

Late-onset interventricular septal perforation from left bundle branch pacing



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Introduction

Conduction system pacing has emerged as an alternative to right ventricular (RV) pacing (RVP) in a desire to avoid the adverse hemodynamic effect of RVP on left ventricular (LV) systolic function and associated morbidity and mortality.¹ Although His bundle pacing (HBP) has gained prominence, it is limited by a higher capture threshold compared to RVP, reducing battery longevity, and concerns over increasing capture thresholds.^{2,3} Left bundle branch pacing (LBBP) is a novel method of conduction system pacing that is now being attempted in the quest for physiological pacing with improved stability and better long-term pacing thresholds.^{4–7} However, there are no large studies or randomized controlled trials evaluating the long-term efficacy and safety of LBBP. Incidence of cardiac perforation with traditional dual-chamber pacemakers is 1.2%; however, delayed complications of cardiac perforation are extremely rare and interventricular septal (IVS) perforation with RVP have only been described in isolated case reports.^{8,9} While acute IVS perforation with LBBP have been reported in 3% of patients at implant, the late occurrence of IVS perforation has not been described.^{4,7} We report the case of a patient with LBBP complicated by a late sudden increase in threshold secondary to IVS perforation. To our knowledge this is the first description of the late occurrence of IVS perforation with LBBP after the initial implant demonstrated appropriate positioning.

KEYWORDS Interventricular septal perforation; Late occurrence; Lead explantation; Left bundle branch pacing; Pacing morphology (Heart Rhythm Case Reports 2020;6:627–631)

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KEY TEACHING POINTS

- Late occurrence of interventricular septal perforation is a rare complication of left bundle branch pacing (LBBP), despite appropriate initial implant characteristics.
- A high index of suspicion for this complication must be maintained when a sudden increase in threshold, higher unipolar capture threshold, and/or a change in LBBP pacing morphologies are noted on follow-up.
- The detailed evaluation of the paced morphology in the unipolar and bipolar configuration on the 12-lead surface electrocardiogram is essential for prompt diagnosis.
- The perforated lead explantation and reimplantation can be performed safely.

Case report

A 71-year-old man presented with symptoms of presyncope and concern for pacemaker malfunction. He had a past medical history of symptomatic Mobitz type 2 atrioventricular block requiring dual-chamber pacemaker implantation with the ventricular lead at the HBP position, a year before presentation. Device interrogation revealed RV septal capture only, with no evidence of His bundle capture and pacing threshold of 3.5 V @ 1 ms. He had a 100% ventricular pacing burden. The underlying rhythm was complete atrioventricular block with a junctional escape rhythm, right bundle branch block morphology, and QRS duration of 170 ms. LV ejection fraction was 60%. Following discussion with the patient, a decision was made for HBP lead revision, to prevent worsening LV function, with placement of a new lead to achieve LBBP for better stability and improved threshold.

The old lead (SelectSecure 3830; Medtronic Inc, Minneapolis, MN) at His position was explanted, a C315 His sheath (Medtronic) was advanced to a position 1–2 cm

distal to the HBP site toward the RV apex, and the new lead was screwed into the interventricular septum until there was evidence of left bundle branch (LBB) capture by surface electrocardiogram (ECG) and intracardiac electrogram morphology. The fixation required 8 clockwise turns and the impedance initially increased from 400 ohms to 800 ohms and then stabilized at 700 ohms upon completion of the rotations. No LBB potential was noted at this site. Injury current was noted on the local electrogram. Paced QRSd was 120 ms with qR morphology in lead V₁, R waves of 12.6 mV, and a final impedance of 570 ohms. Threshold testing in unipolar configuration revealed transition from nonselective LBBP to selective LBBP at 1.2 V @ 0.4 ms with total loss

of capture (LOC) at 0.7 V @ 0.4 ms. Testing in bipolar configuration revealed anodal capture up to 2 V @ 0.4 ms, followed by true bipolar LBB capture until LOC at 0.7 V @ 0.4 ms (Figure 1A). LV activation time was 65 ms. Contrast fluoroscopy demonstrated an appropriate lead position with the ring electrode at the RV septum. Chest radiography from the postoperative day 1 is shown in Figure 1B.

