Original research article

SYSTOLIC AND DIASTOLIC FUNCTION IN LEFT BUNDLE BRANCH AREA PACING VS CONVENTIONAL RIGHT VENTRICULAR APICAL PACING IN PATIENTS WITH COMPLETE HEART BLOCK

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Received: 15-09-2023 / Revised: 20-10-2023 / Accepted: 25-11-2023

ABSTRACT

Aim: The present study was conducted to evaluate the systolic and diastolic function in left bundle branch area pacing vs conventional right ventricular pacing.

Methods: The study was performed at Burdwan Medical College & Hospital in the department of cardiology among patients requiring cardiac pacemaker. All patients were prospectively enrolled from October 2021 to March 2023 and provided written informed consent. 60 patients with cardiac pacemaker indications were enrolled and divided into the RVP group and the LBBP group. It was prospective observational study in which recruited patients underwent pacemaker implantation either by RVP or LBBAP group. The patients were then followed till discharge and follow-up to evaluate the outcome.

Results: A total of 60 consecutive patients were included. 30 patients received LBBAP , while 30 patients received RVP. The patients between the two groups had similar mean age, sex distribution, and other clinical characteristics except for the prevalence of paroxysmal atrial fibrillation (33.34 vs. 13.34%, P = 0.005). Baseline LVEF was also comparable between the LBBAP (61.7 ± 7.4) % and RVP (61.5 ± 6.4) % groups. Compared with RVP, LBBAP showed better sensing R wave amplitude, lower pacing impedance, and similar pacing threshold and significantly narrower QR Sd during the procedure and at the 6-month follow-up. The ventricular pacing percentage was comparable between these two groups (83.9 ± 35.1 vs. 85.7 ± 30.0%, P = 0.614). At the 1-year follow-up, the pacing threshold and sensing R wave amplitude were comparable between the two groups.

Conclusion: The results of this multicenter observational study indicate that LBBAP might be a preferable pacing modality to reduce potential HF compared with traditional RVP.

Keywords: atrioventricular block, left bundle branch area pacing, right ventricular pacing

INTRODUCTION

Hyman first introduced the concept of a pacemaker in 1932.[1] Since the first pacemaker, there has been no consensus on optimal location for placement of ventricular electrodes. Although previous studies have shown that traditional right ventricular apex pacing (RVAP) leads to interventricular and intraventricular dyssynchrony, this location also increases the risk of heart failure and atrial fibrillation.[2,3] Empirically, RVAP is still the most prolific approach for clinical pacemaker implantation. At present His bundle pacing (HBP) is considered to be the most physiological method. Compared with RVAP, HBP can maintain left and right ventricular electrical and mechanical relative synchronicities, and significantly reduce the incidence of heart failure and rehospitalisation rates in patients after pacemaker implantation.[3–5] However, due to the special anatomical structure of the His bundle, adjacent HBP has higher threshold and should lead to events such as abnormal sensing and atrial cross perception.

While left bundle branch area pacing (LBBaP) has been developed on the basis of HBP, LBBaP is able to overcome some of the clinical limitations of traditional HBP.[6-9] In 2017, Huang et al7 proposed the concept of LBBaP, and the results of LBBaP treatment in 210 patients with pacing indications were presented at the 2019 Heart Rhythm Society conference. The threshold was stable at 1-year of follow-up, and minor complications occurred in only five patients. No surgical complications such as lead dislocation, lead infection or stroke were reported at long term follow-up.[8] These data are suggestive that LBBaP is safe and feasible. While a retrospective trial comparing LBBaP and RVAP at 3 months follow-up showed stable pacing thresholds and no adverse events in both groups, the LBBaP group was associated with a narrower QRS duration compared with the RVAP group.[9]

