REPORTS ON THERAPY

Long-Term Follow-Up of Patients After Transcatheter Direct Current Ablation of the Atrioventricular Junction

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The long-term follow-up study (41 ± 23 months) of 47 patients undergoing direct current ablation because of drug-resistant supraventricular arrhythmias is reported. Significant early complications occurred in four patients and included hypotension, pericarditis, nonsustained polymorphic ventricular tachycardia and one sudden death. In 42 patients (86%), complete atrioventricular (AV) block was initially achieved. During the follow-up period, AV conduction resumed in 2 of these 42 patients. Of the seven patients in whom ablation was unsuccessful, two developed late complete AV block and three had symptomatic improvement.

An improved activity level was reported among 83% of the patients with successful ablation. Health care utilization manifest as the number of hospital admissions per year before and after ablation decreased significantly after ablation (2.4 ± 2.0 versus 0.3 ± 0.5, p < 0.001). Echocardiographic evaluation in five patients with a depressed left ventricular ejection fraction (27 ± 7%) before ablation showed a significant increase (45 ± 14%, p < 0.05) after an average follow-up period of 31 months. New onset of congestive heart failure occurred after ablation in four patients, of whom two had no structural heart disease. The total mortality rate, including the one patient with sudden death, was 17.6% and was significantly higher among patients with underlying structural heart disease.

Transcatheter direct current ablation is an effective treatment in patients with drug-resistant supraventricular tachycardia, providing a beneficial long-term outcome including an improved quality of life and a decrease in health care utilization. Because of the small but significant risk of severe complications, this procedure should be reserved for patients with supraventricular arrhythmias who do not respond to conventional drug treatment.

Transcatheter direct current ablation of the atrioventricular (AV) junction is an established method for treating patients with supraventricular arrhythmias who do not respond to drug therapy (1–4). To date, the largest experience with this technique has been provided by a voluntary registry (5). The drawbacks of this registry include retrospective analysis of data, lack of quality control in data procurement and differences in techniques for the ablative procedure itself. In addition, little information is available relating to long-term follow-up study and changes in left ventricular performance.

Although this procedure provides for control of disabling arrhythmias, it is associated with certain risks and requires permanent cardiac pacing. In addition, because most patients undergoing catheter ablation have persistent atrial arrhythmias, the risk of systemic embolization is still present. Thus, overall long-term benefits of this treatment are uncertain.

Catheter ablation of the AV junction was first performed in 1981 (1). Because a substantial number of patients have now been followed up for several years, it is important to review the experience from our center with respect to the
Table 1. Clinical Characteristics of 49 Patients Before Ablation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (yr)</td>
<td>54 ± 15 (range 20-77)</td>
</tr>
<tr>
<td>Male gender</td>
<td>27 (55%)</td>
</tr>
<tr>
<td>DC conversion required</td>
<td>26 (53%)</td>
</tr>
<tr>
<td>Duration of symptoms (yr)</td>
<td>12.6 ± 14 (range 1-57)</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>11 (23%)</td>
</tr>
<tr>
<td>Cardiomyopathy</td>
<td>14 (29%)</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>48 ± 13 (range 15-65)</td>
</tr>
<tr>
<td>Types of arrhythmias</td>
<td></td>
</tr>
<tr>
<td>Atrial fibrillation/flutter</td>
<td>29 (59%)</td>
</tr>
<tr>
<td>AVNRT</td>
<td>13 (26%)</td>
</tr>
<tr>
<td>AVRT</td>
<td>6 (12.5%)</td>
</tr>
<tr>
<td>Atrial tachycardia</td>
<td>1 (2.5%)</td>
</tr>
<tr>
<td>Symptoms during tachycardia</td>
<td></td>
</tr>
<tr>
<td>Syncope</td>
<td>14 (29%)</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>15 (31%)</td>
</tr>
<tr>
<td>Angina</td>
<td>11 (22%)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>19 (38%)</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>4 (8%)</td>
</tr>
<tr>
<td>Maximal HR (beats/min)</td>
<td>177 ± 42 (range 100-300)</td>
</tr>
</tbody>
</table>

| No. of symptomatic episodes per week       |                            |
| <5                                        | 14 (29%)                   |
| 1-5                                       | 20 (40%)                   |
| 5-10                                      | 5 (11%)                    |
| >10                                       | 10 (20%)                   |

| Unsuccessful drugs                         |                            |
| Digitalis                                  | 43 (88%)                   |
| Calcium channel blockers                   | 43 (88%)                   |
| Beta-blockers                              | 42 (85%)                   |
| Procainamide                               | 39 (79%)                   |
| Quinidine                                  | 38 (77%)                   |
| Disopyramide                               | 17 (35%)                   |
| Amiodarone                                 | 17 (35%)                   |
| Flecaainide                                | 8 (16%)                    |

