Comparison of Normal Sinus Rhythm and Pacing Rate in Children with Minute Ventilation Single Chamber Rate Adaptive Permanent Pacemakers

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ÇELİK, A., ET AL.: Comparison of Normal Sinus Rhythm and Pacing Rate in Children with Minute Ventilation Single Chamber Rate Adaptive Permanent Pacemakers. Rate adaptive pacemakers are used to achieve a better cardiac performance during exercise by increasing the heart rate and cardiac output. The ideal rate adaptive sensor should be able to mimic sinus node modulation under various degrees of exercise and other metabolic needs. Minute ventilation sensing has proven to be one of the most accurate sensor systems. In this study, alterations in sinus rhythm and pacing rates during daily life conditions in 11 children (median age 11 years, range 6–14 years) with minute ventilation single chamber pacemakers were investigated. Correlation of sinus rhythm with pacing rates was assessed. ECG records were obtained from 24-hour Holter monitoring. Average rates of five consecutive P waves and pace waves were determined every half hour. The average of the two values was then used to determine hourly rates. Correlation coefficients between the sinus rhythm and pacing rates were calculated. In nine patients, pacing rates correlated well to sinus rhythm (range 0.6793–0.9558, P < 0.001 and P < 0.05), whereas in two cases correlation was not sufficient (P > 0.05). Most of the patients, in whom rate response factor (RRF) measurements during peak exercise by treadmill with chronotropic assessment exercise protocol were performed and pacemakers were programmed to these parameters, had more appropriate ventricular rates compared to spontaneous sinus rates. In these patients mean RRF value was 15.3 ± 2.7 (range 12–20, median 15). This study shows that during daily activities minute ventilation rate adaptive pacemakers can achieve pacing rates well correlated to sinus rhythm that reflects the physiological heart rate in children. (PACE 1998; 21[Pt. II]: 2100–2104)

rate responsive pacemaker, minute ventilation, children

Introduction

Cardiac performance during exercise depends mainly on the ability of the heart to increase its rate.1,2 Many studies, performed on patients with rate adaptive pacemakers, have shown that exercise tolerance and quality-of-life is improved when compared with fixed rate pacing.3–5 Various sensor systems including central venous temperature, oxygen saturation, pH value, stimulus to T wave, body activity, respiratory rate, right ventricular dP/dt, minute ventilation, stroke volume, evoked potentials, and atrial rate have been used for rate adaptive pacing.6 Minute ventilation sensing has proven to be one of the most accurate, even in patients with reduced pulmonary function.7,8

Most of the studies that evaluate the rate responses of the rate adaptive pacemakers are performed on the adult population.8–13 Evaluation methods are different. Comparison of pacing rates with the sinus node responses of healthy people is one of the methods.8 Another method is to compare the pacing rates with the patient’s own sinus rate recorded noninvasively.10,11 We are not aware of any study that evaluates the correlation between pacing rates and the patient’s own sinus node rates in children with minute ventilation rate adaptive pacemakers.

This study was designed to investigate and correlate the alterations in spontaneous atrial
rates, which reflects the physiological heart rate, and pacing rates during everyday activity in children with minute ventilation single chamber rate adaptive permanent pacemakers.

Methods

The study was performed on 12 pacemaker dependent children (mean age 10.6 ± 2.6, range 6–14, median 11 years) with third-degree heart block and normal sinus node function. Heart block was congenital in 3 patients (2 with corrected transposition of great arteries), surgical in 7 patients [closed ventricular septal defect in 5, atrial septal defect in 1, and repaired tetralogy of Fallot in 1], and during treatment course of acute myelogenous leukemia in 1 patient. All patients had a minute ventilation single chamber pacemaker (Telecommunications Meta III MVTM, Telecommunications Pacing Systems Inc., CO, USA) with a bipolar, screw-in, steroid-eluting ventricular electrode. At the time of study, they had been paced for a mean period of 19.2 ± 6.3 months (range 10–27 months). None of the patients had pulmonary disease. Twenty-four-hour Holter monitoring was performed with 24-hour ECG tape recorders. Patients were encouraged to have normal daily activities to obtain low and high heart rates during Holter monitoring. The records were acquired on a computer and ECG traces from three simultaneous leads that had more visible P waves were analyzed. Atrial and ventricular rates were calculated from the mean PP and RR interval of the five consecutive beats every half hour (Fig. 1). The average of the two values was obtained to determine hourly rates. One patient was excluded from the study because of excessive artifacts on Holter recordings.

