Original Article

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Comparison of Left Ventricular Function after His Bundle Pacing vs Left Bundle Branch Area Pacing Implantation

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Abstract

Background: Right ventricular pacing may lead to left ventricular (LV) function deterioration. Recent guideline suggests the use of conduction system pacing (CSP) with either his bundle pacing (HBP) or left bundle branch area pacing (LBBAP). This study aimed to investigate the difference of LV function between HBP and LBBAP.

Methods: This is a prospective cohort study enrolling patients aged>18 years requiring CSP implantation from June 2020 to January 2024 in Hasan Sadikin General Hospital, Bandung. Data regarding QRS duration and several echocardiography parameters were obtained at baseline and during follow-up within 1 year after CSP implantation.

Results: From 66 patients, 35 were included in the HBP group. There was no difference in QRS duration at baseline between both groups with higher left ventricular ejection fraction (LVEF) in the HBP group (51.2 ± 13.9% vs 45.6 ± 11.1%, p=0.078). During follow-up, the HBP group showed a narrower QRS duration (113.40 ± 17.06ms vs 120.81 ± 12.12ms, p=0.029). LV function was preserved in the HBP group while there was a trend of LV function improvement in the LBBAP group (53.1 ± 11.7% in LBBAP vs 53.9 ± 11.5% in the HBP group, p=0.536). Further analysis in 33 patients with LV dysfunction showed a trend of LVEF improvement in both groups (35.3 ± 7.9% to 44.6 ± 11.28% in HBP and 38.7 ± 6.9% to 51.4 ± 13.1% in LBBAP group, p=0.135).

Conclusions: HBP resulted in a narrower QRS complex. However, both HBP and LBBAP showed a trend of LV function improvement in patients with LV dysfunction.

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Keywords: *Conduction system pacing (CSP), his bundle pacing (HBP), left bundle branch area pacing (LBBAP), left ventricular (LV) function*.

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Background

Permanent pacemaker (PPM) implantation is indicated in patients with symptomatic bradycardia or other conditions such as heart failure (HF), certain types of cardiomyopathies, and other rare diseases.[1] Conventional right ventricular pacing (RVP) may lead to deterioration of left ventricular (LV) funinduces it may induced cardiomyopathy due to electrical dyssynchrony, especially in patients anticipated to have a substantial right ventricular pacing.[2-4]

Conduction system pacing (CSP), a more physiologic type of pacing, aims to directly or indirectly stimulate the His-Purkinje cardiac conduction system, consisting of His bundle pacing (HBP), left bundle branch area pacing (LBBAP), and pacing of the surrounding conduction system tissues, including right ventricular septal pacing (RVSP), left ventricular septal pacing (LVSP), and mid-septal pacing.[5] Studies reported that both HBP and LBBAP resulted in a narrower QRS complex, a higher left ventricular ejection fraction (LVEF), and a lower heart failure hospitalization during follow-up compared with RVP.[6-8] Although previous recommendations of using CSP are limited, the recent guideline suggests the use of either cardiac resynchronization therapy (CRT) with biventricular (BiV) pacing or CSP (HBP or LBBAP) in all patients requiring PPM regardless of the patient's left ventricular (LV) function to mitigate the occurrence of HF.[4]

Pacing of the His bundle is thought to be more physiologic and has a lower rate of tricuspid regurgitation (TR), however, it requires a more difficult procedural technique for implantation, resulting in a longer procedure duration and fluoroscopy time.[10-12] It also has a higher capture threshold during follow-up compared to RVP and LBBAP.[10] Furthermore, it may not be able to correct a preexisting bundle branch block.[13] Left bundle branch area pacing was introduced much later in 2017.[14] It is easier to implant with several advantages such as a lower and more stable capture threshold, lower CSP-related complication, and a possibility of correcting a preexisting bundle branch block.[10,15-17] Despite the clear superiority of LBBAP compared to HBP especially in terms of pacing parameters, procedure duration, and pacemaker-related complications, the recommendations for using HBP are more common in the existing guidelines.[1,18-20] Furthermore, the data about head-to-head comparison regarding the LV function after pacemaker implantation between LBBAP and HBP is limited. Therefore, this study aimed to investigate the difference in left ventricular function following HBP and LBBAP implantation.

Methods

Patient Selection

This is a prospective cohort study enrolling consecutive patients aged>18 years old requiring CSP implantation due to symptomatic bradycardia or as a resynchronization therapy in heart failure patients with reduced ejection fraction (HFrEF) in Hasan Sadikin General Hospital, Bandung, Indonesia, from June 2020 to January 2024. From 79 patients undergoing CSP implantation, 13 patients were excluded due to incomplete echocardiography data or loss to follow-up. In general, due to the time required for the learning curves of conduction system pacing and an earlier introduction of HBP implantation, LBBAP implantations were not common practice in our center until early 2022. His bundle pacing is usually the first method for conduction system pacing because it has more physiologic pacing than LBBAP. His bundle pacing was initially attempted in 49 patients, however, cross over to the LBBAP group occurred in 14 patients due to several reasons such as inability to visualize the His region, failure to capture the His signal, presence of a high His bundle capture threshold, or if the HBP is unable to correct a wide QRS complex (Figure 1). Left bundle branch area pacing has a shorter procedure duration, so it is preferred as the first designated type of CSP if the patients were unstable during the procedure or in patients who were suspected to have infra-hisian conduction abnormalities.

