Preexcitation syndromes: surgical ablation therapy

The Cleveland Clinic experience

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■ Thirty-four patients with preexcitation syndrome had surgical ablation of the accessory atrioventricular connection. All presented with sustained symptomatic arrhythmias, which had resulted in syncope in seven patients and aborted sudden cardiac death in four. Arrhythmias induced at electrophysiologic evaluation included orthodromic reciprocating tachycardia in 32 patients, antidromic reciprocating tachycardia in five patients, and atrial fibrillation in 29 patients. A single accessory atrioventricular connection was located in 32 patients and two patients had multiple accessory connections. The accessory connection was located with intraoperative mapping in all patients and the pathway was successfully ablated in 32. Eleven patients underwent a transmural approach and 23 patients underwent an epicardial dissection. Cryotherapy was used in 22 patients. After a mean follow-up of 32 months, 28 patients were free from all arrhythmias without drug therapy. Six patients continued to have symptomatic arrhythmias but only one case was suspected to be secondary to unsuccessful ablation of the accessory connection. One patient with heart block induced at the surgical procedure is dependent upon a pacemaker.

□ INDEX TERMS: ARRHYTHMIA; SURGERY, CARDIOVASCULAR; TACHYCARDIA, PAROXYSMAL □ CLEVE CLIN J MED 1989; 56:607–613

THE PREEXCITATION syndrome describes patients with paroxysmal tachycardias and ventricular preexcitation (Wolff-Parkinson-White syndrome) or atrial preexcitation (concealed bypass tract).[1] Since the original description in 1930[2] and elucidation of the mechanism of the arrhythmias (accessory atrioventricular pathways capable of unidirectional or bidirectional conduction of electrical impulses)[3] a large database of information has accumulated. The incidence of ventricular preexcitation in the general population is about 0.16%[4]; symptomatic arrhythmias develop in about 12% of these cases, with onset at various ages. Unfortunately the first arrhythmia to develop in these patients may be atrial fibrillation with conduction over the atrioventricular pathway, which may result in a rapid ventricular response that may precipitate ventricular fibrillation and cause sudden death; however this occurrence is uncommon and difficult to predict.[5] The incidence of concealed bypass tract is unknown, but it has been determined to be the mechanism for supraventricular tachycardias in approximately 13% of adult patients with normal resting electrocardiograms (ECGs) undergoing electrophysiologic assessment for this condition.[6]

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TABLE 1
PATIENT CLINICAL CHARACTERISTICS

Patient No.	Sex	Age	No. syncopal episodes	Sudden cardiac death*	AF/RR (ms)	SVT/RR (ms)	Arrhythmia episodes/yr	Other cardiac disease	Medications
1	M	21	–	–	–	300	3	–	B, D, Q
2	F	49	–	+ (VF)	200	–	3	–	B, C, D, Q
3	M	51	–	+ (LVF)	214	–	1	–	A, B, P, Q
4	M	68	1	–	240	320	3	CAD	B, D, DI, P
5	M	18	–	–	180	–	2	–	B, C, D, P
6	M	18	–	–	230	–	2	–	B, P, Q
7	M	25	1	–	180	–	1	–	P
8	M	17	–	+ (VF)	190	–	1	–	C, Q
9	M	17	–	–	–	300	3	–	DI, Q
10	M	35	–	–	200	–	1	–	B,C
11	M	19	–	–	200	–	4	–	–
12	F	20	5	–	–	320	1	–	C, P, L
13	M	14	–	–	–	280	6	–	B, C
14	M	14	–	–	–	320	1	–	C, Q
15	F	18	–	–	–	360	2	–	B, C, D, P, Q
16	F	16	–	–	–	320	7	–	D, P, Q
17	F	18	–	–	200	–	2	–	C, D
18	F	21	1	+ (VF)	200	–	3	–	B, Q
19	M	25	–	–	230	–	3	–	A, B, Q
20	F	41	1	–	230	–	1	MVP	DI
21	F	21	30	–	–	300	12	–	–
22	M	29	–	–	140	–	1	MVP	D, P
23	F	25	–	–	–	300	3	–	D, Q, T
24	M	18	–	–	240	–	3	EB	F, P
25	M	17	–	–	–	230	3	MVP	B, C
26	M	20	–	–	–	280	6	–	DI
27	M	17	–	–	–	260	50	–	B, C, P, Q
28	M	19	–	–	–	280	1	–	C, D, P
29	F	53	–	–	–	340	1	–	B, C, F
30	M	17	–	–	–	310	3	–	C, D, F, Q
31	M	52	–	–	240	–	CH	CAD, MS	A, B, DI, F
32	M	19	–	–	180	–	3	–	F, P
33	M	18	–	–	–	320	4	–	B
34	F	44	1	–	300	–	3	–	F, B

