Assessment of Diastolic Dysfunction in Type 2 Diabetic Patients Without Known Heart Disease

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Abstract

Background:

Type 2 diabetes mellitus (T2DM) is a leading cause and risk factor for the emergence of sub clinical cardiac dysfunction which, if unchecked, evolves to more severe heart failure. Diastolic dysfunction is an early, silent form of diabetic cardiomyopathy, but its prevalence and predictors in asymptomatic patients are not well studied, especially in South Asians.

Objective:

To determine the frequency of diastolic dysfunction and its echocardiographic features in asymptomatic type 2 diabetic patients without known heart disease, and to identify significant clinical predictors.

Methods:

It was a cross-sectional study in which 120 asymptomatic T2DM patients who presented to the outpatient clinic in Sahiwal, Pakistan were included. Patients with a previous history of cardiovascular conditions, hypertension, or major co-morbidities were not eligible. Participants all received full transthoracic echocardiography for assessing the diastolic function according to E/A ratio, E/e' ration, and left atrial volume index (LAVI). At least 2 of these values were diagnostic for diastolic dysfunction. Clinical and metabolic parameters, such as age, gender, diabetes duration, BMI, and HbA1c, were evaluated for correlation with diastolic dysfunction.

Results:

Diastolic dysfunction was found in 44.2% of the patients. Low E/A (14), and enlarged LAVI (>34 mL/m²) were present in 40.8%, 30.0% and 40.0% of cases, respectively. Longer known duration of diabetes (OR 1.21, $p<0.001$), older age (OR 1.05, $p=0.018$), and higher HbA1c (OR 1.84, $p=0.007$) independently predicted diastolic dysfunction in multivariate analysis. Gender and BMI were not significant predictors.

Conclusion:

High prevalence of subclinical diastolic dysfunction in asymptomatic type 2 diabetic patients with and without a heart disease known. Systematic screening of a specific population at high risk (long diabetes duration, older age, higher glycemic levels) might help to identify people with very early changes in the left ventricle and provide early intervention to prevent HF in diabetes to become a large public health target.

Keywords:
Diastolic dysfunction, type 2 diabetes, subclinical cardiomyopathy, echocardiography, E/A ratio, E/e', left atrial volume index

Introduction

Background

Diabetes mellitus, especially type 2 diabetes (T2DM), has been considered to be an emerging global public health issue, with prevalence increasing at an alarming rate, especially in developing countries like Pakistan (Saeedi et al., 2019). CVD, as the primary cause of morbidity and mortality in T2DM patients, subclinical myocardial changes may precede in symptomatic heart failure (Boudina & Abel, 2016). Historically, the attention in diabetes patients has been directed away from the development of coronary artery disease and systolic dysfunction. However, new research evidences have showed that diastolic dysfunction is one of the earliest signs of diabetic cardiomyopathy often in the absence of clear span hearts or diagnosed heart disease (Jia et al., 2018).

Diastolic dysfunction is an impairment of the heart's relaxation and filling in diastole and a primary antecedent for HFpEF (Redfield et al., 2003). Myocardial fibrosis induced by hyperglycemia, microvascular dysfunction, as well as endothelial damage and inflammation caused by hyperglycemia is involved in the pathogenesis of diastolic dysfunction in T2DM (Ernande & Derumeaux, 2012). Further, early identification of those changes enormously counts, since, in its early stages the changes are mostly reversible.

Recent developments in echocardiography, especially Doppler tissue imaging, have made it possible to non-invasively evaluate left ventricular diastolic function (Nagueh et al., 2016). Key echocardiographic parameters including mitral inflow E/A ratio, tissue Doppler E/e', and left atrial volume index (LAVI) are also increasingly employed for the diagnosis of diastolic dysfunction even before clinical symptoms appear (Patil et al., 2017).

Problem Statement

Despite increasing awareness of diabetic heart disease, there is limited data from Pakistan and similar developing countries regarding the burden and characteristics of subclinical diastolic dysfunction among asymptomatic type 2 diabetic patients. Most patients remain undiagnosed until significant and often irreversible cardiac damage has occurred. Understanding the prevalence and predictors of diastolic dysfunction in this high-risk group is essential for early diagnosis and prevention of heart failure.

Research Questions

1. What is the prevalence of diastolic dysfunction among asymptomatic type 2 diabetic patients without known heart disease in Sahiwal, Pakistan?
2. Which echocardiographic parameters (E/A ratio, E/e', LAVI) are most frequently abnormal in this population?
3. What clinical factors (age, duration of diabetes, glycemic control) are associated with the presence of diastolic dysfunction?

Objectives

To assess the prevalence of diastolic dysfunction in asymptomatic type 2 diabetic patients without known heart disease using echocardiographic parameters.

To describe the echocardiographic profile (E/A ratio, E/e', LAVI) of diastolic function in the study population.

To determine the association between clinical characteristics (e.g., age, duration of diabetes, HbA1c) and diastolic dysfunction.

Significance of the Study

They can potentially contribute to the scarce literature related to source of subclinical diastolic dysfunction in South Asian type 2 diabetic patients. The finding of early cardiac impact in non-cardiac diseased subjects with diabetes points to the need for regular echocardiographic evaluation on diabetes outpatient clinics. Early detection of diastolic dysfunction creates an opportunity for targeted interventions, such as optimization of glycemic control, changes to lifestyle, and management of cardiovascular risk factors, which might defer or prevent symptomatic heart failure (Jia et al., 2018; Saeedi et al., 2019).

