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Right ventricular apical pacing vs. right ventricular septal pacing: short- and intermediate-term effects on echocardiographic indices, left ventricular function, and clinical outcomes

Porównanie stymulacji koniuszkowej i przegrodowej prawej komory: wpływ na wskaźniki echokardiograficzne, czynność lewej komory i efekty kliniczne w obserwacji krótko- i średniookresowej

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Abstract

Introduction. Right ventricular apical pacing (RVAP) has a greater 'desynchronizing effect' than pacing from the interventricular septum (RVSP) and may translate into worse outcomes in the long run. The aim of the present study was to examine the short- and intermediate-term effects of RVAP versus RVSP on echocardiographic features, left ventricular function, and clinical outcome.

Materials and methods. 467 patients between August 2014 and March 2018 without structural heart disease were prospectively randomised to RVAP (N = 226) or RVSP (N = 241) and were studied at baseline, six months, and 12 months by echocardiography, biochemically [N-terminal pro-B-type natriuretic peptide (NT-proBNP)], and clinically [six-minute walk test (6MWT)]. Left ventricular 2D strain and tissue velocity images were analysed to measure 18-segment time-to-peak longitudinal systolic strain and 12-segment time-to-peak systolic tissue velocity. **Intra**ventricular dyssynchrony was calculated using tissue Doppler velocity data by comparing the time to systolic peak velocity between segments in multiple apical views by their respective standard deviations. **Inter**ventricular dyssynchrony was measured as the temporal difference of left ventricular pre-ejection period and right ventricular pre-ejection period by pulse-wave Doppler images. All the analysis was carried out using statistical package for social service version 17.0 (SPSS Inc., Chicago, IL, USA). A p-value < 0.05 was considered statistically significant.

Results. The commonest indication for pacemaker implantation was atrioventricular block (N = 311, 66.6%), followed by sinus node dysfunction (N = 138, 29.5%) and chronic bifascicular and trifascicular block (N = 18, 3.9%), with all patients receiving a single chamber pacemaker (VVI: n = 107, 22.9% and VVIR: n = 360,77.1%). There were significant differences in NT-proBNP level (410 ± 254 pg/mL vs. 370 ± 168 pg/mL, p = 0.02), 6MWT (442 ± 19 m vs. 482 ± 21 m, p = 0.01), mean QRS duration (164 ± 8.3 ms vs. 148 ± 10.6 ms, p = 0.02), intraventricular dyssynchrony (septal to lateral wall delay: 88.6 ± 24.2 ms vs. 43.7 ± 11.2 ms, p = 0.04), interventricular dyssynchrony (31.2 ± 22.8 vs. 19.4 ± ± 11.2, 0 = 0.03), end diastolic volume (78.4 ± 15.6 mL vs. 72.8 ± 14.2 mL, p = 0.04), and end-systolic volume (30.2 ± ± 13.1 mL vs. 25.6 ± 11.7 mL, p = 0.05) at the end of 12 months between RVAP and RVSP respectively, though not significantly different at six months, favouring the RVS-paced group. However, no significant difference in ejection fraction (59 ± 5% vs. 61.5 ± 3.2%, p = 0.39) and New York Heart Association class (1.29 ± 0.3 vs. 1.28 ± 0.4, p = 0.3) at six and 12 months follow up were noted.

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Conclusion. Right ventricular septal pacing was associated with a better outcome in terms of echocardiographic indices, left ventricular function, and clinical outcome compared to patients with apical pacing over an intermediate-term follow up.

Key words: right ventricular apical pacing, right ventricular septal pacing, NT-proBNP, 6-minute walk test, intraventricular dyssynchrony, interventricular dyssynchrony

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Introduction

Since the advent of cardiac pacemakers in 1959 when Furman described the use of the transvenous route for pacemaker implantation, the right ventricular (RV) apex has been the elective site for placing endocardial pacing leads [1]. It causes electro-mechanical dyssynchrony mainly by an abnormal late activation of the lateral wall of the left ventricle (LV), thereby increasing myocardial work, myocardial oxygen consumption and subsequently heart failure, atrial fibrillation (AF), thromboembolic events and premature deaths [2–6]. In order to minimise right ventricular pacing, prolonged atrioventricular (AV) delay and minimal right ventricular pacing algorithms have been used, but this may not be possible in patients with AV conduction abnormalities or following AV node ablation. Therefore, there has been an ongoing quest to explore alternative sites to pace the right ventricle in order to minimise both **intra**ventricular and **inter**ventricular dyssynchrony. These sites have included the RV septum, His bundle (HB), para-hisian tissues, free wall, inflow tract and right ventricle outflow tract (RVOT). Of these, the RV septum has been the most explored one [7–14]. Furthermore, with the advent of screwing leads, preshaped stylets for lead positioning and Mond's modification of stylets, RV septum (RVS) is becoming the preferred site of pacing. However, trials assessing acute and medium-term haemodynamic changes with selective site pacing (SSP) have provided conflicting results, although similar in terms of long term safety and lead performance [15–17].

