

Electrocardiographic Characteristics and Catheter Ablation of Parahissian Accessory Pathways

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Background Accessory pathways may be located in close proximity to the His bundle, resulting in a high risk of heart block during attempted surgical or electrical interruption of these pathways. This study reports the prevalence, ECG characteristics, and results of catheter ablation of parahissian accessory pathways. They were defined on the basis of both the presence of a high amplitude (>0.1 mV) of His bundle potential at the ablation site and an exclusion of anteroseptal or midseptal location of the accessory pathway.

Methods and Results Eight patients with a parahissian accessory pathway were identified among 582 consecutive patients who underwent radiofrequency ablation of an accessory pathway. They were six males and two females with a mean age of 21 ± 9 years. During maximal preexcitation, the ECG showed a positive delta wave in leads I, II, and aVF in all patients: six had a negative delta wave in leads V_1 and V_2

instead of the positivity usually observed in anteroseptal accessory pathways. This pattern had a sensitivity of 75%, a specificity of 96%, a positive predictive value of 86%, and a negative predictive value of 93% for a parahissian location in comparison with a group of 28 patients with anteroseptal accessory pathways. At the successful ablation site, the mean amplitude of the His bundle potential was 0.2 ± 0.1 (0.12 to 0.4 mV). All accessory pathways were successfully ablated without causing heart block using 5 to 20 W of radiofrequency energy.

Conclusions Parahissian accessory pathways have a preexcitation pattern that is distinctive from that of anteroseptal accessory pathways. Catheter ablation of these pathways is feasible using low energy with preservation of normal atrioventricular conduction. (*Circulation*. 1994;90:1124-1128.)

Key Words • accessory pathway • His bundle • catheter ablation

Catheter ablation has become an important mode of treatment¹⁻⁷ in patients with atrioventricular (AV) accessory pathways (APs). The risks of the procedure, particularly AV block, are dependent on the AP localization. Patients with anteroseptal or midseptal ("intermediate septal") AP are at higher risk of heart block because of the proximity of the His bundle and the AV node.^{4,5,8,9} We report a subset of APs with particular ECG patterns that are situated between the anteroseptal and midseptal regions. They were located and ablated at the His bundle location as evidenced by the recording of a high His bundle potential and therefore are called parahissian APs.

Methods

From February 1991 through April 1994, a total of 582 consecutive patients were referred for radiofrequency ablation of AP. Eight (1.4%) were found to have a parahissian AP (Table 1).

Electrophysiological Study

Verbal consent was obtained from patients or parents of children, particularly with regard to the risk of AV block. The patients were studied in the fasting state under slight sedation with diazepam. Two or three quadripolar catheters were introduced percutaneously into the right femoral and left

subclavian veins and advanced to the right atrium or right ventricular apex and His bundle recording site. The catheter used for mapping and AP ablation was a 7F deflectable catheter (Mansfield-Webster) with a 4-mm tip electrode. It was introduced from the right femoral in five patients and left subclavian vein in three. Localization of the AP was achieved by careful mapping of the atrial and ventricular activation pattern using distal unipolar and bipolar electrograms. Endocardial electrograms were filtered at 30 to 500 Hz and recorded on a multichannel recorder (VR12, Electronics for Medicine, or Midas, PPG Biomedical). Local electrograms were measured peak to peak during preexcitation to assess AV times and the interval from the ventricular electrogram to surface delta wave. The peak-to-peak amplitude of bipolar electrograms was measured to determine the amplitude of the atrial and ventricular electrograms and their ratio, of the AP, and of the His bundle potentials. The bipolar His bundle potential was measured before energy delivery during either stimulation-induced narrow QRS complexes or "mechanical" AP block. When this amplitude was fluctuant, the highest value was taken. In addition, it could be recognized in four patients within the local electrograms during preexcitation. In six patients, pace mapping was performed at the ablation site by pacing with stimuli progressively increasing from 1.5 to 18 mA to reproduce exactly the preexcitation pattern and minimize the number of radiofrequency applications. Pace maps were analyzed when no delay between stimuli and QRS complexes was observed. The threshold of His bundle pacing was determined when a narrower QRS complex occurred following the stimulus by 30 to 70 milliseconds.

