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Tissue Doppler Imaging versus Conventional Echocardiography in Evaluation of Cardiac Functions in Diabetes Mellitus

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Abstract

Background: Conventional echocardiography and tissue Doppler imaging have been highlighted to diagnose diastolic and systolic heart dysfunction. We aimed to compare tissue Doppler imaging with conventional echocardiography to diagnose heart dysfunctions in diabetes mellitus type 1 (DMT1) patients.

Materials and Methods: This case-control study was conducted in the Ali Asghar Clinic, Zahedan, Iran. The study lasted from 2017 to 2018 on 140 participants aged from 4-18 years, and consisted of 70 patients with DMT1, and 70 children who referred to hospital for checkup as control group. The participants went under tissue Doppler imaging and conventional echocardiography (M mode and 2D) by an invariable cardiologist. The 5 ml blood samples were taken to test blood leptin and ferritin. The data were analyzed using SPSS software (version 18.0).

Results: Conventional findings such as left and right deceleration time, left, and right peak E velocity, left ejection time, left Myocardial performance index and TDI findings such as left, and right ET', right S', right E', left MPI', right MPI', and left E/E' were different in patients and the control group ($p<0.05$). Left and right deceleration time, and LV Mass index in conventional and left ET', right ET' in TDI were different in age groups of patients ($p<0.05$). In sex groups, left deceleration time, left peak A velocity, right acceleration time, right deceleration time and right E/A in conventional and left ET', left ICT', left IRT', right ICT', right IRT', right S' and right MPI' in TDI were different ($p<0.05$).

Conclusion: This study concluded that both conventional and TDI were different between DMT1 patients and the control group, but TDI was stronger in discrimination.

Key Words: Children, Diabetes Mellitus, 2D Echocardiography, Tissue Doppler Imaging.

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1- INTRODUCTION

Diabetes mellitus (DM) is one of the most common diseases in which its cardiac related complications are the main causes of death and diabetes mellitus type 1 (DMT1) is an immune system disorder with a strong genetic component that involves all ages and races with tendency in childhood (1-3). DMT1 is an autoimmune disorder that resulted due to immune-mediated destruction of insulin-producing β-cells (4, 5). The frequency of DM is estimated to be 387 million individuals around the world of which DMT1 represents 5 to 10% (6). In Iran, the prevalence of DMT1 is 40 in 100,000 (7) and is expected to increase in future increasing in future (8).

Different researchers demonstrated that in diabetic patients there is broad impedance in left ventricular capacities so that it has been characterized as the most fundamental indication of diabetic myocardial disease (9, 10). Consequently, DMT1 ought to be treated as an alternative subject that needs independent evaluation. DMT1 has been frequently connected with diastolic dysfunction more than systolic one (11). There are only a few non-uniform data on left ventricle (12) and right ventricle (13) systolic function assessed using tissue Doppler imaging (TDI). Few studies have evaluated LV systolic function using 2D in DMT1 (14). Conventional echocardiography method is a diagnostic tool to show heart anomalies in hazardous diseases such as thalassemia, diabetes and celiac (15).But tissue Doppler imaging (TDI) has demonstrated that the systolic myocardial velocity S′ is a more sensitive measure of systolic function than ejection fraction (EF), and that the early diastolic myocardial velocity E' and E/E' have the best correlation with left ventricular relaxation (16). Therefore, it is possible that TDI will become more common in clinical practices, as it offers enhanced quality pictures which expands the affectability of echocardiography for discovery of subclinical ventricular dysfunction compared to conventional echocardiography These potential capabilities with TDI are due to its noninvasive nature and reproducibility of the results, ease of application, and consistency of the results with those of cardiac catheterization (15). Likewise, given that cardiac autonomic function disorder (CAFD) is one of the most severe complications of diabetes, the study aimed to use tissue Doppler imaging versus conventional echocardiography in evaluation of cardiac functions in diabetes mellitus type 1 patients.

2- MATERIALS AND METHODS

This case-control study was conducted in the Ali Asghar Clinic, Zahedan, Iran. The study lasted from January 2017 to June 2018 on 140 participants aged from 4-18 years, and consisted of 70 patients with DMT1, and 70 children who referred to hospital for checkup as control group. The study was done in two centers in collaboration with endocrinology and cardiology departments.

2-1. Criteria

Inclusion criteria were DMT1 patients either symptomatic or asymptomatic. The diabetes was confirmed by clinical manifestations such as polyuria, polydipsia, weight loss, laboratory measures such as fasting blood glucose > 125mg/dl, and random blood glucose>200 mg/dl. However, exclusion criteria were age higher than 18 years, documented evidence of other cardiac disease like ischemic, hypertension, cardiomyopathy, valvular heart disease, congenital heart disease, and myocarditis, features of hypothyroidism, uremia and random blood sugar > 140 mg/dL for the control group. In addition, participants whose body mass index (BMI) were out of normal range were checked for exclusion. The patients with BMI higher than 95th percentiles were excluded from the study.

