Early Experience of Left Bundle Branch Pacing with Lumenless Lead in a Single Center: A Case Series

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ABSTRACT

Left bundle branch pacing (LBBP) has been subject to increasing interest over the last few years due to its capacity for physiological conduction and its advantages compared to His bundle pacing. His bundle pacing has certain limitations, such as a small pacing area for the His bundle, a high threshold that leads to battery depletion, a low R-wave amplitude that may result in atrial or His oversensing, and ventricular signal undersensing. In this case series, four patients (two female and two male) aged 62.2 ± 8.4 years old with symptomatic sick sinus disease and no scar tissue in the interventricular septum underwent LBBP. All LBBPs were done with standard LBBP using a lumenless SelectSecure 3830 lead (Medtronic®, Minneapolis, USA) with a fixed helix. The lead parameters showed a good R-wave amplitudes (13 ± 7.4 mV) and a low threshold (0.77 ± 0.17 V @ 0.4 ms). All patients were discharged on the next day. During follow-up period of 13.3 ± 12.9 months, all patients were well and no complications were noted. In conclusion, LBBP may be as an alternative of novel conduction pacing techniques and can be done relatively easy and safe, even with limited experience center.

***Keywords**: Left bundle branch pacing, novel conduction system pacing, sick sinus syndrome, pacemaker.*

INTRODUCTION

Left bundle branch pacing (LBBP) is a novel conduction system pacing (CSP) approach that can bypass an abnormal conduction system more distal to the left-sided His bundle and capture the left bundle branch to produce near physiological conduction.[1] LBBP has advantages compared to His bundle pacing, such as a lower threshold, larger R wave, and larger area for LBBP.[2,3] The first LBBP in humans was reported by Huang et al. in 2017.[4] In our center, the first LBBP was performed in December 2021. This report describes our four LBBP cases and provides an overview of the implantation technique. To our knowledge, this is the first published case series of LBBP in Indonesia.

CASE ILLUSTRATION

Four patients with symptomatic bradycardia due to sick sinus syndrome were scheduled for permanent pacemakers. All patients had normal ejection fraction and no scar tissue in the interventricular septum (IVS) (**Table 1**). The ECGs showed normal QRS width, with no bundle branch block (BBB), and only one patient had paroxysmal AF but successful PVI ablation . During the procedure, we used intravenous sedation and local anesthesia. Our LBBP technique was using a lumenless SelectSecure 3830 lead (Medtronic®, Minneapolis, USA) and a delivery sheath of fixed-curve 315-HIS (Medtronic®, Minneapolis, USA). Only in the first case we used a His quadripolar catheter for His mapping (**Figure 1A**). After gaining more experience, we did not use this technique in in the subsequent cases (**Figure 1B**). After implantation, the pacing QRS showed a Qr pattern and a relatively narrow QRS in v1, a larger R wave in lead II than in lead III, a negative R wave in aVR and a positive in aVL lead. The pacemaker mode setting was AAI, with a mode switch to DDD. No complications occurred related to the LBBP procedure in any of the patients.

IMPLANTATION TECHNIQUE

Preprocedural assessments and implantation tools should be well prepared. The assessments in this case series included determining the thickness of the basal IVS and the presence or absence of a septal scar. The general approach for LBBP lead implantation in our center was to use a lumenless SelectSecure 3830 lead (Medtronic®, Minneapolis, USA) with a fixed helix for LBBP and a delivery sheath using a fixed-curve 315-HIS sheath (Medtronic®, Minneapolis, USA) or Selectsite C304-HIS deflectable sheath (Medtronic®, Minneapolis, USA). A standard 12-lead ECG, a pacing system analyzer (PSA), and an intracardiac electrogram were used for pacing lead recording and implantation.

Our implantation technique was a standard approach for LBBP and can be found anywhere .[5,6] Basically, our approach was either cutting-down from the left side of cephalic vein or puncturing from the axillary vein. We used a 7-Fr introducer for the C315 sheath or a 9-Fr introducer for the C304 sheath (Medtronic®, Minneapolis, USA).

