Left bundle branch pacing guided by premature ventricular complexes during implant

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Introduction

Physiological pacing has witnessed a rapid growth in the last decade. His bundle pacing (HBP) provides electrical and mechanical synchrony but may be limited by high pacing thresholds and higher need for lead revisions.[1] Left bundle branch pacing (LBBP) has recently been shown to be a promising alternative to HBP. Several criteria for successful left bundle capture have been proposed[2] but need to be validated. LBBP involves advancing the lead deep into the septum by rapid rotations. The goal is to place the lead adjacent to the left bundle branch in the left ventricular (LV) subendocardial region without perforation into the LV cavity. We describe premature ventricular complex (PVC)-guided lead implantation as a novel approach to perform LBBP.

KEY TEACHING POINTS

- Left bundle branch pacing is an effective alternative for His bundle pacing as it overcomes its limitations.
- Premature ventricular complexes (PVCs) with changing morphology from QS pattern to right bundle branch (RBB) conduction delay pattern (qR or rSR) in lead V_1 along with QRS duration reduction are observed as the lead traverses the septum before reaching the left bundle branch area.
- Occurrence of PVCs with narrow QRS duration and RBB delay pattern confirms left bundle branch capture.
- PVC-guided lead placement would help in final positioning of the lead and avoid septal perforation into the left ventricular cavity.

Case report

Case 1

A 65-year-old woman with nonischemic cardiomyopathy, left bundle branch block (LBBB), and LV dysfunction (ejection fraction 30%; interventricular septal [IVS] thickness 11 mm) was referred for cardiac resynchronization therapy. After informed consent was obtained, LBBP was performed using C315 His sheath and 3830 SelectSecure lead (Medtronic, Minneapolis, MN). The pacing lead was positioned deep inside the septum 1.5 cm apical to the distal His bundle region by 4–5 rapid turns. During positioning of the lead deep inside the septum, PVCs with changing morphology were noted. Rotation was stopped immediately on observing PVC (PVC1) with narrow QRS duration and qR (right bundle branch [RBB] delay) in lead V_1 [Figure 1A (i)]. No potentials were noted during baseline LBBB rhythm. The pacing threshold was 0.3 V at 0.5 ms and pacing impedance of 580 ohms. The final left bundle branch (LBB) paced QRS morphology mimicked PVC1 (Figure 1A [ii]) with duration of 124 ms (peak LV activation time [pLVAT] 78 ms). RBB delay was corrected by optimizing the AV interval and pacing output (Figure 1A [iii]). Contrast angiography showed the lead was deployed at a depth of 10 mm inside the septum

Case 2

A 35-year-old woman with nonischemic cardiomyopathy, LBBB, and LV dysfunction (ejection fraction 28%; IVS thickness 11 mm) was referred for cardiac resynchronization therapy. LBBP was performed using C315 His sheath and 3830 SelectSecure lead (Medtronic). PVCs with changing morphology were noted during lead advancement. Rotation was stopped immediately on observing a PVC (PVC2) with narrow QRS duration and rSR (RBB delay) pattern in lead V_1 (Figure 1B [i]). No potentials were noted during baseline LBBB rhythm. Nonselective to selective capture of LBB could be demonstrated by change in QRS

KEYWORDS AV junction ablation; Cardiac resynchronization therapy; Heart failure; Left bundle pacing; Premature ventricular complex
(Heart Rhythm Case Reports 2020;6:850–853)

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Disclosures: Shunumuga Sundaram Ponnusamy: None. Pugazhendhi Vijayaraman: Honoraria, consultant, research, fellowship support: Medtronic; consultant: Boston Scientific, Abbott, Biotronik, Eaglepoint LLC. **Address reprint requests and correspondence:** Dr Pugazhendhi Vijayaraman, Professor of Medicine, Geisinger Commonwealth School of Medicine, Geisinger Heart Institute, MC 36-10, 1000 E Mountain Blvd, Wilkes-Barre, PA 18711. E-mail address: pvijayaraman1@geisinger.edu.

