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Implantation of a permanent left bundle branch pacing lead in a child after tetralogy of fallot repair.

A case study

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ABSTRACT

Conduction system pacing, including His bundle and left bundle branch pacing, is an increasingly utilized strategy in adult patients with bradyarrhythmias and atrioventricular conduction disorders. This technique helps prevent the development of heart failure caused by electrical and mechanical dyssynchrony associated with chronic ventricular pacing. These outcomes support the feasibility of this technique in younger pediatric patients under comparable clinical conditions. A distinct category includes children who have undergone congenital heart defect correction and require permanent cardiac pacing. These patients are at higher risk of developing pacing-induced cardiomyopathy due to non-physiologic ventricular contraction, while options for prevention and management remain limited. Biventricular pacing is technically challenging in pediatric patients, and algorithms for minimizing ventricular pacing cannot be applied in the presence of complete atrioventricular block. We report a case of left bundle branch pacing in a child with a history of surgical repair of tetralogy of Fallot and implantation of a permanent pacemaker for postoperative complete atrioventricular block.

Keywords: Tetralogy of Fallot; atrioventricular block; cardiac pacing; conduction system pacing; left bundle branch pacing.

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Имплантация электрода для постоянной электрокардиостимуляции левой ножки пучка Гиса ребенку после коррекции тетрады Фалло: клинический случай

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АННОТАЦИЯ

Стимуляция проводящей системы сердца (пучка Гиса и его левой ножки) у взрослых пациентов является все более распространенным методом лечения брадиаритмий и нарушений атриовентрикулярной проводимости. Эта методика позволяет предупредить развитие сердечной недостаточности, вызванной электрической и механической диссинхронией, возникающей при постоянной стимуляции желудочков. Эти данные позволяют предположить успешность применения данной технологии также у детей младшего возраста в похожих клинических обстоятельствах. Особую категорию составляют дети, перенесшие коррекцию врожденных пороков сердца и нуждающиеся в постоянной электрокардиостимуляции. Они более склонны к развитию сердечной недостаточности на фоне нефизиологичных желудочковых сокращений, и в то же время возможности профилактики и лечения стимулятор-ассоциированной кардиопатии у них ограничены: имплантация бивентрикулярной системы сопряжена с техническими трудностями, а применение алгоритмов минимизации желудочковой стимуляции невозможно из-за стойкого нарушения атриовентрикулярной проводимости. Мы представляем клинический случай имплантации желудочкового электрода в левую ножку пучка Гиса у ребенка, ранее перенесшего радикальную коррекцию тетрады Фалло и имплантацию постоянного электрокардиостимулятора по поводу постинцизионной полной атриовентрикулярной блокады.

Ключевые слова: тетрада Фалло; атриовентрикулярная блокада; электрокардиостимуляция; стимуляция проводящей системы сердца; стимуляция левой ножки пучка Гиса.

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INTRODUCTION

Conduction system pacing has opened a new chapter in the use of implantable antiarrhythmic devices. In particular, implantation of a ventricular lead in the left bundle branch (LBB) area minimizes electrical dyssynchrony of the left ventricle, thereby preserving its physiological activation and contraction. This technique significantly reduces the risk of pacing-induced cardiomyopathy, demonstrating its advantages, particularly in patients with septal right ventricular pacing. In some cases, it also allows permanent cardiac pacing to be considered as an alternative to cardiac resynchronization therapy [1, 2]. The successful experience with left bundle branch pacing (LBBP) in patients older than 18 years suggests the feasibility of this technique even in younger children [3]. A specific patient category includes children who have undergone congenital heart defect (CHD) correction and require permanent cardiac pacing due to incisional atrioventricular block and other conduction disturbances in the postoperative period. The most extensive experience with ventricular lead implantation in patients with CHD has been accumulated with regard to correction of perimembranous ventricular septal defects. However, there are also sporadic reports on the use of conduction system pacing (CSP) in complex congenital defects, such as tetralogy of Fallot, double outlet right ventricle, atrioventricular canal, and others [4,5].

