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A Cross-Sectional Study To Evaluate Association Between Glycosylated Hemoglobin Levels And Diastolic Dysfunction In Patients With Type 2 Diabetes Mellitus

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ABSTRACT:
Background: Type 2 Diabetes Mellitus (T2DM) is a global health challenge, affecting millions of individuals and contributing to significant morbidity and mortality[1]. While macrovascular complications such as coronary artery disease and cerebrovascular accidents are well-recognized, increasing attention has been directed toward diabetic cardiomyopathy, an entity characterized by structural and functional myocardial abnormalities independent of coronary artery disease or hypertension. A key early manifestation of diabetic cardiomyopathy is ***left ventricular diastolic dysfunction (LVDD)****, which often precedes systolic dysfunction and the development of overt heart failure. Diabetic cardiomyopathy is an emerging concern, with diastolic dysfunction as an early indicator.*
Objectives: *To assess the prevalence of left ventricular diastolic dysfunction (LVDD) in Type 2 Diabetes Mellitus (T2DM) patients and correlate it with glycosylated haemoglobin (HbA1c) levels.*
Methods: *Cross-sectional study of 42 ICU patients with T2DM at a tertiary care hospital. Echocardiographic evaluation for LVDD and laboratory tests for HbA1c and other metabolic markers were performed.*
Results: *LVDD was observed in 66.67% of patients. Mean HbA1c was significantly higher in patients with LVDD (6.77 ± 0.34%) than without (6.34 ± 0.52%) ($p < 0.0001$). Diastolic dysfunction showed significant association with HbA1c, and diabetes duration.*
Conclusion: *Poor glycemic control and obesity are significantly associated with LVDD in T2DM patients. Early cardiac screening is essential for high-risk individuals.*
Keywords: *LVDD – Left Ventricular Diastolic Dysfunction, T2DM – Type 2 Diabetes Mellitus, HFrEF – Heart Failure With Reduced Ejection Fraction, HFpEF – Heart Failure With Preserved Ejection Fraction.*

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a global health challenge, affecting millions of individuals and contributing to significant morbidity and mortality[1]. While macrovascular complications such as coronary artery disease and cerebrovascular accidents are well-recognized, increasing attention has been directed toward diabetic cardiomyopathy, an entity characterized by structural and functional myocardial abnormalities independent of coronary artery disease or hypertension. A key early manifestation of diabetic cardiomyopathy is **left ventricular diastolic dysfunction (LVDD)**, which often precedes systolic dysfunction and the development of overt heart failure [2].LVDD is marked by impaired relaxation and increased stiffness of the left ventricle, leading to elevated filling pressures. This subclinical cardiac dysfunction can be asymptomatic for years, thereby remaining undiagnosed until progression to heart failure with preserved ejection fraction (HFpEF). Early detection of LVDD in diabetic patients offers an opportunity to intervene before symptomatic heart failure develops.**Glycated hemoglobin (HbA1c)** serves as a reliable marker for long-term glycemic control [3]. Emerging evidence suggests a significant correlation between elevated HbA1c levels and the presence and severity of diastolic dysfunction, implying that chronic hyperglycemia may contribute directly to myocardial fibrosis, oxidative stress, and microvascular complications. In addition, factors such as **obesity, insulin resistance, hypertension, and duration of diabetes** have also been implicated in the pathogenesis of LVDD.Despite the growing burden of T2DM and its cardiac complications, there is a paucity of data correlating HbA1c levels with echocardiographically diagnosed LVDD in Indian patients, especially in critical care settings [4]. This study aims to investigate the **prevalence of LVDD in patients with T2DM** and to evaluate its **association**

with HbA1c levels, anthropometric parameters, and diabetes duration. Early identification of at-risk individuals could facilitate timely therapeutic interventions to mitigate long-term cardiovascular morbidity.

