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"Pseudodisappearance" of Atrial Electrogram During Orthodromic Tachycardia: New Criteria for Successful Ablation of Concealed Left-Sided Accessory Pathways

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Objectives. **This study sought to analyze two new criteria along with other known predictors of success of radiofrequency ablation.**

Background. **Although the overall success rate of radiofrequency ablation of accessory pathways is high, the individual predictive value of each of the established criteria is low.**

Methods. **We prospectively studied the local electrograms obtained before the application of radiofrequency energy in 33 patients with a left-sided concealed accessory pathway successfully ablated. Two new criteria ("pseudodisappearance" during tachycardia of a bipolar atrial electrogram visible during sinus rhythm and the presence of an "atrial notch" in the ascending limb of the unipolar ventricular electrogram during tachycardia) were studied along with other known predictors. Electrograms recorded at a total of 157 sites were analyzed (33 successful applications, 124 failures).**

Results. **Electrogram characteristics that were predictive of success during ablation on the basis of univariate analyses were a pseudodisappearance criterion ($p < 0.001$), the presence of a Kent potential ($p < 0.005$) and the presence of an "atrial notch" ($p < 0.005$). After adjustment for between-patient differences, logistic regression analysis showed that only the "pseudodisappearance" criterion (odds ratio [OR] 7.2, 95% confidence interval [CI] 1.2 to 42.5, $p < 0.03$) and the presence of a Kent potential (OR 2.4, 95% CI 1.01 to 5.79, $p < 0.05$) had independent predictive value.**

Conclusions. **The pseudodisappearance during tachycardia or ventricular pacing of a bipolar atrial electrogram present during sinus rhythm is associated with a good outcome during radiofrequency ablation of concealed accessory pathways. These observations may help to ablate accessory pathways and to avoid missing appropriate sites for ablation when the atrial activation is not clearly visible at the local electrogram.**

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Catheter ablation of accessory atrioventricular connections using radiofrequency current has been demonstrated to be effective in the majority of patients with paroxysmal supraventricular tachycardias involving accessory atrioventricular (AV) pathways (1–9). Previously described criteria for success of radiofrequency ablation of concealed accessory connections included, in addition to electrogram stability and the presence of a Kent potential, expressions of the temporal "proximity" between local ventricular and atrial electrograms during retrograde conduction over the accessory pathway. These latter criteria have been reported as a ventriculoatrial (VA) interval (6) or a visual impression of continuity between ventricular and atrial electrograms (continuous electrical activity) (10). Although the overall success of radiofrequency ablation of the accessory pathways is high, the individual predictive value of each of the described criteria for each application is low (6,10). After observing, in individual cases, that there may be other indicators of proximity to the accessory pathway, we undertook the present study to analyze two new criteria along with other known predictors of success of radiofrequency ablation:

1. "Pseudodisappearance" during tachycardia or ventricular pacing of a bipolar atrial electrogram visible during sinus rhythm. This finding could be the consequence of the partial inclusion of the atrial electrogram as part of the ventricular electrogram.

2. Identification of the retrograde atrial activity during orthodromic tachycardia as a "notch" in the ascending limb of the local unfiltered unipolar ventricular electrogram.

Methods

Patients. We prospectively studied the local electrograms obtained immediately before the application of radiofrequency energy in 33 consecutive patients (12 men, 21 women, mean [±SD] age 28 ± 9, range 8 to 61) with a left-sided concealed

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accessory pathway successfully ablated. In 25 cases the accessory pathway was located in the left free wall, and in 8 cases in the posterior zone of the left AV ring (in two patients close to the interventricular septum).

We presumed that the "disappearance criterion" would be observed only in cases in which the ablation was attempted at the ventricular insertion. Our contention was that at the atrial insertion, with a relatively high atrial/ventricular amplitude relationship, the atrial electrogram would be recognizable even if "included" in the ventricular electrogram. Because we (as do the majority of groups) routinely attempt the ablation of the septal and right accessory pathways at their atrial insertion but of left lateral accessory pathways frequently at their ventricular insertion, we decided to include only the latter for analysis.

The indications for ablation were either ineffective drug therapy, symptomatic spontaneous tachyarrhythmias related to the accessory AV pathway or intolerable side effects of antiarrhythmic drugs during long-term therapy.