The RV (Right Ventricular) apex has been the conventional site of pacemaker implantation since the early days of pacing. RVA pacing is generally very-well tolerated and effective. However, dyssynchronous contractility associated with RVA pacing can have detrimental effects on LV function, potentially resulting in myocardial perfusion abnormalities, atrial fibrillation and heart failure. The latter can be attributed to the abnormal mechanical and electrical activation pattern of the ventricles caused by RVA pacing.[10] Hence conventional right ventricular pacing (RVP) can result in left ventricular mechanical dyssynchrony and impaired cardiac function.[11] A previous study reported that the risk of HF death was increased by 8% at every 10% increase in RVP burden.[12]

Left bundle branch area pacing (LBBAP) has emerged recently as a new physiological pacing approach. LBBAP can achieve almost normal paced QRSd with a low and stable pacing threshold, good R wave sensing, and short procedure duration comparable to RVP6. LBBAP can also correct bundle branch block (BBB) in bradycardia patients7 and improve LV systolic function in patients with heart failure8.

The present study was conducted to evaluate the systolic and diastolic function in left bundle branch area pacing vs conventional right ventricular pacing.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 11, 2023

MATERIALS AND METHODS

The study was performed at Burdwan Medical College & Hospital in the department of cardiology among patients requiring cardiac pacemaker. All patients were prospectively enrolled from October 2021 to March 2023 and provided written informed consent. 60 patients with cardiac pacemaker indications were enrolled and divided into the RVP group and the LBBP group. The aetiology of pacemaker implantation included complete heart block with normal LVEF patients. It was prospective observational study in which recruited patients underwent pacemaker implantation either by RVP or LBBAP group. The patients were then followed till discharge and follow-up to evaluate the outcome.

Inclusion criteria:

Patients having complete heart block with presyncope/syncope.

Exclusion criteria:

(1) SSS, Bifascicular block, trifascicular block, LBBB with syncope

(2) Congenital heart diseases, such as atrial septal defect, ventricular septal defect, or rheumatic heart diseases, or valvular heart diseases; and

(3) Patients having compromise ejection fraction.

Implantation procedures

Left bundle branch pacing was achieved by the trans-interventricular septum method in the basal ventricular septum by using the 3830 Select pacing leads (Medtronic Inc., USA) delivered through a fixed sheath (7F C315 HIS, Medtronic Inc., USA). During implantation, a unipolar configuration was used for pacing and recording. The delivery sheath was inserted through the left subclavian vein into the atrial side of the tricuspid valve to mark the His bundle potential under fluoroscopic guidance with a right anterior oblique (20°) view. As a marker in the His bundle region, the sheath with the lead tip was further advanced towards the right side of the ventricular septum approximately 1.5–2 cm, and paced QRS morphology will show left bundle branch block (LBBB) at an output of 2 V/0.42 ms. When the sheath with the lead tip skewed to the left side of the septum, the paced QRS morphology changed from LBBB to right bundle branch block (RBBB), and a gradual change in the notch morphology ("W" waveform) in lead V1 gradually shifted and finally disappeared. LBB capture was confirmed by the following parameters:

a. Paced QRS had an RBBB pattern;

b. Left bundle potential could be recorded;

c. Pacing stimulus to left ventricular activation time (Sti-LVAT) shortened abruptly with increasing output or remaining shortest and constant both at low and high outputs; and

d. Selective LBBP.

The capture threshold and pacing impedance were routinely measured and recorded during the procedure. R-wave amplitudes were also routinely measured, and all of them were more than 5 mV. Another active electrode was implanted in the right auricle.

Patients with RVP: The right ventricular pacing lead was positioned in the low intervals of the right ventricular outflow tract, and an active atrial active lead will be positioned at the right auricle.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 11, 2023

ECG

Twelve-lead ECGs was recorded, including QRS duration (measured from the onset of the QRS complex to the end of the QRS complex before implantation and measured from the stimulus of the paced QRS complex to the end of the QRS complex 7 days after implantation), QRS amplitude (measured from the bottom of the QRS complex to the tip of QRS complex in lead V5 both on before implantation and 7 days after implantation) and QT interval (measured from the onset of the QRS complex to the end of the T wave before implantation and measured from the stimulus of paced the QRS complex to the end of the T wave 7 days after implantation). Two independent experienced cardiologists measured these parameters and took the average values.

