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CASE REPORT

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Transvenous left bundle branch pacing during cardiac surgery: A case report

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Key Clinical Message
Left bundle branch pacing (LBBP) was a promising physiological pacing method, which could prevent or treat heart failure. We reported a young woman with severe valvular disease and heart failure receiving LBBP under direct vision and without x-ray assistance during cardiac surgery. To the best of our knowledge, this was the first case report of this type of pace maker implantation.

KEYWORDS
cardiac surgery, left bundle branch pacing, valvular heart disease

1 | INTRODUCTION

The His-Purkinje system pacing directly stimulated the His bundle or the left bundle branch to achieve synchronous pacing of the left and right ventricles, which could prevent or treat heart failure. Compared with His bundle pacing (HBP), left bundle branch pacing (LBBP) had a wider target area, higher implantation success rate, and stable pacing threshold. Conventional pacemaker implantation was done with the assistance of x-ray. We reported a novel case of LBBP performed under direct vision and without x-ray assistance during cardiac surgery. To the best of our knowledge, this was the first case report of this type of pace maker implantation.

2 | CASE REPORT

The patient was a 32-year-old female with Ebstein deformity, who had undergone twice tricuspid valvuloplasty or replacement. The patient recently developed shortness of breath after exercise and swelling of lower extremities. Echocardiography revealed extremely severe stenosis with regurgitation of the tricuspid valve, severe mitral regurgitation, severe aortic regurgitation, and right atrial mural thrombus. Left ventricular ejection fraction was 68%. Cardiac surgeons were preparing for her third cardiac surgery—mechanical tricuspid valve replacement, mechanical aortic valve replacement, and mitral valvuloplasty. Electrocardiograph (ECG) showed atrial fibrillation, third-degree atrioventricular block, complete right bundle branch block, and slow ventricular rate of only 40–60 bpm (Figure 1). We recommend permanent pacemaker implantation, preferably LBBP. The patient's condition was complex, and pacemaker implantation was impossible before and after cardiac surgery. Therefore, we chose to perform a hybrid operation to complete LBBP under direct vision.

The patient underwent cardiac surgery under general anesthesia and cardiopulmonary bypass. We performed left subclavian vein puncture and indwelled two guide wires to the right atrium before surgery. We planned to implant two