Pacemaker Implantation

CSP implantations were carried out using local anesthesia. Venous accesses were obtained through cephalic and axillary veins. For HBP implantation, the tip of active bipolar SelectSecure 3930 Medtronic lead was placed on the His region after visualization with contrast injection at the membranous septum at the level of the tricuspid annulus. After obtaining the His bundle potential, pacing was attempted to achieve

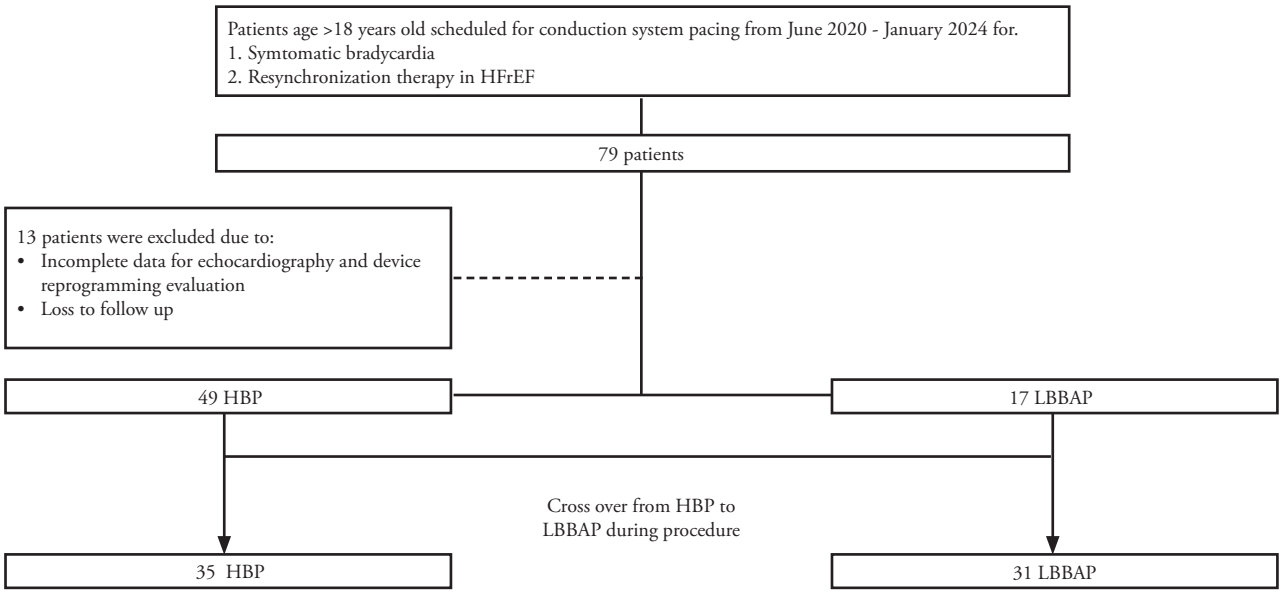

Figure 1. Study recruitment protocol. HFrEF = heart failure reduced ejection fraction; HBP = his bundle pacing; LBBAP = left bundle branch area pacing.

optimal pacing parameters as explained by Ezzeddine et al.[21] A selective his bundle pacing was defined as an equal duration of an interval between stimulus-ventricle interval (S-V) and the intrinsic His-ventricle (H-V), along with an identical paced QRS morphology to the intrinsic QRS complex. A nonselective his bundle pacing was defined as a shorter S-V compared to the intrinsic H-V along with a local fusion of both the His bundle and septal myocardium signals.[22] In LBBAP, the pacing lead was placed 1.5-2 cm distal to the His bundle.[21] The presence of a paced QS morphology in lead V1, a QRS discordance in the inferior leads, and a QRS discordance in lead aVR/aVL were the markers for optimal sites for LBBAP implantation. Once this pacing morphology is obtained, the intraventricular septum is penetrated with a depth of 1.4 ± 0.23 cm.[23] A nonselective LBBAP is characterized by a prolonged peak left ventricular activation time (pLVAT) when there is a change in output from high to low, a longer stimulus-His interval, and a longer stimulus-right atrial interval.[24]

