Permanent Pervenous Atrial Synchronized Ventricular Pacing

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SUMMARY
Permanent pervenous atrial synchronized ventricular pacing was successfully accomplished in three patients. Atrial sensing was obtained from an electrode positioned in the coronary vein. Atrial electrograms with P waves greater than 1.5 mv were present in all three cases. Ventricular stimulation was accomplished through a separate electrode placed in the right ventricular apex. The left cephalic vein admitted both catheters, and the two electrodes were connected to an implantable P wave synchronized unit. The beneficial hemodynamic effects of atrial synchronized ventricular pacing were clinically evident. This new pervenous technique provides an optimal method of synchronized pacing in patients with heart block, intact sinoatrial activity and significantly compromised cardiac function.

Additional Indexing Words: Pacemaker Heart Block Synchronous pacing Double electrode pacemakers

Since the introduction of implantable pacemakers for the treatment of heart block in 1960, ventricular pacing either by epicardial or pervenous endocardial electrodes has been the dominant modality of therapy. In the majority of patients with heart block, loss of synchronized atrial beats during ventricular pacing has not caused hemodynamic difficulty. Nevertheless, there are patients with significant underlying heart disease and atrioventricular block who would benefit from atrial synchronized ventricular pacing. Hemodynamic advantages include atrial contraction filling of the ventricle just prior to its contraction (atrial "kick"). Appropriate closure of the atrioventricular valves and maintenance of sinus dominated rhythm.

Until recently, P wave synchronized pacemakers required either a thoracotomy or mediastinoscopy for stable atrial electrode attachment. Pervenous techniques have been employed, but instability of the atrial electrode has been a problem. During the past three years, the authors have used a pervenous coronary vein electrode location for atrial pacing and the stability and long-term follow-up results of this approach have been excellent. As a result of this experience, the feasibility of pervenous atrial synchronized ventricular pacing became apparent.

The present report describes the effective use of pervenous atrial synchronized ventricular pacing in three patients. Atrial sensing was obtained from an electrode positioned in the coronary vein, and ventricular stimulation was accomplished through a separate pervenous electrode in the right ventricular apex. These two electrodes were connected to an implantable P wave synchronized generator.

Methods
In each of the three cases to be described, electrode catheters were inserted into the coronary vein and right ventricular apex via the left cephalic vein. Three different atrial sensing catheters were employed: a Medtronic bipolar electrode catheter (model 5818) in case 1, a specially designed Cordis' coronary vein electrode catheter in case 2, and a Cordis unipolar uncuffed electrode catheter (model 322B) in case 3. In each case, the length of the coronary vein was explored with the transvenous electrode for maximal amplitude of the P wave on the atrial electrogram (fig. 1). Atrial electrograms with P waves greater than 1.5 mv were obtained in all cases. Cordis unipolar cuffed electrodes (model 322) were used for ventricular pacing. Cordis Atricor and Atricor Jr. generators were utilized for synchronized pacing. The atrioventricular time delay of these units is 120 msec. The atrial and ventricular electrodes were connected to the Atricor unit through a special adapter containing a 7500 ohm resistance.

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Received January 15, 1973; revision accepted for publication March 5, 1973.

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adapter permitted atrial or ventricular sensing, whichever occurred first, following a 360 msec (280 msec for Atricor Jr.) refractory period delay after discharge of the unit. The 7500 ohm resistor between the atrial and ventricular terminals distributed the overwhelming fraction of the pacing stimulus to the ventricular electrode. An Atricor Jr. (model 133C7) unit with synchronous rates from 70 to 150 beats/min was used in case 1, an Atricor (model 133A6) in case 2, and a high sensitivity Atricor (model 145G6) unit with atrial sensing threshold of 0.5 mv in case 3. In each case, the Atricor generator was implanted subcutaneously in the left pectoral region. Postimplantation chest films (fig. 2) and electrocardiograms (fig. 3) were obtained in all cases.

Case Reports

1. A.P. (SMH #51-56-50) is a 74 year old woman with intermittent atrial brady-tachy syndrome. A permanent pervenous atrial pacemaker was implanted in August, 1969 with a Medtronic bipolar electrode positioned in the coronary vein. The atrial stimulation threshold was 2.1 mamps and effective atrial pacing was maintained until May, 1972 when significant atrioventricular block developed. The atrial electrode could not be removed from the coronary vein. A Cordis unipolar electrode was inserted into the right ventricular terminals of a Cordis Atricor Jr. synchronous pacemaker. Atrial synchronized ventricular pacing occurs when the sinus rate is above 70 beats/min and demand ventricular pacing ensues at this rate when the sinus rhythm is slower. The patient continues to do well nine months after the synchronized unit was implanted.

2. N.V. (SMH #35-43-89) is a 76 year old man with severe aortic stenosis and congestive heart failure. Aortic valve replacement was performed on October 2,
1972 and temporary transthoracic myocardial pacing wires were applied prior to closure of the thoracotomy. On the fourth postoperative day progressive atrioventricular block developed and ventricular pacing via the temporary wires resulted in relative hypotension (90/60 mm Hg). Systolic blood pressure was augmented by 30 mm Hg when P-R intervals of 0.12-0.20 sec preceded ventricular paced beats. On October 7, 1972 a pervenous atrial synchronized ventricular pacemaker was implanted using a Cordis Atricor generator (Figs. 2 and 3). The blood pressure stabilized at 120/80 mm Hg and the patient has subsequently done well.

