TECHNIQUE

Radiofrequency catheter ablation of septal accessory atrioventricular pathways

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Abstract

***Objective*—Septal accessory atrioventricular pathways are recognised as being more difficult to ablate than pathways in other locations. This paper describes an experience of 48 consecutive patients with septal accessory pathways who had catheter ablation with radiofrequency current.**

***Patients and methods*—There were 28 male and 20 female patients, mean (SD) age 35 (17). 43 patients had a single accessory pathway and 5 patients had multiple accessory pathways. Pre-excitation was present in 37 patients, and 11 patients had concealed accessory pathways. 21 patients had had a previous electrophysiological study. Catheter ablation was undertaken with radiofrequency current delivered by a standard unipolar technique or by delivery of current across the septum (the bipolar technique).**

***Results*—The median total procedure time was 167 (83) minutes including a 30–40 minute observation period after the abolition of conduction by the accessory pathway. The median total fluoroscopic time was 56 (30) minutes. 42 (88%) out of 48 patients had successful ablation of the pathway during the first session. In the six patients in whom the procedure failed, five had a midseptal pathway and one had a right anteroseptal pathway. A second attempt at ablation was made in two patients and succeeded in both. In total, 49 accessory pathways were successfully ablated in 44 (92%) out of 48 patients. The bipolar technique was used in 11 patients and succeeded in 10 patients. Standard unipolar current delivery had previously failed in seven of the 11 patients. Complications developed in two patients with a mid septal pathway (one with complete atrioventricular block and the other with a small pericardial effusion).**

***Conclusion*—Radiofrequency catheter ablation of septal accessory pathways is efficacious and safe. The procedure time can be shortened and success rate can be increased after improvement of the technique—that is, consideration of a bipolar approach for energy delivery in difficult cases.**

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Patients with Wolff-Parkinson-White syndrome have a risk of recurrent atrioventricular re-entrant tachycardia, syncope, and atrial fibrillation with rapid ventricular response that occasionally deteriorates into ventricular fibrillation.[1] The anatomical substrate of Wolff-Parkinson-White syndrome is the existence of an accessory atrioventricular pathway. Ablation of the accessory pathway can eliminate these arrhythmias.

Catheter based radiofrequency energy ablation is increasingly being used for the ablation of accessory pathways at various sites along the atrioventricular annulus. Septal accessory pathways have been recognised as the most difficult to ablate compared with those in other locations. Several investigators have reported success rates of 67%–68% for catheter ablation of posteroseptal accessory atrioventricular connections with direct current shocks; but complications occurred in up to 21%, such as cardiac tamponade, coronary sinus rupture, and ventricular myocardial infarction.[2,3] More recently, Lesh *et al* reported success rates for catheter ablation with radiofrequency current in 83·7% patients with septal pathways, compared with 97·8% in patients with a left free wall pathway.[4] Furthermore, the reported recurrence rate was higher in patients with septal pathways (11%-25%), particularly in a midseptal location (33·3%) than in patients with a left free wall pathway (5%-6%).[4–6]

This report describes our experience of a consecutive series of 48 patients who had radiofrequency catheter ablation of septal accessory pathways.

Patients and methods

PATIENTS

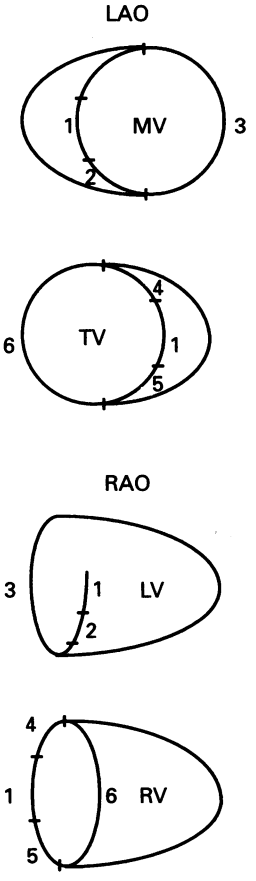
Forty eight patients had radiofrequency catheter ablation of septal accessory pathways between March 1990 and December 1992. Forty three patients had a single accessory pathway and five patients had multiple accessory pathways. Pre-excitation was present in 37 patients and concealed accessory pathways were present in 11. No one had evidence of structural heart disease. Twenty eight patients were male and 20 female; age range 9–72, mean (SD) 35 (17). Each patient had recurrent episodes of atrioventricular re-entrant tachycardia, atrial fibrillation, or both. Most patients had not responded to treatment with several antiarrhythmic drugs due to either lack of efficacy or unacceptable side effects.