2-2. Echocardiography Measures

The participants underwent conventional echocardiography (M mode and 2D) by a cardiologist, using My Lab 60 instrument with 3-8-MHz transducers, made in Italy. Echocardiographic parameters such as, ejection fraction (EF), fractional shortening (FS), ejection time (ET), peak A velocity (A), peak E velocity (E), myocardial performance index (MPI), peak E (early mitral and tricuspid valve flow velocity), peak A (late mitral and tricuspid valve flow velocity) velocity (E/A ratio), deceleration time (DT) and acceleration time (AT), were measured with conventional echocardiography. The sample volume was positioned at the tips of the tricuspid and mitral valve leaflets in the apical four-chamber views to enable measurement of (a): the time interval between the end and the start of trans-mitral and trans tricuspid flow. The sample volume was, thereafter, relocated to the left ventricular outflow tract just below the aortic valve (apical five-chamber view); (b): the left ventricular ejection time. The right ventricular outflow velocity pattern was also recorded from the parasternal short-axis view with the Doppler sample volume positioned just distal to the pulmonary valve for the measurement of (b). Myocardial Performance Index (MPI) which was calculated as a-b/b = (ICT + IRT)/ET (17). The left ventricular mass index (LVMI) was also calculated by the following formula: LVM (g) = 0.8 (1.04 $(((LVDD + PWD + IVSD)^3 - LVDD^3)))$ + 0.6; and LVMI (g/m^2) = LVM / 2.7 (18).

2-3. Tissue Doppler Imaging Measurements

Doppler tissue echocardiography (DTE) was another method performed from the apical four-chamber view and a 3 mm pulsed Doppler sample volume was placed at the level of the lateral mitral annulus. Myocardial velocity profiles of the lateral tricuspid annulus and lateral mitral annulus were obtained by placing the sample volume at the junction of the tricuspid annulus and the right ventricle (RV) free wall and at the junction of the mitral annulus and LV posterior wall, respectively. With this modality, the recorded values were the early (E) and late (A) diastolic mitral and tricuspid annular velocities, and the ratio of E/A. Right ventricle and left ventricle myocardial performance index (MPI) were obtained by dividing the sum of isovolumic relaxation time (IVRT) and isovolumic contraction time (ICT) by the ejection time (ET) (MPI = (ICT + IRT)/ET) (19).

Left and right S: Systolic myocardial velocity above the baseline in mitral and tricuspid. Left and right E: early diastolic myocardial relaxation velocity below the baseline in mitral and tricuspid. Left and right A: myocardial velocity associated with atrial contraction in mitral and tricuspid. Particular attention was paid to placing the sample volume on the myocardium and not the endocardium or epicardium. In each case, the subsequent measurements were obtained in three heartbeats in all positions and the average value was recorded (**Figure.1**). To ensure high precision and reproducibility in conventional echocardiography and tissue Doppler imaging, measurements were repeated via 3 cycles including 2D, M-Mode, Doppler method. Then, the average was considered for the analysis.

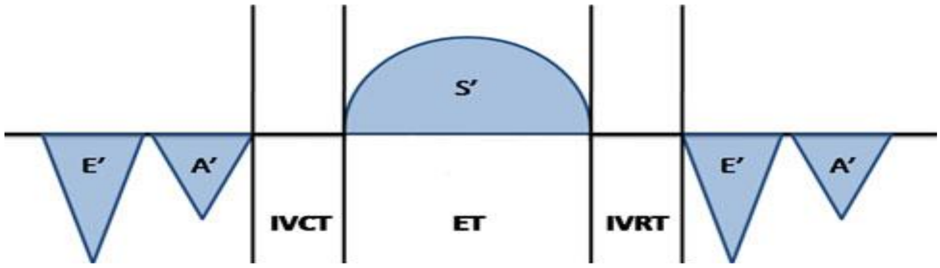

Fig.1: Diagram of Doppler Tissue Echocardiography waves: S', systolic wave; E', early diastolic wave; A', late diastolic wave (20).

2-4. Anthropometric Measures

The patients' height and weight were measured by an experienced expert using standard equipment. Then, BMI was calculated according to the 2000 sex specific BMI-for-age growth charts of the Centers for Disease Control and Prevention.Overweight is defined as a BMI at or above the 85th percentile and below the 95th percentile for 2-19 years, for both groups equally. Obesity is defined as a BMI at or above the 95th percentile (21).

2-5. Ethical Approval

Informed consent was obtained from all participants or their parents after the study approval. The study project was approved by the Children and Adolescent Health Research Center in the Ethics Committee of Zahedan University of Medical Sciences, Zahedan, Iran (ID-code: 7230).

2-6. Statistical Analysis

The data were analyzed using SPSS software version 18.0 (SPSS Inc, Chicago, IL, USA). Descriptive statistics were presented in mean ± standard deviation (SD). Comparisons between DMTI subjects and the control group were performed using t-test and Mann-Whitney U test, and in more than two groups the One-way Analysis of Variance and Kruskal –Wallis tests were used based on normality of the variable data distribution. The correlations between the variables were calculated using Pearson's correlation, while $P<0.05$ was considered significant.

3- RESULTS

The present study aimed to measure the changes in echocardiography findings based on conventional and TDI methods. The findings showed that the participants' characteristics such as age (10.5±3.16, p=0.093), height (144.49±19.10, p=0.053) were placed in normal distribution. In patients, the characteristics of height (135.81±19.91, p= 0.200), and weight (32.00±11.95, p=0.200) were normal. The measures of age (p=0.017) in patients, weight (p=0.004) in participants and BMI (p<0.001) in both participants and patients were distributed freely.