Two weeks after the implant, the patient reported symptoms of intermittent dizziness and review of remote transmission revealed a stable trend of lead parameters until a sudden increase in LBBP lead capture threshold on the day of onset of symptoms, with no change in impedance. The

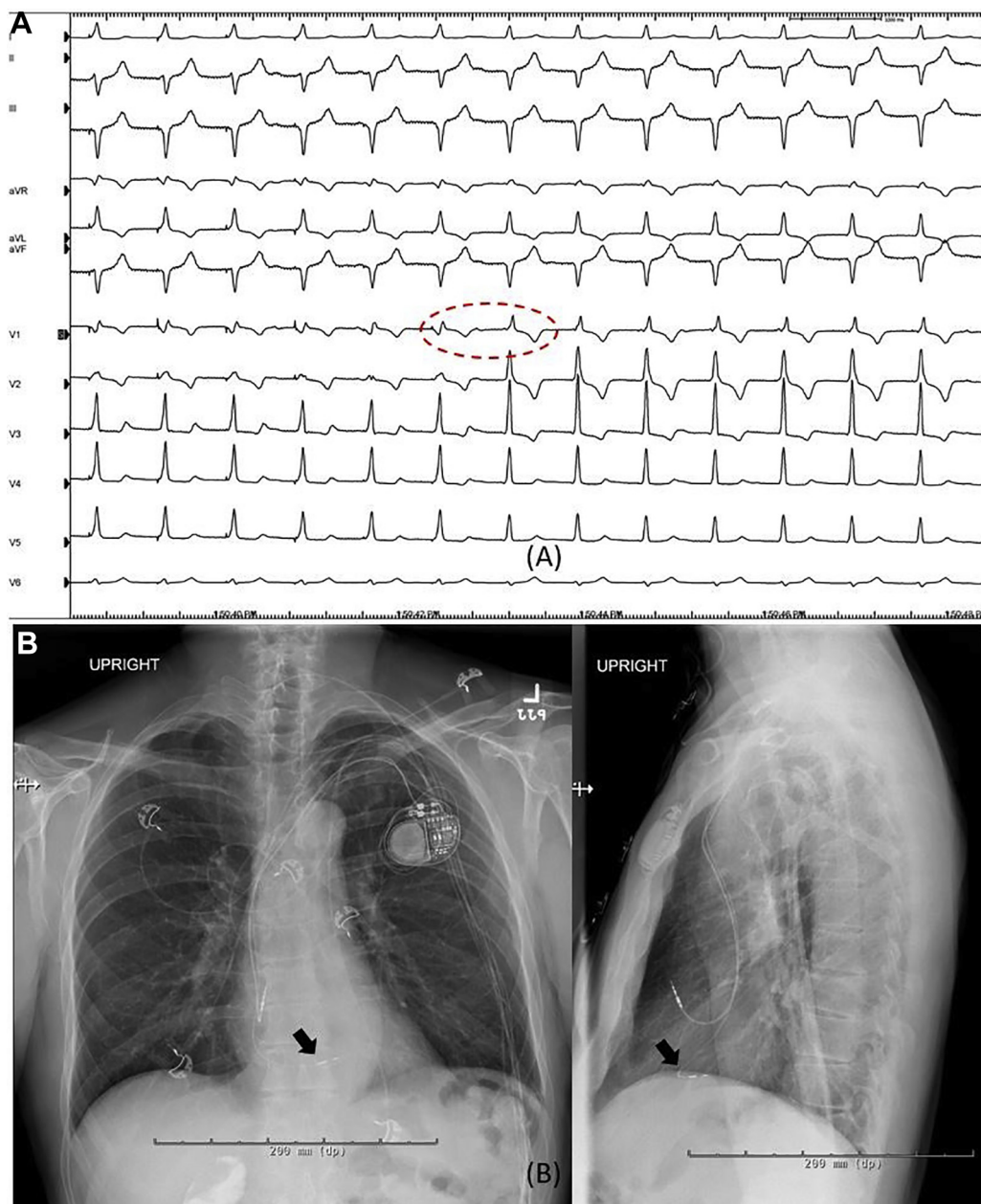


Figure 1 Surface electrocardiographic morphology at initial implant and chest radiograph on postoperative day 1. **A:** Threshold testing in bipolar configuration at initial implant showing the transition from anodal capture to nonselective left bundle branch pacing (LBBP) (red dotted oval). **B:** Chest radiographs in posteroanterior projection (left) and lateral projection (right) showing the LBBP lead (black arrows) and device position.

patient was immediately brought in for device interrogation, which revealed an impedance of 440 ohms. There was an increase in the LBBP lead threshold, with nonselective LBB capture until LOC at 3.5 V @ 0.4 ms (bipolar) and 5 V @ 1 ms (unipolar). There was no evidence of anodal capture in bipolar configuration and there was a change in unipolar paced morphology with notched broader R waves in lead V₁ (Figure 2A). The patient was considered to have micro-lead dislodgement, the LBBP lead output was programmed to 5 V @ 1 ms, and he was planned for close follow-up evaluation in 4 weeks. Repeat evaluation at 4 weeks demonstrated a further increase in the threshold of LBBP lead to 5 V @ 0.4 ms (bipolar) and 6.25 V @ 1 ms (unipolar). Impedance was stable at 456 ohms. However, with the scrutiny of the morphology of 12-lead surface ECG in the unipolar configuration and lack of anodal capture in the bipolar configuration, there was a concern for the forward migration of the lead with IVS perforation. A limited transthoracic echocardiogram (TTE) revealed IVS perforation and the presence of the LBBP lead tip in the left ventricle (Figure 2B). He was initiated on anticoagulation and planned for lead revision in a week.