Echocardiography

Data was measured by a conventional transthoracic echocardiography system and included early diastolic velocity at the septal mitral annulus (e'), peak E-wave velocity (E), peak A-wave velocity (A), E/A, E/e', left ventricular ejection fraction (LVEF).

DATA ANALYSIS:

Data will be collected and subjected to statistical analysis. Data will be tabulated and examined using the Statistical Package for Social Sciences Version 22.0 (IBM SPSS Statistics for Mac, Armonk, NY: IBM Corp, USA). Descriptive statistical analysis will be carried out in the present study. Results on continuous measurements will be presented as Mean±SD. Categorical data will be presented as frequency distribution. P-value of <0.05 will be considered as significant. Difference between two groups was determined using chi square test and student T test for categorical data and continuous data respectively.

RESULTS

Table 1: Baseline characteristics of patients

Variables	**LBBAP group (N = 30)**	**RVP group (N = 30)**	**P**
Age, years	63.3 ± 15	62.1 ± 17.2	0.575
Female, %	6 (40)	5 (33.34)	0.050
Paroxysmal atrial fibrillation, %	5 (33.34)	2 (13.34)	0.005
Hypertension, %	8 (53.34)	9 (60)	0.927
Diabetes, %	3 (20)	3 (20)	0.910
Coronary arterial disease, %	2 (13.34)	3 (20)	0.290
MI history, %	1 (6.66)	1 (6.66)	0.606
Dyslipidemia, %	1 (6.66)	0 (0.0)	0.085
Valvular heart disease, %	1 (6.66)	2 (13.34)	0.463
Baseline QRSd	115.9 ± 26.7	117.9 ± 27.9	0.514
Conduction disorders			
Complete heart block	30	30	0.05
Echo data			
Baseline LVEDD, mm	49.4 ± 6.6	49.6 ± 5.9	0.787
Baseline LVEF, %	61.7 ± 7.4	61.5 ± 6.4	0.738

Journal of Cardiovascular Disease Research
ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 11, 2023

Table 2: Pacing characteristics during the procedure and follow-up

Variables	LBBAP group (N = 30)	RVP group (N = 30)	P
Dual-chamber pacemaker	1(3.3)	15 (50)	1.000
Single chamber pacemaker	29(90.6)	15(50)	
During the procedure			
Sense, mV	12.4 ± 11.2	9.6 ± 5.7	0.013
Threshold, V/0.4ms	0.67 ± 0.23	0.66 ± 0.24	0.762
Impedance, Ω	757.2 ± 164.0	853.6 ± 258.5	<0.001
Paced QRSd, ms	114.2 ± 13.8	158.5 ± 25.5	<0.001
6 month follow up			
LVEF %	61.5± 7.2	58.6 ± 9.4	<0.001
Sense, mV	14.9 ± 5.4	11.7 ± 5.6	<0.001
Threshold, V/0.4ms	0.73 ± 0.25	0.65 ± 0.67	0.122
Impedance, Ω	577.1 ± 145.7	647.8 ± 184.0	<0.001
Paced QRSd, ms	112.5 ± 15.3	153.5 ± 32.6	<0.001
1 year follow up			
LVEF %	61± 7.1	54± 5.2	<0.001
Sense, mV	14.8 ± 4.8	13.0 ± 3.6	0.213
Threshold, V/0.4ms	0.8 ± 0.3	0.7 ± 0.2	0.180
Impedance, Ω	621.3 ± 149.0	771.2 ± 184.4	0.002
Paced QRSd, ms	112.3 ± 16.3	152.9 ± 40.8	<0.001
1 ½ year follow up			
LVEF	61± 6.2	50±5.1	<0.001
Sense, mV	14.9±6.2	13±5.2	<0.001
Threshold, V/0.4ms	0.79±0.24	0.90±0.86	<0.001
Impedance, Ω	600±140.3	900±190.0	<0.001
Paced QRSd, ms	114.5±14.6	154.6±33.5	<0.001
Complications			
Septal perforation during the procedure	1	0	0.172
Septal or apical perforation after procedure	1	1	0.668
Dislocation during follow-up	0	2	0.114