Regarding echocardiography findings, the **Table.1** showed that in all participants, the variables of Et (K.S= 0.060, p=0.200), EF(K.S= 0.075. p=0.055), FS (K.S= 0.074, p=0.060), left MPI (K.S= 0.042, p=0.200) and left E/A (K.S= 0.067, p=0.200) were distributed normally in the case of using conventional echocardiography method when left IRT'(K.S= 0.072, p=0.074), and right MPI' (K.S= 0.055, p=0.200) were normal in the case of DTI methods when compared. Among patients with the conventional echocardiography, the variables of right E, right Peak A velocity, right ET, left MPI, right MPI, and left E/A were normal when left ET, left IRT, right E', right A', left and right MPI' were normal while the DTI methods were applied for measuring cardiac findings.

Sex distribution of participants was 54.7% and 57.1% for boys in patients and control group, respectively. No statistical differences were observed for sex distribution in patients and the control group (chi-square=1.83, p=0.176). Patients' mean age was (10.67±3.55), the same as the age of the control group (10.67±3.55), (p=0.530). Means of age were (135.81±19.91) and (153.17±13.64) for patients and the control group respectively (p<0.001). Weight (44.31±13.15 VS 32.00±11.95) and BMI (18.40±3.10 vs. 16.68±2.40) had the same trends with the level of significance higher than the control group.

Table-1: Echocardiography findings normality test in combined patients and controls, and in only patients

All Participants (140)						Patients (70)					
Conventional functions	K.S	P-value	TDI functions	K.S	P-value	Conventional functions	K.S	P value	TDI function	K.S	P- value
Left AT	0.156	<0.000	Left ET'	0.184	<0.000	Left AT	0.152	<0.000	Left ET'	0.069	0.2
Left DT	0.104	0.001	Left ICT'	0.09	0.008	Left DT	0.127	0.007	Left ICT'	0.128	0.006
Left Peak E velocity	0.112	<0.000	Left IRT'	0.072	0.074	Left Peak E velocity	0.15	0.001	Left IRT'	0.095	0.189
Left Peak A velocity	0.106	0.001	Left S'	0.112	<0.000	Left Peak A velocity	0.125	0.009	Left S'	0.122	0.011
Right DT	0.147	<0.000	Left E'	0.379	<0.000	Right DT	0.138	0.002	Left E'	0.426	<0.000
Right Peak E velocity	0.083	0.02	Left A'	0.099	0.002	Right Peak E velocity	0.097	0.17	Left A'	0.148	0.001
Right Peak A velocity	0.06	0.2	Right ET'	0.167	<0.000	Right Peak A velocity	0.087	0.2	Right ET'	0.11	0.035
Right peak A velocity	0.081	0.025	Right ICT'	0.138	<0.000	Right peak A velocity	0.089	0.2	Right ICT'	0.106	0.051
Right ET	0.09	0.007	Right IRT'	0.099	0.002	Right ET	0.086	0.2	Right IRT'	0.126	0.008
Left ET	0.13	<0.000	Right S'	0.369	<0.000	Left ET	0.112	0.029	Right S'	0.132	0.004
EF	0.075	0.055	Right E'	0.077	0.041	EF	0.102	0.069	Right E'	0.072	0.2
FS	0.074	0.06	Right A'	0.077	0.041	FS	0.111	0.032	Right A'	0.102	0.066
LVMI	0.102	0.001	Left MPI'	0.082	0.021	LVMI	0.118	0.017	Left MPI'	0.059	0.2
Simpson EF	0.1	0.002	Right MPI'	0.055	0.2	Simpson EF	0.118	0.016	Right MPI'	0.094	0.2
Left MPI	0.042	0.2	Left E/E'	0.13	<0.000	Left MPI	0.076	0.2	Left E/E'	0.136	0.003
Right MPI	0.08	0.03	Left E'/A'	0.278	<0.000	Right MPI	0.102	0.066	Left E'/A'	0.344	<0.000
Left E/A	0.067	0.2	Right E/E'	0.136	<0.000	LE/A	0.063	0.2	Right E/E'	0.14	0.002
Right E/A	0.113	<0.000	Right E'/A'	0.091	0.007	RE/A	0 .170	<0.000	Right E'/A'	0.153	<0.000

KS: Kolmogorov-Smirnov, AT: Acceleration time, DT: Deceleration time, peak E: Early mitral valve flow velocity, peak A velocity: Late mitral and tricuspid valve flow velocity, ET: Ejection time, EF: Ejection fraction (calculated in the apical two and four chamber views with Simpson's apical biplane method), FS: Fractional shortening, MPI: Myocardial performance index, LVMI: Left ventricular mass index, S': Systolic myocardial velocity above the baseline in mitral and tricuspid, IVRT: Isovolumic relaxation time, ICT: Isovolumic contraction time.

