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Original article

Assessment of Left Ventricular Dyssynchrony and Cardiac Function in Patients with Different Pacing Modes Using Real-Time Three-Dimensional Echocardiography: Comparison with Tissue Doppler Imaging

Mansour Mohammed Mostafa[a], Mohamed Sayed Bashandy[b], Ahmed Mohamed Ahmed Mostafa[b], Mohamed Moenes Moheyaldeen[a], Mohamed Samy Abdalsamee[a], Waseem Omar Ahmad[b].

Department of Cardiology, Faculty of Medicine, Al-Azhar University, Egypt[a].
Department of Cardiology, Damietta Faculty of Medicine, Al-Azhar University, Egypt[b].

Corresponding author: ***Waseem Omar Ahmad***
Email: Wasiem_o2@yahoo.com

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ABSTRACT

Background: Previous studies revealed that right ventricle apex pacing with different modes may yield abnormal electrical activity and left ventricle dyssynchrony.

Aim of the work: To evaluate systolic function of left ventricle and mechanical dyssynchrony with different modes of pacing using real time three dimensional echocardiography [the RT3DE] and tissue Doppler imaging [TDI].

Patients and Methods: The study included thirty-five individuals with permanent dual chamber pacemaker with atrial leads placed in right atrial appendage and right ventricular leads placed in right ventricular apex, the pacemakers were programmed to different modes. Imaging parameters were obtained following pacing for 24 hours in each mode.

Results: The results revealed that the RT3DE and TDI-derived dyssynchrony indices in the atrial demand pacing [AAI] mode were significantly lower than those in the dual chamber demand pacing [DDD] and ventricular demand pacing [VVI] modes; however, there was no significant difference between the DDD and VVI modes. Also, left ventricular ejection fraction [LVEF] during AAI and DDD modes was significantly higher than that during VVI mode; however, there was no significant difference between the DDD and AAI modes. There were negative correlations between LVEF and Ts-MD and Ts-SD, and there was positive strong correlation between RT3DE and TDI-derived dyssynchrony indices.

Conclusions: Left ventricular systolic synchronicity in AAI mode was superior to that in DDD and VVI modes. Left ventricular ejection fraction in the AAI and DDD pacing modes are superior to that in the VVI mode.

Keywords: Left ventricle mechanical dyssynchrony; Dual chamber demand pacing; Right ventricle apex; Tissue Doppler imaging; Real time three dimensional echocardiography

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INTRODUCTION

Optimal pacing modes used for the management of bradycardia is crucial. In advanced degree of heart block or sick sinus syndrome [SSS], use of DDD and VVI modes, the risk of congestive heart failure, atrial fibrillation and thromboembolism may be increased[1].

This could be explained by derangement of myofibers, intra- or inter-ventricular dyssynchrony, with subsequent reduction of muscular contractility function. This manifested clinically by reduction of left ventricle ejection fraction, and manifestation of heart failure in some cases. Once reduction of LVEF starts, there is deterioration in quality of life, increased tendency of atrial fibrillation and increased incidence of mortality. Therefore, it is important that left ventricular mechanical dyssynchrony [LVMD] and function of the left ventricle are objectively measured in patients with different pacing modes[2].

Current techniques of echocardiography included the use of regional velocity, strain, and strain rate measured by tissue Doppler. Although, other several echocardiographic dyssynchrony parameters were used in multicenter trial to predict clinical and echocardiographic responsiveness to dual chamber pacemaker, the sensitivity and specificity of these parameters were modest[3].

In that regard, real-time three-dimensional echocardiography [RT3DE] provides strong tomographic imaging for the left ventricle, which could provide accurate and reproducible indices of left ventricular dyssynchrony than available techniques. In addition, 3D echo is a sole technique, as it permits comparison between all myocardial segments' dyssynchrony [including the apex] rather than those used within a 2D scan plane [4].