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https://doi.org/10.1016/j.hcrc.2020.08.010

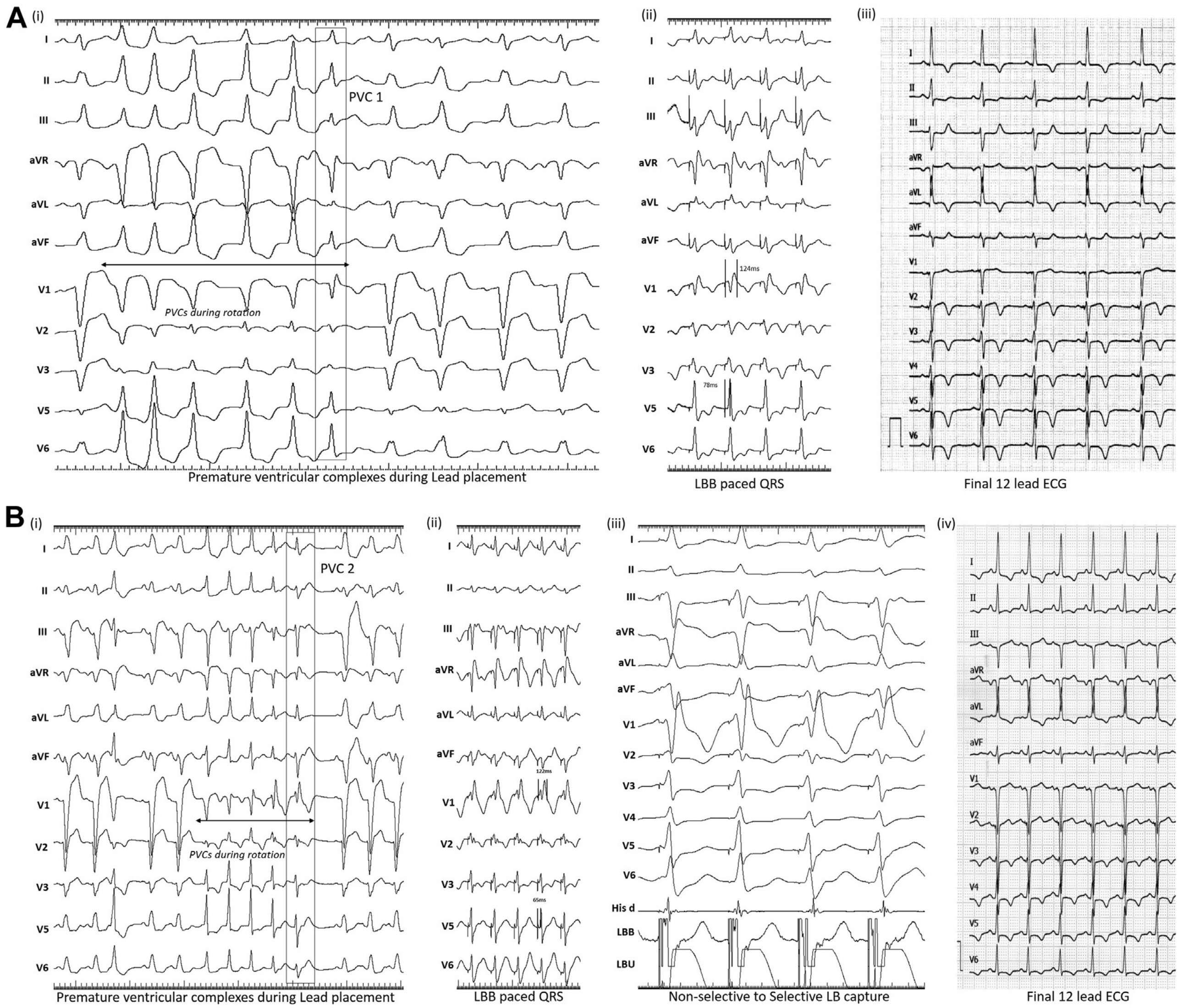

Figure 1 **A:** Left bundle branch pacing (LBBP) for nonischemic cardiomyopathy (NICM) with left bundle branch block (LBBB). (i) Premature ventricular contractions (PVCs) with changing morphology from QS to qR pattern (PVC1) in lead V_1 noted during rapid rotation. (ii) Left bundle branch (LBB) paced QRS mimicked PVC1 with duration of 124 ms and peak left ventricular activation time (pLVAT) of 78ms. (iii) Final 12-lead electrocardiography (ECG) after correcting right bundle branch delay by AV interval optimization (QRS duration 108 ms). **B:** LBBP for NICM with LBBB. (i) PVCs with changing morphology from QS to rSR pattern (PVC2) in lead V_1 noted during rapid rotation. (ii) LBB paced QRS morphology mimicked VES1 with duration of 122 ms and pLVAT of 65 ms. (iii) Nonselective (first 2 beats) to selective LBB capture (last 2 beats) at near threshold output. (iv) Final 12-lead ECG after RBB delay correction by optimizing the AV delay (QRS duration 98 ms). His d = distal His bundle electrogram; LBB = pacing lead electrogram bipolar; LBU = pacing lead electrogram unipolar.