The mean follow-up duration was 13.4 ± 2.7 months. The result shows the pacing parameters and complications during the procedure and follow-up. Compared with RVP, LBBAP showed better sensing R wave amplitude, lower pacing impedance, and similar pacing threshold and significantly narrower QRSd during the procedure and at the 6-month follow-up. The ventricular pacing percentage was comparable between these two groups (83.9 ± 35.1 vs. 85.7 ± 30.0%, P = 0.614). At the 1-year follow-up, the pacing threshold and sensing R wave amplitude were comparable between the two groups. The lower pacing impedance and narrowerQRSd (112.3±16.3 vs. 152.9±40.8ms, P < 0.001) remained in the LBBAP group. The complications in the LBBAP group were similar to those in the RVP group. Even though five patients (2.1%) suffered septal perforation during the procedure, the perforation did not cause any symptoms. Only one septal perforation occurred 2 h after the procedure and resulted in dislodgement and ventricular capture failure. After repositioning the pacing lead, most patients underwent successful LBBAP with uneventful recovery. Lead perforations or dislodgement was not found following hospital discharge. In the RVP group, apical perforation occurred in one patient, ventricular lead dislocation occurred in one patient during follow-up, and all patients underwent uneventful lead revision.

Table 3: Echocardiographic measures at baseline and during follow-up

Variables	**LBBAP group (N = 30)**	**RVP group (N = 30)**	**P**
Baseline			
LVEDD, mm	49.4 ± 6.6	49.6 ± 5.9	0.787
LVEF, %	61.7 ± 7.4	61.5 ± 6.4	0.738
6 month follow up			
LVEDD, mm	48.4 ± 6.5	49.4 ± 6.5	0.435
LVEF, %	61.2 ± 6.7	58.6 ± 9.4	0.045
One year follow up			
LVEDD, mm	48.6 ± 5.2	51.7 ± 7.5	0.005
LVEF, %	62.6 ± 4.6	54±5.2	0.004
1 ½ year follow up			
LVEDD,mm	49.7±4.2	52±4.2	<0.001
LVEF	61± 6.2	50±5.1	<0.001

Compared with baseline, patients with LBBAP had stable LVEF and slightly decreased LVEDD at the 1-year follow-up. In contrast, patients with RVP had gradually decreased LVEF and significantly increased LVEDD from baseline to 6 months and at 1-year follow-up and one and half year followup.

Table 4: Clinical outcomes evaluation

Variables	**LBBAP group (N = 30)**	**RVP group (N = 30)**	**P**
HF hospitalization, N (%)	1 (6.66)	2 (13.34)	<0.001
Upgrade to BiVP, N (%)	0	1 (6.66)	0.011

The primary composite endpoint of HF hospitalization and upgrading to BiVP was 2.6% in the LBBAP group and 10.8% in the RVP group (P < 0.001. Among patients who suffered HF hospitalization, upgrading to BiVP occurred in four patients in the RVP group during three to nine months of follow-up compared with zero patients in the LBBAP group.

