Cardiac resynchronization therapy for rate-related bundle branch block: Is there a role for His-bundle pacing?

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Introduction

Left bundle branch block (LBBB) can result in dyssynchronous left ventricular (LV) contraction, leading to LV remodeling and worsening congestive heart failure (CHF).[1] Traditional cardiac resynchronization therapy (CRT) with a right ventricular endocardial and an LV epicardial lead (in the coronary sinus) has demonstrated reverse remodeling and improvement of LV ejection fraction (EF) as well as clinical outcomes in such patients.[2] Recently, His bundle pacing (HBP) has been attempted as a more physiological method of CRT by reducing the QRS duration in the setting of LBBB.[3–6]

LBBB can be rate-related[7] and may occur at relatively slow heart rates, resulting in dyssynchrony with activities of daily living (eg, 70–80 beats per minute [bpm]). A subset of patients with cardiomyopathy may present with such rate-related LBBB, and case reports have shown improvement in clinical symptoms with traditional CRT.[8,9] In such patients, HBP may result in physiological conduction at rest as well as higher rates, and could be a better option than traditional CRT.

In this report, a case of symptomatic nonischemic cardiomyopathy and rate-related LBBB in which HBP was utilized for cardiac resynchronization is described.

KEY TEACHING POINTS

- His bundle pacing can be utilized for resynchronization in the setting of rate-related bundle branch block and cardiomyopathy.
- Rate cut-off for development of bundle branch block can be variable in the same patient at different times, and hence assessment of true "burden" of bundle branch block is difficult.
- The output threshold for QRS narrowing with His bundle pacing can be high and result in significant battery drain.

Case report

A 59-year-old woman presented with an episode of syncope of unknown duration preceded by a prodrome of shortness of breath and lightheadedness. She had complete neurological recovery. Over the last few months, the patient had noted shortness of breath on exertion with less than routine activity and sometimes at rest (NYHA class 3–4). Her past medical history was notable for right-sided breast cancer for which the patient had undergone bilateral mastectomy, chemotherapy as well as radiation approximately 8 years ago at another institution. Additionally, she also had a history of non-insulin-dependent diabetes and obstructive airway disease. She was on guideline-directed medical therapy including beta-blockers and ACE inhibitor but was not on spironolactone. Laboratory data revealed no significant abnormalities including negative cardiac biomarkers. Electrocardiogram showed normal sinus rhythm with rate-related LBBB at a heart rate of greater than 70 bpm (Figure 1). Echocardiography revealed a LV EF of 15% to 20% without any evidence of wall thinning or scarring. Angiography revealed no evidence of obstructive epicardial coronary artery disease.

Given the presentation of syncope in the setting of structural heart disease as well as significant heart failure symptoms with rate-related LBBB, it was decided to proceed with CRT and defibrillator implantation. To provide physiological conduction at all heart rates, it was decided to attempt HBP instead of traditional LV lead placement for resynchronization therapy. The right ventricular implantable cardioverter-defibrillator lead and right atrial lead were placed in the right ventricular mid septum and the right atrial appendage, respectively (Figure 2A). Using a deflectable sheath (SelectSite;

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Dr Contractor receives speakers honorarium for fellows course from Medtronic (not relevant to this publication). **Address reprint requests and correspondence:** Dr Tahmeed Contractor, Loma Linda University Medical Center, 11234 Anderson St, Loma Linda, CA 92354. E-mail address: tahmeedcontractor@gmail.com.

