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Left Bundle Branch Pacing

A New Alternative to Resynchronization Therapy in the 2020 Pacing Armamentarium

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ABSTRACT

His bundle pacing was developed while seeking a physiological alternative to biventricular cardiac resynchronization therapy. However, His bundle pacing may not be adequate in all patients. In this scenario, left bundle branch pacing has arisen as a new cardiac resynchronization therapy modality to correct left bundle branch block and restore ventricular synchrony. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2020;2:2225–9) © 2020 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Biventricular cardiac resynchronization therapy (CRT) has been an important therapeutic development in patients with heart failure, ventricular dysfunction, and left bundle branch block (LBBB). However, biventricular CRT has some drawbacks. It is a nonphysiological pacing modality because of direct activation of the ventricular myocardium. Moreover, implantation of an electrode into the coronary sinus is limited by venous anatomy and proximity to the phrenic nerve. Once the implantation is done, a significant proportion of patients are nonresponders (30%). All these limitations substantiate increasing interest in physiological pacing techniques.

Since 2018, the American Pacing Guidelines have included His bundle pacing (HBP) as an alternative to biventricular CRT (1). Nevertheless, HBP has some limitations(2) including: 1) difficulty in identifying the location of the His bundle; 2) high and unstable pacing thresholds in 5% to 10% of patients; 3) low R-wave amplitude or large atrial signals complicating pacing management; 4) heart block distal to the His bundle; 5) and potential limitations in long-term performance. The His-Sync trial (3) showed that QRS duration cannot be normalized in 48% of patients with LBBB, suggesting that, in this subset of patients,

LEARNING OBJECTIVES

- LBBP may provide shorter and homogeneous left ventricular activation time.
- LBBP may provide another option for CRT in patients with atrioventricular block post-TAVI with failed His bundle pacing (due to TAVI damage in the Hisian region when placing the valve).
- LBBP may restore left ventricular synchrony in patients with left bundle branch block and left ventricular dysfunction, adding one more tool to the CRT armamentarium.

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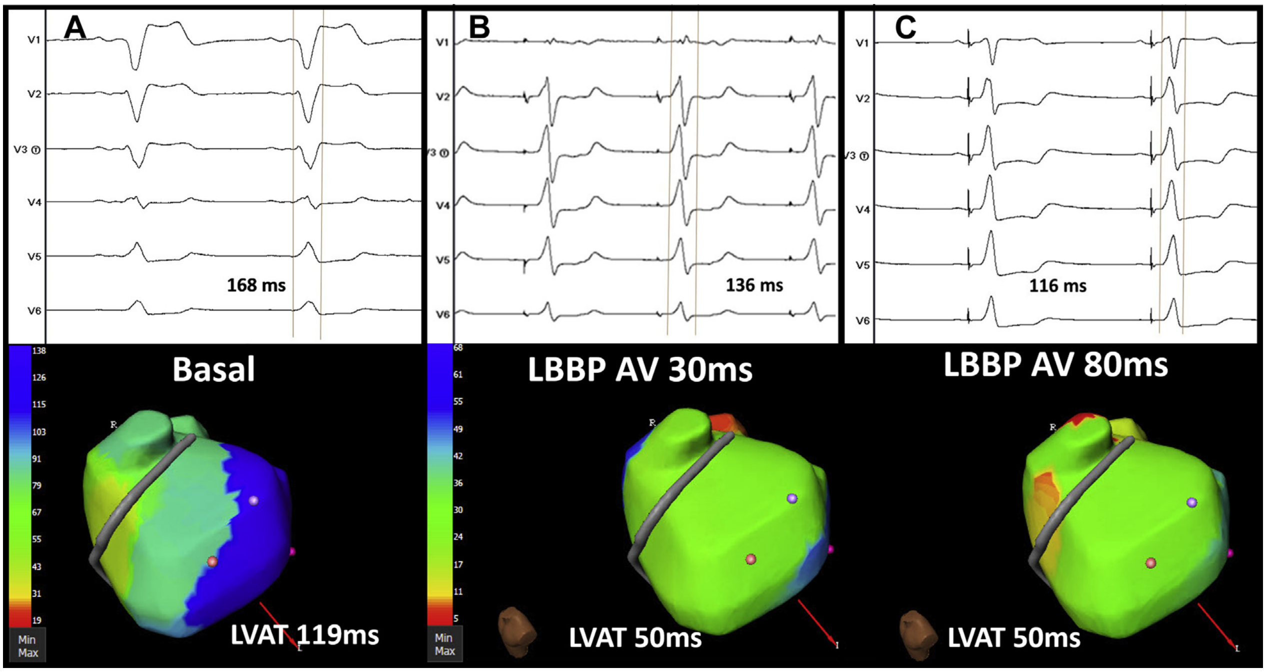
FIGURE 1 **ECGI Mapping and Electrocardiography in a Patient With Nonischemic Cardiomyopathy**



