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Paradoxical atrial undersensing by a dual chamber pacemaker during atrial fibrillation

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Abstract

This report describes paradoxical atrial undersensing by a dual chamber pacemaker in a patient with paroxysmal atrial fibrillation. Atrial undersensing was present only when the device was programmed to a high sensitivity but sensing normalized when a lower sensitivity was programmed. This unusual response should be differentiated from the recently documented "lock-in" behavior of pacemakers delivering managed ventricular pacing. (Cardiol J 2012; 19, 2: 207–209)

Key words: pacemaker, paradoxical atrial undersensing, atrial fibrillation

Introduction

The causes of atrial undersensing by a dual chamber pacemaker include true undersensing (low amplitude electrogram), functional undersensing (related to the effect of special timing cycles in the presence of an adequate signal) and paradoxical undersensing [1–6]. The latter may be perplexing as described in this report because it involves atrial undersensing at a high programmed atrial sensitivity and with the return of normal atrial sensing at a lower programmed sensitivity.

Case report

A Medtronic Adapta ADDR01 dual chamber pacemaker was implanted in a patient with paroxysmal atrial fibrillation (AF) associated with high-degree atrioventricular block which was not drug-induced. At implantation the atrial f waves were > 4 mV. The day after implantation, the pacemaker registered a measured atrial wave amplitude between 4.00–5.00 mV. Yet, there was atrial undersensing at all the sensitivities higher than 1 mV, i.e. at the numerical atrial sensitivities below 1 mV (Fig. 1).

Figure 1. Atrial undersensing at a programmed atrial sensitivity of 0.18 mV. The ECG is on top, the marker channel in the middle and the atrial electrogram at the bottom; AP — atrial paced event according to the emission by the pacemaker; VP — ventricular paced event.

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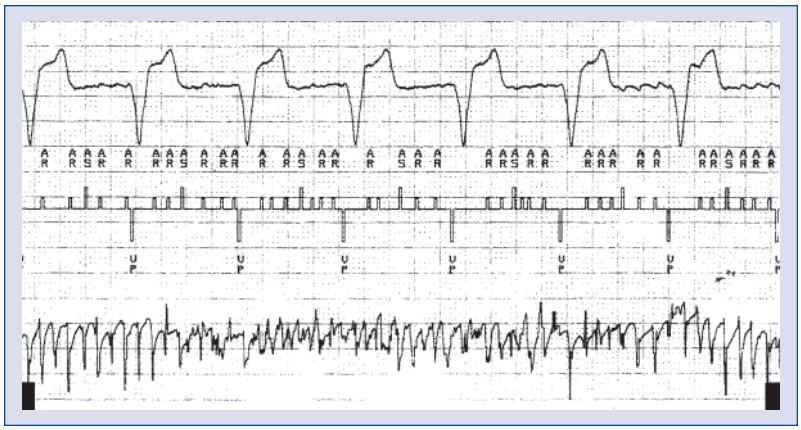

Figure 2. Normal atrial sensing (causing automatic mode switching) at programmed atrial sensitivity of 1.4 mV; AR — atrial sensed event in the atrial refractory period; AS — atrial sensed event; VP — ventricular paced event. Same arrangement as in Figure 1.

At an atrial sensitivity of 1 mV there was occasional atrial undersensing. Normal atrial sensing was documented at an atrial sensitivity of 1.4 mV and lower sensitivities (higher numerical value) (Fig. 2). The final setting of the atrial sensitivity was programmed at 1.6 mV. Long-term monitoring revealed normal atrial sensing during AF.

Discussion

Paradoxical undersensing of AF by a dual chamber pacemaker may occur at a high programmed sensitivity associated with normal sensing at lower sensitivity. This paradoxical response is dependent on the amplitude of the input signal and cannot be explained by an overlap of conventional programmable timing parameters [2–6]. This paradoxical response was first documented in 2001 by Willems et al. [6] in a sheep model. The paradoxical behavior is caused by the occurrence of quiet timer blanking intervals after a large enough intrinsic signal deflection by the sense amplifiers. These intervals are intended to let the noise, or signals created by these events die down, stop bouncing, echoing, or "ringing" through the sense amplifier circuitry before bringing the sense amplifier back on-line. The harder the sense amplifier is "hit" with these signals, the longer it takes to quiet down. If further signals are presented to the inputs by the sense amplifiers, it can cause these quiet timer intervals to be restarted or extended. Typically, quiet timer intervals are in the 50–100 ms range (non-programmable). At high atrial rates and a high sensitivity, repetitive atrial signal input may activate blanking of the atrial amplifier which disables sensing despite the high amplitude of the atrial signal.

In one study 71 patients with dual chamber pacemakers (six different pacemaker models of five different manufacturers) and AF were tested for the occurrence of paradoxical atrial undersensing [4]. After determination of the atrial sensing threshold of AF, the atrial sensitivity was increased (lower numerical number of sensitivity) in a stepwise fashion. Paradoxical atrial undersensing could be provoked in 9 of 71 (13%) patients at a median sensing level of 0.4 (range 0.15–2.0) mV. The occurrence of paradoxical atrial undersensing was significantly associated with the sensing threshold of AF (2.7 ± ± 1.5 mV for patients with paradoxical undersensing compared to 1.6 ± 1.3 mV for those without, $p = 0.02$). Decreasing the atrial sensing level (higher numerical value of sensitivity) prevented paradoxical undersensing in 8 of 9 patients while maintaining an adequate safety margin for the detection of AF. The investigators concluded that paradoxical atrial undersensing occurs with all dual chamber pacemakers and can be resolved in most cases by decreasing atrial sensing levels. As shown in our case, paradoxical behavior of sensitivity programming tends to occur with high amplitude of the atrial electrogram during AF.

Paradoxical atrial undersensing was also reported in a single case of paroxysmal atrial flutter where device interrogation revealed atrial undersensing of 5 mV flutter waves at a programmed sensitivity of 0.5 mV [3].

Paradoxical atrial undersensing may cause the recording of fewer events during AF and delay or

prevent automatic mode switching during paroxysmal AF. Most cases can be corrected by decreasing atrial sensitivity.

"Locked-in" atrial sensitivity constitutes a variant of paradoxical atrial undersensing and occurs in Medtronic devices functioning in the managed ventricular pacing (MVP) mode (AAI ↔ DDD). In the case reported by Nair et al. [7] this response was documented in a patient with a Virtuoso DR defibrillator when a lower sensitivity (1.2 mV) was programmed to eliminate far-field atrial sensing. Then, reprogramming the atrial sensitivity to 0.15 mV was associated with atrial undersensing despite previously documented normal sensing at a setting of 0.3 mV. This response occurs only in the MVP mode of Medtronic devices (Entrust, Virtuoso, Intrinsic) but not in the more recent Vision 3D family and subsequent releases. In the case of the "locked-in" response, the change in sensitivity will only take effect after the device detects a non-refractory atrial paced or sensed event. In the absence of these events, programming a new sensitivity will not take effect. Changing from the AAI+ or AAIR+ component of the MVP mode to the non-MVP mode will immediately prevent this phenomenon. In contrast to our case of atrial undersensing, the "locked-in" response is not permanent and should eventually disappear upon sensing the required specific atrial events to activate the correct atrial sensitivity.

Conflict of interest: none declared

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