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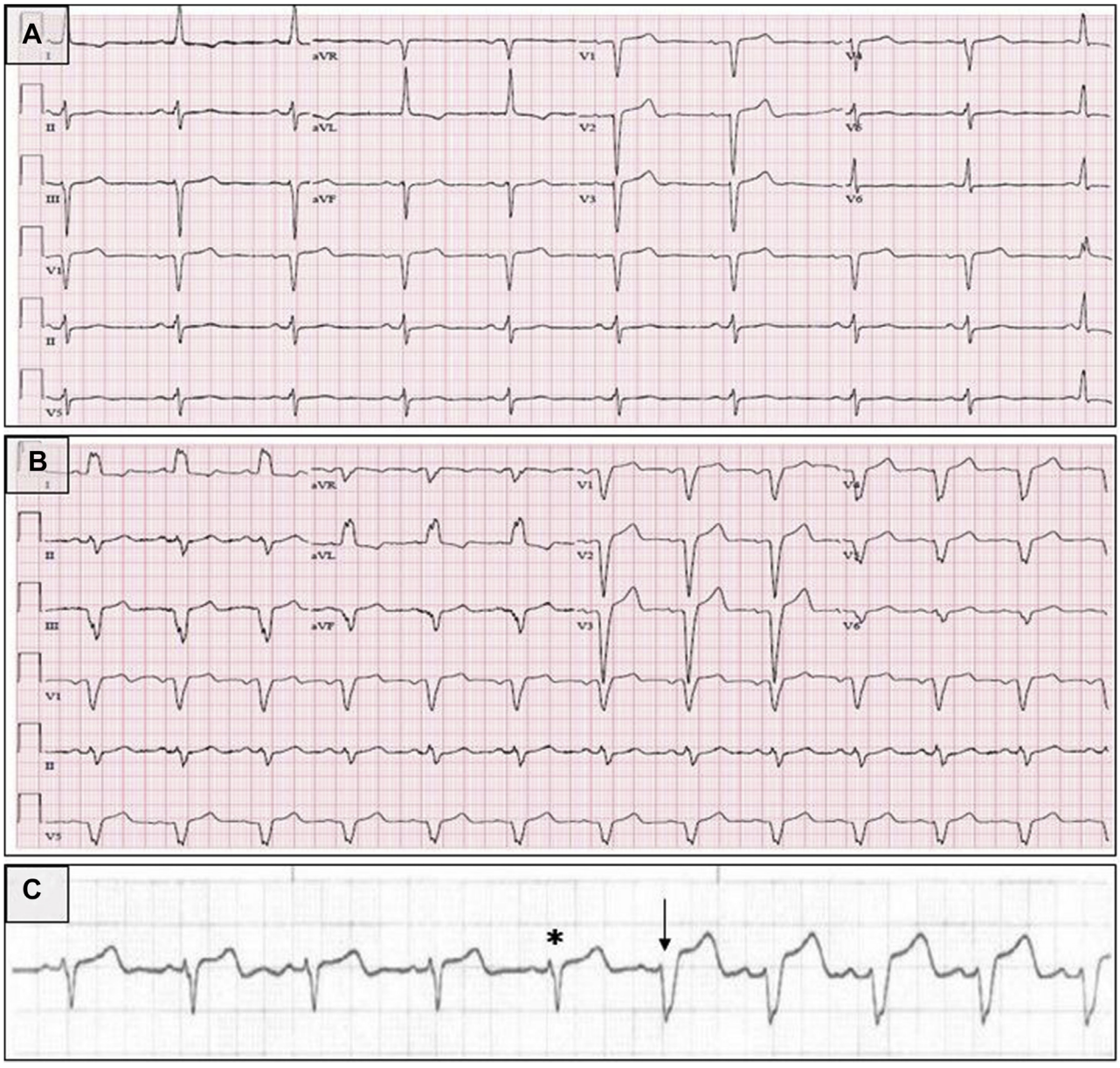

Figure 1 Baseline electrocardiograms. **A:** Electrocardiogram at a heart rate of 50 to 60 beats per minute (bpm) shows normal sinus rhythm with a narrow QRS. **B:** Electrocardiogram at a heart rate of >70 bpm shows normal sinus rhythm with left bundle branch block and a QRS duration > 150 ms. **C:** Telemetry strip showing narrow QRS (*asterisk*) with development of left bundle branch block (*arrow*) associated with a subtle increase in rate.

Medtronic, St. Paul, MN), the active fixation pacing lead (3830 SelectSecure; Medtronic, St. Paul, MN) was used to map the His bundle location using fluoroscopy and unipolar electrogram signals. At the site where a small atrial electrogram, a sharp His deflection, and a large ventricular electrogram was seen, the lead was screwed in (Figure 2B). Excellent capture threshold was seen at this site (0.75 V at 1 ms pulse width) with near-selective HBP and a QRS duration of <120 ms (Figure 2C and D). However, the threshold for achieving a narrow QRS was high (3.8 V at 1 ms pulse width). Given the difficulty in finding the His bundle location in this patient, it was decided to accept this lead position despite the high threshold for narrowing. The HBP lead was attached to the LV port of the CRT defibrillator device (Amplia MRI; Medtronic, St. Paul, MN). The device was programmed to the DDD mode; and the RV pacing was programmed functionally off (output of 0.5 V at a pulse width of 0.03 ms) to allow His bundle–only pacing in a nonadaptive CRT mode. The paced and sensed AV delays were programmed to 130 and 100 ms, respectively. At the time of discharge, spironolactone was initiated as a part of further optimizing her heart failure regimen.

