Particularities of Pacemaker Therapy in Elderly Patients

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Summary

As the demographics of many Western countries begin to shift toward an ever-aging population, geriatrics becomes an increasingly important field. The majority of pacemaker patients are 70 years and older. Physicians implanting pacemakers in older patients need to consider differences in tissue reactions (hematoma, for example), venous approaches to lead implantation, the pacemaker pocket, etc. Selecting the correct device is also a challenge. Sensors based on movement or other activity-related parameters may not serve the needs of less active elderly patients. A system described in this article known as Closed Loop Stimulation (CLS) can provide elderly patients with appropriate heart rates, which ensure appropriate cardiac output, under times of mental and physical stress. Using information about the contractile state of the myocardium, this method of pacing processes intrinsic data to determine an appropriate heart rate. Chronotropically incompetent patients not only benefit from this life-saving technology, but can once again enjoy a restored quality of life.

Key Words

Pacing in the elderly, Closed Loop Stimulation, baroreceptor reflex, sensor technology

Introduction

Pacemaker implantation remains the therapy of choice for patients with bradycardic rhythm disturbances and, increasingly so, for patients with various tachycardic rhythm disturbances. The majority of patients requiring an implant are over 70 years old (Figure 1). Therefore, specific conditions due to the higher patient age must be considered during implantation. Furthermore, when selecting a pacemaker model, the particular requirements of elderly patients must also be taken into account. The goals of pacemaker implantation should not stop at preserving and extending life. The intervention should aim for a true improvement in the patient's quality of life [4-7]. The device should allow patients to take up activities they were able to perform before the disease, in the comforting awareness of the implant functioning safely. In this context, it is also important that the pacemaker implantation procedure does not scare the patients or leave them with frightening memories. In the resulting post-implant state the patients should, after a certain period of time, no longer be pre-occupied with the fact that a pacemaker mostly monitors and controls their heart rate.

Selecting a Pacemaker

By now, implantation of a single-chamber pacemaker should be restricted to patients who suffer from brady-arrhythmia absoluta and irreparably damaged atrioventricular coordination. With the option of rate-adaptive pacemaking, these patients can gain a limited ability to withstand higher loads through the artificial rate increase. The major obstacle to regaining a full quality of life, however, is usually the underlying disease. It usually results from considerable irreversible dilatation of the left ventricle, caused by many years of hypertony or heart valve malformations. For all other pacemaker indications, implantation of a dual-chamber system is appropriate. Figure 2 shows the distribution of the indications of our patient group (1996 - 1998).

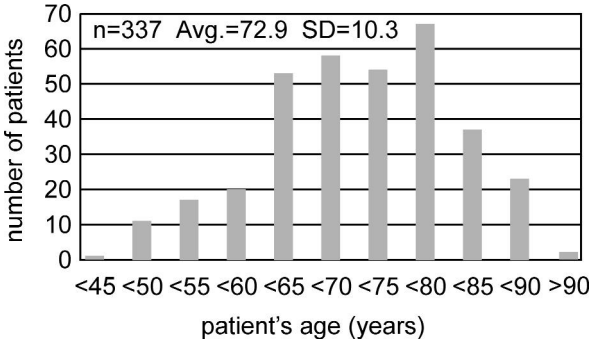

Figure 1. Age distribution of pacemaker implantations 1996-1998.

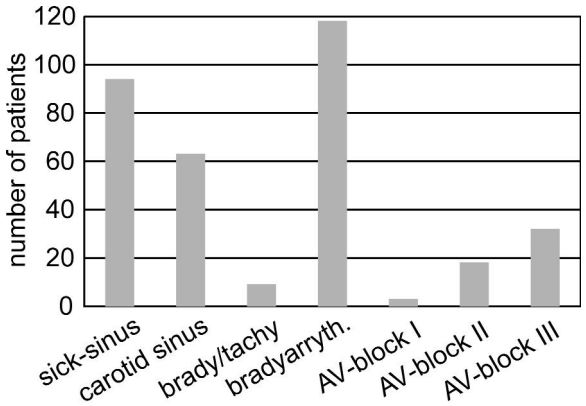

Figure 2. Indications for pacemaker implantations 1996-1998.

Pre-operative Procedures

Prior to the operation, the implantation procedure must, of course, be explicitly explained to the patient in a way that suits his or her level of education and medical knowledge. The principle underlying artificial cardiac pacemakers and how they work must be presented to the patient in simple and understandable words. Questions arising at this point must be answered in detail. It is very important to point out that the pacemaker cannot resolve all problems with the heart to avoid unrealistic expectations connected to the pacemaker implantation. Pre-operative examinations should concentrate on checking the electrolytes, coagulation status, and balance of liquids.