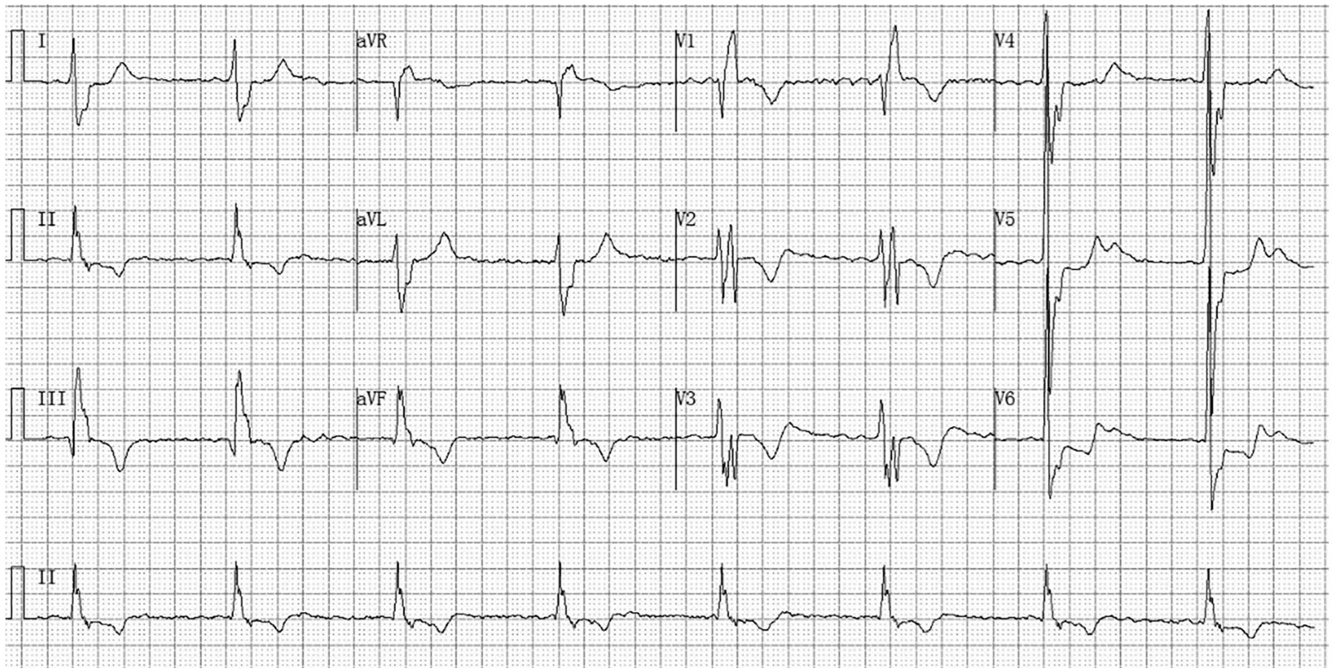

FIGURE 1 ECG before operation: atrial fibrillation, right bundle branch block, ventricular rate 46 bpm, QRS duration: 178 ms.

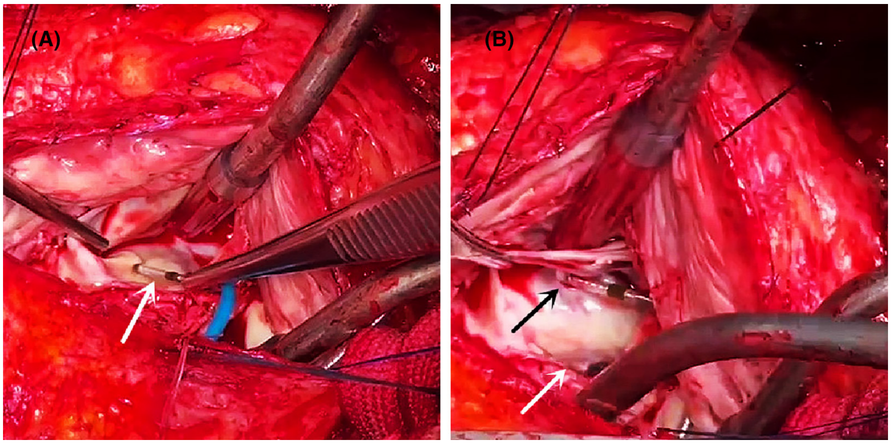

FIGURE 2 Images of the electrode implantation. (A) Left bundle branch electrode (white arrow) was screwed into the ventricular septum under the guidance of the C315HIS sheath. (B) The relative position of the left bundle branch electrode (white arrow) and the lower septum electrode (black arrow).

electrodes, one for LBBP and one for lower septum pacing as a backup. After aortic valve replacement and mitral valvuloplasty, we delivered the electrode (3830, Medtronic) to the right ventricular septum via a C315HIS sheath. Referring to the 9-partition method of the left bundle branch,[1] we screwed the electrode into the anterior and inferior part of the right ventricular septum under direct vision, with a depth of about 6 mm (Figure 2A). Another electrode (5076–58, Medtronic) was sent to the lower right ventricular septum, screwed in and fixed (Figure 2B). The surgeons then performed mechanical tricuspid valve replacement, while placing the pacemaker leads outside the mechanical annulus and sutured them. We tested pacemaker electrodes after heart resuscitation. For the electrode of lower septum, the capture threshold was 0.7 V/0.4 ms, the impedance was 560 Ω and the sensing amplitude was 9.5 mV. The electrode of left bundle branch was non-sensing, unable to pace and had high impedance of 2350 Ω. The left bundle branch lead was inserted into the atrial jack, and the lower septum lead was inserted into the ventricular jack. We placed the dual-chamber pacemaker (A3DR01, Medtronic) into the pocket, finished the operation after fixing and suturing. The pacing mode was set as VVI and the lower rate at 80 bpm.