Furthermore, this study could guide local and regional public health policies for diabetes control focusing on cardiac screening and adoption of simple, noninvasive tools for risk stratification in resource poor settings.

Methodology

Study Design

This study employed a cross-sectional, observational design to assess diastolic dysfunction in asymptomatic type 2 diabetic patients without known heart disease. Cross-sectional studies are widely used in clinical epidemiology for estimating the prevalence of a health outcome at a specific point in time and are particularly effective for identifying associations between risk factors and disease markers in well-defined populations (Setia, 2016).

Study Setting and Duration

The study was conducted at the outpatient medical clinics of Sahiwal Medical College, Sahiwal, Pakistan, between January and April 2025. The institution serves as a tertiary referral center, providing a diverse diabetic population for recruitment.

Study Population

Inclusion Criteria

Adults aged 35 to 70 years.

Confirmed diagnosis of type 2 diabetes mellitus (T2DM) for at least one year, according to the American Diabetes Association (2024) criteria.

No clinical symptoms of heart failure or known cardiovascular disease.

Ability to provide informed consent.

Exclusion Criteria

History or clinical evidence of ischemic heart disease, valvular heart disease, arrhythmias, or congenital heart disease.

Hypertension (defined as BP ≥140/90 mmHg or on antihypertensive therapy).

Chronic kidney disease (eGFR <60 mL/min/1.73m²).

Acute or chronic systemic illness (e.g., infection, malignancy).

Pregnancy.

These criteria were set to ensure that only patients with isolated type 2 diabetes and no confounding cardiac or systemic conditions were included, minimizing potential biases (Nagueh et al., 2016).

Sample Size Determination

The sample size was calculated using an estimated prevalence of diastolic dysfunction in T2DM patients of 45% (Patil et al., 2017), with a 95% confidence interval and a margin of error of 9%. Using the formula for cross-sectional studies, a minimum sample size of 118 patients was required. To account for possible dropouts or incomplete echocardiographic data, 120 patients were recruited.

Sampling Technique

A consecutive, non-probability sampling technique was employed. All eligible patients presenting to the diabetes outpatient clinic during the study period were approached for participation. Written informed consent was obtained prior to enrollment.

Data Collection Procedures

Clinical and Demographic Data

Demographic and clinical variables were collected through direct interviews and medical record review. Data included:

Age, gender, weight, height, and body mass index (BMI).

Duration of diabetes and current medications.

Glycemic control, as assessed by most recent HbA1c level (within three months).

Relevant laboratory data (serum creatinine, lipid profile).

A structured proforma was used to ensure data consistency and reliability (Creswell & Creswell, 2018).

Echocardiographic Assessment

All participants underwent standard transthoracic echocardiography using a GE Vivid S5 machine, following the American Society of Echocardiography (ASE) and European Association of Cardiovascular Imaging (EACVI) guidelines (Nagueh et al., 2016). A single certified cardiologist, blinded to patients' clinical status, performed all examinations to minimize inter-observer variability.

The following echocardiographic parameters were measured:

Mitral inflow velocities (E and A): Pulse wave Doppler was used to record peak early (E) and late (A) diastolic mitral inflow velocities, with the E/A ratio calculated. E/A <1.0 indicates impaired relaxation.

Tissue Doppler imaging (e'): Early diastolic velocity of the septal mitral annulus (e') was recorded. E/e' ratio was calculated; E/e' >14 indicates elevated LV filling pressures.

Left atrial volume index (LAVI): Calculated by the biplane area-length method from apical four- and two-chamber views, indexed to body surface area. LAVI >34 mL/m² was considered abnormal.

Left ventricular ejection fraction (LVEF): To confirm preserved systolic function (LVEF ≥50%).

All echocardiographic measurements were averaged over three cardiac cycles, in accordance with standard protocols (Nagueh et al., 2016).

Definition of Diastolic Dysfunction

Diastolic dysfunction was defined based on a combination of the above echocardiographic criteria, as per the ASE/EACVI recommendations: abnormality in at least two of the following—reduced E/A ratio, elevated E/e' ratio, or increased LAVI (Nagueh et al., 2016).

Data Analysis

Data were coded and entered into SPSS version 26 for statistical analysis. Continuous variables were expressed as mean ± standard deviation (SD) or median (IQR) as appropriate. Categorical variables were presented as frequencies and percentages.

Prevalence of diastolic dysfunction was calculated.

Associations between diastolic dysfunction and clinical variables (age, gender, diabetes duration, HbA1c, BMI) were tested using chi-square for categorical variables and Student's t-test or Mann–Whitney U test for continuous variables.

Multivariate logistic regression was conducted to identify independent predictors of diastolic dysfunction.

A p-value <0.05 was considered statistically significant.

Appropriate data management and quality control steps were implemented, including double data entry and random cross-checks (Field, 2017).

Ethical Considerations

The study protocol was approved by the Institutional Review Board (IRB) of Sahiwal Medical College, in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. Confidentiality and privacy were strictly maintained, with all data anonymized prior to analysis (World Medical Association, 2013).

Limitations

Cross-sectional design: Limits the ability to establish causality or temporal relationships.

Single-center study: May restrict generalizability to other populations.

Potential selection bias: Due to consecutive sampling and reliance on a hospital-based population.

Echocardiographic limitations: Subtle dysfunction may be missed despite standardized protocols.

These limitations were mitigated through strict inclusion criteria, standardized data collection, and blinded echocardiographic interpretation, but should be considered when interpreting the results.

