Continuous, Long-term Recording of Pacemaker Markers: Initial Observations

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Summary

The analysis of a patient's cardiac rhythm between two follow-up examinations can be significantly improved by the use of pacemaker diagnostic counters. The Logos pacemaker (BIOTRONIK) has a high-resolution telemetry channel able to transmit intracardiac signals and pacemaker markers to an external storage device. These pacemaker markers can be checked to see if they are suitable for assessing heart activity. A special protocol was performed in 5 patients. The test lasted about 2.5 hours for each patient. The pacemakers were programmed to detect sinus node activity and, if available, intrinsic AV conduction. A threshold trigger analyzed the transmitted IEGMs in order to generate markers. A comparison of IEGM and pacemaker markers shows a coincidence of nearly 100% of the analyzed events. In all segments of the test, the pacemaker's atrial markers were set at 16 ± 3 ms and the ventricular markers at 32 ± 5 ms after the IEGM marker. The difference of the PP- and RR-intervals between pacemaker and IEGM markers amounted to 0 ms on average. The results show that the system is suitable for simultaneous Holter recordings of IEGM and pacemaker markers. In addition, reliably recorded signals may lead to future improvements in the automatic control and continuous optimization of pacemaker performance.

Key Words

Pacemaker markers, intracardiac signals (IEGM)

Introduction

The analysis of a patient's cardiac rhythm between two follow-up examinations can be significantly improved by the use of pacemaker diagnostic counters. The pacemakers store the intracardiac signals (IEGM) as markers in their diagnostic counters. This significantly reduces the need of memory because pacemaker-marker data can be stored more efficiently than IEGM data.

IEGM and pacemaker markers can be recorded simultaneously during a pacemaker follow-up and are used for a more detailed analysis of pacemaker functions [1]. However, the long-term reliability of pacemaker markers in comparison to real-time IEGM will become more important in the future [2]. One of the main reasons is the limited memory of pacemakers for storing IEGM and pacemaker markers simultaneously. In order to conduct this investigation, a pacemaker with a custom-built, high-resolution telemetry channel was used to transmit IEGM and pacemaker markers in real-time to an external Holter device [3].

The purpose of this study is to assess the extended diagnostic feasibility of a DDD pacemaker and to compare IEGM with pacemaker markers detected during daily activities of a small group of patients.

Methods

Patients

The study included 5 patients (77 ± 8 years, 4m / 1f) who had received a Logos DDD pacemaker (BIOTRONIK) 15 ± 2 months previously. Indication was sick sinus syndrome with 2 and advanced AV-block with 3 patients.

Pacemaker

The extended functionality of the pacemaker includes a

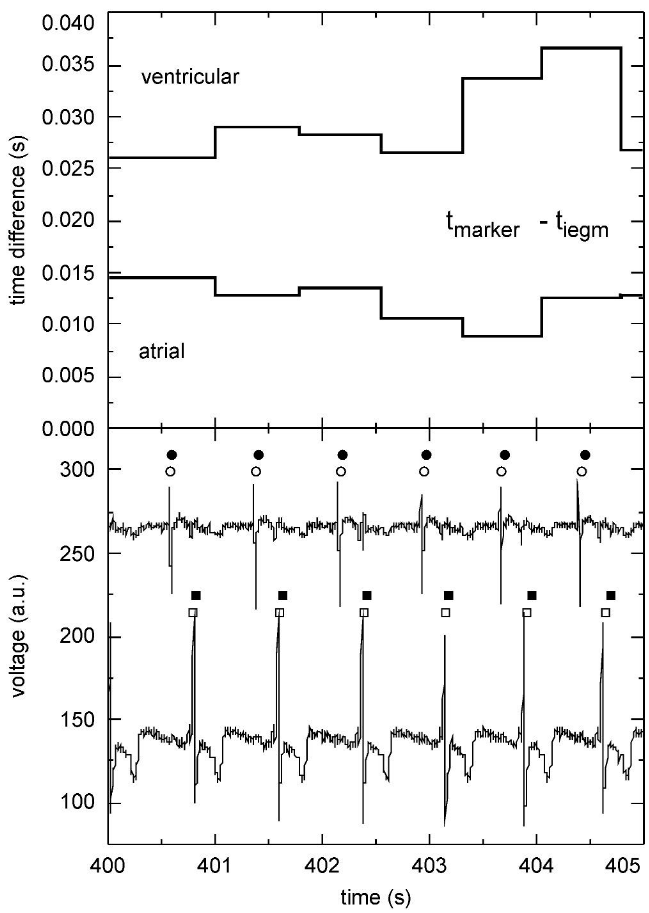

Figure 1. A short interval of the analyzed IEGM. Both IEGM and pacemaker markers are plotted above the IEGM (pacemaker: black-shaded marker, external trigger: white marker). The time differences $t_{pacemaker}$ - t_{IEGM} are depicted in the upper part of the figure.

