Radiofrequency Catheter Ablation of Posteroseptal Atrioventricular Accessory Pathways

— Location-Specific Electrographic Characteristics of Successful Ablation Sites —

Yohkoh Soejima, MD; Yoshito Iesaka, MD; Atsushi Takahashi, MD; Masahiko Goya, MD; Takeshi Tokunaga, MD; Hiroshi Amemiya, MD; Hideomi Fujiwara, MD; Jun-ichi Nitta, MD*; Akihiko Nogami, MD*; Kazutaka Aonuma, MD*; Michiaki Hiroe, MD*; Fumiaki Marumo, MD*; Masayasu Hiraoka, MD**

The electrographic features of successful sites of radiofrequency catheter ablation were analyzed in 33 cases of posteroseptal accessory pathways and compared with those from 155 cases of free wall accessory pathways. The atrioventricular intervals in the posteroseptal cases were significantly longer than in the free wall cases (posteroseptal vs left and right free wall; 38 vs 33 and 26 msec, respectively; $p < 0.05$), and the incidences of continuous electrograms (42 vs 63 and 79%; $p < 0.01$) and QRS-pattern unipolar electrograms (50 vs 76 and 78%; $p < 0.05$) were significantly lower in the posteroseptal cases. The V-delta intervals in the posteroseptal cases were significantly longer than in the left free wall cases (17 vs 13 msec; $p < 0.05$), but shorter than in the right free wall cases (17 vs 23 msec; $p < 0.05$). No statistically significant difference in the incidence of Kent potentials among the 3 groups was observed. In radiofrequency ablation of posteroseptal pathways, the length of the atrioventricular interval and the incidences of continuous electrograms and QRS-pattern unipolar electrograms may be unsatisfactory even at the appropriate target site, but the V-delta interval and Kent potential are good indicators of suitable target sites.

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Radiofrequency catheter ablation of posteroseptal accessory pathways is sometimes very difficult because the anatomic properties of such pathways are quite different from those of free wall accessory pathways^{1,2} as are the electrographic characteristics of successful ablation sites^{3–9}. Several electrographic criteria are used to determine the most suitable ablation site of accessory pathways: atrioventricular (A-V) conduction time, ventriculoatrial (V-A) conduction time, A-V or V-A continuous electrogram, Kent potential, and QRS-pattern unipolar electrogram.^{10–24} The purpose of this study was to investigate differences in the electrographic characteristics of successful

ablation sites between posteroseptal and free wall accessory pathways, and to elucidate the unique electrographic properties of appropriate target sites in posteroseptal accessory pathways.

Methods

Patient Characteristics

We studied 171 consecutive patients referred to the Tsuchiura Kyodo Hospital between August 1991 and March 1995 for management of Wolff-Parkinson-White (WPW) syndrome (107 patients) or paroxysmal supraventricular tachycardia using a concealed acces-

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Cardiovascular Center, Tsuchiura Kyodo Hospital, *Second Department of Medicine, and **Department of Cardiovascular Disease of Medical Research Institute, Tokyo Medical and Dental University, Tokyo, Japan

Mailing address: Yohkoh Soejima, MD, Cardiovascular Division, Social Insurance Mishima Hospital, 20-9, Minami-honcho, Mishima, Shizuoka, 411, Japan

sory pathway (64 patients). A total of 138 patients had free wall accessory pathways (37 right-sided and 118 left-sided) and 33 had posteroseptal accessory pathways. The mean age of the patients was 46.1 ± 4.1 (SD) years (range 15–88 years). There were 47 women and 124 men. The complicating arrhythmia was atrioventricular reciprocating tachycardia (AVRT) in 117 patients, atrial fibrillation with rapid ventricular responses in 20, and both of these in 34. All of the patients had symptoms including palpitation, dizziness, presyncope or syncope during tachyarrhythmia. The mean duration since the first experience of symptoms was 13.2 ± 4.9 years. Drug trials with a median of 2 antiarrhythmic agents (range 1–7) had failed to control the arrhythmia. A total of 160 patients had no evidence of structural heart disease, 4 had coronary artery disease, 4 had Ebstein's anomaly, 1 had an atrial septal defect, 1 had aortic stenosis due to a bicuspid aortic valve, and 1 had aortic regurgitation.

