Multisite Stimulation: Long-Term Performance of Coronary Sinus Leads

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Summary

For some time now, coronary sinus leads have been used for biatrial, biventricular, and left-ventricular pacing. The stability of positioning for these leads, along with the time course of the electrical parameters, is the main subject of this study. 36 patients (31 male, five female; aged 63.9 ± 10.6 years) were implanted with a coronary sinus (CS) lead for pacing of the left atrium (LA) or left ventricle (LV). The lead position was documented with a posterior-anterior X-ray image and inspected upon release of the patient. The fluoroscopy time for the entire operation was noted. The electrical parameters were determined during the implantation, the discharge examination, and each follow-up (4 weeks, 3 months, 6 months, 12 months, and 18 months). Among all patients, successful CS-lead positioning was attained with an average fluoroscopy time of 22 ± 13 min for the LA leads and 35 ± 20 min for the LV leads. Dislocations were observed in the early postoperative phase for both LA leads (3) and the LV leads (2), but it was possible to correct them. The average lead pacing thresholds were 0.94 ± 0.59 V (LV) and 2.1 ± 0.8 V (LA); these showed no significant fluctuations over the long term. The average sensing amplitudes at implantation were 14.2 ± 9.5 mV (LV) and 2.5 ± 1.8 mV (LA). More time is required for implantation, although this depends on the anatomy of the individual heart, and no complications were observed after four weeks.

Key Words

Left-ventricular pacing, left-atrial pacing, threshold, sensing amplitude, dislocations

Introduction

The resynchronization of the heart at the level of the atria and the ventricles has long been discussed as a therapeutic possibility for patients with a drug refractory atrial fibrillation or with chronic heart insufficiency. Left-atrial or left-ventricular pacing is achieved through the implantation of a coronary sinus lead. With biatrial pacing [1], and especially with biventricular pacing, impressive therapeutic success was achieved [2-6]. Due to the widely varying anatomy of the heart, an implantation of this type of lead is not always simple. Fixating the lead at a location with appropriate electrical parameters is an additional difficulty. In this study, the stability of the positioning of coronary sinus leads, as well as the progression of the electrical parameters over time, was observed.

Materials and Methods

Over the past 18 months, 36 patients (31 male, five female; aged 63.9 ± 10.6 years) were implanted with a coronary sinus (CS) lead for pacing of the left atrium (LA) or the left ventricle (LV). Bipolar Corox LA-BP (Biotronik, Germany) leads were implanted for biatrial pacing in twenty-one patients (17 male, four female; aged 61.8 ± 11 years). In a three-chamber system, split-biatrial pacing is delivered between the distal ring of the LA-lead and the tip of the right-atrial lead.

For left-ventricular/biventricular pacing (15 patients; 14 male, one female; aged 66.9 ± 9 years), unipolar Corox LV (Biotronik) leads were used in 11 patients and the Aescula LV (St. Jude Medical, USA) leads were used in four cases. For nine of the 15 patients, a dual-chamber system for biventricular pacing of RV

Figure 1. Lateral X-ray picture showing the position of a LV-electrode.

against pacemaker case; ring of the LV-lead against pacemaker case) was implanted because of permanent atrial fibrillation. For the remaining six patients, a three-chamber system was used wherever the ventricular channel was split (split-biventricular pacing: pacing is delivered between the ring of the LV-lead and the tip of the right-ventricular lead).

For all patients, access was achieved by puncturing the subclavian vein. Using an introducer set (8/7 French in 30/6 patients), the leads were introduced into the subclavian vein and advanced into the coronary sinus via the right atrium. The leads for LA pacing were all implanted from the right and introduced into the coronary sinus without the aid of an introducer. For the positioning of the LV-leads (nine from the left, six from the right), the implanting physicians used introducer kits consisting of a guiding catheter with a hemostatic vent and a balloon catheter for a possible venogram. A detailed description of the implantation technique has already been given in the literature [6-8]. The stable lead position was documented with a posterior-anterior (PA) X-ray image and inspected upon discharge of the patient after three days with a PA- and a lateral image. The fluoroscopy time for the entire operation was noted. The threshold, the amplitude, and the electrical impedance were determined during implantation, at discharge, and at every follow-up (4 weeks, 3 months, 6 months, 12 months, and 18 months). In the three-chamber system, the pacing threshold and sensing amplitude could be measured in a unipolar and a bipolar configuration. In the bipolar configuration, the biventricular threshold was determined. In the case of the dual-chamber system with unipolar leads, only the threshold for the unipolar configuration could be recorded.

Results

Positioning of the CS-lead was successful for all patients. With the 21 leads for biatrial pacing, both pacing rings were positioned in the distal coronary sinus. The LV-leads were fixated in the high (2), middle (5), and apical (2) area of the lateral vein, as well as in the posterior (1) and anterolateral (2) veins (Figure 1). In three cases, a venogram was necessary for proper positioning of the LV-lead. The fluoroscopy time for the implantation of the entire pacemaker system averaged 22 ± 13 min for the LA-leads and 35 ± 20 min for the LV-leads.