The redo procedure was performed under general anesthesia with surgical backup, using intraprocedural transesophageal echocardiographic (TEE) guidance. The LBBP lead tip was making contact with the inferomedial papillary muscle (IMPM), as shown in Figure 3A. There was no evidence of significant mitral regurgitation. A new lead was then implanted with LV septal pacing using a C315 His sheath, with the final position being more anterior and slightly more apical in comparison to the previously perforated lead (Figure 3B). The appropriate position was confirmed with contrast fluoroscopy and direct TEE visualization of the tip. The old perforated LBBP lead was then explanted successfully with 3 counterclockwise turns on the lead, followed by gentle tugging under imaging guidance. TEE did not demonstrate any evidence of significant mitral

regurgitation or left-to-right intracardiac shunt on color Doppler evaluation post explant. The new LV septal pacing lead parameters were all appropriate with qR morphology in lead V₁. The neurological evaluation demonstrated intact function post explant. Chest radiography from postoperative day 1 demonstrated a stable lead and device position. The patient continued to do well with stable parameters 1 month post implant.

Discussion

We described a unique case of a patient with a dual-chamber pacemaker with LBBP lead who developed a sudden increase in threshold 2 weeks after implant, with concern for micro-lead dislodgment, but was later diagnosed with perforation of the LBBP lead across the interventricular septum. To our knowledge, this is the first reported case of late occurrence of LBBP lead perforation after the initial implant characteristics were appropriate. Current guidelines recommend the use of conduction system pacing (HBP) in patients with LV ejection fraction between 35% and 50% who are anticipated to require frequent pacing ($\geq 40\%$), to reduce the risk of pacing-induced cardiomyopathy.¹⁰ Our patient had 100% ventricular pacing burden and an unclear etiology for the rise in HBP lead threshold requiring revision. In such patients, LBBP may offer an advantage to achieve rapid LV activation.