Baseline Electrophysiologic Study

A detailed electrophysiologic study was performed in each patient before catheter ablation. The electrophysiologic studies were performed while patients were in the postabsorptive, mildly sedated state, after informed consent was obtained, and at least 5 half-lives after discontinuation of antiarrhythmic agents. Four quadripolar catheters (interelectrode spacing 5 mm; USCI, USA) were introduced: 3 into a femoral vein and one into the subclavian vein. These were positioned high in the right atrium, in the bundle of His, at the right ventricular apex and in the coronary sinus. Multiple bipolar electrocardiograms filtered with a bandpass of 30–500 Hz and multiple surface electrocardiograms were monitored and recorded with a Mingograph T-16 (Siemens-Elema, Sweden) and EPLab (Quinton, Canada). Pacing was performed with a programmable stimulator (Fukuda-Denshi, Japan) using stimuli that were twice the diastolic threshold and lasted 2 msec. The objective of the diagnostic portion of the electrophysiologic study was to define the conduction properties of the accessory pathway and to localize the accessory pathway to a general region of the heart.

Mapping and Ablative Procedures

After preliminary localization of the accessory pathway, precise mapping was performed with a 7F catheter with a 4 mm distal electrode, 5 mm interelectrode spacing, and a deflectable tip (Mansfield/Webster, USA). The catheter was inserted into a femoral artery for ablation of a left-sided accessory pathway, or into a femoral or a subclavian

vein for ablation of a right-sided accessory pathway, and positioned against the mitral or tricuspid valve. The following characteristics were determined for each local electrogram immediately before delivery of radiofrequency energy: (1) the presence of continuous electrical activity, defined as the absence of an isoelectric segment between the atrial and ventricular components of the local electrogram; (2) the presence of a Kent potential; (3) the A/V ratio, defined as the ratio of the amplitude of the atrial to the amplitude of the ventricular component of the local bipolar electrogram; (4) patterns of the unipolar electrograms (the presence or absence of a PQS-pattern unipolar recording); (5) timing and intervals of the atrial and ventricular components of each local electrogram, ie the interval between the first major activations of the atrial and ventricular components of a local electrogram (Aa-Va interval), the interval between the first major activations of the ventricular and atrial components (Va-Aa interval), and the interval between the onset of the local ventricular electrogram and the onset of the delta wave (Vo-delta interval). A radiofrequency current of 500 kHz was delivered at 45–55 V and 20–40 W using a radiofrequency pulse generator, NL 50-I (Central Industry, Japan) between the distal large-tip electrode and an electrosurgical adhesive grounding plate (Niko, Denmark) on the patient's back. In cases of manifest pre-excitation, radiofrequency current was applied during sinus rhythm or paced atrial rhythm. In patients with a concealed accessory pathway, energy was applied during orthodromic tachycardia or ventricular pacing. Application of radiofrequency energy was maintained for 30–60 sec when accessory pathway conduction was eliminated within 10 sec, but was immediately discontinued in the event of an increase in impedance or catheter dislocation. Intravenous heparin was administered at an initial dose of 5000 U at the start of the procedure, followed by continuous infusion at a rate of 1000 U/h throughout the procedure.

