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Assessment of Left Ventricular Dysfunction among Patients with Type 2 Diabetes Mellitus.

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Abstract

Background: Type 2 diabetes mellitus is associated with structural and functional cardiac abnormalities, with left ventricular diastolic dysfunction representing an important early manifestation of diabetic cardiac involvement. Echocardiography can identify subclinical ventricular dysfunction before the development of overt cardiac symptoms. ***Objective:*** To assess abnormalities in left ventricular function in patients with type 2 diabetes mellitus using 2D colour Doppler echocardiography and to evaluate their relationship with glycaemic status. ***Methods:*** An observational study was conducted among 100 patients with type 2 diabetes mellitus. Participants underwent clinical assessment and 2D colour Doppler echocardiography for evaluation of left ventricular function. Diastolic function was categorized as normal, Grade I, Grade II, or Grade III/IV dysfunction. The prevalence of diastolic dysfunction was assessed according to age, fasting plasma glucose (FPG), and body mass index (BMI). Associations between these variables and echocardiographic findings were statistically evaluated. ***Results:*** Left ventricular diastolic dysfunction was identified in 81% of participants, while 19% had normal diastolic function. Grade I dysfunction was the most frequent abnormality (59%), followed by Grade II (17%) and Grade III/IV dysfunction (5%). Diastolic dysfunction was significantly associated with age (p=0.012), with the highest prevalence among participants aged >60 years (90.6%). A significant association was also observed with FPG (p<0.001); dysfunction was present in 54.2% of participants with FPG of 100–150 mg/dL, 85.7% with FPG of 151–200 mg/dL, and 92.7% with FPG >200 mg/dL. BMI was significantly associated with the grade of diastolic dysfunction (p=0.003). ***Conclusion:*** Left ventricular diastolic dysfunction was highly prevalent among patients with type 2 diabetes mellitus and was significantly associated with advancing age, higher fasting plasma glucose, and BMI. 2D colour Doppler echocardiography may therefore be useful for detecting subclinical cardiac dysfunction in patients with type 2 diabetes mellitus. Although the study aims included correlation with HbA1c, the available results did not provide HbA1c-specific data; therefore, a direct HbA1c correlation could not be established from the supplied dataset.

Keywords: Echocardiography, Hba1c, Left Ventricular Diastolic Dysfunction, Type 2 Diabetes Mellitus.

INTRODUCTION

Type 2 diabetes mellitus is a major metabolic disorder associated with multiple cardiovascular complications. Persistent hyperglycaemia may produce structural and functional changes in the myocardium, even in the absence of clinically apparent cardiovascular disease. Diabetic cardiomyopathy is characterized by abnormalities in myocardial structure and function that may initially remain clinically silent [1,2]. Left ventricular dysfunction, particularly abnormalities of diastolic relaxation and filling, has therefore been recognized as an important early manifestation of cardiac involvement in patients with type 2 diabetes mellitus [3,4].

Diabetic patients may develop impaired left ventricular relaxation and altered ventricular compliance before the appearance of overt systolic dysfunction or clinical symptoms of heart failure [3,5]. Several studies have demonstrated a high prevalence of subclinical left ventricular diastolic dysfunction among otherwise asymptomatic patients with type 2 diabetes, suggesting that echocardiographic assessment may detect early cardiac abnormalities that are not apparent on routine clinical examination [4-8]. The presence and severity of these abnormalities may be influenced by the duration of diabetes, metabolic control, associated cardiovascular risk factors, and microvascular complications.

Two-dimensional and Doppler echocardiography provide a non-invasive method for evaluating cardiac structure and ventricular function. Doppler-derived transmitral flow parameters and other echocardiographic indices can identify abnormalities in ventricular relaxation and filling and are therefore useful in the assessment of early diabetic cardiac involvement [2,4,9]. Echocardiographic assessment is particularly valuable in asymptomatic patients because clinically significant cardiac dysfunction may develop before symptoms become evident.

