TPM Vol. 32, No. S3, 2025
ISSN: 1972-6325
https://www.tpmap.org/

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DIASTOLIC DYSFUNCTION AND ITS CORRELATION WITH HBA1C IN NEWLY DIAGNOSED TYPE 2 DIABETES MELLITUS: A CROSS-SECTIONAL STUDY

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is associated with an increased risk of cardiovascular complications, including diastolic dysfunction, which can progress to diabetic cardiomyopathy. Glycated hemoglobin (HbA1c) serves as a marker of long-term glycemic control and may be a predictor of diastolic dysfunction in newly diagnosed T2DM patients.

Aim: This study aimed to assess the prevalence of diastolic dysfunction in newly diagnosed T2DM patients and to evaluate the correlation between HbA1c levels and echocardiographic parameters of diastolic function.

Methods: In this cross-sectional study, 150 newly diagnosed T2DM patients aged 30-60 years were enrolled. Comprehensive echocardiographic assessments measured parameters such as E/A and E/e' ratios, deceleration time, and isovolumic relaxation time (IVRT). HbA1c levels were obtained and correlated with diastolic parameters to determine the impact of glycemic control on cardiac function.

Results: Diastolic dysfunction was identified in 67% of participants, with significantly lower E/A ratios (0.9 ± 0.3) and elevated E/e' ratios (16.4 ± 3.9) in patients with HbA1c $\geq 7.2\%$ ($p < 0.001$). A strong correlation was observed between HbA1c and key diastolic parameters, including E/A ratio ($r = -0.45$, $p < 0.001$) and E/e' ratio ($r = 0.52$, $p < 0.001$). Patients with higher HbA1c levels also showed prolonged deceleration times (190.8 ± 17.2 ms), suggesting increased myocardial stiffness.

Conclusion: This study demonstrates a high prevalence of diastolic dysfunction in newly diagnosed T2DM patients, with HbA1c levels emerging as a strong predictor of diastolic impairment. Routine echocardiographic screening, along with stringent glycemic control, may be critical in managing early cardiac changes in diabetes and preventing progression to heart failure.

Keywords: Diastolic dysfunction, Type 2 diabetes mellitus, HbA1c, echocardiography, diabetic cardiomyopathy, cardiovascular risk

INTRODUCTION

The global prevalence of type 2 diabetes mellitus (T2DM) continues to rise at an alarming rate, leading to significant public health and economic challenges. As of recent estimates, diabetes affects over 460 million people worldwide, with a substantial proportion of these cases classified as T2DM. T2DM is characterized by chronic hyperglycemia resulting from insulin resistance and pancreatic β-cell dysfunction. Alongside the metabolic and microvascular complications commonly associated with T2DM, the condition also heightens the risk for cardiovascular disease (CVD), which is the leading cause of mortality among diabetic patients.[1]

Cardiac complications in diabetes are not limited to atherosclerosis-driven coronary artery disease; they also encompass diabetic cardiomyopathy, a disorder marked by ventricular dysfunction in the absence of coronary artery disease, hypertension, or other conventional cardiac risk factors.[2,3] Diabetic cardiomyopathy is often identified in its early stages by the presence of diastolic dysfunction, a condition characterized by impaired relaxation of the heart muscle during diastole, which precedes the development of overt heart failure.[4,5] Diastolic dysfunction, therefore, serves as an early indicator of cardiac compromise in diabetic patients, necessitating timely identification and intervention to prevent progression to heart failure.[6]

The pathophysiological underpinnings of diastolic dysfunction in T2DM are multifactorial, involving metabolic derangements, structural changes, and neurohormonal alterations. Central to this dysfunction is the development of endothelial impairment, a hallmark of T2DM, which contributes significantly to the abnormal cardiac mechanics observed in diabetic patients.[7] Endothelial dysfunction impairs nitric oxide bioavailability, reduces myocardial perfusion, and triggers fibrosis, all of which compound the risk of diastolic dysfunction.[8] Additionally, the accumulation of advanced glycation end-products (AGEs) resulting from prolonged hyperglycemia accelerates myocardial stiffness and adversely affects ventricular compliance.[9]

The role of glycemic control in mitigating cardiovascular complications in T2DM is well-documented, with glycated hemoglobin (HbA1c) serving as a reliable marker of long-term blood glucose levels. Elevated HbA1c

has been associated with various microvascular and macrovascular complications, and recent studies suggest that it may also correlate with the severity of diastolic dysfunction.[10,11] However, while the relationship between hyperglycemia and vascular complications is widely recognized, the association between HbA1c levels and subclinical cardiac dysfunction—particularly diastolic dysfunction—in newly diagnosed T2DM patients remains underexplored.[12]

This study aims to fill this gap by evaluating the prevalence of diastolic dysfunction in newly diagnosed T2DM patients and investigating the correlation between HbA1c levels and diastolic parameters. Understanding the relationship between glycemic control and early cardiac dysfunction is essential to optimize treatment strategies and reduce the risk of progression to overt diabetic cardiomyopathy and heart failure. We hypothesize that higher HbA1c levels will correlate with more severe diastolic dysfunction, underscoring the importance of early intervention in glycemic management to prevent cardiac complications.