AIM OF THE WORK

The present study aimed to evaluate the left ventricular mechanical dyssynchrony [LVMD] and function of left ventricle in different pacing modes using real-time three- dimensional echocardio-graphy [RT3DE] and tissue Doppler imaging [TDI]. In addition, to compare dyssynchrony indices derived from RT3DE with different tissue Doppler indices.

PATIENTS AND METHODS

The study included thirty-five individuals with permanent dual chamber pacemaker provided by St. Jude Medical, Inc. [St. Paul, MN, USA] [27 patients received pacemaker due to permanent high grade AV block, 3 due to intermittent AV block, 2 because of suffering from sick sinus syndrome and 3 because of inappropriate bradycardia] with the atrial leads placed in the right atrial appendage and the right ventricular leads placed in the right ventricular apex. All patients selected from Al-Azhar University Hospital [New Damietta], cardiology department between January and December 2017. Any patients with Poor echocardiographic recordings, significant valvular heart disease, atrial fibrillation, coronary heart disease and cardio-myopathy were excluded.

All patients provided an oral consent and full history taking. Then, submitted to full clinical examination, resting 12 lead electrocardiography, confirming lead position and excluding lead fracture throw chest X ray or cinefloroscope postero-anterior and lateral views, pacemaker interrogation and programming and Trans-thoracic echocardio-graphic examination. Dual-chamber pacemakers were programmed for DDD and VVI modes in all patients, in successive manner, i.e. the AAI pacing mode was programmed in 8 patients only who had good AV conduction. DDD pacing mode was initially programmed in all patients, prior to the pacemakers being programmed from DDD to VVI modes and then from VVI to AAI modes. Subsequent to pacing being done in each mode for 24 h, the RT3DE and TDI images were acquired, respectively.

For transthoracic echocardiography: all the following were obtained: 1] modified Simpson's method for assessment of LV systolic function. 2] Color m-mode to assess septal to posterior wall mechanical delay. 3] Pulsed wave Doppler to assess left ventricular pre-ejection period, right ventricular pre-ejection period and interventricular mechanical delay. 4] IV. Doppler tissue imaging [DTI] to assess septal to posterior wall delay, Ts-SD and Ts-MD. 5] RT3DE to assess SDI-6, SDI-12 and SDI-16, LVEDV, LVESV and LVEF.

RT3DE was carried out by available echo-cardiographic system [iE33; Philips Medical Systems, Andover, MA, USA] by using an X3 matrix transducer. Patients were inquired to take and hold

their breath and the images were attached with an electrocardiographic registration. A hard disk of echocardiography system was used to store images to be available for further analysis offline with special software [QLAB, version 10.4; Philips Medical Systems]. The evaluated data included LV end-diastolic volume [LVEDV], LV end-systolic volume [LVESV], LVEF and RT3DE volume-time curves [VTCs]. Left ventricle was allocated into 16 sections, from apex to base, according to the segmentation schema of the American Heart Association and the American Society of Echocardiography, and the regional VTCs were gained for each section [segment]. To assess systolic dyssynchrony, the standard deviation [SD] of time from the onset of QRS to the minimal systolic regional volume was recorded for 16 sections, i.e. 6 basal, 6 middle and 4 apical segments [SDI-16]; as well as 12 sections, i.e. 6 basal and 6 middle segments [SDI-12], and the 6 basal sections [SDI-6] of the left ventricle for each subject. All indices were normalized as percentages of the RR-interval, the cut-off value used in this study was 8.3%. The higher the value, the worse the LV synchronicity.

TDI echocardiograms were obtained through usage of the iE33 echocardiography system with a broadband transducer [S5-1,2-5 MHz]. The images were associated with a record of electrocardiogram. The TDI investigations were carried out according to guidelines of the American Society of Echocardiography. The variables evaluated using TDI were Ts-SD and Ts-MD, which were recognized as the standard deviation and maximal time difference, respectively, from the onset of QRS to the peak systolic tissue velocity for 12 segments of the left ventricle, i.e. 6 basal and 6 middle segments attained from two, three and four-chamber apical views. In addition, TDI analysis of 6 basal and 6 middle segments was obtained from two, three and four-chamber apical views. The cut-off value of Ts-SD used in this study was 32.6 msec. The higher the value, the worse the LV synchronicity.

