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Prevention of Recurrent Sudden Cardiac Arrest: Role of Provocative Electropharmacologic Testing

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This study evaluates the usefulness of serial provocative electropharmacologic testing for predicting the efficacy of prophylactic antiarrhythmic treatment regimens in patients resuscitated from sudden cardiac arrest in the absence of acute myocardial infarction. Testing was carried out in 34 consecutive patients (28 men and 6 women) who required cardiopulmonary resuscitation and direct current countershock for treatment of primary ventricular fibrillation (28 patients), ventricular tachycardia (5 patients) or excessively rapid heart rate during atrial fibrillation with preexcitation (1 patient).

In 8 (24%) of the 34 patients, drug testing either was not feasible because of absence of inducible arrhythmia or was incomplete because of patient withdrawal from study; and 3 of these 8 patients had recurrent sudden cardiac arrest within 10 to 19 months. In an additional five patients, treatment regimens failed to prevent initiation of sustained ventricular tachyarrhythmias in the catheterization laboratory, and two of these five patients had cardiac arrest recurrences within 2 weeks to 25 months of follow-up. In the remaining 21 (62%) of the 34 patients, including 3 patients with preexcitation syndrome, a drug regimen or surgical treatment, or both, was found that prevented inducible life-threatening tachyarrhythmias in the laboratory. Subsequently, only 1 (5%) of these 21 patients died suddenly within a 7 to 38 month (mean ± standard deviation, 18 ± 8.3) follow-up period. Thus, provocative electropharmacologic testing appears to be useful in predicting response to therapy in survivors of sudden cardiac arrest.

Patients resuscitated after an episode of sudden cardiac arrest are at particularly high risk for recurrence of life-threatening arrhythmias, especially within the first year after the initial episode (1–6). The estimated annual recurrence rate for patients whose primary event occurred in the absence of acute myocardial infarction approaches 25 to 40%. Consequently, the development of techniques for assessment of the effectiveness of prophylactic antiarrhythmic therapy in these patients has been of increasing interest.

Recently, Ruskin et al. (7,8) demonstrated that invasive cardiac electrical stimulation techniques, similar to those commonly utilized in many centers to assess therapy for other cardiac arrhythmias, could be adapted safely for evaluation of antiarrhythmic treatment in patients resuscitated from sudden cardiac arrest. Furthermore, although based on a small number of patients, treatment selection resulting from findings during serial in-hospital electropharmacologic testing yielded a reduction of the expected annual recurrence rate of cardiac arrest to approximately 7%, thereby warranting further assessment of this technique.

The object of this study was to evaluate provocative electropharmacologic testing as a tool for assessing the effectiveness of prophylactic antiarrhythmic therapy in a series of consecutive patients resuscitated after sudden cardiac arrest. Our findings in 34 patients with a mean follow-up of approximately 1 year suggest that treatments that prevent reinitiation of previously provocable sustained arrhythmias during electrical stimulation studies are associated with a decreased recurrence rate of cardiac arrest in these high risk patients.

Methods

Study Patients

Between September 1978 and January 1982, clinical electrophysiologic studies (1 to 4 procedures/patient) were

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carried out in 34 consecutive patients referred for evaluation of sudden out of hospital cardiac arrest. Cardiac arrest was determined to have been present if the patient was unresponsive when found and required cardiopulmonary resuscitation and direct current cardioversion before initial hospitalization. In all cases, ventricular fibrillation (28 patients) or ventricular tachycardia (5 patients) was diagnosed by paramedical or emergency room personnel, or both, and in 19 cases, electrocardiographic recordings were obtained at the time of resuscitation. Patients whose cardiac arrest either was associated with acute myocardial infarction or occurred as the result of an underlying debilitating condition were not included in the study.

For purposes of this study, acute myocardial infarction was said to have occurred if electrocardiographic evidence of evolving transmural infarction was present, or if nonspecific electrocardiographic findings were associated with a typical sequence of cardiac enzyme elevation. It is possible, therefore, that some patients whose electrocardiographic and enzyme changes were solely due to resuscitation may have been excluded from the study. All patients included in the study group underwent electrophysiologic evaluation within 6 weeks of cardiac arrest. Thirty-one patients underwent coronary arteriography with left ventriculograms.

