Far-Field R-Wave Sensing

A. LAZARUS
Paris, France

Summary

Far-field R-wave sensing (FFRS) is a potential complication of dual-chamber pacing, favored by a short post-ventricular atrial blanking and a high atrial sensitivity. FFRS occurrence, FFRS time and FFRS thresholds were systematically assessed in 36 patients implanted with Actros D and Actros DR pacemakers. At the maximal atrial sensitivity of 0.1 mV, 31 pts (86%) presented FFRS, whereas at 0.2 mV, 64% were free of FFRS. FFRS time reached 127.3 ms on average but could be as long as 180 ms. At the FFRS threshold, no myopotential sensing was observed during provocative maneuvers. In conclusion, FFRS is a potential problem — especially if very high atrial sensitivity settings are mandatory due to very low atrial signal amplitudes. To overcome this difficulty, new algorithms and technologies for atrial leads and sensing amplifiers should be developed.

Key Words

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

Introduction

Sensing and pacing are the two basic functions of pacing systems. To improve atrial sensing, new pacemaker generations offer short post-ventricular atrial blanking and high maximal atrial sensitivity programming capabilities. However, these two elements tend to favor detection of ventricular electrical activity in the atrium known as far-field R-wave sensing (FFRS). We looked for the presence, time of occurrence, and sensing thresholds of FFRS in the dual-chamber pacemakers with the highest atrial sensitivity on the market.

Materials and Methods

In patients implanted with Actros D or Actros DR dual-chamber pacemakers (BIOTRONIK), FFRS was systematically sought by programming an atrial sensitivity of 0.1 mV in the bipolar mode. Ventricular pacing was usually unipolar with nominal output values (3.6 V and 0.4 ms). Then, 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 FFRS was present (Figure 1). FFRS was defined as the presence of an atrial sensing marker that corresponded to the ventricular paced electrical activity which was visible on the atrial and ventricular filtered electrograms.

If FFRS was present, the FFRS time and FFRS threshold were measured. The FFRS time is defined as the delay between the ventricular pacing marker and the FFRS marker in the atrium. To determine the FFRS threshold, atrial sensitivity was decreased in increments of 0.1 mV until no FFRS was present, defining the FFRS threshold. Finally, myopotential inhibition was assessed in some patients through arm-waving maneuvers at the FFRS threshold-level of atrial sensitivity.

Results

36 patients (20 males, 16 females) with a mean age of 76.9 ± 14.9 years were tested. Only five of them presented no FFRS even at the highest atrial sensitivity setting of 0.1 mV (Figure 2). The individual values of FFRS thresholds for the 36 patients are displayed in Figure 3. The percentage of patients free of FFRS between the atrial sensitivities of 0.1 and 0.5 mV (in 0.1 mV increments) are displayed in Table 1. The mean FFRS time was 127.3 ms ± 31.3 ms, and the longest FFRS time reached was 180 ms. In the last

Figure 1. Presence of an atrial refractory sensed event on the marker channel (top of the figure) following the ventricular marker and corresponding to FFRS. The FFRS time reaches here 110 ms. From top to bottom: marker channel, VII ECG lead, atrial filtered electrogram, ventricular filtered electrogram.

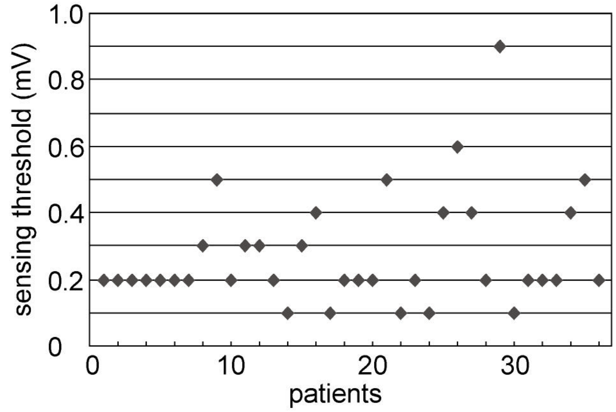

Figure 3. Individual FFRS threshold in the study population (n = 36 patients). Only 5 patients are free of FFRS at the highest (0.1 millivolt) atrial sensitivity.

Atrial sensitivity (mV)	0.1	0.2	0.3	0.4	0.5
Patients (%)	14	64	75	86	94

Table 1. Percentage of patients without FFRS at various atrial sensitivity settings from 0.1 to 0.5 mV.

13 patients, myopotential sensing at the FFRS threshold was tested during arm-waving. No myopotential sensing was found on the atrial channel (Figure 4).

Discussion

Atrio-ventricular crosstalk [1] is a well-known problem in dual-chamber pacing and is easily solved by increasing the post-atrial ventricular blanking value. Ventriculo-atrial crosstalk is less often encountered 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. Problems with FFRS will probably increase, because new pacemaker generations tend to provide

Figure 2. FFRS threshold at 0.1 mV in an 85 y.o. man.

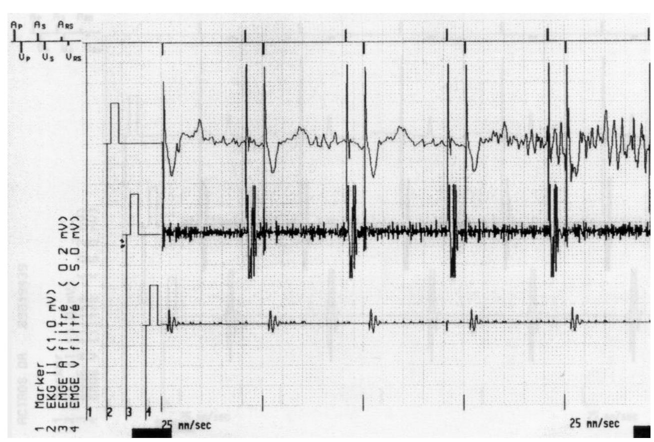

Figure 4. Same patient as Figure 2. No myopotentials are detected on the atrial channel during provocative maneuvers at the FFRS threshold, corresponding to an atrial sensitivity of 0.1 mV in this case.

very short refractory periods, which may not overcome the FFRS time. Additionally, atrial sensitivity is increasing in these newer pacemakers to allow detection of very low amplitude signals, which once could not have been sensed at the maximum atrial sensitivity settings in the earlier pacemaker platforms.

The results of our study confirm that FFRS may be a true concern: FFRS was demonstrated in 86% of the study population (31 patients) at an atrial sensitivity of 0.1 mV. However, at 0.2 mV, approximately two-thirds of the patients appeared to be free of FFRS.

Since the FFRS time may be as long as 180 ms, increasing the post-ventricular atrial blanking value to as much as 200 ms could help solve the problem but would clearly reduce the size of the atrial sensing window during the cardiac cycle. Development of specific algorithms for FFRS is also an alternative to overcoming FFRS. Another solution would be to further improve the sensing amplifier technology, thus avoiding FFRS without compromising detection of the local atrial signals.

At last, it should be emphasized that many parameters such as the amplitude of the ventricular depolarization signal, the position of the atrial lead within the atrium [2], and the interelectrode spacing of the bipolar atrial lead may also potentially influence the occurrence of FFRS.

With very high atrial sensitivity, the question also arises whether myopotentials could be detected on the atrial channel in addition to FFRS. In all cases where myopotentials were sought, no myopotential sensing could be demonstrated through provocative maneuvers at the FFRS threshold.

References

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[2] 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): 916-922.