The aim of this study is to describe a clinical case of ventricular lead implantation in the left bundle branch (LBB)

in a child who previously underwent radical correction of tetralogy of Fallot.

CASE DESCRIPTION

At admission to Morozovskaya Children's City Clinical Hospital in Moscow, the child was 9 years old, weighed 26 kg, and had a body surface area of 0.96 m².

At the age of 9 months, the child underwent radical correction of tetralogy of Fallot. The early postoperative period was complicated by complete atrioventricular block, requiring the implantation of a pacemaker system with an epicardial lead to the left ventricle. For 8 years, the patient was on continuous single-chamber ventricular pacing in VVIR mode, then a pacemaker replacement was carried out due to battery depletion. During routine testing, ventricular lead fracture and dysfunction were detected, prompting the recommendation to replace the epicardial system with an endocardial dual-chamber system, including ventricular lead implantation into the left bundle branch (LBB).

The preoperative electrocardiogram (ECG) showed epicardial left ventricular pacing in VVI mode with a *QRS* complex duration of 152 ms (Fig. 1a). According to the Echo data, left ventricular contractile function was normal prior to surgery.

Using a specialized delivery system designed for targeted lead implantation in the His bundle region (Select Site C315 His, Medtronic, USA; 2.4 mm [7Fr] diameter), a stylet-free active fixation lead (Select Secure 3830, Medtronic, USA;

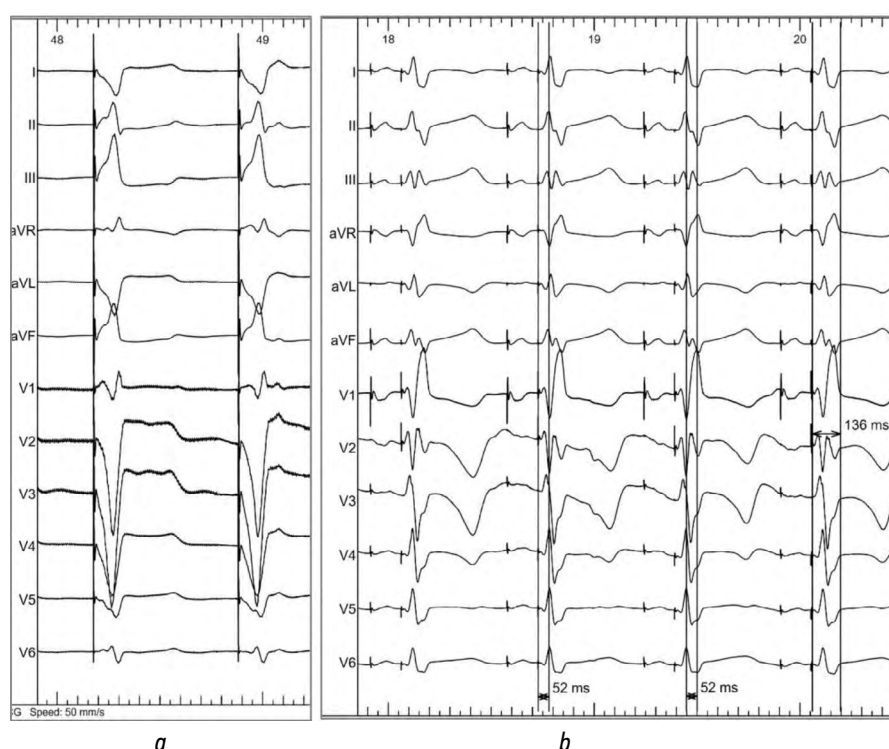


Fig. 1. Twelve-lead electrocardiogram before and after pacemaker system replacement: (a) single-chamber ventricular pacing via an epicardial ventricular lead; (b) sequential dual-chamber pacing with left bundle branch pacing. *ST-T_{V6}* interval, 52 ms; *V₆-V₁* interval, 52 ms; *QRS* duration, 136 ms.

