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CASE REPORT

The Importance of Adequate Programming Dual-Chamber Pacemaker in Physically Active Patients

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Abstract

Limitations to physical activities and sports practice are frequently observed in pacemaker's users, due to patient's difficulties in judging their real physical capacity after device implantation and because of inappropriate programming. In this paper, we describe the cases of two patients with diagnosis of complete atrioventricular block and structurally normal heart, who started having symptoms of exercise intolerance after pacemaker implantation. The pacemaker programming was then individualized, based on treadmill tests, according to the needs of each patient. We concluded that exercise testing was an important tool to guide proper electronic programming of pacemakers during exercise.

Keywords: Dual-chamber Pacemakers, Exercise Testing, Pacemaker Wenckebach, Physical Activity

Introduction

Regular physical activity is considered an important non-pharmacological measure to reduce cardiovascular risks and mortality[1]. Patients with pacemakers often present many limitations to sports practice or physical activity due to the lack of knowledge or medical advice about their potential physical capacity and also because of ineffective devices programming for their needs [1].

In this paper we describe the cases of two patients with structurally normal heart, in whom pacemaker was implanted due to atrioventricular block and who develop limiting symptoms during physical activity.

Case Description

Case 1

A 54-year-old male, non-professional street runner, with structural normal heart and a history of recurrent syncope was investigated. An intermittent 2:1 atrioventricular (AV) block was diagnosed. The patient underwent a dual-chamber pacemaker (PPM) implantation (*Biotronik - Edora 8 DR-T*). After the procedure, he presented with exercise intolerance, although was asymptomatic at rest. His device was programmed in DDD mode with a lower rate limit of 60 beats per minute (bpm), upper maximum tracking rate (MTR) of 130 bpm and post-ventricular atrial refractory period (PVARP) of 275 ms. The automatic PVARP and pacemaker mediated tachycardia (PMT) intervention algorithm were enabled as well as auto mode-switch (AMS) feature. The programmed AV sensed interval was 160 ms and paced interval, 220 ms. He had 0% and 100% pacing burdens in the atrium and ventricle, respectively.

Case 2

A 47-year-old male with structurally normal heart, and intermittent complete AV block, underwent a dual-chamber PPM implantation of (*Medtronic - Advisa DR MRI A3DR01*). He was a CrossFit practitioner and after the procedure, he started presenting presyncope and dizziness during exercises. His device was programmed in DDD mode with a lower rate limit of 50 bpm, MTR of 145 bpm, automatic PVARP (minimum of 250 ms). PMT intervention algorithm and AMS feature were enabled. The programmed AV sensed and paced intervals were 150 ms. He had 1,8% and 100% pacing burdens in the atrium and ventricle, respectively.

The two patients were followed-up and the adjustments of the maximum frequency were made, so they could return to their routine physical activities .

Both patients underwent a treadmill test, which demonstrated a pacemaker induced Wenckebach in the peak of the exercise (Figure 1).

In the first case, the PVARP was shortened to 250 ms, the automatic PVARP feature was disabled. The AV delay sensed/paced was modified to 120/180 ms and the MTR increased to 150 bpm.

In the second case, the automatic PVARP feature was disabled and fixed in 250 ms. The sensed AV delay was adjust to 130 ms and MTR modified to 160 bpm. After two years of follow-up in the first case and five years in the second, other exercise tests were performed. No more Wenckebach events were observed and both patients remained asymptomatic, in their habitual lifestyle.