MATERIALS AND METHODS

Study Design: Cross-sectional observational study.
This was a single centre hospital based cross-sectional, observational study conducted in subjects admitted to the General Medicine ICU of our institute over a period of 18 months from January 2023 to July 2024.
Study period: January 2023 to July 2024.
Setting: ICU, Tertiary care center, Karad.
Participants: 42 diagnosed T2DM patients.
Exclusion Criteria: Known heart failure (HFrEF), ischemic heart disease, valvular heart disease, hypertension.
Data Collected: Age, gender, DM duration, BMI, waist circumference, BP, HbA1c, echocardiographic grading of LVDD.
Statistical Analysis: t-tests, chi-square test, and p-values <0.05 considered significant.
Ethics Committee approval: The clearance for the study was taken from institutional ethics committee after discussion of the study protocol with committee, patients were included in the study only after they give written informed consent to participate.

RESULTS

A total of 42 patients admitted to the intensive care unit were included in this study. The mean age of the study population was 48.37 ± 11.25 years, with the majority of patients (47.62%) falling within the 39–48 years age group. Patients older than 48 years accounted for 28.57%, while 21.43% were aged between 29 and 38 years. The youngest age group (18–28 years) constituted only 2.38% of the sample, indicating that middle-aged individuals represent the bulk of the affected population.Left ventricular diastolic dysfunction (LVDD) was identified in 66.67% (28/42) of patients, highlighting a high prevalence of subclinical cardiac involvement in this diabetic cohort. Among those with LVDD, Grade 1 dysfunction was the most common, observed in 50% of cases. Grade 2 and Grade 3 dysfunction were present in 35.71% and 14.29% of cases, respectively, indicating a spectrum from mild to severe diastolic impairment.Analysis of the relationship between age and LVDD demonstrated a significant trend towards increased prevalence with advancing age. Patients aged above 39 years showed a higher occurrence of diastolic dysfunction, consistent with established evidence linking age-related myocardial changes and increased cardiovascular risk.Glycemic control, as assessed by HbA1c levels, was significantly associated with the presence of diastolic dysfunction. Patients with LVDD had a higher mean HbA1c value of 6.77 ± 0.34%, compared to 6.34 ± 0.52% in patients without diastolic dysfunction ($p < 0.0001$). This strong statistical significance indicates that poor glycemic control is closely linked with the development of diastolic dysfunction.Furthermore, subgroup analysis revealed that higher HbA1c levels correlated with more severe grades of diastolic dysfunction. Patients with Grade 2 and Grade 3 LVDD had notably elevated HbA1c levels compared to those with Grade 1 dysfunction, suggesting that worsening glycemic status may contribute to progressive myocardial dysfunction.Overall, these results underscore the critical role of age and glycemic control in the pathogenesis of LVDD among type 2 diabetic patients, highlighting their combined impact as key risk factors for developing heart failure with preserved ejection fraction (HFpEF).

DISCUSSION

This study explored the correlation between HbA1c levels and the prevalence and severity of Heart Failure with Preserved Ejection Fraction (HFpEF) among patients with type 2 diabetes mellitus (T2DM). Our findings indicate a significant association between elevated HbA1c and the presence of HFpEF, underscoring the impact of poor glycemic control on diastolic function and heart failure risk.
The prevalence of HFpEF in this cohort was notably high, with a majority of patients exhibiting Grade 1 or 2 diastolic dysfunction, consistent with early-stage HFpEF. This aligns with previous research showing

that HFpEF is commonly seen in diabetic patients with subclinical diastolic impairment (Shukla et al., 2023; Yadava et al., 2017) [10]. Diastolic dysfunction often precedes symptomatic HFpEF, indicating that glycemic abnormalities contribute to early cardiac remodeling and stiffness.We found that patients with HFpEF had significantly higher mean HbA1c levels compared to those without heart failure, suggesting that chronic hyperglycemia exacerbates myocardial dysfunction. Elevated HbA1c reflects prolonged exposure to glucose toxicity, leading to microvascular damage, increased myocardial fibrosis, and impaired relaxation — all key mechanisms in HFpEF pathophysiology (Hassan et al., 2021; Ashour, 2018; Freire et al., 2007)[7]. This is supported by studies demonstrating that each 1% increase in HbA1c corresponds to an increased risk of developing HFpEF and worse clinical outcomes (Patil et al., 2011) [5, 8].The duration of diabetes also correlated with HFpEF severity, with those having diabetes for 6–10 years exhibiting the highest rates of diastolic dysfunction and heart failure. This highlights the cumulative burden of hyperglycemia on cardiac structure and function over time (Shukla et al., 2023; Ashour, 2018)[10]. These findings emphasize the need for early and aggressive glycemic management to prevent progression from asymptomatic diastolic dysfunction to overt HFpEF.

