Early Deleterious Effects of Right Ventricular Lower Septal Pacing on Left Ventricular Diastolic Function in Patients with Preserved Ejection Fraction

Ch. Muhammad Kalimullah,[1] Abdual Mannan,[2] Sohail Yousaf,[3] Muhammad Ejaz,[4] Syed Asif Ali,[5] Sami Ullah Mumtaz[6]

Abstract

Objective: To determine the effect of right ventricle lower septal pacing on left ventricle diastolic function in patients with preserved ejection fraction (EF).

Methods: This prospective observational study was done at Punjab Institute of Cardiology, Lahore (PIC), Lahore from July to September 2018.After ethical approval, 54 patients who presented in PIC emergency with hemodynamically significant bradyarrthymias requiring temporary pacemaker (TPM) were selected for this study. Baseline echocardiography was performed to measure baseline diastolic function. All patients were then divided into grade I, II & III diastolic dysfunction. Permanent pacemaker (PPM) was implanted positioning the pacemaker lead in lower septum. After 3 months, a follow up echocardiography was done to see the effect of pacemaker stimulation at lower septum on diastolic function.

Results: Mean age of the patients was 55.13+12.92 years. There were 29 (53.7%) males and 25 (46.3%) females. Diabetes Mellitus was present in 19 (35.18%) & Hypertension in 31 (51.4%) patients. 11 (20%) patients were smokers. Baseline echocardiography showed 46 (85.1%) patients had normal diastolic function, 7 (13%) patients with Grade 1 and 1 (1.9%) patient had grade II diastolic dysfunction. No patient had grade III diastolic dysfunction. After 3 months of right ventricle permanent pacemaker stimulation at lower septum, diastolic dysfunction was found in 40 (74.07%) patients. 16 (29.6%) patients had grade I, 21(38.9%) patients grade II, and 3 (5.5%) patients showed grade III diastolic dysfunction. Frequencies of grade-I and grade-II diastolic dysfunctions were statistically higher at the follow-up of three months (p =0.034 & <0.0001 respectively).

Conclusion: In patients with preserved EF, right ventricular lower septal pacing is associated with deterioration of left ventricular diastolic function.

Keywords: right ventricular septal pacing, diastole, diastolic dysfunction, dyssynchrony, ejection fraction.

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Introduction

Ventricular pacing is the only effective management option for symptomatic bradyarrhythmias like sick sinus syndrome (SSS), third degree heart block (CHB) and other atrioventricular (AV) blocks. In ventricular pacing, the pacemaker lead is usually placed at the right ventricle apex (RVA) and in some cases in right ventricle outflow tract (RVOT). Many observational studies and pacing mode selection trials showed that, conventional pacing with lead in right ventricle apex may cause deleterious effects on left ventricular systolic and diastolic functions leading to development of heart failure.[1] For the effective functioning of heart, all 4 chambers must work together and contract in a coordinated manner and at correct time in order to pump blood to various parts of body.[2] Both intraventricular and interventricular dyssynchrony have detrimental effects on cardiac output. These deleterious effects may be caused by the ventricular dyssynchrony as a result of RVA stimulation by pacing lead resulting in systolic

1. Ch. Muhammad Kalimullah
2. Abdual Mannan
3. Sohail Yousaf
4. Muhammad Ejaz
5. Syed Asif Ali
6. Sami Ullah Mumtaz

1-5: Punjab Institute of Cardiology, Lahore.
6. *King Edward Medical University, Mayo hospital, Lahore*

Correspondence:
Ch. Muhammad Kalimullah, *Senior Registrar, Punjab Institute of Cardiology, Lahore. E-mail:- kelvinkalim119@hotmail.com*

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dysfunction leading to heart failure.[3]

However right ventricle pacing can also result in diastolic dysfunction of heart leading to heart failure with preserved ejection fraction (HFpEF). In this condition, patients develop heart failure with normal well preserved ejection fraction i.e. EF > 50%.[4] Diastolic dysfunction without signs and symptoms of heart failure is much more common than HFpEF. Thus, it is important to have diastolic dysfunction on echocardiography and an EF ≥ 50 percent does not indicate HFpEF unless the clinical syndrome of HF is present. The diastolic dysfunction increases with age and the development or progression of diastolic dysfunction may end up with increased risk of HF.[5-8]

