Radiofrequency catheter ablation of accessory atrioventricular pathways: primary failure and recurrence of conduction

B Xie, S C Heald, A J Camm, E Rowland, D E Ward

Abstract

Objective—To identify possible factors associated with primary failure of radiofrequency ablation of accessory pathways or recurrence of accessory pathway conduction.

Patients and methods—Radiofrequency ablation of accessory pathways failed in 25 of 243 patients, and recurrence of accessory pathway conduction occurred in an additional 13 patients. Factors possibly related to primary failure and recurrence were analysed.

Results—Primary failure and recurrence were less frequent in patients with left sided pathways (7% v 19%; 4% v 24%; $P = 0.04$). The factors that might relate to primary failure included an unstable catheter position (seven patients), a possible epicardial pathway (six patients), or misdiagnosis of accessory pathway location (two patients). The major factors for recurrence included the stability of the local atrial electrogram ≤ 0.5 together with the stability of the local ventricular electrogram ≤ 0.8 , and prolonged time to pathway conduction block ≥ 12 seconds). Thirty one patients underwent repeat ablation which was successful in 28.

Conclusions—Primary failure and recurrence were more frequent in patients with right sided pathways. An unstable catheter position and a possible epicardial pathway location are the main contributing factors for primary failure, while unstable local electrograms and prolonged time to block are independent predictors for recurrence.

(Heart 1997;77:363-368)

Keywords: radiofrequency catheter ablation; accessory pathway; low energy direct current

Radiofrequency catheter ablation is now first line treatment in symptomatic patients with accessory atrioventricular pathways owing to its high efficacy and low risk. Previous studies have shown that the elimination of accessory pathway conduction can be achieved in > 90% patients.^{1,2} However, in some patients accessory pathway conduction cannot be abolished even after a lengthy procedure, and in other patients pathway conduction recurs after apparently successful ablation. Factors that may predispose to failure and recurrence have not been well defined. The objective of this

study was to analyse possible factors associated with primary failure to abolish accessory pathway conduction, or recurrence of accessory pathway conduction after an initially successful procedure.

Methods

STUDY POPULATION

From January 1991 to August 1994 a consecutive series of 243 patients with 248 accessory pathways underwent radiofrequency catheter ablation. One hundred and fifty nine patients were male and 84 female, age range 6 to 71 years, mean 34 (SD 17) years. Each patient had recurrent episodes of atrioventricular reentrant tachycardia, atrial fibrillation, or both. Most patients had failed treatment with several antiarrhythmic drugs, either because of lack of efficacy or because of unacceptable side effects. Structural heart disease was present in nine patients (cardiomyopathy in four, Ebstein's anomaly in three, mitral stenosis in one, and mitral valve prolapse in one).

RECORDING AND ANALYSIS OF LOCAL ELECTROGRAMS

We analysed the endocardial electrograms. These included the interval from onset of the earliest delta wave to local ventricular electrogram (ORS-V), the local atrioventricular interval (AV), the local ventriculoatrial interval (VA), the stability of the local atrial and ventricular electrograms, and the presence of a possible accessory pathway potential, recorded at successful sites (permanent abolition of accessory pathway conduction), at sites where block in accessory pathway conduction was only transient, or the best electrograms obtained during failed procedures. The details of determination of local electrocardiogram characteristics have been described previously.³ The stability of local atrial and ventricular electrograms was defined as the ratio of the minimum to maximum amplitudes of the five complexes immediately preceding radiofrequency current delivery. No attempt was made to verify possible accessory pathway potentials by programmed stimulation.

ELECTROPHYSIOLOGICAL STUDY AND CATHETER ABLATION

Electrophysiological studies had been performed in a separate session in 40 patients, and immediately before catheter ablation in all patients. The protocols for standard electrophysiological studies and radiofrequency ablation have been described elsewhere.^{3,4} In brief,

Department of
Cardiological
Sciences, St George's
Hospital Medical
School, London

B Xie
S C Heald
A J Camm
E Rowland
D E Ward

Correspondence to:
Dr D E Ward, Department
of Cardiological Sciences,
St George's Hospital
Medical School,
Cranmer Terrace,
London SW17 0RE, United
Kingdom.