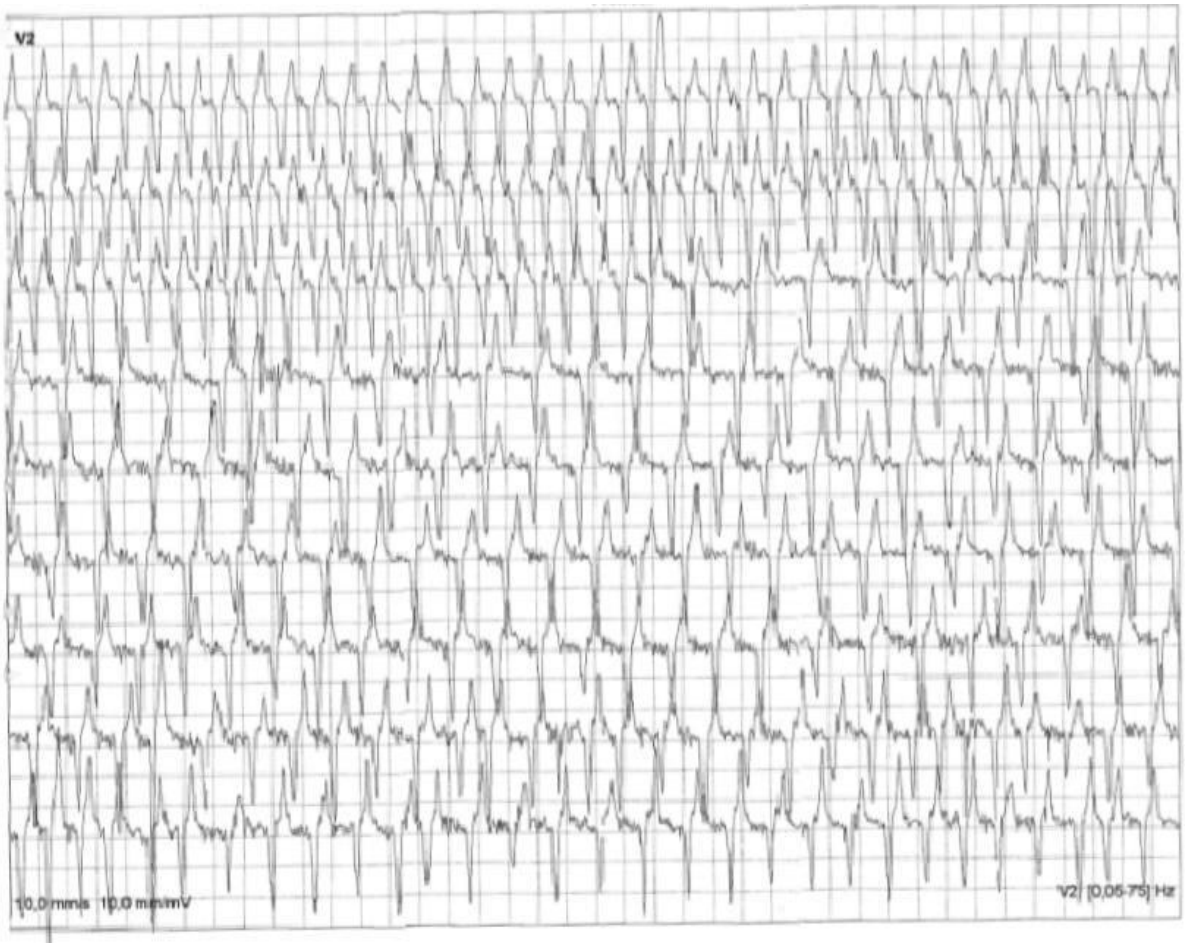

Figure 1A: First Case

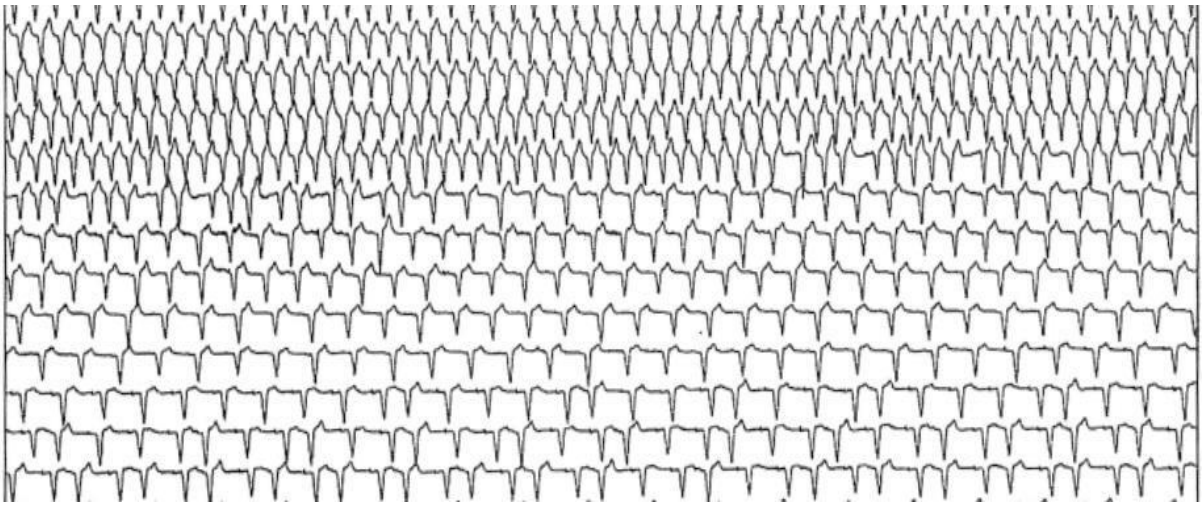

Figure 1B: Second Case

Discussion

The upper rate of a dual-chamber pacemaker can be calculated using the total atrial refractory period (TARP). This is the period in which the atrial canal remains refractory and unresponsive to incoming signals, and is defined by the sum of the AV interval and the PVARP (Figure 2). It occurs after a sensed or paced