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CASE REPORT

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A successful case of left bundle branch area pacing using stylet-driven pacing leads with a steerable delivery sheath in patients with structural heart disease

Hyung Ki Jeong[1] and Sung Soo Kim[2,3*]

Abstract

Background Left bundle branch area pacing (LBBAP) has emerged as a novel form of physiological pacing. However, few physicians have used stylet-driven pacing leads with a steerable delivery sheath for left fascicular bundle pacing.

Case presentation A 75-year-old man with a history of heart valve surgery and atrial fibrillation arrived at the emergency department complaining of exertional dyspnea and general weakness. Twelve-lead electrocardiography showed atrial fibrillation with regular RR intervals with escape beats of 41 beats per minutes, which suggested complete atrioventricular block. Two-dimensional echocardiography showed global hypokinesia and a huge atrium. Given the impaired left ventricular (LV) function and the deleterious effects of right ventricular apical pacing, conduction system pacing was attempted. Mapping of His bundle and left bundle potential using a steerable delivery sheath was attempted; however, it did not appear prominent. Several attempts to deploy the lead failed because the sheath was malpositioned such that the lead could not move perpendicularly. Reshaping the sheath allowed for an extended reach so that the pacing lead could be positioned inferior to the previously attempted site toward the apex, deep inside the septum, where the distal left septal fascicle was captured rather than the left bundle branch trunk. During the 6-month follow-up period, the patient was free of any symptoms. Capture threshold and sensing value were stable and follow-up echocardiography showed slightly improved LV function.

Conclusions Left fascicular bundle pacing may be an alternative strategy when conventional pacing using stylet-driven pacing leads with a steerable delivery sheath fails to capture the left branch bundle in patients with challenging anatomy.

Keyword Artificial pacemaker, Bundle of his, Atrioventricular block

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Background

Left bundle branch pacing (LBBP) has attracted steady interest in recent years as a novel form of physiological pacing [1]. LBBP provides a low and constant pacing threshold with lead stability, while postoperative success rates range from 82 to 92% [2, 3]. In some cases, LBBP could not be achieved because the lead could not penetrate deep into the septum and there was inadequate sheath support and improper sheath–septal orientation. Alternatively, the left fascicular bundle could be targeted by placing the lead mid-septum [4]. However, there are only a limited number of cases in which left bundle branch area pacing (LBBAP) has been performed using stylet-driven pacing leads delivered with a steerable sheath for left fascicular bundle pacing [5]. Herein, we present a case of LBBAP using stylet-driven pacing leads with a steerable delivery sheath in a 75-year-old man with atrial fibrillation with regular escape beats and impaired left ventricular (LV) function.

Case presentation

A 75-year-old man arrived at the emergency department complaining of exertional dyspnea and general weakness. He had a history of heart valve surgery—tissue mitral valve replacement (Carpentier-Edwards Perimount Magna 29 mm), tricuspid annuloplasty (MC 3 ring 29 mm), and modified Cox maze procedure)—and atrial fibrillation, prescribed with anticoagulation (rivaroxaban, 20 mg), diuretics (furosemide, 40 mg, spironolactone, 25 mg), and an angiotensin receptor blocker (valsartan, 40 mg). Twelve-lead electrocardiography showed atrial fibrillation with alternating left anterior and left posterior hemiblock with regular escape beats of 41 beats per minute, which suggested complete atrioventricular block (Fig. 1 A, B). Two-dimensional echocardiography showed global hypokinesia (ejection fraction, EF, 38%) and a huge atrium (LA volume index, 230.2 mL/m^2). Given the impaired LV function and the deleterious effects of right ventricular apical pacing, conduction system pacing was attempted.