Table 1 summarizes clinical and electrophysiologic findings in the 34 patients (28 men, 6 women; age range 15 to 68 years) studied. Coronary artery disease as evidenced by a history of previous (more than 4 months) myocardial infarction with compatible electrocardiographic abnormalities or abnormal coronary arteriograms, or both, was present in 20 (59%) of the 34 patients. Five patients had cardiomyopathy (hypertrophic in one patient, postpartum in one patient, idiopathic in three patients), four patients had a primary arrhythmia with no identifiable underlying heart disease, three patients had Wolff-Parkinson-White syndrome and two patients had valvular heart disease. The arrhythmia diagnosed at time of initial resuscitation was ventricular fibrillation in 28 (82%) of the 34 patients and ventricular tachycardia in 5 patients. In one patient with Wolff-Parkinson-White syndrome (Patient 27), atrial fibrillation resulted in a ventricular response exceeding 300 beats/min and was associated with hemodynamic collapse requiring cardioversion.

Electrophysiologic study. Before initial clinical electrophysiologic study, the procedure was carefully discussed with each patient and written informed consent was obtained. Patients were advised that they could elect to decline further testing at any time and, as a result, studies were incomplete in 4 of the 34 subjects.

Patients were studied in the fasting state. Before the initial study, all cardioactive drugs were discontinued for at least three drug half-lives; however, cardiac glycosides were not withdrawn in those patients taking them before their cardiac arrest. Two to four standard 6 French electrode catheters were inserted percutaneously by way of the femoral or antecubital veins, or both, and positioned at specific intracardiac sites (right ventricular apex, His bundle recording site, right atrium and coronary sinus) as needed. Cardiac electrical stimulation was carried out using a custom-designed optically isolated stimulator capable of delivering up to four independently timed sequential constant current extrastimuli either during sinus rhythm or after a pacing train. Impulse duration was usually 2 ms with current strength twice diastolic pacing threshold. Pulse widths greater than 2 ms were employed only in patients treated with bethanidine sulfate after it had been determined that protection against arrhythmia induction had been obtained at the standard 2 ms impulse duration.

For purposes of this study, sustained ventricular tachycardia was diagnosed if a single episode was of 30 or more QRS complexes in duration, or if hemodynamic impairment was severe enough (that is, loss of consciousness) to require termination of the arrhythmia by pacing techniques or direct current countershock. Nonsustained ventricular tachycardia was diagnosed if the tachyarrhythmia consisted of less than 30 but more than 6 QRS complexes, and terminated spontaneously before hemodynamic impairment became severe.

Pacing protocol. Ventricular pacing trains and extrastimuli were inserted at the right ventricular apex. In most patients, the pacing protocol consisted of sequential insertion of one to four extrastimuli after an 8 to 10 beat pacing train at two fixed basic pacing cycle lengths (either 600 ms [100 beats/min] and 500 ms [120 beats/min] or 500 ms [120 beats/min] and 400 ms [150 beats/min]). The choice of pacing cycle lengths was dictated by the patients' hemodynamic response to pacing (that is, development of hypotension or chest pain resulted in use of slower basic pacing rates). Each extrastimulus was progressively scanned (10 to 20 ms decrements) through diastole until it no longer captured, at which point it was fixed 20 to 50 ms beyond the point of refractoriness; the next extrastimulus was then added and diastole scanned. This process was repeated until all four extrastimuli were applied. The process was terminated if sustained or reproducible nonsustained (see previously) ventricular tachyarrhythmia was provoked.

If no arrhythmia was induced by these methods, right ventricular burst pacing was initiated. The latter procedure consisted of the insertion of two trains of six to eight ventricular pacing beats spaced in time so that one or two sinus beats occurred between the two trains. The pacing cycle length of each train was kept constant. If no arrhythmia was induced, the cycle length of the train was reduced by 10 ms and the two train pacing sequence was repeated. Trains were inserted over a range of cycle lengths (usually 400 to 240 ms, 150 to 260 beats/min), or until 1:1 capture in the ventricle was no longer possible. It should be noted (Table 1) that in this study rapid pacing trains never initiated ven-

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tricular tachyarrhythmias when insertion of four sequential extrastimuli had previously failed to do so. Nonetheless, because use of burst pacing is conventional in provocative electropharmacologic testing, it was employed in this protocol as an added measure to assess drug efficacy.

