His bundle pacing improves left ventricular diastolic function in patients with heart failure with preserved systolic function

Bengt Herweg, MD, FACC, FHRS,* Dipayon Roy, MD,* Allan Welter-Frost, MD, MPH,* Cody Williams, MD,* Arzu Ilercil, MD, FACC,* Pugazhendhi Vijayaraman, MD, FACC, FHRS†

*From the *Department of Cardiovascular Sciences, University of South Florida Morsani College of Medicine, and Tampa General Hospital, Tampa, Florida, and †Geisinger Heart Institute, Wilkes-Barre, Pennsylvania.*

Introduction

Cardiac resynchronization therapy (CRT) is highly effective for patients with left bundle branch block, heart failure, and left ventricular (LV) systolic dysfunction. In heart failure patients with systolic dysfunction, CRT can also improve diastolic dysfunction.[1] Evidence guiding diastolic heart failure treatment is limited.[2]

Similar to left bundle branch block, chronic right ventricular pacing (RVP) is associated with pacing-induced cardiomyopathy and may result in exertional dyspnea in absence of LV systolic dysfunction.[3] Observational studies have shown that His bundle pacing (HBP) in patients dependent on chronic RVP can restore physiologic ventricular activation and improve LV systolic function.[4] We investigated the acute changes of echocardiographic parameters of overall cardiac function and diastolic function[5,6] during HBP compared to RVP in patients with preserved LV systolic function and exertional intolerance.

Case report

We studied 5 consecutive patients with a dual-chamber pacemaker and apical RVP lead implanted for complete atrioventricular (AV) block (all male, aged 78 ± 3 years, body mass index 27 ± 6, QRS duration 179 ± 13 ms, septal and posterior wall thickness 1.16 ± 0.05 and 1.12 ± 0.15 cm, respectively). All patients suffered from exertional intolerance despite preserved LV systolic function. At the time of generator change, an HBP lead (Model 3830; Medtronic Inc, Minneapolis, MN) was implanted and plugged to the LV port of the CRT-pacemaker, which resulted in nonselective HBP capture in all patients. Echocardiographic parameters of diastolic and global cardiac function were then obtained during RVP and HBP, with similar AV intervals. Paced AV intervals were optimized prior to hemodynamic assessment using the mitral inflow iterative method. The grade of diastolic dysfunction was calculated based on standard echocardiographic parameters.[5] The Tei or MPI (myocardial performance index), a measure of combined

KEY TEACHING POINTS

- There currently are no guideline recommendations for cardiac resynchronization therapy or for conduction system pacing in patients dependent on chronic ventricular pacing in the setting of preserved ejection fraction.
- His bundle pacing can improve exertional intolerance in patients with chronic right ventricular pacing in the setting of a normal ejection fraction.
- His bundle pacing may be associated with improved diastolic function when compared to right ventricular apical pacing.
- Prospective randomized controlled trials are warranted to elucidate the benefit of conduction system pacing compared to conventional right ventricular pacing in this patient population.