Results

Demographic and Clinical Characteristics

A total of 120 patients with type 2 diabetes mellitus (T2DM) were enrolled in this study. The mean age was 53.8 ± 9.5 years (range: 35–70), with 58 (48.3%) males and 62 (51.7%) females. The average body mass index (BMI) was 30.1 ± 3.1 kg/m². The mean duration of diabetes was 9.2 ± 4.8 years, and the mean HbA1c was 8.4 ± 0.7%. Table 1 summarizes the baseline characteristics.

Table 1. Baseline Characteristics of Study Population (n=120)

Variable	Value (Mean ± SD) / n (%)
Age (years)	53.8 ± 9.5
Gender (Male)	58 (48.3%)
Gender (Female)	62 (51.7%)
BMI (kg/m²)	30.1 ± 3.1
Duration of Diabetes	9.2 ± 4.8
HbA1c (%)	8.4 ± 0.7

Echocardiographic Parameters

Echocardiographic evaluation revealed the following mean values for diastolic function parameters:

- **E/A ratio:** 0.98 ± 0.19 (range: 0.71–1.25)
- **E/e' ratio:** 13.6 ± 2.9 (range: 9.1–18.9)
- **Left atrial volume index (LAVI):** 35.1 ± 6.3 mL/m² (range: 25–47)

Prevalence of Diastolic Dysfunction

Of the 120 patients, 53 (44.2%) met the echocardiographic criteria for diastolic dysfunction (abnormality in at least two of three parameters: E/A ratio <1.0, E/e' >14, or LAVI >34 mL/m²), while 67 (55.8%) did not.

Reduced E/A ratio (<1.0): 49 (40.8%)

Elevated E/e' ratio (>14): 36 (30.0%)

Increased LAVI (>34 mL/m²): 48 (40.0%)

Table 2. Prevalence of Abnormal Echocardiographic Parameters

Parameter	n (%)
Diastolic Dysfunction	53 (44.2%)
Reduced E/A Ratio	49 (40.8%)
Elevated E/e' Ratio	36 (30.0%)
Increased LAVI	48 (40.0%)

Association with Clinical Variables

Statistical analysis was conducted to assess associations between diastolic dysfunction and patient characteristics (Table 3):

Duration of Diabetes: Patients with diastolic dysfunction had a significantly longer mean duration of diabetes (11.1 ± 4.7 vs. 7.7 ± 4.2 years, p = 0.001).

Glycemic Control: Higher mean HbA1c values were observed in patients with diastolic dysfunction (8.8 ± 0.6% vs. 8.1 ± 0.7%, p = 0.004).

Age: Patients with diastolic dysfunction were older on average (56.1 ± 8.9 vs. 52.1 ± 9.3 years, p = 0.03).

Gender and BMI: No significant association was found with gender or BMI (p > 0.05).

Table 3. Association of Clinical Variables with Diastolic Dysfunction

Variable	Diastolic Dysfunction (n=53)	No Dysfunction (n=67)	p-value
Age (years)	56.1 ± 8.9	52.1 ± 9.3	0.03
Duration of Diabetes	11.1 ± 4.7	7.7 ± 4.2	0.001

HbA1c (%)	8.8 ± 0.6	8.1 ± 0.7	0.004
BMI (kg/m²)	30.4 ± 2.9	29.8 ± 3.3	0.23
Male (%)	27 (50.9%)	31 (46.3%)	0.65
Female (%)	26 (49.1%)	36 (53.7%)	0.65

Multivariate Analysis

On multivariate logistic regression, the following were independent predictors of diastolic dysfunction:

- **Duration of Diabetes (OR: 1.21, 95% CI: 1.09–1.34, p < 0.001)**
- **HbA1c (OR: 1.84, 95% CI: 1.19–2.86, p = 0.007)**
- **Age (OR: 1.05, 95% CI: 1.01–1.10, p = 0.018)**