Accepted for publication
14 January 1997

ablation was attempted with a 7F deflectable catheter with a 4 mm tip and 2.5 mm inter-electrode spacing inserted into the femoral vein, femoral artery, or subclavian vein. After precise mapping, radiofrequency current was delivered between the distal electrode of the ablation catheter and a large skin electrode, using a 500 kHz generator (HAT 200s, Dr Osypka GmbH) at constant preset electrical power (usually 25–35 W, range 15–50 W) for 30 seconds. If conduction in accessory pathway failed to block within 10 seconds (occasionally longer), energy delivery was interrupted. After initially achieving successful interruption of accessory pathway conduction patients remained in the laboratory for between 20 and 60 minutes to see if accessory pathway conduction would recur. Atrial pacing, ventricular pacing, or both were performed immediately after ablation and 20 to 60 minutes after the last radiofrequency application.

Left sided accessory pathways were approached retrogradely through the aorta, or transeptally. Right sided accessory pathways were approached by positioning the ablation catheter on the tricuspid valve annulus through the femoral or subclavian vein. Posteroseptal accessory pathways were approached by positioning the ablation catheter on the medial aspect of the mitral annulus retrogradely through the transaortic route, or on the tricuspid annulus or within the proximal coronary sinus through the femoral vein.

Primary failure was defined as persistence of conduction in the accessory pathway at the time of leaving the catheter laboratory following the first ablation session. Recurrence was defined as successful abolition of accessory pathway conduction but recurrence after the patient left the catheter laboratory. Various factors possibly associated with failure or recurrence were analysed, including accessory pathway location, catheter stability, and local electrogram characteristics: QRS-V interval, the AV interval, the presence of a possible accessory pathway potential, the stability of local atrial and ventricular electrograms, the VA interval and time from energy delivery to block of accessory pathway conduction. Accessory pathway location was determined as the site where energy delivery led to interruption of accessory pathway conduction. For four patients in whom energy delivery did not lead to interruption of accessory pathway conduction, the accessory pathway location was

determined from the results of endocardial mapping. Misdiagnosis of accessory pathway location was determined when the location of pathways defined in the initial unsuccessful procedure was different from the site where the energy delivery led to a successful ablation of the accessory pathway in a repeat procedure. Unstable catheter position was defined as 50% or greater variation in amplitude of the electrogram (five complexes immediately preceding radiofrequency current delivery) recorded at the ablation site, or ablation catheter movement from the target site during current delivery, verified by fluoroscopy, or both.

FOLLOW UP
All patients underwent routine outpatient follow up. If there was a suspicion of recurrence of accessory pathway conduction, an electrophysiological study was performed.

STATISTICAL ANALYSIS
Continuous variables are expressed as mean (SD). Comparisons between successful and unsuccessful sites were made using the Student's *t* test or by χ^2 analysis. Multivariate stepwise logistic regression was then performed to find the most powerful independent predictors of recurrence. A P value of less than 0.05 was regarded as significant.

Results
Primary failure of radiofrequency catheter ablation of accessory pathways occurred in 25 of 243 patients (10%). Recurrence of accessory pathway conduction occurred in 13 of 218 patients (6%) after mean follow up of 20 (13) months (range 6 to 40). Recurrence was manifest by ventricular pre-excitation on routine follow up ECG in eight patients, documented tachycardia in one, and both in four patients. The time to recurrence varied from one hour to within 42 days. In half of these patients recurrence was in the first 12 hours after ablation. In the 35 patients who underwent ablation in 1991, the procedure failed in seven patients and recurrence of accessory pathway conduction occurred in two patients; while in the 208 patients who underwent ablation between 1992 and 1994 primary failure occurred in 18 and recurrence in 11 patients. There were no significant differences in the rate of primary failure and recurrence between 1991 and the following years (*P* = 0.08 and 0.88, respectively) although the rate of primary failure seems higher in 1991. There were no significant differences in the rate of failure or recurrence between manifest and concealed pathways. The clinical characteristics of all patients are summarised in table 1.