Because of the development of testing techniques over time, the pacing protocol was less comprehensive in the first 4 patients (Patients 1 to 4), than in the remaining 30 patients. Furthermore, for patients with Wolff-Parkinson-White syndrome (Patients 17, 23 and 27) additional extensive studies were carried out to evaluate the electrophysiologic characteristics and location of accessory atrioventricular pathways. In these patients, special emphasis was placed on analysis of ventricular cycle lengths during pacing-induced atrial fibrillation (8).

Treatment regimens. In patients with inducible ventricular arrhythmias, serial studies were carried out in the presence of one or more antiarrhythmic treatment regimens with a view toward establishing a treatment program that prevented induction of either sustained or nonsustained arrhythmia, or at least converted previously sustained arrhythmias to nonsustained status. In some patients, it was not possible to achieve either of these goals with standard noninvestigational antiarrhythmic drugs, and several investigational antiarrhythmic agents (bethanidine sulfate, tocainide, amiodarone and flecainide acetate) were evaluated after written informed consent was obtained. In patients in whom surgery was performed, electrical stimulation studies were repeated before hospital discharge.

Follow-up. After discharge from the hospital, patients were followed up by their referring physicians. Follow-up information was updated every 2 to 3 months on the basis of telephone contact with either the patient or the patient's physician; a minimal follow-up interval of 8 months was obtained in all cases.

Results

Inducible ventricular arrhythmias. Potentially life-threatening arrhythmias were induced during initial electrophysiologic study in 30 (88%) of the 34 patients, whereas in 4 patients, either no arrhythmia or only single ventricular premature beats were observed. The extrastimulus sequences required to induce ventricular tachyarrhythmias in the absence of drugs are indicated in Table 1. In the five patients whose cardiac arrest was associated with ventricular tacchycardia, it was possible to induce sustained ventricular tachycardia, it was possible to induce sustained ventricular tachycardia during catheterization laboratory study in four patients and nonsustained ventricular tachycardia in one patient. On the other hand, of the 28 patients presenting with out of hospital ventricular fibrillation, the most frequent arrhythmia induced (in 20 patients) was a rapid ventricular tachycardia (heart rate 180 to 340 beats/min) usually associated with hypotension and often necessitating direct current countershock. The induced rapid ventricular tachycardia initially exhibited a relatively regular rhythm as detected on the intraventricular electrogram, but often manifested a polymorphic appearance on the surface electrocardiogram (Fig. 1). Consequently, differentiation of polymorphic from monomorphic ventricular arrhythmias did not appear to be of practical clinical significance in this patient subgroup.

Association with ventricular fibrillation. The association of inducible rapid ventricular tachycardia with occurrence of ventricular fibrillation in these patients is illustrated by findings in Patient 16 in whom ventricular fibrillation was documented after sudden collapse at home. While in the hospital awaiting electrophysiologic study, she had a second spontaneous cardiac arrest, and a rapid ventricular tachycardia was recorded at its initiation (Fig. 1A). Subsequently, electrical stimulation studies reproduced a similar tachyarrhythmia in the laboratory (Fig. 1B).

Wolff-Parkinson-White syndrome. In the two patients with Wolff-Parkinson-White syndrome and documented out of hospital ventricular fibrillation (Patients 17 and 23), rapid ventricular responses during atrial fibrillation (shortest RR interval less than 220 ms in each patient) were documented during electrophysiologic study (9). Ventricular fibrillation did not recur in the laboratory. In fact, ventricular fibrillation did not occur during catheter study in any of the patients presumably because of prompt termination of hemodynamically serious arrhythmias by pacing techniques or direct current countershock. However, as noted previously, the surface electrocardiogram during induced ventricular tachycardia frequently exhibited a polymorphic appearance that may be difficult to distinquish from ventricular fibrillation in the absence of intracardiac recordings. No deaths or complications were associated with these studies.

