# First report of super-response after left bundle branch area pacing for cardiac resynchronization therapy utilizing a stylet-driven lead

Aalap Narichania, MD, Roderick Tung, MD, FACC, FHRS, Gaurav A. Upadhyay, MD, FACC, FHRS

*From the Center for Arrhythmia Care, Division of Cardiology, University of Chicago Medicine, University of Chicago Pritzker School of Medicine, Chicago, Illinois.*

## Introduction

The deleterious effects of electrical dyssynchrony on myocardial health and function have been firmly established, whether the dyssynchrony is caused by left bundle branch block (LBBB)[1] or by right ventricular pacing.[2] In patients with heart failure with reduced ejection fraction correction of electrical dyssynchrony with biventricular pacing to achieve cardiac resynchronization therapy (CRT) with the implantation of a left ventricular (LV) lead via the coronary sinus (CS) system is a class I guideline-directed therapy.[3] However, in some patients, patient-specific anatomy and technical factors preclude successful implantation of a CS lead. Furthermore, despite successful implantation of a biventricular pacing system, nonresponse to CRT approaches 30% in modern clinical trials despite attempts at optimization.[4,5]

His bundle pacing has been described as a means to preserve or restore physiologic activation with conduction system pacing (CSP), and as alternative means to deliver CRT in heart failure.[5] Recently, pacing at the proximal left conduction system via left bundle branch pacing or left bundle branch area pacing (LBBAP) have been advocated as alternative strategies to achieve CSP in CRT patients with lower and more stable thresholds.[6,7] Prior case series of CSP for CRT, however, have exclusively reported on the use of a fixed-helix, lumen-less lead (Medtronic 3830; Medtronic Inc, Minneapolis, MN) supported by the delivery catheter (C315His; Medtronic Inc). Multiple vendors have now introduced sheath systems using standard stylet-driven leads, designed for CSP. To our knowledge, we report the first case of super-response or normalization of left ventricular ejection fraction (LVEF) with LBBAP, using a new delivery sheath system and a standard stylet-driven lead.

### KEY TEACHING POINTS

- Left bundle branch area pacing (LBBAP) has been recently described as a form of physiological or conduction system pacing (CSP) with lower and more stable thresholds as compared to His bundle pacing (HBP). Both LBBAP and HBP have been described as alternatives to biventricular pacing in the approach to cardiac resynchronization therapy (CRT) in heart failure with a wide QRS duration.
- Previous experience of LBBAP in CRT (LBBAP-CRT) has been generally described with the Medtronic system (Medtronic, Minneapolis, MN), composed of a 3830 lead with fixed helix lumen-less design and a fixed-curve sheath (C315 SelectSite). Multiple vendors have introduced specialized delivery sheaths that allow for CSP using standard stylet-driven leads, which are now being utilized for LBBAP.
- We report the first case of a super-response and complete normalization of left ventricular ejection fraction using the Boston Scientific Ingevity+ 7842 standard lead with a novel Boston Scientific Site Selective Pacing Catheter sheath (Boston Scientific, Marlborough, MA). Our preliminary observation of successful LBBAP-CRT using a standard stylet-driven lead requires further study and reproduction.

## Case report

A 71-year-old man with chronic systolic heart failure secondary to ischemic heart disease with LVEF of 20%

**KEYWORDS** Physiological pacing; Conduction system pacing; Left bundle branch area pacing; Cardiac resynchronization therapy; Heart failure

(Heart Rhythm Case Reports 2022;8:238–242)

Funding Support: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Disclosures: RT reports speaking or consulting for Abbott, Biotronik, and Boston Scientific. GAU reports speaking or consulting for Abbott, Biotronik, and Medtronic. AN reports no conflicts of interests. **Address reprint requests and correspondence:** Dr Gaurav A. Upadhyay, Associate Professor of Medicine, Center for Arrhythmia Care, The University of Chicago Medicine, 5841 S. Maryland Ave, MC 9024, Chicago, IL 60637. E-mail address: upadhyay@uchicago.edu.