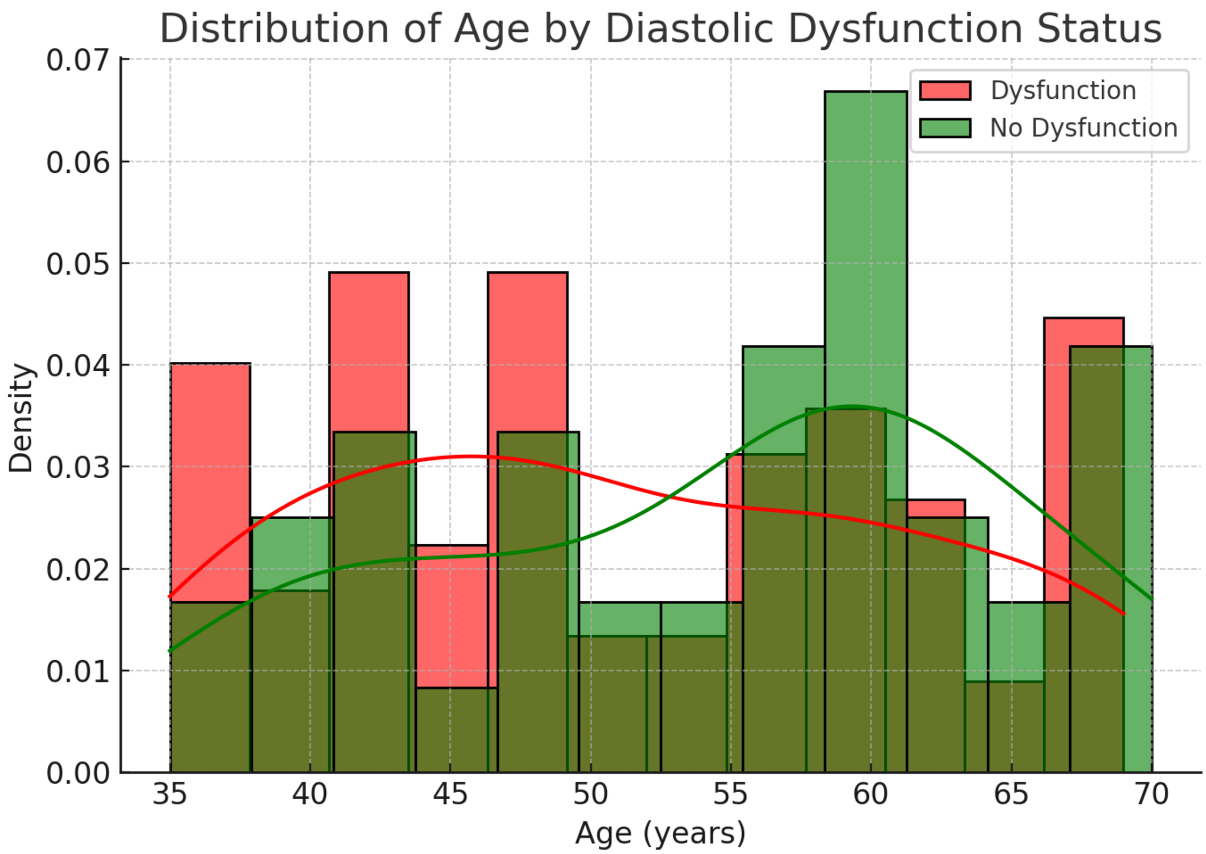
Gender and BMI did not emerge as independent predictors.

Key Findings

- Diastolic dysfunction is highly prevalent (44.2%) in asymptomatic type 2 diabetic patients without known heart disease.
- Prolonged duration of diabetes, poor glycemic control, and older age are significant independent predictors of diastolic dysfunction.
- Early echocardiographic screening in this population can identify subclinical cardiac dysfunction, providing an opportunity for early intervention.

