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CASE REPORT

ADVANCED

CLINICAL CASE: EDITOR'S HIGHLIGHTS

Fortuitous Left Bundle Branch Area Pacing in a Small Child

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ABSTRACT

Deep septal pacing is an emerging technique for physiologic pacing in adults. We report a case where left bundle capture was inadvertently achieved in a small child with routine lead deployment into a thin septum and discuss the potential feasibility of this technique for future study. **(Level of Difficulty: Advanced.)** (J Am Coll Cardiol Case Rep 2021;3:1730–1735)

HISTORY OF PRESENTATION

A young girl presented for pacemaker implantation. Congenital heart block had been diagnosed in utero. At birth, she had stable junctional escape and average heart rate of 81 beats/min. Around age 2 years, she developed mild fatigue, associated with resting and 24-hour-average heart rates in the range of 50 to 55 beats/min. After careful discussion of the tradeoffs of epicardial versus transvenous pacing, the family preferred transvenous and therefore elected to tolerate the mild symptoms to allow further growth before pacemaker insertion.

However, she then presented after an episode of abrupt and unprovoked syncope while seated. Pulse was 59 beats/min, blood pressure was 87/65 mm Hg, and oxygen saturation was 96%. Physical examination findings were normal apart from bradycardia and systolic ejection murmur related to increased stroke volume.

LEARNING OBJECTIVES

- To recognize that left bundle pacing may be feasible in small children or even achieved inadvertently because of thinner septum.
- To appreciate the potential but unproven appeal provided by left bundle pacing's physiologic activation sequence and low pacing thresholds.

PAST MEDICAL HISTORY

The patient's medical history included congenital complete heart block due to maternal Sjögren syndrome.

DIFFERENTIAL DIAGNOSIS

In a patient with heart block, arrhythmic syncope should be considered first. Traditionally known as Stokes-Adams attacks, such episodes may be due to acute bradyarrhythmia or to bradycardia-mediated tachyarrhythmia. Vasovagal syncope can occur while seated, or in very young children, but is not common and should not be diagnosed presumptively, considering that syncope is a long-established predictor of adverse outcome in congenital heart block (1).

INVESTIGATIONS

Electrocardiogram showed complete heart block with junctional escape (**Figure 1A**). Transthoracic

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The author attests they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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echocardiogram showed normal anatomy, mild left ventricular (LV) enlargement, and normal systolic function.

MANAGEMENT

New syncope warranted pacemaker implantation despite the apparently stable junctional rhythm. Potential routes of pacing were rediscussed, given the patient's relatively young age (2.9 years) and small size (13.4 kg). The family elected transvenous pacing.

Our usual practice for small children entails single-chamber pacing with the 4.1-F Medtronic 3830 "SelectSecure" lead, targeting septal placement using the Medtronic C315-S4 or C315-S5 delivery catheter to avoid risks of lead perforation or helix-related pericarditis, acknowledging the uncertain hemodynamic benefits. We did not consider His bundle pacing or left bundle (LB)/left bundle area (LBA) pacing appropriate for routine use in small children in the absence of data.

The left axillary vein was accessed under ultrasonographic guidance. A subpectoral pocket was created via an axillary incision, and the guidewire was internalized. A standard 5-F sheath was used to place 2 guidewires, then removed. A Medtronic C315-S4 delivery catheter was advanced over 1 wire to