event, to avoid inappropriate tracking of sensed signals due to ventricular repolarization or retrograde P waves. TARP is not directly programmable, but it can be achieved indirectly by changing the PVARP and/or the sensed AV delay interval [2,3].

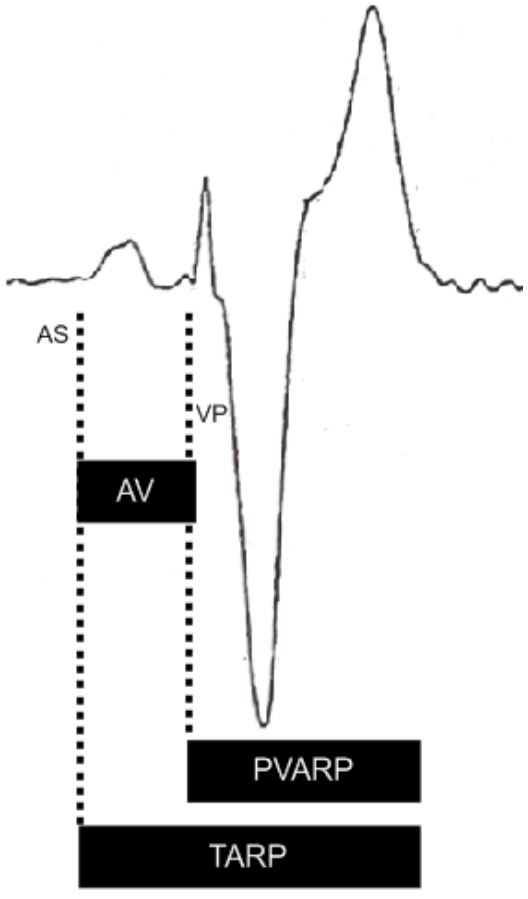

Figure 2: AS - atrial sensed; VP - ventricular paced; AV - atrioventricular; PVARP - post-ventricular atrial refractory period; TARP - total atrial refractory period.