Electrophysiologic testing. After giving written informed consent, each patient underwent a diagnostic electrophysiologic test in conjunction with catheter ablation. The electrophysiologic test was performed during the fasting state. All antiarrhythmic agents were discontinued at least five half-lives before the procedure. Under fluoroscopic control, multipolar catheter electrodes (with 1 to 5-mm spacing) were placed in the high right atrium, His bundle position and in the apex of the right ventricle. A 6F decapolar catheter (USCI) with 1.3 cm spacing among the five pairs of electrodes was positioned in the coronary sinus via the right femoral vein or the right internal jugular vein. Stimulation was performed using a programmable stimulator (Janse Inc.). Data were recorded with a photographic recorder (Honeywell VR 12) at a paper speed of 100 mm/s. Three to seven surface electrocardiographic (ECG) leads were recorded along with three to five bipolar and three to five unipolar intracardiac electrograms. All intracardiac bipolar electrograms were filtered at 30 to 500 Hz. Unipolar recordings were obtained between the explorer electrode and a reference electrode placed in the inferior vena cava and were filtered at 0.05 to 2,500 Hz.

Functional variables of the accessory pathway and tachycardia inducibility were analyzed as previously described (11), in addition to localization of the accessory pathway to a general area.

Ablation protocol. After preliminary location of the accessory AV pathway, precise mapping was performed with a 7F catheter with a 4-mm distal electrode, 5-mm interelectrode spacing and a deflectable tip (Polaris Mansfield/Webster or radiofrequency Ablater CardioRhythm/Medtronic). These catheters were also used for ablation of accessory AV connections, inserted into a femoral artery and passed retrogradely across the aortic valve into the left ventricle. The local bipolar electrograms were recorded using the distal pair of electrodes of the ablation catheter, and the unipolar electrograms were obtained between the distal electrode of the ablation catheter and one reference electrode located in the inferior vena cava.

Target sites for ablation were identified by the presence of stability, "pseudodisappearance" criteria during orthodromic tachycardia or ventricular pacing (see below), the presence of a presumed Kent potential and early atrial activation (identified in the bipolar or in the unipolar recording) relative to the earliest retrograde atrial electrogram recorded at the coronary sinus.

Catheter ablation was performed using radiofrequency energy (Radionics in 12 patients and Atakr, CardioRhythm/Medtronic in 21 patients) delivered between the distal electrode of the ablation catheter and a large skin electrode positioned on the chest. A current of 20 to 35 W for 30 to 60 s was delivered on the ventricular side of the mitral annulus. When the temperature mode was used, the temperature limit was set at 70°C. Energy necessary to obtain this limit was delivered for 30 to 60 s.

After an effective pulse that induced block of the pathway, ventricular stimulation was intermittently performed for at least 30 min to evaluate whether the conduction pathway resumed before the patient left the laboratory.

Analysis of electrograms. Electrograms recorded at a total of 157 sites were analyzed after the completion of the procedure and in an unblinded manner. Analyzed electrograms included 33 permanently successful applications and 124 failures. Sites at which accessory AV conduction was transiently interrupted were excluded from analysis. Nine electrograms were recorded during ventricular pacing (four successes, five failures), and the remaining during orthodromic tachycardia.

Definitions. *"Pseudodisappearance" criterion* = a substantial decrease, during tachycardia or ventricular pacing, of the amplitude of the visible components of the atrial electrogram with no deflections from the baseline with a slope greater than 45° beyond the ventricular potential, producing the visual impression of an absence of a discernible atrial electrogram previously present in sinus rhythm (Fig. 1 to 3). *Continuous electrical activity* = less than 5 ms of isoelectric segment between the atrial and ventricular components of the bipolar electrogram (10) (Fig. 4). *Instability* = more than a 10% change in the atrial/ventricular ratio and the appearance or disappearance of a major deflection in the local electrogram in the five local electrograms recorded immediately before delivery of radiofrequency energy (10). *Kent potential* = deflections in the local electrograms preceding the onset of the atrial activation. Deflections suggestive of a Kent potential were not verified with pacing maneuvers. *Local ventriculoatrial interval* = from the onset of the local ventricular electrogram to the onset of the local atrial electrogram. When the atrial bipolar electrogram was absent, this interval was measured, when possible, to the local unipolar electrogram. *"Atrial notch" in ascending limb of local unipolar QRS complex* = fast deflections present during orthodromic tachycardia lasting <10 ms modifying the ascending limb of the unfiltered unipolar ventriculogram (Fig. 5). These deflections had to be absent during sinus rhythm. *Ventriculoatrial interval* = timing from the onset of the QRS complex to the onset of the local atrial electrogram. When the atrial bipolar electrogram was absent, this interval was measured to the local unipolar electrogram.