ABBREVIATIONS AND ACRONYMS

LB = left bundle

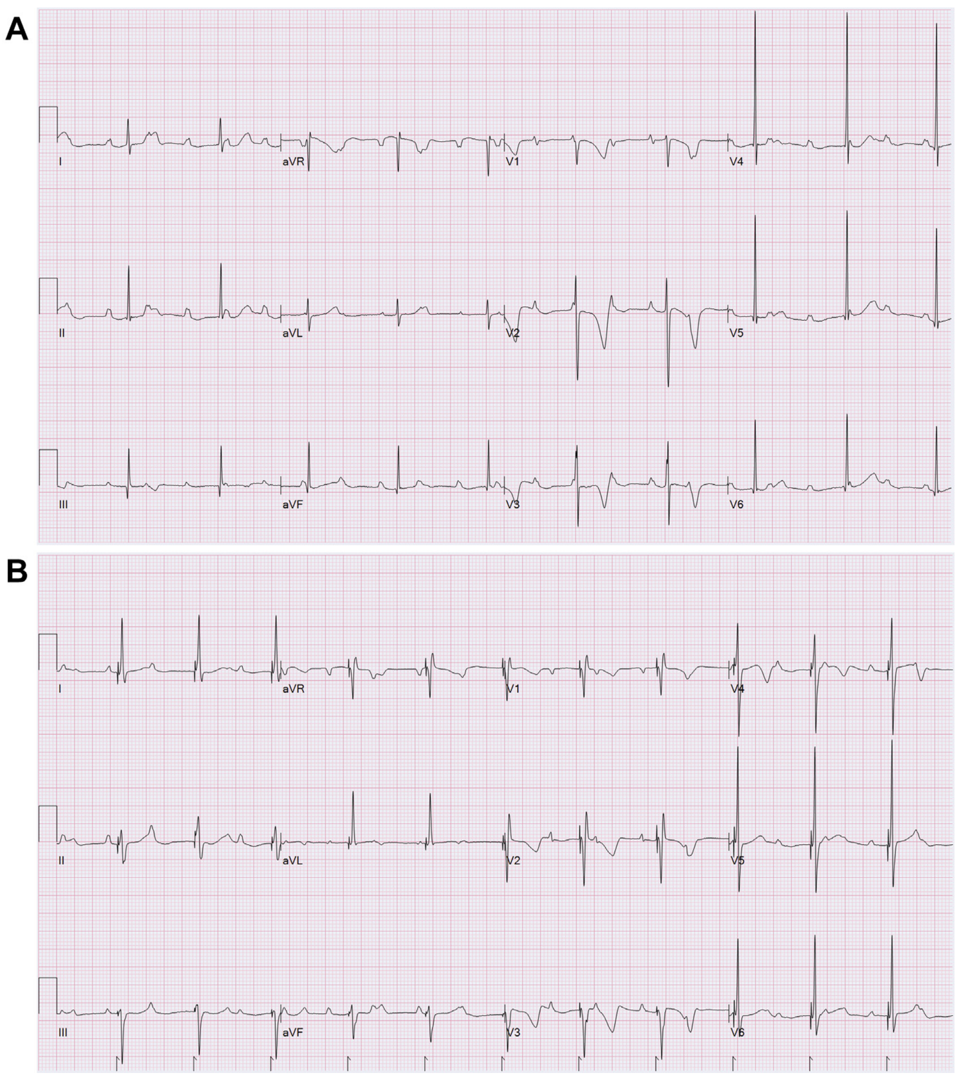
LBA = left bundle area

LV = left ventricle

RBBB = right bundle branch block

RV = right ventricle

FIGURE 1 Electrocardiograms Pre- and Post-Procedure



(A) Heart block with junctional escape. **(B)** Ventricular pacing with incomplete right bundle branch block/left-axis deviation morphology.