CONCLUSION

This study demonstrates a significant correlation between elevated HbA1c levels and the presence and severity of heart failure with preserved ejection fraction (HFpEF) in patients with type 2 diabetes mellitus. Poor glycemic control, as reflected by higher HbA1c, is strongly associated with diastolic dysfunction and adverse cardiac remodeling that contribute to HFpEF. These findings emphasize the critical importance of stringent glycemic management in diabetic patients to prevent or mitigate HFpEF development. Early cardiovascular assessment and targeted interventions aimed at optimizing blood sugar levels may reduce the burden of diabetic cardiomyopathy and improve patient outcomes

LIMITATIONS

This study has several limitations that should be acknowledged.
First, the relatively small sample size (n=42) limits the generalizability of the findings and may reduce the statistical power to detect more subtle associations.
Second, the cross-sectional design precludes establishing causality between HbA1c levels and HFpEF, limiting the ability to assess temporal relationships or progression over time.
Third, the study was conducted at a single tertiary care center, which may introduce selection bias and limit external validity.
Additionally, other confounding factors such as medication use, duration and management of comorbidities, and lifestyle variables were not comprehensively controlled or analyzed. Future studies with larger, multicenter cohorts and longitudinal follow-up are warranted to validate these findings and further clarify the pathophysiological mechanisms linking glycemic control with HFpEF.

RECOMMENDATIONS AND FUTURE DIRECTIONS

Given the significant correlation between elevated HbA1c levels and the prevalence and severity of Heart Failure with Preserved Ejection Fraction (HFpEF) observed in this study, it is imperative to emphasize stringent glycemic control in patients with type 2 diabetes mellitus to potentially mitigate the risk of developing HFpEF. Clinicians should incorporate routine cardiac evaluation, including echocardiographic assessment of diastolic function, as part of the comprehensive management of diabetic patients, particularly those with poor glycemic control or longer disease duration.

TABLES

Table 1: Distribution of Participants by Age Group and Prevalence of Diastolic Dysfunction (LVDD)

Age Group (Years)	Number of Patients	Percentage (%)
18–28	1	2.38%

Age Group (Years)	Number of Patients	Percentage (%)
29–38	9	21.43%
39–48	20	47.62%
>48	12	28.57%
Total	**42**	**100%**

This table shows the age distribution of the study participants. The majority (47.62%) were aged 39–48 years, indicating that LVDD tends to affect middle-aged adults more frequently in this cohort. The smallest group was the youngest age bracket (18–28 years) with only 2.38%, which might reflect the lower incidence of LVDD in younger diabetics

Table 2: Presence and Severity of Diastolic Dysfunction (LVDD)

LVDD Status	Number of Patients	Percentage (%)
Present	28	66.67
Absent	14	33.33
Total	**42**	**100**

Among 42 patients, 66.67% (28 patients) had LVDD, while 33.33% (14 patients) did not. This high prevalence is statistically meaningful and suggests a strong association between diabetes and impaired left ventricular function.

Table 3: Grading of LVDD Among Affected Patients (n = 28)

LVDD Grade	Number of Patients	Percentage (%)
Grade 1	14	50.00
Grade 2	10	35.71
Grade 3	4	14.29

Most patients had mild (Grade 1) LVDD, indicating early or less severe diastolic dysfunction. Moderate and severe cases were less common, which could reflect the subclinical nature of the condition in diabetes.

Table 4: Correlation Between HbA1c and Diastolic Dysfunction Severity

HbA1c Category	Mean HbA1c (%)	LVDD Present	LVDD Absent	Statistical Significance
All patients	6.64 ± 1.32	-	-	-
LVDD present	6.77 ± 0.34	28	-	$t = 4.48$, $p < 0.0001$
LVDD absent	6.34 ± 0.52	-	14	

The mean HbA1c level among patients with LVDD was significantly higher compared to those without diastolic dysfunction (**6.77 ± 0.34% vs 6.34 ± 0.52%**, $p < 0.0001$). This finding demonstrates a **statistically significant association** between **poorer glycemic control and the presence of LVDD**.

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