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Echocardiographic Abnormalities in Type 2 Diabetes Mellitus: A Comparative Case–Control Study in Jazan, Saudi Arabia

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is a major cardiovascular risk factor, yet echocardiographic data from the Jazan region of Saudi Arabia are scarce. ***Methods:*** This retrospective case-control study included Adults 168 patients with T2DM and 160 non-diabetic controls, (age- and gender are matched), who underwent transthoracic echocardiography at two hospitals in Jazan in period from (October 2024 to April 2026). Clinical, demographic, and echocardiographic data were retrieved from electronic medical records. ***Results:*** Echocardiographic abnormalities were detected in 85.1% of diabetic patients. The most common findings were mitral regurgitation (40.5%), left ventricular hypertrophy (30.4%), and tricuspid regurgitation (27.4%). Diabetes duration ≥10 years was a significant risk factor (OR 8.6, p=0.041). BMI <25 kg/m² showed a protective effect in logistic regression (p=0.011), though abnormalities were prevalent across all BMI categories. Compared with controls, diabetic patients had significantly higher LVIDS, LVIDD, ESV, and aortic root area (all p<0.05), with reduced fractional shortening. ***Conclusion:*** In Jazan, echocardiographic abnormalities are common, especially among T2DM patients, where significant risk factors include diabetes duration and BMI. Cardiac screening should be performed routinely, regardless of BMI, as it helps identify and manage cardiac abnormalities.

Keywords: Type 2 Diabetes Mellitus; Echocardiography; Cardiac Abnormalities; Left Ventricular Hypertrophy; Diabetes Duration.

INTRODUCTION

Diabetes mellitus (DM) is among the most prevalent chronic metabolic disorders, and its incidence has markedly risen globally in recent decades. According to the World Health Organization, Saudi Arabia has the second highest rate of diabetes in the Middle East and the seventh highest rate in the world, with a prevalence of 25.4% in age group ≥ 30 years [1]. Age plays a significant role in the amplified prevalence of DM, reaching 40.2% for the aged ≥45 years (1) and are therefore susceptible to developing diabetes complications. Cardiovascular disease (CVD) is the primary cause of mortality within the diabetic population [2,3,4]. Diabetes is associated with heart alterations, including myocardial thickness and primarily diastolic dysfunction, known as diabetic cardiomyopathy. Numerous studies have reported a high prevalence of diastolic dysfunction among this patient population. [5,6]. patients with type 2 diabetes are also may affected with additional cardiac pathologies that impact prognosis, including left ventricular hypertrophy, reduced left and right ventricular ejection fraction, dilated left atrium, and valvular disorders [7-10].

Echocardiography is a very important tool for diagnosing cardiomyopathy. It is the gold standard to assess the structure and function of the heart [11,12]. It is also a useful tool for making an early diagnosis It is a safe and non-invasive imaging tool. Few studies have examined the prevalence of echocardiographic abnormalities in T2DM, this gap underscores the need for more studies in the region.

The main objective of the present study is to assess the frequency and patterns of echocardiographic findings in adult patients with T2DM in Jazan, one of the southern regions of Saudi Arabia. The study aims to provide a better understanding of how different cardiac abnormalities identified in echocardiograms of T2DM patients compare to non-diabetic control group and correlate with various demographic and clinical parameters, such as age, gender, and BMI, and how those parameters influence HbA1c and the duration of diabetes for the population in the region.

MATERIALS AND METHODS

Study Design

This is a retrospective study of 168 Type 2 DM and 160 non-diabetic patients at King Fahad Central Hospital and Prince Mohammed bin Nasser Hospital-Jazan (age- and gender-matched). These groups underwent an echocardiographic study. Approval for this study was obtained from the Jazan Health Cluster – Research Ethics Committee (Approval number:2462).

Data Collection Process

The data for this study were obtained through a systematic process of retrieving information from EMRs using a structured data clinical sheet, which included demographic data, clinical history and body mass index, laboratory parameters (HBA1c).

Inclusion Criteria

This study included adult men and women aged between 14 and 90, (168 Type 2 DM and 160 non-diabetic patients) diagnosed based on ADA guidelines, who underwent an echocardiographic study from Oct 2024 to April 2026.