One week after the operation, the pacemaker was programmed and the electrode of left bundle branch was found to be well paced. It had a pacing threshold of 1.5 V/0.4 ms, impedance of 650 Ω, and sensing amplitude of 10.5 mV. The pacing mode was adjusted to DDD with preferential LBBP. Postoperative ECG showed pacing rhythm, left anterior fascicular block, and right bundle branch block (Figure 3). The QRS duration was 162 ms and there were isoelectric lines from the stimulus signal to the QRS. These indicated successful pacing in the left posterior branch region. Postoperative echocardiography

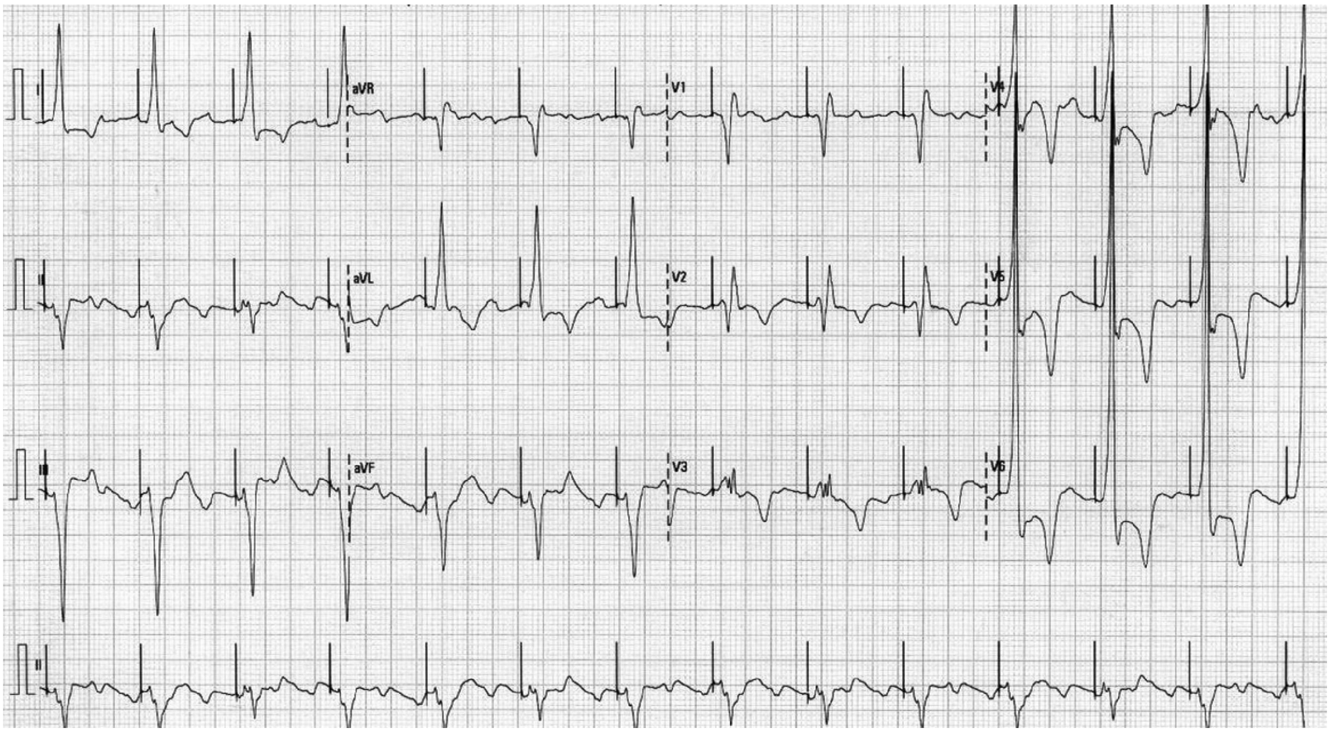

FIGURE 3 ECG after operation: paced rhythm, left anterior fascicular block, right bundle branch block, isoelectric lines between the stimulus and QRS, QRS duration: 162 ms.