A = amiodarone; *AF/RR* = shortest RR intervals during spontaneous atrial fibrillation; *B* = beta blocker; *C* = calcium channel blocker; *CAD* = coronary artery disease; *CH* = chronic; *D* = digoxin; *DI* = disopyramide; *EB* = Ebstein's anomaly; *F* = flecainide; *LVF* = left ventricular failure; *MS* = mitral stenosis; *MVP* = mitral valve prolapse; *P* = procainamide; *Q* = quinidine; *SVT/RR* = shortest RR interval during supraventricular tachycardia; *VF* = ventricular fibrillation.
* Instantaneous death requiring CPR and external defibrillation

The clinical arrhythmias most frequently encountered in patients with preexcitation syndrome, in decreasing order of frequency, are: orthodromic reentry tachycardia, atrial fibrillation, antidromic reentry tachycardia, and ventricular fibrillation.[5] Therapy has been directed at slowing conduction either over the atrioventricular pathways or over the atrioventricular node to prevent and/or terminate arrhythmias. In the past 20 years surgical procedures have evolved that interrupt a limb of the reentry circuit, allowing complete cure of this affliction at low patient risk; this is now the therapy of choice for patients with drug-refractory arrhythmias and those deemed to be at risk of sudden cardiac death.[7–11]

This report relates our experience with 34 consecutive patients and compares the outcome in patients treated with an epicardial *v* a transmural ablative approach.

METHODS

Patients

From January 1982 through January 1988, 220 patients with preexcitation syndrome were evaluated by the cardiac electrophysiology service at our institution; in that time 34 (14%) underwent surgical ablation of their atrioventricular pathways. These 34 patients form the basis of this report. Patient demographic and clinical arrhythmia characteristics are outlined in *Table 1*.

The patients were referred because of symptomatic drug-refractory arrhythmias (33 patients) and chest pain

(one patient). Studies done at clinical presentation included history, physical examination, biochemical analysis, hematologic profile, ECG, Holter monitor (24 hr), and exercise ECG.

Thirty patients were offered surgery because of drug-refractory arrhythmias that were due to atrioventricular pathways. Two patients with clinical arrhythmias that induced syncope and with rapid conduction during induced atrial fibrillation opted for surgery initially in preference to drug therapy. Three patients with symptomatic arrhythmias but whose primary indication for heart surgery was the insertion of coronary artery bypass grafts were also offered atrioventricular pathway ablative surgery.

Electrophysiologic testing

After each patient gave informed consent, cardiac electrophysiologic studies were performed in the postabsorptive state, when all cardioactive drugs had been discontinued for at least 24 hours. Using intravenous diazepam and Nubain (nalbuphine hydrochloride) sedation along with local anesthesia, multiple-electrode catheters with 1-cm interelectrode distance were advanced to the right atrium, right ventricle, His bundle, and coronary sinus using the femoral and/or left subclavian vein approach; they were positioned using fluoroscopic guidance. Programmed stimulation was performed using the Medtronic stimulator (Medtronic, Model No. 5328, Medtronic Inc., Minneapolis, MN) at a pulse of 2 ms and a current strength of 2 mA. Atrial, atrioventricular nodal, His bundle, ventricular, and atrioventricular pathway refractory periods were determined at pacing cycle lengths of 600 ms and 400 ms, with 8-beat overdrive pacing trains and an extra stimulus decreasing by 20 ms until threshold was reached. Pacing sites were the high right atrium, right ventricular apex, and an atrial site as close as possible to the atrioventricular pathway. Standard definitions for the refractory period determinations were used[12] and those reported are the results obtained at a drive cycle and site that yielded the shortest refractory periods.

Right (bipolar preshaped mapping catheter[13]) and left (quadripolar USCI catheter) atrial mapping were performed during orthodromic reentry tachycardia and while pacing from the right ventricular apex. Atrial fibrillation was then induced and the shortest and average RR intervals between preexcited beats were assessed.

