position of the left lung became difficult, the bronchial cuff balloon was noted to be tense, and 4 to 5 ml of air were removed from the balloon at that time. In both cases, perhaps greater vigilance to the filling of the bronchial balloon cuff and the pressure it developed could have prevented rupture.

From our experience and that of others, we would make the following recommendations relating to the use of double-lumen tubes. First, in spite of the increased ease of intubation and placement of the PVC double-lumen tubes, extreme care regarding its use must be exercised. The wire stylet should be removed immediately after inserting the tip of the balloon past the vocal cords. If the bronchial cuff fails to seal with a small volume (2 to 3 ml) of air, the tube position should be reevaluated. Both tracheal and bronchial cuffs should be deflated before repositioning the tube. Second, the bronchial balloon should be inflated only while actually on one-lung anesthesia. After checking for position and after being inflated, the inflation balloon should be checked frequently to avoid overdistention by diffusion of nitrous oxide if that agent is being employed. Finally, ensuring the integrity of the intubated bronchus is mandatory if there are any difficulties in ventilating or if other unusual findings become manifest during the case.

In spite of the potential risks, it is our feeling that if these precautions are observed, PVC double-lumen tubes can be a safe and very helpful adjunct for most thoracic surgical procedures.

REFERENCES

1 Bjork VO, Carlens E, Friberg O. Endobronchial anesthesia. Anesthesiology 1953; 14:60-72
9 Heiser M, Steinberg JJ, MacVaugh H, Klineberg PL. Bronchial rupture, a complication of the use of the Robertshaw double-lumen tube. Anesthesiology 1979; 51:88
11 Bernhard WN, Yost LC, Turndorf H, Cottrell JE, Paegl RD. Physical characteristics of and rates of nitrous oxide diffusion into tracheal tube cuffs. Anesthesiology 1978; 48:413-17

A Combined Atrial/Ventricular Lead for Permanent Dual-Chamber Cardiac Pacing Applications*


A new urethane insulated dual unipolar atrial/ventricular transvenous lead has been developed to facilitate implantation of permanent dual-chamber cardiac pacing systems in man. The atrial portion of the lead has tines and is designed to retain a permanent J configuration, while the coaxially situated ventricular lead is freely and independently adjustable and incorporates a ring tip electrode with four urethane tines. Our initial experience with the dual lead in one patient is reported herein and suggests that combined atrial/ventricular pacing leads are feasible and may obviate need for implantation of two separate pacing electrodes in patients being considered for permanent dual-chamber pacing.

Recently, advances in the design of both implantable pulse generator and lead systems have made permanent dual-chamber cardiac pacing a practical alternative to conventional ventricular pacing techniques. As a result, the potential hemodynamic advantages of more physiologic pacing methods can be made available to many patients being considered for implantation of permanent cardiac pacemakers. The purpose of this report is to describe a combined atrial/ventricular permanent pacing lead (Medtronic model 1X716 dual unipolar atrial/ventricular lead), with which it is possible to achieve pacing and sensing in both the atrium and ventricle with a single lead inserted by percutaneous technique.

DESCRIPTION OF DEVICE

The dual atrial/ventricular pacing lead is a coaxial device with mutually adjustable unipolar atrial and ventricular leads (Fig 1). The atrial J is formed by a nickel alloy memory coil which is electrically inactive. A urethane insulated low-resistance silver/nickel-alloy (DBS) composite wire forms the atrial lead conductor. This is positioned outside the memory coil within another layer of urethane insulation. An 11-mm canted platinum-iridium electrode is located at the tip of the atrial J, close to three short polyurethane tines. The unipolar urethane-insulated DBS ventricular lead slides within the memory coil in a coaxial manner. Its distal tip has an 8-sq mm platinum-iridium ring electrode and four urethane tines.