Glycaemic control is an important determinant of the development and progression of diabetic complications. Glycosylated haemoglobin (HbA1c) provides an estimate of average blood glucose levels over the preceding several months and is routinely used to assess long-term glycaemic control. Several studies have investigated the relationship between poor glycaemic control and abnormalities of left ventricular function in patients with diabetes [1,2,6,10]. Persistent hyperglycaemia may contribute to myocardial metabolic abnormalities, interstitial fibrosis, increased myocardial stiffness, and impaired relaxation, thereby providing a potential link between elevated HbA1c levels and ventricular dysfunction.

Early identification of left ventricular abnormalities in patients with type 2 diabetes may therefore have clinical importance because timely recognition of subclinical cardiac dysfunction could facilitate appropriate risk-factor modification and cardiovascular monitoring. The present study was undertaken to assess abnormalities in left ventricular function among patients with type 2 diabetes mellitus using 2D colour Doppler echocardiography and to determine their relationship with glycaemic control as assessed by HbA1c levels.

MATERIALS AND METHODS

This observational study was conducted to assess left ventricular functional abnormalities in patients with type 2 diabetes mellitus using two-dimensional (2D) colour Doppler echocardiography and to evaluate their relationship with glycaemic status. A total of 100 patients with type 2 diabetes mellitus were included in the available study data. Patients were evaluated clinically and subjected to echocardiographic assessment for identification and grading of left ventricular diastolic dysfunction.

Demographic and clinical characteristics of the study participants were recorded. Age was considered an important demographic variable and participants were categorized into four age groups: 30–40 years, 40–50 years, 50–60 years, and >60 years. The prevalence of diastolic dysfunction was subsequently assessed across these age categories.

Glycaemic status was evaluated using fasting plasma glucose (FPG). Based on the available study data, participants were categorized into three FPG groups: 100–150 mg/dL, 151–200 mg/dL, and >200 mg/dL. The prevalence of diastolic dysfunction was compared across these glycaemic categories to determine whether increasing glucose levels were associated with a greater frequency of left ventricular dysfunction.

Anthropometric assessment included determination of body mass index (BMI). Participants were classified into three BMI categories: 18.5–22.9 kg/m², 23–24.9 kg/m², and >25 kg/m². The relationship between BMI and the presence and grade of diastolic dysfunction was evaluated.

All participants underwent 2D colour Doppler echocardiography for assessment of left ventricular function. Echocardiographic findings were used to identify the presence or absence of diastolic dysfunction and to classify the degree of dysfunction. Participants were categorized as having normal diastolic function, Grade I, Grade II, or Grade III/IV diastolic dysfunction. The distribution of these grades was recorded for the study population.

The primary outcome was the presence of left ventricular diastolic dysfunction on echocardiographic examination. Secondary analyses included assessment of the relationship between diastolic dysfunction and age, fasting plasma glucose, and BMI. The prevalence of diastolic dysfunction was expressed as frequencies and percentages within the respective categories.

For statistical analysis, categorical variables were presented as frequency and percentage. Associations between diastolic dysfunction and the evaluated clinical or demographic variables were assessed using appropriate statistical tests. A p value <0.05 was considered statistically significant. The available results demonstrated statistically significant associations between diastolic dysfunction and age, fasting plasma glucose, and BMI.

RESULTS

The distribution of diastolic dysfunction according to age is presented in **Table 1**. Diastolic dysfunction was observed in 81% of the study population, while 19% had no evidence of dysfunction. The prevalence increased with advancing age. Among participants aged 30–40 years, 33.3% had diastolic dysfunction, compared with 82.4% in the 40–50-year group,

78.6% in the 50–60-year group, and 90.6% among those aged >60 years. The association between age and diastolic dysfunction was statistically significant (p=0.012).

The distribution according to the severity of diastolic dysfunction is shown in **Table 2**. Grade I dysfunction was the most common abnormality, accounting for 59% of the total study population. Grade II dysfunction was observed in 17% of participants, while Grade III/IV dysfunction was present in 5%. Normal diastolic function was observed in 19% of participants. Thus, most participants with an echocardiographic abnormality had relatively early-grade diastolic dysfunction.

The relationship between fasting plasma glucose and diastolic dysfunction is presented in **Table 3**. Among participants with FPG of 100–150 mg/dL, 54.2% had diastolic dysfunction. This proportion increased to 85.7% among those with FPG of 151–200 mg/dL and further to 92.7% among participants with FPG >200 mg/dL. The association between FPG category and diastolic dysfunction was statistically significant (p<0.001), demonstrating a higher prevalence of diastolic dysfunction with increasing fasting glucose levels.