Ablative surgery

The midsternotomy approach was used for all patients; after establishing cardiopulmonary bypass, right and left atrial and ventricular bipolar epimyocardial electrodes were placed and electrophysiologic mapping was performed while the patient was normothermic. Mapping was performed using a bipolar (5-mm) finger probe to assess conduction along the right-left atrioventricular groove on the ventricular epicardial aspect during atrial pacing, and on the atrial epicardial surface during ventricular pacing and orthodromic reentry tachycardia. In the four patients with septal atrioventricular pathways the right atrium was opened and endocardial mapping was also performed.

Transmural dissection was the initial approach for the first 11 patients. This involved establishing cardioplegic arrest, then dissecting away the fat pad and its blood vessels from the atrioventricular groove on the ventricular side at the atrioventricular pathway. When the atrioventricular fibrous ring was in evidence, the atrial muscle wall was incised to disconnect it from the atrioventricular fibrous ring for about 2–3 cm on either side of the atrioventricular pathway insertion site. In the next 23 patients epicardial dissection was the initial procedure, performed with cardiopulmonary bypass (two patients having concomitant heart surgery) or on the normothermic, beating heart (21 patients). Dissection was performed on the ventricular aspect of the atrioventricular groove, freeing the fat pad with its blood vessels to expose the atrioventricular ring. Dissection was continued until loss of conduction over the atrioventricular pathway, then a 1-cm-diameter cryoprobe at −60°C was applied for 2 min (Frigitronics CCS 100, Model 3000-1, Frigitronics, Shelton, CT). Atrioventricular pathway conduction was assessed in all patients just before they were removed from cardiopulmonary bypass. The epicardial wires were left in situ for programmed electrical stimulation, which was performed approximately 5 days after ablative surgery.

Six weeks following surgery the patients were reviewed in the arrhythmia clinic for physical examination and ECG; they were then interviewed by telephone at 12-month intervals thereafter.

Statistical analysis

Values are reported as mean ± one standard deviation. For comparisons between groups, Student's t-test, Fisher's exact test, and the chi-square test were used as appropriate. A P value of $<.05$ was considered significant.

RESULTS

The clinical arrhythmia in 18 patients was due to

atrial fibrillation, whose mean shortest RR interval between preexcited beats was 210 ±35 ms versus 221 ±34 ms for those with induced atrial fibrillation at electrophysiologic study ($P = .3$). The shortest RR intervals between preexcited beats did not differ significantly between the patients who presented with atrial fibrillation plus sudden cardiac death and those who presented with atrial fibrillation only (201 ±10 ms *v* 215 ±39 ms respectively, $P = .5$).

The anterograde and retrograde effective refractory periods of the atrioventricular pathways did not differ significantly (250 ±39 ms *v* 270 ±40 ms, $P = .6$). All patients with anterograde conduction had retrograde conduction. Eighteen patients presented with orthodromic reciprocating tachycardia; the cycle length (305 ±30 ms) was not significantly different from that induced at electrophysiologic evaluation (313 ±35 ms, $P = .3$).

Thirty-six accessory pathways were identified in the 34 patients who underwent surgery. Left free wall pathways were the most common (44%), then posteroseptal (33%), right free wall (19%), and right anteroseptal (3%).

Thirty-two of 34 patients (94%) had successful ablation of their accessory pathways, and after a mean of 32 ±20 months following surgery, 28 patients were free of arrhythmia and not taking antiarrhythmic drugs.

At surgery 35 of the 36 atrioventricular pathways located had been accurately predicted by the preoperative electrophysiologic study. One patient with two atrioventricular pathways, in the left free wall and posteroseptal locations, had been thought to have only a left free wall atrioventricular pathway at electrophysiologic study and at initial surgery, but had new preexcitation and needed reoperation for his posteroseptal atrioventricular pathway.

The delta-wave (initial 40 ms) polarity[5] on the surface 12-lead ECG reasonably predicted the location of the atrioventricular pathway in 23 of 27 patients (85%) with anterograde conduction over a single atrioventricular pathway. In patients with multiple atrioventricular pathways that conducted anterogradely, the delta-wave polarity was consistent with only the septal preexcitation pattern and not with that of the right (one patient) or left (one patient) free wall (*Table 2*).

The epicardial ablative approach was as effective as the transmural approach for both free wall and posterior septal pathways. Also, in comparing both approaches, the total operative time, cardiopulmonary bypass time, and recurrence of preexcitation were not significantly different. The perioperative complication rate also was not significantly different between the approaches used.