AVNRT = atioventricular (AV) node reentrant tachycardia; AVRT = AV reciprocating tachycardia; DC = direct current; HR = heart rate; LVEF = left ventricular ejection fraction.

Effects of ablation of the AV junction on arrhythmia control and quality of life, including health care utilization and ventricular performance.

Methods

Study patients (Table 1). During the time period from March 1981 to May 1988, 49 patients at the University of California, San Francisco, underwent ablation of the AV junction because of intractable supraventricular arrhythmias. Patients were considered candidates for the procedure if persistent disabling supraventricular tachycardia had failed to respond to pharmacologic therapy. All surviving patients with follow-up study of at least 1 year's duration were included in this study. Two patients were lost to follow-up evaluation. The mean age was 54 years (range 20-77) and 56% were men. Structural heart disease was present in 54%. The mean left ventricular ejection fraction was 48 ± 13%; eight patients had an ejection fraction <45%. Atrial fibrillation or flutter, or both, was present in 59%, AV node reentrant tachycardia in 26%, orthodromic supraventricular tachycardia mediated by a concealed accessory pathway in 12.5% and atrial tachycardia in 2.5%.

Symptomatic tachycardia had been present for a mean of 12.6 ± 14.0 years (range 1 to 57) and resulted in syncope in 29% of the patients and cardiac arrest in 8%. The mean heart rate during tachycardia was 177 ± 42 beats/min (range 100 to 300) and external direct current countershock was necessary for 53% of the patients. The frequency of tachycardia episodes is shown in Table 1. The patients had not responded to or had been intolerant of a mean of 5.5 ± 2 drugs (range 1 to 12) (Table 1).

Ablation procedure. A 6F quadrupolar electrode catheter (USCI) was introduced into the femoral vein and positioned across the tricuspid valve to record the largest His bundle potential between the distal electrodes. The catheter was manipulated so that the largest unipolar unfiltered His bundle deflection was recorded from the distal electrode. Another quadrupolar electrode catheter was inserted from the femoral vein and placed against the right ventricular apex for temporary pacing. The distal electrode was used as the cathode for ablation, and a large skin electrode (R2 Corporation) was placed over the left scapula and used as the anode.

A short-acting anesthetic agent was administered and one or more synchronized shocks were delivered. The defibrillator was set at 200 to 300 J per shock and up to five shocks were delivered until persistent complete AV block was achieved. One additional shock of 200 J was always given, even if complete AV block was produced by the initial shock. After a successful procedure, temporary ventricular pacing was instituted from the right ventricular apex, and the patient was observed in the electrophysiology laboratory for at least 20 min to confirm that complete AV block persisted. The patient was then transferred to the coronary care unit for continued observation. If complete AV block persisted after 24 h, a permanent pacemaker was inserted.

If complete AV block was not achieved after five shocks, the session was stopped and the patient brought back to the electrophysiology laboratory the next day for a second session. If recurrence of AV conduction occurred before discharge, the patient underwent a repeat procedure.

Follow-up study. All patients available for follow-up study and their physicians were interviewed with respect to symptoms, prescribed medications, number of hospital admissions and new cardiovascular events during the follow-up period. Patients were asked to compare their functional status with that before ablation. The New York Heart Association classification with respect to symptoms of congestive heart failure was assessed before and after ablation. Health care utilization before and after ablation was defined.
as the number of hospital admissions per year for any cardiovascular disorder. In patients complaining of palpitation during the follow-up period, 24 h Holter electrocardiographic (ECG) monitoring was performed. In the event of death, circumstances surrounding the death were sought and autopsy results collected.