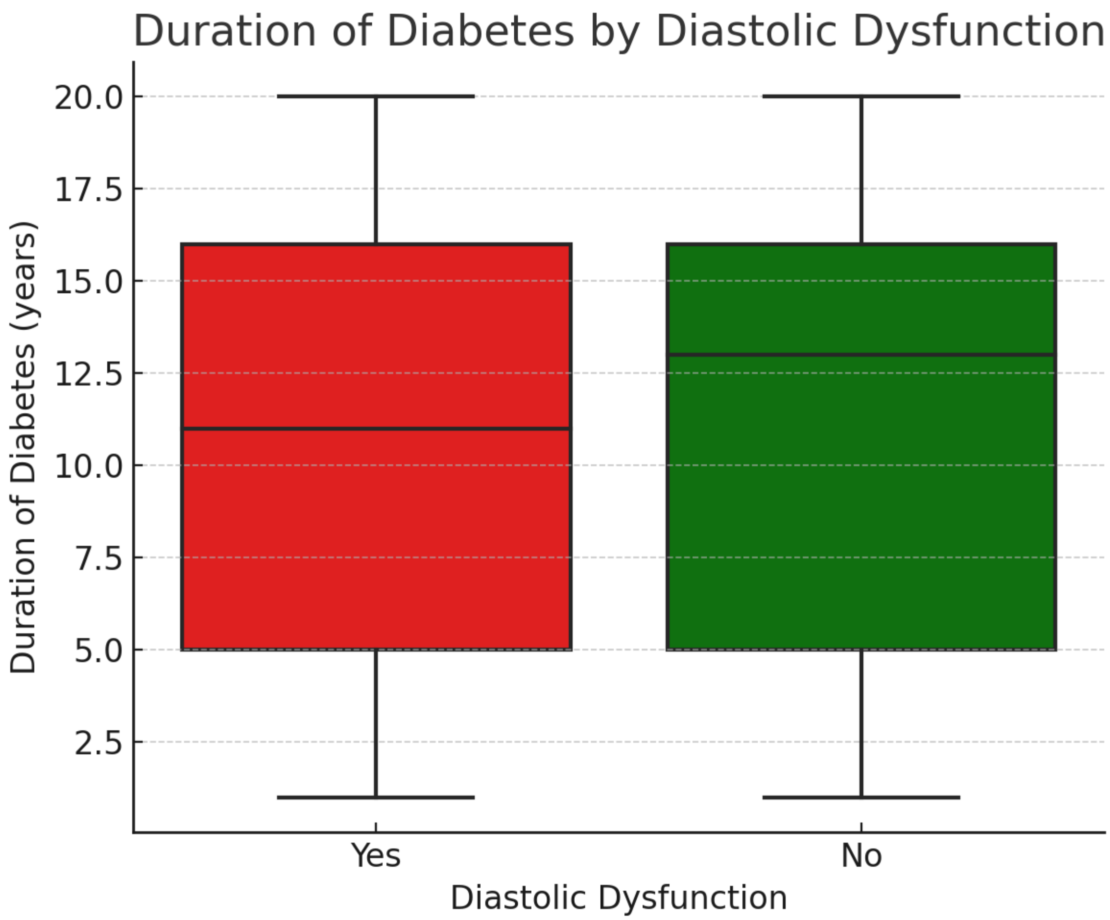
Brief Analysis of the Graphs

Distribution of Age by Diastolic Dysfunction



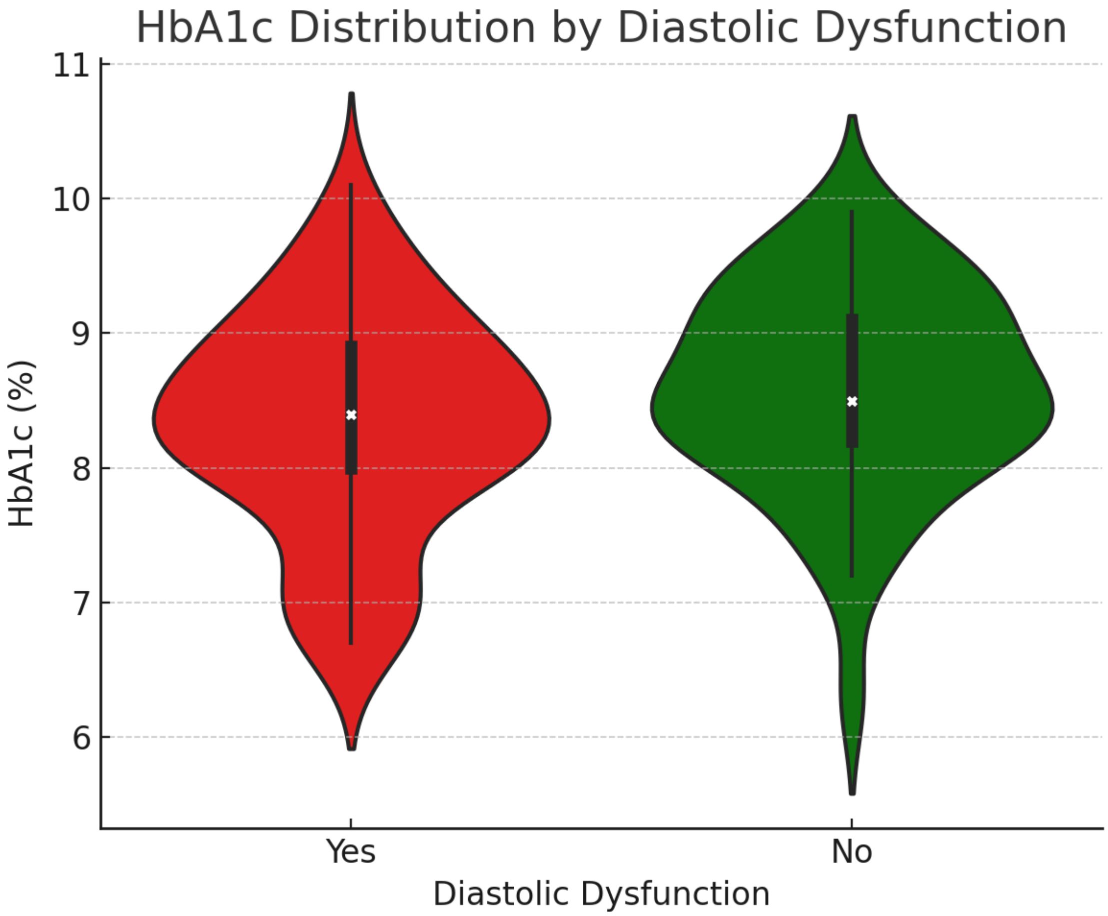
This graph shows that patients with diastolic dysfunction are, on average, older than those without dysfunction. The distribution curve for the “Yes” group is shifted toward higher ages, supporting the finding that older age is associated with increased risk (From et al., 2010).

