Left bundle branch pacing after His bundle lead dysfunction due to physical activity in a pediatric patient

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Introduction

Children with congenital complete heart block may require pacemaker implantation at a young age.[1] Physiological cardiac stimulation using His bundle pacing (HBP) has gained interest in pediatric patients to avoid pacing-induced cardiomyopathy due to chronic right ventricular pacing.[2–5]

Although short-term outcomes of HBP in pediatric and adult patients with congenital heart disease appear to be favorable, concerns exist regarding higher pacing threshold and the need for lead revision over time.[4,6,7] In the adult population, the proposed mechanisms for chronically increased pacing thresholds are micro-dislodgement, local fibrosis, and progressive conduction disease.[8] On the other hand, pediatric patients may need HBP lead revision owing to a more active lifestyle, somatic growth, and small patient and vessel size at implantation. Currently, HBP lead revision remains rare in pediatric patients, and the extraction of these leads is regarded as a complex procedure associated with morbidity and, in some cases, mortality.[8–10]

In this case report, we present a pediatric patient with micro-dislodgement due to vigorous physical activities who underwent successful HBP lead extraction and left bundle branch pacing (LBBP). The more stable LBBP lead should address the issues of elevated thresholds and lead stability associated with HBP and allow the patient to maintain his active lifestyle.

Case report

A 9-year-old male patient with congenital complete heart block underwent selective HBP for symptomatic bradycardia at 7 years of age (minimum heart rate: 35 beats per minute [bpm], maximum: 125 bpm, on average: 45 bpm) (Figure 1). The bipolar ventricular pacing threshold was 0.75 V (pulse width: 0.4 ms) at implant and at the 6-week follow-up. At 3 months postimplant, the patient fell while playing on the monkey bar. Pacemaker interrogation showed stable lead impedance and sensing; however, the pacing threshold was 1.75 V (pulse width: 0.4 ms). The bipolar pacing threshold continued to rise to 2.25 V (pulse width: 1 ms) at 12 months postimplant and 2.5 V (pulse width: 1 ms) at 15 months postimplant, after optimization using the strength-duration curve. The lead's impedance and sensing remained unchanged since implant. The estimated remaining battery life was 1.8 years after 15 months postimplantation. As illustrated in Figure 2, the electrocardiogram review showed initial loss of capture with narrow complex escape rhythm followed by nonselective HBP. Repeated physical examination, echocardiography, and chest radiography showed no other abnormalities. Owing to the patient's injury, we suspected that lead micro-dislodgement, rather than exit block, was the etiology of the sudden increased pacing thresholds and the transition from selective to nonselective HBP with occasional loss of capture. We attempted unipolar pacing during pacemaker check-up at 15 months follow-up.

KEY TEACHING POINTS

- His bundle pacing may not be suitable in all pediatric patients, as lead micro-dislodgement may occur in children who engage in physically vigorous activities.
- Safe extraction of His bundle pacing leads is achievable; a mechanical rotating dilator sheath may be needed even in leads with a relatively short dwelling time.
- Left bundle branch pacing may address the challenges of elevated thresholds and lead stability associated with His bundle pacing, enabling patients to maintain their active lifestyle.