Initially, pacemakers were programmed to the rate response mode with optimal rate response factors (RRFs) according to our experience, which was obtained from previous patients who underwent RRF measurement during exercise test. In eight patients, 24-hour Holter monitoring was performed with these initial RRF programming. In patients in whom no correlation between sinus rate and pacing rates was found, RRF was adjusted at peak exercise obtained by graded treadmill testing according to the chronotropic assessment exercise protocol.24 A second 24-hour Holter monitoring was performed with these new RRF programs. In the remaining three patients, initial 24-hour Holter monitoring was performed after the RRF value adjustment.

Correlation between sinus rates and pacing rates was determined. A P value of < 0.05 was regarded as statistically significant.

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**Figure 1.** An electrocardiographic strip from 24-hour Holter monitoring shows the sinus (P) and pace waves.
Results

In patients in whom sinus rates and paced ventricular rates were correlated, the mean RRF value was 15.3 ± 2.7 (range 12–20, median 15) and the mean correlation coefficient was 0.8792 ± 0.0826 (range 0.6793–0.9558) [P < 0.001 and P < 0.05] (Table I).

In 5 of 11 patients, spontaneous sinus rates correlated well to pacing rates. On the contrary, in the remaining 6 patients correlation was not sufficient. In 4 of these 6 patients, pacemakers were reprogrammed according to the new slope value for RRF, and all showed a well correlation between spontaneous sinus rates and pacing rates in following Holter monitoring (Fig. 2, Table I).

The 24-hour trends of sinus and pacing rates of patient 9, with optimal and adjusted RRF values are given in Figure 3.

Discussion

Rate adaptive pacemakers are increasingly popular because of their beneficial effects on exercise capacity and quality-of-life when compared to fixed rate ventricular pacing. However none of the currently available sensors for rate adaptive pacing can be said to be ideal, and each sensor has its own advantages and disadvantages. Minute ventilation biosensor has been shown that this method closely and accurately reflects the metabolic demands of varying workloads in children and can be used to achieve physiological, rate adaptive pacing. Ergometric test and Holter monitoring are commonly used tools to assess the optimal rate response setting for the pacing system. Comparing observed rates to age and sex-matched normal rates, it is possible by means of the ergometric test to define appropriateness of the response curve. In patients with minute ventilation rate adaptive pacemakers, combined analysis of exercise and gas exchange showed a high correlation between heart rate and workload, VO2, and minute ventilation. It is well known that programmed exercise protocols may not simulate daily activity exactly, since daily life includes burst of activity, mental stress, and intellectual effort in addition to graded physical stress. Hence, 24-hour Holter monitoring may be more demonstrative of the daily use of the sensor function.

Sinus activity, when present and normal, is undoubtedly the ideal triggering signal for a

Table I.

<table>
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<th>Patient</th>
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<th>P</th>
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* Holter monitoring results with optimal RRF value; **Holter monitoring results after adjustment of RRF values; NS = not significant; RRF = rate response factor.
CONTROL OF RATE ADAPTATION IN MINUTE VENTILATION PACEMAKERS

Figure 3. Twenty-four-hour trends of sinus and pacing rates of patient 9. (A) Noncorrelated sinus and pacing rates with arbitrary rate response factor. (B) Correlated sinus and pacing rates after rate response factor adjustment.

It was an important finding that all four patients in whom correlation was insufficient with initial optimal RRF values, showed a well correlation after readjustment of rate adaptation parameters, especially RRF. It suggests that, in patients with rate adaptive pacemakers, rate adaptation parameters should be programmed carefully.

In conclusion, minute ventilation rate adaptive pacemakers can achieve pacing rates that correlates well to patients' own sinus rates in children during daily-life activities. In these patients, rate adaptive parameters should be adjusted during exercise testing for an appropriate rate response.

References