Table.2 showed conventional echocardiography and tissue Doppler imaging findings in diabetic patients and the control group. From the table it can be observed that conventional echocardiography made a difference in left DT (MWU=896.50, p<0.001), left peak E velocity (MWU=1725.50, p=0.003), right DT (MWU=1015.50, p<0.001), right peak E velocity (t= -2.21, p=0.029), left ET(MWU=1875.00, p=0.016), left MPI (t=3.17, p=0.002), and TDI was different in left ET'(MWU=487.50, p<0.001), left IRT'(t=3.75, p<0.001), right ET'(MWU=933.00, p<0.001), right ICT'(MWU=1164.00, p<0.001), right IRT'(MWU=1284.00, p<0.001) right S'(MWU=209.50, p<0.001), right E'(MWU=1721.50, p=0.002), left MPI'(MWU=305.00, p<0.001), right MPI'(MWU=138.00, p<0.001), and left E/E'(MWU=1559.50, p<0.001). **Table.3** showed comparison of conventional echocardiography and tissue Doppler imaging findings in age groups of patients. The table revealed that findings of left DT (MWU=302.00, p<0.001), right DT (MWU=385.00, p=0.009), and LVMI (MWU=195.00, p<0.001) were different in conventional echocardiography method and the findings of left ET' (t= -2.84, p=0.006), right ET' (MWU=423.50, p=0.032) were different in TDI method.

Table-2: Conventional and TDI findings in patients and control.

Conventional functions	Groups	Mean	SD	Value test	P value	TDI functions	Groups	Mean	SD	Value Test	P value
Left AT	Patients	59.54	9.32	2316.50	0.570	Left ET'	Patients	231.97	25.89	487.50	<0.000
	Control	59.46	8.83				Control	334.39	80.64		
Left DT	Patients	177.43	50.27	896.50	<0.000	Left ICT"	Patients	86.23	21.21	2428.00	0.927
	Control	133.96	25.31				Control	86.04	18.79		
Left peak E velocity	Patients	92.26	18.86	1725.50	0.003	Left IRT'	Patients	90.96	16.40	3.75	<0.000
	Control	99.09	19.52				Control	79.76	18.83		
Left peak A velocity	Patients	52.51	10.89	2390.00	0.802	Left S'	Patients	8.76	1.48	2292.00	0.510
	Control	52.71	9.24				Control	8.80	1.69		
Right AT	Patients	63.63	11.13	2133.50	0.181	Left E'	Patients	17.91	18.38	2031.00	0.081
	Control	61.24	9.73				Control	14.92	2.77		
Right DT	Patients	159.21	39.60	1015.50	0.000	Left A'	Patients	7.02	1.73	2300.50	0.533
	Control	126.90	24.99				Control	6.72	1.74		
Right peak E velocity	Patients	64.34	10.98	-2.21	0.029	Right ET'	Patients	235.93	22.76	933.00	<0.000
	Control	68.67	12.21				Control	279.59	56.18		
Right peak A velocity	Patients	48.10	9.53	2378.00	0.764	Right ICT"	Patients	92.11	21.69	1164.00	<0.000
	Control	50.04	13.15				Control	73.43	12.63		
Right ET	Patients	255.24	26.39	2362.00	0.713	Right IRT"	Patients	81.60	13.91	1284.00	<0.000
	Control	255.67	23.89				Control	96.29	19.41		
Left ET	Patients	241.17	27.62	1875.00	0.016	Right S'	Patients	9.25	1.92	209.50	<0.000
	Control	253.43	33.11				Control	49.41	30.67		
EF	Patients	76.41	5.44	-0.91	0.363	Right E'	Patients	13.63	2.91	1721.50	0.002
	Control	77.23	5.11				Control	15.05	2.52		
FS	Patients	44.69	5.06	-0.99	0.323	Right A'	Patients	6.80	1.77	2055.50	0.100
	Control	45.51	4.83				Control	7.43	2.24		

LVMI	Patients	45.19	19.40	2361.00	0.711	Left MPI’	Patients	0.77	0.10	305.00	<0.000
	Control	44.21	19.27				Control	0.52	0.12		
Simpson EF	Patients	43.66	7.05	1584.50	<0.000	Right MPI’	Patients	0.74	0.12	138.00	<0.001
	Control	48.39	8.72				Control	0.62	0.12		
Left MPI	Patients	0.74	0.17	3.17	0.002	Left E/E’	Patients	5.89	1.49	1559.50	<0.000
	Control	0.65	0.17				Control	6.96	2.53		
Right MPI	Patients	0.68	0.16	2313.00	0.568	Left E’/ A’	Patients	2.72	3.03	2337.00	0.638
	Control	0.69	0.16				Control	2.37	0.74		
Left E/A	Patients	1.80	0.39	-1.52	0.130	Right E/E’	Patients	4.97	1.54	2224.00	0.346
	Control	1.91	0.47				Control	4.75	1.53		
Right E/A	Patients	1.37	0.29	2220.50	0.339	Right E’/ A’	Patients	2.11	0.65	2206.00	0.309
	Control	1.43	0.34				Control	2.22	0.76		

AT: Acceleration time, DT: Deceleration time, peak E: Early mitral valve flow velocity, peak A: Late mitral and tricuspid valve flow velocity, ET: Ejection time, EF: Ejection fraction (calculated in the apical two and four chamber views with Simpson’s apical biplane method), FS: Fractional shortening, MPI: Myocardial performance index, LVMI: Left ventricular mass index, S’: Systolic myocardial velocity above the baseline in mitral and tricuspid, IVRT: Isovolumic relaxation time , ICT: Isovolumic contraction time.