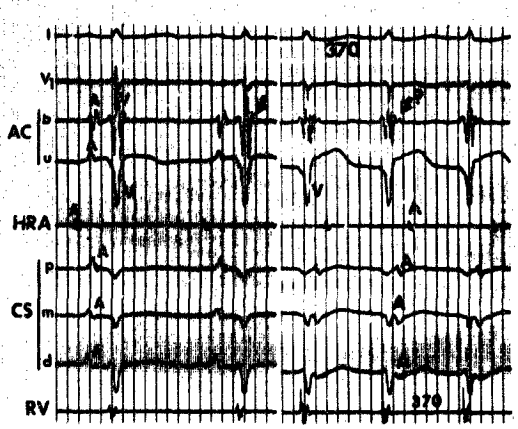


Figure 1. Recordings obtained during sinus rhythm (**left panel**) and orthodromic reciprocating tachycardia (**right panel**) at a site of success in a patient with a concealed left free wall accessory pathway. Tracings are, from top to bottom, surface ECG leads I and V_1, local bipolar (b) and unipolar (u) electrograms from the ablation catheter (AC) at the successful ablation site, bipolar high right atrium (HRA), unipolar coronary sinus (CS), proximal (p), medium (m) and distal (d) and bipolar right ventricular apex (RV). A = atrial electrogram; V = ventricular electrogram. **Left panel,** The atrial electrogram is clearly visible during sinus rhythm. **Right panel,** No deflections from the baseline with a slope >45° can be appreciated beyond the ventricular potential, producing the visual impression of an absence of a discernible atrial electrogram (?). The catheter remained stable, as can be seen by the same configuration of the unipolar and bipolar ventricular electrograms (**solid arrow**). This observation can be explained by the inclusion of the atrial electrogram as part of the ventricular electrogram.

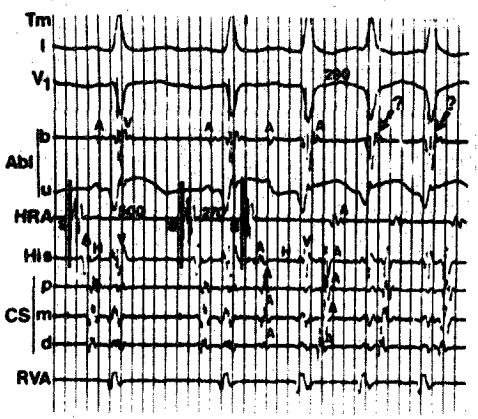


Figure 2. Recordings obtained at the site of a success, during atrial pacing and orthodromic reciprocating tachycardia, in another patient with a concealed left free wall accessory pathway. An atrial extrastimulus delivered with a coupling interval of 270 ms induces tachycardia. The atrial electrogram is clearly visible during atrial pacing but "pseudodisappears" after the first beat of the tachycardia (**arrows**). There are some slow-frequency components during tachycardia beyond the offset of the ventricular electrogram that are not seen during atrial pacing. These slow-frequency components are inscribed after the onset of the earliest retrograde atrial electrogram observed at the coronary sinus, further emphasizing that earlier fast-frequency components might be present within the ventricular electrogram. In fact, the first beat of the tachycardia, having a slightly longer ventriculoatrial interval, has a "visible" atrial electrogram at the ablation site. Abl = electrograms from the ablation catheter; H = His; His = His bundle electrogram; RVA = right ventricular apex; other abbreviations and distribution of the remaining leads are as in Figure 1.

Statistical analysis. Statistical analysis was performed with the JMP 3.0.1 statistical software (SAS Institute, 1994). Data are reported as distributions and mean value ± SD. Univariate analysis included all the variables listed in Table 1. Comparisons between successful and unsuccessful sites were performed by Fisher exact and chi-square test. The correlation between the individual variables and the results of current application were analyzed to determine which variables were independently predictive of success or failure. Variables predictive of success or failure at $p < 0.10$ on the basis of univariate analysis were included in a logistic regression analysis. The results were adjusted for between-patient differences by introducing in the regression model a correcting factor for each patient. A probability value <0.05 was considered significant. Sensitivity, specificity and positive and negative predictive values were calculated.

