The Effect of Right Ventricular Apical Pacing on Asynchrony Parameters in Different Heart Rates Detected By Tissue Doppler Imaging in Patients with Permanent Pacemaker

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ABSTRACT

Introduction: The detrimental effects of right ventricular apical pacing on left ventricular function has been demonstrated by several studies. In this study we aimed to evaluate the dynamic alterations in systolic and diastolic asynchrony parameters in the slowest and fastest paced rhythm.

Patients and Methods: We included 23 permanent pacemaker patients to this study. We assessed dynamic changes in asynchrony and volumetric parameters with increasing heart rates by tissue Doppler and two dimensional imaging.

Results: In basal heart rates systolic asynchrony frequency was 61% and 56% by TsSD and SLD respectively. Frequency of diastolic asynchrony was 44% by TeSD. EF was not associated with asynchrony parameters. There was positive correlation between pacemaker age and systolic asynchrony. Both TsSD and SLD values were similar at basal and peak heart rates in overall study population but there was remarkable individual variability in alterations both in directions and quantities. Correlation between TsSD and SLD was 0.99 and 0.83 at basal and peak heart rate, respectively.

Conclusion: In our study systolic asynchrony and diastolic asynchrony was found to be very frequent independent from EF in pacemaker population. Dynamic changes with different heart rates in asynchrony parameters revealed individual variability. Routine evaluation of pacemaker population must consist asynchrony parameters beside EF. SLD measurement is a relatively easy and accurate method for asynchrony evaluation. Evaluation of asynchrony parameters in different heart rates in symptomatic patients with normal or near normal resting echocardiographic findings can help early modification of pacing modality before systolic dysfunction development.

Key Words: Asynchrony; pacemaker; tissue doppler.

Kalıcı Kalp Pili Olan Hastalarda Sağ Ventrikül Apeksinden Yapılan Uyarımın Farklı Kalp Hızlarında Doku Doppler Görüntüleme ile Elde Edilen Asenkroni Parametrelerine Etkisi

ÖZ

Giriş: Sağ ventrikül apeksinden yapılan ilerleme hızının sol ventrikül fonksiyonları üzerine olan olumsuz etkisi çeşitli çalışmalarda gösterilmiştir. Bu çalışmada, en düşük ve en yüksek kalp hızlarında sistolik ve diyastolik asenkroni parametrelerinde meydana gelen dinamik değişikliklerin değerlendirilmesi amaçlanmıştır.

Hastalar ve Yöntem: Çalışmaya, 23 kalıcı kalp pili hastası dahil edildi. Doku Doppler ve iki boyutlu görüntüleme ile artan kalp hızlarında asenkroni parametrelerinde ve volümetrik parametrelerde meydana gelen dinamik değişiklikler değerlendirildi.

Bulgular: Bazal kalp hızlarında sistolik asenkroni sıklığı TsSd ve SLD ile sırasıyla %61 ve %56 idi. TeSD ile diyastolik asenkroni sıklığı %44 bulunmuştur. EF ile asenkroni parametreleri arasında ilişki bulunmamıştır. Kalp pili yaşı ile sistolik asenkroni arasında korelasyon tespit edilmiştir. TsSD ve SLD ölçümleri tüm çalışma grubunda bazal ve kalp hızlarında benzer bulunmuştur ancak değişimlerde hem yön hem de miktar bakımından belirgin farklılıklar mevcuttur. TsSD ve SLD ölçümleri arasında bazal ve pik kalp hızlarında sırasıyla 0.99 ve 0.83 oranında korelasyon tespit edilmiştir.

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Sonuç: Çalışmamızda kalp pili hastalarında EF'den bağımsız olarak sistolik asenkroni ve diyastolik asenkroni oldukça sık görülmüştür. Farklı kalp hızlarında asenkroni parametrelerinde meydana gelen dinamik değişiklikler bireysel farklılıklar göstermektedir. Kalıcı kalp pili hastalarının rutin değerlendirmesi EF yanında asenkroni parametrelerini mutlaka içermelidir. SLD asenkroni değerlendirilmesinde göreceli olarak kolay ve doğru bir yöntemdir. Semptomatik ve istirahat halinde normal veya normale yakın ekokardiyografik bulguları olan hastalarda asenkroni parametrelerinin değerlendirilmesi sistolik disfonksiyon meydana gelmeden ilerleme hızı modalitesinin değiştirilmesi konusunda yardımcı olabilir.