The Definition of Posteroseptal Pathways

The accessory pathway location was considered to be right posteroseptal when the earliest site of ventricular activation during antegrade accessory pathway conduction or of atrial activation during retrograde accessory pathway conduction was recorded in the posteroseptal region of the tricuspid annulus or at the coronary sinus ostium, and the pathway was successfully ablated at that site by using a transvenous right-sided approach. When the earliest site was recorded in the posteroseptal region of the mitral annulus and the pathway was successfully ablated at that site by

ABLATION SITE FOR Rt. POSTEROSEPTAL ACP

Fig 1. Electrograms and catheter position at the successful ablation site in a patient with a manifest right posteroseptal accessory pathway. A bipolar electrogram (ABL) of the ablation site did not reveal an A-V continuous electrogram; instead a long A-V interval (Aa-Va 47 msec) and an early ventricular potential preceded the delta wave on the surface electrocardiogram (Vo-delta 19 msec). A unipolar electrogram (ABL-UNI) did not show a typical PQS pattern. Shown are surface leads I, II, and V1, the unipolar electrogram at the ablation site (ABL-UNI), and bipolar electrograms high in the right atrium (HRA), in the bundle of His (HBE), the ablation site (ABL), and the right ventricular apex (RVA). The catheter positions shown are the 35° right (top right) and 45° left anterior oblique positions (bottom right). The catheter tip was curved, with the distal electrode located at the right posteroseptal region.

using a transaortic left-sided approach, the location was considered to be left posteroseptal.

Postablation Protocol

An electrophysiologic study was performed 30 min and 5–7 days after completion of the ablation procedure. Holter monitoring and echocardiography were performed immediately and 1 week after the procedure to check for procedure-related complications.

Statistical Analysis

All data are expressed as means $\pm$ SD. Continuous variables were compared using Student's t-test and categorical variables were evaluated using the chi-square test. A p-value <0.05 was considered statistically significant.

Results

A total of 188 accessory pathways were identified in the 171 patients (17 patients had 2 accessory pathways). In 33 cases posteroseptal accessory pathways were present, in 37 cases right free wall pathways, and in 118 cases left free wall pathways. Accessory pathway conduction was successfully eliminated in all of the 188 accessory pathways (100%).

Fig 1 shows electrograms of and catheter position at the successful ablation site in a patient with a right posteroseptal manifest accessory pathway. The bipolar electrogram (ABL) at the ablation site did not show a continuous electrogram; instead, a long A-V interval (Aa-Va 47 msec) and an early ventricular potential preceded the delta wave on the surface electrocardiogram (Vo-delta 19 msec). The unipolar electrogram (ABL-UNI) did not show a typical PQS pattern. The catheter tip was curved, with the distal electrode located in the right posteroseptal region. Fig 2 shows electrograms of and catheter position at the successful ablation site in a patient with a left posteroseptal manifest accessory pathway. The bipolar electrogram at the ablation site (ABL) showed a long A-V interval (Aa-Va 47 msec) and Kent potential (K) between the atrial (A) and the ventricular (V) electrogram, but no continuous electrogram. The unipolar electrogram (ABL-UNI) did not show a typical PQS pattern, whereas the local ventricular potential preceded the delta wave by 17 msec. The ablation catheter was retrogradely advanced into the left ventricle via the femoral artery, and the distal electrode was positioned at the left posteroseptal region beneath the mitral valve annulus.

ABLATION SITE FOR Lt. POSTEROSEPTAL ACP

Fig 2. Electrograms and catheter position at the successful ablation site in a patient with a left posteroseptal manifest accessory pathway. A bipolar electrogram at the ablation site (ABL) showed a long A-V interval (Aa-Va: 47 msec) and Kent potential (K) between the atrial (A) and the ventricular (V) electrogram, but no A-V continuous electrogram. A unipolar electrogram (ABL-UNI) did not show a typical PQS pattern, while local ventricular potential preceded the delta wave by 17 msec. The ablation catheter was advanced retrogradely into the left ventricle via the femoral artery, and the distal electrode was positioned in the left posteroseptal region beneath the mitral valve annulus.