Results

Retrograde atrial electrograms in coronary sinus. During the electrophysiologic study before the ablation procedure, we obtained a clear retrograde bracketing in the coronary sinus in 16 patients and simultaneous atrial retrograde activation in at least two consecutive pair of electrodes (separated by 1.3 cm) in 5 patients. Bracketing could not be observed in the remaining 12 patients.

Characteristics of local electrograms at successful and unsuccessful sites. The characteristics of local electrograms recorded at successful and unsuccessful sites by the ablation catheter are summarized in Table 1. In the 21 cases in which the ablation was performed under temperature control, we did not find significant differences comparing the temperature of definitive successful and unsuccessful RF applications (53 ± 8 vs. 54 ± 7°C, p = NS).

Electrogram characteristics that were predictive of outcome during ablation, based on univariate analyses, were the "pseudodisappearance" criterion ($p < 0.001$), the presence of a Kent potential ($p < 0.005$), the presence of continuous retrograde electrical activity ($p < 0.005$) and the presence of a "atrial notch" in the ascending limb of the unipolar ventricular electrogram ($p < 0.005$). The proportion of electrograms demonstrating stability was not statistically different at successful or unsuccesstul ablation sites. When local electrograms meeting the pseudodisappearance criterion were included as meeting continuous electrical activity criterion, the latter criterion did not reach statistical significance.

JACC Vol. 27, No. 4
March 15, 1996:853–9

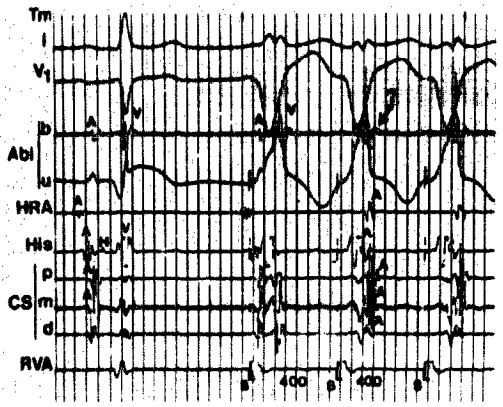


Figure 3. Recordings obtained at a site of success, in the same patient as Figure 2, during sinus rhythm and ventricular pacing. The first ventricular paced beat is coincidental with sinus node atrial activation. The second and third ventricular paced beats are conducted to the atrium through the atrioventricular node and through the accessory pathway. An atrial electrogram is clearly visible during sinus rhythm, which "pseudodisappears" after the second paced beat (**dark arrow**). The tracings are organized as in Figure 2.

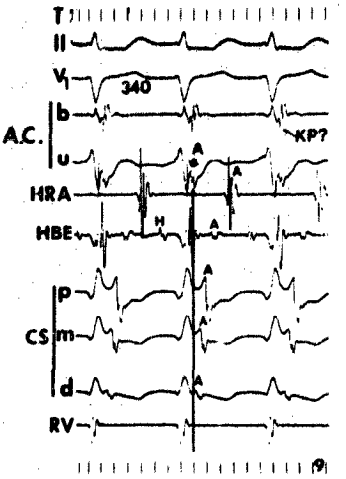
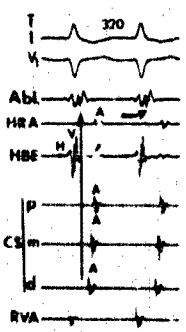


Figure 5. Recordings obtained during orthodromic tachycardia in a patient with a concealed left free wall accessory pathway. Note the presence of a presumed Kent potential in the bipolar electrogram (KP?) coincidental with the onset of the atrial electrogram, which produces a notch (atrial notch) in the ascending limb of the unipolar unfiltered ventricular electrogram (**short solid arrow**). Other abbreviations as in Figures 1 to 3.

The amplitude of the atrial versus the ventricular component of local electrograms was similar at successful and unsuccessful ablation sites. No timing parameter was predictive of outcome. No statistically significant differences were found in the number of unsuccessful applications between patients with and without the pseudodisappearance criterion. Table 2 shows the sensitivity, specificity and the positive and negative predictive values of each variable.

The logistic regression analysis showed that only the "pseudodisappearance" criterion (odds ratio [OR] 7.2, 95% confidence interval [CI] 1.23 to 42.14) and the presence of a Kent potential (OR 2.4, 95% CI 1.01 to 5.79) had an independent predictive value (Table 1).