Anahtar Kelimeler: Asenkroni; kalp pili; doku doppler.

INTRODUCTION

The detrimental effects of right ventricular apical (RVA) pacing on left ventricular function has been demonstrated by several studies. RVA stimulation leads to an abnormal activation sequence, leading to asynchronous ventricular contraction[1-3]. In the normal heart, depolarization rapidly spreads from left to right and from apex to base while the earliest activation initiating from the middle part of the left-sided interventricular septum (IVS) and spreading towards the apex and LV free wall before reaching right ventricular (RV) free wall[4]. Because of this electrical spreading pattern, right and left ventricular free wall contraction follows contraction of the septum[5]. Serious alterations in the formation, spreading direction and speed of electrical impulse are produced during RVA pacing which affects the mechanical properties of the heart[6-9]. Significant changes in the cellular level of the myocardium is also shown with RVA pacing in animal and human studies[2,10,11].

Although the different definitions are present in several studies, the frequency of Pacing Induced Cardiomyopathy (PICM) is reported to be between 5-20%(12). In these studies, the most pronounced risk factors for PICM are paced and native QRS width and pacing percentage which suggest that electromechanical asynchrony plays the most important role in physiopathology[13-16].

Tissue Doppler Imaging (TDI) and 2D echocardiography can be used to evaluate both global cardiac functions and ventricular asynchrony. In this study, we aimed to evaluate systolic and diastolic asynchrony in the slowest to fastest pacing rhythm in patients with RVA pacing and to compare the dynamic changes in the asynchrony parameters obtained by TDI and volumetric parameters obtained by 2D echocardiography

PATIENTS and METHODS

Patient Selection

We included 23 patients who underwent permanent pacemaker implantation for sick sinus syndrome, complete AV block or slow ventricular rate atrial fibrillation (18 VVI, 5 DDD) in this study. The age of the patients mean 43 ± 18, and pacing durations were between 1-144 months (mean 33.0 ± 36.5 months). The study was approved by the local ethics committee (Date: November 10, 2020; Decision no: 2020/14/417) and was conducted in accordance with the requirements of the Declaration of Helsinki. An informed consent letter was obtained from all the patients.

Exclusion Criteria

The patients with angiographically proven coronary artery disease, patients with angina complaints or echocardiographic segmentary wall motion abnormality other than paradoxical septal motion were excluded from the study. Patients with serious myocardial dysfunction and heart valve disease that can lead to asynchrony were also not included. The patients with lead location abnormality were excluded. Also, pacemaker functions were evaluated and patients with pacemaker dysfunction were not included. Before echocardiographic evaluation, the pacemaker lead implantation site of all patients was controlled with posteroanterior and lateral chest X-rays.

Pacemaker Programming

To evaluate the effect of RVA pacing, all DDD coded pacemaker program were changed to VVI mode to achieve RV apical pacing. Pacemaker rate was increased by 20 beats per minute starting from the lowest rate that the pacemaker is activated. The study is finished when 80% of the maximum predicted heart rate (220-age) was reached or when the patient desires (peak heart rate, mean: 130/minutes).

Echocardiographic Evaluation

In the left lateral decubitus position, 3 cardiac cycles were recorded for each heart rate under expiratory apnea with Vivid 7 (GE Vingmed Ultrasound, Horten, Norway) echocardiography device, from apical 4 chambers, 2 chambers and long axis windows. The recordings were analysed by 2 individual physicians (ET, TA) if there is a significant mismatch in the results, it was decided according to the result of consensus. We used EchoPac for PC (GE Vingmed Ultrasound). Left ventricular end-diastolic volume (LV EDV), end-systolic volume (ESV) and ejection fraction (EF) were calculated from apical 2 and 4 chamber views with the Simpson equation. Color TDI images were recorded in the highest possible frame rate and the correction angle was kept under 30 degrees. TD velocity curves were obtained from the basal and mid septum, lateral, inferior, anterior septum and posterior walls and the amplitudes of these velocities were recorded. Time from the initiation of the Q wave of the simultaneous ECG recording to the peak of systolic

velocity (T-Sm) and to the diastolic E wave peak (T-Em) was measured and recorded in each segment. The standard deviation of the T-Sm values (TsSD) measured from 12 segments and the septolateral delay (SLD) durations obtained from septum and lateral walls were used for asynchrony parameters and standard deviation of the T-Em values measured from 12 segments (TeSD) were used for diastolic asynchrony parameter.