Maximum track rate (MTR) is the highest ventricular pacing rate allowed, in response to intrinsec atrial activity, to preserve 1:1 AV synchrony. As the intrinsic atrial rate increases, ventricular pacing cannot violate the upper rate limit, resulting in progressively lengthening of the AV interval until an atrial event falls into the PVARP and is left out as a refractory atrial sensed (AR). So, the ventricular pacing rate will not exceed the programmed MTR. When the atrial rate exceeds the MTR, it is observed the pacemaker Wenckebach phenomenon in which there will be more sinus depolarizations than those that the device is capable of pacing the ventricle. The consequence is a sudden drop-in heart rate and cardiac output at a given level of exercise that can produce immediate symptoms such as dyspnea, fatigue or presyncope. A pacemaker Wenckebach occurs above the MTR, but below the 2:1 block rate. Advanced blocks can occur above the 2:1 block rate [2, 4].

Numerous pacemaker parameters are connected. Frequently, modifying one parameter will influence others. In some cases, PVARP is programmed too long to prevent retrograde conduction and induction of PMT. On the other hand, if MTR is adjusted too high, it may cause prejudicial consequences by inducing PMT. However, modern pacemakers have additional algorithm features to improve the devices safety and performance, such as improved sensing, adaptive refractory periods, intervention algorithms for PMT and mode-switch options. Therefore, making higher MTRs possible is especially important for physically active patients that require an adaptive increase in heart rate to do their exercises [5].

In the first case, the TARP during exercise could be calculated by adding the sensed AV interval and the minimal PVARP: 160 ms + 275 ms = 435 ms. This number

corresponds to a heart rate of 138 bpm (60000/435), consistent with the sinus rate at which the patient develops symptomatic 2:1 block. The MTR is 130 ppm, so 138 bpm is higher than the MTR, which explains why the patient developed the pacemaker Wenckebach. The adjustments that have been done were increasing MTR, shortening the PVARP and sensed AV interval during exercise. These changes resulted in a TARP of 120 + 250 = 370 ms during exercise, allowing the device to track sinus tachycardia up to 162 bpm (60000/370) in 1:1 AV beat. It works as a Wenckebach period of 150-162 bpm followed by 2:1 block above 162 bpm.

In the second case, the TARP at maximal exercise could be calculated adding the sensed AV interval and the minimal PVARP: 150 ms + 250 ms = 400 ms. This corresponds to a heart rate of 150 bpm (60000/400), consistent with the sinus rate at which the patient develops symptomatic 2:1 block. The frequency of 150 bpm is higher than the MTR (145 bpm). This explains why the patient developed pacemaker Wenckebach. The adjustments made were shortening the PVARP, sensed AV interval during exercise and increasing the MTR to 160 bpm. These changes resulted in a TARP of 130 + 250 = 380 ms during exercise, allowing the device to track sinus tachycardia up to 158 bpm (60000/380). Above 158 bpm, it works as a 2:1 block.

After an adequate and safe programming, both patients returned to their physical activities, with disappearance of symptoms along the clinical and electronic follow-up.

The patients above were young and had a structurally normal heart, despite the conduction system disturbance. They could return to their usual physical activities and remain asymptomatic, with a good quality of life, after individual adjustments of PM programming.

Pacemakers programming must be individualized, according to the needs and comorbidity of each patient. Special attention should be given to physically active patients with atrioventricular block, to ensure an adaptive increase in heart rate. As pacemakers are evaluated at rest, exercise testing is an important tool to support proper electronic programming during exercise. A multidisciplinary assessment in conjunction with clinical cardiologists and cardiac rehabilitation experts is fundamental to guide the return of physical activities and performing exercise prescription for these patients.

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Contributions

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Data analysis and interpretation: **MDP, CIGG**

Collection and/or assembly of data: **PAO, CIGG, MIS,**

Writing the article: **PAO, MDP, SCBP, MIS**

Critical revision of the article: **CIG, MIS, PAO**

Final approval of the article: **DTH, MDP**

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