ELECTROPHYSIOLOGICAL STUDY

Twenty one patients had had a previous electrophysiological study, the protocol for which has already been described.[7]

CATHETER ABLATION

After informed consent, the ablation procedure was performed in the postabsorptive state with moderate sedation. Endocardial mapping was performed with the ablation catheter. Accessory pathway locations were verified by careful mapping of the mitral and tricuspid annuli using a 7 F (French) catheter with a deflectable 4 mm tip and 2·5 mm interelectrode spacing (Polaris, Mansfield-Webster). Radiofrequency current was delivered during sinus rhythm in patients with preexcitation and during orthodromic atrioventricular tachycardia or ventricular pacing in patients with concealed conduction. Right anteroseptal accessory pathways were approached by positioning the ablation catheter across the tricuspid valve through the inferior vena cava. Posteroseptal pathways and midseptal accessory pathways were approached by positioning the ablation catheter on the mitral annulus through the retrograde transaortic route, or on the tricuspid annulus, or within the proximal coronary sinus through the femoral vein. In 11 patients (eight midseptal, three left posteroseptal) a bipolar electrode configuration was used with radiofrequency current delivery between catheters positioned on either side of the septum. Catheter position was recorded in the 30° right and left anterior oblique fluoroscopic views. The figure shows the definitions of locations of accessory pathways.



Accessory pathway locations as defined fluoroscopically. LAO, 30° left anterior oblique projection; LV, left ventricle; MV, mitral valve; RAO. 30° right anterior oblique projection; RV, right ventricle; TV, tricuspid valve; 1, midseptal; 2, left posteroseptal; 3, left free wall; 4 right anteroseptal; 5, right posteroseptal; 6 right free wall.

FOLLOW UP AFTER ABLATION

Electrophysiological results were evaluated 30 to 45 minutes and two to six weeks after successful accessory pathway ablation. Right atrial and ventricular stimulation with the extrastimulus technique, as well as incremental pacing, were used to exclude the presence of another accessory pathway and to determine the conduction properties after ablation of the atriventricular node and His bundle system. All patients were discharged within 24 hours of the ablation procedure.

STATISTICAL ANALYSIS

Continuous variables are expressed as mean (SD). The location of the accessory pathway and relation to manifest or concealed pathway conduction was analysed with the χ^2 test. The influence of mode of energy delivery (unipolar, bipolar, or both) on procedure duration was analysed with the student's t test. A P value $<0{\cdot}05$ was considered significant.

Results

LOCATION

Of the 48 patients who had radiofrequency ablation, the accessory pathway was localized in the right posteroseptal region in 16 patients, midseptal in 20 patients, left posteroseptal in seven patients, and right anteroseptal in six patients. Compared with other positions, concealed accessory pathways were less often located in the right posteroseptal region (P = 0·02, table 1). Of the five patients with multiple accessory pathways, two patients had a left posteroseptal and a left lateral pathway, one patient had a mid septal and a left lateral pathway, one patient had a right posteroseptal and a left free wall pathway, and one patient had a right anteroseptal and a mid septal pathway.

DURATION OF PROCEDURE

The median duration of procedure was 167 (83) minutes (range 51–360 minutes) including a 30–45 minute observation period after abolition of conduction along the accessory pathway. The duration of procedure was greatest in patients with multiple accessory atrioventricular pathways (211 minutes) and shortest in patients with mid septal pathways (157 minutes). The median total fluoroscopic time was 56 (30) (range 1·8–172) minutes.