The patient's functional level improved remarkably within 2 months of follow-up, and she was now short of breath with only more than routine activity (NYHA class 2). Echocardiography done on 2 occasions (at 2 and 5 months post-implant) revealed improvement in LV EF to 35% to 40% with no complications from HBP (such as tricuspid

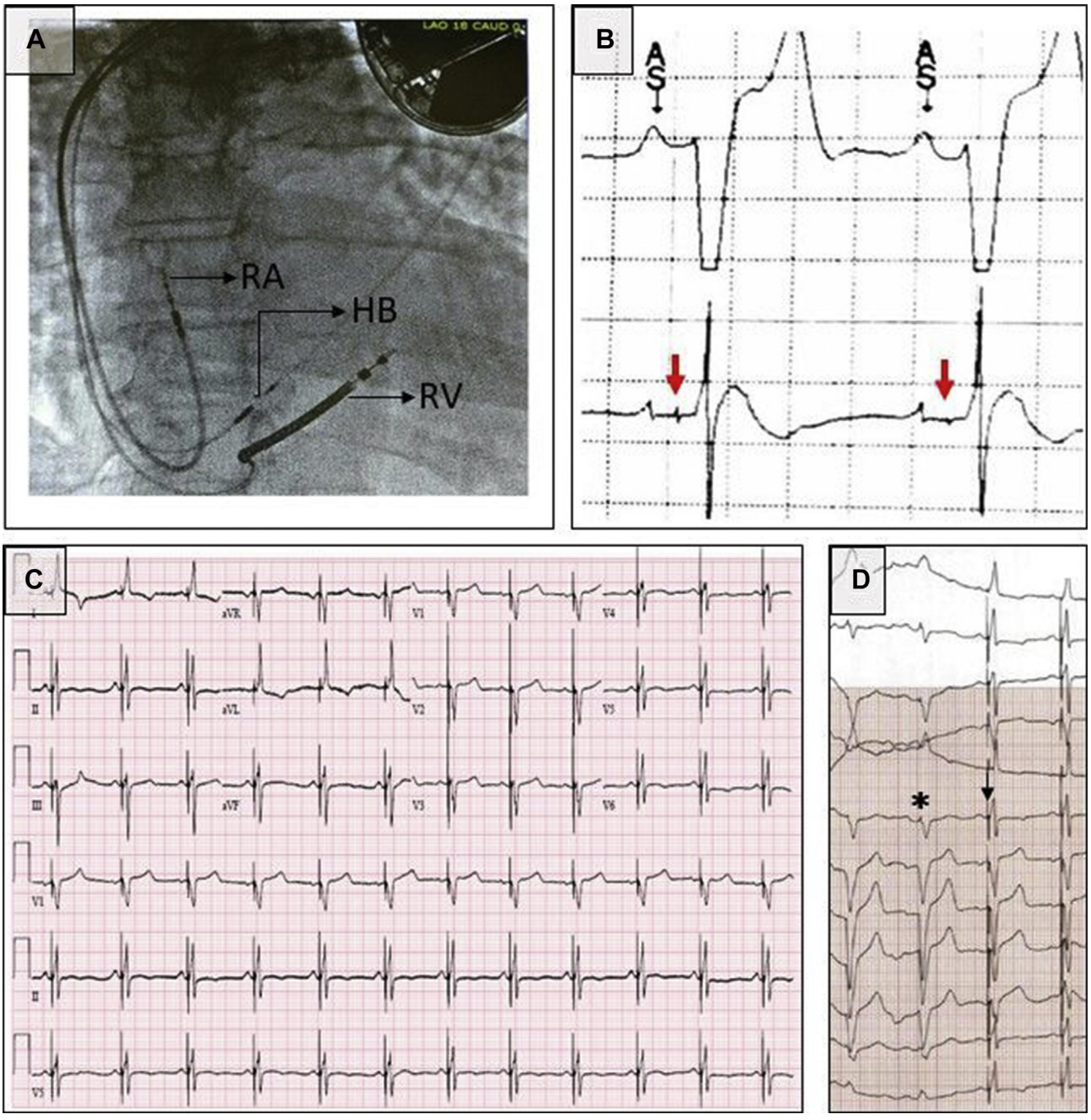

Figure 2 Implantation and results of the His bundle pacing cardiac resynchronization therapy and defibrillator system. **A:** Left anterior oblique view showing right atrial (RA), His bundle pacing (HB), and right ventricular implantable cardioverter-defibrillator (RV) leads. **B:** Top strip is surface electrocardiogram (ECG) and the bottom strip is the unipolar recording from the His bundle pacing site showing a small atrial electrogram, a sharp His deflection (*red arrow*), and a large ventricular electrogram. **C:** ECG showing near-selective His bundle pacing with QRS duration $<$ 120 ms. **D:** Continuous 12-lead ECG showing left bundle branch block (*asterisk*) followed by narrowing of QRS with His bundle pacing (*arrow*).

valve dysfunction or ventricular septal defect). The thresholds on all leads remained unchanged over 1 year during follow-up visits. However, during follow-up it was discovered that there was marked variability in the rate required for developing LBBB (Figure 3). During one of the visits approximately 11 months post-implant, it was noted that the patient had a narrow QRS with AAI pacing up to 120 bpm (Figure 3C). To conserve battery, it was decided to turn off HBP and program the patient in the AAI mode with DDD backup. The patient had worsened CHF symptoms and returned to the clinic a week later. Rate-related LBBB now occurred at AAI pacing of 100 bpm (Figure 3D). HBP was programmed back on with an output of 4 V at 1 ms pulse width; the patient reported significant improvement of symptoms in the ensuing weeks.

Discussion

In this report, a unique case of symptomatic rate-related LBBB in the setting of nonischemic cardiomyopathy that