The prescription of thrombocyte aggregation-inhibitors is no contraindication for an implantation. However, it requires very careful blood stanching intraoperatively, to prevent possible post-operative hematoma. Especially in elderly people, the tissue is sometimes no longer firm enough to arrest bleeding from the smallest blood vessels by self-tamponade. Therefore, post-operative hematoma frequently develops in elderly patients, even if no major bleeding can be detected. Such types of hematoma are, at the very least, unpleasant and unsightly to the patient, but they can also be a source of greater danger, for example, a superinfection.

The Implantation

When implanting the transvenous leads, puncturing the subclavian vein or preparing the cephalic vein may be sometimes more difficult in elderly patients. To mention one obstacle, the cephalic vein is often obliterated. In our work group, this has led to the practice of principally puncturing the subclavian vein, especially if two leads need to be introduced. It is often difficult to puncture the subclavian vein in elderly patients, because the vessels might be distorted or cannot be found at the typical place due to the frequent formation of emphysema or pronouncedly cachectic conditions of the thorax.

When placing the lead in the right ventricle, special care has to be taken in elderly patients with a dilated heart. The endocardium should not be worked on too much. The risk of perforation is markedly higher in older hearts because of the loose tissue structure. In most cases, a perforation with subsequent retraction of the lead has no consequences. However, bleeding into the pericardium and subsequent tamponades have been repeatedly reported. Unfortunately, we have also observed this twice in our patients.

Particular attention must be paid to preparing the pacemaker pocket and placing the pacemaker into this pocket. The pocket should be sufficiently large to house the pacemaker without any tension. Especially dystrophic, older skin has a stronger tendency toward perfusion necrosis (with the resulting pocket defects) than the skin of younger patients. The placement of the pacemaker aggregate may, of course, not restrict the mobility of the shoulders and upper body. The pacemaker must be placed in such a position that it does not disturb the patient, even when lying on his or her side. Post-operative Redon's suction drainage has always

been controversial. A critical step when performing a drainage is the pulling of the drainage. It must be done very carefully and gently. Otherwise, there is a risk of causing new bleeding.

Sensor Technology and the Aged

On a larger scale, pacemaker treatment has the goal of reestablishing the control loop of mean arterial blood pressure (MABP) and heart rate, which has been disturbed by the bradycardic rhythm disturbance, under load and at rest. In essence, this feat enables the patient to withstand loads, thus contributing to a restored quality of life. In elderly patients, circulatory reserves and load reserves are limited to a high degree, and are even exhausted, so closing the intrinsic control loop is of great importance. This insightful, but basic, knowledge seems straightforward, but the approaches taken in rate-adaptive pacing have focused on external input.

In the last 10 years, the problem of adequate rate adaptation in various pacemaker systems has been at the center of the clinical and engineering efforts. Through a variety of sensor systems, it has been attempted to measure physiologic parameters as the correcting variable and to adapt the heart rate to the demand. This was achieved by measuring either the muscle vibration with an accelerometer, the minute ventilation, the right-ventricular ejection period, or the central venous temperature (Table 1). However, these systems did not resolve the problems of chronotropic incompetence, especially for less active elderly patients. None of these well-known sensor principles considered the baroreceptor reflex — the basic mechanism behind rate adaptation and blood pressure control.

Closed Loop Stimulation

The baroreceptors, localized in the vascular walls of the carotids and in the aortic arch, continuously register the blood pressure, which is determined by the cardiac output and the peripheral resistance. Changes in correcting afferent variables transmitted to the neuronal nucleus of the medulla oblongata generate, with input from the central nervous system, an efferent hypothalamic response. This efferent input guarantees a continuous adaptation of the heart rate, AV conduction time, contractility, and peripheral resistance. Therefore, the baroreceptor reflex guarantees a cardiac output that is appropriate to the immediate demand at all times (Figure 3).

Sinus node diseases lead to chronotropic incompetence and, thus, to insufficient rate adaptation. However, all other components of the cardiovascular control loop, most of all the myocardial contractility, still function. The new concept of Closed Loop Stimulation (CLS) successfully integrates the baroreceptor reflex in controlling the pacing rate and the systemic blood pressure, and, thus, reestablishes the intrinsic closed control loop. CLS systems detect an increase or decrease in the contraction dynamics of the heart, which are controlled by the baroreceptor, by measuring the unipolar intracardiac impedance. Subsequently, the pacing rate is increased or decreased [1,11,14].