Table 1 Clinical characteristics of patients with primary failure or recurrence of accessory pathway conduction

	Success	Failure	P*	Recurrence	P*
Mean age (SD) (years)	34 (14)	36 (16)	0.80	35 (16)	0.9
Sex (male/female)	135/70	17/8	1.00	7/6	0.56
Structural heart disease	6	2	0.43	1	0.87
Manifest/concealed AP	171/39	20/5	1.00	12/1	0.22
Multiple AP	5	0	0.49	0	0.53
Number of drug failures	22	21	0.9	31	0.21
Previous EPS	33	5	0.96	2	1.00

AP, accessory pathway; EPS, electrophysiological study.
*P value compared with the success group.

LOCATION OF ACCESSORY PATHWAYS
Failure of interruption of accessory pathway conduction occurred more frequently in patients with right sided pathways, especially in mid-septal and right antero-septal locations. Recurrence occurred more often in patients with right free wall pathways (table 2).

Table 2 Location of accessory pathways

Primary failure*		Successful ablation		Recurrence		No recurrence	
Location	Patients	Location	Patients	Location	Patients	Location	Patients
LFW	9	LFW	118	LFW	4†	LFW	113
LPS	1	LPS	24	LPS	2	LPS	22
MS	7	MS	23	MS	1	MS	23
RPS	3	RPS	28	RPS	1	RPS	27
RAS	2	RAS	9	RAS	1	RAS	8
RFW	3	RFW	21	RFW	4†	RFW	17

AP, accessory pathway; LFW, left free wall; LPS, left posteroseptal; MS, midseptal; RAS, right anteroseptal; RFW, right free wall; RPS, right posteroseptal.
*The failure rate was higher in right sided pathways (MS, RPS, RAS, and RFW as a group) compared with left sided pathways (LFW and LPS as a group) $P < 0.05$.
†The recurrence rate was higher in right free wall compared with left free wall pathways ($P = 0.03$).

FACTORS ASSOCIATED WITH PRIMARY FAILURE
Unstable catheter position

In patients 2, 5, 7, 8, 10, 11, and 17, an unstable catheter position was the main reason for primary failure (table 3). Standard radiofrequency ablation (unipolar technique) was successful at a repeat session in patients 7, 8, 11, and 17. In patient 5 a transeptal approach to a left free wall pathway was employed and succeeded. In patient 2 a repeat procedure was not performed, because manipulation of the catheter across the aortic valve and within the left ventricle was extremely difficult due to tortuosity of the iliac vessels. Patient 10 declined a second ablation.

Epicardial accessory pathway? (table 3)
In patients 3, 4, 12, 24, and 25 the best endocardial electrogram was recorded from within the coronary sinus and in patients 3, 4, 12, and 25 the delta wave in lead II was strikingly negative. Coronary sinus angiography was performed in patients 12 and 25 and showed a large proximally arising middle cardiac vein in

patient 12 and a large cardiac vein and smaller posterior vein in patient 25. Standard radiofrequency ablation was repeated in patients 3, 4 and failed in both; ablation of the atrioventricular junction was performed subsequently. In patient 12, two further radiofrequency ablation procedures failed and low energy direct current was then delivered in the coronary sinus and ultimately ablated the pathway. In patient 25 repeat standard radiofrequency ablation also failed and low energy direct current delivered between two electrodes positioned in the left ventricle and coronary sinus succeeded in ablating the pathway. Low energy direct current delivered through one electrode in the coronary sinus in this patient caused only transient block. Patient 24 preferred not to have a repeat ablation.

In patient 23 with a right lateral pathway, three procedures using standard radiofrequency ablation technique failed (low energy direct current was used in the third session and also failed) before surgical dissection was undertaken. The accessory pathway was mapped to the right lateral position, and the delta wave disappeared with surgical dissection in the epicardial area overlying the catheter ablation scar.