Left ventricular diastolic function is closely related with systolic function that's why it is equally important prognostically. It depends on the compliance, septal and lateral annulus recoil and stiffness of the ventricles.[9] Left ventricular filling occurs in diastole. If diastolic function is compromised, ventricular filling is affected. There are many studies which have well established the RV pacing effect on systolic dysfunction but very few studies done to show the RV pacing affects the diastolic dysfunction of left ventricle (LV).Similarly the lower septal position has not been discussed that much. The available studies couldn't give us a clear conclusion on the effects of RV pacing on LV diastolic function.[10-13] Therefore we conducted this study to find out the effect of RV Lower septal pacing on diastolic function of the heart in our local Pakistani population with symptomatic bradyarrhythmias having permanent pacemaker implanted with preserved LV ejection fraction.

Materials and Methods

This prospective observational study was conducted at Punjab Institute of Cardiology, Lahore for 03 months i.e. July to September 2018. After ethical approval of the study, 54 patients of age 30-80 years with either gender having hemodynamically significant bradyarrthymias requiring temporary pacemaker (TPM) were included in the study from emergency department PIC Lahore. All patients having pre-existing heart failure with reduced ejection fraction (HFrEF) i.e. <50%, atrial fibrillation during echocardiography and significant valvular abnormalities were excluded from the study. Informed consent was taken from all the patients for the study. All patients had echocardiography on admission with Vivid-7 pro machine (3 MHz multi frequency probe) according to the standard protocol equipped with tissue Doppler imaging (TDI) technology. Apical 4 and 2-chamber views with Modified Simpson's method was used to calculate left ventricular ejection fraction (LVEF) taking 50% as preserved. Diastolic parameters measured were: E/A ratio (N=0.75-1.5), where E=peak velocity of early diastolic filling and A=late filling by atrial contraction, E-wave deceleration time (DT), which is the time from peak E inflow velocity to decay to zero with reference value 140 to 240ms.c), Mitral annular septal early diastolic velocity by tissue Doppler imaging (ETDI) (E′) with normal value over 8 cm/s. d), the E/E′ (N=10-15) which is the ratio of early mitral inflow velocity (E) to mitral annular early diastolic velocity(E′), diastolic dysfunction is observed over a ratio of 15. Based on these echocardiography diastolic parameters, all patients were then divided into 3 grades of diastolic dysfunction. Grade I (impaired relaxation) diastolic dysfunction was labeled when E/A ratio was <1.0 and deceleration time of the E wave was prolonged > 200ms. Similarly the E/E' ratio was normal. Grade II (pseudonormal) was labeled when E/A ratio (0.8+ 1.5) and deceleration time were normal (160-200 ms), however the E/E' ratio was elevated'. Grade III (reversible restrictive) was labeled when E/A ratio was > 2.0, the deceleration time was < 160 ms, and the E/E' ratio was elevated. Patients were then implanted permanent pacemaker with right ventricle lead in lower septum in electrophysiological department of PIC Lahore. The pacemaker used was Medtronic SensiaSesr 01 (USA) single chamber pacemaker, and St. Jude Medical Endurity MRI pm 212 dual chamber pacemaker. A follow up echocardiography was performed at 3 months of permanent pacemaker insertion to see changes in diastolic parameters. SPSS version 21 was used for entering and analyzing the data. To compare echocardiographic parameters difference of both study groups paired sample t-test was applied. The frequencies of diastolic dysfunction grades were compared by chai square test.

Results

The mean age of the patients was 55.13+12.92 years. Among 54 patients, 29 (53.7%) were males and 25 (46.3%) were females. Diabetes Mellitus were present in 19(35.18%) and Hypertension in 31(51.4%) patients. 11(20%) patients were smokers. Baseline echocardiography showed 46 (85.1%) patients had normal diastolic function, 7 (13%) patients with Grade 1 and 1(1.9%) patient had grade II diastolic dysfunction. No patient had grade III diastolic dysfunction. All patients had normal baseline systolic function as evidenced by preserved LVEF (>50%). After 3 months of right ventricle permanent pacemaker stimulation at lower septum, diastolic dysfunction was found in 40 (74.07%) of patients. 16 (29.6%) patients had grade I, 21 (38.9%) patients grade II, and 3 (5.5%) patients showed grade III diastolic dysfunction. 14 (25.9%) patients had normal diastolic function. Deterioration of diastolic dysfunction

occurred from grade 1 to grade III in patients who had preexisting diastolic dysfunction. The difference in

