Ventricular Tachycardia Produced by a Normally Functioning AV Sequential Demand (DVI) Pacemaker With “Committed” Ventricular Stimulation

RICHARD M. LUCERI, MD, ANTONIO V. RAMIREZ, MD, AGUSTIN CASTELLANOS, MD, FACC, LIAQAT ZAMAN, MD, RICHARD J. THURER, MD, FACC, ROBERT J. MYERBURG, MD, FACC

Miami, Florida

A case of recurrent ventricular tachycardia produced by an asynchronous ventricular stimulus of a normally functioning “committed” atrioventricular (AV) sequential demand (DVI) pacemaker is described. The characteristics of these units are compared with those of the "noncommitted" type of AV sequential pacemaker. Caution is suggested in the use of committed DVI pacemakers in situations where ventricular vulnerability may occur.

A variety of pacemaker-induced arrhythmias has been observed with the introduction of new cardiac pacing modes (1). With the advent of atrioventricular (AV) sequential demand (DVI) pacemakers, the electrocardiographic features associated with their normal operation have been studied and reported (2). In this report, we describe an abnormal event: the induction of ventricular tachycardia by a normally functioning DVI pacemaker.

Case Report

A Cyberlith IV model 259-01 (Intermedics, Incorporated), pacemaker was implanted at a community hospital in an 81 year old woman with congestive heart failure and syncopal attacks related to documented bradycardia. Tachyarrhythmias were not previously observed. The clinical findings included a third heart sound, bilateral pulmonary rales and evidence of cardiomegaly. The heart rate was generally between 40 to 50 beats/min with occasional sinus pauses indicative of sick sinus syndrome. After temporary transvenous pacing was initiated, the patient was treated with digitalis and diuretic drugs. The permanent pacemaker was implanted on the second hospital day. Pacemaker variables were within acceptable limits. Postimplantation electrolytes were normal. Serum digoxin and potassium levels obtained during the period of the observed ventricular arrhythmias were within normal limits.

This pacemaker is a multiprogrammable unipolar AV sequential (DVI,M) unit with "committed" ventricular stimulation. The latter implies that although an intraventricular signal may be sensed, the pacemaker is committed to deliver ventricular stimuli after each atrial stimulus. In the absence of an atrial emission, ventricular stimulation cannot occur—the so-called all or none phenomenon. By design, the pacemaker "absolute" refractory period begins with the delivery of the atrial spike, therefore extending for 332 ms, which is the sum of the fixed AV interval of 155 plus 177 ms (3).

Figure 1 (monitoring lead equivalent to aVL on the conventional electrocardiogram) depicts dual chamber pacing at a rate of 72/min corresponding to an AA interval of 830 ms. The AV interval is 155 ms. The two ventricular premature complexes occurring in this strip were normally sensed and recycled the pacemaker. Thus, the AA interval encompassing the premature ventricular complexes is less than twice the basic AA interval (1,620 versus 1,660 ms). Although the instant at which the pacemaker sensed the ventricular extrasystoles could not be determined from the surface electrocardiogram, the escape intervals were longer than the basic AV intervals, presumably because of "built-in" rate hysteresis.

In Figure 2, the top strip shows normal AV sequential pacing. The middle strip shows a ventricular extrasystole having a slightly longer coupling interval than those in Figure 1. Because the instant of sensing would have occurred later, an expected atrial spike delivered at the onset of the ectopic beat is followed by an obligatory ventricular spike toward the end of the wide Q wave. The AA interval equals the basic interval and the pacemaker is not recycled by ventricular sensing. The ectopic complex in the bottom strip of Figure 2 had a shorter coupling interval. Again, the atrial stimulus occurred before sensing, this time being delivered further into the QRS complex (pseudo-pseudofusion). The obligatory ventricular spike fell at the beginning of the ST segment, within the so-called vulnerable period producing, with some degree of la-
Figure 1. Monitor lead (M) (equivalent to aVL) showing normal sensing of two premature ventricular complexes (PVC). AA interval = 830 ms.

tency, the expected ventricular complex as well as a repetitive response.

In Figure 3, episodes of uniform or polymorphic ventricular tachycardia are shown, all occurring exclusively when committed ventricular stimuli fell in the latter part of wide QRS complexes. When ventricular spikes fell outside of the “sensitive” zone, repetitive responses did not occur. These occurred on multiple occasions. Clinical spontaneous ventricular tachycardia, unrelated to pacing, was not observed in this patient. These arrhythmias occurred intermittently over several hours. One episode of tachycardia degenerated into ventricular fibrillation from which the patient could not be resuscitated.

Discussion

The occurrence of pacemaker-induced ventricular tachycardia/fibrillation is well documented (4–6), although its frequency remains unknown. Most reported cases are related to the ventricular stimulus falling on or near the peak of the T wave. Asynchronous (VOO) pacing in competition with normal sinus beats or extrasystoles has usually been incriminated. With the advent of R wave-inhibited (VVI) pacemakers, ventricular sensing usually prevented delivery of a stimulus during the ventricular vulnerable period. The present case uncovers problems of a similar nature, related to normal operation of a newer, sophisticated AV sequential (DVI) pacemaker.

Committed versus noncommitted DVI pacing. Depending on design, there are two principal types of ventricular stimulation in DVI pacing. Noncommitted DVI pacemakers are bipolar units in which the atrial escape intervals are initiated by a ventricular output. They are capable of sensing nonpaced ventricular events after atrial output. This ensures that a ventricular stimulus will be delivered only in the absence of ventricular sensing.

In contrast, committed DVI pacemakers are unipolar units that render the total AV interval refractory, thus committing the ventricle to asynchronous stimulation after an atrial emission. This design has permitted the rapid manufacture of smaller units with simplified circuitry. The fixed refractory period is intended to avoid the potential hazard of ventricular capture during the vulnerable period. The present case, however, demonstrated that this concept may not always be valid. Although the incidence of committed ventricular stimuli producing high grade ventricular arrhythmias is unknown, it is not unreasonable to suspect its occurrence in clinical settings similar to the index case. Furman and Cooper (7) recently reported a comparable case of atrial fibrillation produced by a stimulus in the atrial vulnerable period. In fact, any device that interrupts ventricular stimulation may fail to detect a spontaneous ventricular depolarization and thus result in stimulation during the vulnerable phase.

Mechanism of ventricular tachycardia. There are several possibilities to explain the induction of ventricular tachycardia by the ventricular paced stimulus, the most likely of which is vulnerability. It is well known that sensitivity of the myocardium to stimulation changes in relation to the cardiac cycle. In diastole, myocardial threshold for stimulation is lower than in the relative refractory period. However, stimulation thresholds will change in the presence of infarction, ischemia, drug therapy or electrolyte distur-
Figure 3. Continuous strips showing several episodes of similarly coupled non-sensed premature ventricular complexes resulting in ventricular (V) stimulation causing repetitive responses and ventricular tachycardia. Cardioversion terminated one episode of ventricular tachycardia in the bottom strip.

abnormalities. Further analysis is recommended 1) to attempt to estimate the frequency of pacemaker-induced ventricular arrhythmias with committed DVI pacing, and 2) to establish eventual guidelines for reprogramming such pacemakers in clinical situations that predispose to heightened ventricular vulnerability. The ability of a dual chamber pacing system to monitor ventricular events after atrial emission (that is, absence of committed stimulation and blanking) may contribute to the maintenance of true AV synchrony and avoid competitive ventricular stimulation.

References