Table 1 Ablation Data of Each Accessory Pathway Location

	Right Free Wall (n=37)	Posteroseptal (n=33)	Left Free Wall (n=118)
No. of Session	1.1±0.4	1.2±0.5	1.0±0.1
No. of RFC Application	6.5±6.1	5.4±4.9	4.3±5.0
Total Energy (J)	5968±6480	4008±5633	2343±2326
Fluoroscopic Time (min)	67±28	98±89	39±31

$p < 0.01$

$p < 0.05$

$p < 0.01$

Technical Data for Each Accessory Pathway Location

Comparisons of the number of sessions and radiofrequency application, the total cumulative energy, and the fluoroscopic time between the posteroseptal and the free wall groups are shown in Table 1. There were significant differences between the posteroseptal and the left free wall cases in regard to the mean number of sessions (posteroseptal vs left 1.2 ± 0.5 vs 1.0 ± 0.1 ; $p < 0.01$), the mean applied energy (4008 ± 5633 vs 2343 ± 2326 J; $p < 0.05$), and the mean fluoroscopic time (98 ± 89 vs 39 ± 31 min; $p < 0.01$). However, there was no statistically significant difference between the posteroseptal and the right free wall cases in regard to the mean number of sessions and radiofrequency

application, the mean total applied energy, or the fluoroscopic time.

Characteristics of Local Electrograms at Successful Ablation Sites According to Accessory Pathway Location

Examples of local electrograms at each successful ablation site (right lateral, right posteroseptal, and left lateral accessory pathway) are shown in Fig 3. Both of the free wall cases exhibited short A-V intervals, continuous electrograms, and excellent PQS-pattern unipolar electrograms. The right posteroseptal case had a longer A-V interval (45 msec), and had neither a continuous electrogram nor a PQS-pattern unipolar

COMPARISON OF SUCCESSFUL ABLATION SITES

Fig 3. Examples of local electrograms at successful ablation sites (one each for a right lateral, a right posteroseptal, and a left lateral accessory pathway case). Both of the free wall cases showed short A-V intervals, continuous electrograms, and excellent PQS-pattern unipolar recordings. The right posteroseptal case had a longer A-V interval (45 msec), and did not have a continuous electrogram or PQS-pattern unipolar recording. Nonetheless, the right posteroseptal case had a longer V-delta interval than the left free wall case.

Table 2 Characteristics of Local Electrograms at Successful Ablation Sites Organized by Accessory Pathway Location

	Right Free Wall (n=37)	Posteroseptal (n=33)	Left Free Wall (n=118)
A-V Interval (msec)	26±8	38±12	33±7
	$p<0.01$		$p<0.05$
V-Delta Interval (msec)	23±10	17±6	13±8
	$p<0.05$		$p<0.05$
V-A Interval (ms)	33±8	43±12	40±10
A/V Ratio	0.7±0.7	0.8±0.7	0.5±0.7
Continuous Electrogram	79%	42%	63%
	$p<0.01$		$p<0.01$
Kent Potential	26%	28%	28%
PQS-pattern Unipolar Electrogram	78%	50%	76%
	$p<0.05$		$p<0.05$

recording. Nonetheless, the V-delta interval was longer in the right posteroseptal case than in the left free wall case.

Electrograms from successful ablation sites are analyzed in Table 2 according to the location of accessory pathway. The posteroseptal cases had significantly longer A-V (Aa-Va) intervals than patients with left free wall or right free wall accessory pathways (38 vs 33 and 26 msec, respectively; $p<0.05$). The V-delta (Vo-delta) intervals in the posteroseptal cases were significantly shorter than in the right free wall cases (17 vs 23 msec; $p<0.05$), but significantly longer than in the left free wall cases (17 vs 13 msec; $p<0.05$). The incidences of continuous electrograms and PQS-pattern unipolar electrograms were signifi-

cantly lower in the posteroseptal cases than in the left free wall and the right free wall cases (continuous electrogram 42 vs 63 and 79%; $p<0.01$; PQS-pattern unipolar electrogram 50 vs 76 and 78%, respectively; $p<0.05$). There was no statistically significant difference in the incidence of Kent potential among the posteroseptal, the left free wall, and the right free wall cases.