A 12-lead ECG and intracardiac electrogram were continuously recorded using an electrophysiology system (Prucka CardioLab, GE Healthcare, Waukesha, WI). A Tendril STS Model 2088TC lead (St. Jude Medical, St. Paul, MN, USA) was placed through the electrode-incorporated steerable catheter (Abbott Agilis HisPro™) with monitoring of paced QRS morphology and unipolar impedance. First, mapping of His bundle potential was attempted under fluoroscopic RAO 30; however, it did not appear prominent. Using the tricuspid annulus ring as a marker, the tip of the sheath was moved 1.5 cm toward the right ventricular (RV) apex and rotated counterclockwise to come into contact with the interventricular septum perpendicularly. Several attempts to deploy the lead failed because of a malpositioned sheath, such that the lead could not move perpendicularly (Fig. 2A). By slightly bending the primary curve of the sheath (as shown in Fig. 2B), the pacing lead could be positioned deeper inside the septum, toward the apex, than during the previous attempt, thus allowing for an extended reach (Fig. 2C). At this point, sheath pacing showed a W pattern with a notch at the nadir of the QRS in the V1 lead. Clockwise rotation of the lead could be applied three to four turns at a time. During the procedure, the lead depth inside the septum was measured via sheath angiography. As the pacing lead drew closer to the LV endocardial site, the notch was displaced to the end of the QRS and finally showed a typical 'r' pattern in lead V1, a peak left ventricular activation time (LVAT) of 59 ms in lead V6, a V6–V1 interval of 58 ms, and a QRS duration of 128 ms (Fig. 3). The paced LVAT duration measured in lead V6 was short and constant (< 75 ms) at differential pacing output, and a discrete local ventricular electrogram was seen on the pacing lead at low pacing output. The pacing parameters remained stable with a pacing threshold of 0.5 V at a 0.4-ms pulse width and a sensed R wave of 12.0 mV. Finally, a 12-lead ECG showed qR in lead V1, rS in inferior leads, qR in lead I, and aVL, and a deep S wave in lead V6 (Fig. 1C). A chest X-ray showed that the ventricular lead was positioned inferiorly toward the apex, where capture of the distal left septal fascicle rather than the left bundle branch trunk was achieved (Fig. 4). During a 6-month follow-up period, the patient was free of any symptoms. Capture threshold and sensing values were stable (pacing threshold of 0.5 V at a 0.4-ms pulse width and a sensed R wave of > 12.0 mV.). Follow-up echocardiography showed slightly improved LV function (EF, 43%).

Discussion and conclusions

Since the inception of pacing therapy in 1958, the right ventricle remains the established site for pacemaker insertion [6]. Although right ventricular pacing (RVP) can cause both ventricles to contract relatively effectively, it could induce ventricular dyssynchrony and detrimental hemodynamic effects. In turn, this might lead to progressive adverse remodeling at cellular and heart chamber levels, resulting in the deterioration of ventricular function [7]. Chronic RVP can cause or worsen heart failure and increase cardiac mortality [6, 8–10]. The adverse clinical outcomes of prolonged RVP in some patients are increasingly recognized, and might ultimately result in fatal pacing-induced cardiomyopathy, as was shown to occur in 10.1% of patients during 3 years of follow-up [11]. Previous studies reported that a lower EF is a statistically significant factor for the development of pacing-induced cardiomyopathy [9, 10]. Thus, biventricular pacing (BVP) is recommended in patients with a reduced EF and a high degree of atrioventricular blockage requiring ventricular pacing [12, 13]. Several studies demonstrated that BVP was superior to RVP among patients with moderate to severe systolic dysfunction who required ventricular pacing to improve their quality of life, New York Heart Association class, and echocardiographic response [12]. However, although limited data on BVP in AF patients suggest a benefit, it may be less than that in patients with sinus rhythm.