In the early, post-operative phase before discharge of the patient, dislocations were observed in both the LA-leads (3) and the LV-leads (2). Two of the LA-leads were removed, and new leads were implanted, the third lead was repositioned. For the LV-leads, one was likewise removed, and the second one was repositioned in the peripheral area of the lateral vein. No additional dislocations were observed for the two newly fixated leads. One additional dislocation was registered for a different LV-lead during the 4-week follow-up. The lead had come free of the anterolateral vein, and had to be repositioned. No dislocations were observed for any lead after this time period. In one case diaphragmatic stimulation was achieved two weeks after implantation. The lead was repositioned in another vein.

The unipolar pacing thresholds for the LV-leads averaged 0.94 ± 0.59 V (0.3 –2.6 V) during implantation. After an increase to 1.6 ± 1.2 V (0.4 – 8.4 V) at the 4-week follow-up, the threshold in the systems that had been implanted for a longer period dropped back to 1.0 ± 0.4 V (0.6 – 1.6 V). The average bipolar threshold was higher than the average unipolar threshold, and did not exhibit large fluctuations. The detailed results are summarized in Figure 2a. On average, higher thresholds were observed for the LA-leads than for the LV-leads. The thresholds in the bipolar configuration were reduced after 4 weeks from 2.1 ± 0.8 V to 1.3 ± 0.4 V and remained nearly stable afterward. All values as well for the unipolar configuration are portrayed in Figure 2b.

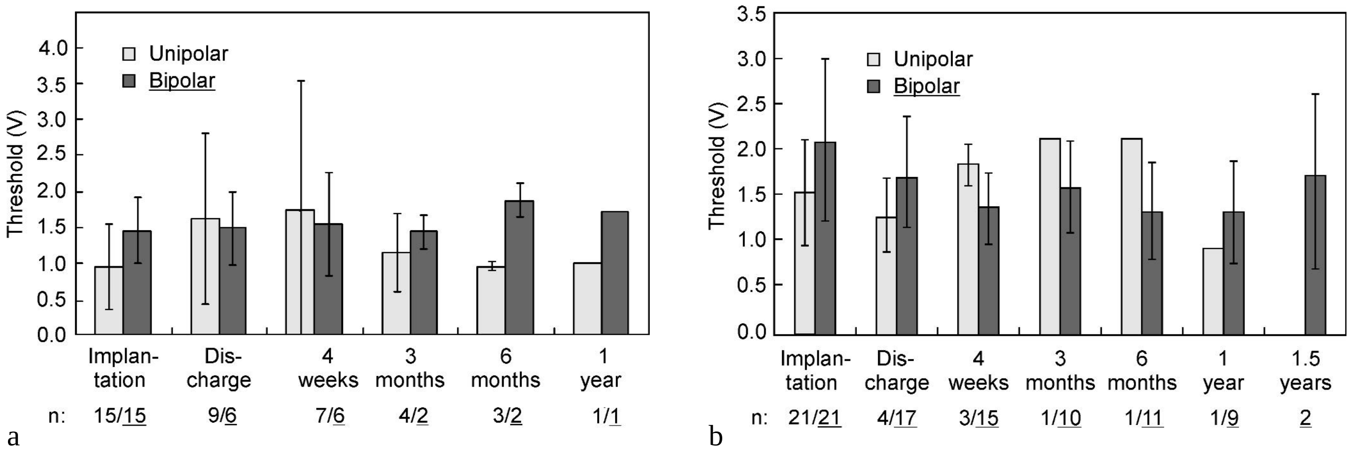

Figure 2. Thresholds of left ventricular (a) and left atrial (b) leads in the time course.

The detailed results for the sensing amplitudes of the CS-leads are compiled graphically in Figure 3a and 3b. The sensing amplitudes for the LV-leads were comparable in all examinations for both, unipolar and bipolar configurations. The average amplitude upon implantation was 14.2 ± 9.5 mV (0.8 – 29.7 mV) and showed no significant change over time. The amplitudes of the LA-leads in bipolar configuration increased from 2.5 ± 1.8 mV at implantation up to 3.5 ± 1.9 mV at the 3-month follow-up. The impedances for the LV-leads were significantly above those of the LA-leads. At implantation, these were 819 ± 297 Ω (LV) and 579 ± 111 Ω (LA). Over time, the mean values were between 750 and 850 Ω for LV-leads and between 400 and 550 Ω for LA-leads (Figure 4).