Figure 4. Recordings obtained during orthodromic tachycardia in a patient with a concealed left free wall accessory pathway. Note the presence of continuous electrical activity in the bipolar electrogram (**short solid arrow**) and the atrial activity preceding the earliest atrial activity recorded in the coronary sinus (**long black arrow**). HBE = His bundle electrogram; other abbreviations as in Figures 1 and 2. Distribution of the remaining leads is similar to that in Figures 1 and 2.



Pseudodisappearance criterion. The pseudodisappearance criterion could be observed at 22 sites (20 during orthodromic tachycardia, 2 during ventricular pacing). In cases ablated during ventricular pacing, the local ventricular electrograms were compared during conduction through the accessory pathway and during VA dissociation (which was frequently observed at the beginning of the train). In 13 sites (59%) the application of radiofrequency was effective. The main obstacle to obtain this criterion was the difficulty in keeping the catheter stable. Very often, during the induction and interruption of tachycardias the ablation catheter moved, and it was necessary to replace it. Obviously, a Kent potential could not be observed in sites where the pseudodisappearance criterion was present. Accessory pathways ablated in the presence of the pseudodisappearance criterion compared with those ablated in the absence of it did not show a statistically significant different anatomic localization but presented shorter VA intervals (measured at the coronary sinus) during orthodromic tachycardia (92 ± 28 vs. 120 ± 38 ms, respectively, $p = 0.03$). No differences were found in the presence of bracketing or in the atrial/ventricular ratio observed at the coronary sinus between these two groups.

Atrial notch in ascending limb of local QRS. During orthodromic tachycardia, in the ablation catheter, the ventricular unipolar local electrogram showed an rS or QS configuration in all patients (Fig. 2). The notch could be observed in

Table 1. Comparison of Local Electrograms Obtained at Successful and Unsuccessful Sites

	Successful (n = 33)	Unsuccessful (n = 124)	Univariate p Value	Multivariate p Value	Odds Ratio	95% CI
Disappearance	13 (40%)	9 (7%)	< 0.001	< 0.03	7.2	1.2–42.5
Kent potential	9 (37.5%)	11 (9%)	< 0.005	< 0.05	2.4	1.01–5.79
Atrial notch	11 (33%)	14 (11%)	< 0.002	0.35	—	—
CEA	15 (45%)	93 (75%)	< 0.001	0.13	—	—
CEA*	28 (85%)	101 (81%)	0.6	NT	NT	NT
Stability	33 (100%)	120 (97%)	0.3	NT	NT	NT
A/V	0.78 ± 1.4	0.6 ± 1.3	0.5	NT	NT	NT
VA (ms)	109 ± 36	114 ± 34	0.4	NT	NT	NT
VA loc (ms)	46 ± 17	49 ± 18	0.4	NT	NT	NT
A_{CS}–A_{AH} (ms)	−2.7 ± 13	−1.3 ± 14	0.7	NT	NT	NT

Data presented are mean value ± SD or number (%) of patients. A_{CS}–A_{AH} = interval between earliest retrograde atrial electrogram recorded at coronary sinus and retrograde atrial electrogram recorded at ablation catheter; Atrial notch = "notch" in ascending limb of unipolar ventricular electrogram; A/V = atrioventricular ratio; CEA = continuous electrical activity; CEA* = continuous electrical activity (when local electrograms meeting "pseudodisappearance" criterion were included as meeting continuous electrical activity criterion); Disappearance = "disappearance" criterion; NT = not tested; VA = ventriculoatrial interval; VA loc = local ventriculoatrial electrogram (see text).

11 (33%) of the 33 successful sites and in 14 (11%) of the 124 unsuccessful sites. In all cases, the notch was absent during sinus rhythm. Occasionally, the observation of spontaneous termination of orthodromic tachycardia as a result of a block in the accessory pathway confirmed that this "notch" had been produced by the overlapped atrial electrogram. The observation of the atrial notch depended on the magnitude of the local atrial electrogram in relation to the local ventricular electrogram. When the atrial/ventricular ratio was >0.5 (Fig. 2), the atrial notch was clearly visible, whereas when this ratio was lower, the atrial notch was extremely difficult to observe. Because the exact configuration at the onset of the notch was difficult to appreciate, we could not differentiate monophasic negative ("QS" like) from biphasic ("rS" like) deflections.

