The Effect of Steroid Elution on the Performance of Coronary Sinus Leads for Left Ventricular Pacing in Dogs

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Summary

Steroid-eluting pacing leads implanted in conventional endocardial positions (right ventricle, right atrium) diminish the post-implantation peak in pacing threshold as compared to non-steroid leads. However, little information is available on the extent and duration of the effect of a steroid agent integrated into a coronary sinus lead. In this study, we compared the electrical performance of two coronary sinus leads that differ only in the presence/absence of a steroid-eluting collar at the electrode tip, with otherwise identical lead design. Data were collected on 12 dogs in whom steroid or non-steroid lead models were alternately implanted in a coronary vein overlaying the left ventricle. Left ventricular pacing threshold at 0.5 ms pulse width and pacing impedance at 3.6 V pulse amplitude and 0.5 ms pulse width were measured at implantation and 3, 7, 14, 21, 28, 60, and 90 days after implantation. The mean pacing threshold in the steroid group remained low throughout the follow-up period, whereas threshold peaks in the non-steroid group reached a maximum at 14 days after lead implantation (1.78 ± 0.52 V vs. 0.85 ± 0.46 V in the steroid group). Significant differences (p-value < 0.05) between the pacing thresholds of the steroid vs. non-steroid leads were observed at days 14 and 28 after implantation. The mean pacing threshold in the non-steroid group subsided thereafter and approximated the values measured in the steroid group. Comparing the left ventricular pacing impedances of the steroid vs. non-steroid group, no significant differences were found during the follow-up period. In conclusion, the steroid effectively suppresses the initial threshold increase observed with the non-steroid lead model and thereby substantially increases the safety margin during the first weeks after implantation.

Key Words

Coronary sinus leads, steroid elution, pacing threshold

Introduction

Consistently low pacing thresholds of steroid-eluting leads are well documented for conventional lead positions [1-10], but not much comparative information is available on the extent and duration of the steroid effect in coronary sinus leads for left ventricular (LV) pacing. In this study, we compare the electrical performance of the coronary sinus leads Corox OTW steroid vs. Corox OTW (both Biotronik, Germany), which differ only in the presence/absence of a steroid-eluting collar at the tip, with an otherwise identical lead design.

Materials and Methods

The Corox OTW 75 UP (steroid) is a unipolar CS lead with a distal helix for fixation in a coronary vein over the left ventricle. It is commercially available with a steroid-eluting collar (0.5 mg dexamethasone acetate) at the tip and can be implanted using the stylet-driven or over-the-wire (OTW) technique. The tip of the lead is fractal coated (material: 80% Pt, 20% Ir) and has a diameter of 5.8 F. The lead body has a diameter of 4.8 F with a conductor insulation made of silicone and a polyurethane coating.

The leads were implanted in 12 dogs (Foxhound, female, ca. 25 kg, Boeringer Ingelheim, Germany). To allow comparison between the steroid and non-steroid lead model, six dogs received the steroid model (Corox OTW 75 UP steroid) and the remaining six dogs the non-steroid lead model (Corox OTW 75 UP). The dogs were alternately assigned to either group. All dogs were also implanted with a three-chamber Stratos LV pacemaker, a Y60BP right atrial lead, and a Kentrox RV right ventricular lead (all from Biotronik).

Lead measurements were performed at implantation and at days 3, 7, 14, 21, 28, 60, and 90. The pacing thresholds were determined at 0.5 ms pulse width and pacing impedances at 3.6 V pacing amplitude and 0.5 ms pulse width. Continuous pacing between the follow-ups was avoided by programming the basic rate to 50 beats/min in the VVI pacing mode.

The Mann-Whitney U test was used to test for significant differences between steroid and non-steroid groups. The Wilcoxon test was applied to assess the significance of the differences between median values within the groups.

Results

The LV leads were successfully implanted in all dogs by using the OTW technique. Possible sites for lead positioning were regularly restricted to a basal, anterolateral area of the heart (Figure 1). At hemodynamically more favorable sites for LV pacing, the possible target veins were too tight for implanting a lead. LV lead dislocation occurred in one dog at day 7. The lead was replaced and the follow-up period was restarted. Other complications were two chewed pacemakers (Figure 2) with failing telemetry. The devices were replaced, but in one case the follow-up at day 21 (non-steroid group) was skipped due to the complication.