Discussion

The implantation of CS-leads is associated with large expenditures of time and materials. The probing of the ostium is problematic for all patients. The implantation of a pacemaker on the left side of the patient has the advantage that the lead or introducer set already exhibits the proper shape, and thus facilitates probing. It should be added that especially for LV-leads, fixation at an appropriate site is not always easy. Gilard, et al., have reported large fluctuations in the diameter of very different coronary veins, which made positioning and fixation at an appropriate location more difficult [9]. The high fluoroscopy times reflect the difficulties associated with this procedure. Similar results were also reported by Ricci, et al., [10]. To a greater degree,

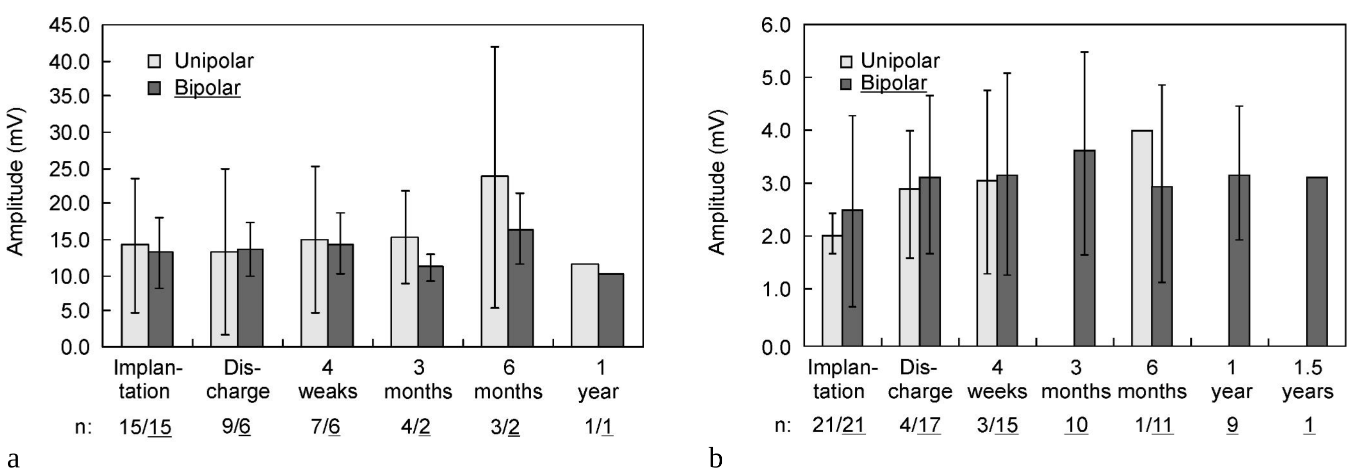

Figure 3. Amplitudes of left ventricular (a) and left atrial (b) leads in the time course.

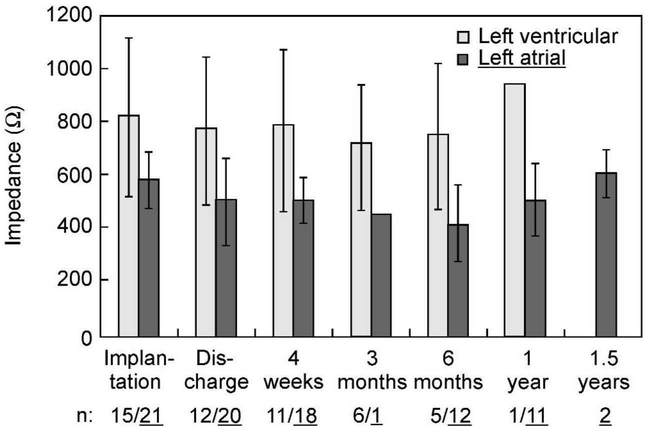

Figure 4. Impedance of left ventricular (a) and left atrial (b) leads in the time course.

the routine followed by the implanting physician plays a decisive role. In an optimal case, LV-leads can be implanted in less than 10 min.

Dislocations of CS-leads occurred in small numbers within the first few days (< 7). The anatomy of the vein system, which varied greatly from patient to patient, is the cause for this occurrence [9]. Implantation is made more difficult both by very narrow vein systems, in which the lead cannot be advanced far enough into the periphery, and by veins with larger-than-average diameters. The tip angle (< 90°) between the target vein and the CS or the great cardiac vein also complicate positioning to such an extent that in some circumstances the lead cannot be fixated [9]. As shown in the results, a dislocation after a period of two weeks is extremely unlikely.

The thresholds and amplitudes that were measured for the LV-leads show behavior, both intraoperative and postoperative, that is identical to that reported in other large studies [10]. The values were the most favorable in the mid-lateral and apical-lateral positions. Since pacing impulses are delivered between the right and the left ventricle in bipolar configuration, there are higher thresholds here than for the unipolar configuration. The increased values upon discharge and at the 4-week follow-up can be accounted for by noting that the high thresholds of a dislocated lead were included in the statistics. The higher thresholds of the LA-leads can be attributed to the fact that the pacing rings were located in the CS and, therefore, were not necessarily in contact with the wall.

Conclusion

The implantation of CS-leads requires significantly higher expenditures of time and materials, which, nevertheless, depends on the anatomy of the individual heart and the routine followed by the physician. With regard to the threshold for LV-leads, values between 0.5 and 2 V are entirely realistic. The electrical parameters remain stable after a certain encapsulation phase. There was a low probability of lead dislocation in the early postoperative phase, and no complications were noted in the observation period.

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