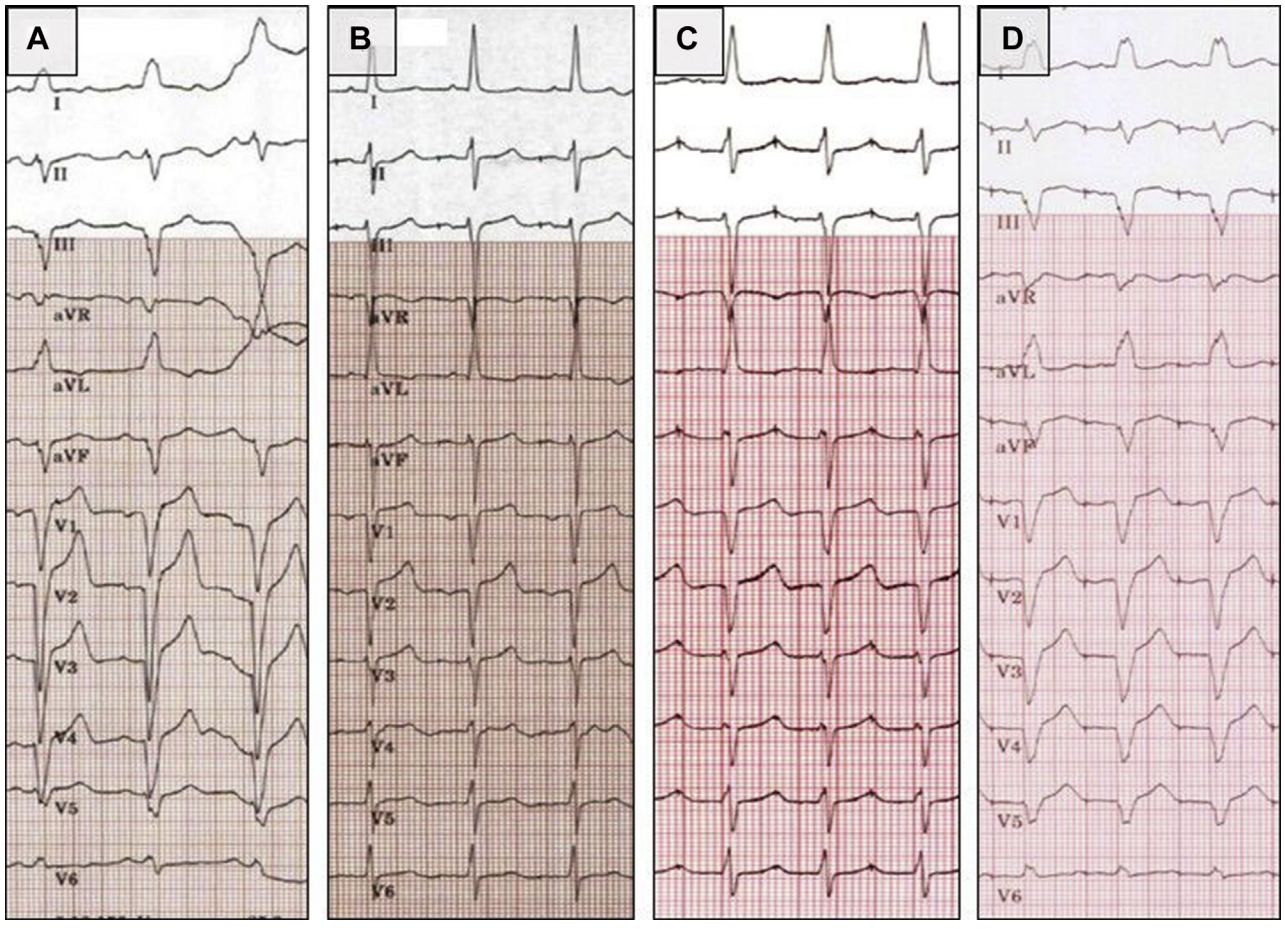

Figure 3 Varying rate cut-offs for development of left bundle branch block (LBBB). **A:** April 2017; shows LBBB development at a heart rate of 75 beats per minute (bpm). **B:** September 2017; shows a narrow QRS while pacing AAI at a rate of 90 bpm. **C:** March 15, 2018; shows a narrow QRS while pacing AAI at a rate of 120 bpm. **D:** March 21, 2018; shows LBBB while pacing AAI at a rate of 100 bpm.

had improvement in symptoms and LV EF after HBP is described. To the best of the authors' knowledge, this is the first such reported case.

The role of LBBB in causing dyssynchrony and remodeling, as well as the benefit of traditional CRT in improving clinical outcomes, is well known.[1,2] However, in rate-related LBBB, there is no electrical dyssynchrony at rest when the QRS duration is normal. Implantation of an LV lead with traditional CRT has been done in these situations but poses a clinical dilemma. On the one hand, traditional CRT can correct dyssynchrony at a higher rate and decrease symptoms. On the other hand, biventricular pacing at rest (when the native QRS is narrow) with traditional CRT is rarely as physiological as native normal His-Purkinje conduction and can worsen LV function. There is currently no device programming that can accurately allow LV pacing to occur only at higher heart rates, which would be ideal. There are currently 2 reported cases with rate-related LBBB and low LV EF that presented with acute decompensation of CHF and in which traditional CRT was performed.[8,9] The detrimental effect of unnecessary biventricular pacing at the time of narrow QRS was not addressed in these reports.

