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Left Bundle Branch Pacing in a Pediatric Patient With Tricuspid Valve Replacement for a Complex Ebstein Anomaly

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ABSTRACT

This paper presents a unique case of successful implementation of left bundle branch pacing (LBBP) in a pediatric patient with third-degree atrioventricular block following tricuspid valve replacement for a complex Ebstein anomaly. The procedure was performed under real-time recording technique, and resulted in the resolution of the patient's symptoms. This case underscores the feasibility and potential benefits of LBBP in pediatric patients, particularly in those with complex congenital heart conditions and following valve replacement surgery. The successful implementation of LBBP in this case provides valuable insights and a reference for similar cases in the future.

1 | Introduction

Left bundle branch pacing (LBBP), a novel physiological pacing strategy, ensures stable pacing parameters by directly engaging the conduction system in the left ventricular sub-endocardium. The feasibility and clinical advantages of permanent LBBP have been substantiated in adult subjects. However, the application of LBBP in pediatric cases has been documented in only a handful of studies, and its utilization in valve replacement is exceedingly uncommon. In this report, we present a case where selective LBBP was successfully implemented in a pediatric patient with third-degree AVB following tricuspid valve replacement for a complex Ebstein anomaly, guided by a continuous pacing and recording technique.

2 | Case Report

An 11-year-old girl patient was referred to the cardiovascular surgery department due to chest tightness and exertional dyspnea. Transthoracic echocardiography revealed her congenital heart conditions, including Ebstein's anomaly and a 20 mm atrial septal defect, accompanied by severe tricuspid regurgitation and moderate pulmonary arterial hypertension. Although an atrial septal defect repair and tricuspid valvuloplasty under general anesthesia were initially planned, intraoperative exploration found poorly developed septal and posterior valves, making reshaping impossible. Consequently, a tricuspid bioprosthetic valve replacement was performed. Postoperative ultrasonography confirmed the normal

functioning of the tricuspid bioprosthetic valve and the resolution of the atrial level shunt.

Regrettably, the patient experienced several episodes of syncope on the fifth night post-surgery. A 24 h Holter electrocardiogram (ECG) revealed a second to third degree atrioventricular block with the longest R-R interval being 6.625 s. Despite sequential treatments with methylprednisolone sodium succinate, isoproterenol, and atropine, the patient's symptoms of chest tightness and shortness of breath in the supine position worsened, and syncope recurred. A temporary pacemaker was then employed, which provided symptomatic relief. However, atrioventricular conduction progressed to a complete block and demonstrated a dependency on the temporary pacemaker. Consequently, LBBP was performed under general anesthesia 10 days post-surgery.

Under the guidance of real-time recording of ECG and intracardiac electrogram (EGM) using the John Jiang connecting cable (Xinwell Medical Technology Co. Ltd., Ningbo, Zhejiang, China), the 3830 lead (Medtronic, Minneapolis, MN) was implanted (Figure 1A). During this process, the notch in the V1 lead gradually migrated, resulting in a QR pattern. However, no evidence of LBB capture was observed. Consequently, the initial lead was retained, and a second lead was inserted. During the screw-in process of the lead into the interventricular septum, an abrupt shortening of 12 ms was observed in V6 R wave peak time (V6RWPT) between the morphologies of two adjacent paced QRS complexes. A threshold test was performed, and when the output was reduced to 1.5 V/0.5 ms, discrete component was displayed, confirming selective LBB capture (Figure 1B). Sheath angiography revealed that the lead depth was approximately 15 mm (Figure 1A). The pacing parameters were as follows: sensing 15.8 mV, impedance 763 Ω, and LBB threshold 0.2 V. The first lead was retracted to the right atrium and subsequently implanted into the right atrial septum. The patient's symptoms of chest tightness and shortness of breath resolved by the first postoperative day. Postoperative electrocardiogram showed that the pacemaker worked well with a narrow QRS duration (Figure 1C). All symptoms had resolved, with the child resuming normal daily activities and physical development over the course of a 6-month follow-up.

3 | Discussion

Ebstein's anomaly is a rare cardiac malformation characterized by congenital valvular and ventricular dysplasia of the right side of the heart. The surgical repair of Ebstein's anomaly typically involves the repair or replacement of the tricuspid valve, selective plication of the atrialized right ventricle, right atrial reduction plasty, among other procedures (Cherry et al. 2009; Holst et al. 2019). Postsurgical repair of Ebstein's anomaly necessitates pacemaker implantation to manage bradyarrhythmia in approximately 3%–4% of patients (Allen et al. 1997; Romer et al. 2019). In the case presented, a poorly developed septal and posterior leaflet was identified during the operation, rendering valve plasty unfeasible. A bioprosthetic tricuspid valve replacement was selected. Ten days post-operation, the patient's third-degree atrioventricular block did not resolve, leading to repeated episodes of syncope and worsening heart failure symptoms.