DISCUSSION

This multicenter prospective study demonstrated that permanent LBBAP presented stable pacing parameters and procedural complications similar to RVP during a 1 and ½ year follow-up. In patients with normal cardiac function and a high burden of VP, LBBAP achieved preserved LVEF and reduced LVEDD, while RVP resulted in reduced LVEF and enlarged LVEDD. Patients with LBBAP had a significant reduction in HF hospitalization events (including upgrading to BiVP) compared with conventional RVP (central illustration). The effect of LBBAP was seen predominantly in patients with VP >40%, patients with LVEF ≤60%, or patients with baseline organic cardiac disease or AF. LBBAP was an independent predictor for a reduced risk. A recent study [16] indicated that an RVP > 20% is an independent risk factor for pacing-induced cardiomyopathy in AVB patients with baseline preserved LV function during a mean follow-up of 4.3 years. His bundle pacing is effective in preventing ventricular dyssynchrony and can reduce the risk of death, HF hospitalization, or upgrading to BiVP by 35% in patients with a VP burden of >20%.[17]

His bundle pacing (HBP) is foreseen as the most physiological method.[18] Compared with traditional right ventricular apex pacing, HBP significantly reduced the incidence of heart failure, mortality and morbidity.[17] Furthermore, in patients with reduced systolic function and left bundle branch block (LBBB), HBP ameliorates quality of life. During societal development, the incidence of heart failure has increased.[19] Heart failure is the end stage of all kinds of cardiac diseases and is correlated with elevated rates of hospitalization, mortality and morbidity. Heart failure is related to LBBB.[20] As the cardiac conduction system works, LBBB results in left ventricular delays in contraction and left and right ventricle desynchronisation, which leads to heart failure. Biventricular pacing (Bi-V) is an advanced choice for correcting these conduction abnormalities.[21] LBBAP can pace the conduction system beyond pathological or disease-vulnerable regions to produce nearly physiological ventricular capture. In recent studies, LBBAP generally achieves paced QRSd within 130ms, mostly between 110 and 120ms.[9,14,15,22,23] This study verified the narrower-paced QRSd by LBBAP at the 1-year follow-up in patients with a high VP burden. Because the capture thresholds of His bundle pacing might be unstable and increase during long-term follow-up, the long-term stability of low pacing thresholds of LBBAP has been questioned.[24] A previous study [25] reported comparable R wave amplitudes and pacing thresholds between LBBAP and RVP at the 6-month follow-up. Our study confirmed the low and stable pacing thresholds of LBBAP at the 1-year follow-up and similar sensing amplitudes to those of RVP in patients with AVB and a high burden of VP. Although our previous study showed similar success rates of LBBAP (91.3%) to His bundle pacing (87.2%), successful LBBAP appears to be easily achieved with increasing procedure experience.[26] LBBAP could achieve LV synchrony and preserve LV function in bradycardia patients with normal cardiac function.[27] A recent study[28] evaluated the systolic dyssynchrony index and the standard deviation of time-to-peak contraction velocity in LV 12 segments among native-conduction mode, LBBAP, and RVP situations and found that the LV synchrony of LBBAP is similar to that of native-conduction mode and superior to that of RV septal pacing. LBBAP could correct left bundle branch block (LBBB) and deliver cardiac resynchronization therapy (CRT) to effectively improve LV function and reduce HF symptoms in patients with HF and LBBB.[29]

The main limitation of this study is the observational study design. The clinical homogeneity of patients could not be guaranteed between LBBAP and RVP. However, the higher prevalence of atrial fibrillation in the LBBAP group further demonstrated the potential benefit of LBBAP compared with RVP. Second, the relatively small sample size and the high percentage of RVAP in the RVP group might contribute to the difference in the clinical outcomes between RVP and LBBAP. Third, the clinical outcomes of all-cause death or cardiovascular death during longer follow-up may provide more solid evidence for the superiority of LBBAP. Therefore, future prospective randomized clinical trials with a large sample size are needed in patients with a high burden of VP.

CONCLUSION

The results of this multicenter observational study indicate that LBBAP might be a preferable pacing modality to reduce potential HF events in patients requiring a high burden of VP compared with traditional RVP.

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