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Plethyzmography in assessment of hemodynamic results of pacemaker functions programming

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The paper presents potential role of plethyzmography in optimization of heart hemodynamic function during pacemaker programming.

The assessment of optimal stroke volume in patients, with implanted dual chamber pacemaker (DDD), by plethyzmography was a goal of the study. The data were collected during pacing rhythm. 20 patients (8 female and 12 male, average 77.4+/-4.6 years) with dual chamber pacemaker (DDD) and with pacing rhythm during routine pacemaker control and study tests were incorporated in the study group. Hemodynamic parameters were assessed during modification of atrio-ventricular delay (AVD) for pacing rhythm of 70 bpm and 90 bpm. The time of atrio-ventricular was programmed with 20 ms steps within range 100-200 ms and data were recorded with two minutes delay between two consecutive measurements. Stroke volume (SV) and cardiac output (CO) were calculated from plethyzmographic signal by using Beatscope software (TNO Holand). Highest SV calculated for given pacing rhythm was named optimal stroke volume (OSV) and consequently highest cardiac output was named maximal cardiac output (MCO). The time of atrio-ventricular delay for OSV was named optimal atrioventricular delay (OAVD).

The results have showed: mean values of OAVD for 70 bpm - 152+/-33 ms and for 90 bpm -149+/-35 ms, shortening of the mean OAVD time caused by increase of pacing rate from 70 bpm to 90 bpm what resulted in statistically significant decrease of OSV with not statistically significant increase of MCO. The analysis of consecutive patients revealed three types of response to increase of pacing rhythm: 1. typical – shortening of OAVD, 2. neutral – no change of OAVD and 3.atypical – lengthening of OAVD.

Key Words: plethyzmography, atrio -ventricular delay, stroke volume, cardiac output, pacemaker.

Introduction

The pacemaker implantation is widely used method of treatment of patients with heart rhythm and conduction disturbances. Permanent pacing has impact on heart hemodynamic performance. The effect can be positive i.e. cardiac resynchronization or harmful, i.e. pacemaker syndrome [6]. Conduction system of the heart consists of sinoatrial node located in right atrium, atrioventricular node and bundle of his located in intraventricular septum with branches and Purkinje fibers located in ventricles muscles. The conduction signal is transmitted from sinoatrial node to atrioventricular node, bundle of his with branches to Purkinje fibers and finally to muscle cells of the heart. In the heart we can observe intraatrial, atrioventricular and intraventricular conduction disturbance. In dual chamber pacing heart electrical impulses are delivered from the tips of implanted electrodes placed in right atrium and in right ventricle apex. For patients treated by bichannel DDD pacing atrioventricular conduction disturbance can be substituted or corrected. For such patients the proper tailoring of AVD seems to be crucial because the improper values of AVD can cause decrease the CO [5]. Appropriate programming of AVD should be performed individually considering underlying heart disease, the patient age, activity etc. Routinely AVD time is programmed based on stroke volume or cardiac output assessed with ultrasonocardiography, which requires highly skilled operators and there is a time consuming method or impedance cardiography [2]. Programming is carried out in lying position just with only one heart rate.

The goal of the present study was non-invasive evaluation of hemodynamic heart performance by plethyzmography in patients with dual chamber pacing rhythm.

Methodology

Study group included 20 patients (8 female and 12 male, mean age 77.4+/-4.6 years) treated by dual chamber pacemaker (DDD), and with pacemaker driven rhythm during routine pacemaker control and study tests.

Hemodynamic parameters of paced heart were assessed by Portapres (Finapres Medical Systems, Holand) system. The system provides non-invasive continuous blood pressure measurements based on volume – clamp method. Pneumatic cuff with photodiode and LED diode is wrapped around the finger. Results were analyzed off line with Betscope software. Heart rate, stroke volume and cardiac output were calculated.

Hemodynamic parameters were assessed during modification of AVD for given pacing rhythm of 70 bpm and 90 bpm. The time of atrio-ventricular was programmed with 20 ms steps within range of 100-200 ms. Data were recorded with two minutes delay between two consecutive measurements. SV and CO were calculated from plethyzmographic signal by using Beatscope software (TNO Holand). Highest SV calculated for given pacing rhythm was named OSV and consequently highest cardiac output was named MCO. The time of AVD for OSV was named OAVD.

For statistical evaluation the Wilcoxon test ($p \leq 0.05$) was used.

Results

The results have shown: mean values of OAVD for 70 bpm - 152+/-33 ms and for 90/min - 149+/-35 ms, shortening of the mean OAVD time caused by increase of pacing rate from 70 bpm to 90 bpm what resulted in statistically significant decrease of OSV with not statistically significant increase of MCO. The analysis of consecutive patients revealed three types of response to increase of pacing rhythm: 1. typical – shortening of OAVD, 2. neutral – no change of OAVD and 3. atypical – lengthening of OAVD.

Table 1. Comparison of mean values of OSV and MCO for pacemaker given rhythm 70 bpm and 90 bpm.

Pacing rate	70 bpm	90 bpm	p
Mean values of OSV	76.95+/-16.44 ml	62.3+/-16.12 ml	$p \leq 0.05$
Mean values of MCO	5.1+/-1.53 l/min	5.61+/-1.45 l/min	ns

Discussion

Dynamic development of heart pacing and introduction of new methods and algorithms for programming of pacemakers allowed deterioration of unwanted, harmful effects of permanent pacing on the heart. Individualization of pacemaker programming generated the requirements for assessment of hemodynamic effects [4]. Routinely AVD is programmed based on SV or CO assessed by ultrasonocardiography, which is difficult and time consuming method, or impedance cardiography [3]. Programming is carried out in lying position just for the only one heart rate. Above listed methods do not provide sufficient data regarding patient activity. The acceleration of the heart rate during exercise is a basic physiological mechanism of cardiac output increase. The increase of the heart rate is followed by shortening of PR interval. The PR interval in paced heart is represented by AVD. This paper presents potential role of plethyzmography in assessment of heart hemodynamic function in patients with two programmed heart rates. Plethyzmography is a non-invasive and simply method [1]. Results of our study have shown that in some patients acceleration of pacing rhythm along with shortening of AVD cannot change or can even impair hemodynamic performance of the paced heart. This observation is coherent with our previous studies with use of ultrasonocardiography and impedance cardiography. Above described finding, and varied response of OAVD to increase of cardiac rhythm have proved the need for simple, fast method of optimization of hemodynamic activity of the heart.

Conclusion

Plethysmography provides reliable values of heart hemodynamic parameters suitable for pacemaker function programming in order to optimize the atrioventricular delay time.

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