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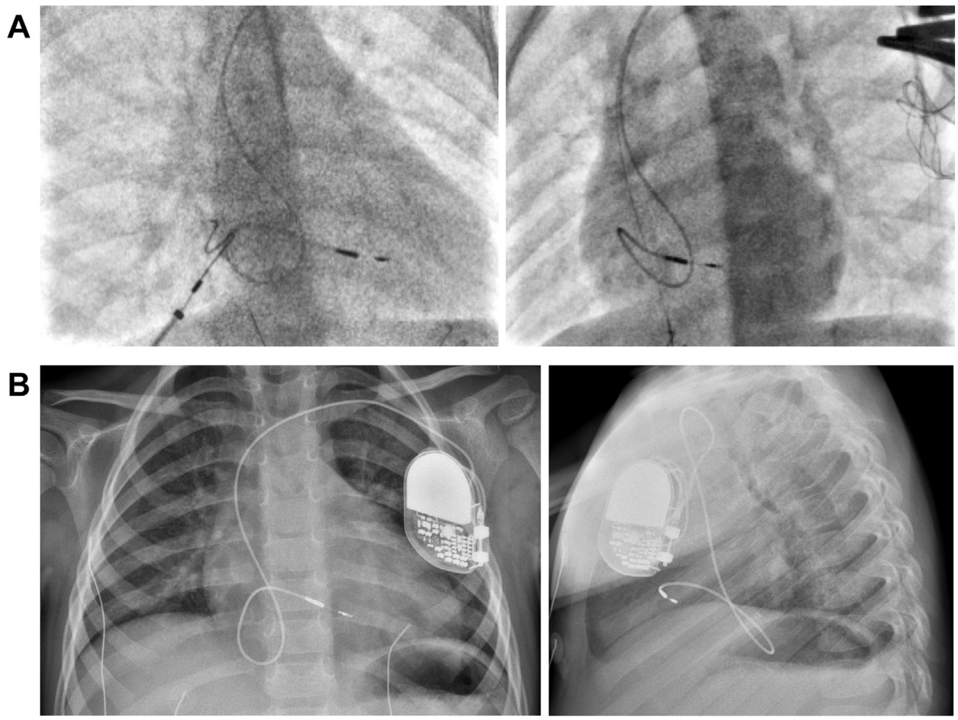
FIGURE 2 **Radiographic Lead Position**



(A) Septal lead position by intraprocedure fluoroscopy (right anterior oblique: 27°; left anterior oblique: 26°) with retained micropuncture wire still present. **(B)** Postprocedure radiography (frontal, lateral).

the right atrium and then over a 4-F balloon catheter to the right ventricle (RV) to reduce the chance of tricuspid valve entanglement.

Multiple attempts at Medtronic 3830 deployment were unsuccessful because of difficulty engaging the septum. With firm counterclockwise rotation of the catheter, the lead was eventually secured in a midseptal position using 4 to 5 turns, but R-wave measurements were poor. The lead was repositioned to an adjacent site with excellent measurements. The delivery catheter was slit. While adjusting the amount of slack, the lead dislodged.

Access was recovered using the retained guidewire, and another C315-S4 catheter was inserted. The lead was delivered in the same fashion to a midseptal position and secured with 6 to 8 turns, given the prior dislodgement. Electrical measurements were excellent (R waves: 12 mV; pacing threshold: 0.5 V at 0.5 ms; bipolar impedance: 833 Ω).

The paced QRS morphology was unexpectedly narrow with right bundle branch block (RBBB)-like morphology (Figure 1B). Angulated fluoroscopy (Figure 2) excluded placement in the coronary venous system or LV cavity. Realizing that we might have inadvertently achieved LB/LBA pacing, unipolar electrogram was evaluated via the atrial port of the analyzer and did show small Purkinje potentials (Figure 3). Unipolar impedance was about 700 Ω. No attempt was made to optimize position, given the absence of data in children. No contrast was given to evaluate septal depth. Retrospective review of limited stored fluoroscopy did not demonstrate the fulcrum sign. Subsequent echocardiogram demonstrated the lead traversing the basal septum at an oblique angle (Figure 4, Video 1).

The procedure was completed in standard fashion using a MicroPort Reply SR generator configured to the VVIR mode using a blended minute ventilation sensor. The procedure used 12 minutes of low-dose, low-frame-rate fluoroscopy; air kerma of 0.8 mGy; and dose-area product of 6.6 μGm^2.

Final QRS morphology (Figure 1B) did not change significantly with unipolar versus bipolar configuration or high versus low pacing outputs (not shown). We did not attempt programmed stimulation to clarify the tissues captured by the pacing stimulus. The paced QRS duration was 95 ms total and 90 ms from the onset of intrisicoid deflection in V_1/V_2; the

FIGURE 3 **Deep Septal Electrogram**

Unipolar recording via the atrial port of the analyzer at 50 mm/s showing small Purkinje potentials during junctional rhythm.

time from pacing stimulus to peak R-wave in V_5/V_6 was 40 ms.