Methods	Modell	Company
vibration measurement	Ergos/Actros Legend Sensolg Relay	BIOTRONIK Medtronic Siemens Intermedics
minute ventilation	Meta Chorus	Telectronics Ela Medical
right ventricular ejection interval	Precept	CPI
central venous temperature	Thermos	BIOTRONIK

Table 1. Different sensor systems for rate-responsive pacemakers.

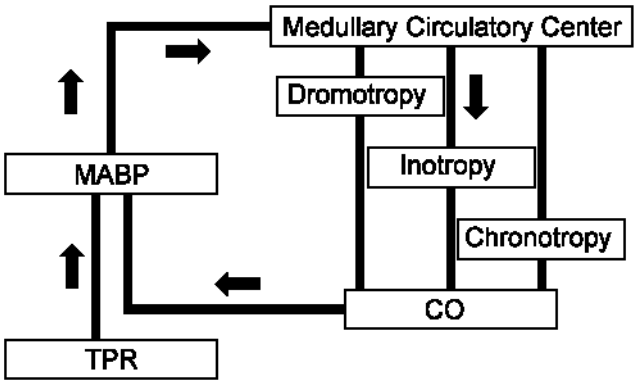

Figure 3. Cardio-circulatory system in the closed control loop.

The pacemaker INOS^2 CLS (BIOTRONIK, Germany) detects the reactive change of the contraction dynamics of the cardiac muscle and adjusts the pacing rate accordingly [12]. It is of decisive importance that a change in blood pressure, due to a new load situation, is recognized by the baroreceptors and reflected in the contractility via the circulatory regulation. The INOS^2 CLS causes a change in pacing rate in parallel to the changing contractility. The pacing rate is, thus, constantly monitored by the body with its own control system: If the pacing rate is set to a value that is too high, the baroreceptors register an increase in blood pressure that is too high. This leads to an immediate decrease in contractility and, therefore, in the end, to a decrease in the pacing rate. Thus, a constant control of the set pacing rate, in the form of a negative feedback loop, is evident in maintaining the blood pressure [15].

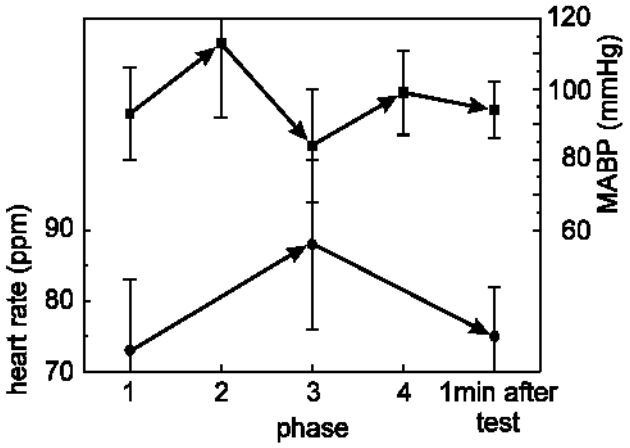

Figure 4. Time course of the mean atrial blood pressure (MABP) and the heart rate (HR) during Valsalva maneuver

Clinical Evaluation of CLS

The Valsalva maneuver, described by Valsalva in 1707 and systemized by Hamilton in 1944, proves the reintegration of the baroreceptor reflex into the control of MABP and heart rate impressively. During this maneuver, typical courses of MABP and heart rate arise during forced exhalation against a manometer-controlled pressure of 30 mmHg. These typical curves of MAPB and heart rate can only be observed if the pacing rate is controlled by the baroreceptor reflex. Our own studies in 30 patients about the regained functioning of the baroreceptor reflex confirmed the functioning of the closed system impressively by means of the Valsalva press test (Figure 4). As stated above, this control is disturbed in chronotropically incompetent patients. There is no adjustment of mean arterial pressure and rate. However, after implanting a CLS pacemaker, the adaptation of mean arterial pressure and rate courses to physiologic conditions can again be detected in these patients, Thus, the integration of the baroreceptor reflex into the Closed Loop Stimulation system can be proven.

Numerous studies have already established that a demand-oriented rate modulation is possible with this system: The results show that the Closed Loop system offers immense advantages when compared with a sensor-controlled system [8,9].