With respect to the steroid effect, our data show that the increase in pacing threshold observed in the non-steroid lead did not occur with the steroid-eluting leads (Figure 3). Regarding the latter, mean pacing thresholds remained stable from day 3 after implantation, whereas in the non-steroid group an increase occurred, peaking 14 days after implantation with 1.78 ± 0.52 V vs. 0.85 ± 0.46 V in the steroid group. Significant differences of pacing threshold between the steroid vs. the non-steroid group were observed regarding the lead measurements at days 14 and 28 after implantation ($p < 0.05$, U test). Differences at day 21 were not significant ($p = 0.053$), probably due to the missing data point (chewed pacemaker). During the late follow-up period, the mean pacing thresholds in the non-steroid group decreased and approximated the values measured in the steroid group. Comparing the LV pacing

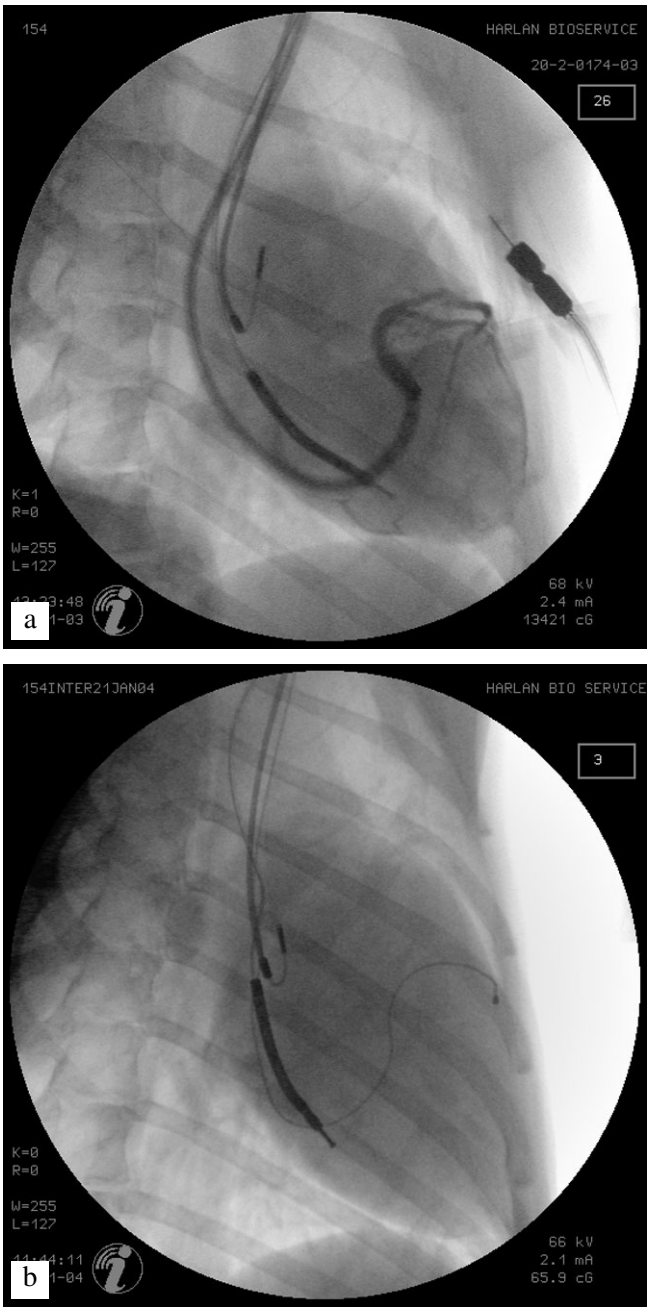

Figure 1. (a) Fluoroscopic image of a characteristic morphology of the coronary venous system with the atrial and right ventricular leads already in place. (b) Image of the same heart after implantation of the left ventricular lead.

Figure 2. Chewed pacemaker. Faulty interrogation required replacement of this device.

