

Feasibility of Using Atrial Sensitivities below 0.5 mV in a DDD(R) Pacemaker with Mode-Switching Algorithm

F. COOLS¹, R. VAN TWEMBEKE², H. HEMELHOF², J. BACKERS³
¹Klina, Brasschaat, Belgium; ²Biotronik Brussels, Belgium; ³Biotronik Berlin, Germany

Summary

Recently, dual chamber pacemakers offering very high atrial sensitivities have become available. Availability of these sensitivities (below 0.5 mV) may especially be important in patients with paroxysms of atrial fibrillation whereby a mode-switching algorithm is necessary to prevent tracking of these arrhythmias. Since atrial fibrillation often produces small and irregular signal amplitudes, a very high atrial sensitivity is often required as to assure a stable Mode Switch behavior. This article describes our experiences in a study group of 45 patients implanted with a dual chamber pacemaker offering atrial sensitivities down to 0.1 mV (Actros DR, Biotronik). Special testing was done, focussing on the incidence of both far field and myopotential sensing at these very high atrial sensitivities. As expected, we found that high atrial sensitivities in the unipolar sensing mode should be avoided under all circumstances given the high susceptibility to both far field and myopotential sensing. On the other hand, a bipolar setting of 0.3 mV proved to be 100% safe both in terms of far field and myopotential sensing. Atrial sensitivities below 0.3 mV (bipolar) require careful evaluation, especially in terms of far field sensing.

Key Words

Oversensing, far field sensing, myopotential sensing, sensing polarity

Introduction

With the advent of dual chamber pacemakers offering high atrial sensitivities (< 0.5 mV), questions may arise about the potential impact on atrial oversensing.

The most common forms of atrial oversensing as reported in literature are myopotential sensing [1,2] and far field R-wave sensing [3-8], far field R-wave sensing being defined as sensing of the ventricular depolarization by the atrial channel of the pacemaker. Myopotential sensing in the atrial channel of a dual chamber pacemaker may result in fast and irregular ventricular pacing rates, false positive mode switching or cause the pacemaker to run in it's 'noise' mode.

Far field R-wave sensing occurs in the majority of cases no later than 150 ms after the ventricular event [8]. Since this basically falls within the post ventricular atrial refractory period (PVARP), it is usually of no practical concern for as long no mode switching algorithm is involved.

However, in modern DDD(R) devices provided with

Mode Switching Algorithms, atrial senses occurring during PVARP are used to 'feed' the mode switching algorithm. Therefore, far field R-wave sensing has become an important issue and should be avoided since it may lead to false positive mode switching [9]. In this in vivo study, we focussed on the incidence of both myopotential and far field sensing when using high atrial sensitivity settings (< 0.5 mV).

Methods

The patient group consisted of 45 patients (24 male, 21 female), age 48 - 90 years (mean 71 y). All patients received a dual chamber device (Actros DR, Biotronik), allowing programming of atrial sensitivities down to 0.1 mV.

All patients were implanted with an atrial bipolar pre-shaped tined J lead (Synox SX 53 JBP: ring - tip distance of 14 mm, Biotronik). The atrial lead was prefer-



Figure 1. Left panel: Far field R-wave sensing (FFS) is clearly present at 0.1 mV/bi as indicated by the atrial refractory sense marker beyond the V pace. Right panel: pacemaker reprogrammed to 0.3 mV/bi, FFS no longer present - absence of atrial refractory sense marker post V pace. From top to bottom: marker channel, surface ECG, atrial IEGM and ventricular IEGM.

ably positioned in the right atrial appendage under fluoroscopic guidance. Ventricular leads were either of the unipolar tined type (Polyrox PX 60 UP, n = 43; Biotronik) or of the bipolar tined type (Synox SX 60 BP, n = 2; Biotronik).

All patients were tested either at hospital discharge or on the occasion of the first 'routine' follow-up.

Prior to the 'specialized' testing, both pacing and sensing thresholds were determined.