Discussion

Precise localization of an accessory pathway is an essential prerequisite for successful transcatheter ablation because delivery of radiofrequency power causes discrete myocardial lesions (12). Previously, the site of a concealed accessory pathway was inferred from localization of the earliest atrial activation during reentrant tachycardia (11). However, if the accessory pathway is oblique, the ventricular insertion of the accessory pathway may not be coincidental with the atrial insertion (13). Thus, the application of radiofrequency energy at the ventricular site guided by the earliest retrograde atrial activation might not be successful. In the last few years, new criteria have been evaluated during procedures of radiofrequency ablation of left-sided pathways from the ventricular insertion. Direct recording of accessory pathway potentials by ablation catheters in the left ventricle has proven to be feasible (13). However, delivery of energy to those regions where accessory pathway potentials are presumed is often ineffective (6,10,14). More recently, Calkins et al. (10) described retrograde continuous electrical activity during orthodromic tachycardia or ventricular pacing as a predictor of successful ablation of concealed pathways. Even though this criterion alone had only a 20% probability of success, when it was added to a stable local electrogram and a probable or possible Kent potential, the predicted probability of success rose to 82% (10).

Table 2. Sensitivity, Specificity and Predicted Probability of Success During Ablation of Concealed Accessory Atrioventricular Connection

	Sensitivity	Specificity	+PV	−PV
Stability	100%	3%	15%	100%
Kent potential	27%	91%	45%	82%
CEA	45%	25%	14%	63%
CEA*	85%	19%	22%	82%
Disappearance	39%	93%	59%	85%
Atrial notch	33%	89%	44%	83%

+PV = positive predicted value; −PV = negative predicted value; other abbreviations as in Table 1.

In the present study, we have demonstrated the utility of two new electrographic criteria in order to localize the insertion of the accessory pathway. The first, called the pseudodisappearance criterion, is based in the local bipolar recordings, and the second, called the atrial notch criterion, is based in the local unfiltered monopolar recordings.

Pseudodisappearance criterion. In our prospective series, we required the electrogram obtained with the distal electrodes of the ablation catheter to show the presence of stability and discrete atrial and ventricular signals during sinus rhythm. This permitted us to appreciate the pseudodisappearance criterion during orthodromic tachycardia or ventricular pacing. If an atrial electrogram present during sinus rhythm is not clearly discernible during orthodromic tachycardia (only the ventricular electrogram can be observed) while the catheter remains stable, it is likely that such pseudodisappearance results from the "inclusion" of the atrial electrogram into the components of the ventricular electrogram.

Interestingly, patients in whom the accessory pathway was ablated in the presence of the pseudodisappearance criterion

showed shorter VA intervals during orthodromic tachycardia compared with patients in whom the accessory pathway was ablated in the absence of this phenomenon. This might suggest that conduction time (because of conduction velocity or anatomic factors, or both) over the accessory pathways is not always short enough to produce this "inclusion" of the atrial electrogram into the components of the ventricular electrogram. A marked slanting of the accessory pathway might also influence the predicted probability of success of the analyzed criteria. The failure of the "pseudodisappearance" criterion to localize the site of success might result from the existence of an oblique fiber orientation. In such a case, the atrial electrogram may be most likely to "disappear" when the catheter is located at a ventricular site "in front of" the atrial insertion, and therefore, an application might fail to ablate both the atrial and the ventricular sites of the accessory pathway. Unfortunately, because of the absence of anterograde conduction through the accessory pathway, we could not determine which anomalous bundle crossed the sulcus in an oblique way. This anatomic factor might have been helpful in understanding the predictive value for success of local electrograms.

An alternative explanation for the "pseudodisappearance" criterion could be a decrease in amplitude of the atrial electrogram simply related to a change in activation wavefront (15), producing the low amplitude components commonly observed beyond the offset of the ventricular electrogram. This explanation seems unlikely because we have only included instances in which the local atrial electrogram was clearly visible during sinus rhythm. Although changes in amplitude are frequently seen in relation to changes in the direction of the wavefront (15), they are not great enough to render the electrogram unidentifiable or limited to only low-frequency components, as was observed in our study. Such low frequency components are likely to represent nonlocal activation (16). In fact, they were always recorded after the onset of the earliest retrograde atrial electrogram observed at the coronary sinus, further emphasizing that earlier fast frequency components might be present within the ventricular electrogram. Therefore, it is necessary to have a clearly visible atrial electrogram during sinus rhythm before the induction of tachycardia to check for this criterion. This is also valid when ablation is performed during ventricular pacing.