Selection and results of antiarrhythmic treatment. Table 2 summarizes both the various antiarrhythmic drugs tested in this study and the frequency with which these agents were a part of the final treatment regimen. Several factors played a role in selection of drugs for testing in individual patients; for example, the patient's hemodynamic status, allergies, previously documented drug intolerance and availability of investigational agents influenced the protocol. In addition, anatomic factors demonstrated by angiography altered treatment recommendations in certain patients. For example, the presence of a ventricular aneurysm or discrete regional dyskinesia associated with inducible ventricular tachyarrhythmias was considered to be a potentially surgically treatable condition. As a result, in 11 patients cardiac surgery was advised and, when appropriate, was carried out with the aid of intraoperative electrophysiologic mapping (coronary artery bypass grafting alone in

Table 1. Clinical Features and Electrophysiologic Findings

Patient and Group	Age (yr) & Sex	Principal Cardiac Diagnosis	Presenting Arrhythmia	Arrhythmia Induced During EP Study	Effective Extrastimulus Sequence	Surgery	Drug Therapy at Discharge	Follow-Up (mo)
1E	15M	PEHD	VF	None	N/A	None	Prop	13 (sudden death)
2E	61M	CAD	VF	Single VPBs	N/A	CABG	Prop	10 (sudden death)
3E	42M	CM	VF	Single VPBs	N/A	None	Proc	38
4D	18F	PEHD	VF	VT (NS)	2	None	Prop, Ph*	VF at 19 mo; (alive at 38 mo)
5A	54M	CAD	VF	VT	2	None	Proc Ph	38
6A	56M	CAD	VF	VT	3	None	Beth, Q	38
7C	68F	PEHD	VF	VT	2	ER, EEV	None	5 (sudden death)
8A	66M	CAD	VF	VT	2	ER, CABG	Q	26†
9C	52M	CAD	VF	VT	3	None	Proc, Ph	25
10D	52F	VHD	VF	VT	2	None	Proc*	37
11A	29M	PEHD	VF	VT	3	None	Proc	27
12E	68M	CAD	VT	None	N/A	None	None	40
13A	56M	CAD	VF	VT	2	ER, CABG	Q	20
14A	49M	CAD	VF	VT	3	ER, CABG	None	20
15A	40M	CAD	VT	VT	3	CABG	None	22
16A	28F	CM	VF	VT	3	None	Q	7 (sudden death)
17B	48M	WPW	VF	AF, PSVT	N/A	None	Prop, Q	34
18A	45M	CAD	VF	VT	2	None	Beth	19
19C	57M	CM	VF	VT	3	None	Toc	2 wk (sudden death)
20A	49M	CAD	VF	VT	2	None	Prop	23
21A	47M	CAD	VF	VT	1	ER, CABG	Proc	16
22D	59M	CAD	VF	VT	3	None	Diso*	15
23B	18M	WPW	VF	AF, PSVT	N/A	AP ablation	None	None
24A	55F	CM	VF	VT	3	None	Beth	12
25A	55M	CM	VT	VT (NS)	2	None	Proc, Toc	20
26C	56F	CAD	VF	VT	2	None	Amio	11
27B	15M	WPW	AF with rapid ventricular response	AF, PSVT	N/A	AP ablation	None	11
28A	65M	CAD	VF	VT	2	ER, CABG	None	11
29A	55M	CAD	VF	VT	1	None	Prop	12
30D	54M	CAD	VT	VT	3	None	Proc*	12
31A	64M	CAD	VF	VT	3	EEV	Prop	12
32C	67M	CAD	VF	VT	3	None	Amio	12
33A	67M	VHD	VF	VT	2	None	Proc, Ph	29
34A	52M	CAD	VF	VT	2	Previous CABG	Flec, Prop	28

* Complete evaluation declined following entry into study. † Died of congestive heart failure