Acute IVS perforation at implant has been reported in 3% of patients with LBBP lead implants. This is recognized by an increase in threshold >3 V and drop in impedance >200 ohms, following which the leads have been successfully repositioned.^{4,5} Although acute/intraoperative lead dislodgements have previously been described, the late occurrence of IVS perforation has not been reported in the studies with short-term follow-up safety outcomes of 3–6 months.^{4,5,6} In our experience of 60 cases with LBBP lead implantation, we have had 1 case of IVS perforation. Although contrast fluoroscopy identifies

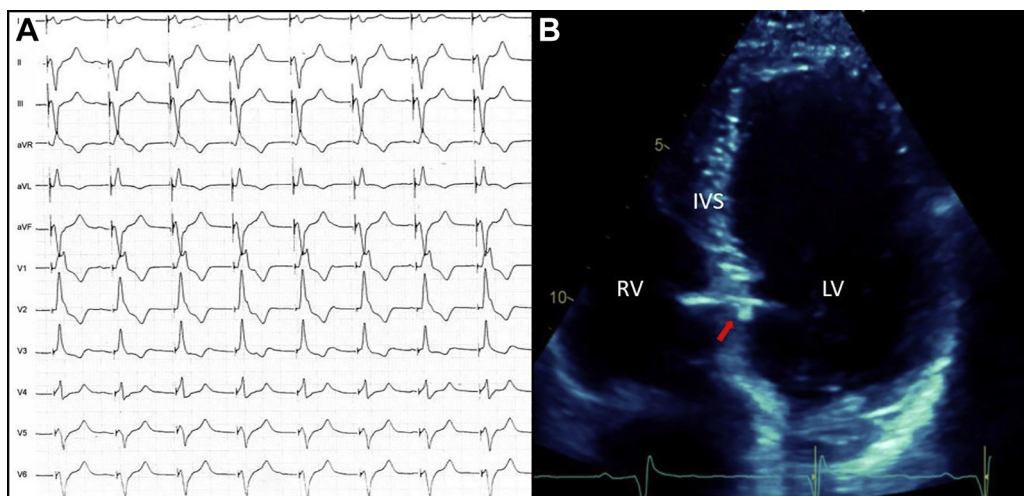


Figure 2 A: Testing in a unipolar configuration on follow-up demonstrating change in left bundle branch pacing (LBBP) paced morphology with wide notched R waves in V₁. B: Apical 4-chamber view on transthoracic echocardiogram demonstrating perforated LBBP (red arrow) traveling across the interventricular septum (IVS), from the right ventricle (RV) into the left ventricle (LV).

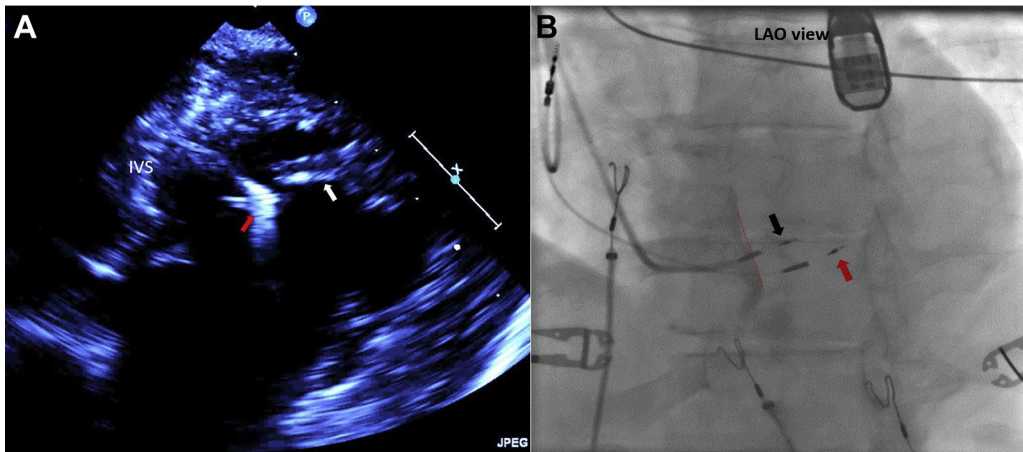


Figure 3 **A:** Intraoperative transesophageal echocardiogram, transgastric view, demonstrating perforated left bundle branch pacing (LBBP) (*red arrow*) lead making contact with the inferomedial papillary muscle (*white arrow*) in the left ventricle. IVS = interventricular septum; MV = mitral valve leaflet. **B:** Contrast fluoroscopy in the left anterior oblique (LAO) view demonstrating the new LBBP lead (*black arrow*), the old perforated lead (*red arrow*), and the contrast layering on the right ventricular aspect of the IVS (*red dotted line*).