Table-3: Age group comparison of Conventional and TDI findings in Patients.

Conventional functions	Age groups	Number	Mean	SD	T value	P-value	TDI l functions	Age groups	Number	Mean	SD	T value	P-value
Left AT	<10	31	59.23	11.74	599.50	0.952	Left ET’	<10	31	222.58	26.86	-2.84	0.001
	>10	39	59.79	6.99				>10	39	239.44	22.77		
Left DT	<10	31	156.81	26.52	302.00	0.001	Left ICT”	<10	31	83.13	20.53	466.00	0.100
	>10	39	193.82	58.40				>10	39	88.69	21.69		
Left peak E velocity	<10	31	93.23	23.81	562.50	0.619	Left IRT’	<10	31	87.45	16.76	-1.61	0.111
	>10	39	91.49	14.02				>10	39	93.74	15.76		
Left peak A velocity	<10	31	53.06	11.82	594.50	0.906	Left S’	<10	31	8.59	1.60	486.50	0.162
	>10	39	52.08	10.23				>10	39	8.90	1.38		
Right AT	<10	31	63.71	10.96	600.00	0.957	Left E’	<10	31	15.55	2.50	553.00	0.542
	>10	39	63.56	11.41				>10	39	19.79	24.50		
Right DT	<10	31	144.35	40.35	385.00	0.009	Left A’	<10	31	6.68	1.78	440.00	0.052
	>10	39	171.03	35.20				>10	39	7.29	1.67		
Right peak E velocity	<10	31	63.52	11.82	-0.56	0.579	Right ET’	<10	31	228.35	21.12	423.50	0.032
	>10	39	65.00	10.38				>10	39	241.95	22.46		
Right peak A velocity	<10	31	48.16	9.40	0.05	0.964	Right ICT”	<10	31	89.42	26.01	519.00	0.310
	>10	39	48.06	9.75				>10	39	94.26	17.60		
Right ET	<10	31	249.23	26.23	-1.72	0.089	Right IRT”	<10	31	80.90	14.64	578.00	0.751
	>10	39	260.03	25.86				>10	39	82.15	13.46		
Left RT	<10	31	230.10	27.38	600.50	0.962	Right S’	<10	31	8.95	1.76	488.00	0.168
	>10	39	249.97	24.77				>10	39	9.49	2.02		
EF	<10	31	75.55	5.46	-1.19	0.237	Right E’	<10	31	13.26	3.38	-0.94	0.351
	>10	39	77.10	5.38				>10	39	13.92	2.48		

FS	<10	31	43.77	4.67	517.50	0.302	Right A’	<10	31	6.81	1.82	0.03	0.977
	>10	39	45.41	5.30				>10	39	6.80	1.75		
LVMI	<10	31	33.16	12.77	195.00	0.001	Left MPI’	<10	31	0.77	0.09	0.07	0.948
	>10	39	54.74	18.52				>10	39	0.77	0.10		
Simpson EF	<10	31	43.81	6.74	587.00	0.836	Right MPI’	<10	31	0.75	0.13	0.43	0.668
	>10	39	43.54	7.37				>10	39	0.73	0.10		
Left MPI	<10	31	0.78	0.19	485.50	0.159	Left E/E’	<10	31	6.08	1.52	553.50	0.546
	>10	39	0.71	0.15				>10	39	5.75	1.47		
Right MPI	<10	31	0.66	0.13	464.00	0.097	Left E’/ A’	<10	31	2.46	0.69	515.00	0.290
	>10	39	0.70	0.18				>10	39	2.92	4.02		
Left E/A	<10	31	1.79	0.36	-0.32	0.749	Right E/E’	<10	31	5.15	1.89	591.00	0.873
	>10	39	1.82	0.41				>10	39	4.83	1.21		
Right E/A	<10	31	1.34	0.23	576.50	0.741	Right E’/ A’	<10	31	2.05	0.71	519.50	0.315
	>10	39	1.40	0.33				>10	39	2.15	0.60		

AT: Acceleration time, DT: Deceleration time, peak E: Early mitral valve flow velocity, peak A: Late mitral and tricuspid valve flow velocity, ET: Ejection time, EF: Ejection fraction (calculated in the apical two and four chamber views with Simpson’s apical biplane method), FS: Fractional shortening, MPI: Myocardial performance index, LVMI: Left ventricular mass index, S’: Systolic myocardial velocity above the baseline in mitral and tricuspid, IVRT: Isovolumic relaxation time , ICT: Isovolumic contraction time.

Table.4 showed Conventional echocardiography and TDI findings in comparison with the gender of the patients. Likewise, **Table.4** revealed that findings of Left DT (MWU=335.00, p<0.001), left peak A (MWU= 387.00, p=0.009), right AT(MWU=314.50, p<0.001), right DT(MWU=265.50, p<0.001), right peak A (t= -2.84, p= 0.006), right ET(t=2.08, p=0.042), LVMI (MWU=386.00, =0.009), left E/A(t=2.84, p=0.006), and right E/A(MWU=378.00, p=0.007) were different in conventional echocardiography method and the findings of left ET’(t= 4.10, p<0.001), left ICT’(MWU=435.50, p=0.041), left IRT’(t=2.68, p=0.009), right ICT’(MWU=402.00, p=0.015), right IRT’(MWU=434.50, p=0.038), right S’(MWU=426.50, p=0.032), and right MPI’(t= 2.01, p=0.049) were different in TDI method. MPI shows the systolic and diastolic heart functions. The preference of TDI against conventional MPI was collected for the analysis between the patients and the control group.