https://doi.org/10.1016/j.hrcr.2021.12.018

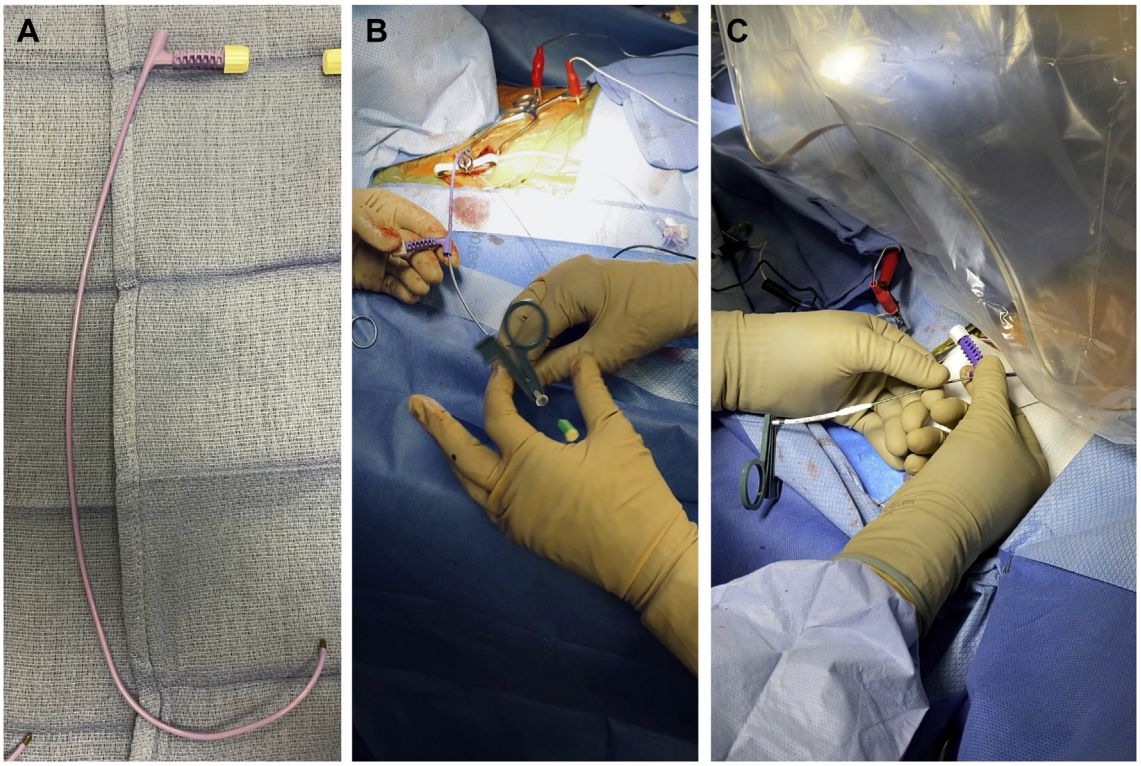


**Figure 1** **A:** The Boston Scientific Site Selective Pacing Catheter 3, "extended hook" fixed curve sheath (Boston Scientific, Marlborough, MA). The sheath can be reshaped as necessary. **B:** The stylet-driven lead has followed the sheath to the interventricular septum and the helix is deployed with the stylet at the lead tip. **C:** The entire lead is turned clockwise with slight forward pressure and the stylet in place at the lead tip for support. The lead is advanced until a suitable position is found, as described in the text.