Definition of a Parahissian Accessory Pathway

A parahissian location of AP was defined when its atrial and ventricular insertions were associated with a large His bundle potential of >0.1 mV. An "anteroseptal" or midseptal location

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TABLE 1. Clinical and Electrocardiographic Characteristics of Eight Patients With Parahissian Accessory Pathways

| Patient | Sex | Age, y | Organic Heart Disease | Clinical Tachycardia | Wolff-Parkinson-White Syndrome | ECG: Delta Wave Pattern During Maximal Preexcitation | | | | | | | |
|---------|-----|--------|---------------------------|----------------------|--------------------------------|--|-----|-----|-----|----------------|----------------|----------------|------------------|
| | | | | | | I, II, and aVF | III | aVR | aVL | V ₁ | V ₂ | V ₃ | V ₄₋₆ |
| 1 | M | 37 | No | AF | Overt | + | ± | - | ± | - | - | + | + |
| 2 | M | 24 | No | AF | Overt | + | + | - | ± | - | - | - | + |
| 3 | M | 11 | No | ORT | Overt | + | - | - | + | - | - | - | + |
| 4 | M | 14 | No | ORT | Overt | + | ± | - | + | - | - | + | + |
| 5 | M | 27 | No | ORT | Overt | + | - | - | + | + | + | + | + |
| 6* | M | 14 | No | ORT | Concealed* | + | ± | - | + | + | + | + | + |
| 7 | F | 21 | No | ORT | Overt | + | - | - | + | - | - | + | + |
| 8 | F | 19 | Myocardial fibroelastosis | ORT | Overt | + | + | - | ± | - | - | - | + |

AF indicates atrial fibrillation; ORT, orthodromic reciprocating tachycardia; ±, isoelectric; +, positive; and -, negative.

*This patient had a permanent narrow QRS complex and ORT induced during exercise testing. However, a preexcitation was disclosed during pacing at the ablation site.

of the AP was excluded by meticulous mapping of the anterior region of the tricuspid annulus and the area located some millimeters below and posterior to the His bundle recording site, respectively. Therefore, there was virtually no distance between the tip electrodes of the ablation and His bundle catheters in any fluoroscopic view.

ECG Characteristics

Maximally preexcited 12-lead ECGs were recorded during sinus rhythm or atrial overdrive pacing. The initial 40 milliseconds of the QRS complex was used to determine delta wave polarity. In the patient with a concealed AP, stimulation performed at an intensity above 8 mA on the ablation site disclosed a preexcitation pattern following the local paced atrial electrogram.

Catheter Ablation

Radiofrequency energy was delivered using a commercially available generator (HAT 200, Osypka, or Radionics) that provides continuous monitoring of impedance and power. Current was applied between the 4-mm tip electrode and a cutaneous pad over the left posterior chest. All applications were begun using a power setting of 3 to 15 W, which was progressively increased to 20 W in some patients. Application of energy was interrupted if AP block did not occur within 10 seconds or if sustained junctional rhythm (more than five consecutive junctional narrow QRS complexes) appeared during energy delivery. The end point was elimination of antero- and retrograde AP conduction. When retrograde ventriculoatrial conduction was present following ablation, retrograde AP conduction was differentiated from retrograde His bundle conduction by recording the His bundle potential during incremental ventricular pacing and extrastimulation. In the former situation, the His bundle potential followed the earliest atrial activity, whereas it preceded it in the latter. All patients were monitored continuously for 3 days after the procedure and discharged without medication. In patients with preexcitation, the absence of tachycardia and preexcitation on the surface ECG during follow-up was considered as indicative of successful ablation. The patient with a concealed AP was assessed by repeated exercise tests.