(A) Left bundle branch block (LBBB) with QRS 168 ms. In patients with LBBB, the location of the later activation is left lateral or posterolateral. Electrocardiographic imaging (ECGI) recording of the intrinsic rhythm showing late **(blue)** lateral left ventricular activation. **(B, C)** Left bundle branch pacing (LBBP) with QRS shortening and ECGI with left ventricular activation time (LVAT) of 50 ms. LBBP allows uniform activation of the entire left ventricle **(green)**. Prolongation of the atrioventricular delay allows coordinating the stimulation of the left branch with the intrinsic activation of the right branch, normalizing the QRS (116 ms). AV = atrioventricular interval.

the conduction block may lie beyond the His bundle and require distal pacing in the conduction system. Zhang et al. (4) performed a study (n = 11) showing that LBBP was clinically feasible in patients with heart failure, LBBB, and an indication for CRT. They suggested that LBBP may be a new CRT modality to correct LBBB, enhance ventricular synchrony, and improve symptoms and left ventricular (LV) reverse remodeling (4).

This study presents 3 cases that show the resynchronizing capacity of LBBP.

CASE

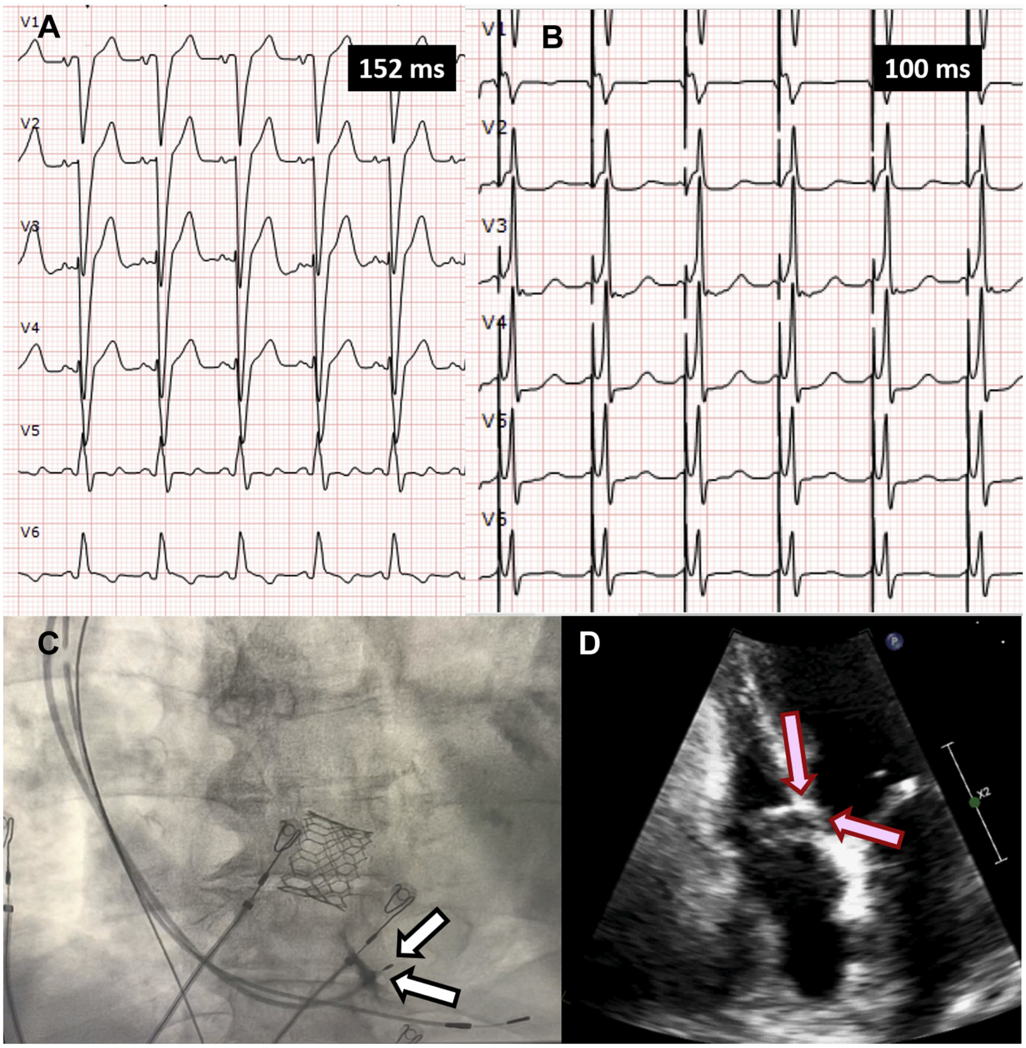
PATIENT 1. Patient 1 was a 75-year-old man with hypertension and a nonischemic cardiomyopathy. Echocardiography showed a left ventricular ejection fraction (LVEF) of 25% and mild ventricular dilation. Despite being taking optimal heart failure medical treatment, he remained in New York Heart Association (NYHA) functional class III. Cardiac magnetic resonance showed late gadolinium enhancement in the basal septum. Electrocardiography showed LBBB with QRS of 168 ms (**Figure 1A**).