Notch in ascending limb of local QRS complex. The second new criterion that we have analyzed was the identification of the retrograde atrial electrogram, obtained by means of unfiltered unipolar electrograms, as a notch in the ascending limb of the QRS complex during orthodromic tachycardia that is absent during sinus rhythm. For this to occur, two conditions are probably necessary: 1) the local VA interval has to be short enough for a temporal coincidence of part of the ventricular depolarization with the atrial depolarization; that is, the ablation catheter is recording "early" atrial activation; and 2) the voltage of the atrial electrogram has to be high enough to produce an indentation in the ventricular electrogram.

Theoretically, the morphology of the local unipolar recording obtained by means of the ablation catheter might provide some information about the atrial insertion of the accessory pathway (17). Several experimental studies have previously demonstrated that the pure negative ("QS-like") waveform is circumscribed in the area of excitation origin, estimated at 100 to 200 μm along the fast axis by Spach et al. (18). However, consistent with other investigators (19), we have found that the precise identification of the onset of the atrial electrogram in the ablation catheter with very short VA intervals is often unreliable, and consequently, its morphology was not analyzed. However, in individual cases, the unipolar recordings may help to identify the atrial electrogram when this is difficult in the bipolar signal.

Importance of different criteria. The presence of a Kent potential was, in this study, an independent predictor of successful accessory pathway ablation. The relatively low prevalence of Kent potentials at sites of successful catheter ablation in this study (37%) compared with the 80% prevalence reported by Calkins et al. (10) is probably because, searching for the pseudodisappearance criterion, we did not require its presence to apply radiofrequency energy. Moreover, by its temporal nature, the disappearance of the atrial electrogram precludes the recognition of a Kent potential.

Very often, we observed continuous electrical activity at the local electrogram, but this was a nonspecific finding. In fact, and probably because of the bias produced by the search of the pseudodisappearance criterion, the presence of continuous electrical activity, although without reaching statistical significance in the multivariate analysis, was more frequently observed in failed than in the successful radiofrequency applications. However, the "pseudodisappearance" criterion was more difficult to demonstrate but was more specific and showed the highest predicted probability of success. As we have previously hypothesized, this probably means that to meet this criterion, what is needed is an extremely early local atrial activation, and consequently, the catheter must be very close to the insertion of the accessory pathway, closer than what is needed to obtain retrograde continuous electrical activity.

Study limitations. The "disappearance criterion" is in part a subjective criterion. It is based on the visual difficulty of identifying the atrial electrogram. To some extent it may be the maximal expression of the so-called continuous electrical activity (10).

The findings in the present study were obtained only from left-sided accessory pathways. Therefore, the validity of an extrapolation of these results to other accessory pathway locations is uncertain.

Not all accessory pathway potentials were validated by interventions such as atrial or ventricular stimulation. Previous studies have shown that detection of accessory pathway potentials based on the configuration of and time relation to ventricular or atrial potentials is valid (6,10). Thus, it may not be essential to validate accessory pathway potentials using stimulation maneuvers that may markedly prolong the procedure and cause displacement of the catheter.

In the present study, a multivariate logistic regression analysis was applied, assuming each radiofrequency pulse to be

an independent event with no influence from the antecedent pulse. Because an unsuccessful pulse might affect the outcome of the subsequent pulse, the applicability of the statistical approach used in our study may be limited.

Conclusions. The pseudodisappearance during tachycardia or ventricular pacing of a bipolar atrial electrogram present during sinus rhythm is associated with a high probability of success during radiofrequency ablation of concealed accessory pathways. The atrial electrogram can be observed in unipolar recordings as a notch on the ascending limb of the ventricular electrogram. These observations have practical implications because they may help to ablate accessory pathways, identifying the onset of atrial activation in the unipolar recording when this is not clearly discernible at the bipolar electrogram and avoiding missing appropriate sites for ablation when the atrial activation is not visible at the local electrogram.