Exclusion Criteria:

1. Patients with Type I Diabetes Mellitus.
2. Patients with diabetic end-stage renal disease
3. Patients with rheumatic, valvular heart disease
4. Patients with pregnancy, UTI, and any other condition causing proteinuria.
5. Patients with congenital heart disease.
6. Patients under age 14. This was documented in the patient's medical records.

Echocardiographic Evaluations

Transthoracic echocardiographic imaging was performed using a PHILIPS EPIQ 5C Ultrasound system (Philips, Amsterdam, The Netherlands),Exams done by cardiologist Patients were positioned supine and turned to the left lateral ,using high frequency Probe Examinations were performed using parasternal long, short-axis (PLAX & PSAX) and apical window (PA2CH, PA4CH (Two and four chambers) views were taken , final diagnosis was made by specialists in echocardiography based on the diagnostic criteria of the American Society of Echocardiography and the European Association of Cardiovascular Imaging.

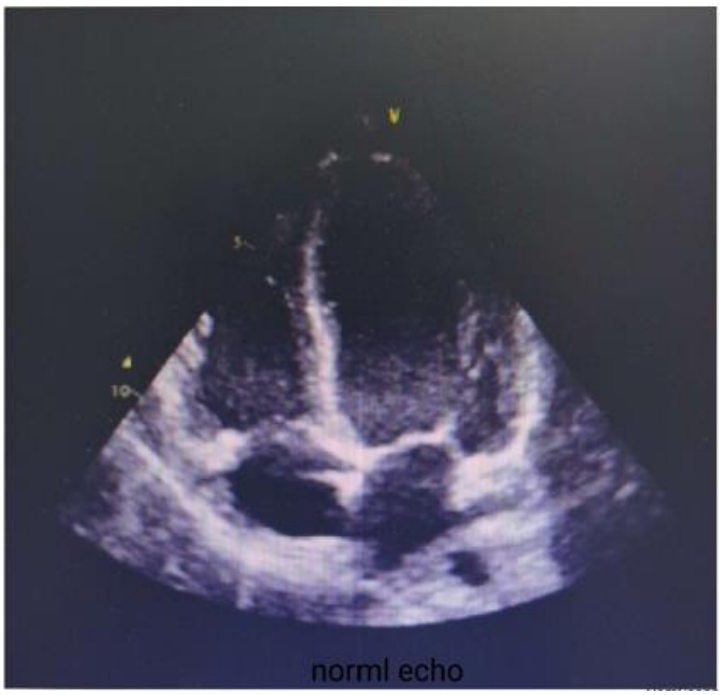

Image 1: Showed Apical 4 Chamber view of 2D echocardiography with normal findings