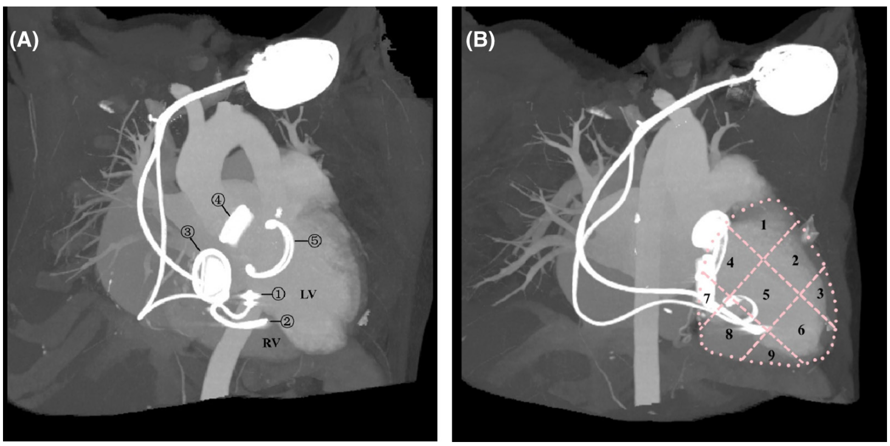

FIGURE 4 Cardiac CT for position of electrodes. (A) Left-anterior oblique (LAO) view: left bundle branch electrode was inserted vertically into the ventricular septum. ① Left bundle branch electrode; ② lower septum electrode; ③ tricuspid mechanical valve; ④ aortic mechanical valve; ⑤ mitral metal ring. (B) Right anterior oblique (RAO) view: The implant site of left bundle branch electrode was at the junction of the partition zones "4/5/7/8" of nine sections ("3 × 3" partitions). LV, left ventricle; RV, right ventricle.

showed that the LBBP lead was inserted vertically into the ventricular septum, the depth of the lead in the ventricular septum was about 10 mm, and the distance from the left ventricular surface of the ventricular septum was 0 mm. Postoperative ejection fraction was 65%. The cardiac CT indicated that the left bundle branch electrode was inserted vertically into the ventricular septum at the left anterior oblique position and just at the junction of the partition zones "4/5/7/8" of nine sections at the right anterior oblique position (Figure 4). The patient was followed up for 3 months after the operation, and the threshold of left bundle branch electrode decreased to 1.2 V/0.4 ms, and the impedance and sensing amplitude remain stable (630 Ω, 11.0 mV).

3 | DISCUSSION

HBP was the most physiological pacing method. Compared with right ventricular pacing, it could significantly improve the electromechanical synchronization and prevent and treat heart failure. However, HBP had shortcomings such as high pacing threshold, low R wave amplitude, and difficulty in implantation.[2] Huang et al. screwed the lead to the left ventricular septum to directly capture the left bundle branch, and proposed a new technology of LBBP for the first time.[3] The left bundle branch and its branches were distributed in fan-shaped under the intimal surface of the left ventricular septum, with a large distribution area and a relatively fixed course. Therefore, compared with HBP, the LBBP electrode was easier to locate and implant, and the pacing threshold was low and stable.[4] Previous studies had confirmed that LBBP can maintain left ventricular electromechanical synchronization, which had similar clinical benefits as HBP.[5]