Successful ablation achieved by low energy direct current or bipolar technique (table 3)
In patients 1, 6, 13–15, 18–20, and 22 the factors associated with primary failure were unclear. Repeat standard radiofrequency ablation was attempted in all these patients but failed. In patients 1 and 6 radiofrequency current delivered subsequently in a bipolar fashion across the septum succeeded. In patients 13–15, 18–20, and 22 low energy direct current was employed and succeeded in all

Table 3 Reasons for primary failure

Pts	Age/sex	Px	Location	PT	ST	Sites	UCP	Negative in II	Best EGM in CS	Other	2nd Ablation	Success
1	14M	No	LPS	180	67	13				MD	Bipolar‡	Yes
2	34M	Yes	MS	245	88	23	Yes				No#	
3	35F	Inter	MS	290	96	50		Yes	Yes		Unipolar	No, AVN
4	71M	Inter	MS	360	135	21		Yes	Yes		Unipolar	No, AVN
5	42M	Yes	LFW	180	56	22	Yes				Transseptal	Yes
6	24F	Yes	MS	280	141	17					Bipolar	Yes
7	42F	Inter	RPS	180	52	16	Yes				Unipolar	Yes
8	48M	Yes	LFW	230	89	22	Yes				Unipolar	Yes
9	23M	Yes	RFW	270	105	47				Back pain	Unipolar	Yes
10	13F	Yes	RAS	335	172	49	Yes				No	
11	68F	No	MS	240	100	6	Yes				Unipolar	Yes
12	41M	Yes	MS	200	125	14		Yes^	Yes		Low energy	Yes
13	30F	Yes	RAS	190	83	29					Low energy	Yes
14	19M	Yes	RFW	225	91	31				MD	Low energy†	Yes
15	23M	Yes	LFW	230	86	23					Low energy	Yes
16	42M	Yes	LFW	190	61	21					Late block§	
17	51F	No	LFW	150	65	10	Yes				Unipolar	Yes
18	33M	Yes	RPS	165	124	32					Low energy	Yes
19	33M	Inter	LFW	103	31	9					Low energy	Yes
20	40F	Yes	RPS	210	72	33					Low energy	Yes
21	39M	Inter	LFW	90	10	2				RAF	Unipolar	Yes
22	41M	Yes	LFW	160	48	18					Low energy	Yes
23	29F	No	RFW	230	103	39					Surgical	Yes
24	28M	No	LFW	180	23	9			Yes		No	
25	25M	Yes	MS	195	60	20		Yes^	Yes		Low energy	Yes

Ab, ablation; AP, accessory pathway; AVN, successful radiofrequency ablation of atrioventricular node; Best EGM in CS, best endocardial electrogram obtained within coronary sinus; F, female; Inter, intermittent pre-excitation; LFW, left free wall; LPS, left posteroseptal; M, male; MD, misdiagnosis of accessory pathway location; MS, mid-septal; Negative in II, strikingly negative delta wave in lead II; PT, procedure time; Pts, patients; Px, pre-excitation; RAF, recurrent atrial fibrillation during procedure; RAS, right anteroseptal; RFW, right free wall; RPS, right posteroseptal; Sites, number of sites at which energy was delivered; ST, screening time; UCP, unstable catheter position.
‡Right posteroseptal location diagnosed in the first procedure, actual location (right free wall) identified in repeat successful procedure in which conventional unipolar radiofrequency current was attempted prior to low energy ablation.
#Midseptal location diagnosed in first procedure, left posteroseptal position identified in repeat successful procedure in which conventional unipolar radiofrequency ablation was attempted prior to successful ablation using bipolar technique.
§Late permanent block following first radiofrequency ablation.
^Manipulation of the catheter across the aortic valve and within the left ventricle was extremely difficult due to tortuosity of the iliac vessels.
^Coronary sinus angiography revealed a large middle cardiac vein.

Table 4 Final success with low energy direct current shock or bipolar radiofrequency technique

	Initial RF	Sites	Transient block	Same site	Initial shock (joules)	Total energy (joules)	Prior RF	Low energy success
12	Yes	6	No	Yes	5	92	3	Yes
13	Yes	29	4	No	20	310	1	Yes
14	Yes	18	1	Yes	10	190	2	Yes
15	Yes	23	6	Yes	5	85	1	Yes
18	Yes	7	2	Yes	5	115	1	Yes
19	Yes	9	4	Yes	5	90	1	Yes
20	Yes	17	No	Yes	2	132	1	Yes
22	Yes	18	1	Yes	2	172	1	Yes
25	Yes	6	No	No	20	222	2	Yes
	Initial RF	Site	Transient block					Bipolar success
1	Yes	17	No	Yes				Yes
6	Yes	1	No	Yes			2	Yes