Table 1 Locations of septal accessory pathways and relation to accessory pathway conduction

	RPS	*MS*	*LPS*	*RAS*
Manifest	16*	14	4	4
Concealed	0	6	3	2

* Concealed pathways were less frequent in the RPS location (P = 0·02). LPS, left posteroseptal, MS, mid septal, RAS, right anteroseptal, RPS, right posteroseptal.

CHARACTERISTICS OF INTRACARDIAC ELECTROGRAM AT SUCCESSFUL ABLATION SITES

Accessory atrioventricular pathway potentials were seen at 17 (38%) of 45 successful ablation sites of septal accessory pathways but no effort was made to validate them. During anterograde conduction mean atrioventricular interval of the local electrocardiogram recorded during sinus rhythm was 38 (16) ms. The atrial to ventricular electrogram amplitude ratio was 0·9 (0·9). The mean interval from the onset of the delta wave on the surface electrocardiogram to local intracardiac ventricular activation (delta-V) was 6·8 (11·9) ms. The mean ventricular to atrial interval was 54 (50) ms and ventriculoatrial amplitude ratio of the local electrocardiogram was 3(2·7) recorded during ventricular pacing or orthodromic tachycardia. The mean stability (defined as the ratio of the minimum to maximum amplitudes of the five complexes immediately before radiofrequency current delivery) of the local atrial electrocardiogram was 0·7 (0·2). The mean stability of the local ventricular electrocardiogram was 0·8 (0·2). No difference was found between the unipolar and bipolar approach. In two patients temperature controlled ablation catheters were used during the procedure, the mean temperature was 87·5°C at successful ablation sites. The mean time to block in the accessory pathway during delivery of radiofrequency was 4 (3) s. In one patient the time to block was not estimated. Radiofrequency current was applied at a mean of 12 (10) sites.

SUCCESSFUL ABLATION OF ACCESSORY PATHWAYS

Forty seven accessory pathways in 42 patients were successfully ablated in the initial session (88%). In the six patients in whom the procedure failed the accessory pathway was located in the midseptum in five patients and anteroseptally in one. As the failure rate was so high in patients with midseptal pathways (five out of 20), we analysed the method of ablation in all 20 patients with midseptal pathways (table 2). Two septal accessory pathways in two patients that were not successfully ablated in the first session were both ablated in a repeat procedure (one with a temperature controlled catheter and one with the bipolar technique). In the remaining four patients radiofrequency energy only caused a transient disappearance of preexcitation. The overall success rate including the repeat procedure was 92%.

Table 2 Midseptal accessory pathways: relation of mode of ablation to procedure and screening time

Method	*Patients (n)*	*Procedure time (min)*	*Screen time (min)*
Unipolar Only:			
Unsuccessful	5	259(46)	122 (5)
Successful	7	159(68)*	57 (44)*
Bipolar only, successful	4	92(22)*	26 (13)*
Unipolar-bipolar, successful	3	203(40)	79 (17)
Unipolar-bipolar-unipolar, successful	1†	200	83

* $P < 0.05$. †After starting with a unipolar technique and progressing to bipolar mode of energy delivery the unipolar mode was reverted to because of difficulty in manipulation of the left ventricular catheter.