morphology and discreet local ventricular electrogram at near threshold output (Figure 1B [iii]). Pacing threshold was 0.4 V at 0.5 ms and unipolar pacing impedance of 670 ohms. LBB paced QRS morphology mimicked PVC2 with duration of 122 ms and pLVAT in lead V_5 of 65 ms (Figure 1B [ii]). AV interval was optimized to correct the RBB delay (Figure 1B [iv]). Contrast angiography showed a lead depth of 10 mm.

Case 3

A 72-year-old man was referred for the management of permanent atrial fibrillation with uncontrolled ventricular rates and LV dysfunction. Echocardiography showed moderate mitral regurgitation with LV ejection fraction of 32% and IVS thickness of 10 mm. Atrioventricular junction (AVJ) ablation with physiological pacing option was recommended. LBBP was attempted as previously described. PVCs of changing morphology were noted while placing the lead deep inside the septum. Rotation was stopped immediately on observing PVC (PVC3) with narrow QRS duration and qR (RBB delay) in lead V_1 (Figure 2A). Nonselective to selective capture of LBB could be demonstrated at near threshold output (Figure 2D). LBB paced QRS mimicked PVC3 with duration of 124 ms and pLVAT of 65 ms (Figure 2B). The pacing threshold was 0.6 V at 0.5 ms pulse width and lead impedance of 730 ohms. LBB potential was recorded on the LBBP lead electrogram (LBB-ventricular interval of 25 ms, Figure 2C). AVJ ablation was completed