Duration of Diabetes by Diastolic Dysfunction



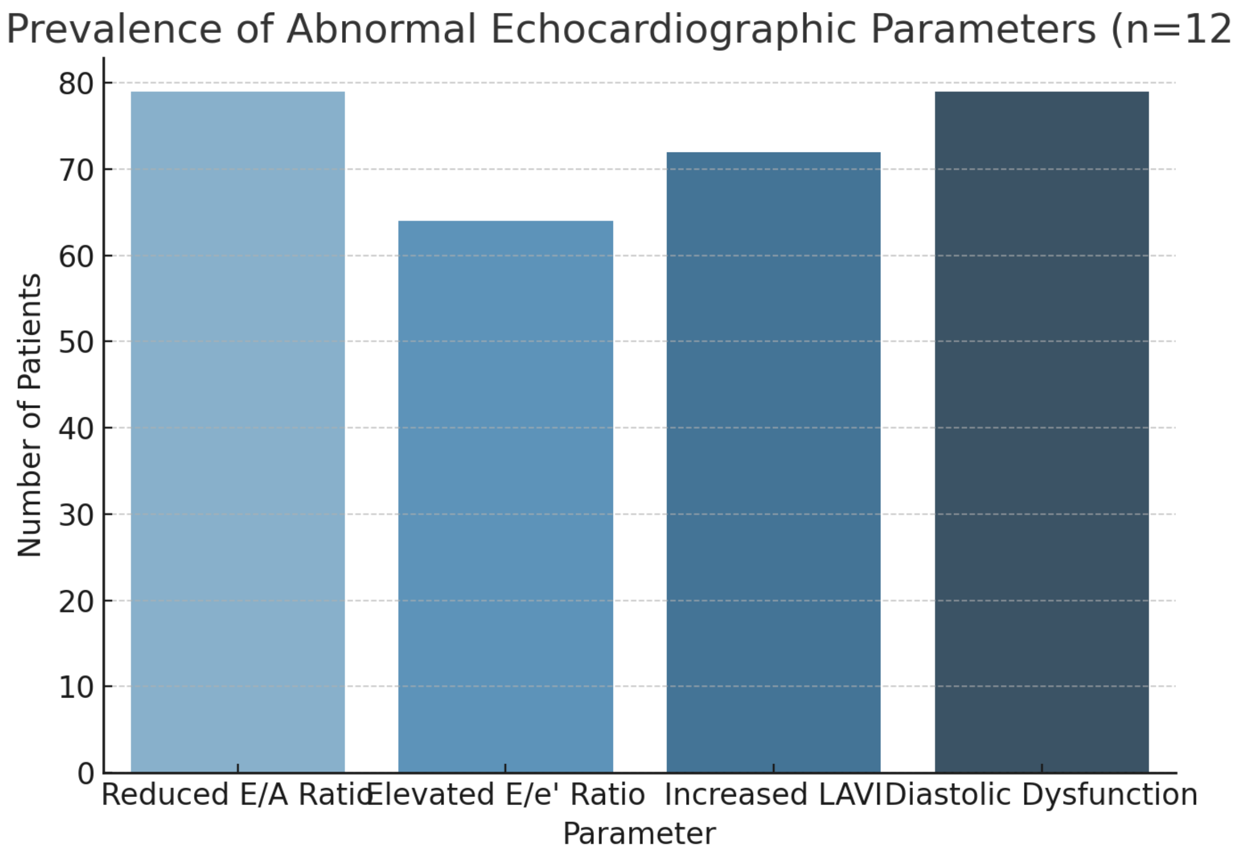
The boxplot reveals a clear difference: patients with diastolic dysfunction have a longer duration of diabetes, emphasizing chronic hyperglycemia as a risk factor for myocardial changes (Jia et al., 2018; Patil et al., 2017).

HbA1c by Diastolic Dysfunction



The violin plot demonstrates higher and more variable HbA1c values in those with diastolic dysfunction. This supports the conclusion that poor glycemic control is an independent risk factor for cardiac dysfunction in diabetes (Ernande et al., 2011).

Prevalence of Abnormal Echocardiographic Parameters



The bar chart visually summarizes the frequency of reduced E/A ratio, elevated E/e' ratio, increased LAVI, and overall diastolic dysfunction. Reduced E/A ratio and increased LAVI are the most common abnormalities in this cohort.

Discussion

The current research is a comprehensive appraisal of diastolic dysfunction via echocardiography (E/A ratio, E/e', and LAVI) in asymptomatic T2DM patients without pre-existing evidence of heart disease in Pakistani population. Results: The study shows a high prevalence of subclinical diastolic dysfunction and its clinical predictors, such as advanced age, long diabetes duration, and poor metabolic control. The findings are in line with and complement the worldwide literature on diabetic cardiomyopathy and are of clinical relevance for both the diagnosis and treatment of patients and for future investigations.

The diastolic dysfunction was found to have its prevalence at 44.2% and almost 50% of all asymptomatic T2DM patients had the echocardiographic anomalies. This is quite comparable to previous investigations in the region and internationally, the prevalence has ranged from 30%–54% for populations with similar characteristics (Patil et al., 2017; Ernande et al., 2011; From et al., 2010). These consistent results in different populations emphasize the pan universal burden of subclinical cardiac involvement in diabetes and the inadequacy of relying solely on symptoms or on traditional risk stratification for detecting early action of the heart.

In multivariate analysis, duration of diabetes, age, and HbA1c were found as independent predictors of diastolic dysfunction. Length of diabetes was significantly longer in patients with dysfunction (11.1 years) compared to patients without (7.7 years), and they had higher HbA1c levels (8.8% vs. 8.1%). These results are in alignment with the pathophysiological paradigm of diabetic cardiomyopathy in which chronic hyperglycemia, cumulative metabolic insult, and the age-related process hasten up transformation of myocardial fibrosis, microvascular rarefaction and the modifications in ventricular compliance (Jia et al., 2018; Nagueh et al., 2016; Boudina & Abel, 2016).

The correlation between duration of diabetes and cardiac complications has been confirmed by various longitudinal and cross-sectional studies. For example, from et al. (2010) reported that T2DM patients with preclinical diastolic dysfunction are at a ~3-fold increased risk for developing symptomatic HF, an effect that increases with the duration of diabetes. In the same way, the association of poor glycemic control with myocardial damage has been consistently established in mechanistic (Ernande & Derumeaux, 2012; Nunes et al., 2013) and clinical studies.

But gender and BMI, where the association was not independent of age, time, and glucose control, not in this study any significant independent ones with diastolic dysfunction. There has been evidence supporting that women are at increased risk for diastolic dysfunction and subsequently HFpEF, especially after menopause (Redfield et al., 2003), whereas other studies have suggested that the risk related to sex is attenuated after adjustment for age, metabolic status, and duration of diabetes (Low Wang et al., 2016). Likewise, even though obesity is established as a risk factor for cardiovascular diseases, its role in diastolic dysfunction of T2DM patients is controversial and is likely to be influenced by comorbidities and lifestyle factors (Bozkurt et al., 2016).