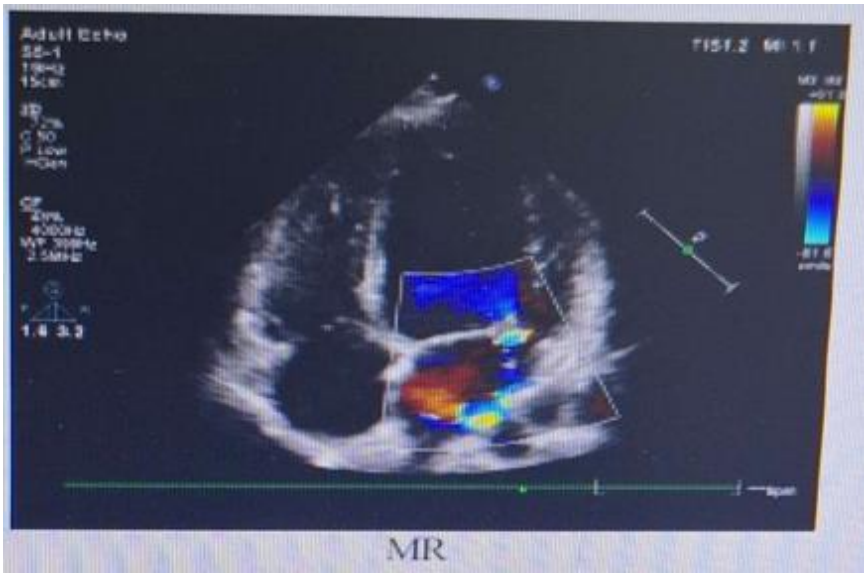

Image 2: Showed MR finding

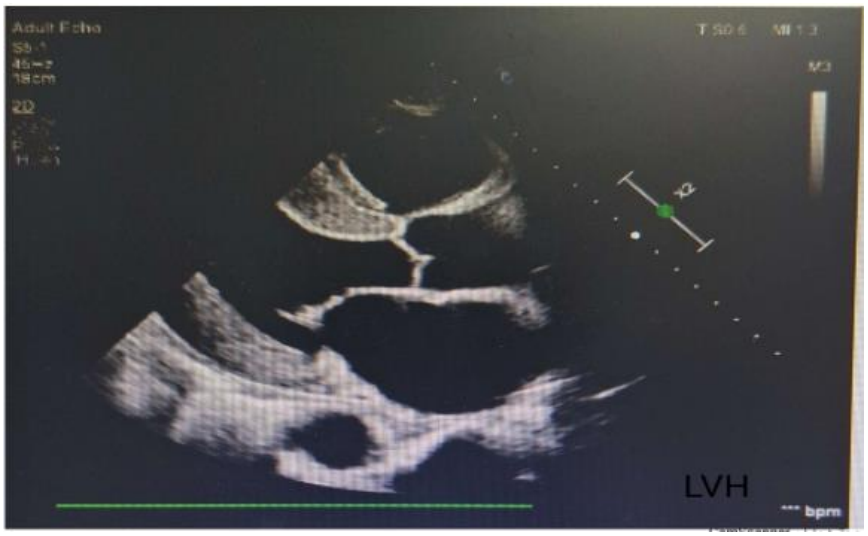

Image 3: Showed LVH finding

Statistical Analysis

An analysis was performed using IBM SPSS Statistics version 27. Descriptive statistics are presented as frequency and percentage. Chi-square test used to correlate the demographic characteristics and DM duration with the presence of cardiac abnormalities. Furthermore, univariate (Crude OR) and multivariate (OR) logistic regression were used to estimate the odds ratios for the presence of disease-related conditions, adjusting for demographic and clinical factors. P-value of less than 0.05 was considered significant.

RESULTS

The Results are presented in two categories includes: Results and analysis for Type2 DM patients, and comparison of results of Type 2 diabetic patients with the normal subjects as following:

Table 1: Demographic characters of patients with Type-2 DM

Character		Frequency	Percent%
Age	14-24	12	7.1
	25-40	26	15.5
	41-60	81	48.2
	More than 60	49	29.2
Gender	Female	75	44.6
	Male	93	55.4
HA1c	Less than 7 (Control)	11	6.5
	7 or more (Uncontrolled)	157	93.5

Character		Frequency	Percent%
Duration years	3-10	72	42.9
	11-20	67	39.9
	More than 20	29	17.3
BMI kg/m^2	18-25	88	52.4
	More than 25	80	47.6
	Total	168	100.0