3. V.K. (SMH #17-55-92) is a 73 year old man with cardiomyopathy, borderline compensated congestive heart failure and relative hypotension (90/70 mm Hg). The ECG reveals left bundle branch block, left axis deviation and P-R interval prolongation of 0.24-0.28 sec. On October 10, 1972 intermittent Wenckebach block developed with increased congestive heart failure. Digoxin was withheld, but the atrioventricular block persisted. On October 17, 1972 a pervenous atrial synchronized ventricular pacemaker was implanted using a Cordis Atricor high sensitivity generator. The patient has subsequently done well with stabilization of his cardiac rhythm and improvement of his heart failure.

**Discussion**

In each of the three cases, atrial sensing was accomplished from an electrode positioned in the coronary vein. Prior experience indicates that this electrode location is not only stable and safe, but also is associated with effective atrial sensing during long-term follow-up. To date, a late rise in threshold for atrial stimulation, erratic atrial sensing, perforation and thrombosis have not occurred in 42 patients with pervenous electrodes positioned in the coronary vein for an average duration of 26 months.

The hemodynamic advantages of atrial synchronized ventricular pacing in a select group of patients with heart block and impaired cardiac performance are obvious. Although not quantitatively substantiated in the three current cases, numerous animal and human studies1-3, 12-14 have demonstrated significant improvement in cardiac function with atrial synchronized ventricular contractions. In addition, the maintenance of spontaneous sinus dominated rhythm permits appropriate rate adjustment for the fluctuating demands of varying activity. The beneficial hemodynamic effects of atrial synchronized ventricular pacing were clinically evident in cases 2 and 3.

This implantation procedure is somewhat more involved than that required for standard pervenous ventricular pacing. Two electrodes are required and manipulation of the catheter into the coronary sinus may be time consuming. Recently, by using the left cephalic vein and placing a 60° bend six cm back from the tip of the coronary vein electrode, entry into the coronary sinus has been markedly facilitated. To date, the left cephalic vein has admitted both catheters, but this may not always be the case. In such situations, use of both cephalic and external jugular veins may be required.

The synchronized generator utilized in these patients is a commercially available unit which was originally designed for transthoracic atrial and ventricular electrodes. The use of pervenous electrodes does not alter or compromise the function of this generator. The only modification that was made was the addition of a 7500 ohm resistor between the atrial and ventricular terminals of the adapter connecting the electrodes to the generator. This 7500 ohm resistor does not influence reception of atrial activity from the coronary sinus electrode; rather, it allows the generator to sense 70% of the signal of an incoming ventricular premature beat through the ventricular electrode. Also, this resistor distributes 94% of the output of the generator stimulus to the ventricular electrode with minimal dissipation through the atrial coronary sinus electrode. Thus, the 7500 ohm resistor optimizes both atrial and ventricular sensing as well as ventricular pacing.

The Cordis Atricor pulse generators have been in use since 1963, and they are so designed that physiologic maximal and minimal rates are established when atrial input signals above or below these limits occur. If the atrial potential is inadequate to trigger the pacemaker, such as might occur with atrial asystole, atrial fibrillation or low voltage atrial P waves, the synchronized generator will automatically function as a fixed-rate ventricular pacing unit. If a ventricular premature beat occurs, the VPB signal would be sensed and the unit would discharge 120 msec later. Such a discharge would be in the absolute refractory period of the ventricular depolarization, well before the vulnerable period of the relative refractory period. Complex arrhythmias which may occur with atrial synchronized pacemakers are well described in the literature.15

Recently, two other pervenous double-electrode pacing systems have been described. Sequential atrioventricular pacing was used by Chamberlain et al. in the management of heart block complicating acute myocardial infarction.16 Twin stimuli were used to pace both the right atrium and right ventricle sequentially by means of an external
generator. The restoration of normal atrioventricular relations resulted in significant beneficial changes in cardiac output, arterial pressure and venous pressure. Castillo et al. have reported the successful use of an implantable "bifocal" demand pacemaker in three patients. This modality of electrical stimulation combines QRS-inhibited ventricular demand pacing with QRS-inhibited atrial demand stimulation. The generator senses the ventricular electrogram and sequentially paces the atrium and ventricle on demand. This approach may be useful for combined atrial bradycardia and atrioventricular block, but only limited follow-up results have been reported. Both of these double-electrode pacemaker systems stimulate the atrium as well as the ventricle. The synchronized unit utilized in the present report does not stimulate the atrium. Rather, it synchronizes ventricular pacing from a sensed atrial signal or else functions as a ventricular demand pacemaker when the ventricular rate falls below a preset limit.

Although the results with the present technique have been most satisfactory, the authors do not recommend this approach for the routine management of patients with heart block. This perversus atrial synchronized ventricular pacing technique is specifically indicated for patients with heart block, intact sinoatrial activity and impaired function since they would benefit from atrial synchronized contractions and maintenance of physiologic sinus rhythm.

Acknowledgment

The authors deeply appreciate the help and cooperation of Drs. William Murphy, Jr. and Peter Tarjan of the Cordis Corporation and thank Elizabeth Tifft for her secretarial assistance.

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Circulation. 1973;48:37-40
doi: 10.1161/01.CIR.48.1.37
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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