

Direct and indirect capture of the left bundle branch: Dynamic retrograde atrial potential abrupt and gradual decrease



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Introduction

Left bundle branch pacing (LBBP) is defined as a direct capture of the left main bundle or one of its fascicles along with the left ventricular septal myocardium at a low output (<1 V/0.5 ms).¹ Wu and colleagues² proposed that direct LBB capture could be confirmed by recording retrograde His potential, although they did not elaborate on indirect LBB capture.

Retrograde right atrial potential (P_{ORA}) is very common in an electrophysiological examination. However, the clinical significance of the stimulus-to-atrial (S-A) potential interval in LBBP has not been investigated. Here, we report 1 case that demonstrates direct and indirect capture of the LBB with P_{ORA} using John Jiang's connecting cable (Xinwell Medical Technology Co, Ltd, Ningbo, Zhejiang, China), which allows for simultaneous monitoring and recording of an electrocardiogram and an intracardiac electrogram (EGM) during the transseptal placement of the pacing lead.³

Case report

A 65-year-old woman presented with symptoms of syncope for 1 week. Holter monitoring showed sick sinus syndrome, intermittent high-grade atrioventricular (AV) block, and 15 long R-R intervals of >2 seconds, with the longest R-R interval of 30 seconds. Echocardiography examination revealed left ventricular end-diastolic diameter of 46 mm and left ventricular ejection fraction of 75%. The patient also had hypertension. A dual-chamber pacemaker was indicated for the patient to improve the symptoms of syncope caused by the

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KEY TEACHING POINTS

- Left bundle branch was captured (including direct and indirect) at all times during monitoring in the traverse septum.
- Stimulus-to-atrial interval abruptly decreased when stimulus-to-left ventricle activation time was suddenly shortened, identifying direct capture of the left bundle branch (LBB).
- Gradual decrease in stimulus-to-atrial interval indicated indirect LBB capture as the lead gradually advanced into the septum.

long R-R interval and the intermittent high-grade AV block. To address the possible progression to complete AV block in the future and to achieve a near physiological pattern of left ventricular activation, we decided to place an LBB lead.

In this case, dynamic QRS morphologic changes served as a criterion for the LBB capture diagnostic.⁴ When the QRS morphology changed and the stimulus-to-left ventricle activation time (Stim-LVAT) was decreased by ≥ 10 ms,² it was confirmed that left ventricular septum pacing changed to nonselective LBBP. This means that activation of the myocardium was achieved in addition to LBB. It was confirmed that nonselective LBBP changed to selective LBBP when the QRS morphology changed, Stim-LVAT remained unchanged, and the distinct isoelectric interval appeared. This represented the LBB recruitment, and the myocardium capture was lost.¹

The 5076 lead (Medtronic, Minneapolis, MN) was placed in the right atrium. The lumenless pacing lead (Model 3830; Medtronic) was successfully implanted into the LBB area. Continuous pacing at 2 V/0.5 ms allowed for beat-to-beat monitoring of electrocardiogram and EGM to guide implantation (Supplemental Videos 1 and 2). A pacing protocol at 100 beats/min above the native sinus rate was performed to