His bundle potential was recorded with a quadripolar catheter or a SelectSecure 3830 lead (Medtronic®, Minneapolis, USA). The His bundle location was mapped from the right anterior oblique (RAO) fluoroscopic view using a delivery sheath and a SelectSecure 3830 lead (Medtronic®, Minneapolis, USA). However, in some cases, it was difficult to record the His signal. Therefore, we used the tricuspid annulus as an anatomical landmark (fluoroscopic) (**Figure 1A, B**) or recorded it electrically with A and V waves based on an intracardiac electrogram.[6]

To locate the left bundle branch area, we used the RAO position, and the delivery sheath was turned clockwise and advanced 1.5–2 cm apico-inferiorly from the His bundle area into the RV cavity (**Figure 1A**). Unipolar pacing was performed to find the optimal lead site and the paced morphology of the QS complex, with a notch in the nadir or a “w” pattern in lead V1, R wave in lead II larger than in lead III, a negative aVR, and a positive aVL (**Figure 2B**).[5]

For fixation of the lead, the delivery sheath was rotated (typically counter-clockwise) to make the lead and tip of the sheath perpendicular to the septum at approximately 3 o’clock in the LAO view (**Figure 1C**) and 1 o’clock in the RAO view (**Figures 1A** and **1B**). If the above ECG criteria were met, the lead was subject to several rotations.[6] Due to the floppiness of the 3830 lead, in our experience, the rotation number could vary from eight turns up to more than 12 turns depending on the tissue characteristics. Clockwise rotation was performed until the paced QRS morphology resembled the RBBB pattern in lead V1 (qR or rSR’) (**Figure 2D**). During the clockwise rotation, the impedance would gradually increase, and after reaching the left bundle branch (LBB) area, the impedance would gradually drop by 100 Ω.[6]

A contrast injection of approximately several milliliters through the delivery sheath port was performed in the LAO view (**Figure 1C**) to define the RV septal wall and to confirm the lead depth inside the RV septum. When the tip of the lead was approximately 6–8 mm inside the IVS, the fulcrum sign was observed in fluoroscopy. As the lead was advanced inside the septum, the notch on the S wave in lead V1 moved up, and after additional rotation, the end of the QRS became r’ in V1.[5] During fixation, “fixation beats” were observed when the lead was already near the left bundle branch (**Figure 2C**).[7] We continuously monitored the unipolar pacing morphology and the impedance to ensure a value $> 500\ \Omega$. The lead rotation was stopped when a low threshold (< 1.5 V at 0.5 ms) was confirmed for the LBB capture.[5]

The final step consisted of removing the sheath and confirming the proper slack. The delivery sheath was pulled back to the right atrium, and the