Assessment of LV function

Echocardiography evaluation was carried out by 2 independent cardiologists with more than 5 years of working experience. Results were validated using ViewPoint 6 GE reporting software for cardiology in the workstation. Echocardiographic parameters were obtained before and within 1 year after pacemaker implantation using Vivid S70 or Vivid iq (GE Vingmend Ultrasound, Horten Norway) evaluating the left atrial anteroposterior diameter using M-mode (mm), left atrial volume index (LAVI), left ventricular end diastolic-diameter (LVEDD), left ventricular ejection fraction (LVEF) using Simpson Biplane technique, degree of valvular regurgitation (mitral and tricuspid), and degree of probability of pulmonary hypertension as recommended by the guidelines.[25] Left atrial dilatation was defined based on left atrial anteroposterior diameter of >4.0 cm in males or >3.8 cm in females, or if LAVI is ≥35 ml/m2. Left ventricular dilatation was defined as LVEDD divided by body surface area (BSA) of ≥3.1 cm/m2 in males or ≥3.2 cm/m2 in females. Left ventricular dysfunction was defined as LVEF <50%. Left ventricular function improvement was defined as those who initially have left ventricular dysfunction with a final LVEF of ≥50% during follow-up.

Data collection and follow-up

The baseline clinical data analyzed in this study

Table 1. Baseline Characteristics.

Baseline	HBP n = 35	LBBAP n = 31	p Value
Age (years)	57.00 ± 16.15	57.68 ± 17.45	0.404
Gender			
Male	21 (60.0%)	11 (35.5%)	
Female	14 (40.0%)	20 (64.5%)	
CSP indication			0.177
	33 (94.3%)	31 (100%)	
Symptomatic Bradycardia	2 (5.7%)	0 (0%)	
Resynchronization therapy			
Pacemaker chambers			0.258
Single	9 (25.7%)	12 (38.7%)	
Dual	26 (74.3%)	19 (61.3%)	
History of pacemaker			0.197
No history of pacemaker	19 (54.3%)	10 (32.3%)	
Temporary Pacemaker	12 (34.3%)	16 (51.6%)	
Permanent Pacemaker	4 (11.4%)	5 (16.1%)	
QRS duration (ms)	124.63 ± 33.36	121.94 ± 32.91	0.981

CSP = conduction system pacing
*P value <0.05

included the history of pacemaker implantation (temporary or permanent pacemaker) and QRS complex duration (ms) obtained from 12 lead ECGs. For patients with LV dysfunction, additional data regarding doses of guideline-directed medical including angiotensin-converting enzyme (ACE) inhibitor, angiotensin receptor blocker (ARB), angiotensin receptor/neprilysin inhibitor (ARNI), beta-blocker (BB), mineralocorticoid receptor antagonist (MRA), and sodium-glucose cotransporter 2 (SGLT-2) inhibitor were collected.

Statistical analysis

Descriptive statistics were used to summarize the data. Categorical data were presented as frequencies and percentages. The normality test using the Kolmogorov-Smirnov test was performed on continuous data. Normally distributed data were presented as mean and standard deviation. Otherwise, the data were presented in the median and interquartile range. Continuous data were compared with a 2-tailed Student's t-test, while categorical data were analyzed using a Chi-square ($\chi 2$) test. A p-value of <0.05 was considered statistically significant. The statistical analysis was conducted using SPSS 29.0 software (SPSS, Inc., Chicago, Illinois.)

Results

Baseline clinical characteristics

From the final 66 patients, 35 patients (53%) had HBP implantation, while the other 31 (47%) patients had LBBAP implantation (Table 1). There was no significant age difference between both groups, and only 2 patients (5.7%) from the HBP group underwent the procedure as a resynchronization therapy for heart failure. More than half of the patients from each group had dual-chamber pacemakers. A considerable number of patients from the LBBAP group had a history of previous pacemaker implantation (67.7%, p=0.197). Both groups had a wide QRS complex duration at baseline (124.63 ± 33.36 ms in HBP vs. 121.94 ± 32.91 ms in LBBAP group, p=0.981).