Statistical Analysis

Data are presented as mean ± SD. ECG characteristics were evaluated in the study group relative to a group of 28 consecutive patients referred during the same period with right antero-septal AP. In all of these patients, the successful AP insertion site was associated with an amplitude of the His

bundle potential of <0.1 mV. The statistical significance was tested using χ^2 test, and a value of $P < .05$ was considered significant. Sensitivity, specificity, and predictive accuracy were determined for the most characteristic ECG pattern.

Results

ECG Characteristics

The delta wave polarity in each patient is detailed in Table 1. All patients with a parahissian AP had a positive delta wave in leads I, II, and aVF, as did 100% of patients with antero-septal APs. The delta wave in lead III was isoelectric or negative in six (75%) parahissian APs and seven (25%) antero-septal APs ($P = .01$). Six patients with parahissian APs had a predominantly negative delta wave in V₁ and V₂, whereas this was observed in 1 (4%) of 28 patients with antero-septal APs ($P < .001$). Therefore, in patients with a delta wave positive in leads I, II, and aVF, delta wave negativity in leads V₁ and V₂ had a sensitivity of 75%, a specificity of 96%, a positive predictive accuracy of 86%, and a negative predictive accuracy of 93% for a parahissian AP.

Catheter Ablation

One ablation session was performed in the eight patients, resulting in permanent abolition of AP conduction in all patients. The mean and median of all radiofrequency applications was 6 ± 6 and 4, respectively. A total of 49 applications were made, including the 8 final successful ones. Twenty of the 41 unsuccessful applications interrupted AP conduction but were stopped due to the occurrence of junctional rhythm. The total session duration and fluoroscopy times including the diagnostic study were 119 ± 71 and 21 ± 12 minutes, respectively. Table 2 summarizes electrogram characteristics at successful ablation sites and data regarding energy applications. During pace-mapping maneuvers, local atrial or ventricular tissue was captured from a stimulus intensity of 2 mA, whereas consistent His bundle pacing was achieved beyond 13 mA. A mechanically induced AP block was observed in two patients during mapping. At the successful site, a QS pattern of the unipolar ventricular waveform was observed in all patients with preexcitation and a presumed AP potential was recorded in seven of eight patients.

TABLE 2. Data Related to Ablation

| Patient | No of RF Pulses | Power, W | Duration, s | Successful Application | | | |
|----------|-----------------|----------|-------------|---|----------------------------------|----------------------|----------------------------|
| | | | | Atrial-to-Ventricular Electrogram Amplitude Ratio (In Sinus Rhythm) | AV Time During Preexcitation, ms | V-Delta Interval, ms | AP Potential Amplitude, mV |
| 1 | 5 | 15-20 | 60 | 1 | 20 | 30 | 0.15 |
| 2 | 4 | 5-10 | 50 | 0.25 | 50* | 10 | 0.3 |
| 3 | 3 | 5-15 | 60 | 1 | 30 | 20 | 0.05 |
| 4 | 6 | 10-20 | 62 | 0.15 | 50* | 0 | 0.3 |
| 5 | 2 | 10-18 | 75 | 0.2 | 10 | 40 | |
| 6 | 1 | 10-15 | 90 | 1.5 | | | 0.15 |
| 7 | 18 | 7-12 | 90 | 0.3 | 10 | 35 | 0.2 |
| 8 | 10 | 5-20 | 90 | 0.1 | 25 | 20 | 0.05 |
| Mean±SEM | 6±6 | | | 0.6±0.5 | 28±17 | 22±14 | 0.17±0.1 |

RF indicates radiofrequency; AV, atrioventricular.

*AV was prolonged after initial RF applications.

There were no short-term or late complications related to the ablation procedure. None of the patients developed any transient or persistent PR prolongation with delivery of radiofrequency energy. Patient 4 had a complete persistent right bundle-branch block. Although this pattern was present before energy delivery during mechanically induced AP block, it

was not documented previously during orthodromic reciprocating tachycardia, suggesting it may have been rendered permanent after radiofrequency energy delivery. During a follow-up period of 7 ± 6 months (1 to 18 months), all patients were free of arrhythmias. ECGs showed no preexcitation. Repeated exercise tests did not produce tachycardia in patient 6.

