

Paradoxical undersensing due to quiet timer blanking

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A case of undersensing of atrial activity by a dual chamber pacemaker is presented. Programming to more sensitive voltages exacerbated undersensing, and programming to less sensitive levels resolved the undersensing. The mechanism by which pacemaker sense amplifiers function to create apparent paradoxical undersensing is reviewed.

KEYWORDS Pacemaker; Undersensing; Malfunction

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Inappropriate sensing of atrial and ventricular electrical activity is a common cause of pacemaker malfunction and is routinely screened for during pacemaker clinic visits. Undersensing is typically resolved by programming the voltage level required for sensing to lower, ie, more sensitive, levels. This report discusses a situation in which, paradoxically, undersensing was resolved by programming the voltage level required for sensing to higher, ie, less sensitive, levels.

Case report

A 65-year-old male with a history of paroxysmal atrial fibrillation and atrial flutter underwent implantation of a Medtronic Kappa 703 DR (Medtronic Corporation, Minneapolis, MN) dual-chamber pacemaker because of bradycardia and syncope.

Several years later, he presented with paroxysmal rapidly conducted atrial arrhythmias that proved refractory to medical therapy. Radiofrequency ablation of the atrioventricular (AV) conduction system was performed without difficulty. His atrial rhythm at the time of the procedure was flutter; his pacemaker was programmed to VOO during the ablation and to DDD 90 to 120 beats per minute afterwards with mode switch on with a detect rate of 175 bpm. Programmed parameters are shown in Table 1.

The day following the procedure, occasional atrial pacing indicating failure of atrial sensing was noted on bedside

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monitor; the atrial sensitivity was set at .5 mV bipolar (Figure 1). Atrial sensitivity was set to .35 mV; undersensing was exacerbated and the frequency of atrial pacing increased (Figure 2). Entering and exiting mode switch did not affect this behavior. With atrial sensitivity at .25 mV, there was total loss of atrial sensing and failure to mode switch (not shown). Atrial sensitivity was programmed to 1.0 mV and nearly complete atrial sensing was noted (Figure 3). P wave amplitudes measured 4.0 to 5.6 mV during the atrial arrhythmia.

Discussion

This case illustrates apparently paradoxical undersensing of atrial events by a dual-chamber pacemaker. As the atrial sensitivity was increased, undersensing became worse; as atrial sensitivity was decreased, sensing improved and appropriate inhibition of atrial pacing occurred.

Blanking intervals following paced events or large-amplitude signal deflections are referred to as "quiet timer blanking intervals."¹ These intervals allow the noise or signals created by large-amplitude events to attenuate or stop "ringing" through the sense amplifier before the sense amplifier is subjected to another input. The larger the input signal, the longer it takes for the amplifier to recover or quiet down.

The normal quiet timer interval in the Kappa pacemaker ranges from 50 to 100 ms (nonprogrammable). With very large amplitude or prolonged-duration sensed signals (or high levels of postpace polarization) these quiet timer blanking periods have been seen to cover the entire sensing window. In addition, if the amplifiers are repeatedly "hit"

Table 1 Programmed parameters

Mode	DDDR
Mode switch	On
Detect rate	175
Rate	90-120
Paced AV delay	150 ms
Sensed AV delay	120ms
PVARP	260 ms
PVAB	180 ms
Ventricular refractory	230 ms
Ventricular blanking (after A pace)	28 ms

AV = atrioventricular; PVARP = postventricular atrial refractory period; PVAB = postventricular atrial blanking period.

with large-amplitude signals, the quiet timer blanking intervals are reinitiated or extended.

In the present case, very large amplitude flutter waves likely caused repeated initiation of quiet timer blanking intervals, resulting in failure to sense atrial events during such intervals. With a decrease in atrial sensitivity, the difference between the programmed sensitivity and flutter wave amplitude was diminished. This resulted in less “ringing” in the sense amplifier and quiet timer blanking. Paradoxically, with decreased programmed sensitivity detection of atrial events, improved and appropriate mode switching occurred.

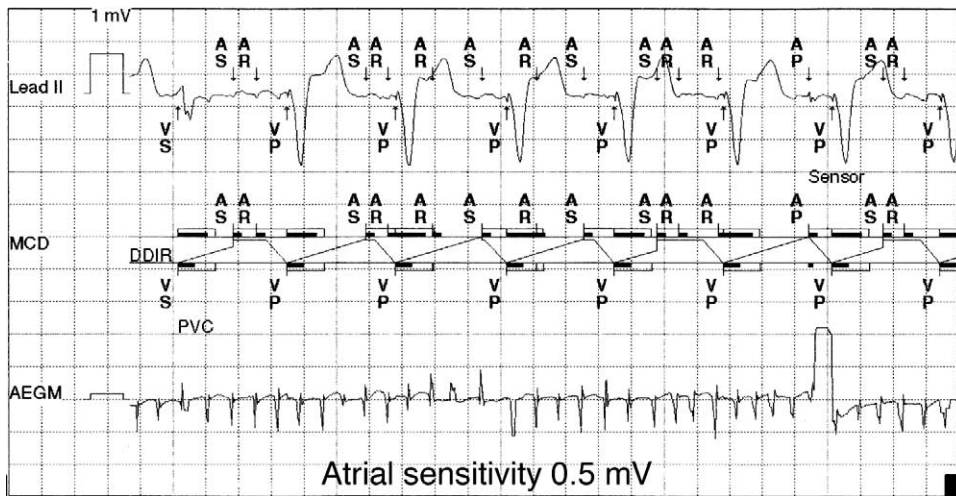


Figure 1 Surface lead II, markers channel diagrams (MCD), and intracardiac atrial electrograms with atrial sensitivity at .5 mV. Black bars in marker channel diagram indicate blanking periods; open bars indicate refractory periods. Mode switch has occurred to DDIR but there is undersensing of the atrial events as indicated by an atrial paced (AP) event at the sensor rate in the right side of the figure. AS = atrial sensed event; AP = atrial paced event; AR = atrial refractory sensed event; VP = ventricular paced event; AEGM = atrial intracardiac electrogram.