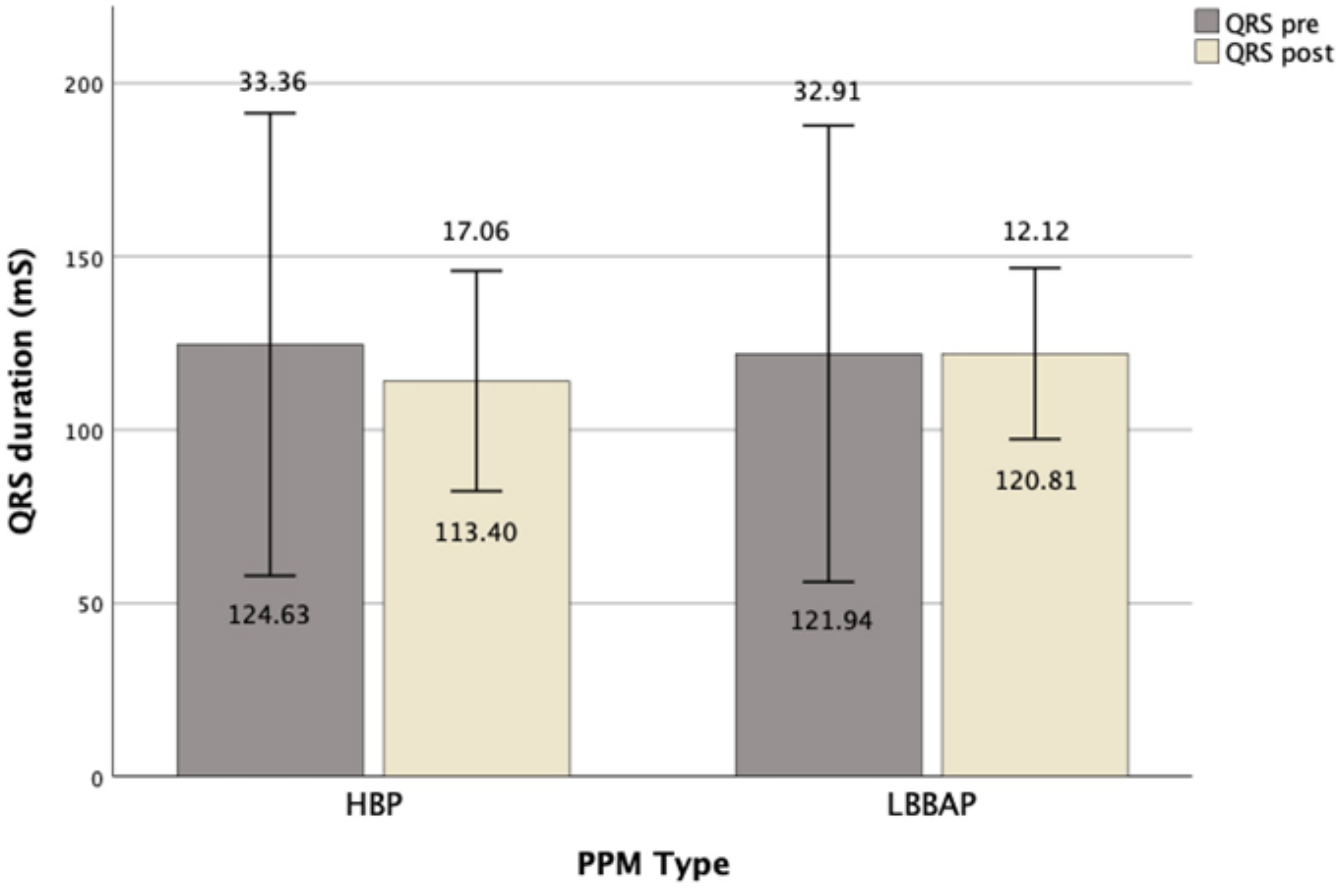

Figure 2. QRS duration before and after CSP implantation. HBP = His Bundle Pacing; LBBAP = Left Bundle Branch Area Pacing; PPM = Permanent Pacemaker.

Baseline echocardiography parameters

From the baseline data of echocardiography parameters measured before PPM implantation, the majority of patients in either the HBP or LBBAP group had a normal LA and LV size, with a higher mean of LVEF in the HBP group (51.2 ± 13.9% vs. 45.6 ± 11.1%, p=0.078) (Table 2). Most patients had a normal or mild degree of mitral regurgitation or tricuspid valve regurgitation along with a low or intermediate probability of pulmonary hypertension.

After pacemaker implantation, the HBP group had a shorter mean QRS duration compared to LBBAP group (113.40 ± 17.06 ms vs 120.81 ± 12.12 ms, p=0.029) (Figure 2).

Compared with baseline, the mean LVEF was increased in the LBBAP group (45.6 ± 11.1% to 53.1% ± 11.7%, p = 0.536), while in the HBP group the mean LVEF remained preserved (51.2 ± 13.9% to 53.9 ± 11.45%) (Figure 3).

Patients with left ventricular dysfunction

Subgroup analysis was performed for patients with LV dysfunction. The majority of patients receiving HBP had no history of previous pacemaker implantation (69.2%), while only 25% of patients in the LBBAP group had neither history of temporary nor permanent pacemaker implantation, respectively. There was a reduction in QRS duration in the HBP group, while in the LBBAP group, the QRS duration was relatively similar. At the end of follow-up, 38.5% of patients in the HBP group and 50% in the LBBAP group had LVEF improvement (p=0.515).

Table 2. Baseline Echocardiographic Parameters.