Statistics Analysis

For all statistical analysis, SPSS (Statistical Package for Social Sciences) for Windows 15.0 was applied. An evaluation of study data, besides descriptive statistical methods (mean, standard deviation), for the intragroup comparison of quantitative data, Paired Sample t-test was applied for parameters with normal distribution and Wilcoxon sign test was applied for parameters non-normal distribution. For the comparison of parameters without normal distribution of different groups, Mann Whitney U test was used. Pearson correlation analysis was applied for parameters with normal distribution and Spearman's correlation analysis for parameters without normal distribution. The results were evaluated with a 95% confidence interval and a $p< 0.05$ set a statistical significance level.

RESULTS

Findings in the Basal Heart Rate

The relationship between mean peak systolic velocities (Sm) obtained by color TDI and systolic functions.

When the study patients are grouped in two according to EF values (EF < 45% and EF ≥ 45%), it was observed that mean Sm values obtained from 12 segments (Sm mean), Sm values obtained from the basal septum and basal lateral walls (Septal and Lateral Sm) and mean value of basal septal and basal lateral wall Sm values (Sm E mean) were lower in patients with systolic dysfunction group (5 patients) compared to patients with normal systolic function (18 patients) (Table 1).

Evaluation of systolic and diastolic asynchrony parameters in basal heart rate and the effect of asynchrony over EDV, ESV and EF.

In all samples, the delay was most common in the lateral wall (75% of all delayed segments), followed by a consecutively posterior wall (15%) and septum (5%). TsSD values of all patients ranged between 5.14 and 66.71 msec (mean: 32.75 ± 17.93 msn). When a TsSD value of 30 msec is accepted as a cut-off value, 14 of the patients (61%) had systolic asynchrony. TsSD value of this group was 45.5 ± 9.5 msec, compared to 14.8 ± 7.1 msec mean TsSD value of the patients with TsSD value < 30 msec. Although there was a statistically significant difference between TsSD values of the two group, basal EF, EDV and ESV values were similar (Table 2).

SLD durations of all patients ranged between 0-130 msec (63.47 ± 46.96). When a SLD value of 60 msec is accepted as a cut-off value 13 of the patients (56%) had systolic asynchrony. The mean SLD value of the asynchrony group was 99.2 ± 24.9 msec, compared to the 17.0 ± 17.6 msec mean duration of the group without asynchrony. There was no statistically significant difference between the ESV, EDV and EF values of the two group (Table 3).

With respect to diastolic asynchrony, TeSD values of all patients ranged between 3.89-86.49 msec (mean: 22.24 ± 16.9 msec). When a TeSD value of 20 msec was accepted as a cut-off value 10 of the patients (44%) had diastolic asynchrony. The mean TeSD value of this group was 33.8 ± 20.0 msec, compared to 13.3 ± 4.8 msec mean TeSD value of patients without diastolic asynchrony. There was no statistically significant difference between basal EDV, ESV and EF values of the two groups (Table 4).

Evaluation of basal asynchrony parameters of patients with and without systolic dysfunction.

When the patients are grouped in two according to EF value (< 45 and ≥ 45), there was no statistically significant difference between asynchrony parameters such as Ts-SD, SLD duration and TeSD value (Table 5).