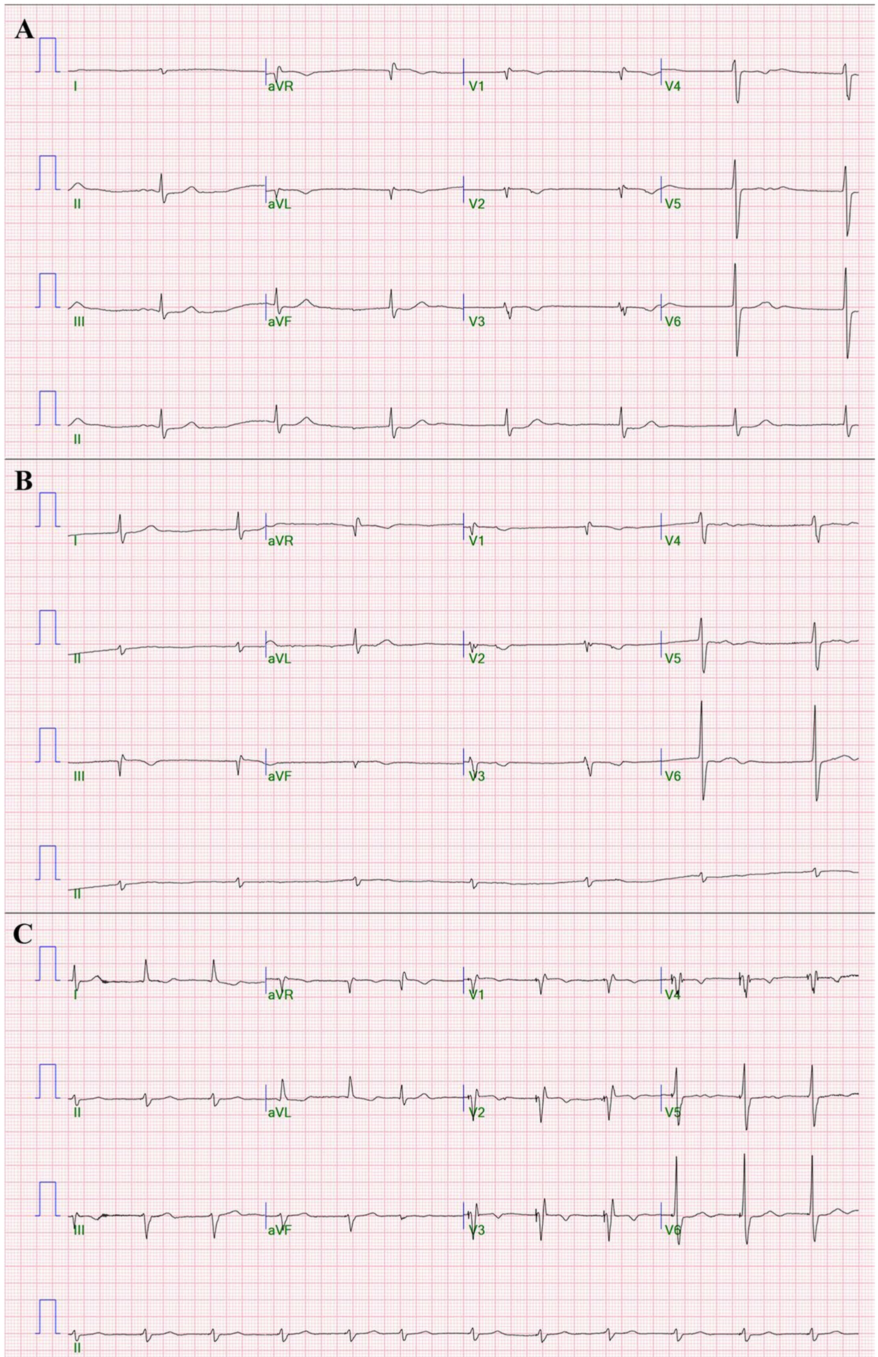

Fig. 1 **A**. Twelve-lead ECG shows atrial fibrillation, left posterior block and regular RR interval with escape of 41 beats per minutes (bpm). **B**. Twelve-lead ECG shows atrial fibrillation, left anterior block, and regular RR interval with escape of 40 bpm. **C**. Twelve-lead ECG showed qR in lead V1, rS in inferior leads, qR in lead I and aVL, a deep S wave in lead V6, and intermediate QRS axis (lead II predominantly positive, and lead III with negative component), suggestive of left septal fascicular conduction

Recently, conduction system pacing, including His bundle pacing and LBBAP, was introduced. However, His bundle pacing has limitations, including a relatively low success rate, a delayed rise in capture thresholds leading to a higher revision rate, undersensing of ventricular signals, and oversensing of atrial or His signals. Therefore, LBBAP has attracted steady interest over recent years as a novel approach to physiological pacing. It provides a low