The combined circumference of the atrial and ventricular segments is equivalent to No. 12 Fr when the leads are positioned as in Figure 2(top panel). Consequently, the device can be inserted using available conventional introducer techniques. The connector terminal of the dual lead has a standard pin for the atrial connector, but the

*From the Departments of Medicine, Surgery, and Pediatrics, University of Minnesota Hospitals, and Medtronic Inc, Minneapolis.
†Assistant Professor of Medicine.
‡Associate Professor of Pediatrics.
§Senior Leads Engineer, Medtronic Inc.
∥Instructor in Medicine.
¶Professor of Surgery.
Reprint requests: Dr. Benditt, Box 341, Mayo Building, University of Minnesota Hospitals, Minneapolis 55455
ventricular lead slides through a hollow silicone rubber terminal assembly. A groove in the silicone terminal sleeve accepts an O ring that fixes the ventricular lead in place. Prior to lead insertion, stylets are positioned to stiffen the ventricular lead and straighten the atrial J. Following implantation (to be described), with proper thresholds and signal sensing verified, the O ring is pushed into place. The ventricular lead proximal to this silicone sleeve is cut to the same length as the atrial pin (Fig 3). The terminal assembly is then inserted in the generator connector box, using the exposed section of ventricular lead as a terminal pin. Set screws are fixed to the atrial terminal pin and the ventricular lead segment.

CASE REPORT

A 52-year-old white man, who had had a secundum atrial septal defect closed at the age of 36 years, was referred for evaluation of symptomatic bradycardia-tachycardia syndrome. Medical management had been successful in controlling recurrent episodes of atrial fibrillation, but at the expense of inducing profound sinus bradycardia associated with fatigue during moderate exertion.

Electrophysiologic study in the absence of all medications revealed a sinus cycle length of 1,290 msec (47 beats per minute), a P-A interval of 50 msec, an atrio-His (A-H) interval of 70 msec, and a His-ventricle (H-V) interval of 45 msec. One-to-one atrioventricular conduction was present between paced cycle lengths of 1,000 msec.

**FIGURE 2.** A (top), Distal end of atrial/ventricular pacing lead with stylets in place. Two components of lead are in close apposition. B (bottom), Distal end of atrial/ventricular pacing lead with atrial stylet removed. Atrial component has assumed its permanent J configuration.

**FIGURE 3.** Proximal end of atrial/ventricular pacing lead. Atrial portion and atrial lead connector pin are at left. Ventricular portion with O ring slipped onto connector sleeve at third most proximal sealing ring is shown at right. Ventricular lead proximal to connector sleeve is cut to same length as atrial connector pin (hatched line). (60 beats per minute) and 400 msec (150 beats per minute). Over this pacing range the A-H interval increased from 60 to 120 msec, while the H-V interval remained relatively constant (45 msec). Ventriculoatrial conduction was not present at ventricular pacing cycle lengths less than 900 msec.

**Lead Implantation**

In view of this patient's predisposition to symptomatic drug-induced bradycardia, implantation of a permanent pacing system was indicated. Furthermore, since suppression of the paroxysmal episodes of atrial fibrillation had been successful, use of either an atrial demand (AAI) or atrioventricular sequential (DVI) pacing mode was feasible.

Following careful discussion with the patient, informed consent was obtained to use the dual unipolar atrial/ventricular pacing lead. At surgery a right subclavicular pacemaker pocket was fashioned. Although the dual lead may be implanted by conventional subclavian venous technique, an internal jugular venous approach was selected in this patient. Consequently, the right internal jugular vein was isolated at a point adjacent to the body of the sternocleidomastoid muscle. A venotomy incision was made; and the dual unipolar lead, with stylets in place to maintain both tips straight and in close opposition (Fig 2, top panel), was passed into the internal jugular vein using a disposable vein lifter. Under fluoroscopic control the dual lead was advanced so that the distal (ventricular) lead tip was in the right atrium just above the tricuspid valve. The stylet was partially withdrawn from the ventricular portion of the lead, and with the atrial lead held fixed the ventricular lead was then passed across the tricuspid valve and positioned at the right ventricular apex. The ventricular stylet was removed, and adequacy of ventricular pacing thresholds and recorded R-wave amplitude were determined using a pacing system analyzer. Following completion of placement of the ventricular segment, the atrial stylet was then partially withdrawn to allow the atrial portion of the lead to assume its natural J shape (Fig 2, bottom panel). The atrial segment could then be manipulated independently of the ventricular component and was maneuvered anteriorly and medially until lodged in the right atrial appendage.