Table 1. Association between tissue velocities and EF

	EF < 45% (n= 5)	EF ≥ 45% (n= 18)	p
Sm Mean	2.26 ± 0.7	4.14 ± 0.4	***0.001***
Septal Sm	2.26 ± 0.6	4.16 ± 0.5	***0.001***
Lateral Sm	2.62 ± 0.3	4.69 ± 1.0	***0.001***
SmE Mean	2.44 ± 0.4	4.32 ± 0.6	***0.001***

Table 2. Comparison of EF, EDV and ESV values between basal asynchrony and basal no asynchrony group by TsSD

	Basal asynchrony group* (n= 14)	No basal asynchrony group (n= 9)	p
Basal TsSD	45.5 ± 9.5	14.8 ± 7.1	***0.001***
Basal EDV	75.3 ± 34.4	75.7 ± 19.4	0.48
Basal ESV	37.7 ± 30.4	30.5 ± 11.9	0.99
Basal EF %	54.6 ± 15.1	59.2 ± 11.3	0.50

* TsSD > 30 msec.

Table 3. Comparison of EF, EDV and ESV values between basal asynchrony and no asynchrony group by SLD

	Basal asynchrony group* (n= 13)	No basal asynchrony group (n= 10)	p
Basal SLD	99.2 ± 24.9	17.0 ± 17.6	***0.001***
Basal EDV	79.3 ± 35.9	74.2 ± 18.8	0.87
Basal ESV	44.3 ± 40.7	30.0 ± 11.4	0.53
Basal EF %	53.6 ± 16.0	59.9 ± 9.5	0.35

* SLD > 60 msec.

Table 4. Comparison of EF, EDV and ESV values between basal diastolic asynchrony and no diastolic asynchrony group by TeSD

	Basal asynchrony group* (n= 10)	No basal asynchrony group (n= 13)	p
Basal TeSD	33.8 ± 20.0	13.3 ± 4.8	***0.01***
Basal EDV	74.4 ± 17.9	76.4 ± 35.9	0.57
Basal ESV	34.0 ± 10.9	35.6 ± 32.1	0.21
Basal EF %	54.9 ± 14.0	57.5 ± 13.8	0.68

* TeSD > 20 msec.

Table 5. Comparison of systolic and diastolic asynchrony parameters in terms of EF

	EF < 45%	EF ≥ 45%	p
Basal TsSD	36.5 ± 13.2	32.6 ± 18.7	0.65
Basal SLD	78.0 ± 43.8	59.4 ± 48.1	0.47
Basal TeSD	31.5 ± 31.1	19.6 ± 10.4	0.60

Comparison of baseline EDV, ESV and EF values of patients with diastolic asynchrony and systolic asynchrony according to both systolic parameters.

In our study population, there was diastolic and systolic asynchrony together in 4 patients according to both systolic asynchrony parameters. In terms of the same parameters, no asynchrony was observed in 4 patients. There was no significant difference between basal EDV, ESV and EF values of patients with systolic and diastolic asynchrony.

The relationship between patient age and implantation duration and basal systolic and diastolic asynchrony parameters.

There was no correlation between age and systolic asynchrony parameters, while there was a significant positive correlation between age and diastolic asynchrony (p= 0.03). And a positive significant correlation was observed between the time interval from pacemaker implantation and TsSD.

Comparison of Asynchrony Parameters in Basal and Peak Heart Rates

Alterations in TsSD values and EDV, ESV and EF in basal and peak heart rates: The mean basal TsSD value of all patients was 32.7 ± 17.9 msec, compared to 30.69 ± 31.38 msec in peak heart rate. There was no significant difference between basal and peak TsSD levels of all patients (p= 0.468). EDV and ESV values were significantly lower in peak heart rates, while EF levels during peak and basal heart rates were similar.

More than 20% change in TsSD level with increased heart rate was accepted as significant and the patients were grouped into increased asynchrony, decreased asynchrony and unchanged asynchrony groups; There was a significant difference in the basal and peak heart rate TsSD values in the increased asynchrony group (7 patients) while EDV, ESV and EF values were similar. There was a significant difference in the basal and peak heart rate TsSD values in the decreased asynchrony group (10 patients). Other parameters were similar except the alteration in EDV. In the unchanged asynchrony group EDV, ESV and EF values were also similar (Table 6).