Initial RF, standard radiofrequency ablation was attempted before low energy direct current or bipolar radiofrequency technique; Initial shock, magnitude of low energy direct current shock causing interruption of accessory pathway conduction; Prior RF, number of failed radio frequency ablation sessions before the successful session; Same site, successful low energy ablation at site where radiofrequency ablation failed; Sites, number of radiofrequency current delivery sites; Transient block, number of episodes of transient block of accessory pathway conduction during radiofrequency ablation.

patients. In patients 14, 15, 18–20, and 22 low energy direct current was successful in abolishing accessory pathway conduction when delivered at the same site where standard unipolar radiofrequency current had failed (table 4).

Other factors (table 3)

In patients 1 and 14 misdiagnosis of accessory pathway location occurred during the first procedure. In patient 21, recurrent atrial fibrillation together with intermittent anterograde conduction in the accessory pathway during the procedure contributed to failure. In patient 9 the procedure failed because of patient discomfort (back pain) precluding continuation under local anaesthesia. In patient 16, late block of accessory pathway conduction was observed.

The median procedure and fluoroscopic times were longer (180 *v* 80 minutes, *P* < 0.05; 65 *v* 21 minutes, *P* < 0.05) and the number of radiofrequency ablation sites was greater (18 *v* 5, *P* < 0.05) in the failed group compared with the successful group.

SUMMARY

In summary, repeat catheter ablation was performed in 20 patients and succeeded in 18. Standard radiofrequency ablation technique was initially used in all patients in the repeat procedure, two patients subsequently underwent successful bipolar radiofrequency ablation, and nine patients underwent low energy direct current ablation (table 4). After a mean follow up period of 14 (11) months (range 3 to 34) there was no recurrence. No difference in QRS-V interval (−5.6 (5) *v* −5.7 (7.9) ms) and AV interval (30 (10) *v* 34 (9) ms) was observed between patients during the initial failure and the repeat successful procedure. In the two patients with concealed accessory pathways in whom a repeat procedure succeeded after primary failure, the VA interval recorded on the ablating catheter was shorter on the second occasion (30 and 40 ms *v* 45 and 50 ms, respectively).

RECURRENCE OF ACCESSORY PATHWAY CONDUCTION

The time from onset of radiofrequency current to block of accessory pathway conduction was

≥ 12 seconds (12, 14.5, 27, 86) in four of 13 patients with recurrence compared to eight of 205 patients without recurrence (*P* = 0.0005). In one of the four, temperature monitoring was used during delivery and the desired temperature could not be constantly achieved despite maximum power output (50 W).

Recurrence of accessory pathway conduction occurred in five of eight patients with poor ablation electrogram stability (atrial stability ≤ 0.5, ventricular stability ≤ 0.8) compared to eight of 210 patients with stable ablating electrograms (*P* = 0.001).

Multivariate stepwise logistic regression showed that prolonged time to block (*P* = 0.003) and stability of the local atrial electrogram ≤ 0.5 together with stability of the local ventricular electrogram ≤ 0.8 (*P* = 0.002) were independent predictors of recurrence.

The median procedure and fluoroscopic times were longer (162 *v* 80 minutes (*P* < 0.05) and 47 *v* 21 minutes (*P* < 0.05)) and the number of radiofrequency ablation sites was greater (18 *v* 5 (*P* < 0.05)) in the group with recurrent conduction than in that without.

No differences were observed in the presence of transient block of accessory pathway conduction before interruption of accessory pathway conduction (4/48 *v* 8/170 (*P* = 0.54)), presence of a possible accessory pathway potential (5/13 *v* 55/205 (*P* > 0.05)), QRS-V interval (−11.6 (13.8) *v* −9.5 (12.3) ms (*P* > 0.05)), AV interval (34 (18) *v* 31 (12) ms (*P* > 0.05)), between recurrence and non-recurrence groups.

