% of 176 APs where AP was ablated at a single site), but these were not statistically significant. All 17 patients with recurrence of AP conduction underwent a second successful ablation. In conclusion, the overall incidence of recurrence of AP conduction is low, but is higher for right free-wall and septal APs, concealed APs, and probably relates to poor AP localization. (PACE, Vol. 14, November, Part II 1991)*

*catheter ablation, radiofrequency current, accessory atrioventricular pathways, Wolff-Parkinson-White syndrome, preexcitation syndrome, supraventricular tachycardia*

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## Introduction

Catheter ablation of accessory atrioventricular (AV) pathways is becoming first-line therapy for symptomatic patients with the Wolff-Parkinson-White syndrome. Radiofrequency current is increasingly being used as the ablation energy source, because it can be delivered effectively without causing hemodynamic compromise, cardiac rupture, serious arrhythmias, or neuromuscular stimulation (eliminating the need for general anesthesia).[1,2] Lesions produced by radiofrequency current are small (approximately 0.5 cm in diameter), requiring close proximity of the ablation electrode to the accessory pathway (AP) for successful ablation.[3] Firm electrode-tissue contact is also required to produce an effective lesion. When these requirements are fulfilled, the clinical results have been excellent, with successful elimination of AP conduction in up to 99% of patients,[4,5] However, AP conduction may return in some patients following apparently successful catheter ablation. Factors that might influence the rate of recurrence of AP conduction include: (1) accuracy of AP localization; (2) adequacy of electrode-tissue contact; (3) adequacy of the energy applied to produce a significant area of necrosis; and (4) the presence of multiple fibers. The purpose of this study was to examine the incidence, clinical characteristics, and possible factors associated with recurrence of AP conduction after radiofrequency catheter ablation.

## Methods

### Patient Population

The study population consisted of 204 consecutive patients who underwent radiofrequency catheter ablation of 215 APs and who had a minimum of 1 month of clinical follow-up. Patients were not excluded for any technical reason, including the presence of multiple pathways (11 patients), prior unsuccessful surgical or catheter ablation (27 patients), presumed difficult AP location, or previous inability to catheterize the coronary sinus for localization of left free-wall APs. Patient age ranged from 6–78 years (mean 32.2 ± 15.7 years).

### Ablation Technique

Radiofrequency current (continuous wave, 550–750 kHz) was applied at 20–62 watts (W) for 5–152 seconds between a 7 French, 4 mm tip electrode on a deflectable catheter (Mansfield/Webster Catheters, Boston Scientific Inc., Watertown, MA, USA) positioned against the mitral or tricuspid annulus, and a standard electrosurgical dispersive pad applied to the chest wall.[4] Direct catheter recordings of AP activation were utilized as the principle guide to localize APs and for the site of energy delivery.[6]

### Postablation Management

Beginning 30–60 minutes after the final application of radiofrequency current, incremental and extrastimulation of the atrium and ventricle were repeated to verify the absence of AP conduction and to exclude the presence of another AP or other arrhythmias. Patients were usually discharged on the second day after ablation and were followed by the investigators or by the referring physician,usually being seen within 7–14 days. A repeat electrophysiological study, 2–3 months after ablation, was recommended to all patients and was performed in 92 of 204 patients (45%) at a mean of 2.9 ± 2.0 months after ablation.

### Factors Influencing Accessory Pathway Recurrence

AP localization was considered to be poor if the ablation electrode failed to record AP activation potentials. Electrode-tissue contact was considered to be poor when some degree of sliding of the ablation electrode was recorded by the cineangiogram obtained immediately prior to ablation. The interval of time from the onset of the energy application to the loss of AP conduction was also used as a measure of AP localization and electrode-tissue contact. The adequacy of ablation energy was assessed by the power and duration of application of radiofrequency current. Multiple AP fibers were felt to be present if an application of radiofrequency current resulted in a shift in the site of earliest antegrade or retrograde activation (with a prolongation of the AP conduction time) or if antegrade and retrograde AP conduction were ablated by separate applications of current at two different sites. In patients undergoing a second ablation for recurrent AP conduction, the original and repeat ablation sites were compared and a disparity of > 1 cm was considered to be suggestive of either multiple fibers or poor AP localization during the initial procedure.