Echocardiographic measurements. Echocardiographic recordings were analyzed by the use of a computer-assisted and phantom-calibrated digitization system (GTI Freeland Medical). From two-dimensional measurements, the left ventricular end-diastolic and end-systolic volumes were calculated using a biapical modified Simpson's rule algorithm (6,7). Ejection fraction and heart rate were recorded. The measurements were made by an investigator who was unaware of patient data. Patients with impaired left ventricular function (ejection fraction <45%) before ablation underwent serial echocardiographic studies.

Statistical methods. Comparison between groups was performed using a two-sided Student's t test. Actuarial survival curves were constructed according to the method of Colton (8). Comparisons between curves were made both on a 6 month basis using chi-square analysis and by a comparison of the overall probability of survival using a Cox proportional hazards model (9). A p value <0.05 was considered significant.

Results

Short-Term Outcome After Ablation

The underlying rhythm immediately before ablation was sinus rhythm in 33 (68%) of the 49 patients and atrial fibrillation in the remaining 16 patients. The mean unipolar His bundle amplitude was 0.36 ± 0.20 mV. The total delivered energy per patient was 705 ± 360 J, with a mean of 2.5 ± 0.9 shocks per patient. Ten patients required three or more shocks and nine patients (19%) required two ablation sessions. In seven of these nine patients, complete AV block could not be achieved and they were discharged with intact AV conduction.

The mean energy delivered to the 7 patients without successful ablation was 1,015 ± 130 J versus 661 ± 360 J for the 42 patients with successful ablation (p < 0.05). There was no difference in the recorded His bundle amplitudes between patients with successful compared with failed ablation (0.37 ± 0.21 versus 0.31 ± 0.13 mV, respectively). Five of the six patients with unsuccessful ablation were men. Complete AV block with an average escape rate of 37.5 ± 10 beats/min (range 15 to 56) was achieved in 42 (86%) of the 49 patients.

Complications. Four patients had significant early complications. One patient, a 59 year old woman with recurrent atrial fibrillation and mild left ventricular hypertrophy, died suddenly 2 weeks after ablation. The patient collapsed after leaving the hospital for a routine check-up and resuscitation efforts were initiated within approximately 7 min. The initial ECG showed ventricular fibrillation. This patient has been extensively described in an earlier report (10). A second patient developed hypotension immediately after the ablation procedure but recovered after treatment with intravenous fluids, and one patient developed clinical signs of pericarditis with chest pain that resolved spontaneously after 36 h; no pericardial effusion was documented by echocardiography. A fourth patient, a 58 year old woman with ischemic heart disease and frequent ventricular premature complexes before ablation, had a brief episode of polymorphic ventricular tachycardia during intentional inhibition of her pacemaker 6 h after the ablation. No further episodes of tachycardia were documented during a follow-up period of 3 years.

Long-Term Outcome After Ablation (Fig. 1)

The long-term follow-up study included 47 patients, with an average follow-up time of 41 ± 23 months (range 2 weeks to 90 months). All survivors were followed up for at least 1 year. Two patients with successful achievement of complete AV block were lost to follow-up study.

Recurrence of AV conduction. Atrioventricular conduction resumed in two patients (4%) who initially had had successful ablation with recurrence of symptoms. One of these patients had AV node reentrant tachycardia and the second had paroxysmal atrial fibrillation. These recurrences of AV conduction occurred after 3 and 6 months, respectively. One of these patients underwent successful repeat
catheter ablation. The other, who had hypertrophic cardiomyopathy, underwent surgical ablation of the AV junction along with a myotomy/myectomy procedure at another institution but died perioperatively from congestive heart failure.

Among the seven patients who had persistent AV conduction at hospital discharge, two developed complete AV block after 4 and 24 months, respectively. Three patients had improved arrhythmia control with previously ineffective drugs. Of the remaining two patients, one ultimately responded to repeat catheter ablation and the other required surgical division of the His bundle. Thus, 42 (89.5%) of the 47 patients had complete AV block produced by catheter ablation at the end of the follow-up period.

Subsequent cardiovascular events. New onset of congestive heart failure occurred after ablation in four patients; two had known structural heart disease and two did not. Two patients developed signs of ischemic heart disease during the follow-up period. One developed angina pectoris 2 years after ablation and one had an acute myocardial infarction 14 months after ablation.