A simple example is the comparison of the load during bicycle ergometry and during stair climbing. An accelerometer-controlled system can guarantee a sufficient heart rate when climbing stairs. With bicycle ergometry, which causes fewer vibrations in the upper body region, a rate adaptation is not possible to such a degree. Tilt-table examinations also showed that CLS allows for a sufficiently fast and demand-oriented rate regulation in cases of neurocardiogenic syncope [3].

Beyond the tests for a rate-adaptive response to physical loads, CLS performs equally well in response to other loads. A catecholamine stress test was passed: A load situation was induced by external administration of dobutamine, and the Closed Loop system reacted adequately in all cases [2].

The reaction to a mental stress test or other stress studies, such as about the patient's fear of an injection or about pleasant excitations, provides further evidence that the closed control loop is functioning and, most importantly, being taken into consideration by the implant. In a Color Word test, the heart rate curve hardly differed from that of a healthy study participant. A rate modulation toward higher rates with increasing blood pressure during mental stress and the immediate decrease in the resting phase clearly show that CLS enables the body to again process mental stimuli adequately on a physical basis [10]. The same is illustrated by Lang's studies concerning the rate response of pacemaker patients supplied by CLS in the sleep laboratory: In the REM phases, a clear, psychologically induced increase in heart rate could be proven.

Such an appropriate reaction to mental stimuli has another, not negligible effect: It makes CLS well suited to geriatric, not very mobile patients in whom phys-

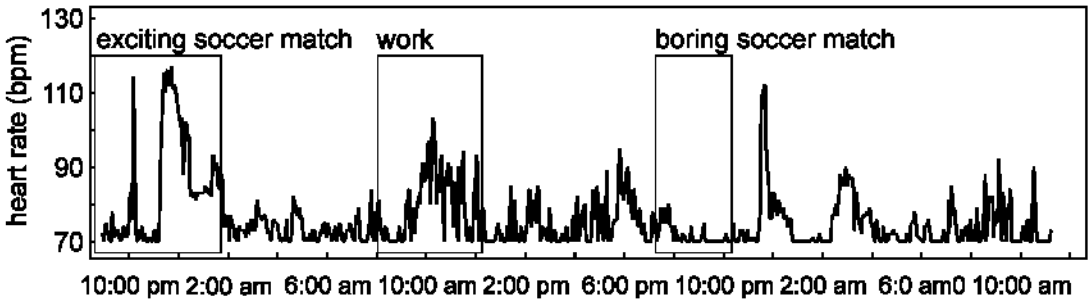

Figure 5. 68 year old soccerfan watching different matches on TV.

iologic or physical sensor systems do not provide adequate rate adaptation. In addition, this system enables elderly patients to process emotional events, such as rest and stress, with physiologic accuracy (Figure 5).

Conclusion

Modern pacemaker therapy does not necessarily aim at just extending life, but at meeting the patient's needs and improving the quality of life. For optimal results, it is necessary to preserve the short-term intrinsic mechanism for maintaining a heart rate adapted to the load and an adequate blood pressure. The baroreceptor reflex constitutes this decisive short-term mechanism. Only a functioning baroreceptor reflex can lead to a sufficient cardiac output, which, in the end, guarantees an adequate metabolism for maintaining homeostasis in the organism. If the baroreceptor reflex is no longer effective or impaired due to disease, chronotropic incompetence results, the lack of an adequate adaptation of the heart rate to the respective load situation. Underlying diseases can originate in the heart itself, such as in case of the sick sinus syndrome, but they can also have extracardiac causes, e.g., polyneuropathy in diabetes mellitus.

With the various sensor systems, attempts have been made to develop short-term or long-term effective systems that achieve an adequate demand-oriented rate. What all these systems have in common is the attempt to substitute the no longer effective baroreceptor reflex by artificial control loops. However, they succeed only to an insufficient degree, because correcting variables from outside of the control loop are used. In contrast, the new CLS system reestablishes the intrinsic control loop of the baroreceptor reflex. It integrates itself into the feedback mechanism [13].

In conclusion, it can be stated that this new stimulation system optimizes the entire circulatory dynamics by reestablishing a closed control loop. It provides patients with chronotropic incompetence with a system that assists them in an important step to regain their original quality of life. It supplies them with adequate circulatory regulation in all daily-life situations, be they marked by psychological or physical stress or events. Just as important for the patient's quality of life as the performance of the implant is the entire implantation experience. The end result should be that the patient is not continually aware of his or her pacemaker dependence.

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