

## Rate-Responsive Pacing in Patients with Angina Pectoris

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### Summary

*One of the most unfavorable condition depending on rate responsive pacing is an inappropriate onset of angina pectoris in patients with concomitant ischaemic heart disease. The goal of the present study is to define the optimal parameters for rate adaptation, to ensure the maximal exercise tolerance and to preserve patients from attacks of angina pectoris. We made a clinical trial on 49 patients (28 male, 21 female, mean age  $59 \pm 11$  and mean NYHA class of angina pectoris  $2.8 \pm 0.8$  in the period between paroxysms of atrial fibrillation, mean follow up  $16 \pm 8.2$  months). All the patients underwent AV-node radiofrequency ablation with consequent VVIR pacemaker implantation with motion activity sensor. According to the age, constitution, NYHA class and primary exercise tolerance basic rate, rate increase, sensor gain and maximum sensor rate (MSR) were adjusted. Preferable MSR was 125. Mean sensor gain  $14 \pm 6$ , mean rate increase  $3.5 \pm 1.8$  ppm/s. In the long term follow up period 37 patients exhibited strong improvement of the life quality. Nine patients have not noticed significant changes in their life status. Three patients complained of worsening of their condition. Two of that three had undergone CABG procedure with good results and one died of non cardiac pathology.*

### Key Words

Rate-responsive pacing, angina pectoris, exercise test

### Introduction

Costeas and Schoenfeld [1] have summarized the goal of rate-adaptive pacing as following: "...Because metabolic needs varies with different types of physical and psychological challenge, the heart must provide the appropriate output, not merely the maximum output. This concept of matching just enough cardiac output to the current metabolic needs is intrinsic to the heart's efficiency and to contemporary pacing efforts intended to replicate normal cardiac function."

The roots of activity-controlled pacing date back to the early 1970s [2]. At that time, several groups investigated the possibility of ventilation detection by means of a small piezoelectric sensor placed in the vicinity of the thorax. For practical purposes an intrathoracic implants were not feasible, and an extrathoracic sensors yielded a variety of signals with a high component of what was considered to be unwanted noise. The signal representing respiration was found to be of a minor amplitude in comparison to noise. The primary idea of using a piezosensor for detection of ventilation

was abandoned. In the early 1980s, the idea of using what was previously considered "a background noise" as an indicator of general body activity was explored and implemented in practice.

In 1987, the possibility of using acceleration forces for rate control was reported [3]. This new principle of pacing was based on the body acceleration due to the movement activity which was detected in the antero-posterior direction by means of a small accelerometer located within the hybrid electronic circuitry inside the pacemaker. Since late 1970s and early 1980s, a variety of sensors have been used for rate-adaptive pacing. Activity-guided rate-adaptive pacing has achieved a wide clinical acceptance as the primary rate-controlling principle.

One of the most unfavorable condition depending on rate responsive pacing is an inappropriate onset of angina pectoris in patients with concomitant ischaemic heart disease. At the high frequency pacing the diastolic time decreases. As the coronary blood flow occurs

Basic rate	Number of patients		
	Post operatively	After ECG monitoring	6 months follow-up
62	16	22	29
72	29	24	19
82	4	3	1

Table 1. Results of basic rate adjusting.

basically during a diastole the increased oxygen demand versus its inadequate delivery might cause ischaemia. Despite the advantages of coronary artery bypass grafting, balloon angioplasty and stenting the number of patients which are contraindicated for these procedures on one hand and need for cardiac pacing on the other hand is still high. Some investigators [4] consider the coexisting coronary artery disease to be an "a priori" contraindication for rate-responsive pacing despite its obvious advantages.

The goal of the present study is to define the optimal parameters for rate adaptation, (i.e. basic rate, sensor gain, maximum sensor rate) to ensure the maximal exercise tolerance and to preserve patients from attacks of angina pectoris.

## Methods

### Patient Selection

We made a clinical trial on 49 patients (28 male, 21 female, mean age  $59 \pm 11$  and mean NYHA class of angina pectoris  $2.8 \pm 0.8$  in the period between paroxysms of atrial fibrillation, mean follow up  $16 \pm 8.2$  months). All the patients underwent AV-node radiofrequency ablation with consequent VVIR pacemaker implantation with motion activity sensor (Metros TC 01, Biotronik, Germany).