COMPLICATIONS

There were no operative deaths. One patient with coronary artery disease and ventricular tachycardia died suddenly 4.5 years after surgery for preexcitation. He had undergone regular review in the arrhythmia clinic and his ECG did not show preexcitation subsequent to his surgery. He was receiving amiodarone therapy at the time of his death and he refused electrophysiologic evaluation for possible implantation of a defibrillator. Six patients required reoperation, four because of recurrence of conduction over the atrioventricular pathway (two patients required two reoperations), which became manifest on the first postoperative day in all instances. Free wall atrioventricular pathways were present in two patients and posterior septal pathways in two. In addition, the epicardial approach was used as the initial surgical procedure in three patients, and the transmural approach in one. One of the patients who required two reoperations had an unsuspected atrioventricular pathway (posteroseptal) in addition to recurrence of conduction over a previously treated atrioventricular pathway (left free wall). One patient needed reoperation because of bleeding.

One patient with an anterior septal pathway developed heart block secondary to the close proximity of the His bundle to the atrioventricular pathway and is now dependent upon a pacemaker. Six patients (18%) continue to have symptomatic arrhythmias (premature ventricular contractions in one, atrioventricular node reentry in one, atrioventricular pathway in two, atrial fibrillation in one, undocumented short episodes in one) and all require antiarrhythmic medication. Two patients had late pericardial effusions due to the postpericardiotomy syndrome.

DISCUSSION

The preexcitation syndrome is uncommon; about 12% of patients with the syndrome will develop symptomatic arrhythmias that may begin at any age.[4] Onset of symptomatic arrhythmias in infancy (<1 yr) is frequently associated with spontaneous resolution of symptoms as the child ages, but conduction over the atrioventricular pathway remains unchanged.[14] With onset in adults, symptoms usually persist and recur despite antiarrhythmic drug therapy.[15]

Patients with the preexcitation syndrome are at risk of sudden cardiac death due to atrial fibrillation with a

TABLE 2
MAPPING AND INDUCED ARRHYTHMIA CHARACTERISTICS

Patient No.	AP MAP	ECG MAP	AG	Anterograde ERP (ms)	Retrograde ERP (ms)	AF/RR (ms)	ORT/RR (ms)	ART/RR (ms)
1	LFW/CBT	–	–	–	280	–	300	–
2	RFW	2	+	<230	<280	215	–	–
3	PS	6	+	<240	<250	215	300	–
4	PS	6	+	300	<280	200	–	–
5	PS	5	+	0	0	200	330	–
6	LFW	9	+	320	0	240	340	–
7	PS	5	+	<260	<250	250	340	–
8	LFW	9	+	190	0	190	310	–
9	PS	5	+	240	0	240	300	–
10	LFW	10	+	<230	<260	180	330	–
11	PS	7	–	270	<280	170	360	–
12	LFW/CBT	–	–	–	<240	–	275	–
13	LFW	9	+	<260	0	180	300	–
14	LFW/(PS)	6	–/+	<220	0	185	340	–
15	LFW/CBT	–	–	–	<280	–	300	–
16	LFW/CBT	–	–	–	<260	–	360	–
17	AS	1	+	<260	0	280	280	–
18	LFW	–	–	240	260	200	200	300
19	RFW	2	+	220	190	195	310	–
20	RFW/PS	6	–/+	<200	<220	210	300	–
21	PS	2	–	<260	<260	180	280	–
22	LFW	9	+	<250	220	280	290	300
23	LFW	10	+	280	280	270	280	–
24	PS	6	+	240	0	230	340	350
25	LFW	10	+	240	240	220	300	–
26	RFW	2	+	320	300	260	280	–
27	LFW	9	+	<220	0	240	360	330
28	RFW	4	+	320	280	240	290	–
29	LFW/CBT	–	–	–	330	–	320	–
30	LFW	9	+	240	260	230	320	–
31	PS	6	+	240	300	240	–	–
32	RFW	4	+	<250	<250	180	350	280
33	PS	5	+	260	250	250	360	–
34	RFW	5	–	300	340	190	380	–

AF/RR = shortest preexcited RR interval (ms) during induced atrial fibrillation; *AG* = agreement between delta wave MAP and bypass tract location noted at surgery; *AP MAP* = location of accessory pathway noted at electrophysiology study and during surgery; *ART/RR* = antidromic tachycardia cycle length (ms); *AS* = anteroseptal; *ECG MAP* = location of bypass tracts based on delta wave polarity (ref: 5); *ERP* = effective refractory period; *LFW* = left free wall; *0* = no data; *ORT/RR* = orthodromic tachycardia cycle length (ms); *PS* = posteroseptal; *(PS)* = accessory pathway not identified at electrophysiology study; *RFW* = right free wall.