Characteristics of Local Electrograms at Successful Ablation Sites in the Right and the Left Posteroseptal Accessory Pathways

Comparisons of the successful electrographic characteristics between the right posteroseptal cases (n=18) and the left posteroseptal cases (n=15), both defined

Table 3 Characteristics of Local Electrograms at Successful Ablation Sites of the Right and the Left Posteroseptal Accessory Pathways

	Posteroseptal Right (n=18)	Posteroseptal Left (n=15)	p value
A-V Interval (msec)	38±14	38±2	NS
V-Delta Interval (msec)	19±6	12±5	p<0.05
V-A Interval (ms)	35±9	48±11	p<0.05
A/V Ratio	1.2±0.7	0.2±0.1	p<0.01
Continuous Electrogram	38%	40%	NS
Kent Potential	31%	25%	NS
PQS-pattern Unipolar Electrogram	56%	44%	NS

by catheter positioning at the successful ablation site, are shown in Table 3. There was no statistically significant difference in the A-V intervals, and the incidences of a continuous electrogram, Kent potential, and PQS-pattern unipolar electrogram were similar. However, patients with right posteroseptal accessory pathways had significantly longer V-delta intervals (19 vs 12 msec; $p<0.05$), significantly shorter V-A intervals (35 vs 48 msec; $p<0.05$), and significantly higher A/V ratio (1.2 vs 0.2; $p<0.01$) than patients with left posteroseptal accessory pathways.

There was no major complication in any of these cases, nor any significant abnormal finding detectable by echocardiography or Holter monitoring immediately and 1 week after procedures.

Throughout the mean follow-up period of 18.6 months (4–42 months), there was no recurrence of accessory pathway conduction.

Discussion

Radiofrequency catheter ablation has become the commonest and most successful method of curing WPW syndrome in patients with atrioventricular re-entrant tachycardia. The procedure has an excellent record of efficacy and safety^{10–24}. However, no previous study has examined the location-specific electrographic characteristics of successful ablation sites in patients with posteroseptal accessory atrioventricular connections. The ablation of posteroseptal accessory pathways is at times very difficult, sometimes with reason: the precise and detailed anatomy of posteroseptal accessory pathways is still unknown^{1,2} and definitive electrographic criteria to determine the accurate ablative site of posteroseptal accessory pathway are also controversial^{5,6,8,9}.

Differences in Technical Data Affected by Accessory Pathway Location

In our study, more sessions, more applied energy,

and more fluoroscopic time were necessary for the successful ablation of posteroseptal cases than of left free wall cases; in contrast, there was no statistically significant difference between the posteroseptal and the right free wall cases with regard to the number of sessions or radiofrequency applications, the applied energy, and the fluoroscopic time. It is therefore concluded that posteroseptal accessory pathway ablation is more difficult than ablation of left free wall pathway, whereas posteroseptal and right free wall pathway ablation are equally difficult technically. These conclusions are consistent with previous reports^{8–12,14,16–19} and some reasons are proposed below.

When performing left free wall pathway ablation, it is relatively easy to achieve a stable catheter position and to identify a successful site. Right free wall ablation is more difficult because catheter stability is sometimes difficult to achieve and it may be necessary to reintroduce the ablation catheter via the subclavian vein after having introduced it via the femoral vein. In the case of a posteroseptal pathway, the anatomic substrate is heterogeneous and complicated, and there is often a discrepancy between the delta-wave polarity on the electrocardiogram and the actual location of the accessory pathway. Thus, a broad mapping of the entire posterior area, ranging from the left posteroseptal to the right posteroseptal as well as the midseptal portion, is required. Furthermore, as in right free wall cases, catheter stability in posteroseptal cases is difficult to achieve. All of these factors have influenced the technical data.