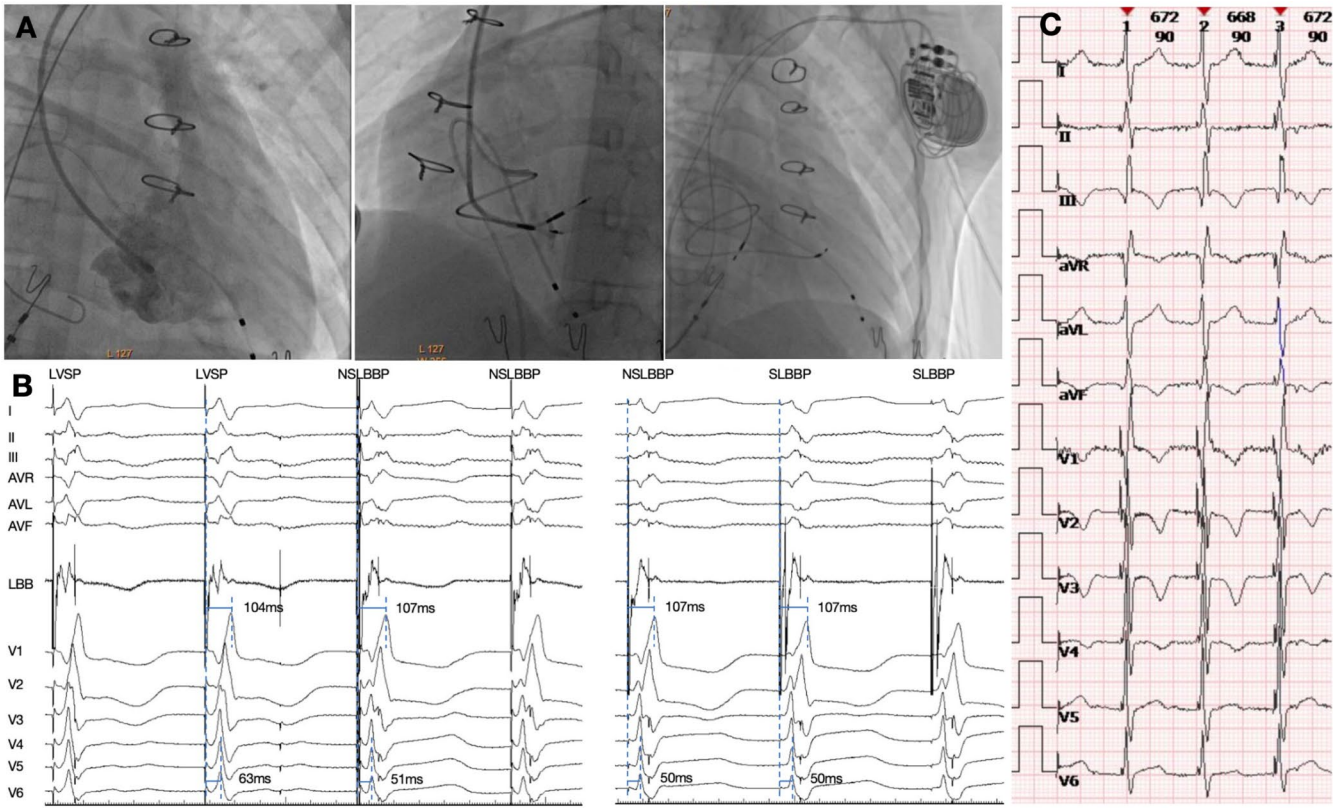

FIGURE 1 | (A) The fluoroscopic imaging associated with the implantation of LBBP. (B) LBB capture could be demonstrated by observing NSLBBP and SLBBP. (C) The postoperative electrocardiogram of the patient. LBB, left bundle branch; LVSP, left ventricular septum pacing; NSLBBP, nonselective left bundle branch pacing; SLBBP, selective left bundle branch pacing.

Consequently, the implantation of a permanent cardiac pacemaker was deemed necessary for this patient.

The demand for an ideal, physiological pacing strategy is higher in children, given that they utilize pacemakers for extended periods and have a higher percentage of pacing compared to adults. In recent years, LBBP is a new type of physiological pacing modality, which has been proven to be feasible and beneficial in adult patients, and has been implemented in a few cardiac centers for pediatric patients. (Huang et al. 2020; Ponnusamy et al. 2020; Li et al. 2024). However, the experience with selective LBBP in pediatric populations remains limited, and to the best of our knowledge, there have been no reports following tricuspid valve replacement in children.

Following previously published adult studies, we utilized a continuous rotary cable to link to the electrophysiological recorder system, thereby monitoring electrode impedance during the screw-in process, as well as the morphology of the surface ECG and EGM in real time (Shen et al. 2023, 2022, 2024; Wu et al. 2022). This was done until the discrete component, which provides direct evidence of selective LBB capture, was observed. Performing selective LBBP in this case, following biological valve replacement for tricuspid valve malformation, proved challenging. The anatomical aberration in her heart cavity and the increased difficulty in positioning the cardiac conduction system made it harder to accurately achieve selective LBB capture. During the first attempt at lead rotation, no abrupt shortening of the V6RWPT and discrete component within the reducing output process were observed, indicating without certain direct capture of the left conduction system. Subsequently, the screw site was repositioned using the dual-electrode method. Continuous monitoring of the screw-in procedure allowed for the recording of abrupt shortening by adjacent paced beats of V6RWPT by 12 ms, and discrete EGM in the descending output testing as evidence for direct LBB capture.

In conclusion, the case we presented further demonstrates the feasibility of selective LBBP in a child with tricuspid bioprosthesis replacement, thereby providing a reference for similar cases.

Author Contributions

Di Tian and Jiabo Shen wrote the manuscript. Longfu Jiang and Jiabo Shen performed device implantation. Longfu Jiang reviewed the manuscript. All authors approved the final manuscript and agreed to their contributions.

Ethics Statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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