KEYWORDS Lead extractions; Pediatrics; Congenital complete heart block; His bundle pacing; Left bundle branch pacing; Conduction system pacing
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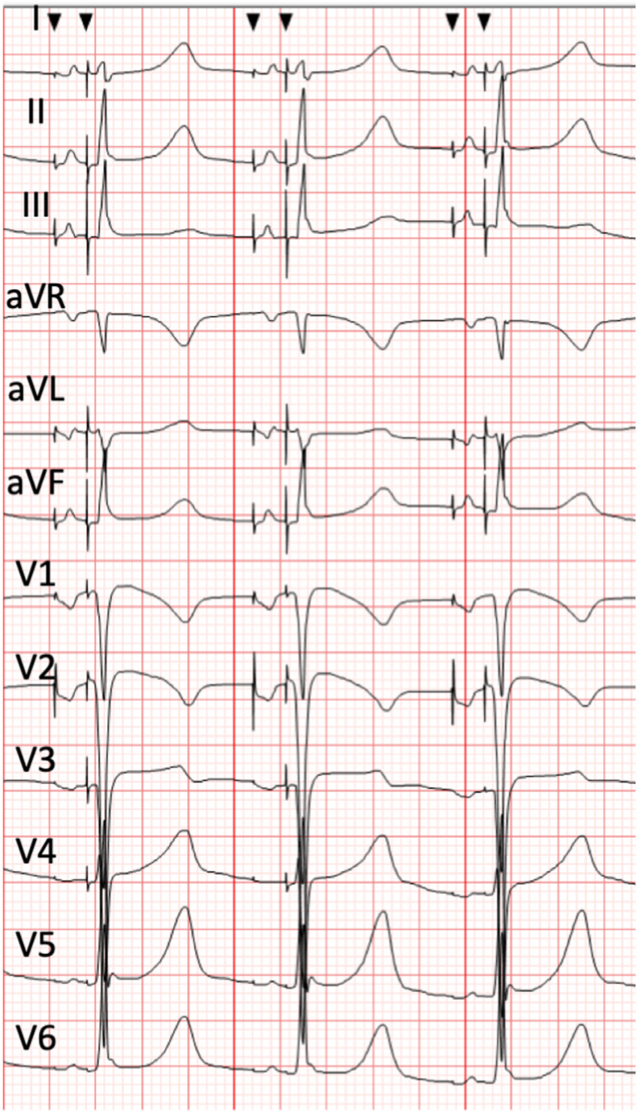

Figure 1 Electrocardiogram demonstrates selective His bundle pacing 18 months prior to lead revision for acute micro-dislodgement.

Although it provided stable capture (threshold: 4.5 V, pulse width: 1.0 ms), the patient felt significant discomfort during this alternative setting.

Various options for lead and pacemaker management were discussed between the treating cardiologist, electrophysiologist, parents, and patient. First, the patient could continue with high pacing outputs and accepting risk of intermittent failure, symptomatic bradycardia, and frequent generator change. Second, the HBP lead would be extracted, and a new lead would be implanted at either the His or left bundle branch position with generator change, which would approximately last >10 years. The patient and his parents opted to remove the existing HBP lead and implant a new lead, as the bradycardia was deemed too symptomatic, and frequent generator change would be too debilitating. To maintain physiological cardiac excitation and avoid lead dislodgement owing to his active lifestyle in the future, LBBP was chosen as an alternative site. LBBP is traditionally characterized by a lower pacing threshold and better stability owing to its deep intraseptal fixation.

The procedure was performed under general anesthesia. A venogram via the left arm showed a patent left-sided venous system and the location of the HBP lead (Supplemental Video 1). An incision was made over the previous incision, and electrocautery and blunt dissection were carried down to the pacemaker device and the atrial and His bundle pacing leads. There was calcification noted in the pocket. The axillary vein was accessed once using the modified Seldinger technique under fluoroscopic guidance. Under continuous fluoroscopy, the HBP lead (3830; Medtronic, Minneapolis, MN) was easily unscrewed from the septum by rotating the lead counterclockwise while gently pulling on it. The lead then could be retracted into the atrium; however, adhesions between the HBP lead and its vascular surroundings prohibited further extraction of the HBP lead. Therefore, we used a TightRail mechanical rotating dilator sheath (Spectranetics, Colorado Springs, CO) to free the HBP lead. The lead-locking device was inserted in the distal lumen of the HBP lead and tied together with the HBP lead using surgical sutures. The dilator sheath was introduced over the lead to the venous entry site using fluoroscopic guidance. As shown in Supplemental Video 2, by carefully triggering the blades and performing countertraction the dilator sheath was advanced over the HBP lead until complete separation was obtained. Inspection of the tip of the HBP lead showed no significant fibrous tissue. In combination with ease of removal of the lead from within the septum, lead micro-dislodgement was assumed to be more likely to be the etiology rather than exit block.