Only 2 of the 47 patients were treated with long-term anticoagulant therapy after ablation. None of the patients had a cerebrovascular accident, including 27 patients with chronic or paroxysmal atrial fibrillation. One patient, who did not receive anticoagulant therapy and had an unsuccessful ablation, had a brachial artery thrombosis 26 months after ablation.

Drug therapy. Seven of the 42 patients with successful ablation were treated with cardiac drugs during the follow-up period. Three patients were treated with quinidine, flecaïnide or encainide because of symptomatic premature ventricular complexes (present before ablation), and four patients had digitalis, calcium channel blockers or beta-adrenergic blockers prescribed for ischemic heart disease, hypertension or congestive heart failure.

Mortality. During the follow-up period, 9 (17%) of the 47 patients died. The causes of death and the clinical characteristics of these patients are presented in Table 2. Two patients without significant underlying heart disease died; one died suddenly 2 weeks after ablation and the other died of a subarachnoid hemorrhage 52 months after successful ablation. Of the seven patients who had unsuccessful ablation (either with early or late failure), two died of congestive heart failure and two other patients died from noncardiac causes.

Four of the 12 patients with preexisting heart failure (3 patients in New York Heart Association class III and 1 patient in class II) died of progressive heart failure despite successful ablation. Survival curves (Fig. 2) show that the mortality rate was significantly higher among patients with underlying heart disease.

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Gender</th>
<th>Cardiac Diagnosis</th>
<th>EF (%)</th>
<th>Chronic AV Block</th>
<th>FU (mo)</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>73M 79F</td>
<td>IHD 55M</td>
<td>—</td>
<td>Yes</td>
<td>2</td>
<td>—</td>
<td>IHD</td>
</tr>
<tr>
<td>69M 58F</td>
<td>CMP 60M</td>
<td>—</td>
<td>Yes</td>
<td>5</td>
<td>—</td>
<td>CHF</td>
</tr>
<tr>
<td>61M 42M</td>
<td>HCM 55M</td>
<td>47</td>
<td>Yes</td>
<td>40</td>
<td>—</td>
<td>COPD</td>
</tr>
<tr>
<td>58M 42M</td>
<td>IHD 55M</td>
<td>—</td>
<td>36</td>
<td>—</td>
<td>—</td>
<td>Cancer</td>
</tr>
<tr>
<td>69M 63M</td>
<td>CMP 60M</td>
<td>47</td>
<td>Yes</td>
<td>36</td>
<td>—</td>
<td>CHF</td>
</tr>
</tbody>
</table>

Mann 58.1 31.4 27 6 SD ± 16 ± 7 ± 21

AV = atrioventricular; CHF = congestive heart failure; CMP = cardiomyopathy; COPD = chronic obstructive lung disease; EF = ejection fraction; F = female; FU = follow-up; HCM = hypertrophic cardiomyopathy; IHD = ischemic heart disease; M = male; SD = sudden death; SH = subarachnoid hemorrhage.

Arrhythmic symptoms and results of Holter recordings. Palpitation during the follow-up period was reported in all 7 patients with unsuccessful ablation compared with 11 of 42 patients with successful long-term ablation (p < 0.05). Twenty-four hour Holter recordings revealed episodes of supraventricular tachycardia in all patients with failed ablation. In contrast, no tachycardia was observed in the 11 patients with successful ablation but with complaints of palpitation. In 3 of these 11 patients, palpitation could be ascribed to premature ventricular complexes; no cause was found in the other 8.

Echocardiographic findings (Table 3). Five of the nine patients with an ejection fraction <45% before ablation underwent repeat echocardiographic evaluation during the follow-up period, with a median of 34 months (range 8 to 77) between investigations. Among the remaining four patients,

Figure 2. Actuarial survival curves for patients undergoing AV junctional ablation. The **upper** curve describes the probability of survival among patients without underlying heart disease and the **lower** curve the probability of survival among patients with underlying heart disease. See text for discussion.

Cumulative survival
one had had an unsuccessful ablation, one was lost to follow-up, one refused follow-up evaluation and one died of ischemic heart disease during the follow-up period.