Echocardiographic parameters	HBP n = 35	LBBAP n = 31	p Value
LA Size (mm)	38.9 ± 8.4	36.1 ± 10.1	0.236
LAVI (ml/m2)	41.6 ± 34.3	34.3 ± 20.3	0.302
LVEDd (mm)	48.5 ± 7.4	49.6 ± 9.1	0.623
LV dilatation			
Yes	13 (37.1%)	13 (41.9%)	0.691
No	22 (62.9%)	18 (58.1%)	
LA dilatation			0.805
Yes	17 (48.6%)	16 (51.6%)	
No	18 (51.4%)	15 (48.4%)	
LVEF (%)	51.2 ± 13.9	45.6 ± 11.1	0.078
EF			0.026*
Preserved EF	22 (62.9%)	11 (35.5%)	
Reduced EF	13 (37.1%)	20 (64.5%)	
Mitral regurgitation			
No	23 (65.7%)	24 (77.4%)	0.739
Mild	9 (25.7%)	5 (16.1%)	
Moderate	2 (5.7%)	1 (3.2%)	
Severe	1 (2.9%)	1 (3.2%)	
Tricuspid regurgitation			
No	22 (62.9%)	21 (67.7%)	0.803
Mild	8 (22.9%)	7 (22.6%)	
Moderate	4 (11.4%)	3 (9.7%)	
Severe	1 (2.9%)	0 (0%)	
Probability of pulmonary hypertension			
Low	23 (65.7%)	20 (64.5%)	0.962
Intermediate	7 (20.0%)	7 (22.6%)	
High	5 (14.3%)	4 (12.9%)	

EF = ejection fraction; LAVI = left atrial volume index; LA = left atrium; LV = left ventricle; LVEDd = left ventricular end diastolic dimension; LVEF = left ventricular ejection fraction

The majority of patients in the HBP group receive no or less than 50% of the recommended dose of the guideline medical therapies, while in the LBBAP group, more patients received adequate doses of renin-angiotensin-aldosterone system (RAAS) blockers (ACE-I, ARB, or ARNI) and MRA.

Discussion

CSP recently has become the main option for the type of PPM especially to prevent the occurrence of pacemaker-induced cardiomyopathy in patients anticipated to have substantial right ventricular pacing.[2-4] Despite the absence of a clear head-to-head comparison between HBP and LBBAP implantation in terms of LV

Table 3. QRS Duration and Echocardiographic Parameters after Pacemaker Implantation.

Echocardiographic parameters	HBP n = 35	LBBAP n = 31	p Value
Mean follow up (months)	6.33	4.81	0.316
QRS duration (ms)	113.40 ± 17.06	120.81 ± 12.12	0.029*
Pacing selectivity			
Selective	18 (51.4%)	25 (80.6%)	0.013*
Nonselective	17 (48.6%)	6 (19.4%)	
LA Size (mm)	36.2 ± 7.0	37.3 ± 8.6	0.574
LAVI (ml/m2)	37.1 ± 24.8	35.9 ± 16.7	0.815
LVEDD (mm)	47.3 ± 7.9	47.6 ± 7.5	0.902
LV dilatation			0.579
Yes	6 (17.1%)	7 (22.6%)	
No	29 (82.9%)	24 (77.4%)	
LA dilatation			0.782
Yes	17 (48.6%)	14 (45.2%)	
No	18 (51.4%)	17 (54.8%)	
LVEF	53.9 ± 11.5	53.1 ± 11.7	0.536
Ejection fraction			0.558
Preserved EF	26 (74.3%)	21 (67.7%)	
Reduced EF	9 (25.7%)	10 (32.3%)	
Mitral regurgitation			0.472
No	27 (77.1%)	21 (67.7%)	
Mild	7 (20.0%)	7 (22.6%)	
Moderate	0 (0.0%)	2 (6.5%)	
Severe	1 (2.9%)	1 (3.2%)	
Tricuspid regurgitation			0.406
No	28 (80.0%)	21 (67.7%)	
Mild	5 (14.3%)	9 (29.0%)	
Moderate	1 (2.9%)	1 (3.2%)	
Severe	1 (2.9%)	0 (0%)	
Probability of pulmonary hypertension			0.248
Low	30 (85.7%)	29 (93.5%)	
Intermediate	3 (8.6%)	0 (0%)	
High	2 (5.7%)	2 (6.5%)	

EF = ejection fraction; LAVI = left atrial volume index; LA = left atrium; LV = left ventricle; LVEDd = left ventricular end diastolic dimension; LVEF = left ventricular ejection fraction