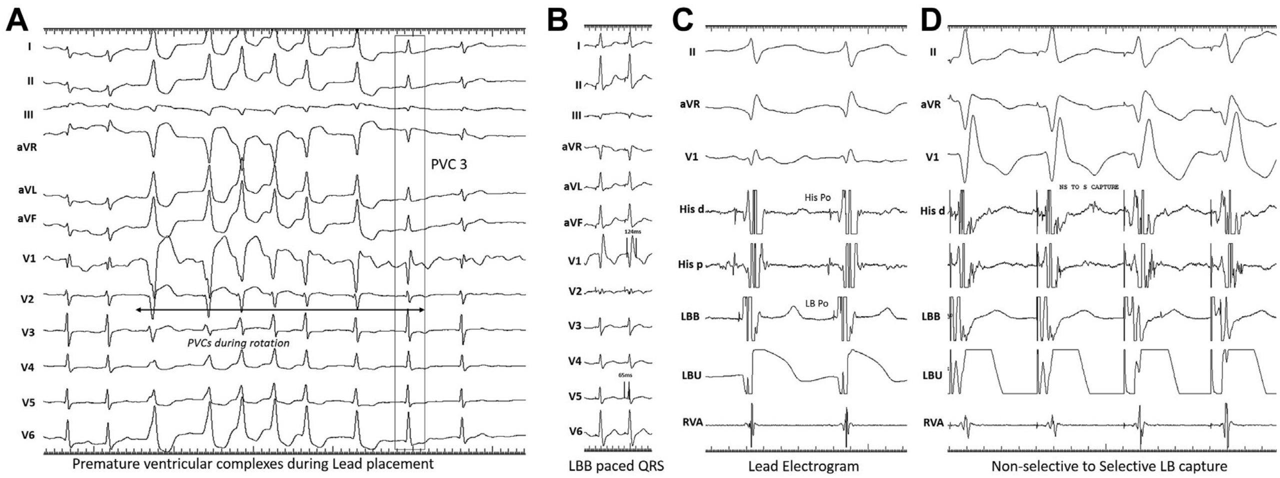

Figure 2 Left bundle branch pacing (LBBP) and atrioventricular junction ablation. **A:** Premature ventricular contractions (PVC) with changing morphology during lead rotation. **B:** Left bundle branch (LBB) paced QRS mimicked PVC3 with duration of 124 ms and peak left ventricular activation time 65 ms. **C:** Pacing lead electrogram (LBB) showing sharp LBB potentials (LB Po) preceding the local ventricular electrogram. **D:** Nonselective (first 2 beats) to selective (last 2 beats) capture of LBB. His d = distal His bundle electrogram; His p = proximal His bundle electrogram; His Po = His bundle potential; LBB = pacing lead electrogram bipolar; LBU = pacing lead electrogram unipolar; RVA = right ventricular electrogram.

using an irrigated-tip ablation catheter. Contrast angiography showed a lead depth of 9 mm.

Case 4

A 73-year-old woman with normal LV function (IVS thickness 11 mm) presented with symptomatic complete heart block. LBBP was performed using a 3830 SelectSecure lead and C315 His sheath (Medtronic). The pacing lead was positioned deep inside the septum by 4–5 rapid turns. PVCs with changing morphology were noted during lead advancement. Lead rotation was stopped immediately after observing narrow complex PVC (PVC4) with qR (RBB delay) pattern in lead V_1 (Figure 3A). Electrograms from the pacing lead demonstrated sharp left bundle potential (Figure 3C) preceding the ventricular electrogram (LB-ventricular interval of 20 ms). Pacing threshold was 0.4 V at 0.5 ms and lead impedance was 680 ohms. The paced QRS morphology mimicked the narrow PVC morphology (PVC4) with QRS duration of 114 ms with pLVAT in lead V_5 of 70 ms (Figure 3B). RBB delay was corrected by optimizing pacing output to allow anodal capture (Figure 3D). Contrast angiography showed a lead depth of 10 mm.

Discussion

LBBP is a promising alternative to HBP. Presence of RBB conduction delay pattern (qR in lead V_1) and demonstration of LBB potentials are often used as criteria for LBB capture.[2,3] LBB potentials may be demonstrable in 30%–80% of the study population at the time of implantation.[4,5] Transition in QRS morphology from nonselective to selective left bundle capture or nonselective to LV septal capture may be noted at near threshold outputs.[6] Rapid rotation of the pacing lead is necessary to achieve deep penetration of the interventricular septum. Perforation into the LV cavity can occur if