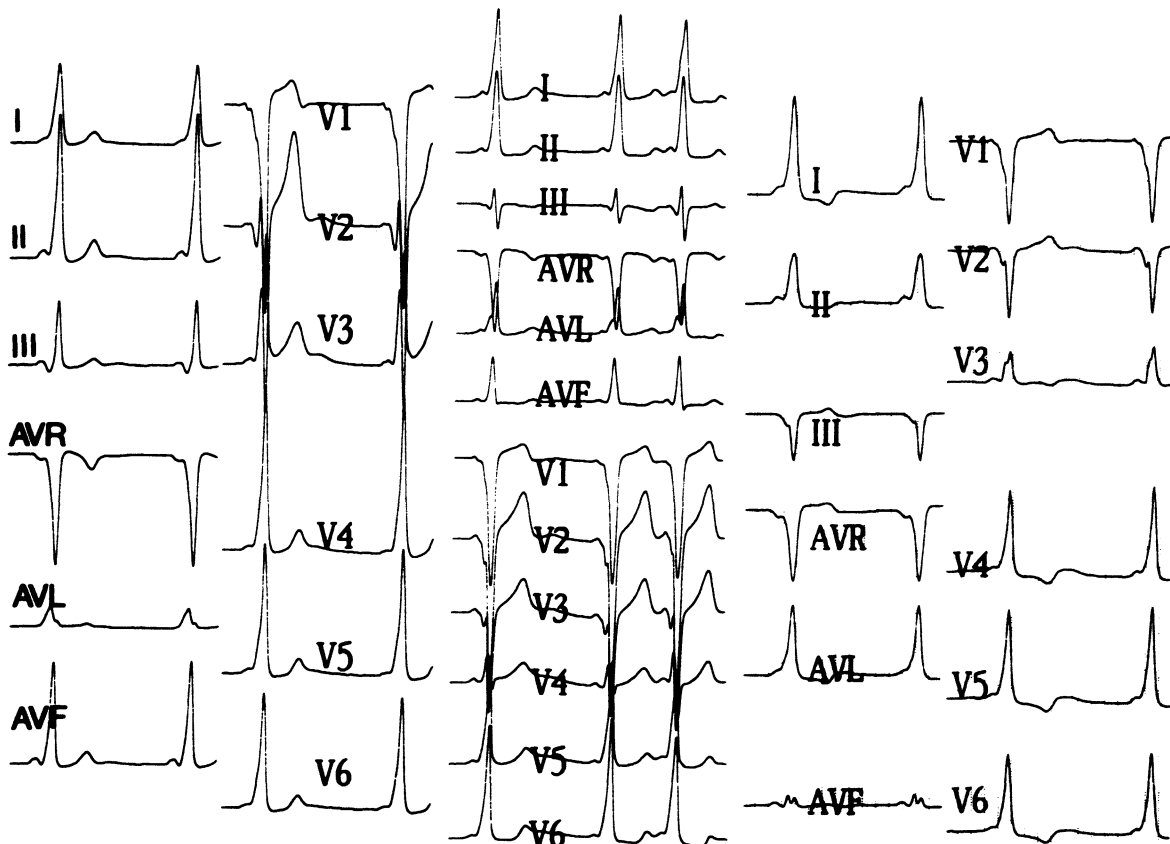


FIG 1. ECGs with maximal preexcitation during sinus rhythm in patients 4 (left), 3 (middle), and 7 (right). Delta wave is uniformly positive in leads I, II, and aVF but isoelectric or negative in lead III. The most specific pattern for a parahissian accessory pathway is the negativity of delta wave in leads V₁ and V₂ and even lead V₃ (middle).