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References

1. Jackman WM, Wang X, Friday KJ, et al. Catheter ablation of accessory atrioventricular pathways (Wolff-Parkinson-White syndrome) by radiofrequency current. N Engl J Med 1991;324:1605–11.
2. Calkins H, Langberg J, Sousa J, et al. Radiofrequency catheter ablation of accessory atrioventricular connections in 250 patients. Abbreviated therapeutic approach to Wolff-Parkinson-White syndrome. Circulation 1992;85: 1337–46.
3. Gursoy S, Chiladakis I, Kuck H. Current status of radiofrequency ablation in the preexcitation syndromes. Herz 1992;17:151–7.
4. Lesh MD, Van Hare G, Schamp DJ, et al. Curative percutaneous catheter ablation using radiofrequency energy for accessory pathways in all locations: results in 100 consecutive patients. J Am Coll Cardiol 1992;19:1303–9.
5. Swartz JF, Tracy CM, Fletcher RD. Radiofrequency endocardial catheter ablation of accessory atrioventricular pathway atrial insertion sites. Circulation 1993;87:487–99.
6. Chen X, Borggrefe M, Shenasa M, Haverkamp W, Hindricks G, Breithardt G. Characteristics of local electrogram predicting successful transcatheter ablation of left-sided accessory pathways. J Am Coll Cardiol 1992;20:656–65.
7. Leather RA, Leitch JW, Klein GJ, Guiraudon GM, Yee R, Kim YH. Radiofrequency catheter ablation of accessory pathways: a learning experience. Am J Cardiol 1991;68:1651–5.
8. Schluter M, Geiger M, Siebels J, Duckeck W, Kuck KH. Catheter ablation using radiofrequency current to cure symptomatic patients with tachyarrhythmias related to an accessory atrioventricular pathway. Circulation 1991;84:1644–61.
9. Villacastín J, Almendral J, Arenal A, et al. Ablación mediante radiofrecuencia de vías accesorias auriculoventriculares. Rev Esp Cardiol 1993;46:367–80.
10. Calkins H, Kim YN, Schmaltz S, et al. Electrogram criteria for identification of appropriate target sites for radiofrequency catheter ablation of accessory atrioventricular connections. Circulation 1992;85:565–73.
11. Wellens HJJ, Brugada P, Farré J, et al. Diagnosis and treatment of concealed accessory pathways in patients suffering from paroxysmal AV junctional tachycardia. In: Rosenbaum M, Elizari MV, editors. Frontiers of Cardiac Arrhythmias. The Hague: Martinus Nijhoff, 1983:773–97.
12. Chin MC, Scheunmeyer T, Finkebeiner WE, Stern RA, Scheinman MM, Langberg JJ. Histopathology of monopolar transcatheter radiofrequency ablation at the mitral valve annulus. PACE 1991;14:1956–60.
13. Jackman WM, Friday KJ, Fitzgerald DM, Bowman AJ, Yeung LW, Lazzara R. Localization of left free-wall and posteroseptal accessory atrioventricular pathways by direct recording of accessory pathway activation. PACE 1989; 12:204–10.
14. Silka MJ, Kron J, Halperin BD, et al. Analysis of local electrogram characteristics correlated with successful radiofrequency catheter ablation of accessory atrioventricular pathways. PACE 1992;15:1000–7.
15. Swartz JF, Tracy CM, Fletcher RD. Radiofrequency endocardial catheter ablation of accessory atrioventricular pathway atrial insertion sites. Circulation 1993;87:487–99.
16. Paul T, Moak JP, Morris C, Garson JR. Epicardial mapping: how to measure local activation? PACE 1990;13:285–92.
17. Farré J, Grande A, Martinell J, Fraile J, Ramírez JA, Rábago G. Atrial unipolar waveform analysis during retrograde conduction over left-sided accessory atrioventricular pathways. In: Brugada P, Wellens HJJ, editors. Cardiac Arrhythmia: Where to Go From Here? Armonk (NY): Futura 1987:243–69.
18. Spach MS, Miller WT, Dolber PC, Kootsey JM, Sommer JR, Mosher CE. The functional role of structural complexities in the propagation of depolarization in the atrium of the dog. Cardiac conduction disturbances due to discontinuities of effective axial resistivity. Circ Res 1982;50:175–91.
19. Haissaguerre M, Dartigues JF, Warin JF, Le Metayer P, Montserrat P, Salamon R. Electrogram patterns predictive of successful catheter ablation of accessory pathways. Value of unipolar recording mode. Circulation 1991;84:188–202.