MATERIALS AND METHODS

Study Design

This cross-sectional study aimed to assess the prevalence of diastolic dysfunction and its correlation with HbA1c levels in newly diagnosed type 2 diabetes mellitus (T2DM) patients. Conducted over a 15-month period at a tertiary care center, this research was designed to gather comprehensive data on cardiac function and glycemic control in a sample of 150 participants.

Study Population

A total of 150 participants, aged 30-60 years, newly diagnosed with T2DM within the last month, were included in the study. These individuals were carefully selected to eliminate confounding variables and better isolate the impact of T2DM on diastolic function.

Inclusion and Exclusion Criteria

The inclusion criteria required participants to have a confirmed T2DM diagnosis, blood pressure readings below 130/80 mmHg, and a normal baseline electrocardiogram (ECG) to ensure that cardiac assessments were specific to diastolic function changes associated with T2DM. Exclusion criteria included any known history of cardiovascular disease, type 1 diabetes, pregnancy, or lactation, aiming to prevent the influence of external factors on diastolic dysfunction evaluation.

Data Collection

Demographic information, clinical measurements (age, sex, BMI), and lifestyle factors were documented at baseline. Laboratory assessments for HbA1c levels were conducted to gauge long-term glucose control, alongside fasting lipid profiles (FLP), fasting plasma glucose (FPG), and renal function tests. All laboratory measurements followed standardized procedures to maintain consistency across the sample population.

Echocardiographic Evaluation

Echocardiography was performed by trained cardiologists, employing a high-resolution transthoracic echocardiography machine. Diastolic function parameters, including E and A wave velocities, isovolumic relaxation time (IVRT), E/A ratio, and deceleration time, were assessed using pulsed-wave Doppler imaging. Tissue Doppler imaging (TDI) was used to measure the E/e' ratio, a critical indicator of left ventricular filling pressures, and left ventricular ejection fraction (LVEF) was calculated using the biplane method. An LVEF of ≥50% was classified as normal, indicating preserved systolic function.

Definition of Diastolic Dysfunction

Diastolic dysfunction was defined based on echocardiographic criteria such as an E/A ratio <1, prolonged deceleration time, and an elevated E/e' ratio, in line with established clinical guidelines. These measures allowed for grading diastolic dysfunction into categories, from impaired relaxation to more severe stages of dysfunction.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics software (version 21.0). Continuous variables were expressed as means ± standard deviations and analyzed with independent t-tests, while categorical variables were presented as frequencies and percentages and compared using Chi-square tests. Pearson correlation analysis was used to examine the association between HbA1c levels and diastolic function parameters, with statistical significance set at $p < 0.05$ for all analyses.

Table 1: Baseline Demographic and Clinical Characteristics of Participants

Characteristic	Total (N=150)	Male (N=90)	Female (N=60)
Age (years)	50.4 ± 6.8	51.2 ± 6.9	49.1 ± 6.7
BMI (kg/m²)	26.5 ± 3.2	27.0 ± 3.4	25.8 ± 3.1
HbA1c (%)	7.2 ± 1.1	7.3 ± 1.2	7.1 ± 1.0
Blood Pressure (mmHg)	128.5 ± 9.5 / 79.5 ± 5.4	129.3 ± 9.2 / 80.1 ± 5.2	127.3 ± 9.8 / 78.7 ± 5.6
Smoking Status (Current)	20 (13.3%)	18 (20%)	2 (3.3%)
Family History of T2DM	60 (40%)	38 (42.2%)	22 (36.7%)

Table 2: Distribution of Diastolic Dysfunction Among Study Participants

Diastolic Dysfunction Grade	Total (N=150)	Male (N=90)	Female (N=60)
Normal	52 (34.7%)	30 (33.3%)	22 (36.7%)
Impaired Relaxation	48 (32%)	28 (31.1%)	20 (33.3%)
Pseudo-normalization	30 (20%)	18 (20%)	12 (20%)
Restrictive Pattern	20 (13.3%)	14 (15.6%)	6 (10%)

Table 3: Echocardiographic Parameters of Participants by HbA1c Levels

Echocardiographic Parameter	HbA1c < 7.2% (N=75)	HbA1c ≥ 7.2% (N=75)	p-value
E/A Ratio	1.1 ± 0.2	0.9 ± 0.3	<0.001
E/e' Ratio	12.3 ± 3.1	16.4 ± 3.9	<0.001
IVRT (ms)	92.4 ± 10.3	104.7 ± 12.5	<0.01
Deceleration Time (ms)	170.5 ± 15.7	190.8 ± 17.2	<0.01
LVEF (%)	56.3 ± 4.2	52.1 ± 4.8	<0.05