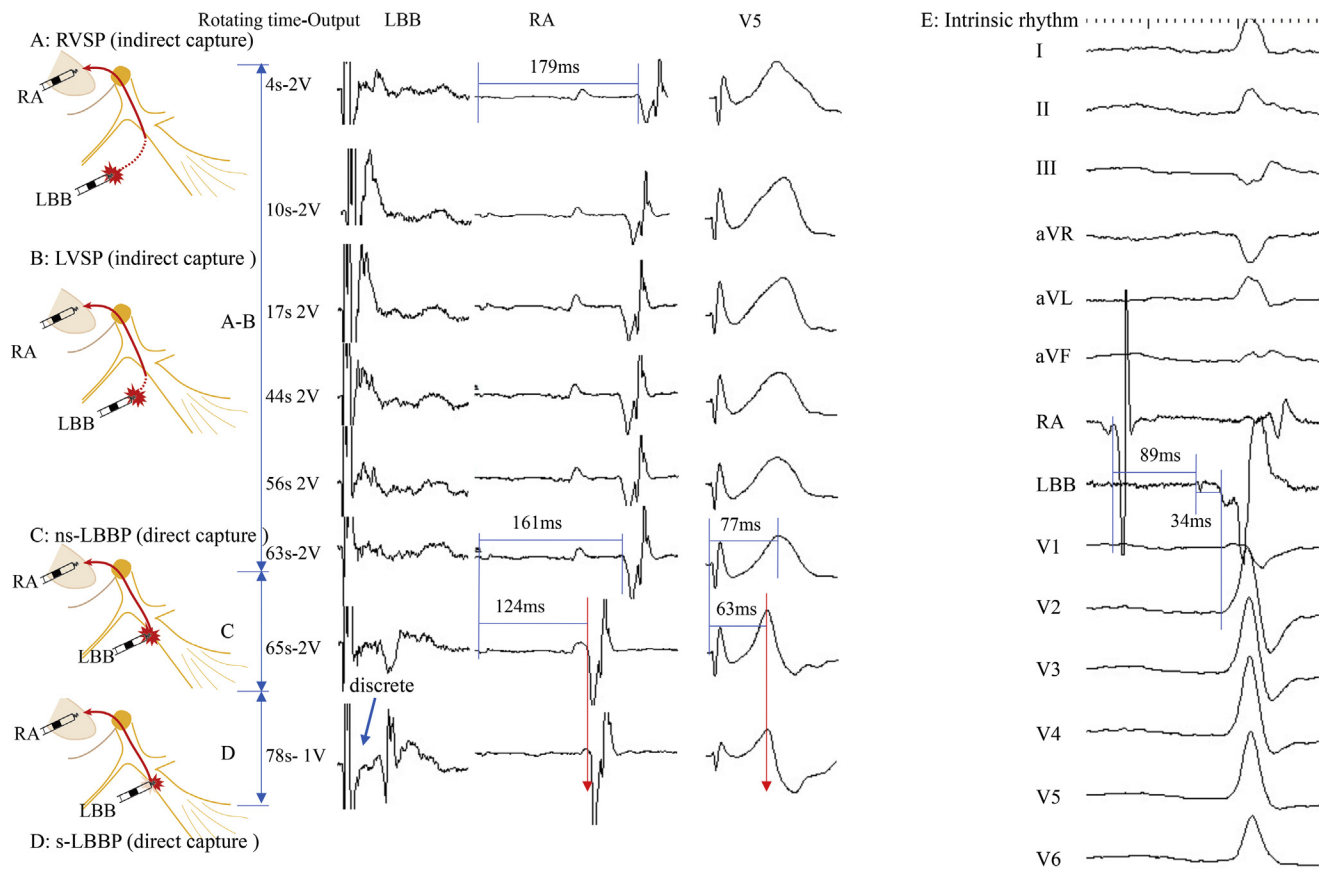


Figure 1 A,B: Retrograde right atrial potential (PO_{RA}) was gradually decreased as the pacing electrode was screwed from the right ventricular septum to the left ventricular septum. C: When the electrode was screwed into the left bundle branch (LBB) area, PO_{RA} abruptly decreased and the stimulus-to-left ventricle activation time was suddenly shortened. D: An isoelectric interval was observed during decreased in pacing output. E: LBB potential and PO_{RA} were recorded. LVSP = left ventricular septal pacing; ns-LBBP = nonselective left bundle branch pacing; RA = right atrium; RVSP = right ventricular septal pacing; s-LBBP = selective left bundle branch pacing.