The RT3DE and TDI analysis of each patient was carried out by three different investigators and the data shown are the mean of three consecutive measurements

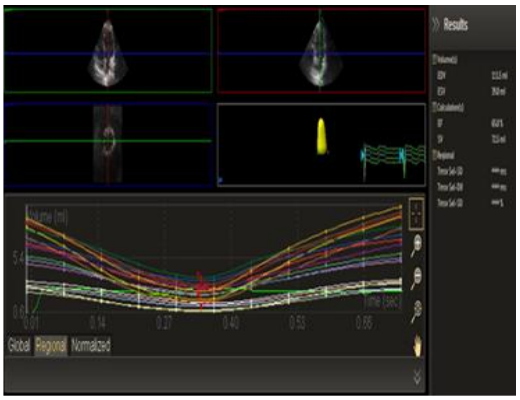

Figure [1]: Generated report and time-volume curves

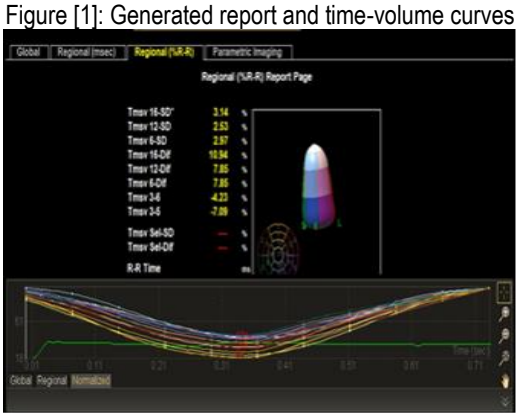

Figure [2]: Automatically calculated different SDI.

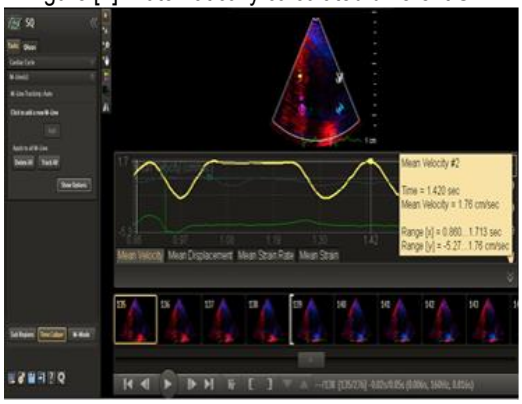

Figure [3]: Off-line analysis of the acquired 2-D color DTI images from apical 4-chamber view.

Statistical analysis

Data were collected in a pre-prepared excel sheet, coded and transferred to statistical package for sciences, version 20.0 [SPSS Inc., Chicago, Illinois, USA]. Arithmetic means and standard deviations were used for expression for numerical, normally distributed data; while frequency and percentages were used for representation of categorical data. For comparison between two means, independent samples student [t] test was used, while Chi square test was used in ordered to compare percentages between two qualitative variables. P value < 0.05 was considered significant.

RESULTS

This study included 21 females [60%]. The mean patient's age was 61.8 ± 11.67 years. Sixteen patients [45.7%] suffered from complete heart block, 11 patients [31.4%], suffered from permanent Mobitiz II heart block, 5 patients [14.4%], suffered from sinus node dysfunction, 2 patients [5.7%] suffered from intermittent complete heart block and 1 patient [2.9 %] suffered from intermittent Mobitiz II heart block. Twelve patients [34.4%] were hypertensive while 14 patients [40%] had diabetes mellitus type II. Duration of pacemaker implantation before the study ranged from 0.5 to 6 years with mean duration was 3.6± 1.6 years [Table 1]. The Ts-SD in the DDD and VVI modes was 44.84±6.99, 44.80±7.39 msec, respectively, while the Ts-MD in DDD and VVI modes was 113.97±8.97, 114.55±8.55msec, respectively. There was no significant difference between the DDD and VVI modes [P>0.05]. The SDI-16, SDI-12 and SDI-6 were [10.0±1.25, 10.54±1.39 and 10.52±1.42 %, respectively] during DDD mode while they were [10.05±1.24, 10.56± 1.36 and 10.58±1.35%, respectively] during VVI mode. There was no significant difference between the DDD and VVI [P>0.05]. The LVEF in the DDD and VVI modes was 64.53±4.85, 58.6±11.2 and 62.69±4.90%, respectively [P< 0.001] [Table 2].