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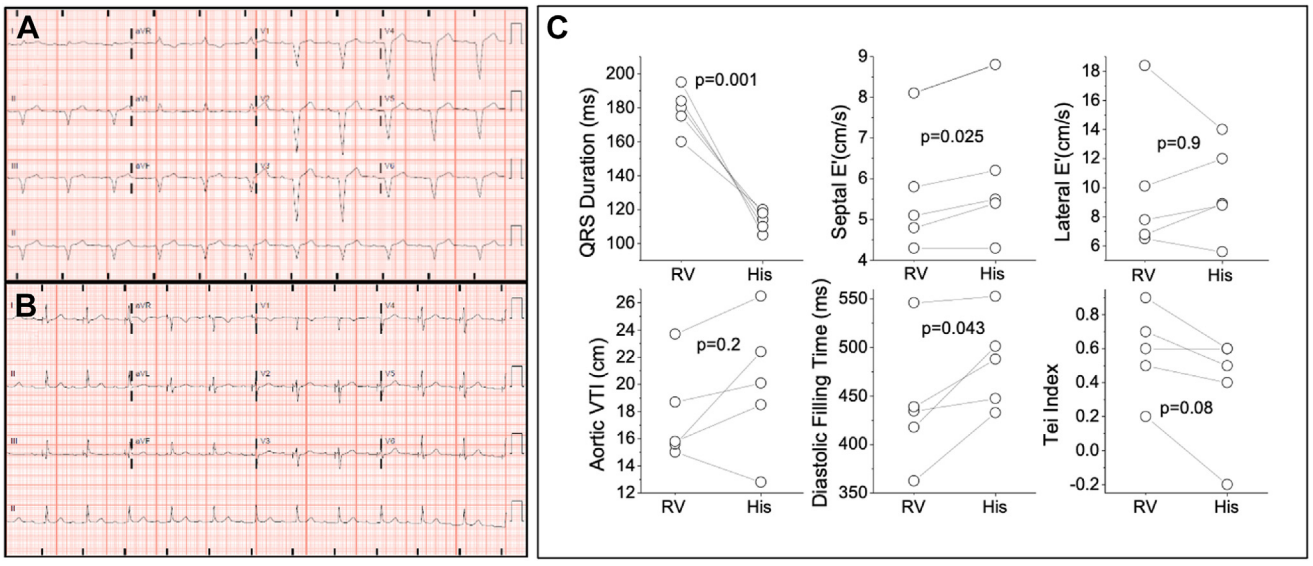

Figure 1 **A, B:** Comparison of right ventricular–paced (QRS 160 ms) vs His bundle–paced electrocardiogram (QRS 120 ms). **C:** Notable echocardiographic parameters.

diastolic and systolic function, was calculated as the ratio of the time spent in isovolumetric activity divided by the time spent in ventricular ejection.[6]

Results

The QRS duration decreased from 179 ± 13 ms with RVP to 113 ± 6 ms with HBP ($P < .001$, Figure 1A and 1B). Four out of 5 patients noted acute improvement of dyspnea. LV ejection fraction was 59% ± 6% with RVP and 64% ± 8% with HBP ($P = .5$). Compared to RVP, HBP was associated with increased diastolic filling time (440 ± 67 ms vs 484 ± 47 ms, $P < .05$), increase in septal E′ (5.6 ± 1.5 vs 6.0 ± 1.7, $P < .05$), and decreased Tei index (0.57 ± 0.27 vs 0.44 ± 0.19, $P = .08$) (Figure 1). No differences were found in lateral E′ (9.9 ± 4.9 with RVP vs 9.8 ± 3.2 with HBP) and mitral inflow E/A ratio (1.2 ± 0.6 for both). The LV outflow tract velocity time integral (reflecting stroke volume) increased from 17.7 ± 3.6 with RVP to 20.0 ± 5.0 with HBP ($P = .19$). The clinical characteristics, echocardiographic findings, and long-term HBP thresholds are summarized in Table 1.

At follow-up of 57 ± 21 months, 4 of 5 patients reported good functional tolerance; 1 patient had diminished functional capacity due to advanced lung disease. One patient died from an acute unrelated illness 22 months after implantation.

Discussion

We present 5 consecutive patients with AV block and preserved LV systolic function experiencing disabling exertional intolerance presumed to be related to chronic RVP and diastolic dysfunction. Owing to lack of other therapeutic alternatives, we upgraded their conventional dual-chamber pacing system to a CRT-pacemaker with a His bundle pacing lead. This enabled us to compare echocardiographic parameters of overall cardiac function and diastolic dysfunction during RVP and HBP at optimized AV interval settings.

