Permanent Pervenous Atrial Pacing
From the Coronary Vein
Long-Term Follow-Up

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SUMMARY
This report details our clinical experience during a 12 to 63 month follow-up period in 30 patients with permanent pervenous atrial pacemakers implanted in the coronary vein prior to May 1972. Indications for permanent atrial pacing included 20 patients with symptomatic sinus bradycardia, seven with atrial brady-tachy syndrome refractory to pharmacologic therapy, and three patients with atrial overdrive suppression for intractible ventricular arrhythmias. The average duration of atrial pacing was 29.2 ± 2.4 (SEM) months, median 24 months. A bipolar electrode was used in 28 patients and a unipolar system in two. The atrial signal was of sufficient amplitude (>1.5 mV) to permit atrial demand pacing when required. The atrial pacing threshold averaged 2.0 ± 0.2 ma initially and increased by less than 1.0 ma at the time of battery replacement 20 months later. Only four of 30 patients (13%) developed pacemaker related problems during the 879 pacing months of this follow-up period. Coronary vein perforation or thrombosis was not observed, and there were no pacemaker related deaths. The coronary vein provides a safe and effective electrode location for long-term permanent pervenous atrial pacing.

Additional Indexing Words:
Pacemakers  Brady-tachy syndrome  Sinus bradycardia  Ventricular tachyarrhythmias

The technique for pervenous atrial pacing through an electrode positioned in the coronary vein was introduced in 1968. This pacing method was originally intended for limited use in selected cases. With greater appreciation of the advantages of atrial pacing in the treatment of symptomatic atrial bradyarrhythmias and for overdrive suppression of recurrent ventricular irritability in the low output syndrome, the original uses of this technique have expanded.

Initially, because the authors were concerned about potential complications which might occur with a pacemaker electrode positioned in the coronary vein, only three patients had atrial pacing systems implanted in 1968. In 1970, our early follow-up experience in ten patients with atrial pacing for one to 30 months was reported, and the results were encouraging. Since that time, an additional 33 patients in the Rochester area have had permanent pervenous atrial pacemakers implanted, and the long-term results have been excellent. The purpose of this report is to summarize our clinical experience during the late (12-63 months) follow-up period in 30 patients who had atrial pacemakers implanted prior to May 1972 and who survived the first year of pacemaker implantation. Twelve patients who had pervenous atrial pacemakers implanted during the past year and one patient who died within the first year of implantation will not be included in this report because of the brevity of their follow-up.

Methods
Details of the method of implanting a permanent coronary venous atrial pacemaker have been described previously from this laboratory. Slight modification of the originally described technique has afforded easier access to the coronary vein. By using the left cephalic vein and placing a gentle 60° bend six cm back from the tip of the electrode and an additional "J" configuration at the electrode tip, the catheter is easily directed away from the tricuspid valve and into the
coronary sinus. Bipolar* and unipolar electrodes as well as fixed rate and demand generators* have been utilized for atrial pacing.

Results

The 30 patients who had atrial pacemakers implanted prior to May 1972 and were followed for a year or longer included 19 males and 11 females with a mean age of 67 years. Indications for permanent atrial pacing were symptomatic sinus bradycardia in 20 patients, atrial brady-tachycardia refractory to pharmacologic therapy in seven, and intractable ventricular arrhythmias in combination with low output state in three patients. The average duration of pacing was 29.2 ± 2.4 (SEM) months, median 24 months, with a range from 12 to 63 months. A bipolar electrode was used in 28 patients and a unipolar electrode in two patients.

The atrial pacing threshold and the P-R interval at the time of initial implantation and at the time of elective battery replacement are presented in table 1. The atrial pacing threshold increased less than 1.0 ma at the time of battery replacement 20 months after initial implantation; also there was a negligible change in the P-R interval.

The problems which have developed in patients in whom the pervenous atrial pacemaker systems have been implanted for more than a year are presented in table 2. One patient had the catheter electrode come out of the coronary vein 14 months after implantation with concomitant failure to pace. The electrode was repositioned in the ventricle. One patient developed progressive atrioventricular block with P-R interval prolongation. The patient required the hemodynamic benefit of atrial contraction and the unit was converted to a synchronous, atrioventricular system using the coronary vein electrode for atrial sensing. No patient developed a late (12-63 mo) failure to pace due to high threshold, but two patients developed intermittent atrial flutter-fibrillation with non-pacing during the fibrillatory activity. Three patients died during this 12-63 month follow-up, at 16, 17 and 40 months after implantation, all of non-pacemaker problems. Autopsy examination on two patients revealed patent coronary sinuses and veins without clot or perforation. In both cases the catheter electrode was adherent to the wall of the vein by endothelial sheaths which had formed about the catheter. To date, thrombosis or perforation has not been encountered in any patients.

The atrial electrogram was measured in 20 patients in whom atrial demand pacemakers were implanted. In each case, the bipolar atrial signal was greater than 1.5 mV and was sufficient to meet the threshold requirement for the Medtronic demand generators. Initially, demand generators with standard refractory periods of 200 to 240 msec were used. However, in two patients these units subsequently sensed their own generated QRS complex as the combined P-R interval and QRS width lengthened with time to a duration greater than the refractory period of the unit. The result was an inappropriate pacemaker bradycardia (fig. 1). More recently, demand generator units with refractory periods of 400 msec have been used,

Table 1

Atrial Pacing Threshold and P-R Interval

<table>
<thead>
<tr>
<th></th>
<th>Patients (number)</th>
<th>Pacing duration (mo)</th>
<th>Pacing threshold (ma)</th>
<th>P-R interval (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial implantation</td>
<td>30</td>
<td>29.2 ± 2.4</td>
<td>2.0 ± 0.2</td>
<td>0.18 ± 0.01</td>
</tr>
<tr>
<td>Battery replacement</td>
<td>16</td>
<td>20.3 ± 2.5</td>
<td>2.9 ± 0.1</td>
<td>0.19 ± 0.01</td>
</tr>
</tbody>
</table>

Values are mean ± SEM.