There was subgroup of 8 patients who were suitable for AAI programming. We assessed different left ventricle mechanical dyssynchronization indices [tissue Doppler and real time tree dimensions' indices] in those patients after twenty-four hours from being programmed to AAI mode. Ts-SD was [24.19 ± 1.89 msec] during AAI mode which was significantly lower than that during DDD mode which was [37.69 ± 3.34 msec] [P< 0.001] and it was significantly lower than that during VVI modes which was [37.91 ± 3.75 msec] [P< 0.001]. There was no significant difference between Ts-SD measured during DDD and VVI modes in those patients [P=1.000]. The Ts-MD was [38.69 ± 2.20 msec] during AAI mode which was significantly lower than that during DDD mode which was [109.75 ± 6.88 msec] [P< 0.001] and it was significantly lower than that during VVI modes which was [110.06 ± 7.50 msec]. There was no significant difference between Ts-MD measured during DDD and VVI modes in those patients [P=1.000]. The SDI-16, SDI-12 and SDI-6 were [5.69 ± 0.68, 66.10 ± 0.62 and 6.05 ± 0.73%, respectively] during AAI mode which was significantly lower than that during DDD mode which were [9.49 ± 0.91, 10.08 ± 1.21and 9.88 ± 1.17%%, respectively] [P< 0.001] and it was significantly lower than that during VVI modes which were [9.75 ± 1.01, 10.31 ± 1.20 and 8.6-11.6%, respectively] [P< 0.001]. There was no significant difference between the DDD and VVI [P>0.05]. The changes in LVED volume, LVES volume and LVEF function in patients with AAI, DDD and VVI pacing modes are shown in Table 3. The LVEF during AAI mode was [69.69 ± 2.64 %] which was significantly higher than that during VVI mode [66.98 ± 2.69 %] [P=0.004], while there was no significant difference between EF measured during AAI and DDD modes [69.06 ± 2.40 %] in those patients [P=0.592] [Table 3].

There was strong correlation between RT3DE and TDI dyssynchrony indices during different pacing modes, Pearson coefficient was 0.828[P<0.001], 0.834[P<0.001], 0.792[P<0.001] between TS-SD and SDI-6, SDI-16, SDI-12 respectively during DDD mode while it was 0.864 [P<0.001], 0.846 [P<0.001], 0,872[P<0.001] between TS-MD and SDI-6, SDI-12, SDI-16 respectively. During VVI mode Pearson coefficient was 0.766 [P<0.001], 0.787 [P<0.001], 0.756[P<0.001] between TS-SD and SDI-6, SDI-16, SDI-12 respectively, while it was 0.831[P<0.001], 0.819 [P<0.001], 0.833[P<0.001] between TS-MD and SDI-6, SDI-12, SDI-16 respectively. During AAI mode Pearson coefficient was 0.792, 0.708, 0.785 between TS-SD and SDI-6[P=0.019], SDI-16 [P=0.049], SDI-12 [P=0.021] respectively, while it was 0.807 [P=0.015], 0.706 [P=0.05], 0.747 [P=0.033] between TS-MD and SDI-6, SDI-16, SDI-12 respectively. LVEF was inversely correlated with the TDI-derived LV dyssynchrony indices during DDD and VVI modes, Pearson coefficient was -0.798[P<0.001] and -0.569[P<0.001] between LVEF and TS-SD and TS-MD respectively during DDD mode while it was -0.82[P<0.001] and -0.566 [P<0.001] between LVEF and TS-SD and TS-MD respectively during VVI mode. LVEF had no correlation with the TDI-derived LV dyssynchrony indices during AAI mode, Pearson coefficient was 0.424 [P=0.295] and 0.472[p=0.238] between LVEF and TS-SD and TS-MD respectively [Table 4].