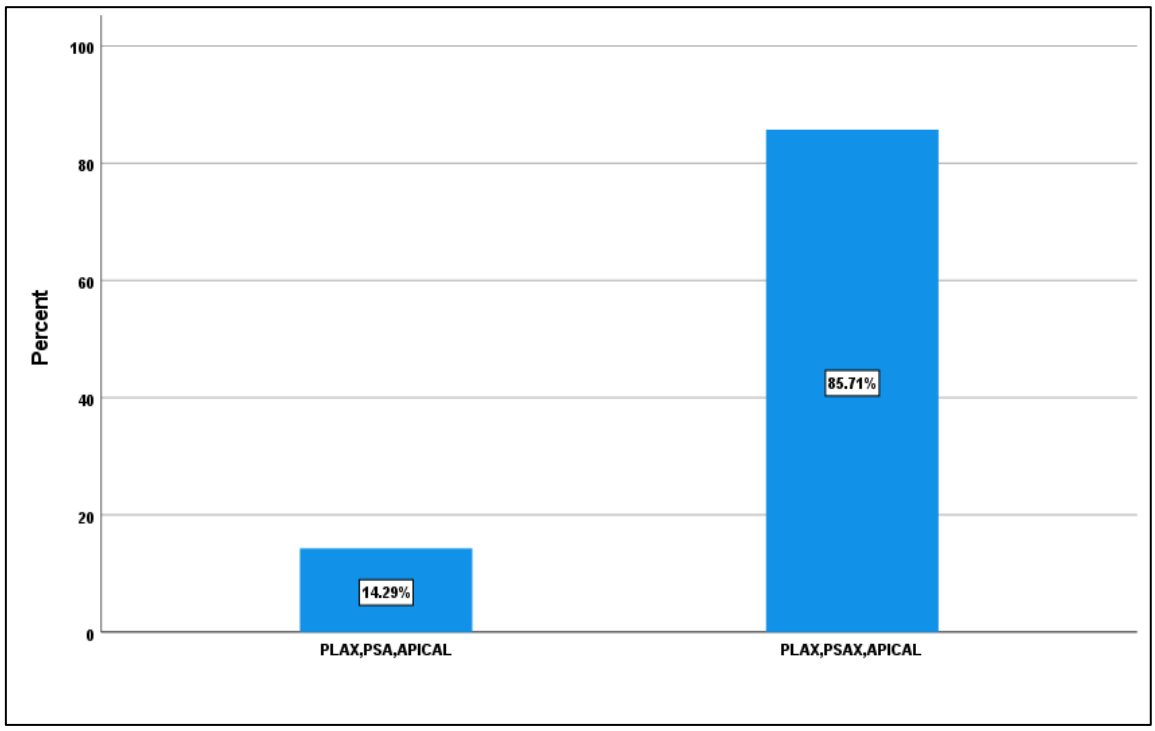

Figure 1: Cardiac views taken

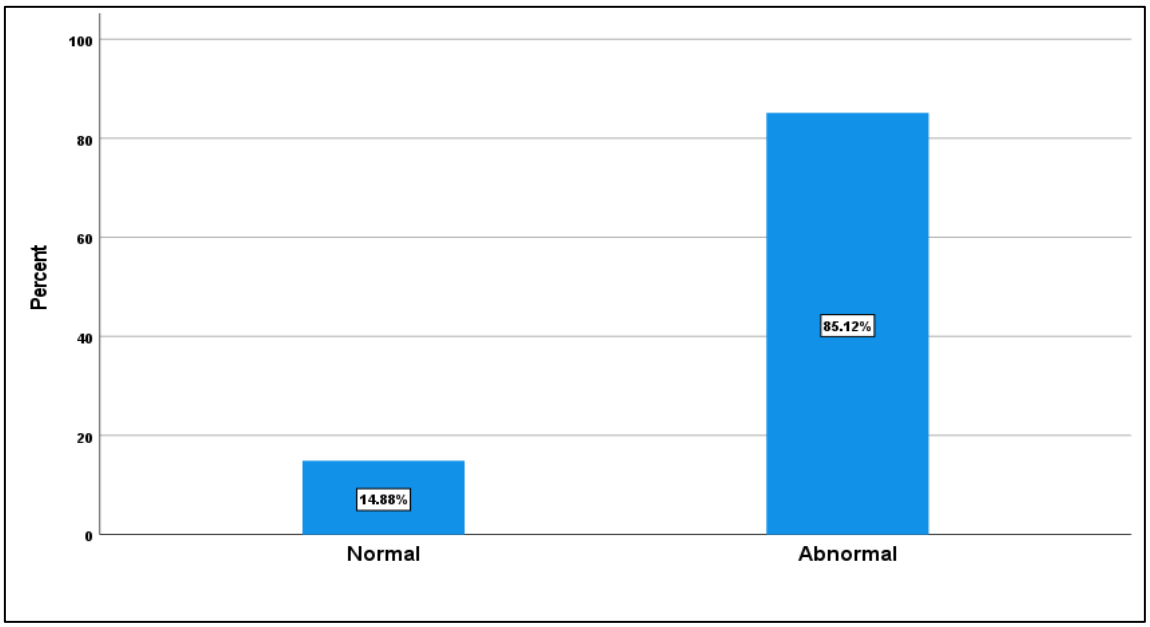

Figure 2: Prevalence of echocardiographic abnormalities among patients with Type 2 DM (n=168) Abnormal findings were detected in 85.1% of participants