Material and methods

Design

This was a prospective, single-centre study conducted in the Department of Cardiology, LPS Institute of Cardiology, GSVM Medical College, Kanpur, India, from August 2014 to March 2018. 467 consecutive patients with an indication of permanent cardiac pacing with (a) sinus node dysfunction, (b) AV block, symptomatic congenital AV block, acquired symptomatic AV block, acquired asymptomatic complete heart block, symptomatic second-degree AV block regardless of its type, or (c) chronic bifascicular and trifascicular block with intermittent third-degree AV block, Type II second degree AV block and alternating bundle branch block were enrolled, in whom a pacemaker with VVVI/VVIR was implanted.

Exclusion criteria were: (a) indications of cardiac resynchronisation therapy (CRT) or implantable cardioverter-defibrillator (ICD) device; (b) those who were unable to perform a six-minute walk test (6MWT) due to musculoskeletal abnormalities, co-morbid conditions or respiratory diseases; and (c) patients with underlying left ventricular dysfunction. Enrolled patients underwent a comprehensive clinical examination and investigations including electrocardiography, cardiac enzymes, viral markers, serum electrolytes, and 2D-transthoracic echocardiography. Those patients who were finally eligible for the study were randomised blindly into two groups: either right ventricular apical pacing (the RVAP group) or right ventricular septal pacing (the RVSP group). These two groups were matched with respect to age, sex, ejection fraction, QRS duration, baseline New York Heart Association (NYHA) class, presence of arrhythmias, and mode of pacing, cardiovascular risk factors and baseline medications.

This study was undertaken with the objective of comparing QRS duration, echocardiographic features (ejection fraction, left ventricular volumes and dyssynchrony parameters), NYHA functional class, N-terminal pro-B-type natriuretic peptide (NT-proBNP) level and six-minute walk test (6 MWT) at baseline, and after six months and 12 months.

Permanent pacemaker implantation

All the pacemakers were implanted using either cephalic cut down or subclavian puncture and bipolar; a steroid-eluting electrode was used. For septal positioning, either a preshaped stylet (Mond stylet, St. Jude) or preshaping the stylet with primary and secondary curve was used, similar to the design suggested by Vlay [13]. In cases when we could not reach the septum directly, then the withdrawal technique was applied i.e. the stylet-lead assembly was advanced into the pulmonary artery/ RVOT and withdrawn into the RV septum. The pacing site in the ventricular septum was determined by fluoroscopy. A posteroanterior (PA) view was used to position the lead into the septum (Figure 1). A 40° right anterior oblique (RAO)/left anterior

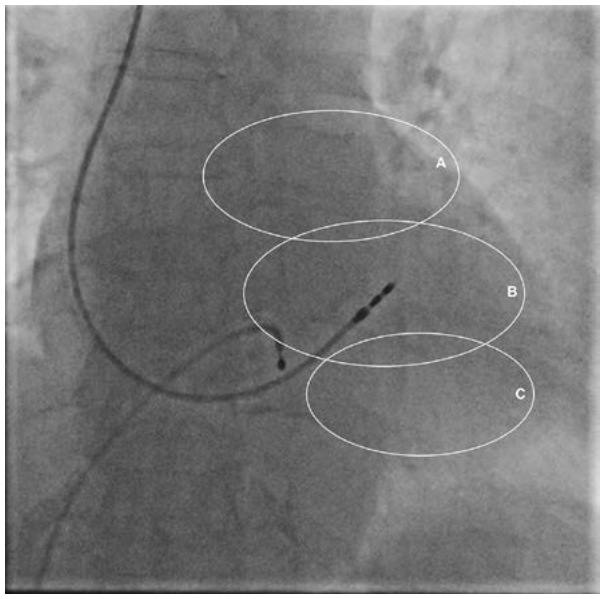

Figure 1. Typical position of lead into septum in posteroanterior view (B), right ventricle outflow tract (RVOT) (A), and apex (C)

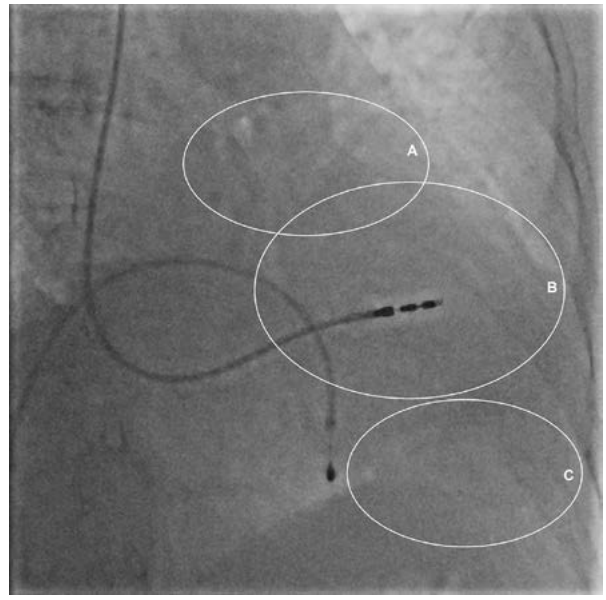

Figure 3. Typical position of lead into septum in right anterior oblique 40° view (B), right ventricle outflow tract (RVOT) (A) and apex (C)