AF = atrial fibrillation; Amio = amiodarone; AP = accessory bypass pathway; Beth = bethanidine (bretylium analog); CABG = coronary artery bypass grafting; CAD = coronary artery disease; CM = cardiomyopathy; Diso = disopyramide; EEV = encircling endocardial ventriculotomy; ER = endocardial resection, Flec = flecainide; N/A = not available; NS = nonsustained (<30 complexes), PEHD = "primary electrical heart disease"; Ph = phenytoin; Proc = procainamide; Prop = propranolol; PSVT = paroxysmal supraventricular tachycardia; Q = quinidine; SD = standard deviation; Toc = tocainide; VF = ventricular fibrillation; VHD = valvular heart disease; VPB = ventricular premature beat; VT = ventricular tachycardia (sustained); WPW = Wolff-Parkinson-White syndrome.

one patient and aneurysmectomy and endocardial resection in five patients, endocardial resection or encircling endocardial ventriculotomy, or both, in two patients, accessory atrioventricular bypass tract ablation in two patients). However, the efficacy of cardiac surgery, as with drug therapy, was assessed by electrical stimulation studies before hospital discharge. Therefore, for purposes of this study, both drugs and cardiac surgery were considered to be forms of antiarrhythmic prophylaxis and were used in conjunction with each other when deemed appropriate.

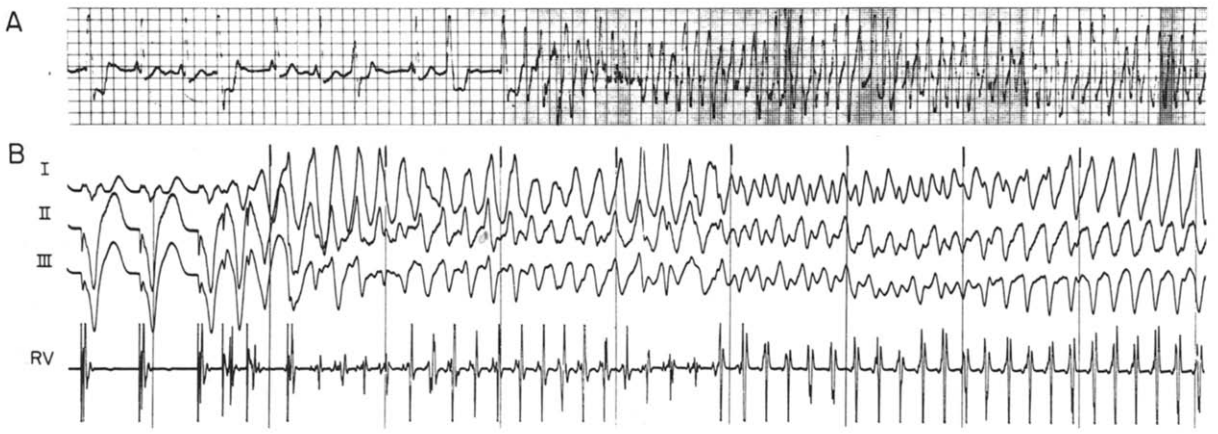


Figure 1. Electrocardiographic and intracardiac recordings in Patient 16. **A**, Electrocardiographic recording obtained by in-hospital telemetry demonstrating spontaneous onset of a rapid ventricular tachycardia (cycle length 180 to 280 ms, heart rate 214 to 333 beats/min) resembling torsade de pointes (14,15). The patient was being monitored before electrophysiologic evaluation of an out of hospital episode of documented ventricular fibrillation 2 weeks earlier and was receiving no cardiac medications. Direct current cardioversion (not shown) terminated the tachycardia promptly and sinus rhythm was restored. **B**, Electrocardiographic recordings (leads I, II and III) and intracardiac right ventricular (RV) electrogram during electrophysiologic study in the absence of antiarrhythmic drugs. At left, a 10 beat sequence of right ventricular pacing (cycle length 500 ms, heart rate 120 beats/min) was terminated by three sequential extrastimuli coupling intervals ($S_1 - S_2 = 210$ ms, $S_2 - S_3 = 210$ ms, $S_3 - S_4 = 350$ ms). Before capture of the third extrastimulus, a sustained rapid ventricular tachycardia (cycle length 180 to 210 ms, heart rate 286 to 333 beats/min) was initiated. The induced tachyarrhythmia was similar to the patient's spontaneous tachycardia, exhibiting features suggestive of torsade de pointes. Direct current cardioversion was required to restore sinus rhythm.