Repeat ablation was performed in 11 patients (and scheduled in the remaining two) and succeeded in 10. Standard radiofrequency ablation technique was initially employed during the repeat procedure in all patients and succeeded in seven. In the remaining three patients, low energy direct current ablation (two patients) and bipolar ablation (one patient) succeeded at the same site where standard unipolar radiofrequency energy initially failed. There was no further recurrence after mean follow up 12 (11) months (range 2 to 25). No differences in QRS-V interval (−11 (13.6) *v* −11 (8.6) ms (*P* > 0.05)), AV interval (41 (23) *v* 37 (19) ms (*P* > 0.05)), the presence of a possible accessory pathway potential

(3/12 *v* 2/11 ($P > 0.05$)), and the power of the radiofrequency application for ablation (32 (10) *v* 33 (9) W ($P > 0.05$) were observed between the two procedures, with the exception of time to block, which was longer in the initial procedure (4.5 (4.6) *v* 2.4 (1.4) ($P < 0.01$); the patient with the longest time to block (86 seconds) was not included in the statistical analysis).

Discussion

FAILURE OF INTERRUPTION OF ACCESSORY PATHWAY CONDUCTION

Failure to abolish accessory pathway conduction in a single procedure occurred in 10% of patients. In seven of the 25 patients an unstable catheter position was identified as the main reason for primary failure of accessory pathway ablation. This may have been due to individual anatomical variation, catheter design, mode of approach to the atrioventricular valve annulus, rhythm during energy application, the use or not of a supporting long sheath, or as yet unidentified factors. However, in these patients, a repeat radiofrequency ablation procedure often led to successful interruption of accessory pathway conduction.

In five patients the best endocardial electrogram was recorded from within the coronary sinus and in four patients the delta wave in lead II was strikingly negative. Arruda *et al*⁵ studied 255 patients (135 retrospectively and 120 prospectively) undergoing radiofrequency ablation of accessory pathways and showed that posteroseptal accessory pathways in an epicardial location or with venous anomalies can be identified by a strikingly negative delta wave in lead II (false positive rate $< 1\%$). In those patients, radiofrequency energy applied at usual posteroseptal ablation sites was unsuccessful. In the present study, one or more standard radiofrequency ablation sessions were performed in four patients and failed in all (in two, coronary sinus angiography showed a large middle cardiac vein, and low energy direct current delivered in the coronary sinus led to success). This result, together with the surface ECG and endocardial electrogram features, favours an epicardial pathway. In one patient (in whom three radiofrequency ablation sessions failed and in whom low energy direct current in the final procedure also failed) this was proven when an epicardial pathway was confirmed at surgical dissection.

In nine patients repeat standard radiofrequency ablation was attempted but failed. In two of these, radiofrequency current delivered in bipolar fashion across the septum was subsequently successful. In another seven patients, low energy direct current was employed and succeeded in all, four of whom had successful low energy direct current deliveries at the same site where radiofrequency energy failed. The reason why standard unipolar radiofrequency ablation failed and bipolar radiofrequency delivery or low energy direct current succeeded at the same site in some patients is unclear. Previous studies have

shown that the lesion produced by low energy direct current and bipolar radiofrequency energy is larger than that by standard unipolar radiofrequency energy.⁶⁻⁹ In these cases we concluded that the catheter could not be placed close enough to the accessory pathway or that anatomical variation of the accessory pathway may have played a role. The small lesions created by standard radiofrequency current could not penetrate to the pathway, or caused only transient or partial block. Low energy direct current shocks or bipolar radiofrequency energy delivery may, by creating a larger and deeper lesion, permit a successful outcome in these cases.

The accessory pathway location was incorrectly identified in two patients. Following improvements in mapping technique this is not a common reason for failure. Recurrent atrial fibrillation in conjunction with intermittent anterograde conduction through the accessory pathway may occasionally make ablation difficult.