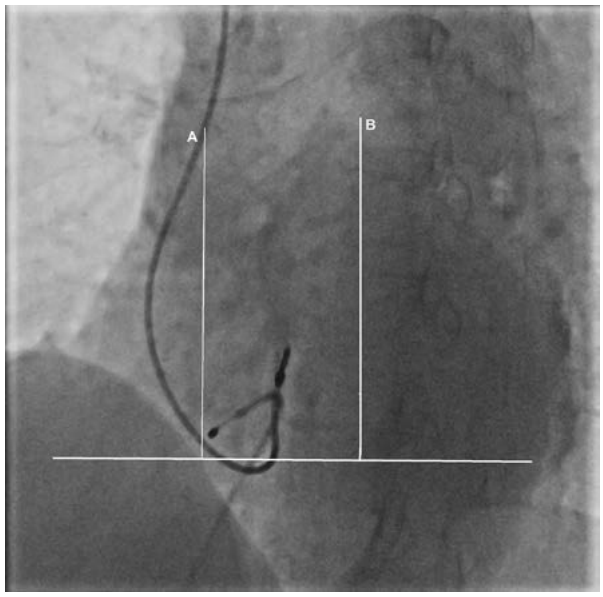

Figure 2. Typical position of lead left anterior oblique (LAO) 40° view (line A and B indicates free-wall and into septum respectively)

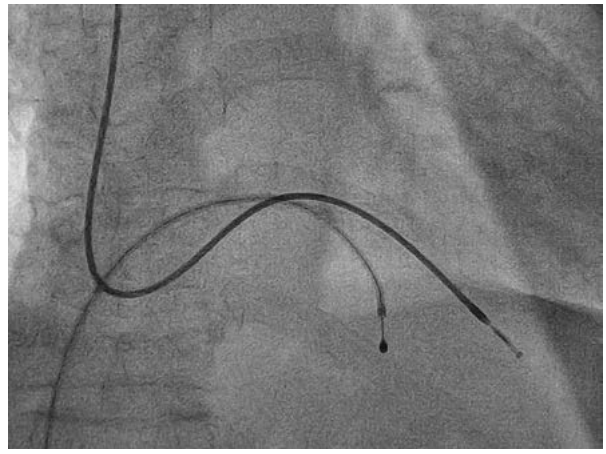

Figure 4. Posteroanterior view showing position of the passive fixation electrodes into the right ventricular apex

oblique (LAO) projection was used to prevent inadvertent positioning in the coronary sinus and great cardiac vein. Septal and free-wall sites were determined by a leftward orientation of the lead tip in the LAO 40° view as proposed by Mond (Figure 2) [18]. The septal positioning was confirmed by three fluoroscopic views: PA, LAO 40° and RAO 30° (Figure 3). In the RVAP group, the passive fixation electrodes were positioned toward the right ventricular apex which was confirmed in antero-posterior view (Figure 4). Active fixation lead was screwed into the septum under fluoroscopic guidance for septal pacing. Pacing parameters, including pacing threshold, sensitivity, lead impedance, and percentage of ventricular pacing were assessed after implantation regularly on an out-patient basis.

Echocardiographic assessment

Images were obtained by the same single investigator using an iE33 model (Philips Medical Systems,

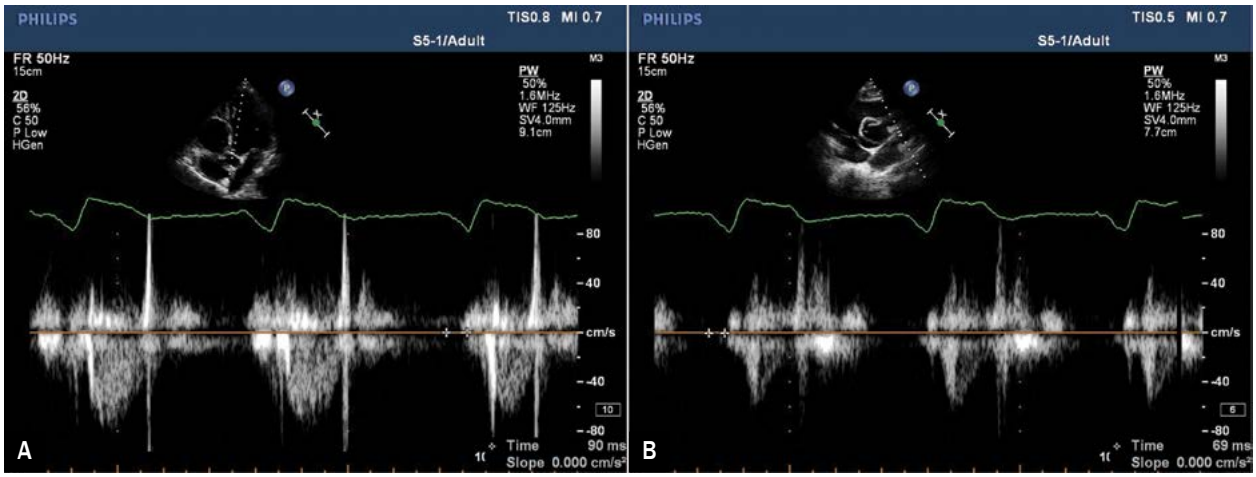

Figure 5. Calculation of pre-ejection period as time interval from onset of QRS complex to the onset of pulse-Doppler velocity curve: **A.** Left ventricular pre-ejection periods (LVPEP); **B.** Right ventricular pre-ejection periods (RVPEP)