Table [1]: Distribution of the studied cases according to baseline patient characteristics

	No.	%
Sex		
Male	14	40.0
Female	21	60.0
Age [years]		
Min. – Max.	30.0 – 73.0	
Mean ± SD.	61.0 ± 11.67	
Cause		
SSS	3	8.6
ISB	1	2.9
MOB 2	11	31.4
I-MOB 2	1	2.9
CHB	16	45.7
I-CHB	2	5.7
S-PAUSE	1	2.9
Duration		
Min. – Max.	0.50 – 6.0	
Mean ± SD.	3.29 ± 1.65	
Median	3.0	
Comorbidities		
HTN	12	34.3
DM	14	34.3

SSS, sick sinus syndromes; ISB, inappropriate sinus bradycardia; I-MOB. Intermittent Mobitiz II; I-CHB, intermittent complete heart block; HTN, hypertension; DM, diabetes mellitus; CAD, coronary artery disease.

Table [2]: Comparison between DDD and VVI according to different parameters [n= 35].

	DDD	VVI	T	P
Systolic function				
EDV mean[SD] in ml	95.97[11.06]	91.91[10.53]	21.127*	<0.001*
ESV mean[SD] in ml	34.11 [7.51]	34.51 [7.10]	1.148	0.259
EF mean[SD] in %	64.53 [4.85]	62.69 [4.90]	12.812*	<0.001*
TDI				
Ts-SD mean[SD] in ms	44.84 [6.99]	44.80 [7.39]	0.103	0.919
Ts-MD mean[SD] in ms	113.97 [8.97]	114.55 [8.55]	1.393	0.173
RT3DE				
SDI6 mean[SD] in %	10.52 [1.42]	10.58 [1.35]	0.870	0.390
SDI12 mean[SD] in %	10.54 [1.39]	10.56 [1.36]	0.564	0.576
SDI16 mean[SD] in %	10.0 [1.25]	10.05 [1.24]	0.989	0.330

Table [3]: Comparison between DDD, VVI and AAI [n= 8]:

	DDD	VVI	AAI	F	P
EDV mean[SD] in ml	[89.25[9.25	[85.50 [9.50	[90.13[8.97	67.050*	<0.001*
Between groups	**p_1<0.001*,p_2=0.123,p_3<0.001***				
ESV mean[SD] in ml	[27.0 [3.70	[28.38 [4.37	[26.63 [3.42	1.303	0.303
EF mean[SD] in %	[69.06 [2.40	[66.98 [2.69	[69.69 [2.64	21.734*	<0.001*
Between groups	**p_1=0.001*,p_2=0.592,p_3=0.004***				
TDI					
Ts-SD mean[SD] in ms	[37.69 [3.34	[37.91 [3.75	[24.19 [1.89	262.459*	<0.001*
Between groups	**p_1=1.000,p_2<0.001*,p_3<0.001***				
Ts-MD mean[SD] in ms	[109.75 [6.88	[110.06 [7.50	[38.69 [2.20	1285.077*	<0.001*
Between groups	**p_1=1.000,p_2<0.001*,p_3<0.001***				
RT3DE					
SDI-6 mean [SD] in%	[9.88 [1.17	[10.24 [1.14	[6.05 [0.73	142.385*	<0.001*
Between groups	**p_1=0.863,p_2<0.001*,p_3<0.001***				
SDI-12 mean [SD] in%	[10.08 [1.21	[10.31 [1.20	[6.10 [0.62	246.081*	<0.001*
Between groups	**p_1=0.692,p_2<0.001*,p_3<0.001***				
SDI-16 mean [SD] in%	[9.49 [0.91	[9.75 [1.01	[5.69 [0.68	174.841*	<0.001*
Between groups	**p_1=0.562,p_2<0.001*,p_3<0.001***				

P1: comparison between DDD and VVI; P2: comparison between DDD and AAI and P3: comparison between VVI and AAI, * significant differnce.