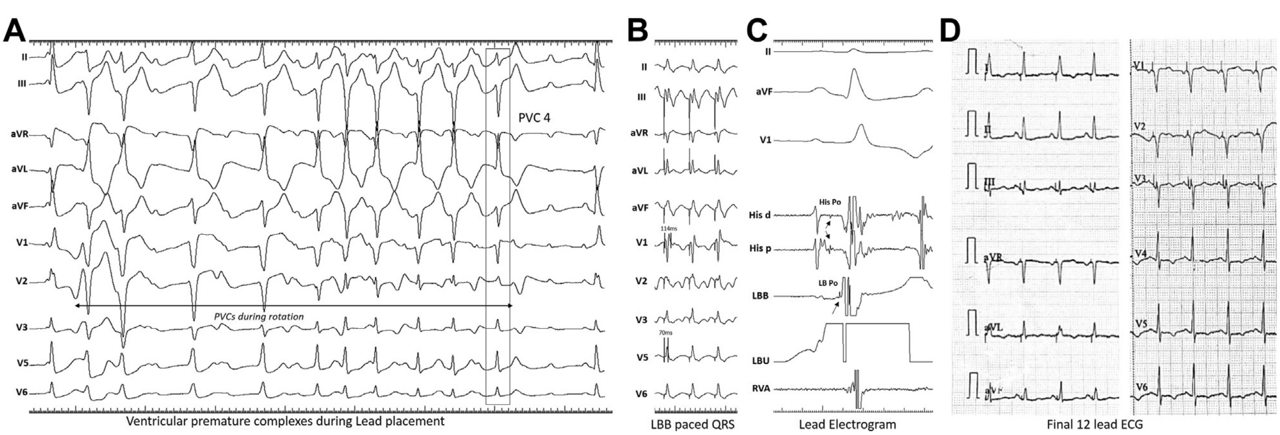

Figure 3 Left bundle branch pacing for complete heart block. **A:** Premature ventricular contractions (PVCs) during left bundle branch (LBB) lead placement. **B:** Paced QRS morphology mimicked PVC4 with duration of 114 ms and peak left ventricular activation time of 70 ms. **C:** Pacing lead electrogram showing sharp LBB potential (LB Po) preceding the local ventricular electrogram. **D:** Final 12-lead electrogram (ECG) after right bundle branch delay correction by anodal capture (QRS duration 100 ms). His d = distal His bundle electrogram; His p = proximal His bundle electrogram; His Po = His bundle potential; LBB = pacing lead electrogram bipolar; LBU = pacing lead electrogram unipolar; RVA = right ventricular electrogram.

the lead is advanced too rapidly, resulting in (1) fall in unipolar pacing impedance to <400 ohms, (2) rise in capture threshold, and (3) loss of current of injury in unipolar lead electrogram. PVCs are commonly noted while positioning the lead in the interventricular septum. The PVC morphology depends on the depth of the lead in the septum. We observed gradual change in morphology from wide QRS with QS morphology in lead V_1 to narrow QRS with RBB delay pattern (qR/rSR) as the lead penetrated the septum from the right ventricular side to the LBB area. In all 4 cases, rapid rotations were stopped as soon as PVCs with narrow QRS and RBB delay pattern were observed (PVC1, PVC2, PVC3, and PVC4). Paced QRS morphology matched the PVC morphology with short and constant pLVAT at differential pacing (high and low output). Though the pacing indications varied in these patients, PVC morphology predicted left bundle capture and guided in deciding the lead depth. LBB potentials were noted in 2 patients (complete heart block and AVJ ablation cases). It is possible to record LBB potentials in patients with LBBB during PVCs of RBB morphology if continuous recording can be performed during lead rotations. Lack of a revolving connector pin during lead rotations is a limitation with the current implant technique. Further rotations were avoided, preventing perforation of septum. Monitoring the change in PVC morphology and QRS duration during lead fixation would help in final positioning of the LBB pacing lead and confirming conduction system capture.

While deploying the lead deep inside the proximal septum, we monitored the 12-lead electrocardiogram for the appearance of PVCs. The morphology of the PVC was observed carefully, and the rotations were stopped immediately after getting RBB delay pattern in lead V_1 along with reduction in QRS duration. If the rotations were interrupted for some reason before getting the desired QRS pattern, a further few turns were given after checking the unipolar paced QRS morphology and pacing impedance to get RBB delay pattern. In our study cohort of 50 patients who had undergone successful LBBP, two-thirds of the patients ($n = 34$) showed PVCs during rapid lead deployment.[7] Excluding the patients with baseline LBBB, LBB potentials were noted in 75% of the patients who showed PVCs with changing morphology during lead deployment (21 of 28 patients). Lack of availability of the revolving connector pin prevented us from showing the potentials on the PVC with RBB delay pattern. Rapid rotations with lead deployment within 10 seconds usually resulted in runs of PVCs. The incidence of PVCs with changing morphology were infrequent if there was difficulty in rapid penetration of the septum where the lead deployment took more than 20 seconds. It is possible that Purkinje fibers are more sensitive to trauma induced by the pacing lead to trigger PVCs during implantation.

Since the initial description of LBBP, multiple studies have shown the safety and efficacy of left bundle branch pacing. Huang and colleagues[8] demonstrated 97% success rate in LBBP for nonischemic cardiomyopathy and LBBB along with significant improvement in LV ejection fraction at 1 year. A large retrospective multicenter study by Vijayaraman and colleagues[9] showed an 85% success rate in achieving cardiac resynchronization therapy by LBBP (277 out of 325 patients). Improvement in LVEF was noted in both ischemic and nonischemic cardiomyopathy and similarly in patients with LBBB and non-LBBB. Conduction system pacing combined with AV node ablation showed a high success rate in persistent atrial fibrillation patients with heart failure and implantable cardioverter-defibrillator indication.[10] This study also showed significant improvement in LV function and reduction in inappropriate shocks.

LBBP is emerging as a promising option to deliver physiological pacing. Though several criteria have been proposed to confirm capture of left bundle, prospective studies are necessary to validate. PVC-guided lead placement would help in final positioning of the lead and avoid septal perforation into the LV cavity.

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