Four of these five patients with a low ejection fraction before ablation showed significant improvement during long-term follow-up. The median ejection fraction was 24% (range 20% to 35%) before ablation and 50% (range 21% to 58%) after ablation ($p < 0.05$). The heart rate at the two evaluations was comparable in four of the five patients ($82 \pm 10$ versus $75 \pm$ beats/min). In the fifth patient, the heart rate was 134 beats/min before ablation and 70 beats/min 8 months after ablation.

Among the four patients who showed an improvement in ejection fraction, functional class improved in three and remained unchanged in one, whereas functional class deteriorated in the patient who had an unchanged ejection fraction. Figure 3 summarizes changes in functional class among patients with preexisting heart failure.

Changes in lifestyle. An improved activity level was reported by 35 (83%) of the 42 patients with successful ablation. Seven patients considered their condition unchanged and one felt worse than before ablation. When separating the patients into those with and without preexisting heart disease, 10 (67%) of the 15 patients with preexisting heart disease reported an improved activity level after ablation as compared with 25 (89%) of 28 without preexisting heart disease ($p < 0.01$).

In the 11 patients with preexisting heart failure and a successful ablation, the functional class improved in 3, remained unchanged in 3 and deteriorated in 5.

Health care utilization manifested as the number of hospital admissions per year before and after ablation showed a significant decrease after ablation ($2.4 \pm 2.0$ versus $0.3 \pm 0.5$ admissions per year, $p < 0.001$).

Pacemaker follow-up (Fig. 4). A ventricular pacemaker (VVI) without rate response was implanted in 27 patients (65%), a ventricular pacemaker with rate response (VVI-R) in 8 patients (17.5%) and an AV sequential pacemaker (DDD) in 8 patients (17.5%).

During the follow-up period, 9 (33%) of the 27 patients with a VVI pacemaker underwent revision. One received a DDD and eight received a VVI-R pacemaker. The patient who received the DDD unit had complained of symptoms compatible with pacemaker syndrome with her VVI unit.

One of the eight patients with a VVI-R pacemaker had his unit replaced with a DDD unit because of the pacemaker syndrome. Two of the eight patients who initially received a DDD unit had it replaced by a VVI-R unit because of symptoms of supraventricular tachycardia caused with tracking of the atrial rate. Another two patients with a concealed accessory pathway and a DDD pacemaker had documented pacemaker-mediated tachycardia that could be avoided by prolonging the atrial refractory period. The
of note was the experience to date comes from the voluntary worldwide current catheter ablation has been documented. The largest successful induction of complete heart block using direct eventful generator replacement.

Two generators had to be reprogrammed to avoid pacemaker-mediated tachycardia.

remaining four patients with a DDD generator had their pacemaker programmed in the DDD mode during the follow-up period.

One patient had premature acute complete battery failure and developed symptoms of fatigue associated with an idioventricular rhythm of 40 beats/min and underwent uneventful generator replacement.

Discussion

In previous reports (1-4,11), marked variability in the successful induction of complete heart block using direct current catheter ablation has been documented. The largest experience to date comes from the voluntary worldwide registry (5) in which the incidence of chronic complete AV block was 64%. The present report suggests that centers performing a large number of these procedures should expect an efficacy rate in the range of 90%. Of note was the late development of complete AV block in two of six patients: in whom this procedure was originally unsuccessful. This finding suggests the need for long-term pacemaker support even in those patients without persistent complete AV block after ablation.

Changes in life-style before and after ablation. Kay et al. (12) reported an overall improved quality of life in 12 consecutive patients with paroxysmal atrial fibrillation who were assessed prospectively with a self-administered questionnaire before and 6 weeks after ablation. Changes in functional capacity correlated strongly with changes in treadmill exercise duration. In our present study, 88% of the patients who had permanent complete AV block reported improved activity levels. This improvement was more pronounced among patients without preexisting structural heart disease. This finding is in agreement with the suggestion of Kay et al. (12) that patients without underlying structural heart disease would benefit more than other groups from ablation therapy. It is also supported by the absence of a significant change in functional capacity, as assessed by the New York Heart Association classification, in patients with preexisting heart failure and structural heart disease.