TABLE 2. (Continued)

| His Bundle Potential Amplitude at Ablation Site, mV | Local Pacing, mA | | Session Duration, min | Radiation Exposure Time, min |
|---|-------------------------------|--------------------|-----------------------|------------------------------|
| | Atrial or Ventricular Capture | His Bundle Capture | | |
| 0.12 | | | 72 | 18 |
| 0.15 | | | 29 | 8 |
| 0.4 | 3 | 17 | 61 | 7 |
| 0.2 | 2 | 13 | 205 | 41 |
| 0.15 | 2 | 14 | 84 | 15 |
| 0.15 | 3 | 17 | 118 | 18 |
| 0.2 | 4 | 15 | 160 | 24 |
| 0.12 | 2 | 14 | 225 | 37 |
| 0.2±0.1 | 2.7±0.8 | 15±2 | 119±71 | 21±12 |

Discussion

This study demonstrates that AP in a parahissian location has distinctive ECG characteristics and that radiofrequency energy using low power can be applied to the His bundle recording position for successful AP

elimination with preservation of normal AV conducting system. The fact that these AP are truly septal is evidenced by their hisian location in different radiological views and by the recording of a large His bundle potential. The latter finding is not sufficient by itself to define a parahissian AP since it can also be observed in anteroseptal AP. However, in anteroseptal AP, electrograms consistent with the pathway location are also recorded on the anterior tricuspid annulus in association with a His bundle potential of <0.1 mV, allowing their ablation with a low risk of AV block. Our study shows that true parahissian APs can be ablated with preservation of physiological AV conduction provided that certain precautions are strictly observed in all patients. Most important, current must be stopped immediately if a sustained junctional rhythm of more than five consecutive beats occurs because this phenomenon is a reliable marker of impending AV block. Also, the initial RF energy must be low (5 to 7 W) and may be increased cautiously and progressively if no junctional rhythm appears. Finally, energy application is not continued if AP block does not occur within 10 seconds. All these precautions are mandatory to avoid heart block as reported in up to 36% of intermediate septal APs⁹ and even in anteroseptal AP. In our series, the efficacy and