Subsequently, a new Medtronic 3830 lead for LBBP was delivered through a nondeflectable C135 sheath. The target site for the lead deployment was identified as previously described.[11] As the lead was advanced into the septum, the notch of the paced QRS in lead V_1 moved from the nadir to the end of the QRS, resulting in right bundle branch block pattern and concomitant gradual increase in unipolar pacing impedance (≥500 Ω). Four initial fast turns, and then 3 more slow turns, were performed to position the lead at the left bundle. Electrocardiogram characteristics, pacing parameters, including impedances and current of injury, were checked after the fast turns and after each of the slow turns. As shown in Figure 3, selective LBB capture was confirmed by the presence of a right bundle branch block pattern, V_6–V_1 R-wave interpeak interval of 44 ms, and a constant (at high and low pacing output) R-wave peak time of 67 ms in V_6.[11,12]

Transesophageal echocardiography confirmed the location of the lead in the septum, abutting the subendocardium of the left ventricular septal border (Figure 3). Since the old generator's estimated remaining battery life was 6 years with the new lead, a new generator was used to maintain 10–12 years estimated battery life. The final R-wave amplitude was 15 mV, impedance 608 Ω, and ventricular pacing threshold 0.5 V at 0.5 ms pulse duration.

The patient was discharged the next day, and it was recommended to observe the left arm restrictions for 8 weeks.