Characteristics of Local Electrograms Recorded at Successful Ablation Sites in Posteroseptal Accessory Pathways

With the advent of catheter ablation techniques, precise localization of accessory pathways has become more and more necessary. Jackman et al^{4,10} reported the importance of the Kent potential. Calkins et al¹⁸ suggested that the important characteristics of a suc-

successful site are electrographic stability, Kent potential, V-delta interval, and a continuous electrogram. Haïssaguerre et al^{13,15} reported the importance of A-V interval, V-delta interval, and the PQS-pattern unipolar electrogram. These findings were also confirmed by Iesaka et al²⁰, Chen et al²¹, Grimm et al²², Bashir et al²³ and Cappato et al²⁴. However, none of the former investigators described the location-specific electrographic characteristics of successful ablation sites of posteroseptal accessory pathways.

The present study established the unique electrographic characteristics of appropriate target sites of posteroseptal accessory pathways. The length of the A-V interval and the presence of a continuous electrogram and a PQS-pattern unipolar electrogram, all of which are currently considered by several investigators to be good and important indicators for determining the target site of accessory pathways, are of little importance in targeting posteroseptal accessory pathways. On the other hand, the V-delta interval and the existence of a Kent potential should be given high priority in determining the appropriate target site of posteroseptal accessory pathways. Such electrographic features may be explained by the fact that posteroseptal pathways are often situated deep beneath the endocardium, inside the posteroseptal region, so that the distance between the catheter electrode on the endocardium and the accessory fiber is relatively longer even when the endocardial electrode is 'right on site'.

Because of the anatomic complexity and heterogeneity of posteroseptal accessory pathways, some investigators have reported the usefulness of radiofrequency application within the coronary sinus or middle cardiac vein. Wang et al⁶ reported that in some cases ablation of posteroseptal accessory pathways needed radiofrequency application within the coronary sinus or middle cardiac vein. Oren et al⁷ reported that, in 9% of their posteroseptal cases, Kent potentials were recorded only from the middle cardiac vein or an adjacent vein, suggesting an epicardial location, and that radiofrequency application within the middle cardiac vein was effective but carried the risk of venous perforation or occlusion. Dhala et al⁹ reported the need for radiofrequency delivery within the terminal portion of the coronary sinus in a few posteroseptal cases, but found that there was still a risk of perforation and tamponade. Jackman et al¹⁰ also reported the risk of current delivery within the coronary sinus. Bashir et al⁸ reported that, in patients with posteroseptal accessory pathways, bipolar current delivery across the septal region using a tricuspid-mitral annulus electrode configuration may be successful when radiofrequency application from con-

ventional sites along the tricuspid or mitral annulus is not. Schlüter et al¹² reported that left posteroseptal accessory pathways with a Kent potential recorded within the coronary sinus, although not eliminated by radiofrequency application within the coronary sinus, were successfully ablated by current delivery using a left-sided approach.

In all our patients, right posteroseptal accessory pathways were successfully ablated using a transvenous right-sided approach along the tricuspid annulus or at the coronary sinus ostium (n=18) and left posteroseptal cases were ablated using a transaortic left-sided approach along the mitral annulus (n=15). In other words, in no patient with a posteroseptal accessory pathway was it necessary to use radiofrequency application within the coronary sinus or middle cardiac vein. It is therefore possible, by evaluating the location-specific electrographic characteristics of posteroseptal accessory pathways, to minimize or obviate the need for delivery of radiofrequency pulses within the coronary sinus or middle cardiac vein.