No single antiarrhythmic drug regimen proved to be most effective. In particular, although Table 2 suggests that propranolol was a consistently useful agent, this is somewhat misleading because in the early stages of the study propranolol was selected for treatment of patients in whom electrophysiologic studies were inadequate to define therapy. Indeed, three of six patients treated with propranolol as the principal antiarrhythmic agent had recurrence of out of hospital cardiac arrest, and two of these patients died. In general, available standard antiarrhythmic agents were effective alone or in combination in the majority of patients studied (Table 1).

Follow-up results correlated with initial electrophysiologic study and drug testing. Figure 2 summarizes the results of in-hospital evaluation and subsequent follow-up (range 2 weeks to 40 months) for all 34 patients. The patients were classified into five groups (A to E). In 4 of the 34 patients (Patients 1,2,3 and 12) either no arrhythmia or only ventricular premature beats were elicited during initial laboratory study; consequently serial drug testing was not feasible (Fig. 2, group E). Two of these four patients have had recurrence of out of hospital cardiac arrest. Similarly, in 4 of the remaining 30 patients (Patients 4,10,22 and 30) serial testing was terminated before completion of the protocol (Fig. 2, group D), and subsequent therapy was empiric. One of these four patients (Patient 4) subsequently had recurrence of out of hospital cardiac arrest at 19 months but is alive at 38 months.

In five patients (Patients 7,9,19,26 and 32) (Fig. 2, group C), an antiarrhythmic treatment regimen that prevented initiation of sustained tachyarrhythmias during serial electropharmacologic testing was not found. Two (40%) of these five patients had recurrence of out of hospital cardiac arrest at 2 weeks and 5 months, respectively. In one of these subjects (Patient 7), combined endocardial resection and encircling endocardial ventriculotomy was carried out with the aid of intraoperative mapping. However, postoperatively a sustained ventricular tachyarrhythmia was still inducible (requiring four closely coupled extrastimuli compared with

Table 2. Drugs Utilized in Electropharmacologic Testing

Drug	No. of Patients Tested	Discharged on Drug*
1. Procainamide	17	8
2 Quinidine	11	5
3. Bethanidine† (bretylium analog)	7	3
4. Propranolol‡	8	8
5. Lidocaine	6	0
6. Bretylium	4	0
7. Phenytoin (diphenylhydantoin)§	3	4
8 Disopyramide phosphate	2	1
9. Amiodarone†	5	2
10. Tocainde†	2	2
11. Verapamil	1	0
12. Flecainide†	1	1

* Several patients were discharged on more than one agent (see Table 1). † Investigational drug. ‡ Propranolol was initially utilized in patients whose studies were inadequate (see Table 1, Patients 1, 2 and 4), and was associated with recurrence of cardiac arrest in three of seven patients. § Utilized only as a second agent in conjunction with other antiarrhythmic therapy.

preoperative initiation using two extrastimuli), and this patient died suddenly 5 months later. Patients 26 and 32 were treated empirically with amiodarone and are alive at 11 and 12 months, respectively.