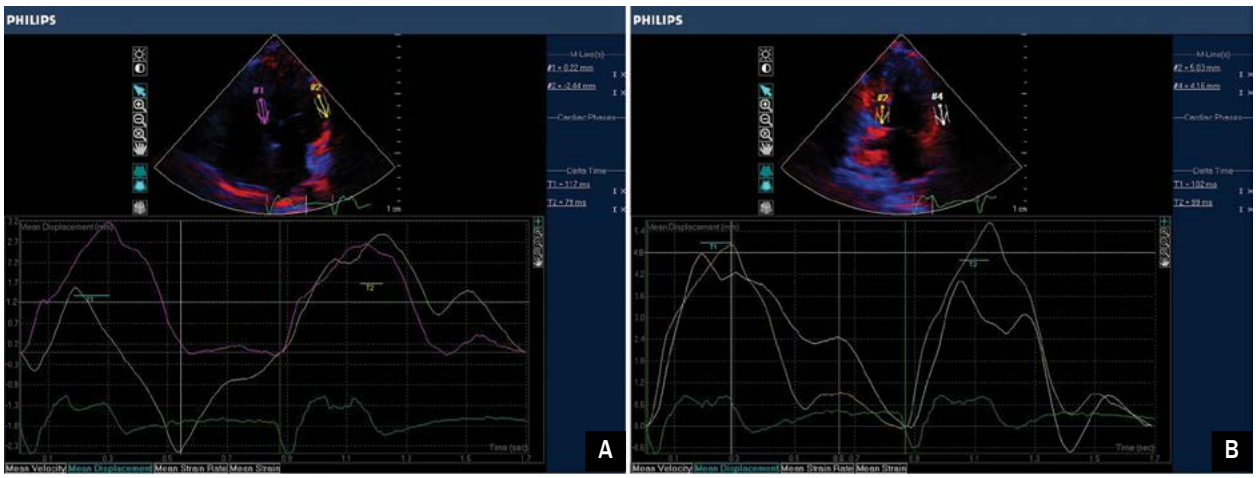

Figure 6. Intraventricular dyssynchrony among patients with right ventricular apical pacing (RVAP) by strain imaging using speckle tracking method: **A.** Septal to lateral wall delay of 117 ms in apical four-chamber view; **B.** Anterior to inferior wall delay of 102 ms in apical two--chamber view

Netherlands) with a 3.5-MHz transducer in parasternal long axis (PLAX), short-axis (PSAX) ,and apical (2-, 3-, and 4-chamber) views. Left ventricular end-diastolic volume (LVEDV), end-systolic volume (LVESV) and ejection fraction (EF) were calculated using the biplane Simpson's rule. **Inter**ventricular dyssynchrony, the discordance between the times of RV and LV contraction, was assessed by measuring the interventricular mechanical delay (IVMD) using pulse-wave Doppler (PWD) images of aortic and pulmonary flow velocities. Time to onset of LV ejection and RV ejection were derived by placing pulsed-Doppler sample volume at the left ventricular outflow tract (LVOT) in apical five--chamber view and by imaging RVOT in PSAX respectively. Therefore, the LV and RV pre-ejection periods (LVPEP/ /RVPEP) were calculated as the time intervals from onset of QRS complex to the onset of pulse-Doppler velocity curve in respective views (Figure 5A, B). **Inter**ventricular dyssynchrony was derived as the difference of LVPEP and RVPEP. **Intra**ventricular dyssynchrony was calculated using tissue Doppler velocity data by comparing the time to systolic peak velocity between segments in multiple apical views (Figures 6, 7).

Analytical technique

Tissue Doppler imaging (TDI) was performed in the apical four-chamber (A4C), two-chamber (A2C) and long-axis views to image the long axis motion of the left ventricle. Myocardial regional velocity curves were constructed from the digitised images offline by using inbuilt software QLAB using the curved M-line sampling method for regional comparison, timing and function. Thus, time to peak systolic velocity was displayed for as many sub-regions

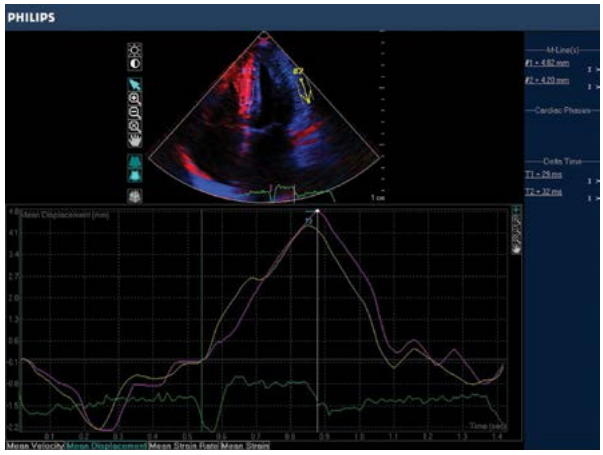

Figure 7. Intraventricular dyssynchrony among patients with RVSP by strain imaging using speckle tracking method showing delay of 32 ms between septal and lateral wall in apical four-chamber view

as required. In this way, dyssynchrony between septal to lateral, septal to posterior and anterior to inferior wall were calculated.

NT-proBNP estimation

Venous blood was withdrawn from an antecubital vein in a vaccutainer containing potassium ethylene diamine tetraacetic acid (EDTA), centrifuged at 3,000 rpm (15°C for 10 min) and separated plasma was immediately assayed. Plasma natriuretic peptide concentrations were measured with a specific immunoradiometric assay for human NT-proBNP using commercially available, enzyme-linked immunoassay (Biomedica Gruppe, Austria) and reported in pg/mL. It was analysed at baseline, and at six month and 12 month follow ups.