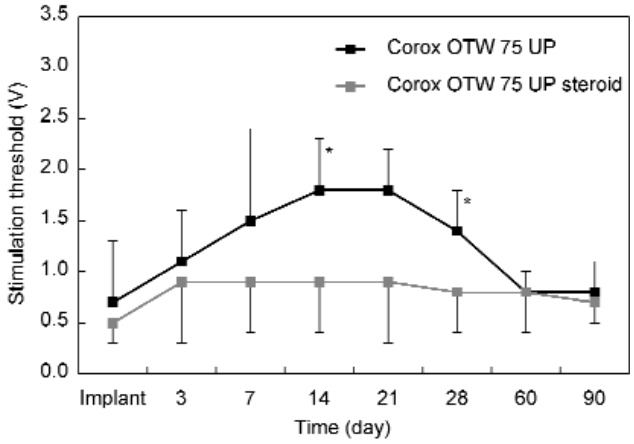

*Figure 3. Pacing thresholds (at 0.5 ms pulse width) for the steroid and non-steroid model of the Corox OTW lead. The * indicates significant ($p < 0.05$) differences between the two lead models (N = 6 each); differences at day 21 were not significant ($p = 0.053$), most probably due to a missing data point (chewed pacemaker).*

impedances of the steroid vs. non-steroid group, no significant differences between the groups were found during the follow-up. After a significant initial decrease ($p < 0.05$, Wilcoxon test), the mean pacing impedance increased in both groups (Figure 4). At the end of the follow-up period the mean impedance values for both lead models returned to the level measured at implantation.

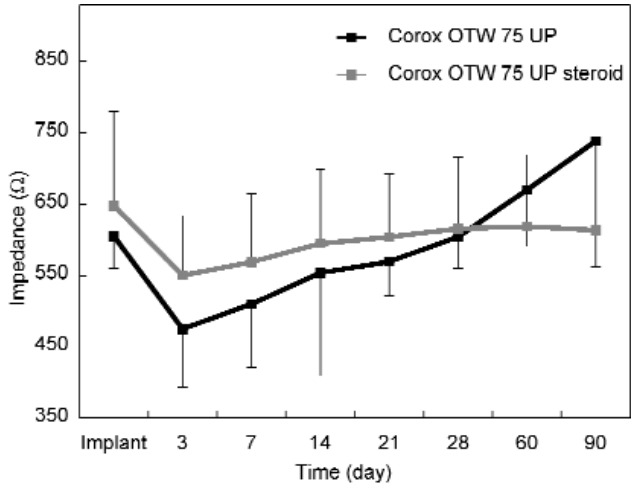

Figure 4. Pacing impedances (at 3.6 V pacing amplitude and 0.5 ms pulse width) for the steroid and non-steroid model of the Corox OTW lead (N = 6 each).

Discussion and Conclusion

By comparing data from coronary sinus leads of equal design, differing only in the presence/absence of steroid elution, it was possible to determine the effect of steroid elution on lead performance. The results show that the steroid effectively suppresses the post-implantation threshold increase observed with the non-steroid version of the lead.

Regarding conventional endocardial lead positions, it has been generally accepted that the threshold increase is due to inflammation caused by the activity of phagocytes at the electrode-tissue interface that release many different inflammatory mediators, including hydrolytic enzymes, oxidants, and chemotactic agents [11-13]. Although there may be differences in the inflammation process between endocardial conventional lead positions and endothelial coronary vein positions, the duration of the initial threshold increase and the effect of steroid elution is very similar in both cases.

In the non-steroid Corox OTW leads the duration of the early threshold increase was less than 2 months, with a significant increase only during the first month after implantation. However, during this period the pacing threshold of the leads without steroid was up to twice as high as in the steroid-eluting leads. Pacing thresholds in steroid-eluting Corox OTW leads were stabilized as soon as 3 days after implantation. This is comparatively early, since a 2-week post-implantation stabilization phase was reported from the Ventak CHF/CONTAK

CD Biventricular Pacing Study of a steroid-eluting coronary sinus lead applied in humans [14]. Regarding pacing impedance, no significant differences were observed between the steroid and non-steroid models; based on our data, no steroid effect on battery current drain can be suspected. The significant initial drop in pacing impedance seen in both lead models is a well known behavior, observed in many other lead designs. In conclusion, the steroid substantially increases the safety margin during the critical first weeks after implantation by suppressing the post-implantation threshold increase observed with the non-steroid model of the Corox OTW lead.

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