Figure.2 showed that MPI in patients had changed more than in control groups in all aspects, while only left MPI’ was significant.

Table-4: Sex comparison of Conventional and TDI findings in patients

Conventional						TDI					
Variables	Gender	Mean	SD	Test value	P-value	Variables	Gender	Mean	SD	Test value	P-value
Left AT	Boys	60.75	8.71	525.50	0.322	Left ET'	Boys	244.44	21.57	4.10	< 0.001
	Girls	58.53	9.80				Girls	221.47	24.76		
Left DT	Boys	195.44	50.70	335.00	0.001	Left ICT'	Boys	90.38	18.21	435.50	0.041
	Girls	162.26	45.19				Girls	82.74	23.11		
Left peak E velocity	Boys	92.13	14.40	551.50	0.505	Left IRT'	Boys	96.44	13.68	2.68	0.009
	Girls	92.37	22.12				Girls	86.34	17.22		
Left peak A velocity	Boys	48.62	9.25	387.00	0.009	Left S'	Boys	8.50	1.55	443.00	0.051
	Girls	55.79	11.19				Girls	8.98	1.39		
Right AT	Boys	68.97	11.13	314.50	< 0.001	Left E'	Boys	20.93	26.95	482.00	0.137
	Girls	59.13	9.06				Girls	15.37	2.56		
Right DT	Boys	178.41	29.22	265.50	< 0.001	Left A'	Boys	6.99	1.84	557.00	0.547
	Girls	143.05	40.28				Girls	7.05	1.66		
Right peak E velocity	Boys	64.16	10.81	-0.13	0.898	Right ET'	Boys	241.13	22.20	474.50	0.114
	Girls	64.50	11.27				Girls	231.55	22.59		
Right peak A velocity	Boys	44.75	8.66	-2.84	0.006	Right ICT"	Boys	99.41	20.91	402.00	0.015
	Girls	50.93	9.40				Girls	85.97	20.65		
Right ET	Boys	262.22	19.97	2.08	0.042	Right IRT"	Boys	84.84	11.10	434.50	0.038
	Girls	249.37	29.79				Girls	78.87	15.52		
Left ET	Boys	247.72	26.88	499.50	0.199	Right S'	Boys	8.95	2.15	426.50	0.032
	Girls	235.66	27.36				Girls	9.51	1.69		
EF	Boys	76.78	4.18	0.52	0.608	Right E'	Boys	13.58	3.15	-0.11	0.911
	Girls	76.11	6.34				Girls	13.66	2.73		
FS	Boys	45.09	4.18	556.00	0.542	Right A'	Boys	6.64	2.00	-0.72	0.477
	Girls	44.34	5.73				Girls	6.94	1.56		
LVMI	Boys	52.38	21.65	386.00	0.009	Left MPI'	Boys	0.77	0.09	-0.08	0.934
	Girls	39.13	15.07				Girls	0.77	0.10		
Simpson EF	Boys	44.19	7.07	550.00	0.493	Right MPI'	Boys	0.77	0.11	2.01	0.049
	Girls	43.21	7.09				Girls	0.71	0.12		
Left MPI	Boys	0.76	0.19	0.74	0.461	Left E/E'	Boys	5.63	1.49	493.00	0.175
	Girls	0.73	0.15				Girls	6.11	1.48		
Right MPI	Boys	0.71	0.17	1.45	0.153	Left E'/ A'	Boys	3.22	4.41	514.50	0.270
	Girls	0.65	0.15				Girls	2.29	0.64		
Left E/A	Boys	1.94	0.37	2.84	0.006	Right E/E'	Boys	4.96	1.36	565.50	0.616
	Girls	1.69	0.37				Girls	4.98	1.70		
Right E/A	Boys	1.47	0.33	378.00	0.007	Right E'/ A'	Boys	2.20	0.81	581.00	0.750
	Girls	1.29	0.22				Girls	2.03	0.47		

AT: Acceleration time, DT: Deceleration time, peak E: Early mitral valve flow velocity, peak A: Late mitral and tricuspid valve flow velocity, ET: Ejection time, EF: Ejection fraction (calculated in the apical two and four chamber views with Simpson's apical biplane method), FS: Fractional shortening, MPI: Myocardial performance index, LVMI: Left ventricular mass index, S': Systolic myocardial velocity above the baseline in mitral and tricuspid; IVRT: Isovolumic relaxation time, ICT: Isovolumic contraction time.