LBBP was performed using a SelectSecure 3830 pacing lead (Medtronic, Minneapolis, Minnesota), delivered through a fixed-curve C315-HIS sheath. The location for LBBP was 1 to 1.5 cm distal to the His signal. At this site, the unipolar paced QRS morphology before fixation showed a "W" pattern in lead V_1. The sheath was rotated counterclockwise to maintain the lead-tip perpendicular to the septum. The pacing lead was rapidly rotated clockwise, controlling impedance. Sheath angiography was performed to determine the lead depth in the ventricular septum. Unipolar pacing showed right bundle branch block, and LBBP was confirmed by published criteria (5).

Selective LBBP resulted in QRS shortening (136 ms) (**Figure 1B**), and optimization with the fusion-optimized intervals method (6) achieved further shortening of the QRS to 116 ms (**Figure 1C**). The pacing threshold was 0.6 V/0.4 ms.

Noninvasive electrocardiographic imaging (ECGI) mapping was performed to determine the ventricular activation time and pattern (Video 1). The basal left ventricular activation time (LVAT) was 119 ms

FIGURE 2 **LBBP in a Patient With LBBB and Severe Ventricular Dysfunction Post-Transcatheter Aortic Valve Implantation**



(A) Left bundle branch block (LBBB). **(B)** Electrocardiography with left bundle branch pacing (LBBP) with atrioventricular fusion optimization. Deep lead pacing in the left bundle seen with fluoroscopy **(C)** and with echocardiography **(D)** (**arrows** point to the tip of the lead).