RECURRENCE OF ACCESSORY PATHWAY CONDUCTION

Recurrence of accessory pathway conduction occurred in 6% of patients. Langberg *et al*¹⁰ reported a 12% recurrence rate in their series and Twidale *et al*¹¹ reported 8%. Independent factors which predicted recurrence in our series included poor ablating electrogram stability and prolonged time to block ≥ 12 seconds). It has previously been reported that time to block is longer in accessory pathways which later show recurrence of conduction, suggesting either electrode-tissue contact or lack of proximity of the ablating electrode to the pathway.¹¹ Either temperature monitoring or continuous impedance monitoring may provide important verification of tissue-electrode contact, and previous studies have suggested that catheter tip temperature monitoring may be useful for detecting poor electrode-tissue contact.^{12,13} The principal mechanism of radiofrequency induced myocardial injury is presumed to be thermal, with cell injury and death reproducibly occurring once the temperature reaches 50°C. The lesion size is proportional to the temperature at the electrode-tissue interface. If power is applied and little or no heating is observed, poor electrode-tissue contact is suggested. In one of our patients with prolonged time to block of accessory pathway conduction, temperature monitoring showed the target temperature could not be achieved despite maximum power output (50 W).

LOCATION OF ACCESSORY PATHWAYS

Failure to ablate and recurrent conduction occurred more frequently in right sided accessory pathways, consistent with previous studies.^{2,10,11}

LOCAL ENDOCARDIAL ELECTROGRAM

There were no differences in QRS-V interval, AV interval, VA interval, and the presence of a possible accessory pathway potential between the initial procedure and the repeat successful

procedure in patients with primary failure. In patients with recurrence, the time to block was longer in the initial procedure, as in previous reports. An earlier study also suggests that the absence of accessory pathway potential is a strong predictor for recurrence of accessory pathway conduction.¹¹ In our series, as is common practice in most centres, possible accessory pathway potentials were noted but no attempt was made at verification.

CONCLUSIONS

Failure of ablation and recurrence of accessory pathway conduction were more frequent in patients with right sided accessory pathways. Catheter instability and possible epicardial location were identified as the major reasons for primary failure. Where catheter instability is identified then there is a good chance of success with a further attempt, but pathways situated deep within the myocardium may well require an alternative method of energy delivery, in particular the use of bipolar radiofrequency energy delivery or low energy dc shocks should be considered.

Where recurrence of accessory pathway conduction occurs after initially successful ablation, catheter instability or prolonged time to conduction block during energy delivery were identified as the likely cause. This, once again, emphasises the need for stable catheter contact and precise mapping to position the ablation electrode as close as possible to the substrate for ablation.

- 1 Jackman WM, Wang X, Friday KJ, Roman CA, Moulton KP, Beckman KJ, *et al.* Catheter ablation of accessory atrioventricular pathways (Wolff-Parkinson-White syn-

- drome) by radiofrequency current. *N Engl J Med* 1991; 324:1605-11
- 2 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.
- 3 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.
- 4 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.
- 5 Arruda MS, Wang X, McClelland JH, Beckman KJ, Nakagawa H, Widman LE, *et al.* Negative delta wave in lead II identifies posteroseptal accessory pathways requiring ablation in venous branches of the coronary sinus [abstract]. *J Am Coll Cardiol* 1994;73:224A.
- 6 Katritsis D, Heald S, Bashir Y, Ward DE, Rowland E. Low energy ablation of accessory pathways in cases for which the radiofrequency approach had failed. *Am J Cardiol* 1993;72:1211-12
- 7 Lemery R, Talajic M, Roy D, Fournier A, Coutu B, Hiji T, *et al.* Catheter ablation using radiofrequency or low energy direct current in paediatric patients with the Wolff-Parkinson-White syndrome. *Am J Cardiol* 1994;73:191-4.
- 8 Jackman WM, Kuck KH, Naccarelli GV, Carmen L, Pitha J. Radiofrequency current directed across the mitral annulus with a bipolar epicardial-endocardial catheter electrode configuration in dogs. *Circulation* 1988;78:1288-98.
- 9 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;22:550-6.
- 10 Langberg JJ, Calkins 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.
- 11 Twidale N, Wang X, Beckman KJ, McClelland JH, Moulton KP, Prior MI, *et al.* Factors associated with recurrence of accessory pathway conduction after radiofrequency catheter ablation. *PACE* 1991;14:2042-8.
- 12 Haines DE. The biophysics of radiofrequency catheter ablation in the heart: the importance of temperature monitoring. *PACE* 1993;16:586-91.
- 13 Avital B, Khan M, Krum D, Hare J, Lessila C, Dhala A, *et al.* Physics and engineering of transcatheter cardiac tissue ablation. *J Am Coll Cardiol* 1993;22:921-32.