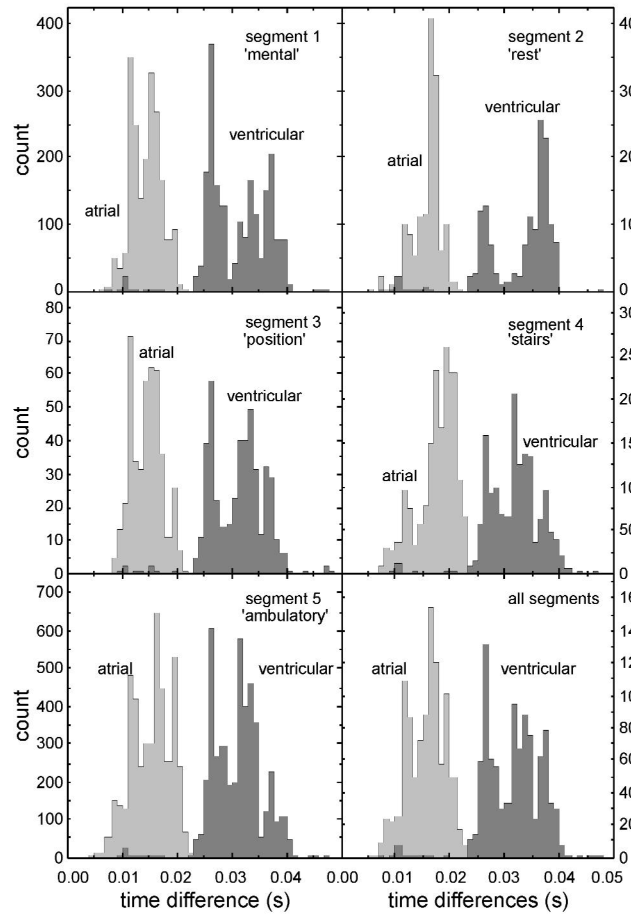

Figure 2. Atrial and ventricular time differences of pacemaker markers compared to IEGM markers.

high-resolution telemetry channel which enables permanent, simultaneous recording of the atrial and ventricular IEGM and of pacemaker markers as well as the transmission to the external recording device (Unilyzer, BIOTRONIK). The pacemaker transmits and filters the IEGM data to an external device within a frequency range of 0.5 Hz to 200 Hz. The scan frequency of the IEGM amounts to 333 Hz. The detection range of the atrial and ventricular channel can be programmed separately in order to optimize its adaptation to the patients' individual signals. The markers for every atrial and ventricular event are stored in the pacemakers internal memory. In order to investigate the correlation between pacemaker markers and IEGM, data were transmitted to the Unilyzer and stored on a flash ROM card.

Study protocol

The pacemakers were programmed to detect sinus node activity and any available intrinsic AV conduction. The pacing mode for all patients was DDI. The lower pacing rate was 37 ± 8 ppm and the fixed AV-delay was 234 ± 18 ms.

The patients performed a protocol to simulate daily activities. First, they completed a mental stress test: They subtracted successively 7 from 700 within 3 minutes and repeated the test after a 2-minute break. Second, they remained supine for 20 minutes. Third, signals were recorded during different body positions for one minute each: lying supine, lying on the right and left side, and finally while standing. Fourth, the patients ascended and descended stairs for 3 minutes, interrupted by a 3-minute break. Finally, the patients performed a 45-minute ambulatory test that consisted of walking, standing, and sitting.

	Atrial (ms)	SD (ms)	Ventricular (ms)	SD (ms)
Mental	0.01438	0.00278	0.03104	0.0055
Rest	0.01588	0.00291	0.03287	0.00597
Position	0.01456	0.0036	0.03107	0.00507
Stairs	0.01749	0.00361	0.0316	0.00484
Ambulatory	0.01531	0.0036	0.03106	0.00458
All segments	0.016	0.0033	0.032	0.0052

Table 1. Time delay of pacemaker markers compared to IEGM markers.