Six-minute walk test

The 6MWT was performed indoors, along a long, flat, straight, enclosed corridor with a hard surface around 100ft in length and was marked every 3 m. The object of this test is to walk as far as possible in six minutes. The patient was instructed to walk back and forth in the corridor and was permitted to slow down, to stop, and to rest as necessary. It was explained that the goal was to walk as far as possible in six minutes and the total distance (6MWT) covered was recorded in metres. 6MWT of patient with both RVAP and RVSP was evaluated at baseline, and again at six month and 12 month follow ups.

Statistical evaluation

The continuous variables were expressed as the mean ± ± standard deviation (SD) or range, while discrete variables were expressed as frequency and percentage. The categorical variables were compared using the χ^2 test and continuous variables using either Student's *t*-test when normally distributed or Wilcoxon rank sum test when non-normally distributed. One-way analysis of variance (ANOVA) was used to compare the repeated measures of continuous variables between groups. The p-value < 0.05 was considered statistically significant. All the analysis was carried out by using statistical package for social service version 17.0 (SPSS Inc., Chicago, IL, USA).

Results

Baseline characteristics (Table 1)

A total of 467 patients had single chamber pacemaker implantation (VVI: N = 107, 22.9% and VVIR: N = 360, 77.1%) between August 2014 and March 2018 who were randomised to RVAP and RVSP. At the end of a 12 month period, data was available for 226 and 241 patients respectively, and therefore these subjects were considered enrolled in the study (Figure 8). The commonest indication for pacemaker implantation was atrioventricular block (N = 311, 66.6%), followed by sinus node dysfunction (N = 138, 29.5%) and chronic bifascicular and trifascicular block (N = 18, 3.9%).

Clinical and biochemical parameters of patients with their follow up (Table 2)

There was no significant difference among NYHA class at six months and 12 months in either group, although an insignificant fall was noted in both groups. There were significant differences in NT-proBNP level (410 ± 254 pg/mL vs. 370 ± 168 pg/mL, p = 0.02) and 6MWT (442 ± 19 m vs. 482 ± 21 m, p = 0.01) at the end of 12 months between RVAP and RVSP respectively, though there were no significant differences at six months.

Echocardiographic parameters with their follow up (Table 3)

The mean QRS duration at baseline of patients with RVAP and RVSP was 136 ± 12.8 and 126 ± 13.7 ms respectively, becoming 160 ± 8.3 ms and 146 ± 10.6 ms respectively, significantly higher (p = 0.02) among the RVAP group at the end of 12 months, although there was no significant difference either at the baseline or at the end of six months. Similarly, there were no differences among the echocardiographic parameters at baseline and six months, but there were significant differences at 12 months except for LVEDD, LVESD and EF. Thus the results were favourable towards RVSP.

Discussion

Natural activation through the His-Purkinje system is the ideal way to depolarise the ventricular mass under any circumstances irrespective of underlying conduction or contractile disturbances. The physiological rationale behind pacing the septum rather than the apex is based on

Table 1. Baseline characteristics of patients (N = 467)

Variables	RVAP (N, %) (N = 226)	RVSP (N, %) (N = 241)	p-value
Age	65.4 ± 11.2	64.7 ± 9.6	0.32
Sex (M; F)	145 (64)/81 (36)	149 (62)/92 (38)	0.5
NYHA class	1.3 ± 0.9	1.2 ± 0.8	0.42
Ejection fraction (%)	63.6 ± 5	64.3 ± 6	0.35
HTN	42 (18.5)	47 (19.5)	0.6
Type 2 DM	27 (11.9)	29 (12.3)	0.19
Hypercholesterolemia	18 (7.9)	17 (7.5)	0.28
AF	19 (8.4)	21 (8.7)	0.4
Pacing indication:			
• sinus node dysfunction (SND)	66 (29.2)	72 (29.8)	0.18
• atrioventricular (AV) block	154(68.1)	157 (65.2)	0.16
• chronic BFB and TFB	06 (2.7)	12(5)	0.2
Pacing mode:			
• VVI	49 (21.7)	58 (24.1)	0.3
• bVVIR	177(78.3)	183 (75.1)	0.23
Procedural complications:			
• lead dislodgement	3 (1.3)	1 (0.4)	0.04
• tamponade	0 (0)	0 (0)	–
• pneumothorax	1 (0.4)	1 (0.4)	0.35
• local site complications	2 (0.8)	2 (0.8)	0.4

RVAP — right ventricular apical pacing; RVSP — right ventricular septal pacing; NYHA — New York Heart Association; HTN — hypertension; DM — diabetes mellitus; AF — atrial fibrillation; BFB — bifascicular block; TFB — trifascicular block