(Supplemental Movie 1) and NYHA class III symptoms was referred for CRT. He had LBBB for greater than 4 years; he developed declining LVEF 5 months before referral and had been started on appropriate goal-directed medical therapy on carvedilol and losartan and had achieved target dosages for greater than 3 months. Nonetheless, he had persistent severe LV dysfunction and we proceeded with device implantation. The CS demonstrated a markedly posterior take-off and was unable to be cannulated stably despite multiple attempts (Supplemental Figure 1A and 1B). Conduction system pacing with targeting of the left bundle branch area was pursued as a bail-out strategy. A stylet-driven pacing lead with an extendable helix (Ingevity+, Model 7842; Boston Scientific, Marlborough, MA) was delivered through a fixed-curve sheath (Site Selective Pacing Catheter 3; Boston Scientific) (Figure 1A). The lead helix was deployed at the right ventricular (RV) septum (Figure 1B) and then tunneled to the left conduction system by rotating the lead 6–7 times (Figure 1C). Left septal position was demonstrated by contrast injection through the sheath (Figure 2A). The capture threshold was excellent at 0.4 V @ 0.4 ms. Postimplant chest radiograph is shown (Figure 2B and 2C). At baseline, the patient demonstrated LBBB pattern with QRS duration of 182 ms (Figure 3A). Paced QRS duration narrowed with LBBAP (measured from stimulation-artifact to QRS-end [QRSst] = 156 ms; measured from intrinsicoid deflection in $V_2$ to QRS-end [QRSid] = 122 ms). The patient demonstrated a left axis deviation suggestive of nonselective left posterior fascicular capture. Left ventricular activation time (LVAT), defined[8] as the time from stimulus to the peak of the R wave in the lateral precordial leads ($V_4$–$V_6$), was 84 ms when measured to $V_6$ (Figure 3B).

On postoperative day 1, the patient underwent an echocardiogram, which demonstrated acute improvement of LVEF from 20% to 41% (Supplemental Movie 2). Quantitative markers of synchrony using strain imaging also improved with time to peak strain from basal septum to basal lateral wall, shortening from 402 ms to 36 ms. The mechanical index (standard deviation of time to peak strain for 12 basal to mid segments) decreased from 150 ms to 60 ms. Four months later, the patient's LVEF had completely normalized to 62% (Supplemental Movie 3). Lead parameters remained stable, with pacing threshold of 0.6 V @ 0.4 ms. He reported marked improvement in clinical symptoms from NYHA III to NYHA I–II.

## Discussion

To our knowledge, this is the first report of super-response after LBBAP for CRT using a stylet-driven lead. Zanon and colleagues[9] recently reported their initial experience on LBBAP using a stylet-driven lead through a new delivery sheath (Biotronik Selectra 3D; Biotronik SE & Co KG, Berlin, Germany). Both patients in the case series had a normal

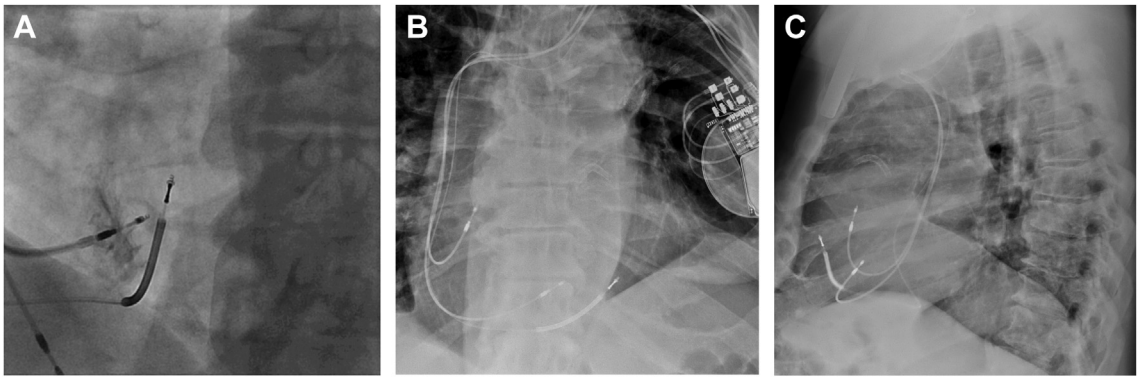


**Figure 2** **A:** Contrast injection through sheath (ie, right ventricular "septography") in left anterior oblique projection demonstrating lead embedded within septum with tip reaching left ventricle surface. Tip-to-ring distance is 12.5 mm to the proximal edge of ring. **B:** Posteroanterior chest radiograph. The right ventricular (RV) lead was implanted in the low septal RV outflow tract owing to a stable position with suitable parameters being found at this location. **C:** Lateral chest radiograph.