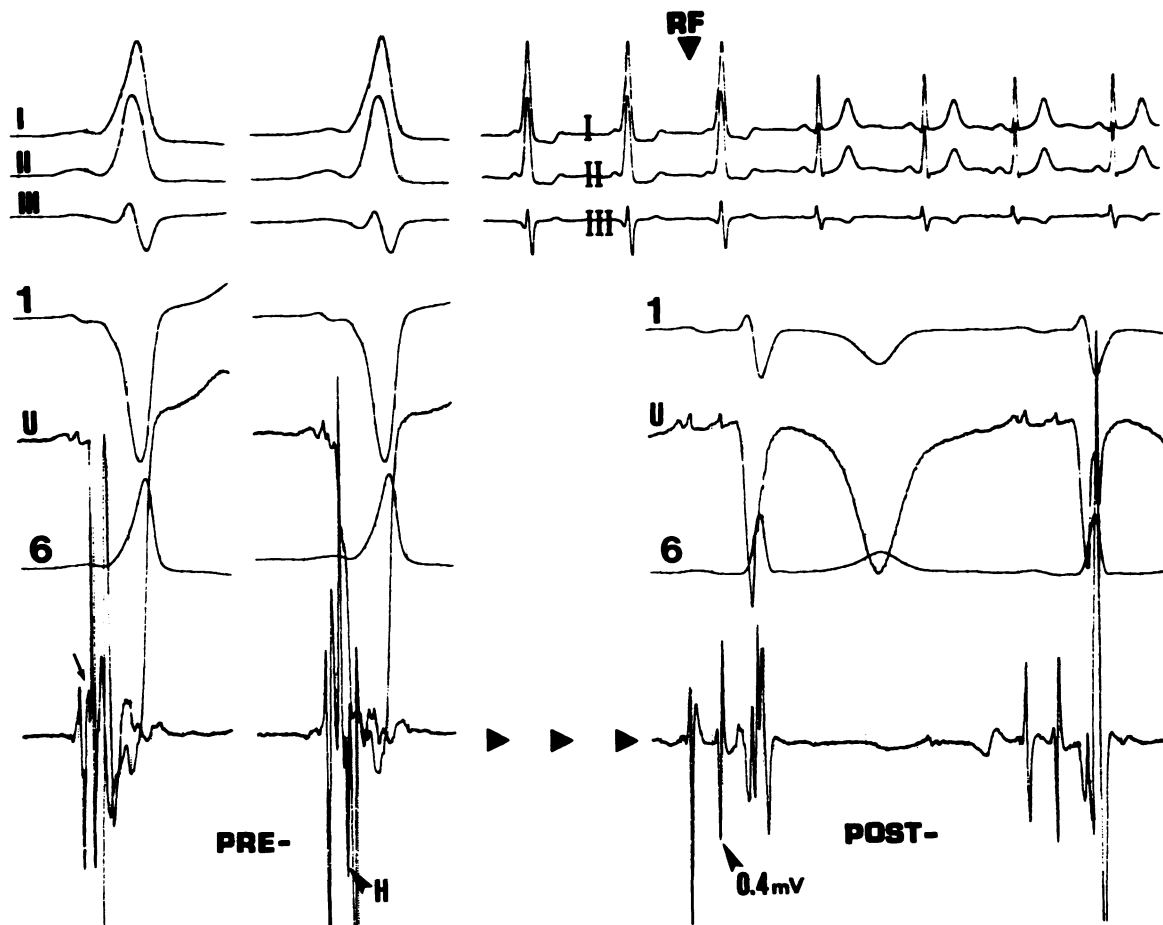


FIG 2. Data from patient 3. Left, Bipolar and unipolar (U) recordings in two different electrograms at the successful ablation site. The presumed accessory pathway potential is recorded in the first bipolar electrogram (arrow), and the His bundle potential (H) is best recognized in the second one. Top right, Immediate disappearance of preexcitation with application of 5 W of radiofrequency energy. Bottom right, Postablation recording in two consecutive beats with a large His bundle potential of 0.4 mV. Note that the morphology of the two atrial and His bundle electrograms is similar to that seen before ablation.

safety of ablation as well as mechanically induced AP block in two patients strongly suggest a subendocardial location of parahissian AP in contrast with the deeper location of the His bundle within the central fibrous body. This is also supported by the differential effects of local stimulation capturing atrial or ventricular tissue at low intensity and requiring higher output to pace the His bundle. However, there was no apparent correlation between the differential pacing threshold and the energy needed to achieve ablation. Therefore, low energies applied for 50 to 90 seconds can burn the superficial endocardial layers where the AP is located while sparing the His bundle.

For catheter ablation, it is useful to designate parahissian AP because of its specific location requiring particular safety precautions. In our experience, the incidence of parahissian pathways is 1.4%. In other series, it has probably been included in patients with septal APs. Whether it may be recognized by its ECG characteristics needs to be prospectively assessed. The ECG pattern of parahissian AP is similar to those with an anteroseptal location including positive delta wave in leads I, II, and aVF. Depending on the delta wave pattern in lead III, it would have been classified as either anteroseptal or midseptal by others.¹⁰ The most specific pattern is the delta wave negativity in leads V₁ and V₂ and sometimes V₃, which has a 86% predictive value for a parahissian AP. This pattern is somewhat different than one case of parahissian AP ("type 2") described by Epstein et al⁸ during a surgical study where the delta wave was negative only in lead V₁ and positive in lead V₂.⁸ Parahissian APs were also reported by Yeh et al⁹ and defined on the basis of a "discernible" His bundle potential. It is not surprising that no ECG criteria were distinctive⁹ because the presence of a His potential without measuring its amplitude is not specific, since a small His bundle potential is frequently observed in anteroseptal as well as midseptal AP. No patient in our series had a negative delta wave in lead aVF. This pattern occurs in more posterior AP insertions that have been termed intermediate septal or midseptal. In these locations, AP may be close to the AV node, and its ablation will require precautions similar to those used in a parahissian location to avoid AV block.

Conclusions

Some APs must be ablated by the application of radiofrequency energy in the His bundle recording position. They can be suspected by their ECG criteria, but this needs to be studied prospectively. Ablation is feasible using low incremental energy with preservation of AV conduction, suggesting a subendocardial location of AP, whereas the His bundle is located deeper.

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