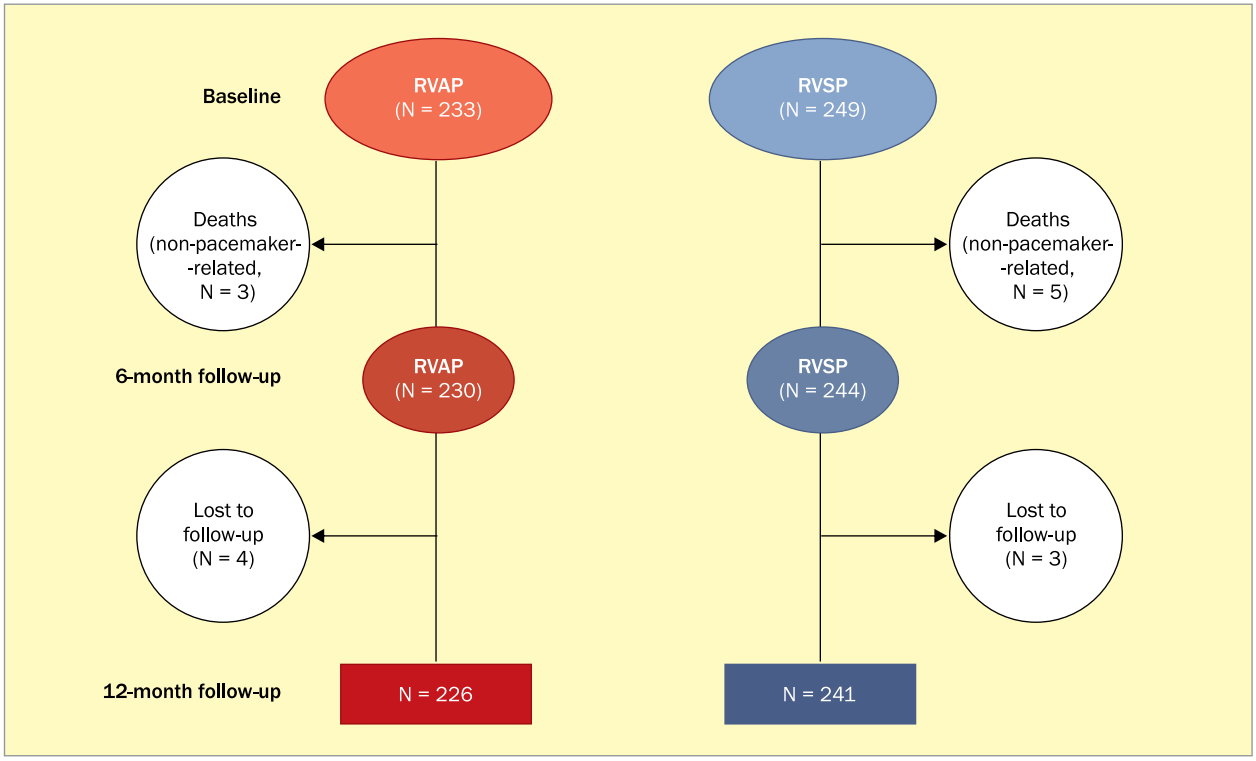

Figure 8. Flow chart of patients enrolled in the study and their follow up (N = 467); RVAP — right ventricular apical pacing; RVSP — right ventricular septal pacing

Table 2. Clinical and biochemical parameters of patients with right ventricular apical pacing (RVAP) and right ventricular septal pacing (RVSP) at baseline and on follow up (n = 467)

Variables	Baseline			Follow-up					
				6 month			12 month		
	RVAP (N = 226)	RVSP (N = 241)	p value	RVAP (N = 226)	RVSP (N = 241)	p value	RVAP (N = 226)	RVSP (N = 241)	p value
NT-proBNP [pg/mL]	574 ± 278	563 ± 236	0.6	496 ± 301	410 ± 241	0.19	410 ± 254	370 ± 168	0.02
6MWT [m]	423 ± 14	429 ± 22	0.35	435 ± 16	465 ± 17	0.4	442 ± 19	482 ± 21	0.01
NYHA class	1.34 ± 0.9	1.32 ± 0.2	0.42	1.32 ± 0.7	1.29 ± 0.7	0.5	1.29 ± 0.3	1.28 ± 0.4	0.3

NT-proBNP — N-terminal pro-B-type natriuretic peptide; 6MWT — six-minute walk test; NYHA — New York Heart Association

Table 3. Echocardiographic indices of patients with right ventricular apical pacing (RVAP) and right ventricular septal pacing (RVSP) at their follow-up (n = 467)

Variables	Baseline			Follow-up					
				6 months			12 months		
	RVAP	RVSP	p value	RVAP	RVSP	p value	RVAP	RVSP	p value
QRS interval [ms]	136 ± 12.8	129 ± 13.7	0.34	148 ± 9.6	134 ± 8.4	0.4	160 ± 8.3	146 ± 10.6	0.02
LVEDV [mL]	85.2 ± 17.6	82.5 ± 13.8	0.42	83 ± 14.4	81.2 ± 11.5	0.15	78.4 ± 15.6	72.8 ± 14.2	0.04
LVESV [mL]	33.4 ± 11.4	32.3 ± 12.6	0.45	31.5 ± 9.8	31.7 ± 10.4	0.15	30.2 ± 13.1	25.6 ± 11.7	0.05
LVEF [%]	63.6 ± 4.4	64.3 ± 2.1	0.5	60.4 ± 6.8	62.6 ± 4.7	0.19	59 ± 5.3	61.5 ± 3.2	0.39
Interventricular delay[ms]	25.6 ± 17.1	17.8 ± 11.3	0.39	27.7 ± 21.2	18.1 ± 13.7	0.29	31.2 ± 22.8	19.4 ± 11.2	0.03
Septal-LWD [ms]	46.7 ± 29.8	45.2 ± 28.2	0.49	49.1 ± 31.2	44.7 ± 18.2	0.37	88.6 ± 24.2	43.7 ± 11.2	0.04
Septal-PWD [ms]	42.4 ± 31.8	47.8 ± 32.4	0.28	43.4 ± 31.8	47.8 ± 32.4	0.36	76.2 ± 33.6	48.2 ± 16.4	0.03
Anterior-IWD [ms]	40.4 ± 24.8	44.2 ± 18.7	0.26	46.6 ± 22.8	48.7 ± 14.2	0.43	72.6 ± 22.7	42.8 ± 11.4	0.02