For the purpose of both far field and myopotential testing, all pacemakers were programmed as follows: DDD, unipolar ventricular pacing at 3.6 V / 0.4 ms and 'fixed' AV delay of 100 ms (as to assure ventricular pacing).

Far field sensing (FFS) and myopotential sensing (MS) was evaluated at different atrial sensing polarities (unipolar / bipolar). Far field sensing threshold was defined as the highest atrial sensitivity setting without far field detection of the paced R wave by the atrial sensing amplifier. During both FFS and MS testing, simultaneous recording of the atrial and ventricular IEGM (intracardiac signals), marker channels (A&V) and surface ECG was done by means of the pacemaker programmer (PMS1000 C, Biotronik).

Far field sensing was evaluated during AV synchronous ventricular pacing, applying a post ventricular atrial blanking period (PVAB) of 56 ms during which the atrial channel of the pacemaker is completely 'blinded'. As illustrated in the left panel of Figure 1, FFS could clearly be demonstrated by the presence of a refractory atrial sense marker within the first 200 ms following the ventricular pacing stimulus. In case FFS was present, testing was repeated at the next available

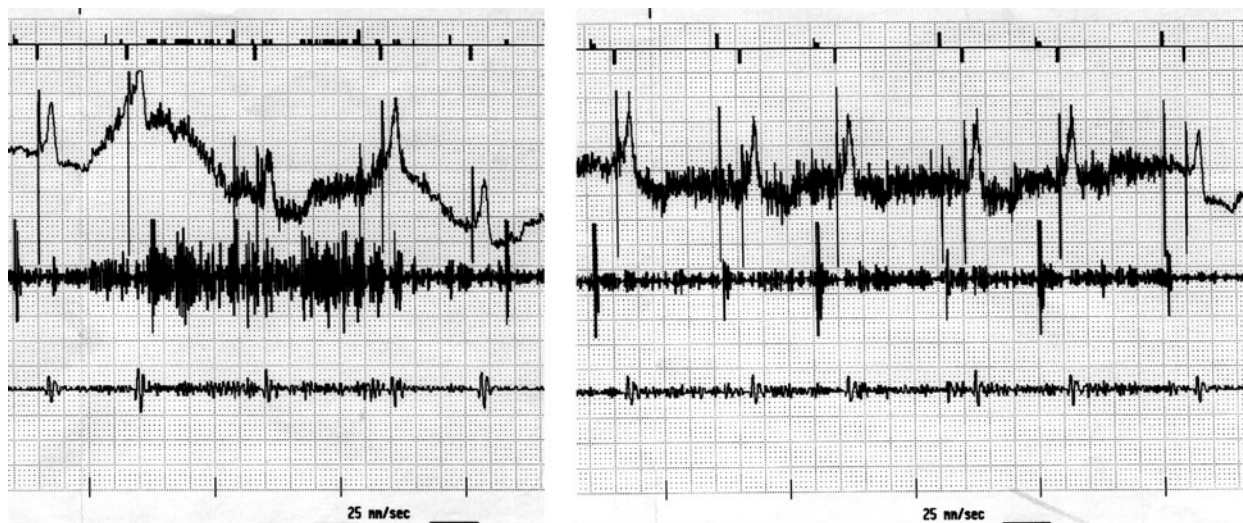


Figure 2. Left panel: myopotential sensing at 0.3 mV/uni as indicated by multiple atrial sense markers not related to spontaneous atrial activity. Please note that in the middle part of the left tracing the pacemaker behaves in its noise mode due to the continuous recycling of its atrial noise interval. Right panel: pacemaker reprogrammed to 1.0 V/uni, MS no longer present. From top to bottom: marker channel, surface ECG, atrial IEGM and ventricular IEGM.