the approximate lead distance into the IVS, the course of the lead can be oblique, which limits reliable assessment. The TTE measurement of IVS thickness may not always correlate with the septal thickness at the location of the septum where the lead is implanted. Adequate lead slack is required to avoid lead dislodgement and perforation¹¹; however, the role of excess slack on the lead at implant in increasing the risk of late IVS perforation needs to be evaluated.

In patients with traditional dual-chamber RVP, the predictors of cardiac perforation were the use of a temporary pacemaker, steroid use, helical screw ventricular leads, body mass index <20, and older age.¹² In patients with LBBP leads, close attention should be paid to the paced morphology. During implant there is a transition from a w pattern to a qR pattern in lead V₁ as the lead is screwed into the interventricular septum up to the LV sub-endocardium, with evidence of LBB capture.⁶ Testing of lead post implant in bipolar configuration at high outputs may reveal anodal capture with left bundle branch block morphology, which then transitions to true LBBP capture with a qR morphology until total LOC. Anodal capture at high voltage during testing in bipolar configuration can be seen in about 69% of LBBP lead implants⁴ and occurs owing to the capture of the RV septum, as the ring electrode is abutting the RV septum.¹³

Our patient demonstrated anodal capture at high output during implant (*Figure 1A*), suggesting that the ring electrode was making contact with the interventricular septum. On follow-up evaluation, there was no anodal capture noted (at 8 V @ 0.4 ms) and although bipolar evaluation revealed a morphology similar to implant, the unipolar morphology was suggestive of LV IMPM capture (*Figure 2A*). This would explain the significant discordance in the unipolar and bipolar thresholds, which were capturing the LV IMPM and LV septum/LBB, respectively. We recommend

that patients with LBBP lead implants undergo threshold testing in both unipolar and bipolar configuration with a 12-lead ECG during the initial few follow-up sessions to ensure the stability of lead parameters and paced morphology. A sudden increase in threshold with a marked discrepancy in unipolar and bipolar thresholds should trigger prompt evaluation with TTE. In our patient, changes in remote monitoring did not provide a warning before the onset of symptoms. However, in patients who are not dependent on the LBBP lead, changes in remotely monitored parameters of capture threshold may help with early detection.

The presence of the LBBP pacing lead tip in the left ventricle raises the concern for systemic thromboembolism. Short-term anticoagulation as seen with our patient may reduce the risk of thromboembolic complications; however, delaying the lead explant procedure for anticoagulation may not offer any additional benefit. Also, the delay may lead to the development of fibrosis around the lead tip, increasing the complexity of explantation, especially if the lead tip is located at the chordal structures / papillary muscle, as seen in our patient. We demonstrated the safety of a lead explantation at 3 months post implant along with reimplantation of new lead under intraoperative TEE guidance. TEE guidance during lead revision was primarily used to ensure the absence of fibrinous strands on the tip of the perforated lead and monitor for damage to the mitral valve. We do not recommend routine TEE guidance for the implantation of new LBBP leads.

Conclusion

Late occurrence of IVS perforation despite appropriate initial implant characteristics is an uncommon but potential complication of LBBP. A high index of suspicion for this complication must be maintained when a sudden increase in threshold, higher unipolar capture threshold, and/or a change in LBBP pacing morphologies are noted on

follow-up. The detailed evaluation of the paced morphology on 12-lead surface ECG is essential for prompt diagnosis. Imaging with TTE/TEE can help establish the diagnosis. Prompt lead explantation and reimplantation can be performed safely.

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