The patient we reported had severe valvular heart disease and heart failure, with persistent atrial fibrillation and third-degree atrioventricular block. Although traditional right ventricular pacing or epicardial apical pacing could solve the problem of bradycardia in the short term, it would inevitably deteriorate the cardiac function in the long term. The patient had normal left ventricular ejection fraction and no indication for cardiac resynchronization therapy (CRT) currently. Epicardial CRT was also considered, but was too expensive. The patient had undergone tricuspid valve surgery for twice and this time she would receipted mechanical tricuspid valve replacement. The anatomical position of the His bundle was close to the tricuspid valve, so HBP was not feasible. Therefore, we chose LBBP, with right ventricular lower septum pacing as a backup. How to locate the left bundle branch without the guidance of x-ray and intracardiac electrogram (EGM) was the biggest difficulty in this case. No relevant literature has been reported before. We could only refer to the nine-partition method. Zhang et al.[1] divided right anterior oblique 30° fluoroscopic image of the ventricle into nine sections ("3×3" partitions), named zones 1–9, respectively. Most successful initial implant sites of LBBP were found at the junction of the partition zones "4/5/7/8" and more points were located in zones "4/5". Based on this, we screwed the electrode into the anterior and inferior part of the right ventricular septum under direct vision. The postoperative cardiac CT confirmed that the electrodes were in perfect position and the ECG showed that the electrode was located in the left posterior branch area, which achieved the expected goal.

The ECG and EGM characteristics of LBBP can be summarized as: (1) right bundle branch block pattern; (2) usually with the left bundle branch potential; (3) Selective LBBP with specific ECG changes and a discrete component in EGM; (4) The isoelectric line between the pacing stimulus and the onset of QRS complex; and (5) with a constant and shortest stimulus to left ventricular activation time (LVAT) at different pacing outputs and less than 80 ms.[6,7] This case was special. The patient was unable to map the left bundle branch potential during surgery. After the electrodes were screwed in, the position, and depth could not be changed any more. In this case, the leads were sutured at tricuspid annulus. Before suturing the tricuspid valve, the sheath had withdrawn, thus the electrodes could not be revised. The pacing parameters could only be measured after heart resuscitation. Interestingly, at the end of the surgery, the left bundle branch electrode could neither sense nor pace, but it returned to normal when retested 1 week after the operation, which may be related to the inhibition of the electrical activity of the myocardium at the early stage of resuscitation. The pacing ECG showed a pattern of right bundle branch block, but the shape was different and the QRS duration was shorter than that before the implantation. And there were isoelectric lines between the stimulus and QRS. These indicated that the LBBP of the patient was successful.

There were some possible complications associated with this new technique. First, perivalvular leakage may occur due to the electrodes being sutured to the external aspect of the mechanical tricuspid annulus. This can be minimized by meticulous suturing during the procedure. Second, a pocket hematoma may develop. Given systemic heparinization during cardiac surgery, the risk of bleeding was heightened. Adequate hemostasis during the operation, coupled with intensive nursing care, can potentially reduce this risk. Third, LBBP may be unsuccessful, with only left ventricular septal pacing being achieved. The electrodes cannot be tested during the hybrid operation, and their position was solely reliant on anatomic alignment, which might not reach the left bundle branch. Nonetheless, even left ventricular septal pacing was superior to conventional right ventricular pacing or epicardial pacing. Fourthly, there was a risk of infection. Extracorporeal circulation and prolonged operative time could elevate the risk of infection of the pacing system. Strict adherence to aseptic technique and the administration of prophylactic antibiotics may serve to mitigate this risk.

4 | CONCLUSION

Through this case, we further confirmed that LBBP was a clinically feasible physiological pacing method. Even without x-ray imaging, without intracardiac electrogram, LBBP may be possible in extreme cases. For patients undergoing mechanical tricuspid valve replacement with an indication for pacemaker implantation, hybrid operation with LBBP under direct vision may be a choice.

AUTHOR CONTRIBUTIONS

Ning Wang: Investigation; methodology; writing – original draft. **Yan Li:** Investigation; methodology. **Guanliang Cheng:** Data curation; investigation. **Xuezhi Chen:** Conceptualization; investigation; writing – review and editing.

FUNDING INFORMATION

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The study was approved by the Ethics Committee of Peking University International Hospital (Ethics number: 2022-KY-0038-01).

CONSENT

Written informed consent for publication of patient's clinical details and images was obtained from the patient.

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