Table [4]: Correlation between Ts-SD and Ts-MD with different parameters for DDD cases [n = 35]

DDD	Ts-SD		Ts-MD	
	R	p	R	p
RT3DE				
SDI6	0.828*	<0.001*	0.864*	<0.001*
SDI16	0.834*	<0.001*	0.846*	<0.001*
SDI12	0.792*	<0.001*	0.872*	<0.001*
EF	-0.798*	<0.001*	-0.569*	<0.001*
VVI				
RT3DE				
SDI6	0.766*	<0.001*	0.831*	<0.001*
SDI16	0.787*	<0.001*	0.819*	<0.001*
SDI12	0.756*	<0.001*	0.833*	<0.001*
EF	-0.82*	<0.001*	-0.566*	<0.001*
AAI				
RT3DE				
SDI6	0.792*	0.019*	0.807*	0.015*
SDI16	0.708*	0.049*	0.706*	0.05*
SDI12	0.785*	0.021*	0.747*	0.033*
EF	0.424	0.295	0.472	0.238

DISCUSSION

In the present study we assessed different left ventricle mechanical dyssynchronization indices [basic, tissue Doppler and real time three dimensions' indices] in all patients after 24 hours from pacing on DDD and VVI modes and in subgroups of eight patients after twenty-four hours from pacing on AAI mode. The study tried to answer the following questions; 1] Is there any difference between different pacing modes regarding left ventricle mechanical dyssynchrony and left ventricle systolic function? 2], can real time three dimensions' echocardiography used for assessment of left ventricle mechanical dyssynchrony in comparison with Doppler tissue imaging?

Regarding difference between pacing modes regarding left ventricle mechanical dyssynchrony and left ventricle systolic function, results of the present work showed agreement with **Dai *et al.*[5]** who studied 20 individuals with sick sinus syndrome to assess the mechanical dyssynchrony and function of the left ventricle in AAI, DDD and VVI by RT3DE TDI, 24 hours after mode programming. They concluded that DTI and RT3DE dyssynchrony indices in AAI mode were significantly reduced than those in DDD and VVI modes [P<0.05]; however, DDD and VVI modes did not differ significantly [P>0.05]. There were negative correlations between the LVEF and dyssynchrony indices. The LVEF in the AAI was also higher than that of DDD and VVI modes, but unlike our study there were no significant difference between LVEF in different modes and that could be explained by the difference between both studies in number and nature of patients. **Cai *et al.*[6]** studied 15 individuals with sick sinus syndrome to assess the left ventricle function and mechanical dyssynchrony in AAI, DDD and VVI pacing modes by RT3DE and TDI after pacing for 5 minutes in each mode. They concluded DTI and RT3DE dyssynchrony indices in the AAI mode significantly reduced than DDD and VVI modes; and no significant differences were registered between the DDD and VVI modes. There were negative correlations between the LVEF and dyssynchrony indices. But, unlike our study the LVEF in the AAI was significantly higher than that of DDD and VVI modes and that could be explained by the difference between both studies in number, nature of patients and duration of pacing on each mode before the assessment. In addition, results of the present work coincide with **Albertsen *et al.*[7]** who investigated global function of left ventricle and regional left ventricular mechanical dyssynchrony in 50 consecutive patients with sick sinus syndrome [SSS], 24 patients underwent AAI [R] and 26 patients submitted to DDD [R]. TDI quantifies LV dyssynchrony regarding number of sections [segments] with delayed longitudinal contraction. LVEF was assessed by using 3-D echocardio-

graphy. They found that, there was significant pronunciation of dyssynchrony in the DDD [R] group when compared to the AAI[R] group at the 12 months' follow-up. These results indicated a marked increase of dyssynchrony segments in the DDD[R] group from baseline onwards to the 12 months' follow-up. No significant changes were observed in the AAI[R] group. In both modes, the LVEF revealed no significant change overtime between basal values and values at the 12 months of follow-up.