Comparison of Electrograms at Successful Ablation Sites in Right and Left Posteroseptal Accessory Pathways

In this study, the definition of whether a posteroseptal pathway was right-sided or left-sided depended solely upon the catheter position at which success was achieved, irrespective of delta-wave polarity. There are few reports of comparison of electrograms at successful ablation sites in the right and the left posteroseptal accessory pathways; Haïssaguerre et al¹⁵ reported that the right posteroseptal cases had shorter A-V intervals and longer V-delta intervals than the left posteroseptal cases, the corresponding incidence of PQS-pattern unipolar recording being 27% and 13%, respectively. In our study, there was no statistically significant difference in the A-V interval or the incidence of continuous electrograms, Kent potentials, or PQS-pattern unipolar recordings. However, the right posteroseptal cases had significantly longer V-delta intervals, shorter V-A intervals, and higher A/V ratios than the left posteroseptal cases. The reasons for these differences are still unknown, but it may be there is less intervening cardiac muscle and connective tissue in the right posteroseptal region than in the left posteroseptal region. Furthermore, the right posteroseptal cases were more often ablated on the atrial side (above the tricuspid valve) than on the ventricular side (beneath the valve), whereas the left posteroseptal cases were commonly ablated on the ventricular side (beneath the mitral valve). These factors may have affected the A/V ratio differences.

Conclusion

This study demonstrates that local electrographic characteristics at the successful ablation site of posteroseptal accessory pathways are different from those of free wall accessory pathways. These features were examined in 33 patients with posteroseptal accessory pathways (right-sided in 18 and left-sided in 15) and compared with those in 155 patients with free wall accessory pathways. The A-V intervals in the posteroseptal cases were significantly longer than in the free wall cases, and the incidences of continuous electrograms and PQS-pattern unipolar electrograms were significantly lower in the posteroseptal cases than in the free wall cases. The V-delta intervals in the posteroseptal cases were significantly longer than in the left free wall cases but shorter than in the right free wall cases. No statistically significant difference in the incidence of Kent potential among the posteroseptal, the right free wall, and the left free wall cases was observed. These results indicate that, in radiofrequency ablation of posteroseptal accessory pathways, the length of the A-V interval, the incidence of continuous electrograms, and the occurrence of PQS-pattern unipolar electrograms may be unsatisfactory even at the appropriate target site, but that the V-delta interval and Kent potential are good indicators for determining the target site as well as in free wall cases.