rapid ventricular response, which induces pulmonary edema or degenerates to ventricular fibrillation. The incidence of aborted sudden cardiac death in this series, 11.4%, corresponds to the incidence reported in other surgical series, which ranges from 0.6% to 15%.[7,9] The incidence of sudden cardiac death in the total population of patients with the Wolff-Parkinson-White syndrome is unknown, although available evidence indicates that it is low.[16] Determining which patients with the Wolff-Parkinson-White syndrome are at risk of sudden death remains a challenge. Parameters found in patients with a history of ventricular fibrillation that are thought to be helpful in distinguishing those at increased risk are a high incidence of reentry tachycardias and atrial fibrillation, multiple atrioventricular pathways, and short RR interval between preexcited beats during induced atrial fibrillation (<250 ms); however, a significant degree of overlap occurs between patients with and without a history of ventricular fibrillation.[17] Others have used noninvasive tests (exercise testing alone or with procainamide or disopyramide infusions) to help determine which patients have slow conduction over their atrioventricular pathways. Slow conduction indicates low risk; this test has good sensitivity but poor positive predictive accuracy.[18,19] We believe that patients with symptomatic supraventricular tachycardia and rapid conduction over the atrioventricular pathway during induced atrial fibrillation (shortest RR < 250 ms)

should be offered curative surgery. Ventricular fibrillation may be due to other mechanisms unrelated to the atrioventricular pathway, and these should be excluded.

Paroxysmal supraventricular tachycardia in the preexcitation syndrome most frequently results from reciprocating tachycardia utilizing the atrioventricular node and His bundle in the anterograde direction and the accessory pathway in the retrograde direction (orthodromic reentry tachycardia). Therapy in this instance is directed at slowing conduction in the atrioventricular node or over the atrioventricular pathway; either limb of the circuit may be ablated to abolish the rhythm disturbance.

Paroxysmal supraventricular tachycardia may be disabling but is usually not life-threatening. Thus antiarrhythmic drug therapy is usually the initial approach. Should drug therapy fail or the patient prefer, curative surgery should be offered; however one should be fully cognizant of the local expertise, success, and complications.

The mechanism of atrial fibrillation in the preexcitation syndromes is of interest but is not fully understood. Fibrillation has been shown to result from the degeneration of orthodromic reentry tachycardia and antidromic reentry tachycardia,[20] but it may arise spontaneously; a postulated mechanism is localized reentry within the atrioventricular pathway,[21] which may make the atria vulnerable to atrial fibrillation. Thus, surgical interruption of the atrioventricular pathway should abolish this rhythm. In one patient in this series with mitral stenosis and a large left atrium, the atrial fibrillation persisted. Otherwise atrial fibrillation has not recurred in any of our patients who had successful atrioventricular pathway ablation surgery. This is in agreement with previous reports.[22]

The majority of patients with ventricular preexcitation are asymptomatic, and management of their condition represents a current dilemma. We believe that the correct management will not be known until results are obtained from natural history studies to determine the risk of sudden cardiac death; then curative surgery can be offered if its risk is substantially less. Special consideration should be given to patients who engage in competitive athletics or in high-risk professions.[23]

Surgical success in our series was 94% (34 of 36 atrioventricular pathway ablations). Success rates for patients treated with epicardial dissection were similar to those for patients undergoing the transmural approach. The epicardial approach, which was pioneered by Guiraudon et al,[11] allows dissection to be performed on the normothermic beating heart and thus permits intermittent mapping if required and is free of the risks of cardioplegia.

All our patients were given cardiopulmonary bypass; however, the epicardial approach can be used without bypass support. The recurrence rate (11%) of preexcitation in this series is similar to that reported by Gallagher et al[7] (13%); however, with repeat operation, success was achieved in 94%.

There was no operative mortality, but surgical morbidity included reoperation in six patients, pericarditis in two patients, postpericardiotomy syndrome in two patients, and sternal wire pain requiring reoperation to remove wires in one patient.

CONCLUSIONS

1. Surgical ablation therapy is curative for patients with arrhythmias due to the preexcitation syndrome.
2. Epicardial dissection is as effective as transmural dissection.
3. In our experience epicardial and transmural dissection offered effective ablation.

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