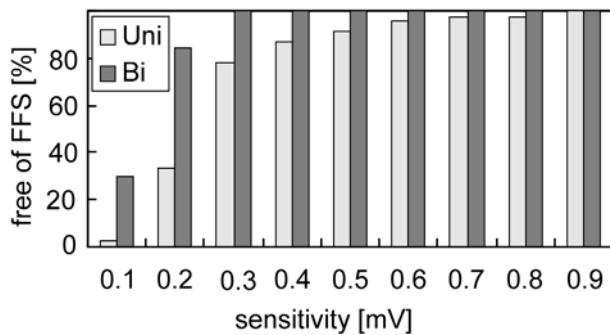


Figure 3. Cumulative percentage of patients free of far field R-wave sensing in function of the programmed atrial sensitivity and polarity.

(less sensitive) setting and this until FFS no longer was present (Figure 1, right panel).

Myopotential testing was done by provoking (pectoralis) muscle potentials by means of a typical 'push/pull' maneuver at the pacemaker site. As illustrated in the left panel of Figure 2, the presence of multiple atrial sensing markers not related to atrial activity was the indicator for myopotential sensing. In contrast to FFS testing, testing was not always started at the most sensitive setting (0.1 mV), but at a setting corresponding to the FFS threshold as determined by the FFS test. Similar to the above described FFS testing, MS testing was repeated at the next available (less sensitive) setting and this until MS was no longer present (Figure 2, right panel).

Results

At follow-up, P-wave amplitudes measured in the bipolar sensing configuration were 3.40 ± 1.31 mV ($n = 44$, range 0.9 - 6.4 mV). R-wave amplitudes measured in unipolar sensing configuration were 13.4 ± 3.87 mV ($n = 42$, range 6.8 - 23.4 mV).

Unipolar atrial pacing thresholds were 0.48 ± 0.30 V at 0.4 ms ($n = 45$, range 0.1 - 1.4 V). Unipolar ventricular pacing thresholds were 0.64 ± 0.32 V at 0.4 ms ($n = 44$, range 0.3 - 1.9 V).

Figure 3 represents the cumulative percentage of patients free of far field R-wave sensing in function of the programmed atrial sensitivity and polarity. As expected, susceptibility to far field R-wave sensing was significantly higher when programmed to unipolar sensing. At a setting of 0.3 mV / bipolar all patients were free of far field R-wave sensing.

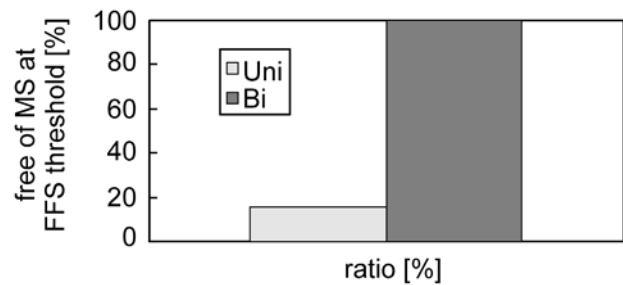


Figure 4. Graph representing the percentage of patients that was free of myopotential sensing at the previously determined far field sensing threshold (both in the unipolar and bipolar sensing configuration).

Figure 4 represents the percentage of patients free of myopotential sensing at the previously determined far field threshold (for both uni- and bipolar sensing configurations). As expected, myopotential sensing was only observed in the unipolar sensing mode. In the overall majority of cases (84.1%), the unipolar myopotential sensing threshold was found to be higher than the unipolar far field sensing threshold. The average unipolar myopotential sensing threshold for those patients was 0.68 ± 0.24 mV.

Discussion

The use of high atrial sensitivities in combination with unipolar sensing should be avoided given the high incidence of both myopotential and far field R-wave sensing. On the other hand, high atrial sensitivities (< 0.5 mV) may safely be used together with a bipolar atrial lead configuration. Careful evaluation of FFS (e.g. by means of the methodology as described above) is however advised: in 'our' configuration an atrial sensitivity of 0.3 mV / bipolar combined with a short PVAB of 56 ms has proven to be a reliable setting in all patients both in terms of far field and myopotential sensing.