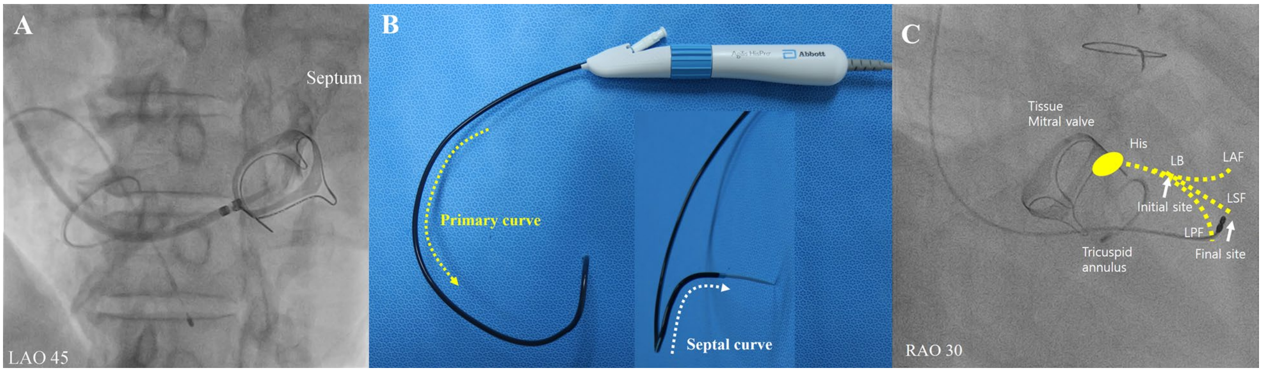

Fig. 2 **A**. Angiography shows the tip of the sheath did not reach to the septum. Left anterior oblique 45 fluoroscopic view. **B**. Electrode-incorporated steerable catheter (Abbott Agilis HisPro™). Reshaping the catheter proximal (primary curve) allowed for an extended reach so that the pacing lead could be positioned inferior to the previously attempted site toward the apex. The further addition of a septal curve would allow us to maintain a catheter orientation perpendicular to the septum. **C**. Fluoroscopic image of the tricuspid annulus and actual placement of the ventricular lead to capture the left fascicular bundle. First, proximal left bundle branch capture was attempted at the initial site. Then, the left septal fascicle was captured at the final site. Right anterior oblique 30 fluoroscopic view