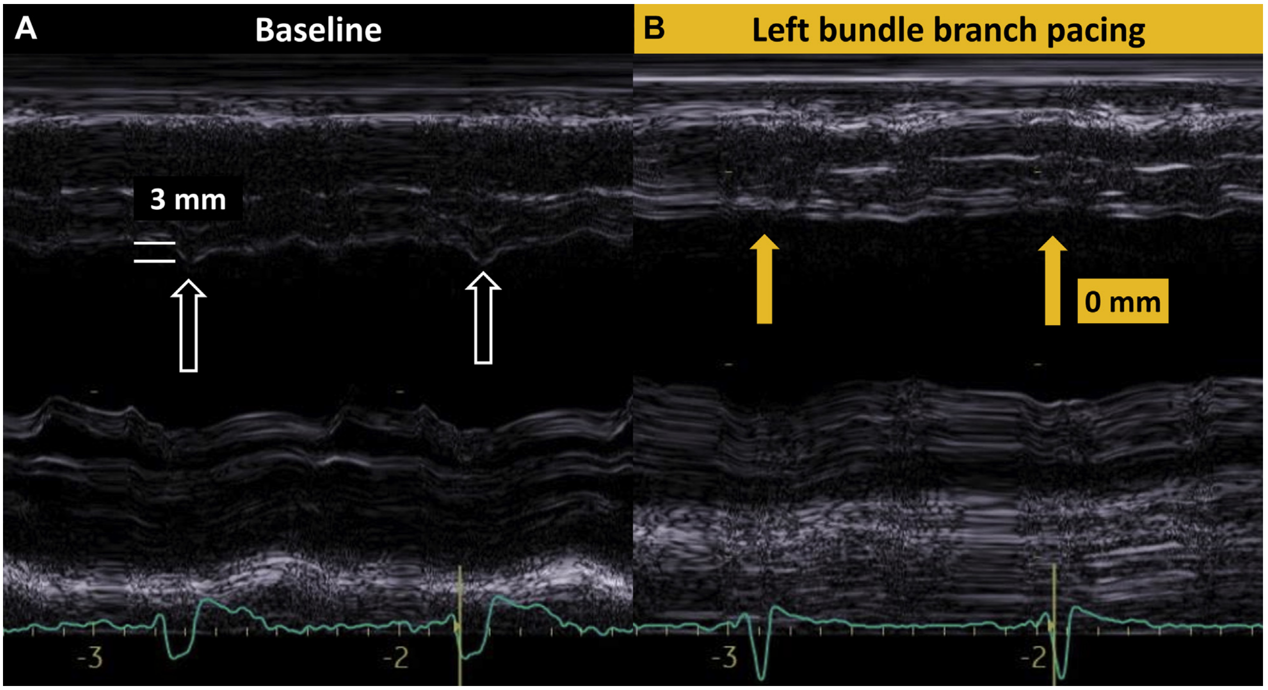
(Figure 1A, bottom). LBBP with and without atrioventricular optimization showed the same LVAT, 50 ms (Figures 1B and 1C, bottom). In this case, LBBP allowed 31% shortening of the QRS complex and homogeneous LV activation.

At the 3-month follow-up, the LVEF clearly improved to 38%, and clinically, the patient improved by 1 NYHA functional class point.

PATIENT 2. Patient 2 was an 81-year-old man with diabetes, chronic renal failure (glomerular filtration rate of 22 ml/min), chronic pulmonary disease, and ischemic cardiomyopathy. He had dyspnea due to severe aortic stenosis with LVEF of 55% and moderate mitral regurgitation. A balloon-expandable transcatheter aortic valve implantation (TAVI) was performed, which was complicated by persistent LBBB (Figure 2A). Subsequently, the patient presented with tachypnea, tachycardia, crackles on lung auscultation, and 89% basal oxygen saturation and acute pulmonary edema was diagnosed. Echocardiography showed severe mitral regurgitation and LVEF of 30%. A coronary event was ruled out with coronary angiography. The patient required hemodialysis due to exacerbation of renal failure.