References

- Sealy WC, Mikat EM: Anatomical problems with identification and interruption of posterior septal Kent bundles. *Ann Thorac Surg* 1983; **36**: 584–595
- Guiraudon GM, Klein GJ, Sharma AD, Jones DL, McLellan DG: Surgical ablation of posterior septal accessory pathways in the Wolff-Parkinson-White syndrome by a closed heart technique. *J Thorac Cardiovasc Surg* 1986; **92**: 406–413
- Morady F, Scheinman MM, Winston SA, Dicarlo Jr LA, Davis JC, Griffin JC et al: Efficacy and safety of transcatheter ablation of posteroseptal accessory pathways. *Circulation* 1985; **72**: 170–177
- Jackman WM, Friday KJ, Fitzgerald DM, Bowman AJ, Yeung-Lai-Wai JA, Lazzara R: Localization of left free-wall and posteroseptal accessory atrioventricular pathways by direct recording of accessory pathway activation. *PACE* 1989; **12**: 204–214
- Morady F, Scheinman MM, Kou WH, Griffin JC, Dick II M, Herre J et al: Long-term results of catheter ablation of a posteroseptal accessory atrioventricular connection in 48 patients. *Circulation* 1989; **79**: 1160–170
- Wang X, Jackman WM, McClelland J, Beckman K, Roman C, Oren J et al: Sites of successful radiofrequency ablation of posteroseptal accessory pathways (abstract). *PACE* 1992; **15**: 535
- Oren J, McClelland J, Beckman K, Wang X, Santoro I, Roman C et al: Epicardial posteroseptal accessory pathways requiring ablation from the middle cardiac vein (abstract). *PACE* 1992; **15**: 535
- Bashir Y, Heald SC, O'Nunain S, Katritsis D, Camm AJ, Ward DE: Radiofrequency current delivery by way of a bipolar tricuspid annulus-mitral annulus electrode configuration for ablation of posteroseptal accessory pathways. *J Am Coll Cardiol* 1993; **22**: 550–556
- Dhala AA, Deshpande SS, Bremner S, Hempe S, Sra JS, Blank Z et al: Transcatheter ablation of posteroseptal accessory pathways using a venous approach and radiofrequency energy. *Circulation* 1994; **90**: 1799–1810
- Jackman WM, Wang X, Friday KJ, Roman CA, Moulton KP, Beckman KJ et al: Catheter ablation of accessory atrioventricular pathways (Wolff-Parkinson-White syndrome) by radiofrequency current. *N Engl J Med* 1991; **324**: 1605–1611
- Calkins H, Sousa J, El-Atassi R, Rosenheck S, Buitler M, Kou WH et al: Diagnosis and cure of the Wolff-Parkinson-White syndrome or paroxysmal supraventricular tachycardias during a single electrophysiologic test. *N Engl J Med* 1991; **324**: 1612–1618
- Schlüter 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**: 1644–1661
- Haissaguerre M, Darteigues JF, Warin JF, Metayer PL, Montserrat P, Salamon R: Electrogram patterns predictive of successful catheter ablation of accessory pathways: value of unipolar recording mode. *Circulation* 1991; **84**: 188–202
- Lesh MD, Van Hare GF, Schamp DJ, Chien W, Lee MA, Griffin JC 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**: 1303–1309
- Haissaguerre M, Fisher B, Warin JF, Darteigues JF, Lemetayer P, Egloff P: Electrogram patterns predictive of successful radiofrequency catheter ablation of accessory pathways. *PACE* 1992; **15**: 2138–2145
- Kuck KH, Schlüter M: Radiofrequency catheter ablation of accessory pathways. *PACE* 1992; **15**: 1380–1386
- Calkins H, Langberg J, Sousa J, El-Atassi R, Leon A, Kou W et al: Radiofrequency catheter ablation of accessory atrioventricular connections in 250 patients. *Circulation* 1992; **85**: 1337–1346
- Calkins H, Kim YN, Schmaltz S, Sousa J, El-Atassi R, Leon A et al: Electrogram criteria for identification of appropriate target sites for radiofrequency catheter ablation of accessory atrioventricular connections. *Circulation* 1992; **85**: 565–573
- Gursoy S, Schlüter M, Kuck KH: Radiofrequency current catheter ablation for control of supraventricular arrhythmias. *J Cardiovasc Electrophysiol* 1993; **4**: 194–205
- Iesaka Y, Takahashi A, Chun YH, Igawa M, Tokunaga T, Amemiya H et al: Radiofrequency catheter ablation of atrioventricular accessory pathways in Wolff-Parkinson-White syndrome with drug-refractory and symptomatic supraventricular tachycardia. *Jpn Circ J* 1994; **58**: 767–777

21. Cappato R, Schlüter M, Mont L, Kuck KH: Anatomic, electrical, and mechanical factors affecting bipolar endocardial electrograms: impact on catheter ablation of manifest left free-wall accessory pathways. *Circulation* 1994; **90**: 884–894
22. Bashir Y, Heald SC, Katritsis D, Hammouda M, Camm AJ, Ward DE: Radiofrequency ablation of accessory atrioventricular pathways: predictive value of local electrogram characteristics for the identification of successful target sites. *Br Heart J* 1993; **69**: 315–321
23. Chen X, Borggrefe M, Shenasa M, Haverkamp W, Hindricks G, Breithardt G: Characteristics of local electrogram predicting successful transcatheter radiofrequency ablation of left-sided accessory pathways. *J Am Coll Cardiol* 1992; **20**: 656–665
24. Grimm W, Miller J, Josephson ME: Successful and unsuccessful sites of radiofrequency catheter ablation of accessory atrioventricular connections. *Am Heart J* 1994; **128**: 77–87