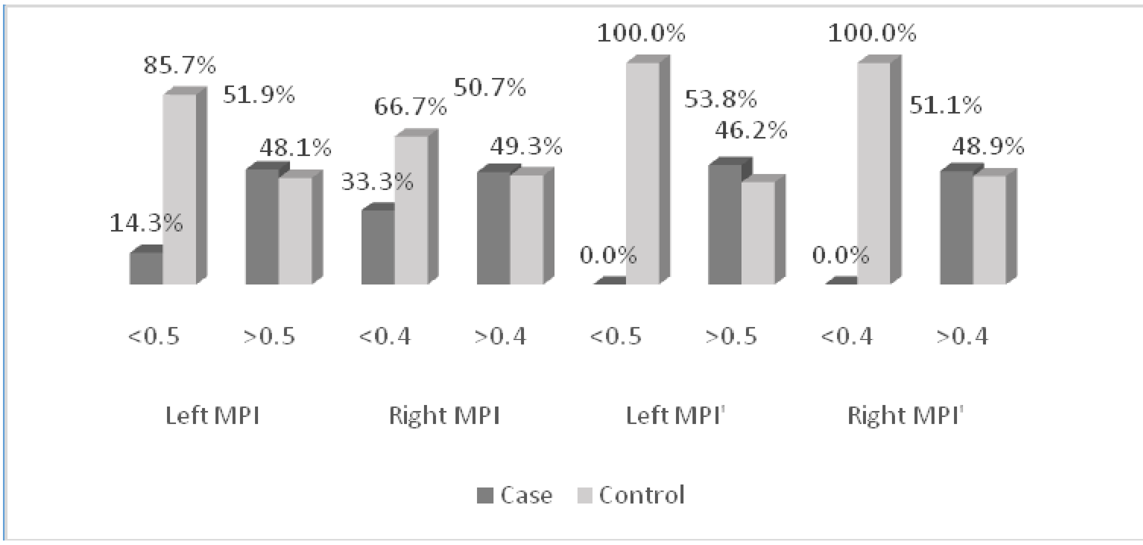

Fig.2: Comparison of left and right MPI by conventional and TDI echocardiography in diabetes mellitus type 1 patients and controls.

MPI: Myocardial Performance Index; TDI: Tissue Doppler Imaging.

4- DISCUSSION

The present study aimed to compare tissue Doppler imaging with conventional echocardiography to diagnose heart dysfunctions in diabetes mellitus type 1 patients. It is indicated that conventional echocardiography was different in left DT, left peak E velocity, right DT, right peak E velocity, left ET and left MPI parameters. However, DTI was different in left ET', left IRT', right ET', right ICT', right IRT', right S', right E', left and right MPI' and left E/E' between the case and the control group. Similarly, the results showed that left MPI'was more associated with the patients. The present study also revealed that EF was not different between diabetic and healthy individuals, similar to Al Zubeidy et al. (22), Kamile Gul et al. (23) and Febe et al. (24) studies. In this line, Salem et al. (13) resulted in higher value of LVPW and LV and RV diastolic dysfunction diagnosed in one fourth of patients. They also found higher A and MPI and lower E/A by conventional echocardiography, but TDI showed delayed myocardial relaxation in more than half of diabetics with lower LV and RV peak E' and E'/A'. Ahmed et al. (25) reported a significant decrease in E/A unlike our findings that discovered the values for E/A were similar in patients and the control group when left and right peak E peak E velocities were lower in diabetic children. In line with this, the study results are concordant with Brunvand et al. (26). Hensel et al. (27), in comparison with the present study observed the diastolic parameters of the right and left DT, right and left peak E velocity, aortic diameter in diastole were different in patients and healthy children. Acar et al. (28) found that E, A, E/A, DT and MPI were not significantly different when MPI values of both ventricles were statistically higher and ET was lower in patients compared to controls, similar to our results. Using the method of conventional echocardiography, Ozdemir et al. (29) assessed A, E and found similarity. In contrast the present study observed statistically significant differences. TDI revealed reduction in mitral septal and lateral E' velocities as well as tricuspid E' velocity among patients. ICT indicated reduction in contractility of both ventricles in diabetics compared to the control group (1). Di Cori et al. (30) concluded IRT was significantly longer and A', E' and S' were lower in patients. Suran et al. (31) concluded that septal mitral isovolumetric contraction had better diagnostic accuracy than lateral tricuspid annulus to predict early contractile impairments in patients. In comparison with the results from the present study, left heart TDI parameters were similar to our findings. So that E' was decreased in diabetic group compared to the control group in left and right heart ventricles. In case of E/E', an increase was observed in diabetic group. The results of this study indicated worse diastolic functioning of both ventricles in this child patient population. In the present study, right E' and left E/E' were significant and higher in controls when left E' and right E/E' were similar in patients and the control group. The possible reason for dissimilarity with the present findings, could be the age of the patients when our patients were younger than 18 years.

Regarding the design and methodology, the difference between the present study with Suran et al. (31) was in the right heart findings. Konduracka et al. (32) concluded no significant difference in LV diastolic function, neither by conventional echocardiography nor by TDI except E/E'. In comparison with the present study, E/E' was significant in left heart. The present study concluded that E' was significant in right heart while A' was not significant in both sides of heart. This suggests that subclinical LV systolic and diastolic alterations might develop concurrently in DMT1 patients, who have not been observed till now. However, Konduracka et al. (32) did not confirm these achievements in right ventricle when the present study ended. A recent study by Fagan et al. (33) concluded only a slight reduction in E/A, while an increase in E/E' was found compared to control group, but the present study found a decrease. A study by Khattab and Soliman (34) demonstrated, in left heart, the TDI parameters of E', E'/A', E/E', IRT' and MPI' were significant between diabetic and healthy children when in right heart, E', E'/A' and E/E' were significant. In this regard, the present study demonstrated that E', A', E'/A' and ICT' were non-significant in left heart but in right heart most of the parameters were significant, except A' and E'/A'. Acar et al. (28) resulted that in left heart, E' and E'/ A' were lower and in right heart, A', IRT' and MPI' were higher in patients. ICT', S' and ET' did not show any difference. They concluded that left E / E' was significantly higher in patients, similar to the present study, and in right heart resulted that E', A', E'/A' S', IRT', ICT', and MPI' values were not different between the groups. However, the present study resulted that diastolic functions of both ventricles were impaired in comparison with healthy ones. From the study results, left ET', left IRT', right ET', right ICT', right IRT', right S', right E', left MPI', right MPI', left E'/E, and left E/E' were different. Diastolic dysfunction has been defined as the earliest sign of diabetic myocardial disease to occur before systolic impairment.