Table 1: *Echocardiographic Diastolic Parameters at Baseline and 3months*

Echocardiographic Diastolic Dysfunction Parameters	Baseline On TPM	PPM 3 Months	p-value
E/A	1.13±0.28	1.08±0.40	0.454
DT (ms)	251±24.79	236.93±31.66	0.012
ETDI (cm/sec)	7.98±1.56	6.00±1.54	<0.0000001
E/E′	6.80±1.9	10.02±3.65	0.0000002

Table 2: *Comparison of Diastolic Dysfunction at Baseline And 3 Months*

Diastolic Dysfunction	Baseline-TPM Group N=54	PPM Group N= 54	p-value
Normal	46(85.1%)	14 (25.9%)	<0.0001
Grade- I (Impaired relaxation)	7(13.0%)	16 (29.6%)	0.034
Grade- II (LV Pseudonormalisation)	1(1.9%)	21(38.9%)	<0.0001
Grade- III (Left Ventricle Restriction)	0	3(5.5%)	0.2422

frequencies of diastolic dysfunction grade I and II at baseline and 3months follow up echocardiography was significant. (P=0.034 and P=<0.0001 respectively).

Discussion

In our study deterioration of diastolic dysfunction occurred from grade 1 to grade III in patients who had preexisting diastolic dysfunction. Most of the literature review showed the influence of pacemaker lead position on systolic functions, and only few studies showed influence on diastolic function which is equally important. Liberman et al studied changes in LV relaxation in patients with normal and decreased ejection fraction, with pacemaker leads in RVOT and RVA and concluded that pacemaker stimulation from either of these positions worsens the hemodynamic characteristics of left ventricle.[14] Other similar studies also found diastolic dysfunction in pacemaker stimulation from RVA.[15] On the other hand pacemaker stimulation from the apex was a strong predictor of LV diastolic dysfunction as shown on echocardiography.[16]

In another study Fang F et.al concluded that patients with preserved ejection fraction, pacemaker stimulation of right ventricle by placing lead in apex have deleterious effects on both systolic and diastolic function of LV, which is particularly more prominent in those patients having already existing LV diastolic dysfunction by causing systolic dyssynchrony and they suggested RVOT position of the lead as a solution.[17] But Mitov V et al in a study concluded that in patients with preserved LVEF right ventricle pacing by placing lead in RVOT causes diastolic dysfunction. This deleterious effect of pacemaker stimulation from RVOT on diastolic function was also confirmed by two modalities, echocardiography and radionuclide ventriculography (RNV).[18]

Above mentioned studies showed stimulation of both right ventricle apex as well as RVOT causes diastolic dysfunction of left ventricle. So in this study frequency of development of diastolic dysfunction with pacing lead in lower septum was quite higher than observed in previous studies with leads in RVA and RVOT. It was quite significant because patients with diastolic dysfunction were at risk of developing diastolic heart failure and even systolic heart failure in future. Underlying mechanism of developing diastolic dysfunction by permanent pacemaker is most probably lower septal pacing induced LV dyssynchrony. Right ventricle septal pacing can induce both interventricular, as well as intraventricular dyssynchrony. Left ventricle dyssynchrony slowed the left ventricular relaxation process and prolonged the isovolumetric relaxation time leading to decreased E′. The delayed LV relaxation and the increased LV filling pressure as shown by increased E/E′ resulted in left atrial compensatory contraction.[19-20] Therefore diastolic parameters are strong prognostic markers that give us an un-doubtful prognosis.

There were few limitations of our study; Firstly it was a single centered study, secondly our study included most of the elderly patients with complete heart block (CHB), which is caused by degenerative changes in conduction pathways, which requires high degree pacing (95%). Thirdly elderly patients are prone to diastolic dysfunction by any invasive cardiac procedure other than pacing.

Conclusion

Right ventricle pacemaker stimulation with pacing lead in lower septum is associated with very early deterioration of LV diastolic function.

Conmflict of Interest

None

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Authors Contribution

KMC: Conceptualization of Project
KMC, : Data Collection
YS, EM: Literature Search
KMC, AAS: Statistical Analysis
KMC : Drafting, Revision
YS, EM: Writing of Manuscript