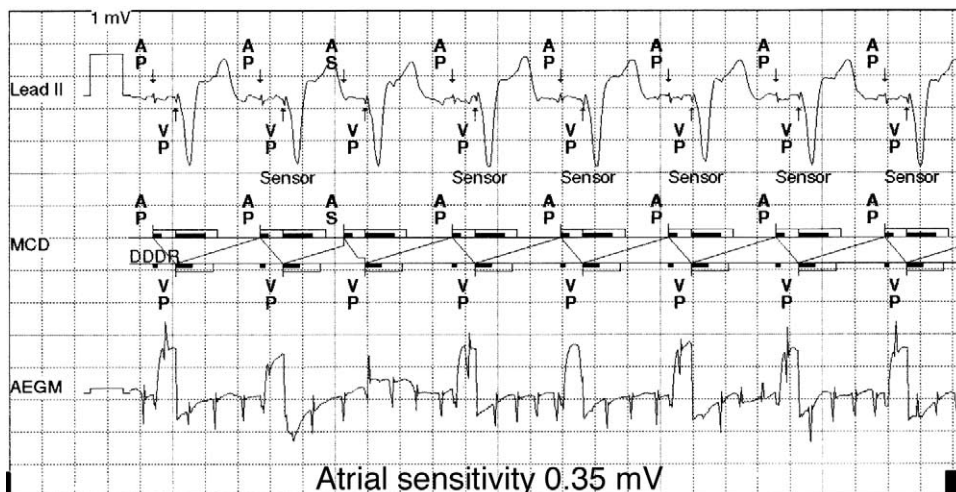


Figure 2 Arrangement of tracings is the same as in Figure 1. Atrial sensitivity is now programmed to .35 mV. Mode switch has not occurred and the device remains DDIR and AV paces at the sensor indicated rate. There is nearly complete failure to sense atrial events and dual-chamber pacing at the sensor rate is seen. Abbreviations as in Figure 1.

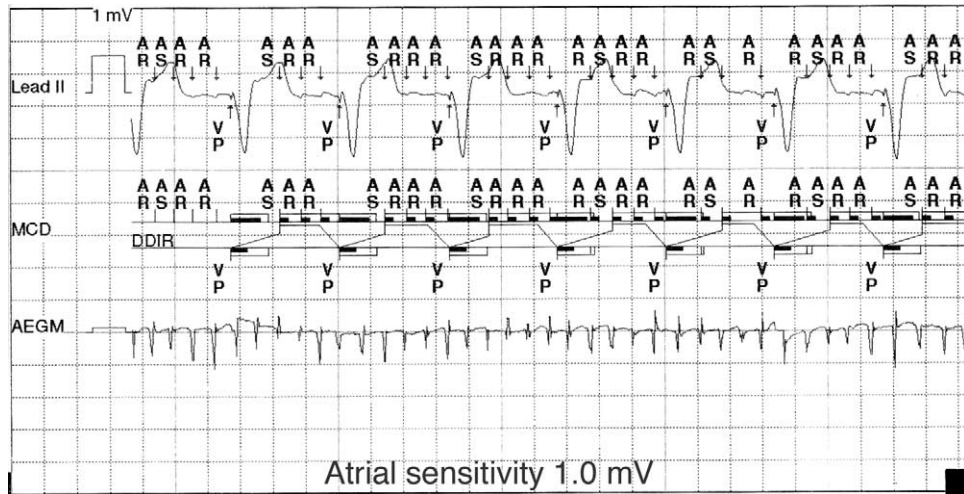


Figure 3 Arrangement of tracings is the same as in Figures 1 and 2. Atrial sensitivity is now programmed to 1.0 mV. The device has mode switched to DDIR and there is nearly complete sensing of atrial events that fall outside the postventricular atrial blanking period. Abbreviations as in Figure 1.

This phenomenon has been described in a sheep model of atrial fibrillation and modeled in vitro with electrical signals created by an electrical pulse generator.² It was observed in devices manufactured by Medtronic (Thera DR) and Vitatron (Diamond, Saphir). These investigators concluded that undersensing was likely to occur if the pacemaker was programmed four or more times more sensitive than the sensing threshold. In the present case, sensed atrial events measured 4 to 5.6 mV. Undersensing was seen at programmed sensitivities ≤ 5 mV, roughly in agreement with this prediction.

Not all pacemakers may be prone to this behavior. In the study described above, an Intermedics (Guidant Corporation, St. Paul, MN) pacemaker (Marathon) did not exhibit this behavior. This was ascribed to a unique algorithm for interference detection that interprets any signal greater than 7 Hz (such as can occur with amplifier ringing) as noise. However, in this experiment, the Marathon pacemaker reverted to VVI, the noise reversion mode.

Conclusion

This case report demonstrates an uncommon cause of undersensing that is correctable with a nonintuitive maneuver, ie, programming to less sensitive voltage levels. This represents normal pacemaker sense amplifier function for many pulse generators. In the present case, failure of appropriate mode switching was the clinical outcome. This phenomenon may, however, assume greater importance as atrial antitachycardia devices gain wider use.

References

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