Taking into account the LBBB (QRS: 152 ms), severe mitral regurgitation, LV dysfunction and refractory

FIGURE 3 **Septal Flash Correction With Left Bundle Branch Pacing**



(A) Baseline, 3-mm septal flash excursion. **(B)** Septal flash abolishment.

heart failure, the heart team opted for resynchronization therapy. LBBP was performed, achieving a QRS of 100 ms (**Figure 2B**) with a threshold of 0.75 V/ 0.4 ms.

The patient evolved favorably and was weaned from dialysis and oxygen therapy 24 h post-implantation. At the 15-day outpatient clinic follow-up, the patient was in NYHA functional class III, echocardiography showed LVEF of 35%, mitral regurgitation was moderate, and the LBBP lead was deep in the septum (**Figures 2C and 2D**).

PATIENT 3. Patient 3 was a 78-year-old diabetic male with nonischemic cardiomyopathy, LVEF of 35%, and LBBB (QRS duration: 210 ms). Cardiac magnetic resonance confirmed LVEF of 34% and demonstrated a small intramyocardial late gadolinium enhancement patch in the basal septum. An abnormal movement of the septum with a 3-mm septal flash (SF) (**Figure 3A**) was evident in the echocardiogram. Septal flash (SF) is a fast contraction and relaxation of the septum during the isovolumetric contraction period and is a marker of intraventricular dyssynchrony (7). He was in NYHA functional class II, despite optimal medical treatment.

LBBP obtained a 120-ms QRS, with a pacing threshold of 1V/1 ms. The 15-day follow-up examination showed a 10-point increase in the LVEF and correction of the SF (**Figure 3B**).

DISCUSSION

This study describes 3 cases that help to explain the beneficial effects of LBBP at different levels. LBBP shortens the paced QRS and causes rapid and homogeneous LV activation. As biventricular CRT, LBBP corrects intraventricular asynchrony, thus decreasing the grade of mitral regurgitation and improving the LVEF.

ECGI shows the ventricular activation time and pattern. In the case of HBP, an acute crossover study between HBP and biventricular CRT using ECGI showed a significant shortening of LVAT with HBP in 17 of 23 patients (8). Evidence supporting CRT with LBBP is scarce, but Chan et al. (9) reported the use of ECGI in a patient with LBBB; both selective HBP and peri-LBBP demonstrated synchronous activation. Patient 1 presented with shortening of LVAT and favorable clinical and echocardiographic improvements at 3 months of follow-up.

The need for permanent pacing after TAVI could be due to mechanical compression or ischemia of the conduction system. De Potter et al. (10) showed a 69% correction of LBBB with HBP in a cohort of 16 patients requiring a pacemaker post-TAVI. LBBP is an alternative mode of physiological pacing for post-TAVI patients with unsuccessful HBP. Moreover, as in the present case, LBBP could decrease LBBB-induced mitral regurgitation worsening.

Finally, improvement in dyssynchrony is expected with LBBP due to myocardial depolarization using specialized conduction tissue. Cai et al. (11) showed that LBBP could preserve LV synchrony in patients undergoing dual-chamber pacemaker implantation for sick sinus syndrome and normal LVEF. In Patient 3, LBBP completely corrected the grade of intraventricular dyssynchrony (measured by SF) in a patient with LBBB and low LVEF, almost causing LVEF correction within a few days after implantation.

LBBP was performed in all cases after failure of HBP, either due to a high pacing threshold or to an inability to correct the LBBB. However, as shown in these 3 cases, LBBP could be a promising tool in the resynchronization therapy armamentarium. In the particular case of requiring resynchronization after TAVI implantation, direct LBBP increased the percentage of implantation success (12). The best thing would be to implement the most appropriate therapy in each patient: biventricular CRT, HBP, or LBBP. Knowledge of the best candidate for each type of pacing would be the key.

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AUTHOR DISCLOSURES

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KEY WORDS cardiac pacemaker, cardiac resynchronization therapy, systolic heart failure

APPENDIX For a supplemental video, please see the online version of this paper.