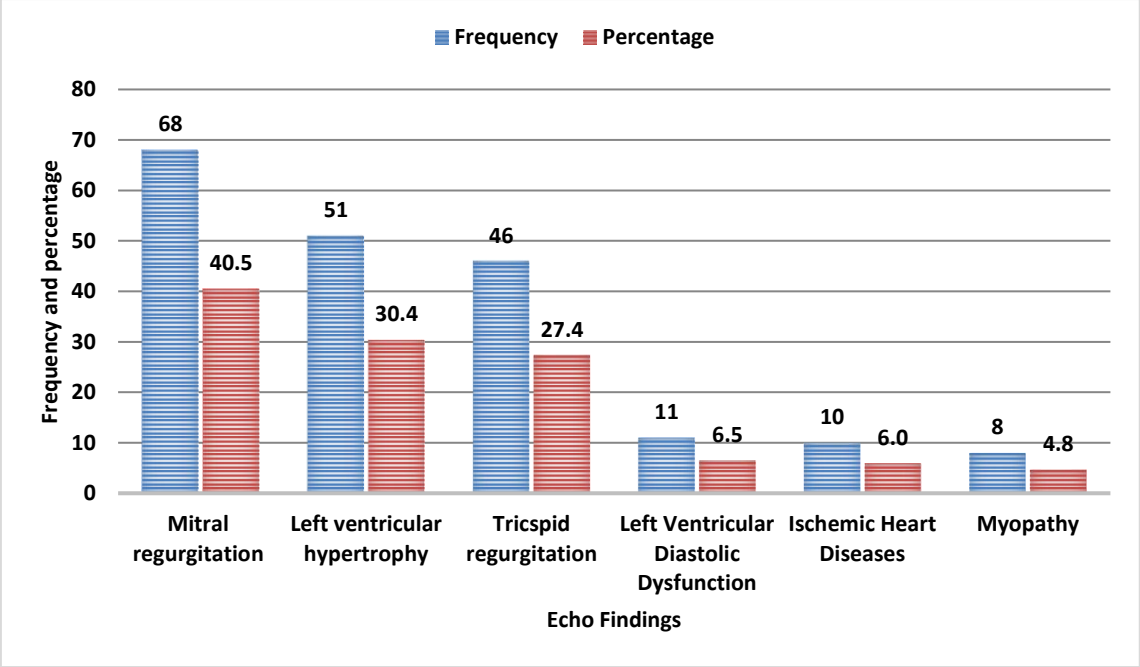

Figure 3: Type of abnormality in echocardiography among type2 DM, Mitral regurgitation was the most common abnormality (40.5%), followed by LVH (30.4%) and tricuspid regurgitation (27.4%)

Table 2: Univariate and multivariate logistic regression analysis showing the odd ratios for independent factors associated echocardiographic findings in type-2 DM

Variables	Univariate analysis			Multivariate analysis		
	Crude OR	P-value	CI	Adjusted OR	P-value	CI
Gender-Female	0.97	0944	.412–2.282	1.021	.964	.405–2.576
Age < 60 years	3.869	0.076	.869–17.227	1.437	.694	.237–8.726
HA1c ≥ 7	1.295	.751	.263– 6.379	.907	1.106	.206–5.932
Duration of DM, ≥ 10 years	8.6	.041	1.095–68.413	.152	5.968	.517–68.833
BMI < 25 kg/cm2	.298	.011	.117–.757	.022	.326	.125 –.849

Table 3: Cross tabulation between demographic and duration with presence of abnormalities

Factors		Abnormalities		Total	Chi^2	P value	' 'Effect size '
		Normal	Abnormal				
Age	<65	23	107	130	3.59	0.58	0.15
	>65	2	36	38			
Gender	Female	11	64	75	0.00	0.944	0.01
	Male	14	79	93			
BMI/ kg/m^2	18-25	7	81	88	7.00	0.008**	0.20
	More than 25	18	62	80			
HA1c	<7 (Control)	2	9	11	0.10	0.75	0.02
	≥ (Uncontrolled)	23	134	157			
Duration / years	3-10	17	55	72	8.36	0.015*	0.22
	11-20	7	60	67			
	More than 20	1	28	29			
	Total	25	143	168			

(note: *p<0.05, **p<0.01)