exclude spontaneous changes in heart rate and to ensure 1:1 ventricular-atrial (V-A) conduction. The S-A interval gradually decreased from 179 ms to 161 ms (Figure 1A and 1B, Figure 2). When the Stim-LVAT between 2 adjacent paced QRS complexes was abruptly decreased from 77 ms to 63 ms, the S-A interval was also abruptly shortened from 161 ms to 124 ms (Figure 1C, Figure 2). The unipolar pacing at 2 V/0.5 ms captured both the LBB and the septal myocardium, while a reduced output was required to selectively capture the LBB. Then, the output was gradually reduced to the level near the LBB threshold. Notably, a distinct isoelectric interval was observed in the EGM during 1.0 V/0.5 ms pacing (Figure 1D, Figure 2). Both the S-A interval and Stim-LVAT remained unchanged (red arrow). The lead was placed at a depth of 16 mm. Pacemaker implantation was performed under local anesthesia with a total procedure time of 2 hours. There were no complications, such as perforation, pneumothorax, lead dislodgements, and pocket hematoma.

Discussion

At present, the methods that confirm the diagnosis of LBB capture require dynamic maneuvers, such as programmed LBB stimulation and output-dependent produced paced

QRS morphology change.⁵ The use of traditional intermittent pacing methods for the diagnosis of LBB capture is limited by the inability to dynamically monitor PO_{RA} and paced QRS morphology changes. Here, we showed a novel method to confirm LBB capture. Instead of examining S-A interval and QRS changes after the lead screw-in actions, the continuous pacing technique allows for a complete real-time monitoring of QRS parameters while the lead is being screwed in.

This case report indicated that the LBB was captured (including direct and indirect) at all times, because PO_{RA} was continuously observed and recorded during the transeptal placement of the pacing lead, showing evidence of direct and indirect LBB capture using stimulus-to-right atrial conduction time. As the pacing lead gradually advanced from the right to the left septum, the electrical stimulation indirectly captured LBB via myocardial spread and then activated the His bundle at the right atrium, resulting in gradual shortening of the S-A interval. The abrupt shortening is an indication for the transition from indirect to direct LBB capture.

A previous study has demonstrated LBB capture in the non-LBB block group by investigating the relationship between the stimulus-to-retrograde His (S-H) potential interval and the interval of His to LBB potential during intrinsic conduction.² The process of studying the S-A