It is impressive that despite normal LV systolic function, the LV stroke volume, a measure of overall cardiac function, increased by 13%, and the diastolic filling time increased by 11%, accompanied by improved septal early diastolic myocardial relaxation velocity (E′). In 4 out of 5 of our patients with symptomatic heart failure with preserved ejection fraction, conduction system pacing resulted in a remarkable improvement of heart failure symptoms. The acute impact of HBP on diastolic function has not been reported in patients with preserved LV function, although it has been demonstrated in patients with reduced ejection fraction.[7]

Pacing to maintain physiologic ventricular activation is recommended in patients with AV nodal block and an LV ejection fraction of 36%–50% if the ventricular pacing burden is expected to be >40% (class IIa indication). There are no current guideline recommendations for conduction system pacing in patients with preserved LV systolic function.[8] Randomized controlled trials are warranted to explore the effects of conduction system pacing on diastolic function and to determine the potential therapeutic benefits for heart failure patients with preserved ejection fraction.[9]

Table 1 Clinical characteristics, device-related data, and echocardiographic findings during right ventricular vs His bundle pacing

Patient / age (y) / sex	Heart rate (bpm) AV interval (ms)	LA volume (mL)	BMI / BSA	Valvular disease	LVEF	E/e' •septal, lateral (avg)	Mitral valve inflow •E, A wave (cm/s), (E/A ratio)	Tricuspid regurgitation velocity (m/s)	Tei/MPI, DD grade	QRS duration His bundle threshold at follow-up
Patient 1 / 82 / female	RV paced •60/200* His paced •60/200*	RV paced •22.5 His paced •27.4	20 / 2.1	Mild MR	72%	RV paced •17.7, 21.4 (19.5) His bundle paced •25.2, 16.7 (20.9)	RV paced • 124, 60 (2.1) His bundle paced •124, 48 (2.6)	RV paced •3.3 His bundle paced •3.3	RV paced •0.16, 3 His bundle paced •0.15, 3	RV paced •180 ms His bundle •114 ms •0.4 V @ 1.0 ms
Patient 2 / 78 / male	RV paced •65/140* His paced •65/140*	RV paced •27.2 His paced •27.5	26 / 2.0	None	63%	RV paced •10.5, 10.9 (10.7) His bundle paced •7.4, 7.2 (7.3)	RV paced • 93, 93 (1.0) His bundle paced •68, 89 (0.75)	RV paced •2.6 His bundle paced • 2.5	RV paced •0.51, normal His bundle paced •0.35, normal	RV paced •175 ms His bundle •118 ms •1.75 V @ 0.5 ms
Patient 3 / 78 / male	RV paced •68/210* His paced •68/210*	NA; poor image quality	37 / 2.6	Trivial MR	55%	RV paced •10.7, 7.5 (9.1) His bundle paced •9.1, 5.5 (7.3)	RV paced • 54, 55 (0.98) His bundle paced •58, 61 (0.95)	RV paced •2.1 His bundle paced • 2.1	RV paced •0.69, 1 His bundle paced •0.52, 1	RV paced •160 ms His bundle •120 ms •1.3 V @ 1.0 ms
Patient 4 / 85 / male	RV paced •60/250† His paced •60/250†	RV paced •61.5 His paced •61.5	24 / 1.8	Mild MR	56%	RV paced •12.7, 5.4 (9.1) His bundle paced •13.2, 4.6 (8.9)	RV paced • 59, 65 (0.91) His bundle paced •68, 67 (1.01)	RV paced •2.2 His bundle paced • 2.2	RV paced •0.92, 1 His bundle paced •0.6, 1	RV paced •184 ms His bundle •110 ms •1.1 V @ 0.5 ms
Patient 5 / 80 / male	RV paced •65/230* His paced •65/230*	RV paced •31.1 His paced •31.1	29 / 2.2	None	56%	RV paced •14.3, 3.97 (9.1) His bundle paced •15.3, 5.99 (10.6)	RV paced • 92, 85 (1.1) His bundle paced •90, 80 (1.3)	RV paced •2.4 His bundle paced • 2.2	RV paced •0.57, normal His bundle paced •0.56, normal	RV paced •195 ms His bundle •105 ms •0.5 V @ 0.5 ms

Avg = average; BMI = body mass index; BPM = beats per minute; BSA = body surface area; LA = left atrium; LVEF = left ventricular ejection fraction; MPI = myocardial performance index; MR = mitral regurgitation; RV = right ventricle.

*Atrial sensed.

†Atrial paced.

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