### Statistical Analysis

Grouped data are expressed as mean values ± standard deviation. For comparison of differences, a nonpaired Student's *t*-test was used for continuous outcome variables and a Chi-square test was used for nominal outcome variables. Multiple stepwise regression analysis was used to test the relationship between independent variables and recurrence of AP conduction. A probability value of $< 0.05$ was considered significant.

## Results

Radiofrequency current eliminated conduction in 212 of 215 (99%) APs. Of these 212 APs, conduction returned in 17 (8%) over a mean follow-up period of 8.5 ± 5.4 months (range 1–31 months). The return of AP conduction was manifest by documented AV reentrant tachycardia in six patients, palpitations suggestive of AV reentrant tachycardia in five patients, ventricular preexcitation on routine follow-up electrocardiogram in five patients, and inducible AV reentrant tachycardia during follow-up electrophysiological study in one asymptomatic patient. AP conduction returned as early as 12 hours and as late as 4.7 months, but 88% of patients with recurrence of AP conduction presented within 2 months after ablation (Fig. 1).

### Distribution and Conduction Characteristics of AP Recurrence

The distribution of APs in which conduction recurred is shown in Figure 2. Conduction recurred in 12%–14% of the 14 anteroseptal, 22 right free-wall, and 49 posteroseptal APs. The rate of recurrence in the 127 left free-wall APs was significantly less, at 5% ($P < 0.01$). In addition to location, there was a significant difference in the rate of recurrence between pathways that conducted antegradely compared to those that conducted only retrogradely (concealed). Of the 50 concealed APs, conduction returned in 16%, compared to 5.5% of 162 APs that exhibited antegrade conduction ($P < 0.01$).

### Factors Influencing AP Recurrence

A multivariate analysis found the following to be independent predictors of recurrence in decreasing order of rank: (1) absence of antegrade AP conduction ($P = 0.002$); (2) failure to record AP potential from the ablation electrode ($P = 0.003$); (3) right free-wall or septal AP location ($P = 0.004$); and (4) prolonged time to AP conduction block after the onset of energy application ($P = 0.01$). The results are shown in Table I. Failure to record AP potentials from the ablation electrode (reflecting poor AP localization) was associated with recurrence of AP conduction. There was return of AP conduction in 19% of 48 APs where the ablation electrode did not record

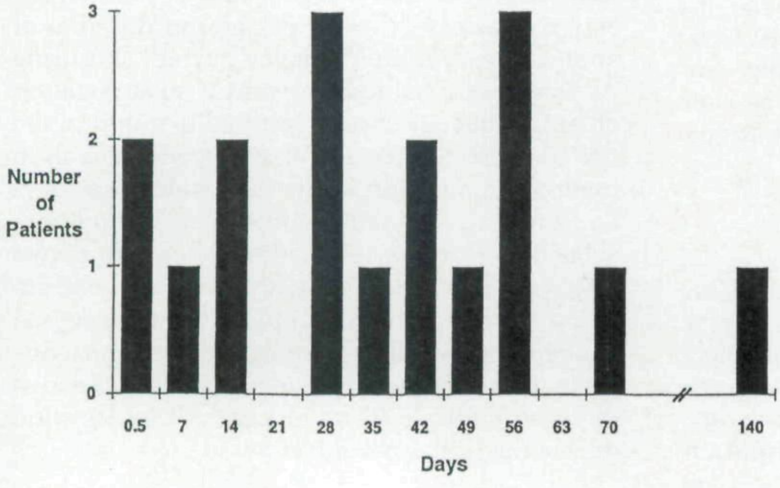


**Figure 1.** *Histogram showing time in days that recurrence of accessory pathway conduction was identified for each of the 17 patients.*