Changes in myocardial function after catheter ablation. It is well appreciated that persistent tachycardia may result in myocardial dysfunction; less well documented is reversal of myocardial dysfunction after successful control of the arrhythmia. McLaran et al. (13) described four pediatric patients with supraventricular arrhythmias and depressed left ventricular ejection fraction who underwent serial echocardiographic investigations before and after pharmacologic control of their tachycardia. All four patients showed marked improvement in ejection fraction after their arrhythmia had been brought under control. Similarly, Packer et al. (14) described eight patients (aged 6 to 57 years) with incessant or frequent supraventricular arrhythmia and a depressed ejection fraction who underwent catheter or surgical ablation of the AV junction. Radionuclide angiography performed at baseline and early (5 to 14 days) and late (4 to 40 months) after ablation showed that the ejection fraction increased significantly soon after ablation. At late evaluation, a further although nonsignificant increase in ejection fraction was noted. Similar findings were reported by Gillette et al. (15) among 10 pediatric patients who underwent surgical ablation of ectopic atrial tachycardia foci.

A limitation of all these studies is that the ejection fraction was assessed at markedly different heart rates before and after ablation. For example, in the study of Packer et al. (14), only one of the eight patients was assessed at a comparable heart rate in the preablation and early and late postablation studies. Because it is well known (16) that ejection fraction diminishes with increased heart rate, it is difficult to draw any firm conclusions from these studies (13-16) regarding the long-term effect of supraventricular tachycardia on myocardial function.

In a preliminary report from our laboratory (17) of patients undergoing catheter ablation of the AV junction, we found no significant change in the mean ejection fraction before or after ablation. In the present review, we performed serial echocardiographic studies in five patients with a depressed ejection fraction; serial measurements were performed over a median of 34 months after ablation. A significant improvement in ejection fraction was found in four of the five patients, whereas in the fifth patient, the ejection fraction remained virtually unchanged. The heart rate at the two evaluations was virtually the same in four of the patients, and the changes in ejection fraction correlated well with changes in functional class.

Conclusions relative to changes in ejection fraction after...
Ablation remain tentative because serial echocardiographic studies were not available in four of nine patients with depressed left ventricular function at baseline. Our preliminary findings suggest the need for prospective evaluation of this important issue in a larger patient cohort.

Development of symptoms and objective signs of congestive heart failure after ablation occurred mainly in patients with either preexisting heart disease or with unsuccessful ablation, indicating that the ablative procedure itself rarely caused any short- or long-term myocardial dysfunction. Two patients without structural heart disease developed new onset of congestive heart failure during the follow-up period. In these patients, the arrhythmia may have been an early manifestation of a cardiomyopathic process. We cannot exclude the possibility that heart failure may have been due to the ablation procedure or to an unphysiologic activation pattern caused by ventricular pacing (18).

Adverse effects associated with ablation. In this study, three patients suffered serious complications in association with the ablative procedure. One patient with idiopathic cardiomyopathy died suddenly 2 weeks after a successful ablation. Autopsy showed marked fibrosis and inflammatory changes at the summit of the ventricular septum, which may have been the nidus for malignant ventricular arrhythmias. Data from the Percutaneous Cardiac Mapping and Ablation Registry (5) have documented eight episodes (1.8%) of sudden death among a total of 480 patients in whom mortality statistics are known. In all but one instance, these deaths occurred within 6 months after attempted ablation. However, the reported 1.8% incidence rate of sudden death emphasizes the importance of reserving this procedure only for patients with severe supraventricular arrhythmias who do not respond to conventional drug treatment.

One patient experienced an episode of nonsustained polymorphic ventricular tachycardia (torsade de pointes) 6 h after ablation. This arrhythmia was clearly initiated by bradycardia and has not recurred with consistent pacing at a rate of 80 beats/min. Nonsustained ventricular arrhythmias have been reported in 3.5% of patients undergoing direct current ablation in the Percutaneous Cardiac Mapping and Ablation Registry (5). Polymorphic ventricular tachycardia in three patients shortly after the ablation procedure during intentional pacemaker inhibition was recently reported (19).