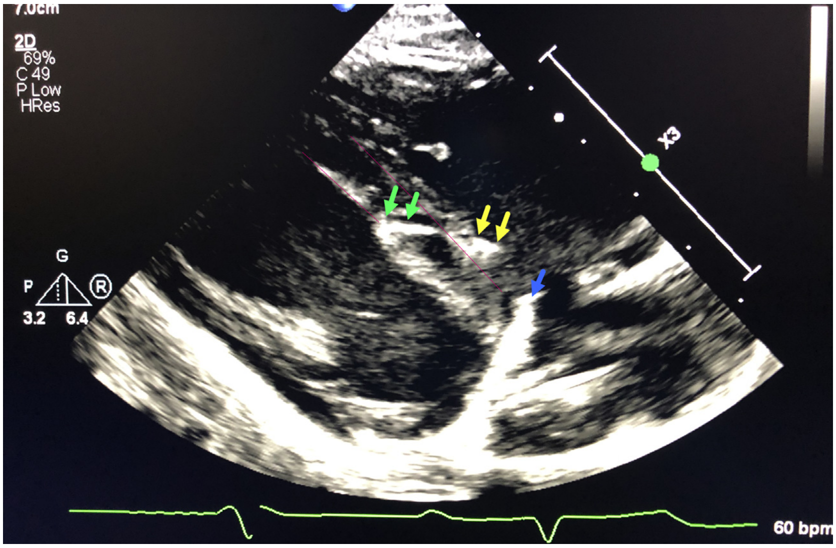
DISCUSSION

Congenital complete heart block is a common indication for permanent pacing in childhood. The best route for pacemaker implantation in small children is unknown and may be influenced by potential strategies to reduce risk for pacemaker-induced cardiomyopathy. Indeed, some centers accomplish this with routine use of epicardial LV apex pacing, even in patients old enough to have transvenous leads (2).

Given the known downsides of epicardial pacing and known dyssynchrony present with transvenous RV pacing (whether apical or septal) (3), there is theoretical appeal to transvenous provision of (near) physiologic pacing by His bundle pacing or LB/LBA pacing, which are gaining popularity in adult electrophysiology practice (4-6). However, there are limited data on these techniques in small children, with the youngest patient reported 6 years of age (7). Importantly, there are both potential benefits and risks related to these techniques (including tricuspid valve injury, septal perforation, and coronary artery injury).

In adults, LB/LBA pacing requires intentional deep septal lead deployment. In small children, the combination of thinner ventricular septum and softer myocardium may predispose to inadvertent LB/LBA pacing when the Medtronic 3830 lead is delivered using standard techniques targeting midseptal lead

FIGURE 4 **Echocardiographic Lead Position**



Oblique parasternal view showing the lead entering the ventricular septum **(red outlines)** below the tricuspid valve hinge point **(blue arrow)**, with helix **(green arrows)** deep in the septum and ring electrode **(yellow arrows)** in the right ventricle cavity.