QRS duration and LBBAP was performed to preserve physiologic activation vs to deliver CRT, as in our case. In a 50-patient comparison[10] of lumen-less lead vs stylet-driven lead system (Biotronik Selectra 3D) for LBBAP, only 3 patients underwent LBBAP in the setting of heart failure with reduced ejection fraction and LBBB. There was a trend toward improved LVEF in this group from 37% to 45% over 1 month of follow-up; whether any particular patients had an acute

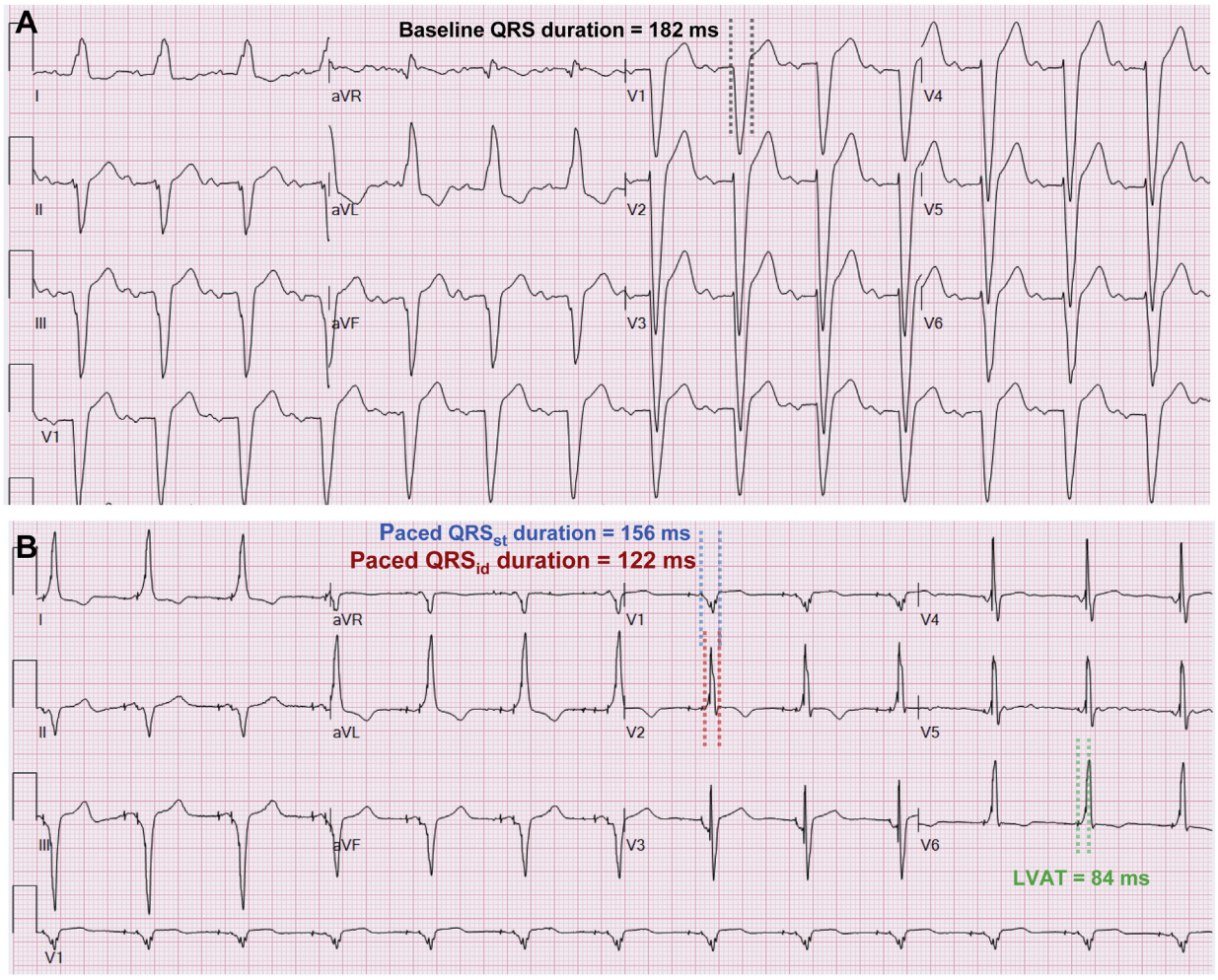


**Figure 3** **A:** Baseline electrocardiogram (ECG) with left bundle branch block and QRS duration 182 ms. **B:** Postoperative ECG demonstrating left bundle branch area pacing for cardiac resynchronization therapy. Paced QRS duration shortened to 156 ms when measured from the stimulation artifact to QRS-end ($QRS_{st}$) and 122 ms when measured from onset of the intrinsicoid deflecton in $V_2$ to QRS-end ($QRS_{id}$). Left ventricular activation time (LVAT) was 84 ms.

super-response and complete normalization of LVEF was not reported. Our case is distinct in reporting a super-response and using the Boston Scientific Ingevity+ lead. With the availability of sheath systems from multiple vendors (eg, Boston Scientific Site Selective Pacing, Biotronik Selectra 3D, and Abbott Agilis HisPro), opportunity for LBBAP with stylet-driven leads will undoubtedly rise.

Briefly, the procedure is performed as follows using the Boston Scientific system and is similar across vendors with minor variations. A Wholey wire is used to introduce the long fixed-curve sheath (Figure 1A) into the right ventricle. The wire is exchanged for a stylet-driven lead and the RV septum can be mapped in a unipolar fashion. A site for initial tunneling is chosen based on fluoroscopic location, distance from His potential if one has been found, and paced morphology. This step is similar to finding an appropriate site when using the traditional lumen-less lead system, as has been described previously.[6] The sheath can be reshaped as necessary. Once an appropriate location has been chosen, with slight forward pressure on the sheath, the lead helix is deployed using the pinch-on tool (Figure 1B). The tool is kept attached to the lead so that the helix does not retract during tunneling and the stylet should be at the tip of the lead. The entire lead is then rotated clockwise to advance the lead through the septum toward the LV endocardial surface. Pacing and sensing can be performed during lead advancement by attaching electrodes to the stylet. Once a satisfactory position is found, the stylet is withdrawn (so as not to advance the lead further during split), and the sheath is then split with careful attention toward sufficient slack (Figure 1C). Lead advancement is monitored under fluoroscopy. Endpoints for successful LBBAP have been described elsewhere[8] and are similar whether using a stylet-driven lead or a traditional lumen-less lead. These include R′ on paced $V_1$ QRS morphology, presence of a left bundle potential (if intact), drop in pacing impedance suggestive of approach toward the LV endocardium, presence of fixation beats or premature ventricular contractions with a morphology suggestive of left bundle branch ectopy, and lack of change between very high (10 V) and programmed pacing output (suggestive that changes in the size of the virtual electrode do not lead to intermittent capture of the conduction system at a distance from the lead tip). Importantly, however, output-dependent changes during threshold testing may show loss of anodal capture of the septum by the ring, and are more apparent in patients with narrow QRS or right bundle branch block, in which it may be used to facilitate QRS narrowing.

In our case, the final site of pacing was likely a left septal position with some secondary recruitment of the left-sided conduction system or nonselective left bundle branch pacing. Given the prominent left axis deviation and the fluoroscopic position, the posterior fascicle is likely the site of conduction system capture and the final QRS axis may also reflect the underlying cardiomyopathy. Though our paced QRS morphology in lead $V_1$ does not have an R′ (Figure 3B), the significantly shortened or partially corrected QRS duration and the relatively short LVAT suggest recruitment of the conduction system. An LVAT less than 85 ms[11] in the setting of LBBB as well as relative shortening of LVAT by 10 ms have recently been correlated with left conduction system capture with validation by left septal recordings. Both of these criteria were met in this case. Underlying intramyocardial delay (intraventricular conduction delay) may also preclude a short LVAT and/or R′ in $V_1$ despite conduction system capture. In addition, anodal capture of the RV septum can abrogate the R′ but may not change the LVAT. It is important to note that despite an "imperfect" final paced QRS morphology, this patient with profound cardiomyopathy and underlying LBBB nonetheless had acute evidence of echocardiographic resynchronization and sustained echocardiographic and clinical improvement. This finding may speak to a wider tolerance for lead position when adopting an LBBAP strategy.