The most common abnormality in the echocardiographic parameters was the decreased E/A velocity ratio followed by increased LAVI and higher E/e' velocity ratio. The application of composite criteria, as per ASE/EACVI guidelines, enhances specificity of the diagnosis of true diastolic dysfunction (Nagueh et al., 2016). This observed pattern of structure and mechanical inefficiency is consistent with the concept that the failure of LV relaxation and atrial remodeling are among the early events of the diabetic heart that precede obvious changes in ejection fraction or symptomatic disease (8).

The high prevalence and risk factors found in this study contrast positively with local and worldwide figures. For instance, Patil et al. (2017) reported the diastolic dysfunction to be as high as 54% in Indian T2DM patients and Ernande et al. (2011) observed 46% in a French diabetic population. In Japan, Yamamoto et al. (2016) found early diastolic dysfunction in more than 40 % of newly diagnosed T2DM patients, confirming subclinical character of this entity over the world. The consistency of findings among diverse races and cultural and physical environments implies that race, culture, and environment are likely to exert little influence on early diabetic cardiomyopathy than do the underlying pathophysiologic mechanisms of chronic hyperglycemia and metabolic stress.

However, only limited research has been conducted in the Pakistani population. However, the few available data indicate comparable trends, with Aamir et al. (2019) on the burden of undetected cardiovascular co-morbidities in Pakistani diabetics. The current study extends this evidence base by using standardized echo protocols and multivariate methods in a large community-based cohort.

The mechanisms of diastolic dysfunction in T2DM are multifactorial and complex, interrelated processes:

Metabolic Disorders: Long-term hyperglycemia and insulin resistance predispose individuals to accumulation of advanced glycation end products (AGEs), oxidative stress and lip toxicity, which ultimately cause damage to the extracellular matrix of the myocardium (Jia et al., 2018).

Fibrosis of the Myocardium: The inflammatory cytokines and pro-fibrosis activation pathway can induce collagen formation which can decrease the compliance and relaxation of the ventricles (Ernande & Derumeaux, 2012).

Microvascular Disease: Endothelial dysfunction, capillary rarefaction, and limitations in coronary flow reserve cause subclinical ischemia and some extent of diastolic dysfunction (Miki et al.

Autonomic Dysfunction: Change in autonomic tone – HRV and ventricular filling. It masks other pathology (Kahal et al., 2018).

Diabetes mellitus: Histopathologic studies in diabetic animals and humans have shown interstitial fibrosis, myocyte hypertrophy, and microangiopathy in a necessarily coincidental fashion through with a performance of functional echocardiographic findings (Nunes et al., 2013).

The high asymptomatic diastolic dysfunction burden among T2DM patients demonstrates the insufficiency of screening based on symptoms or risk factors alone. Echocardiographic evaluation including tissue Doppler imaging and LAVI is a very sensitive and noninvasive approach to early diagnosis of subclinical cardiac involvement (Nagueh et al., 2016; Bozkurt et al., 2016).

Early diagnosis of diastolic dysfunction creates a crucial window of opportunity to intervene prior to symptomatic development of heart failure or irreversible structural alterations. Approaches such as aggressive glycemic control, lifestyle changes, blood pressure reduction, and pharmacotherapy (i.e., SGLT2 inhibitors, ACE inhibitors) have demonstrated potential to halt or reverse the remodeling of the heart and the evolution of symptomatic heart failure (Jia et al., 2018; Bozkurt et al., 2016).

Considering the increasing prevalence of diabetes in Pakistan and a huge burden of undetected CVD, evidence of the present study favors the incorporation of routine echocardiographic screening as part of the standard of care for patients with T2DM, especially when they have longer duration of T2DM or suboptimal control of glycaemia. Screening for abnormalities should be performed regardless of symptoms or known cardiovascular disease, as subclinical changes are frequent and carry prognostic value.

Strengths and Limitations

Strengths

Standardized assessment: All echocardiograms were performed in one blinded cardiologist with the application of the ASE/EACVI protocols, thus reducing bias and technical variability.

Thorough Clinical Data: The investigation recorded important demographic and metabolic risk factors for strong bivariate analysis.

Representative Cohort: The patients are representative of the population of patients with T2DM attending outpatient clinics in Pakistan.

Limitations

Cross-Sectional Design: The study does not allow us to infer causality or to determine the sequence from diastolic dysfunction to heart failure. Prospective, longitudinal studies are needed.

Single-center Study: Results may not be applicable to all populations or geographic regions, but the findings align well with those of other studies and may be well generalizable.

Selection Bias: Simply put, consecutive, clinic-based sampling may miss diabetics who are not seeking regular care or who have a milder form of the disease.

Unmeasured Confounders: Levels of physical activities, dietary habits level of socioeconomic status or any genetic predisposition have not been estimated and could affect cardiac outcomes.

Echocardiographic Screening: Routine echocardiography in all T2DM patients, more so those with disease duration >5 years or HbA1c >8%, for early detection of diastolic dysfunction.

The Prevention of CVD: Routine cardiac assessment should be included in diabetes care guidelines with appropriate cascade mechanisms to cardiology review, if dysfunction is detected.

Patient Education: Patients should receive counseling regarding the potential consequences of subclinical cardiac disease, the need for good glycemic control, and management of blood pressure and follow-up evaluations.

Long-term Studies: Prospective studies monitoring the evolution of diastolic dysfunction and the effect of early intervention on clinical end points, such as the development of HFpEF and death are required.

Interventional Studies: Prospective randomized controlled trials to evaluate the effect of targeted pharmacological or lifestyle interventions on the reversal or attenuation of diastolic dysfunction in asymptomatic diabetic patients are needed.