Table 4: Compares mean measurements between normal and abnormal cases

Metric Variables	Normal		Abnormal			t	p
	Mean	Std. Deviation	Mean	Std. Deviation	df		
IVSD	1.14	0.14	1.45	0.39	102.13	-7.18	<.001
IVIDS	4.81	19.00	1.84	7.18	25.21	0.77	.447
LVIDSS	3.39	1.56	3.88	1.21	29.26	-1.51	.142
LVIDDS	4.96	0.85	5.12	3.12	139.55	-0.52	.605

Metric Variables	Normal		Abnormal			t	p
	Mean	Std. Deviation	Mean	Std. Deviation	df		
LVPWD	0.93	0.23	1.75	6.71	143.91	-1.45	.149
ESV	52.82	35.64	68.28	33.83	32.02	-2.02	.052
EDV	121.41	45.00	123.32	49.11	34.78	-0.19	.848
EF	57.56	10.95	57.88	13.33	37.61	-0.13	.897
FS	30.66	6.02	28.84	8.25	41.61	1.31	.196
Aorta diameter	3.08	0.53	2.91	0.38	28.54	1.48	.149
LADD	4.82	5.07	3.82	0.68	24.15	0.99	.333
Area	5.43	1.90	6.22	1.64	30.64	-1.97	.058
Ratio	1.21	0.18	1.24	0.74	151.31	-0.51	.608

Table 5: a.b correlation duration with measurements

		Duration	IVSD	IVIDS	LVIDSS	LVIDDS	LVPWD
Duration	Correlation	1.00	0.21	0.22	0.07	0.06	0.09
	p		.007	.003	.399	.435	.25

b.

		Duration	ESV	EDV	LVEF	FS	AOD	LADD	Area	MV E/A Ratio
Duration	Correlation	1.00	0.13	0.01	0.06	-0.06	0.12	0.04	0.11	-0.17
	p		.103	.881	.426	.429	.122	.584	.146	.03

Table 6: Chi square test to assess the differences in age and gender among the study groups

		Study groups		Total	P value
		DM	Control		
Age group	14-24	12	5	17	0.000
	25-40	26	90	116	
	41-60	81	58	139	
	More than 60	49	7	56	
Gender	Female	75	75	150	0.384
	Male	93	85	178	
Total		168	160	328	

Table 7: Test of normality for measurement of echo parameters

Measurements	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
IVSD/S/CM	.189	328	.000	.796	328	.000
"IVSD/D/CM"	.508	328	.000	.320	328	.000
LVIDS/CM	.127	328	.000	.958	328	.000
LVIDD/CM	.237	328	.000	.365	328	.000
LVPWD/CM	.470	328	.000	.073	328	.000
"ESV/ ML"	.181	328	.000	.815	328	.000
"EDV/ ML"	.117	328	.000	.919	328	.000
LV EF%	.185	328	.000	.806	328	.000
%FS	.135	328	.000	.849	328	.000
"AOD/ CM"	.092	328	.000	.978	328	.000
"LAD/ CM"	.316	328	.000	.241	328	.000
AOR.AREA/CM²	.157	328	.000	.940	328	.000
MV E/A ratio	.471	328	.000	.050	328	.000
a. Lilliefors Significance Correction						

Table 8: a.b correlation HBA1c duration with measurements

		HBA1C	IVSD	IVIDS	LVIDSS	LVIDDS	LVPWD
HBA1C	Correlation	1.00	0.05	-0.06	-0.08	-0.07	0.07
	p		.495	.469	.289	.366	.369

b.

		HBA1C	ESV	EDV	LVEF	FS	AOD	LADD	Area	MV E/A Ratio
HBA1C	Correlation	1.00	0.09	0.05	0.06	-0.04	0.16	0.11	0.17	-0.07
	p		.25	.514	.414	.592	.039	.144	.032	.347