LVEDV — left ventricular end diastolic volume; LVESV — left ventricular end systolic volume; LVEF — left ventricular ejection fraction; LWD — lateral wall delay; PWD — posterior wall delay; IWD — inferior wall delay

initiating the ventricular depolarisation in the RV septal wall, across the base of the mitral septal papillary muscle, where the first activation vector normally is shorter than that with pacing from the apex, and the ventricular contraction, in theory, will be physiological. Therefore, pacing from the apex has a greater 'desynchronizing effect' than pacing from the interventricular septum, and if the patient is pacemaker-dependent, more stimulation might translate into worse outcomes [3, 4, 19–22].

Our study revealed that the QRS duration post pacemaker implantation at the end of 12 months was significantly shorter in the RVS-pacing group than in the right ventricular apical (RVA) pacing group, which probably indicates that RVS-pacing was associated with reduced electrical dyssynchrony. This is a finding similarly reported by Cano et al. [23], Leong et al. [24], Tse et al. [25], and Zhang et al. [26]. Furthermore, pacing parameters (R-wave sensing, amplitude and impedance) remain stable over time in the RVS-pacing group with a similar rate of lead dislodgement to that of RVA-pacing, proving its safety and efficacy over an intermediate term follow up.

In our study, mean QRS duration increased in both the groups, but the difference was more pronounced in RVAP at the end of 12 months, meaning it induced more electrical dyssynchrony. Electrical dyssynchrony is a harbinger of mechanical dyssynchrony. Nonetheless, there was no left ventricular dysfunction in either group as it remained within the normal range. But as our study had an intermediate follow up, therefore it failed to draw a firm conclusion. As RVSP is physiologically more similar to normal intrinsic conduction, therefore it induces less mechanical dyssynchrony as the difference in ejection fraction was not significant, but still higher, in patients with septal pacing. A similar finding has also been drawn by Zhang et al. [26] in elderly patients with normal LV function where they considered QRS widening from baseline among patients with RVAP and right ventricular outflow tract pacing. In our study, baseline **inter** and **intra**ventricular dyssynchrony was noted

in patients with RVAP and RVSP, although a little higher in the former group. This may be possibly due to some degree of acute electrical stunning associated with both underlying atrioventricular block and the temporary right ventricular apical pacing used preimplantation, which may have disappeared over time in patients with RVSP but may have persisted in patients with RVAP.

Our findings also correspond to the study by Flevari et al. [11] conducted among 36 patients with atrioventricular block who were randomised to receive either apical pacing or lower septal pacing. They noted increases in LV volume and EF at 12 months follow up among the septal pacing group, and assigned these late changes to changes in LV dyssynchrony imposed by pacing. Although we did not demonstrate any improvement in ejection fraction, nonetheless it was better preserved in the septal pacing group. In contrast to our study, Ng et al. [27] in their study of 55 subjects demonstrated septal pacing to be associated with more impaired circumferential strain and worse LV dyssynchrony than apical pacing and a control group. This was mainly attributed to a heterogeneous group of different pacing sites as septal pacing sites and a different duration of follow up period.

A meta-analysis by Shimony et al. [28] found that baseline LV function was an important predictor of the effect of pacing on LVEF. They found that patients with non-apical pacing (RVNA) with a ≤ 40–45% lower ejection fraction at baseline had improved EF after follow up > 12 months, although those who had normal EF at baseline had no difference at the end of follow up but still fared better than those with RVAP. However, Tse et al. [25] among 24 patients randomised to receive apical pacing and outflow tract pacing having normal LV function at baseline, noted worsening of LV functions, in the form of fixed perfusion defect and regional wall motion defect, in an apical pacing group at the end of 18 months of follow up.

In our study, NT-proBNP levels were lower and six-minute walk test results were better in the RVS-pacing group than in the RVA-pacing group, similar to the study by Fang et al. [29]. The mechanical disarray in the former group leading to asynchronous cardiac contraction may be responsible for this. The NT-proBNP levels had a significant reduction from baseline to 12 months in the RVSP group. Although it was also noted in the RVAP group, it did not reach statistical significance. Similarly, there was a significant fall at the end of 12 months between both the groups in our study. The echocardiographic evaluation revealed that patients in the RVAP group had more **inter**ventricular and **intra**ventricular dyssynchrony than the RVSP and control groups, without differences in LV systolic function.