Mechanistic Studies: Additional study of molecular and genetic mechanisms of diabetic cardiomyopathy in South Asians could lead to new preventive or treatment options.

General Populations: Multi-center and population-based studies are required to confirm findings and increase generalizability, in particular among rural, under-resourced, or ethnic populations.

This research shows that diastolic dysfunction is a frequent and under-diagnosed complication among asymptomatic patients with type 2 DM in Pakistan in subjects without known CVD. Independent predictors are duration of diabetes, poor glycemic control, and old age. The results reaffirm the importance of regular echocardiographic screening and multidisciplinary management in intercepting the progress to clinical heart failure. Early detection and interventions could lead to improved cardiac outcomes and quality of life for millions of diabetics world-wide.

Conclusion and Recommendations

Conclusion

The purpose of this study was to evaluate the prevalence and predictors of diastolic dysfunction in asymptomatic diabetic patients with type 2 diabetes, who do not have a prior history of heart disease, applying standardized echo parameters. The results demonstrate a heavy load of subclinical diastolic dysfunction in this cohort as almost 44% of all patients showed echocardiographic signs of left ventricular (LV) relaxation and filling impairment.

Three risk factors (duration of diabetes, poor glycemic control [i.e., high HbA_{1c}], and increasing age) were independently associated with an increased likelihood of diastolic dysfunction. These findings are in agreement with international data and emphasize the importance of chronic metabolic strain in the development of DCMrocess. Significantly, most patients affected did not have symptoms, highlighting the inadequacy of symptom-based cardiac screening for routine diabetes management.

The echocardiographic characteristic of the studied population reflects a predominance of E/A ratio <1 and a high LAVI, manifestations of the alterations in the early left ventricular myocardial relaxation and the atrial remodeling. These alterations, if not identified, may evolve to HFpEF or if unchecked overt HF as shown by previous follow-up studies (From et al., 2010; Patil et al., 2017). Early screening and comprehensive early intervention are important in avoiding irreversible cardiac injury and ameliorating the long-term prognosis of type 2 diabetic patients.

Implications for Clinical Practice

Implications of the findings for practice with emphasis on the management of type 2 diabetics in Pakistan and similar settings:

Routine Echocardiographic Evaluation: Since tools for detection of subclinical left ventricular dysfunction are advocated in current guidelines, screening echocardiographic evaluation ought to be considered in all patients with T2DM, particularly those who have been suffering for a longer duration of diabetes and/or have been poorly controlled glycemia. It is imperative that high risk individuals can be recognized before symptoms and cardiac remodeling becomes advanced and irreversible (Nagueh et al.

Collaborated Diabetes and Cardiovascular Care: Multidisciplinary care models that incorporate diabetology, cardiology and primary care can enable an early detection, risk stratification, and intervention of the diabetic patients with sub-clinical cardiac dysfunction.

Patient Education and Empowerment: Patients should receive education on the hazards of diabetic cardiomyopathy, the necessity of achieving glycemic control, and the value of periodic cardiovascular screening. Involving patients in their own care may improve treatment and lifestyle compliance.

Focused Interventions Higher risk patients (e.g., longer duration of diabetes, higher HbA1c, elderly) Intensified interventions: tighter glycemic control BP lowering Wt loss Use of cardioprotective medications may prevent progression to overt heart failure (Bozkurt et al., 2016).

Policy Implications

The escalation of diabetes and its debilitating complications in Pakistan demand policy-level interventions:

Screening Recommendations: National diabetes management guidelines should include recommendations for echocardiographic screening of diastolic dysfunction among high-risk populations.

Capacity building: Investments in training health workers on echocardiographic techniques and how to manage diabetic cardiomyopathy is required to expand the screening and treatment capacity at the primary and secondary healthcare levels.

Resource Allocation: Health care providers need to allocate resources for the provision of echocardiography and the required follow up in public and private sector facilities.

Study Limitations

Despite the positive implications of this research, the following limitations must be considered:

Cross-sectional Design: Because of cross-sectional design, temporal relationship between risk factors and development of diastolic dysfunction, or progression to heart failure cannot be evaluated.

Single-center and Urban Location: All these findings are not necessarily applicable to rural or different areas of Pakistan with other sociodemographic features.

Unmeasured Confounders: Environmental moderators including levels of physical activity, dietary habits, SES, and genetic predisposition were not considered, but may affect cardiac outcomes.

Echocardiography operator differences: All scans were performed by one blinded cardiologist but the interpretation of the echocardiography could have some variability.

Recommendations for Future Research

Prospective Longitudinal Studies: To establish the natural history and progression of diastolic dysfunction, and to test the effect of early intervention, future research is needed that tracks diabetic patients over time.

Interventional Trials: Randomized trials investigating the efficacy of drugs and lifestyle modifications in the reversal or prevention of diastolic dysfunction should be encouraged.

Population-level studies: Multicenter, rural and ethnically diverse population-based studies will enhance generalization and contribute to the national approach for screening and management.

Mechanistic Studies: Investigating more molecular and genetic mechanisms that contribute towards diabetic cardiomyopathy in this particular ethnic group may guide us to new therapeutic strategies.

Diastolic dysfunction is a frequent and neglected sequale in type 2 diabetes mellitus patients in Pakistan. The asymptomatic nature of this cardiac involvement cautions to the requirements of active screening and integrated care delivery models. Routine echocardiographic screening and intervention could be used to avoid progression to symptomatic heart failure, enhancing quality and quantity of life and mitigating increasing rates of diabetes-related cardiovascular disease.

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