Table 9: Compares mean measurements between DM and Control group

Measurements	Groups	Median	95% CI	Mean ± SD	Mean rank	U	P value	r
	Control	10	6.53 - 18.21	9.46 ±5.25	96.24			
IVSD/S/CM	DM	1.3	1.35 - 1.46	1.4 ±0.38	181.75	10542.0	.001	0.19
	Control	1.2	1.23 - 1.38	1.31 ±0.48	146.39			
IVIDS	DM	1.11	0.79 - 3.78	2.28±9.84	176.83	11369.00	0.016	0.13
	Control	1	10.23 - 20.84	15.54±33.98	151.56			
LVIDS/CM	DM	3.75	3.62 - 4.01	3.81 ±1.28	192.71	8701.50	<.001	0.31
	Control	3.2	2.92 - 3.21	3.06±0.93	134.88			
LVIDD/CM	DM	5	4.66 - 5.54	5.1 ±2.9	181.00	10668.50	.001	0.18
	Control	4.6	4.31 - 4.63	4.47 ± 1.05	147.18			
LVPWD/CM	DM	1.1	0.68 - 2.57	1.63 ± 6.19	184.84	10023.00	<.001	0.22
	Control	1	0.39 - 2.79	1.59 ±7.68	143.14			
"ESV/ ML""	DM	62.25	60.74 - 71.23	65.98 ±34.44	196.81	8012.00	<.001	0.35
	Control	46	43.55 - 46.82	45.19 ±10.5	130.58			
"EDV/ ML"	DM	120.1	115.66 - 130.41	123.04 ±48.4	163.97	13350.50	.917	0.01
	Control	118	116.54 - 123.34	119.94±21.78	165.06			
LV EF%	DM	60.9	55.86 - 59.81	57.84 ±12.97	161.85	12995.00	.605	0.03
	Control	62	60.44 - 62.01	61.23 ± 5.02	167.28			
%FS	DM	30	27.9 - 30.33	29.11 ±7.97	150.79	11137.00	.007	0.15
	Control	31	30.51 - 32.17	31.34 ± 5.3	178.89			
"AOD/ CM"	DM	2.9	2.88 - 3	2.94 ±0.41	115.23	5162.00	<.001	0.53
	Control	3.3	3.31 - 3.4	3.35 ± 0.29	216.24			
"LAD/ CM"	DM	3.8	3.65 - 4.28	3.97 ±2.05	169.26	12640.00	.352	0.05
	Control	3.55	3.61 - 4.51	4.06 ± 2.88	159.50			
AOR.AREA/CM²	DM	6.1	5.85 - 6.36	6.1 ± 1.7	194.80	8349.50	<.001	0.33
	Control	4.9	4.9 - 5.3	5.1 ±1.3	132.68			
MV E/A ratio	DM	1.21	1.13 - 1.34	1.24±0.69	136.94	8810.00	<.001	0.30
	Control	1.23	0.56 - 3.54	2.05±9.55	193.44			

DISCUSSION

This study characterises the echocardiographic profile of patients with type2 DM in the Jazan Region and Compare Finding with Non diabetic Control group, the results highlight the importance of regular echocardiographic screenings for diabetic patients to detect cardiac abnormalities. Most of them had structural and functional heart changes, with mitral regurgitation, left ventricular hypertrophy, and tricuspid regurgitation being the most common findings. These findings add to the literature by identifying how diabetes duration and other clinical characteristics affect cardiac health and reinforce the importance of early detection and intervention to reduce the risk of adverse outcomes in this high-risk group.

The present study reveals that echocardiographic abnormalities are more prevalent in male than in female patients, particularly in the age groups 41–60 and 60+ years. This finding agreed with Esawi *et al.,* who identified advanced age—specifically over 60 years as a notable risk factor for diabetic complications [13] Similarly, Koster *et al.,* reported that men exhibit a greater likelihood than women of developing coronary artery disease[14] whereas Ahmadi *et al.,* found that both substantial and minor abnormalities are more common in males, with a propensity to increase with advancing age[15] The findings underscore the significance of male gender and advanced age as critical predictors for the development of cardiac diseases in patients with T2DM, as diagnosed by transthoracic echocardiography.

The current study identified cardiac abnormalities in 85.12%. It also was observed that the most common abnormality was mitral regurgitation (40.5%), followed by left ventricular hypertrophy (LVH) (30.4%) and tricuspid regurgitation (27.4%). The mitral regurgitation was not the most prevalent finding in previous studies. Zhao et al reported that LVM was higher in T2DM patients [16] Additionally, Jørgensen reported that the prevalence of diastolic dysfunction was19.4%, left ventricular hypertrophy (21.0%), and left atrial enlargement (19.6%) [17] Similarly, several studies agreed with our finding that the incidence of LVH is the second echocardiographic finding [18-20].