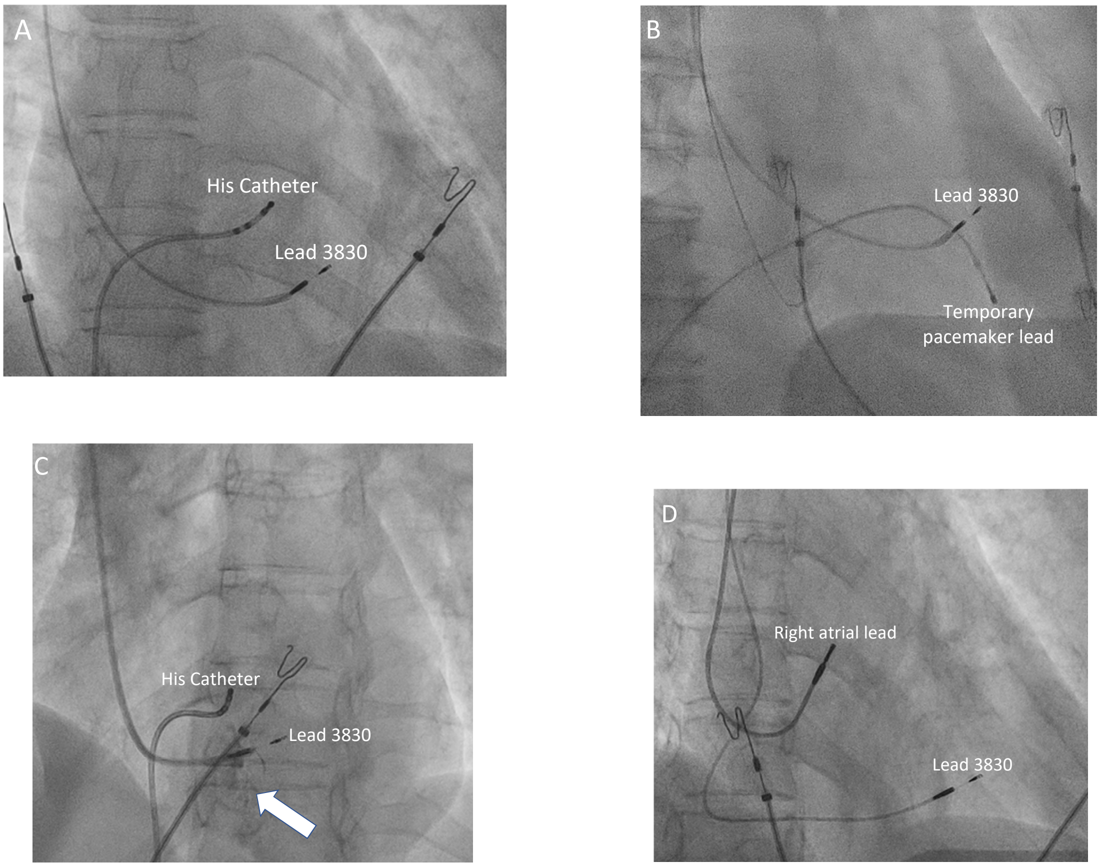

Figure 1. Fluoroscopy of the pacemaker lead 3830.
A. RAO view, His quadripolar catheter, and lead 3830 with sheath C315 pointing 1 -2 o'clock. B. RAO view, lead 3830 with sheath C315 without mapping the His bundle. C. Left anterior oblique (LAO) view, His quadripolar catheter, and lead 3830 pointing 3 o'clock with contrast injection (arrow). D. RAO view, final fluoroscopy lead RA, and LBBP lead (lead 3830).

lead was slightly advanced to allow for adequate slack. Adequate slack is very important to avoid lead dislodgement after slitting the sheath. In this case series, there were no complications related to LBBP. All patients had left bundle branch capture. The mean procedure time was 142.5 ± 55 minutes, and the mean fluoroscopic time was 16.7 ± 9.3 minutes. The lead parameters, such as threshold for LBBP and impedance, remained stable and within the normal range during follow-up (**Table 1**). Generally, the symptoms related to bradycardia were improved.

DISCUSSION

LBBP is relatively new compared to RVA or RVOT and His bundle pacing in clinical practice. This modality shows promising results regarding safety, success rates, and resulting narrow QRS.[8] LBBP and His bundle pacing can be used for patient with symptomatic bradycardia with or without BBB, especially patient with reduced ejection fraction. The overall success rate varies for LBBP between 80–94% and His bundle pacing between 56-95%.[6] The implantation technique is relatively easier to perform compared to His bundle pacing. Other advantages of LBBP compared to His bundle pacing include a larger anatomic target site of pacing, shorter procedural and fluoroscopic times, a lower threshold , stable lead parameters during follow-up, and longer battery life.[6] The benefit of LBBP pacing for the patient is preservation or restoring the LV synchrony.[6]

To obtain a narrow QRS and improve LV synchrony, the LBB must be captured during pacing. Rotating the lead and penetrating the IVS does not mean it will capture the LBB, because some patients only have IVS pacing. Therefore,