We used the standard deviation of time from the QRS onset to the minimal systolic regional volume for basal 6 segments [SDI-6], for basal 6 segments and mid 6 segments [SDI-12] and for basal 6 segments mid 6 segments and apical 4 segments [SDI-16] for assessment of LV mechanical dyssynchrony in each pacing mode and compare it with Doppler tissue indices; the standard deviation of time from the QRS onset to the peak systolic tissue velocity[Ts-SD] and The maximal difference in time from the QRS onset to the peak systolic tissue velocity[Ts-MD], we found strong correlation between RT3DE indices and DTI indices in each pacing mode[P<0.001]. In agreement with our study **Dai *et al.*[5]** found strong correlation between DTI indices and SDI-12 and SDI-16 [p<0, 001]; however there was no correlation between DTI indices and SDI-6. This difference could be explained by the difference between both studies in number and the study population as they studied only patients with sick sinus syndrome while we studied patients with permanent and intermittent high grade AV block and patients with different types of sinus node dysfunction. The study of **Takeuchi *et al.*[8]** showed agreement with our results as they studied a total of 122 participants, including 21 control subjects and 101 patients with a wide range of LV ejection fraction [EF] [13% to 81%]. Patients were selected based on image adequacy, the aim of their study was assessment of the usefulness and reproducibility of real time RT3DE for evaluating LV dyssynchrony, and compared its results with Doppler tissue image [DTI] indices. They found strong correlation between correlation between parameters of left ventricular dyssynchrony by RT3DE and DTI, [Pearson coefficient was 0.71, 0.62 and 0.49 between Ts-SD and SDI-16, SDI-12 and SDI-6 respectively [p<0.001] and it was 0.73, 0.66 and 0.49 between Ts-MD and SDI-16, SDI-12 and SDI-6 respectively [p<0.001]. **Park *et al.*[9]** who studied 23 heart failure [HF] patients and 16 normal control subjects submitted to TDI and RT3DE. RT3DE was used to obtain the SDI-16 of the end systolic time reaching minimal systolic volume for the 16 segments on VTCs. The standard deviation [Ts-SD] of the electromechanical coupling time for the 12 segments was measured using TDI. They found SDI-16 was markedly higher in HF patients than in controls [7.7±2.5 Vs 1.5±1.0%, P<0.01] and increased as LVEF decreased [r= −0.85, P<0.01]. Ts-SD was also significantly higher in HF patients [27.0±8.6 Vs 12.6±5.0 ms, P<0.01] and in agreement with our study Ts-SD had a good negative correlation with LVEF [r=−0.72, P<0.01] and well correlated to SDI-16 [r=0.66, P<0.01].

In contrast to our study, **Samir *et al.*[3]**found no correlation between SDI-16 and Ts-SD [r = 0.14, P = 0.3] when they assessed LVMD using RT3DE in 60 consecutive patients who were considered candidates for CRT and compared it with the different dyssynchrony indices derived from Doppler tissue imaging [DTI] for the same patient. This contrast could be explained by the difference in patients' number and study population as they studied only patients with impaired LVEF and before implantation of CRT while we exclude any patient with impaired LVEF and studied only patients who had dual chamber pacemaker. however, SDI-16 in their study showed good correlation with QRS duration [r = 0.45, P < 0.001] and inverse correlation with left ventricular ejection fraction [LVEF] calculated by RT3DE [r = −0.37, P = 0.004], while 12 Ts-SD index showed no correlation with QRS duration [r = −0.0082, P = 0.51] or 2D LVEF [r = −0.26, P = 0.84].So, they concluded that RT3DE could quantify LVMD by providing the SDI-16 and it might prove to be more useful than DTI.