The relationship between BMI and the grade of diastolic dysfunction is shown in **Table 4**. Among participants with Grade I dysfunction, 33.9% had a BMI of 18.5–22.9 kg/m², 42.4% had a BMI of 23–24.9 kg/m², and 23.7% had a BMI >25 kg/m². Among participants with Grade II dysfunction, the corresponding proportions were 29.4%, 35.3%, and 35.3%, respectively. All participants with Grade III dysfunction had BMI ≥23 kg/m². In contrast, among participants without diastolic dysfunction, 78.9% had a BMI of 18.5–22.9 kg/m² and none had BMI >25 kg/m². The relationship between BMI and diastolic dysfunction was statistically significant (p=0.003).

Table 1. Prevalence of Diastolic Dysfunction in Relation to Age

Age group	No diastolic dysfunction, n (%)	Diastolic dysfunction, n (%)	Total, n (%)
30–40 years	4 (66.7)	2 (33.3)	6 (100.0)
40–50 years	6 (17.6)	28 (82.4)	34 (100.0)
50–60 years	6 (21.4)	22 (78.6)	28 (100.0)
>60 years	3 (9.4)	29 (90.6)	32 (100.0)
Total	**19 (19.0)**	**81 (81.0)**	**100 (100.0)**
p value			**0.012***

Table 2. Distribution of Subjects According to Grade of Diastolic Dysfunction

Grade of diastolic dysfunction	Frequency, n	Percentage (%)
Normal	19	19.0
Grade I	59	59.0
Grade II	17	17.0
Grade III/IV	5	5.0
Total	**100**	**100.0**

Table 3. Relationship of Fasting Plasma Glucose with Prevalence of Diastolic Dysfunction

FPG (mg/dL)	No diastolic dysfunction, n (%)	Diastolic dysfunction, n (%)	Total, n (%)
100–150	11 (45.8)	13 (54.2)	24 (100.0)
151–200	5 (14.3)	30 (85.7)	35 (100.0)
>200	3 (7.3)	38 (92.7)	41 (100.0)
Total	**19 (19.0)**	**81 (81.0)**	**100 (100.0)**
p value			**<0.001***

Table 4. Relationship of BMI with Prevalence of Diastolic Dysfunction

Grade of diastolic dysfunction	BMI 18.5–22.9, n (%)	BMI 23–24.9, n (%)	BMI >25, n (%)	Total, n (%)
Grade I	20 (33.9)	25 (42.4)	14 (23.7)	59 (100.0)
Grade II	5 (29.4)	6 (35.3)	6 (35.3)	17 (100.0)
Grade III	0 (0.0)	4 (80.0)	1 (20.0)	5 (100.0)
No dysfunction	15 (78.9)	4 (21.1)	0 (0.0)	19 (100.0)
Total	**40 (40.0)**	**39 (39.0)**	**21 (21.0)**	**100 (100.0)**
p value				**0.003***

DISCUSSION

The present study demonstrated a high prevalence of left ventricular diastolic dysfunction among patients with type 2 diabetes mellitus, with 81% of the study population showing evidence of dysfunction on echocardiographic assessment. Grade I dysfunction was the predominant abnormality, accounting for 59% of participants, while Grade II and Grade III/IV dysfunction were observed in 17% and 5%, respectively. These findings support the concept that abnormalities of ventricular relaxation and filling may occur early in the course of diabetic cardiac involvement, even before overt clinical heart failure becomes apparent [11,12].

The high prevalence observed in the present study is consistent with previous evidence describing diastolic dysfunction as an important manifestation of diabetic cardiomyopathy. Cosson and Kevorkian emphasized that left ventricular diastolic dysfunction may represent an early manifestation of diabetic cardiomyopathy and can precede clinically apparent systolic impairment [11]. Similarly, Fang et al. described several metabolic and structural mechanisms through which diabetes may produce myocardial functional abnormalities, supporting the concept of diabetic cardiomyopathy as a distinct cardiac complication of diabetes [12].