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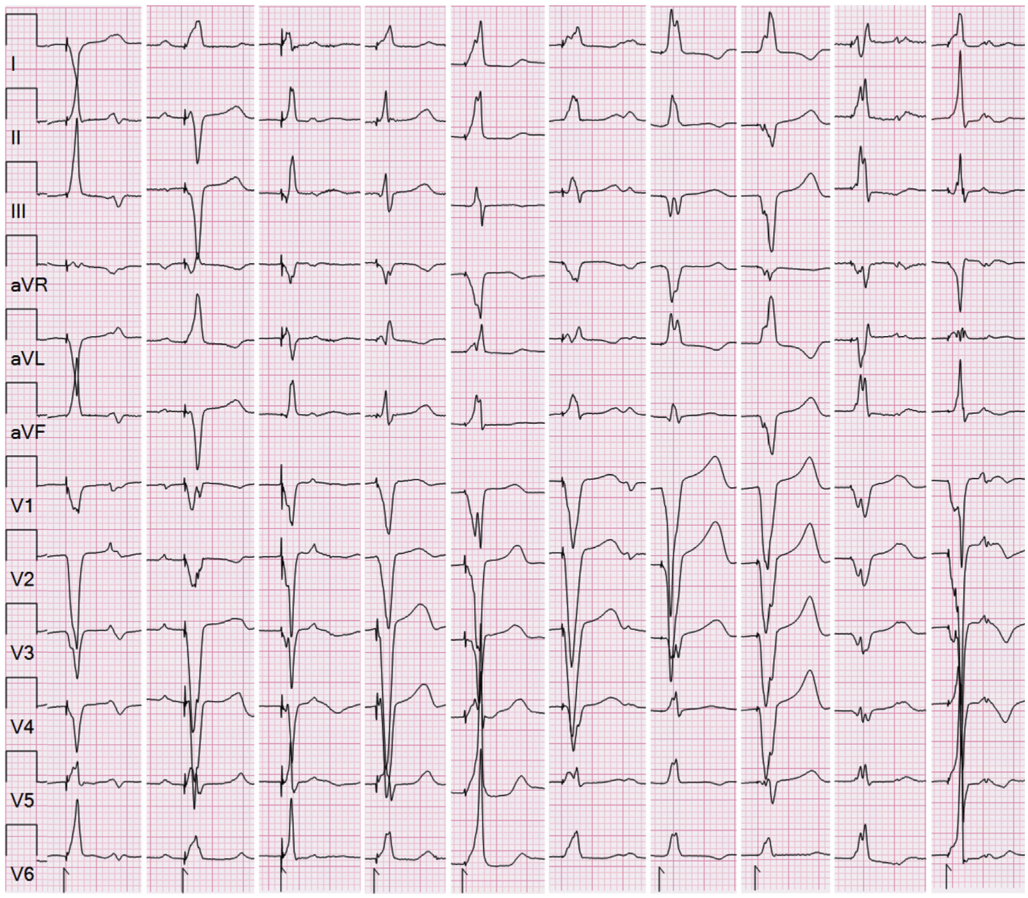
FIGURE 5 Septal QRS Morphologies



Paced QRS morphology from a convenience sample of children under 10 years of age with nontargeted right ventricle septal pacing using the Medtronic 3830 and C315-S4 or C315-S5 delivery catheters, with about half showing a notched QRS morphology in V_1, that is, the "W" pattern as described by Huang et al (6).

placement. Notably, the Medtronic 3830 helix is 1.8 mm, versus a normal septal thickness of 3 to 6 mm for an average-size 2-year-old or 4 to 8 mm for an average-size 10-year-old (8,9) (see Supplemental Table 1).

Anecdotally, we have noticed that untargeted septal pacing using the C315-S4/S5 delivery catheters in smaller children frequently provides paced QRS morphology suggesting feasibility of LB/LBA implantation (**Figure 5**).