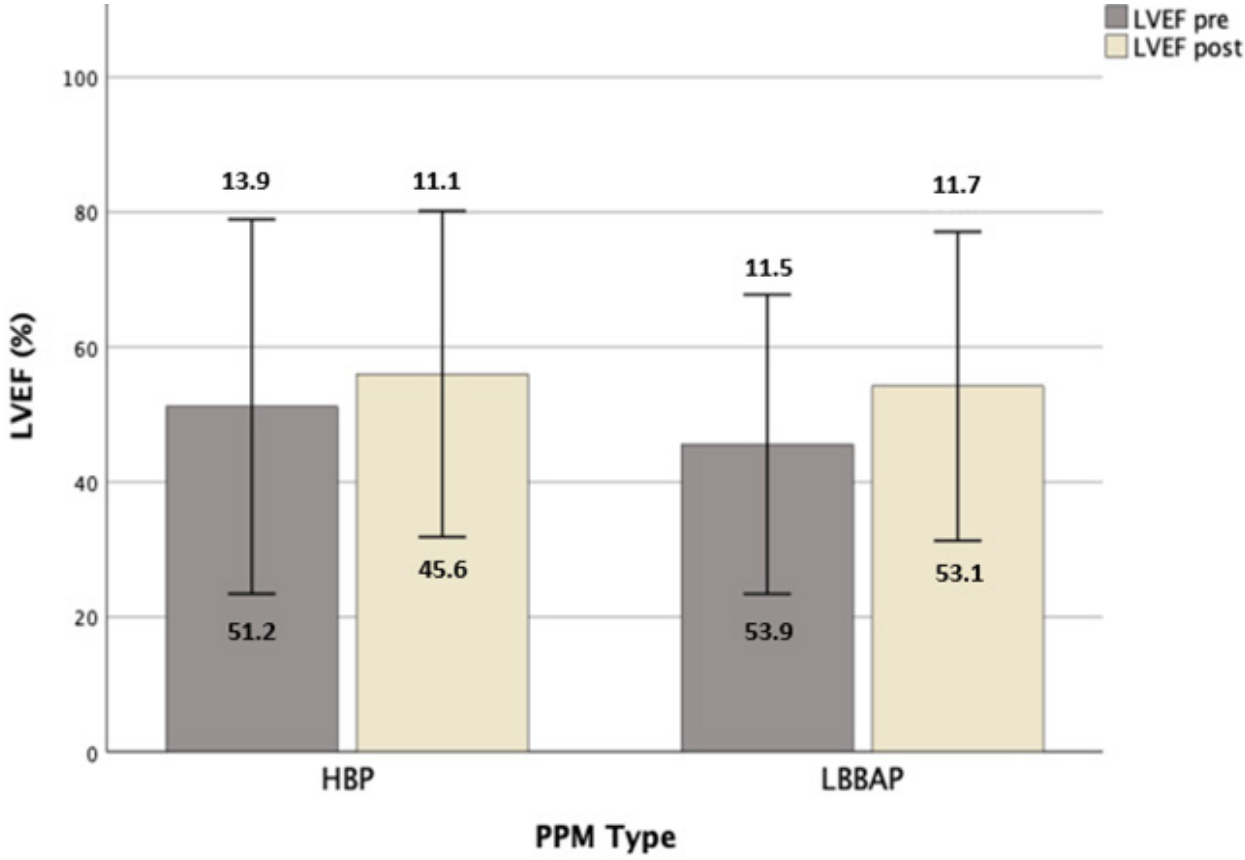

Figure 3. LVEF before and after CSP implantation. HBP = His Bundle Pacing; LBBAP = Left Bundle Branch Area Paci. PPM = Permanent Pacemaker: LBBAP = Left Bundle Branch Area Pacing.

function, more guidelines tend to recommend the use of HBP implantation instead of LBBAP.1,[18-20] This study involved 66 patients undergoing CSP implantation for symptomatic bradycardia or as a resynchronization therapy in HFrEF. From 35 patients in the HBP group (53%) and 31 patients in the LBBAP group (47%), there was no significant difference in terms of age with most of them having dual chamber pacemaker implantation (74.3% in HBP vs 61.3% in LBBAP, p=0.258). Both groups also have a similarly wide baseline QRS complex (124.63 ± 33.36ms in HBP vs 121.94 ± 32.91ms, p=0.981) (Table 1).

For the baseline echocardiography data, the HBP group has a relatively higher mean of LVEF compared to the LBBAP group (51.2 ± 13.9% vs 45.6 ± 11.1%, p=0.078) due to a higher number of patients having LV dysfunction in the LBBAP group (64.5% in LBBAP vs 37.1% in HBP, p=0.026). Despite having a lower mean LVEF baseline in the LBBAP group, most of the patients in this group have a normal LV dimension as well as normal or mild abnormalities of the mitral and tricuspid valves (Table 2), reflecting the possibility of acute LV dysfunction due electrical dyssynchrony resulted from a wide baseline QRS complex before CSP implantation. As shown by the previous study, a wide QRS complex, especially in patients with LBBB morphology, delayed regional electrical activation at the left posterobasal region of the left ventricle will result in loss of energy of the intraventricular septum for the late-developing lateral forces, leading to a reduction in cardiac output.[26]

Evaluation after HBP implantation showed a marked reduction in the QRS duration (113.40 ± 17.06ms) with a relatively similar QRS duration in the LBBAP group compared to baseline (120.81 ± 12.12ms, p=0.029) (Figure 2). This result is slightly different from data from a recent meta-analysis by Abidin et al. involving 9 studies which showed a slightly decreased QRS duration

Table 4. Subgroup Analysis on Patient with Left Ventricular Dysfunction.