S' shows abnormal systolic function in early stages of the disease. Thus, S' appears to be a more sensitive measure than the other systolic measures such as EF and FS. Acar et al. (28) also concluded that the baseline S' value less than 4.4 cm/s was considered to have accurately predicted abnormal systolic functions. Based on this result, systolic dysfunction was not mentioned in any of the patients and the control group, Khattab and Soliman (34). Ozdemir et al. (29) reported that E', S', E/E', left ET', and MPI' varied in patients and healthy, but the other parameters of left ventricle were similar. In right heart they also resulted that there was significant difference in parameters observed with TDI such as E', E/E', right ventricular ET', and right ventricular MPI' and other parameters of right ventricle were not significantly different. In comparison with the present study that resulted left ET', left IRT', right ET', right ICT', right IRT', right S', right E', left MPI', right MPI', left E'/E, and left E/E' were different in patients and controls, in both studies, right heart parameters were approximately similar. Ahmad et al. (25) observed an increase of E/E', A' and E' and a decrease in S' in patients. The changes were significant except in E'. The present study revealed similarity in S' and dissimilarity with the other parameters. From the study it was resulted that left DT, right DT, and LVMI, were different in conventional echocardiography method based on age group comparison in patients and the findings of left ET', right ET', were different in Doppler tissue imaging method. In patients of Abd-El Aziz et al. (35) study the FS was significantly lower in young diabetic patients and remained within normal values which may imply an early affection of the systolic function.

All the findings in this matter were dissimilar with our study that found the FS and EF were not different in patients and healthy ones. Suys et al. (36) assessed whether children and adolescents with type 1 diabetes have early echocardiographic signs of subclinical cardiac dysfunction and whether sex has any influence. From this study it resulted that female diabetic patients showed significantly larger left ventricular wall and signs of significant diastolic filling abnormalities on conventional and TDI such as mitral valve-atrial contraction velocity; tricuspid valve-atrial contraction velocity; early filling velocity/myocardial velocity during early filling; IRT compared with female control subjects, suggesting delayed myocardial relaxation. Male diabetic patients only differed significantly from their control subjects for IRT. The measured parameters showed an expected correlation with age in the control group. This correlation was significantly weaker in the diabetic population; only a weak influence was found for diabetes duration and glycosylated hemoglobin levels. From the study it was also concluded that the young diabetic patients already have significant changes in left ventricular dimensions and myocardial relaxation, with the girls clearly being more affected. Tissue Doppler proved to have additional value in the evaluation of ventricular filling in this population. All these results are able to be compared with the results of the present study that revealed gender difference in patients was demonstrated in conventional echocardiography of left DT, left peak A, right AT, right DT, right peak A, right ET, LVM, left E/A, and right E/A in DTI parameters of left ET', left ICT', left IRT', right ICT', right IRT', right S', and right MPI'. Al Zubeidy et al. (22) compared the echocardiographic parameters between male and female in patients, the results were statistically not significant regarding E/A and E / É, while EF was significantly lower in male patients than female without reaching systolic dysfunction, also, there was significant increase in septal thickness in males compared to females. Gusso et al. (37) found systolic dysfunction in DMTI adolescents during short exercise, implying a loss of systolic reserve. Patients with very long diabetes duration exhibited diastolic dysfunction, evidenced by lower E/A ratios and higher E/E' ratios, but this was mild and has been demonstrated in patients with a much shorter duration of diabetes.

4-1. Study Limitations

The main limitation of this study was the lack of the proper cooperation of the parents on measuring heart parameters that took a long time for sample collection in the control group; the other limitation was that the patients with DMT1 could also be categorized as good or poor control that was not considered in the study.

5- CONCLUSION

Based on the results, tissue Doppler echocardiography parameters were abnormal in diabetic mellitus type 1 patients compared to the control group such as left and right MPI that indicates impairment in systolic and diastolic heart functions. The main clinical findings from the study were that in DMT1 children and adolescents without clinically evident heart diseases, primarily, both systolic and diastolic functions were impaired and secondly, the tissue Doppler imaging had more power to show this impairment. Diabetic patients should be evaluated as early as possible for diastolic functions even in the absence of clinical manifestation. Diastolic function of diabetic patients can be easily and practically assessed by TDI. It seems to be more valuable than the conventional echocardiography. The assessment of early myocardial relaxation velocities provides an additional window on LV diastolic function in a manner complementary to evaluation of mitral inflow.

6- CONFLICT OF INTEREST: None.

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