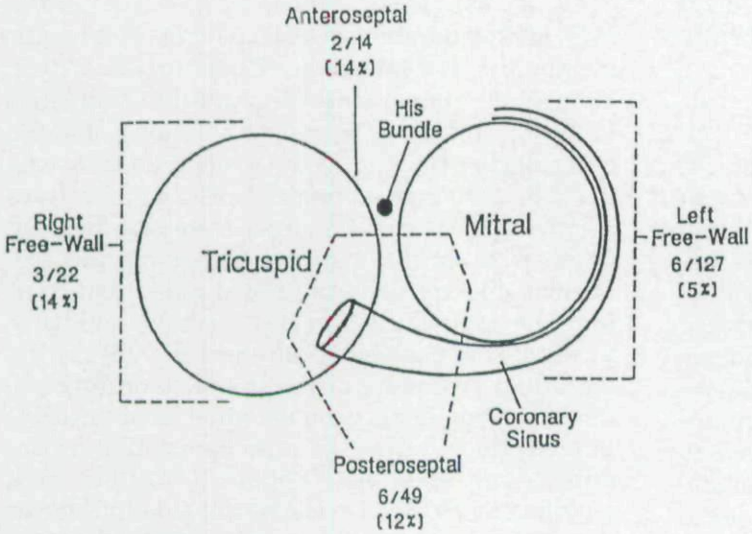


**Figure 2.** *Distribution of accessory pathways with recurrence of conduction. This schematic of the tricuspid and mitral anuli in the left anterior oblique projection shows the number of accessory pathways with recurrence of conduction (numerator) and total number of pathways ablated (denominator) at each of the four main location categories.*

an AP potential, compared to 5% of 164 APs when an AP potential was recorded from the ablation electrode. Difficulty in AP localization may contribute to the higher recurrence rate in concealed APs. In support of this premise was the finding that AP potentials were not recorded in five of eight concealed APs in which conduction recurred. The mean time to block in AP conduction (from the onset of energy application) for those pathways that had a recurrence of con-

**Table I.**

Factors Influencing Recurrence of Accessory Pathway Conduction

| | n | Recurrence | No Recurrence | P |
|---|---|---|---|---|
| Antegrade AP Conduction | | | | |
| Present | 162 | 9 (5%) | 153 | |
| Absence | 50 | 8 (16%) | 42 | 0.002 |
| AP Potential | | | | |
| Recorded | 164 | 8 (5%) | 156 | |
| Not recorded | 48 | 9 (19%) | 39 | 0.003 |
| AP Location | | | | |
| Right free-wall/septal | 85 | 11 (13%) | 74 | |
| Left free-wall | 127 | 6 (5%) | 121 | 0.004 |
| Time to Block (sec) | | 4.9 ± 6.1 | 2.9 ± 3.4 | 0.01 |
| Catheter Position | | | | |
| Stable | 171 | 12 (7%) | 159 | |
| Sliding | 41 | 5 (12%) | 36 | NS |
| Multiple Fibers | | | | |
| Not present | 176 | 13 (7%) | 163 | |
| Present | 36 | 4 (11%) | 32 | NS |
| RF Power (watts) | | 28.8 ± 6.7 | 32.1 ± 6.8 | NS |
| RF Duration (seconds) | | 37.0 ± 19.1 | 43.9 ± 25.2 | NS |

AP = accessory pathway, RF = radiofrequency; NS = not significant.

duction was 4.9 ± 6.1 seconds, compared to 2.9 ± 3.4 seconds for APs that were permanently ablated.