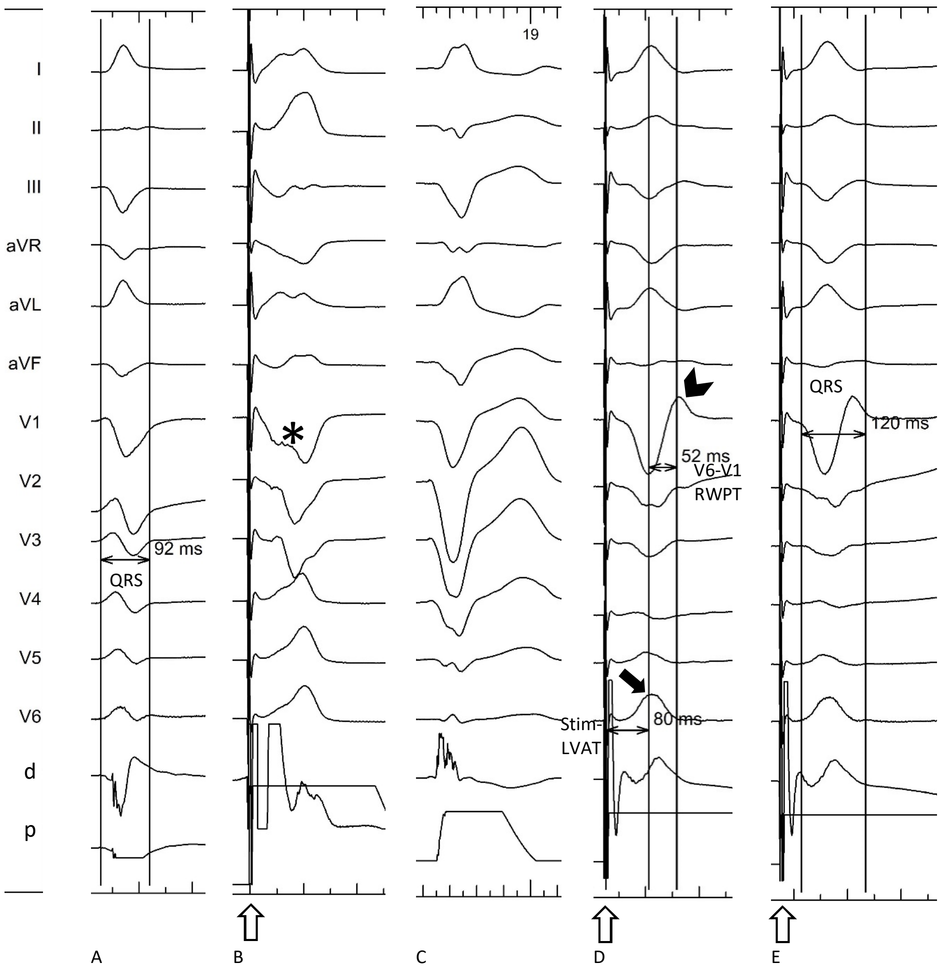

Figure 2. ECG prior to procedure and during LBBP implantation.

A. QRS morphology pre-implantation. B. Paced morphology of QS complex with a notch in the nadir or "w" pattern in V1 (asterisk), an R wave in lead II larger than lead III, a negative aVR, and a positive aVL. C. PVC during rotation called a fixation beat. D. QRS morphology resembling RBBB pattern in lead V1. Pacing stimulus (hollow arrow) to left ventricular activation time (Stim-LVAT) is an interval from pacing stimulus (hollow arrow) to the peak R wave in lead V6 (solid arrow). In this case, the Stim-LVAT is 80 ms. V6-V1 interpeak interval is an interval between R-wave peak time (RWPT) in V1 (arrow head) and V6 (solid arrow). R-wave peak time in V6-V1 interpeak interval is 52 ms. E. qR morphology in lead V1 and QRS duration of 120 ms. Stim-LVAT: stimulus to left ventricular activation time, V6-V1 RWPT: R-wave peak time in V6-V1.

Huang et al. proposed criteria to determine LBB capture,[5] which include paced morphology of the RBBB pattern (qR or rSR'), the presence of LBB potential, left ventricular activation time measured from stimulus to peak of the R wave in lead V5/V6 (Stim-LVAT) ≤ 80 ms, and evidence for direct LBB capture.[5] [9]Jastrzębski et al. reported additional novel criteria for left bundle branch capture to differentiate the technique from ventricular septal pacing. The different combinations of R-wave peak time (RWPT) in the V6-V1 interpeak interval with a cut-off value > 44 ms are specific for diagnosing left bundle branch capture.[10] (**Figure 2.D**). Recently, the European Heart Rhythm Association (EHRA) published a clinical consensus statement on CSP, including LBBP and an algorithm for confirming LBBP capture.[11] In this case series, the Stim-LVAT was ≤ 80 ms, and the V6-V1 interpeak interval was > 44 ms (only one patient had < 44 ms). During implantation, only one patient with left bundle potential was observed. Based on the EHRA consensus, LBBP capture may be obtained even without the presence of left bundle potential. Therefore, during implantation, it is very important to understand the techniques and criteria for LBBP. In early experience for LBBP, it is better and safer to have proctor that can guide