A clear association between increasing age and diastolic dysfunction was observed in the present study. The prevalence increased from 33.3% among participants aged 30–40 years to 90.6% among those aged >60 years, with the association reaching statistical significance (p=0.012). Age-related alterations in ventricular relaxation and myocardial compliance may contribute to this finding. However, the particularly high prevalence among older diabetic patients suggests that the effects of ageing may be compounded by chronic metabolic abnormalities associated with diabetes.

The present findings are also consistent with the broader evidence that diabetes is associated with subclinical cardiac dysfunction. Marwick highlighted that diabetes may be associated with myocardial structural and functional abnormalities and that diabetic heart disease can develop through multiple mechanisms, including metabolic, vascular, and myocardial changes [13]. Thus, the increasing prevalence of diastolic dysfunction with age in the present study may reflect the cumulative effects of diabetes duration and associated metabolic abnormalities.

An important finding of the present study was the significant relationship between fasting plasma glucose and diastolic dysfunction. Diastolic dysfunction was present in 54.2% of participants with FPG of 100–150 mg/dL, increasing to 85.7% among those with FPG of 151–200 mg/dL and 92.7% among those with FPG >200 mg/dL (p<0.001). This progressive increase suggests that poorer glycaemic status may be associated with a greater likelihood of ventricular dysfunction.

The association between glycaemic control and cardiac function is biologically plausible. Persistent hyperglycaemia may contribute to oxidative stress, altered myocardial metabolism, fibrosis, and increased myocardial stiffness, ultimately impairing ventricular relaxation. Recent evidence has also demonstrated an association between HbA1c and subclinical left ventricular dysfunction in patients with type 2 diabetes. Chen et al. found that HbA1c was independently associated with reduced global longitudinal strain and identified HbA1c as a significant risk factor for subclinical left ventricular systolic dysfunction [15]. Although the available results of the present study primarily provide FPG-based analysis and do not include the actual HbA1c results, the observed relationship between increasing FPG and diastolic dysfunction supports the importance of glycaemic status in diabetic cardiac assessment.

Echocardiography provides a non-invasive approach for detecting these abnormalities. Current echocardiographic recommendations emphasize the assessment of multiple parameters when evaluating left ventricular diastolic function rather than relying on a single measurement [14]. This is particularly important in diabetic patients because early abnormalities may be subtle and may not be accompanied by symptoms or overt systolic dysfunction. The use of 2D colour Doppler echocardiography in the present study therefore provides clinically relevant information regarding subclinical cardiac involvement.

The present study also demonstrated a significant relationship between BMI and diastolic dysfunction (p=0.003). Participants without diastolic dysfunction were predominantly in the BMI range of 18.5–22.9 kg/m², whereas higher grades of dysfunction were more frequently represented among participants with BMI ≥23 kg/m². Obesity and increased body mass may influence ventricular loading conditions, myocardial structure, and relaxation properties and may therefore contribute to the development or progression of diastolic dysfunction. Diabetes and increased adiposity may consequently act together to increase cardiovascular risk [13].

The findings should nevertheless be interpreted in light of the available study data. The present dataset provides detailed information regarding age, FPG, BMI, and grades of diastolic dysfunction; however, the actual HbA1c distribution and specific echocardiographic parameters used for grading were not provided in the supplied results. Therefore, a direct statistical correlation between HbA1c and diastolic dysfunction cannot be claimed from the available data. Further studies

incorporating detailed HbA1c measurements, diabetes duration, individual Doppler parameters, and longitudinal follow-up would help clarify the relationship between long-term glycaemic control and progression of left ventricular dysfunction.

CONCLUSION

The present study demonstrated a high prevalence of left ventricular diastolic dysfunction among patients with type 2 diabetes mellitus, with Grade I dysfunction being the most common abnormality. Diastolic dysfunction showed a significant association with advancing age, increasing fasting plasma glucose, and BMI. The findings support the role of 2D colour Doppler echocardiography in identifying subclinical cardiac abnormalities in patients with type 2 diabetes. Early echocardiographic assessment may help identify patients at increased cardiovascular risk before the development of overt heart failure. However, because HbA1c-specific results were not available in the provided dataset, a direct correlation between HbA1c and diastolic dysfunction could not be established from the present results.

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