Factors found not to be predictors of recurrence of AP conduction, but where there appeared to be a trend, were the following: (1) in examining cineangiograms obtained prior to ablation, some degree of sliding of the ablation electrode was observed at 41 ablation sites, suggesting poor electrode-tissue contact. AP conduction returned in 12% of these 41 APs compared to 7% where the electrode moved synchronously with the heart. (2) The power of the radiofrequency application for APs that had recurrence of conduction was 28.8 ± 6.7 W compared to 32.1 ± 6.58 W for APs that were permanently ablated while the duration of the energy application was 37.0 ± 19.1 seconds compared to 43.9 ± 25.2 seconds, respectively. (3) In the presence of multiple fibers, conduction returned in 11% of 36 APs compared to 7% in those APs ablated at a single site.

### Treatment of Recurrent AP Conduction

All 17 patients underwent a second ablation procedure with elimination of AP conduction in all. Comparison of AP conduction characteristics measured at the original AP ablation procedure, and those measured at the repeat ablation procedure showed that the shortest ventricular pacing cycle length maintaining 1:1 retrograde AP conduction was longer at the time of repeat ablation, 384 ± 64 msec vs 321 ± 69 msec ($P < 0.05$). However, neither the shortest atrial pacing cycle length maintaining 1:1 antegrade AP conduction (320 ± 53 msec at original ablation procedure compared to 385 ± 133 msec at repeat ablation), nor the cycle length of the induced AV reentrant tachycardia (378 ± 78 msec at original ablation procedure compared to 371 ± 72 msec) were significantly different. In six of 17 patients, the second and permanent ablation site was located more than 1 cm from the original ablation site, as shown in Figure 3, suggesting poor localization of the AP during the initial procedure or the presence of multiple fibers. AP potentials were recorded from the ablation electrode during the original ablation procedure in only eight of 17 patients (47%) but were recorded in 13 (76%) at the repeat ablation procedure. At repeat ablation in three of the eight patients with concealed APs, AP potentials were recorded from the ablation electrode positioned above the mitral leaflet (one patient) or tricuspid leaflet (two patients), and was associated with permanent ablation in all three patients.

During a mean follow-up of 9.0 ± 5.7 months (range 2–20 months) after the second ablation procedure, AP conduction recurred in one patient with a concealed posteroseptal AP necessitating a third ablation procedure. AP conduction has not recurred in any of the other 16 patients. A follow-up electrophysiological study was performed in ten of the 16 patients 2–8 months (mean 3.4 ± 2.0 months) after the second ablation, confirming the absence of AP conduction.

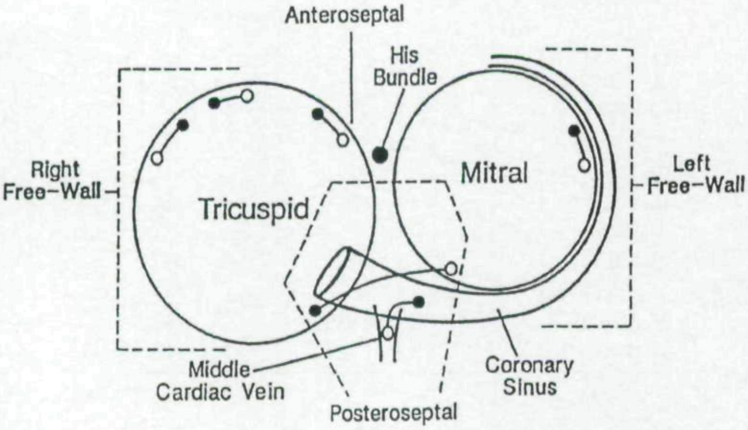


**Figure 3.** *Comparison of the initial and repeat ablation sites. The schematic of the tricuspid and mitral annuli in the left anterior oblique projection shows the location of the initial ablation site (filled circles) and repeat ablation site (open circles) for the 6 (of 17) pathways in which the repeat ablation site was further than 1 cm from the original ablation site.*