Echocardiographic parameters	Pre PPM			Post PPM		
	HBP n = 13	LBBAP n = 20	p Value	HBP n = 13	LBBAP n = 20	p Value
Mean follow up (months)				5.00 ± 4.45	6.50 ± 4.16	0.332
Age	64.08 ± 8.98	63.35 ± 11.90	0.852			
Chambers pacing			0.963			
Single	4 (30.8%)	6 (30.0%)				
Dual	9 (69.2%)	14 (70.0%)				
Pacing selectivity			0.110			
Selective	7 (53.8%)	16 (80.0%)				
Nonselective	6 (46.2%)	4 (20.0%)				
Previous pacemaker						
No	9 (69.2%)	5 (25.0%)				
TPM	4 (30.8%)	11 (55.0%)	0.053			
PPM	0 (0%)	4 (20.0%)				
QRS duration	128.15 ± 41.04	129.05 ± 33.84	0.946	113.23 ± 19.50	123.35 ± 11.68	0.071
LVEF	35.3 ± 7.9	38.8 ± 6.9	0.197	44.5 ± 11.3	51.4 ± 13.1	0.135
ΔLVEF improvement (%)				10.9 ± 9.1	11.5 ± 12.5	0.887
LA dilatation						
No	10 (76.9%)	9 (45.0%)	0.070	12 (92.3%)	8 (40.0%)	0.003*
Yes	3 (23.1%)	11 (55.0%)		1 (7.7%)	12 (60.0%)	
LV dilatation						
No	3 (23.1%)	9 (45.0%)	0.201	8 (61.5%)	14 (70.0%)	0.614
Yes	10 (76.9%)	11 (55.0%)		5 (38.5%)	6 (30.0%)	
LVEDD	52.5 ± 7.6	52.5 ± 7.6	0.997	49.9 ± 9.6	48.7 ± 7.9	0.681
Mitral regurgitation						
No	6 (46.2%)	16 (80.0%)		8 (61.5%)	14 (70.0%)	
Mild	5 (38.5%)	3 (15.0%)	0.130	5 (38.5%)	5 (25.0%)	0.547
Moderate	2 (15.4%)	1 (5%)		0 (0%)	1 (5.0%)	
Severe	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
Tricuspid regurgitation						
No	5 (38.5%)	16 (80.0%)		9 (69.2%)	13 (65.0%)	
Mild	4 (30.8%)	3 (15.0%)	0.081	2 (15.4%)	6 (30.0%)	0.503
Moderate	3 (23.1%)	1 (5.0%)		1 (7.7%)	1 (5.0%)	
Severe	1 (7.7%)	0 (0%)		1 (7.7%)	0 (0%)	
Probability of PH						
Low	4 (30.8%)	14 (70.0%)		10 (76.9%)	18 (90.0%)	
Intermediate	5 (38.5%)	5 (25.0%)	0.046*	2 (15.4%)	0 (0%)	0.194
High	4 (30.8%)	1 (5.0%)		1 (7.7%)	2 (10.0%)	
Reduced E						
Yes				8 (61.5%)	10 (50.0%)	0.515
Improved LVEF						
Yes				5 (38.5%)	10 (50.0%)	0.515

EF = ejection fraction; LAVI = left atrial volume index; LA = left atrium; LV = left ventricle; LVEDd = left ventricular end diastolic dimension; LVEF = left ventricular ejection fraction; PH = pulmonary hypertension PPM = permanent pacemaker; TPM = temporary pacemaker;
*P value <0.05

Table 5. Guideline Medical Therapy in Patients with Left Ventricular Dysfunction.

Medication	HBP n = 13	LBBAP n = 20	p Value
No ACE-I/ARB	7 (53.8%)	7 (35.0%)	
ACE-I/ARB <50% target dose	5 (38.5%)	3 (15.0%)	0.035*
ACE-I/ARB ≥50% target dose	1 (7.7%)	10 (50.0%)	
No ARNI	11 (84.6%)	18 (90.0%)	
ARNI <50% target dose	1 (7.7%)	1 (5.0%)	0.898
ARNI ≥50% target dose	1 (7.7%)	1 (5.0%)	
No beta blocker	7 (53.8%)	7 (35.0%)	
Beta blocker <50% target dose	2 (15.4%)	7 (35.0%)	0.412
Beta blocker ≥50% target dose	4 (30.8%)	6 (30.0%)	
No MRA	8 (61.5%)	7 (35.0%)	
MRA <50% target dose	0 (0%)	1 (5%)	0.275
MRA ≥50% target dose	5 (38.5%)	12 (60.0%)	
SGLT2 inhibitor (no)	11 (84.6%)	19 (95.0%)	0.311
SGLT2 inhibitor (yes)	2 (15.4%)	1 (5.0%)	

ACE-I = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker; ARNI = angiotensin receptor neprilysin inhibitor; MRA = mineralocorticoid receptor antagonist; SGLT-2 = Sodium-Glucose Cotransporter 2.