When all basal and peak heart rate TsSD values are investigated, a significant individual difference is observed with increased heart rates. In the 10th patient, 7 times higher TsSD levels were observed with respect to basal heart rate, while significant opposite changes were observed in 14th and 18th patients in peak heart rate (Figure 1a).

Alterations in SLD durations and EDV, ESV and EF in basal and peak heart rates: The mean basal SLD duration of all patients was 63.47 ± 46.96 msec, compared to 46.95 ± 38.66 msec in peak heart rate (p= 0.12). The patients are grouped into increased asynchrony, decreased asynchrony and unchanged asynchrony groups in peak heart rate, according to the presence of > 20% change in SLD duration. Increased SLD duration group and unchanged SLD duration group had similar EDV, ESV and EF levels in basal and peak heart rates. In the decreased asynchrony group SLD durations were significantly different in basal and peak heart rates and there was significantly decreased EDV and ESV values in the peak heart rates. EF values were similar (Table 7).

When all patients were evaluated with respect to SLD durations in basal and peak heart rates, there were significant individual changes in the TsSD values. There were almost 8

Table 6. Dynamic changes in EF, EDV and EF in different asynchrony groups according to TsSD

	Increased asynchrony (n= 7)	Decreased asynchrony (n= 10)	Unchanged asynchrony (n= 6)
Basal TsSD	18.9 ± 10.2	45.2 ± 10.4	31.0 ± 21.1
Peak TsSD	37.9 ± 16.7	28.5 ± 7.6	29.1 ± 19.9
p	***0.01***	***0.005***	0.17
Basal EDV	76.5 ± 19.6	81.3 ± 38.8	64.6 ± 17.1
Peak EDV	66.4 ± 17.4	66.1 ± 41.7	54.8 ± 18.6
p	0.06	***0.04***	0.22
Basal ESV	31.8 ± 13.4	40.3 ± 35.4	29.5 ± 10.8
Peak ESV	29.2 ± 14.1	35.3 ± 28.9	26.8 ± 10.4
p	0.39	0.28	0.59
Basal EF %	59.5 ± 10.8	56.3 ± 15.4	52.7 ± 15.1
Peak EF %	58.4 ± 12.0	51.5 ± 9.12	52.7 ± 17.2
p	0.98	0.10	0.75

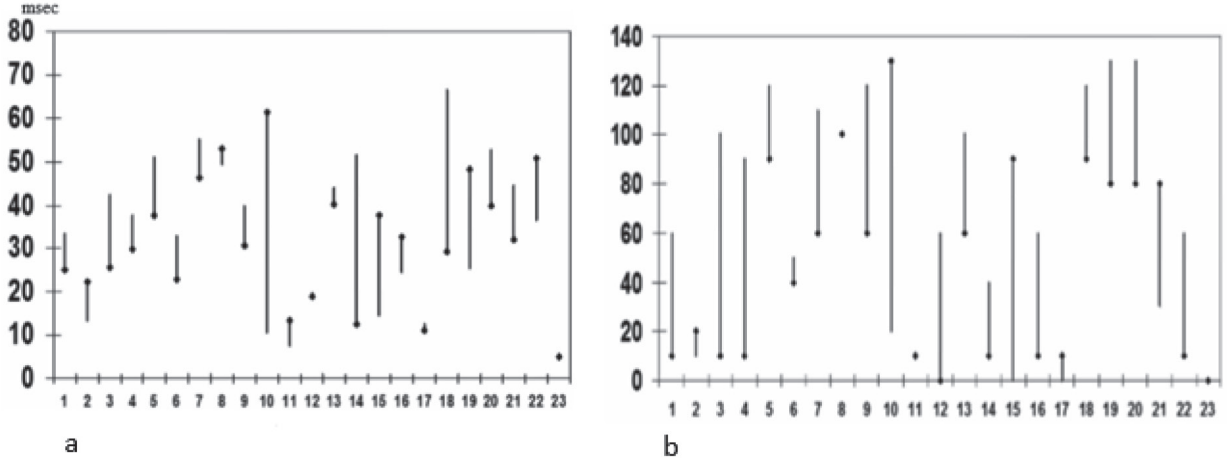

Figure 1. Individual variabilities in TsSD (a) and SLD (b) with increasing heart rate. Numbers represent same patient.
♦ Measurements in peak heart rates.

