Prevention of Far-Field Oversensing at High Atrial Sensitivity in Dual-Chamber Pacemaker

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Summary

In dual-chamber pacing systems, a high atrial sensitivity is required for reliable atrial sensing, especially in the presence of atrial arrhythmias. Far-field oversensing (FFOS) of R-wave or myopotentials is a potential complication of dual-chamber pacing, favored by a high atrial sensitivity. We assessed the efficiency of a new atrial sensing amplifier with common-mode rejection implemented in the dual-chamber pacemaker Actros DR of preventing FFOS at an atrial sensitivity of 0.1 mV. 10 patients were included and FFOS was provoked by high unipolar ventricular output (7.5 V at 0.5 ms) and lateral hand pressing. FFOS during high ventricular output stimulation at 7.5 V was observed in 2 of the 10 cases at 6 weeks and 3 months. Adjustment of the atrial sensitivity to 0.2 mV prevented FFOS also in these two cases. No FFOS was detected during provoked myopotentials in all patients during both follow-up examinations. No atrial undersensing was observed in the two patients with intermittent AF. Conclusively, an appropriate atrial sensing amplifier with common-mode rejection prevents FFOS at 0.2 mV sensitivity providing appropriate timing function.

Key Words

Dual-chamber pacing, crosstalk, far-field sensing, myopotentials

Introduction

Correct sensing of atrial P-wave is a prerequisite for appropriate dual-chamber pacemaker- or automatic intracardiac defibrillator (aICD) function. Recording of a stable, high atrial sensing during placement of the atrial lead together with programming of short post-ventricular atrial blanking and high maximal atrial sensitivity are required for appropriate atrial sensing. Unfortunately, the last two elements tend to increase oversensing of myopotentials or R-wave known as Far-Field Oversensing (FFOS). On the other side, the amplitude of intracardiac amplitudes tends to change considerable both in the presence of atrial arrhythmias, such as atrial flutter or atrial fibrillation and during physical exertion. For that reason, avoidance of FFOS in the setting of a high atrial sensitivity is requested for a continuously optimal atrial sensing.

The dual-chamber pacemaker Actros DR (BIOTRONIK, Germany) has a high atrial sensitivity (0.1 mV) and is equipped with an atrial sensing amplifier with common mode rejection. The aim of common mode rejection is to amplify near-field signals and to dump far-field signals. The atrial sensing channel consists of a separate amplifier for the tip and the ring electrode. The separately amplified signals of each electrode of the atrial lead are processed by a differential amplifier (DA). The DA amplifies the difference of the signal amplitudes at the two inputs. If the same signal is present at both input lines for example, the difference is zero and the output of the DA is zero. In contrast, different signals at the input produce a high signal amplitude at the DA output. An excitation front in the atrium originates an electrical field in the proximity of the electrodes of the atrial lead. Therefore, the signals arrive at different times at the tip and the ring electrode. The signal at the DA input is shifted in time, therefore very different and the DA processes a high

amplitude signal. This processed signal is above the sensing threshold. An excitation front generated far from the atrial lead in the ventricle produces a plane wave which arrives at the two electrodes almost at the same time. Therefore, the difference of both signals is very small and the output of the DA is under the sensing threshold. The measure of quality of far-field-signal dumping is the common mode rejection ratio (CMRR). The amplitude of the DA output is analyzed by a usual sensing threshold module comparable with other pacemaker sensing stages. The sensing threshold can be programmed to very high sensitivity (e.g. 0.1 mV) because the influence of cross-sensed signals is comparatively small.

The purpose of this study was to test the efficiency of this sensing amplifier of preventing FFOS at a high level of atrial sensitivity (0.1 mV).

Methods

10 patients (4 males, 6 females) with a mean age of 71 ± 5 years were tested. Indications for pacing were sick sinus syndrome in 3 cases and high degree atrioventricular block in the remaining cases. Dual-chamber pacemakers Actros DR were implanted together with a bipolar atrial and ventricular lead. During 6 week and 3 month follow-up FFOS was systematically tested at 0.1 mV atrial sensitivity and bipolar sensing polarity. The filtered atrial and ventricular electrograms provided by the PMS 1000 programmer (BIOTRONIK), together with markers and a surface ECG lead were analyzed to determine if FFOS were present. Far-field potentials were provoked by both high unipolar ventricular output (7.5 V at 0.5 ms) and lateral hand pressing for 30 seconds (myopotentials). FFOS was defined as the presence of an atrial sensing that corresponded to the ventricular paced electrical activity or as multiple, asynchronous atrial sensing events coincident with the period of lateral hand pressing. In the case of FFOS atrial sensitivity was readjusted to 0.2 mV and the tests were repeated.

Results

The pacing threshold and sensing values during the observation period are shown in Table 1. No FFOS was detected at 0.1 mV atrial sensitivity during provoked myopotentials in all patients during both follow-up's (Figure 1). FFOS during high ventricular unipolar output at 7.5 V was observed in 2 of the 10 patients at 6 weeks and 3 months. Adjustement of the atrial sensitivity to 0.2 mV prevented FFOS also in these two cases. Two patients with known intermittent atrial fibrillation presented with this arrhythmia at 6 week and 3 month follow-up, respectively. No atrial undersensing was observed in these patients at 0.1 and 0.2 mV atrial sensitivity.

	Sensing (mV)	Pacing (V at 0.5 ms)	Impedance (Ω)
atrial	2.8 ± 2.1	0.7 ± 0.4	481 ± 78.0
ventricular	16.3 ± 8.4	0.6 ± 0.2	505 ± 63.6

Table 1. Mean sensing-, threshold- and impedance values during 6 week- and 3 month follow-up.