One patient experienced transient symptomatic hypotension after ablation that required pressor support and one patient developed pericarditis with chest pain that resolved without treatment. Both these complications have been reported in the Percutaneous Cardiac Mapping and Ablation Registry report (5). Although only 2 of 47 patients received long-term anticoagulant therapy, only 1 patient developed systemic embolism. Of the 29 patients with chronic or paroxysmal atrial fibrillation or flutter who were followed up for 843 patient-months none developed systemic embolism. In contrast, other reports (20) of systemic embolism in patients with nonrheumatic atrial fibrillation suggest a projected incidence of two to three episodes of stroke for this group of patients.

Arrhythmic symptoms despite successful ablation. A new finding was the occasional occurrence of palpitation in almost 25% of patients who achieved chronic complete AV block. In these patients, repeat 24 h ambulatory ECG recordings showed that the symptoms were either due to premature ventricular complexes or were not associated with any arrhythmia disturbance. The latter finding may be expected in patients sensitized by long-term abnormalities in heart rhythm (21).

Choosing the optimal pacemaker mode after ablation. Our experience suggests that great care is needed in the choice of the cardiac pacing mode in patients who have had successful AV junction ablation. Approximately 20% of our patients who originally received a ventricular-inhibited (VVI) pacemaker had this unit replaced with a rate-responsive unit (VVI-R) because of symptoms related to a low exercise capacity. This finding is also in agreement with the work of Kay et al. (12), who noted improved exercise capacity after ablation in patients with paroxysmal atrial fibrillation who received a ventricular rate-responsive pacemaker after a successful ablation procedure.

Four of eight patients with an AV sequential (DDD) pacemaker had to have the unit replaced or reprogrammed either because of tachycardia associated with a concealed accessory pathway or because of tracking of faster atrial rhythms in the patients with persistent paroxysmal supraventricular tachycardia. This finding emphasizes that a dual chamber pacemaker probably should not be the first choice in patients who have undergone ablation because of supraventricular arrhythmias. However, in a subset of patients (for example, those with hypertrophic cardiomyopathy), the advantages of AV synchronous pacing may outweigh these disadvantages. These observations were made before availability of DDI-R mode programming, a mode of pacing that may be particularly effective for those with chronic complete AV block and recurrent paroxysmal supraventricular arrhythmias.

Summary and clinical implications. We report our long-term experience with catheter ablation of the AV junction in patients with drug-resistant supraventricular tachycardia. In contrast to previous reports, our success rate for achieving complete AV block with the catheter technique was 88%. The vast majority of patients, particularly those without organic heart disease, reported an improved quality of life after the procedure. In addition, we document a dramatic decrease in health care costs in terms of reduction in need for antiarrhythmic drugs as well as in need for hospitalization for cardiac-related problems.

Two observations related to heart rate control are particularly intriguing. In a limited subset of patients, the ejection fraction tended to increase in those with depressed...
left ventricular function at baseline, suggesting that improved rate control may reverse changes due to a tachycardia myopathy for at least some of our patients with left ventricular dysfunction. In addition, in the follow-up evaluation of 29 patients with paroxysmal or chronic atrial fibrillation, none with chronic AV block had systemic embolism, suggesting that rate control may be an important factor in preventing development of cardiac thrombus. Although no procedure-related deaths were detected, one patient died suddenly 2 weeks after ablation. Therefore, it should be emphasized that this procedure should be limited to patients with drug-resistant disabling arrhythmias. The recent introduction of radiofrequency energy for catheter ablation (22) might avoid some of the adverse effects seen with direct current ablation.

Long-term pacing should probably be initiated even for those with failed ablative attempts because in our experience, one-third (two of six) of these patients developed late AV block. Great care must be taken in the choice of the optimal pacing mode for these patients. Our current experience suggests that rate-responsive ventricular pacing seems adequate for most patients apart from those with largely intact sinus function who are dependent on AV synchrony for optimal cardiac function.

The clinical decision relative to choice of drug versus ablative therapy is individualized, taking into account symptoms (including need for resuscitation), response to prior drug therapy (including the risk of proarrhythmic effects), presence of associated cardiac disease and the patient's desire to be free of lifelong drug therapy. Balanced against the potential adverse effects and the need for long-term pacing after catheter ablation are the advantages of more consistent arrhythmia control, improved quality of life for the vast majority of patients, less expense relative to the cost of drugs, hospital and emergency visits and the possibility of improved cardiac output in those with depressed left ventricular function.

References

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