## Discussion

These results demonstrate that catheter-delivered radiofrequency current can effectively ablate APs in all locations, but resumption of AP conduction occurs in 8% and is usually apparent within 2 months of ablation. A right free-wall or septal AP location, absence of antegrade AP conduction, the failure to record AP activation potentials from the ablation electrode and a longer time to AP conduction block during the application of radiofrequency current were each found to be independent predictors of recurrent AP conduction. The failure to record AP potentials was associated with a more than threefold increase in the rate of recurrence of AP conduction, and was the single most significant factor predicting recurrence. The lower rate of recurrence for left free-wall pathways may relate to the ease and stability of ablation electrode placement using the retrograde (left ventricular) approach and by the simultaneous recording of AP potentials from the coronary sinus, greatly facilitating the localization of the AP. Anatomical constraints make localization and catheter placement more difficult for right free-wall and septal APs. Difficulty in AP localization may be a significant contributing factor leading to the higher recurrence rate in concealed APs. Localization of concealed APs using an ablation electrode beneath the mitral or tricuspid annulus is confounded by the tendency for retrograde AP activation potentials to be obscured by the large, overlapping ventricular potential (Fig. 4). In maneuvering the catheter along the annulus, it is often difficult to determine whether the amplitude of the retrograde AP potential is increasing or decreasing. This difficulty in analyzing AP potential amplitude from beneath the leaflet is not present for APs that conduct antegradely because, during antegrade conduction, the AP is activated before local ventricular activation. Positioning the ablation electrode on the atrial side of the mitral or tricuspid leaflet may facilitate recording of retrograde AP potentials, and may be the preferred approach for concealed pathways.

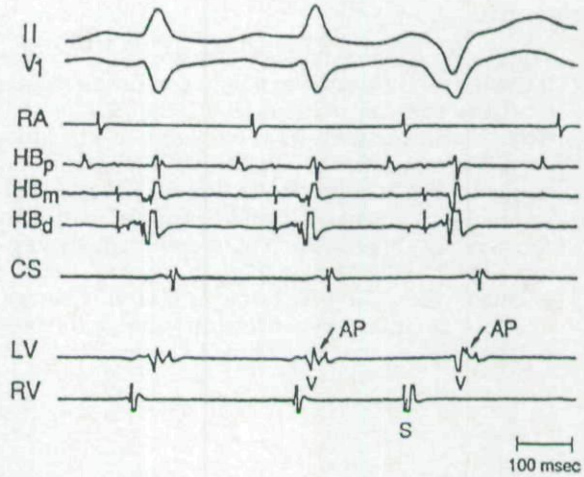


**Figure 4.** *Difficulties recording retrograde accessory pathway activation potentials from an ablation electrode positioned beneath the mitral leaflet. Recordings were obtained during trioventricular reentrant tachycardia in a patient with a concealed left free-wall accessory pathway. Tracings from the top are ECG Lead II and $V_1$ and electrograms recorded from the right atrium (RA), the proximal (HBp), middle (HBm), and distal (HBd) His-bundle electrodes, the coronary sinus (CS), the left ventricular ablation electrode positioned beneath the mitral leaflet (LV), and the ventricular apex (RV). A ventricular extrastimulus (S) shifts the left ventricular activation pattern, allowing clear recording of the retrograde accessory pathway (AP) activation potential. Note in the other complexes, the AP potential is completely masked by the local ventricular potential (V). Because of the problem of the large overlapping ventricular potential recorded during retrograde AP conduction, comparisons of the amplitude of the retrograde AP potential are difficult and may account for poorer localization and contribute to the higher recurrence rate for ablation of concealed APs.*

In conclusion, recurrence of AP conduction following an initially successful radiofrequency catheter ablation occurs in 8% of patients. The likelihood of AP conduction returning is higher for APs that are located in right free-wall and septal locations, and if an AP potential was not recorded from the ablation electrode. Recurrence of AP conduction does not preclude permanently successful AP ablation at a second procedure.

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