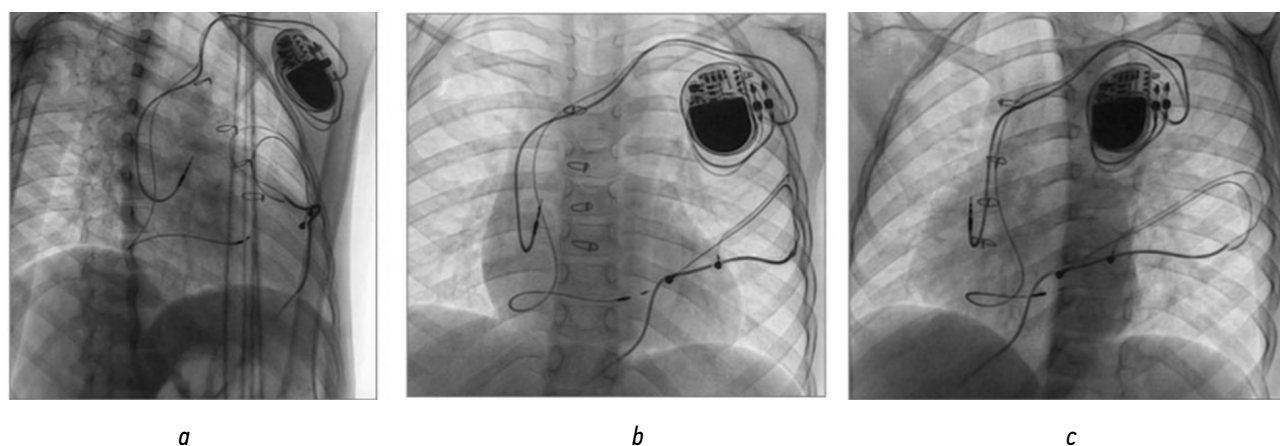


Fig. 2. Chest radiography after implantation of an endocardial dual-chamber pacemaker system with a ventricular lead in the left bundle branch: (a) right oblique view; (b) anteroposterior view; (c) left oblique view. © Dishekov et al., 2024.

59 cm long) was screwed into the interventricular septum under fluoroscopic guidance, with monitoring of electrical impedance and stimulated *QRS* morphology. The impedance at the final lead placement site was 923 ohm; the *R*-wave amplitude ranged 9.6–11.3 mV; the pacing threshold was 0.5 V with a pulse duration of 0.40 ms. The *QRS* complex duration in lead V_6 was 134 ms; the peak-to-peak interval (RV_1 – RV_6) was 52 ms; the *St*– RV_6 interval was 52 ms. The atrial lead was implanted in the right atrial appendage. Upon completion of the procedure, a multi-projection assessment of lead positioning was performed (Fig. 2). The pacemaker was programmed to DDD mode with a basic pacing rate of 70 bpm. Left bundle branch pacing (LBBP) enabled a more physiological pacing mode, reducing the *QRS* complex duration from 152 ms to 136 ms (see Fig. 1b).

CONCLUSION

In some cases, the correction of certain congenital defects, such as tetralogy of Fallot, may require the implantation of a permanent pacemaker, making patients lifelong-dependent on permanent cardiac pacing. The lead implantation site largely determines the prognosis and the risk of complications. For example, it is now well established that right ventricular apical lead placement is strongly associated with a high risk of intraventricular and interventricular electrical and mechanical dyssynchrony, which may ultimately contribute to the development of pacing-induced cardiomyopathy. Accumulating experience with His bundle and bundle branch pacing indicates a more favorable prognosis and the achievement of more physiological conduction, contributing to an increase in conduction system pacing procedures.

ADDITIONAL INFORMATION

Authors' contribution. All the authors participated in the clinical case and the preparation of the article, read and

approved the final version before publication. M.R. Dishekov, study design and concept, text writing, pacemaker implantation; M.V. Gorev, participation in the pacemaker implantation procedure, text edit, preparation for the publication; E.A. Talalaeva, participation in the pacemaker implantation procedure, text writing, scientific consultation; M.A. Abramyan, study design and concept, text edit.

Consent for publication. The authors have received written informed voluntary consent from the patient's legal representatives to publish personal data.

Competing interests. The authors declare that they have no conflict of interest.

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ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

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