Limiting steps of the present work include small sample size, the study is single-centered and self-contrasted. In addition, the study analyzed acute phase changes of differed modes of pacemakers. However, the study concluded that, systolic synchronicity of left ventricle, in AAI mode is

superior to that in the DDD and VVI modes. Ejection fraction in AAI and DDI modes is superior to VVI mode. Finally, real time three dimensional echocardiography is able to give objective and accurate evaluation of left ventricle mechanical dyssynchrony in patients with various pacing modes in comparison to tissue Doppler imaging. Worsening of left ventricle ejection fraction is associated with increased LV dyssynchrony indices in real time 3-D echocardiography and tissue Doppler imaging.

References

1. **Garg J, Reddy VY.** Leadless cardiac pacemakers: Paradigm shift in cardiac pacing. HearT Rhythm. **2019;** 16[1]:72–3. [PMID: 30340063. DOI: 10.1016/ j.hrthm. 2018.10.012].
2. **Osorio APS, Warpechowski SN, Ley ALG, Miglioranza MH, Ley LLG, Almeida ED, Sant'anna RT, Leiria TLL.** Analysis of Dyssynchrony and Ventricular Function in Right Univentricular Stimulation at Different Positions. Braz J Cardiovasc Surg. **2017** Nov-Dec;32[6]:492-497. [PMID: 29267612. DOI: 10.21470/1678-9741-2017-0056].
3. **Samir R, Tawfik M, El Missiri AM, El Shahid G, Maaty MA, El Sayed M.** Assessment of left ventricular mechanical dyssynchrony using real time three-dimensional echocardiography: a comparative study to Doppler tissue imaging. Echocardiography **2012**;29 [2]:173-81. [PMID: 22044613. DOI: 10.1111/ j.1540-8175.2011.01548.x].
4. **Ali Sl, Li Y, Adam M, Xie M.** Evaluation of Left Ventricular Systolic Function and Mass in Primary Hypertensive Patients by Echocardiography. J Ultrasound Med. **2019;** 38[1]:39–49. [PMID:30027675. DOI: 10.1002/jum.14687].
5. **Dai M, Lu J, Qian DJ, Cai JF, Liu XY, Wu XQ, et al.** Assessment of left ventricular dyssynchrony and cardiac function in patients with different pacing modes using real-time three-dimensional echocardiography: Comparison with tissue Doppler imaging. Exp Ther Med **2013;** 6[5]:1213–9. [PMID: 24223646. DOI: 10.3892/ etm.2013.1292].
6. **Cai J, Wang R, Li X, Dai M, Zhang CY, Liu XY, Qian DJ.** Evaluation on left ventricular systolic synchronicity and cardiac function in patients with permanent cardiac pacing by real-time three-dimensional echocardiography. Zhonghua Xin Xue Guan Bing Za Zhi **2010;** 38[3]:215–9. [English Abstract]; [PMID: 20450562].
7. **Albertsen AE, Nielsen JC, Poulsen SH, Mortensen PT, Pedersen AK, Hansen PS, Jensen HK, Egeblad H.** DDD[R]-pacing, but not AAI[R]-pacing induces left ventricular desynchronization in patients with sick sinus syndrome: tissue-Doppler and 3D echocardiographic evaluation in a randomized controlled comparison. Europace **2008**;10[2]:127-33. [PMID: 18192700. doi: 10.1093/europace/eum279].
8. **Takeuchi M, Jacobs A, Sugeng L, Nishikage T, Nakai H, Weinert L, Salgo IS, Lang RM.** Assessment of left ventricular dyssynchrony with real-time 3-dimensional echocardiography: comparison with Doppler tissue imaging. J Am Soc Echocardiogr. **2007;** 20[12]:1321–9. [PMID: 17764902. DOI: 10.1016/j.echo.2007.05.001].
9. **Park SM, Kim KC, Jeon MJ, Lee CK, Kim DH, Park KS, Lee WH, Kwan J.** Assessment of left ventricular asynchrony using volume-time curves of 16 segments by real-time 3 dimensional echocardiography: comparison with tissue Doppler imaging. Eur J Heart Fail. **2007** 9[1]:62–7. [PMID: 16890014. DOI: 10.1016/j.ejheart.2006.04.009].