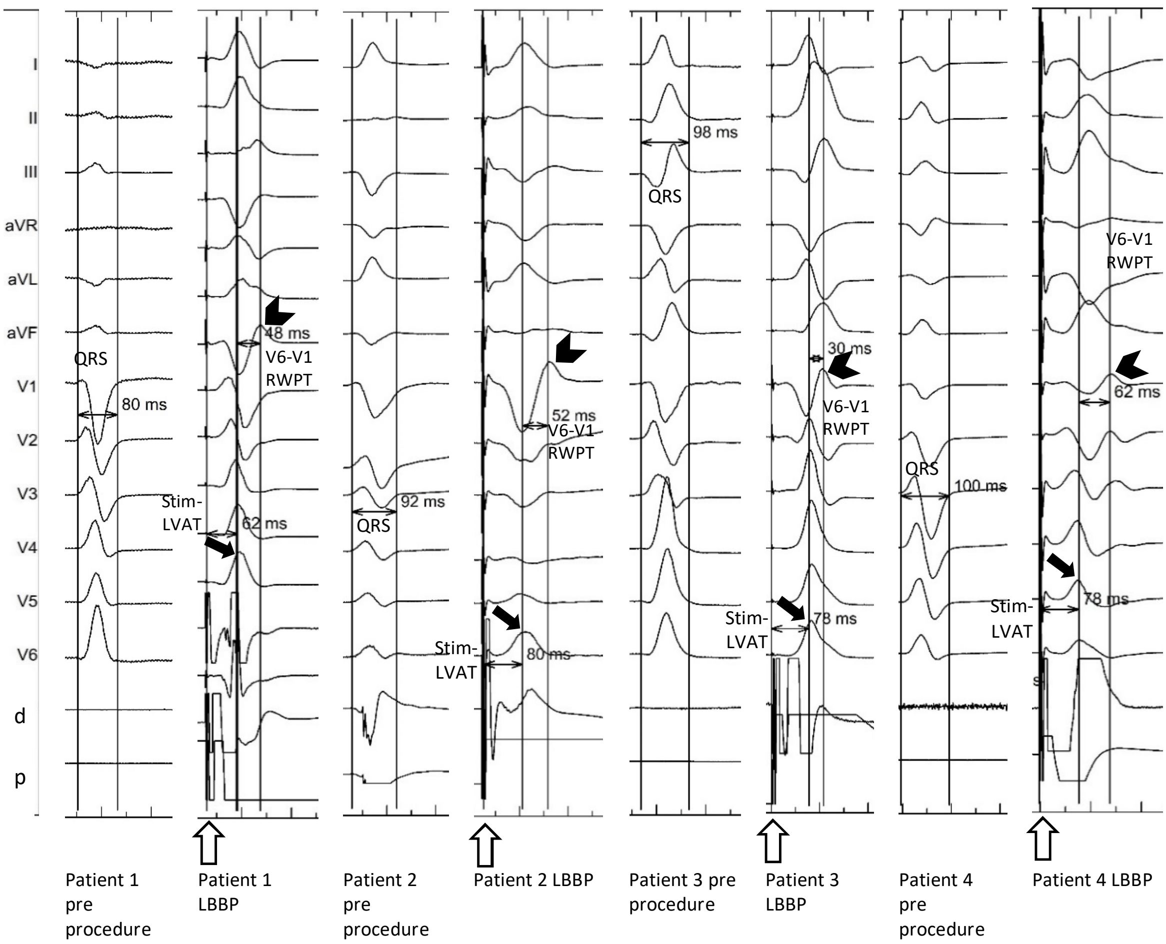

Figure 3. ECG patients pre- and post-LBBP.

Left ventricular activation time (Stim-LVAT) is an interval from pacing stimulus (hollow arrow) to the peak R wave in lead V6 (solid arrow). V6-V1 interpeak interval is an interval between R-wave peak time (RWPT) in V1 (arrow head) and V6 (solid arrow). *LBBP: left bundle branch pacing, Stim*-LVAT: stimulus to left ventricular activation time, V6-V1 RWPT: R-wave peak time in V6-V1.

the procedure, and without adding any cost for the pacemaker implantation.

CONCLUSION

Although we had limited experience with the procedure , we successfully implanted LBBP without any difficulties or complications, and we therefore conclude that it is a relatively easy and safe approach.

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Table 1. Patient data, procedure duration, and lead parameters

Patient	Age	Sex	Diagnosis	QRS	IVS (mm)	QRS width pre LBBP	QRS width post LBBP	LB potential	Stim-LVAT	V6-V1 RWPT inter-peak interval	Procedure time (min)	Fluoro time (min)	Contrast (ml)	During implantation			During follow-up			
														R wave (mV)	Threshold (V at 0.4 ms)	Impe-dance (Ω)	R wave (mV)	Threshold (V at 0.4 ms)	Impe-dance (Ω)	Complication
1	60	F	SSS	Normal QRS	13	80	116	Yes	62	48	190	14	25	24,8	0,8	602	22,4	0.7	608	No
2	73	M	SSS	Normal QRS	15	92	120	No	80	52	50	5	10	6,1	0,8	934	9.1	1.0	475	No
3	66	F	SSS, post AF ablation	Normal QRS	9	98	116	No	78	30	180	17	20	14	0,5	1211	11.2	0.6	804	No
4	50	M	SSS	Normal QRS	9	100	156	No	78	72	150	31	20	7.4	1.0	753	16.2	0.75	772	No
Average	62.5±8.4				11.5±2.5	92.5±7.8	127±16.8		74.5±7.2	50.5±14.9	142.5±55	16.7± 9.3	18.7± 5.4	14.9±7.6	0.7±0.14	875±226	22.4	0.76±0.14	664±132	

SSS: sick sinus syndrome, AF: atrial fibrillation, IVS: interventricular septum, LB: left bundle; LBBP: left bundle branch pacing; Stim-LVAT: stimulus to left ventricular activation time, V6-V1 RWPT: R-wave peak time in V6-V1.

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