Table 7. Dynamic changes in EF, EDV and EF in different asynchrony groups in terms of SLD

	Increased asynchrony (n= 7)	Decreased asynchrony (n= 10)	Unchanged asynchrony (n= 6)
Basal SLD	14.0 ± 11.4	94.6 ± 29.8	32.0 ± 43.2
Peak SLD	76.0 ± 40.3	41.5 ± 34.1	32.0 ± 42.0
p	***0.04***	***0.001***	0.99
Basal EDV	76.6 ± 22.4	81.3 ± 34.2	23.4 ± 4.7
Peak EDV	67.0 ± 21.2	62.1 ± 37.5	24.0 ± 8.6
p	0.08	***0.007***	0.99
Basal ESV	35.2 ± 14.5	44.9 ± 40.3	23.4 ± 4.7
Peak ESV	32.0 ± 16.2	33.7 ± 26.3	24.0 ± 8.6
p	0.49	***0.04***	0.98
Basal EF %	55.6 ± 10.5	54.1 ± 16.1	62.8 ± 8.2
Peak EF %	55.1 ± 14.0	50.0 ± 12.2	62.4 ± 7.2
p	0.99	0.08	0.68

times increase in the SLD durations of 10th and 15th patients in peak heart rates, while an opposite change was observed in 3rd and 4th patients (Figure 1b).

Investigation of the correlation between the evaluated parameters: The correlation between SLD duration and TsSD levels in the basal heart rate was 0.99, while in peak heart rate it was 0.83. The high correlation between technically difficult TsSD level and relatively easier SLD duration suggests that measurement of SLD duration in the pacemaker carrying patient population might be sufficient.

DISCUSSION

In our color TDI study performed with the pacemaker population tissue velocities were found to be significantly lower in the reduced EF group. Measurement of tissue velocities from basal segments with TD is also an easy method in this group of patients. At periodic follow-up of the patients following pacemaker implantation, the power of detecting and predicting the development of systolic dysfunction by TD method might be evaluated.

Another significant finding of our study is the positive correlation between the development of systolic asynchrony and time interval from the pacemaker implantation. Delay was most common in the lateral wall as demonstrated in several asynchrony studies about Left Bundle Brunch Block (LBBB)[17]. Although in our study there was no significant difference in the asynchrony parameters of patients with and without systolic dysfunction, this finding suggests that systolic dysfunction may be developed after an uncertain period of asynchrony. Probably delay in the conduction of electrical impulse produces a similar synchronization disorder in patients with a permanent pacemaker and normal EF. In the pacemaker population frequency of cardiac pathologies resulting in systolic dysfunction and asynchrony is high and exclusion of such pathologies in our study may be caused by underestimation of both parameters[18,19]. In the pacemaker population during periodic follow-up and in circumstances that needing echocardiographic examination such as changes in patient's functional status asynchrony evaluation can give additional information besides 2D echocardiography.

In light of the mean values of systolic asynchrony parameters evaluated by both TsSD and SLD durations (32.75 ± 17.93 msec and 63.47 ± 46.96 msec, consecutively), asynchrony is shown to be very common in patients with a permanent pacemaker. The presence of asynchrony in 14 patients (61%) with TsSD and 13 patients (56%) with SLD durations during RV apical pacing has shown that during periodical follow-ups of patients with a permanent pacemaker, routine echocardiographic parameters are not sufficient.

Observed high correlation between SLD duration and TsSD levels in both basal and peak heart rates (0.99 and 0.83 consecutively) suggests that asynchrony evaluation in pacemaker population may be performed by SLD duration which is relatively easier to be measured, compared to TsSD measurement.

Possible deleterious effects of right ventricular apical pacing on left ventricular function has been demonstrated in several studies. Batista et al. evaluated 20 patients for up to 24 months after pacemaker implantation and reported statistically significant variation in time on conventional echocardiography and dyssynchrony parameters[20]. In another study, Kachboura et al., prospectively investigated 43 patients with RV apical pacing for 18 months. They observed the development of congestive heart failure in 25% of the patients, decreased EF and increased NYHA compared to preimplantation values[21].