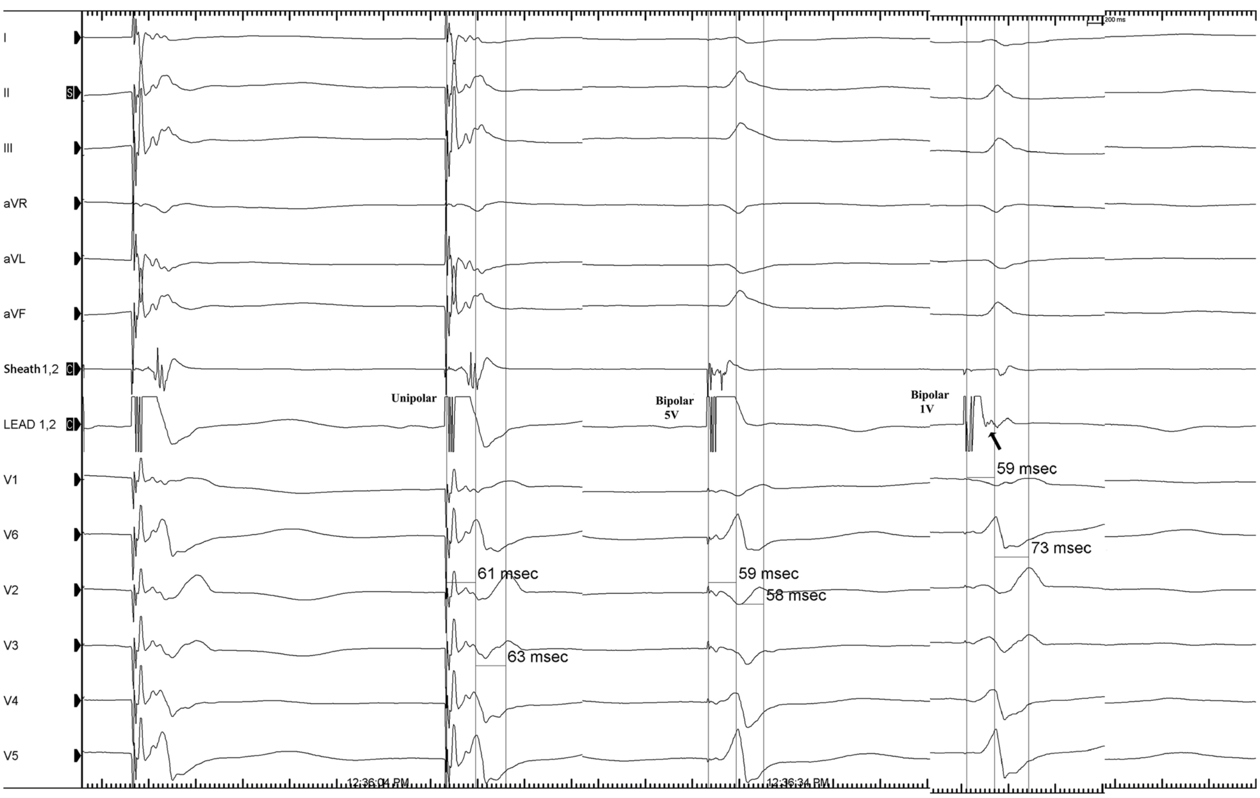

Fig. 3 Typical 'r' pattern in lead V1, a peak left ventricular activation time (LVAT) of 59 ms in lead V5, V6–V1 interval of 58 ms, and a QRS duration of 128 ms. The paced LVAT duration measured in lead V6 was short and constant at differential pacing output (5 V → 1 V) and a discrete local ventricular electrogram (arrow) is seen for the pacing lead at low pacing output

and constant pacing threshold with lead stability, while postoperative success rate ranges from 92.4% to 82.2% [2, 3]. The reasons for failure include inability of the lead to penetrate deep into the septum, inadequate sheath support, and improper sheath–septal orientation. Current experience with LBBAP has been exclusively with the lumenless pacing lead (Medtronic 3830), which has shown excellent lead performance and clinical outcomes.