In the univariate analysis, the study found that age < 60 years, HbA1c ≥ 7, and duration of diabetes ≥ 10 years were associated with a higher OR of developing cardiac abnormalities. Consistently, Yao *et al.,* reported that age and diabetes duration were associated with the risk of CVD. [21] Furthermore, Wan *et al.,* reported that all age groups exhibited positive log-linear correlations between HbA1c variability and cardiovascular disease (CVD) and death. The hazard ratios (HRs) for the composite of CVD and all-cause mortality indicated that age was inversely correlated with HbA1c variability [22] Age is a significant risk factor for cardiovascular disease. Substantial evidence indicates that effective management of cardiovascular risk factors improves clinical outcomes, even among older adults [23].

The study found a significant association between BMI and cardiac abnormalities ($\chi^2 = 7.00$, $p = 0.008$), with patients having a BMI of 18–25 kg/m² showing a high incidence. In agreement to this finding, Lio et al reported that BMI in early age was positively correlated to CVD [24]. Similarly, a previous study reported that Obesity directly contributes to the emergence of cardiovascular risk factors. Obesity independently contributes to the onset of CVD and associated mortality, regardless of other risk factors [25]. this finding highlights the essential function of BMI in effectiveness, indicating that individuals with a normal BMI may nevertheless be vulnerable to cardiac abnormalities in the setting of diabetes. Consequently, it is imperative for diabetic patients to prioritize weight management and metabolic health, and regular cardiac monitoring should be deemed necessary irrespective of BMI status. This underscores the necessity for thorough cardiovascular risk evaluation and preventive measures aimed at both obese and non-obese diabetes cohorts.

The predominance of mitral regurgitation in our cohort may reflect the older age profile and the high rate of uncontrolled glycaemia, both of which promote annular calcification and papillary muscle dysfunction. The modest but significant correlation between diabetes duration and IVSD ($r=0.21$, $p=0.007$) supports a progressive structural remodeling process that worsens over time, irrespective of blood glucose control.

This study has several limitations that should be considered. A retrospective study means the design may introduce selection bias that cannot be controlled. Additionally, the records may be incomplete. This adds to the inability to create a cause-and-effect scenario. Also, the study was conducted in only 2 hospitals in the Jazan region; therefore, there are likely limitations on how the rest of the country and/or the rest of the world can generalize these findings. Although some important clinical and demographic variables were factored in, variables such as medication history, lifestyle, comorbidities, and other associated factors were not addressed and will likely affect the results and, therefore, the conclusions drawn from any echocardiographic analysis. Because there is a lack of longitudinal data, there is no way to know how heart abnormalities may change over time, or how their clinical importance may change. Specialists may have performed the echocardiographic assessments, variances in assessments done by different specialists were not factored in, and this is a critical. Prospective studies that account for many variables and planned studies with follow-up are needed.

CONCLUSION

This study demonstrated echocardiographic abnormalities were highly prevalent among patients with type 2 diabetes mellitus compared to non-diabetic, in the Jazan region (85.1%), with mitral regurgitation, left ventricular hypertrophy, and tricuspid regurgitation as dominant findings.

The study confirms that diabetes duration plays a critical role in the development of cardiac abnormalities, with a progressive increase in prevalence observed over time. Although factors such as age, gender, and HbA1c were associated with increased odds of cardiac involvement, these relationships were not statistically significant in multivariate analysis. Nevertheless, trends suggest that younger patients, males, and those with poor glycemic control may still be at higher risk.

Significant differences in several echocardiographic parameters between diabetic and non-diabetic individuals indicate early subclinical cardiac changes in patients with diabetes, even in the absence of overt symptoms. Additionally, the presence of cardiac abnormalities across different BMI categories suggests that cardiovascular risk in diabetes is not limited to obese individuals.

Overall, these findings emphasize the importance of early cardiovascular evaluation using echocardiography in patients with type 2 diabetes mellitus. Regular screening, along with effective management of modifiable risk factors such as glycemic control and disease duration, is essential to reduce the burden of cardiovascular complications and improve long term outcomes in this high-risk population.

In conclusion, these results underscore the need for regular echocardiographic screening and thorough risk assessment in individuals with T2DM, regardless of BMI classification, to facilitate early identification and intervention. Future research should focus on prospective, multi center studies that encompass a wider array of clinical factors and longitudinal follow up to enhance the understanding of the course and outcomes of cardiac complications in this high-risk population.

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