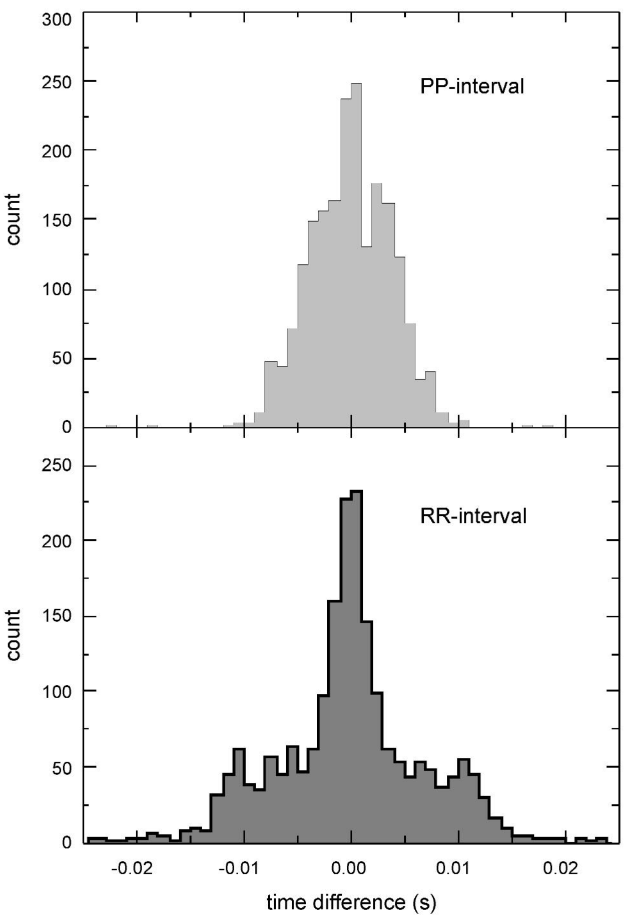

Figure 3. The difference of PP- and RR-intervals between pacemaker and IEGM markers.

Data analysis
The stored data were transmitted from the Unilyzer to a personal computer. The IEGM data were filtered with a frequency range of 4.5 to 110 Hz. IEGM markers were generated and compared to pacemaker markers.

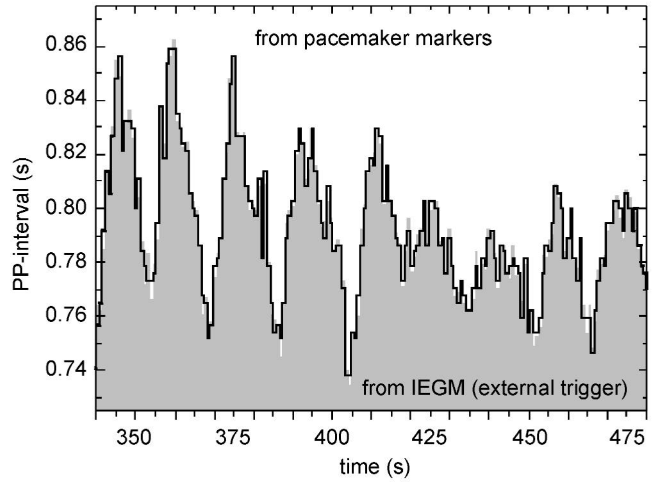

Figure 4. PP-intervals during mental stress test. Pacemaker markers are indicated in gray, IEGM markers in black.

Statistics
Where appropriate, data are presented as mean ± SD. Continuous variables were compared with help of the Student two tailed t-test for paired data. A probability of less than 5% was considered to be statistically significant.

Results

All patients underwent the study protocol as described above. The recording time of the protocol was 124 ± 22 min.
Figure 1 shows an example of IEGM and pacemaker markers. The correlation coefficients between pacemaker and IEGM markers were r = 0.99 for both atrial and ventricular events. The pacemaker markers had a time delay compared to the IEGM markers (Table 1): 16 ± 3 ms for atrial and 32 ± 5 ms for ventricular markers. It remained similar during all parts of the test (Figure 2).
The mean difference of PP- and RR-intervals between pacemaker and IEGM markers was 0 ms with a standard deviation of ± 6 ms for PP- and of ± 7 ms for RR-intervals (Figure 3). Figure 4 shows the findings of the mental stress test of one patient.

Discussion

This study demonstrates that pacemaker markers were correctly transmitted to an external recording device and stored on a flash ROM card. The findings from these data indicate that pacemaker markers reliably reflect atrial and ventricular IEGM. Daily activities had no influence on the reliability of the pacemaker-marker detection. A constant time delay between IEGM and detected pacemaker markers has to be considered.

The difference between pacemaker and IEGM markers is caused by the delay between the detection of the IEGM at the electrode tip and the data processing in the pacemaker's internal circuits. It is important for further extended pacemaker applications that the time delay of the pacemaker markers remains constant during daily activities. In this case, pacemaker markers still correctly reflect PP- and RR-intervals.

The clinical implications of the present results prove the reliability and practicability of pacemaker markers. In addition, reliably recorded signals may lead to future improvements in the automatic control and continuous optimization of pacemaker performance.

References

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