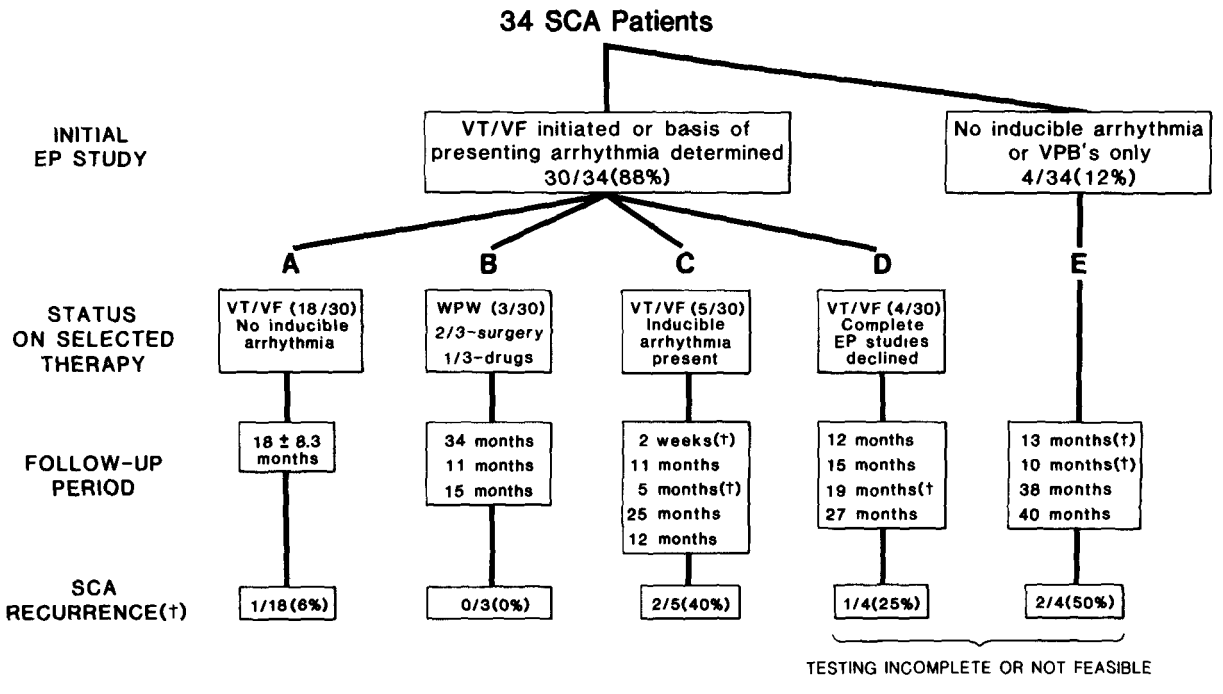
In 21 patients (Fig. 2, groups A and B), electrophysiologic pharmacologic testing appeared to define appropriate treatment. Accessory bypass tract ablation was advised and carried out in two of three patients in group B with Wolff-Parkinson-White syndrome: the third patient declined surgery and was treated with a combination of quinidine and propranolol. All group B patients are alive. Drug and surgical regimens for the 18 patients in group A are provided in Table 1. In these 18 patients, efficacy of therapy was determined by repeat extrastimulus testing and was defined as successful completion of the entire stimulation protocol. During follow-up, 1 (6%) of the 18 group A patients (Patient 16) had recurrence of sudden cardiac arrest; 1 other patient (Patient 8) died 26 months after the study as a result of congestive heart failure.

Discussion

The results of this study provide three principal observations. First, patients resuscitated from sudden out of hospital cardiac arrest usually exhibited susceptibility to initiation of sustained, potentially lethal ventricular arrhythmias during programmed electrical stimulation studies. Second, the most common arrhythmia initiated during electrophysiologic study was a rapid ventricular tachycardia, and although ventricular fibrillation did not occur during the study, its ultimate occurrence would likely have been inevitable given the marked hemodynamic compromise usually associated with the rapid ventricular tachyarrhythmia induced. Third, efficacy of antiarrhythmic therapy was predicted by response to cardiac electrical stimulation before hospital discharge. During comparable follow-up periods (excluding 3 group B patients who had Wolff-Parkinson-White syndrome), only a single cardiac arrest has occurred among 18 patients in whom an effective medical or surgical treatment regimen, or both, was predicted by laboratory evaluation, compared with recurrence in 5 (38%) of 13 patients in whom catheter studies either suggested lack of treatment efficacy (Fig. 2, group C) or were inadequate (Fig. 2, groups D and E).

Routine prophylactic antiarrhythmic treatment for survivors of cardiac arrest. In the past several years, a consensus has evolved in regard to the importance of prophylactic antiarrhythmic treatment for patients resuscitated after sudden cardiac arrest. Several approaches have been advocated. It has been proposed that adequate prophylaxis could be provided by careful maintenance of currently accepted standard therapeutic antiarrhythmic drug levels (5,10–

Figure 2. Diagram summarizing the results of electropharmacologic (EP) studies and follow-up in 34 survivors of sudden cardiac arrest (SCA). VF = ventricular fibrillation, VPB's = ventricular premature beats; VT = ventricular tachycardia: WPW = Wolff-Parkinson-White syndrome.