Table 4: Correlation between HbA1c Levels and Diastolic Dysfunction Parameters

Parameter	Pearson Correlation (r)	p-value
E/A Ratio	r = -0.45	<0.001
E/e' Ratio	r = 0.52	<0.001
IVRT	r = 0.41	<0.01
Deceleration Time	r = 0.39	<0.01
LVEF	r = -0.30	<0.05

DISCUSSION

This study reveals a substantial prevalence of diastolic dysfunction in newly diagnosed type 2 diabetes mellitus (T2DM) patients and demonstrates a strong correlation between elevated HbA1c levels and diastolic impairment. Among the 150 participants, 67% exhibited some form of diastolic dysfunction. Key echocardiographic parameters, including the E/A and E/e' ratios, showed a significant association with HbA1c levels, supporting the impact of glycemic control on early cardiac changes in T2DM.[13,14]

The observed relationship between HbA1c and diastolic dysfunction is consistent with findings from previous studies. Patients in our study with HbA1c ≥7.2% had a lower mean E/A ratio (0.9 ± 0.3) and a higher mean E/e' ratio (16.4 ± 3.9) compared to those with lower HbA1c levels, both statistically significant at $p < 0.001$. These results align with findings in similar studies, where a threshold HbA1c of 7.5% was linked to a 1.5-fold increase in diastolic dysfunction risk.[15] The correlation coefficients in our study (E/A: r = -0.45, E/e': r = 0.52) indicate that as HbA1c levels rise, diastolic function declines—a trend corroborated by other studies linking hyperglycemia to myocardial stiffness and impaired relaxation.[16,17]

The high E/e' ratio observed in patients with elevated HbA1c levels is consistent with research demonstrating that E/e' ratios above 15 are indicative of increased left ventricular filling pressures in T2DM.[18] In our study, the restrictive diastolic pattern, often linked to advanced myocardial stiffness, was noted in 13.3% of cases, with a mean deceleration time of 190.8 ± 17.2 ms in those with HbA1c ≥7.2%. Prior studies have also shown that HbA1c levels exceeding 8.0% are associated with prolonged deceleration times and increased ventricular stiffness,[19,20] further highlighting the role of glycemic control in preserving cardiac function.

Hyperglycemia-induced oxidative stress and inflammatory cytokine release are major contributors to myocardial stiffness. Saad demonstrated that these factors promote fibrosis, leading to increased myocardial stiffness in diabetes.[21] Our study's findings, including prolonged deceleration times and higher E/e' ratios in the high HbA1c group, reflect these pathological changes and align with studies linking oxidative stress to compromised myocardial compliance.[22]

Patients with HbA1c levels exceeding 7.0% in our study exhibited impaired relaxation, reinforcing findings from research showing that even normotensive, asymptomatic T2DM patients exhibit diastolic impairment at this level.[23] The silent progression of diastolic dysfunction in T2DM supports HbA1c's role as a predictor of diastolic dysfunction severity, strengthening its utility in routine cardiovascular risk assessments for diabetic patients.

In terms of clinical applications, our study emphasizes the need for early echocardiographic screening in T2DM. Zhang has suggested that routine assessments of E/e' ratio and deceleration time are sensitive indicators of diastolic dysfunction and can complement HbA1c monitoring in diabetes care.[24] The results from our study support this approach, indicating that HbA1c serves as a practical biomarker for identifying T2DM patients at elevated risk for diastolic dysfunction.

Our findings add to evidence linking HbA1c with microvascular and macrovascular complications in T2DM. Stratton's study highlighted a close association between HbA1c and cardiovascular events, a trend observed here with diastolic impairment.[10] Additionally, the Strong Heart Study demonstrated significant structural heart changes in diabetic patients with poorly controlled HbA1c, further underscoring HbA1c's role in predicting early diastolic impairment.[11]

The broader implications suggest that rigorous glycemic control could reduce the risk of progression to advanced diabetic cardiomyopathy. The UKPDS study emphasized HbA1c reduction as key to lowering microvascular complications in T2DM.[12] Thus, incorporating echocardiographic assessments in routine T2DM care may facilitate early intervention, potentially improving long-term cardiovascular outcomes.

CONCLUSION

This study highlights a strong association between elevated HbA1c levels and diastolic dysfunction in newly diagnosed T2DM patients, identifying HbA1c as a significant predictor of diastolic impairment. The findings emphasize the need for routine cardiac assessments in diabetes care and underscore strict glycemic management to prevent progression to diabetic cardiomyopathy.

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