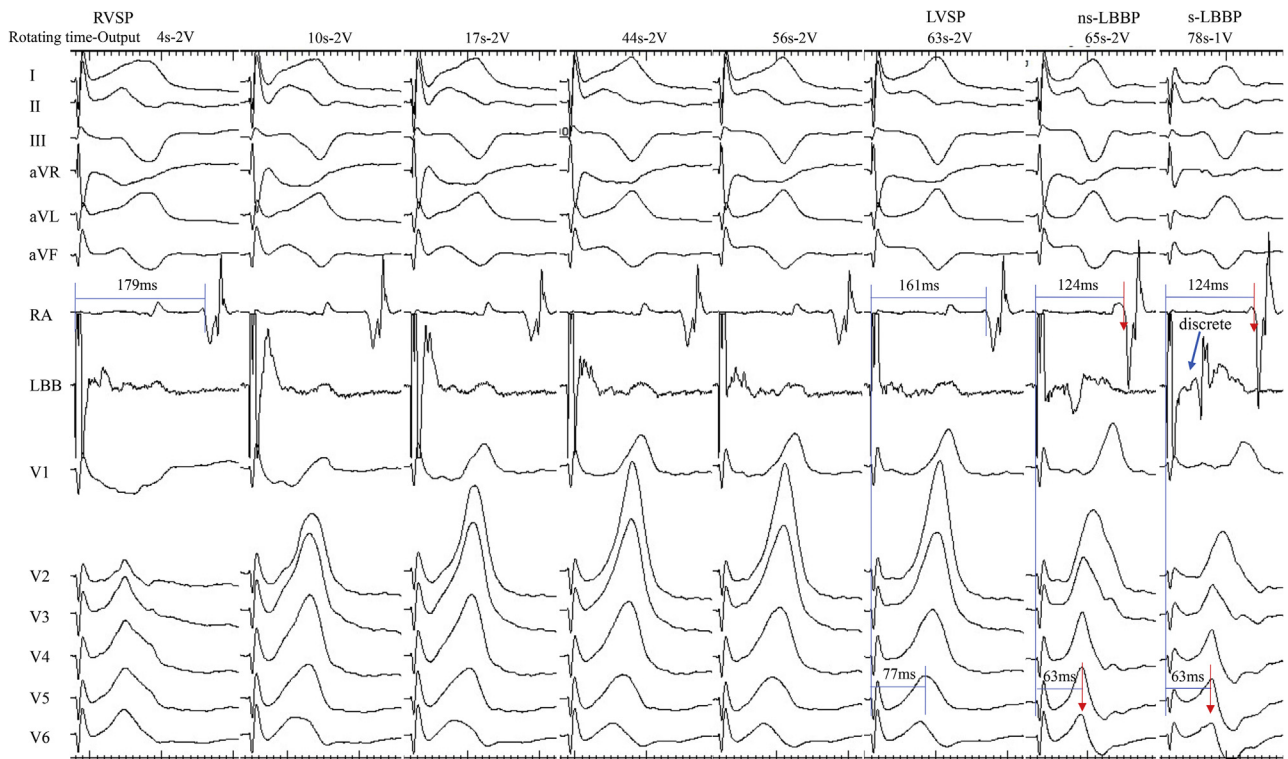


Figure 2 Retrograde right atrial potential (P_{oRA}) was gradually decreased as the pacing electrode was screwed from the right ventricular septum to the left ventricular septum. When the electrode was screwed into the left bundle branch (LBB) area, P_{oRA} abruptly decreased and the stimulus-to-left ventricle activation time was suddenly shortened. An isoelectric interval was observed during decrease in pacing output. Abbreviations as in Figure 1.

interval is similar to that for the S-H interval. A sudden shortening can also be monitored in the S-H interval, but it is not easily observed owing to the small amplitude of the retrograde LBB potential (P_{oHis}). Sometimes, the retrograde P_{oHis} fuses with the ventricular EGM, which also increases the difficulty of identifying the P_{oHis} . This limits the application of retrograde activation of the His bundle in clinical practice. In contrast, the P_{oRA} has a significantly larger amplitude than the P_{oHis} , and the abrupt shortening of the S-A interval is more easily observed.

The S-A interval includes retrograde conduction of the AV node, which could be affected by the pacing interval. The response to ventricular pacing is a gradual prolongation of V-A conduction as the ventricular paced cycle length is decreased. Therefore, it is necessary to apply an appropriate and constant pacing protocol to ensure 1:1 V-A conduction to avoid retrograde AV nodal Wenckebach block, thereby confirming the direct LBB capture by an abrupt shortening of the atrial potential retrograde conduction. These findings may not be applicable when 1:1 V-A conduction cannot be performed owing to the presence of Wenckebach V-A conduction.

LBBP is emerging as a promising option to deliver physiological pacing. Several criteria have been proposed to confirm the LBB capture. An abrupt decrease in P_{oRA} provides the basis for capturing the conduction system and is a

way of differentiating LBB capture from left ventricular septum capture.

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The study was conducted after getting the ethical committee's and the patient's approval.

Appendix Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.hrcr.2022.03.009>.

References

1. Ponnusamy SS, Arora V, Nambodiri N, et al. Left bundle branch pacing: a comprehensive review. *J Cardiovasc Electrophysiol* 2020;31:2462–2473.
2. Wu S, Chen X, Wang S, et al. Evaluation of the criteria to distinguish left bundle branch pacing from left ventricular septal pacing. *JACC Clin Electrophysiol* 2021; 7:1166–1177.
3. Jiang F, Jiang L. Left bundle branch pacing with dynamic retrograde His bundle potential and intracardiac isoelectric interval: a case report. *HeartRhythm Case Rep* 2021;7:553–557.
4. Jastrzębski M, Burri H, Kielbasa G, et al. The V6-V1 interpeak interval: a novel criterion for the diagnosis of left bundle branch capture. *Europace* 2022;24:40–47.
5. Jastrzębski M, Kielbasa G, Curila K, et al. Physiology-based electrocardiographic criteria for left bundle branch capture. *Heart Rhythm* 2021;18:935–943.