BIPOLAR AND UNIPOLAR TECHNIQUES

In 11 patients (eight with a midseptal and three with a left posteroseptal pathway), catheter ablation was tried with a bipolar approach, delivering energy between two catheters positioned either side of the septum. The number of applications of current was 3 (2) range (2–6) and the range of current strengths used was 25–50 W. In patients who underwent ablation with a unipolar approach before proceeding to the bipolar technique, the number of applications of current was two to 15 on the left and eight to 13 on the right side of the septum. No temperature sensing was used in any of these cases. In seven patients, this technique was used after failure with standard unipolar techniques and was successful in six. In the remaining patient with a midseptal pathway only one energy application was made with the bipolar technique before abandoning the method due to difficulty in manipulation of the left ventricular ablating electrode. In the other four patients with midseptal pathways the bipolar technique was used as the mode of choice with encouraging results (table 2). In these patients, later in the series, mapping showed early ventricular activation on both sides of the interventricular septum, suggesting a pathway coursing between the two ablating catheters. Although there were no significantly different features of the electrograms at successful ablation sites, the similar timing of ventricular activation on either side of the septum led us to believe that this mode of energy delivery would be appropriate. This is supported by the lower number of deliveries required for successful bipolar ablation of midseptal accessory pathways (two to six) compared with successful unipolar ablation of midseptal accessory pathways (four to 50, mean 18 (15)).

COMPLICATIONS

Complications developed in two patients with a midseptal accessory pathway. One had complete atrioventricular block and needed the insertion of a permanent pacemaker, and another had a small pericardial effusion with no haemodynamic consequences.

Discussion

EFFICACY AND COMPLICATIONS

Our experience suggests that catheter ablation of septal accessory pathways with radiofrequency energy can be performed with a high success rate and low incidence of complications. Forty nine of 53 pathways in 44 of 48 consecutive patients (92%) were successfully ablated. The success rate of the initial attempt at catheter ablation was 88% rising to 92% after a second procedure in two patients. No significant difference was found in intracardiac electrogram characteristics between successful and unsuccessful ablation sites.[8] The total 92% success rate is similar to the 90% success rate reported by Calkins *et al*[9] and greater than the 60%-85% success rate reported by Lesh *et al* and Josephson[4 10] dur-

ing radiofrequency ablation of septal accessory pathways. Also the success rate we achieved compares favourably with previous reports of catheter ablation with direct current shocks. Several other investigators have reported a success rate of <70% for ablation of posteroseptal accessory pathways with direct current shocks.[2 3] Despite the similar efficacy of direct current compared with radiofrequency current energy for catheter ablation, radiofrequency current may be a preferable energy source because it does not need general anaesthesia and is associated with a lower incidence of complications. Atrioventricular block is the most common complication of catheter ablation in patients with septal accessory pathways as these lie close to the atrioventricular node and His bundle system. Although there was no significant difference in the occurrence of atrioventricular block between radiofrequency energy (2%-5·5%) and direct current shock (2%-8·3%), other significant complications including cardiac tamponade, coronary sinus rupture, and ventricular myocardial infarction are more often associated with direct current shock.[2 3] A series of studies with radiofrequency current for catheter ablation of septal accessory pathways has not reported these complications.[4 5 11]

BIPOLAR AND UNIPOLAR TECHNIQUE

In seven patients, catheter ablation of septal accessory pathways was tried with a bipolar approach after failure with standard unipolar techniques and was successful in six patients. In four patients, the bipolar approach was used as the initial mode of energy delivery, was successful in all patients, and had a short procedure time. As the depth of the septal space[12] may make it difficult to deliver adequate energy to an accessory pathway coursing in the septum, we conclude that it is reasonable to try the bipolar technique if standard unipolar techniques fail, before abandoning the procedure.

DURATION OF PROCEDURE

One limitation of radiofrequency ablation is the potentially long procedure, a median duration of 4·6 h for ablation of septal accessory pathways having been reported.[13] Efforts have been made to shorten the ablation procedure as much as possible: for example, the single catheter ablation technique reported by Kuck and Schluter[14] and the abbreviated therapeutic approach to Wolff-Parkinson-White syndrome reported by Calkins *et al.*[9] In our study the median duration procedure was 2·8 hours, similar to the 2·2 hours reported by Calkins *et al.*[9] Contributing factors to a shorter procedure may include previous electrophysiological study, and the use of the bipolar technique.