12). In this regard, Myerburg et al. (11) reported findings in 16 patients followed up on a plasma level-monitored treatment regimen. During follow-up, eight patients (50%) had recurrent cardiac arrest and all were found to have had unstable plasma drug levels before recurrence, while in six of the eight patients without cardiac arrest recurrence, stable therapeutic drug levels had been documented. Recently, empiric prophylactic amiodarone therapy for sudden cardiac arrest survivors has also been suggested to diminish recurrence rates. Nademanee et al. (13) noted only four recurrences of cardiac arrest among 24 patients (16%) during a follow-up period of 4 days to 23 months, whereas Peter et al. (14) reported four deaths among 27 patients (15%) treated empirically with amiodarone for 5 to 22 months. In addition, Morady et al. (15) reported only two recurrences of tachycardia during an 18 ± 14 month follow up period in 23 survivors of cardiac arrest treated with amiodarone after conventional antiarrhythmic drugs had failed to prevent ventricular tacharrhythmias during electropharmacologic testing.

Use of ventricular stimulation techniques to select optimal antiarrhythmic treatment. An alternative approach for selection of antiarrhythmic therapy in resuscitated victims of sudden cardiac arrest has been proposed by Ruskin et al. (7,8). With the use of programmed right ventricular electrical stimulation techniques, prevention of ventricular arrhythmia induction by antiarrhythmic treatment was possible in 19 (61%) of the 31 subjects. Subsequently, there were no recurrences of cardiac arrest in the latter 19 patients over a mean 15 month follow-up, compared with 3 recurrences among the remaining 12 patients. Recently, these same investigators have updated and essentially reconfirmed their initial experience (8). It is important to note, however, that their findings now make clear that despite optimal antiarrhythmic therapy many patients will nonetheless die nonarrhythmic deaths during the follow-up period, presumably because of progression of underlying heart disease.

The relative ease of inducing potentially life-threatening arrhythmias during electrical stimulation studies in 30 (88%) of our 34 patients closely parallels the results reported by Ruskin et al. (7,8), and is similar to the recent findings of Morady et al. (15), who induced ventricular tachyarrhythmias in 76% of patients. In addition, although ventricular fibrillation was the most frequent arrhythmia documented on initial presentation in both this study (28 of 34, 82%) and those of Ruskin et al. (23 of 31, 74%), a rapid hemodynamically unstable ventricular tachycardia was the arrhythmia most often initiated during electrophysiologic testing in both series. The results in both our study and those of Ruskin's group differ somewhat with the observations of Josephson et al. (16), who reported induction of sustained or nonsustained ventricular tachycardia in only 9 (30%) of 30 patients presenting with ventricular fibrillation, whereas ventricular fibrillation did occur in the laboratory in 4 subjects. An explanation for this discrepancy is not apparent.

Implications of study. Our findings further support those of Ruskin et al. (7,8) in that establishment of a treatment regimen that appeared to suppress laboratory arrhythmia induction in 21 (62%) of our 34 patients was associated with only one subsequent cardiac arrest during the follow-up period, compared with five recurrences among the remaining 13 patients. Indeed, the reduction in the rate of recurrence of cardiac arrest documented in those cases in which an antiarrhythmic regimen was predicted to be effective in the laboratory was similar to that noted by Ruskin et al. (7,8) and appeared to be an improvement compared with previously reported historical controls (1–4,6). Consequently, our findings support the view that serial electrophysiologic testing is useful to predict effectiveness of prophylactic antiarrhythmic therapy in survivors of out of hospital cardiac arrest. However, follow-up in our patients has been relatively short, and an ongoing surveillance to document long-term results is necessary to establish an appropriate role for provocative electropharmacologic testing in these high risk patients. Furthermore, the optimal treatment for patients in whom ventricular tachyarrhythmias cannot be induced in the laboratory, or in whom antiarrhythmic therapy fails to prevent arrhythmia induction in the electrophysiologic laboratory, remains a critical unanswered question.

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