LBBB normalization by pacing the distal His bundle was reported several years ago,[10] and recently, small studies have shown benefit of HBP instead of LV lead placement in patients that are suitable for CRT.[3–6] In patients with rate-related LBBB, successful HBP may result in physiological conduction at rest as well as with exertion, potentially solving the aforementioned dilemma with traditional coronary sinus leads. This is the first report of HBP improving LV EF and clinical symptoms in a patient with rate-related LBBB.

There are several issues with HBP in patients with rate-related LBBB and reduced LV EF that are highlighted in this report. Most importantly, pacing thresholds to achieve selective and near-selective His bundle capture can be high, as in this patient. This can result in significant battery drain, especially if the voltage output required is higher than the battery voltage. This in turn leads to frequent generator changes, increasing the likelihood of device-related infections, including endocarditis. Additionally, the reason for variable rate cut-offs for development of rate-related LBBB seen in the same patient at different times is unclear. This phenomenon makes it difficult to predict how much "burden" of LBBB such a patient may have. As such, the definitive role of any form of resynchronization therapy in this patient

population will always be unclear. Optimization of medical therapy (addition of spironolactone) may also contribute to improvement of symptoms and LV EF in this clinical setting. In this patient, with the history of syncope on presentation and LVEF of 15% to 20% on beta-blockers and ACE inhibitors, it was felt that CRT and defibrillator implantation was reasonable even prior to addition of spironolactone.

Conclusion

In conclusion, a case of symptomatic rate-related LBBB in the setting of cardiomyopathy that showed significant echocardiographic and clinical improvement after resynchronization with HBP is described. There are several unanswered questions in the use of HBP in this clinical setting that need to be addressed with larger clinical studies.

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