### Study

#### Adjusting the basic rate

The role of basic rate in coronary artery disease patients is not clear. According to the age, constitution and NYHA class we primarily used three basic rates (62; 72; and 82 per min) [5]. A week after pacemaker implantation all patients underwent 24 hours ECG monitoring. In patients exhibiting ECG signs of angina pectoris [6] and having basic rate 72 or 82 the latter was reduced by 10. Moreover, if a patient in a six months follow up period showed the impairment of life

Max. sensor rate (bpm)	Number of patients
100	13
125	32
150	4

Table 2. Results of the maximum sensor rate adjusting.

quality parameters due to ischaemic heart disease the basic rate was also reduced by 10 if previously has been 72 or more.

#### Adjusting the maximum sensor rate (MSR)

The MSR adjustment was carried out after the basic rate establishment. The most common method of estimating the patient's maximum rate is subtracting the patient's age in years from 220: age-predicted maximum heart rate =  $220 - \text{age (years)}$  [7]. According to our experience, this method is not quite appropriate in patients with CAD as it does not evaluate the coronary artery lesions and LV function. Practically to define MSR value we had to choose between 100 bpm, 125 bpm and 150 bpm. We used the following algorithm. Firstly, in patients with NYHA class 4 and in those elder then 70 years of age with NYHA class 2-3 we established the MSR 100 bpm. In all remaining patients, we established MSR 150 bpm and they underwent exercise testing.

1. 6 minutes of walking on level ground at a rate of steps per seconds.
2. 1.5 minutes of climbing stairs at a rate of one step per second.
3. 1.5 minutes of descending stairs at a rate of one step per second.
4. 0.5 minutes of sit-ups at a maximum individual rhythm.

Heart rate was monitored continuously using portable pulseoximeter.

Once ECG signs of ischaemia appeared, the exercise test was stopped and the patient received the MSR no more than 0.7 of the rate which caused test termination.

If exercise test termination occurred due to fatigue or shortness of breath before MSR was achieved, we changed sensor gain and rate increase in order to reach MSR more rapidly and vice versa, if MSR was reached inappropriately fast the sensor gain and rate increase was adjusted as well.

If exercise test was carried out successfully at the MSR 150 bpm, it was repeated the day after at the MSR 125 bpm. Within absence of significant difference, the last meaning remained.

## Results

The adjustment of the basic rate after 24 h ECG monitoring was necessary in 6 patients. Seven patients demanded basic rate adjustment after 6 months follow up period (Table1).

Preferable MSR was 125 bpm. Mean sensor gain  $14 \pm 6$ , mean rate increase  $3.5 \pm 1.8$  ppm/s. In the long term follow-up period, 37 patients exhibited strong improvement of the life quality. Nine patients have not noticed significant changes in their life status. Three patients complained of worsening of their condition. Two of that three had undergone CABG procedure with good results and one died of non cardiac pathology.

## Discussion

Despite exercise tolerance increasing and improvement of the life quality the VVIR pacing has some limitations and «dark sides».

1. Maximum sensor rate is a fixed value, failing to adjust for disease progression, changes in the hemodynamic state, or variation in the emotional status of the patient. This statement seems obvious, however, we consider that appropriate long term follow up including in time correction of somatic status on one hand and creating a physiological pacemakers adjusting the heart rate not only to emotional changes but to inotropic and metabolic demands of the myocardium on the other hand might maintain the highest possible life quality level [8].
2. Some studies [9] demonstrated that RV apical pacing was associated with reduced local myocardium perfusion at the site of pacing as was detected by Tl-201 scintigraphy. These perfusion abnormalities may have been due to alteration in myocardial activation and contraction in RV apical pacing, and the incidence of impaired perfusion increased with time. In the long term, these perfusion deterioration may lead to regional wall motion abnormalities, resulting in impaired global left ventricular function as was noted on radionuclide ventriculography. Unfortunately the lack of long term follow up of the

patients with VVIR pacemakers associated with CAD does not permit to draw a conclusion on their mortality, morbidity and quality of life. That is the special field of our scientific interest and demands the further analysis.

## Limitations of the study

The present study has following limitations:

1. Some points of this article regarding the adjustment of rate responsive settings are presented briefly and are planned to be reported in details in the future.
2. The more accurate approach to the problem demands additional analysis of LV function as well as metabolic parameters of the myocardium.
3. The clinical trial should include not only patients after RFA of His bundle, but all patients with CAD demanding pacemaker implantation.
4. In order to draw a reliable conclusions it is necessary to extend long term follow up.

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