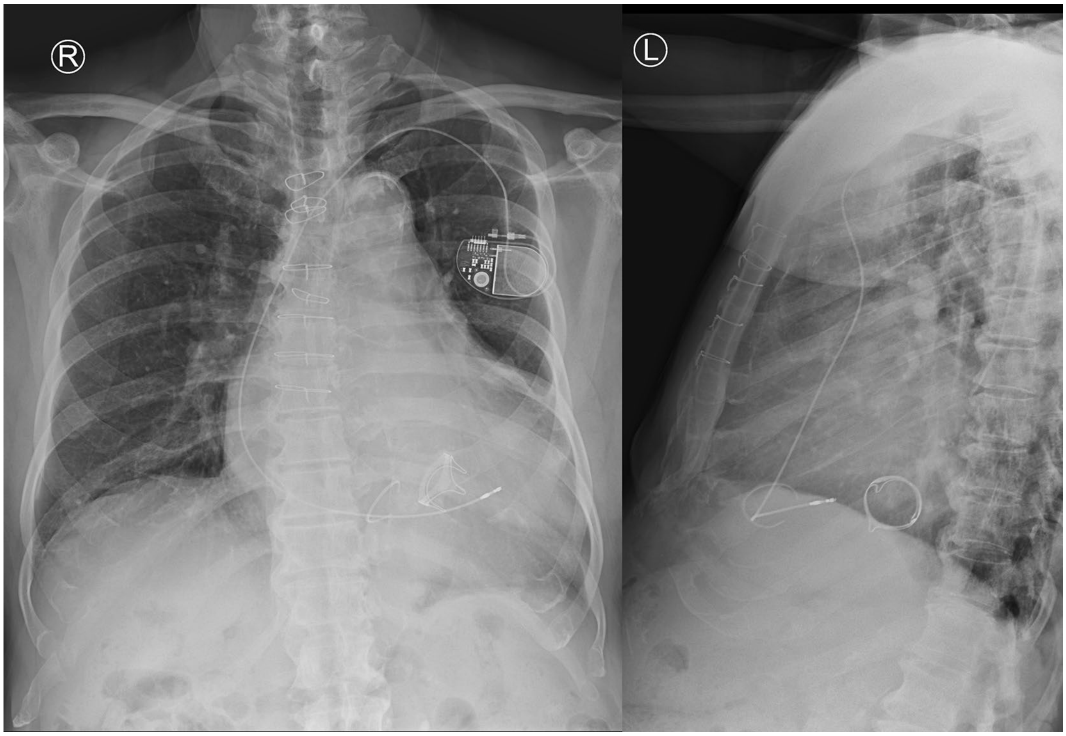

Fig. 4 Chest X-ray. Tissue mitral valve replacement (Carpentier-Edwards Perimount Magna 29 mm) and tricuspid annuloplasty (MC 3 ring 29 mm). A Tendril STS Model 2088TC lead was positioned inferior toward to the apex, where the distal left fascicular bundle was captured rather than the left bundle branch trunk

The use of a steerable catheter (Medtronic, C304) with the lumenless lead on LBBAP was limited in cases with a challenging anatomy. On the other hand, the stylet-driven pacing lead (SDL) as the adequate lead design on LBBAP remained questionable due to the thicker lead body, extendable helix and the stylet design. Recent studies exploring the safety and feasibility of LBBAP using SDL showed the use of SDL to achieve LBBAP as a safe and feasible technique characterized by high implant success rates, low complication rates, and stable low pacing thresholds [3, 14]. However, these studies all used the Biotronik devices with preshaped fixed-curve sheathes.

Abbott Agilis HisPro™ was developed primarily for His bundle pacing. This makes it difficult to obtain left bundle branch capture in patients with a large atrium (such as in atrial fibrillation or structural heart disease) because it would not have enough reach to cross the tricuspid valve and arrive at the RV septum. Thus, reshaping the secondary curve proximal to the second deflection and septal curve would extend the lead's reach beyond the tricuspid valve to the RV septum perpendicularly [15]. In our patient, several attempts to deploy the lead at true left bundle branch trunk failed because the sheath and the lead would have an oblique orientation to the RV septum, not a perpendicular one. We found that a more perpendicular septal orientation could be achieved by further deflecting and then retracting the catheter, making the sheath position inferior to the previously attempted site toward the apex at the left fascicular bundle.

In the MELOS study, the definition of LBBAP encompasses a proximal left bundle to distal conduction system (fascicles) pacing [3]. The type of LBBAP capture was classified according to the evidence of direct left conduction system capture and location of left conduction system capture. In patients with confirmed direct left conduction system capture, the LBB/fascicular Purkinje potential to QRS interval and QRS polarity in leads II and III were analyzed to determine the location of capture within the left ventricular conduction system. Based on a combination of intracardiac electrograms, fluoroscopy, chest X-ray, and postprocedural 12-lead ECG features, the Tendril lead captured the left septal fascicle, resulting in a right bundle branch delay pattern in lead V1 and intermediate QRS axis (lead II predominantly positive, and lead III with negative component with short (<75 ms) and constant LVAT at differential pacing output, and a V6–V1 interval >44 ms in our patient [16].

In conclusion, left fascicular bundle pacing may be an alternative strategy when conventional pacing using stylet-driven pacing leads with a steerable delivery sheath fails to capture the proximal left branch bundle. This will increase the success rate of conduction system capture in patients with a challenging anatomy.

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None.

Author contributions
Dr. HK Jeong and SS Kim has conceptualized, designed the study and collected the data. And all authors contributed to the interpretation of the data and drafted the manuscript. All authors have reviewed and approved the submission of the paper to the journal.

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Availability of data and materials
The datasets during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Written informed consent was obtained, which was approved by the Institutional Review Board of the Chosun University Hospital.

Consent for publication
We agree.

Competing interests
The authors declare that they have no competing interests.

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