To overcome the deleterious effect of RV apical pacing on LV functions, the superiority of many non-RV apical pacing locations were investigated in several studies. Yu et al., compared the effects of atrial (AAI), septal (DDDspt) and apical (DDDapx) pacing on LV mechanical performance and contractile synchronism before and within 72 hours of pacemaker implantation at different programmed rates and reported that RV septal pacing revealed the better mechanical performance and less ventricular contractile asynchrony compared to RV apical pacing[22]. In another study, Gong et al., compared RV outflow pacing (RVOT) with RV apical pacing in terms of ventricular synchrony, cardiac functions and remodeling in 96 patients with normal ventricular function. After 12 months of pacing, they reported more severe systolic asynchrony in the RVA pacing group and similar diastolic synchrony in both groups. Mean systolic (Sm), early diastolic (Em) velocities, LV EF, LV end-diastolic and systolic volumes were similar. They concluded that despite the presence of more synchronous LV contraction by RVOT pacing, it revealed no benefit over RVA pacing with respect to preserved LV systolic functions and cardiac remodelling[23]. Recently, his bundle pacing (HBP) has gained the interest of maintaining more physiologic electrical activation compared to RVA pacing. Catanzariti et al. implanted an HBP lead and an RVA lead as back up to 26 patients. After almost 3 years of HB pacing, pacing modality was changed to RVA pacing temporarily and they observed significantly decreased EF, increased mitral regurgitation, worsened inter-ventricular delay compared to HB pacing. During RVA pacing, the asynchrony index was significantly higher, however, the myocardial performance index was similar between two pacing modalities[24]. Although HB pacing is the closest modality to normal physiology, difficulties in the implantation technique, unsatisfactory results observed in patients with wide QRS complex and short battery life brought LBB pacing as an alternative technique, recently[25,26].

Asynchrony is an alteration in the harmony of ventricular contraction which can result from disturbing electrical conduction or myocardial organic diseases. Although advances in echocardiography technology provide important information about the presence and severity of asynchrony, the best echocardiographic technique is yet to be determined[27]. Adverse factors in the applied technique, such as interobserver and intra-observes changes, the importance of image quality, angle dependence of some techniques, absence of clearly defined asynchrony parameters and inter-technical differences produce difficulties and identification and evaluation of asynchrony. Also, evaluation of asynchrony at rest and obtaining normal or near-normal asynchrony parameters might underestimate patients with exertional symptoms. The significant individual differences in the alterations of TsSD and SLD durations and directions in basal and peak heart rates that are observed in our study patients gave us an important point of view in the evaluation of patients with permanent pacemaker especially for the patients with restricted exercise capacity but normal 2D echocardiographic findings.

In patients with low TDI velocities, the possible benefits of alterations of medical treatment strategies and pacing modalities over primary protection against heart failure should be investigated.

LIMITATIONS

A limited number of patients and absence of follow up results and lack of Electrocardiographic parameters such as QRS durations are the most important limitations of this study. Patients' clinical and functional status data that added to echocardiographic findings can give more information about the pacemaker population in terms of asynchrony and its clinical implications.

CONCLUSION

In our study asynchrony was found to be very frequent independent from EF. Dynamic changes with different heart rates in asynchrony parameters revealed individual variability. Routine evaluation PM population must consist of asynchrony parameters besides EF. SLD measurement is a relatively easy and accurate method for asynchrony evaluation. Evaluation of asynchrony parameters in different heart rates in symptomatic patients with normal or near-normal resting echocardiographic findings can help early modification of pacing modality and medical therapy before systolic dysfunction development.

Ethics Committee Approval: This study was approved by Kartal Kosuyolu High Specialization Training and Research Hospital Ethics Committee (2020-14-417, Date: 10.11.2020).

Informed Consent: Informed consent was obtained.

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Author Contributions: Concept/Design - ET, TA, CK; Analysis/Interpretation - ET, TA, HT; Data Collection - ET; Writing - ET, CK, MC; Critical Revision - CK, CK, CM; Statistical Analysis - ET, HT; Overall Responsibility - ET; Final Approval - All of authors.

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