MANIFEST AND CONCEALED ACCESSORY PATHWAYS

It is interesting to note that in this series concealed pathways were less often located in the right posteroseptal region than other septal locations. Previous studies have found concealed accessory pathways more often in the left free wall than in the right free wall.[15] Morady *et al*[3] have found that catheter ablation with direct current is particularly suited to patients with a concealed posteroseptal accessory pathway, in whom the success rate is higher than in patients with manifest septal accessory pathways. In our study, ablation was successful in all patients with a concealed pathway and in 31 of 37 (84%) patients with a manifest accessory pathway.

In conclusion catheter based ablation of septal accessory pathways with radiofrequency current as the energy source is efficacious and safe. The procedure time can be shortened and success rate can be increased after improvement of the technique, with particular attention to careful mapping of the septal region, and consideration of a bipolar approach for energy delivery in difficult cases.

1 De Chillou C, Rodriquez LM, Schlapfer J, Kappos KG, Katsivas A, Xie B, *et al.* Clinical characteristics and electrophysiologic properties of atrioventricular accessory pathways: importance of the accessory pathway location. *J Am Coll Cardiol* 1992;**20**:666–71.

2 Bardy GH, Ivey TD, Coltorti F, Stewart RB, Johnson G, Greene HL. Developments, complications and limitations of catheter-mediated electrical ablation of posterior accessory atrioventricular pathways. *Am J Cardiol* 1988;**61**:309–16.

3 Morady F, Scheinman MM, Kou WH, Griffin JC, Dick II M, Herre J, *et al.* Longterm results of catheter ablation of a posteroseptal accessory atrioventricular connection in 48 patients. *Circulation* 1989;**89**:1160–70.

4 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**:1303–9.

5 Twidale N, Wang X, Moulton K, Beckman K, Prior M, Hazlitt A, *et al.* Catheter placement for radiofrequency ablation of anteroseptal accessory pathways [abstract]. *J Am Coll Cardiol* 1991;**17**:231A.

6 Langberg J, Calhins H, Kim YN, Sousa J, el-Atassi R, Leon A, *et al.* Recurrence of conduction in accessory atrioventricular connections after initially successful radiofrequency catheter ablation. *J Am Coll Cardiol* 1992;**19**:1588–92.

7 Ward DE, Camm AJ, Pearce RC, Spurrell RAJ, Rees GM. Incessant atrioventricular tachycardia involving an accessory pathway: preoperative and intraoperative electrophysiological studies and surgical correction. *Am J Cardiol* 1979;**44**:428–34.

8 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**:315–21.

9 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: abbreviated therapeutic approach to Wolff-Pakinson-White syndrome. *Circulation* 1992;**85**:1337–46.

10 Josephson ME. *Clinical cardiac electrophysiology: techniques and interpretations.* 2nd ed. Philadelphia: Lea and Febiger, 1993:755.

11 Schluter M, Kuck KH. Catheter ablation from right atrium of anteroseptal accessory pathways using radiofrequency current. *J Am Coll Cardiol* 1992;**19**:663–70.

12 Selle JG, Sealy WC, Gallagher JJ, Svenson RH, Zimmern SH, Fedor JM, *et al.* The complex posterior septal space in the Wolff-Parkinson-White syndrome: surgical experience with 47 patients. *Thorac Cardiovasc Surg* 1989;**37**:299–304.

13 Schluter M, Kuck KH. Catheter ablation of septal accessory conduction pathways with high frequency electric current. *Z Kardiol* 1992;**81**:249–57.

14 Kuck KH, Schluter M. Single-catheter approach to radiofrequency current ablation of left-sided accessory pathways in patients with Wolff-Parkinson-White syndrome. *Circulation* 1991;**84**:2366–75.

15 Farre J, Wellens HJJ. The value of the electrocardiogram in diagnosing site of origin and mechanism of supraventricular tachycardia. In: Wellens HJJ, Hulbertus H, eds. *What's new in electrocardiography.* Hague: Martinus Nijhoff, 1980:131–71.