Some concerns exist in terms of reliability and durability of bipolar leads. For this reason, Esner et al. suggest unipolar leads can be safely used if isometric maneuvers are used to individually assess the myopotential sensing threshold [11]. However, as our results indicate, this often means programming atrial sensitivity settings of more than 1.0 mV, possibly compromising adequate atrial sensing of P waves and atrial arrhythmias. A comparison of unipolar and bipolar

sensing was made by Wiegand et al. [12], wherein both sensing modes are evaluated by means of holter recordings and superiority of bipolar sensing is confirmed.

Avoiding far field sensing is crucial as to prevent false positive mode switching. Depending on the programmable parameters of the device, one may adjust the atrial sensitivity and polarity parameters and / or program a long post ventricular atrial blanking period. Programming a long post ventricular atrial blanking period may, however, cause mode switching failure especially in case of (slow) atrial flutter, which may happen if systematically every second flutter wave is blanked within the PVAB [9,10]. Therefore, keeping a short PVAB in combination with an atrial sensitivity setting slightly above the FFS threshold should be the preferred choice, unless contraindicated due to too small signal amplitudes.

Since, in our study, we focussed on a specific pacemaker/lead combination, further testing may be required to evaluate the potential impact of other parameters such as lead position, ring-tip distance of the atrial lead and the filter characteristics of the device used.

References

- [1] Gross JN, Platt S, Ritacco R, et al. The clinical relevance of electromyopotential oversensing in current unipolar devices. *Pacing Clin Electrophysiol.* 1992; 15 (11 Pt 2): 2023-7.
- [2] Castro A, Liebold A, Vincente J, et al. Evaluation of autosensing as an automatic means of maintaining a 2:1 sensing safety margin in an implanted pacemaker. *Pacing Clin Electrophysiol.* 1996; 19 (11 Pt 2): 1708-13.
- [3] Griffin JC. Sensing Characteristics of the Right Atrial Appendage Electrode. *Pacing Clin Electrophysiol.* 1983; 8: 22-25.
- [4] Berns E, Keefe JM. Inverted pacemaker mediated tachycardia induced during noninvasive electrophysiology testing. *Pacing Clin Electrophysiol.* 1992; 15 (4 Pt 1): 377-81.
- [5] Brouwer J, Nagelkerke D, den Heijer P, et al. Analysis of atrial sensed far-field ventricular signals: a reassessment. *Pacing Clin Electrophysiol.* 1997; 20 (4 Pt 1): 916-22.
- [6] Seidl K, Meisel E, VanAgt E, et al. Is the atrial high rate episode diagnostic feature reliable in detecting paroxysmal episodes of atrial tachyarrhythmias? *Pacing Clin Electrophysiol.* 1998; 21 (4 Pt 1): 694-700.
- [7] Nowak B, Kramm B, Schwaier H, et al. Is Atrial Sensing of Ventricular Far-Field Signals Important in Single-Lead VDD Pacing? *Pacing Clin Electrophysiol.* 1998; 21 (11 Pt 2): 2236-2239.
- [8] Lazarus A. Far Field R wave sensing. *Prog Biomed Res.* 1998; 4: 229-231.
- [9] Internet, Vitatron site, page http://www.vitatron.com/MODE_SW.HTM.
- [10] Ellenbogen KA, Mond HG, Wood MA, et al. Failure of automatic mode switching: recognition and management. *Pacing Clin Electrophysiol.* 1997; 20 (2 Pt 1): 268-75.
- [11] Exner DV, Rothschild JM, Heal S, et al. Unipolar sensing in contemporary pacemakers : using myopotential testing to define optimal sensitivity settings. *J Interv Card Electrophysiol.* 1998; 2: 1, 33-40.
- [12] Wiegand UK, Schier H, Bode F, et al. Should unipolar leads be implanted in the atrium? A holter electrocardiographic comparison of treshold adapted unipolar and high sensitive bipolar sensing. *Pacing Clin Electrophysiol.* 1998; 21: 8, 1601-8.