in the paced rhythm compared to baseline in both HBP and LBBA group.[27] However if analyzed separately in the meta-analysis, only studies with a very wide QRS complex (≥140 ms) have a significant reduction in the QRS duration after CSP implantation, while baseline QRS duration of both HBP and LBBAP groups in this study are ±120ms.[27] Furthermore, in our study, patients who initially attempted to have HBP implantation but failed to correct the wide QRS complex would switch to LBBAP implantation in the hope of correcting more distal conduction abnormalities, resulting in a wide-paced rhythm QRS duration in the LBBAP group. However, despite a persistent wide QRS duration even after LBBAP implantation, there was a trend of LVEF improvement in the LBBAP group compared to baseline (45.6 ± 11.1% to 53.1 ± 11. 7) (Figure 1). This result may be explained by previous studies stating that not all wide QRS complexes lead to a reduction in cardiac output, and in this situation, resynchronization therapy would result in an improvement of LV function, even in patients with mechanical dyssynchrony despite having a narrow baseline QRS complex.[26,28-29]

Further analysis was carried out for patients with LV dysfunction. This subgroup has a higher mean of age (64.08 ± 8.98 years in HBP and 63.35 ± 11.090 years in LBBAP, p=0.852) compared with the overall mean age in this study (57.00 ± 16.15 years in HBP and 57.68 ± 17.45 years in LBBAP, p=0.404) (Table 4). In this subgroup analysis, similar results of a trend of QRS duration reduction in the HBP group (128.15 ± 43.02ms to 112.00 ± 21.10ms) with persistently wide QRS complex in the LBBAP group (125.13 ± 32.82ms to 122.07 ± 11.61ms) were found. These results were accompanied with a trend of LVEF improvement in both groups (35.3 ± 7.9% to 44.5 ± 11.3% in HBP group vs 44.5 ± 11.3% to 51.4 ± 13.1% in LBBAP group) with relatively similar value of delta LVEF improvement (10.9 ± 9.1% in HBP vs 11.5 ± 12.5% in LBBAP group, p=0.887) by the end of follow up (Table 4). Several reasons may explain the more dramatic LVEF improvement in the LBBAP group of this subgroup analysis compared to the HBP group. First, there were 2 patients in the HBP group who underwent HBP implantation as a form of resynchronization therapy. These patients were known to have significant coronary artery disease with several non-viable myocardial regions as assessed by imaging testing. Therefore, narrowing of the QRS duration may not lead to an LVEF improvement in these patients.

Second, despite a lower baseline of LVEF in the HBP group, more patients received less adequate doses of guideline-directed medical therapy compared with the LBBAP group (Table 5). Third, this subgroup analysis may be underpowered to truly show a significant improvement of LVEF in the HBP group due to the relatively small subjects in the HBP group compared to the LBBAP group. Lastly, previous meta-analysis stated that CSP may induce LVEF improvement after 6 months or even 12 months of follow-up, however in this subgroup analysis, the mean of follow-up in the HBP group of this subgroup analysis was only 5.00 ± 4.45 months, p=0.332 group, therefore LVEF improvement may not occur yet in all subjects of this group.[30-31]

Limitation

This study is a prospective cohort study with a small sample size and a relatively short duration of follow-up. A larger study with a longer follow-up duration may be needed to demonstrate a statistically significant difference in LV function after HBP and LBBAP implantation. This study also did not evaluate echocardiographic parameters for inter- and intraventricular dyssynchrony, which might be able to explain the trend of LVEF improvement despite a persistently wide QRS complex after LBBAP implantation. Even though it might be underpowered, this is the first study trying to further analyze the difference in LV function following HBP and LBBAP implantation in a subgroup of patients with underlying LV dysfunction. However, the inability to routinely evaluate coronary anatomy in this group may affect the result, especially regarding LVEF improvement. Nevertheless, the findings from this study provided additional information that LBBAP was comparable to HBP regarding improving and preserving LV function.

Conclusion

In this study, HBP resulted in a narrower QRS complex duration compared to LBBAP. However, both HBP and LBBAP groups showed a trend of LV function improvement in patients with preexisting LV dysfunction.

List of Abbreviations

ACE	Angiotensin-Converting Enzyme
ACE-I	Angiotensin-Converting Enzyme Inhibitor
ARB	Angiotensin Receptor Blocker
ARNI	Angiotensin Receptor/Neprilysin Inhibitor
BB	Beta-Blocker
CSP	Conduction System Pacing
EF	Ejection Fraction
HBP	His Bundle Pacing
LA	Left Atrium
LAVI	Left Atrial Volume Index
LBBAP	Left Bundle Branch Area Pacing
LV	Left Ventricle
LVEDd	Left Ventricular End Diastolic Dimension
LVEF	Eft ventricular Ejection Fraction
PH	Pulmonary Hypertension
PPM	Permanent Pacemaker
RAAS	Renin-Angiotensin-Aldosterone System
RVSP	Right Ventricular Septal Pacing
SGLT-2	Sodium-Glucose Cotransporter 2
TPM	Temporary Pacemaker

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