This report of a patient having normalization of LVEF after LBBAP using a stylet-driven lead invites the question of when to use the traditional lumen-less 3830 lead and when to opt for one of the newer systems that use a stylet-driven lead. The 3830 lead is narrower, with a 4.1F diameter, while the Boston Scientific Ingevity lead is wider, with a 6F diameter. In addition, the isodiametric shape between the lead helix and the lead body of the 3830 is thought to facilitate advancement of the lead into the septum (owing to a larger bore being made by the helix). On the other hand, stylet-driven leads have a smaller helix relative to the lead body. With that noted, multiple operators have noted the stylet provides additional and stiffer support to allow for penetration into the septum[10] and avoid the risk of RV septal entanglement, as has been noted in prior cadaveric study of the 3830.[12] An additional advantage of the stylet-driven leads is the opportunity to assess real-time changes in QRS morphology and impedance during lead advancement (by attaching sensing cables to the exposed stylet in a unipolar fashion).

Theoretically, the wider diameter of the stylet-driven lead may be associated with greater damage to the septum if there are multiple redeployments. The larger tunnel could also theoretically dispose toward higher risk of lead dislodgement. Relevant to longer-term follow-up, the presence of a lumen may facilitate future extraction if needed. More experience and direct comparisons, as well as future investigations on long-term thresholds, safety, and clinical outcomes, are needed.

## Appendix

### Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2021.12.018.

## References

1. Vaillant C, Martins RP, Donal E, et al. Resolution of left bundle branch block-induced cardiomyopathy by cardiac resynchronization therapy. J Am Coll Cardiol 2013;61:1089–1095.

2. Sharma AD, Rizo-Patron C, Hallstrom AP, et al. Percent right ventricular pacing predicts outcomes in the DAVID trial. Heart Rhythm 2005;2:830–834.
3. Epstein AE, DiMarco JP, Ellenbogen KA, et al. 2012 ACCF/AHA/HRS focused update incorporated into the ACCF/AHA/HRS 2008 guidelines for device-based therapy of cardiac rhythm abnormalities: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol 2013;61:e6–e75.
4. Naqvi SY, Jawaid A, Goldenberg I, Kutyifa V. Non-response to cardiac resynchronization therapy. Curr Heart Fail Rep 2018;15:315–321.
5. Upadhyay GA, Vijayaraman P, Nayak HM, et al. His corrective pacing or biventricular pacing for cardiac resynchronization in heart failure. J Am Coll Cardiol 2019;74:157–159.
6. Huang W, Su L, Wu S, et al. A novel pacing strategy with low and stable output: pacing the left bundle branch immediately beyond the conduction block. Can J Cardiol 2017;33:1736.e1–1736.e3.
7. Vijayaraman P, Ponnusamy S, Cano Ó, et al. Left bundle branch area pacing for cardiac resynchronization therapy: results from the International LBBAP Collaborative Study Group. JACC Clin Electrophysiol 2021;7:135–147.
8. Chen X, Wu S, Su L, Su Y, Huang W. The characteristics of the electrocardiogram and the intracardiac electrogram in left bundle branch pacing. J Cardiovasc Electrophysiol 2019;30:1096–1101.
9. Zanon F, Marcantoni L, Pastore G, Baracca E. Left bundle branch pacing by standard stylet-driven lead: preliminary experience of two case reports. HeartRhythm Case Rep 2020;6:614–617.
10. De Pooter J, Calle S, Timmermans F, Van Heuverswyn F. Left bundle branch area pacing using stylet-driven pacing leads with a new delivery sheath: a comparison with lumen-less leads. J Cardiovasc Electrophysiol 2021;32:439–448.
11. 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.
12. Jastrzębski M, Moskal P, Hołda MK, et al. Deep septal deployment of a thin, lumenless pacing lead: a translational cadaver simulation study. Europace 2020;22:156–161.