After both segments of the dual lead were positioned, an O ring was positioned over the silicone sealing ring to fix the ventricular lead in position, after which the ventricular lead proximal to the silicone sealing sleeve was cut to the same length as the atrial pin (Fig 3). The proximal portion of the dual lead was tunneled to the pacemaker pocket, where the lead terminal assembly (ie, the cut ventricular lead and the atrial connecting pin) is designed to be

**Combined Atrial-Ventricular Lead (Benditt et al)**
inserted into the pulse generator connector blocks. The set screw has been fabricated to cut through the urethane insulation of the ventricular lead to secure electrical contact.

The electrogram (P wave) recorded from the atrial segment of the dual lead was 2.0 mV, while the atrial pacing threshold at 0.5-msec pulse width was 0.6 V and 1.2 mamp. The ventricular lead electrogram (R-wave) was 3.7 mV, and the ventricular pacing threshold at 0.5-msec pulse width was 2.4 V and 7.0 mamp.

The atrial/ventricular lead in this patient has been observed for 16 months by clinical examination, chest x-ray films, and ambulatory electrocardiographic recording. Electrode position has remained stable, and both sensing and pacing functions have been normal. The patient has had no symptoms related to either tachyarrhythmias or bradycardia during this period.

DISCUSSION

As a result of technologic advances in pulse generator capabilities in conjunction with reduction of the size of the device, the implantation of pacing systems capable of sensing and stimulating in both the atrium and ventricle is now clinically practical, but presently requires insertion of two separate pacing electrodes. Consequently, a combined single-pass atrial/ventricular pacing lead was designed, and experience with its initial application is reported herein.

It is generally accepted that the most important drawback to use of physiologic dual-chamber pacing techniques was overcome with the development of tined and untined J leads, transvenous “screw-in” leads, and coronary sinus leads for use with atrial pacing systems. In addition, the wide application of both unipolar pacing systems and urethane-insulated permanent pacemaker leads has played an important role in reducing the diameter of permanent pacemaker leads, thereby facilitating use of multiple lead systems in patients. Nonetheless, despite these technologic improvements and the description of several relatively straightforward techniques for insertion, the placement of two separate pacing electrodes can present a problem in some patients.

The combined atrial/ventricular pacing lead described herein combines the advantages of a tined atrial J lead with those of a relatively thin flexible urethane-insulated permanent pacing electrode. The ventricular component of the dual lead is designed to slide freely through the surrounding atrial segment, so that each may be positioned relatively independently; however, it should be pointed out that care must be taken with insertion of stylets, since a crimped stylet will result in binding of the coaxial leads, thereby making positioning more difficult to achieve.

A potentially important limitation with single atrial/ventricular pacing leads should be pointed out. In the event that malfunction of one portion of the lead requires its removal, it would be necessary to remove both atrial and ventricular segments. Alternatively, the unit could be left in position, and a single conventional urethane electrode could be positioned as necessary.

In summary, single-pass permanent dual atrial/ventricular pacing leads are feasible and may be useful in patients being considered for dual-chamber pacing systems, thereby obviating the need for two separate pacing electrodes.

ACKNOWLEDGMENT: We thank Ms. Wendy Markson for assistance in preparation of the manuscript.

REFERENCES

2. Ogawa S, Dreifsus L, Shenoy FN, Brockman S, Berkovits BV. Hemodynamic consequences of atrioventricular and ventricular atrial pacing.PACE 1978; 1:8-15