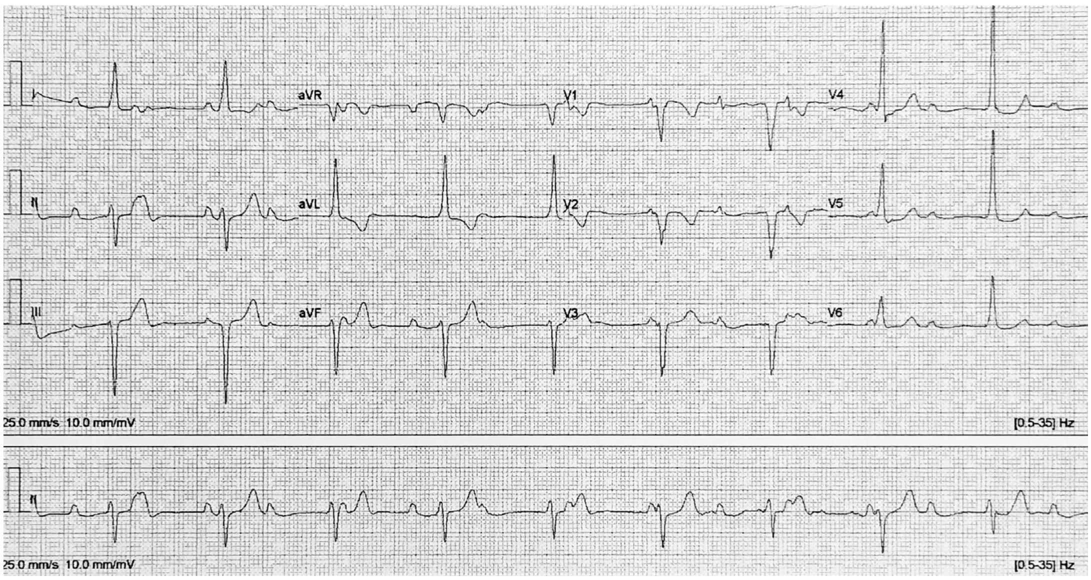
FOLLOW-UP

At 1-year postprocedure, the patient was thriving. Electrocardiogram showed fairly narrow paced QRS complex (about 100 ms), although no longer with an RBBB pattern (**Figure 6**), suggesting LBA capture but now without LB capture. Interrogation showed bipolar R waves of >15 mV, bipolar threshold of 1.50 V at 0.25 ms and 1.00 V at 0.50 ms (impedance: 791 Ω), and unipolar threshold of 1.00 V at 0.25 ms (impedance: 426 Ω).

CONCLUSIONS

LB/LBA pacing is technically feasible in small children using Medtronic 3830 and commercial preshaped delivery catheters, and indeed caution is required, as deep septal deployment can be accomplished inadvertently. This technique cannot presently be recommended for routine use, as the durability and clinical outcomes of conduction system pacing in children are unknown. However, this is an important area for future research, given the potential utility for children with anticipated long durations of pacing, elevated risk for pacemaker-induced

FIGURE 6 **Electrocardiogram at 1 Year**



In late follow-up, the paced QRS complex is still narrow but lacks the right bundle branch block pattern of left bundle capture.

cardiomyopathy, and limited candidacy for traditional cardiac resynchronization therapy.

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REFERENCES

1. Michaëlsson M, Jonzon A, Riesenfeld T. Isolated congenital complete atrioventricular block in adult life: a prospective study. *Circulation*. 1995;92:442–449.

2. Kovanda J, Ložek M, Ono S, Kubuš P, Tomek V, Janoušek J. Left ventricular apical pacing in children: feasibility and long-term effect on ventricular function. *Europace*. 2020;22(2):306–313.

3. Janoušek J, van Geldorp IE, Krupičková S, et al. Permanent cardiac pacing in children: choosing the optimal pacing site: a multicenter study. *Circulation*. 2013;127(5):613–623.

4. Vijayaraman P, Chung MK, Dandamundi G, et al. His bundle pacing. *J Am Coll Cardiol*. 2018;72(8):927-947.

5. Vijayaraman P, Dandamudi G, Zanon F, et al. Permanent His bundle pacing: recommendations from a Multicenter His Bundle Pacing Collaborative Working Group for standardization of definitions, implant measurements, and follow-up. *Heart Rhythm*. 2018;15(3):460–468.

6. Huang W, Chen X, Su L, et al. A beginner's guide to permanent left bundle branch pacing. *Heart Rhythm*. 2019;16(12):1791-1796.

7. Huang J, Zhou R, Pan Y, Yang B. Permanent left bundle branch area pacing in a child with a third-degree atrioventricular block: A case report. *J Cardiovasc Electrophysiol*. 2020;31(6):1539-1543.

8. Lopez L, Colan S, Stylianou M, et al. Relationship of echocardiographic *Z* scores adjusted for body surface area to age, sex, race, and ethnicity. *Circ Cardiovasc Imaging*. 2017;10(11).

9. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. *Vital Health Stat 11*. 2002;246:1-190.

KEY WORDS cardiac pacemaker, conduction system pacing, congenital complete heart block, left bundle branch pacing, Medtronic 3830, pediatric

APPENDIX For a supplemental video and table, please see the online version of this paper.