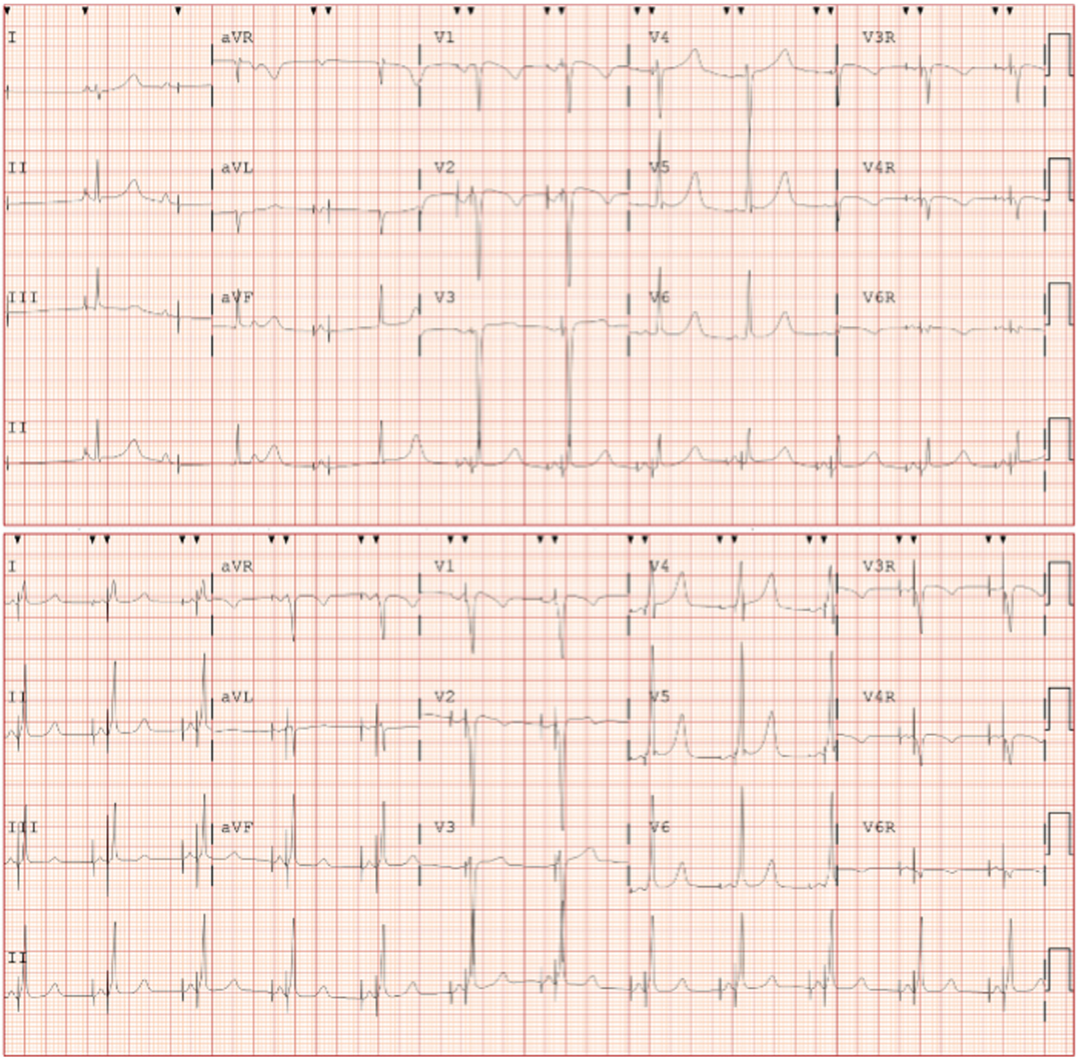

Figure 2 Upper and lower electrograms show, respectively, loss of capture and nonselective HBP, in a patient with previous selective His bundle pacing prior to acute micro-dislodgement.

Chest radiograph showed stable lead position and device interrogation revealed unchanged pacing parameters. The LBBP lead parameters were unchanged at the 2-week follow-up.

Discussion

Extraction of His bundle leads

Extraction of conventional pacemaker leads with greater than 1 year dwelling time is challenging, with a number of risks and complications.[9,13] On the other hand, the Medtronic 3830 lead, commonly used for HBP, may be easier to extract. However, at present, experience with extractions in the pediatric population remains limited.[2–4]

The Medtronic 3830 lead is lumen-less, which precludes lead extraction with a locking stylet. While this may raise concerns, the tensile strength of this lead allows, owing to its cable design, the use of mechanical or powered extraction tools.[8,14] In our case, the proximal part of the lead was already attached to the atrial lead and its surrounding by fibrotic adhesions despite its relatively short dwelling time (16 months). Similar to conventional leads with long-dwelling times in adults, this HBP lead required the use of an extraction tool. The 11F TightRail sheath was appropriate for the patient's vessel size and allowed for precise and controlled separation of the HBP lead from its surrounding, resulting in a safe and effective extraction.

LBBP as a new solution

While HBP has several advantages compared to right ventricular or biventricular pacing owing to its preservation of physiological cardiac excitation, it is characterized by challenges related to implantation, lead dysfunction, and extraction.[8,15] In pediatric patients, the risk of micro-dislodgement owing to somatic growth in combination with physical activity may be more substantial as compared to their adult counterparts, in whom other factors result in high pacing threshold and lead extraction. In the current case report, micro-dislodgement because of physical activity was suspected