Considering the six-minute walk test, there was an increment in both the groups, and a significant difference at the end of 12 months suggested a better outcome among the septal pacing group. Our finding is similar to that reported by Tse et al. [25], Roshdy et al. [30], and Occhetta et al. [31]. This change has also been noted among those who have had an upgrade of pacemaker from RV apical pacing to septal pacing, and that improvement continued 18 months after the upgrade, although there was no upgrade in our study. In our study, no serious complications related to the implantation were detected.

Conclusion

We have shown that after a 12 month follow-up in persistently pacemaker-dependent patients with normal LV function, septal pacing is superior to apical pacing. We observed significant improvements in clinical (6MWT), echocardiographic, and biochemical parameters (NT-proBNP).

Limitation of study

This was a single centre study with an intermediate follow up of only 12 months. A larger study with more subjects, a longer follow up and encompassing different sites is required.

Conflict(s) of interest

The authors declare no conflict of interest.

Streszczenie

Wstęp. Stymulacja koniuszkowa prawej komory ma większy „wpływ desynchronizacyjny" niż stymulacja przegrodowa prawej komory (RVSP) i w dłuższej perspektywie może prowadzić do poważniejszych skutków. Przedstawione badanie przeprowadzono w celu porównania krótko- i długookresowego wpływu RVAP i RVSP na parametry echokardiograficzne, czynność lewej komory i efekty kliniczne.

Materiał i metody. Prospektywne badanie prowadzono od sierpnia 2014 roku do marca 2018 roku. Uczestniczyło w nim 467 chorych bez choroby strukturalnej serca, których przydzielono losowo do RVAP (N = 226) lub RVSP (N = 241). W czasie pierwszej wizyty wszystkich uczestników poddano badaniu echokardiograficznemu, badaniu biochemicznemu [stężenie N-końcowego fragmentu propeptydu natriuretycznego typu B (NT-proBNP)] i ocenie stanu klinicznego [test 6-minutowego marszu (6MWT)]. Badania te powtórzono po 6 i 12 miesiącach. Przeanalizowano lewokomorowe obrazy 2D z badania odkształcenia (*strain*) i prędkości ruchu miokardium (*tissue velocity*), aby zmierzyć czas do maksymalnego skurczowego odkształcenie podłużnego w 18 segmentach i czas do maksymalnej skurczowej prędkości ruchu miokardium w 12 segmentach. Dyssynchronię **śród**komorową obliczano na podstawie danych uzyskanych w badaniu doplera tkankowego, porównując czas do maksymalnej prędkości skurczowej między segmentami w wielu projekcjach koniuszkowych na podstawie ich odchyleń standardowych. Dyssynchronię **między**komorową mierzono jako różnicę w czasie okresu przedwyrzutowego lewej i prawej komory w badaniu doplera fali pulsacyjnej. Wszystkie analizy statystyczne wykonano za pomocą pakietu oprogramowania SPSS, wersja 17.0 (SPSS Inc., Chicago, IL, USA). Wartości p wynoszące poniżej 0,05 uznano za statystycznie istotne.

Wyniki. Najczęstszym wskazaniem do wszczepienia stymulatora był blok przedsionkowo-komorowy (n = 311; 66,6%), a w następnej kolejności dysfunkcja węzła zatokowego (n = 138; 29,5%) i przewlekły blok dwu- lub trójwiązkowy (n = 18; 3,9%). Wszystkim chorym wszczepiono stymulator jednokomorowy (VVI: n = 107; 22,9% lub VVIR: n = 360;77,1%). Stwierdzono istotne różnice między RVAP i RVSP na korzyść stymulacji RVS w wartościach NT-proBNP (odpowiednio 410 ± 254 pg/ml *vs.* 370 ± 168 pg/ml; p = 0,02), dystansu 6MWT (442 ± 19 m *vs.* 482 ± 21 m; p = 0,01), średniego czasu trwania zespołu QRS (164 ± 8,3 ms *vs.* 148 ± 10,6 ms; p = 0,02), dyssynchronii śródkomorowej (opóźnienie między przegrodą międzykomorową a ścianą boczną: 88,6 ± 24,2 ms *vs.* 43,7 ± 11,2 ms; p = 0,04), dyssynchronii międzykomorowej (31,2 ± 22,8 *vs.* 19,4 ± 11,2; 0 = 0,03) oraz objętości końcoworozkurczowej (78,4 ± 15,6 ml *vs.* 72,8 ± 14,2 ml; p = 0,04) i końcowoskurczowej (30,2 ± 13,1 ml *vs.* 25,6 ± 11,7 ml; p = 0,05) po 12 miesiącach, jednak różnice zaobserwowane po 6 miesiącach. W badaniach przeprowadzonych po 6 i 12 miesiącach nie stwierdzono natomiast istotnych różnic pod względem frakcji wyrzutowej (59 ± 5% *vs.* 61.5 ± 3.2%, p = 0.39) ani klasy według *New York Heart Association* (1,29 ± 0,3 *vs.* 1,28 ± 0,4; p = 0,3).

Wnioski. W obserwacji średnioterminowej stymulacja przegrody prawej komory wiązała się z lepszymi efektami w odniesieniu do wskaźników echokardiograficznych, czynności lewej komory i efektu klinicznego niż stymulacja koniuszkowa.

Słowa kluczowe: stymulacja koniuszkowa prawej komory, stymulacja przegrodowa prawej komory, NT-proBNP, test 6-minutowego marszu, dyssynchronia śródkomorowa, dyssynchronia międzykomorowa

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