Discussion

High atrial sensitivity in a dual-chamber pacemaker provides for an adequate sensing of a wide variety of atrial intracardial signals of normal or pathologic (i.e. atrial tachycardia/flutter/fibrillation) origin. This happens at the expense of specificity with which these signals can be differentiated from sensed events arising extraatrially. Ventriculo-atrial crosstalk is known to occur at high levels of atrial sensitivity and may be due to sensing in the atrial channel of either the ventricular output or, even later, of the ventricular depolarization signal-termed far-field R-wave sensing. Sensing of myopotentials in the atrial channel leads to ventricular pacing at the upper rate limit, producing a pacemaker-mediated tachycardia.

Lazarus [1] has shown that in patients with Actros DR dual-chamber pacemaker and a conventional sensing amplifier, far-field R-wave sensing at a unipolar ventricular pacing of 3.5 V at 0.5 ms occurred in 86% of patients at the maximal atrial sensitivity of 0.1 mV.

We tested a new technology sensing amplifier implemented in Actros DR dual-chamber pacemaker. Despite a very high unipolar ventricular output (7.5 V at 0.5 ms) far-field R-wave sensing could be prevented in 8 of 10 patients at 0.1 mV atrial sensitivity. No myopotential were sensed during a 30 s lateral hand pressing. At 0.2 mV atrial sensitivity no FFOS occurred in any of the patients. Atrial fibrillation was

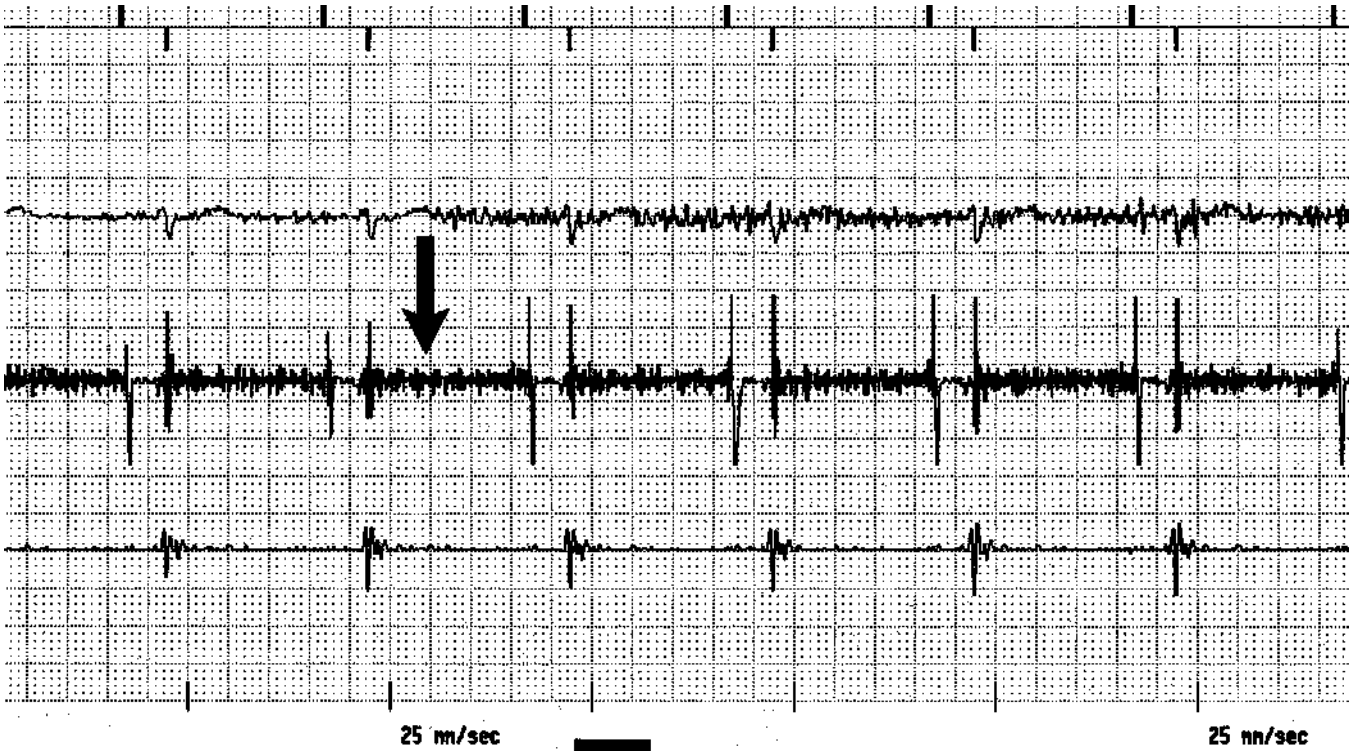

Figure 1. No myopotentials are detected on the atrial channel during hand lateral-pressing (arrow) at an atrial sensitivity of 0.1 mV. From top to bottom: marker channel, III ECG lead, atrial filtered electrogram, ventricular filtered electrogram.

still adequately sensed in the atrial channel in 2 patients.

This new technology sensing amplifier seems be an optimal solution for prevention of FFOS at high atrial sensitivity. By reliably rejecting far-field potentials, obviates the need of increasing the post-ventricular atrial blanking time. The last one could also help solve the problem but would clearly reduce the size of the atrial sensing window.

References

[1] Lazarus A. Far-Field R-Wave Sensing. Prog Biomed Res. 1998; 3 (4): 229-231.