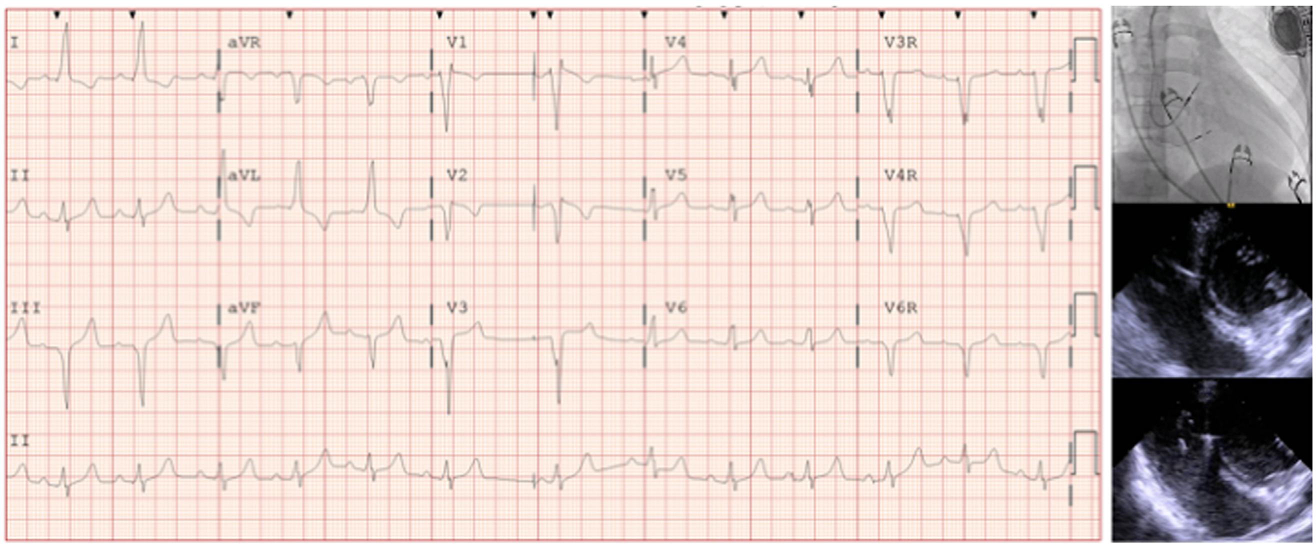

Figure 3 Selective left bundle branch pacing (LBBP) was successfully performed after extraction of a His bundle pacing lead. Electrogram shows selective LBBP, indicated by the presence of right bundle branch delay pattern, V_6–V_1 R-wave interpeak interval of 44 ms, a pacing stimulus–to–peak R wave (stim-LVAT) of 67 ms, and isoelectric stimulus to QRS interval. Fluoroscopic and transesophageal echocardiographic images demonstrate the position of the LBBP lead.

owing to transient noncapture alternating with new nonselective HBP. In addition, the absence of fibrous tissue on the catheter tip and ease of extraction from within the septum suggest that acute micro-dislodgement is the main etiology in this patient.

In recent years, LBBP has emerged in adult patients as an alternative to HBP.[2,11] Similar to HBP, LBBP preserves physiological activation and avoids pacing-induced cardiomyopathy, while maintaining a lower pacing threshold. Deep fixation of the lead in the thicker muscular interventricular septum for LBBP results in more stability, thereby decreasing the likelihood of dislodgement owing to traction during physical activity. In the current case report, LBBP was feasible with stable, low pacing thresholds. On the other hand, young children may have a thinner septum, which may pose potential challenges such as septal perforation. Both acute and late septal perforation have been described in adults undergoing LBBP. A septum thinner than 10 mm would not accommodate both the tip and ring of the 3830 lead (tip-to-ring distance 9 mm), leading to the inability for anodal capture of the right bundle branch. In this case, we used transesophageal echocardiography to directly visualize the position of the tip of the lead. Transesophageal echocardiography is a useful adjunct imaging modality in LBBP.

As experience with conduction system pacing is still limited in pediatric patients, future studies will need to show the long-term incidence of lead dysfunction, the safety and feasibility of lead extraction, and the role of LBBP over HBP.

Conclusion

The current case report discusses important considerations regarding lead implantation, dysfunction, and extraction in pediatric patients with conduction system pacing. With the introduction of HBP in pediatric patients, new challenges occur, including acute dislodgement owing to physical activity. To preserve patients' active lifestyle, LBBP can be performed as an alternative treatment after HBP lead extraction.

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Disclosures: None.

Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2023.07.011.

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