Table 2

Problems During Long-Term Pervenous Atrial Pacing

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refractory period bradycardia*</td>
<td>2</td>
</tr>
<tr>
<td>Atrioventricular block</td>
<td>1</td>
</tr>
<tr>
<td>Catheter dislodgement</td>
<td>1</td>
</tr>
<tr>
<td>Coronary vein perforation</td>
<td>0</td>
</tr>
<tr>
<td>Coronary vein thrombosis</td>
<td>0</td>
</tr>
<tr>
<td>High threshold</td>
<td>0</td>
</tr>
<tr>
<td>Pacemaker-related deaths</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
</tr>
</tbody>
</table>

*See text for explanation.

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The significance of the duration of the refractory period of atrial demand pacemakers. Top: With a standard generator refractory period of 220 msec, the QRS produced by atrial pacing is sensed and the effective rate is equal to the automatic rate (860 msec) plus the refractory period duration (220 msec). Bottom: With a long generator refractory period of 400 msec, the QRS produced by atrial pacing falls within the long refractory period of the unit; the effective rate equals the automatic rate.

Discussion

This report substantiates the safety of permanent venous atrial pacing from the coronary vein for periods as long as five years. The potential problems of electrode dislodgment, perforation, thrombosis and significant increase in threshold have not materialized. The long-term success with this approach requires careful case selection. At the time of initial electrode implantation, the threshold for atrial pacing should be less than 3.0 ma. With higher implantation thresholds, inconstant pacing has developed early in the clinical course. Also, this technique should not be used in patients who show evidence of atrioventricular conduction disturbance. Patients with sinus node disease and atrial bradycardia are prime candidates for atrial pacing, yet this group is quite susceptible to atrioventricular node disease, trifascicular block, or both. As a precautionary measure, atrial tachypacing at rates of 130-140 beats per minute should be carried out to test the adequacy of atrioventricular conduction. If the P-R interval prolongs to greater than 0.24 sec or if bundle branch block or bifascicular block develops during tachypacing, an atrial pacemaker should not be implanted.

In an earlier communication, the short-term results with permanent venous atrial pacing were reported. Two of 14 patients in whom this technique was attempted developed inconstant pacing within the first week of implantation due to high threshold. Both of these patients had thresholds for pacing in excess of 5.0 ma at the time of implantation. Two other patients required early electrode repositioning due to unsuccessful atrial pacing. The long-term follow-up results as reported herein are most favorable. Only four of 30 patients (13%) developed pacemaker related problems during the 879 pacing months of this follow-up period. Thus, the combined early and late results substantiate not only the benignity but also the high degree of reliability of the technique for long-term atrial pacing.

A limited number of reports have appeared in the literature on long-term pacing of the heart from electrodes located in the coronary sinus. In 1967, Siddons and Sowton commented on their experience and noted a rapid rise in the threshold requirements for ventricular pacing in patients in whom electrodes were inadvertently positioned in the inferior coronary vein. However, other investigators have described successful long-term ventricular pacing from the coronary vein. Kitamura, Jorgensen and From have reported a case in which a temporary infusion-pacing catheter perforated the coronary vein and produced an infusion tamponade in the pericardial cavity. The authors are also aware of one other similar occurrence in an unreported case (R. Easley, personal communication). Although isolated cases of successful atrial pacing from electrodes positioned in the coronary vein have been noted by other investigators, a systematic long-term follow-up study has not been previously reported.

During the past eight years, placement of atrial electrodes without thoracotomy has been accomplished using a number of different techniques. In 1965, Carlens et al. described the application of an electrode onto the epicardial surface of the atrial wall through a mediastinoscope. Follow-up results with this approach have been promising.
Smyth and associates,14 Kastor et al.15 and Costello and coworkers16 have used pervenous J-shaped electrodes positioned in the right atrial appendage for atrial sensing and pacing, but late dislodgement has been a problem. More recently, Zucker, Parsonnet and Gilbert have had better success with this approach. Other techniques for pervenous right atrial pacing have included the use of electrodes with barbs or hooks for fixation,18 but these electrodes are potentially dangerous and have not gained general acceptance.

This study indicates that a coronary venous site for atrial pacing may be safely utilized in patients with symptomatic sinus bradycardia. However, atrial pacing is especially indicated in the subgroup of patients with sinus bradycardia complicated by relative hypotension, or low cardiac output. This group of patients has responded most dramatically to atrial pacing since the hemodynamic benefit of synchronized atrial contraction is maintained. The favorable long-term results with the pervenous coronary venous technique provides a broader armamentarium for therapeutic intervention in the management of patients with complex arrhythmias. For example, recent studies have demonstrated that atrial pacing and tachypacing on demand may be useful in terminating recurrent supraventricular tachycardias intractable to standard medical management.19,20 Such techniques have been used with temporary pacemakers. The presently described technique makes long-term pervenous atrial demand pacing a realistic approach for the management of refractory or recurrent atrial tachycardias. This atrial technique would be analogous to the ventricular demand pacemaker approach which has been used successfully in the treatment of recurrent tachycardia associated with the pre-excitation syndrome.21

Acknowledgment

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